

# Power Management Integrated Circuit

## BD71837AMWV

### General Description

- BD71837AMWV is a programmable Power Management IC (PMIC) for powering single-core, dual-core, and quad-core SoC's such as NXP-i.MX 8M. It is optimized for low BOM cost and compact solution footprint. It integrates 8 Buck regulators and 7 LDO's to provide all the power rails required by the SoC and the commonly used peripherals.
- QFN package and pinout support low cost Type 3 (non-HDI) PCB. Programmable power sequencing and output voltages, flexible power state control for easier system design and supports a wide variety of processors and system implementations.

### Features

- 8 Buck Regulators
  - 2.0 MHz Switching Frequency. (BUCK1, BUCK2, BUCK3, BUCK4, BUCK5, BUCK7, and BUCK8).
  - 1.5MHz Switching Frequency. (BUCK6)
  - Target Efficiency: 83% to 95%.
  - Output Current & Voltage.
    - BUCK1: 3.6 A, 0.7 V to 1.3 V/10 mV step, DVS
    - BUCK2: 4.0 A, 0.7 V to 1.3 V/10 mV step, DVS
    - BUCK3: 2.1 A, 0.7 V to 1.3 V/10 mV step, DVS
    - BUCK4: 1.0 A, 0.7 V to 1.3 V/10 mV step, DVS
    - BUCK5: 2.5 A, 0.70 V to 1.35 V/8steps
    - BUCK6: 3.0 A, 3.0 V to 3.3 V/100 mV step
    - BUCK7: 1.5 A, 1.605 V to 1.995 V/8steps
    - BUCK8: 3.0 A, 0.8 V to 1.4 V/10 mV step
- 7ch Linear Regulators(7 LDOs)
  - LDO1: 10 mA, 3.0 V to 3.3 V, 1.6 V to 1.9 V
  - LDO2: 10 mA, 0.9 V, 0.8 V
  - LDO3: 300 mA, 1.8 V to 3.3 V
  - LDO4: 250 mA, 0.9 V to 1.8 V
  - LDO5: 300 mA, 1.8 V to 3.3 V
  - LDO6: 300 mA, 0.9 V to 1.8 V
  - LDO7: 150 mA, 1.8 V to 3.3 V
- Power Mux Switch
  - 1.8V Input: 200 mΩ(Max)
  - 3.3V Input: 280 mΩ(Max)
- 32.768 kHz Crystal Oscillator Driver
- Power Button Detector
- Protection and Monitoring: Soft Start, Power Rails Fault Detection, UVLO, OVP and TSD
- OTP Configurable Power Sequencing
- OTP and Software Programmable Output Voltage, Ramp rates.
- Hardware Signaling with SoC for Transition into or out of Low Power States
- Interfaces:
  - I2C: 100 kHz/400 kHz, 1 MHz
  - Power-on Reset Output: POR\_B, RTC\_RESET\_B,
  - Watchdog Reset Input: WDOG\_B:
  - Power State Control:
    - PMIC\_STBY\_REQ, PMIC\_ON\_REQ, PWRON\_B
  - Interrupt to SoC: IRQ\_B
- Type3 PCB Applicable

### Key Specifications

- Input Voltage Range (VSYS): 2.7 V to 5.5 V
- SNVS State Current: 30 μA(Typ)
- SUSPEND State Current: 137 μA(Typ)
- IDLE State Current: 167 μA(Typ)
- RUN State Current: 197 μA(Typ)
- Operating Temperature Range: -40 °C to +105 °C

### Applications

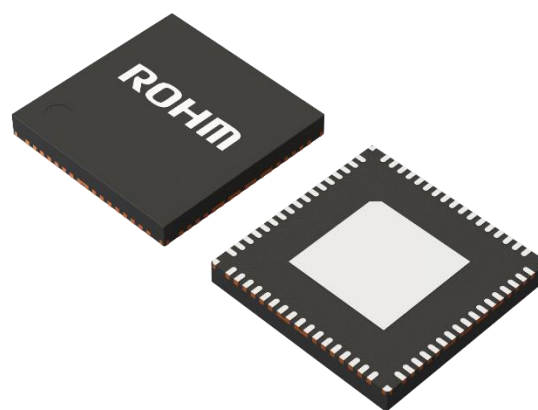
- Streaming Media Boxes and Dongles
- AV Receivers and Wireless Sound Bars
- Industrial HMI, SBC, IPC and Panel Computer

### Package

UQFN68CV8080

### W(Typ) x D(Typ) x H(Max)

8.00mm x 8.00mm x 1.00mm



## Contents

|           |                                                     |    |
|-----------|-----------------------------------------------------|----|
| 1.        | Introduction.....                                   | 7  |
| 1.1.      | Terminology.....                                    | 7  |
| 1.2.      | System Power Map & Typical Application Circuit..... | 8  |
| 1.3.      | Pin Configuration.....                              | 10 |
| 1.4.      | Pin Description.....                                | 11 |
| 1.5.      | I/O Equivalence Circuit.....                        | 12 |
| 1.6.      | Power Rail.....                                     | 14 |
| 1.7.      | Register Map.....                                   | 15 |
| 1.8.      | ESD.....                                            | 17 |
| 2.        | Operating Conditions.....                           | 18 |
| 2.1.      | Absolute Maximum Ratings (Ta=25 °C).....            | 18 |
| 2.2.      | Thermal Resistance.....                             | 18 |
| 2.3.      | Recommended Operating Conditions.....               | 19 |
| 2.4.      | Current Consumption.....                            | 19 |
| 2.5.      | Power Reference and Detectors (UVLO).....           | 20 |
| 3.        | Power State Control.....                            | 21 |
| 3.1.      | Power Control Signals.....                          | 21 |
| 3.1.1.    | PWRON_B.....                                        | 22 |
| 3.1.2.    | PMIC_ON_REQ.....                                    | 22 |
| 3.1.3.    | PMIC_STBY_REQ.....                                  | 22 |
| 3.1.4.    | WDOG_B.....                                         | 22 |
| 3.1.5.    | RTC_RESET_B.....                                    | 23 |
| 3.1.6.    | POR_B.....                                          | 23 |
| 3.2.      | Power States.....                                   | 24 |
| 3.2.1.    | Power State Diagram.....                            | 24 |
| 3.2.2.    | Power State Register.....                           | 25 |
| 3.2.3.    | Power State Definition.....                         | 27 |
| 3.2.4.    | Power State Control Events.....                     | 28 |
| 3.2.4.1.  | Reset Event.....                                    | 28 |
| 3.2.4.2.  | Emergency Shutdown Event.....                       | 30 |
| 3.2.5.    | Power State Transitions.....                        | 30 |
| 3.2.5.1.  | OFF to READY.....                                   | 30 |
| 3.2.5.2.  | READY to SNVS.....                                  | 31 |
| 3.2.5.3.  | SNVS to RUN.....                                    | 34 |
| 3.2.5.4.  | RUN to IDLE.....                                    | 36 |
| 3.2.5.5.  | IDLE to RUN.....                                    | 36 |
| 3.2.5.6.  | RUN to SUSPEND.....                                 | 36 |
| 3.2.5.7.  | SUSPEND to RUN.....                                 | 36 |
| 3.2.5.8.  | IDLE to SUSPEND.....                                | 37 |
| 3.2.5.9.  | Emergency Shutdown.....                             | 37 |
| 3.2.5.10. | VR Fault.....                                       | 38 |
| 3.2.5.11. | EMG to OFF.....                                     | 42 |
| 3.2.5.12. | EMG to READY.....                                   | 43 |
| 3.2.5.13. | EMG_STAY Condition.....                             | 44 |
| 3.2.5.14. | Warm Reset.....                                     | 44 |
| 3.2.5.15. | PWROFF.....                                         | 45 |
| 3.2.5.16. | PWROFF to READY.....                                | 47 |
| 3.2.5.17. | PWROFF to SNVS.....                                 | 47 |
| 3.2.5.18. | PWRON_B Functionality.....                          | 47 |
| 3.3.      | Power Sequence.....                                 | 49 |
| 3.3.1.    | Power ON Sequence.....                              | 49 |
| 3.3.2.    | Power OFF Sequence.....                             | 51 |
| 3.3.3.    | RUN to IDLE.....                                    | 55 |
| 3.3.4.    | IDLE to RUN.....                                    | 56 |
| 3.3.5.    | RUN to SUSPEND.....                                 | 57 |
| 3.3.6.    | SUSPEND to RUN.....                                 | 58 |
| 3.3.7.    | IDLE to SUSPEND.....                                | 59 |
| 3.3.8.    | Emergency Shutdown.....                             | 60 |
| 3.3.9.    | Warm Reset.....                                     | 61 |
| 3.3.10.   | Reset Source Indicators.....                        | 62 |
| 4.        | I2C and Interrupt.....                              | 63 |
| 4.1.      | I2C Bus Interface.....                              | 63 |
| 4.1.1.    | I2C Bus Interface Overview.....                     | 63 |
| 4.1.2.    | I2C Bus Interface Electrical Characteristics.....   | 64 |
| 4.1.3.    | Device Addressing.....                              | 66 |
| 4.1.4.    | Write / Read Operation.....                         | 67 |
| 4.2.      | Interrupt.....                                      | 68 |
| 4.2.1.    | Interrupt Overview.....                             | 68 |
| 5.        | Power Rails.....                                    | 71 |

|          |                                                                       |     |
|----------|-----------------------------------------------------------------------|-----|
| 5.1.     | Output Voltage Range .....                                            | 71  |
| 5.2.     | Details of Buck .....                                                 | 73  |
| 5.2.1.   | BUCK1 .....                                                           | 73  |
| 5.2.1.1. | BUCK1 Block Diagram .....                                             | 73  |
| 5.2.1.2. | BUCK1 Electrical Characteristics .....                                | 74  |
| 5.2.1.3. | BUCK1 Control .....                                                   | 75  |
| 5.2.2.   | BUCK2 .....                                                           | 77  |
| 5.2.2.1. | BUCK2 Block Diagram .....                                             | 77  |
| 5.2.2.2. | BUCK2 Electrical Characteristics .....                                | 78  |
| 5.2.2.3. | BUCK2 Control .....                                                   | 79  |
| 5.2.3.   | BUCK3 .....                                                           | 81  |
| 5.2.3.1. | BUCK3 Block Diagram .....                                             | 81  |
| 5.2.3.2. | BUCK3 Electrical Characteristics .....                                | 82  |
| 5.2.3.3. | BUCK3 Control .....                                                   | 83  |
| 5.2.4.   | BUCK4 .....                                                           | 84  |
| 5.2.4.1. | BUCK4 Block Diagram .....                                             | 84  |
| 5.2.4.2. | BUCK4 Electrical Characteristics .....                                | 85  |
| 5.2.4.3. | BUCK4 Control .....                                                   | 86  |
| 5.2.5.   | BUCK5 .....                                                           | 87  |
| 5.2.5.1. | BUCK5 Block Diagram .....                                             | 87  |
| 5.2.5.2. | BUCK5 Electrical Characteristics .....                                | 88  |
| 5.2.5.3. | BUCK5 Control .....                                                   | 89  |
| 5.2.6.   | BUCK6 .....                                                           | 90  |
| 5.2.6.1. | BUCK6 Block Diagram .....                                             | 90  |
| 5.2.6.2. | BUCK6 Electrical Characteristics .....                                | 91  |
| 5.2.6.3. | BUCK6 Control .....                                                   | 92  |
| 5.2.7.   | BUCK7 .....                                                           | 93  |
| 5.2.7.1. | BUCK7 Block Diagram .....                                             | 93  |
| 5.2.7.2. | BUCK7 Electrical Characteristics .....                                | 94  |
| 5.2.7.3. | BUCK7 Control .....                                                   | 95  |
| 5.2.8.   | BUCK8 .....                                                           | 96  |
| 5.2.8.1. | BUCK8 Block Diagram .....                                             | 96  |
| 5.2.8.2. | BUCK8 Electrical Characteristics .....                                | 97  |
| 5.2.8.3. | BUCK8 Control .....                                                   | 98  |
| 5.3.     | Details of LDO .....                                                  | 99  |
| 5.3.1.   | LDO1 .....                                                            | 99  |
| 5.3.1.1. | LDO1 Block Diagram .....                                              | 99  |
| 5.3.1.2. | LDO1 Electrical Characteristics .....                                 | 100 |
| 5.3.1.3. | LDO1 Control .....                                                    | 101 |
| 5.3.2.   | LDO2 .....                                                            | 102 |
| 5.3.2.1. | LDO2 Block Diagram .....                                              | 102 |
| 5.3.2.2. | LDO2 Electrical Characteristics .....                                 | 103 |
| 5.3.2.3. | LDO2 Control .....                                                    | 103 |
| 5.3.3.   | LDO3 .....                                                            | 104 |
| 5.3.3.1. | LDO3 Block Diagram .....                                              | 104 |
| 5.3.3.2. | LDO3 Electrical Characteristics .....                                 | 105 |
| 5.3.3.3. | LDO3 Control .....                                                    | 106 |
| 5.3.4.   | LDO4 .....                                                            | 107 |
| 5.3.4.1. | LDO4 Block Diagram .....                                              | 107 |
| 5.3.4.2. | LDO4 Electrical Characteristics .....                                 | 108 |
| 5.3.4.3. | LDO4 Control .....                                                    | 109 |
| 5.3.5.   | LDO5 .....                                                            | 110 |
| 5.3.5.1. | LDO5 Block Diagram .....                                              | 110 |
| 5.3.5.2. | LDO5 Electrical Characteristics .....                                 | 111 |
| 5.3.5.3. | LDO5 Control .....                                                    | 112 |
| 5.3.6.   | LDO6 .....                                                            | 113 |
| 5.3.6.1. | LDO6 Block Diagram .....                                              | 113 |
| 5.3.6.2. | LDO6 Electrical Characteristics .....                                 | 114 |
| 5.3.6.3. | LDO6 Control .....                                                    | 115 |
| 5.3.7.   | LDO7 .....                                                            | 116 |
| 5.3.7.1. | LDO7 Block Diagram .....                                              | 116 |
| 5.3.7.2. | LDO7 Electrical Characteristics .....                                 | 117 |
| 5.3.7.3. | LDO7 Control .....                                                    | 118 |
| 5.4.     | MUXSW .....                                                           | 119 |
| 5.4.1.   | MUXSW Block Diagram .....                                             | 119 |
| 5.4.2.   | MUXSW Electrical Characteristics .....                                | 120 |
| 6.       | 32.768 kHz Crystal Oscillator Driver .....                            | 121 |
| 6.1.     | 32.768 kHz Crystal Oscillator Driver Block Diagram .....              | 121 |
| 6.2.     | 32.768 kHz Crystal Oscillator Driver Electrical Characteristics ..... | 121 |
| 7.       | Operational Notes .....                                               | 122 |

|     |                                                  |     |
|-----|--------------------------------------------------|-----|
| 8.  | Ordering Information.....                        | 124 |
| 9.  | Marking Diagram .....                            | 124 |
| 10. | Physical Dimension and Packing Information ..... | 125 |
| 11. | Revision History .....                           | 126 |

## Figure

|              |                                                                  |     |
|--------------|------------------------------------------------------------------|-----|
| Figure 1-1.  | System Power Map .....                                           | 8   |
| Figure 1-2.  | Typical Applications Circuit .....                               | 9   |
| Figure 1-3.  | Pin Configuration (TOP VIEW) .....                               | 10  |
| Figure 1-4.  | I/O Equivalence Circuit 1 .....                                  | 12  |
| Figure 1-5.  | I/O Equivalence Circuit 2 .....                                  | 13  |
| Figure 2-1.  | Power Reference and Detectors Block Diagram .....                | 20  |
| Figure 3-1.  | Power Control Signals of BD71837AMWV .....                       | 21  |
| Figure 3-2.  | Power State Transition .....                                     | 24  |
| Figure 3-3.  | Power Sub State Definition.....                                  | 26  |
| Figure 3-4.  | VSYS Condition for moving to SNVS .....                          | 31  |
| Figure 3-5.  | PMIC_ON_REQ Condition for moving to SNVS.....                    | 31  |
| Figure 3-6.  | PWRON_B Short Push Condition for moving to SNVS .....            | 32  |
| Figure 3-7.  | PWRON_B Long Push Condition for moving to SNVS.....              | 32  |
| Figure 3-8.  | Cold Reset Condition for moving to SNVS .....                    | 32  |
| Figure 3-9.  | VSYS Condition for moving to RUN .....                           | 34  |
| Figure 3-10. | PMIC_ON_REQ Condition for moving to RUN.....                     | 34  |
| Figure 3-11. | PWRON_B Short Push Condition for moving to RUN .....             | 35  |
| Figure 3-12. | PWRON_B Long Push Condition for moving to RUN.....               | 35  |
| Figure 3-13. | Cold Reset Condition for moving to RUN .....                     | 35  |
| Figure 3-14. | Example of VR Fault and Recovery Sequence (RCVLT[3:0] = 2) ..... | 42  |
| Figure 3-15. | EMG to OFF Power State Transition .....                          | 42  |
| Figure 3-16. | EMG to READY Power State Transition (VSYS_UVLO) .....            | 43  |
| Figure 3-17. | EMG to READY Power State Transition (Die Temperature) .....      | 43  |
| Figure 3-18. | Warm Reset by WDOG_B .....                                       | 44  |
| Figure 3-19. | Cold Reset Duration Time set by PONT[3:0] .....                  | 46  |
| Figure 3-20. | Power Button Block Diagram.....                                  | 47  |
| Figure 3-21. | Power ON Sequence.....                                           | 49  |
| Figure 3-22. | Power OFF Sequence (To SNVS) .....                               | 51  |
| Figure 3-23. | Power OFF Sequence (To READY) .....                              | 53  |
| Figure 3-24. | RUN to IDLE.....                                                 | 55  |
| Figure 3-25. | IDLE to RUN.....                                                 | 56  |
| Figure 3-26. | RUN to SUSPEND .....                                             | 57  |
| Figure 3-27. | SUSPEND to RUN .....                                             | 58  |
| Figure 3-28. | IDLE to SUSPEND .....                                            | 59  |
| Figure 3-29. | Emergency Shutdown .....                                         | 60  |
| Figure 3-30. | Warm Reset (SWRESET) .....                                       | 61  |
| Figure 3-31. | Warm Reset (WDOG_B) .....                                        | 61  |
| Figure 3-32. | Warm Reset (PWRON_B Long Push) .....                             | 61  |
| Figure 4-1.  | I2C (Slave) Block Diagram .....                                  | 63  |
| Figure 4-2.  | I2C Bus Interface AC Timing .....                                | 65  |
| Figure 4-3.  | I2C Device Addressing .....                                      | 66  |
| Figure 4-4.  | I2C Write / Read Operation .....                                 | 67  |
| Figure 4-5.  | IRQ_B Architecture Block Diagram .....                           | 68  |
| Figure 5-1.  | BUCK1 Block Diagram .....                                        | 73  |
| Figure 5-2.  | BUCK2 Block Diagram .....                                        | 77  |
| Figure 5-3.  | BUCK3 Block Diagram .....                                        | 81  |
| Figure 5-4.  | BUCK4 Block Diagram .....                                        | 84  |
| Figure 5-5.  | BUCK5 Block Diagram .....                                        | 87  |
| Figure 5-6.  | BUCK6 Block Diagram .....                                        | 90  |
| Figure 5-7.  | BUCK7 Block Diagram .....                                        | 93  |
| Figure 5-8.  | BUCK8 Block Diagram .....                                        | 96  |
| Figure 5-9.  | LDO1 Block Diagram.....                                          | 99  |
| Figure 5-10. | LDO2 Block Diagram.....                                          | 102 |
| Figure 5-11. | LDO3 Block Diagram.....                                          | 104 |
| Figure 5-12. | LDO3 Voltage Source Switching .....                              | 106 |
| Figure 5-13. | LDO4 Block Diagram.....                                          | 107 |
| Figure 5-14. | LDO4 Voltage Source Switching .....                              | 109 |
| Figure 5-15. | LDO5 Block Diagram.....                                          | 110 |
| Figure 5-16. | LDO6 Block Diagram.....                                          | 113 |
| Figure 5-17. | LDO7 Block Diagram.....                                          | 116 |
| Figure 5-18. | MUXSW Block Diagram .....                                        | 119 |
| Figure 5-19. | MUXSW Sequence .....                                             | 120 |
| Figure 6-1.  | 32.768 kHz Crystal Oscillator Driver Block Diagram .....         | 121 |
| Figure 9-1.  | Marking Diagram.....                                             | 124 |

## Table

|                                                                           |    |
|---------------------------------------------------------------------------|----|
| Table 1-1. Acronyms, Conventions and Terminology .....                    | 7  |
| Table 1-2. Pin Description.....                                           | 11 |
| Table 1-3. Power Rails and Output Signals .....                           | 14 |
| Table 1-4. Register Map.....                                              | 15 |
| Table 1-5. REV - Revision Register .....                                  | 15 |
| Table 1-6. REGLOCK - Lock Register .....                                  | 16 |
| Table 1-7. OTPVER – OTP Version Register.....                             | 16 |
| Table 1-8. ESD .....                                                      | 17 |
| Table 2-1. Absolute Maximum Ratings.....                                  | 18 |
| Table 2-2. Thermal Resistance <sup>(Note 1)</sup> .....                   | 18 |
| Table 2-3. Recommended Operating Conditions .....                         | 19 |
| Table 2-4. Current Consumption.....                                       | 19 |
| Table 2-5. Power Reference and Detectors Electrical Characteristics ..... | 20 |
| Table 3-1. PWRON_B Electrical Characteristics.....                        | 22 |
| Table 3-2. PMIC_ON_REQ Electrical Characteristics.....                    | 22 |
| Table 3-3. PMIC_STBY_REQ Electrical Characteristics.....                  | 22 |
| Table 3-4. WDOG_B Electrical Characteristics.....                         | 22 |
| Table 3-5. RTC_RESET_B Electrical Characteristics .....                   | 23 |
| Table 3-6. POR_B Electrical Characteristics.....                          | 23 |
| Table 3-7. POW_STATE – Power State Register.....                          | 25 |
| Table 3-8. Voltage Rails ON/OFF for Respective Power State .....          | 28 |
| Table 3-9. Setting of Cold or Warm Reset Selection.....                   | 29 |
| Table 3-10. SWRESET - Software Reset Register .....                       | 29 |
| Table 3-11. PWRCTRL0 - Power Control 0 Register .....                     | 29 |
| Table 3-12. Conditions from OFF to READY state.....                       | 30 |
| Table 3-13. Conditions from READY to SNVS.....                            | 31 |
| Table 3-14. TRANS_COND0 - Transition Condition Select 0 Register .....    | 33 |
| Table 3-15. Conditions from SNVS to RUN .....                             | 34 |
| Table 3-16. Conditions from RUN to IDLE .....                             | 36 |
| Table 3-17. PWRCTRL1 - Power Control 1 Register .....                     | 36 |
| Table 3-18. Conditions from IDLE to RUN .....                             | 36 |
| Table 3-19. Conditions from RUN to SUSPEND.....                           | 36 |
| Table 3-20. Conditions from SUSPEND to RUN.....                           | 36 |
| Table 3-21. Conditions from IDLE to SUSPEND.....                          | 37 |
| Table 3-22. Conditions from SNVS, RUN, IDLE, SUSPEND, PWROFF to EMG.....  | 37 |
| Table 3-23. VR_FAULT threshold and monitoring condition.....              | 38 |
| Table 3-24. VRFAULTEN - VR_FAULT ON/OFF Register: Debugging Purpose.....  | 39 |
| Table 3-25. MVRFLTMASK0 - VR_FAULT Mask 0 Register .....                  | 39 |
| Table 3-26. MVRFLTMASK1 - VR_FAULT Mask 1 Register .....                  | 40 |
| Table 3-27. MVRFLTMASK2 - VR_FAULT Mask 2 Register .....                  | 40 |
| Table 3-28. RCVCFG - Recovery Configuration Register .....                | 41 |
| Table 3-29. RCVNUM - Recovery Number Register.....                        | 41 |
| Table 3-30. Conditions from EMG to OFF.....                               | 42 |
| Table 3-31. Conditions from EMG to READY .....                            | 43 |
| Table 3-32. Conditions for Stay at EMG.....                               | 44 |
| Table 3-33. Conditions from RUN, IDLE, SUSPEND to PWROFF .....            | 45 |
| Table 3-34. TRANS_COND1 - Transition Condition Select 1 Register .....    | 45 |
| Table 3-35. VR Summary After Power OFF Sequence.....                      | 46 |
| Table 3-36. PWRONCONFIG0 - PWRON_B Configuration 0 Register.....          | 47 |
| Table 3-37. PWRONCONFIG1 - PWRON_B Configuration 1 Register.....          | 48 |
| Table 3-38. Power ON Sequence Timing Specification.....                   | 50 |
| Table 3-39. Power OFF Sequence Timing Specification (To SNVS).....        | 52 |
| Table 3-40. Power OFF Sequence Timing Specification (To READY) .....      | 54 |
| Table 3-41. RUN to IDLE Timing Specification .....                        | 55 |
| Table 3-42. IDLE to RUN Timing Specification .....                        | 56 |
| Table 3-43. RUN to SUSPEND Timing Specification .....                     | 57 |
| Table 3-44. SUSPEND to RUN Timing Specification .....                     | 58 |
| Table 3-45. IDLE to SUSPEND Timing Specification .....                    | 59 |
| Table 3-46. Emergency Shutdown Timing Specification .....                 | 60 |
| Table 3-47. Warm Reset (SWRESET) Timing Specification .....               | 61 |
| Table 3-48. Warm Reset (WDOG_B) Timing Specification .....                | 61 |
| Table 3-49. Warm Reset (PWRON_B Long Push) Timing Specification.....      | 61 |
| Table 3-50. RESETSRC - Reset Source Indicator Register.....               | 62 |
| Table 4-1. I2C Bus Interface DC Electrical Characteristics .....          | 64 |
| Table 4-2. I2C Bus Interface AC Timing - Fast Mode .....                  | 65 |
| Table 4-3. I2C_DEV - I2C Device Address Indicator Register .....          | 66 |
| Table 4-4. Interrupt Event .....                                          | 68 |

|                                                                                  |     |
|----------------------------------------------------------------------------------|-----|
| Table 4-5. IRQ_B Electrical Characteristics .....                                | 68  |
| Table 4-6. IRQ - Interrupt Register .....                                        | 69  |
| Table 4-7. MIRQ – IRQ Mask Register .....                                        | 69  |
| Table 4-8. IN_MON - Input Port Monitor Register .....                            | 70  |
| Table 5-1. Output Voltage Range1 .....                                           | 71  |
| Table 5-2. Output Voltage Range2 .....                                           | 72  |
| Table 5-3. BUCK1 Electrical Characteristics .....                                | 74  |
| Table 5-4. BUCK1_CTRL - BUCK1 Control Register .....                             | 75  |
| Table 5-5. BUCK1_VOLT_RUN - BUCK1 Voltage (RUN) Register .....                   | 75  |
| Table 5-6. BUCK1_VOLT_IDLE - BUCK1 Voltage (IDLE) Register .....                 | 76  |
| Table 5-7. BUCK1_VOLT_SUSP - BUCK1 Voltage (SUSPEND) Register .....              | 76  |
| Table 5-8. BUCK2 Electrical Characteristics .....                                | 78  |
| Table 5-9. BUCK2_CTRL - BUCK2 Control Register .....                             | 79  |
| Table 5-10. BUCK2_VOLT_RUN - BUCK2 Voltage (RUN) Register .....                  | 79  |
| Table 5-11. BUCK2_VOLT_IDLE - BUCK2 Voltage (IDLE) Register .....                | 80  |
| Table 5-12. BUCK3 Electrical Characteristics .....                               | 82  |
| Table 5-13. BUCK3_CTRL - BUCK3 Control Register .....                            | 83  |
| Table 5-14. BUCK3_VOLT_RUN - BUCK3 Voltage (RUN) Register .....                  | 83  |
| Table 5-15. BUCK4 Electrical Characteristics .....                               | 85  |
| Table 5-16. BUCK4_CTRL - BUCK4 Control Register .....                            | 86  |
| Table 5-17. BUCK4_VOLT_RUN - BUCK4 Voltage (RUN) Register .....                  | 86  |
| Table 5-18. BUCK5 Electrical Characteristics .....                               | 88  |
| Table 5-19. BUCK5_CTRL - BUCK5 Control Register .....                            | 89  |
| Table 5-20. BUCK5_VOLT - BUCK5 Voltage Register .....                            | 89  |
| Table 5-21. BUCK6 Electrical Characteristics .....                               | 91  |
| Table 5-22. BUCK6_CTRL - BUCK6 Control Register .....                            | 92  |
| Table 5-23. BUCK6_VOLT - BUCK6 Voltage Register .....                            | 92  |
| Table 5-24. BUCK7 Electrical Characteristics .....                               | 94  |
| Table 5-25. BUCK7_CTRL - BUCK7 Control Register .....                            | 95  |
| Table 5-26. BUCK7_VOLT - BUCK7 Voltage Register .....                            | 95  |
| Table 5-27. BUCK8 Electrical Characteristics .....                               | 97  |
| Table 5-28. BUCK8_CTRL - BUCK8 Control Register .....                            | 98  |
| Table 5-29. BUCK8_VOLT - BUCK8 Voltage Register .....                            | 98  |
| Table 5-30. LDO1 Electrical Characteristics .....                                | 100 |
| Table 5-31. LDO1_VOLT - LDO1 Voltage Register .....                              | 101 |
| Table 5-32. LDO2 Electrical Characteristics .....                                | 103 |
| Table 5-33. LDO2_VOLT - LDO2 Voltage Register .....                              | 103 |
| Table 5-34. LDO3 Electrical Characteristics .....                                | 105 |
| Table 5-35. LDO3_VOLT - LDO3 Voltage Register .....                              | 106 |
| Table 5-36. LDO4 Electrical Characteristics .....                                | 108 |
| Table 5-37. LDO4_VOLT - LDO4 Voltage Register .....                              | 109 |
| Table 5-38. LDO5 Electrical Characteristics .....                                | 111 |
| Table 5-39. LDO5_VOLT - LDO5 Voltage Register .....                              | 112 |
| Table 5-40. LDO6 Electrical Characteristics .....                                | 114 |
| Table 5-41. LDO6_VOLT - LDO6 Voltage Register .....                              | 115 |
| Table 5-42. LDO7 Electrical Characteristics .....                                | 117 |
| Table 5-43. LDO7_VOLT - LDO7 Voltage Register .....                              | 118 |
| Table 5-44. MUXSW Electrical Characteristics .....                               | 120 |
| Table 5-45. SD_VSELECT Electrical Characteristics .....                          | 120 |
| Table 5-46. MUXSW Sequence Timing .....                                          | 120 |
| Table 5-47. MUXSW_EN - MUXSW Enable Register .....                               | 120 |
| Table 6-1. C32K_OUT Control Register .....                                       | 121 |
| Table 6-2. 32.768 kHz Crystal Oscillator Driver Electrical Characteristics ..... | 121 |

## 1. Introduction

### 1.1. Terminology

**Table 1-1. Acronyms, Conventions and Terminology**

| Term | Definition                                               |
|------|----------------------------------------------------------|
| BOM  | Bill Of Materials                                        |
| DAC  | Digital to Analog Converter                              |
| DVS  | Dynamic Voltage Scaling                                  |
| FET  | Field Effect Transistor                                  |
| I2C  | Inter-Integrated Circuit                                 |
| IRQ  | Interrupt Request                                        |
| LDO  | Low Drop-Out regulator                                   |
| NTC  | Negative Temperature Coefficient. (a type of thermistor) |
| OCP  | Over Current Protection                                  |
| OTP  | One Time Programmable memory                             |
| OVP  | Over Voltage Protection                                  |
| PFM  | Pulse-Frequency Modulation                               |
| POR  | Power On Reset                                           |
| PWM  | Pulse-Width Modulation                                   |
| SMPS | Switched Mode Power Supply                               |
| SoC  | System-On-a-Chip                                         |
| UVLO | Under Voltage-LockOut                                    |
| VR   | Voltage Regulator                                        |

## 1.2. System Power Map &amp; Typical Application Circuit

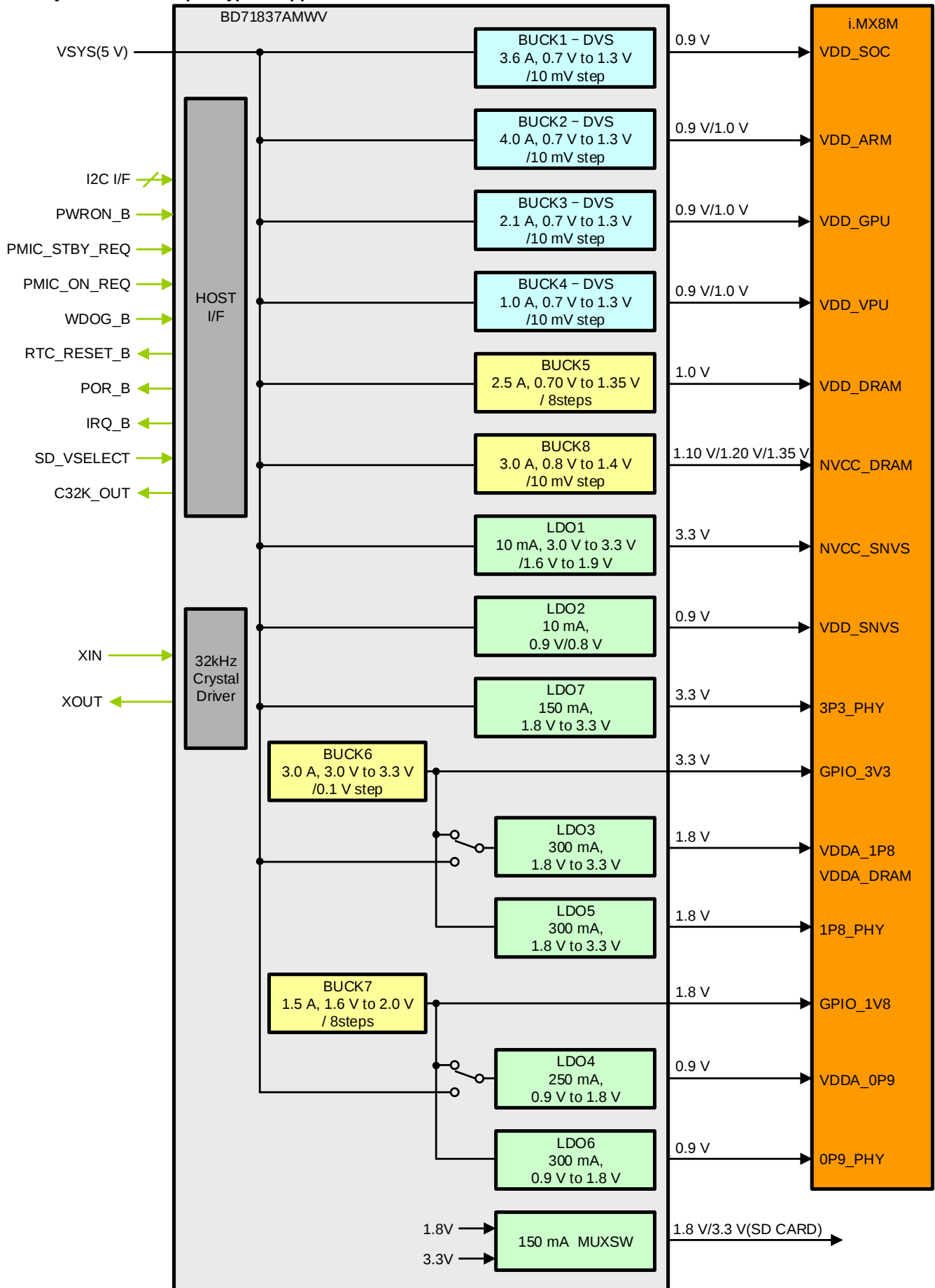


Figure 1-1. System Power Map

## 1.2. System Power Map &amp; Typical Application Circuit - continued

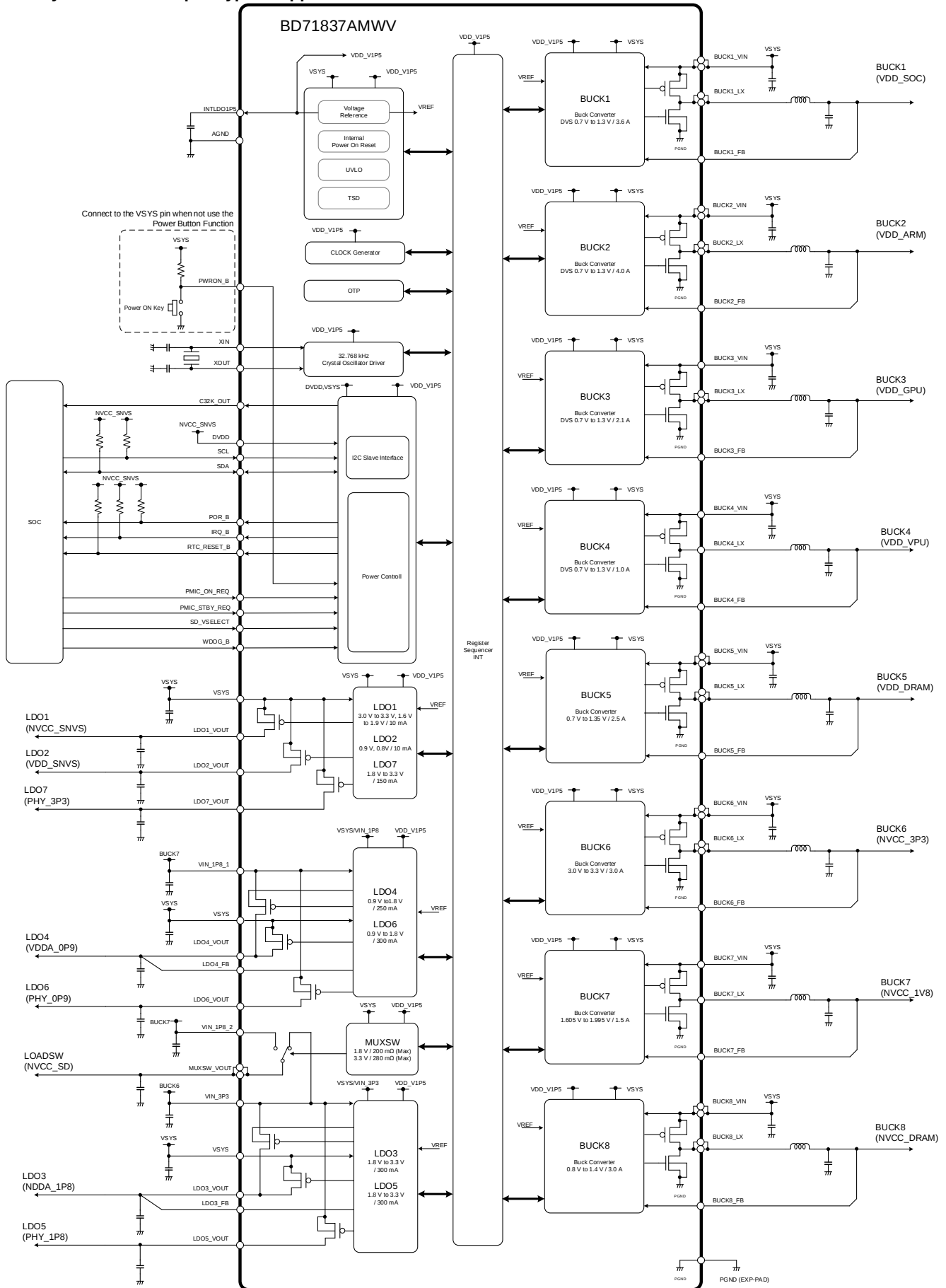


Figure 1-2. Typical Applications Circuit

1.3. Pin Configuration

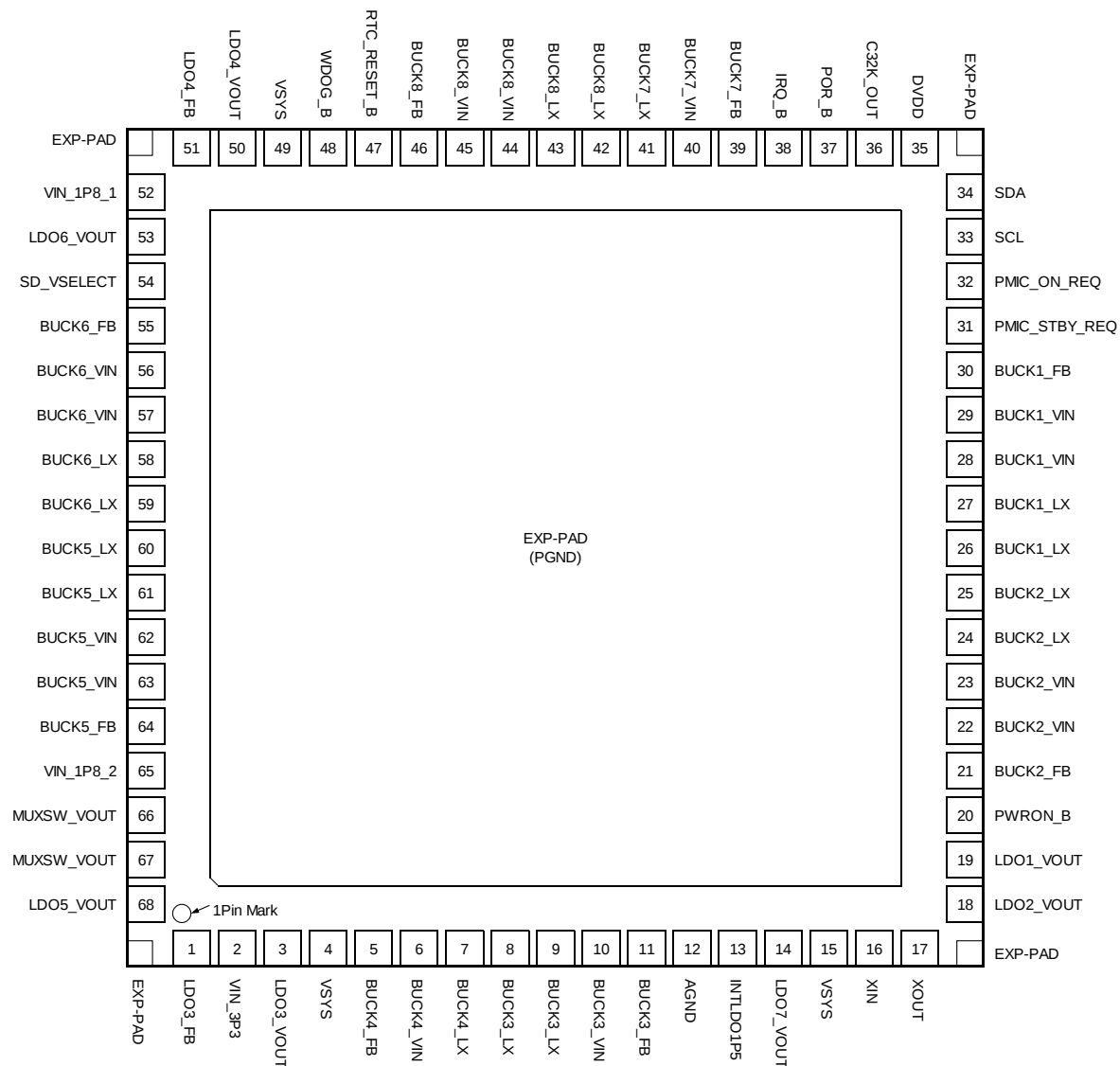


Figure 1-3. Pin Configuration (TOP VIEW)

## 1.4. Pin Description

Table 1-2. Pin Description

| Pin# | Block Name         | Pin Name       | Dir | Pin Description                                                                                                                                                 | PWR /GND | Voltage Level | Terminal Equivalent | Internal pull         |
|------|--------------------|----------------|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---------------|---------------------|-----------------------|
| 28   | BUCK1              | BUCK1_VIN      | I   | BUCK1 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 29   |                    | BUCK1_VIN      | I   | BUCK1 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 26   |                    | BUCK1_LX       | O   | BUCK1 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 27   |                    | BUCK1_LX       | O   | BUCK1 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 30   |                    | BUCK1_FB       | I   | BUCK1 feedback sense                                                                                                                                            | -        | BUCK1         | D2_1                | No                    |
| 22   | BUCK2              | BUCK2_VIN      | I   | BUCK2 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 23   |                    | BUCK2_VIN      | I   | BUCK2 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 24   |                    | BUCK2_LX       | O   | BUCK2 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 25   |                    | BUCK2_LX       | O   | BUCK2 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 21   |                    | BUCK2_FB       | I   | BUCK2 feedback sense                                                                                                                                            | -        | BUCK2         | D2_1                | No                    |
| 10   | BUCK3              | BUCK3_VIN      | I   | BUCK3 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 8    |                    | BUCK3_LX       | O   | BUCK3 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 9    |                    | BUCK3_LX       | O   | BUCK3 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 11   |                    | BUCK3_FB       | I   | BUCK3 feedback sense                                                                                                                                            | -        | BUCK3         | D2_1                | No                    |
| 6    | BUCK4              | BUCK4_VIN      | I   | BUCK4 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 7    |                    | BUCK4_LX       | O   | BUCK4 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 5    |                    | BUCK4_FB       | I   | BUCK4 feedback sense                                                                                                                                            | -        | BUCK4         | D2_1                | No                    |
| 62   |                    | BUCK5_VIN      | I   | BUCK5 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 63   | BUCK5              | BUCK5_VIN      | I   | BUCK5 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 60   |                    | BUCK5_LX       | O   | BUCK5 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 61   |                    | BUCK5_LX       | O   | BUCK5 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 64   |                    | BUCK5_FB       | I   | BUCK5 feedback sense                                                                                                                                            | -        | BUCK5         | D2_1                | No                    |
| 56   | BUCK6              | BUCK6_VIN      | I   | BUCK6 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 57   |                    | BUCK6_VIN      | I   | BUCK6 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 58   |                    | BUCK6_LX       | O   | BUCK6 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 59   |                    | BUCK6_LX       | O   | BUCK6 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 55   |                    | BUCK6_FB       | I   | BUCK6 feedback sense                                                                                                                                            | -        | BUCK6         | D2_1                | No                    |
| 40   | BUCK7              | BUCK7_VIN      | I   | BUCK7 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 41   |                    | BUCK7_LX       | O   | BUCK7 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 39   |                    | BUCK7_FB       | I   | BUCK7 feedback sense                                                                                                                                            | -        | BUCK7         | D2_1                | No                    |
| 44   | BUCK8              | BUCK8_VIN      | I   | BUCK8 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 45   |                    | BUCK8_VIN      | I   | BUCK8 switcher input supply                                                                                                                                     | PWR      | VSYS          | H1_1                | No                    |
| 42   |                    | BUCK8_LX       | O   | BUCK8 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 43   |                    | BUCK8_LX       | O   | BUCK8 switch node connection                                                                                                                                    | -        | VSYS          | H1_1                | No                    |
| 46   |                    | BUCK8_FB       | I   | BUCK8 feedback sense                                                                                                                                            | -        | BUCK8         | D2_1                | No                    |
| 15   | LDO1               | VSYS           | I   | LDO1, LDO2, LDO7 input supply                                                                                                                                   | PWR      | VSYS          | G1_1                | No                    |
| 19   |                    | LDO1_VOUT      | O   | LDO1 output(Default:3.3V)                                                                                                                                       | -        | LDO1          | G1_1                | No                    |
| 18   |                    | LDO2_VOUT      | O   | LDO2 output(Default:0.9V)                                                                                                                                       | -        | LDO2          | G1_1                | No                    |
| 14   |                    | LDO7_VOUT      | O   | LDO7 output(Default:3.3V)                                                                                                                                       | -        | LDO7          | G1_1                | No                    |
| 52   | LDO4               | VIN_1P8_1      | I   | LDO4, LDO6 input supply(Default:1.8V)                                                                                                                           | PWR      | BUCK7         | G1_1, G3_1          | No                    |
| 49   |                    | VSYS           | I   | LDO4 input supply                                                                                                                                               | PWR      | VSYS          | G3_1                | No                    |
| 50   |                    | LDO4_VOUT      | O   | LDO4 output(Default:0.9V)                                                                                                                                       | -        | LDO4          | G3_1                | No                    |
| 51   |                    | LDO4_FB        | I   | LDO4 feedback sense                                                                                                                                             | -        | LDO4          | D2_1                | No                    |
| 53   |                    | LDO6_VOUT      | O   | LDO6 output(Default:0.9V)                                                                                                                                       | -        | LDO6          | G1_2                | No                    |
| 2    | LDO3               | VIN_3P3        | I   | LDO3, LDO5, MUXSW input supply(Default:3.3V)                                                                                                                    | PWR      | BUCK6         | G1_3, G3_2          | No                    |
| 4    |                    | VSYS           | I   | LDO3 input supply                                                                                                                                               | PWR      | VSYS          | G3_2                | No                    |
| 3    |                    | LDO3_VOUT      | O   | LDO3 output(Default:1.8V)                                                                                                                                       | -        | LDO3          | G3_2                | No                    |
| 1    |                    | LDO3_FB        | I   | LDO3 feedback sense                                                                                                                                             | -        | LDO3          | D2_1                | No                    |
| 68   |                    | LDO5_VOUT      | O   | LDO5 output(Default:1.8V)                                                                                                                                       | -        | LDO5          | G1_3                | No                    |
| 65   | MUXSW              | VIN_1P8_2      | I   | MUXSW input supply(Default:1.8V)                                                                                                                                | PWR      | BUCK7         | G1_1, G3_1          | No                    |
| 66   |                    | MUXSW_VOUT     | O   | MUXSW output(3.3V/1.8V)                                                                                                                                         | -        | VIN3P3        | F2_1                | No                    |
| 67   |                    | MUXSW_VOUT     | O   | MUXSW output(3.3V/1.8V)                                                                                                                                         | -        | VIN1P8        | F2_1                | No                    |
| 13   | REF                | INTLDO1P5      | O   | Internal LDO for PMIC                                                                                                                                           | PWR      | INTLDO1P5     | G1_4                | No                    |
| 12   |                    | AGND           | I   | AGND                                                                                                                                                            | GND      | 0V            | Z1_1                | No                    |
| 16   | Crystal Oscillator | XIN            | I   | 32.768kHz crystal input                                                                                                                                         | -        | INTLDO1P5     | E1_1                | No                    |
| 17   |                    | XOUT           | O   | 32.768kHz crystal output                                                                                                                                        | -        | INTLDO1P5     | E1_1                | No                    |
| 35   | Interface          | DVDD           | I   | Interface input supply                                                                                                                                          | PWR      | DVDD          | Z1_1                | No                    |
| 33   |                    | SCL            | I   | I <sup>2</sup> C CLOCK                                                                                                                                          | -        | DVDD          | A1_1                | No <sup>(Note1)</sup> |
| 34   |                    | SDA            | I/O | I <sup>2</sup> C DATA                                                                                                                                           | -        | DVDD          | A3_1                | No <sup>(Note1)</sup> |
| 36   |                    | C32K_OUT       | O   | 32.768kHz clock output                                                                                                                                          | -        | DVDD          | C1_1                | No                    |
| 38   |                    | IRQ_B          | O   | Interrupt signal to processor(Open Drain)                                                                                                                       | -        | DVDD          | C1_1                | No <sup>(Note1)</sup> |
| 37   |                    | POR_B          | O   | Power on reset output(Open Drain)                                                                                                                               | -        | DVDD          | C1_1                | No <sup>(Note1)</sup> |
| 47   |                    | RTC_RESET_B    | O   | Power OK signal for LDO1,2(Open Drain)                                                                                                                          | -        | DVDD          | C1_1                | No <sup>(Note1)</sup> |
| 48   |                    | WDOG_B         | I   | Watchdog input from processor                                                                                                                                   | -        | DVDD          | C1_1                | No                    |
| 32   |                    | PMIC_ON_REQ    | I   | Power on/off control Input                                                                                                                                      | -        | VSYS          | A6_1                | No                    |
| 31   |                    | PMIC_STBY_REQ  | I   | Standby input signal                                                                                                                                            | -        | DVDD          | C1_1                | No                    |
| 54   |                    | SD_VSELECT     | I   | Voltage select for SD                                                                                                                                           | -        | DVDD          | C1_1                | No                    |
| 20   |                    | PWRON_B        | I   | Power Button                                                                                                                                                    | -        | VSYS          | A6_1                | No                    |
| -    | -                  | EXP-PAD (PGND) | -   | Power Ground. Connect the center EXP-PAD in the Figure 1-3 to the GND plane of PCB. The EXP-PADs on the 4-corner have the same potential as the center EXP-PAD. | GND      | 0V            | Z1_1                | No                    |

(Note 1) Need to pull up external resistance to DVDD

## 1.5. I/O Equivalence Circuit

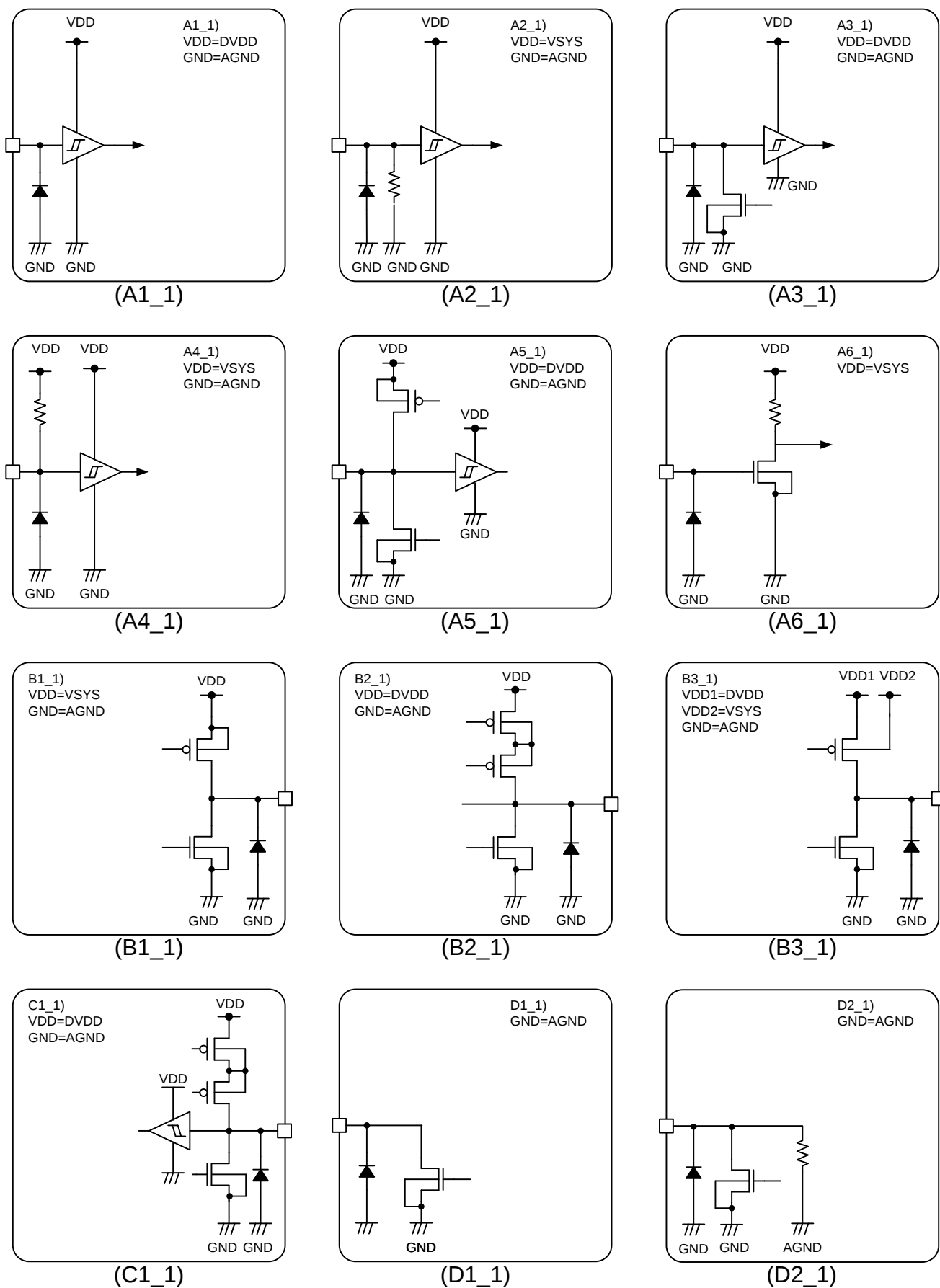


Figure 1-4. I/O Equivalence Circuit 1

## 1.5. I/O Equivalence Circuit – continued

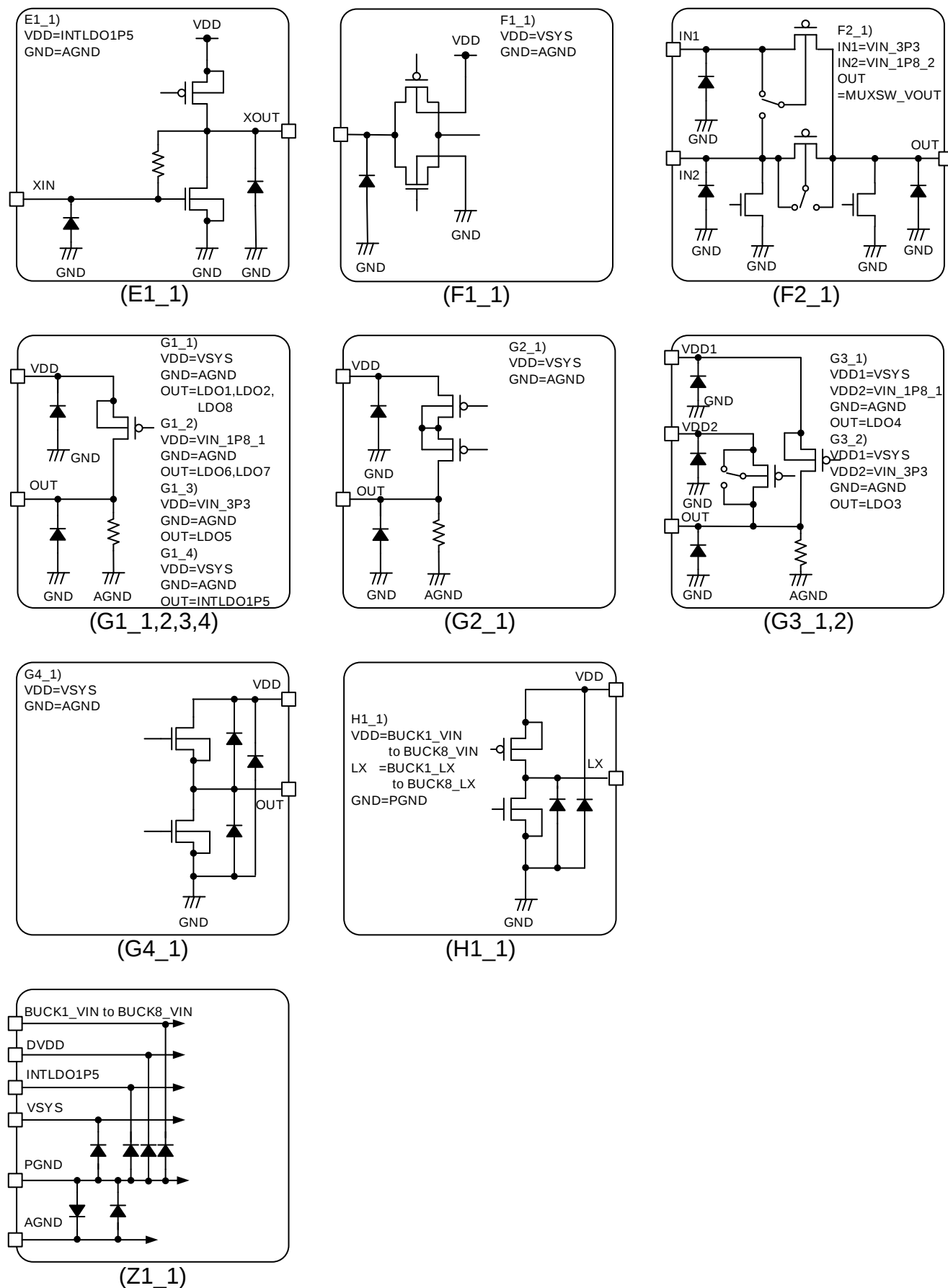


Figure 1-5. I/O Equivalence Circuit 2

## 1.6. Power Rail

Table 1-3. Power Rails and Output Signals

| Sequence Order | Function      | Rail/Signal Name | Type       | Input Rail      | Output Voltage Initial Value [V] | Output Voltage Adjustable Range [V]                          | DVS | I <sub>OMAX</sub> [A] |
|----------------|---------------|------------------|------------|-----------------|----------------------------------|--------------------------------------------------------------|-----|-----------------------|
| 1              | NVCC_SNVS     | LDO1             | Source LDO | VSYS            | 3.3                              | 3.0 to 3.3, 1.6 to 1.9 (100 mV step)                         | -   | 0.01                  |
| 2              | VDD_SNVS      | LDO2             | Source LDO | VSYS            | 0.9                              | 0.9, 0.8                                                     | -   | 0.01                  |
| 3              | RTC_RESET_B   | RTC_RESET_B      | Open drain | -               | -                                | -                                                            | -   | -                     |
| 4              | 32K_OUT       | C32K_OUT         | CMOS       | DVDD            | -                                | -                                                            | -   | -                     |
| 5              | VDD_SOC       | BUCK1            | SMPS       | VSYS            | 0.9                              | 0.7 to 1.3 (10 mV step)                                      | DVS | 3.6                   |
| 5              | VDDA_0P9      | LDO4             | Source LDO | VSYS/<br>BUCK7  | 0.9                              | 0.9 to 1.8 (100 mV step)                                     | -   | 0.25                  |
| 6              | VDD_DRAM      | BUCK5            | SMPS       | VSYS            | 1.0                              | 0.70, 0.80, 0.90, 1.00<br>1.05, 1.10, 1.20, 1.35             | -   | 2.5                   |
| 7              | VDD_VPU       | BUCK4            | SMPS       | VSYS            | 1.0                              | 0.7 to 1.3 (10 mV step)                                      | DVS | 1                     |
| 8              | VDD_GPU       | BUCK3            | SMPS       | VSYS            | 1.0                              | 0.7 to 1.3 (10 mV step)                                      | DVS | 2.1                   |
| 9              | VDD_ARM       | BUCK2            | SMPS       | VSYS            | 1.0                              | 0.7 to 1.3 (10 mV step)                                      | DVS | 4.0                   |
| 10             | VDDA_1P8/DRAM | LDO3             | Source LDO | VSYS/<br>BUCK6  | 1.8                              | 1.8 to 3.3 (100 mV step)                                     | -   | 0.3                   |
| 11             | NVCC_3P3      | BUCK6            | SMPS       | VSYS            | 3.3                              | 3.0 to 3.3 (100 mV step)                                     | -   | 3.0                   |
| 11             | NVCC_SD       | MUXSW            | MUX Switch | BUCK6/<br>BUCK7 | 3.3/1.8                          | -                                                            | -   | 0.15                  |
| 12             | NVCC_1P8      | BUCK7            | SMPS       | VSYS            | 1.8                              | 1.605, 1.695, 1.755,<br>1.800, 1.845, 1.905,<br>1.950, 1.995 | -   | 1.5                   |
| 13             | NVCC_DRAM     | BUCK8            | SMPS       | VSYS            | 1.1                              | 0.8 to 1.4 (10 mV step)                                      | -   | 3.0                   |
| 14             | PHY_1P8       | LDO5             | Source LDO | BUCK6           | 1.8                              | 1.8 to 3.3 (100 mV step)                                     | -   | 0.3                   |
| 14             | PHY_0P9       | LDO6             | Source LDO | BUCK7           | 0.9                              | 0.9 to 1.8 (100 mV step)                                     | -   | 0.3                   |
| 14             | PHY_3P3       | LDO7             | Source LDO | VSYS            | 3.3                              | 1.8 to 3.3 (100 mV step)                                     | -   | 0.15                  |
| 15             | POR_B         | POR_B            | Open drain | -               | -                                | -                                                            | -   | -                     |

(Note) Sequence order, interval time of each outputs, and initial output voltages are configurable by OTP.

## 1.7. Register Map

Table 1-4. Register Map

| Address (Hex) | Reset Condition (Note 1) | Register Name   | D7                  | D6               | D5               | D4              | D3                   | D2                  | D1                  | D0                  | Initial Value (Hex) | Access (R, W, RW) | OTP | Write Access Lock (Note 2) |
|---------------|--------------------------|-----------------|---------------------|------------------|------------------|-----------------|----------------------|---------------------|---------------------|---------------------|---------------------|-------------------|-----|----------------------------|
| 00            | NA                       | REV             | MAJREV[3:0]         |                  |                  |                 | MINREV[3:0]          |                     |                     |                     | A3                  | R                 | No  | -                          |
| 01            | UVLO                     | SWRESET         | -                   | -                | -                | -               | -                    | SWRESET_SEL[1:0]    |                     | SWRESET             | 04                  | RW                | No  | -                          |
| 02            | UVLO                     | IC_DEV          | -                   | -                | -                | -               | -                    | IC_DEV_ADRS[1:0]    |                     | -                   | 03                  | R                 | Yes | -                          |
| 03            | UVLO                     | PWRCTRL0        | DEBUG_STATE[1:0]    |                  | RELOAD_REG       |                 | -                    | -                   | WDOG6_SEL[1:0]      |                     | A2                  | RW                | Yes | PWRSEQ                     |
| 04            | UVLO                     | PWRCTRL1        | -                   | -                | -                | -               | -                    | -                   | IDLE_MODE           |                     | 00                  | RW                | Yes | -                          |
| 05            | READY                    | BUCK1_CTRL      | BUCK1_RAMPRATE[1:0] |                  | -                | -               | BUCK1_PWM_FX         | -                   | BUCK1_SEL           | BUCK1_EN            | 40                  | RW                | Yes | VREG                       |
| 06            | READY                    | BUCK2_CTRL      | BUCK2_RAMPRATE[1:0] |                  | -                | -               | BUCK2_PWM_FX         | -                   | BUCK2_SEL           | BUCK2_EN            | 40                  | RW                | Yes | VREG                       |
| 07            | READY                    | BUCK3_CTRL      | BUCK3_RAMPRATE[1:0] |                  | -                | -               | BUCK3_PWM_FX         | BUCK3_RUN_ON        | BUCK3_SEL           | BUCK3_EN            | 44                  | RW                | Yes | VREG                       |
| 08            | READY                    | BUCK4_CTRL      | BUCK4_RAMPRATE[1:0] |                  | -                | -               | BUCK4_PWM_FX         | BUCK4_RUN_ON        | BUCK4_SEL           | BUCK4_EN            | 44                  | RW                | Yes | VREG                       |
| 09            | READY                    | BUCK5_CTRL      | -                   | -                | -                | -               | BUCK5_PWM_FX         | -                   | BUCK5_SEL           | BUCK5_EN            | 00                  | RW                | Yes | VREG                       |
| 0A            | READY                    | BUCK6_CTRL      | -                   | -                | -                | -               | BUCK6_PWM_FX         | -                   | BUCK6_SEL           | BUCK6_EN            | 00                  | RW                | Yes | VREG                       |
| 0B            | READY                    | BUCK7_CTRL      | -                   | -                | -                | -               | BUCK7_PWM_FX         | -                   | BUCK7_SEL           | BUCK7_EN            | 00                  | RW                | Yes | VREG                       |
| 0C            | READY                    | BUCK8_CTRL      | -                   | -                | -                | -               | BUCK8_PWM_FX         | -                   | BUCK8_SEL           | BUCK8_EN            | 00                  | RW                | Yes | VREG                       |
| 0D            | READY                    | BUCK1_VOLT_RUN  | -                   | -                | -                | -               | BUCK1_VOLT_RUN[5:0]  |                     |                     |                     | 14                  | RW                | Yes | VREG                       |
| 0E            | READY                    | BUCK1_VOLT_IDLE | -                   | -                | -                | -               | BUCK1_VOLT_IDLE[5:0] |                     |                     |                     | 14                  | RW                | Yes | VREG                       |
| 0F            | READY                    | BUCK1_VOLT_SUSP | -                   | -                | -                | -               | BUCK1_VOLT_SUSP[5:0] |                     |                     |                     | 14                  | RW                | Yes | VREG                       |
| 10            | READY                    | BUCK2_VOLT_RUN  | -                   | -                | -                | -               | BUCK2_VOLT_RUN[5:0]  |                     |                     |                     | 1E                  | RW                | Yes | VREG                       |
| 11            | READY                    | BUCK2_VOLT_IDLE | -                   | -                | -                | -               | BUCK2_VOLT_IDLE[5:0] |                     |                     |                     | 14                  | RW                | Yes | VREG                       |
| 12            | READY                    | BUCK3_VOLT_RUN  | -                   | -                | -                | -               | BUCK3_VOLT_RUN[5:0]  |                     |                     |                     | 1E                  | RW                | Yes | VREG                       |
| 13            | READY                    | BUCK4_VOLT_RUN  | -                   | -                | -                | -               | BUCK4_VOLT_RUN[5:0]  |                     |                     |                     | 1E                  | RW                | Yes | VREG                       |
| 14            | READY                    | BUCK5_VOLT      | BUCK5_VOLT_SEL      | -                | -                | -               | -                    | BUCK5_VOLT[2:0]     |                     | -                   | 03                  | RW                | Yes | VREG                       |
| 15            | READY                    | BUCK6_VOLT      | -                   | -                | -                | -               | -                    | BUCK6_VOLT[1:0]     |                     | -                   | 03                  | RW                | Yes | VREG                       |
| 16            | READY                    | BUCK7_VOLT      | -                   | -                | -                | -               | -                    | BUCK7_VOLT[2:0]     |                     | -                   | 03                  | RW                | Yes | VREG                       |
| 17            | READY                    | BUCK8_VOLT      | -                   | -                | -                | -               | -                    | BUCK8_VOLT[5:0]     |                     | -                   | 1E                  | RW                | Yes | VREG                       |
| 18            | READY                    | LDO1_VOLT       | LDO1_SEL            | LDO1_EN          | LDO1_VOLT_SEL    | -               | -                    | -                   | LDO1_VOLT[1:0]      |                     | 03                  | RW                | Yes | VREG                       |
| 19            | READY                    | LDO2_VOLT       | LDO2_SEL            | LDO2_EN          | LDO2_VOLT_SEL    | -               | -                    | -                   | LDO2_VOLT[1:0]      |                     | 00                  | RW                | Yes | VREG                       |
| 1A            | READY                    | LDO3_VOLT       | LDO3_SEL            | LDO3_EN          | LDO3_VOLT_SEL    | -               | -                    | -                   | LDO3_VOLT[3:0]      |                     | 00                  | RW                | Yes | VREG                       |
| 1B            | READY                    | LDO4_VOLT       | LDO4_SEL            | LDO4_EN          | LDO4_VOLT_SEL    | -               | -                    | -                   | LDO4_VOLT[3:0]      |                     | 00                  | RW                | Yes | VREG                       |
| 1C            | READY                    | LDO5_VOLT       | LDO5_SEL            | LDO5_EN          | LDO5_VOLT_SEL    | -               | -                    | -                   | LDO5_VOLT[3:0]      |                     | 00                  | RW                | Yes | VREG                       |
| 1D            | READY                    | LDO6_VOLT       | LDO6_SEL            | LDO6_EN          | LDO6_VOLT_SEL    | -               | -                    | -                   | LDO6_VOLT[3:0]      |                     | 00                  | RW                | Yes | VREG                       |
| 1E            | READY                    | LDO7_VOLT       | LDO7_SEL            | LDO7_EN          | LDO7_VOLT_SEL    | -               | -                    | -                   | LDO7_VOLT[3:0]      |                     | 0F                  | RW                | Yes | VREG                       |
| 1F            | UVLO                     | TRANS_COND0     | CI_VSYS_3P0_ONLY_EN | CI_PMC_ON_REQ_EN | CI_SHORT_PUSH_EN | CI_LONG_PUSH_EN | C0_VSYS_3P0_ONLY_EN  | C0_PMC_ON_REQ_EN    | C0_SHORT_PUSH_EN    | C0_LONG_PUSH_EN     | 48                  | RW                | Yes | PWRSEQ                     |
| 20            | UVLO                     | TRANS_COND1     | PONT[3:0]           |                  |                  |                 | PWRON_POFF_TO_READY  | PWRON_POFF_TO_READY | PWRON_POFF_TO_READY | PWRON_POFF_TO_READY | C4                  | RW                | Yes | PWRSEQ                     |
| 21            | UVLO                     | VRFALTEN        | -                   | -                | -                | -               | -                    | -                   | -                   | VRFALTEN            | 01                  | RW                | Yes | -                          |
| 22            | UVLO                     | MVRFALTMASK0    | MBUCK8_VOUTOKH      | MBUCK8_VOUTOKL   | MBUCK7_VOUTOKH   | MBUCK7_VOUTOKL  | MBUCK6_VOUTOKH       | MBUCK6_VOUTOKL      | MBUCK5_VOUTOKH      | MBUCK5_VOUTOKL      | 00                  | RW                | Yes | -                          |
| 23            | UVLO                     | MVRFALTMASK1    | MBUCK4_VOUTOKH      | MBUCK4_VOUTOKL   | MBUCK3_VOUTOKH   | MBUCK3_VOUTOKL  | MBUCK2_VOUTOKH       | MBUCK2_VOUTOKL      | MBUCK1_VOUTOKH      | MBUCK1_VOUTOKL      | 00                  | RW                | Yes | -                          |
| 24            | UVLO                     | MVRFALTMASK2    | -                   | MLDO7_VOUTOKL    | MLDO6_VOUTOKL    | MLDO5_VOUTOKL   | MLDO4_VOUTOKL        | MLDO3_VOUTOKL       | MLDO2_VOUTOKL       | MLDO1_VOUTOKL       | 00                  | RW                | Yes | -                          |
| 25            | UVLO                     | RCVCFG          | RCVLMT[3:0]         |                  |                  |                 | RCVDT[3:0]           |                     |                     |                     | 4C                  | RW                | Yes | -                          |
| 26            | UVLO                     | RCVNUM          | -                   | -                | -                | -               | RCVNUM[3:0]          |                     |                     |                     | 00                  | RW                | No  | -                          |
| 27            | UVLO                     | PWRONCONFIG0    | -                   | -                | -                | -               | SHORT[3:0]           |                     |                     |                     | 16                  | RW                | Yes | -                          |
| 28            | UVLO                     | PWRONCONFIG1    | -                   | -                | -                | -               | LONGT[3:0]           |                     |                     |                     | 0A                  | RW                | Yes | -                          |
| 29            | UVLO                     | RESETSRC        | RPWRON              | RWDG             | RSWRST           | RPMIC_ON_REQ    | RVSYS_2P7            | RTEMP               | ROCP                | RVR_FAULT           | 00                  | RW                | No  | -                          |
| 2A            | UVLO                     | MIRQ            | -                   | MSWRST           | MPWRON_S         | MPWRON_L        | MPWRON               | MDG                 | MON_REQ             | MSBY_REQ            | 7F                  | RW                | No  | -                          |
| 2B            | UVLO                     | IRQ             | -                   | SWRST            | PWRON_S          | PWRON_L         | PWRON                | WDG                 | ON_REQ              | STBY_REQ            | 00                  | RW                | No  | -                          |
| 2C            | UVLO                     | IN_MON          | -                   | -                | -                | -               | STAT_PWRON           | STAT_WDOG           | STAT_ON_REQ         | STAT_STBY_REQ       | 00                  | R                 | No  | -                          |
| 2D            | UVLO                     | POW_STATE       | POW_ST[3:0]         |                  |                  |                 | POW_SUB[1:0]         |                     |                     |                     | 00                  | R                 | No  | -                          |
| 2E            | READY                    | OUT32K          | -                   | -                | -                | -               | -                    | -                   | -                   | OUT32K_EN           | 01                  | RW                | Yes | -                          |
| 2F            | READY                    | REGLOCK         | -                   | -                | -                | VREG            | -                    | -                   | -                   | PWRSEQ              | 11                  | RW                | No  | -                          |
| 30            | READY                    | MUXSW_EN        | -                   | -                | -                | -               | -                    | -                   | -                   | MUXSW_EN            | 01                  | RW                | Yes | -                          |
| FF            | NA                       | OTPPER          | OTPPER[7:0]         |                  |                  |                 |                      |                     |                     |                     | 01                  | R                 | Yes | -                          |

(Note 1) Reset Condition of each register is classified as follows.

UVLO : When INTLDO1P5\_UVLO=0, register values are reset to the default value.

READY : When Power State enters READY, register values are reset to the default value.

(Note 2) Regarding registers labeled in this column, its write access is disabled as follows.

PWRSEQ : When PWRSEQ in REGLOCK register is set to 1, write access is disabled.

VREG : When VREG in REGLOCK register is set to 1, write access is disabled.

Table 1-5. REV - Revision Register

| Register Name | R/W | D7          | D6 | D5 | D4 | D3          | D2 | D1 | D0 | Initial | Address |
|---------------|-----|-------------|----|----|----|-------------|----|----|----|---------|---------|
| REV           | R   | MAJREV[3:0] |    |    |    | MINREV[3:0] |    |    |    | 0xA3    | 0x00    |

| Bit    | Name        | Function       | Initial |
|--------|-------------|----------------|---------|
| D[7:4] | MAJREV[3:0] | Major Revision | 1010    |
| D[3:0] | MINREV[3:0] | Minor Revision | 0011    |

## 1.7. Register Map – continued

Table 1-6. REGLOCK - Lock Register

| Register Name | R/W | D7 | D6 | D5 | D4   | D3 | D2 | D1 | D0     | Initial | Address |
|---------------|-----|----|----|----|------|----|----|----|--------|---------|---------|
| REGLOCK       | R/W | -  | -  | -  | VREG | -  | -  | -  | PWRSEQ | 0x11    | 0x2F    |

| Bit  | Name   | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Initial |
|------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[4] | VREG   | 0 = Enable to write following 26 registers.<br>BUCK1_CTRL, BUCK2_CTRL, BUCK3_CTRL, BUCK4_CTRL<br>BUCK5_CTRL, BUCK6_CTRL, BUCK7_CTRL, BUCK8_CTRL<br>BUCK1_VOLT_RUN, BUCK1_VOLT_IDLE<br>BUCK1_VOLT_SUSP, BUCK2_VOLT_RUN<br>BUCK2_VOLT_IDLE, BUCK3_VOLT_RUN<br>BUCK4_VOLT_RUN, BUCK5_VOLT, BUCK6_VOLT, BUCK7_VOLT<br>BUCK8_VOLT, LDO1_VOLT, LDO2_VOLT, LDO3_VOLT<br>LDO4_VOLT, LDO5_VOLT, LDO6_VOLT, LDO7_VOLT<br><br>1 = Disable to write following 26 registers.<br>BUCK1_CTRL, BUCK2_CTRL, BUCK3_CTRL, BUCK4_CTRL<br>BUCK5_CTRL, BUCK6_CTRL, BUCK7_CTRL, BUCK8_CTRL<br>BUCK1_VOLT_RUN, BUCK1_VOLT_IDLE<br>BUCK1_VOLT_SUSP, BUCK2_VOLT_RUN<br>BUCK2_VOLT_IDLE, BUCK3_VOLT_RUN<br>BUCK4_VOLT_RUN, BUCK5_VOLT, BUCK6_VOLT, BUCK7_VOLT<br>BUCK8_VOLT, LDO1_VOLT, LDO2_VOLT, LDO3_VOLT<br>LDO4_VOLT, LDO5_VOLT, LDO6_VOLT, LDO7_VOLT | 1       |
| D[0] | PWRSEQ | 0 = Enable to write three registers, PWRCTRL0, TRANS_COND0, TRANS_COND1<br>1 = Disable to write three registers, PWRCTRL0, TRANS_COND0, TRANS_COND1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1       |

Table 1-7. OTPVER – OTP Version Register

| Register Name | R/W | D7          | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|---------------|-----|-------------|----|----|----|----|----|----|----|---------|---------|
| OTPVER        | R   | OTPVER[7:0] |    |    |    |    |    |    |    | 0x01    | 0xFF    |

| Bit    | Name         | Function    | Initial |
|--------|--------------|-------------|---------|
| D[7:0] | OTP_VER[7:0] | OTP Version | 0x01    |

## 1.8. ESD

Table 1-8. ESD

| Parameter                 | Minimum<br>Limit | Unit |
|---------------------------|------------------|------|
| Human Body Model(HBM)     | ±2000            | V    |
| Charged Device Model(CDM) | ±1000            | V    |

## 2. Operating Conditions

### 2.1. Absolute Maximum Ratings (Ta=25 °C)

Table 2-1. Absolute Maximum Ratings

| Parameter                                                                                                      | Symbol             | Limit                  |      | Unit |
|----------------------------------------------------------------------------------------------------------------|--------------------|------------------------|------|------|
|                                                                                                                |                    | Min                    | Max  |      |
| Voltage Range in PINs:<br>VSYS, BUCK1_VIN to BUCK8_VIN, VIN_1P8_1, VIN_1P8_2,<br>VIN_3P3, PWRON_B, PMIC_ON_REQ | V <sub>AMR_1</sub> | -0.3                   | +6.0 | V    |
| Voltage Range in PIN:<br>DVDD                                                                                  | V <sub>AMR_2</sub> | -0.3                   | +4.5 | V    |
| Voltage Range in PIN:<br>INTLDO1P5                                                                             | V <sub>AMR_3</sub> | -0.3                   | +2.1 | V    |
| Voltage Range in PINs:<br>BUCK1_LX to BUCK8_LX                                                                 | V <sub>AMR_4</sub> | -1.0(DC)<br>-2.0(10ns) | +7.0 | V    |
| Voltage Range in PINs:<br>SCL, SDA, IRQ_B, POR_B, WODG_B<br>PMIC_STB_REQ, SD_VSELECT, C32K_OUT                 | V <sub>AMR_5</sub> | -0.3                   | +4.5 | V    |
| Voltage Range in PINs:<br>BUCK1_FB to BUCK8_FB, LDO3_FB, LDO4_FB,<br>LDO1_VOUT to LDO7_VOUT, MUXSW_VOUT        | V <sub>AMR_6</sub> | -0.3                   | +4.5 | V    |
| Voltage Range in PINs:<br>XIN, XOUT                                                                            | V <sub>AMR_7</sub> | -0.3                   | +2.1 | V    |
| Maximum Junction Temperature                                                                                   | T <sub>jmax</sub>  |                        | 150  | °C   |
| Storage Temperature Range                                                                                      | T <sub>stg</sub>   | -55                    | +150 | °C   |

**Caution 1:** Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

**Caution 2:** Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.

### 2.2. Thermal Resistance

Table 2-2. Thermal Resistance <sup>(Note 1)</sup>

| Parameter                                                      | Symbol          | Thermal Resistance (Typ) |                          | Unit |
|----------------------------------------------------------------|-----------------|--------------------------|--------------------------|------|
|                                                                |                 | 1s <sup>(Note 3)</sup>   | 2s2p <sup>(Note 4)</sup> |      |
| UQFN68CV8080                                                   |                 |                          |                          |      |
| Junction to Ambient                                            | θ <sub>JA</sub> | 76.8                     | 28.1                     | °C/W |
| Junction to Top Characterization Parameter <sup>(Note 2)</sup> | Ψ <sub>JT</sub> | 6                        | 6                        | °C/W |

(Note 1) Based on JESD51-2A(Still-Air).

(Note 2) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

(Note 3) Using a PCB board based on JESD51-3.

(Note 4) Using a PCB board based on JESD51-5, 7.

| Layer Number of Measurement Board | Material | Board Size                  |
|-----------------------------------|----------|-----------------------------|
| Single                            | FR-4     | 114.3mm x 76.2mm x 1.57mm t |

| Top                   |           |
|-----------------------|-----------|
| Copper Pattern        | Thickness |
| Footprints and Traces | 70μm      |

| Layer Number of Measurement Board | Material | Board Size                 | Thermal Via <sup>(Note 5)</sup> |          |
|-----------------------------------|----------|----------------------------|---------------------------------|----------|
|                                   |          |                            | Pitch                           | Diameter |
| 4 Layers                          | FR-4     | 114.3mm x 76.2mm x 1.6mm t | 1.20mm                          | Φ0.30mm  |

| Top                   |           | 2 Internal Layers |           | Bottom          |           |
|-----------------------|-----------|-------------------|-----------|-----------------|-----------|
| Copper Pattern        | Thickness | Copper Pattern    | Thickness | Copper Pattern  | Thickness |
| Footprints and Traces | 70μm      | 74.2mm x 74.2mm   | 35μm      | 74.2mm x 74.2mm | 70μm      |

(Note 5) This thermal via connects with the copper pattern of all layers.

## 2.3. Recommended Operating Conditions

Table 2-3. Recommended Operating Conditions

| Parameter                                                                  | Symbol             | Limit |      |      | Unit |
|----------------------------------------------------------------------------|--------------------|-------|------|------|------|
|                                                                            |                    | Min   | Typ  | Max  |      |
| Voltage Range in PINs:<br>VSYS, BUCK1_VIN to BUCK8_VIN <sup>(Note 1)</sup> | V <sub>OPR_1</sub> | 2.70  | 5.00 | 5.50 | V    |
| Voltage Range in PINs:<br>DVDD, VIN_3P3 <sup>(Note 2)</sup>                | V <sub>OPR_2</sub> | 2.70  | 3.30 | 3.60 | V    |
| Voltage Range in PIN:<br>VIN_1P8_1 <sup>(Note 3)</sup>                     | V <sub>OPR_3</sub> | 1.71  | 1.80 | 5.50 | V    |
| Voltage Range in PIN:<br>VIN_1P8_2 <sup>(Note 3)</sup>                     | V <sub>OPR_4</sub> | 1.71  | 1.80 | 1.89 | V    |
| Operating Temperature                                                      | Topr               | -40   | +25  | +105 | °C   |

(Note 1) It is necessary to supply the same voltage to the VSYS pin and the BUCK1\_VIN to BUCK8\_VIN pins.

(Note 2) The VIN\_3P3 pin is recommended to connect with BUCK6 outputs.

(Note 3) The VIN\_1P8\_1 pin and the VIN\_1P8\_2 pin are recommended to connect with BUCK7 outputs.

## 2.4. Current Consumption

Table 2-4. Current Consumption

(Unless otherwise specified, Ta=+25 °C, VSYS=5.0 V, DVDD=3.3 V)

| Parameter              | Symbol               | Limit |     |     | Unit | Condition                                                   |
|------------------------|----------------------|-------|-----|-----|------|-------------------------------------------------------------|
|                        |                      | Min   | Typ | Max |      |                                                             |
| VSYS Circuit Current 1 | I <sub>Q_VSYS1</sub> | -     | 14  | 23  | μA   | READY State <sup>(Note 1)</sup>                             |
| VSYS Circuit Current 2 | I <sub>Q_VSYS2</sub> | -     | 30  | 50  | μA   | SNVS State <sup>(Note 1)</sup>                              |
| VSYS Circuit Current 3 | I <sub>Q_VSYS3</sub> | -     | 137 | 205 | μA   | SUSPEND State <sup>(Note 1)</sup>                           |
| VSYS Circuit Current 4 | I <sub>Q_VSYS4</sub> | -     | 167 | 250 | μA   | IDLE State <sup>(Note 1)</sup>                              |
| VSYS Circuit Current 5 | I <sub>Q_VSYS5</sub> | -     | 197 | 295 | μA   | Run State <sup>(Note 1)</sup>                               |
| DVDD Circuit Current 1 | I <sub>Q_DVDD1</sub> | -     | -   | 2   | μA   | DVDD static current (OUT32K_EN=0)                           |
| DVDD Circuit Current 2 | I <sub>Q_DVDD2</sub> | -     | 4   | -   | μA   | DVDD operation current (OUT32K_EN=1)<br><sup>(Note 2)</sup> |

(Note 1) When DVDD is connected with LDO1, total circuit current is the value that added VSYS and DVDD circuit current of this table.

(Note 2) This circuit current is affected by parasitic capacitance of the board.

## 2.5. Power Reference and Detectors (UVLO)

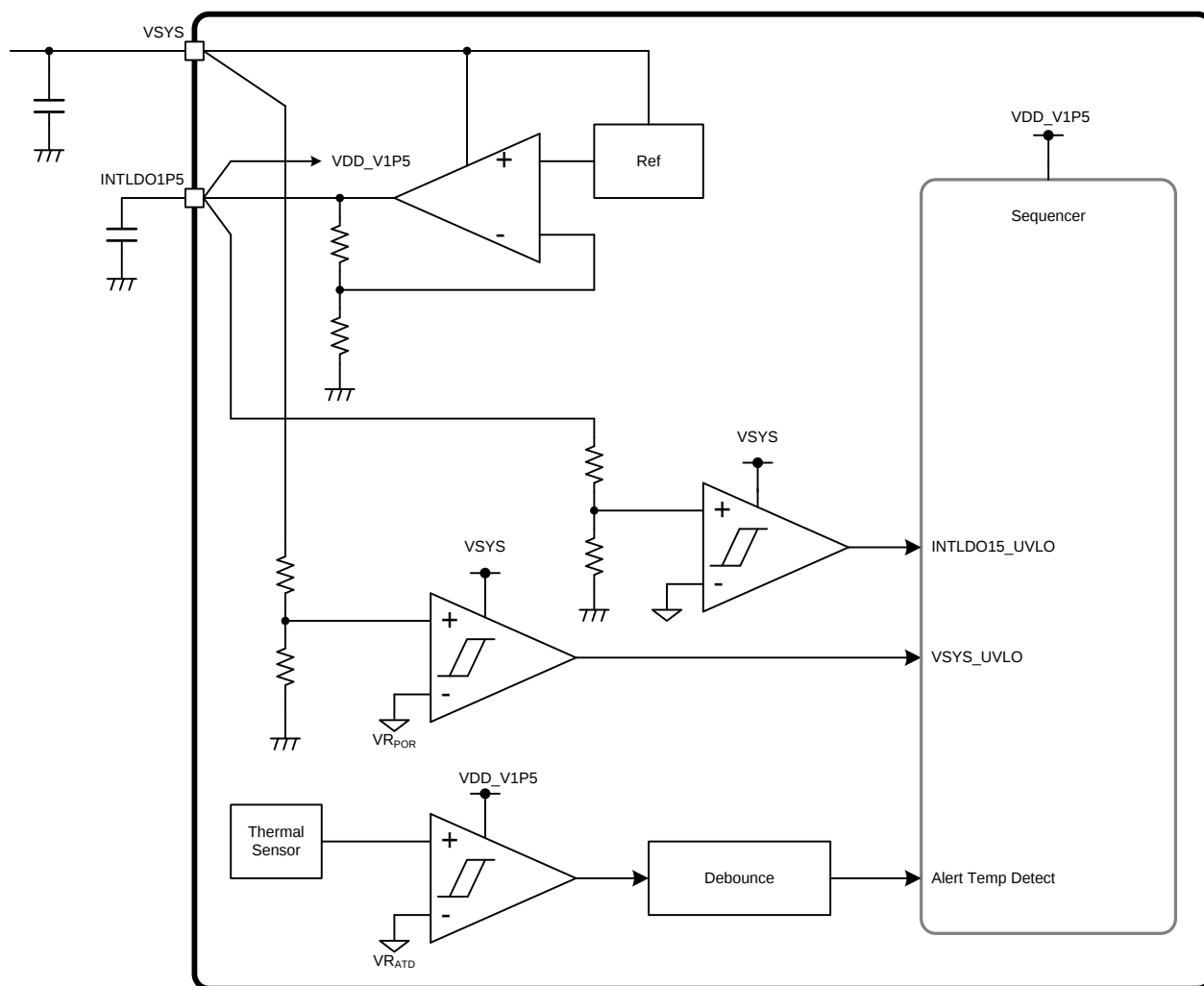


Figure 2-1. Power Reference and Detectors Block Diagram

Table 2-5. Power Reference and Detectors Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, VSYS=5.0 V)

| Parameter                                                        | Symbol                 | Limit |      |      | Unit | Remarks                                       |
|------------------------------------------------------------------|------------------------|-------|------|------|------|-----------------------------------------------|
|                                                                  |                        | Min   | Typ  | Max  |      |                                               |
| Voltage Detector - VSYS under voltage(VSYS_ UVLO)                |                        |       |      |      |      |                                               |
| Release Voltage                                                  | V <sub>UVLORL</sub>    | 2.65  | 3.00 | 3.35 | V    | VSYS=Sweep up                                 |
| Detect Voltage                                                   | V <sub>UVLODT</sub>    | 2.65  | 2.70 | 2.75 | V    | VSYS =Sweep down                              |
| Hysteresis Voltage                                               | V <sub>UVLOHYS</sub>   | -     | 0.3  | -    | V    |                                               |
| Voltage Detector - INTLDO1P5 under voltage(INTLDO1P5_ UVLO)      |                        |       |      |      |      |                                               |
| Release Voltage                                                  | V <sub>INTUVLORL</sub> | -     | 1.39 | -    | V    | VSYS=Sweep up                                 |
| Detect Voltage                                                   | V <sub>INTUVLODT</sub> | -     | 1.35 | -    | V    | VSYS =Sweep down                              |
| PMIC Die Critical Temperature Detector (Thermal Shutdown factor) |                        |       |      |      |      |                                               |
| Detect Temperature                                               | T <sub>CTD</sub>       | -     | 150  | -    | °C   | Die Temperature=Sweep up                      |
| Power Reference                                                  |                        |       |      |      |      |                                               |
| INTLDO1P5 Output Voltage                                         | V <sub>LDO15</sub>     | -     | 1.5  | -    | V    | This output voltage is for internal use only. |
| COUT Capacitor                                                   | C <sub>O_LDO15</sub>   | 0.5   | 1.0  | 5.0  | μF   |                                               |

3. Power State Control

3.1. Power Control Signals

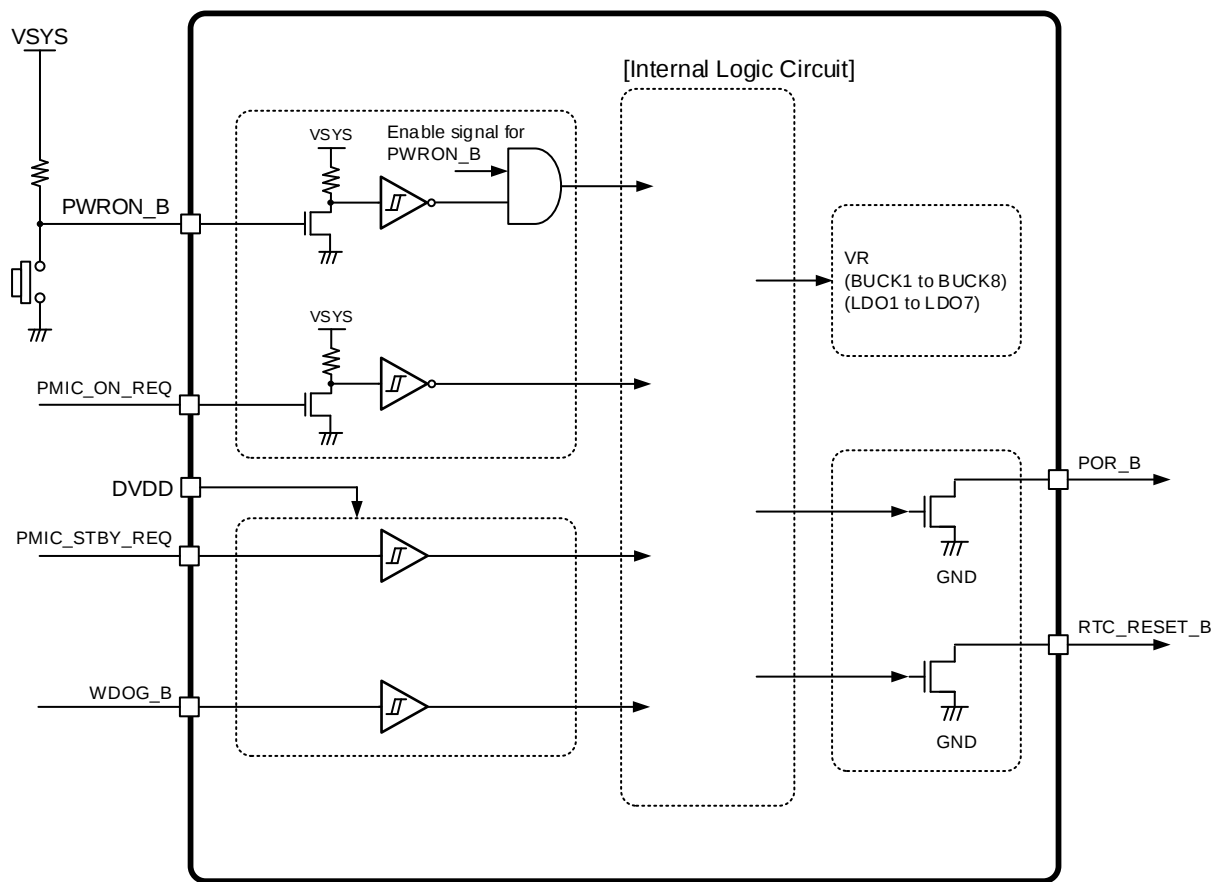


Figure 3-1. Power Control Signals of BD71837AMWV

**3.1.1. PWRON\_B**

PWRON\_B is an active-low input for triggering the system to power on or off. Normally, PWRON\_B is connected to a power button.

**Table 3-1. PWRON\_B Electrical Characteristics**

(Unless otherwise specified, Ta= +25 °C, V<sub>SY</sub>S=5.0 V, DVDD=3.3 V)

| Parameter       | Symbol                | Limit |     |      | Unit | Condition |
|-----------------|-----------------------|-------|-----|------|------|-----------|
|                 |                       | Min   | Typ | Max  |      |           |
| Input "H" Level | V <sub>IH_PWRON</sub> | 1.44  | -   | -    | V    |           |
| Input "L" Level | V <sub>IL_PWRON</sub> | -     | -   | 0.40 | V    |           |

**3.1.2. PMIC\_ON\_REQ**

PMIC\_ON\_REQ is an active-high input for going to RUN state.

**Table 3-2. PMIC\_ON\_REQ Electrical Characteristics**

(Unless otherwise specified, Ta= +25 °C, V<sub>SY</sub>S=5.0 V, DVDD=3.3 V)

| Parameter       | Symbol                | Limit |     |      | Unit | Condition |
|-----------------|-----------------------|-------|-----|------|------|-----------|
|                 |                       | Min   | Typ | Max  |      |           |
| Input "H" Level | V <sub>IH_ONREQ</sub> | 1.44  | -   | -    | V    |           |
| Input "L" Level | V <sub>IL_ONREQ</sub> | -     | -   | 0.40 | V    |           |

**3.1.3. PMIC\_STBY\_REQ**

PMIC\_STBY\_REQ is an active-high input for going to SUSPEND state.

**Table 3-3. PMIC\_STBY\_REQ Electrical Characteristics**

(Unless otherwise specified, Ta= +25 °C, V<sub>SY</sub>S=5.0 V, DVDD=3.3 V)

| Parameter       | Symbol                  | Limit       |     |             | Unit | Condition |
|-----------------|-------------------------|-------------|-----|-------------|------|-----------|
|                 |                         | Min         | Typ | Max         |      |           |
| Input "H" Level | V <sub>IH_STBYREQ</sub> | DVDD x 0.75 | -   | -           | V    |           |
| Input "L" Level | V <sub>IL_STBYREQ</sub> | -           | -   | DVDD x 0.25 | V    |           |

**3.1.4. WDOG\_B**

WDOG\_B is an active-low input for triggering Cold Reset or Warm Reset.

**Table 3-4. WDOG\_B Electrical Characteristics**

(Unless otherwise specified, Ta= +25 °C, V<sub>SY</sub>S=5.0 V, DVDD=3.3 V)

| Parameter       | Symbol               | Limit       |     |             | Unit | Condition |
|-----------------|----------------------|-------------|-----|-------------|------|-----------|
|                 |                      | Min         | Typ | Max         |      |           |
| Input "H" Level | V <sub>IH_WDOG</sub> | DVDD x 0.75 | -   | -           | V    |           |
| Input "L" Level | V <sub>IL_WDOG</sub> | -           | -   | DVDD x 0.25 | V    |           |

**3.1.5. RTC\_RESET\_B**

RTC\_RESET\_B is an active-low output for RTC.

**Table 3-5. RTC\_RESET\_B Electrical Characteristics**

(Unless otherwise specified, Ta= +25 °C, V<sub>SY</sub>S=5.0 V, DVDD=3.3 V)

| Parameter                | Symbol                    | Limit |     |            | Unit | Condition                  |
|--------------------------|---------------------------|-------|-----|------------|------|----------------------------|
|                          |                           | Min   | Typ | Max        |      |                            |
| Output "L" Level Voltage | V <sub>OL_RTCRESET</sub>  | -     | -   | DVDD x 0.2 | V    | I <sub>OL</sub> =3 mA Sink |
| Output Off Leak Current  | I <sub>OLK_RTCRESET</sub> | -1    | -   | +1         | μA   |                            |

**3.1.6. POR\_B**

POR\_B is an active-low output for the reset of SoC.

**Table 3-6. POR\_B Electrical Characteristics**

(Unless otherwise specified, Ta= +25 °C, V<sub>SY</sub>S=5.0 V, DVDD=3.3 V)

| Parameter                | Symbol               | Limit |     |            | Unit | Condition                  |
|--------------------------|----------------------|-------|-----|------------|------|----------------------------|
|                          |                      | Min   | Typ | Max        |      |                            |
| Output "L" Level Voltage | V <sub>OL_POR</sub>  | -     | -   | DVDD x 0.2 | V    | I <sub>OL</sub> =3 mA Sink |
| Output Off Leak Current  | I <sub>OLK_POR</sub> | -1    | -   | +1         | μA   |                            |

### 3.2. Power States

#### 3.2.1. Power State Diagram

BD71837AMWV has eight power states or modes: OFF, READY, SNVS, RUN, IDLE, SUSPEND, PWROFF and EMG. Figure 3-2 shows the state transition diagram along with the conditions to enter and exit each state.

READY\_TO\_SNVS Condition is described in 3.2.5.2. This condition is configurable by TRANS\_COND0 registers. SNVS\_TO\_RUN Condition is described in 3.2.5.3. This condition is configurable by TRANS\_COND0 registers.

BD71837AMWV has Thermal Shutdown, OCP, VR Fault, and VSYS\_UVLO=0 as Emergency Shutdown events.

Emergency Shutdown Condition is described in 3.2.5.9. EMG\_TO\_READY Condition is described in 3.2.5.12. EMG\_STAY Condition is described in 3.2.5.13.

BD71837AMWV has WDOG\_B, SWRESET, and PWRON\_B long detection as Cold Reset events. COLD\_RESET Condition is described in 3.2.4.1. After cold reset events or PMIC\_ON\_REQ=0, BD71837AMWV is configurable that it returns to READY or SNVS state. POFF\_TO\_READY Condition is described in 3.2.5.16. POFF\_TO\_SNVS Condition is described in 3.2.5.17. Concerning VSYS\_UVLO and INTLDO1P5\_UVLO, please refer to 2.5.

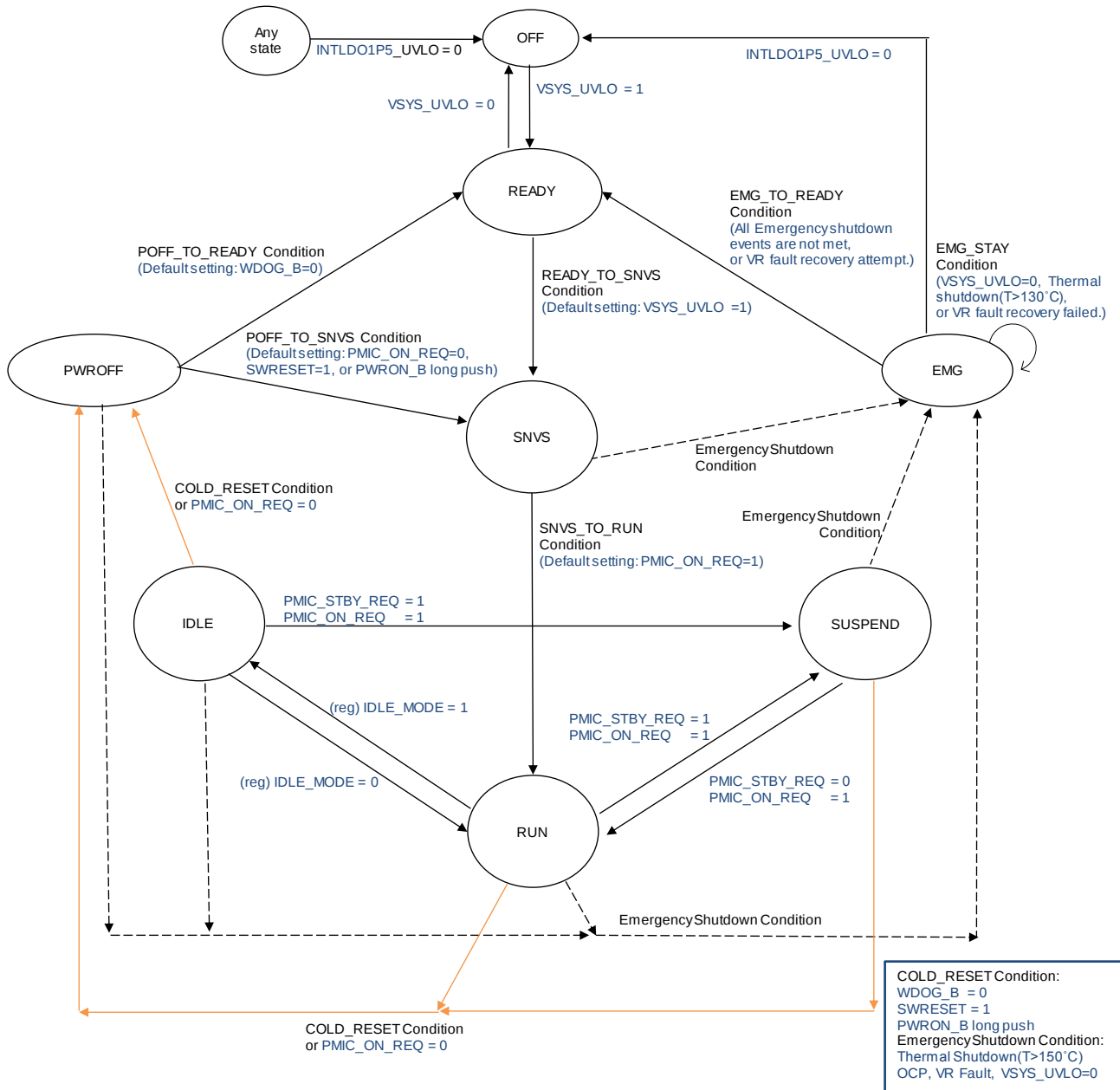


Figure 3-2. Power State Transition

### 3.2.2. Power State Register

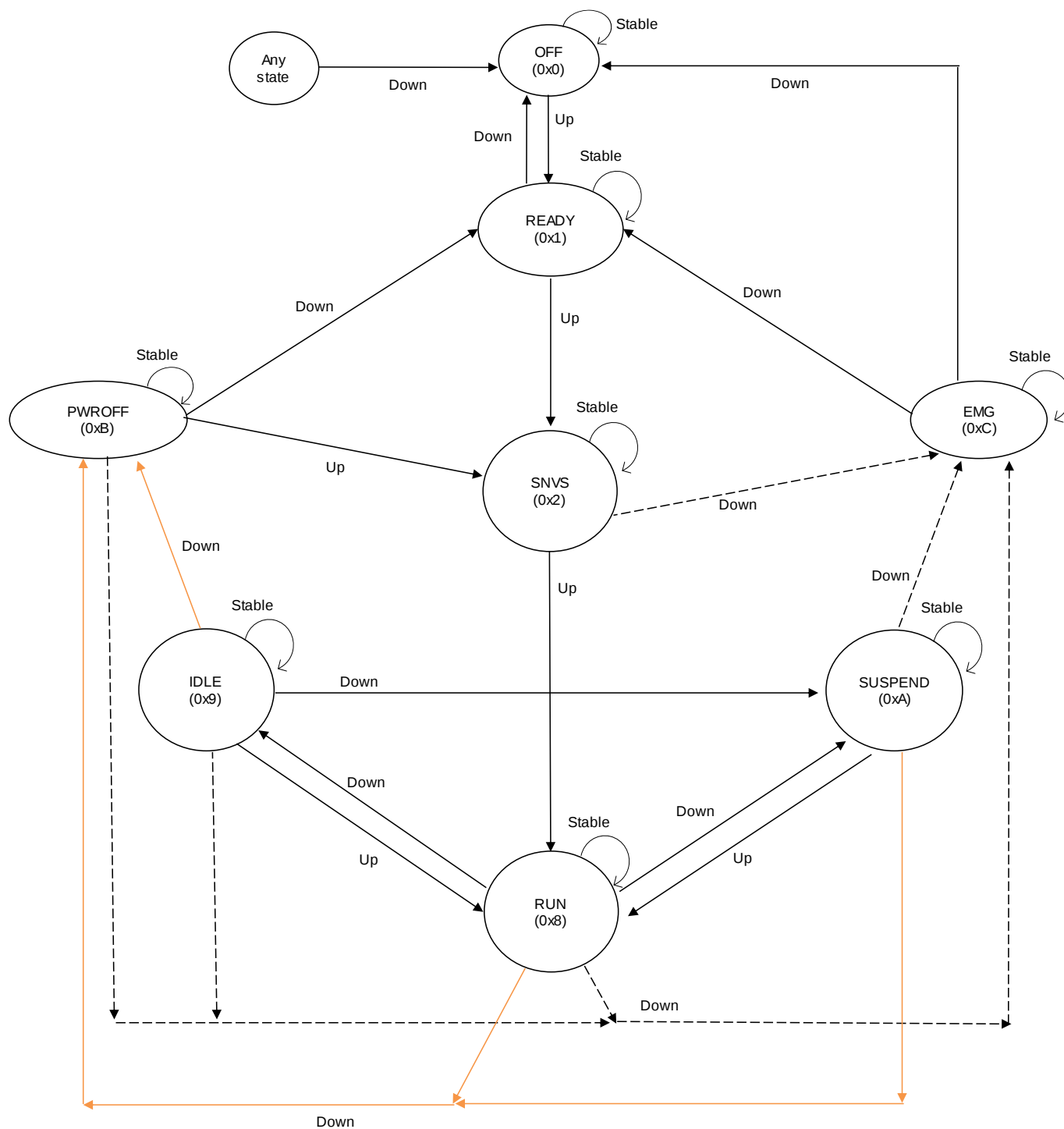
The POW\_STATE register shows current power state and power sub state in Table 3-7. The power sub state definition is illustrated in [Figure 3-3](#).

**Table 3-7. POW\_STATE – Power State Register**

| Register Name | R/W | D7          | D6 | D5 | D4 | D3 | D2 | D1           | D0 | Initial | Address |
|---------------|-----|-------------|----|----|----|----|----|--------------|----|---------|---------|
| POW_STATE     | R   | POW_ST[3:0] |    |    |    | -  | -  | POW_SUB[1:0] |    | 0x00    | 0x2D    |

| Bit    | Name         | Function                                                                                                                                                        | Initial |
|--------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7:4] | POW_ST[3:0]  | This bit field shows current power state.<br>0x0 = OFF      0x1 = READY<br>0x2 = SNVS     0x8 = RUN<br>0x9 = IDLE     0xA = SUSPEND<br>0xB = PWROFF   0xC = EMG | 0000    |
| D[1:0] | POW_SUB[1:0] | This bit field shows current power sub state.<br>00 = Stable<br>01 = Up<br>10 = Down<br>11 = Counting Cold Reset duration time (set by PONT[3:0])               | 00      |

### 3.2.2. Power State Register – continued



### Figure 3-3. Power Sub State Definition

### 3.2.3. Power State Definition

(a) OFF state

BD71837AMWV is in OFF state when INTLDO1P5\_UVLO is detected. If INTLDO1P5\_UVLO is 0, the data in all registers are reset to their default values.

To exit this state, VSYS voltage must exceed 3.0 V (VSYS\_UVLO = 1)

(b) READY state

In this state, VSYS voltage is over 3.0V. When power state transitions from OFF state to READY state, OTP data will only be loaded to registers with "Yes" in "OTP" column of Register Map ([Table 1-4](#)). When power state transitions from PWROFF or EMG state to READY state, OTP data will only be loaded to registers with reset condition during READY state and "Yes" condition in "OTP" column. This OTP loading can be skipped depending on the value of RELOAD\_REG in PWRCTRL0 register.

(c) SNVS state

If READY\_TO\_SNVS condition is satisfied, the power state changes to SNVS state. In this state, LDO1(NVCC\_SNVS) and LDO2(VDD\_SNVS) are turned on as shown in [Table 3-8](#).

(d) RUN state

If SNVS\_TO\_RUN condition is satisfied, the power state changes to RUN state. In this state, the VR's shown in [Table 3-8](#) are turned ON.

The value of BUCK3\_RUN\_ON in BUCK3\_CTRL register decides whether BUCK3(VDD\_GPU) is ON or OFF. The value of BUCK4\_RUN\_ON in BUCK4\_CTRL register decides whether BUCK4(VDD\_VPU) is ON or OFF.

The voltage of BUCK1(VDD\_SOC) depends on BUCK1\_VOLT\_RUN register.

The voltage of BUCK2(VDD\_ARM) depends on BUCK2\_VOLT\_RUN register.

The voltage of BUCK3(VDD\_GPU) depends on BUCK3\_VOLT\_RUN register.

The voltage of BUCK4(VDD\_VPU) depends on BUCK4\_VOLT\_RUN register.

(e) IDLE state

If IDLE\_MODE in PWRCTRL1 register is set to 1, the power state changes to IDLE state. The voltage of BUCK1(VDD\_SOC) depends on BUCK1\_VOLT\_IDLE register. The voltage of BUCK2(VDD\_ARM) depends on BUCK2\_VOLT\_IDLE register.

(f) SUSPEND state

If PMIC\_STBY\_REQ is set to 1, the power state changes to SUSPEND state. The voltage of BUCK1(VDD\_SOC) depends on BUCK1\_VOLT\_SUSP register.

(g) EMG state

If Emergency Shutdown Condition is satisfied, the power state changes to EMG state. In this state, all VR's are OFF.

(h) PWROFF state

If COLD\_RESET Condition is satisfied or PMIC\_ON\_REQ is reset to 0, the power state changes to PWROFF state. In this state, all VR's except LDO1(NVCC\_SNVS) and LDO2(VDD\_SNVS) are OFF. The next state of PWROFF is either READY or SNVS. TRANS\_COND1[3:0] values decide which power state to go.

## 3.2.3. Power State Definition – continued

Table 3-8. Voltage Rails ON/OFF for Respective Power State

| VR No. | Function      | Rail Name | Power State |       |      |         |      |        |        |     |
|--------|---------------|-----------|-------------|-------|------|---------|------|--------|--------|-----|
|        |               |           | OFF         | READY | SNVS | SUSPEND | IDLE | RUN    | PWROFF | EMG |
| VR1    | NVCC_SNVS     | LDO1      | OFF         | OFF   | ON   | ON      | ON   | ON     | ON/OFF | OFF |
| VR2    | VDD_SNVS      | LDO2      | OFF         | OFF   | ON   | ON      | ON   | ON     | ON/OFF | OFF |
| VR3    | VDD_SOC       | BUCK1     | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |
| VR4    | VDD_ARM       | BUCK2     | OFF         | OFF   | OFF  | OFF     | ON   | ON     | OFF    | OFF |
| VR5    | VDD_GPU       | BUCK3     | OFF         | OFF   | OFF  | OFF     | OFF  | ON/OFF | OFF    | OFF |
| VR6    | VDD_VPU       | BUCK4     | OFF         | OFF   | OFF  | OFF     | OFF  | ON/OFF | OFF    | OFF |
| VR7    | VDD_DRAM      | BUCK5     | OFF         | OFF   | OFF  | OFF     | ON   | ON     | OFF    | OFF |
| VR8    | VDDA_1P8/DRAM | LDO3      | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |
| VR9    | VDDA_0P9      | LDO4      | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |
| VR10   | NVCC_3P3      | BUCK6     | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |
| VR11   | NVCC_1P8      | BUCK7     | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |
| VR12   | NVCC_DRAM     | BUCK8     | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |
| VR13   | PHY_1P8       | LDO5      | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |
| VR14   | PHY_0P9       | LDO6      | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |
| VR15   | PHY_3P3       | LDO7      | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |
| VR16   | NVCC_SD       | MUXSW     | OFF         | OFF   | OFF  | ON      | ON   | ON     | OFF    | OFF |

## 3.2.4. Power State Control Events

## 3.2.4.1. Reset Event

BD71837AMWV has Cold and Warm resets.

Cold reset initiates POR\_B asserted to L and power rails are turned off. Then, the power state changes to either READY state or SNVS state. Next, the power state returns to RUN state automatically.

Warm reset initiates POR\_B asserted to L for 1 ms. It does not affect the on/off status of all power rails. Warm reset does not initiate the power state transition.

BD71837AMWV has three reset sources as follows.

- PWRON\_B terminal is set H to L. (PWRON\_B Long Push reset)
- WDOG\_B terminal is set H to L. (WDOG\_B reset)
- SWRESET in SWRESET register is set 0 to 1 (Software reset)

The cold or warm reset selection setting is shown in [Table 3-9](#).

The details of the two registers related to the setting are shown in [Table 3-10](#) and [Table 3-11](#).

## 3.2.4.1. Reset Event – continued

Table 3-9. Setting of Cold or Warm Reset Selection

| Reset Source         | Register Name | Register Bit Name | Value        | Cold/Warm Reset or No Reset |
|----------------------|---------------|-------------------|--------------|-----------------------------|
| PWRON_B<br>Long Push | PWRCTRL0      | DEBUG_STATE[1:0]  | 10 (default) | Cold reset                  |
|                      |               |                   | 11           | Warm reset                  |
|                      |               |                   | 00 or 01     | No reset action             |
| WDOG_B               | PWRCTRL0      | WDOGB_SEL[1:0]    | 10 (default) | Cold reset                  |
|                      |               |                   | 11           | Warm reset                  |
|                      |               |                   | 00 or 01     | No reset action             |
| Software             | SWRESET       | SWRESET_SEL[1:0]  | 10 (default) | Cold reset                  |
|                      |               |                   | 11           | Warm reset                  |
|                      |               |                   | 00 or 01     | No reset action             |

Table 3-10. SWRESET - Software Reset Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3 | D2               | D1      | D0 | Initial | Address |
|---------------|-----|----|----|----|----|----|------------------|---------|----|---------|---------|
| SWRESET       | R/W | -  | -  | -  | -  | -  | SWRESET_SEL[1:0] | SWRESET |    | 0x04    | 0x01    |

| Bit    | Name             | Function                                                                                                                                                                                                                                                                                                        | Initial |
|--------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[2:1] | SWRESET_SEL[1:0] | Select Cold reset, Warm reset or No reset action when SWRESET bit ( D[0] ) is set to 1.<br>00 = No reset action<br>01 = No reset action<br>10 = Cold reset<br>11 = Warm reset                                                                                                                                   | 10      |
| D[0]   | SWRESET          | 0 – No action<br>1 – Initiates Cold Reset or Warm Reset in accordance with SWRESET_SEL bit.<br>Writing 1 to SWRESET bit, then SWRESET bit is automatically cleared to 0 when Cold Reset or Warm Reset operation is completed.<br>Writing 1 to SWRESET bit can be done when Power State = RUN, IDLE and SUSPEND. | 0       |

Table 3-11. PWRCTRL0 - Power Control 0 Register

| Register Name | R/W | D7               | D6 | D5         | D4 | D3 | D2 | D1             | D0 | Initial | Address |
|---------------|-----|------------------|----|------------|----|----|----|----------------|----|---------|---------|
| PWRCTRL0      | R/W | DEBUG_STATE[1:0] |    | RELOAD_REG | -  | -  | -  | WDOGB_SEL[1:0] |    | 0xA2    | 0x03    |

| Bit    | Name             | Function                                                                                                                                                                      | Initial |
|--------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7:6] | DEBUG_STATE[1:0] | Select Cold reset, Warm reset or No reset action when PWRON_B long push is detected.<br>00 = No reset action<br>01 = No reset action<br>10 = Cold reset<br>11 = Warm reset    | 10      |
| D[5]   | RELOAD_REG       | Select OTP configurable registers initialization when the power state goes through READY state.<br>0 = No initialization<br>1 = Reload OTP registers and set to initial value | 1       |
| D[1:0] | WDOGB_SEL[1:0]   | Select Cold reset, Warm reset or No reset action when WDOG_B is asserted to 0.<br>00 = No reset action<br>01 = No reset action<br>10 = Cold reset<br>11 = Warm reset          | 10      |

**3.2.4.2. Emergency Shutdown Event**

There are four Emergency Shutdown Events as follows:

- Thermal Shutdown (Thermal Protection)

If the die temperature surpasses 150°C, the thermal protection circuit will shut down all VR's to avoid damage. This detection is not valid at OFF, READY and SNVS state.

- OCP

If the OCP is triggered in any VR's, all VR's are turned off.

- VR Fault

If the voltage of VR is not within the regular range, all VR's are turned off.

- VSYS\_UVLO = 0

If the VSYS\_UVLO = 0, Emergency Shutdown sequence is initiated.

**3.2.5. Power State Transitions****3.2.5.1. OFF to READY**

Table 3-12 shows the conditions for exiting OFF state. "VSYS\_UVLO = 1" is necessary.

**Table 3-12. Conditions from OFF to READY state**

| Event Trigger                           | Conditions<br>(All must be satisfied per Event Trigger) | Next State | Notes                                         |
|-----------------------------------------|---------------------------------------------------------|------------|-----------------------------------------------|
| 1) VSYS Voltage Up<br>from 0 V or 2.7 V | VSYS_UVLO = 1<br>(VSYS > 3.0 V)                         | READY      | VSYS Insertion or<br>VSYS recovery from 2.7 V |

### 3.2.5.2. READY to SNVS

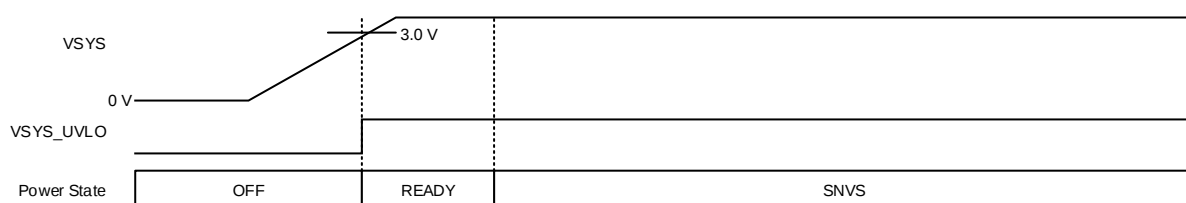
There are six event triggers for shifting from READY to SNVS as shown in Table 3-13. The event trigger of VSYS\_UVLO, PMIC\_ON\_REQ, PWRON\_B Short Push, and PWRON\_B Long Push are configurable to be valid or invalid by TRANS\_COND0 registers. VSYS\_UVLO condition is valid with default setting.

**Table 3-13. Conditions from READY to SNVS**

| Event Trigger                | Conditions<br>(All must be satisfied per Event Trigger)   | Next State | Notes                                                      |
|------------------------------|-----------------------------------------------------------|------------|------------------------------------------------------------|
| 1) VSYS_UVLO                 | VSYS_UVLO = 1                                             | SNVS       | No other event is necessary.<br>Valid with default setting |
| 2) PMIC_ON_REQ               | VSYS_UVLO = 1 and<br>PMIC_ON_REQ = 1                      | SNVS       | Invalid with default setting                               |
| 3) PWRON_B Short Push        | VSYS_UVLO = 1 and<br>PWRON_B = 0 ==> Short Push Detection | SNVS       | Invalid with default setting                               |
| 4) PWRON_B Long Push         | VSYS_UVLO = 1 and<br>PWRON_B = 0 ==> Long Push Detection  | SNVS       | Invalid with default setting                               |
| 5) Cold Reset Sequence       | VSYS_UVLO = 1 and<br>Cold_Reset_flag = 1                  | SNVS       | On the way back to RUN state<br>in Cold Reset sequence     |
| 6) VR Fault Recovery Attempt | VSYS_UVLO = 1 and<br>VR Fault Recovery                    | SNVS       |                                                            |

#### 1) VSYS\_UVLO

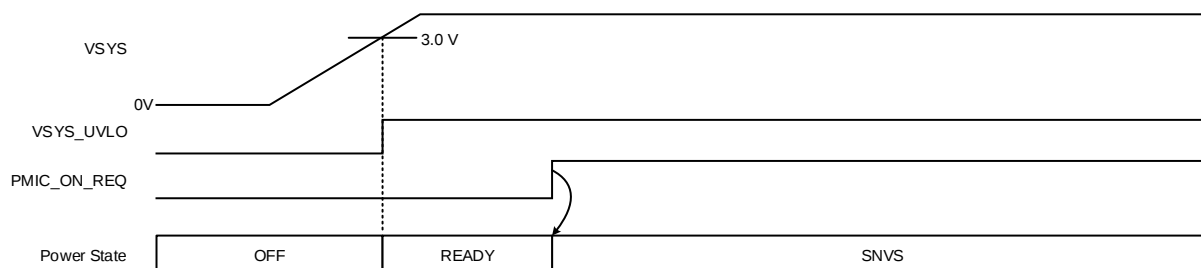
The power state shifts to SNVS if VSYS\_UVLO = 1 as shown in Figure 3-4. No other conditions are necessary.



**Figure 3-4. VSYS Condition for moving to SNVS**

#### 2) PMIC\_ON\_REQ

The power state shifts to SNVS if PMIC\_ON\_REQ = 1 as shown in Figure 3-5.



**Figure 3-5. PMIC\_ON\_REQ Condition for moving to SNVS**

3.2.5.2.   **READY to SNVS – continued**  
3) PWRON\_B Short Push  
The power state shifts to SNVS if PWRON\_B Short Push is detected as shown in Figure 3-6.

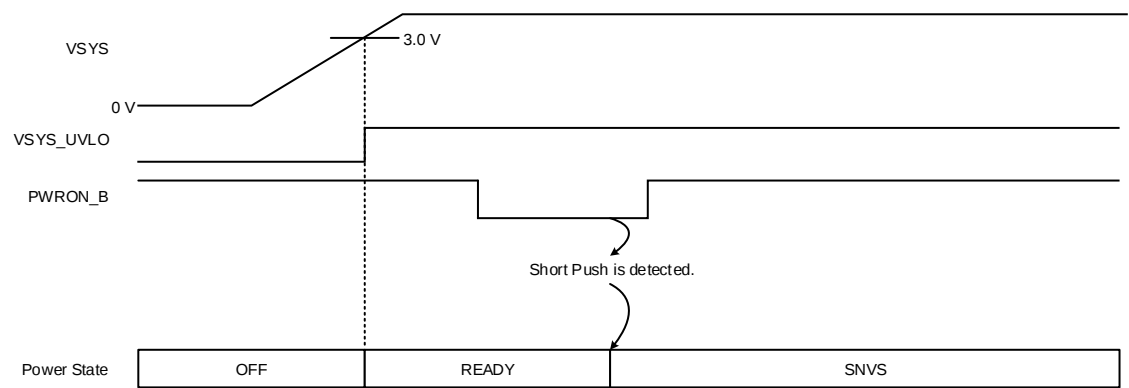


Figure 3-6. PWRON\_B Short Push Condition for moving to SNVS

4) PWRON\_B Long Push  
The power state shifts to SNVS if PWRON\_B Long Push is detected as shown in Figure 3-7.

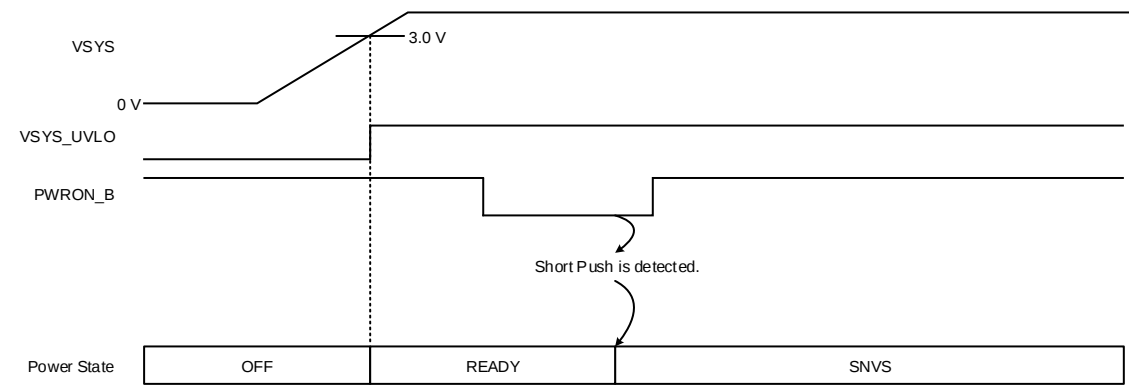


Figure 3-7. PWRON\_B Long Push Condition for moving to SNVS

5) Cold Reset  
The power state shifts to SNVS if Cold\_Reset\_flag = 1 as shown in Figure 3-8.

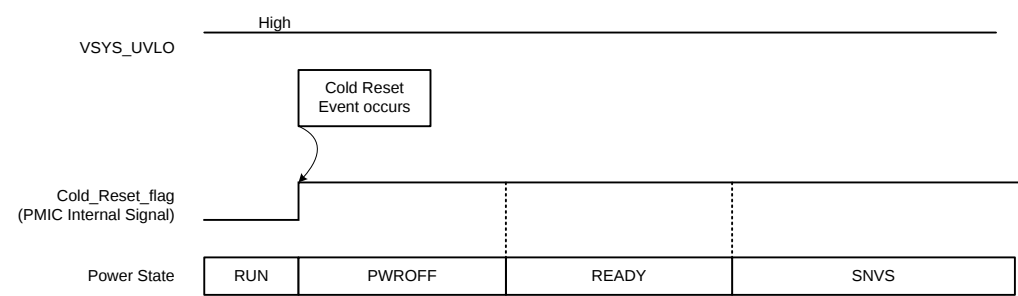


Figure 3-8. Cold Reset Condition for moving to SNVS

## 3.2.5.2. READY to SNVS – continued

6) VR Fault Recovery Attempt

Please see [3.2.5.10](#).

It is possible to use each four event triggers such as:

VSYS\_UVLO,

PMIC\_ON\_REQ,

PWRON\_B Short Push and

PWRON\_B Long Push

These triggers are configurable to use them respectively by D[3:0] in TRANS\_CONDO register as shown in Table 3-14.

Table 3-14. TRANS\_CONDO - Transition Condition Select 0 Register

| Register Name | R/W | D7             | D6                | D5               | D4              | D3             | D2                | D1               | D0              | Initial | Address |
|---------------|-----|----------------|-------------------|------------------|-----------------|----------------|-------------------|------------------|-----------------|---------|---------|
| TRANS_CONDO   | R/W | C1_VSYS_3P0_EN | C1_PMIC_ON_REQ_EN | C1_SHORT_PUSH_EN | C1_LONG_PUSH_EN | C0_VSYS_3P0_EN | C0_PMIC_ON_REQ_EN | C0_SHORT_PUSH_EN | C0_LONG_PUSH_EN | 0x48    | 0x1F    |

| Bit  | Name              | Function                                                                                                                                                                          | Initial |
|------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7] | C1_VSYS_3P0_EN    | Select only VSYS_UVLO = 1 as SNVS ==> RUN transition condition or not<br>0 = VSYS_UVLO = 1 is not used as the condition<br>1 = VSYS_UVLO = 1 is used as the condition             | 0       |
| D[6] | C1_PMIC_ON_REQ_EN | Select PMIC_ON_REQ as SNVS ==> RUN transition condition or not<br>0 = PMIC_ON_REQ is not used as the condition<br>1 = PMIC_ON_REQ is used as the condition                        | 1       |
| D[5] | C1_SHORT_PUSH_EN  | Select PWRON_B Short Push as SNVS ==> RUN transition condition or not<br>0 = PWRON_B Short Push is not used as the condition<br>1 = PWRON_B Short Push is used as the condition   | 0       |
| D[4] | C1_LONG_PUSH_EN   | Select PWRON_B Long Push as SNVS ==> RUN transition condition or not<br>0 = PWRON_B Long Push is not used as the condition<br>1 = PWRON_B Long Push is used as the condition      | 0       |
| D[3] | C0_VSYS_3P0_EN    | Select only VSYS_UVLO = 1 as READY ==> SNVS transition condition or not<br>0 = VSYS_UVLO = 1 is not used as the condition<br>1 = VSYS_UVLO = 1 is used as the condition           | 1       |
| D[2] | C0_PMIC_ON_REQ_EN | Select PMIC_ON_REQ as READY ==> SNVS transition condition or not<br>0 = PMIC_ON_REQ is not used as the condition<br>1 = PMIC_ON_REQ is used as the condition                      | 0       |
| D[1] | C0_SHORT_PUSH_EN  | Select PWRON_B Short Push as READY ==> SNVS transition condition or not<br>0 = PWRON_B Short Push is not used as the condition<br>1 = PWRON_B Short Push is used as the condition | 0       |
| D[0] | C0_LONG_PUSH_EN   | Select PWRON_B Long Push as READY ==> SNVS transition condition or not<br>0 = PWRON_B Long Push is not used as the condition<br>1 = PWRON_B Long Push is used as the condition    | 0       |

**3.2.5.3. SNVS to RUN**

There are six event triggers for shifting from SNVS to RUN as shown in Table 3-15. The event trigger of VSYS\_UVLO=1, PMIC\_ON\_REQ, PWRON\_B Short Push, and PWRON\_B Long Push are configurable to be valid or invalid by TRANS\_COND0 registers. PMIC\_ON\_REQ condition is valid with default setting.

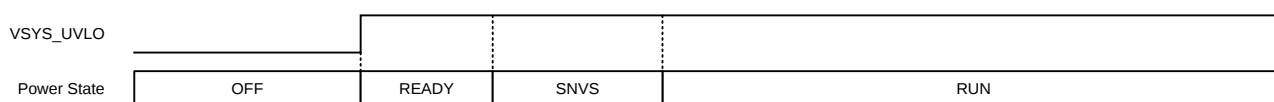
**Table 3-15. Conditions from SNVS to RUN**

| Event Trigger                | Conditions<br>(All must be satisfied per Event Trigger)   | Next State | Notes                                                        |
|------------------------------|-----------------------------------------------------------|------------|--------------------------------------------------------------|
| 1) VSYS_UVLO                 | VSYS_UVLO = 1                                             | RUN        | No other event is necessary.<br>Invalid with default setting |
| 2) PMIC_ON_REQ               | VSYS_UVLO = 1 and<br>PMIC_ON_REQ = 1                      | RUN        | Valid with default setting                                   |
| 3) PWRON_B Short Push        | VSYS_UVLO = 1 and<br>PWRON_B = 0 ==> Short Push Detection | RUN        | Invalid with default setting                                 |
| 4) PWRON_B Long Push         | VSYS_UVLO = 1 and<br>PWRON_B = 0 ==> Long Push Detection  | RUN        | Invalid with default setting                                 |
| 5) Cold Reset Sequence       | VSYS_UVLO = 1 and<br>Cold_Reset_flag = 1                  | RUN        | On the way back to RUN state<br>in Cold Reset sequence       |
| 6) VR Fault Recovery Attempt | VSYS_UVLO = 1 and<br>VR Fault Recovery                    | RUN        |                                                              |

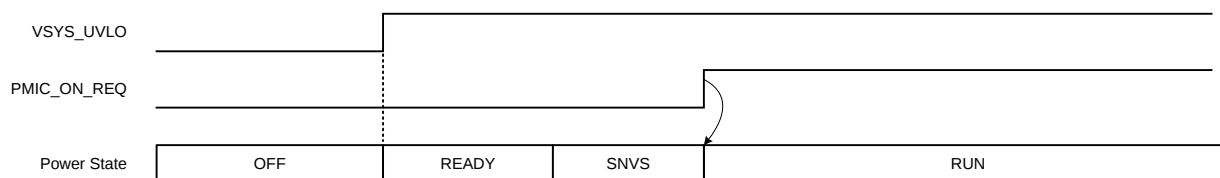
(Note) Die Temperature must be less than 150 °C.

**1) VSYS\_UVLO**

The power state shifts to RUN if VSYS\_UVLO = 1 as shown in Figure 3-9. No other condition is required.

**Figure 3-9. VSYS Condition for moving to RUN****2) PMIC\_ON\_REQ**

The power state shifts to RUN if PMIC\_ON\_REQ = 1 as shown in Figure 3-10.

**Figure 3-10. PMIC\_ON\_REQ Condition for moving to RUN**

## 3.2.5.3. SNVS to RUN – continued

## 3) PWRON\_B Short Push

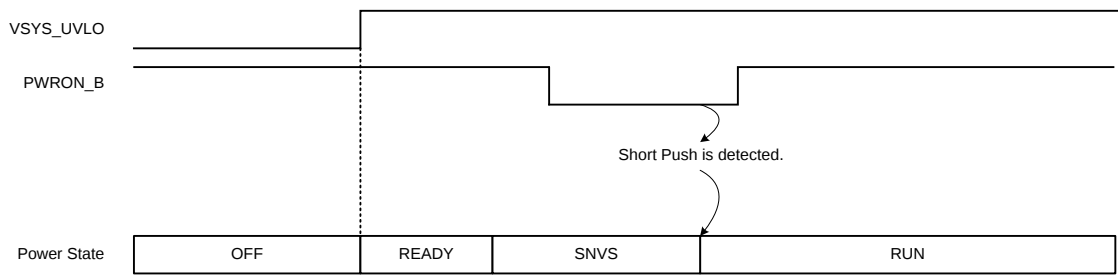


Figure 3-11. PWRON\_B Short Push Condition for moving to RUN

## 4) PWRON\_B Long Push

The power state shifts to RUN if PWRON\_B Long Push is detected as shown in Figure 3-12.

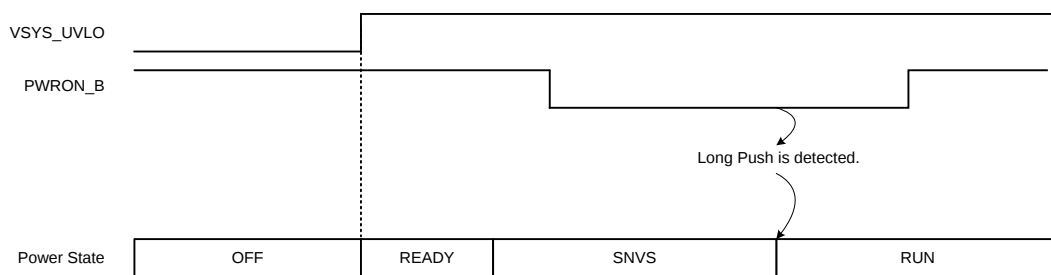


Figure 3-12. PWRON\_B Long Push Condition for moving to RUN

## 5) Cold Reset

The power state shifts to RUN if Cold\_Reset\_flag = 1 as shown in Figure 3-13.

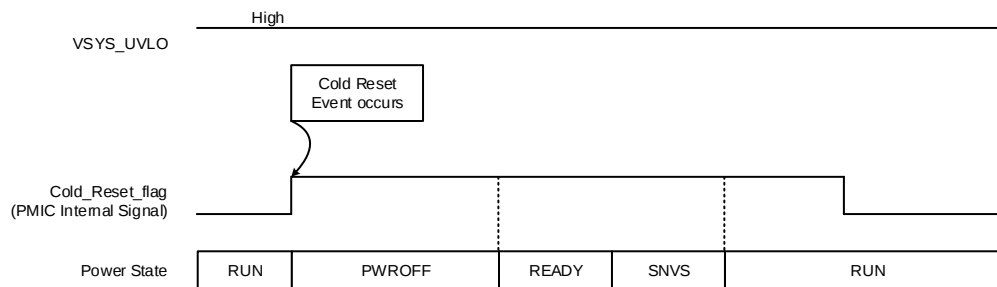


Figure 3-13. Cold Reset Condition for moving to RUN

## 6) VR Fault Recovery Attempt

Please see [3.2.5.10](#).

It is possible to use each four event triggers such as:

VSYS\_UVLO,  
PMIC\_ON\_REQ,  
PWRON\_B Short Push and  
PWRON\_B Long Push

These triggers are configurable to use them respectively by D[7:4] in TRANS\_COND0 register as shown in [Table 3-14](#).

**3.2.5.4. RUN to IDLE**

Table 3-16 shows the conditions for shifting from RUN to IDLE. The details of PWRCTRL1 register were described in Table 3-17.

**Table 3-16. Conditions from RUN to IDLE**

| Event Trigger                               | Conditions<br>(All must be satisfied) | Next State | Notes                    |
|---------------------------------------------|---------------------------------------|------------|--------------------------|
| Set IDLE_MODE<br>(PWRCTRL1<br>register) = 1 | PMIC_STBY_REQ = 0                     | IDLE       | Register Write Operation |
|                                             | PMIC_ON_REQ = 1                       |            |                          |
|                                             | Set IDLE_MODE = 1                     |            |                          |

(Note) Die Temperature must be less than 150 °C. VSYS\_UVLO = 1.

**Table 3-17. PWRCTRL1 - Power Control 1 Register**

| Register Name | R/W | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0        | Initial | Address |
|---------------|-----|----|----|----|----|----|----|----|-----------|---------|---------|
| PWRCTRL1      | R/W | -  | -  | -  | -  | -  | -  | -  | IDLE_MODE | 0x00    | 0x04    |

| Bit  | Name      | Function                                                                                                                                                                                                                                                                                | Initial |
|------|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[0] | IDLE_MODE | Control power state transition between RUN and IDLE<br>0 = Exit IDLE and back to RUN, or indicates power state = except IDLE<br>1 = Enter IDLE from RUN, or indicates power state = IDLE<br>Note : this bit automatically returns to 0 when power state enters PWROFF, EMG and SUSPEND. | 0       |

**3.2.5.5. IDLE to RUN**

Table 3-18 shows the conditions for shifting from IDLE to RUN.

**Table 3-18. Conditions from IDLE to RUN**

| Event Trigger                               | Conditions<br>(All must be satisfied) | Next State | Notes                    |
|---------------------------------------------|---------------------------------------|------------|--------------------------|
| Set IDLE_MODE<br>(PWRCTRL1<br>register) = 0 | PMIC_STBY_REQ = 0                     | RUN        | Register Write Operation |
|                                             | PMIC_ON_REQ = 1                       |            |                          |
|                                             | Set IDLE_MODE = 0                     |            |                          |

(Note) Die Temperature must be less than 150 °C. VSYS\_UVLO = 1.

**3.2.5.6. RUN to SUSPEND**

Table 3-19 shows the conditions for shifting from RUN to SUSPEND.

**Table 3-19. Conditions from RUN to SUSPEND**

| Event Trigger | Conditions<br>(All must be satisfied) | Next State | Notes |
|---------------|---------------------------------------|------------|-------|
| PMIC_STBY_REQ | PMIC_STBY_REQ = 1                     | SUSPEND    |       |
|               | PMIC_ON_REQ = 1                       |            |       |

(Note) Die Temperature must be less than 150 °C. VSYS\_UVLO = 1.

**3.2.5.7. SUSPEND to RUN**

Table 3-20 shows the conditions for shifting from SUSPEND to RUN.

**Table 3-20. Conditions from SUSPEND to RUN**

| Event Trigger | Conditions<br>(All must be satisfied) | Next State | Notes |
|---------------|---------------------------------------|------------|-------|
| PMIC_STBY_REQ | PMIC_STBY_REQ = 0                     | RUN        |       |
|               | PMIC_ON_REQ = 1                       |            |       |

(Note) Die Temperature must be less than 150 °C. VSYS\_UVLO = 1.

**3.2.5.8. IDLE to SUSPEND**

Table 3-21 shows the conditions for shifting from IDLE to SUSPEND. IDLE\_MODE in PWRCTRL1 register automatically returns to 0.

**Table 3-21. Conditions from IDLE to SUSPEND**

| Event Trigger | Conditions<br>(All must be satisfied) | Next State | Notes |
|---------------|---------------------------------------|------------|-------|
| PMIC_STBY_REQ | PMIC_STBY_REQ = 1                     | SUSPEND    |       |
|               | PMIC_ON_REQ = 1                       |            |       |

(Note) Die Temperature must be less than 150 °C. VSYS\_UVLO = 1.

**3.2.5.9. Emergency Shutdown**

There are four Emergency Shutdown events which are:

Thermal Shutdown (Thermal Protection)

OCP

VR Fault

VSYS\_UVLO = 0 as shown in Table 3-22.

**Table 3-22. Conditions from SNVS, RUN, IDLE, SUSPEND, PWROFF to EMG**

| Event Trigger       | Conditions<br>(All must be satisfied per Event Trigger) | Next State | Notes                                                                          |
|---------------------|---------------------------------------------------------|------------|--------------------------------------------------------------------------------|
| 1) Thermal Shutdown | Die Temperature > 150 °C                                | EMG        | Thermal Protection<br>This protection is invalid at OFF, READY, and SNVS state |
| 2) OCP              | Any VR's OCP                                            | EMG        |                                                                                |
| 3) VR Fault         | Any VR's out of the target voltage                      | EMG        |                                                                                |
| 4) VSYS_UVLO = 0    | VSYS_UVLO = 0                                           | EMG        |                                                                                |

The detail of VR Fault is described in [3.2.5.10](#).

**3.2.5.10. VR Fault**

BD71837AMWV has VR fault detection function which monitors all relevant VR's of the system. The system is shut down when a monitored voltage rail goes out of the target voltage. Once the system has shut down, the system tries to boot up several times which is determined by RCVLMT[3:0] in RCVCFG register.

Table 3-23 shows the VR fault threshold and monitoring conditions.

**Table 3-23. VR FAULT threshold and monitoring condition**

| VR No. | Function      | Rail Name | SNVS        |                      | SUSPEND     |                      | IDLE        |                      | RUN         |                      |
|--------|---------------|-----------|-------------|----------------------|-------------|----------------------|-------------|----------------------|-------------|----------------------|
|        |               |           | Monitor Y/N | Voltage Target Range | Monitor Y/N | Voltage Target Range | Monitor Y/N | Voltage Target Range | Monitor Y/N | Voltage Target Range |
| VR1    | NVCC_SNVS     | LDO1      | Y           | 80% < LDO1           | Y           | 80% < LDO1           | Y           | 80% < LDO1           | Y           | 80% < LDO1           |
| VR2    | VDD_SNVS      | LDO2      | Y           | 80% < LDO2           | Y           | 80% < LDO2           | Y           | 80% < LDO2           | Y           | 80% < LDO2           |
| VR3    | VDD_SOC       | BUCK1     | N           | -                    | Y           | 80% < BUCK1 < 130%   | Y           | 80% < BUCK1 < 130%   | Y           | 80% < BUCK1 < 130%   |
| VR4    | VDD_ARM       | BUCK2     | N           | -                    | N           | -                    | Y           | 80% < BUCK2 < 130%   | Y           | 80% < BUCK2 < 130%   |
| VR5    | VDD_GPU       | BUCK3     | N           | -                    | N           | -                    | N           | -                    | Y when ON   | 80% < BUCK3 < 130%   |
| VR6    | VDD_VPU       | BUCK4     | N           | -                    | N           | -                    | N           | -                    | Y when ON   | 80% < BUCK4 < 130%   |
| VR7    | VDD_DRAM      | BUCK5     | N           | -                    | N           | -                    | Y           | 80% < BUCK5 < 130%   | Y           | 80% < BUCK5 < 130%   |
| VR8    | VDDA_1P8/DRAM | LDO3      | N           | -                    | Y           | 80% < LDO3           | Y           | 80% < LDO3           | Y           | 80% < LDO3           |
| VR9    | VDDA_0P9      | LDO4      | N           | -                    | Y           | 80% < LDO4           | Y           | 80% < LDO4           | Y           | 80% < LDO4           |
| VR10   | NVCC_3P3      | BUCK6     | N           | -                    | Y           | 80% < BUCK6 < 130%   | Y           | 80% < BUCK6 < 130%   | Y           | 80% < BUCK6 < 130%   |
| VR11   | NVCC_1P8      | BUCK7     | N           | -                    | Y           | 80% < BUCK7 < 130%   | Y           | 80% < BUCK7 < 130%   | Y           | 80% < BUCK7 < 130%   |
| VR12   | NVCC_DRAM     | BUCK8     | N           | -                    | Y           | 80% < BUCK8 < 130%   | Y           | 80% < BUCK8 < 130%   | Y           | 80% < BUCK8 < 130%   |
| VR13   | PHY_1P8       | LDO5      | N           | -                    | Y           | 80% < LDO5           | Y           | 80% < LDO5           | Y           | 80% < LDO5           |
| VR14   | PHY_0P9       | LDO6      | N           | -                    | Y           | 80% < LDO6           | Y           | 80% < LDO6           | Y           | 80% < LDO6           |
| VR15   | PHY_3P3       | LDO7      | N           | -                    | Y           | 80% < LDO7           | Y           | 80% < LDO7           | Y           | 80% < LDO7           |

Y: VR output is monitored to trigger VR Fault Emergency Shutdown sequence.

N: Not monitored at default (If the VR is turned ON by changing the register setting, its output is monitored for the VR Fault event trigger)

**3.2.5.10. VR Fault – continued**

BD71837AMWV monitors each rail. If a monitored VR goes out of the target voltage in a certain time, the system will shut down. When the system cannot shift to RUN state after Power ON sequence several times which is defined by RCVLMT[3:0] in RCVCFG register, the system stays at EMG state until INTLDO1P5\_UVLO = 0.

If a VR is turned OFF by VR control registers (BUCK1 to BUCK8 and LDO1 to LDO7), VR fault of that VR is masked.

BD71837AMWV has VR individual masking registers as shown in Table 3-25, Table 3-26 and Table 3-27. This masking function is used for mainly debugging in development phase.

**Table 3-24. VRFAULTEN - VR FAULT ON/OFF Register: Debugging Purpose**

| Register Name | R/W | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0      | Initial | Address |
|---------------|-----|----|----|----|----|----|----|----|---------|---------|---------|
| VRFAULTEN     | R/W | -  | -  | -  | -  | -  | -  | -  | VRFLTEN | 0x01    | 0x21    |

| Bit  | Name    | Function                                                                                                                                                            | Initial |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[0] | VRFLTEN | VR Fault enable bit<br>0 = VR Fault is disabled.<br>1 = VR Fault is enabled.<br>This bit is used for debugging purpose. Please do not set 0x00 in normal operation. | 1       |

**Table 3-25. MVRFLTMASK0 - VR FAULT Mask 0 Register**

| Register Name | R/W | D7             | D6             | D5             | D4             | D3             | D2             | D1             | D0             | Initial | Address |
|---------------|-----|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------|---------|
| MVRFLTMASK0   | R/W | MBUCK8_VOUTOKH | MBUCK8_VOUTOKL | MBUCK7_VOUTOKH | MBUCK7_VOUTOKL | MBUCK6_VOUTOKH | MBUCK6_VOUTOKL | MBUCK5_VOUTOKH | MBUCK5_VOUTOKL | 0x00    | 0x22    |

| Bit  | Name           | Function                                                                                                             | Initial |
|------|----------------|----------------------------------------------------------------------------------------------------------------------|---------|
| D[7] | MBUCK8_VOUTOKH | Masking bit of BUCK8 130% threshold for target voltage<br>0 = monitoring 130% threshold<br>1 = masked 130% threshold | 0       |
| D[6] | MBUCK8_VOUTOKL | Masking bit of BUCK8 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold    | 0       |
| D[5] | MBUCK7_VOUTOKH | Masking bit of BUCK7 130% threshold for target voltage<br>0 = monitoring 130% threshold<br>1 = masked 130% threshold | 0       |
| D[4] | MBUCK7_VOUTOKL | Masking bit of BUCK7 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold    | 0       |
| D[3] | MBUCK6_VOUTOKH | Masking bit of BUCK6 130% threshold for target voltage<br>0 = monitoring 130% threshold<br>1 = masked 130% threshold | 0       |
| D[2] | MBUCK6_VOUTOKL | Masking bit of BUCK6 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold    | 0       |
| D[1] | MBUCK5_VOUTOKH | Masking bit of BUCK5 130% threshold for target voltage<br>0 = monitoring 130% threshold<br>1 = masked 130% threshold | 0       |
| D[0] | MBUCK5_VOUTOKL | Masking bit of BUCK5 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold    | 0       |

## 3.2.5.10. VR Fault – continued

Table 3-26. MVRFLTMASK1 - VR FAULT Mask 1 Register

| Register Name | R/W | D7             | D6             | D5             | D4             | D3             | D2             | D1             | D0             | Initial | Address |
|---------------|-----|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------|---------|
| MVRFLTMASK1   | R/W | MBUCK4_VOUTOKH | MBUCK4_VOUTOKL | MBUCK3_VOUTOKH | MBUCK3_VOUTOKL | MBUCK2_VOUTOKH | MBUCK2_VOUTOKL | MBUCK1_VOUTOKH | MBUCK1_VOUTOKL | 0x00    | 0x23    |

| Bit  | Name           | Function                                                                                                             | Initial |
|------|----------------|----------------------------------------------------------------------------------------------------------------------|---------|
| D[7] | MBUCK4_VOUTOKH | Masking bit of BUCK4 130% threshold for target voltage<br>0 = monitoring 130% threshold<br>1 = masked 130% threshold | 0       |
| D[6] | MBUCK4_VOUTOKL | Masking bit of BUCK4 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold    | 0       |
| D[5] | MBUCK3_VOUTOKH | Masking bit of BUCK3 130% threshold for target voltage<br>0 = monitoring 130% threshold<br>1 = masked 130% threshold | 0       |
| D[4] | MBUCK3_VOUTOKL | Masking bit of BUCK3 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold    | 0       |
| D[3] | MBUCK2_VOUTOKH | Masking bit of BUCK2 130% threshold for target voltage<br>0 = monitoring 130% threshold<br>1 = masked 130% threshold | 0       |
| D[2] | MBUCK2_VOUTOKL | Masking bit of BUCK2 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold    | 0       |
| D[1] | MBUCK1_VOUTOKH | Masking bit of BUCK1 130% threshold for target voltage<br>0 = monitoring 130% threshold<br>1 = masked 130% threshold | 0       |
| D[0] | MBUCK1_VOUTOKL | Masking bit of BUCK1 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold    | 0       |

Table 3-27. MVRFLTMASK2 - VR FAULT Mask 2 Register

| Register Name | R/W | D7 | D6            | D5            | D4            | D3            | D2            | D1            | D0            | Initial | Address |
|---------------|-----|----|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------|---------|
| MVRFLTMASK2   | R/W | -  | MLDO7_VOUTOKL | MLDO6_VOUTOKL | MLDO5_VOUTOKL | MLDO4_VOUTOKL | MLDO3_VOUTOKL | MLDO2_VOUTOKL | MLDO1_VOUTOKL | 0x00    | 0x24    |

| Bit  | Name          | Function                                                                                                         | Initial |
|------|---------------|------------------------------------------------------------------------------------------------------------------|---------|
| D[6] | MLDO7_VOUTOKL | Masking bit of LDO7 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold | 0       |
| D[5] | MLDO6_VOUTOKL | Masking bit of LDO6 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold | 0       |
| D[4] | MLDO5_VOUTOKL | Masking bit of LDO5 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold | 0       |
| D[3] | MLDO4_VOUTOKL | Masking bit of LDO4 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold | 0       |
| D[2] | MLDO3_VOUTOKL | Masking bit of LDO3 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold | 0       |
| D[1] | MLDO2_VOUTOKL | Masking bit of LDO2 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold | 0       |
| D[0] | MLDO1_VOUTOKL | Masking bit of LDO1 80% threshold for target voltage<br>0 = monitoring 80% threshold<br>1 = masked 80% threshold | 0       |

Following a VR Fault and an Emergency Shutdown sequence, BD71837AMWV stays in READY state for a programmed time which is specified by RCVDT[3:0] of RCVCFG register. Power ON sequence is then initiated once RCVDT[3:0] time has elapsed.

To prevent an infinite loop of VR Fault induced power cycles, BD71837AMWV limits the number of attempts to recover the system by RCVLMT[3:0] of RCVCFG register when these failures occur. Once BD71837AMWV has attempted to recover from a VR Fault for a number of times which is specified by RCVLMT[3:0], the next VR Fault results in BD71837AMWV staying in EMG state until INTLDO1P5\_UVLO = 0.

The ability to reset RCVNUM register which tracks the number of VR Fault recovery attempts via I2C is supported. This will allow the SoC to reset this count value when needed.

## 3.2.5.10. VR Fault – continued

Table 3-28. RCVCFG - Recovery Configuration Register

| Register Name | R/W | D7          | D6 | D5 | D4 | D3         | D2 | D1 | D0 | Initial | Address |
|---------------|-----|-------------|----|----|----|------------|----|----|----|---------|---------|
| RCVCFG        | R/W | RCVLMT[3:0] |    |    |    | RCVDT[3:0] |    |    |    | 0x4C    | 0x25    |

| Bit    | Name        | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Initial |
|--------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7:4] | RCVLMT[3:0] | The limit number of attempts to recover the system after a VR Fault occurred.<br>0000 = No recovery. BD71837AMWV stays in EMG state until VSYS is triggered again.<br>0001 = 1 time<br>0010 = 2 times<br>0011 = 3 times<br>0100 = 4 times<br>:<br>1110 = 14 times<br>1111 = No limit of attempts to recover                                                                                                                                                                                                                                                                         | 0100    |
| D[3:0] | RCVDT[3:0]  | The duration time during which BD71837AMWV stays in READY state after a VR Fault event.<br>BD71837AMWV remains in READY state for the duration programmed here then BD71837AMWV performs a Power ON sequence, if RCVLMT[3:0] is not 0x0 or 0xF and RCVLMT[3:0] is not equal to RCVNUM[3:0] of RCVNUM register.<br>0000 = 5 ms<br>0001 = 10 ms<br>0010 = 15 ms<br>0011 = 20 ms<br>0100 = 25 ms<br>0101 = 30 ms<br>0110 = 35 ms<br>0111 = 40 ms<br>1000 = 45 ms<br>1001 = 50 ms<br>1010 = 75 ms<br>1011 = 100 ms<br>1100 = 250 ms<br>1101 = 500 ms<br>1110 = 750 ms<br>1111 = 1500 ms | 1100    |

Table 3-29. RCVNUM - Recovery Number Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3          | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----|----|----|----|-------------|----|----|----|---------|---------|
| RCVNUM        | R/W | -  | -  | -  | -  | RCVNUM[3:0] |    |    |    | 0x00    | 0x26    |

| Bit    | Name        | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Initial |
|--------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[3:0] | RCVNUM[3:0] | The number of attempts to recover the system after a VR Fault occurred.<br>Once BD71837AMWV has attempted to recover from a power failure times which is indicated in RCVLMT[3:0] in RCVCFG register, the next failure shall result in BD71837AMWV staying in EMG state until VSYS is triggered again.<br>When SoC writes RCVNUM register via I2C, then RCVNUM[3:0] is cleared to 0000. As a result, the tracking number of power failure recovery attempts is reset.<br>Note : When RCVLMT[3:0] = 0xF (no limit of attempts to recover) and the number of attempt is over 0xF, RCVNUM[3:0] value is fixed to 0xF. | 0000    |

3.2.5.10. VR Fault – continued

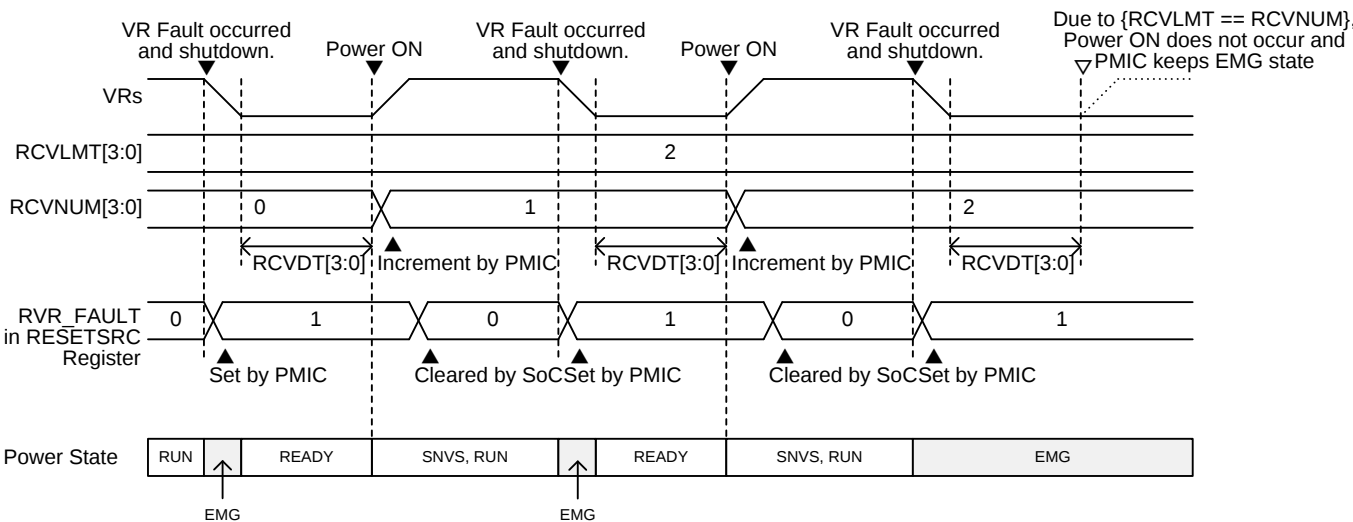


Figure 3-14. Example of VR Fault and Recovery Sequence (RCVLMT[3:0] = 2)

3.2.5.11. EMG to OFF

Table 3-30 shows the conditions for shifting from EMG to OFF. If INTLDO1P5\_UVLO = 0 after entry to EMG, the power state immediately goes to OFF as shown in Figure 3-15.

Table 3-30. Conditions from EMG to OFF

| Event Trigger    | Conditions<br>(All must be satisfied per Event Trigger) | Next State | Notes |
|------------------|---------------------------------------------------------|------------|-------|
| VSYS Voltage Low | INTLDO1P5_UVLO = 0                                      | OFF        |       |

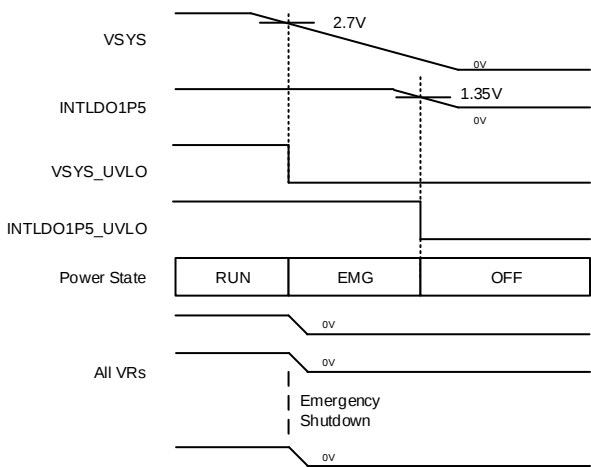


Figure 3-15. EMG to OFF Power State Transition

3.2.5.12. EMG to READY

Table 3-31 shows the conditions for shifting from EMG to READY. Basically, the power state can exit EMG when no emergency events are found as shown in [Figure 3-14](#), [Figure 3-16](#), and [Figure 3-17](#).

Table 3-31. Conditions from EMG to READY

| Event Trigger                | Conditions<br>(All must be satisfied per Event Trigger) | Next State | Notes |
|------------------------------|---------------------------------------------------------|------------|-------|
| 1) No Emergency Event        | VSYS_UVLO = 1                                           | READY      |       |
|                              | Die Temperature < 150 °C                                |            |       |
|                              | No OCP                                                  |            |       |
|                              | No VR Fault                                             |            |       |
| 2) VR Fault Recovery Attempt | VSYS_UVLO = 1                                           | READY      |       |
|                              | Die Temperature < 150 °C                                |            |       |
|                              | During VR Fault Recovery Attempt                        |            |       |

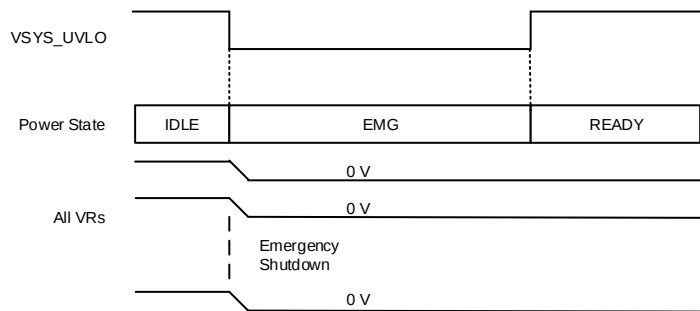


Figure 3-16. EMG to READY Power State Transition (VSYS\_UVLO)

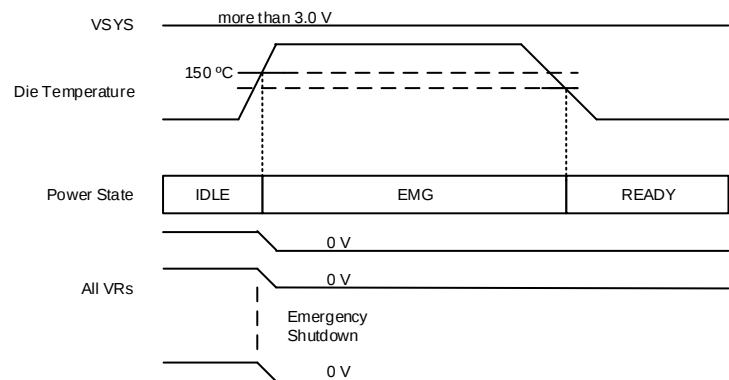


Figure 3-17. EMG to READY Power State Transition (Die Temperature)

3.2.5.13. EMG\_STAY Condition

Table 3-32 shows the conditions for staying at EMG. Basically, the power state stays at EMG when emergency events are found as shown in [Figure 3-14](#), [Figure 3-16](#), and [Figure 3-17](#).  
Note: In case of 3) VR Fault Recovery Failure in Table 3-32; in order to exit EMG, VSYS voltage must be less than 2.7V and then the power state goes to OFF.

Table 3-32. Conditions for Stay at EMG

| Event Trigger                | Conditions<br>(All must be satisfied per Event Trigger) | Next State | Notes              |
|------------------------------|---------------------------------------------------------|------------|--------------------|
| 1) VSYS < 2.7 V              | VSYS_UVLO = 0                                           | EMG        |                    |
|                              | INTLDO1P5_UVLO = 1                                      |            |                    |
| 2) Thermal Shutdown          | Die Temperature > 150 °C                                | EMG        | Thermal Protection |
|                              | INTLDO1P5_UVLO = 1                                      |            |                    |
| 3) VR Fault Recovery Failure | VR Fault Recovery Attempt Failed                        | EMG        |                    |
|                              | INTLDO1P5_UVLO = 1                                      |            |                    |

3.2.5.14. Warm Reset

Warm Reset is executed when the power state = RUN, IDLE and SUSPEND.  
Warm Reset set POR\_B = L for 1 ms as shown in Figure 3-18.  
Please refer to the [Table 3-9](#) for necessary register setting.

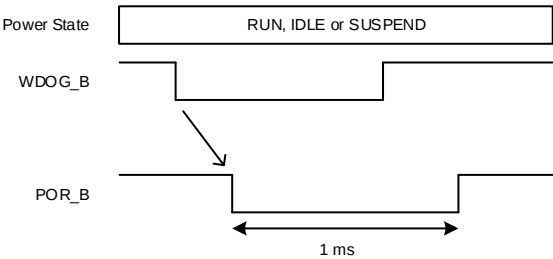


Figure 3-18. Warm Reset by WDOG\_B

**3.2.5.15. PWROFF**

Table 3-33 shows the conditions for shifting from RUN, IDLE, SUSPEND to PWROFF.

When the power state is PWROFF, BD71837AMWV runs Power OFF sequence and VR's are turned OFF in a defined sequential order.

In the end of the sequence, the on-off state of C32K\_OUT, RTC\_RESET\_B, LDO2 and LDO1 depends on the setting of TRANS\_COND1 register as shown in Table 3-34. The summary is shown in [Table 3-35](#).

**Table 3-33. Conditions from RUN, IDLE, SUSPEND to PWROFF**

| Event Trigger        | Conditions<br>(All must be satisfied per Event Trigger) | Next State | Notes            |
|----------------------|---------------------------------------------------------|------------|------------------|
| 1) PWRON_B Long Push | PWRON_B = 0 ==> Long Push Detection                     | PWROFF     | COLD_RESET event |
| 2) WDOG_B            | WDOG_B = 0                                              | PWROFF     | COLD_RESET event |
| 3) Software Reset    | Write 1 to SWRESET in SWRESET register                  | PWROFF     | COLD_RESET event |
| 4) PMIC_ON_REQ       | PMIC_ON_REQ = 0                                         | PWROFF     |                  |

(Note) Die Temperature must be less than 150 °C. VSYS\_UVLO = 1.

**Table 3-34. TRANS\_COND1 - Transition Condition Select 1 Register**

| Register Name | R/W | D7        | D6 | D5 | D4 | D3                          | D2                         | D1                          | D0                           | Initial | Address |
|---------------|-----|-----------|----|----|----|-----------------------------|----------------------------|-----------------------------|------------------------------|---------|---------|
| TRANS_COND1   | R/W | PONT[3:0] |    |    |    | PWRON_<br>POFF_TO_<br>READY | WDOG_<br>POFF_TO_<br>READY | SWRST_<br>POFF_TO_<br>READY | ON_REQ_<br>POFF_TO_<br>READY | 0xC4    | 0x20    |

| Bit    | Name                     | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Initial |
|--------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7:4] | PONT[3:0]                | COLD RESET duration during which the BD71837AMWV stays in READY or SNVS in a COLD RESET event.<br>The BD71837AMWV remains in READY or SNVS for the duration programmed here then BD71837AMWV performs a Power ON sequence.<br>0000 = 5 ms<br>0001 = 10 ms<br>0010 = 15 ms<br>0011 = 20 ms<br>0100 = 25 ms<br>0101 = 30 ms<br>0110 = 35 ms<br>0111 = 40 ms<br>1000 = 45 ms<br>1001 = 50 ms<br>1010 = 75 ms<br>1011 = 100 ms<br>1100 = 250 ms<br>1101 = 500 ms<br>1110 = 750 ms<br>1111 = 1500 ms | 1100    |
| D[3]   | PWRON_<br>POFF_TO_READY  | Set which power state to go after PWROFF triggered by PWRON_B Long Push<br>0 = to SNVS<br>1 = to READY                                                                                                                                                                                                                                                                                                                                                                                          | 0       |
| D[2]   | WDOG_<br>POFF_TO_READY   | Set which power state to go after PWROFF triggered by WDOG_B = 0<br>0 = to SNVS<br>1 = to READY                                                                                                                                                                                                                                                                                                                                                                                                 | 1       |
| D[1]   | SWRST_<br>POFF_TO_READY  | Set which power state to go after PWROFF triggered by Software Reset<br>0 = to SNVS<br>1 = to READY                                                                                                                                                                                                                                                                                                                                                                                             | 0       |
| D[0]   | ON_REQ_<br>POFF_TO_READY | Set which power state to go after PWROFF triggered by PMIC_ON_REQ = 0<br>0 = to SNVS<br>1 = to READY                                                                                                                                                                                                                                                                                                                                                                                            | 0       |

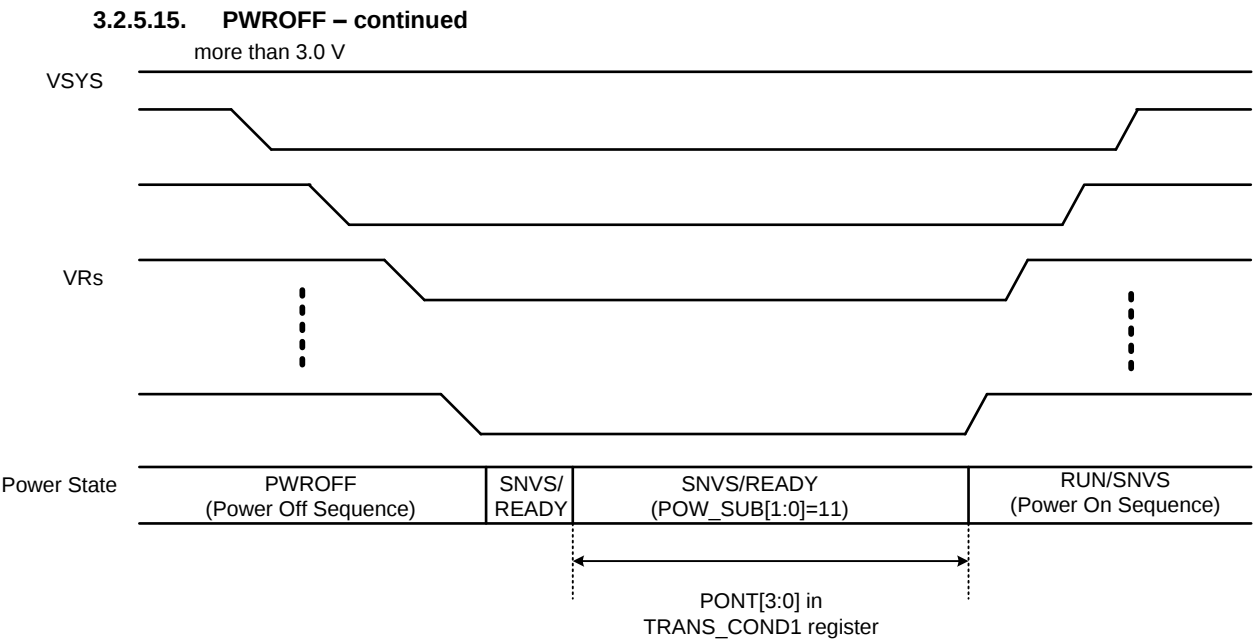


Figure 3-19. Cold Reset Duration Time set by PONT[3:0]

Table 3-35. VR Summary After Power OFF Sequence

| PWROFF trigger    | PWRON_POFF_TO_READY | WDOG_POFF_TO_READY | SWRST_POFF_TO_READY | ON_REQ_POFF_TO_READY | C32K_OUT | RTC_RESET_B | LDO2 | LDO1 |
|-------------------|---------------------|--------------------|---------------------|----------------------|----------|-------------|------|------|
| PWRON_B Long Push | 0                   | -                  | -                   | -                    | On       | High        | On   | On   |
|                   | 1                   | -                  | -                   | -                    | Off      | Low         | Off  | Off  |
| WDOG_B = 0        | -                   | 0                  | -                   | -                    | On       | High        | On   | On   |
|                   | -                   | 1                  | -                   | -                    | Off      | Low         | Off  | Off  |
| Software Reset    | -                   | -                  | 0                   | -                    | On       | High        | On   | On   |
|                   | -                   | -                  | 1                   | -                    | Off      | Low         | Off  | Off  |
| PMIC_ON_REQ = 0   | -                   | -                  | -                   | 0                    | On       | High        | On   | On   |
|                   | -                   | -                  | -                   | 1                    | Off      | Low         | Off  | Off  |

**3.2.5.16. PWROFF to READY**

After the completion of Power OFF sequence, the power state goes READY if the POFF\_TO\_READY = 1. This is in accordance with PWROFF trigger event in the TRANS\_COND1 register.

**3.2.5.17. PWROFF to SNVS**

After the completion of Power OFF sequence, the power state goes SNVS if the POFF\_TO\_READY = 0. This is in accordance with PWROFF trigger event in the TRANS\_COND1 register.

**3.2.5.18. PWRON\_B Functionality**

The system has a button that can be used for triggering the system to power on or off. PWRON\_B is an active-low input to BD71837AMWV. Timer circuitry measures the length of time the button is pressed. Then the timer detects short push and long push events.

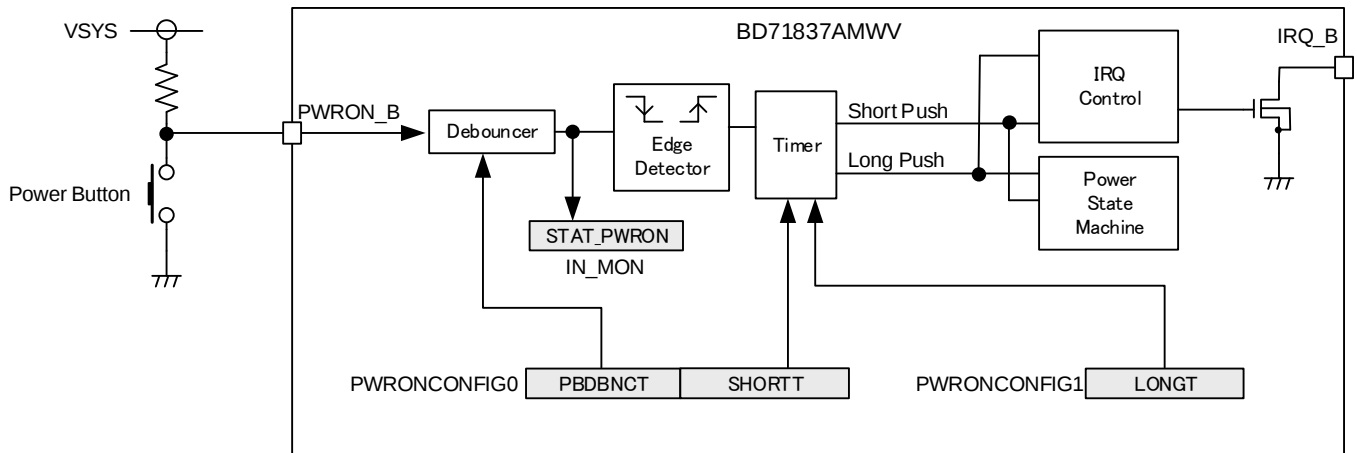


Figure 3-20. Power Button Block Diagram

Table 3-36. PWRONCONFIG0 - PWRON\_B Configuration 0 Register

| Register Name | R/W | D7 | D6 | D5           | D4 | D3          | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----|----|--------------|----|-------------|----|----|----|---------|---------|
| PWRONCONFIG0  | R/W | -  | -  | PBDBNCT[1:0] |    | SHORTT[3:0] |    |    |    | 0x16    | 0x27    |

| Bit    | Name         | Function                                                                                                                                                                                                                                                                                     | Initial |
|--------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[5:4] | PBDBNCT[1:0] | PWRON_B Input Pin Debounce Time<br>00 = 10 ms 01 = 30 ms(default) 10 = 60 ms 11 = 100 ms                                                                                                                                                                                                     | 01      |
| D[3:0] | SHORTT[3:0]  | Short Push Timer :<br>0000 = 10 ms<br>0001 = 0.5 s<br>0010 = 1.0 s<br>0011 = 1.5 s<br>0100 = 2.0 s<br>0101 = 2.5 s<br>0110 = 3.0 s (default)<br>0111 = 3.5 s<br>1000 = 4.0 s<br>1001 = 4.5 s<br>1010 = 5.0 s<br>1011 = 5.5 s<br>1100 = 6.0 s<br>1101 = 6.5 s<br>1110 = 7.0 s<br>1111 = 7.5 s | 0110    |

## 3.2.5.18. PWRON\_B Functionality – continued

Table 3-37. PWRONCONFIG1 - PWRON\_B Configuration 1 Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3         | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----|----|----|----|------------|----|----|----|---------|---------|
| PWRONCONFIG1  | R/W | -  | -  | -  | -  | LONGT[3:0] |    |    |    | 0x0A    | 0x28    |

| Bit    | Name       | Function                                                                                                                                                                                                                                                            | Initial |
|--------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[3:0] | LONGT[3:0] | Long Push Timer :<br>0000 = 10 ms<br>0001 = 1 s<br>0010 = 2 s<br>0011 = 3 s<br>0100 = 4 s<br>0101 = 5 s<br>0110 = 6 s<br>0111 = 7 s<br>1000 = 8 s<br>1001 = 9 s<br>1010 = 10 s (default)<br>1011 = 11 s<br>1100 = 12 s<br>1101 = 13 s<br>1110 = 14 s<br>1111 = 15 s | 1010    |

3.3. Power Sequence

3.3.1. Power ON Sequence

Figure 3-21 shows an example when TRANS\_COND0 = 0x48, which are:  
READY to SNVS condition : VSYS\_UVLO = 1  
SNVS to RUN condition : PMIC\_ON\_REQ

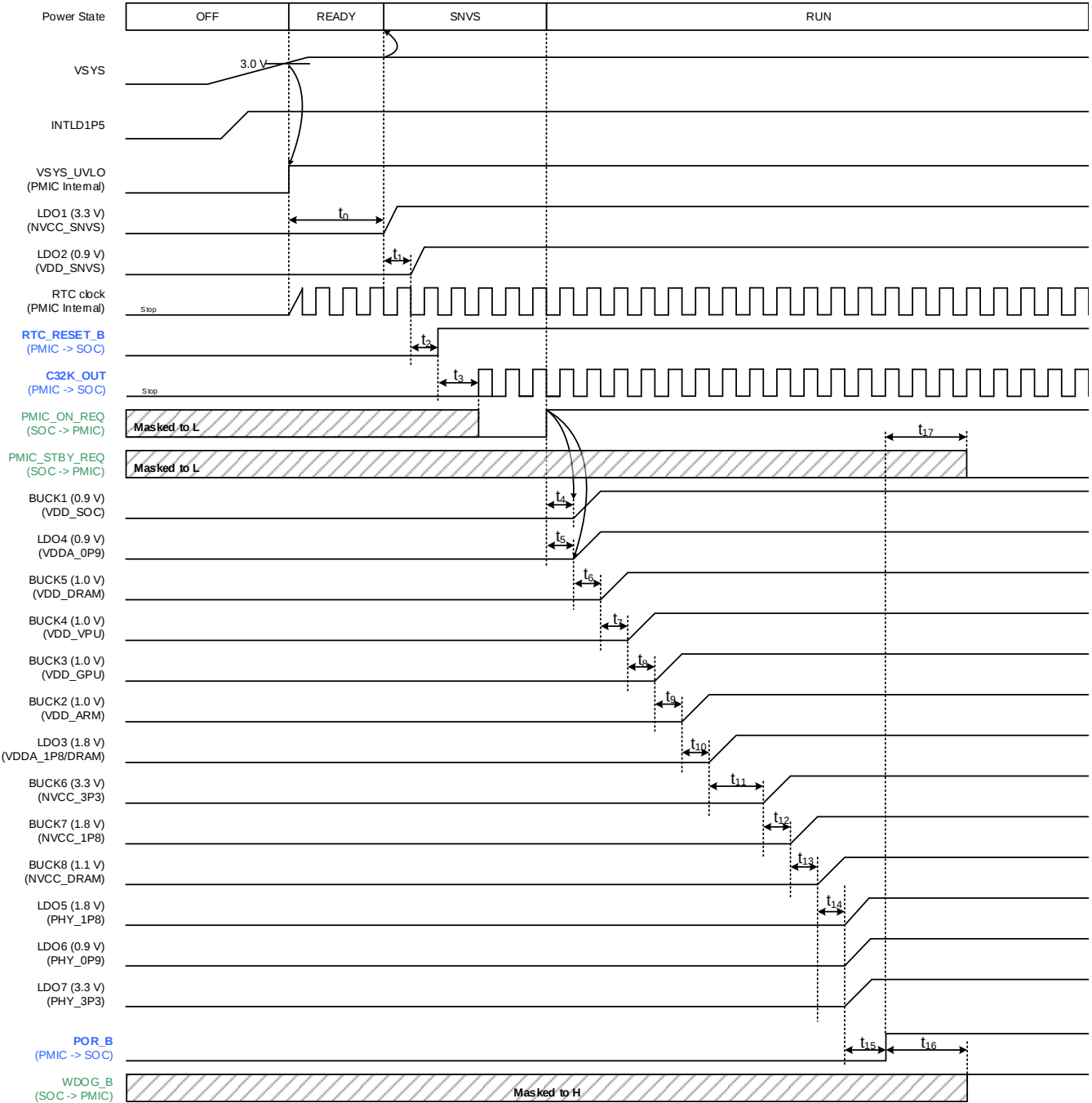


Figure 3-21. Power ON Sequence

## 3.3.1. Power ON Sequence – continued

Table 3-38. Power ON Sequence Timing Specification

| Symbol          | Description                                             | Min | Typ | Max | Unit |
|-----------------|---------------------------------------------------------|-----|-----|-----|------|
| t <sub>0</sub>  | VSYS = 3.0 V to LDO1 Assert Delay                       | 0   | 20  | 22  | ms   |
| t <sub>1</sub>  | LDO1 Assert to LDO2 Assert Delay                        | 0   | 1.0 | 1.2 | ms   |
| t <sub>2</sub>  | LDO2 Assert to RTC_RESET_B De-assert Delay              | 0   | 10  | 12  | ms   |
| t <sub>3</sub>  | RTC_RESET_B De-assert to C32K_OUT Output Delay          | 0   | 40  | 90  | μs   |
| t <sub>4</sub>  | PMIC_ON_REQ Assert to BUCK1 Assert Delay                | 0   | 125 | 200 | μs   |
| t <sub>5</sub>  | PMIC_ON_REQ Assert to LDO4 Assert Delay                 | 0   | 140 | 220 | μs   |
| t <sub>6</sub>  | LDO4 Assert to BUCK5 Assert Delay                       | 0   | 1.0 | 1.2 | ms   |
| t <sub>7</sub>  | BUCK5 Assert to BUCK4 Assert Delay                      | 0   | 1.0 | 1.2 | ms   |
| t <sub>8</sub>  | BUCK4 Assert to BUCK3 Assert Delay                      | 0   | 1.0 | 1.2 | ms   |
| t <sub>9</sub>  | BUCK3 Assert to BUCK2 Assert Delay                      | 0   | 1.0 | 1.2 | ms   |
| t <sub>10</sub> | BUCK2 Assert to LDO3 Assert Delay                       | 0   | 1.0 | 1.2 | ms   |
| t <sub>11</sub> | LDO3 Assert to BUCK6 Assert Delay                       | 0   | 1.0 | 1.2 | ms   |
| t <sub>12</sub> | BUCK6 Assert to BUCK7 Assert Delay                      | 0   | 1.0 | 1.2 | ms   |
| t <sub>13</sub> | BUCK7 Assert to BUCK8 Assert Delay                      | 0   | 2.0 | 2.4 | ms   |
| t <sub>14</sub> | BUCK8 Assert to LDO5,6,7 De-assert Delay                | 0   | 2.0 | 2.4 | ms   |
| t <sub>15</sub> | LDO5,6,7 Assert to POR_B De-assert Delay                | 0   | 4.0 | 4.8 | ms   |
| t <sub>16</sub> | POR_B De-assert to WDOG_B Internal Mask Disabled        | 0   | 10  | 12  | ms   |
| t <sub>17</sub> | POR_B De-assert to PMIC_STBY_REQ Internal Mask Disabled | 0   | 10  | 12  | ms   |

3.3.2. Power OFF Sequence

Figure 3-22 shows an example when triggered by PMIC\_ON\_REQ when ON\_REQ\_POFF\_TO\_READY = 0 in TRANS\_COND1 register.

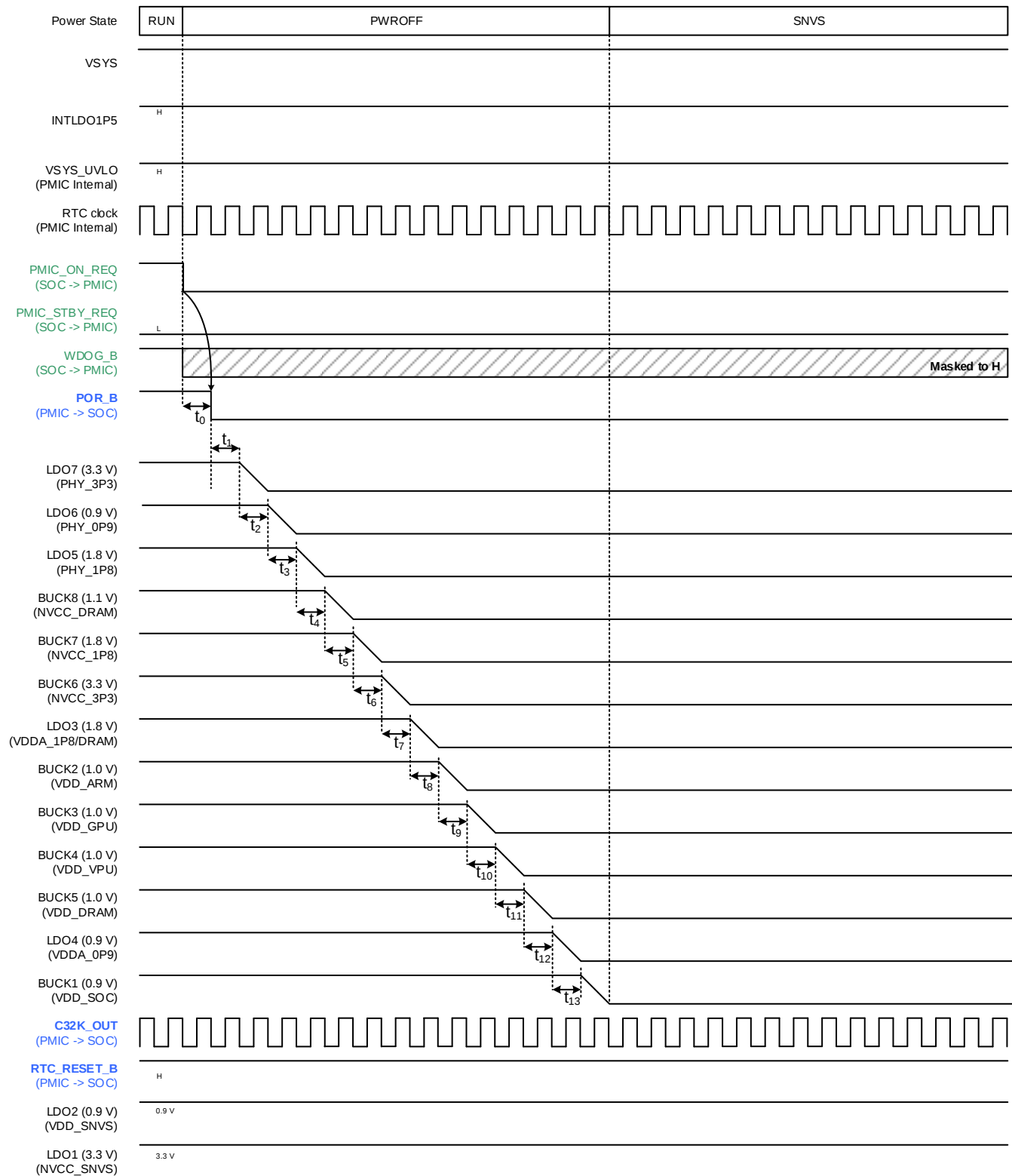


Figure 3-22. Power OFF Sequence (To SNVS)

## 3.3.2. Power OFF Sequence – continued

Table 3-39. Power OFF Sequence Timing Specification (To SNVS)

| Symbol          | Description                                 | Min | Typ | Max | Unit |
|-----------------|---------------------------------------------|-----|-----|-----|------|
| t <sub>0</sub>  | PMIC_ON_REQ De-assert to POR_B Assert Delay | 0   | 120 | 200 | μs   |
| t <sub>1</sub>  | POR_B De-assert to LDO7 De-assert Delay     | 0   | 10  | 12  | ms   |
| t <sub>2</sub>  | LDO7 De-assert to LDO6 De-assert Delay      | 0   | 10  | 12  | ms   |
| t <sub>3</sub>  | LDO6 De-assert to LDO5 De-assert Delay      | 0   | 10  | 12  | ms   |
| t <sub>4</sub>  | LDO5 De-assert to BUCK8 De-assert Delay     | 0   | 10  | 12  | ms   |
| t <sub>5</sub>  | BUCK8 De-assert to BUCK7 De-assert Delay    | 0   | 30  | 35  | ms   |
| t <sub>6</sub>  | BUCK7 De-assert to BUCK6 De-assert Delay    | 0   | 10  | 12  | ms   |
| t <sub>7</sub>  | BUCK6 De-assert to LDO3 De-assert Delay     | 0   | 10  | 12  | ms   |
| t <sub>8</sub>  | LDO3 De-assert to BUCK2 De-assert delay     | 0   | 10  | 12  | ms   |
| t <sub>9</sub>  | BUCK2 De-assert to BUCK3 De-assert Delay    | 0   | 10  | 12  | ms   |
| t <sub>10</sub> | BUCK3 De-assert to BUCK4 De-assert Delay    | 0   | 10  | 12  | ms   |
| t <sub>11</sub> | BUCK4 De-assert to BUCK5 De-assert Delay    | 0   | 10  | 12  | ms   |
| t <sub>12</sub> | BUCK5 De-assert to LDO4 De-assert Delay     | 0   | 10  | 12  | ms   |
| t <sub>13</sub> | LDO4 De-assert to BUCK1 De-assert delay     | 0   | 10  | 12  | ms   |

### 3.3.2. Power OFF Sequence – continued

Figure 3-23 shows an example when triggered by PMIC\_ON\_REQ when ON\_REQ\_POFF\_TO\_READY = 1 in TRANS\_COND1 register.

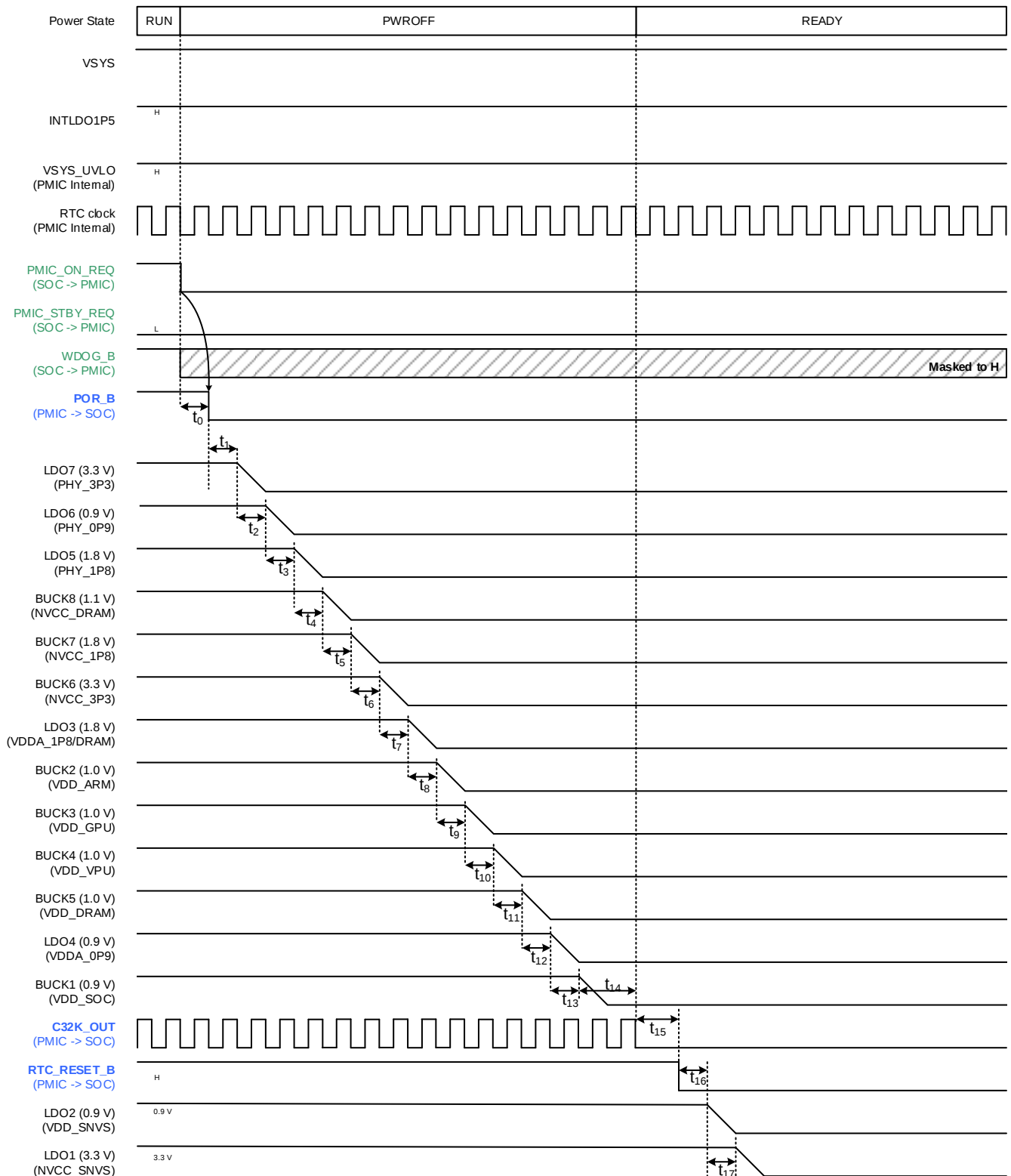


Figure 3-23. Power OFF Sequence (To READY)

## 3.3.2. Power OFF Sequence – continued

Table 3-40. Power OFF Sequence Timing Specification (To READY)

| Symbol          | Description                                      | Min | Typ | Max | Unit |
|-----------------|--------------------------------------------------|-----|-----|-----|------|
| t <sub>0</sub>  | PMIC_ON_REQ De-assert to POR_B Assert Delay      | 0   | 120 | 200 | μs   |
| t <sub>1</sub>  | POR_B Assert to LDO7 De-assert Delay             | 0   | 10  | 12  | ms   |
| t <sub>2</sub>  | LDO7 De-assert to LDO6 De-assert Delay           | 0   | 10  | 12  | ms   |
| t <sub>3</sub>  | LDO6 De-assert to LDO5 De-assert Delay           | 0   | 10  | 12  | ms   |
| t <sub>4</sub>  | LDO5 De-assert to BUCK8 De-assert Delay          | 0   | 10  | 12  | ms   |
| t <sub>5</sub>  | BUCK8 De-assert to BUCK7 De-assert Delay         | 0   | 30  | 35  | ms   |
| t <sub>6</sub>  | BUCK7 De-assert to BUCK6 De-assert Delay         | 0   | 10  | 12  | ms   |
| t <sub>7</sub>  | BUCK6 De-assert to LDO3 De-assert Delay          | 0   | 10  | 12  | ms   |
| t <sub>8</sub>  | LDO3 De-assert to BUCK2 De-assert Delay          | 0   | 10  | 12  | ms   |
| t <sub>9</sub>  | BUCK2 De-assert to BUCK3 De-assert Delay         | 0   | 10  | 12  | ms   |
| t <sub>10</sub> | BUCK3 De-assert to BUCK4 De-assert Delay         | 0   | 10  | 12  | ms   |
| t <sub>11</sub> | BUCK4 De-assert to BUCK5 De-assert Delay         | 0   | 10  | 12  | ms   |
| t <sub>12</sub> | BUCK5 De-assert to LDO4 De-assert Delay          | 0   | 10  | 12  | ms   |
| t <sub>13</sub> | LDO4 De-assert to BUCK1 De-assert Delay          | 0   | 10  | 12  | ms   |
| t <sub>14</sub> | BUCK1 De-assert to C32K_OUT Output Stop Delay    | 0   | 10  | 12  | ms   |
| t <sub>15</sub> | C32K_OUT Output Stop to RTC_RESET_B Assert Delay | 0   | 10  | 12  | ms   |
| t <sub>16</sub> | RTC_RESET_B Assert to LDO2 De-assert Delay       | 0   | 10  | 12  | ms   |
| t <sub>17</sub> | LDO2 De-assert to LDO1 De-assert Delay           | 0   | 10  | 12  | ms   |

## 3.3.3. RUN to IDLE

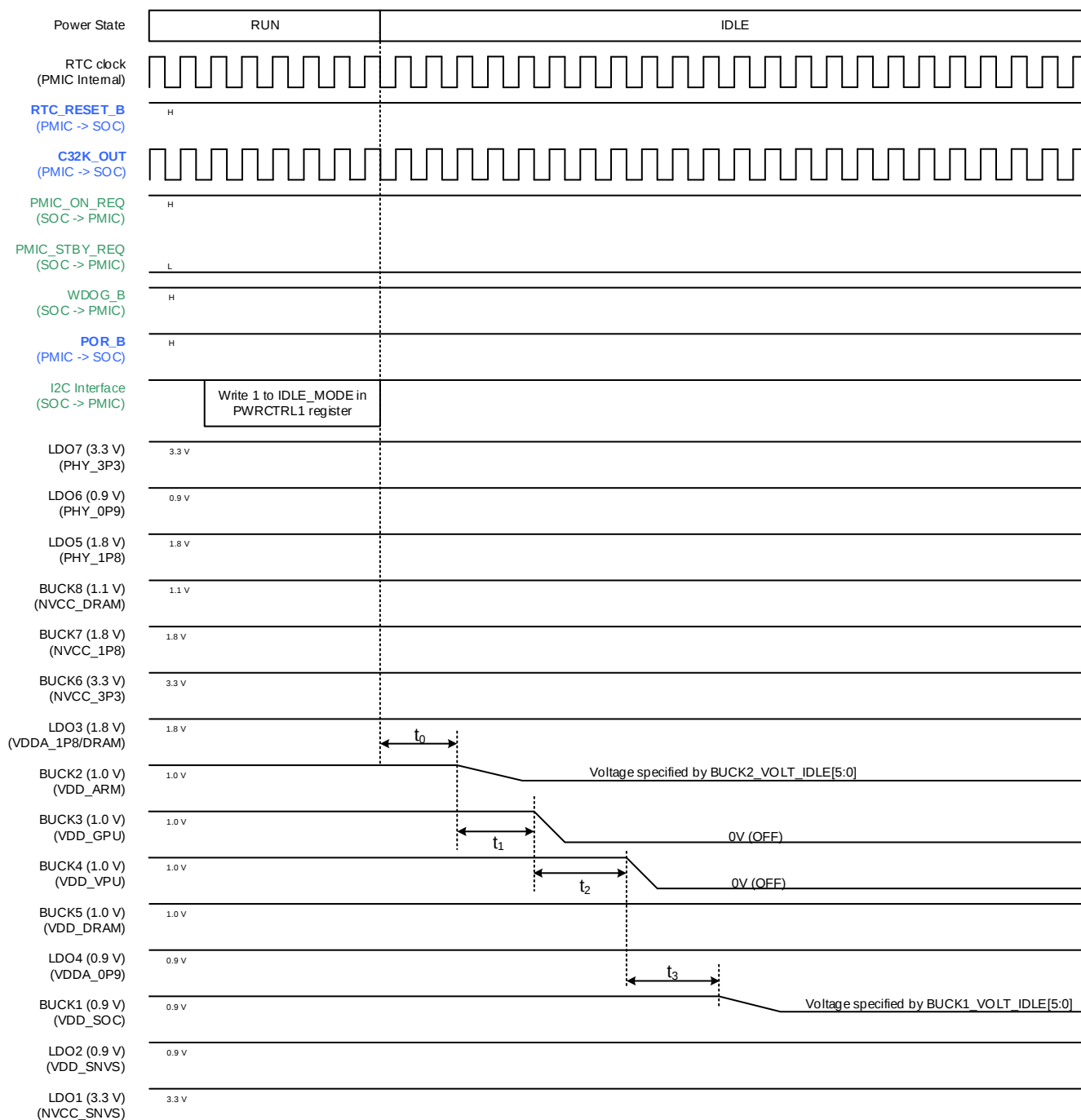


Figure 3-24. RUN to IDLE

Table 3-41. RUN to IDLE Timing Specification

| Symbol | Description                                         | Min | Typ | Max | Unit    |
|--------|-----------------------------------------------------|-----|-----|-----|---------|
| $t_0$  | End of I2C Access to BUCK2 Voltage Change Start     | 0   | 120 | 200 | $\mu$ s |
| $t_1$  | BUCK2 Voltage Change Start to BUCK3 De-assert Delay | 0   | 120 | 200 | $\mu$ s |
| $t_2$  | BUCK3 De-assert to BUCK4 De-assert Delay            | 0   | 1.0 | 1.2 | ms      |
| $t_3$  | BUCK4 De-assert to BUCK1 Voltage Change Start       | 0   | 1.0 | 1.2 | ms      |

## 3.3.4. IDLE to RUN

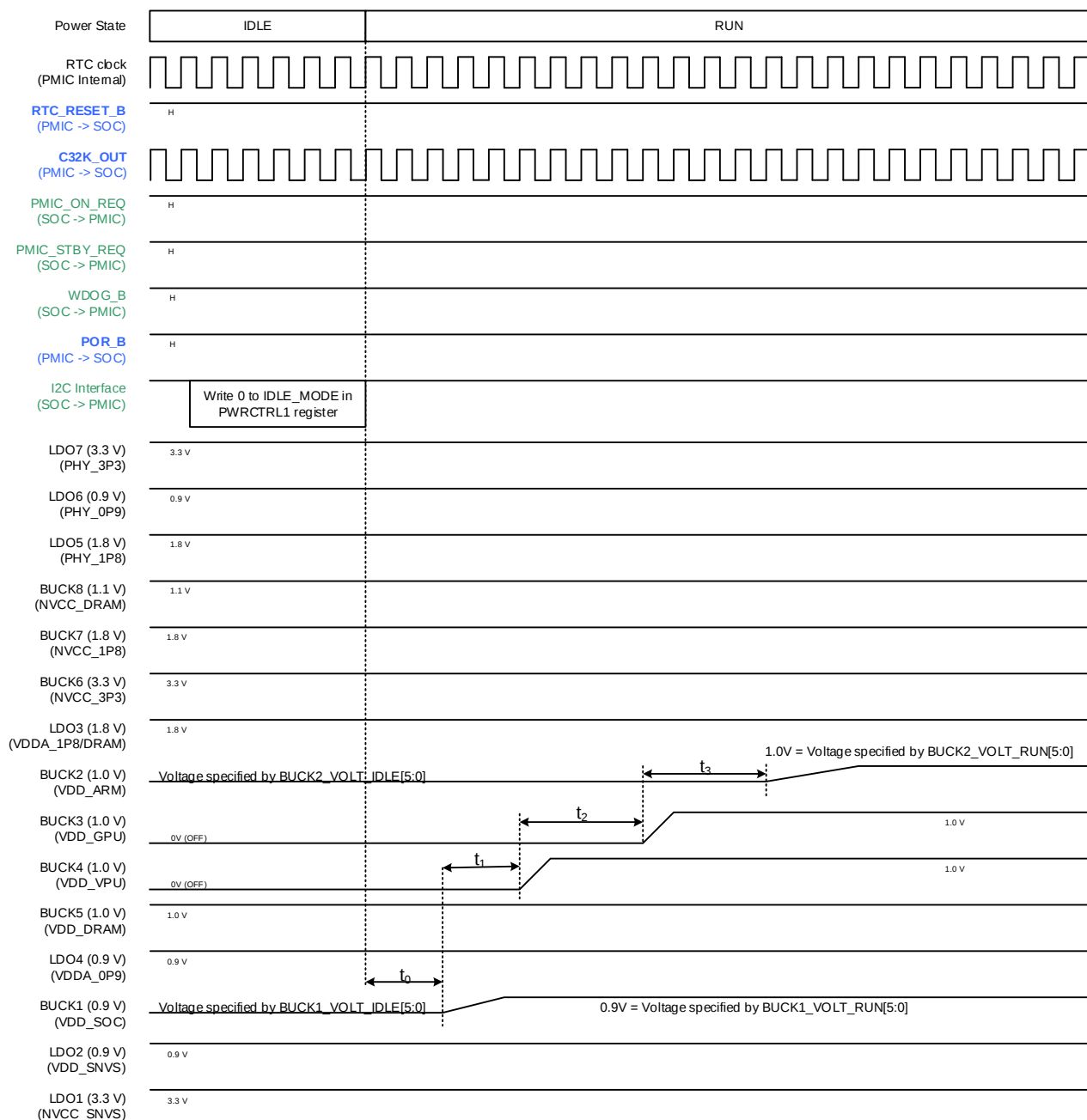


Figure 3-25. IDLE to RUN

Table 3-42. IDLE to RUN Timing Specification

| Symbol | Description                                      | Min | Typ | Max | Unit    |
|--------|--------------------------------------------------|-----|-----|-----|---------|
| $t_0$  | End of I2C Access to BUCK1 Voltage Change Start  | 0   | 120 | 200 | $\mu$ s |
| $t_1$  | BUCK1 Voltage Change Start to BUCK4 Assert Delay | 0   | 120 | 200 | $\mu$ s |
| $t_2$  | BUCK4 Assert to BUCK3 Assert Delay               | 0   | 1.0 | 1.2 | ms      |
| $t_3$  | BUCK3 Assert to BUCK2 Voltage Change Start       | 0   | 1.0 | 1.2 | ms      |

## 3.3.5. RUN to SUSPEND

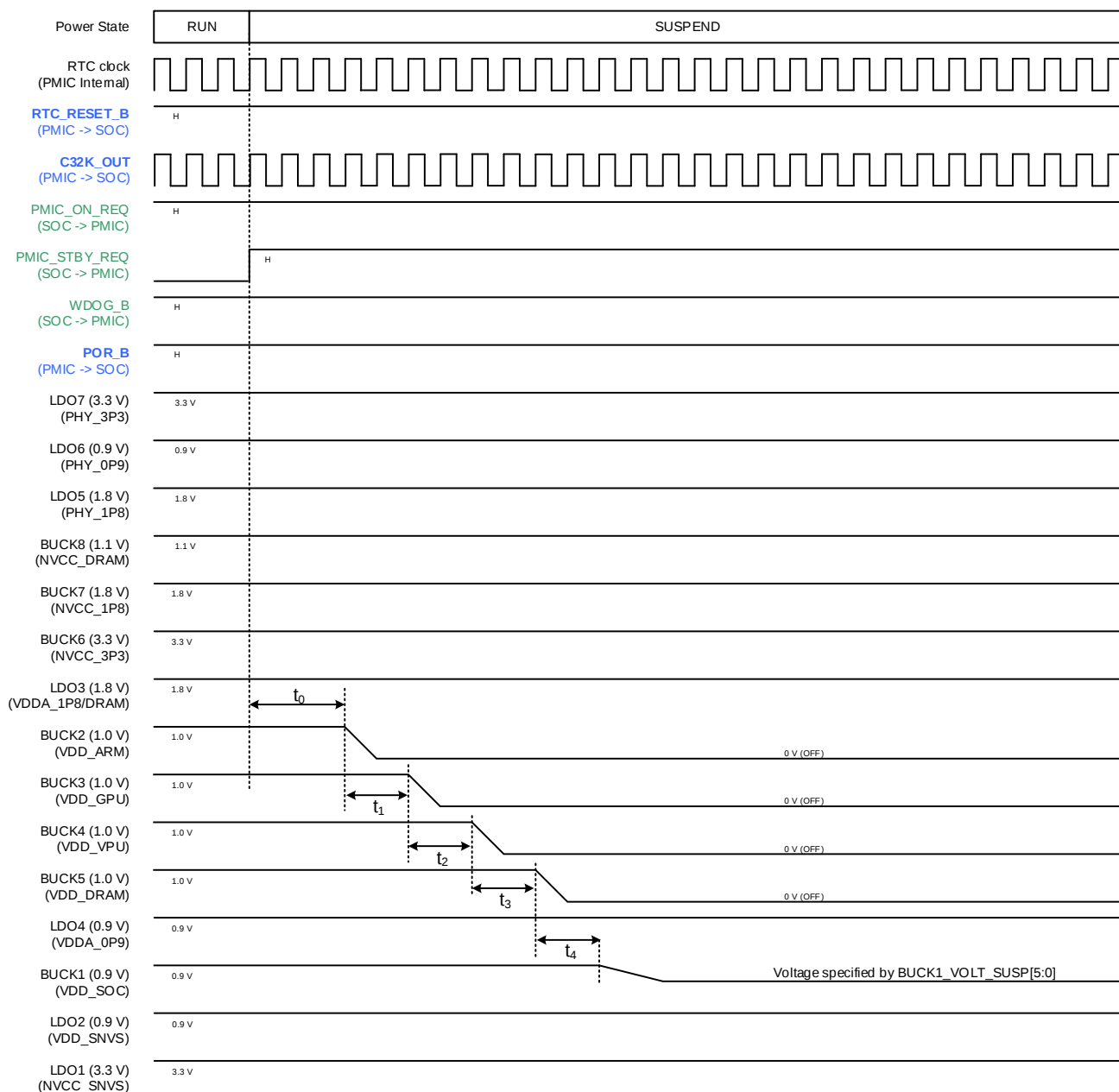


Figure 3-26. RUN to SUSPEND

Table 3-43. RUN to SUSPEND Timing Specification

| Symbol | Description                                   | Min | Typ | Max | Unit    |
|--------|-----------------------------------------------|-----|-----|-----|---------|
| $t_0$  | PMIC_STBY_REQ High to BUCK2 De-assert Delay   | 0   | 120 | 200 | $\mu$ s |
| $t_1$  | BUCK2 De-assert to BUCK3 De-assert Delay      | 0   | 10  | 12  | ms      |
| $t_2$  | BUCK3 De-assert to BUCK4 De-assert Delay      | 0   | 10  | 12  | ms      |
| $t_3$  | BUCK4 De-assert to BUCK5 De-assert Delay      | 0   | 10  | 12  | ms      |
| $t_4$  | BUCK5 De-assert to BUCK1 Voltage Change Start | 0   | 10  | 12  | ms      |

## 3.3.6. SUSPEND to RUN

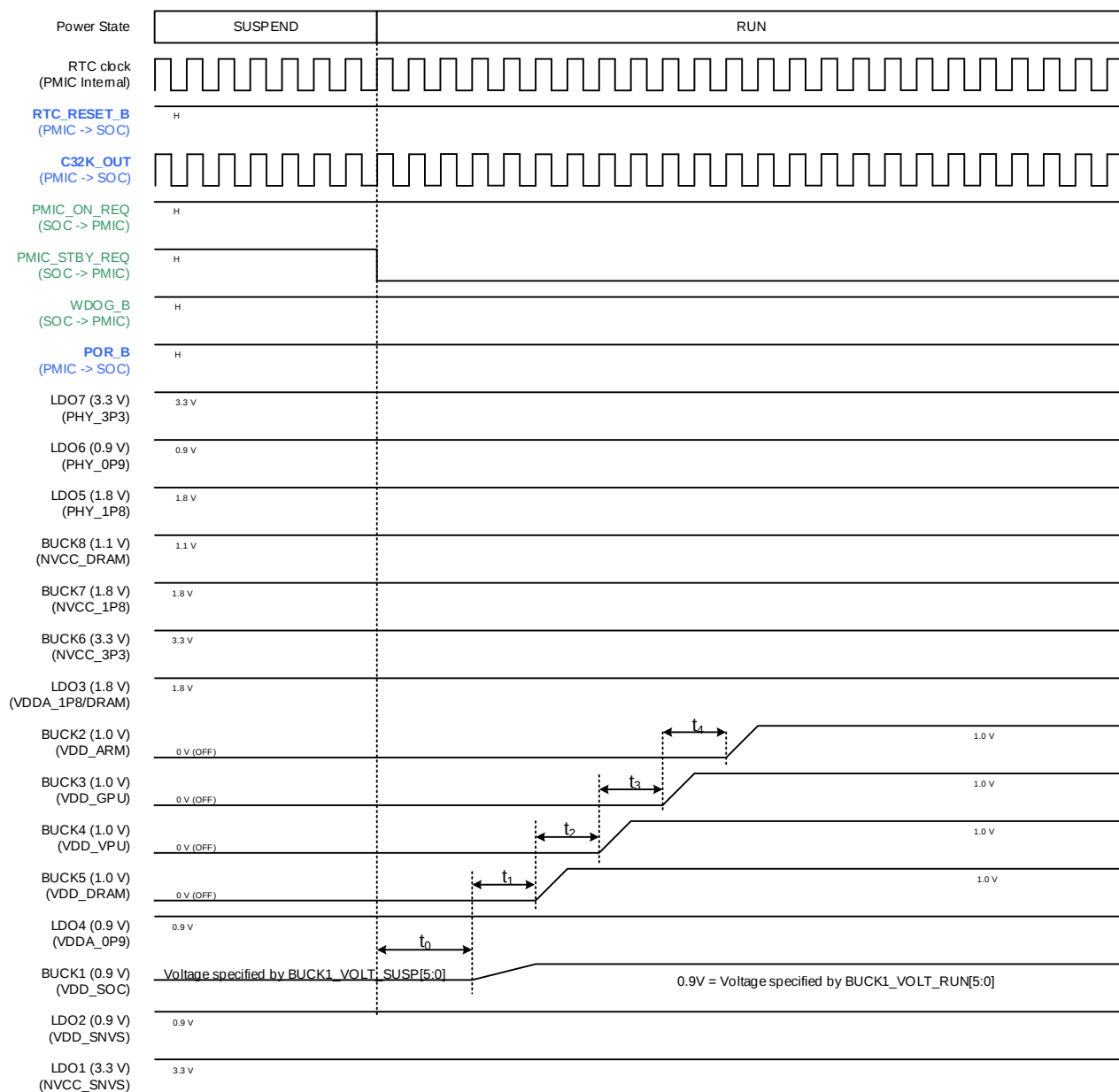


Figure 3-27. SUSPEND to RUN

Table 3-44. SUSPEND to RUN Timing Specification

| Symbol | Description                                      | Min | Typ | Max | Unit    |
|--------|--------------------------------------------------|-----|-----|-----|---------|
| $t_0$  | PMIC_STBY_REQ Low to BUCK1 Voltage Change Start  | 0   | 120 | 200 | $\mu$ s |
| $t_1$  | BUCK1 Voltage Change Start to BUCK5 Assert Delay | 0   | 1.0 | 1.2 | ms      |
| $t_2$  | BUCK5 Assert to BUCK4 Assert Delay               | 0   | 1.0 | 1.2 | ms      |
| $t_3$  | BUCK4 Assert to BUCK3 Assert Delay               | 0   | 1.0 | 1.2 | ms      |
| $t_4$  | BUCK3 Assert to BUCK2 Assert Delay               | 0   | 1.0 | 1.2 | ms      |

## 3.3.7. IDLE to SUSPEND

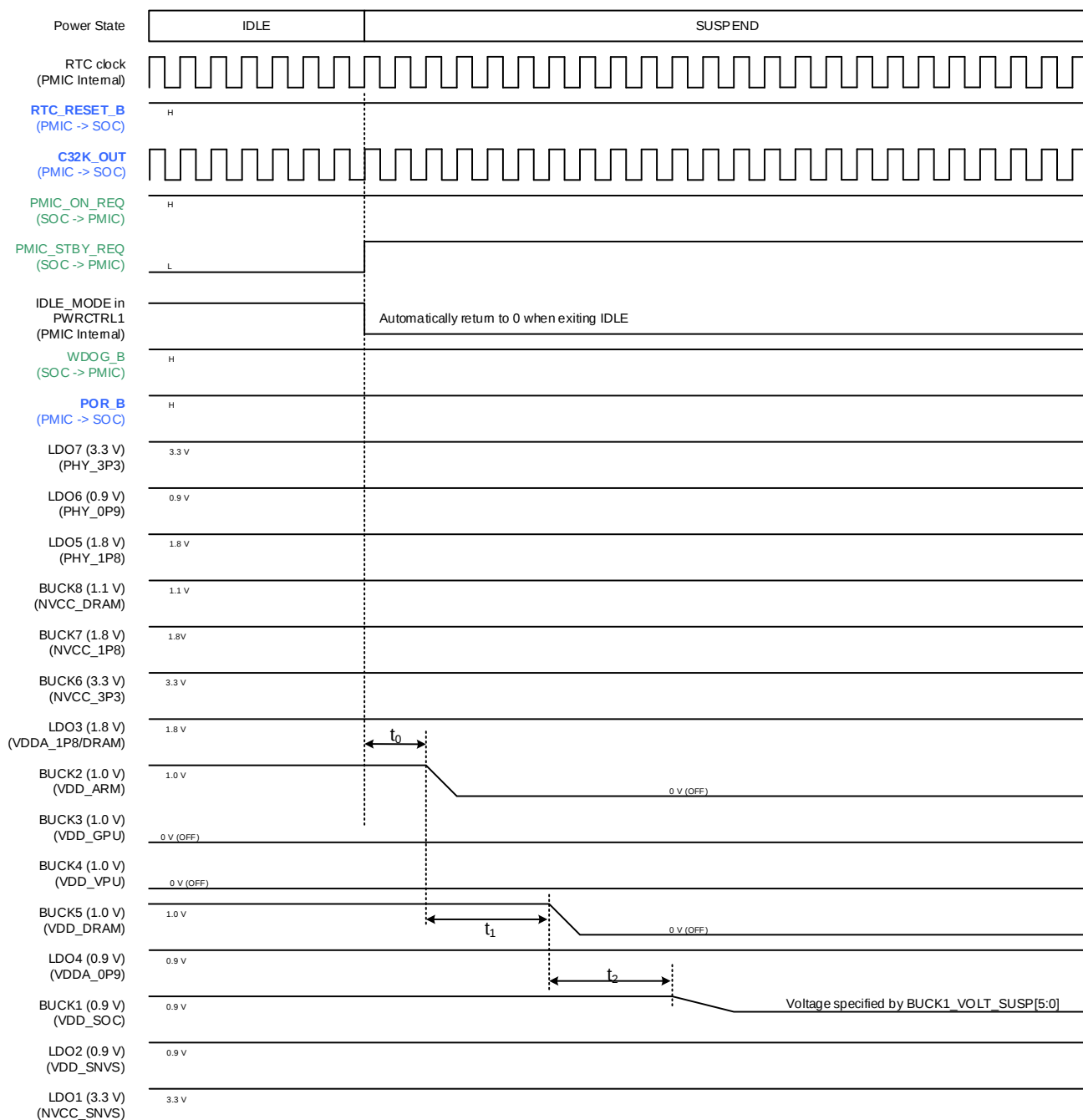


Figure 3-28. IDLE to SUSPEND

Table 3-45. IDLE to SUSPEND Timing Specification

| Symbol | Description                                   | Min | Typ | Max | Unit    |
|--------|-----------------------------------------------|-----|-----|-----|---------|
| $t_0$  | PMIC_STBY_REQ High to BUCK2 De-assert Delay   | 0   | 120 | 200 | $\mu$ s |
| $t_1$  | BUCK2 De-assert to BUCK5 De-assert Delay      | 0   | 10  | 12  | ms      |
| $t_2$  | BUCK5 De-assert to BUCK1 Voltage Change Start | 0   | 10  | 12  | ms      |

## 3.3.8. Emergency Shutdown

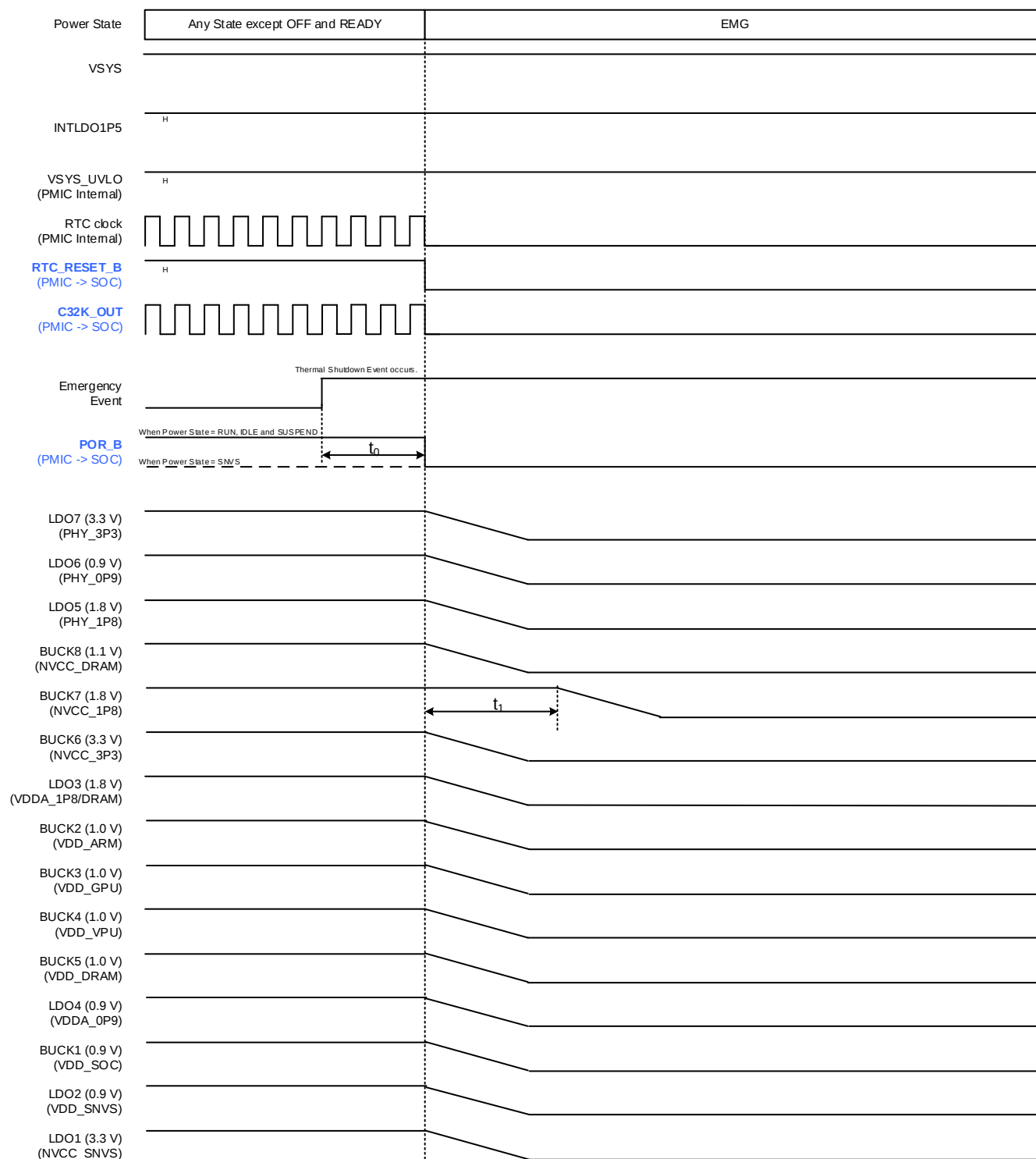


Figure 3-29. Emergency Shutdown

Table 3-46. Emergency Shutdown Timing Specification

| Symbol | Description                                                              | Min | Typ | Max | Unit    |
|--------|--------------------------------------------------------------------------|-----|-----|-----|---------|
| $t_0$  | Emergency Event to POR_B Assert and All VRs Except BUCK7 De-assert Delay | 0   | 120 | 200 | $\mu$ s |
| $t_1$  | POR_B Assert to BUCK7 De-assert Delay                                    | 0   | 30  | 35  | ms      |

## 3.3.9. Warm Reset

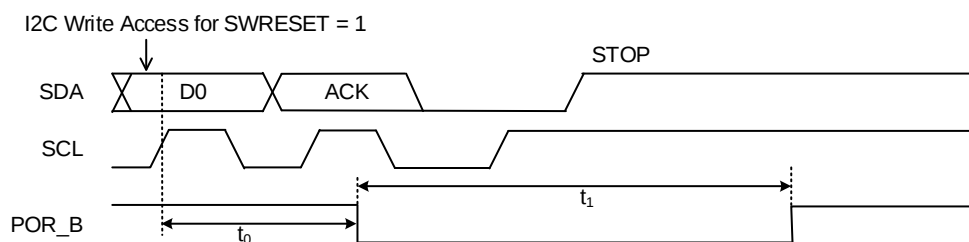


Figure 3-30. Warm Reset (SWRESET)

Table 3-47. Warm Reset (SWRESET) Timing Specification

| Symbol | Description                      | Min  | Typ  | Max  | Unit          |
|--------|----------------------------------|------|------|------|---------------|
| $t_0$  | SCL rising to POR_B assert delay | -    | -    | 1.0  | $\mu\text{s}$ |
| $t_1$  | POR_B assert duration time       | 0.95 | 1.00 | 1.05 | ms            |

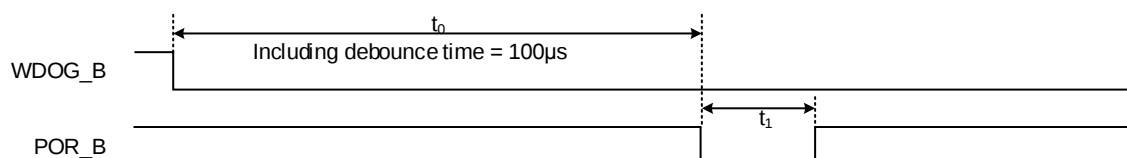


Figure 3-31. Warm Reset (WDOG\_B)

Table 3-48. Warm Reset (WDOG\_B) Timing Specification

| Symbol | Description                          | Min  | Typ  | Max  | Unit          |
|--------|--------------------------------------|------|------|------|---------------|
| $t_0$  | WDOG_B falling to POR_B assert delay | 100  | 110  | 120  | $\mu\text{s}$ |
| $t_1$  | POR_B assert duration time           | 0.95 | 1.00 | 1.05 | ms            |

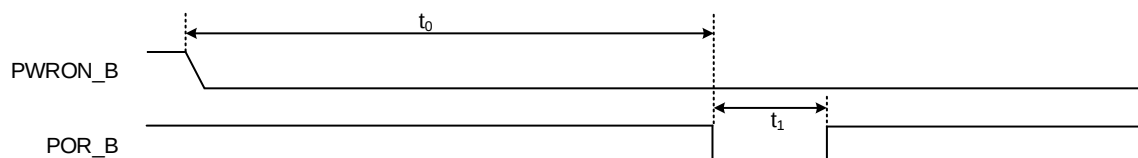


Figure 3-32. Warm Reset (PWRON\_B Long Push)

Table 3-49. Warm Reset (PWRON\_B Long Push) Timing Specification

| Symbol | Description                           | Min                                                           | Typ                                                       | Max                                                           | Unit |
|--------|---------------------------------------|---------------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------------------|------|
| $t_0$  | PWRON_B falling to POR_B assert delay | PBDBNCT[1:0] in PWRONCONFIG0 + LONGT[3:0] in PWRONCONFIG1 -50 | PBDBNCT[1:0] in PWRONCONFIG0 + LONGT[3:0] in PWRONCONFIG1 | PBDBNCT[1:0] in PWRONCONFIG0 + LONGT[3:0] in PWRONCONFIG1 +50 | ms   |
| $t_1$  | POR_B assert duration time            | 0.95                                                          | 1.00                                                      | 1.05                                                          | ms   |

### 3.3.10.Reset Source Indicators

The BD71837AMWV has RESETSRC register which is intended to store the cause of a shutdown or reset, the firmware reads this data on the next startup. Depending on the cause of a shutdown or reset, the only bit of RESETSRC register is 1.

**Table 3-50. RESETSRC - Reset Source Indicator Register**

| Register Name | R/W | D7     | D6    | D5     | D4           | D3        | D2    | D1   | D0        | Initial | Address |
|---------------|-----|--------|-------|--------|--------------|-----------|-------|------|-----------|---------|---------|
| RESETSRC      | R/W | RPWRON | RWDOG | RSWRST | RPMIC_ON_REQ | RVSYS_2P7 | RTEMP | ROCP | RVR_FAULT | 0x00    | 0x29    |

| Bit  | Name         | Function                                                                                             | Initial |
|------|--------------|------------------------------------------------------------------------------------------------------|---------|
| D[7] | RPWRON       | 0 = Default<br>1 = Previous shutdown was due to the PWRON_B Long Push Cold Reset (Write-1-clear bit) | 0       |
| D[6] | RWDOG        | 0 = Default<br>1 = Previous shutdown was due to the WDOG_B Cold Reset (Write-1-clear bit)            | 0       |
| D[5] | RSWRST       | 0 = Default<br>1 = Previous shutdown was due to the Software Cold Reset (Write-1-clear bit)          | 0       |
| D[4] | RPMIC_ON_REQ | 0 = Default<br>1 = Previous shutdown was due to the PMIC_ON_REQ = 0 (Write-1-clear bit)              | 0       |
| D[3] | RVSYS_2P7    | 0 = Default<br>1 = Previous shutdown was due to the Emergency VSYS < 2.7V (Write-1-clear bit)        | 0       |
| D[2] | RTEMP        | 0 = Default<br>1 = Previous shutdown was due to the Emergency Thermal Shutdown (Write-1-clear bit)   | 0       |
| D[1] | ROCP         | 0 = Default<br>1 = Previous shutdown was due to the Emergency OCP (Write-1-clear bit)                | 0       |
| D[0] | RVR_FAULT    | 0 = Default<br>1 = Previous shutdown was due to the Emergency VR Fault (Write-1-clear bit)           | 0       |

#### 4. I2C and Interrupt

##### 4.1. I2C Bus Interface

##### 4.1.1. I2C Bus Interface Overview

I2C access is not permitted when the power state = READY.

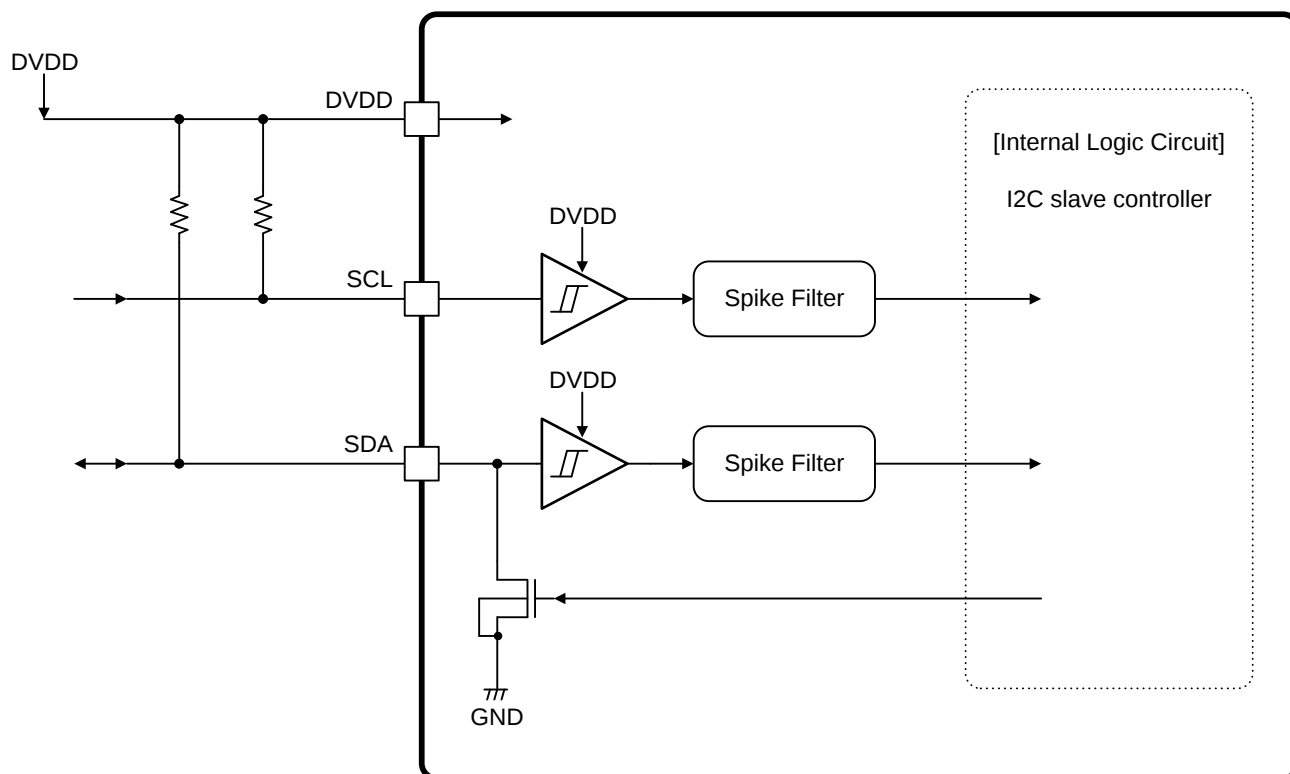


Figure 4-1. I2C (Slave) Block Diagram

## 4.1.2. I2C Bus Interface Electrical Characteristics

Table 4-1. I2C Bus Interface DC Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, V<sub>SY</sub>=5.0 V, DVDD=3.3 V)

| Parameter                                  | Symbol                | Limit         |     |               | Unit | Condition            |
|--------------------------------------------|-----------------------|---------------|-----|---------------|------|----------------------|
|                                            |                       | Min           | Typ | Max           |      |                      |
| Digital pin characteristics – Input (SCL)  |                       |               |     |               |      |                      |
| SCL<br>Input "H" Level                     | V <sub>IH_SCL</sub>   | DVDD<br>x 0.7 | -   | DVDD<br>+ 0.3 | V    |                      |
| SCL<br>Input "L" Level                     | V <sub>IL_SCL</sub>   | -0.3          | -   | DVDD<br>x 0.3 | V    |                      |
| SCL<br>Input Hysteresis                    | V <sub>IHYS_SCL</sub> | 0.1           | -   | -             | V    |                      |
| SCL<br>Input Leak Current(Input=0 V)       | I <sub>OFF1_SCL</sub> | -1            | -   | +1            | μA   |                      |
| SCL<br>Input Leak Current(Input=5.5 V)     | I <sub>OFF2_SCL</sub> | -1            | -   | +1            | μA   |                      |
| Digital pin characteristics – Input (SDA)  |                       |               |     |               |      |                      |
| SDA<br>Input "H" Level                     | V <sub>IH_SDA</sub>   | DVDD<br>x 0.7 | -   | DVDD<br>+ 0.3 | V    |                      |
| SDA<br>Input "L" Level                     | V <sub>IL_SDA</sub>   | -0.3          | -   | DVDD<br>x 0.3 | V    |                      |
| SDA<br>Input Hysteresis                    | V <sub>IHYS_SDA</sub> | 0.1           | -   | -             | V    |                      |
| SDA<br>Input Leak Current(Input=0 V)       | I <sub>OFF1_SDA</sub> | -1            | -   | +1            | μA   |                      |
| SDA<br>Input Leak Current(Input=5.5 V)     | I <sub>OFF2_SDA</sub> | -1            | -   | +1            | μA   |                      |
| Digital pin characteristics - Output (SDA) |                       |               |     |               |      |                      |
| SDA<br>Output "L" Level Voltage            | V <sub>OL_SDA</sub>   | -             | -   | 0.4           | V    | I <sub>OL</sub> =6mA |
| Output Off Leak Current<br>(Input=0 V)     | I <sub>OFF3_SDA</sub> | -1            | -   | +1            | μA   |                      |
| Output Off Leak Current<br>(Input=5.5 V)   | I <sub>OFF4_SDA</sub> | -1            | -   | +1            | μA   |                      |

## 4.1.2. I2C Bus Interface Electrical Characteristics – continued

Table 4-2. I2C Bus Interface AC Timing - Fast Mode

(Unless otherwise specified, Ta=+25 °C, VSYS=5.0 V, DVDD=3.3 V)

| Parameter                                                     | Symbol        | Fast mode |     |      | Fast mode plus |     |      | Unit    |
|---------------------------------------------------------------|---------------|-----------|-----|------|----------------|-----|------|---------|
|                                                               |               | Min       | Typ | Max  | Min            | Typ | Max  |         |
| I2C_CLK Clock Frequency                                       | $f_{SCLH}$    | 0         | -   | 400  | 0              | -   | 1000 | kHz     |
| Hold Time START Condition                                     | $t_{HD\_STA}$ | 0.60      | -   | -    | 0.26           | -   | -    | $\mu s$ |
| LOW Period of I2C_CLK Clock                                   | $t_{LOW}$     | 1.3       | -   | -    | 0.5            | -   | -    | $\mu s$ |
| HIGH Period of I2C_CLK Clock                                  | $t_{HIGH}$    | 0.60      | -   | -    | 0.26           | -   | -    | $\mu s$ |
| Set-up Time for a Repeated START Condition                    | $t_{SU\_STA}$ | 0.60      | -   | -    | 0.26           | -   | -    | $\mu s$ |
| Data Hold Time                                                | $t_{HD\_DAT}$ | 0         | -   | -    | 0              | -   | -    | ns      |
| Data Set-up Time                                              | $t_{SU\_DAT}$ | 100       | -   | -    | 50             | -   | -    | ns      |
| Set-up Time for STOP Condition                                | $t_{SU\_STO}$ | 0.60      | -   | -    | 0.26           | -   | -    | $\mu s$ |
| Fall Time of I2C_DATA Signal                                  | $t_{FDA}$     | 20        | -   | 300  | -              | -   | 120  | ns      |
| Capacitive Load for Each Bus Line                             | $C_B$         | -         | -   | 400  | -              | -   | 550  | pF      |
| Pulse Width of Spikes that are Suppressed by the Input Filter | $t_{SP}$      | 0         | -   | 50   | 0              | -   | 50   | ns      |
| Bus Free Time                                                 | $t_{BUFF}$    | 1.3       | -   | -    | 0.5            | -   | -    | $\mu s$ |
| Data Valid Time                                               | $t_{VD\_DAT}$ | -         | -   | 0.90 | -              | -   | 0.45 | $\mu s$ |
| Data Valid Acknowledge Time                                   | $t_{VD\_ACK}$ | -         | -   | 0.90 | -              | -   | 0.45 | $\mu s$ |

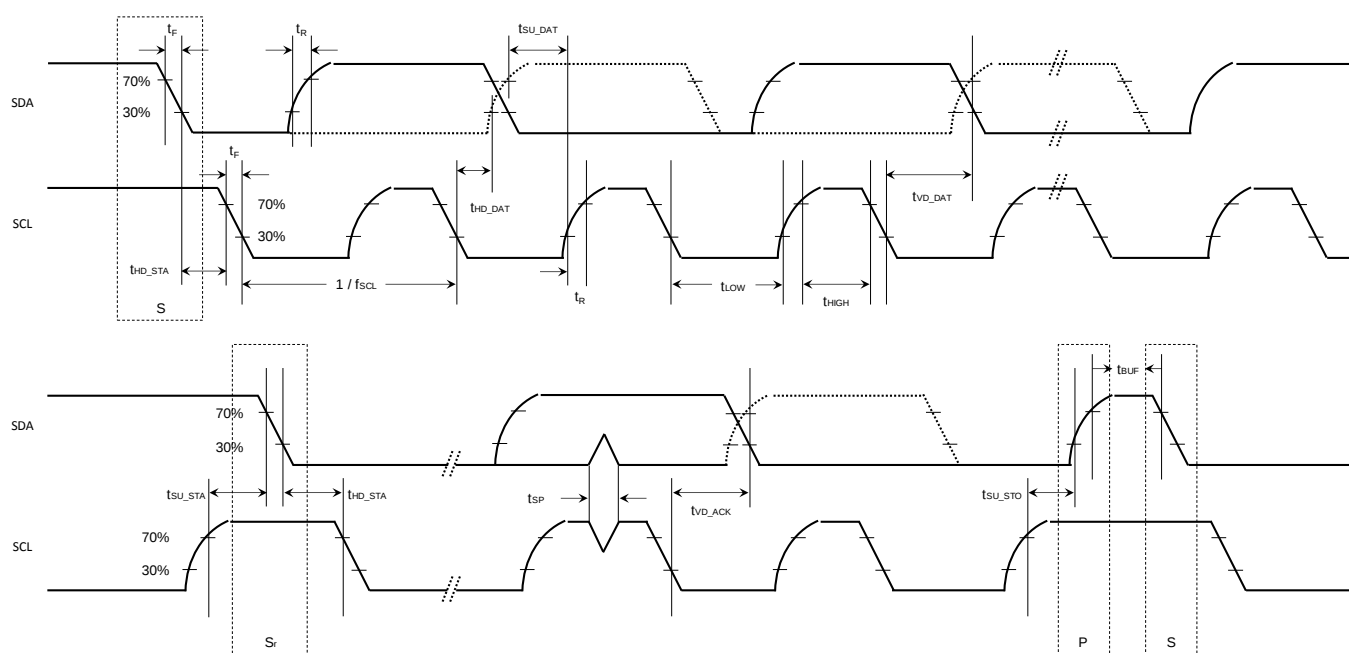


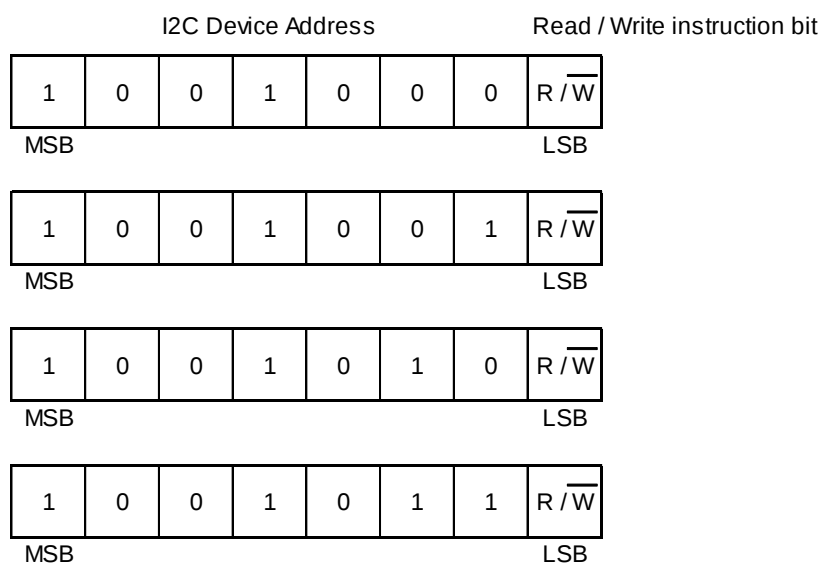
Figure 4-2. I2C Bus Interface AC Timing

## 4.1.3. Device Addressing

Table 4-3. I2C\_DEV - I2C Device Address Indicator Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3 | D2 | D1                | D0 | Initial | Address |
|---------------|-----|----|----|----|----|----|----|-------------------|----|---------|---------|
| I2C_DEV       | R   | -  | -  | -  | -  | -  | -  | I2C_DEV_ADRS[1:0] |    | 0x03    | 0x02    |

| Bit    | Name              | Function                                                                                                                                                     | Initial |
|--------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[1:0] | I2C_DEV_ADRS[1:0] | 00 = I2C 7 bit Device Address = 0x48<br>01 = I2C 7 bit Device Address = 0x49<br>10 = I2C 7 bit Device Address = 0x4A<br>11 = I2C 7 bit Device Address = 0x4B | 11      |

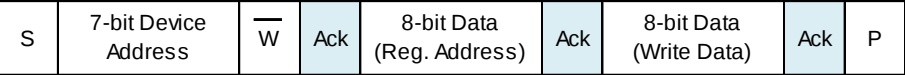


I2C Device Address is decided by OTP setting.

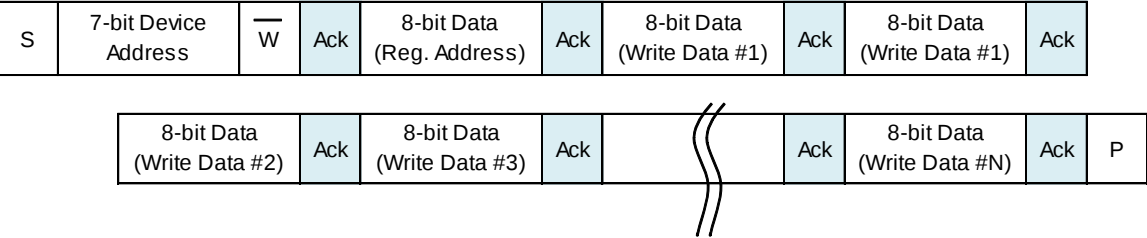
Figure 4-3. I2C Device Addressing

4.1.4. Write / Read Operation

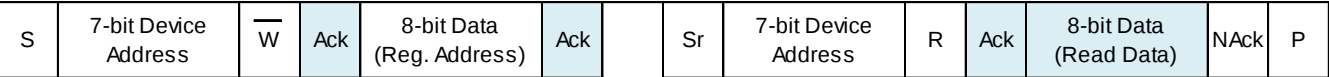
Write single register



Write multiple registers (Address Auto-Increment)



Read single register



Read multiple registers (Address Auto-Increment)

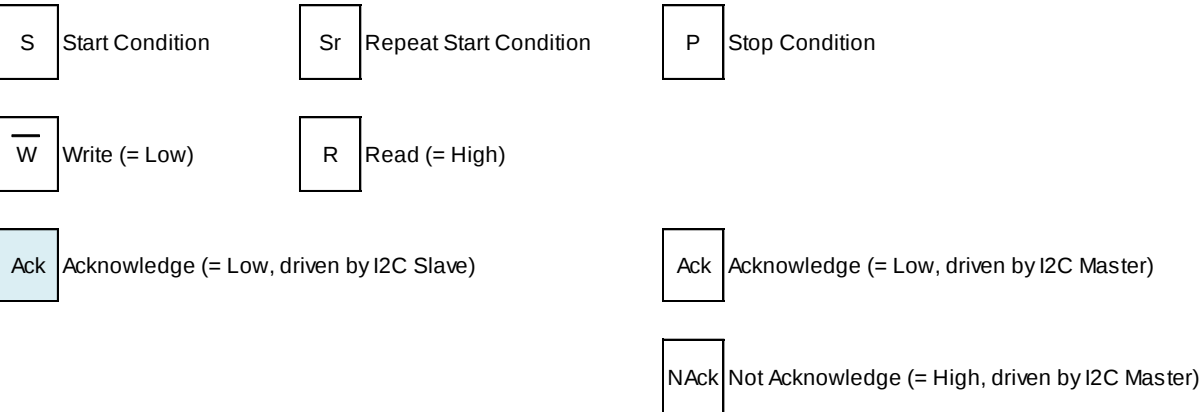
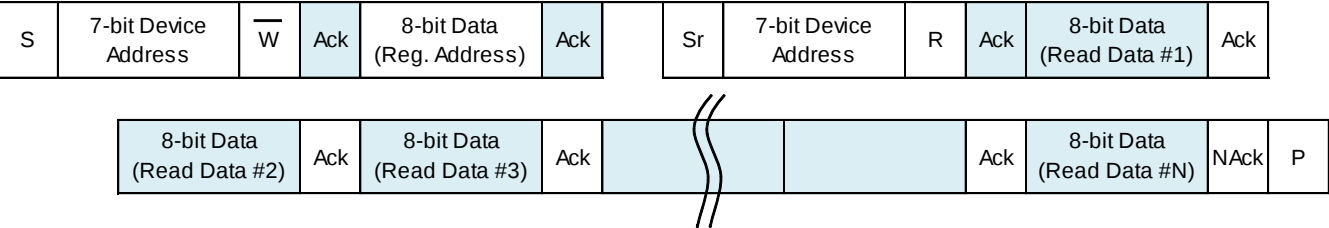


Figure 4-4. I2C Write / Read Operation

4.2. Interrupt  
4.2.1. Interrupt Overview

Table 4-4. Interrupt Event

| IRQ Event | Definition                               |
|-----------|------------------------------------------|
| PWRON     | PWRON_B Pin Level Changed                |
| PWRON_S   | PWRON_B Short Push Detection             |
| PWRON_L   | PWRON_B Long Push Detection              |
| WDOG      | WDOG_B Pin Level Changed                 |
| SWRST     | Written 1 to SWRESET in SWRESET Register |
| ON_REQ    | PMIC_ON_REQ Pin Level Changed            |
| STBY_REQ  | PMIC_STBY_REQ Pin Level Changed          |

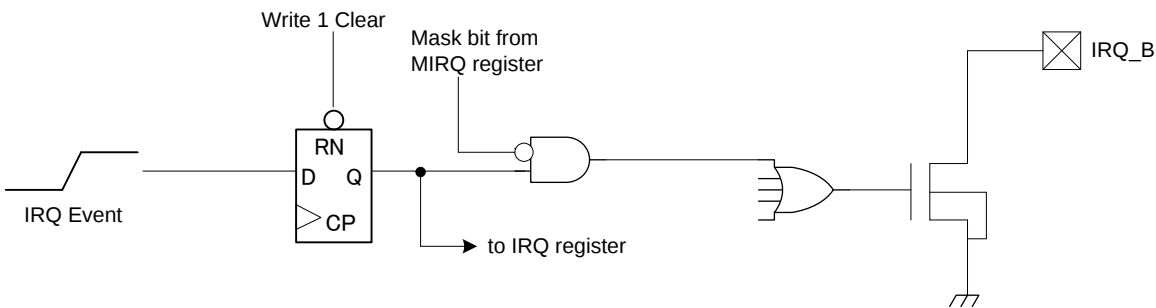


Figure 4-5. IRQ\_B Architecture Block Diagram

Table 4-5. IRQ\_B Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, VSYS=5.0 V, DVDD=3.3 V)

| Parameter                | Symbol                | Limit |     |            | Unit | Condition                  |
|--------------------------|-----------------------|-------|-----|------------|------|----------------------------|
|                          |                       | Min   | Typ | Max        |      |                            |
| Output "L" Level Voltage | V <sub>OL_IRQB</sub>  | -     | -   | DVDD x 0.2 | V    | I <sub>OL</sub> =3 mA Sink |
| Output Off Leak Current  | I <sub>OLK_IRQB</sub> | -1    | -   | +1         | µA   |                            |

## 4.2.1. Interrupt Overview – continued

Table 4-6. IRQ - Interrupt Register

| Register Name | R/W | D7 | D6    | D5      | D4      | D3    | D2   | D1     | D0       | Initial | Address |
|---------------|-----|----|-------|---------|---------|-------|------|--------|----------|---------|---------|
| IRQ           | R/W | -  | SWRST | PWRON_S | PWRON_L | PWRON | WDOG | ON_REQ | STBY_REQ | 0x00    | 0x2B    |

| Bit  | Name     | Function                                                                                                                                | Initial |
|------|----------|-----------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[6] | SWRST    | 0 = SWRESET in SWRESET register is not written 1<br>1 = SWRESET in SWRESET register is written 1<br>This bit is a write-1-to-clear bit. | 0       |
| D[5] | PWRON_S  | 0 = PWRON_B Short Push not detected<br>1 = PWRON_B Short Push detected<br>This bit is a write-1-to-clear bit.                           | 0       |
| D[4] | PWRON_L  | 0 = PWRON_B Long Push not detected<br>1 = PWRON_B Long Push detected<br>This bit is a write-1-to-clear bit.                             | 0       |
| D[3] | PWRON    | 0 = PWRON_B level change not generated<br>1 = PWRON_B level change generated<br>This bit is a write-1-to-clear bit.                     | 0       |
| D[2] | WDOG     | 0 = WDOG_B level change not generated<br>1 = WDOG_B level change generated<br>This bit is a write-1-to-clear bit.                       | 0       |
| D[1] | ON_REQ   | 0 = PMIC_ON_REQ level change not generated<br>1 = PMIC_ON_REQ level change generated<br>This bit is a write-1-to-clear bit.             | 0       |
| D[0] | STBY_REQ | 0 = PMIC_STBY_REQ level change not generated<br>1 = PMIC_STBY_REQ level change generated<br>This bit is a write-1-to-clear bit.         | 0       |

Table 4-7. MIRQ – IRQ Mask Register

| Register Name | R/W | D7 | D6     | D5       | D4       | D3     | D2    | D1      | D0        | Initial | Address |
|---------------|-----|----|--------|----------|----------|--------|-------|---------|-----------|---------|---------|
| MIRQ          | R/W | -  | MSWRST | MPWRON_S | MPWRON_L | MPWRON | MWDOG | MON_REQ | MSTBY_REQ | 0x7F    | 0x2A    |

| Bit  | Name      | Function                          | Initial |
|------|-----------|-----------------------------------|---------|
| D[6] | MSWRST    | 0 = No Mask<br>1 = Mask Interrupt | 1       |
| D[5] | MPWRON_S  | 0 = No Mask<br>1 = Mask Interrupt | 1       |
| D[4] | MPWRON_L  | 0 = No Mask<br>1 = Mask Interrupt | 1       |
| D[3] | MPWRON    | 0 = No Mask<br>1 = Mask Interrupt | 1       |
| D[2] | MWDOG     | 0 = No Mask<br>1 = Mask Interrupt | 1       |
| D[1] | MON_REQ   | 0 = No Mask<br>1 = Mask Interrupt | 1       |
| D[0] | MSTBY_REQ | 0 = No Mask<br>1 = Mask Interrupt | 1       |

## 4.2.1. Interrupt Overview – continued

Table 4-8. IN\_MON - Input Port Monitor Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3         | D2        | D1          | D0            | Initial | Address |
|---------------|-----|----|----|----|----|------------|-----------|-------------|---------------|---------|---------|
| IN_MON        | R   | -  | -  | -  | -  | STAT_PWRON | STAT_WDOG | STAT_ON_REQ | STAT_STBY_REQ | 0x00    | 0x2C    |

| Bit  | Name          | Function                                                     | Initial |
|------|---------------|--------------------------------------------------------------|---------|
| D[3] | STAT_PWRON    | 0 = PWRON_B level is 0<br>1 = PWRON_B level is 1             | 0       |
| D[2] | STAT_WDOG     | 0 = WDOG_B level is 0<br>1 = WDOG_B level is 1               | 0       |
| D[1] | STAT_ON_REQ   | 0 = PMIC_ON_REQ level is 0<br>1 = PMIC_ON_REQ level is 1     | 0       |
| D[0] | STAT_STBY_REQ | 0 = PMIC_STBY_REQ level is 0<br>1 = PMIC_STBY_REQ level is 1 | 0       |

## 5. Power Rails

## 5.1. Output Voltage Range

Table 5-1. Output Voltage Range1

| Data [Hex] | BUCK1            | BUCK2            | BUCK3            | BUCK4            | BUCK5            | BUCK6            | BUCK7            | BUCK8            | LDO1             | LDO2             | LDO3             | LDO4             | LDO5             | LDO6             | LDO7             |
|------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 00         | 0.70             | 0.70             | 0.70             | 0.70             | 0.70             | 3.00             | 1.605            | 0.80             | 3.00             | 0.90<br>(Note 1) | 1.80<br>(Note 1) | 0.90<br>(Note 1) | 1.80<br>(Note 1) | 0.90<br>(Note 1) | 1.80             |
| 01         | 0.71             | 0.71             | 0.71             | 0.71             | 0.80             | 3.10             | 1.695            | 0.81             | 3.10             |                  | 1.90             | 1.00             | 1.90             | 1.00             | 1.90             |
| 02         | 0.72             | 0.72             | 0.72             | 0.72             | 0.90             | 3.20             | 1.755            | 0.82             | 3.20             |                  | 2.00             | 1.10             | 2.00             | 1.10             | 2.00             |
| 03         | 0.73             | 0.73             | 0.73             | 0.73             | 1.00<br>(Note 1) | 3.30<br>(Note 1) | 1.80<br>(Note 1) | 0.83             | 3.30<br>(Note 1) |                  | 2.10             | 1.20             | 2.10             | 1.20             | 2.10             |
| 04         | 0.74             | 0.74             | 0.74             | 0.74             | 1.05             |                  | 1.845            | 0.84             |                  |                  | 2.20             | 1.30             | 2.20             | 1.30             | 2.20             |
| 05         | 0.75             | 0.75             | 0.75             | 0.75             | 1.10             |                  | 1.905            | 0.85             |                  |                  | 2.30             | 1.40             | 2.30             | 1.40             | 2.30             |
| 06         | 0.76             | 0.76             | 0.76             | 0.76             | 1.20             |                  | 1.950            | 0.86             |                  |                  | 2.40             | 1.50             | 2.40             | 1.50             | 2.40             |
| 07         | 0.77             | 0.77             | 0.77             | 0.77             | 1.35             |                  | 1.995            | 0.87             |                  |                  | 2.50             | 1.60             | 2.50             | 1.60             | 2.50             |
| 08         | 0.78             | 0.78             | 0.78             | 0.78             |                  |                  |                  | 0.88             |                  |                  | 2.60             | 1.70             | 2.60             | 1.70             | 2.60             |
| 09         | 0.79             | 0.79             | 0.79             | 0.79             |                  |                  |                  | 0.89             |                  |                  | 2.70             | 1.80             | 2.70             | 1.80             | 2.70             |
| 0A         | 0.80             | 0.80             | 0.80             | 0.80             |                  |                  |                  | 0.90             |                  |                  | 2.80             |                  | 2.80             |                  | 2.80             |
| 0B         | 0.81             | 0.81             | 0.81             | 0.81             |                  |                  |                  | 0.91             |                  |                  | 2.90             |                  | 2.90             |                  | 2.90             |
| 0C         | 0.82             | 0.82             | 0.82             | 0.82             |                  |                  |                  | 0.92             |                  |                  | 3.00             |                  | 3.00             |                  | 3.00             |
| 0D         | 0.83             | 0.83             | 0.83             | 0.83             |                  |                  |                  | 0.93             |                  |                  | 3.10             |                  | 3.10             |                  | 3.10             |
| 0E         | 0.84             | 0.84             | 0.84             | 0.84             |                  |                  |                  | 0.94             |                  |                  | 3.20             |                  | 3.20             |                  | 3.20             |
| 0F         | 0.85             | 0.85             | 0.85             | 0.85             |                  |                  |                  | 0.95             |                  |                  | 3.30             |                  | 3.30             |                  | 3.30<br>(Note 1) |
| 10         | 0.86             | 0.86             | 0.86             | 0.86             |                  |                  |                  | 0.96             |                  |                  |                  |                  |                  |                  |                  |
| 11         | 0.87             | 0.87             | 0.87             | 0.87             |                  |                  |                  | 0.97             |                  |                  |                  |                  |                  |                  |                  |
| 12         | 0.88             | 0.88             | 0.88             | 0.88             |                  |                  |                  | 0.98             |                  |                  |                  |                  |                  |                  |                  |
| 13         | 0.89             | 0.89             | 0.89             | 0.89             |                  |                  |                  | 0.99             |                  |                  |                  |                  |                  |                  |                  |
| 14         | 0.90<br>(Note 1) | 0.90             | 0.90             | 0.90             |                  |                  |                  | 1.00             |                  |                  |                  |                  |                  |                  |                  |
| 15         | 0.91             | 0.91             | 0.91             | 0.91             |                  |                  |                  | 1.01             |                  |                  |                  |                  |                  |                  |                  |
| 16         | 0.92             | 0.92             | 0.92             | 0.92             |                  |                  |                  | 1.02             |                  |                  |                  |                  |                  |                  |                  |
| 17         | 0.93             | 0.93             | 0.93             | 0.93             |                  |                  |                  | 1.03             |                  |                  |                  |                  |                  |                  |                  |
| 18         | 0.94             | 0.94             | 0.94             | 0.94             |                  |                  |                  | 1.04             |                  |                  |                  |                  |                  |                  |                  |
| 19         | 0.95             | 0.95             | 0.95             | 0.95             |                  |                  |                  | 1.05             |                  |                  |                  |                  |                  |                  |                  |
| 1A         | 0.96             | 0.96             | 0.96             | 0.96             |                  |                  |                  | 1.06             |                  |                  |                  |                  |                  |                  |                  |
| 1B         | 0.97             | 0.97             | 0.97             | 0.97             |                  |                  |                  | 1.07             |                  |                  |                  |                  |                  |                  |                  |
| 1C         | 0.98             | 0.98             | 0.98             | 0.98             |                  |                  |                  | 1.08             |                  |                  |                  |                  |                  |                  |                  |
| 1D         | 0.99             | 0.99             | 0.99             | 0.99             |                  |                  |                  | 1.09             |                  |                  |                  |                  |                  |                  |                  |
| 1E         | 1.00             | 1.00<br>(Note 1) | 1.00<br>(Note 1) | 1.00<br>(Note 1) |                  |                  |                  | 1.10<br>(Note 1) |                  |                  |                  |                  |                  |                  |                  |
| 1F         | 1.01             | 1.01             | 1.01             | 1.01             |                  |                  |                  | 1.11             |                  |                  |                  |                  |                  |                  |                  |

(Note 1) initial voltage(run mode)

## 5.1. Output Voltage Range – continued

Table 5-2. Output Voltage Range2

| Data [Hex] | BUCK1 | BUCK2 | BUCK3 | BUCK4 | BUCK5 | BUCK6 | BUCK7 | BUCK8 | LDO1 | LDO2 | LDO3 | LDO4 | LDO5 | LDO6 | LDO7 |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|
| 20         | 1.02  | 1.02  | 1.02  | 1.02  |       |       |       | 1.12  | 1.60 | 0.80 |      |      |      |      |      |
| 21         | 1.03  | 1.03  | 1.03  | 1.03  |       |       |       | 1.13  | 1.70 |      |      |      |      |      |      |
| 22         | 1.04  | 1.04  | 1.04  | 1.04  |       |       |       | 1.14  | 1.80 |      |      |      |      |      |      |
| 23         | 1.05  | 1.05  | 1.05  | 1.05  |       |       |       | 1.15  | 1.90 |      |      |      |      |      |      |
| 24         | 1.06  | 1.06  | 1.06  | 1.06  |       |       |       | 1.16  |      |      |      |      |      |      |      |
| 25         | 1.07  | 1.07  | 1.07  | 1.07  |       |       |       | 1.17  |      |      |      |      |      |      |      |
| 26         | 1.08  | 1.08  | 1.08  | 1.08  |       |       |       | 1.18  |      |      |      |      |      |      |      |
| 27         | 1.09  | 1.09  | 1.09  | 1.09  |       |       |       | 1.19  |      |      |      |      |      |      |      |
| 28         | 1.10  | 1.10  | 1.10  | 1.10  |       |       |       | 1.20  |      |      |      |      |      |      |      |
| 29         | 1.11  | 1.11  | 1.11  | 1.11  |       |       |       | 1.21  |      |      |      |      |      |      |      |
| 2A         | 1.12  | 1.12  | 1.12  | 1.12  |       |       |       | 1.22  |      |      |      |      |      |      |      |
| 2B         | 1.13  | 1.13  | 1.13  | 1.13  |       |       |       | 1.23  |      |      |      |      |      |      |      |
| 2C         | 1.14  | 1.14  | 1.14  | 1.14  |       |       |       | 1.24  |      |      |      |      |      |      |      |
| 2D         | 1.15  | 1.15  | 1.15  | 1.15  |       |       |       | 1.25  |      |      |      |      |      |      |      |
| 2E         | 1.16  | 1.16  | 1.16  | 1.16  |       |       |       | 1.26  |      |      |      |      |      |      |      |
| 2F         | 1.17  | 1.17  | 1.17  | 1.17  |       |       |       | 1.27  |      |      |      |      |      |      |      |
| 30         | 1.18  | 1.18  | 1.18  | 1.18  |       |       |       | 1.28  |      |      |      |      |      |      |      |
| 31         | 1.19  | 1.19  | 1.19  | 1.19  |       |       |       | 1.29  |      |      |      |      |      |      |      |
| 32         | 1.20  | 1.20  | 1.20  | 1.20  |       |       |       | 1.30  |      |      |      |      |      |      |      |
| 33         | 1.21  | 1.21  | 1.21  | 1.21  |       |       |       | 1.31  |      |      |      |      |      |      |      |
| 34         | 1.22  | 1.22  | 1.22  | 1.22  |       |       |       | 1.32  |      |      |      |      |      |      |      |
| 35         | 1.23  | 1.23  | 1.23  | 1.23  |       |       |       | 1.33  |      |      |      |      |      |      |      |
| 36         | 1.24  | 1.24  | 1.24  | 1.24  |       |       |       | 1.34  |      |      |      |      |      |      |      |
| 37         | 1.25  | 1.25  | 1.25  | 1.25  |       |       |       | 1.35  |      |      |      |      |      |      |      |
| 38         | 1.26  | 1.26  | 1.26  | 1.26  |       |       |       | 1.36  |      |      |      |      |      |      |      |
| 39         | 1.27  | 1.27  | 1.27  | 1.27  |       |       |       | 1.37  |      |      |      |      |      |      |      |
| 3A         | 1.28  | 1.28  | 1.28  | 1.28  |       |       |       | 1.38  |      |      |      |      |      |      |      |
| 3B         | 1.29  | 1.29  | 1.29  | 1.29  |       |       |       | 1.39  |      |      |      |      |      |      |      |
| 3C         | 1.30  | 1.30  | 1.30  | 1.30  |       |       |       | 1.40  |      |      |      |      |      |      |      |
| 3D         | 1.30  | 1.30  | 1.30  | 1.30  |       |       |       | 1.40  |      |      |      |      |      |      |      |
| 3E         | 1.30  | 1.30  | 1.30  | 1.30  |       |       |       | 1.40  |      |      |      |      |      |      |      |
| 3F         | 1.30  | 1.30  | 1.30  | 1.30  |       |       |       | 1.40  |      |      |      |      |      |      |      |

5.2. Details of Buck

5.2.1. BUCK1

5.2.1.1. BUCK1 Block Diagram

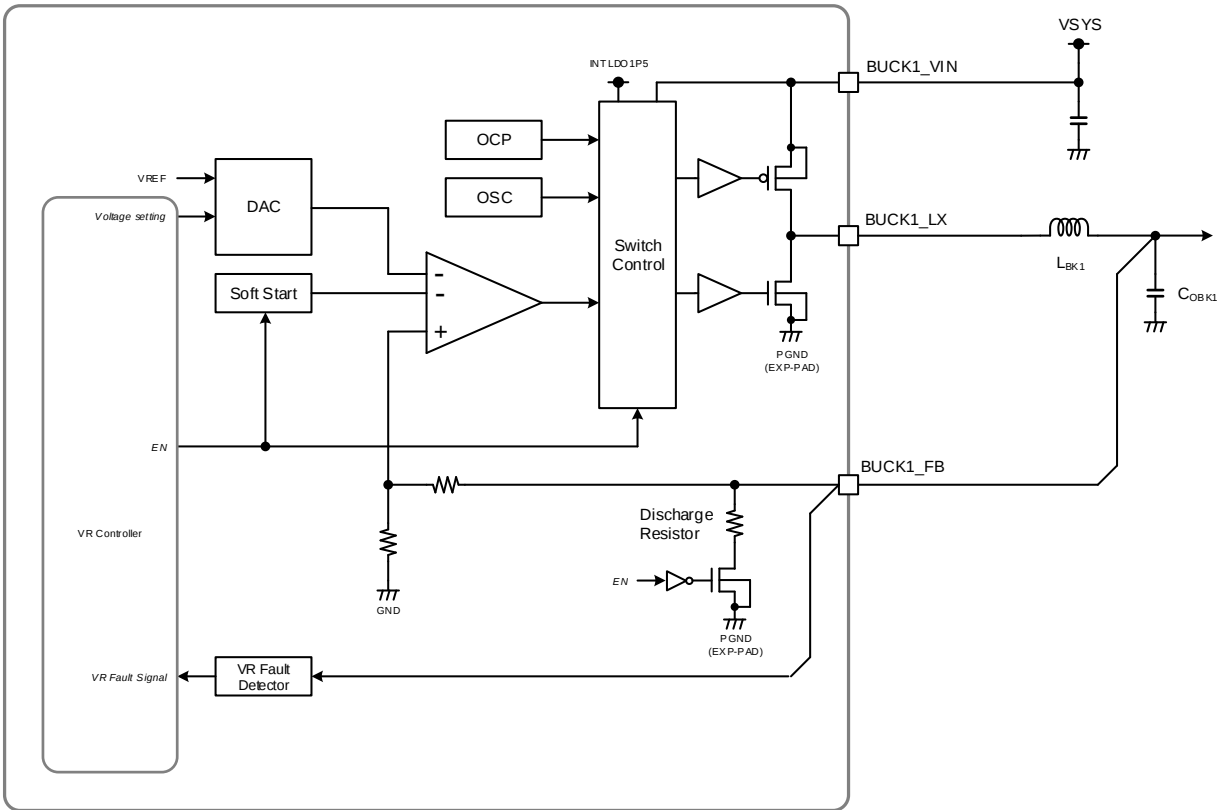


Figure 5-1. BUCK1 Block Diagram

## 5.2.1.2. BUCK1 Electrical Characteristics

Table 5-3. BUCK1 Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, V<sub>SY</sub>=5.0 V)

| Parameter                            | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                                                                                      |
|--------------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                      |                          | Min   | Typ   | Max   |      |                                                                                                                                                                                                |
| Output Voltage                       | V <sub>O_BK1</sub>       | 0.891 | 0.900 | 0.909 | V    | V <sub>O</sub> = 0.9 V<br>I <sub>O</sub> = 200 mA, PWM fix Mode                                                                                                                                |
| Programmable Output Voltage Range    | V <sub>ORG_BK1</sub>     | 0.7   | -     | 1.3   | V    | 10 mV step                                                                                                                                                                                     |
| Quiescent Current                    | I <sub>O_BK1</sub>       | -     | 15    | -     | μA   | V <sub>O</sub> = 0.9 V<br>I <sub>O</sub> = 0 mA, Auto mode                                                                                                                                     |
| Maximum Output Current               | I <sub>OMAX_BK1</sub>    | 3600  | -     | -     | mA   |                                                                                                                                                                                                |
| Over Current Protection              | I <sub>OC_P_BK1</sub>    | 5000  | -     | -     | mA   | Peak current of inductor <sup>(Note 1)</sup>                                                                                                                                                   |
| DC Output Voltage Load Regulation    | ΔV <sub>LDR_BK1</sub>    | -1    | 0     | +1    | %    | I <sub>O</sub> = 1 mA to I <sub>Omax</sub> , PWM fix Mode                                                                                                                                      |
| Efficiency                           | η <sub>BK1_1mA</sub>     | -     | 80    | -     | %    | I <sub>O</sub> = 1 mA, V <sub>O</sub> = 0.9 V                                                                                                                                                  |
|                                      | η <sub>BK1_500mA</sub>   | -     | 85    | -     | %    | I <sub>O</sub> = 500 mA, V <sub>O</sub> = 0.9 V                                                                                                                                                |
|                                      | η <sub>BK1_max</sub>     | -     | 72    | -     | %    | I <sub>O</sub> = I <sub>Omax</sub> , V <sub>O</sub> = 0.9 V                                                                                                                                    |
| Oscillating Frequency                | f <sub>SW_BK1</sub>      | -     | 2     | -     | MHz  | PWM fix mode, I <sub>O</sub> = 0 mA                                                                                                                                                            |
| Start up Time                        | t <sub>ST_BK1</sub>      | -     | 160   | 500   | μs   | During EN to 90% of nominal Voltage,<br>BUCK1_RAMPRATE_RUN[1:0] = 01                                                                                                                           |
| Discharge Resistance                 | R <sub>D_BK1</sub>       | -     | 100   | -     | Ω    |                                                                                                                                                                                                |
| Low Side VR Fault Detect Level       | D <sub>VRFBK1_L</sub>    | -     | 80    | -     | %    | V <sub>O</sub> = 0.9 V (FB = Sweep down)<br>VR fault detect level / V <sub>O</sub> x 100                                                                                                       |
| Low Side VR Fault Detect Hysteresis  | D <sub>VRFBK1_LHYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                                                                                                 |
| High Side VR Fault Detect Level      | D <sub>VRBK1_H</sub>     | -     | 130   | -     | %    | V <sub>O</sub> = 0.9 V (FB = Sweep up)<br>Power good detect level / V <sub>O</sub> x 100                                                                                                       |
| High Side VR Fault Detect Hysteresis | D <sub>VRFBK1_HHYS</sub> | -     | 20    | -     | %    | (VR fault detect level - release level) / V <sub>O</sub> x 100                                                                                                                                 |
| Output Inductance                    | L <sub>BK1</sub>         | -     | 0.47  | -     | μH   | (Note 2)                                                                                                                                                                                       |
| Output Capacitance                   | C <sub>OBK1</sub>        | 22    | 44    | 100   | μF   | (Note 2)<br>Effective capacitance with BUCK's DC bias<br>Max value is limited by ramp rate.<br><Output Max Capacitance><br>ramp rate 1.25 mV, 2.5 mV, 5 mV : 100 μF<br>ramp rate 10 mV : 50 μF |

(Note 1) For Buck- DCDC converters, (minimum Over Current Protection Current – ½ inductor ripple current) is the maximum output current.

(Note 2) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.2.1.3. BUCK1 Control

Table 5-4. BUCK1\_CTRL - BUCK1 Control Register

| Register Name | R/W | D7                      | D6 | D5 | D4 | D3            | D2 | D1        | D0       | Initial | Address |
|---------------|-----|-------------------------|----|----|----|---------------|----|-----------|----------|---------|---------|
| BUCK1_CTRL    | R/W | BUCK1_RAMPRATE<br>[1:0] |    | -  | -  | BUCK1_PWM_FIX | -  | BUCK1_SEL | BUCK1_EN | 0x40    | 0x05    |

| Bit    | Name                | Function                                                                                                                                                                                                                                                                               | Initial |
|--------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7:6] | BUCK1_RAMPRATE[1:0] | BUCK1 DVS ramp rate<br>00 = 10 mV/μs<br>01 = 5 mV/μs<br>10 = 2.5 mV/μs<br>11 = 1.25 mV/μs<br>Note : When BUCK1 voltage starts up from 0V,<br>the ramp rate is fixed 5mV/μs, regardless of the value of<br>BUCK1_RAMPRATE[1:0].                                                         | 01      |
| D[3]   | BUCK1_PWM_FIX       | 0 – AUTO PWM/PFM mode<br>VR adjusts the operating mode (PFM/PWM) automatically based on the load<br>current to maximize power efficiency.<br>1 – Forced PWM Mode<br>VR operates in PWM mode only.                                                                                      | 0       |
| D[1]   | BUCK1_SEL           | BUCK1 control select bit<br>0 = BUCK1 ON/OFF is controlled by state machine.<br>1 = BUCK1 ON/OFF is controlled by D[0] on this register.                                                                                                                                               | 0       |
| D[0]   | BUCK1_EN            | BUCK1 control bit with condition of D[1]<br>0 = BUCK1 OFF<br>1 = BUCK1 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency<br>shutdown.<br>When system is in SNVS, BUCK1_SEL = 1 and BUCK1_EN = 1, BUCK1<br>voltage is specified by BUCK1_VOLT_SUSP register. | 0       |

Table 5-5. BUCK1\_VOLT\_RUN - BUCK1 Voltage (RUN) Register

| Register Name  | R/W | D7 | D6 | D5                  | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|----------------|-----|----|----|---------------------|----|----|----|----|----|---------|---------|
| BUCK1_VOLT_RUN | R/W | -  | -  | BUCK1_VOLT_RUN[5:0] |    |    |    |    |    | 0x14    | 0x0D    |

| Bit    | Name                | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Initial |
|--------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[5:0] | BUCK1_VOLT_RUN[5:0] | BUCK1 voltage when Power State = RUN<br>0x00 = 0.70 V    0x01 = 0.71 V    0x02 = 0.72 V    0x03 = 0.73 V<br>0x04 = 0.74 V    0x05 = 0.75 V    0x06 = 0.76 V    0x07 = 0.77 V<br>0x08 = 0.78 V    0x09 = 0.79 V    0x0A = 0.80 V    0x0B = 0.81 V<br>0x0C = 0.82 V    0x0D = 0.83 V    0x0E = 0.84 V    0x0F = 0.85 V<br>0x10 = 0.86 V    0x11 = 0.87 V    0x12 = 0.88 V    0x13 = 0.89 V<br>0x14 = 0.90 V (initial)<br>0x15 = 0.91 V    0x16 = 0.92 V    0x17 = 0.93 V    0x18 = 0.94 V<br>0x19 = 0.95 V    0x1A = 0.96 V    0x1B = 0.97 V    0x1C = 0.98 V<br>0x1D = 0.99 V    0x1E = 1.00 V    0x1F = 1.01 V    0x20 = 1.02 V<br>0x21 = 1.03 V    0x22 = 1.04 V    0x23 = 1.05 V    0x24 = 1.06 V<br>0x25 = 1.07 V    0x26 = 1.08 V    0x27 = 1.09 V    0x28 = 1.10 V<br>0x29 = 1.11 V    0x2A = 1.12 V    0x2B = 1.13 V    0x2C = 1.14 V<br>0x2D = 1.15 V    0x2E = 1.16 V    0x2F = 1.17 V    0x30 = 1.18 V<br>0x31 = 1.19 V    0x32 = 1.20 V    0x33 = 1.21 V    0x34 = 1.22 V<br>0x35 = 1.23 V    0x36 = 1.24 V    0x37 = 1.25 V    0x38 = 1.26 V<br>0x39 = 1.27 V    0x3A = 1.28 V    0x3B = 1.29 V    0x3C = 1.30 V<br>0x3D = 1.30 V    0x3E = 1.30 V    0x3F = 1.30 V | 010100  |

## 5.2.1.3. BUCK1 Control – continued

Table 5-6. BUCK1\_VOLT\_IDLE - BUCK1 Voltage (IDLE) Register

| Register Name   | R/W | D7 | D6 | D5                   | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|-----------------|-----|----|----|----------------------|----|----|----|----|----|---------|---------|
| BUCK1_VOLT_IDLE | R/W | -  | -  | BUCK1_VOLT_IDLE[5:0] |    |    |    |    |    | 0x14    | 0x0E    |

| Bit    | Name                 | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Initial |
|--------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[5:0] | BUCK1_VOLT_IDLE[5:0] | BUCK1 voltage when Power State = IDLE<br>0x00 = 0.70 V    0x01 = 0.71 V    0x02 = 0.72 V    0x03 = 0.73 V<br>0x04 = 0.74 V    0x05 = 0.75 V    0x06 = 0.76 V    0x07 = 0.77 V<br>0x08 = 0.78 V    0x09 = 0.79 V    0x0A = 0.80 V    0x0B = 0.81 V<br>0x0C = 0.82 V    0x0D = 0.83 V    0x0E = 0.84 V    0x0F = 0.85 V<br>0x10 = 0.86 V    0x11 = 0.87 V    0x12 = 0.88 V    0x13 = 0.89 V<br>0x14 = 0.90 V (initial)<br>0x15 = 0.91 V    0x16 = 0.92 V    0x17 = 0.93 V    0x18 = 0.94 V<br>0x19 = 0.95 V    0x1A = 0.96 V    0x1B = 0.97 V    0x1C = 0.98 V<br>0x1D = 0.99 V    0x1E = 1.00 V    0x1F = 1.01 V    0x20 = 1.02 V<br>0x21 = 1.03 V    0x22 = 1.04 V    0x23 = 1.05 V    0x24 = 1.06 V<br>0x25 = 1.07 V    0x26 = 1.08 V    0x27 = 1.09 V    0x28 = 1.10 V<br>0x29 = 1.11 V    0x2A = 1.12 V    0x2B = 1.13 V    0x2C = 1.14 V<br>0x2D = 1.15 V    0x2E = 1.16 V    0x2F = 1.17 V    0x30 = 1.18 V<br>0x31 = 1.19 V    0x32 = 1.20 V    0x33 = 1.21 V    0x34 = 1.22 V<br>0x35 = 1.23 V    0x36 = 1.24 V    0x37 = 1.25 V    0x38 = 1.26 V<br>0x39 = 1.27 V    0x3A = 1.28 V    0x3B = 1.29 V    0x3C = 1.30 V<br>0x3D = 1.30 V    0x3E = 1.30 V    0x3F = 1.30 V | 010100  |

Table 5-7. BUCK1\_VOLT\_SUSP - BUCK1 Voltage (SUSPEND) Register

| Register Name   | R/W | D7 | D6 | D5                   | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|-----------------|-----|----|----|----------------------|----|----|----|----|----|---------|---------|
| BUCK1_VOLT_SUSP | R/W | -  | -  | BUCK1_VOLT_SUSP[5:0] |    |    |    |    |    | 0x14    | 0x0F    |

| Bit    | Name                 | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Initial |
|--------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[5:0] | BUCK1_VOLT_SUSP[5:0] | BUCK1 voltage when Power State = SUSPEND<br>0x00 = 0.70 V    0x01 = 0.71 V    0x02 = 0.72 V    0x03 = 0.73 V<br>0x04 = 0.74 V    0x05 = 0.75 V    0x06 = 0.76 V    0x07 = 0.77 V<br>0x08 = 0.78 V    0x09 = 0.79 V    0x0A = 0.80 V    0x0B = 0.81 V<br>0x0C = 0.82 V    0x0D = 0.83 V    0x0E = 0.84 V    0x0F = 0.85 V<br>0x10 = 0.86 V    0x11 = 0.87 V    0x12 = 0.88 V    0x13 = 0.89 V<br>0x14 = 0.90 V (initial)<br>0x15 = 0.91 V    0x16 = 0.92 V    0x17 = 0.93 V    0x18 = 0.94 V<br>0x19 = 0.95 V    0x1A = 0.96 V    0x1B = 0.97 V    0x1C = 0.98 V<br>0x1D = 0.99 V    0x1E = 1.00 V    0x1F = 1.01 V    0x20 = 1.02 V<br>0x21 = 1.03 V    0x22 = 1.04 V    0x23 = 1.05 V    0x24 = 1.06 V<br>0x25 = 1.07 V    0x26 = 1.08 V    0x27 = 1.09 V    0x28 = 1.10 V<br>0x29 = 1.11 V    0x2A = 1.12 V    0x2B = 1.13 V    0x2C = 1.14 V<br>0x2D = 1.15 V    0x2E = 1.16 V    0x2F = 1.17 V    0x30 = 1.18 V<br>0x31 = 1.19 V    0x32 = 1.20 V    0x33 = 1.21 V    0x34 = 1.22 V<br>0x35 = 1.23 V    0x36 = 1.24 V    0x37 = 1.25 V    0x38 = 1.26 V<br>0x39 = 1.27 V    0x3A = 1.28 V    0x3B = 1.29 V    0x3C = 1.30 V<br>0x3D = 1.30 V    0x3E = 1.30 V    0x3F = 1.30 V | 010100  |

5.2.2. BUCK2  
5.2.2.1. BUCK2 Block Diagram

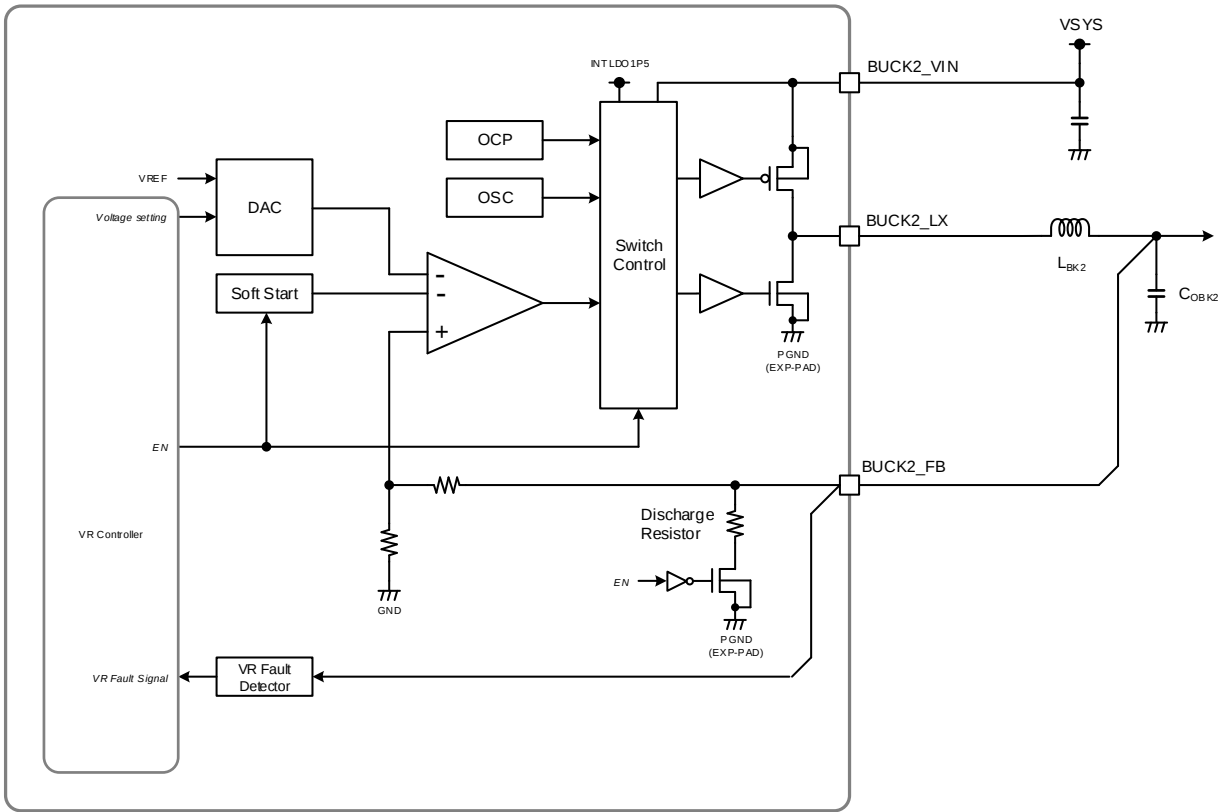


Figure 5-2. BUCK2 Block Diagram

## 5.2.2.2. BUCK2 Electrical Characteristics

Table 5-8. BUCK2 Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, V<sub>SY</sub>=5.0 V)

| Parameter                            | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                                                                                      |
|--------------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                      |                          | Min   | Typ   | Max   |      |                                                                                                                                                                                                |
| Output Voltage                       | V <sub>O_BK2</sub>       | 0.990 | 1.000 | 1.010 | V    | V <sub>O</sub> = 1.0 V<br>I <sub>O</sub> = 200 mA, PWM fix Mode                                                                                                                                |
| Programmable Output Voltage Range    | V <sub>ORG_BK2</sub>     | 0.7   | -     | 1.3   | V    | 10 mV step                                                                                                                                                                                     |
| Quiescent Current                    | I <sub>Q_BK2</sub>       | -     | 15    | -     | μA   | V <sub>O</sub> = 1.0 V<br>I <sub>O</sub> = 0 mA, Auto mode                                                                                                                                     |
| Maximum Output Current               | I <sub>OMAX_BK2</sub>    | 4000  | -     | -     | mA   |                                                                                                                                                                                                |
| Over Current Protection              | I <sub>OC_P_BK2</sub>    | 5500  | -     | -     | mA   | Peak current of inductor <sup>(Note 1)</sup>                                                                                                                                                   |
| DC Output Voltage Load Regulation    | ΔV <sub>LDR_BK2</sub>    | -1    | 0     | +1    | %    | I <sub>O</sub> = 1 mA to I <sub>Omax</sub> , PWM fix Mode                                                                                                                                      |
| Efficiency                           | η <sub>BK2_1mA</sub>     | -     | 80    | -     | %    | I <sub>O</sub> = 1 mA, V <sub>O</sub> = 1.0 V                                                                                                                                                  |
|                                      | η <sub>BK2_500mA</sub>   | -     | 86    | -     | %    | I <sub>O</sub> = 500 mA, V <sub>O</sub> = 1.0 V                                                                                                                                                |
|                                      | η <sub>BK2_max</sub>     | -     | 72    | -     | %    | I <sub>O</sub> = I <sub>Omax</sub> , V <sub>O</sub> = 1.0 V                                                                                                                                    |
| Oscillating Frequency                | f <sub>SW_BK2</sub>      | -     | 2     | -     | MHz  | PWM fix mode, I <sub>O</sub> = 0 mA                                                                                                                                                            |
| Start up Time                        | t <sub>ST_BK2</sub>      | -     | 180   | 500   | μs   | During EN to 90% of nominal Voltage,<br>BUCK2_RAMPRATE_RUN[1:0] = 01                                                                                                                           |
| Discharge Resistance                 | R <sub>D_BK2</sub>       | -     | 100   | -     | Ω    |                                                                                                                                                                                                |
| Low Side VR Fault Detect Level       | D <sub>VRFBK2_L</sub>    | -     | 80    | -     | %    | V <sub>O</sub> = 1.0 V (FB = Sweep down)<br>VR fault detect level / V <sub>O</sub> x 100                                                                                                       |
| Low Side VR Fault Detect Hysteresis  | D <sub>VRFBK2_LHYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                                                                                                 |
| High Side VR Fault Detect Level      | D <sub>VRBK2_H</sub>     | -     | 130   | -     | %    | V <sub>O</sub> = 1.0 V (FB = Sweep up)<br>Power good detect level / V <sub>O</sub> x 100                                                                                                       |
| High Side VR Fault Detect Hysteresis | D <sub>VRFBK2_HHYS</sub> | -     | 20    | -     | %    | (VR fault detect level - release level) / V <sub>O</sub> x 100                                                                                                                                 |
| Output Inductance                    | L <sub>BK2</sub>         | -     | 0.47  | -     | μH   | (Note 2)                                                                                                                                                                                       |
| Output Capacitance                   | C <sub>OBK2</sub>        | 22    | 44    | 100   | μF   | (Note 2)<br>Effective capacitance with BUCK's DC bias<br>Max value is limited by ramp rate.<br><Output Max Capacitance><br>ramp rate 1.25 mV, 2.5 mV, 5 mV : 100 μF<br>ramp rate 10 mV : 50 μF |

(Note 1) For Buck- DCDC converters, (minimum Over Current Protection Current – ½ inductor ripple current) is the maximum output current.

(Note 2) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.2.2.3. BUCK2 Control

Table 5-9. BUCK2\_CTRL - BUCK2 Control Register

| Register Name | R/W | D7                  | D6 | D5 | D4 | D3            | D2 | D1        | D0       | Initial | Address |
|---------------|-----|---------------------|----|----|----|---------------|----|-----------|----------|---------|---------|
| BUCK2_CTRL    | R/W | BUCK2_RAMPRATE[1:0] |    | -  | -  | BUCK2_PWM_FIX | -  | BUCK2_SEL | BUCK2_EN | 0x40    | 0x06    |

| Bit    | Name                | Function                                                                                                                                                                                                                                                                                          | Initial |
|--------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7:6] | BUCK2_RAMPRATE[1:0] | BUCK2 DVS ramp rate<br>00 = 10 mV/μs<br>01 = 5 mV/μs<br>10 = 2.5 mV/μs<br>11 = 1.25 mV/μs<br>Note : When BUCK2 voltage starts up from 0V,<br>the ramp rate is fixed 5mV/μs, regardless of the value of<br>BUCK2_RAMPRATE[1:0].                                                                    | 01      |
| D[3]   | BUCK2_PWM_FIX       | 0 – AUTO PWM/PFM mode<br>VR adjusts the operating mode (PFM/PWM) automatically based on the load<br>current to maximize power efficiency.<br>1 – Forced PWM Mode<br>VR operates in PWM mode only.                                                                                                 | 0       |
| D[1]   | BUCK2_SEL           | BUCK2 control select bit<br>0 = BUCK2 ON/OFF is controlled by state machine.<br>1 = BUCK2 ON/OFF is controlled by D[0] on this register.                                                                                                                                                          | 0       |
| D[0]   | BUCK2_EN            | BUCK2 control bit with condition of D[1]<br>0 = BUCK2 OFF<br>1 = BUCK2 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency<br>shutdown.<br>When system is in SNVS or SUSPEND, BUCK2_SEL = 1 and BUCK2_EN = 1,<br>BUCK2 voltage is specified by BUCK2_VOLT_IDLE register. | 0       |

Table 5-10. BUCK2\_VOLT\_RUN - BUCK2 Voltage (RUN) Register

| Register Name  | R/W | D7 | D6 | D5                  | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|----------------|-----|----|----|---------------------|----|----|----|----|----|---------|---------|
| BUCK2_VOLT_RUN | R/W | -  | -  | BUCK2_VOLT_RUN[5:0] |    |    |    |    |    | 0x1E    | 0x10    |

| Bit    | Name                | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Initial |
|--------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[5:0] | BUCK2_VOLT_RUN[5:0] | BUCK2 voltage when Power State = RUN<br>0x00 = 0.70 V    0x01 = 0.71 V    0x02 = 0.72 V    0x03 = 0.73 V<br>0x04 = 0.74 V    0x05 = 0.75 V    0x06 = 0.76 V    0x07 = 0.77 V<br>0x08 = 0.78 V    0x09 = 0.79 V    0x0A = 0.80 V    0x0B = 0.81 V<br>0x0C = 0.82 V    0x0D = 0.83 V    0x0E = 0.84 V    0x0F = 0.85 V<br>0x10 = 0.86 V    0x11 = 0.87 V    0x12 = 0.88 V    0x13 = 0.89 V<br>0x14 = 0.90 V    0x15 = 0.91 V    0x16 = 0.92 V    0x17 = 0.93 V<br>0x18 = 0.94 V    0x19 = 0.95 V    0x1A = 0.96 V    0x1B = 0.97 V<br>0x1C = 0.98 V    0x1D = 0.99 V<br>0x1E = 1.00 V (initial)<br>0x1F = 1.01 V    0x20 = 1.02 V    0x21 = 1.03 V    0x22 = 1.04 V<br>0x23 = 1.05 V    0x24 = 1.06 V    0x25 = 1.07 V    0x26 = 1.08 V<br>0x27 = 1.09 V    0x28 = 1.10 V    0x29 = 1.11 V    0x2A = 1.12 V<br>0x2B = 1.13 V    0x2C = 1.14 V    0x2D = 1.15 V    0x2E = 1.16 V<br>0x2F = 1.17 V    0x30 = 1.18 V    0x31 = 1.19 V    0x32 = 1.20 V<br>0x33 = 1.21 V    0x34 = 1.22 V    0x35 = 1.23 V    0x36 = 1.24 V<br>0x37 = 1.25 V    0x38 = 1.26 V    0x39 = 1.27 V    0x3A = 1.28 V<br>0x3B = 1.29 V    0x3C = 1.30 V    0x3D = 1.30 V    0x3E = 1.30 V<br>0x3F = 1.30 V | 011110  |

## 5.2.2.3. BUCK2 Control – continued

Table 5-11. BUCK2\_VOLT\_IDLE - BUCK2 Voltage (IDLE) Register

| Register Name   | R/W | D7 | D6 | D5                   | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|-----------------|-----|----|----|----------------------|----|----|----|----|----|---------|---------|
| BUCK2_VOLT_IDLE | R/W | -  | -  | BUCK2_VOLT_IDLE[5:0] |    |    |    |    |    | 0x14    | 0x11    |

| Bit    | Name                 | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Initial |
|--------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[5:0] | BUCK2_VOLT_IDLE[5:0] | BUCK2 voltage when Power State = IDLE<br>0x00 = 0.70 V    0x01 = 0.71 V    0x02 = 0.72 V    0x03 = 0.73 V<br>0x04 = 0.74 V    0x05 = 0.75 V    0x06 = 0.76 V    0x07 = 0.77 V<br>0x08 = 0.78 V    0x09 = 0.79 V    0x0A = 0.80 V    0x0B = 0.81 V<br>0x0C = 0.82 V    0x0D = 0.83 V    0x0E = 0.84 V    0x0F = 0.85 V<br>0x10 = 0.86 V    0x11 = 0.87 V    0x12 = 0.88 V    0x13 = 0.89 V<br>0x14 = 0.90 V (initial)<br>0x15 = 0.91 V    0x16 = 0.92 V    0x17 = 0.93 V    0x18 = 0.94 V<br>0x19 = 0.95 V    0x1A = 0.96 V    0x1B = 0.97 V    0x1C = 0.98 V<br>0x1D = 0.99 V    0x1E = 1.00 V    0x1F = 1.01 V    0x20 = 1.02 V<br>0x21 = 1.03 V    0x22 = 1.04 V    0x23 = 1.05 V    0x24 = 1.06 V<br>0x25 = 1.07 V    0x26 = 1.08 V    0x27 = 1.09 V    0x28 = 1.10 V<br>0x29 = 1.11 V    0x2A = 1.12 V    0x2B = 1.13 V    0x2C = 1.14 V<br>0x2D = 1.15 V    0x2E = 1.16 V    0x2F = 1.17 V    0x30 = 1.18 V<br>0x31 = 1.19 V    0x32 = 1.20 V    0x33 = 1.21 V    0x34 = 1.22 V<br>0x35 = 1.23 V    0x36 = 1.24 V    0x37 = 1.25 V    0x38 = 1.26 V<br>0x39 = 1.27 V    0x3A = 1.28 V    0x3B = 1.29 V    0x3C = 1.30 V<br>0x3D = 1.30 V    0x3E = 1.30 V    0x3F = 1.30 V | 010100  |

5.2.3. BUCK3  
5.2.3.1. BUCK3 Block Diagram

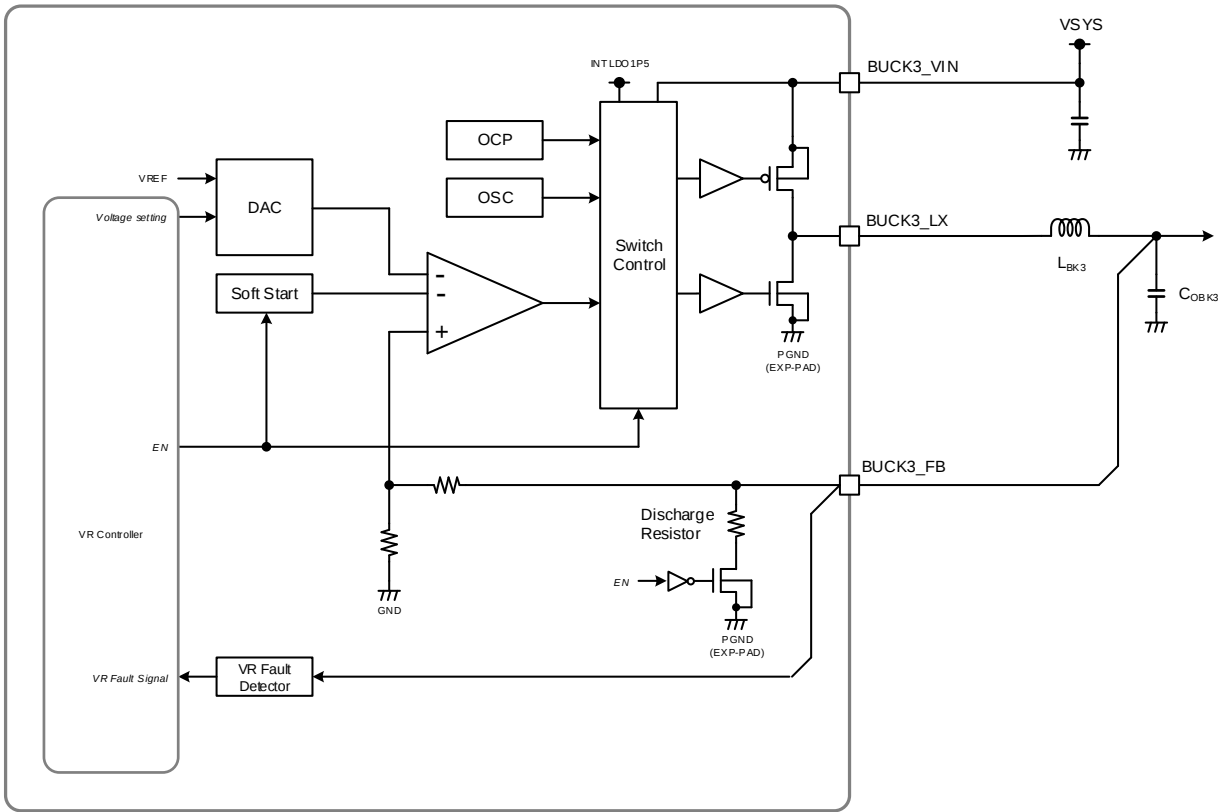


Figure 5-3. BUCK3 Block Diagram

## 5.2.3.2. BUCK3 Electrical Characteristics

Table 5-12. BUCK3 Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, VSYS=5.0 V)

| Parameter                            | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                                                                                      |
|--------------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                      |                          | Min   | Typ   | Max   |      |                                                                                                                                                                                                |
| Output Voltage                       | V <sub>O_BK3</sub>       | 0.990 | 1.000 | 1.010 | V    | V <sub>O</sub> = 1.0 V<br>I <sub>O</sub> = 200 mA, PWM fix Mode                                                                                                                                |
| Programmable Output Voltage Range    | V <sub>ORG_BK3</sub>     | 0.7   | -     | 1.3   | V    | 10 mV step                                                                                                                                                                                     |
| Quiescent Current                    | I <sub>O_BK3</sub>       | -     | 15    | -     | μA   | V <sub>O</sub> = 1.0 V<br>I <sub>O</sub> = 0 mA, Auto mode                                                                                                                                     |
| Maximum Output Current               | I <sub>OMAX_BK3</sub>    | 2100  | -     | -     | mA   |                                                                                                                                                                                                |
| Over Current Protection              | I <sub>OCP_BK3</sub>     | 3150  | -     | -     | mA   | Peak current of inductor <sup>(Note 1)</sup>                                                                                                                                                   |
| DC Output Voltage Load Regulation    | ΔV <sub>LDR_BK3</sub>    | -1    | 0     | +1    | %    | I <sub>O</sub> = 1 mA to I <sub>Omax</sub> , PWM fix Mode                                                                                                                                      |
| Efficiency                           | η <sub>BK3_1mA</sub>     | -     | 80    | -     | %    | I <sub>O</sub> = 1 mA, V <sub>O</sub> = 1.0 V                                                                                                                                                  |
|                                      | η <sub>BK3_500mA</sub>   | -     | 85    | -     | %    | I <sub>O</sub> = 500 mA, V <sub>O</sub> = 1.0 V                                                                                                                                                |
|                                      | η <sub>BK3_max</sub>     | -     | 79    | -     | %    | I <sub>O</sub> = I <sub>Omax</sub> , V <sub>O</sub> = 1.0 V                                                                                                                                    |
| Oscillating Frequency                | f <sub>SW_BK3</sub>      | -     | 2     | -     | MHz  | PWM fix mode, I <sub>O</sub> = 0 mA                                                                                                                                                            |
| Start up Time                        | t <sub>ST_BK3</sub>      | -     | 180   | 500   | μs   | During EN to 90% of nominal Voltage,<br>BUCK3_RAMPRATE_RUN[1:0] = 01                                                                                                                           |
| Discharge Resistance                 | R <sub>D_BK3</sub>       | -     | 100   | -     | Ω    |                                                                                                                                                                                                |
| Low Side VR Fault Detect Level       | D <sub>VRFBK3_L</sub>    | -     | 80    | -     | %    | V <sub>O</sub> = 1.0 V (FB = Sweep down)<br>VR fault detect level / V <sub>O</sub> x 100                                                                                                       |
| Low Side VR Fault Detect Hysteresis  | D <sub>VRFBK3_LHYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                                                                                                 |
| High Side VR Fault Detect Level      | D <sub>VRBK3_H</sub>     | -     | 130   | -     | %    | V <sub>O</sub> = 1.0 V (FB = Sweep up)<br>Power good detect level / V <sub>O</sub> x 100                                                                                                       |
| High Side VR Fault Detect Hysteresis | D <sub>VRFBK3_HHYS</sub> | -     | 20    | -     | %    | (VR fault detect level - release level) / V <sub>O</sub> x 100                                                                                                                                 |
| Output Inductance                    | L <sub>BK3</sub>         | -     | 0.47  | -     | μH   | (Note 2)                                                                                                                                                                                       |
| Output Capacitance                   | C <sub>OBK3</sub>        | 11    | 22    | 100   | μF   | (Note 2)<br>Effective capacitance with BUCK's DC bias<br>Max value is limited by ramp rate.<br><Output Max Capacitance><br>ramp rate 1.25 mV, 2.5 mV, 5 mV : 100 μF<br>ramp rate 10 mV : 50 μF |

(Note 1) For Buck- DCDC converters, (minimum Over Current Protection Current – ½ inductor ripple current) is the maximum output current.

(Note 2) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.2.3.3. BUCK3 Control

Table 5-13. BUCK3\_CTRL - BUCK3 Control Register

| Register Name | R/W | D7                  | D6 | D5 | D4 | D3            | D2           | D1        | D0       | Initial | Address |
|---------------|-----|---------------------|----|----|----|---------------|--------------|-----------|----------|---------|---------|
| BUCK3_CTRL    | R/W | BUCK3_RAMPRATE[1:0] |    | -  | -  | BUCK3_PWM_FIX | BUCK3_RUN_ON | BUCK3_SEL | BUCK3_EN | 0x44    | 0x07    |

| Bit    | Name                | Function                                                                                                                                                                                                                       | Initial |
|--------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7:6] | BUCK3_RAMPRATE[1:0] | BUCK3 DVS ramp rate<br>00 = 10 mV/μs<br>01 = 5 mV/μs<br>10 = 2.5 mV/μs<br>11 = 1.25 mV/μs<br>Note : When BUCK3 voltage starts up from 0V,<br>the ramp rate is fixed 5mV/μs, regardless of the value of<br>BUCK3_RAMPRATE[1:0]. | 01      |
| D[3]   | BUCK3_PWM_FIX       | 0 – AUTO PWM/PFM mode<br>VR adjusts the operating mode (PFM/PWM) automatically based on the load<br>current to maximize power efficiency.<br>1 – Forced PWM Mode<br>VR operates in PWM mode only.                              | 0       |
| D[2]   | BUCK3_RUN_ON        | 0 = BUCK3 is OFF when entering RUN state<br>1 = BUCK3 is ON when entering RUN state                                                                                                                                            | 1       |
| D[1]   | BUCK3_SEL           | BUCK3 control select bit<br>0 = BUCK3 ON/OFF is controlled by state machine.<br>1 = BUCK3 ON/OFF is controlled by D[0] on this register.                                                                                       | 0       |
| D[0]   | BUCK3_EN            | BUCK3 control bit with condition of D[1]<br>0 = BUCK3 OFF<br>1 = BUCK3 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency<br>shutdown.                                                               | 0       |

Table 5-14. BUCK3\_VOLT\_RUN - BUCK3 Voltage (RUN) Register

| Register Name  | R/W | D7 | D6 | D5                  | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|----------------|-----|----|----|---------------------|----|----|----|----|----|---------|---------|
| BUCK3_VOLT_RUN | R/W | -  | -  | BUCK3_VOLT_RUN[5:0] |    |    |    |    |    | 0x1E    | 0x12    |

| Bit    | Name                | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Initial |
|--------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[5:0] | BUCK3_VOLT_RUN[5:0] | BUCK3 voltage when Power State = RUN<br>0x00 = 0.70 V    0x01 = 0.71 V    0x02 = 0.72 V    0x03 = 0.73 V<br>0x04 = 0.74 V    0x05 = 0.75 V    0x06 = 0.76 V    0x07 = 0.77 V<br>0x08 = 0.78 V    0x09 = 0.79 V    0x0A = 0.80 V    0x0B = 0.81 V<br>0x0C = 0.82 V    0x0D = 0.83 V    0x0E = 0.84 V    0x0F = 0.85 V<br>0x10 = 0.86 V    0x11 = 0.87 V    0x12 = 0.88 V    0x13 = 0.89 V<br>0x14 = 0.90 V    0x15 = 0.91 V    0x16 = 0.92 V    0x17 = 0.93 V<br>0x18 = 0.94 V    0x19 = 0.95 V    0x1A = 0.96 V    0x1B = 0.97 V<br>0x1C = 0.98 V    0x1D = 0.99 V<br>0x1E = 1.00 V (initial)<br>0x1F = 1.01 V    0x20 = 1.02 V    0x21 = 1.03 V    0x22 = 1.04 V<br>0x23 = 1.05 V    0x24 = 1.06 V    0x25 = 1.07 V    0x26 = 1.08 V<br>0x27 = 1.09 V    0x28 = 1.10 V    0x29 = 1.11 V    0x2A = 1.12 V<br>0x2B = 1.13 V    0x2C = 1.14 V    0x2D = 1.15 V    0x2E = 1.16 V<br>0x2F = 1.17 V    0x30 = 1.18 V    0x31 = 1.19 V    0x32 = 1.20 V<br>0x33 = 1.21 V    0x34 = 1.22 V    0x35 = 1.23 V    0x36 = 1.24 V<br>0x37 = 1.25 V    0x38 = 1.26 V    0x39 = 1.27 V    0x3A = 1.28 V<br>0x3B = 1.29 V    0x3C = 1.30 V    0x3D = 1.30 V    0x3E = 1.30 V<br>0x3F = 1.30 V | 011110  |

5.2.4. BUCK4  
5.2.4.1. BUCK4 Block Diagram

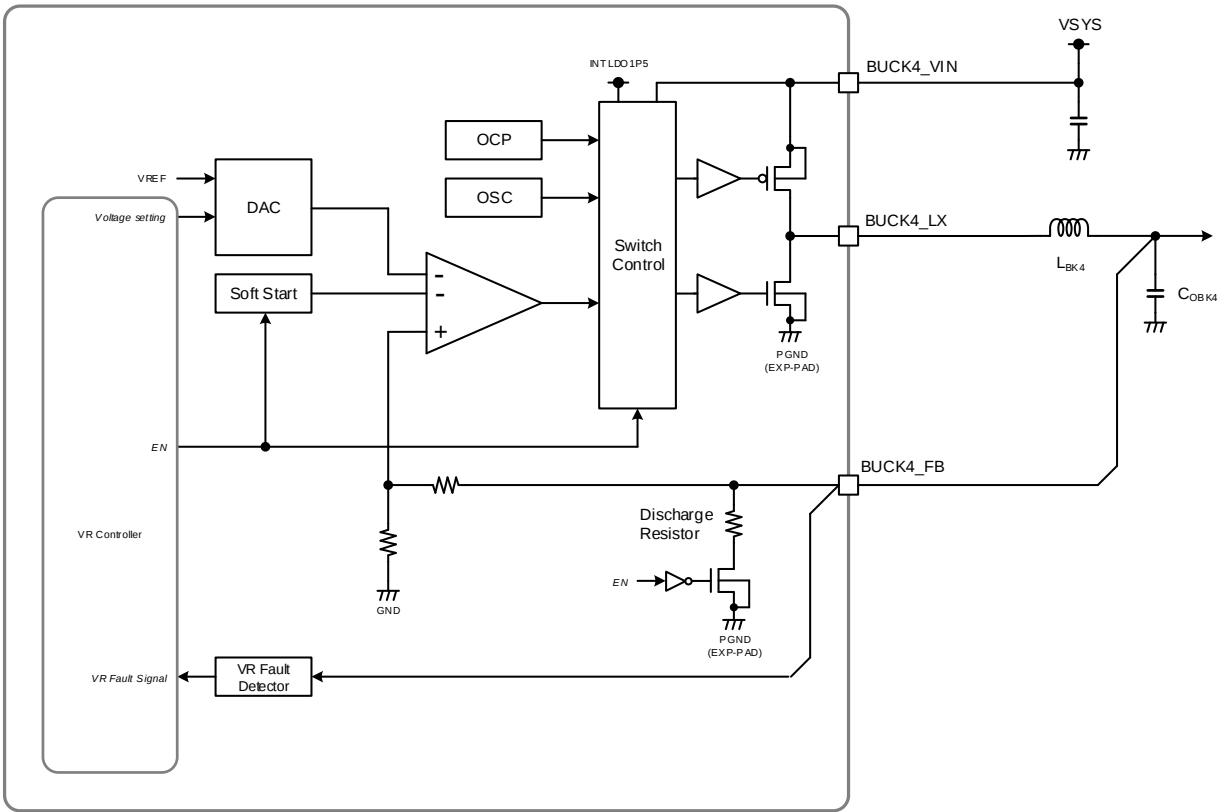


Figure 5-4. BUCK4 Block Diagram

## 5.2.4.2. BUCK4 Electrical Characteristics

Table 5-15. BUCK4 Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, VSYS=5.0 V)

| Parameter                            | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                                                                                      |
|--------------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                      |                          | Min   | Typ   | Max   |      |                                                                                                                                                                                                |
| Output Voltage                       | V <sub>O_BK4</sub>       | 0.990 | 1.000 | 1.010 | V    | V <sub>O</sub> = 1.0 V<br>I <sub>O</sub> = 200 mA, PWM fix Mode                                                                                                                                |
| Programmable Output Voltage Range    | V <sub>ORG_BK4</sub>     | 0.7   | -     | 1.3   | V    | 10 mV step                                                                                                                                                                                     |
| Quiescent Current                    | I <sub>Q_BK4</sub>       | -     | 15    | -     | μA   | V <sub>O</sub> = 1.0 V<br>I <sub>O</sub> = 0 mA, Auto mode                                                                                                                                     |
| Maximum Output Current               | I <sub>OMAX_BK4</sub>    | 1000  | -     | -     | mA   |                                                                                                                                                                                                |
| Over Current Protection              | I <sub>OCP_BK4</sub>     | 2500  | -     | -     | mA   | Peak current of inductor <sup>(Note 1)</sup>                                                                                                                                                   |
| DC Output Voltage Load Regulation    | ΔV <sub>LDR_BK4</sub>    | -1    | 0     | +1    | %    | I <sub>O</sub> = 1 mA to I <sub>Omax</sub> , PWM fix Mode                                                                                                                                      |
| Efficiency                           | η <sub>BK4_1mA</sub>     | -     | 80    | -     | %    | I <sub>O</sub> = 1 mA, V <sub>O</sub> = 1.0 V                                                                                                                                                  |
|                                      | η <sub>BK4_500mA</sub>   | -     | 85    | -     | %    | I <sub>O</sub> = 500 mA, V <sub>O</sub> = 1.0 V                                                                                                                                                |
|                                      | η <sub>BK4_max</sub>     | -     | 84    | -     | %    | I <sub>O</sub> = I <sub>Omax</sub> , V <sub>O</sub> = 1.0 V                                                                                                                                    |
| Oscillating Frequency                | f <sub>SW_BK4</sub>      | -     | 2     | -     | MHz  | PWM fix mode, I <sub>O</sub> = 0 mA                                                                                                                                                            |
| Start up Time                        | t <sub>ST_BK4</sub>      | -     | 180   | 500   | μs   | During EN to 90% of nominal Voltage,<br>BUCK4_RAMPRATE_RUN[1:0] = 01                                                                                                                           |
| Discharge Resistance                 | R <sub>D_BK4</sub>       | -     | 100   | -     | Ω    |                                                                                                                                                                                                |
| Low Side VR Fault Detect Level       | D <sub>VRFBK4_L</sub>    | -     | 80    | -     | %    | V <sub>O</sub> = 1.0 V (FB = Sweep down)<br>VR fault detect level / V <sub>O</sub> x 100                                                                                                       |
| Low Side VR Fault Detect Hysteresis  | D <sub>VRFBK4_LHYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                                                                                                 |
| High Side VR Fault Detect Level      | D <sub>VRBK4_H</sub>     | -     | 130   | -     | %    | V <sub>O</sub> = 1.0 V (FB = Sweep up)<br>Power good detect level / V <sub>O</sub> x 100                                                                                                       |
| High Side VR Fault Detect Hysteresis | D <sub>VRFBK4_HHYS</sub> | -     | 20    | -     | %    | (VR fault detect level - release level) / V <sub>O</sub> x 100                                                                                                                                 |
| Output Inductance                    | L <sub>BK4</sub>         | -     | 0.47  | -     | μH   | (Note 2)                                                                                                                                                                                       |
| Output Capacitance                   | C <sub>OBK4</sub>        | 11    | 22    | 100   | μF   | (Note 2)<br>Effective capacitance with BUCK's DC bias<br>Max value is limited by ramp rate.<br><Output Max Capacitance><br>ramp rate 1.25 mV, 2.5 mV, 5 mV : 100 μF<br>ramp rate 10 mV : 50 μF |

(Note 1) For Buck- DCDC converters, (minimum Over Current Protection Current – ½ inductor ripple current) is the maximum output current.

(Note 2) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.2.4.3. BUCK4 Control

Table 5-16. BUCK4\_CTRL - BUCK4 Control Register

| Register Name | R/W | D7                  | D6 | D5 | D4 | D3            | D2           | D1        | D0       | Initial | Address |
|---------------|-----|---------------------|----|----|----|---------------|--------------|-----------|----------|---------|---------|
| BUCK4_CTRL    | R/W | BUCK4_RAMPRATE[1:0] |    | -  | -  | BUCK4_PWM_FIX | BUCK4_RUN_ON | BUCK4_SEL | BUCK4_EN | 0x44    | 0x08    |

| Bit    | Name                | Function                                                                                                                                                                                                                       | Initial |
|--------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7:6] | BUCK4_RAMPRATE[1:0] | BUCK4 DVS ramp rate<br>00 = 10 mV/μs<br>01 = 5 mV/μs<br>10 = 2.5 mV/μs<br>11 = 1.25 mV/μs<br>Note : When BUCK4 voltage starts up from 0V,<br>the ramp rate is fixed 5mV/μs, regardless of the value of<br>BUCK4_RAMPRATE[1:0]. | 01      |
| D[3]   | BUCK4_PWM_FIX       | 0 – AUTO PWM/PFM mode<br>VR adjusts the operating mode (PFM/PWM) automatically based on the load<br>current to maximize power efficiency.<br>1 – Forced PWM Mode<br>VR operates in PWM mode only.                              | 0       |
| D[2]   | BUCK4_RUN_ON        | 0 = BUCK4 is OFF when entering RUN state<br>1 = BUCK4 is ON when entering RUN state                                                                                                                                            | 1       |
| D[1]   | BUCK4_SEL           | BUCK4 control select bit<br>0 = BUCK4 ON/OFF is controlled by state machine.<br>1 = BUCK4 ON/OFF is controlled by D[0] on this register.                                                                                       | 0       |
| D[0]   | BUCK4_EN            | BUCK4 control bit with condition of D[1]<br>0 = BUCK4 OFF<br>1 = BUCK4 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency<br>shutdown.                                                               | 0       |

Table 5-17. BUCK4\_VOLT\_RUN - BUCK4 Voltage (RUN) Register

| Register Name  | R/W | D7 | D6 | D5                  | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|----------------|-----|----|----|---------------------|----|----|----|----|----|---------|---------|
| BUCK4_VOLT_RUN | R/W | -  | -  | BUCK4_VOLT_RUN[5:0] |    |    |    |    |    | 0x1E    | 0x13    |

| Bit    | Name                | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Initial |
|--------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[5:0] | BUCK4_VOLT_RUN[5:0] | BUCK4 voltage when Power State = RUN<br>0x00 = 0.70 V    0x01 = 0.71 V    0x02 = 0.72 V    0x03 = 0.73 V<br>0x04 = 0.74 V    0x05 = 0.75 V    0x06 = 0.76 V    0x07 = 0.77 V<br>0x08 = 0.78 V    0x09 = 0.79 V    0x0A = 0.80 V    0x0B = 0.81 V<br>0x0C = 0.82 V    0x0D = 0.83 V    0x0E = 0.84 V    0x0F = 0.85 V<br>0x10 = 0.86 V    0x11 = 0.87 V    0x12 = 0.88 V    0x13 = 0.89 V<br>0x14 = 0.90 V    0x15 = 0.91 V    0x16 = 0.92 V    0x17 = 0.93 V<br>0x18 = 0.94 V    0x19 = 0.95 V    0x1A = 0.96 V    0x1B = 0.97 V<br>0x1C = 0.98 V    0x1D = 0.99 V<br>0x1E = 1.00 V (initial)<br>0x1F = 1.01 V    0x20 = 1.02 V    0x21 = 1.03 V    0x22 = 1.04 V<br>0x23 = 1.05 V    0x24 = 1.06 V    0x25 = 1.07 V    0x26 = 1.08 V<br>0x27 = 1.09 V    0x28 = 1.10 V    0x29 = 1.11 V    0x2A = 1.12 V<br>0x2B = 1.13 V    0x2C = 1.14 V    0x2D = 1.15 V    0x2E = 1.16 V<br>0x2F = 1.17 V    0x30 = 1.18 V    0x31 = 1.19 V    0x32 = 1.20 V<br>0x33 = 1.21 V    0x34 = 1.22 V    0x35 = 1.23 V    0x36 = 1.24 V<br>0x37 = 1.25 V    0x38 = 1.26 V    0x39 = 1.27 V    0x3A = 1.28 V<br>0x3B = 1.29 V    0x3C = 1.30 V    0x3D = 1.30 V    0x3E = 1.30 V<br>0x3F = 1.30 V | 011110  |

5.2.5. BUCK5  
5.2.5.1. BUCK5 Block Diagram

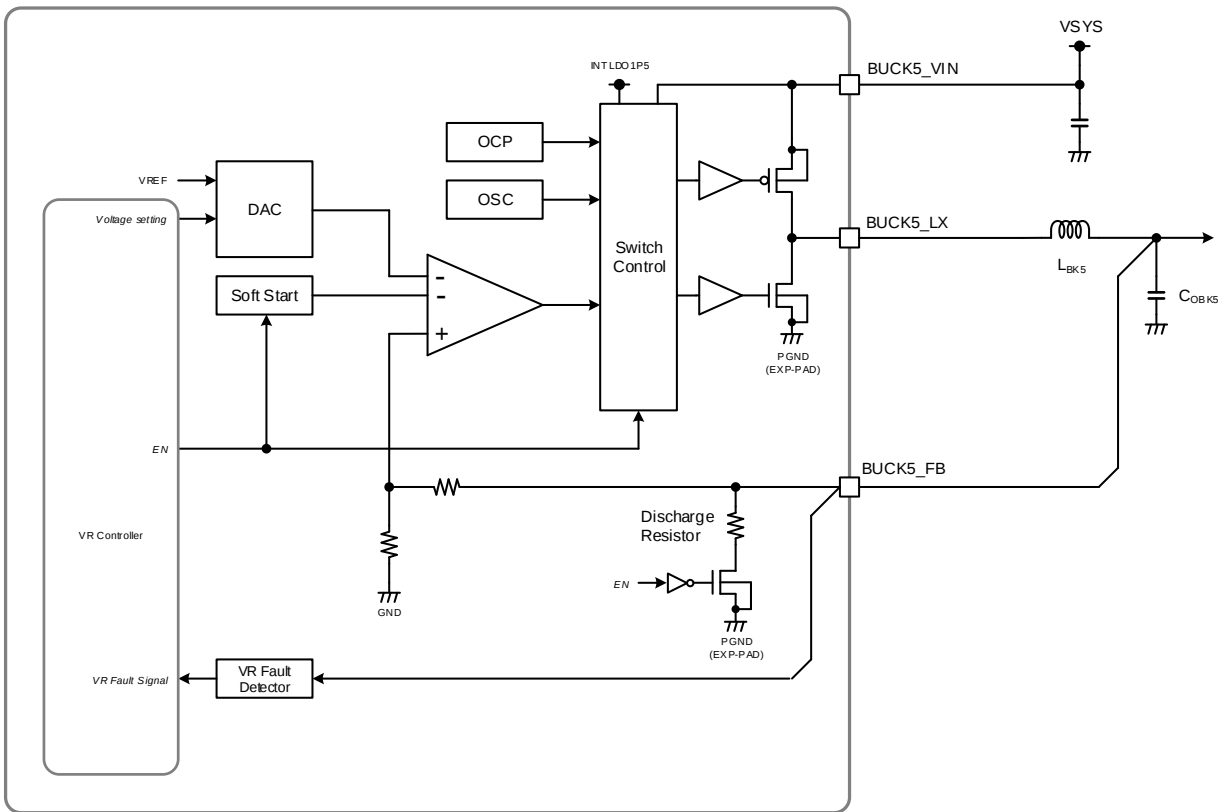


Figure 5-5. BUCK5 Block Diagram

## 5.2.5.2. BUCK5 Electrical Characteristics

Table 5-18. BUCK5 Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, VSYS=5.0 V)

| Parameter                            | Symbol                   | Limit |       |       | Unit | Condition                                                                                |
|--------------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------|
|                                      |                          | Min   | Typ   | Max   |      |                                                                                          |
| Output Voltage                       | V <sub>O_BK5</sub>       | 0.990 | 1.000 | 1.010 | V    | V <sub>O</sub> = 1.0 V<br>I <sub>O</sub> = 200 mA, PWM fix Mode                          |
| Programmable Output Voltage Range    | V <sub>ORG_BK5</sub>     | 0.70  | -     | 1.35  | V    | 0.70 V, 0.80 V, 0.90 V, 1.00 V, 1.05 V, 1.10 V, 1.20 V, 1.35 V                           |
| Quiescent Current                    | I <sub>Q_BK5</sub>       | -     | 15    | -     | μA   | V <sub>O</sub> = 1.0 V<br>I <sub>O</sub> = 0 mA, Auto mode                               |
| Maximum Output Current               | I <sub>OMAX_BK5</sub>    | 2500  | -     | -     | mA   |                                                                                          |
| Over Current Protection              | I <sub>OC_P_BK5</sub>    | 3500  | -     | -     | mA   | Peak current of inductor <sup>(Note 1)</sup>                                             |
| DC Output Voltage Load Regulation    | ΔV <sub>LDR_BK5</sub>    | -1    | 0     | +1    | %    | I <sub>O</sub> = 1 mA to I <sub>Omax</sub> , PWM fix Mode                                |
| Efficiency                           | η <sub>BK5_1mA</sub>     | -     | 79    | -     | %    | I <sub>O</sub> = 1 mA, V <sub>O</sub> = 1.0 V                                            |
|                                      | η <sub>BK5_500mA</sub>   | -     | 85    | -     | %    | I <sub>O</sub> = 500 mA, V <sub>O</sub> = 1.0 V                                          |
|                                      | η <sub>BK5_max</sub>     | -     | 75    | -     | %    | I <sub>O</sub> = I <sub>Omax</sub> , V <sub>O</sub> = 1.0 V                              |
| Oscillating Frequency                | f <sub>SW_BK5</sub>      | -     | 2     | -     | MHz  | PWM fix mode, I <sub>O</sub> = 0 mA                                                      |
| Start up Time                        | t <sub>ST_BK5</sub>      | -     | 160   | 500   | μs   | During EN to 90% of nominal Voltage                                                      |
| Discharge Resistance                 | R <sub>D_BK5</sub>       | -     | 100   | -     | Ω    |                                                                                          |
| Low Side VR Fault Detect Level       | D <sub>VRFBK5_L</sub>    | -     | 80    | -     | %    | V <sub>O</sub> = 1.0 V (FB = Sweep down)<br>VR fault detect level / V <sub>O</sub> x 100 |
| Low Side VR Fault Detect Hysteresis  | D <sub>VRFBK5_LHYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                           |
| High Side VR Fault Detect Level      | D <sub>VRBK5_H</sub>     | -     | 130   | -     | %    | V <sub>O</sub> = 1.0 V (FB = Sweep up)<br>Power good detect level / V <sub>O</sub> x 100 |
| High Side VR Fault Detect Hysteresis | D <sub>VRFBK5_HHYS</sub> | -     | 20    | -     | %    | (VR fault detect level - release level) / V <sub>O</sub> x 100                           |
| Output Inductance                    | L <sub>BK5</sub>         | -     | 0.47  | -     | μH   | (Note 2)                                                                                 |
| Output Capacitance                   | C <sub>OBK5</sub>        | 11    | 22    | 100   | μF   | (Note 2)<br>Effective capacitance with BUCK's DC bias                                    |

(Note 1) For Buck- DCDC converters, (minimum Over Current Protection Current – ½ inductor ripple current) is the maximum output current.

(Note 2) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.2.5.3. BUCK5 Control

Table 5-19. BUCK5\_CTRL - BUCK5 Control Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3              | D2 | D1        | D0       | Initial | Address |
|---------------|-----|----|----|----|----|-----------------|----|-----------|----------|---------|---------|
| BUCK5_CTRL    | R/W | -  | -  | -  | -  | BUCK5_PWM_M_FIX | -  | BUCK5_SEL | BUCK5_EN | 0x00    | 0x09    |

| Bit  | Name          | Function                                                                                                                                                                                       | Initial |
|------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[3] | BUCK5_PWM_FIX | 0 – AUTO PWM/PFM mode<br>VR adjusts the operating mode (PFM/PWM) automatically based on the load current to maximize power efficiency.<br>1 – Forced PWM Mode<br>VR operates in PWM mode only. | 0       |
| D[1] | BUCK5_SEL     | BUCK5 control select bit<br>0 = BUCK5 ON/OFF is controlled by state machine.<br>1 = BUCK5 ON/OFF is controlled by D[0] on this register.                                                       | 0       |
| D[0] | BUCK5_EN      | BUCK5 control bit with condition of D[1]<br>0 = BUCK5 OFF<br>1 = BUCK5 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                  | 0       |

Table 5-20. BUCK5\_VOLT - BUCK5 Voltage Register

| Register Name | R/W | D7             | D6 | D5 | D4 | D3 | D2              | D1 | D0 | Initial | Address |
|---------------|-----|----------------|----|----|----|----|-----------------|----|----|---------|---------|
| BUCK5_VOLT    | R/W | BUCK5_VOLT_SEL | -  | -  | -  | -  | BUCK5_VOLT[2:0] |    |    | 0x03    | 0x14    |

| Bit    | Name            | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Initial |
|--------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7]   | BUCK5_VOLT_SEL  | Select the BUCK5 voltage range set by D[2:0].<br>0 = 0.70 V to 1.35 V<br>1 = 0.675 V to 1.325 V<br><br>Note: Changing BUCK5 voltage value is not allowed when BUCK5 is still ON.<br>In the case where this register value is changed, BUCK5 should be turned OFF.                                                                                                                                                                                                                             | 0       |
| D[2:0] | BUCK5_VOLT[2:0] | BUCK5 voltage<br>If D[7]=0,<br>000 = 0.70 V<br>001 = 0.80 V<br>010 = 0.90 V<br>011 = 1.00 V (Initial)<br>100 = 1.05 V<br>101 = 1.10 V<br>110 = 1.20 V<br>111 = 1.35 V<br>If D[7]=1,<br>000 = 0.675 V<br>001 = 0.775 V<br>010 = 0.875 V<br>011 = 0.975 V<br>100 = 1.025 V<br>101 = 1.075 V<br>110 = 1.175 V<br>111 = 1.325 V<br><br>Note: Changing BUCK5 voltage value is not allowed when BUCK5 is still ON.<br>In the case where this register value is changed, BUCK5 should be turned OFF. | 011     |

## 5.2.6. BUCK6

## 5.2.6.1. BUCK6 Block Diagram

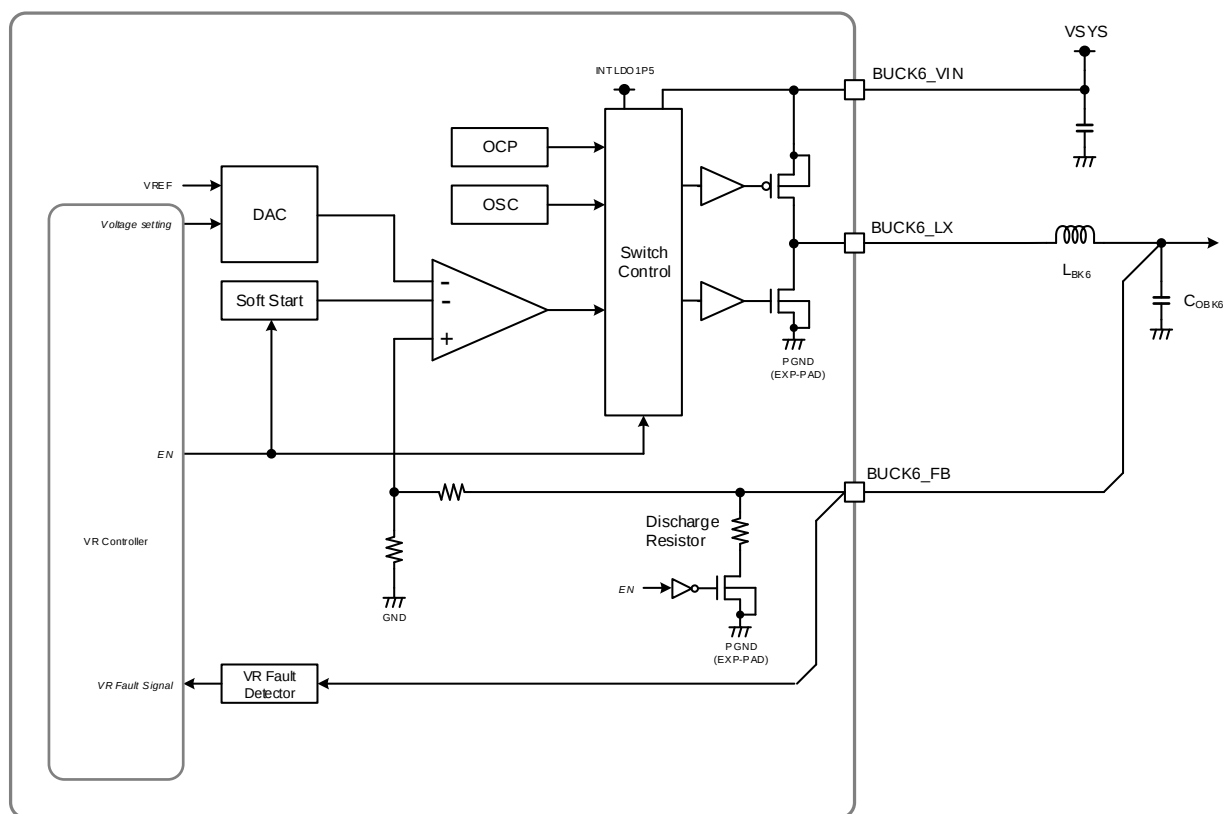


Figure 5-6. BUCK6 Block Diagram

BUCK6 can be configured to the highest output voltage up to 3.3V. There is no concern for subharmonic oscillations even at 50% or higher switching duty cycle as the Buck regulator adopts hysteretic topology. However, there might be consideration required for the input and output voltage headroom as described in the “Headroom for BUCK6” section in the “5.2.6.2 BUCK6 Electrical Characteristics” of this datasheet.

## 5.2.6.2. BUCK6 Electrical Characteristics

Table 5-21. BUCK6 Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, V<sub>SY</sub>S=5.0 V)

| Parameter                            | Symbol                   | Limit |       |       | Unit | Condition                                                                                |
|--------------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------|
|                                      |                          | Min   | Typ   | Max   |      |                                                                                          |
| Output Voltage                       | V <sub>O_BK6</sub>       | 3.267 | 3.300 | 3.333 | V    | V <sub>O</sub> =3.3 V<br>I <sub>O</sub> = 200 mA, PWM fix Mode                           |
| Programmable Output Voltage Range    | V <sub>ORG_BK6</sub>     | 3.0   | -     | 3.3   | V    | 3.0 V, 3.1 V, 3.2 V, 3.3 V                                                               |
| Quiescent Current                    | I <sub>Q_BK6</sub>       | -     | 9     | -     | μA   | V <sub>O</sub> =3.3 V<br>I <sub>O</sub> =0 mA, Auto mode                                 |
| Maximum Output Current               | I <sub>OMAX_BK6</sub>    | 3000  | -     | -     | mA   |                                                                                          |
| Over Current Protection              | I <sub>OC_P_BK6</sub>    | 4500  | -     | -     | mA   | Peak current of inductor <sup>(Note 1)</sup>                                             |
| DC Output Voltage Load Regulation    | ΔV <sub>LDR_BK6</sub>    | -1    | 0     | +1    | %    | I <sub>O</sub> =1 mA to I <sub>Omax</sub> , PWM fix Mode                                 |
| Efficiency                           | η <sub>BK6_1mA</sub>     | -     | 92    | -     | %    | I <sub>O</sub> = 1 mA, V <sub>O</sub> =3.3 V                                             |
|                                      | η <sub>BK6_500mA</sub>   | -     | 95    | -     | %    | I <sub>O</sub> = 500 mA, V <sub>O</sub> =3.3 V                                           |
|                                      | η <sub>BK6_max</sub>     | -     | 88    | -     | %    | I <sub>O</sub> = I <sub>Omax</sub> , V <sub>O</sub> =3.3 V                               |
| Oscillating Frequency                | f <sub>SW_BK6</sub>      | -     | 1.5   | -     | MHz  | PWM fix mode, I <sub>O</sub> = 0 mA                                                      |
| Start up Time                        | t <sub>ST_BK6</sub>      | -     | 240   | 500   | μs   | During EN to 90% of nominal Voltage                                                      |
| Discharge Resistance                 | R <sub>D_BK6</sub>       | -     | 100   | -     | Ω    |                                                                                          |
| Low Side VR Fault Detect Level       | D <sub>VRFBK6_L</sub>    | -     | 80    | -     | %    | V <sub>O</sub> = 3.3 V (FB = Sweep down)<br>VR fault detect level / V <sub>O</sub> x 100 |
| Low Side VR Fault Detect Hysteresis  | D <sub>VRFBK6_LHYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                           |
| High Side VR Fault Detect Level      | D <sub>VRBK6_H</sub>     | -     | 130   | -     | %    | V <sub>O</sub> = 3.3 V (FB = Sweep up)<br>Power good detect level / V <sub>O</sub> x 100 |
| High Side VR Fault Detect Hysteresis | D <sub>VRFBK6_HHYS</sub> | -     | 20    | -     | %    | (VR fault detect level - release level) / V <sub>O</sub> x 100                           |
| Output Inductance                    | L <sub>BK6</sub>         | -     | 1     | -     | μH   | (Note 2)                                                                                 |
| Output Capacitance                   | C <sub>OBK6</sub>        | 15.4  | 44    | 100   | μF   | (Note 2)<br>Effective capacitance with BUCK's DC bias                                    |

(Note 1) For Buck- DCDC converters, (minimum Over Current Protection Current – ½ inductor ripple current) is the maximum output current.

(Note 2) This part value range need to be guaranteed over the operating surrounding temperature.

**Headroom for BUCK6**

BUCK6 cannot maintain output voltage when the input voltage is close to the output voltage. The headroom voltage is determined by output current and the impedance from V<sub>SY</sub>S to BUCK6 output including the inductor parasitic impedance (DCR). The PMIC internal impedance from BUCK6\_VIN to BUCK6\_LX is 121 mΩ at the worst case. Please calculate total impedance using this value, and secure enough headroom for V<sub>SY</sub>S according to the output current and voltage.

(Example – ROHM Evaluation Board case)

V<sub>O</sub> = 3.3V setting: V<sub>O</sub>V<sub>SY</sub>S to BUCK6\_VIN impedance of the EVB = 3 mΩ: R<sub>VIN</sub>BUCK6\_LX to inductor impedance of the EVB = 6 mΩ: R<sub>LX</sub>Inductor parasitic impedance (DCR) = 45 mΩ: R<sub>IND</sub>PMIC internal impedance from BUCK6\_VIN to BUCK6\_LX = 121 mΩ: R<sub>PMIC</sub>Total impedance = 175 mΩ: R<sub>TOTAL</sub>=R<sub>VIN</sub>+R<sub>LX</sub>+R<sub>IND</sub>+R<sub>PMIC</sub>Headroom = R<sub>TOTAL</sub> X Output Current

| Output current | Required minimum V <sub>SY</sub> S voltage |
|----------------|--------------------------------------------|
| 1.0 A          | 3.475 V                                    |
| 2.0 A          | 3.650 V                                    |
| 3.0 A          | 3.825 V                                    |

## 5.2.6.3. BUCK6 Control

Table 5-22. BUCK6\_CTRL - BUCK6 Control Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3            | D2 | D1        | D0       | Initial | Address |
|---------------|-----|----|----|----|----|---------------|----|-----------|----------|---------|---------|
| BUCK6_CTRL    | R/W | -  | -  | -  | -  | BUCK6_PWM_FIX | -  | BUCK6_SEL | BUCK6_EN | 0x00    | 0x0A    |

| Bit  | Name          | Function                                                                                                                                                                                       | Initial |
|------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[3] | BUCK6_PWM_FIX | 0 – AUTO PWM/PFM mode<br>VR adjusts the operating mode (PFM/PWM) automatically based on the load current to maximize power efficiency.<br>1 – Forced PWM Mode<br>VR operates in PWM mode only. | 0       |
| D[1] | BUCK6_SEL     | BUCK6 control select bit<br>0 = BUCK6 ON/OFF is controlled by state machine.<br>1 = BUCK6 ON/OFF is controlled by D[0] on this register.                                                       | 0       |
| D[0] | BUCK6_EN      | BUCK6 control bit with condition of D[1]<br>0 = BUCK6 OFF<br>1 = BUCK6 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                  | 0       |

Table 5-23. BUCK6\_VOLT - BUCK6 Voltage Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3 | D2 | D1              | D0 | Initial | Address |
|---------------|-----|----|----|----|----|----|----|-----------------|----|---------|---------|
| BUCK6_VOLT    | R/W | -  | -  | -  | -  | -  | -  | BUCK6_VOLT[1:0] |    | 0x03    | 0x15    |

| Bit    | Name            | Function                                                                                                                                                                                                                                          | Initial |
|--------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[1:0] | BUCK6_VOLT[1:0] | BUCK6 voltage<br>00 = 3.0 V<br>01 = 3.1 V<br>10 = 3.2 V<br>11 = 3.3 V (Initial)<br><br>Note: Changing BUCK6 voltage value is not allowed when BUCK6 is still ON.<br>In the case where this register value is changed, BUCK6 should be turned OFF. | 11      |

5.2.7. BUCK7  
5.2.7.1. BUCK7 Block Diagram

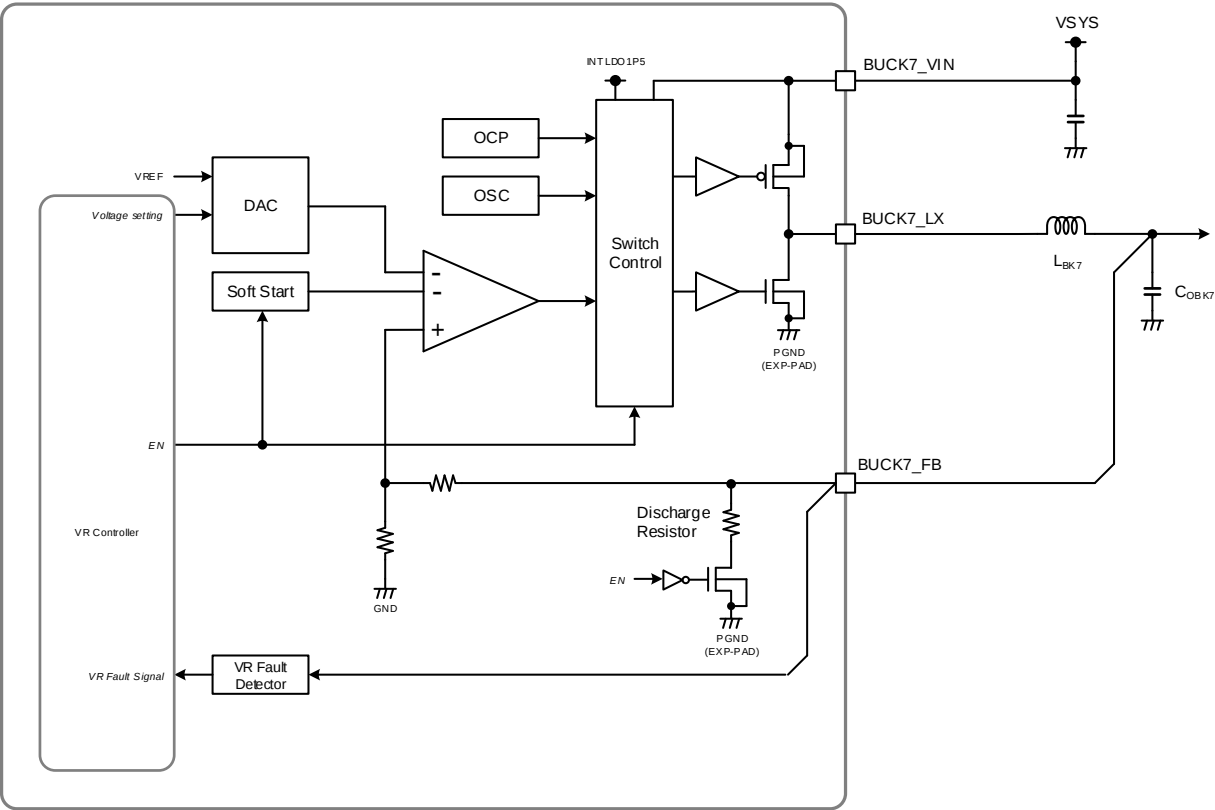


Figure 5-7. BUCK7 Block Diagram

## 5.2.7.2. BUCK7 Electrical Characteristics

Table 5-24. BUCK7 Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, VSYS=5.0 V)

| Parameter                            | Symbol                | Limit |       |       | Unit          | Condition                                                                          |
|--------------------------------------|-----------------------|-------|-------|-------|---------------|------------------------------------------------------------------------------------|
|                                      |                       | Min   | Typ   | Max   |               |                                                                                    |
| Output Voltage                       | $V_{O\_BK7}$          | 1.782 | 1.800 | 1.818 | V             | $V_o = 1.8\text{ V}$<br>$I_o = 200\text{ mA}$ , PWM fix Mode                       |
| Programmable Output Voltage Range    | $V_{ORG\_BK7}$        | 1.605 | -     | 1.995 | V             | 1.605 V, 1.695 V, 1.755 V, 1.800 V, 1.845 V, 1.905 V, 1.950 V, 1.995 V             |
| Quiescent Current                    | $I_{Q\_BK7}$          | -     | 15    | -     | $\mu\text{A}$ | $V_o = 1.8\text{ V}$<br>$I_o = 0\text{ mA}$ , Auto mode                            |
| Maximum Output Current               | $I_{OMAX\_BK7}$       | 1500  | -     | -     | mA            |                                                                                    |
| Over Current Protection              | $I_{OCP\_BK7}$        | 3000  | -     | -     | mA            | Peak current of inductor <sup>(Note 1)</sup>                                       |
| DC Output Voltage Load Regulation    | $\Delta V_{LDR\_BK7}$ | -1    | 0     | +1    | %             | $I_o = 1\text{ mA}$ to $I_{omax}$ , PWM fix Mode                                   |
| Efficiency                           | $\eta_{BK7\_1mA}$     | -     | 84    | -     | %             | $I_o = 1\text{ mA}$ , $V_o=1.8\text{ V}$                                           |
|                                      | $\eta_{BK7\_500mA}$   | -     | 89    | -     | %             | $I_o = 500\text{ mA}$ , $V_o=1.8\text{ V}$                                         |
|                                      | $\eta_{BK7\_max}$     | -     | 87    | -     | %             | $I_o = I_{omax}$ , $V_o=1.8\text{ V}$                                              |
| Oscillating Frequency                | $f_{SW\_BK7}$         | -     | 2     | -     | MHz           | PWM fix mode, $I_o = 0\text{ mA}$                                                  |
| Start up Time                        | $t_{ST\_BK7}$         | -     | 220   | 500   | $\mu\text{s}$ | During EN to 90% of nominal Voltage                                                |
| Discharge Resistance                 | $R_{D\_BK7}$          | -     | 100   | -     | $\Omega$      |                                                                                    |
| Low Side VR Fault Detect Level       | $D_{VRFBK7\_L}$       | -     | 80    | -     | %             | $V_o = 1.8\text{ V}$ (FB = Sweep down)<br>VR fault detect level / $V_o \times 100$ |
| Low Side VR Fault Detect Hysteresis  | $D_{VRFBK7\_LHYS}$    | -     | 10    | -     | %             | (VR fault release level - detect level) / $V_o \times 100$                         |
| High Side VR Fault Detect Level      | $D_{VRBK7\_H}$        | -     | 130   | -     | %             | $V_o = 1.8\text{ V}$ (FB = Sweep up)<br>Power good detect level / $V_o \times 100$ |
| High Side VR Fault Detect Hysteresis | $D_{VRFBK7\_HHYS}$    | -     | 20    | -     | %             | (VR fault detect level - release level) / $V_o \times 100$                         |
| Output Inductance                    | $L_{BK7}$             | -     | 0.47  | -     | $\mu\text{H}$ | (Note 2)                                                                           |
| Output Capacitance                   | $C_{OBK7}$            | 11    | 22    | 100   | $\mu\text{F}$ | (Note 2)<br>Effective capacitance with BUCK's DC bias                              |

(Note 1) For Buck- DCDC converters, (minimum Over Current Protection Current – ½ inductor ripple current) is the maximum output current.

(Note 2) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.2.7.3. BUCK7 Control

Table 5-25. BUCK7\_CTRL - BUCK7 Control Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3            | D2 | D1        | D0       | Initial | Address |
|---------------|-----|----|----|----|----|---------------|----|-----------|----------|---------|---------|
| BUCK7_CTRL    | R/W | -  | -  | -  | -  | BUCK7_PWM_FIX | -  | BUCK7_SEL | BUCK7_EN | 0x00    | 0x0B    |

| Bit  | Name          | Function                                                                                                                                                                                       | Initial |
|------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[3] | BUCK7_PWM_FIX | 0 – AUTO PWM/PFM mode<br>VR adjusts the operating mode (PFM/PWM) automatically based on the load current to maximize power efficiency.<br>1 – Forced PWM Mode<br>VR operates in PWM mode only. | 0       |
| D[1] | BUCK7_SEL     | BUCK7 control select bit<br>0 = BUCK7 ON/OFF is controlled by state machine.<br>1 = BUCK7 ON/OFF is controlled by D[0] on this register.                                                       | 0       |
| D[0] | BUCK7_EN      | BUCK7 control bit with condition of D[1]<br>0 = BUCK7 OFF<br>1 = BUCK7 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                  | 0       |

Table 5-26. BUCK7\_VOLT - BUCK7 Voltage Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3 | D2              | D1 | D0 | Initial | Address |
|---------------|-----|----|----|----|----|----|-----------------|----|----|---------|---------|
| BUCK7_VOLT    | R/W | -  | -  | -  | -  | -  | BUCK7_VOLT[2:0] |    |    | 0x03    | 0x16    |

| Bit    | Name            | Function                                                                                                                                                                                                                                                                                                                          | Initial |
|--------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[2:0] | BUCK7_VOLT[2:0] | BUCK7 voltage<br>000 = 1.605 V<br>001 = 1.695 V<br>010 = 1.755 V<br>011 = 1.800 V (Initial)<br>100 = 1.845 V<br>101 = 1.905 V<br>110 = 1.950 V<br>111 = 1.995 V<br><br>Note: Changing BUCK7 voltage value is not allowed when BUCK7 is still ON.<br>In the case where this register value is changed, BUCK7 should be turned OFF. | 011     |

5.2.8. BUCK8  
5.2.8.1. BUCK8 Block Diagram

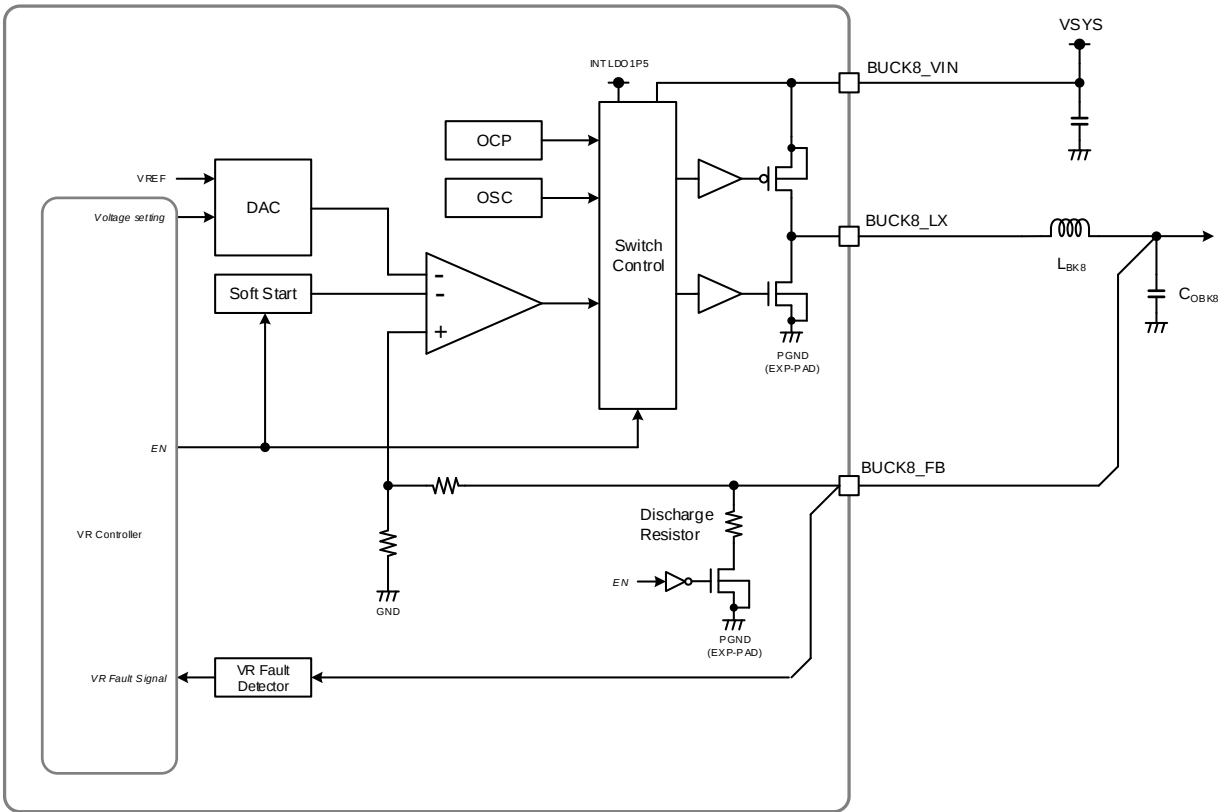


Figure 5-8. BUCK8 Block Diagram

## 5.2.8.2. BUCK8 Electrical Characteristics

Table 5-27. BUCK8 Electrical Characteristics

(Unless otherwise specified, Ta=+25 °C, VSYS=5.0 V)

| Parameter                            | Symbol                | Limit |       |       | Unit          | Condition                                                                          |
|--------------------------------------|-----------------------|-------|-------|-------|---------------|------------------------------------------------------------------------------------|
|                                      |                       | Min   | Typ   | Max   |               |                                                                                    |
| Output Voltage                       | $V_{O\_BK8}$          | 1.089 | 1.100 | 1.111 | V             | $V_o = 1.1\text{ V}$<br>$I_o = 200\text{ mA}$ , PWM fix Mode                       |
| Programmable Output Voltage Range    | $V_{ORG\_BK8}$        | 0.8   | -     | 1.4   | V             | 10 mV step                                                                         |
| Quiescent Current                    | $I_{Q\_BK8}$          | -     | 15    | -     | $\mu\text{A}$ | $V_o = 1.1\text{ V}$<br>$I_o = 0\text{ mA}$ , Auto mode                            |
| Maximum Output Current               | $I_{OMAX\_BK8}$       | 3000  | -     | -     | mA            |                                                                                    |
| Over Current Protection              | $I_{OCP\_BK8}$        | 4500  | -     | -     | mA            | Peak current of inductor <sup>(note 1)</sup>                                       |
| DC Output Voltage Load Regulation    | $\Delta V_{LDR\_BK8}$ | -1    | 0     | +1    | %             | $I_o = 1\text{ mA}$ to $I_{omax}$ , PWM fix Mode                                   |
| Efficiency                           | $\eta_{BK8\_1mA}$     | -     | 82    | -     | %             | $I_o = 1\text{ mA}$ , $V_o=1.1\text{ V}$                                           |
|                                      | $\eta_{BK8\_500mA}$   | -     | 87    | -     | %             | $I_o = 500\text{ mA}$ , $V_o=1.1\text{ V}$                                         |
|                                      | $\eta_{BK8\_max}$     | -     | 76    | -     | %             | $I_o = I_{omax}$ , $V_o=1.1\text{ V}$                                              |
| Oscillating Frequency                | $f_{SW\_BK8}$         | -     | 2     | -     | MHz           | PWM fix mode, $I_o = 0\text{ mA}$                                                  |
| Start up Time                        | $t_{ST\_BK8}$         | -     | 200   | 500   | $\mu\text{s}$ | During EN to 90% of nominal Voltage                                                |
| Discharge Resistance                 | $R_{D\_BK8}$          | -     | 100   | -     | $\Omega$      |                                                                                    |
| Low Side VR Fault Detect Level       | $D_{VRFBK8\_L}$       | -     | 80    | -     | %             | $V_o = 1.1\text{ V}$ (FB = Sweep down)<br>VR fault detect level / $V_o \times 100$ |
| Low Side VR Fault Detect Hysteresis  | $D_{VRFBK8\_LHYS}$    | -     | 10    | -     | %             | (VR fault release level - detect level) / $V_o \times 100$                         |
| High Side VR Fault Detect Level      | $D_{VRBK8\_H}$        | -     | 130   | -     | %             | $V_o = 1.1\text{ V}$ (FB = Sweep up)<br>Power good detect level / $V_o \times 100$ |
| High Side VR Fault Detect Hysteresis | $D_{VRFBK8\_HHYS}$    | -     | 20    | -     | %             | (VR fault detect level - release level) / $V_o \times 100$                         |
| Output Inductance                    | $L_{BK8}$             | -     | 0.47  | -     | $\mu\text{H}$ | (Note 2)                                                                           |
| Output Capacitance                   | $C_{OBK8}$            | 22    | 44    | 100   | $\mu\text{F}$ | (Note 2)<br>Effective capacitance with BUCK's DC bias                              |

(Note 1) For Buck- DCDC converters, (minimum Over Current Protection Current – ½ inductor ripple current) is the maximum output current.

(Note 2) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.2.8.3. BUCK8 Control

Table 5-28. BUCK8\_CTRL - BUCK8 Control Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3              | D2 | D1        | D0       | Initial | Address |
|---------------|-----|----|----|----|----|-----------------|----|-----------|----------|---------|---------|
| BUCK8_CTRL    | R/W | -  | -  | -  | -  | BUCK8_PWM_M_FIX | -  | BUCK8_SEL | BUCK8_EN | 0x00    | 0x0C    |

| Bit  | Name          | Function                                                                                                                                                                                       | Initial |
|------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[3] | BUCK8_PWM_FIX | 0 – AUTO PWM/PPM mode<br>VR adjusts the operating mode (PPM/PWM) automatically based on the load current to maximize power efficiency.<br>1 – Forced PWM Mode<br>VR operates in PWM mode only. | 0       |
| D[1] | BUCK8_SEL     | BUCK8 control select bit<br>0 = BUCK8 ON/OFF is controlled by state machine.<br>1 = BUCK8 ON/OFF is controlled by D[0] on this register.                                                       | 0       |
| D[0] | BUCK8_EN      | BUCK8 control bit with condition of D[1]<br>0 = BUCK8 OFF<br>1 = BUCK8 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                  | 0       |

Table 5-29. BUCK8\_VOLT - BUCK8 Voltage Register

| Register Name | R/W | D7 | D6 | D5              | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----|----|-----------------|----|----|----|----|----|---------|---------|
| BUCK8_VOLT    | R/W | -  | -  | BUCK8_VOLT[5:0] |    |    |    |    |    | 0x1E    | 0x17    |

| Bit                     | Name            | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Initial       |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
|-------------------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|--|--|-------------------------|--|--|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|--|--|--|--------|
| D[2:0]                  | BUCK8_VOLT[5:0] | <p>BUCK8 voltage</p> <table border="0"> <tr> <td>0x00 = 0.80 V</td><td>0x01 = 0.81 V</td><td>0x02 = 0.82 V</td><td>0x03 = 0.83 V</td></tr> <tr> <td>0x04 = 0.84 V</td><td>0x05 = 0.85 V</td><td>0x06 = 0.86 V</td><td>0x07 = 0.87 V</td></tr> <tr> <td>0x08 = 0.88 V</td><td>0x09 = 0.89 V</td><td>0x0A = 0.90 V</td><td>0x0B = 0.91 V</td></tr> <tr> <td>0x0C = 0.92 V</td><td>0x0D = 0.93 V</td><td>0x0E = 0.94 V</td><td>0x0F = 0.95 V</td></tr> <tr> <td>0x10 = 0.96 V</td><td>0x11 = 0.97 V</td><td>0x12 = 0.98 V</td><td>0x13 = 0.99 V</td></tr> <tr> <td>0x14 = 1.00 V</td><td>0x15 = 1.01 V</td><td>0x16 = 1.02 V</td><td>0x17 = 1.03 V</td></tr> <tr> <td>0x18 = 1.04 V</td><td>0x19 = 1.05 V</td><td>0x1A = 1.06 V</td><td>0x1B = 1.07 V</td></tr> <tr> <td>0x1C = 1.08 V</td><td>0x1D = 1.09 V</td><td></td><td></td></tr> <tr> <td>0x1E = 1.10 V (initial)</td><td></td><td></td><td></td></tr> <tr> <td>0x1F = 1.11 V</td><td>0x20 = 1.12 V</td><td>0x21 = 1.13 V</td><td>0x22 = 1.14 V</td></tr> <tr> <td>0x23 = 1.15 V</td><td>0x24 = 1.16 V</td><td>0x25 = 1.17 V</td><td>0x26 = 1.18 V</td></tr> <tr> <td>0x27 = 1.19 V</td><td>0x28 = 1.20 V</td><td>0x29 = 1.21 V</td><td>0x2A = 1.22 V</td></tr> <tr> <td>0x2B = 1.23 V</td><td>0x2C = 1.24 V</td><td>0x2D = 1.25 V</td><td>0x2E = 1.26 V</td></tr> <tr> <td>0x2F = 1.27 V</td><td>0x30 = 1.28 V</td><td>0x31 = 1.29 V</td><td>0x32 = 1.30 V</td></tr> <tr> <td>0x33 = 1.31 V</td><td>0x34 = 1.32 V</td><td>0x35 = 1.33 V</td><td>0x36 = 1.34 V</td></tr> <tr> <td>0x37 = 1.35 V</td><td>0x38 = 1.36 V</td><td>0x39 = 1.37 V</td><td>0x3A = 1.38 V</td></tr> <tr> <td>0x3B = 1.39 V</td><td>0x3C = 1.40 V</td><td>0x3D = 1.40 V</td><td>0x3E = 1.40 V</td></tr> <tr> <td>0x3F = 1.40 V</td><td></td><td></td><td></td></tr> </table> <p>Note: Changing BUCK8 voltage value is not allowed when BUCK8 is still ON. In the case where this register value is changed, BUCK8 should be turned OFF.</p> | 0x00 = 0.80 V | 0x01 = 0.81 V | 0x02 = 0.82 V | 0x03 = 0.83 V | 0x04 = 0.84 V | 0x05 = 0.85 V | 0x06 = 0.86 V | 0x07 = 0.87 V | 0x08 = 0.88 V | 0x09 = 0.89 V | 0x0A = 0.90 V | 0x0B = 0.91 V | 0x0C = 0.92 V | 0x0D = 0.93 V | 0x0E = 0.94 V | 0x0F = 0.95 V | 0x10 = 0.96 V | 0x11 = 0.97 V | 0x12 = 0.98 V | 0x13 = 0.99 V | 0x14 = 1.00 V | 0x15 = 1.01 V | 0x16 = 1.02 V | 0x17 = 1.03 V | 0x18 = 1.04 V | 0x19 = 1.05 V | 0x1A = 1.06 V | 0x1B = 1.07 V | 0x1C = 1.08 V | 0x1D = 1.09 V |  |  | 0x1E = 1.10 V (initial) |  |  |  | 0x1F = 1.11 V | 0x20 = 1.12 V | 0x21 = 1.13 V | 0x22 = 1.14 V | 0x23 = 1.15 V | 0x24 = 1.16 V | 0x25 = 1.17 V | 0x26 = 1.18 V | 0x27 = 1.19 V | 0x28 = 1.20 V | 0x29 = 1.21 V | 0x2A = 1.22 V | 0x2B = 1.23 V | 0x2C = 1.24 V | 0x2D = 1.25 V | 0x2E = 1.26 V | 0x2F = 1.27 V | 0x30 = 1.28 V | 0x31 = 1.29 V | 0x32 = 1.30 V | 0x33 = 1.31 V | 0x34 = 1.32 V | 0x35 = 1.33 V | 0x36 = 1.34 V | 0x37 = 1.35 V | 0x38 = 1.36 V | 0x39 = 1.37 V | 0x3A = 1.38 V | 0x3B = 1.39 V | 0x3C = 1.40 V | 0x3D = 1.40 V | 0x3E = 1.40 V | 0x3F = 1.40 V |  |  |  | 011110 |
| 0x00 = 0.80 V           | 0x01 = 0.81 V   | 0x02 = 0.82 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x03 = 0.83 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x04 = 0.84 V           | 0x05 = 0.85 V   | 0x06 = 0.86 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x07 = 0.87 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x08 = 0.88 V           | 0x09 = 0.89 V   | 0x0A = 0.90 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x0B = 0.91 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x0C = 0.92 V           | 0x0D = 0.93 V   | 0x0E = 0.94 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x0F = 0.95 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x10 = 0.96 V           | 0x11 = 0.97 V   | 0x12 = 0.98 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x13 = 0.99 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x14 = 1.00 V           | 0x15 = 1.01 V   | 0x16 = 1.02 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x17 = 1.03 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x18 = 1.04 V           | 0x19 = 1.05 V   | 0x1A = 1.06 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x1B = 1.07 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x1C = 1.08 V           | 0x1D = 1.09 V   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x1E = 1.10 V (initial) |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x1F = 1.11 V           | 0x20 = 1.12 V   | 0x21 = 1.13 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x22 = 1.14 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x23 = 1.15 V           | 0x24 = 1.16 V   | 0x25 = 1.17 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x26 = 1.18 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x27 = 1.19 V           | 0x28 = 1.20 V   | 0x29 = 1.21 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x2A = 1.22 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x2B = 1.23 V           | 0x2C = 1.24 V   | 0x2D = 1.25 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x2E = 1.26 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x2F = 1.27 V           | 0x30 = 1.28 V   | 0x31 = 1.29 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x32 = 1.30 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x33 = 1.31 V           | 0x34 = 1.32 V   | 0x35 = 1.33 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x36 = 1.34 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x37 = 1.35 V           | 0x38 = 1.36 V   | 0x39 = 1.37 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x3A = 1.38 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x3B = 1.39 V           | 0x3C = 1.40 V   | 0x3D = 1.40 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0x3E = 1.40 V |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |
| 0x3F = 1.40 V           |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |                         |  |  |  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |  |  |  |        |

5.3. Details of LDO

5.3.1. LDO1

5.3.1.1. LDO1 Block Diagram

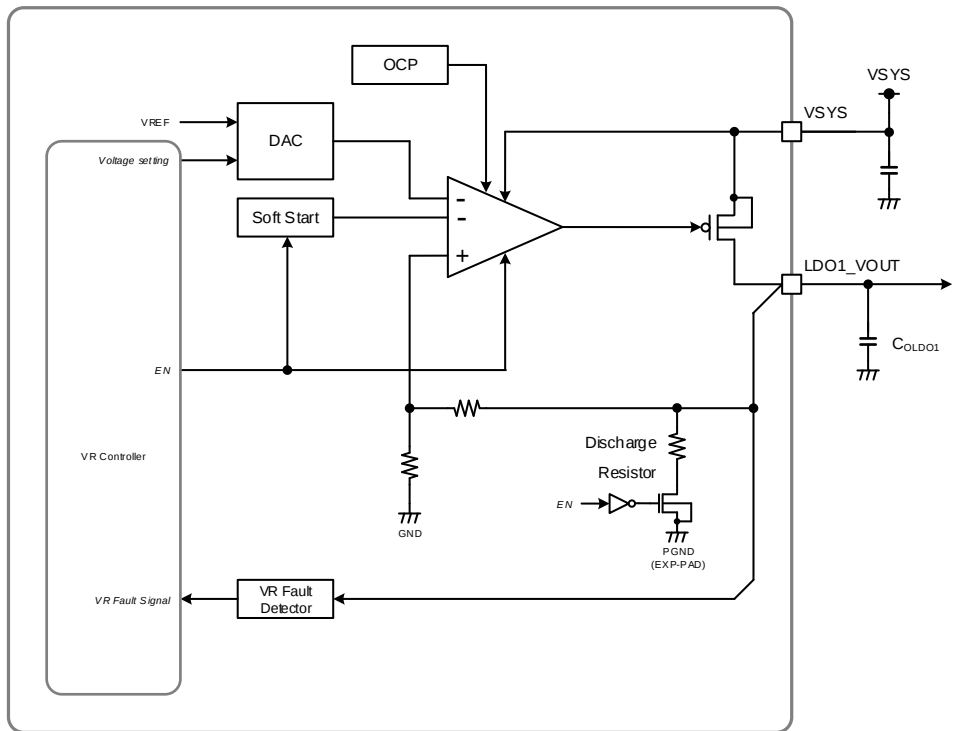


Figure 5-9. LDO1 Block Diagram

## 5.3.1.2. LDO1 Electrical Characteristics

Table 5-30. LDO1 Electrical Characteristics

(Unless otherwise specified, Ta = +25 °C, VSYS = 5.0 V, VIN\_3P3 = 3.3 V, VIN\_1P8\_1 = 1.8 V, Vo = 3.3 V setting)

| Parameter                         | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                    |
|-----------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------|
|                                   |                          | Min   | Typ   | Max   |      |                                                                                                                              |
| Output Voltage                    | V <sub>O_LDO1</sub>      | 3.267 | 3.300 | 3.333 | V    | V <sub>O</sub> =3.3 V setting<br>I <sub>O</sub> =1 mA                                                                        |
| Output Voltage Range 1            | V <sub>ORG_LDO1_1</sub>  | 1.600 | -     | 1.900 | V    | 100 mV step                                                                                                                  |
| Output Voltage Range 2            | V <sub>ORG_LDO1_2</sub>  | 3.000 | -     | 3.300 | V    | 100 mV step                                                                                                                  |
| Maximum Output Current            | I <sub>OMAX_LDO1</sub>   | 10    | -     | -     | mA   |                                                                                                                              |
| Over Current Protection           | I <sub>OC_P_LDO1</sub>   | 20    | -     | -     | mA   |                                                                                                                              |
| Quiescent Current                 | I <sub>Q_LDO1</sub>      | -     | 6     | -     | μA   | I <sub>O</sub> =0 mA                                                                                                         |
| Dropout Voltage                   | ΔV <sub>ODP_LDO1</sub>   | -     | 40    | -     | mV   | I <sub>O</sub> = I <sub>OMAX</sub><br>VSYS=3.2 V, V <sub>O</sub> =3.3 V setting                                              |
| Start up Time                     | t <sub>ST_LDO1</sub>     | -     | 440   | 1000  | μs   | I <sub>O</sub> =0 mA,<br>During EN to 90 % of nominal Voltage                                                                |
| DC Output Voltage Load Regulation | ΔV <sub>LDR_LDO1</sub>   | -     | 10    | 20    | mV   | I <sub>O</sub> =1 mA to I <sub>OMAX</sub>                                                                                    |
| DC Output Voltage Line Regulation | ΔV <sub>LNR_LDO1</sub>   | -     | 2     | 5     | mV   | VSYS = 4.5 V to 5.5 V, I <sub>O</sub> =I <sub>OMAX</sub>                                                                     |
| Discharge Resistance              | R <sub>DIS_LDO1</sub>    | -     | 100   | 200   | Ω    |                                                                                                                              |
| VR Fault Detect Level             | D <sub>VRFLDO1</sub>     | -     | 80    | -     | %    | Output = Sweep down<br>Power good detect level / V <sub>O</sub> x 100                                                        |
| VR Fault Detect Hysteresis        | D <sub>VRFLDO1_HYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                               |
| Ripple Rejection Ratio            | RR <sub>LDO1</sub>       | -     | 60    | -     | dB   | VSYS = 5.0 V, I <sub>O</sub> =I <sub>OMAX</sub> /2<br>V <sub>R</sub> = -20 dBV, f <sub>R</sub> =100 Hz<br>BW=20 Hz to 20 kHz |
| Output Capacitance                | C <sub>OLD01</sub>       | 0.5   | 1.0   | 5.0   | μF   | (Note 1)<br>Effective capacitance with LDO's DC bias                                                                         |

(Note 1) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.3.1.3. LDO1 Control

Table 5-31. LDO1\_VOLT - LDO1 Voltage Register

| Register Name | R/W | D7       | D6      | D5            | D4 | D3 | D2 | D1             | D0 | Initial | Address |
|---------------|-----|----------|---------|---------------|----|----|----|----------------|----|---------|---------|
| LDO1_VOLT     | R/W | LDO1_SEL | LDO1_EN | LDO1_VOLT_SEL | -  | -  | -  | LDO1_VOLT[1:0] |    | 0x03    | 0x18    |

| Bit    | Name           | Function                                                                                                                                                                                                                                                                                                                          | Initial |
|--------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7]   | LDO1_SEL       | LDO1 control select bit<br>0 = LDO1 ON/OFF is controlled by state machine.<br>1 = LDO1 ON/OFF is controlled by D[6] on this register.                                                                                                                                                                                             | 0       |
| D[6]   | LDO1_EN        | LDO1 control bit with condition of D[7]<br>0 = LDO1 OFF<br>1 = LDO1 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                                                                                                                                                        | 0       |
| D[5]   | LDO1_VOLT_SEL  | Select the LDO1 voltage range set by D[1:0].<br>0 = 3.0 V to 3.3 V<br>1 = 1.6 V to 1.9 V<br><br>Note: Changing LDO1 voltage value is not allowed when LDO1 is still ON.<br>In the case where this register value is changed, LDO1 should be turned OFF.                                                                           | 0       |
| D[1:0] | LDO1_VOLT[1:0] | LDO1 voltage<br>If D[5]=0,<br>00 = 3.0 V<br>01 = 3.1 V<br>10 = 3.2 V<br>11 = 3.3 V (Initial)<br>If D[5]=1,<br>00 = 1.6 V<br>01 = 1.7 V<br>10 = 1.8 V<br>11 = 1.9 V<br><br>Note: Changing LDO1 voltage value is not allowed when LDO1 is still ON.<br>In the case where this register value is changed, LDO1 should be turned OFF. | 11      |

5.3.2. LDO2  
5.3.2.1. LDO2 Block Diagram

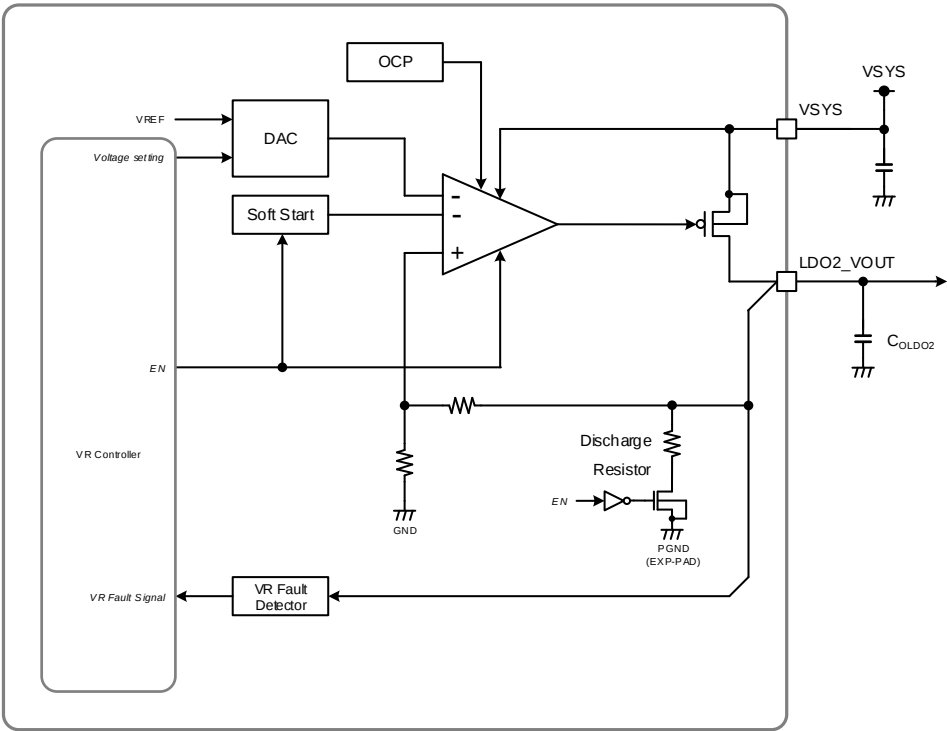


Figure 5-10. LDO2 Block Diagram

## 5.3.2.2. LDO2 Electrical Characteristics

Table 5-32. LDO2 Electrical Characteristics

(Unless otherwise specified, Ta = +25 °C, VSYS = 5.0 V, VIN\_3P3 = 3.3 V, VIN\_1P8\_1 = 1.8 V, Vo = 0.9 V setting)

| Parameter                         | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                    |
|-----------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------|
|                                   |                          | Min   | Typ   | Max   |      |                                                                                                                              |
| Output Voltage                    | V <sub>O_LDO2</sub>      | 0.885 | 0.900 | 0.915 | V    | V <sub>O</sub> =0.9 V setting<br>I <sub>O</sub> =1 mA                                                                        |
| Output Voltage Range 1            | V <sub>ORG_LDO1_1</sub>  | 0.800 | -     | 0.900 | V    | 100 mV step                                                                                                                  |
| Maximum Output Current            | I <sub>OMAX_LDO2</sub>   | 10    | -     | -     | mA   |                                                                                                                              |
| Over Current Protection           | I <sub>OCP_LDO2</sub>    | 20    | -     | -     | mA   |                                                                                                                              |
| Quiescent Current                 | I <sub>Q_LDO2</sub>      | -     | 6     | -     | μA   | I <sub>O</sub> = 0 mA                                                                                                        |
| Start up Time                     | t <sub>ST_LDO2</sub>     | -     | 370   | 1000  | μs   | I <sub>O</sub> = 0 mA,<br>During EN to 90 % of nominal Voltage                                                               |
| DC Output Voltage Load Regulation | ΔV <sub>LDR_LDO2</sub>   | -     | 10    | 20    | mV   | I <sub>O</sub> = 1 mA to I <sub>Omax</sub>                                                                                   |
| DC Output Voltage Line Regulation | ΔV <sub>LNR_LDO2</sub>   | -     | 2     | 5     | mV   | VSYS = 4.5 V to 5.5 V, I <sub>O</sub> = I <sub>Omax</sub>                                                                    |
| Discharge Resistance              | R <sub>DIS_LDO2</sub>    | -     | 100   | 200   | Ω    |                                                                                                                              |
| VR Fault Detect Level             | D <sub>VRFLDO2</sub>     | -     | 80    | -     | %    | Output = Sweep down<br>Power good detect level / V <sub>O</sub> x 100                                                        |
| VR Fault Detect Hysteresis        | D <sub>VRFLDO2_HYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                               |
| Ripple Rejection Ratio            | RR <sub>LDO2</sub>       | -     | 60    | -     | dB   | VSYS = 5.0 V, I <sub>O</sub> =I <sub>Omax</sub> /2<br>V <sub>R</sub> = -20 dBV, f <sub>R</sub> =100 Hz<br>BW=20 Hz to 20 kHz |
| Output Capacitance                | C <sub>OLD02</sub>       | 0.5   | 1.0   | 5.0   | μF   | (Note 1)<br>Effective capacitance with LDO's DC bias                                                                         |

(Note 1) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.3.2.3. LDO2 Control

Table 5-33. LDO2\_VOLT - LDO2 Voltage Register

| Register Name | R/W | D7       | D6      | D5            | D4 | D3 | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----------|---------|---------------|----|----|----|----|----|---------|---------|
| LDO2_VOLT     | R/W | LDO2_SEL | LDO2_EN | LDO2_VOLT_SEL | -  | -  | -  | -  | -  | 0x00    | 0x19    |

| Bit  | Name          | Function                                                                                                                                                                                                        | Initial |
|------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7] | LDO2_SEL      | LDO2 control select bit<br>0 = LDO2 ON/OFF is controlled by state machine.<br>1 = LDO2 ON/OFF is controlled by D[6] on this register.                                                                           | 0       |
| D[6] | LDO2_EN       | LDO2 control bit with condition of D[7]<br>0 = LDO2 OFF<br>1 = LDO2 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                                      | 0       |
| D[5] | LDO2_VOLT_SEL | Select the LDO2 voltage.<br>0 = 0.9V<br>1 = 0.8V<br><br>Note: Changing LDO2 voltage value is not allowed when LDO2 is still ON.<br>In the case where this register value is changed, LDO2 should be turned OFF. | 0       |

5.3.3. LDO3

5.3.3.1. LDO3 Block Diagram

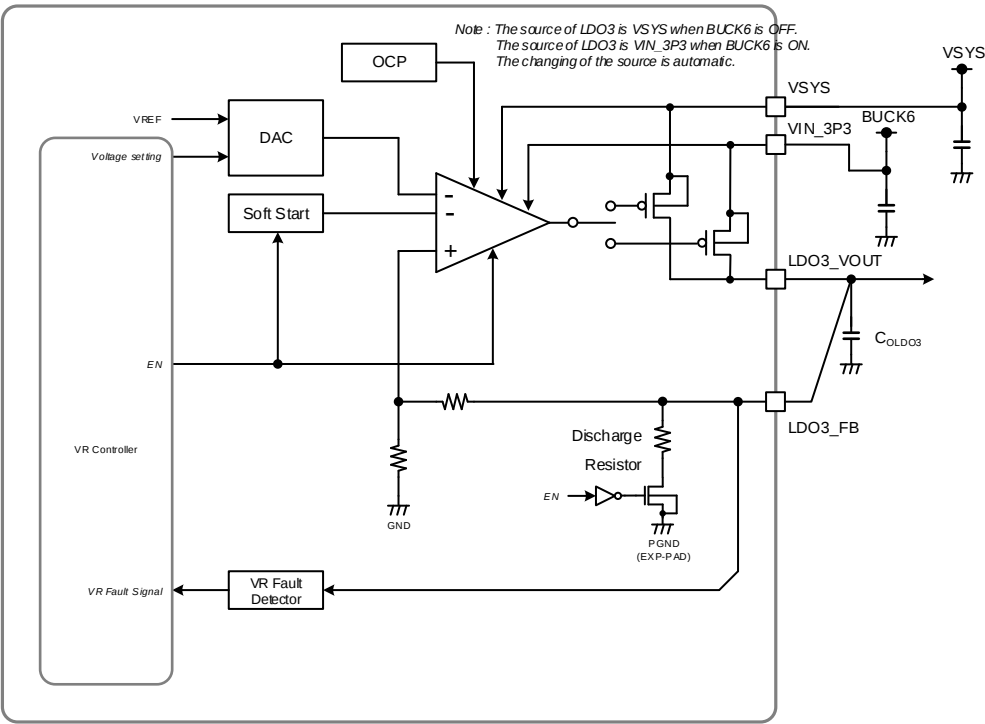


Figure 5-11. LDO3 Block Diagram

## 5.3.3.2. LDO3 Electrical Characteristics

Table 5-34. LDO3 Electrical Characteristics

(Unless otherwise specified, Ta = +25 °C, VSYS = 5.0 V, VIN\_3P3 = 3.3 V, VIN\_1P8\_1 = 1.8 V, Vo = 1.8 V setting)

| Parameter                         | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                    |
|-----------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------|
|                                   |                          | Min   | Typ   | Max   |      |                                                                                                                              |
| Output Voltage                    | V <sub>O_LDO3</sub>      | 1.782 | 1.800 | 1.818 | V    | V <sub>O</sub> =1.8 V setting<br>I <sub>O</sub> =1 mA                                                                        |
| Output Voltage Range              | V <sub>ORG_LDO3</sub>    | 1.800 | -     | 3.300 | V    | 100 mV step                                                                                                                  |
| Maximum Output Current            | I <sub>OMAX_LDO3</sub>   | 300   | -     | -     | mA   |                                                                                                                              |
| Over Current Protection           | I <sub>OCP_LDO3</sub>    | 390   | -     | -     | mA   |                                                                                                                              |
| Quiescent Current                 | I <sub>Q_LDO3</sub>      | -     | 9     | -     | μA   | I <sub>O</sub> = 0 mA                                                                                                        |
| Dropout Voltage                   | ΔV <sub>ODP_LDO3</sub>   | -     | 450   | -     | mV   | I <sub>O</sub> = I <sub>OMAX</sub><br>VIN_3P3 = 1.7 V, V <sub>O</sub> = 1.8 V setting                                        |
| Start up Time                     | t <sub>ST_LDO3</sub>     | -     | 310   | 1000  | μs   | I <sub>O</sub> = 0 mA,<br>During EN to 90 % of nominal Voltage                                                               |
| DC Output Voltage Load Regulation | ΔV <sub>LDR_LDO3</sub>   | -     | 10    | 20    | mV   | I <sub>O</sub> = 1 mA to I <sub>OMAX</sub>                                                                                   |
| DC Output Voltage Line Regulation | ΔV <sub>LNR_LDO3</sub>   | -     | 2     | 5     | mV   | VSYS = 4.5 V to 5.5 V, I <sub>O</sub> = 50 mA                                                                                |
| Discharge Resistance              | R <sub>DIS_LDO3</sub>    | -     | 100   | 200   | Ω    |                                                                                                                              |
| VR Fault Detect Level             | D <sub>VRFLDO3</sub>     | -     | 80    | -     | %    | Output = Sweep down<br>Power good detect level / V <sub>O</sub> x 100                                                        |
| VR Fault Detect Hysteresis        | D <sub>VRFLDO3_HYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                               |
| Ripple Rejection Ratio            | RR <sub>LDO3</sub>       | -     | 60    | -     | dB   | VSYS = 5.0 V, I <sub>O</sub> =I <sub>OMAX</sub> /2<br>V <sub>R</sub> = -20 dBV, f <sub>R</sub> =100 Hz<br>BW=20 Hz to 20 kHz |
| Output Capacitance                | C <sub>OLD03</sub>       | 1.1   | 2.2   | 22.0  | μF   | (Note 1)<br>Effective capacitance with LDO's DC bias                                                                         |

(Note 1) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.3.3.3. LDO3 Control

Table 5-35. LDO3\_VOLT - LDO3 Voltage Register

| Register Name | R/W | D7       | D6      | D5 | D4 | D3             | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----------|---------|----|----|----------------|----|----|----|---------|---------|
| LDO3_VOLT     | R/W | LDO3_SEL | LDO3_EN | -  | -  | LDO3_VOLT[3:0] |    |    |    | 0x00    | 0x1A    |

| Bit    | Name           | Function                                                                                                                                                                                                                                                                                                                                                                                                                              | Initial |
|--------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7]   | LDO3_SEL       | LDO3 control select bit<br>0 = LDO3 ON/OFF is controlled by state machine.<br>1 = LDO3 ON/OFF is controlled by D[6] on this register.                                                                                                                                                                                                                                                                                                 | 0       |
| D[6]   | LDO3_EN        | LDO3 control bit with condition of D[7]<br>0 = LDO3 OFF<br>1 = LDO3 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                                                                                                                                                                                                                                                            | 0       |
| D[3:0] | LDO3_VOLT[3:0] | LDO3 voltage<br>0x0 = 1.8 V (Initial)<br>0x1 = 1.9 V<br>0x2 = 2.0 V<br>0x3 = 2.1 V<br>0x4 = 2.2 V<br>0x5 = 2.3 V<br>0x6 = 2.4 V<br>0x7 = 2.5 V<br>0x8 = 2.6 V<br>0x9 = 2.7 V<br>0xA = 2.8 V<br>0xB = 2.9 V<br>0xC = 3.0 V<br>0xD = 3.1 V<br>0xE = 3.2 V<br>0xF = 3.3 V<br><br>Note: Changing LDO3 voltage value is not allowed when LDO3 is still ON.<br>In the case where this register value is changed, LDO3 should be turned OFF. | 0000    |

It is recommended that the VIN\_3P3 pin is connected to BUCK6. LDO3 power source is switched from the VSYS pin to the VIN\_3P3 pin after BUCK6 is turned on. On the other hand, LDO3 power source is switched from the VIN\_3P3 pin to the VSYS pin when BUCK6 is turned off. It takes 3 ms to complete this switching operation. Therefore, actual BUCK6 turn-off is delayed as shown in Figure 5-12.

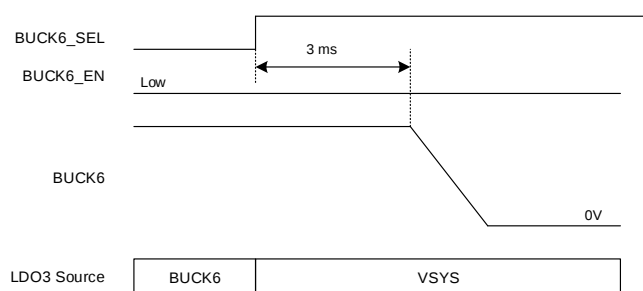


Figure 5-12. LDO3 Voltage Source Switching

5.3.4. LDO4

5.3.4.1. LDO4 Block Diagram

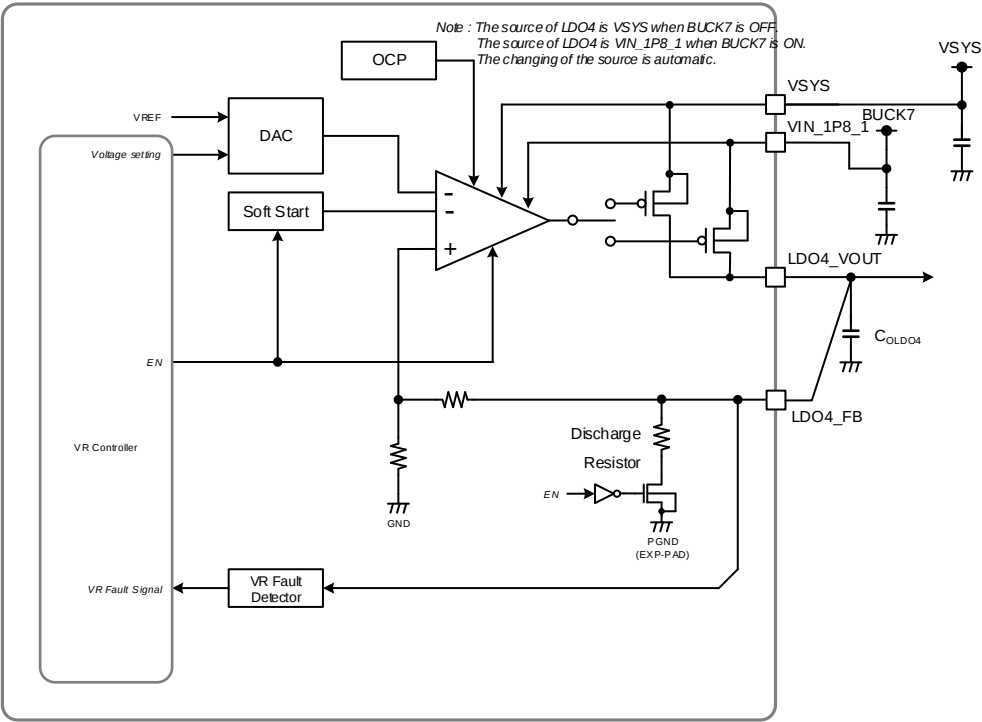


Figure 5-13. LDO4 Block Diagram

## 5.3.4.2. LDO4 Electrical Characteristics

Table 5-36. LDO4 Electrical Characteristics

(Unless otherwise specified, Ta = +25 °C, VSYS = 5.0 V, VIN\_3P3 = 3.3 V, VIN\_1P8\_1 = 1.8 V, Vo = 0.9 V setting)

| Parameter                         | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                    |
|-----------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------|
|                                   |                          | Min   | Typ   | Max   |      |                                                                                                                              |
| Output Voltage                    | V <sub>O_LDO4</sub>      | 0.885 | 0.900 | 0.915 | V    | V <sub>O</sub> =0.9 V setting<br>I <sub>O</sub> =1 mA                                                                        |
| Output Voltage Range              | V <sub>ORG_LDO4</sub>    | 0.900 | -     | 1.800 | V    | 100 mV step                                                                                                                  |
| Maximum Output Current            | I <sub>OMAX_LDO4</sub>   | 250   | -     | -     | mA   |                                                                                                                              |
| Over Current Protection           | I <sub>OCP_LDO4</sub>    | 325   | -     | -     | mA   |                                                                                                                              |
| Quiescent Current                 | I <sub>Q_LDO4</sub>      | -     | 9     | -     | μA   | I <sub>O</sub> = 0 mA                                                                                                        |
| Dropout Voltage                   | ΔV <sub>ODP_LDO4</sub>   | -     | 450   | -     | mV   | I <sub>O</sub> = I <sub>OMAX</sub><br>VIN_V1P8_1 = 1.7 V, V <sub>O</sub> = 1.8 V setting                                     |
| Start up Time                     | t <sub>ST_LDO4</sub>     | -     | 400   | 1000  | μs   | I <sub>O</sub> = 0 mA,<br>During EN to 90 % of nominal Voltage                                                               |
| DC Output Voltage Load Regulation | ΔV <sub>LDR_LDO4</sub>   | -     | 10    | 20    | mV   | I <sub>O</sub> = 1 mA to I <sub>OMAX</sub>                                                                                   |
| DC Output Voltage Line Regulation | ΔV <sub>LNR_LDO4</sub>   | -     | 2     | 5     | mV   | VSYS = 4.5 V to 5.5 V, I <sub>O</sub> = 50 mA                                                                                |
| Discharge Resistance              | R <sub>DIS_LDO4</sub>    | -     | 100   | 200   | Ω    |                                                                                                                              |
| VR Fault Detect Level             | D <sub>VRFLDO4</sub>     | -     | 80    | -     | %    | Output = Sweep down<br>Power good detect level / V <sub>O</sub> x 100                                                        |
| VR Fault Detect Hysteresis        | D <sub>VRFLDO4_HYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                               |
| Ripple Rejection Ratio            | RR <sub>LDO4</sub>       | -     | 60    | -     | dB   | VSYS = 5.0 V, I <sub>O</sub> =I <sub>OMAX</sub> /2<br>V <sub>R</sub> = -20 dBV, f <sub>R</sub> =100 Hz<br>BW=20 Hz to 20 kHz |
| Output Capacitance                | C <sub>OLD04</sub>       | 1.1   | 2.2   | 22.0  | μF   | (Note 1)<br>Effective capacitance with LDO's DC bias                                                                         |

(Note 1) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.3.4.3. LDO4 Control

Table 5-37. LDO4\_VOLT - LDO4 Voltage Register

| Register Name | R/W | D7       | D6      | D5 | D4 | D3             | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----------|---------|----|----|----------------|----|----|----|---------|---------|
| LDO4_VOLT     | R/W | LDO4_SEL | LDO4_EN | -  | -  | LDO4_VOLT[3:0] |    |    |    | 0x00    | 0x1B    |

| Bit    | Name           | Function                                                                                                                                                                                                                                                                                                                                                                                                                              | Initial |
|--------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7]   | LDO4_SEL       | LDO4 control select bit<br>0 = LDO4 ON/OFF is controlled by state machine.<br>1 = LDO4 ON/OFF is controlled by D[6] on this register.                                                                                                                                                                                                                                                                                                 | 0       |
| D[6]   | LDO4_EN        | LDO4 control bit with condition of D[7]<br>0 = LDO4 OFF<br>1 = LDO4 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                                                                                                                                                                                                                                                            | 0       |
| D[3:0] | LDO4_VOLT[3:0] | LDO4 voltage<br>0x0 = 0.9 V (Initial)<br>0x1 = 1.0 V<br>0x2 = 1.1 V<br>0x3 = 1.2 V<br>0x4 = 1.3 V<br>0x5 = 1.4 V<br>0x6 = 1.5 V<br>0x7 = 1.6 V<br>0x8 = 1.7 V<br>0x9 = 1.8 V<br>0xA = 1.8 V<br>0xB = 1.8 V<br>0xC = 1.8 V<br>0xD = 1.8 V<br>0xE = 1.8 V<br>0xF = 1.8 V<br><br>Note: Changing LDO4 voltage value is not allowed when LDO4 is still ON.<br>In the case where this register value is changed, LDO4 should be turned OFF. | 0000    |

It is recommended that the VIN\_1P8\_1 pin is connected to BUCK7. LDO4 power source is switched from the VSYS pin to the VIN\_1P8\_1 pin after BUCK7 is turned on. On the other hand, LDO4 power source is switched from the VIN\_1P8\_1 pin to the VSYS pin when BUCK7 is turned off. It takes 3 ms to complete this switching operation. Therefore, actual BUCK7 turn-off is delayed as shown in Figure 5-14.

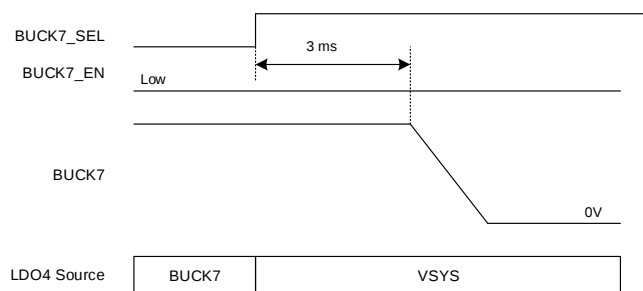


Figure 5-14. LDO4 Voltage Source Switching

5.3.5. LDO5  
5.3.5.1. LDO5 Block Diagram

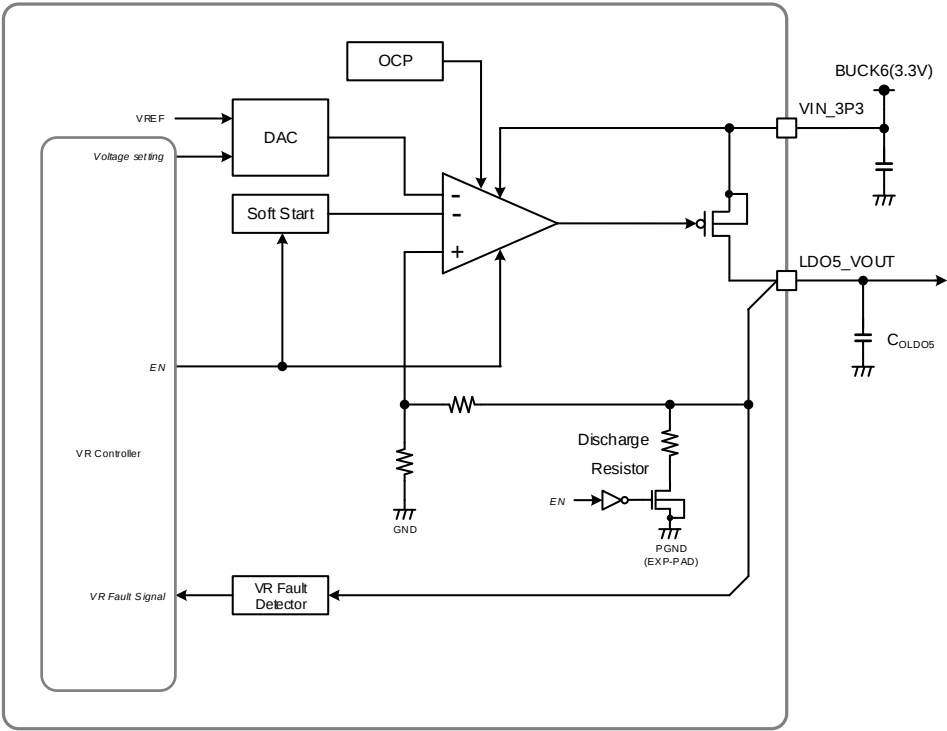


Figure 5-15. LDO5 Block Diagram

## 5.3.5.2. LDO5 Electrical Characteristics

Table 5-38. LDO5 Electrical Characteristics

(Unless otherwise specified, Ta = +25 °C, VSYS = 5.0 V, VIN\_3P3 = 3.3 V, VIN\_1P8\_1 = 1.8 V, Vo = 1.8 V setting)

| Parameter                         | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                    |
|-----------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------|
|                                   |                          | Min   | Typ   | Max   |      |                                                                                                                              |
| Output Voltage                    | V <sub>O_LDO5</sub>      | 1.782 | 1.800 | 1.818 | V    | V <sub>O</sub> =1.8 V setting<br>I <sub>O</sub> =1 mA                                                                        |
| Output Voltage Range              | V <sub>ORG_LDO5</sub>    | 1.800 | -     | 3.300 | V    | 100 mV step                                                                                                                  |
| Maximum Output Current            | I <sub>OMAX_LDO5</sub>   | 300   | -     | -     | mA   |                                                                                                                              |
| Over Current Protection           | I <sub>OCP_LDO5</sub>    | 390   | -     | -     | mA   |                                                                                                                              |
| Quiescent Current                 | I <sub>Q_LDO5</sub>      | -     | 9     | -     | μA   | I <sub>O</sub> = 0 mA                                                                                                        |
| Dropout Voltage                   | ΔV <sub>ODP_LDO5</sub>   | -     | 650   | -     | mV   | I <sub>O</sub> = I <sub>OMAX</sub><br>VIN_3P3 = 1.7 V, V <sub>O</sub> = 1.8 V setting                                        |
| Start up Time                     | t <sub>ST_LDO5</sub>     | -     | 310   | 1000  | μs   | I <sub>O</sub> = 0 mA,<br>During EN to 90 % of nominal Voltage                                                               |
| DC Output Voltage Load Regulation | ΔV <sub>LDR_LDO5</sub>   | -     | 10    | 20    | mV   | I <sub>O</sub> = 1 mA to I <sub>OMAX</sub>                                                                                   |
| DC Output Voltage Line Regulation | ΔV <sub>LNR_LDO5</sub>   | -     | 2     | 5     | mV   | VSYS = 4.5 V to 5.5 V, I <sub>O</sub> = 50 mA                                                                                |
| Discharge Resistance              | R <sub>DIS_LDO5</sub>    | -     | 100   | 200   | Ω    |                                                                                                                              |
| VR Fault Detect Level             | D <sub>VRFLDO5</sub>     | -     | 80    | -     | %    | Output = Sweep down<br>Power good detect level / V <sub>O</sub> x 100                                                        |
| VR Fault Detect Hysteresis        | D <sub>VRFLDO5_HYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                               |
| Ripple Rejection Ratio            | RR <sub>LDO5</sub>       | -     | 60    | -     | dB   | VSYS = 5.0 V, I <sub>O</sub> =I <sub>OMAX</sub> /2<br>V <sub>R</sub> = -20 dBV, f <sub>R</sub> =100 Hz<br>BW=20 Hz to 20 kHz |
| Output Capacitance                | C <sub>OLD05</sub>       | 1.1   | 2.2   | 22.0  | μF   | (Note 1)<br>Effective capacitance with LDO's DC bias                                                                         |

(Note 1) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.3.5.3. LDO5 Control

Table 5-39. LDO5\_VOLT - LDO5 Voltage Register

| Register Name | R/W | D7       | D6      | D5 | D4 | D3             | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----------|---------|----|----|----------------|----|----|----|---------|---------|
| LDO5_VOLT     | R/W | LDO5_SEL | LDO5_EN | -  | -  | LDO5_VOLT[3:0] |    |    |    | 0x00    | 0x1C    |

| Bit    | Name           | Function                                                                                                                                                                                                                                                                                                                                                                                                                              | Initial |
|--------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7]   | LDO5_SEL       | LDO5 control select bit<br>0 = LDO5 ON/OFF is controlled by state machine.<br>1 = LDO5 ON/OFF is controlled by D[6] on this register.                                                                                                                                                                                                                                                                                                 | 0       |
| D[6]   | LDO5_EN        | LDO5 control bit with condition of D[7]<br>0 = LDO5 OFF<br>1 = LDO5 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                                                                                                                                                                                                                                                            | 0       |
| D[3:0] | LDO5_VOLT[3:0] | LDO5 voltage<br>0x0 = 1.8 V (Initial)<br>0x1 = 1.9 V<br>0x2 = 2.0 V<br>0x3 = 2.1 V<br>0x4 = 2.2 V<br>0x5 = 2.3 V<br>0x6 = 2.4 V<br>0x7 = 2.5 V<br>0x8 = 2.6 V<br>0x9 = 2.7 V<br>0xA = 2.8 V<br>0xB = 2.9 V<br>0xC = 3.0 V<br>0xD = 3.1 V<br>0xE = 3.2 V<br>0xF = 3.3 V<br><br>Note: Changing LDO5 voltage value is not allowed when LDO5 is still ON.<br>In the case where this register value is changed, LDO5 should be turned OFF. | 0000    |

5.3.6. LDO6  
5.3.6.1. LDO6 Block Diagram

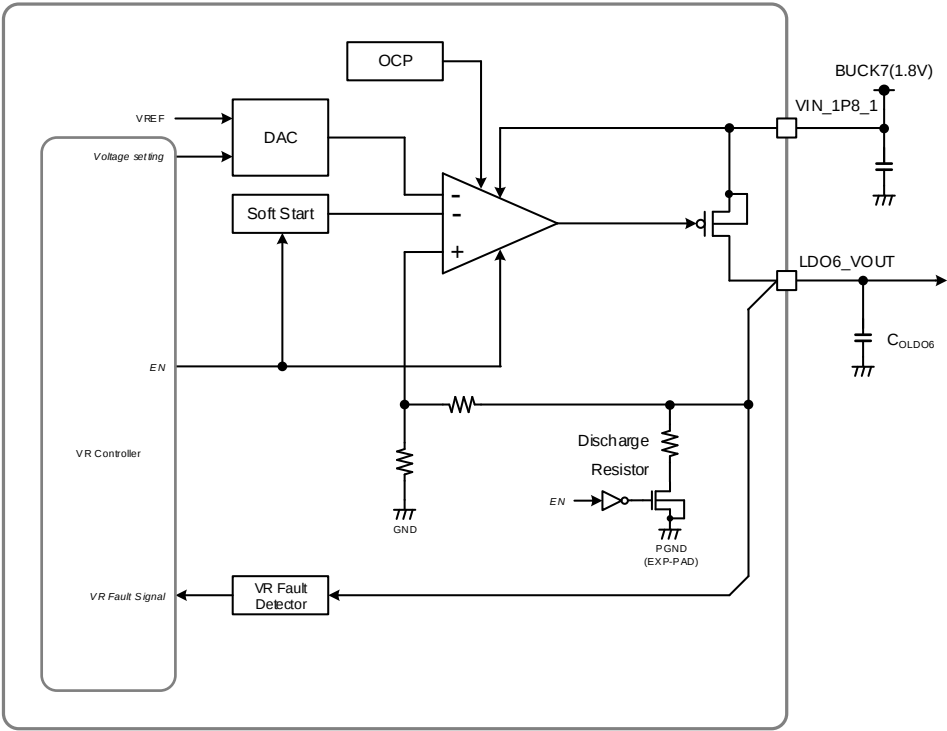


Figure 5-16. LDO6 Block Diagram

## 5.3.6.2. LDO6 Electrical Characteristics

Table 5-40. LDO6 Electrical Characteristics

(Unless otherwise specified, Ta = +25 °C, VSYS = 5.0 V, VIN\_3P3 = 3.3 V, VIN\_1P8\_1 = 1.8 V, Vo = 0.9 V setting)

| Parameter                         | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                    |
|-----------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------|
|                                   |                          | Min   | Typ   | Max   |      |                                                                                                                              |
| Output Voltage                    | V <sub>O_LDO6</sub>      | 0.885 | 0.900 | 0.915 | V    | V <sub>O</sub> =0.9 V setting<br>I <sub>O</sub> =1 mA                                                                        |
| Output Voltage Range              | V <sub>ORG_LDO6</sub>    | 0.900 | -     | 1.800 | V    | 100 mV step                                                                                                                  |
| Maximum Output Current            | I <sub>OMAX_LDO6</sub>   | 300   | -     | -     | mA   |                                                                                                                              |
| Over Current Protection           | I <sub>OCP_LDO6</sub>    | 340   | -     | -     | mA   |                                                                                                                              |
| Quiescent Current                 | I <sub>Q_LDO6</sub>      | -     | 9     | -     | μA   | I <sub>O</sub> = 0 mA                                                                                                        |
| Dropout Voltage                   | ΔV <sub>ODP_LDO6</sub>   | -     | 450   | -     | mV   | I <sub>O</sub> = I <sub>OMAX</sub><br>VIN_1P8_1 = 1.7 V, V <sub>O</sub> = 1.8 V setting                                      |
| Start up Time                     | t <sub>ST_LDO6</sub>     | -     | 400   | 1000  | μs   | I <sub>O</sub> = 0 mA,<br>During EN to 90 % of nominal Voltage                                                               |
| DC Output Voltage Load Regulation | ΔV <sub>LDR_LDO6</sub>   | -     | 10    | 20    | mV   | I <sub>O</sub> = 1 mA to I <sub>OMAX</sub>                                                                                   |
| DC Output Voltage Line Regulation | ΔV <sub>LNR_LDO6</sub>   | -     | 2     | 5     | mV   | VSYS = 4.5 V to 5.5 V, I <sub>O</sub> = 50 mA                                                                                |
| Discharge Resistance              | R <sub>DIS_LDO6</sub>    | -     | 100   | 200   | Ω    |                                                                                                                              |
| VR Fault Detect Level             | D <sub>VRFLDO6</sub>     | -     | 80    | -     | %    | Output = Sweep down<br>Power good detect level / V <sub>O</sub> x 100                                                        |
| VR Fault Detect Hysteresis        | D <sub>VRFLDO6_HYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                               |
| Ripple Rejection Ratio            | RR <sub>LDO6</sub>       | -     | 60    | -     | dB   | VSYS = 5.0 V, I <sub>O</sub> =I <sub>OMAX</sub> /2<br>V <sub>R</sub> = -20 dBV, f <sub>R</sub> =100 Hz<br>BW=20 Hz to 20 kHz |
| Output Capacitance                | C <sub>OLD06</sub>       | 1.1   | 2.2   | 22.0  | μF   | (Note 1)<br>Effective capacitance with LDO's DC bias                                                                         |

(Note 1) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.3.6.3. LDO6 Control

Table 5-41. LDO6\_VOLT - LDO6 Voltage Register

| Register Name | R/W | D7       | D6      | D5 | D4 | D3             | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----------|---------|----|----|----------------|----|----|----|---------|---------|
| LDO6_VOLT     | R/W | LDO6_SEL | LDO6_EN | -  | -  | LDO6_VOLT[3:0] |    |    |    | 0x00    | 0x1D    |

| Bit    | Name           | Function                                                                                                                                                                                                                                                                                                                                                                                                                              | Initial |
|--------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7]   | LDO6_SEL       | LDO6 control select bit<br>0 = LDO6 ON/OFF is controlled by state machine.<br>1 = LDO6 ON/OFF is controlled by D[6] on this register.                                                                                                                                                                                                                                                                                                 | 0       |
| D[6]   | LDO6_EN        | LDO6 control bit with condition of D[7]<br>0 = LDO6 OFF<br>1 = LDO6 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                                                                                                                                                                                                                                                            | 0       |
| D[3:0] | LDO6_VOLT[3:0] | LDO6 voltage<br>0x0 = 0.9 V (Initial)<br>0x1 = 1.0 V<br>0x2 = 1.1 V<br>0x3 = 1.2 V<br>0x4 = 1.3 V<br>0x5 = 1.4 V<br>0x6 = 1.5 V<br>0x7 = 1.6 V<br>0x8 = 1.7 V<br>0x9 = 1.8 V<br>0xA = 1.8 V<br>0xB = 1.8 V<br>0xC = 1.8 V<br>0xD = 1.8 V<br>0xE = 1.8 V<br>0xF = 1.8 V<br><br>Note: Changing LDO6 voltage value is not allowed when LDO6 is still ON.<br>In the case where this register value is changed, LDO6 should be turned OFF. | 0000    |

5.3.7. LDO7  
5.3.7.1. LDO7 Block Diagram

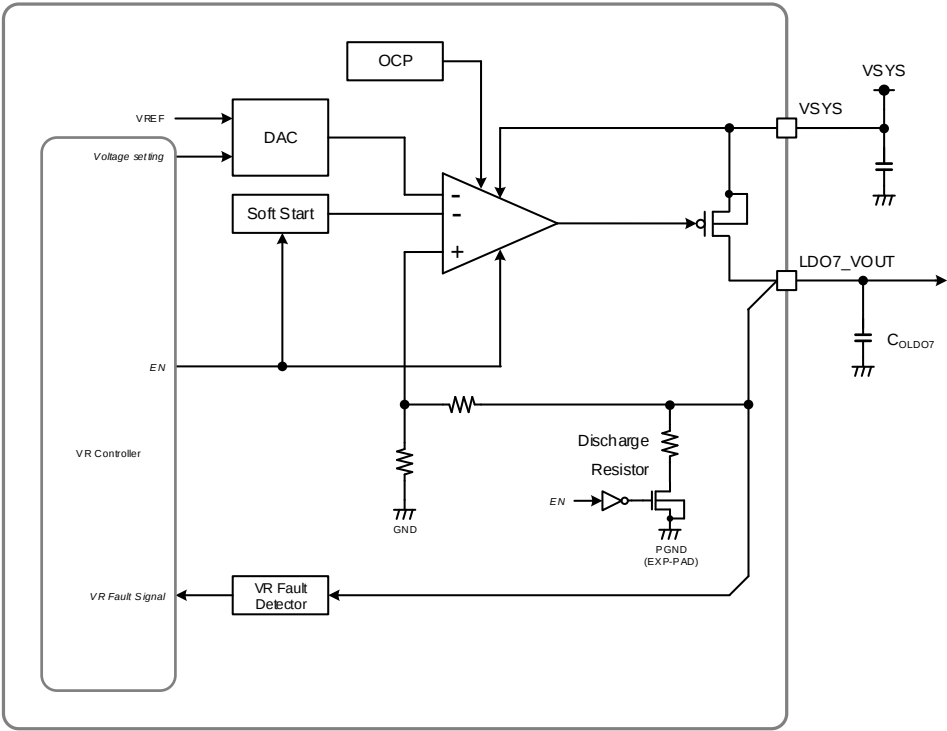


Figure 5-17. LDO7 Block Diagram

## 5.3.7.2. LDO7 Electrical Characteristics

Table 5-42. LDO7 Electrical Characteristics

(Unless otherwise specified, Ta = +25 °C, VSYS = 5.0 V, VIN\_3P3 = 3.3 V, VIN\_1P8\_1 = 1.8 V, Vo = 3.3 V setting)

| Parameter                         | Symbol                   | Limit |       |       | Unit | Condition                                                                                                                    |
|-----------------------------------|--------------------------|-------|-------|-------|------|------------------------------------------------------------------------------------------------------------------------------|
|                                   |                          | Min   | Typ   | Max   |      |                                                                                                                              |
| Output Voltage                    | V <sub>O_LDO7</sub>      | 3.267 | 3.300 | 3.333 | V    | V <sub>O</sub> =3.3 V setting<br>I <sub>O</sub> =1 mA                                                                        |
| Output Voltage Range              | V <sub>ORG_LDO7</sub>    | 1.800 | -     | 3.300 | V    | 100 mV step                                                                                                                  |
| Maximum Output Current            | I <sub>OMAX_LDO7</sub>   | 150   | -     | -     | mA   |                                                                                                                              |
| Over Current Protection           | I <sub>OCP_LDO7</sub>    | 195   | -     | -     | mA   |                                                                                                                              |
| Quiescent Current                 | I <sub>Q_LDO7</sub>      | -     | 9     | -     | μA   | I <sub>O</sub> = 0 mA                                                                                                        |
| Dropout Voltage                   | ΔV <sub>ODP_LDO7</sub>   | -     | 90    | -     | mV   | I <sub>O</sub> = I <sub>OMAX</sub><br>VSYS = 3.2 V, V <sub>O</sub> = 3.3 V setting                                           |
| Start up Time                     | t <sub>ST_LDO7</sub>     | -     | 530   | 1000  | μs   | I <sub>O</sub> = 0 mA,<br>During EN to 90 % of nominal Voltage                                                               |
| DC Output Voltage Load Regulation | ΔV <sub>LDR_LDO7</sub>   | -     | 10    | 20    | mV   | I <sub>O</sub> = 1 mA to I <sub>OMAX</sub>                                                                                   |
| DC Output Voltage Line Regulation | ΔV <sub>LNR_LDO7</sub>   | -     | 2     | 5     | mV   | VSYS = 4.5 V to 5.5 V, I <sub>O</sub> = I <sub>OMAX</sub>                                                                    |
| Discharge Resistance              | R <sub>DIS_LDO7</sub>    | -     | 100   | 200   | Ω    |                                                                                                                              |
| VR Fault Detect Level             | D <sub>VRFLDO7</sub>     | -     | 80    | -     | %    | Output = Sweep down<br>Power good detect level / V <sub>O</sub> x 100                                                        |
| VR Fault Detect Hysteresis        | D <sub>VRFLDO7_HYS</sub> | -     | 10    | -     | %    | (VR fault release level - detect level) / V <sub>O</sub> x 100                                                               |
| Ripple Rejection Ratio            | RR <sub>LDO7</sub>       | -     | 60    | -     | dB   | VSYS = 5.0 V, I <sub>O</sub> =I <sub>OMAX</sub> /2<br>V <sub>R</sub> = -20 dBV, f <sub>R</sub> =100 Hz<br>BW=20 Hz to 20 kHz |
| Output Capacitance                | C <sub>OLD07</sub>       | 1.1   | 2.2   | 22.0  | μF   | (Note 1)<br>Effective capacitance with LDO's DC bias                                                                         |

(Note 1) This part value range need to be guaranteed over the operating surrounding temperature.

## 5.3.7.3. LDO7 Control

Table 5-43. LDO7\_VOLT - LDO7 Voltage Register

| Register Name | R/W | D7       | D6      | D5 | D4 | D3             | D2 | D1 | D0 | Initial | Address |
|---------------|-----|----------|---------|----|----|----------------|----|----|----|---------|---------|
| LDO7_VOLT     | R/W | LDO7_SEL | LDO7_EN | -  | -  | LDO7_VOLT[3:0] |    |    |    | 0x0F    | 0x1E    |

| Bit    | Name           | Function                                                                                                                                                                                                                                                                                                                                                                                                                              | Initial |
|--------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| D[7]   | LDO7_SEL       | LDO7 control select bit<br>0 = LDO7 ON/OFF is controlled by state machine.<br>1 = LDO7 ON/OFF is controlled by D[6] on this register.                                                                                                                                                                                                                                                                                                 | 0       |
| D[6]   | LDO7_EN        | LDO7 control bit with condition of D[7]<br>0 = LDO7 OFF<br>1 = LDO7 ON<br>This bit returns to 0 at the beginning of PWROFF sequence or emergency shutdown.                                                                                                                                                                                                                                                                            | 0       |
| D[3:0] | LDO7_VOLT[3:0] | LDO7 voltage<br>0x0 = 1.8 V<br>0x1 = 1.9 V<br>0x2 = 2.0 V<br>0x3 = 2.1 V<br>0x4 = 2.2 V<br>0x5 = 2.3 V<br>0x6 = 2.4 V<br>0x7 = 2.5 V<br>0x8 = 2.6 V<br>0x9 = 2.7 V<br>0xA = 2.8 V<br>0xB = 2.9 V<br>0xC = 3.0 V<br>0xD = 3.1 V<br>0xE = 3.2 V<br>0xF = 3.3 V (Initial)<br><br>Note: Changing LDO7 voltage value is not allowed when LDO7 is still ON.<br>In the case where this register value is changed, LDO7 should be turned OFF. | 1111    |

5.4. MUXSW  
MUX Switch is for SD card power.

5.4.1. MUXSW Block Diagram

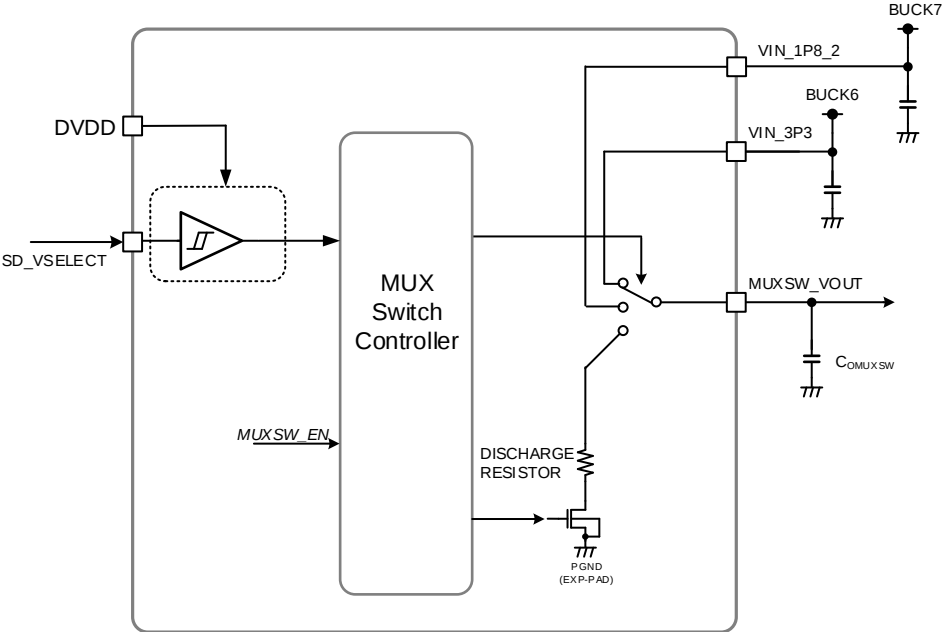


Figure 5-18. MUXSW Block Diagram

## 5.4.2. MUXSW Electrical Characteristics

Table 5-44. MUXSW Electrical Characteristics

(Unless otherwise specified, Ta = +25 °C, VSYS = 5.0 V, VIN\_3P3 = 3.3 V, VIN\_1P8\_2 = 1.8 V, Vo = 3.3 V setting)

| Parameter                        | Symbol                | Limit |       |     | Unit | Condition                                             |
|----------------------------------|-----------------------|-------|-------|-----|------|-------------------------------------------------------|
|                                  |                       | Min   | Typ   | Max |      |                                                       |
| VIN_3P3 Input Voltage            | V <sub>IN_3P3</sub>   | -     | 3.300 | -   | V    |                                                       |
| Switch ON Resistance(3.3 V mode) | R <sub>ON_3P3</sub>   | -     | -     | 280 | mΩ   | SD_VSELECT=0 V, VIN_3P3>3.2 V                         |
| VIN_1P8_2 Input Voltage          | V <sub>IN_1P8</sub>   | -     | 1.800 | -   | V    |                                                       |
| Switch ON Resistance(1.8 V mode) | R <sub>ON_1P8</sub>   | -     | -     | 200 | mΩ   | SD_VSELECT=DVDD, VIN_1P8_2>1.7 V                      |
| Maximum Output Current           | I <sub>OMAX_MUX</sub> | 150   | -     | -   | mA   |                                                       |
| Discharge Resistance             | R <sub>DIS_MUX</sub>  | -     | 30    | 60  | Ω    | VIN_1P8_2=0 V, VIN_3P3=0 V, I <sub>O</sub> =-10 mA    |
| Output Capacitance               | C <sub>O_MUX</sub>    | 11    | 22    | 33  | μF   | (Note 1)<br>Effective capacitance with Output voltage |

(Note 1) This part value range need to be guaranteed over the operating surrounding temperature.

Table 5-45. SD\_VSELECT Electrical Characteristics

(Unless otherwise specified, Ta=25 °C, DVDD=3.3V)

| Parameter       | Symbol             | Limit         |     |               | Unit | Condition |
|-----------------|--------------------|---------------|-----|---------------|------|-----------|
|                 |                    | Min           | Typ | Max           |      |           |
| Input "H" Level | V <sub>IHSDV</sub> | DVDD<br>x0.75 | -   | -             | V    |           |
| Input "L" Level | V <sub>ILSDV</sub> | -             | -   | DVDD<br>x0.25 | V    |           |

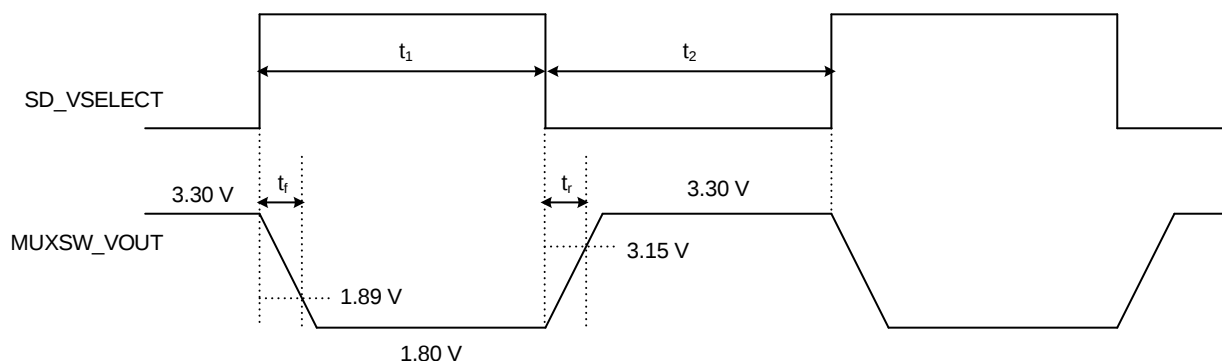


Figure 5-19. MUXSW Sequence

Table 5-46. MUXSW Sequence Timing

| Symbol         | Description                             | Min | Typ | Max | Unit |
|----------------|-----------------------------------------|-----|-----|-----|------|
| t <sub>1</sub> | SD_VSELCT High Time <sup>(Note 1)</sup> | 2   | -   | -   | ms   |
| t <sub>2</sub> | SD_VSELCT Low Time <sup>(Note 1)</sup>  | 2   | -   | -   | ms   |
| t <sub>f</sub> | Transition Time 3.3 V to 1.8 V          | -   | -   | 1   | ms   |
| t <sub>r</sub> | Transition Time 1.8 V to 3.3 V          | -   | -   | 1   | ms   |

(Note 1) t<sub>1</sub> and t<sub>2</sub> need over 2ms.

Table 5-47. MUXSW\_EN - MUXSW Enable Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0       | Initial | Address |
|---------------|-----|----|----|----|----|----|----|----|----------|---------|---------|
| MUXSW_EN      | R/W | -  | -  | -  | -  | -  | -  | -  | MUXSW_EN | 0x01    | 0x30    |

| Bit  | Name     | Function                                           | Initial |
|------|----------|----------------------------------------------------|---------|
| D[0] | MUXSW_EN | MUXSW control bit<br>0 = MUXSW OFF<br>1 = MUXSW ON | 1       |

## 6. 32.768 kHz Crystal Oscillator Driver

### 6.1. 32.768 kHz Crystal Oscillator Driver Block Diagram

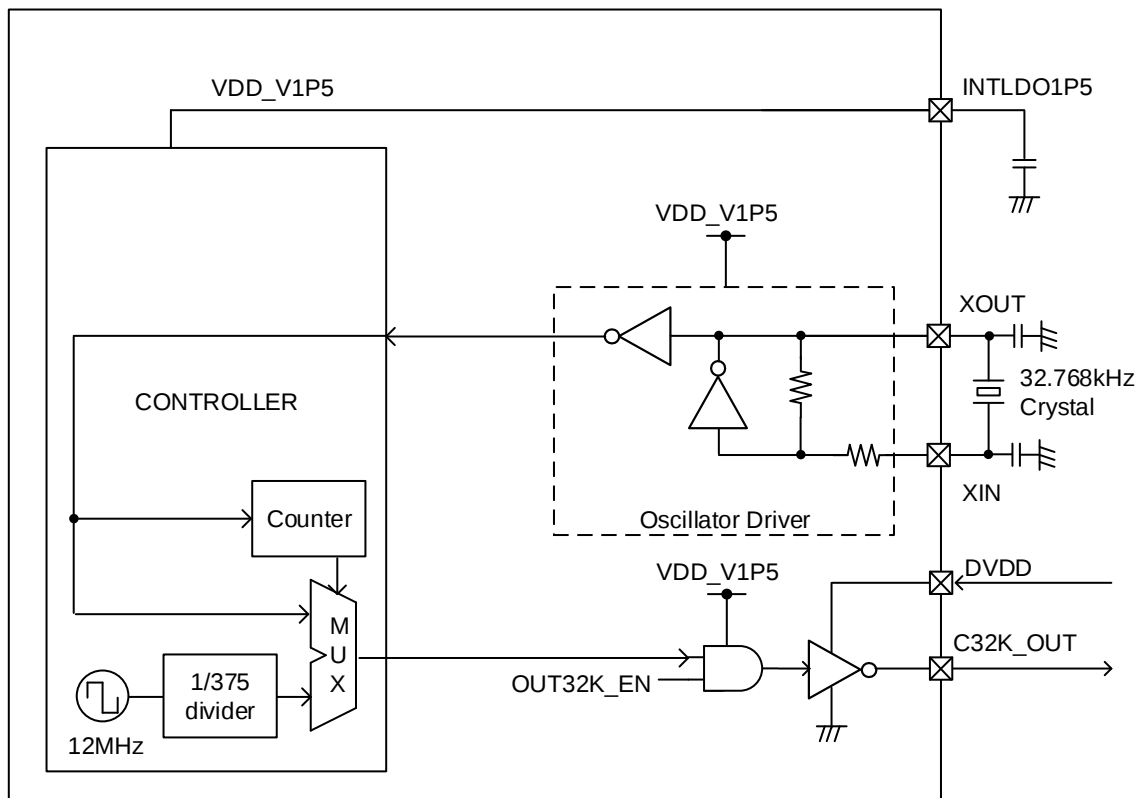


Figure 6-1. 32.768 kHz Crystal Oscillator Driver Block Diagram

Table 6-1. C32K\_OUT Control Register

| Register Name | R/W | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0        | Initial | Address |
|---------------|-----|----|----|----|----|----|----|----|-----------|---------|---------|
| OUT32K        | R/W | -  | -  | -  | -  | -  | -  | -  | OUT32K_EN | 0x01    | 0x2E    |

| Bit  | Name      | Function                                          | Initial |
|------|-----------|---------------------------------------------------|---------|
| D[0] | OUT32K_EN | 0 = Disable (C32K_OUT is Low level)<br>1 = Enable | 1       |

The C32K\_OUT pin outputs 32kHz pulse which is divided internal oscillator output(12 MHz/375), at the beginning of the power on sequence. The C32K\_OUT pin output is switched automatically from internal oscillator to 32.768 kHz crystal oscillator driver after 32.768 kHz crystal oscillator driver is begun oscillating stably. The internal controller counts 32.768 kHz crystal oscillator outputs. It judges that the oscillating is stable when the counter expires 3000 counts.

### 6.2. 32.768 kHz Crystal Oscillator Driver Electrical Characteristics

Table 6-2. 32.768 kHz Crystal Oscillator Driver Electrical Characteristics

(Unless otherwise specified, Ta = +25 °C, VSYS = 5.0 V, DVDD = 3.3 V)

| Parameter              | Symbol      | Limit |        |     | Unit | Condition                |
|------------------------|-------------|-------|--------|-----|------|--------------------------|
|                        |             | Min   | Typ    | Max |      |                          |
| Output Frequency       | $f_{RTCLK}$ | -     | 32.768 | -   | kHz  | With external crystal    |
| Output Duty Cycle      |             | 40    | 50     | 60  | %    |                          |
| Output H Level Voltage | $V_{OH32K}$ | 2.64  | -      | -   | V    | $I_{OH} = -1 \text{ mA}$ |
| Output L Level Voltage | $V_{OL32K}$ | -     | -      | 0.4 | V    | $I_{OL} = 1 \text{ mA}$  |

(Note) The following 32.768 kHz crystal is recommended.  
ST3215SB32768H5HPWAA (KYOCERA:  $C_L=12.5 \text{ pF}$ )

## 7. Operational Notes

### 1. Reverse Connection of Power Supply

Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

### 2. Power Supply Lines

Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

### 3. Ground Voltage

Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

### 4. Ground Wiring Pattern

When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

### 5. Recommended Operating Conditions

The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

### 6. Inrush Current

When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

### 7. Operation Under Strong Electromagnetic Field

Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

### 8. Testing on Application Boards

When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

## 7. Operational Notes – continued

### 9. Inter-pin Short and Mounting Errors

Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

### 10. Unused Input Pins

Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

### 11. Regarding the Input Pin of the IC

This monolithic IC contains P<sup>+</sup> isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.

When GND > Pin B, the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

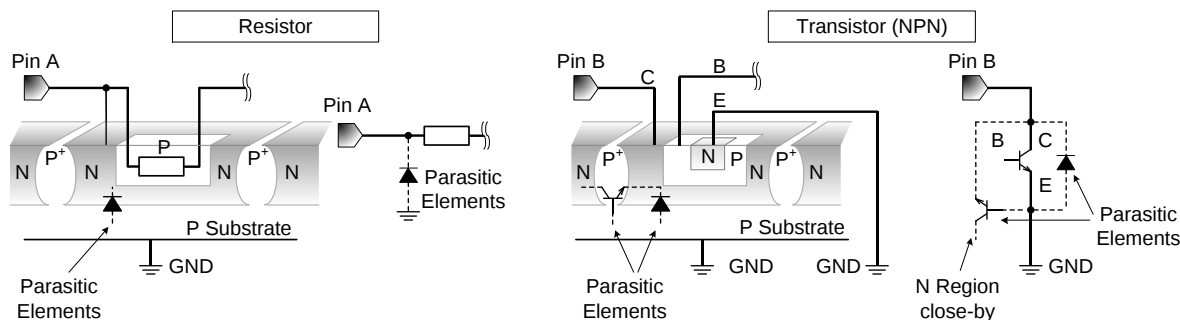


Figure 7-1. Example of Monolithic IC Structure

### 12. Ceramic Capacitor

When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

### 13. Area of Safe Operation (ASO)

Operate the IC such that the output voltage, output current, and the maximum junction temperature rating are all within the Area of Safe Operation (ASO).

### 14. Thermal Shutdown Circuit(TSD)

This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature ( $T_j$ ) will rise which will activate the TSD circuit that will turn OFF power output pins. When the  $T_j$  falls below the TSD threshold, the circuits are automatically restored to normal operation.

Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

### 15. Over Current Protection Circuit (OCP)

This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

8. Ordering Information

|                       |  |  |  |  |  |  |  |  |  |  |                              |                                                                   |
|-----------------------|--|--|--|--|--|--|--|--|--|--|------------------------------|-------------------------------------------------------------------|
| B D 7 1 8 3 7 A M W V |  |  |  |  |  |  |  |  |  |  | -                            | E 2                                                               |
| Part Number           |  |  |  |  |  |  |  |  |  |  | Package<br>MWV: UQFN68CV8080 | Packaging and forming specification<br>E2: Embossed tape and reel |

9. Marking Diagram

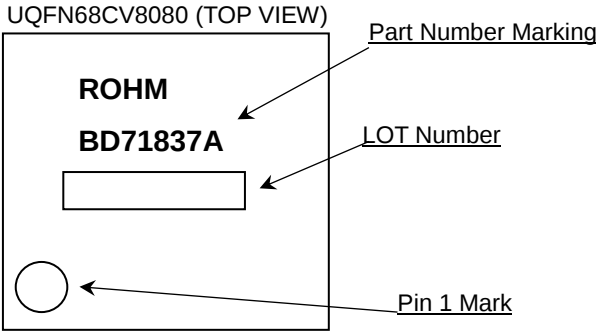
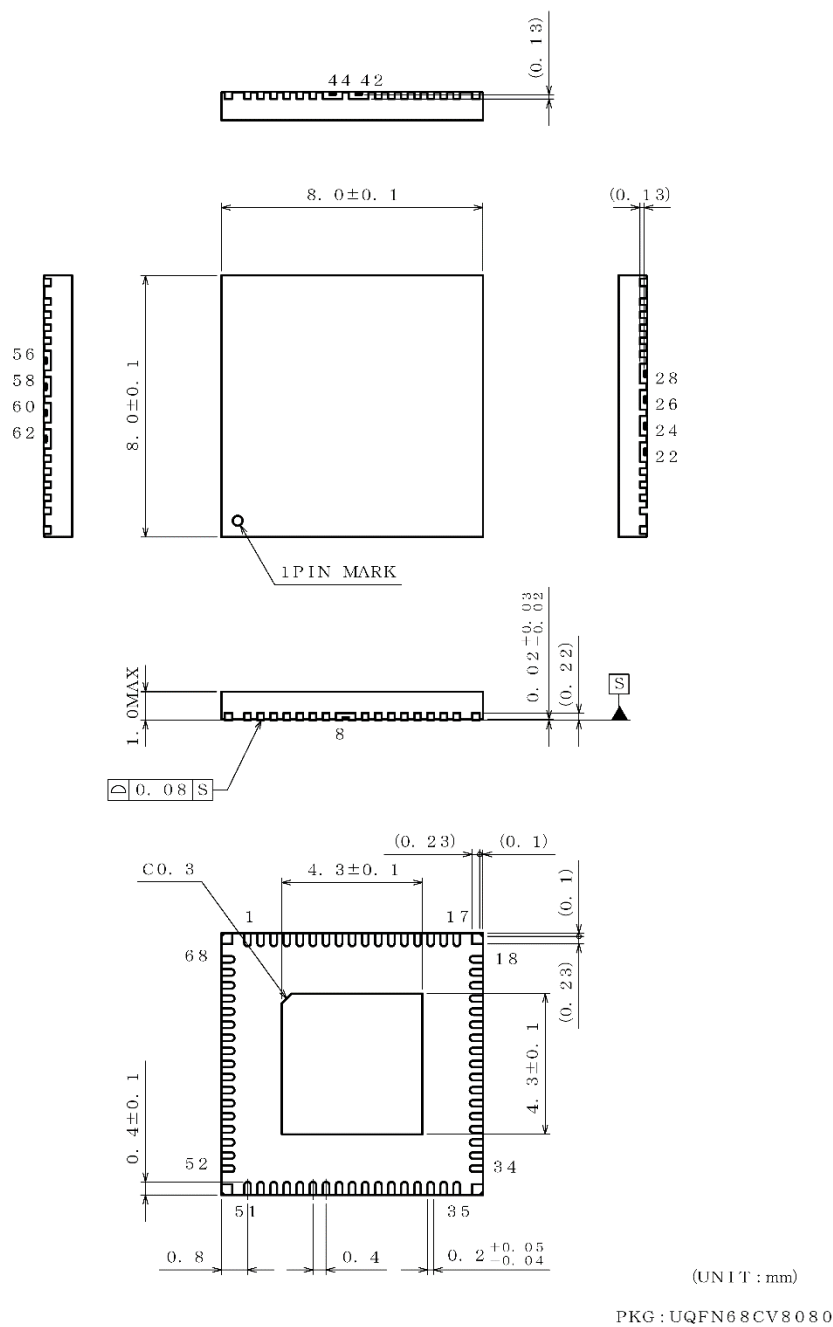


Figure 9-1. Marking Diagram

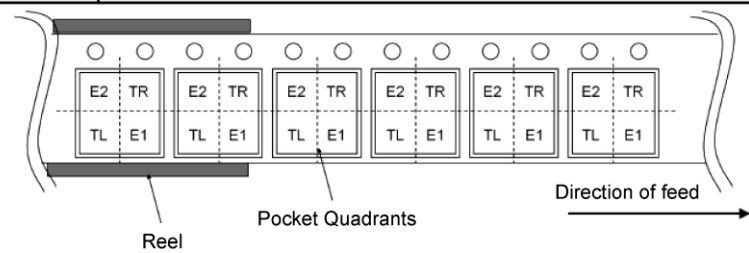
10. Physical Dimension and Packing Information

|              |              |
|--------------|--------------|
| Package Name | UQFN68CV8080 |
|--------------|--------------|



< Tape and Reel Information >

|                   |                                                                                                                                                  |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| Tape              | Embossed carrier tape                                                                                                                            |
| Quantity          | 1000pcs                                                                                                                                          |
| Direction of feed | E2<br>The direction is the pin 1 of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand |



**11. Revision History**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 17.Apr.2019 | 001      | New Release                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 12.Nov.2019 | 002      | <p>p.11 Corrected typo of Pin Description of EXP-PAD.</p> <p>p.42 Added INTLDO1P5 and INTLDO1P5_UVLO signals and corrected VSYS_UVLO signal in Figure 3-15.</p> <p>p.66 Clarified explanation of I2C slave address.</p> <p>p.90 Added the description about subharmonic for BUCK6.</p> <p>p.91 Changed the minimum value of Output Capacitor from 22 <math>\mu</math>F to 15.4 <math>\mu</math>F.</p> <p>p.91 Added the description about Headroom of BUCK6.</p> <p>p.74,78,82,85,88,91,94,97 Corrected typos (VR Fault parameter name of BUCK1, 2, 3, 4, 5, 6, 7 and 8. Symbol of VR Fault of BUCK8.).</p> |
| 16.Mar.2020 | 003      | <p>p.1,19 Changed the maximum operating temperature to 105 °C.</p> <p>p.74,78,82,85,88,91,94,97,100,103,105,108,111,114,117,120 Deleted temperature condition of parts. Added note about parts temperature.</p>                                                                                                                                                                                                                                                                                                                                                                                             |

# Notice

## Precaution on using ROHM Products

- Our Products are designed and manufactured for application in ordinary electronic equipment (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment <sup>(Note 1)</sup>, transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

| JAPAN     | USA       | EU         | CHINA     |
|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV  |           | CLASS III  |           |

- ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
  - Installation of protection circuits or other protective devices to improve system safety
  - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
- Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc. prior to use, must be necessary:
  - Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
  - Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
  - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - Sealing or coating our Products with resin or other coating materials
  - Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.) ; or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

## Precaution for Mounting / Circuit board design

- When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

## Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

## Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of ionizer, friction prevention and temperature / humidity control).

## Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
  - [a] the Products are exposed to sea winds or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [b] the temperature or humidity exceeds those recommended by ROHM
  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

## Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

## Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

## Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

## Precaution Regarding Intellectual Property Rights

1. All information and data including but not limited to application example contained in this document is for reference only. ROHM does not warrant that foregoing information or data will not infringe any intellectual property rights or any other rights of any third party regarding such information or data.
2. ROHM shall not have any obligations where the claims, actions or demands arising from the combination of the Products with other articles such as components, circuits, systems or external equipment (including software).
3. No license, expressly or implied, is granted hereby under any intellectual property rights or other rights of ROHM or any third parties with respect to the Products or the information contained in this document. Provided, however, that ROHM will not assert its intellectual property rights or other rights against you or your customers to the extent necessary to manufacture or sell products containing the Products, subject to the terms and conditions herein.

## Other Precaution

1. This document may not be reprinted or reproduced, in whole or in part, without prior written consent of ROHM.
2. The Products may not be disassembled, converted, modified, reproduced or otherwise changed without prior written consent of ROHM.
3. In no event shall you use in any way whatsoever the Products and the related technical information contained in the Products or this document for any military purposes, including but not limited to, the development of mass-destruction weapons.
4. The proper names of companies or products described in this document are trademarks or registered trademarks of ROHM, its affiliated companies or third parties.

**General Precaution**

1. Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.
2. All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.
3. The information contained in this document is provided on an "as is" basis and ROHM does not warrant that all information contained in this document is accurate and/or error-free. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties resulting from inaccuracy or errors of or concerning such information.