

## 50 V Ultra Low Noise FOC Motor Controller

### FEATURES AND BENEFITS

- Code-free sensorless field-oriented control (FOC)
- I<sup>2</sup>C interface for speed control and status readback
- Ultra-quiet low speed operation
- Proprietary non-reverse fast startup
- Soft-On Soft-Off (SOSO) for quiet operation
- Analog / PWM / Clock mode speed control
- Closed-loop speed control
- Configurable current limit
- Windmill startup operation
- Lock detection
- Short-circuit protection (OCP)
- Brake and direction inputs
- Adjustable gate drive

### APPLICATIONS

- Ceiling fans
- Pedestal fans
- Bathroom exhaust fans
- Home appliance fans and pumps

### DESCRIPTION

The A89301 is a 3-phase, sensorless, brushless DC (BLDC) motor driver (gate driver) which can operate from 5.5 to 50 V.

A field-oriented control (FOC) algorithm is fully integrated to achieve the best efficiency and acoustic noise performance. The device optimizes the motor startup performance in a stationary condition, a windmill condition, and even in a reverse windmill condition.

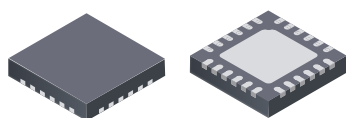
Motor speed is controlled through analog, PWM, or CLOCK input. Closed-loop speed control is optional, and RPM-to-clock frequency ratio is programmable.

A simple I<sup>2</sup>C interface is provided for setting motor-rated voltage, rated current, rated speed, resistance, and startup profiles. The I<sup>2</sup>C interface is also used for on/off control, speed control, and speed readback.

The A89301 is available in a 24-contact 4 mm × 4 mm QFN with exposed thermal pad (suffix ES). The package is lead (Pb) free, with 100% matte-tin leadframe plating.



### PACKAGE



24-contact QFN  
with exposed thermal pad  
4 mm × 4 mm × 0.75 mm  
(ES package)

*Not to scale*

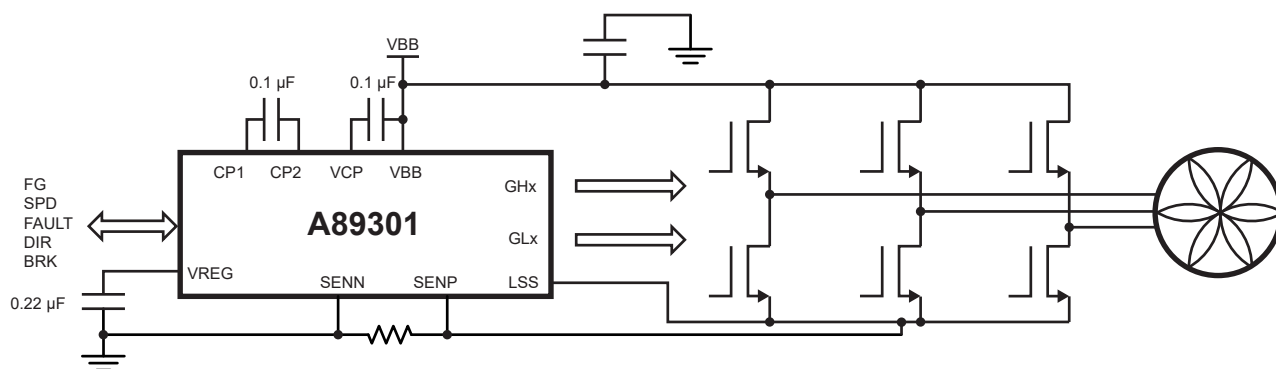


Figure 1: Typical Application

## SELECTION GUIDE

| Part Number | Ambient Temperature Range ( $T_A$ ) (°C) | Packaging                               | Packing                      |
|-------------|------------------------------------------|-----------------------------------------|------------------------------|
| A89301GESSR | –40 to 105                               | 24-contact QFN with exposed thermal pad | 6000 pieces per 13-inch reel |



## ABSOLUTE MAXIMUM RATINGS

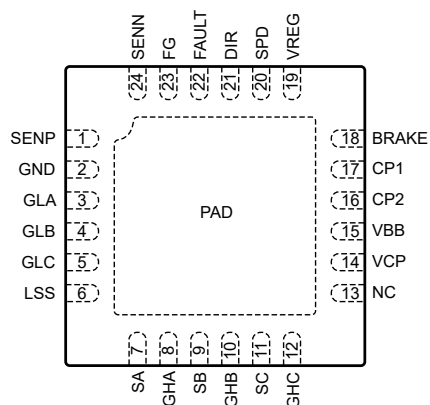
| Characteristic              | Symbol               | Notes                     | Rating                           | Unit |
|-----------------------------|----------------------|---------------------------|----------------------------------|------|
| Supply Voltage              | $V_{BB}$             |                           | 50                               | V    |
| Logic Input Voltage Range   | $V_{IN}$             | SPD, BRAKE, DIR           | –0.3 to 6                        | V    |
| Logic Output                | $V_O$                | FG, FAULT ( $I < 5$ mA)   | 6                                | V    |
| LSS                         | $V_{LSS}$            | DC                        | ±500                             | mV   |
|                             |                      | $t_W < 500$ ns            | ±4                               | V    |
| VREG                        | $V_{REG}$            |                           | 0 to 4                           | V    |
| SENN, SENP                  | $V_{SENN}, V_{SENP}$ | DC                        | ±500                             | mV   |
|                             |                      | $t_W < 500$ ns            | ±4                               | V    |
| Output Voltage              | $V_{OUT}$            | SA, SB, SC                | –2 to $V_{BB} + 2$               | V    |
|                             |                      | SA, SB, SC, $t_W < 50$ ns | –4 to $V_{BB} + 4$               | V    |
| GHx                         | $V_{GHx}$            |                           | $V_{SX} - 0.3$ to $V_{CP} + 0.3$ | V    |
| GLx                         | $V_{GLx}$            |                           | $V_{LSS} - 0.3$ to 8.5           | V    |
| VCP                         | $V_{CP}$             |                           | $V_{BB} - 0.3$ to $V_{BB} + 8$   | V    |
| CP1                         | $V_{CP1}$            |                           | –0.3 to $V_{BB} + 0.3$           | V    |
| CP2                         | $V_{CP2}$            |                           | $V_{BB} - 0.3$ to $V_{CP} + 0.3$ | V    |
| Junction Temperature        | $T_J$                |                           | 150                              | °C   |
| Storage Temperature Range   | $T_{stg}$            |                           | –55 to 150                       | °C   |
| Operating Temperature Range | $T_A$                | Range G                   | –40 to 105                       | °C   |

## THERMAL CHARACTERISTICS

| Characteristic             | Symbol          | Test Conditions*                                                      | Value | Unit |
|----------------------------|-----------------|-----------------------------------------------------------------------|-------|------|
| Package Thermal Resistance | $R_{\theta JA}$ | 24-contact QFN (package ES), on 2-sided PCB 1-in. <sup>2</sup> copper | 45    | °C/W |

\*Additional thermal information available on the Allegro website.

## PINOUT DIAGRAM AND TERMINAL LIST



ES Package Pinouts

Terminal List Table

| Terminal Number | Name  | Function                                     |
|-----------------|-------|----------------------------------------------|
| 16              | CP2   | Charge pump                                  |
| 17              | CP1   | Charge pump                                  |
| 18              | BRAKE | Logic input                                  |
| 19              | VREG  | 2.8 V regulator voltage                      |
| 20              | SPD   | PWM or clock mode speed control              |
| 21              | DIR   | Direction control                            |
| 22              | FAULT | Fault indicator output                       |
| 23              | FG    | Motor speed output                           |
| 24              | SENN  | Current sense negative terminal              |
| 1               | SENP  | Current sense positive terminal              |
| 2               | GND   | Ground                                       |
| 3               | GLA   | Low-side gate drive output                   |
| 4               | GLB   | Low-side gate drive output                   |
| 5               | GLC   | Low-side gate drive output                   |
| 6               | LSS   | Low-side source                              |
| 7               | SA    | Motor output                                 |
| 8               | GHA   | High-side gate drive output                  |
| 9               | SB    | Motor output                                 |
| 10              | GHB   | High-side gate drive output                  |
| 11              | SC    | Motor output                                 |
| 12              | GHC   | High-side gate drive output                  |
| 13              | NC    | No connect                                   |
| 14              | VCP   | Charge pump                                  |
| 15              | VBB   | Power supply                                 |
| PAD             | PAD   | Exposed pad for enhanced thermal dissipation |

## FUNCTIONAL BLOCK DIAGRAM

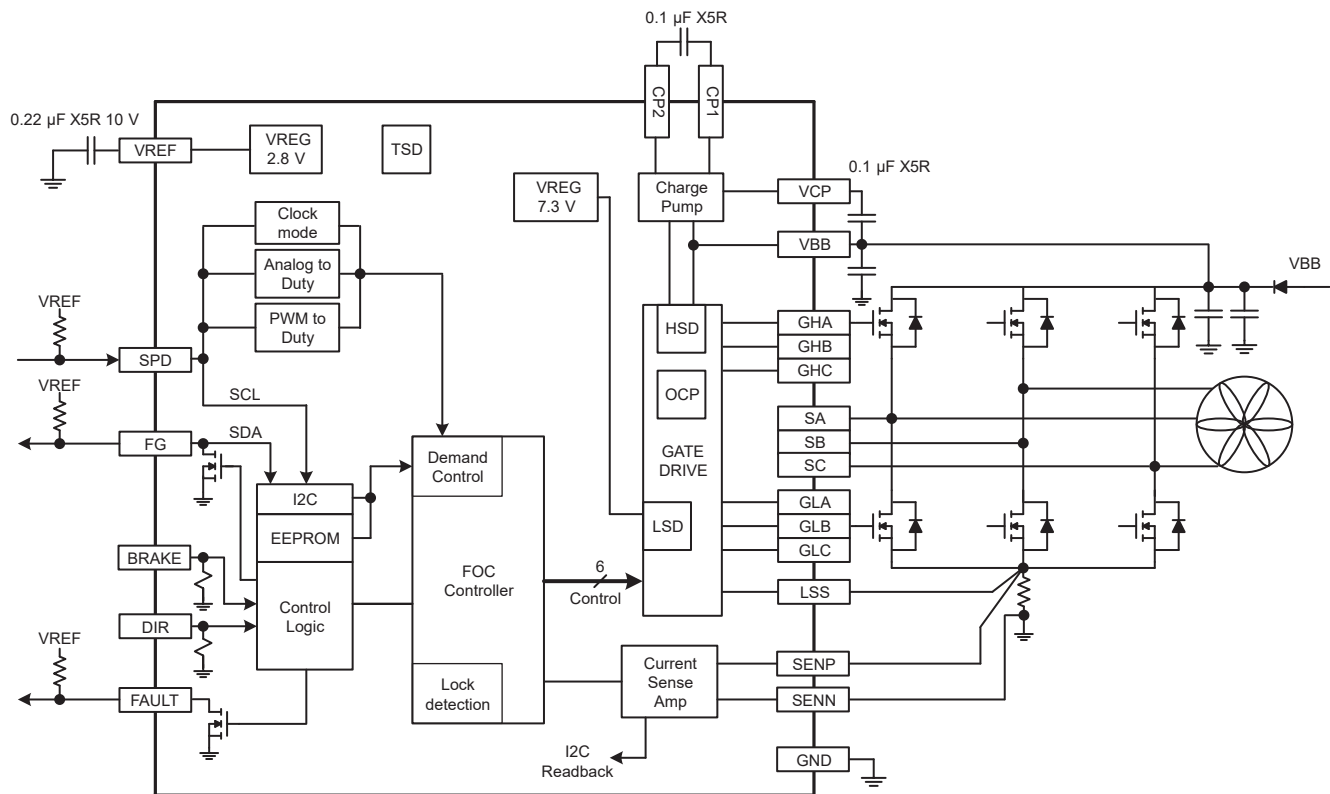


Figure 2: Functional Block Diagram

**ELECTRICAL CHARACTERISTICS** [1]: Valid over operating ambient temperature range and operating voltage range, unless noted otherwise

| Characteristics                      | Symbol                    | Test Conditions                 | Min. | Typ. | Max. | Unit |
|--------------------------------------|---------------------------|---------------------------------|------|------|------|------|
| GENERAL                              |                           |                                 |      |      |      |      |
| Supply Voltage Range                 | V <sub>BB</sub>           | Driving                         | 5.5  | –    | 48   | V    |
|                                      |                           | Operating                       | 5.5  | –    | 50   | V    |
| VBB Supply Current                   | I <sub>BB</sub>           | I <sub>VREG</sub> = 0 mA        | –    | 8    | 12   | mA   |
|                                      |                           | Standby mode                    | –    | 10   | 20   | μA   |
| Reference Voltage                    | V <sub>REG</sub>          | I <sub>OUT</sub> = 10 mA        | 2.7  | 2.86 | 2.95 | V    |
| GATE DRIVE                           |                           |                                 |      |      |      |      |
| High Side Gate Drive Output          | V <sub>GH</sub>           | V <sub>BB</sub> = 8 V           | 6.5  | 6.8  | –    | V    |
|                                      |                           | V <sub>BB</sub> = 24 V          | 6.5  | 6.8  | –    | V    |
| Low Side Gate Drive Output           | V <sub>GL</sub>           | V <sub>BB</sub> = 8 V           | 6.5  | 7.3  | –    | V    |
|                                      |                           | V <sub>BB</sub> = 24 V          | 6.5  | 7.3  | –    | V    |
| Gate Drive Source Current            | I <sub>SO</sub>           | V <sub>BB</sub> = 8 V; level 0  | –    | 15   | –    | mA   |
|                                      |                           | V <sub>BB</sub> = 8 V; level 1  | –    | 30   | –    | mA   |
|                                      |                           | V <sub>BB</sub> = 8 V; level 2  | –    | 55   | –    | mA   |
| Gate Drive Sink Current              | I <sub>SI</sub>           | V <sub>BB</sub> = 8 V; level 0  | –    | 30   | –    | mA   |
|                                      |                           | V <sub>BB</sub> = 8 V; level 1  | –    | 60   | –    | mA   |
|                                      |                           | V <sub>BB</sub> = 8 V; level 2  | –    | 105  | –    | mA   |
| VDS SENSING FOR OCP                  |                           |                                 |      |      |      |      |
| VDS Comparator Threshold             | V <sub>DS_THR</sub>       | level 0                         | –    | 1    | –    | V    |
|                                      |                           | level 1                         | –    | 2    | –    | V    |
| MOTOR DRIVE                          |                           |                                 |      |      |      |      |
| PWM Duty On Threshold                | PWM <sub>ON</sub>         | Relative to target              | –0.5 | –    | 0.5  | %    |
| PWM Duty Off Threshold               | PWM <sub>OFF</sub>        | Relative to target              | –0.5 | –    | 0.5  | %    |
| PWM Input Frequency Range            | f <sub>PWM(MIN)</sub>     | PWM input frequency setting = 0 | 2.5  | –    | 100  | kHz  |
|                                      |                           | PWM input frequency setting = 1 | 80   | –    | 3200 | Hz   |
| Clock Input Frequency Range          | f <sub>CLOCK</sub>        | CLOCK mode                      | 1    | –    | 2000 | Hz   |
| SPD Standby Threshold (Analog Enter) | V <sub>SPD(TH_ENT)</sub>  |                                 | 50   | 100  | 150  | mV   |
| SPD Standby Threshold (Analog Exit)  | V <sub>SPD(TH_EXIT)</sub> |                                 | 0.4  | 0.75 | 1    | V    |
| SPD On Threshold                     | V <sub>SPD(ON)</sub>      | ON/OFF setting = 10%            | 210  | 250  | 290  | mV   |
| SPD Max                              | V <sub>SPD(MAX)</sub>     |                                 | –    | 2.5  | –    | V    |
| SPD ADC Resolution                   | V <sub>SPDADC(RES)</sub>  |                                 | –    | 9.78 | –    | mV   |
| SPD ADC Accuracy                     | V <sub>SPDADC(ACC)</sub>  | V <sub>SPD</sub> = 0.2 to 2.5 V | –40  | –    | 40   | mV   |
| Speed Closed Loop Accuracy           | f <sub>SPD(ACC)</sub>     | PWM mode or Analog mode         | –5   | –    | 5    | %    |
|                                      |                           | Clock mode                      | –0.1 | –    | 0.1  | rpm  |
| Dead Time                            | t <sub>DT</sub>           | Code = 9                        | –    | 400  | –    | ns   |
| Motor PWM Frequency                  | f <sub>PWM</sub>          | T <sub>A</sub> = 25°C           | 23.3 | 24.4 | 25.3 | kHz  |

Continued on next page...

**ELECTRICAL CHARACTERISTICS** <sup>[1]</sup> (continued): Valid over operating ambient temperature range and operating voltage range, unless noted otherwise

| Characteristics                  | Symbol         | Test Conditions                    | Min. | Typ. | Max. | Unit |
|----------------------------------|----------------|------------------------------------|------|------|------|------|
| <b>PROTECTION</b>                |                |                                    |      |      |      |      |
| VBB UVLO                         | $V_{BB(UVLO)}$ | $V_{BB}$ rising                    | –    | 4.75 | 4.95 | V    |
| VBB UVLO Hysteresis              | $V_{BB(HYS)}$  |                                    | 200  | 300  | 450  | mV   |
| Thermal Shutdown Temperature     | $T_{JTSD}$     | Temperature increasing             | –    | 165  | –    | °C   |
| Thermal Shutdown Hysteresis      | $\Delta T_J$   | Recovery = $T_{JTSD} - \Delta T_J$ | –    | 20   | –    | °C   |
| <b>LOGIC, IO, I<sup>2</sup>C</b> |                |                                    |      |      |      |      |
| Input Current                    | $I_{IN}$       | SPD, FG; $V_{IN} = 0$ to 5.5 V     | –5   | 1    | 5    | μA   |
|                                  |                | BRK, DIR; $V_{IN} = 5$ V           | –    | 50   | –    | μA   |
| Logic Input, Low Level           | $V_{IL}$       |                                    | 0    | –    | 0.8  | V    |
| Logic Input, High Level          | $V_{IH}$       |                                    | 2    | –    | 5.5  | V    |
| Logic Input Hysteresis           | $V_{HYS}$      |                                    | 200  | 300  | 600  | mV   |
| FG Output Leakage                | $I_{FG}$       | $V = 5.5$ V                        | –    | –    | 1    | μA   |

<sup>[1]</sup> Specified limits are tested at 25°C and 125°C and statistically assured over operating temperature range by design and characterization.

## FUNCTIONAL DESCRIPTION

The A89301 is a three-phase BLDC controller with integrated gate driver. It operates from 5.5 to 50 V and targets pedestal fan, ceiling fan, and ventilation fan applications.

The integrated field-oriented control (FOC) algorithm achieves the best efficiency and dynamic response and minimizes acoustic noise. Allegro's proprietary non-reverse startup algorithm improves startup performance. The motor will start up towards the target direction after power-up without reverse shaking or vibration. The Soft-On Soft-Off (SOSO) feature gradually increases the current to the motor at "on" command (windmill condition), and gradually reduces the current from the motor at the "off" command, further reducing the acoustic noise and operating the motor smoothly.

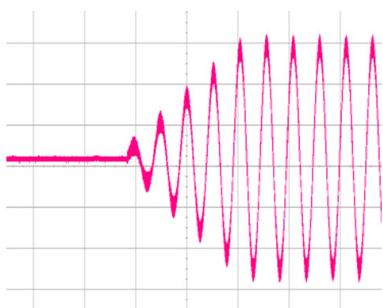


Figure 3: Current Waveform of Soft-On

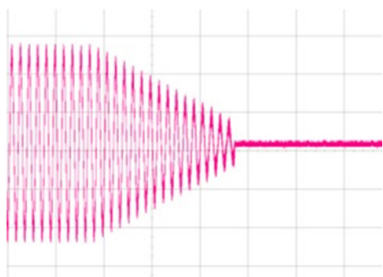


Figure 4: Current Waveform of Soft-Off

## Speed Control

Speed demand is provided via the SPD pin. Three speed control modes are selectable through the EEPROM. The A89301 also features a closed-loop speed function, which can be enabled or disabled via the EEPROM.

**PWM Mode:** The motor speed is controlled by the PWM duty cycle on the SPD pin, and higher duty cycle represents higher speed demand. If closed-loop speed is disabled, the output voltage amplitude will be proportional to the PWM duty cycle. If closed-loop speed is enabled, the motor speed is proportional to the PWM duty cycle, and 100% duty represents the rated speed of the motor, which can be programmed in the EEPROM.

$$close\_loop\_speed = rated\_speed \times duty\_input$$

The SPD PWM frequency range is 80 Hz to 100 kHz. If it is higher than 2.8 kHz, set PWMfreq = 0; if it is lower than 2.8 kHz, set PWMfreq = 1.

**Analog Mode:** The motor speed is controlled by the analog voltage on the SPD pin, with higher voltage representing higher speed demand. If closed-loop speed is disabled, the output voltage amplitude will be proportional to the analog voltage input. If closed-loop speed is enabled, the motor speed is as follows:

$$closed\_loop\_speed = rated\_speed \times analog\_input / SPD_{MAX}$$

**CLOCK Mode:** In the clock speed control mode, the closed-loop speed is always enabled. Higher frequency on the SPD pin will drive a higher motor speed as follows:

$$close\_loop\_speed (rpm) = clock\_input \times speed\_ctrl\_ratio,$$

where the speed\_ctrl\_ratio can be programmed in the EEPROM.

For example, if the ratio is 4 and the clock input frequency is 60 Hz, then the motor will operate at 240 rpm. Note the number of motor pole pairs must be set properly in the programming application for the rated speed (rpm) setting to be accurate.

If the clock frequency commands a speed that is higher than twice the rated speed, the A89301 treats it as a clock input error and stops the motor.

CLOCK mode can achieve the best speed closed-loop accuracy.

For all three speed control modes with closed-loop speed enabled, if the demand speed is higher than the maximum speed, the system can run at a certain supply voltage and load condition, and the A89301 will just provide the maximum output voltage (if current limit is not triggered) or the maximum output current (if current limit is triggered).

The SPD pin is also used as SCL in the I<sup>2</sup>C mode.

Speed control can also be achieved through I<sup>2</sup>C command. Refer to

register table for more details. While in Analog mode, PWM mode, or CLOCK mode, sending I<sup>2</sup>C command may cause motor speed change, unexpected startup attempts, or operation failure. Changing from I<sup>2</sup>C mode to CLOCK (Analog, PWM) mode requires either power cycle, or enter and then exit from standby mode.

## Motor Stop and Standby Mode

If the speed demand is less than the programmed threshold, the motor will stop.

| On/Off Setting | On Threshold | Off Threshold |
|----------------|--------------|---------------|
| 6%             | 7.8%         | 5.9%          |
| 10%            | 11.7%        | 9.8%          |
| 15%            | 14.9%        | 12.9%         |
| 20%            | 21.5%        | 19.6%         |

For example, consider 10% is set as the threshold. If PWM duty is less than 9.8% (in PWM mode), or the analog voltage is less than 250 mV (in Analog mode), or the CLOCK input frequency is less than 9.8% of the “rated speed” (in CLOCK mode), the IC will stop the motor and enter the “idle” mode.

In order to enter standby, two conditions must be met: 1) the motor must be stationary (this condition can be ignored by setting the EEPROM), and 2) PWM or CLOCK signal must remains logic low (in PWM and CLOCK mode) or the analog voltage remains less than  $V_{SPD(TH\_ENT)}$  (in Analog mode) for longer than one second.

A rising edge on PWM or CLOCK will wake the IC in PWM and CLOCK mode, and in Analog mode, the SPD voltage must be higher than  $V_{SPD(TH\_EXIT)}$  to wake up the IC.

Standby Mode will turn off all circuitry including the charge pump and VREG.

After powering on, the device will always be in the active mode before entering standby mode.

The standby mode can be disabled in the EEPROM.

**Direction Input:** Logic input to control motor direction. For logic high, the motor phases are ordered A→B→C. For logic low, the motor phases are ordered A→C→B. The A89301 supports changing the direction input while the motor is running. The direction can also be controlled through register.

**BRAKE:** Active-high signal turns on all low sides for braking function. The Brake function overrides speed control input. Care should be taken to avoid stress on the MOSFET when braking while the motor is running. With braking, the current will be limited only by  $V_{BEMF}/R_{MOTOR}$ .

The A89301 includes an optional feature which holds off braking until the motor speed drops to a low enough (configurable) level so that the braking current will not damage the MOSFET.

**FAULT:** Open-drain output provides motor operation fault status. Default is high when there is no fault.

Recommended maximum sink current is 10 mA.

An LED and a serial resistor is recommended between the FAULT and VREG pins. The LED indicates fault information.

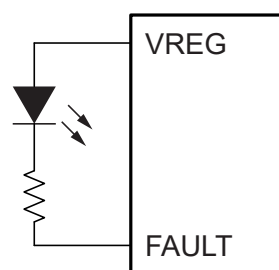


Figure 5: A89301 with LED and Serial Resistor

| Fault Type                   | FAULT Pin                                                                                                               | LED Pattern               |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Lock detected                | low                                                                                                                     | constant on               |
| OCP                          | 0.67 seconds high<br>0.67 seconds low                                                                                   | slow flashing             |
| Thermal Shutdown             | 0.67 seconds low<br>0.17 seconds high<br>0.08 seconds low<br>0.17 seconds high<br>0.08 seconds low<br>0.17 seconds high | long-short-short flashing |
| System Error                 | 0.08 seconds low<br>0.08 seconds high<br>0.08 seconds low<br>1.09 seconds high                                          | double short flashing     |
| OVP                          | 0.17 seconds high<br>0.17 seconds low                                                                                   | fast flashing             |
| Input demand below threshold | 0.25 seconds high<br>0.08 seconds low<br>0.34 seconds high<br>0.67 seconds low                                          | long-short flashing       |

**FG:** Open-drain output provides motor speed information to the system. The open-drain output can be pulled up to VREG or an external 3.3 or 5 V supply.

The FG pin is also used as SDA in I<sup>2</sup>C mode. The first I<sup>2</sup>C command can pass only when the FG is high (open drain off). After the first I<sup>2</sup>C command, the FG pin is no longer used for speed

information, and the FG pin is dedicated as a data pin for the I<sup>2</sup>C interface.

FG is default high after power-on and exit from standby mode, and stays high for at least 9.8 ms. To ensure successful I<sup>2</sup>C communication, it is recommended to have the first I<sup>2</sup>C demand within 9.8 ms after power up or exit from standby mode.

FG function can be disabled in the EEPROM; then the FG pin will be dedicated as SDA.

If observing FG signal is required in I<sup>2</sup>C mode, the FG signal can be reassigned to the FAULT pin by sending I<sup>2</sup>C command 0x00A0 to address 165 (Decimal).

**System Error:** A system error occurs when  $V_{BB}$ , the charge pump voltage, or the internal regulator which supplies the low-side gate drivers falls below the respective undervoltage threshold. The motor outputs are disabled upon a system error and will remain off until the voltage that caused the error rises above the respective UVLO threshold plus hysteresis.

**OVP:** An OVP event occurs when  $V_{BB}$  exceeds 47 V typical. OVP is only an indication and the outputs are not disabled. The indication is removed when  $V_{BB}$  falls below the threshold.

**VREG:** Voltage reference (2.8 V) to power internal digital logic and analog circuitry. VREG can be used to power external circuitry with up to 10 mA bias current, if desired. A ceramic capacitor with 0.22  $\mu$ F or greater is required on the pin to stabilize the supply.

When VREG is loaded externally, the power consumption of the internal LDO is calculated by the equation:

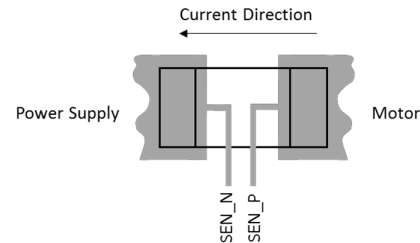
$$P_{LDO} = (I_{LOAD} + I_{INTERNAL}) \times (V_{BB} - V_{REG}).$$

Ensure that the system has good power dissipation and the temperature is within the operating temperature range. The A89301 thermal shutdown function does not protect the LDO.

**Bus Current Sensing:** A single shunt-resistor connection between SENN and SENP is used to measure the bus current for the FOC algorithm and current limit. The resistor value is approximately tens of a milliohm, depends on the rated current of the system. The integrated shunt-resistor amplifier has a gain

of 14.5 and the output range is 0 to 1 V. The voltage difference between SENN and SENP should be less than 65 mV to prevent the signal saturation. For example, if the rated current is 4 A, it is recommend to use a 15 m $\Omega$  sensing resistor, so that  $4 \text{ A} \times 15 \text{ m}\Omega$  is between 55 and 65 mV.

Use Kelvin sensing connection for the shunt resistor.



**Lock Detect:** A logic circuit monitors the motor position to determine if motor is running as expected. If a fault is detected, the motor drive will be disabled for the configurable  $t_{LOCK}$  time before an auto-restart is attempted. For additional information, refer to the application note.

**Current Control:** The motor's rated current at rated speed and normal load must be programmed to the EEPROM for proper operation. The A89301 will limit the motor current (phase current peak value) to 1.3 times the programmed rated current during acceleration or increasing load, which protects the IC and the motor. The current profile during startup can also be programmed.

**Overcurrent Protection (short protection):** The  $V_{DS}$  voltages across each power MOSFET are monitored by the A89301. If a  $V_{DS}$  is higher than the threshold when that MOSFET enabled, an OCP fault is triggered and the IC will stop driving immediately.

The VDS comparator threshold can be configured in the EEPROM.

**Dead-Time Configuration:** In order to avoid shoot-through current in the H-bridge, dead-time is implemented that delays the high-side from turning on after the low-side turns off, and delays the low-side from turning on after the high-side turns off. The dead-time is configurable in the EEPROM with 16 options from 40 to 640 ns.

**Direct Phase Angle Control:** The A89301 implements phase angle control based on the user-programmed inductance, together with motor phase current and motor speed. The user may want to bypass this calculated phase advance angle and use direct control from the register.

This function is supported in A89301 by enabling the “direct drive angle” bit in the register. Once enabled, the “motor inductance” register will directly set the phase advance angle, with units of degrees.

**Gate Drive Slew Control:** A89301 gate driver outputs are current source/sink drivers. The gate drive sink current  $I_{SI}$  and source current  $I_{SO}$  can be configured in EEPROM to adjust the MOSFET slew rate.

Refer to the application note for details.

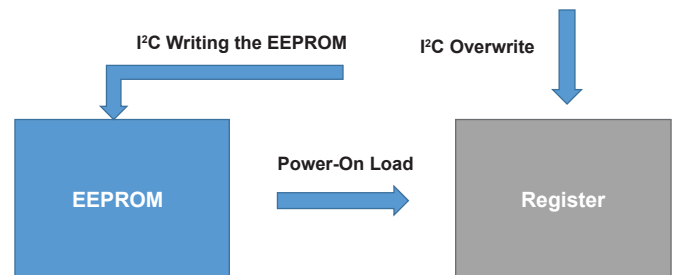
## I<sup>2</sup>C OPERATION AND EEPROM MAP

The I<sup>2</sup>C interface allows the user to program the register and parameters into EEPROM. The A89301 7-bit slave address is 0x55.

After power-on, the default values in EEPROM will be loaded into the registers, which determines motor system operation. I<sup>2</sup>C can overwrite those values and change the motor system operation on the fly.

I<sup>2</sup>C can also be used to program the EEPROM, which is normally done in the production line.

The figures below shows the I<sup>2</sup>C interface timing.



### Read command: Two Step Process

- Start Condition
- 7-bit I<sup>2</sup>C Slave Address (Device ID) 1010101, R/W Bit = 0
- Internal Register Address to be read
- Stop Condition
- Start Condition
- 7-bit I<sup>2</sup>C Slave Address (Device ID) 1010101, R/W Bit = 1
- Read 2 data bytes
- Stop Condition

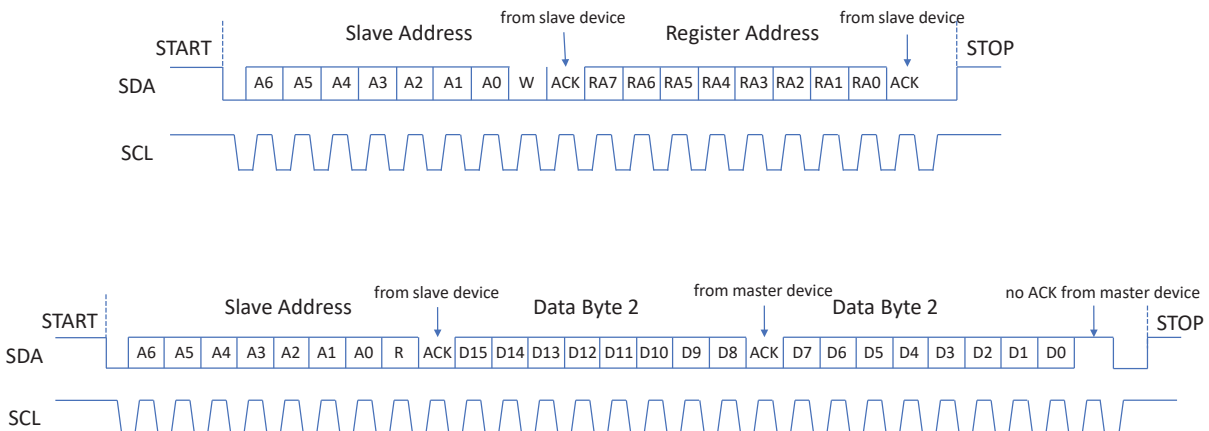
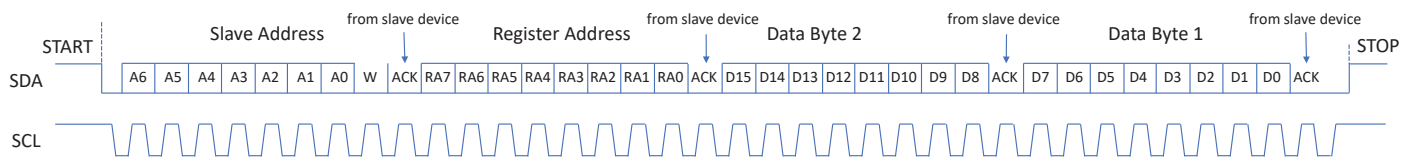


Figure 6: Read Command

**Write command:**

## Start Condition

- Start Condition
- 7-bit I<sup>2</sup>C Slave Address (Device ID) 1010101, R/W Bit = 0
- Internal Register Address
- 2 data bytes, MSB first
- Stop Condition

**Figure 7: Write Command**

## Register and EEPROM Map

Each register bit is associated with one EEPROM bit. The register address is the associated EEPROM bit address plus 64. For example, the rated speed is in EEPROM address 8, bit[10:0]; the associated register address is 72, bit[10:0].

In the following table, the bits shaded in gray should be kept at their default values. Changing these values may cause malfunction or damage to the part. If programming the EEPROM with

a custom programmer, it is recommended to use the A89301 application to determine the appropriate settings, save the settings file, and use the file contents to program to the EEPROM. The application's settings file contains one line for each EEPROM address, containing addresses 8 through 22 (15 lines/addresses).

Registers not shown in the table are not for users to access. Changing the value in undocumented registers may cause malfunction or damage to the part.

**Table 1: Register and EEPROM Map**

| Address |       | A89301 Register Map                                                                                                                                      |                      |                  |                      |
|---------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------------|----------------------|
|         |       | MSB → LSB                                                                                                                                                |                      |                  |                      |
| 0       |       | Allegro internal information. No associated register for these EEPROM data                                                                               |                      |                  |                      |
| 1       |       |                                                                                                                                                          |                      |                  |                      |
| 2       |       |                                                                                                                                                          |                      |                  |                      |
| 3       |       |                                                                                                                                                          |                      |                  |                      |
| 4       |       |                                                                                                                                                          |                      |                  |                      |
| 5       |       |                                                                                                                                                          |                      |                  |                      |
| 6       |       | User-flexible code. No associated register for these EEPROM data. Provided to user. For example, tracking number of product, product revision info, etc. |                      |                  |                      |
| 7       |       |                                                                                                                                                          |                      |                  |                      |
| 8 / 72  | 3:0   | Rated_speed [3:0]                                                                                                                                        |                      |                  |                      |
|         | 7:4   | Rated_speed [7:4]                                                                                                                                        |                      |                  |                      |
|         | 11:8  | speed_close_loop                                                                                                                                         | Rated speed [10:8]   |                  |                      |
|         | 15:12 | PWMin_range                                                                                                                                              | Direction            | Accelerate_range | Clock_PWM            |
| 9 / 73  | 3:0   | Acceleration [3:0]                                                                                                                                       |                      |                  |                      |
|         | 7:4   | Acceleration [7:4]                                                                                                                                       |                      |                  |                      |
|         | 11:8  | Motor_Resistance [3:0]                                                                                                                                   |                      |                  |                      |
|         | 15:12 | Motor_Resistance [7:4]                                                                                                                                   |                      |                  |                      |
| 10 / 74 | 3:0   | Rated Current [3:0]                                                                                                                                      |                      |                  |                      |
|         | 7:4   | Rated Current [7:4]                                                                                                                                      |                      |                  |                      |
|         | 11:8  | SPD mode                                                                                                                                                 | Rated Current [10:8] |                  |                      |
|         | 15:12 | Startup_Current [2:0]                                                                                                                                    |                      |                  |                      |
| 11 / 75 | 3:0   | Open_Drive                                                                                                                                               |                      |                  |                      |
|         | 7:4   | Power_Ctl_En                                                                                                                                             | Max_start_curr       | Direct_dr_Angle  |                      |
|         | 11:8  | Startup_mode [1:0]                                                                                                                                       |                      |                  |                      |
|         | 15:12 |                                                                                                                                                          | Extend_lock_mask     |                  | Wait_stationary      |
| 12 / 76 | 3:0   | PID_P [3:0]                                                                                                                                              |                      |                  |                      |
|         | 7:4   | PID_P [7:4]                                                                                                                                              |                      |                  |                      |
|         | 11:8  | Motor_Inductance [3:0]                                                                                                                                   |                      |                  |                      |
|         | 15:12 | Open_Window                                                                                                                                              |                      | over_Speed_Lock  | Motor_Inductance [4] |

Continued on next page...

Table 1: Register and EEPROM Map (continued)

| Address |       | A89301 Register Map                     |                |                                         |               |
|---------|-------|-----------------------------------------|----------------|-----------------------------------------|---------------|
| 13 / 77 | 3:0   | PID_I [3:0]                             |                |                                         |               |
|         | 7:4   | PID_I [7:4]                             |                |                                         |               |
|         | 11:8  |                                         |                |                                         |               |
|         | 15:12 |                                         | delay_start    |                                         |               |
| 14 / 78 | 3:0   |                                         |                |                                         |               |
|         | 7:4   |                                         |                |                                         | FG_pin_dis    |
|         | 11:8  |                                         |                |                                         |               |
|         | 15:12 |                                         |                |                                         |               |
| 15 / 79 | 3:0   | Angle_Error_Lock (startup)              |                |                                         |               |
|         | 7:4   | soft_on                                 | soft_off       |                                         |               |
|         | 11:8  | Deadtime_setting [3:0]                  |                |                                         |               |
|         | 15:12 | Safe_Brake_thrd [1:0]                   |                |                                         |               |
| 16 / 80 | 3:0   | OCP_reset_mode                          | OCP_Enable     |                                         |               |
|         | 7:4   | First_cycle_speed [1:0]                 |                | OCP_Masking                             |               |
|         | 11:8  | Decelerate_buffer [1:0]                 |                | Accelerate_buffer [1:0]                 |               |
|         | 15:12 |                                         |                | BEMF_Lock_filter [1:0]                  |               |
| 17 / 81 | 8:0   | Speed_demand [8:0]                      |                |                                         |               |
|         | 9     | i2c_speed_mode                          |                |                                         |               |
|         | 15:10 |                                         |                |                                         |               |
| 18 / 82 | 3:0   |                                         |                |                                         |               |
|         | 7:4   |                                         |                |                                         |               |
|         | 11:8  | IPD_Current_Thr [3:0]                   |                |                                         |               |
|         | 15:12 | drive_gate_slew[1:0]                    |                | IPD_Current_Thr [5:4]                   |               |
| 19 / 83 | 7:0   |                                         |                |                                         |               |
|         | 15:8  | mosfet_ciss_comp[7:0]                   |                |                                         |               |
| 20 / 84 | 7:0   | Rated_Voltage                           |                |                                         |               |
|         | 15:8  | Sense_Resistor                          |                |                                         |               |
| 21 / 85 | 3:0   |                                         |                |                                         |               |
|         | 7:4   | slight_mv_demand [2:0]                  |                |                                         |               |
|         | 11:8  |                                         |                | speed_input_off_threshold [1:0]         |               |
|         | 15:12 | standby_dis                             |                |                                         |               |
| 22 / 86 | 3:0   | speed_response_tc_and_clock_speed_ratio |                |                                         |               |
|         | 7:4   | Restart_attempt                         |                | speed_response_tc_and_clock_speed_ratio |               |
|         | 11:8  | Lock_restart_set                        | vibration_lock | Soft_off_time                           | Brake_mode    |
|         | 15:12 | vds_threshold_sel                       |                |                                         | deadtime_comp |

Table 2: Register and EEPROM Map Notes

| Parameter                               | Address    | Notes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rated_Voltage                           | 20 [7:0]   | Rated Voltage (V) = Rated_voltage_register_value / 5                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Rated_Speed                             | 8 [10:0]   | Rated Speed (Hz) = Rated_speed_register_value × 0.530                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Motor_Resistance                        | 9 [15:8]   | Motor Resistance ( $\Omega$ ) = Motor_resistance_register_value / [ (Rated_voltage_register_value × 4.096) / (Sense_resistor_register_value / 125) / (Rated_voltage_register_value / 10) ]                                                                                                                                                                                                                                                                                                                  |
| Rated_Current                           | 10 [10:0]  | Rated Current (mA) = Rated_current_register_value / (Sense_resistor_register_value / 125)                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Startup_Current                         | 10 [15:13] | 0: NA.<br>else Startup Current = Rated Current × 1/8 × (startup_current_register_value + 1)                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Max_start_curr                          | 11[6]      | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Acceleration                            | 9 [7:0]    | Acceleration (Hz/s) = Acceleration_register_value × k if range = 0 then k = 0.05, else k = 3.2                                                                                                                                                                                                                                                                                                                                                                                                              |
| Accelerate_range                        | 8 [13]     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| speed_close_loop                        | 8 [11]     | 1: closed loop.      0: open loop.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Direction                               | 8 [14]     | 1: A→B→C.      0: A→C→B.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| SPD mode                                | 10 [11]    | 1: analog      0: digital (PWM or Clock).                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Clock_PWM                               | 8 [12]     | 1: clock mode.      0: PWM mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| PWMin_range                             | 8 [15]     | 1: ≤ 2.8 kHz      0: > 2.8 kHz.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| speed_response_tc_and_clock_speed_ratio | 22 [5:0]   | When 'open loop' speed is enabled, this setting has no effect.<br>When 'closed loop' speed is enabled, the setting controls the speed response time constant:<br>Time constant (seconds) = speed_response_tc_and_clock_speed_ratio / 15.<br>When clock mode is enabled, this setting also controls the ratio between input frequency and target motor speed:<br>Ratio (rpm/Hz) = speed_response_tc_and_clock_speed_ratio × 0.25.<br>If used, the programmed value of this setting must be between 1 and 41. |
| Speed_input_off_threshold               | 21 [9:8]   | 00: 10%.      01: 6%<br>10: 15%.      11: 20%                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| FG_pin_dis                              | 14[4]      | 1: FG pin is always high, facilitate the I <sup>2</sup> C communication.                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Startup_mode                            | 11 [11:10] | 00: 6 pulse mode.      01: 2 pulse mode.<br>10: slight-move mode.      11: align & go.                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Wait_stationary                         | 11[12]     | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IPD_current_thrd                        | 18 [13:8]  | IPD current threshold (A) = IPD_current_thrd_value × 0.086                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Slight_mv_demand                        | 21 [7:5]   | Amplitude demand in slight move mode (%) = value × 3.2 + 2.4                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| PID_P                                   | 12 [7:0]   | Position observer loop P gain.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| PID_I                                   | 13 [7:0]   | Position observer loop I gain.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Motor_Inductance                        | 12 [12:8]  | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Direct_dr_Angle                         | 11[5]      | 1: The 12[12:8] value will directly control the phase advance angle in units of degrees.                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Sense_Resistor                          | 20 [15:8]  | Sense resistor value (m $\Omega$ ) = sense_resistor_value / 3.7                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Open_drive                              | 11 [3]     | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Power_Ctrl_En                           | 11 [7]     | 1: enable the current limit.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Open_window                             | 12 [15]    | 1: open window for inductance tuning. 0: normal                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| delay_start                             | 13[13]     | 1: delayed start. 0: start right after windmill checking.                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

Continued on next page...

Table 2: Register and EEPROM Map Notes (continued)

| Parameter                                       | Address    | Notes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|-------------------------------------------------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|--------------|--------------|--------|------|------|------|--------|------|------|------|--------|------|------|------|---------|------|------|------|---------|------|------|------|---------|------|------|------|---------|------|------|------|
| Soft_off                                        | 15 [6]     | Refer to the functional description.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Soft_on                                         | 15 [7]     | Refer to the functional description.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Soft_off_time                                   | 22[9]      | Maximum soft off-time. 1: 4 seconds. 0: 1 second.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| First_Cycle_Speed                               | 16 [7:6]   | 00: 0.55 Hz.                      01: 1.1 Hz.                      10: 2.2 Hz.                      11: 4.4 Hz                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Accelerate_buffer                               | 16 [9:8]   | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Decelerate_buffer                               | 16 [11:10] | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Deadtime_setting                                | 15[11:8]   | (n + 1) × 40 ns.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| deadtime_comp                                   | 22[12]     | 1: enable the deadtime compensation logic.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| drive_gate_slew                                 | 18[15:14]  | Refer to the electronics characterization table.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| mosfet_ciss_comp                                | 19[15:8]   | Refer to the electronics characterization table.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            | <table><tr><td>Ciss</td><td>gate slew 00</td><td>gate slew 01</td><td>gate slew 10</td></tr><tr><td>200 pF</td><td>0x55</td><td>0x44</td><td>0x33</td></tr><tr><td>400 pF</td><td>0x88</td><td>0x66</td><td>0x44</td></tr><tr><td>600 pF</td><td>0xBB</td><td>0x77</td><td>0x55</td></tr><tr><td>1000 pF</td><td>0xCC</td><td>0x88</td><td>0x66</td></tr><tr><td>2000 pF</td><td>0xFF</td><td>0xCC</td><td>0x88</td></tr><tr><td>3000 pF</td><td>0xFF</td><td>0xFF</td><td>0xBB</td></tr><tr><td>4000 pF</td><td>0xFF</td><td>0xFF</td><td>0xEE</td></tr></table> | Ciss         | gate slew 00 | gate slew 01 | gate slew 10 | 200 pF | 0x55 | 0x44 | 0x33 | 400 pF | 0x88 | 0x66 | 0x44 | 600 pF | 0xBB | 0x77 | 0x55 | 1000 pF | 0xCC | 0x88 | 0x66 | 2000 pF | 0xFF | 0xCC | 0x88 | 3000 pF | 0xFF | 0xFF | 0xBB | 4000 pF | 0xFF | 0xFF | 0xEE |
|                                                 |            | Ciss                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | gate slew 00 | gate slew 01 | gate slew 10 |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            | 200 pF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0x55         | 0x44         | 0x33         |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            | 400 pF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0x88         | 0x66         | 0x44         |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            | 600 pF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0xBB         | 0x77         | 0x55         |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            | 1000 pF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0xCC         | 0x88         | 0x66         |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            | 2000 pF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0xFF         | 0xCC         | 0x88         |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            | 3000 pF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0xFF         | 0xFF         | 0xBB         |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            | 4000 pF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0xFF         | 0xFF         | 0xEE         |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Refer to the application note for more details. |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
|                                                 |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Standby_mode                                    | 21 [15]    | 0: enable.                      1: disable.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Brake_mode                                      | 22 [8]     | 0: brake when safe.                      1: 100% uncontrolled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Safe_brake_thrd                                 | 15 [15:14] | 00: 1× rated current.                      01: 2×.                      10: 4×.                      11: 8×.                                                                                                                                                                                                                                                                                                                                                                                                                                                      |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| OCP_reset_mode                                  | 16 [3]     | 0: upon motor restart.                      1: after 5 seconds.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| OCP_Enable                                      | 16 [2:0]   | 100: 480 ns filter.                      111: OCP disabled.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| OCP_masking                                     | 16 [5:4]   | 00: no masking.                      01: 320 ns masking.                      10: 640 ns masking.                      11: 1280 ns masking.<br>Refer to the application note for more details.                                                                                                                                                                                                                                                                                                                                                                    |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| vds_threshold_sel                               | 22 [15]    | 1: 2 V.                      0: 1 V.<br>Refer to the application note for more details.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Angle_Error_Lock                                | 15 [3:2]   | Lock detect during startup.<br>00: disabled.                      01: 5 degrees.                      10: 9 degrees.                      11: 13 degrees                                                                                                                                                                                                                                                                                                                                                                                                          |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| BEMF_lock_filter                                | 16 [13:12] | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Extend_lock_mask                                | 11 [14]    | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Vibration_lock                                  | 22 [10]    | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Over_speed_lock                                 | 12 [13]    | Refer to the application note.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Restart_attempt                                 | 22 [7:6]   | 00: Always.                      01: 3 times.                      10: 5 times.                      11: 10 times.                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| Lock_restart_set                                | 22 [11]    | 0: 5 seconds.                      1: 10 seconds.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| i2c_spd_mode                                    | 17 [9]     | 0: controlled by SPD pin.                      1: controlled by register value in 17 [8:0].                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |
| i2c_spd_demand                                  | 17 [8:0]   | 0~511 represents 0~100%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |              |              |              |        |      |      |      |        |      |      |      |        |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |         |      |      |      |

Continued on next page...

Table 2: Register and EEPROM Map Notes (continued)

| Parameter       | Address     | Notes                                                                        |
|-----------------|-------------|------------------------------------------------------------------------------|
| <b>READBACK</b> |             |                                                                              |
| Motor speed     | 120         | Motor Speed (Hz) = register_value × 0.530 Hz                                 |
| Bus current     | 121         | Bus current (mA) = register_value / (Sense_resistor_register_value / 125)    |
| Q-axis current  | 122         | Q-axis current (mA) = register_value / (Sense_resistor_register_value / 125) |
| V <sub>BB</sub> | 123         | V <sub>BB</sub> (V) = register_value / 5                                     |
| Temperature     | 124         | Temperature (°C) = register_value – 53                                       |
| Control demand  | 125         | 0~511 represents 0~100%                                                      |
| Control command | 126         | 0~511 represents 0~100%                                                      |
| Operation state | 127 [15:12] |                                                                              |

Note: Refer to application note and user interface for additional detail.

## Programming EEPROM

The A89301 contains 24 words of EEPROM, each of 16 bit length. The EEPROM is controlled with the following I<sup>2</sup>C registers.

### EEPROM Control – Register 161: Used to control programming of EEPROM

| Bit  | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3  | 2  | 1  | 0  |
|------|----|----|----|----|----|----|---|---|---|---|---|---|----|----|----|----|
| Name | 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 0 | 0 | RD | WR | ER | EN |

| Bit  | Name | Description                                                    |
|------|------|----------------------------------------------------------------|
| 0    | EN   | Set EEPROM voltage required for Writing or Erasing.            |
| 1    | ER   | Sets Mode to Erase.                                            |
| 2    | WR   | Sets Mode to Write.                                            |
| 3    | RD   | Sets Mode to Read.                                             |
| 15:4 | n/a  | Do not use; always set to zero (0) during programming process. |

### EEPROM Address – Register 162: Used to set the EEPROM address to be altered

| Bit  | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4         | 3 | 2 | 1 | 0 |
|------|----|----|----|----|----|----|---|---|---|---|---|-----------|---|---|---|---|
| Name | 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 0 | eeADDRESS |   |   |   |   |

| Bit  | Name      | Description                                                                                                                          |
|------|-----------|--------------------------------------------------------------------------------------------------------------------------------------|
| 0:4  | eeADDRESS | Used to specify EEPROM address to be changed. There are 20 addresses. Do not change address 0 or 19 as these are factory-controlled. |
| 15:5 | n/a       | Do not use; always set to zero (0) during programming process.                                                                       |

### EEPROM Data\_In – Register 163: Used to set the EEPROM new data to be programmed

| Bit  | 15       | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|------|----------|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|
| Name | eeDATAin |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |

| Bit  | Name     | Description                                                                         |
|------|----------|-------------------------------------------------------------------------------------|
| 15:0 | eeDATAin | Used to specify the EEPROM address to be erased or written. There are 24 addresses. |

## EEPROM Commands

There are three basic commands, Read, Erase, and Write. To change the contents of a memory location, the word must be first erased. The EEPROM programming process (writing or erasing) takes 10 ms per word.

Each word must be written individually. The following examples are shown in the following format:

I2C\_register\_address [data] ; comment

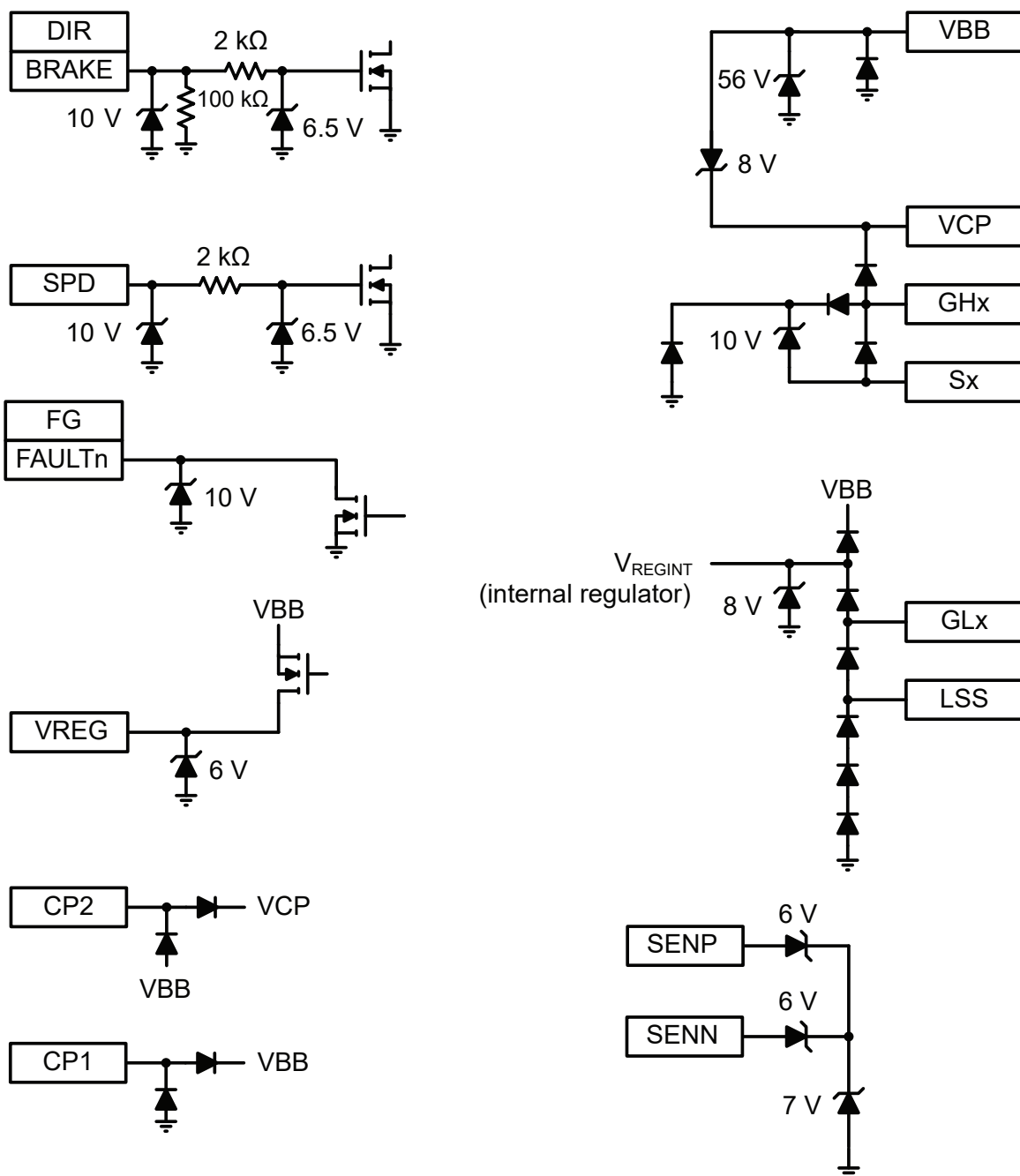
Example #1: Write EEPROM address 7 to 261 (hex = 0x0105)

1. Erase the existing data.
  - A. 162 [7] ; set EEPROM address to erase.
  - B. 163 [0] ; set Data\_In = 0x0000.
  - C. 161 [3] ; set control to Erase and Voltage High.
  - D. Wait 15 ms ; requires 15 ms High Voltage Pulse to Write.
2. Write the new data.
  - A. 162 [7] ; set EEPROM address to write.
  - B. 163 [261] ; set Data\_In = 261.
  - C. 161 [5] ; set control to Write and Set Voltage High.
  - D. Wait 15 ms ; requires 15 ms High Voltage Pulse to Write.

Example #2: Read address 7 to confirm correct data properly programmed.

1. Read the word.
  - A. 7 [N/A for read] ; read register 7; this will be contents of EEPROM.

## PIN DIAGRAMS



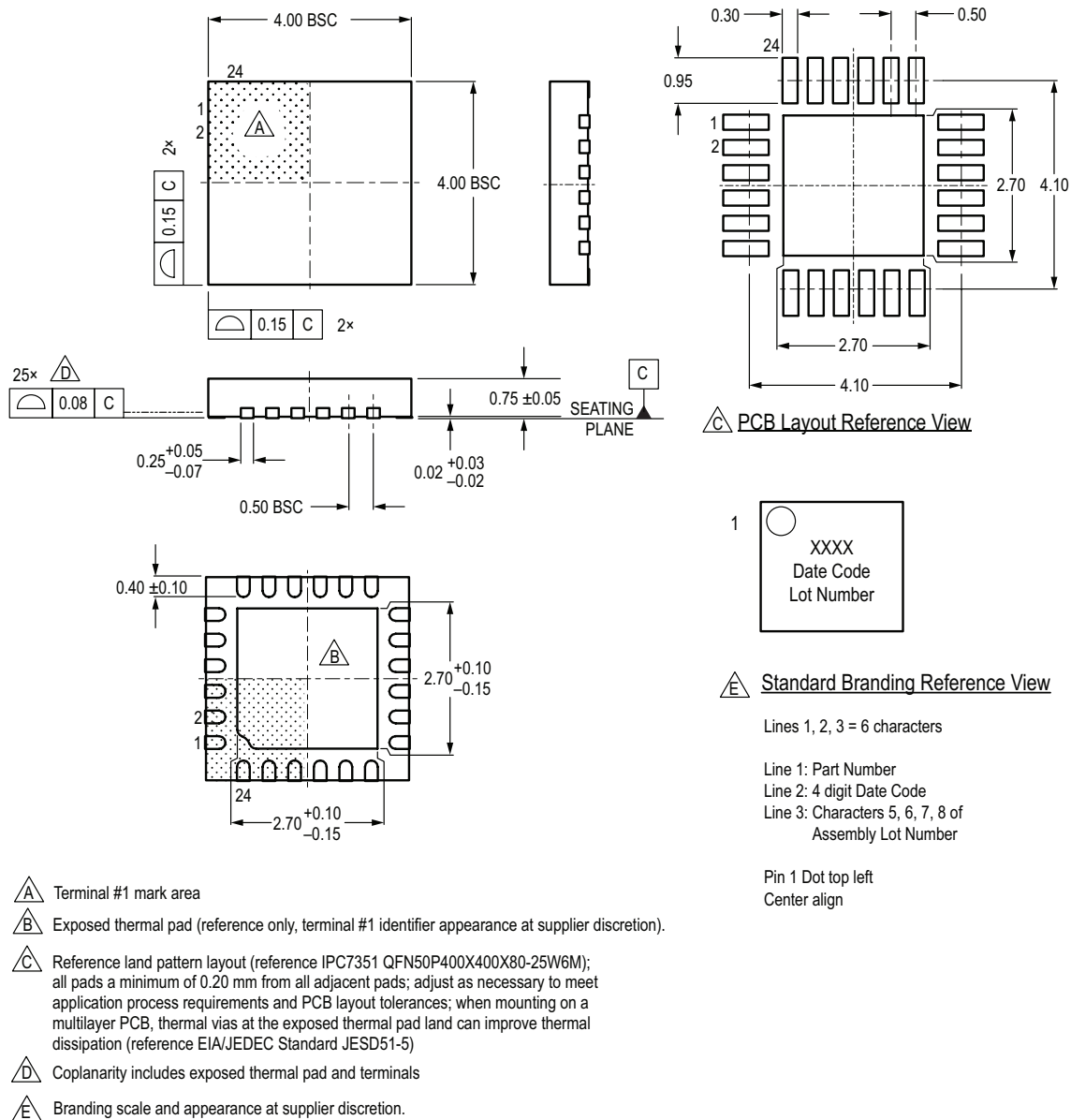
## PACKAGE OUTLINE DRAWING

**For Reference Only – Not for Tooling Use**

(Reference Allegro DWG-0000222 Rev. 4 or JEDEC MO-220WGGD.)

Dimensions in millimeters – NOT TO SCALE.

Exact case and lead configuration at supplier discretion within limits shown.

**Figure 8: Package ES, 24-Contact QFN with Exposed Pad**

**Revision History**

| Number | Date              | Description                                                                                                                                                                                                            |
|--------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| –      | December 13, 2018 | Initial release                                                                                                                                                                                                        |
| 1      | January 24, 2019  | Updated Motor PWM Frequency (page 4); added <code>deadtime_comp</code> to Table 1 (page 11) and Table 2 (page 13); added <code>mosfet_comp</code> to Table 2 (page 13).                                                |
| 2      | March 19, 2019    | Updated Output Voltage Absolute Maximum Rating (page 2), PWM Mode and Clock Mode (page 6), Motor Stop and Standby Mode (page 7-9), I <sup>2</sup> C Operation, EEPROM Map (page 10-15), and EEPROM Commands (page 17). |
| 3      | June 10, 2019     | Minor editorial updates                                                                                                                                                                                                |
| 4      | August 10, 2020   | Updated table 1, “ <code>support_gt_slew[7:0]</code> ” to “ <code>mosfet_ciss_comp[7:0]</code> ” (page 13).<br>Updated table 2, “ <code>mosfet_comp</code> ” to “ <code>mosfet_ciss_comp</code> ” (page 15).           |
| 5      | March 19, 2021    | Added Functional Block Diagram (page 4); updated Register 22[5:0] (pages 14-15), EEPROM Register 163 description (page 18), EEPROM Commands section (page 19)                                                          |
| 6      | August 9, 2021    | Updated Fault Table (page 8) and package drawing (page 21); added System Error and OVP sections (page 9)                                                                                                               |

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