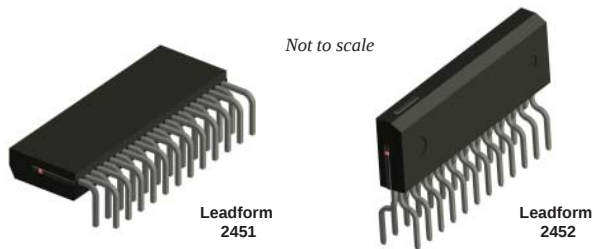


## High Voltage 3-Phase Motor Drivers

### Features and Benefits

- Built-in pre-drive IC
- MOSFET power element
- CMOS compatible input (3.3 to 5 V)
- High-side gate driver using bootstrap circuit or floating power supply
- Built-in protection circuit for controlling power supply voltage drop
- Built-in overtemperature detection circuit (TD)
- Output of fault signal during operation of protection circuits
- Output current 1.5, 2, and 2.5 A
- Small SIP (SMA 24-pin)

### Packages: Power SIP



### Description

The SMA6850MX/MZ inverter power module (IPM) series provides a robust, highly-integrated solution for optimally controlling 3-phase motor power inverter systems and variable speed control systems used in energy-conserving designs to drive motors of residential and commercial appliances. These ICs take 230 VAC input voltage, and up to 2.5 A (continuous) output current. They can withstand voltages of up to 500 V (MOSFET breakdown voltage).

The SMA6850MX/MZ power package includes an IC with all of the necessary power elements (six MOSFETs) and pre-driver ICs (two), needed to configure the main circuit of an inverter. This enables the main circuit of the inverter to be configured with fewer external components than traditional designs.

Applications include residential white goods (home applications) and commercial appliance motor control:

- Air conditioner fan
- Small ventilation fan
- Dishwasher pump

### Functional Block Diagram

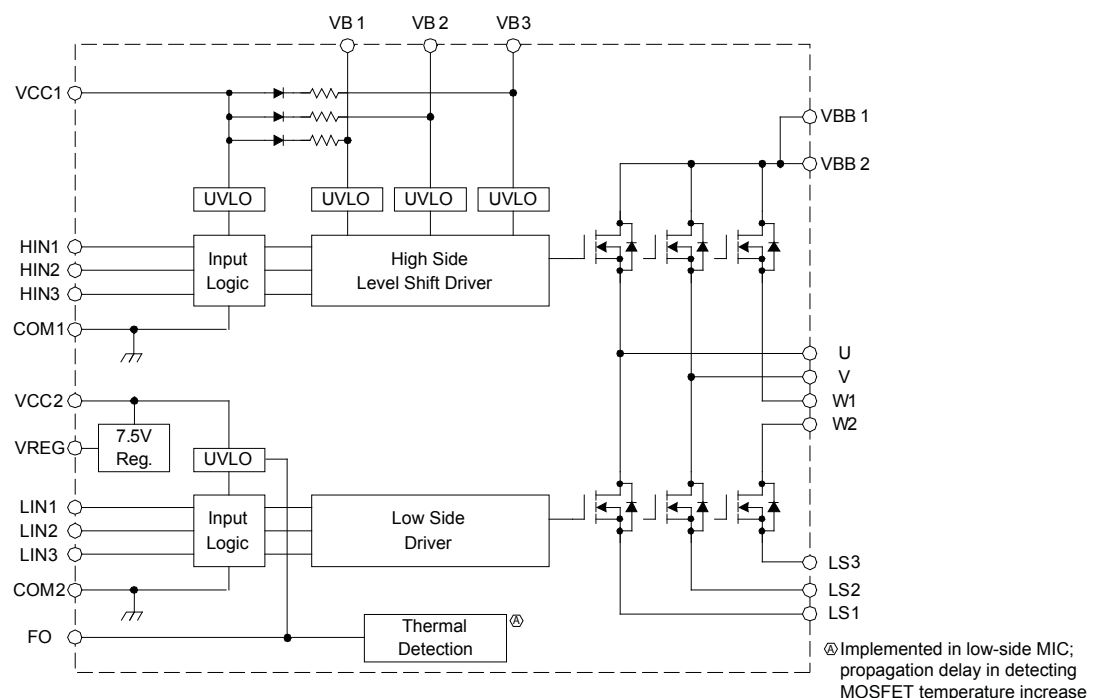


Figure 1. Driver block diagram

## Selection Guide

| Part Number | Packing            | MOSFET Breakdown Voltage, $V_{DSS}(\text{min})$ (V) | Output Current                    |                                  |
|-------------|--------------------|-----------------------------------------------------|-----------------------------------|----------------------------------|
|             |                    |                                                     | Continuous, $I_O(\text{max})$ (A) | Pulsed, $I_{OP}(\text{max})$ (A) |
| SMA6852MZ   | 18 pieces per tube | 500                                                 | 1.5                               | 2.25                             |
| SMA6853MX   | 18 pieces per tube | 500                                                 | 2.5                               | 3.75                             |
| SMA6854MZ   | 18 pieces per tube | 600                                                 | 1.5                               | 2.25                             |

Absolute Maximum Ratings, valid at  $T_A = 25^\circ\text{C}$ 

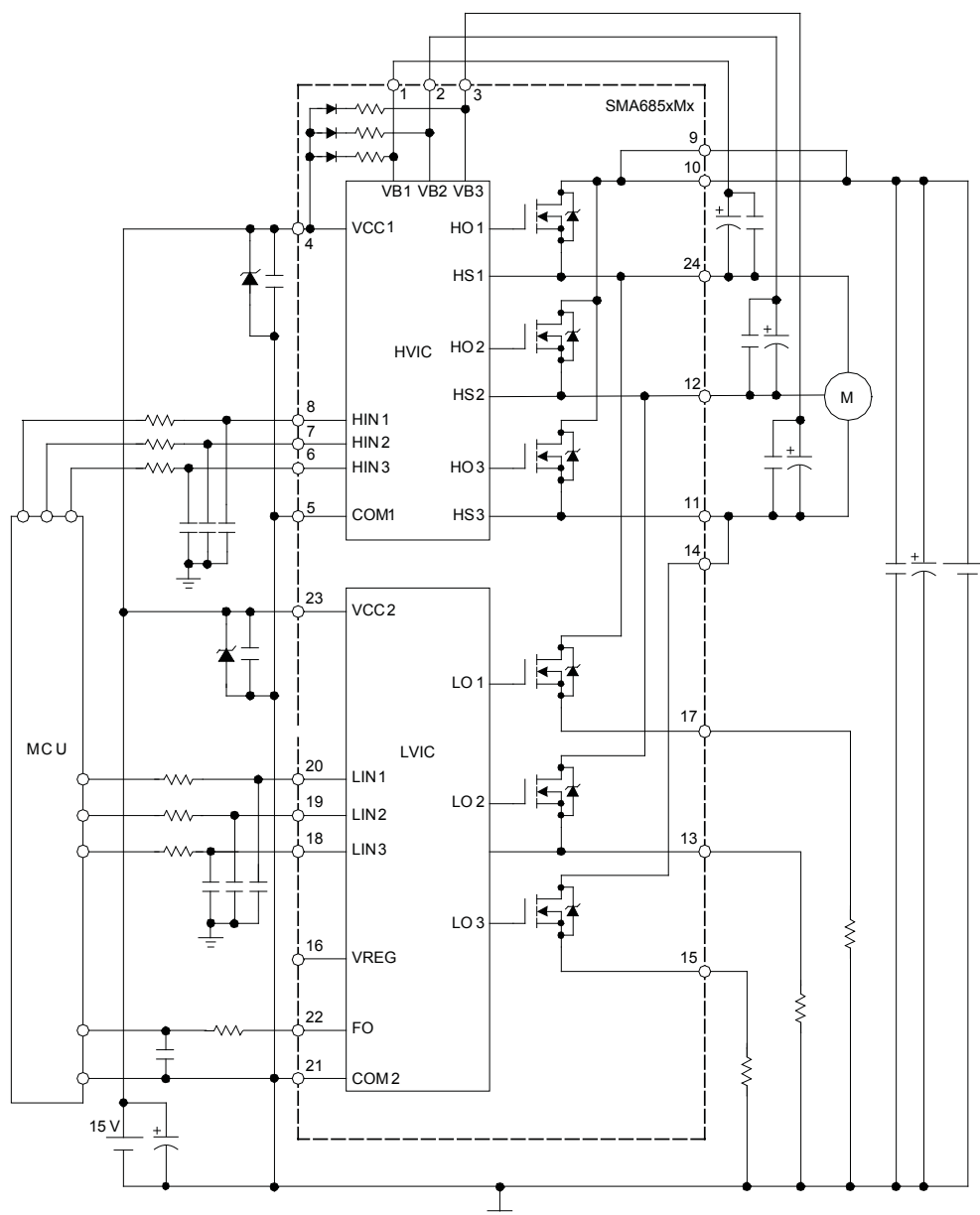
| Characteristic                           | Symbol          | Remarks                               | Rating     | Unit               |
|------------------------------------------|-----------------|---------------------------------------|------------|--------------------|
| MOSFET Breakdown Voltage                 | $V_{DSS}$       | SMA6852MZ                             | 500        | V                  |
|                                          |                 | SMA6853MX                             | 500        | V                  |
|                                          |                 | SMA6854MZ                             | 600        | V                  |
| Logic Supply Voltage                     | $V_{CC}$        | Between VCC and COM                   | 20         | V                  |
| Bootstrap Voltage                        | $V_{BS}$        | Between VB and HS (U,V, and W phases) | 20         | V                  |
| Output Current, Continuous               | $I_O$           | SMA6852MZ                             | 1.5        | A                  |
|                                          |                 | SMA6853MX                             | 2.5        | A                  |
|                                          |                 | SMA6854MZ                             | 1.5        | A                  |
| Output Current, Pulsed                   | $I_{OP}$        | SMA6852MZ                             | 2.25       | A                  |
|                                          |                 | SMA6853MX                             | 3.75       | A                  |
|                                          |                 | SMA6854MZ                             | 2.25       | A                  |
| Input Voltage                            | $V_{IN}$        |                                       | -0.5 to 7  | V                  |
| Allowable Power Dissipation              | $P_D$           | $T_C = 25^\circ\text{C}$              | 28         | W                  |
| Thermal Resistance (Junction to Case)    | $R_{\theta JC}$ | All elements operating                | 4.46       | $^\circ\text{C/W}$ |
| Thermal Resistance (Junction to Ambient) | $R_{\theta JA}$ | All elements operating                | 31.25      | $^\circ\text{C/W}$ |
| Case Operating Temperature               | $T_{COP}$       |                                       | -20 to 100 | $^\circ\text{C}$   |
| Junction Temperature (MOSFET)            | $T_J$           |                                       | 150        | $^\circ\text{C}$   |
| Storage Temperature                      | $T_{stg}$       |                                       | -40 to 150 | $^\circ\text{C}$   |

## Recommended Operating Conditions

| Characteristic       | Symbol            | Remarks             | Min. | Typ. | Max. | Units         |
|----------------------|-------------------|---------------------|------|------|------|---------------|
| Main Supply Voltage  | $V_{BB}$          | SMA6852MZ           | —    | 280  | 400  | V             |
|                      |                   | SMA6853MX           | —    | —    | 400  | V             |
|                      |                   | SMA6854MZ           | —    | 300  | 450  | V             |
| Logic Supply Voltage | $V_{CC}$          | Between VCC and COM | 13.5 | —    | 16.5 | V             |
| Minimum Input Pulse  | $T_W(\text{min})$ |                     | 0.5  | —    | —    | $\mu\text{s}$ |
| Dead Time            | $t_{\text{dead}}$ |                     | 1.5  | —    | —    | $\mu\text{s}$ |

All performance characteristics given are typical values for circuit or system baseline design only and are at the nominal operating voltage and an ambient temperature,  $T_A$ , of  $25^\circ\text{C}$ , unless otherwise stated.

## Typical Application Diagram



## NOTE:

- All of the input pins are connected to GND with internal pull-down resistors rated at 100 k $\Omega$ , however, an external pull-down resistor may be required to secure stable condition of the inputs if high impedance conditions are applied to them.
- The external electrolytic capacitors should be placed as close to the IC as possible, in order to avoid malfunctions from external noise interference. Put a ceramic capacitor in parallel with the electrolytic capacitor if further reduction of noise susceptibility is necessary.
- This IPM does not have an overcurrent detection feature. It is recommended to implement the feature externally. When an overcurrent condition occurs, the application MCU must stop driving the IPM within 2  $\mu$ s.
- Snubber capacitors should be surge suppressor film capacitors with sufficient rating to suppress surge voltages. To determine the capacitance for an application, please verify the surge voltage in the actual application.

ELECTRICAL CHARACTERISTICS, valid at  $T_A=25^{\circ}\text{C}$ , unless otherwise noted

| Characteristics                                                               | Symbol       | Conditions                                                                      | Min  | Typ  | Max  | Units              |
|-------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------|------|------|------|--------------------|
| Logic Supply Voltage                                                          | $V_{CC}$     | Between VCC and COM                                                             | 13.5 | 15   | 16.5 | V                  |
| Logic Supply Current                                                          | $I_{CC}$     | SMA6852MZ                                                                       | –    | 4    | 6    | mA                 |
|                                                                               |              | SMA6853MX                                                                       | –    | 2.5  | 4.0  | mA                 |
|                                                                               |              | SMA6854MZ                                                                       | –    | 3.8  | –    | mA                 |
| Input Voltage                                                                 | $V_{IH}$     | $V_{CC} = 15\text{ V}$ , output on                                              | –    | 2.0  | 2.5  | V                  |
|                                                                               | $V_{IL}$     | $V_{CC} = 15\text{ V}$ , output off                                             | 1.0  | 1.5  | –    | V                  |
| Input Voltage Hysteresis                                                      | $V_{Ihys}$   | $V_{CC} = 15\text{ V}$                                                          | –    | 0.5  | –    | V                  |
| Input Current                                                                 | $I_{IH}$     | High side, $V_{CC} = 15\text{ V}$ , $V_{IN} = 5\text{ V}$                       | –    | 50   | 100  | $\mu\text{A}$      |
|                                                                               | $I_{IL}$     | Low side, $V_{CC} = 15\text{ V}$ , $V_{IN} = 0\text{ V}$                        | –    | –    | 2    | $\mu\text{A}$      |
| Undervoltage Lock Out                                                         | $V_{UVHL}$   | High side, between VB and U, V, or W                                            | 9.0  | 10.0 | 11.0 | V                  |
|                                                                               | $V_{UVHH}$   |                                                                                 | 9.5  | 10.5 | 11.5 | V                  |
|                                                                               | $V_{UVHhys}$ | High side, hysteresis                                                           | –    | 0.5  | –    | V                  |
|                                                                               | $V_{UVLL}$   | Low side, between VCC and COM                                                   | 10.0 | 11.0 | 12.0 | V                  |
|                                                                               | $V_{UVLH}$   |                                                                                 | 10.5 | 11.5 | 12.5 | V                  |
|                                                                               | $V_{UVLhys}$ | Low side, hysteresis                                                            | –    | 0.5  | –    | V                  |
| FO Terminal Output Voltage                                                    | $V_{FOL}$    | $V_{CC} = 15\text{ V}$                                                          | 0    | –    | 1.0  | V                  |
|                                                                               | $V_{FOH}$    |                                                                                 | 4.0  | –    | 5.5  | V                  |
| Overtemperature Detection Threshold Temperature (activation and deactivation) | $T_{DH}$     | $V_{CC} = 15\text{ V}$ , no heatsink                                            | 135  | 150  | 165  | $^{\circ}\text{C}$ |
|                                                                               | $T_{DL}$     |                                                                                 | 105  | 120  | 135  | $^{\circ}\text{C}$ |
|                                                                               | $T_{Dhys}$   |                                                                                 | –    | 30   | –    | $^{\circ}\text{C}$ |
| Output Voltage for Regulator                                                  | $V_{REG}$    | $I_{REG} = 35\text{ mA}$ , $T_C = -20^{\circ}\text{C}$ to $100^{\circ}\text{C}$ | 6.75 | 7.5  | 8.25 | V                  |
| Bootstrap Diode Leakage Current                                               | $I_{LBD}$    | $V_R = 500\text{ V}$                                                            | –    | –    | 10   | $\mu\text{A}$      |
| Bootstrap Diode Forward Voltage                                               | $V_{FBD}$    | $I_F = 0.15\text{ A}$                                                           | –    | 1.1  | 1.3  | V                  |
| Bootstrap Diode Series Resistor                                               | $R_{BD}$     | SMA6852MZ                                                                       | 17.6 | 22   | 26.4 | $\Omega$           |
|                                                                               |              | SMA6853MX                                                                       | 17.6 | 22   | 26.4 | $\Omega$           |
|                                                                               |              | SMA6854MZ                                                                       | 48   | 60   | 72   | $\Omega$           |
| MOSFET Breakdown Voltage                                                      | $V_{DSS}$    | SMA6852MZ                                                                       | 500  | –    | –    | V                  |
|                                                                               |              | SMA6853MX                                                                       | 500  | –    | –    | V                  |
|                                                                               |              | SMA6854MZ                                                                       | 600  | –    | –    | V                  |
| MOSFET Leakage Current                                                        | $I_{DSS}$    | $V_{CC} = 15\text{ V}$ , $V_{DS} = 500\text{ V}$ , $V_{IN} = 0\text{ V}$        | –    | –    | 100  | $\mu\text{A}$      |
| MOSFET On State Resistance                                                    | $R_{DS(on)}$ | SMA6852MZ                                                                       | –    | 3.6  | 4.0  | $\Omega$           |
|                                                                               |              | SMA6853MX                                                                       | –    | 2.0  | 2.4  | $\Omega$           |
|                                                                               |              | SMA6854MZ                                                                       | –    | 3.0  | 3.5  | $\Omega$           |
| MOSFET Diode Forward Voltage                                                  | $V_{SD}$     | SMA6852MZ                                                                       | –    | 1.1  | 1.5  | V                  |
|                                                                               |              | SMA6853MX                                                                       | –    | 1.1  | 1.5  | V                  |
|                                                                               |              | SMA6854MZ                                                                       | –    | 1.0  | 1.5  | V                  |

SMA6852MZ SWITCHING CHARACTERISTICS, valid at  $T_A=25^{\circ}\text{C}$ , unless otherwise noted

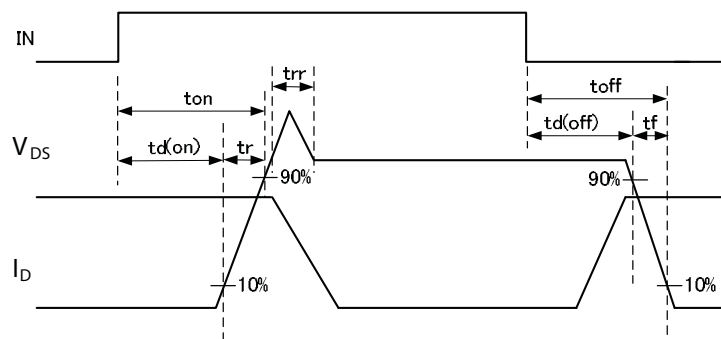
| Characteristics           | Symbol        | Conditions                                                                                                | Min | Typ | Max | Units |
|---------------------------|---------------|-----------------------------------------------------------------------------------------------------------|-----|-----|-----|-------|
| Switching Time, High Side | $t_{dH(on)}$  | $V_{BB} = 300\text{ V}, V_{CC} = 15\text{ V}, I_D = 1.5\text{ A}, 0\text{ V} \leq V_{IN} \leq 5\text{ V}$ | –   | 530 | –   | ns    |
|                           | $t_{rH}$      |                                                                                                           | –   | 95  | –   | ns    |
|                           | $t_{rr}$      |                                                                                                           | –   | 130 | –   | ns    |
|                           | $t_{dH(off)}$ |                                                                                                           | –   | 385 | –   | ns    |
|                           | $t_{fH}$      |                                                                                                           | –   | 40  | –   | ns    |
| Switching Time, Low Side  | $t_{dL(on)}$  | $V_{BB} = 300\text{ V}, V_{CC} = 15\text{ V}, I_D = 1.5\text{ A}, 0\text{ V} \leq V_{IN} \leq 5\text{ V}$ | –   | 530 | –   | ns    |
|                           | $t_{rL}$      |                                                                                                           | –   | 95  | –   | ns    |
|                           | $t_{rr}$      |                                                                                                           | –   | 120 | –   | ns    |
|                           | $t_{dL(off)}$ |                                                                                                           | –   | 445 | –   | ns    |
|                           | $t_{fL}$      |                                                                                                           | –   | 30  | –   | ns    |

SMA6853MX SWITCHING CHARACTERISTICS, valid at  $T_A=25^{\circ}\text{C}$ , unless otherwise noted

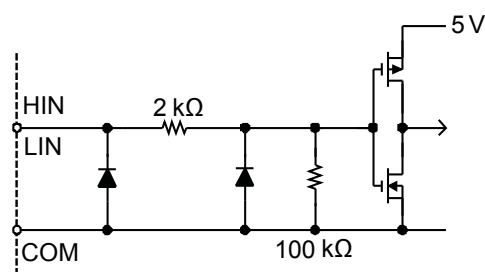
| Characteristics           | Symbol        | Conditions                                                                                                | Min | Typ | Max | Units |
|---------------------------|---------------|-----------------------------------------------------------------------------------------------------------|-----|-----|-----|-------|
| Switching Time, High Side | $t_{dH(on)}$  | $V_{BB} = 300\text{ V}, V_{CC} = 15\text{ V}, I_D = 2.5\text{ A}, 0\text{ V} \leq V_{IN} \leq 5\text{ V}$ | –   | 650 | –   | ns    |
|                           | $t_{rH}$      |                                                                                                           | –   | 100 | –   | ns    |
|                           | $t_{rr}$      |                                                                                                           | –   | 150 | –   | ns    |
|                           | $t_{dH(off)}$ |                                                                                                           | –   | 520 | –   | ns    |
|                           | $t_{fH}$      |                                                                                                           | –   | 50  | –   | ns    |
| Switching Time, Low Side  | $t_{dL(on)}$  | $V_{BB} = 300\text{ V}, V_{CC} = 15\text{ V}, I_D = 2.5\text{ A}, 0\text{ V} \leq V_{IN} \leq 5\text{ V}$ | –   | 700 | –   | ns    |
|                           | $t_{rL}$      |                                                                                                           | –   | 100 | –   | ns    |
|                           | $t_{rr}$      |                                                                                                           | –   | 150 | –   | ns    |
|                           | $t_{dL(off)}$ |                                                                                                           | –   | 580 | –   | ns    |
|                           | $t_{fL}$      |                                                                                                           | –   | 40  | –   | ns    |

SMA6854MZ SWITCHING CHARACTERISTICS, valid at  $T_A=25^{\circ}\text{C}$ , unless otherwise noted

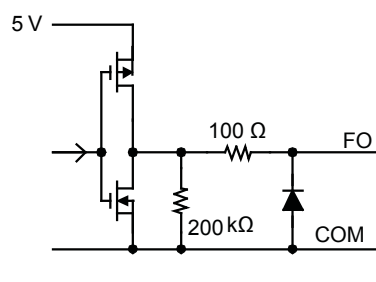
| Characteristics           | Symbol        | Conditions                                                                                              | Min | Typ | Max | Units |
|---------------------------|---------------|---------------------------------------------------------------------------------------------------------|-----|-----|-----|-------|
| Switching Time, High Side | $t_{dH(on)}$  | $V_{BB} = 150\text{ V}, V_{CC} = 15\text{ V}, I_D = 2\text{ A}, 0\text{ V} \leq V_{IN} \leq 5\text{ V}$ | –   | 530 | –   | ns    |
|                           | $t_{rH}$      |                                                                                                         | –   | 55  | –   | ns    |
|                           | $t_{rr}$      |                                                                                                         | –   | 125 | –   | ns    |
|                           | $t_{dH(off)}$ |                                                                                                         | –   | 510 | –   | ns    |
|                           | $t_{fH}$      |                                                                                                         | –   | 50  | –   | ns    |
| Switching Time, Low Side  | $t_{dL(on)}$  | $V_{BB} = 150\text{ V}, V_{CC} = 15\text{ V}, I_D = 2\text{ A}, 0\text{ V} \leq V_{IN} \leq 5\text{ V}$ | –   | 530 | –   | ns    |
|                           | $t_{rL}$      |                                                                                                         | –   | 60  | –   | ns    |
|                           | $t_{rr}$      |                                                                                                         | –   | 125 | –   | ns    |
|                           | $t_{dL(off)}$ |                                                                                                         | –   | 540 | –   | ns    |
|                           | $t_{fL}$      |                                                                                                         | –   | 55  | –   | ns    |



Switching Characteristics Definitions



HINx and LINx Terminals Internal Equivalent Circuit



FO Terminal Internal Equivalent Circuit

Truth Table

| Mode                                | Hin | Lin | H-side MOSFET | L-side MOSFET |
|-------------------------------------|-----|-----|---------------|---------------|
| Normal                              | L   | L   | Off           | Off           |
|                                     | H   | L   | On            | Off           |
|                                     | L   | H   | Off           | On            |
|                                     | H   | H   | On            | On            |
| Thermal Detection (TD) <sup>1</sup> | L   | L   | Off           | Off           |
|                                     | H   | L   | On            | Off           |
|                                     | L   | H   | Off           | On            |
|                                     | H   | H   | On            | On            |
| UVLO (VCC) <sup>2</sup>             | L   | L   | Off           | Off           |
|                                     | H   | L   | Off           | Off           |
|                                     | L   | H   | Off           | Off           |
|                                     | H   | H   | Off           | Off           |
| UVLO (VB) <sup>3</sup>              | L   | L   | Off           | Off           |
|                                     | H   | L   | Off           | Off           |
|                                     | L   | H   | Off           | On            |
|                                     | H   | H   | Off           | On            |

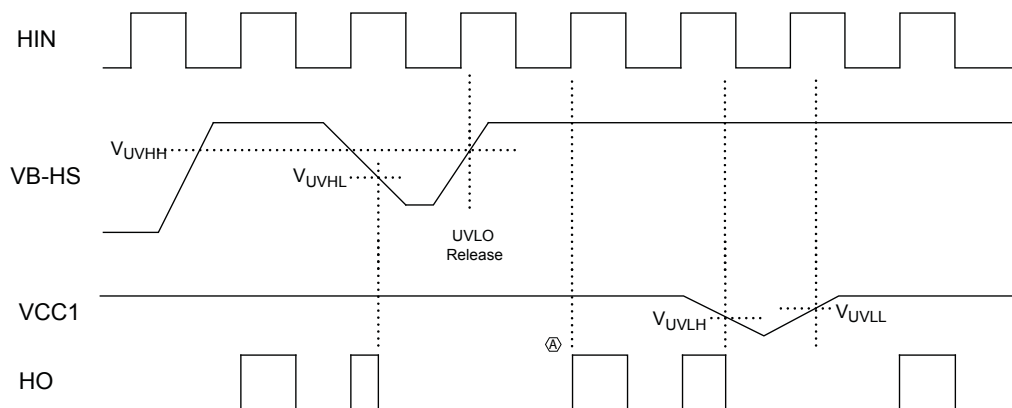
<sup>1</sup>The Thermal Detection function drives the FO pin output to logic high. The external microcontroller should detect this condition.

<sup>2</sup>Returning to the Normal mode of operation from a V<sub>CC</sub> UVLO condition, a low-side MOSFET resumes switching on the first logic high of a LINx input.

<sup>3</sup>Returning to the Normal mode of operation from a V<sub>B</sub> UVLO condition, a high-side MOSFET resumes switching on the rising edge of an HINx input.

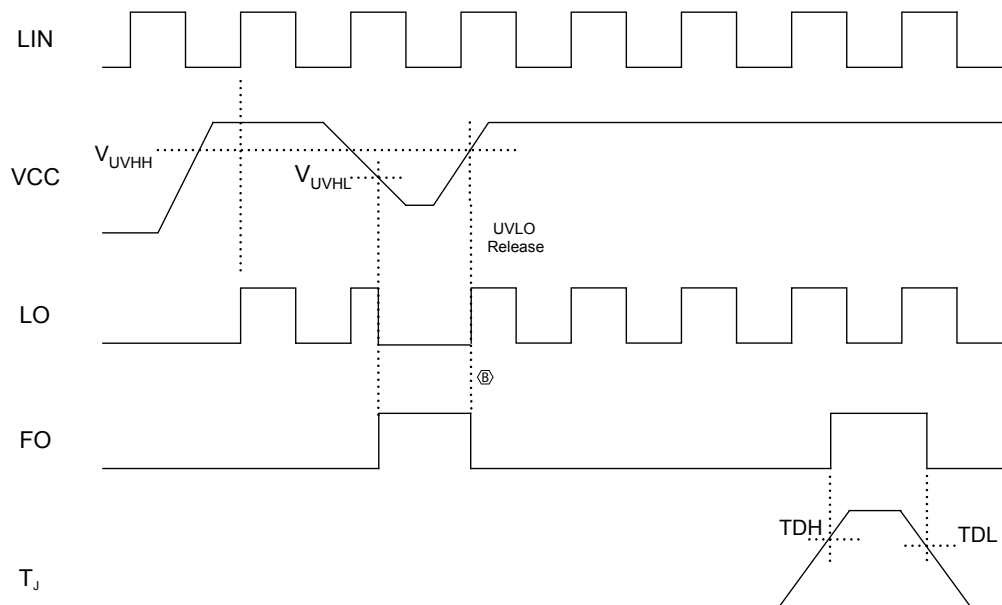
Note: To prevent a shoot-through condition, the external microcontroller should not drive HINx = LINx = H at the same time.

High Side Driver Input/Output Timing Diagrams



Ⓐ After a high-side UVLO is released, HO output is activated at the rising edge of HIN.  
High-side UVLO conditions are not reflected in the FO pin output.

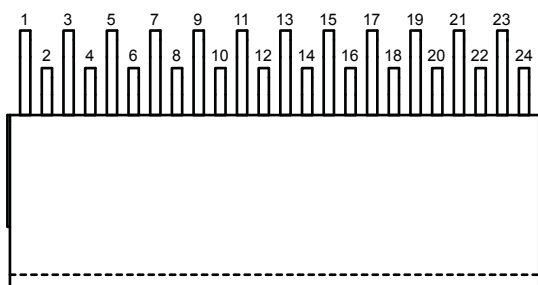
Low Side Driver Input/Output Timing Diagrams



Ⓑ After a low-side UVLO is released, LO output is activated at the logic high of an LINx input.  
Low-side UVLO conditions drive the FO pin to logic high.

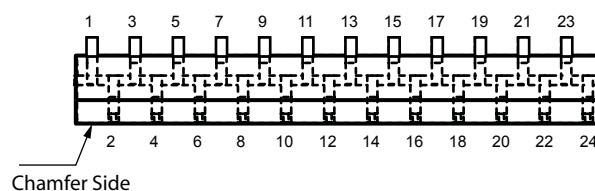
## Pin-out Diagrams

Leadform 2451



Chamfer on Opposite Side

Leadform 2452



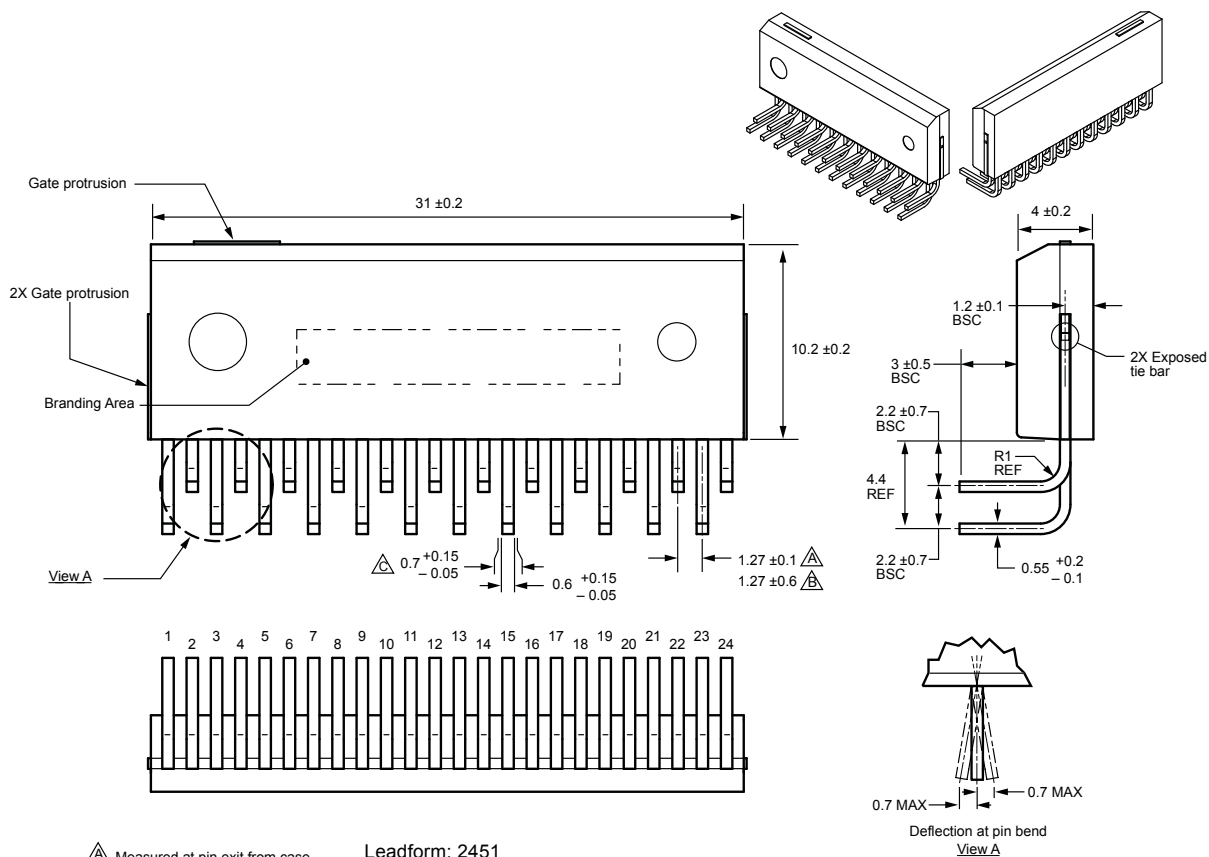
Terminal List Table

| Number | Name | Function                                               |
|--------|------|--------------------------------------------------------|
| 1      | VB1  | High side bootstrap terminal (U phase)                 |
| 2      | VB2  | High side bootstrap terminal (V phase)                 |
| 3      | VB3  | High side bootstrap terminal (W phase)                 |
| 4      | VCC1 | High side logic supply voltage                         |
| 5      | COM1 | High side logic GND terminal                           |
| 6      | HIN3 | High side input terminal (W phase)                     |
| 7      | HIN2 | High side input terminal (V phase)                     |
| 8      | HIN1 | High side input terminal (U phase)                     |
| 9      | VBB1 | Main supply voltage 1 (connect to VBB2 externally)     |
| 10     | VBB2 | Main supply voltage 2 (connect to VBB1 externally)     |
| 11     | W1   | Output of W phase (connect to W2 externally)           |
| 12     | V    | Output of V phase                                      |
| 13     | LS2  | Source terminal of V phase                             |
| 14     | W2   | Output of W phase (connect to W1 externally)           |
| 15     | LS3  | Source terminal of W phase                             |
| 16     | VREG | Internal regulator output terminal                     |
| 17     | LS1  | Source terminal of U phase                             |
| 18     | LIN3 | Low side input terminal (W phase)                      |
| 19     | LIN2 | Low side input terminal (V phase)                      |
| 20     | LIN1 | Low side input terminal (U phase)                      |
| 21     | COM2 | Low side GND terminal                                  |
| 22     | FO   | Overtemperature detection fault-signal output terminal |
| 23     | VCC2 | Low side logic supply voltage                          |
| 24     | U    | Output of U phase                                      |

## Package Outline Drawing

### Leadform 2451

Dual rows, 24 alternating pins; pins bent 90° for horizontal case mounting; pin #1 in outer row



- △ Measured at pin exit from case
- △ Measured at pin tips
- △ Maximum dambar protrusion

Leadform: 2451

Terminal core material: Cu

Terminal plating: Ni and solder (Sn 97.5%, Ag 2.5%) plating

Case material: Epoxy resin

Dimensions in millimeters

Branding codes (exact appearance at manufacturer discretion):

1st line, lot: YMDD#

Where: Y is the last digit of the year of manufacture

M is the month (1 to 9, O, N, D)

DD is the date

# is the letter X for the SMA6853MX series or the reference number

2nd line, type: SMA6852MZ, SMA6853M, or SMA6854MZ

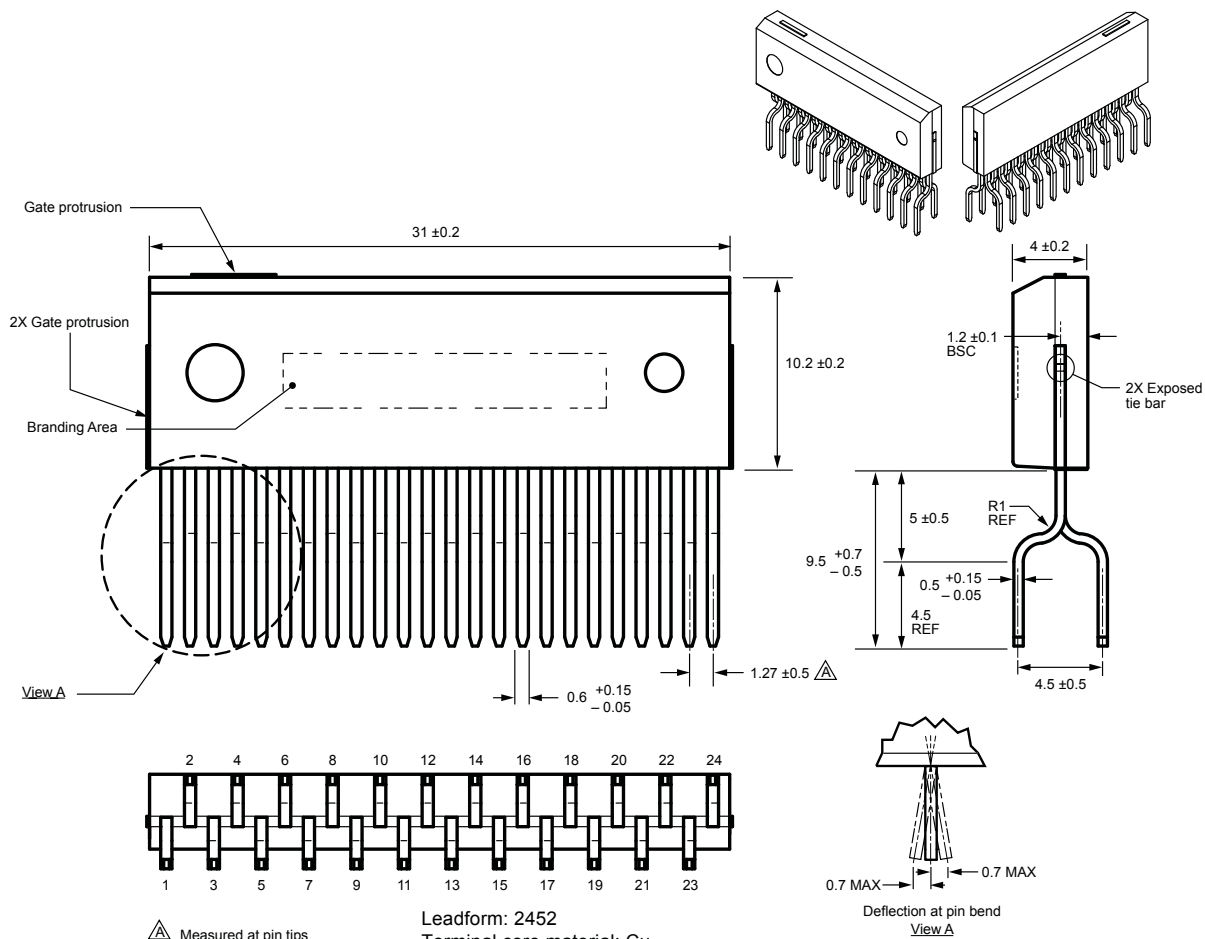


Leadframe plating Pb-free. Device composition complies with the RoHS directive.

## Package Outline Drawing

### Leadform 2452

Dual rows, 24 alternating pins; vertical case mounting; pin #1 opposite chamfer side



Leadframe plating Pb-free. Device composition complies with the RoHS directive.

Because reliability can be affected adversely by improper storage environments and handling methods, please observe the following cautions.

**Cautions for Storage**

- Ensure that storage conditions comply with the standard temperature (5°C to 35°C) and the standard relative humidity (around 40 to 75%); avoid storage locations that experience extreme changes in temperature or humidity.
- Avoid locations where dust or harmful gases are present and avoid direct sunlight.
- Reinspect for rust on leads and solderability of products that have been stored for a long time.

**Cautions for Testing and Handling**

When tests are carried out during inspection testing and other standard test periods, protect the products from power surges from the testing device, shorts between adjacent products, and shorts to the heatsink.

**Remarks About Using Silicone Grease with a Heatsink**

- When silicone grease is used in mounting this product on a heatsink, it shall be applied evenly and thinly. If more silicone grease than required is applied, it may produce stress.
- Volatile-type silicone greases may permeate the product and produce cracks after long periods of time, resulting in reduced heat radiation effect, and possibly shortening the lifetime of the product.
- Our recommended silicone greases for heat radiation purposes, which will not cause any adverse effect on the product life, are indicated below:

| Type   | Suppliers                            |
|--------|--------------------------------------|
| G746   | Shin-Etsu Chemical Co., Ltd.         |
| YG6260 | Momentive Performance Materials      |
| SC102  | Dow Corning Toray Silicone Co., Ltd. |

**Soldering**

- When soldering the products, please be sure to minimize the working time, within the following limits:  
260±5°C 10 s  
380±5°C 5 s
- Soldering iron should be at a distance of at least 1.5 mm from the body of the products

**Electrostatic Discharge**

- When handling the products, operator must be grounded. Grounded wrist straps worn should have at least 1 MΩ of resistance to ground to prevent shock hazard.
- Workbenches where the products are handled should be grounded and be provided with conductive table and floor mats.
- When using measuring equipment such as a curve tracer, the equipment should be grounded.
- When soldering the products, the head of soldering irons or the solder bath must be grounded in order to prevent leak voltages generated by them from being applied to the products.
- The products should always be stored and transported in our shipping containers or conductive containers, or be wrapped in aluminum foil.

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