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

Not to scale

Leadform 2451

Leadform 2452

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

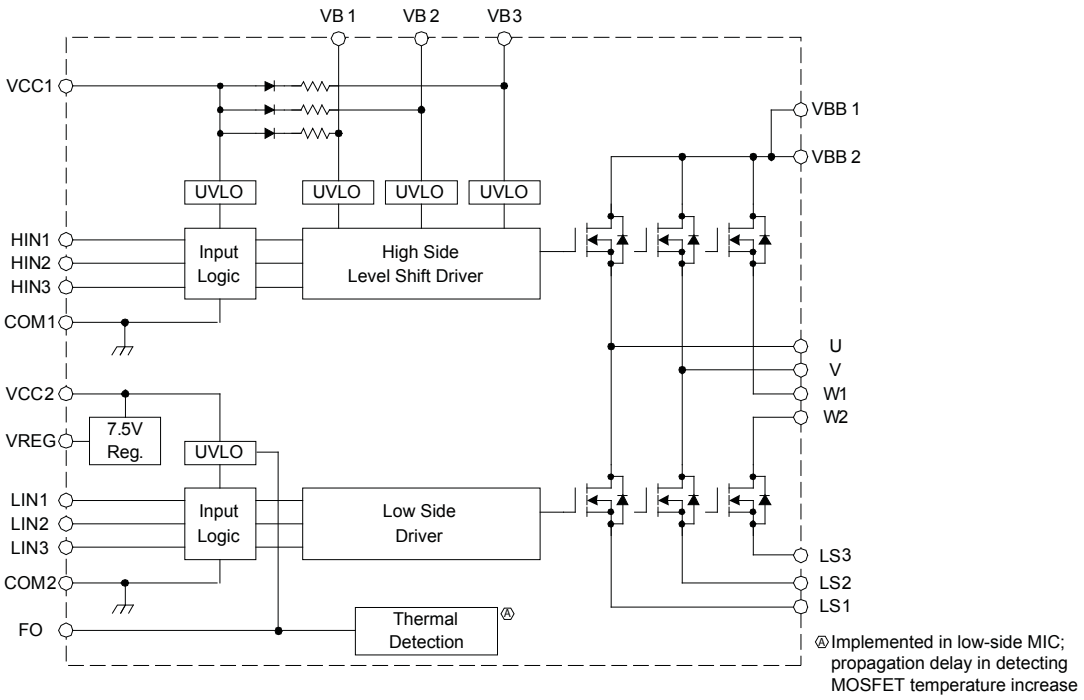

Figure 1. Driver block diagram

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http://www.sanken-ele.co.jp/en/

Selection Guide

Part Number	Packing	MOSFET Breakdown Voltage, V_{DSS}(min) (V)	Output Current	
			Continuous, I_O(max) (A)	Pulsed, I_{OP} (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°C

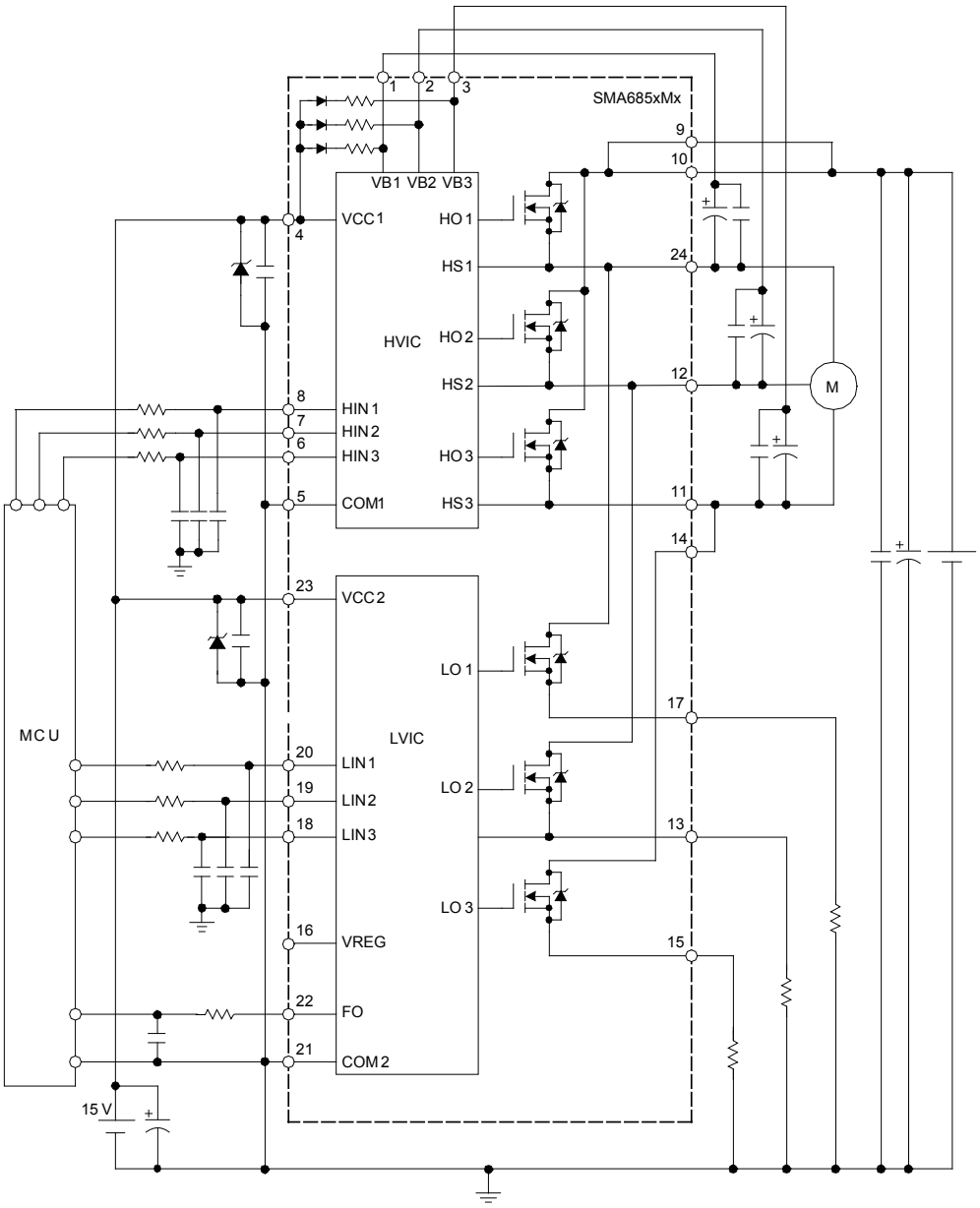
Characteristic	Symbol	Remarks		Rating	Unit
MOSFET Breakdown Voltage	V_{DSS}	SMA6852MZ	V_{CC} = 15 V, I_D = 100 µA, V_{IN} = 0 V	500	V
		SMA6853MX		500	V
		SMA6854MZ		600	V
Logic Supply Voltage	V_{CC}	Between VCC and COM		20	V
Bootstrap Voltage	V_{BS}	Between VB and HS (U,V, and W phases)		20	V
Output Current, Continuous	I_O	SMA6852MZ		1.5	A
		SMA6853MX		2.5	A
		SMA6854MZ		1.5	A
Output Current, Pulsed	I_{OP}	SMA6852MZ	PW ≤ 100 µs, duty cycle = 1%	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°C		28	W
Thermal Resistance (Junction to Case)	$R_{\theta JC}$	All elements operating		4.46	°C/W
Thermal Resistance (Junction to Ambient)	$R_{\theta JA}$	All elements operating		31.25	°C/W
Case Operating Temperature	T_{COP}			–20 to 100	°C
Junction Temperature (MOSFET)	T_J			150	°C
Storage Temperature	T_{stg}			–40 to 150	°C

Recommended Operating Conditions

Characteristic	Symbol		Remarks	Min.	Typ.	Max.	Units
Main Supply Voltage	V_{BB}	SMA6852MZ	Between VBB and LS	–	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(min)			0.5	–	–	µs
Dead Time	t_{dead}			1.5	–	–	µs

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°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 kΩ, 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 µs.
- Snubber capacitors should be surge suppressor film capacitors with sufficient rating to suppress surge voltavges. To determine the capacitance for an application, please verify the surge voltage in the actual application.

ELECTRICAL CHARACTERISTICS, valid at T_A=25°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	V_{CC} = 15 V, I_{REG} = 0 A	–	4	6	mA
		SMA6853MX		–	2.5	4.0	mA
		SMA6854MZ		–	3.8	–	mA
Input Voltage	V_{IH}	V_{CC} = 15 V, output on		–	2.0	2.5	V
	V_{IL}	V_{CC} = 15 V, output off		1.0	1.5	–	V
Input Voltage Hysteresis	V_{Ihys}	V_{CC} = 15 V		–	0.5	–	V
Input Current	I_{IH}	High side, V_{CC} = 15 V, V_{IN} = 5 V		–	50	100	µA
	I_{IL}	Low side, V_{CC} = 15 V, V_{IN} = 0 V		–	–	2	µA
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 V		0	–	1.0	V
	V_{FOH}			4.0	–	5.5	V
Overtemperature Detection Threshold Temperature (activation and deactivation)	T_{DH}	V_{CC} = 15 V, no heatsink		135	150	165	°C
	T_{DL}			105	120	135	°C
	T_{Dhys}			–	30	–	°C
Output Voltage for Regulator	V_{REG}	I_{REG} = 35 mA, T_C = –20°C to 100°C		6.75	7.5	8.25	V
Bootstrap Diode Leakage Current	I_{LBD}	V_R = 500 V		–	–	10	µA
Bootstrap Diode Forward Voltage	V_{FBD}	I_F = 0.15 A		–	1.1	1.3	V
Bootstrap Diode Series Resistor	R_{BD}	SMA6852MZ		17.6	22	26.4	Ω
		SMA6853MX		17.6	22	26.4	Ω
		SMA6854MZ		48	60	72	Ω
MOSFET Breakdown Voltage	V_{DSS}	SMA6852MZ	V_{CC} = 15 V, I_D = 100 µA, V_{IN} = 0 V	500	–	–	V
		SMA6853MX		500	–	–	V
		SMA6854MZ		600	–	–	V
MOSFET Leakage Current	I_{DSS}	V_{CC} = 15 V, V_{DS} = 500 V, V_{IN} = 0 V		–	–	100	µA
MOSFET On State Resistance	$R_{DS(on)}$	SMA6852MZ	V_{CC} = 15 V, I_D = 0.75 A, V_{IN} = 5 V	–	3.6	4.0	Ω
		SMA6853MX	V_{CC} = 15 V, I_D = 1.25 A, V_{IN} = 5 V	–	2.0	2.4	Ω
		SMA6854MZ	V_{CC} = 15 V, I_D = 1.25 A, V_{IN} = 5 V	–	3.0	3.5	Ω
MOSFET Diode Forward Voltage	V_{SD}	SMA6852MZ	V_{CC} = 15 V, I_{SD} = 0.75 A, V_{IN} = 0 V	–	1.1	1.5	V
		SMA6853MX	V_{CC} = 15 V, I_{SD} = 1.25 A, V_{IN} = 0 V	–	1.1	1.5	V
		SMA6854MZ	V_{CC} = 15 V, I_{SD} = 1.25 A, V_{IN} = 0 V	–	1.0	1.5	V

SMA6852MZ SWITCHING CHARACTERISTICS, valid at T_A=25°C, unless otherwise noted

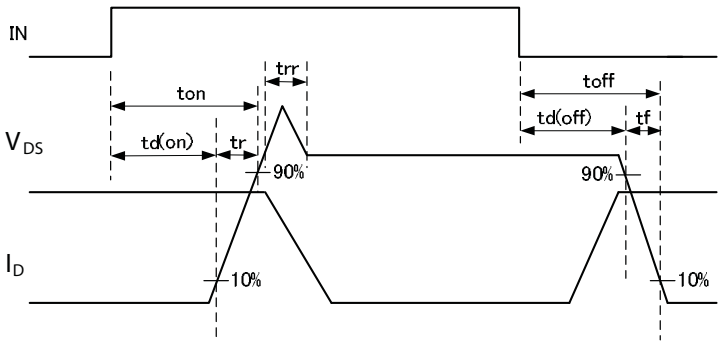
Characteristics	Symbol	Conditions	Min	Typ	Max	Units
Switching Time, High Side	$t_{dH(on)}$	V_{BB} = 300 V, V_{CC} = 15 V, I_D = 1.5 A, 0 V ≤ V_{IN} ≤ 5 V	–	530	–	ns
	t_{rH}		–	95	–	ns
	t_{rr}		–	130	–	ns
	$t_{dH(off)}$		–	385	–	ns
	t_{fH}		–	40	–	ns
Switching Time, Low Side	$t_{dL(on)}$	V_{BB} = 300 V, V_{CC} = 15 V, I_D = 1.5 A, 0 V ≤ V_{IN} ≤ 5 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°C, unless otherwise noted

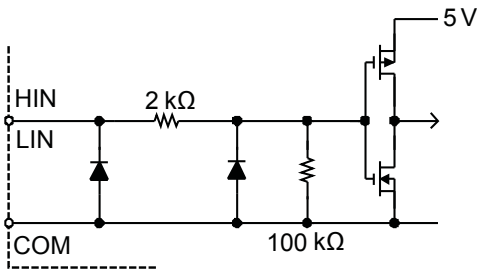
Characteristics	Symbol	Conditions	Min	Typ	Max	Units
Switching Time, High Side	$t_{dH(on)}$	V_{BB} = 300 V, V_{CC} = 15 V, I_D = 2.5 A, 0 V ≤ V_{IN} ≤ 5 V	–	650	–	ns
	t_{rH}		–	100	–	ns
	t_{rr}		–	150	–	ns
	$t_{dH(off)}$		–	520	–	ns
	t_{fH}		–	50	–	ns
Switching Time, Low Side	$t_{dL(on)}$	V_{BB} = 300 V, V_{CC} = 15 V, I_D = 2.5 A, 0 V ≤ V_{IN} ≤ 5 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°C, unless otherwise noted

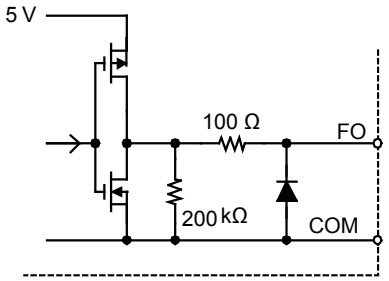
Characteristics	Symbol	Conditions	Min	Typ	Max	Units
Switching Time, High Side	$t_{dH(on)}$	V_{BB} = 150 V, V_{CC} = 15 V, I_D = 2 A, 0 V ≤ V_{IN} ≤ 5 V	–	530	–	ns
	t_{rH}		–	55	–	ns
	t_{rr}		–	125	–	ns
	$t_{dH(off)}$		–	510	–	ns
	t_{fH}		–	50	–	ns
Switching Time, Low Side	$t_{dL(on)}$	V_{BB} = 150 V,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

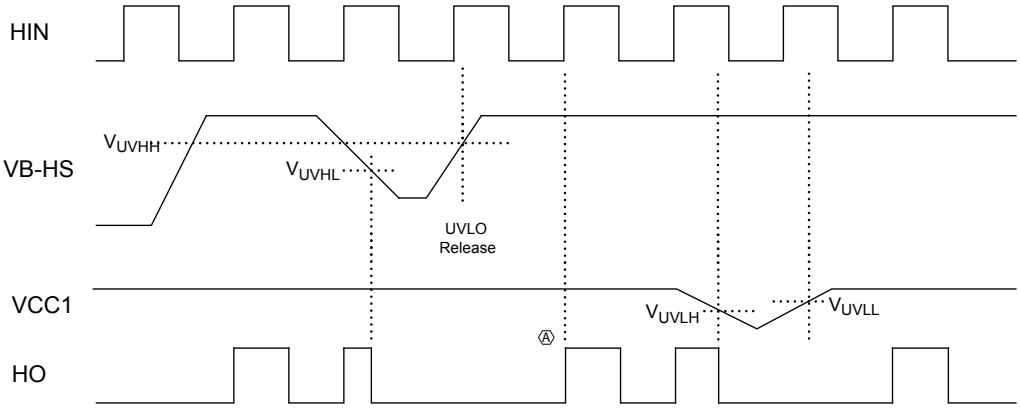
Truth Table

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)[1]	L	L	Off	Off
	H	L	On	Off
	L	H	Off	On
	H	H	On	On
UVLO (VCC)[2]	L	L	Off	Off
	H	L	Off	Off
	L	H	Off	Off
	H	H	Off	Off
UVLO (VB)[3]	L	L	Off	Off
	H	L	Off	Off
	L	H	Off	On
	H	H	Off	On

[1]The Thermal Detection function drives the FO pin output to logic high. The external microcontroller should detect this condition.
[2]Returning to the Normal mode of operation from a V_{CC} UVLO condition, a low-side MOSFET resumes switching on the first logic high of a LINx input.
[3]Returning to the Normal mode of operation from a V_B UVLO condition, a high-side MOSFET resumes switching on the rising edge of an HINx input.

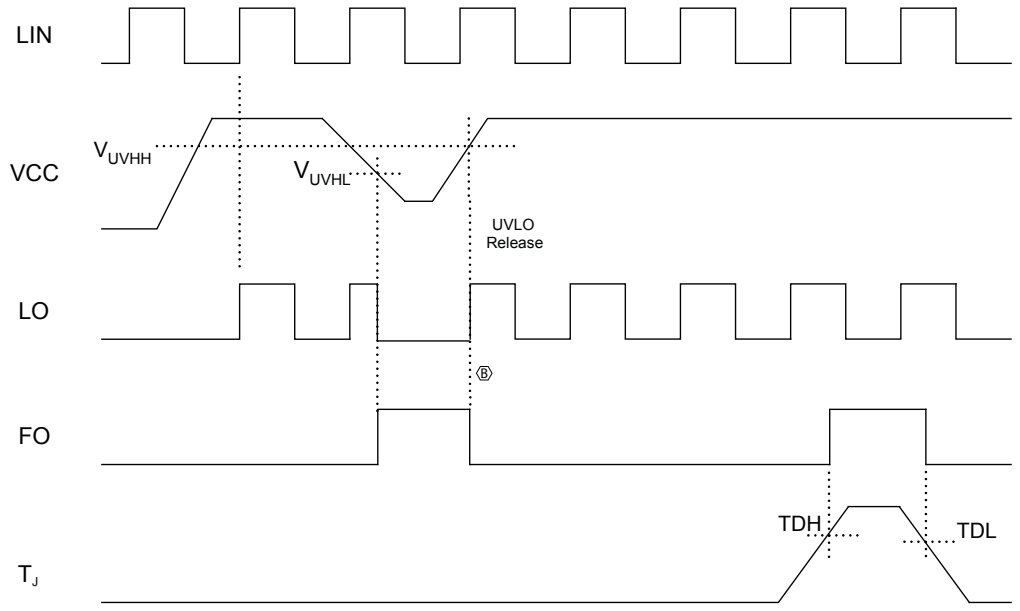
Note: To prevent a shoot-through condition, the external microcontroller should not drive HINx = LINx = H at the same time.

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.

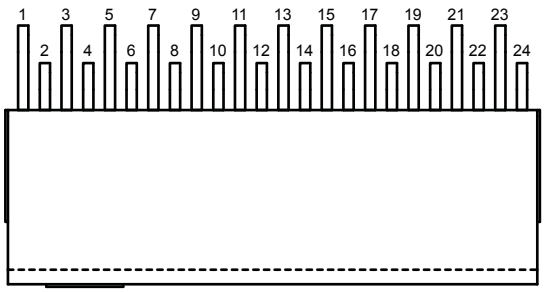
Low Side Driver Input/Output Timing Diagrams



Ⓑ 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.

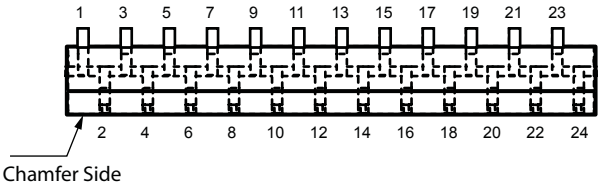
Pin-out Diagrams

Leadform 2451



Chamfer on Opposite Side

Leadform 2452



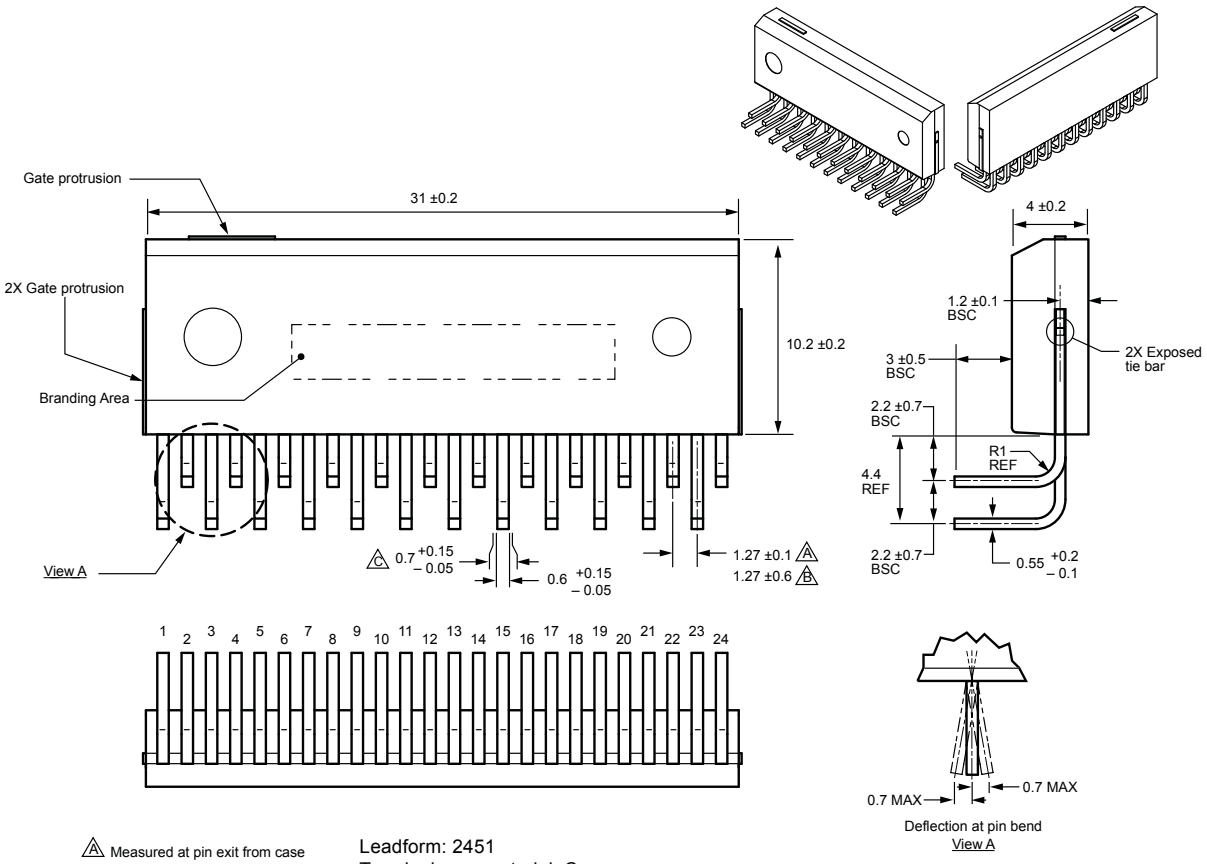
Terminal List Table

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



A Measured at pin exit from case

B Measured at pin tips

C 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):

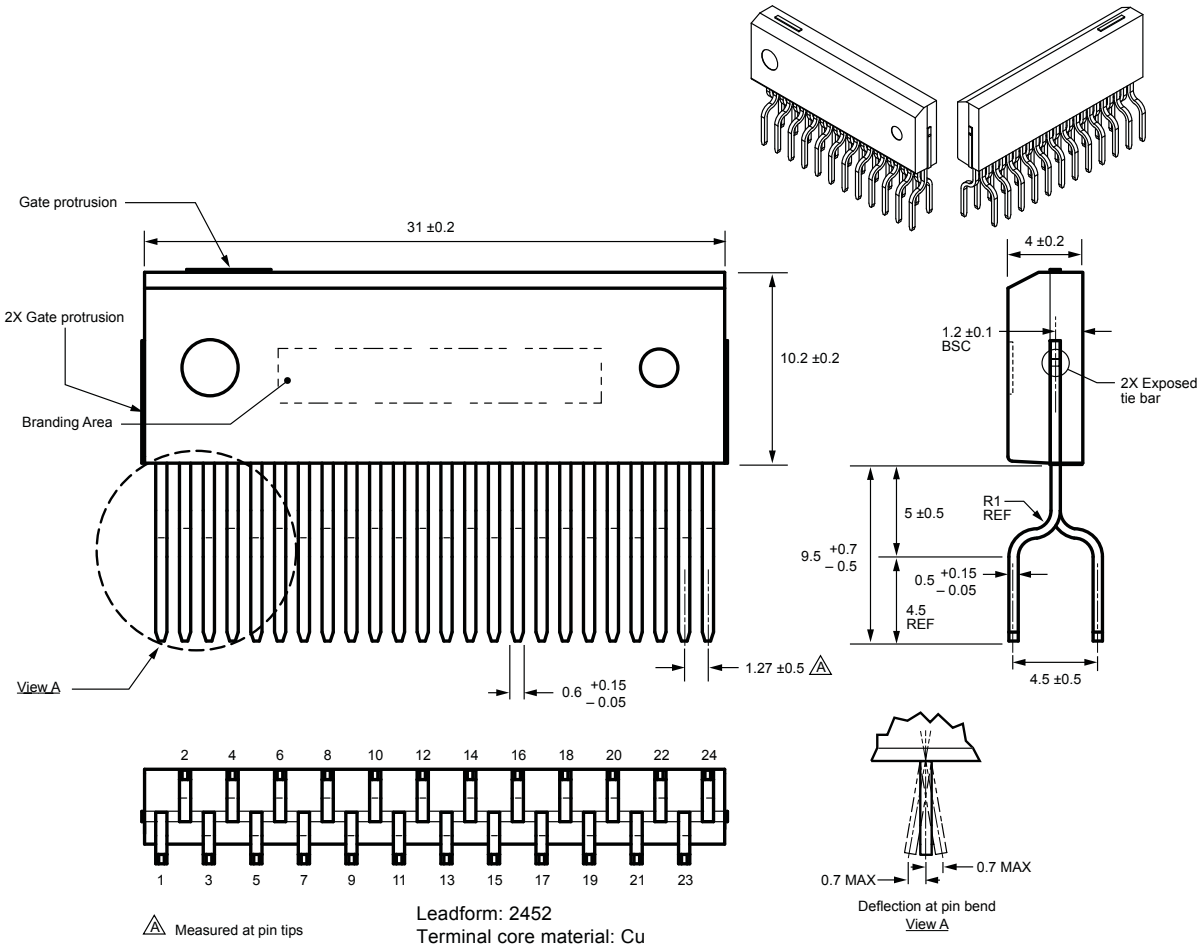
1st line, lot: *YMDD#*
Where: Y is the last digit of the year of manufacture
M is the month (*1* to *9, O, N, D*)
DD is the date
is the letter X for the SMA6853MX series or the reference number
2nd line, type: SMA6852MZ, SMA6853M, or SMA6854MZ

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



A Measured at pin tips

Leadform: 2452
Terminal core material: Cu
Terminal plating: Ni
Recommended attachment: Solder dip (Sn-Ag-Cu)

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.

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 other 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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- In the case that you use our semiconductor devices or design your products by using our semiconductor devices, the reliability largely depends on the degree of derating to be made to the rated values. Derating may be interpreted as a case that an operation range is set by derating the load from each rated value or surge voltage or noise is considered for derating in order to assure or improve the reliability. In general, derating factors include electric stresses such as electric voltage, electric current, electric power etc., environmental stresses such as ambient temperature, humidity etc. and thermal stress caused due to self-heating of semiconductor devices. For these stresses, instantaneous values, maximum values and minimum values must be taken into consideration.
  In addition, it should be noted that since power devices or IC's including power devices have large self-heating value, the degree of derating of junction temperature (T_J) affects the reliability significantly.
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