

SMA685xM Series

March, 2015

General Description

The SMA685xM series provides a highly-integrated solution by incorporating key components into one package – MOSFETs in a 3-phase full-bridge configuration, built-in protection functions such as UVLO (undervoltage lockout) and TD (thermal detection) circuits, pre-driver ICs with 7.5 V regulator output, and bootstrap diodes with limiting resistors.

The products are capable of detecting overcurrent through three shunt resistors. And their packages are fully-molded SIPs.

Applications

Include motor control for:

- Air conditioner fan
- Air purifier fan
- Washer-dryer fan

Features and Benefits

- Built-in bootstrap diodes with limiting resistors
- CMOS-compatible input (3.3 or 5 V)
- Built-in protection circuit for controlling power supply voltage drop (UVLO)
- Built-in overheat detection circuit (TD)
- Regulator output: 7.5 V, 35 mA
- Overcurrent detection enabled via three shunt resistors
- Small SIP (SMA, 24 pins)

Package

- Package Name: SMA
- Pin Pitch: 1.27 mm
- External Size: 31 × 10.2 × 4 mm

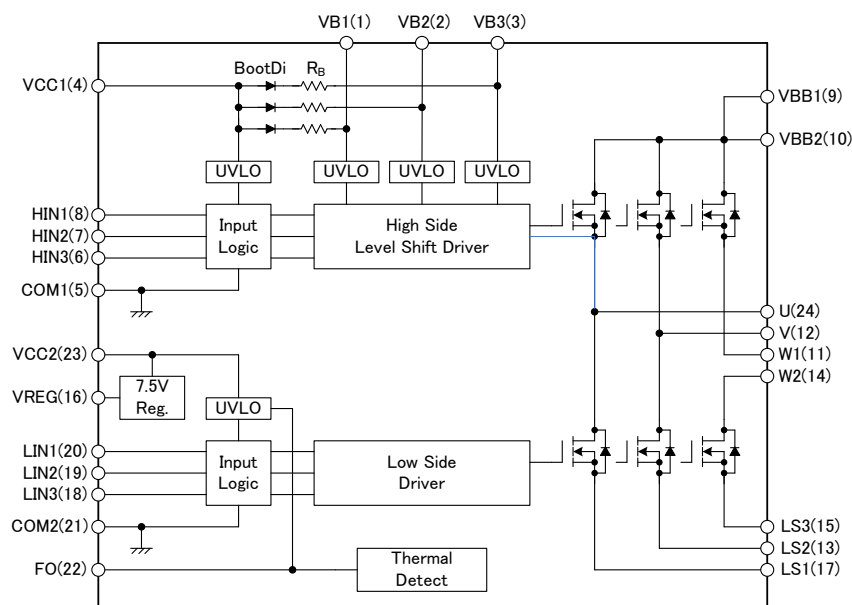


Not to scale

Product Specifications

Part Number	MOSFET Breakdown Voltage, V_{DDS} (V)	Output Current (Continuous), I_O (A)	MOSFET On-Resistance, $R_{DS(ON)}$ (Ω Max.)
SMA6852MZ	500	1.5	4.0
SMA6853MX	500	2.5	2.4
SMA6854MZ	600	1.5	3.5

Functional Block Diagram



SMA685xM Series

March, 2015

1. Scope

The specifications described in this document shall apply to the SMA685xM series, high-voltage 3-phase motor driver ICs.

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

Characteristics	Symbol	Remarks	Ratings	Unit
MOSFET Breakdown Voltage	V_{DSS}	SMA6852MZ $V_{CC} = 15\text{ V}$, $I_D = 100\text{ }\mu\text{A}$, $V_{IN} = 0\text{ V}$	500	V
		SMA6853MX $V_{CC} = 15\text{ V}$, $I_D = 100\text{ }\mu\text{A}$, $V_{IN} = 0\text{ V}$	500	V
		SMA6854MZ $V_{CC} = 15\text{ V}$, $I_D = 100\text{ }\mu\text{A}$, $V_{IN} = 0\text{ V}$	600	V
Logic Supply Voltage	V_{CC}	Between VCC and COM	20	V
Bootstrap Voltage	V_{BS}	Between VB and phase U, V, or W	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 $P_W \leq 100\text{ }\mu\text{s}$	2.25	A
		SMA6853MX $P_W \leq 100\text{ }\mu\text{s}$	3.75	A
		SMA6854MZ $P_W \leq 100\text{ }\mu\text{s}$	2.25	A
Output Current for Regulator	I_{REG}		35	mA
Input Voltage	V_{IN}	HIN and LIN pins	-0.5 to 7	V
Allowable Power Dissipation	P_D	$T_C = 25^\circ\text{C}$	28	W
Thermal Resistance (Junction-to-Case)	R_{j-c}	All elements operating	4.46	$^\circ\text{C/W}$
Thermal Resistance (Junction-to-Ambient)	R_{j-a}	All elements operating	31.25	$^\circ\text{C/W}$
Case Operating Temperature	$T_{C(OP)}$		-20 to 100	$^\circ\text{C}$
Junction Temperature	T_j		150	$^\circ\text{C}$
Storage Temperature	T_{stg}		-40 to 150	$^\circ\text{C}$

SMA685xM Series

March, 2015

3. Electrical Characteristics

3-1. Electrical Characteristics, valid at $T_a = 25^\circ\text{C}$, $V_{CC} = 15\text{ V}$

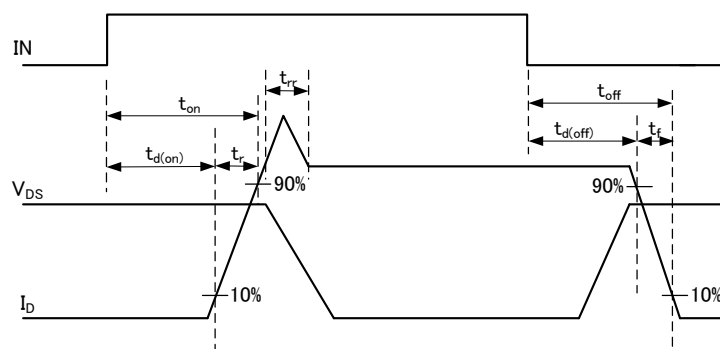
Characteristics	Symbol	Remarks	Ratings			Unit
			Min.	Typ.	Max.	
Logic Supply Current	I_{CC}	$I_{REG} = 0\text{ A}$	—	2.5	4	mA
Input Voltage	V_{IH}	Output ON	—	2.0	2.5	V
	V_{IL}	Output OFF	1.0	1.5	—	V
	V_{HYS}	Hysteresis	—	0.5	—	V
Input Current	I_{IH}	$V_{IN} = 5\text{ V}$	—	50	100	μA
	I_{IL}	$V_{IN} = 0\text{ V}$	—	—	2	μA
Undervoltage Lockout (Bootstrap)	V_{UVHL}	Between VB and U, V, or W	9.0	10.0	11.0	V
	V_{UVHH}	Between VB and U, V, or W	9.5	10.5	11.5	V
	V_{UVhys}	Between VB and U, V, or W; hysteresis	—	0.5	—	V
Undervoltage Lockout (Logic Supply)	V_{UVLL}	Between VCC and COM	10.0	11.0	12.0	V
	V_{UVLH}	Between VCC and COM	10.5	11.5	12.5	V
	V_{UVhys}	Between VCC and COM; hysteresis	—	0.5	—	V
FO Terminal Output Voltage	V_{FOL}		0	—	1.0	V
	V_{FOH}		4.0	—	5.5	V
Overheat Detection Threshold Temperature (Activation/Deactivation)	T_{DH}	$I_{REG} = 0\text{ mA}$, no heatsink	135	150	165	$^\circ\text{C}$
	T_{DL}	$I_{REG} = 0\text{ mA}$, no heatsink	105	120	135	$^\circ\text{C}$
	T_{DHYS}	$I_{REG} = 0\text{ mA}$, no heatsink, hysteresis	—	30	—	$^\circ\text{C}$
Output Voltage for Regulator	V_{REG}	$I_{REG} = 0\text{ to }35\text{ mA}$	6.75	7.5	8.25	V
Bootstrap Diode Leakage Current	I_{LBD}	SMA6852MZ $V_R = 500\text{ V}$	—	—	10	μA
		SMA6853MX $V_R = 500\text{ V}$	—	—	10	μA
		SMA6854MZ $V_R = 600\text{ V}$	—	—	10	μA
Bootstrap Diode Forward Voltage	V_{FB}	$I_{FB} = 0.15\text{ A}$	—	1.1	1.3	V
Bootstrap Diode Series Resistor	R_B	SMA6852MZ	17.6	22.0	26.4	Ω
		SMA6853MX	17.6	22.0	26.4	Ω
		SMA6854MZ	48	60	72	Ω
MOSFET Breakdown Voltage	I_{DSS}	SMA6852MZ $V_{DS} = 500\text{ V}$, $V_{IN} = 0\text{ V}$	—	—	100	μA
		SMA6853MX $V_{DS} = 500\text{ V}$, $V_{IN} = 0\text{ V}$	—	—	100	μA
		SMA6854MZ $V_{DS} = 600\text{ V}$, $V_{IN} = 0\text{ V}$	—	—	100	μA
MOSFET On-Resistance	$R_{DS(ON)}$	SMA6852MZ $I_D = 0.75\text{ A}$, $V_{IN} = 5\text{ V}$	—	3.6	4.0	Ω
		SMA6853MX $I_D = 1.25\text{ A}$, $V_{IN} = 5\text{ V}$	—	2.0	2.4	Ω
		SMA6854MZ $I_D = 0.75\text{ A}$, $V_{IN} = 5\text{ V}$	—	3.0	3.5	Ω
MOSFET Diode Forward Voltage	V_{SD}	SMA6852MZ $I_{SD} = 0.75\text{ A}$, $V_{IN} = 0\text{ V}$	—	1.1	1.5	V
		SMA6853MX $I_{SD} = 1.25\text{ A}$, $V_{IN} = 0\text{ V}$	—	1.1	1.5	V
		SMA6854MZ $I_{SD} = 0.75\text{ A}$, $V_{IN} = 0\text{ V}$	—	1.1	1.5	V

SMA685xM Series

March, 2015

3-1. Electrical Characteristics, valid at $T_a = 25^\circ\text{C}$ (continued)

Characteristics	Symbol	Remarks		Ratings						Unit
				H-Side			L-Side			
				Min.	Typ.	Max.	Min.	Typ.	Max.	
Switching Time	t _{d(on)}	SMA6852MZ	V _{DC} = 300 V, V _{CC} = 15 V, I _D = 1.5 A, V _{IN} = 0→5 V or 5→0 V, T _j = 25°C, inductive load	—	530	—	—	530	—	ns
	t _r			—	95	—	—	95	—	ns
	t _{rr}			—	130	—	—	120	—	ns
	t _{d(off)}			—	385	—	—	445	—	ns
	t _f			—	40	—	—	30	—	ns
	t _{d(on)}	SMA6853MX	V _{DC} = 300 V, V _{CC} = 15 V, I _D = 2.5 A, V _{IN} = 0→5 V or 5→0 V, T _j = 25°C, inductive load	—	650	—	—	700	—	ns
	t _r			—	100	—	—	100	—	ns
	t _{rr}			—	150	—	—	150	—	ns
	t _{d(off)}			—	520	—	—	580	—	ns
	t _f			—	50	—	—	40	—	ns
	t _{d(on)}	SMA6854MZ	V _{DC} = 300 V, V _{CC} = 15 V, I _D = 1.5 A, V _{IN} = 0→5 V or 5→0 V, T _j = 25°C, inductive load	—	530	—	—	530	—	ns
	t _r			—	55	—	—	60	—	ns
	t _{rr}			—	125	—	—	125	—	ns
	t _{d(off)}			—	510	—	—	540	—	ns
	t _f			—	50	—	—	55	—	ns



Switching Characteristics Definitions

3-2. Recommended Operating Conditions

Characteristics	Symbol	Remarks		Ratings			Unit
				Min.	Typ.	Max.	
Main Supply Voltage	V _{DC}	SMA6852MZ	Between VBB and LS	—	300	400	V
		SMA6853MX	Between VBB and LS	—	300	400	V
		SMA6854MZ	Between VBB and LS	—	300	450	V
Logic Supply Voltage	V _{CC}	Between VCC and COM		13.5	—	16.5	V
Minimum Input Pulse Width	t _{INmin(on)}			0.5	—	—	μs
	t _{INmin(off)}			0.5	—	—	μs
Dead Time	t _{dead}			1.5	—	—	μs

SMA685xM Series

March, 2015

3-3. Truth Table

Mode	HIN	LIN	High-Side MOSFET	Low-Side MOSFET
Normal	L	L	OFF	OFF
	H	L	ON	OFF
	L	H	OFF	ON
	H	H	ON	ON
Thermal Detection (TD)	L	L	OFF	OFF
	H	L	ON	OFF
	L	H	OFF	ON
	H	H	ON	ON
UVLO (VCC)	L	L	OFF	OFF
	H	L	OFF	OFF
	L	H	OFF	OFF
	H	H	OFF	OFF
UVLO (VB)	L	L	OFF	OFF
	H	L	OFF	OFF
	L	H	OFF	ON
	H	H	OFF	ON

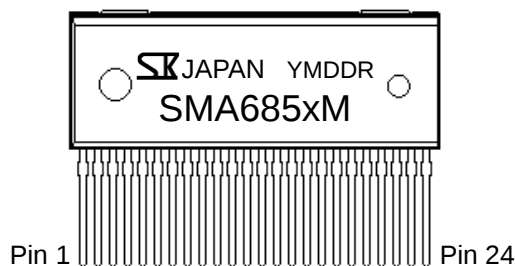
NOTES:

- An arm short-circuit may occur when inputs on the HIN and LIN pins for the same phase are all logic high. Therefore, extra attention should be paid to prevent a condition in which the pins for the same phase are fully ON at once.
- A MOSFET in a V_{CC} UVLO state gets re-activated when an input signal is detected at a certain logic level (level triggering), while a MOSFET in a V_B UVLO state resumes its operation at a point where an input signal transits from one state to another (edge triggering).

SMA685xM Series

March, 2015

4. Pin-Out Diagram



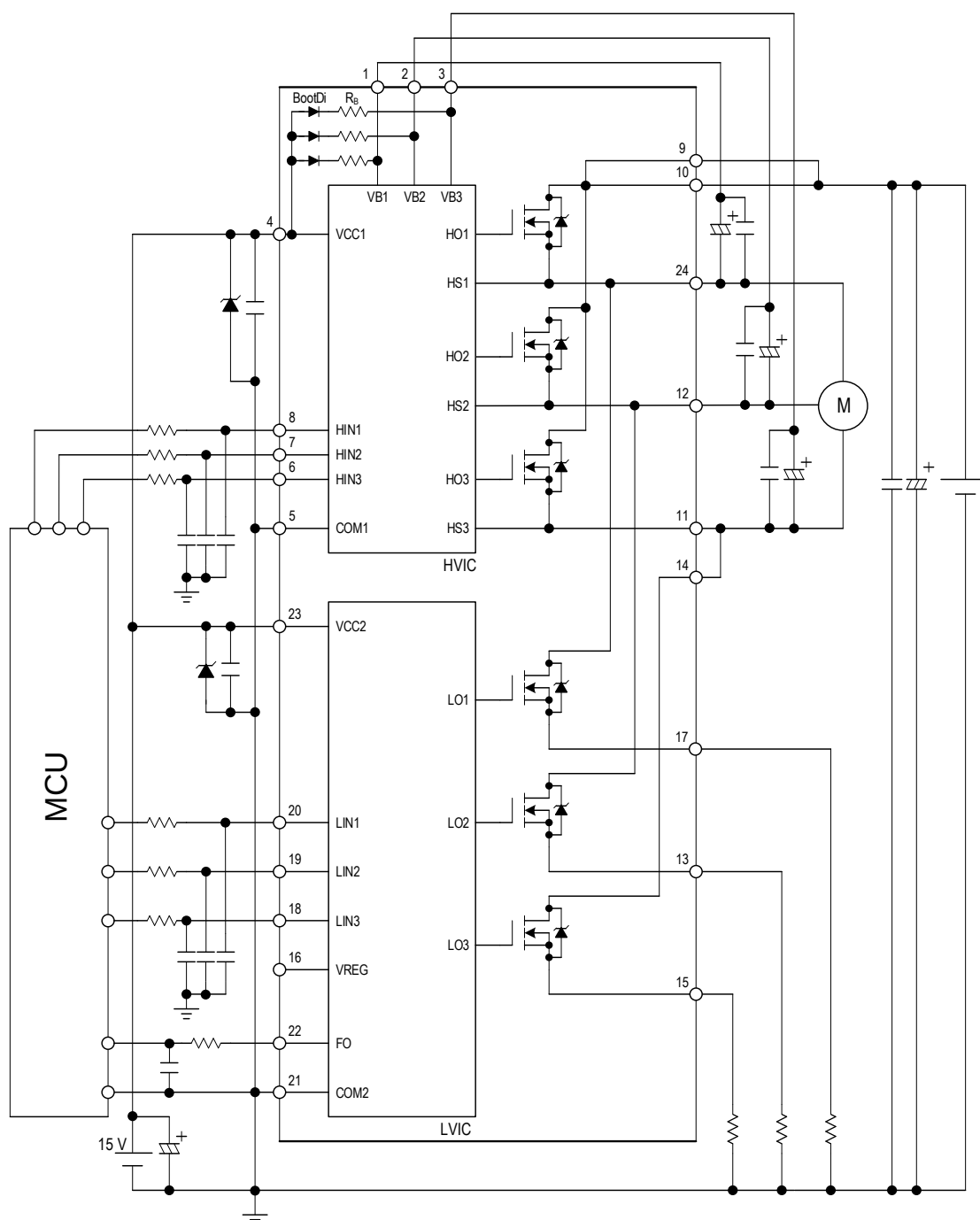
Terminal List Table

Pin Number	Pin Name	Functions	I/O
1	VB1	High-side bootstrap (phase U)	—
2	VB2	High-side bootstrap (phase V)	—
3	VB3	High-side bootstrap (phase W)	—
4	VCC1	High-side logic supply voltage	—
5	COM1	High-side logic GND	—
6	HIN3	High-side input (phase W)	Input
7	HIN2	High-side input (phase V)	Input
8	HIN1	High-side input (phase U)	Input
9	VBB1	Main supply voltage 1 (connected to VBB2 externally)	—
10	VBB2	Main supply voltage 2 (connected to VBB1 externally)	—
11	W1	Phase W output (connected to W2 externally)	—
12	V	Phase V output	—
13	LS2	Low-side source (phase V)	—
14	W2	Phase W output (connected to W1 externally)	—
15	LS3	Low-side source (phase W)	—
16	VREG	Internal regulator output	Output
17	LS1	Low-side source (phase U)	—
18	LIN3	Low-side input (phase W)	Input
19	LIN2	Low-side input (phase V)	Input
20	LIN1	Low-side input (phase U)	Input
21	COM2	Low-side logic GND	—
22	FO	Error output	Output
23	VCC2	Low-side logic supply voltage	—
24	U	Phase U output	—

SMA685xM Series

March, 2015

5. Application Example



NOTES:

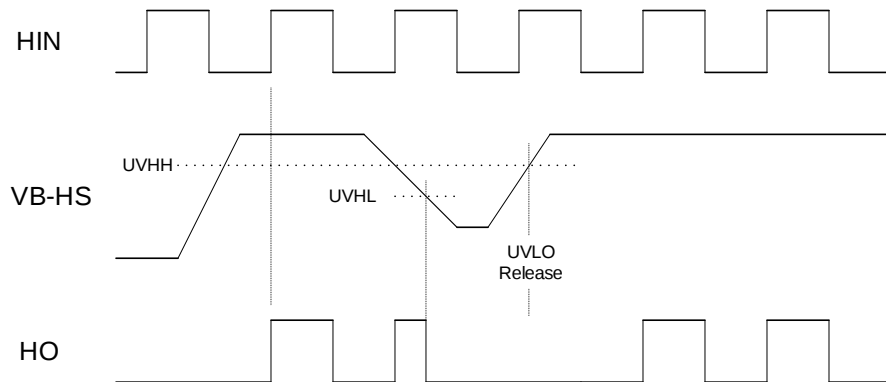
- All of the input pins are connected to GND with internal pull-down resistors rated at 100 kΩ. However, an external pull-down resistor may be required to secure stable condition of the inputs if high impedance conditions are applied to them.
- The external electrolytic capacitors should be placed as 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.

SMA685xM Series

March, 2015

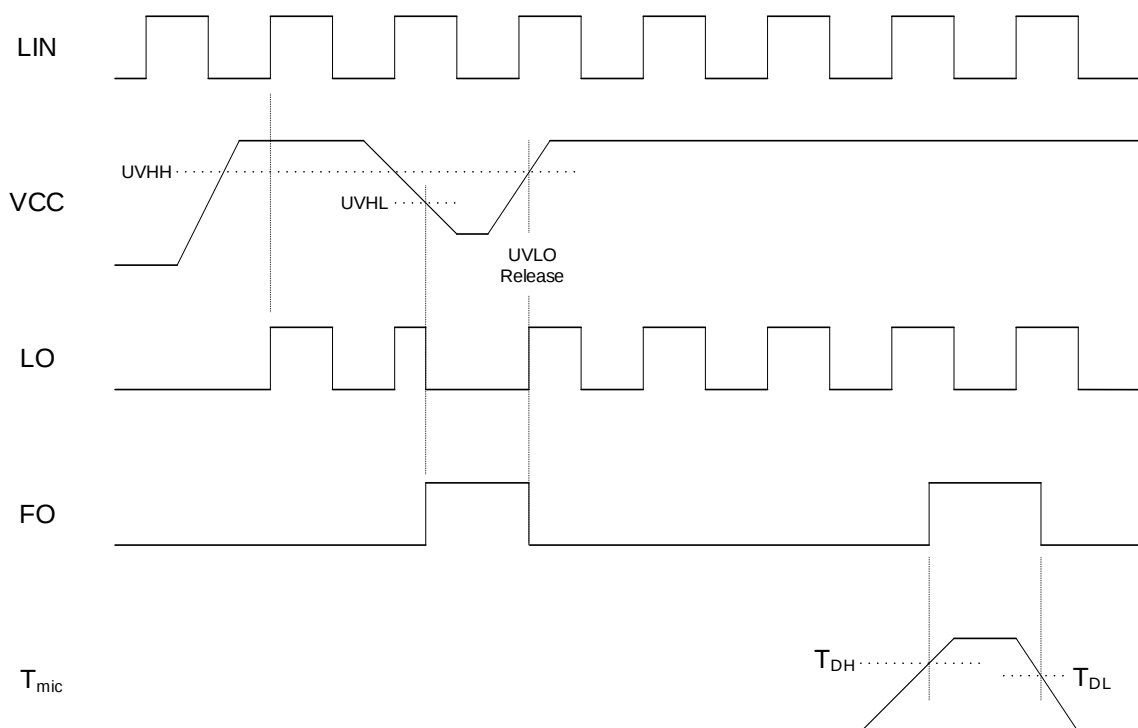
6. Timing Diagrams for Protection Operations

High-Side Input/Output



High-side turn-on at the next rising edge on HIN signal after UVLO release.

Low-Side Input/Output



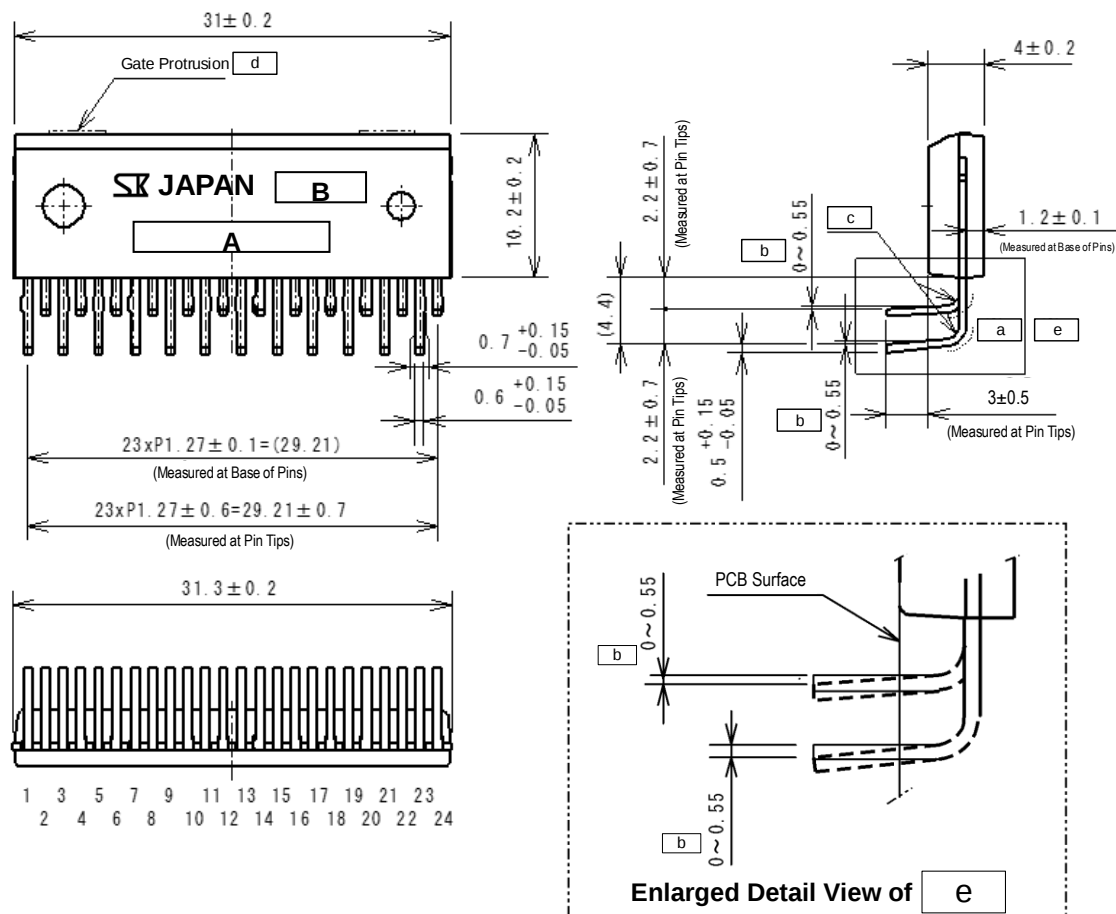
Low-side turn-on in accordance with LIN signal level after UVLO release.

SMA685xM Series

March, 2015

7. Package Outline Drawing

7-1. Leadform 2451 (Dimensions in Millimeters)



NOTES:

- a depicts the intentionally-curved part of a pin whose plated surface may easily be cracked and/or peeled off. Note that this kind of damaged surface does NOT indicate negative effects on terminal flexural toughness or any other reliability characteristics.
- b represents terminal curvature exaggerated for illustration purposes, not actual states of being bent or curved.
- c shows pins with a minimum inside radius (R) of 0.65 mm.
- d describes the area(s) where either one or two gate protrusions up to 0.3 mm high will appear on the package surface, drawn with dashed double-dotted lines. (The number of gate protrusions varies depending on the package mold type used.)

■ Branding Codes

A. Part number: SMA685xMX/MZ

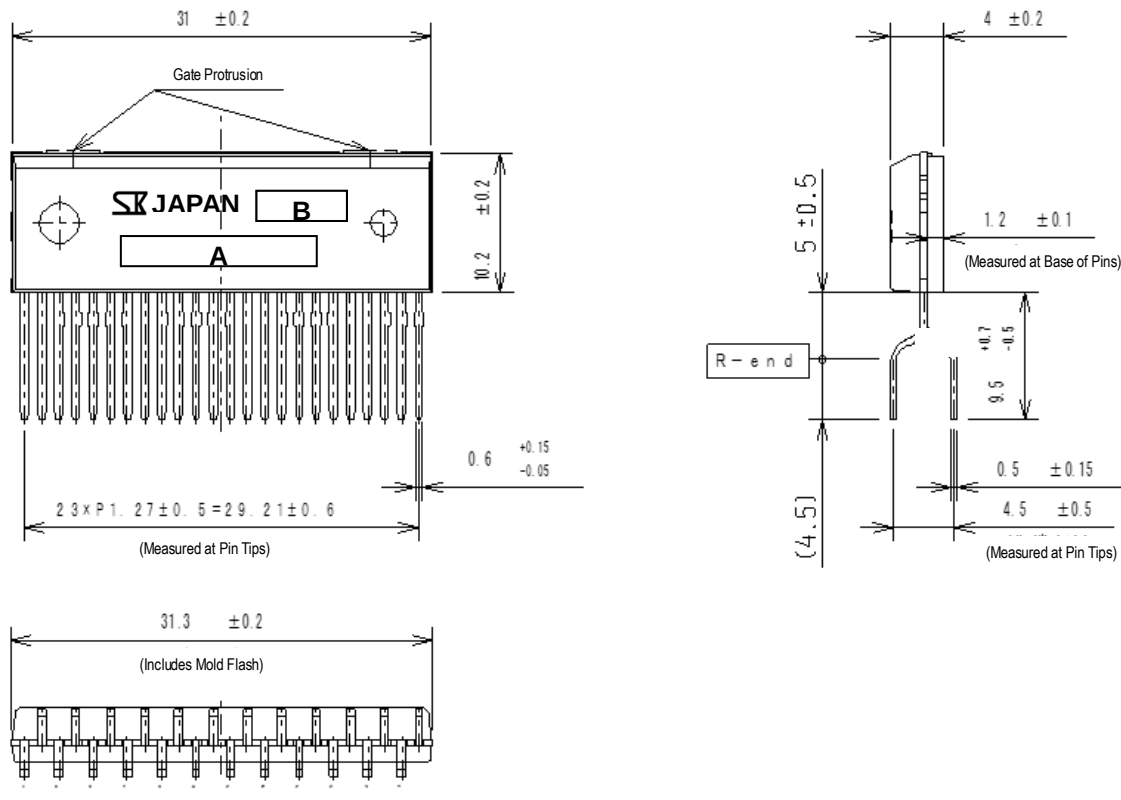
B. Lot number: YMDDR

- Y is the last digit of the year of manufacture
- M is the month of the year manufactured (1 to 9, O, N, or D)
- DD is the day of the month manufactured (01 to 31)
- R is the Sanken control number

SMA685xM Series

March, 2015

7-2. Leadform 2452 (Dimensions in Millimeters)



NOTE: Either one or two gate protrusions up to 0.3 mm high will appear on the package surface, as drawn with dashed double-dotted lines in the illustration above. (The number of gate protrusions varies depending on the package mold type used.)

■ Branding Codes

A. Part number: SMA685xMX/MZ

B. Lot number: YMDDR

- Y is the last digit of the year of manufacture
- M is the month of the year manufactured (1 to 9, O, N, or D)
- DD is the day of the month manufactured (01 to 31)
- R is the Sanken control number

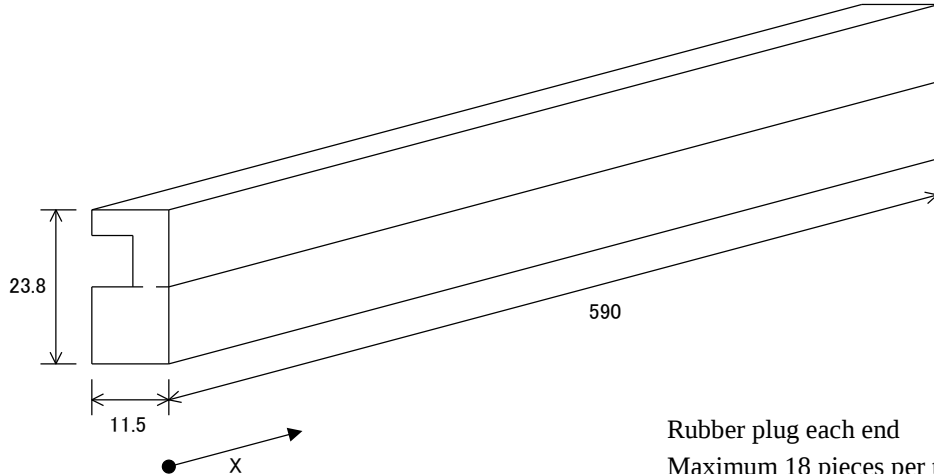
SMA685xM Series

March, 2015

8. Packing Specifications

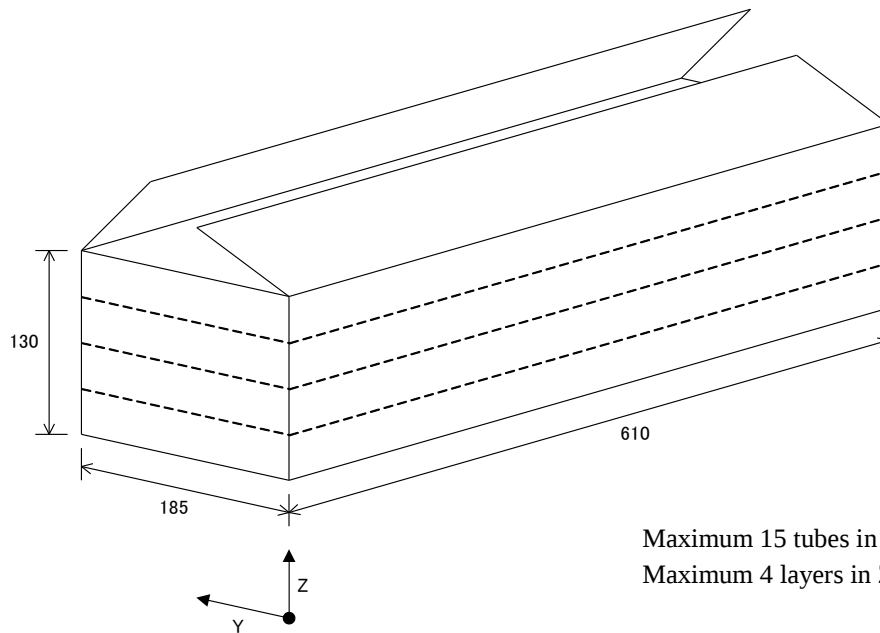
8-1. Leadform 2451 (Dimensions in Millimeters)

- Tube Type: SCM-C



Rubber plug each end
Maximum 18 pieces per tube
(pins aligned along X direction)

- Corrugated Shipping Carton



Maximum 15 tubes in Y direction
Maximum 4 layers in Z direction

Maximum pieces per carton:

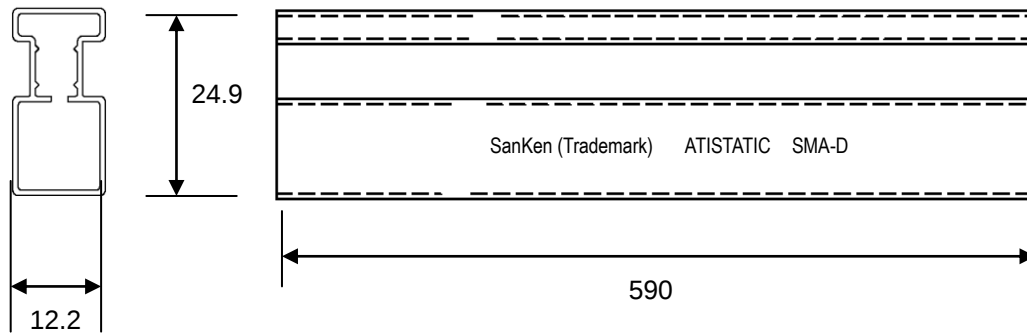
$$\begin{array}{r}
 18 \text{ pieces per tube} \\
 15 \text{ tubes per layer} \\
 \times \quad 4 \text{ layers of tubes} \\
 \hline
 1080 \text{ pieces per carton}
 \end{array}$$

SMA685xM Series

March, 2015

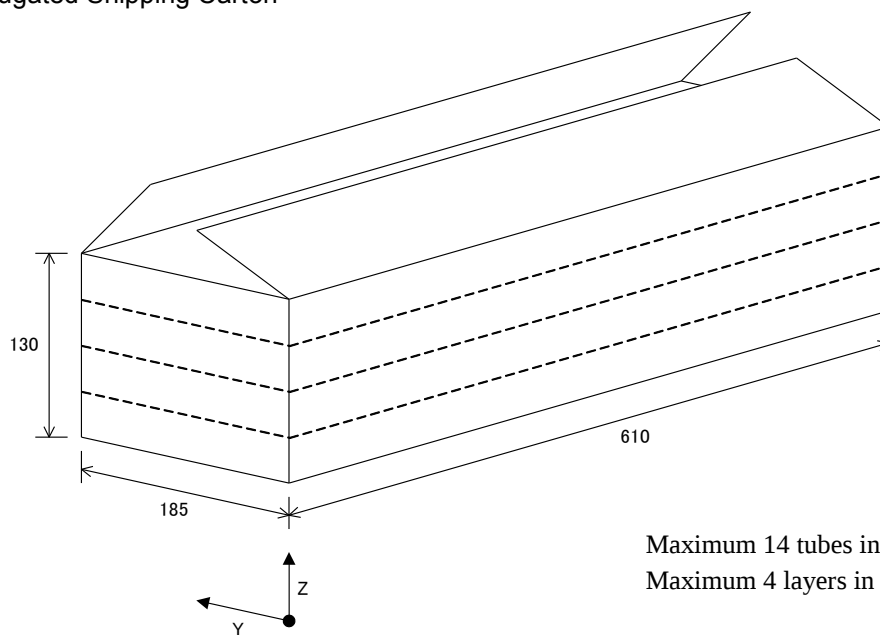
8-2. Leadform 2452 (Dimensions in Millimeters)

■ Tube Type: SMA-D



Rubber plug each end
Maximum 18 pieces per tube
(pins aligned along X direction)

■ Corrugated Shipping Carton



Maximum 14 tubes in Y direction
Maximum 4 layers in Z direction

Maximum pieces per carton:

$$\begin{array}{r}
 18 \text{ pieces per tube} \\
 14 \text{ tubes per layer} \\
 \times \quad 4 \text{ layers of tubes} \\
 \hline
 1008 \text{ pieces per carton}
 \end{array}$$

SMA685xM Series

March, 2015

IMPORTANT NOTES

- All data, illustrations, graphs, tables and any other information included in this document as to Sanken's products listed herein (the "Sanken Products") are current as of the date this document is issued. All contents in this document are subject to any change without notice due to improvement, etc. Please make sure that the contents set forth in this document reflect the latest revisions before use.
- The Sanken Products are intended for use as components of general purpose electronic equipment or apparatus (such as home appliances, office equipment, telecommunication equipment, measuring equipment, etc.). Prior to use of the Sanken Products, please put your signature, or affix your name and seal, on the specification documents of the Sanken Products and return them to Sanken. If considering use of the Sanken Products for any applications that require higher reliability (transportation equipment and its control systems, traffic signal control systems or equipment, disaster/crime alarm systems, various safety devices, etc.), you must contact a Sanken sales representative to discuss the suitability of such use and put your signature, or affix your name and seal, on the specification documents of the Sanken Products and return them to Sanken, prior to the use of the Sanken Products. Any use of the Sanken Products without the prior written consent of Sanken in any applications where extremely high reliability is required (aerospace equipment, nuclear power control systems, life support systems, etc.) is strictly prohibited.
- In the event of using the Sanken Products by either (i) combining other products or materials therewith or (ii) physically, chemically or otherwise processing or treating the same, you must duly consider all possible risks that may result from all such uses in advance and proceed therewith at your own responsibility.
- Although Sanken is making efforts to enhance the quality and reliability of its products, it is impossible to completely avoid the occurrence of any failure or defect in semiconductor products at a certain rate. You must take, at your own responsibility, preventative measures including using a sufficient safety design and confirming safety of any equipment or systems in/for which the Sanken Products are used, upon due consideration of a failure occurrence rate or derating, etc., in order not to cause any human injury or death, fire accident or social harm which may result from any failure or malfunction of the Sanken Products. Please refer to the relevant specification documents and Sanken's official website in relation to derating.
- No anti-radioactive ray design has been adopted for the Sanken Products.
- No contents in this document can be transcribed or copied without Sanken's prior written consent.
- The circuit constant, operation examples, circuit examples, pattern layout examples, design examples, recommended examples and evaluation results based thereon, etc., described in this document are presented for the sole purpose of reference of use of the Sanken Products and Sanken assumes no responsibility whatsoever for any and all damages and losses that may be suffered by you, users or any third party, or any possible infringement of any and all property rights including intellectual property rights and any other rights of you, users or any third party, resulting from the foregoing.
- All technical information described in this document (the "Technical Information") is presented for the sole purpose of reference of use of the Sanken Products and no license, express, implied or otherwise, is granted hereby under any intellectual property rights or any other rights of Sanken.
- Unless otherwise agreed in writing between Sanken and you, Sanken makes no warranty of any kind, whether express or implied, as to the quality of the Sanken Products (including the merchantability, or fitness for a particular purpose or a special environment thereof), and any information contained in this document (including its accuracy, usefulness, or reliability).
- In the event of using the Sanken Products, you must use the same after carefully examining all applicable environmental laws and regulations that regulate the inclusion or use of any particular controlled substances, including, but not limited to, the EU RoHS Directive, so as to be in strict compliance with such applicable laws and regulations.
- You must not use the Sanken Products or the Technical Information for the purpose of any military applications or use, including but not limited to the development of weapons of mass destruction. In the event of exporting the Sanken Products or the Technical Information, or providing them for non-residents, you must comply with all applicable export control laws and regulations in each country including the U.S. Export Administration Regulations (EAR) and the Foreign Exchange and Foreign Trade Act of Japan, and follow the procedures required by such applicable laws and regulations.
- Sanken assumes no responsibility for any troubles, which may occur during the transportation of the Sanken Products including the falling thereof, out of Sanken's distribution network.
- Although Sanken has prepared this document with its due care to pursue the accuracy thereof, Sanken does not warrant that it is error free and Sanken assumes no liability whatsoever for any and all damages and losses which may be suffered by you resulting from any possible errors or omissions in connection with the contents included herein.
- Please refer to the relevant specification documents in relation to particular precautions when using the Sanken Products, and refer to our official website in relation to general instructions and directions for using the Sanken Products.