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# SMA685xM Series

## 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:

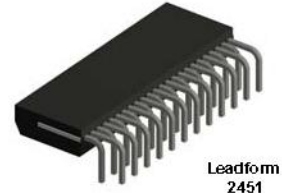
- Air conditioner fan
- Air purifier fan
- Washer-dryer fan

## 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

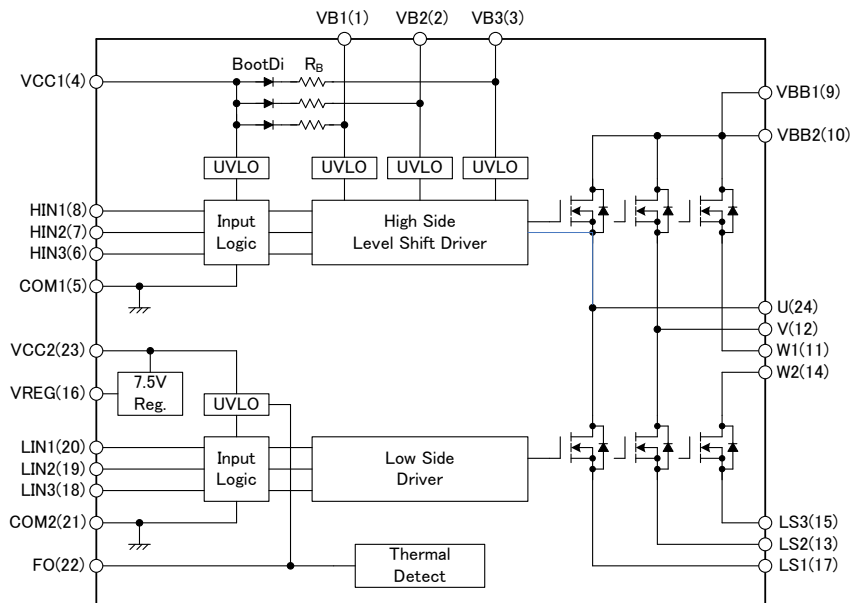


Not to scale

## Product Specifications

Part Number	MOSFET Breakdown Voltage, $V_{DD5}$ (V)	Output Current (Continuous), $I_O$ (A)	MOSFET On-Resistance, $R_{DS(ON)}$ ( $\Omega$ Max.)
SMA6852MZ	500	1.5	4.0
SMA6853MX	500	2.5	2.4
SMA6854MZ	600	1.5	3.5

## Functional Block Diagram



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## 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 $V_{CC} = 15\text{ V}$ , $I_D = 100\ \mu\text{A}$ , $V_{IN} = 0\text{ V}$	500	V
		SMA6853MX $V_{CC} = 15\text{ V}$ , $I_D = 100\ \mu\text{A}$ , $V_{IN} = 0\text{ V}$	500	V
		SMA6854MZ $V_{CC} = 15\text{ V}$ , $I_D = 100\ \mu\text{A}$ , $V_{IN} = 0\text{ V}$	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 $P_W \leq 100\ \mu\text{s}$	2.25	A
		SMA6853MX $P_W \leq 100\ \mu\text{s}$	3.75	A
		SMA6854MZ $P_W \leq 100\ \mu\text{s}$	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	$^\circ\text{C}/\text{W}$
Thermal Resistance (Junction-to-Ambient)	$R_{j-a}$	All elements operating	31.25	$^\circ\text{C}/\text{W}$
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	$^\circ\text{C}$



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## 3. Electrical Characteristics

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

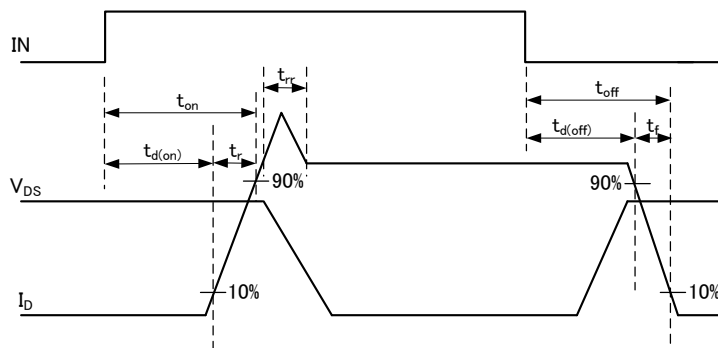
Characteristics	Symbol	Remarks	Ratings			Unit
			Min.	Typ.	Max.	
Logic Supply Current	$I_{CC}$	$I_{REG} = 0\text{ A}$	—	2.5	4	mA
Input Voltage	$V_{IH}$	Output ON	—	2.0	2.5	V
	$V_{IL}$	Output OFF	1.0	1.5	—	V
	$V_{HYS}$	Hysteresis	—	0.5	—	V
Input Current	$I_{IH}$	$V_{IN} = 5\text{ V}$	—	50	100	$\mu\text{A}$
	$I_{IL}$	$V_{IN} = 0\text{ V}$	—	—	2	$\mu\text{A}$
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	$\mu\text{A}$
		SMA6853MX $V_R = 500\text{ V}$	—	—	10	$\mu\text{A}$
		SMA6854MZ $V_R = 600\text{ V}$	—	—	10	$\mu\text{A}$
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	$\Omega$
		SMA6853MX	17.6	22.0	26.4	$\Omega$
		SMA6854MZ	48	60	72	$\Omega$
MOSFET Breakdown Voltage	$I_{DSS}$	SMA6852MZ $V_{DS} = 500\text{ V}$ , $V_{IN} = 0\text{ V}$	—	—	100	$\mu\text{A}$
		SMA6853MX $V_{DS} = 500\text{ V}$ , $V_{IN} = 0\text{ V}$	—	—	100	$\mu\text{A}$
		SMA6854MZ $V_{DS} = 600\text{ V}$ , $V_{IN} = 0\text{ V}$	—	—	100	$\mu\text{A}$
MOSFET On-Resistance	$R_{DS(ON)}$	SMA6852MZ $I_D = 0.75\text{ A}$ , $V_{IN} = 5\text{ V}$	—	3.6	4.0	$\Omega$
		SMA6853MX $I_D = 1.25\text{ A}$ , $V_{IN} = 5\text{ V}$	—	2.0	2.4	$\Omega$
		SMA6854MZ $I_D = 0.75\text{ A}$ , $V_{IN} = 5\text{ V}$	—	3.0	3.5	$\Omega$
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

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### 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	$V_{DC} = 300\text{ V}$ , $V_{CC} = 15\text{ V}$ , $I_D = 1.5\text{ A}$ , $V_{IN} = 0 \rightarrow 5\text{ V}$ or $5 \rightarrow 0\text{ V}$ , $T_j = 25^\circ\text{C}$ , 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	$V_{DC} = 300\text{ V}$ , $V_{CC} = 15\text{ V}$ , $I_D = 2.5\text{ A}$ , $V_{IN} = 0 \rightarrow 5\text{ V}$ or $5 \rightarrow 0\text{ V}$ , $T_j = 25^\circ\text{C}$ , 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	$V_{DC} = 300\text{ V}$ , $V_{CC} = 15\text{ V}$ , $I_D = 1.5\text{ A}$ , $V_{IN} = 0 \rightarrow 5\text{ V}$ or $5 \rightarrow 0\text{ V}$ , $T_j = 25^\circ\text{C}$ , 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	—	—	$\mu\text{s}$
	$t_{INmin(off)}$			0.5	—	—	$\mu\text{s}$
Dead Time	$t_{dead}$			1.5	—	—	$\mu\text{s}$

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## 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

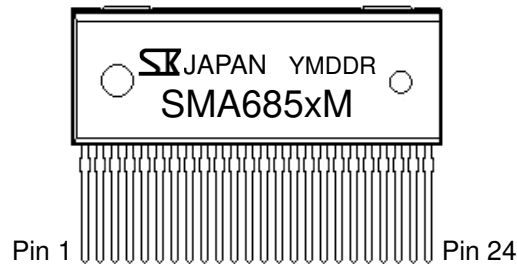
### NOTES:

- 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).

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## 4. Pin-Out Diagram



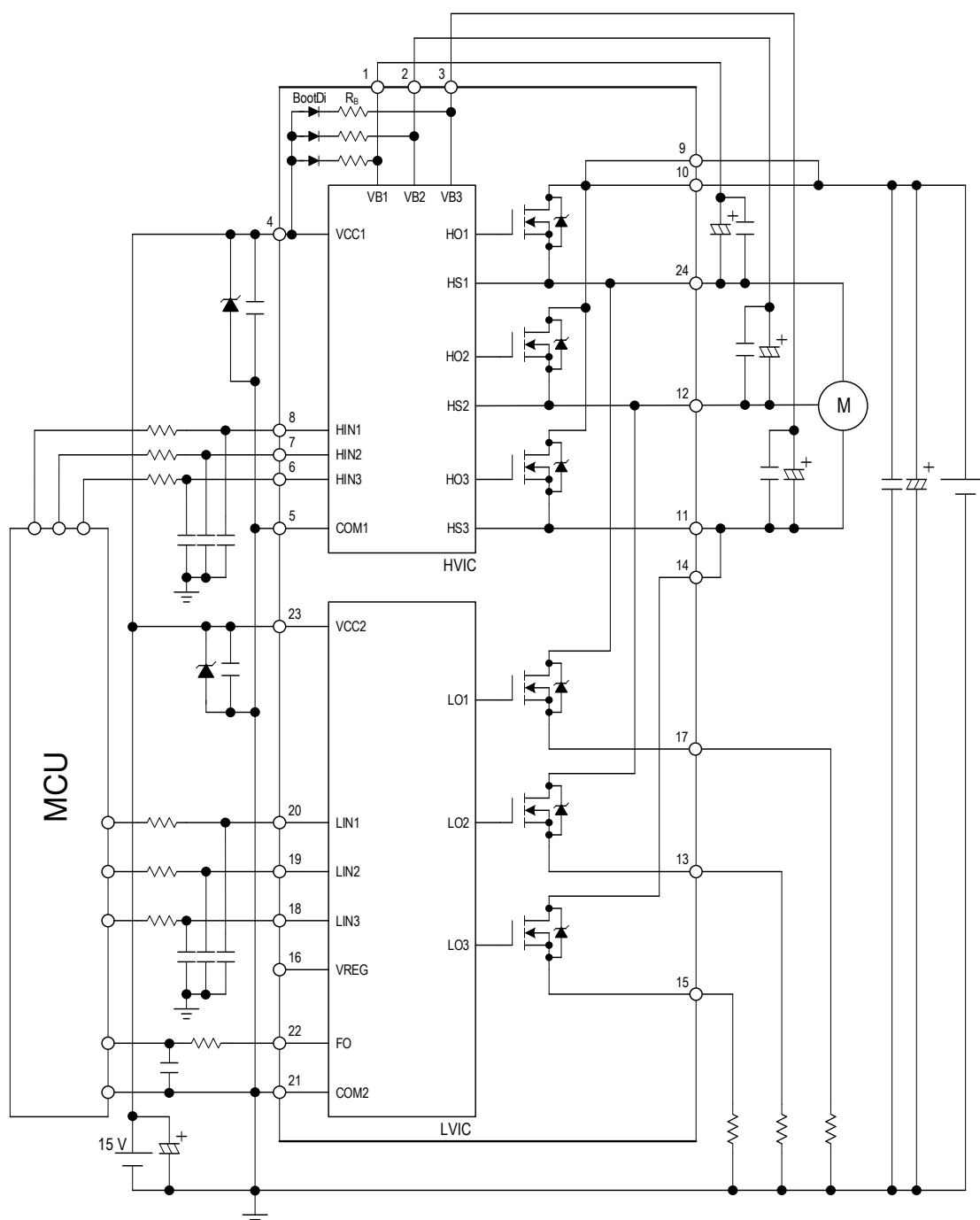
Terminal List Table

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	—

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## 5. Application Example



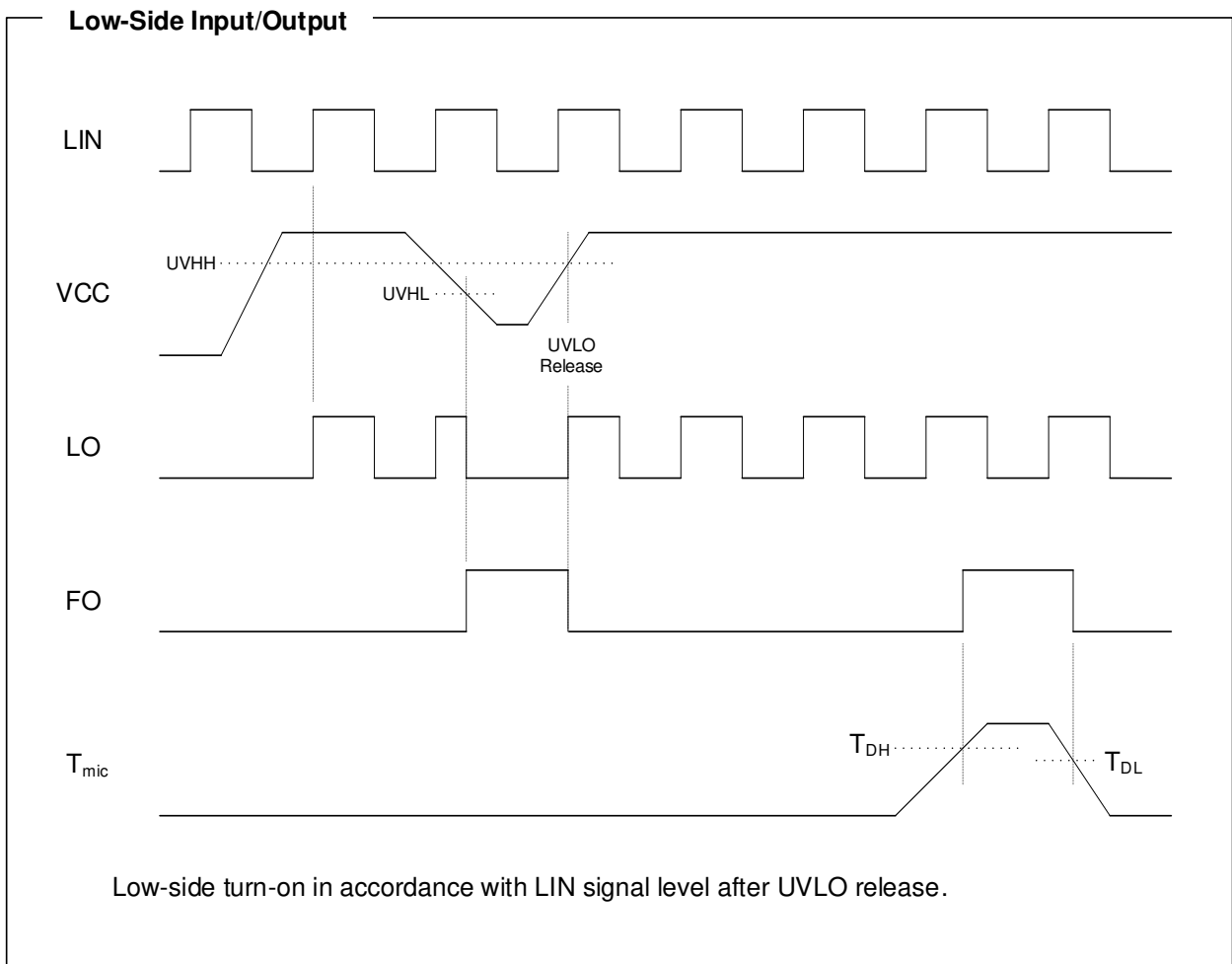
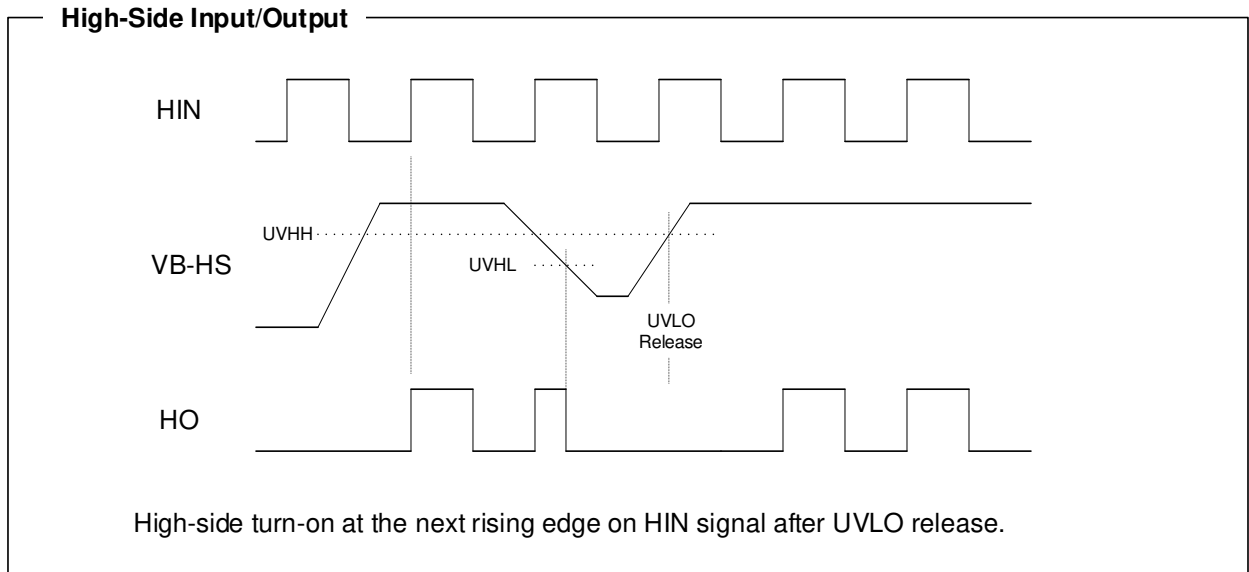
**NOTES:**

- 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.



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## 6. Timing Diagrams for Protection Operations

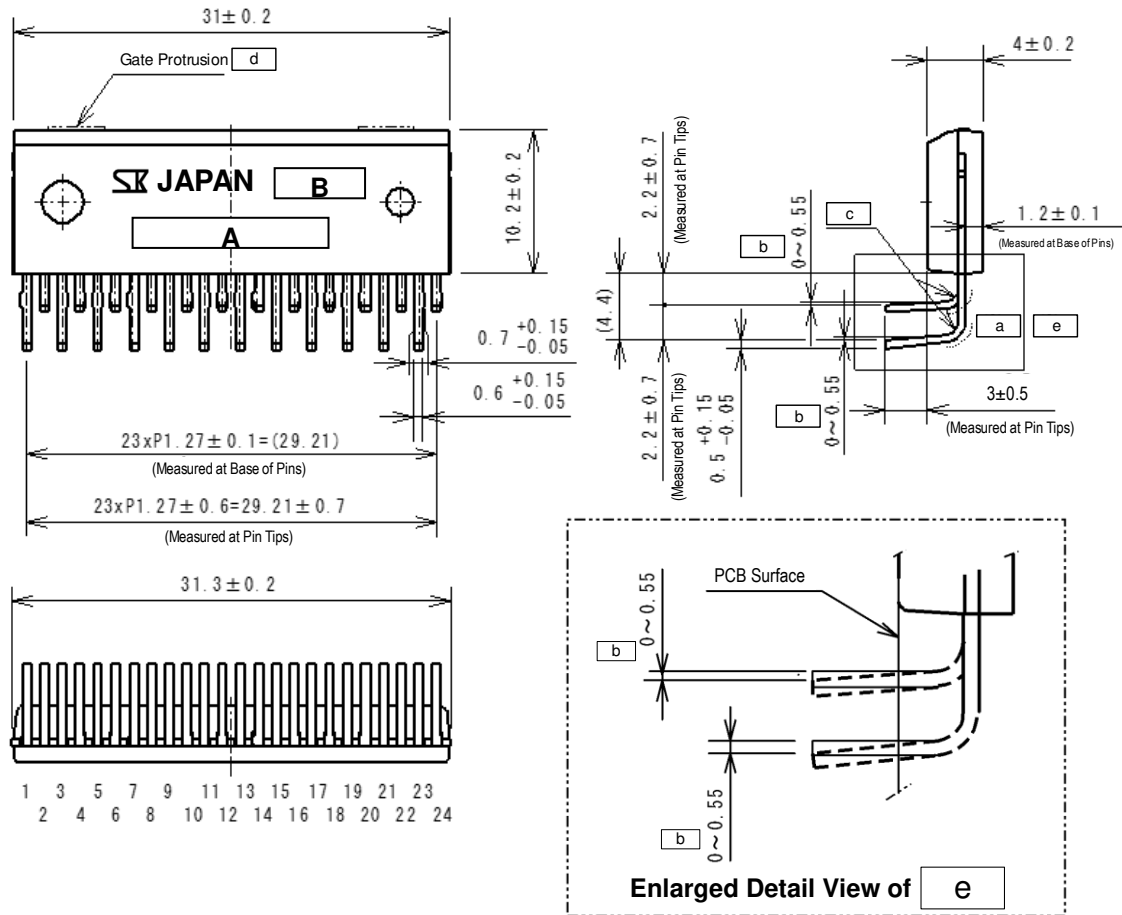


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## 7. Package Outline Drawing

### 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*

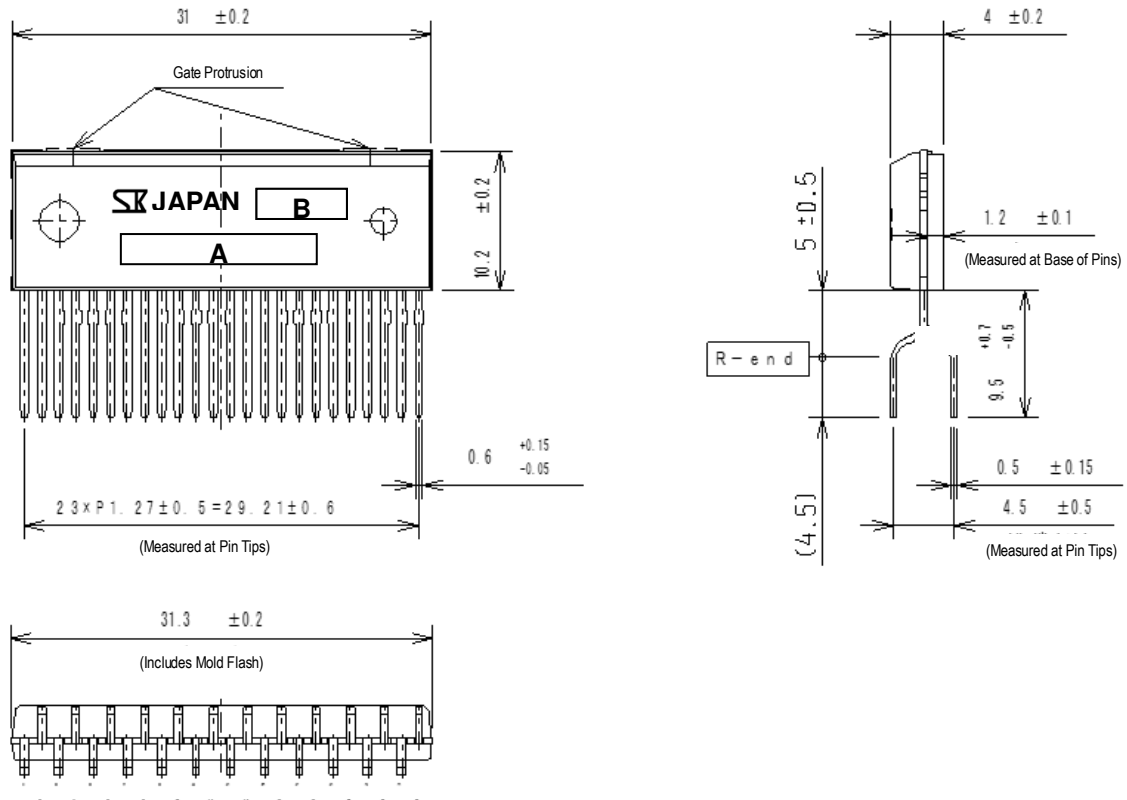
B. Lot number: *YMDDR*

- *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

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## 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
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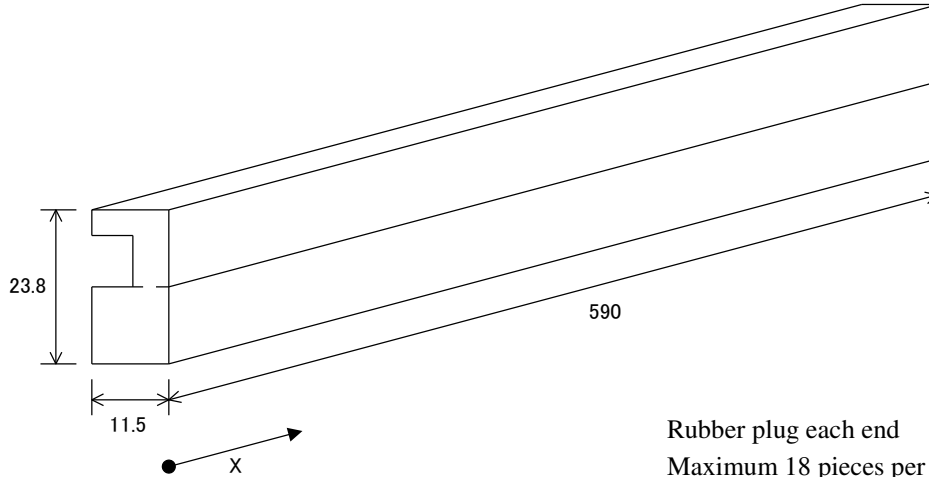
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## 8. Packing Specifications

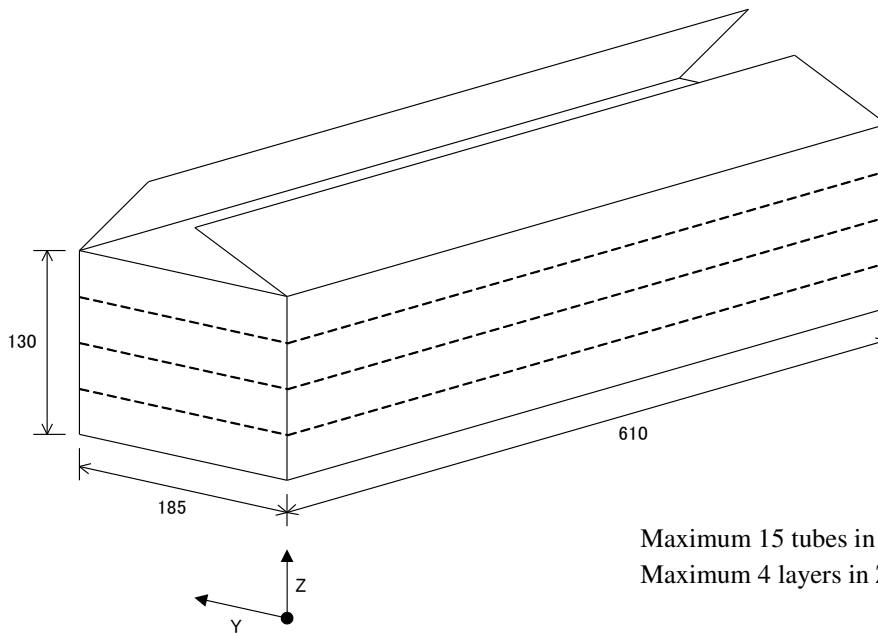
### 8-1. Leadform 2451 (Dimensions in Millimeters)

- 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

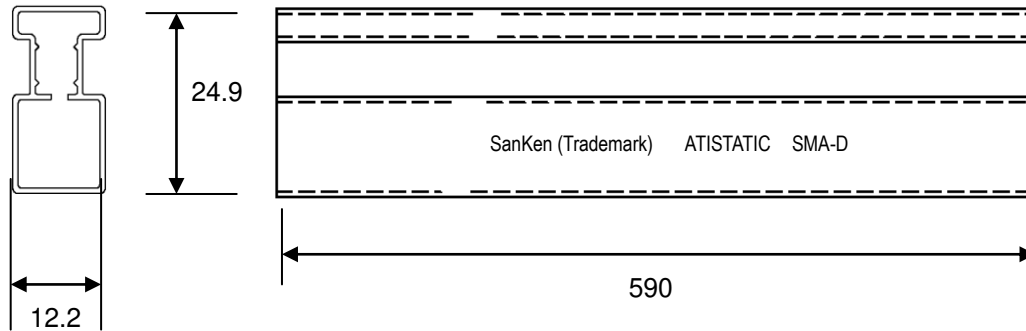
Maximum pieces per carton:  
 18 pieces per tube  
 15 tubes per layer  
× 4 layers of tubes  
 1080 pieces per carton

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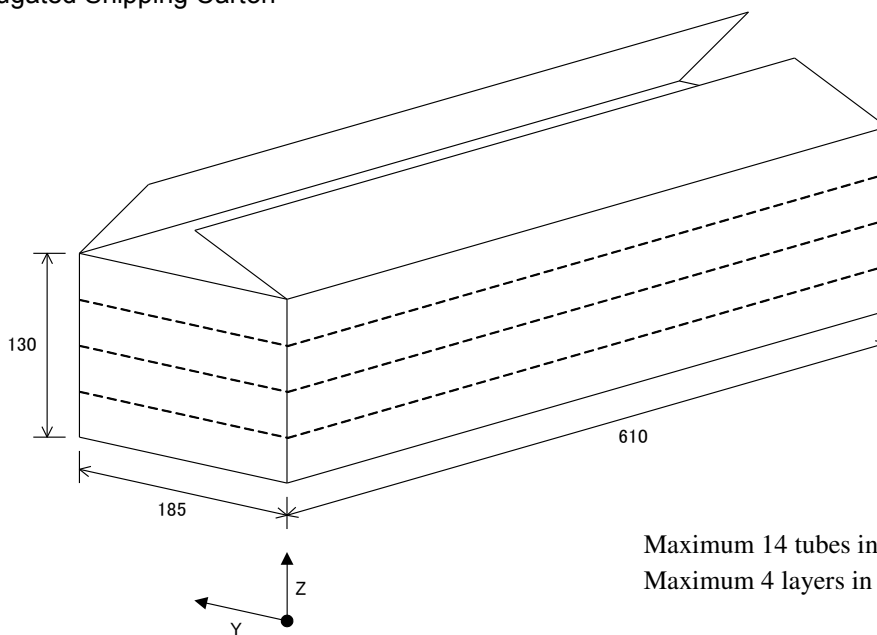
## 8-2. Leadform 2452 (Dimensions in Millimeters)

- 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:  
 18 pieces per tube  
 14 tubes per layer  
× 4 layers of tubes  
 1008 pieces per carton



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