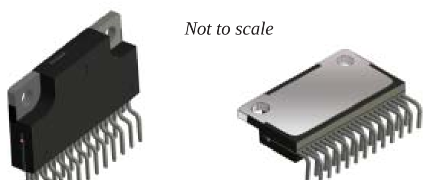
High Voltage 3-Phase Motor Drivers

Features and Benefits

- Built-in pre-drive IC
- MOSFET power element
- Alleviate noise generation by adjusting an internal resistor
- CMOS compatible input (5 V)
- High-side gate driver using bootstrap circuit or floating power supply
- Built-in protection circuit for controlling power supply voltage drop (UVLO on VCC)
- Overcurrent protection (OCP), overcurrent limiting (OCL), and thermal shutdown (TSD)
- Output of fault signal during operation of protection circuit
- Output current 3 A
- Small SIP (SLA 24-pin)

Packages: Power SIP

Not to scale



Leadform 2171 Leadform 2175

Description

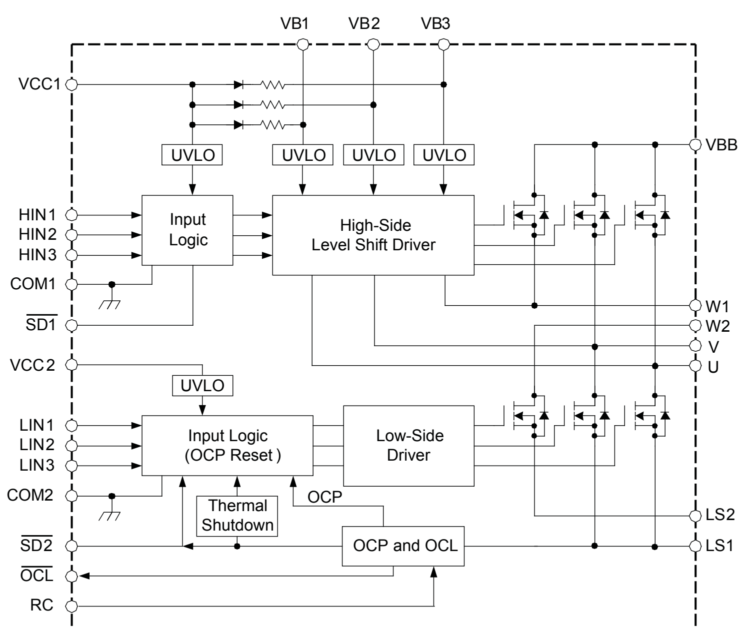
The SLA6870MZ inverter power module (IPM) series provides a robust, highly-integrated solution for optimally controlling 3-phase motor power inverter systems and variable speed control systems used in energy-conserving designs to drive motors of residential and commercial appliances. These ICs take 230 VAC input voltage, and up to 3 A (continuous) output current. They can withstand voltages of up to 500 V (MOSFET breakdown voltage).

The SLA6870MZ power package includes an IC with all of the necessary power elements (six MOSFETs), pre-driver ICs (two), and bootstrap diodes (three), 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



A. $\overline{SD1}$ and $\overline{SD2}$ terminals are used for both input and output.
B. $\overline{SD1}$, $\overline{SD2}$ and $\overline{OCL}$ terminals are open-collector output. RC terminal is open-drain output.
C. Blanking Time (t_{blank}) is used in Overcurrent Limiting (OCL) and Overcurrent Protection ($\overline{OCP}$). If the time exceeds the limit, the signal will be output (open-collector output turns on) on the $\overline{SD2}$ pin, and protection operation will start up.

Figure 1. Driver block diagram

Selection Guide

Part Number	Packing	MOSFET Breakdown Voltage, V_{DSS}(min) (V)	Output Current	
			Continuous, I_O(max) (A)	Pulsed, I_{OP} (max) (A)
SLA6870MZ	18 pieces per tube	500	3	4.5

Absolute Maximum Ratings, valid at T_A = 25°C

Characteristic	Symbol	Remarks	Rating	Unit
MOSFET Breakdown Voltage	V_{DSS}	V_{CC} = 15 V, I_D = 100 μA, V_{IN} = 0 V	500	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		3	A
Output Current, Pulsed	I_{OP}	PW ≤ 100 μs, duty cycle = 1%	4.5	A
Input Voltage	V_{IN}	HINx and LINx pins	–0.5 to 7	V
Pull-up Voltage for Shutdown Pins	V_{SDX}	SDx pins	7	V
Pull-up Voltage for Overcurrent Limiting Pin	V_{OCL}		7	V
Allowable Power Dissipation	P_D	T_C = 25°C	32.8	W
Thermal Resistance (Junction to Case)	$R_{\theta JC}$	All elements operating	3.8	°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

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.

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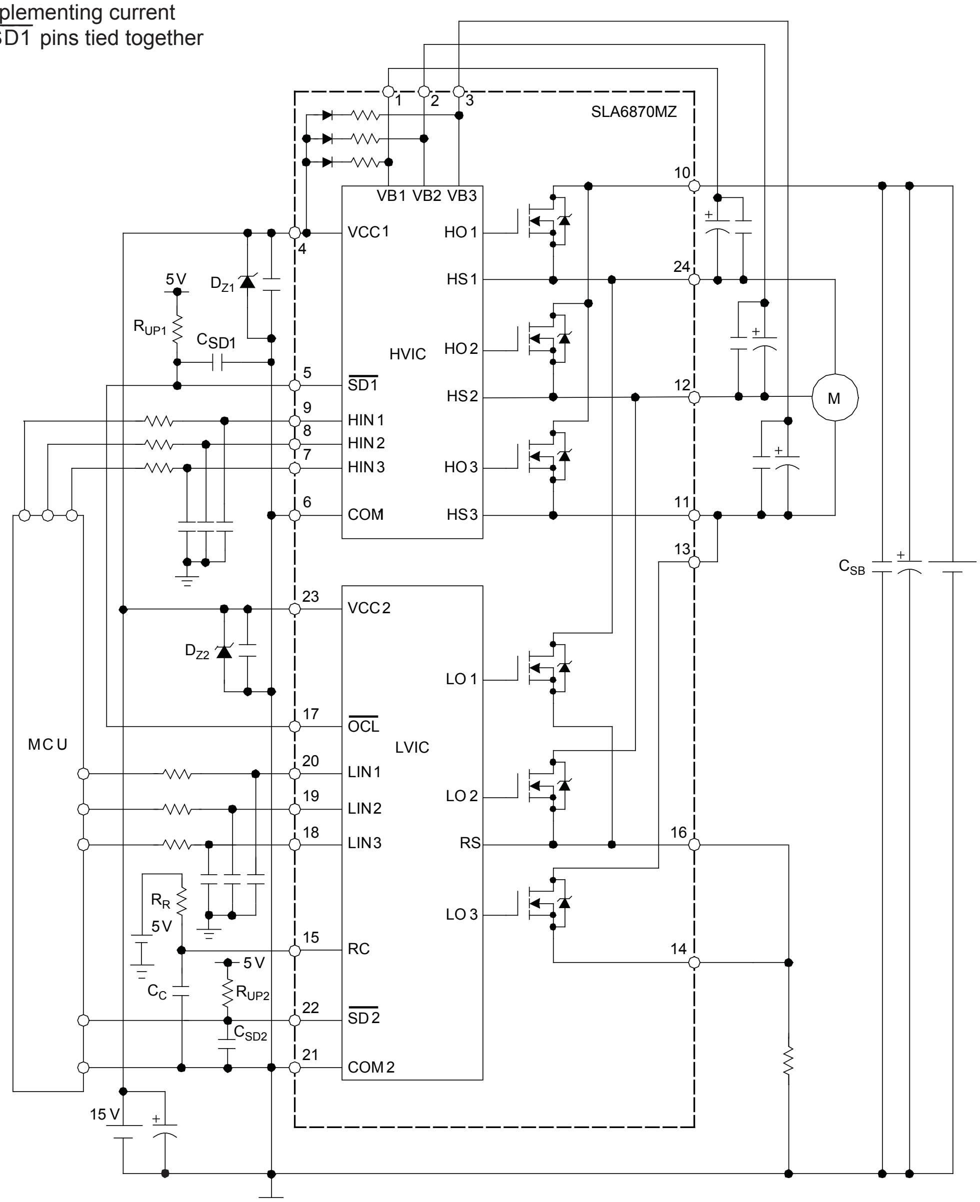
Recommended Operating Conditions

Characteristic	Symbol	Remarks	Min.	Typ.	Max.	Units
Main Supply Voltage	V_{BB}	Between VBB and LS	–	–	400	V
V_{BB} Snubber Capacitor	C_{SB}		0.01	–	0.1	µF
Logic Supply Voltage	V_{CC}	Between VCC and COM	13.5	15	16.5	V
Zener Voltage for VCCx Pins	V_Z	Between VCC and COM	18	–	20	V
Pull-up Voltage	V_{SDx}, V_{OCL}		4.5	5	5.5	V
Pull-up Resistor $\overline{SD2}$ Pin	R_{UP2}		3.3	–	10	kΩ
Pull-up Resistor $\overline{OCL}$ Pin	R_{UP1}		1	–	10	kΩ
Pull-up Resistor RC Pin	R_R		33	–	390	kΩ
Capacitor $\overline{SDx}$ and $\overline{OCL}$ Pins	C_{SDX}		1	–	10	nF
Capacitor RC Pin	C_C		1	–	4.7	nF
Dead Time	t_{dead}	T_J = –20°C to 150°C	1.5	–	–	µs
Minimum Input Pulse Width	$I_{INMIN(on)}$	T_J = –20°C to 150°C	0.5	–	–	µs
	$I_{INMIN(off)}$	T_J = –20°C to 150°C	0.5	–	–	µs
Switching Frequency	f_{PWM}		–	–	20	kHz
Junction Temperature	T_J		–	–	125	°C

Typical Application Diagram

Shows configuration for implementing current limiter function: $\overline{OCL}$ and $\overline{SD1}$ pins tied together



NOTE:
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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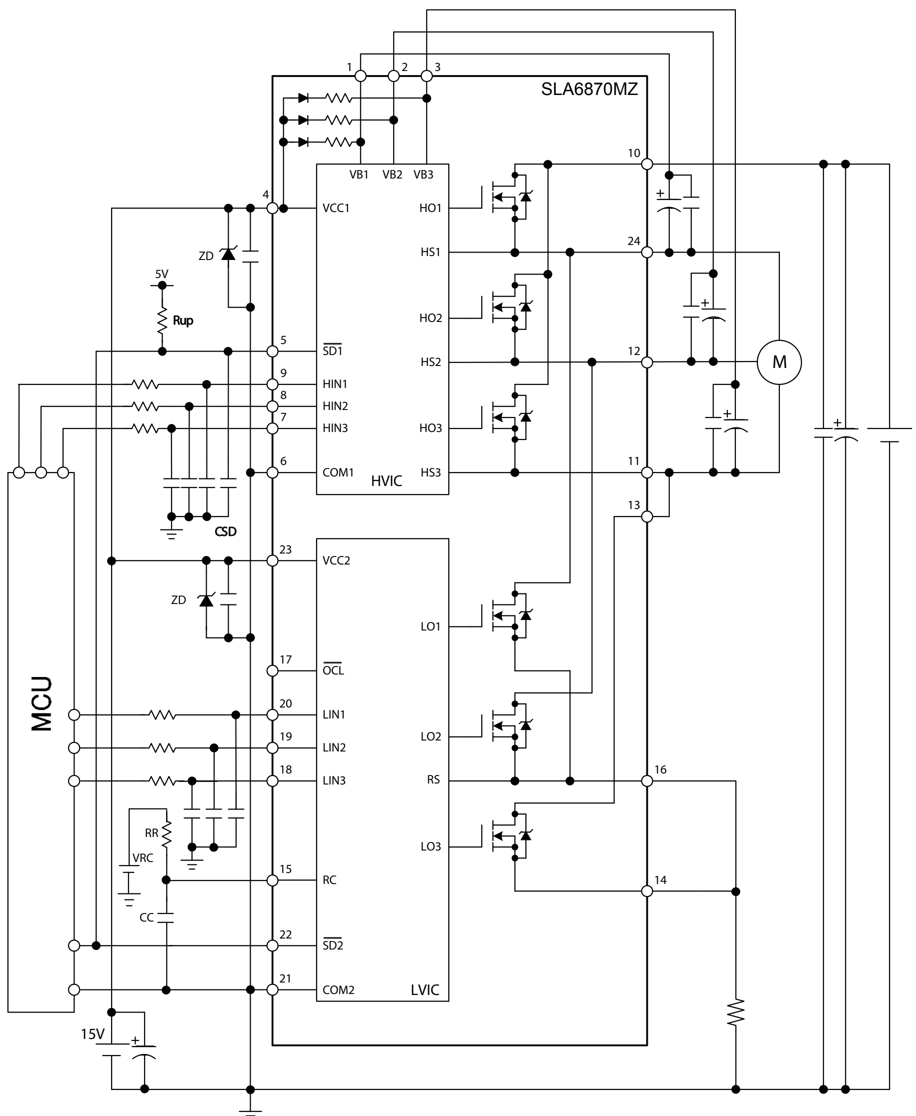
Typical Application Diagram

Shows configuration without current limiter function: $\overline{SD1}$ and $\overline{SD2}$ pins tied together



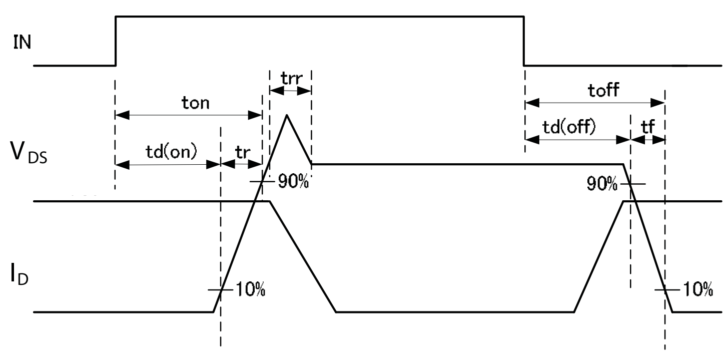
NOTE:
The external electrolytic capacitors should be placed as close to the IC as possible, in order to avoid malfunctions from external noise interference. Put a ceramic capacitor in parallel with the electrolytic capacitor if further reduction of noise susceptibility is necessary.

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

Characteristics	Symbol	Conditions	Min	Typ	Max	Units
Logic Supply Current	I_{CC}	V_{CC} = 15 V, T_C = –20°C to 125°C	–	2.7	5.0	mA
Bootstrap Supply Current	I_{BX}	V_{BX} = 15 V, V_{HIN} = 5 V, T_C = –20°C to 125°C	–	135	380	μA
Input Voltage	V_{IH}	V_{CC} = 15 V	–	2.9	3.4	V
	V_{IL}	V_{CC} = 15 V	1.6	2.1	–	V
Input Voltage Hysteresis	V_{Ihys}	V_{CC} = 15 V	–	0.8	–	V
Input Current	I_{IN}	V_{IN} = 5 V	–	230	500	μA
Undervoltage Lock Out	V_{UVHL}	High side, between VBx 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 VCC2 and COM2	10.0	11.0	12.0	V
	V_{UVLH}		10.5	11.5	12.5	V
	V_{UVLhys}	Low side, hysteresis	–	0.5	–	V
$\overline{SDx}$ and $\overline{OCL}$ Output Voltage	$V_{SDX(on)}$, V_{OCL}	V_{SDX} = V_{OCL} = 5 V, R_{UPX} = 3.3 kΩ	–	–	0.6	V
Overtemperature DetectionThreshold Temperature (Activation and Deactivation)	T_{DH}	V_{CC} = 15 V, high-side and low side	120	135	150	°C
	T_{DL}		100	115	130	°C
	T_{Dhys}		–	20	–	°C
Overcurrent Protection Trip Voltage	V_{TRIP}	V_{CC} = 15 V	0.9	1.0	1.1	V
Overcurrent Limit Reference Voltage	V_{LIM}	V_{CC} = 15 V	0.5035	0.53	0.5565	V
Overcurrent Protection Hold Time	t_p	V_{RC} = 5 V, R_R = 360 kΩ, C_C = 0.0047 μF	–	2.0	–	ms
Blanking Time	t_{blank}	V_{CC} = 15 V	1.4	2.0	2.6	μs
Bootstrap Diode Leakage Current	I_{LBD}	V_R = 500 V	–	–	10	μA
Bootstrap Diode Forward Voltage	V_{FBD}	I_F = 0.05 A	–	0.8	1.3	V
Bootstrap Diode Recovery Time	t_{rrb}	I_F / I_{RP} = 100 mA / 100 mA	–	70	–	ns
Bootstrap Diode Series Resistor	R_{BD}		168	210	252	Ω
MOSFET Breakdown Voltage	V_{DSS}	V_{CC} = 15 V, I_D = 100 μA, V_{IN} = 0 V	500	–	–	V
MOSFET Leakage Current	I_{DSS}	V_{CC} = 15 V, V_{DS} = 500 V, V_{IN} = 0 V	–	–	100	μA
MOSFET On State Resistance	$R_{DS(on)}$	V_{CC} = 15 V, I_D = 1.25 A, V_{IN} = 5 V	–	1.4	1.7	Ω
MOSFET Diode Forward Voltage	V_{SDF}	V_{CC} = 15 V, I_D = 1.25 A, V_{IN} = 5 V	–	1.0	1.5	V

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, inductive load	–	755	–	ns
	t_{rH}		–	65	–	ns
	t_{rrH}		–	100	–	ns
	$t_{dH(off)}$		–	680	–	ns
	t_{fH}		–	15	–	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, inductive load	–	645	–	ns
	t_{rL}		–	70	–	ns
	t_{rrL}		–	105	–	ns
	$t_{dL(off)}$		–	560	–	ns
	t_{fL}		–	20	–	ns



Switching Characteristics Definitions

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
TSD	L	L	Off	Off
	H	L	On	Off
	L	H	Off	Off
	H	H	On	Off
OCP	L	L	Off	Off
	H	L	On	Off
	L	H	Off	Off
	H	H	On	Off
OCL (= L)[1]	L	L	Off	Off
	H	L	Off	Off
	L	H	Off	On
	H	H	Off	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
SD2 (= L)	L	L	Off	Off
	H	L	On	Off
	L	H	Off	Off
	H	H	On	Off

[1]The OCL feature is enabled when the $\overline{\text{OCL}}$ and $\overline{\text{SD1}}$ pins are tied together externally. If these pins are not tied when an OCL condition occurs, device operation continues in Normal mode.

[2]Returning to the Normal mode of operation from a V_{CC} UVLO condition, a high-side MOSFET resumes switching on the rising edge of an HINx input. On the other hand, a low-side MOSFET resumes switching on the first logic high of a LINx input after release of the UVLO condition.

[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.

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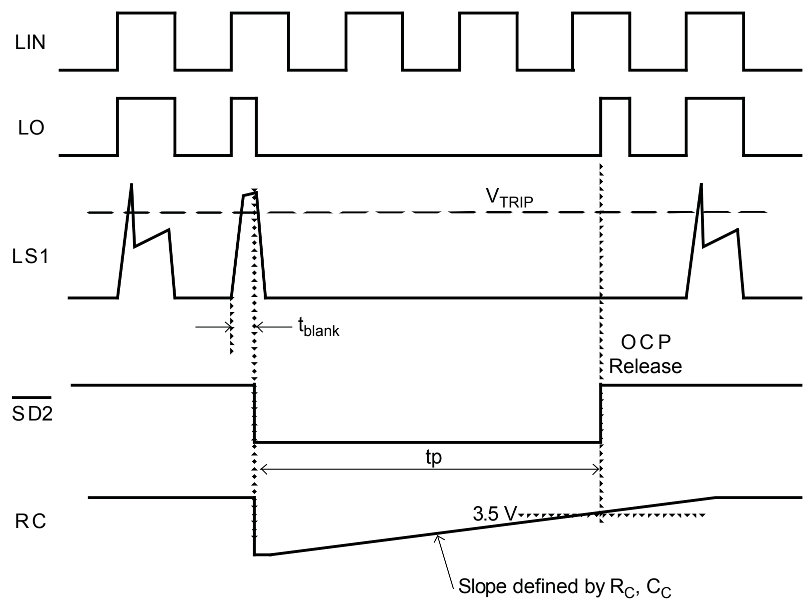
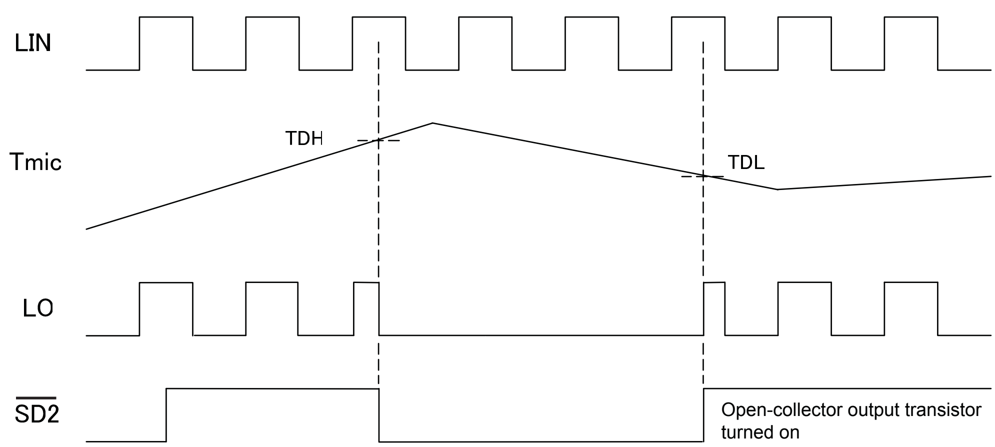
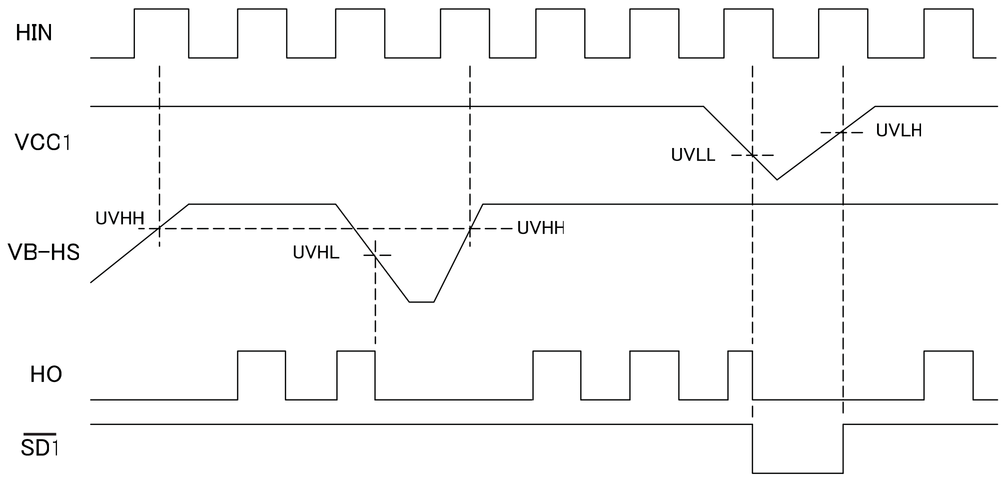
OCP Timing Diagram



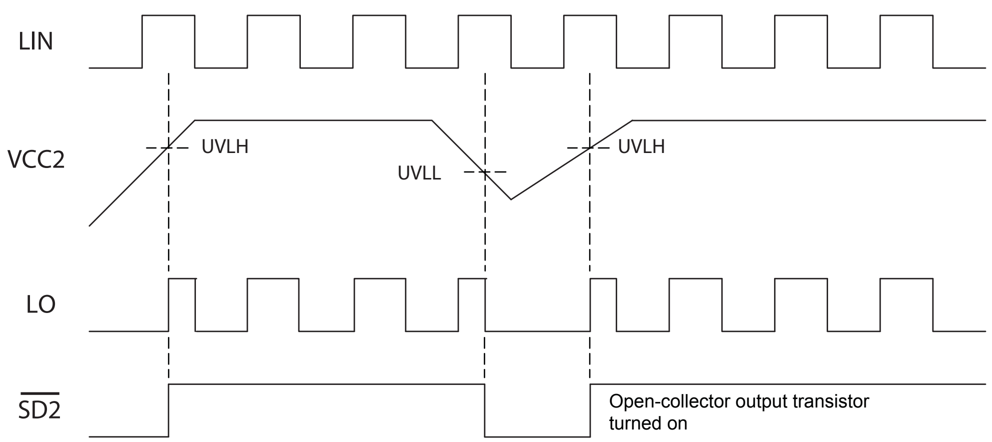
Low-Side Logic TSD Timing Diagram



High-Side UVLO Timing Diagram

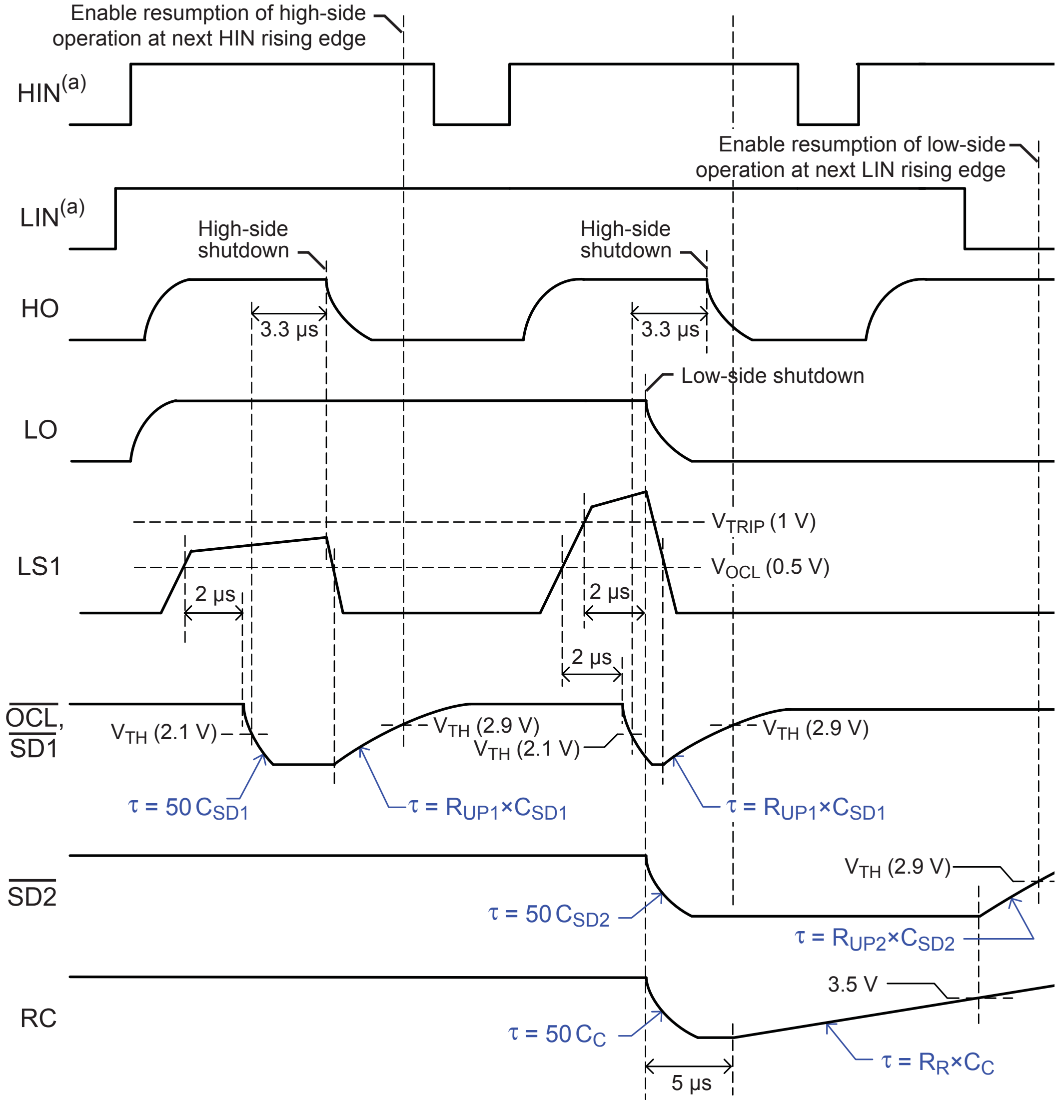


Low-Side UVLO Timing Diagram



OCL Timing Diagram

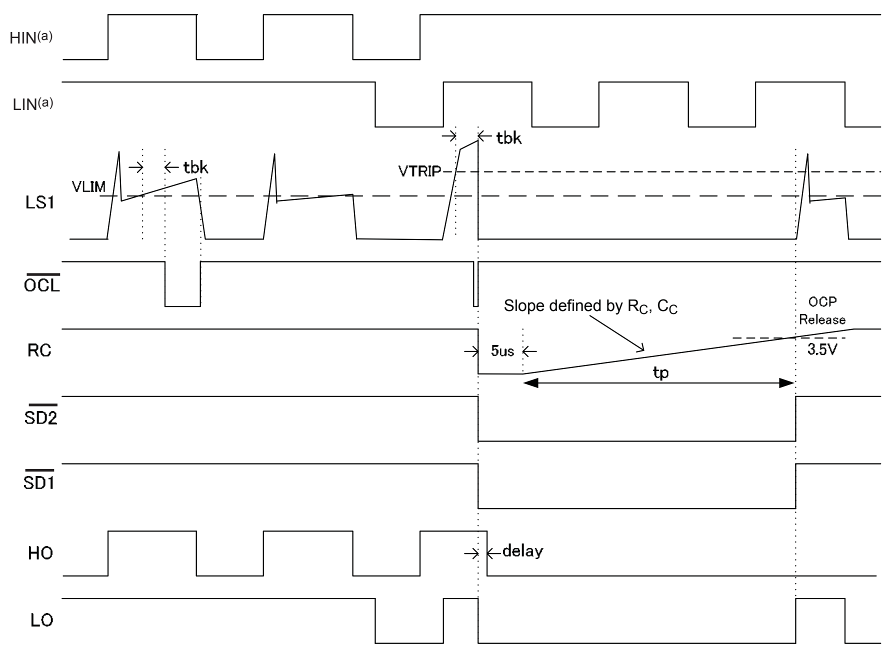
OCL and SD1 pins connected externally; current-limiter function in use



(a) Each HINx or LINx pin drives a independent side of a phase, that is, the high-side and the low-side swtiching devices of a U, V, or W motor coil phase are each driven separately, by the corresponding dedicated HINx or LIN

Shut Down Timing Diagram

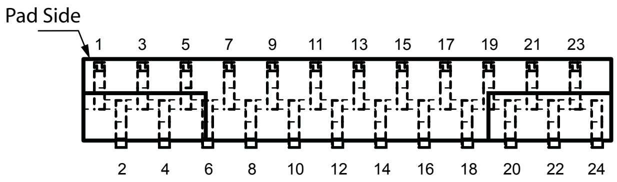
$\overline{SD1}$ and $\overline{SD2}$ pins connected externally; current-limiter function not in use



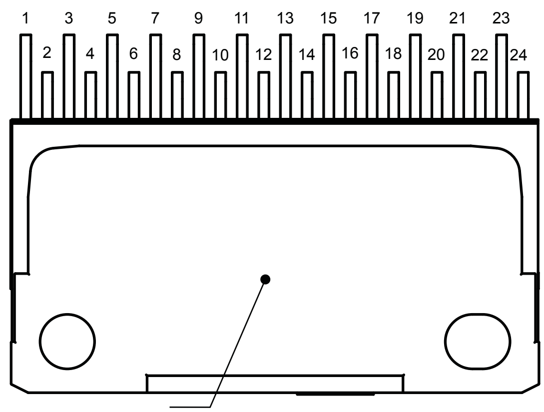
(a) Each HINx or LINx pin drives a independent side of a phase, that is, the high-side and the low-side swtiching devices of a U, V, or W motor coil phase are each driven separately, by the corresponding dedicated HINx or LINx input

Pin-out Diagram

Leadform 2171



Leadform 2175



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	$\overline{\text{SD1}}$	High side shutdown input and UVLO fault signal output
6	COM1	High side logic GND terminal
7	HIN3	High side input terminal (W phase)
8	HIN2	High side input terminal (V phase)
9	HIN1	High side input terminal (U phase)
10	VBB	Main supply voltage
11	W1	Output of W phase (connect to W2 externally)
12	V	Output of V phase
13	W2	Output of W phase (connect to W1 externally)
14	LS2	Low side source terminal (connect to LS1 externally)
15	RC	Overcurrent protection hold time adjustment input terminal
16	LS1	Low side source terminal (connect to LS2 externally)
17	$\overline{\text{OCL}}$	Output for overcurrent limiting
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	$\overline{\text{SD2}}$	Low side shutdown input and overtemperature, overcurrent, and UVLO fault signals output
23	VCC2	Low side logic supply voltage
24	U	Output of U phase

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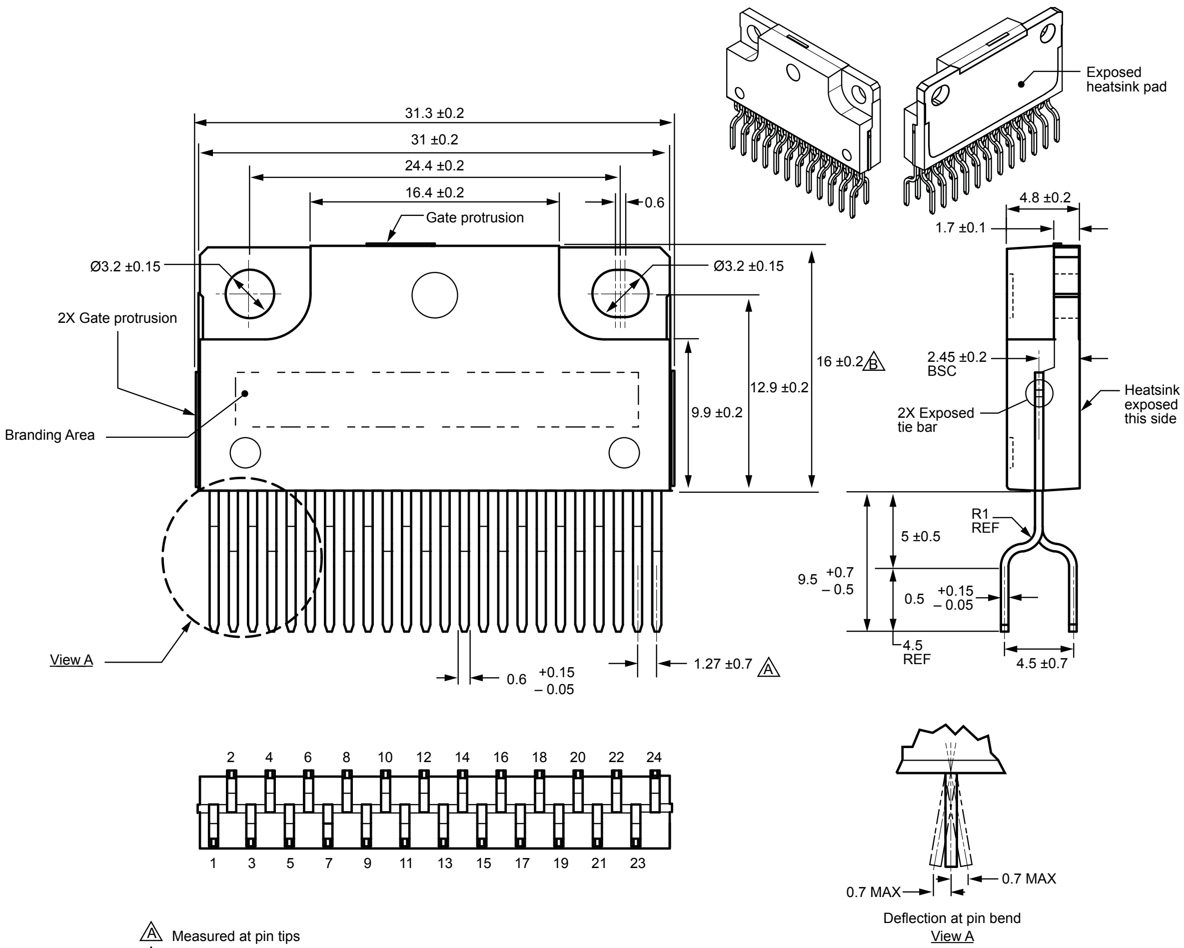
Package Outline Drawing

Leadform 2171

Dual rows, 24 alternating pins; vertical case mounting; pin #1 on pad side



A Measured at pin tips

B To case top

Leadform: 2171
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, type: SLA6870MZ

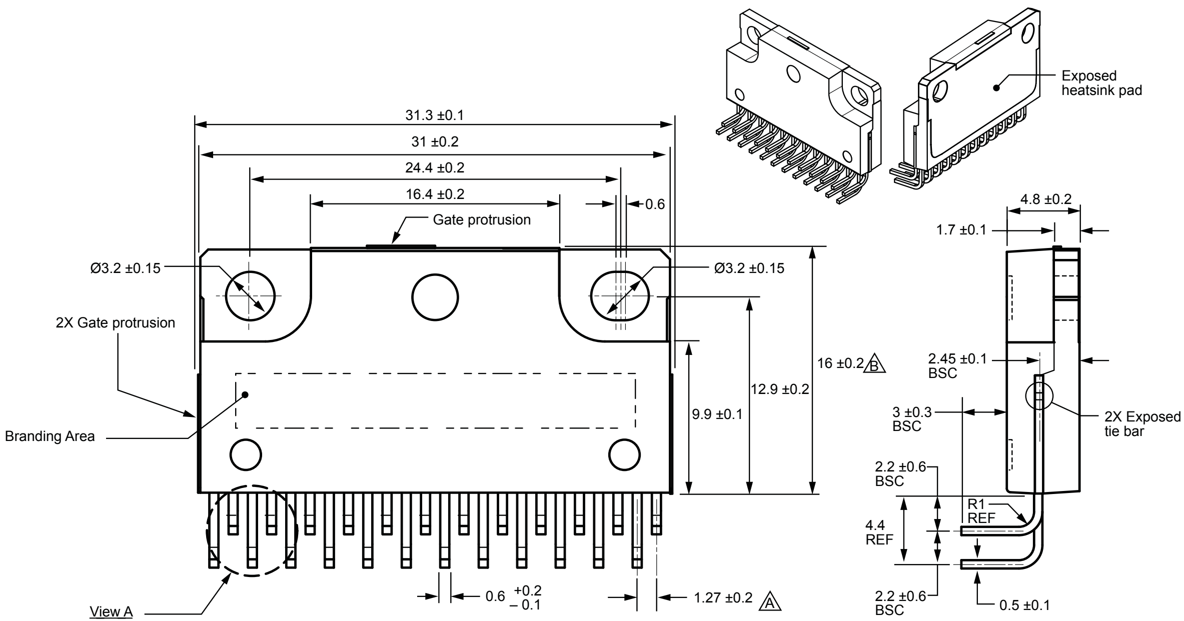
2nd line, lot: *YMDD#*
Where: Y is the last digit of the year of manufacture
M is the month (*1* to *9*, *O*, *N*, *D*)
DD is the date
\# is the tracking letter

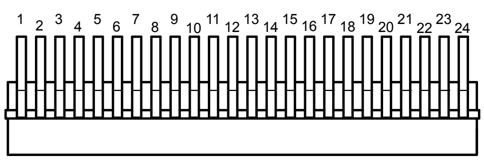
Leadframe plating Pb-free. Device composition complies with the RoHS directive.

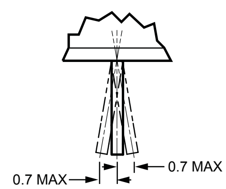
Package Outline Drawing

Leadform 2175

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







Deflection at pin bend
View A

A Measured at pin exit from case

B To case top

Leadform: 2175
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, type: SLA6870MZ

2nd line, lot: *YMDD#*
Where: Y is the last digit of the year of manufacture
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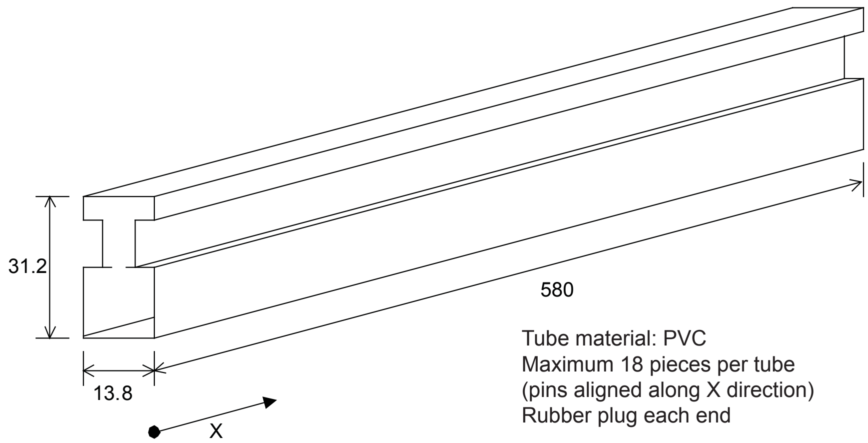
Leadframe plating Pb-free. Device composition complies with the RoHS directive.

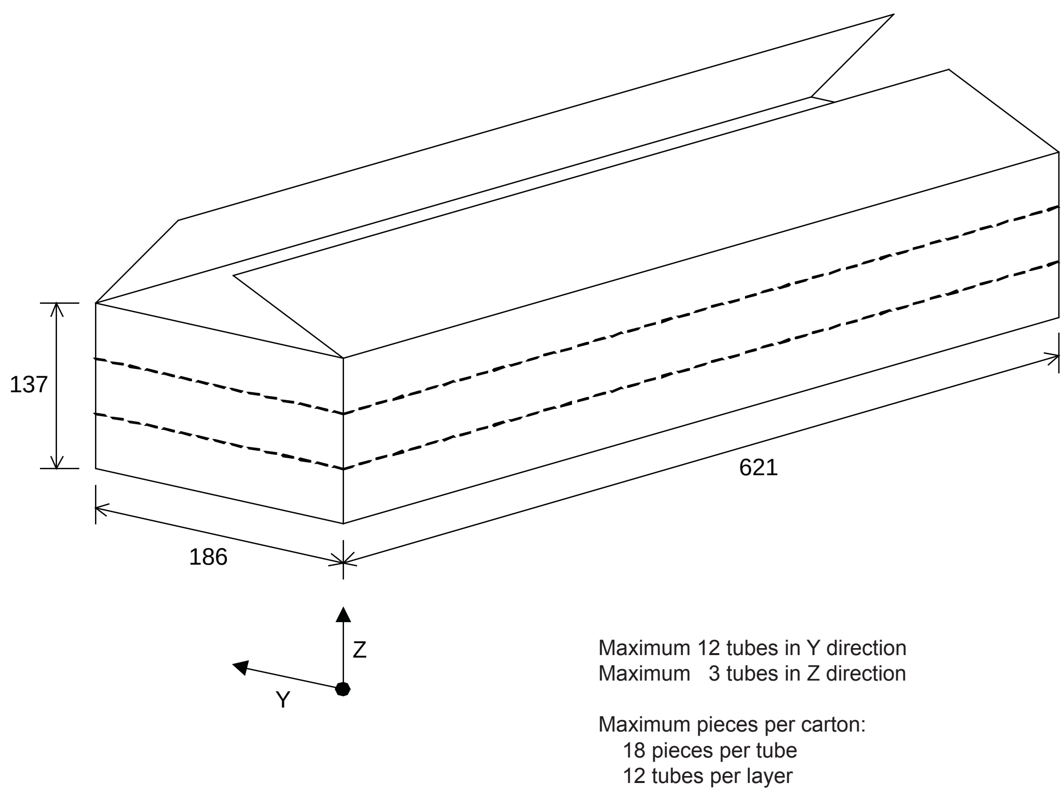
Packing Specification

Leadform 2171

Dimensions in millimeters



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



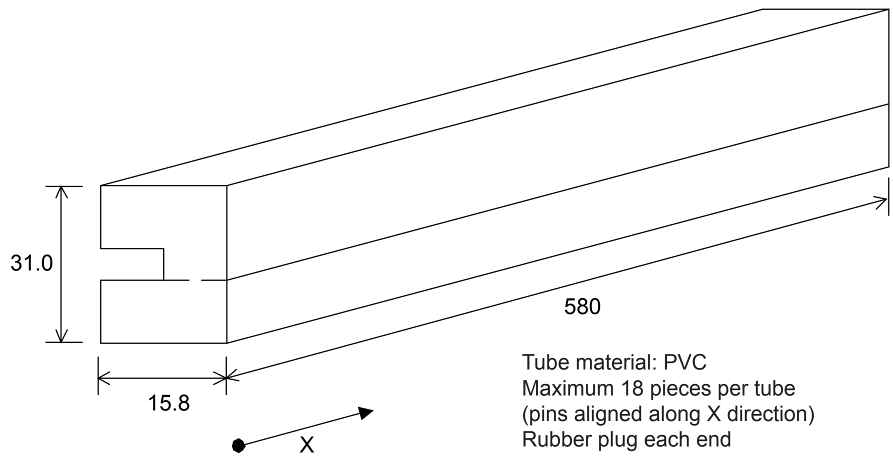
Maximum 12 tubes in Y direction
Maximum 3 tubes in Z direction

Maximum pieces per carton:
18 pieces per tube
12 tubes per layer
x 3 layers of tubes
648 pieces per carton

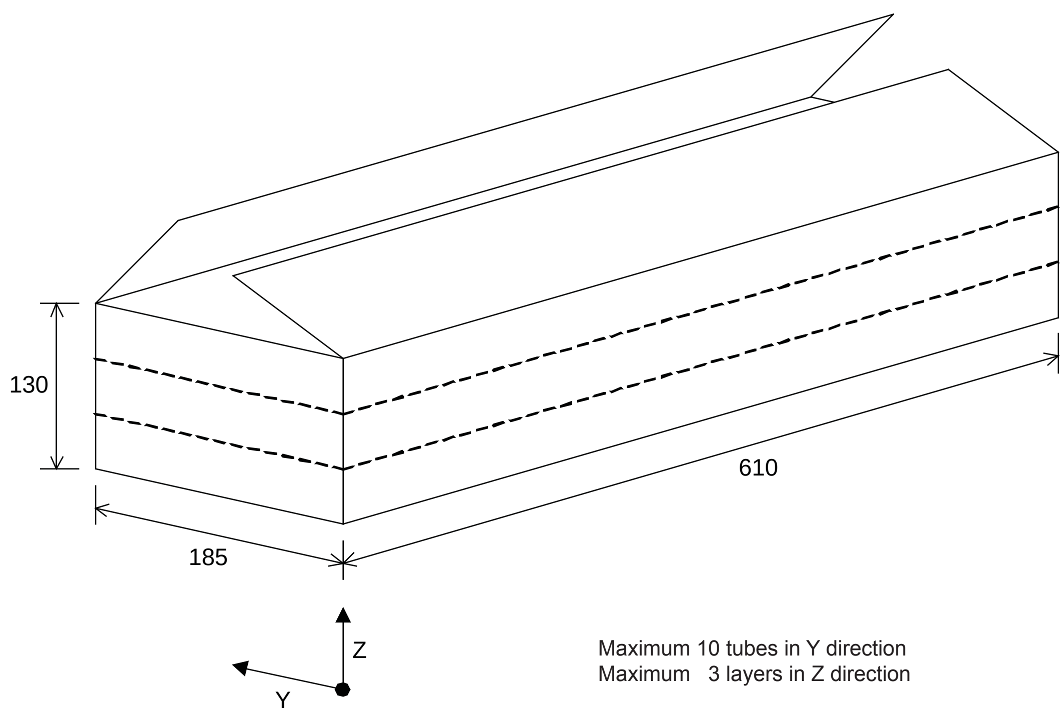
Packing Specification

Leadform 2175

Dimensions in millimeters



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



Maximum 10 tubes in Y direction
Maximum 3 layers in Z direction

Maximum pieces per carton:
18 pieces per tube
10 tubes per layer
x 3 layers of tubes
540 pieces per carton

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WARNING — These devices are designed to be operated at lethal voltages and energy levels. Circuit designs that embody these components must conform with applicable safety requirements. Precautions must be taken to prevent accidental contact with power-line potentials. Do not connect grounded test equipment.

The use of an isolation transformer is recommended during circuit development and breadboarding.

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, Inc.
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.

The products described herein are manufactured in Japan by Sanken Electric Co., Ltd. for sale by Allegro MicroSystems, Inc.

Sanken and Allegro reserve the right to make, from time to time, such departures from the detail specifications as may be required to permit improvements in the performance, reliability, or manufacturability of its products. Therefore, the user is cautioned to verify that the information in this publication is current before placing any order.

When using the products described herein, the applicability and suitability of such products for the intended purpose shall be reviewed at the users responsibility.

Although Sanken undertakes to enhance the quality and reliability of its products, the occurrence of failure and defect of semiconductor products at a certain rate is inevitable.

Users of Sanken products are requested to take, at their own risk, preventative measures including safety design of the equipment or systems against any possible injury, death, fires or damages to society due to device failure or malfunction.

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