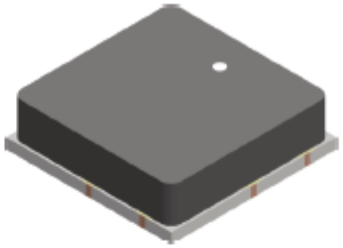
MSW6000-600

SP6T PIN Diode Switches

Rev. V1

Features

- Wide Frequency Range: 32 MHz to 512 MHz, in 1 band
- Surface Mount SP6T Switch in Compact Outline:
  - 8 mm L x 8 mm W x 2.5 mm H
- Higher Average Power Handling than Plastic Packaged
  - MMIC Switches: 100 W CW
- High RF Peak Power: 200 W
- Low Insertion Loss: 0.25 dB
- High IIP3: 60 dBm
- Operates From Positive Voltage Only: 5 V & -200 V
- RoHS Compliant



Case Style CS600

Description

The MSW6000-600 is a surface mount silicon PIN diode SP6T switch which can handle 200 W peak input power. Manufactured using Aeroflex/Metelics proven hybrid manufacturing process incorporating high voltage PIN diodes and passive devices integrated on a ceramic substrate. This low profile, compact, surface mount component, (8 mm L x 8 mm W x 2.5 mm H) offers superior small and large signal performance compared to MMIC devices in QFN packages. The SP6T switches are designed in a symmetrical topology to optimize insertion loss and isolation performance.

These switches can be used for high power (cold) switching applications with high RF circuit VSWR @ +85 C. The PIN diode series resistance (<1.5 Ω), coupled with the long minority carrier lifetime, (>2 µs), provides better IIP3 distortion values > +60 dBm.

These MSW6000-600 SP6T switch is designed to be used in high average and peak power switch applications from 30 MHz to 512 MHz. This switch is designed to be compatible with high volume, surface mount, solder re-flow manufacturing. This product is durable, reliable, and capable of meeting all military, commercial, and industrial environments. This device is RoHS compliant.

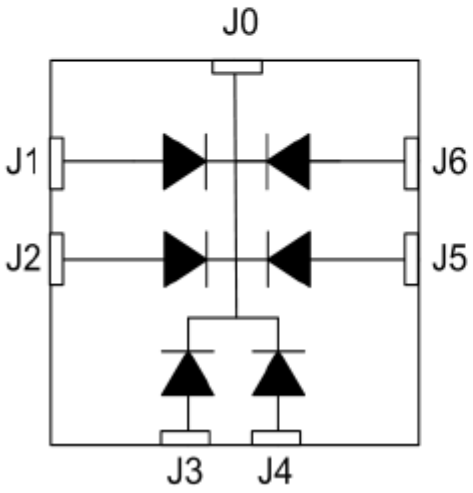
Environmental Capabilities

The MSW6000-600 SP6T switch is capable of meeting the environmental requirements of MIL-STD-202 and MIL-STD-750.

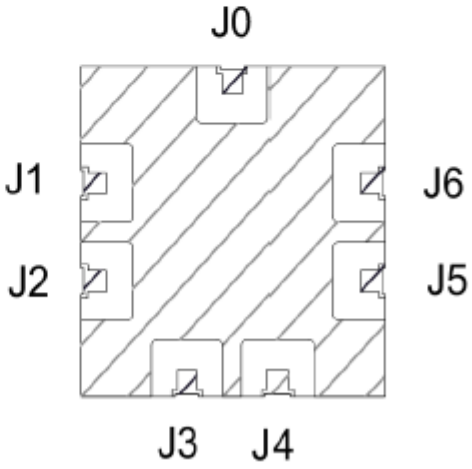
ESD and Moisture Sensitivity Level Rating

PIN diodes are susceptible to damage from electrostatic discharge (ESD) events, as are all semiconductor devices. The ESD rating for this device is Class 1C, HBM. The moisture sensitivity level rating for this device is MSL 1.

Pin Out



Schematic



MSW6000-600Electrical Specifications

Z_0 = 50 Ω, P_{IN}= 0 dBm, T_A= 25 ºC (Unless Otherwise Defined)

Parameter	Symbol	Test Conditions	Min. Value	Typ. Value	Max. Value	Units
Frequency	F		30	-	512	MHz
Insertion Loss (Note 2)	IL	J0 : J1 Thru J6 ON ARM : I_F = 100 mA, OFF ARMS : V_R = - 28 V @ 0 mA P_{IN} = 0 dBm	-	0.25	0.4	dB
Return Loss (Note 2)	RL	J0 : J1 Thru J6 ON ARM : I_F = 100 mA, OFF ARM : V_R = - 28 V @ 0 mA P_{IN} = 0 dBm	18	20	-	dB
Isolation (Note 2)	Isol	J0 : J1 Thru J6 ON ARM : I_F = 100 mA, OFF ARM : V_R = - 28 V @ 0 mA P_{IN} = 0 dBm F = 30 MHz to 88 MHz	40	42	-	dB
		J0 : J1 Thru J6 ON ARM : I_F = 100 mA, OFF ARM : V_R = - 28 V @ 0 mA P_{IN} = 0 dBm F = 89 MHz to 512 MHz	30	32	-	dB
CW Incident Power (Note 2)	P_{inc}(CW)	J0 : J1 Thru J6 ON ARM : I_F = 100 mA, OFF ARM : V_R = - 28 V @ 0 mA 3.5:1 source VSWR & 1.1:1 load VSWR	-	50	-	dBm
Peak Incident Power (Note 2)	P_{inc}(Pk)	J0 : J1 Thru J6 ON ARM : I_F = 100 mA, OFF ARM : V_R = - 28 V @ 0 mA 3.5:1 source VSWR & 1.1:1 load VSWR pulse width = 10 µs, duty cycle = 1 %	-	53	-	dBm
Switching Time (Note 1)	t_{SW}	10% -90% RF voltage, TTL rep rate = 100 kHz	-	1	2	µs
Input 3rd Order Intercept Point	IIP3	ON ARM : I_F = 100 mA, OFF ARMS : V_R = - 28 V @ 0 mA F_1 = 200 MHz, F_2 = 210 MHz, P_1 = P_2 = 0 dBm, measured on path biased to low loss state	60	65	-	dBm

Notes:

1 Switching and propagation delay time (50 % TTL – 10%/90 % RF Voltage) is a function of the PIN diode driver performance as well as the characteristics of the diode. An RC "current spiking network" is used on the driver output to provide a transient current to rapidly remove stored charge from the PIN diode. Typical component values are: R = 50 to 220 Ω and C = 470 to 1,000 pF. The MPD3T5N200-703 is the recommended PIN diode driver to interface with the MSW6000-600 SP6T switch.

2 PIN diode DC reverse voltage to maintain high resistance in the OFF PIN diode is determined by RF frequency, incident power, and VSWR as well as by the characteristics of the diode. The minimum reverse bias voltage values are provided on page 8 of this datasheet.

RF Bias Network Component Values

P/N	F (MHz)	DC Blocking Capacitors	Inductors	RF Bypass Capacitors	Resistor R1	Resistor R2
MSW6000-600	30 – 512	0.1 µF	1.1 µH	0.1 µF	36 Ω	0 Ω

Minimum Reverse Bias Voltage at TX, RX, DC Ports vs. Signal Frequency

P_{INC} = 100 W CW, Z_0 = 50Ω with 3.5:1 source VSWR & 1.1:1 load VSWR

Part Number	F = 30 MHz	F = 88 MHz	F = 225 MHz	F = 512 MHz
MSW6000-600	160 V	150 V	110 V	60 V

Note: "NA" denotes the switch is not recommended for use in that frequency band.

Absolute Maximum Ratings

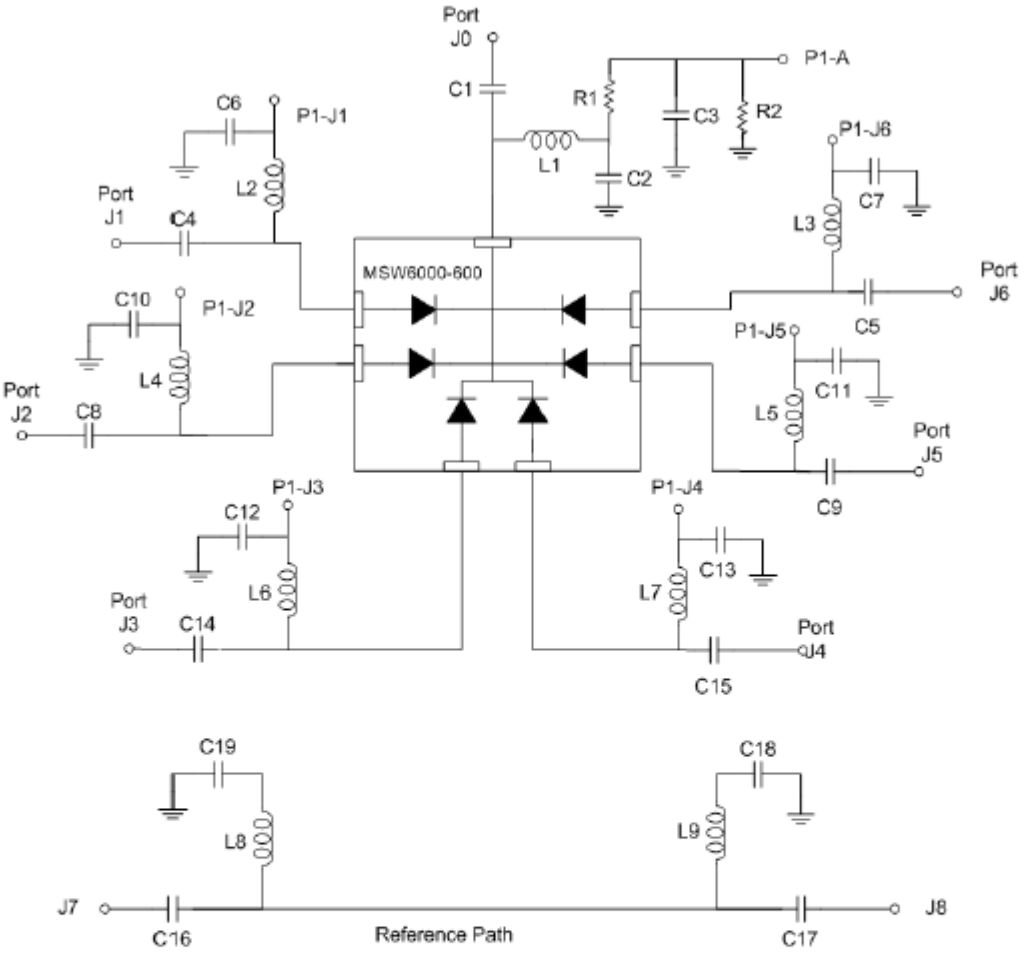
Z_0 = 50 Ω, T_A = +25 °C (Unless Otherwise Defined)

Parameter	Conditions	Absolute Maximum Value
Forward Current – ON ARM		250 mA
Reverse Voltage – OFF ARM		300 V
Forward Diode Voltage	I_F = 250 mA	1.2 V
Operating Temperature		-65°C to 125 °C
Storage Temperature		-65°C to 125 °C
Junction Temperature		175°C
Assembly Temperature	t = 10 s	260°C
CW Incident Power Handling – (Note 1)	Source VSWR = 3.5 :1, Load VSWR = 1.1 :1, T_{CASE} = 85 °C, cold switching	50 dBm
Peak Incident Power Handling – (Note 1)	Source VSWR = 3.5 :1, Load VSWR = 1.1 :1, T_{CASE} = 85 °C, cold switching, pulse width = 10 µs, duty cycle = 1 %	53 dBm
Total Dissipated RF & DC Power (Note 1)	T_{CASE} = 85°C, cold switching	3 W

Notes:

1 Backside RF and DC grounding area of device must be completely solder-attached to RF circuit board vias for proper electrical and thermal circuit grounding.

SP6T Switch Evaluation Board Schematic



Evaluation Board Description

The evaluation boards for the MSW6000-600 surface mount silicon PIN diode SP6T T-R switches allow the full exercise of the switch for small signal performance analysis, as well as for large signal operation with maximum input signal power of 45 dBm (CW or peak power). Each evaluation board includes MSW6000-600 SP6T switch, DC blocking capacitors at each RF port and bias decoupling networks at each RF port which allow DC or low frequency control signals to be applied to the switch.

Two complementary control signals are required for proper operation. Control voltages are applied to the ON bias port and OFF bias ports. A bias voltage of 0 V must be applied to the J0 bias port (pin A of multi-pin connector P1) whenever the switch is in operation. The evaluation board is shipped from the factory with a 0 Ω resistor installed in position R2, which grounds Pin A of connector P1.

State 1

In State 1, the J0 – J1 low loss state, the series PIN diode between the J0 and J1 ports is forward biased by applying 0 V to the J0 bias input port (pin A of multi-pin connector P1). The magnitude of the resultant bias current through the diode is primarily determined by the voltage applied to the J1 bias port (pin 1 of P1), the magnitude of the forward voltage across the PIN diode and the resistance of R1 (39 Ω). This current is nominally 100 mA. At the same time, the PIN diodes connected between J0 and J2, J3, J4, J5 and J6 are reverse biased by applying a higher bias voltage, nominally -28 V for small signal operation, to the J2 thru J6 bias ports (pins 2, 3, 4, 5 and 6 of P1). Under this condition, the PIN diodes connected between the J0 and J2 thru J6 ports are reverse biased with the DC voltage drop across R1, nominally 3.9 V on their cathodes and the large, negative bias voltage connected to each of their anodes . There is no DC current flowing through the off diodes.

The J0 to J2 thru J6 series PIN diodes, must be reverse biased during the transmit state. The reverse bias voltage must be sufficiently large to maintain the diode in its non-conducting, high impedance state when large RF signal voltage may be present in the J0-to-J1 path.

The minimum voltage required to maintain the series diodes in the isolation paths out of conduction is a function of the magnitude of the RF voltage present, the standing wave present at the series diodes' cathodes, the frequency of the RF signal and the characteristics of the reverse bias series diodes, among other factors. Minimum control voltages for several signal frequencies are shown in the table "Minimum Reverse Bias Voltage", assuming the input power to the J1 to J0 path to be 100 W CW and the VSWR on the J1- J0 path to be 1.5:1. **It is important to note that the evaluation board, as supplied from the factory, is not capable of handling RF input signals larger than 45 dBm.** If performance of the switch under larger input signals is to be evaluated, an adequate heat sink must be properly attached to the evaluation board, and several of the passive components on the board must be changed in order to safely handle the dissipated power as well as the high bias voltage necessary for proper performance. Contact the factory for recommended components and heat sink.

State 2

In State 2, to produce the low loss condition from J0 to a different RF port, for example the J0 to J4 path, Pin A of the P1 connector must remain grounded, , the J4 bias port (Pin 4 on the P1 connector) should be connected to +5 V and the bias connections for the remaining RF ports (pins 1, 2, 3, 5 and 6 of the P1 connector)must be connected to the large negative bias voltage described above, nominally -28 V for RF small signal performance. Refer to the DC Bias to RF Truth Table below.

Truth Table

P_{IN} = 0 dBm, Z_0 = 50 Ω (Unless otherwise noted)

Path J0 – J1	Path J2 – J6	Path J3 – J6	Path J4 – J6	Path J5 – J6	J1 Bias	J2 Bias	J3 Bias	J4 Bias	J5 Bias	J6 Bias
Low Loss	High Isolation	High Isolation	High Isolation	High Isolation	5 V 100 mA	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA

Path J0 – J2	Path J1 – J6	Path J3 – J6	Path J4 – J6	Path J5 – J6	J1 Bias	J2 Bias	J3 Bias	J4 Bias	J5 Bias	J6 Bias
Low Loss	High Isolation	High Isolation	High Isolation	High Isolation	-28 V 0 mA	5 V 100 mA	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA

Path J0 – J3	Path J1 – J6	Path J2 – J6	Path J4 – J6	Path J5 – J6	J1 Bias	J2 Bias	J3 Bias	J4 Bias	J5 Bias	J6 Bias
Low Loss	High Isolation	High Isolation	High Isolation	High Isolation	-28 V 0 mA	-28 V 0 mA	5 V 100 mA	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA

Path J0 – J4	Path J1 – J6	Path J2 – J6	Path J3 – J6	Path J5 – J6	J1 Bias	J2 Bias	J3 Bias	J4 Bias	J5 Bias	J6 Bias
Low Loss	High Isolation	High Isolation	High Isolation	High Isolation	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA	5 V 100 mA	-28 V 0 mA	-28 V 0 mA

Path J0 – J5	Path J1 – J6	Path J2 – J6	Path J3 – J6	Path J4 – J6	J1 Bias	J2 Bias	J3 Bias	J4 Bias	J5 Bias	J6 Bias
Low Loss	High Isolation	High Isolation	High Isolation	High Isolation	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA	5 V 100 mA	-28 V 0 mA

Path J0 – J6	Path J1 – J6	Path J2 – J6	Path J3 – J6	Path J4 – J6	Path J5 – J6	J1 Bias	J2 Bias	J3 Bias	J4 Bias	J5 Bias	J6 Bias
Low Loss	High Isolation	High Isolation	High Isolation	High Isolation	High Isolation	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA	-28 V 0 mA	5 V 100 mA

Notes:

1 As shipped from the factory, R2 is a 0 Ω resistor, which connects Pin A of connector P1 to ground.

2 Refer to Minimum Reverse Bias Voltage vs. Frequency table for required reverse bias voltage for higher input power level operation.

Calculation of Resistor Values

The magnitude of the forward bias current applied to the series diode is set by the magnitude of the supply voltage $+V_{CC1}$, which is nominally 5 V, the value of resistor R1 and the forward voltage of the series diode, V_{DIODE}, among other factors. Given the desired current value, the resistance is given by the formula:

$$R_1 = \frac{(+V_{CC1} - V_{DIODE})}{I_{BIAS}}$$

The magnitude of the current through the shunt diode is set by the magnitude of the supply voltage $+V_{CC2}$, the value of resistor in series with the shunt diode (R_2 or R_4 or R_5)and the forward voltage of the shunt diode, VDIODE, among other factors. Given the desired current value, this resistance is given by the formula:

$$R_{SHUNT} = \frac{(+V_{CC2} - 0.3 - V_{DIODE})}{I_{BIAS}}$$

It is important to note that the switch module evaluation board, as supplied from the factory, is not capable of handling RF input signals larger than 45 dBm. If per-formance of the switch under larger input signals is to be evaluated, an adequate heat sink must be properly attached to the evaluation board, and several of the passive components on the board must be changed in order to safely handle the dissipated power as well as the high bias voltage necessary for proper performance. Contact the factory for recommended components and heat sink.

Minimum Reverse Bias Voltage

The minimum reverse bias voltage required to maintain a PIN diode out of conduction in the presence of a large RF signal is given by:

$$|V_{DC}| = \frac{|V_{RF}|}{\sqrt{1 + \left[\left(\frac{0.0142 \times f_{MHz} \times W_{mils}^2}{V_{RF} \times \sqrt{D}}\right) \times \left(1 + \sqrt{1 + \left(\frac{0.056 \times V_{RF} \times \sqrt{D}}{W_{mils}}\right)^2}\right)\right]^2}}$$

where

$\|V_{DC}\|$	=	magnitude of the minimum DC reverse bias voltage
$\|V_{RF}\|$	=	magnitude of the peak RF voltage (including the effects of VSWR)
f_{MHz}	=	lowest RF signal frequency expressed in MHz
D	=	duty factor of the RF signal
W_{mils}	=	thickness of the diode I layer, expressed in mils (thousandths of an inch)

(Caverly, R. H. & Hiller, G., "Establishing the Minimum Reverse Bias for a p-i-n Diode in a High-Power Switch", IEEE Transactions on Microwave Theory and Techniques, Vol. 38, No. 12, December 1990)

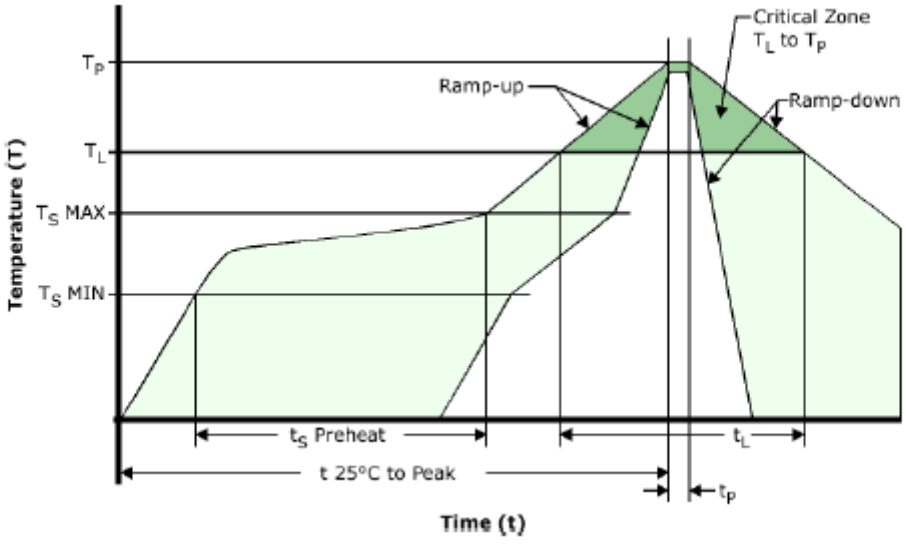
Assembly Instructions

The MSW6000-600 switch is capable of being placed onto circuit boards with pick and place manufacturing equipment from tube or tape-reel dispensing. The device is attached to the circuit board using conventional solder re-flow or wave soldering procedures with RoHS-compliant or Sn60/Pb40 type solders per the conditions specified in Table 1 and Figure 1.

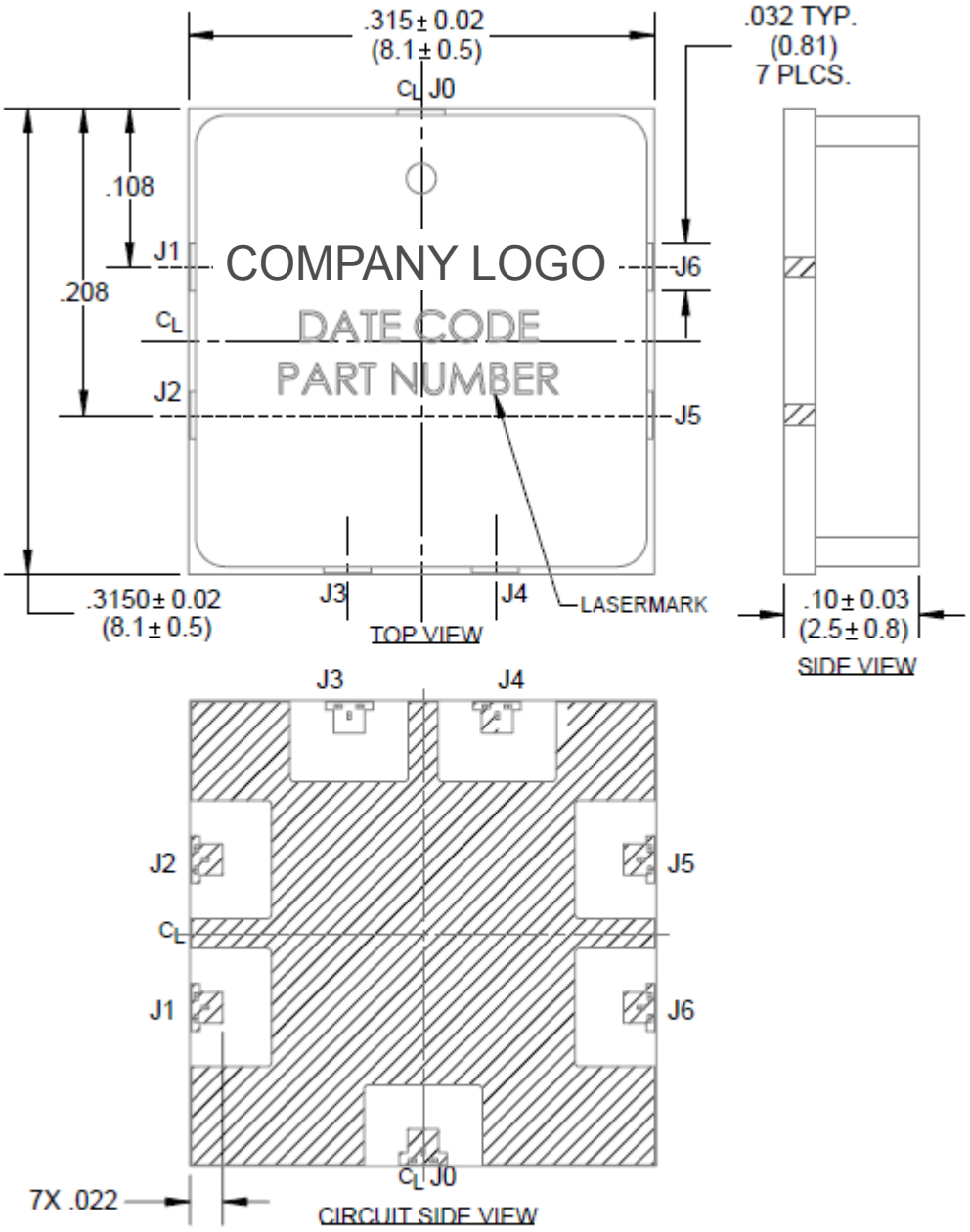
Table 1. Time-Temperature Profile for Sn60/Pb40 or RoHS Type Solders

Profile Feature	SnPb Solder Assembly	Pb-Free Solder Assembly
Average Ramp-Up Rate (T_L to T_p)	3 °C /second maximum	3 °C /second maximum
Preheat: - Temperature Min (T_{SMIN}) - Temperature Max (T_{SMAX}) - Time (min to max)(t_s)	 100 °C 150 °C 60-120 s	 150 °C 200 °C 60-180 s
T_{SMAX} to T_L - Ramp-Up Rate		 3 °C/s maximum
Time Maintained Above: - Temperature (T_L) - Time (t_L)	 183 °C 60-150 s	 217 °C 60-150 s
Peak temperature (T_p)	225 +0/-5 °C	260 +0/-5 °C
Time Within 5 °C of Actual Peak Temperature (t_p)	10 – 30 s	20 – 40 s
Ramp-Down Rate	6 °C /s maximum	6 °C /s maximum
Time 25 °C to Peak Temperature	6 minutes maximum	8 minutes maximum

Figure 1. Solder Re-Flow Time-Temperature Profile



SP3T Switch Outline for Case Style 600 (CS600)



Notes:

1. Hatched Metal Area on Circuit Side of Device is RF, D.C., and Thermal Ground.

Part Number Ordering Information

Part Number	Description	Packaging
MSW6000-600-T		Tube
MSW6000-600-R		Tape-Reel (Quantities of 250 or 500)
MSW6000-600-W		Waffle Pack
MSW6000-600-E		RF Evaluation Board