MSW2000-200, MSW2001-200, MSW2002-200 SP2T Switch Series, 20 MHz to 6.5 GHz, Data Sheet

Features

- Wide Frequency Range: 20 MHz to 6.5 GHz, in 3 bands
- Surface Mount SP2T Switch in Compact Outline: 8 mm L x 5 mm W x 2.5 mm H
- Higher Average Power Handling than Plastic Packaged MMIC Switches: 125 W CW
- High RF Peak Power: 500 W
- Low Insertion Loss: 0.25 dB
- High IIP3: 65 dBm
- Operates From Positive Voltage Only: 5 V & 28 V to 125 V
- RoHS Compliant

Applications

- High Power Transmit/Receive (TR) Switching
- Active Receiver Protection

Description

The MSW2000-200, MSW2001-200, and MSW2002-200 series of surface mount silicon PIN diode SP2T switches handle high power signals from 20 MHz to 1.5 GHz, 200 MHz to 4.5 GHz and 1.5 to 6.5 GHz respectively, in transmit-receive (TR), active receiver protection and other applications. This series is manufactured using Aeroflex/Metelics proven hybrid manufacturing process incorporating high voltage PIN diodes and passive devices integrated within a ceramic substrate. These low profile, compact, surface mount components, (8 mm L x 5 mm W x 2.5 mm H) offer superior small and large signal performance superior to that of MMIC devices in QFN packages. The SP2T switches are designed in an asymmetrical topology to minimize Tx-Ant loss and maximize Tx-Rx isolation performance. The very low thermal resistance (< 10 °C/W) of the PIN diodes in these devices enables them to reliably handle RF incident power levels of 50 dBm CW and RF peak incident power levels of 53 dBm in cold switching applications at $T_A = 85$ °C. The low PIN diode series resistance (< 0.8 Ω), coupled with their long minority carrier lifetime, (> 2 µs), provides input third order intercept point (IIP3) greater than 65 dBm.

These MSW2000-200, MSW2001-200, and MSW2002-200 series SP2T switches are designed to be used in high average and peak power switch applications, operating from 20 MHz to 6.5 GHz in three bands, which utilize high volume, surface mount, solder re-flow manufacturing. These products are durable and capable of reliably operating in military, commercial, and industrial environments The devices are RoHS compliant.

Environmental Capabilities

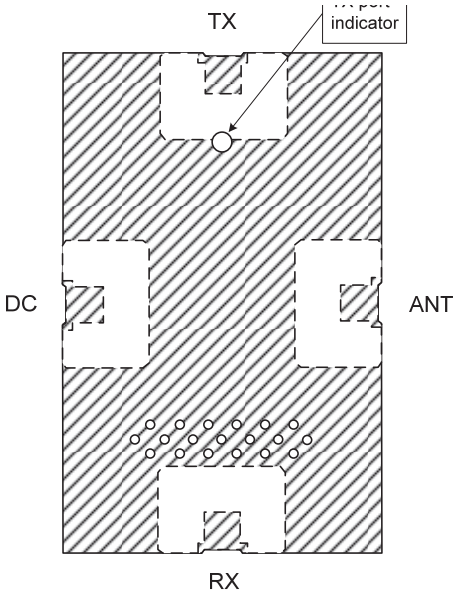
The MSW2000-200, MSW2001-200, and MSW2002-200 series SP2T switches are capable of meeting the environmental requirements of MIL-STD-202 and MIL-STD-750.

ESD and Moisture Sensitivity Level Rating

PIN Diode switches are susceptible to damage from ESD events, as are all semiconductors. The ESD rating for these devices is Class 1C, HBM. The moisture sensitivity level rating is MSL 1.

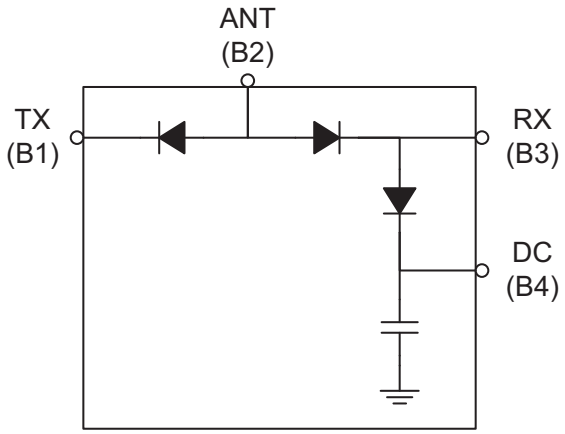
Document DS 12633 REV. E, ECN 12450
Revision Date: 12/1/2012

Pinouts



Top View

Schematic



Truth Table

Ant – Tx Path	Ant – Rx Path	B1 Bias	B2 Bias	B3 Bias	B4 Bias
Low insertion loss	Isolation	-100 mA	100 mA	25 mA @ 28 V	-25 mA
Isolation	Low insertion loss	28 mA	25 mA	-25 mA	28 mA

MSW2000-200 Electrical Specifications

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

PIN	Symbol	Test Conditions	Minimum Value	Typical Value	Maximum Value	Units
Frequency	F		20	50 - 1000	1500	MHz
Tx-Ant Insertion Loss	IL(Tx)	Condition 1	- - -	0.15	0.25	dB
Ant-Rx Insertion Loss	IL(Rx)	Condition 2	- - -	0.25	0.35	dB
Tx-Ant Return Loss	RL(Tx)	Condition 1	20	22	- - -	dB
Ant-Rx Return Loss	RL(Rx)	Condition 2	20	23	- - -	dB
Tx-Rx Isolation	Isol(Rx)	Condition 1	48	52	- - -	dB
Rx-Tx Isolation	Isol(Tx)	Condition 2	22	26	- - -	dB
Tx CW Incident Power (Note 2)	P_{inc}(CW)	Condition 1, 1.5:1 source & load VSWR	- - -	- - -	50	dBm
Rx CW Incident Power (Note 2)	P_{inc}(CW)	Condition 2, 1.5:1 source & load VSWR	- - -	- - -	43	dBm
Tx Peak Incident Power (Note 2)	P_{inc}(Pk)	Condition 1, 10 µs pulse width, 1 % duty cycle, 1.5:1 source & load VSWR (IL)	- - -	- - -	57	dBm
Switching Time (Note 1)	t_{SW}	10% -90% RF voltage	- - -	2	3	µs
Input 3rd Order Intercept Point	IIP3	F_1 = 2.0 GHz, F_2 = 2.01 GHz, $P_1 = P_2$ = 40 dBm	60	65	- - -	dBm

MSW2001-200 Electrical Specifications

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

PIN	Symbol	Test Conditions	Minimum Value	Typical Value	Maximum Value	Units
Frequency	F		200	400 - 4000	4500	MHz
Tx-Ant Insertion Loss	IL(Tx)	Condition 1	- - -	0.3	0.4	dB
Ant-Rx Insertion Loss	IL(Rx)	Condition 2	- - -	0.4	0.5	dB
Tx-Ant Return Loss	RL(Tx)	Condition 1	15	18	- - -	dB
Ant-Rx Return Loss	RL(Rx)	Condition 2	15	17	- - -	dB
Tx-Rx Isolation	Isol(Rx)	Condition 1	32	36	- - -	dB
Rx-Tx Isolation	Isol(Tx)	Condition 2	12	14	- - -	dB
Tx CW Incident Power (Note 2)	P_{inc}(CW)	Condition 1, 1.5:1 source & load VSWR	- - -	- - -	50	dBm
Rx CW Incident Power (Note 2)	P_{inc}(CW)	Condition 2, 1.5:1 source & load VSWR	- - -	- - -	43	dBm
Tx Peak Incident Power (Note 2)	P_{inc}(Pk)	Condition 1, 10 µs pulse width, 1 % duty cycle, 1.5:1 source & load VSWR (IL)	- - -	- - -	57	dBm
Switching Time (Note 1)	t_{SW}	10% -90% RF voltage	- - -	1.5	2	µs
Input 3rd Order Intercept Point	IIP3	F_1 = 2.0 GHz, F_2 = 2.01 GHz, $P_1 = P_2$ = 40 dBm	60	65	- - -	dBm

MSW2002-200 Electrical Specifications

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

PIN	Symbol	Test Conditions	Minimum Value	Typical Value	Maximum Value	Units
Frequency	F		1.5	2 - 6	6.5	GHz
Tx-Ant Insertion Loss	IL(Tx)	Condition 1	- - -	0.6	0.7	dB
Ant-Rx Insertion Loss	IL(Rx)	Condition 2	- - -	0.9	1.0	dB
Tx-Ant Return Loss	RL(Tx)	Condition 1	13	15	- - -	dB
Ant-Rx Return Loss	RL(Rx)	Condition 2	11	13	- - -	dB
Tx-Rx Isolation	Isol(Rx)	Condition 1	32	34	- - -	dB
Rx-Tx Isolation	Isol(Tx)	Condition 2	11	13	- - -	dB
Tx CW Incident Power (Note 2)	P_{inc}(CW)	Condition 1, 1.5:1 source & load VSWR	- - -	- - -	50	dBm
Rx CW Incident Power (Note 2)	P_{inc}(CW)	Condition 2, 1.5:1 source & load VSWR	- - -	- - -	43	dBm
Tx Peak Incident Power (Note 2)	P_{inc}(Pk)	Condition 1, 10 µs pulse width, 1 % duty cycle, 1.5:1 source & load VSWR (IL)	- - -	- - -	57	dBm
Switching Time (Note 1)	t_{SW}	10% -90% RF voltage	- - -	1.0	1.5	µs
Input 3rd Order Intercept Point	IIP3	F_1 = 2.0 GHz, F_2 = 2.01 GHz, $P_1 = P_2$ = 40 dBm	60	65	- - -	dBm

Conditions:

1. Transmit state (Tx – Ant in low insertion loss state):
   a. B1: -100 mA
   b. B2: 100 mA
   c. B3: -25 mA, 28 V
   d. B4: 25 mA
2. Small Signal Receive State (Ant-Rx in low insertion loss state):
   a. B1: 28 V
   b. B2: 100 mA
   c. B3: -100 mA, 0 V
   d. B4: 28 V

Notes:

1. Switching Speed (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. Aeroflex/Metelics MPD2T28125-700 is the recommended PIN diode driver to interface with the MSW2000-200, MSW2001-200, and MSW2002-200 SP2T switches. Its data sheet may be found at (http://www.aeroflex.com/metelics).
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 11 of this datasheet. The input signal level applied for small signal testing is approximately 0 dBm.

Absolute Maximum Ratings

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

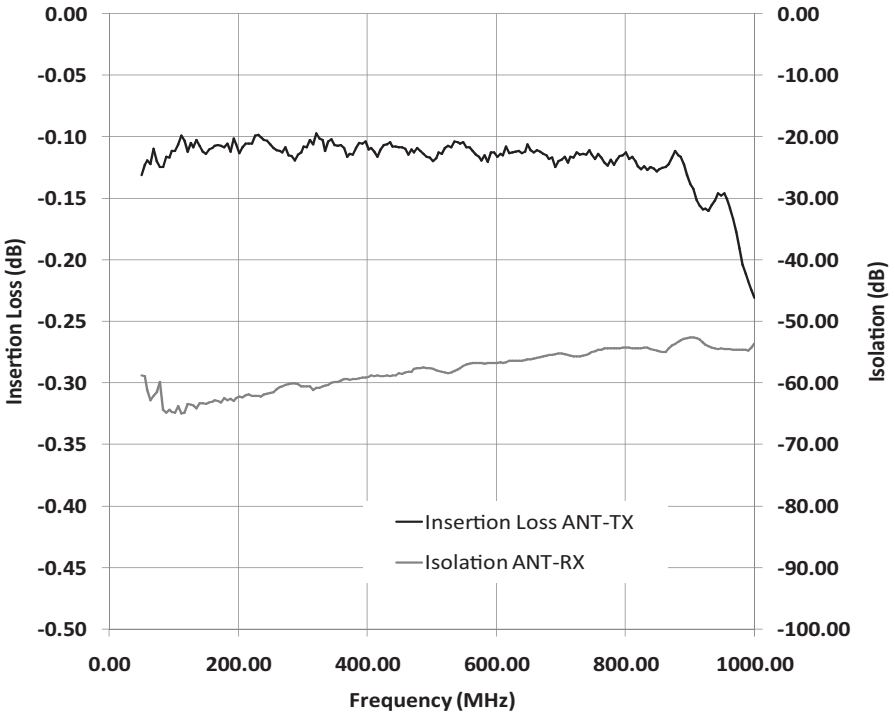
Parameter	Conditions	Absolute Maximum Value
Forward Current - Ant, Tx or Rx Port	- - -	250 mA
Forward Current - DC Port	- - -	150 mA
Reverse Voltage - Tx or Rx Port	- - -	125 V
Reverse Voltage - DC Port	- - -	125 V
Forward Diode Voltage	I_F = 250 mA	1.2 V
Operating Temperature	- - -	-65 °C to 125 °C
Storage Temperature	- - -	-65 °C to 150 °C
Junction Temperature	- - -	175 °C
Assembly Temperature	- - -	260 °C for 10 s
CW Incident Power Handling – Tx or Ant Port (Note 1)	Source & load VSWR = 1.5 :1, T_{CASE} = 85 °C, cold switching	50 dBm
CW Incident Power Handling – Rx or Ant Port (Note 1)	Source & load VSWR = 1.5 :1, T_{CASE} = 85 °C, cold switching	43 dBm
Peak Incident Power Handling – Tx or Ant Port (Note 1)	Source & load VSWR = 1.5 :1, T_{CASE} = 85 °C, cold switching, pulse width = 10 µs, duty cycle = 1 %	57 dBm
Total Dissipated RF & DC Power (Note 1)	T_{CASE} = 85 °C, cold switching	8 W

Notes:

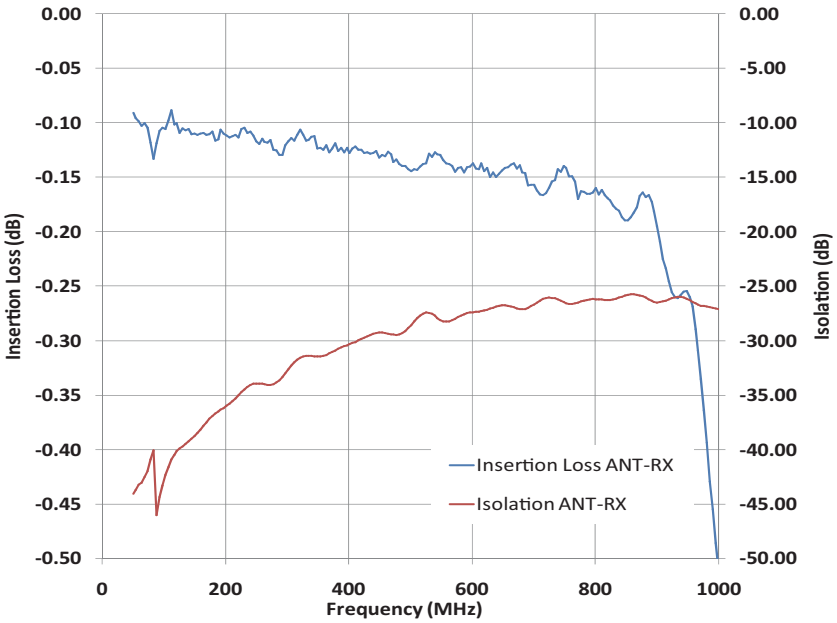
1. Backside RF and DC grounding area of device must be completely solder-attached to RF circuit board vias for proper electrical and thermal circuit grounding.

MSW2000-200 Small Signal Typical Performance

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



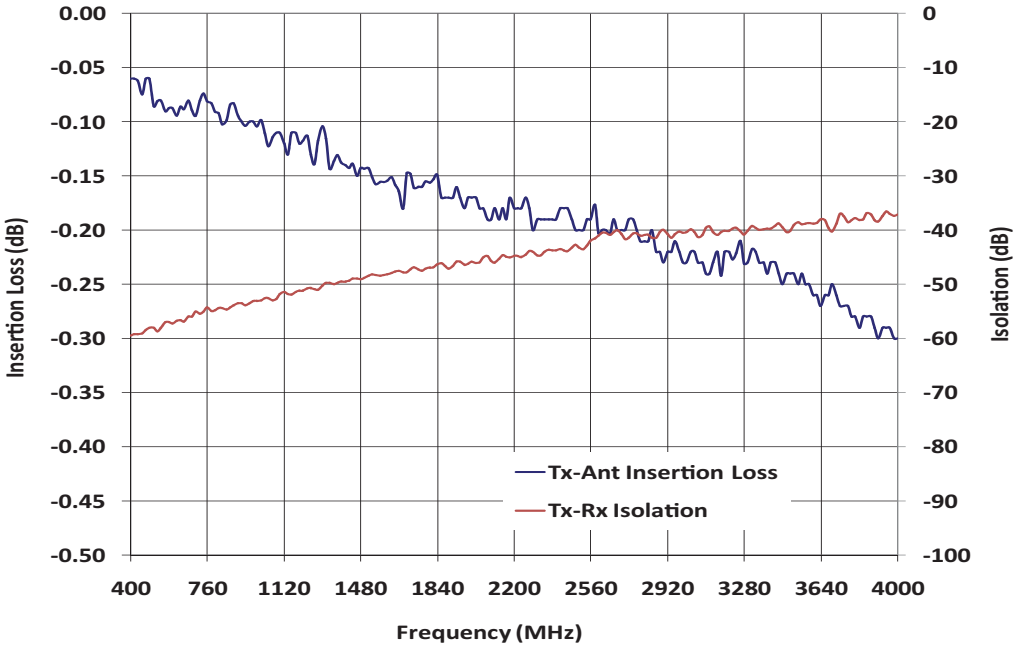
MSW2000-200 TX State TX-ANT Insertion Loss and ANT-RX Isolation



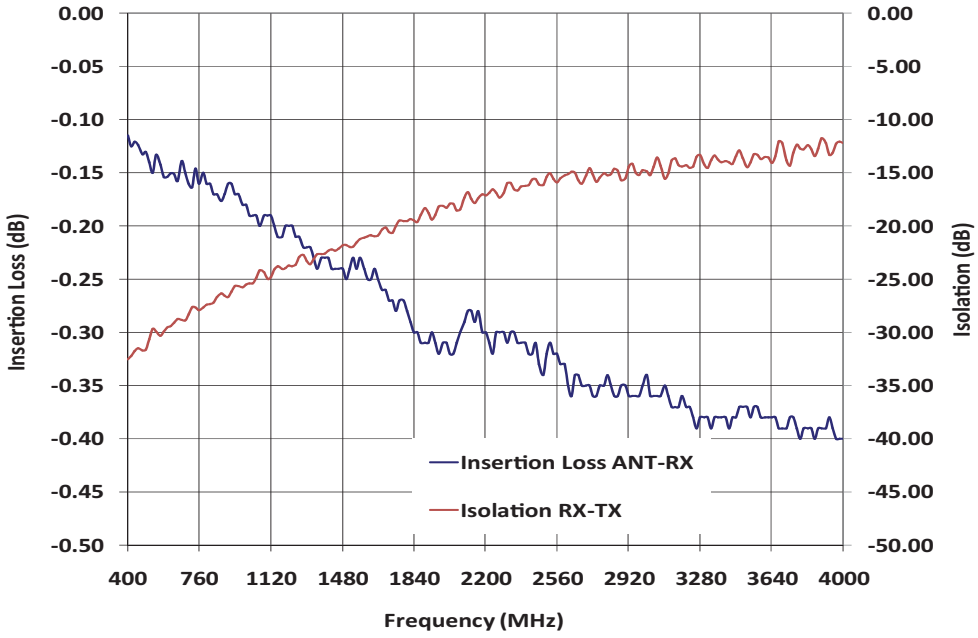
MSW2000-200 RX State ANT-RX Insertion Loss and TX-ANT Isolation

MSW2001-200 Small Signal Typical Performance

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



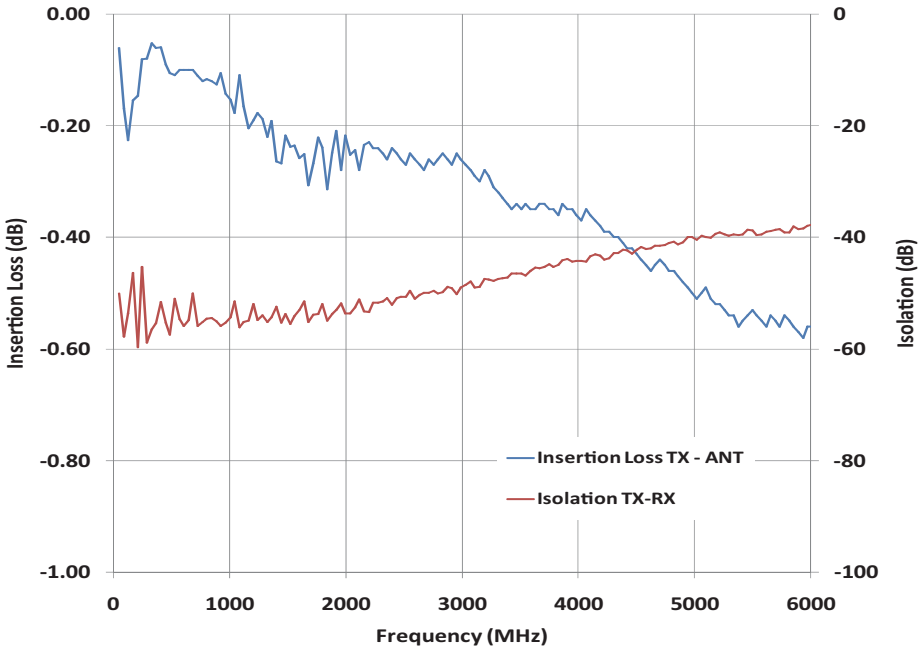
MSW2001-200 TX State TX-ANT Insertion Loss and RX-TX Isolation



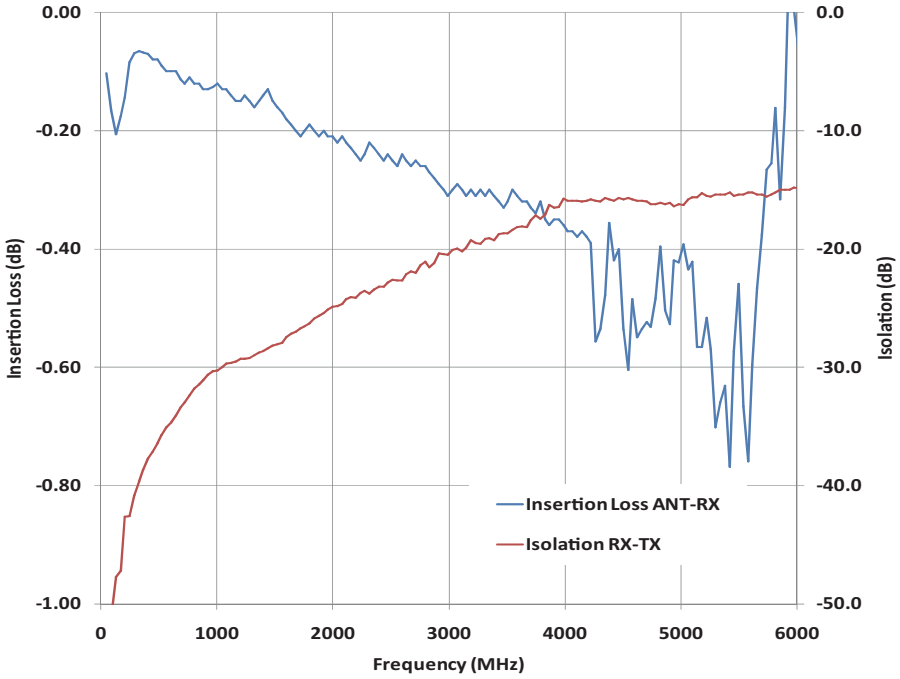
MSW2001-200 RX State ANT-RX Insertion Loss and TX-RX Isolation

MSW2002-200 Small Signal Typical Performance

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

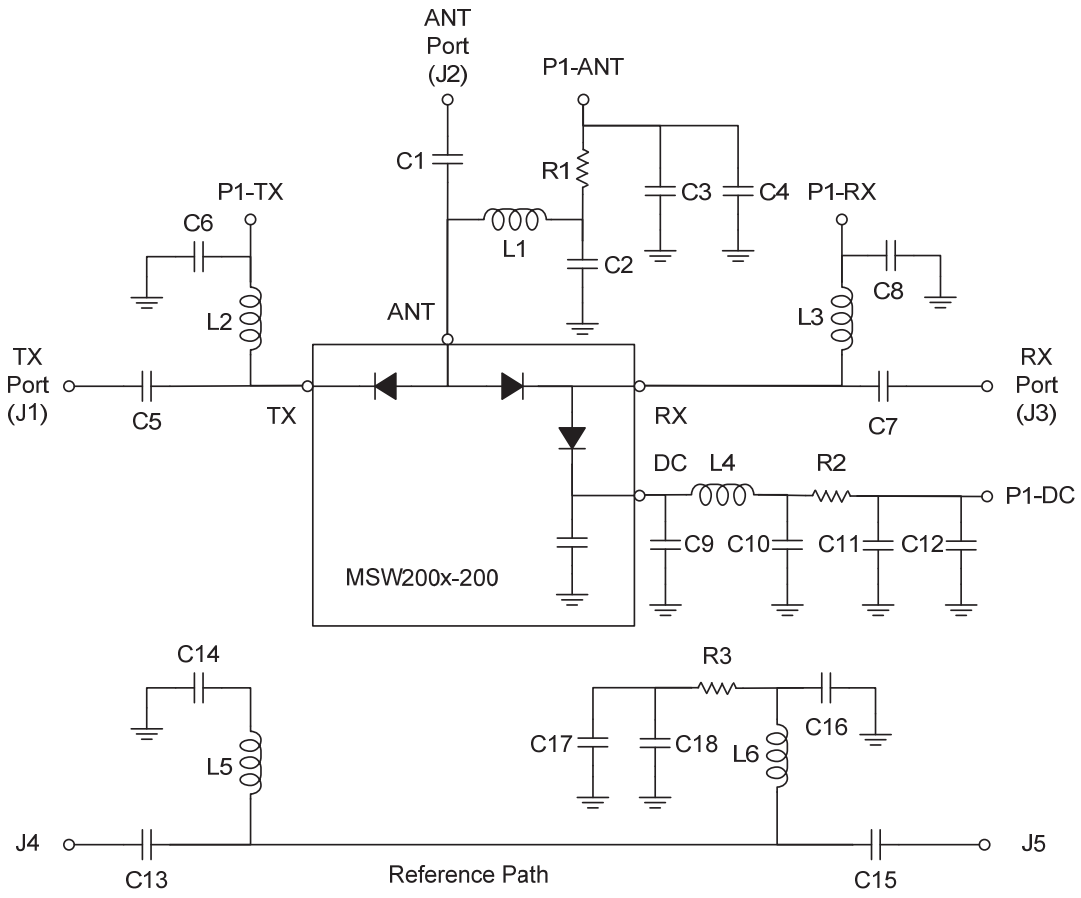


MSW2002-200 TX State TX-ANT Insertion Loss and ANT-RX Isolation



MSW2002-200 RX State ANT-RX Insertion Loss and TX-ANT Isolation

SP2T Switch Evaluation Board Schematic



Evaluation Board Description

The evaluation boards for the MSW2000 family of surface mount silicon PIN diode SP2T T-R switches allow the full exercise of each 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 the appropriate MSW200x-200 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.

Three complementary control signals are required for proper operation. Bias voltages are applied to the TX bias port, RX bias port and the DC bias port to control the state of the switch. A bias voltage of 5 V must be applied to the Ant Bias (pin 3 of multi-pin connector P1) port whenever the switch is in operation.

Transmit State

In the TX state, the series PIN diode between the ANT and TX ports is forward biased by applying 0 V to the TX bias input port (pin 1 of multi-pin connector P1). The magnitude of the resultant bias current through the diode is primarily determined by the voltage applied to the ANT bias port (pin 3 of J1), the magnitude of the forward voltage across the PIN diode and the resistance of R1. This current is nominally 100 mA. At the same time, the PIN diode connected between RX and DC ports is also forward biased by applying a higher bias voltage, nominally 28 V, to the RX bias port (pin 7 of P1) and 0 V to the DC bias port (pin 5 of P1). Under this condition, the PIN diode connected between the ANT and RX port is reverse biased and the PIN diode connected between the RX and DC ports is forward biased. The magnitude of the bias current through

this diode is primarily determined by the voltage applied to the RX bias port, the magnitude of the forward voltage across the PIN diode and the resistance of R2. This current is nominally 25 mA.

The RX series PIN diode, which is connected between the ANT and RX ports, 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 ANT-to-TX path. The reverse voltage across this diode is the arithmetic difference of the bias voltage applied to the RX bias port and the DC forward voltage of the forward-biased transmit series PIN diode.

The minimum voltage required to maintain the series diode on the RX side of the switch out of conduction is a function of the magnitude of the RF voltage present, the standing wave present at the RX series diode's anode, the frequency of the RF signal and the characteristics of the RX series diode, 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 RX or ANT port to be 100 W CW and the VSWR on the ANT-TX 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.

Receive State

In the RX state, the series PIN diode between the ANT and RX ports is forward biased by applying 0 V to the RX bias input port (pin 7 of multi-pin connector P1). The magnitude of the resultant bias current through the diode is primarily determined by the voltage applied to the ANT bias port (pin 3 of P1), the magnitude of the forward voltage across the PIN diode and the resistance of R1. This current is nominally 100 mA. At the same time, the PIN diode connected between RX and DC ports is reverse biased by applying a high bias voltage, nominally 28 V, to the DC bias port (pin 5 of P1). A high voltage, nominally 28 V, is also applied to the TX bias port (pin 1 of P1). Under this condition, the PIN diode connected between the ANT and TX port is reverse biased thus isolating the TX RF port from the RX signal path. The reverse voltage across this diode is the arithmetic difference of the bias voltage applied to the TX bias port and the DC forward voltage of the forward-biased receive series PIN diode. The minimum voltage required to maintain the series diode on the TX side of the switch out of conduction is a function of the magnitude of the RF voltage present, the standing wave present at the RX series diode's anode, the frequency of the RF signal and the characteristics of the TX series diode, among other factors. For typical receive-level signals, this diode is held out of conduction with a relatively small reverse bias voltage.

The values of the reactive components which comprise the bias decoupling networks as well as the signal path DC blocking are shown in the table RF Bias Network Component Values.

Reference Path

A reference path is provided on the evaluation board, complete with bias decoupling networks, so that the magnitude of the insertion loss of the microstrip transmission lines connected to the switch and the associated bias decoupling components can be measured and removed from the measured performance of the switch.

RF Bias Network Recommended Component Values

Part Number	F (MHz)	DC Blocking Capacitors	Inductors	RF Bypass Capacitors
MSW2000-200	50 – 1,000	0.1 µF	4.7 µH	0.1 µF
MSW2001-200	400 – 4,000	27 pF	82 nH	270 pF
MSW2002-200	2,000 – 6,000	22 pf	33 nH	33 pF

Evaluation Board Truth Table

RF State	Ant Bias (P1-pin 3)	TX Bias (P1-pin 1)	RX Bias (P1-pin 7)	DC Bias (P1-pin 5)
Tx-Ant Low Loss & Tx-Rx Isolation	5 V @ 100 mA	0 V @ 100 mA	28 V @ 25 mA	0 V @ 25 mA
Ant-Rx Low Loss & Rx – Tx Isolation	5 V @ 100 mA	28 V @ 0 mA	0 V @ 100 mA	28 V @ 0 mA

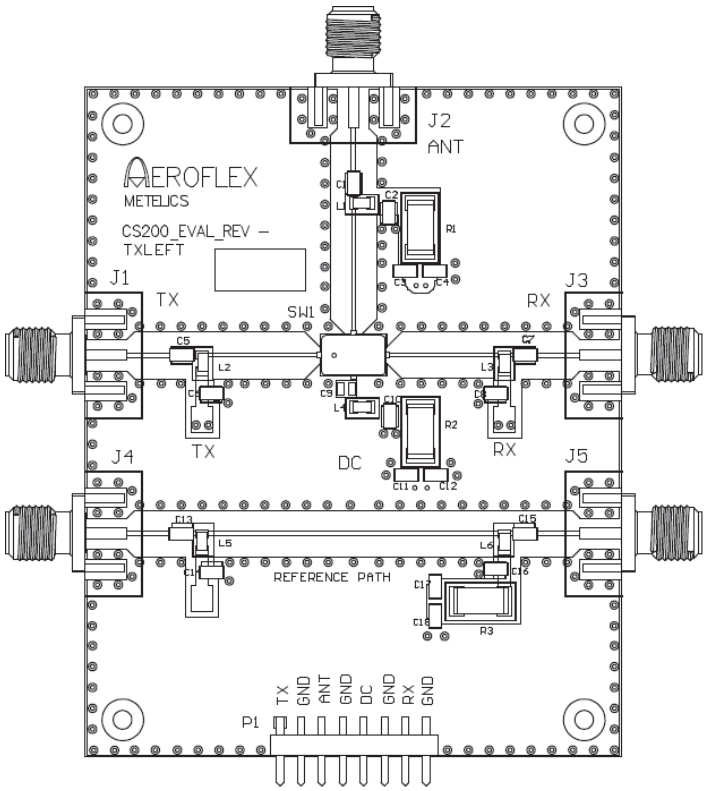
Minimum Reverse Bias Voltage at TX, RX, DC Ports vs. Signal Frequency

P_{IN} = 100 W CW, Z_0 = 50 Ω with 1.5:1 VSWR

Part Number	F = 20 MHz	F = 100 MHz	F = 200 MHz	F = 400 MHz	F = 1 GHz	F = 4 GHz
MSW2000-200	120 V	110 V	85 V	55 V	28 V	NA
MSW2001-200	NA	NA	110 V	85 V	55 V	28 V
MSW2002-200	(F = 1 GHz) 55 V	(F = 2 GHz) 28 V	(F = 3 GHz) 28 V	(F = 4 GHz) 28 V	(F = 5 GHz) 28 V	(F = 6 GHz) 28 V

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

Evaluation Board



Document DS 12633 REV. E, ECN 12450
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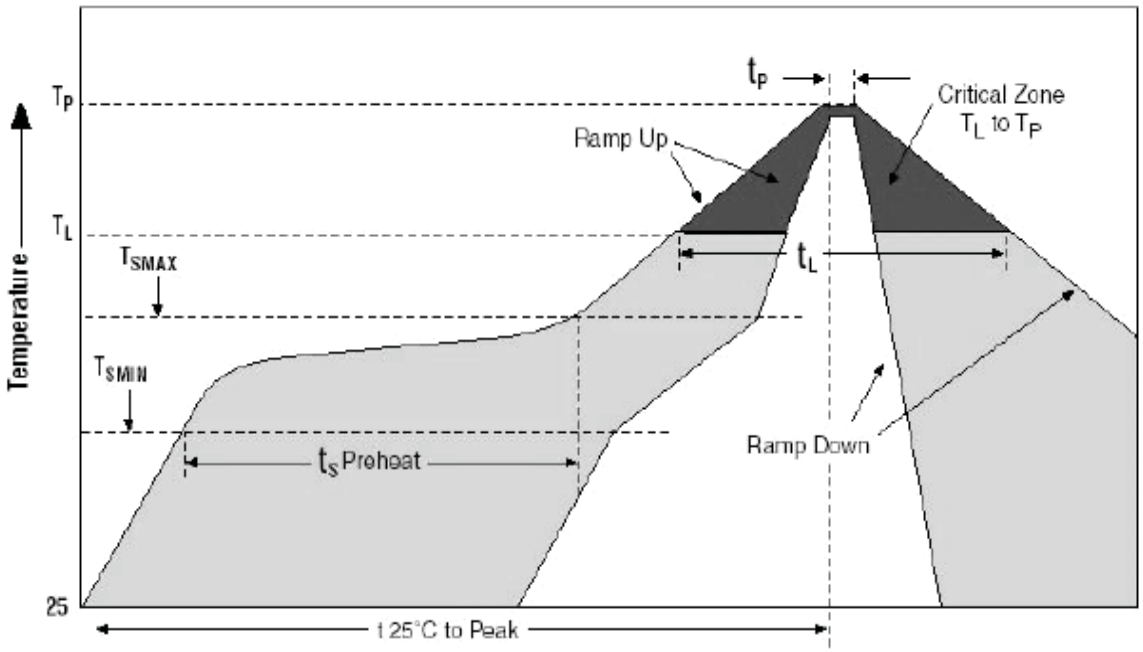
Assembly Instructions

The MSW2000-200, MSW2001-200, and MSW2002-200 switches are capable of being placed onto circuit boards with pick and place manufacturing equipment from tube or tape-reel dispensing. The devices are attached to the circuit board using conventional solder re-flow or wave soldering procedures with RoHS type or Sn60/Pb40 type solders per Table 1 and Figure 1.

Table 1: Time-Temperature Profile for Sn 60/Pb40 or RoHS Type Solders

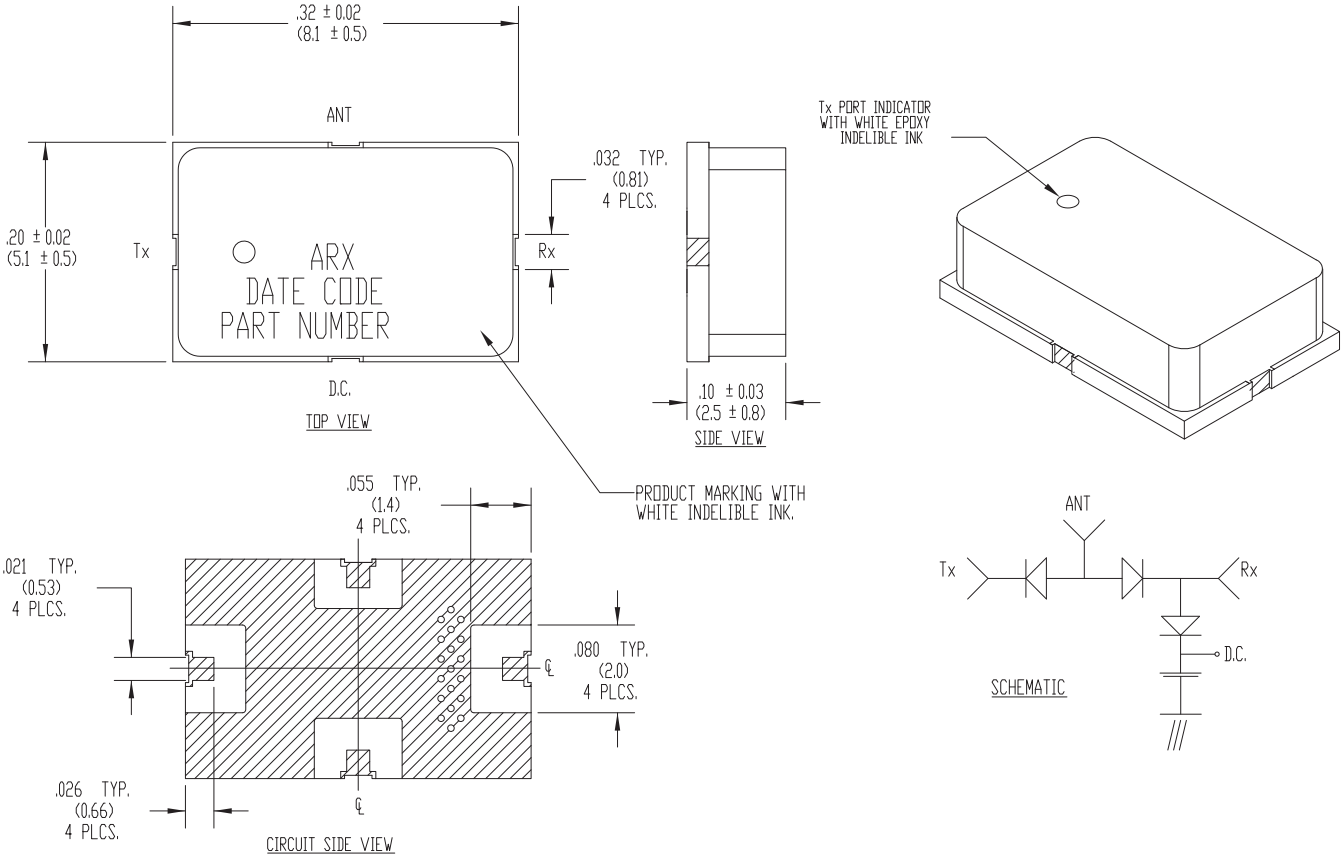
Profile Feature	Sn-Pb Assembly	Pb-Free Assembly
Average ramp-up rate (T_L to T_P)	3°C/second maximum	3°C/second maximum
Preheat - Temperature Minimum (T_{SMIN}) - Temperature Maximum (T_{SMAX}) - Time (Minimum to maximum) (t_S)	 100 °C 150 °C 60-120 seconds	 150 °C 200 °C 60-180 seconds
T_{SMAX} to T_L - Ramp-up Rate		 3° C/second maximum
Time Maintained above: - Temperature (T_L) - Time (t_L)	 183 °C 60-150 seconds	 217 °C 60-150 seconds
Peak Temperature (T_P)	225 +0 / -5 °C	260 +0/-5 °C
Time within 5°C of actual Peak Temperature (T_P)	10-30 seconds	20-40 seconds
Ramp-down Rate	6 °C/second maximum	6 °C/second maximum
Time 25°C to Peak Temperature	6 minutes maximum	8 minutes maximum

Figure 1: Solder Re-Flow Time-Temperature Profile



Outline Drawing

MSW2000-200, MSW2001-200, and MSW2002-200 SP2T Switch Outline (Case Style 200)

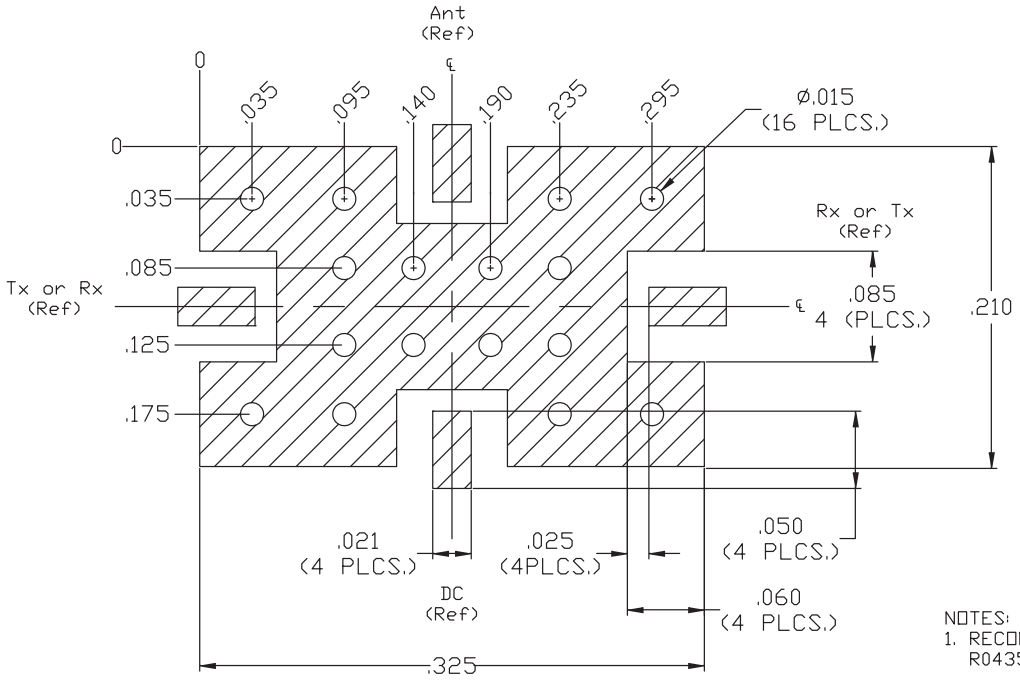


NOTES:
1. SUBSTRATE MATERIAL: 20 MIL THICK ALUMINA NITRIDE (AlN) RF COVER: BLACK CERAMIC.
2. TOP SIDE AND BACKSIDE METALLIZATION: 40µ IN PLATED Au, 60µ IN PLATED Ni OVER Ti-Pd-Au.
3. DIMENSION IN PARENTHESIS ARE IN MM.

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

Document DS 12633 REV. E, ECN 12450
Revision Date: 12/1/2012

RF Circuit Solder Footprint for Case Style 200 (CS 200)



Hatched Area is RF, DC, and thermal ground. Vias should be solid copper filled and gold plated for optimum heat transfer from backside of switch module through circuit vias to metal thermal ground.

Part Number Ordering Information:

Part Number	Packaging
MSW2000-200-T	Tube
MSW2000-200-R	Tape-Reel (Quantities of 250 or 500)
MSW2000-200-W	Waffle Pack
MSW2001-200-T	Tube
MSW2001-200-R	Tape-Reel (Quantities of 250 or 500)
MSW2001-200-W	Waffle Pack
MSW2002-200-T	Tube
MSW2002-200-R	Tape-Reel (Quantities of 250 or 500)
MSW2002-200-W	Waffle Pack
MSW2000-200-E	RF Evaluation Board
MSW2001-200-E	RF Evaluation Board
MSW2002-200-E	RF Evaluation Board

AEROFLEX METELICS

SP2T PIN Diode Switches

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