

PIN Diode SPDT 200 W Switch for High Power Applications

0.03 - 6.0 GHz



MASW-011120

Rev. V3

Features

- Broadband Performance
- Low Loss @ 2.7 GHz:
TX = 0.25 dB
RX = 0.35 dB
- High Isolation @ 2.7 GHz:
RX = 44 dB
- Power Handling @ 2.7 GHz:
200 W CW @ +85 °C
122 W CW @ +120 °C
- Lead-Free 5 mm 20-Lead HQFN Package
- RoHS* Compliant
- Designed for High Power TDD-LTE Applications

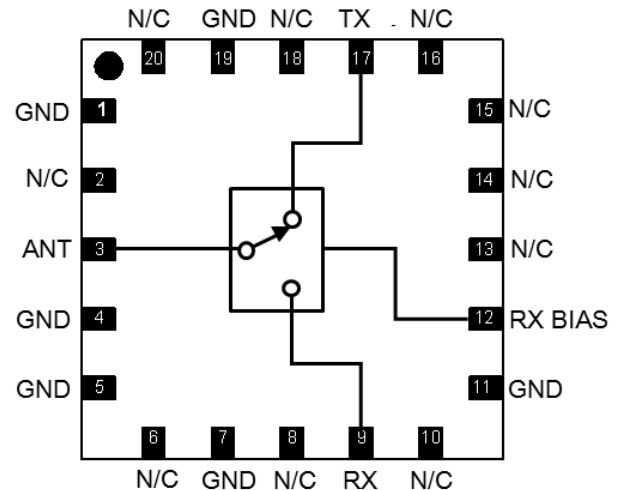
Description

The MASW-011120 is a SPDT high power, broadband, high linearity, PIN diode T/R switch for 0.03 - 6.0 GHz high power applications. The device is provided in an industry standard lead free 5 mm HQFN plastic package.

This device incorporates PIN diode die fabricated with a low loss, high isolation switching diode process.

MASW-011120 can be used in any application requiring a low-loss, high-isolation, and high-power-handling SPDT.

Functional Schematic



Pin Configuration³

Pin #	Pin Name	Function
1,4,5,7,11,19	GND	Ground
2,6,8,10,13,14,15,16,18,20	N/C	No Connection
3	ANT	RF Port
9	RX	RF Port
12	RX BIAS	RX Bias Input
17	TX	RF Port
21	Paddle	Ground ⁴

3. MACOM recommends connecting all No Connection (N/C) pins to ground.

4. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

Ordering Information^{1,2}

Part Number	Package
MASW-011120-TR1000	1000 Piece Tape and Reel
MASW-011120-TR3000	3000 Piece Tape and Reel
MASW-011120-SMB	Sample Board

1. Reference Application Note M513 for reel size information.

2. All sample boards include 3 loose parts.

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.

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Rev. V3

Electrical Specifications:

Freq. = 2.7 GHz, 3.5 GHz, $T_A = +25\text{ }^\circ\text{C}$, $Z_0 = 50\ \Omega$, Bias = 60 V / 0 V. See Bias Table.

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Insertion Loss	ANT to TX ON @ 2.7 GHz	dB	—	0.25	0.45
	ANT to TX ON @ 3.5 GHz			0.30	0.50
	ANT to RX ON @ 2.7 GHz			0.35	0.60
	ANT to RX ON @ 3.5 GHz			0.50	0.70
Isolation	ANT to RX (TX ON) @ 2.7 GHz	dB	35	44	—
	ANT to RX (TX ON) @ 3.5 GHz		35	44	
	ANT to TX (RX ON) @ 2.7 GHz		12	15	
	ANT to TX (RX ON) @ 3.5 GHz		10	13	
ANT Return Loss	ANT to RX ON	dB	—	23	—
	ANT to TX ON			25	
TX Return Loss	ANT to TX ON	dB	—	22	—
RX Return Loss	ANT to RX ON	dB	—	26	—
Input P0.1 dB ⁵	ANT to TX ON	dBm	—	51	—
IIP3 TX	ANT to TX, $P_{IN} = 30\text{ dBm}$	dBm	—	68	—
IIP3 RX	ANT to RX, $P_{IN} = 30\text{ dBm}$	dBm	—	68.5	—
RF Input Power CW ⁵ ANT to TX ON	85°C @ 2.7 GHz; 100 mA 85°C @ 2.7 GHz; 200 mA 120°C @ 2.7 GHz; 100 mA 120°C @ 2.7 GHz; 200 mA	W	—	145	—
				200	
				97	
				122	
Switching Speed TX T_{ON} TX T_{OFF} RX T_{ON} RX T_{OFF}	T_{ON} - 50% control to 90% RF T_{OFF} - 50% control to 10% RF	μs	—	0.5	—
				1.6	
				0.3	
				0.3	
Group Delay	—	ns	—	50	—
In-band Ripple	20 MHz	dB	—	0.05	—
	200 MHz			0.1	

5. Maximum source and load VSWR < 1.2:1.

Bias Table

Bias Table	TX	RX	RX BIAS	ANT
Pin	17	9	12	3
ANT to TX ON (Insertion Loss)	(GND), -100 mA ⁶	(+60 V), 10 mA ⁶	(GND), -10 mA ⁶	+5 V, 100 mA ⁶
ANT to RX (Isolation)	(GND), -100 mA ⁶	(+60 V), 10 mA ⁶	(GND), -10 mA ⁶	+5 V, 100 mA ⁶
ANT to RX ON (Insertion Loss)	(+60 V), 0 mA	(GND), -100 mA ⁶	(+60 V), 0 mA	+5 V, 100 mA ⁶
ANT to TX (Isolation)	(+60 V), 0 mA	(GND), -100 mA ⁶	(+60 V), 0 mA	+5 V, 100 mA ⁶

6. Currents level comply with the schematic on page 8.

2

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DC-0020391

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MASW-011120

Rev. V3

Maximum Operating Conditions⁷

Parameter	Operating Maximum
TX Forward Current	250 mA
RX Forward Current	250 mA
Reverse Voltage (RF & DC)	200 V
ANT to TX Power CW	See Power Derating Curve
ANT to TX Peak Power (LTE Signal)	1000 W
Junction Temperature ^{8, 9}	+175 °C
Case (Paddle) Temperature	-40 °C to +120 °C
Storage Temperature	-55 °C to +150 °C

7. Exceeding these limits may cause permanent damage.
8. MACOM does not recommend sustained operation near these survivability limits.
9. Operating at nominal conditions with $T_J \leq +175$ °C will ensure $MTTF > 1 \times 10^6$ hours.

Handling Procedures

Please observe the following precautions to avoid damage:

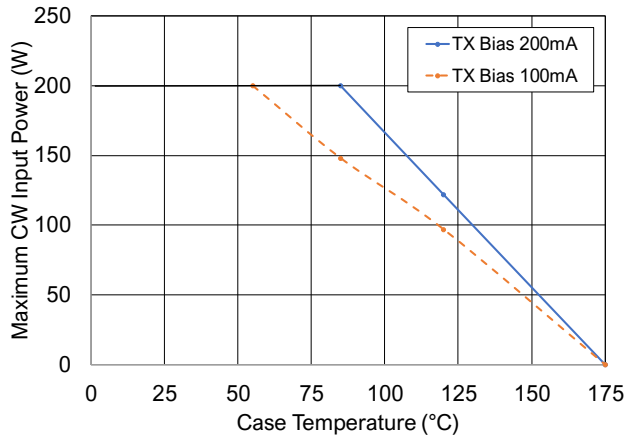
Static Sensitivity

These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

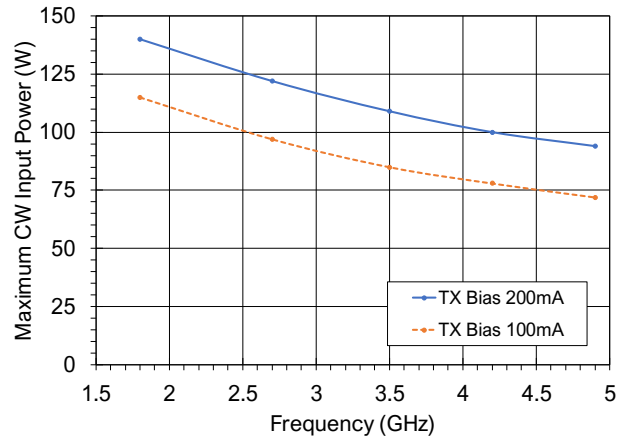
Parameter	Rating	Standard
Human Body Model (HBM)	500 V (Class 1B)	ESDA / JEDEC JS-001
Charged Device Model (CDM)	2000 V (Class C7)	JEDEC JESD22-C101

Typical Performance Curves

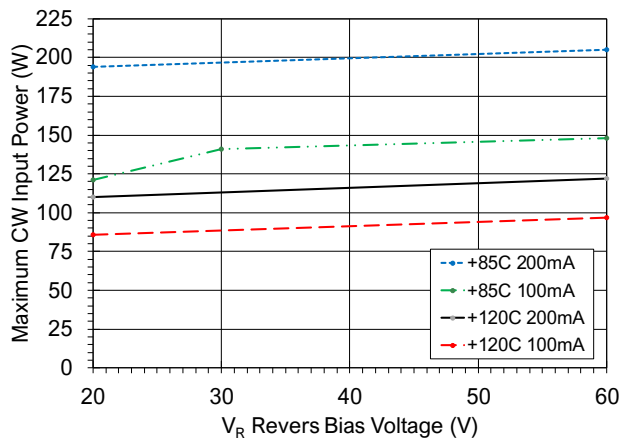
ANT to TX Input Power Derating Curve @ 2.7 GHz



ANT to TX Input Power Derating Curve over Frequency @ 120 °C Case Temp



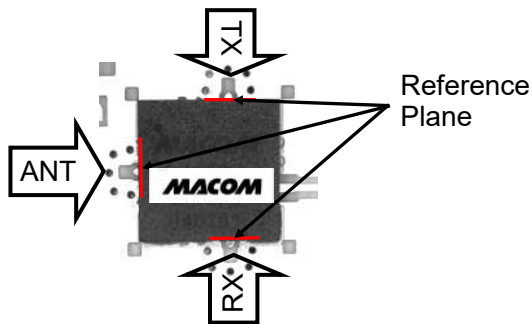
ANT to TX Input Power Derating Curve over Reverse Bias Voltage @ 2.7 GHz



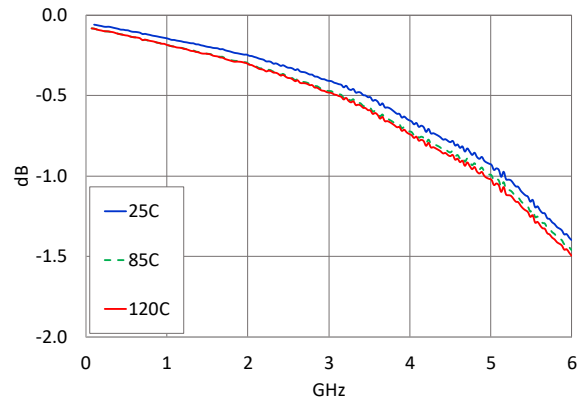
Typical Performance Curves over Temperature

All plots herein are taken with bias per the Bias Table on Page 2 unless otherwise specified.

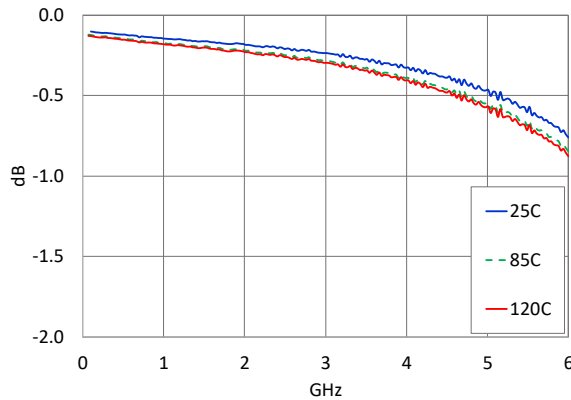
S-parameters were measured using G-S-G probes on a sample board; reference planes are at the part's RF ports. The sample board and its layer stack-up are on page 7



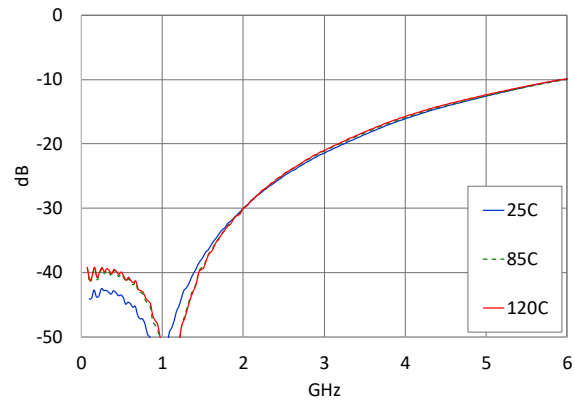
ANT to RX Insertion Loss



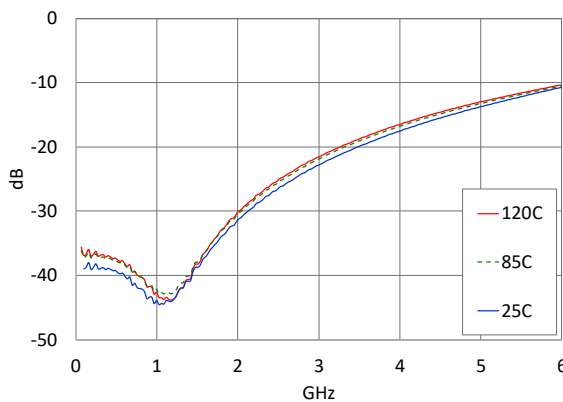
ANT to TX Insertion Loss



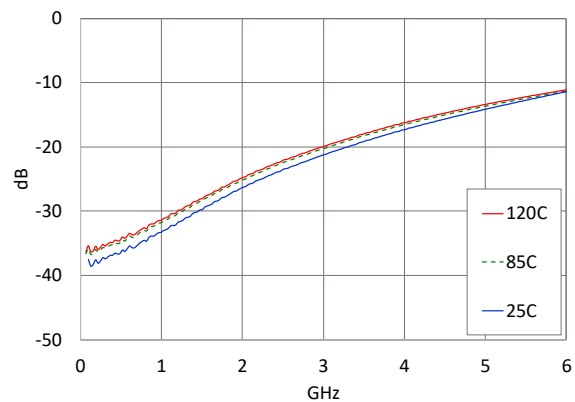
ANT Return Loss in RX ON state



ANT Return Loss in TX ON state

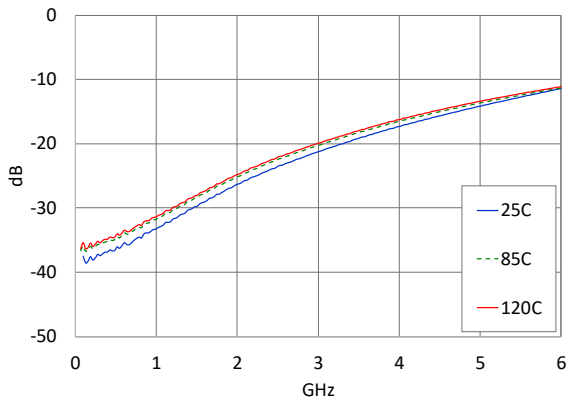


RX Return Loss in RX ON state

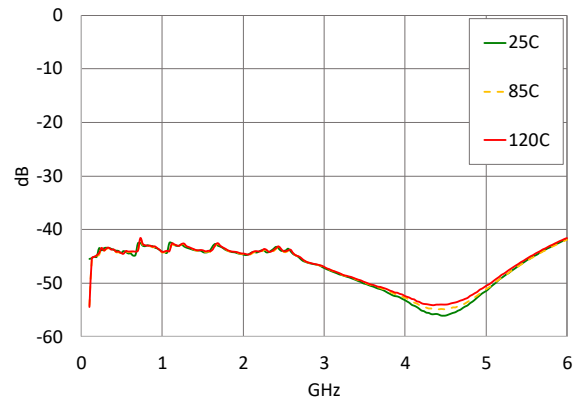


Typical Performance Curves over Temperature

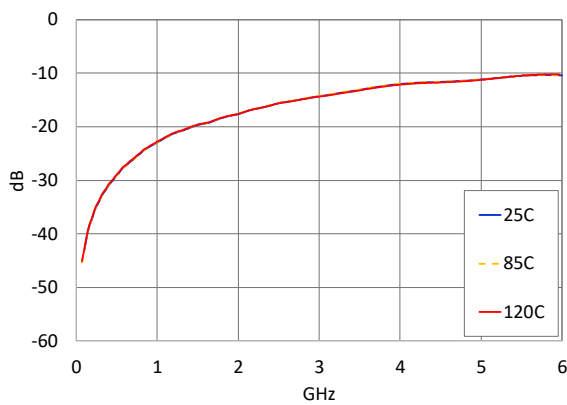
TX Return Loss in TX ON state



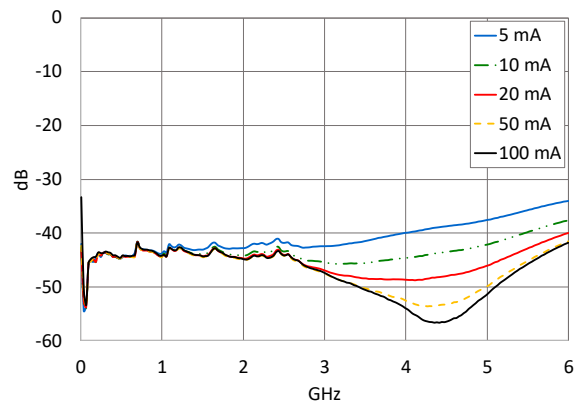
ANT to RX Isolation in TX ON state @ 100 mA



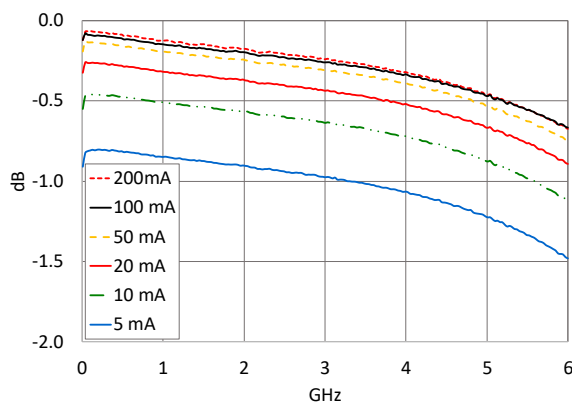
ANT to TX Isolation in RX ON state



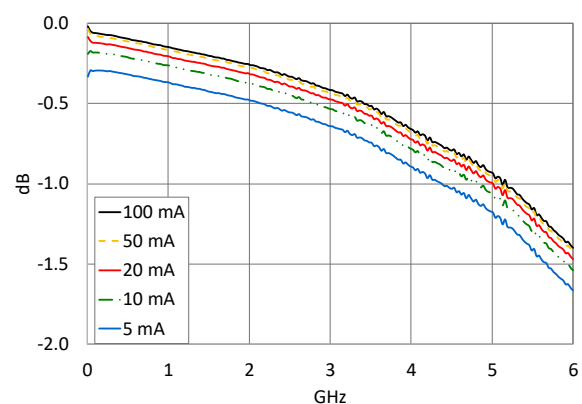
ANT to RX Isolation in TX ON state, over RX Bias Current @ 25°C



ANT to TX Insertion Loss over Current @ 25 °C



ANT to RX Insertion Loss over Current @ 25 °C



PIN Diode SPDT 200 W Switch for High Power Applications

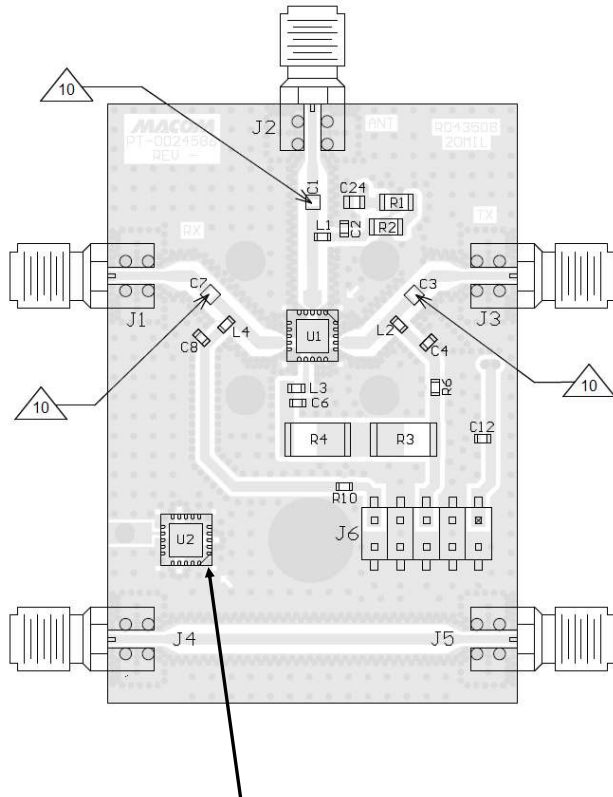
0.03 - 6.0 GHz



MASW-011120

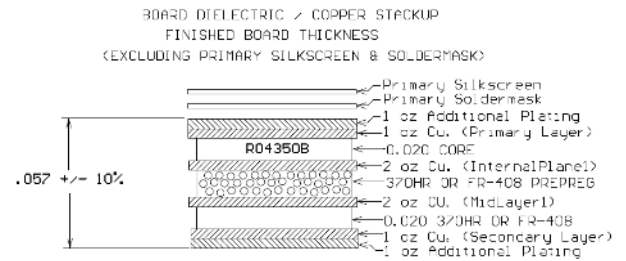
Rev. V3

Sample Board



Optional part for probing, provided per request

PCB Layout Stack-Up



Dimensions are in inches.

To use the sample board: bias VCC at 5 V (current will be limited to 100 mA by on-board resistors R1, R2) and bias RX and TX according to the control table on page 8.

PIN Diode SPDT 200 W Switch for High Power Applications

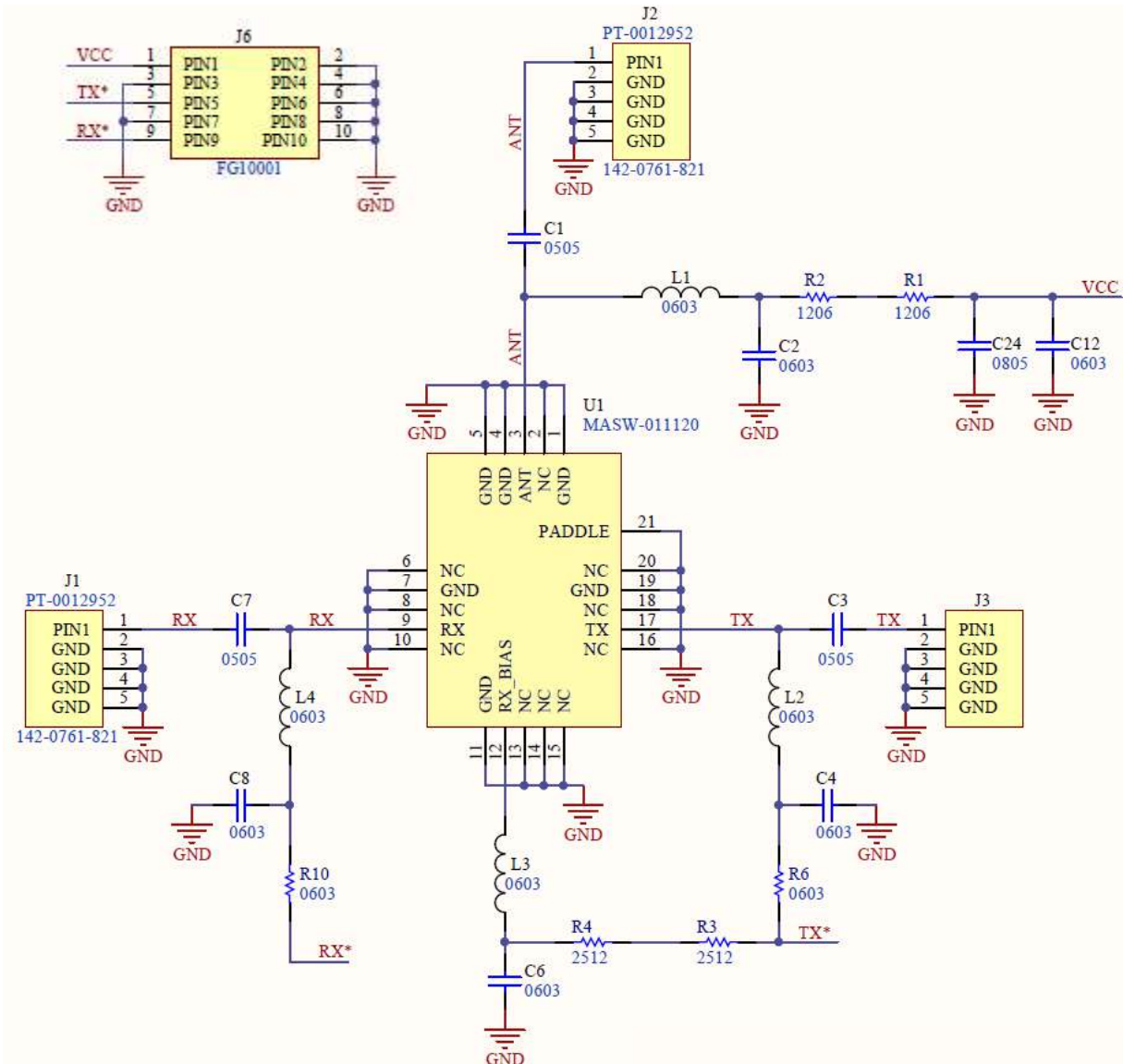
0.03 - 6.0 GHz



MASW-011120

Rev. V3

Sample Board Schematic (parts list on page 9)



Control Table

Configuration	VCC	RX	TX/RX_Bias
TX ON RX OFF	5 V (100 mA)	60 V (10 mA)	GND
TX OFF RX ON	5 V (100 mA)	GND	60 V

PIN Diode SPDT 200 W Switch for High Power Applications 0.03 - 6.0 GHz



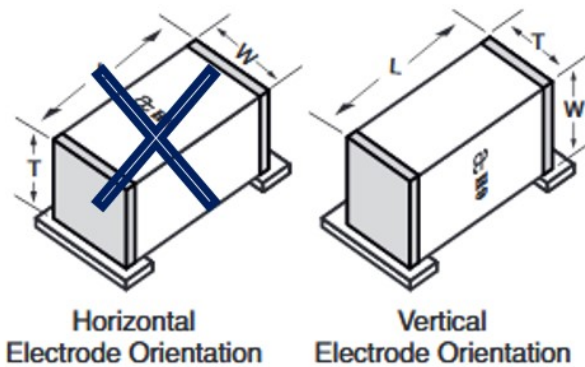
MASW-011120

Rev. V3

Parts List

Component ID	Value	Package	Mfg. Part#	Spec
U1	—	HQFN-20LD 5 mm	MASW-011120	—
L1, L2, L3, L4	33 nH	0603	LQW18AN33NJ8ZD	>200 mA
C1, C3, C7 ¹⁰	10 pF	0505	800A100JT250X	High Freq
C2, C4, C6, C8, C12	22 pF	0603	600S220FT250XT	High Freq
C24	1 μ F	0805	C2012X7S2A105K125AB	High Freq
R1, R2	20 Ω	1206	CRCW120620R0FKEA	0.25 W
R3, R4	2.37 k Ω	2512	CRCW25122K37FKEA	1.0 W
R6, R10	0 Ω	0603	—	—
J1-J5	RF CONN	SMA	142-0761-821	—
J6	DC CONN	10-pin	—	Surmount

10. Required vertical mounting orientation of C1, C3, & C7. Noted on PCB Layout on page 7.



Determination of 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 the voltage standing wave ratio, VSWR)

f_{MHz} = lowest RF signal frequency expressed in MHz

D = duty factor (DF) of the RF signal

W_{mils} = thickness of the diode I layer, expressed in mils (thousands of an inch)

(R. Caverly and G. Hiller, “Establishing the Minimum Reverse Bias for a PIN Diode in a High Power Switch”, IEEE Transactions on Microwave Theory and Techniques, Vol. 38, No. 12, December 1990)

In the transmit state, the large transmit signal voltage appears across a series PIN diode in the receive side of the switch. This diode must be held in its nonconducting state in order to isolate the receiver output port from the large transmit signal applied to the transmit input port.

The minimum magnitude of the reverse DC bias which is necessary to maintain the receive diode in its nonconducting state can be seen from the equation above to be a function of the RF signal voltage, the VSWR in the signal path, the characteristic impedance (Z₀) of the signal path, the frequency of the RF signal, the DF of the RF signal and the I layer thickness of the diode in the receive side of the switch.

For a continuous wave signal (i.e., DF = 1) in a Z₀ = 50 Ω signal path with VSWR = 1.5:1, the minimum reverse bias voltage required for the MASW-011120 switch to operate properly as a function of input signal frequency and signal power applied to the transmit input is shown in the table below.

Minimum Reverse Bias Voltage vs. Signal Frequency & Transmit Input Signal Power
VSWR = 1.5:1, Z₀ = 50 W, Duty Cycle = 1

Frequency (MHz)	Transmit Input Signal Power (W)							
	1	2	5	10	25	50	100	200
30	13	18	29	40	63	90	125	175
100	12	17	27	38	61	85	122	170
500	5	8	16	26	45	68	98	145
1000	3	5	9.5	16	30	45	70	105
2000	2	3	6	9	17	27	40	60
4000	1	2	4	5	9	15	23	35
6000	1	1.5	2	3	7.5	12	15	25

For other conditions, contact the factory for recommended minimum reverse bias voltage.

PIN Diode SPDT 200 W Switch for High Power Applications

0.03 - 6.0 GHz

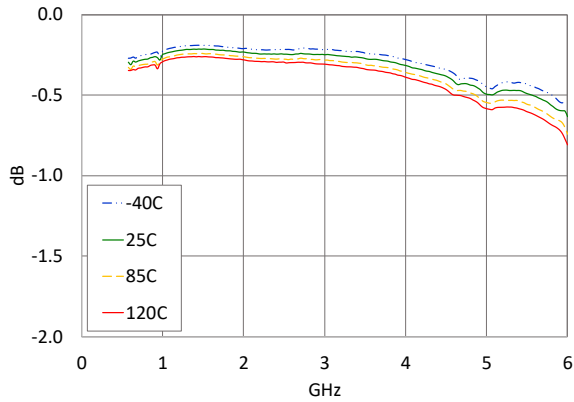


MASW-011120

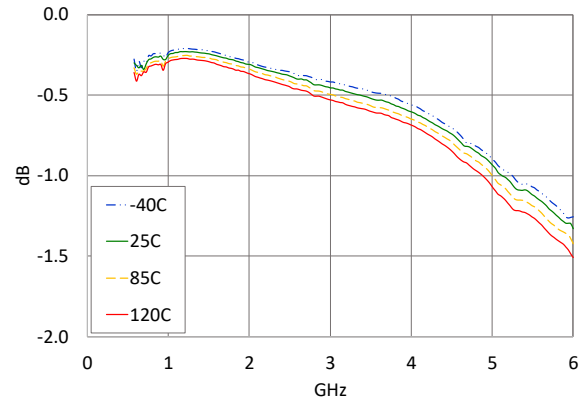
Rev. V3

Typical Performance Curves on the Sample Board over Temperature

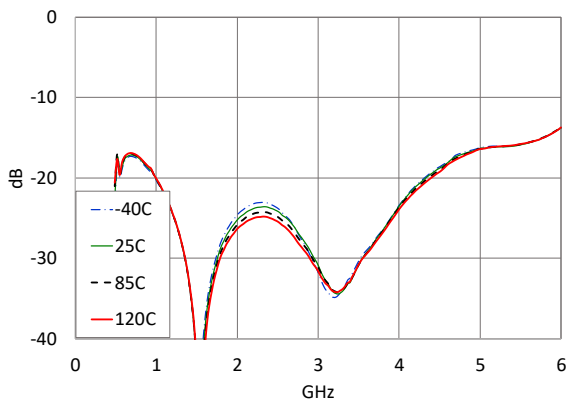
ANT to TX Insertion Loss (PCB loss de-embedded)



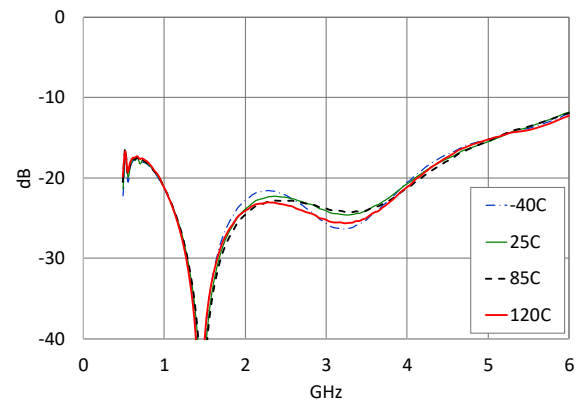
ANT to RX Insertion (PCB loss de-embedded)



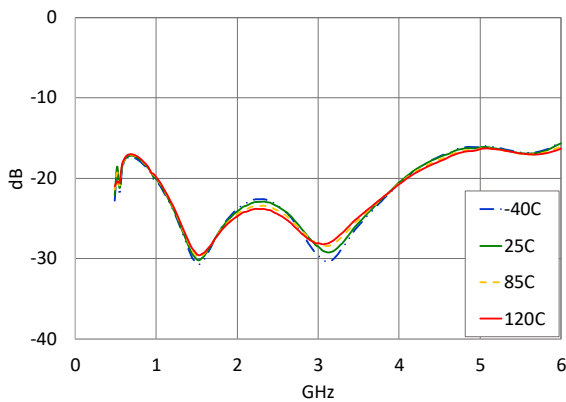
ANT Return Loss in TX ON state



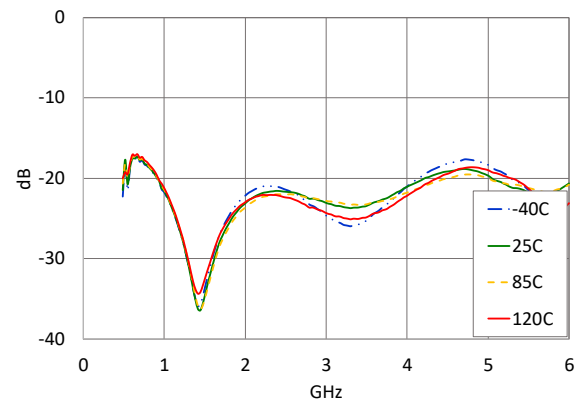
ANT Return Loss in RX ON state



TX Return Loss in TX ON state

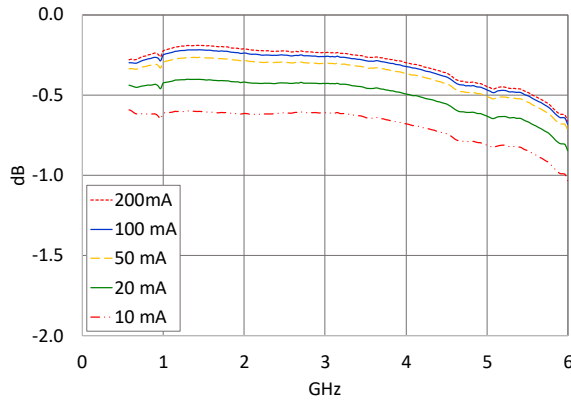


RX Return Loss in RX ON state

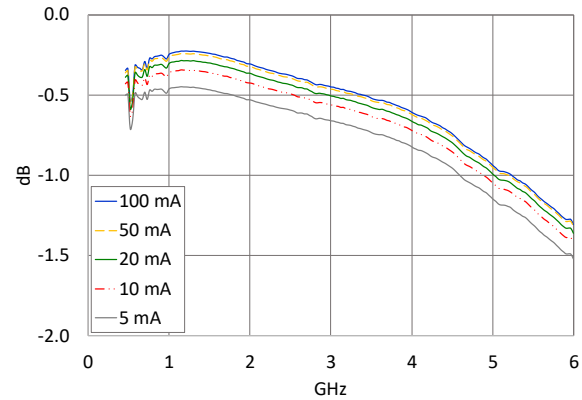


Typical Performance Curves on the Sample Board over Temperature

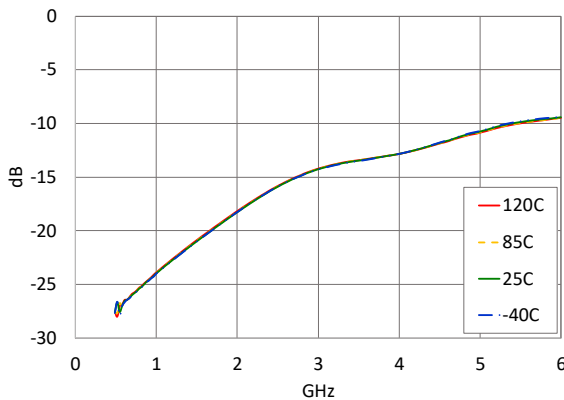
ANT to TX Insertion Loss over Current @ 25 °C, PCB Loss De-embedded



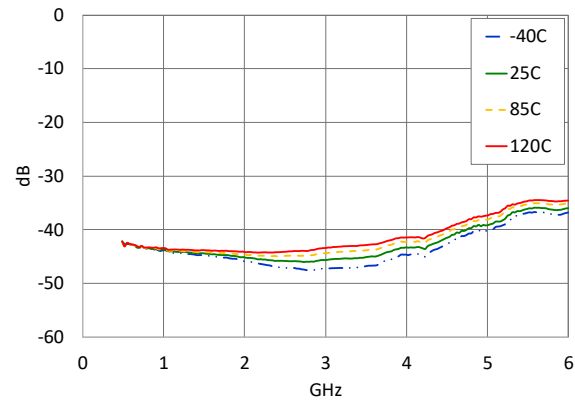
ANT to RX Insertion Loss over Current @ 25 °C, PCB Loss De-embedded



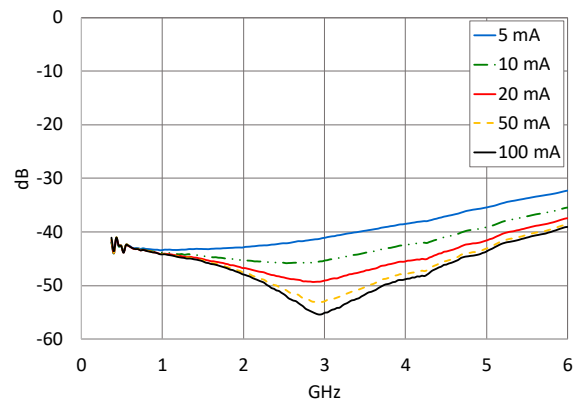
ANT to TX Isolation



ANT to RX Isolation



ANT to RX Isolation over Current @ 25 °C



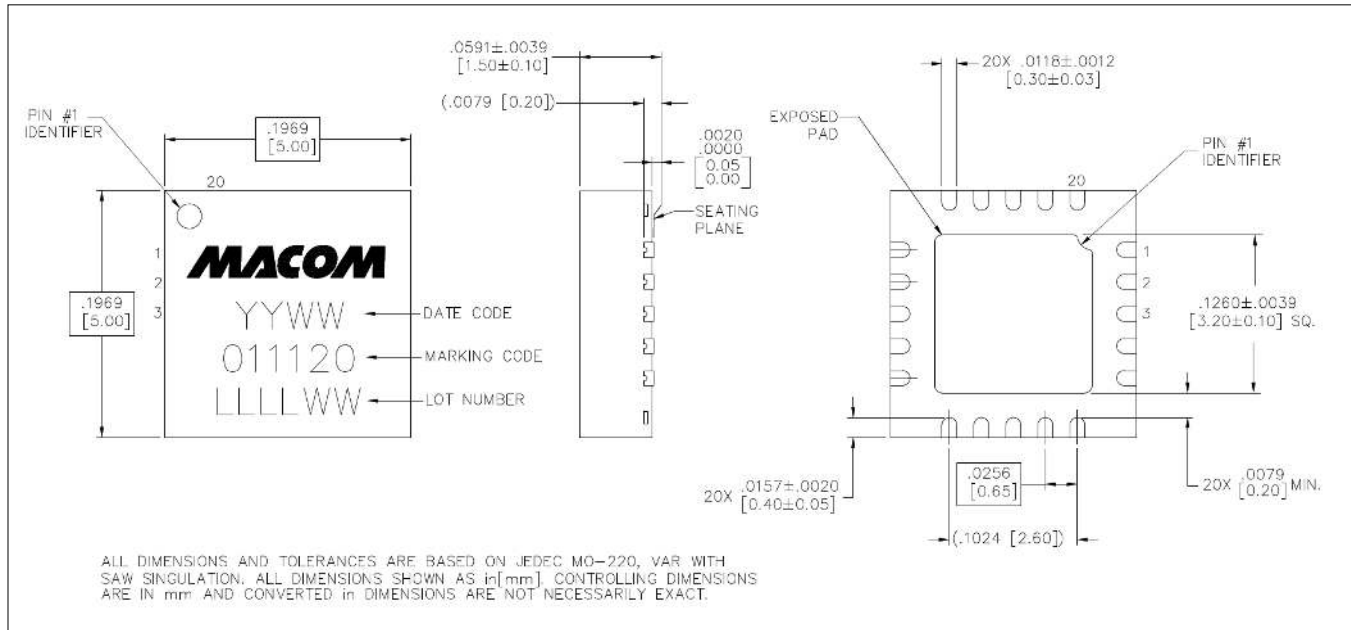
PIN Diode SPDT 200 W Switch for High Power Applications 0.03 - 6.0 GHz



MASW-011120

Rev. V3

Lead-Free 5 mm 20-Lead HQFN[†]



[†] Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity MSL level 1 requirements.
Plating is NiPdAuAg.

PIN Diode SPDT 200 W Switch for High Power Applications

0.03 - 6.0 GHz



MASW-011120

Rev. V3

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