

# HMIC™ PIN Diode SPDT 50 W Switch for 0.05 - 6.0 GHz High Power Applications



MASW-000834

Rev. V10

## Features

- Exceptional Broadband Performance
- Low Loss:
  - $T_x = 0.33 \text{ dB @ } 2010 \text{ MHz, } 5 \text{ V / } 20 \text{ mA}$
  - $T_x = 0.38 \text{ dB @ } 3.5 \text{ GHz, } 5 \text{ V / } 20 \text{ mA}$
- High Isolation:
  - $R_x = 44 \text{ dB @ } 2010 \text{ MHz, } 20 \text{ mA / } 5 \text{ V}$
  - $R_x = 36 \text{ dB @ } 3.5 \text{ GHz, } 20 \text{ mA / } 5 \text{ V}$
- High  $T_x$  RF Input Power:
  - 50 W CW @ 2010 MHz
- High  $T_x$  RF Input Peak Power:
  - >1000 W
- Suitable for Very High Power TD-SCDMA & WiMAX Applications
- Surface Mount 4 mm PQFN Package
- RoHS\* Compliant

## Applications

- Aerospace & Defense
- Wireless Networking & Communication

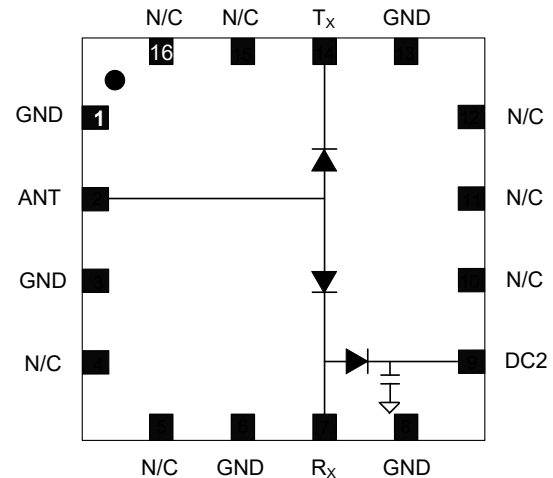
## Description

The MASW-000834 is a SPDT broadband, high linearity, common anode, PIN diode T/R switch, for 0.05 - 6.0 GHz applications, including WiMAX & WiFi. The device is provided in industry standard 4 mm PQFN plastic packaging. This device incorporates a PIN diode die fabricated with MACOMs' patented silicon-glass HMIC™ process. This chip features two silicon pedestals embedded in a low loss, low dispersion glass. The diodes are formed on the top of each pedestal. The topside is fully encapsulated with silicon nitride and has an additional polymer passivation layer that prevents damage and contamination during handling and assembly.

This compact SPDT switch offers wideband performance with excellent isolation to loss ratio for both  $T_x$  and  $R_x$  states. The PIN diode provides 50 W typical CW power handling and 65 dBm IIP3 at 2010 MHz for maximum switch performance.

This compact SPDT switch offers wideband performance with excellent isolation to loss ratio for both  $T_x$  and  $R_x$  states. The PIN diode provides 45 W CW power handling at an 85°C baseplate temperature and 72 dBm IIP3 at 2010 MHz for maximum switch performance.

## Functional Diagram (Top View)



## Pin Configuration<sup>1</sup>

Pin	Function
1,3,6,8,13,15	GND
2	ANT
4,5,10,11,12,16	N/C <sup>2</sup>
7	RX
9	DC2
14	TX
17	Pad

1. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.
2. MACOM recommends connecting all No Connection (N/C) pins to ground.

## Ordering Information<sup>3</sup>

Part Number	Package
MASW-000834-13560T	1000 piece reel
MASW-000834-001SMB	Sample Board

3. Reference Application Note M513 for reel size information.

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

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## Electrical Specifications<sup>4</sup>:

$T_A = +25^\circ\text{C}$ , 20 mA / 5 V,  $P_{\text{INC}} = 0 \text{ dBm}$ ,  $Z_0 = 50 \Omega$

Parameter	Symbol	Units	Min.	Typ.	Max.
<b>F = 900 MHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.34	0.56
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.26	0.445
Isolation, ANT To $R_X$	$R_X$ ISO	dB	45.8	52.1	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	21.7	27.1	—
<b>F = 1800 MHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.40	0.72
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.32	0.49
Isolation, ANT To $R_X$	$R_X$ ISO	dB	43.7	48.9	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	18.4	21.4	—
<b>F = 2010 MHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.42	0.75
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.33	0.5
Isolation, ANT To $R_X$	$R_X$ ISO	dB	43.2	44.6	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	17.7	19.9	—
Input Return Loss, $T_X$	$T_X$ RL	dB	—	32.1	—
Input Return Loss, $R_X$	$R_X$ RL	dB	—	24.2	—

4. See Bias Table 1.

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## Electrical Specifications<sup>4</sup>:

$T_A = +25^\circ\text{C}$ , 20 mA / 5 V,  $P_{\text{INC}} = 0 \text{ dBm}$ ,  $Z_0 = 50 \Omega$

Parameter	Symbol	Units	Min.	Typ.	Max.
<b>F = 2.3 - 2.7 GHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.46	0.84
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.35	0.525
Isolation, ANT To $R_X$	$R_X$ ISO	dB	40.2	41.2	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	16.2	18.6	—
Input Return Loss, $T_X$	$T_X$ RL	dB	—	30.5	—
Input Return Loss, $R_X$	$R_X$ RL	dB	—	22.9	—
<b>F = 3.3 - 3.8 GHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.56	1.0
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.38	0.575
Isolation, ANT To $R_X$	$R_X$ ISO	dB	33.7	35.9	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	13.6	16.1	—
Input Return Loss, $T_X$	$T_X$ RL	dB	—	27.4	—
Input Return Loss, $R_X$	$R_X$ RL	dB	—	21.9	—
<b>F = 4.9 - 5.9 GHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.78	—
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.52	—
Isolation, ANT To $R_X$	$R_X$ ISO	dB	—	26.4	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	—	11.8	—
Input Return Loss, $T_X$	$T_X$ RL	dB	—	20.3	—
Input Return Loss, $R_X$	$R_X$ RL	dB	—	24.2	—

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## Electrical Specifications<sup>5</sup>:

$T_A = +25^\circ\text{C}$ , 50 mA / 25 V,  $P_{\text{INC}} = 0 \text{ dBm}$ ,  $Z_0 = 50 \Omega$

Parameter	Symbol	Units	Min.	Typ.	Max.
<b>F = 900 MHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.27	—
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.22	—
Isolation, ANT To $R_X$	$R_X$ ISO	dB	—	53.3	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	—	27.4	—
<b>F = 1800 MHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.32	—
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.27	—
Isolation, ANT To $R_X$	$R_X$ ISO	dB	—	50.2	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	—	21.6	—
<b>F = 2010 MHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.34	—
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.28	—
Isolation, ANT To $R_X$	$R_X$ ISO	dB	—	45.5	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	—	20.1	—
Input Return Loss, $T_X$	$T_X$ RL	dB	—	33.1	—
Input Return Loss, $R_X$	$R_X$ RL	dB	—	24.1	—

5. See Bias Table 2.

# HMIC™ PIN Diode SPDT 50 W Switch for 0.05 - 6.0 GHz High Power Applications



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## Electrical Specifications<sup>5</sup>:

$T_A = +25^\circ\text{C}$ , 50 mA / 25 V,  $P_{\text{INC}} = 0 \text{ dBm}$ ,  $Z_0 = 50 \Omega$

Parameter	Symbol	Units	Min.	Typ.	Max.
<b>F = 2.3 - 2.7 GHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.38	—
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.30	—
Isolation, ANT To $R_X$	$R_X$ ISO	dB	—	41.8	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	—	18.7	—
Input Return Loss, $T_X$	$T_X$ RL	dB	—	31.3	—
Input Return Loss, $R_X$	$R_X$ RL	dB	—	22.8	—
<b>F = 3.3 - 3.8 GHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.47	—
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.33	—
Isolation, ANT To $R_X$	$R_X$ ISO	dB	—	36.2	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	—	16.2	—
Input Return Loss, $T_X$	$T_X$ RL	dB	—	28.0	—
Input Return Loss, $R_X$	$R_X$ RL	dB	—	21.8	—
<b>F = 4.9 - 5.9 GHz</b>					
Insertion Loss, $R_X$	$R_X$ IL	dB	—	0.72	—
Insertion Loss, $T_X$	$T_X$ IL	dB	—	0.48	—
Isolation, ANT To $R_X$	$R_X$ ISO	dB	—	26.6	—
Isolation, ANT To $T_X$	$T_X$ ISO	dB	—	11.8	—
Input Return Loss, $T_X$	$T_X$ RL	dB	—	20.5	—
Input Return Loss, $R_X$	$R_X$ RL	dB	—	24.2	—

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## Electrical Specifications: $T_A = +25^\circ\text{C}$ , 50 mA / 25 V, $Z_0 = 50 \Omega$

Parameter	Symbol	Test Conditions	Units	Min.	Typ.	Max.
$T_X$ Input P1dB	$T_X$ P1dB	2010 MHz, $T_X$ to Antenna 3.5 GHz, $T_X$ to Antenna	dBm	—	>45.5 >45.0	—
$T_X$ 2 <sup>nd</sup> Harmonic	$T_X$ 2F <sub>o</sub>	2010 MHz, P <sub>IN</sub> = 30 dBm 3.5 GHz, P <sub>IN</sub> = 30 dBm	dBc	—	80 88	—
$T_X$ 3 <sup>rd</sup> Harmonic	$T_X$ 3F <sub>o</sub>	2010 MHz, P <sub>IN</sub> = 30 dBm 3.5 GHz, P <sub>IN</sub> = 30 dBm	dBc	—	95 105	—
$T_X$ Input IP3	$T_X$ IIP3	P <sub>IN</sub> = 10 dBm, F1 = 2010 MHz, F2 = 2020 MHz P <sub>IN</sub> = 10 dBm, F1 = 3.5 GHz, F2 = 3.51 GHz	dBm	—	>64 >64	—
$T_X$ CW Input Power	$T_X$ P <sub>INC</sub>	F = 2010 MHz	dBm / W	—	47 / 50	—
$R_X$ CW Input Power	$R_X$ P <sub>INC</sub>	F = 2010 MHz F = 3.5 GHz	dBm / W	—	41.5 / 14 40.5 / 11	—
$T_X$ RF Switching Speed	$t_{RF}$	F = 2010 MHz (10 - 90% RF Voltage) F = 3.5 GHz (10 - 90% RF Voltage) 1 MHz Rep Rate in Modulating Mode	ns	—	200 200	—

## Absolute Maximum Ratings<sup>6,7</sup> @ $T_A = +25^\circ\text{C}$ (unless otherwise specified)

Parameter	Absolute Maximum
Forward Current	100 mA
DC Reverse Voltage	100 V
$T_X$ Incident CW Power	50 W (47 dBm) <sup>8</sup> @ 2010 MHz
$T_X$ Peak Incident Power	>300 W, 5 $\mu$ s, 1% duty cycle
Junction Temperature	+175°C
Operating Temperature	-40°C to +85°C
Storage Temperature	-55°C to +150°C

6. Exceeding these limits may cause permanent damage.
7. MACOM does not recommend sustained operation near these survivability limits.
8. Baseplate temperature must be controlled to a constant +25°C. See derating curve.

## Handling Procedures

Please observe the following precautions to avoid damage:

### Static Sensitivity

Silicon Integrated Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these Class 1B Human Body devices.

# HMIC™ PIN Diode SPDT 50 W Switch for 0.05 - 6.0 GHz High Power Applications

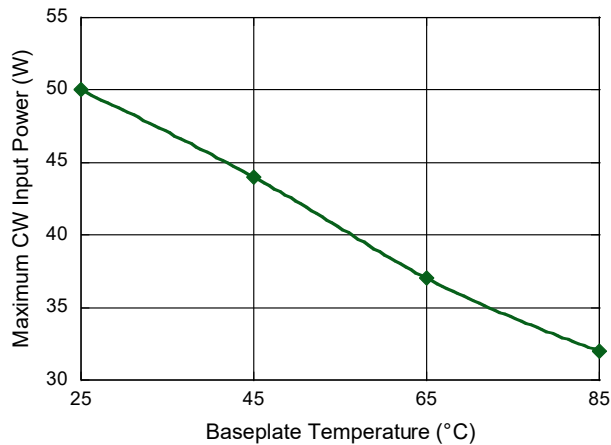


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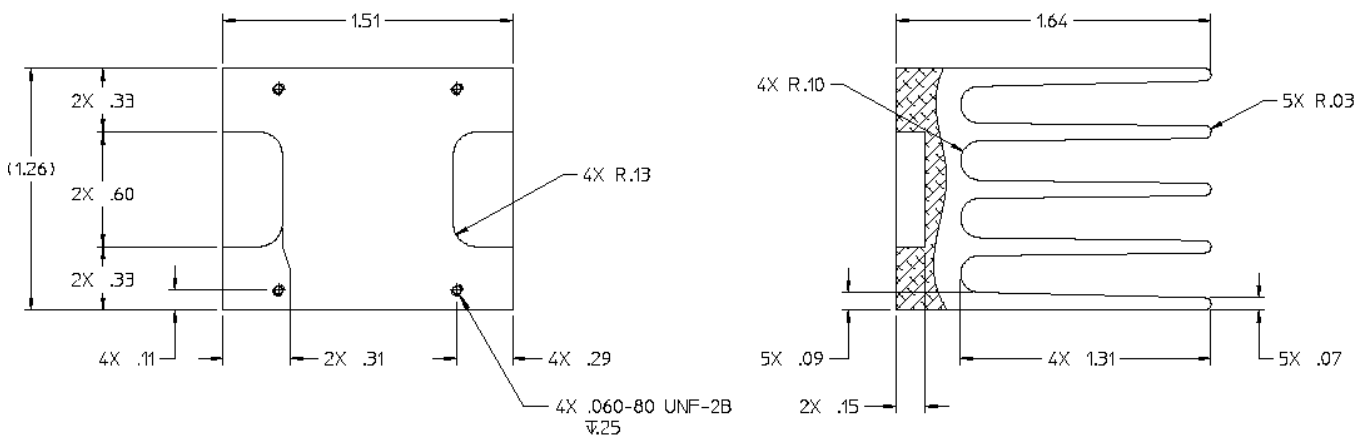
## Typical Power Derating Curve

$T_x$  Maximum CW Input Power  
(50 mA Forward Bias, 2010 MHz)



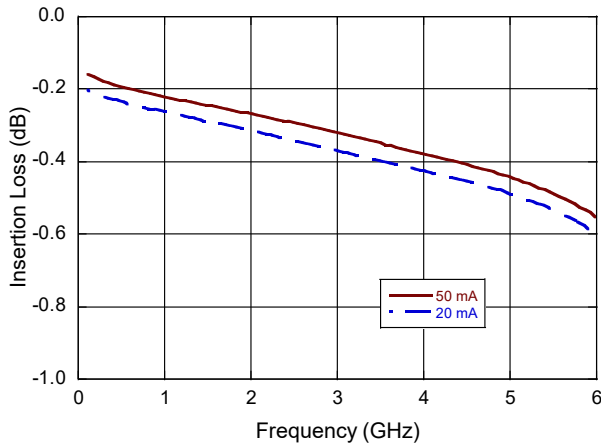
Note that this part must be held to a constant baseplate temperature to achieve the power handling results specified above. Adding a heatsink to the baseplate will improve performance to values greater than shown here. The increase in maximum input power from using a heatsink depends on the specific heatsink design.

With a sample board mounted onto a heatsink of dimensions and fins shown below, this switch can handle up to 35 W CW of incident power.

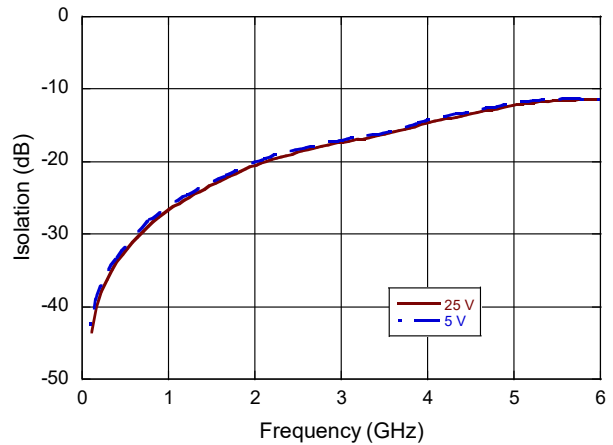


## $T_x$ Performance Curves @ +25°C, $Z_0 = 50 \Omega$

$T_x$  Insertion Loss, 20 mA & 50 mA

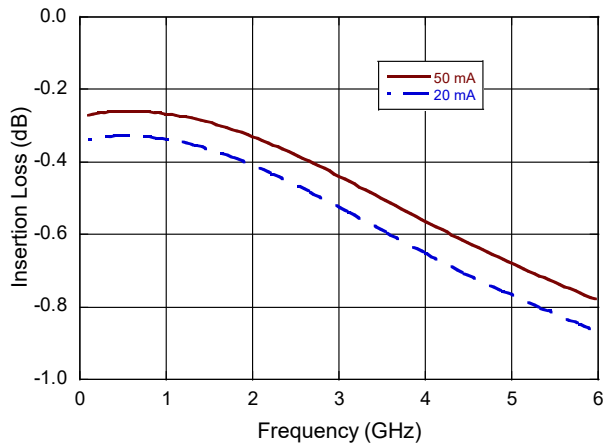


$T_x$  Isolation, 5 V & 25 V

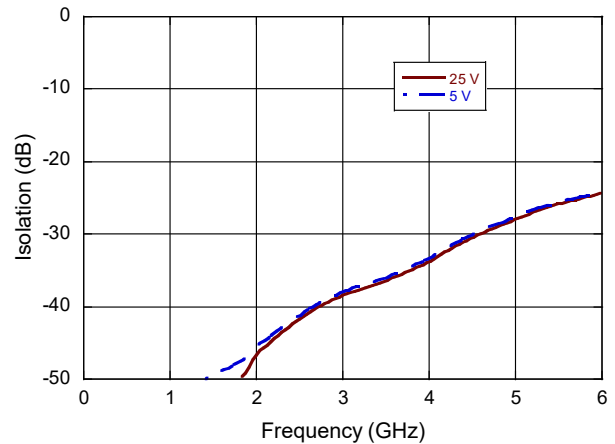


## $R_x$ Performance Curves @ +25°C, $Z_0 = 50 \Omega$

$R_x$  Insertion Loss, 20 mA & 50 mA



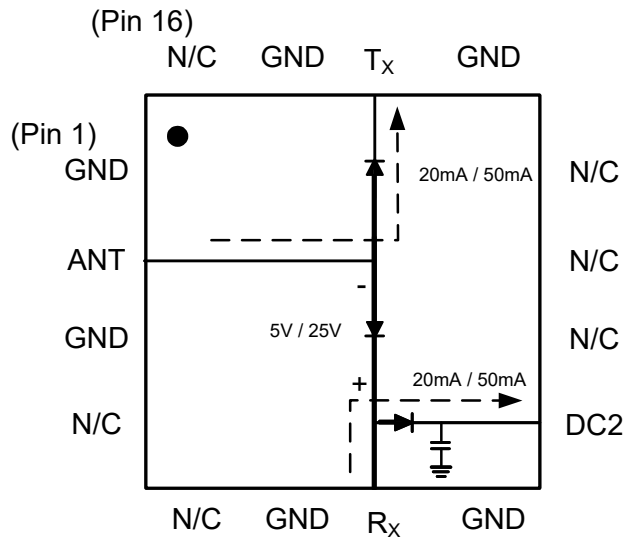
$R_x$  Isolation, 5 V & 25 V



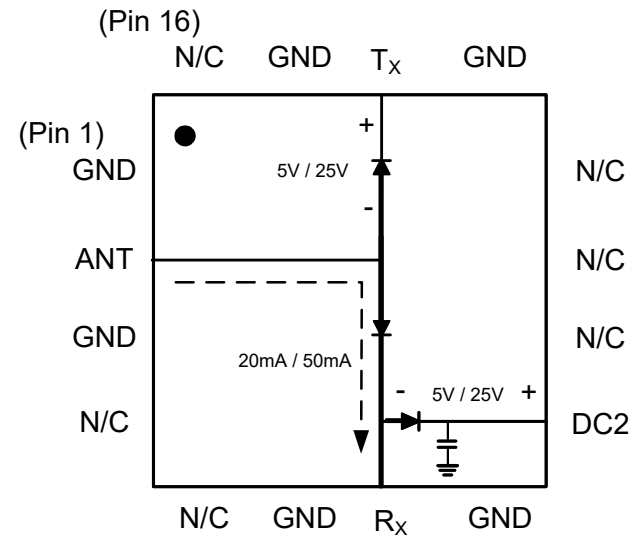


## Bias Diagrams & Tables<sup>9</sup>

### T<sub>X</sub>-ANT Insertion Loss, R<sub>X</sub>-ANT Isolation



### R<sub>X</sub>-ANT Insertion Loss, T<sub>X</sub>-ANT Isolation



### Bias Table 1

Parameter	T <sub>x</sub>	R <sub>x</sub>	DC2	ANT
	Pin 14	Pin 7	Pin 9	Pin 2
T <sub>x</sub> -ANT Insertion Loss	-20 mA	+5 V, +20 mA	-20 mA	0 V, +20 mA
R <sub>x</sub> -ANT Isolation				
R <sub>x</sub> -ANT Insertion Loss	+5 V, 0 mA	-20 mA	+5 V, 0 mA	0 V, +20 mA
T <sub>x</sub> -ANT Isolation				

### Bias Table 2

Parameter	T <sub>x</sub>	R <sub>x</sub>	DC2	ANT
	Pin 14	Pin 7	Pin 9	Pin 2
T <sub>x</sub> -ANT Insertion Loss	-50 mA	+25 V, +50 mA	-50 mA	0 V, +50 mA
R <sub>x</sub> -ANT Isolation				
R <sub>x</sub> -ANT Insertion Loss	+25 V, 0 mA	-50 mA	+25 V, 0 mA	0 V, +50 mA
T <sub>x</sub> -ANT Isolation				

9. Diode Based Products require different minimum reverse bias voltages depending on the frequency and incident power levels. More details can be found on page 10 of this datasheet.

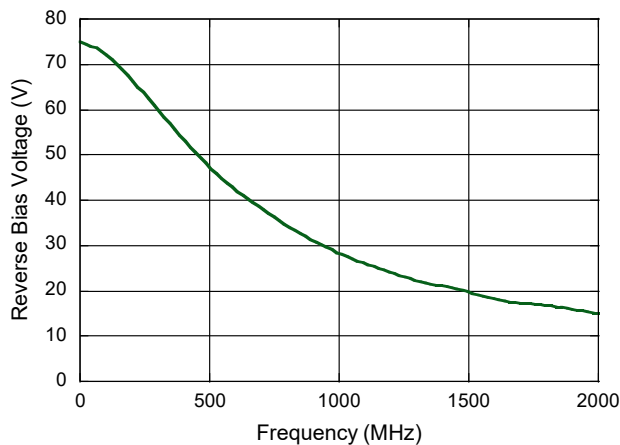
## Minimum Required Reverse Bias Voltage

Minimum reverse bias voltage on a PIN diode based product varies with frequency of operation and incident power levels. As a rule of thumb, a designer can always use the magnitude of the peak RF voltage or empirically locate lower bias values than the peak RF voltage magnitude. However, it has been shown that lower DC voltages can be used depending on the RF environment in which a diode is placed. In the plot below, the minimum required reverse voltage vs. frequency is shown for an incident RF power of 50 Watts. This trend line will shift lower if the incident RF power is decreased. The biasing values have not been verified through measurement at MACOM. As a result, please use the data below as a guide only for biasing requirements as this data is based solely on generic PIN diode equations.<sup>10</sup>

Please be cautious in that lower reverse bias levels can degrade isolation and distortion in a PIN diode based product. Also, if using the MARD-009150 driver, keep in mind the maximum voltage available is 55 V. If a voltage greater than 55 V is desired, then one may want to consider using the MADR-010574 driver.

10. R. Caverly and G. Hiller, "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.

### Reverse Bias Required vs. Frequency (50 W Power Handling)



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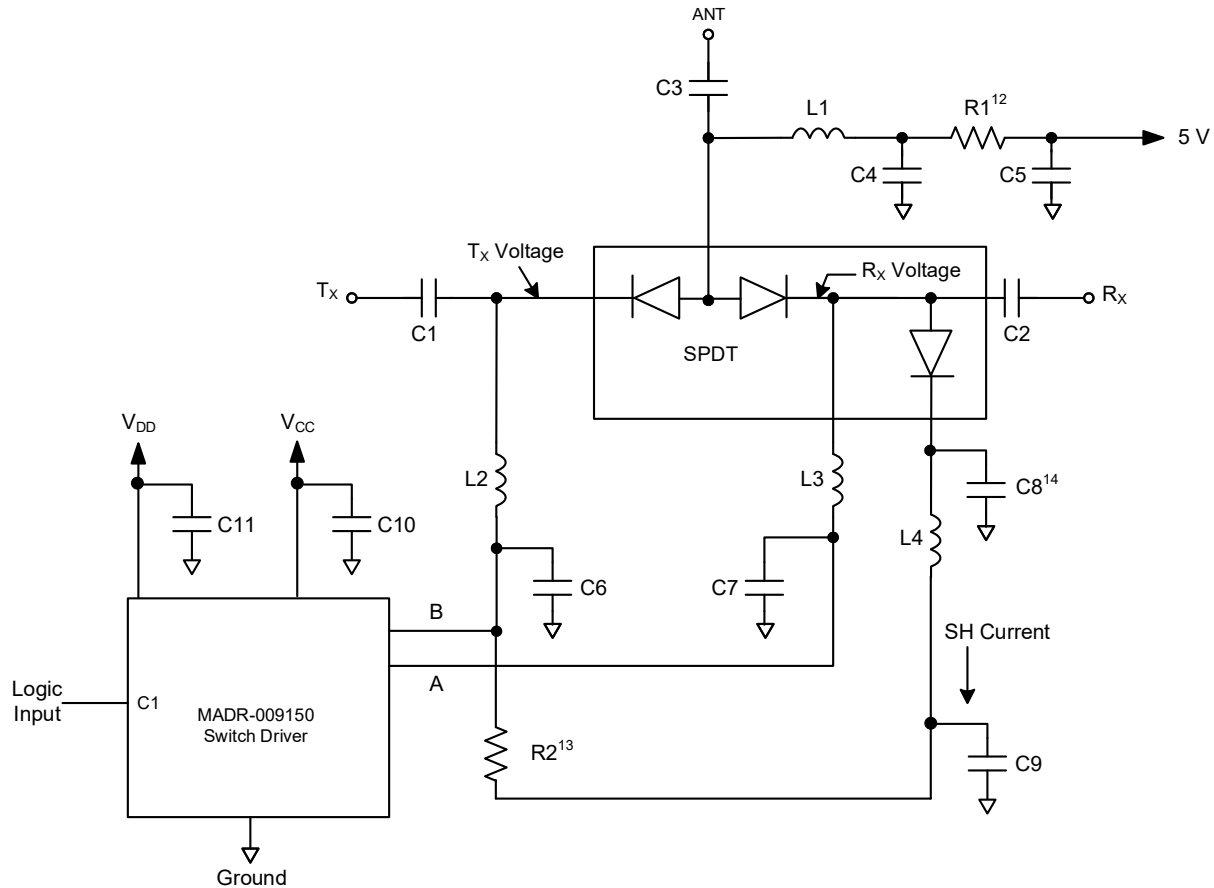


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## MASW-000834 and Recommended Driver with 5 V & 28 V DC Power<sup>11,12,13,14,15,16</sup>

MADR-009150 is the recommended driver for the MASW-000834 Switch.



11. Forward bias diode voltage:  $DV_F$  is  $\sim 0.9$  V @ 22 mA;  $DV_F$  is  $\sim 1.0$  V @ 35 mA
12. R1 is calculated by  $(V_{CC} - 1.3 \text{ V approximation since Tx and Rx voltages on driver will be slightly different})/I_{SERIES}$ , where  $I_{SERIES}$  is the desired bias current for the series diodes.
13. R2 is calculated by  $(V_{DD} - 1.5 \text{ V})/I_{SHUNT}$ , where  $I_{SHUNT}$  is the desired forward bias current for the shunt diode. The power dissipation is calculated by  $I_{SHUNT} \times (V_{DD} - 1.5 \text{ V})$ .
14. C8 is already built-in for MASW-000834-13560T switch.
15. The current in through the back-biased diodes will be the leakage current for the diodes.
16. C1-C7, C9-C11, L1-L4, R1, R2, and the switch are discrete components that should be installed on the users board. It is recommended that Coilcraft 0603CS-27NXJLW or equivalent be used for L1-L4 at 2 GHz (values may vary based on the frequency).

## Parts List

Part	Value
C1 - C3	27 pF, 100 V
C4	1000 pF
C5,C10,C11	0.1 $\mu$ F
C6,C7,C8 <sup>14</sup> ,C9	50 pF
L1, L2, L3,L4	27 nH
R1	100 $\Omega$ <sup>12</sup>
R2	480 $\Omega$ <sup>13</sup>

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DC-0008120

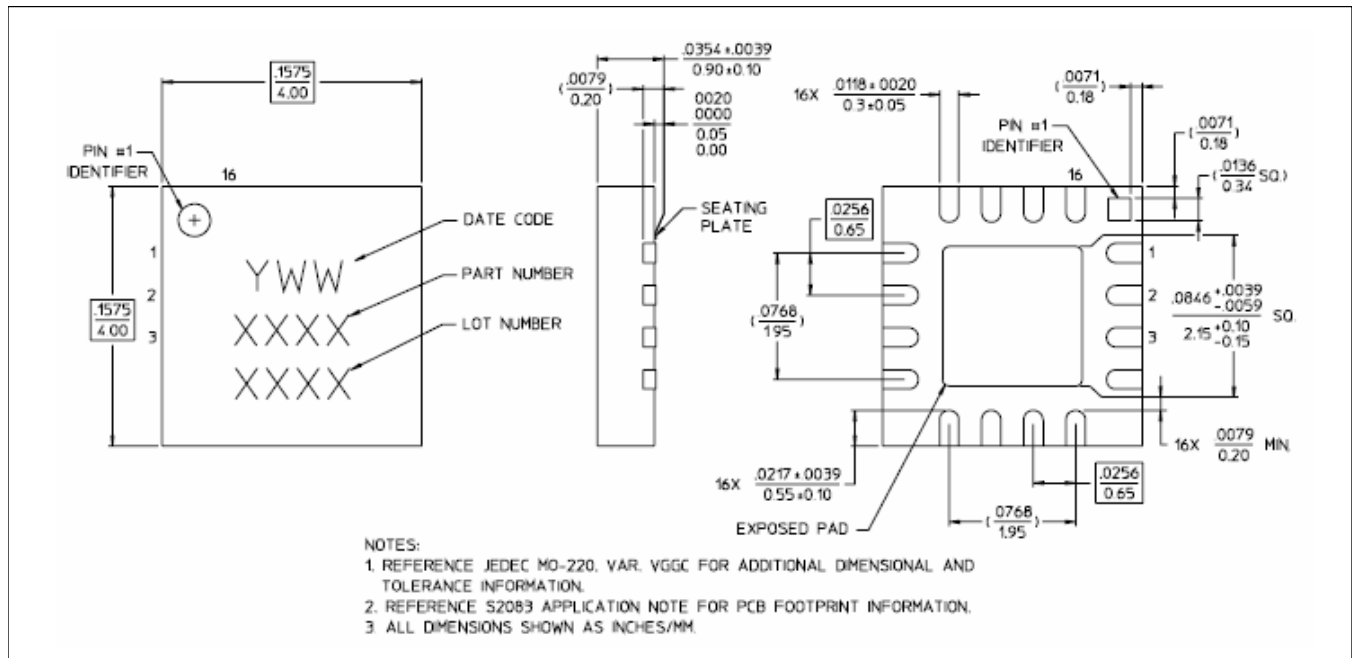
# HMIC™ PIN Diode SPDT 50 W Switch for 0.05 - 6.0 GHz High Power Applications



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## Outline: 4 mm PQFN 16-Lead Saw Singulated



† Reference Application Note S2083 for lead-free solder reflow recommendations.  
 Meets JEDEC moisture sensitivity level (MSL) 1 requirements.

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