UM9601 – UM9608

FOR MICROSTRIP 900 MHz ANTENNNA SWITCHES

AND MICROWAVE APPLICATIONS

DESCRIPTION

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The UM9601-UM9608 series of PIN diodes was developed for shunt mount applications in microstrip circuits. Good switch performance is demonstrated at frequencies from UHF to 4 GHz and higher. This performance is achieved using discrete low inductance Microsemi PIN diodes assembled with special hardware to permit good electrical and mechanical compatibility with microstrip transmission lines.

Design information is presented for preparation of microstrip circuit boards to accommodate these PIN diodes. A detailed design for a 900 MHz quarter-wave antenna switch is given. This switch which employs a low cost UM9401 axial leaded PIN diode in conjunction with a UM9601 performs with 30 dB receiver isolation over a 100 MHz bandwidth and with a transmitter insertion loss of less than 0.4 dB. This switch can safely handle transmitter power levels up to 100 watts at infinite SWR.

The Microsemi UM9601 series PIN diodes are constructed using a fused-in-glass which results in a highly reliable, hermetic package. The process utilizes symmetrical, full faced metallurgical bonds to both surfaces of the silicon chip. This construction greatly minimizes the normal parasitic inductance and capacitance found in conventional glass or ceramic packaged diodes which employ straps, springs, or whiskers.

The use of discrete UM9601-UM9608 diodes greatly minimizes handling problems commonly associated with passivated PIN diode chips while maintaining good microwave performance. In addition the power handling capability of the UM9601-UM9608 series is considerably higher than PIN diode chips can provide.

Environmentally, the UM9601-9608 series PIN diodes can withstand thermal cycling from -195 ^{o}C to +300 ^{o}C and exceed all military environmental specifications for shock, vibration, acceleration, and moisture.

IMPORTANT: For the most current data, consult *MICROSEMI*'s website: **http://www.microsemi.com**

KEY FEATURES

- Low Inductance Shunt Mount Package
- Characterized for Microstrip
- Microsemi Ruggedness and Reliability
- High Power Handling Capability
- Low Bias Current Requirement
- Excellent Distortion Properties
- Cost Effective in High Quantity Applications

APPLICATIONS/BENEFITS

- RoHS compliant packaging available: use UMX9601, etc.

UM9601 SERIES

Typical Microwave Performance

	UM9601-9604			UM9605-UM9608		
	SPST	SPST	SPNT*	SPST	SPST	SPNT*
	Insertion Loss	Isolation	Isolation	Insertion Loss	Isolation	Isolation
Frequency	0 Bias	100 mA	100 mA	0 Bias	100 mA	100 mA
GHz	dB	dB	dB	dB	dB	dB
0.5	0.20	30	36	0.20	25	31
1.0	0.25	26	32	0.20	22	28
1.5	0.35	22	28	0.20	20	26
2.0	0.50	18	24	0.25	17	22
3.0	1.00	15	21	0.25	15	21
4.0	1.50	13	19	0.40	14	20

* Performance based on SPST Measurements in 0.025" (0.635mm) Microstrip Test Circuit.
Note: All dimensions in inches and (millimeters).

Maximum Ratings

		UM9601-UM9604		UM9605-UM9608	
		P_D	θ	P_D	θ
	Flange @ 25 °C	7.5 W	20 °C/W	4 W	37.5 °C/W
	Free Air	1.5 W		0.5 W	

Peak Power 1 µs Single Pulse at 25 °C Ambient	25 kW	10 kW

Operating and Storage Temperature	-65 °C to +175 °C

Reverse Voltage Ratings @ 10 µA

100 V	400 V
UM9601	UM9602
UM9603	UM9604
UM9605	UM9606
UM9607	UM9608

Electrical Specifications (at 25 °C)

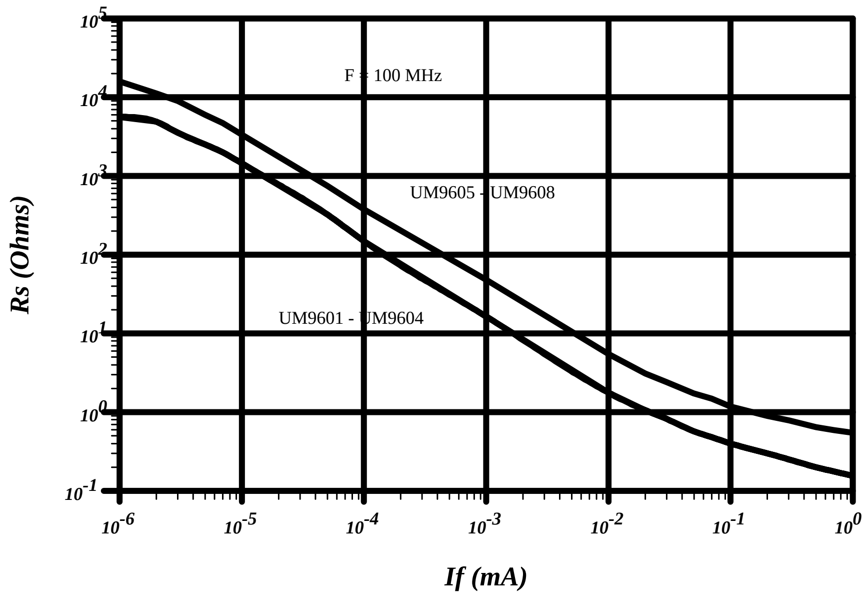
		UM9601-UM9604			UM9605-UM9608				
Test	**Symbol**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Units**	**Condition**
Series Resistance	Rs		0.4	0.6		1.5	1.7	Ω	I_F = 100 mA F = 100 MHz
Parallel Resistance	Rp	100k			150k			Ω	Vr = 100 V F = 100 MHz
Total Capacitance	C_T			1.2			0.5	pF	Vr = 100 V F = 1 MHz
Carrier Lifetime	τ	2.0			1.0			µs	If = 10 mA
Forward Voltage	V_F		0.85			0.95		V	I_F = 100 mA
I-Region Width	W	80			150			µm	

Selection Guide

The following chart serves as a general guide for indicating the most likely diode from the series for a given application.

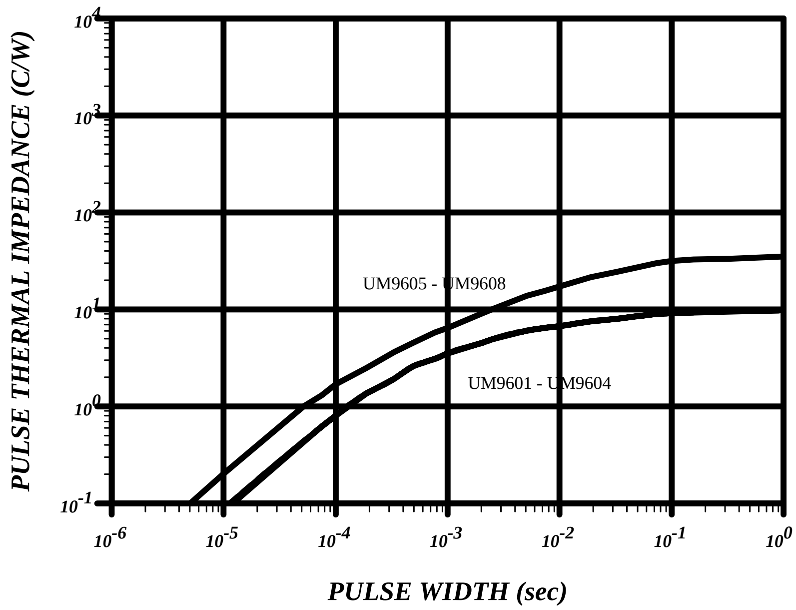
Applications	Recommended Types
1. High isolation switches to 2 GHz at low drive 2. Quarter-wave antenna switches to 100 watts 3. Priced for high volume commercial applications	UM9601 (Affixes to microstrip ground plane) UM9603 (Affixes to microstrip backing plate)
High voltage rating version of UM9601 and UM9603 Respectively for peak power handling to 3 kW	UM9602 UM9604
1. Low insertion loss switches to 4 GHz 2. Low distortion attenuator applications	UM9605 (Affixes to microstrip ground plane) UM9607 (Affixes to microstrip backing plate)
High voltage version of UM9605 and UM9607 For peak power handling to 10 kW	UM9606 UM9608

DIODE RESISTANCE vs DIODE CURRENT
TYPICAL

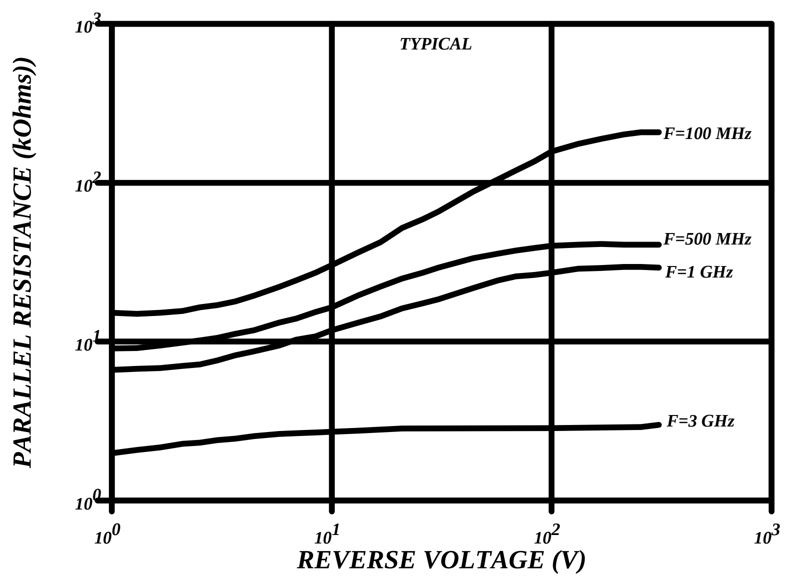


ELECTRICALS

PULSE THERMAL IMPEDANCE
TYPICAL

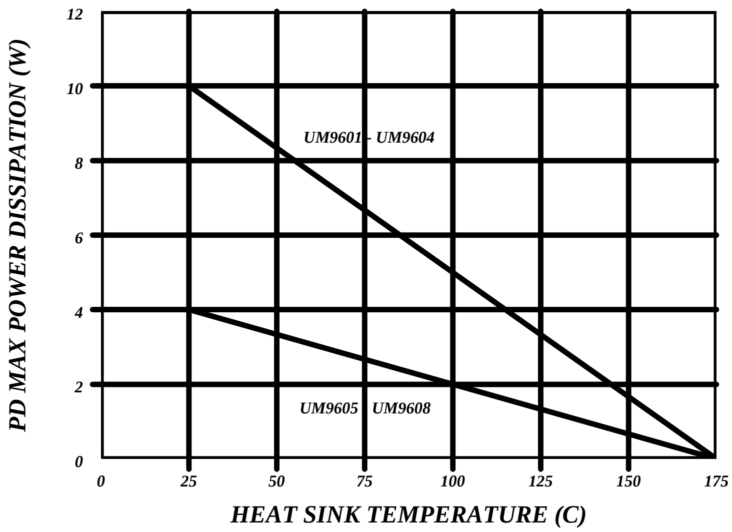


Rp VERSUS VOLTAGE AND FREQUENCY
UM9601 - UM9604

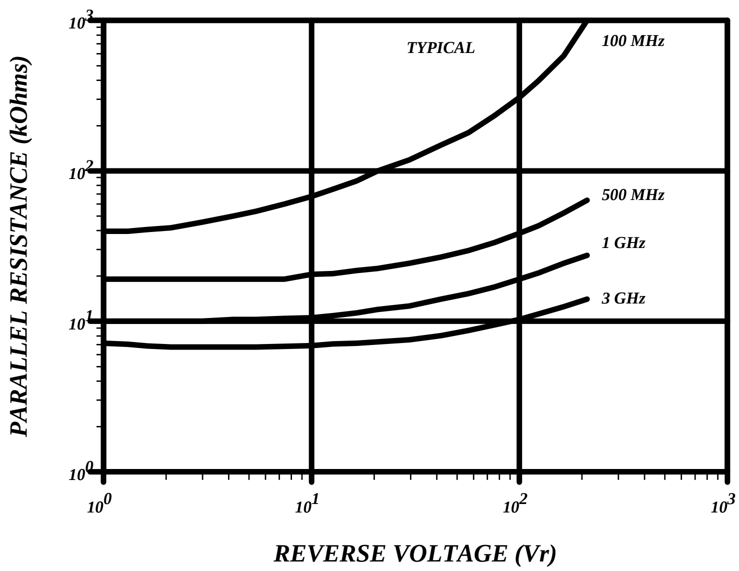


ELECTRICALS

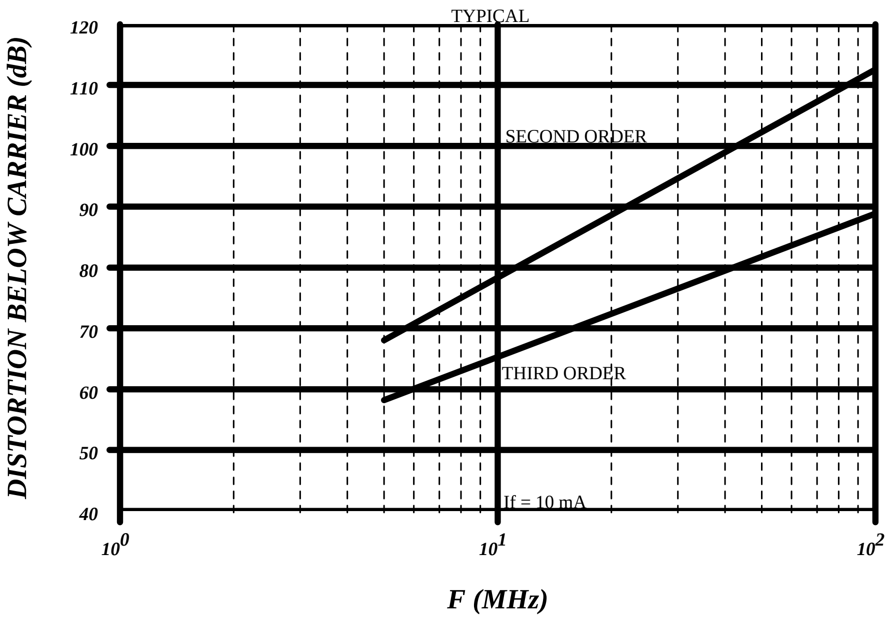
POWER RATING
TYPICAL



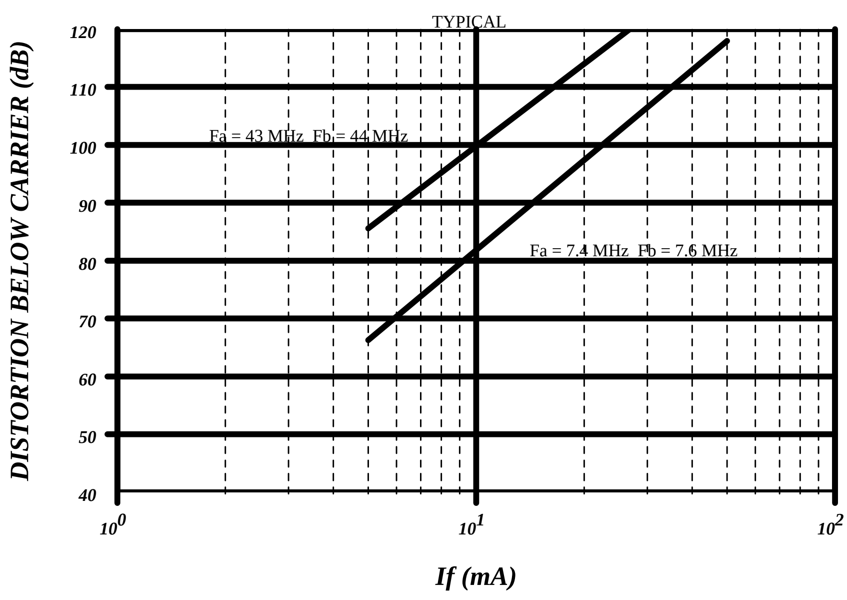
Rp vs VOLTAGE AND FREQUENCY
UM9605-UM9608



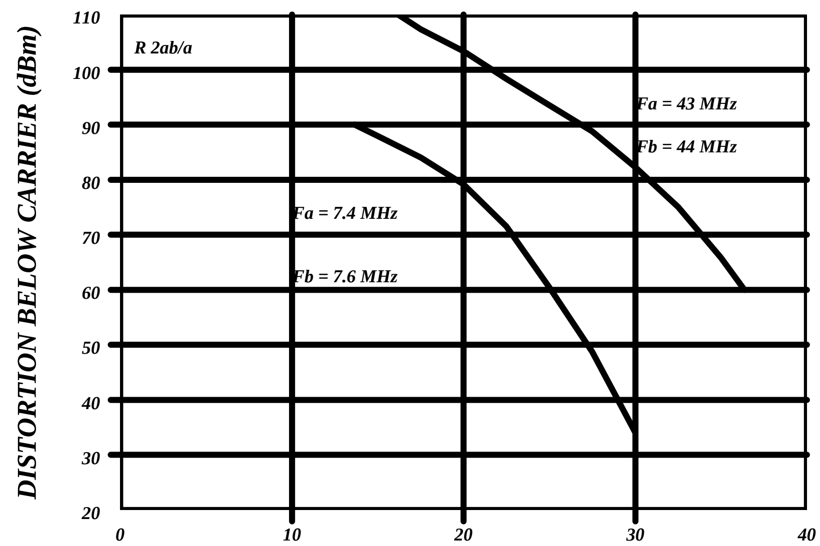
FORWARD BIAS INTERMODULATION DISTORTION VERSUS NOMINAL CARRIER FREQUENCY AT 20 dBm PER CHANNEL



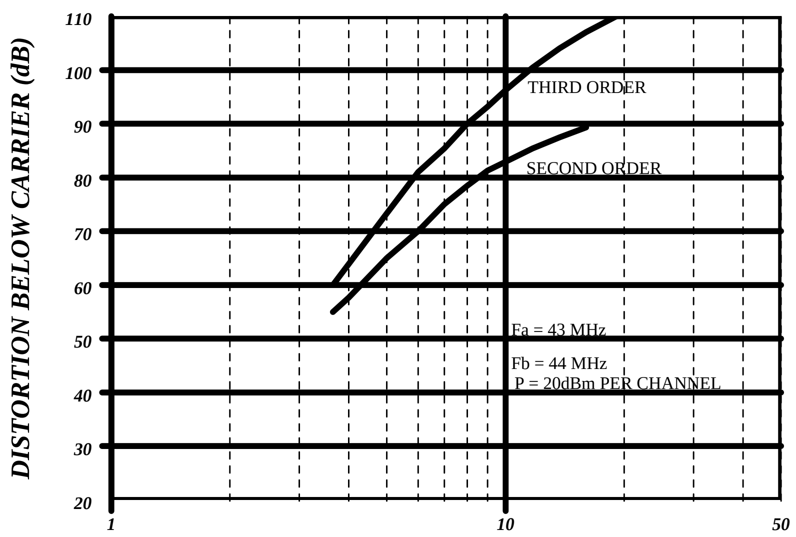
THIRD ORDER INTERMODULATION DISTORTION VERSUS FORWARD BIAS CURRENT AT 20 dBm PER CHANNEL



TYPICAL FORWARD BIAS THIRD ORDER INTERMODULATION DISTORTION vs INPUT POWER PER CHANNEL

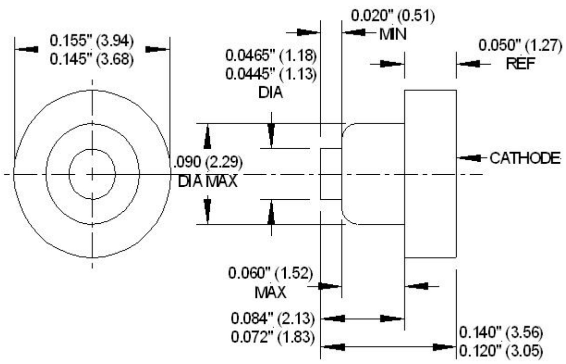


REVERSE BIAS INTERMODULATION DISTORTION TYPICAL

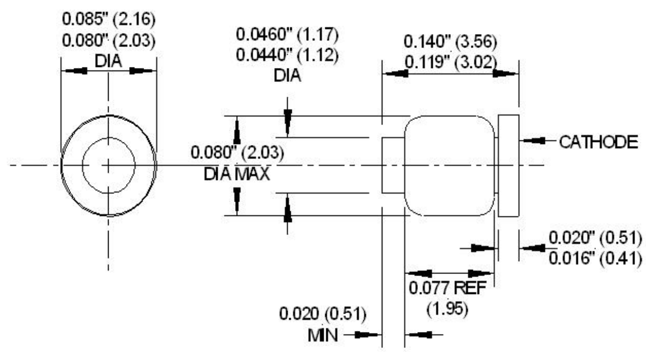


REVERSE VOLTAGE (Vr)

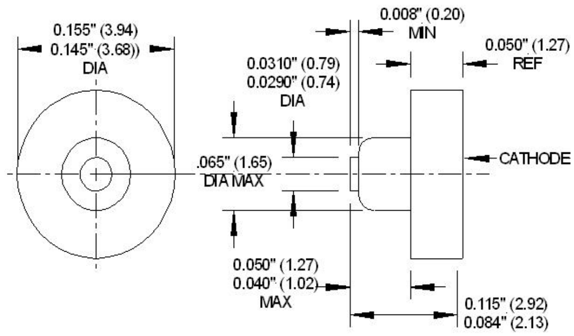
UM9601 UM9602



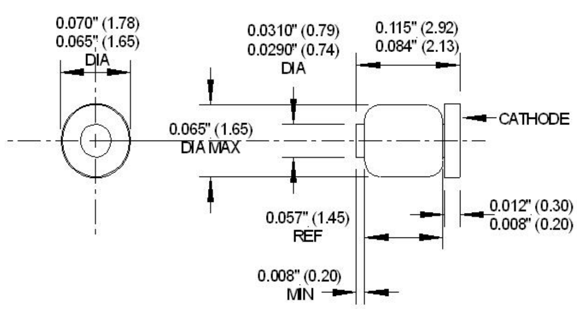
UM9603 UM9604

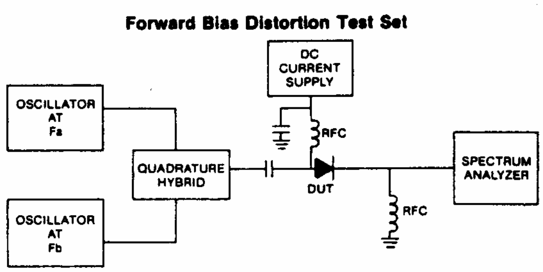


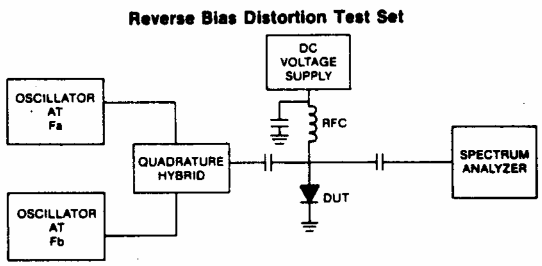
UM9605 UM9606



UM9607 UM9608







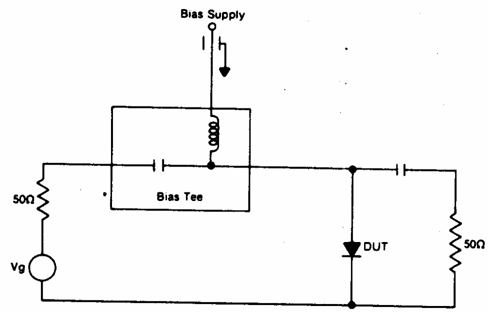
Microwave Characterization

The UM9601-UM9608 series has been designed and characterized as shunt switch elements at frequencies to 4 GHz in microstrip circuits. Performance curves are given which demonstrate switch performance in 0.025” (.635mm) alumina microstrip.

The performance data were derived by evaluating externally biased microstrip circuits in which a UM9601 diode was installed. Each circuit consisted of a 1 inch length of 50 Ohm nominal impedance 0.025” (.635mm) thick alumina microstrip and two SMA connectors. The data shown include the board and connector loss. Measurements performed using 00.050” (1.27mm) alumina substrates show similar performance at frequencies to1.5 GHz

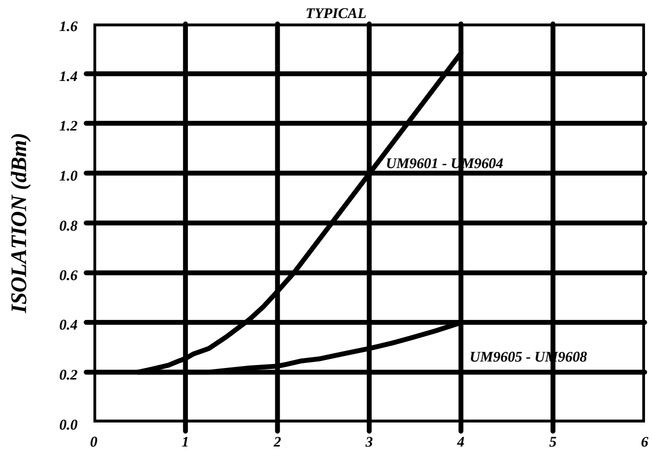
These circuits simulate SPST switches. Many designs require multi-throw switches. It is important to recognize that a multi-throw switch will have 6dB higher isolation than indicated for SPST switches. Also, a multi-throw switch using shunt mounted PIN diodes require the diodes be placed a quarter-wavelength from the common port.

A further improvement in switch performance may be achieved by using 2 shunt PIN diodes in each arm spaced a quarter-wavelength from each other. In this case the isolation of each section will be twice the dB value of the switch. The insertion loss due to the diodes should be less than twice the insertion loss of an SPST section due to the transforming effect of the quarter-wave line on the capacitance of a single diode.

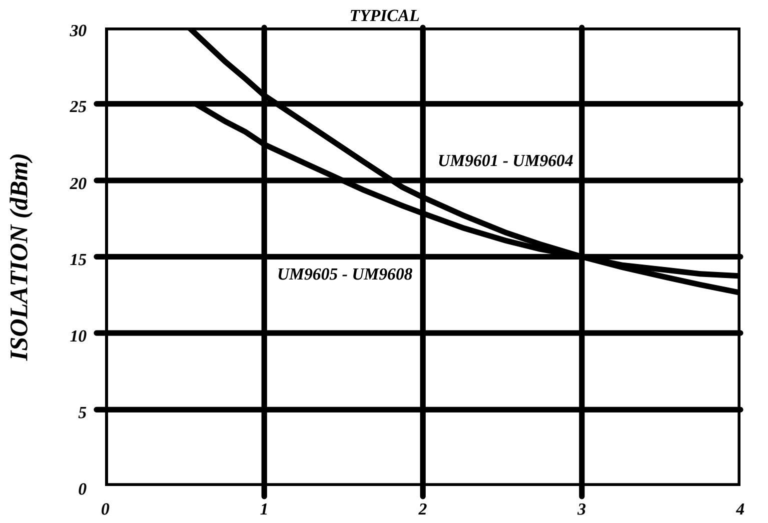


Microwave Test Circuit

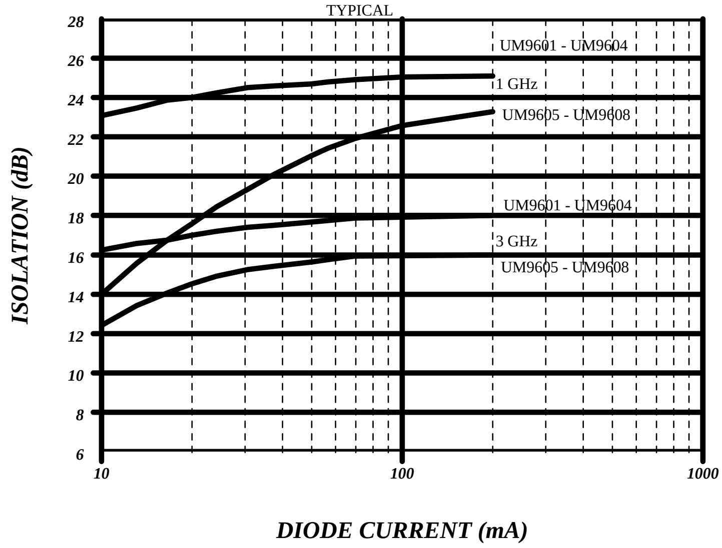
ISOLATION vs FREQUENCY .025" (.635mm) ALUMINA MICROSTRIP SPST SWITCH DIODE CURRENT = 100 mA



ISOLATION vs FREQUENCY .025" (.635mm) ALUMINA MICROSTRIP SPST SWITCH DIODE CURRENT = 100 mA



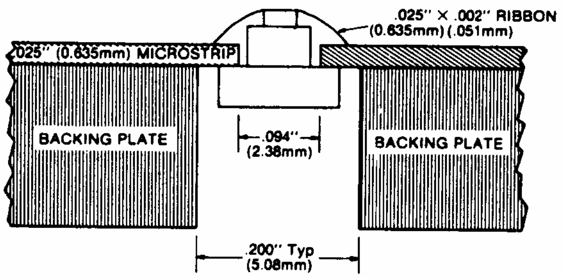
ISOLATION vs FREQUENCY AND DIODE CURRENT
0.025" (0.635mm) ALUMINA MICROSTRIP SPST SWITCH



Installation in Microstrip

The cup type flange on the UM9601, UM9602, UM9605, and UM9606 is designed to be affixed to the ground plane surface of a microstrip board. The UM9603, UM9604, UM9607, and UM9608 were designed to be affixed to a backing plate as shown. It was experimentally determined that at frequencies greater than 2 GHz the anode of the diode should be approximately 0.010” (.254mm) above the top surface of the microstrip for lowest insertion loss.

Figure: UM9601/UM9602 Microstrip Mount



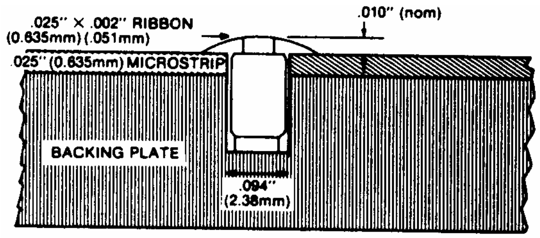
Design Example – 900 MHz Antenna Switch

An example of a practical circuit design using a UM9601 diode is a quarter-wave antenna switch covering the frequency of 800-900 MHz. The circuit design for this switch is shown and was constructed using 0.025” (0.645mm) alumina microstrip.

This antenna switch uses a series mounted diode and a shunt mounted diode. The UM9601 was selected for shunt mounted device (SPST performance at 1 GHz: 0.2dB insertion loss and 25dB isolation) and because it is the lowest cost diode in the UM9601-UM9608 series. A UM9401 axial lead diode was chosen for the series mounted device.

The performance of this switch is displayed in the graphs and in the following table. It should be noted that the loss values are actual measured numbers including losses due to the capacitors, bias networks, connectors, as well as the board. In a typical radio application where the antenna switch circuit board is integrated in the same microstrip board that contains transmitter and receiver elements the connector loss is eliminated. This will result in lower overall insertion loss values than indicated here.

For solder adhesion the microstrip may be heated to solder melting temperature (up to 300 ^{o}C) with no damage to the diode. Conductive epoxy may also be employed. The thermal resistance of solder mounted UM9601-UM9604 in their test boards was less than 20 ^{o}C/W; for the UM9605-UM9608 thermal resistance was less than 30 ^{o}C/W.



The CW power handling capacity is determined by the allowable power dissipation of the series mounted UM9401. Using a gap in the line of 0.190" (4.82mm) and lead soldered attached spacing of 0.250" (6.35mm) the power rating of the UM9401 is 6 watts at a 25 °C ambient. This was determined by performing a thermal resistance measurement on the circuit mount UM9401. The relationship that derives the maximum transmitter power, P_T is:

$$P_T = \frac{P_{DISS}}{Rs} Zo \left(\frac{\sigma + 1}{2\sigma} \right)^2$$

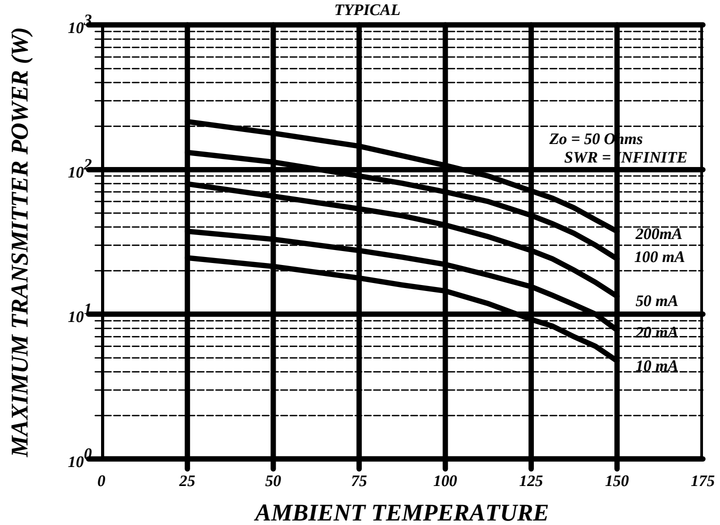
where σ = maximum antenna SWR

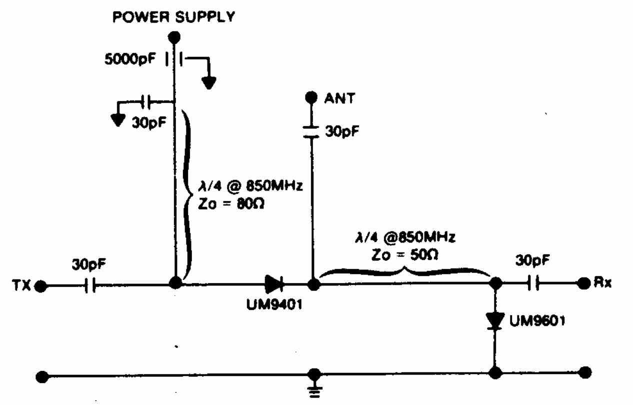
Using resistance values for UM9401 and UM9601 the maximum transmitter power curve is given and shows that this circuit is able to handle 100 watts of transmitter power at 100 mA forward bias and totally mismatched antenna at an ambient temperature of 60 °C. For a perfectly match antenna the power handling increases to 400 watts under the same bias and ambient conditions.

Distortion is an important consideration in the selection of a PIN diode antenna switch design. The UM9401 and UM9601 PIN diodes are designed for low distortion applications. The level of distortion produced by this 900 MHz antenna switch when operated in the transmit state (forward bias of 100 mA) is expected to be at least 90 dB below the carrier for a 50 watt transmitter level. In the receiver state (zero bias) the intermodulation distortion caused by two in-band signals at 0 dBm are estimated to be at least 100 dB below this level

MAX. TRANSMITTER POWER vs FORWAD CURRENT FOR UM9601/UM9401 900 MHz MICROSTRIP ANTENNA SWITCH

TYPICAL





Circuit Diagram

Antenna Switch Performance

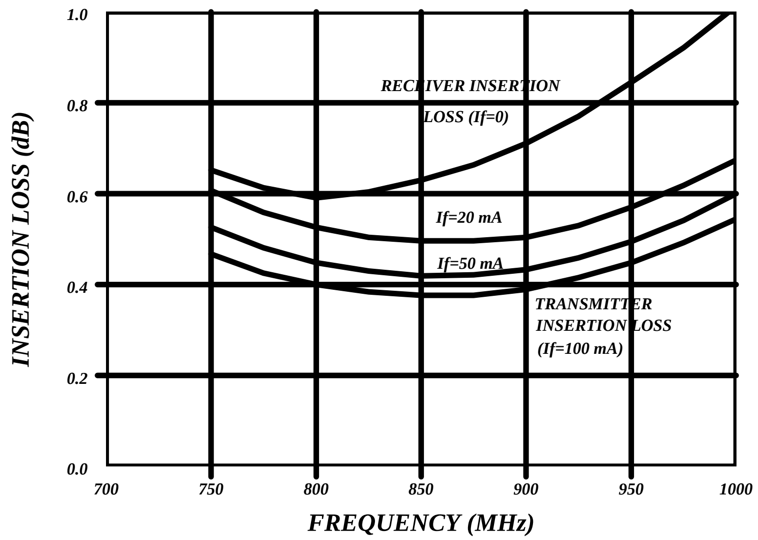
Frequency Range 800-900 MHz

1. Transmit State
   (I = 100 mA, T_A = 60 °C)

   A. Maximum Transmitter Power 100 watts
      (antenna SWR = ∞)
   B. Maximum Transmitter Power 40 watts
      (antenna SWR = 1)
   C. Transmitter Insertion Loss 0.4 dB
   D. Receiver Isolation 31 dB
   E. Harmonic Distortion -90 dB
      (P_T = 100 watts)

II. Receive State
   (zero Bias)
   A. Receiver Isolation Loss 0.6-0.7 dB
   B. Intermodulation Distortion -100 dB
      P_{IN} = 0 dBm

ANTENNA SWITCH INSERTION LOSS
TYPICAL



RECEIVER ISOLATION vs FREQUENCY AND DIODE CURRENT
TYPICAL

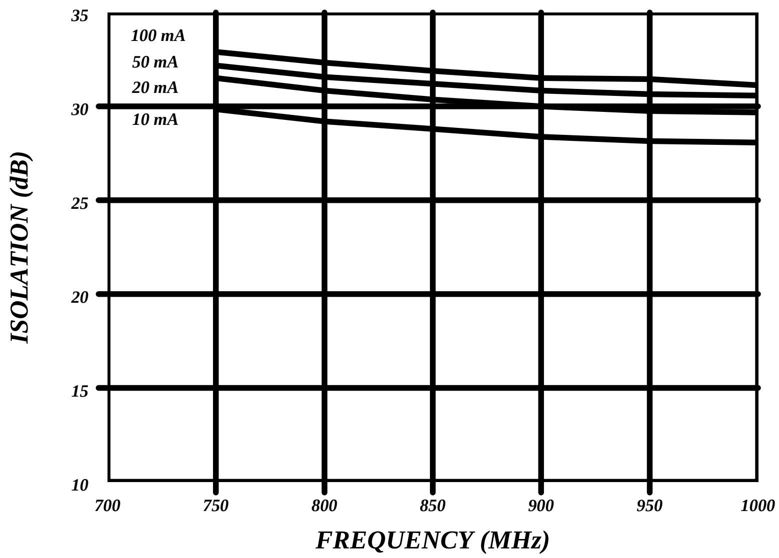
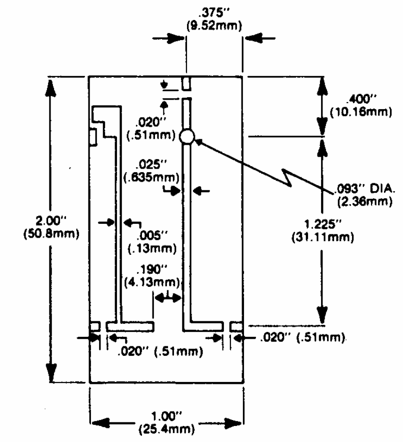
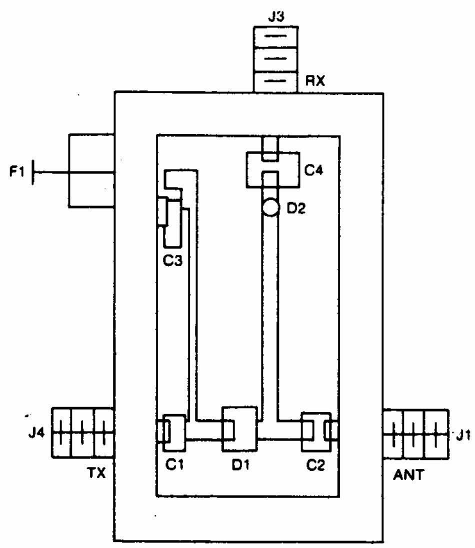


Figure: Substrate Drawing



Substrate Drawing



Assembly Drawing

Figure: Assembly Drawing

Parts list

F1	5000 pF Feed Through Filter	Erie 1270-016
C1-C4	30 pF Chip Capacitor	Vitramon VJ0805A300KF
D1	PIN Diode	Microsemi UM9401
D2	PIN Diode	Microsemi UM9601
J1-J3	SMA Connector	Cableware 971-028
	Substrate	Vectronics Microwave 79-9081-0401

NOTES: