

# 250 mW Power Amplifier with T/R and Diversity Switches

## 2.4 - 2.5 GHz

### AM55-0003

#### Features

- Highly Integrated Power Amplifier With T/R and Diversity Switches
- Operates Over 2.7 V to 6 V Supply Voltage
- High Linear Output Power ( $P_{1dB}$ : +24 dBm)
- Individual Gate Control for Each Amplifier Stage
- Low Cost SSOP-28 Plastic Package

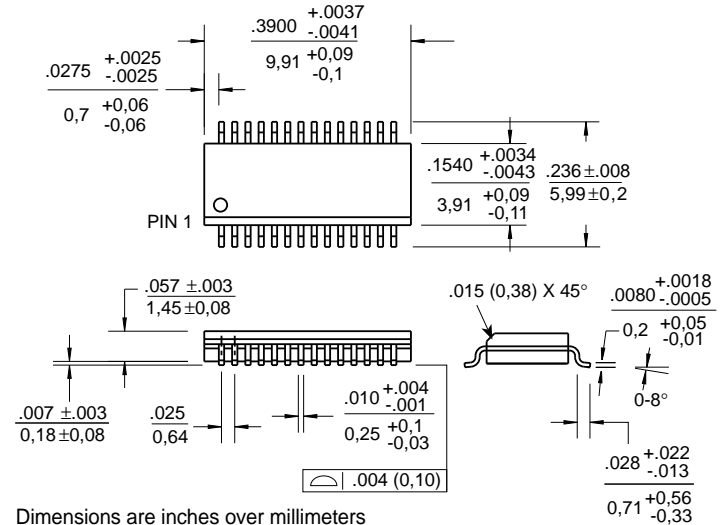
#### Description

M/A-COM's AM55-0003 is a GaAs power amplifier with integrated transmit/receive and an antenna diversity switch in a low cost SSOP 28 plastic package. The power amplifier delivers +24 dBm of linear power with high efficiency and can be operated with voltages as low as 2.7 volts. The power amplifier switch is fully monolithic. The T/R and diversity switches achieve good insertion loss and isolation without degrading the overall linearity. The switches can be controlled with CMOS logic levels.

The AM55-0003 is ideally suited for QPSK, BPSK or other linearly modulated systems in the 2.4 GHz ISM frequency band. It can also be used in GFSK systems where levels of +25 dBm are required. Typical applications include WLAN and wireless portable data collection. This power amplifier can be combined with a transceiver IC (MD58-0001 or MD58-0002) to form a complete RF front end.

M/A-COM's AM55-0003 is fabricated using a mature 0.5-micron gate length GaAs process. The process features full passivation for increased performance and reliability.

#### SSOP-28



#### Ordering Information

Part Number	Description
AM55-0003	SSOP 28-Lead Plastic Package
AM55-0003TR	Forward Tape & Reel*
AM55-0003RTR	Reverse Tape & Reel*
AM55-0003SMB	Designer's Kit

\* If specific reel size is required, consult factory for part number assignment.

#### Typical Electrical Specifications

**Test Conditions:** Frequency: 2.45 GHz,  $V_{DD1,2,3} = 5 V \pm 5\%$ ,  $V_{G1}$  adjusted for 20 mA quiescent bias on  $V_{DD1}$ ,  $V_{G2}$  adjusted for 70 mA quiescent bias on  $V_{DD2}$ ,  $V_{G3}$  adjusted for 90 mA quiescent bias on  $V_{DD3}$ ,  $T_A = +25^\circ C$

Parameter	Units	Min.	Typ.	Max.
<b>Power Amplifier</b>				
Linear Gain	dB	24	28	32
VSWR In/Out			1.75:1	
Output Power @ $P_{1dB}$	dBm	22.5	24.5	
Second Harmonic @ $P_{1dB}$	dBc		-20	0
Third Harmonic @ $P_{1dB}$	dBc		-30	-10
$I_{DD}$ @ $P_{1dB}$ ( $V_{DD1} + V_{DD2} + V_{DD3}$ )	mA		270	375
<b>T/R and Diversity Switches</b>				
Insertion Loss	dB		1.2	
Isolation	dB	10	12	
VSWR In/Out			1.5:1	

## Pin Configuration

Pin No.	Pin Name	Description
1	ANT CTRL	Antenna selection: Select ANT 1 (0V) or ANT 2 (+5 V)
2	ANT COMMON	Common Port of Diversity Switch
3	GND	DC and RF Ground
4	ANT 1	Output #1 of Diversity Switch
5	GND	DC and RF Ground
6	ANT 2	Output #2 of Diversity Switch
7	GND	DC and RF Ground
8	RX OUT	Output of T/R Switch for receive mode
9	V <sub>G2</sub>	Negative bias control for the second PA stage, adjusted to set V <sub>DD2</sub> quiescent bias current, which is typically 70 mA. Typical voltage at pin = -0.55 V Input impedance: > 1 MΩ
10	GND	DC and RF Ground
11	V <sub>DD1</sub>	Positive bias for the first stage of the PA, 2.7 to 6 volts
12	GND	DC and RF Ground
13	GND	DC and RF Ground
14	V <sub>G1</sub>	Negative bias control for the first PA stage, adjusted to set V <sub>DD1</sub> quiescent bias current, which is typically 20 mA. Typical voltage at pin = -0.75 V Input impedance: > 1 MΩ
15	RF IN	RF Input of the Power Amplifier
16	GND	DC and RF Ground
17	V <sub>G3</sub>	Negative bias control for the third PA stage, adjusted to set V <sub>DD3</sub> quiescent bias current, which is typically 90 mA. Typical voltage at pin = -0.95 V Input impedance: > 1 MΩ
18	V <sub>DD2</sub>	Positive bias for the second stage of the PA, 2.7 to 6 volts
19	GND	DC and RF Ground
20	GND	DC and RF Ground
21	GND	DC and RF Ground
22	GND	DC and RF Ground
23	V <sub>DD3</sub>	Positive bias for the third stage of the PA, 2.7 to 6 volts
24	GND	DC and RF Ground
25	RF OUT	RF output of T/R switch and power amplifier for transmit mode
26	T/R CTRL	0 V for transmit mode, +5 V for receive mode
27	V <sub>DD</sub> TR	V <sub>DD</sub> for T/R switch
28	V <sub>DD</sub> ANT	V <sub>DD</sub> for Diversity Switch

Absolute Maximum Ratings<sup>1</sup>

Parameter	Absolute Maximum
Max. Input Power <sup>2</sup>	+23 dBm
Operating Voltages <sup>2,3</sup>	V <sub>DD</sub> = 8 V V <sub>GG</sub> = -8 V
Operating Temperature	-40°C to +85°C
Storage Temperature	-65°C to +150°C

1. Exceeding these limits may cause permanent damage.

2. Ambient temperature (T<sub>A</sub>) = +25°C

3. |V<sub>DD</sub>| + |V<sub>GG</sub>| not to exceed 12 volts.

## Truth Table

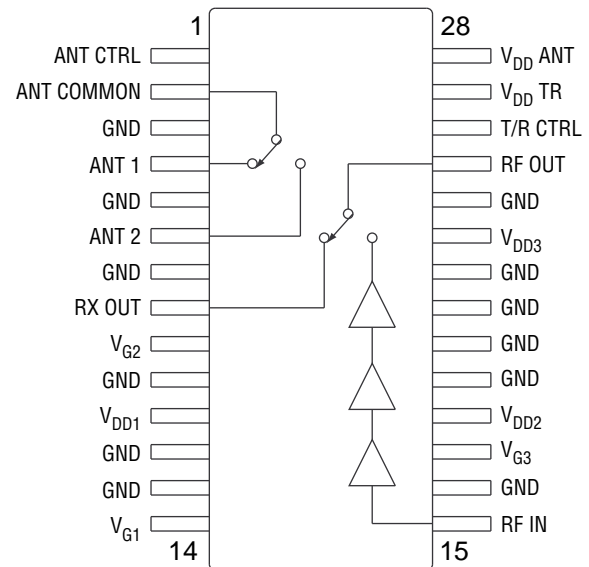
Control Line		Operating Mode
ANT CTRL	T/R CTRL	
X	1	Receive
X	0	Transmit
0	X	ANT 1
1	X	ANT 2

X - Don't Care

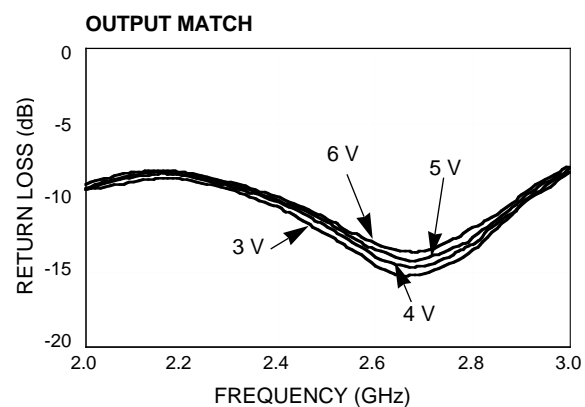
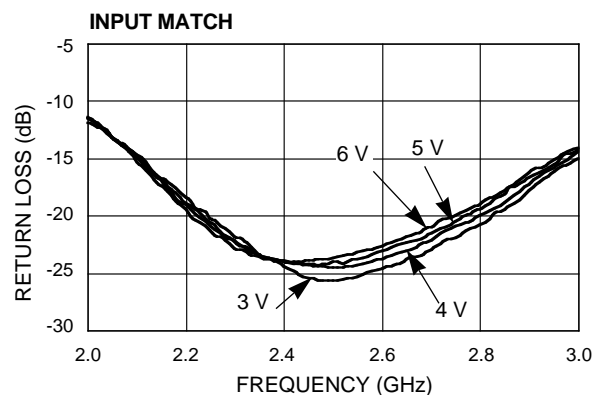
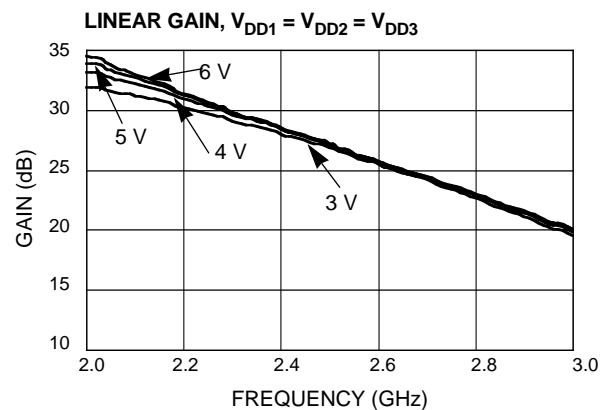
"0" = 0 V to 0.2 V @ 100 μA

"1" = V<sub>DD</sub> to V<sub>DD</sub> - 0.2 V @ 200 μA

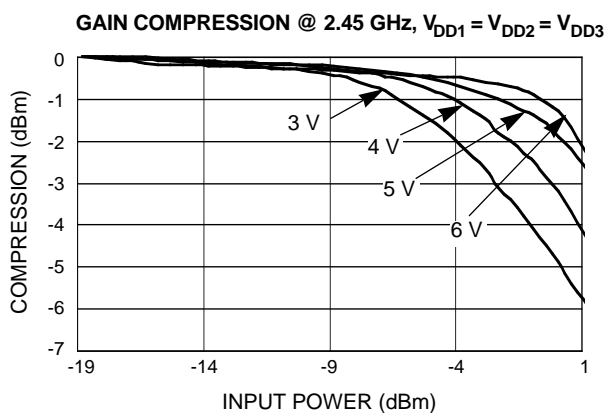
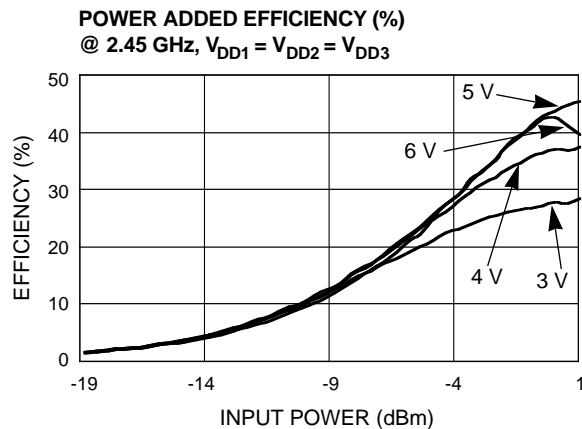
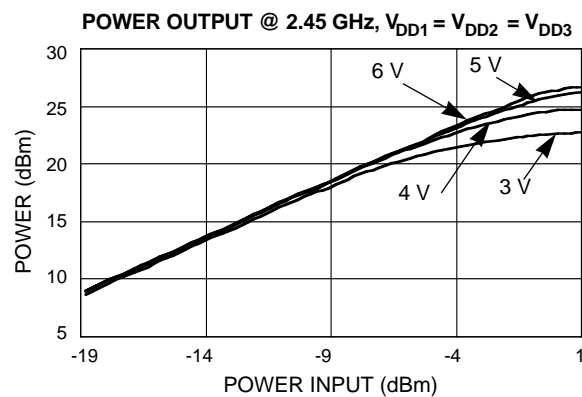
## Functional Diagram and Pin Configuration



### Power Amplifier Small Signal Performance<sup>1</sup>

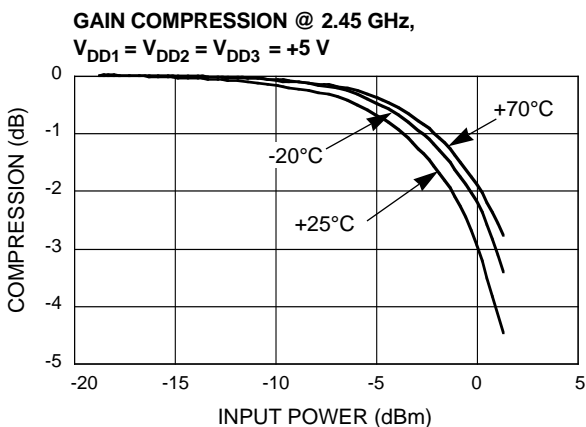
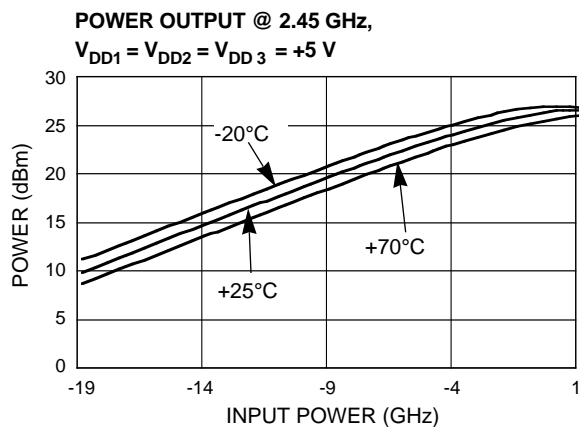
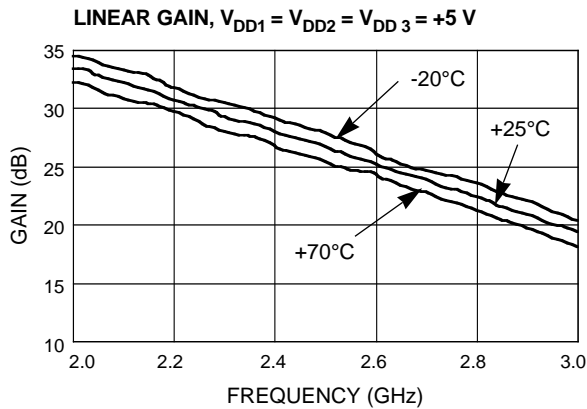


### Power Amplifier CW Performance at Various Supply Voltages<sup>1</sup>

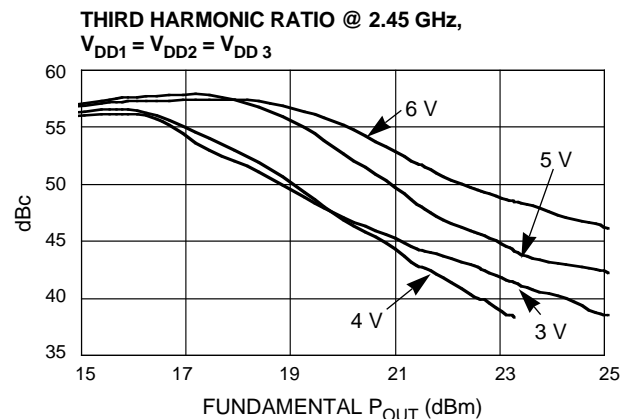
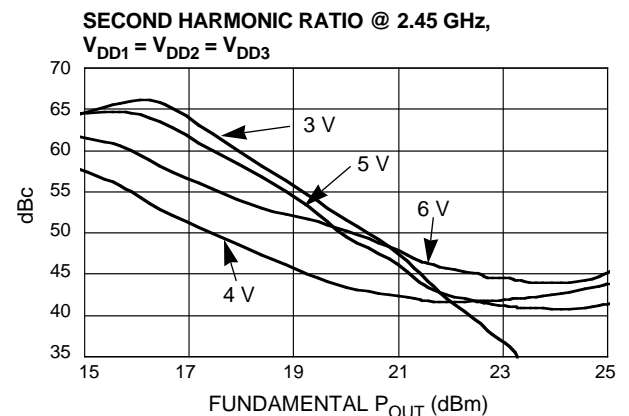
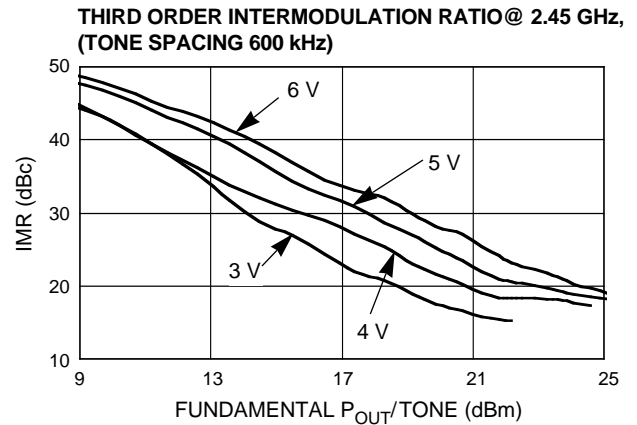


1. All data measured at  $T_A = +25^\circ\text{C}$  and  $V_{G1}$ ,  $V_{G2}$  and  $V_{G3}$  adjusted for first stage quiescent current of 20 mA, second stage current of 70 mA and third stage current of 90 mA, respectively.

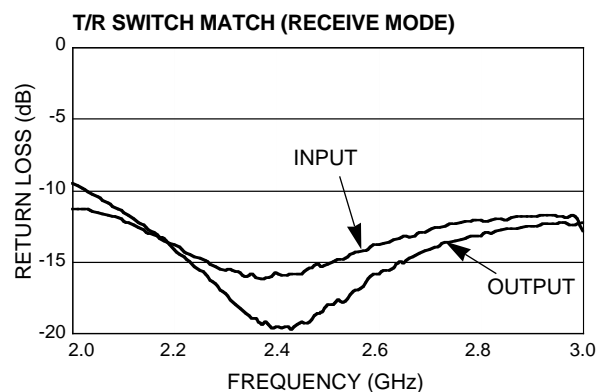
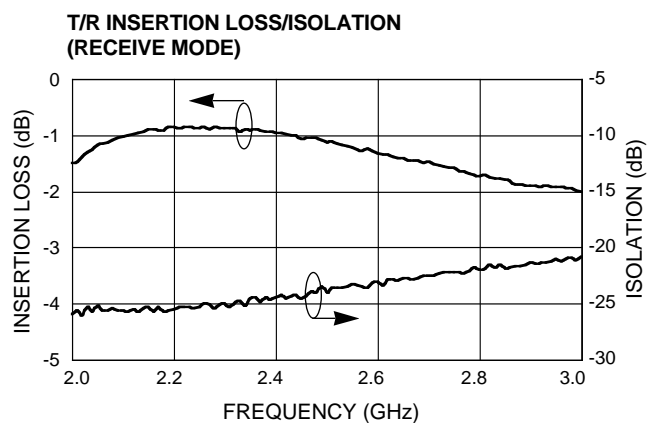
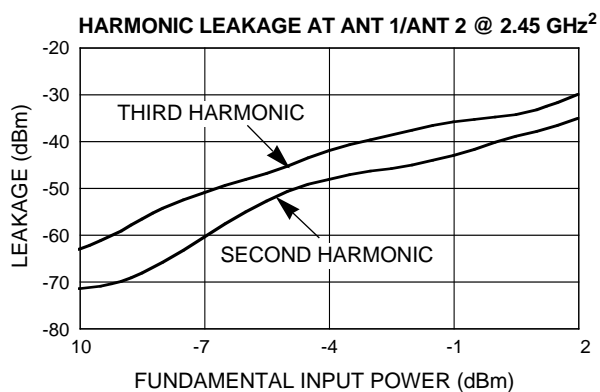
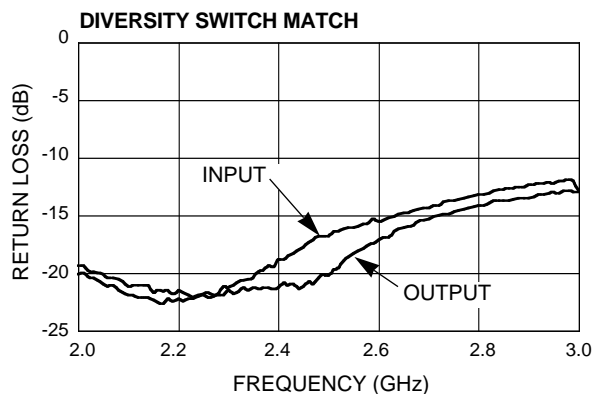
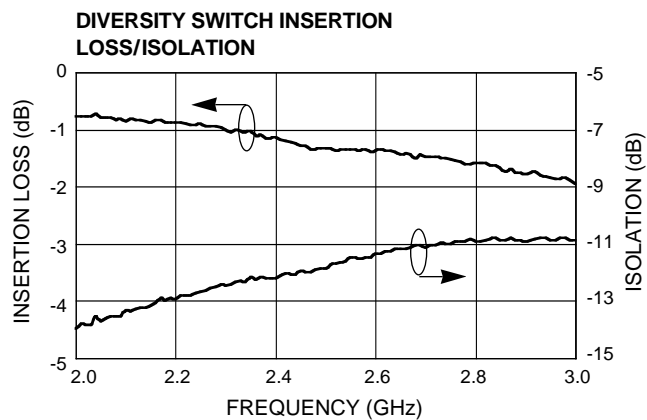
### Power Amplifier Temperature Performance<sup>1</sup>



### Power Amplifier Spurious Response at Various Supply Voltages<sup>1</sup>



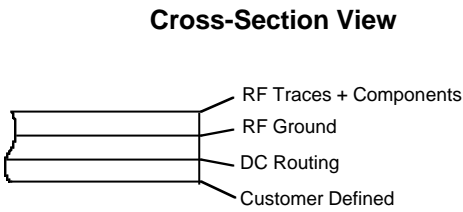
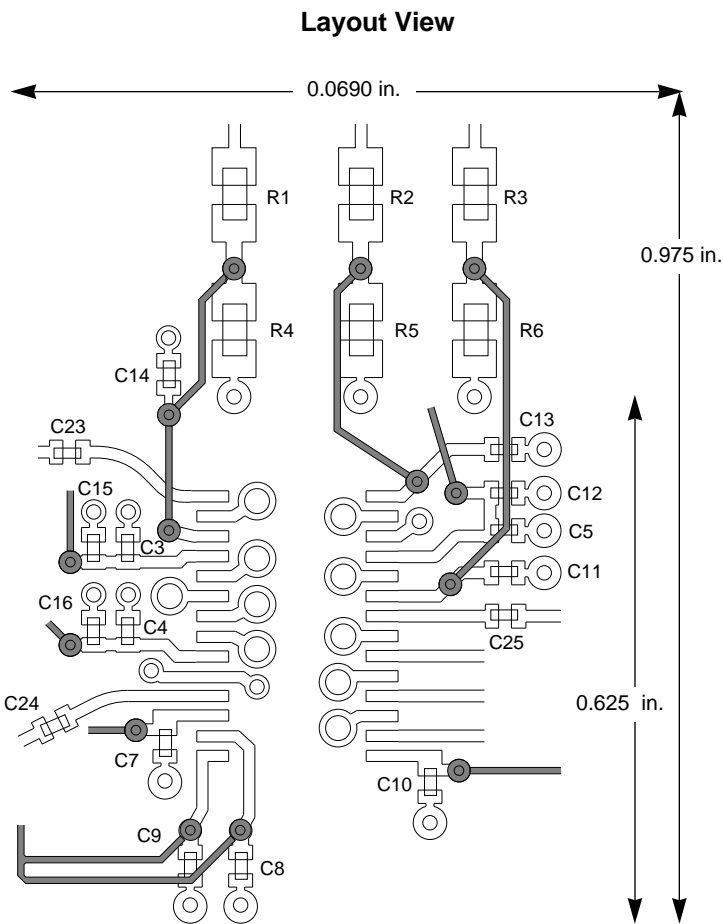
1. All data measured at  $T_A = +25^\circ\text{C}$  and  $V_{G1}$ ,  $V_{G2}$  and  $V_{G3}$  adjusted for first stage quiescent current of 20 mA, second stage current of 70 mA and third stage current of 90 mA, respectively.

Transmit/Receive Switch Performance<sup>1</sup>Diversity Switch Performance<sup>1</sup>

1. All data measured with  $V_{DD} = V_{DD} = V_{ANT} = +5\text{ V}$ ,  $T_A = +25^\circ\text{C}$ .

2. Measured at 2.45 GHz at RF IN. Output measured at ANT 1 or ANT 2, with RF OUT and ANT COMMON terminated in  $50\ \Omega$ .

Recommended PCB Configuration



The PCB dielectric between RF traces and RF ground layers should be chosen to reduce RF discontinuities between 50-Ω lines and package pins. M/A-COM recommends an FR-4 dielectric thickness of 0.008 in. (0.2 mm), yielding a 50-Ω line width of 0.015 in. (0.38 mm). The recommended metalization thickness is 1 oz. copper.

Shaded traces are vias to DC routing layer and traces on DC routing layer.

**Biasing Procedure**

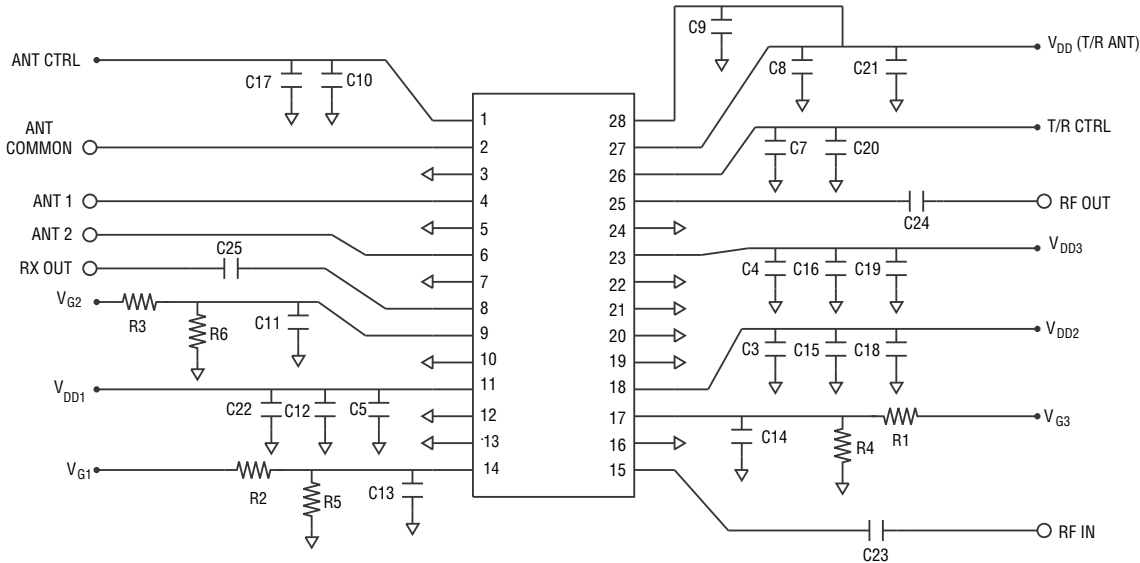
The AM55-0003 requires that  $V_{GG}$  bias be applied prior to *any*  $V_{DD}$  bias. Permanent damage may occur if this procedure is not followed. All FETs in the PA will draw excessive current and damage internal circuitry.

External Circuitry Parts List

Label	Value	Purpose
C1 - C6	22 pF	Bypass (GHz)
C23 - C24	22 pF	DC Block
C7 - C16	1000 pF	Bypass (MHz)
C17 - C22	0.01 μF	Bypass (kHz)
R1, R6	1.5 kΩ	FET Gate Divider Network
R3, R5	5 kΩ	
R2	12 kΩ	
R4	1 kΩ	

All off-chip components are low-cost surface mount components obtainable from multiple sources. (0.020 in. x 0.040 in. or 0.030 in. x 0.050 in.)

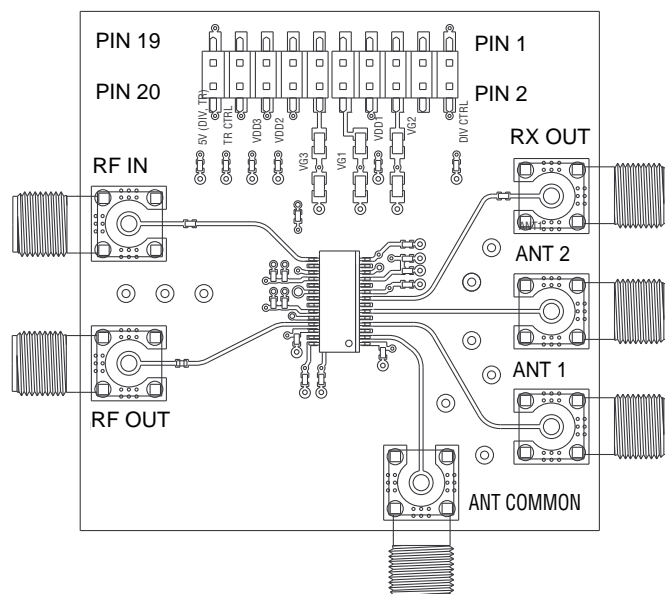
External Circuitry



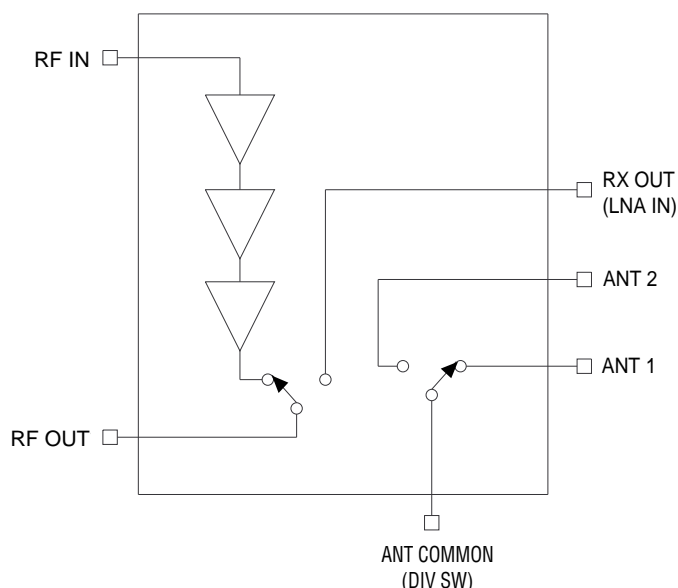
## Designer's Kit (AM55-0003SMB)

The AM55-0003SMB Designer's Kit allows for immediate evaluation of M/A-COM's AM55-0003 integrated power amplifier with T/R and diversity switches. The evaluation board consists of an AM55-0003, recommended external surface mount circuitry, RF connectors and a DC multi-pin connector, all mounted to a multi-layer FR-4 PCB. Other items included in the Designer's Kit: a floppy disk (with typical performance data and a .DXF file of the recommended PCB layout) and any additional Application Notes. The AM55-0003SMB evaluation PCB and block diagram are illustrated below with all functional ports labeled.

## P/A Switch Sample Board



## Functional Block Diagram



## DC Connector Pinout

PCB DC Connector	Function	Device Pin Number
1	GND	N/C
2	ANT CTRL (0 V/ +5 V)	1
3	N/C	N/C
4	N/C	N/C
5	N/C	N/C
6	$V_{G2}$	9
7	VSW	N/C
8	$V_{DD1}$ (+5 V)	11
9	N/C	N/C
10	$V_{G1}$	14

PCB DC Connector	Function	Device Pin Number
11	N/C	N/C
12	V <sub>G3</sub>	17
13	N/C	N/C
14	V <sub>DD2</sub> (+5 V)	18
15	N/C	N/C
16	V <sub>DD3</sub> (+5 V)	23
17	N/C	N/C
18	T/R CTRL (0 V/ +5 V)	8
19	GND	N/C
20	V <sub>DD</sub> TR, V <sub>DD</sub> ANT(+5 V)	27, 28

## AM55-0003SMB Biasing Procedure

*In order to prevent transients which may damage the MMIC, please adhere to the following procedure.*

- Turn on all power supplies and set all voltages to 0 volts BEFORE connecting the power supplies to the DC connector.
- Apply a -5.0 volt supply to DC connector pin 10 ( $V_{G1}$ ).
- Apply a -5.0 volt supply to DC connector pin 6 ( $V_{G2}$ ).
- Apply a -5.0 volt supply to DC connector pin 12 ( $V_{G3}$ ).
- Apply a +5.0 volt supply to the DC connector pin 20 ( $V_{DD}$  TR,  $V_{DD}$  ANT).
- Apply a +5.0 volt supply to the DC connector pin 8 ( $V_{DD1}$ ).
- Apply a +5.0 volt supply to the DC connector pin 14 ( $V_{DD2}$ ).
- Apply a +5.0 volt supply to the DC connector pin 16 ( $V_{DD3}$ ).
- Apply a GND or +5.0 volt supply to the DC connector pin 18 (T/R CTRL, see truth table for desired mode).
- Apply a GND or +5.0 volt supply to the DC connector pin 2 (ANT CTRL, see truth table for desired mode).
- Adjust  $V_{G1}$ ,  $V_{G2}$ ,  $V_{G3}$  supplies to -5 volts.
- Adjust all  $V_{DD}$  supplies to +5 volts.
- Adjust  $V_{G1}$  supply for desired  $V_{DD1}$  quiescent current (typically 20 mA,  $V_{G1}$  nominally -2.5 volts).
- Adjust  $V_{G2}$  supply for desired  $V_{DD2}$  quiescent current (typically 70 mA,  $V_{G2}$  nominally -2.5 volts).
- Adjust  $V_{G3}$  supply for desired  $V_{DD3}$  quiescent current (typically 90 mA,  $V_{G3}$  nominally -2.5 volts).
- To power off, reverse above procedure.
  - 1) Set all  $V_{DD}$  lines to 0 volts.
  - 2) Set  $V_{G1}$ ,  $V_{G2}$  and  $V_{G3}$  to 0 volts.
  - 3) Disconnect bias lines from DC connector.
  - 4) Turn off power supplies.

## Evaluation PCB and RF Connector Losses

Port Reference	Loss (dB)
RF IN	0.25
RF OUT	0.25
RX OUT (LNA IN)	0.25
ANT COMMON (DIV SW)	0.25
ANT 1	0.25
ANT 2	0.25

The DC connector on the Designer's Kit PCB allows selection of all the device's operating modes. It is accomplished by one or more of the following methods.

1. A mating female multi-pin connector (Newark Electronics Stock #46F-4658, not included)
2. Wires soldered to the necessary pins (not included)
3. Clip leads (not included)
4. A combination of clip leads or wires and jumpers (jumpers included as required)