Voltage Variable Attenuator, 32 dB Range
DC - 12 GHz

MAAV-011017
Rev. V3

Features

- Analog Control
- Attenuation Range: 32 dB
- Input IP3: 52 dBm
- Input IP2: 80 dBm
- Supply Voltage: 3.15 to 5.25 V
- Operating Temperature: -40 to +120°C
- Low DC Power Consumption
- Lead-Free 3 mm 16-Lead Package
- RoHS* Compliant

Applications

- Microwave Radio
- Cellular, 5G Infrastructure
- WiFi, WiMax, LTE
- High Linearity Power Control

Description

The MAAV-011017 is a wide band voltage variable attenuator with analog control. It is assembled in a lead-free 3 mm, 16 PQFN package. This device is ideally suited for use where high accuracy, very low power consumption, and low intermodulation products are required.

V_{MODE} is a control pin to select either a positive or negative slope to the attenuation vs. control voltage curve. When V_{MODE} is high, there is a positive slope to the curve. There is a negative slope when V_{MODE} is low.

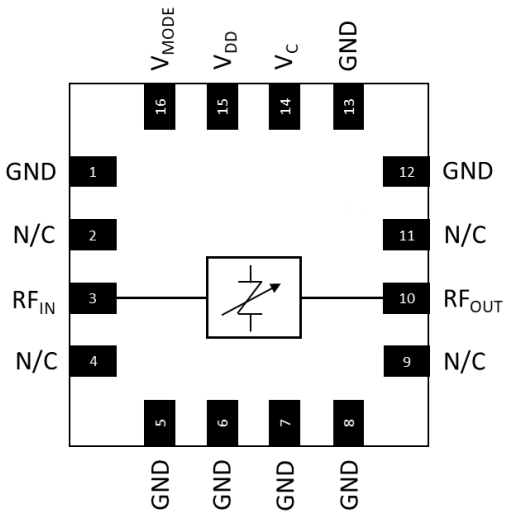
The part operates down to DC but the power handling degrades below 50 MHz. No DC blocks on RF pins are needed if the source and loads have a DC connection to ground.

Ordering Information[1,2]

Part Number	Package
MAAV-011017-TR0500	500 piece reel
MAAV-011017-SMB	Sample Board

1. Reference Application Note M513 for reel size information.
2. All sample boards include 5 loose parts.

Functional Schematic



Pin Function[3]

Pin #	Function
1,5,6,7,8,12,13	Ground
2,4,9,11	No Connection
3	RF Input
10	RF Output
14	Control Voltage
15	Supply Voltage
16	Slope Control
17	Exposed Pad[4]

3. MACOM recommends connecting unused package pins to ground.
4. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

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

Pin Description

Pin #	Name	Description
1, 5, 6, 7, 8, 12, 13	GND	These pins are not connected internally but should be grounded on the board in the shortest way.
2, 4, 9, 11	N/C	These pins are not connected internally and can stay opened (or grounded) on the board.
3	RF_{IN}	This pin is DC coupled to ground internally. No external coupling capacitor is needed if the DC voltage applied is 0V.
10	RF_{OUT}	This pin is DC coupled to ground internally. No external coupling capacitor is needed if the DC voltage applied is 0V.
14	V_C	Control voltage. Standard diode ESD protection at the input. An external RC low pass filter is recommended to reduce noise.
15	V_{DD}	Supply voltage. Bypass with 1nF close to the pin.
16	V_{MODE}	Slope control voltage. Digital input. 1.8V to 3.3V logic. Standard diode ESD protection at the input. An external RC low pass filter is recommended to reduce noise. V_{MODE}=V_C=0V is lowest attenuation.
17	E_P	Exposed paddle. This is where our reference case temperature is measured. Ground with as many vias as practical for electrical and thermal performance.

RF Electrical Specifications[5]: Freq. = 8 GHz, T_C = 25°C, 50 Ω, V_{DD} = 5 V, V_{MODE} = 0 V, P_{IN} = 0 dBm

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Reference Insertion Loss	2 GHz 4 GHz 6 GHz 8 GHz 12 GHz	dB	—	1.2 1.5 1.8 2.1 3.2	— — — 2.5 3.8
Maximum Attenuation	V_C = 2.2 V, relative to IL state 2 GHz 4 GHz 8 GHz 12 GHz	dB	— — 29 23	32.5 32.5 31.0 27.0	—
Mid Range Attenuation	V_C = 2.2 V, relative to IL state 1 GHz 4 GHz 8 GHz 12 GHz	dB	— — 12.5 13.5	15 15 16 17	—
Mid Range Insertion Phase	V_C = 1.2 V, relative to IL state	deg	—	-63.5	—
Attenuation Slope	Over V_C	mV/dB	—	42	—
Attenuation Variation	Over V_C, over temp, process and V_{DD}	dB	—	+/-3	—
Input Return Loss	Full control voltage range	dB	—	14	—
Output Return Loss	Full control voltage range	dB	—	20	—
Input P0.1dB	V_C = 0 V, 5 MHz V_C = 0 V, 1800 MHz	dBm	—	30	—
IIP_3	20 dBm/tone, 50 MHz Spacing (Full control voltage range)	dBm	—	52	—
IIP_2 sum	20 dBm/tone, 50 MHz Spacing (Full control voltage range), F1+F2	dBm	—	95	—
IIP_2 diff	20 dBm/tone, 50 MHz Spacing (Full control voltage range), F1-F2	dBm	—	80	—
Settling Time	50% V_C to ±0.1 dB of final value, for any 1 dB change in attenuation	µs	—	20	—

5. Parameters are measured on a test board, which is de-embedded to the package pins.

DC Electrical Specifications: T_A = 25°C, V_{DD} = +5 V

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Supply Voltage	—	V	3.15	5.0	5.25
Supply Current	V_{MODE} = 0 V, V_C = 2.5 V	mA	—	1.3	1.7
Control Voltage	P_{IN} V_C, Any supply voltage	V	0	—	2.5
Control Current	P_{IN} V_C, Any supply voltage	µA	-1	—	50
V_{MODE} Logic high	—	V	1.17	—	3.45
V_{MODE} Logic low	—	V	0	—	0.63
V_{MODE} current	0 V, from pullup resistor	µA	—	5	—

Recommended Operating Conditions

Parameter	Symbol	Unit	Min.	Typ.	Max.
Input Power	-	dBm	—	—	32
DC Supply voltage	V_{DD}	V	3.15	5.0	5.25
Junction Temperature[6,7]	T_J	°C	—	—	125
Operating Temperature[8]	T_C	°C	-40	—	120

6. Operating at nominal conditions with $T_J \leq +125°C$ will ensure MTTF > 1 x 10^6 hours.
7. Junction Temperature (T_J) = T_C + Θjc * (P_{RF})
   Typical thermal resistance (Θjc) = 30 °C/W.
8. Defined as case temperature and measured on the exposed paddle.

Absolute Maximum Ratings[9,10]

Parameter	Symbol	Unit	Min.	Max.
Input Power	—	dBm	—	36
DC Supply Voltage	V_{DD}	V	—	5.5
Control Voltage	V_C	V	-0.5	3.5
Junction Temperature	T_J	°C	—	150
Operating Temperature[9]	T_C	°C	—	135
Storage Temperature	—	°C	-65	150

8. Exceeding any one or combination of these limits may cause permanent damage to this device.
9. MACOM does not recommend sustained operation near these survivability limits.

Power Supply Sequencing

Pins V_C and V_{MODE} should be at zero before and when V_{DD} is ramped up.

V_{DD} should not ramp faster than 1 V / 20 µs.

Pins V_C and V_{MODE} should be set to zero before V_{DD} is ramped down.

Handling Procedures

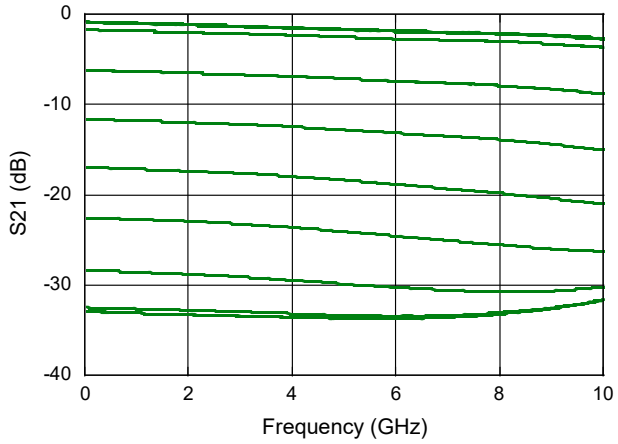
Please observe the following precautions to avoid damage:

Static Sensitivity

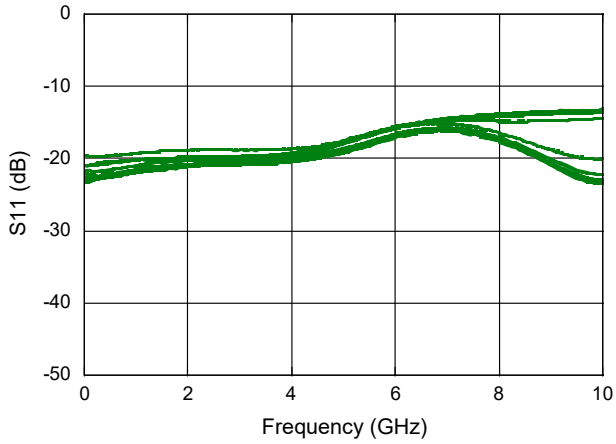
These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM class 1C devices.

Typical Performance[10]: V_{DD} = 5 V, V_{MODE} = 2 V, T_C = +25°C, V_C from 0 to 2.4 V, step 0.2 V

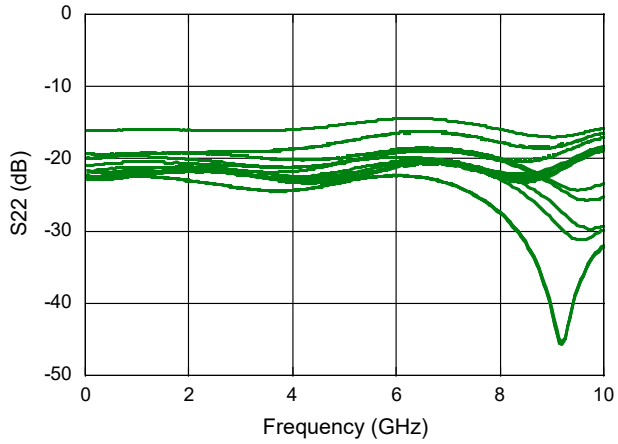
S21



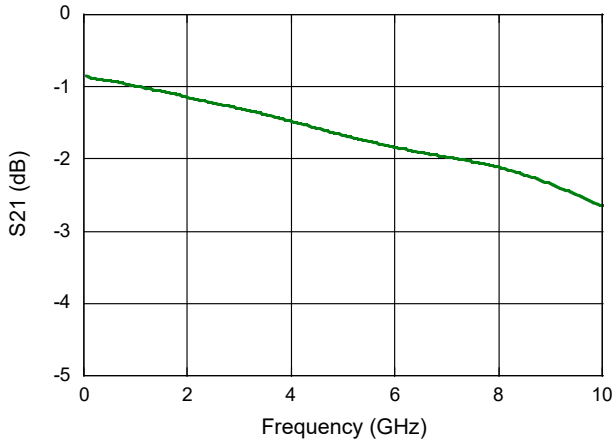
S11



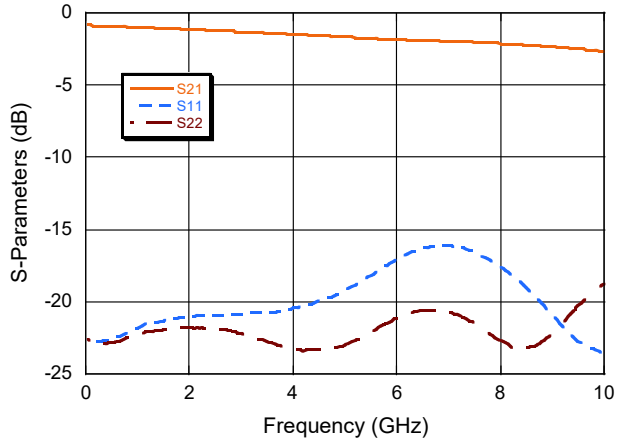
S22



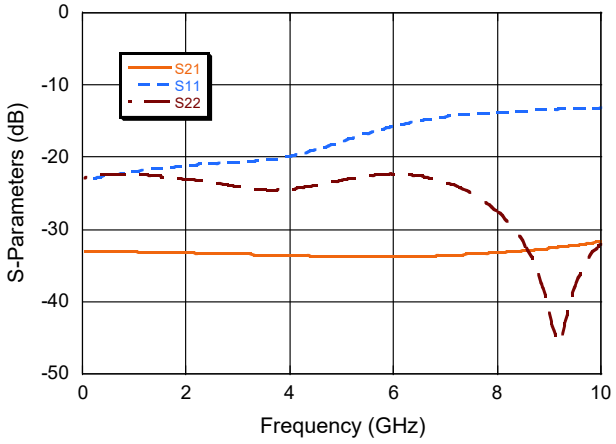
S21 @ V_C = 0 V



S11, S22, S21 @ V_C = 0 V

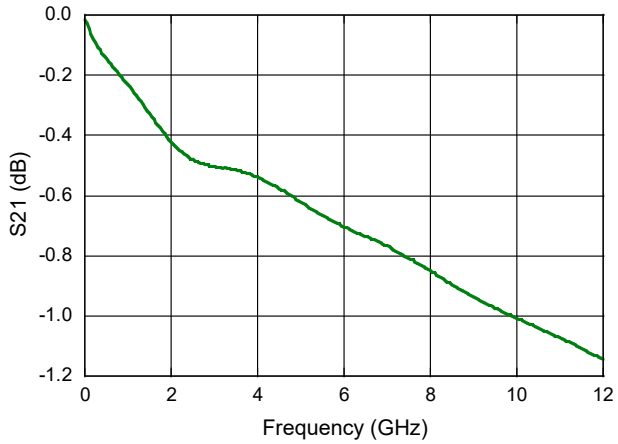


S11, S22, S21 @ V_C = 2.5 V

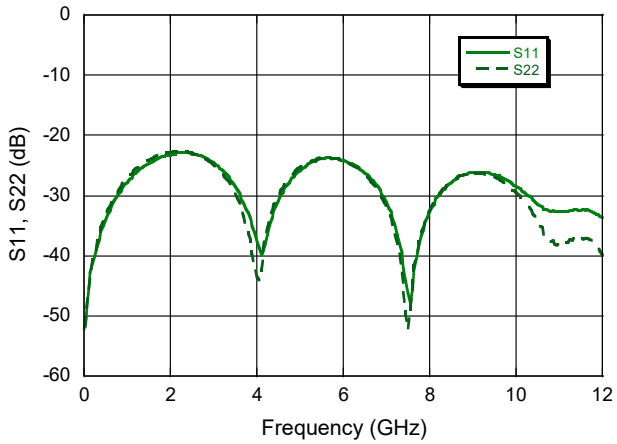


Typical Performance[10]: V_{DD} = 5 V, V_{MODE} = 0 V, T_C = +25°C, V_C from 0 to 2.4 V, step 0.2 V

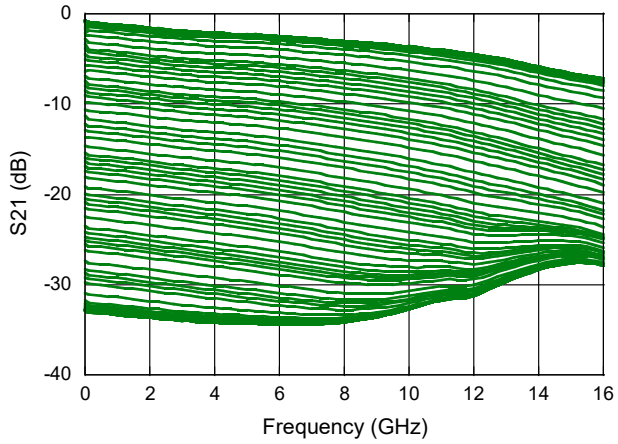
S21 Through Line



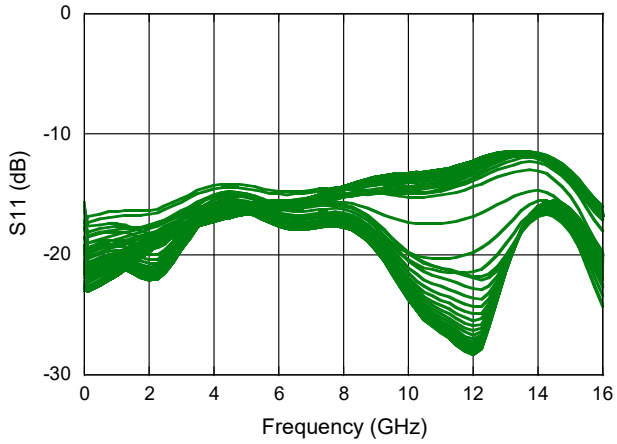
S11, S22 Through Line



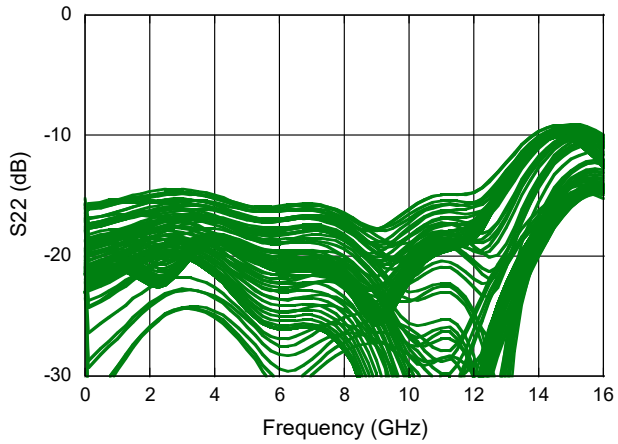
S21, Wide Band, not de-embedded



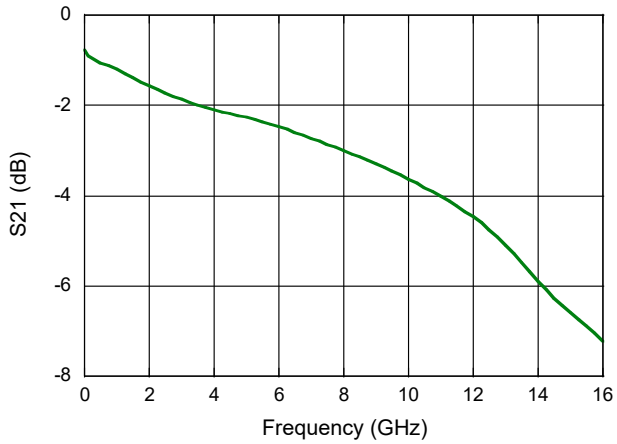
S11, Wide Band, not de-embedded



S22, Wide Band, not de-embedded

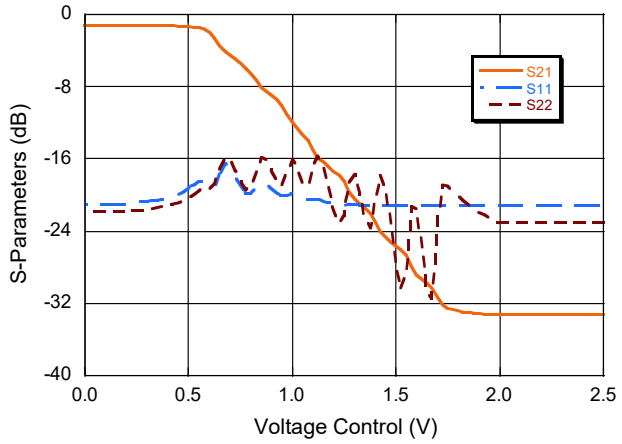


S21 @ V_C = 2.5 V, not de-embedded

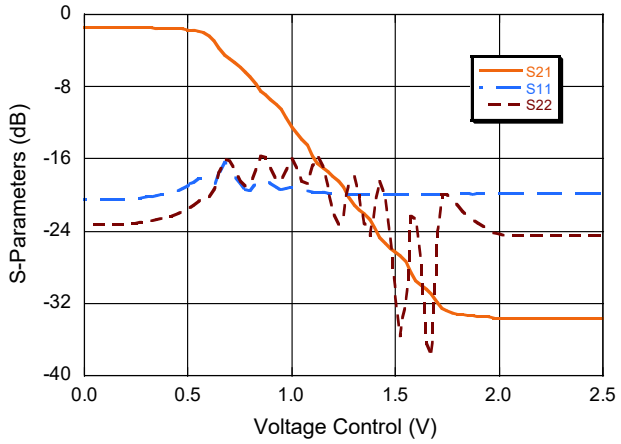


Typical Performance[10], V_{DD} = 5 V, V_{MODE} = 0 V, T_C = +25°C, V_C from 0 to 2.4 V, step 0.2 V

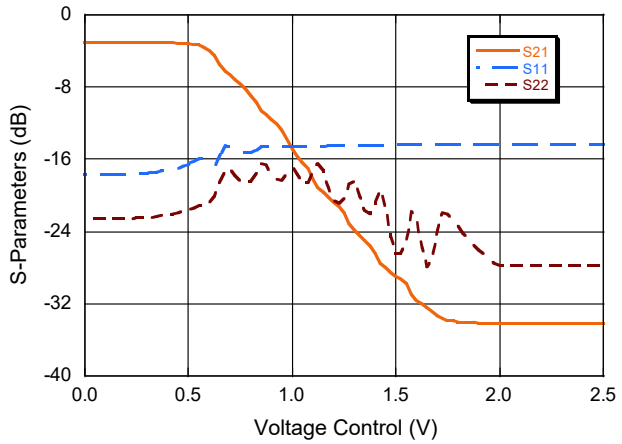
S21, S11, S22 @ 2 GHz



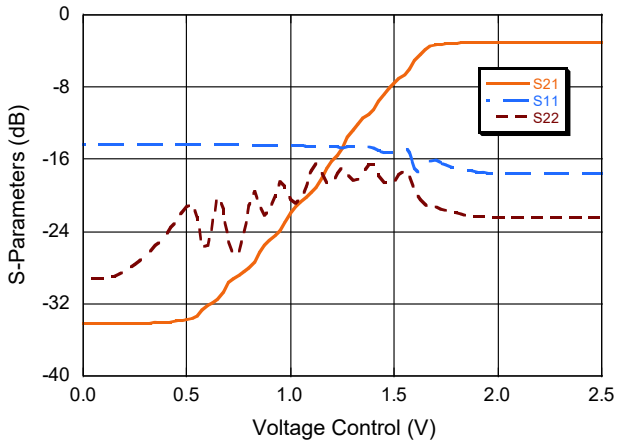
S21, S11, S22 @ 4 GHz



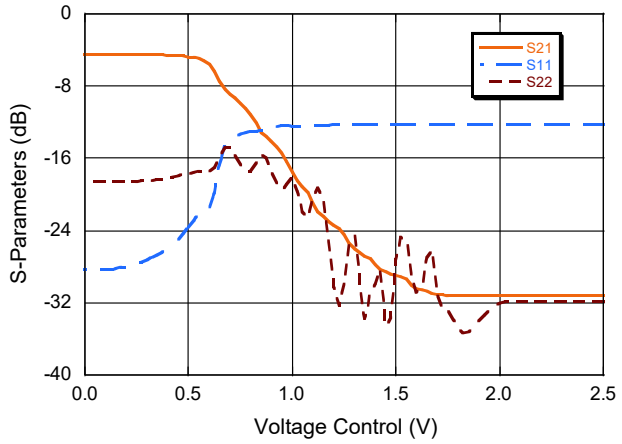
S21, S11, S22 @ 8 GHz



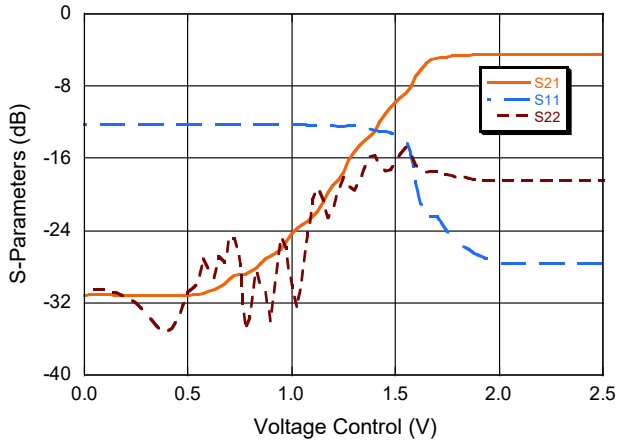
S21, S11, S22 @ 8 GHz, V_{MODE} = 2 V not de-embedded



S21, S11, S22 @ 12 GHz

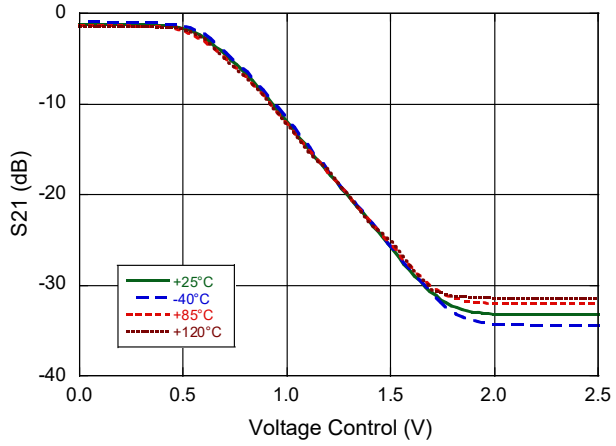


S21, S11, S22 @ 12 GHz, V_{MODE} = 2 V not de-embedded

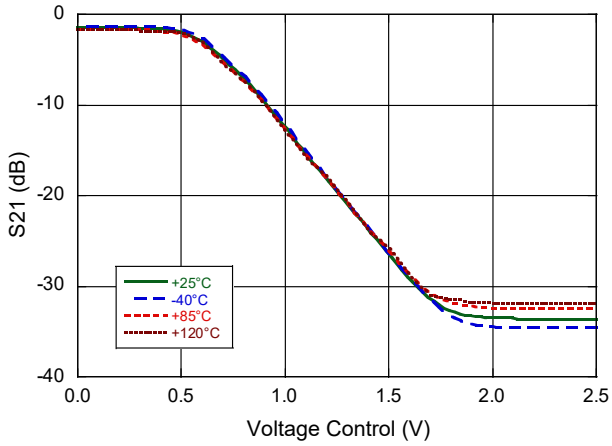


Typical Performance Curves[10]: V_{DD} = 5 V, V_{MODE} = 0 V

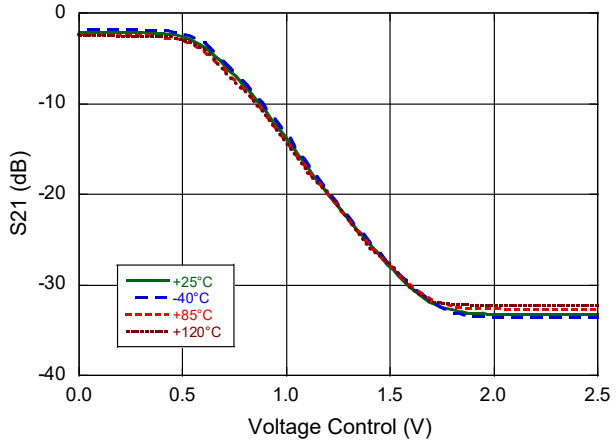
S21 @ 2 GHz



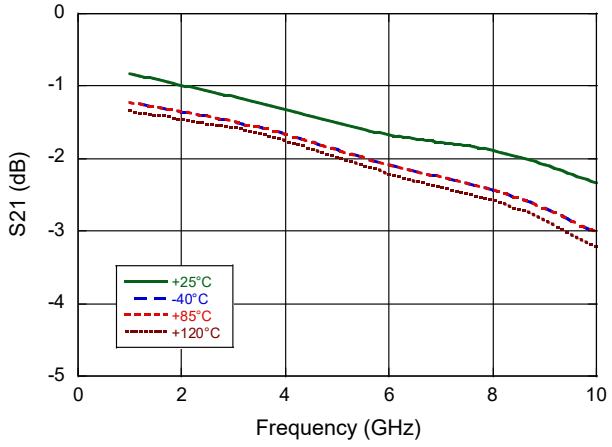
S21 @ 4 GHz



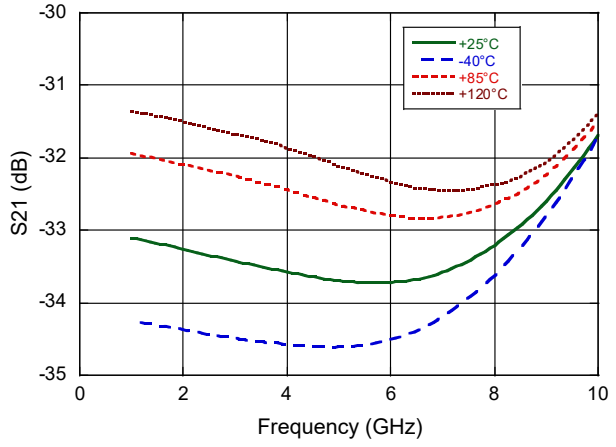
S21 @ 8 GHz



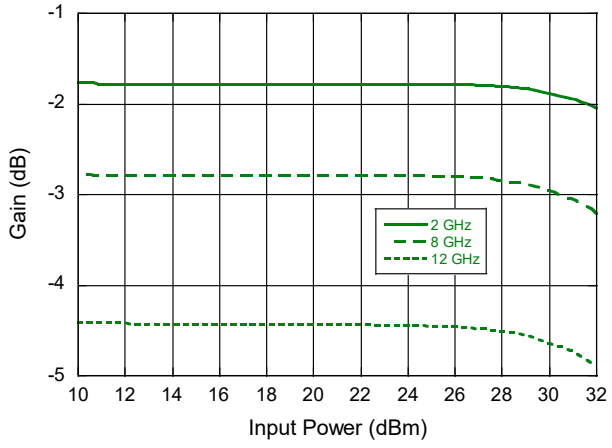
S21 V_C = 0 V



S21 V_C = 2.5 V

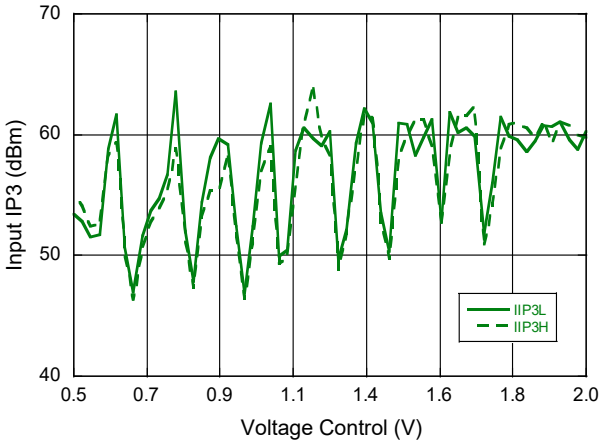


Power Gain, V_C = 0.3 V

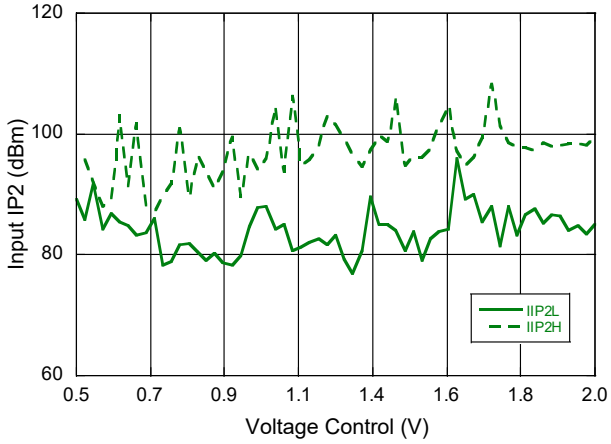


Typical Performance Curves[10]: V_{DD} = 5 V, V_{MODE} = 0 V, PRF = 20 dBm, F1-F2 = 50 MHz

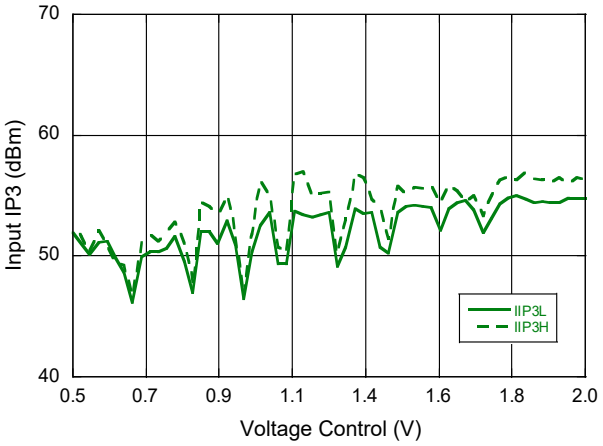
Input IP3 @ 2 GHz



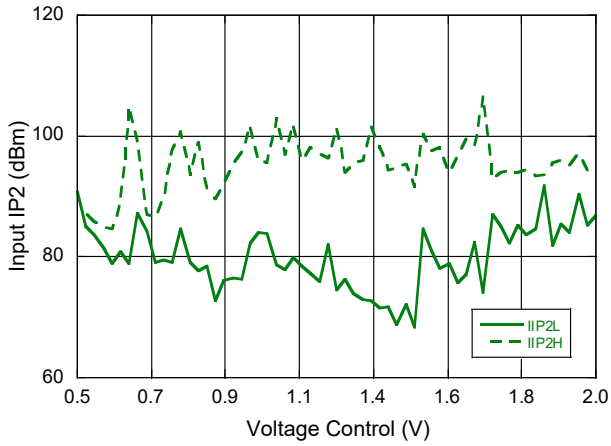
Input IP2 @ 2 GHz



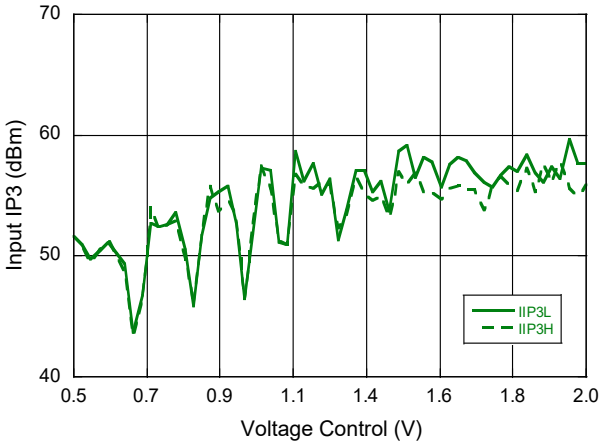
Input IP3 @ 8 GHz



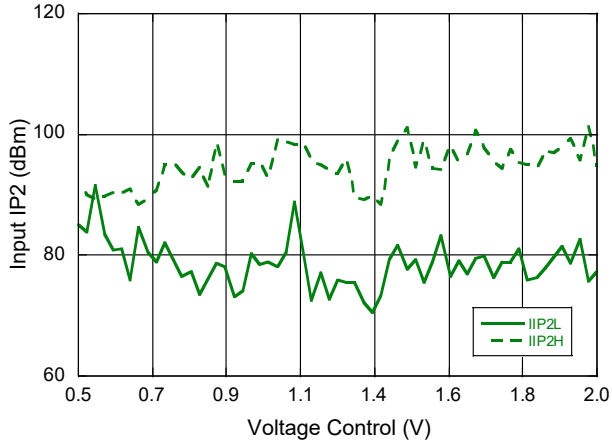
Input IP2 @ 8 GHz



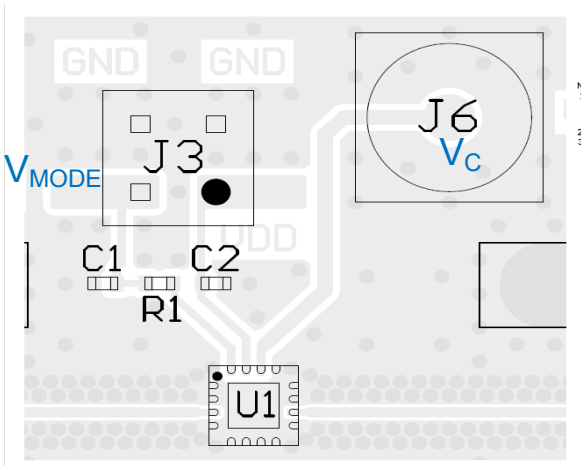
Input IP3 @ 12 GHz



Input IP2 @ 12 GHz



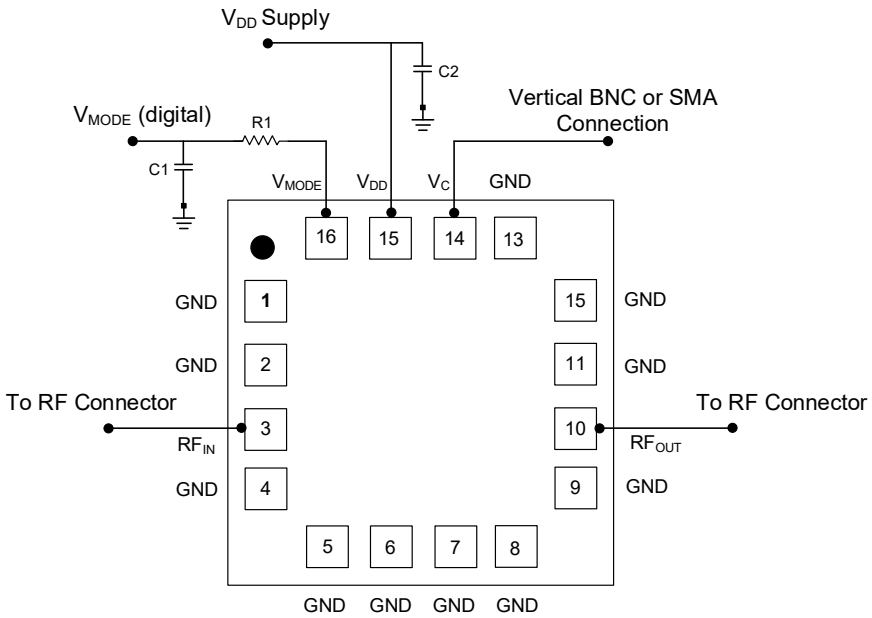
PCB Layout



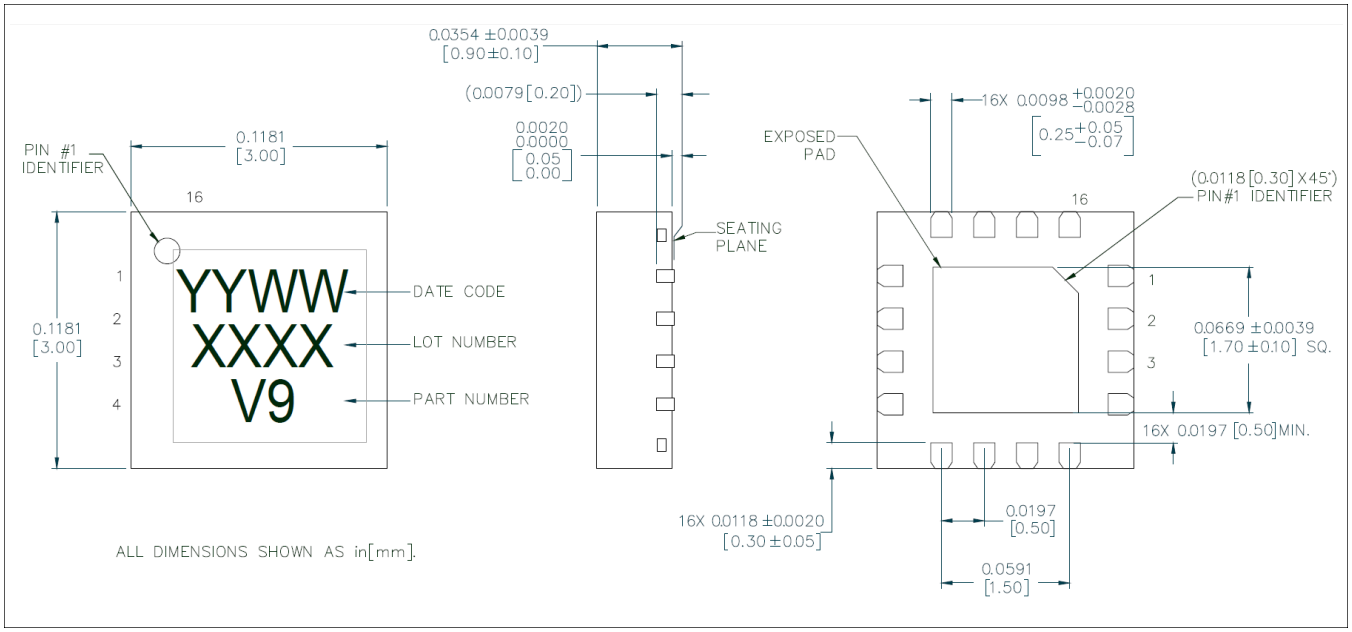
Parts List

Part	Value	Case Style
R1	1 kΩ	0402
C1	10 pF	0402
C2	10 nF	0402

Application Schematic



Lead-Free 3 mm 16-Lead PQFN†



† Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 1 requirements.
Plating is 100% matte tin over copper

Revision history

Rev	Date	Change description
V1	Sept 2023	Initial Final datasheet release.
V2	Nov 2023	Change ordering table to TR0500
V2	Jan 2024	Min limits for Mid Range Attenuation to 12.5 dB for 8 GHz and 13.5 dB for 12 GHz. Also fix the typo on top of spec table on page 3 to 50 Ω.