Voltage Variable Attenuator, 31 dB
5 - 3000 MHz, 75 Ω

MAAV-011018
Rev. V2

Features
- DC - 6 GHz in 50 Ω Application Possible
- 31 dB Range
- Analog Control
- Input IP3: 50 dBm
- Supply Voltage: 3.15 to 5.25 V
- Operating Temperature Range: -40°C to +120°C
- DC Current: 1.5 mA
- Lead-Free 3 mm 16-Lead Package
- RoHS* Compliant

Applications
- DOCSIS 4.0 & Extended Spectrum DOCSIS
- CATV/DOCSIS Amplifiers and Nodes
- High Linearity Power Control
- Cable Modems
- Remote PHY

Description
The MAAV-011018 is a 75 Ω voltage variable attenuator with analog control that provides 31 dB of attenuation over the 5 to 3000 MHz frequency band. 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.

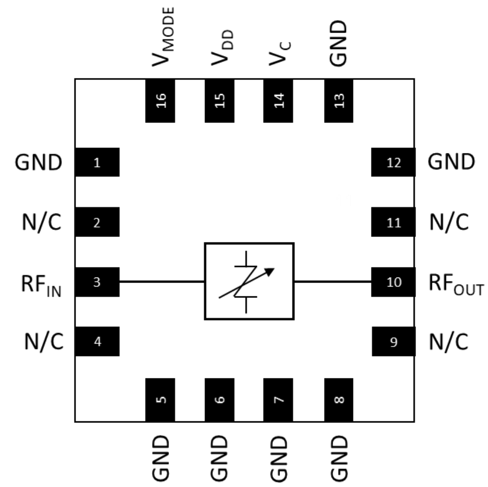
The part actually operates down to DC but the power handling degrades below 5 MHz. No DC blocks on RF pins are needed if the source and loads have a DC connection to ground.

Ordering Information[1,2]

Part Number	Package
MAAV-011018-TR1000	1000 piece reel
MAAV-011018-TR3000	3000 piece reel
MAAV-011018-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.

DC-0028012

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 0 V.
10	RF_{OUT}	This pin is DC coupled to ground internally. No external coupling capacitor is needed if the DC voltage applied is 0 V.
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 1 nF close to the pin.
16	V_{MODE}	Slope control voltage. Digital input. 1.8 V to 3.3 V logic. Standard diode ESD protection at the input. An external RC low pass filter is recommended to reduce noise. $V_{MODE} = V_C = 0$ V 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. = 1.8 GHz, T_C = 25°C, Z_0 = 75 Ω, V_{DD} = 5 V, V_{MODE} = 0 V, P_{IN} = 0 dBm

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Reference Insertion Loss	5 MHz, V_C = 0 V 1.2 GHz, V_C = 0 V 1.8 GHz, V_C = 0 V 3.0 GHz, V_C = 0 V	dB	—	0.4 0.7 1.0 1.8	— — 1.5 2.3
Maximum Attenuation	Small Signal, V_C = 2.2 V, relative to 0 dB state	dB	29	31	35
Mid Range Attenuation	V_C = 1.2 V , relative to 0 dB state	dB	10.5	13.5	17.5
Mid Range Insertion Phase	V_C = 1.2 V, relative to 0 dB state	deg	—	-3	—
Attenuation Slope	Over V_C	mV/dB	—	45	—
Attenuation Variation	V_C = 1.2 V, over temp, process and V_{DD}	dB	—	2.0	—
Input Return Loss	Full control voltage range	dB	14	18	—
Output Return Loss	Full control voltage range	dB	14	18	—
Input P1dB	V_C = 0 V, 5 MHz V_C = 0 V, 1800 MHz	dBm	—	26 33	—
IIP_3	Over V_C, 5 MHz, P_{IN} = 15 dBm/tone, 1 MHz Spacing Over V_C, 1.8 GHz, P_{IN} = 15 dBm/ 10 MHz Spacing	dBm	—	43 52	—
IIP_2	Over V_C, 5 MHz, P_{IN} = 15 dBm/tone, 1 MHz Spacing Over V_C, 1.8 GHz, P_{IN} = 15 dBm/ 10 MHz Spacing	dBm	—	75 87	—
Settling Time	50% V_C to ±0.1 dB of final value, for any 1 dB change in attenuation	µs	—	15	—

5. Parameters are measured on a test board, which is de-embedded to the package pins. The high frequency data (>2 GHz) is obtained from a 50 Ω board with wide-band connectors.

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	—	1.5	1.9
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 >50 MHz, T_c<105°C 5 - 50 MHz, T_c<105°C	-	dBm	—	—	33 30
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

Absolute Maximum Ratings[9,10]

Parameter	Symbol	Unit	Min	Max
Input Power >50 MHz, T_c<105°C 5 - 50 MHz, T_c<105°C	-	dBm	—	36 35
DC Supply Voltage	V_{DD}	V	—	5.5
Control Voltage	V_C	V	-0.5	3.5
Slope Control	V_{MODE}	V	-0.5	4.0
Junction Temperature	T_J	°C	—	150
Operating Temperature[8]	T_C	°C	—	135
Storage Temperature	T_S	°C	-65	150

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 + Ɵjc * (P_{RF})
   Typical thermal resistance (Ɵjc) = 30 °C/W.
8. Defined as case temperature and measured on the exposed paddle.
9. Exceeding any one or combination of these limits may cause permanent damage to this device.
10. 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

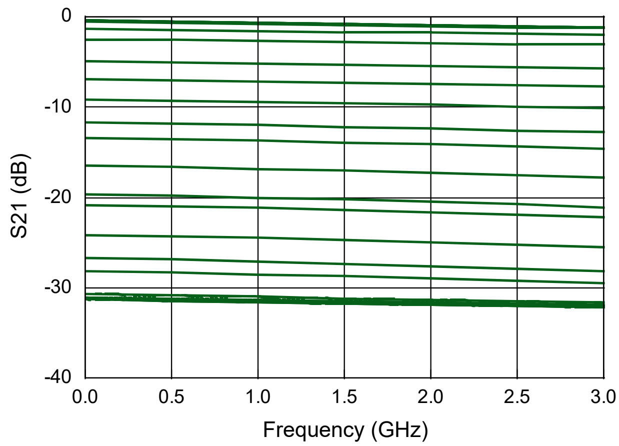
Please observe the following precautions to avoid damage:

Static Sensitivity

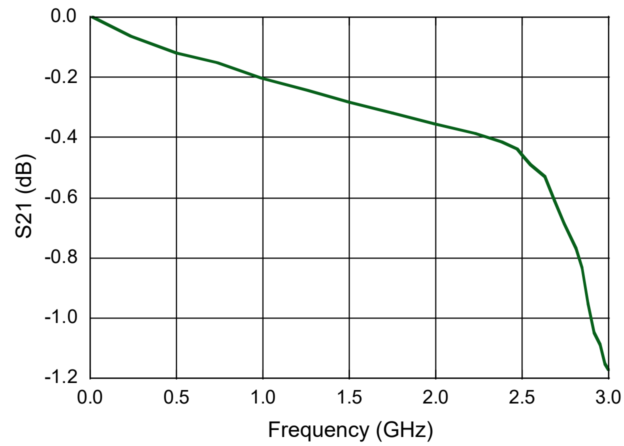
These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM class 1A devices.

Typical Performance: 75 Ω, V_{DD} = 5 V, V_{MODE} = 2 V, +25°C, V_C from 0 to 2.4 V, step 0.2 V

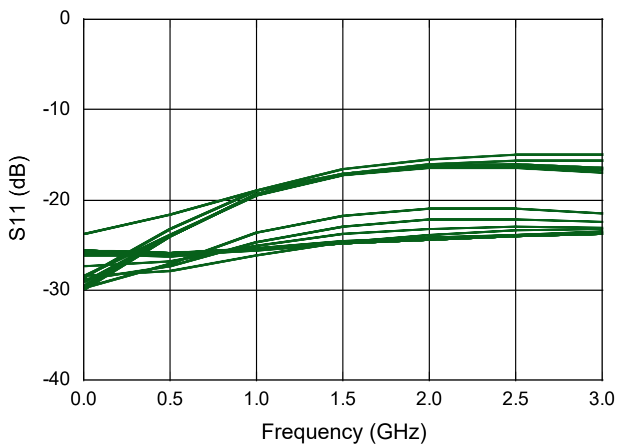
S21



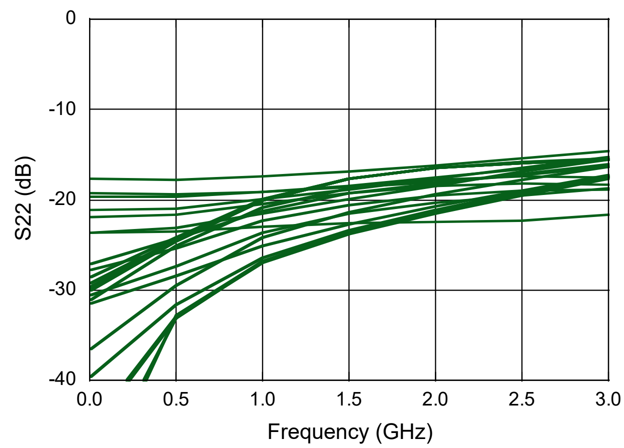
75 Ω Thru Line



S11

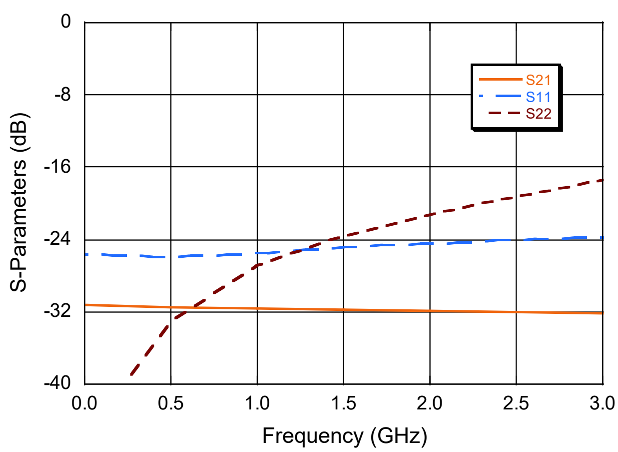


S22

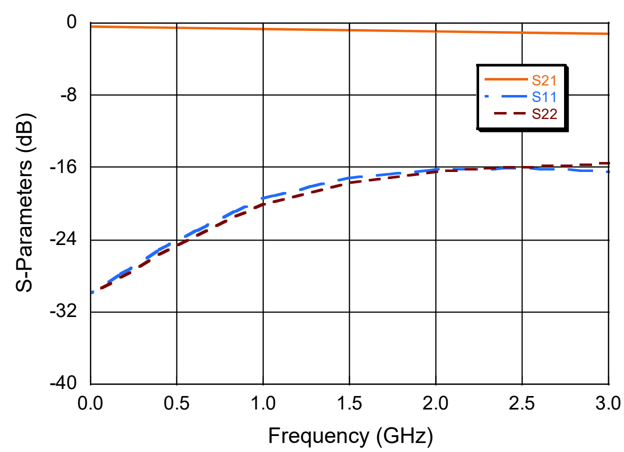


Typical Performance: 75 Ω, V_{DD} = 5 V, V_{MODE} = 2 V, +25°C, V_C from 0 to 2.4 V, step 0.2 V

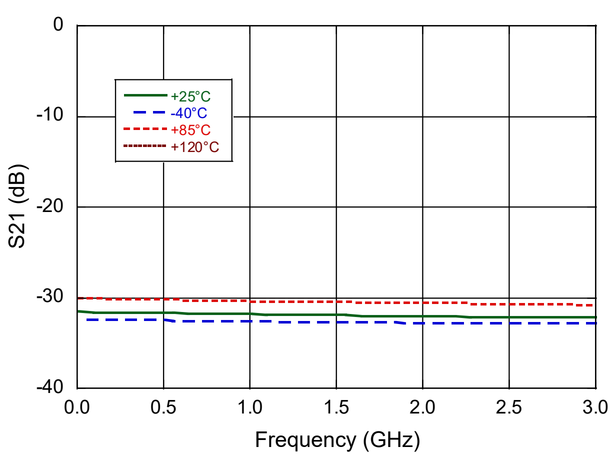
S11, S22, S21 @ V_C = 0 V



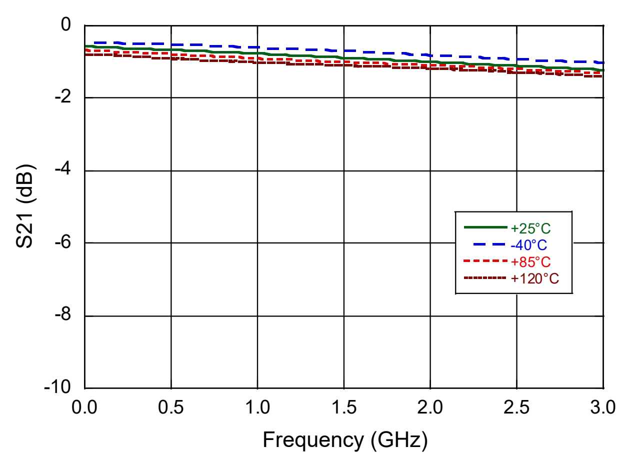
S11, S22, S21 @ V_C = 2.5 V



S21 Over Temp @ V_C = 0 V

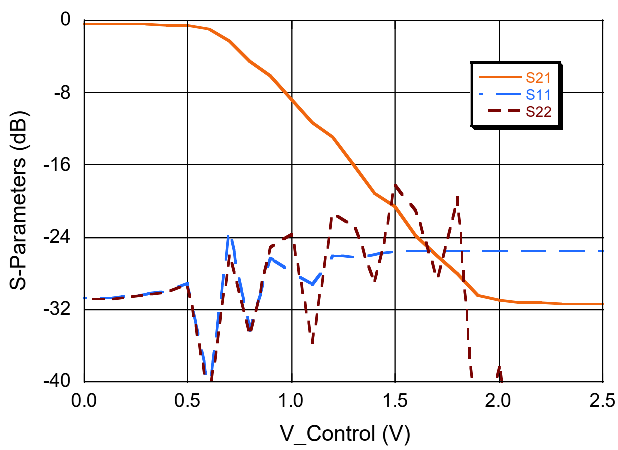


S21 Over Temp @ V_C = 2.5 V

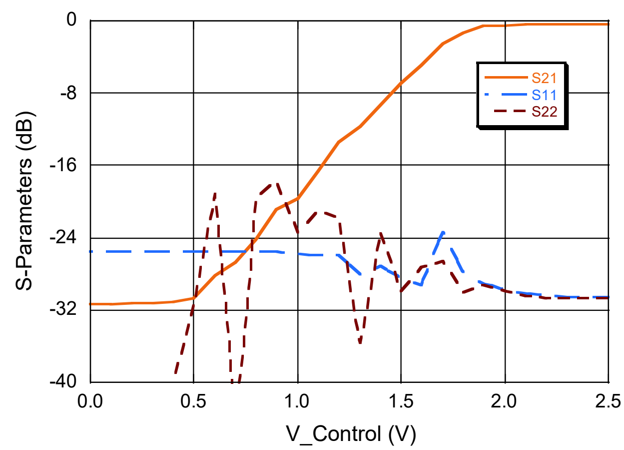


Typical Performance: 75 Ω, V_{DD} = 5 V, +25°C, V_C from 0 to 2.4 V, step 0.2 V

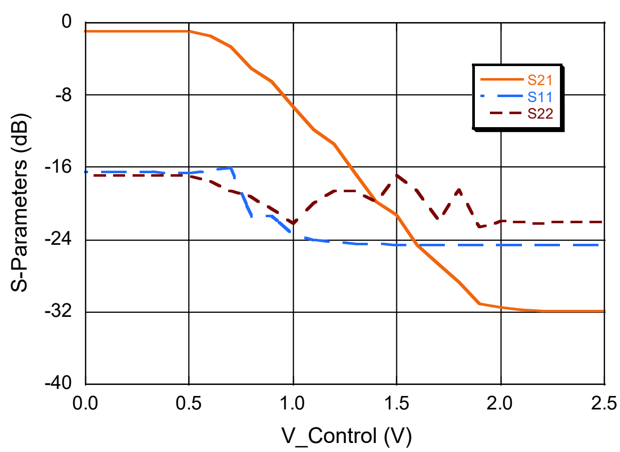
S11, S22, S21 @ 5 MHz, V_{MODE} = 0 V



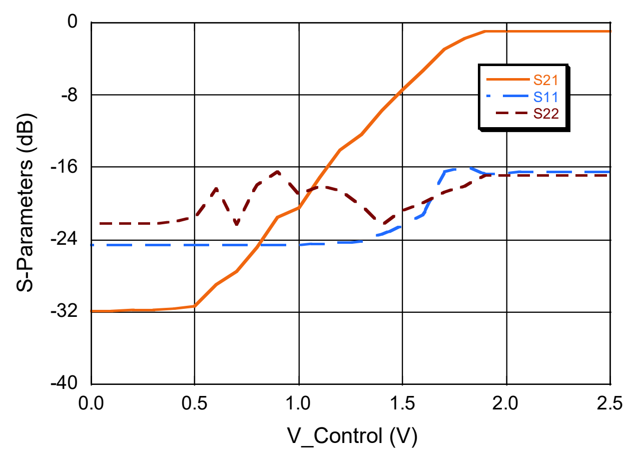
S11, S22, S21 @ 5 MHz, V_{MODE} = 2 V



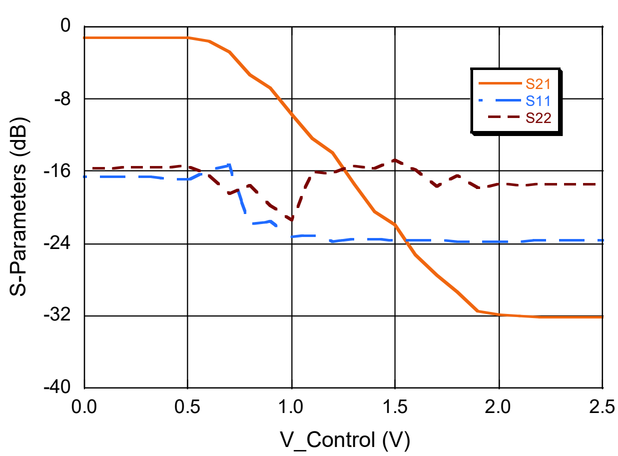
S11, S22, S21 @ 1.8 GHz, V_{MODE} = 0 V



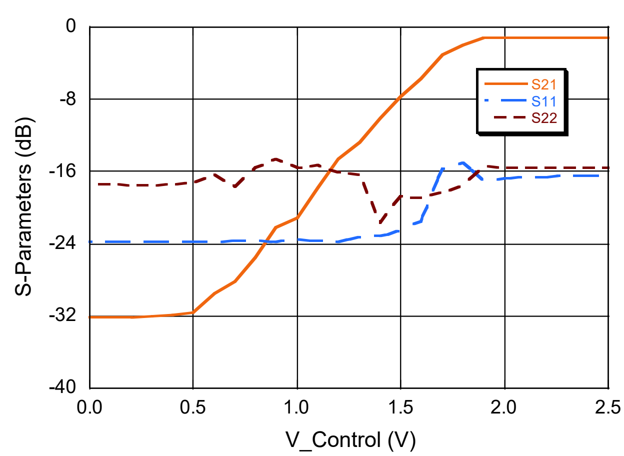
S11, S22, S21 @ 1.8 GHz, V_{MODE} = 2 V



S11, S22, S21 @ 3 GHz, V_{MODE} = 0 V

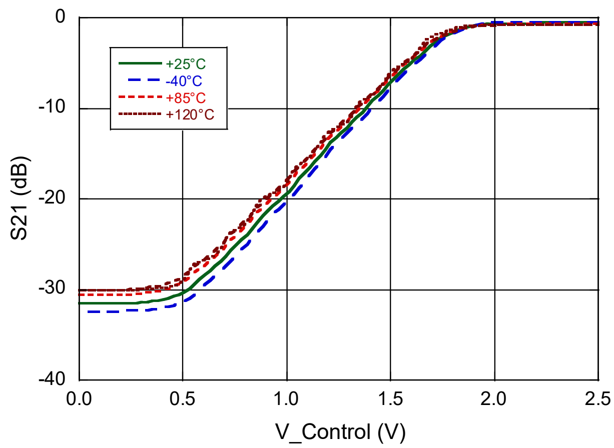


S11, S22, S21 @ 3 GHz, V_{MODE} = 2 V

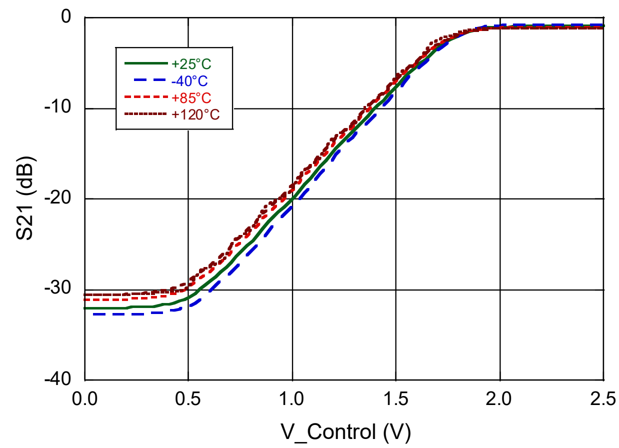


Typical Performance, 75 Ω, V_{DD} = 5 V, V_{MODE} = 2 V, V_C from 0 to 2.4 V, step 0.2 V

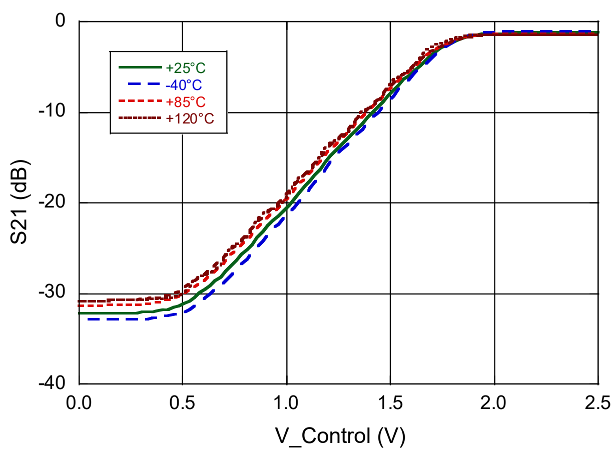
S21 @ 5 MHz



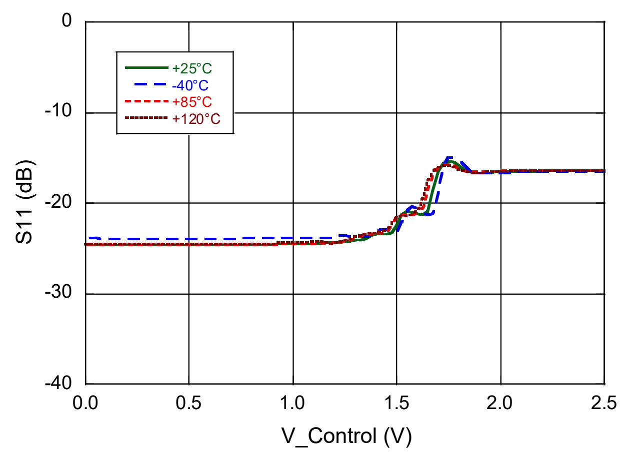
S21 @ 1.8 GHz



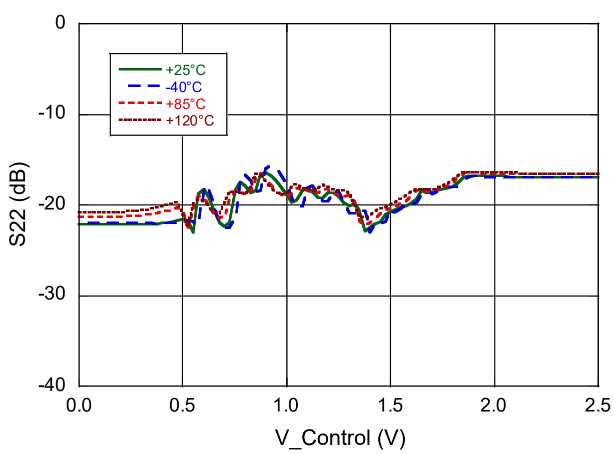
S21 @ 3 GHz



S11 @ 1.8 GHz

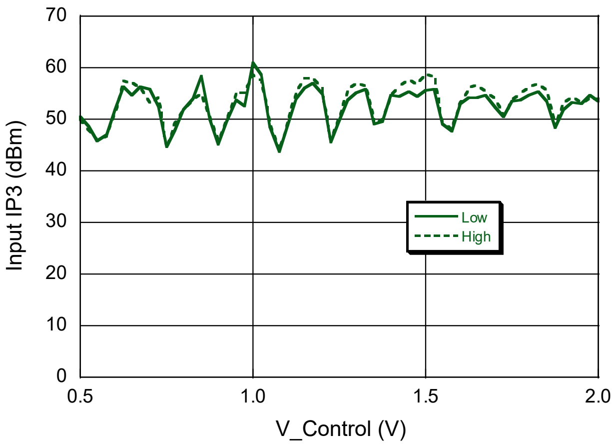


S22 @ 1.8 GHz

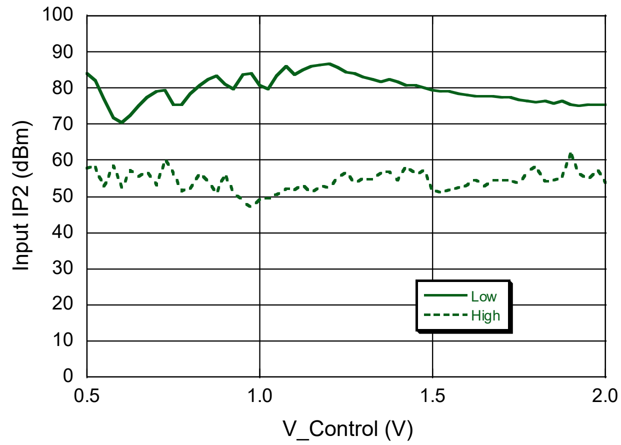


Typical Performance: 75 Ω, V_{DD} = 5 V, V_{MODE} = 2 V

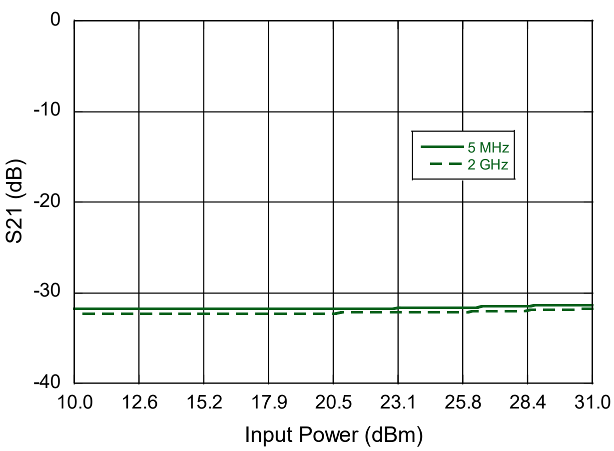
IIP3 @ 1.8 GHz



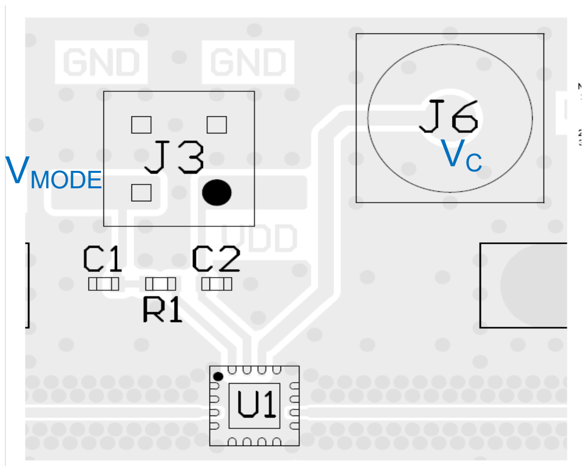
IIP2 @ 1.8 GHz



S21 Compression @ 5 MHz & 2 GHz, V_C = 0 V



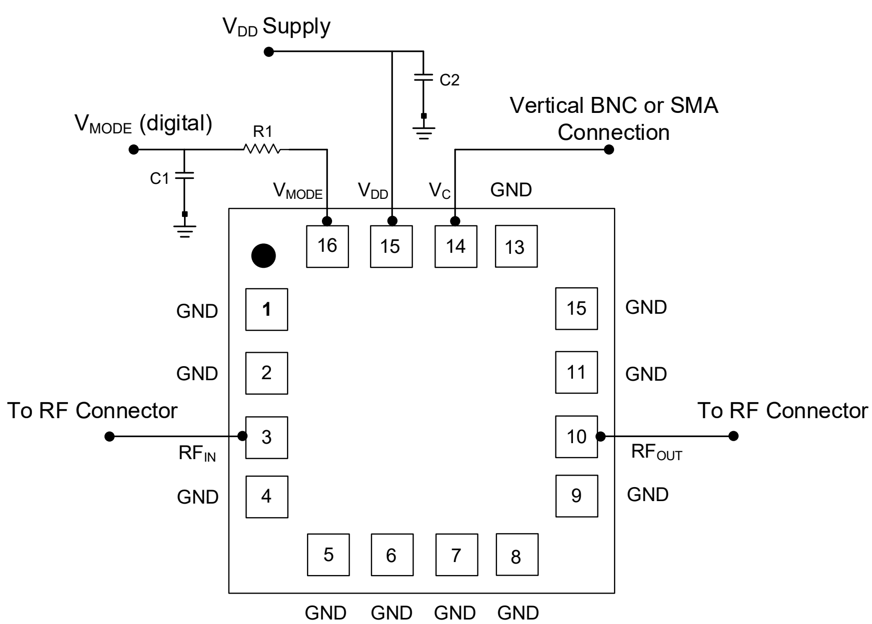
PCB Layout



Parts List

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

Application Schematic



50 Ω Performance Application Section

The MAAV-011018 can be operated in the 5 to 6000 MHz band with no external tuning or component changes required.

Typical Performance[11]:

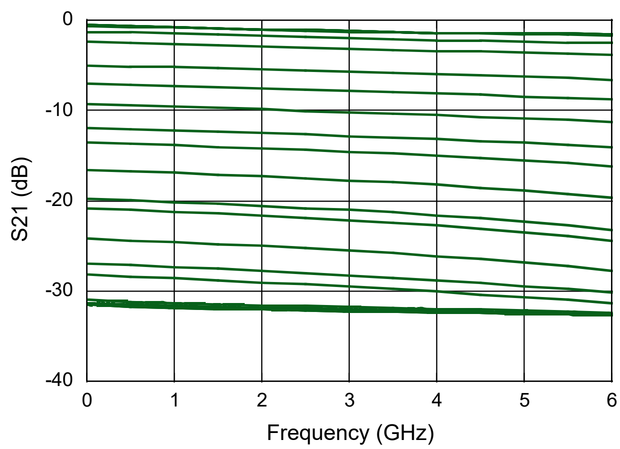
Z_0 = 50 Ω, Freq. = 3 GHz, T_A = 25°C, V_{DD} = +5.0 V, V_{MODE}=0 V, P_{IN} = 0 dBm (small signal)

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Reference Insertion Loss	5 MHz, V_C=0 V 3 GHz, V_C=0 V 6 GHz, V_C=0 V	dB	—	0.6 1.2 1.6	—
Maximum Attenuation	Small Signal, V_C = 2.2 V, relative to 0 dB state	dB	—	31	—
Mid-V_C Attenuation	V_C = 1.2 V, relative to 0 dB state	dB	—	13	—
Insertion Phase	Small Signal, V_C = 1.2 V, relative to 0 dB state	deg	—	-4.3	—
Attenuation Variation	V_C = 1.2 V, over temp, process and V_{DD}	dB	—	1	—
Input Return Loss	Full control voltage range	dB	—	17	—
Output Return Loss	Full control voltage range	dB	—	15	—
Input P1dB	Reference State	dBm	—	33	—
IIP_3	Over V_C, 5 MHz, P_{IN} = 15 dBm/tone, 1 MHz Spacing Over V_C, 3 GHz, P_{IN} = 15 dBm/10 MHz Spacing	dBm	—	45+/-4 54+/-3	—
Sum IIP_2	Over V_C, 5 MHz, P_{IN} = 15 dBm/tone, 1 MHz Spacing Over V_C, 3 GHz, P_{IN} = 15 dBm/10 MHz Spacing	dBm	—	65+/-6 90+/-8	—
Settling Time	50% V_C to ±0.1 dB of final value, for any 1 dB change in attenuation	µs	—	5 to 15	—

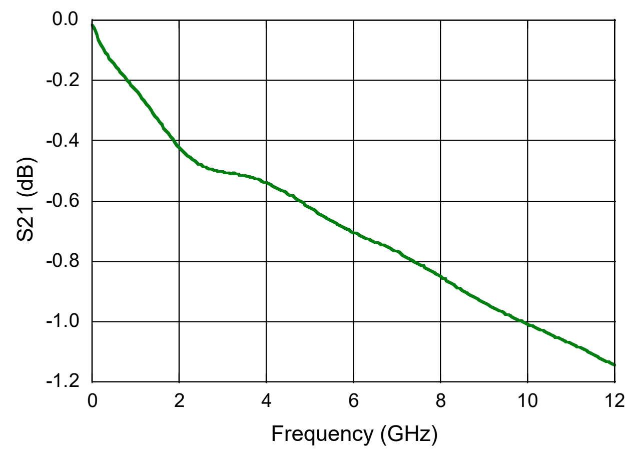
11. Parameters are measured on a test board, which is de-embedded to the package pins. The high frequency data (>2 GHz) is obtained from a 50 Ω board with wide band connectors.

Typical Performance: 50 Ω, V_{DD} = 5 V, V_{MODE} = 2 V, +25°C, V_C from 0 to 2.4 V, step 0.2 V

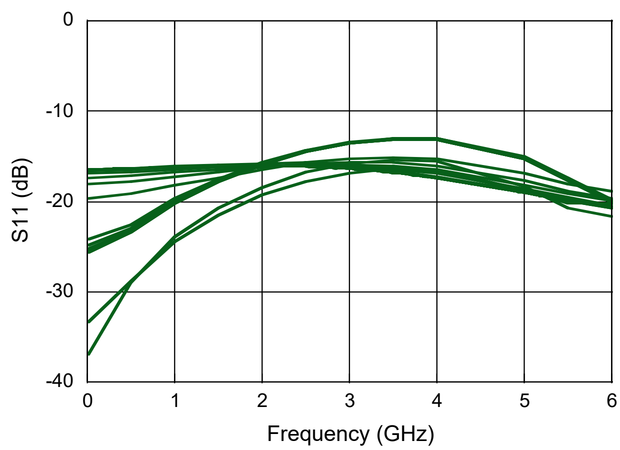
S21



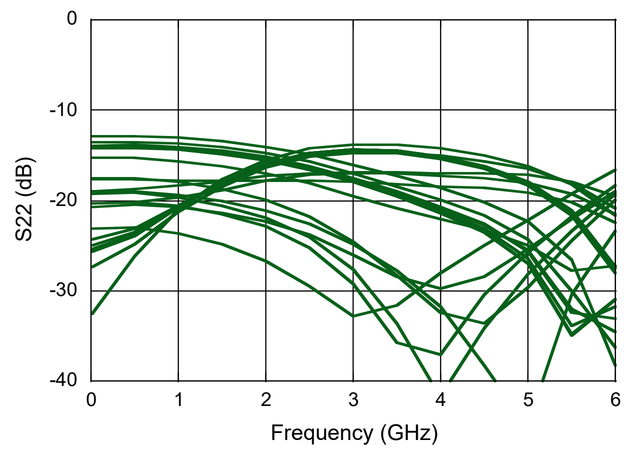
50 Ω Thru Line



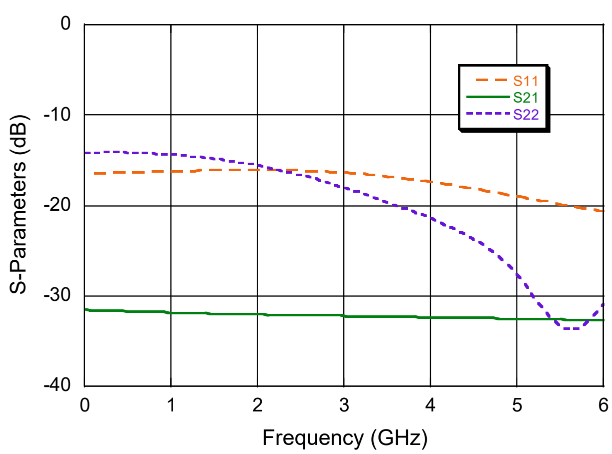
S11



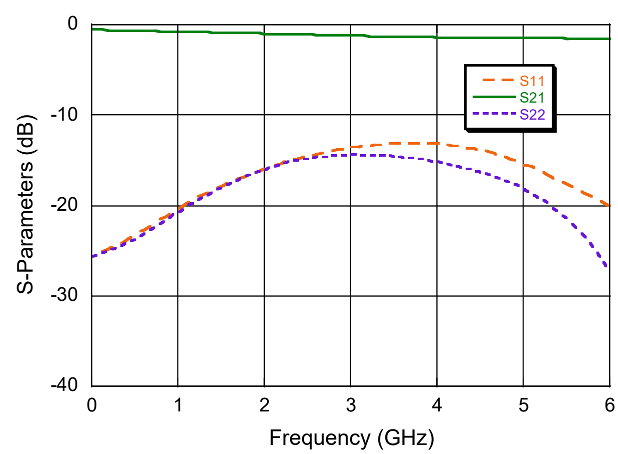
S22



S11, S22, S21 @ V_C = 0 V

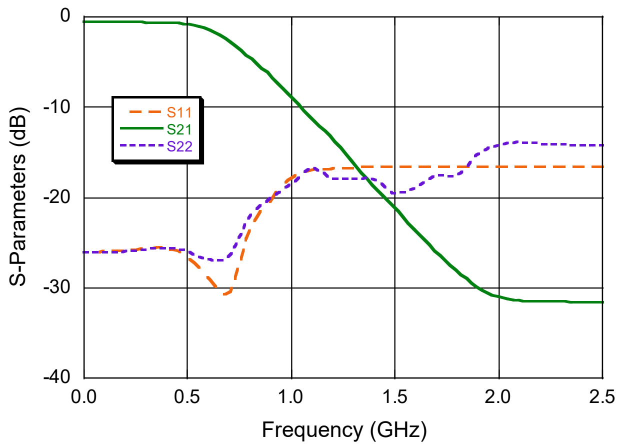


S11, S22, S21 @ V_C = 2.5 V

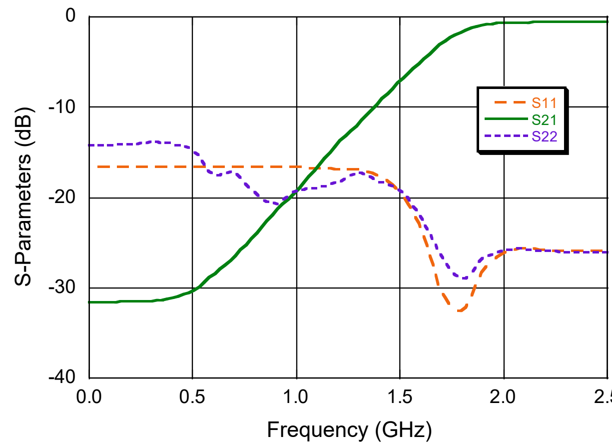


Typical Performance: 50 Ω, V_{DD} = 5 V, V_{MODE} = 2 V, +25C, V_C from 0 to 2.4 V, step 0.2 V

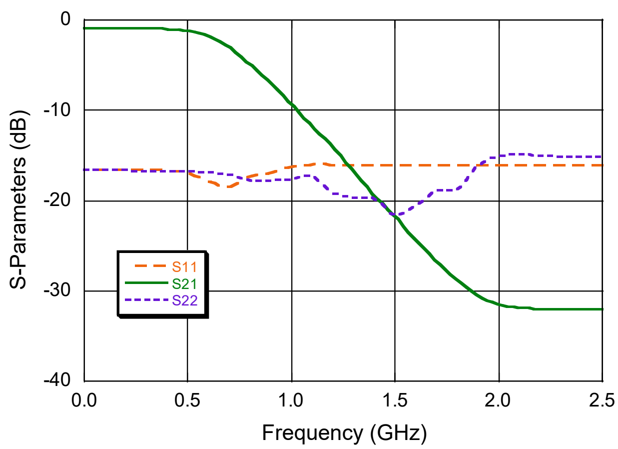
S11, S22, S21 @ 5 MHz, V_{MODE} = 0 V



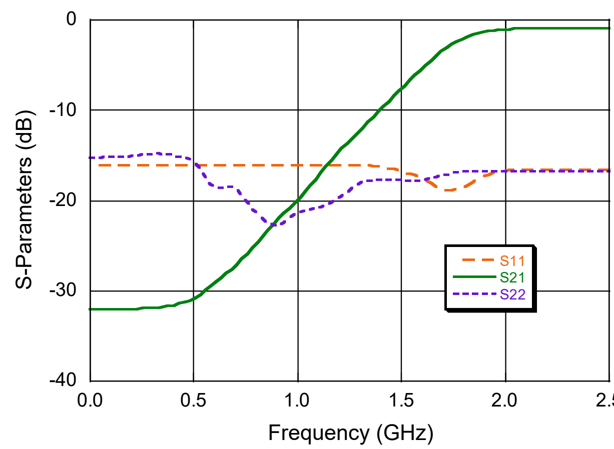
S11, S22, S21 @ 5 MHz, V_{MODE} = 2 V



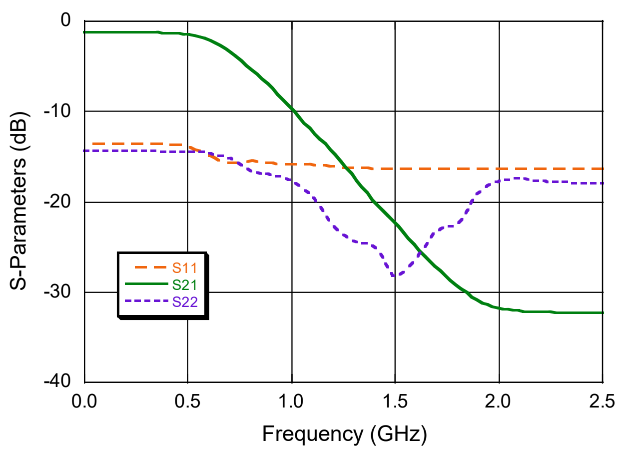
S11, S22, S21 @ 1.8 GHz, V_{MODE} = 0 V



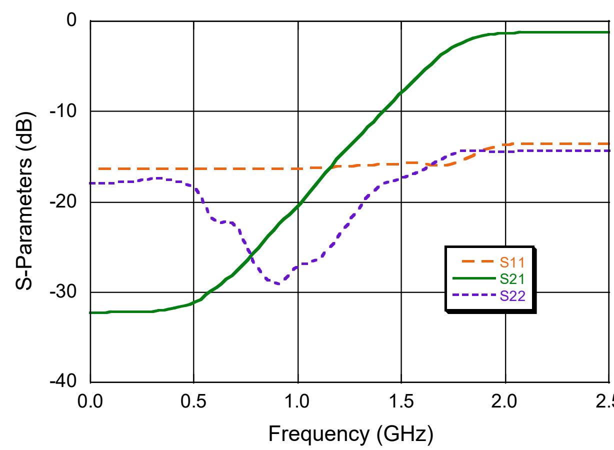
S11, S22, S21 @ 1.8 GHz, V_{MODE} = 2 V



S11, S22, S21 @ 3 GHz, V_{MODE} = 0 V

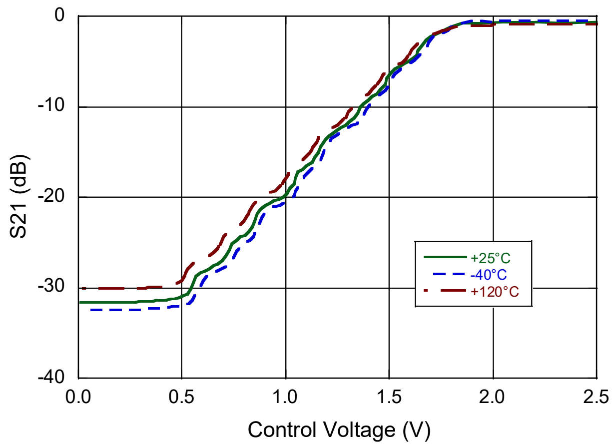


S11, S22, S21 @ 3 GHz, V_{MODE} = 2 V

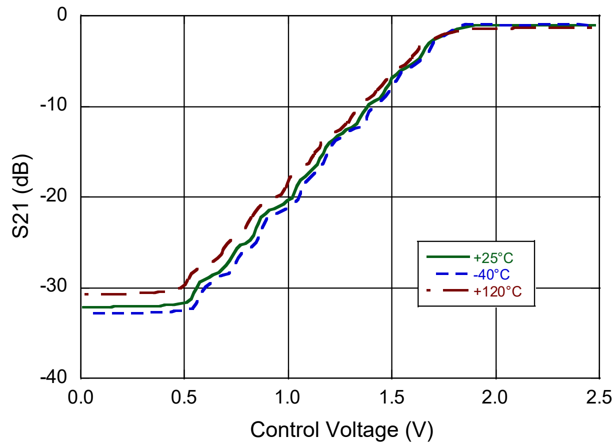


Typical Performance: 50 Ω, V_{DD} = 5 V, V_{MODE} = 0 V, +25°C, V_C from 0 to 2.4 V, step 0.2 V

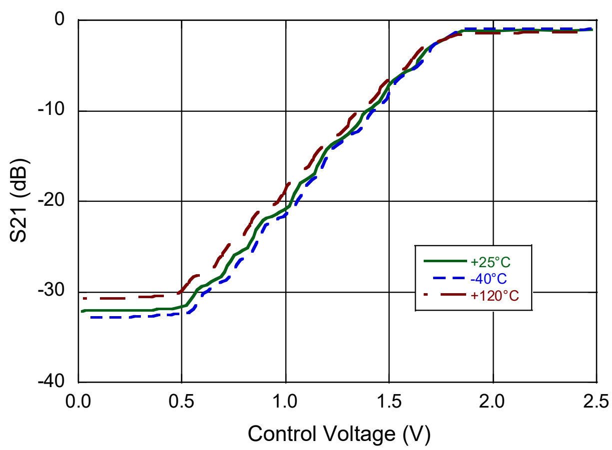
S21 Over temp @ 5 MHz



S21 Over temp @ 1.8 GHz

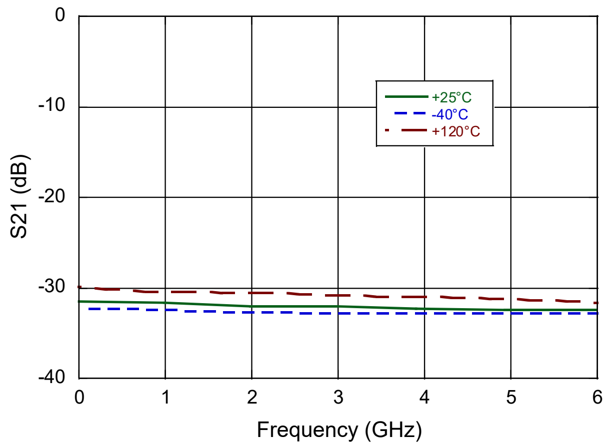


S21 Over temp @ 3 GHz

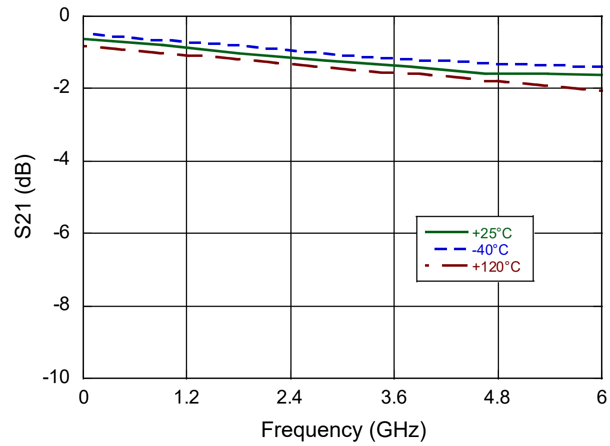


Typical Performance: 50 Ω, V_{DD} = 5 V, V_{MODE} = 2 V, V_C from 0 to 2.4 V, step 0.2 V

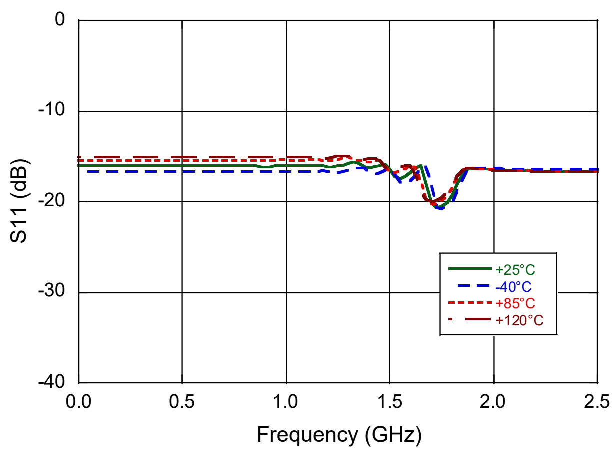
S21 Over temp @ V_C = 0 V



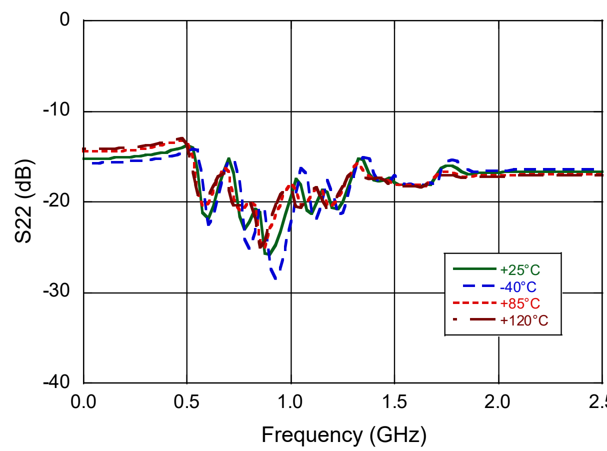
S21 Over temp @ V_C = 2.5 V



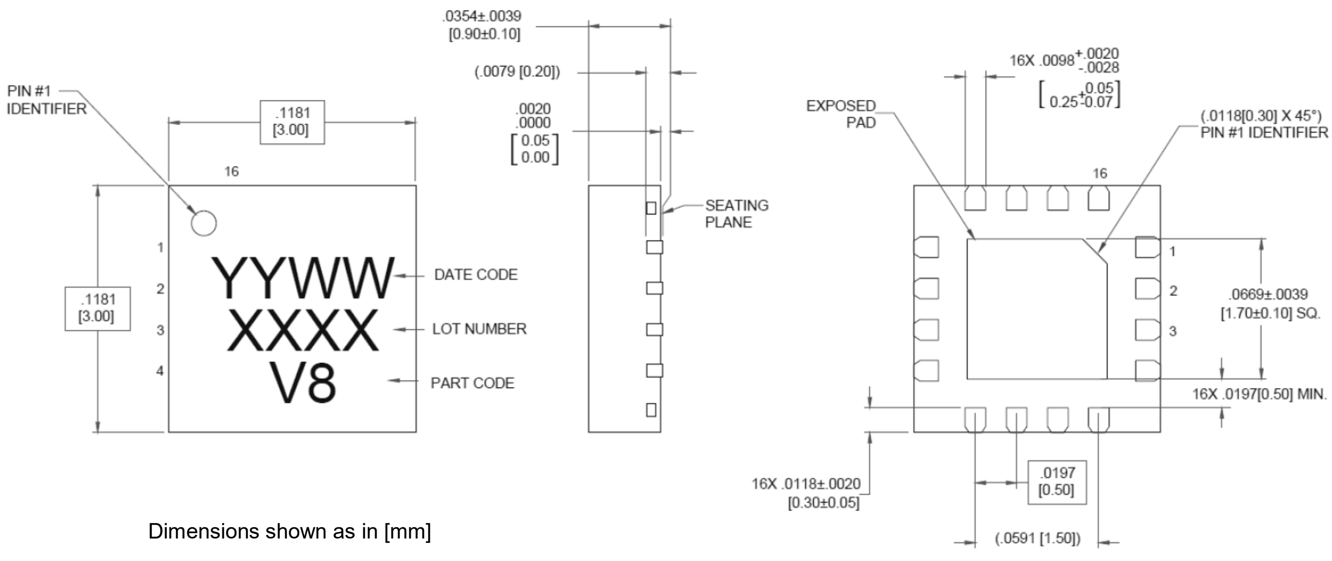
S11 Over temp @ 1.8 GHz



S22 Over temp @ 1.8 GHz



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	June 2023	Initial release
V2	Jan. 2024	Updating limits after completion of offset testing