DC – 50 GHz Variable Attenuator

Technical Data

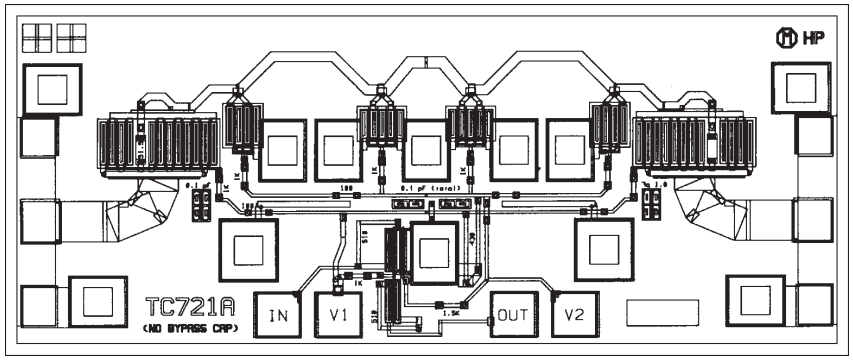
HMMC-1002

Features

- **Specified Frequency Range:** DC - 26.5 GHz
- **Return Loss:** 10 dB
- **Minimum Attenuation:** 2.0 dB
- **Maximum Attenuation:** 30.0 dB

Description

The HMMC-1002 is a monolithic, voltage variable, GaAs IC attenuator that operates from DC to 50 GHz. It is fabricated using MWTC's MMICB process which features an MBE epitaxial layer, backside ground vias, and FET gate lengths of approximately 0.4 mm. The variable resistive elements of the HMMC-1002 are two 750 mm wide series FETs and four 200 mm wide shunt FETs. The distributed topology of the HMMC-1002 minimizes the parasitic effects of its series and shunt FETs, allowing the HMMC-1002 to exhibit a wide dynamic range across its full bandwidth. An on-chip DC reference circuit may be used to maintain optimum VSWR for any attenuation setting or to improve the attenuation versus voltage linearity of the attenuator circuit.



Chip Size:	1470 x 610 µm (57.9 x 24.0 mils)
Chip Size Tolerance:	± 10 µm (± 0.4 mils)
Chip Thickness:	127 ± 15 µm (5.0 ± 0.6 mils)
RF Pad Dimensions:	60 x 70 µm (2.4 x 2.8 mils), or larger
DC Pad Dimensions:	75 x 75 µm (3.0 x 3.0 mils), or larger

Absolute Maximum Ratings[1]

Symbol	Parameters/Conditions	Units	Min.	Max.
V_{DC-RF}	DC Voltage to RF Ports	V	-0.6	+1.6
V_1	V_1 Control Voltage	V	-5.0	+0.5
V_2	V_1 Control Voltage	V	-5.0	+0.5
V_{DC}	DC In/DC Out	V	-0.6	+1.0
P_{in}	RF Input Power	dBm		17
T_{mina}	Minimum Ambient Operating Temperature	°C	-55	
T_{maxa}	Maximum Ambient Operating Temperature	°C		+125
T_{STG}	Storage Temperature	°C	-65	+165
T_{max}	Maximum Assembly Temp.	°C		+300

Note:

1. Operation in excess of any one of these conditions may result in permanent damage to this device.

DC Specifications/Physical Properties, $T_A = 25°C$

Symbol	Parameters and Test Conditions	Units	Min.	Typ.	Max.
I_{V1}	V_1 Control Current, (V_1 = -4V)	mA	5.3	9.3	12
I_{V2}	V_2 Control Current, (V_2 = -4V)	mA	5.3	9.3	12
V_p	Pinch-off Voltage (V_2, with V_1 = 0 V) Four 200 µm wide shunt FETs, V_{DD} = 1 V @ RF_{in}, I_{DD} = 5 mA	V	-0.6	-1.3	-2.5

Electrical Specifications[1], $T_A = 25°C$, $Z_O = 50\ \Omega$

Parameters and Test Conditions	Units	Freq. (GHz)	Min.	Typ.	Max.
Minimum Attenuation, $\|S_{21}\|$ V_1 = 0 V, V_2 = -4 V	dB	1.5		1.0	2.4
		8.0		1.4	2.4
		20.00		1.7	2.4
		26.5		2.0	2.4
		50.0		3.9	
Input/Output Return Loss @ Min. Attenuation Setting, V_1 = 0 V, V_2 = -4 V	dB	<26.5	10	16	
		<50.0		8	
Maximum Attenuation, $\|S_{21}\|$ V_1 = -4 V, V_2 = 0 V	dB	1.5	27	30	
		8.0	27	38	
		20.0	27	38	
		26.5	27	40	
		50.0		35	
Input/Output Return Loss @ Max. Attenuation Setting, V_1 = -4 V, V_2 = 0 V	dB	<26.5	8	10	
		<50.0		10	
DC Power Dissipation (does not include input signals) V_1 = -5 V, V_2 = -5 V	mW				152

Applications

The HMMC-1002 is designed to be used as a gain control block in an AGC assembly. Because of its wide dynamic range and return loss performance, the HMMC-1002 may also be used as a broadband pulse modulator or single-pole single-throw, non-reflective switch.

Operation

The attenuation of the HMMC-1002 is adjusted by applying negative voltages to V1 and V2. V1 controls the drain-to-source resistances of the series FETs while V2 controls the drain-to-source resistances of the shunt FETs. For any HMMC-1002 the values of V1 may be adjusted so that the device attenuation versus voltage is monotonic for both V1 and V2; however, this will slightly degrade the input and output return loss.

The attenuation of the HMMC-1002 may also be controlled using only a single input voltage by utilizing the on-chip DC reference circuit and the driver circuit shown in Figure 4. This circuit optimizes VSWR for any attenuation setting. Because of process variations, the values of V_{REF}, R_{REF}, and R_L are different for each wafer if optimum performance is required. Typical values for these elements are given. The ratio of the resistors R1 and R2 determines the sensitivity of the attenuation versus voltage performance of the attenuator. For more information on the performance of the HMMC-1002 and the driver circuits previously mentioned see MWTC's Application Note #37, "HMMC-1002 Attenuator: Attenuation Control." For more S-parameter information, see MWTC's Application Note #44, "HMMC-1002 Attenuator: S-Parameters."

Assembly Techniques

Solder die attach using a AuSn solder preform is the recommended assembly method; however, an epoxy die attach method using ABLEBOND® 71-1LM1 or ABLEBOND® 36-2 may also be employed. Gold thermosonic wedge bonding with 0.7 mil wire is the recommended method for bonding to the device. Tool force should be 22 grams ± 1 gram, stage temperature is 150 ± 2 °C, and ultrasonic power and duration of 64 ± 1 dB and 76 ± 8 msec, respectively. The top and bottom metallization is gold.

For more detailed information see HP application note #999 "GaAs MMIC Assembly and Handling Guidelines."

GaAs MMICs are ESD sensitive. Proper precautions should be used when handling these devices.

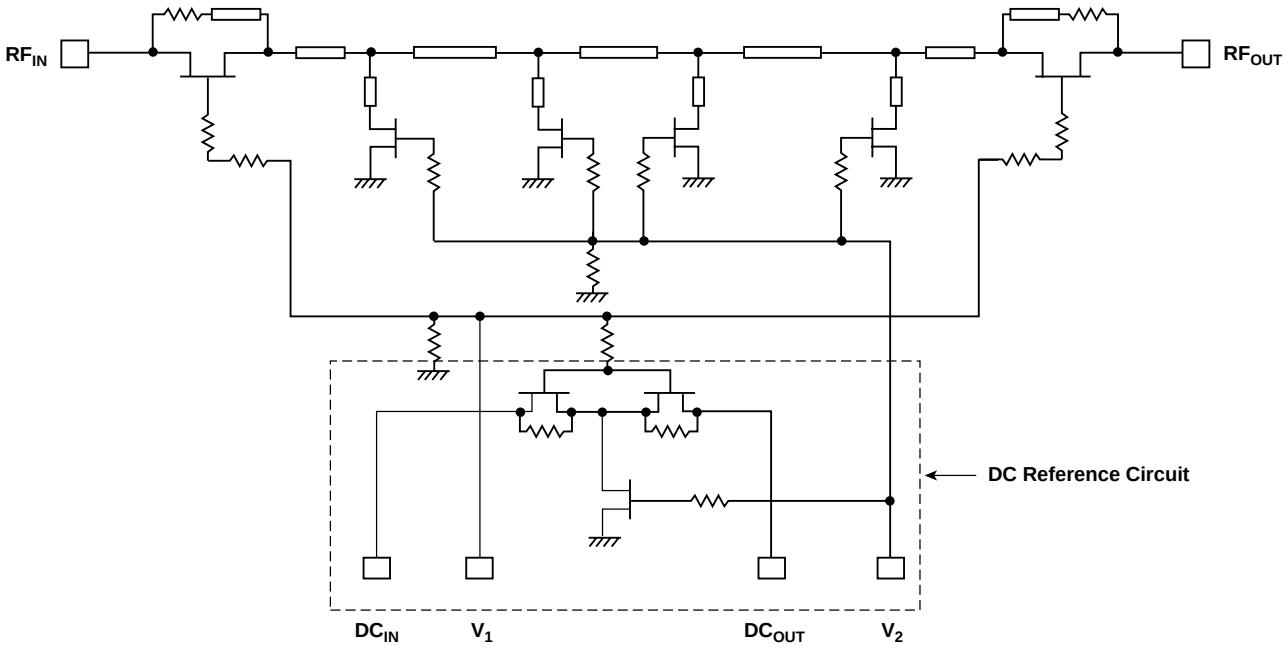
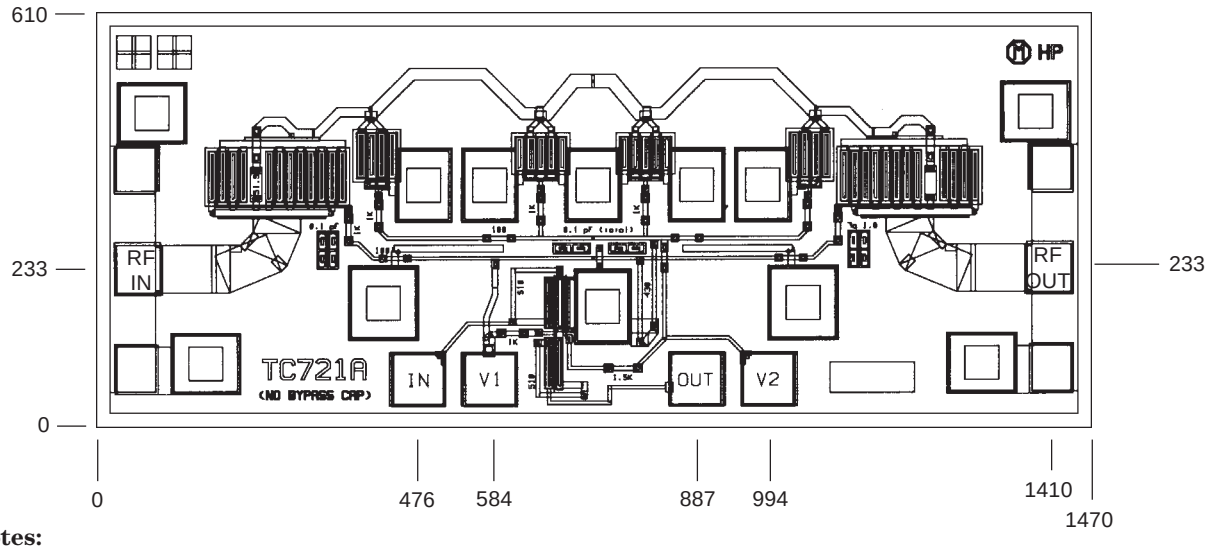


Figure 1. HMMC-1002 Schematic.



Notes:

1. All dimensions in microns and shown to center of bond pad.
2. DC_{in}, V1, DC_{out}, and V_2 bonding pads are 75 x 75 microns.
3. RF input and output bonding pads are 60 x 70 microns.
4. Chip thickness: 127 ± 15 µm.

Figure 2. HMMC-1002 Bonding Pad Locations.

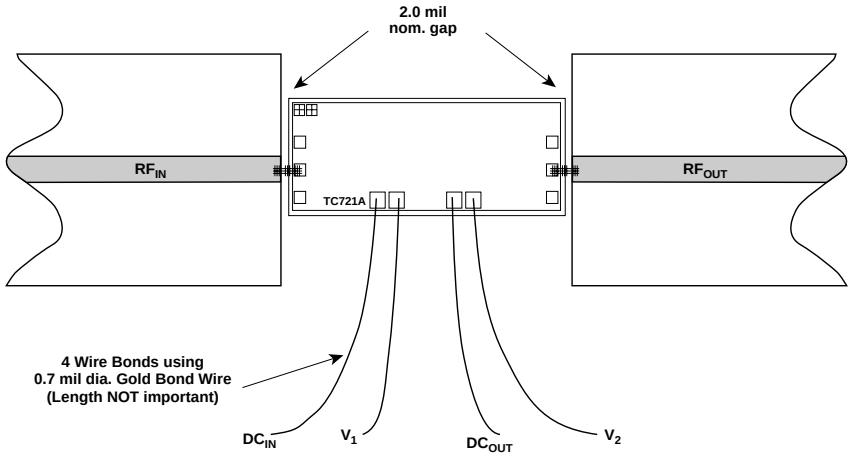


Figure 3. HMMC-1002 Assembly Diagram.

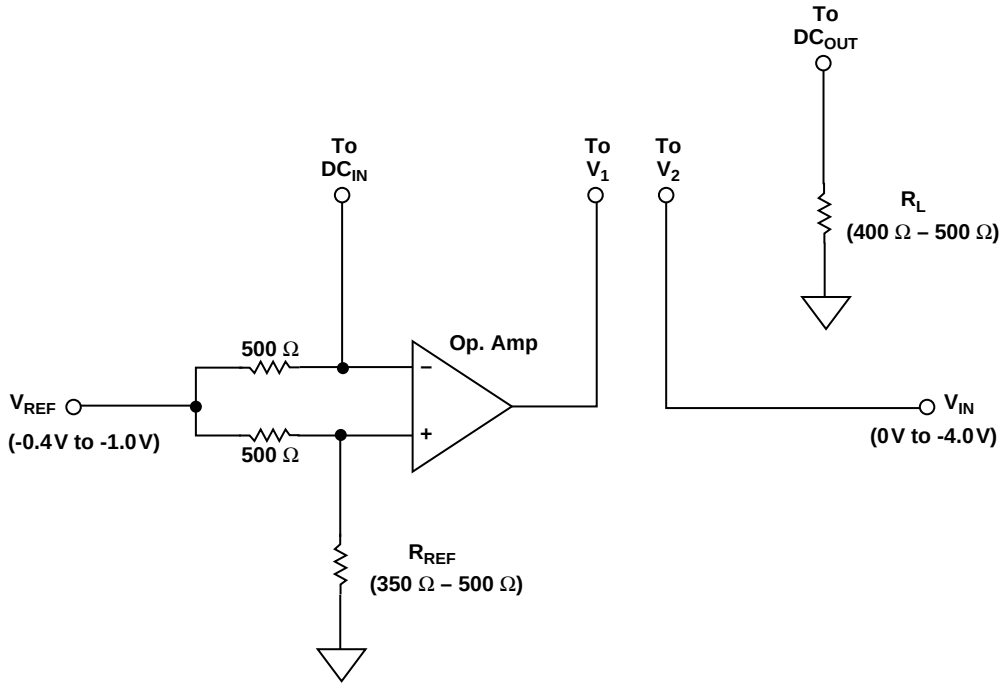


Figure 4. Attenuator Driver.

HMMC-1002 Typical Performance

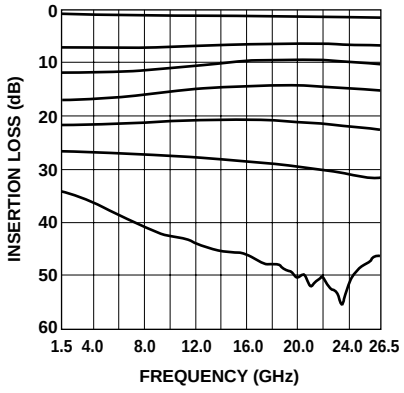


Figure 5. Attenuation vs. Frequency[1].

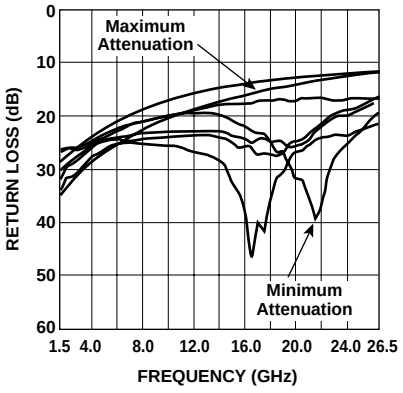


Figure 6. Output Return Loss vs. Frequency[1].

Note:

1. Data obtained from on-wafer measurements. $T_{chuck} = 25℃$.

HMMC-1002 Typical Power Performance

All Attenuation Settings were done at 1 GHz.

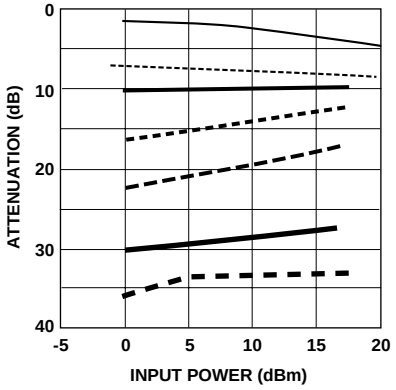


Figure 7. Attenuation vs. Input Power @ 50.0 MHz.[1].

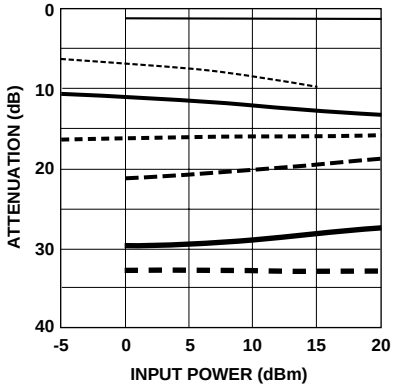


Figure 8. Attenuation vs. Input Power @ 2.0 GHz.[1].

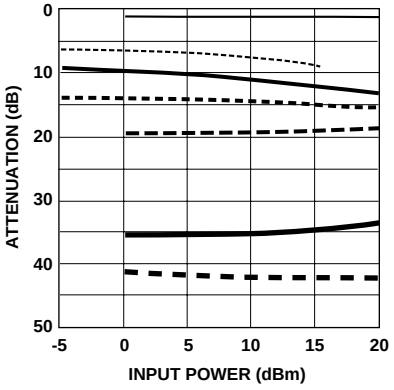


Figure 9. Attenuation vs. Input Power @ 10.0 GHz.[1].

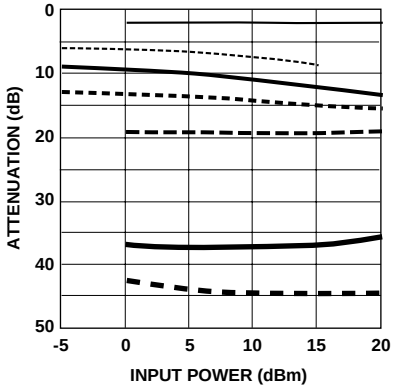


Figure 10. Attenuation vs. Input Power @ 14.0 GHz.[1].

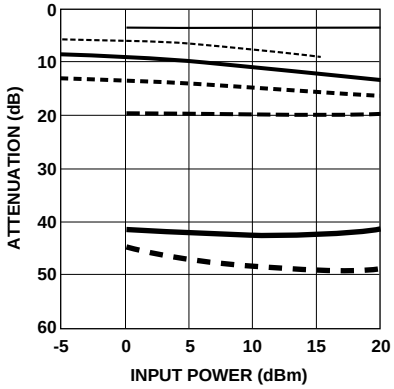


Figure 11. Attenuation vs. Input Power @ 18.0 GHz.[1].

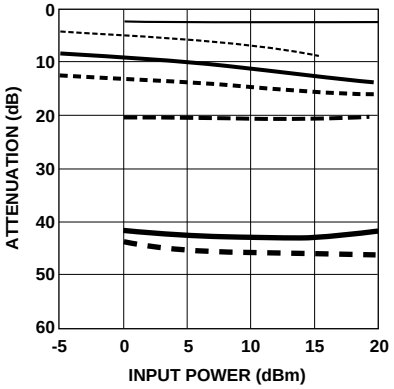


Figure 12. Attenuation vs. Input Power @ 22.0 GHz.[1].

Note:

1. Data taken with the device mounted in connectorized package.

Key for Attenuation Settings:

- Min.
- Min. + 5 dB
- Min. + 10 dB
- Min. + 15 dB
- Min. + 20 dB
- Min. + 30 dB
- Max.

HMMC-1002 Typical Harmonic Performance

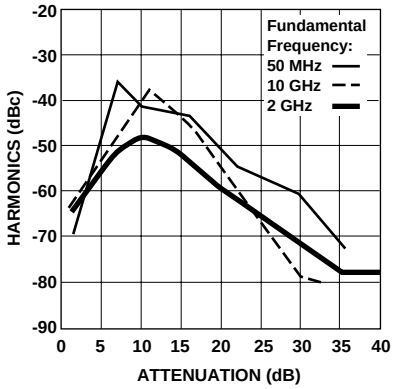


Figure 13. Second Harmonic Suppression vs. Attenuation. Input Power = 0 dBm[1].

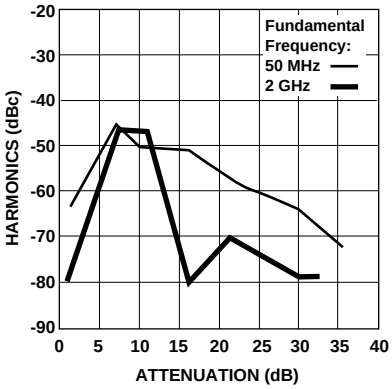


Figure 14. Third Harmonic Suppression vs. Attenuation. Input Power = 0 dBm[1].

Note:

1. Data taken with the device mounted in connectorized package.

HMMC-1002 Typical Temperature Performance

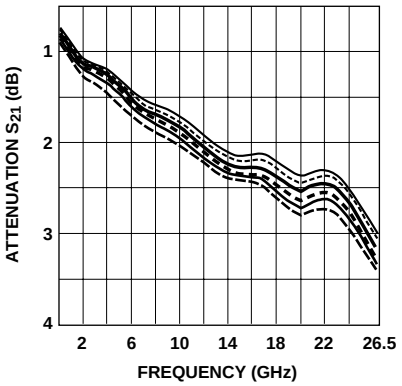


Figure 15. Attenuation vs. Temperature @ Minimum Attenuation.[2].

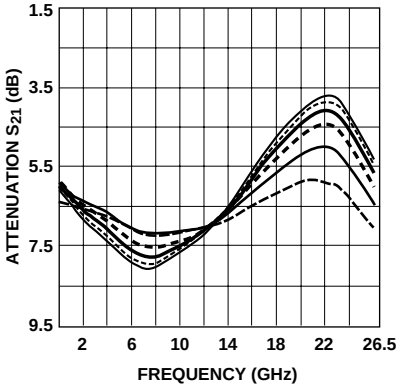


Figure 16. Attenuation vs. Temperature @ 5 dB Attenuation.[2].

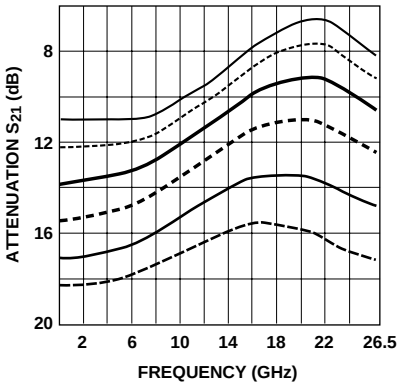


Figure 17. Attenuation vs. Temperature @ 10 dB Attenuation.[2].

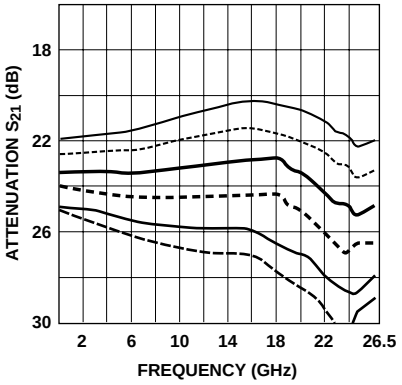


Figure 18. Attenuation vs. Temperature @ 20 dB Attenuation.[2].

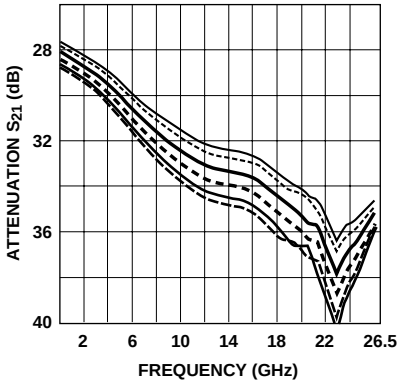


Figure 19. Attenuation vs. Temperature @ 30 dB Attenuation.[2].

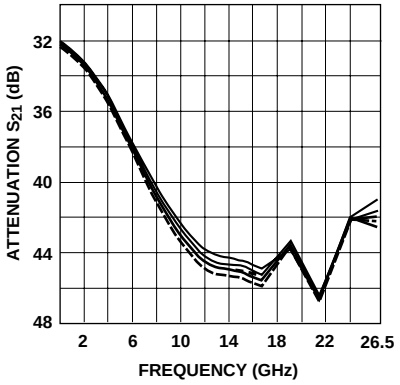


Figure 20. Attenuation vs. Temperature @ Max. Attenuation.[2].

Note:

1. Data taken with the device mounted in connectorized package.

Key for Temperature Settings:

- -55°C
- -25°C
- 0° C
- +25°C
- +55°C
- +85°C

This data sheet contains a variety of typical and guaranteed performance data. The information supplied should not be interpreted as a complete list of circuit specifications. In this data sheet the term *typical* refers to the 50th percentile performance. For additional information contact your local HP sales representative.