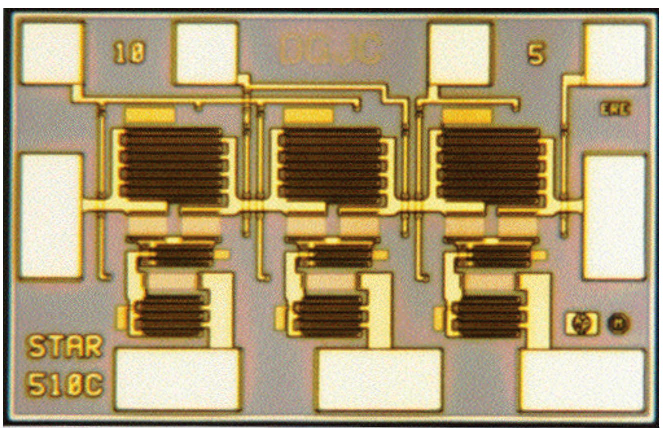
Keysight 1GG7-4081
DC - 6 GHz 15 dB/3 Bit GaAs MMIC Step Attenuator



Data Sheet

Features

- Frequency range:
- DC - 6.0 GHz
- Attenuation values:
  3 bit
  5, 10, 15 dB
- Min. insertion loss:
  < 0.8 @ 3 GHz
  < 1.3 @ 6 GHz
- Step accuracy:
  (–15 dB state)
  ±0.4 dB
- Return loss:
  20 dB through 3 GHz
  15 dB through 6 GHz
- Switching speed:
  < 1 µs (10% - 90% T_R)
- P_{-1dB}:
  25 dBm @ 10 MHz
  30 dBm @ 3 GHz
- Distortion:
  SHI: + 100 dBm
  THI: + 70 dBm
  TOI: + 57 dBm

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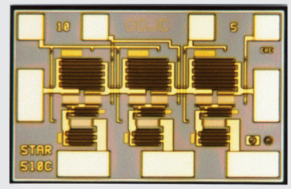
Description

The 1GG7-4081 is a 3 bit, 0–15 dB by 5 dB step GaAs MMIC step attenuator designed for low insertion loss and low distortion from DC to 6 GHz. It is intended for use as a general–purpose solid–state step–attenuator for RF instrumentation or commercial communication systems. Each 5 dB cell incorporates a "T" attenuator combined with integral series and shunt MESFET switching elements. This device incorporates a unique diode/resistor bias topology to improve low frequency RF performance and is fabricated with the Keysight–HFTC DF7S GaAs MMIC process which is specifically designed to eliminate GaAs anomalies common in control circuit components.



- Chip size: 1310 × 835 (51.6 × 32.9 mils)
- Chip size tolerance: ±10 µm (±0.4 mils)
- Chip thickness: 127 ±15 µm (5.0 ±0.6 mils)
- Small pad dimensions: 114 × 114 µm (4.5 × 4.5 mils)
- Large pad dimensions: 114 × 228 µm (4.5 × 9.0 mils)

Absolute maximum ratings[1]

Symbol	Parameters/conditions	Min	Max	Units
$V_{C1,2,3,4}$	Control line voltages	–12	+12	volts
$P_{in(CW)}$	CW RF input power		33	dBm
T_{op}	Operating temperature	–55	+125	°C
T_{st}	Storage temperature	–65	+165	°C
T_{max}	Max. assembly temperature		+300	°C

1. Operation in excess of any one of these may result in permanent damage to this device. T_A = 25 °C except for T_{op}, T_{st}, and T_{max}.

DC specifications/physical properties

(T_A = 25 °C)

Symbol	Parameters/conditions	Min	Typ	Max	Units
$V_{C1,2,3,4(+)}$	Positive control line voltage	7	10	10.5	volts
$V_{C1,2,3,4(-)}$	Negative control line voltage	–10.5	–10	–7	volts
$I_{L(+)}$	Positive control line leakage current ($V_{C1,2,3,4}$ = +10 volts)			100	µA
$I_{L(-)}$	Negative control line leakage current ($V_{C1,2,3,4}$ = –10 volts)			100	µA

Symbol	Parameters/conditions	50 MHz	1 GHz	2 GHz	3 GHz	4 GHz	Units
α_T	Attenuation temperature coefficient	50 MHz	1 GHz	2 GHz	3 GHz	4 GHz	dB/°C
	@ Min. Insertion loss state	.0008	.0007	.0006	.0005	.0003	
	@ –5 dB state	.0002	.0001	.0000	–.0002	–.0003	
	@ –10 dB state	–.0004	–.0005	–.0006	–.0008	–.0010	
	@ –15 dB state	–.0009	–.0011	–.0012	–.0014	–.0016	

RF specifications

(T_A = 25 °C, Z_0 = 50 Ω, $V_{C1,2,3,4}$ = ±10 volts)

Symbol	Parameters/conditions		Min	Typ	Max	Min	Typ	Max	Units
BW	Guaranteed operating bandwidth			DC - 3.0			DC - 6.0		GHz
$IL_{(min)}$	Minimum insertion loss ($V_{C1} = V_{C3}$ = +10 v, $V_{C2} = V_{C4}$ = –10 v)			.75[1]	.8		1.25	1.30	dB
D_{step}	Attenuation step	@ –5 dB state	4.8	5	5.2	4.8	5	5.2	dB
		@ –10 dB state	9.7	10	10.3	9.7	10	10.3	
		@ –15 dB state	14.6	15	15.4	14.6	15	15.4	
RL	Return loss				20			15	dB
T_R	Rise time switching speed (10% - 90% of RF swing, f_0 = 3 GHz)			1.0			1.0		µs
SHI	Second harmonic intercept point (Referred to P_{in})			100			100		dBm
THI	Third harmonic intercept point (Referred to P_{in})			70			70		
TOI	Two–tone third order intercept point (For two–tone power levels < +20 dBm)			57			57		dBm
P_{-1dB}	Input power @ 1 dB increase in insertion loss:			30[2]			30		dBm
P_{in}(max)	Maximum continuous RF input power				30			30	dBm

1. Typical $IL_{(min)}$ @ < 10 MHz = 0.4 dB.
2. Typical P_{-1dB} @ < 10 MHz = 25 dBm.

Applications

The 1GG7-4081 is designed for use in instrumentation, communications, radar, ECM, EW, and many other systems requiring fast switching speed, low distortion to input signals, and high cycle lifetimes. It can be used for pulse modulation, port isolation, replacement of mechanical relays, and in any application requiring the advantages of solid–state performance.

This device does not include any on-chip driver circuitry. An external driver circuit is required to convert TTL or ECL logic signals to the ±10 volt switching levels required by this device.

Figure 3 shows the device assembly diagram for operation through 6 GHz. Dual RF input and output bonds are recommended for assemblies where the device to thin film circuit gap exceeds 10 mils.

Assembly Techniques

This device is compatible with Au–Sn eutectic or conductive epoxy processes Gold thermo-sonic ball or wedge bonding is recommended for all bonds. The bond pads are designed to be large enough to facilitate autobonding. The top and bottom metallization is gold.

MMIC ESD precautions, handling considerations, die attach and bonding methods are critical factors in successful GaAs MMIC performance and reliability.

The Keysight *GaAs MMIC ESD, Die Attach and Bonding Guidelines* – Application Note (5991-3484EN) provides basic information on these subjects.

RoHS Compliance

The 1GG7-4081 prescaler is RoHS Compliant. This means the component meets the requirements of the European Parliament and the Council of the European Union *Restriction of Hazardous Substances* Directive 2011/65/EU, commonly known as *RoHS*. The six regulated substances are lead, mercury, cadmium, chromium VI (hexavalent), polybrominated biphenyls (PBB) and polybrominated biphenyl ethers (PBDE). RoHS compliance implies that any residual concentration of these substances is below the RoHS Directive’s maximum concentration values (MVC); being less than 1000 ppm by weight for all substances except for cadmium which is less than 100 ppm by weight.

Logic table

(V_{C1-C4} typical values in volts)

Attenuation setting	V_{C1}	V_{C2}	V_{C3}	V_{C4}
Min. insertion loss	+10	–10	+10	–10
–5 dB state	+10	–10	–10	+10
–10 dB state	–10	+10	+10	–10
–15 dB state	–10	+10	–10	+10

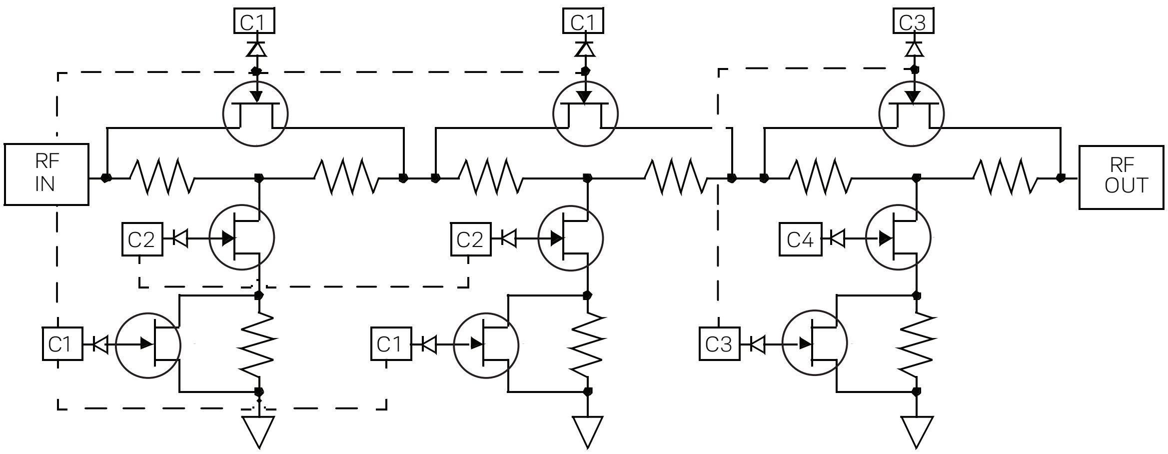
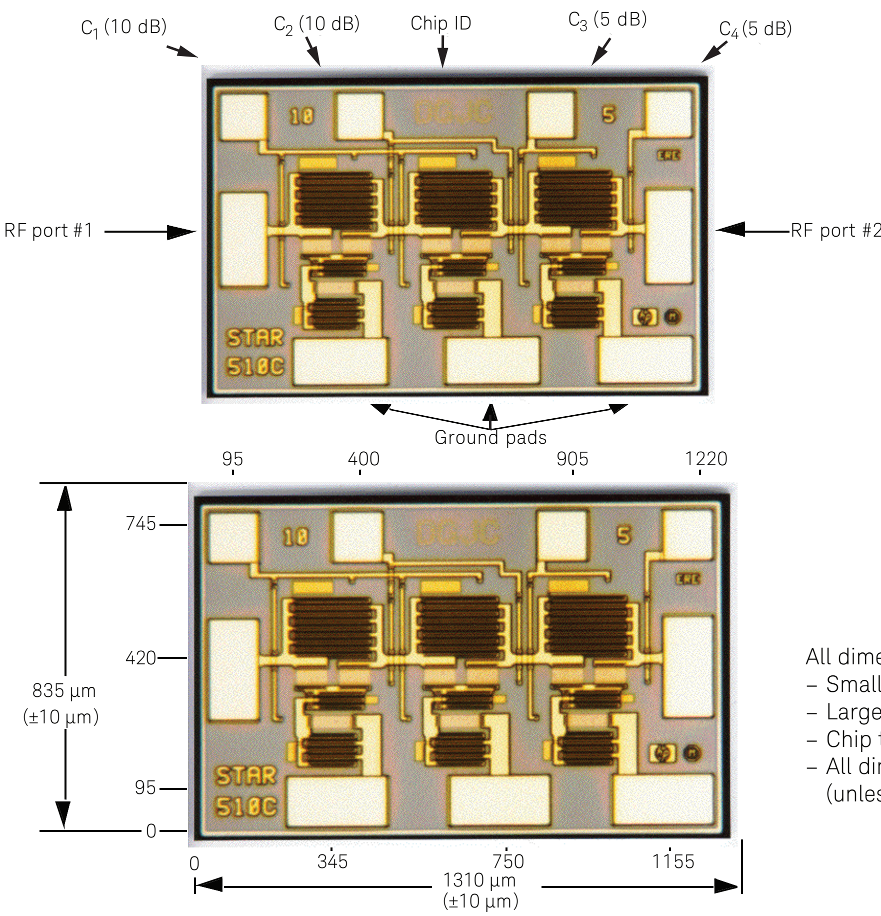


Figure 1. 1GG7-4081 schematic



All dimensions in microns
- Small pads: 114 × 114 µm
- Large pads: 114 × 228 µm
- Chip thickness: 127 µm
- All dimensions ±5 µm
  (unless otherwise noted)

Figure 2. 1GG7-4081 bond pad locations

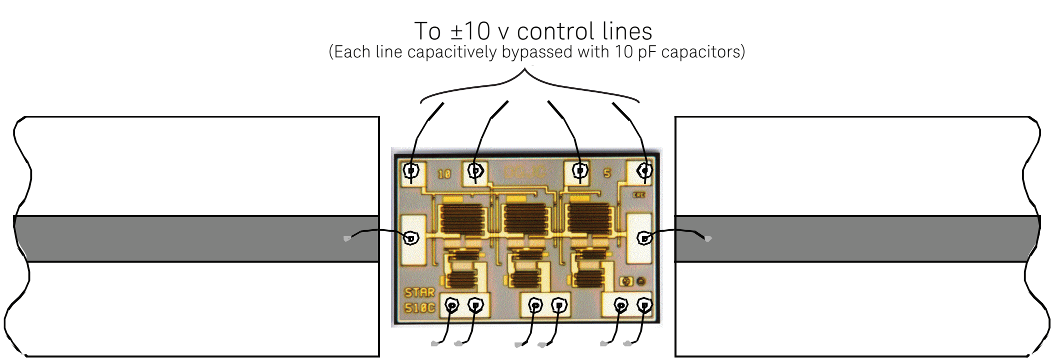


Figure 3. 1GG7-4081 assembly diagram

- No device pedestal/shim req.
- Ball bonding shown for clarity.

Typical S-Parameters[1]

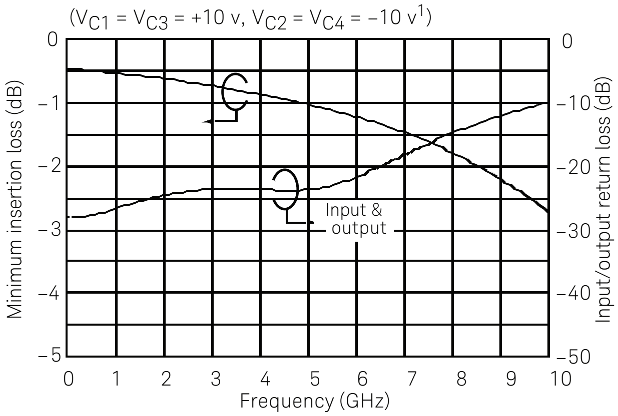


Figure 4. Min. insertion loss and return loss vs. frequency

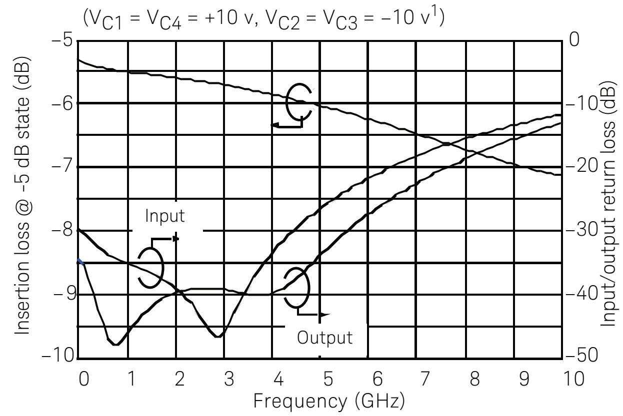


Figure 5. Insertion loss @ –5 dB state and return loss vs. frequency

Minimum insertion loss state

(T_A = 25 °C, $V_{C1} = V_{C3}$ = +10 v, $V_{C2} = V_{C4}$ = –10 v, $Z_{in} = Z_{out}$ = 50 Ω)

Freq		S_{11}			S_{12}			S_{21}			S_{22}	
(GHz)	dB	mag	ang	dB	mag	ang	dB	mag	ang	dB	mag	ang
0.001	–27.1	0.044	0.023	–0.41	0.954	–0.02	–0.41	0.954	–0.02	–26.7	0.046	0.023
0.01	–27.1	0.044	–0.334	–0.41	0.954	–0.18	–0.41	0.954	–0.18	–26.7	0.046	–0.334
0.1	–27.1	0.044	–3.2	–0.45	0.951	–1.6	–0.45	0.951	–1.6	–27.1	0.044	–3.2
0.5	–27.8	0.041	6.4	–0.51	0.943	–6.7	–0.51	0.943	–6.7	–27.8	0.041	6.4
1.0	–26.8	0.046	13.2	–0.54	0.940	–13.1	–0.54	0.940	–13.1	–26.8	0.046	13.1
1.5	–25.6	0.052	13.9	–0.58	0.936	–19.5	–0.58	0.936	–19.5	–25.6	0.052	13.8
2.0	–24.7	0.059	10.7	–0.62	0.931	–25.9	–0.62	0.931	–25.9	–24.7	0.058	10.6
2.5	–24.0	0.063	4.6	–0.68	0.925	–32.3	–0.68	0.925	–32.3	–24.0	0.063	4.4
3.0	–23.6	0.066	–3.9	–0.74	0.919	–38.6	–0.74	0.919	–38.6	–23.6	0.066	–4.1
3.5	–23.5	0.067	–14.9	–0.80	0.912	–44.9	–0.80	0.912	–44.9	–23.5	0.066	–15.2
4.0	–23.6	0.066	–28.6	–0.87	0.904	–51.3	–0.87	0.904	–51.3	–23.6	0.066	–29.0
4.5	–23.8	0.065	–45.7	–0.95	0.896	–57.6	–0.95	0.896	–57.6	–23.8	0.065	–46.1
5.0	–23.7	0.066	–66.2	–1.0	0.888	–64.0	–1.0	0.888	–64.0	–23.7	0.066	–66.7
5.5	–23.0	0.070	–88.9	–1.1	0.879	–70.4	–1.1	0.879	–70.4	–23.0	0.071	–89.4
6.0	–21.8	0.082	–111.0	–1.2	0.869	–76.8	–1.2	0.869	–76.8	–21.7	0.082	–111.5
7.0	–18.3	0.122	–146.8	–1.5	0.844	–89.9	–1.5	0.844	–89.9	–18.2	0.123	–147.1
8.0	–14.9	0.180	–172.2	–1.8	0.814	–103.0	–1.8	0.814	–103.0	–14.8	0.182	–172.4
9.0	–12.1	0.247	168.2	–2.2	0.775	–116.0	–2.2	0.775	–116.0	–12.1	0.249	168.1
10.0	–10.0	0.316	152.0	–2.7	0.731	–128.9	–2.7	0.731	–128.9	–10.0	0.317	151.9

@ –5 dB state

(T_A = 25 °C, $V_{C1} = V_{C4}$ = +10 v, $V_{C2} = V_{C3}$ = –10 v, $Z_{in} = Z_{out}$ = 50 Ω)

Freq		S_{11}			S_{12}			S_{21}			S_{22}	
(GHz)	dB	mag	ang	dB	mag	ang	dB	mag	ang	dB	mag	ang
0.001	–28.0	0.040	–0.08	–5.4	0.535	–0.02	–5.4	0.535	–0.02	–34.2	0.019	–0.14
0.01	–28.0	0.040	–1.4	–5.4	0.535	–0.22	–5.4	0.535	–0.22	–34.2	0.020	–1.9
0.1	–28.7	0.037	–13.4	–5.4	0.535	–1.9	–5.4	0.535	–1.9	–35.1	0.018	–18.8
0.5	–32.9	0.023	–21.1	–5.4	0.535	–6.5	–5.4	0.535	–6.5	–44.4	0.006	–28.5
1.0	–34.8	0.018	–16.4	–5.5	0.531	–11.8	–5.5	0.531	–11.8	–46.1	0.005	42.2
1.5	–36.3	0.015	–16.8	–5.5	0.529	–17.3	–5.5	0.529	–17.3	–41.8	0.008	62.2
2.0	–38.7	0.012	–22.7	–5.6	0.526	–22.8	–5.6	0.526	–22.8	–39.7	0.010	67.6
2.5	–43.0	0.007	–41.5	–5.6	0.523	–28.3	–5.6	0.523	–28.3	–38.9	0.011	71.7
3.0	–46.0	0.005	–110.2	–5.7	0.519	–33.8	–5.7	0.519	–33.8	–39.0	0.011	78.6
3.5	–38.9	0.011	–159.2	–5.8	0.515	–39.3	–5.8	0.515	–39.3	–39.7	0.010	92.6
4.0	–33.4	0.021	–174.0	–5.8	0.510	–44.7	–5.8	0.510	–44.7	–39.7	0.010	117.8
4.5	–29.5	0.034	178.0	–5.9	0.505	–50.2	–5.9	0.505	–50.2	–37.4	0.014	145.1
5.0	–26.4	0.048	172.1	–6.0	0.500	–55.5	–6.0	0.500	–55.5	–33.8	0.021	161.5
5.5	–23.9	0.064	167.0	–6.1	0.494	–60.8	–6.1	0.494	–60.8	–30.3	0.031	168.9
6.0	–21.7	0.082	162.2	–6.2	0.488	–66.1	–6.2	0.488	–66.1	–27.3	0.043	171.6
7.0	–18.2	0.123	152.9	–6.5	0.475	–76.4	–6.5	0.475	–76.4	–22.5	0.075	171.0
8.0	–15.5	0.168	143.9	–6.7	0.462	–86.5	–6.7	0.462	–86.5	–18.7	0.116	167.0
9.0	–13.4	0.215	134.9	–6.9	0.450	–96.1	–6.9	0.450	–96.1	–15.6	0.166	161.9
10.0	–11.7	0.260	126.2	–7.1	0.441	–105.4	–7.1	0.441	–105.4	–13.0	0.225	156.0

1. Data obtained from small-signal linear modeling

Typical S-Parameters[1] (continued)

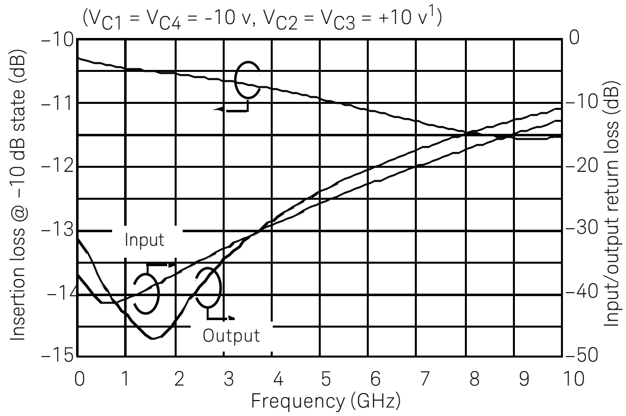


Figure 6. Insertion loss @ −10 dB state and return loss vs. frequency

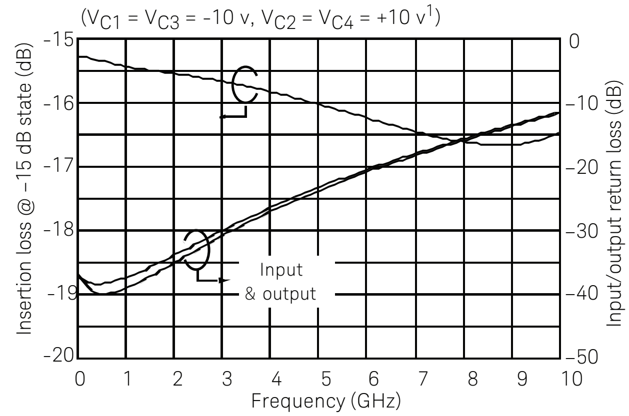


Figure 7. Insertion loss @ −15 dB state and return loss vs. frequency

@ −10 dB state

(T_A = 25 °C, $V_{C1} = V_{C4}$ = −10 v, $V_{C2} = V_{C3}$ = +10 v, $Z_{in} = Z_{out}$ = 50 Ω)

Freq (GHz)	S_{11}			S_{12}			S_{21}			S_{22}		
	dB	mag	ang	dB	mag	ang	dB	mag	ang	dB	mag	ang
0.001	−37.1	0.014	−0.32	−10.3	0.304	−0.03	−10.3	0.304	−0.03	−31.2	0.028	−0.15
0.01	−37.0	0.014	−3.7	−10.3	0.304	−0.25	−10.3	0.304	−0.25	−31.1	0.028	−2.0
0.1	−37.6	0.013	−36.7	−10.4	0.303	−2.2	−10.4	0.303	−2.2	−31.9	0.025	−19.8
0.5	−41.3	0.009	−125.2	−10.4	0.303	−6.2	−10.4	0.303	−6.2	−38.3	0.012	−47.3
1.0	−40.9	0.009	−170.5	−10.4	0.300	−10.4	−10.4	0.300	−10.4	−43.3	0.007	−56.9
1.5	−39.0	0.011	170.3	−10.5	0.299	−14.9	−10.5	0.299	−14.9	−46.9	0.004	−89.6
2.0	−36.9	0.014	161.9	−10.5	0.297	−19.5	−10.5	0.297	−19.5	−44.4	0.006	−141.4
2.5	−34.9	0.018	158.4	−10.6	0.296	−24.1	−10.6	0.296	−24.1	−39.1	0.011	−165.4
3.0	−32.9	0.023	157.2	−10.6	0.294	−28.7	−10.6	0.294	−28.7	−34.8	0.018	−175.8
3.5	−31.1	0.028	157.2	−10.7	0.292	−33.3	−10.7	0.292	−33.3	−31.4	0.027	177.9
4.0	−29.3	0.034	157.6	−10.8	0.289	−37.8	−10.8	0.289	−37.8	−28.6	0.037	173.3
4.5	−27.6	0.042	158.1	−10.8	0.287	−42.3	−10.8	0.287	−42.3	−26.1	0.049	169.4
5.0	−25.9	0.051	158.4	−10.9	0.284	−46.7	−10.9	0.284	−46.7	−24.0	0.063	165.9
5.5	−24.3	0.061	158.6	−11.0	0.281	−51.0	−11.0	0.281	−51.0	−22.1	0.078	162.5
6.0	−22.8	0.072	158.5	−11.1	0.279	−55.2	−11.1	0.279	−55.2	−20.4	0.095	159.2
7.0	−20.0	0.100	157.6	−11.3	0.273	−63.3	−11.3	0.273	−63.3	−17.5	0.134	152.6
8.0	−17.4	0.135	155.9	−11.4	0.268	−70.9	−11.4	0.268	−70.9	−14.9	0.179	145.8
9.0	−15.0	0.179	153.3	−11.5	0.265	−77.8	−11.5	0.265	−77.8	−12.7	0.230	138.6
10.0	−12.7	0.233	149.8	−11.5	0.265	−84.2	−11.5	0.265	−84.2	−10.9	0.286	131.0

@ −15 dB state

(T_A = 25 °C, $V_{C1} = V_{C3}$ = −10 v, $V_{C2} = V_{C4}$ = +10 v, $Z_{in} = Z_{out}$ = 50 Ω)

Freq (GHz)	S_{11}			S_{12}			S_{21}			S_{22}		
	dB	mag	ang	dB	mag	ang	dB	mag	ang	dB	mag	ang
0.001	−37.5	0.013	−0.39	−15.4	0.169	−0.03	−15.4	0.169	−0.03	−37.5	0.013	−0.35
0.01	−37.5	0.013	−4.4	−15.4	0.169	−0.30	−15.4	0.169	−0.30	−37.5	0.013	−3.9
0.1	−37.6	0.013	−42.8	−15.4	0.169	−2.6	−15.4	0.169	−2.6	−37.8	0.013	−39.0
0.5	−38.2	0.012	−127.4	−15.4	0.169	−6.2	−15.4	0.169	−6.2	−39.8	0.010	−122.5
1.0	−37.3	0.014	−155.1	−15.4	0.169	−9.6	−15.4	0.169	−9.6	−39.0	0.011	−154.2
1.5	−35.7	0.016	−166.3	−15.5	0.168	−13.4	−15.5	0.168	−13.4	−37.2	0.014	−167.3
2.0	−33.8	0.020	−172.8	−15.5	0.167	−17.3	−15.5	0.167	−17.3	−35.1	0.018	−174.6
2.5	−31.9	0.025	−177.3	−15.6	0.166	−21.3	−15.6	0.166	−21.3	−32.9	0.023	−179.4
3.0	−30.0	0.032	179.2	−15.6	0.165	−25.2	−15.6	0.165	−25.2	−30.8	0.029	177.0
3.5	−28.1	0.039	176.2	−15.7	0.164	−29.1	−15.7	0.164	−29.1	−28.8	0.036	174.0
4.0	−26.4	0.048	173.5	−15.8	0.162	−32.9	−15.8	0.162	−32.9	−27.0	0.045	171.4
4.5	−24.8	0.058	171.1	−15.9	0.160	−36.7	−15.9	0.160	−36.7	−25.3	0.054	169.1
5.0	−23.2	0.069	168.8	−16.0	0.158	−40.3	−16.0	0.158	−40.3	−23.7	0.065	166.9
5.5	−21.8	0.081	166.6	−16.1	0.156	−43.8	−16.1	0.156	−43.8	−22.2	0.078	164.9
6.0	−20.4	0.095	164.5	−16.2	0.155	−47.1	−16.2	0.155	−47.1	−20.8	0.091	162.9
7.0	−17.9	0.128	160.5	−16.4	0.151	−53.1	−16.4	0.151	−53.1	−18.2	0.123	159.1
8.0	−15.6	0.167	156.5	−16.6	0.148	−58.3	−16.6	0.148	−58.3	−15.9	0.161	155.4
9.0	−13.4	0.214	152.4	−16.6	0.147	−62.4	−16.6	0.147	−62.4	−13.7	0.208	151.4
10.0	−11.3	0.273	147.8	−16.5	0.150	−65.6	−16.5	0.150	−65.6	−11.6	0.264	147.1

1. Data obtained from small-signal linear modeling

Typical Attenuation Step Values[1]

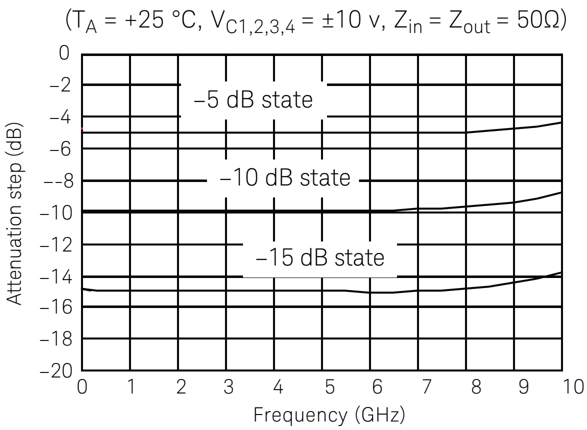


Figure 8. Attenuation step values vs. frequency

(T_A = 25 °C, $V_{C1,2,3,4}$ = +10 v, Z_{in} = Z_{out} = 50 Ω)

Freq. (GHz)	–5 dB state (dB)	–10 dB state (dB)	–15 dB state (dB)
0.001	–5	–9.9	–14.9
0.01	–5	–9.9	–14.9
0.1	–5	–9.9	–14.9
0.5	–5	–9.9	–14.9
1.0	–5.0	–9.9	–14.9
1.5	–5.0	–9.9	–14.9
2.0	–5.0	–9.9	–14.9
2.5	–5.0	–9.9	–14.9
3.0	–5.0	–9.9	–14.9
3.5	–5.0	–9.9	–14.9
4.0	–5.0	–9.9	–14.9
4.5	–5.0	–9.9	–15.0
5.0	–5.0	–9.9	–15.0
5.5	–5.0	–9.9	–15.0
6.0	–5.0	–9.9	–15.0
6.5	–5.0	–9.9	–15.0
7.0	–5.0	–9.8	–15.0
7.5	–5.0	–9.7	–14.9
8.0	–4.9	–9.7	–14.8
8.5	–4.8	–9.5	–14.7
9.0	–4.7	–9.3	–14.4
9.5	–4.6	–9.1	–14.2
10.0	–4.4	–8.8	–13.8

1. Data obtained from small–signal linear modelling.

All compression and harmonic data measured on individual device mounted in an Keysight 83040 Series Modular Microcircuit Package @ T_{case} = 25 °C.

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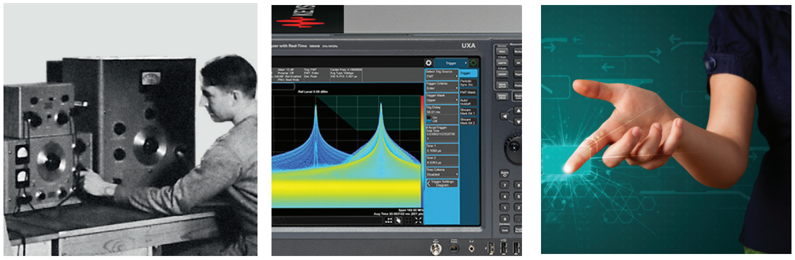

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