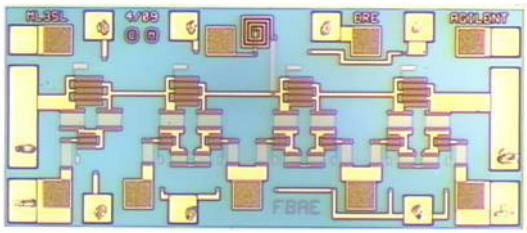
Keysight 1GG7-4169
DC - 26.5 GHz 35 dB/ 5 dB Step Attenuator



Data Sheet

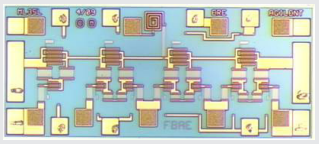
Features

- Frequency Range: DC to 26.5 GHz
- Attenuation Values: 0 to 35 dB in 5 dB steps
- Insertion Loss:
  On–chip pre– and post–amps
  -5 dB @ 20 GHz
  –6.5 dB @ 26.5 GHz
- Switching Speed:
  < 0.1 $_{\mu s}$ (10% to 90% T_R)
- Distortion:
  SHI: +80 dBm
  THI: +55 dBm
  TOI: +50 dBm
- P_{1dB}: 27 dBm

KEYSIGHT TECHNOLOGIES
Unlocking Measurement Insights

Description

The 1GG7-4169 is a 35-dB by 5-dB step GaAs MMIC step attenuator designed for low insertion loss and low distortion from DC to 26.5 GHz. It is intended for use as a high performance solid-state step-attenuator for RF instrumentation applications. Each attenuator cell incorporates a resistive Bridged-T topology with series and shunt MESFET switching elements. Bias to the gate of the FET switches is through a resistor and a diode which improves distortion at low frequencies. Ground connection is through backside vias. The 1GG7-4169 is fabricated using the Keysight Technologies, Inc. GaAs FET MMIC process.



- Chip size: 1460 x 640 µm (57.5 x25.2 mils)
- Chip size tolerance: ± 10 µm (± 0.4 mils)
- Chip thickness: 127 ± 15 µm (5 ± 0.6 mils)
- Pad dimensions: 80 x 80 µm (3.1 x 3.1 mils)
- Large pad dimensions: 80 x 280 µm (3.1 x 11 mils)

Absolute maximum ratings[1] Continuous operation

Symbol	Parameters/conditions	Min	Max	Units
$V_{(C5A, C10A, C20A, C5B, C10B, C20B)}$	Control line voltages	-10	+10	Volts
P_{in}	Input power		27	dBm
$V_{RMS (in and out)}$	Input/output RMS voltage	-5	+5	Volts
$V_{Peak (in and out)}$	Input/output peak voltage	-7.1	7.1	Volts
$I_{RMS(in and out)}$	Input/output RMS current	-100	100	mA
$I_{Peak(in and out)}$	Input/output peak current	-141	+141	mA
Tbs	Maximum backside temperataure		+90	°C
Tst	Storage temperature	-65	+65	°C
Tmax	Storage temperature		+300	°C
ESD[2]	RF_{IN} and RF_{OUT}		500	V
ESD[2]	Control lines		100	V

1. Operation in excess of any one of these may result in permanent damage to this device.
2. Human Body Model: 100 pF, 1500 Ohms

DC specifications/physical properties

(T_A = 25 °C)

Symbol	Parameters/conditions	Min	Typ	Max	Units
$V_{C5A, C10A, C20A, C5B, C10B, C20B}$	Positive control line voltage	7	10	10	Volts
$V_{C5A, C10A, C20A, C5B, C10B, C20B}$	Negative control line voltage	-10	-10	-7	Volts
$IL_{(+)}$	Positive control line leakage current (@ 10V)			50	µA
$IL_{(-)}$	Negative control line leakage current (@ -10V)	-50			µA
Rseries0	Series resistance, 0-dB state	21	28	35	Ohms
Rshunt0	Shunt resistance, 0-dB state	204	243	283	Ohms
Rshunt5	Shunt resistance	53	66	79	Ohms
	$V(C_{5A},C_{10A},C_{20A},C_{5B})$ = +10V				
	$V(C_{10B},C_{20B})$=-10V				
Shunt10	Shunt resistance	38	48	58	Ohms
	$V(C_{5A},C_{10A},C_{20A},C_{10B})$ = +10V				
	$V(C_{5A},C_{20A})$ = -10V				
Shunt20	Shunt resistance	30	39	48	Ohms
	$V(C_{5A},C_{10A},C_{20A},C_{20B})$ = +10V				
	$V(C_{5A},C_{10A})$ = -10V				

Frequency-domain RF specifications

(T_A = 25 °C)

Symbol	Parameters/ conditions	1 GHz			10 GHz			20 GHz			27 GHz			
		Min.	Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Units
S21_0	0-dB state	-4.8	-3.5	-2.2	-5.7	-4.4	-3.1	-6.7	-5.2	-3.7	-8.3	-6.6	-4.9	dB
S11_0			-17	-12		-20	-12		-21	-12		-15	-9	dB
S22_5			-17	-12		-17	-12		-19	-12		-14	-9	dB
S21_5	5-dB state	-9.5	-8.4	-7.3	-10.4	-9.1	-7.8	-11.6	-10.6	-8.6	-13	-11.3	-9.6	dB
S11_5			-28	-12		-27	-12		-22	-12		-17	-9	dB
S22_5			-18	-12		-16	-12		-18	-12		-18	-9	dB
S21_10	10-dB state	-15.1	-13.4	-11.7	-15.9	-14.1	-12.3	-17.3	-15.6	-13.9	-18.5	-16.6	-14.7	dB
S11_10			-23	-12		-21	-12		-17	-9		-15	-9	dB
S22_10			-22	-12		-18	-12		-15	-9		-15	-9	dB
S21_20	20-dB state	-25.5	-23.2	-20.9	-26.3	-23.8	-21.3	-27.3	-25.5	-23.7	-28.8	-26.3	-23.8	dB
S11_20			-25	-12		-21	-12		-16	-9		-16	-9	dB
S22_20			-39	-12		-24	-12	-17	-9			-14	-9	dB
S11_35	35-dB state		-38	-12		-29	-12		-20	-9		-16	-9	dB
S22_35			-38	-12		-24	-12		-17	-9		-14	-0	dB

Symbol	Parameters/ conditions	Typ	Units
SHI	2nd harmonic intercept point @ 3 and 10 GHz (referred to Pin)	80	dBm
THI	3rd harmonic intercept point @ 3 and 10 GHz (referred to Pin)	55	dBm
TOI	Two-tone 3rd order Intercept point @ 9.5 and 24 GHz (referred to Pin)	50	dBm
P1dB	Input power @ 1dB increase or decrease in insertion loss	27	dBm
Switching Speed	0-dB state to 35-dB state, 10% to 90%	<0.1	µs

Logic table

"1" corresponds to "+10V control line voltage"
"0" corresponds to "-10V control line voltage"

Attenuation Setting	C5A	C5B	C10A	C10B	C20A	C20B
Min. Insertion loss	1	0	1	0	1	0
5 dB	0	1	1	0	1	0
10 dB	1	0	0	1	1	0
15 dB	0	1	0	1	1	0
20 dB	1	0	1	0	0	1
25 dB	0	1	1	0	0	1
30 dB	1	0	0	1	0	1
25 dB	0	1	0	1	0	1

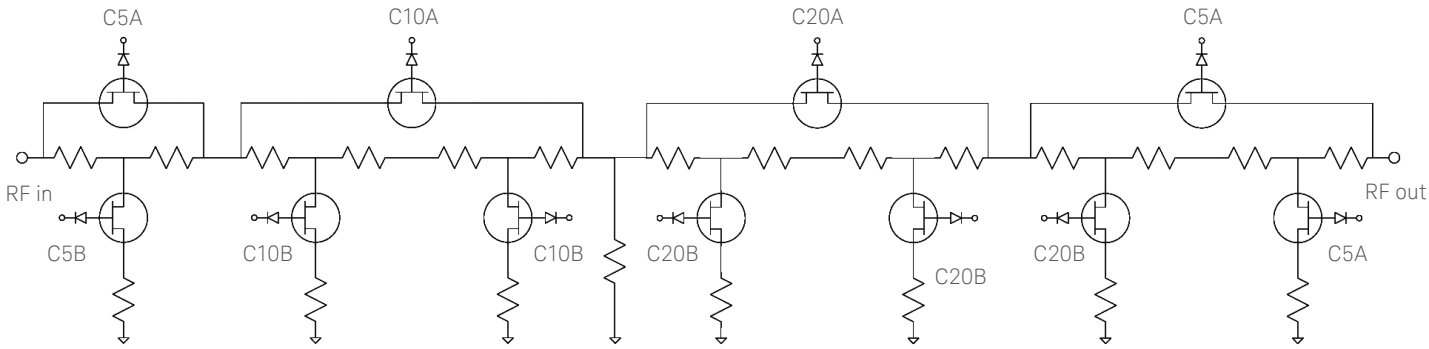


Figure 1. 1GG7-4169 simplified schematic diagram

Applications

The 1GG7-4169 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 lifetime. It can be used for pulse modulation, port isolation, and replacement of mechanical relations 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, ECL (or other logic) levels to the ±10 Volt switching levels required by this device. Figure 3 shows the device assembly diagram for operation through 26.5 GHz. Four 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 thermosonic ball or wedge bonding is recommended for all wire bonds. The bond pads are designed to be large enough to facilitate auto-bonding. The top and bottom metallization is gold.

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

ESD and Handling Precautions

GaAs MMICs in either chip or SMT packages are ESD sensitive. ESD preventive measures must be employed in all aspects of storage, handling, and assembly.

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

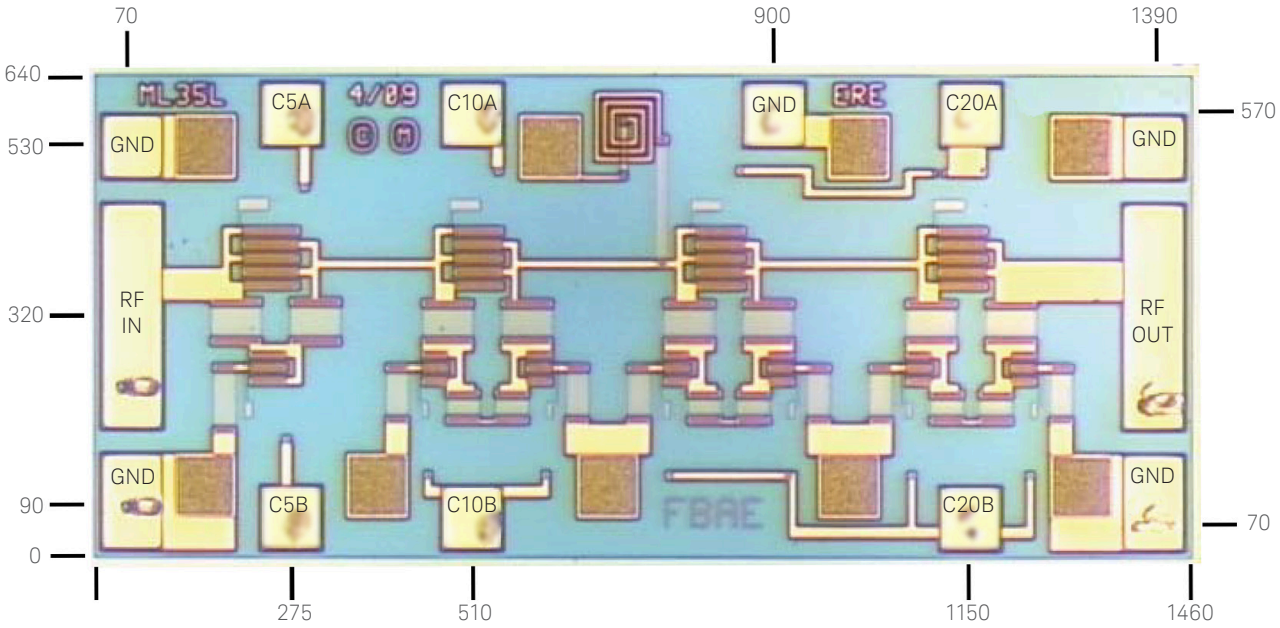


Figure 2. 1GG7-4169 Bond pad locations

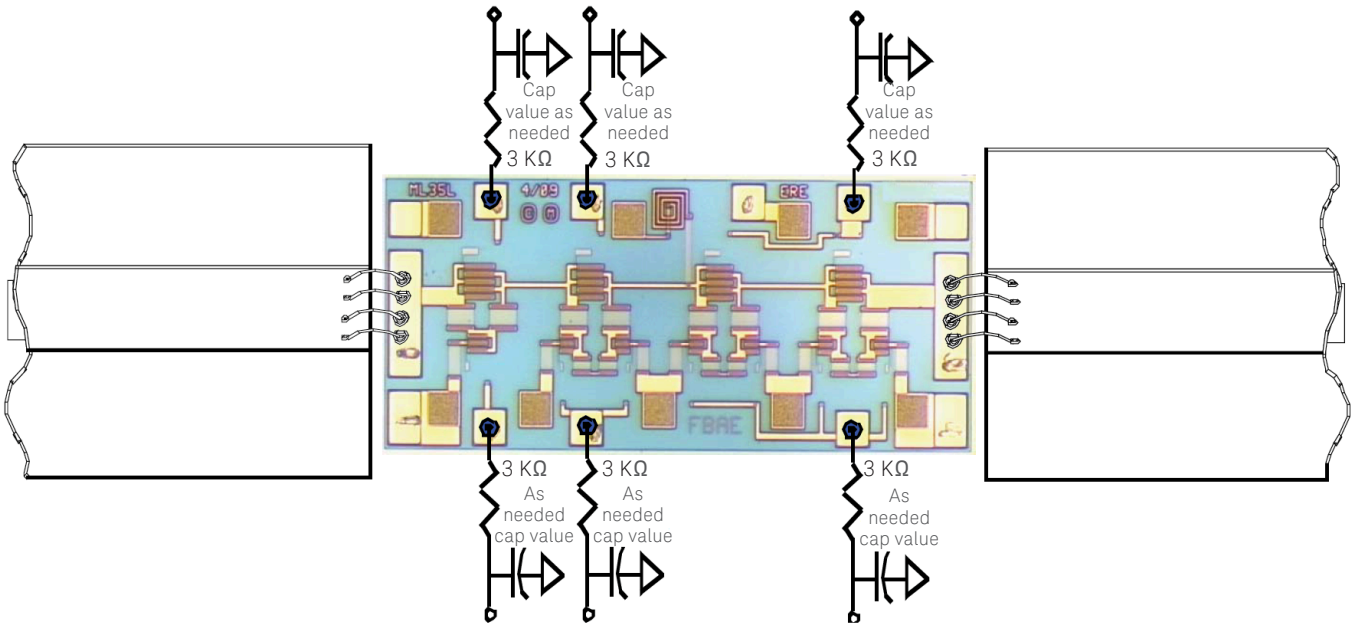


Figure 3. 1GG7-4169 Assembly diagram

Small-signal S-parameters, 0 dB state[1]

(T_A = 25 °C)

Freq. (GHz)	S11			S21			S22		
	dB	Mag.	Ang.	dB	Mag.	Ang.	dB	Mag.	Ang.
0.1	-18.289	0.122	-2.0	-3.336	0.681	-1.2	-17.383	0.135	-1.7
1	-18.428	0.120	-16.8	-3.382	0.678	-10.6	-17.515	0.133	-16.4
2	-18.521	0.119	-32.2	-3.430	0.674	-20.9	-17.585	0.132	-31.5
3	-18.522	0.119	-47.3	-3.484	0.670	-31.0	-17.656	0.131	-45.8
4	-18.407	0.120	-63.3	-3.539	0.665	-41.4	-17.629	0.131	-62.1
5	-18.526	0.119	-78.9	-3.624	0.659	-51.6	-17.697	0.130	-76.9
6	-18.590	0.118	-93.9	-3.727	0.651	-61.7	-17.832	0.128	-92.1
7	-18.778	0.115	-109.4	-3.852	0.642	-71.7	-17.987	0.126	-106.4
8	-18.740	0.116	-123.8	-3.978	0.633	-81.7	-17.020	0.126	-119.8
9	-18.864	0.114	-137.1	-4.119	0.622	-91.4	-18.193	0.123	-134.1
10	-19.245	0.109	-149.7	-4.235	0.614	-100.7	-18.411	0.120	-147.0
11	-19.422	0.107	-159.9	-4.251	0.613	-110.4	-18.512	0.119	-157.3
12	-19.697	0.104	-172.1	-4.333	0.607	-120.5	-18.564	0.118	-170.2
13	-20.148	0.098	178.3	-4.380	0.604	-129.9	-18.999	0.112	-179.2
14	-20.055	0.099	167.5	-4.437	0.600	-140.3	-19.676	0.110	169.2
15	-20.552	0.094	158.2	-4.547	0.592	-150.5	-19.676	0.104	157.3
16	-21.804	0.081	150.3	-4.689	0.583	-160.6	-20.722	0.092	151.2
17	-23.070	0.070	148.5	-4.799	0.576	-170.5	-22.016	0.079	146.8
18	-25.031	0.056	149.2	-4.917	0.568	179.5	-23.191	0.069	144.4
19	-26.082	0.050	160.1	-4.917	0.560	169.4	-23.507	0.067	154.0
20	-24.777	0.058	172.1	-5.121	0.555	159.2	24.788	0.058	161.1
21	-23.355	0.068	-177.8	-5.250	0.546	149.0	-22.072	0.079	169.5
22	-20.777	0.091	-177.1	-5.368	0.539	138.8	-20.954	0.090	175.5
23	-18.678	0.116	-179.4	-5.447	0.534	128.2	-19.336	0.108	172.4
24	-17.025	0.141	175.4	-5.637	0.523	117.4	-17.663	0.131	167.2
25	-15.736	0.163	168.8	-5.885	0.508	106.6	-16.141	0.156	166.3
26	-14.609	0.186	162.4	-6.070	0.497	96.3	-15.171	0.174	158.9
27	-13.600	0.209	153.4	-6.307	0.484	85.5	-13.849	0.203	150.8
28	-12.581	0.235	144.4	-6.581	0.469	74.8	-13.039	0.223	146.3
29	-11.947	0.253	136.8	-6.845	0.455	64.3	-12.626	0.234	134.8
30	-11.294	0.272	128.8	-7.122	0.440	53.8	-11.752	0.258	128.9

1. Wafer probed data with simulated four 20-mil long bond wires added to RF_IN and RF_OUT

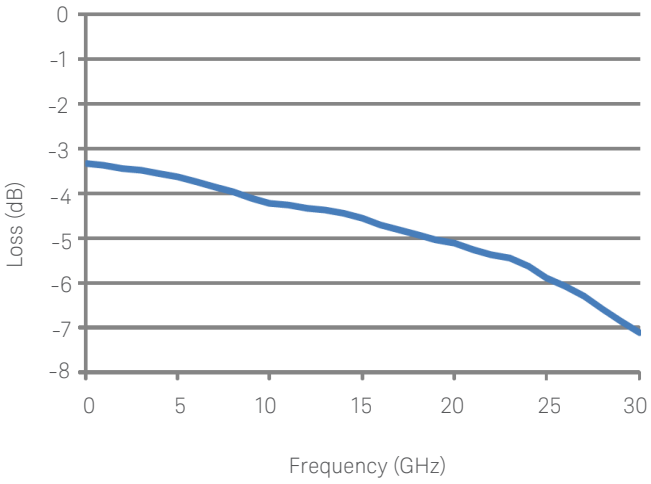


Figure 4. Insertion loss (S_{21}) , 0 dB state

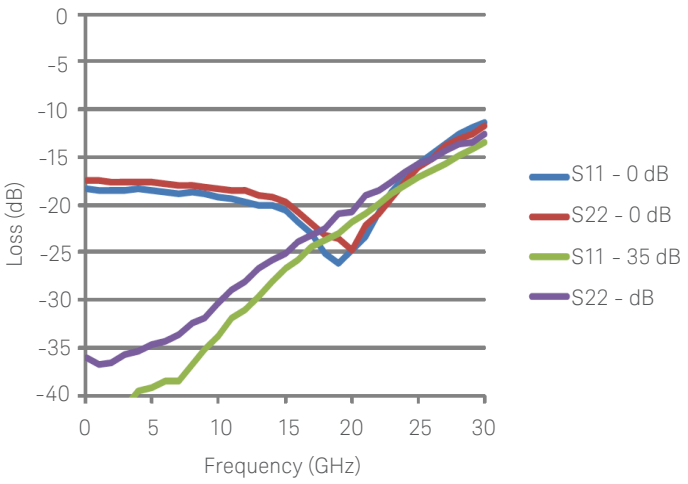


Figure 5. Small-signal input (S_{11}) and output (S_{22}) return loss at 0 dB and 35 dB attenuation.

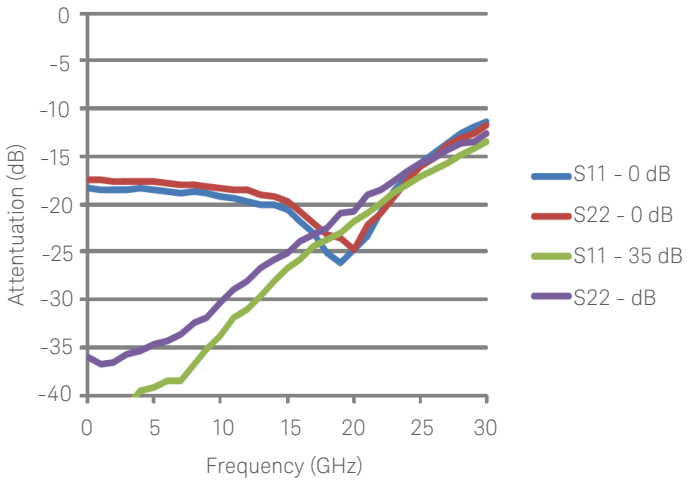


Figure 6. Typical attenuation step values vs frequency (normalized to 0-dB state)

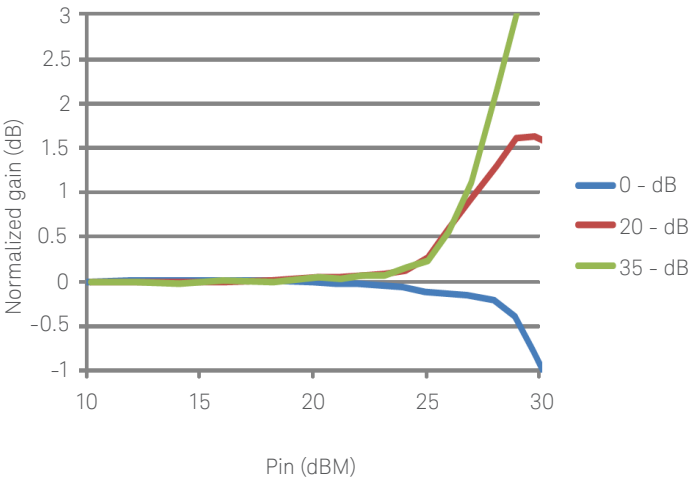


Figure 7. Typical normalized gain vs Pin @ 10 GHz

Small-signal S-parameters, -35 dB state[1]

(T_A = 25 °C)

Freq. (GHz)	S11			S21			S22		
	dB	Mag.	Ang.	dB	Mag.	Ang.	dB	Mag.	Ang.
0.1	-40.942	0.009	-5.9	-38.169	0.012	-0.9	-36.147	0.016	-2.5
1	-43.169	0.007	-19.3	-38.331	0.012	-6.7	-36.702	0.015	-13.2
2	-43.189	0.007	-28.8	-38.392	0.012	-12.6	-36.557	0.015	-24.1
3	-41.359	0.009	-41.9	-38.379	0.012	-18.6	-35.738	0.016	-32.8
4	-39.573	0.011	-52.3	-38.411	0.012	-25.0	-35.309	0.017	-49.9
5	-39.273	0.011	-67.6	-38.442	0.012	-31.6	-34.633	0.019	-60.0
6	-38.593	0.012	-76.7	-38.561	0.012	-38.6	-34.295	0.019	-72.3
7	-38.481	0.012	-88.9	-38.692	0.012	-45.3	-33.654	0.021	-82.0
8	-36.759	0.015	-100.7	-38.958	0.011	-53.6	-32.430	0.024	-88.9
9	-35.145	0.017	-102.9	-39.751	0.010	-59.2	-31.814	0.026	-98.3
10	-33.833	0.020	-105.3	-39.930	0.010	-58.4	-30.247	0.031	-108.2
11	-31.958	0.025	-109.0	-39.362	0.011	-65.0	-28.986	0.036	-113.8
12	-30.954	0.028	-114.7	-39.727	0.010	-74.0	-28.028	0.040	-125.3
13	-29.696	0.033	-125.0	-39.277	0.011	-78.2	-26.752	0.046	-131.7
14	-28.090	0.039	-134.3	-39.862	0.010	-88.6	-25.846	0.051	-138.3
15	-26.698	0.046	-140.0	-40.329	0.010	-95.8	-25.183	0.055	-147.9
16	-25.722	0.052	-145.6	-41.010	0.009	-100.6	-23.888	0.064	-151.0
17	-24.433	0.060	-149.7	-41.302	0.009	-105.9	-23.178	0.069	-154.8
18	-23.801	0.065	-152.8	-41.130	0.009	-109.3	-22.518	0.075	-162.0
19	-22.953	0.071	-157.6	-41.655	0.008	-118.1	-20.888	0.090	-166.0
20	-21.818	0.081	-163.8	-42.653	0.007	-122.3	-20.790	0.091	-169.1
21	-20.892	0.090	-167.9	-42.559	0.007	-124.0	-18.954	0.113	-176.1
22	-19.964	0.100	-171.8	-42.196	0.008	-127.2	-18.448	0.120	-178.4
23	-18.796	0.115	-175.5	-41.535	0.008	-137.8	-17.704	0.130	175.8
24	-17.959	0.126	179.7	-42.662	0.007	-148.7	-16.598	0.148	168.5
25	-17.086	0.140	174.3	-43.858	0.006	-151.6	-15.661	0.165	166.3
26	-16.330	0.153	171.1	-43.725	0.007	-152.9	-15.261	0.173	160.1
27	-15.663	0.165	164.5	-43.686	0.007	-151.3	-14.257	0.194	153.1
28	-14.875	0.180	158.8	-42.309	0.008	-153.7	-13.686	0.207	150.6
29	-14.216	0.195	154.7	-41.621	0.008	-165.0	-13.478	0.212	141.5
30	-13.392	0.214	149.8	-42.421	0.008	178.3	-12.525	0.236	136.9

1. Wafer probed data with simulated four 20-mil long bond wires added to RF_IN and RF_OUT

Typical attenuation values (normalized to 0-dB state)[1]

(T_A = 25 °C)

Freq (GHz)	5 dB	10 dB	15 dB.	20 dB	25 dB	30 dB	35 dB
0.1	-4.94	-10.04	-14.93	-20.04	-24.92	-29.95	-34.83
1	-4.96	-10.07	-14.98	-20.09	-24.99	-30.04	-34.95
2	-4.96	-10.06	-14.98	-20.08	-25.00	-30.05	-34.96
3	-4.94	-10.05	-14.96	-20.05	-24.94	-30.01	-34.89
4	-4.92	-10.03	-14.93	-20.02	-24.92	-29.98	-34.87
5	-4.90	-10.00	-14.90	-19.98	-24.88	-29.93	-34.82
6	-4.87	-9.98	-14.87	-19.96	-24.85	-29.93	-34.83
7	-4.85	-9.96	-14.85	-19.93	-24.83	-29.93	34.84
8	-4.83	-9.95	-14.83	-19.92	-24.82	-30.00	-34.98
9	-4.82	-9.97	-14.87	-20.03	-24.99	-30.40	-35.63
10	-4.83	-10.00	-14.90	-20.05	-25.02	-30.48	-35.70
11	-4.83	-10.00	-14.87	-19.93	-24.83	-30.11	-35.11
12	-4.83	-10.02	-14.89	-19.96	-24.87	-30.25	-35.39
13	-4.84	-10.06	-14.89	-19.87	-24.71	-29.97	-34.90
14	-14.94	-10.10	-4.86	-19.93	-24.81	-30.25	-35.43
15	-4.89	-10.16	-14.99	-20.02	-24.91	-30.50	-35.78
16	-4.92	-10.25	-15.10	-20.14	-25.07	-30.83	-36.32
17	-4.95	-10.33	-15.17	-20.20	-25.12	-30.97	-36.50
18	-4.96	-10.40	-15.22	-20.22	-25.09	-30.86	-36.21
19	-4.97	-10.47	-15.29	-20.26	-25.13	-31.10	-36.62
20	-4.97	-10.54	-15.37	-20.37	-25.32	-31.60	-37.53
21	-4.95	-10.58	-15.39	-20.34	-25.28	-31.47	-37.31
22	-4.92	-10.57	-15.37	-20.20	-25.14	-31.16	-36.83
23	-4.88	-10.50	-15.25	-19.94	-24.78	-30.60	-36.09
24	-4.83	-10.45	-15.20	-19.91	-24.82	-31.02	-37.03
25	-4.79	-10.39	-15.15	-19.91	-24.97	-31.43	-37.97
26	-4.75	-10.30	-15.07	-19.72	-24.81	-31.15	-37.66
27	-4.72	-10.19	-14.98	-19.54	-24.77	-30.82	-37.38
28	-4.71	-10.04	-14.81	-19.17	-24.34	-29.83	-35.73
29	-4.71	-9.83	-14.55	-18.71	-23.82	-29.26	-34.78
30	-4.71	-9.57	-14.26	-18.27	-23.44	-29.14	-35.30

1. Wafer probed data with simulated four 20-mil long bond wires added to RF_IN and RF_OUT

Supplemental data

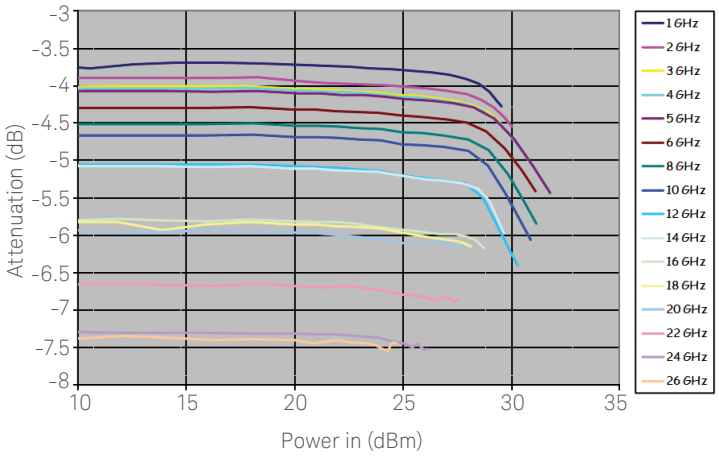


Figure 8. Attenuation vs pin, 0 dB state

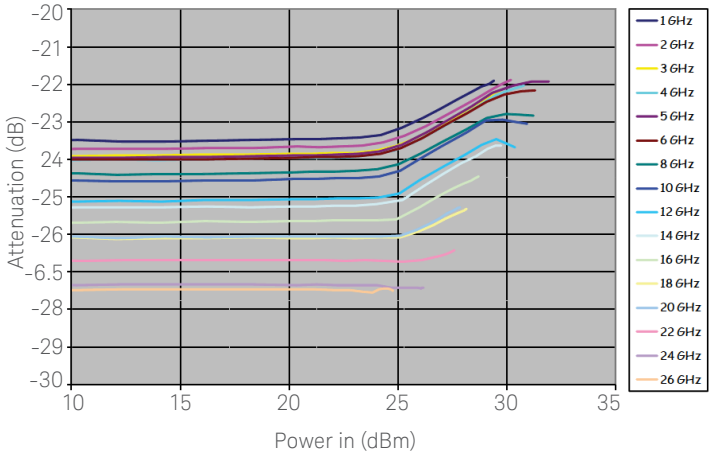


Figure 9. Attenuation vs pin, -20 dB state

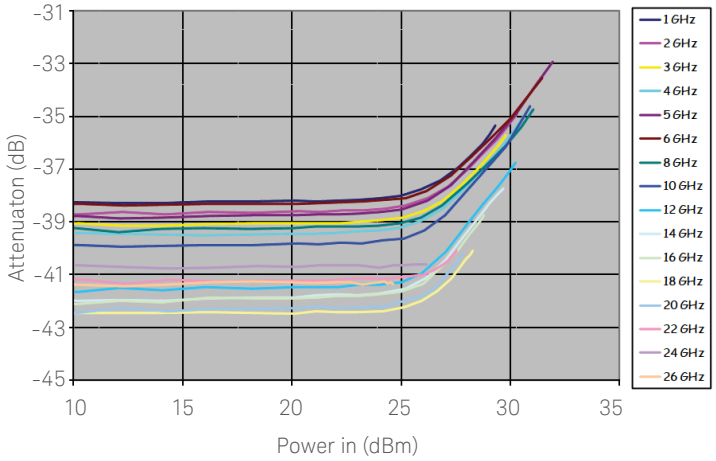


Figure 10. Attenuation vs pin, -35 dB state

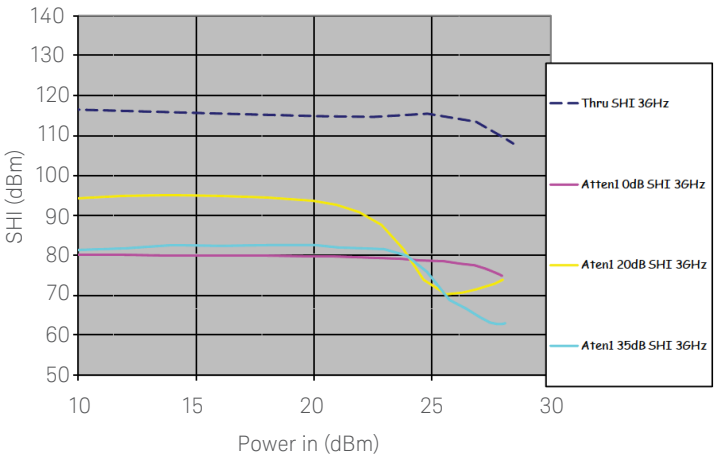


Figure 11. Pin vs SHI @ 3 GHz

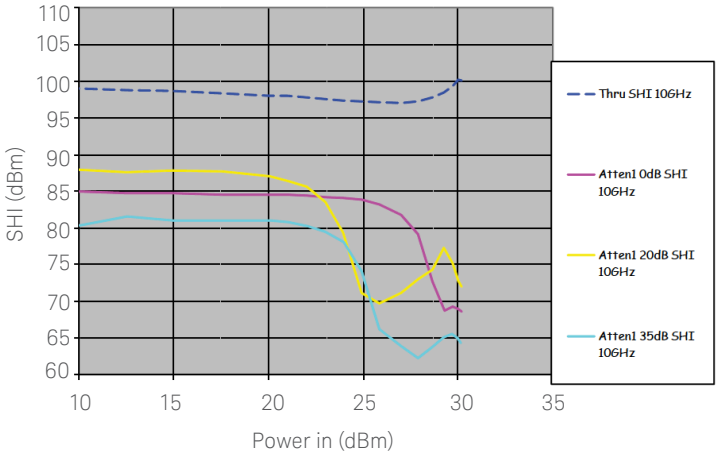


Figure 12. Pin vs SHI @ 10 GHz

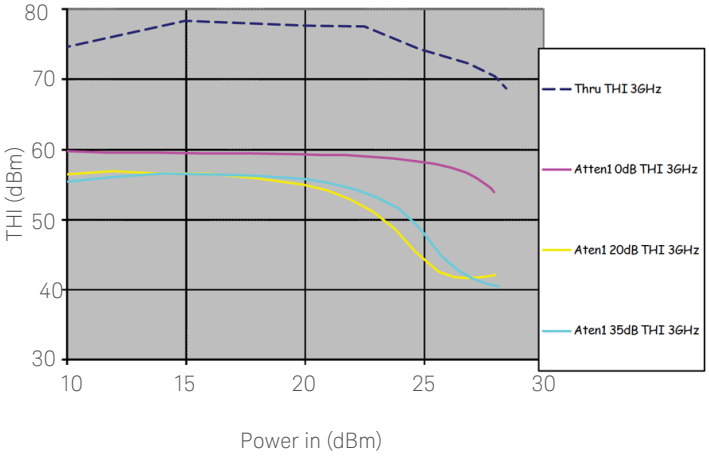


Figure 13. Pin vs THI @ 3 GHz

Supplemental data (continued)

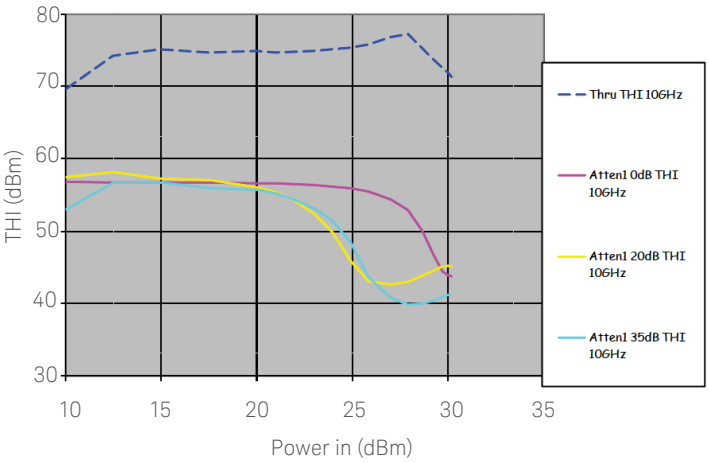


Figure 14. Pin vs THI @ 10 GHz

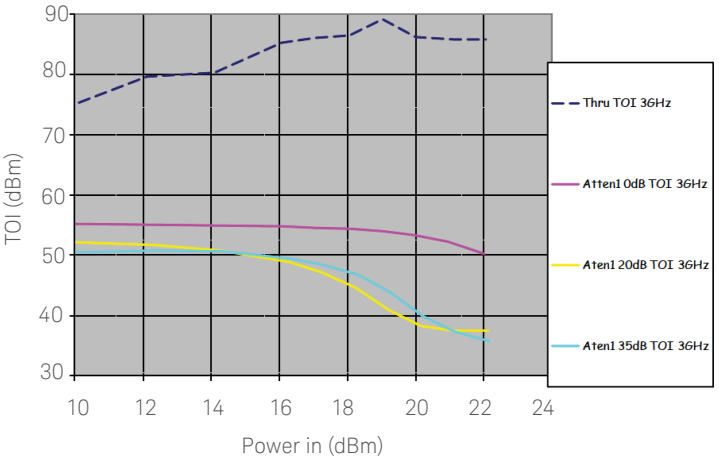


Figure 15. Pin vs TOI @ 3 GHz

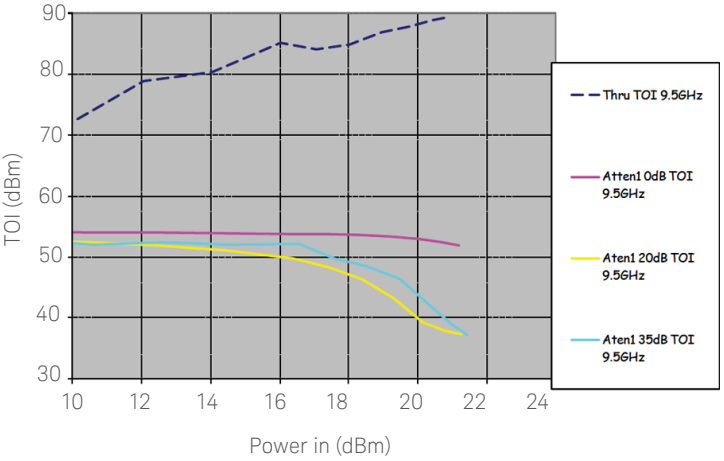


Figure 16. Pin vs TOI @ 9.5 GHz

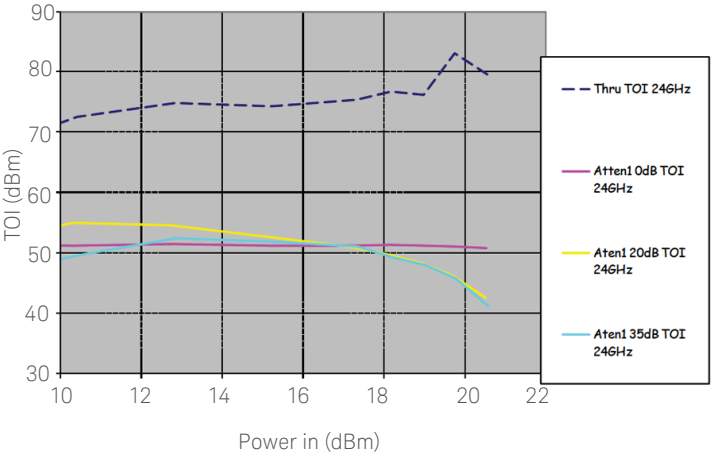


Figure 17. Pin vs TOI @ 9.5 GHz

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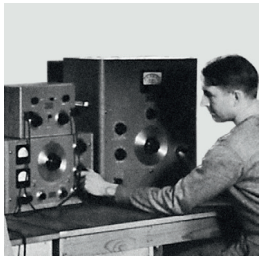

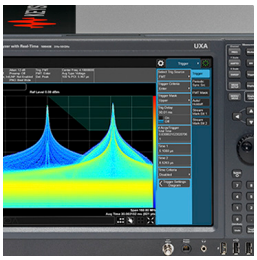

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