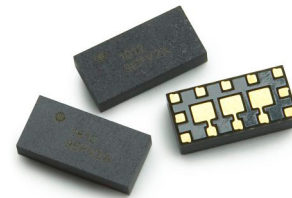


ALM-GP002

GPS Filter-LNA-Filter Front-End Module



Data Sheet



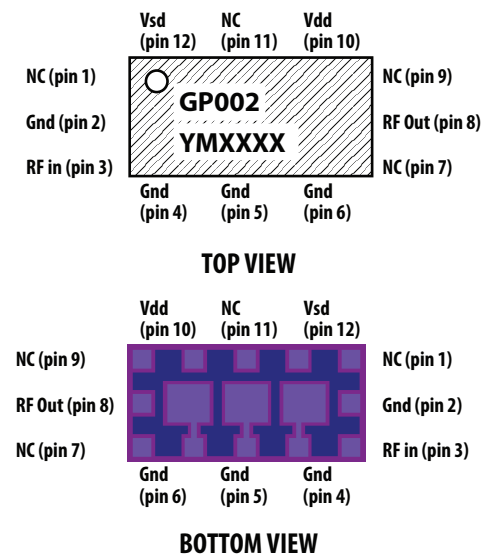
Description

Avago Technologies' ALM-GP002 is a GPS front-end module that combines a high-gain low-noise amplifier (LNA) with GPS FBAR filters. The LNA uses Avago Technologies' proprietary GaAs Enhancement-mode pHEMT process to achieve high gain with very low noise figure and high linearity. Noise figure distribution is very tightly controlled. A CMOS-compatible shutdown pin is included either for turning the LNA on/off, or for current adjustment. The integrated filter utilizes an Avago Technologies' leading-edge FBAR filter for exceptional rejection at Cell/PCS-Band frequencies.

The low noise figure and high gain, coupled with low current consumption make it suitable for use in critical low-power GPS applications or during low-battery situations.

Component Image

Surface Mount 4.5 x 2.2 x 0.95 mm³ 12-lead MCOB



Note:
Package marking provides orientation and identification
"GP002" = Product Code
"Y" = Year of manufacture
"M" = Month of manufacture
"XXXX" = Last 4 digits of lot number

Features

- Operating temperature range -40 to +85 °C
- Very Low Noise Figure
- Exceptional Cell/PCS-Band rejection
- Low external component count
- Fully-matched at RF input and RF output
- Shutdown current: < 1 μ A
- CMOS compatible shutdown pin (SD)
- ESD: > 3kV at RFin pin
- 4.5 x 2.2 x 0.95 mm³ size
- Adjustable bias current via single external resistor/voltage
- Lead-free, Halogen free and meets MSL3

Specifications (Typical performance @ 25°C)

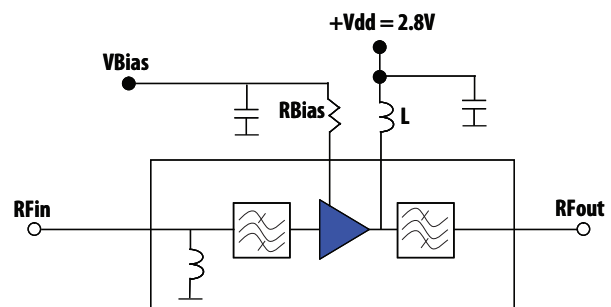
At 1.575GHz, Vdd = 2.8V, Idd = 6.8mA

- Gain = 19.1 dB
- NF = 1.66 dB
- IIP3 = +2 dBm, IP1dB = -8 dBm
- S11 = -10 dB, S22 = -15 dB
- Cell-Band Rejection: > 90 dBc
- PCS-Band Rejection: > 85 dBc

Application

- GPS Front-end Module

Application Circuit



Absolute Maximum Rating ^[1] T_A = 25 °C

Symbol	Parameter	Units	Absolute Max.
V _{dd}	Device Drain to Source Voltage ^[2]	V	3.6
I _{dd}	Drain Current ^[2]	mA	15
P _{in,max}	CW RF Input Power (V _{dd} = 2.8V, I _{dd} = 6mA)	dBm	13
P _{diss}	Total Power Dissipation ^[4]	mW	54
T _L	Operating Temperature	°C	-40 to 85
T _j	Junction Temperature	°C	150
T _{STG}	Storage Temperature	°C	-65 to 150

Thermal Resistance ^[3]

(V_{dd} = 2.8 V, I_{dd} = 6mA) θ_{JC} = 82.1 °C/W

Notes:

1. Operation of this device in excess of any of these limits may cause permanent damage.
2. Assuming DC quiescent conditions.
3. Thermal resistance measured using Infra-Red measurement technique.
4. Board (module belly) temperature T_B is 25 °C. Derate 4.2 mW/°C for T_B > 145.6 °C.

Electrical Specifications

T_A = 25 °C, Freq = 1.575 GHz, measured on demo board^[1], unless otherwise specified – Typical Performance^[1]

Table 1. Performance at V_{dd} = V_{sd} = 2.8V, I_{dd} = 6.8mA (R₂ = 3.9 kΩ, see Figure 1) nominal operating conditions

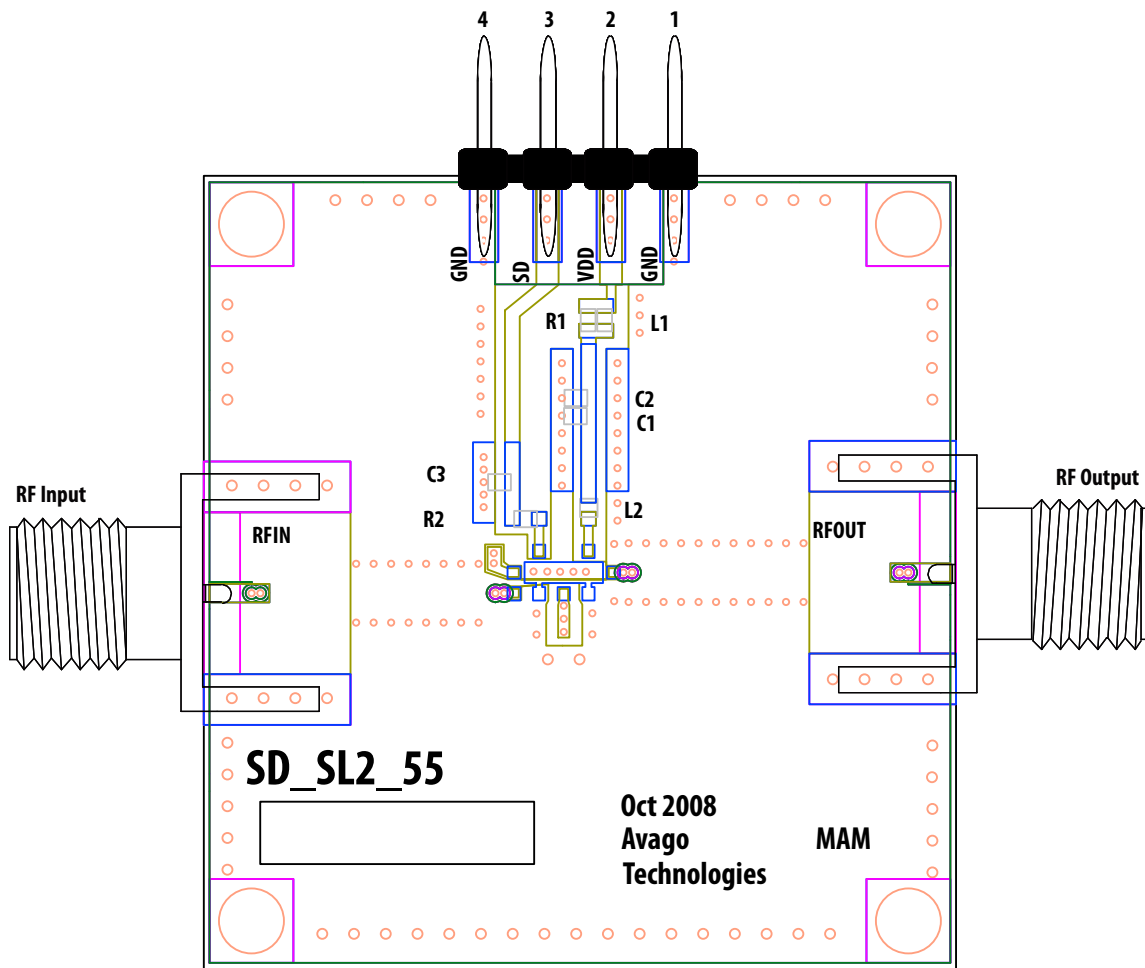
Symbol	Parameter and Test Condition	Units	Min.	Typ	Max.
G	Gain	dB	16.5	19.1	–
NF	Noise Figure	dB	–	1.66	2.3
IP1dB	Input 1dB Compressed Power	dBm	–	-8	–
IIP3 ^[2]	Input 3 rd Order Intercept Point (2-tone @ F _c +/- 2.5MHz)	dBm	–	+2	–
S11	Input Return Loss	dB	–	-10	–
S22	Output Return Loss	dB	–	-15	–
S12	Reverse Isolation	dB	–	-30	–
Cell Band Rejection	Relative to 1.575GHz @ 827.5MHz	dBc	78	96.6	–
PCS Band Rejection	Relative to 1.575GHz @ 1885MHz	dBc	78	91.7	–
IP1dB _{890MHz}	Input 1dB gain compression interferer signal level at 890MHz	dBm		29	
IP1dB _{1885MHz}	Input 1dB gain compression interferer signal level at 1885MHz	dBm		26	
I _{dd}	Supply DC current at Shutdown (SD) voltage V _{sd} = 2.8V	mA	–	6.8	11.5
I _{sh}	Shutdown Current @ V _{SD} = 0V	uA	–	0.5	–

Table 2. Performance at V_{dd} = V_{sd} = 1.8V, I_{dd} = 4mA (R₂ = 3.9k Ohm, see Fig 1) nominal operating conditions

Symbol	Parameter and Test Condition	Units	Typ
G	Gain	dB	16.5
NF	Noise Figure	dB	1.9
IP1dB	Input 1dB Compressed Power	dBm	-11
IIP3 ^[2]	Input 3 rd Order Intercept Point (2-tone @ F _c +/- 2.5MHz)	dBm	-1
S11	Input Return Loss	dB	-9
S22	Output Return Loss	dB	-13
S12	Reverse Isolation	dB	-29
Cell Band Rejection	Relative to 1.575GHz @ 827.5MHz	dBc	>90
PCS Band Rejection	Relative to 1.575GHz @ 1885MHz	dBc	>85
IP1dB _{890MHz}	Input 1dB gain compression interferer signal level at 890MHz	dBm	29
IP1dB _{1885MHz}	Input 1dB gain compression interferer signal level at 1885MHz	dBm	26
I _{dd}	Supply DC current at Shutdown (SD) voltage V _{sd} = 1.8V	mA	4
I _{sh}	Shutdown Current @ V _{SD} = 0V	uA	0.5

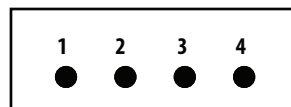
Notes:

1. Measurements at 1.575GHz obtained using schematic described in Figure 1.
2. 1.575GHz IIP3 test condition: F_{RF1} = 1572.5 MHz, F_{RF2} = 1577.5 MHz with input power of -20 dBm per tone measured at the worst-case side band.



DC Pin Configuration of 4-pin connector

Pins pointing
out of the page



Pins 1, 4 = GND
Pin 2 = Vdd Supply
Pin 3 = Shutdown (SD)

Circuit Symbol	Size	Description
L1	0402	22 nH Inductor (Taiyo Yuden HK100522NJ-T)
L2	0402	1.5 nH Inductor (Taiyo Yuden HK10051N5S-T)
C1	0402	0.1 uF Capacitor (Kyocera CM05X5R104K10AH)
C2	0402	47 pF Capacitor (Kyocera CM05CH470J50AHF)
C3	0402	330 pF Capacitor (Kyocera CM05CH331J16AHF)
R1	0402	10 Ohms Resistor (KOA RK73B1ETTB100J)
R2	0402	3.9 kOhm Resistor (KOA RK73B1ETTB392J)

Figure 1. Demoboard and application circuit components table

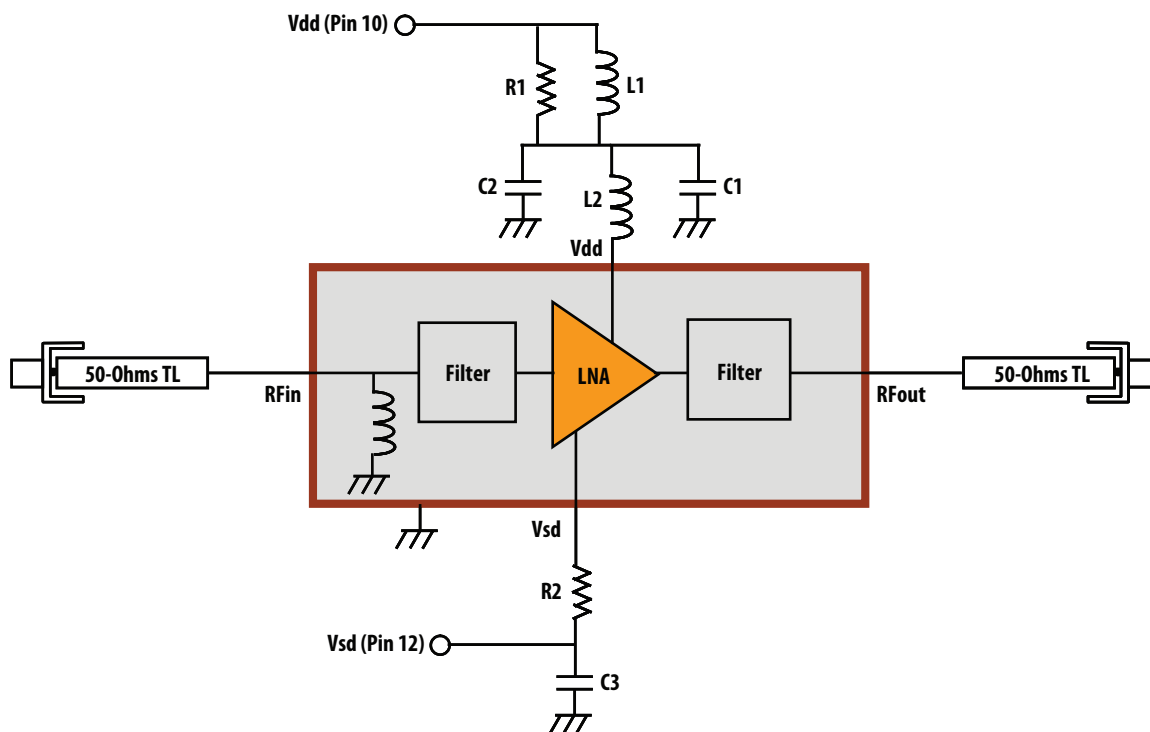


Figure 2. Demoboard and application schematic diagram

Notes

1. The module is fully matched at the input and output RF pins. The RFin pin is directly connected to a shunt inductor that is grounded. The RF output filter blocks DC. Best noise performance is obtained using high-Q wirewound inductors. This circuit demonstrates that low noise figures are obtainable with standard 0402 chip inductors.
2. C2 and L2 form a matching network that affects the frequency response and linearity of the LNA, these can be tuned to optimize gain and return loss.
3. L1 and R1 isolates the demoboard from external disturbances during measurement. It is not needed in actual application. Likewise, C1 and C3 mitigate the effect of external noise pickup on the Vdd and Vsd lines respectively. These components are not required in actual operation.
4. Bias control is achieved by either varying the Vsd voltage with/ without R2, or fixing the Vsd voltage to Vdd and adjusting R2 for the desired current.

ALM-GP002 Typical Performance Curves at 25°

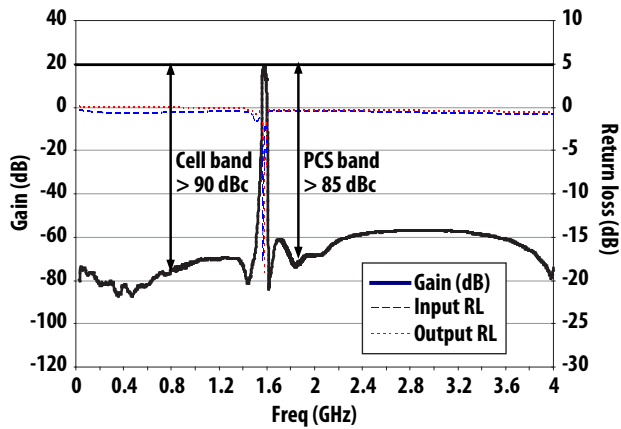


Figure 3a. Typical S-Parameter Plot @ Vdd = 2.8V, Idd = 6.8mA

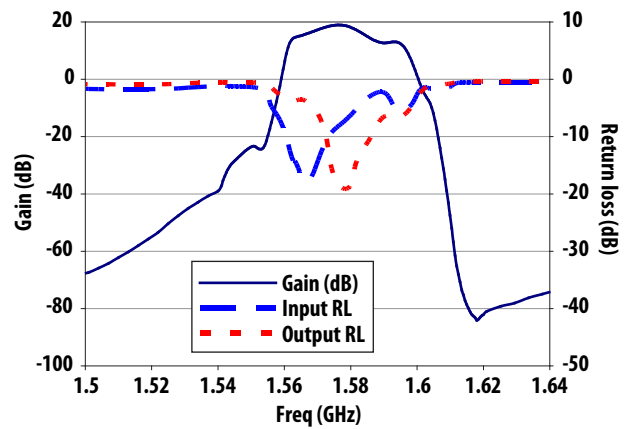


Figure 3b. Passband response of typical S-Parameter Plot @ Vdd = 2.8V, Idd = 6.8mA

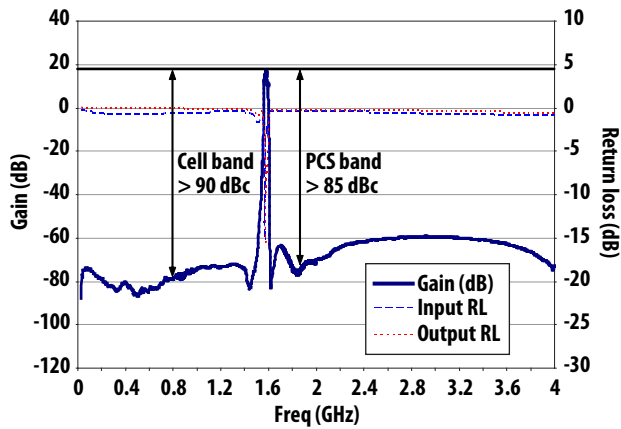


Figure 4a. Typical S-Parameter Plot @ Vdd = 1.8V, Idd = 4mA

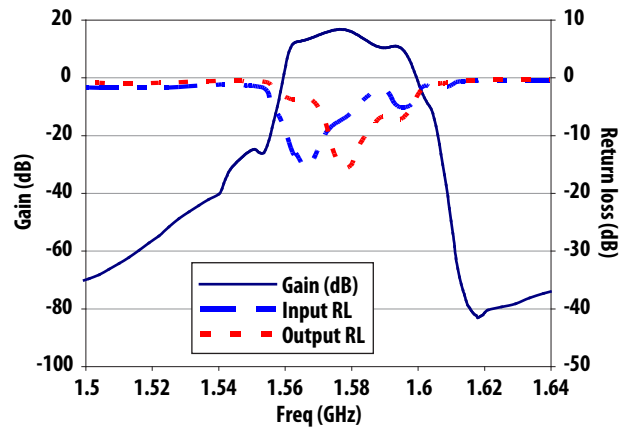


Figure 4b. Passband response of typical S-Parameter Plot @ Vdd = 1.8V, Idd = 4mA

ALM-GP002 Typical Performance Curves at 25°C, R2 = 3.9k0hm

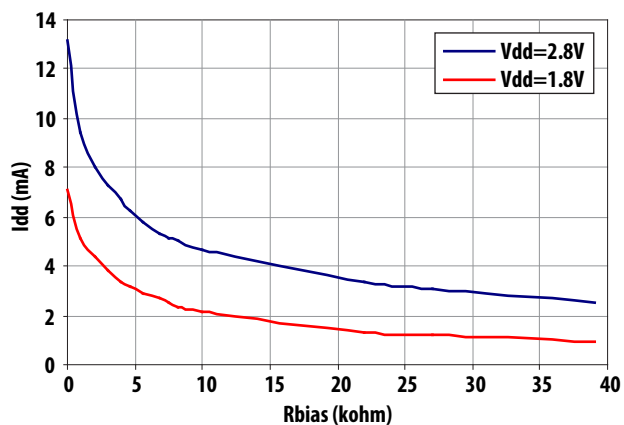


Figure 5. Idd vs Rbias at 25°C

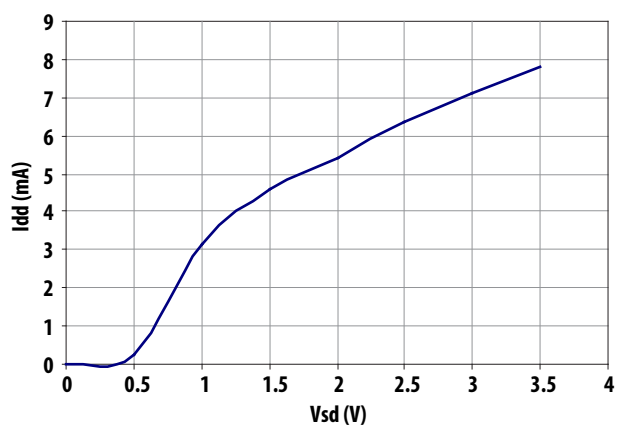


Figure 6. Idd vs Vsd for Vdd = 2.8V, R2 = 3.9k Ohm

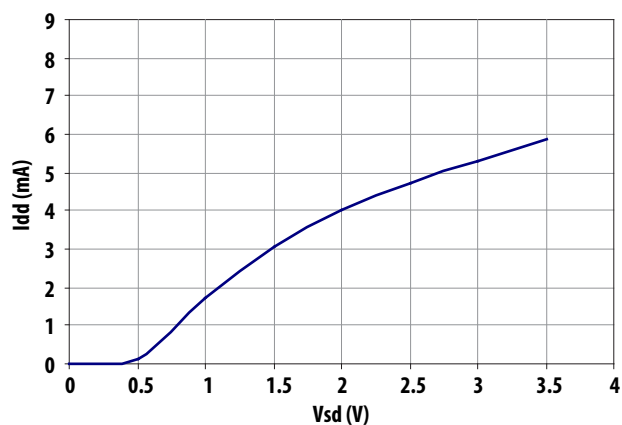


Figure 7. Idd vs Vsd for Vdd = 1.8V, R2 = 3.9k Ohm

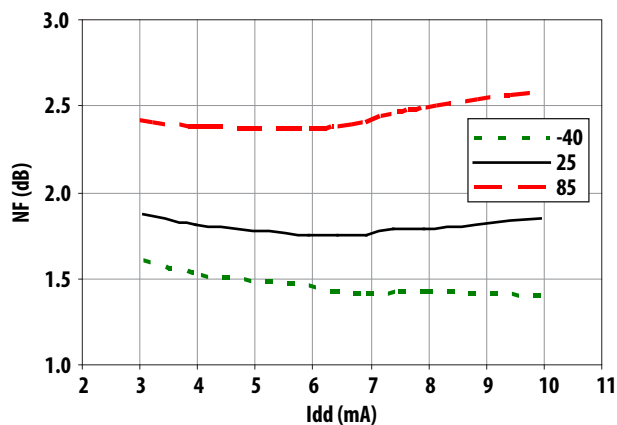


Figure 8. NF vs. Idd at Vdd = 2.8V

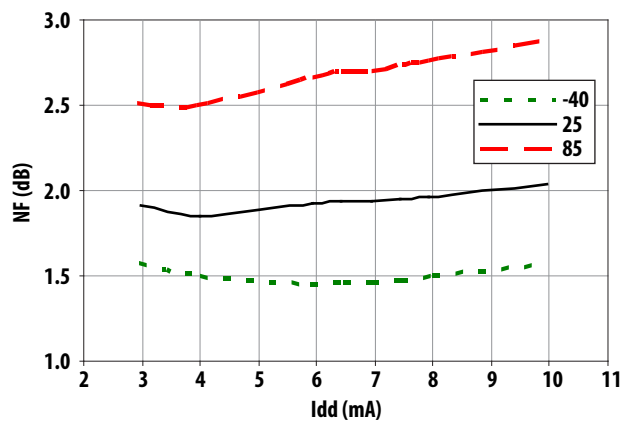


Figure 9. NF vs Idd at Vdd = 1.8V

ALM-GP002 Typical Performance Curves at 25°C, R2 = 3.9k0hm (cont'd)

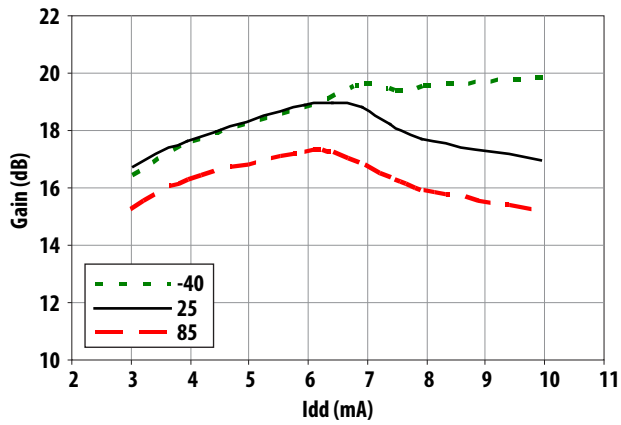


Figure 10. Gain vs. Idd at Vdd = 2.8V

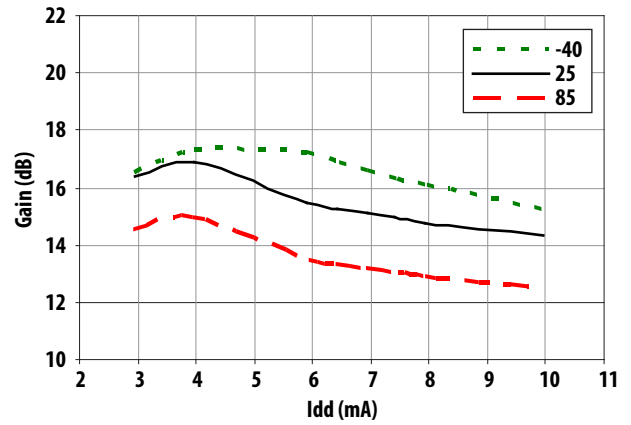


Figure 11. Gain vs. Idd at Vdd = 1.8V

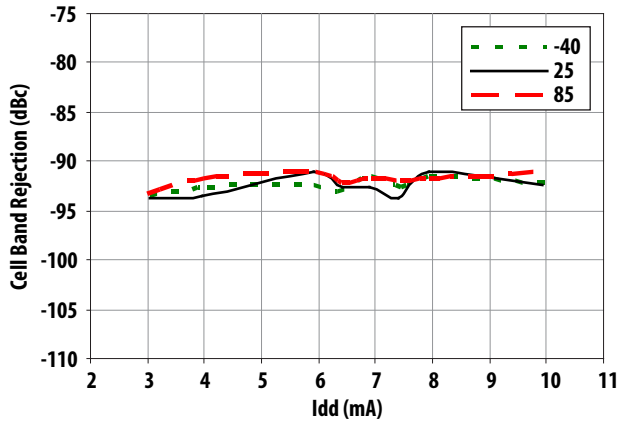


Figure 12. Cell band rejection vs. Idd at Vdd = 2.8V

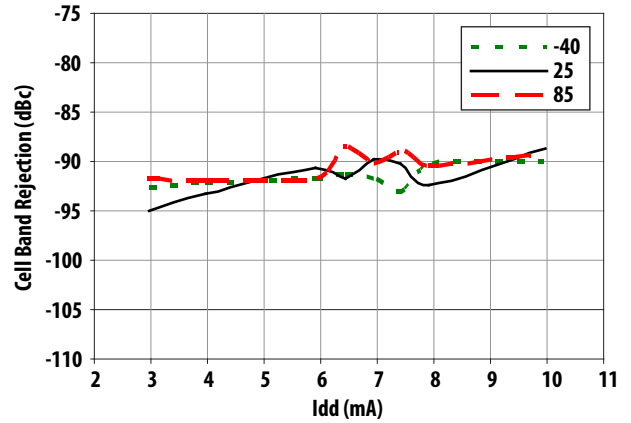


Figure 13. Cell band rejection vs. Idd at Vdd = 1.8V

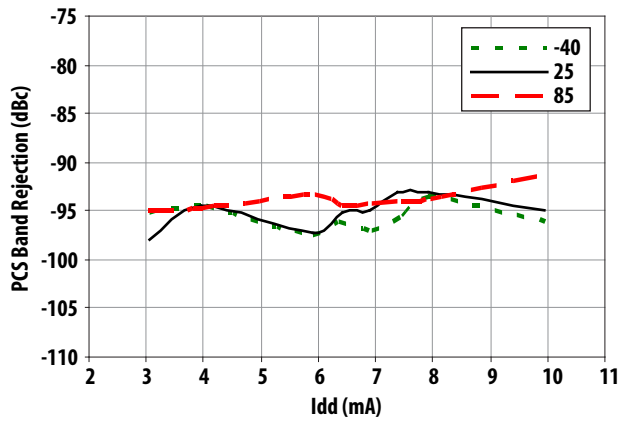


Figure 14. PCS band rejection vs. Idd at Vdd = 2.8V

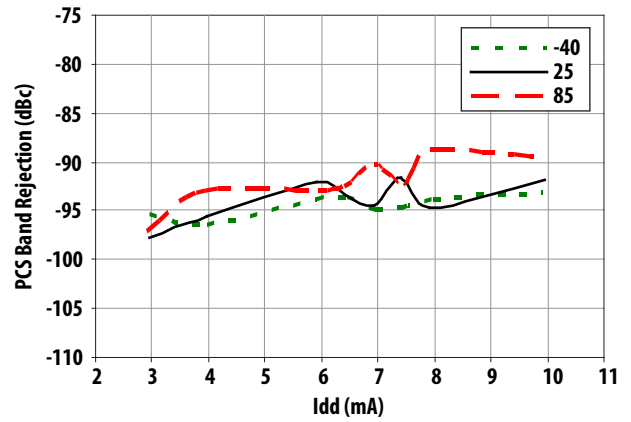


Figure 15. PCS band rejection vs. Idd at Vdd = 1.8V

ALM-GP002 Typical Performance Curves at 25°C, R2 = 3.9kOhm (cont'd)

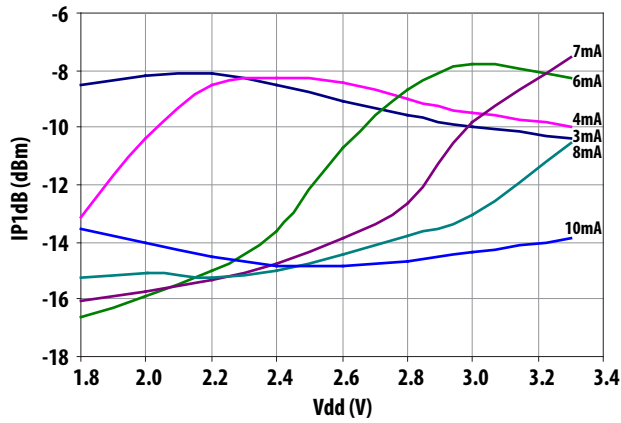


Figure 16. IP1dB vs. Vdd at 25°C

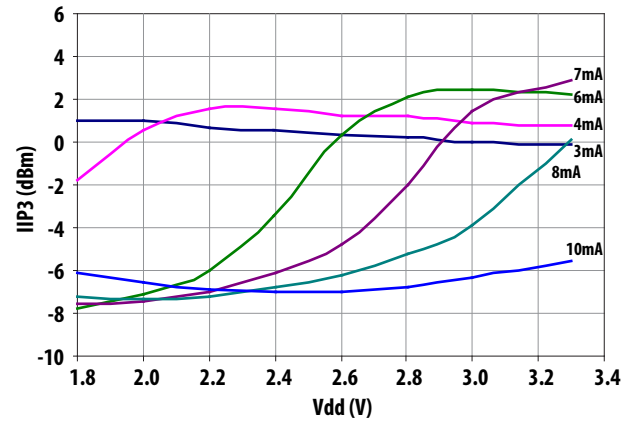


Figure 17. IIP3 vs. Vdd at 25°C

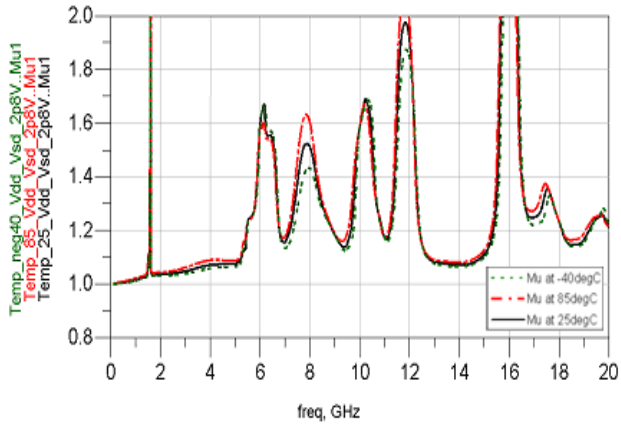


Figure 18. Edwards-Sinsky Output Stability Factor (Mu) at Vdd = 2.8V

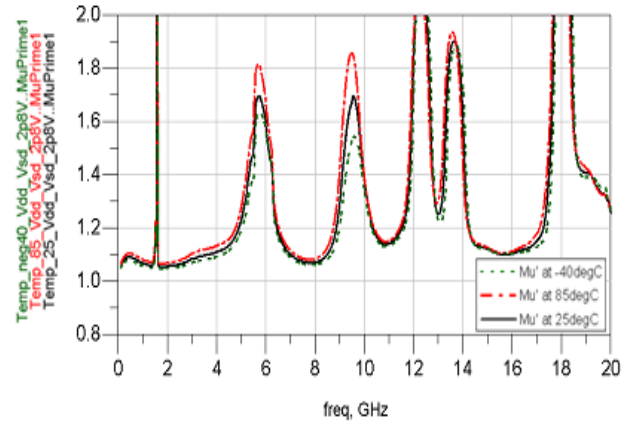


Figure 19. Edwards-Sinsky Input Stability Factor (Mu') at Vdd = 2.8V

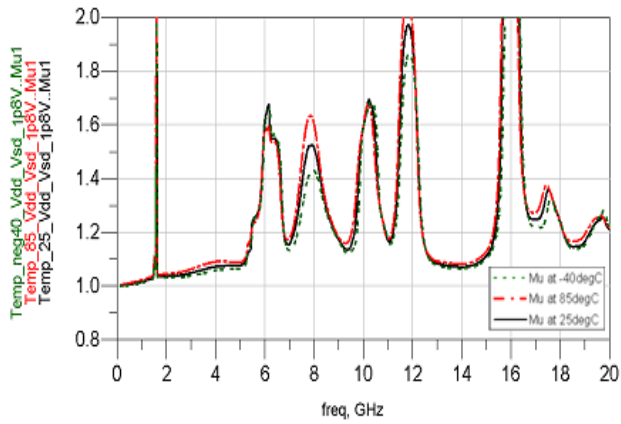


Figure 20. Edwards-Sinsky Output Stability Factor (Mu) at Vdd = 1.8V

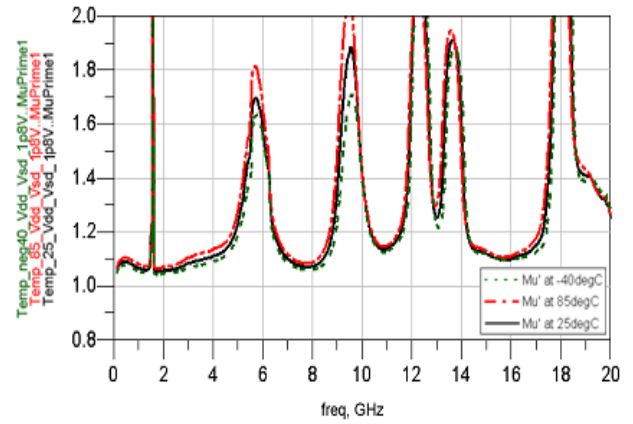


Figure 21. Edwards-Sinsky Input Stability Factor (Mu) at Vdd = 1.8V

ALM-GP002 Scattering Parameter and Measurement Reference Planes

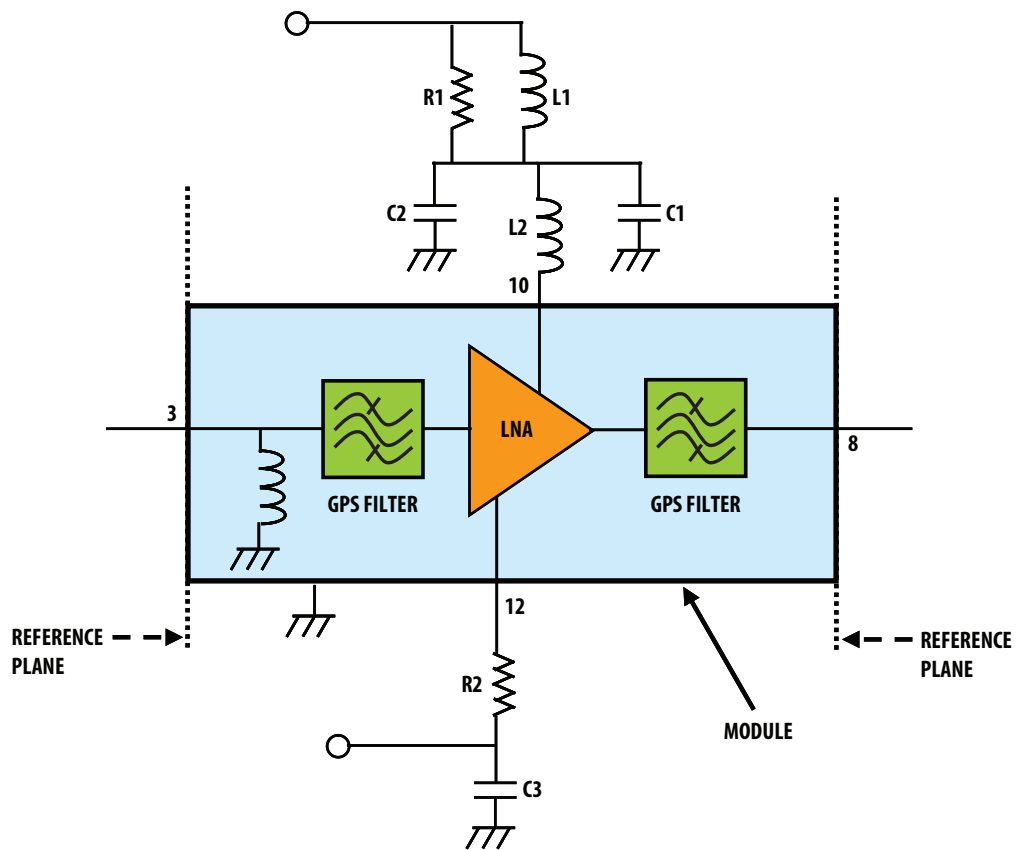


Figure 22. Scattering parameter measurement reference planes

ALM-GP002 Typical Scattering Parameters at 25°C, Vdd = 2.8V, Idd = 6.8mA

The S- and Noise Parameters are measured using a coplanar waveguide PCB with 10 mils Rogers® RO4350. Figure 22 shows the input and output reference planes. The circuit values are as indicated in Figure 1.

Freq (GHz)	S11 Mag. (dB)	S11 Ang.	S21 Mag. (dB)	S21 Ang.	S12 Mag. (dB)	S12 Ang.	S22 Mag. (dB)	S22 Ang.
0.05	-0.36	167.90	-70.91	179.43	-72.41	-33.51	-0.02	-1.13
0.1	-0.48	157.43	-73.83	90.22	-72.95	-44.37	-0.02	-2.30
0.2	-0.61	137.05	-75.70	-98.13	-76.85	143.01	-0.03	-4.72
0.3	-0.59	118.80	-79.52	144.78	-78.22	18.52	-0.03	-7.15
0.4	-0.56	102.02	-80.81	-93.44	-80.94	-96.45	-0.05	-9.58
0.5	-0.54	86.73	-80.23	173.99	-81.68	49.58	-0.07	-12.00
0.6	-0.51	72.90	-84.40	-139.64	-83.85	-22.49	-0.08	-14.49
0.7	-0.48	60.09	-80.13	31.21	-84.39	104.85	-0.10	-17.07
0.8	-0.47	48.25	-77.24	19.91	-82.49	140.19	-0.13	-19.77
0.8275	-0.46	45.13	-76.66	-1.05	-81.84	-26.77	-0.13	-20.53
0.9	-0.45	37.19	-74.69	-9.12	-80.63	159.19	-0.15	-22.57
1.0	-0.44	26.19	-72.60	-22.11	-83.78	49.06	-0.17	-25.01
1.1	-0.44	15.97	-71.50	-42.85	-83.42	164.49	-0.20	-27.52
1.2	-0.46	6.12	-71.18	-53.20	-84.42	-64.80	-0.23	-31.01
1.3	-0.51	-4.06	-70.88	-56.47	-84.53	28.25	-0.26	-34.89
1.4	-0.60	-16.54	-77.69	-86.33	-78.22	-127.64	-0.30	-40.11
1.5	-2.15	-39.74	-52.92	178.08	-71.88	-163.04	-1.14	-49.93
1.575	-12.00	-162.25	18.44	157.76	-30.80	116.58	-7.66	49.43
1.6	-0.95	56.36	-4.42	-5.83	-53.21	-47.84	-1.14	4.99
1.7	-0.51	-13.71	-77.00	-145.33	-80.55	-115.70	-0.32	-35.94
1.8	-0.57	-27.70	-76.26	-121.44	-78.53	-131.67	-0.33	-42.70
1.885	-0.60	-36.23	-84.37	147.81	-71.90	-132.40	-0.34	-46.60
1.9	-0.61	-37.61	-77.77	96.20	-72.22	-128.72	-0.34	-47.22
2.0	-0.66	-46.35	-62.56	48.44	-70.83	-128.36	-0.35	-51.19
2.1	-0.70	-54.49	-52.67	3.05	-67.29	-138.82	-0.35	-54.92
2.2	-0.70	-62.05	-49.53	-43.62	-64.95	-149.31	-0.36	-58.43
2.3	-0.69	-69.58	-49.33	-75.23	-63.28	-150.12	-0.36	-61.85
2.4	-0.69	-76.98	-49.47	-93.88	-62.60	-160.56	-0.36	-65.19
2.5	-0.69	-84.41	-49.34	-107.39	-61.30	-165.14	-0.37	-68.55
3.0	-0.71	-118.39	-48.63	-151.44	-56.60	176.28	-0.37	-83.99
3.5	-0.69	-150.17	-48.84	171.67	-53.14	154.09	-0.36	-98.92
4.0	-0.83	176.10	-54.58	125.18	-50.85	127.76	-0.41	-115.73
4.5	-1.07	145.32	-52.45	-42.92	-51.74	108.49	-0.49	-131.29
5.0	-1.37	108.52	-36.63	-103.59	-57.19	116.36	-0.71	-153.16
6.0	-3.36	39.77	-24.42	135.12	-42.94	124.29	-7.89	89.52
7.0	-1.25	-20.47	-39.38	-6.98	-53.09	139.34	-0.95	178.08
8.0	-1.50	-73.87	-32.30	82.78	-40.36	141.29	-0.96	135.38
9.0	-1.57	-129.61	-30.13	163.08	-27.18	86.19	-1.65	118.05
10.0	-2.49	-178.13	-22.11	54.31	-22.22	41.54	-2.73	71.53
11.0	-4.03	132.11	-18.89	-75.98	-20.13	-111.40	-3.60	82.03
12.0	-4.63	63.14	-29.16	-95.52	-35.45	-70.23	-2.13	53.32
13.0	-4.96	-64.89	-24.87	-131.78	-28.36	-120.38	-1.60	27.95
14.0	-3.23	-143.72	-24.81	158.49	-28.55	171.46	-2.11	-5.53
15.0	-3.78	131.84	-28.69	146.44	-29.29	160.75	-2.96	-34.59
16.0	-5.51	49.69	-21.18	55.22	-23.10	62.73	-4.57	-100.39
17.0	-10.35	174.02	-24.73	-68.32	-27.84	-66.54	-4.47	107.18
18.0	-4.30	89.47	-26.34	99.23	-26.72	92.85	-2.37	28.83
19.0	-5.60	49.69	-24.29	-38.15	-25.85	-43.76	-4.27	-29.69
20.0	-3.34	1.63	-21.00	178.45	-21.72	-176.08	-8.70	114.20

ALM-GP002 Typical Scattering Parameters at 25°C, Vdd = 1.8V, Idd = 4mA

Freq (GHz)	S11	S11	S21	S21	S12	S12	S22	S22
	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.05	-0.37	167.91	-70.39	-97.32	-69.97	-112.11	-0.02	-1.20
0.1	-0.49	157.48	-69.16	-138.73	-72.30	169.58	-0.02	-2.34
0.2	-0.62	137.11	-76.73	63.86	-73.74	-156.90	-0.03	-4.76
0.3	-0.60	118.84	-76.40	176.75	-78.51	129.65	-0.04	-7.16
0.4	-0.57	102.07	-79.44	149.69	-80.33	-109.07	-0.05	-9.57
0.5	-0.55	86.79	-82.26	-11.94	-78.34	-150.44	-0.07	-12.01
0.6	-0.52	72.98	-81.51	153.55	-82.35	-45.85	-0.09	-14.48
0.7	-0.49	60.16	-82.42	40.14	-85.39	163.19	-0.11	-17.06
0.8	-0.47	48.32	-81.13	4.95	-80.01	130.58	-0.13	-19.74
0.8275	-0.46	45.21	-80.98	20.28	-81.98	114.35	-0.14	-20.51
0.9	-0.46	37.27	-77.14	-3.31	-79.31	87.20	-0.15	-22.55
1.0	-0.44	26.28	-75.53	-6.38	-82.00	123.22	-0.18	-25.00
1.1	-0.44	16.08	-74.01	-31.95	-81.92	-13.35	-0.20	-27.48
1.2	-0.47	6.22	-75.82	-51.00	-86.49	-162.55	-0.23	-30.95
1.3	-0.51	-3.92	-74.62	-52.43	-82.08	-66.69	-0.26	-34.83
1.4	-0.60	-16.42	-78.94	-94.19	-78.84	-121.08	-0.31	-40.01
1.5	-2.07	-39.34	-54.42	173.14	-70.76	-152.73	-1.07	-49.72
1.575	-11.07	-146.67	16.10	157.09	-29.37	109.49	-6.41	52.69
1.6	-1.03	57.61	-6.09	-3.46	-51.01	-52.59	-1.20	4.51
1.7	-0.52	-13.37	-75.43	-141.27	-80.16	-92.38	-0.32	-35.70
1.8	-0.57	-27.52	-77.68	-133.47	-75.83	-134.34	-0.33	-42.55
1.885	-0.61	-36.04	-79.90	-164.72	-75.06	-137.96	-0.34	-46.47
1.9	-0.62	-37.42	-79.59	150.62	-73.21	-126.80	-0.34	-47.08
2.0	-0.67	-46.25	-65.59	57.67	-70.33	-133.91	-0.35	-51.03
2.1	-0.72	-54.30	-54.83	2.11	-67.29	-132.12	-0.36	-54.76
2.2	-0.71	-61.83	-51.92	-51.69	-64.81	-146.54	-0.36	-58.27
2.3	-0.70	-69.36	-52.25	-82.45	-63.37	-150.82	-0.37	-61.70
2.4	-0.70	-76.80	-52.26	-99.40	-62.01	-157.87	-0.37	-65.02
2.5	-0.70	-84.22	-51.91	-111.81	-61.19	-162.45	-0.37	-68.40
3.0	-0.72	-118.09	-50.59	-154.73	-56.43	176.99	-0.38	-83.94
3.5	-0.69	-149.84	-49.90	169.50	-53.05	153.40	-0.36	-98.87
4.0	-0.84	175.62	-53.88	123.13	-50.94	127.37	-0.41	-115.93
4.5	-1.08	145.43	-54.39	-10.94	-51.69	108.35	-0.49	-131.23
5.0	-1.37	108.81	-39.20	-100.13	-56.65	120.15	-0.73	-153.35
6.0	-3.23	43.37	-27.63	130.07	-43.36	116.78	-6.93	78.08
7.0	-1.29	-20.01	-42.97	-39.94	-53.04	143.68	-0.94	178.58
8.0	-1.58	-73.96	-37.01	61.20	-39.13	149.21	-1.03	135.81
9.0	-1.98	-129.44	-24.67	117.64	-27.12	69.33	-1.64	116.29
10.0	-2.39	-174.95	-20.63	41.58	-23.81	38.85	-2.93	71.46
11.0	-3.68	133.54	-19.84	-86.50	-23.10	-107.44	-3.54	83.40
12.0	-4.41	68.72	-29.61	-94.04	-34.87	-65.55	-2.20	54.36
13.0	-5.02	-56.19	-25.13	-126.95	-28.33	-111.80	-1.57	29.96
14.0	-3.16	-142.79	-24.93	161.15	-28.26	178.99	-2.04	-4.80
15.0	-3.76	133.45	-28.24	145.51	-28.54	162.38	-3.01	-34.28
16.0	-5.59	50.35	-21.00	54.18	-22.58	64.69	-4.55	-100.24
17.0	-10.67	179.81	-24.58	-71.53	-27.36	-63.53	-4.52	108.07
18.0	-4.41	91.57	-25.69	96.10	-26.34	92.52	-2.40	29.96
19.0	-5.90	52.36	-24.25	-42.63	-25.64	-45.43	-4.30	-28.21
20.0	-3.26	4.18	-21.63	177.14	-22.08	-177.16	-8.61	114.98

**ALM-GP002 Typical Noise Parameters at 25°C, Freq = 1.575 GHz,
Vdd = 2.8V, Idd = 6.8mA**

Freq (GHz)	Fmin (dB)	GAMMA OPT		
		Mag	Ang	Rn/50
1.575	1.50	0.24	-99	0.19

**ALM-GP002 Typical Noise Parameters at 25°C, Freq = 1.575 GHz,
Vdd = 1.8V, Idd = 4mA**

Freq (GHz)	Fmin (dB)	GAMMA OPT		
		Mag	Ang	Rn/50
1.575	1.52	0.24	-99	0.19

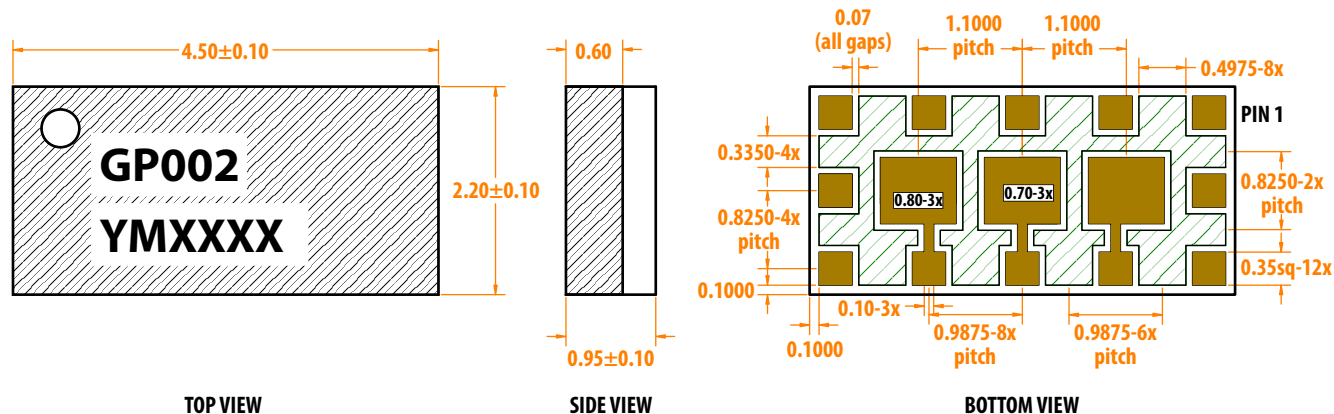
Notes:

- The exceptional noise figure performance of the ALM-GP002 is due to its highly optimized design. In this regard, the Fmin of the ALM-GP002 shown above is locked down by the internal input pre-match. This allows the use of relatively inexpensive chip inductors for external matching.

Part Number Ordering Information

Part Number	Qty	Container
ALM-GP002-BLKG	100	Antistatic Bag
ALM-GP002-TR1G	3000	13" Reel

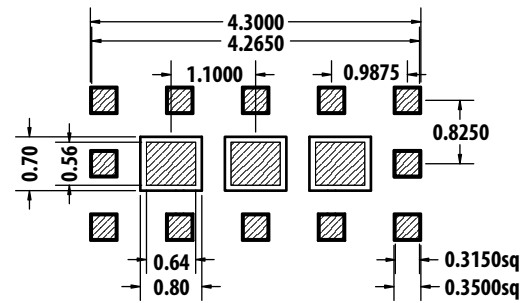
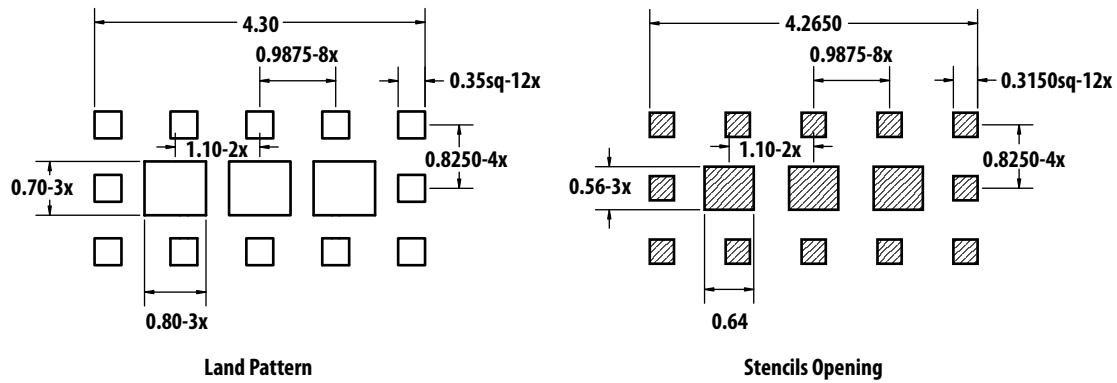
Package Dimension



Notes:

- All dimensions are in millimeters.
- Dimensions are inclusive of plating.
- Dimensions are exclusive of mold flash and metal burr.
- Y refers to year, M refers to month, and XXXX refers to the last 4 digits of the lot number.

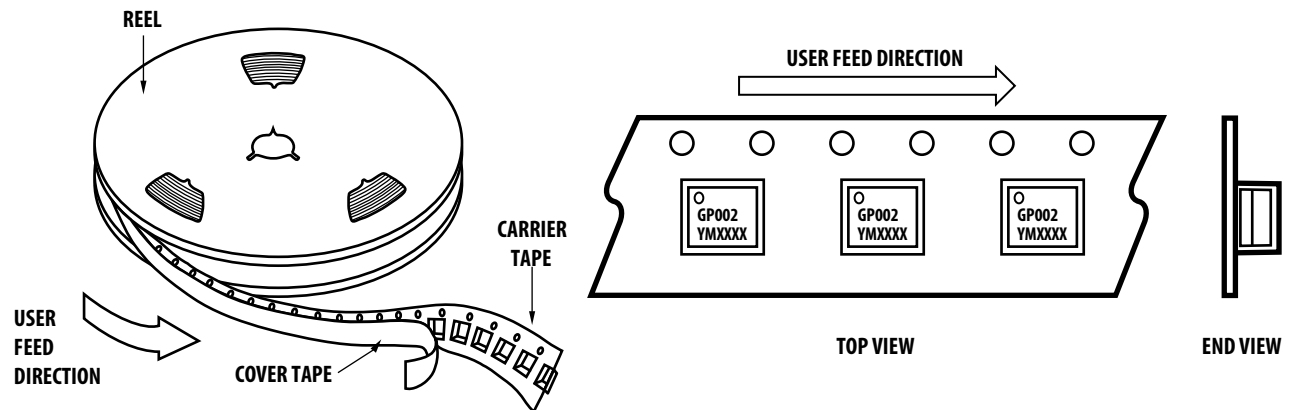
PCB Land Patterns and Stencil Design



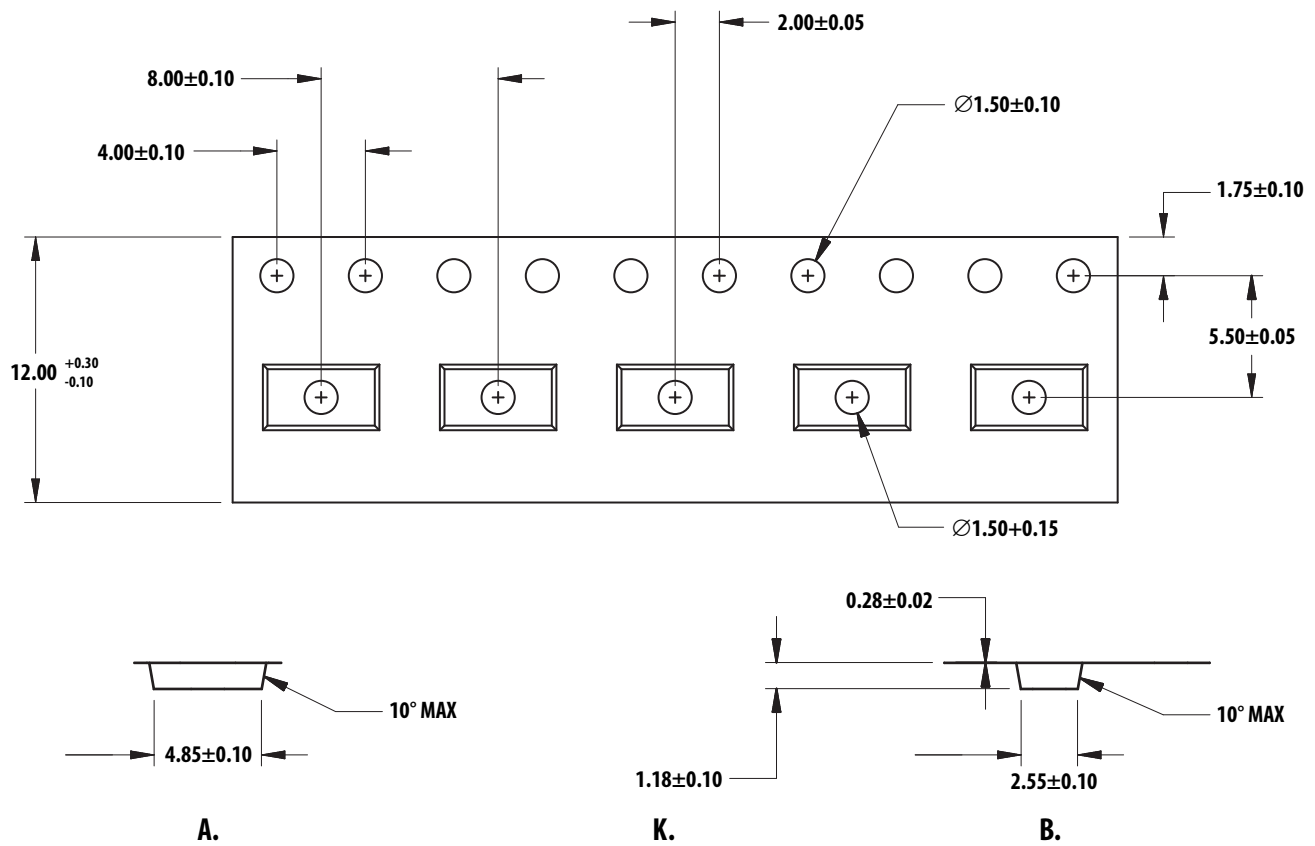
Combined Land Pattern & Stencil Opening

Dimensions are in mm

Device Orientation

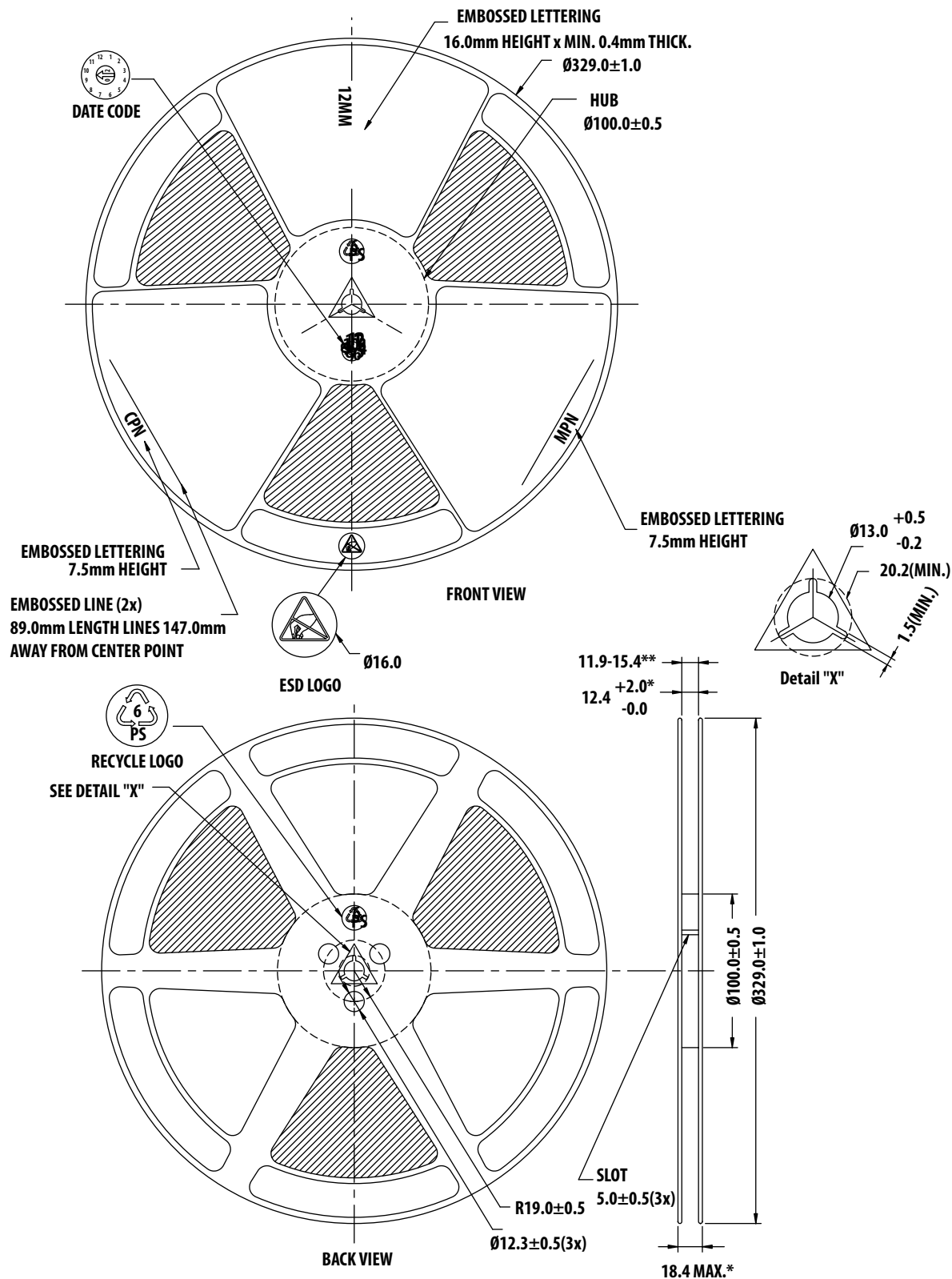


Tape Dimensions



All dimensions are in millimeters.

Reel Dimensions (13" reel)



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