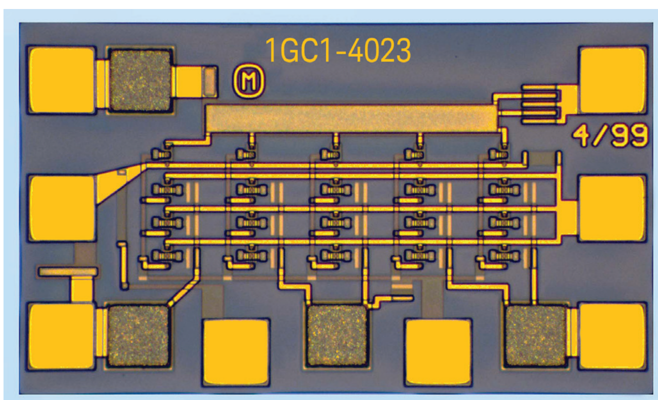
Keysight 1GC1-4023
DC - 4 GHz, High-Gain, Dual-Mode: Low-Noise/Medium-Power HBT Amplifier



Data Sheet

Features

- Dual operating modes[1]:
  - Low-noise mode:
    NF = 3 dB
    P_{-1dB} = 14 dBm
    TOI = 24 dBm
    SHI = 48 dBm
    I_{Total} = 64 mA
    P_{DC} = 207 mW
  - High-power mode:
    NF = 3.5 dB
    P_{-1dB} = 19.5 dBm
    TOI = 33 dBm
    SHI = 53 dBm
    I_{Total} = 90 mA
    P_{DC} = 373 mW
- Broad bandwidth, F_{-1dB}:
  7 GHz (S.S. gain)
  3 GHz (P_{OUT})
- High gain: (3 GHz)
  20.5 dB ±0.8 dB
- Low l/f noise corner: < 20 kHz
- Single supply operation:
  V_{Supply} > 4.8 volts

1. Typical performance @ F=3 GHz, P_{DC}=DC power dissipation on-chip.

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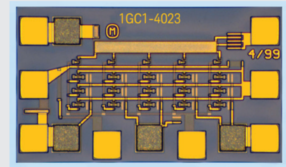
Description

The 1GC1-4023 is a DC to 4 GHz, 20 dB gain, amplifier designed for use as a cascadable gain block as either a Low–Noise preamplifier for receivers or as an output amplifier for moderate output power applications. The device consists of a modified Darlington feed-back pair which reduces the sensitivity to process variations and provides 50 ohm input/output port matches. This amplifier is fabricated using HFTC's GaAs Heterojunction Bipolar Transistor (HBT) process which provides excellent process uniformity, reliability and 1/f noise performance.



- Chip size: 790 x 480 µm (31.1 x 18.9 mils)
- Chip size tolerance: ±10 µm (±0.4 mils)
- Chip thickness: 127 ±15 µm (5.0 ±0.6 mils)
- Pad dimensions: 70 x 70 µm (2.8 x 2.8 mils), or larger

Absolute maximum ratings[1]

(@ T_A = 25 °C, unless otherwise indicated)

Symbol	Parameters/conditions	Min	Max	Units
V_{CC}	V_{CC} pad voltage		6.0	Volts
V_{OUT}	RF output pad voltage		4.3	Volts
I_{CC}	Stage one current		22	mA
I_{OUT}	Stage two current		75	mA
P_{in}	RF input power, continuous 0 dbm			
T_{ch}	Channel temperature +150 °C			
T_{bs}[2]	Die backside temperature	–55	+85	°C
T_{st}	Storage temperature	–65	+165	°C
T_{max}	Max. assembly temperature		+300	°C

1. Operation in excess of any one of these conditions may result in permanent damage to this device.
2. MTTF > 5 x 10^5 hours @ T_{bs} = 85 °C. Operation in excess of maximum backside temperature (T_{bs}) will degrade MTTF.

DC specifications/physical properties[1]

(T_A = 25 °C, $Z_{IN} = Z_{OUT}$ = 50 Ω, $R_{OUT} = [(V_{Supply} - V_{OUT})/I_{OUT}]$)

Symbol	Parameters/conditions	Min	Typ	Max	Units
V_{CC}	Stage one collector voltage	4.8	5.0	6.0	Volts
$\theta_{J\text{-}bs}$	Thermal resistance (junction–to–backside at T_J = 150 °C)		175		°C/Watt
		Low-noise mode V_{SEL} **= OPEN,** I_{SEL} **= OPEN**			
I_{CC}	Stage one collector current	7	9	11	mA
I_{OUT}	Stage two collector current		55	75	mA
$I_{CC} + I_{OUT}$	Total supply current		64		mA
V_{RFin}	RF input voltage (I_{CC} = 9 mA, I_{OUT} = 55 mA)	2.6	2.85	3.1	Volts
V_{OUT}	RF output voltage (I_{CC} = 9 mA, I_{OUT} = 55 mA)	2.7	2.95	3.2	Volts
P_{DC}	Total DC power dissipation (on–chip) (V_{CC} = +5 V, V_{OUT} = 3 V, I_{OUT} = 55 mA)		207		mW
		High P_{OUT} **mode** V_{SEL} **= GND,** I_{SEL} **= GND**			
I_{CC}	Stage one collector current	15.0	18.5	21.5	mA
I_{OUT}	Stage two collector current		72	75	mA
$I_{CC} + I_{OUT}$	Total supply current		90.5		mA
V_{RFin}	RF input voltage (I_{CC} = 18.5 mA, I_{OUT} = 72 mA)	2.7	2.90	3.1	Volts
V_{OUT}	RF output voltage (I_{CC}= 18.5 mA, I_{OUT} = 72 mA)	3.6	3.85	4.1	Volts
P_{DC}	Total DC power dissipation (on–chip) (V_{CC} = +5 V, V_{OUT} = 3.9 V, I_{OUT} = 72 mA)		373		mW

1. Backside ambient operating temperature $T_A = T_{bs}$ = 25 °C unless otherwise noted.

RF specifications[1]

(T_A = 25 °C, $Z_{IN} = Z_{OUT}$ = 50 Ω, $R_{OUT} = [(V_{Supply} - V_{OUT})/I_{OUT}]$)

Symbol	Parameters/conditions	Min	Typ	Max	Units
BW	Operating bandwidth (f_{-1db}, high P_{OUT} mode)	6	7		GHz
S_{21}	Small–signal gain (DC - 3 GHz, low-noise mode)	19.5	20.5	21.5	dB
	Small–signal gain (DC - 3 GHz, high P_{OUT} mode)	19.5	21	22	dB
ΔS_{21}	Gain flatness (DC - 3 GHz)		±0.8		dB
T_C	Gain temperature coefficient (DC - 3 GHz, low-noise mode)		0.005		dB/°C
	Gain temperature coefficient (DC - 3 GHz, high P_{OUT} mode)		0.003		dB/°C
$RL_{IN(Min)}$	Minimum input return loss (DC - 3 GHz)		15		dB
$RL_{OUT(Min)}$	Minimum output return loss (DC - 3 GHz)		15		dB
S_{12}	Reverse isolation (DC - 3 GHz)		22		dB

RF specifications[1] *(continued)*

(T_A = 25 °C, Z_{IN} = Z_{OUT} = 50 Ω, R_{OUT} = [(V_{Supply} – V_{OUT})/I_{OUT}])

Symbol	Parameters/conditions	Min	Typ	Max	Units
		Low-noise mode V_{SEL} = OPEN, I_{SEL} = OPEN			
P_{-1dB}	Output power at 1 dB gain compression (F = 3 GHz)	12	14		dBm
P_{SAT}	Output power at 4 dB gain compression (F = 3 GHz)		15		dBm
H_2	2nd harmonics (F = 3 GHz, P_{OUT} = +5 dBm)		–30		dBc
H_3	3rd harmonics (F = 3 GHz, P_{OUT} = +5 dBm)		–50		dBc
SHI	2nd harmonic intercept point (fund. = 1.5 GHz, 2*fund. = 3.0 GHz, P_{OUT} (fund.) = 0 dBm)		48		dBm
TOI	Two-tone, third order intercept point (tone spacing = 200 kHz, fund. = 3 GHz)		24		dBm
NF	Noise figure (F = 3 GHz)		3.0	4.0	dB
		High P_{OUT} mode V_{SEL} = GND, I_{SEL} = GND			
P_{-1dB}	Output power at 1 dB gain compression (F = 3 GHz)	18.5	19.5		dBm
P_{SAT}	Output power at 4 dB gain compression (F = 3 GHz)		20.5		dBm
H_2	2nd harmonics (F = 3 GHz, P_{OUT} = +5 dBm)		–35		dBc
H_3	3rd harmonics (F = 3 GHz, P_{OUT} = +5 dBm)		–57		dBc
SHI	2nd harmonic intercept point (fund. = 1.5 GHz, 2*fund. = 3.0 GHz, P_{OUT} (fund.) = 0 dBm)		53		dBm
TOI	Two–tone, third order intercept point (tone spacing = 200 kHz, fund. = 3 GHz)		33		dBm
NF	Noise figure (F = 3 GHz)		3.5	5.0	dB

1. All large–signal specifications referred to output power

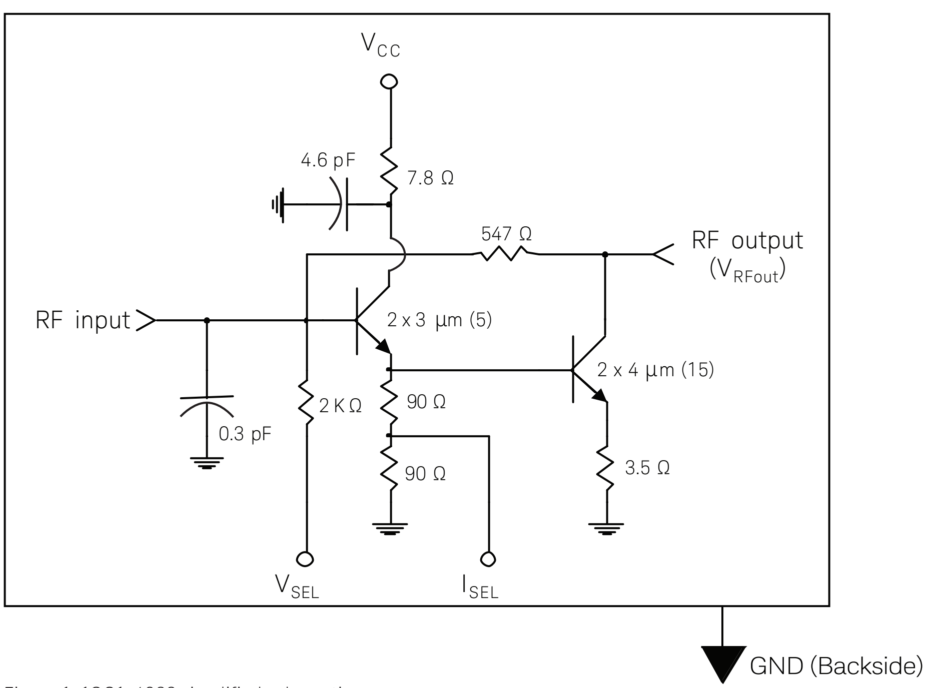


Figure 1. 1GC1-4023 simplified schematic

Applications

The 1GC1-4023 is designed for use in RF and microwave communications systems and instrumentation applications where broadband low-noise operation or moderate output power amplification is required. The device is designed to operate into 50 Ω.

Biasing and Operation

The 1GC1-4023 can be operated from a single positive supply or two independent supplies greater than 4.8 volts. The first stage collector voltage (V_{CC}) must be biased between 4.8 and 6 volts. An external R_{CC} resistor is required if the supply voltage is greater than 6 volts.

The second stage collector voltage (V_{OUT}) is supplied through the RF output port and should be biased through an off-chip drop resistor (R_{OUT}) or current source. An external RF choke circuit consisting of a series inductor and shunt capacitor is typically used to pass the DC bias to the RF output. This high impedance bias feed eliminates loading on the amplifier output. The output current is adjustable via the off-chip R_{OUT} bias resistor value. For more information on the correct values of R_{CC} and R_{OUT}, refer to the information and formulas available in Figure 2.

The 1GC1-4023 features dual-mode operation in either a low-noise, low-P_{DC} mode or high P_{OUT} mode and are selectable by two independent control contacts as summarized in the following table:

Operating mode states

Operating mode	V_{SEL} state (Pin 4)	V_{OUT} (V)	I_{SEL} state (Pin 5)	I_{CC} (mA)
Low noise	OPEN	+ 2.9	OPEN	~9
High power	GND	+ 3.9	GND	~18.5

R_{CC} bias formulas

For: 4.8 V ≤ V_{Supply} ≤ 6 ⇒ R_{CC} = 0 Ω
For: V_{Supply} > 6 V ⇒ R_{CC} = [(V_{Supply} - 5) ÷ (I_{CC})] K Ω
where I_{CC} = 9 mA @ I_{SEL} = Open circuit
or I_{CC} = 18.5 mA @ ISEL = GND

R_{OUT} bias formulas

R_{OUT} = [(V_{Supply} - V_{OUT}) ÷ (I_{OUT})] K Ω
where V_{OUT} = 3.0 v @ V_{SEL} = Open circuit
or V_{OUT} = 3.9 v @ V_{SEL} = GND
and I_{OUT} £ 72 mA

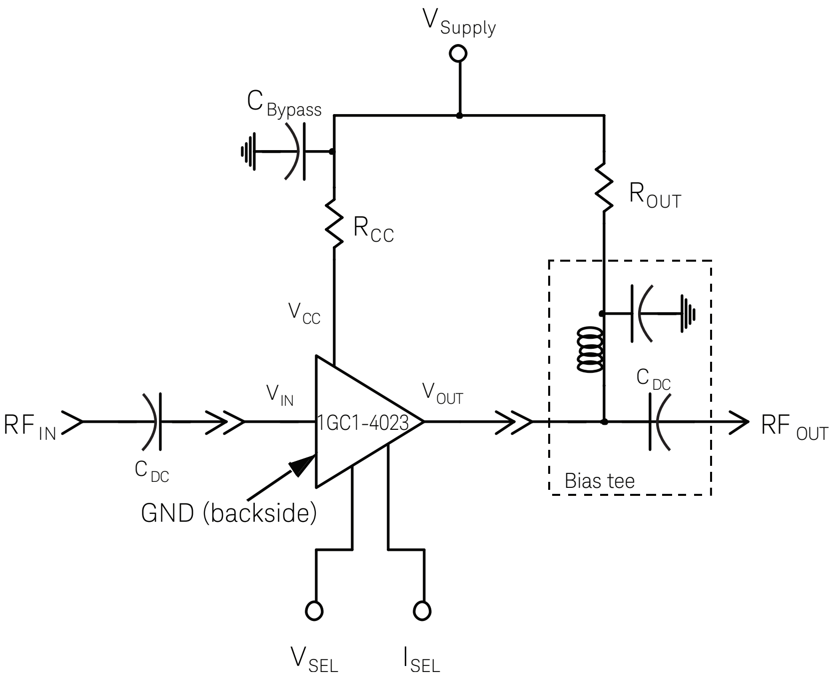


Figure 2. 1GC1-4023 biasing diagram

Low-noise mode operation

In this mode the device is biased to operate with the lowest possible noise figure and minimum DC power dissipation. The RF output voltage is set to V_{OUT} = 2.9 volts by applying an open circuit to the V_{SEL} pad and the stage one current is reduced to ~9 mA by applying an open circuit to the I_{SEL} pad.

High P_{OUT} mode operation

In this mode the device is biased to operate with the highest possible output power and power bandwidth while still delivering reasonably low DC power dissipation. The RF output voltage is set to V_{OUT} = 3.9 volts by grounding the V_{SEL} pad and the stage one current is increased to ~18 mA to optimize power compression characteristics by applying an short circuit to the I_{SEL}pad.

In either mode the output current (I_{OUT}) can be adjusted to any value up to 72 mA by varying the off-chip biasing resistor (R_{OUT}) or adjusting the RF output current source, whichever is employed. Output currents (I_{OUT}) lower than 55 mA will adversely affect output power performance above 2 GHz. Higher output currents (maximum of 72 mA) will maximize P_{OUT} and output power bandwidth at the expense of slightly higher DC power dissipation and higher noise figure. If R_{OUT} is greater than 300 ohms, the output RF choke may be omitted, however, the amplifier's gain may be reduced by ~1.0 dB.

DC blocking caps are recommended at the package RF input and output pads since the voltage at these pins will be between 3 and 4 volts above ground potential. A 100 pF AC bypass cap is recommended between VCC and ground to prevent low– frequency bias oscillations. Bypass caps are not required on the VSEL or ISEL pads. For chip bond pad identification and the device schematic refer to Figures 1 and 3. Refer to the Keysight Technologies, Inc. document, *GaAs MMIC ESD, Die Attach and Bonding Guidelines - Application Note* (5991-3484EN) for additional information.

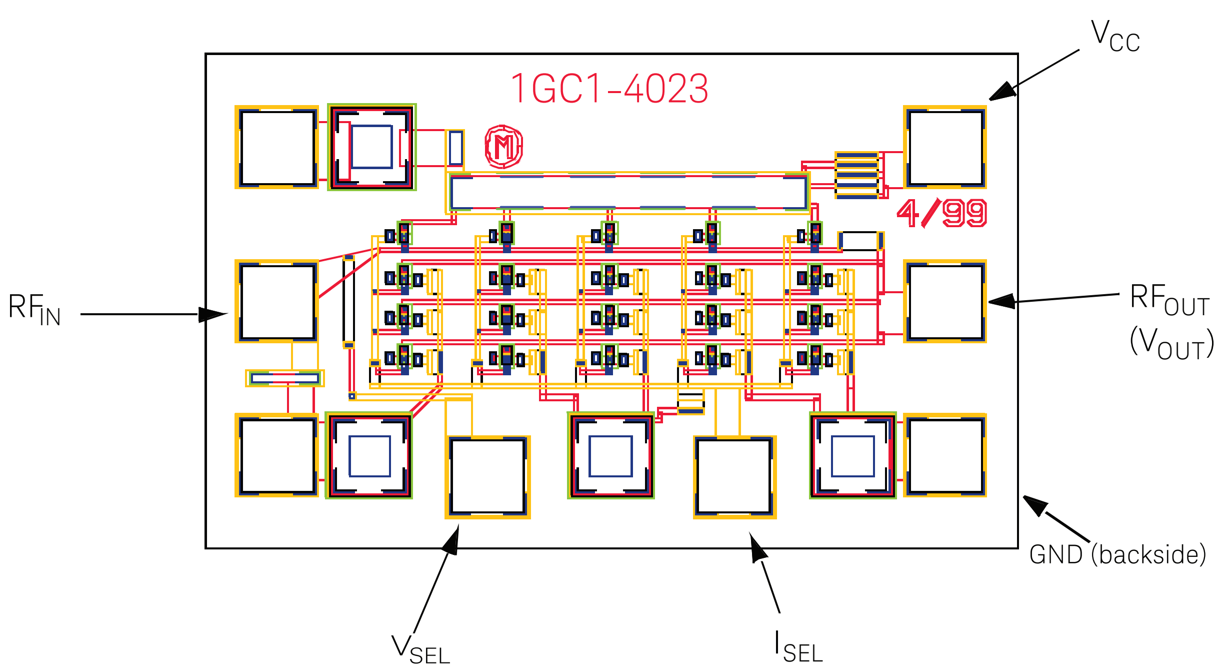


Figure 3. 1GC1-4023 chip bias/RF bond pad locations

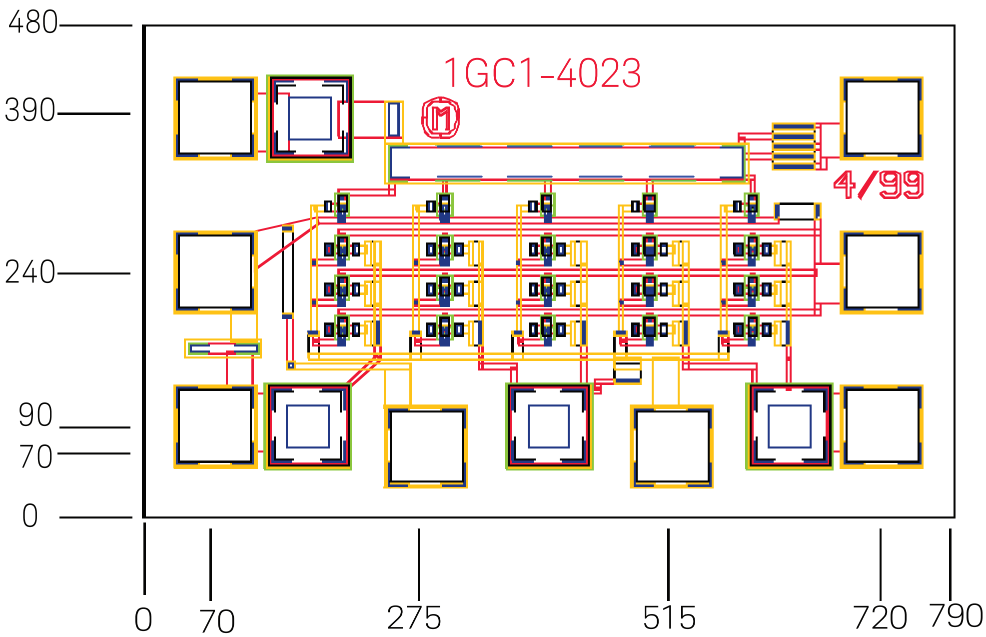


Figure 4. 1GC1-4023 chip dimensions

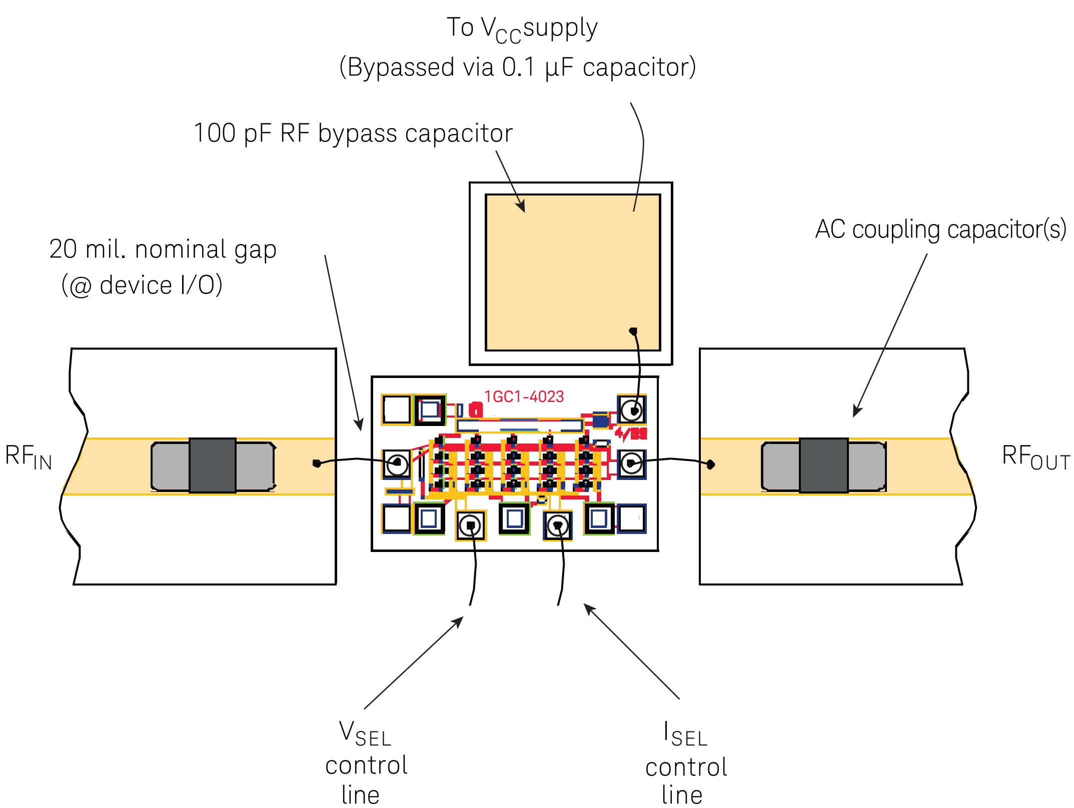


Figure 5. 1GC1-4023 chip assembly diagram

RoHS Compliance

This part is RoHS compliant, meeting the requirements of the EU *Restriction of Hazardous Substances* Directive 2011/65/EU, commonly known as *RoHS*. Six substances are regulated: lead, mercury, cadmium, chromium VI (hexavalent chromium), polybrominated biphenyls (PBB), and polybrominated biphenyl ethers (PBDE). RoHS compliance requires that any residual concentration of these substances is below the Directive's maximum concentration values (MCV): cadmium 100 ppm by weight and all others 1000 ppm by weight.

Typical S-parameter Response[1]

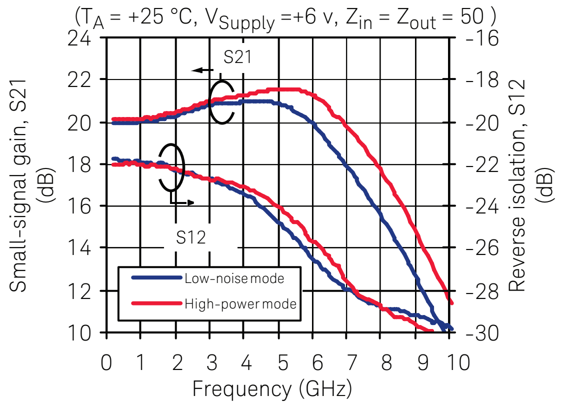


Figure 6. Small-signal gain and reverse isolation min. insertion loss and return loss vs. frequency

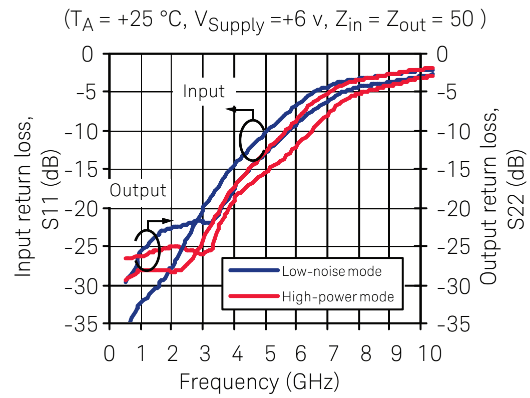


Figure 7. Small-signal input/output return loss

Low-noise/low-power mode

(T_A = 25 °C, V_{Supply} = +6 v, I_{OUT} = 55 mA, V_{SEL}= I_{SEL} = Open Circuit, Z_{in} = Z_{OUT} = 50)

Freq.		S_{12}			S_{12}			S_{21}			S_{22}	
(MHz)	dB	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang
100	–29.8	0.032	–11.3	–21.8	0.081	–1.2	19.9	9.851	177.9	–36.1	0.016	7.3
500	–27.0	0.045	–55.1	–21.9	0.080	–6.0	19.9	9.841	169.4	–32.7	0.023	25.8
1000	–23.5	0.067	–89.5	–22.0	0.080	–13.2	19.9	9.913	158.6	–30.2	0.031	39.1
1500	–21.9	0.080	–119.8	–22.1	0.079	–19.7	20.1	10.061	147.7	–27.7	0.041	51.7
2000	–21.7	0.083	–147.2	–22.4	0.075	–26.3	20.2	10.286	136.4	–24.6	0.059	61.7
2500	–22.2	0.078	–162.8	–22.5	0.075	–32.2	20.5	10.601	124.3	–21.0	0.089	59.9
3000	–21.6	0.083	–158.9	–22.8	0.072	–38.4	20.7	10.883	110.8	–18.1	0.124	47.2
3500	–18.6	0.117	–161.8	–23.1	0.070	–45.1	20.8	11.004	96.8	–15.1	0.175	33.0
4000	–15.7	0.163	178.3	–23.6	0.066	–52.6	20.9	11.062	82.6	–13.0	0.223	20.9
5000	–11.6	0.263	124.0	–25.0	0.057	–65.0	20.8	10.912	51.4	–9.0	0.353	1.7
6000	–8.1	0.393	67.8	–26.8	0.046	–72.8	19.7	9.674	17.0	–5.7	0.517	–18.3
7000	–5.4	0.536	26.4	–28.0	0.040	–76.0	17.7	7.652	–13.7	–4.0	0.633	–38.1
8000	–4.3	0.613	–1.5	–28.6	0.037	–74.7	15.3	5.820	–40.8	–3.3	0.686	–59.9
9000	–3.7	0.656	–24.7	–29.3	0.034	–84.7	12.4	4.178	–65.4	–2.7	0.733	–77.2
10000	–2.8	0.721	–42.3	–29.9	0.032	–91.9	9.3	2.908	–83.0	–2.2	0.773	–83.3

High-power mode[1]

(T_A = 25 °C, V_{Supply} = +6 v, I_{OUT} = 72 mA, V_{SEL}= I_{SEL} = GND, Z_{in} = Z_{OUT} = 50)

Freq.		S_{12}			S_{12}			S_{21}			S_{22}	
(MHz)	dB	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang
500	–24.9	0.057	–34.8	–22.1	0.079	–6.1	20.0	10.025	169.9	–28.2	0.039	6.2
1000	–23.5	0.067	–66.5	–22.2	0.077	–12.5	20.1	10.090	159.9	–28.0	0.040	5.8
1500	–23.6	0.066	–93.5	–22.2	0.078	–18.3	20.2	10.245	149.6	–28.2	0.039	15.3
2000	–25.2	0.055	–118.9	–22.4	0.076	–25.4	20.4	10.506	139.2	–27.4	0.043	35.1
2500	–27.2	0.044	–124.3	–22.5	0.075	–30.9	20.7	10.809	128.0	–25.2	0.055	45.4
3000	–24.2	0.062	–109.3	–22.7	0.073	–37.0	20.9	11.147	115.5	–21.5	0.084	39.8
3500	–19.7	0.103	–118.1	–22.9	0.072	–42.8	21.1	11.344	102.6	–18.1	0.125	27.8
4000	–17.3	0.136	–141.5	–23.2	0.069	–50.0	21.2	11.517	89.7	–15.8	0.163	18.4
5000	–14.5	0.189	158.6	–24.4	0.060	–63.7	21.5	11.865	61.0	–11.4	0.268	4.9
6000	–10.7	0.291	91.8	–25.8	0.051	–76.6	21.1	11.395	27.2	–7.1	0.443	–11.0
7000	–6.8	0.457	40.9	–27.6	0.042	–83.7	19.6	9.551	–5.8	–4.5	0.599	–30.3
8000	–5.0	0.565	8.7	–28.9	0.036	–87.5	17.4	7.454	–35.8	–3.3	0.680	–54.1
9000	–4.0	0.630	–17.5	–29.5	0.034	–90.0	14.6	5.339	–62.9	–2.6	0.740	–73.2
10000	–3.0	0.705	–37.6	–30.3	0.031	–94.6	11.3	3.674	–82.4	–2.1	0.785	–80.6

1. Data obtained from device mounted in RF text fixture. Magnitudes and Phase have been corrected for fixture loss and phase delay.

Supplemental Data[1]

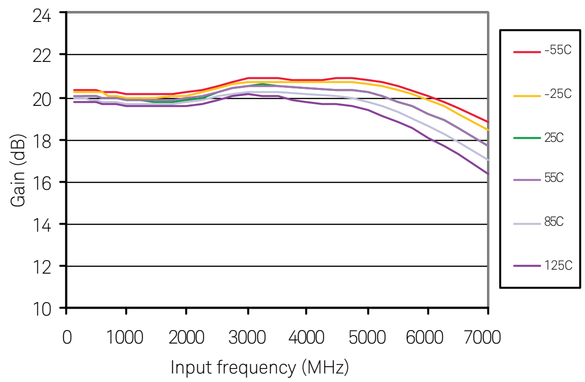


Figure 8. Typical small signal gain vs. frequency and temperature in low-noise mode

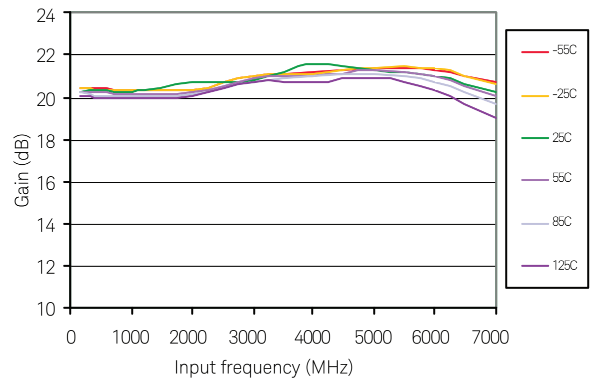


Figure 9. Typical small signal gain vs. frequency and temperature in high-power mode

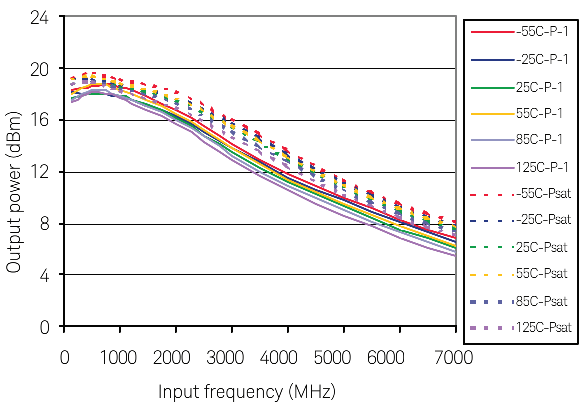


Figure 10. Typical output power P_{-1dB} and P_{sat} vs. frequency and temperature in low-noise mode

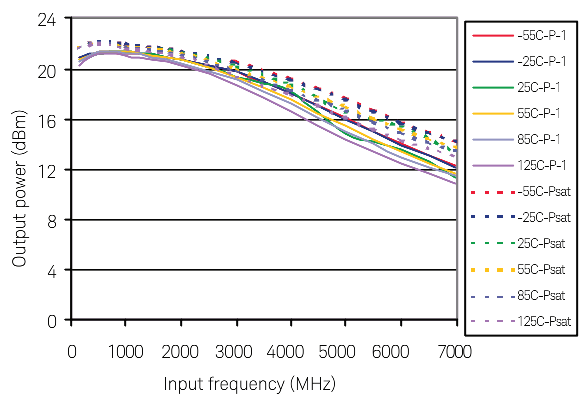


Figure 11. Typical output power P_{-1dB} and P_{sat} vs. frequency and temperature in high-power mode

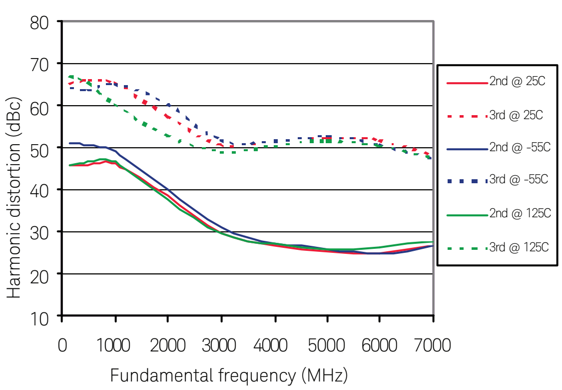


Figure 12. Typical 2nd and 3rd harmonics vs. frequency and temperature in low-noise mode[2]

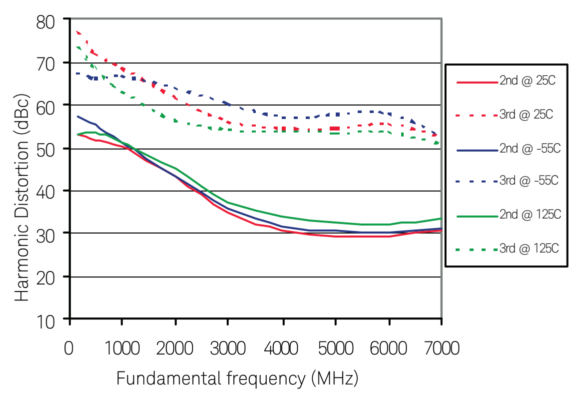


Figure 13. Typical 2nd and 3rd harmonics vs. frequency and temperature in high-power mode[2]

1. Data measured on device mounted in RF test fixture. Data has been corrected for fixture insertion loss.
2. Measured at P_{OUT} = +5 dBm

Supplemental Data[1] (continued)

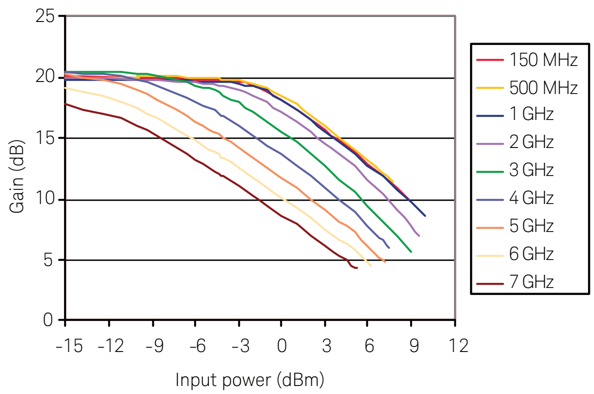


Figure 14. Typical gain vs. input power at T_A= 25 °C

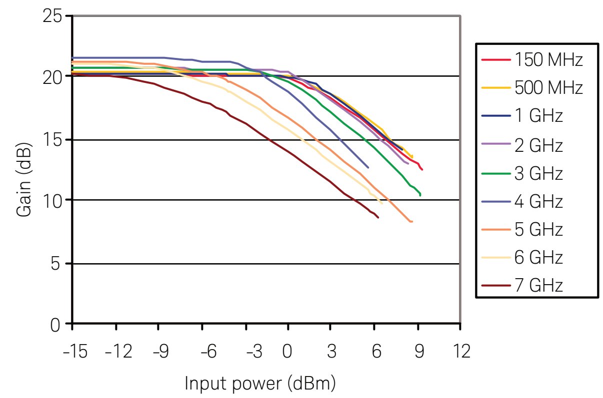


Figure 15. Typical gain vs. input power at T_A= 25 °C

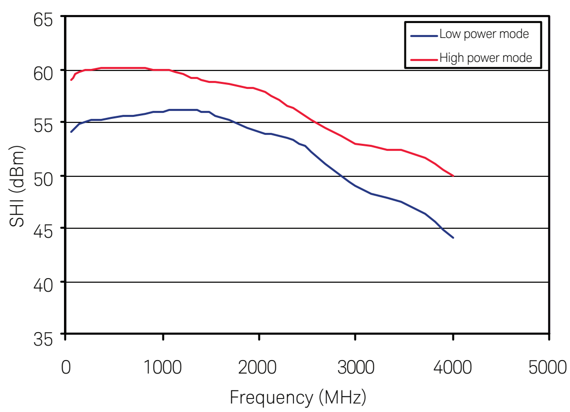


Figure 16. Typical SHI vs. 2nd harmonic frequency at T_A= 25 °C and P_{OUT} = 0 dBm

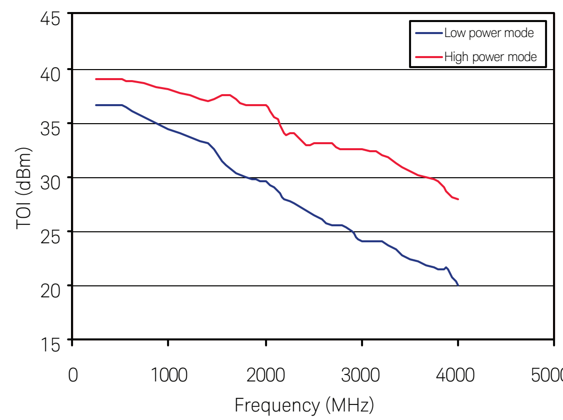


Figure 17. Typical TOI vs. frequency at T_A= 25 °C, P_{OUT} = 0 dBm and 200 KHz spacing

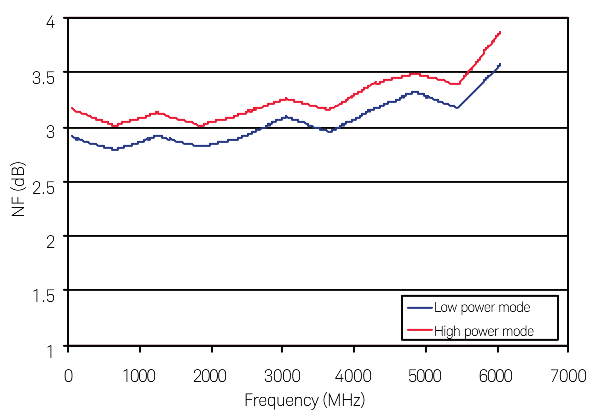
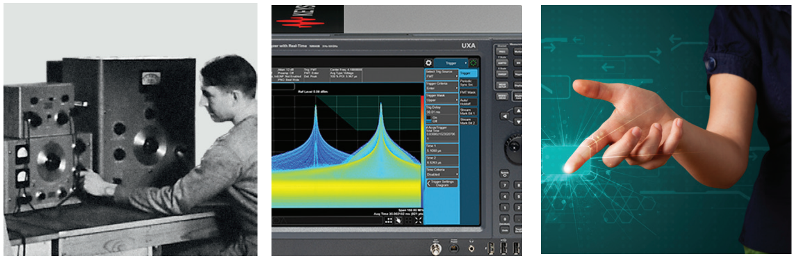


Figure 18. Typical noise figure vs. frequency at T_A= 25 °C and P_{OUT} 0 dBm.

1. Data measured on device mounted in RF test fixture. Data has been corrected for fixture insertion loss.

Evolving

Our unique combination of hardware, software, support, and people can help you reach your next breakthrough. We are unlocking the future of technology.



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The product described in this data sheet is RoHS Compliant. See *RoHS Compliance* section for more details.

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