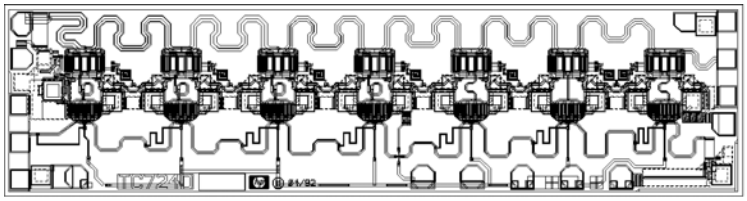
Agilent 1GG7-8045
2-26.5 GHz
High Power Output Amplifier

TC724
Data Sheet



Chip Size:	2980 × 770 μm (117.3 × 30.3 mils)
Chip Size Tolerance:	±10 μm (±0.4 mils)
Chip Thickness:	127 ± 15 μm (5.0 ± 0.6 mils)
Pad Dimensions:	75 × 75 μm (2.95 × 2.95 mils), or larger

Features

- **Wide–Frequency Range: 2–26.5 GHz**
- **Moderate Gain: 7.5 dB**
- **Gain Flatness: ± 1 dB**
- **Return Loss: Input: –17 dB Output: –14 dB**
- **Low–Frequency Operation Capability: < 2 GHz**
- **Gain Control: 30 dB Dynamic Range**
- **High Power:**
  - **20 GHz: P_{-1dB}: 26 dBm, P_{sat}: 28.5 dBm**
  - **26.5 GHz: P_{-1dB}: 23 dBm, P_{sat}: 26 dBm**

Description

The TC724 is a broadband GaAs MMIC Traveling Wave Amplifier designed for high output power and moderate gain over the full 2 to 26.5 GHz frequency range. Seven MESFET cascode stages provide a flat gain response, making the TC724 an ideal wideband power block. E–beam lithography is used to produce gate lengths of ≈0.3 μm. The TC724 incorporates advanced MBE technology, Ti–Pt–Au gate metallization, silicon nitride passivation, and polyimide for scratch protection.

Absolute Maximum Ratings[1]

Symbol	Parameters/Conditions	Min.	Max.	Units
V_{DD}	Positive Drain Voltage		13.0	volts
I_{DD}	Total Drain Current		450	mA
V_{G1}	First Gate Voltage	–4.5	0	volts
I_{G1}	First Gate Current	–10	1	mA
V_{G2}[2]	Second Gate Voltage	–4.5	3	volts
I_{G2}	Second Gate Current	–25	20	mA
P_{DC}	DC Power Dissipation		5.8	watts
P_{in}	CW Input Power		25	dBm
T_{ch}	Operating Channel Temperature		180	°C
T_{case}	Operating Case Temperature	–55		°C
T_{stg}	Storage Temperature	–65	180	°C
T_{max}	Maximum Assembly Temperature (for 60 seconds maximum)		300	°C

Notes:

1. Operation in excess of any one of these conditions may result in permanent damage to this device. T_A = 25°C except for T_{ch}, T_{stg}, and T_{max}.
2. Minimum voltage on V_{G2} must not violate the following: $V_{G2}(min) > V_{DD} – 12$ volts.

DC Specifications/Physical Properties[1]

Symbol	Parameters/Conditions	Min.	Typ.	Max.	Units
I_{DSS}	Saturated Drain Current (V_{DD}=11.0V, V_{G1}=0.0V, V_{G2}= open circuit)	470	710	940	mA
V_P	First Gate Pinch-off Voltage (V_{DD}=11.0V, I_{DD}=80mA, V_{G2}= open circuit)	–3.5	–1.7	–0.5	volts
V_{G2}	Second Gate Self-Bias Voltage (V_{DD}=11.0V, V_{G1}=0.0V)	1.0	2.1	3.0	volts
$I_{DSOFF}(V_{G1})$	First Gate Pinch-Off Current (V_{DD}=11.0V, V_{G1}= –3.5V, V_{G2}= open circuit)		2.8	45	mA
$I_{DSOFF}(V_{G2})$	Second Gate Pinch-Off Current (V_{DD}=11.0V, V_{G1}=0.0V, V_{G2}= –3.5)		3.7	45	mA
Θ_{ch-bs}	Thermal Resistance ($T_{backside}$=25°C)		22.5		°C/W

Notes:

1. Measured in wafer form with T_{chuck} = 25°C. (Except Θ_{ch-bs}).

RF Specifications[1]

(V_{DD} = 11.0V, $I_{DD}(Q)$ = 400mA, Z_{in}=Z_o=50Ω)

Symbol	Parameters/Conditions	1GG7-8045			Units
		Min.	Typical	Max.	
BW	Guaranteed Bandwidth[2]	2		26.5	GHz
S_{21}	Small Signal Gain	5.5	7.5		dB
ΔS_{21}	Small Signal Gain Flatness (>4GHz)		±1.0	±1.8	dB
RL_{in}	Input Return Loss		–17	–10	dB
RL_{out}	Output Return Loss		–14	–10	dB
S_{12}	Reverse Isolation		–27	–20	dB
P_{-1dB}	Output Power at 1dB Gain Compression	19.5	23		dBm
P_{sat}	Saturated Output Power	22.5	26		dBm
H_2	2nd Harm. (2<f_o<20) [$P_o(f_o)$ = 24 dBm or P_{-1dB} whichever is less]		–20	–14	dBc
H_3	3rd Harm. (2 <f_o<20) [$P_o(f_o)$ = 24 dBm or P_{-1dB} whichever is less]		–30	–14	dBc
NF	Noise Figure		11		dB

Notes:

1. Small-signal data measured in wafer form with T_{chuck} = 25°C. Large–signal data measured on individual devices.
2. Performance may be extended to lower frequencies through the use of appropriate off–chip circuitry. Upper corner frequency ~ 30 GHz.

Applications

The TC724 series of traveling wave amplifiers are designed for use as general purpose wideband power stages in communication systems and microwave instrumentation. They are ideally suited for broadband applications requiring high output power and excellent port matches over a 2 to 26.5 GHz frequency range. Dynamic gain control and low-frequency extension capabilities are designed into these devices.

It is characteristic of traveling wave amplifiers that S_{22} tends to 0dB and greater out of band. This is the design trade–off for the broadband performance of TWAs. As a consequence, TWAs are not necessarily unconditionally stable out of band. This means that if a TWA is followed by a reflective low–pass filter, oscillations can occur. This phenomenon is exacerbated by low temperature where the gain is higher. More data will follow on individual devices.

Biasing and Operation

These amplifiers are biased with a single positive drain supply (V_{DD}) and a single negative gate supply (V_{G1}). The recommended bias conditions for the TC724 are V_{DD} = 11.0V, I_{DD} = 400mA. To achieve this drain current level, V_{G1} is typically biased between –0.3V and –1.0V. No other bias supplies or connections to the device are required for 2 to 26.5 GHz operation. The gate voltage (V_{G1}) **MUST** be applied prior to the drain voltage (V_{DD}) during power up and removed after the drain voltage during power down. See Figure 3 for assembly information.

The auxiliary gate and drain contacts are used only for low-frequency performance extension below ≈ 1.0 GHz. When used, these contacts must be AC coupled only. (Do not attempt to apply bias to these pads.)

The second gate (V_{G2}) can be used to obtain 30 dB (typical) dynamic gain control. For normal operation, no external bias is required on this contact and its self-bias potential is + 2.0 volts. Applying an external bias between its open circuit potential and a negative voltage of no less than (V_{DD}–12) volts will adjust the gain while maintaining a good input/output port match.

Assembly Techniques

Solder die–attach using a fluxless AuSu solder preform is the recommended assembly method. Gold thermosonic wedge bonding with 0.7 mil diameter Au wire is recommended for all bonds. Tool force should be 22 ± 1gram, stage temperature should be 150 ± 2°C and ultrasonic power and duration should be 64 ±1 dB and 76 ±8 msec, respectively. The bonding pad and chip backside metallization is gold.

Agilent application note #54, "GaAs MMIC ESD, Die Attach and Bonding Guidelines" provides basic information on these subjects.

Additional References:

AN #56, “GaAs MMIC TWA Users Guide.”

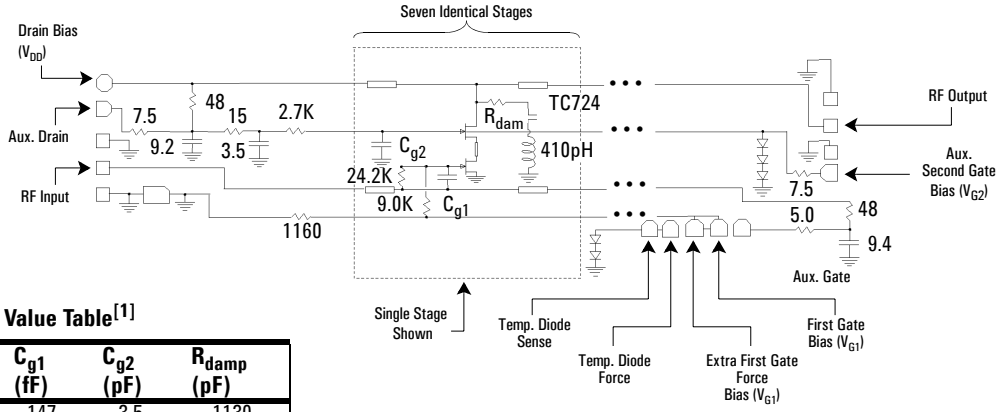


Figure 1.
TC724 Schematic

Parameter Value Table[1]

Stage No.	C_{g1} (fF)	C_{g2} (pF)	R_{damp} (pF)
1	147	3.5	1130
2	163	5.5	470
3	181	5.5	376
4	214	5.5	417
5	240	5.5	470
6	280	5.5	496
7	327	5.9	391

1. Damping circuit topology has been approximated by these values.

Notes:

- All FETs have 390 micron gate periphery.
- All Resistors in ohms (W) (or in K–ohms, where indicated).
- All capacitors in pico–farads (pF), or in femto-farads, where indicated.

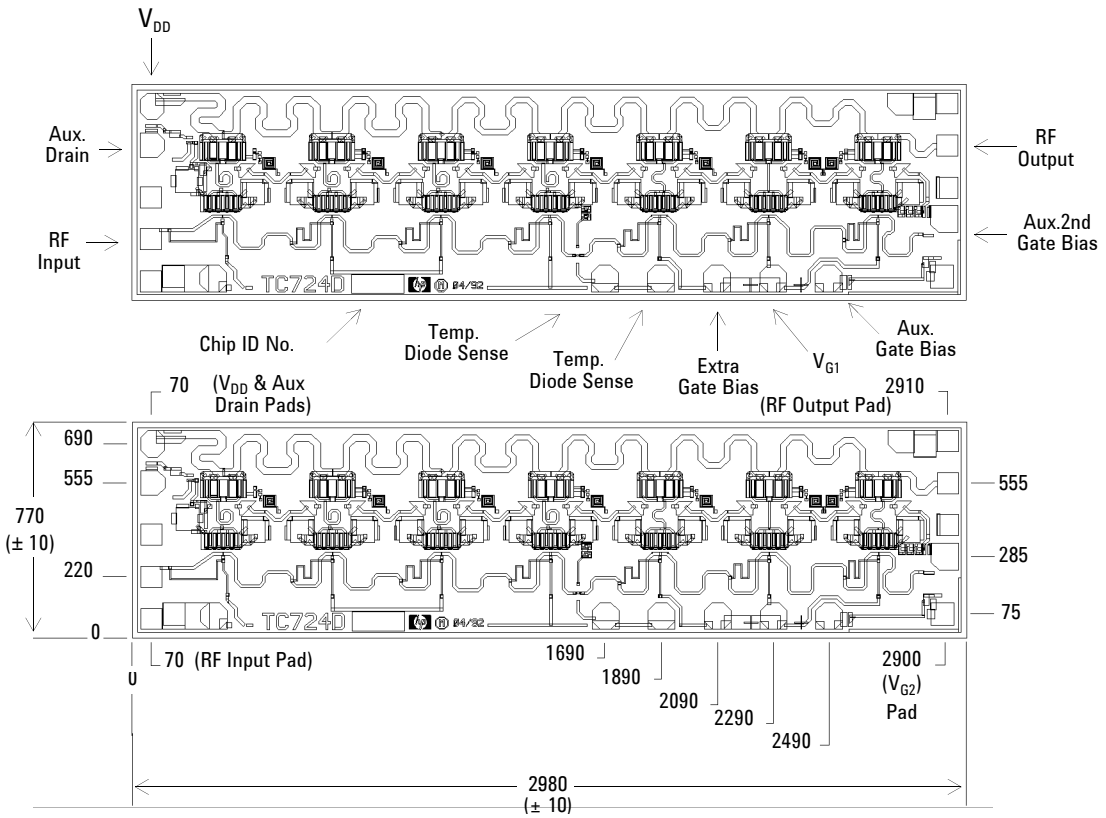
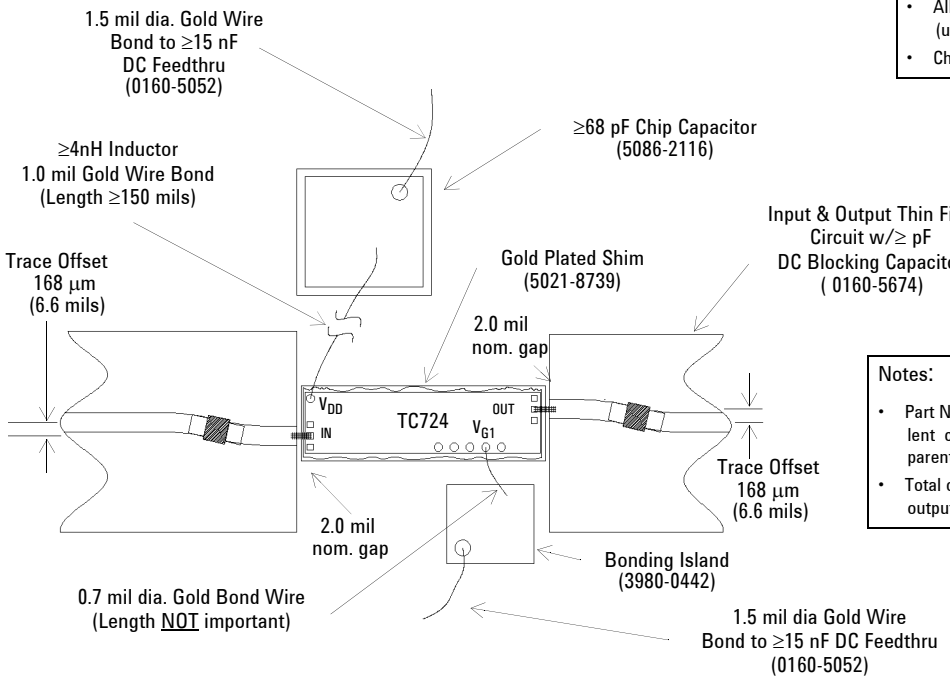


Figure 2.
TC724 Bond Pad Locations

Notes:

- All dimensions in microns.
- RF input and output Pads Dim.: 75 × 75 μm.
- Polygon Pad Dim.: 95 μm dia.
- All other dimensions: ± 5 μm (unless otherwise noted).
- Chip thickness: 127 ± 15 μm.



Notes:

- Part Numbers for recommended Agilent components shown in parenthesis.
- Total offset between RF input and RF output pad is 335 μm (13.2 mils).

Figure 3.
TC724 Assembly Diagram
(For 2.0–26.5 GHz Operation)

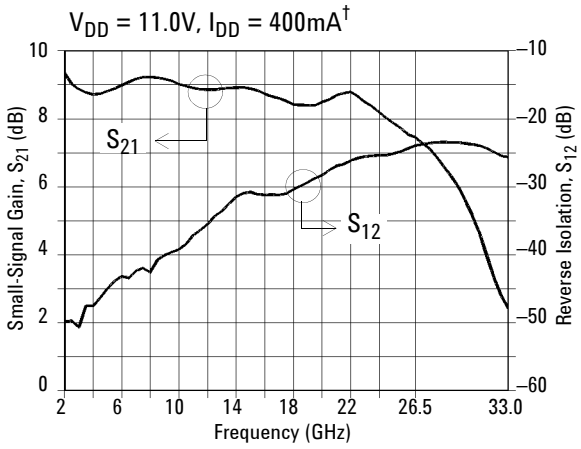


Figure 4.
Typical Gain and Reverse Isolation vs. Frequency

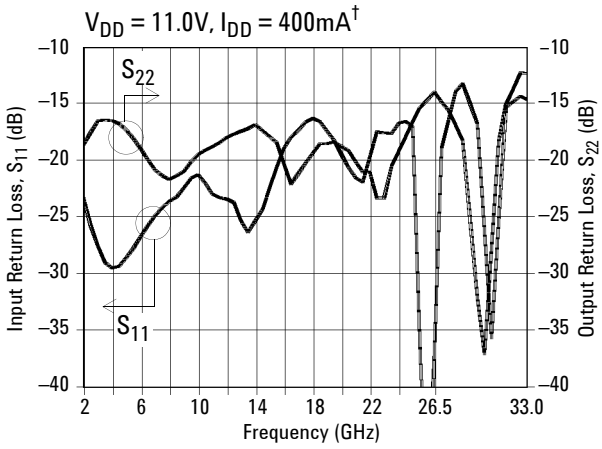


Figure 5.
Typical Input and Output Return Loss vs. Frequency

Typical S-Parameters[1]

(T_{chuck} = 25°C,V_{DD} = 11.0V, I_{DD}= 400 mA, Z_{in} = Z_o = 50Ω)

Freq.	S_{11}			S_{12}			S_{21}			S_{22}		
(GHz)	dB	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang
2.0	–23.7	0.065	–165.7	–49.9	0.0032	–174.3	9.4	2.941	118.1	–18.5	0.118	–157.5
3.0	–27.8	0.041	138.7	–50.6	0.0029	167.8	8.9	2.775	94.9	–16.5	0.150	167.7
4.0	–29.9	0.032	102.6	–47.5	0.0042	140.8	8.7	2.728	71.5	–16.3	0.152	137.1
5.0	–28.7	0.037	71.8	–45.0	0.0056	127.3	8.8	2.760	47.6	–17.2	0.138	106.1
6.0	–26.8	0.046	35.7	–43.1	0.0070	96.2	9.0	2.815	22.2	–18.9	0.113	68.9
7.0	–25.1	0.056	5.4	–42.3	0.0076	73.5	9.2	2.876	–4.4	–20.8	0.091	26.4
8.0	–23.6	0.066	–24.6	–42.6	0.0074	56.1	9.2	2.894	–31.8	–21.7	0.083	–21.5
9.0	–22.8	0.073	–65.6	–40.0	0.0100	37.5	9.2	2.876	–59.4	–20.9	0.090	–75.0
10.0	–21.0	0.089	–101.6	–39.2	0.0110	19.6	9.0	2.824	–86.6	–19.4	0.107	–109.0
11.0	–23.1	0.070	–148.5	–37.1	0.0139	2.8	8.9	2.788	–113.3	–18.7	0.117	–139.7
12.0	–22.1	0.079	170.8	–35.5	0.0168	–21.0	8.9	2.772	–140.0	–17.9	0.128	–169.5
13.0	–25.8	0.051	129.8	–33.6	0.0210	–46.9	8.9	2.782	–167.0	–17.6	0.132	172.3
14.0	–22.8	0.072	44.5	–31.5	0.0267	–75.0	8.9	2.791	165.0	–16.8	0.144	134.7
15.0	–22.2	0.078	–20.1	–30.8	0.0289	–109.6	8.9	2.782	136.3	–17.9	0.128	76.4
16.0	–18.6	0.117	–76.5	–31.2	0.0275	–135.8	8.7	2.732	107.6	–22.1	0.078	6.3
17.0	–18.0	0.126	–115.6	–31.2	0.0276	–156.5	8.6	2.694	79.0	–21.2	0.088	–69.3
18.0	–15.6	0.166	–154.5	–30.3	0.0304	–175.3	8.4	2.634	50.6	–21.0	0.089	–109.6
19.0	–16.3	0.154	159.8	–29.3	0.0341	160.2	8.4	2.628	22.4	–18.6	0.118	–147.0
20.0	–19.1	0.110	107.2	–28.3	0.0385	136.0	8.5	2.659	–6.8	–18.1	0.124	176.5
21.0	–21.7	0.082	34.6	–26.9	0.0451	106.4	8.7	2.720	–37.7	–20.2	0.098	145.0
22.0	–22.4	0.076	–69.5	–26.1	0.0493	78.3	8.8	2.751	–71.0	–19.9	0.101	99.6
23.0	–15.1	0.175	–120.0	–25.5	0.0529	46.7	8.5	2.657	–104.7	–23.3	0.069	19.7
24.0	–16.4	0.151	–168.2	–25.4	0.0539	15.8	8.2	2.564	–138.3	–17.7	0.130	–42.4
25.0	–17.0	0.141	161.3	–25.1	0.0555	–11.6	7.9	2.473	–171.2	–16.4	0.151	–97.9
26.0	–54.6	0.002	153.6	–24.4	0.0604	–41.4	7.5	2.382	154.1	–12.6	0.233	–131.4
26.5	–21.6	0.084	–35.2	–23.9	0.0635	–58.8	7.5	2.361	136.1	–13.9	0.201	–130.8
27.0	–18.9	0.114	–53.0	–23.8	0.0648	–75.8	7.3	2.309	117.8	–15.1	0.176	–160.3
28.0	–13.9	0.203	–144.0	–23.4	0.0672	–111.3	6.9	2.207	81.4	–16.2	0.155	165.5
29.0	–12.3	0.243	–165.5	–23.5	0.0670	–147.6	6.3	2.070	43.4	–18.9	0.113	163.1
30.0	–18.9	0.114	–156.2	–23.6	0.0659	175.0	5.6	1.904	3.7	–37.0	0.014	–47.6
31.0	–14.4	0.190	–176.3	–23.9	0.0635	136.0	4.6	1.705	–37.3	–18.3	0.122	–90.9
32.0	–12.7	0.233	–162.5	–24.9	0.0569	97.8	3.3	1.464	–76.0	–12.7	0.232	–112.3
33.0	–14.6	0.187	–358.3	–25.6	0.0524	61.9	2.4	1.321	–475.8	–12.2	0.244	–136.0

1. Data obtained from on-wafer measurements.

Additional TC724 Performance Characteristics

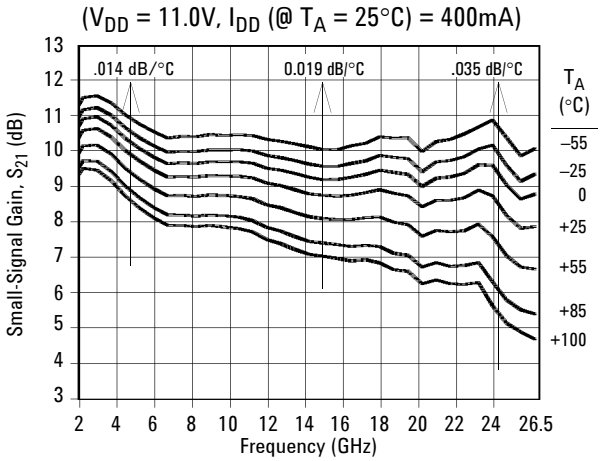


Figure 6.
Typical Small-Signal Gain vs. Temperature

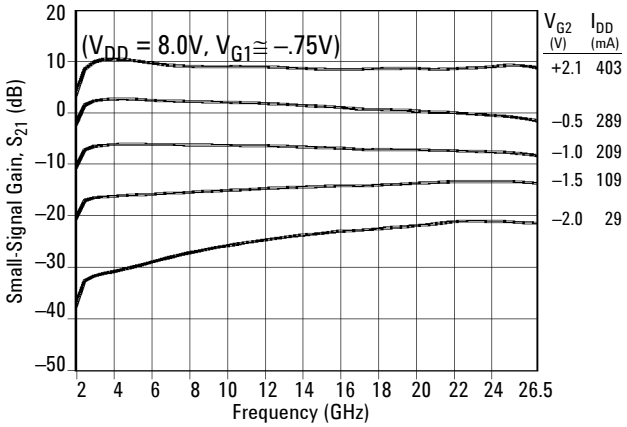


Figure 7.
Typical Gain vs. Second Gate Control Voltage

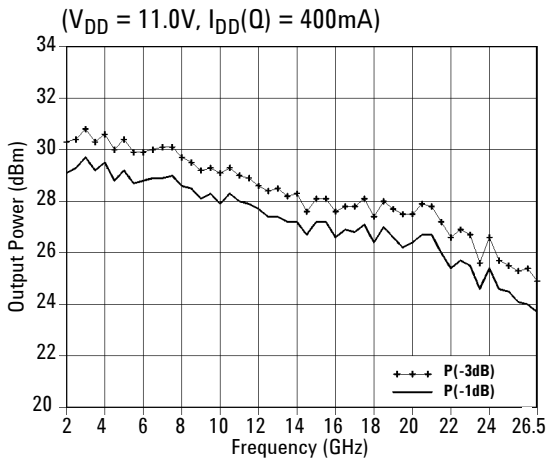


Figure 8.
Typical 1dB Gain Compression and Saturated Output Power vs. Frequency

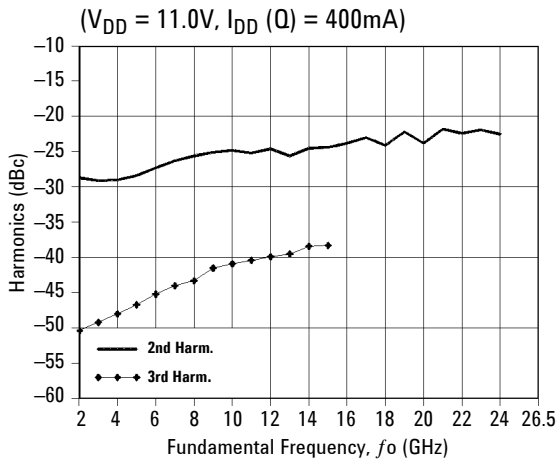


Figure 9.
Typical Second and Third Harmonics vs. Fundamental Frequency at P_{out} = +24 dBm

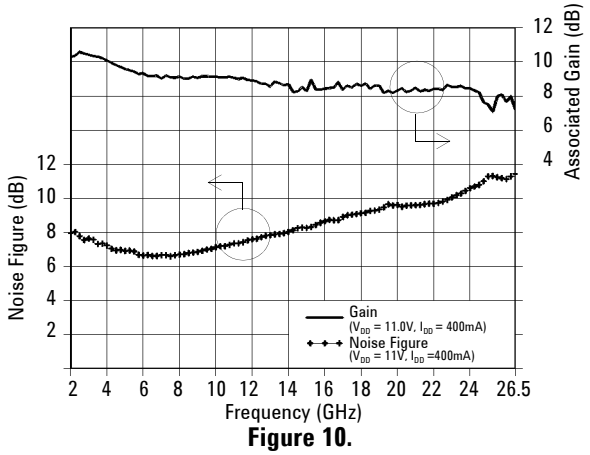


Figure 10.
Typical Noise Figure Performance

Notes:
All data measured on individual devices mounted in an Agilent83040 Series Modular Microcircuit Package @ T_A = 25°C, except where noted.

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. Customers considering the use of this, or other WPTC GaAs ICs, for their design should obtain the current production specifications from WPTC Marketing. In this data sheet the term typical refers to the 50th percentile performance. For additional information contact WPTC Marketing at 707-577-4482.