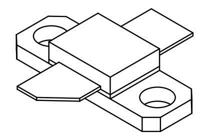
The RF Line
# NPN Silicon RF Power Transistor

**MRF6404**
**MRF6404K**

The MRF6404 is designed for 26 volts microwave large signal, common emitter, class AB linear amplifier applications operating in the range 1.8 to 2.0 GHz.

- Specified 26 Volts, 1.88 GHz Characteristics
  Output Power — 30 Watts
  Gain — 7.5 dB Min @ 30 Watts
  Efficiency — 38% Min @ 30 Watts
- Characterized with Series Equivalent Large–Signal Parameters from 1.8 to 2.0 GHz
- To be used in Class AB for DCS1800 and PCS1900/Cellular Radio
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration

**30 W, 1.88 GHz**
**RF POWER TRANSISTOR**
**NPN SILICON**



CASE 395C–01, STYLE 1

**MAXIMUM RATINGS**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Collector–Emitter Voltage | $V_{CEO}$ | 24 | Vdc |
| Collector–Emitter Voltage | $V_{CES}$ | 60 | Vdc |
| Emitter–Base Voltage | $V_{EBO}$ | 4 | Vdc |
| Collector–Current — Continuous | $I_C$ | 10 | Adc |
| Total Device Dissipation @ $T_C$ = 25°C<br>Derate above 25°C | $P_D$ | 125<br>0.71 | Watts<br>W/°C |
| Storage Temperature Range | $T_{stg}$ | –65 to +150 | °C |
| Operating Junction Temperature | $T_J$ | 200 | °C |

**THERMAL CHARACTERISTICS**

| Characteristic | Symbol | Max | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case (1) | $R_{\theta JC}$ | 1.4 | °C/W |

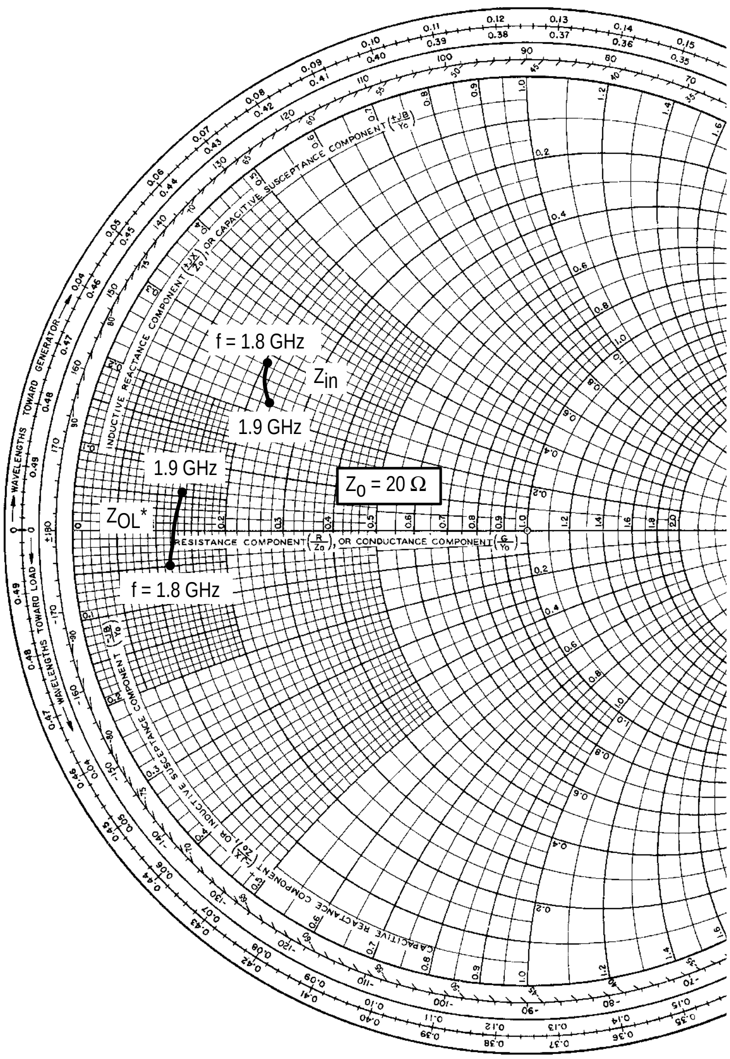
**ELECTRICAL CHARACTERISTICS** ($T_C$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| Collector–Emitter Breakdown Voltage ($I_C$ = 50 mA, $I_B$ = 0) | $V_{(BR)CEO}$ | 24 | 29 | — | Vdc |
| Emitter–Base Breakdown Voltage ($I_E$ = 10 mAdc) | $V_{(BR)EBO}$ | 4 | 5 | — | Vdc |
| Collector–Base Breakdown Voltage ($I_C$ = 50 mAdc) | $V_{(BR)CES}$ | 60 | 68 | — | Vdc |
| Collector–Base Breakdown Voltage ($I_C$ = 50 mAdc, $R_{BE}$ = 75 Ω) | $V_{(BR)CER}$ | 40 | 56 | — | Vdc |
| Collector Cutoff Current ($V_{CE}$ = 30 V, $V_{BE}$ = 0) | $I_{CES}$ | — | — | 10 | mA |
| **ON CHARACTERISTICS** | | | | | |
| DC Current Gain ($I_C$ = 1 Adc, $V_{CE}$ = 5 Vdc) | $h_{FE}$ | 20 | 50 | 120 | — |

(1) Thermal resistance is determined under specified RF operating condition.

**ELECTRICAL CHARACTERISTICS — continued** ($T_C$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **DYNAMIC CHARACTERISTICS** | | | | | |
| Output Capacitance ($V_{CB}$ = 26 V, $I_E$ = 0, f = 1 MHz) For information only. This part is collector matched. | $C_{ob}$ | 30 | 38 | — | pF |
| **FUNCTIONAL TESTS** | | | | | |
| Common–Emitter Amplifier Power Gain ($V_{CC}$ = 26 V, $P_{out}$ = 30 W, $I_{CQ}$ = 150 mA, f = 1.88 GHz) | $G_{pe}$ | 7.5 | 8.5 | — | dB |
| Common–Emitter Amplifier Power Gain ($V_{CC}$ = 26 V, $P_{out}$ = 28 W, $I_{CQ}$ = 150 mA) (f = 1.99 GHz) | $G_{pe}$ | 7 | 8 | — | dB |
| Collector Efficiency | η | | | | % |
| ($V_{CC}$ = 26 V, $P_{out}$ = 30 W, f = 1.88 GHz) | | 38 | 43 | — | |
| ($V_{CC}$ = 26 V, $P_{out}$ = 28 W, f = 1.99 GHz) | | 35 | 40 | — | |
| Output Power at 1 dBc | $P_{1dBc}$ | | | | Watts |
| ($V_{CC}$ = 26 V, f = 1.88 GHz) | | 30 | 35 | — | |
| ($V_{CC}$ = 26 V, f = 1.99 GHz) | | 28 | 33 | — | |
| Output Mismatch Stress: VSWR = 3:1 (all phase angles) ($V_{CC}$ = 26 Vdc, $P_{out}$ = 25 W, $I_{CQ}$ = 150 mA, f = 1.88 GHz) | Ψ | No Degradation in Output Power | | | |




**DCS EVALUATION**

| f (GHz) | $Z_{in}$ (Ω) | $Z_{OL}$* (Ω) |
|---|---|---|
| 1.8 | 4.3 + j6.1 | 2.7 – j1.0 |
| 1.85 | 4.6 + j5.3 | 2.9 + j0.3 |
| 1.9 | 4.8 + j5.0 | 3.0 + j1.2 |

$Z_{OL}$*: Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

**Figure 1. Input and Output Impedances with Circuit Tuned for Maximum Gain @ $V_{CC}$ = 26 V, $I_{CQ}$ = 150 mA, $P_{out}$ = 30 W**

## TYPICAL CHARACTERISTICS

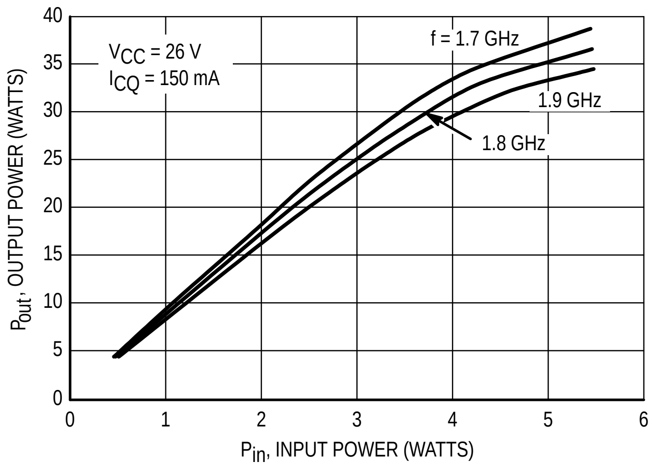



**Figure 2. Output Power versus Input Power**

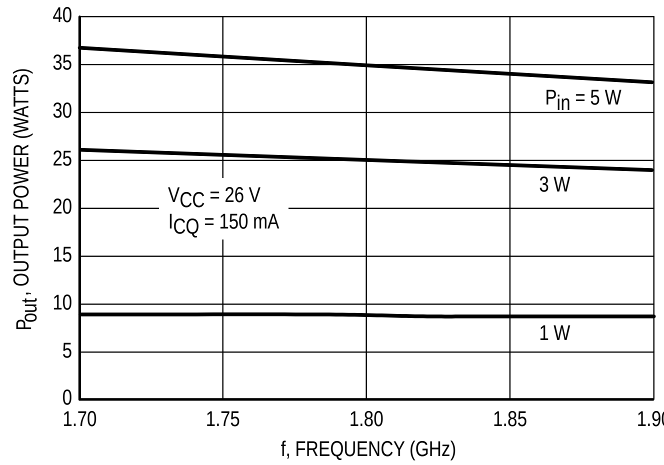



**Figure 3. Output Power versus Frequency**

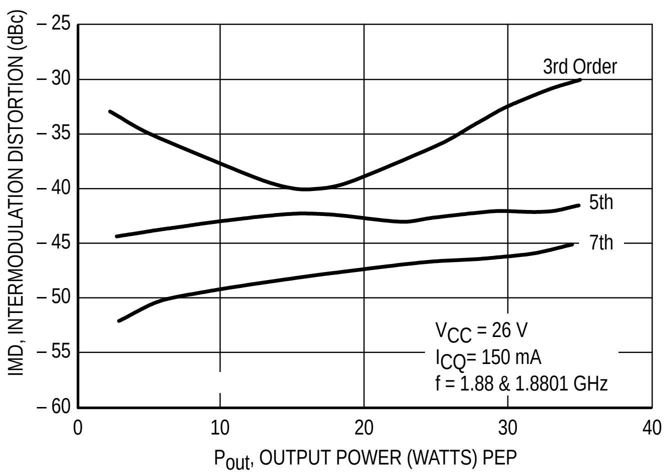



**Figure 4. Intermodulation versus Output Power**

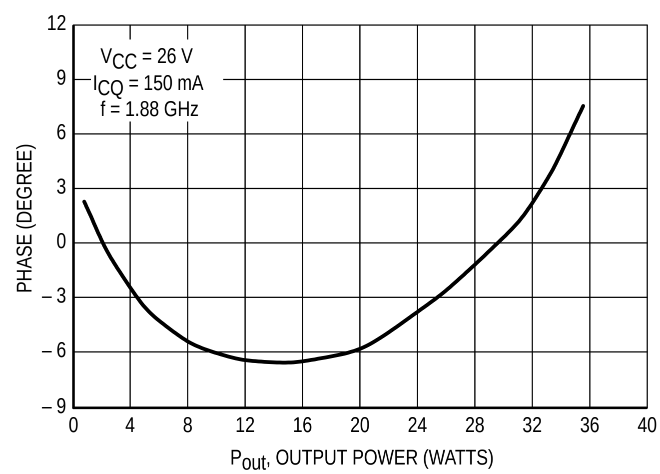
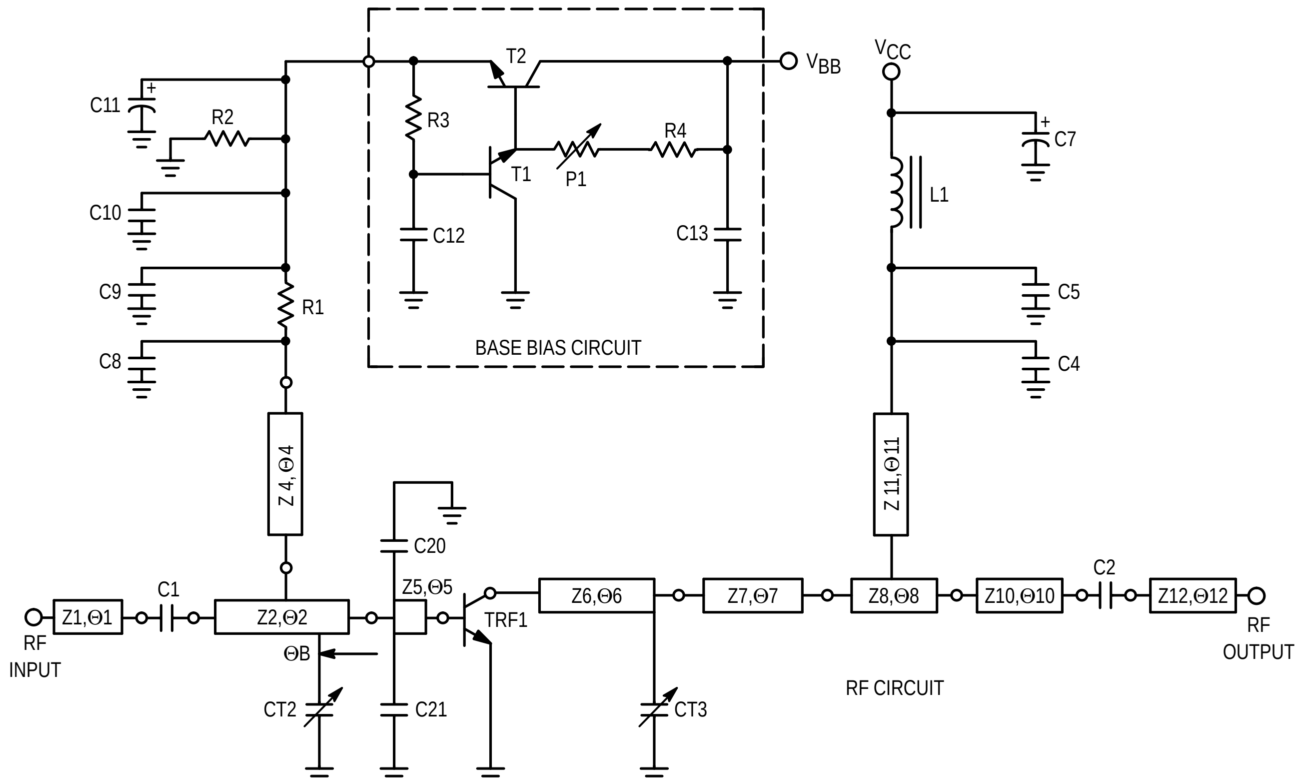



**Figure 5. AM/PM Conversion**




**Base Bias Circuit**

| | |
|---|---|
| C12, C13 | 15 nF, Chip Capacitor, Vitramon (0805 A153 JXB) |
| P1 | 1 KΩ, Trimmer |
| R3 | 47 Ω, Chip Resistor, 0805 |
| R4 | 330 Ω, Chip Resistor, 0805 |
| T1,T2 | Motorola MJD 31C |

**Decoupling Base Bias Circuit**

| | |
|---|---|
| C4 | 68 pF, Chip Capacitor, ATC 100A |
| C5, C9 | 330 pF, Chip Capacitor, Vitramon (0805 A331 JXB) |
| C7, C11 | 4.7 µF, 63 V, Electrolytic Capacitor |
| C8 | 68 pF, Chip Capacitor, ATC 100A |
| C10 | 15 nF, Chip Capacitor, Vitramon (0805 A153 JXB) |
| R1 | 1.5 Ω, Chip Resistor, 0805 |
| R2 | 56 Ω, Chip Resistor, 1206 |

**RF Circuit**

| | |
|---|---|
| C1, C2 | 68 pF, Chip Capacitor, ATC 100A |
| C20, C21 | 1.3 pF, Chip Capacitor, ATC 100A |
| CT2 | Trimmer Capacitor, Gigatrim, Ref 37281 |
| CT3 | Trimmer Capacitor, Gigatrim, Ref 37291 |
| TRF1 | MRF6404 |

PC Board Material:
$\varepsilon_r$ = 2.55, H = 0.508 mm, T = 0.035 mm

All Electrical Lengths Are Referenced from $\lambda g$ @ f = 1.9 GHz

| | |
|---|---|
| Z1 : 50 Ω | Θ1 : 10° |
| Z2 : 50 Ω | Θ2 : 74.5° ΘB : 16.5° |
| Z4 : 74 Ω | Θ4 : 68° |
| Z5 : 12.8 Ω | Θ5 : 21° |
| Z6 : 10.4 Ω | Θ6 : 49.5° |
| Z7 : 18 Ω | Θ7 : 36.5° |
| Z8 : 45 Ω | Θ8 : 20° |
| Z10 : 50 Ω | Θ10 : 10° |
| Z11 : 74 Ω | Θ11 : 74.5° |
| Z12 : 50 Ω | Θ12 : 10° |

**Figure 6. 1.80 – 1.88 GHz Test Circuit Electrical Schematic and Components List**

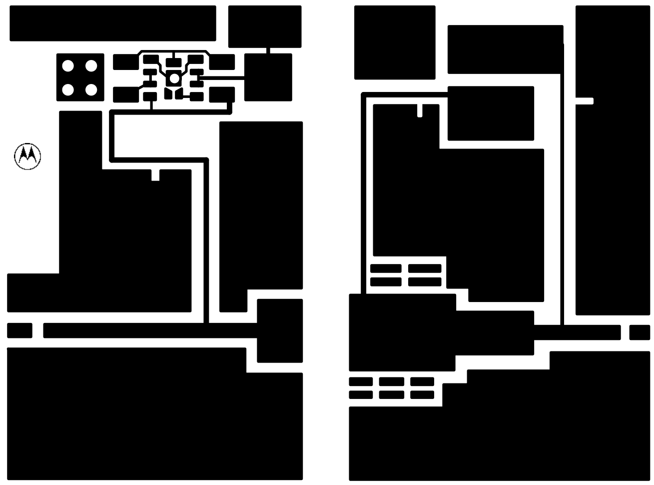



**Figure 7. 1.80 – 1.88 GHz PCN Test Circuit Photomaster**

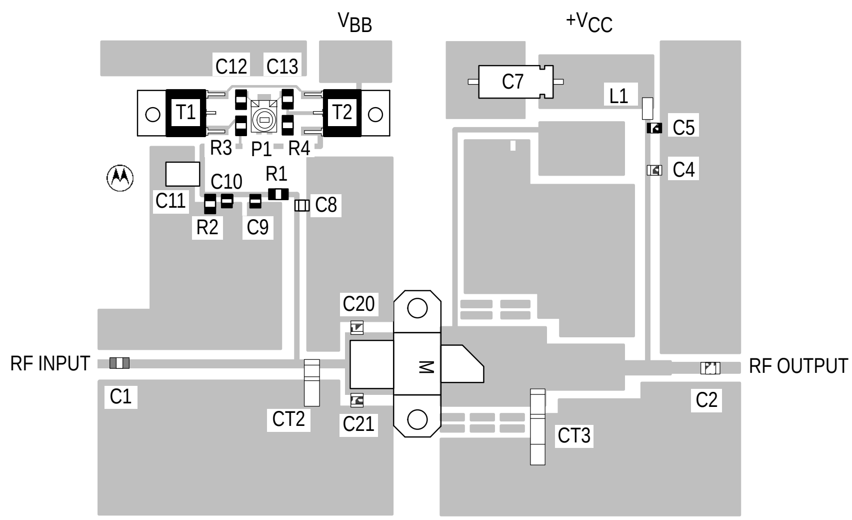
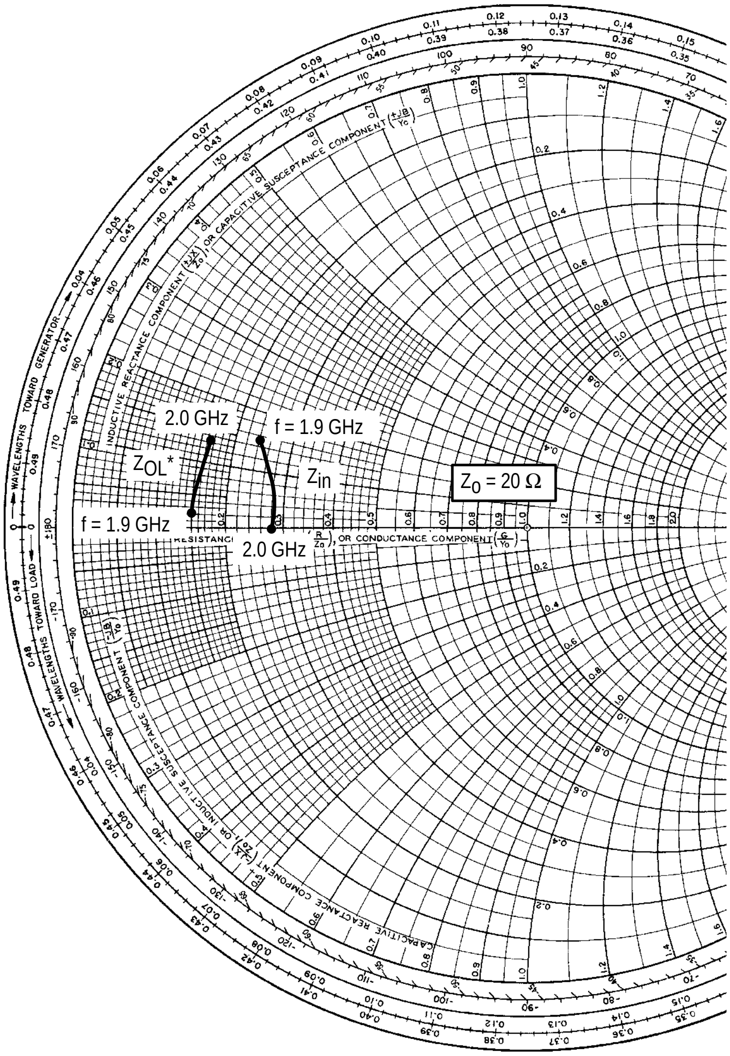



**Figure 8. 1.80 – 1.88 GHz PCN Test Circuit Components Layout**




**PCS EVALUATION**

| f (GHz) | $Z_{in}$ (Ω) | $Z_{OL}$* (Ω) |
|---|---|---|
| 1.90 | 4.9 + j3.0 | 3.2 + j0.5 |
| 1.93 | 5.4 + j2.5 | 3.3 + j1.2 |
| 1.97 | 5.6 + j1.4 | 3.4 + j1.5 |
| 2.00 | 5.4 – j0.2 | 3.6 + j2.5 |

$Z_{OL}$*: Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

**Figure 9. Input and Output Impedances with Circuit Tuned for Maximum Gain @ $V_{CC}$ = 26 V, $I_{CQ}$ = 150 mA, $P_{out}$ = 28 W**

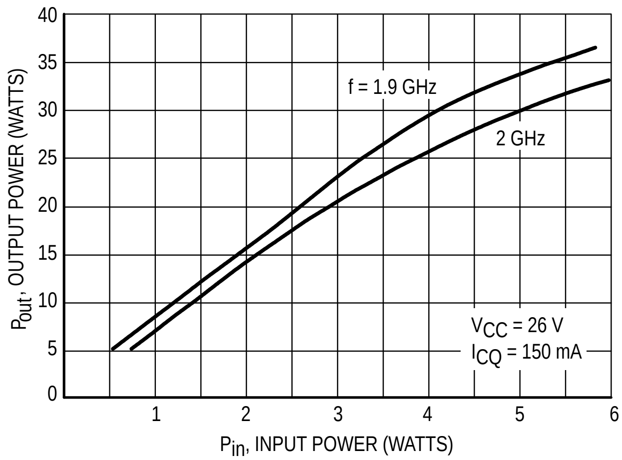



**Figure 10. Output Power versus Input Power**

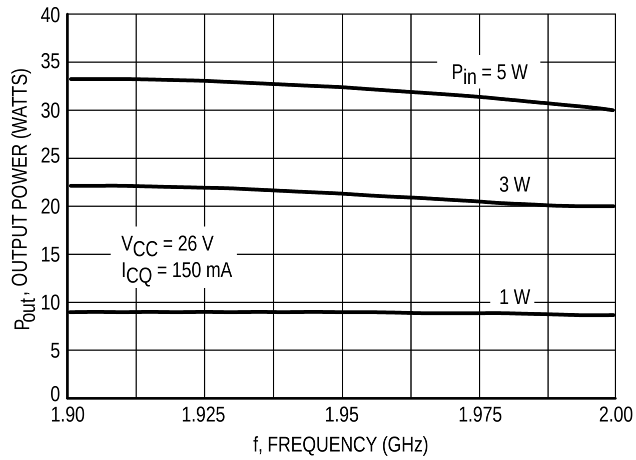



**Figure 11. Output Power versus Frequency**

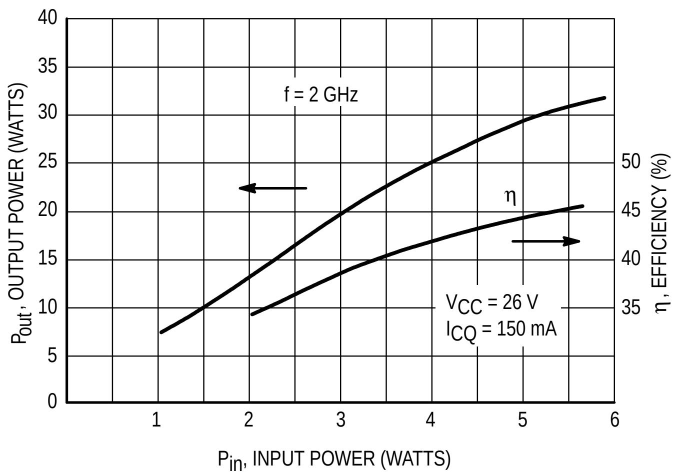



**Figure 12. Output Power and Efficiency versus Input Power**

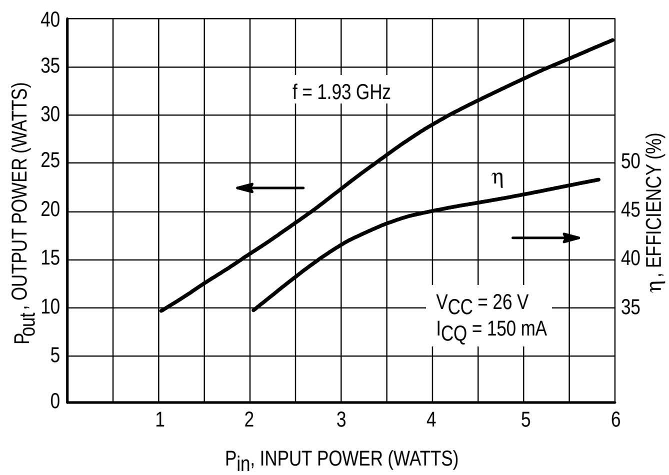



**Figure 13. Output Power and Efficiency versus Input Power**

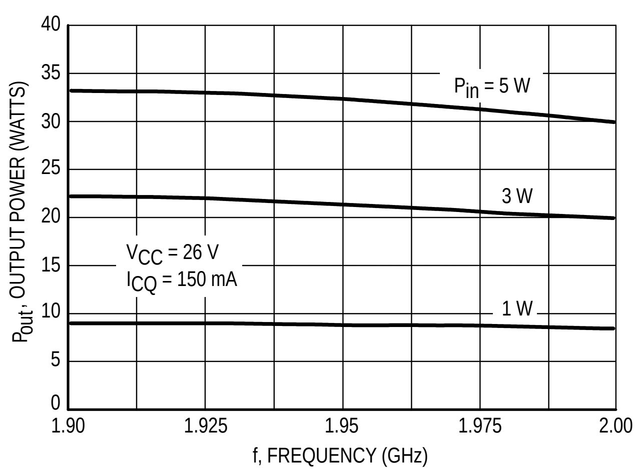
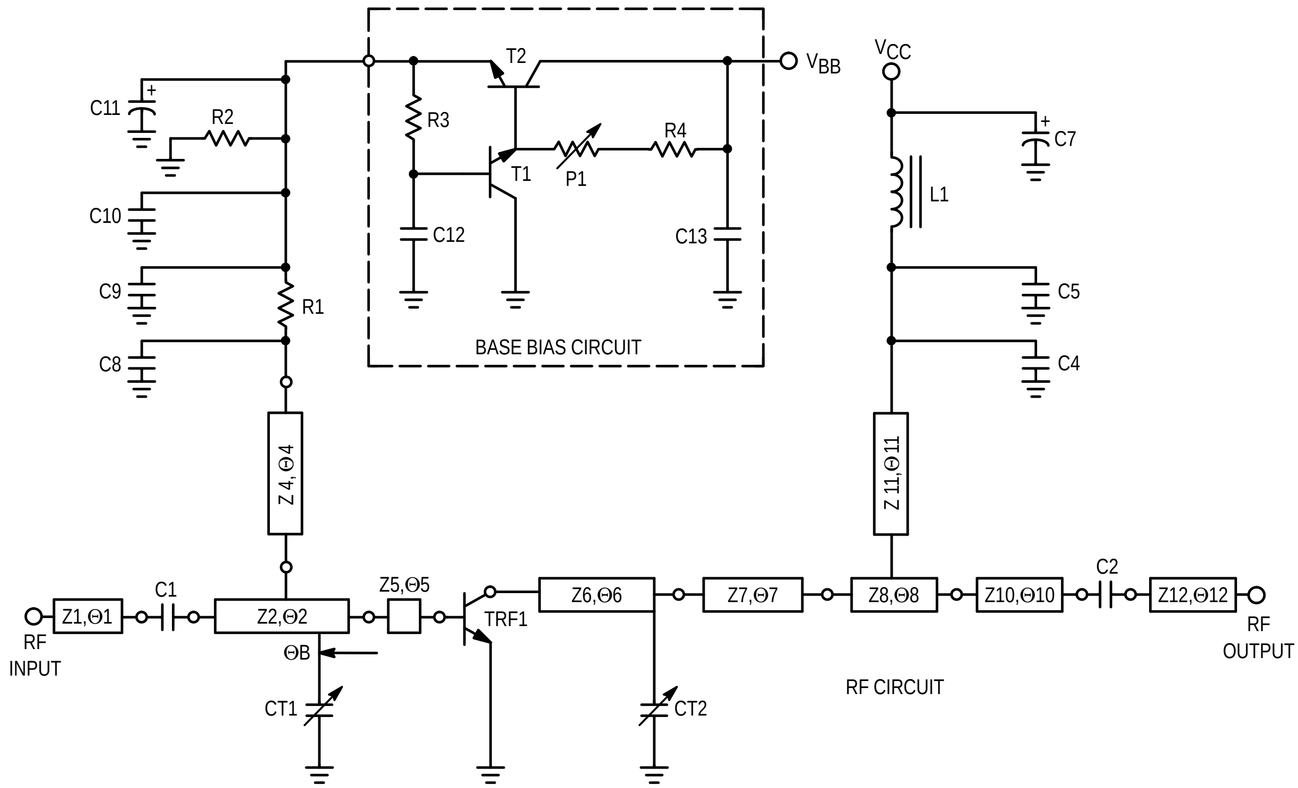



**Figure 14. Output Power versus Frequency**




### Base Bias Circuit

| | |
|---|---|
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### Decoupling Base Bias Circuit

| | |
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| C5, C9 | 330 pF, Chip Capacitor, Vitramon (0805 A331 JXB) |
| C7, C11 | 4.7 µF, 63 V, Electrolytic Capacitor |
| C8 | 68 pF, Chip Capacitor, ATC 100A |
| C10 | 15 nF, Chip Capacitor, Vitramon (0805 A153 JXB) |
| R1 | 1.2 Ω, Chip Resistor, 0805 |
| R2 | 56 Ω, Chip Resistor, 1206 |

### RF Circuit

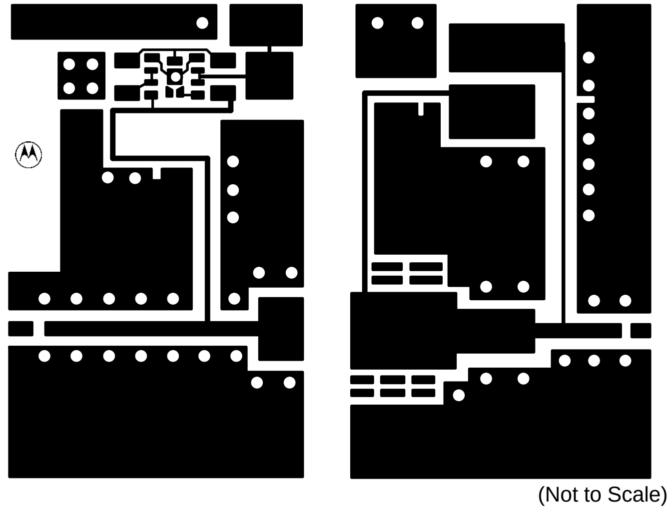
| | |
|---|---|
| C1, C2 | 68 pF, Chip Capacitor, ATC 100A |
| C20, C21 | 1.3 pF, Chip Capacitor, ATC 100A |
| CT1, CT2 | Trimmer Capacitor, Gigatrim, Ref 37271 |
| TRF1 | MRF6404 |

PC Board Material:
$\varepsilon_r$ = 2.55, H = 0.508 mm, T = 0.035 mm

All Electrical Lengths Are Referenced from λg @ f = 1.9 GHz

| | |
|---|---|
| Z1 : 50 Ω | Θ1 : 10° |
| Z2 : 50 Ω | Θ2 : 74.5° ΘB : 16.5° |
| Z4 : 74 Ω | Θ4 : 68° |
| Z5 : 12.8 Ω | Θ5 : 21° |
| Z6 : 10.4 Ω | Θ6 : 49.5° |
| Z7 : 18 Ω | Θ7 : 36.5° |
| Z8 : 45 Ω | Θ8 : 20° |
| Z10 : 50 Ω | Θ10 : 10° |
| Z11 : 74 Ω | Θ11 : 60° |
| Z12 : 50 Ω | Θ12 : 10° |

**Figure 15. 1.9 – 2.0 GHz Test Circuit Electrical Schematic and Components List**





Teflon® Glass 0.5 mm – Double Side 35 µm Cu.

**Figure 16. 1.9 – 2.0 GHz Test Circuit Photomaster**

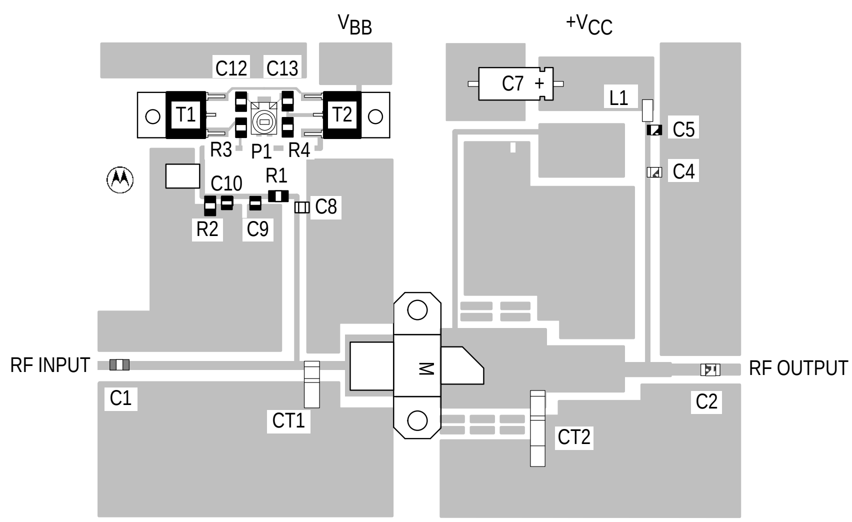
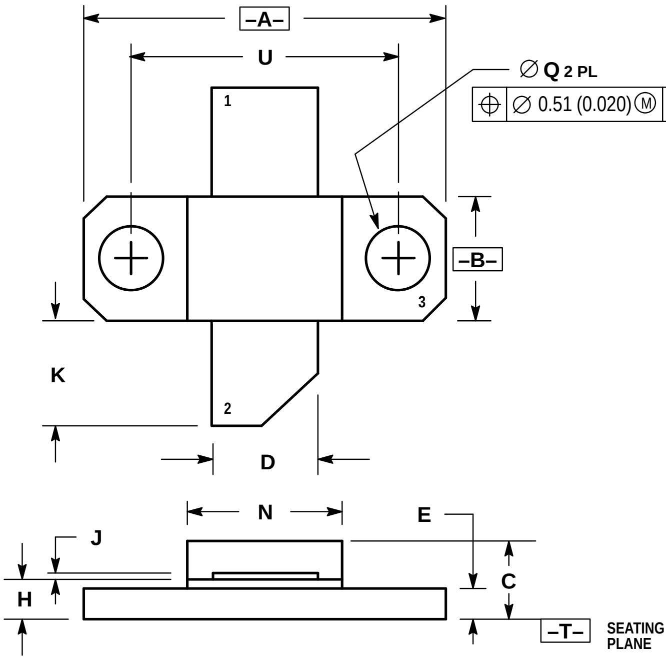




**Figure 17. 1.9 – 2.0 GHz Test Circuit Components Layout**

## PACKAGE DIMENSIONS




NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.739 | 0.750 | 18.77 | 19.05 |
| B | 0.240 | 0.260 | 6.10 | 6.60 |
| C | 0.165 | 0.198 | 4.19 | 5.03 |
| D | 0.215 | 0.225 | 5.46 | 5.72 |
| E | 0.055 | 0.070 | 1.40 | 1.78 |
| H | 0.079 | 0.091 | 2.01 | 2.31 |
| J | 0.004 | 0.006 | 0.10 | 0.15 |
| K | 0.210 | 0.240 | 5.33 | 6.10 |
| N | 0.315 | 0.330 | 8.00 | 8.38 |
| Q | 0.125 | 0.135 | 3.18 | 3.42 |
| U | 0.560 BSC | | 14.23 BSC | |

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

**CASE 395C–01**
**ISSUE A**



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**INTERNET**: http://Design–NET.com

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