MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

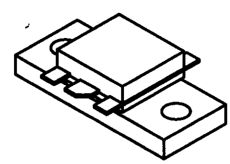
TP3064

The RF Line
RF Power Transistor

50 W, 960 MHz
RF POWER TRANSISTOR
NPN SILICON

The TP3064 is designed for 960 MHz mobile base stations in both analog and digital applications. It incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness. The TP3064 also features input and output matching networks and high impedances.

- Oxynitride Passivation
- Specified 26 Volts, 960 MHz Characteristics
  Output Power — 50 Watts
  Gain — 7.5 dB min
  Efficiency — 50% typ
- Class AB Operation



CASE 333A, STYLE 2

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CBO}	48	Vdc
Emitter-Base Voltage	V_{EBO}	4	Vdc
Collector-Current — Continuous	I_C	10	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	145 0.8	Watts 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)	$R_{\theta JC}$	1.2	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 60$ mA, $R_{BE} = 75\ \Omega$)	$V_{(BR)CER}$	40	—	—	Vdc
Emitter Base Breakdown Voltage ($I_E = 15$ mAdc)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 50$ mAdc)	$V_{(BR)CBO}$	48	—	—	Vdc
Collector-Emitter Leakage ($V_{CE} = 26$ V, $R_{BE} = 75\ \Omega$)	I_{CER}	—	—	15	mA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1$ Adc, $V_{CE} = 10$ Vdc)	h_{FE}	15	—	100	—

NOTE:
1. Thermal resistance is determined under specified RF operating condition.

(continued)

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

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS (V_{CB} = 26 V, f = 1 MHz)					
Output Capacitance (V_{CB} = 26 V, I_E = 0, f = 1 MHz)	C_{ob}	—	60	—	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Gain (P_{out} = 50 W, I_{CQ} = 200 mA, V_{CC} = 26 V, f = 960 MHz)	G_{pa}	7.5	8.5	—	dB
Collector Efficiency (P_{out} = 50 W, V_{CC} = 26 V, f = 960 MHz)	η	48	50	—	%
Load Mismatch (P_{out} = 50 W, I_{CQ} = 200 mA, V_{CC} = 26 V, Load VSWR = 5:1, all phase angles at frequency of test)	ψ	No Degradation in Output Power			

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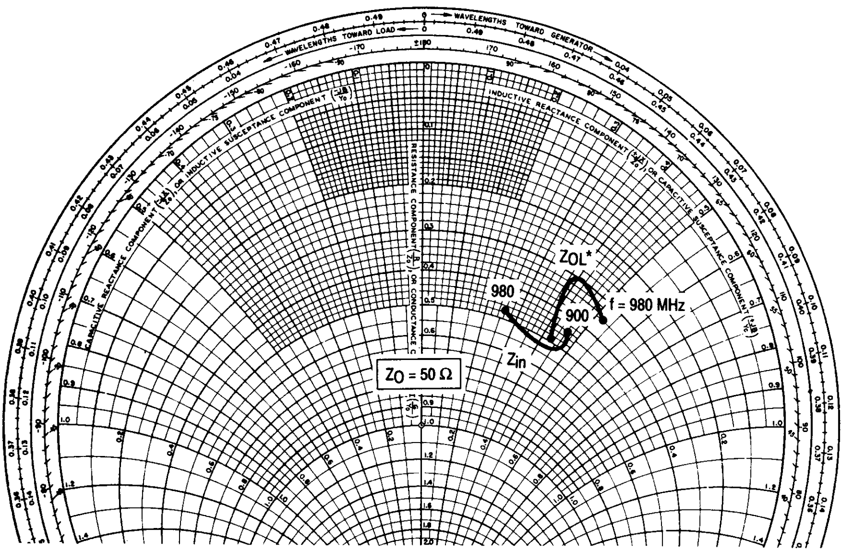
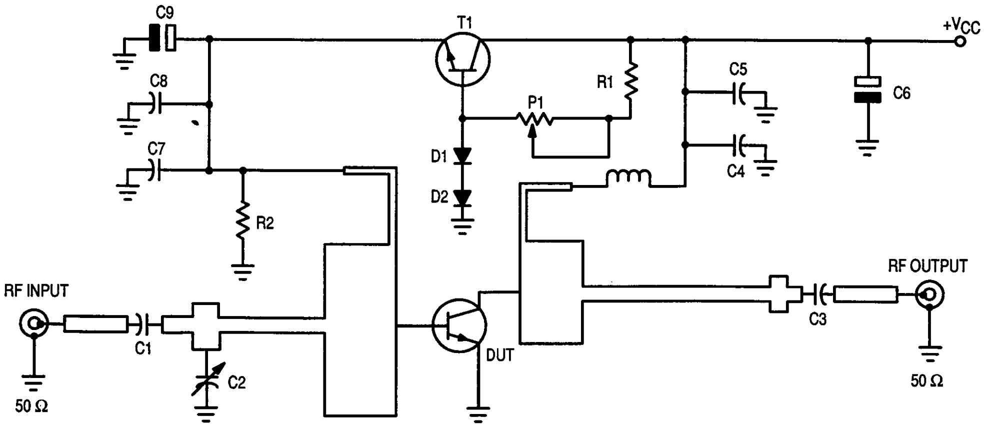


Output impedance with circuit tuned for maximum gain
@ P_{out} = 50 W, V_{CE} = 26 V

f (MHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
900	4.4 + j4.6	5 + j4.4
935	5.1 + j4.8	3 + j4.1
960	5.4 + j3.6	3.1 + j4.6
980	4.7 + j2.5	3.5 + j5

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

Figure 1. Series Equivalent Input and Output Impedances



C1,C3	100 pF, ATC Chip Capacitor 100A	L1	1.5 Turns, 18 AWG Choke
C4,C7	330 pF, Chip Capacitor 0805	P1	1 kΩ, Trimmer
C5,C6	10 nF, Chip Capacitor 0805	R1	1 kΩ, Resistor
C6	15 µF, 63 V, Capacitor	R2	56 Ω, Resistor 0805
C9	100 µF, 16 V, Capacitor	T1	Transistor, NPN Type, BD135
D1,D2	Diode, 1N4007		

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Figure 2. 960 MHz Test Circuit Schematic

TYPICAL CHARACTERISTICS

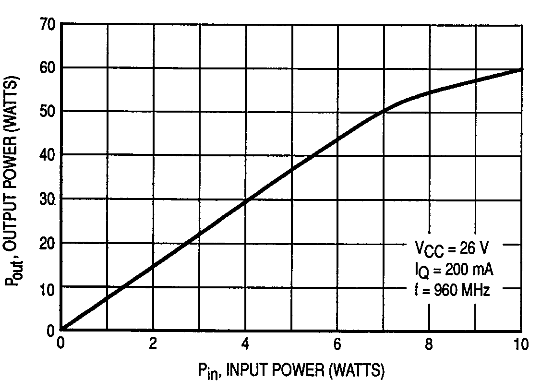

Figure 3. Output Power versus Input Power

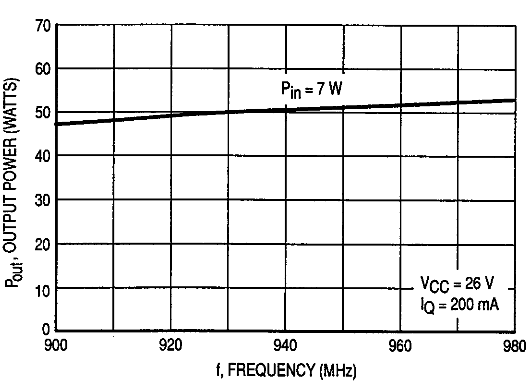

Figure 4. Output Power versus Frequency

TYPICAL CHARACTERISTICS

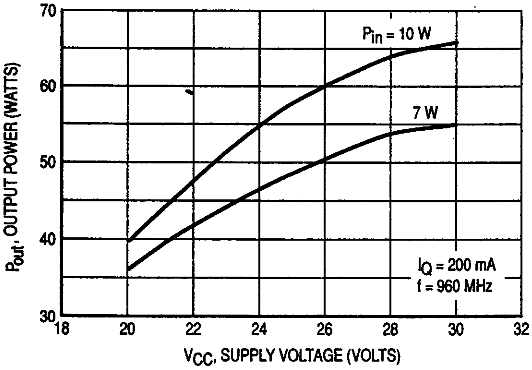

Figure 5. Output Power versus Supply Voltage

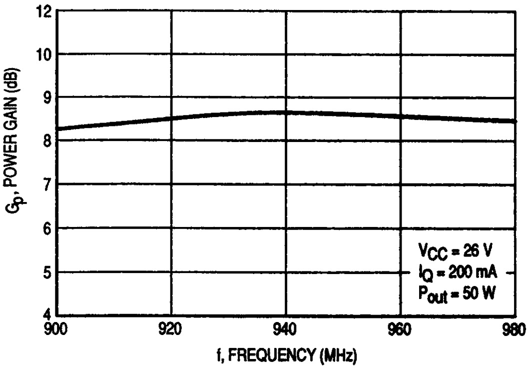

Figure 6. Broadband Amplifier

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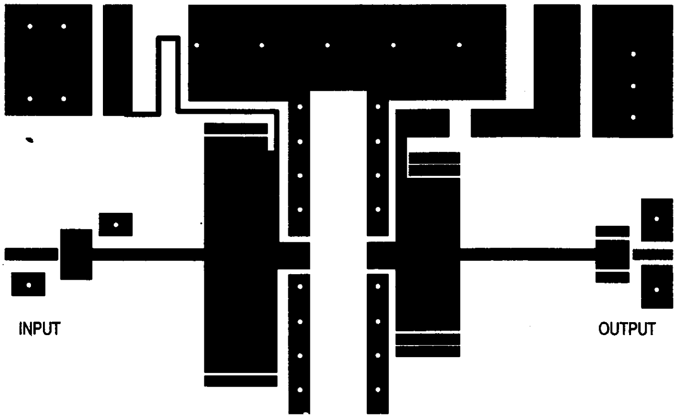

Figure 7. Photomaster

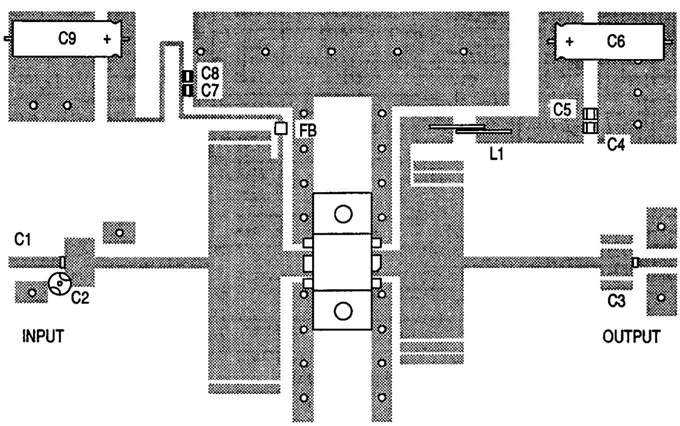

Figure 8. 960 MHz Test Circuit Components View

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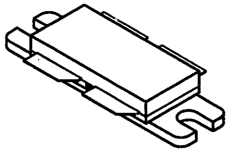
TP3069

The RF Line
RF Power Transistor

100 W, 960 MHz
RF POWER TRANSISTOR
NPN SILICON

The TP3069 is designed for cellular radio base station amplifiers up to 960 MHz. It incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness. The TP3069 also features input and output matching networks and high impedances. It can easily operate in a full 935–960 MHz bandwidth in a simple circuit.

- Class AB Operation
- Specified 26 Volts, 960 MHz Characteristics
  Output Power — 100 Watts
  Gain — 7.5 dB min



CASE 375A, STYLE 1

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	4	Vdc
Collector Current — Continuous	I_C	20	Adc
Storage Temperature Range	T_{stg}	– 40 to +100	°C
Operating Junction Temperature	T_J	200	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	245 1.4	Watts W/°C
Quiescent Current	I_{CQ}	2 x 500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case (1)	$R_{\theta JC}$	0.7	°C/W

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

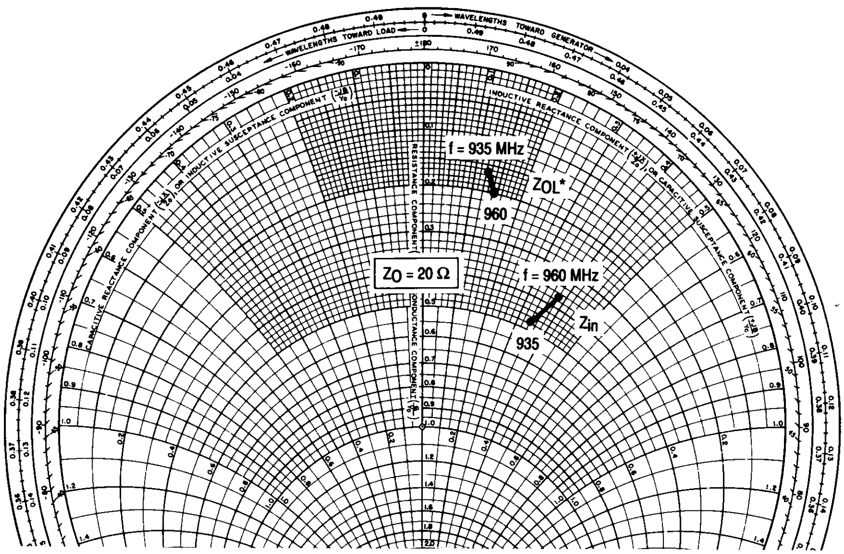
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mA)	$V_{(BR)CEO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 20 mAdc)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 35 mAdc)	$V_{(BR)CBO}$	65	—	—	Vdc
Collector-Emitter Leakage (V_{CE} = 28 V, R_{BE} = 75 Ω)	I_{CER}	—	—	15	mA
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 Adc, V_{CE} = 10 V)	h_{FE}	30	—	120	—
DYNAMIC CHARACTERISTICS (V_{CB} = 28 V, I_E = 0, f = 1 MHz)					
Output Capacitance (each side) (2)	C_{ob}	—	75	—	pF

NOTES:
1. Thermal resistance is determined under specified RF operating condition.
2. Value of "C_{ob}" is that of die only. It is not measurable in TP3069 because of internal matching network.

(continued)

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

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (V_{CC} = 26 V, f = 960 MHz)					
Common-Emitter Amplifier Gain (P_{out} = 100 W, I_{CQ} = 2 x 100 mA)	G_p	7.5	8.8	—	dB
Collector Efficiency (P_{out} = 100 W)	η	45	50	—	%
Over Drive 2 dB Input Power Overdrive	OD	No Degradation in Output Power			
3rd Order Intermodulation (P_{out} = 100 W PEP, I_{CQ} = 2 x 50 mA, Δf = 400 KHz)	IMD3	—	− 32	—	dB



V_{CE} = 26 V P_{out} = 100 W

f (MHz)	Z_{in} (Ω)	Z_{OL}^* (Ω)
935	9.5 + j7	3.4 + j2.7
960	8.8 + j7.5	3.8 + j2.8

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

Figure 1. Series Equivalent Input and Output Impedances

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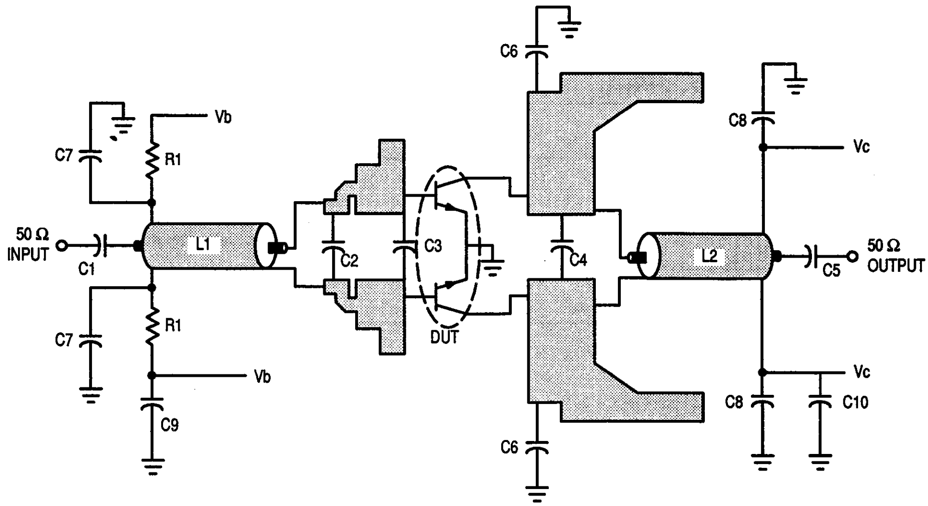
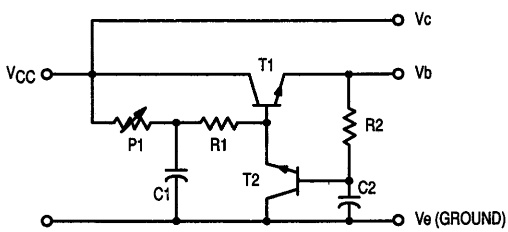


C1	10 pF, ATC Chip Capacitor 100A	C8	1 µF, Vitramon
C2	2.2 pF, ATC Chip Capacitor 100A	C9	1 µF, 16 V, Tantalum
C3	12 pF, ATC Chip Capacitor 100A	C10	4.7 µF, 35 V, Tantalum
C4	10 pF, ATC Chip Capacitor 175B	L1	25 Ω/41 mm (Teflon)
C5	47 pF, ATC Chip Capacitor 100A	L2	25 Ω/41 mm (Teflon)
C6	5.6 pF, ATC Chip Capacitor 175B	R1	0.5 Ω, Resistor 0805 (2 x 1 Ω)
C7	1000 pF, Vitramon		



C1	15 nF
C2	15 nF
P1	2.2 kΩ
R1	3.3 kΩ
R2	51 Ω
T1	BD135
T2	BD135

Figure 2. 960 MHz Test Circuit and Its Bias Circuit

TYPICAL CHARACTERISTICS

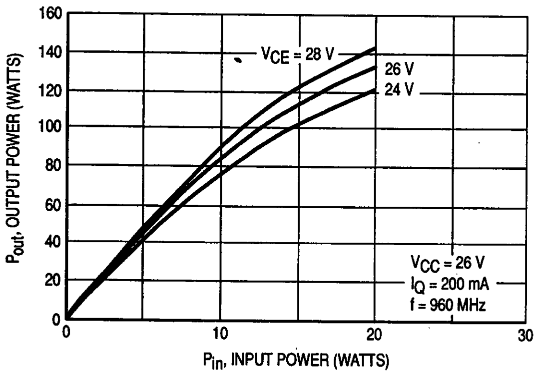


Figure 3. Output Power versus Input Power

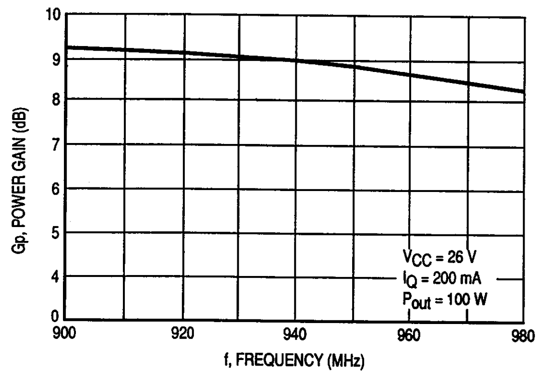


Figure 4. Power Gain versus Frequency

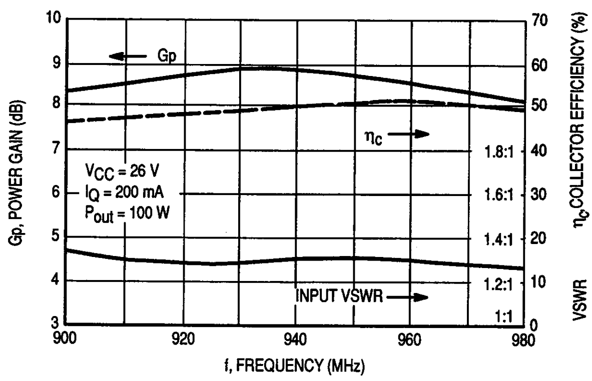


Figure 5. Broadband Amplifier

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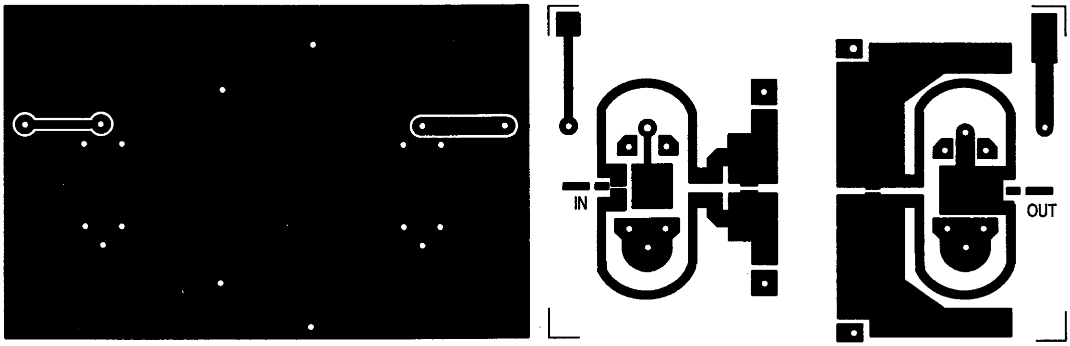


Figure 6. Photomaster (1/50″ Teflon® Glass, $\varepsilon_r = 2.55$) Scale 0.75:1

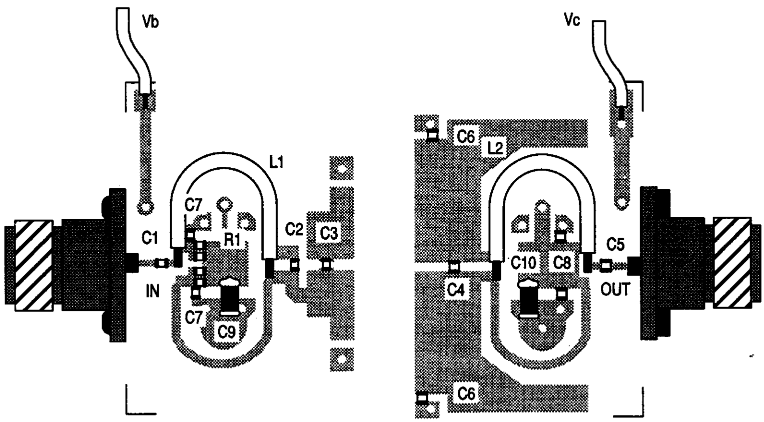


Figure 7. 960 MHz Test Circuit: Printed Circuit Board (PCB) + Components Location (Scale 0.75:1)

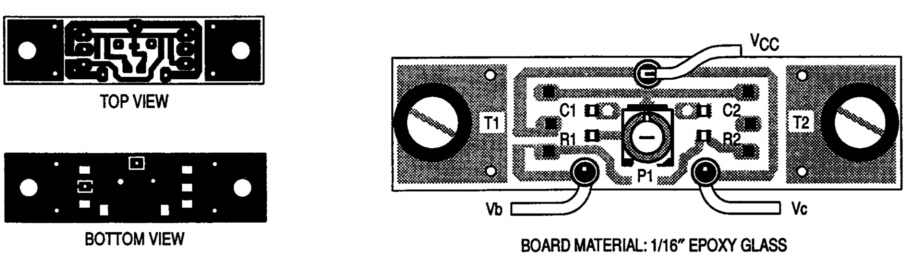


Figure 8. Bias Printed Circuit Board (PCB) (Scale 0.75:1) & Components Location (Not to Scale)

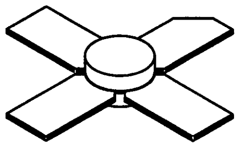
TP5002S

The RF Line
UHF Linear Power Transistor

The TP5002S is an NPN gold metallized transistor using diffused ballast resistors for reliability and ruggedness. The TP5002S was specifically designed as a low power driver with high gain and can be operated in Class A, B or C.

- 380–512 MHz
- 1.5 W — P_{out}
- 24 V — V_{CC}
- High Gain — 13 dB Min, Class A @ 470 MHz

1.5 W, 380 to 512 MHz
UHF LINEAR
POWER TRANSISTOR
NPN SILICON



CASE 249-05, STYLE 1
(.280 SOE S)
TP5002S

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MAXIMUM RATINGS

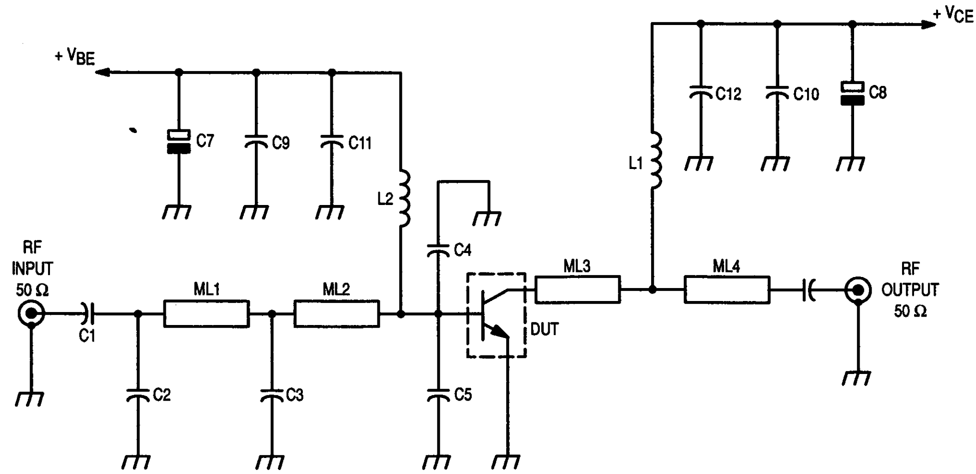
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 0.045	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (T_C = 70°C)	$R_{\theta JC}$	21	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 2.0 mA, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mA, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 24 V, I_E = 0)	I_{CBO}	—	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	15	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	4.5	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 23 V, P_{out} = 1.5 W, f = 470 MHz, I_C = 200 mA)	G_{PE}	13	—	—	dB
Saturated Output Power (V_{CE} = 23 V, f = 470 MHz, I_C = 200 mA)	P_{sat}	—	2.2	—	W



C1, C6 — 220 pF 0805 681C Sprague
C2 — 8.2 pF ATC100A8R2DP50
C3 — 10 pF ATC100A100DP50
C4, C5 — 27 pF ATC100A8R2DP50
C7 — 10 µF 35 V
C8 — 100 µF 63 V
C9, C10 — 1.0 nF 0805 681C Sprague
C11, C12 — 220 pF 0805 681C Sprague

L1 — Hairpin wire 1.1 mm L = 33 mm
L2 — 4 turns, ID 2.5 mm, 0.5 mm wire
ML1 — Microstrip Line W = 2.5 mm Z_o = 70 Ω, L = 6% λg at 470 MHz
ML2 — Microstrip Line W = 2.5 mm Z_o = 70 Ω, L = 3% λg at 470 MHz
ML3 — Microstrip Line W = 2.5 mm Z_o = 70 Ω, L = 5% λg at 470 MHz
ML4 — Microstrip Line W = 2.5 mm Z_o = 70 Ω, L = 3% λg at 470 MHz
Board Material: 1/16 In. Teflon Glass, ε_r = 2.55, h = 1.59 mm

Figure 1. 400–500 MHz Broadband Amplifier

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FREQUENCY (MHz)	400	410	420	430	440	450	460	470	480	490	500
RE(Zin)Ω	2.5	2.5	2.5	2.3	2.4	2.3	2.2	2.2	2.1	2.1	2.0
IM(Zin)Ω	2.0	2.2	2.7	3.2	3.5	3.8	3.9	4.0	4.2	4.9	5.0
RE(Zload)Ω	33.4	35.5	36.5	37.0	38.4	39.5	40.4	41.4	42.4	43.4	44.4
IM(Zload)Ω	48.3	48.9	49.4	49.9	50.8	50.9	51.3	51.7	52.2	52.6	53.0

Table 1. Impedance Data
V_{CC} = 23 Volts
I_C = 200 mA
P_{out} = 1.5 Watts

TYPICAL CHARACTERISTICS

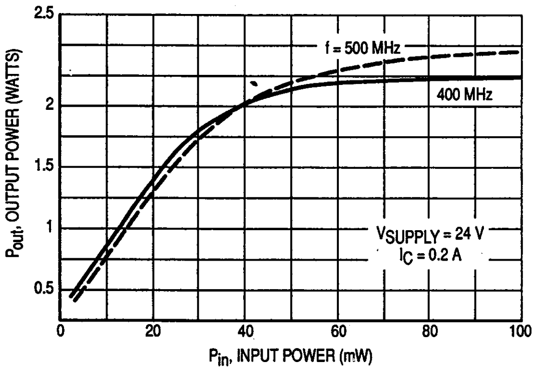


Figure 2. Output Power versus Input Power

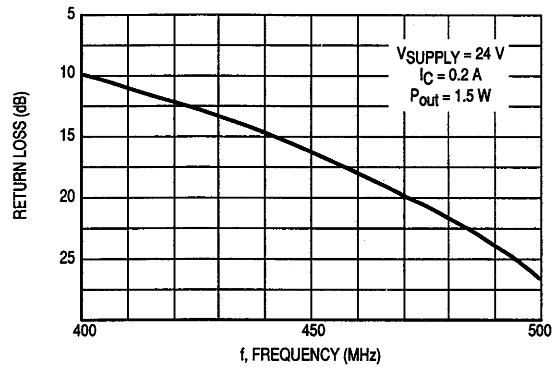


Figure 3. Return Loss versus Frequency

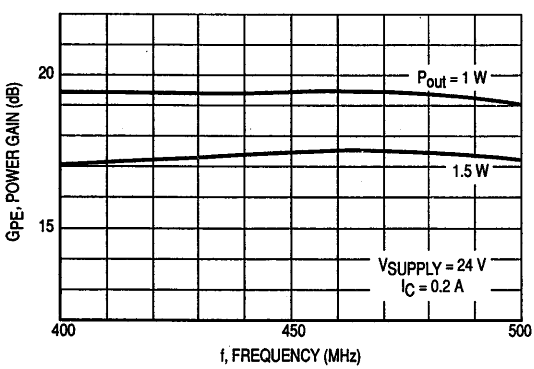


Figure 4. Power Gain versus Frequency

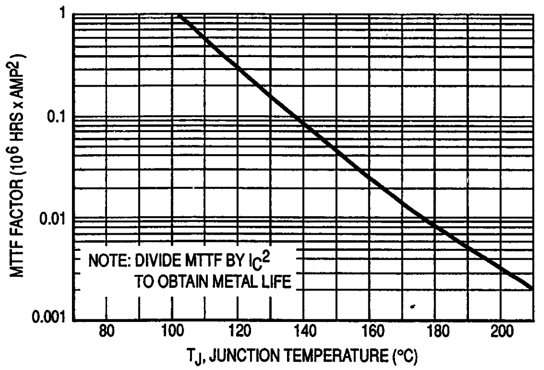
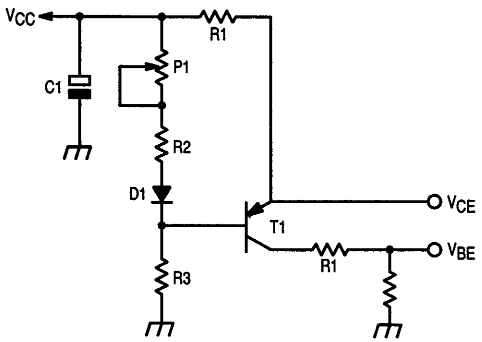


Figure 5. MTTF Factor versus Junction Temperature



C1 — 100 μF 63 V
D1 — 1N4148
P1 — 1.0 kΩ
R1 — 10 Ω 1/2 W
R2 — 180 Ω 1/4 W
R3 — 10 kΩ 1/4 W
R4 — 50 Ω 1/4 W
R5 — 100 Ω 1/4 W
T1 — BD136

Figure 6. Class A Bias Circuit

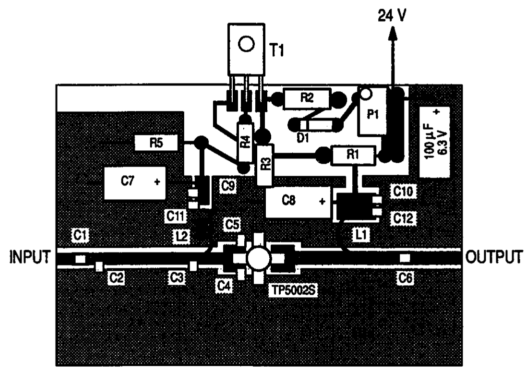


Figure 7. Component Layout

TP5015

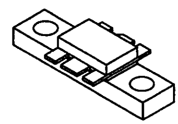
Advance Information

The RF Line
UHF Linear Power Transistor

15 W, 380–512 MHz
UHF LINEAR
POWER TRANSISTOR
NPN SILICON

. . . designed for 24 Volt UHF large-signal common emitter amplifier applications in industrial and commercial FM equipment operating in the 380 to 512 MHz frequency range, i.e., cellular radio base stations.

- 380–512 MHz
- 15 W — P_{out}
- 24 V — V_{CC}
- High Gain — 11 dB Min, Class AB
- Gold Metallization for Reliability



CASE 319, STYLE 2
(EB)

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ T_C = 70°C Derate above 70°C	P_D	18 0.143	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (T_C = 70°C)	$R_{\theta JC}$	7.0	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Emitter-Base Breakdown Voltage (I_E = 5.0 mA, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mA, R_{BE} = 75 Ω)	$V_{(BR)CER}$	40	—	—	Vdc
Collector Cutoff Current (V_{CE} = 26 V, R_{BE} = 75 Ω)	I_{CER}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 10 V)	h_{FE}	15	—	100	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	16	24	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 24 V, P_{out} = 15 W, f = 470 MHz, I_Q = 50 mA)	G_{PE}	11	—	—	dB
Collector Efficiency (V_{CE} = 24 V, P_{out} = 15 W, f = 470 MHz, I_Q = 50 mA)	η_c	50	60	—	%

This document contains information on a new product. Specifications and information herein are subject to change without notice.

TP5051

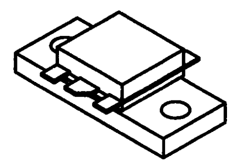
Motorola Preferred Device

The RF Line
NPN Silicon
RF Power Transistor

50/60 W, 470 MHz
RF POWER TRANSISTOR
NPN SILICON

The TP5051 is designed for 470 MHz cellular radio base stations in both analog and digital applications. It incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness.

- Specified 470 MHz Characteristics
  Output Power — 50 Watts @ 24 Volts, 60 Watts @ 26 Volts
  Gain — 9 dB min
  Efficiency — 60% min
  Class AB or C Operation



CASE 333A, STYLE 2

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CBO}	48	Vdc
Emitter-Base Voltage	V_{EBO}	4	Vdc
Collector-Current — Continuous	I_C	10	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	145 0.8	Watts 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 at 70°C Case (1)	$R_{\theta JC}$	1.2	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 60$ mA, $R_{BE} = 75\ \Omega$)	$V_{(BR)CER}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 15$ mAdc)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 50$ mAdc)	$V_{(BR)CBO}$	48	—	—	Vdc
Collector-Emitter Leakage ($V_{CE} = 26$ V, $R_{BE} = 75\ \Omega$)	I_{CER}	—	—	15	mA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1$ Adc, $V_{CE} = 10$ Vdc)	h_{FE}	15	—	80	—

NOTE:
1. Thermal resistance is determined under specified RF operating condition.

(continued)

Preferred devices are Motorola recommended choices for future use and best overall value.

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)	C_{ob}	—	60	—	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CC} = 24 V, P_{out} = 50 W, I_{CQ} = 150 mA, f = 470 MHz)	G_{p1}	9	10	—	dB
Collector Efficiency (V_{CC} = 24 V, P_{out} = 50 W, f = 470 MHz)	η1	60	65	—	%
Load Mismatch (V_{CC} = 24 V, P_{out} = 50 W, I_{CQ} = 150 mA Load VSWR = 5:1, all phase angles at frequency of test)	ψ1	No Degradation in Output Power			
Overdrive (V_{CC} = 24 V, P_{in} = 12 W, f = 470 MHz)	OD	No Degradation in Output Power			
Power Saturation (V_{CC} = 24 V, f = 470 MHz)	P_{sat}	65	—	—	W
Common-Emitter Amplifier Power Gain (V_{CC} = 26 V, P_{out} = 60 W, I_{CQ} = 150 mA, f = 470 MHz)	G_{p2}	9	10	—	dB
Collector Efficiency (V_{CC} = 26 V, P_{out} = 60 W, f = 470 MHz)	η2	60	65	—	%
Load Mismatch (V_{CC} = 26 V, P_{out} = 60 W, I_{CQ} = 150 mA Load VSWR = 5:1, all phase angles at frequency of test)	ψ2	No Degradation in Output Power			

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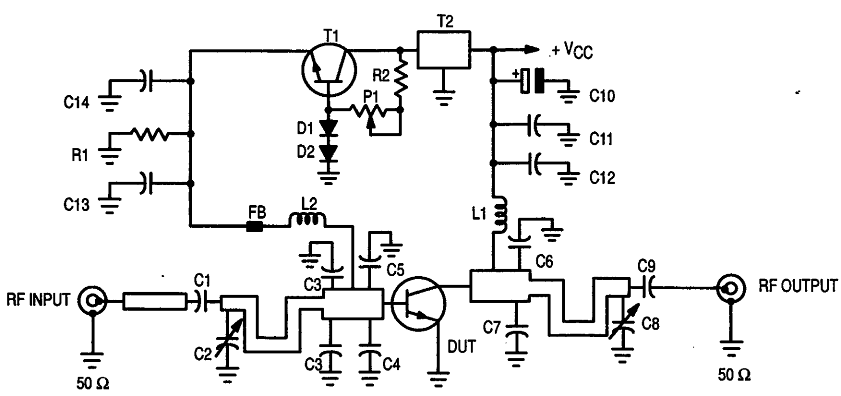
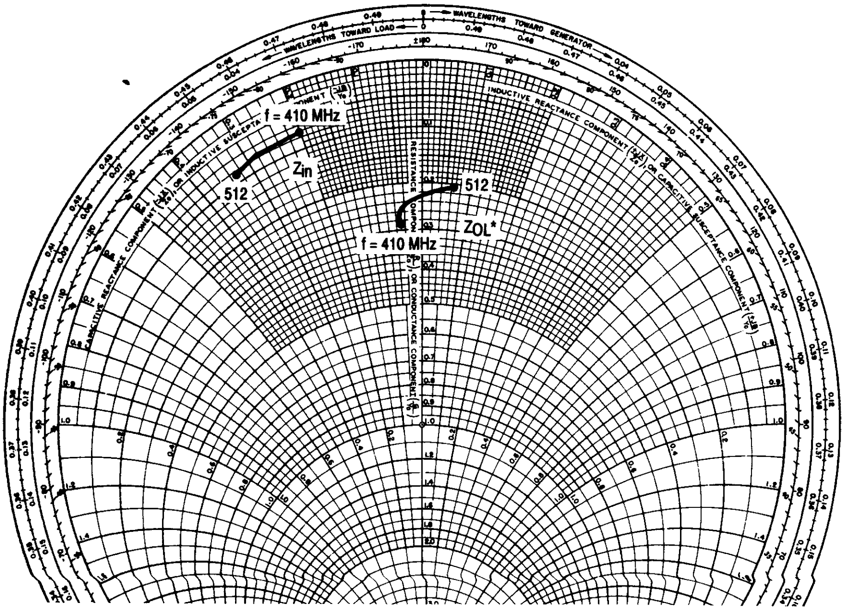


Components List

C1,C9,	330 pF, 5%, Chip Capacitor 0805	D1,D2	Diode, 1N4148
C2,C8	AIRTRONIC Trimmer Capacitor 5400	FB	Ferrite Board
C3	10 pF, ATC Chip Capacitor	L1,L2	6 Turns, #18 AWG ϕ 4 mm Choke
C3′	12 pF, ATC Chip Capacitor	P1	1 kΩ, Trimmer
C4,C5	22 pF, ATC Chip Capacitor	R1	56 Ω, 5%, Chip Resistor 1205
C6	15 pF, ATC Chip Capacitor	R2	470 Ω, 5%, Chip Resistor 0805
C7	18 pF, ATC Chip Capacitor	T1	SMD Transistor, MJD31C or Similiar
C10	47 μF, 63 V, Electrolytic Capacitor	T2	Voltage Regulator 7805
C11,C14	15 nF, Chip Capacitor 0805		
C12,C13	330 pF, 5%, Chip Capacitor 0805		

Figure 1. 470 MHz Electrical Schematic



P_{out} = 50 W, V_{CE} = 24 V

f (MHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
512	1 – j3.2	2 – j0.7
490	0.97 – j2.8	2.2 – j0.5
470	0.9 – j2.7	2.4 + j0.13
450	0.85 – j2.5	2.6 + j0.9
410	0.8 – j2.1	3 + j0.5

Figure 2. Series Equivalent Input and Output Impedances

TYPICAL CHARACTERISTICS

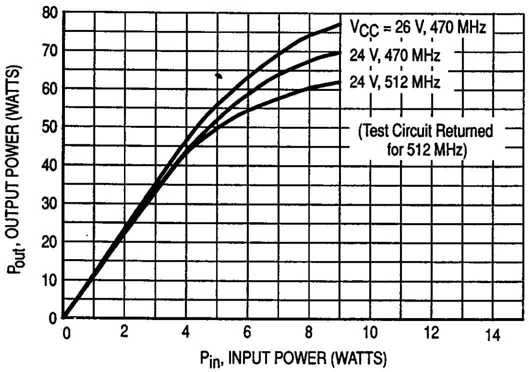


Figure 3. Output Power versus Input Power

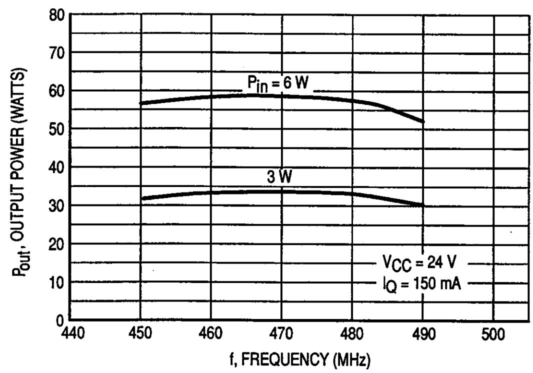


Figure 4. Output Power versus Frequency

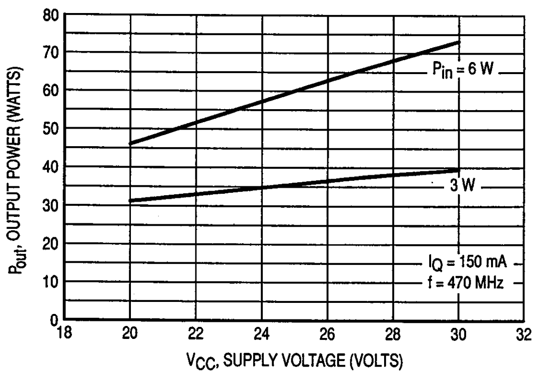


Figure 5. Output Power versus Supply Voltage

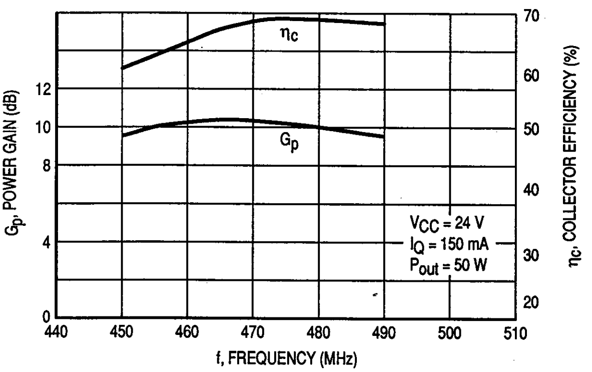


Figure 6. Power Gain, Collector Efficiency versus Frequency

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