MRF641

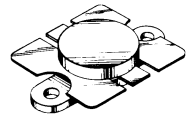
The RF Line

15 W – 470 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 15 Watts
  Minimum Gain = 7.8 dB
  Efficiency = 55%
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broadband Operation
- Tested for Load Mismatch Stress at all Phase Angles with 20:1 VSWR @ 16-Volt High Line and Overdrive.

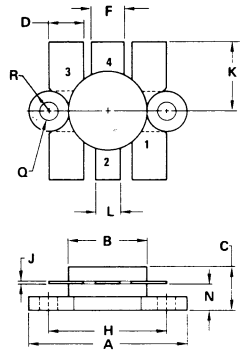


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	3.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	50 0.25	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case	$R_{\theta JC}$	4.0	°C/W



STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE-ISOLATED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.33	5.59	0.210	0.220
F	5.08	5.33	0.200	0.210
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	10.29	–	0.405	–
L	3.81	4.06	0.150	0.160
N	3.81	4.32	0.150	0.170
Q	2.92	3.30	0.115	0.130
R	3.05	3.30	0.120	0.130

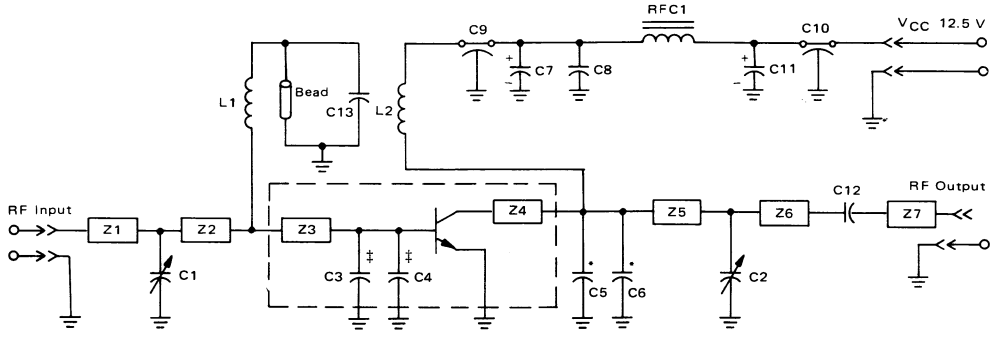
CASE 316-01

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	–	–	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	30	70	150	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	40	60	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 470 MHz)	G_{pe}	7.8	8.5	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 470 MHz)	η	55	60	–	%
Output Mismatch Stress (V_{CC} = 16 Vdc, P_{in} = 3.0 W, f = 470 MHz, VSWR = 20:1, All Phase Angles)	ψ	No Degradation in Output Power			

3

FIGURE 1 – TEST CIRCUIT SCHEMATIC



Z1 = 1.225" X 0.187" Microstrip
Z2 = 0.884" X 0.187" Microstrip
Z3 = Capacitor Block (Base)
Z4 = Collector Block
Z5 = 1.1" X 0.187" Microstrip
Z6 = 0.433" X 0.187" Microstrip
Z7 = 0.4" X 0.187" Microstrip

Dotted Area – Capacitor Assembly

PARTS

C1, C2 – 0.8–10 pF Johanson
C3, C4 – 24 pF Chip Caps 100 mils ATC
C5, C6 – 22 pF Chip Caps 100 mils ATC
C12 – 220 pF Chip Cap 100 mils ATC
C7, C11 – 1.0 μF Tantalum 35 Vdc
C9, C10 – 680 pF Feedthrough Allen-Bradley
C13 – 200 pF UNELCO
C8 – 0.1 μF, 50 V Erie Red Cap
RFC1 – VK 200 – 104B Ferrite Choke
L1 – 4 Turns 0.2" Dia. #16 AWG
L2 – 9 Turns 0.15" Dia. #16 AWG

Bead – Ferroxcube 56-590-65-35EB

NOTES

**C5, C6, are mounted as close to the capacitor assembly as possible.

‡‡C3, C4 are mounted in the capacitor assembly.

Board – 62.5 mil Glass Teflon, ϵ_R = 2.55.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

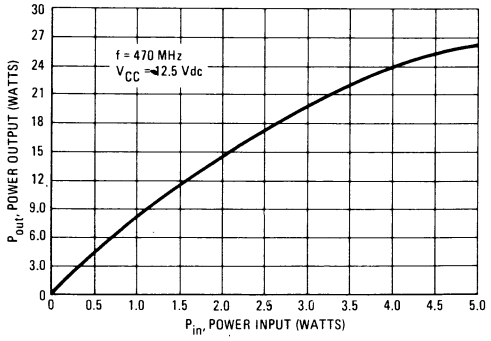


FIGURE 3 – POWER OUTPUT versus FREQUENCY

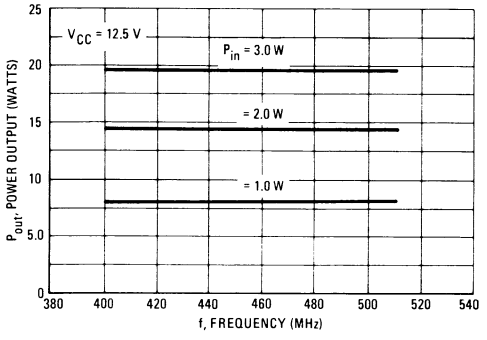


FIGURE 4 – POWER OUTPUT versus SUPPLY VOLTAGE

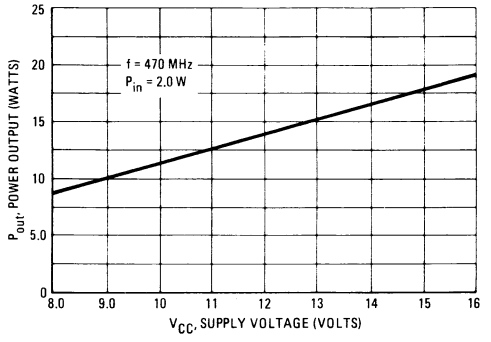


FIGURE 5 – POWER SATURATION PROFILE

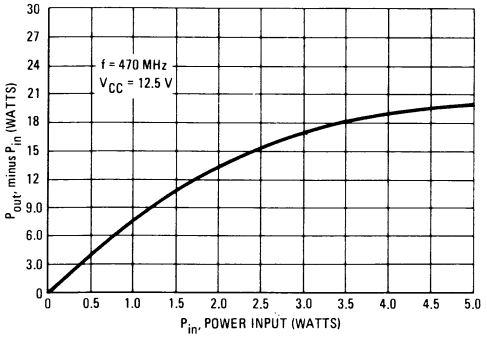
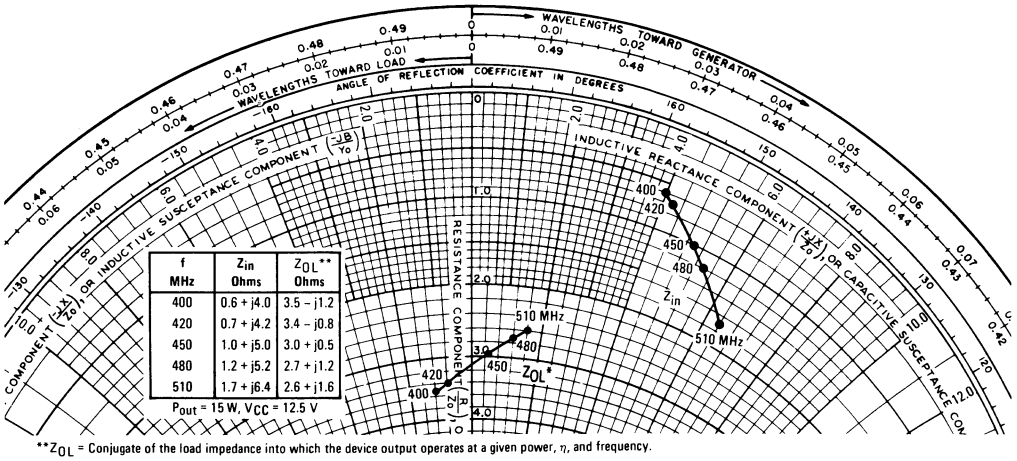


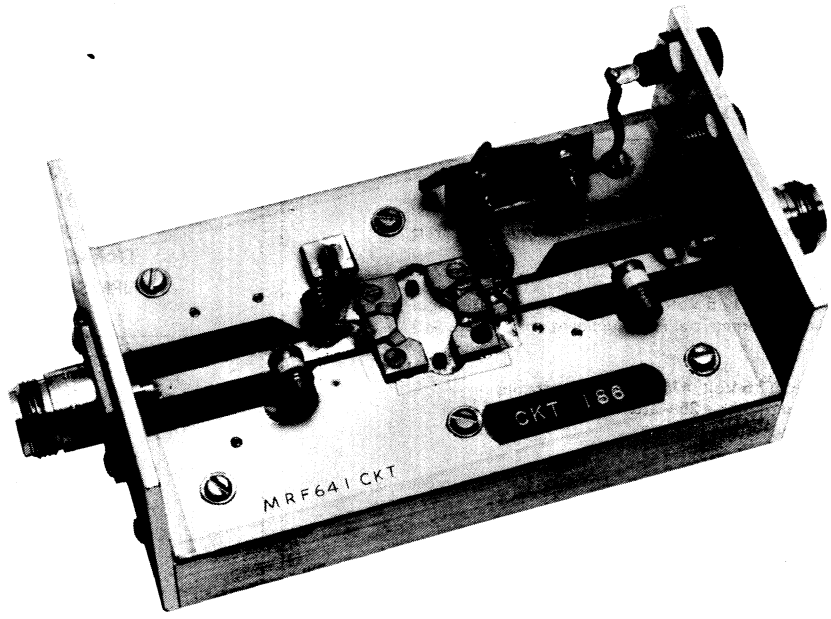
FIGURE 6 – SERIES EQUIVALENT INPUT-OUTPUT IMPEDANCE



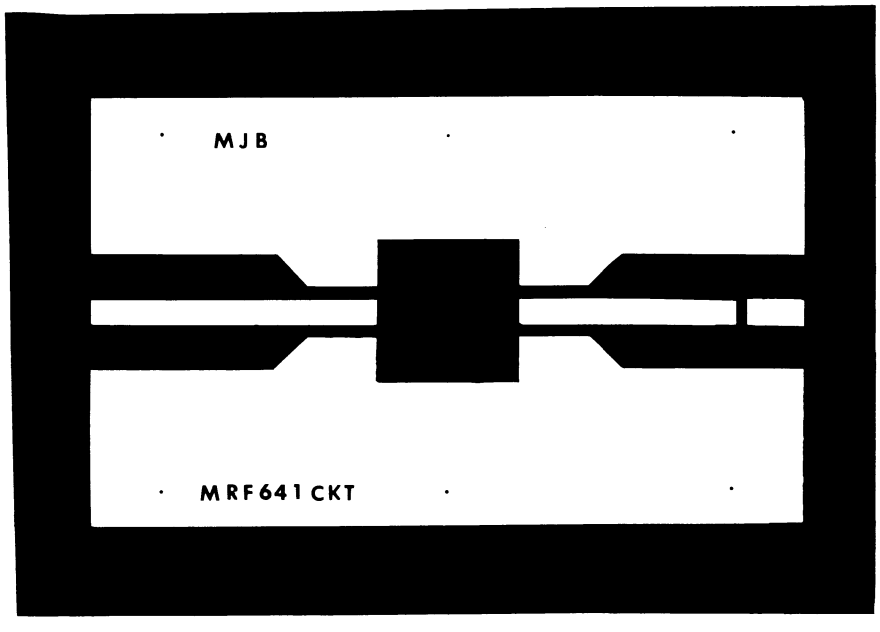
f MHz	Z_{in} Ohms	Z_{OL}^{**} Ohms
400	0.6 + j4.0	3.5 – j1.2
420	0.7 + j4.2	3.4 – j0.8
450	1.0 + j5.0	3.0 + j0.5
480	1.2 + j5.2	2.7 + j1.2
510	1.7 + j6.4	2.6 + j1.6

P_{out} = 15 W, V_{CC} = 12.5 V

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



MRF641 TEST CIRCUIT



NOTE: The Printed Circuit Board shown is 75% of the original.

MRF644

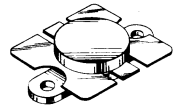
The RF Line

25 W — 470 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON

NPN SILICON RF POWER TRANSISTOR

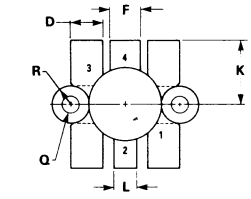
. . . designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics —
  Output Power = 25 Watts
  Minimum Gain = 6.2 dB
  Efficiency = 60%
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broadband Operation
- Tested for Load Mismatch Stress at all Phase Angles with 20:1 VSWR @ 16-Volt High Line and 50% Overdrive.



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	4.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	103 0.59	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
THERMAL CHARACTERISTICS			
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.7	°C/W



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

NOTE:
FLANGE IS ISOLATED IN ALL STYLES.

DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	24.38	25.14	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.33	5.58	0.210	0.220
E	2.16	3.04	0.085	0.120
F	5.08	5.33	0.200	0.210
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K	10.29	11.17	0.405	0.440
L	3.81	4.06	0.150	0.160
N	3.81	4.31	0.150	0.170
Q	2.92	3.30	0.115	0.130
R	3.05	3.30	0.120	0.130
U	11.94	12.57	0.470	0.495

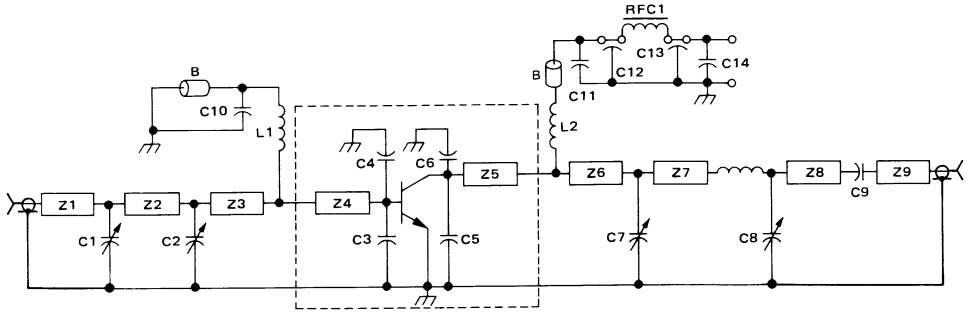
CASE 316-01

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	–	–	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	40	70	100	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	60	85	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 25 W, I_C (MAX) = 3.6 Adc, f = 470 MHz)	G_{pe}	6.2	7.0	–	dB
Input Power (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz)	P_{in}	–	5.0	6.0	Watts
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 25 W, I_C (MAX) = 3.6 Adc, f = 470 MHz)	η	55	60	–	%
Output Mismatch Stress (V_{CC} = 16 Vdc, P_{in} = Note 1, f = 470 MHz, VSWR = 20:1, All Phase Angles)	ψ*	No Degradation in Output Power			
Series Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz)	Z_{in}	–	1.2+j3.3	–	Ohms
Series Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz)	Z_{OL}	–	1.9 + j2.1	–	Ohms

Notes:
1. P_{in} = 150% of Drive Requirement for 25 W Output at 12.5 Vdc.
* ψ = Mismatch stress factor—the electrical criterion established to verify the device resistance to load mismatch failure. The mismatch stress test is accomplished in the standard test fixture (Figure 1) terminated in a 20:1 minimum load mismatch at all phase angles.

FIGURE 1 – TEST CIRCUIT SCHEMATIC



C1, C2, C7, C8	1–20 pF JOHANSON Variable	C12, C13	680 pF Feedthrough	Z3	0.20" x 0.20" Microstrip
C3	27 pF 100 mil ATC	L1	5" #22 AWG 0.100" ID	Z4, Z5	1/2" #18 AWG bent in a "V" shape 1/8" Wide
C4	30 pF 100 mil ATC	L2	5" #20 AWG 0.187" ID	Z6	0.20" x 0.20" Microstrip
C5, C6	33 pF 100 mil ATC	RFC1	Ferroxcube VK200-20-4B	Z7	0.70" x 0.20" Microstrip
C9	250 pF 100 mil ATC	B	Ferroxcube Bead 56-590-65-3B	Z8	0.33" x 0.20" Microstrip
C10	100 pF UNELCO	Z1	0.25" x 0.20" Microstrip	Z9	0.50" x 0.20" Microstrip
C11, C14	1 μF 35 V TANTALUM	Z2	1.63" x 0.20" Microstrip	Board	62.5 mil Glass Teflon, ϵ_R = 2.55

3

FIGURE 2 – POWER OUTPUT versus POWER INPUT

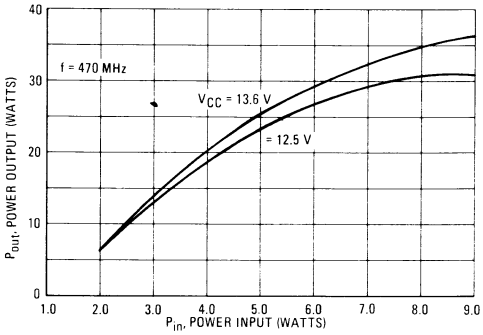


FIGURE 3 – POWER OUTPUT versus FREQUENCY

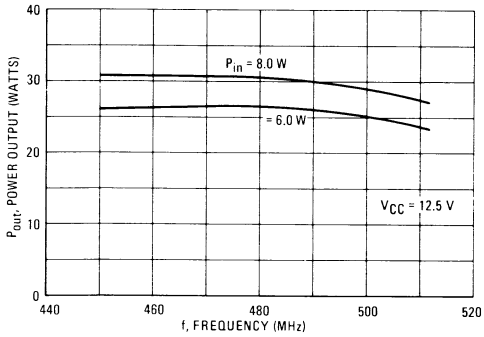


FIGURE 4 – POWER OUTPUT versus SUPPLY VOLTAGE

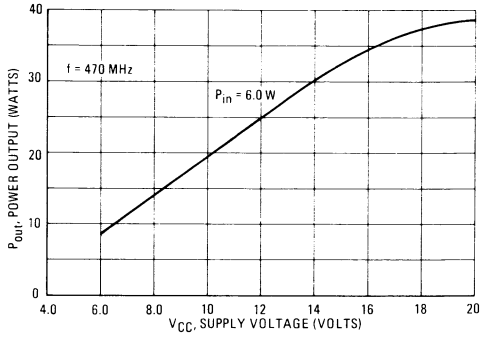


FIGURE 5 – POWER SATURATION PROFILE

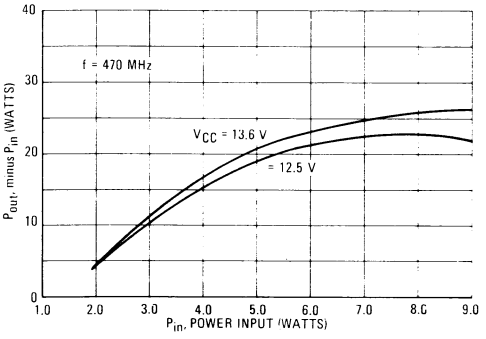
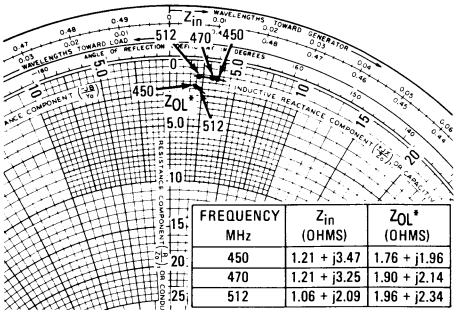


FIGURE 7 – SERIES EQUIVALENT INPUT-OUTPUT IMPEDANCE



FREQUENCY MHz	Z_{in} (OHMS)	Z_{OL}* (OHMS)
450	1.21 + j3.47	1.76 + j1.96
470	1.21 + j3.25	1.90 + j2.14
512	1.06 + j2.09	1.96 + j2.34

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

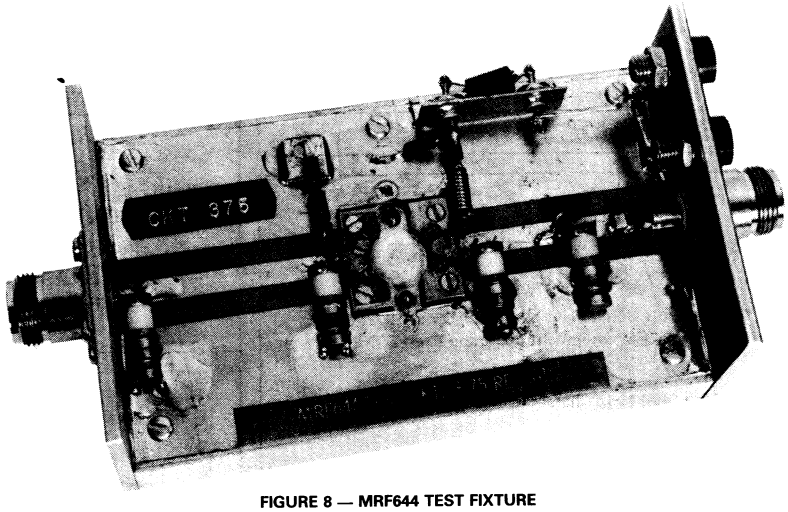
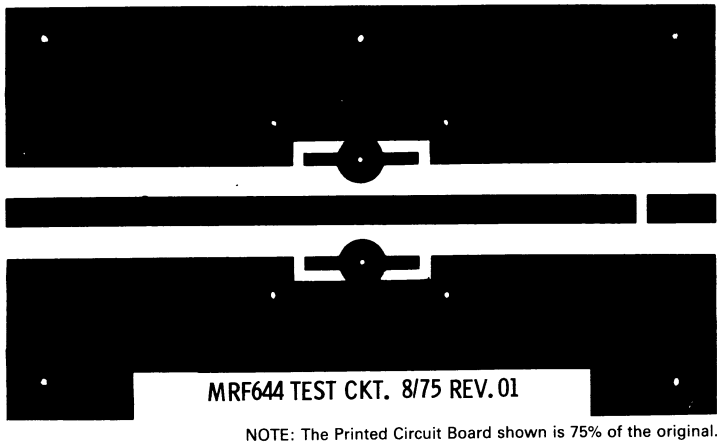


FIGURE 8 — MRF644 TEST FIXTURE



NOTE: The Printed Circuit Board shown is 75% of the original.

FIGURE 9 — PRINTED CIRCUIT BOARD

MRF646

The RF Line

45 W — 470 MHz
CONTROLLED Q
RF POWER
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NPN SILICON

NPN SILICON RF POWER TRANSISTOR

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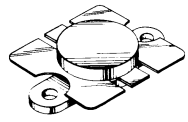

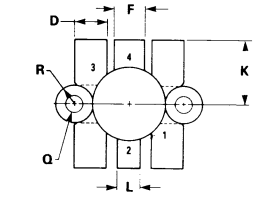

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PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE

NOTE:
FLANGE IS ISOLATED IN ALL STYLES.

DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
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D	5.33	5.58	0.210	0.220
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N	3.81	4.31	0.150	0.170
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U	11.94	12.57	0.470	0.495

CASE 316-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
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Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	9.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	117 0.67	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	°C/W

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

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Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	–	–	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	70	150	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	90	125	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 45 W, I_C(Max) = 5.8 Adc, f = 470 MHz)	G_{pe}	4.8	5.4	–	dB
Input Power (V_{CC} = 12.5 Vdc, P_{out} = 45 W, f = 470 MHz)	P_{in}	–	13	15	Watts
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 45 W, I_C (Max) = 5.8 Adc, f = 470 MHz)	η	55	60	–	%
Load Mismatch Stress (V_{CC} = 16 Vdc, P_{in} = Note 1, f = 470 MHz, VSWR = 20:1, All Phase Angles)	ψ*	No Degradation in Output Power			
Series Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 45 W, f = 470 MHz)	Z_{in}	–	1.4 + j4.0	–	Ohms
Series Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 45 W, f = 470 MHz)	Z_{OL}*	–	1.2 + j2.8	–	Ohms

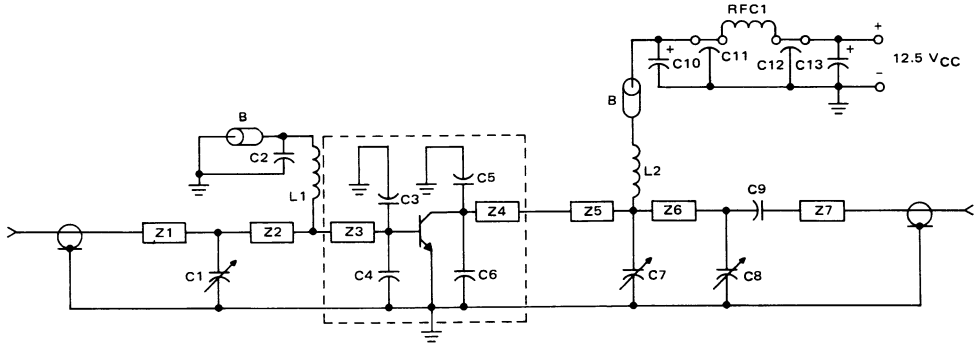
Notes:

1. P_{in} = 150% of Drive Requirement for 45 W output @ 12.5 V.

* ψ = Mismatch stress factor—the electrical criterion established to verify the device resistance to load mismatch failure. The mismatch stress test is accomplished in the standard test fixture (Figure 1) terminated in a 20:1 minimum load mismatch at all phase angles.

3

FIGURE 1 – TEST CIRCUIT SCHEMATIC



C1, C8	1.0–20 pF JOHANSON	L2	5" # 20 AWG, 0.1" I.D.
C2	100 pF UNELCO	RFC1	Ferroxcube VR200-20-4B
C3, C6	33 pF 100 mil ATC	Z1	0.525" x 0.190" Microstrip
C4	30 pF 100 mil ATC	Z2	1.475" x 0.190" Microstrip
C5	39 pF 100 mil ATC	Z3, Z4	(0.2 x 0.2)/0.25 Alumina
C7	1–10 pF JOHANSON	Z5	0.190" x 0.190" Microstrip
C9	100 pF 100 mil ATC	Z6	1.150" x 0.190" Microstrip
C10, C13	1 μF 35 V TANTALUM	Z7	0.660" x 0.190" Microstrip
C11, C12	680 pF Feedthrough	Board	62.5 mil Glass Teflon, ϵ_R = 2.55, λ = 0.0018
B	Ferroxcube Bead 56-590-65-3B		
L1	5" # 22 AWG, 0.1" I.D.		

FIGURE 2 – POWER OUTPUT versus POWER INPUT

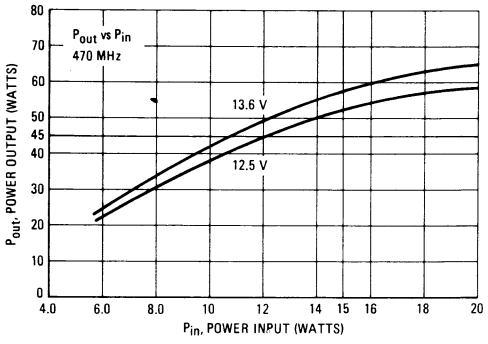


FIGURE 3 – POWER OUTPUT versus FREQUENCY

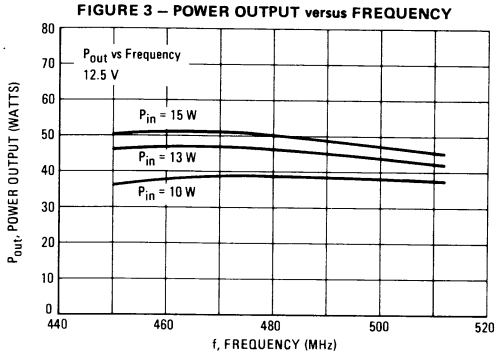


FIGURE 4 – POWER OUTPUT versus SUPPLY VOLTAGE

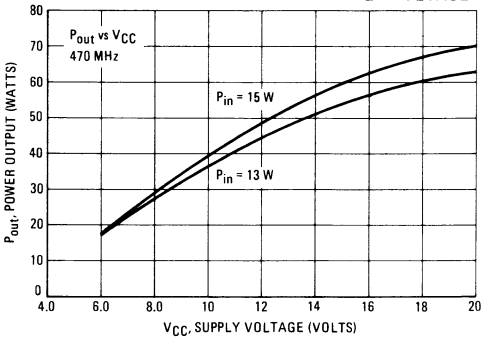


FIGURE 5 – POWER SATURATION PROFILE

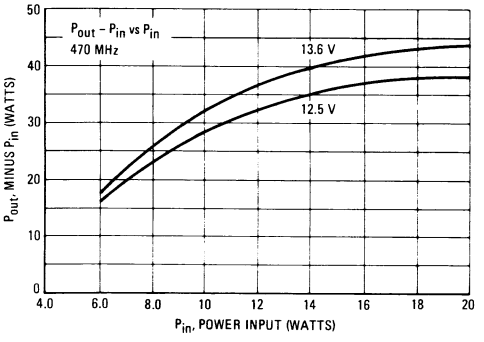
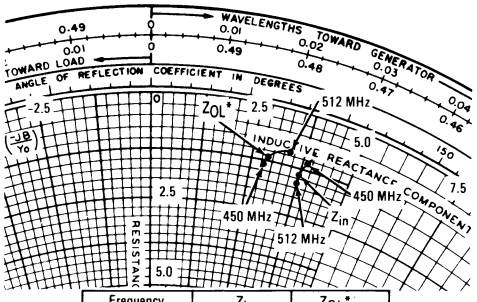


FIGURE 7 – SERIES EQUIVALENT INPUT-OUTPUT IMPEDANCE



Frequency (MHz)	Z_{in} (Ohms)	Z_{OL}^* (Ohms)
450	1.21 + j3.91	1.27 + j2.79
470	1.41 + j3.75	1.20 + j2.80
512	1.64 + j3.75	0.93 + j3.36

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

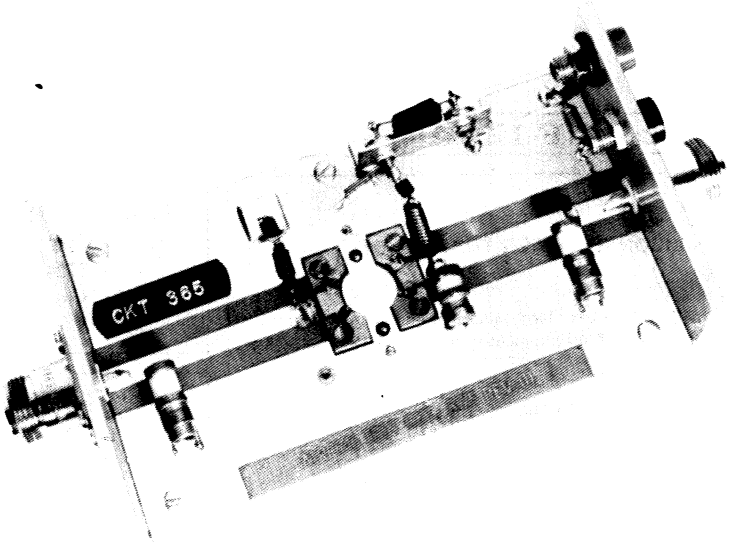
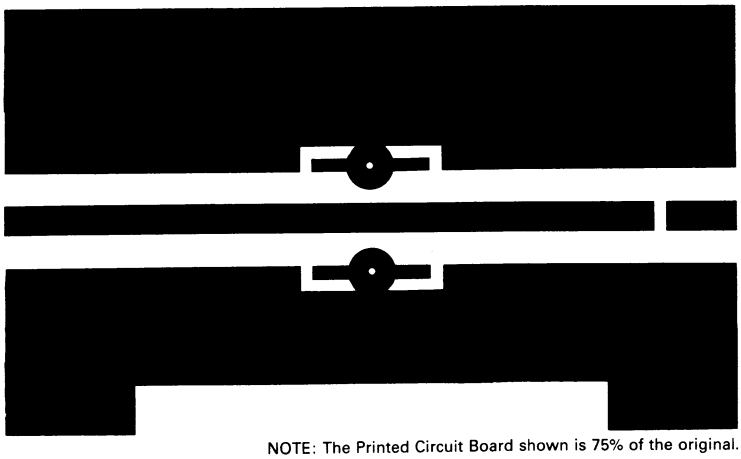


FIGURE 8 — MRF644 TEST FIXTURE



NOTE: The Printed Circuit Board shown is 75% of the original.

FIGURE 9 — PRINTED CIRCUIT BOARD

MRF648

The RF Line

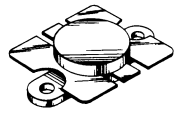
60 W – 470 MHz

CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics
  - Output Power = 60 Watts
  - Minimum Gain = 4.4 dB
  - Efficiency = 55%
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broadband Operation
- Tested for Load Mismatch Stress at all Phase Angles with 20:1 VSWR @ 16-Volt High Line and 20% Overdrive



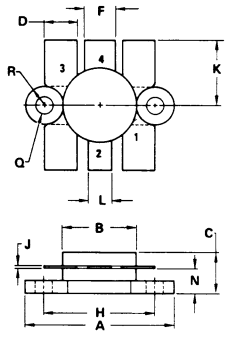
3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	11.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	175 1.0	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W



STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE-ISOLATED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.33	5.59	0.210	0.220
F	5.08	5.33	0.200	0.210
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	10.29	11.18	0.405	0.440
L	3.81	4.06	0.150	0.160
N	3.81	4.32	0.150	0.170
Q	2.92	3.30	0.115	0.130
R	3.05	3.30	0.120	0.130

CASE 316-01

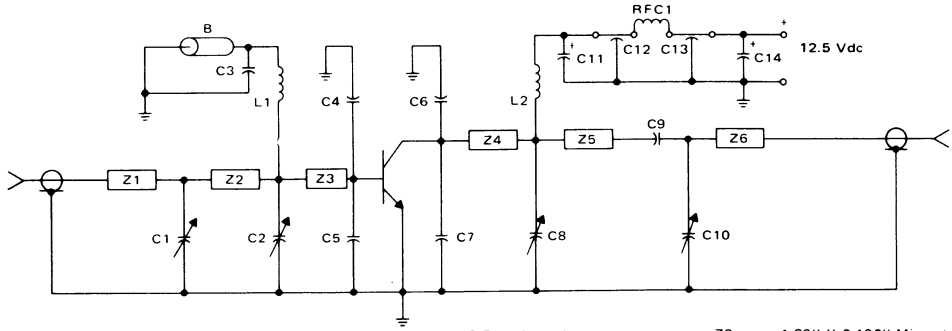
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	–	–	15	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 6.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	70	150	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	130	150	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 60 W, f = 470 MHz)	G_{pe}	4.4	5.0	–	dB
Input Power (V_{CC} = 12.5 Vdc, P_{out} = 60 W, f = 470 MHz)	P_{in}	–	19	22	Watts
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 60 W, f = 470 MHz)	η	55	65	–	%
Output Mismatch Stress (V_{CC} = 16 Vdc, P_{in} = 26 W, f = 470 MHz, VSWR = 20:1, All Phase Angles)	ψ*	No Degradation in Output Power			

Notes:

* ψ = Mismatch stress factor – the electrical criterion established to verify the device resistance to load mismatch failure. The mismatch stress test is accomplished in the standard test fixture (Figure 1) terminated in a 20:1 minimum load mismatch at all phase angles.

FIGURE 1 – TEST CIRCUIT SCHEMATIC



C1, C2, C8, C10	1-20 pF Johanson	C12, C13	680 pF Feedthrough	Z2	1.39" X 0.190" Microstrip
C3	200 pF Unelco	B	Ferroxcube Bead 56 590 65 3B	Z3, Z4	(0.2 X 0.2)/0.25 Alumina
C4, C5	33 pF 100mil ATC	L1	10 Turns #26 AWG 0.1" I.D. X 0.23"	Z5	1.30" X 0.190" Microstrip
C6, C7	36 pF 100mil ATC	L2	10 Turns #20 AWG 0.1" I.D. X 0.50"	Z6	0.330" X 0.190" Microstrip
C9	100 pF 100mil ATC	RFC1	Ferroxcube VR200 19 4B	Board	62.5mil Glass Teflon, ϵ_R = 2.55,
C11, C14	1.0 μF 35 V Tantalum	Z1	0.46" X 0.190" Microstrip		λ = 0.0018, Dimension: 5.0" X 3.0" X 0.06"

3

FIGURE 2 – POWER OUTPUT versus POWER INPUT

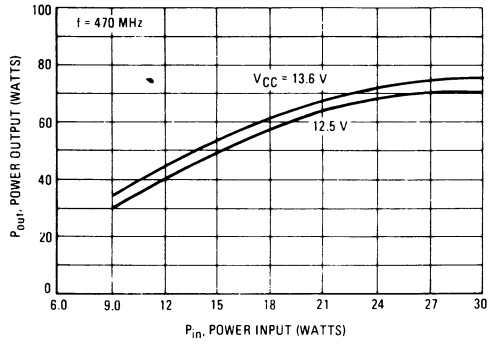


FIGURE 3 – POWER OUTPUT versus FREQUENCY

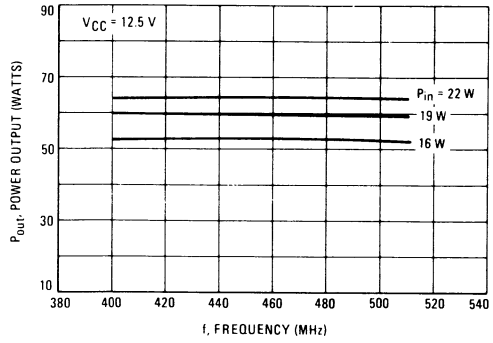


FIGURE 4 – POWER OUTPUT versus SUPPLY VOLTAGE

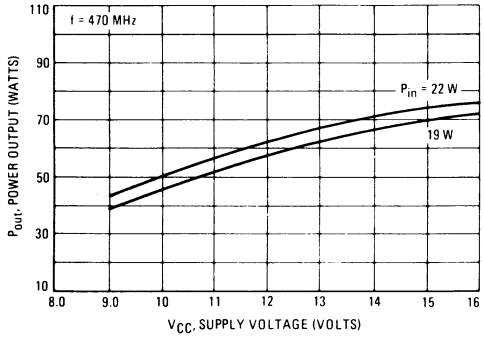


FIGURE 5 – POWER SATURATION PROFILE

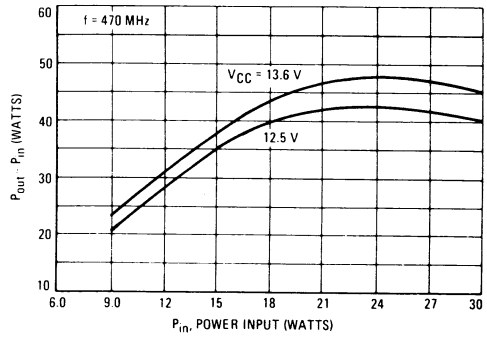
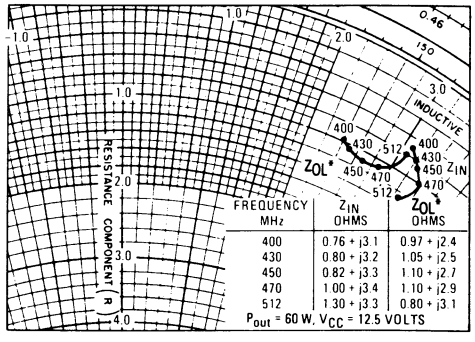
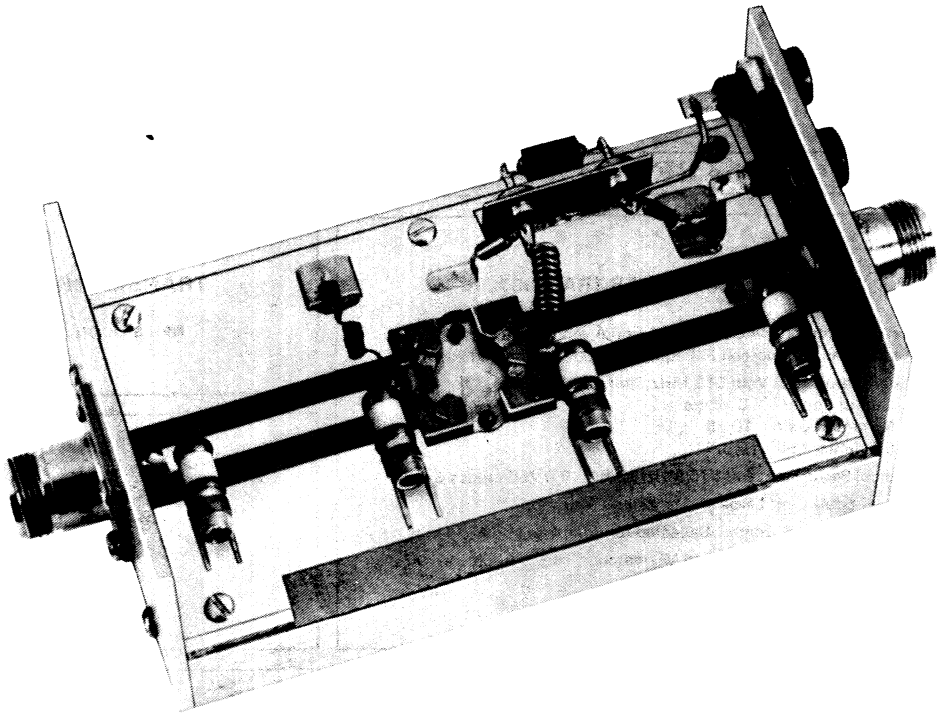


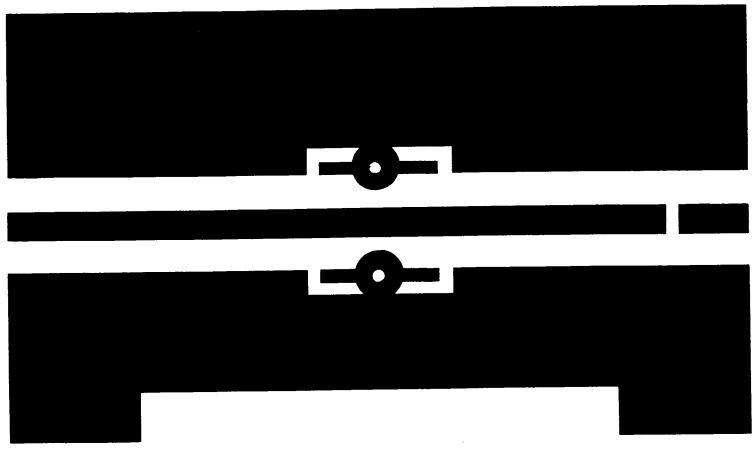
FIGURE 6 – SERIES EQUIVALENT INPUT-OUTPUT IMPEDANCE



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



TEST CIRCUIT TEST FIXTURE



NOTE: The Printed Circuit Board shown is 75% of the original.

MRF652

The RF Line

5.0 W 512 MHz

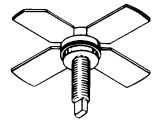
RF POWER TRANSISTOR

NPN SILICON

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Vdc UHF large-signal, amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Guaranteed 12.5 Volt, 512 MHz Characteristics
  Output Power = 5.0 Watts
  Minimum Gain = 10 dB
  Efficiency = 65% (Typ)
- Typical Performance at 870 MHz, 12.5 V, 5.0 W Output = 6.0 dB
- Series Equivalent Large-Signal Characterization
- Gold Metallized, Emitter Ballasted for Long Life and Reliability
- Capable of 30:1 VSWR Load Mismatch at 15.5 V Supply Voltage



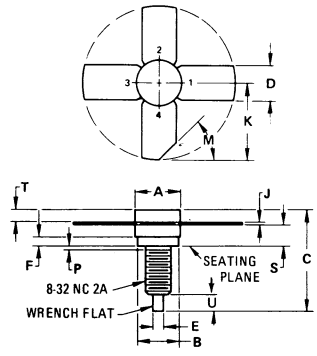
3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	25 143	Watts mW/°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	$R_{\theta JC}$	7.0	°C/W



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

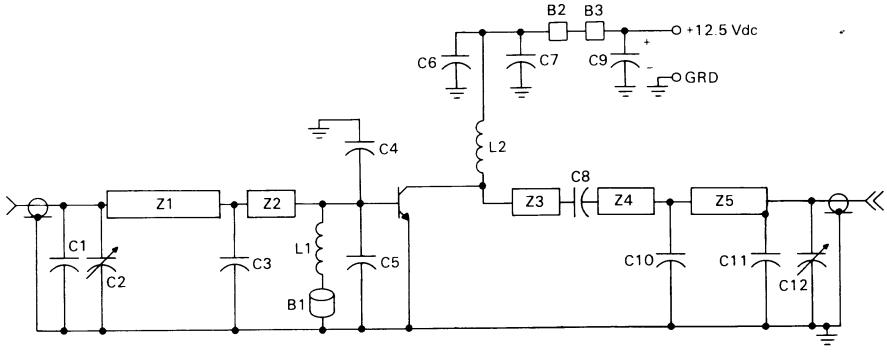
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.06	7.26	0.278	0.286
B	6.20	6.50	0.244	0.256
C	14.99	16.51	0.590	0.650
D	5.46	5.97	0.215	0.235
E	1.40	1.65	0.055	0.065
F	1.52	–	0.060	–
J	0.08	0.18	0.003	0.007
K	11.05	–	0.435	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
S	3.00	3.25	0.118	0.128
T	1.40	1.78	0.055	0.070
U	2.92	3.68	0.115	0.145

CASE 244-04

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 25 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	9.5	15	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 5.0 W) f = 512 MHz f = 870 MHz	G_{pe}	10 —	11 6.0	— —	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 5.0 W, f = 512 MHz)	η	—	65	—	%
Load Mismatch (V_{CC} = 15.5 Vdc, P_{out} = 6.0 W, f = 512 MHz, VSWR 30:1 At All Phase Angles)	ψ	No Degradation in Output Power			

FIGURE 1 — 440-512 MHz BROADBAND TEST CIRCUIT



B1-B3 — Ferrite Bead
C1 — 7.0 pF Unelco Mica
C2 — 1.0-6.0 pF Johanson Variable 5201
C3 — 15 pF Unelco Mica
C4 — 43 pF Mini-Underwood Mica
C5 — 56 pF Mini-Underwood Mica
C6 — 1000 pF Unelco Mica
C7 — 0.1 μF Ceramic
C8 — 68 pF Mini-Underwood Mica
C9 — 1.0 μF Electrolytic 25 V
C10, C11 — 5.0 pF Unelco Mica
C12 — 1.0-10 pF Johanson Variable 5501
L1, L2 — 6 Turns, 20 AWG Wire 0.125" ID
Z1, Z2 -- 25 Ohm μStripline (See Photo-Mask - Figure 7)
Z3-Z5 — 50 Ohm μStripline (See Photo-Mask - Figure 7)
Board — 0.032" Glass-Teflon

FIGURE 2 — OUTPUT POWER versus INPUT POWER

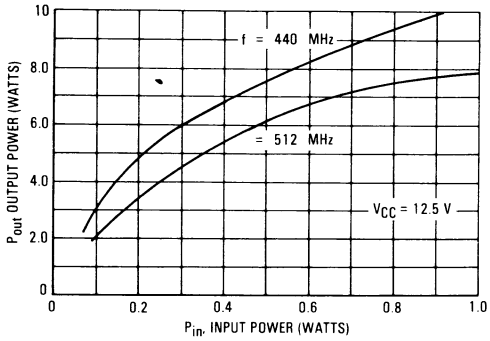


FIGURE 3 — OUTPUT POWER versus FREQUENCY

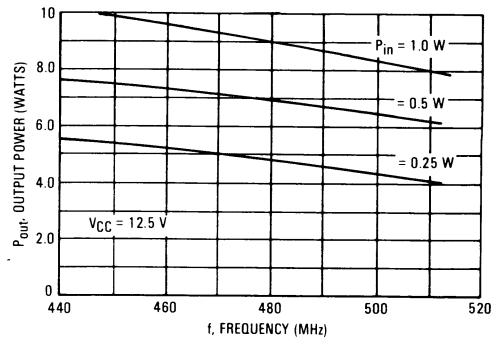


FIGURE 4 — OUTPUT POWER versus SUPPLY VOLTAGE

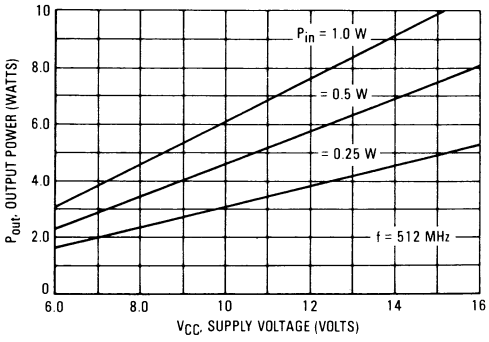


FIGURE 5 — TYPICAL BROADBAND CIRCUIT PERFORMANCE

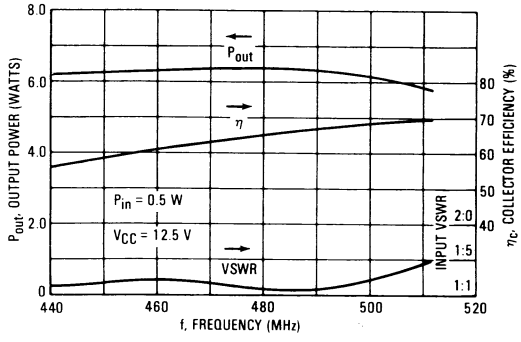
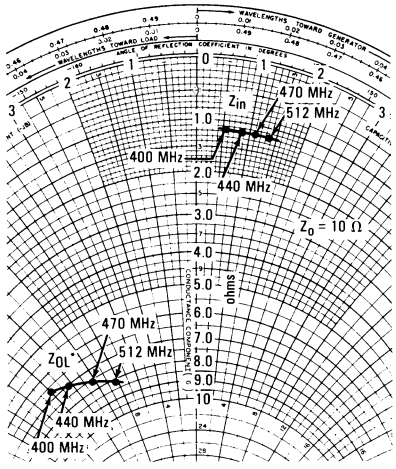


FIGURE 6 — SERIES EQUIVALENT INPUT/OUTPUT IMPEDANCE

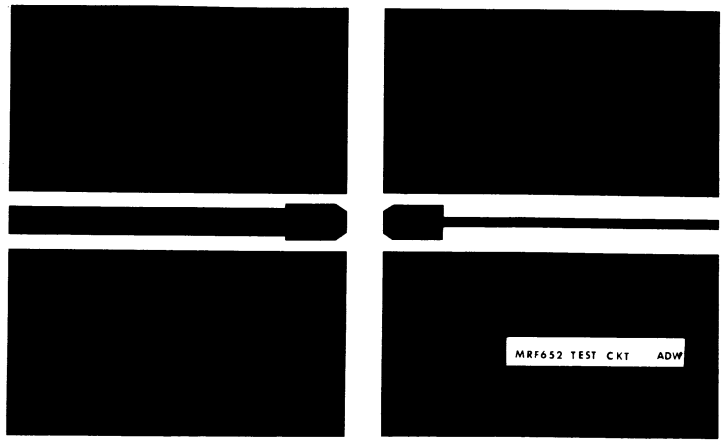


V_{CC} = 12.5 Vdc
P_{out} = 5.0 W

f MHz	Z_{in} Ohms	Z_{OL}^* Ohms
400	1.18 + j0.54	6.7 – j6.9
440	1.19 + j0.88	7.05 – j6.1
470	1.19 + j1.11	7.6 – j5.1
512	1.19 + j1.35	8.1 – j4.1

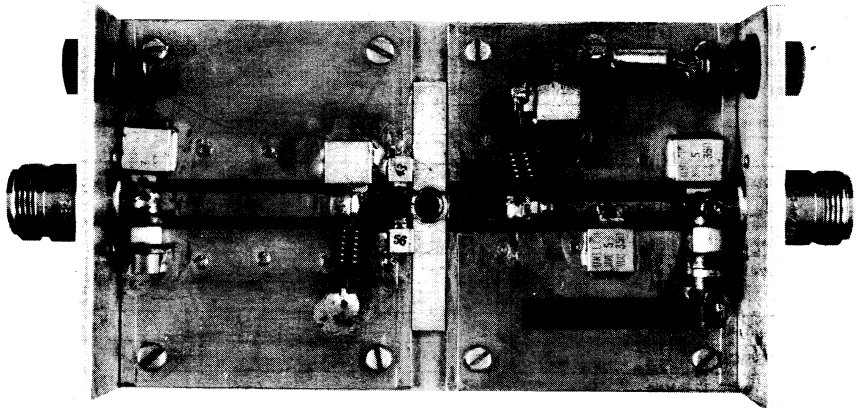
*Z_{OL} = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage, and frequency.

FIGURE 7 — PHOTOMASTER BROADBAND TEST CIRCUIT



NOTE: The Printed Circuit Board shown is 75% of the original.

FIGURE 8 — BROADBAND TEST CIRCUIT



MRF653

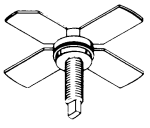
**10 W 512 MHz
RF POWER
TRANSISTOR
NPN SILICON**

The RF Line

NPN Silicon RF Power Transistor

. . . designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 512 MHz Characteristics
  - Output Power = 10 W
  - Gain = 8 dB (Typ)
  - Efficiency = 65% (Typ)
- Gold Metallized, Emitter Ballasted for Long Life and Reliability
- Capable of 20:1 VSWR Load Mismatch at 16 V Supply Voltage



**CASE 244-04
CERAMIC**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16.5	Vdc
Collector-Base Voltage	V_{CBO}	38	Vdc
Emitter-Base Voltage	V_{EBO}	4	Vdc
Collector-Current — Continuous	I_C	2.75	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	44 0.25	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	$R_{\theta JC}$	4	°C/W

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

Characteristics	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	16.5	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	38	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 5 mAdc, I_C = 0)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	—	—	5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1 Adc, V_{CE} = 5 Vdc)	h_{FE}	20	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	22	28	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 10 W, f = 512 MHz)	G_{pe}	7	8	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 10 W, f = 512 MHz)	η_c	55	65	—	%
Load Mismatch Stress (V_{CC} = 16 Vdc, f = 512 MHz, P_{in}* = 2.6 W, VSWR = 20:1 All Phase Angles)	ψ	No Degradation in Output Power			

*P_{in} = 2 dB over the typical input power required for 10 W output power @ 12.5 Vdc

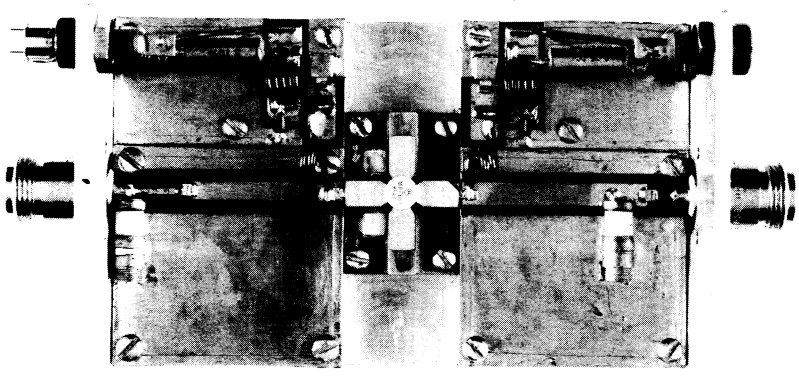
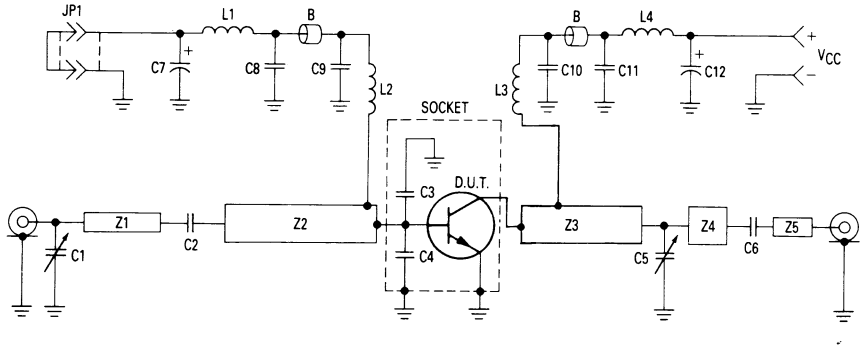


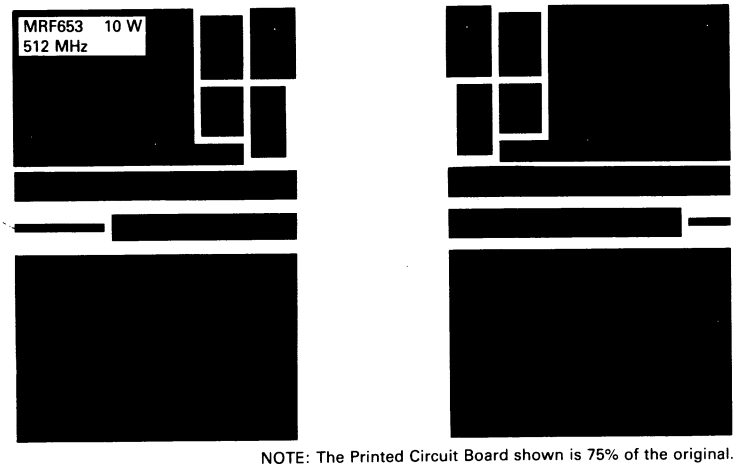
Figure 1. Broadband Test Circuit



C1, C5 — 1–20 pF, Johanson
C2, C6 — 330 pF, 100 Mil ATC
C3, C4 — 36 pF, Mini-Unelco
C7, C12 — 10 μF, 35 V, Tantalum
C8, C11 — 0.1 μF, Ceramic
C9, C10 — 91 pF, Mini-Unelco

L1, L4 — 4-1/2 Turns, #18 AWG, 0.16″ ID
L2, L3 — 2 Turns, #18 AWG, 0.16″ ID
B — Ferrite Bead, Ferroxcube 56-590-65-3B
Z1 — 51 x 630 mils
Z2 — 162 x 1300 mils
Z3 — 210 x 1350 mils
Z4 — 210 x 280 mils
Z5 — 51 x 300 mils
Board Material — 0.032″ epoxy glass G10, 1 oz., copper clad, double sided, ϵ_r = 5
JP1 — Jumper, #14 AWG w/Banana Plugs

Figure 2. Broadband Test Circuit Schematic



NOTE: The Printed Circuit Board shown is 75% of the original.

Figure 3. Photomaster

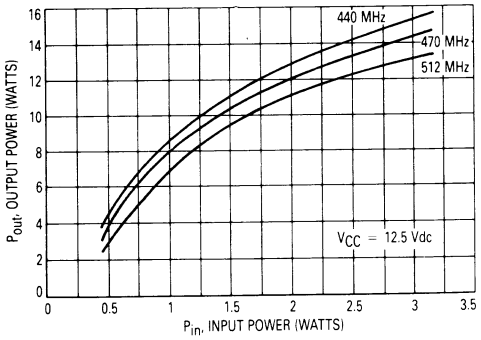


Figure 4. Output Power versus Input Power

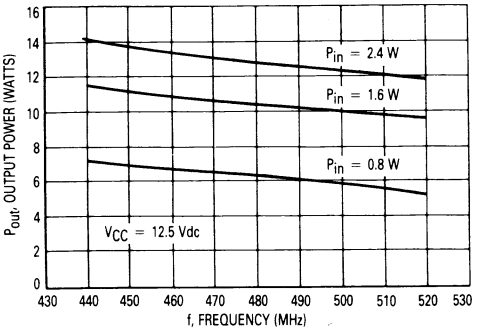


Figure 5. Output Power versus Frequency

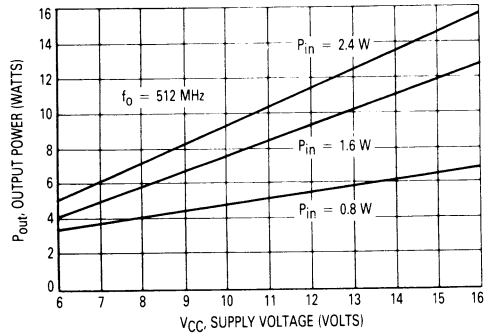


Figure 6. Output Power versus Supply Voltage

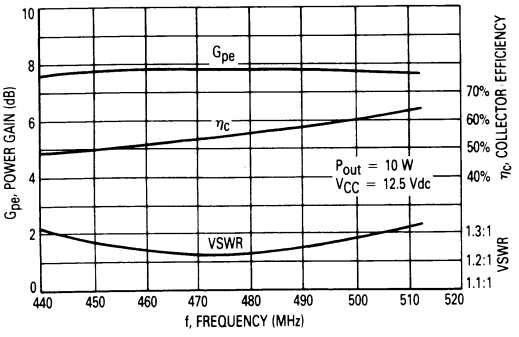


Figure 7. Typical Broadband Circuit Performance

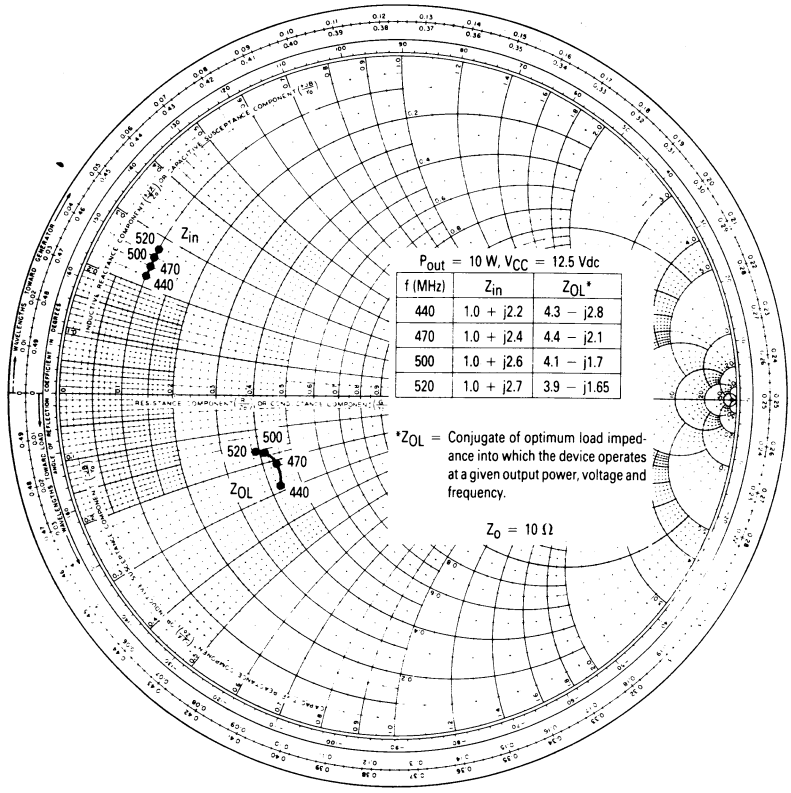
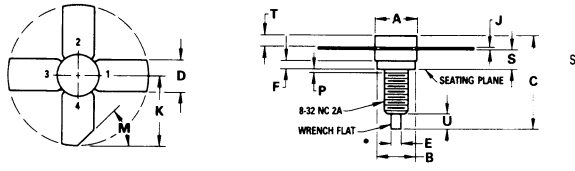


Figure 8. Series Equivalent Input and Output Impedance

OUTLINE DIMENSIONS

CASE 244-04
CERAMIC



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

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.06	7.26	0.278	0.286
B	6.20	6.50	0.244	0.256
C	14.99	16.51	0.590	0.650
D	5.46	5.96	0.215	0.235
E	1.40	1.65	0.055	0.065
F	1.52	—	0.060	—
J	0.08	0.17	0.003	0.007
K	11.05	—	0.435	—
M	45° NOM		45° NOM	
P	—	1.27	—	0.050
S	3.00	3.25	0.118	0.128
T	1.40	1.77	0.055	0.070
U	2.92	3.68	0.115	0.145

MRF654

The RF Line

15 W 470 MHz

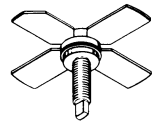
RF POWER TRANSISTOR

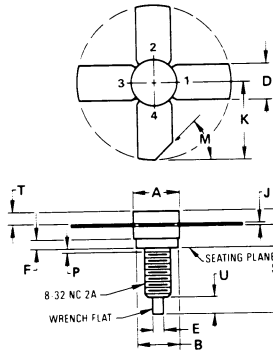
NPN SILICON

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 512 MHz Characteristics
  Output Power = 15 W
  Minimum Gain = 7.8 dB
  Efficiency = 55%
- Built-In Matching Network for Broadband Operation
- Gold Metallized, Emitter Ballasted for Long Life and Reliability
- Capable of 20:1 VSWR Load Mismatch at 15.5 V Supply Voltage





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

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.06	7.26	0.278	0.286
B	6.20	6.50	0.244	0.256
C	14.99	16.51	0.590	0.650
D	5.46	5.96	0.215	0.235
E	1.40	1.65	0.055	0.065
F	1.52	–	0.060	–
J	0.08	0.17	0.003	0.007
K	11.05	–	0.435	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
S	3.00	3.25	0.118	0.128
T	1.40	1.77	0.055	0.070
U	2.92	3.68	0.115	0.145

CASE 244-04

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector-Current — Continuous	I_C	4.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	44 0.25	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

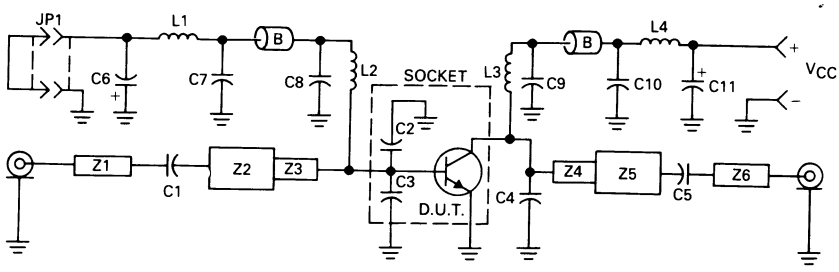
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	4.0	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector-Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	—	—	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	31	45	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 512 MHz)	G_{pe}	7.8	8.8	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 512 MHz)	η	55	63	—	%
Load Mismatch Stress (V_{CC} = 15.5 Vdc, f = 470 MHz, 2.0 dB Overdrive, VSWR = 20:1 All Phase Angles)	ψ	No Degradation In Output Power			

3

FIGURE 1 — 440–512 MHz BROADBAND TEST CIRCUIT



C1, C5 — 68 pF Mini-Unelco
C2, C3 — 33 pF, Mini-Unelco
C4 — 47 pF, Mini-Unelco
C6, C11 — 10 μF, 25 V Tantalum
C7, C10 — 0.1 μF, Ceramic
C8, C9 — 91 pF, Mini-Unelco
L1, L4 — 4½ Turns, #18 AWG, Enamel Covered, 0.16″ ID
L2, L3 — 2 Turns, #18 AWG Enamel Covered, 0.16″ ID
B — Ferrite Bead, Ferroxcube 56-590-65-3B
Z1-Z6 — See PCB Artwork
PCB — 1/32″ G-10, E_r = 4.5 @ UHF
Socket — See Socket Drawings
JP1 — Jumper, #14 AWG w/Banana Plugs

FIGURE 2 — OUTPUT POWER versus INPUT POWER

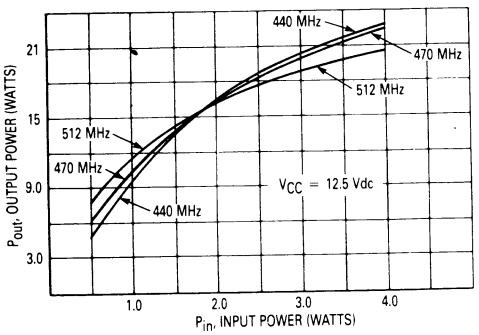


FIGURE 3 — OUTPUT POWER versus FREQUENCY

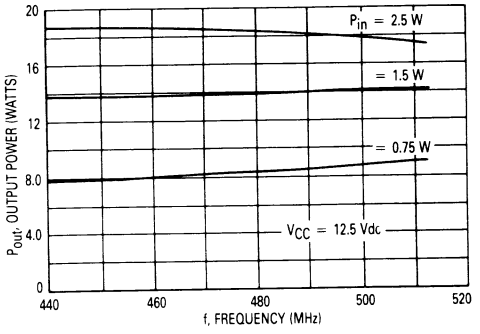


FIGURE 4 — OUTPUT POWER versus SUPPLY VOLTAGE

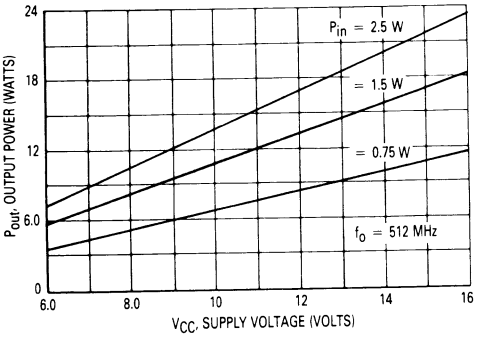


FIGURE 5 — TYPICAL BROADBAND CIRCUIT PERFORMANCE

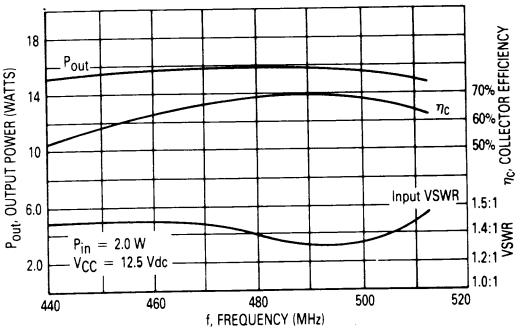
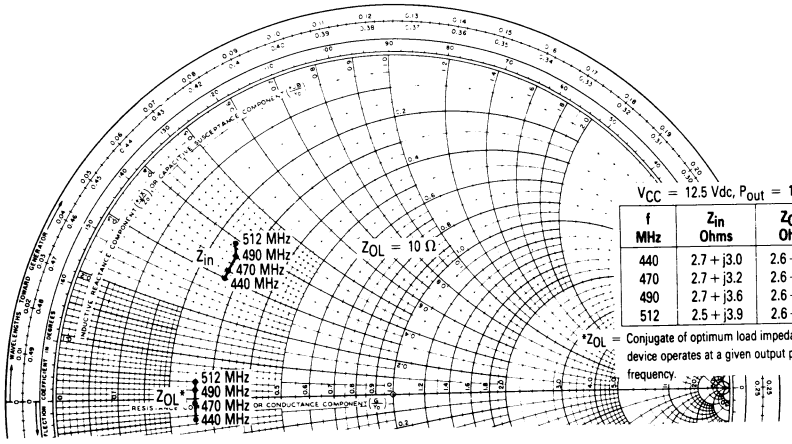


FIGURE 6 — SERIES EQUIVALENT INPUT AND OUTPUT IMPEDANCE



V_{CC} = 12.5 Vdc, P_{out} = 15 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
440	2.7 + j3.0	2.6 − j0.5
470	2.7 + j3.2	2.6 − j0.1
490	2.7 + j3.6	2.6 + j0.2
512	2.5 + j3.9	2.6 + j0.4

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

FIGURE 7 — 440–512 MHz BROADBAND TEST CIRCUIT

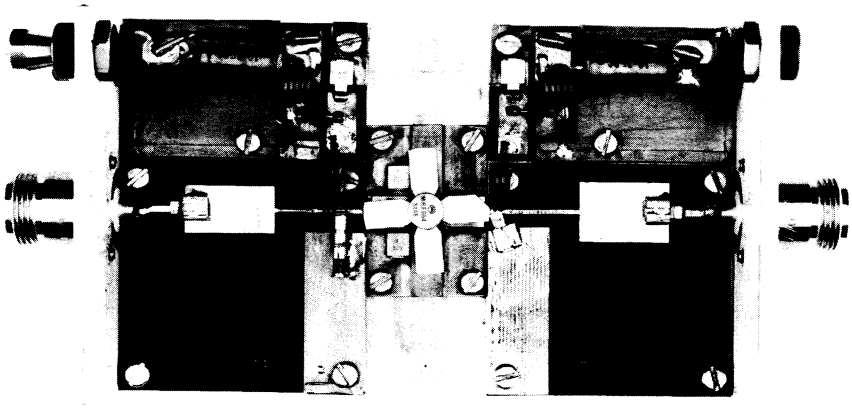
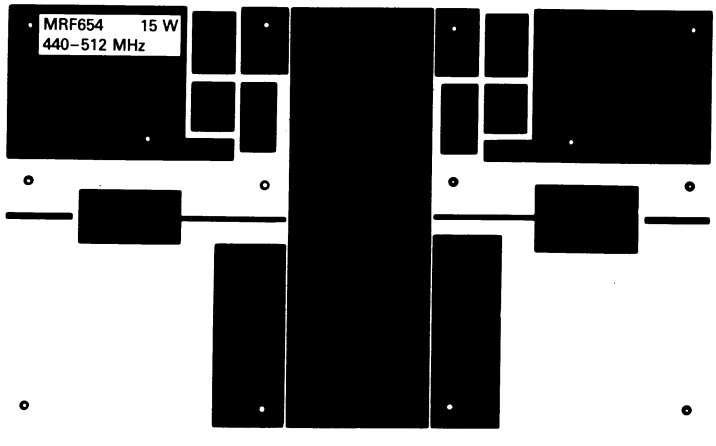


FIGURE 8 — PCB BOARD LAYOUT



NOTE: The Printed Circuit Board shown is 75% of the original.