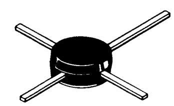
MRF2369

The RF Line

NPN Silicon High Frequency Transistors

f_T = 6 GHz @ 50 mA
NF = 1.5 dB @ 1 GHz
HIGH FREQUENCY TRANSISTOR
NPN SILICON



... designed for low-noise, wide dynamic range front end amplifiers, low-noise VCO's and microwave power multipliers.

- Low Noise
- High Gain
- Available in Low Cost Plastic
- State-of-the-Art Technology
  - Fine Line Geometry
  - Ion Implanted Arsenic Emitters
  - Gold Top Metallization and Wires
  - Silicon Nitride Passivation
- Fully Characterized
- Higher Voltage Version of MRF571
- Internally Ballasted for Improved Ruggedness

3

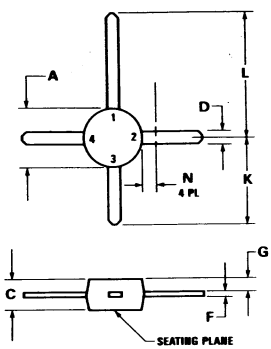
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	70	mAdc
Total Device Dissipation @ T_C = 50°C (1) Derate above 50°C	P_D	0.75 7.5	Watt mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	133	°C/W

OUTLINE DIMENSIONS



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

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.44	5.21	0.175	0.205
C	1.90	2.54	0.075	0.100
D	0.84	0.99	0.033	0.039
F	0.20	0.30	0.008	0.012
G	0.76	1.14	0.030	0.045
K	7.24	8.13	0.285	0.320
L	10.54	11.43	0.415	0.450
N	–	1.65	–	0.065

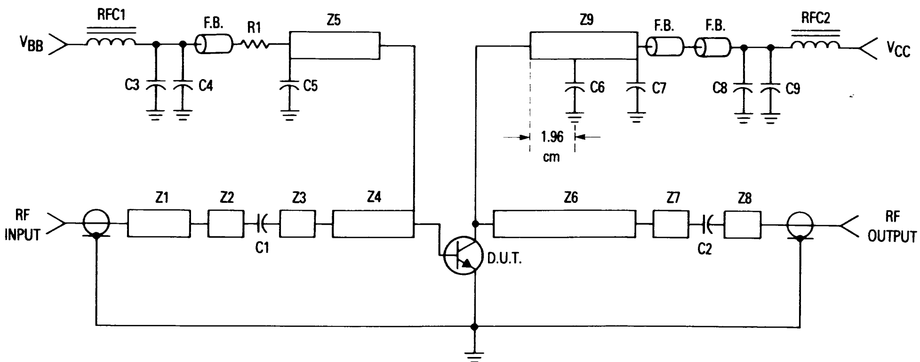
NOTE:
DIMENSION D NOT APPLICABLE IN ZONE N.

MACRO-X
CASE 317-01

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

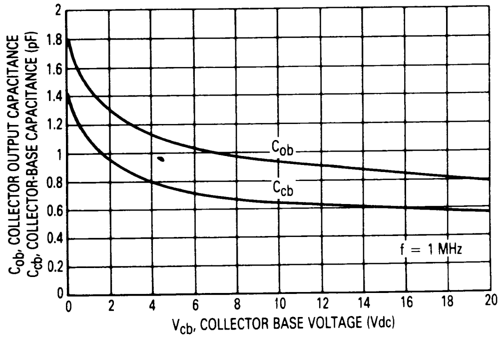
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 50 μAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 5 Vdc)	h_{FE}	50	—	300	—
DYNAMIC CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{cb}	—	0.7	1	pF
Current Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 40 mA, f = 1 GHz)	f_T	—	6	—	GHz
FUNCTIONAL TESTS					
Gain @ Noise Figure (I_C = 5 mAdc, V_{CE} = 10 Vdc) f = 0.5 GHz f = 1 GHz	G_{NF}	— 10	16.5 12	— —	dB
Noise Figure (I_C = 5 mAdc, V_{CE} = 10 Vdc) f = 0.5 GHz f = 1 GHz f = 2 GHz	NF	— — —	1 1.5 2.8	— 2 —	dB

3



C1, C2, C6	560 pF Chip Capacitor	RFC1, RFC2	VK-200, Ferroxcube
C5, C7	0.018 μF Chip Capacitor	Z1–Z9	Microstrip, See Photomaster
C3, C8	0.1 μF Mylar Capacitor	Bead	Ferrite Bead, Ferroxcube 56-590-65/3B
C4, C9	1 μF Electrolytic Capacitor	Board Material	0.0625″ Teflon Fiberglass ϵ_r = 2.5 ± 0.05
R1	2.7 kΩ		

Figure 1. MRF2369 1 GHz Test Circuit



C_{ob}, Collector Output Capacitance
Figure 2. C_{cb}, Collector-Base Capacitance versus Voltage

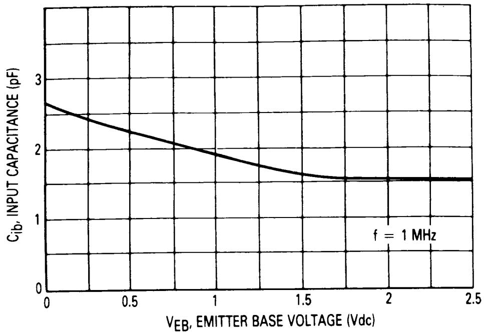


Figure 3. C_{ib}, Input Capacitance versus Emitter Base Voltage

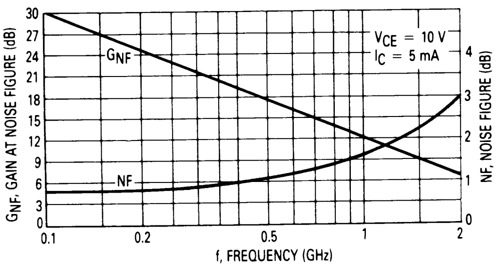


Figure 4. Gain at Noise Figure and Noise Figure versus Frequency

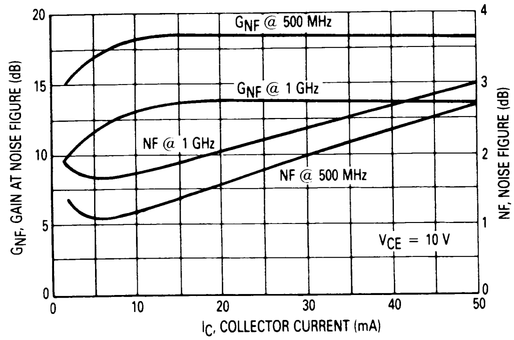


Figure 5. Gain at Noise Figure and Noise Figure versus Collector Current

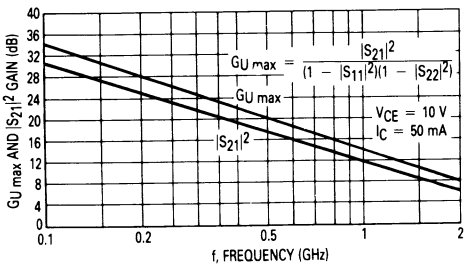


Figure 6. G_U max and $|S_{21}|^2$ versus Frequency

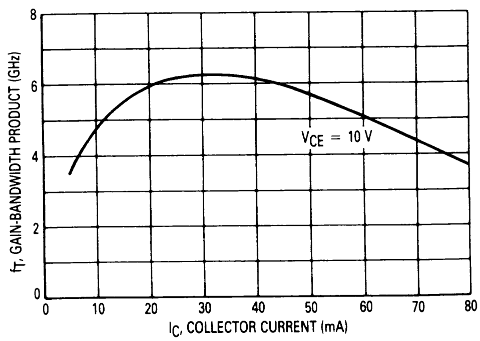
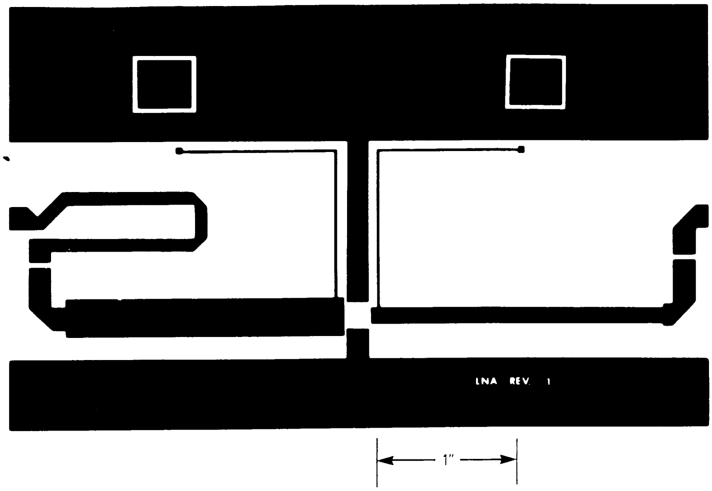


Figure 7. Gain-Bandwidth Product versus Collector Current

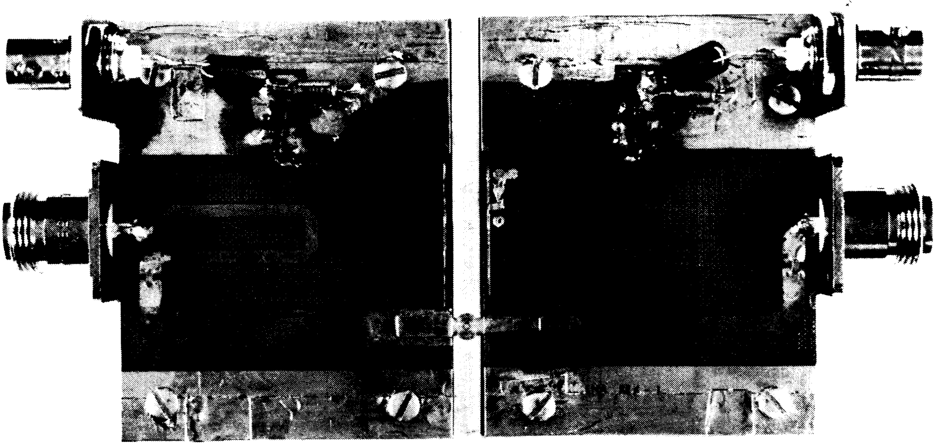
MRF2369 Common Emitter S-Parameters

V_{CE} (Volts)	I_C (mA)	f (MHz)	S11 $\|S_{11}\|$	S11 $\angle\phi$	S21 $\|S_{21}\|$	S21 $\angle\phi$	S12 $\|S_{12}\|$	S12 $\angle\phi$	S22 $\|S_{22}\|$	S22 $\angle\phi$
5	5	100	0.83	−45	14.1	152	0.03	69	0.88	−24
		200	0.70	−81	10.5	130	0.06	51	0.74	−37
		500	0.63	−140	5.7	98	0.08	35	0.47	−57
		1000	0.59	175	3	72	0.10	38	0.36	−68
		1500	0.57	150	2	56	0.12	45	0.35	−85
		2000	0.56	128	1.5	43	0.15	50	0.37	−96
	10	100	0.72	−63	21.2	142	0.03	61	0.83	−33
		200	0.63	−103	14.4	122	0.05	49	0.60	−51
		500	0.59	−156	7	93	0.07	42	0.35	−69
		1000	0.56	166	3.6	71	0.09	50	0.24	−79
		1500	0.55	143	2.4	57	0.12	55	0.24	−95
		2000	0.53	123	1.8	45	0.16	55	0.26	−101
	25	100	0.54	−93	29.1	132	0.02	63	0.68	−47
		200	0.57	−132	17.9	111	0.03	50	0.45	−66
		500	0.57	−173	7.9	88	0.05	53	0.23	−83
		1000	0.55	157	3.9	70	0.09	62	0.15	−93
		1500	0.54	137	2.6	57	0.13	62	0.16	−109
		2000	0.52	118	2	46	0.18	59	0.18	−109
	50	100	0.51	−118	31.6	126	0.02	63	0.58	−52
		200	0.57	−150	17.9	106	0.03	50	0.36	−66
		500	0.59	178	7.6	85	0.05	61	0.19	−76
		1000	0.58	153	3.7	68	0.09	67	0.15	−82
		1500	0.57	135	2.5	55	0.13	67	0.16	−100
		2000	0.55	116	1.9	44	0.17	63	0.19	−103
10	5	100	0.87	−39	14	155	0.03	70	0.89	−22
		200	0.75	−74	10.8	133	0.05	55	0.78	−32
		500	0.64	−134	6.1	100	0.08	37	0.53	−47
		1000	0.57	179	3.2	73	0.09	40	0.42	−57
		1500	0.56	153	2.1	56	0.11	47	0.41	−73
		2000	0.54	130	1.6	44	0.13	54	0.44	−83
	10	100	0.76	−57	21.9	145	0.02	70	0.83	−28
		200	0.64	−95	15.1	124	0.04	52	0.64	−43
		500	0.57	−151	7.5	94	0.06	43	0.40	−55
		1000	0.54	169	3.8	72	0.08	52	0.30	−61
		1500	0.53	146	2.5	57	0.11	57	0.30	−76
		2000	0.51	125	1.9	45	0.15	59	0.33	−84
	25	100	0.60	−82	30.4	133	0.02	60	0.73	−40
		200	0.56	−123	19.1	114	0.03	49	0.48	−53
		500	0.54	−168	8.5	89	0.05	54	0.28	−60
		1000	0.52	159	4.3	70	0.08	63	0.21	−64
		1500	0.52	139	2.8	57	0.12	64	0.22	−79
		2000	0.50	120	2.1	46	0.16	63	0.25	−84
	50	100	0.54	−104	33.5	127	0.01	60	0.63	−44
		200	0.55	−141	19.4	107	0.02	51	0.40	−51
		500	0.55	−177	8.3	85	0.04	61	0.26	−52
		1000	0.54	155	4.1	68	0.08	68	0.22	−56
		1500	0.54	137	2.7	55	0.11	69	0.23	−73
		2000	0.52	118	2	45	0.16	66	0.27	−81



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

Photomaster of MRF2369 Circuit Layout



MRF2369 Test Circuit

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MRF2628

The RF Line

NPN SILICON POWER TRANSISTOR

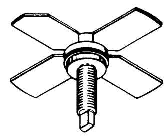
Designed for 12.5 volt VHF large-signal power amplifiers in commercial and industrial FM equipment.

- Compact .280 Stud Package
- Specified 12.5 V, 175 MHz Performance
  Output Power = 15 Watts
  Power Gain = 12 dB Min
  Efficiency = 60% Min
- Characterized to 220 MHz
- Load Mismatch Capability at High Line and Overdrive

15 W 136–220 MHz

RF POWER TRANSISTOR

NPN SILICON

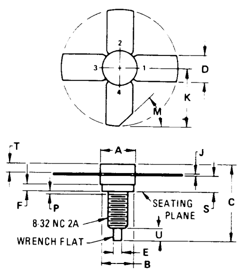


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector-Current — Continuous	I_C	2.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	40 0.23	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

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



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

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	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

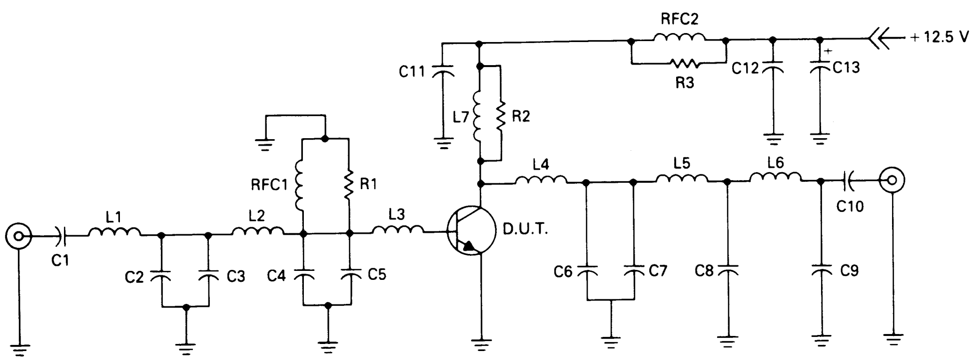
CASE 244-04

3

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)	$V_{(BR)CEO}$	18	—	—	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_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	70	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	33	60	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 175 MHz)	G_{pe}	12	13	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 175 MHz)	η	60	68	—	%
Load Mismatch (V_{CC} = 15.5 V, P_{in} = 2.0 dB Overdrive, Load VSWR = 30:1)	ψ	No Degradation in Output Power			

FIGURE 1 — BROADBAND CIRCUIT



C1, C10, C11 = 1000 pF Ceramic Chip Capacitor
C2 = 27 pF Mini Unelco Capacitor
C3 = 33 pF Mini Unelco Capacitor
C4, C5 = 270 pF Unelco J101 Capacitor
C6, C9 = 18 pF Mini Unelco Capacitor
C7 = 91 pF Mini Unelco Capacitor
C8 = 68 pF Mini Unelco Capacitor
C12 = 0.1 μF Monolythic Capacitor
C13 = 100 μF, 15 V Electrolytic
L1 = 3 Turns #18 AWG, 3/16″ ID
L2 = 1 1/8″ #18 AWG into 1/2″ High Loop
L3 = Copper Pad, 0.200 x 0.400 x 0.060
L4 = 1/4″ #18 AWG into 1/8″ High Loop
L5 = 3 Turns #24 AWG Enameled, 3/32″ ID
L6 = 6 Turns #24 AWG Enameled, 3/32″ ID
L7 = 1 3/4″ #16 AWG into 3/4″ High Loop
R1 = 12 Ω, 1/2 W Carbon
R2 = 100 Ω, 1.0 W Carbon
R3 = 10 Ω, 1.0 W Carbon
RFC1 = 0.15 μH Molded Choke
RFC2 = Ferrocube Choke, VK200-4B

FIGURE 2 — OUTPUT POWER versus FREQUENCY

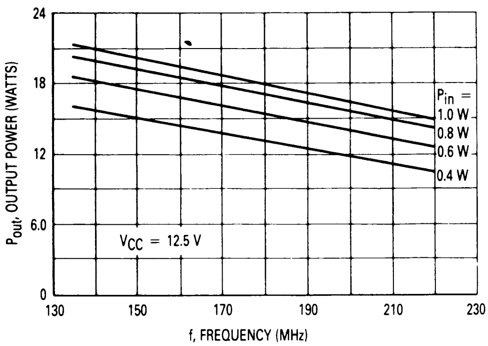


FIGURE 3 — OUTPUT POWER versus INPUT POWER

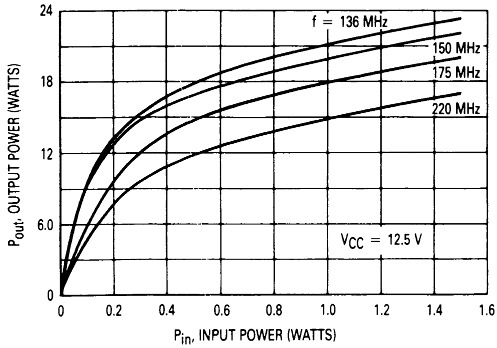


FIGURE 4 — OUTPUT POWER versus SUPPLY VOLTAGE
f = 220 MHz

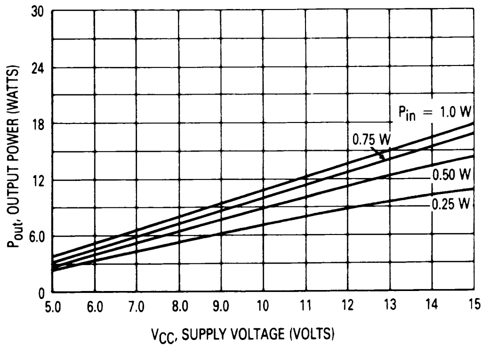


FIGURE 5 — OUTPUT POWER versus SUPPLY VOLTAGE
f = 175 MHz

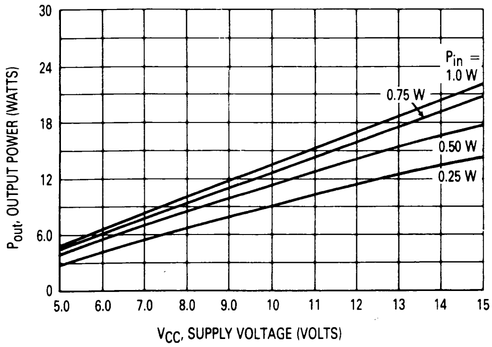


FIGURE 6 — OUTPUT POWER versus SUPPLY VOLTAGE
f = 150 MHz

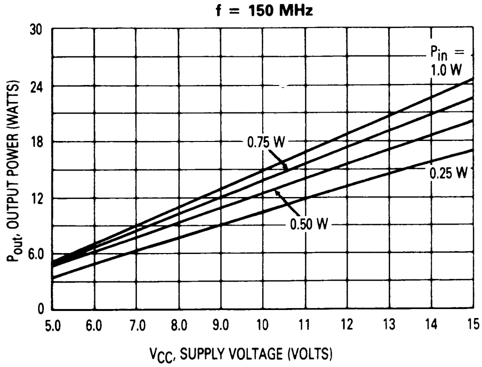


FIGURE 7 — OUTPUT POWER versus SUPPLY VOLTAGE
f = 136 MHz

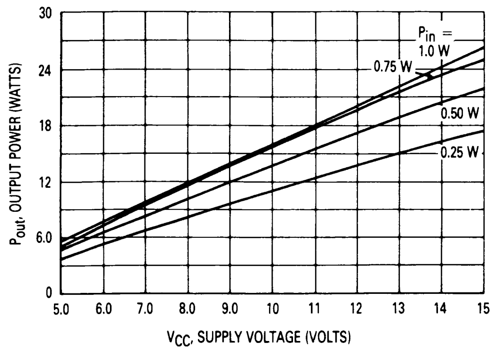


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FIGURE 8 — TYPICAL PERFORMANCE IN A BROADBAND CIRCUIT

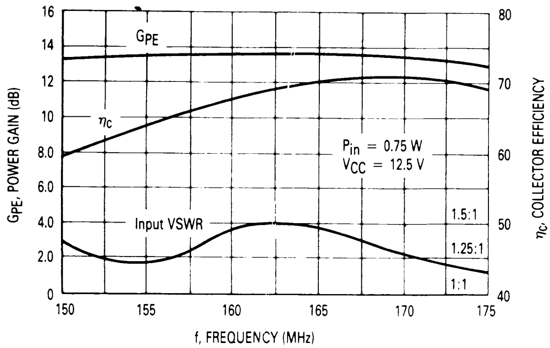
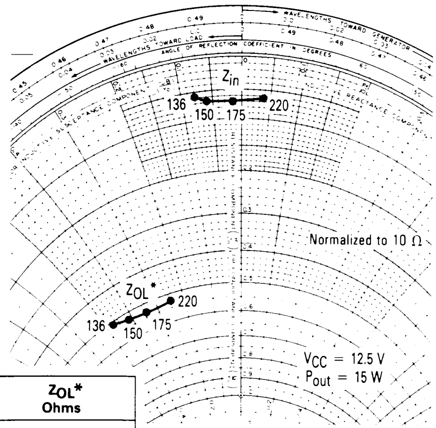


FIGURE 9 — SERIES EQUIVALENT IMPEDANCE

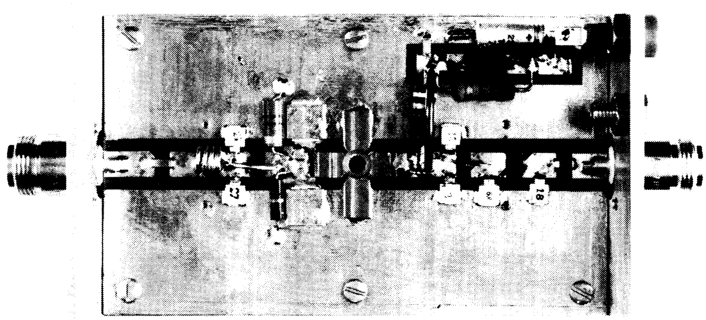


f MHz	Zin Ohms	ZOL* Ohms
220	0.62 + j0.39	5.25 – j2.46
175	0.69 – j0.17	5.26 – j3.46
150	0.68 – j0.61	5.23 – j4.14
136	0.59 – j0.80	5.07 – j4.76

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

3

FIGURE 10 — BROADBAND TEST CIRCUIT



MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

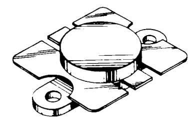
MRF4070

The RF Line

70 W 175 MHz

CONTROLLED Q
RF POWER
TRANSISTOR

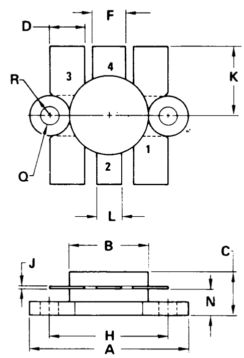
NPN SILICON



NPN SILICON RF POWER TRANSISTORS

. . . designed for 12.5 Volt VHF large-signal amplifier applications in industrial and commercial FM equipment operating to 175 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics —
  Output Power = 70 Watts
  Minimum Gain = 5.0 dB
  Efficiency = 55%
- Characterized With Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broadband Operation
- Capable of Withstanding VSWR of 20:1 at Rated P_{out} and 15.5 V



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

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 — Peak	I_C	20	Adc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	250 1.43	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

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

3

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)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 12.5 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	275	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 70 Watts, F = 175 MHz)	G_{PE}	5.0	—	—	dB
Input Power (V_{CC} = 12.5 Vdc, P_{out} = 70 Watts, f = 175 MHz)	P_{in}	—	—	20	Watts
Collector Efficienty (V_{CC} = 12.5 Vdc, P_{out} = 70 Watts, f = 175 MHz)	η	55	—	—	%

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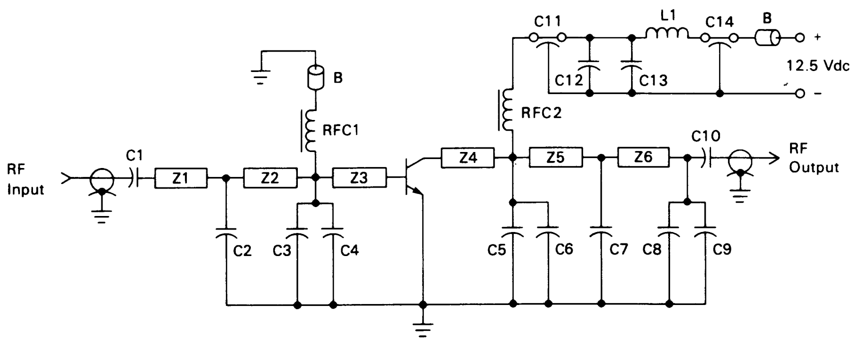
FIGURE 1 — 175 MHz TEST CIRCUIT SCHEMATIC



C1, C10 — 470 pF Unelco
C2 — 40 pF Unelco
C3, C4, C5, C6 — 150 pF Unelco
C7 — 80 pF Unelco
C8 — 25 pF Unelco
C9 — 15 pF Unelco
C11, C14 — 1000 pF Unelco
C12 — 0.05 μF Erie Disc Ceramic
C13 — 10 μF Electrolytic

Z1 = Microstrip 0.5 cm W × 3.5 cm L
Z2 = Microstrip 0.5 cm W × 9.0 cm L
Z3 = Microstrip 0.5 cm W × 1.0 cm L
Z4 = Microstrip 0.5 cm W × 1.0 cm L
Z5 = Microstrip 0.5 cm W × 1.0 cm L
Z6 = Microstrip 0.5 cm W × 9.0 cm L

RFC1 = 0.15 μH Molded Choke
RFC2 = 10 Turns #18 AWG Enameled Wire on 470 Ω, 2.0 W Resistor
L1 = 2.0 cm AWG #16 Wire
B = Fairite #2643021801, Ferrite Bead
Board Material = G10
$\epsilon_r \approx 5$
t = 62 mils

FIGURE 2 — OUTPUT POWER versus INPUT POWER

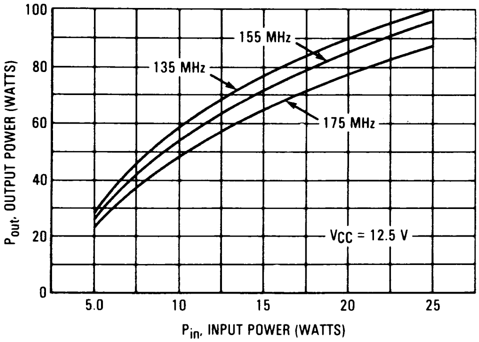


FIGURE 3 — OUTPUT POWER versus INPUT POWER

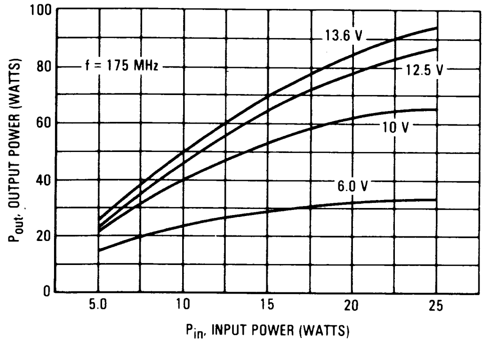


FIGURE 4 — OUTPUT POWER versus FREQUENCY

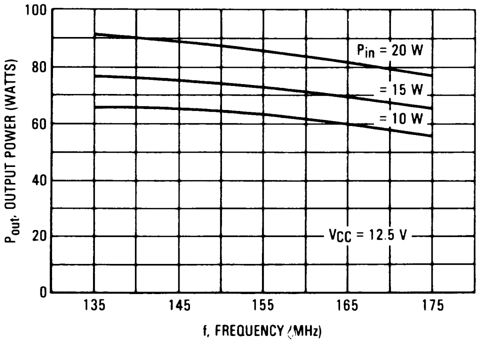
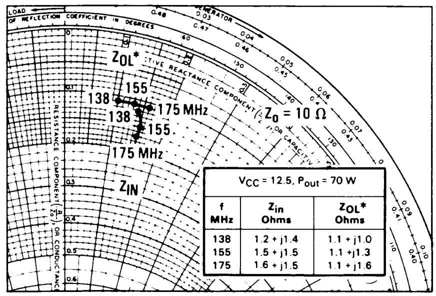


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



V_{CC} = 12.5, P_{out} = 70 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
138	1.2 + j1.4	1.1 + j1.0
155	1.5 + j1.5	1.1 + j1.3
175	1.6 + j1.5	1.1 + j1.6

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

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FIGURE 6 — OUTPUT POWER versus SUPPLY VOLTAGE

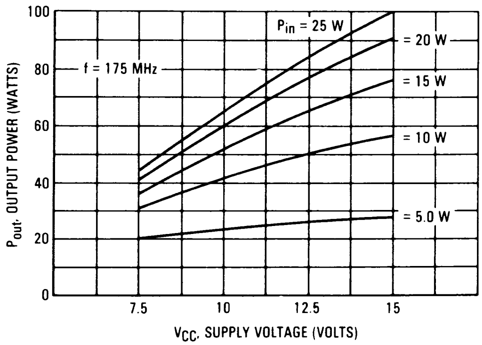

FIGURE 7 — OUTPUT POWER versus VOLTAGE

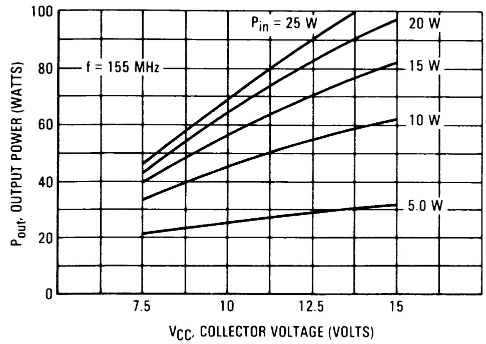

FIGURE 8 — OUTPUT POWER versus VOLTAGE

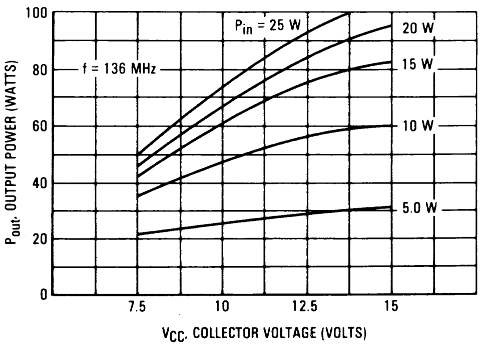

FIGURE 9 — BROADBAND PERFORMANCE GAIN, RETURN LOSS, EFFICIENCY versus FREQUENCY