

MRF515

The RF Line

NPN SILICON HIGH FREQUENCY TRANSISTOR

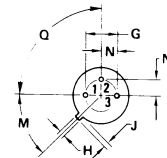
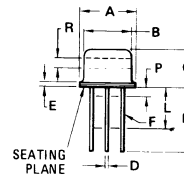
... designed for 12.5 Volt UHF large-signal amplifier applications required in industrial equipment

- Specified 12.5 Volt, 470 MHz Characteristics --
 Output Power = 0.75 Watts
 Minimum Gain = 8.0 dB
 Efficiency = 50%
- S Parameter Data From 100 MHz to 1.0 GHz

0.75 W – 470 MHz

**HIGH FREQUENCY
 TRANSISTOR**

NPN SILICON



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	-	0.500	-
L	6.35	-	0.250	-
M	45° NOM	-	45° NOM	-
P	-	1.27	-	0.050
Q	90° NOM	-	90° NOM	-
R	2.54	-	0.100	-

All JEDEC dimensions and notes apply.

STYLE 1

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

CASE 79-02
 TO-39

MAXIMUM RATINGS

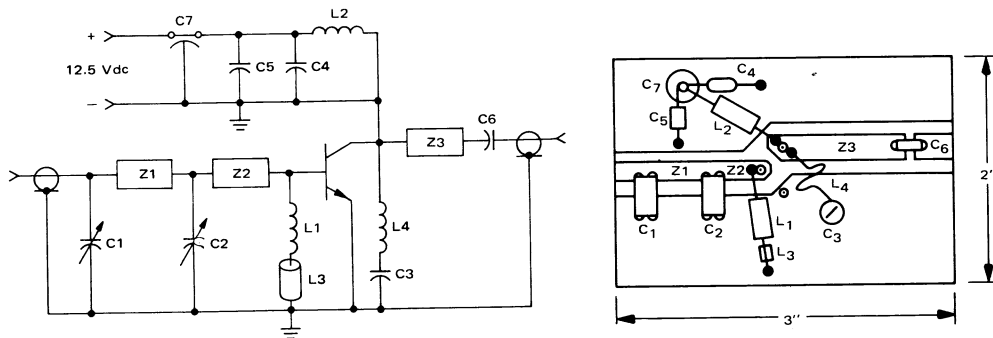
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	20	Vdc
Collector-Base Voltage	V _{CBO}	35	Vdc
Emitter-Base Voltage	V _{EBO}	4.0	Vdc
Collector Current – Continuous	I _C	150	mAdc
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	2.5 14.3	Watts mW/°C
Storage Temperature Range	T _{stg}	-65 to +200	°C

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 5.0 mA, I _B = 0)	V _{(BR)CEO}	20	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA, I _E = 0)	V _{(BR)CBO}	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μA, I _C = 0)	V _{(BR)EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V _{CE} = 15 Vdc, I _B = 0)	I _{CEO}	—	—	10	μA
ON CHARACTERISTICS					
DC Current Gain (I _C = 50 mA, V _{CE} = 10 Vdc)	h _{FE}	20	60	150	—
Collector-Emitter Saturation Voltage (I _C = 50 mA, I _B = 5.0 mA)	V _{CE(sat)}	—	—	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I _C = 100 mA, V _{CE} = 10 Vdc, f = 200 MHz)	f _T	1800	2000	—	MHz
Output Capacitance (V _{CB} = 12.5 Vdc, I _E = 0, f = 1.0 MHz)	C _{ob}	—	3.5	4.0	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V _{CC} = 12.5 Vdc, P _{out} = 0.75 W, f = 470 MHz)	G _{PE}	8.0	8.5	—	dB
Collector Efficiency (V _{CC} = 12.5 Vdc, P _{out} = 0.75 W, f = 470 MHz)	η	50	70	—	%
Series Equivalent Input Impedance (V _{CC} = 12.5 Vdc, P _{out} = 0.75 W, f = 470 MHz)	Z _{in}	—	14+j4.0	—	Ohms
Series Equivalent Output Impedance (V _{CC} = 12.5 Vdc, P _{out} = 0.75 W, f = 470 MHz)	Z _{out}	—	28-j38	—	Ohms

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FIGURE 1 – 470 MHz TEST CIRCUIT



- C1, C2, C3 - 1.0-10 pF JOHANSON
 - C4 - 0.1 μF disc
 - C5 - 1.0 μF TANTULAM
 - C6 - 0.018 μF chip
 - C7 - 1000 pF Feedthru
 - L1, L2 - 0.15 μF Choke
 - L3 - Bead Ferrite
 - Z1, Z2 - 0.09" x 0.5" LINE, Z₀ = 100 Ω
 - Z3 - 0.18" x 1.0" LINE, Z₀ = 50 Ω
- BOARD = 0.032" TEFLONGLASS,
ε_R = 2.5

FIGURE 2 – OUTPUT POWER versus INPUT POWER

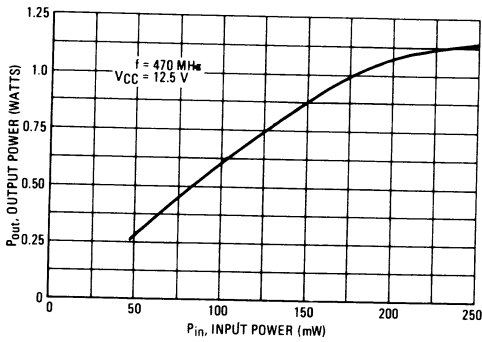


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT versus COLLECTOR CURRENT

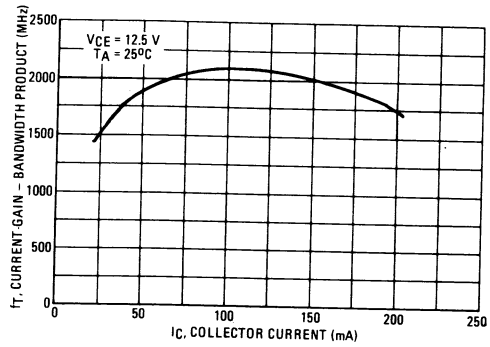


FIGURE 4 – OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE

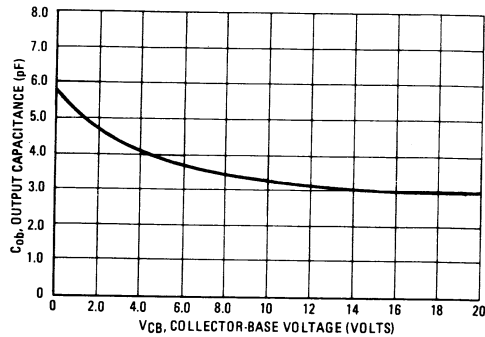


FIGURE 5 – S₁₁ and S₂₂ versus FREQUENCY

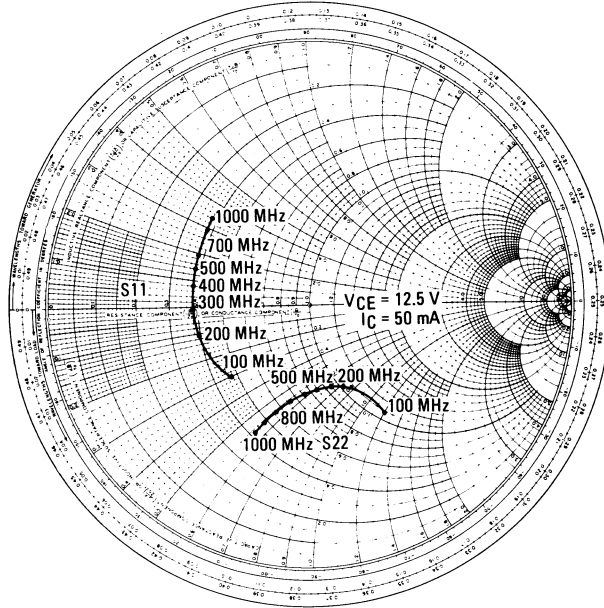


FIGURE 6 – S₁₂ versus FREQUENCY

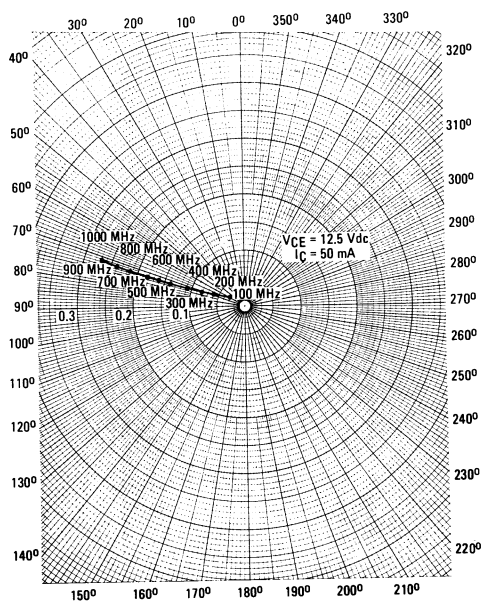
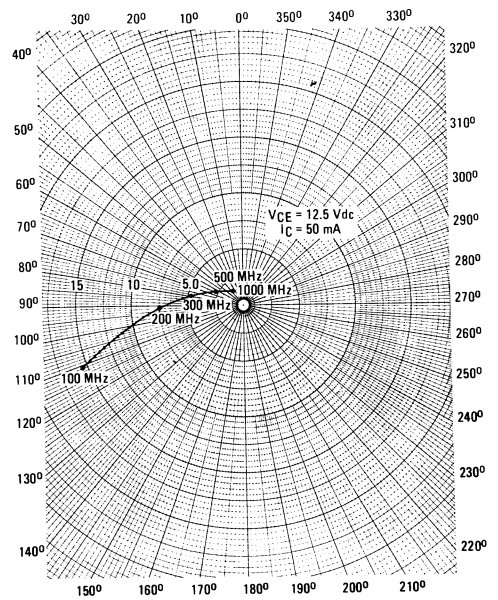


FIGURE 7 – S₂₁ versus FREQUENCY



MRF517

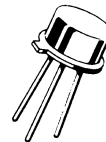
The RF Line

NPN SILICON HIGH FREQUENCY TRANSISTOR

... designed specifically for broadband applications requiring low distortion characteristics. Specified for use in CATV distribution equipment.

- Specified +45 dBmV Output, 60 mA Distortion Characteristics –
 Triple Beat = -72 dB (Max)
 12 Channel Cross Modulation = -57 dB (Max)
 Second Order = -60 dB (Max)
- Broadband Power Gain –
 $G_{PE} = 10$ dB (Typ)
- Broadband Noise Figure –
 $NF = 7.5$ dB (Max) @ $f = 300$ MHz

**HIGH FREQUENCY
 TRANSISTOR
 NPN SILICON**

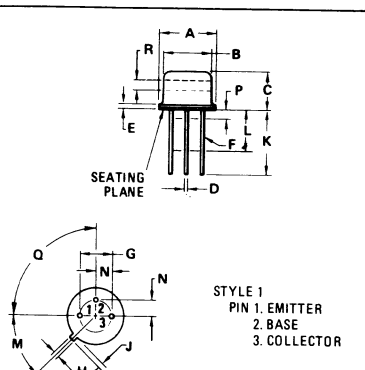
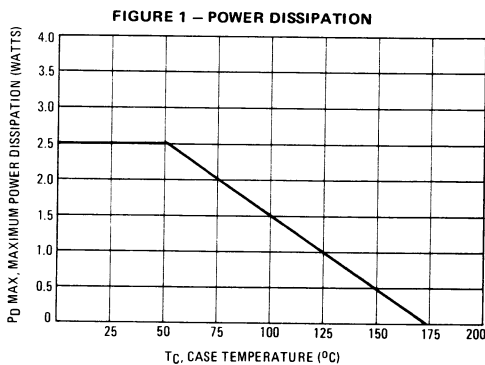


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage ($R_{BE} = 330 \Omega$)	V_{CER}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current – Continuous	I_C	150	mAdc
Total Power Dissipation @ $T_C = 50^\circ C$ Derate above $50^\circ C$	P_D	2.5	Watts
		0.02	W/ $^\circ C$
Operating Junction Temperature	T_J	+175	$^\circ C$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ C$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	$^\circ C/W$



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
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G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45 $^\circ$ NOM	–	45 $^\circ$ NOM	–
P	–	1.27	–	0.050
Q	90 $^\circ$ NOM	–	90 $^\circ$ NOM	–
R	2.54	–	0.100	–

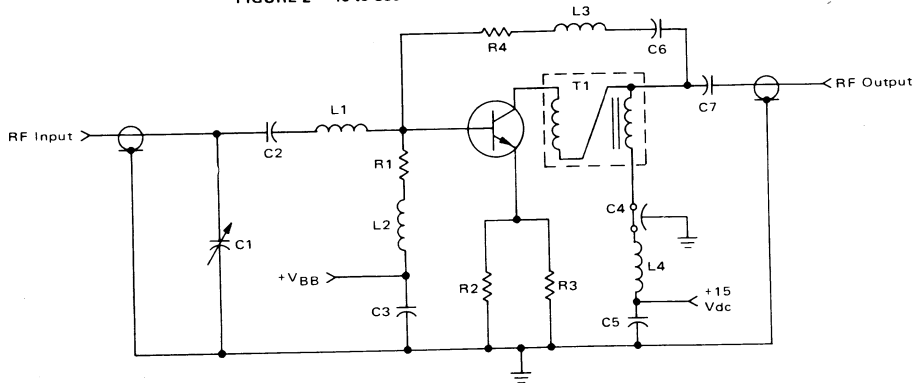
All JEDEC dimensions and notes apply.

**CASE 79-02
 TO-39**

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 5.0 mA, I _B = 0)	V _{(BR)CEO}	20	—	—	Vdc
Collector-Emitter Breakdown Voltage (I _C = 5.0 mA, R _{BE} = 330 Ohms)	V _{(BR)CER}	25	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 100 μA, I _E = 0)	V _{(BR)CBO}	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 100 μA, I _C = 0)	V _{(BR)EBO}	3.5	—	—	Vdc
Collector Cutoff Current (V _{CE} = 15 Vdc, I _B = 0)	I _{CEO}	—	—	100	μA
ON CHARACTERISTICS					
DC Current Gain (I _C = 60 mA, V _{CE} = 10 Vdc)	h _{FE}	40	—	200	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I _C = 60 mA, V _{CE} = 15 Vdc, f = 200 MHz)	f _T	2200	2700	—	MHz
Output Capacitance (V _{CB} = 15 Vdc, I _E = 0, f = 1.0 MHz)	C _{ob}	—	3.0	4.5	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (V _{CE} = 15 Vdc, I _C = 60 mA, f = 300 MHz)	G _{pe}	—	10	—	dB
Broadband Noise Figure (V _{CE} = 15 Vdc, I _C = 50 mA, f = 300 MHz)	NF	—	—	7.5	dB
2nd Order Distortion (V _{CE} = 15 Vdc, I _C = 60 mA, E _{out} = +45 dBmV, Ch 2 + Ch G = 212.5 MHz)	IMD ₂	—	—	-57	dB
NCTA Cross Modulation Distortion, 12 Ch's (2-13) (V _{CE} = 15 Vdc, I _C = 60 mA, E _{out} = +45 dBmV, Measured at Ch's 2 and 13)	XMD ₁₂	—	—	-57	dB
Triple Beat Distortion, 3 Ch's (V _{CE} = 15 Vdc, I _C = 60 mA, E _{out} = +45 dBmV, Ch's (4 + 5 + A) = 265 MHz)	TB ₃	—	—	-72	dB

FIGURE 2 — 40 to 330 MHz BROADBAND TEST CIRCUIT SCHEMATIC



- | | | | |
|------------|-----------------------------|--------|---|
| C1 | 1.0 — 10 pF JOHANSON | L4 | VK200 |
| C2, C6, C7 | 0.002 μF Ceramic Disk | T1 | 16:1 Bifilar Wound, #20 AWG Enameled Wire,
Wound on a FERROXCUBE 1041T060.4C4 Core |
| C3, C5 | 0.1 μF, 50 Vdc Tantalum | R1 | 4.7 kΩ, 1/4 Watt, 5% |
| C4 | 1000 pF Button | R2, R3 | 27 Ω, 1/4 Watt, 5% |
| L1 | 1 Turn, #20 AWG | R4 | 270 Ω, 1/4 Watt, 5% |
| L2 | 5.6 μH Molded Choke | | |
| L3 | 4 Turns, #20 AWG, 1/4" I.D. | | |
- Input/Output Connectors — Type F
Z₀ = 75 Ohms

FIGURE 3 – TYPICAL RESPONSE CURVE
(See Figure 2)

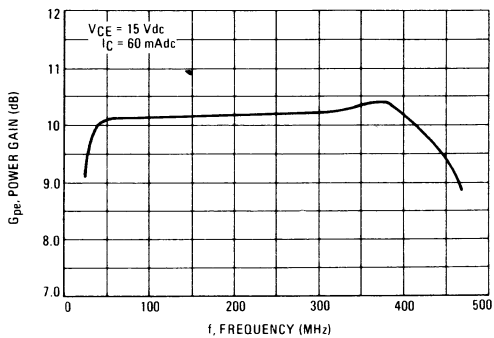


FIGURE 4 – COMMON-EMITTER POWER GAIN
versus FREQUENCY

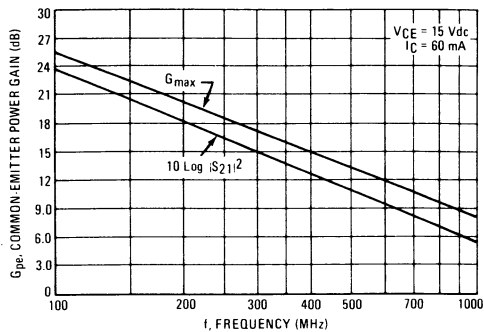


FIGURE 5 – CURRENT GAIN BANDWIDTH PRODUCT
versus COLLECTOR CURRENT

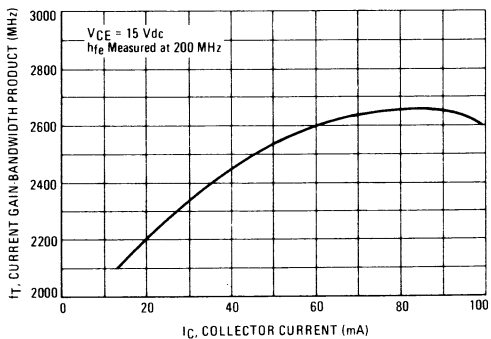


FIGURE 6 – INPUT CAPACITANCE versus
EMITTER-BASE VOLTAGE

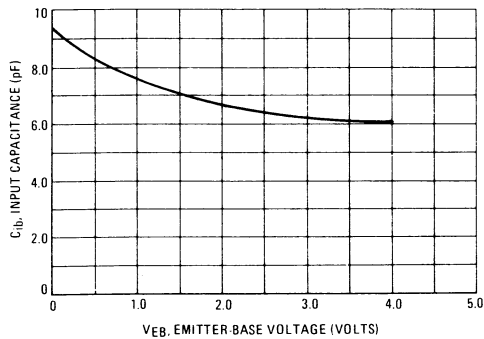


FIGURE 7 – OUTPUT CAPACITANCE versus
COLLECTOR-BASE VOLTAGE

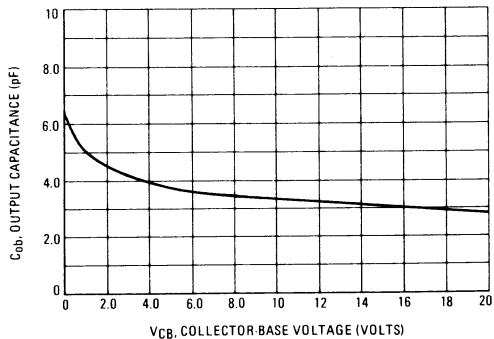


FIGURE 8 – BROADBAND NOISE FIGURE versus
COLLECTOR CURRENT

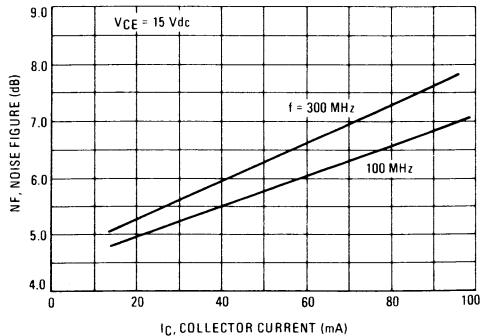


FIGURE 9 – 2nd ORDER DISTORTION ($f_1 \pm f_2$) versus COLLECTOR CURRENT

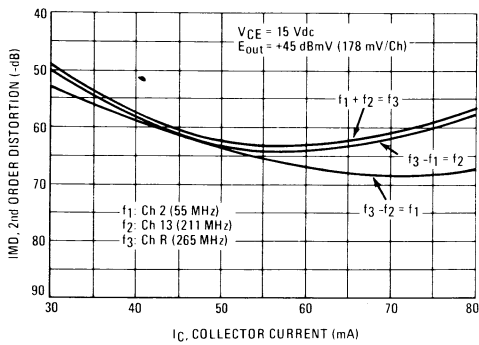


FIGURE 10 – 12-CHANNEL CROSS MODULATION DISTORTION versus COLLECTOR CURRENT

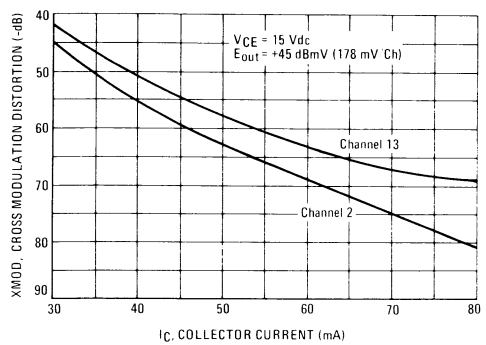


FIGURE 11 – DIN 45004 CROSS-MODULATION DISTORTION

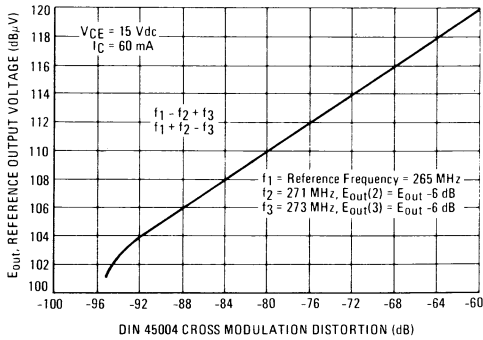


FIGURE 12 – TRIPLE BEAT DISTORTION ($f_1 + f_2 + f_3$) versus COLLECTOR CURRENT

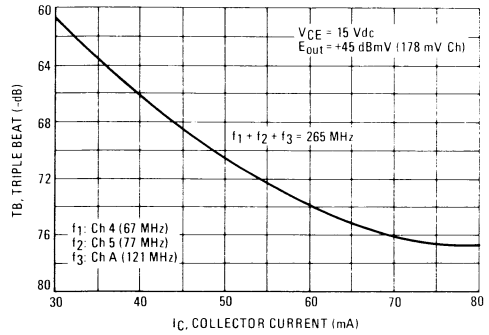
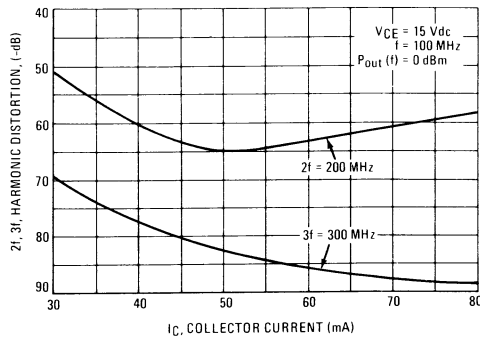


FIGURE 13 – HARMONIC DISTORTION (2f, 3f) versus COLLECTOR CURRENT



VCE (Volts)	IC (mA)	Frequency (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
5	30	100	0.538	-152	12.821	100	0.043	49	0.381	-102
		200	0.546	-173	6.612	86	0.064	55	0.314	-121
		400	0.557	163	3.440	71	0.105	60	0.315	-132
		600	0.602	147	2.357	59	0.144	61	0.360	-140
		800	0.625	136	1.872	46	0.181	59	0.437	-143
		1000	0.626	120	1.614	34	0.211	57	0.482	-144
	60	100	0.532	-160	13.475	98	0.040	54	0.362	-111
		200	0.542	-178	6.850	86	0.063	60	0.314	-130
		400	0.558	160	3.586	72	0.109	63	0.313	-140
		600	0.602	145	2.475	60	0.151	62	0.353	-146
		800	0.619	134	1.962	48	0.190	59	0.423	-147
		1000	0.616	118	1.706	35	0.221	57	0.464	-147
	90	100	0.532	-163	13.530	98	0.038	57	0.354	-115
		200	0.545	179	6.908	85	0.063	62	0.313	-133
		400	0.558	159	3.607	72	0.111	64	0.312	-143
		600	0.604	145	2.489	61	0.153	63	0.352	-148
		800	0.620	133	1.982	48	0.193	59	0.419	-149
		1000	0.614	117	1.721	35	0.224	57	0.455	-148
10	30	100	0.500	-145	14.176	102	0.040	50	0.386	-87
		200	0.502	-170	7.358	87	0.059	55	0.304	-105
		400	0.512	164	3.819	71	0.097	61	0.304	-118
		600	0.559	149	2.593	59	0.133	62	0.356	-128
		800	0.583	137	2.033	46	0.166	60	0.442	-134
		1000	0.584	122	1.724	34	0.194	59	0.497	-137
	60	100	0.487	-154	14.977	100	0.037	55	0.353	-96
		200	0.498	-174	7.715	86	0.059	60	0.287	-114
		400	0.506	161	4.009	72	0.101	63	0.294	-125
		600	0.553	146	2.731	60	0.139	63	0.341	-133
		800	0.572	135	2.158	47	0.174	60	0.422	-137
		1000	0.569	119	1.835	35	0.202	58	0.475	-139
	90	100	0.486	-157	15.192	99	0.036	57	0.337	-98
		200	0.493	-176	7.764	86	0.058	61	0.280	-116
		400	0.508	160	4.043	72	0.101	64	0.287	-126
		600	0.555	145	2.761	60	0.141	63	0.336	-134
		800	0.574	134	2.184	47	0.176	60	0.417	-138
		1000	0.568	118	1.861	35	0.204	58	0.469	-139
15	30	100	0.465	-153	15.774	100	0.035	56	0.337	-88
		200	0.475	-174	8.091	86	0.056	61	0.274	-105
		400	0.487	161	4.209	71	0.097	64	0.284	-116
		600	0.532	146	2.863	59	0.133	63	0.337	-126
		800	0.551	135	2.249	47	0.167	60	0.425	-132
		1000	0.547	119	1.909	34	0.193	58	0.482	-135
	60	100	0.468	-150	15.650	101	0.036	54	0.354	-87
		200	0.475	-172	8.088	87	0.057	60	0.282	-104
		400	0.486	163	4.178	72	0.096	63	0.290	-116
		600	0.530	147	2.846	60	0.133	63	0.341	-126
		800	0.549	136	2.228	47	0.166	60	0.429	-132
		1000	0.547	120	1.887	34	0.192	59	0.487	-135
	90	100	0.487	-141	14.773	103	0.039	50	0.391	-80
		200	0.486	-167	7.724	87	0.057	55	0.303	-97
		400	0.491	166	3.986	71	0.093	61	0.306	-110
		600	0.537	150	2.694	59	0.127	62	0.359	-122
		800	0.565	138	2.108	45	0.159	60	0.448	-129
		1000	0.566	123	1.779	33	0.185	60	0.507	-134



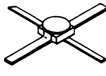


The RF Line
PNP Silicon
High-Frequency Transistors

MRF521
MRFC521
MRF522
MRF524
MRF5211,L

... designed primarily for use in the high-gain, low-noise small-signal amplifiers for operation up to 3.5 GHz. Also usable in applications requiring fast switching times.

- High Current Gain-Bandwidth Product — $f_T = 4.2$ GHz (Typ) @ $I_C = 50$ mAdc
- Low Noise Figure @ $f = 1$ GHz — $NF_{(matched)} = 2.8$ dB (Typ)
- High Power Gain — G_{pe} (matched) = 11 dB (Typ)
- Guaranteed RF Parameters
- Surface Mounted SOT-143 Offers Improved RF Performance
 - Lower Package Parasitics
 - Higher Gain
- Available In Both Standard Profile (MRF5211) and Low Profile (MRF5211L)
- Tape and Reel Packaging Options

HIGH FREQUENCY
TRANSISTORS
PNP SILICON

	MRFC521	MRF521	MRF522	MRF524	MRF5211,L		
							
	Chip	Macro-X Case 317-01	Case 303-01	Case 20-03 (TO-72)	Case 318B-01 (SOT-143)		
MAXIMUM RATINGS							
Ratings	Symbol	Values					Unit
Collector-Emitter Voltage	V_{CEO}	10	10	10	10	10	Vdc
Collector-Base Voltage	V_{CBO}	20	20	20	20	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	2.5	2.5	2.5	2.5	Vdc
Maximum Junction Temperature	T_{Jmax}	200	150	200	200	150	°C
Collector Current — Continuous	I_C	50	70	50	50	70	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	—	—	—	0.2 1.14	0.58 4.64	Watts mW/°C
Total Device Dissipation @ $T_C = 75^\circ\text{C}$ Derate above 75°C	P_D	0.75 —	0.75 10	0.62 5	—	0.58 7.7	Watts mW/°C
Storage Temperature	T_{stg}	-65 to +200	-65 to +150	-65 to +200	-65 to +200	-65 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	—	—	—	870	216	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	—	100	200	—	130	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
----------------	--------	-----	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	10	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 50$ μ Adc, $I_C = 0$)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 8$ Vdc, $I_E = 0$)	I_{CBO}	—	—	10	μ Adc

Note 1. Case Temperature is measured on the collector lead where it first contacts the printed circuit board closest to the package.

(continued)

MRF521 Series

ELECTRICAL CHARACTERISTICS — continued ($T_C = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain ($I_C = 30 \text{ mA}$, $V_{CE} = 5 \text{ Vdc}$)	h_{FE}	25	—	125	—
DYNAMIC CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 6 \text{ Vdc}$, $I_E = 0$, $f = 1 \text{ MHz}$)	Figure 1 C_{cb}	—	1	1.5	pF
Current Gain — Bandwidth Product ($V_{CE} = 8 \text{ Vdc}$, $I_C = 50 \text{ mA}$, $f = 1 \text{ GHz}$)	Figure 7 f_T	—	4.2	—	GHz
FUNCTIONAL TESTS					
Power Gain at Minimum Noise Figure ($V_{CE} = 6 \text{ V}$, $I_C = 5 \text{ mA}$, $f = 500 \text{ MHz}$) ($V_{CE} = 6 \text{ V}$, $I_C = 5 \text{ mA}$, $f = 1 \text{ GHz}$)	Figure 6 MRF524 MRF521/522/5211,L	G_{NFmin}	9 10 11	— — —	dB
Noise Figure ($V_{CE} = 6 \text{ V}$, $I_C = 5 \text{ mA}$, $f = 500 \text{ MHz}$) ($V_{CE} = 6 \text{ V}$, $I_C = 5 \text{ mA}$, $f = 1 \text{ GHz}$)	Figure 6 MRF524 MRF521/522/5211,L	NF_{min}	— — 2.8	— — 3.5	dB

TYPICAL CHARACTERISTICS

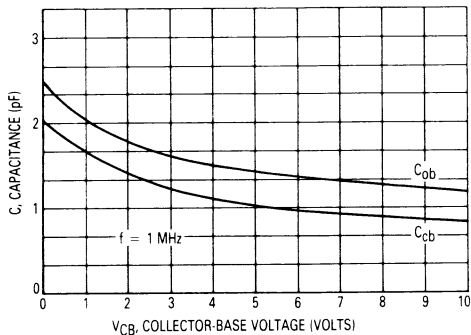


Figure 1. Junction Capacitance versus Voltage

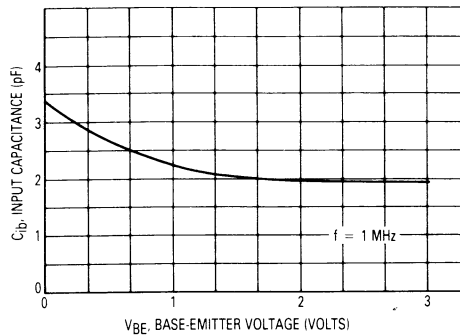


Figure 2. Input Capacitance versus Voltage

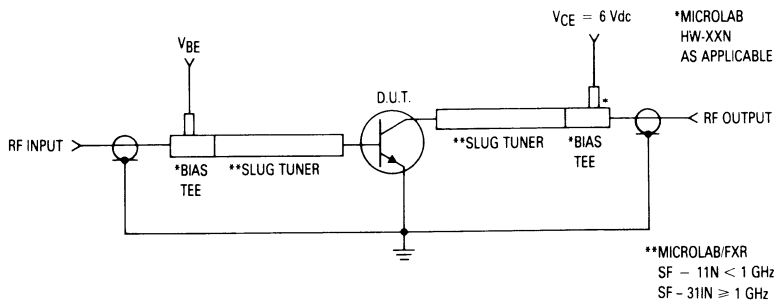


Figure 3. Functional Circuit Schematic

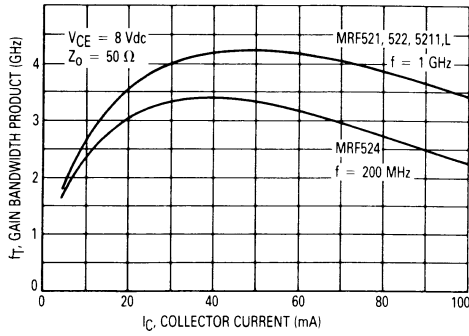


Figure 4. Gain-Bandwidth Product versus Current

GAIN AND NOISE FIGURE VERSUS FREQUENCY

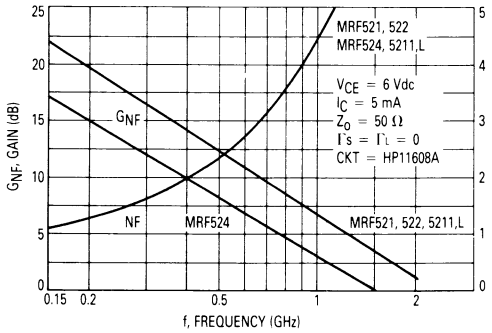


Figure 5. 50 Ohm System

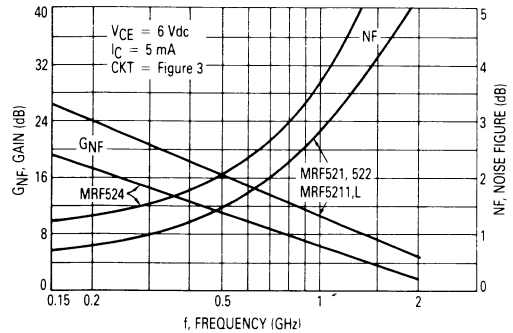


Figure 6. Tuned Circuit

GAIN AND NOISE FIGURE VERSUS CURRENT

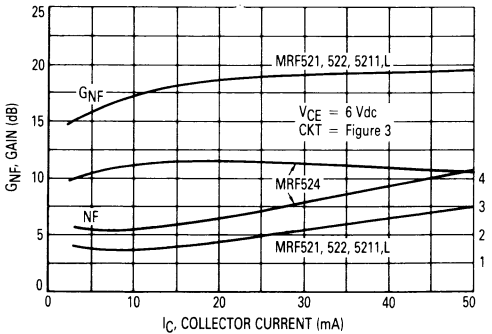


Figure 7. Tuned Circuit — Frequency 500 MHz

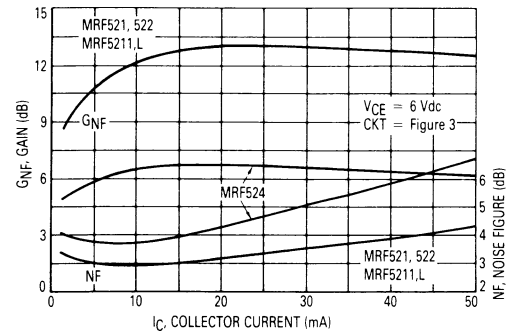


Figure 8. Tuned Circuit — Frequency 1 GHz

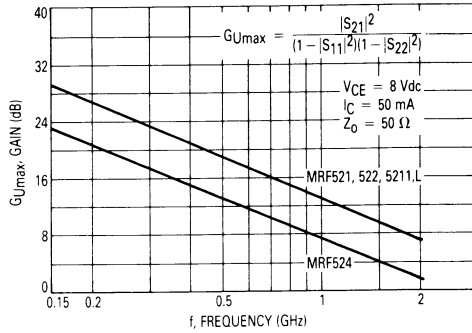


Figure 9. GUmmax versus Current

MRF521 COMMON EMITTER S-PARAMETERS

VCE (Vdc)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
6	5	200	0.75	-116	7.6	117	0.06	36	0.59	-42
		500	0.75	-164	3.9	86	0.07	28	0.42	-51
		1000	0.74	165	2	63	0.08	37	0.37	-64
		1500	0.75	144	1.3	45	0.09	53	0.39	-85
		2000	0.74	124	1	32	0.14	61	0.43	-101
	10	200	0.71	-138	10.7	109	0.04	37	0.45	-54
		500	0.72	-175	4.7	82	0.06	40	0.29	-61
		1000	0.72	148	2.4	63	0.08	55	0.20	-73
		1500	0.72	140	1.6	47	0.11	63	0.28	-94
		2000	0.71	122	1.2	34	0.16	61	0.31	-108
	50	200	0.71	-172	12.9	100	0.02	59	0.26	-77
		500	0.72	170	5.3	78	0.05	68	0.15	-88
		1000	0.72	152	2.7	62	0.09	71	0.13	-99
		1500	0.72	136	1.8	46	0.13	70	0.17	-116
		2000	0.71	118	1.4	63	0.18	63	0.20	-123
8	5	200	0.77	-107	8.3	119	0.06	40	0.64	-38
		500	0.74	-163	4.1	88	0.07	28	0.45	-46
		1000	0.74	167	2.2	64	0.07	39	0.40	-58
		1500	0.74	146	1.4	47	0.08	54	0.42	-79
		2000	0.73	126	1.1	33	0.13	62	0.45	-95
	10	200	0.69	-133	11.5	111	0.04	39	0.49	-49
		500	0.71	-172	5.1	83	0.05	41	0.32	-55
		1000	0.71	161	2.6	64	0.07	56	0.28	-64
		1500	0.71	142	1.7	48	0.10	64	0.30	-85
		2000	0.70	123	1.3	34	0.15	63	0.33	-98
	50	200	0.67	-171	13.2	99	0.02	59	0.25	-70
		500	0.70	171	5.8	81	0.04	67	0.17	-74
		1000	0.69	151	2.9	62	0.08	72	0.15	-82
		1500	0.70	136	2	38	0.12	70	0.17	-100
		2000	0.68	117	1.5	33	0.17	63	0.20	-109

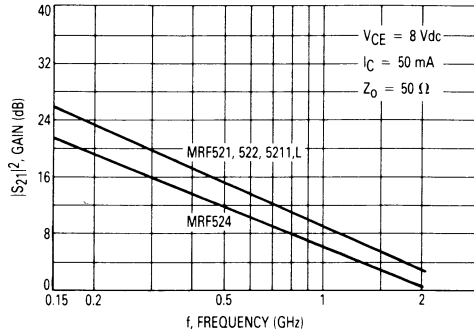


Figure 10. Insertion Gain versus Frequency

MRF522 COMMON EMITTER S-PARAMETERS

VCE (Vdc)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	$\angle \phi$	S21	$\angle \phi$	S12	$\angle \phi$	S22	$\angle \phi$
6	5	200	0.77	-113	7.5	120	0.06	34	0.60	-40
		500	0.80	-157	3.9	90	0.07	18	0.42	-51
		1000	0.83	177	2	70	0.07	14	0.36	-63
		1500	0.84	164	1.3	52	0.06	17	0.37	-88
		2000	0.88	153	1	39	0.06	27	0.41	-106
	10	200	0.77	-138	10.4	112	0.04	32	0.47	-56
		500	0.82	-168	4.9	88	0.05	25	0.28	-65
		1000	0.85	173	2.5	71	0.05	21	0.23	-77
		1500	0.86	163	1.7	56	0.06	39	0.26	-100
		2000	0.88	153	1.3	45	0.07	47	0.30	-112
	50	200	0.81	-169	13.2	104	0.02	43	0.30	-88
		500	0.84	177	5.8	85	0.03	53	0.17	-112
		1000	0.87	166	3	71	0.04	63	0.13	-130
		1500	0.87	158	2	57	0.06	65	0.19	-138
		2000	0.90	149	1.5	47	0.08	66	0.21	-142
8	5	200	0.80	-109	8	121	0.06	36	0.64	-39
		500	0.81	-153	4.1	92	0.07	20	0.43	-46
		1000	0.83	-179	2.1	72	0.07	15	0.38	-58
		1500	0.85	168	1.4	55	0.06	18	0.39	-80
		2000	0.87	157	1.1	43	0.06	28	0.42	-95
	10	200	0.76	-133	11.1	113	0.04	33	0.49	-52
		500	0.80	-167	5.3	89	0.05	25	0.28	-60
		1000	0.83	174	2.7	71	0.05	31	0.23	-69
		1500	0.85	163	1.8	57	0.06	38	0.27	-91
		2000	0.87	153	1.4	46	0.07	46	0.30	-105
	50	200	0.76	-160	14.4	105	0.02	44	0.30	-86
		500	0.80	178	6.4	85	0.03	52	0.16	-110
		1000	0.84	164	3.2	70	0.04	62	0.16	-125
		1500	0.85	154	2.1	55	0.06	64	0.16	-140
		2000	0.88	145	1.7	45	0.08	62	0.19	-141

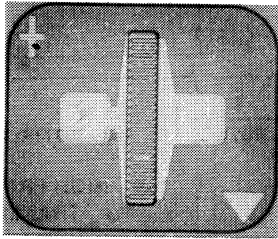
MRF524 COMMON EMITTER S-PARAMETERS

VCE (Vdc)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
6	5	200	0.42	-98	5.8	109	0.07	57	0.65	-26
		400	0.29	-143	3.5	84	0.10	58	0.54	-29
		600	0.27	-175	2.5	71	0.13	60	0.50	-33
		800	0.27	166	2	60	0.17	61	0.47	-42
		1000	0.25	147	1.7	49	0.21	61	0.47	-49
	10	200	0.28	-111	7.3	100	0.06	64	0.54	-28
		400	0.21	-152	4.1	81	0.10	64	0.46	-28
		600	0.20	-179	2.9	69	0.14	63	0.41	-32
		800	0.20	167	2.3	59	0.19	61	0.39	-41
		1000	0.18	149	1.9	49	0.22	58	0.41	-47
	50	200	0.15	-136	8.1	92	0.06	73	0.42	-26
		400	0.13	-172	4.4	77	0.12	70	0.36	-25
		600	0.15	166	3.1	66	0.17	65	0.33	-28
		800	0.15	159	2.4	56	0.21	60	0.32	-38
		1000	0.13	143	2	47	0.25	55	0.32	-45
8	5	200	0.45	-93	6.1	109	0.06	57	0.67	-25
		400	0.30	-137	3.7	86	0.09	58	0.57	-27
		600	0.27	-167	2.6	72	0.12	60	0.51	-32
		800	0.26	174	2.1	61	0.15	60	0.49	-40
		1000	0.23	155	1.8	51	0.19	60	0.50	-47
	10	200	0.28	-100	7.5	101	0.06	65	0.57	-25
		400	0.18	-139	4.3	82	0.10	65	0.49	-26
		600	0.17	-171	3	70	0.13	64	0.45	-30
		800	0.16	174	2.3	60	0.18	61	0.43	-39
		1000	0.13	153	2	50	0.21	58	0.44	-45
	50	200	0.14	-107	8.3	94	0.06	72	0.47	-23
		400	0.10	-155	4.6	78	0.11	70	0.42	-23
		600	0.10	172	3.2	67	0.16	66	0.39	-26
		800	0.10	163	2.5	57	0.20	61	0.37	-36
		1000	0.09	144	2	47	0.24	57	0.37	-42

MRF5211,L COMMON EMITTER S-PARAMETERS

VCE (Vdc)	IC (mA)	f (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
6	5	200	0.82	-114	7.9	118	0.07	35	0.59	-46
		500	0.81	-158	4	88	0.08	21	0.40	-54
		1000	0.79	175	2	67	0.08	21	0.37	-68
		1500	0.76	158	1.3	50	0.07	30	0.43	-82
		2000	0.74	143	1	38	0.08	47	0.47	-95
	10	200	0.78	-137	10.6	109	0.05	32	0.43	-63
		500	0.79	-168	4.9	84	0.06	28	0.26	-75
		1000	0.77	169	2.5	66	0.06	39	0.24	-87
		1500	0.74	155	1.6	50	0.08	49	0.29	-97
		2000	0.71	140	1.2	39	0.10	55	0.32	-106
	50	200	0.77	-167	13.1	99	0.02	45	0.26	-108
		500	0.77	176	5.7	80	0.04	57	0.18	-132
		1000	0.76	161	2.8	65	0.06	65	0.17	-142
		1500	0.73	149	1.9	51	0.08	67	0.19	-137
		2000	0.70	136	1.4	40	0.12	65	0.20	-137
8	5	200	0.82	-109	8.1	119	0.07	36	0.62	-43
		500	0.80	-154	4.2	90	0.08	22	0.42	-52
		1000	0.78	175	2.2	67	0.08	22	0.38	-65
		1500	0.75	159	1.4	50	0.07	31	0.43	-78
		2000	0.72	143	1	37	0.09	43	0.46	-89
	10	200	0.77	-132	11.2	110	0.05	33	0.45	-61
		500	0.77	-167	5.2	86	0.06	29	0.27	-70
		1000	0.76	169	2.6	67	0.06	39	0.25	-81
		1500	0.73	155	1.7	51	0.07	49	0.29	-90
		2000	0.70	140	1.3	39	0.10	54	0.31	-98
	50	200	0.75	-164	14.2	100	0.02	43	0.26	-101
		500	0.76	178	6.1	82	0.04	55	0.17	-121
		1000	0.75	163	3.1	67	0.06	64	0.15	-131
		1500	0.72	151	2	53	0.08	67	0.18	-126
		2000	0.70	139	1.5	42	0.11	68	0.19	-127

CHIP TOPOGRAPHY



Nominal Chip Size: 0.015" x 0.016" x 0.005"
 Front Metallization: Gold
 Back Metallization: Gold
 Emitter Base Bond Pad: 2.2 x 2.2 mil
 #Emitter Fingers: 22
 #Base Fingers: 23
 Emitter Diffusion: Ion-Implanted Arsenic

OUTLINE DIMENSIONS

NOTE: ALL RULES AND NOTES ASSOCIATED WITH TO-72 OUTLINE SHALL APPLY.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

CASE 20-03 TO-206 AF (TO-72)

NOTE: DIMENSION K APPLIES TO ALL LEADS.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.29	2.67	0.090	0.105
C	0.89	1.40	0.035	0.055
D	0.41	0.61	0.016	0.024
F	0.89	1.09	0.035	0.043
J	0.08	0.15	0.003	0.006
K	4.45	5.84	0.175	0.230

CASE 303-01

NOTE: DIMENSION D NOT APPLICABLE IN ZONE N

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
X	7.24	8.13	0.285	0.320
L	10.54	11.43	0.415	0.450
N	—	1.65	—	0.065

CASE 317-01

NOTE: *Low Profile = Case 318A-02

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.80	3.04	0.110	0.120
B	1.20	1.29	0.047	0.055
C	0.85	1.14	0.033	0.045
D	0.38	0.45	0.015	0.018
F	0.08	0.15	0.003	0.006
G	1.78	2.03	0.070	0.080
H	0.51	0.60	0.020	0.024
K	0.10	0.25	0.004	0.010
L	2.11	2.48	0.083	0.098
M	0.46	0.60	0.018	0.024
R	0.71	0.83	0.028	0.033
U	0.78	0.88	0.031	0.035
K	0.013	0.102	0.0005	0.0040

CASE 318B-01 (SOT-143)

MRF525

The RF Line

NPN SILICON HIGH FREQUENCY TRANSISTOR

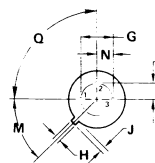
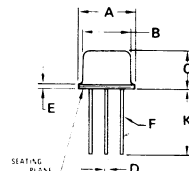
... designed specifically for broadband linear amplifier stages in the 100–500 MHz frequency range.

- Guaranteed Performance at 225–400 MHz, 26 Vdc
 Minimum Gain = 13 dB
 Maximum NF = 4.0 dB
- Third Order Intercept +35 dBm (Typ)
- Common Emitter TO-39 Package
- S-Parameter Characterization

100–500 MHz BROADBAND

**HIGH FREQUENCY
 TRANSISTOR**

NPN SILICON



STYLE 5
 PIN 1. COLLECTOR
 PIN 2. BASE
 PIN 3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.02	9.30	0.355	0.366
B	8.00	8.51	0.315	0.335
C	4.19	4.57	0.165	0.180
D	0.43	0.53	0.017	0.021
E	0.43	0.89	0.017	0.035
F	0.41	0.48	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.71	0.86	0.028	0.034
J	0.74	1.02	0.029	0.040
K	12.70	—	0.500	—
M	45° NOM	—	45° NOM	—
N	2.54 TYP	—	0.100 TYP	—
Q	90° NOM	—	90° NOM	—

NOTE: The pin configuration of this version of the TO-39 package differs from the common isolated emitter type.

All JEDEC dimensions and notes apply.

CASE 79-03
 TO-39

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage ($R_{BE} = 330 \Omega$)	V_{CER}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current – Continuous	I_C	150	mAdc
Total Power Dissipation @ $T_A = 50^\circ\text{C}$ Derate above 50°C	P_D	2.5 0.017	Watts W/ $^\circ\text{C}$
Operating Junction Temperature	T_J	+175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

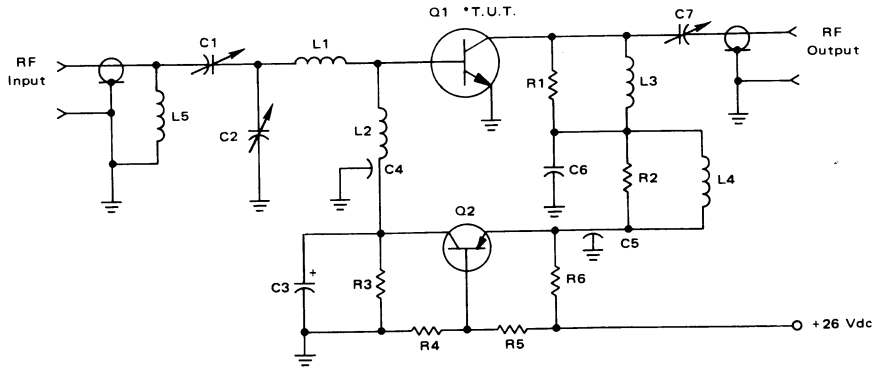
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	60	$^\circ\text{C}/\text{W}$

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I _C = 5.0 mA, I _B = 0)	V _{(BR)CEO}	20	—	—	Vdc
Collector-Emitter Breakdown Voltage (I _C = 5.0 mA, R _{BE} ≈ 330 Ohms)	V _{(BR)CER}	25	—	—	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mA, I _E = 0)	V _{(BR)CBO}	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.1 mA, I _C = 0)	V _{(BR)EBO}	3.5	—	—	Vdc
Collector Cutoff Current (V _{CE} = 15 Vdc, I _B = 0)	I _{CEO}	—	—	100	μA
ON CHARACTERISTICS					
DC Current Gain (I _C = 80 mA, V _{CE} = 10 Vdc)	h _{FE}	60	—	175	—
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I _C = 50 mA, V _{CE} = 20 Vdc, f = 200 MHz)	f _T	2.2	2.5	—	GHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 1.0 MHz)	C _{ob}	—	3.0	4.0	pF
FUNCTIONAL TEST – BROADBAND (Figure 1)					
Common-Emitter Amplifier Power Gain (V _{CC} = 26 Vdc, P _{IN} = 0 dBm, f = 400 MHz)	G _{PE}	13	14	—	dB
Broadband Noise Figure (V _{CE} = 26 Vdc, f = 400 MHz)	NF	—	—	4.0	dB

FIGURE 1 – 225 to 400 MHz BROADBAND TEST CIRCUIT SCHEMATIC



- C1, C2 – 2.5–11 pF Erie Ceramic Variable
- C3 – 47 μF 6.0 Volt Electrolytic
- C4, C5 – 1000 pF Feedthru
- C6 – 470 pF Ceramic Chip
- C7 – 5.5–18 pF Erie Ceramic Variable
- R1 – 150 Ω 1/8 Watt Carbon
- R2 – 100 Ω 1/8 Watt Carbon
- R3, R4 – 10 kΩ 1/8 Watt Carbon
- R5 – 3.3 kΩ 1/8 Watt Carbon

- R6 – 120 Ω 1/2 Watt Carbon
- L1 – 1 Turn #24, 0.125 mil ID
- L2, L4 – 0.47 μH Molded Choke
- L3 – 2 Turns #24, 0.125 mil ID
- L5 – 4 Turns #24, 0.125 mil ID
- Q2 – 2N2907A
- *Transistor Under Test
- I_E = 47 mA (Nominal)

FIGURE 2 – COMMON-EMITTER POWER GAIN (G_{max}) versus FREQUENCY

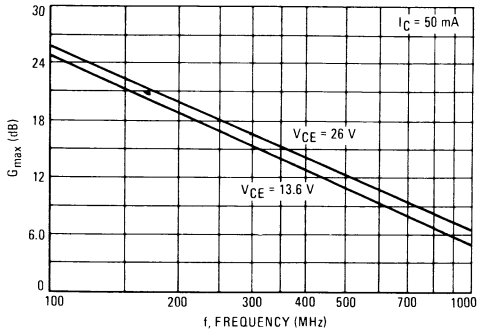


FIGURE 3 – CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT

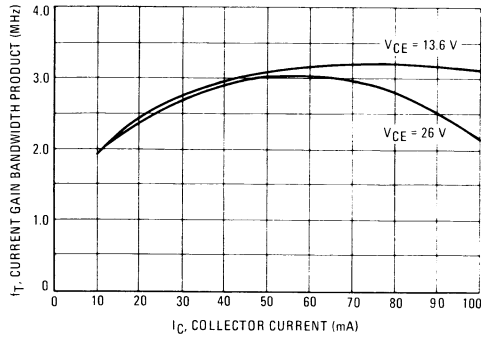


FIGURE 4 – BROADBAND AMPLIFIER RESPONSE

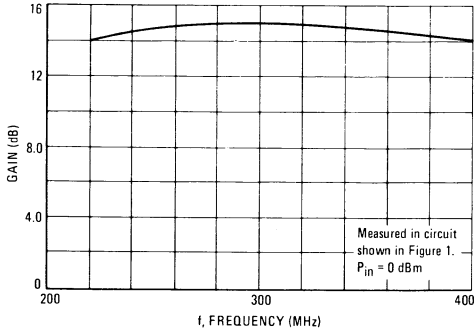


FIGURE 5 – 1.0 dB GAIN COMPRESSION OUTPUT versus FREQUENCY

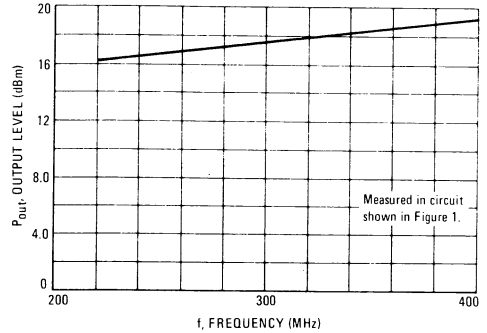
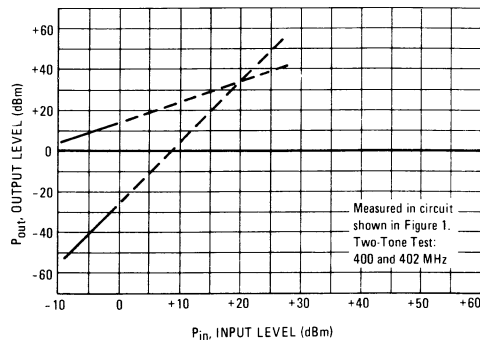


FIGURE 6 – THIRD ORDER INTERCEPT



S-PARAMETERS

V _{CE} (Volts)	I _C (mA)	Frequency (MHz)	S11		S21		S12		S22	
			S11	∠φ	S21	∠φ	S12	∠φ	S22	∠φ
13.6	10	100	0.388	-111	12.318	107	0.032	61	0.597	-24
		200	0.331	-151	6.768	88	0.049	68	0.480	-25
		300	0.337	-171	4.650	77	0.072	73	0.443	-31
		400	0.344	176	3.580	68	0.096	78	0.442	-40
		500	0.349	166	2.889	59	0.125	80	0.459	-47
	20	100	0.287	-125	14.160	103	0.030	67	0.516	-24
		200	0.263	-160	7.585	86	0.053	73	0.414	-23
		300	0.275	-177	5.167	76	0.078	76	0.378	-30
		400	0.288	172	3.968	68	0.104	77	0.378	-38
		500	0.293	164	3.214	60	0.135	78	0.396	-45
	50	100	0.206	-140	15.745	99	0.029	74	0.446	-24
		200	0.208	-171	8.299	84	0.056	76	0.358	-21
		300	0.226	176	5.612	75	0.084	76	0.324	-27
		400	0.235	169	4.307	68	0.113	77	0.326	-36
		500	0.243	161	3.488	60	0.114	76	0.345	-42
	100	100	0.179	-151	15.931	98	0.029	77	0.430	-22
		200	0.187	-177	8.293	85	0.058	80	0.358	-19
		300	0.203	171	5.626	77	0.087	80	0.330	-25
		400	0.212	164	4.276	70	0.115	80	0.338	-33
		500	0.213	157	3.456	63	0.147	79	0.364	-39
26	10	100	0.454	-100	13.580	105	0.027	58	0.625	-15
		200	0.313	-138	7.339	88	0.040	67	0.552	-17
		300	0.291	-161	4.989	78	0.060	76	0.532	-23
		400	0.287	-175	3.826	70	0.080	84	0.544	-30
		500	0.287	173	3.096	63	0.106	89	0.570	-36
	20	100	0.313	-105	15.191	102	0.025	62	0.566	-14
		200	0.220	-144	8.086	87	0.044	73	0.509	-15
		300	0.213	-166	5.487	77	0.067	78	0.489	-20
		400	0.215	-178	4.204	71	0.092	83	0.498	-28
		500	0.214	170	3.404	64	0.116	86	0.523	-34
	50	100	0.165	-117	16.375	102	0.026	71	0.529	-14
		200	0.139	-157	8.695	87	0.048	78	0.471	-14
		300	0.151	-176	5.882	78	0.073	80	0.449	-20
		400	0.157	173	4.494	71	0.098	82	0.458	-27
		500	0.158	164	3.659	65	0.124	84	0.485	-32
	100	100	0.215	-147	13.156	103	0.023	72	0.602	-14
		200	0.212	-176	7.220	88	0.044	82	0.536	-17
		300	0.222	171	4.951	79	0.069	84	0.507	-24
		400	0.230	164	3.851	72	0.093	87	0.513	-31
		500	0.233	156	3.123	64	0.123	89	0.534	-36

MRF531

The RF Line

NPN SILICON HIGH FREQUENCY TRANSISTOR

... designed for high voltage and high current f_T switching applications. These devices are also ideal for CRT drivers.

- High Collector-Emitter Breakdown Voltage – $V_{CE0} = 100$ Vdc (Min) @ $I_C = 10$ mA dc
- High Current-Gain – Bandwidth Product – $f_T = 800$ MHz (Typ) @ $I_C = 50$ mA dc
- Characterized with Safe Operating Area (SOA) Curves

HIGH FREQUENCY TRANSISTOR
NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	100	Vdc
Collector-Base Voltage	V_{CB0}	100	Vdc
Emitter-Base Voltage	V_{EB0}	3.5	Vdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.5 14	Watts mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

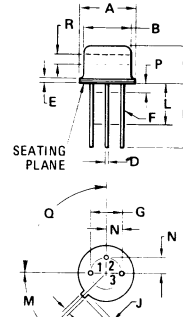
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA dc, $I_B = 0$)	$V_{(BR)CE0}$	100	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mA dc, $I_E = 0$)	$V_{(BR)CB0}$	100	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mA dc, $I_C = 0$)	$V_{(BR)EB0}$	3.5	–	–	Vdc
Collector Cutoff Current ($V_{CE} = 75$ Vdc, $V_{BE} = 0$)	I_{CES}	–	–	10	μA dc

ON CHARACTERISTICS

DC Current Gain ($I_C = 5.0$ mA dc, $V_{CE} = 10$ Vdc)	h_{FE}	25	–	–	–
Collector-Emitter Saturation Voltage ($I_C = 10$ mA dc, $I_B = 1.0$ mA dc)	$V_{CE(sat)}$	–	–	1.0	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain – Bandwidth Product ($I_C = 50$ mA dc, $V_{CE} = 25$ Vdc, $f = 100$ MHz)	f_T	500	800	–	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{ob}	–	–	4.0	pF
Input Capacitance ($V_{BE} = 3.0$ Vdc, $I_C = 0$, $f = 1.0$ MHz)	C_{ib}	–	9.0	–	pF



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

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45 $^\circ$ NOM	45 $^\circ$ NOM	–	–
P	–	1.27	–	0.050
Q	90 $^\circ$ NOM	90 $^\circ$ NOM	–	–
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79.02
 TO-39

FIGURE 1 – CURRENT-GAIN – BANDWIDTH PRODUCT

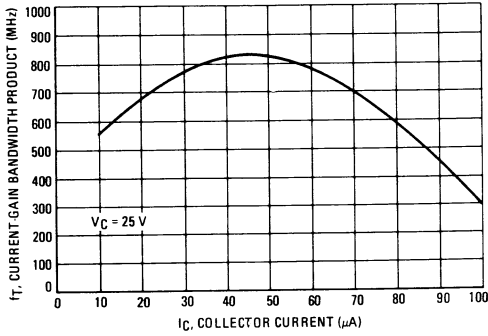


FIGURE 2 – INPUT CAPACITANCE

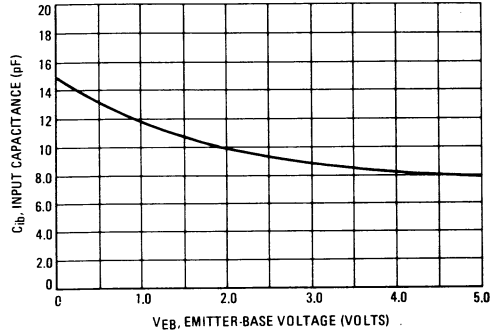


FIGURE 3 – OUTPUT CAPACITANCE

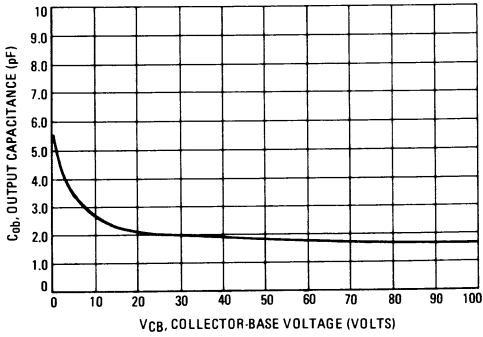


FIGURE 4 – DC SAFE OPERATING AREA

