2N6166

The RF Line

100 WATTS – 150 MHz

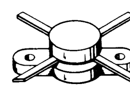
RF POWER
TRANSISTOR

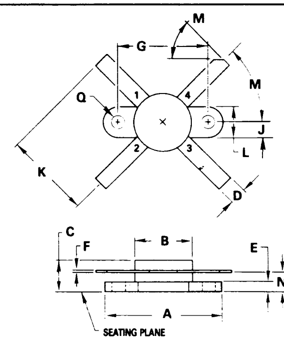
NPN SILICON

NPN SILICON RF POWER TRANSISTOR

. . . designed for VHF power amplifier applications in military and industrial equipment. Particularly suited for use in Class AB, B, or C amplifier applications to 200 MHz

- Specified 28-Volt, 150-MHz Characteristics –
  Output Power = 100 Watts
  Minimum Gain = 6.0 dB
  Efficiency = 60%
- Specified 13.5-Volt, 150 MHz Characteristics –
  Output Power = 30 Watts
  Minimum Gain = 4.5 dB
- Parallel Impedance Characterization





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

NOTE:
1. 211-06 OBS, NEW STD 211-10 FOR REFERENCE, SEE ISSUE "F".

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.38	25.15	0.960	0.990
B	11.81	12.95	0.465	0.510
C	5.82	6.98	0.229	0.275
D	2.16	3.94	0.085	0.155
E	2.13	2.79	0.084	0.110
F	0.08	0.18	0.003	0.007
G	18.29	18.54	0.720	0.730
K	17.78	—	0.700	—
L	6.22	6.48	0.245	0.255
M	45° NOM		45° NOM	
N	3.66	4.52	0.144	0.178
Q	2.92	3.30	0.115	0.130

CASE 211-10

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	9.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ (1) Derate above 25^oC	P_D	117 0.667	Watts $W/^oC$
Storage Temperature Range	Tstg	–65 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	$^oC/W$

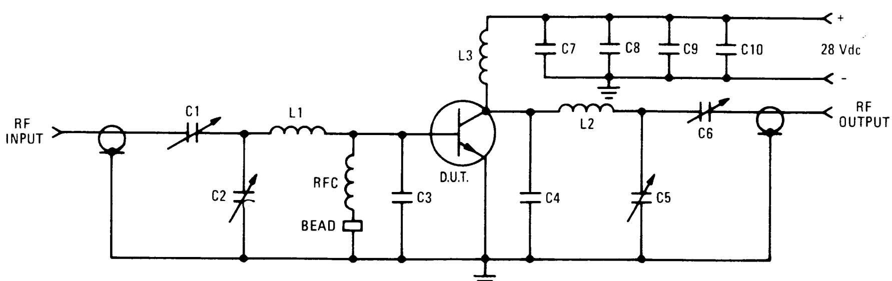
(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	$V_{(BR)CEO}$	35	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	65	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	5.0	mAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	3.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	130	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (P_{out} = 100 W, V_{CC} = 28 Vdc, I_C (Max) = 5.95 Adc, f = 150 MHz)	G_{PE}	6.0	–	dB
Common-Emitter Amplifier Power Gain (P_{out} = 30 W, V_{CC} = 13.5 V, f = 150 MHz)	G_{PE}	4.5	–	dB
Collector Efficiency (P_{out} = 100 W, V_{CC} = 28 Vdc, I_C (Max) = 5.95 Adc, f = 150 MHz)	η	60	–	%

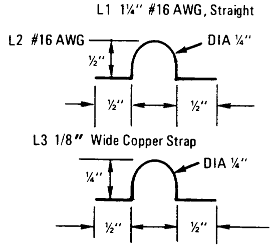
3

FIGURE 1 – 150 MHz TEST CIRCUIT



C1, C6 2.7-30 pF, Arco 461 or Equivalent
C2, C5 9.0-180 pF, Arco 463 or Equivalent
C3 100 pF Underwood
C4 25 pF Underwood
C7 0.01 μF Ceramic Disc
C8 0.1 μF Ceramic Disc
C9 2400 pF Button
C10 5.0 μF/50 V
RFC 0.15 μH J. W. Miller
BEAD: FERROXCUBE 56-590-65-3B

L1 1¼" #16 AWG, Straight



OUTPUT POWER versus FREQUENCY

FIGURE 2 – V_{CC} = 28 Vdc

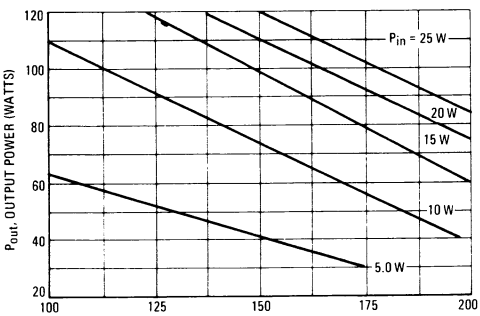


FIGURE 3 – V_{CC} = 13.5 Vdc

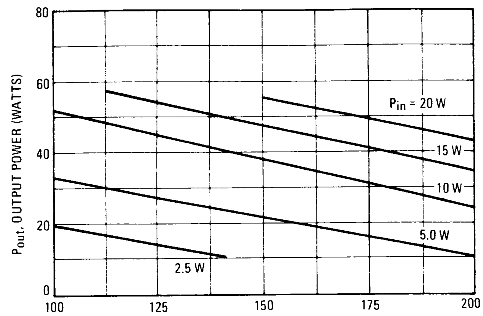


FIGURE 4 – OUTPUT POWER versus INPUT POWER

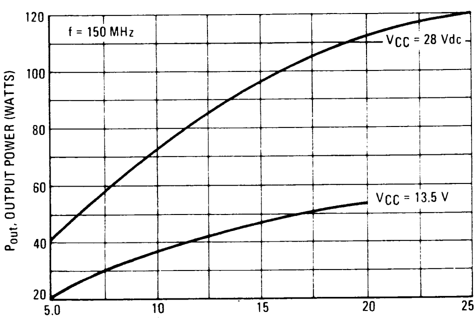


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE

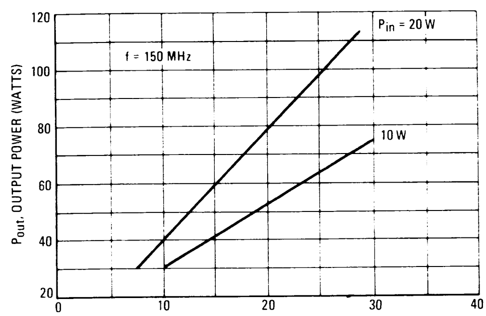


FIGURE 6 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

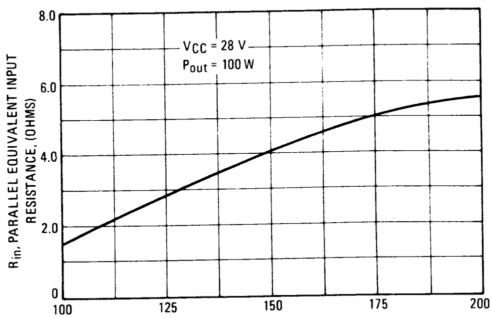


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FIGURE 7 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

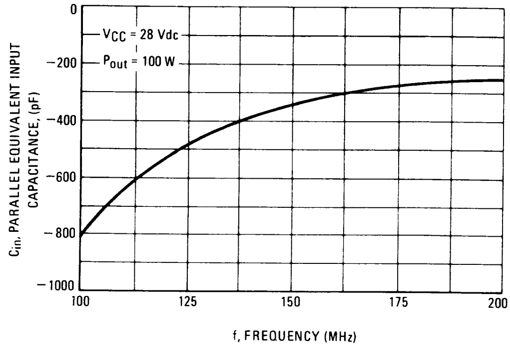
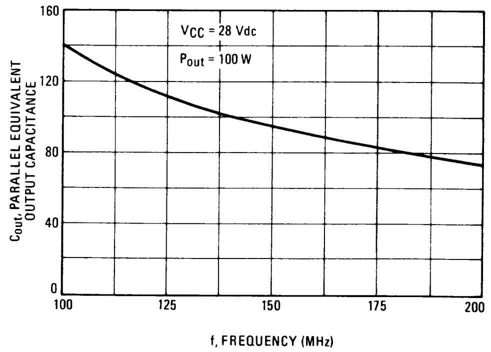


FIGURE 8 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



3

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

2N6304
2N6305

The RF Line

NPN SILICON HIGH-FREQUENCY TRANSISTORS

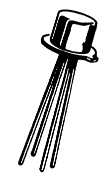
... designed for use as low-noise, high-gain, general-purpose amplifiers.

- High Current-Gain – Bandwidth Product –
  f_T = 1.4 GHz (Min) @ I_C = 10 mAdc – 2N6304
  = 1.2 GHz (Min) @ I_C = 10 mAdc – 2N6305
- Low Noise Figure –
  NF = 4.5 dB (Max) @ f = 450 MHz – 2N6304
  = 5.5 dB (Max) @ f = 450 MHz – 2N6305
- High Power Gain –
  G_{pe} = 15 dB (Min) @ f = 450 MHz – 2N6304
  = 12 dB (Min) @ f = 450 MHz – 2N6305

1.4 GHz @ 10 mAdc – 2N6304
1.2 GHz @ 10 mAdc – 2N6305

HIGH FREQUENCY TRANSISTORS

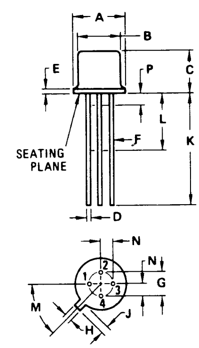
NPN SILICON



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage 1.0 to 20 mAdc	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current Continuous	I_C	50	mAdc
Total Continuous Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



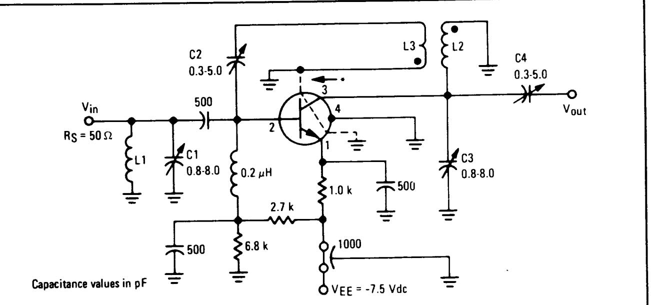
STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

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

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.
L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.
* – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:
(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.
(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.
(D) Interchange connections to signal generator and RF voltmeter.
(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.
(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 5.0 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 = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	3.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	25	–	250	–
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} - 5.0 Vdc, f - 100 MHz)	2N6304 2N6305	f_T	1400 1200	– –	– –	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	–	0.8	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	25	–	250	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 5.0 Vdc, f = 31.8 MHz)	2N6304 2N6305	$r_b'C_c$	2.0 2.0	–	12 15	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 50 ohms, f = 450 MHz) (Figure 1)	2N6304 2N6305	NF	– –	– –	4.5 5.5	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 450 MHz) (Figure 1)	2N6304 2N6305	G_{pe}	15 12	– –	– –	dB

*Indicates JEDEC Registered Data.

FIGURE 2 — COLLECTOR-BASE CAPACITANCE versus COLLECTOR BASE VOLTAGE

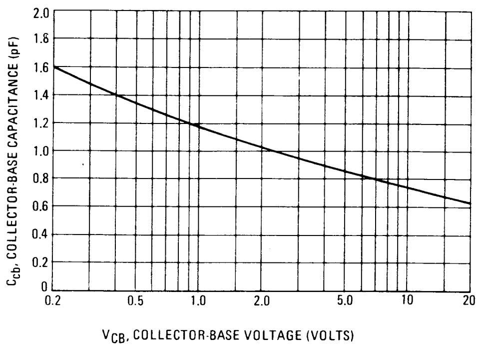


FIGURE 3 – CURRENT-GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

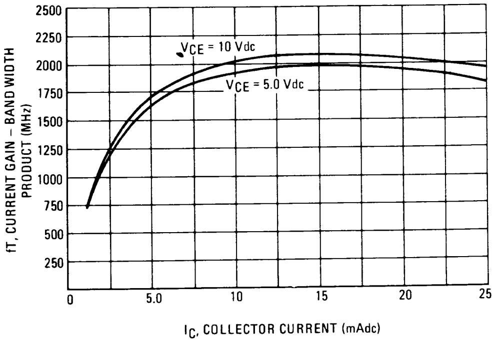


FIGURE 4 – COLLECTOR-BASE TIME CONSTANT versus EMITTER CURRENT

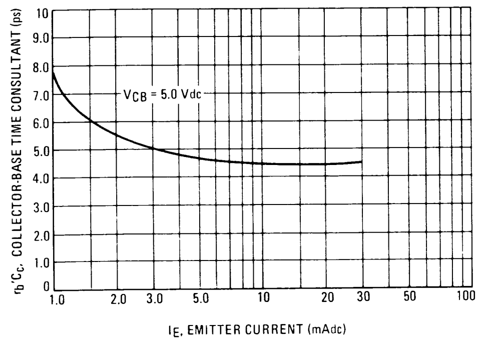


FIGURE 5 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

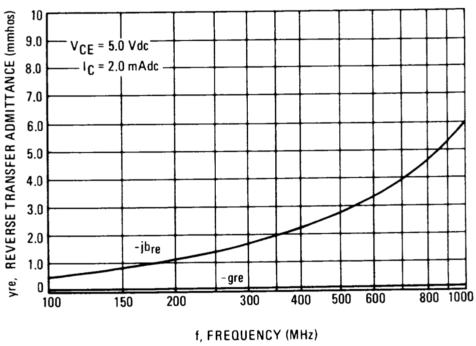


FIGURE 6 – INPUT ADMITTANCE versus FREQUENCY

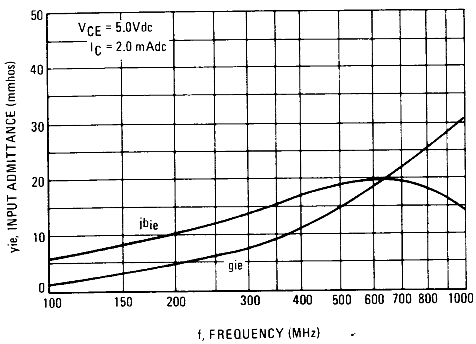


FIGURE 7 – OUTPUT ADMITTANCE versus FREQUENCY

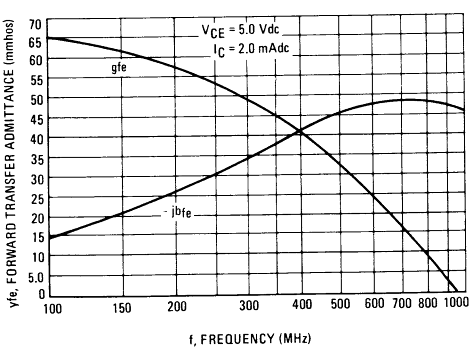


FIGURE 8 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

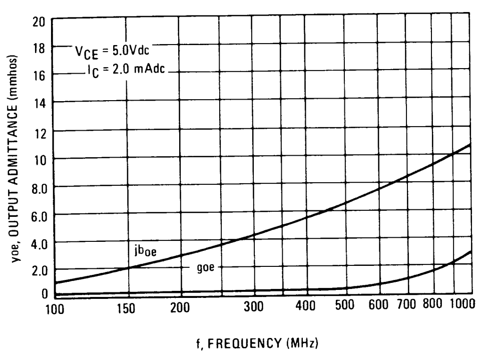


FIGURE 9 – S_{11}, INPUT REFLECTION COEFFICIENT

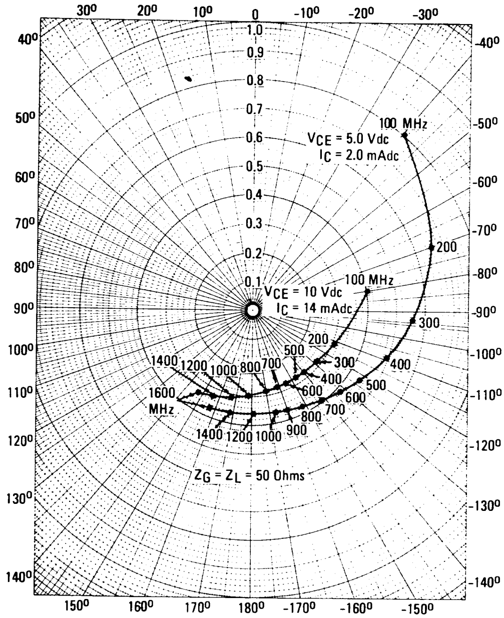


FIGURE 10 – S_{22}, OUTPUT REFLECTION COEFFICIENT

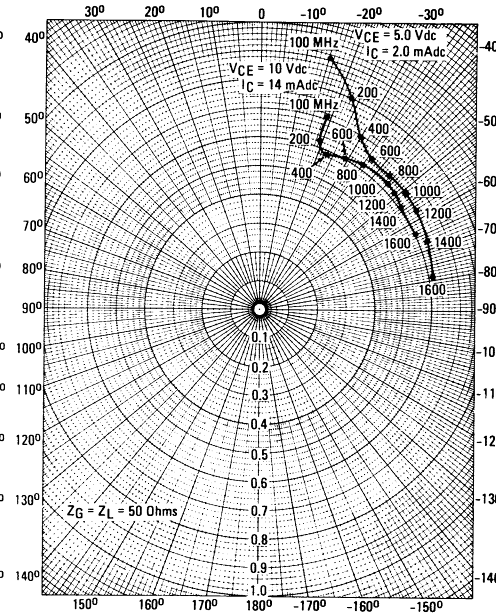


FIGURE 11 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

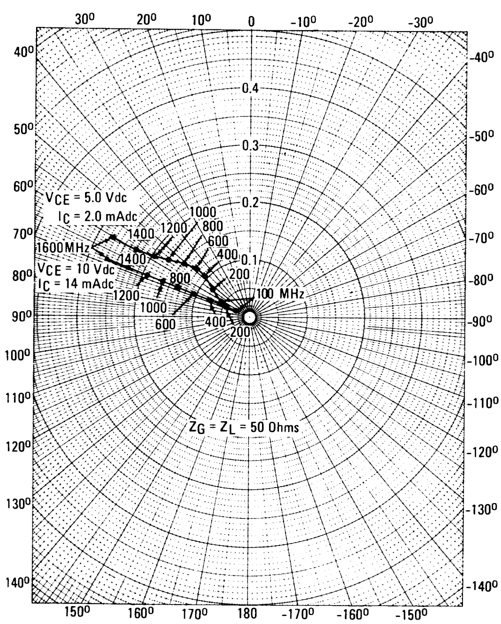


FIGURE 12 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

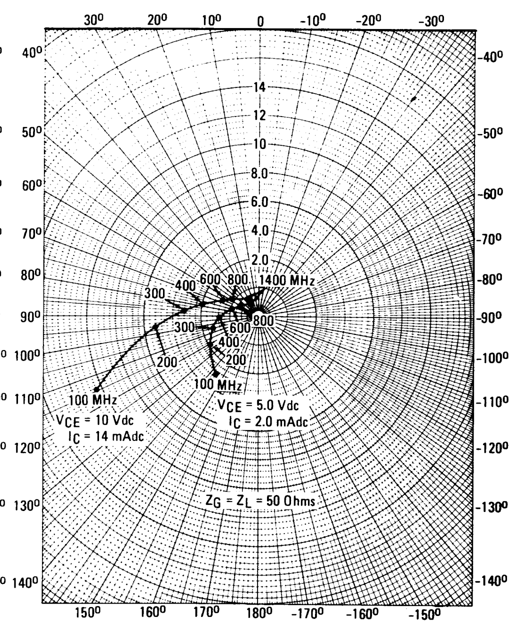
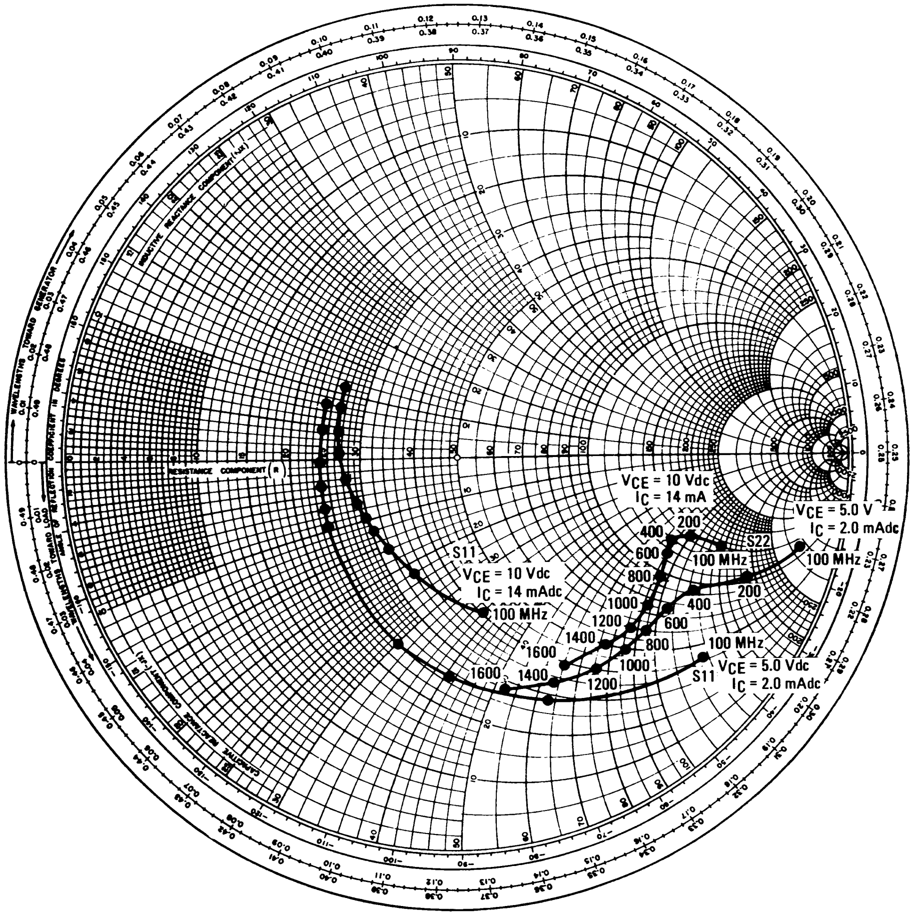


FIGURE 13 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



2N6439

The RF Line

NPN SILICON RF POWER TRANSISTOR

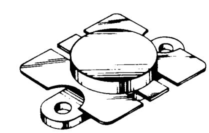
. . . designed primarily for wideband large-signal output amplifier stages in the 225-400 MHz frequency range.

- Guaranteed Performance in 225–400 MHz Broadband Amplifier @ 28 Vdc
  Output Power = 60 Watts over 225–400 MHz Band
  Minimum Gain = 7.8 dB @ 400 MHz
- Built-In Matching Network for Broadband Operation Using Double Match Technique
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Gold Metallization System for High Reliability Applications

60 W – 225–400 MHz

CONTROLLED "Q" BROADBAND RF POWER TRANSISTOR

NPN SILICON



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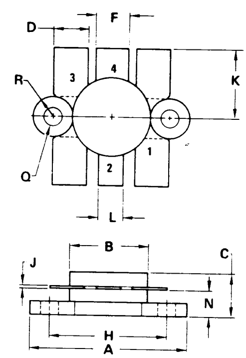


STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE

NOTE:
FLANGE IS ISOLATED IN ALL STYLES.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES 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
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
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

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	33	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ $T_C = 25^{\circ}C$ (1) Derate above 25°C	P_D	146 0.83	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.2	°C/W

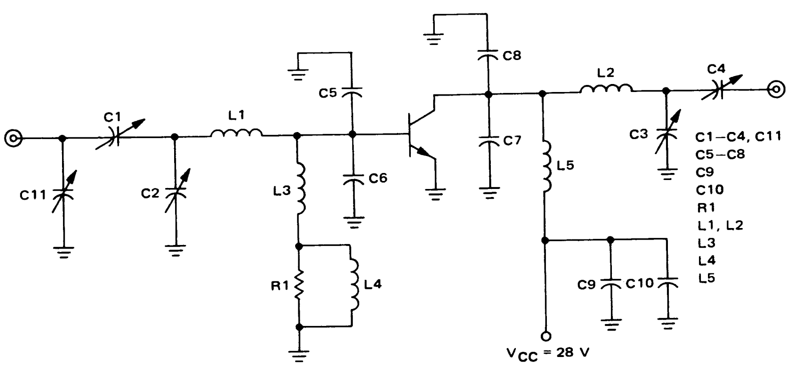
(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.

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

Characteristics	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	33	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	100	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	67	75	pF
BROADBAND FUNCTIONAL TESTS (Figure 6)					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 60 W, f = 225–400 MHz)	G_{PE}	7.8	8.5	–	dB
Electrical Ruggedness (P_{out} = 60 W, V_{CC} = 28 Vdc, f = 400 MHz, VSWR 30:1 all phase angles)	–	No Degradation in P_{out}			–
NARROW BAND FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 60 W, f = 400 MHz)	G_{PE}	7.8	10	–	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 60 W, f = 400 MHz)	η	55	–	–	%

3

FIGURE 1 – 400 MHz TEST AMPLIFIER (NARROW BAND)



C1–C4, C11	4–40 pF
C5–C8	33 pF
C9	1000 pF
C10	5.0 μF
R1	15 Ω
L1, L2	3/16" x 1" Copper Strap
L3	1.5 μH
L4	10 μH
L5	1 Turn #16 AWG, 5/16" I.D.

NARROW BAND DATA

FIGURE 2 — P_{out} versus FREQUENCY

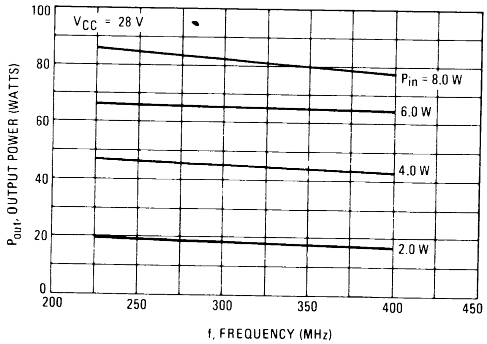


FIGURE 3 — OUTPUT POWER versus INPUT POWER

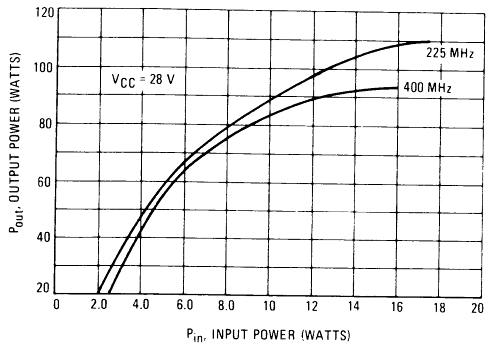


FIGURE 4 — POWER-GAIN versus FREQUENCY

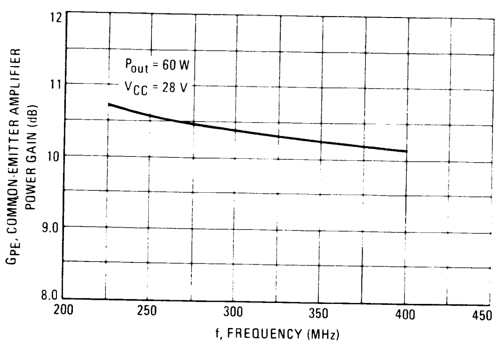


FIGURE 5 — OUTPUT POWER versus SUPPLY VOLTAGE

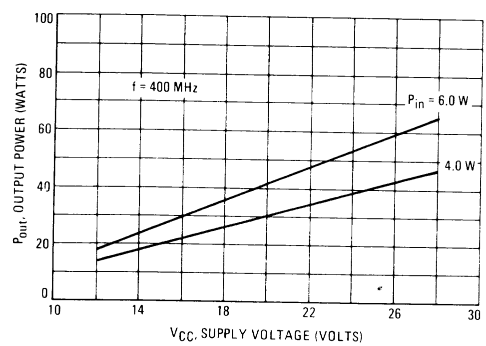


FIGURE 6 — OUTPUT POWER versus SUPPLY VOLTAGE

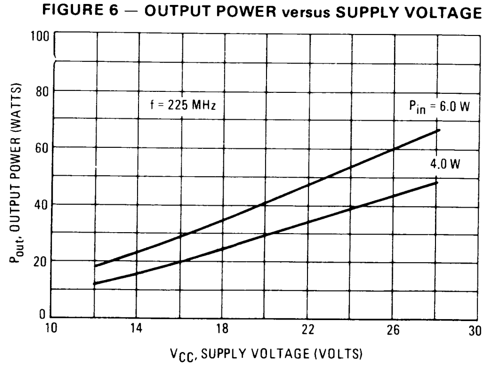


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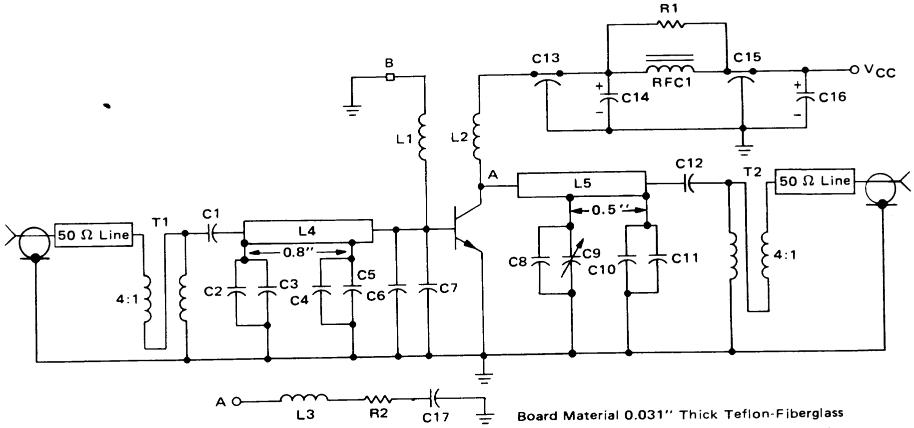
FIGURE 7 — 225-400 MHz BROADBAND TEST CIRCUIT SCHEMATIC



C1	68 pF		Board Material 0.031" Thick Teflon-Fiberglass
C2, C4, C8, C10	27 pF	RFC1	Ferrite Bead Choke, Ferroxcube VK200 19/4B
C3, C5, C11	10 pF	B	Ferroxcube 56-590-65/4B Ferrite Bead
C6, C7	51 pF	T1, T2	25 Ohms (UT25) Miniature Coaxial Cable, 1 turn
C9	1–10 pF JOHANSON	R1	11 Ω, 1 W
C12	100 pF	R2	20 Ω, 1/4 W
C13, C15	680 pF	L1	10 Turns, #22 AWG, 1/8" I.D.
C14, C16	1.0 μF, 35 V Tantalum	L2	4 Turns, #16 AWG, 1/4" I.D.
C17	0.1 μF, ERIE Red Cap	L3	6 Turns, #24 AWG, 1/8" I.D.
		L4, L5	1" x 0.25" Microstrip Line

BROADBAND DATA (Circuit, Figure 7)

FIGURE 8 — POWER GAIN versus FREQUENCY

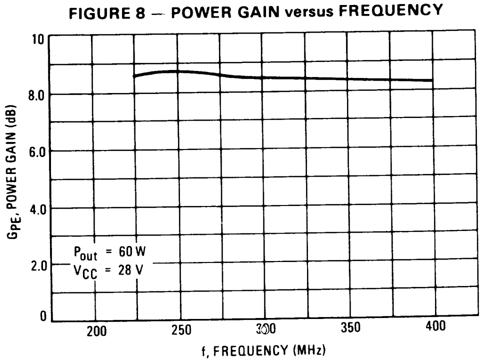


FIGURE 9 — EFFICIENCY versus FREQUENCY

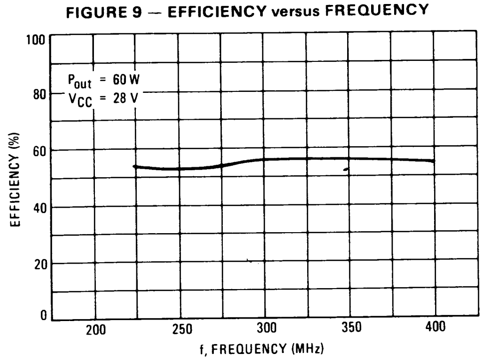


FIGURE 10 — INPUT VSWR versus FREQUENCY

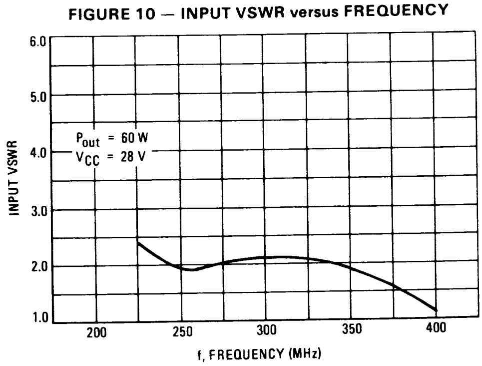
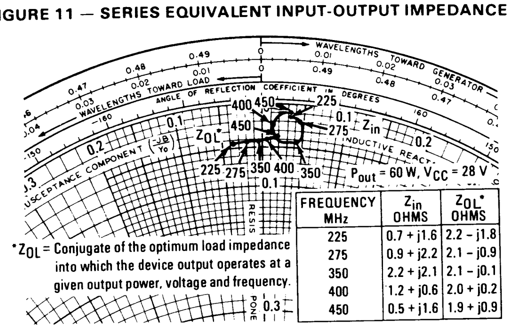


FIGURE 11 — SERIES EQUIVALENT INPUT-OUTPUT IMPEDANCE



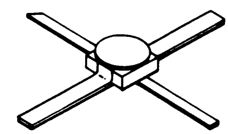
FREQUENCY MHz	Z_{in} OHMS	Z_{OL}* OHMS
225	0.7 + j1.6	2.2 – j1.8
275	0.9 + j2.2	2.1 – j0.9
350	2.2 + j2.1	2.1 – j0.1
400	1.2 + j0.6	2.0 + j0.2
450	0.5 + j1.6	1.9 + j0.9

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

2N6603

The RF Line

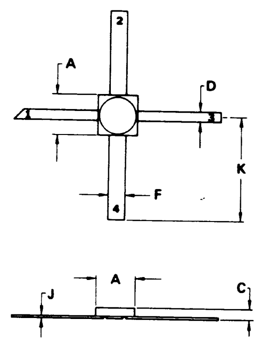
NF = 2.0 dB @ 1.0 GHz
HIGH FREQUENCY TRANSISTOR
NPN SILICON



NPN SILICON HIGH FREQUENCY TRANSISTOR

... designed for use in high-gain, low-noise, small signal, narrow and wideband amplifiers. Ideal for use in microstrip thin and thick film applications.

- Low Noise Figure —
  NF = 2.0 dB (Typ) @ f = 1.0 GHz
  = 2.9 dB (Typ) @ f = 2.0 GHz
- High Power Gain —
  MAG = 17 dB (Typ) @ f = 1.0 GHz
  = 11 dB (Typ) @ f = 2.0 GHz
- Ion Implantation and Gold Metallization
- Metal/Ceramic Hermetic Package
- JAN, JTX, JTXV Available



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES 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

NOTE:
1. DIMENSION K APPLIES TO ALL LEADS.

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

CASE 303-01

***MAXIMUM RATINGS (T_A = 25°C Free Air Temperature)**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current—Continuous	I_C	30	mAdc
Total Device Dissipation @ T_C = 125°C Derate Above 100°C	P_D	400 5.33	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

Specification and Package Options

Devices using the same die type as the 2N6603:

MRF901 — 4 Lead Plastic Macro-T Case 302-01
MRF902 — 100 mil Metal/Ceramic Case 303-01
MRF904 — TO-72
MMBR901 — MiniBloc Plastic (SOT-23) TO-236
MRFC901 — Unencapsulated Chip

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

Characteristic	Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
***ON CHARACTERISTICS**					
DC Current Gain (I_C = 15 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	–	200	–
***DYNAMIC CHARACTERISTICS**					
Collector-Base Capacitance (1) (V_{CB} = 10 Vdc, I_E = 0, 0.1 MHz ≤ f ≤ 1.0 MHz)	C_{cb}	0.25	–	0.75	pF
***FUNCTIONAL TEST**					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 15 mA, f = 1.0 GHz—Figure 2)	G_{pe}	15	–	21	dB
Spot Noise Figure (R_S = Optimum—Figure 2) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	NF	1.0	–	2.5	dB
Power Gain at Optimum Noise Figure (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	G_{NF}	10	–	–	dB
TYPICAL 2 GHz PERFORMANCE					
Maximum Available Gain (Figure 2) (2) (V_{CE} = 10 Vdc, I_C = 15 mA, f = 2.0 GHz)	MAG	–	11	–	dB
Noise Figure (R_S = Optimum—Figure 2) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 2.0 GHz)	NF	–	2.9	–	dB

*Indicates JEDEC Registered Data.

(1) C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal of the bridge.

(2) MAG is calculated from the S-Parameters using the equation $MAG = \frac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

FIGURE 1 – BLOCK DIAGRAM FOR POWER GAIN AND NOISE FIGURE

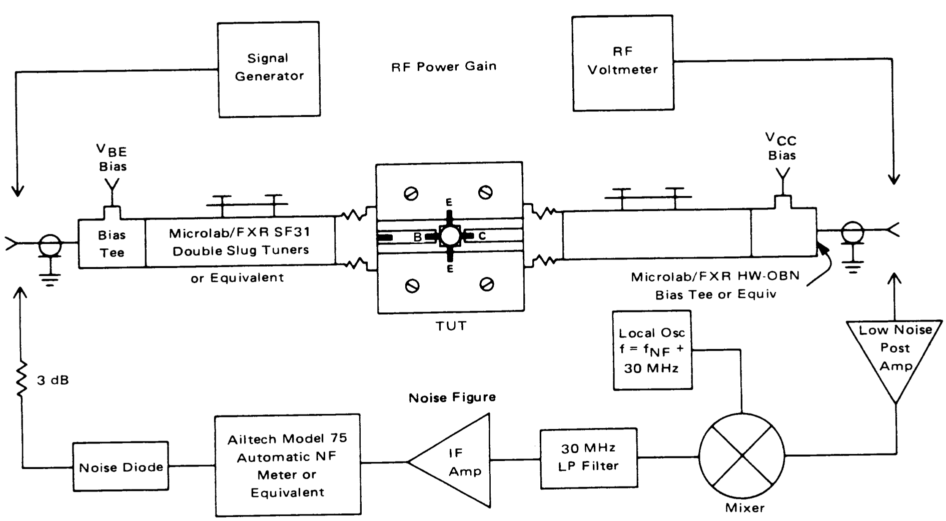


FIGURE 2 — POWER GAIN AND NOISE FIGURE versus FREQUENCY

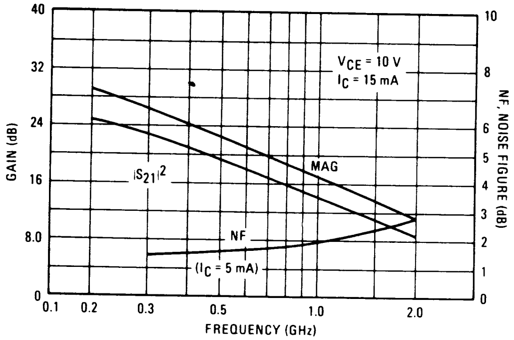


FIGURE 3 — OUTPUT CAPACITANCE versus VOLTAGE

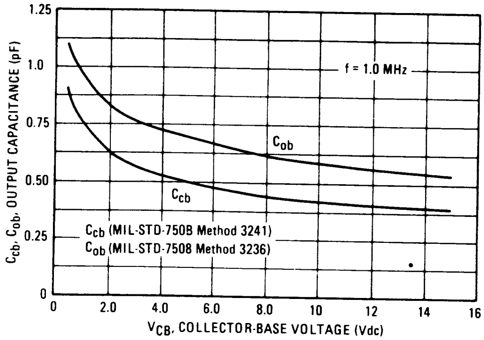


FIGURE 4 — CURRENT GAIN—BANDWIDTH PRODUCT versus COLLECTOR CURRENT

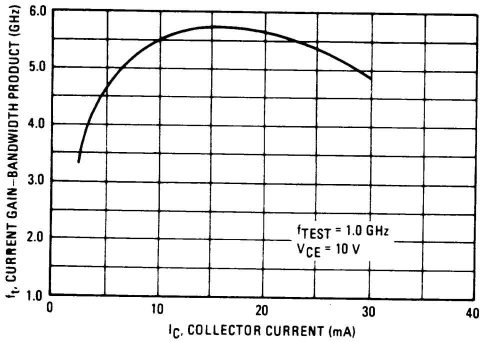


FIGURE 5 — POWER GAIN versus COLLECTOR CURRENT

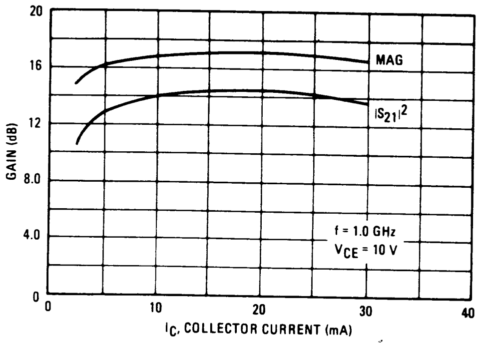
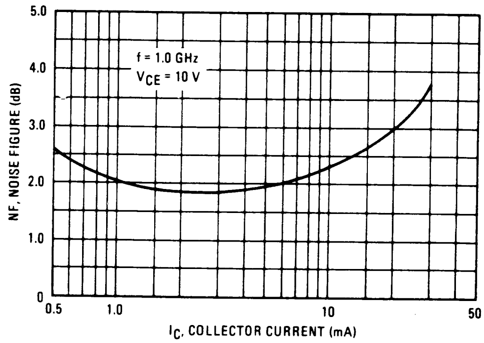


FIGURE 6 — NOISE FIGURE versus COLLECTOR CURRENT



3

COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 — INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY

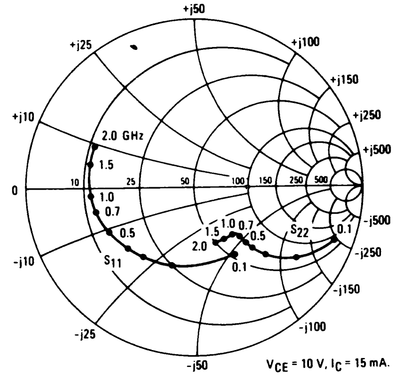
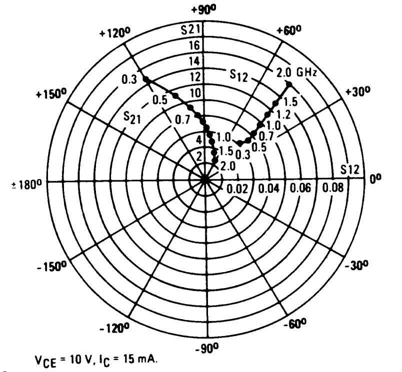


FIGURE 8 — FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



S — PARAMETERS

V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S11 |S11|	S11 ∠φ	S21 |S21|	S21 ∠φ	S12 |S12|	S12 ∠φ	S22 |S22|	S22 ∠φ
5.0	5	100	0.69	-30	12.16	160	0.026	72	0.95	-16
		200	0.65	-61	11.03	143	0.046	59	0.84	-31
		500	0.63	-122	7.05	111	0.074	36	0.56	-54
		1000	0.64	-158	4.13	88	0.087	28	0.39	-68
		2000	0.65	170	2.14	61	0.107	29	0.33	-91
	10	100	0.52	-50	18.74	154	0.022	69	0.91	-22
		200	0.54	-92	15.53	135	0.037	53	0.74	-40
		500	0.62	-146	8.49	104	0.052	38	0.43	-62
		1000	0.65	-172	4.66	84	0.065	37	0.29	-75
		2000	0.67	162	2.38	60	0.094	42	0.26	-97
	15	100	0.42	-70	22.72	150	0.019	66	0.87	-26
		200	0.51	-113	17.72	130	0.030	50	0.68	-44
		500	0.63	-157	8.96	100	0.042	41	0.38	-64
		1000	0.66	-178	4.80	82	0.056	44	0.26	-75
		2000	0.69	159	2.43	59	0.090	48	0.24	-97
	30	100	0.39	-116	24.57	142	0.014	62	0.80	-29
		200	0.55	-145	17.17	120	0.021	49	0.58	-42
		500	0.67	-171	7.96	95	0.030	49	0.34	-49
		1000	0.69	175	4.18	78	0.047	56	0.29	-56
		2000	0.71	157	2.13	55	0.084	58	0.29	-81
10	5	100	0.71	-27	12.01	161	0.021	73	0.96	-13
		200	0.67	-55	11.10	145	0.039	60	0.87	-25
		500	0.63	-115	7.44	114	0.064	39	0.62	-44
		1000	0.64	-153	4.43	90	0.077	30	0.46	-55
		2000	0.64	172	2.27	62	0.094	31	0.39	-76
	10	100	0.55	-43	18.77	155	0.018	71	0.92	-18
		200	0.55	-83	16.00	137	0.031	54	0.78	-32
		500	0.60	-140	9.06	106	0.046	39	0.49	-48
		1000	0.63	-168	5.02	85	0.058	39	0.36	-56
		2000	0.65	164	2.55	60	0.084	43	0.33	-76
	15	100	0.46	-60	23.14	152	0.016	68	0.90	-21
		200	0.51	-103	18.39	131	0.027	52	0.72	-36
		500	0.61	-152	9.67	102	0.037	42	0.43	-49
		1000	0.64	-175	5.21	83	0.049	45	0.33	-54
		2000	0.66	161	2.61	59	0.079	51	0.31	-74
	30	100	0.39	-98	27.29	144	0.013	63	0.83	-24
		200	0.53	-135	19.38	122	0.019	50	0.63	-35
		500	0.64	-167	9.11	96	0.027	48	0.41	-39
		1000	0.66	177	4.77	79	0.042	55	0.36	-45
		2000	0.69	157	2.41	56	0.074	58	0.35	-67

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

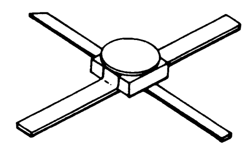
2N6604

The RF Line

NF = 2.7 dB @ 1.0 GHz

HIGH FREQUENCY TRANSISTOR

NPN SILICON



NPN SILICON HIGH FREQUENCY TRANSISTOR

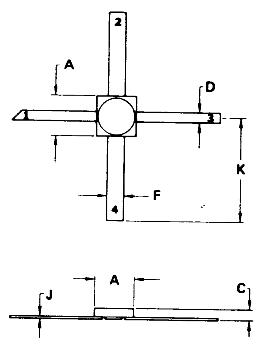
. . . designed for use in high-frequency, low-noise, small-signal, narrow and wideband amplifiers. Ideal for use in microstrip thin and thick film applications.

- Low Noise Figure — NF = 2.7 dB (Typ) @ f = 1.0 GHz
- High Power Gain — G_U(max) = 16 dB (Typ) @ f = 1.0 GHz
- High Current — Specified Performance @ I_C = 30 mA
- Ion Implantation and Gold Metallization
- Metal/Ceramic Hermetic Package
- JAN, JTXV Available

***MAXIMUM RATINGS (T_A = 25°C Free Air Temperature)**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current—Continuous	I_C	50	mAdc
Total Device Dissipation @ T_C = 125°C Derate Above 75°C	P_D	500 6.66	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES 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

NOTE:
1. DIMENSION K APPLIES TO ALL LEADS.

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

CASE 303-01

Specifications and Package Options

Devices using the same die type as the 2N6604:

MRF911 — 4 Lead Plastic Macro-T Case 302-01
MRF914 — TO-72
MMBR930 — MiniBloc Plastic (SOT-23) TO-236
BFR91 — 3 Lead Plastic Macro-T Case 302A-01
BFRC91 — Unencapsulated Chip

3

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

Characteristic	Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	–	200	–
***DYNAMIC CHARACTERISTICS**					
Collector-Base Capacitance (1) (V_{CB} = 10 Vdc, I_E = 0, 0.1 MHz $\leq f \leq$ 1.0 MHz)	C_{cb}	0.30	–	0.80	pF
***FUNCTIONAL TEST**					
Common-Emitter Amplifier Power Gain (Figure 2) (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 1.0 GHz)	G_{pe}	15	–	21	dB
Spot Noise Figure (R_S = Optimum – Figure 2) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	NF	1.5	–	3.0	dB
Power Gain at Optimum Noise Figure (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	G_{NF}	9.0	–	–	dB
TYPICAL 2 GHz PERFORMANCE					
Maximum Unilateral Gain (Figure 2) (2) (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 2.0 GHz)	$G_U(max)$	–	10	–	dB
Noise Figure (R_S = Optimum – Figure 2) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 2.0 GHz)	NF	–	4.3	–	dB

*Indicates JEDEC Registered Data.

(1) C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal of the bridge.

(2) $G_U(max)$ is calculated from the S-Parameters using the equation $G_U(max) = \frac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

FIGURE 1 – BLOCK DIAGRAM FOR POWER GAIN AND NOISE FIGURE

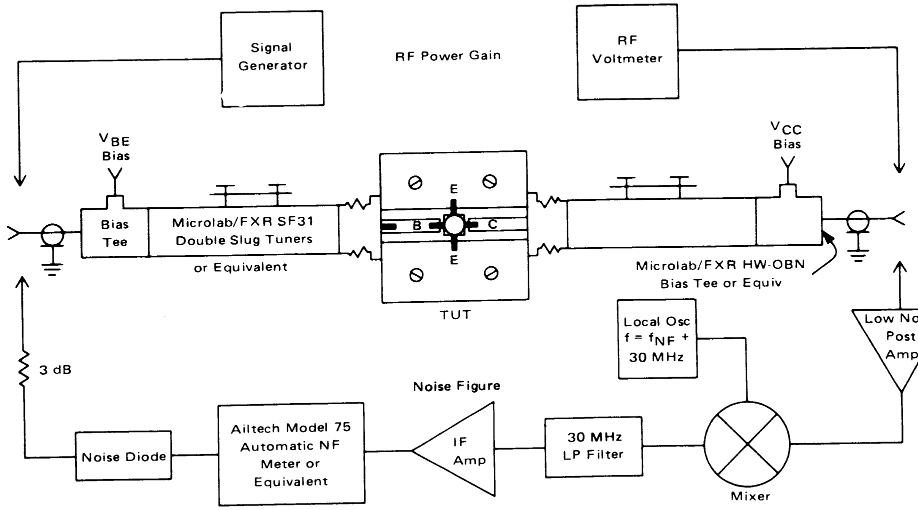


FIGURE 2 — POWER GAIN AND NOISE FIGURE versus FREQUENCY

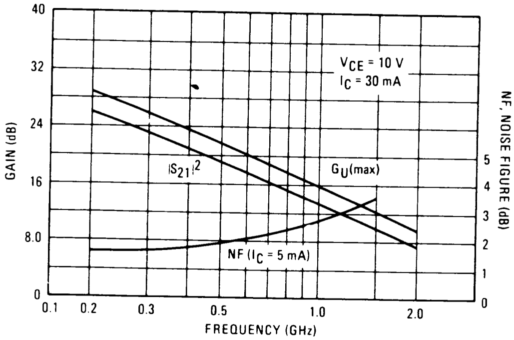


FIGURE 3 — OUTPUT CAPACITANCE versus VOLTAGE

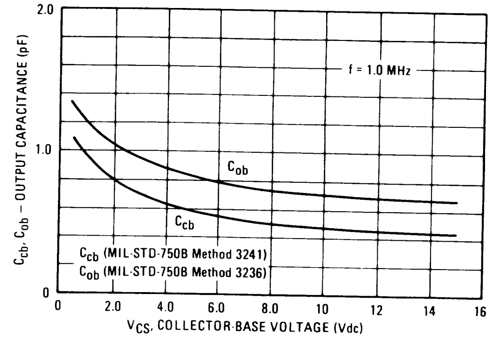


FIGURE 4 — CURRENT GAIN—BANDWIDTH PRODUCT versus COLLECTOR CURRENT

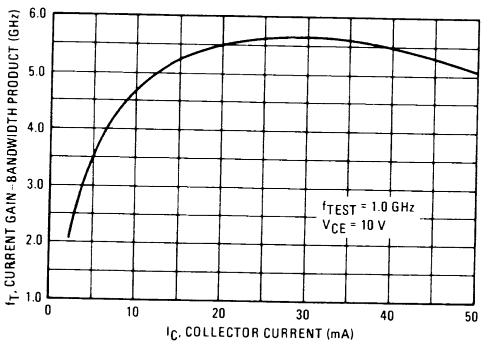


FIGURE 5 — POWER GAIN versus COLLECTOR CURRENT

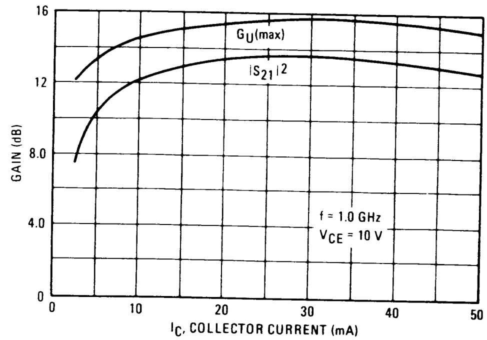
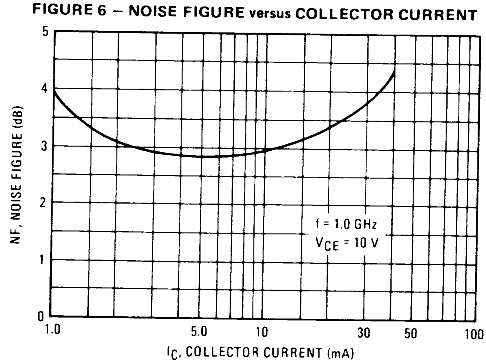
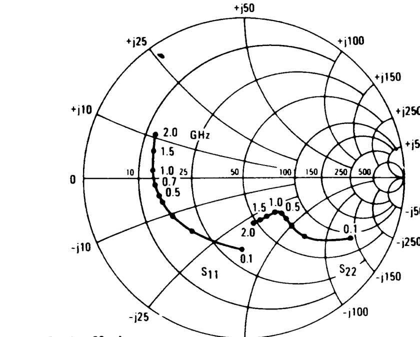


FIGURE 6 — NOISE FIGURE versus COLLECTOR CURRENT



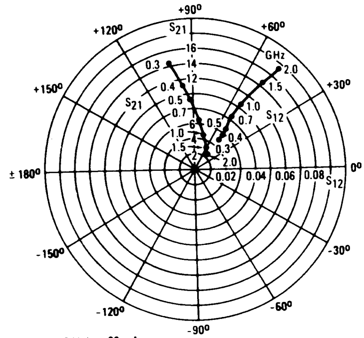
COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 – INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY



V_{CE} = 10 V, I_C = 30 mA.

FIGURE 8 – FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



V_{CE} = 10 V, I_C = 30 mA.

S – PARAMETERS

V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S11 |S11|	S11 ∠φ	S21 |S21|	S21 ∠φ	S12 |S12|	S12 ∠φ	S22 |S22|	S22 ∠φ
5.0	5	100	0.72	-40	12.37	153	0.028	67	0.91	-18
		200	0.65	-78	10.38	133	0.048	51	0.76	-32
		500	0.61	-137	5.75	100	0.067	34	0.50	-45
		1000	0.61	-168	3.13	78	0.082	31	0.41	-54
		2000	0.63	161	1.58	47	0.112	30	0.41	-80
	10	100	0.57	-60	19.54	146	0.024	63	0.85	-27
		200	0.55	-105	14.70	125	0.038	47	0.64	-43
		500	0.59	-155	7.12	95	0.051	39	0.37	-55
		1000	0.61	-178	3.77	76	0.069	40	0.29	-62
		2000	0.64	156	1.91	50	0.106	39	0.30	-86
	30	100	0.43	-111	30.58	135	0.016	57	0.72	-39
		200	0.53	-145	19.35	114	0.022	49	0.46	-57
		500	0.62	-173	8.42	91	0.035	51	0.24	-69
		1000	0.63	172	4.36	75	0.058	54	0.18	-76
		2000	0.67	151	2.19	52	0.099	49	0.21	-99
	50	100	0.46	-134	32.34	129	0.013	57	0.64	-42
		200	0.57	-158	19.19	110	0.018	51	0.40	-56
		500	0.64	-178	8.13	89	0.031	57	0.22	-62
		1000	0.65	170	4.17	74	0.053	58	0.19	-70
		2000	0.70	150	2.10	52	0.092	54	0.22	-97
10	5	100	0.74	-36	12.34	154	0.023	69	0.93	-15
		200	0.67	-71	10.56	135	0.040	54	0.81	-25
		500	0.59	-131	6.09	102	0.058	37	0.57	-36
		1000	0.58	-164	3.32	79	0.073	33	0.50	-44
		2000	0.60	164	1.67	48	0.098	32	0.49	-69
	10	100	0.60	-52	19.75	148	0.020	65	0.87	-21
		200	0.56	-95	15.30	127	0.032	49	0.69	-33
		500	0.56	-149	7.69	97	0.044	41	0.45	-41
		1000	0.58	-174	4.07	77	0.061	42	0.39	-47
		2000	0.61	159	2.03	50	0.095	40	0.39	-70
	30	100	0.44	-94	32.03	136	0.014	59	0.75	-31
		200	0.50	-135	20.76	115	0.021	49	0.52	-41
		500	0.57	-168	9.13	91	0.032	52	0.33	-43
		1000	0.59	175	4.71	75	0.052	54	0.29	-48
		2000	0.64	154	2.34	52	0.089	49	0.30	-72
	50	100	0.44	-117	33.56	129	0.012	59	0.68	-31
		200	0.52	-150	19.94	109	0.017	50	0.47	-36
		500	0.59	-174	8.52	89	0.028	56	0.34	-35
		1000	0.61	173	4.38	75	0.049	57	0.32	-43
		2000	0.66	152	2.21	51	0.083	52	0.34	-70

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