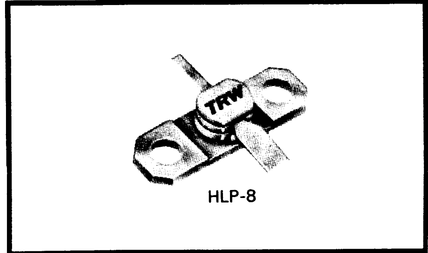
SUPER 3 GHz Series

TRW

- **TRW 3001 - 1 W**
- **TRW 3003 - 3 W**
- **TRW 3005 - 5 W**
- **∞VSWR**



HLP-8

This data describes TRW's SUPER 3GHz transistors. The etchless gold die metallization, the diffused ballast resistors, and the avalanche protection are available exclusively from TRW.

∞ VSWR Tolerance. A TRW first. Every SUPER 3GHz transistor is tested to guarantee each device is capable of withstanding all mismatch conditions (any magnitude, any phase angle). This guarantee precludes costly failures due to an inadvertent impedance mismatch in the laboratory, on the production line or in the field. A 100% production line test for ∞ VSWR capability also assures the die mount integrity. This is not possible with less rugged transistors.

Diffused Ballast Resistors. Another TRW first. Only TRW offers this major technological advance in microwave transistors (patents pending). High resistance ballast resistors are diffused directly into the silicon die totally avoiding the primary failure mechanism of peeling and microcracking associated with conventional thin film, metal ballast resistors. Also, diffused ballasting safely allows much higher resistance values to be achieved (25Ω-100Ω) than does thin film metal ballasting (8Ω-10Ω). Higher ballast levels preclude "hot spotting" since near perfect finger-to-finger and cell-to-cell current sharing is realized. The positive temperature coefficient of the diffused resistor further equalizes uneven temperature distribution.

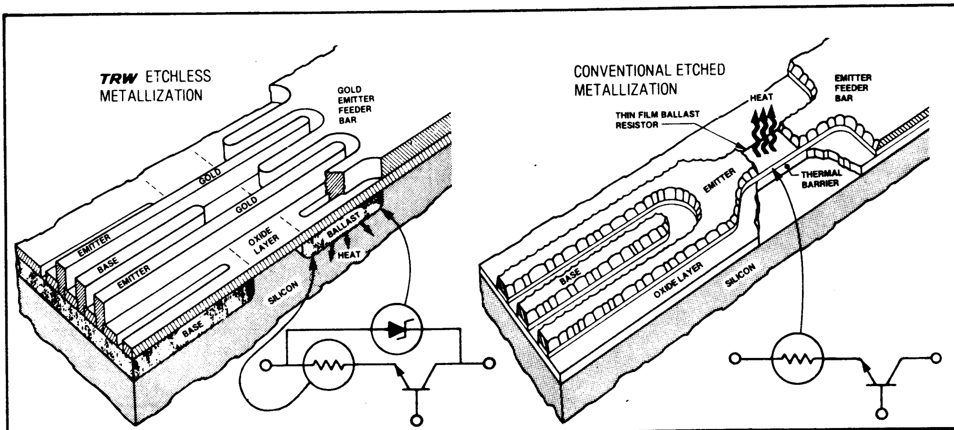
Avalanche Protection. Yet another TRW first. TRW's exclusive avalanche protection mechanism (patent pending) precludes the failure mode not handled by ballasting alone — secondary breakdown. The voltage across the transistor junction is never allowed to reach breakdown. The P-N diode of the ballast resistor is diffused to avalanche several volts less than the transistor junctions. Under severe mismatch conditions when voltages in excess of breakdown occur, the diode conducts the full avalanche current, thus, protecting the transistor junction. True "full-circle" VSWR protection is achieved with these devices.

Gold Die Metallization. One more TRW first. TRW's etchless, gold metallization process (patent pending) provides exact finger definition. This process is capable of defining sub-micron finger spacing in the interdigitated geometry even though the cross sectional dimension of each gold finger is deeper than it is wide. The etchless process precludes finger scalloping characteristic of all etching processes and eliminates resultant current crowding where metal fingers are necked down. With TRW's gold die metallization original design values are not compromised in the manufacturing process for the primary wear-out mechanism in RF transistors — metal migration. Thus, TRW's etchless, gold metallization system not only capitalizes on the vast improvement in electromigration properties of gold over aluminum but it also assures that the metal lifetime design criteria is retained in the manufacturing process. This achievement cannot be accomplished with any etch-dependent metal system.

Mono-Metal System. TRW's use of gold metallized die, gold wire bonds, and gold package metal on all SUPER 3GHz transistors precludes intermetallic formations and resultant failures. Gold bonding wire does not work-harden and is thousands of times more resistant to fatigue than is the more brittle aluminum wire alternative. Fatigue tests have verified that TRW's thermal-compression bonding technique provides bond-to-pad mechanical integrity, not possible with aluminum, ultra-sonic bonding systems.

Mil-Package. The Space Qualified HLP-8 is a fully hermetic, glass-free, co-fired ceramic package. It is available with or without a flange.

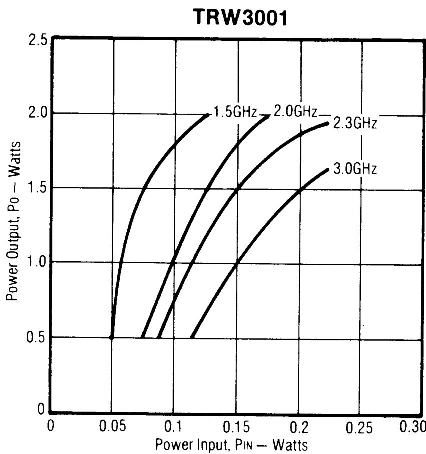
TRW DIFFUSED BALLAST RESISTORS WITH ETCHLESS GOLD METALLIZATION VS. CONVENTIONAL THIN FILM BALLAST RESISTORS WITH ETCHED METALLIZATION

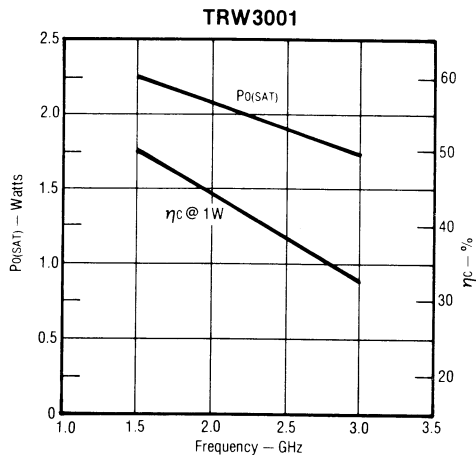


Electrical Characteristics (T_{case} = 25 °C)

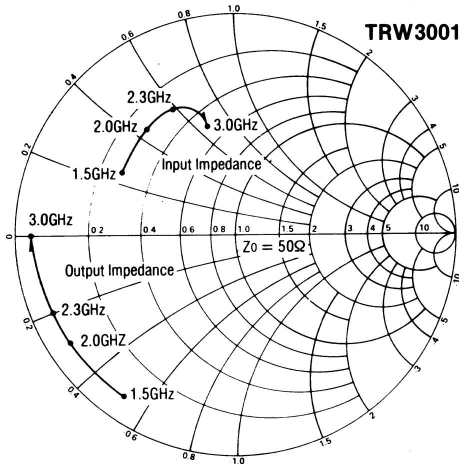
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1.0 mA b	45			V
	BV_{CES}	Collector - Emitter Breakdown Voltage (EB Shorted)	I_C = 10 mA	50			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.5	mA
	H_{FE}	DC Current Gain	V_{CE} = 5.0 V I_C = 100 mA	10		120	
RF TEST	P_{gain}	Power Gain	F_O = 3 GHz P_O = 1.0 W V_{CC} = 28 V	7.0			dB
	η_C	Collector Efficiency	F_O = 3 GHz P_O = 1.0 W V_{CC} = 28 V	30			%
	VSWR	Mismatch Tolerance (Without Damage)	F_O = 3 GHz P_O = 1.0 W V_{CC} = 28 V	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F_O = 1 MHz		3.5	4.0	pF
THERMAL	θ_{JC}	Thermal Impedance Junction to Case	—			35	°C/W
	T_{STG} & T_J	Junction & Storage Temperature Range	—	— 65		+ 200	°C

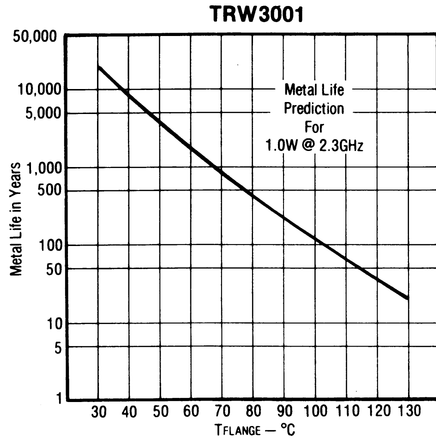
TYPICAL CHARACTERISTICS



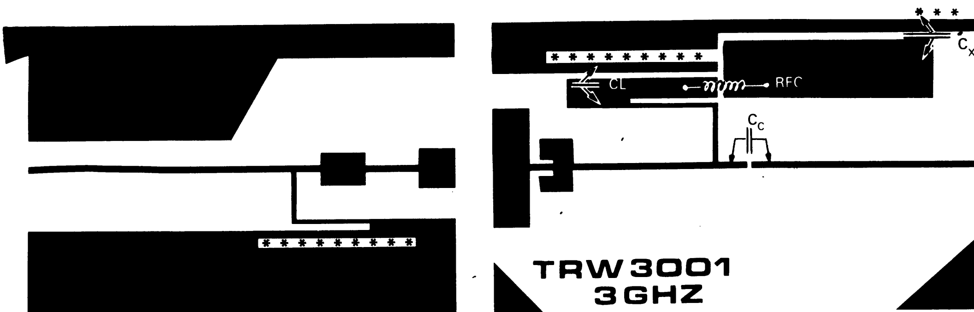


TYPICAL CHARACTERISTICS





PC BOARD LAYOUT F = 3 GHz



1 inch = 19,48 mm

PARTS DETAILS

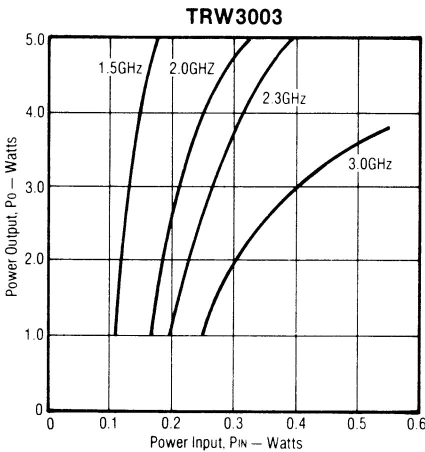
Board material ≃ 0.020″ Glass teflon (ε_r = 2.55).

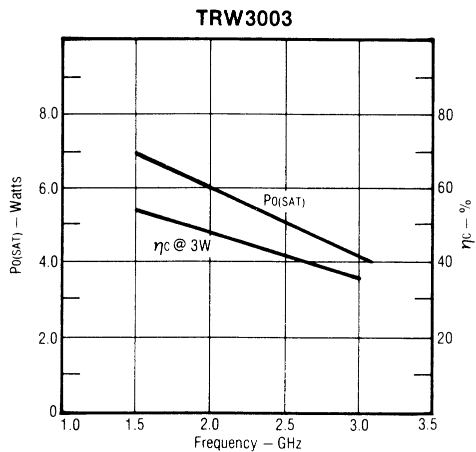
- * = Foil wrap asterisked edge to ground plane.
- C_C = 100 pF chip.
- C_X = 100 pF, 1 nF, 10 nF chip capacitors and 10 μF.
- C_L = 100 pF chip capacitor. The capacitor position can be tuned.
- R_{FC} = 8 turns # 28AWG, 0.010 dia.

Electrical Characteristics (T_{case} = 25 °C)

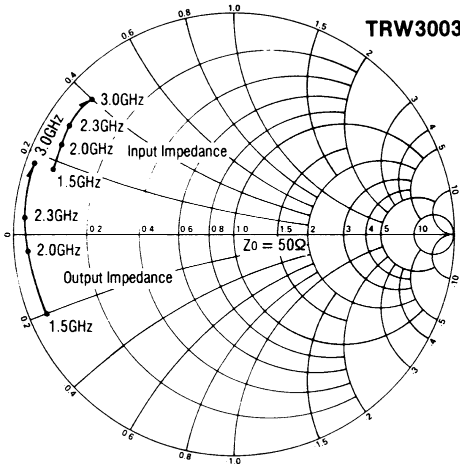
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 3.0 mA	45			V
	BV_{CES}	Collector - Emitter Breakdown Voltage (EB Shorted)	I_C = 30.0 mA	50			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.75	mA
RF TEST	H_{FE}	DC Current Gain	V_{CE} = 5.0 V I_C = 300 mA	10		120	
	P_{Gain}	Power Gain	F_O = 3 GHz P_O = 3.0 W V_{CC} = 28 V	6.0			dB
	η_C	Collector Efficiency	F_O = 3 GHz P_O = 3.0 W V_{CC} = 28 V	30			%
	VSWR	Mismatch Tolerance (Without Damage)	F_O = 3 GHz P_O = 3.0 W V_{CC} = 28 V	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F_O = 1 MHz		5.7	7.0	pF
THERMAL	θ_{JC}	Thermal Impedance Junction to Case	—			17	°C/W
	T_{STG} & T_J	Junction & Storage Temperature Range	—	— 65		+ 200	°C

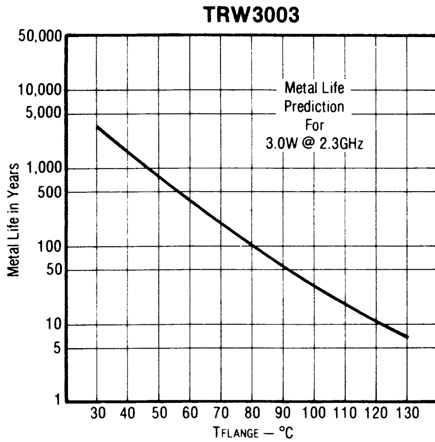
TYPICAL CHARACTERISTICS



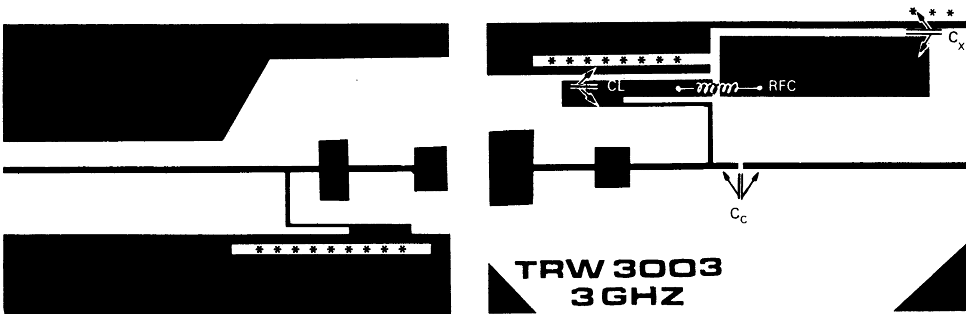


TYPICAL CHARACTERISTICS





PC BOARD LAYOUT F = 3 GHz



1 inch = 19,48 mm

PARTS DETAILS

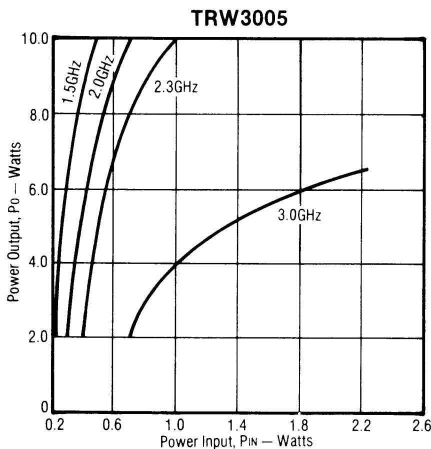
Board material : 0.020″ Glass Teflon (ε_r = 2.55)

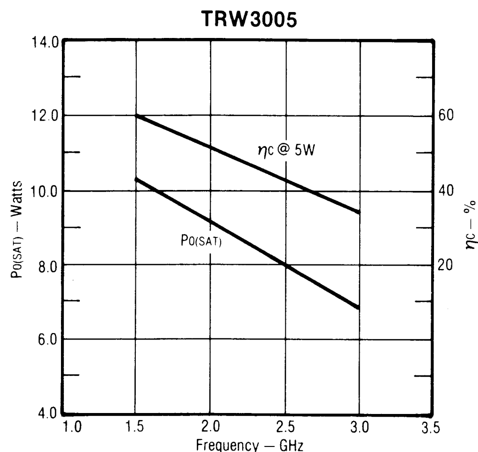
- * = Foil wrap asterisked edge to ground plane.
- C_C = 100 pF chip.
- C_X = 100 pF, 1 nF, 10 nF chip capacitors and 10 μF.
- C_L = 100 pF chip capacitor. The capacitor position can be tuned.
- R_{FC} = 8 turns # 28AWG, 0.010 dia.

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 5.0 mA	45			V
	BV_{CES}	Collector - Emitter Breakdown Voltage (EB Shorted)	I_C = 50.0 mA	50			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			1.25	mA
RF TEST	H_{FE}	DG Current Gain	V_{CE} = 5.0 V I_C = 500 mA	10		120	
	P_{Gain}	Power Gain	F_O = 3 GHz P_O = 5 W V_{CC} = 28 V	5.0			dB
	η_C	Collector Efficiency	F_O = 3 GHz P_O = 5 W V_{CC} = 28 V	30			%
	VSWR	Mismatch Tolerance (Without Damage)	F_O = 3 GHz P_O = 5 W V_{CC} = 28 V	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F_O = 1 MHz		8.4	10	pF
THERMAL	θ_{JC}	Thermal Impedance Junction to Case	—			8.5	°C/W
	T_{STG} & T_J	Junction & Storage Temperature Range	—	— 65		+ 200	°C

TYPICAL CHARACTERISTICS





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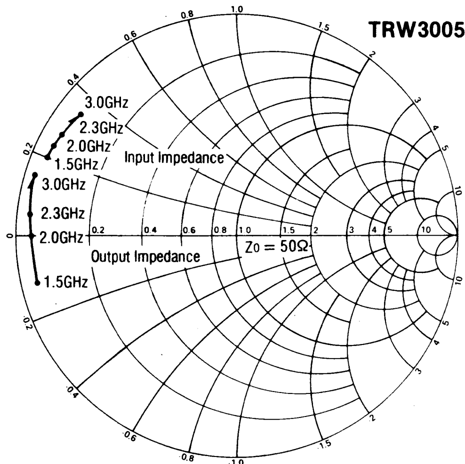

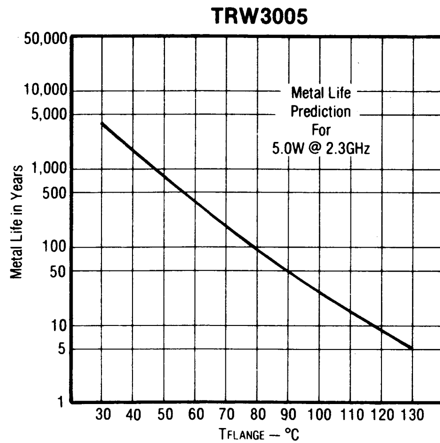

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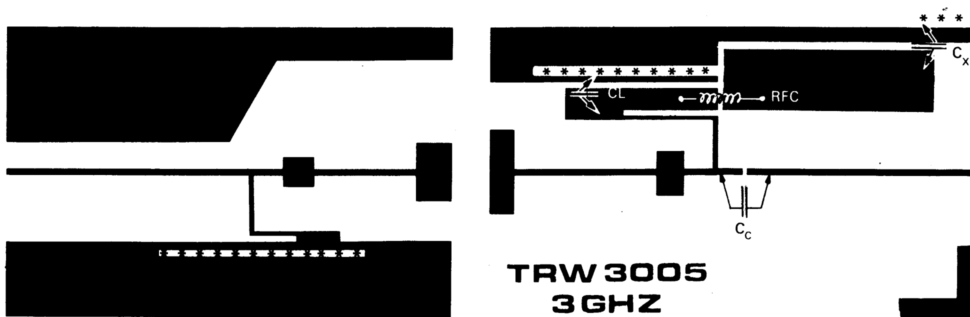

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- * = Foil wrap asterisked edge to ground plane.
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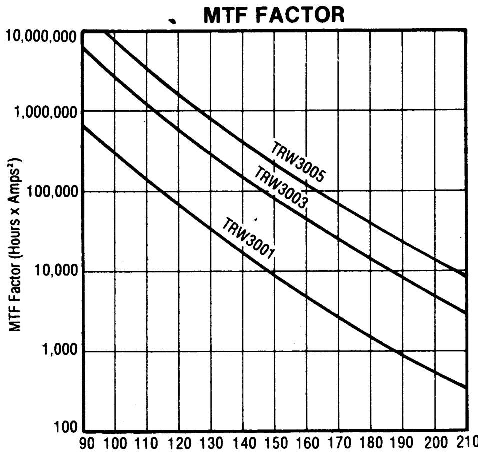


MTTF FACTOR

(Normalized to 1 ampere² Continuous Duty)

The graph shown displays MTTF in hours x ampere² emitter current for each of the 3 GHz devices. Life tests at elevated temperatures have correlated to better than ± 10 % to the theoretical prediction for metal failure. **CAUTION** ε A calculation is required to obtain actual metal life. Sample MTTF calculations based on operating conditions are shown below.

Junction Temperature — °C

To calculate metal lifetime under any set of conditions, obtain actual data or estimate from typical performance curves. Solve for T_J (°C):

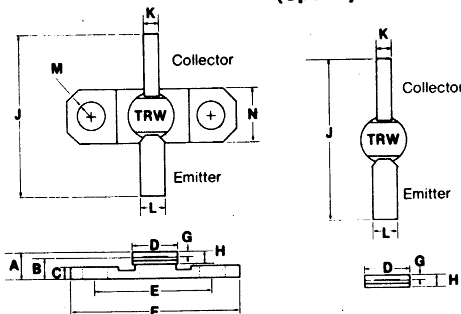
(1) $$T_j = \theta_{jF}\left(\frac{P_{OUT} \times 100}{\eta c\,\%} + P_{IN} - P_{OUT}\right) + T_{FLANGE}$$

Enter graph of MTF factor vs. T_j. Obtain MTF factor. Calculate metal life by:

(2) $$\text{Metal Life in Hours} = \frac{\text{MTF Factor}}{I_C^2\ (\text{Amps})}$$

Mechanical Dimensions

HLP-8 Normal Package — **Flangeless HLP-8 (Specify « F » Suffix)**

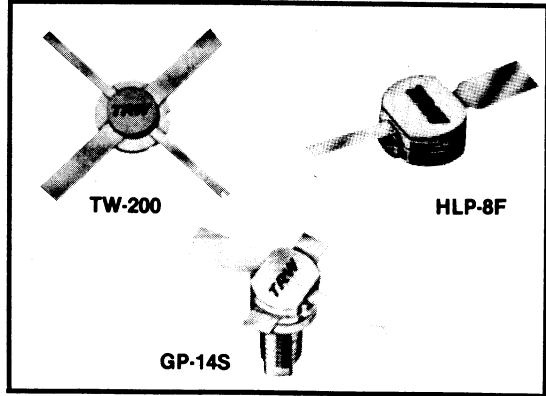


Dimension	U.S. (Inches ± 0.005)	Metric (Centimeters ± 0.0127)
A	0.155	0.3937
B	0.125	0.3175
C	0.060	0.1524
D	0.230	0.5842
E	0.562	1.4270
F	0.800	2.030
G	0.030	0.0762
H	0.095	0.2413
J	0.730 nom	1.85 nom
K	0.050	0.127
L	0.120	0.3048
M	0.130 dia	0.3302 dia
N	0.250	0.6350

TRW

Microwave Linear Transistors

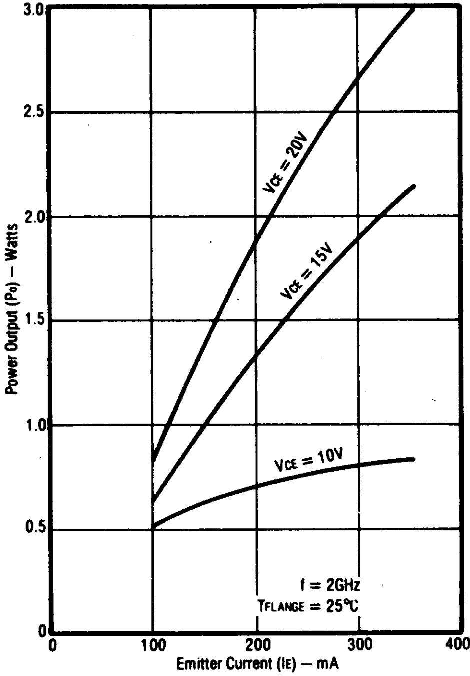
- Gold Metalized
- Diffused Ballast Resistors
- Linear per DIN-45004K
- Common Emitter
- 5 Package Options
- 2 GHz
- 1.5 W
- ∞ VSWR

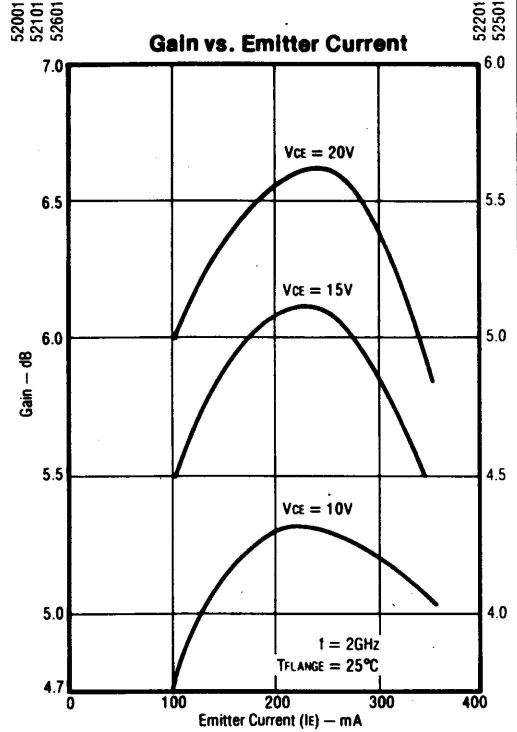


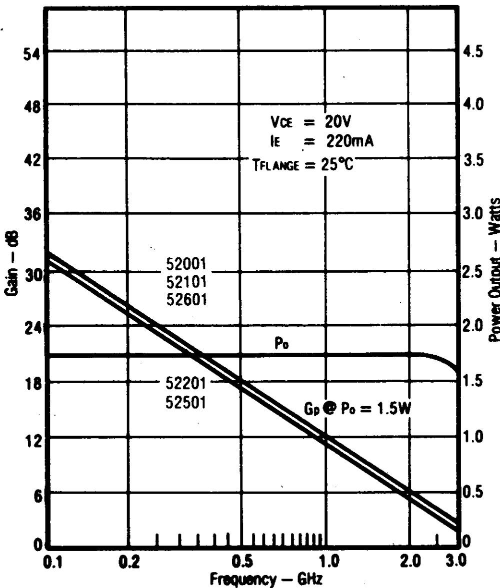
Electrical Characteristics (T_{CASE} = 25°C)

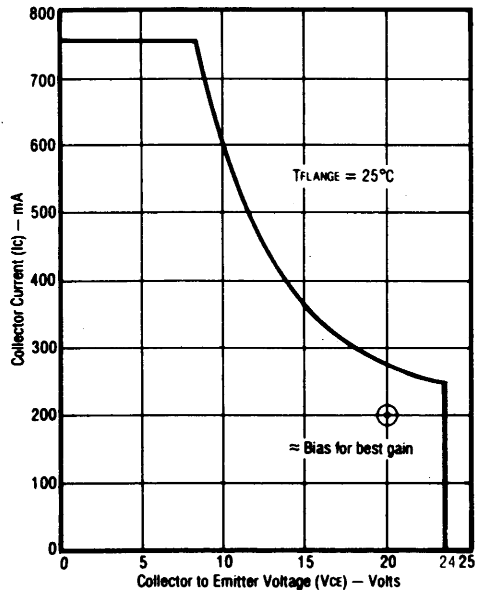
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 20mA	24			V
	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 20mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 1.0mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28V			0.125	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0V, I_C = 100mA	20		120	—
RF TEST	C_{ob}	Collector-Base Capacitance	V_{CB} = 28V, f = 1MHz			5	pF
	P_O	Power Output	V_{CE} = 20V, I_E = 220mA f = 2.0GHz, P_{in} = 0.375W *P_{in} = 0.474W f/52201 & 52501	1.5			W
	f_t	Frequency Cutoff	V_{CE} = 20V, I_E = 220mA	2.7	3.0		GHz
	VSWR	Mismatch Tolerance	P_O = 1.5W, I_E = 220mA, V_{CE} = 20V	∞			
	IMD	Third Order Intermodulation Distortion	V_{CE} = 20V, I_E = 220mA f = 2.0GHz, $P_{O(PEP)}$ = 1.5W Tones at 2.05GHz and 2.1GHz		-30		dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20V, I_E = 150mA, f = 1.0GHz, P_{REF} = 0.5W		-60		dB
	L_G	Gain Linearity	V_{CE} = 20V, I_E = 220mA f = 2.0GHz, P_{O1} = 1.5W, P_{O2} = 1.5mW			-0.2 +1.0	dB
OPER.	T_j & T_{stg}	Max. Junction & Storage Temperature		-65		+200	°C
	θ_{jC}	Thermal Resistance	T_C = 25°C			16	°C/W

ELECTRICAL CHARACTERISTICS
TRW52001, TRW52101, TRW52201, TRW52501, TRW52601



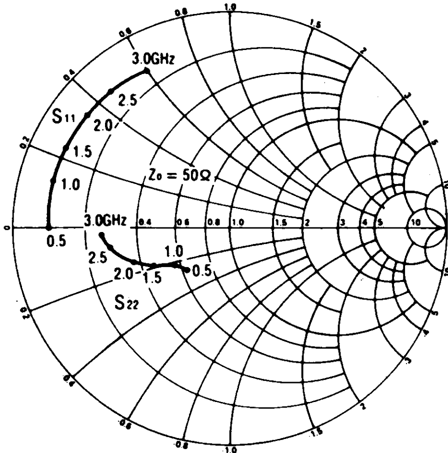




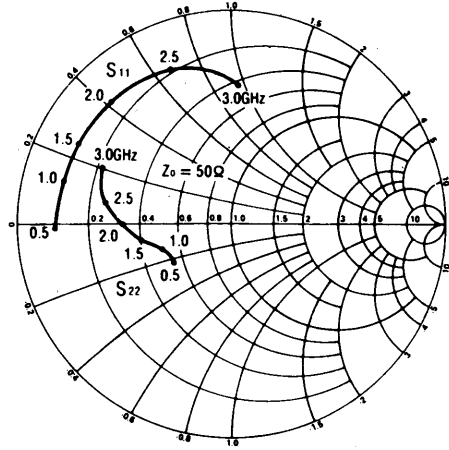


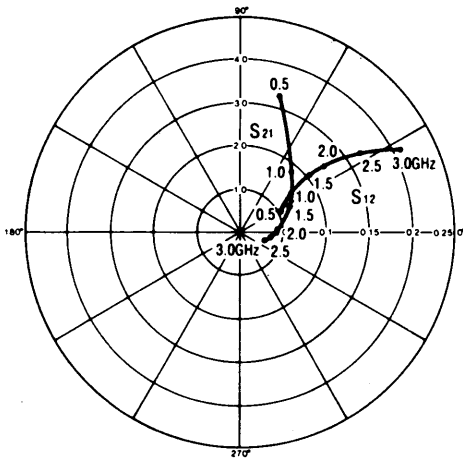
S-PARAMETERS
V_{CE} = 20V, I_E = 220mA, T_{FLANGE} = 25°C

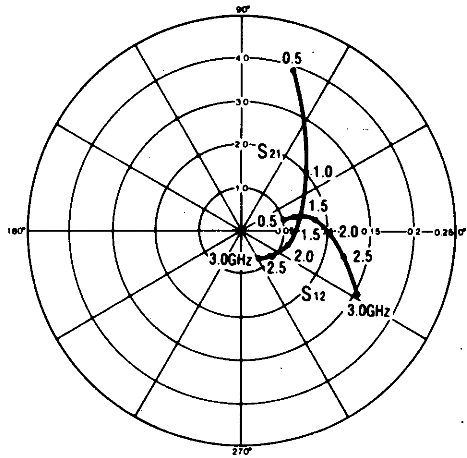
TRW52001



TRW52101, TRW52601

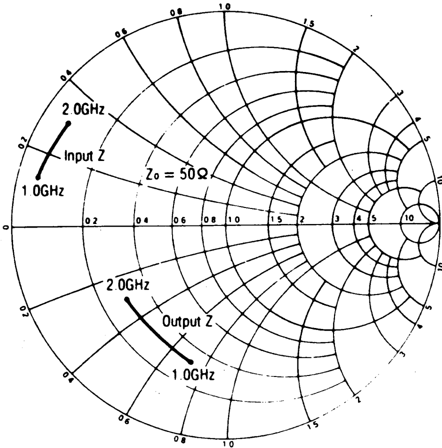




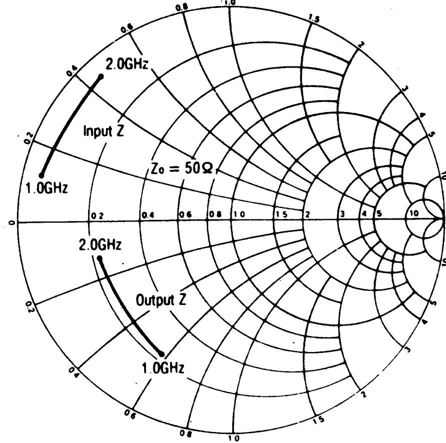


LARGE SIGNAL IMPEDANCE DATA
V_{CE} = 20V, I_E = 220mA, T_{FLANGE} = 25°C

TRW52001

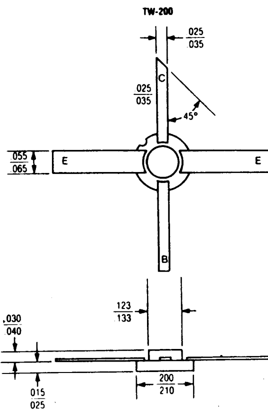


TRW52101, TRW52601

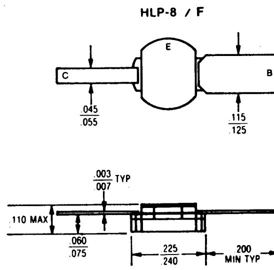


Package Outlines

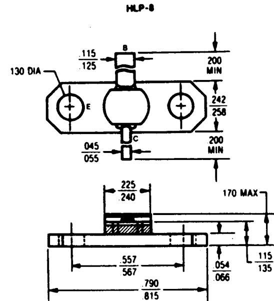
TRW52001



TRW52101



TRW52601



Mechanical Design Specifications

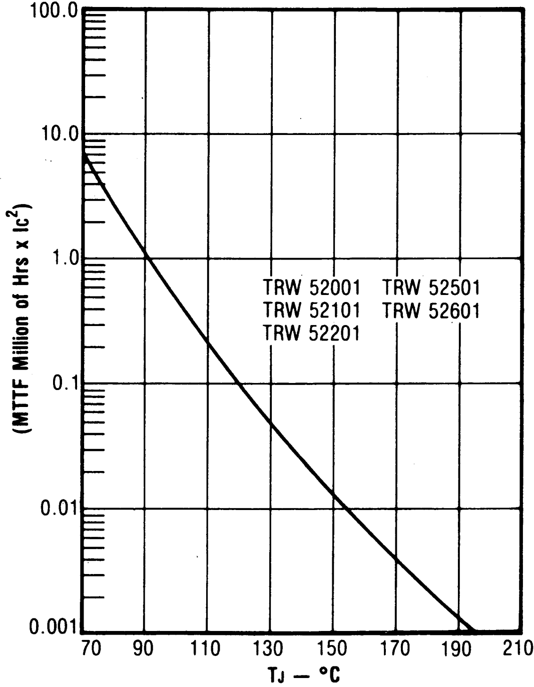
The following are design specifications for this transistor series:

Dimensions: Per outline drawing.
Solderability: Per MIL STD 750.
Marking: Per MIL S 19500, "TRW," 4 digit date code, type number.
Hermeticity: Per MIL STD 750, 10^{7} atmospheres gross and fine leak. (Available on special order screened to 10^{8} atmospheres.)

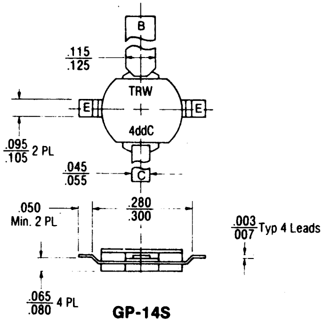
Acceleration: Per MIL STD 750, 20,000 G in any plane.
Lead Pull: Per MIL STD 750, 3 grams min.
Package: A brazed ceramic package assuring long term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.

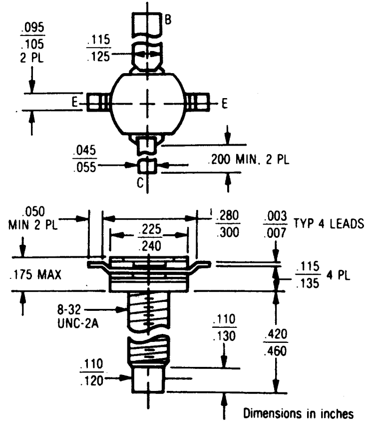


TRW52201



GP-14S

TRW52501

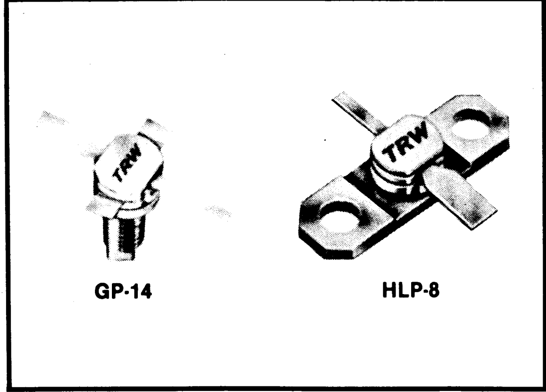


GP-14

TRW

Microwave Linear Transistors

- Gold Metalized
- Diffused Ballast Resistors
- Linear per DIN 45004K
- Common Emitter
- Package Options
- 3 Watts
- 2 GHz
- Hermetic
- ∞ VSWR



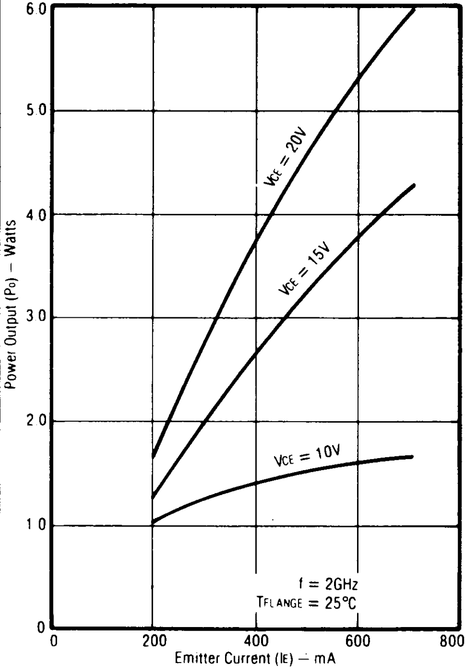
GP-14 HLP-8

Electrical Characteristics (T_{CASE} = 25°C)

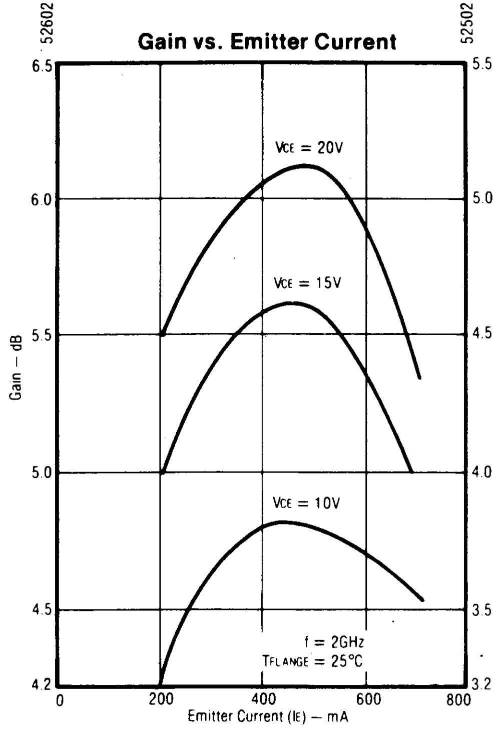
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 40mA	24			V
	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 40mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.50mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 2.0mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28V			0.25	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0V, I_C = 200mA	20		120	–
RF TEST	C_{ob}	Collector-Base Capacitance	V_{CB} = 28V, f = 1MHz			7	pF
	P_O	Power Output	V_{CE} = 20V, I_E = 440mA f = 2.0GHz, P_{in} = 0.75W (52602) P_{in} = .95W f/(52502)	3.0			W
	f_t	Frequency Cutoff	V_{CE} = 20V, I_E = 440mA	2.7	3.0		GHz
	VSWR	Mismatch Tolerance	P_O = 3.0W, I_E = 440mA, V_{CE} = 20V	∞			
	IMD	Third Order Intermodulation Distortion	V_{CE} = 20V, I_E = 440mA $P_{O(PEP)}$ = 3.0W Tones at 2.000GHz and 2.005GHz		-30		dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20V, I_E = 300mA, f = 1.0GHz, P_{REF} = 1.0W		-60		dB
	L_G	Gain Linearity	V_{CE} = 20V, I_E = 440mA f = 2.0GHz, P_{O1} = 3.0W, P_{O2} = 3.0mW			-0.2 +1.0	dB
OPER.	T_j & T_{stg}	Max. Junction & Storage Temperature		-65		+200	°C
	θ_{jC}	Thermal Resistance	T_C = 25°C			8.5	°C/W

ELECTRICAL CHARACTERISTICS
TRW52502, TRW52602

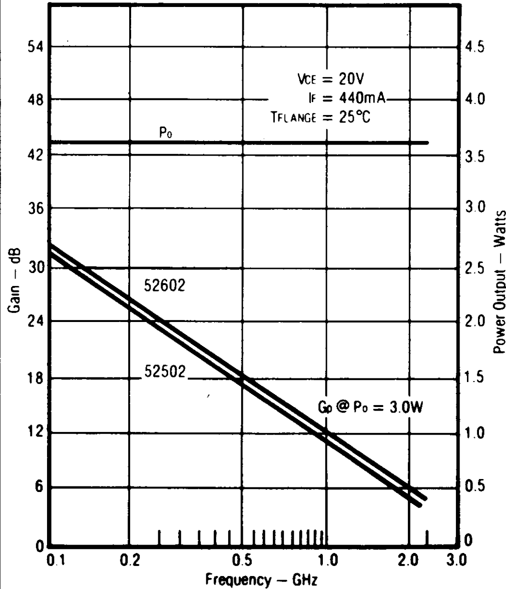
1dB Compression Point vs. Emitter Current



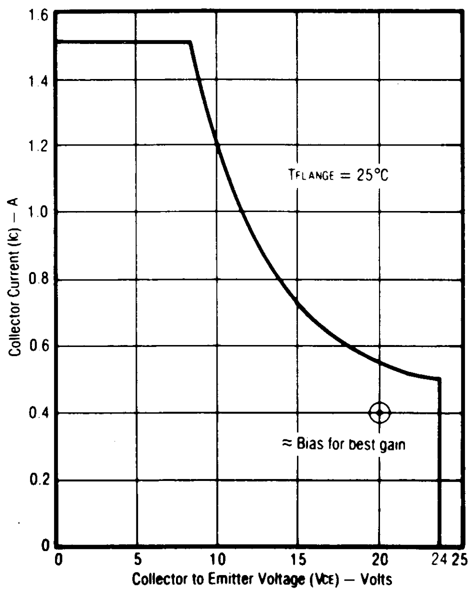
Gain vs. Emitter Current



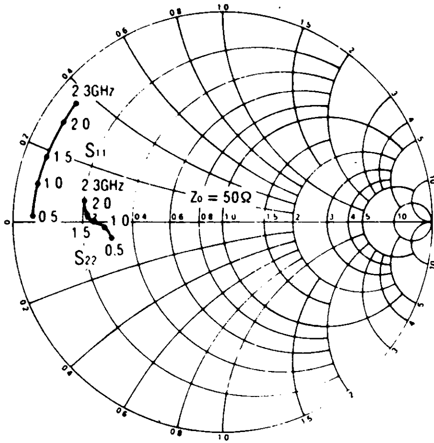
Gain and 1dB Compressed Power vs. Frequency

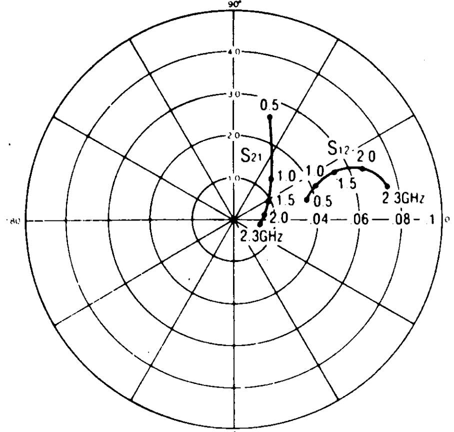


D.C. Safe Operating Area

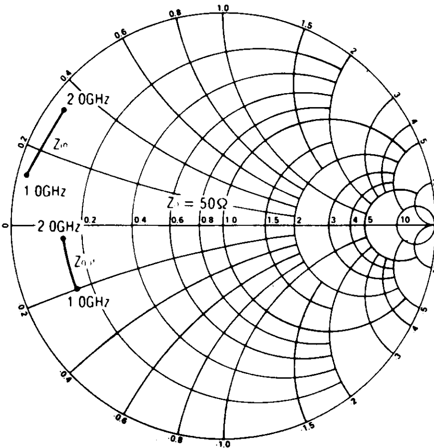


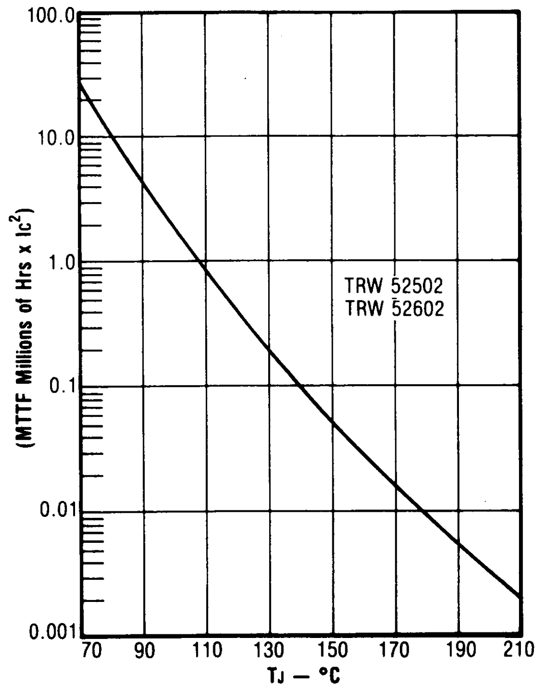
S-PARAMETERS
V_{CE} = 20V, I_E = 440mA, T_{FLANGE} = 25°C





Large Signal Impedance Data





Mechanical Design Specifications

The following are design specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermeticity: Per MIL-STD-750, 10⁻⁷ atmospheres gross and fine leak. (Available on special order screened to 10⁻⁸ atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of NICKEL base material with minimum 60 microinches of gold plating.

TRW52502

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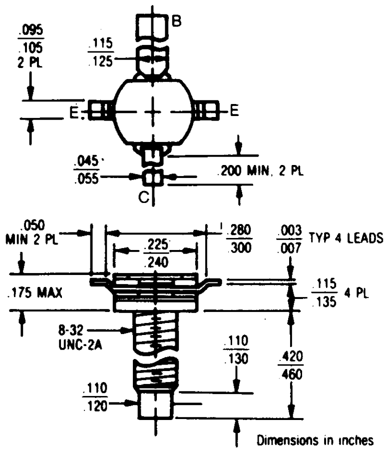
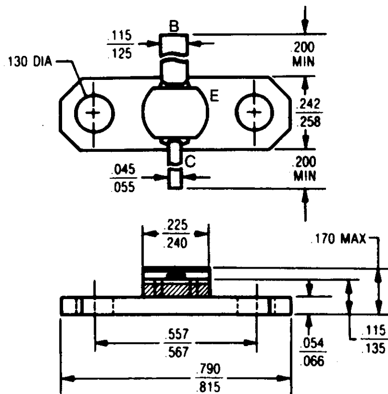


TRW52602

HLP-8



TRW

Microwave Linear Transistors

- Gold Metalized
- Diffused Ballast Resistors
- Linear per DIN 45004K
- Common Emitter
- Package Options
- 6 Watts
- 2 GHz
- ∞ VSWR
- Hermetic

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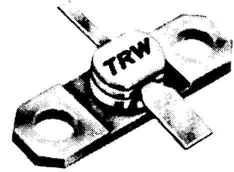


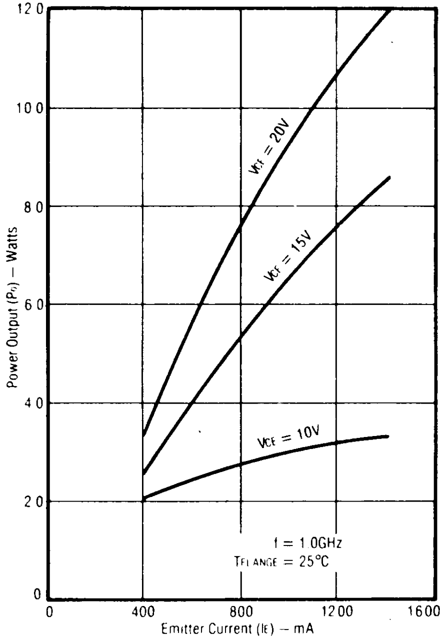
HLP-8

Electrical Characteristics (T_{CASE} = 25°C)

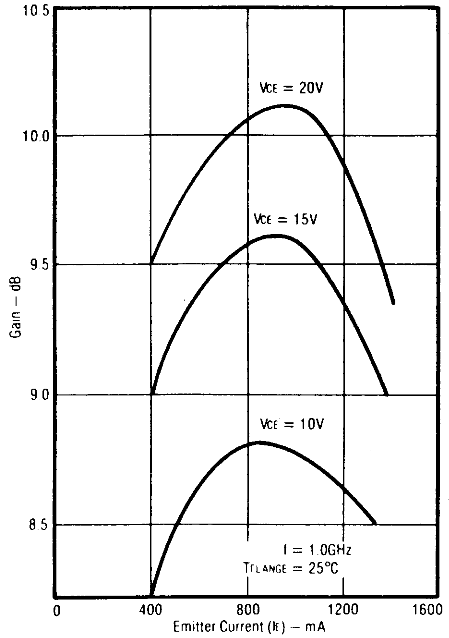
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 80mA	24			V
	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 80mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 4.0mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28V			0.5	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0V, I_C = 400mA	20		120	–
RF TEST	C_{ob}	Collector-Base Capacitance	V_{CB} = 28V, f = 1MHz			12	pF
	P_O	Power Output	V_{CE} = 20V, I_E = 880mA f = 2.0GHz, P_{in} = 2.0W	6.0			W
	f_t	Frequency Cutoff	V_{CE} = 20V, I_E = 880mA	2.4	2.6		GHz
	VSWR	Mismatch Tolerance	P_O = 6.0W, I_E = 880mA, V_{CE} = 20V	3:1			
	IMD	Third Order Intermodulation Distortion	V_{CE} = 20V, I_E = 880mA $P_{O(PEP)}$ = 6.0W Tones at 1.000GHz and 1.005GHz		-30		dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20V, I_E = 600mA, f = 1.0GHz, P_{REF} = 2.0W		-60		dB
	L_G	Gain Linearity	V_{CE} = 20V, I_E = 880mA f = 2.0GHz, P_{O1} = 6W, P_{O2} = 6mW			-0.2 +1.0	dB
OPER.	T_j & T_{stg}	Max. Junction & Storage Temperature		-65		+200	°C
	θ_{JC}	Thermal Resistance	P_O = 5W, V_{CE} = 20V, I_E = 880mA			6.0	°C/W

ELECTRICAL CHARACTERISTICS

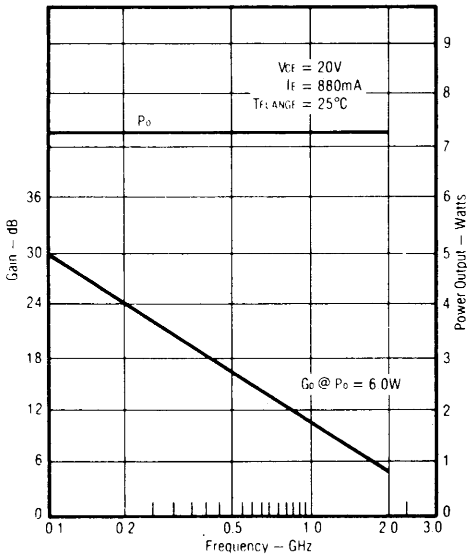
1dB Compression Point vs. Emitter Current



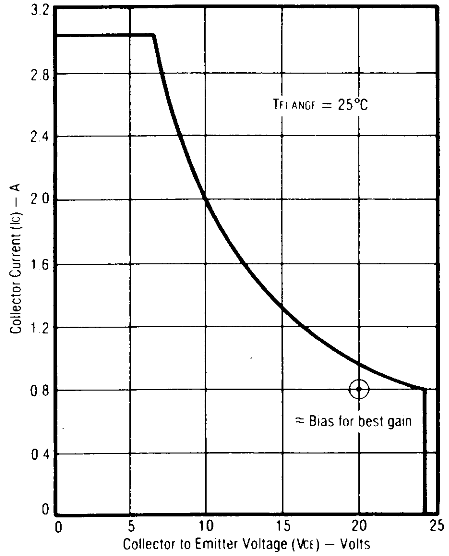
Gain vs. Emitter Current



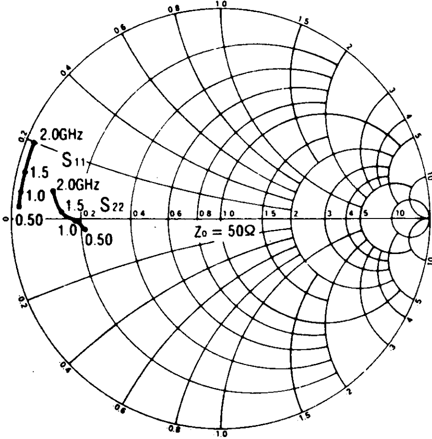
Gain and 1dB Compressed Power vs. Frequency

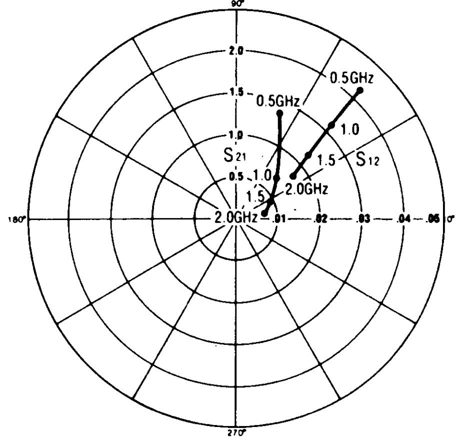


D.C. Safe Operating Area

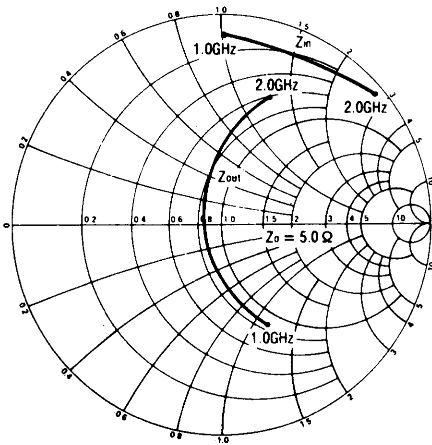


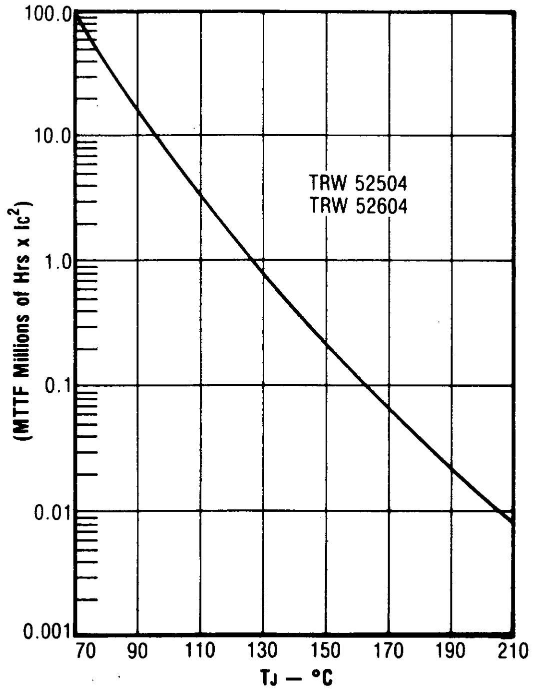
S-Parameters
V_{CE} = 20V, I_E = 880mA, T_{FLANGE} = 25°C





Large Signal Impedance Data





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The following are design specifications for this transistor series.

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Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermeticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

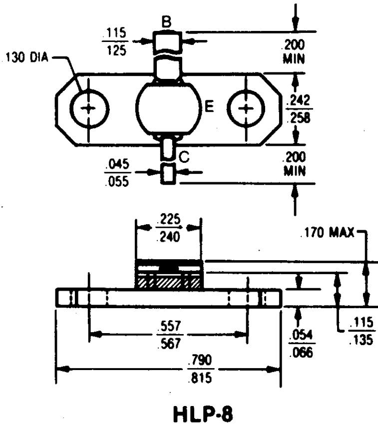
Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of NICKEL base material with minimum 60 microinches of gold plating.

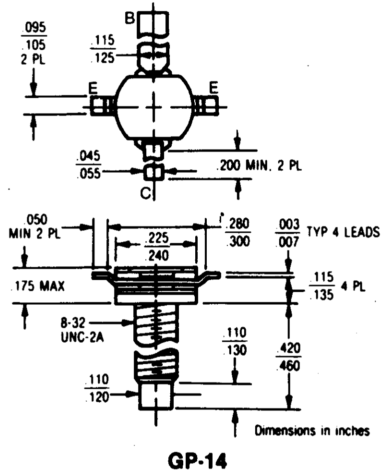
Package Outlines

TRW52604



HLP-8

TRW52504



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