MICROWAVE

PRODUCT SUMMARY

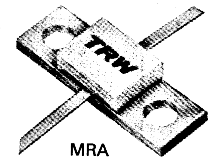
PART NUMBER	APPLICATION	FREQUENCY	POWER OR GAIN (dB)	SUPPLY VOLTAGE (V)	PACKAGE	PAGE
MRA 0610-3	MICROWAVE	600-1000 MHz	3 W	28	MRA .25	E 5
MRA 0610-9	MICROWAVE	600-1000 MHz	9 W	28	MRA .25	E 6
MRA 0610-18	MICROWAVE	600-1000 MHz	18 W	28	MRA .25	E 7
MRA 0610-40	MICROWAVE	600-1000 MHz	40 W	28	MRA .25	E 8
MRA 1014-2	MICROWAVE	1.0-1.4 GHz	2 W	28	MRA .25	E 13
MRA 1014-6	MICROWAVE	1.0-1.4 GHz	6 W	28	MRA .25	E 14
MRA 1014-12	MICROWAVE	1.0-1.4 GHz	12 W	28	MRA .25	E 15
MRA 1014-35	MICROWAVE	1.0-1.4 GHz	35 W	28	MRA .25	E 16
MRA 1214-55H	MICROWAVE	1.2-1.4 GHz	55 W	28	MRA .4	E 19
MRA 1417-2	MICROWAVE	1.4-1.7 GHz	2 W	28	MRA .25	E 23
MRA 1417-6	MICROWAVE	1.4-1.7 GHz	6 W	28	MRA .25	E 24
MRA 1417-11	MICROWAVE	1.4-1.7 GHz	11 W	28	MRA .25	E 25
MRA 1417-25	MICROWAVE	1.4-1.7 GHz	25 W	28	MRA .25	E 26
MRA 1720-2	MICROWAVE	1.7-2.0 GHz	2 W	28	MRA .25	E 31
MRA 1720-5	MICROWAVE	1.7-2.0 GHz	5 W	28	MRA .25	E 32
MRA 1720-9	MICROWAVE	1.7-2.0 GHz	9 W	28	MRA .25	E 33
MRA 1720-20	MICROWAVE	1.7-2.0 GHz	20 W	28	MRA .25	E 34
MRAL 1417-2	MICROWAVE	1.4-1.7 GHz	2 W	22	MRA .25	E 37
MRAL 1417-6	MICROWAVE	1.4-1.7 GHz	6 W	22	MRA .25	E 37
MRAL 1417-11	MICROWAVE	1.4-1.7 GHz	11 W	22	MRA .25	E 37
MRAL 1417-25	MICROWAVE	1.4-1.7 GHz	25 W	22	MRA .25	E 37
MRAL 1720-2	MICROWAVE	1.7-2.0 GHz	2 W	22	MRA .25	E 39
MRAL 1720-5	MICROWAVE	1.7-2.0 GHz	5 W	22	MRA .25	E 40
MRAL 1720-9	MICROWAVE	1.7-2.0 GHz	9 W	22	MRA .25	E 41
MRAL 1720-20	MICROWAVE	1.7-2.0 GHz	20 W	22	MRA .25	E 42
MRAL 2023-1,5	MICROWAVE	2.0-2.3 GHz	1.5 W	22	MRA .25	E 46
MRAL 2023-3	MICROWAVE	2.0-2.3 GHz	3 W	22	MRA .25	E 47
MRAL 2023-6	MICROWAVE	2.0-2.3 GHz	6 W	22	MRA .25	E 48
MRAL 2023-12	MICROWAVE	2.0-2.3 GHz	12 W	22	MRA .25	E 49
MRAL 2023-1,5H	MICROWAVE	2.0-2.3 GHz	1.5 W	22	HLP 11	E 53
MRAL 2023-3H	MICROWAVE	2.0-2.3 GHz	3 W	22	HLP 11	E 54
MRAL 2023-6H	MICROWAVE	2.0-2.3 GHz	6 W	22	HLP 11	E 55
MRAL 2023-12H	MICROWAVE	2.0-2.3 GHz	12 W	22	HLP 11	E 56
TRW 2001	MICROWAVE	2 GHz	1 W	28	HLP 8	E 59
TRW 2003	MICROWAVE	2 GHz	3 W	28	HLP 8	E 61
TRW 2005	MICROWAVE	2 GHz	5 W	28	HLP 8	E 63
TRW 2010	MICROWAVE	2 GHz	10 W	28	HLP 8	E 65
TRW 2015	MICROWAVE	2 GHz	15 W	28	HLP 11	E 67
TRW 2020	MICROWAVE	2 GHz	20 W	28	HLP 11	E 68
TRW 2301	MICROWAVE	2.3 GHz	1.5 W	20	HLP 8	E 70
TRW 2304	MICROWAVE	2.3 GHz	4 W	20	HLP 8	E 71
TRW 2307	MICROWAVE	2.3 GHz	7 W	20	HLP 8	E 72
TRW 3001	MICROWAVE	3 GHz	1 W	28	HLP 8	E 75
TRW 3003	MICROWAVE	3 GHz	3 W	28	HLP 8	E 77
TRW 3005	MICROWAVE	3 GHz	5 W	28	HLP 8	E 79
TRW 52001	MICROWAVE	2 GHz	1.5 W	20	TW 200	E 82
TRW 52002	MICROWAVE	2 GHz	3 W	20	TW 200	E 87
TRW 52004	MICROWAVE	2 GHz	6 W	20	TW 200	E 91
TRW 52101	MICROWAVE	2 GHz	1.5 W	20	HLP 8F	E 83
TRW 52201	MICROWAVE	2 GHz	1.5 W	20	GP 14S	E 83
TRW 52501	MICROWAVE	2 GHz	1.5 W	20	GP 14	E 83
TRW 52502	MICROWAVE	2 GHz	3 W	20	GP 14	E 88
TRW 52504	MICROWAVE	2 GHz	6 W	20	GP 14	E 93
TRW 52601	MICROWAVE	2 GHz	1.5 W	20	HPL 8	E 83
TRW 52602	MICROWAVE	2 GHz	3 W	20	HLP 8	E 88
TRW 52604	MICROWAVE	2 GHz	6 W	20	HLP 8	E 93
TRW 53001	MICROWAVE	3 GHz	0.8 W	20	TW 200	E 95

PRODUCT SUMMARY

PART NUMBER	APPLICATION	FREQUENCY	POWER OR GAIN (dB)	SUPPLY VOLTAGE (V)	PACKAGE	PAGE
TRW 53002	MICROWAVE	3 GHz	1.6 W	20	TW 200	E 99
TRW 53101	MICROWAVE	3 GHz	0.8 W	20	HLP 8F	E 96
TRW 53201	MICROWAVE	3 GHz	0.8 W	20	GP 14S	E 96
TRW 53501	MICROWAVE	3 GHz	0.8 W	20	GP 14	E 96
TRW 53502	MICROWAVE	3 GHz	1.6 W	20	GP 14	E 100
TRW 53601	MICROWAVE	3 GHz	0.8 W	20	HLP 8	E 96
TRW 53602	MICROWAVE	3 GHz	1.6 W	20	HLP 8	E 100
TRW 54001	MICROWAVE	2 GHz-4 GHz	0.5 W	20	TW 200	E 103
TRW 54101	MICROWAVE	2 GHz-4 GHz	0.5 W	20	HLP 8F	E 104
TRW 54201	MICROWAVE	2 GHz-4 GHz	0.5 W	20	GP 14S	E 104
TRW 54501	MICROWAVE	2 GHz-4 GHz	0.5 W	20	GP 14	E 104
TRW 54601	MICROWAVE	2 GHz-4 GHz	0.5 W	20	HLP 8	E 104
TRW 62601	MICROWAVE	2 GHz	1.2 W	20	HLP 8	E 107
TRW 62602	MICROWAVE	2 GHz	2.5 W	20	HLP 8	E 111
TRW 63601	MICROWAVE	3 GHz	0.45 W	20	HLP 8	E 115
TRW 63602	MICROWAVE	3 GHz	0.85 W	20	HLP 8	E 119
TRW 64601	MICROWAVE	4 GHz	0.3 W	20	HLP 8	E 123
TRW 64602	MICROWAVE	4 GHz	0.6 W	20	HLP 8	E 127

MICroAMP

- **3-9-18-40 W**
- **Broadband 600-1000 MHz**
- **Internally Compensated***
- **Gold Metalized**
- **Diffused Ballast Resistors**
- **MTTF Data**



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

Symbol	Characteristic	MRA0610-3	MRA0610-9	MRA0610-18	MRA0610-40
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 60 mA 50 V Min	I_C = 100 mA 50 V Min	I_C = 200 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_B = 0.5 mA 3.5 V Min	I_B = 1.25 mA 3.5 V Min	I_E = 2.5 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 28 V 0.5 mA	V_{CB} = 28 V 1.5 mA	V_{CB} = 28 V 2.5 mA	V_{CB} = 28 V 5.0 mA
		V_{CB} = 45 V 1.0 mA	V_{CB} = 45 V 3.0 mA	V_{CB} = 45 V 5.0 mA	V_{CB} = 45 V 10.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.5 A	1.5 A	5.0 A	10.0 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-100	I_C = 0.3 A 10-100	I_C = 0.5 A 10-100	I_C = 1.0 A 10-100
θ_{jF}	Thermal Resistance Junction to Flange	15 °C/W	6 °C/W	4 °C/W	2.5 °C/W
P_o	Min Broadband Power Output	3.0 W	9.0 W	18.0 W	40.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 28 V, f = 1 MHz	4.5 pF	10 pF	14 pF	28 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 28 V	P_o = 3.0 W 7.8 dB	P_o = 9.0 W 7.8 dB	P_o = 18.0 W 7.8 dB	P_o = 40.0 W 7.0 dB
MTTF	Metal Failure Factor Hrs × $Amps^2$ T_j = 150 °C*	60,692	546,227	1,517,298	6,069,192
η_c	Min Broadband Collector Efficiency	P_o = 3.0 W 50 %	P_o = 9.0 W 55 %	P_o = 18.0 W 50 %	P_o = 40.0 W 55 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : —65 to + 200 °C				

* Based on Black's equation and using φ = 0.96 EV, β = 1.07 × 10^{-12} for unpassivated Au. Empirical data indicates a 3-10 times improvement for glass passivated units. These units are glass passivated.

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, inc. (US # 3,713,006).

The TRW MRA0610 series offers a complete family of broadband, high-gain transistors for applications in the 600-1000MHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRA0610 series is intended for use in a variety of military and industrial applications including ECM, radio relay and the "960" mobile band for fixed station use.

The smooth, broadband transfer characteristics of the MRA0610 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

Device output power levels of 3, 9, 18 and 40 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

Microwave transistor devices are universally constructed using multiple cell combinations for higher power. A number of advantages are obtained using the cellular concept including better thermal balance and the ability to adjust power output capability using more or less cells to construct a device. Unless proper ballasting techniques are employed, some difficulty can be encountered in the act of combining cells. Ballasting makes cell combining practical. The alternative to ballasted cells is an operator-dependent assembly technique called "contour-bonding." Herein, bond wires of varying lengths are employed to adjust inductance and thereby achieve the expected balance. TRW has decided in favor of ballasting rather than contour-bonding because it is a controlled, repeatable and totally reliable technique.

While ballasting is desirable, certain techniques for creating ballast resistors in fine geometry microwave transistors have proven unreliable. Such an example is "metal" ballast resistors. Such resistors are incorporated by introducing an exposed section of barrier metal between the emitter finger and feeder bar. This type of resistor, of necessity, lies on top of an oxide layer. Because the metal resistor is required to dissipate as much as $10KW/CM^2$, extreme temperatures are generated in the resistor material. With this construction there is no adequate means of removing heat from the metal resistor. Therefore, the ballast resistor undergoes radical changes in physical dimension during its operating profile. This results in separation from the oxide layer or micro-cracking, or both.

Given that ballasting is desirable, a better solution, **diffused ballast resistors**, is incorporated in the MRA0610 series. Several advantages accrue from this approach. It is integral in the silicon carrier, has the same coefficient of expansion and is heat sinked. Experience has shown that the diffused ballast resistor has none of the metal resistor disadvantages, yet offers an additional advantage. In the MRA0610 series, the diffused resistor is designed to current limit (because of limited carriers) before destructive current levels at the junction occur. Diffused ballast resistors are definitely superior in performance and reliability. Test data is available to verify this fact.

METALIZATION AND RELIABILITY

Metal migration is the main concern when considering a metal system. In fine geometry devices such as microwave transistors, the use of aluminum having sufficiently large grain size to provide an activation energy equal to that of gold is not possible since geometrical definition would be impossible. In order to adequately define small geometries, one must use aluminum with a grain size (1 micron or less) which has a very unattractive activation energy. Activation energy has an exponential relationship to metal migration.

A fair comparison of two metal systems (aluminum versus gold) would be to construct the same transistor using both metal systems and calculate the anticipated metal failure point using Black's equation. The following example is based upon the same transistor cell as is used in the TRW MRA0610 series.

Junction Temperature	Times Improvement of MTTF with Gold vs Aluminum
100°C	691
125°C	370
150°C	168
175°C	56
200°C	30

For this reason, TRW RF Semiconductors uses a gold metalization system on all microwave transistors including the MRA0610 series.

TRW'S PATENTED* MICroAMP

Since power microwave transistors became feasible, the bandwidth limiting problem of excessively high input "Q's" has vexed the solid state microwave amplifier designer.

Parasitic reactances (primarily due to the package) become increasingly more significant past 200MHz and impose severe limitations on band width past 1GHz. Additionally, the real component of input $Z(R_{bh})$ becomes smaller as higher drive power and higher power outputs are achieved.

Microwave power transistors generally employ several emitter ballasted cells in parallel to obtain power outputs required with the small cell geometry necessary to realize a microwave transistor. Figure 1 shows the schematic representation of such a device.

Note that all components of the input impedance are in parallel, which compounds the "Q" and bandwidth problem as more cells are used to achieve power, or the operating frequency is raised (or both). Figure 2 illustrates a more acceptable solution which combines inputs after an impedance transformation at the input of each device cell. It is convenient to do this all or partially within the package.

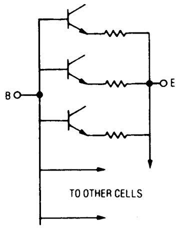


Figure 1. Elementary Method of Cell Combining

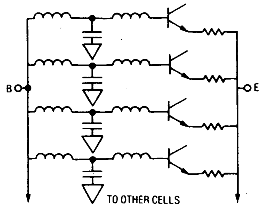


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

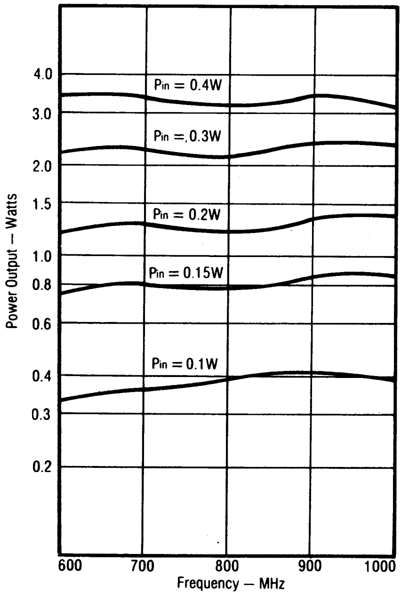
Because of the nature of source impedance driving the transistor cell (essentially a voltage source), as much as 10dB additional usable dynamic range without noticeably altering bandwidth or tuning is possible with the MICroAMP.

Additional gain and bandwidth advantage can be obtained by operation of the MICroAMP device cells in a common base configuration. The devices described therein are so configured.

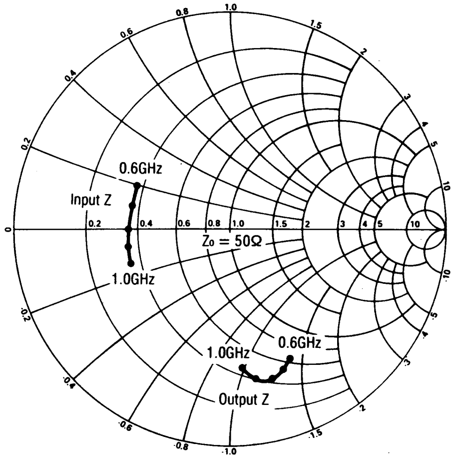
*TRW U.S. Patent #3,713,006

MRA0610-3 — 3 WATTS BROADBAND

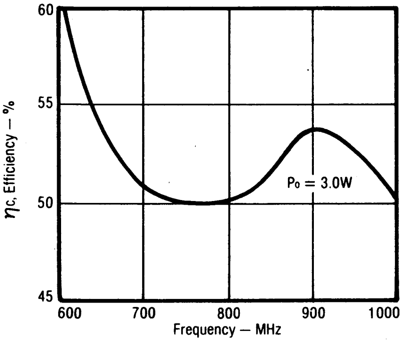
Typical Power Output vs Frequency



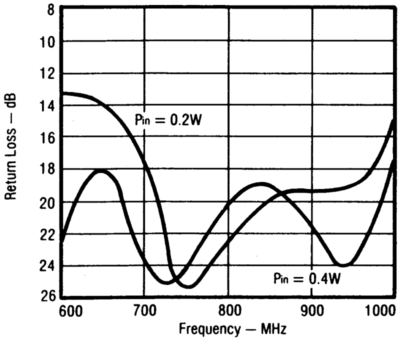
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

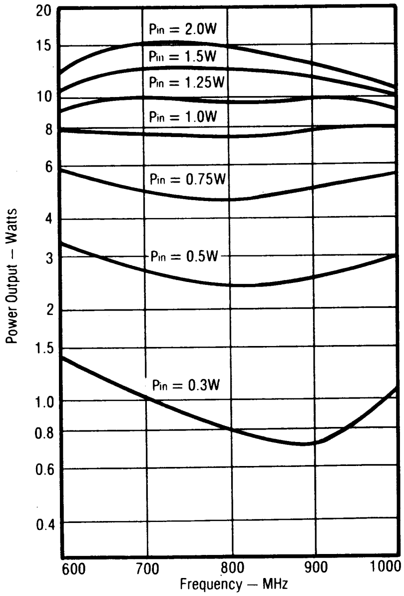


Typical Return Loss vs Frequency

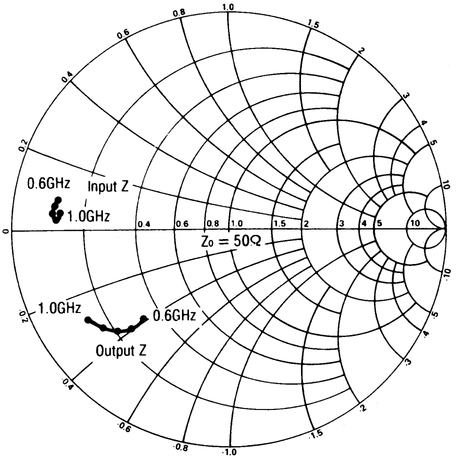


MRA0610-9 — 9 WATTS BROADBAND

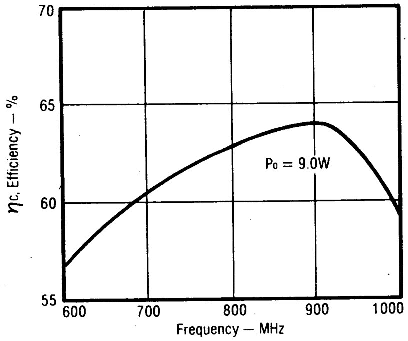
Typical Power Output vs Frequency



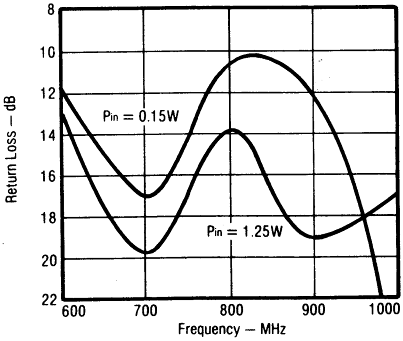
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

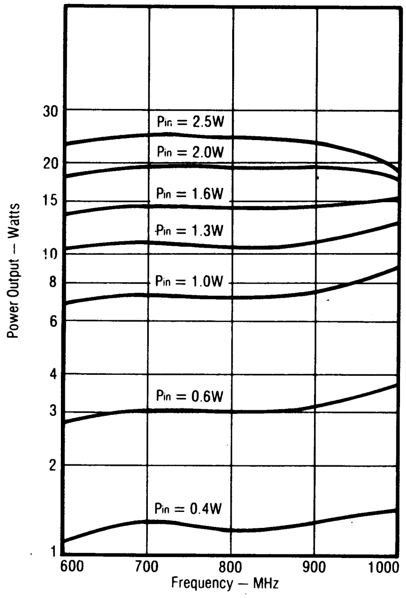


Typical Return Loss vs Frequency

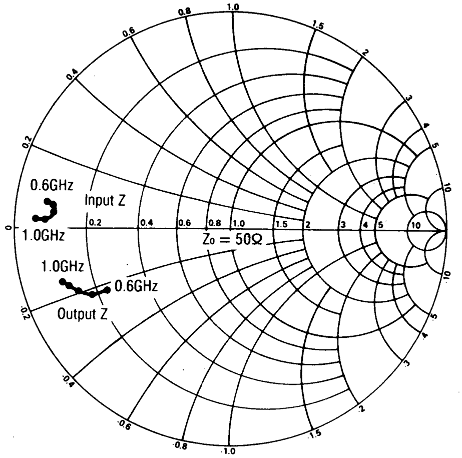


MRA0610-18 — 18 WATTS BROADBAND

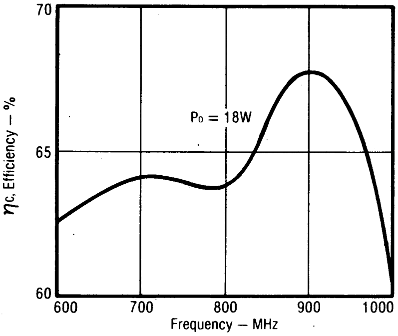
Typical Power Output vs Frequency



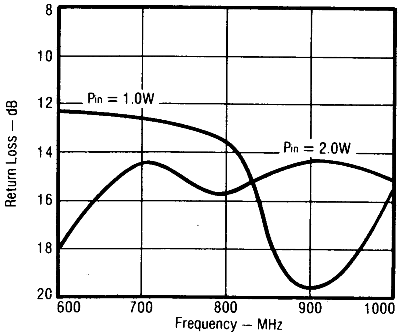
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

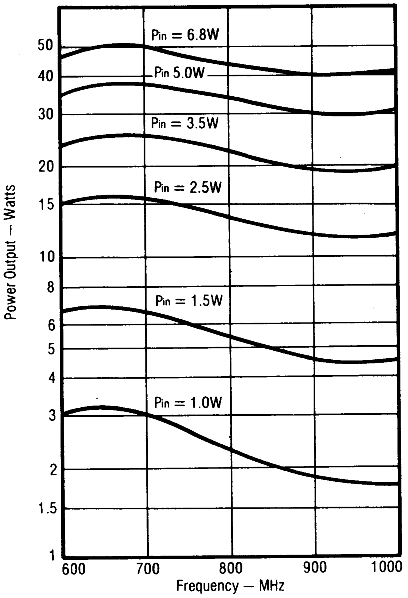


Typical Return Loss vs Frequency

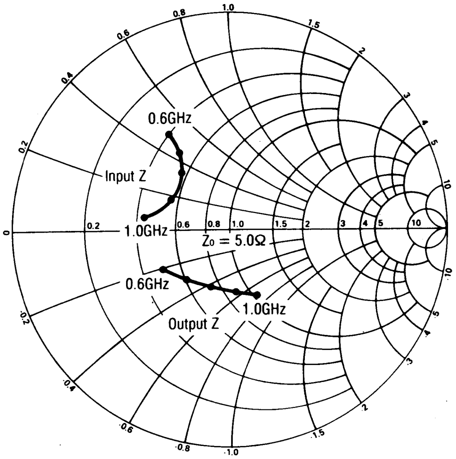


MRA0610-40 — 40 WATTS BROADBAND

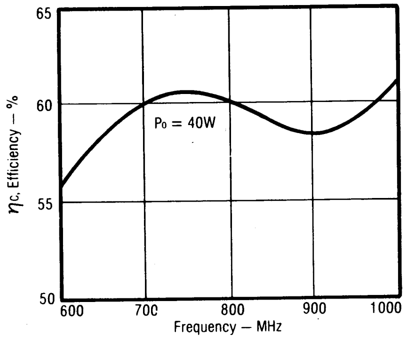
Typical Power Output vs Frequency



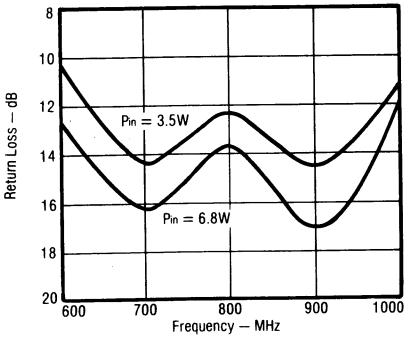
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

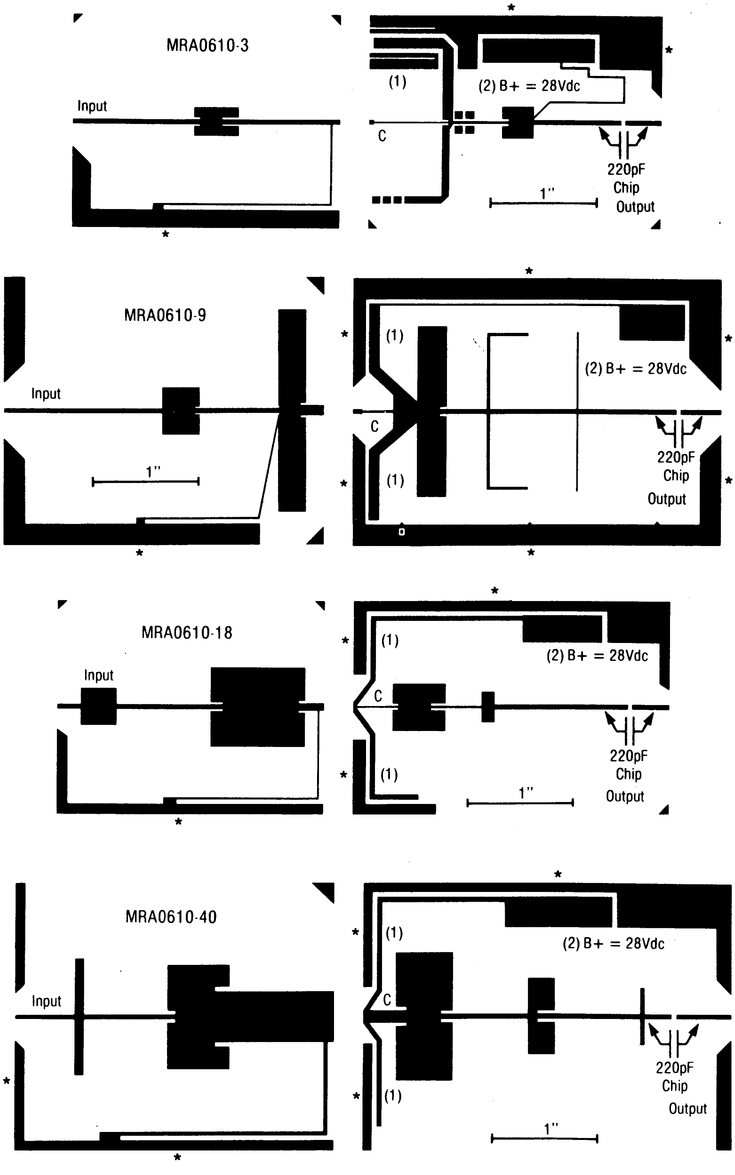


Typical Return Loss vs Frequency



TEST CIRCUIT BOARDS FOR MRA0610 SERIES

NOTE: Scale is not 1:1.



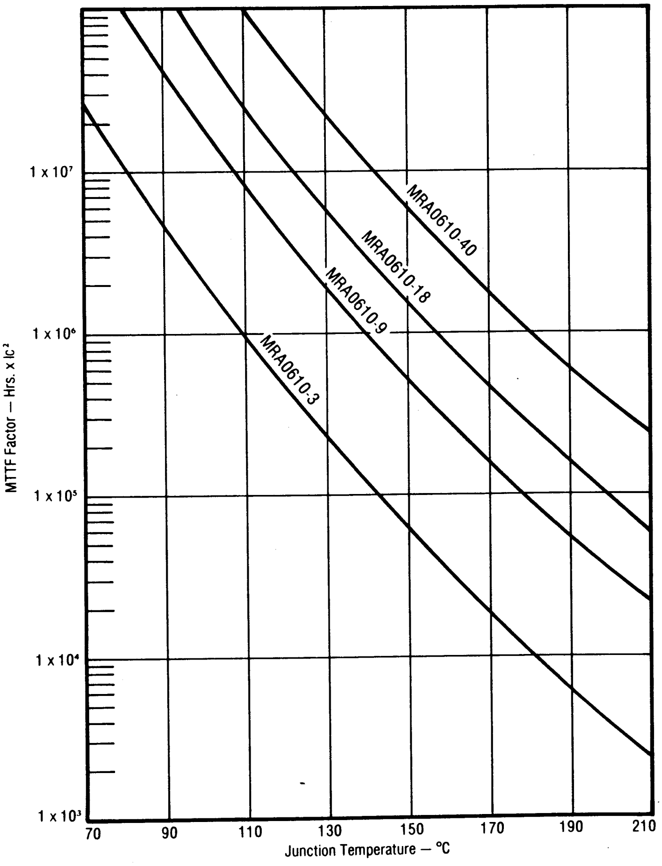
*Foil wrap or plate around to ground plane. Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

(1) Bypass capacitor to ground for shunt inductor (220pF chip).

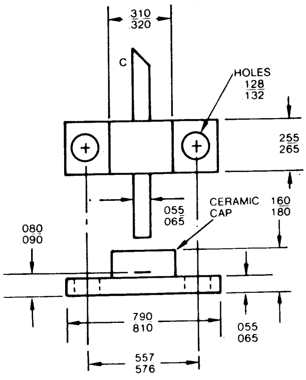
(2) Use B+ bypass of 0.01 and 1μF capacitors at this point.

MTTF FACTOR vs Tj

(Divide by Ic² to obtain metal lifetime in hours.)



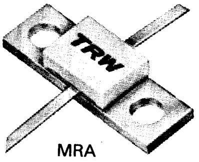
MRA Series Package



MRA 1014 Series

MICroAMP.

- **2-6-12-35 W**
- **Broadband 1000-1400 MHz**
- **Internally Compensated***
- **Gold Metalized**
- **Diffused Ballast Resistors**
- **MTTF Data**



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

Symbol	Characteristic	MRA1014-2	MRA1014-6	MRA1014-12	MRA1014-35
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 40 mA 50 V Min	I_C = 80 mA 50 V Min	I_C = 200 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_E = 0.5 mA 3.5 V Min	I_E = 1.0 mA 3.5 V Min	I_E = 2.5 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 28 V 0.5 mA	V_{CB} = 28 V 1.0 mA	V_{CB} = 28 V 2.0 mA	V_{CB} = 28 V 5.0 mA
		V_{CB} = 45 V 1.0 mA	V_{CB} = 45 V 2.0 mA	V_{CB} = 45 V 4.0 mA	V_{CB} = 45 V 10.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.5 A	1.5 A	5.0 A	10.0 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-100	I_C = 0.2 A 10-100	I_C = 0.4 A 10-100	I_C = 1.0 A 10-100
θ_{jF}	Thermal Resistance Junction to Flange	15 °C/W	8 °C/W	4.5 °C/W	2 °C/W
P_o	Min Broadband Power Output	3.0 W	6.0 W	12.0 W	35.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 28 V, f = 1 MHz	4.5 pF	8 pF	12 pF	28 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 28 V	P_o = 2.0 W 8.2 dB	P_o = 6.0 W 7.4 dB	P_o = 12.0 W 7.8 dB	P_o = 35.0 W 7.0 dB
η_c	Min Broadband Collector Efficiency	P_o = 2.0 W 45 %	P_o = 6.0 W 50 %	P_o = 12.0 W 50 %	P_o = 35.0 W 50 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : — 65 to + 200 °C				

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, Inc. (US # 3,713,006).

The TRW MRA1014 series offers a complete family of broadband, high-gain transistors for applications in the 1000-1400MHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRA1014 series is intended for use in a variety of military and industrial applications including ECM, radio relay and telemetry for fixed station use.

The smooth, broadband transfer characteristics of the MRA1014 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

Device output power levels of 2, 6, 12 and 35 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

Microwave transistor devices are universally constructed using multiple cell combinations for higher power. A number of advantages are obtained using the cellular concept including better thermal balance and the ability to adjust power output capability using more or less cells to construct a device. Unless proper ballasting techniques are employed, some difficulty can be encountered in the act of combining cells. Ballasting makes cell combining practical. The alternative to ballasted cells is an operator-dependent assembly technique called "contour-bonding." Herein, bond wires of varying lengths are employed to adjust inductance and thereby achieve the expected balance. TRW has decided in favor of ballasting rather than contour-bonding because it is a controlled, repeatable and totally reliable technique.

While ballasting is desirable, certain techniques for creating ballast resistors in fine geometry microwave transistors have proven unreliable. Such an example is "metal" ballast resistors. Such resistors are incorporated by introducing an exposed section of barrier metal between the emitter finger and feeder bar. This type of resistor, of necessity, lies on top of an oxide layer. Because the metal resistor is required to dissipate as much as $10KW/CM^2$, extreme temperatures are generated in the resistor material. With this construction there is no adequate means of removing heat from the metal resistor. Therefore, the ballast resistor undergoes radical changes in physical dimension during its operating profile. This results in separation from the oxide layer or micro-cracking, or both.

Given that ballasting is desirable, a better solution, **diffused ballast resistors**, is incorporated in the MRA1014 series. Several advantages accrue from this approach. It is integral in the silicon carrier, has the same coefficient of expansion and is heat sinked. Experience has shown that the diffused ballast resistor has none of the metal resistor disadvantages, yet offers an additional advantage. In the MRA1014 series, the diffused resistor is designed to current limit (because of limited carriers) before destructive current levels at the junction occur. Diffused ballast resistors are definitely superior in performance and reliability. Test data is available to verify this fact.

METALIZATION AND RELIABILITY

Metal migration is the main concern when considering a metal system. In fine geometry devices common to all microwave transistors, the use of aluminum having sufficiently large grain size to provide an activation energy equal to that of gold is not possible since geometrical definition would be impossible. In order to adequately define small geometries, one must use aluminum with a grain size (1 micron or less) which has a very unattractive activation energy. Activation energy has an exponential relationship to metal migration.

A fair comparison of two metal systems (aluminum versus gold) would be to construct the same transistor using both metal systems and calculate the anticipated metal failure point using Black's equation. The following example is based upon the same transistor cell as is used in the TRW MRA1014 series.

Junction Temperature	Times Improvement of MTTF with Gold vs Aluminum
100°C	691
125°C	370
150°C	168
175°C	56
200°C	30

For this very obvious reason TRW RF Semiconductors uses a gold metalization system on all microwave transistors including the MRA1014 series.

TRW'S PATENTED* MICroAMP

Since power microwave transistors became feasible, the bandwidth limiting problem of excessively high input "Q's" has vexed the solid state microwave amplifier designer.

Parasitic reactances (primarily due to the package) become increasingly more significant past 200MHz and impose severe limitations on band width past 1GHz. Additionally, the real component of input Z(R_{bb}) becomes smaller as higher drive power and higher power outputs are achieved.

Microwave power transistors generally employ several emitter ballasted cells in parallel to obtain power outputs required with the small cell geometry necessary to realize a microwave transistor. Figure 1 shows the schematic representation of such a device.

Note that all components of the input impedance are in parallel, which compounds the "Q" and bandwidth problem as more cells are used to achieve power, or the operating frequency is raised (or both). Figure 2 illustrates a more acceptable solution which combines inputs after an impedance transformation at the input of each device cell. It is convenient to do this all or partially within the package.

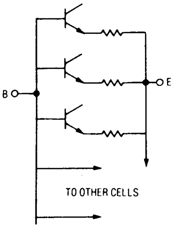


Figure 1. Elementary Method of Cell Combining

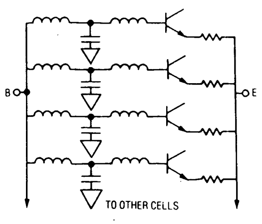


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

Because of the nature of source impedance driving the transistor cell (essentially a voltage source), as much as 10dB additional usable dynamic range without noticeably altering bandwidth or tuning is possible with the MICroAMP.

Additional gain and bandwidth advantage can be obtained by operation of the MICroAMP device cells in a common base configuration. The devices described therein are so configured.

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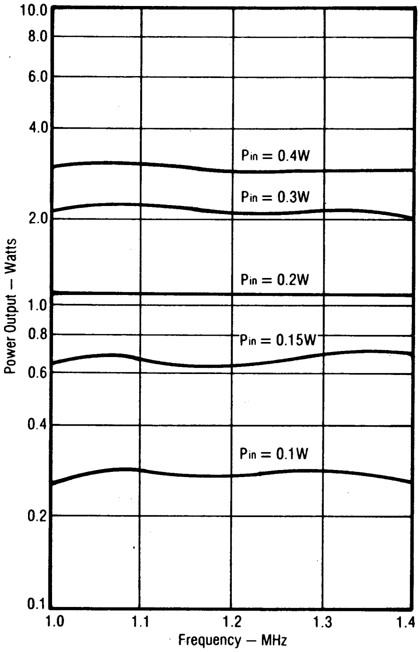
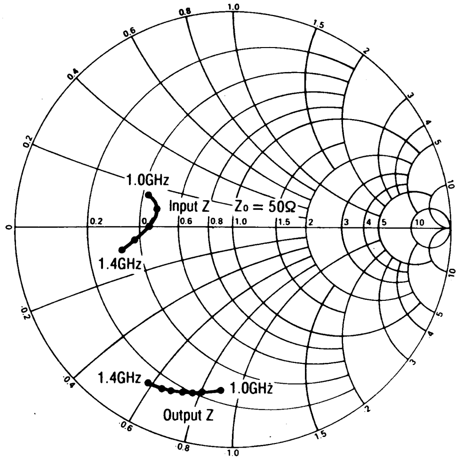
*TRW U.S. Patent #3,713,006

MRA1014-2 — 2 WATTS BROADBAND

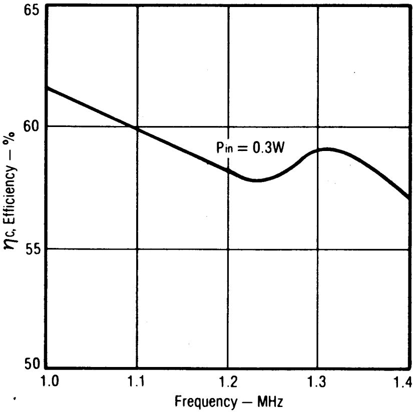
Typical Power Output vs Frequency



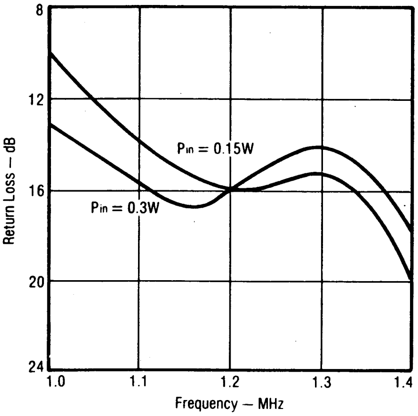
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

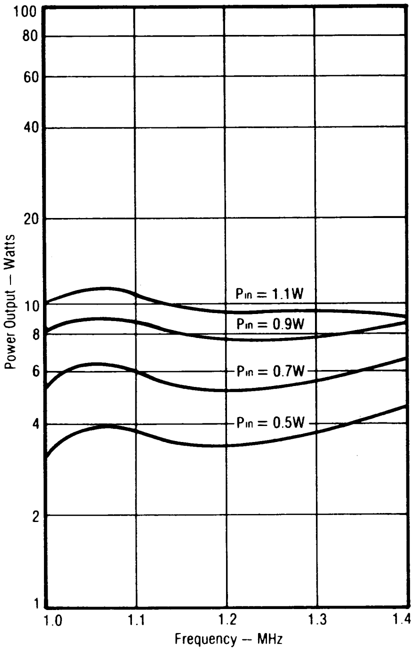


Typical Return Loss vs Frequency

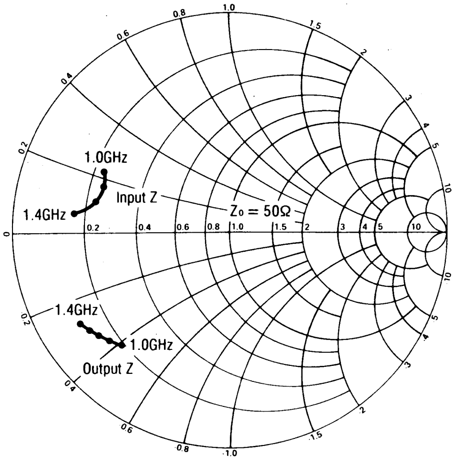


MRA1014-6 — 6 WATTS BROADBAND

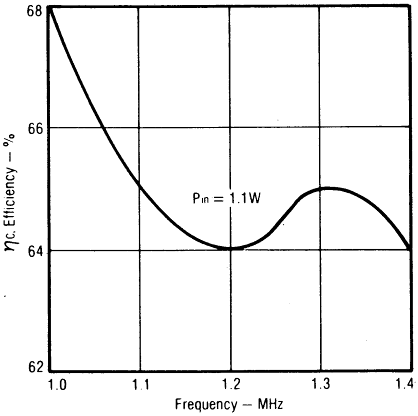
Typical Power Output vs Frequency



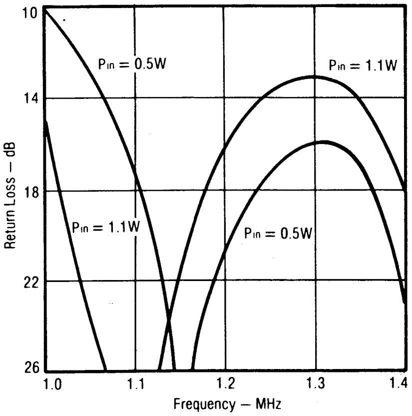
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

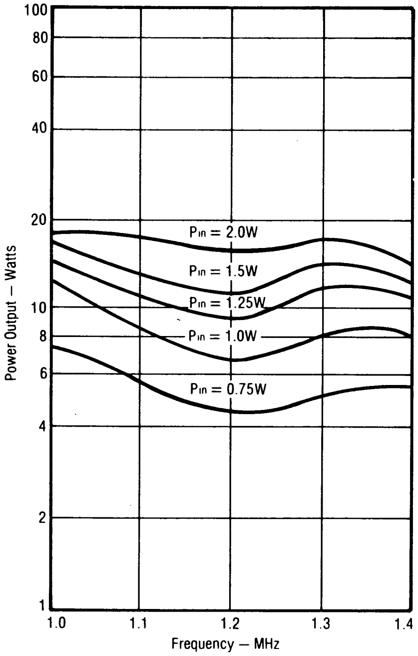


Typical Return Loss vs Frequency



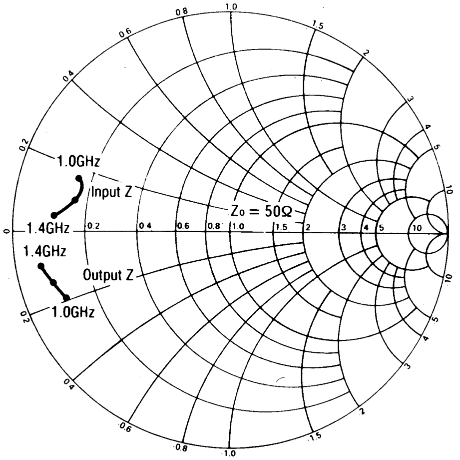
MRA1014-12 — 12 WATTS BROADBAND

Typical Power Output vs Frequency

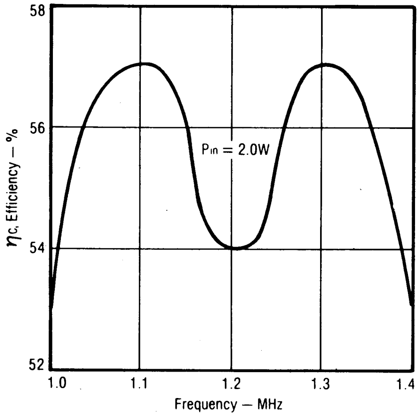


Impedance Data

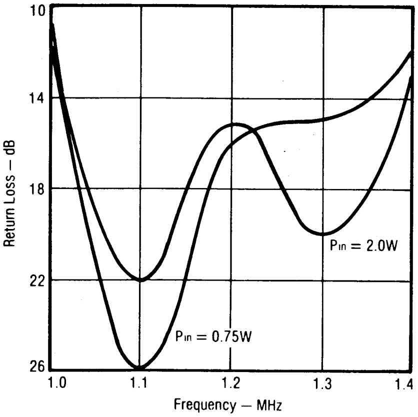
Vcc = 28V



Typical Efficiency vs Frequency

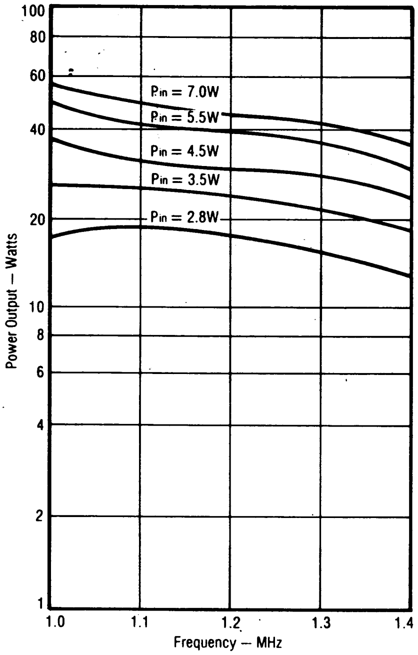


Typical Return Loss vs Frequency

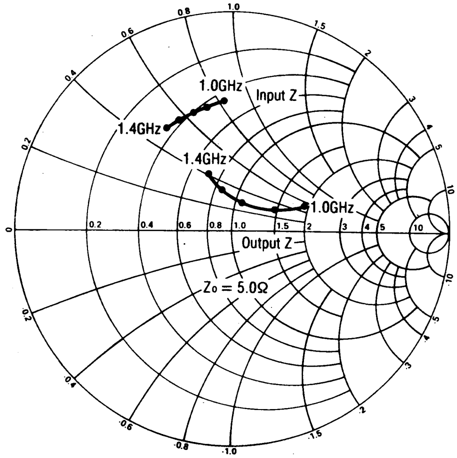


MRA1014-35 — 35 WATTS BROADBAND

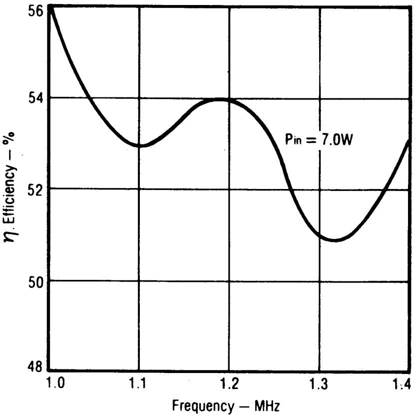
Typical Power Output vs Frequency



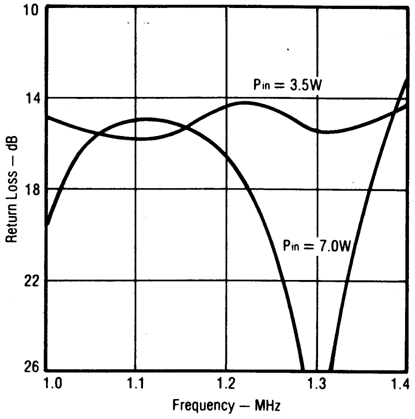
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

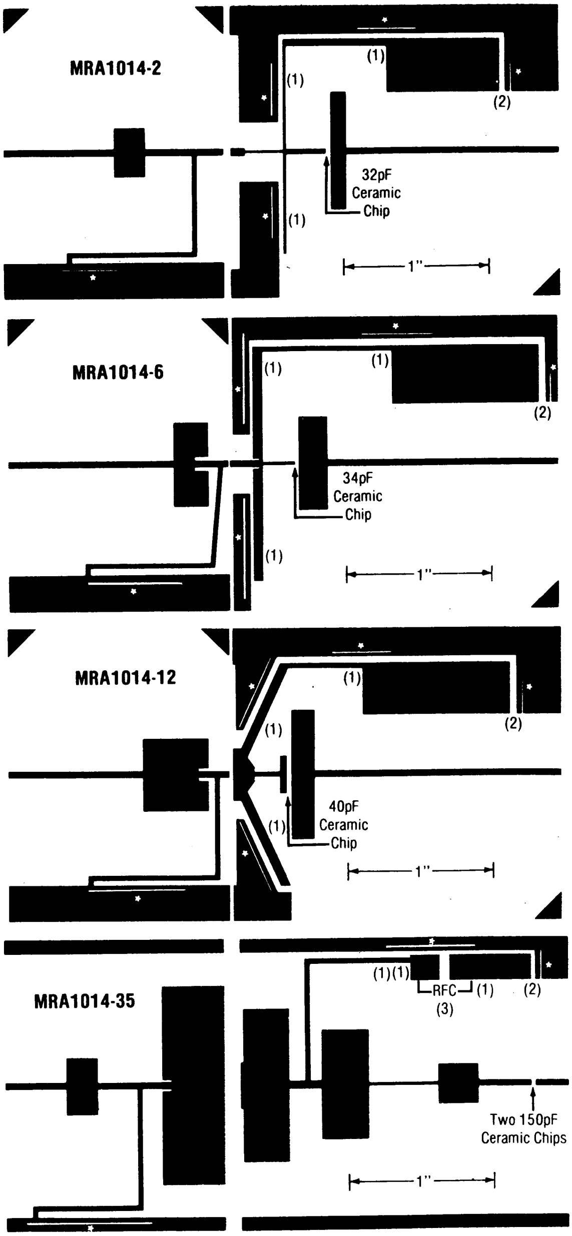


Typical Return Loss vs Frequency



TEST CIRCUIT BOARDS FOR MRA1014 SERIES

NOTE: Scale is not 1:1.



*Foil wrap or plate around to ground plane. Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

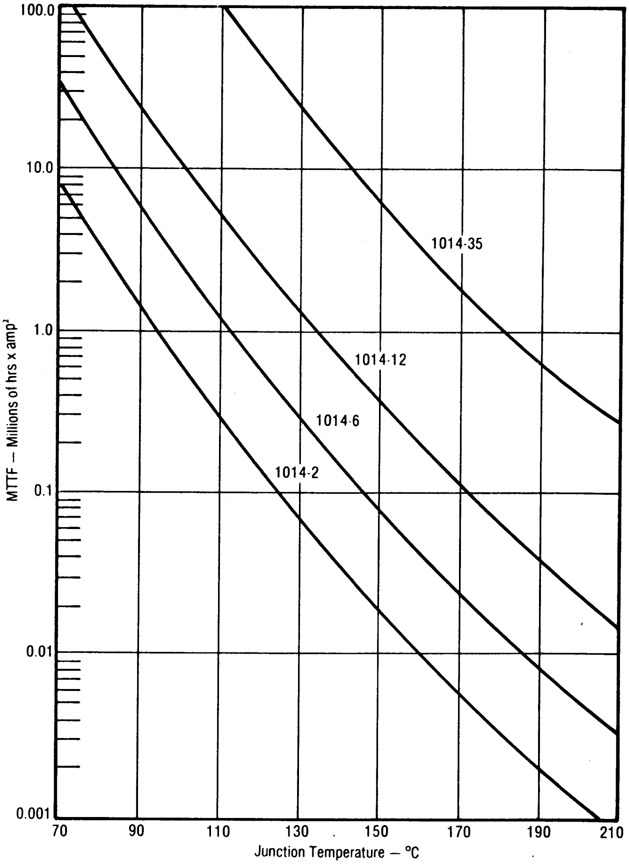
(1) Bypass capacitor to ground (150pF chip).

(2) Use B+ bypass of 0.01 and 1μF capacitors at this point.

(3) 10 turns #20 enamel close wound on 0.040 mandril.

MTTF FACTOR (Normalized to 1 Ampere^2 Continuous Duty)

The graph shown below displays MTTF in hours x ampere^2 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.



Example of MTTF for MRA1014-12 Conditions

where:

$P_o = 12W$
$P_{in} = 2W$
$V_{CC} = 28V$
$\eta_C = 50\%$
$T_{flange} = 70°C$

$$I_C \cong I_E = \frac{100\, P_o}{\eta_C \times V_{CC}} = 0.857A$$

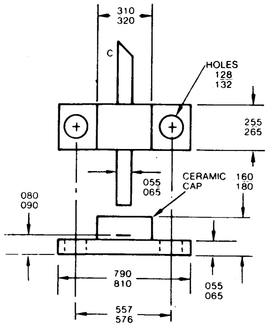
$$P_{diss} = P_{in} + V_{CC}\, I_C - P_o = 14.0W$$

$$T_{junc} = T_{flange} + \theta_{JF} \times P_{diss} = 133°C$$

$$MTTF = \frac{1.2 \times 10^6 \text{ hrs amp}^2}{I_C^2} = 1{,}400{,}200 \text{ hrs}$$

$$= 159 \text{ yrs}$$

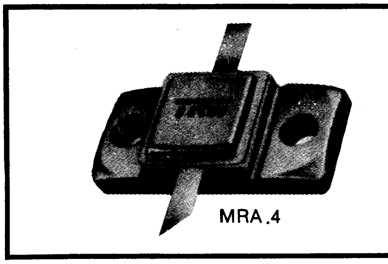
MRA Series Package



MRA 1214-55H

L-Band High Power

- **55 W**
- **1200-1400 MHz**


MRA.4

The TRW MRA 1214-55H* is an NPN silicon power RF transistor which is intended for military and industrial use in the 1200-1400 MHz range. It provides a minimum of 55 watts output power at 28 VDC collector potential.

In a pulsed mode (100 µs, modest duty) as much as 100 watts output power is available.

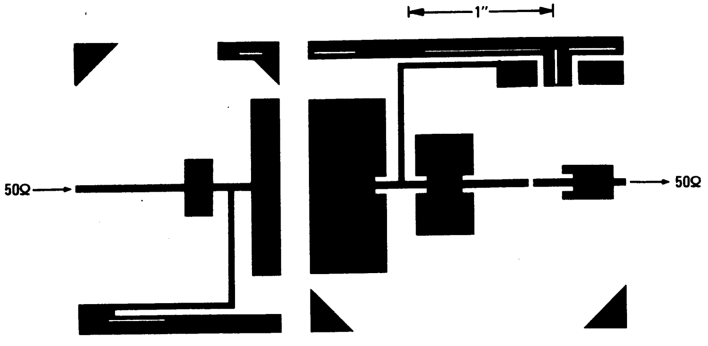
The devices feature TRW-pioneered advantages such as PtSi-TiWAu metalization and diffused silicon ballast resistors.

These high power microwave transistors find use in radar systems, ECM systems and other L-Band systems. 6.5 dB of power gain allows hybrid combining of multiple devices. The high power output of the MRA 1214-55H assures combining of a minimum number of devices to achieve desired power output.

Electrical Characteristics (25°C unless otherwise noted)

Test	Characteristic	Test Conditions	Min.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 2.0mA	3.5		Volts
BV_{CES}	Collector-Base Breakdown Voltage	I_C = 6.0mA I_C = 12.0mA I_C = 120.0mA	28 45 58		Volts
P_O	Min. Broadband Power Output	P_{IN} = 12.3W 1.2-1.4 GHz (@ 6.5dB Gain)	55		Watts
η_C	Min. Broadband Collector Efficiency	P_O = 55W 1.2-1.4 GHz V_{CC} = 28V	45	50 (typ.)	Percent
θ_{JF}	Thermal Resistance Junction to Flange	T_{FLANGE} = 25°C	1.5		0°C/W

MRA1214-55H stripline circuit for .020" glass-Teflon



NOTE: Foil bond all slots to ground plane (back).

MRA 4

Typical Efficiency vs. Frequency
Power Output vs. Frequency