

# RF Power Field-Effect Transistor

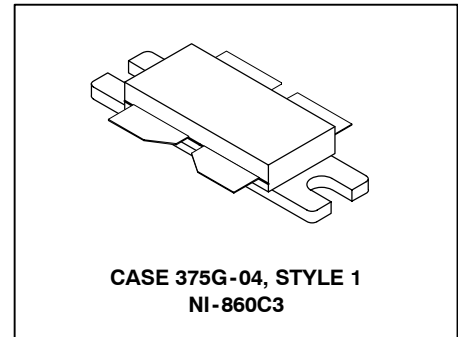
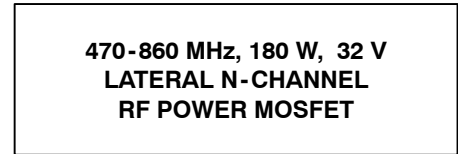
## N-Channel Enhancement-Mode Lateral MOSFET

Designed for broadband commercial and industrial applications with frequencies from 470 to 860 MHz. The high gain and broadband performance of this device make it ideal for large-signal, common source amplifier applications in 32 volt transmitter equipment.

- Typical Narrowband Two-Tone Performance @  $f_1 = 857$  MHz,  $f_2 = 863$  MHz, 32 Volts  
Output Power — 180 Watts PEP  
Power Gain — 17 dB  
Efficiency — 36%  
IMD — -35 dBc
- Typical Broadband Two-Tone Performance @  $f_1 = 857$  MHz,  $f_2 = 863$  MHz, 32 Volts  
Output Power — 180 Watts PEP  
Power Gain — 14.5 dB  
Efficiency — 37%  
IMD — -31 dBc
- Capable of Handling 3:1 VSWR @ 32 Vdc, 857 MHz, 90 Watts CW Output Power

### Features

- Internally Matched for Ease of Use
- Integrated ESD Protection
- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.  
R5 Suffix = 50 Units per 56 mm, 13 inch Reel.



**Table 1. Maximum Ratings**

| Rating   | Symbol    | Value       | Unit                     |
|--|-----------|-------------|--------------------------|
| Drain-Source Voltage   | $V_{DSS}$ | -0.5, +68   | Vdc                      |
| Gate-Source Voltage  | $V_{GS}$  | -0.5, +15   | Vdc                      |
| Drain Current - Continuous   | $I_D$     | 17          | Adc                      |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$     | 350<br>2.0  | W<br>W/ $^\circ\text{C}$ |
| Storage Temperature Range  | $T_{stg}$ | -65 to +150 | $^\circ\text{C}$         |
| Case Operating Temperature   | $T_C$     | 150         | $^\circ\text{C}$         |
| Operating Junction Temperature   | $T_J$     | 200         | $^\circ\text{C}$         |

**Table 2. Thermal Characteristics**

| Characteristic                       | Symbol          | Value | Unit                      |
|--------------------------------------|-----------------|-------|---------------------------|
| Thermal Resistance, Junction to Case | $R_{\theta JC}$ | 0.5   | $^\circ\text{C}/\text{W}$ |

**Table 3. ESD Protection Characteristics**

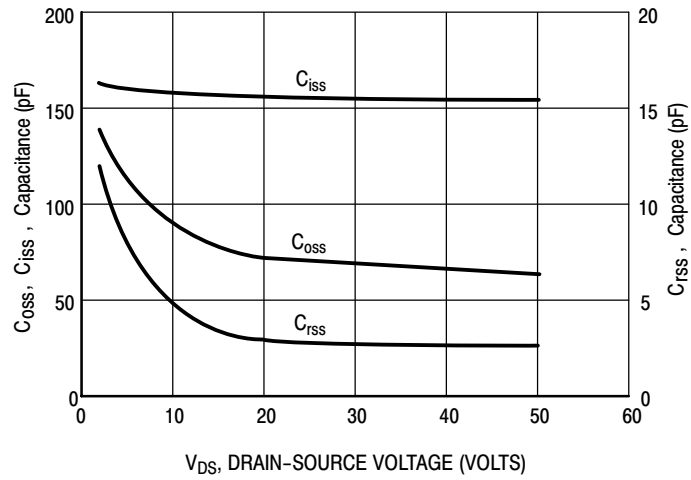
| Test Conditions  | Class        |
|------------------|--------------|
| Human Body Model | 1 (Minimum)  |
| Machine Model    | M3 (Minimum) |

**Table 4. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

| Characteristic  | Symbol        | Min | Typ  | Max  | Unit            |
|---|---------------|-----|------|------|-----------------|
| <b>Off Characteristics</b> <sup>(1)</sup>   |               |     |      |      |                 |
| Drain-Source Breakdown Voltage<br>( $V_{GS} = 0 \text{ Vdc}$ , $I_D = 10 \mu\text{A}$ )   | $V_{(BR)DSS}$ | 68  | —    | —    | Vdc             |
| Zero Gate Voltage Drain Current<br>( $V_{DS} = 32 \text{ Vdc}$ , $V_{GS} = 0 \text{ Vdc}$ )   | $I_{DSS}$     | —   | —    | 10   | $\mu\text{Adc}$ |
| Gate-Source Leakage Current<br>( $V_{GS} = 5 \text{ Vdc}$ , $V_{DS} = 0 \text{ Vdc}$ )  | $I_{GSS}$     | —   | —    | 1    | $\mu\text{Adc}$ |
| <b>On Characteristics</b>   |               |     |      |      |                 |
| Gate Threshold Voltage <sup>(1)</sup><br>( $V_{DS} = 10 \text{ V}$ , $I_D = 200 \mu\text{A}$ )  | $V_{GS(th)}$  | 2   | 3    | 4    | Vdc             |
| Gate Quiescent Voltage <sup>(2)</sup><br>( $V_{DS} = 32 \text{ V}$ , $I_D = 100 \text{ mA}$ )   | $V_{GS(Q)}$   | 2.5 | 3.5  | 4.5  | Vdc             |
| Drain-Source On-Voltage <sup>(1)</sup><br>( $V_{GS} = 10 \text{ V}$ , $I_D = 3 \text{ A}$ )   | $V_{DS(on)}$  | —   | 0.28 | 0.45 | Vdc             |
| Forward Transconductance<br>( $V_{DS} = 10 \text{ V}$ , $I_D = 3 \text{ A}$ )   | $g_{fs}$      | —   | 2.6  | —    | S               |
| <b>Dynamic Characteristics</b> <sup>(1)</sup>   |               |     |      |      |                 |
| Input Capacitance (Includes Input Matching Capacitance)<br>( $V_{DS} = 32 \text{ V}$ , $V_{GS} = 0 \text{ V}$ , $f = 1 \text{ MHz}$ )   | $C_{iss}$     | —   | 260  | —    | pF              |
| Output Capacitance<br>( $V_{DS} = 32 \text{ V}$ , $V_{GS} = 0 \text{ V}$ , $f = 1 \text{ MHz}$ )  | $C_{oss}$     | —   | 69   | —    | pF              |
| Reverse Transfer Capacitance<br>( $V_{DS} = 32 \text{ V}$ , $V_{GS} = 0 \text{ V}$ , $f = 1 \text{ MHz}$ )  | $C_{rss}$     | —   | 2.5  | —    | pF              |
| <b>Functional Characteristics, Narrowband Operation</b> <sup>(2)</sup> (In Freescale MRF372 Narrowband Circuit, 50 ohm system)  |               |     |      |      |                 |
| Common Source Power Gain<br>( $V_{DD} = 32 \text{ V}$ , $P_{out} = 180 \text{ W PEP}$ , $I_{DQ} = 800 \text{ mA}$ ,<br>$f_1 = 857 \text{ MHz}$ , $f_2 = 863 \text{ MHz}$ )      | $G_{ps}$      | 16  | 17   | —    | dB              |
| Drain Efficiency<br>( $V_{DD} = 32 \text{ V}$ , $P_{out} = 180 \text{ W PEP}$ , $I_{DQ} = 800 \text{ mA}$ ,<br>$f_1 = 857 \text{ MHz}$ , $f_2 = 863 \text{ MHz}$ )              | $\eta$        | 33  | 36   | —    | %               |
| Intermodulation Distortion<br>( $V_{DD} = 32 \text{ Vdc}$ , $P_{out} = 180 \text{ W PEP}$ , $I_{DQ} = 800 \text{ mA}$ ,<br>$f_1 = 857 \text{ MHz}$ , $f_2 = 863 \text{ MHz}$ )  | IMD           | —   | -35  | -31  | dBc             |
| <b>Typical Characteristics, Broadband Operation</b> <sup>(2)</sup> (In Freescale MRF372 Broadband Circuit, 50 ohm system)   |               |     |      |      |                 |
| Common Source Power Gain<br>( $V_{DD} = 32 \text{ Vdc}$ , $P_{out} = 180 \text{ W PEP}$ , $I_{DQ} = 1000 \text{ mA}$ ,<br>$f_1 = 857 \text{ MHz}$ , $f_2 = 863 \text{ MHz}$ )   | $G_{ps}$      | —   | 14.5 | —    | dB              |
| Drain Efficiency<br>( $V_{DD} = 32 \text{ Vdc}$ , $P_{out} = 180 \text{ W PEP}$ , $I_{DQ} = 1000 \text{ mA}$ ,<br>$f_1 = 857 \text{ MHz}$ , $f_2 = 863 \text{ MHz}$ )           | $\eta$        | —   | 37   | —    | %               |
| Intermodulation Distortion<br>( $V_{DD} = 32 \text{ Vdc}$ , $P_{out} = 180 \text{ W PEP}$ , $I_{DQ} = 1000 \text{ mA}$ ,<br>$f_1 = 857 \text{ MHz}$ , $f_2 = 863 \text{ MHz}$ ) | IMD           | —   | -31  | —    | dBc             |

1. Each side of device measured separately.
2. Measurement made with device in push-pull configuration.

## TYPICAL CHARACTERISTICS



Note:  $C_{iss}$  does not include input matching capacitance.

**Figure 1. Capacitance versus Voltage**

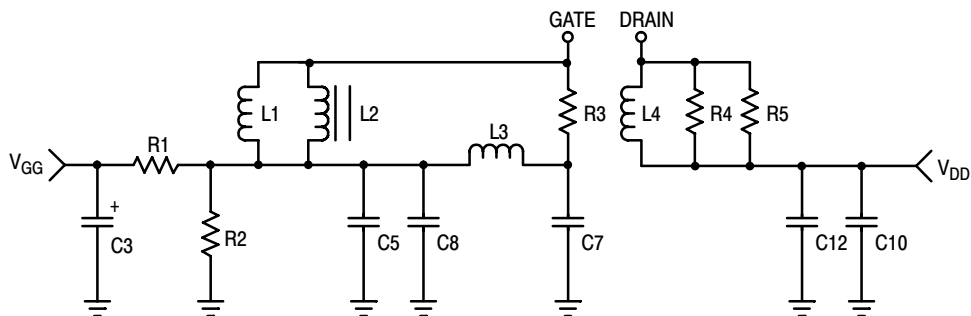
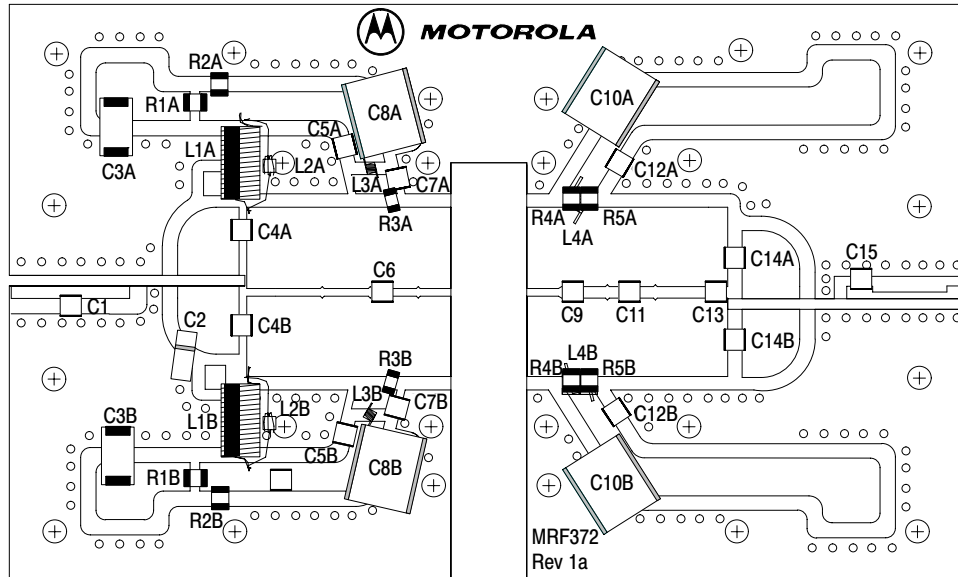


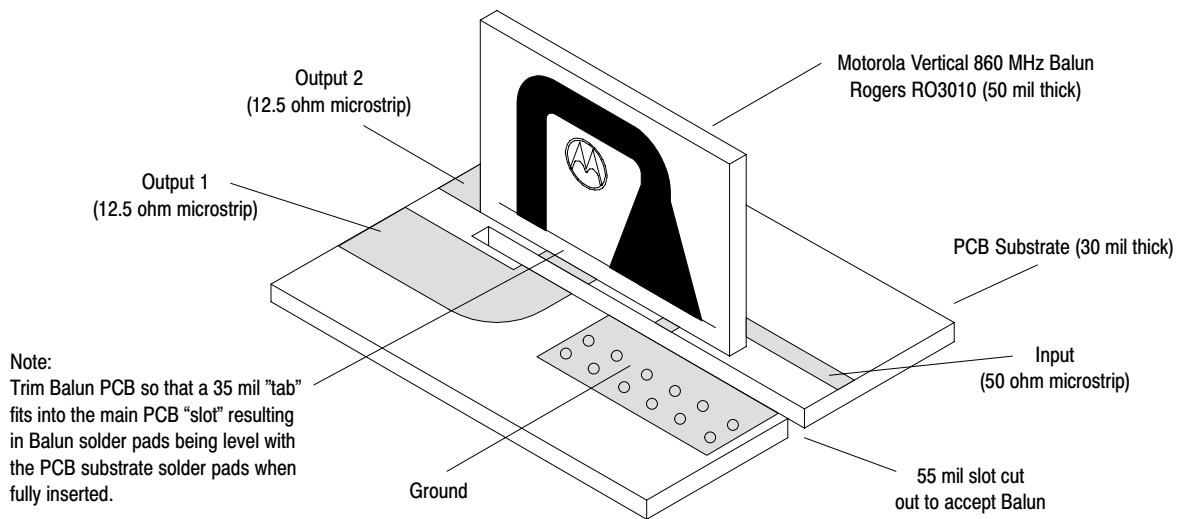
Figure 2. 860 MHz Narrowband DC Bias Networks

Table 5. 860 MHz Narrowband DC Bias Networks Component Designations and Values

| Designation                      | Description  |
|----------------------------------|--|
| C1                               | 2.2 pF Chip Capacitor, ATC   |
| C2                               | 0.5 — 5.0 pF Variable Capacitor, Johansen Gigatrim   |
| C3A, B                           | 22 $\mu$ F, 22 V Tantalum Chip Capacitors, Kemet #T491D226K22AS  |
| C4A, B, C14A, B                  | 47.0 pF Chip Capacitors, ATC   |
| C5A, B                           | 100 pF Chip Capacitors, ATC  |
| C6                               | 10.0 pF Chip Capacitor, ATC  |
| C7A, B                           | 2.7 pF Chip Capacitors, ATC  |
| C8A, B                           | 1.0 $\mu$ F, 100 V Chip Capacitors, Vitramon #VJ3640Y105KXBAT  |
| C9                               | 10.0 pF Chip Capacitor, ATC  |
| C10A, B                          | 2.2 $\mu$ F, 100 V Chip Capacitors, Vitramon #VJ3640Y225KXBAT  |
| C11                              | 5.1 pF Chip Capacitor, ATC   |
| C12A, B                          | 0.01 $\mu$ F, 100 V Chip Capacitors, Kemet #VJ1210Y103KXBAT  |
| C13                              | 3.9 pF Chip Capacitor, ATC   |
| C15                              | 1.2 pF Chip Capacitor, ATC   |
| L1A, B                           | 130 nH, Coilcraft #132-11SM  |
| L2A, B                           | #24 AWG, 3 Turns Loose, Fair Rite #2643706001  |
| L3A, B                           | 3.85 nH, Coilcraft #0906-4   |
| L4A, B                           | 5.0 nH, Coilcraft #A02T  |
| R1A, B, R2A, B<br>R4A, B, R5A, B | 180 $\Omega$ , 1/4 W Chip Resistors, Vishay Dale (1210)  |
| R3A, B                           | 12 $\Omega$ , 1/8 W Chip Resistors, Vishay Dale (1206)   |
| PCB                              | MRF372 Printed Circuit Board Rev 1a, Rogers RO4350, Height 30 mils, $\epsilon_r = 3.48$                            |
| Balun A, B                       | Vertical 860 MHz Broadband Balun, Printed Circuit Board Rev 01, Rogers RO3010, Height 50 mils, $\epsilon_r = 10.2$ |



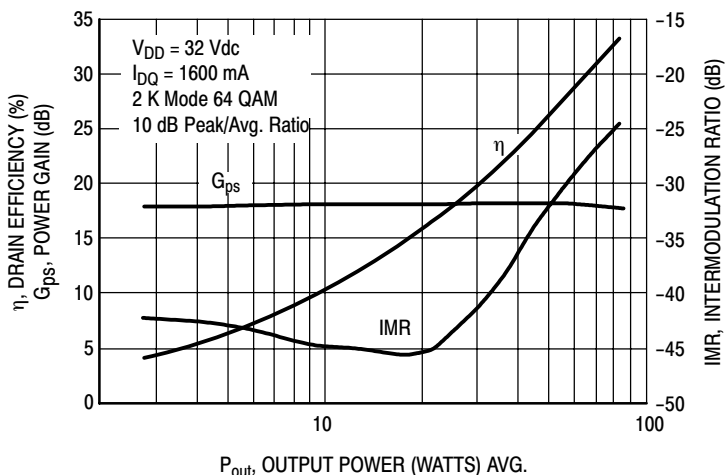
### Vertical Balun Mounting Detail



Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

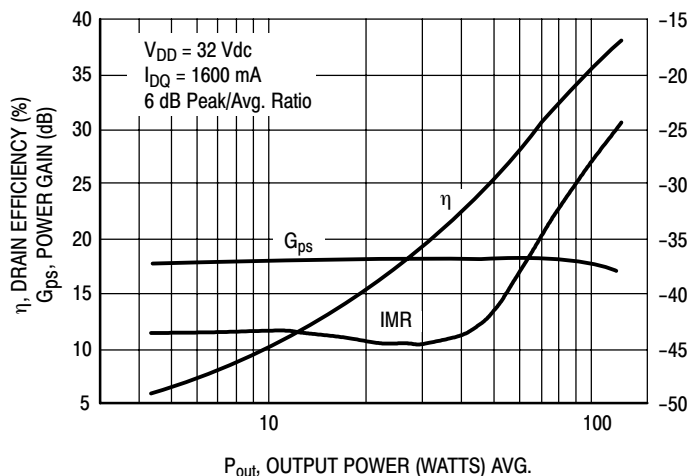
**Figure 3. 860 MHz Narrowband Component Layout**

## TYPICAL TWO-TONE NARROWBAND CHARACTERISTICS



Note: IMR measured using Delta Marker Method.

Figure 4. COFDM Performance (860 MHz)



Note: IMR measured using Delta Marker Method.

Figure 5. 8-VSB Performance (860 MHz)

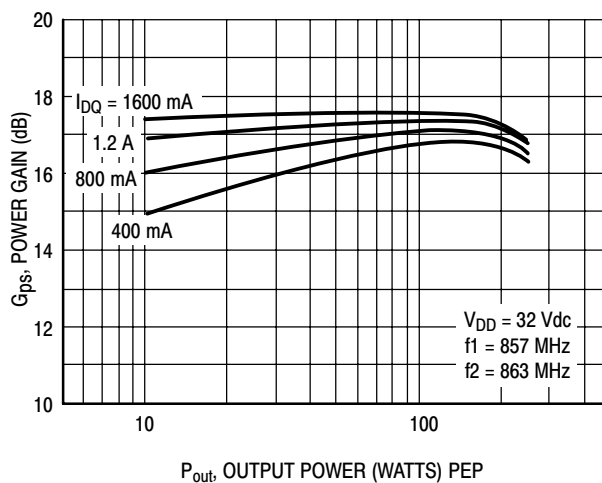


Figure 6. Power Gain versus Output Power

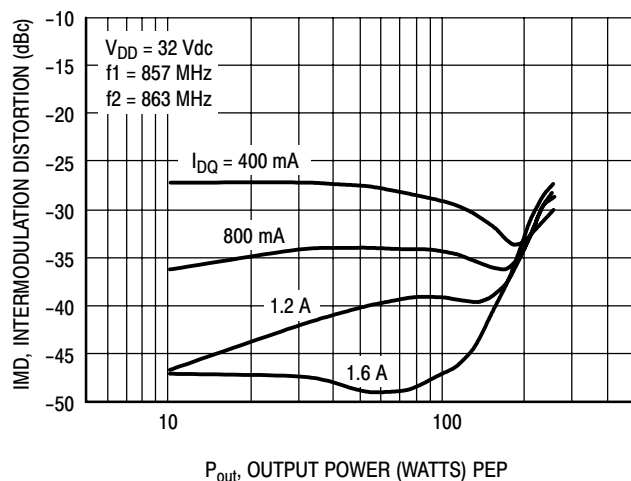


Figure 7. Intermodulation Distortion versus Output Power

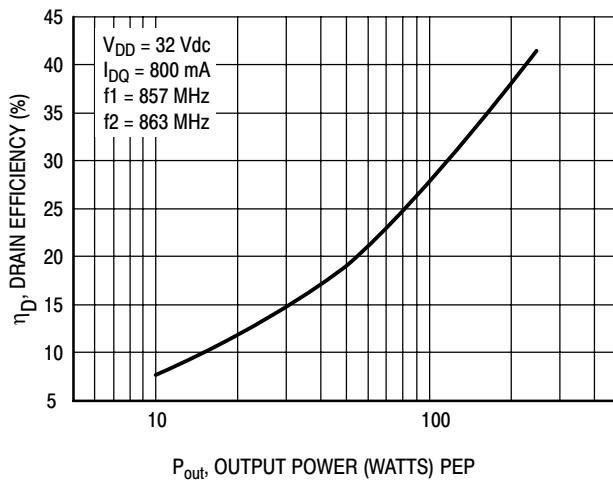
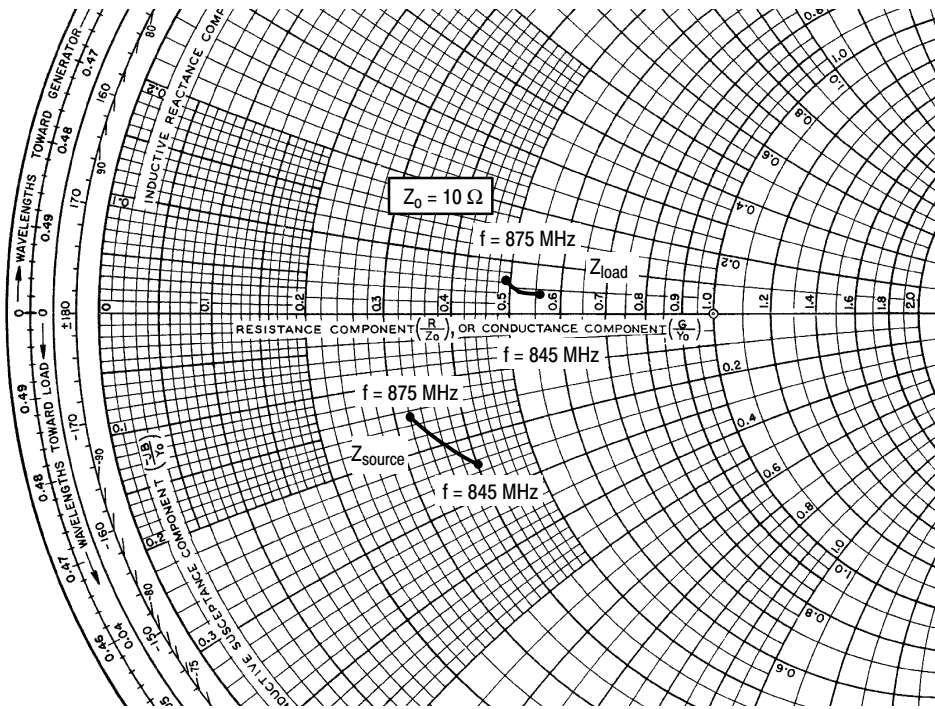


Figure 8. Drain Efficiency versus Output Power



$V_{DD} = 32\text{ V}$ ,  $I_{DQ} = 800\text{ mA}$ ,  $P_{out} = 180\text{ W PEP}$

| f<br>MHz  | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|-----------|--------------------------|------------------------|
| 845       | $3.99 - j2.50$           | $5.63 + j0.38$         |
| 860       | $3.56 - j1.98$           | $5.28 + j0.43$         |
| 875       | $3.18 - j1.46$           | $4.94 + j0.56$         |
| Harmonics |                          |                        |
| f<br>GHz  | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
| 1.69      | $2.85 + j14.30$          | $1.23 + j9.37$         |
| 1.72      | $3.27 + j14.32$          | $1.54 + j9.60$         |
| 1.75      | $3.35 + j14.36$          | $1.73 + j9.62$         |

$Z_{source}$  = Test circuit impedance as measured from gate to gate, balanced configuration.

$Z_{load}$  = Test circuit impedance as measured from drain to drain, balanced configuration.

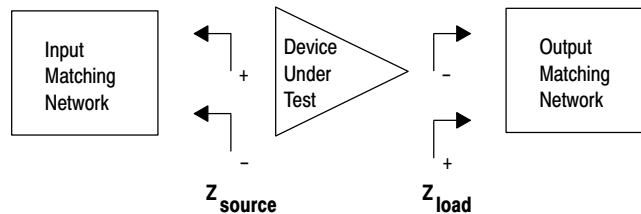


Figure 9. Narrowband Series Equivalent Source and Load Impedance

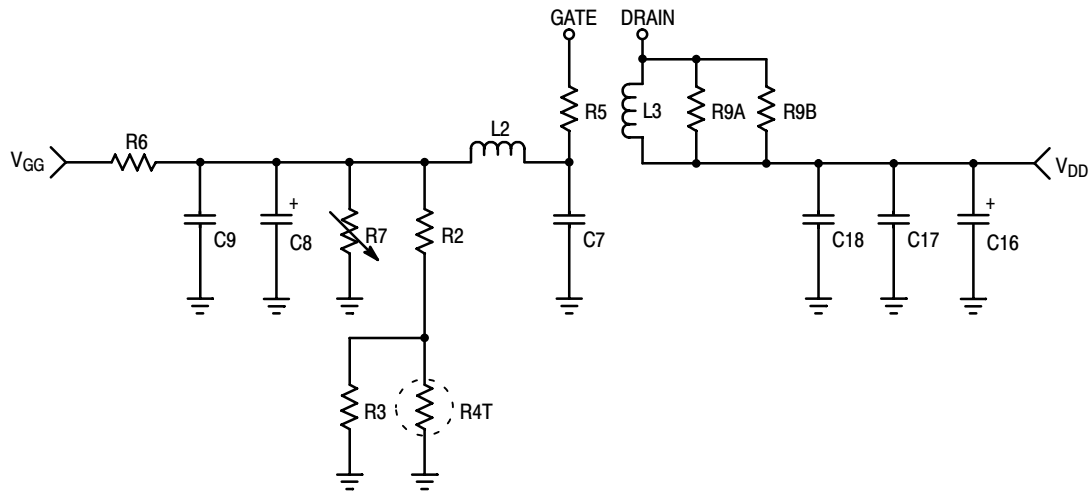
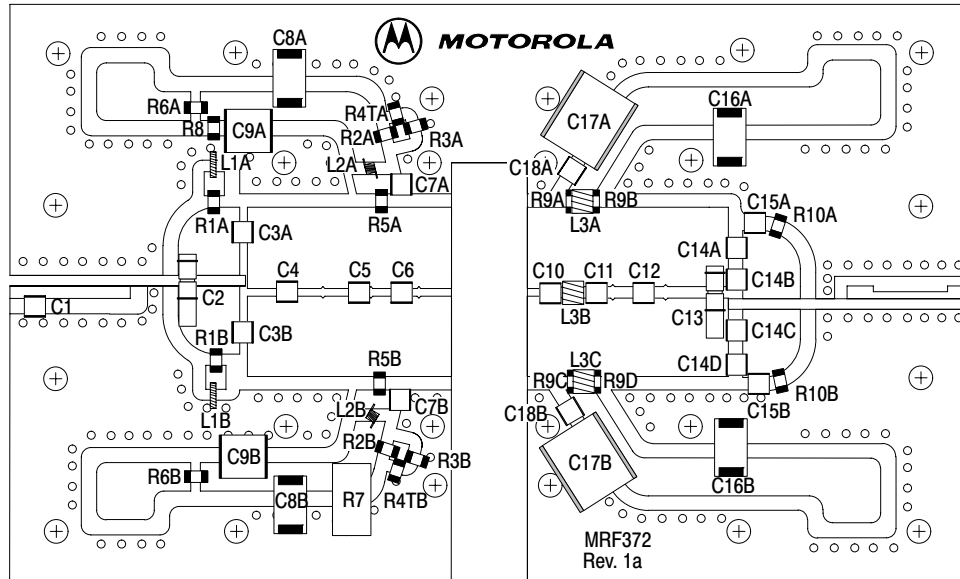


Figure 10. 470-860 MHz Broadband DC Bias Networks

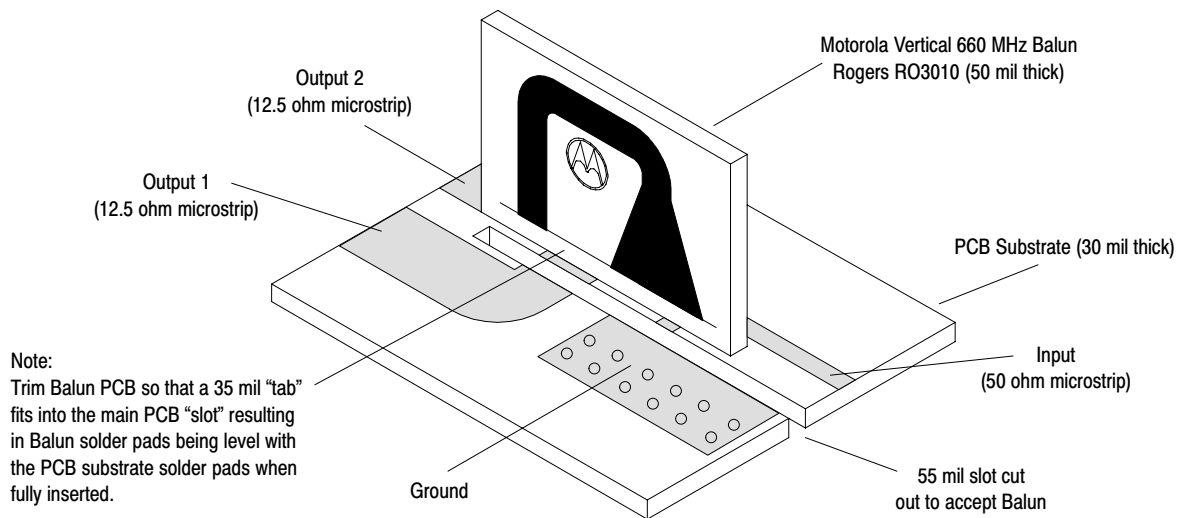
Table 6. 470-860 MHz Broadband DC Bias Networks Component Designations and Values

| Designation           | Description  |
|-----------------------|--|
| C1                    | 0.7 pF Chip Capacitor, ATC   |
| C2, C13               | 0.8 — 8.0 pF Variable Capacitors, Johansen Gigatrim  |
| C3A, B, C14A, B, C, D | 100 pF Chip Capacitors, ATC  |
| C4                    | 4.7 pF, Chip Capacitor, ATC  |
| C5                    | 7.5 pF Chip Capacitor, ATC   |
| C6                    | 10.0 pF Chip Capacitor, ATC  |
| C7A, B                | 6.2 pF Chip Capacitors, ATC  |
| C8A, B                | 22 $\mu$ F, 22 V Tantalum Chip Capacitors, Kemet #T491D226K22AS  |
| C9A, B                | 0.1 $\mu$ F, 100 V Chip Capacitors, Vitramon #VJ3640Y104KXBAT  |
| C10                   | 13 pF Chip Capacitor, ATC  |
| C11                   | 6.8 pF Chip Capacitor, ATC   |
| C12                   | 3.9 pF Chip Capacitor, ATC   |
| C15A, B               | 3.3 pF Chip Capacitors, ATC  |
| C16A, B               | 10 $\mu$ F, 35 V Tantalum Chip Capacitors, Kemet #T491D106K35AS  |
| C17A, B               | 3.3 $\mu$ F, 100 V Chip Capacitors, Vitramon #VJ3640Y335KXBAT  |
| C18A, B               | 0.01 $\mu$ F Chip Capacitors, ATC  |
| L1A, B                | 12.55 nH, Coilcraft #1606-10   |
| L2A, B                | 5.45 nH, Coilcraft #0906-5   |
| L3A, B, C             | 12.5 nH, Coilcraft #A04T   |
| R1A, B                | 10 $\Omega$ , 1/4 W Chip Resistors, Vishay Dale (1210)   |
| R2A, B                | 2.2 k $\Omega$ , 1/4 W Chip Resistors, Vishay Dale (1210)  |
| R3A, B, R10A, B       | 390 $\Omega$ , 1/8 W Chip Resistors, Vishay Dale (1206)  |
| R4TA, B               | 520 $\Omega$ , Thermistor, Vishay #NTHS—1206J14520R5%  |
| R5A, B                | 6.2 $\Omega$ , 1/4 W Chip Resistors, Vishay Dale (1210)  |
| R6A, B                | 6.8 k $\Omega$ , 1/4 W Chip Resistors, Vishay Dale (1210)  |
| R7                    | 100 k $\Omega$ Potentiometer, Bourns   |
| R8                    | 47.3 k $\Omega$ , 1/8 W Chip Resistor, Vishay Dale (1206)  |
| R9A, B, C, D          | 180 $\Omega$ , 1/4 W Chip Resistors, Vishay Dale (1210)  |
| PCB                   | MRF372 Printed Circuit Board Rev 1a, Rogers RO4350, Height 30 mils, $\epsilon_r = 3.48$                            |
| Balun A, B            | Vertical 660 MHz Broadband Balun, Printed Circuit Board Rev 01, Rogers RO3010, Height 50 mils, $\epsilon_r = 10.2$ |





### Vertical Balun Mounting Detail



Freescall has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescall Semiconductor signature/logo. PCBs may have either Motorola or Freescall markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 11. 470-860 MHz Broadband Component Layout**

## TYPICAL TWO-TONE BROADBAND CHARACTERISTICS

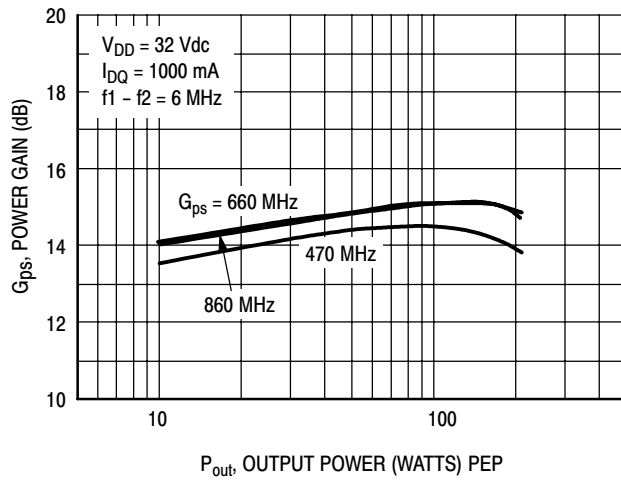


Figure 12. Power Gain versus Output Power

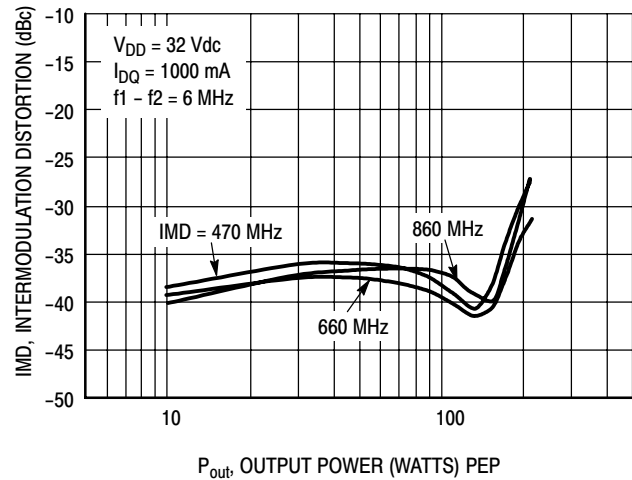


Figure 13. Intermodulation Distortion versus Output Power

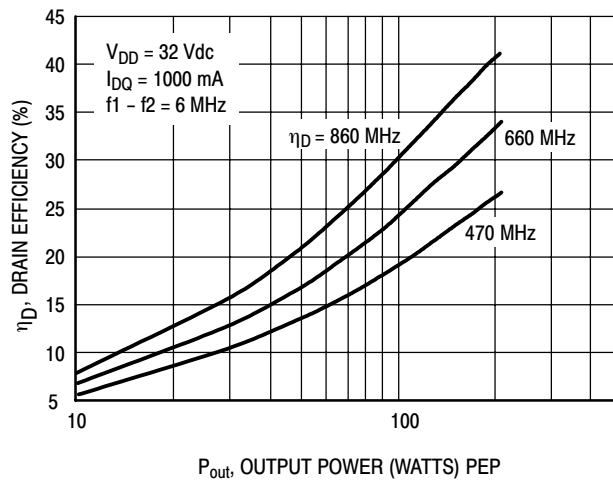
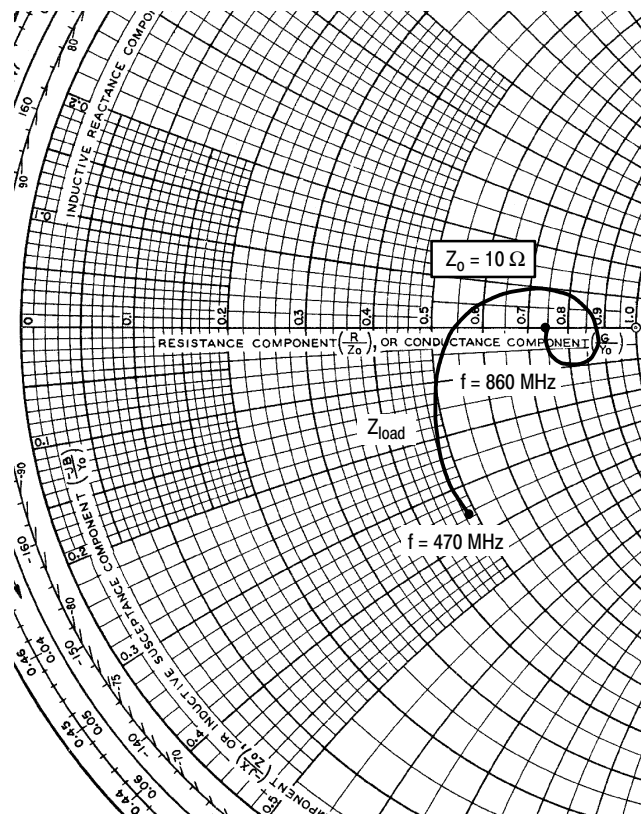
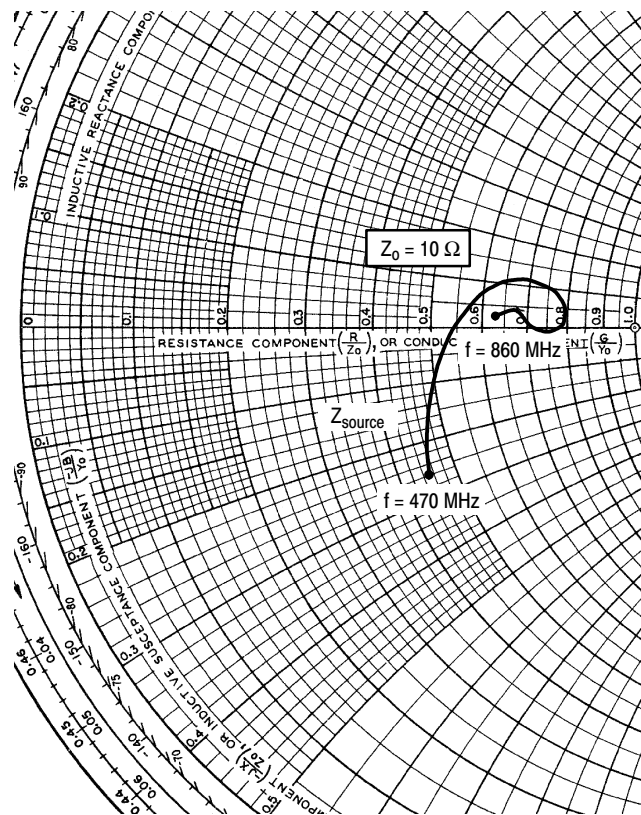


Figure 14. Drain Efficiency versus Output Power



$V_{DD} = 32\text{ V}$ ,  $I_{DQ} = 1000\text{ mA}$ ,  $P_{out} = 180\text{ W PEP}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 470      | $4.46 - j2.57$           | $4.88 - j3.50$         |
| 560      | $6.40 + j1.06$           | $5.45 - j0.07$         |
| 660      | $7.84 + j0.14$           | $8.13 + j0.73$         |
| 760      | $6.67 + j0.46$           | $8.27 - j1.00$         |
| 860      | $6.25 + j0.31$           | $7.52 + j0.02$         |

$Z_{source}$  = Test circuit impedance as measured from gate to gate, balanced configuration.

$Z_{load}$  = Test circuit impedance as measured from drain to drain, balanced configuration.

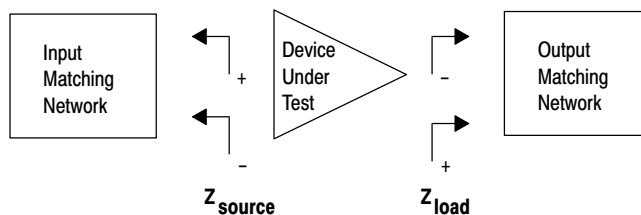


Figure 15. Broadband Series Equivalent Source and Load Impedance

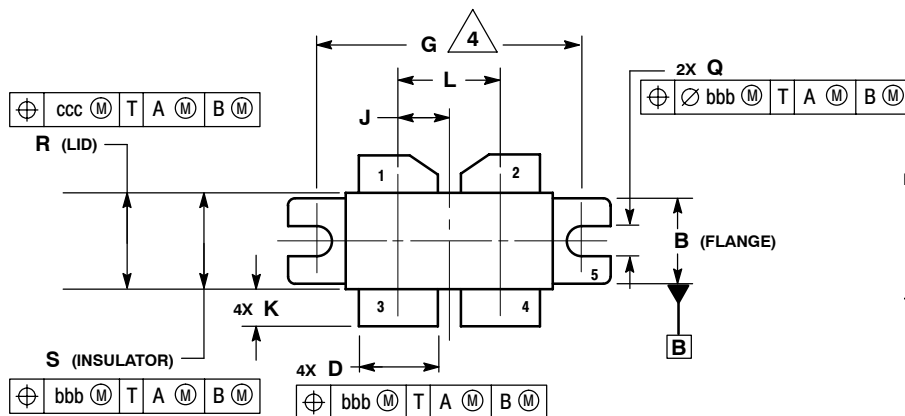
# NOTES

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# NOTES

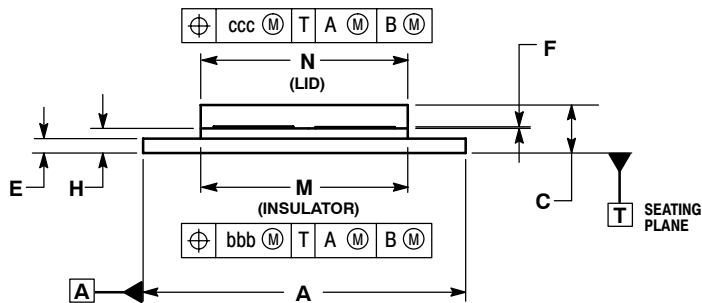
# NOTES

# PACKAGE DIMENSIONS



- NOTES:
1. CONTROLLING DIMENSION: INCH.
  2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
  3. DIMENSION H TO BE MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.
  4. RECOMMENDED BOLT CENTER DIMENSION OF 1.140 (28.96) BASED ON 3M SCREW.

| DIM | INCHES     |       | MILLIMETERS |       |
|-----|------------|-------|-------------|-------|
|     | MIN        | MAX   | MIN         | MAX   |
| A   | 1.335      | 1.345 | 33.91       | 34.16 |
| B   | 0.380      | 0.390 | 9.65        | 9.91  |
| C   | 0.180      | 0.224 | 4.57        | 5.69  |
| D   | 0.325      | 0.335 | 8.26        | 8.51  |
| E   | 0.060      | 0.070 | 1.52        | 1.78  |
| F   | 0.004      | 0.006 | 0.10        | 0.15  |
| G   | 1.100 BSC  |       | 27.94 BSC   |       |
| H   | 0.097      | 0.107 | 2.46        | 2.72  |
| J   | 0.2125 BSC |       | 5.397 BSC   |       |
| K   | 0.135      | 0.165 | 3.43        | 4.19  |
| L   | 0.425 BSC  |       | 10.8 BSC    |       |
| M   | 0.852      | 0.868 | 21.64       | 22.05 |
| N   | 0.851      | 0.869 | 21.62       | 22.07 |
| Q   | 0.118      | 0.138 | 3.00        | 3.30  |
| R   | 0.395      | 0.405 | 10.03       | 10.29 |
| S   | 0.394      | 0.406 | 10.01       | 10.31 |
| bbb | 0.010 REF  |       | 0.25 REF    |       |
| ccc | 0.015 REF  |       | 0.38 REF    |       |



- STYLE 1:  
 PIN 1. DRAIN  
 2. DRAIN  
 3. GATE  
 4. GATE  
 5. SOURCE

**CASE 375G-04  
 ISSUE G  
 NI-860C3**

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