

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for GSM and GSM EDGE base station applications with frequencies from 1805 to 1880 MHz. Can be used in Class AB and Class C for all typical cellular base station modulation formats.

- Typical GSM Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 800$  mA,  $P_{out} = 72$  Watts CW

| Frequency | $G_{ps}$<br>(dB) | $\eta_D$<br>(%) |
|-----------|------------------|-----------------|
| 1805 MHz  | 18.2             | 49.8            |
| 1840 MHz  | 18.6             | 51.4            |
| 1880 MHz  | 18.7             | 53.9            |

- Capable of Handling 7:1 VSWR, @ 32 Vdc, 1840 MHz, 150 Watts CW Output Power (3 dB Input Overdrive from Rated  $P_{out}$ )
- Typical  $P_{out}$  @ 1 dB Compression Point  $\approx 120$  Watts CW
- Typical GSM EDGE Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 800$  mA,  $P_{out} = 46$  Watts Avg.

| Frequency | $G_{ps}$<br>(dB) | $\eta_D$<br>(%) | SR1<br>@ 400 kHz<br>(dBc) | SR2<br>@ 600 kHz<br>(dBc) | EVM<br>(% rms) |
|-----------|------------------|-----------------|---------------------------|---------------------------|----------------|
| 1805 MHz  | 17.9             | 41.0            | -64                       | -76                       | 1.6            |
| 1840 MHz  | 18.2             | 41.9            | -63                       | -76                       | 1.7            |
| 1880 MHz  | 18.3             | 43.2            | -61                       | -76                       | 2.0            |

### Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters and Common Source S-Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Optimized for Doherty Applications
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**Table 1. Maximum Ratings**

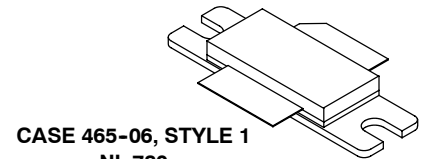
| Rating                               | Symbol    | Value       | Unit |
|--------------------------------------|-----------|-------------|------|
| Drain-Source Voltage                 | $V_{DSS}$ | -0.5, +65   | Vdc  |
| Gate-Source Voltage                  | $V_{GS}$  | -6.0, +10   | Vdc  |
| Operating Voltage                    | $V_{DD}$  | 32, +0      | Vdc  |
| Storage Temperature Range            | $T_{stg}$ | -65 to +150 | °C   |
| Case Operating Temperature           | $T_C$     | 150         | °C   |
| Operating Junction Temperature (1,2) | $T_J$     | 225         | °C   |

1. Continuous use at maximum temperature will affect MTTF.

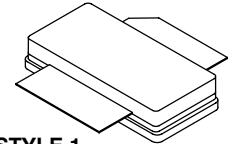
2. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

**MRF8S18120HR3**  
**MRF8S18120HSR3**

**1805-1880 MHz, 72 W CW, 28 V**  
**GSM, GSM EDGE**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF8S18120HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF8S18120HSR3**

**Table 2. Thermal Characteristics**

| Characteristic                                                                                                                                                                | Symbol           | Value (1,2)  | Unit |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------|------|
| Thermal Resistance, Junction to Case<br>Case Temperature 79°C, 72 W CW, 28 Vdc, I <sub>DQ</sub> = 800 mA<br>Case Temperature 79°C, 120 W CW, 28 Vdc, I <sub>DQ</sub> = 800 mA | R <sub>θJC</sub> | 0.47<br>0.46 | °C/W |

**Table 3. ESD Protection Characteristics**

| Test Methodology                      | Class        |
|---------------------------------------|--------------|
| Human Body Model (per JESD22-A114)    | 2 (Minimum)  |
| Machine Model (per EIA/JESD22-A115)   | A (Minimum)  |
| Charge Device Model (per JESD22-C101) | IV (Minimum) |

**Table 4. Electrical Characteristics** (T<sub>A</sub> = 25°C unless otherwise noted)

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

**Off Characteristics**

|                                                                                                |                  |   |   |    |      |
|------------------------------------------------------------------------------------------------|------------------|---|---|----|------|
| Zero Gate Voltage Drain Leakage Current<br>(V <sub>DS</sub> = 65 Vdc, V <sub>GS</sub> = 0 Vdc) | I <sub>DSS</sub> | — | — | 10 | μAdc |
| Zero Gate Voltage Drain Leakage Current<br>(V <sub>DS</sub> = 28 Vdc, V <sub>GS</sub> = 0 Vdc) | I <sub>DSS</sub> | — | — | 1  | μAdc |
| Gate-Source Leakage Current<br>(V <sub>GS</sub> = 5 Vdc, V <sub>DS</sub> = 0 Vdc)              | I <sub>GSS</sub> | — | — | 1  | μAdc |

**On Characteristics**

|                                                                                                              |                     |     |     |     |     |
|--------------------------------------------------------------------------------------------------------------|---------------------|-----|-----|-----|-----|
| Gate Threshold Voltage<br>(V <sub>DS</sub> = 10 Vdc, I <sub>D</sub> = 260 μAdc)                              | V <sub>GS(th)</sub> | 1.2 | 1.8 | 2.7 | Vdc |
| Gate Quiescent Voltage<br>(V <sub>DD</sub> = 28 Vdc, I <sub>D</sub> = 800 mAdc, Measured in Functional Test) | V <sub>GS(Q)</sub>  | 1.8 | 2.6 | 3.3 | Vdc |
| Drain-Source On-Voltage<br>(V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 2.3 Adc)                              | V <sub>DS(on)</sub> | 0.1 | 0.2 | 0.3 | Vdc |

**Functional Tests** <sup>(3)</sup> (In Freescale Test Fixture, 50 ohm system) V<sub>DD</sub> = 28 Vdc, I<sub>DQ</sub> = 800 mA, P<sub>out</sub> = 72 W CW, f = 1805 MHz

|                                               |                 |     |      |    |    |
|-----------------------------------------------|-----------------|-----|------|----|----|
| Power Gain                                    | G <sub>ps</sub> | 17  | 18.2 | 20 | dB |
| Drain Efficiency                              | η <sub>D</sub>  | 48  | 49.8 | —  | %  |
| Input Return Loss                             | IRL             | —   | -11  | -8 | dB |
| P <sub>out</sub> @ 1 dB Compression Point, CW | P1dB            | 112 | —    | —  | W  |

**Typical Broadband Performance** (In Freescale Test Fixture, 50 ohm system) V<sub>DD</sub> = 28 Vdc, I<sub>DQ</sub> = 800 mA, P<sub>out</sub> = 72 W CW

| Frequency | G <sub>ps</sub><br>(dB) | η <sub>D</sub><br>(%) | IRL<br>(dB) |
|-----------|-------------------------|-----------------------|-------------|
| 1805 MHz  | 18.2                    | 49.8                  | -11         |
| 1840 MHz  | 18.6                    | 51.4                  | -15         |
| 1880 MHz  | 18.7                    | 53.9                  | -12         |

1. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.
3. Part internally matched both on input and output.

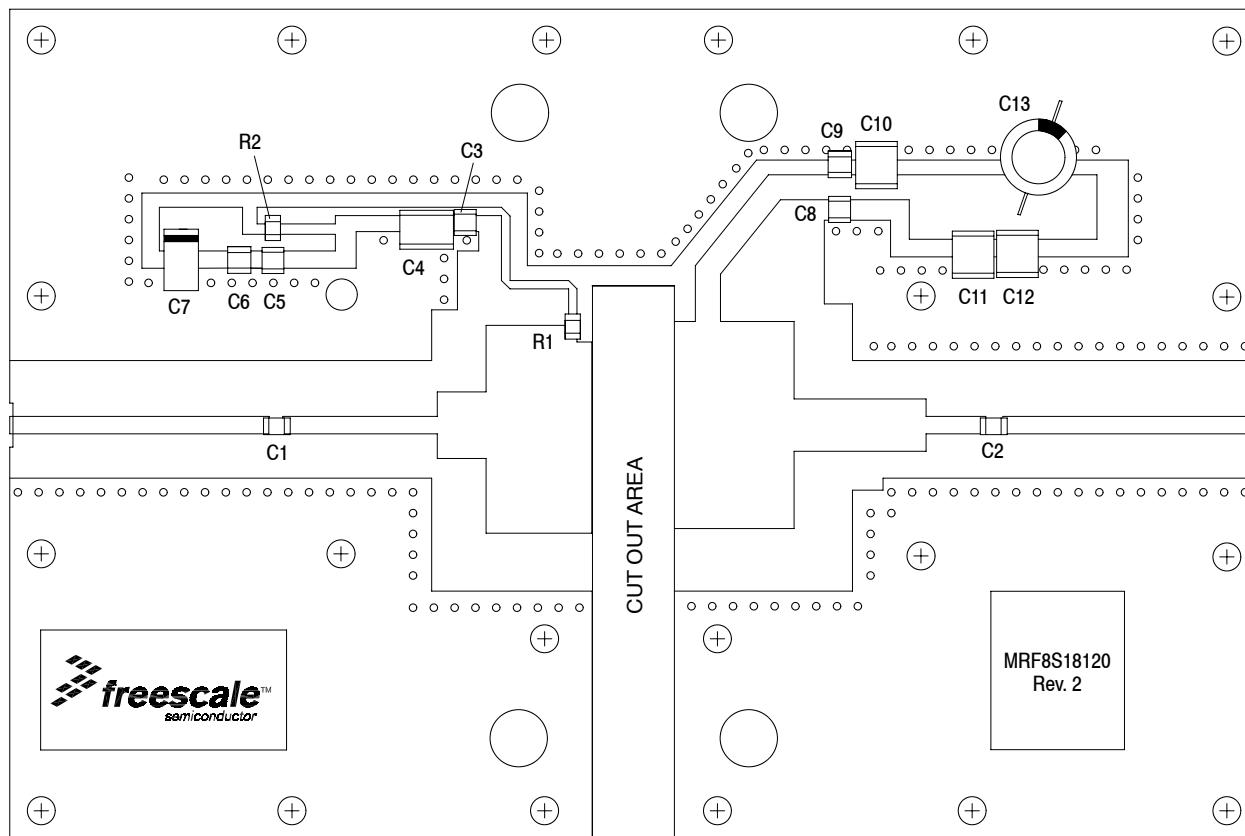
(continued)

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

| Characteristic                                                                                                                                                                               | Symbol           | Min | Typ   | Max | Unit                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----|-------|-----|----------------------|
| <b>Typical Performances</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 800\text{ mA}$ , 1805–1880 MHz Bandwidth                                         |                  |     |       |     |                      |
| $P_{out}$ @ 1 dB Compression Point, CW                                                                                                                                                       | $P_{1dB}$        | —   | 120   | —   | W                    |
| IMD Symmetry @ 94 W PEP, $P_{out}$ where IMD Third Order Intermodulation $\cong 30\text{ dBc}$<br>(Delta IMD Third Order Intermodulation between Upper and Lower Sidebands $> 2\text{ dB}$ ) | $IMD_{sym}$      | —   | 10    | —   | MHz                  |
| VBW Resonance Point<br>(IMD Third Order Intermodulation Inflection Point)                                                                                                                    | $VBW_{res}$      | —   | 35    | —   | MHz                  |
| Gain Flatness in 75 MHz Bandwidth @ $P_{out} = 72\text{ W CW}$                                                                                                                               | $G_F$            | —   | 0.5   | —   | dB                   |
| Gain Variation over Temperature<br>( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )                                                                                                            | $\Delta G$       | —   | 0.01  | —   | dB/ $^\circ\text{C}$ |
| Output Power Variation over Temperature<br>( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )                                                                                                    | $\Delta P_{1dB}$ | —   | 0.004 | —   | dB/ $^\circ\text{C}$ |

**Typical GSM EDGE Performances** (In Freescale GSM EDGE Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 800\text{ mA}$ ,  $P_{out} = 46\text{ W Avg.}$ , 1805–1880 MHz EDGE Modulation

| Frequency | $G_{ps}$<br>(dB) | $\eta_D$<br>(%) | SR1<br>@ 400 kHz<br>(dBc) | SR2<br>@ 600 kHz<br>(dBc) | EVM<br>(% rms) |
|-----------|------------------|-----------------|---------------------------|---------------------------|----------------|
| 1805 MHz  | 17.9             | 41.0            | -64                       | -76                       | 1.6            |
| 1840 MHz  | 18.2             | 41.9            | -63                       | -76                       | 1.7            |
| 1880 MHz  | 18.3             | 43.2            | -61                       | -76                       | 2.0            |



**Figure 1. MRF8S18120HR3(HSR3) Test Circuit Component Layout**

**Table 5. MRF8S18120HR3(HSR3) Test Circuit Component Designations and Values**

| Part          | Description                              | Part Number         | Manufacturer |
|---------------|------------------------------------------|---------------------|--------------|
| C1, C2        | 12 pF Chip Capacitors                    | ATC100B120JT500XT   | ATC          |
| C3, C8        | 9.1 pF Chip Capacitors                   | ATC100B9R1CT500XT   | ATC          |
| C4            | 10 nF Chip Capacitor                     | C1825C103K1GAC-TU   | Kemet        |
| C5            | 8.2 pF Chip Capacitor                    | ATC100B8R2CT500XT   | ATC          |
| C6, C9        | 2.2 $\mu$ F, 100 V Chip Capacitors       | C3225X7R2A225KT     | TDK          |
| C7            | 47 $\mu$ F, 16 V Tantalum Capacitor      | T491D476K016AT      | Kemet        |
| C10, C11, C12 | 10 $\mu$ F, 50 V Chip Capacitors         | GRM55DR61H106KA88L  | Murata       |
| C13           | 330 $\mu$ F, 63 V Electrolytic Capacitor | MCRH63V337M13X21-RH | Multicomp    |
| R1            | 10 $\Omega$ , 1/4 W Chip Resistor        | CRCW120610R0JNEA    | Vishay       |
| R2            | 4.75 $\Omega$ , 1/4 W Chip Resistor      | CRCW12064R75FNEA    | Vishay       |
| PCB           | 0.030", $\epsilon_r = 2.55$              | 250GX-0300-55-22    | Arlon        |

## TYPICAL CHARACTERISTICS

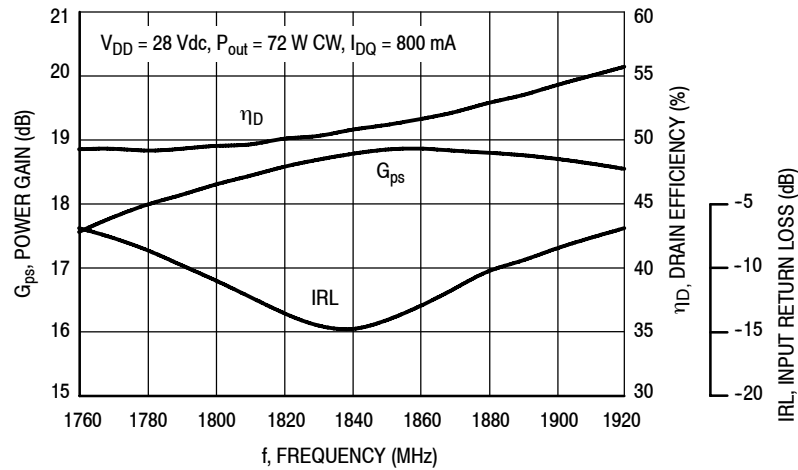


Figure 2. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @  $P_{out} = 72$  Watts CW

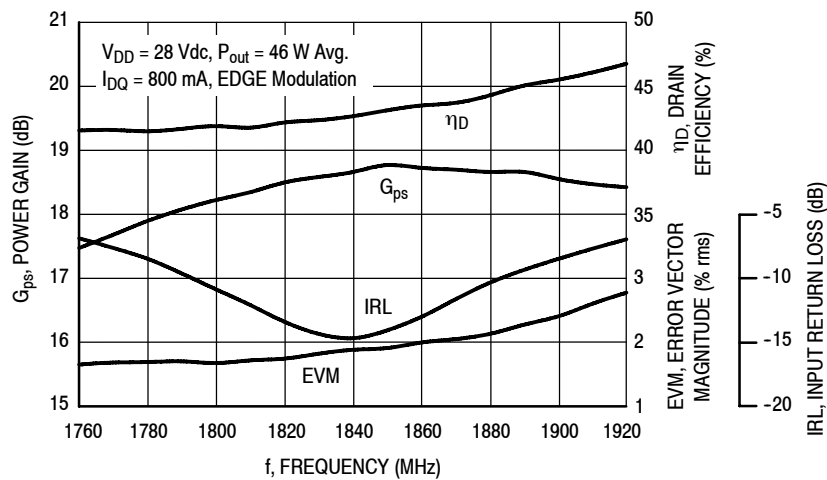


Figure 3. Power Gain, Input Return Loss, EVM and Drain Efficiency versus Frequency @  $P_{out} = 46$  Watts Avg.

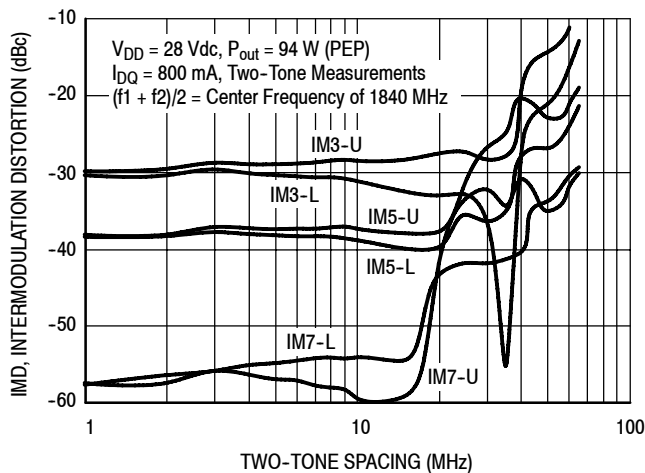


Figure 4. Intermodulation Distortion Products versus Two-Tone Spacing

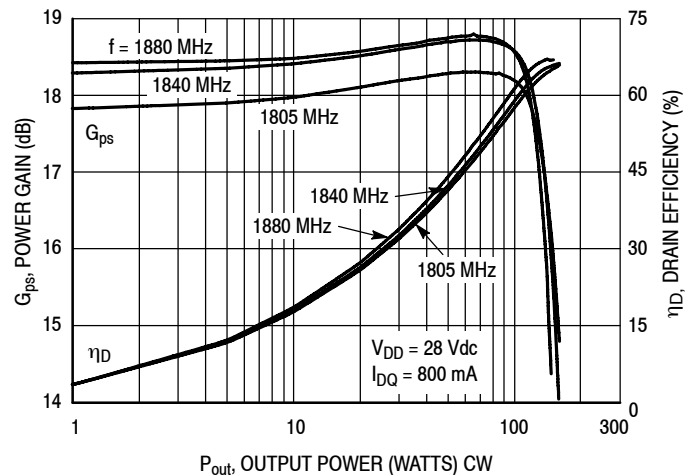


Figure 5. Power Gain and Drain Efficiency versus Output Power

## TYPICAL CHARACTERISTICS

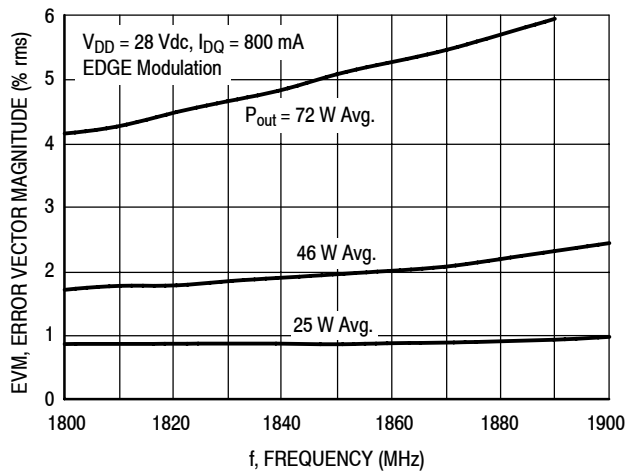


Figure 6. EVM versus Frequency

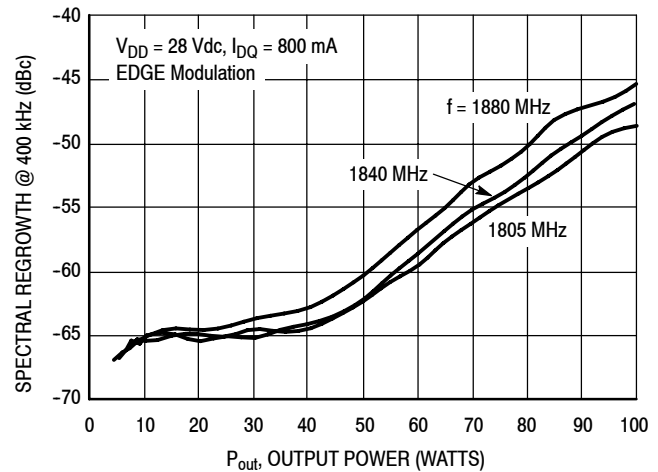


Figure 7. Spectral Regrowth at 400 kHz versus Output Power

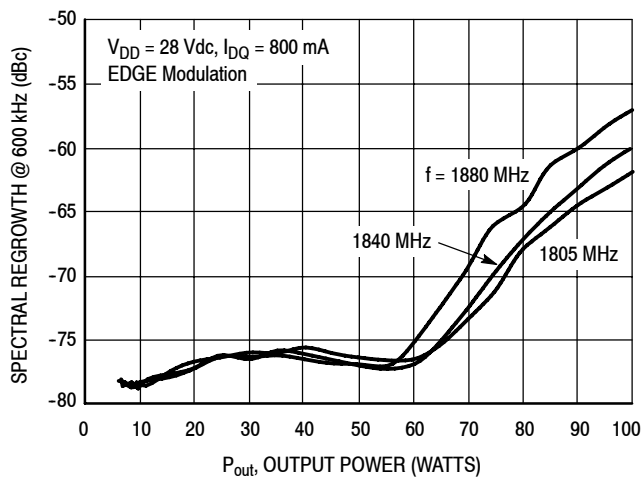


Figure 8. Spectral Regrowth at 600 kHz versus Output Power

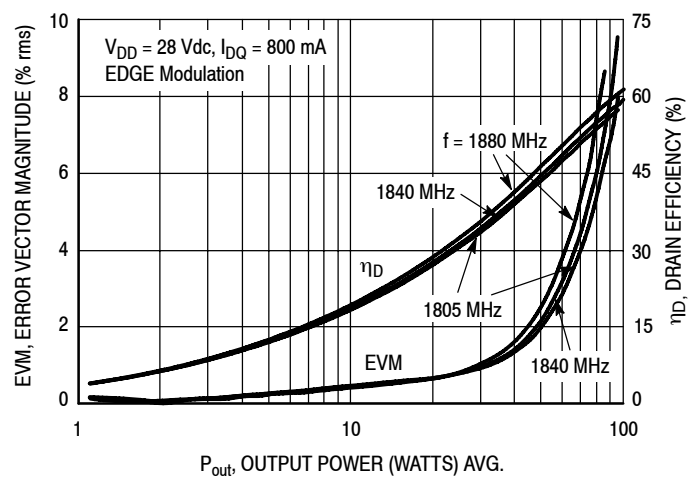


Figure 9. EVM and Drain Efficiency versus Output Power

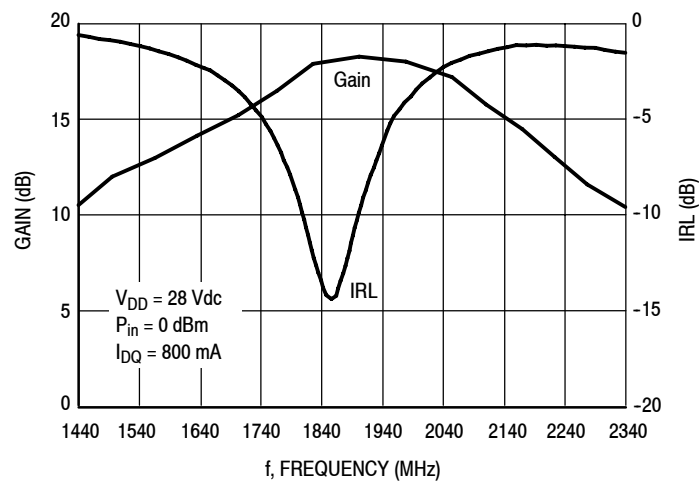


Figure 10. Broadband Frequency Response

## GSM TEST SIGNAL

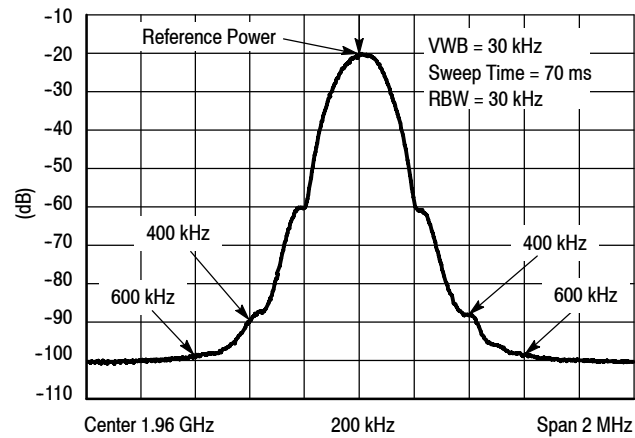


Figure 11. EDGE Spectrum

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 800 \text{ mA}$ ,  $P_{out} = 72 \text{ W CW}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 1760     | $1.53 - j1.94$           | $2.32 - j0.41$         |
| 1780     | $1.53 - j1.82$           | $2.31 - j0.51$         |
| 1800     | $1.56 - j1.90$           | $2.31 - j0.49$         |
| 1820     | $1.56 - j1.86$           | $2.32 - j0.40$         |
| 1840     | $1.57 - j1.75$           | $2.33 - j0.26$         |
| 1860     | $1.51 - j1.64$           | $2.29 - j0.12$         |
| 1880     | $1.49 - j1.58$           | $2.29 - j0.01$         |
| 1900     | $1.49 - j1.55$           | $2.29 + j0.05$         |
| 1920     | $1.48 - j1.53$           | $2.31 + j0.06$         |

$Z_{source}$  = Test circuit impedance as measured from gate to ground.

$Z_{load}$  = Test circuit impedance as measured from drain to ground.

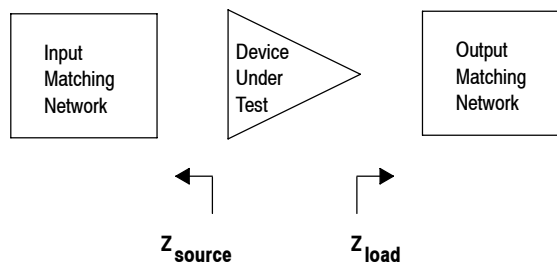
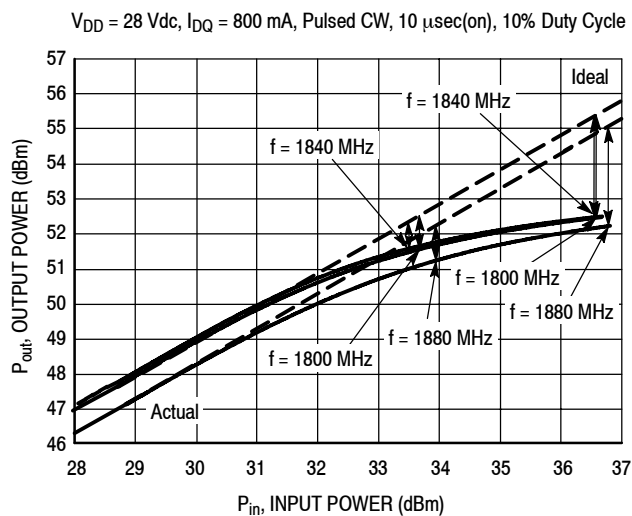


Figure 12. Series Equivalent Source and Load Impedance

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS



NOTE: Load Pull Test Fixture Tuned for Peak P1dB Output Power @ 28 V

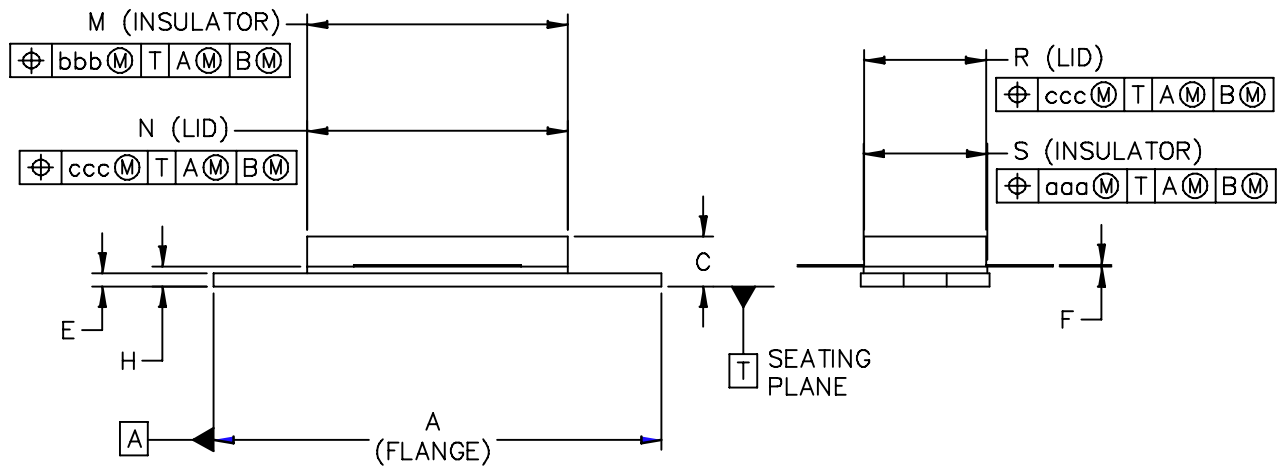
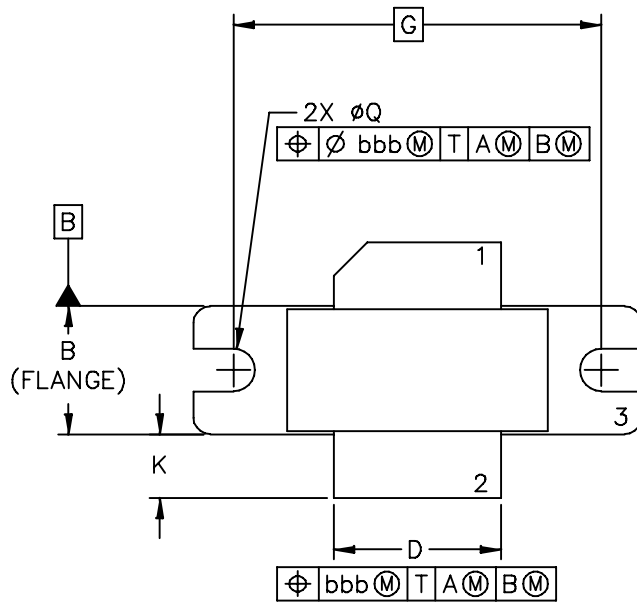
| f<br>(MHz) | P1dB  |      | P3dB  |      |
|------------|-------|------|-------|------|
|            | Watts | dBm  | Watts | dBm  |
| 1805       | 145   | 51.6 | 178   | 52.5 |
| 1840       | 141   | 51.5 | 178   | 52.5 |
| 1880       | 135   | 51.3 | 170   | 52.3 |

Test Impedances per Compression Level

| f<br>(MHz) |      | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|------------|------|--------------------------|------------------------|
| 1805       | P1dB | $1.14 - j4.65$           | $1.54 - j2.60$         |
| 1840       | P1dB | $1.04 - j4.88$           | $1.49 - j2.75$         |
| 1880       | P1dB | $0.94 - j4.59$           | $1.50 - j2.74$         |

Figure 13. Pulsed CW Output Power  
versus Input Power @ 28 V

## PACKAGE DIMENSIONS



|                                                         |  |                    |                          |                            |             |
|---------------------------------------------------------|--|--------------------|--------------------------|----------------------------|-------------|
| © FREESCALE SEMICONDUCTOR, INC.<br>ALL RIGHTS RESERVED. |  | MECHANICAL OUTLINE |                          | PRINT VERSION NOT TO SCALE |             |
| TITLE:<br><br>NI-780                                    |  |                    | DOCUMENT NO: 98ASB15607C |                            | REV: G      |
|                                                         |  |                    | CASE NUMBER: 465-06      |                            | 31 MAR 2005 |
|                                                         |  |                    | STANDARD: NON-JEDEC      |                            |             |

MRF8S18120HR3 MRF8S18120HSR3

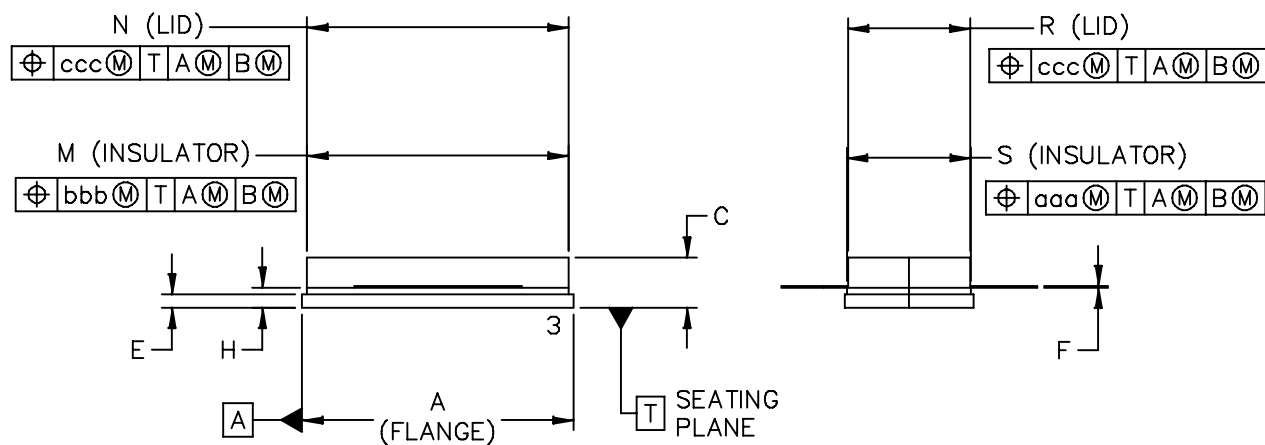
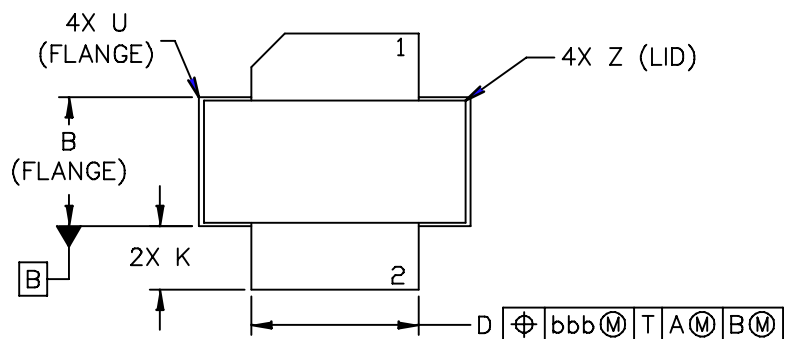
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M–1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED .030 (.762) AWAY FROM PACKAGE BODY.

STYLE 1:

- PIN 1. DRAIN  
2. GATE  
3. SOURCE

| INCH                                                    |           |         | MILLIMETER |                    | DIM                      | INCH   |                            |      | MILLIMETER  |  |  |
|---------------------------------------------------------|-----------|---------|------------|--------------------|--------------------------|--------|----------------------------|------|-------------|--|--|
| DIM                                                     | MIN       | MAX     | MIN        | MAX                |                          | MIN    | MAX                        | MIN  | MAX         |  |  |
| A                                                       | 1.335     | — 1.345 | 33.91      | — 34.16            | R                        | .365   | — .375                     | 9.27 | — 9.53      |  |  |
| B                                                       | .380      | — .390  | 9.65       | — 9.91             | S                        | .365   | — .375                     | 9.27 | — 9.52      |  |  |
| C                                                       | .125      | — .170  | 3.18       | — 4.32             | aaa                      | — .005 | —                          | —    | 0.127 —     |  |  |
| D                                                       | .495      | — .505  | 12.57      | — 12.83            | bbb                      | — .010 | —                          | —    | 0.254 —     |  |  |
| E                                                       | .035      | — .045  | 0.89       | — 1.14             | ccc                      | — .015 | —                          | —    | 0.381 —     |  |  |
| F                                                       | .003      | — .006  | 0.08       | — 0.15             | —                        | —      | —                          | —    | —           |  |  |
| G                                                       | 1.100 BSC |         | 27.94 BSC  |                    | —                        | —      | —                          | —    | —           |  |  |
| H                                                       | .057      | — .067  | 1.45       | — 1.7              | —                        | —      | —                          | —    | —           |  |  |
| K                                                       | .170      | — .210  | 4.32       | — 5.33             | —                        | —      | —                          | —    | —           |  |  |
| M                                                       | .774      | — .786  | 19.66      | — 19.96            | —                        | —      | —                          | —    | —           |  |  |
| N                                                       | .772      | — .788  | 19.6       | — 20               | —                        | —      | —                          | —    | —           |  |  |
| Q                                                       | ø.118     | — ø.138 | ø3         | — ø3.51            | —                        | —      | —                          | —    | —           |  |  |
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| TITLE:<br><br>NI—780                                    |           |         |            |                    | DOCUMENT NO: 98ASB15607C |        |                            |      | REV: G      |  |  |
|                                                         |           |         |            |                    | CASE NUMBER: 465—06      |        |                            |      | 31 MAR 2005 |  |  |
|                                                         |           |         |            |                    | STANDARD: NON—JEDEC      |        |                            |      |             |  |  |



|                                                         |  |                          |  |                            |  |
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| TITLE:<br><br>NI-780S                                   |  | DOCUMENT NO: 98ASB16718C |  | REV: H                     |  |
|                                                         |  | CASE NUMBER: 465A-06     |  | 31 MAR 2005                |  |
|                                                         |  | STANDARD: NON-JEDEC      |  |                            |  |

NOTES:

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2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

STYLE 1:

- PIN 1. DRAIN  
2. GATE  
3. SOURCE

| INCH                                                    |      | MILLIMETER |                    | DIM     | INCH                     |                            | MILLIMETER |             |     |
|---------------------------------------------------------|------|------------|--------------------|---------|--------------------------|----------------------------|------------|-------------|-----|
| DIM                                                     | MIN  | MAX        | MIN                |         | MAX                      | MIN                        | MAX        | MIN         | MAX |
| A                                                       | .805 | — .815     | 20.45              | — 20.7  | U                        | — — .040                   | — — 1.02   |             |     |
| B                                                       | .380 | — .390     | 9.65               | — 9.91  | Z                        | — — .030                   | — — 0.76   |             |     |
| C                                                       | .125 | — .170     | 3.18               | — 4.32  | aaa                      | — .005 —                   | — 0.127 —  |             |     |
| D                                                       | .495 | — .505     | 12.57              | — 12.83 | bbb                      | — .010 —                   | — 0.254 —  |             |     |
| E                                                       | .035 | — .045     | 0.89               | — 1.14  | ccc                      | — .015 —                   | — 0.381 —  |             |     |
| F                                                       | .003 | — .006     | 0.08               | — 0.15  | —                        | — — —                      | — — —      |             |     |
| H                                                       | .057 | — .067     | 1.45               | — 1.7   | —                        | — — —                      | — — —      |             |     |
| K                                                       | .170 | — .210     | 4.32               | — 5.33  | —                        | — — —                      | — — —      |             |     |
| M                                                       | .774 | — .786     | 19.61              | — 20.02 | —                        | — — —                      | — — —      |             |     |
| N                                                       | .772 | — .788     | 19.61              | — 20.02 | —                        | — — —                      | — — —      |             |     |
| R                                                       | .365 | — .375     | 9.27               | — 9.53  | —                        | — — —                      | — — —      |             |     |
| S                                                       | .365 | — .375     | 9.27               | — 9.52  | —                        | — — —                      | — — —      |             |     |
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|                                                         |      |            |                    |         | CASE NUMBER: 465A—06     |                            |            | 31 MAR 2005 |     |
|                                                         |      |            |                    |         | STANDARD: NON—JEDEC      |                            |            |             |     |

## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents, tools and software to aid your design process.

### Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

### Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

### Software

- Electromigration MTTF Calculator
- RF High Power Model
- .s2p File

For Software, do a Part Number search at <http://www.freescale.com>, and select the “Part Number” link. Go to the Software & Tools tab on the part’s Product Summary page to download the respective tool.

## REVISION HISTORY

The following table summarizes revisions to this document.

| Revision | Date       | Description                                                                                                                                                           |
|----------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0        | Sept. 2009 | <ul style="list-style-type: none"><li>• Initial Release of Data Sheet</li></ul>                                                                                       |
| 1        | Oct. 2010  | <ul style="list-style-type: none"><li>• Changed Human Body Model ESD rating from Class 1A to Class 2 to reflect recent ESD test results of the device, p. 2</li></ul> |

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