

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for broadband commercial and industrial applications with frequencies from 400 to 500 MHz. The high gain and broadband performance of these devices make them ideal for large-signal, common-source amplifier applications in 28-volt base station equipment.

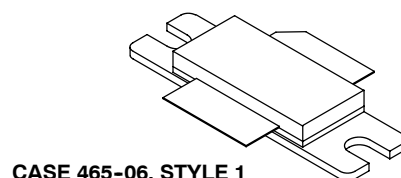
- Typical Single-Carrier N-CDMA Performance @ 465 MHz:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1250$  mA,  $P_{out} = 28$  Watts Avg., IS-95 CDMA (Pilot, Sync, Paging, Traffic Codes 8 Through 13). Channel Bandwidth = 1.2288 MHz. PAR = 9.8 dB @ 0.01% Probability on CCDF.  
Power Gain — 21 dB  
Drain Efficiency — 30%  
ACPR @ 750 kHz Offset — -47.6 dBc in 30 kHz Bandwidth
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 465 MHz, 140 Watts CW Output Power

### Features

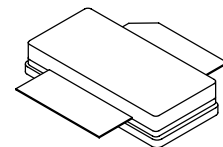
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32  $V_{DD}$  Operation
- Integrated ESD Protection
- Lower Thermal Resistance Package
- Low Gold Plating Thickness on Leads, 40 $\mu$ m Nominal.
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRF5S4140HR3**  
**MRF5S4140HSR3**

**465 MHz, 28 W AVG., 28 V**  
**SINGLE N-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF5S4140HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF5S4140HSR3**

**Table 1. Maximum Ratings**

| Rating                                                                                 | Symbol    | Value        | Unit                     |
|----------------------------------------------------------------------------------------|-----------|--------------|--------------------------|
| Drain-Source Voltage                                                                   | $V_{DSS}$ | -0.5, +65    | Vdc                      |
| Gate-Source Voltage                                                                    | $V_{GS}$  | -0.5, +15    | Vdc                      |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$     | 427<br>2.4   | 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 (1,2) | Unit               |
|------------------------------------------------|-----------------|-------------|--------------------|
| Thermal Resistance, Junction to Case           | $R_{\theta JC}$ |             | $^\circ\text{C/W}$ |
| Case Temperature $73^\circ\text{C}$ , 140 W CW |                 | 0.41        |                    |
| Case Temperature $74^\circ\text{C}$ , 28 W CW  |                 | 0.47        |                    |

1. MTTF calculator available at <http://www.freescale.com/rf>. Select Tools/Software/Application Software/Calculators to access the 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.

**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** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

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

**Off Characteristics**

|                                                                                                   |           |   |   |    |                 |
|---------------------------------------------------------------------------------------------------|-----------|---|---|----|-----------------|
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 10 | $\mu\text{Adc}$ |
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 1  | $\mu\text{Adc}$ |
| Gate-Source Leakage Current<br>( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )              | $I_{GSS}$ | — | — | 1  | $\mu\text{Adc}$ |

**On Characteristics**

|                                                                                                                |              |     |     |     |     |
|----------------------------------------------------------------------------------------------------------------|--------------|-----|-----|-----|-----|
| Gate Threshold Voltage<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 400\text{ }\mu\text{Adc}$ )                      | $V_{GS(th)}$ | 2   | 3   | 4   | Vdc |
| Gate Quiescent Voltage<br>( $V_{DS} = 28\text{ Vdc}$ , $I_D = 1250\text{ mAdc}$ , Measured in Functional Test) | $V_{GS(Q)}$  | 3   | 4   | 5   | Vdc |
| Drain-Source On-Voltage<br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2.42\text{ Adc}$ )                              | $V_{DS(on)}$ | 0.1 | 0.2 | 0.3 | Vdc |
| Forward Transconductance<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 3\text{ Adc}$ )                                | $g_{fs}$     | —   | 6.2 | —   | S   |

**Dynamic Characteristics <sup>(1)</sup>**

|                                                                                                                       |           |   |     |   |    |
|-----------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|
| Reverse Transfer Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ ) | $C_{rss}$ | — | 2.3 | — | pF |
|-----------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1250\text{ mA}$ ,  $P_{out} = 28\text{ W Avg. N-CDMA}$ ,  $f = 465\text{ MHz}$ , Single-Carrier N-CDMA, 1.2288 MHz Channel Bandwidth Carrier. ACPR measured in 30 kHz Channel Bandwidth @  $\pm 750\text{ kHz}$  Offset. PAR = 9.8 dB @ 0.01% Probability on CCDF.

|                              |          |      |       |     |     |
|------------------------------|----------|------|-------|-----|-----|
| Power Gain                   | $G_{ps}$ | 20   | 21    | 23  | dB  |
| Drain Efficiency             | $\eta_D$ | 28.5 | 30    | —   | %   |
| Adjacent Channel Power Ratio | ACPR     | —    | -47.6 | -45 | dBc |
| Input Return Loss            | IRL      | —    | -14   | -9  | dB  |

1. Part internally input matched.

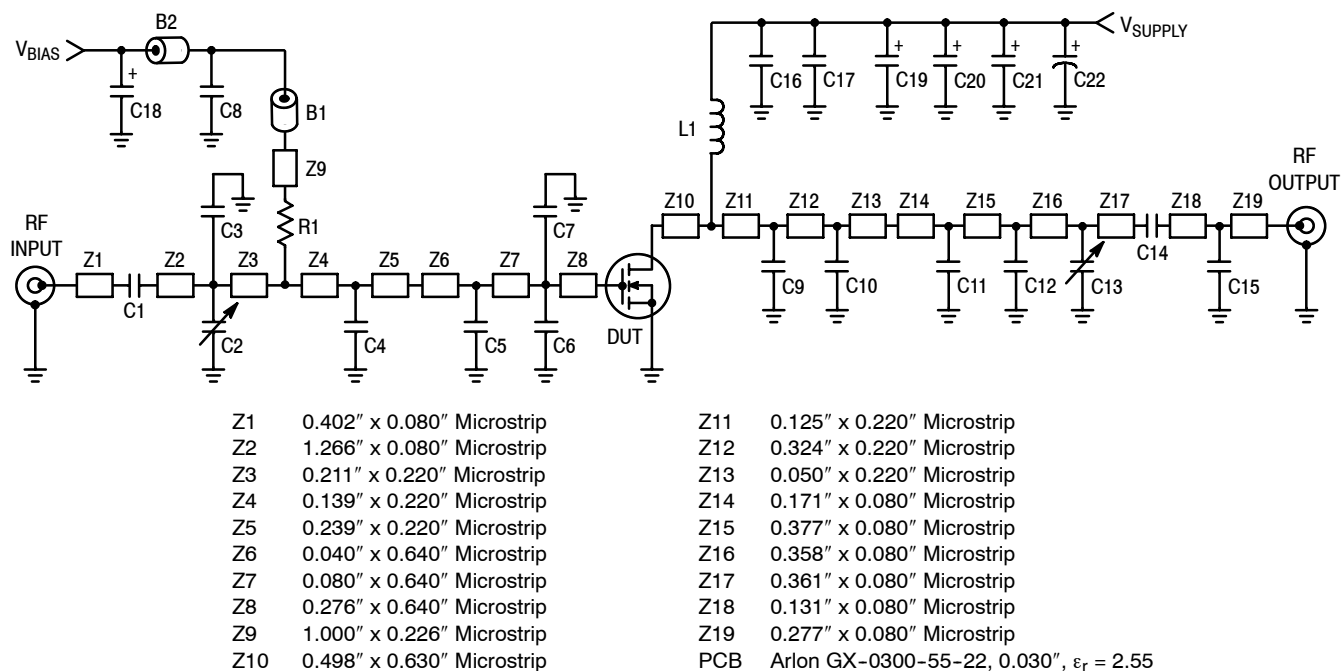


Figure 1. MRF5S4140HR3(SR3) Test Circuit Schematic — 460-470 MHz

Table 5. MRF5S4140HR3(SR3) Test Circuit Component Designations and Values — 460-470 MHz

| Part               | Description                               | Part Number       | Manufacturer     |
|--------------------|-------------------------------------------|-------------------|------------------|
| B1, B2             | Ferrite Beads, Short                      | 2743019447        | Fair-Rite        |
| C1, C14            | 120 pF Chip Capacitors                    | 100B121JP500X     | ATC              |
| C2, C13            | 0.8–8.0 pF Variable Capacitors, Gigatrim  | 27291SL           | Johanson         |
| C3                 | 18 pF Chip Capacitor                      | 100B180JP500X     | ATC              |
| C4                 | 30 pF Chip Capacitor                      | 100B300JP500X     | ATC              |
| C5                 | 24 pF Chip Capacitor                      | 100B240JP500X     | ATC              |
| C6, C7             | 13 pF Chip Capacitors                     | 100B130JP500X     | ATC              |
| C8                 | 0.02 $\mu$ F, 50 V Chip Capacitor         | 200B203MW50B      | ATC              |
| C9, C10            | 22 pF Chip Capacitors                     | 100B220JP500X     | ATC              |
| C11                | 1.0 pF Chip Capacitor                     | 100B1R0JP500X     | ATC              |
| C12                | 5.6 pF Chip Capacitor                     | 100B5R6JP500X     | ATC              |
| C15                | 1.5 pF Chip Capacitor                     | 100B1R5JP500X     | ATC              |
| C16                | 47 pF Chip Capacitor                      | 100B47JP500X      | ATC              |
| C17                | 0.56 $\mu$ F, 50 V Chip Capacitor         | C1825C564J5GAC    | Kemet            |
| C18, C19, C20, C21 | 10 $\mu$ F, 35 V Tantalum Chip Capacitors | T491D106K035AS    | Kemet            |
| C22                | 470 $\mu$ F, 63 V Electrolytic Capacitor  | SME63V471M12X25LL | United Chemi-Con |
| L1                 | 39 nH Inductor                            | 1812SMS-39N       | Coilcraft        |
| R1                 | 100 $\Omega$ , 1/4 W Chip Resistor (1210) |                   |                  |

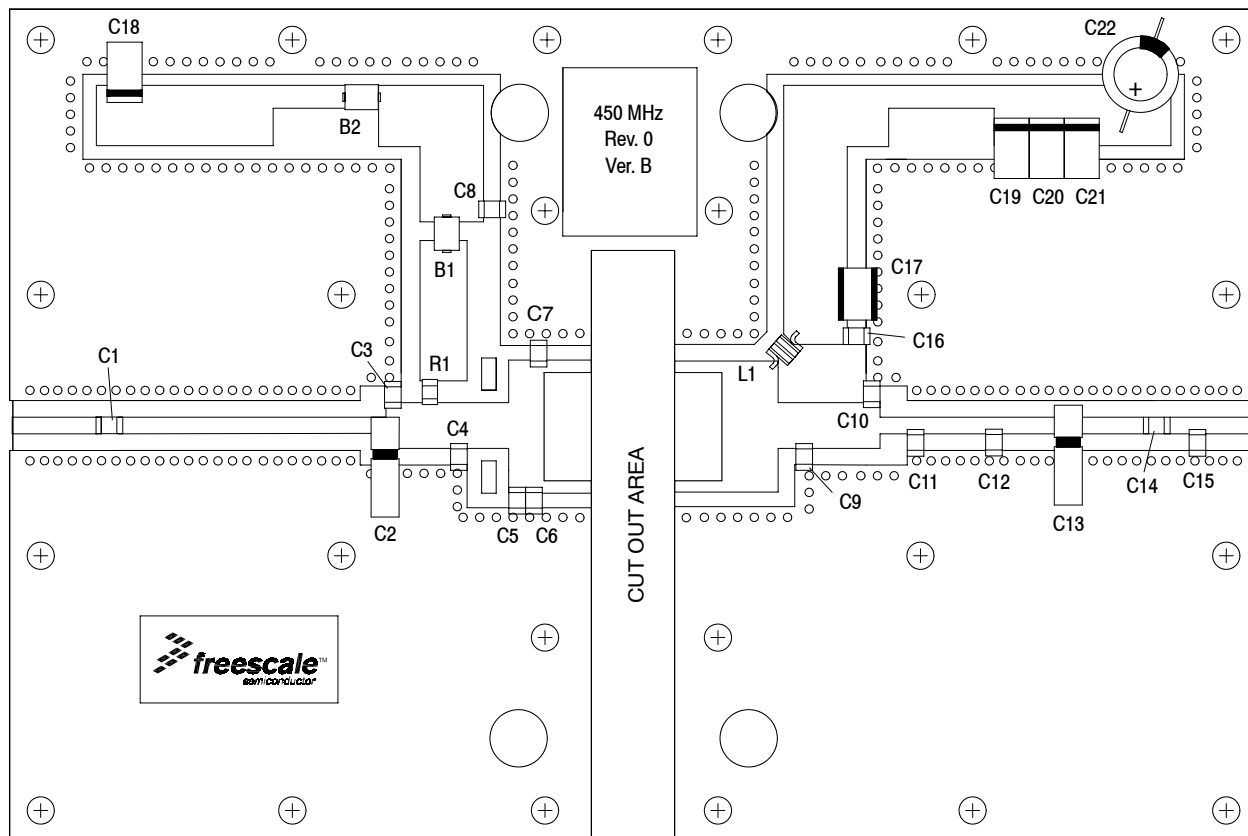
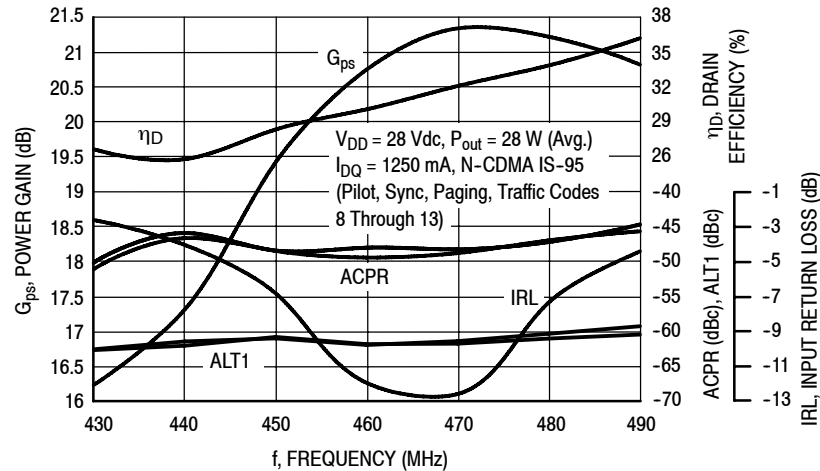
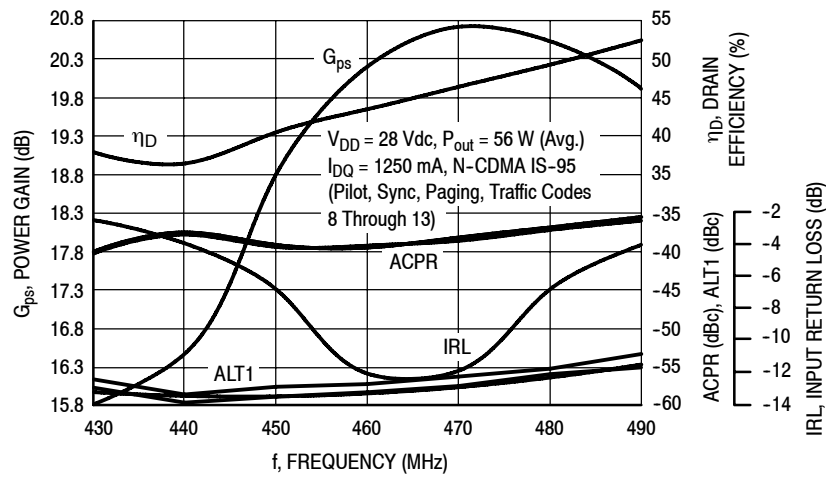


Figure 2. MRF5S4140HR3(SR3) Test Circuit Component Layout — 460-470 MHz

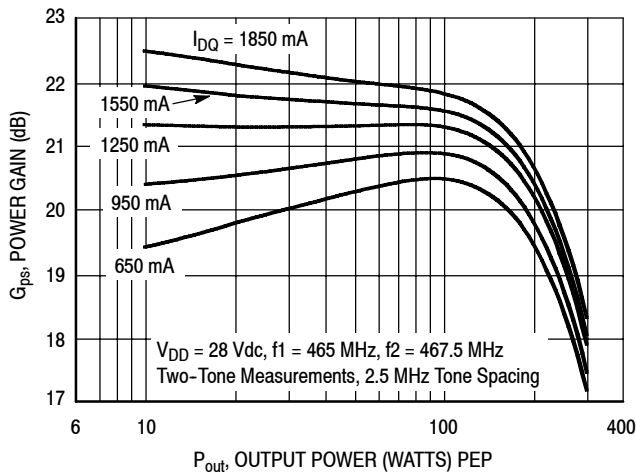
# TYPICAL CHARACTERISTICS — 460-470 MHz



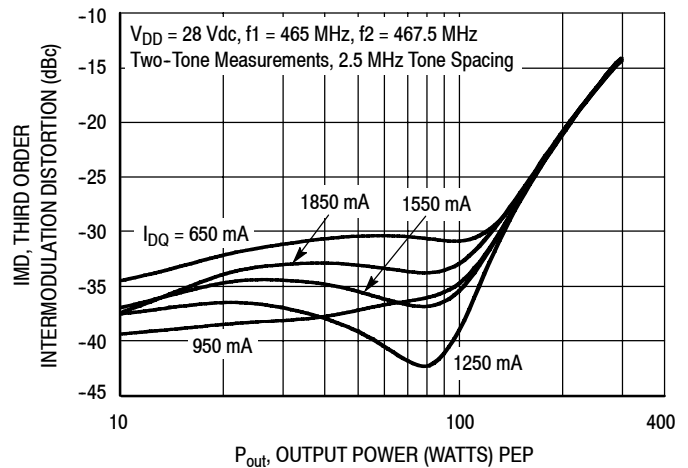
**Figure 3. Single-Carrier N-CDMA Broadband Performance  
@  $P_{out} = 28$  Watts Avg.**



**Figure 4. Single-Carrier N-CDMA Broadband Performance  
@  $P_{out} = 56$  Watts Avg.**

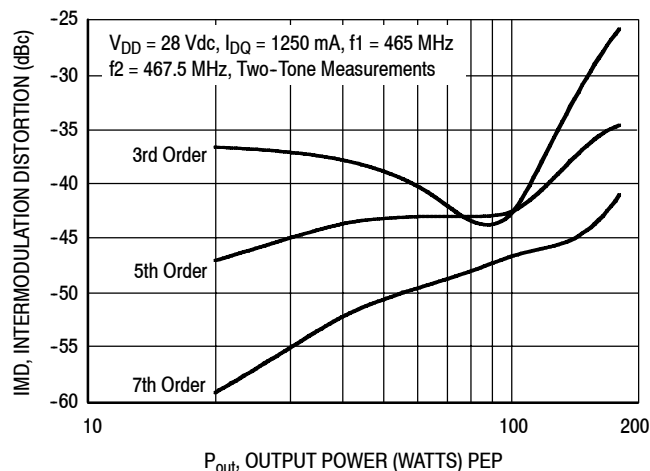


**Figure 5. Two-Tone Power Gain versus  
Output Power**

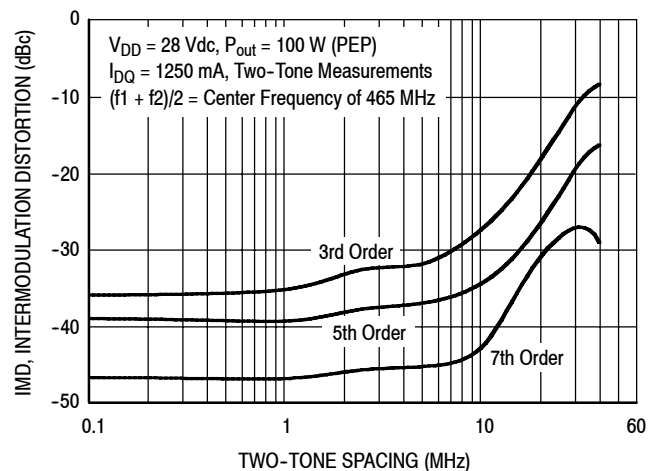


**Figure 6. Third Order Intermodulation Distortion  
versus Output Power**

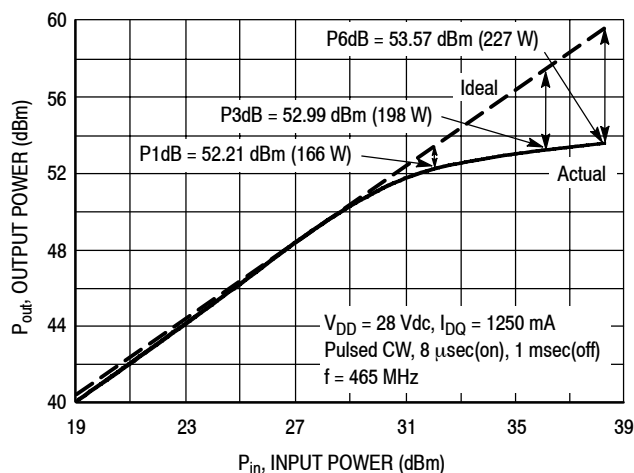
# TYPICAL CHARACTERISTICS — 460-470 MHz



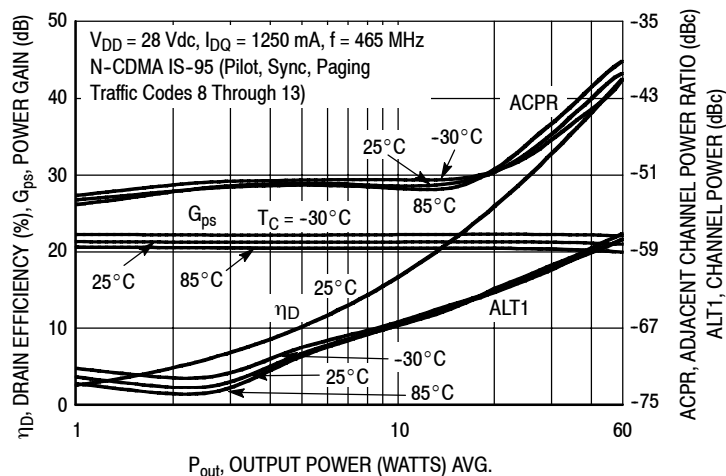
**Figure 7. Intermodulation Distortion Products versus Output Power**



**Figure 8. Intermodulation Distortion Products versus Tone Spacing**

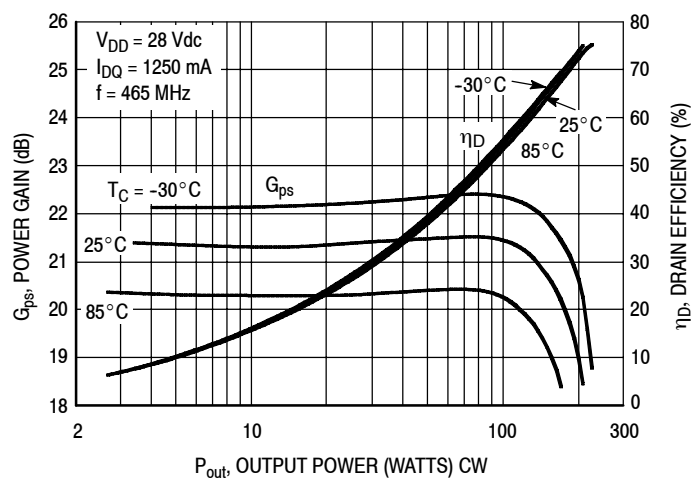


**Figure 9. Pulse CW Output Power versus Input Power**

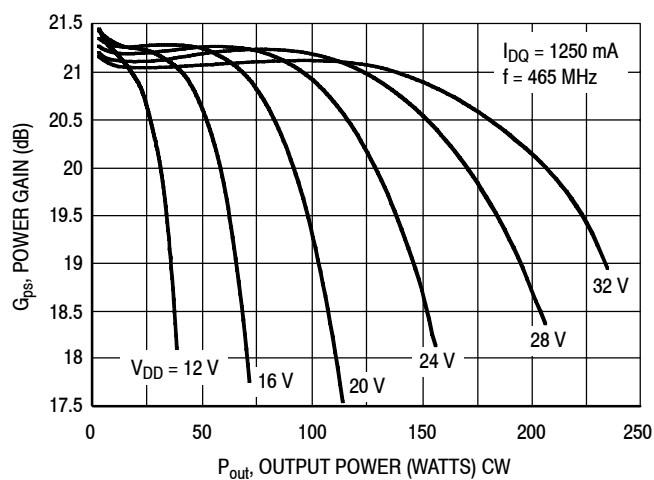


**Figure 10. Single-Carrier N-CDMA ACPR, ALT1, Power Gain and Drain Efficiency versus Output Power**

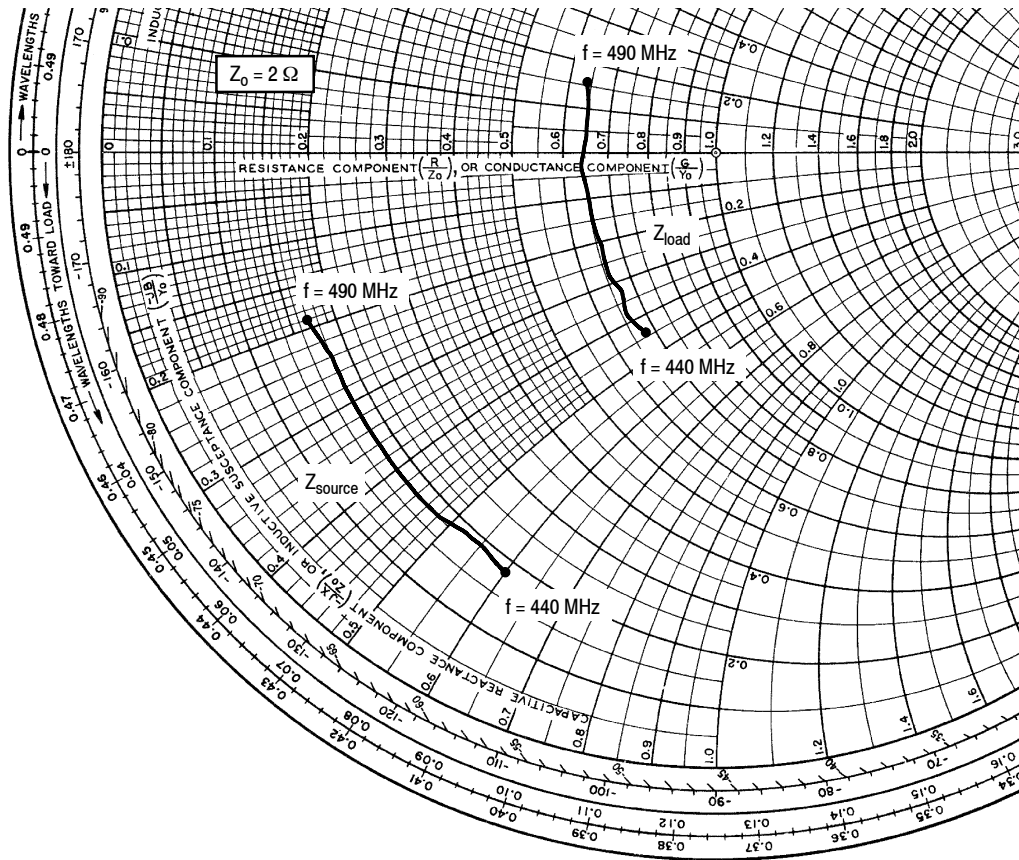
# TYPICAL CHARACTERISTICS — 460-470 MHz



**Figure 11. Power Gain and Drain Efficiency versus CW Output Power**



**Figure 12. Power Gain versus Output Power**



$V_{DD} = 28$  Vdc,  $I_{DQ} = 1250$  mA,  $P_{out} = 28$  W Avg.

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 440      | $0.359 - j1.19$          | $1.35 - j0.870$        |
| 445      | $0.389 - j1.11$          | $1.31 - j0.743$        |
| 450      | $0.379 - j1.03$          | $1.34 - j0.641$        |
| 455      | $0.360 - j0.959$         | $1.32 - j0.539$        |
| 460      | $0.355 - j0.873$         | $1.31 - j0.420$        |
| 465      | $0.352 - j0.773$         | $1.30 - j0.274$        |
| 470      | $0.350 - j0.710$         | $1.29 - j0.173$        |
| 475      | $0.350 - j0.628$         | $1.28 - j0.044$        |
| 480      | $0.356 - j0.540$         | $1.29 + j0.090$        |
| 485      | $0.355 - j0.473$         | $1.29 + j0.195$        |
| 490      | $0.345 - j0.388$         | $1.28 + j0.313$        |

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

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

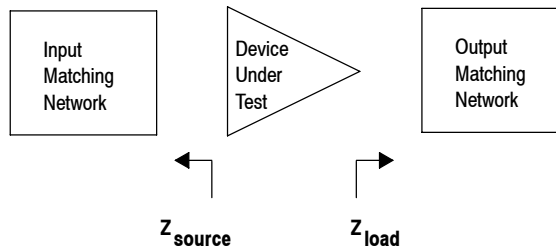


Figure 13. Series Equivalent Source and Load Impedance — 460-470 MHz

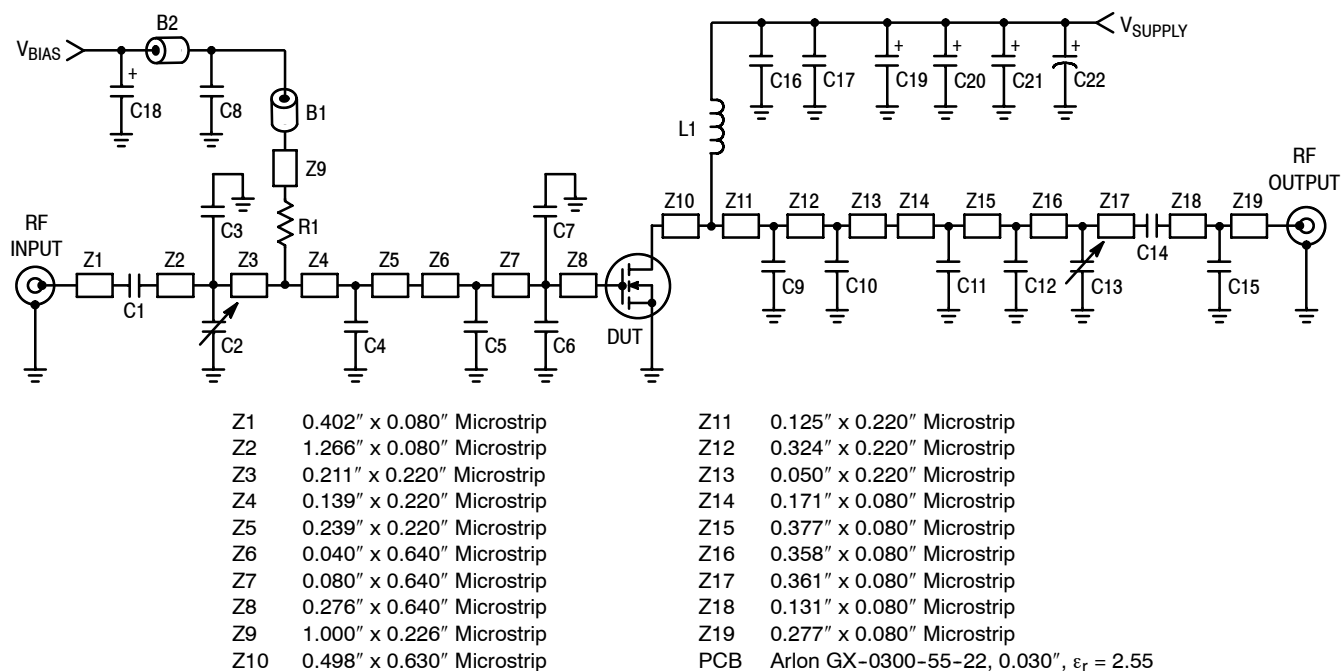


Figure 14. MRF5S4140HR3(SR3) Test Circuit Schematic — 420-430 MHz

Table 6. MRF5S4140HR3(SR3) Test Circuit Component Designations and Values — 420-430 MHz

| Part               | Description                              | Part Number       | Manufacturer     |
|--------------------|------------------------------------------|-------------------|------------------|
| B1, B2             | Ferrite Beads, Short                     | 2743019447        | Fair-Rite        |
| C1, C14            | 120 pF Chip Capacitors                   | 100B121JP500X     | ATC              |
| C2, C13            | 0.8-8.0 pF Variable Capacitors, Gigatrim | 27291SL           | Johanson         |
| C3                 | 18 pF Chip Capacitor                     | 100B180JP500X     | ATC              |
| C4                 | 39 pF Chip Capacitor                     | 100B390JP500X     | ATC              |
| C5                 | 24 pF Chip Capacitor                     | 100B240JP500X     | ATC              |
| C6, C7             | 13 pF Chip Capacitors                    | 100B130JP500X     | ATC              |
| C8                 | 0.02 μF, 50 V Chip Capacitor             | 200B203MW50B      | ATC              |
| C9, C10            | 22 pF Chip Capacitors                    | 100B220JP500X     | ATC              |
| C11                | 1.0 pF Chip Capacitor                    | 100B1R0JP500X     | ATC              |
| C12                | 5.6 pF Chip Capacitor                    | 100B5R6JP500X     | ATC              |
| C15                | 1.5 pF Chip Capacitor                    | 100B1R5JP500X     | ATC              |
| C16                | 47 pF Chip Capacitor                     | 100B47JP500X      | ATC              |
| C17                | 0.56 μF, 50 V Chip Capacitor             | C1825C564J5GAC    | Kemet            |
| C18, C19, C20, C21 | 10 μF, 35 V Tantalum Chip Capacitors     | T491D106K035AS    | Kemet            |
| C22                | 470 μF, 63 V Electrolytic Capacitor      | SME63V471M12X25LL | United Chemi-Con |
| L1                 | 39 nH Inductor                           | 1812SMS-39N       | Coilcraft        |
| R1                 | 100 Ω, 1/4 W Chip Resistor (1210)        |                   |                  |

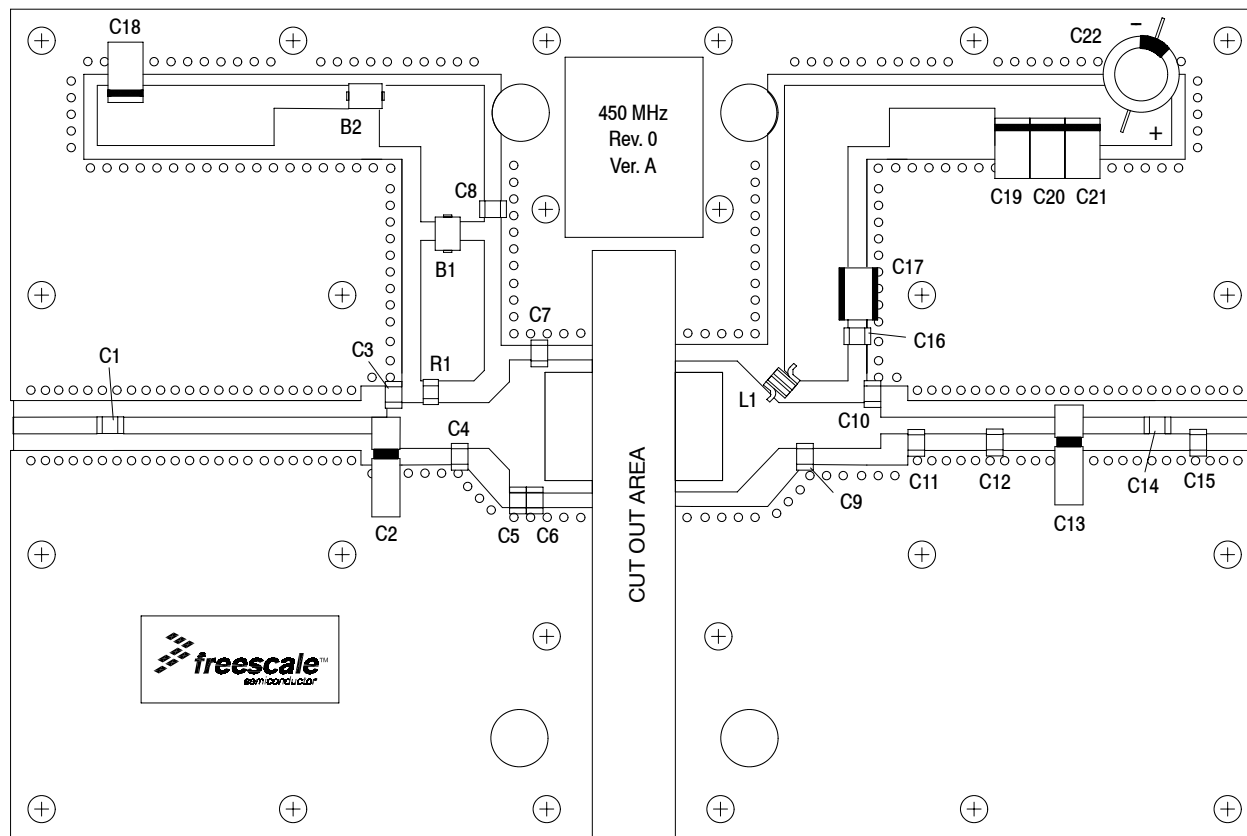
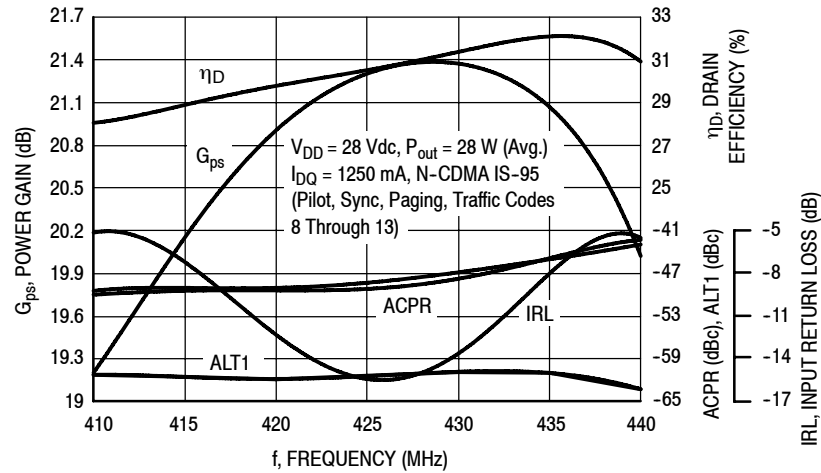
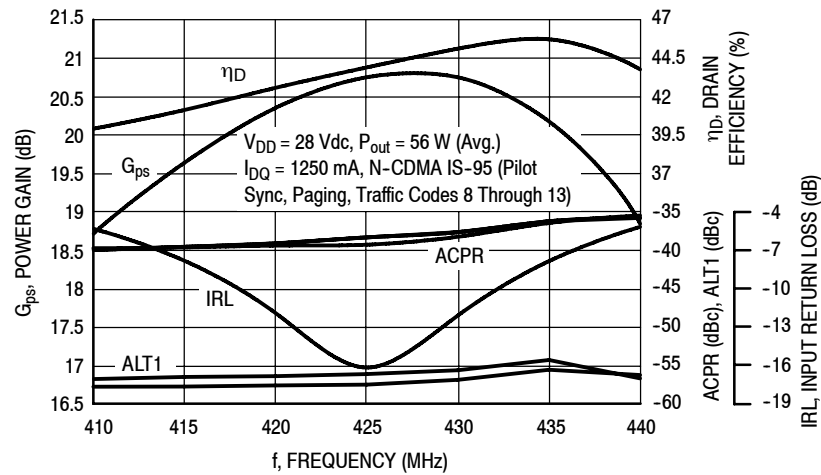


Figure 15. MRF5S4140HR3(SR3) Test Circuit Component Layout — 420-430 MHz

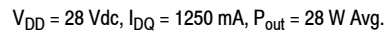
# TYPICAL CHARACTERISTICS — 420-430 MHz



**Figure 16. Single-Carrier N-CDMA Broadband Performance  
@  $P_{out} = 28$  Watts Avg.**



**Figure 17. Single-Carrier N-CDMA Broadband Performance  
@  $P_{out} = 56$  Watts Avg.**



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

Block diagram illustrating the setup for a Device Under Test (DUT). The DUT is connected to an Input Matching Network and an Output Matching Network. The input and output impedances are labeled  $Z_{\text{source}}$  and  $Z_{\text{load}}$  respectively.

**MRF5S4140HR3 MRF5S4140HSR3**

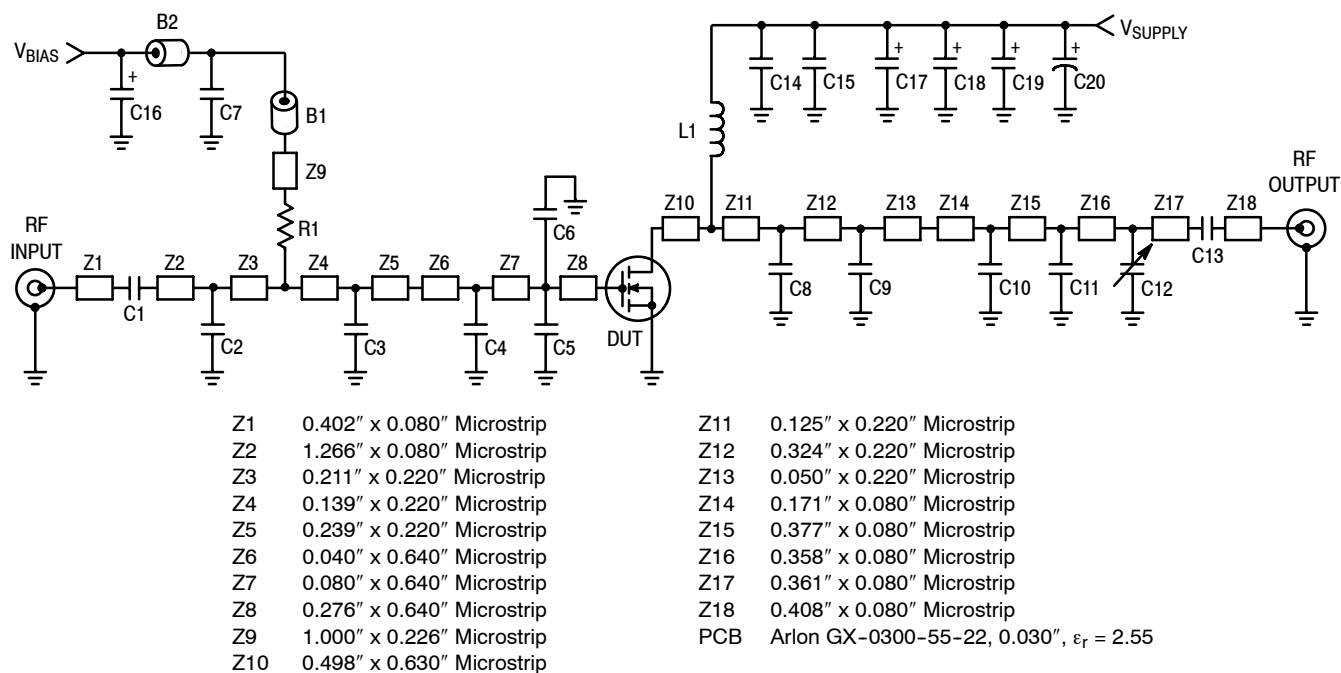


Figure 19. MRF5S4140HR3(SR3) Test Circuit Schematic — 489-499 MHz

Table 7. MRF5S4140HR3(SR3) Test Circuit Component Designations and Values — 489-499 MHz

| Part               | Description                               | Part Number       | Manufacturer     |
|--------------------|-------------------------------------------|-------------------|------------------|
| B1, B2             | Ferrite Beads, Short                      | 2743019447        | Fair-Rite        |
| C1, C13            | 120 pF Chip Capacitors                    | 100B121JP500X     | ATC              |
| C2                 | 18 pF Chip Capacitor                      | 100B180JP500X     | ATC              |
| C3, C4             | 24 pF Chip Capacitors                     | 100B240JP500X     | ATC              |
| C5, C6             | 13 pF Chip Capacitors                     | 100B130JP500X     | ATC              |
| C7                 | 0.02 $\mu$ F, 50 V Chip Capacitor         | 200B203MW50B      | ATC              |
| C8, C9             | 22 pF Chip Capacitors                     | 100B220JP500X     | ATC              |
| C10                | 1.0 pF Chip Capacitor                     | 100B1R0JP500X     | ATC              |
| C11                | 5.6 pF Chip Capacitor                     | 100B5R6JP500X     | ATC              |
| C12                | 0.8-8.0 pF Variable Capacitor, Gigatrim   | 27291SL           | Johanson         |
| C14                | 47 pF Chip Capacitor                      | 100B47JP500X      | ATC              |
| C15                | 0.56 $\mu$ F, 50 V Chip Capacitor         | C1825C564J5GAC    | Kemet            |
| C16, C17, C18, C19 | 10 $\mu$ F, 35 V Tantalum Capacitors      | T491D106K035AS    | Kemet            |
| C20                | 470 $\mu$ F, 63 V Electrolytic Capacitor  | SME63V471M12X25LL | United Chemi-Con |
| L1                 | 39 nH Inductor                            | 1812SMS-39N       | Coilcraft        |
| R1                 | 100 $\Omega$ , 1/4 W Chip Resistor (1210) |                   |                  |

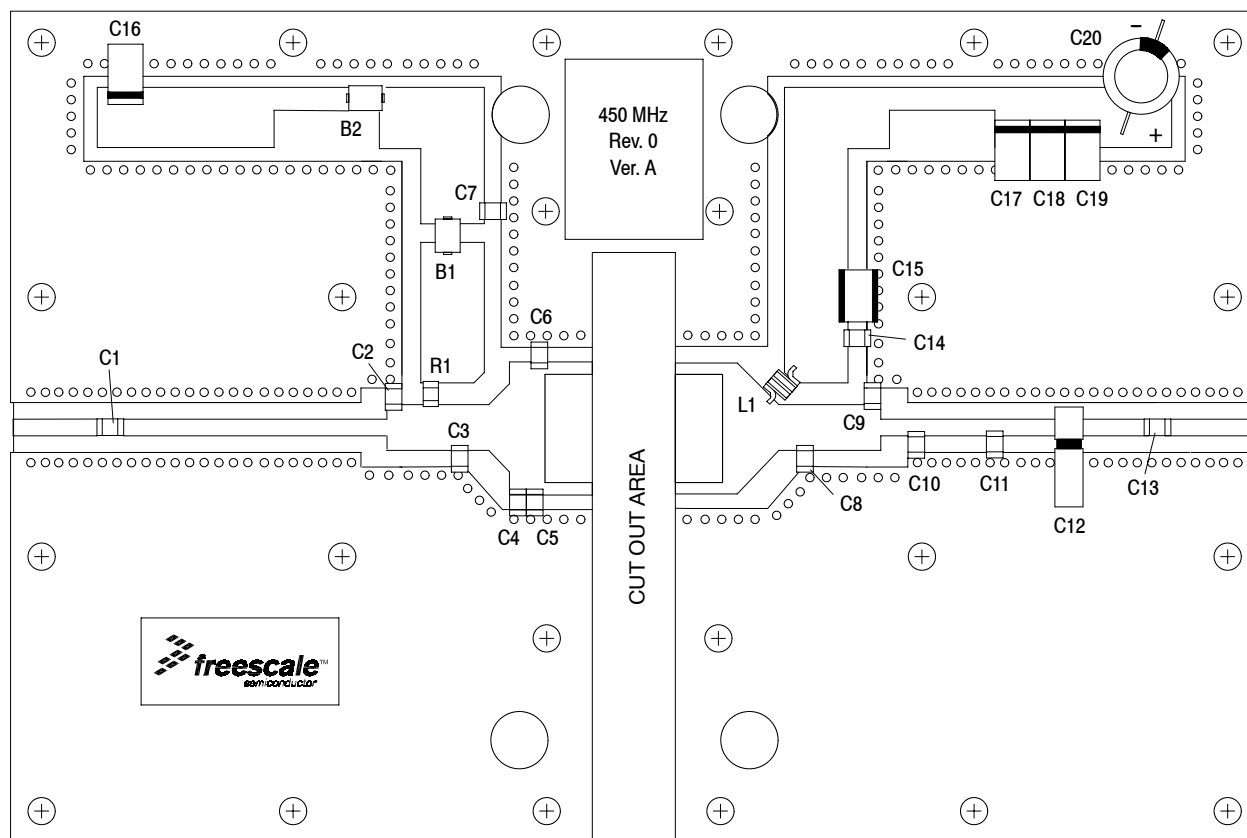
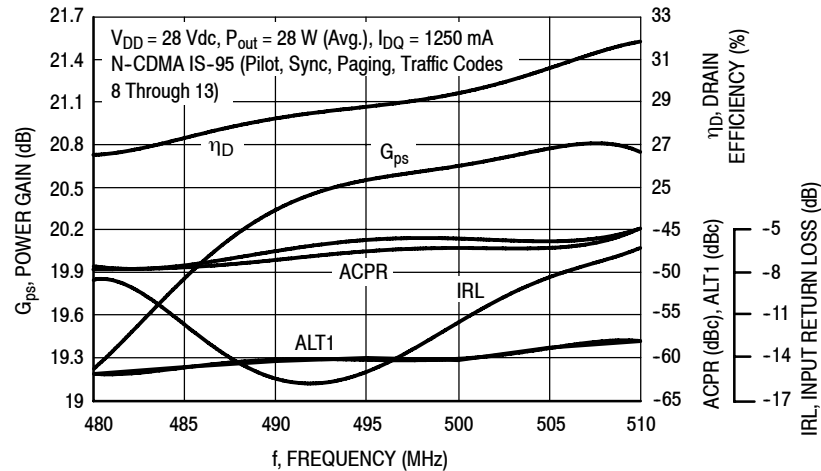
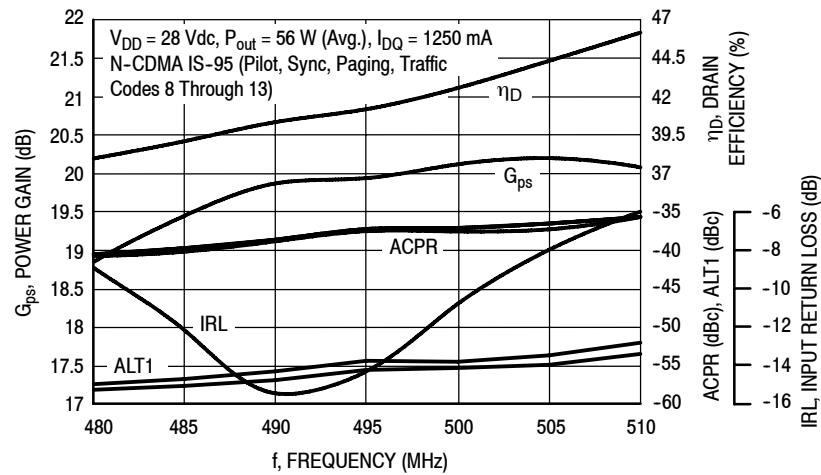


Figure 20. MRF5S4140HR3(SR3) Test Circuit Component Layout — 489-499 MHz

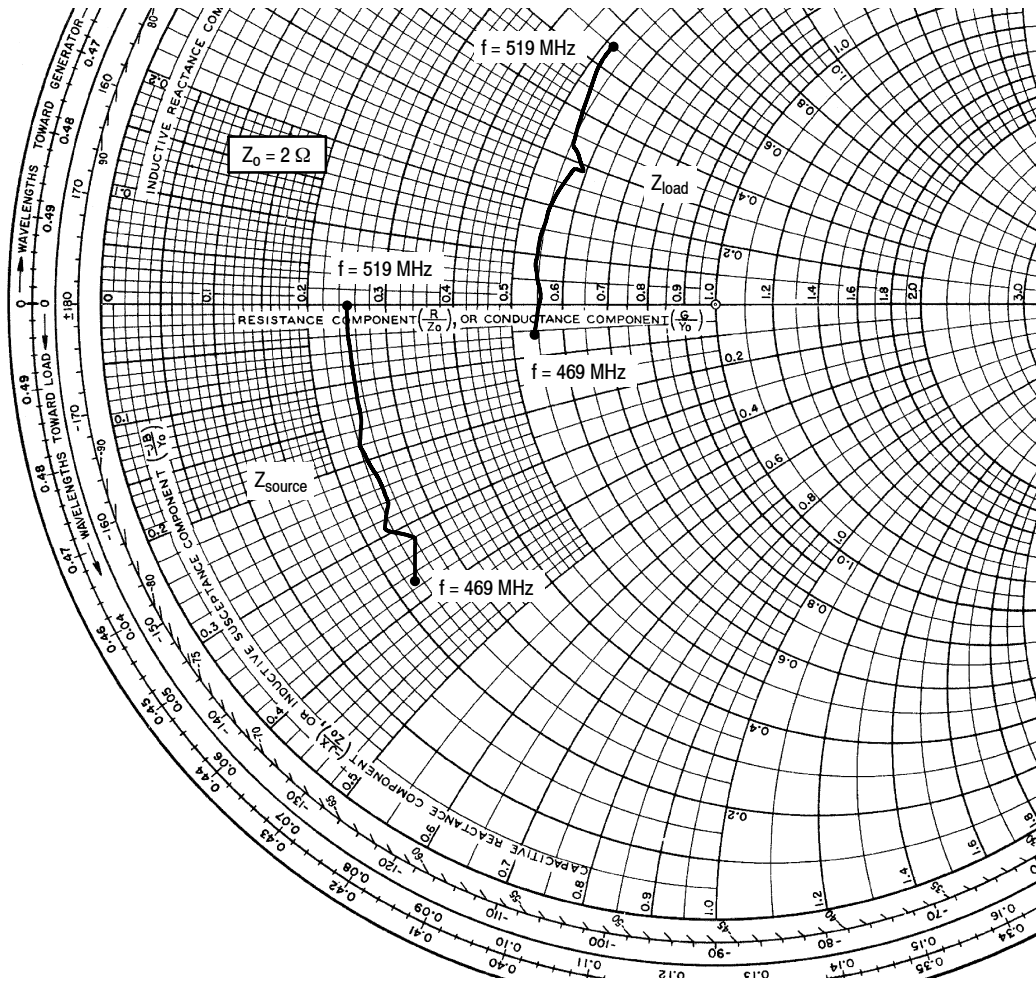
# TYPICAL CHARACTERISTICS — 489-499 MHz



**Figure 21. Single-Carrier N-CDMA Broadband Performance  
@  $P_{out} = 28$  Watts Avg.**



**Figure 22. Single-Carrier N-CDMA Broadband Performance  
@  $P_{out} = 56$  Watts Avg.**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1250 \text{ mA}$ ,  $P_{out} = 28 \text{ W Avg.}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 469      | $0.454 - j0.742$         | $1.08 - j0.129$        |
| 474      | $0.510 - j0.637$         | $1.12 + j0.043$        |
| 479      | $0.467 - j0.581$         | $1.07 + j0.160$        |
| 484      | $0.495 - j0.513$         | $1.09 + j0.294$        |
| 489      | $0.495 - j0.457$         | $1.12 + j0.430$        |
| 494      | $0.478 - j0.360$         | $1.16 + j0.573$        |
| 499      | $0.505 - j0.295$         | $1.18 + j0.586$        |
| 504      | $0.502 - j0.249$         | $1.11 + j0.653$        |
| 509      | $0.502 - j0.048$         | $1.07 + j0.810$        |
| 514      | $0.499 + j0.002$         | $1.03 + j1.01$         |
| 519      | $0.502 + j0.003$         | $1.03 + j1.10$         |

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

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

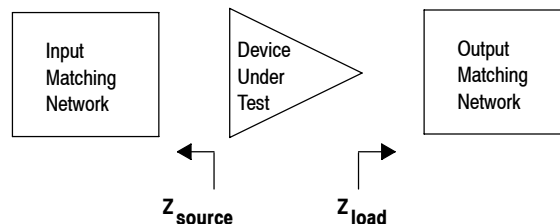
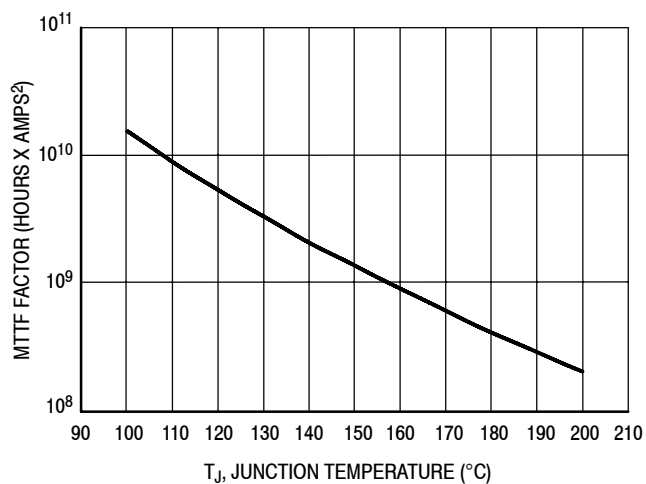


Figure 23. Series Equivalent Source and Load Impedance — 489-499 MHz

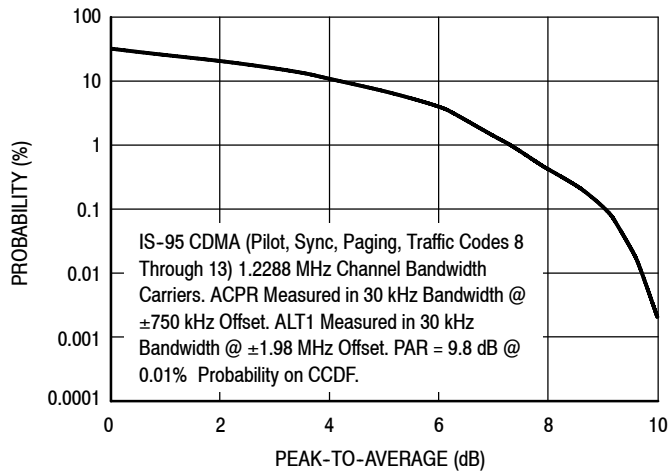
## TYPICAL CHARACTERISTICS



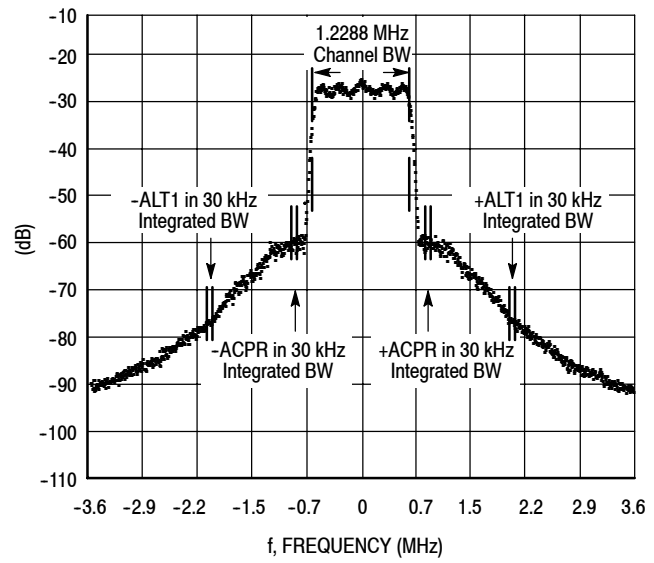
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

**Figure 24. MTTF Factor versus Junction Temperature**

## N-CDMA TEST SIGNAL

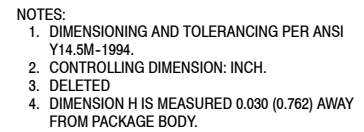


**Figure 25. Single-Carrier CCDF N-CDMA**



**Figure 26. Single-Carrier N-CDMA Spectrum**

# ARCHIVE INFORMATION



STYLE 1:  
PIN 1. DRAIN  
2. GATE  
3. SOURCE

**Top View Dimensions and Labels:**

- $4X\ U$  (FLANGE)
- $B$  (FLANGE)
- $4X\ Z$  (LID)
- $2X\ K$
- $D$

**Top View Cross-Section Table:**

|          |         |   |       |       |
|----------|---------|---|-------|-------|
| $\oplus$ | bbb (M) | T | A (M) | B (M) |
|----------|---------|---|-------|-------|

**Bottom View Dimensions and Labels:**

- $H$
- $E$
- $A$  (FLANGE)
- $N$  (LID)
- $M$  (INSULATOR)
- $C$
- $T$  SEATING PLANE
- $3$

**Bottom View Cross-Section Table 1:**

|          |         |   |       |       |
|----------|---------|---|-------|-------|
| $\oplus$ | ccc (M) | T | A (M) | B (M) |
|----------|---------|---|-------|-------|

**Bottom View Cross-Section Table 2:**

|          |         |   |       |       |
|----------|---------|---|-------|-------|
| $\oplus$ | aaa (M) | T | A (M) | B (M) |
|----------|---------|---|-------|-------|

**Right View Dimensions and Labels:**

- $R$  (LID)
- $S$  (INSULATOR)
- $F$

**Right View Cross-Section Table 1:**

|          |         |   |       |       |
|----------|---------|---|-------|-------|
| $\oplus$ | ccc (M) | T | A (M) | B (M) |
|----------|---------|---|-------|-------|

**Right View Cross-Section Table 2:**

|          |         |   |       |       |
|----------|---------|---|-------|-------|
| $\oplus$ | aaa (M) | T | A (M) | B (M) |
|----------|---------|---|-------|-------|

**CASE 465A-06**

NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

STYLE 1:  
PIN 1. DRAIN  
2. GATE  
5. SOURCE

**MRF5S4140HR3 MRF5S4140HSR3**

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