Freescale Semiconductor
Technical Data

Document Number: MRF5S4140H
Rev. 2, 5/2006

RoHS

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.

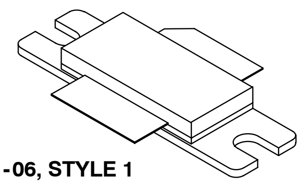
- Typical Single-Carrier N-CDMA Performance @ 465 MHz: V_{DD} = 28 Volts, I_{DQ} = 1250 mA, P_{out} = 28 Watts Avg., IS-95 CDMA (Pilot, Sync, Paging, Traffic Codes 8 Through 13). Channel Bandwidth = 1.2288 MHz. PAR = 9.8 dB @ 0.01% Probability on CCDF.
  Power Gain — 21 dB
  Drain Efficiency — 30%
  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

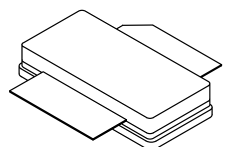
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32 V_{DD} Operation
- Integrated ESD Protection
- Lower Thermal Resistance Package
- Low Gold Plating Thickness on Leads, 40μ″ Nominal.
- RoHS Compliant
- In Tape 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°C Derate above 25°C	P_D	427 2.4	W W/°C
Storage Temperature Range	T_{stg}	- 65 to +150	°C
Case Operating Temperature	T_C	150	°C
Operating Junction Temperature	T_J	200	°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (1,2)	Unit
Thermal Resistance, Junction to Case Case Temperature 73°C, 140 W CW Case Temperature 74°C, 28 W CW	$R_{\theta JC}$	 0.41 0.47	°C/W

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.

freescale™ semiconductor

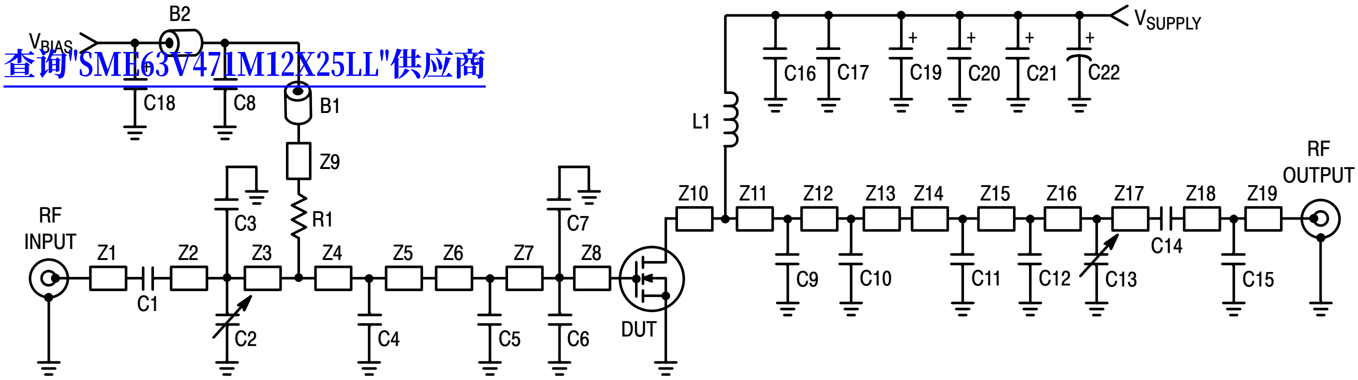
Table 3. ESD Protection Characteristics

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°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 65 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	1	μAdc
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1	μAdc
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 400 μAdc)	$V_{GS(th)}$	2	3	4	Vdc
Gate Quiescent Voltage (V_{DS} = 28 Vdc, I_D = 1250 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	3	4	5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 2.42 Adc)	$V_{DS(on)}$	0.1	0.2	0.3	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 3 Adc)	g_{fs}	—	6.2	—	S
Dynamic Characteristics [1]					
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	2.3	—	pF
Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1250 mA, P_{out} = 28 W Avg. N-CDMA, f = 465 MHz, Single-Carrier N-CDMA, 1.2288 MHz Channel Bandwidth Carrier. ACPR measured in 30 kHz Channel Bandwidth @ ±750 kHz Offset. PAR = 9.8 dB @ 0.01% Probability on CCDF.					
Power Gain	G_{ps}	20	21	23	dB
Drain Efficiency	η_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.



Z1	0.402″ x 0.080″ Microstrip	Z11	0.125″ x 0.220″ Microstrip
Z2	1.266″ x 0.080″ Microstrip	Z12	0.324″ x 0.220″ Microstrip
Z3	0.211″ x 0.220″ Microstrip	Z13	0.050″ x 0.220″ Microstrip
Z4	0.139″ x 0.220″ Microstrip	Z14	0.171″ x 0.080″ Microstrip
Z5	0.239″ x 0.220″ Microstrip	Z15	0.377″ x 0.080″ Microstrip
Z6	0.040″ x 0.640″ Microstrip	Z16	0.358″ x 0.080″ Microstrip
Z7	0.080″ x 0.640″ Microstrip	Z17	0.361″ x 0.080″ Microstrip
Z8	0.276″ x 0.640″ Microstrip	Z18	0.131″ x 0.080″ Microstrip
Z9	1.000″ x 0.226″ Microstrip	Z19	0.277″ x 0.080″ Microstrip
Z10	0.498″ x 0.630″ Microstrip	PCB	Arlon GX-0300-55-22, 0.030″, ε_r = 2.55

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 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)		

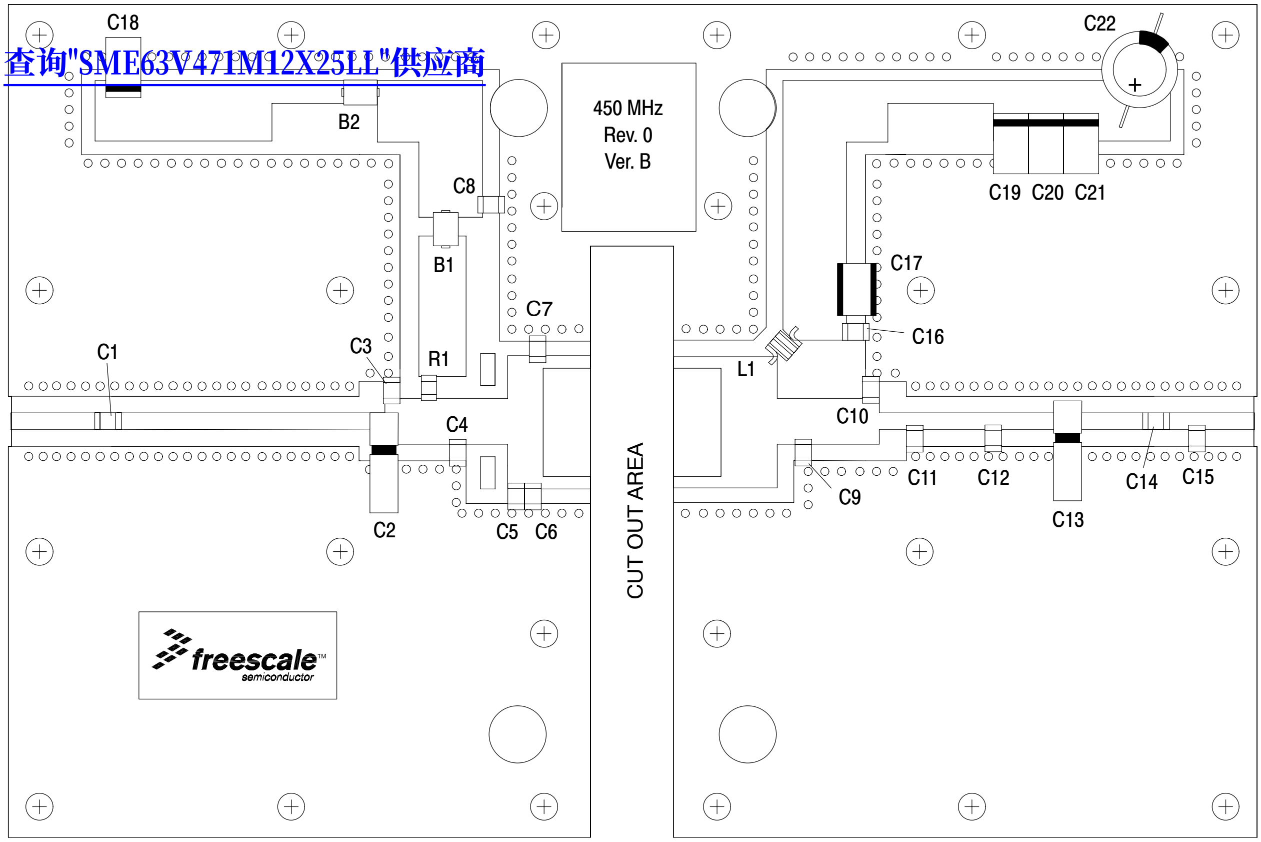


Figure 2. MRF5S4140HR3(SR3) Test Circuit Component Layout — 460-470 MHz

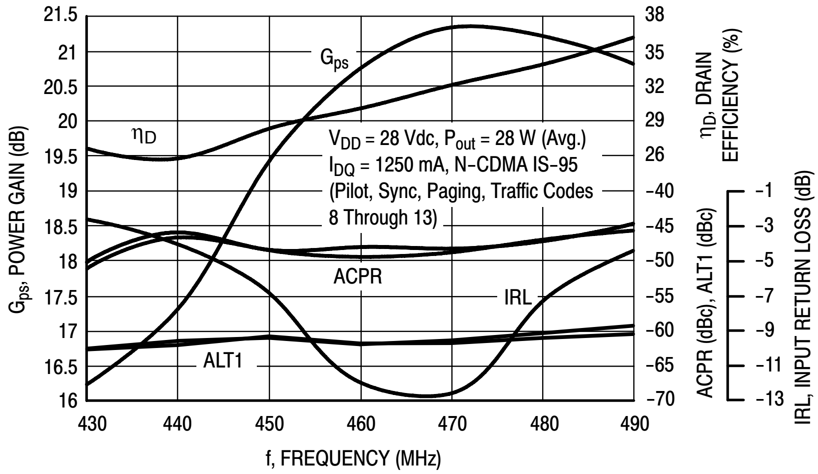


Figure 3. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 28 Watts Avg.

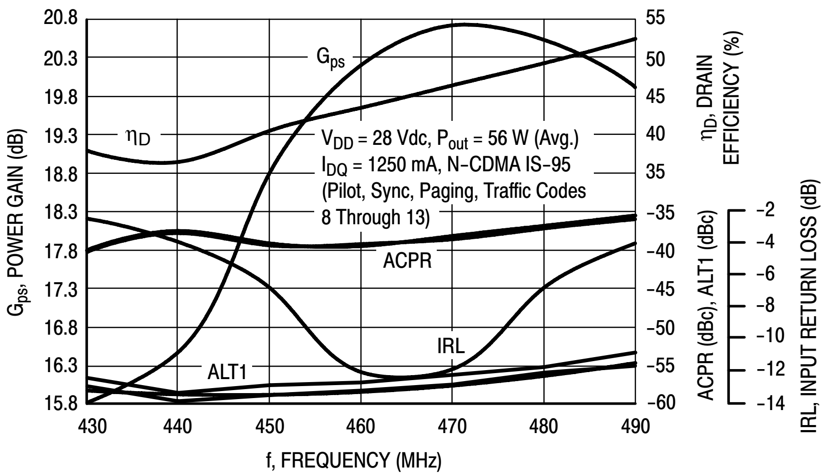


Figure 4. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 56 Watts Avg.

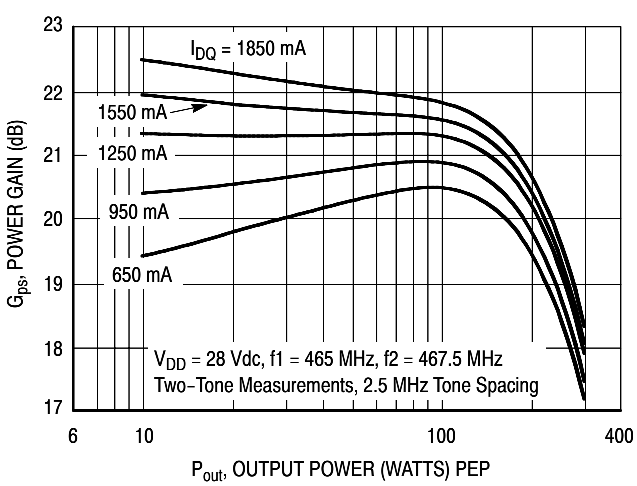


Figure 5. Two-Tone Power Gain versus Output Power

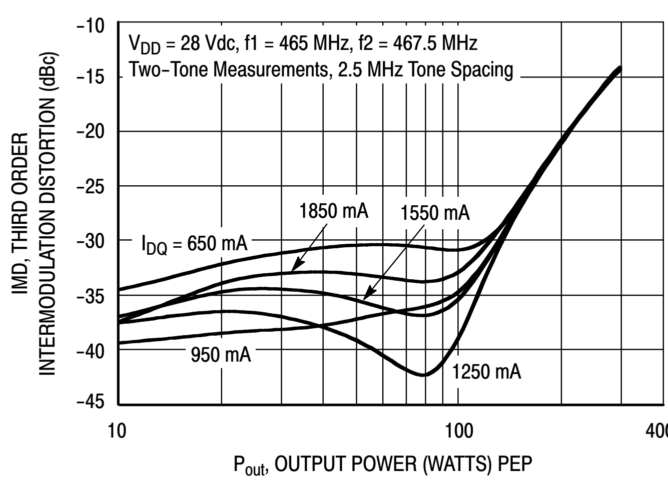


Figure 6. Third Order Intermodulation Distortion versus Output Power

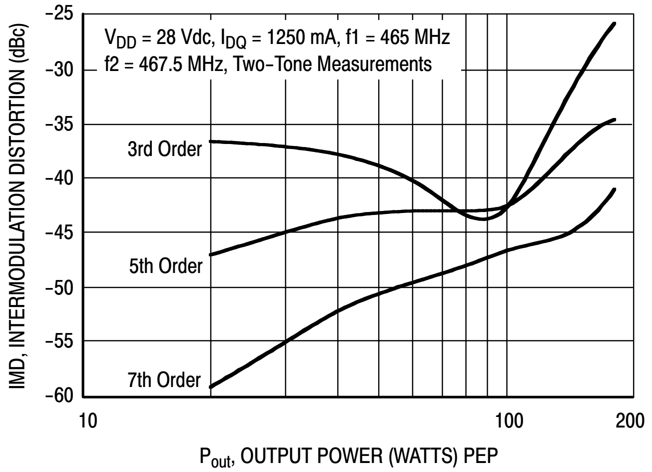


Figure 7. Intermodulation Distortion Products versus Output Power

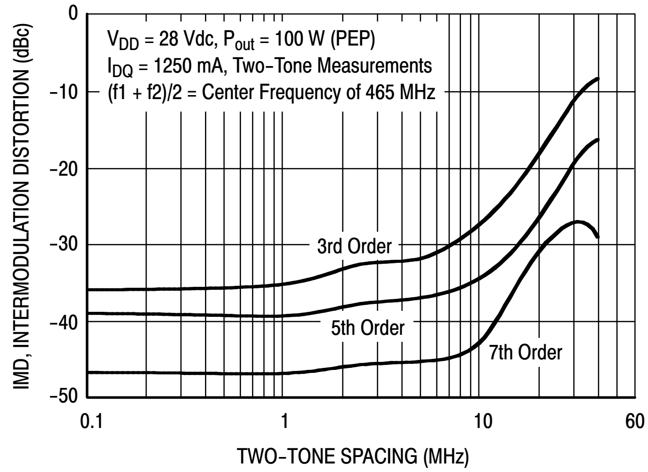


Figure 8. Intermodulation Distortion Products versus Tone Spacing

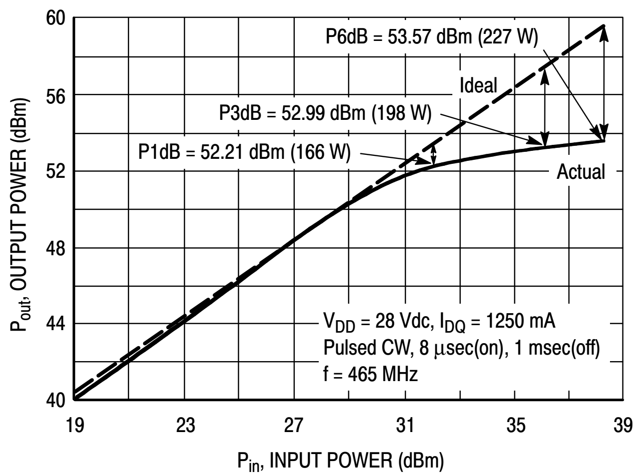


Figure 9. Pulse CW Output Power versus Input Power

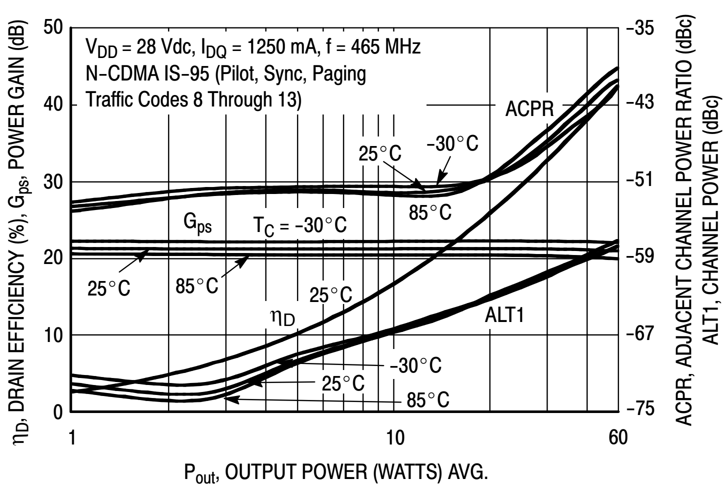


Figure 10. Single-Carrier N-CDMA ACPR, ALT1, Power Gain and Drain Efficiency versus Output Power

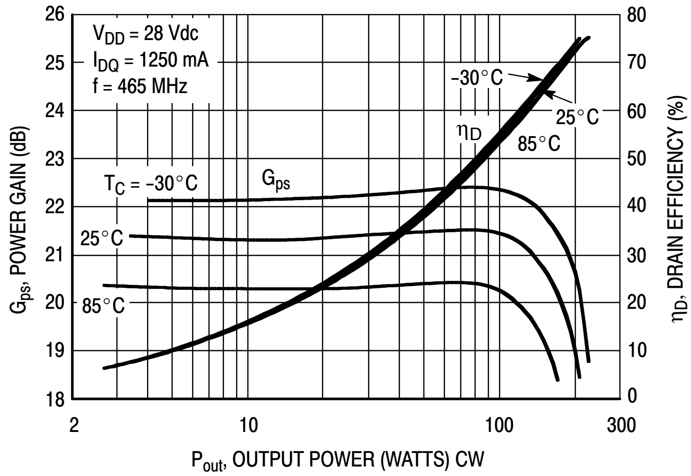


Figure 11. Power Gain and Drain Efficiency versus CW Output Power

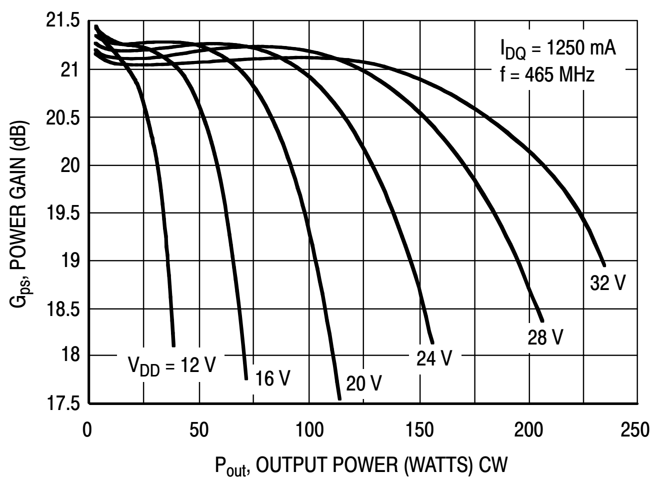
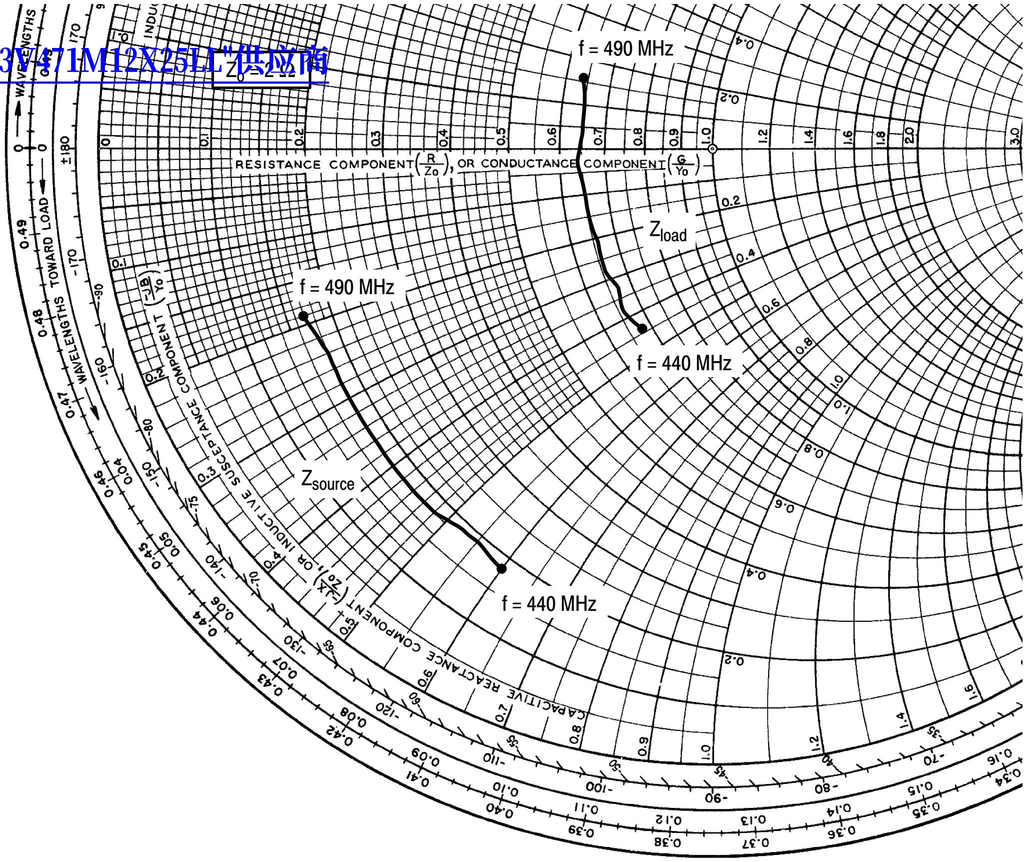


Figure 12. Power Gain versus Output Power



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

f MHz	Z_{source} Ω	Z_{load} Ω
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.

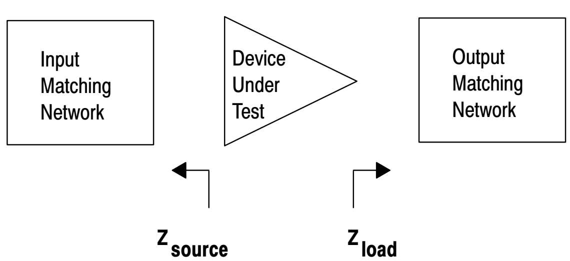
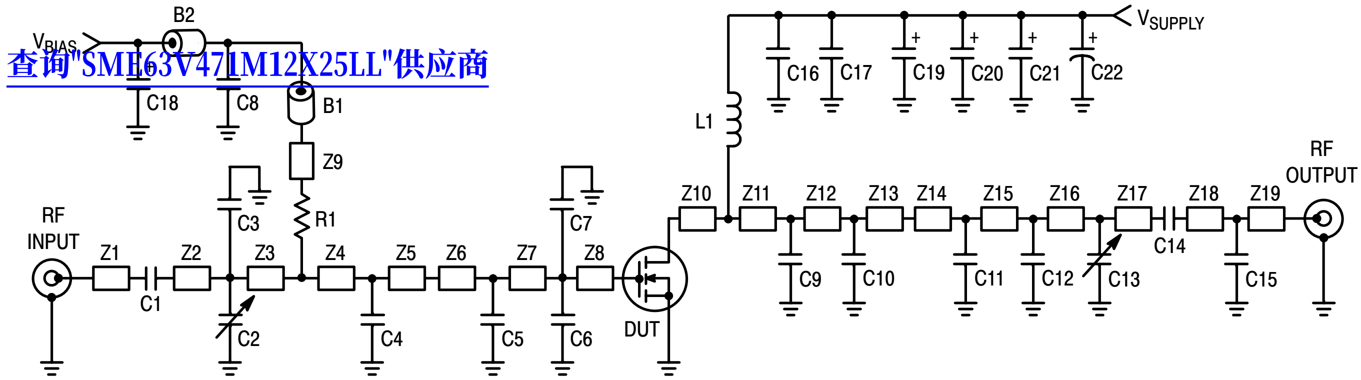


Figure 13. Series Equivalent Source and Load Impedance — 460-470 MHz



Z1	0.402″ x 0.080″ Microstrip	Z11	0.125″ x 0.220″ Microstrip
Z2	1.266″ x 0.080″ Microstrip	Z12	0.324″ x 0.220″ Microstrip
Z3	0.211″ x 0.220″ Microstrip	Z13	0.050″ x 0.220″ Microstrip
Z4	0.139″ x 0.220″ Microstrip	Z14	0.171″ x 0.080″ Microstrip
Z5	0.239″ x 0.220″ Microstrip	Z15	0.377″ x 0.080″ Microstrip
Z6	0.040″ x 0.640″ Microstrip	Z16	0.358″ x 0.080″ Microstrip
Z7	0.080″ x 0.640″ Microstrip	Z17	0.361″ x 0.080″ Microstrip
Z8	0.276″ x 0.640″ Microstrip	Z18	0.131″ x 0.080″ Microstrip
Z9	1.000″ x 0.226″ Microstrip	Z19	0.277″ x 0.080″ Microstrip
Z10	0.498″ x 0.630″ Microstrip	PCB	Arlon GX-0300-55-22, 0.030″, ε_r = 2.55

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)		

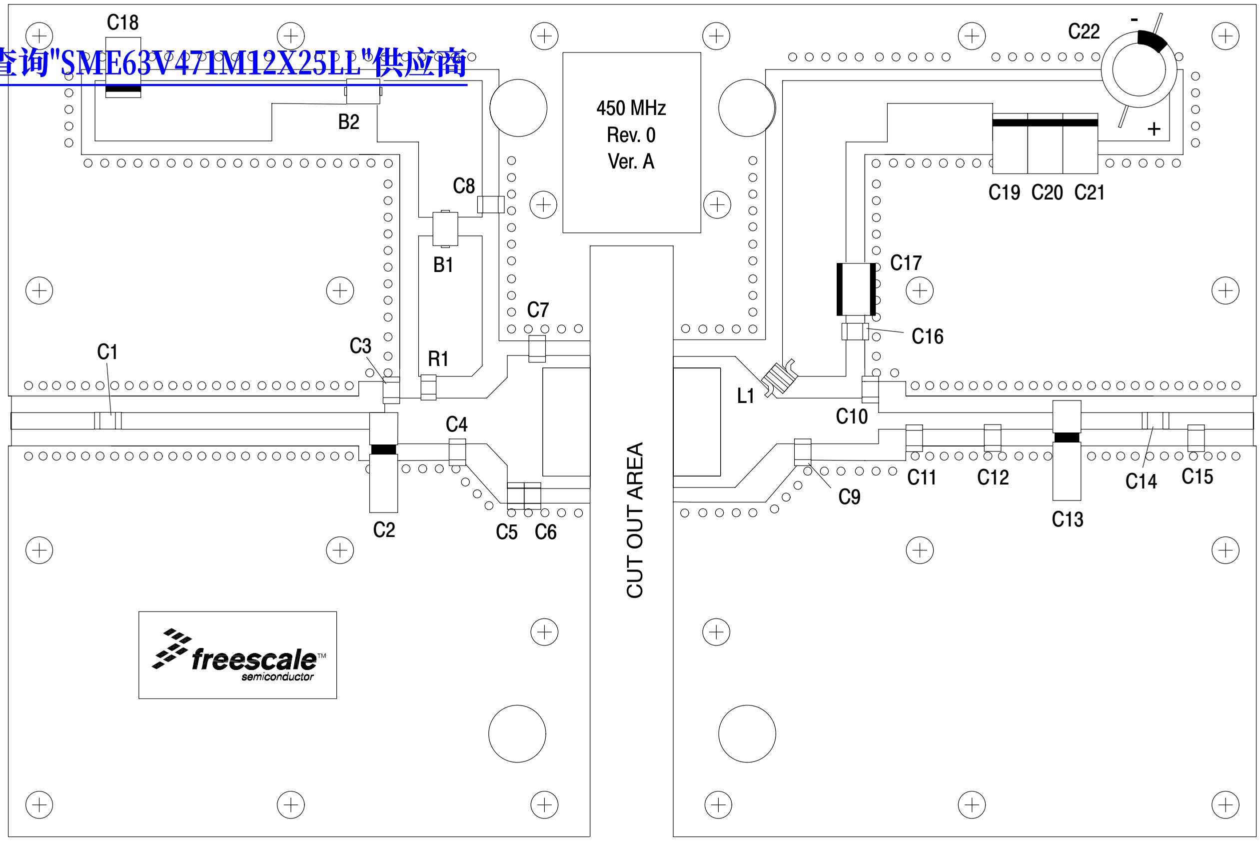


Figure 15. MRF5S4140HR3(SR3) Test Circuit Component Layout — 420-430 MHz

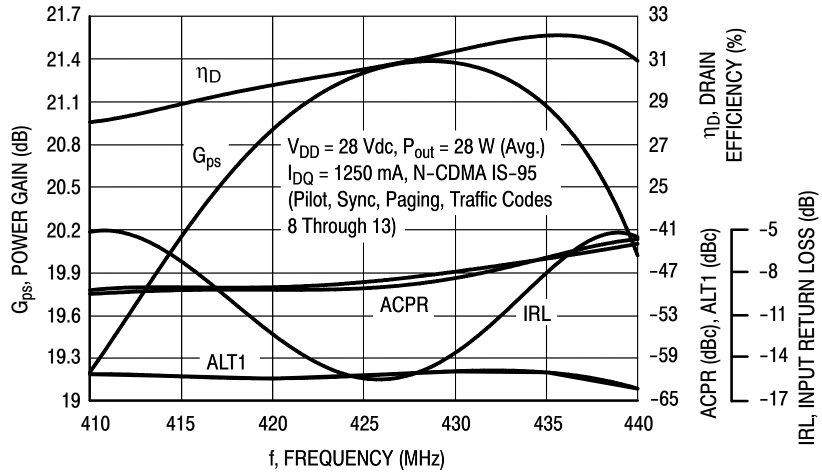


Figure 16. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 28 Watts Avg.

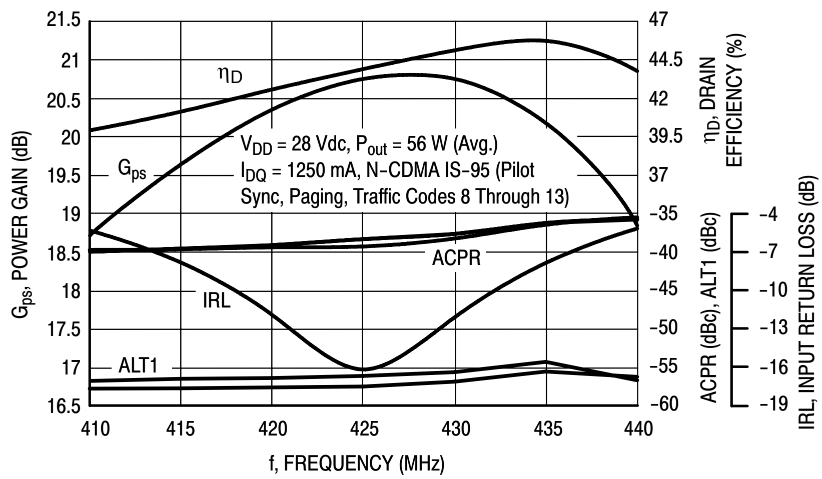
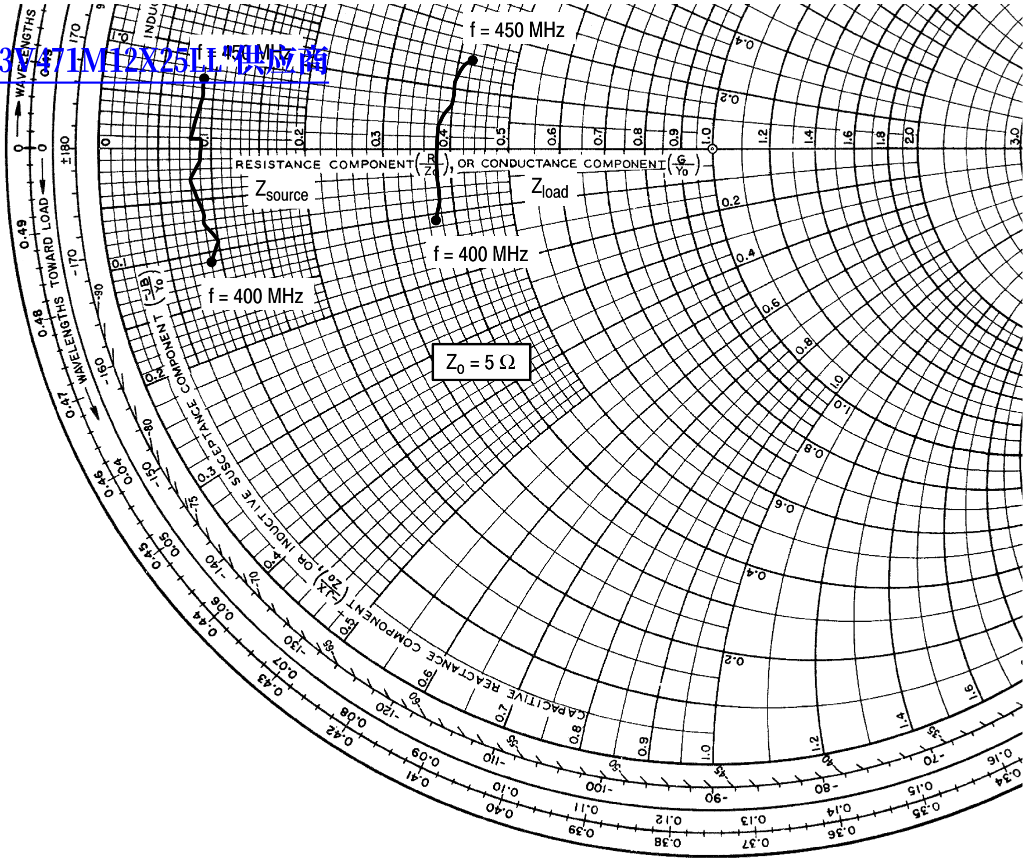


Figure 17. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 56 Watts Avg.



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

f MHz	Z_{source} Ω	Z_{load} Ω
400	0.454 - j0.530	1.87 - j0.530
405	0.476 - j0.435	1.91 - j0.376
410	0.430 - j0.360	1.88 - j0.276
415	0.455 - j0.281	1.91 - j0.046
420	0.419 - j0.153	1.89 - j0.019
425	0.421 - j0.135	1.92 + j0.128
430	0.435 - j0.032	1.97 + j0.276
435	0.426 + j0.048	1.99 + j0.392
440	0.407 + j0.044	1.99 + j0.537
445	0.429 + j0.262	2.05 + j0.675
450	0.452 + j0.341	2.10 + j0.765

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

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

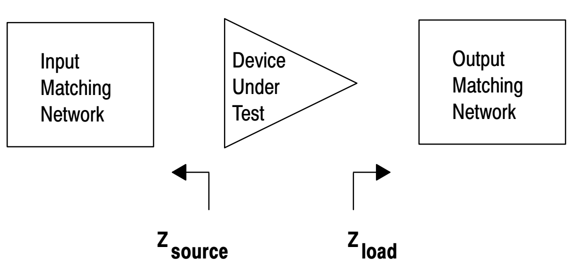
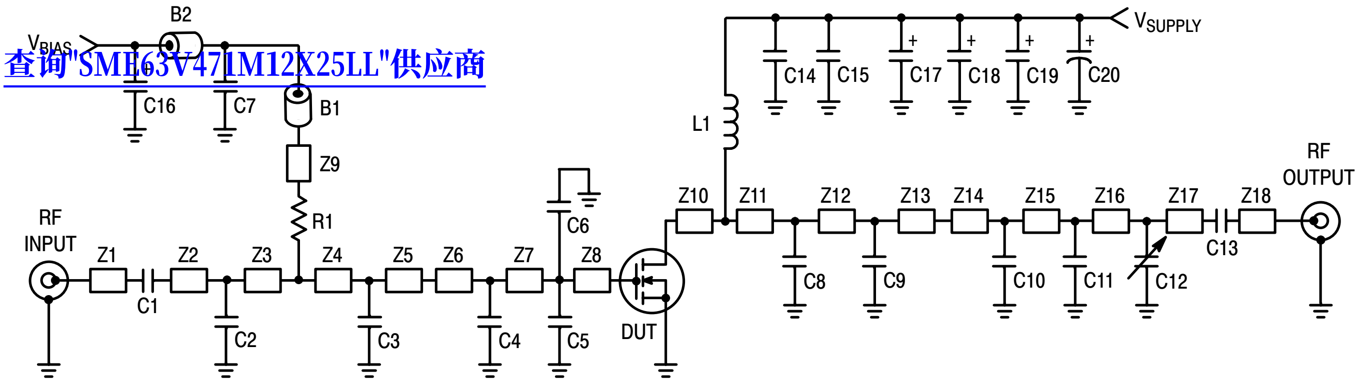


Figure 18. Series Equivalent Source and Load Impedance — 420-430 MHz



Z1	0.402″ x 0.080″ Microstrip	Z11	0.125″ x 0.220″ Microstrip
Z2	1.266″ x 0.080″ Microstrip	Z12	0.324″ x 0.220″ Microstrip
Z3	0.211″ x 0.220″ Microstrip	Z13	0.050″ x 0.220″ Microstrip
Z4	0.139″ x 0.220″ Microstrip	Z14	0.171″ x 0.080″ Microstrip
Z5	0.239″ x 0.220″ Microstrip	Z15	0.377″ x 0.080″ Microstrip
Z6	0.040″ x 0.640″ Microstrip	Z16	0.358″ x 0.080″ Microstrip
Z7	0.080″ x 0.640″ Microstrip	Z17	0.361″ x 0.080″ Microstrip
Z8	0.276″ x 0.640″ Microstrip	Z18	0.408″ x 0.080″ Microstrip
Z9	1.000″ x 0.226″ Microstrip	PCB	Arlon GX-0300-55-22, 0.030″, ε_r = 2.55
Z10	0.498″ x 0.630″ Microstrip		

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 μF, 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 μF, 50 V Chip Capacitor	C1825C564J5GAC	Kemet
C16, C17, C18, C19	10 μF, 35 V Tantalum Capacitors	T491D106K035AS	Kemet
C20	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)		

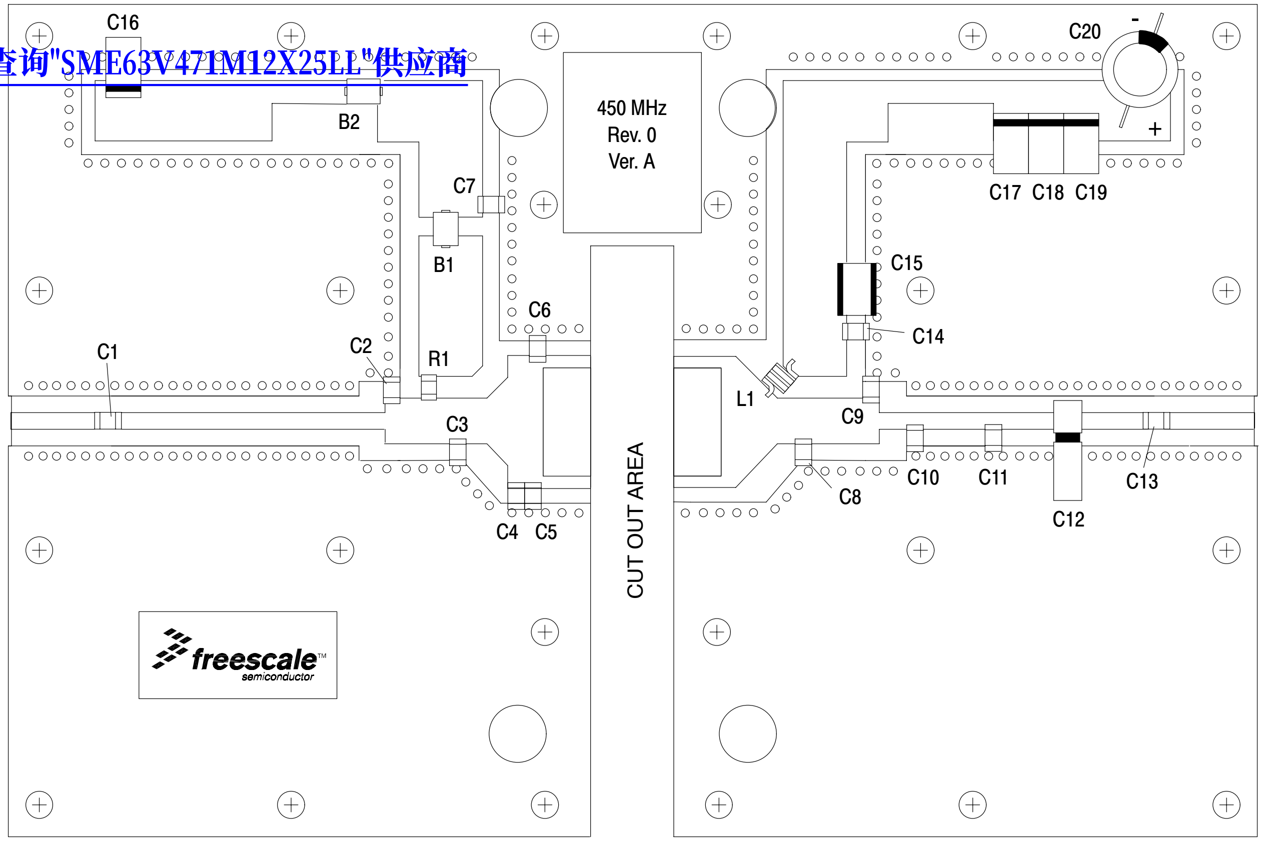


Figure 20. MRF5S4140HR3(SR3) Test Circuit Component Layout — 489-499 MHz

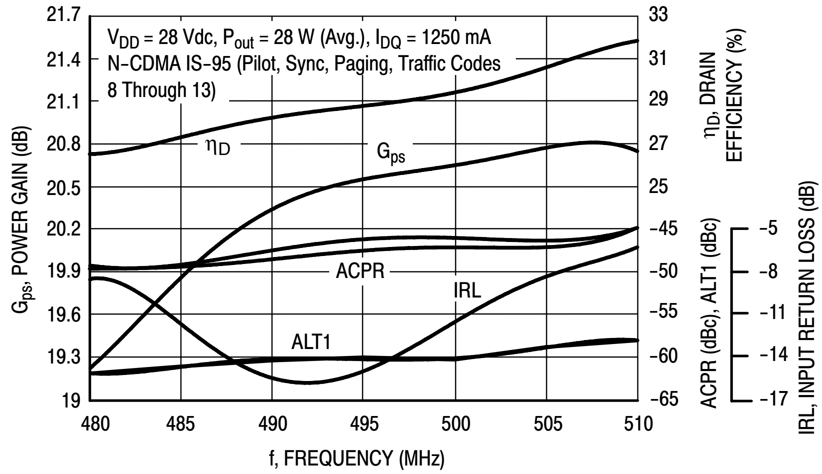


Figure 21. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 28 Watts Avg.

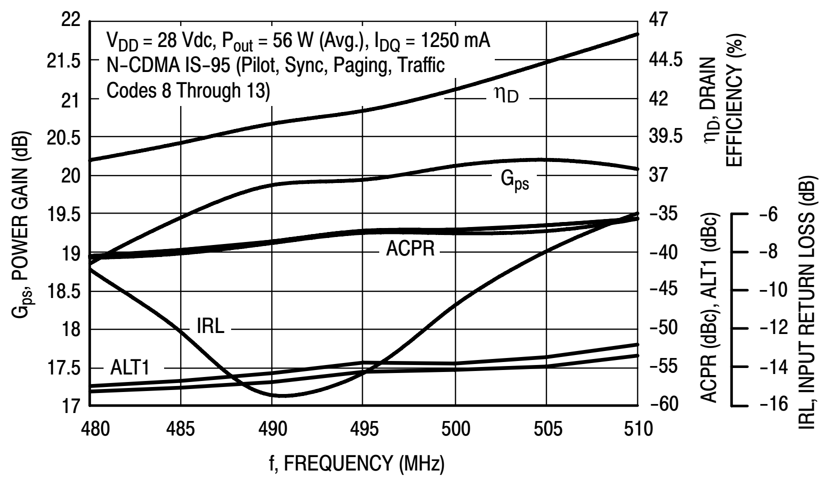
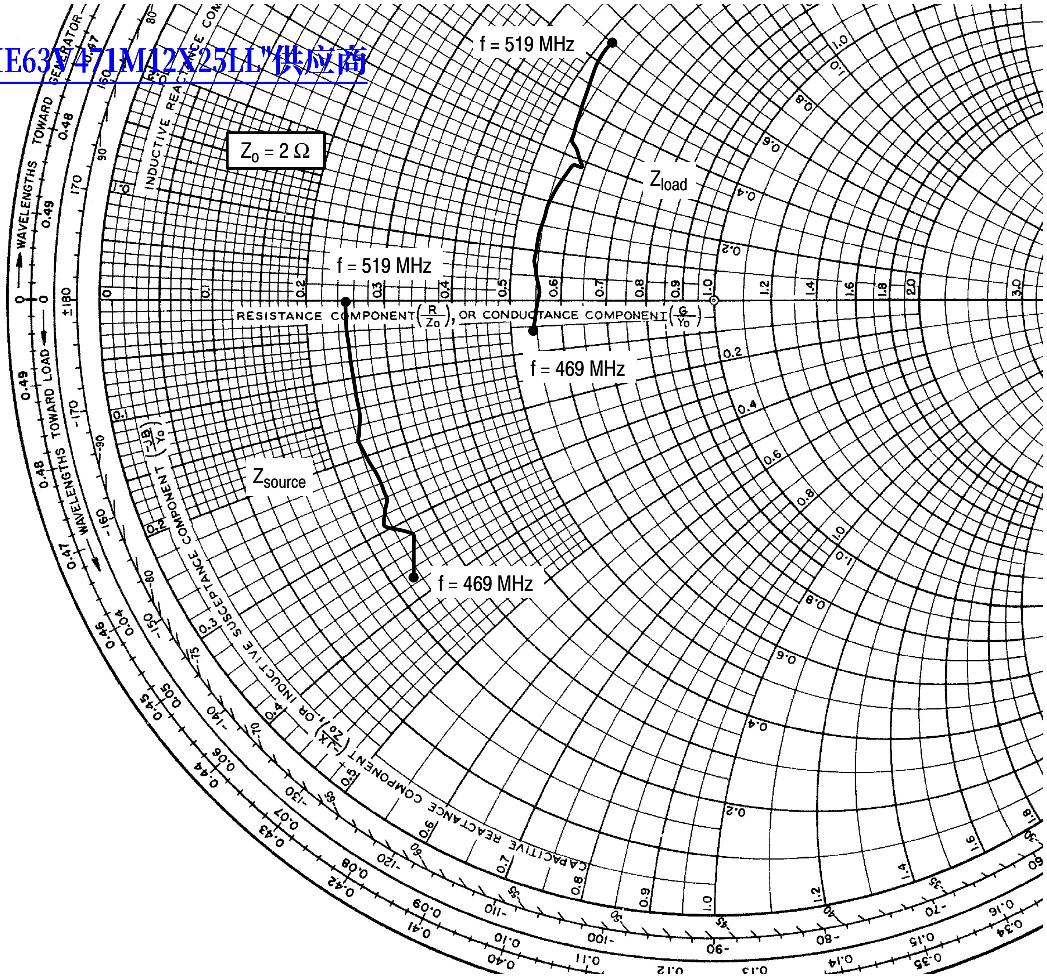


Figure 22. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 56 Watts Avg.



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

f MHz	Z_{source} Ω	Z_{load} Ω
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.

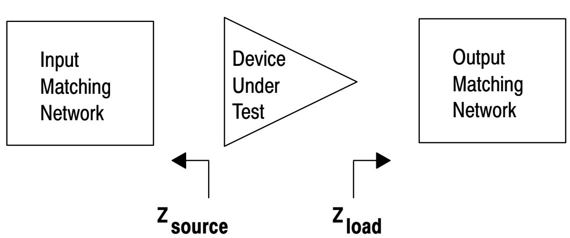
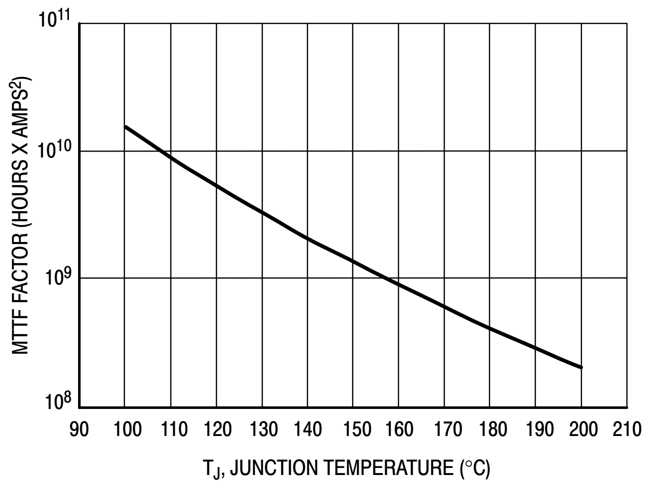


Figure 23. Series Equivalent Source and Load Impedance — 489-499 MHz



This above graph displays calculated MTTF in hours x ampere^2 drain current. Life tests at elevated temperatures have correlated to better than ±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

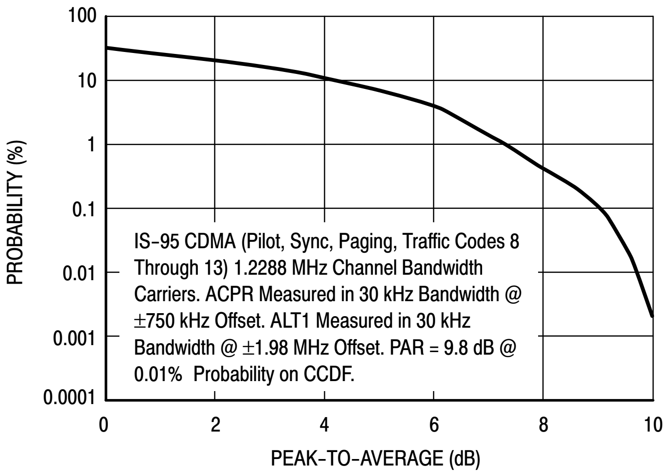


Figure 25. Single-Carrier CCDF N-CDMA

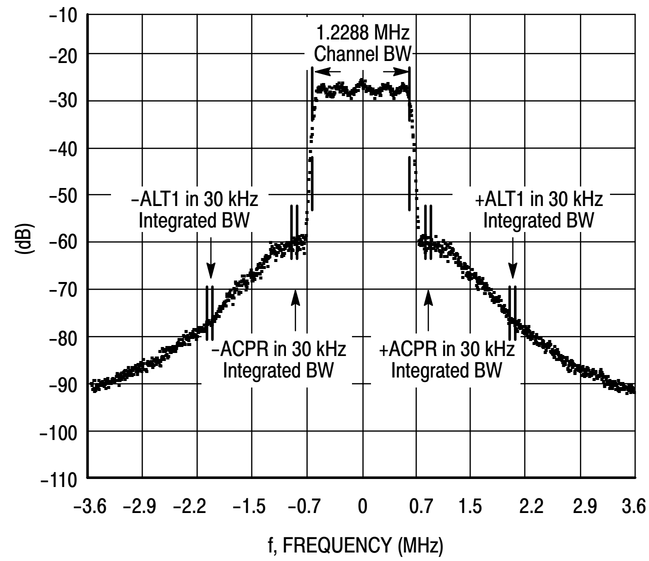
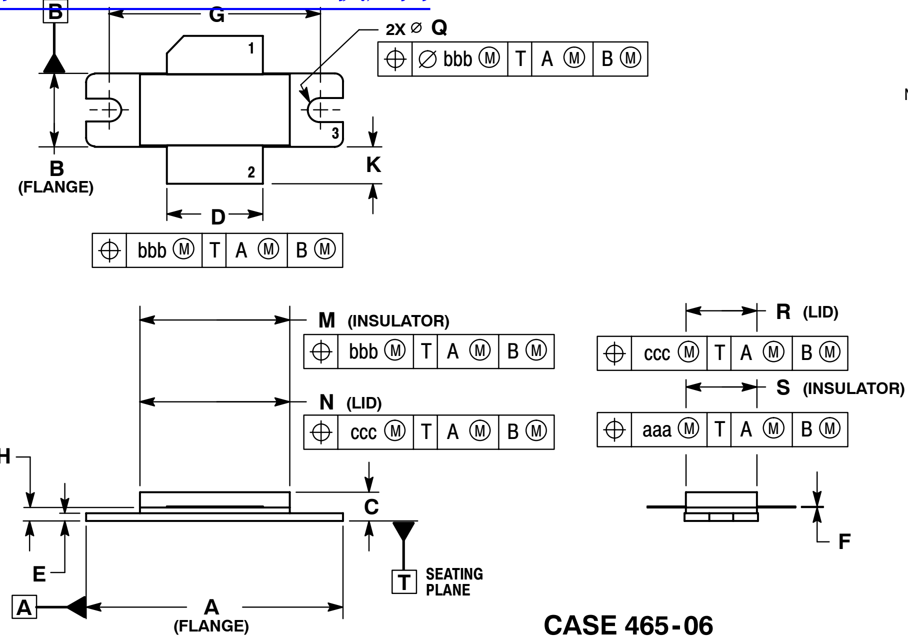


Figure 26. Single-Carrier N-CDMA Spectrum



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.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	1.335	1.345	33.91	34.16
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
G	1.100 BSC		27.94 BSC	
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.774	0.786	19.66	19.96
N	0.772	0.788	19.60	20.00
Q	∅.118	∅.138	∅3.00	∅3.51
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
aaa	0.005 REF		0.127 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	

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

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ISSUE G
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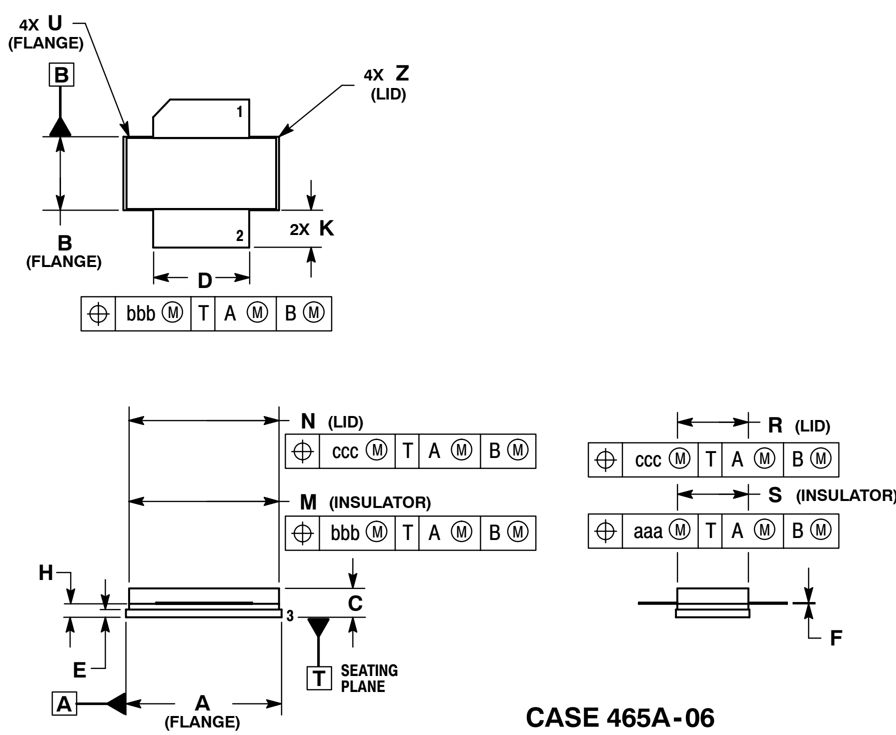
MRF5S4140HR3



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.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.805	0.815	20.45	20.70
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.774	0.786	19.61	20.02
N	0.772	0.788	19.61	20.02
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
U	---	0.040	---	1.02
Z	---	0.030	---	0.76
aaa	0.005 REF		0.127 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	

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

CASE 465A-06
ISSUE H
NI-780S
MRF5S4140HSR3

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