

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

Designed for GSM and GSM EDGE base station applications with frequencies from 1800 to 2000 MHz. Suitable for TDMA, CDMA, and multicarrier amplifier applications.

GSM Application

- Typical GSM Performance: $V_{DD} = 26$ Vdc, $I_{DQ} = 600$ mA, $P_{out} = 60$ Watts CW, Full Frequency Band (1805-1880 MHz or 1930-1990 MHz)
Power Gain — 15 dB
Drain Efficiency - 50%

GSM EDGE Application

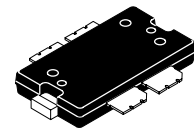
- Typical GSM EDGE Performance: $V_{DD} = 26$ Volts, $I_{DQ} = 450$ mA, $P_{out} = 25$ Watts Avg., Full Frequency Band (1805-1880 MHz or 1930-1990 MHz)
Power Gain — 15.5 dB
Spectral Regrowth @ 400 kHz Offset = -62 dBc
Spectral Regrowth @ 600 kHz Offset = -76 dBc
EVM — 2% rms
- Capable of Handling 5:1 VSWR, @ 26 Vdc, 1990 MHz, 60 Watts CW Output Power

Features

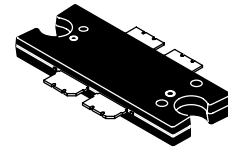
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32 V_{DD} Operation
- Integrated ESD Protection
- 200°C Capable Plastic Package
- N Suffix Indicates Lead-Free Terminations. RoHS Compliant.
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

MRF6S18060NR1
MRF6S18060NBR1

1800-2000 MHz, 60 W, 26 V
GSM/GSM EDGE
LATERAL N-CHANNEL
RF POWER MOSFETs



CASE 1486-03, STYLE 1
TO-270 WB-4
PLASTIC
MRF6S18060NR1



CASE 1484-04, STYLE 1
TO-272 WB-4
PLASTIC
MRF6S18060NBR1

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +68	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +12	Vdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	216 1.2	W W/°C
Storage Temperature Range	T_{stg}	- 65 to +175	°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 80°C, 60 W CW Case Temperature 77°C, 25 W CW	$R_{\theta JC}$	0.81 0.95	°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.

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	1B (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	III (Minimum)

Table 4. Moisture Sensitivity Level

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD 22-A113, IPC/JEDEC J-STD-020	3	260	°C

Table 5. Electrical Characteristics ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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Off Characteristics

Zero Gate Voltage Drain Leakage Current ($V_{DS} = 68\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current ($V_{DS} = 26\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	1	μAdc
Gate-Source Leakage Current ($V_{GS} = 5\text{ Vdc}$, $V_{DS} = 0\text{ Vdc}$)	I_{GSS}	—	—	1	μAdc

On Characteristics

Gate Threshold Voltage ($V_{DS} = 10\text{ Vdc}$, $I_D = 200\ \mu\text{Adc}$)	$V_{GS(th)}$	1	2	3	Vdc
Gate Quiescent Voltage ($V_{DS} = 26\text{ Vdc}$, $I_D = 600\ \text{mAdc}$)	$V_{GS(Q)}$	2	2.8	4	Vdc
Drain-Source On-Voltage ($V_{GS} = 10\text{ Vdc}$, $I_D = 2\ \text{Adc}$)	$V_{DS(on)}$	—	0.24	—	Vdc
Forward Transconductance ($V_{DS} = 10\text{ Vdc}$, $I_D = 2\ \text{Adc}$)	g_{fs}	—	5.3	—	S

Dynamic Characteristics

Reverse Transfer Capacitance (1) ($V_{DS} = 26\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{rss}	—	1.5	—	pF
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Functional Tests (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 26\text{ Vdc}$, $I_{DQ} = 600\ \text{mA}$, $P_{out} = 60\ \text{W CW}$, $f = 1930\ \text{MHz}$, $f = 1990\ \text{MHz}$

Power Gain	G_{ps}	14	15	17	dB
Drain Efficiency	η_D	48	50	—	%
Input Return Loss	IRL	—	-12	-9	dB
P_{out} @ 1 dB Compression Point	P1dB	60	65	—	W

1. Part is internally matched both on input and output.

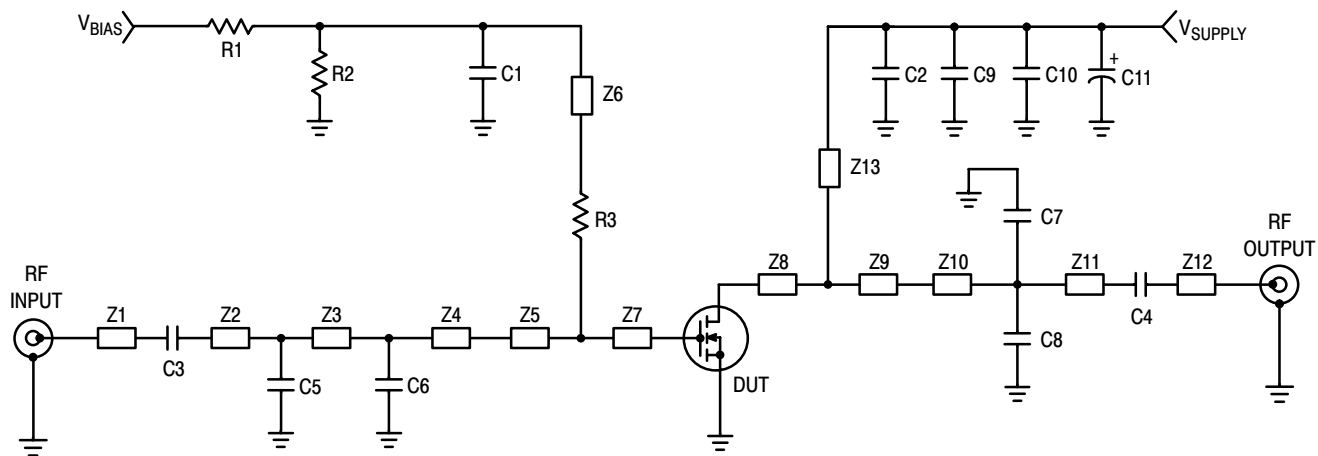
(continued)

Table 5. Electrical Characteristics ($T_C = 25^\circ\text{C}$ unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Typical GSM EDGE Performances (In Freescale Broadband Test Fixture, 50 ohm system) $V_{DD} = 26\text{ Vdc}$, $I_{DQ} = 450\text{ mA}$, $P_{out} = 25\text{ W Avg.}$, 1805-1880 MHz or 1930-1990 MHz, EDGE Modulation					
Power Gain	G_{ps}	—	15.5	—	dB
Drain Efficiency	η_D	—	32	—	%
Error Vector Magnitude	EVM	—	2	—	% rms
Spectral Regrowth at 400 kHz Offset	SR1	—	-62	—	dBc
Spectral Regrowth at 600 kHz Offset	SR2	—	-76	—	dBc

Typical CW Performances (In Freescale Broadband Test Fixture, 50 ohm system) $V_{DD} = 26\text{ Vdc}$, $I_{DQ} = 600\text{ mA}$, $P_{out} = 60\text{ W}$, 1805-1880 MHz or 1930-1990 MHz

Power Gain	G_{ps}	—	15	—	dB
Drain Efficiency	η_D	—	50	—	%
Input Return Loss	IRL	—	-12	—	dB
P_{out} @ 1 dB Compression Point, CW	P1dB	—	65	—	W



Z1	0.250" x 0.083" Microstrip	Z9	0.485" x 1.000" Microstrip
Z2*	0.950" x 0.083" Microstrip	Z10*	0.500" x 0.083" Microstrip
Z3*	0.250" x 0.083" Microstrip	Z11*	0.895" x 0.083" Microstrip
Z4*	0.315" x 0.083" Microstrip	Z12	0.250" x 0.083" Microstrip
Z5	0.365" x 1.000" Microstrip	Z13	0.200" x 0.080" Microstrip
Z6	0.680" x 0.080" Microstrip	PCB	Taconic TLX8-0300, 0.030", $\epsilon_r = 2.55$
Z7, Z8	0.115" x 1.000" Microstrip		

* Variable for tuning

Figure 1. MRF6S18060NR1(NBR1) Test Circuit Schematic — 1900 MHz

Table 6. MRF6S18060NR1(NBR1) Test Circuit Component Designations and Values — 1900 MHz

Part	Description	Part Number	Manufacturer
C1, C2, C3, C4	6.8 pF 100B Chip Capacitors	100B6R8CW	ATC
C5	1.5 pF 100B Chip Capacitor	100B1R5BW	ATC
C6	1.8 pF 100B Chip Capacitor	100B1R8BW	ATC
C7, C8	1 pF 100B Chip Capacitors	100B1R0BW	ATC
C9, C10	10 μ F Chip Capacitors (2220)	C5750X5R1H106MT	TDK
C11	220 μ F, 63 V Electrolytic Capacitor, Radial	13668221	Philips
R1, R2	10 k Ω , 1/4 W Chip Resistors (1206)		
R3	10 Ω , 1/4 W Chip Resistor (1206)		

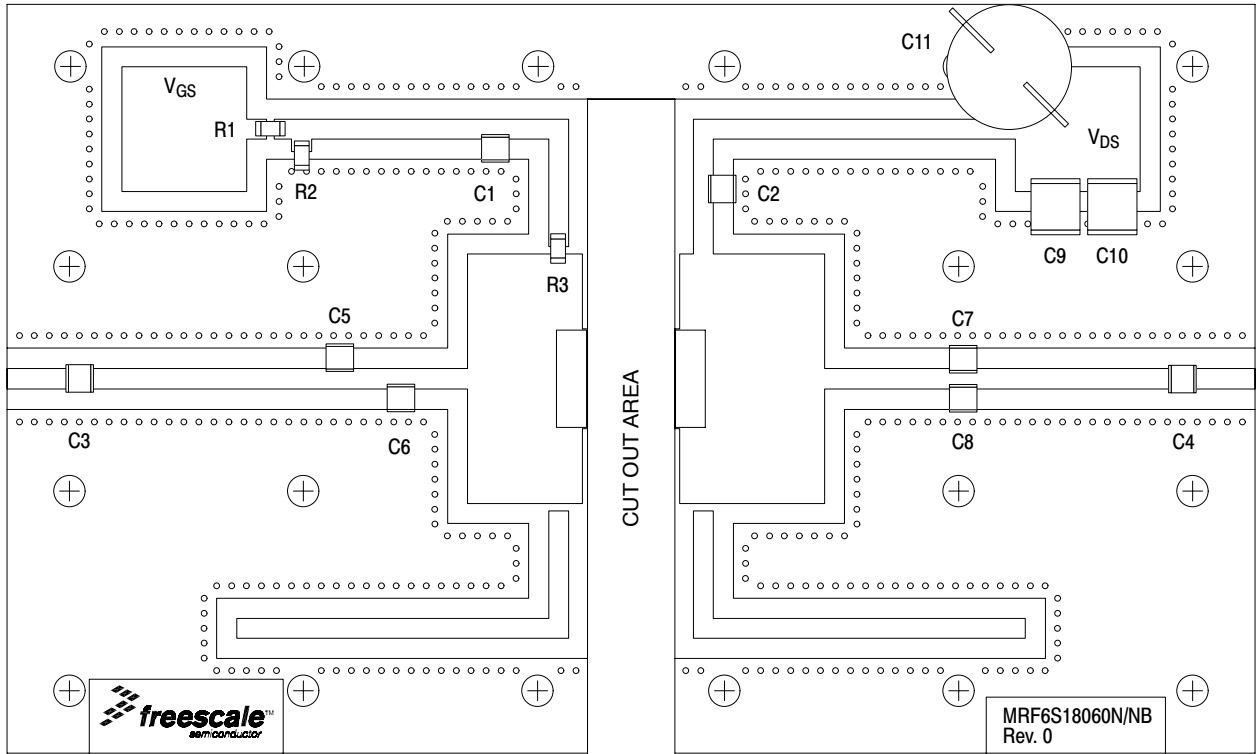


Figure 2. MRF6S18060NR1(NBR1) Test Circuit Component Layout — 1900 MHz

TYPICAL CHARACTERISTICS — 1900 MHz

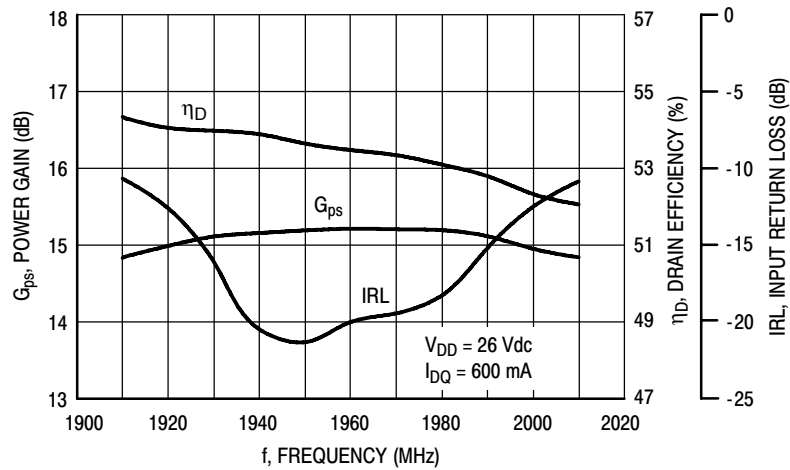


Figure 3. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ $P_{out} = 60$ Watts

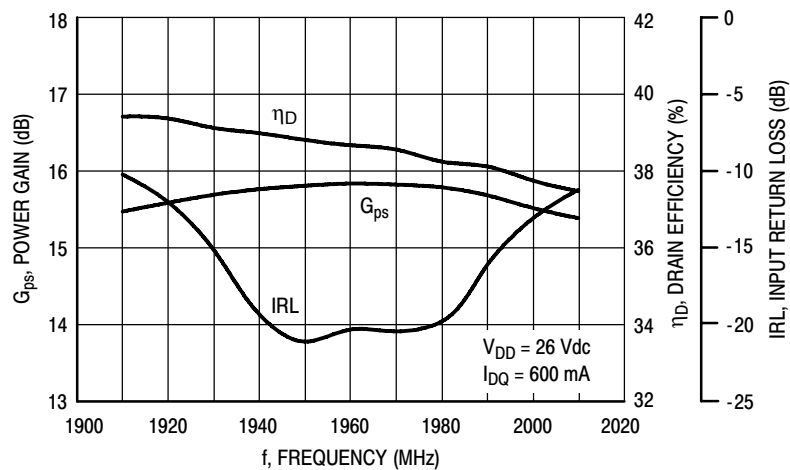


Figure 4. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ $P_{out} = 30$ Watts

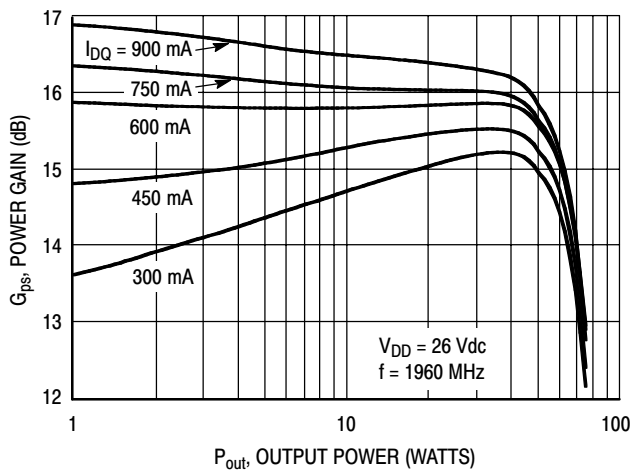


Figure 5. Power Gain versus Output Power

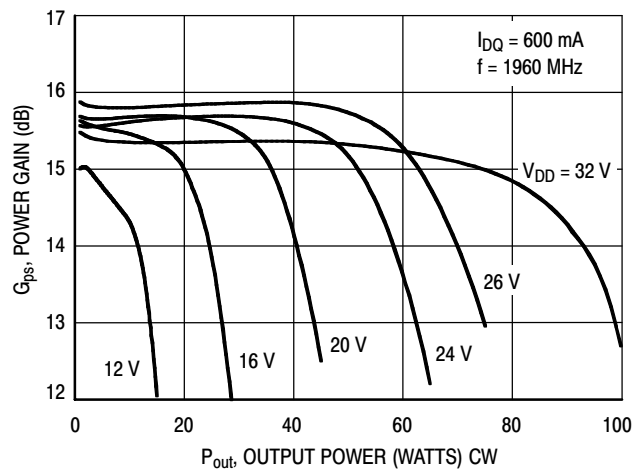


Figure 6. Power Gain versus Output Power

TYPICAL CHARACTERISTICS — 1900 MHz

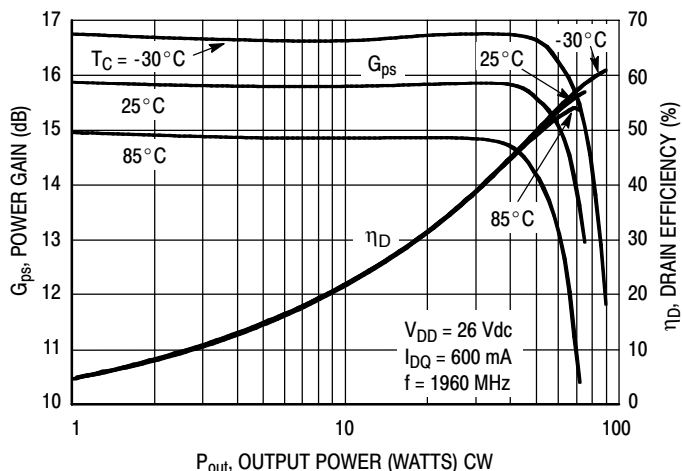


Figure 7. Power Gain and Drain Efficiency versus CW Output Power

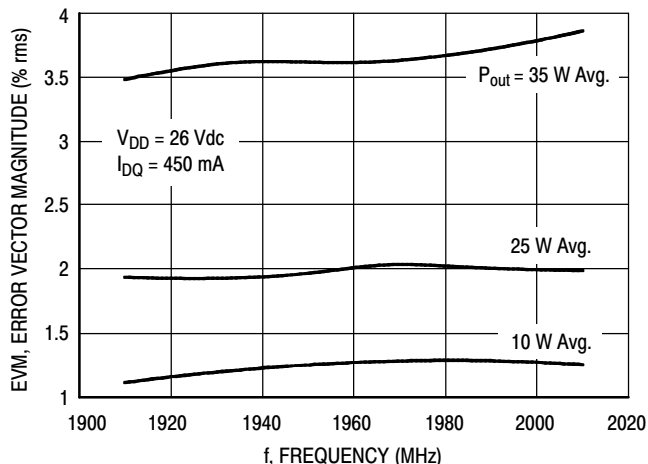


Figure 8. EVM versus Frequency

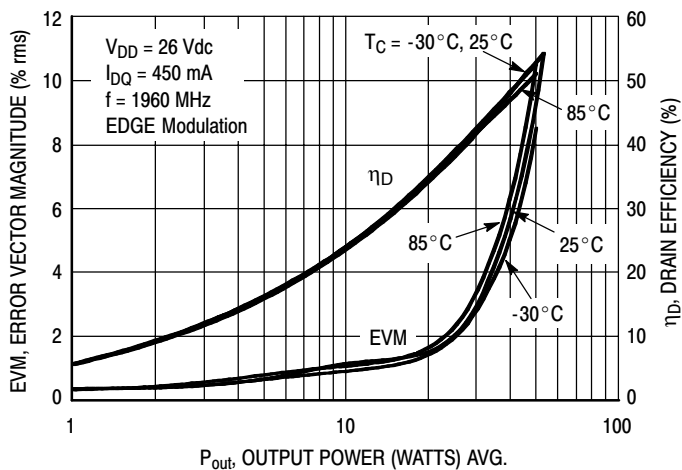


Figure 9. EVM and Drain Efficiency versus Output Power

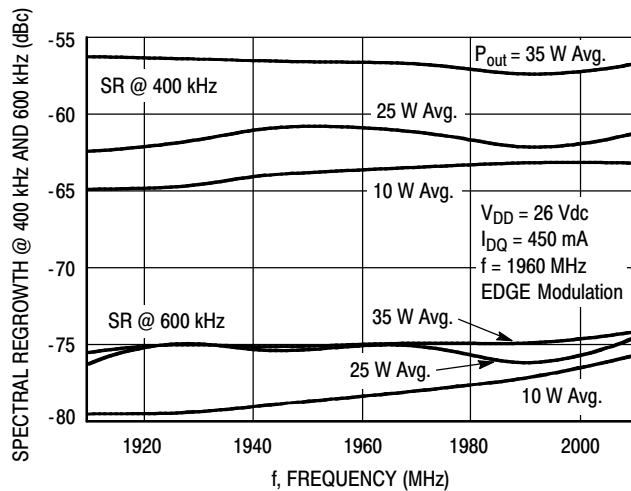


Figure 10. Spectral Regrowth at 400 kHz and 600 kHz versus Frequency

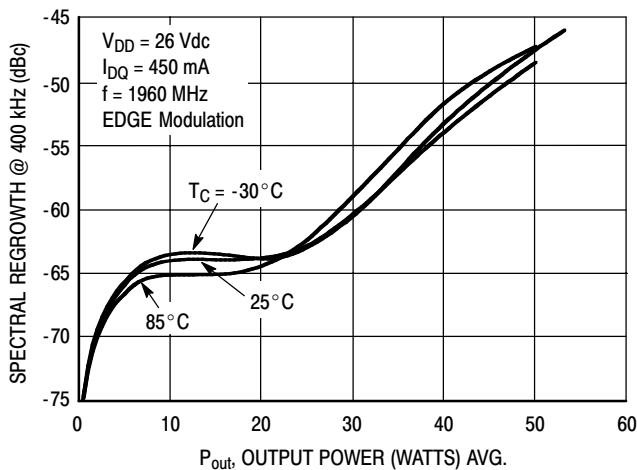


Figure 11. Spectral Regrowth at 400 kHz versus Output Power

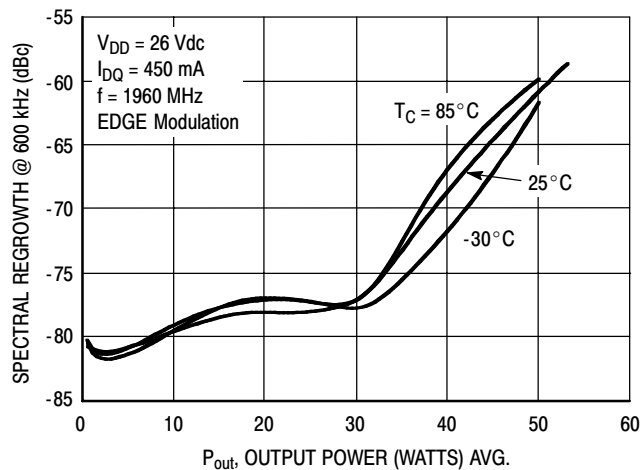
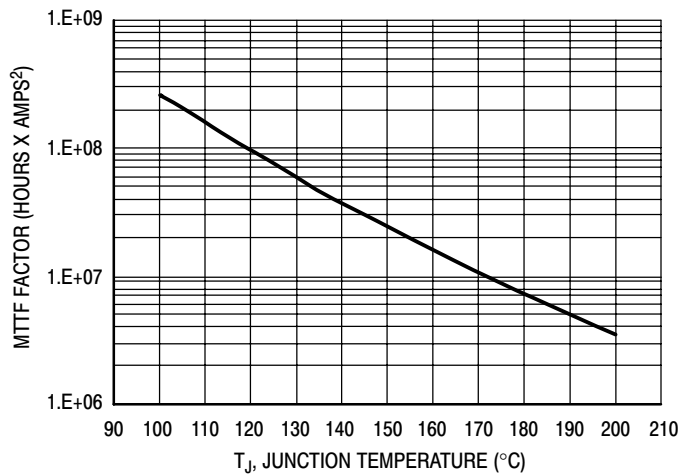


Figure 12. Spectral Regrowth at 600 kHz versus Output Power

TYPICAL CHARACTERISTICS



This above graph displays calculated MTTF in hours x ampere² 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 13. MTTF Factor versus Junction Temperature

GSM TEST SIGNAL

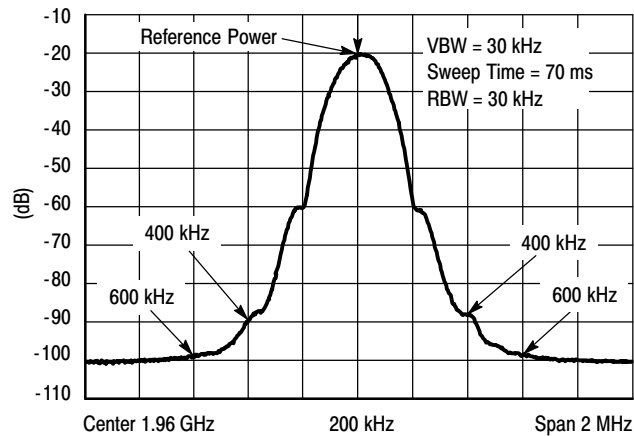
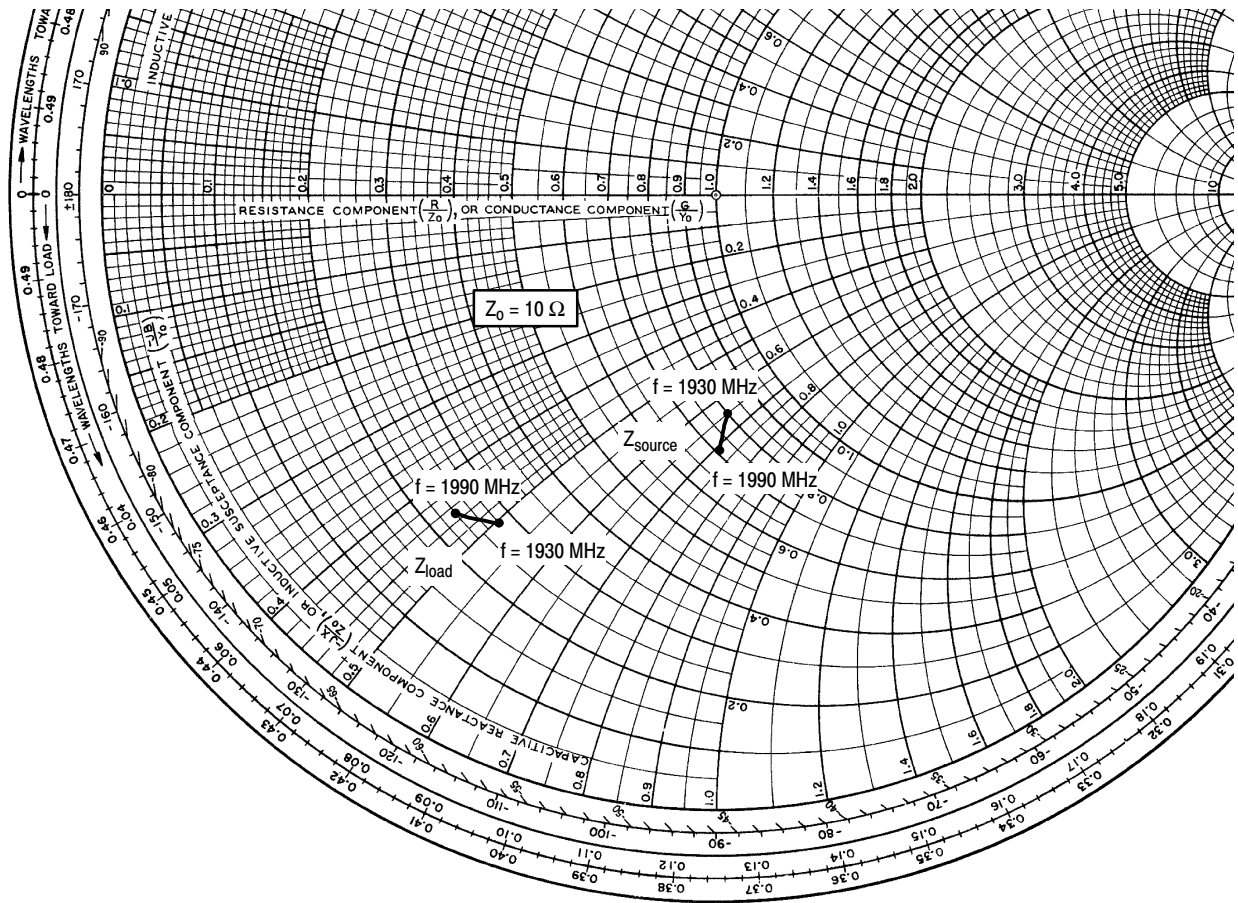


Figure 14. EDGE Spectrum



$V_{DD} = 26 \text{ Vdc}$, $I_{DQ} = 600 \text{ mA}$, $P_{out} = 60 \text{ W CW}$

f MHz	Z_{source} Ω	Z_{load} Ω
1930	$8.00 - j6.48$	$2.83 - j5.13$
1960	$7.57 - j6.82$	$2.63 - j4.84$
1990	$7.06 - j7.06$	$2.44 - j4.54$

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

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

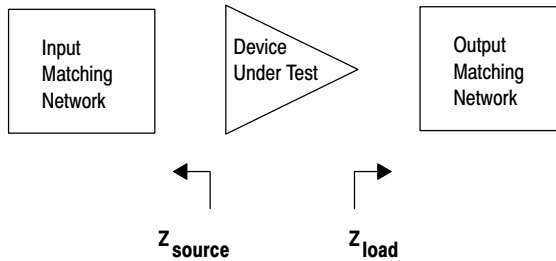
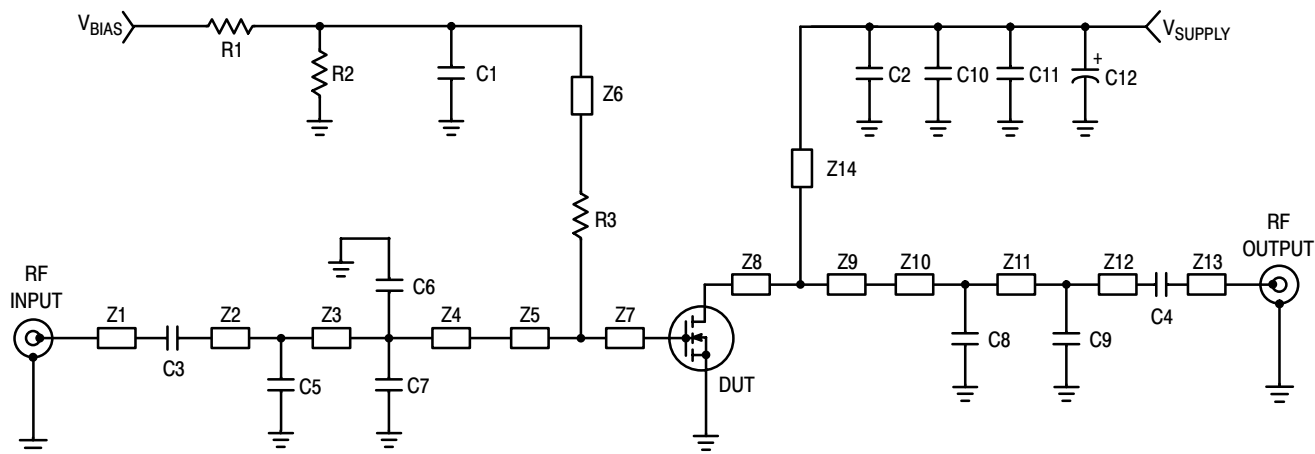


Figure 15. Series Equivalent Source and Load Impedance — 1900 MHz



Z1	0.250" x 0.083" Microstrip	Z9	0.485" x 1.000" Microstrip
Z2*	0.320" x 0.083" Microstrip	Z10*	0.420" x 0.083" Microstrip
Z3*	0.660" x 0.083" Microstrip	Z11*	0.230" x 0.083" Microstrip
Z4*	0.535" x 0.083" Microstrip	Z12*	0.745" x 0.083" Microstrip
Z5	0.365" x 1.000" Microstrip	Z13	0.250" x 0.083" Microstrip
Z6	0.860" x 0.080" Microstrip	Z14	0.640" x 0.080" Microstrip
Z7, Z8	0.115" x 1.000" Microstrip	PCB	Taconic TLX8-0300, 0.030", $\epsilon_r = 2.55$

* Variable for tuning

Figure 16. MRF6S18060NR1(NBR1) Test Circuit Schematic — 1800 MHz

Table 7. MRF6S18060NR1(NBR1) Test Circuit Component Designations and Values — 1800 MHz

Part	Description	Part Number	Manufacturer
C1, C2, C3, C4	6.8 pF 100B Chip Capacitors	100B6R8CW	ATC
C5	0.8 pF 600B Chip Capacitor	600B0R8BW	ATC
C6, C9	0.5 pF 600B Chip Capacitors	600B0R5BW	ATC
C7	2.2 pF 200B Chip Capacitor	200B2R2BW	ATC
C8	1.5 pF 600B Chip Capacitor	600B1R5BW	ATC
C10, C11	10 μ F Chip Capacitors (2220)	C5750X5R1H106MT	TDK
C12	220 μ F, 63 V Electrolytic Capacitor, Radial	13668221	Philips
R1, R2	10 k Ω , 1/4 W Chip Resistors (1206)		
R3	10 Ω , 1/4 W Chip Resistor (1206)		

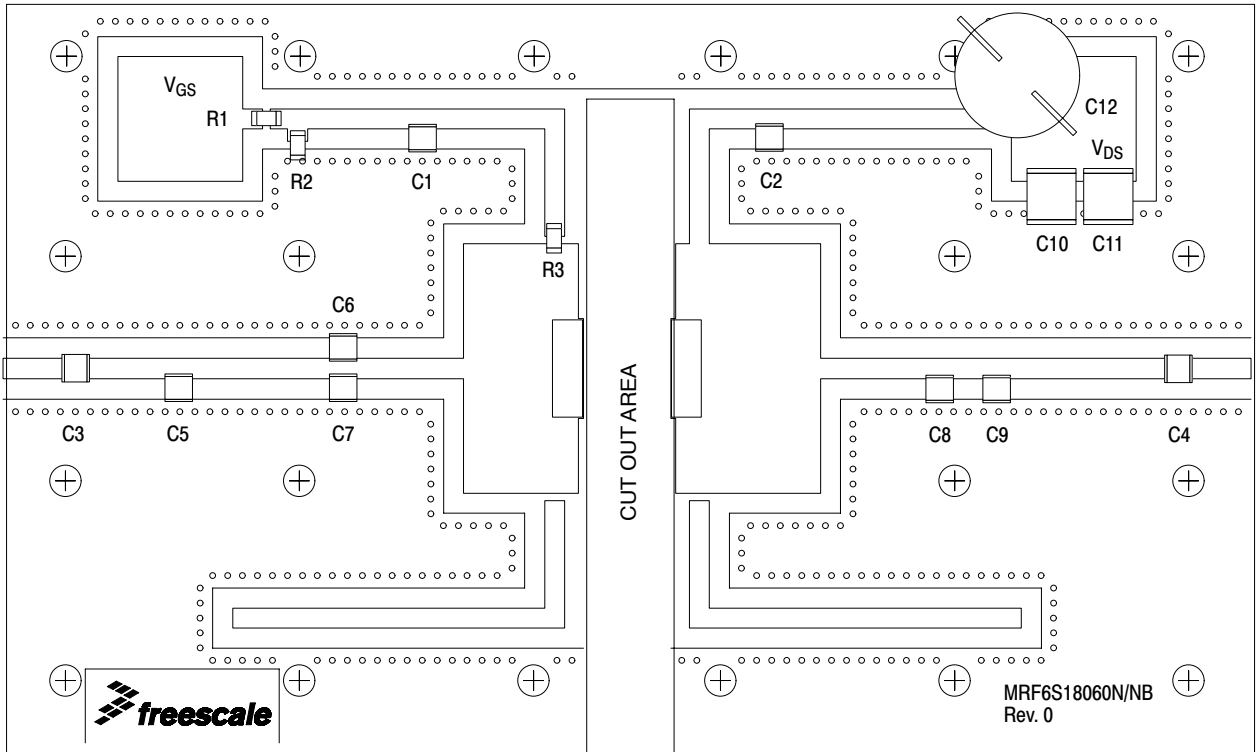


Figure 17. MRF6S18060NR1(NBR1) Test Circuit Component Layout — 1800 MHz

TYPICAL CHARACTERISTICS — 1800 MHz

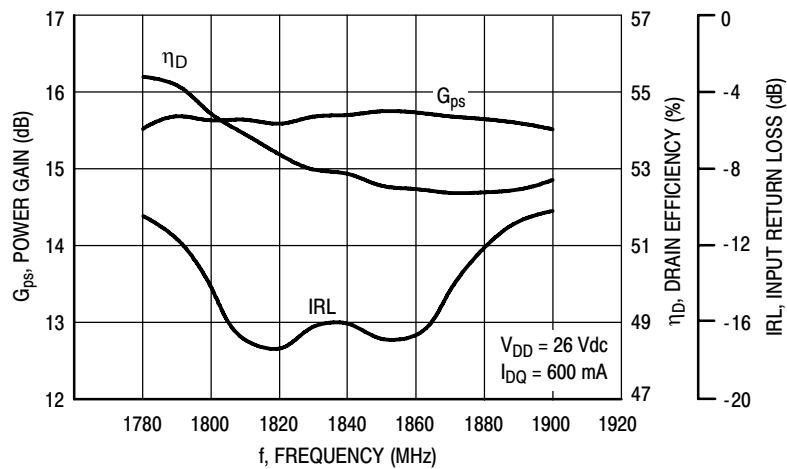


Figure 18. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ $P_{out} = 60$ Watts

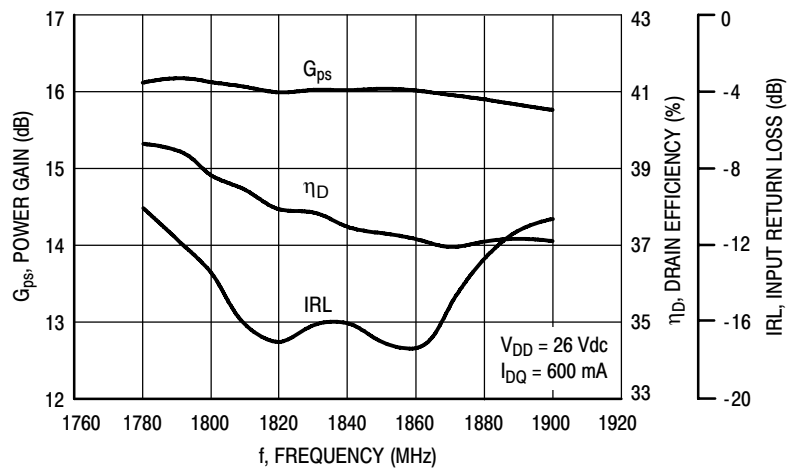


Figure 19. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ $P_{out} = 30$ Watts

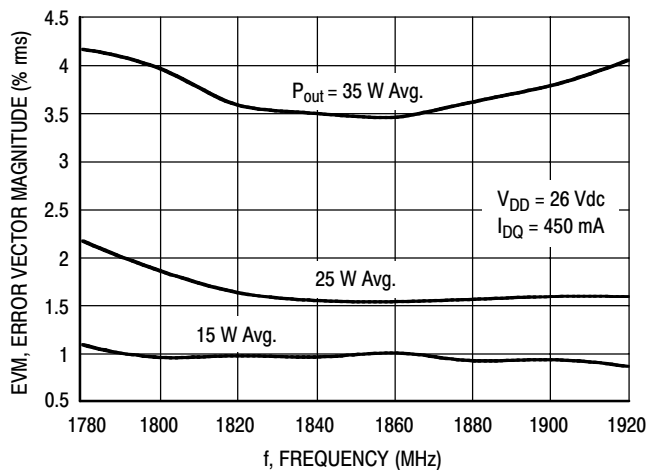


Figure 20. EVM versus Frequency

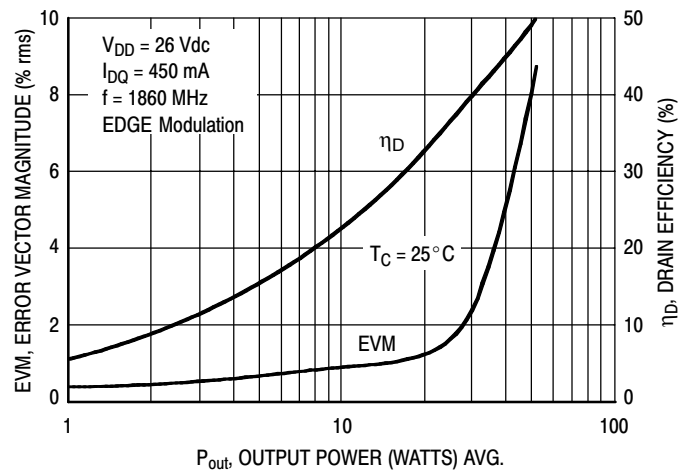


Figure 21. EVM and Drain Efficiency versus Output Power

TYPICAL CHARACTERISTICS — 1800 MHz

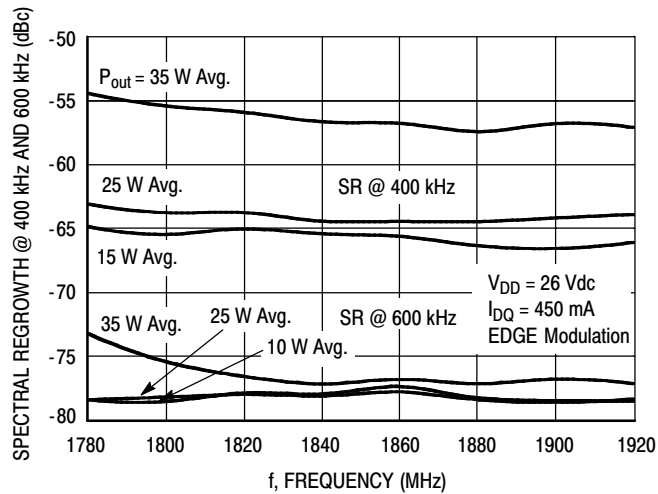


Figure 22. Spectral Regrowth at 400 kHz and 600 kHz versus Frequency

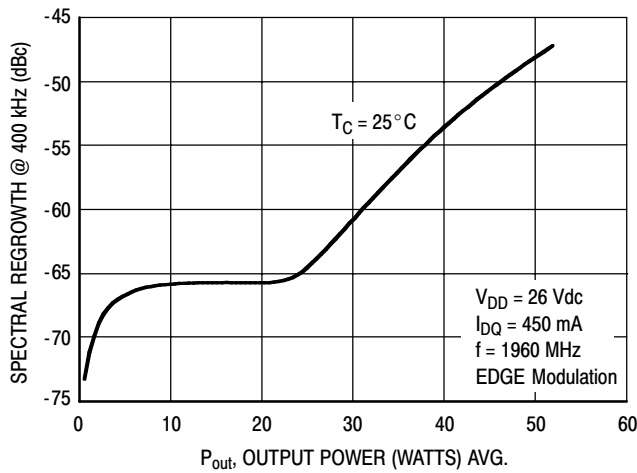


Figure 23. Spectral Regrowth at 400 kHz versus Output Power

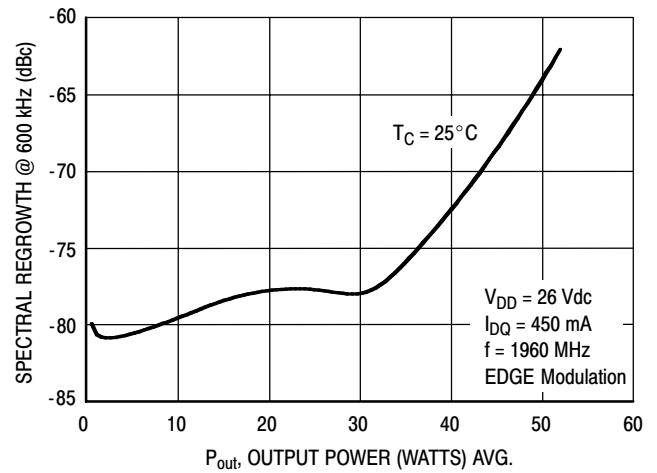
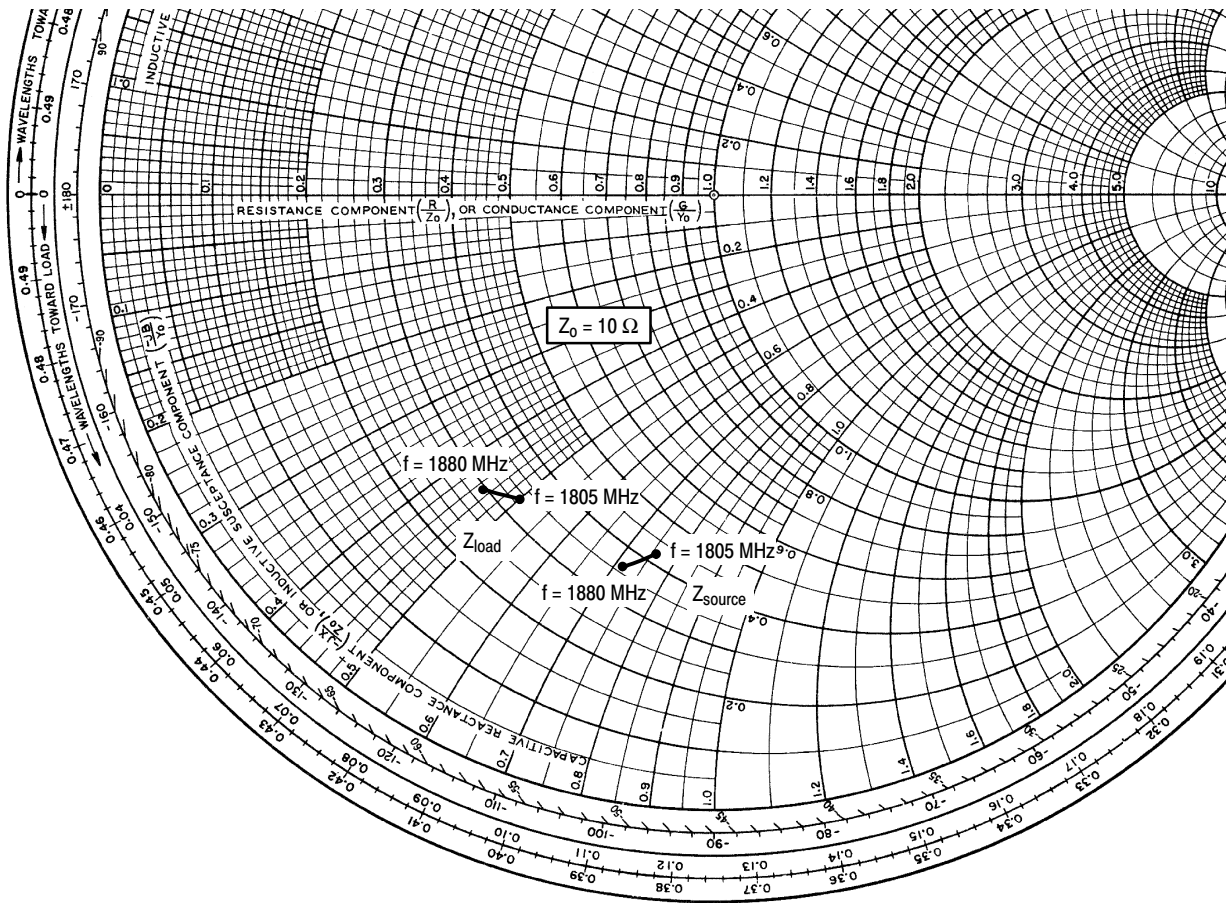


Figure 24. Spectral Regrowth at 600 kHz versus Output Power



$V_{DD} = 26 \text{ Vdc}$, $I_{DQ} = 600 \text{ mA}$, $P_{out} = 65 \text{ W CW}$

f MHz	Z_{source} Ω	Z_{load} Ω
1805	$4.16 - j7.56$	$3.29 - j4.91$
1840	$3.89 - j7.40$	$3.10 - j4.69$
1880	$3.56 - j7.21$	$2.88 - j4.45$

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

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

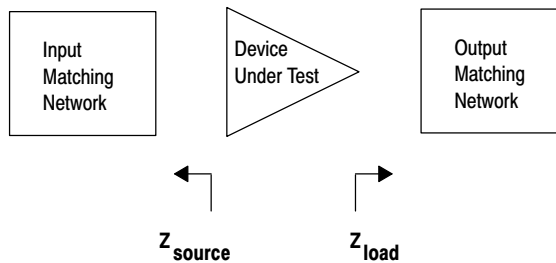
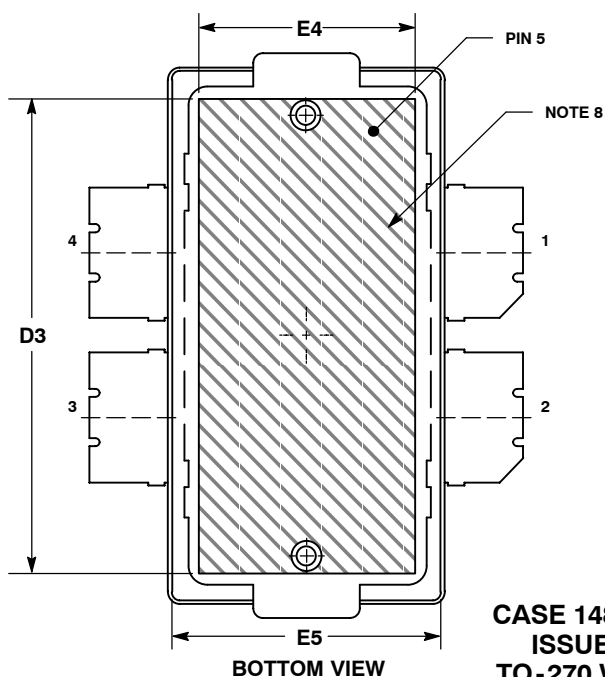
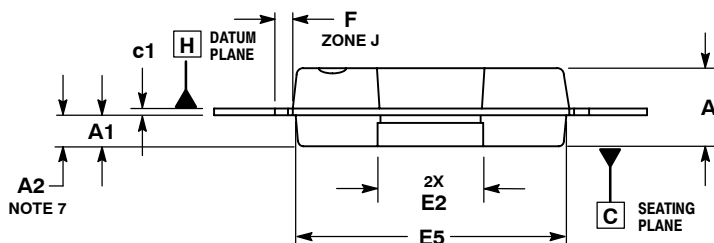
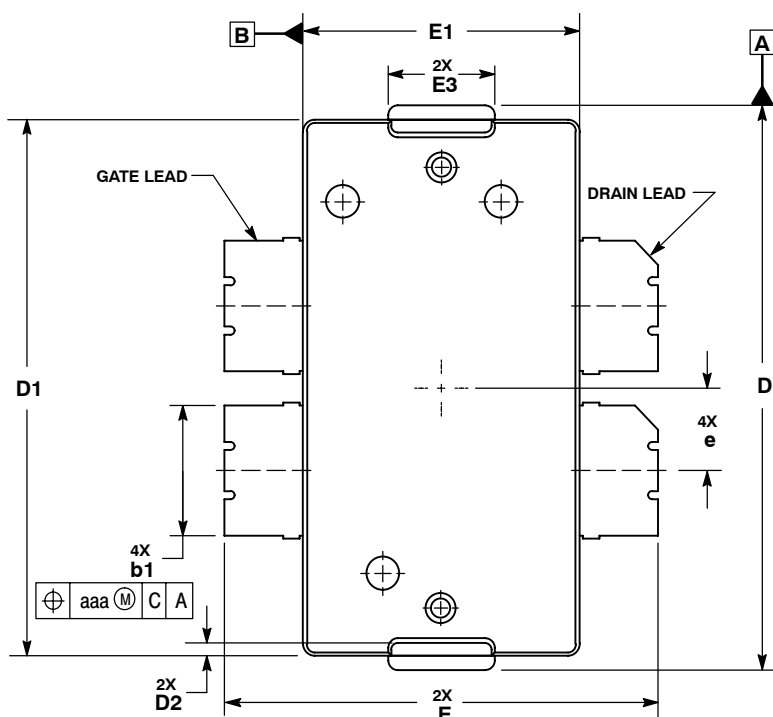


Figure 25. Series Equivalent Source and Load Impedance — 1800 MHz



NOTES

PACKAGE DIMENSIONS

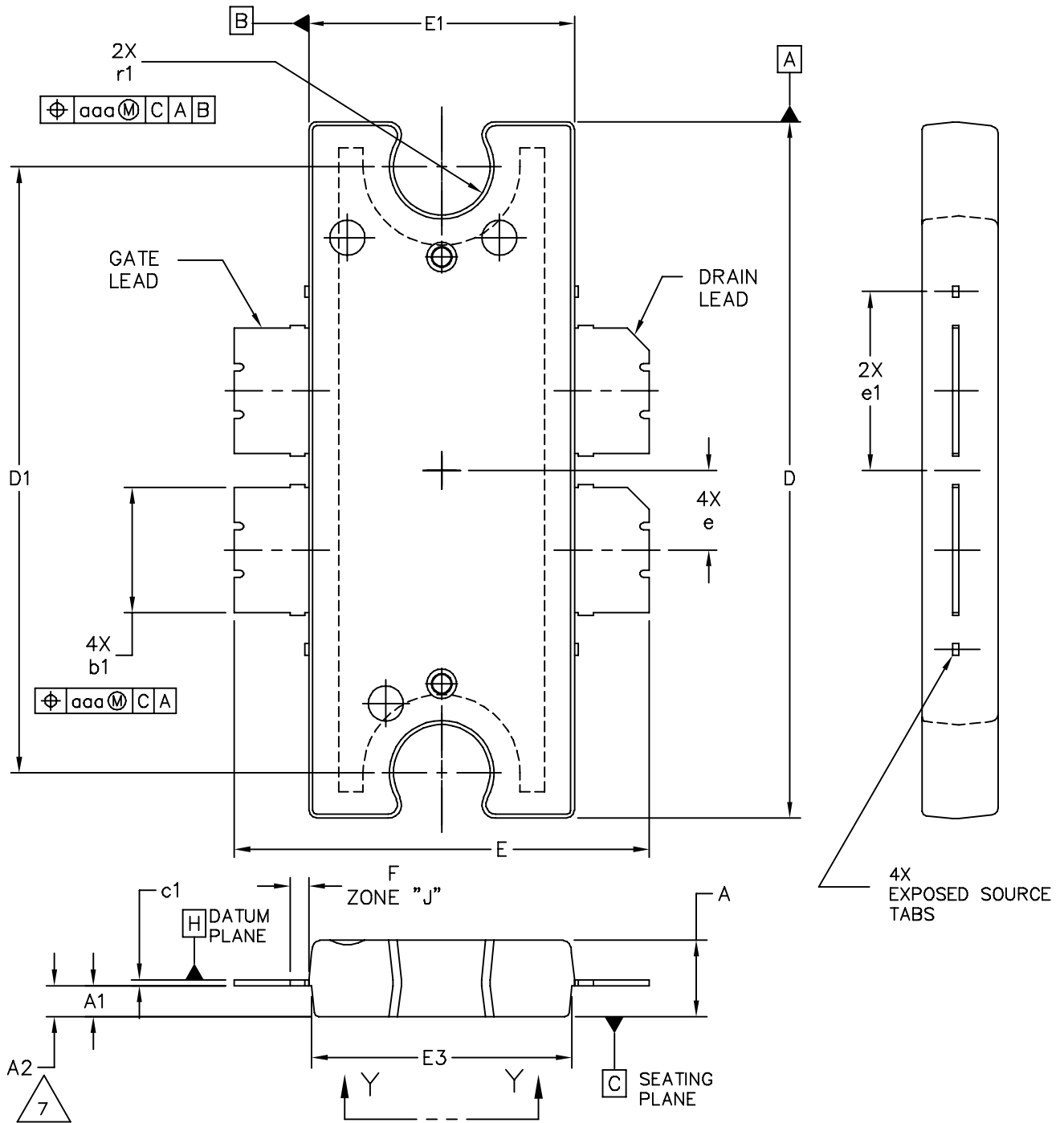


- NOTES:
1. CONTROLLING DIMENSION: INCH.
 2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M - 1994.
 3. DATUM PLANE -H- IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
 4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
 5. DIMENSION "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.
 6. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-.
 7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
 8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64
A1	.039	.043	0.99	1.09
A2	.040	.042	1.02	1.07
D	.712	.720	18.08	18.29
D1	.688	.692	17.48	17.58
D2	.011	.019	0.28	0.48
D3	.600	---	15.24	---
E	.551	.559	14	14.2
E1	.353	.357	8.97	9.07
E2	.132	.140	3.35	3.56
E3	.124	.132	3.15	3.35
E4	.270	---	6.86	---
E5	.346	.350	8.79	8.89
F	.025 BSC		0.64 BSC	
b1	.164	.170	4.17	4.32
c1	.007	.011	0.18	0.28
e	.106 BSC		2.69 BSC	
aaa	.004		0.10	

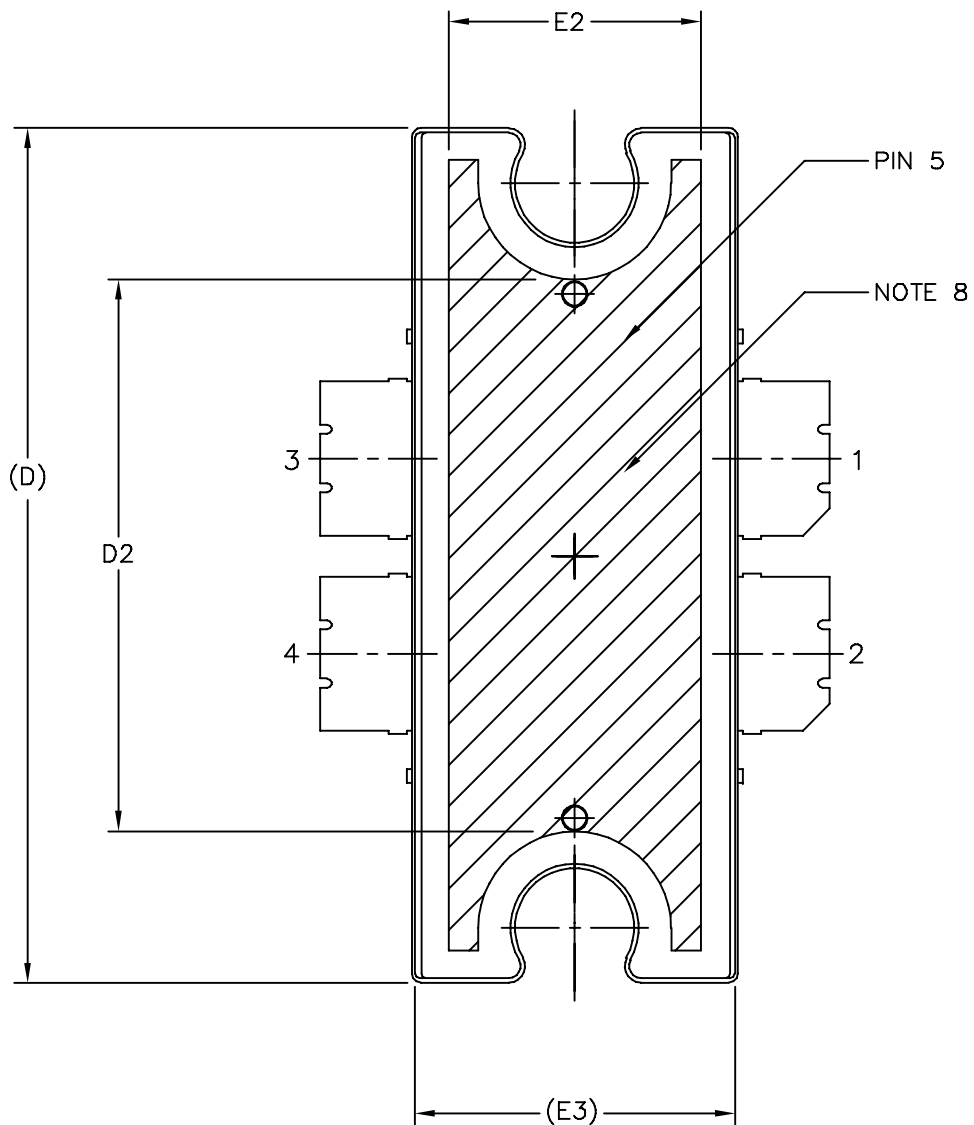
- STYLE 1:
 PIN 1. DRAIN
 2. DRAIN
 3. GATE
 4. GATE
 5. SOURCE

**CASE 1486-03
 ISSUE C
 TO-270 WB-4
 PLASTIC
 MRF6S18060NR1**



© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.		MECHANICAL OUTLINE		PRINT VERSION NOT TO SCALE	
TITLE: TO-272 4 LEAD, WIDE BODY			DOCUMENT NO: 98ASA10575D		REV: D
			CASE NUMBER: 1484-04		05 APR 2006
			STANDARD: NON-JEDEC		

MRF6S18060NR1 MRF6S18060NBR1



© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE	
TITLE: TO-272 4 LEAD, WIDE BODY	DOCUMENT NO: 98ASA10575D	REV: D	
	CASE NUMBER: 1484-04	05 APR 2006	
	STANDARD: NON-JEDEC		

NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE H IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
5. DIMENSIONS "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUM A AND B TO BE DETERMINED AT DATUM PLANE H.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
8. HATCHING REPRESENTS EXPOSED AREA OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.

STYLE 1:

PIN 1 - DRAIN PIN 2 - DRAIN
 PIN 3 - GATE PIN 4 - GATE
 PIN 5 - SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64	b1	.164	.170	4.17	4.32
A1	.039	.043	0.99	1.09	c1	.007	.011	.18	.28
A2	.040	.042	1.02	1.07	r1	.063	.068	1.60	1.73
D	.928	.932	23.57	23.67	e	.106 BSC		2.69 BSC	
D1	.810 BSC		20.57 BSC		e1	.239 INFO ONLY		6.07 INFO ONLY	
D2	.600	---	15.24	---	aaa	.004		.10	
E	.551	.559	14	14.2					
E1	.353	.357	8.97	9.07					
E2	.270	---	6.86	---					
E3	.346	.350	8.79	8.89					
F	.025 BSC		0.64 BSC						

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