



# RF LDMOS Wideband Integrated Power Amplifiers

The MD7IC18120N/GN wideband integrated circuit is designed with on-chip matching that makes it usable from 1805 to 1880 MHz. This multi-stage structure is rated for 26 to 32 Volt operation and covers all typical cellular base station modulation formats.

- Typical Doherty Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ1A} = 70$  mA,  $I_{DQ1B} = 160$  mA,  $I_{DQ2B} = 500$  mA,  $V_{GS2A} = 1.7$  Vdc,  $P_{out} = 30$  Watts Avg., IQ Magnitude Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.

Frequency	$G_{ps}$ (dB)	PAE (%)	Output PAR (dB)
1805 MHz	25.7	36.7	6.9
1840 MHz	25.7	36.3	6.9
1880 MHz	25.8	35.3	6.7

- Capable of Handling 10:1 VSWR, @ 32 Vdc, 1840 MHz, 140 Watts CW Output Power
- Stable into a 5:1 VSWR. All Spurs Below -60 dBc @ 100 Watts CW  $P_{out}$
- Typical  $P_{out}$  @ 1 dB Compression Point  $\approx$  120 Watts CW

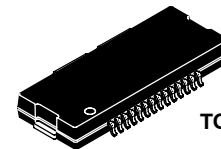
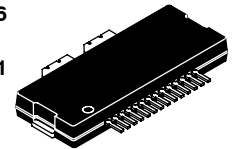
### Features

- Production Tested in a Symmetrical Doherty Configuration
- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Large-Signal Load-Pull Parameters and Common Source S-Parameters
- On-Chip Matching (50 Ohm Input, DC Blocked)
- Integrated Quiescent Current Temperature Compensation with Enable/Disable Function (1)
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- 225°C Capable Plastic Package
- RoHS Compliant
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

## MD7IC18120NR1 MD7IC18120GNR1

1805-1880 MHz, 30 W AVG., 28 V  
 SINGLE W-CDMA  
 RF LDMOS WIDEBAND  
 INTEGRATED POWER AMPLIFIERS

CASE 1866-02  
 TO-270 WBL-16  
 PLASTIC  
 MD7IC18120NR1



CASE 1867-02  
 TO-270 WBL-16 GULL  
 PLASTIC  
 MD7IC18120GNR1

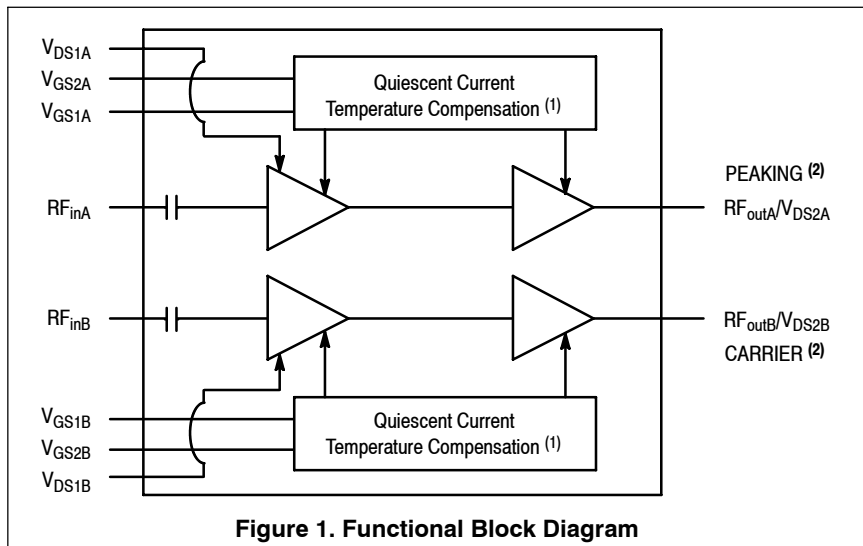
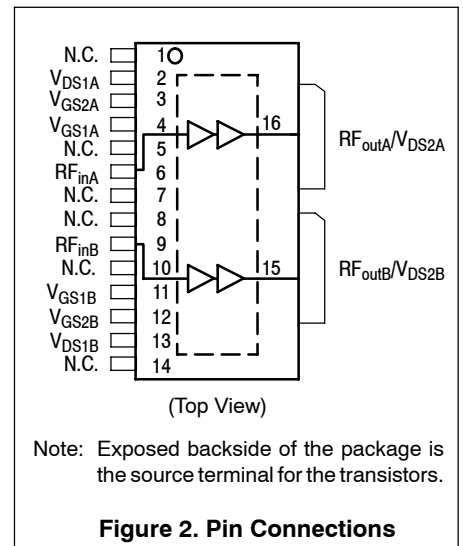


Figure 1. Functional Block Diagram



Note: Exposed backside of the package is the source terminal for the transistors.

Figure 2. Pin Connections

1. Refer to AN1977, *Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family* and to AN1987, *Quiescent Current Control for the RF Integrated Circuit Device Family*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1977 or AN1987.  
 2. Peaking and Carrier orientation is determined by the test fixture design.

**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
CW Operation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	CW	175 1.5	W W/°C
Input Power	$P_{in}$	30	dBm

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
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**Final Doherty Application**

Thermal Resistance, Junction to Case Case Temperature 78°C, $P_{out} = 30$ W CW, 1880 MHz Stage 1A, 28 Vdc, $I_{DQ1A} = 70$ mA Stage 1B, 28 Vdc, $I_{DQ1B} = 160$ mA Stage 2A, 28 Vdc, $V_{G2A} = 1.7$ Vdc Stage 2B, 28 Vdc, $I_{DQ2B} = 500$ mA	$R_{\theta JC}$	4.5 4.5 0.88 0.88	°C/W
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**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)	III (Minimum)

**Table 4. Moisture Sensitivity Level**

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD22-A113, IPC/JEDEC J-STD-020	3	260	°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.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

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

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Stage 1 — Off Characteristics</b> (1)					
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 1.5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{Adc}$

**Stage 1 — On Characteristics** (1)

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 28\ \mu\text{Adc}$ )	$V_{GS(th)}$	1.2	2.0	2.7	Vdc
Gate Quiescent Voltage ( $V_{DS} = 28\text{ Vdc}$ , $I_{DQ1A} = 70\text{ mA}$ , $I_{DQ1B} = 160\text{ mA}$ )	$V_{GS(Q)}$	—	2.9	—	Vdc
Fixture Gate Quiescent Voltage ( $V_{DD} = 28\text{ Vdc}$ , Measured in Functional Test)	$I_{DQ1A} = 70\text{ mA}$ $I_{DQ1B} = 160\text{ mA}$ $V_{GG(Q)}$	4.0 7.1	5.0 8.1	6.0 9.1	Vdc

**Stage 2 — Off Characteristics** (1)

Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 1.5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{Adc}$

**Stage 2 — On Characteristics** (1)

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 185\ \mu\text{Adc}$ )	$V_{GS(th)}$	1.2	2.0	2.7	Vdc
Gate Quiescent Voltage ( $V_{DS} = 28\text{ Vdc}$ , $I_{DQ2B} = 500\text{ mA}$ )	$V_{GS(Q)}$	—	2.6	—	Vdc
Fixture Gate Quiescent Voltage ( $V_{DD} = 28\text{ Vdc}$ , $I_{DQ2B} = 500\text{ mA}$ , Measured in Functional Test)	$V_{GG(Q)}$	5.3	6.3	7.3	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1.8\text{ Adc}$ )	$V_{DS(on)}$	—	0.35	—	Vdc

**Functional Tests** (2,3,4) (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ1A} = 70\text{ mA}$ ,  $I_{DQ1B} = 160\text{ mA}$ ,  $I_{DQ2B} = 500\text{ mA}$ ,  $V_{GS2A} = 1.7\text{ Vdc}$ ,  $P_{out} = 30\text{ W Avg.}$ ,  $f = 1880\text{ MHz}$ , Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	24.0	25.8	28.0	dB
Power Added Efficiency	PAE	33.0	35.3	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	6.0	6.7	—	dB

1. Each side of device measured separately.
2. Part internally matched both on input and output.
3. Measurement made with device in a Symmetrical Doherty configuration.
4. Measurement made with device in straight lead configuration before any lead forming operation is applied.

(continued)

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

**Typical Broadband Performance** <sup>(1)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ1A} = 70\text{ mA}$ ,  $I_{DQ1B} = 160\text{ mA}$ ,  $I_{DQ2B} = 500\text{ mA}$ ,  $V_{GS2A} = 1.7\text{ Vdc}$ ,  $P_{out} = 30\text{ W Avg.}$ , Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset.

Frequency	$G_{ps}$ (dB)	PAE (%)	Output PAR (dB)
1805 MHz	25.7	36.7	6.9
1840 MHz	25.7	36.3	6.9
1880 MHz	25.8	35.3	6.7

**Typical Performances** <sup>(1)</sup> (In Freescale Doherty Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ1A} = 70\text{ mA}$ ,  $I_{DQ1B} = 160\text{ mA}$ ,  $I_{DQ2B} = 500\text{ mA}$ ,  $V_{GS2A} = 1.7\text{ Vdc}$ , 1805-1880 MHz Bandwidth

Characteristic	Symbol	Min	Typ	Max	Unit
$P_{out}$ @ 1 dB Compression Point, CW	P1dB	—	120	—	W
IMD Symmetry @ 30 W PEP, $P_{out}$ where IMD Third Order Intermodulation $\cong 30\text{ dBc}$ (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands > 2 dB)	IMD <sub>sym</sub>	—	15	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW <sub>res</sub>	—	35	—	MHz
Gain Flatness in 75 MHz Bandwidth @ $P_{out} = 30\text{ W Avg.}$	$G_F$	—	0.3	—	dB
Quiescent Current Accuracy over Temperature with 2 k $\Omega$ Gate Feed Resistors (-30 to 85°C) <sup>(2)</sup>	$\Delta I_{QT}$	—	4.26 5.04	—	%
Gain Variation over Temperature (-30°C to +85°C)	$\Delta G$	—	0.04	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	$\Delta P1dB$	—	0.04	—	dBm/°C

1. Measurement made with device in a Symmetrical Doherty configuration.
2. Refer to AN1977, *Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family* and to AN1987, *Quiescent Current Control for the RF Integrated Circuit Device Family*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1977 or AN1987.

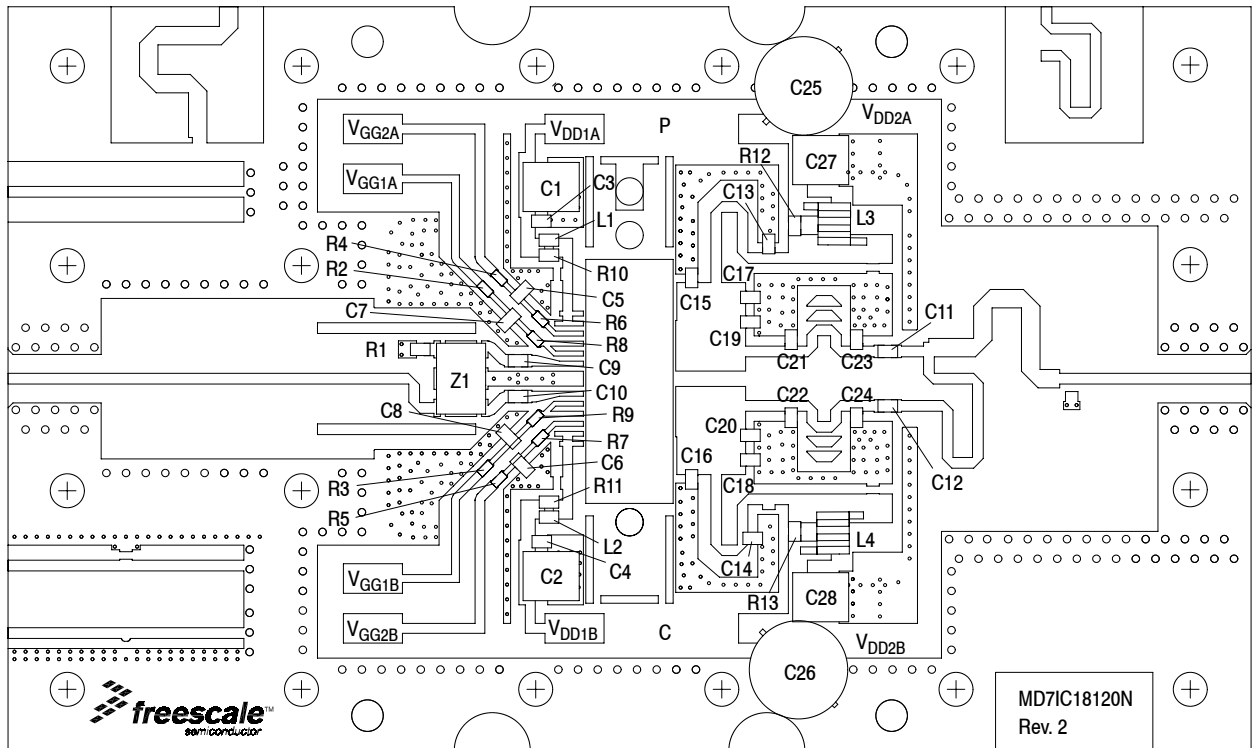
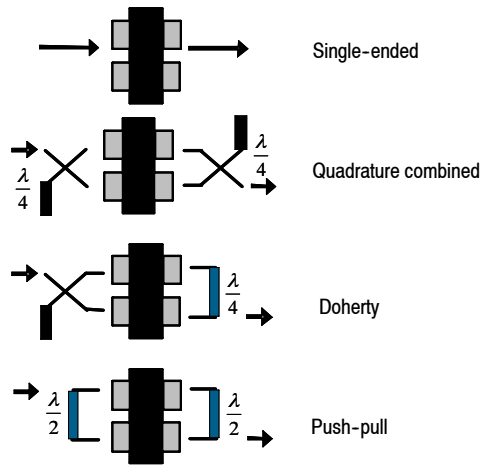


Figure 3. MD7IC18120NR1(GNR1) Test Circuit Component Layout

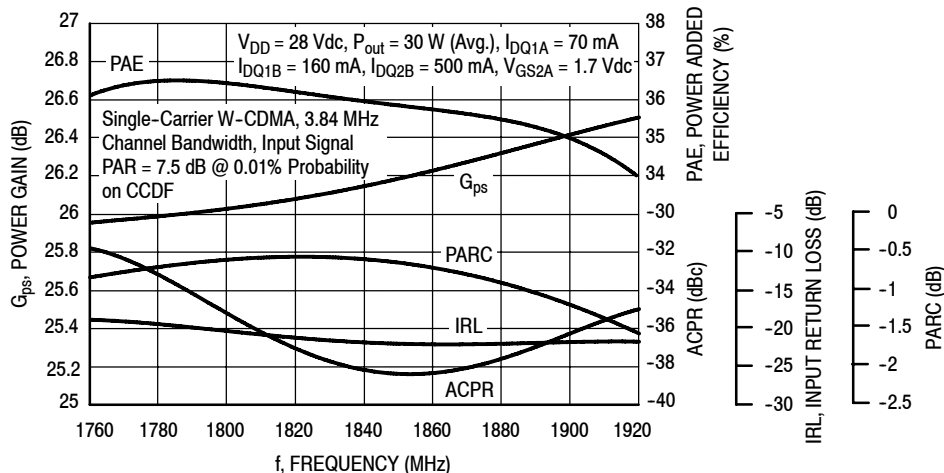
Table 6. MD7IC18120NR1(GNR1) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C2, C27, C28	10 $\mu$ F, 50 V Chip Capacitors	GRM55DR61H106KA88L	Murata
C3, C4, C5, C6, C7, C8	0.1 $\mu$ F Chip Capacitors	GRM21BR71H104KA01B	Murata
C9, C10, C11, C13, C14	10 pF Chip Capacitors	ATC600F100JT250XT	ATC
C12	100 pF Chip Capacitor	ATC600F101JT250XT	ATC
C15, C16, C17, C18	2.2 pF Chip Capacitors	ATC600F2R2BT250XT	ATC
C19, C20	1.5 pF Chip Capacitors	ATC600F1R5BT250XT	ATC
C21, C22, C23	1.0 pF Chip Capacitors	ATC600F1R0BT250XT	ATC
C24	0.5 pF Chip Capacitor	ATC600F0R5BT250XT	ATC
C25, C26	330 $\mu$ F, 35 V Electrolytic Capacitors	MCGPR35V337M10X16-RH	Panasonic
L1, L2	6.8 nH Chip Inductors	0805CS-060XJLB	CoilCraft
L3, L4	2.5 nH, 1 Turn Inductors	A01TKLC	CoilCraft
R1	50 $\Omega$ , 1/8 W Chip Resistor	SG732ATTDD51R0F	KOA Speer
R2, R3, R4, R5, R6, R7, R8, R9	1000 $\Omega$ , 1/10 W Chip Resistors	SG731JTTDD1001F	KOA Speer
R10, R11, R12, R13	10 $\Omega$ , 1/10 W Chip Resistors	CRCW060310R0FKEA	Vishay
Z1	1900 MHz Band 90°, 3 dB Chip Hybrid Coupler	GSC351-HYB1900	SOSHIN
PCB	0.020", $\epsilon_r = 3.5$	RO4350B	Rogers

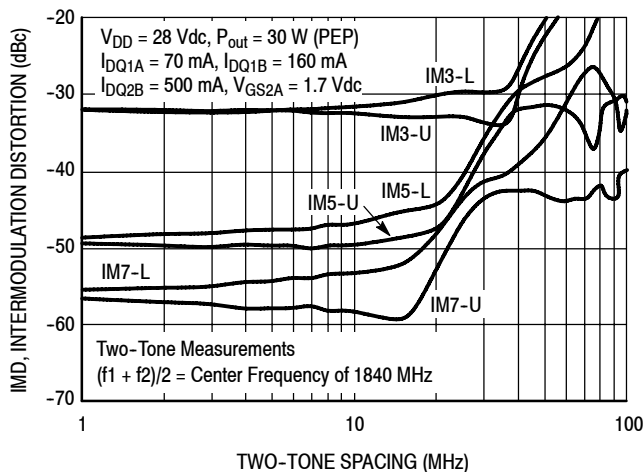


**Figure 4. Possible Circuit Topologies**

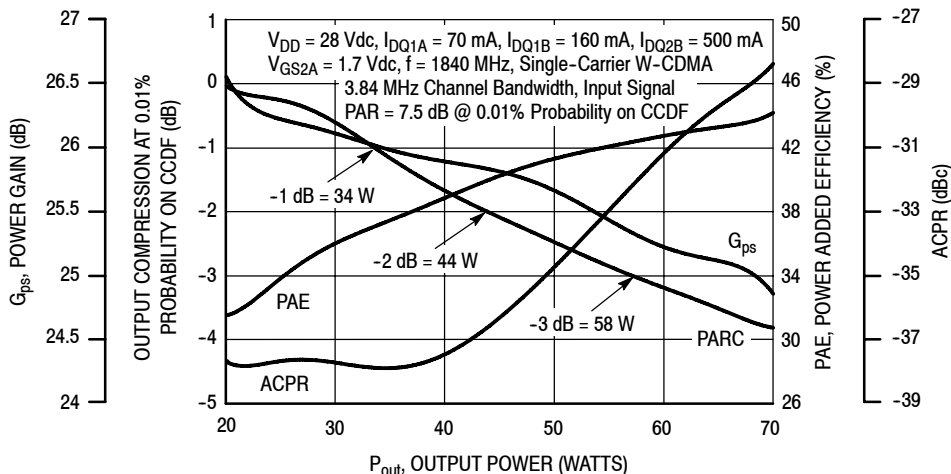
## TYPICAL CHARACTERISTICS



**Figure 5. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 30$  Watts Avg.**

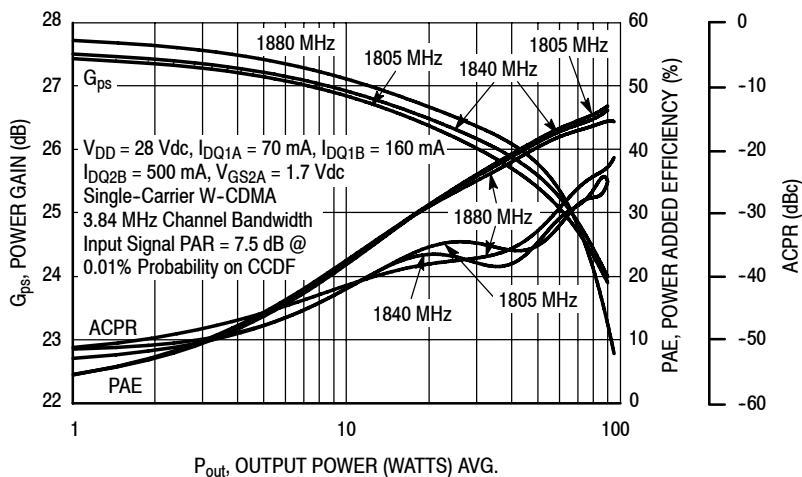


**Figure 6. Intermodulation Distortion Products versus Two-Tone Spacing**

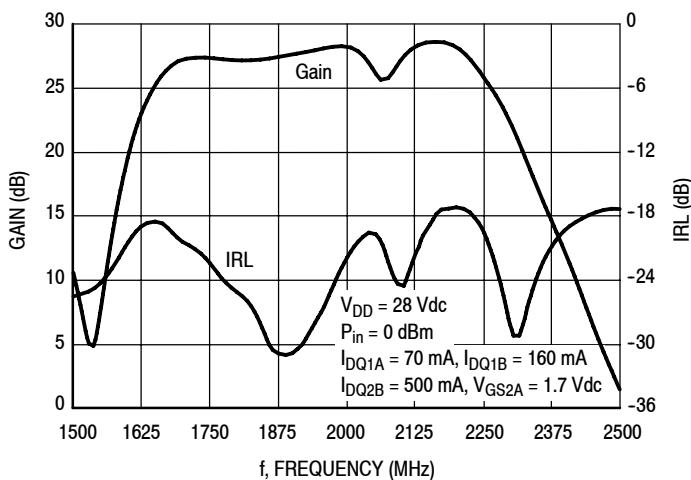


**Figure 7. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

## TYPICAL CHARACTERISTICS

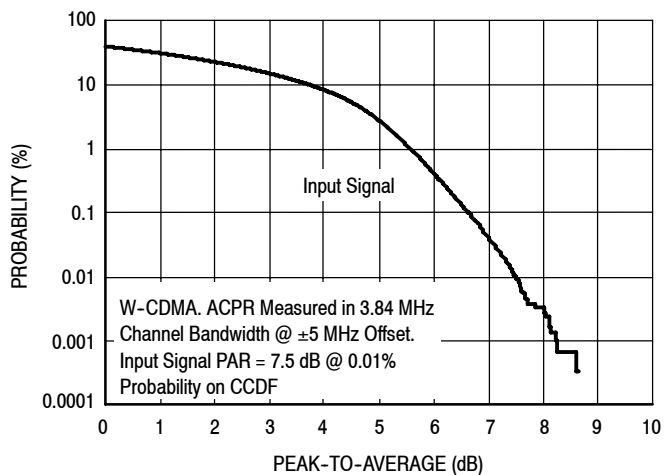


**Figure 8. Single-Carrier W-CDMA Power Gain, Power Added Efficiency and ACPR versus Output Power**

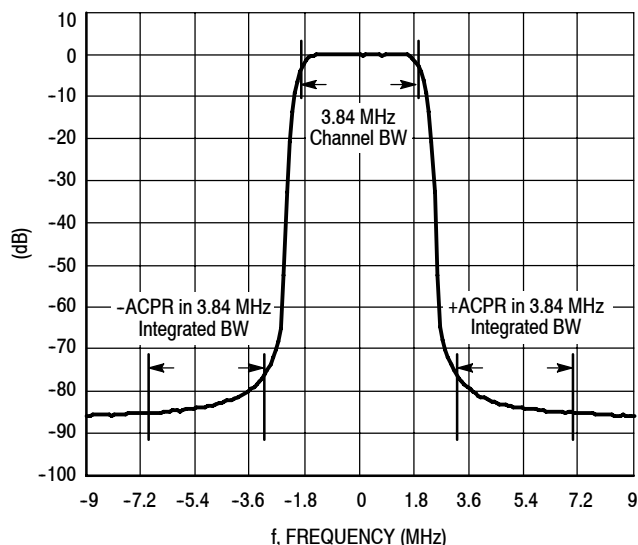


**Figure 9. Broadband Frequency Response**

## W-CDMA TEST SIGNAL



**Figure 10. CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal**



**Figure 11. Single-Carrier W-CDMA Spectrum**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ1B} = 120 \text{ mA}$ ,  $I_{DQ2B} = 450 \text{ mA}$

f MHz	Max $P_{out}$ (1)		$Z_{in}$ $\Omega$	$Z_{load}$ $\Omega$
	Watts	dBm		
1805	68	48.3	$56.20 + j3.50$	$2.79 - j5.39$
1840	69	48.4	$60.80 - j6.10$	$2.81 - j5.45$
1880	74	48.7	$57.90 - j12.00$	$2.41 - j5.63$

(1) Maximum output power measurement reflects pulsed 1 dB gain compression.

$Z_{in}$  = Device input impedance as measured from gate to ground.

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

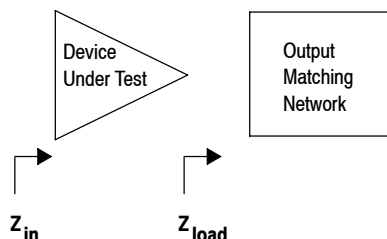


Figure 12. Maximum Output Power — Doherty Load Pull Optimization for Carrier Side

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ1B} = 120 \text{ mA}$ ,  $I_{DQ2B} = 450 \text{ mA}$

f MHz	Max Eff. (1) %	$Z_{in}$ $\Omega$	$Z_{load}$ $\Omega$
1840	53.4	$60.80 - j6.10$	$3.74 - j4.54$
1880	54.0	$57.90 - j12.00$	$3.65 - j4.55$

(1) Maximum efficiency measurement reflects pulsed 1 dB gain compression.

$Z_{in}$  = Device input impedance as measured from gate to ground.

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

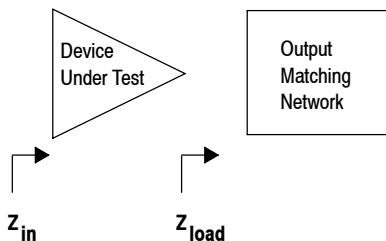
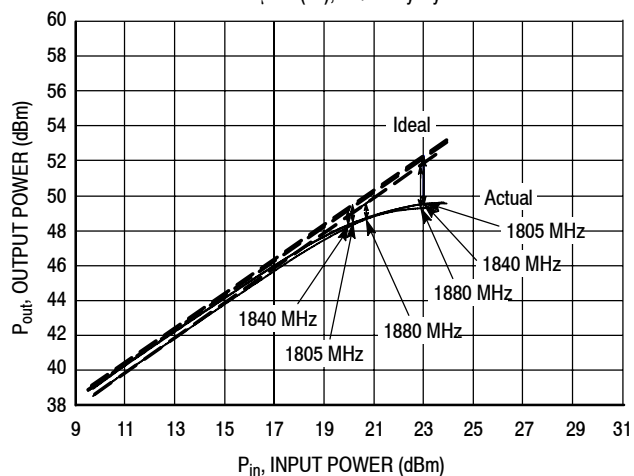


Figure 13. Maximum Efficiency — Doherty Load Pull Optimization for Carrier Side

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ1B} = 120 \text{ mA}$ ,  $I_{DQ2B} = 450 \text{ mA}$ , Pulsed CW,  
 $10 \mu\text{sec(ON)}$ , 10% Duty Cycle



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

f (MHz)	P1dB		P3dB	
	Watts	dBm	Watts	dBm
1805	70	48.5	89	49.5
1840	69	48.4	89	49.5
1880	74	48.7	85	49.3

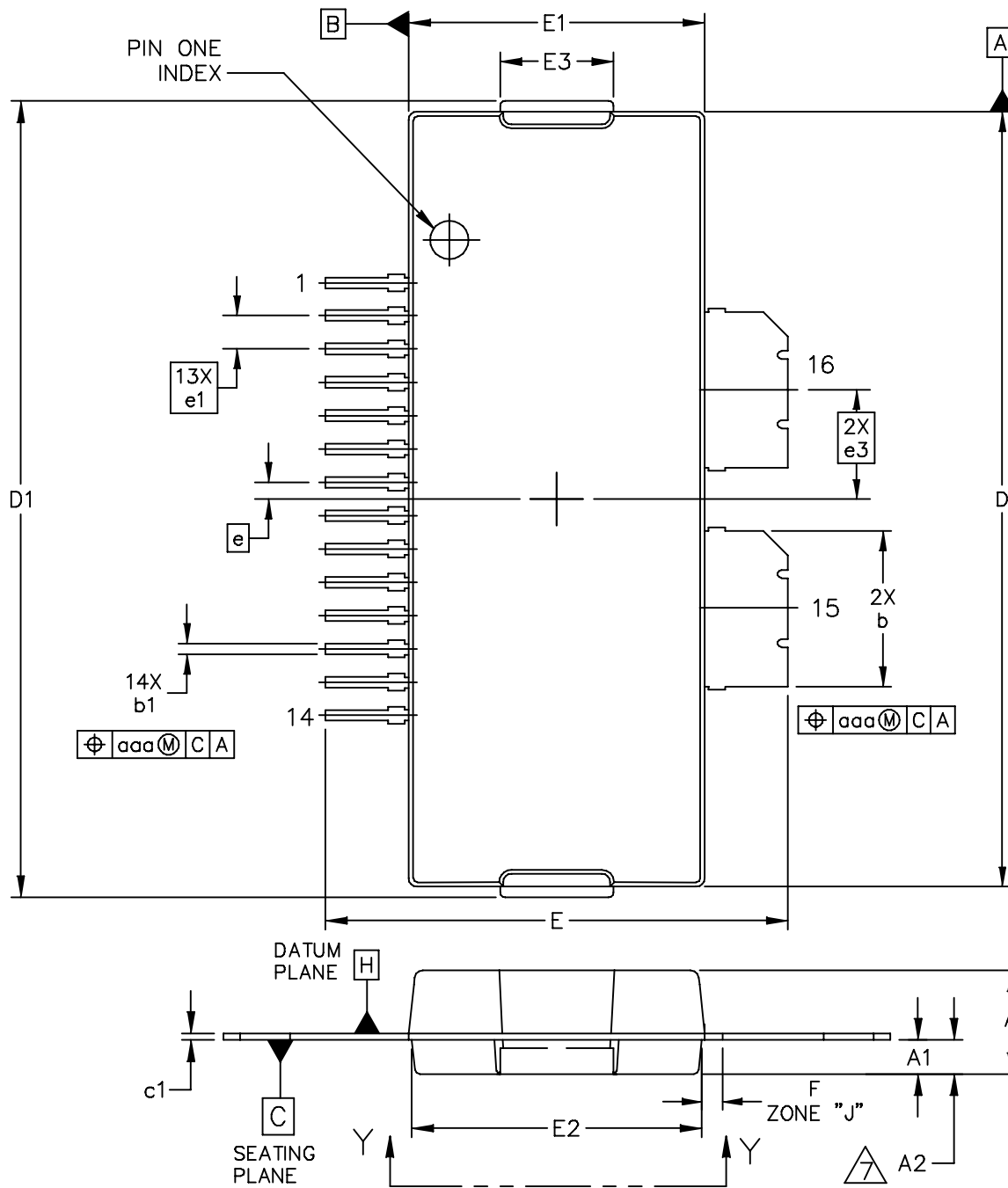
Test Impedances per Compression Level

f (MHz)		$Z_{\text{source}}$ $\Omega$	$Z_{\text{load}}$ $\Omega$
1805	P1dB	$56.20 - j3.50$	$2.80 - j5.40$
1840	P1dB	$60.80 + j6.10$	$2.80 - j5.40$
1880	P1dB	$57.90 + j12.00$	$2.40 - j5.60$

Figure 14. Pulsed CW Output Power  
 versus Input Power @ 28 V

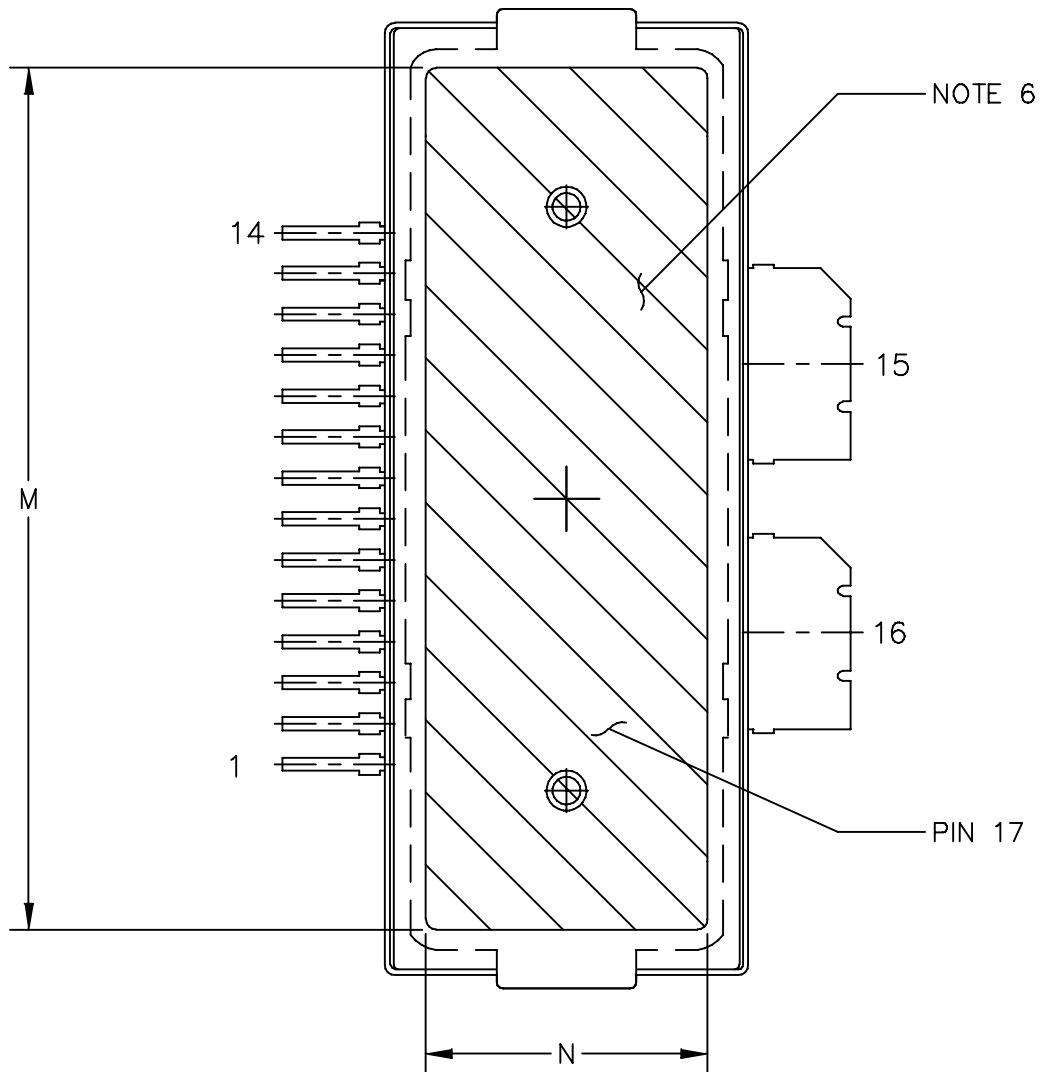
NOTE: Measurement made on the Class AB, carrier side of the device.

### PACKAGE DIMENSIONS



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TITLE: TO-270 WIDE BODY LONG, 16 LEAD, PLASTIC	DOCUMENT NO: 98ASA10739D	REV: A	
	CASE NUMBER: 1866-02	02 AUG 2007	
	STANDARD: NON-JEDEC		

MD7IC18120NR1 MD7IC18120GNR1



VIEW Y-Y

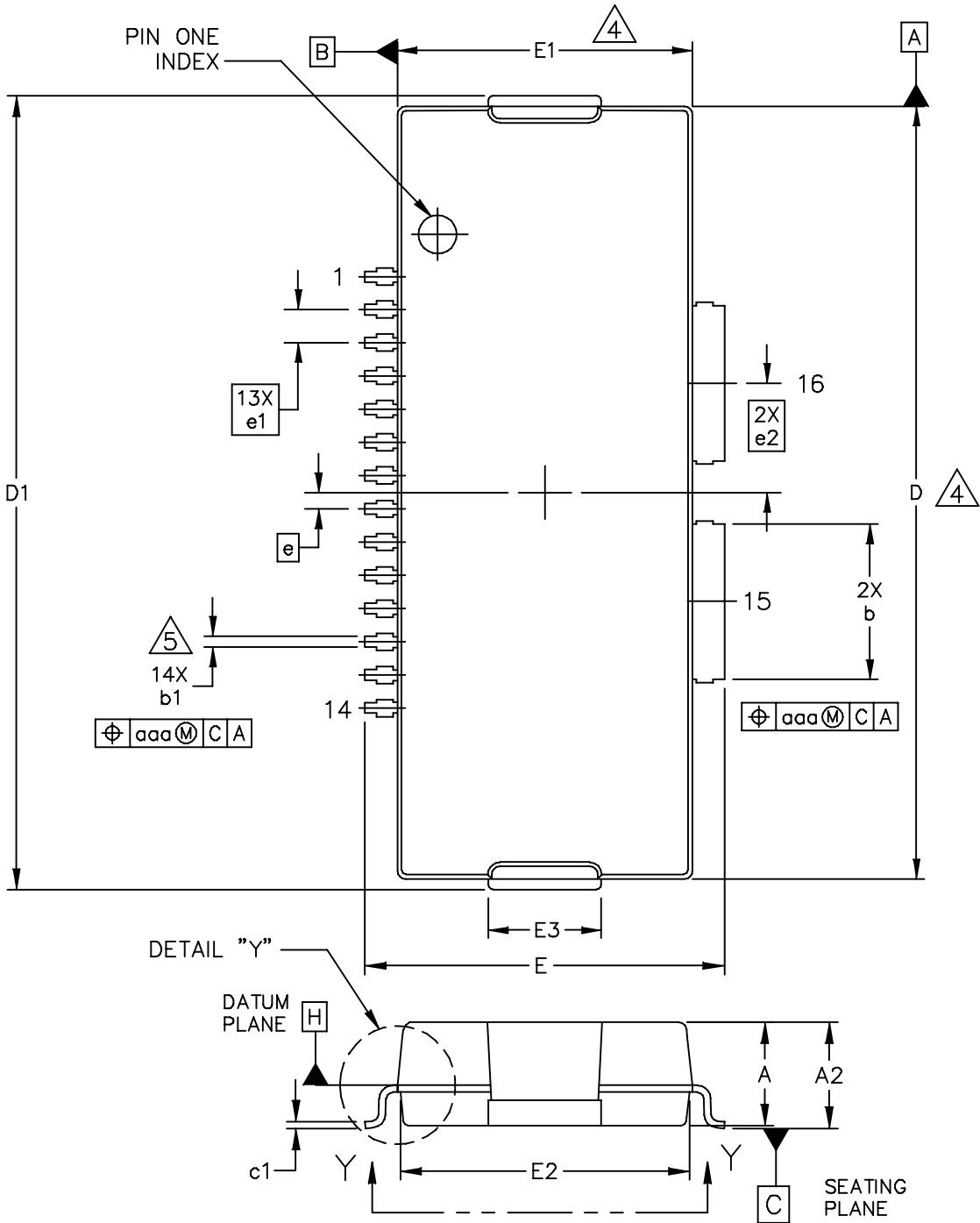
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	STANDARD: NON-JEDEC		

NOTES:

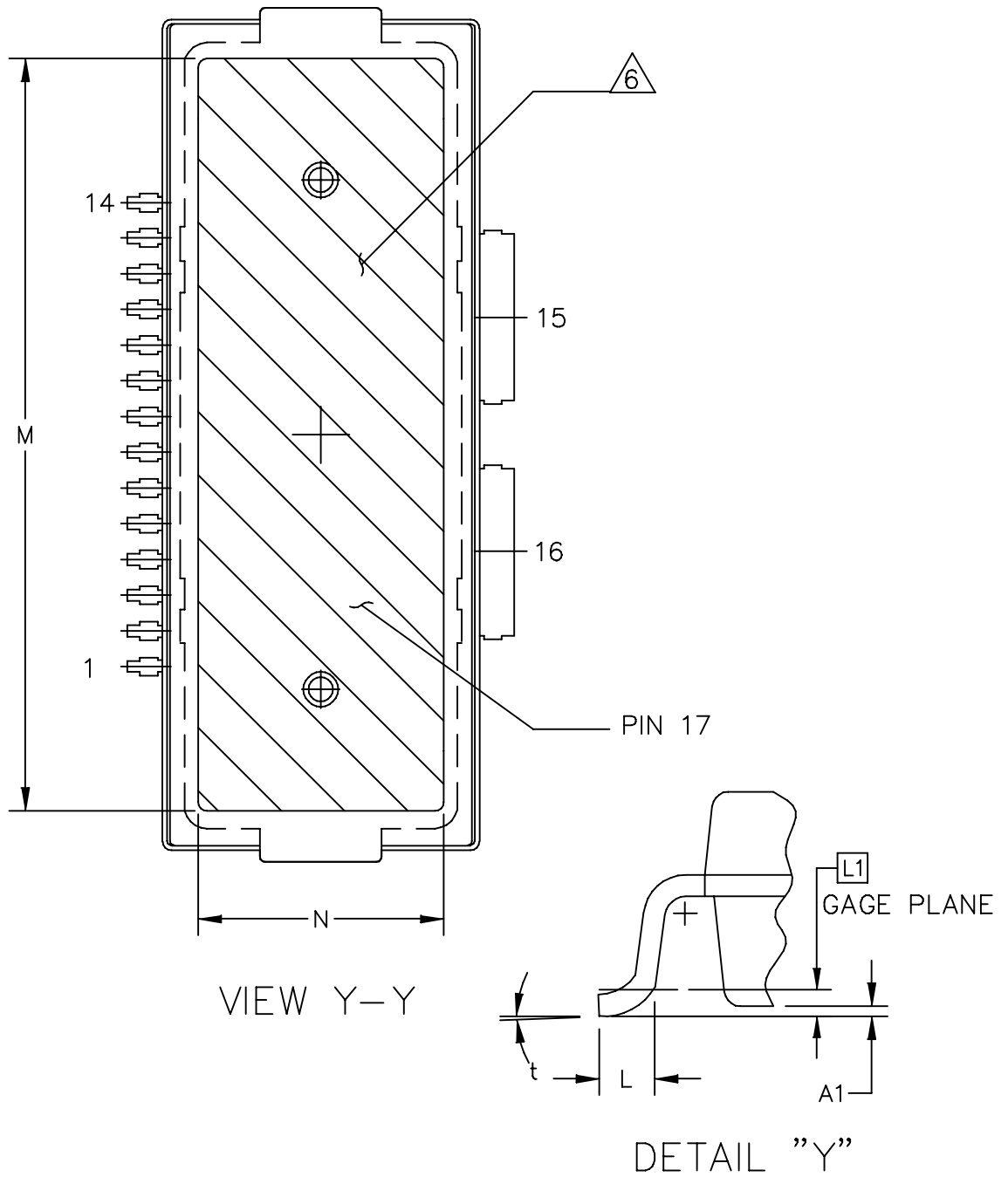
1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE -H- IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 (0.15) PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
5. DIMENSIONS "b" AND "b1" DO NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 (0.13) TOTAL IN EXCESS OF THE "b" AND "b1" DIMENSIONS AT MAXIMUM MATERIAL CONDITION.
6. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.
7. DIM A2 APPLIES WITHIN ZONE "J" ONLY.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.122	.128	3.10	3.25	M	.800	----	20.32	----
A1	.039	.043	0.96	1.12	N	.270	----	6.86	----
A2	.040	.042	1.02	1.07	b	.184	.190	4.67	4.83
D	.928	.932	23.57	23.67	b1	.010	.016	0.25	0.41
D1	.954	.958	24.23	24.33	c1	.007	.011	0.18	0.28
E	.551	.559	14.00	14.20	e	.020 BSC		0.51 BSC	
E1	.353	.357	8.97	9.07	e1	.040 BSC		1.02 BSC	
E2	.346	.350	8.79	8.89	e3	.131 BSC		3.33 BSC	
E3	.132	.140	3.35	3.56					
F	.025 BSC		0.64 BSC		aaa	.004		0.10	

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		STANDARD: NON-JEDEC			



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MD7IC18120NR1 MD7IC18120GNR1

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 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
5. DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.122	.128	3.10	3.25	b	.184	.190	4.67	4.83
A1	.001	.004	0.02	0.10	b1	.010	.016	0.25	0.41
A2	.125	.131	3.18	3.33	c1	.007	.011	0.18	0.28
D	.928	.932	23.57	23.67	e	.020 BSC		0.51 BSC	
D1	.954	.958	24.23	24.33	e1	.040 BSC		1.02 BSC	
E	.429	.437	10.9	11.1	e2	.131 BSC		3.33 BSC	
E1	.353	.357	8.97	9.07	t	2°	8°	2°	8°
E2	.346	.350	8.79	8.89	aaa	.004		0.10	
E3	.132	.140	3.35	3.56					
L	.018	.024	0.46	0.61					
L1	.01 BSC		0.25 BSC						
M	.800	----	20.32	----					
N	.270	----	6.86	----					
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TITLE: TO-270 WIDE BODY LONG, 16 LEAD, GULL WING PLASTIC					DOCUMENT NO: 98ASA10740D			REV: A	
					CASE NUMBER: 1867-02			02 AUG 2007	
					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
- AN1977: Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family
- AN1987: Quiescent Current Control for the RF Integrated Circuit Device Family

### 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	May 2010	• Initial Release of Data Sheet

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