**Freescale Semiconductor**
Technical Data

Document Number: AFT20P060-4N
Rev. 1, 12/2013

RoHS

# RF Power LDMOS Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

These 6.3 W RF power LDMOS transistors are designed for cellular base station applications covering the frequency range of 1805 to 2170 MHz.

**2100 MHz**

- Typical Single-Carrier W-CDMA Performance: $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 450 mA, $P_{out}$ = 6.3 W Avg., Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF.

| Frequency | $G_{ps}$ (dB) | $\eta_D$ (%) | Output PAR (dB) | ACPR (dBc) | IRL (dB) |
|---|---|---|---|---|---|
| 2110 MHz | 18.6 | 20.0 | 9.4 | –43.0 | –13 |
| 2140 MHz | 18.8 | 20.0 | 9.2 | –42.5 | –14 |
| 2170 MHz | 18.9 | 20.0 | 9.1 | –42.5 | –14 |

**1800 MHz**

- Typical Single-Carrier W-CDMA Performance: $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 450 mA, $P_{out}$ = 6.3 W Avg., Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF.

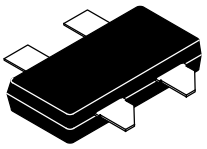
| Frequency | $G_{ps}$ (dB) | $\eta_D$ (%) | Output PAR (dB) | ACPR (dBc) | IRL (dB) |
|---|---|---|---|---|---|
| 1805 MHz | 18.8 | 23.0 | 9.5 | –43.0 | –10 |
| 1840 MHz | 19.1 | 23.8 | 9.4 | –42.9 | –15 |
| 1880 MHz | 18.7 | 24.5 | 9.1 | –42.9 | –10 |

**Features**

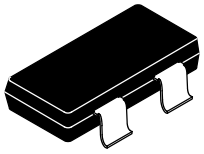
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems
- Optimized for Doherty Applications
- In Tape and Reel. R3 Suffix = 250 Units, 32 mm Tape Width, 13-inch Reel.

**AFT20P060-4NR3**
**AFT20P060-4GNR3**

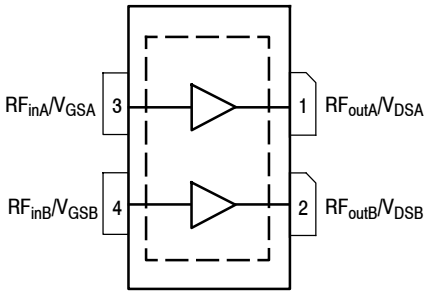
**1805–2170 MHz, 6.3 W AVG., 28 V AIRFAST RF POWER LDMOS TRANSISTORS**



**OM-780-4L**
**PLASTIC**
**AFT20P060-4NR3**



**OM-780G-4L**
**PLASTIC**
**AFT20P060-4GNR3**




(Top View)

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

**Figure 1. Pin Connections**



freescale Airfast

**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 Range | $T_C$ | –40 to +150 | °C |
| Operating Junction Temperature Range (1,2) | $T_J$ | –40 to +225 | °C |

**Table 2. Thermal Characteristics**

| Characteristic | Symbol | Value (2,3) | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case<br>Case Temperature 77°C, 6.3 W CW, 28 Vdc, $I_{DQ}$ = 450 mA, 2140 MHz<br>Case Temperature 80°C, 60 W CW, 28 Vdc, $I_{DQ}$ = 450 mA, 2140 MHz | $R_{\theta JC}$ | <br>0.56<br>0.53 | °C/W |

**Table 3. ESD Protection Characteristics**

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

**Table 4. Moisture Sensitivity Level**

| Test Methodology | Rating | Package Peak Temperature | Unit |
|---|---|---|---|
| Per JESD22-A113, IPC/JEDEC J-STD-020 | 3 | 260 | °C |

**Table 5. Electrical Characteristics** ($T_A$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Off Characteristics (4)** | | | | | |
| 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 (4)** | | | | | |
| Gate Threshold Voltage ($V_{DS}$ = 10 Vdc, $I_D$ = 36 μAdc) | $V_{GS(th)}$ | 1.5 | 2.0 | 2.5 | Vdc |
| Gate Quiescent Voltage ($V_{DS}$ = 28 Vdc, $I_D$ = 450 mAdc) | $V_{GS(Q)}$ | — | 2.9 | — | Vdc |
| Fixture Gate Quiescent Voltage (5) ($V_{DD}$ = 28 Vdc, $I_D$ = 450 mAdc, Measured in Functional Test) | $V_{GG(Q)}$ | 5.3 | 5.8 | 6.3 | Vdc |
| Drain-Source On-Voltage ($V_{GS}$ = 10 Vdc, $I_D$ = 0.36 Adc) | $V_{DS(on)}$ | 0.1 | 0.2 | 0.3 | Vdc |

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.
4. Each side of device measured separately.
5. $V_{GG} = 2 \times V_{GS(Q)}$. Parameter measured on Freescale Test Fixture, due to resistor divider network on the board. Refer to Test Fixture Layout.

(continued)

**Table 5. Electrical Characteristics** ($T_A$ = 25°C unless otherwise noted) **(continued)**

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Functional Tests** (1,2) (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 450 mA, $P_{out}$ = 6.3 W Avg., f = 2170 MHz, Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 9.9 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset. | | | | | |
| Power Gain | $G_{ps}$ | 17.5 | 18.9 | 20.5 | dB |
| Drain Efficiency | $\eta_D$ | 18.7 | 20.0 | — | % |
| Output Peak-to-Average Ratio @ 0.01% Probability on CCDF | PAR | 8.7 | 9.1 | — | dB |
| Adjacent Channel Power Ratio | ACPR | — | –42.5 | –40.5 | dBc |
| Input Return Loss | IRL | — | –14 | –7 | dB |
| **Load Mismatch** (In Freescale Test Fixture, 50 ohm system) $I_{DQ}$ = 450 mA, f = 2140 MHz | | | | | |
| VSWR 10:1 at 32 Vdc, 83 W CW Output Power (3 dB Input Overdrive from 60 W CW Rated Power) | No Device Degradation | | | | |
| **Typical Performances** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 450 mA, 2110–2170 MHz Bandwidth | | | | | |
| $P_{out}$ @ 1 dB Compression Point, CW | P1dB | — | 60 | — | W |
| AM/PM (Maximum value measured at the P3dB compression point across the 2110–2170 MHz frequency range. Measurement made on a single path of the device under Class AB conditions, $P_{out}$ = 47 W, $I_{DQ}$ = 177 mA.) | Φ | — | –20 | — | ° |
| VBW Resonance Point (IMD Third Order Intermodulation Inflection Point) | $VBW_{res}$ | — | 70 | — | MHz |
| Gain Flatness in 60 MHz Bandwidth @ $P_{out}$ = 6.3 W Avg. | $G_F$ | — | 0.33 | — | dB |
| Gain Variation over Temperature (–30°C to +85°C) | ΔG | — | 0.012 | — | dB/°C |
| Output Power Variation over Temperature (–30°C to +85°C) | ΔP1dB | — | 0.0002 | — | dB/°C |

1. Part internally matched both on input and output.
2. Measurements made with device in straight lead configuration before any lead forming operation is applied. Lead forming is used for gull wing (GN) parts.

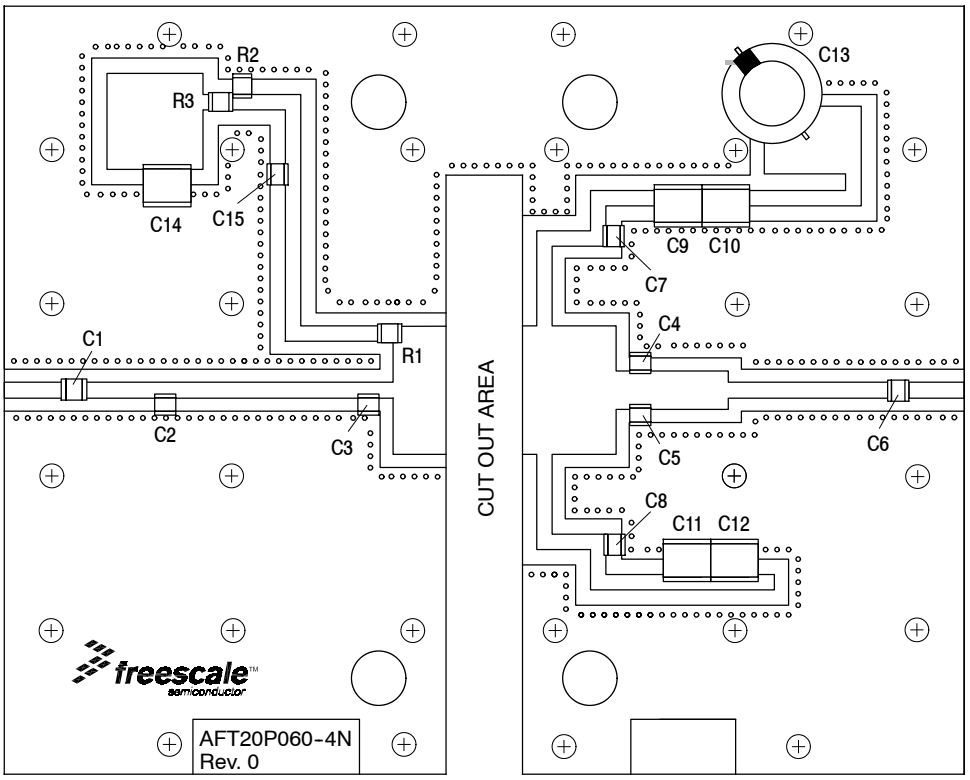



**Figure 2. AFT20P060-4NR3 Test Circuit Component Layout — 2110–2170 MHz**

**Table 6. AFT20P060-4NR3 Test Circuit Component Designations and Values — 2110–2170 MHz**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| C1, C7, C8, C15 | 6.8 pF Chip Capacitors | ATC100B6R8CT500XT | ATC |
| C2 | 0.8 pF Chip Capacitor | ATC100B0R8BT500XT | ATC |
| C3 | 1.5 pF Chip Capacitor | ATC100B1R5BT500XT | ATC |
| C4, C5 | 0.2 pF Chip Capacitors | ATC100B0R2BT500XT | ATC |
| C6 | 5.6 pF Chip Capacitor | ATC100B5R6CT500XT | ATC |
| C9, C10, C11, C12, C14 | 10 μF Chip Capacitors | C5750X7S2A106M | Kemet |
| C13 | 470 μF, 63 V Electrolytic Capacitor | MCGPR63V477M13X26-RH | Multicomp |
| R1 | 5.9 Ω, 1/4 W Chip Resistor | CRCW12065R90FKEA | Vishay |
| R2, R3 | 2 KΩ, 1/4 W Chip Resistors | CRCW12062K00FKEA | Vishay |
| PCB | 0.030″, $\varepsilon_r$ = 2.55 | AD255A | Arlon |

## TYPICAL CHARACTERISTICS

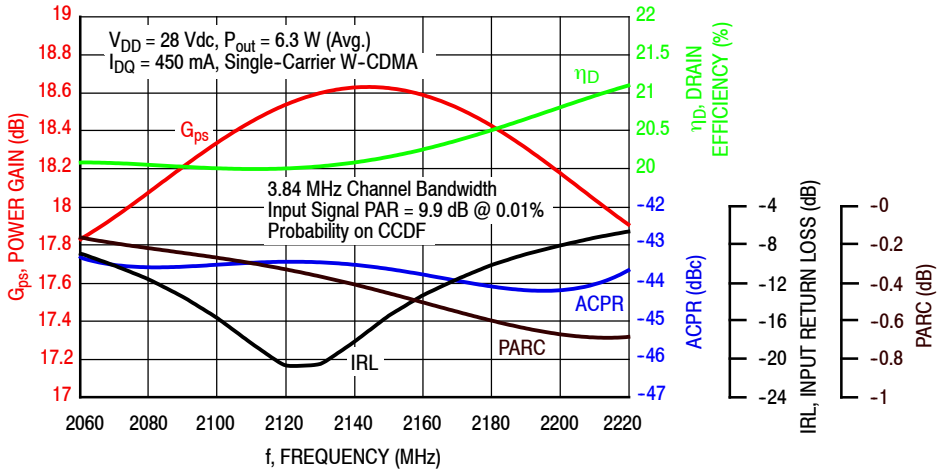



**Figure 3. Single-Carrier Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ $P_{out}$ = 6.3 Watts Avg.**

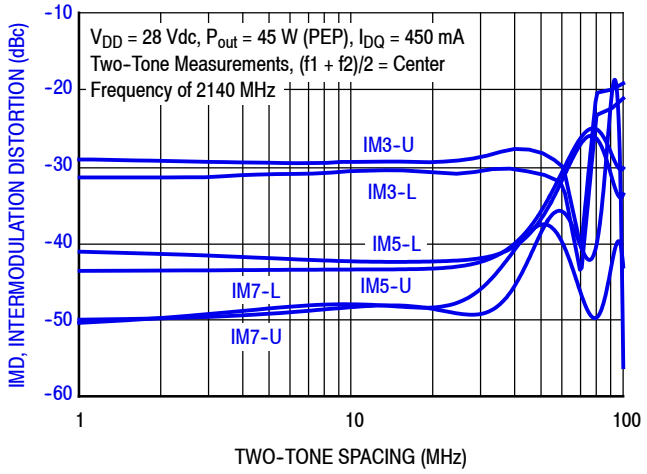



**Figure 4. Intermodulation Distortion Products versus Two-Tone Spacing**

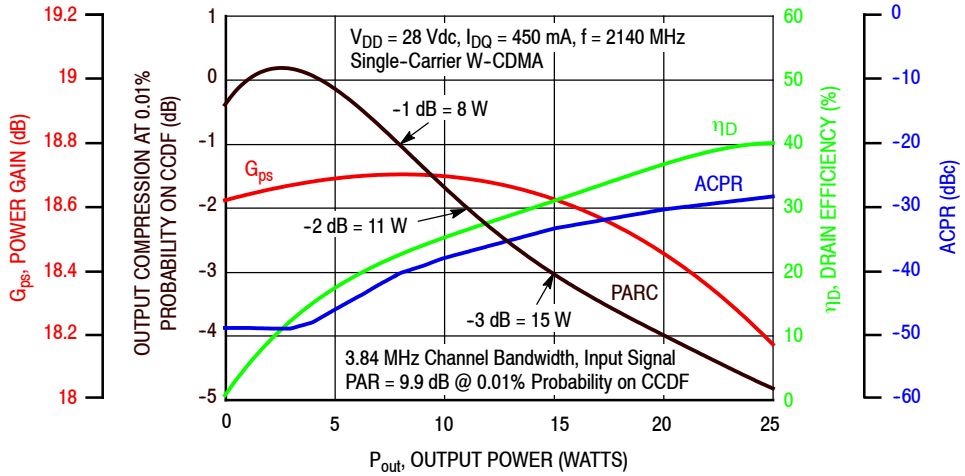



**Figure 5. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

## TYPICAL CHARACTERISTICS

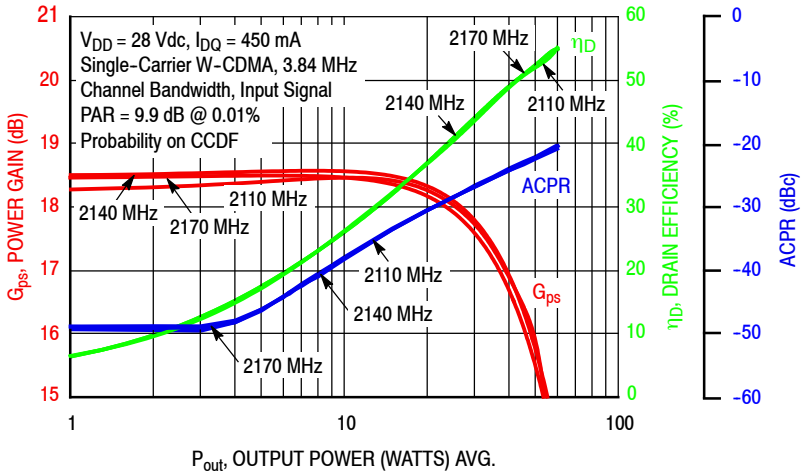



**Figure 6. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power**

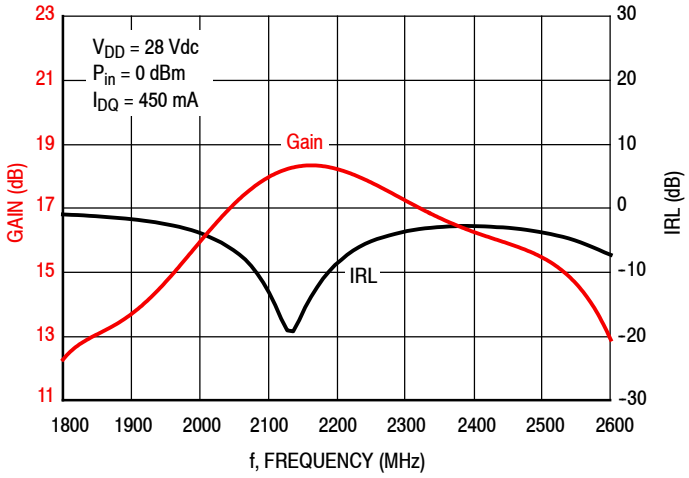



**Figure 7. Broadband Frequency Response**

## ALTERNATE CHARACTERIZATION — 1805–1880 MHz

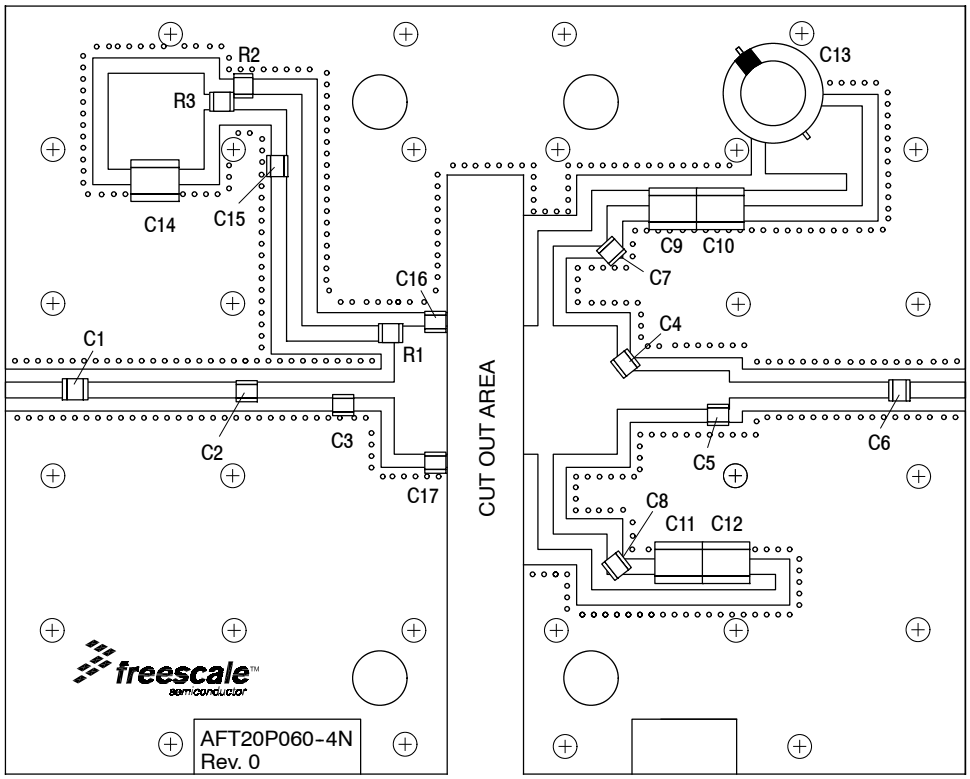



**Figure 8. AFT20P060-4NR3 Test Circuit Component Layout — 1805–1880 MHz**

**Table 7. AFT20P060-4NR3 Test Circuit Component Designations and Values — 1805–1880 MHz**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| C1 | 11 pF Chip Capacitor | ATC100B110JT500XT | ATC |
| C2, C5 | 1.1 pF Chip Capacitors | ATC100B1R1BT500XT | ATC |
| C3 | 1.8 pF Chip Capacitor | ATC100B1R8BT500XT | ATC |
| C4 | 0.5 pF Chip Capacitor | ATC100B0R5BT500XT | ATC |
| C6 | 15 pF Chip Capacitor | ATC100B150JT500XT | ATC |
| C7, C8, C15 | 12 pF Chip Capacitors | ATC100B120JT500XT | ATC |
| C9, C10, C11, C12, C14 | 10 μF Chip Capacitors | C5750X7S2A106M | Kemet |
| C13 | 470 μF, 63 V Electrolytic Capacitor | MCGPR63V477M13X26-RH | Multicomp |
| C16 | 2.7 pF Chip Capacitor | ATC100B2R7BT500XT | ATC |
| C17 | 3 pF Chip Capacitor | ATC100B3R0BT500XT | ATC |
| R1 | 5.9 Ω, 1/4 W Chip Resistor | CRCW12065R90FKEA | Vishay |
| R2, R3 | 2 KΩ, 1/4 W Chip Resistors | CRCW12062K00FKEA | Vishay |
| PCB | 0.030″, $\varepsilon_r$ = 2.55 | AD255A | Arlon |

## TYPICAL CHARACTERISTICS — 1805–1880 MHz

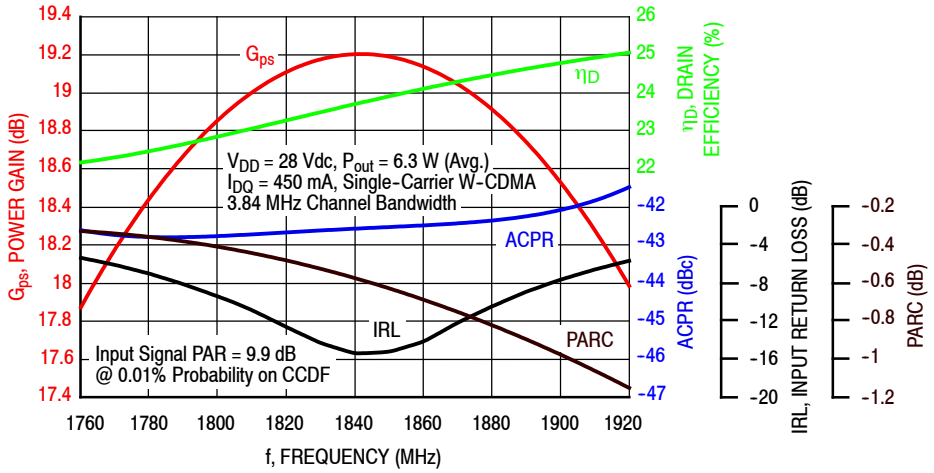



**Figure 9. Single-Carrier Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ $P_{out}$ = 6.3 Watts Avg.**

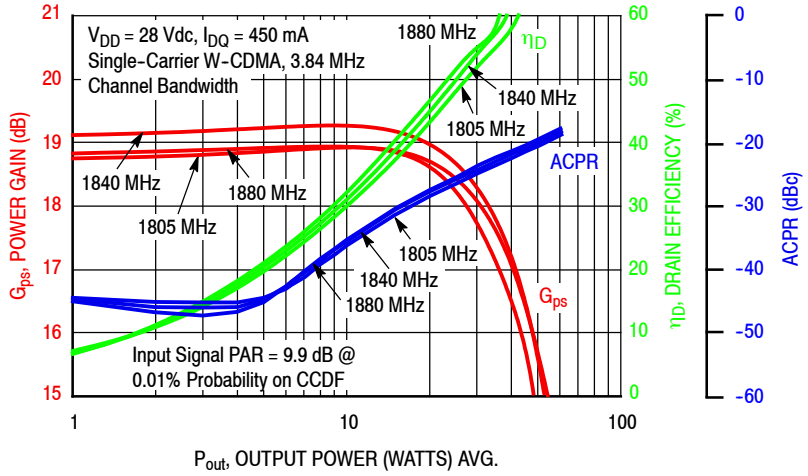



**Figure 10. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power**

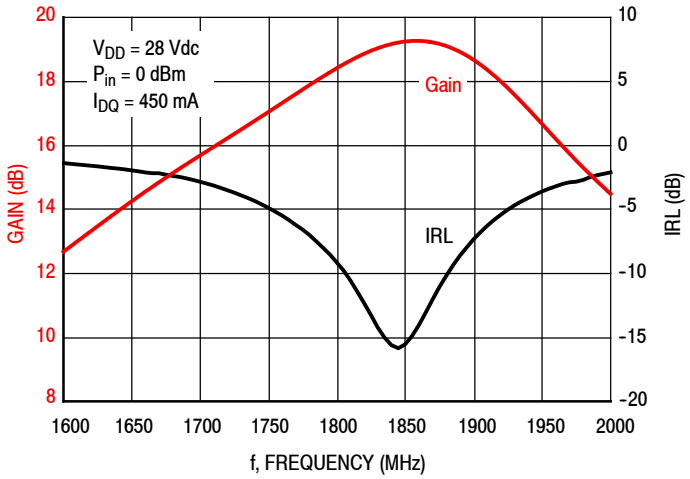
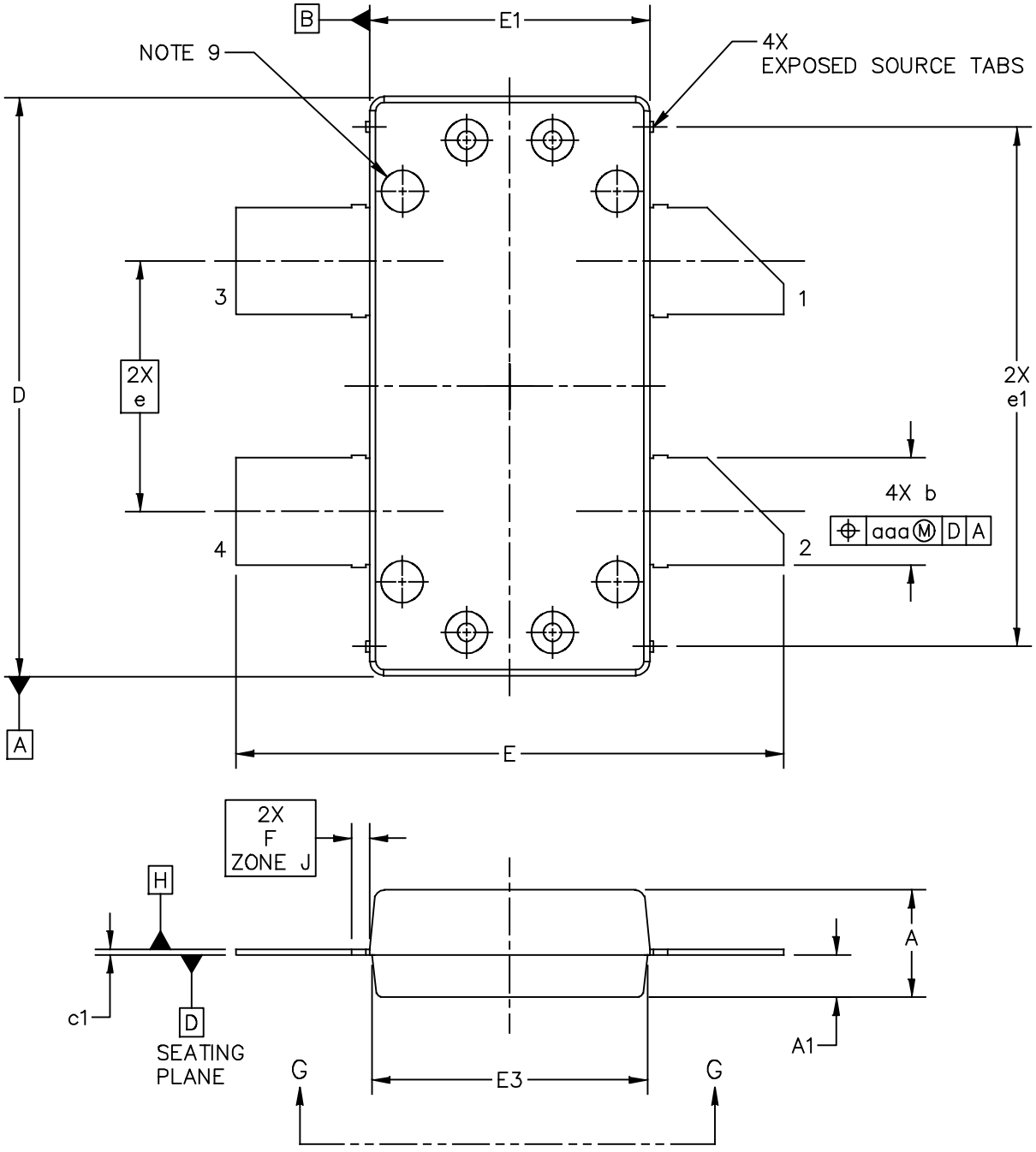



**Figure 11. Broadband Frequency Response**

## PACKAGE DIMENSIONS

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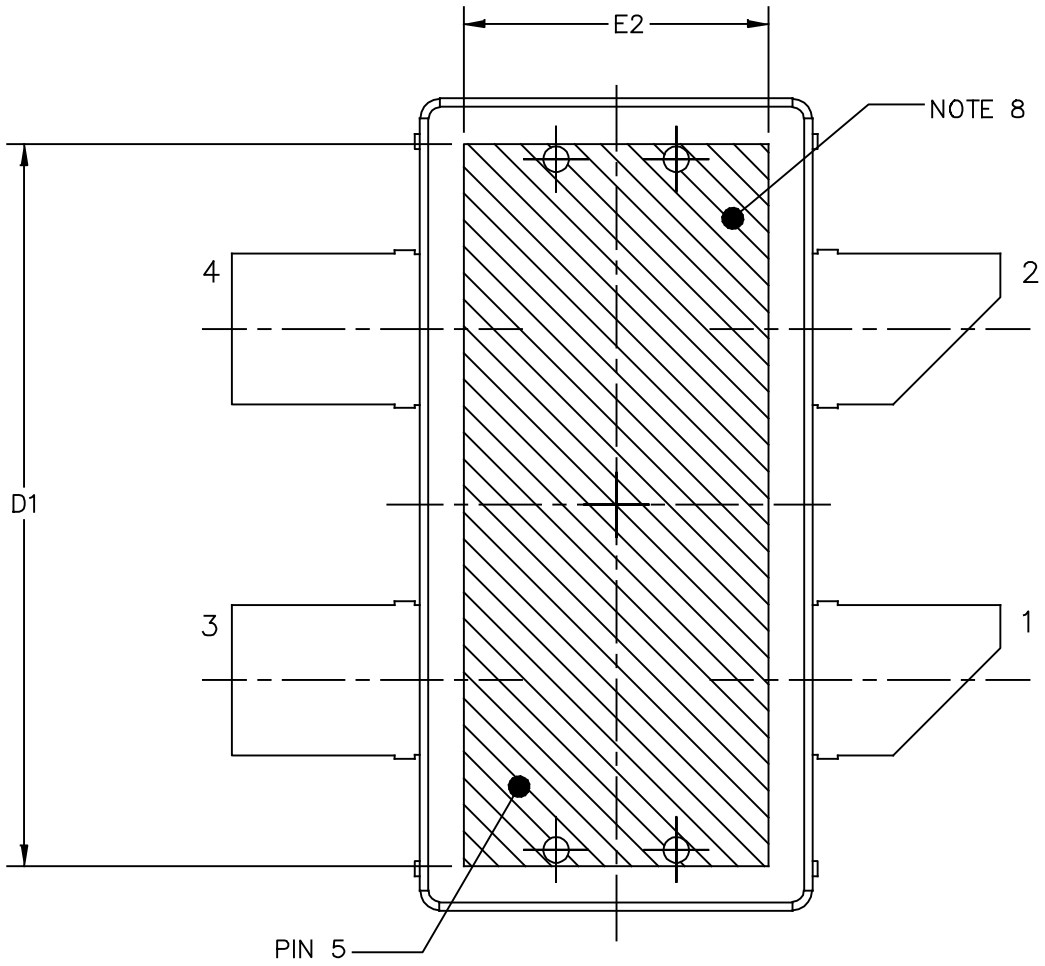
|---|---|---|
| TITLE: OM780–4 STRAIGHT LEAD | DOCUMENT NO: 98ASA10833D | REV: A |
| | CASE NUMBER: 2023–02 | 10 FEB 2010 |
| | STANDARD: NON–JEDEC | |




BOTTOM VIEW
VIEW G–G

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| | CASE NUMBER: 2023–02 | 10 FEB 2010 |
| | 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 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 b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.

6. DATUMS –A– AND –B– TO BE DETERMINED AT DATUM PLANE –H–.

7. DIMENSION A1 APPLIES WITHIN ZONE "J" ONLY.

8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. THE DIMENSIONS D1 AND E2 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF HEAT SLUG.

9. DIMPLED HOLE REPRESENTS INPUT SIDE.

| DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX | DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX |
|---|---|---|---|---|---|---|---|---|---|
| A | 0.148 | .152 | 3.76 | 3.86 | b | .147 | .153 | 3.73 | 3.89 |
| A1 | .059 | .065 | 1.50 | 1.65 | c1 | .007 | .011 | 0.18 | 0.28 |
| D | .808 | .812 | 20.52 | 20.62 | e | .350 BSC | | 8.89 BSC | |
| D1 | .720 | ---- | 18.29 | ---- | e1 | .721 | .729 | 18.31 | 18.52 |
| E | .762 | .770 | 19.36 | 19.56 | | | | | |
| E1 | .390 | .394 | 9.91 | 10.01 | aaa | .004 | | 0.10 | |
| E2 | .306 | ---- | 7.77 | ---- | | | | | |
| E3 | .383 | .387 | 9.72 | 9.83 | | | | | |
| F | .025 BSC | | 0.635 BSC | | | | | | |



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|---|---|---|
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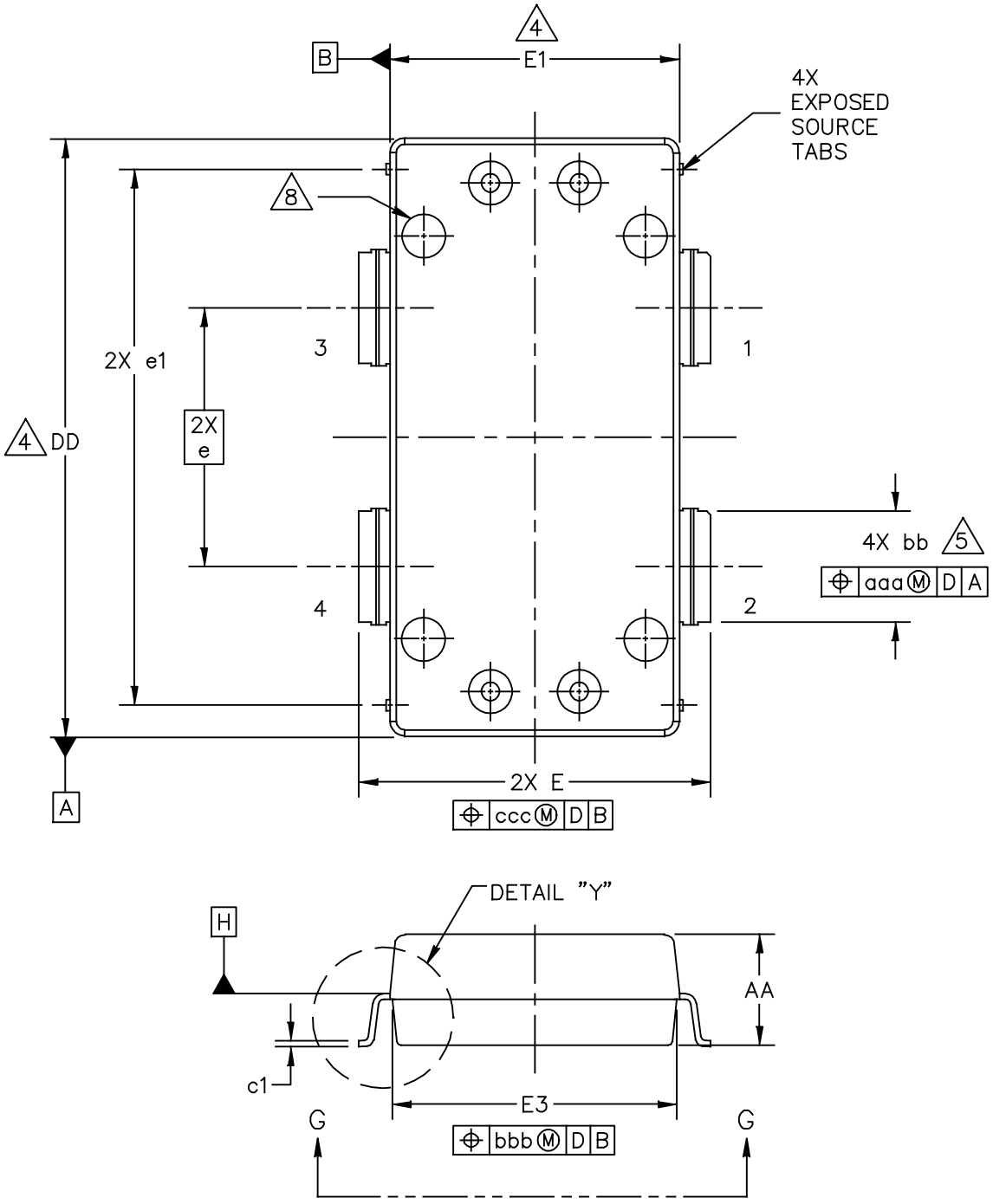
| | STANDARD: NON–JEDEC | |

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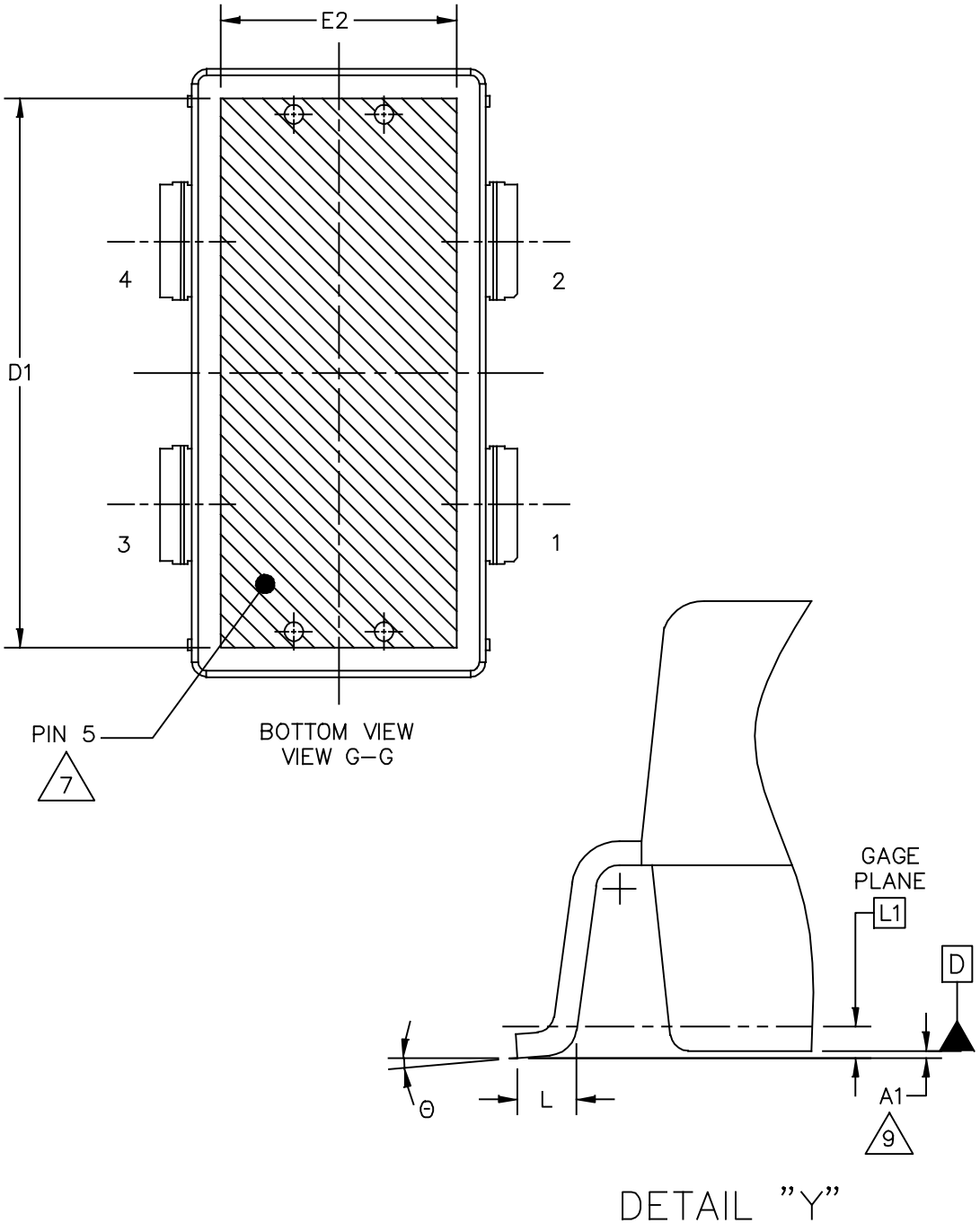
| | 14 NOV 2013 | |

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| | STANDARD: NON–JEDEC | |
| | 14 NOV 2013 | |

NOTES:
1. CONTROLLING DIMENSION: INCH

2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.

3. DATUM PLANE H IS LOCATED AT 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 DD AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 INCH (0.15 MM) PER SIDE. DIMENSIONS DD AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.

5. DIMENSION bb DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 INCH (0.13 MM) TOTAL IN EXCESS OF THE bb DIMENSION AT MAXIMUM MATERIAL CONDITION.

6. DATUMS A AND B TO BE DETERMINED AT DATUM PLANE H.

7. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. THE DIMENSIONS D1 AND E2 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF HEAT SLUG.

8. DIMPLED HOLE REPRESENTS INPUT SIDE.

9. DIMENSION A1 IS MEASURED WITH REFERENCE TO DATUM D. THE POSITIVE VALUE IMPLIES THAT THE BOTTOM OF PACKAGE IS HIGHER THAN THE BOTTOM OF THE LEAD.

| DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX | DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX |
|---|---|---|---|---|---|---|---|---|---|
| AA | .148 | .152 | 3.76 | 3.86 | bb | .147 | .153 | 3.73 | 3.89 |
| A1 | –.002 | .002 | –0.05 | 0.05 | c1 | .007 | .011 | 0.18 | 0.28 |
| DD | .808 | .812 | 20.52 | 20.62 | e | 0.350 BSC | | 8.89 BSC | |
| D1 | .720 | ---- | 18.29 | ---- | e1 | .721 | .729 | 18.31 | 18.52 |
| E | .470 | .482 | 11.94 | 12.24 | Θ | 0° | 8° | 0° | 8° |
| E1 | .390 | .394 | 9.91 | 10.01 | aaa | .004 | | 0.10 | |
| E2 | .306 | ---- | 7.77 | ---- | bbb | .006 | | 0.15 | |
| E3 | .383 | .387 | 9.73 | 9.83 | ccc | .010 | | 0.25 | |
| L | .018 | .024 | 0.46 | 0.61 | | | | | |
| L1 | .010 BSC | | 0.25 BSC | | | | | | |



MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

TITLE: OM–780G–4L

DOCUMENT NO: 98ASA10834D REV: D

STANDARD: NON–JEDEC

14 NOV 2013

## PRODUCT DOCUMENTATION, SOFTWARE AND TOOLS

Refer to the following documents, software and tools 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

**Development Tools**

- Printed Circuit Boards

For Software and Tools, 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 | Jan. 2013 | • Initial Release of Data Sheet |
| 1 | Dec. 2013 | • Added part number AFT20P060-4GNR3, p. 1<br>• Added OM780G-4L isometric, p. 1, and Mechanical Outline, pp. 12-14 |

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