ECM001

Dual Mode Cellular CDMA/AMPS 3.5V POWER AMPLIFIER MODULE

Description

The ECM001 is a dual mode power amplifier module at 3.5V Vcc with high efficiency. This device was developed using EiC's own InGaP Gallium Arsenide Heterojunction Bipolar Transistor (HBT) process. It is optimized for cellular CDMA (digital) and AMPS (analog) in the 824 MHz to 849 MHz band. It operates from a positive voltage (3 - 4V Vcc) and includes a power-down feature. The input and output are both matched to 50Ω. It is housed in a 6 X 6 mm Land Grid Array package.

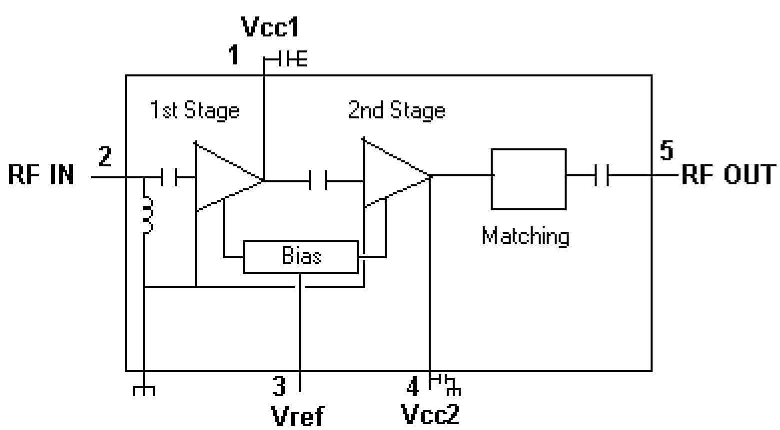
Applications

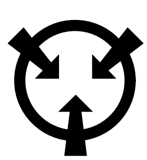
- 3.5 V CDMA/AMPS Cellular Handsets

Features

- Dual Mode CDMA/AMPS
- Single 3.5V Supply for 3-Cell Ni or Li-Ion Battery
- Power-down activated when Vref pin <1V
- 28.0 dBm CDMA Power
- 31.5 dBm AMPS Power
- 35% CDMA Efficiency
- Power-down Capability
- 80mA Typical Quiescent Current
- High Reliability InGaP Design

Functional Block Diagram





CAUTION!
SENSITIVE ELECTRONIC DEVICE

ELECTRICAL SPECIFICATIONS

The following tables list the electrical characteristics of the ECM001 Power Amplifier Module. Table 1 lists the electrical performance of the ECM001 for nominal operating conditions for the cellular CDMA (digital) and AMPS (analog) in the 824MHz to 849MHz band. Table 2 lists the absolute maximum ratings for continuous operation.

Table 1 - Electrical Specifications

Test Conditions: Ta = 25°C, V_{CC} = +3.5 V, $V_{REF / PD}$ (reference / power-down voltage) = +3.0 V, F = 824 to 849 MHz

SYMBOL	PARAMETER	LIMITS			UNIT	TEST CONDITION
		MIN.	TYP.	MAX.		
F	Frequency	824		849	MHz	
G	Gain (CDMA Modulation)	26	28		dB	
Pout	Output Power (CDMA)	28			dBm	NOTE 1
ACPR	Adjacent Channel Power Rejection @ 28.0 dBm		-50	-45	dBc	NOTE 2
Alt CPR	Alternate Channel Power Rejection @ 28.0 dBm		-60	-56	dBc	NOTE 3
PAE	Power Added Efficiency (CDMA) @ 28.0 dBm		35		%	
P_{SAT}	Output Power (AMPS)	31	31.5		dBm	
PAE	Power Added Efficiency (AMPS)	42	48		%	
G	Gain (AMPS)	24	28		dB	
	Output Stability		6:1		VSWR	NOTE 4
I_{CQ}	Quiescent Current (No RF)		80	100	mA	
Vcc	Supply Voltage		3.5		V	
IRL	Input Return Loss		10		dB	
NF	Noise Figure		5		dB	
	Harmonics, 2f, 3f, 4f		-35	-30.0	dBc	
$T_{ON/OFF}$	Power Down On/Off Time		<100		ns	

NOTE 1: Using Application Schematic. Tuned for CDMA.
NOTE 2: @ 885 KHz offset from band center.
NOTE 3: @ 1980 KHz offset from band center.
NOTE 4: No oscillation all phases (RF power up to P_{SAT})

Table 2 - Absolute Maximum Ratings

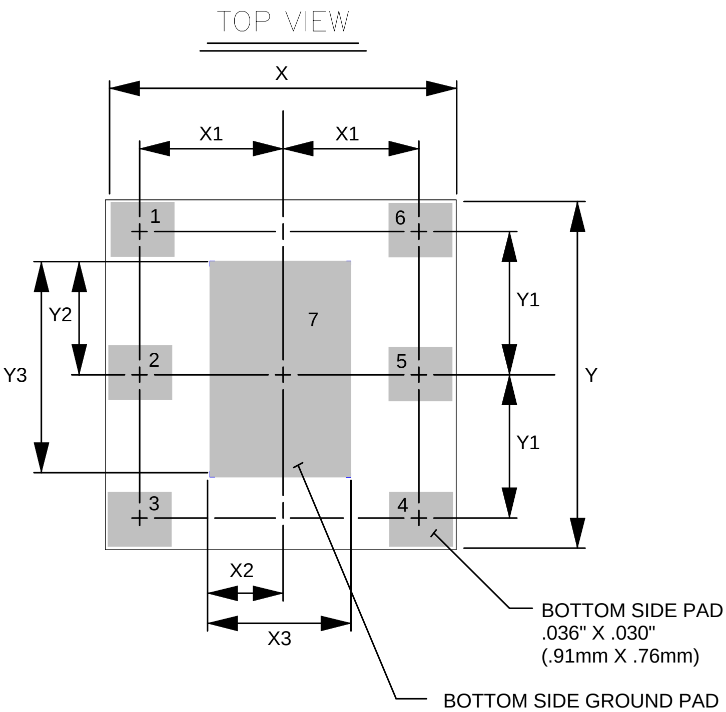
Exceeding any of the absolute maximum ratings may cause permanent damage to the device. No damage assuming only one parameter is set at limit at a time with other parameters set at or below nominal value.

PARAMETER	RATING	UNIT	TEST CONDITION
Supply Voltage	7	Volts	$V_{REF / PD}$ = 3.0V
Reference / Power-down Voltage(Vcc=$V_{REF / PD}$)	4	Volts	V_{CC} = 3.5V
RF Power Input	+15	dBm	V_{CC}, $V_{REF / PD}$ = 3.0V
Ambient Operating Temperature	-40 to +110	°C	
Storage Temperature	-65 to +140	°C	

PACKAGE DIMENSIONS AND MARKINGS

The ECM001 is a multi-layer laminate base, overmold encapsulated modular package designed for surface-mounted solder attachment to a printed circuit board.

Package Dimensions



	inches			millimeters		
	min	nom	max	min	nom	max
X	.228	.232	.236	5.78	5.89	5.99
X1	.091	.095	.099	2.31	2.41	2.51
X2	.043	.047	.051	1.09	1.19	1.29
X3	.090	.094	.098	2.29	2.39	2.49
Y	.228	.232	.236	5.78	5.89	5.99
Y1	.091	.095	.099	2.31	2.41	2.51
Y2	.071	.075	.079	1.81	1.91	2.01
Y3	.139	.143	.147	3.53	3.63	3.73

Metric values are converted from English values.
Metric values are rounded off.

PINOUT	
1	Vcc1
2	RFin
3	V_{PD}
4	Vcc2
5	RFout
6	GND
7	GND

Device Marking

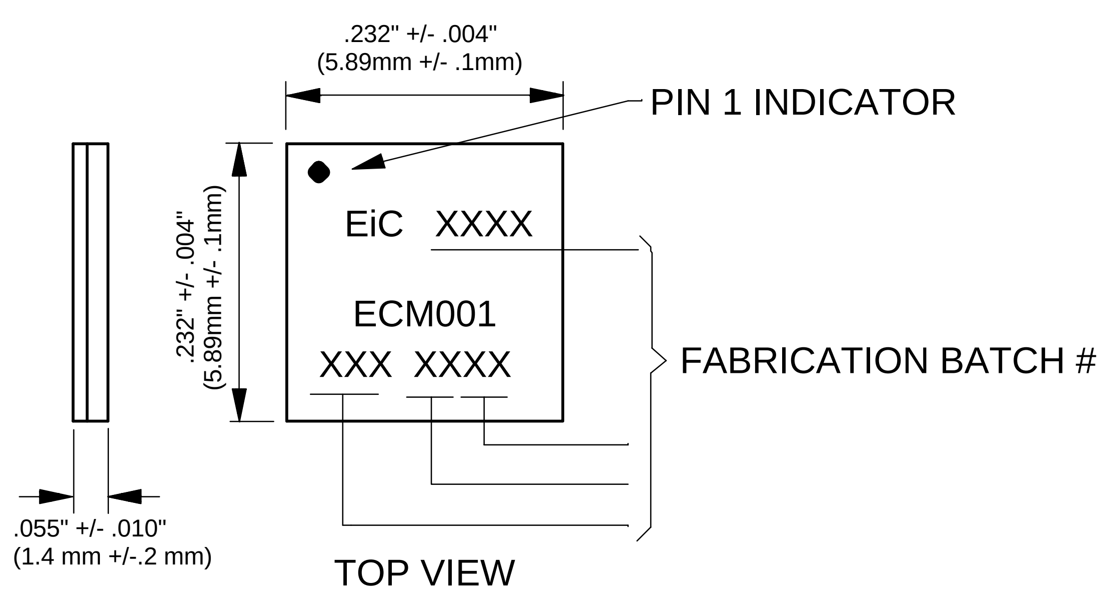


Figure 1

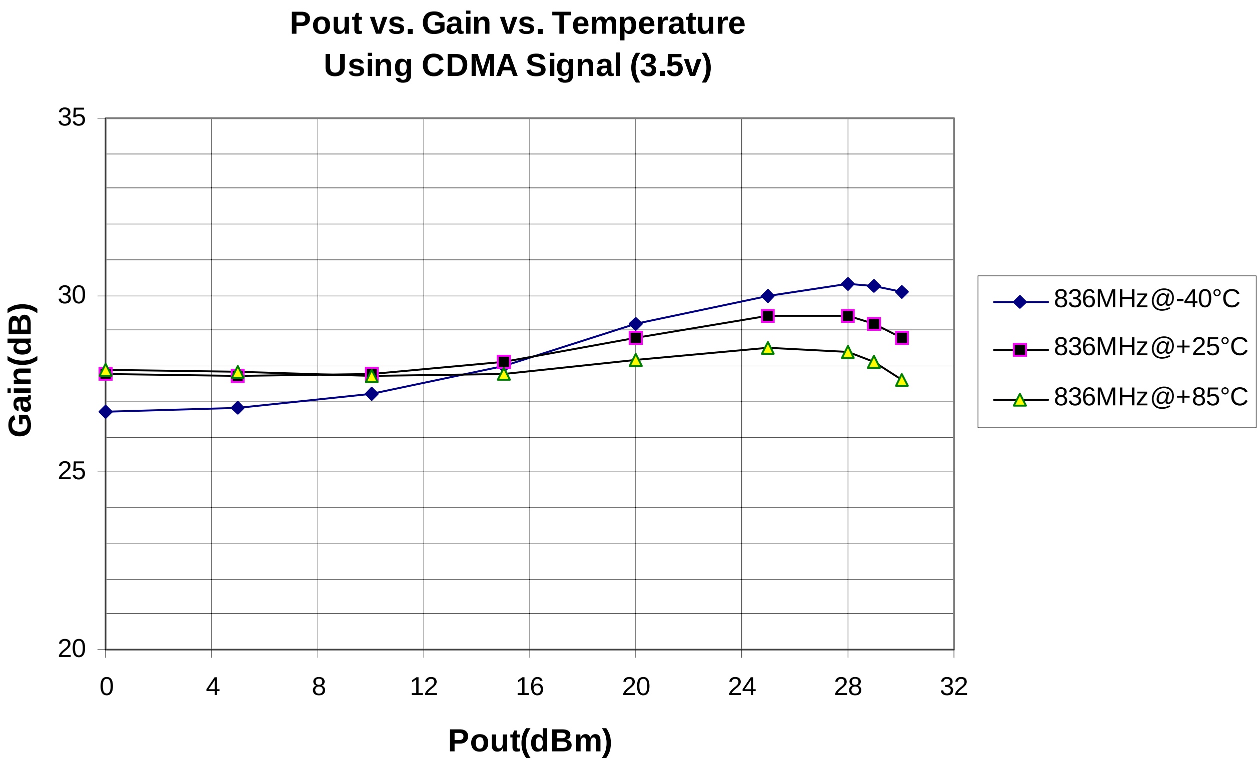


Figure 2

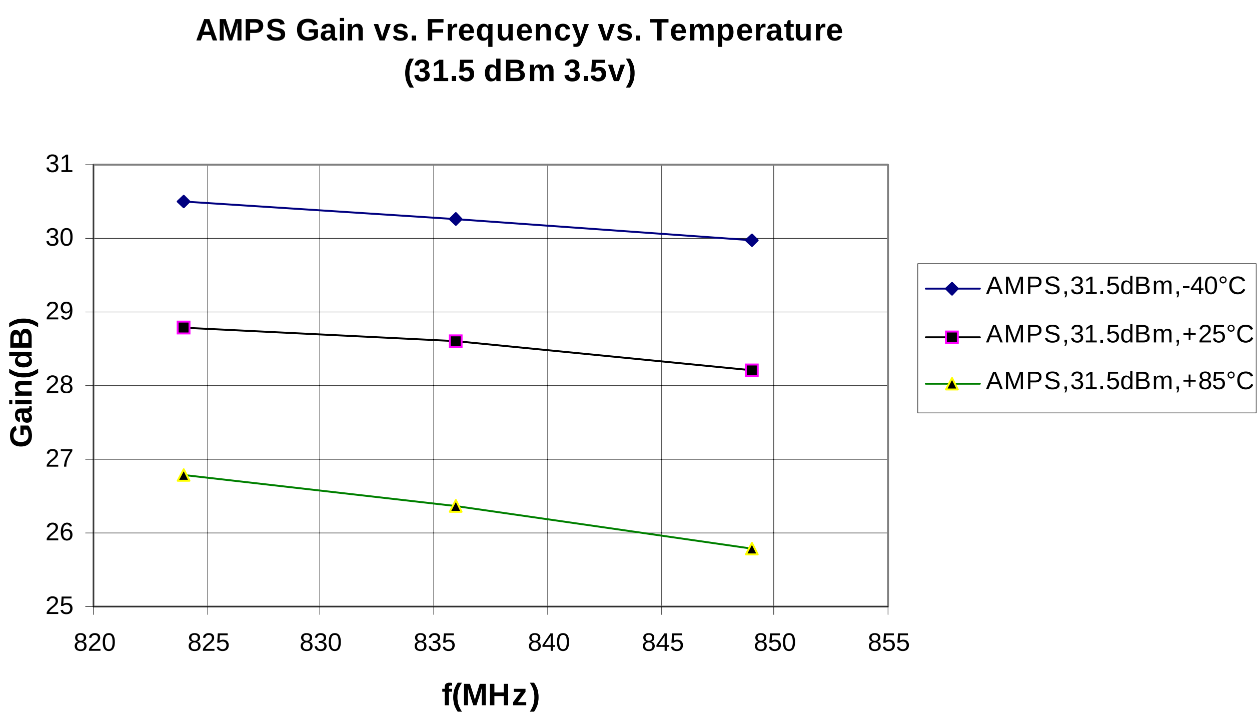


Figure 3

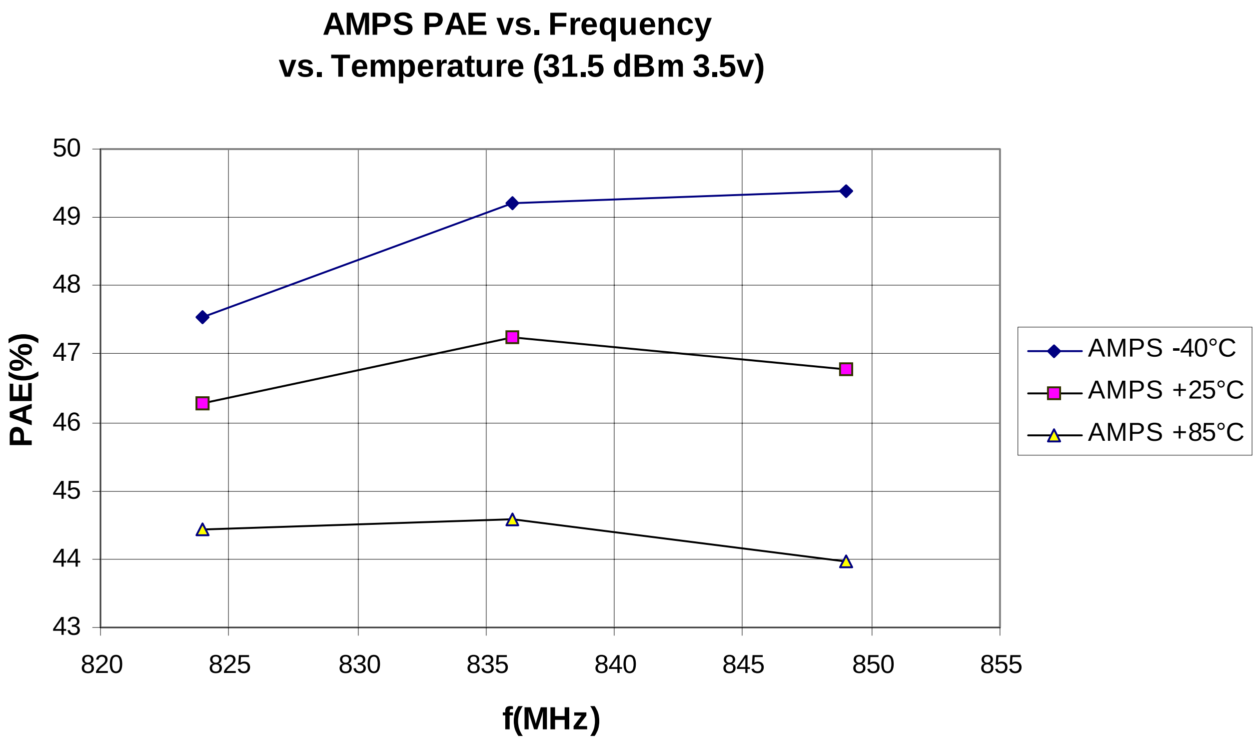


Figure 4

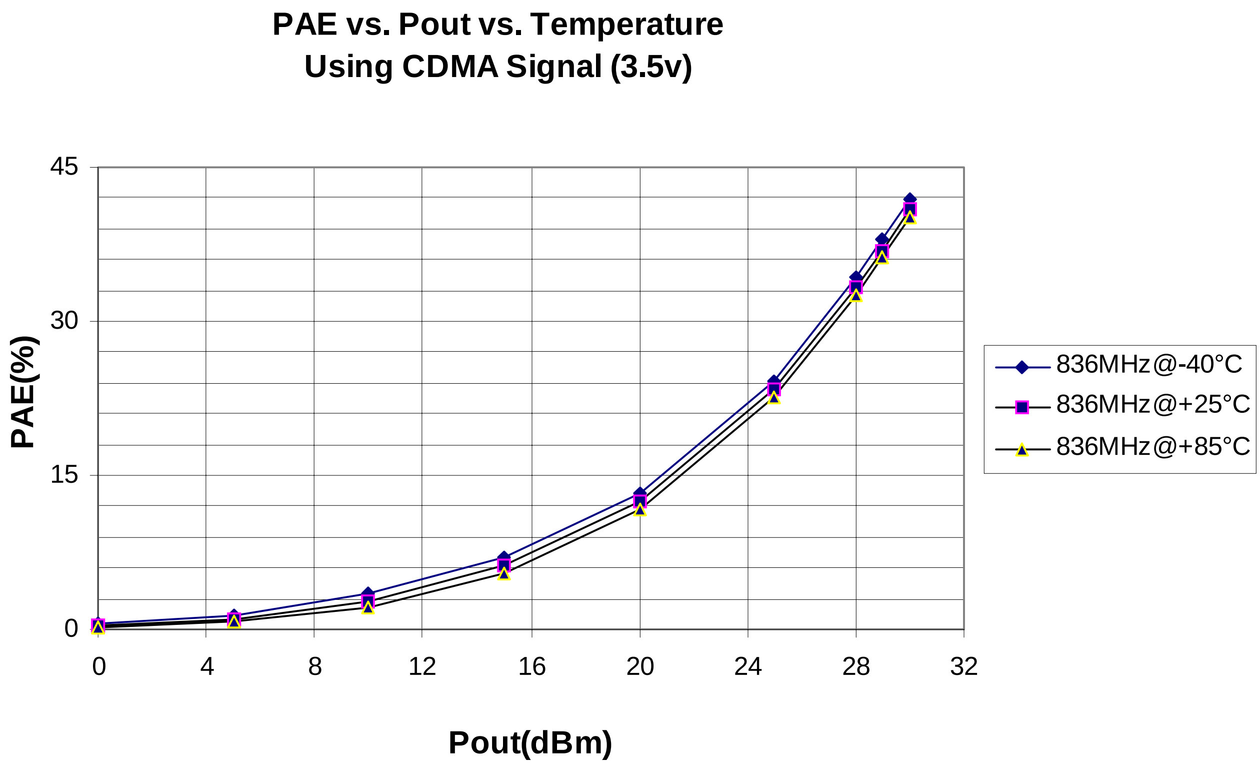


Figure 5

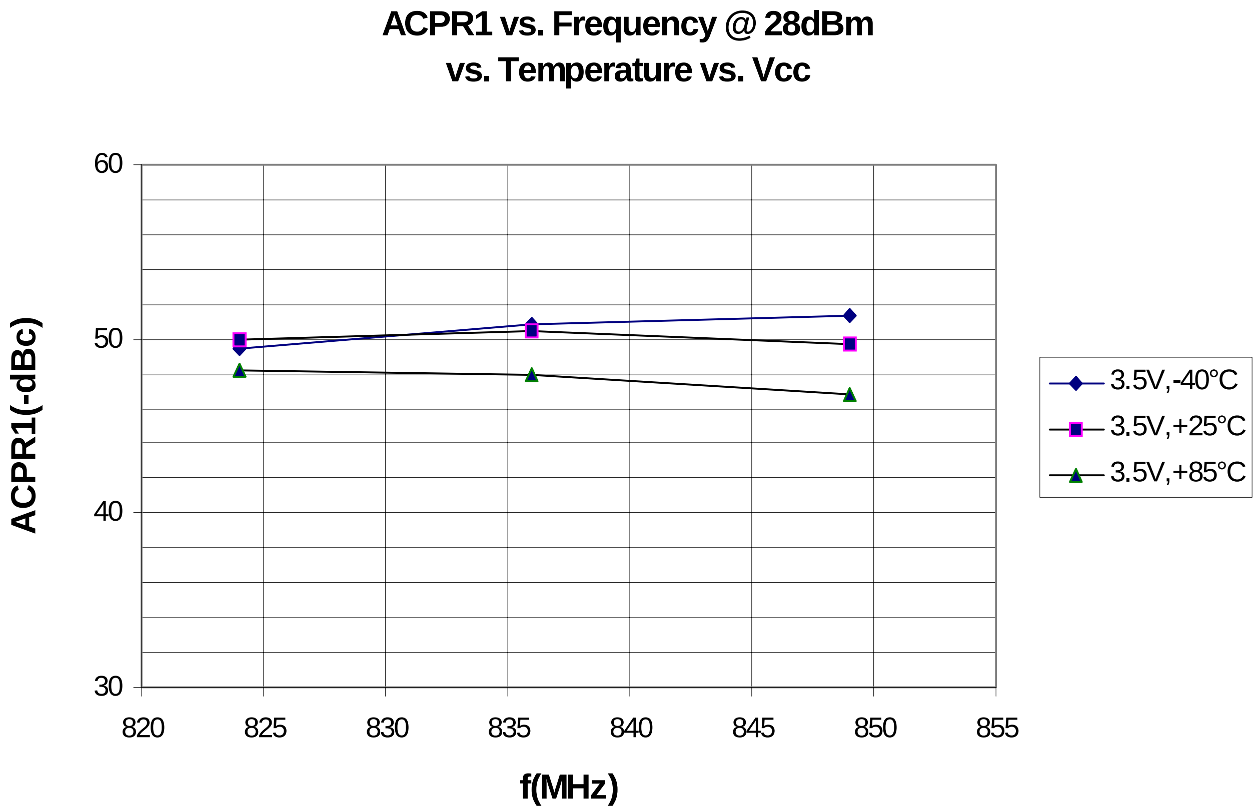


Figure 6

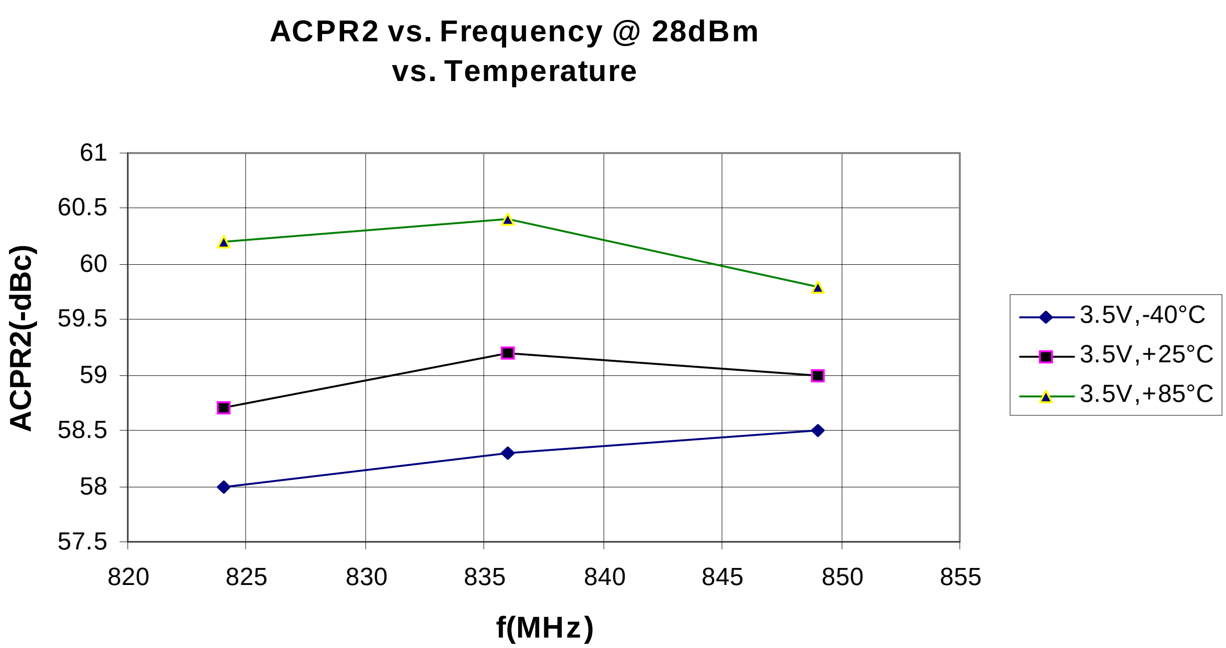


Figure 7

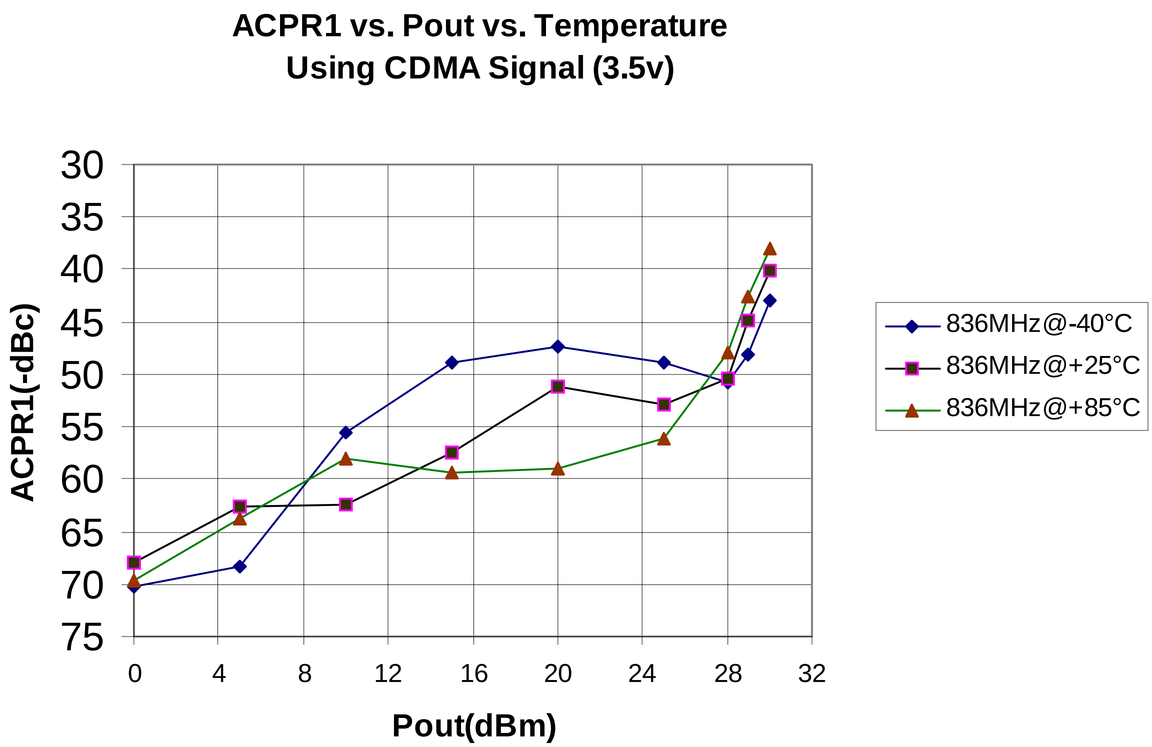


Figure 8

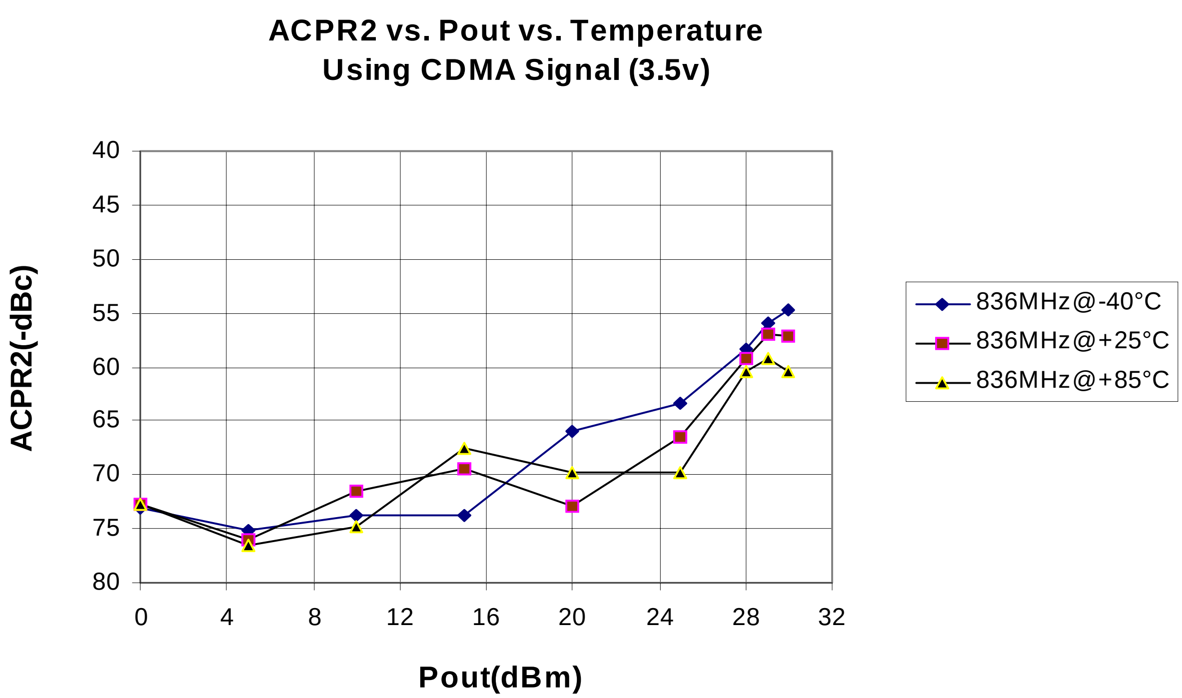
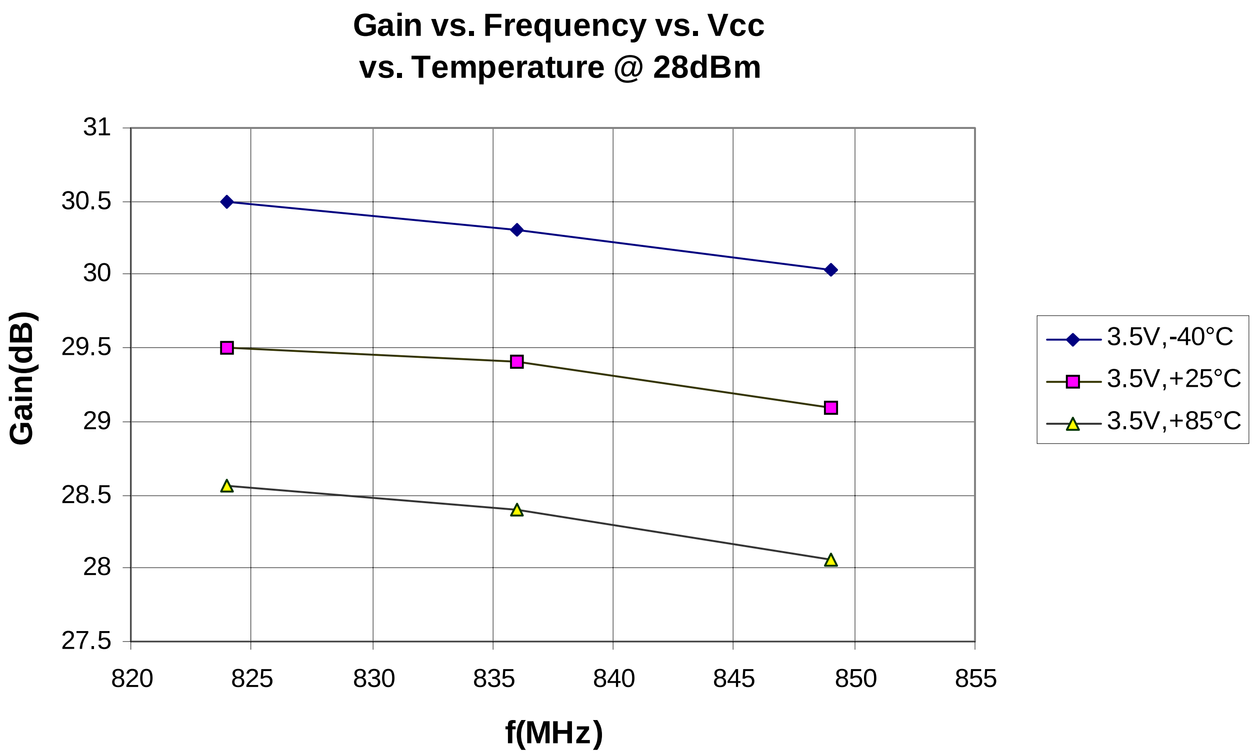


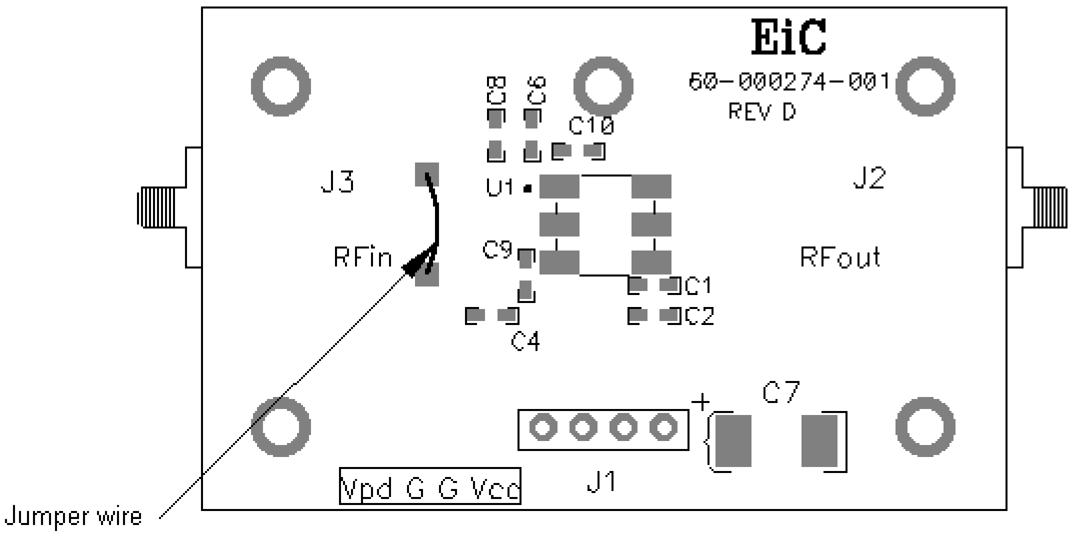
Figure 9


Gain vs. Frequency vs. Vcc
vs. Temperature @ 28dBm
31
30.5
30
29.5
29
28.5
28
27.5
Gain(dB)
820
825
830
835
840
845
850
855
f(MHz)
3.5V,-40°C
3.5V,+25°C
3.5V,+85°C

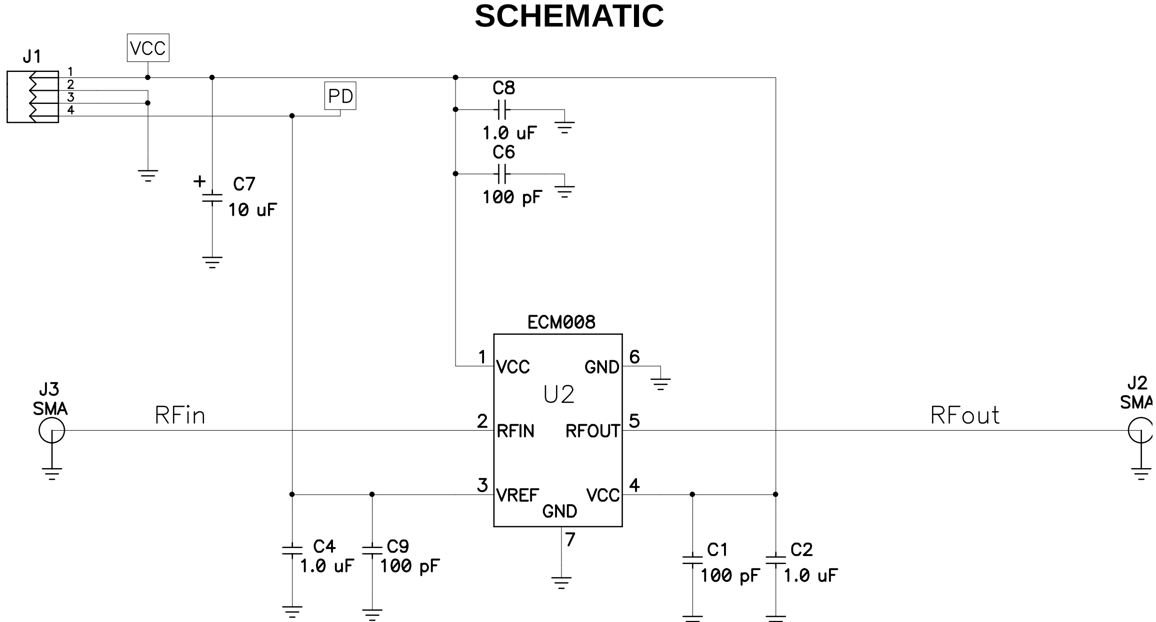
PCB LAYOUT

1. The front side of the pcb ground area under the PAM requires the use of multiple vias to provide low thermal resistance to the backside of the pcb ground.

EVAL BOARD



SCHEMATIC



MANUFACTURER	MFG PART NUMBER	DESCRIPTION	QTY	VALUE	DESIG
ROHM	MCH185A101JK	CAPACITOR, 0603	3	100 pF	C1,9,6
ROHM	MCH182F105ZK	CAPACITOR, 0603	3	1.0 uF	C2,C4,C8
PANASONIC	ECS-HICC106R	CAP 6032 TANT 16V	1	10 uF	C7
SULLINS	PZC04SGAN	CONNECTOR, RT ANG	1	---	J1
CDI	5260CC	CONNECTOR, SMA	2	---	J2,J3
EiC CORPORATION	ECM001	IC, ECM001	1	---	U1
ANY	---	WIRE, 26 AWG	1	---	---
EiC CORPORATION	60-000274-001	PRINTED CIRCUIT BOARD	1	---	---

PIN	FUNCTION	DESCRIPTION
1	Vcc1	PIN 1 connects to the driver stage HBT collector.
2	RF In	RF input port connects to internally matched 50 ohm circuit.
3	Vref / Vpd	Ref. Voltage for the bias circuit. No significant amplifier current is drawn
		until Vref reaches approximately 2.5V.
4	Vcc2	Vcc2 connects to the power amplifier stage HBT collector.
5	RF Out	RF out is internally matched to 50 ohms and expects a 50 ohm load impedance.
6	GND	Ground
7	GND	Ground. This ground also serves as heat sink and must connect well to the PCB
		RF ground and heat sink.
Notes:		All supply pins may be connected together at the supply.

ECM001 Operating Principles and Key Features

ECM001 is a 6x6mm size Power Amplifier Module (PAM) for cellular band CDMA (digital) and AMPS (analog) handset market..
The PAM utilizes InGaP HBT technology and a multi layer laminate base, over molded modular package with a LGA signal pad.

I. In GaP HBT offers Reliability and Quality

EiCs proprietary InGaP HBT provides excellent reliability and is used in the infrastructure industry. The InGaP HBT is inherently superior to AlGaAs HBT. The surface defect density in InGaP is much lower than that of AlGaAs.

The HBT life test of EiC InGaP HBT has gone through 315^{o}C junction temperature and 50kA/cm^2 for over 6000 hours (8 ½ months), translating to multi-million hours lifetime or longer in the operation envelope [1]. This kind of robust performance is far superior to conventional AlGaAs HBT.

The InGaP HBT PAM goes through a product burn-in test as well. A large sample group, usually 100 pieces, goes through burn-in test at an ambient temperature of 125 to 145 ^{o}C for 1000 hours. The FIT number is than calculated based upon the data collected. The MTTF is simply 1/FIT, this MTTF should agree with the HBT life test results.

The agreement between the MTTF of HBT from life test and the FIT is essential: it validates both tests! If there is a large discrepancy [2], the quality claim may be flawed.

Although handset applications do not have as stringent operating requirements as the infrastructure market, the high reliability of InGaP HBT offers an assurance to the user of a high quality product designed for high volume production.

II. InGaP HBT and Patent-pending Circuit Design Offers Low Temperature Variation

Current gain of InGaP HBT varies about 10% over –40 to +85^{o}C range, compared with 50% of AlGaAs HBT. This low gain variation over temperature, coupled with the patent-pending circuit design approach, provides for more stable electrical performance.

III. ECM001 Offers High Gain and Margin for Transmitter Chain Design

The typical gain of the ECM001 is 27dB. This high gain allows the driver amplifier to run very linear which results in reduced current. Taking into account the 3dB loss of the BPF in front of the PAM, the driver needs to deliver only 4dBm linear power. The P_{1dB} of the driver amplifier should be more than 10dBm.

If a lower gain PAM is used, the driver needs to provide more power, at the expense of more operation current and possible degradation in ACPR.

Therefore the ECM001 can replace a lower gain PAM, this allows the driver to work at a lower output power and provide better ACPR, this improved performance offers more design margin in the transmitter chain.

IV. Easy Shut Down and Low Leakage Current

The V_{cc} pin of the PAM is connected directly to the battery, therefore a shut down FET is not required. A voltage is applied to the V_{ref} pin, which then brings up the quiescent current.

Removing the voltage applied to V_{ref} pin, the quiescent current will drop to a small leakage current, typically <10uA. The low leakage current of the PAM allows for a longer standby time for the phone.

V. General Application

The PAM requires a minimal number of external components. Both the input and output are dc-blocked within the PAM as shown in the function diagram. The input pin is connected to ground through a shunt inductor within the PAM.

ECM001 is designed with a low quiescent current of 80mA typical. At full CDMA power of 28dBm, the operation current will be greater than 500mA. Therefore it is a “quasi class B” or “deep class AB” amplifier. The operation current increases with output power.

CDMA signal has a time varying amplitude. The peak power is 4dB above the average RF power (it can be more accurately defined by PDF, power density function). As the peak power is clipped by the amplifier saturation power level, the distortion of the signal will cause the ACPR to deteriorate rapidly. Therefore the P_{1dB} (as tested by a SINE wave) of the amplifier should be over 31dBm to provide good ACPR at 28 dBm of output power.

A 100pF capacitor is required adjacent to the V_{cc2} pin. In addition, a large capacitor (>uF) is required. The CDMA signal has a time-varying amplitude; therefore the PAM draws on operation current corresponding to the instantaneous demand by the RF power. The large capacitor near-by is the electric charge reservoir, providing current on demand. The long electrical path from battery behaves as a large inductor; the instantaneous demand on current will cause a voltage drop, resulting in poor ACPR.

On the evaluation board, a large shunt capacitor is added to protect the V_{ref} pin from power supply over-voltage during ON/OFF. This is similar but different from the ESD. Therefore the rise and fall time test of the power down feature needs to be tested with the shunt capacitor on V_{ref} pin removed.

Conclusion

ECM001 offers high gain, low quiescent current, and a small footprint. The InGaP technology provides excellent reliability and quality, assuring the phone set manufacturer a high quality product designed for high volume production.

Reference

1. "InGaP HBTs offer Enhanced Reliability", Barry Lin, Applied Microwave and Wireless. pp 115-116, Dec. 2000
2." Interaction of Degradation Mechanisms in Be-Doped GaAs HBTs", Darrell Hill and John Parsey, Digest GaAs IC Symposium, Oct., 2000. pp 241-244

APPLICATION NOTES

Please visit our website at www.eiccorp.com to view or download the following documents.
You may also call our Customer Service to request a hardcopy.

Document #	Description
AP-000513-000	Tape and Reel Specifications: PAMS
AP-000516-000	Application Note Index