Corp.

Excellence in Communications

Product Overview ***June 2002***

Contents

EiC Corp.

A Silicon Valley Integrated Design Manufacturer (IDM) focused on RFICs.

Pioneered the development of InGaP GaAs HBT's for power amplifiers.

In-house 4" GaAs HBT wafer fab

Strong international management and technical team.

Our Market Focus

- Broadband Infrastructure Applications
  - Wireless Communications
  - Optical Fiber Communications
  - Cable TV
- Cellular Handset Applications
  - CDMA → CDMA 1X → cdma2000 / WCDMA
  - GSM → GPRS → WCDMA

Contact EIC Corporation

- EIC Corp Headquarters
  - Fremont, CA. Main no. (510) 979 8999
    Sales no. (510) 979 8953; fax (510) 979 8902
  - www.eiccorp.com sales@eiccorp.com
  - To locate our **Representatives**…refer to EIC Web Site

- Distributed in Asia and America's by
  - (866) AVNET RF www.avnetrf.com

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  - (44) 1908 326 326
  - www.bfioptilas.avnet.com
  - RFsales.UK@bfioptilas.avnet.com

InGaP HBT Technology

Enabling Technologies for RFICs

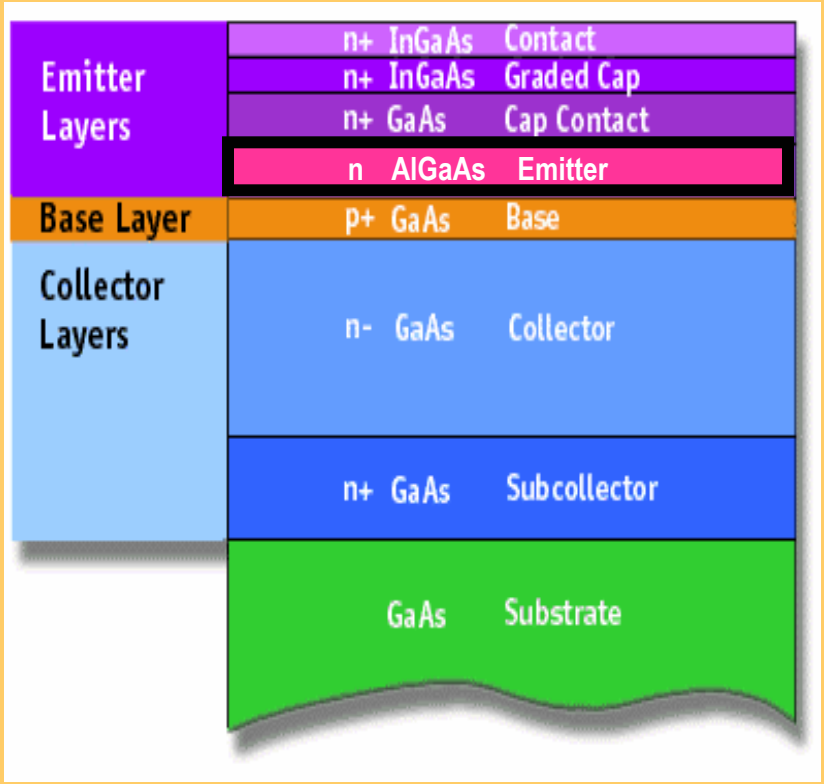
Performance	GaAs HBT	GaAs PHEMT	Si Bipolar	RF CMOS	SiGe HBT
High breakdown voltage for RF power Circuits	High	High	Low	Low	Low
RF Power Efficiency	High	High	Low	Very Low	Low
Single Supply	Yes	No	Yes	Yes	Yes
Linearity	High	High	Medium	Low	Medium
RF Front-end Chip Set	Fair	Fair	Good	Very Good	Very Good
Cost	Medium	High	Low	Low	Medium

- **InGaP/GaAs HBT: Best technology for high performance and highest reliability, medium to higher power amplifiers !!**

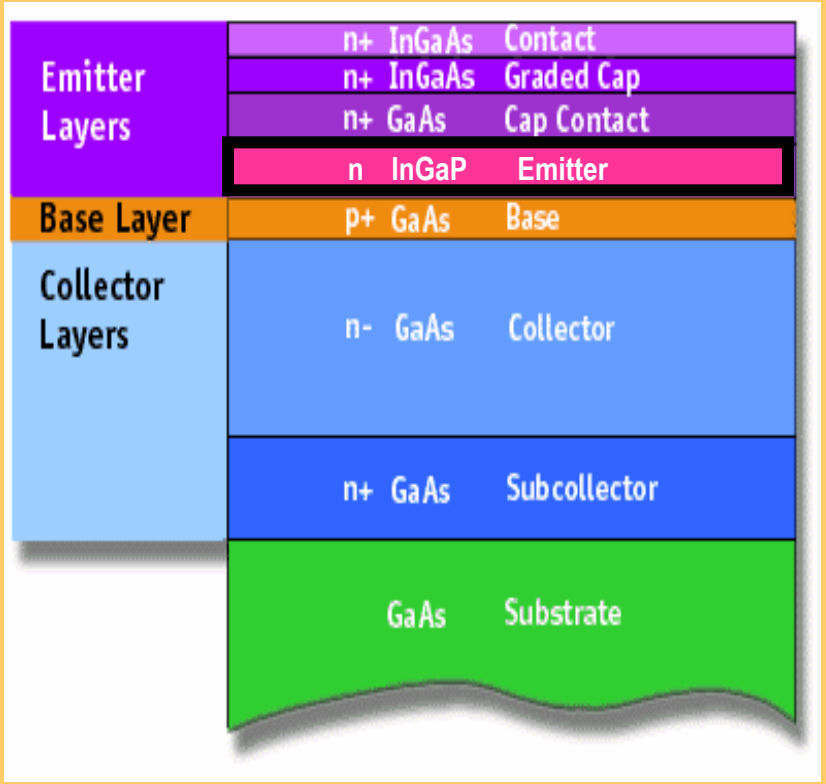
InGaP VERSUS AlGaAs HBTs

AlGaAs HBT	InGaP HBT (EiC Leadership)
• Mature Technology in Production for a Number of Years • Widely Accepted in the Field • More Epi-wafer Suppliers • More Reliability Data; less reliable	• Proven Technology in Production • Better Reliability • Higher Current Handling • Smaller Die Size • Better Temperature Stability • Lower Turn-on Voltage • Constant Current Gain over Decades of Collector Current • Better Manufacturability • Lower Phase Noise in Oscillators

HBT Epi Structures



AlGaAs/GaAs HBT

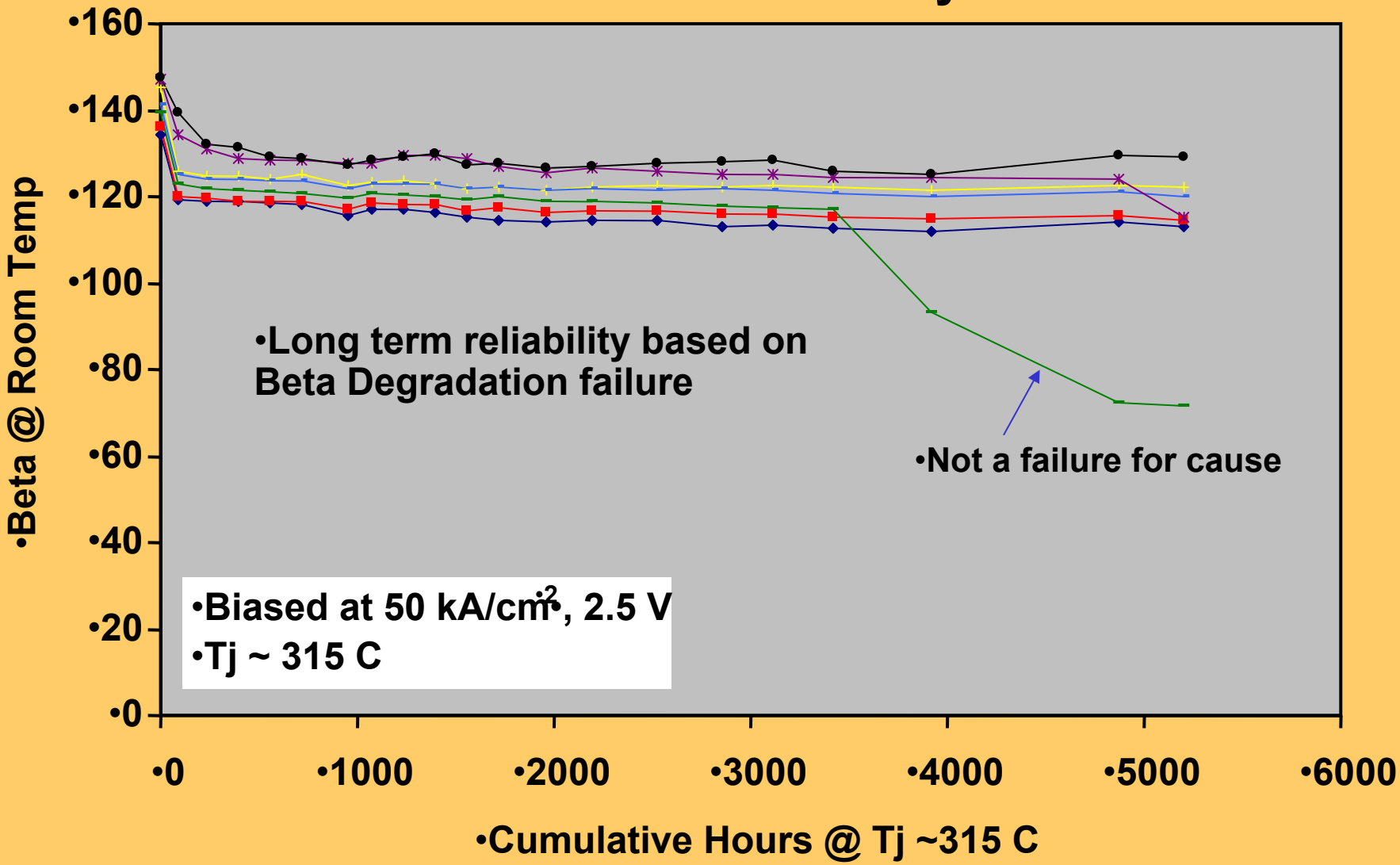


InGaP/GaAs HBT

InGaP/GaAs Advantages

- InGaP emitter forms better E/B junction
  - Better lattice structure; less defects than AlGaAs
  - Higher current handling
- MOCVD for epitaxial growth
  - Molecular Organic Chemical Vapor Deposition
  - Low temperature process allows for Carbon doped base for stability over temperature and current
- All this adds up to the most RELIABLE and LOWEST COST solution

•InGaP HBT Reliability



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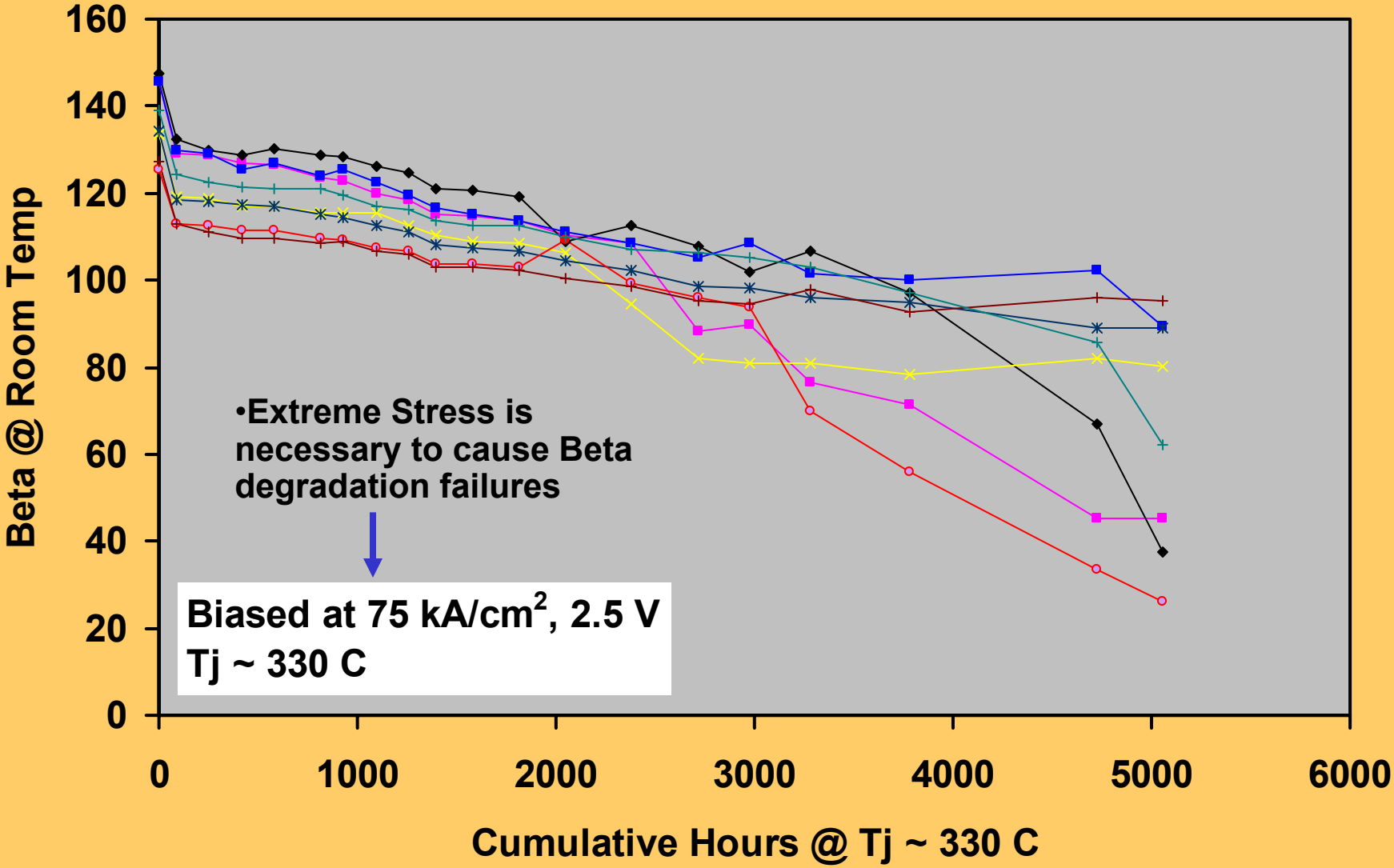
InGaP HBT Reliability



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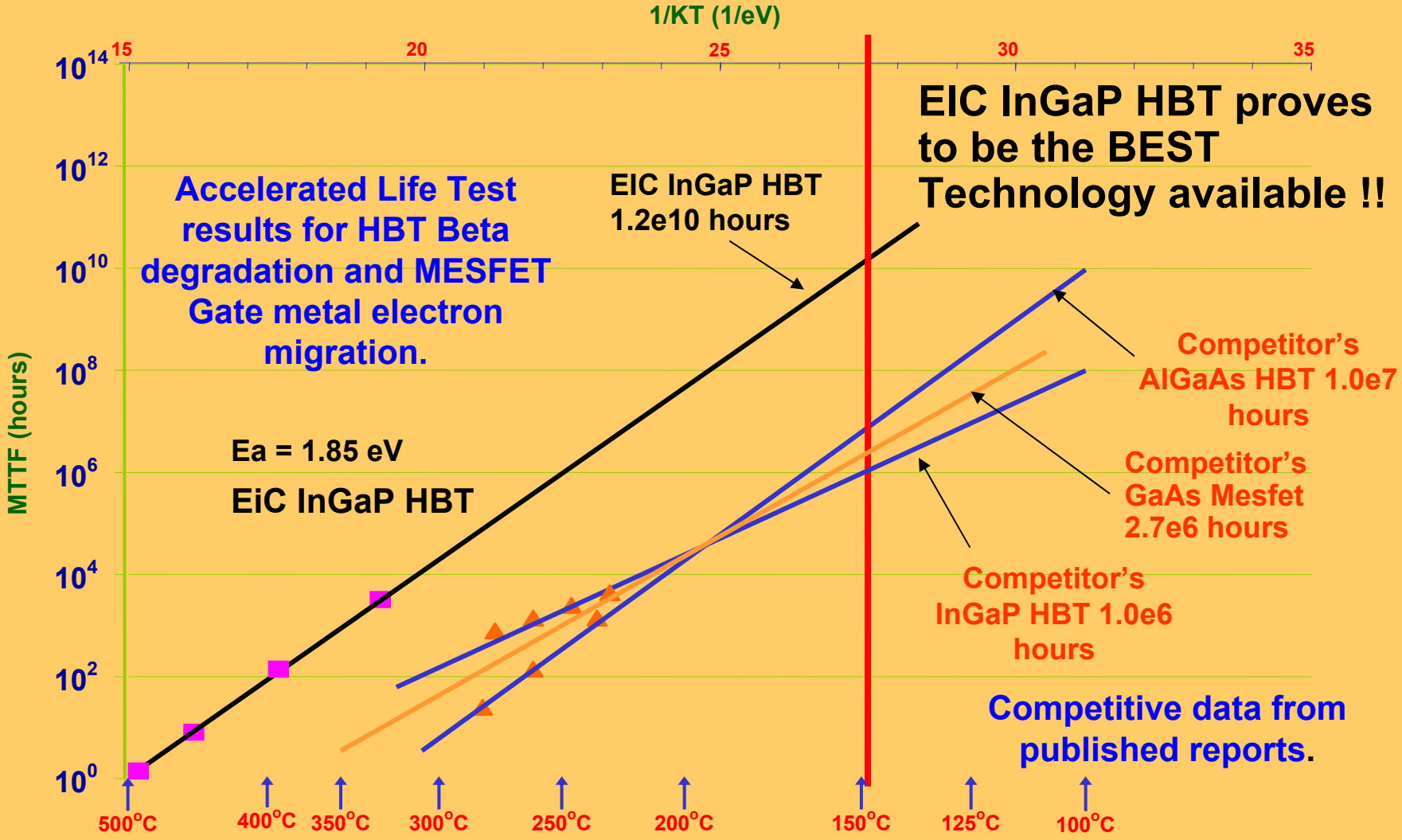
RELIABILITY ADVANTAGE (MTTF)



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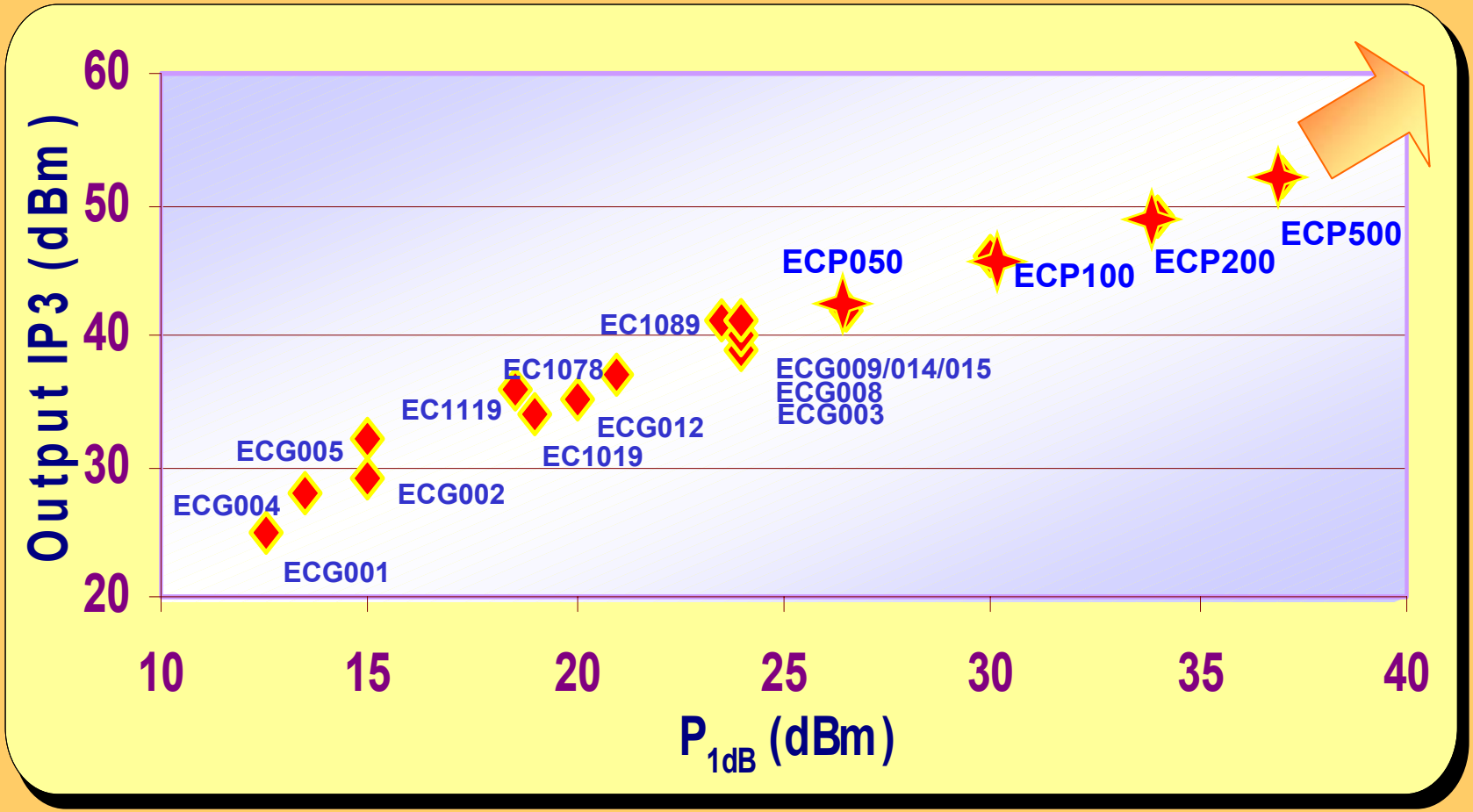
Broadband Amplifiers for Infrastructures

Leadership Products

- EiC supplies gain block, broad band amplifier IC's, to major base station infrastructure manufacturers
- Cellular base station applications demand superior reliability and performance
- Infrastructure Broadband Amplifiers based on EiC's proprietary InGaP/GaAs HBT technology provide:
  - The Best Linearity (critical for 3G)
  - The Best Reliability (>1000X better than competition)
- EiC's Broadband Amplifiers being shipped to Primary base station suppliers today

EiC Gain Block Product Evolution



◆ = Released ✦ = Under Development

EiC's Gain Block Selection

Broadband Linear Amplifier	Small Signal Gain (dB)	Noise Figure (dB)	Output P1dB (dBm)	Output IP3 (dBm)	Input Return Loss (dB)	Output Return Loss (dB)	Δ Tj	BW {MHz}	Vde (V)	Icc (mA)	Package
ECG014	20.5	5.0	24.0	42	15	10	45°C	50-2000	5.0	100	B
ECG015*	15.0	5.0	24.0	41	15	10	45°C	1800-2500	5.0	100	B
ECG009	19.0	5.1	24.0	41	15	10	65°C	DC-3000	5.0	150	B
ECG003	20.0	3.5	24.0	39	12	12	45°C	DC-6000	7.2	110	B
EC-1089	15.0	5.1	23.5	42	15	10	65°C	DC-2500	5.0	150	B
ECG008	15.0	5.0	23.0	40	15	10	75°C	DC-6000	7.3	120	B
EC-1078	19.5	4.4	21.0	37	12	8	65°C	DC-6000	6.0	96	B.C
ECG012	14.0	5.1	20.0	36	15	10	65°C	DC-2500	3.0	100	B
EC-1019	18.5	5.0	19.0	34	19	15	45°C	DC-6000	5.0	70	B.C
EC-1119	14.8	5.5	18.6	36	20	24	60°C	DC-6000	4.8	80	B.C
ECG005*	18.5	4.3	18.5	33	16	15	40°C	DC-6000	4.8	65	B.C
ECG002	20.0	4.0	15.0	29	15	15	23°C	DC-6000	3.9	45	B,C,F
ECG006	15.0	4.0	15.0	32	15	15	23°C	DC-6000	3.9	45	B,C,F
ECG001	20.0	3.8	12.0	26	15	15	17°C	DC-6000	3.4	30	B,C,F
ECG004*	15.0	3.0	12.0	26	15	15	17°C	DC-6000	3.4	35	B,C,F

*Data taken at 2 GHz All other data at 1 GHz

Note:	High Linearity	Darlington

PACKAGE CODES: **B: SOT89 C: Micro X**
F: SOT363 G: SOIC8 H: LCC

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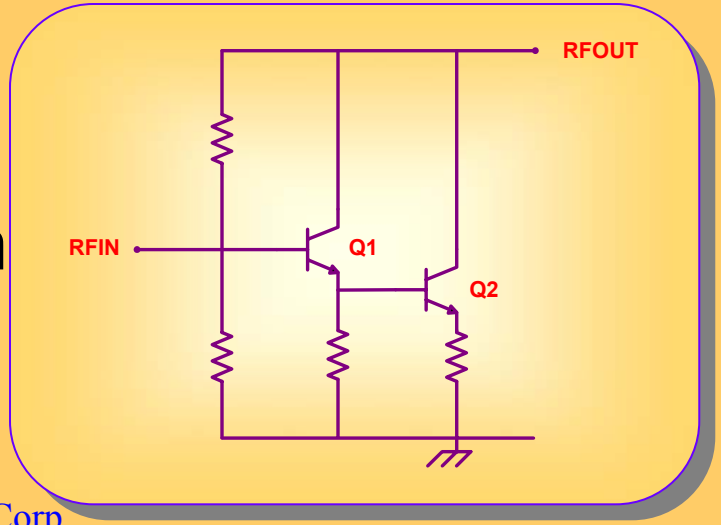
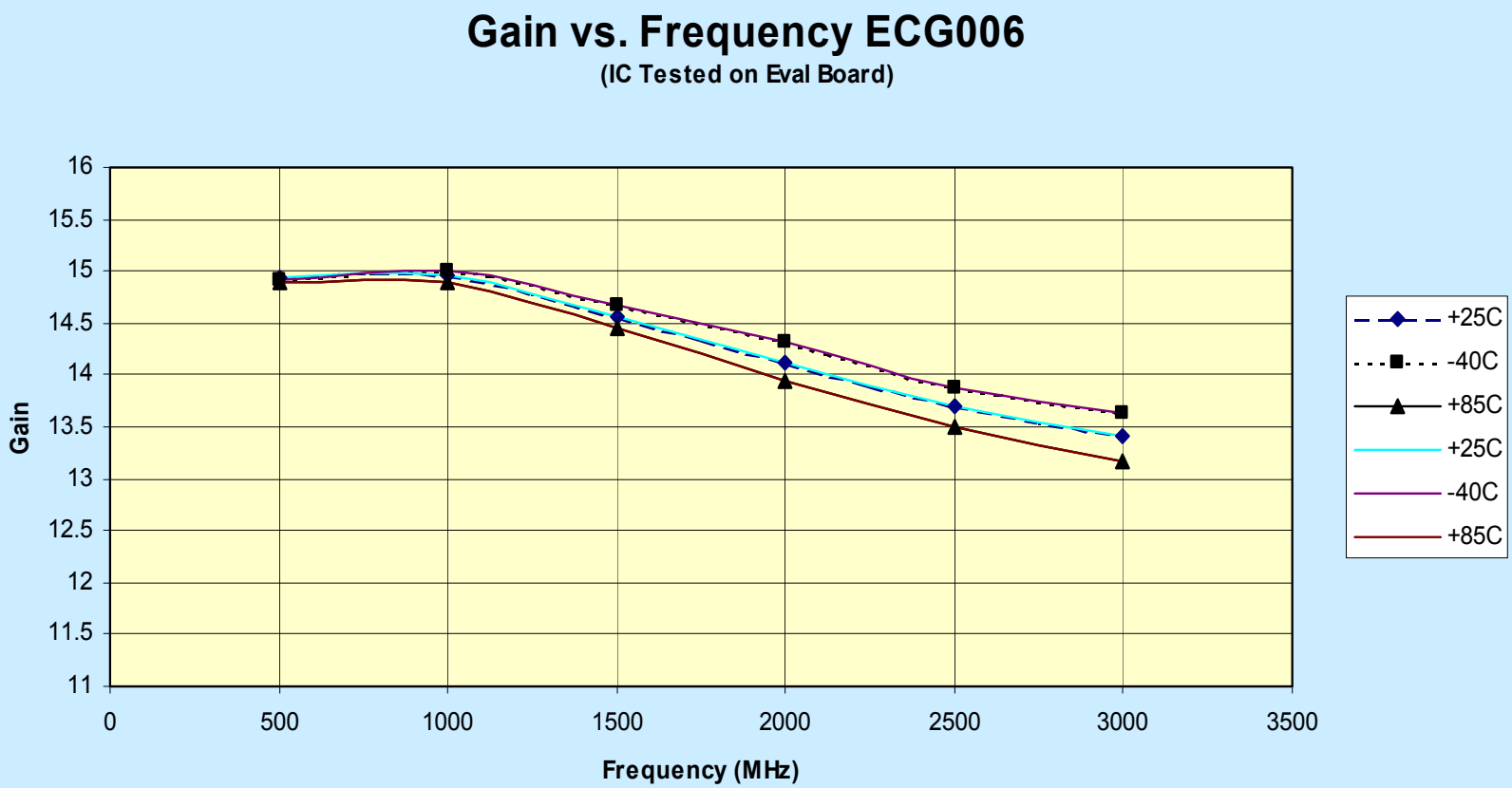
EiC Darlington Amplifier Features

- 50 ohm input/output internal matched MMIC
- Easy to use functional blocks
- Available in several small surface mount plastic packages
  - SOT363, SOT89, micro-X
- Very broad band application
  - DC to 6GHz

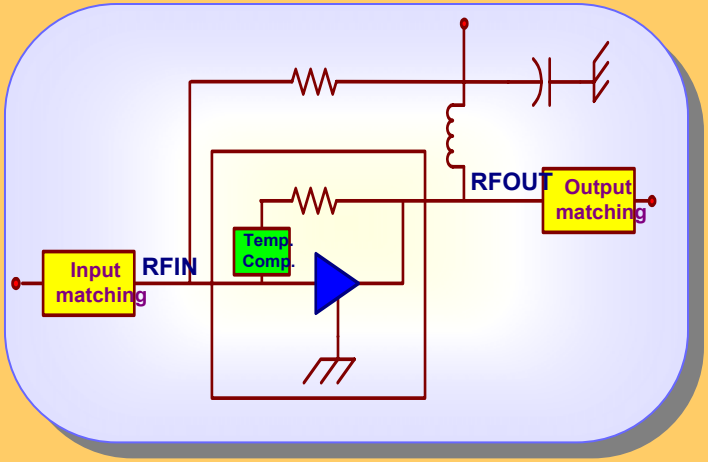


Gain Stability - Darlington



EiC High Linearity Amplifiers Features

- Require external matching circuit to each frequency bands of interest
- High linearity with OIP3 >40dBm (min.)
- Typical S_{11}<-15dB with external PCB matching circuit
- Low thermal resistance
- SOT89 package



EC1089 / ECG009

- Common Features
  - Can directly connect to 5V supply
  - Icc=150mA (typical)
  - P1dB~24dBm
  - Optimized performance with external matching circuits for each band
  - On chip temperature compensated bias circuit

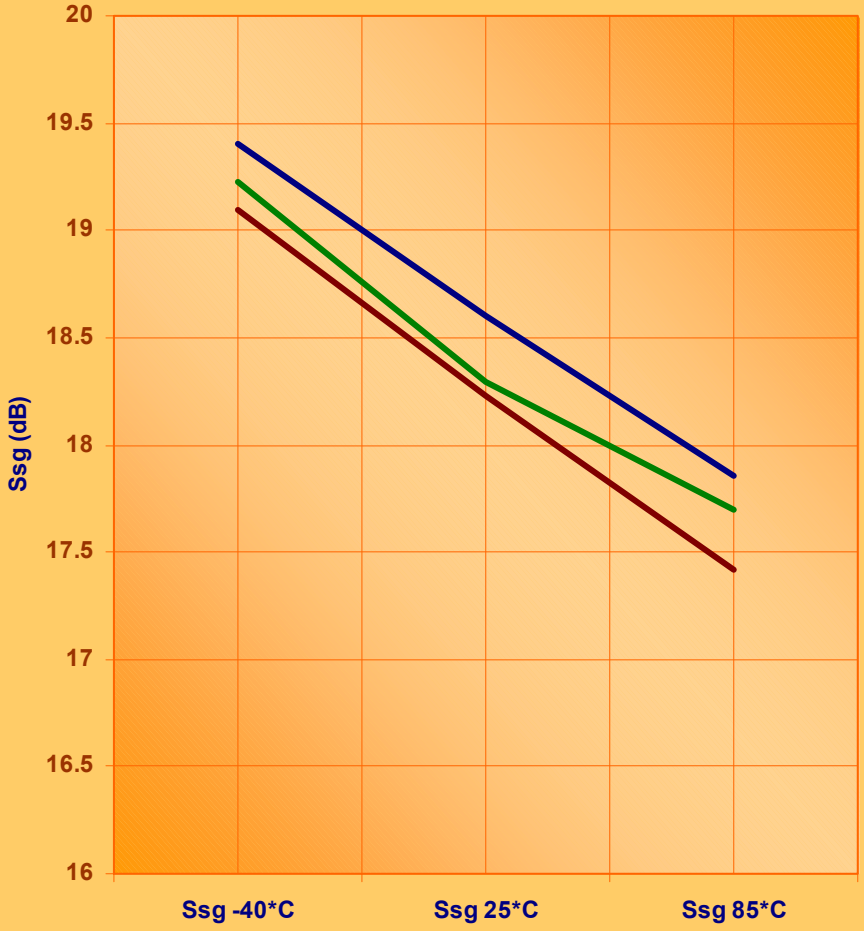
- Product Differentiation
  - Gain @900MHz
    - EC1089:15dB
    - ECG009:19dB
  - Gain @1.9GHz
    - EC1089: 13dB
    - ECG009: 14dB
  - Gain @2.14GHz
    - EC1089: 12dB
    - ECG009: 13.5dB

ECG014 / ECG015

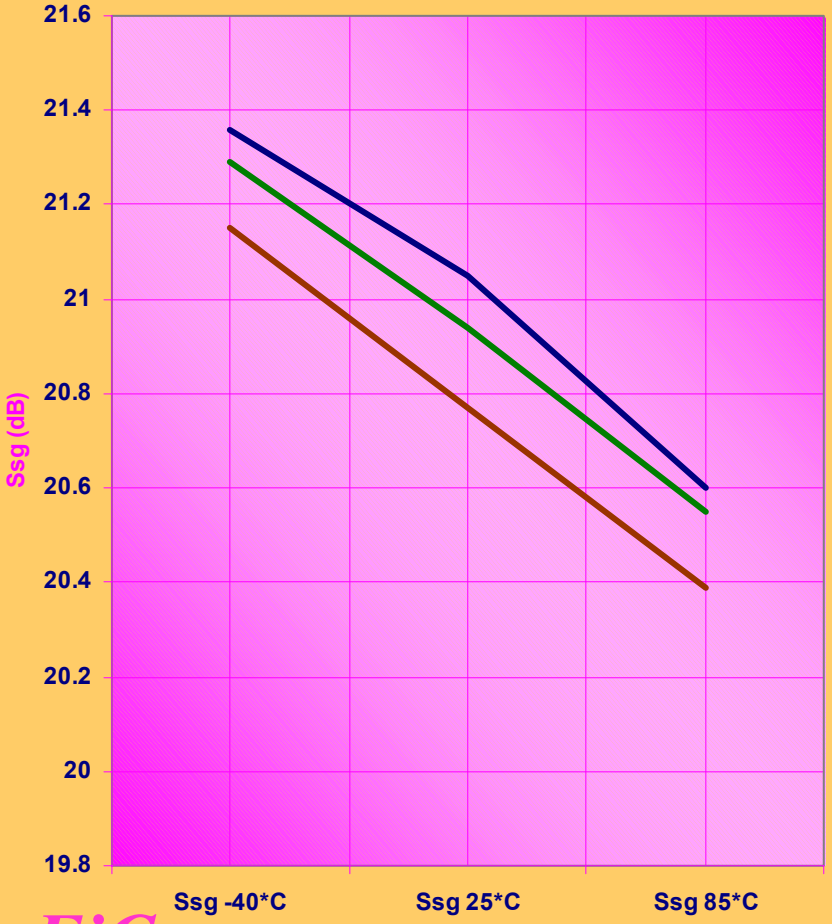
- **Common Features**
  - Allow Vcc>8V operation with a bias resistor
  - Low current, Icc~100mA (typical)
  - P1dB~24dBm
  - Optimize performance with external matching circuits for each band
  - Stable gain over all operating temperature range
- **Product Differentiation**
  - Different frequency band of application
    - ECG014: 50MHz - 1.9GHz
    - ECG015: 1.8GHz - 2.5GHz
  - Gain
    - ECG014:
      20dB @900MHz
      15dB @1900MHz
    - ECG015
      15.5dB @1900MHz
      15dB @2140MHz
      14dB @2450MHz

EVG014 Gain vs. Temperature

3 Eval boards at 1.9GHz



3 Eval boards at 900MHz



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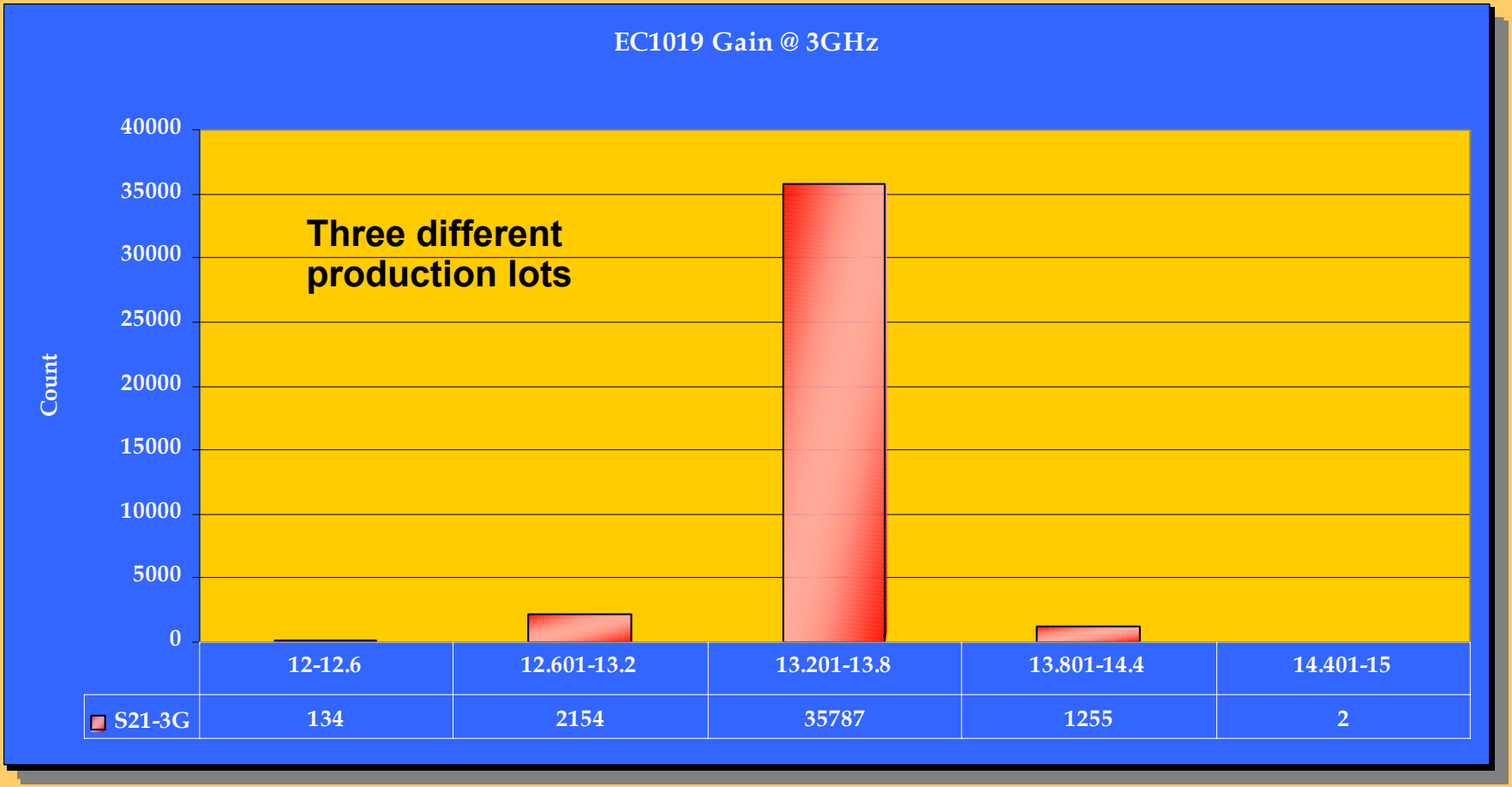
EC1019 Gain SPC Distribution



Benefits of EiC's Gain Block Amplifiers

- Leading-edge performance (Linearity, Temperature Stability, Robustness)
- A complete product family
- Consistent and tight performance distribution
- Consistent quality and delivery from in-house fab
- Good part traceability
  - Wafer fab process lot and package lot numbers are coded on all package marking
  - In-house wafer PCM / final testing SPC data are available for failure analysis
- High reliability EiC InGaP HBT technology
- Low junction temperature through thermal design

IPA
Intermediate Power Amplifier
Coming Soon

IPA's Key Features

- Temperature compensated bias circuit is included
- Class A / Class AB bias can be selected
- Surface mount package
- High P1dB at –45dBc ACPR…linear operation
- EiC InGaP HBT reliability

Intermediate Power Amplifier Target Performance

- One Stage amplifiers
- Adjustable Current feature
- SOIC-8 or 4x4 mm LCC package

	0.5 watt	1-watt	1-watt
	1800-2300 MHz	800-1000 MHz	1800-2300 MHz
	ECP050	ECP102	ECP100
P-1(dBm)	27	30	30
Gain(dB)	13	15	12
Pout(ACPR=-45dBC)	18.0	22.5	21.0
Gain Flatness/200MHz	±0.2dB	±0.2dB	±0.2dB
Phase Flatness/200MHz	±0.7°	±1.2°	±1.2°
S11 (dB)	-15	-15	-15
Vcc (V)	5	5	5
Iop(mA)	250	400	400
OIP3(dBm)	42	45	45
NF(dB)	6.5	7.5	7.0

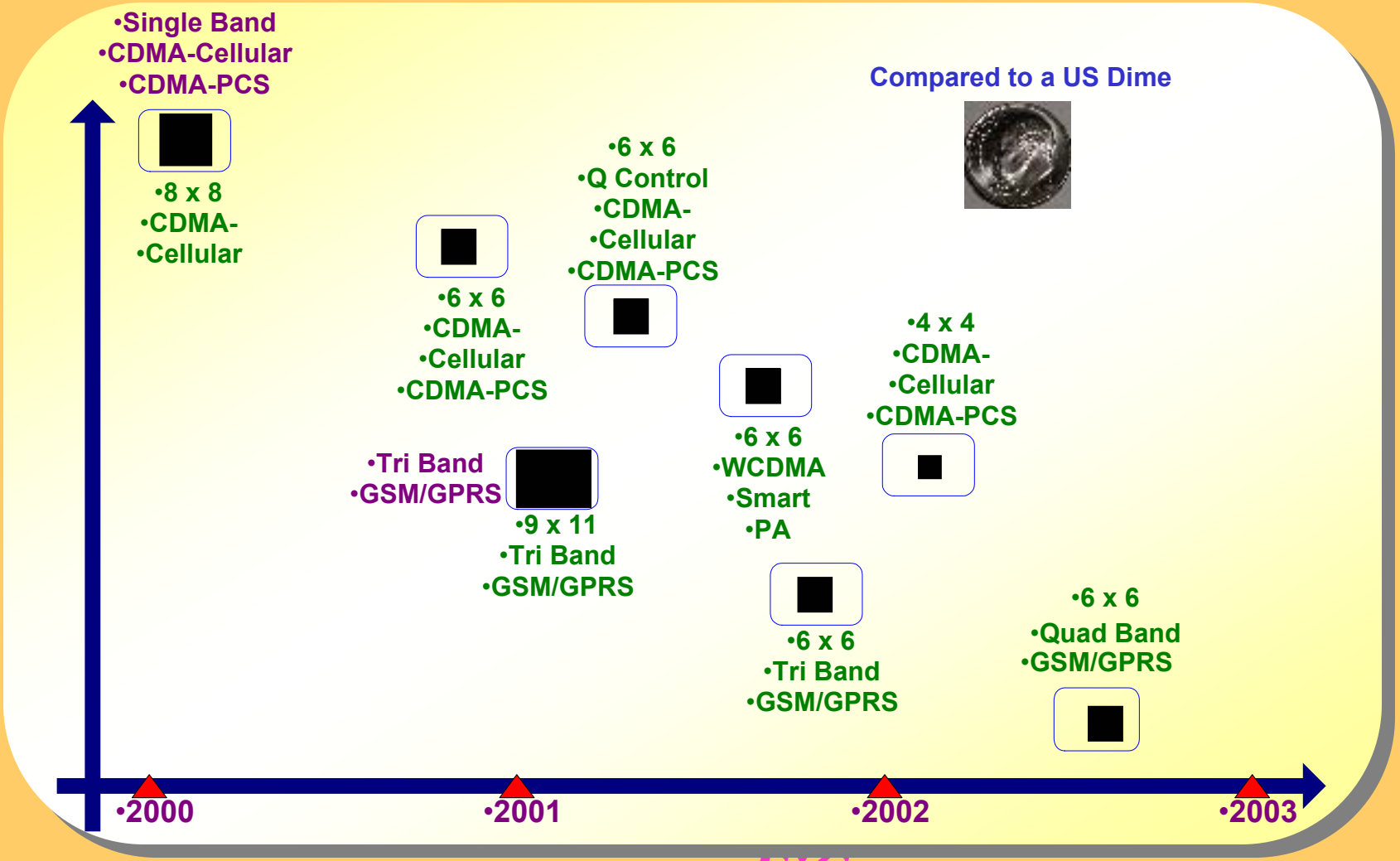
Power Modules
for
2G & 2.5G Cellular Handset

PAM Product Families

	Cellular			PCS		DCS	WCDMA	Size
	US	Japan	GSM	US	Korea			
CDMA	ECM001	ECM005		ECM004	ECM008/ ECM028*			6 X 6mm
CDMA w/ Step Bias Control	ECM011			ECM014	ECM018		ECM010	6 X 6mm
	ECM051*			ECM054*			ECM050*	4 X 4mm*
IS136 TDMA	ECM806			ECM807				
GSM / GPRS-12			ECM007	ECM007		ECM007		9 X 11mm
			ECM009	ECM009		ECM009		6 X 6mm

* Sample in Q2 2002

EiC PAM Product Evolution



New GSM Leadership Products

- New GPRS Handset Power Amplifiers
  - Unique single-chip tri-band design allowing smallest form factor package.
  - Superior thermal design allowing Class 12 GPRS data rates.
  - Available in 6X6 and 9X11 mm LCC packages
- New GPRS Class 12 products position EiC to serve 2.5G handset and PDA (Personal Digital Assistant) customers as well as existing GSM cellular phones
- Leading technology to serve a growing market

Benefit of GPRS-12 Tri-band PAM

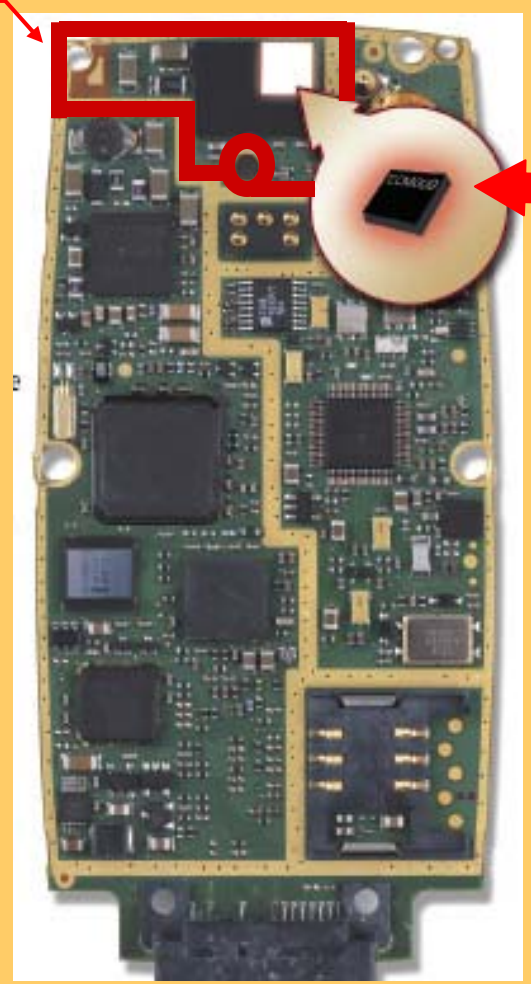
- World's 1st InGaP HBT GPRS Class 12 Tri-Band PAM
- High Module Assembly Reliability with Single HBT Die
- ECM009 is the industry's smallest footprint (6x6mm) Tri-Band GSM solution
- ECM007 is compatible with CX77302 and RF3160 with the benefit of class 12 operation

Key Features of GSM / GPRS Tri-band PAMs

- 9x11mm and 6x6mm footprints (2 PAMs)
- 50 ohms matched at Input and Output
- Tri-band Operation (GSM / DCS / PCS)
- GPRS class 12 operation (50% duty cycle)
- Compatible with ADI, LT & Phillips Power Control IC
- APC has over-voltage protection
- Low ΔPout/ ΔVapc for easy control

World's Smallest GSM/GPRS Power Amplifier Module

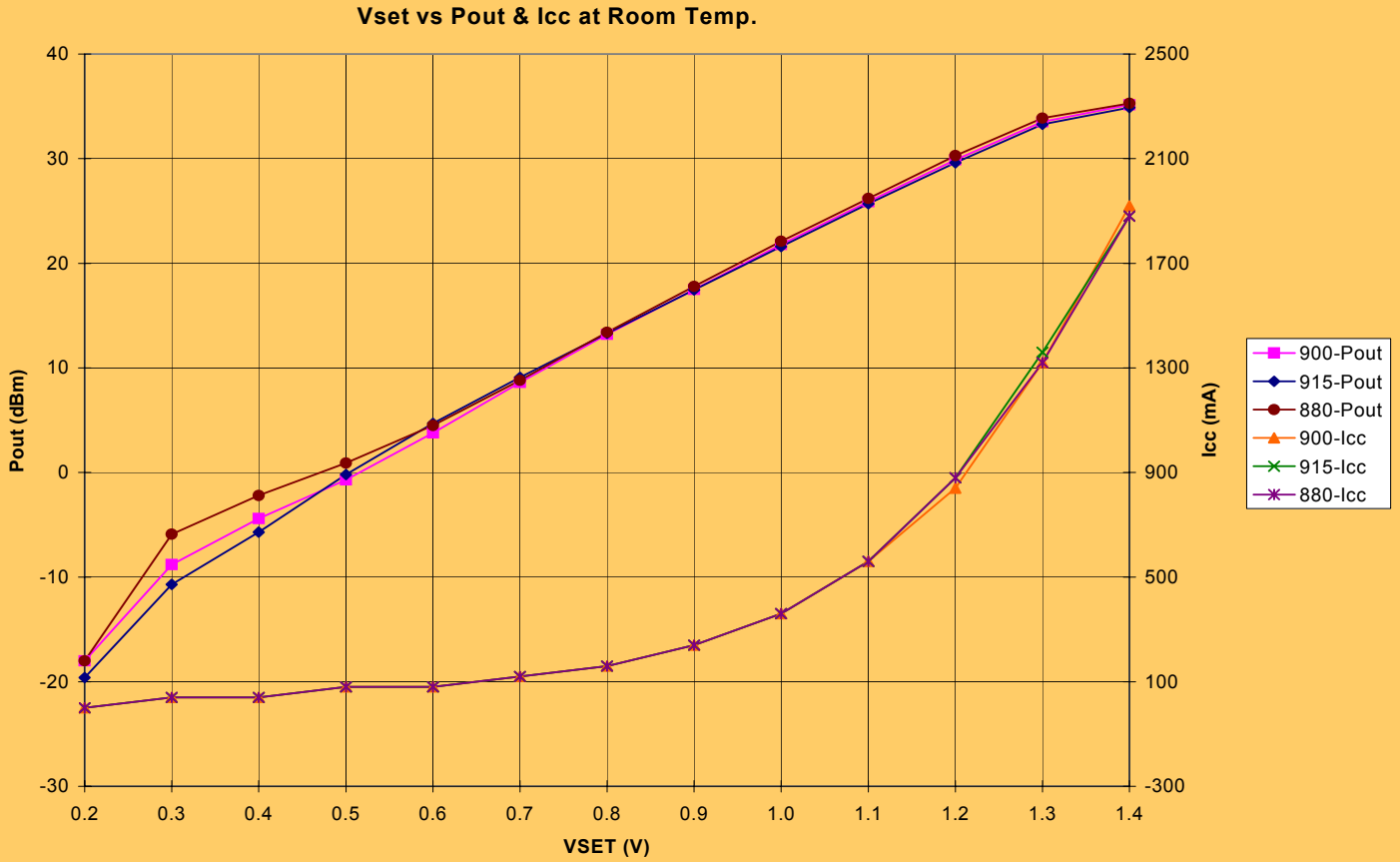
TX Section



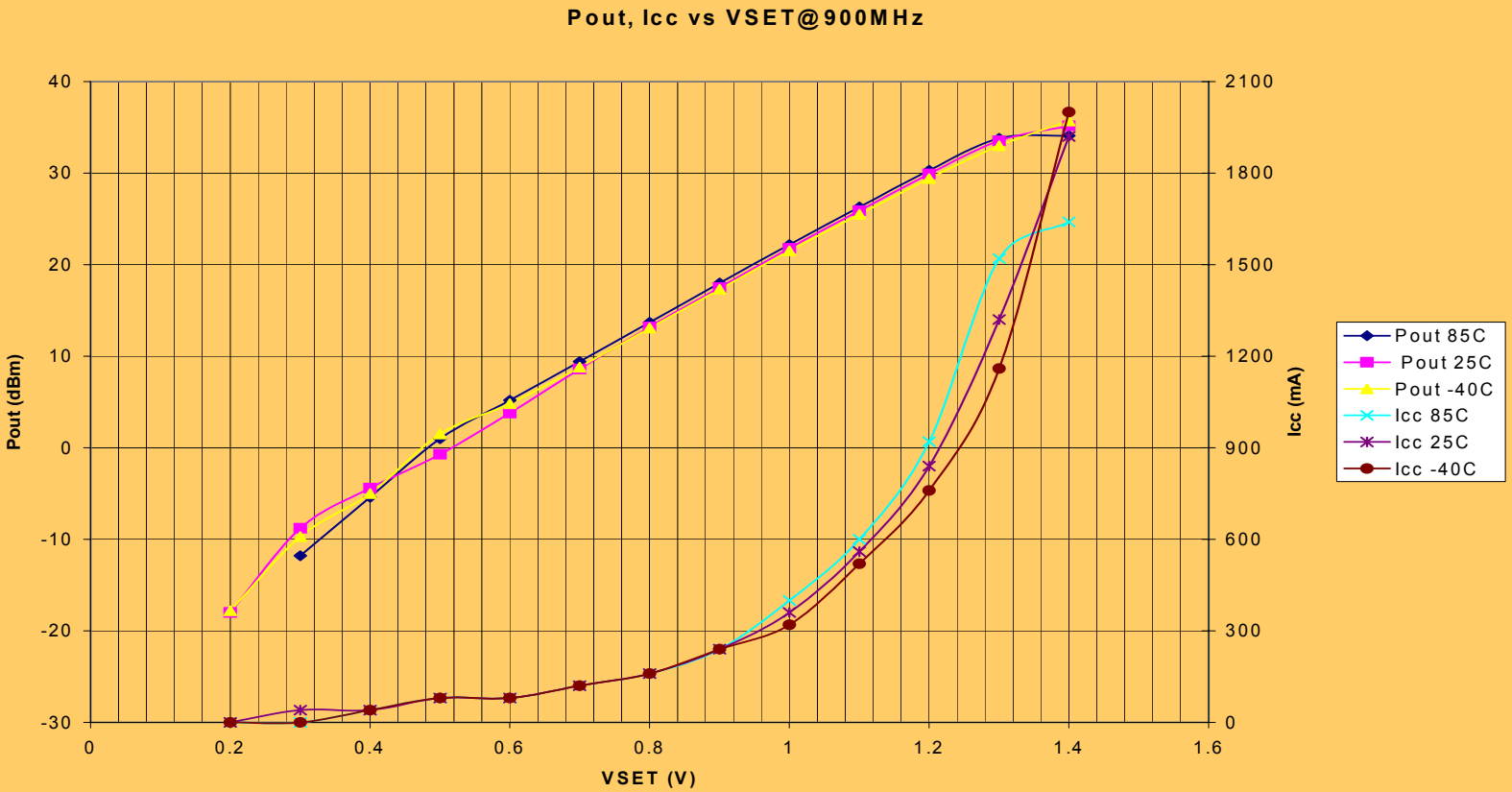
ECM009

- GSM/GPRS Class 12
- Single chip tri-band power amplifier module
- Manufactured using EiC's industry leading InGaP HBT process
- 1/3 the size of current product available
- Increases design flexibility for smaller handsets and PDAs
- Provides more space for increased functionality

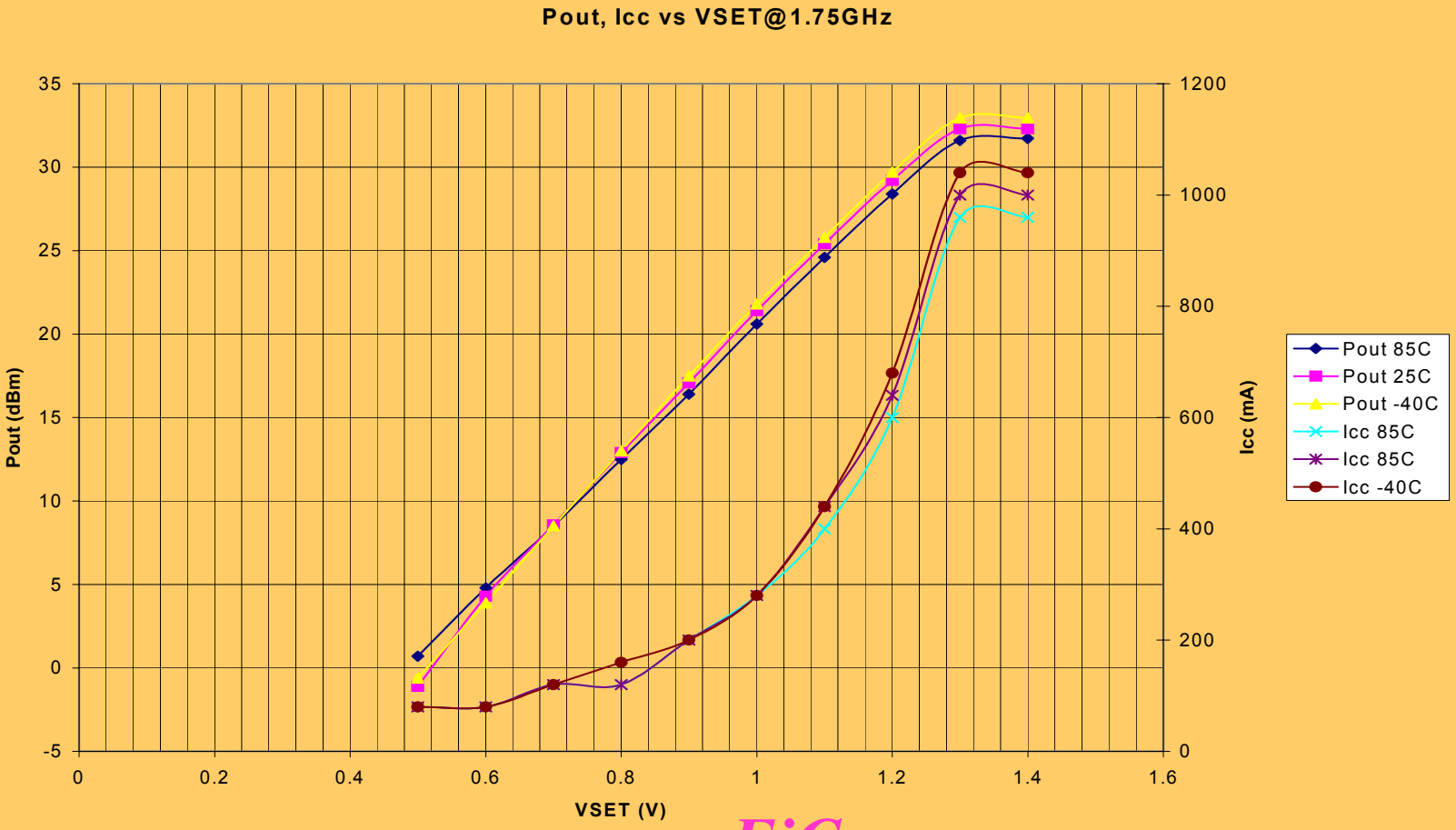
GSM band Power Control Frequency Response



GSM Band Power Control Temperature Response



DCS Band Power Control Temperature Response



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Leakage Current

	25°C		-40°C		85°C	
Leakage Current	DCS	GSM	DCS	GSM	DCS	GSM
BS	2V	0	2V	0	2V	0
V_{APC}	0	0	0	0	0	0
V_{CC}	3.69V	3.82V	3.69V	3.82V	3.69V	3.82V
I_{CC}	2.8uA	2.9uA	0.9uA	0.9uA	10.8uA	11uA

Conclusion

- ECM007/9 are supported by EiC's highly reliable InGaP HBT process
- Single die for easy module assembly and reliability
- Significant board space savings
- EiC ECM009: 6x6 mm…GPRS-12…Tri-Band means market leadership !!

CDMA Power Amplifier Modules

- EiC CDMA PCS modules have industry leading performance
- New Q-Control (stepped bias) CDMA modules are currently being shipped
- Q-Control modules have superior performance vs. competing solutions and unique features
  - Highest efficiency at lower power mode, 9% @ 16dBm Po
  - Temperature compensation circuitry integrated into chip

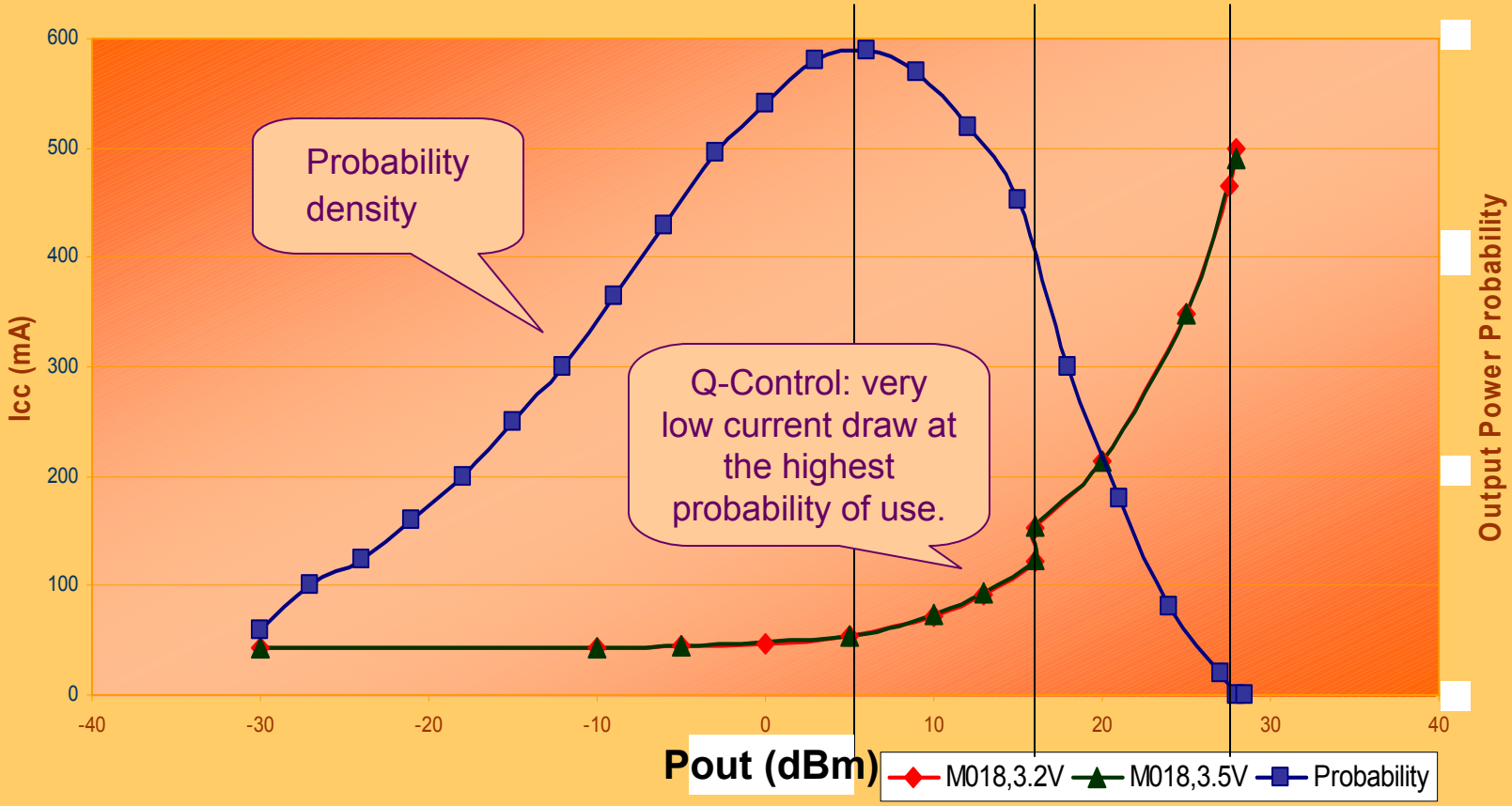
Advantages of EiC's CDMA Q-Control PAM Family (1)

- Highest efficiency at lower power mode, 9% @ 16dBm Pout
  - Longer talk time due to higher probability of use at lower power level
  - 9% efficiency at 16dBm is 33% better than "typical" value of leading competitors

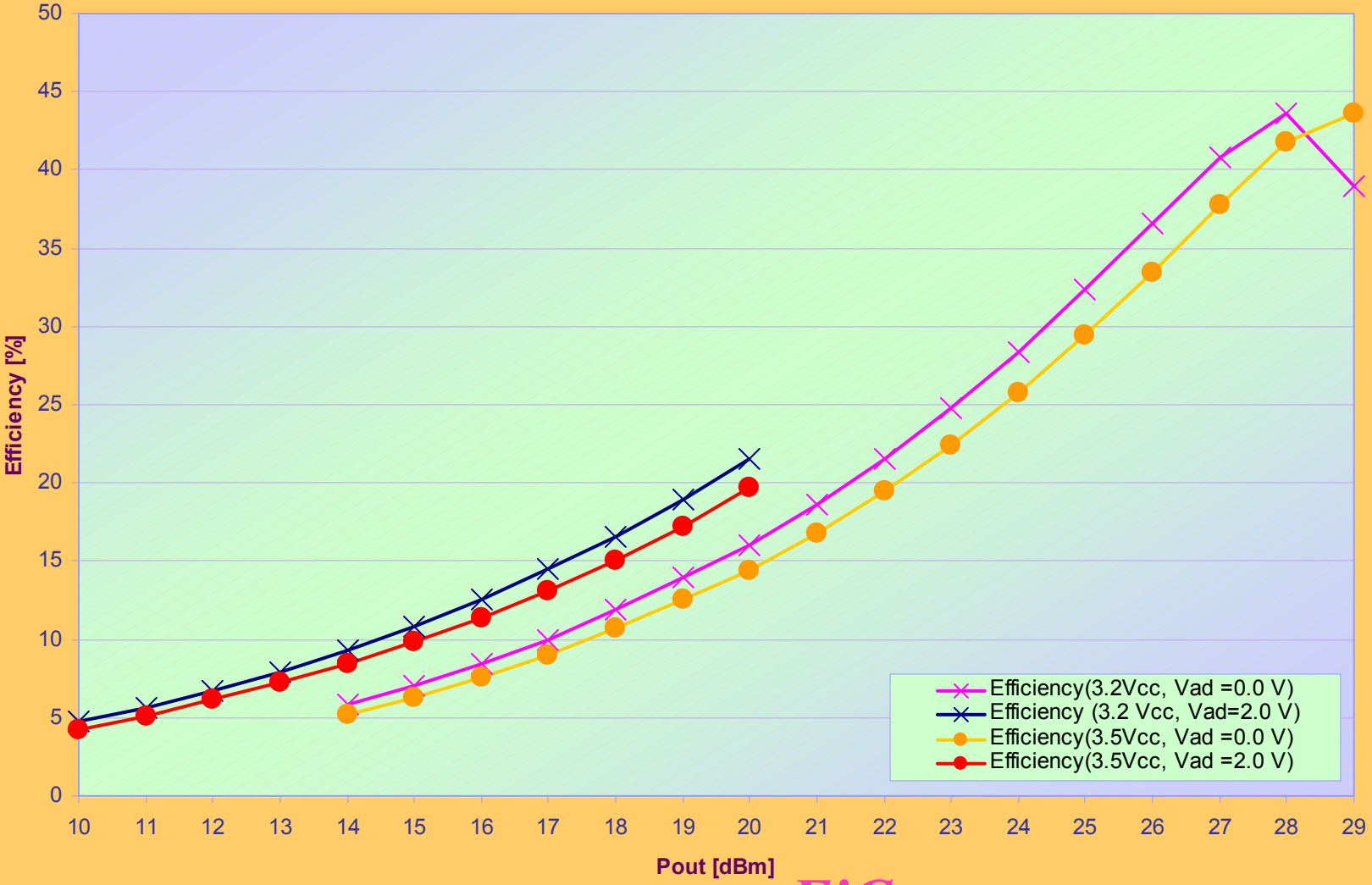
Advantages of EiC's CDMA Q-Control PAM Family (2)

- Less temperature sensitivity with on chip temperature compensation circuitry
  - Quiescent current is well controlled over temperature resulting in higher operation efficiency.
  - ACPR is stable over temperature.
  - As phone board heats up, the Icq is kept constant to further conserve battery power.

ECM018 (PCS-K Band)
Operation Current vs Probability Density



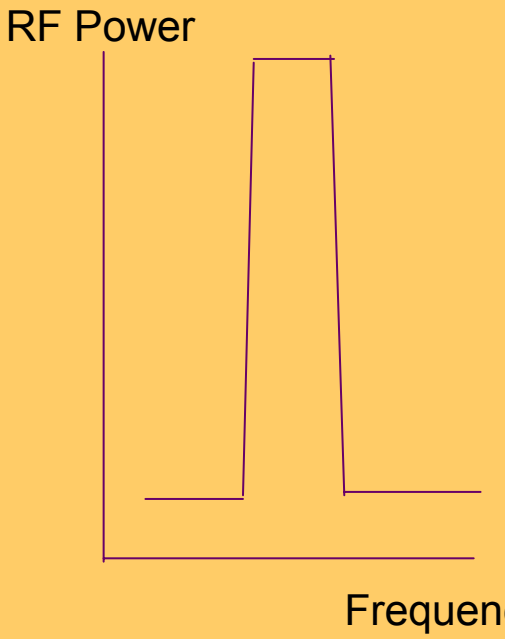
Efficiency vs. Pout of WCDMA

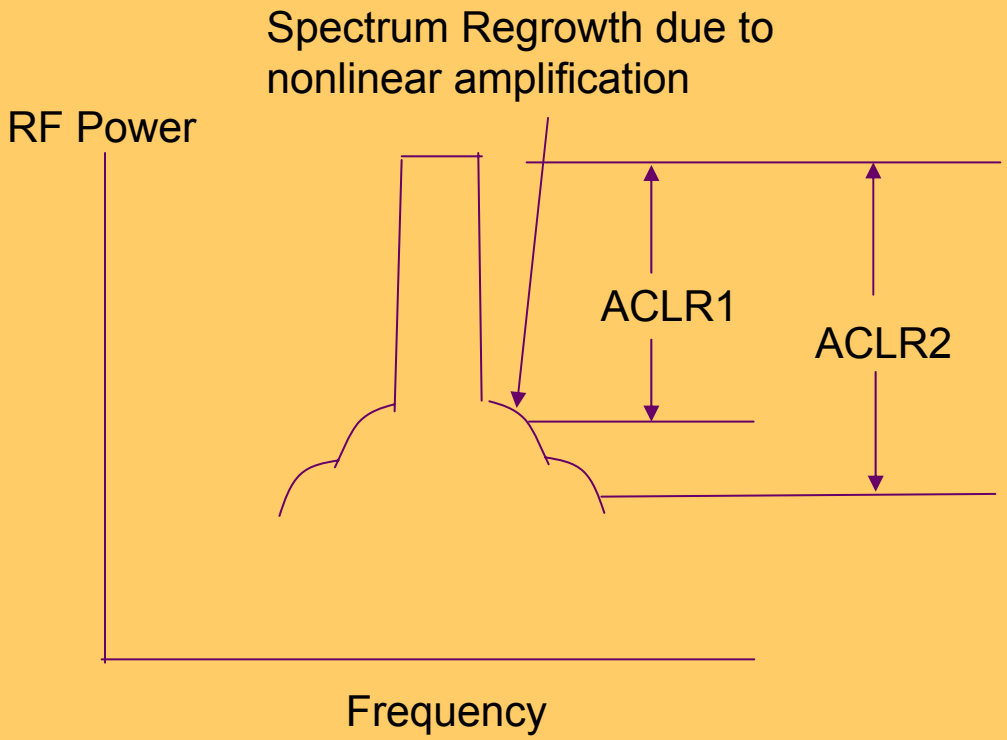


Linearity in CDMA System

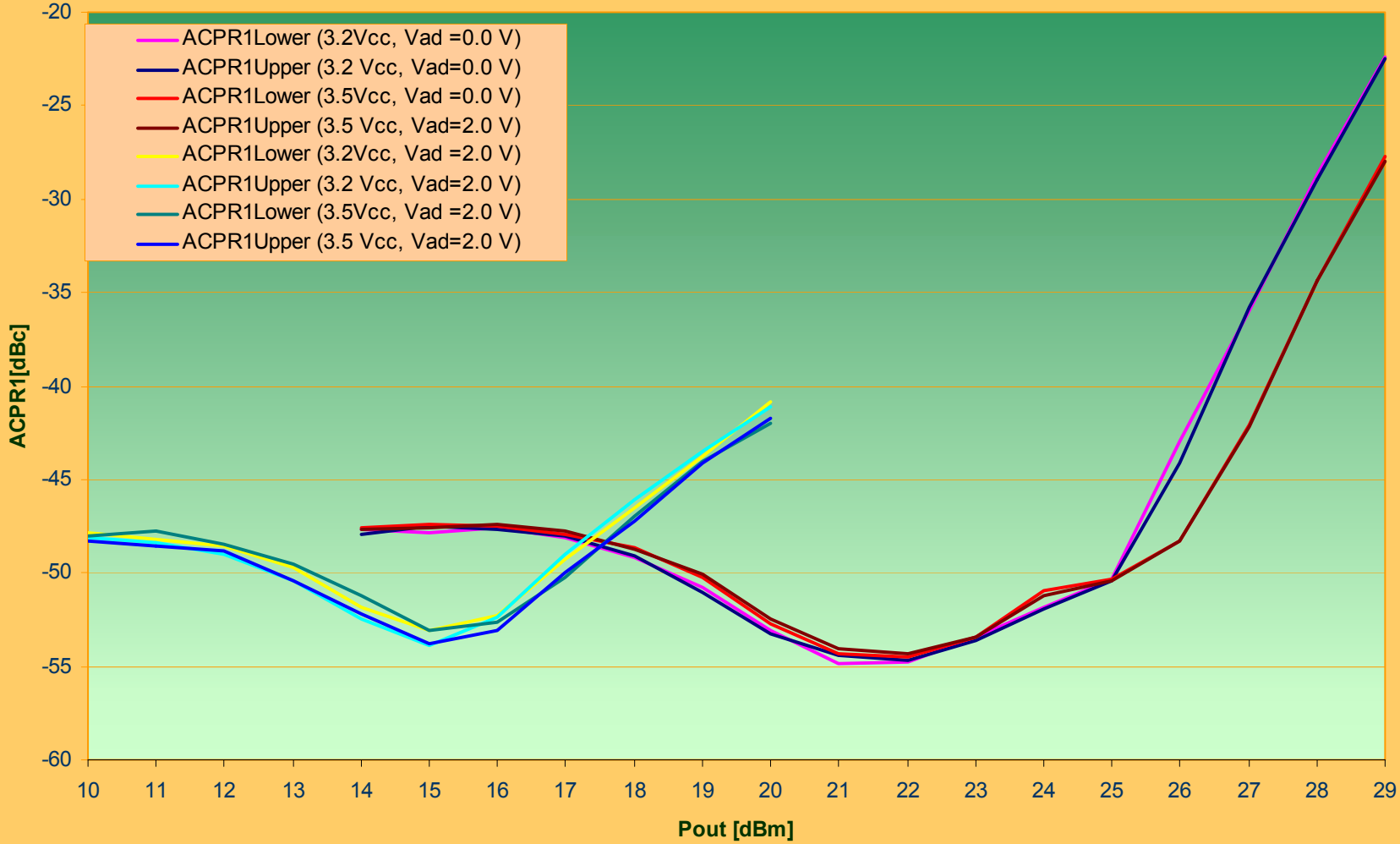
- CDMA-one (IS-95), CDMA-2000, and WCDMA all operate with time-varying amplitude modulation
- Therefore the amplifier non-linearity will increase the spill over of signal power into adjacent and alternate channels
- The linearity of the PAM is measured by ACPR / ACLR

Spectrum Re-growth through a Nonlinear Amplifier

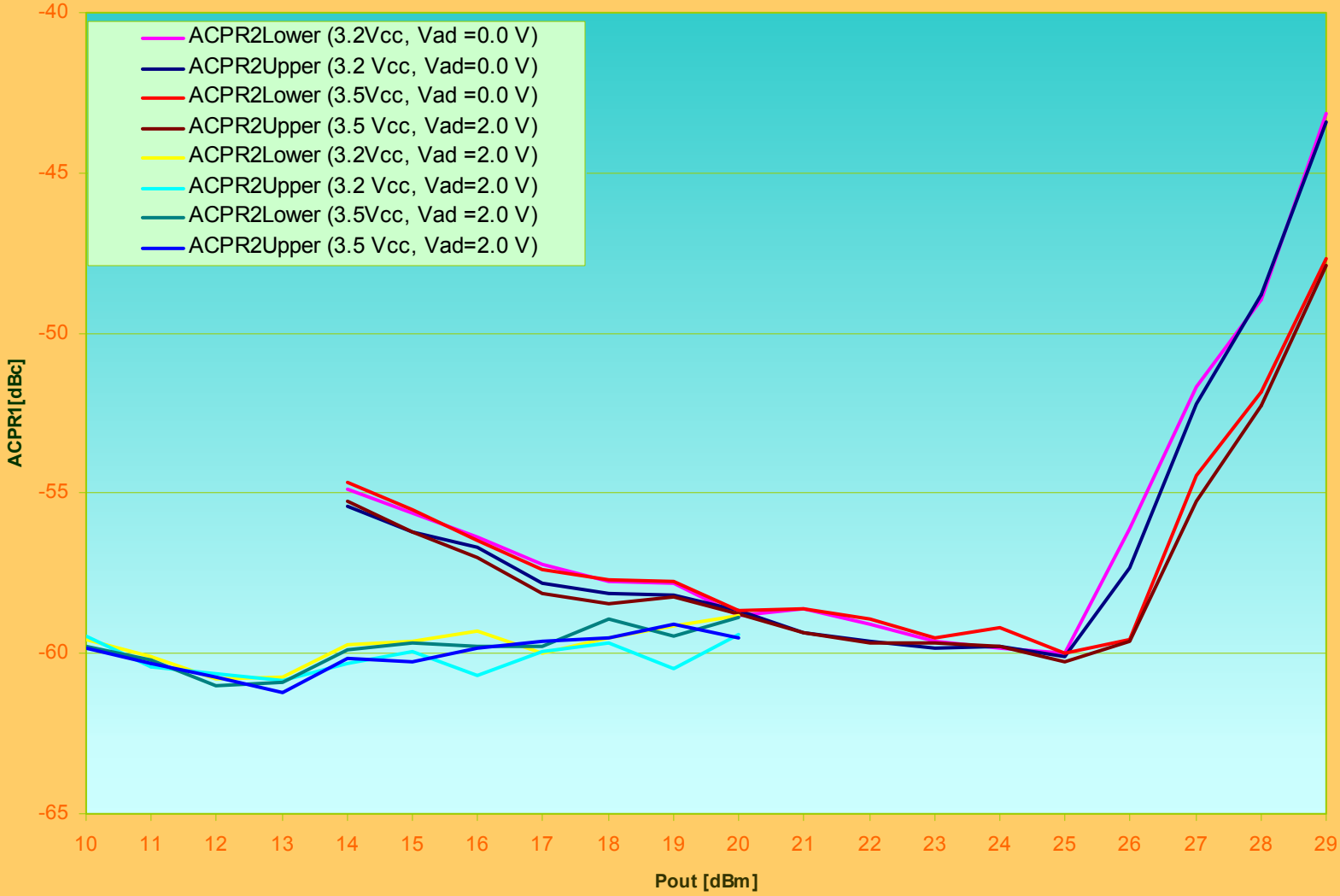




ACLR 1 for WCDMA



ACLR 2 for WCDMA



Benefits of EiC CDMA Q-Control PAM

- Increased Efficiency at Low Output Power Level
  - **Longer Talk Time**
    - Q-Control “stepped bias” feature.
    - Quiescent current is well controlled over temperature resulting in higher operation efficiency.
    - Integrated temperature compensation circuit maintains Icq relatively constant.
      - ACPR is stable over temperature.
      - As phone board heats up, the Icq is kept constant to further conserve battery power.
- Same PAM operation current over full temperature range.
- Reliable world class package