

Features

- DC to 3000 MHz
- 40 dBm Typical OIP3 at 1000 MHz
- Highly Reliable InGaP HBT
- 15.0 dB Typical Gain at 1000 MHz
- 23.0 dBm Typical P1dB at 2000 MHz
- 4.8 dB Typical Noise Figure at 2000 MHz
- Excellent Stability

Applications

- Multi-carrier Systems
- High Linearity Amplifiers
- Cellular, PCS, WLL

Package Available

(-B) SOT-89

Description

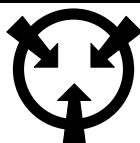
The ECG008 is a high reliability, high OIP3 amplifier in a low cost SOT-89 package, optimized for the commercial communications market. The device is manufactured using advanced Indium Gallium Phosphide Heterojunction Bipolar Transistor (InGaP HBT) technology. The amplifier is internally matched to achieve low VSWR and high OIP3 over the DC to 3000 MHz range. Typical OIP3 at 1000 MHz is +40 dBm. The ECG008 operates from a single positive voltage power supply. The ECG008 is designed in the Darlington configuration with direct feedback. Its operation frequency at low end is limited only by the DC blocking capacitor and the RF choke inductor (large values are required in both cases).

Electrical Specifications

Test Conditions: $I_c = 120\text{mA}$ $T_a = 25^\circ\text{C}$,

| SYMBOL | PARAMETER | | LIMITS | | | UNIT | TEST CONDITION |
|-------------------|---------------------------------|--|--------|----------------------|------|------|----------------|
| | | | MIN. | TYP. | MAX. | | |
| F | Frequency | | DC | | 3000 | MHz | |
| G | Gain (Small Signal) | f = 1000 MHz f = 2000 MHz f = 3000 MHz | 13 | 15.0 15.0 15.0 | | dB | |
| P _{1dB} | Output Power @ 1 dB Compression | f = 1000 MHz f = 2000 MHz f = 3000 MHz | | 24 23 20 | | dBm | |
| OIP3 | Output Third Order Intercept | f = 1000 MHz f = 2000 MHz f = 3000 MHz | 34 | 40 37 33 | | dBm | Note 1 |
| RL _{IN} | Input Return Loss, 50 Ohm | 1000 to 3000 MHz | | 18.0 | | dB | |
| RL _{OUT} | Output Return Loss, 50 Ohm | 1000 to 2000 MHz | | 14.0 | | dB | |
| RL _{OUT} | Output Return Loss, 50 Ohm | 3000 MHz | | 9.0 | | dB | |
| NF | Noise Figure | f = 1000 MHz f = 2000 MHz | | 4.6 4.8 | | dB | |
| V _{de} | Device Voltage | | 6.8 | 7.3 | 7.8 | V | |
| | Output Mismatch without Spurs | | | 10:1 | | | |

Note 1: $OIP3 = P_{out} \text{ (by power meter, total 2-tone power)} + (IM3 \text{ (dBc)}) / 2 - 3 \text{ dB}$

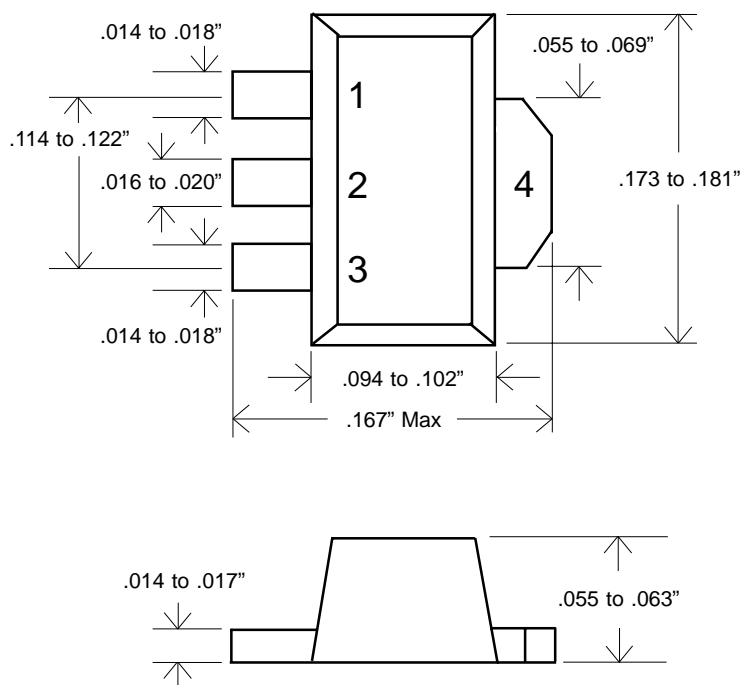


CAUTION!
SENSITIVE ELECTRONIC DEVICE

Absolute Maximum Ratings

| | | |
|-----------------------|-------------|-----|
| Device Current | 160 | mA |
| RF Power Input | 10 | dBm |
| Operating Temperature | -40 to +85 | °C |
| Storage Temperature | -65 to +150 | °C |
| Junction Temperature | 200 | °C |

Package Outline



Pin Definitions

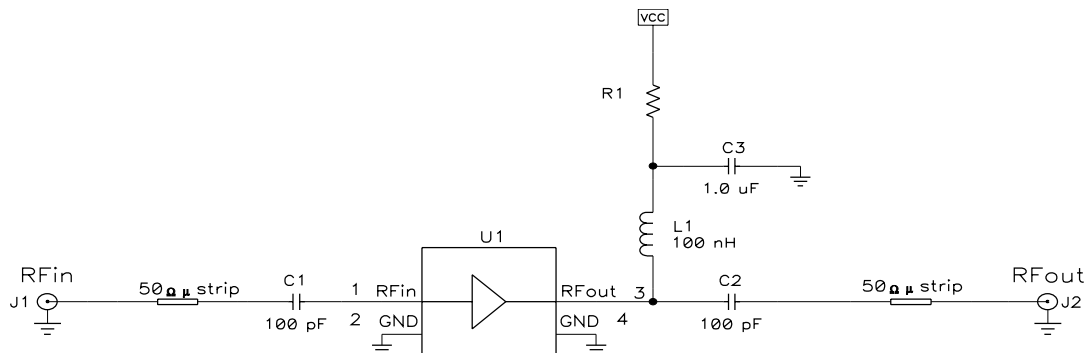
| Pin # | Pin | Definition |
|-------|-------|--|
| 1 | RFin | This pin has a nominal 50 ohm input impedance. It requires a DC blocking capacitor large enough to handle the lowest frequency used. |
| 2, 4 | Gnd | The two ground connections should be directly connected together to the ground plane on the PCB. The ground connection also serves as a heatsink. |
| 3 | RFout | This pin has a nominal 50 ohm output impedance. It requires a DC bias of 120mA through a series inductor and a resistor. A bypass capacitor (1.0 micro Farad) on the DC side of the inductor is recommended for providing instantaneous current during a modulated RF signal. Use a DC blocking capacitor on the output with similar requirements as the input side. |

Evaluation Board Schematic
SOT-89

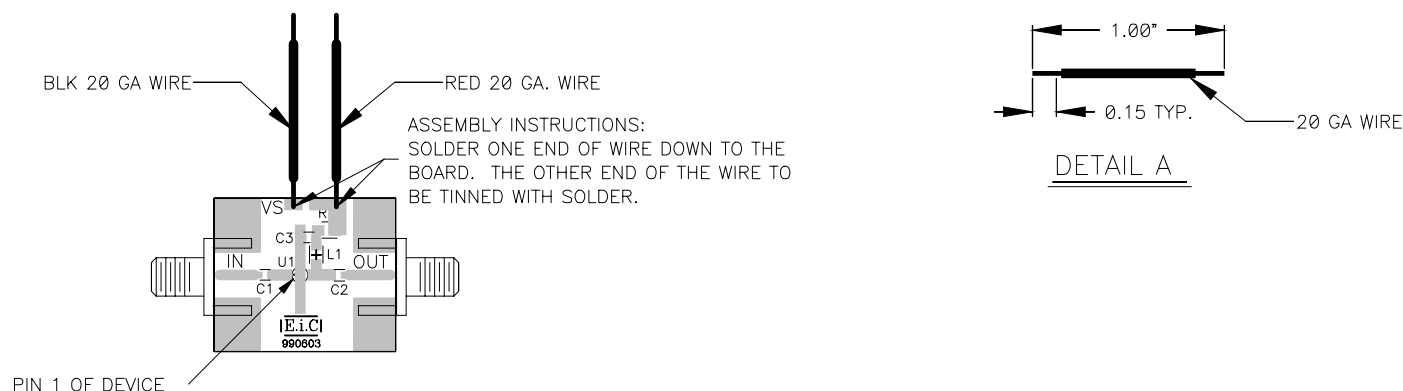
Recommended Bias Resistor Values

$$R = (V_{cc} - V_{de}) / I_{cc} = (V_{cc} - 7.3) / 0.120$$

| | | | | |
|--|----|----|----|----|
| Approximate Supply Voltage (V_{cc}) based on standard values for R1 | 9 | 10 | 11 | 12 |
| R1 (Ohms) | 15 | 22 | 30 | 39 |



Evaluation Board Layout



Evaluation Board Materials

| MANUFACTURER | PART NUMBER | QTY | VALUE | DESIGNATOR |
|--------------------|---------------|-----|--------|------------|
| MARUWA | CE101J1N0 | 2 | 100 pF | C1,C2 |
| MARUWA | CE105K1NR | 1 | 1uF | C3 |
| ROHM | MCR10J300 | 1 | 30ohm | R1 |
| TOKO | LL2012-FR10K | 1 | 100 nH | L1 |
| EF JOHNSTON | 142-0701-881 | 2 | | IN,OUT |
| ETC CORP | EC0008 | 1 | | U1 |
| ETC CORP | 60-000009-003 | 1 | - | |
| 20 GA. WIRE X 1.0" | ANY | 1 | RED | |
| 20 GA. WIRE X 1.0" | ANY | 1 | BLK | |

NOTE 1 & 2

NOTE 1

NOTE 1

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NOTE 1

SEE DETAIL A

SEE DETAIL A

1. EIC RECOMMENDED COMPONENTS ARE SHOWN. EQUIVALENT COMPONENTS MAY BE USED.
 2. LARGER VALUES GIVE BETTER LOW FREQUENCY RESPONSE (<500MHz)
- NOTES: UNLESS OTHERWISE SPECIFIED

Figure 1

Vde vs. Icc
(IC Tested on Eval Board)

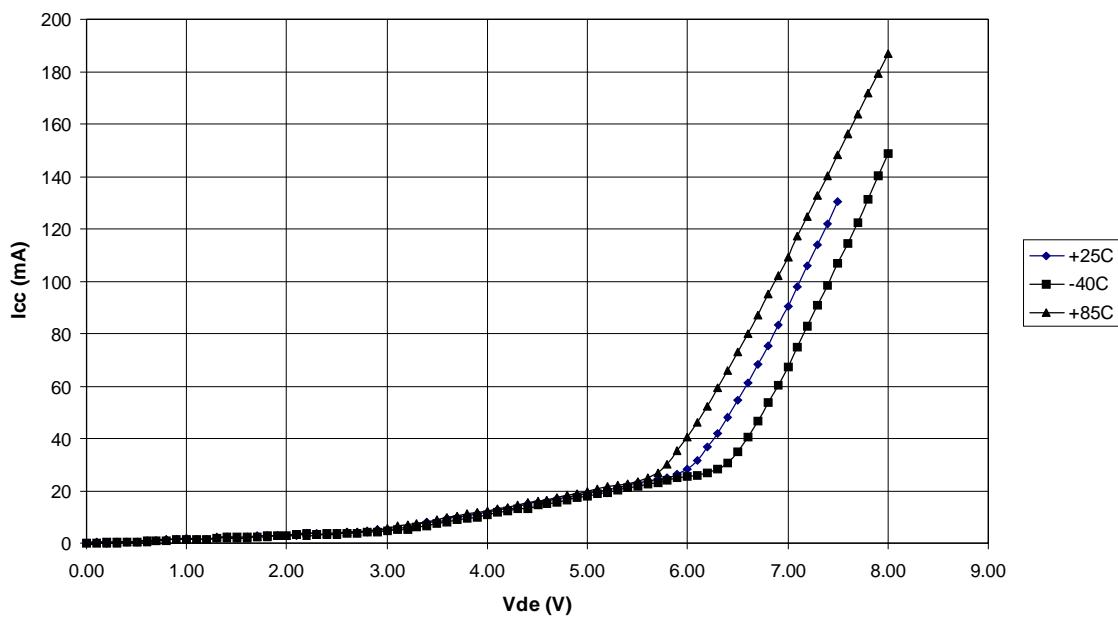


Figure 2

P1dB vs. Frequency
(IC Tested on Eval Board)

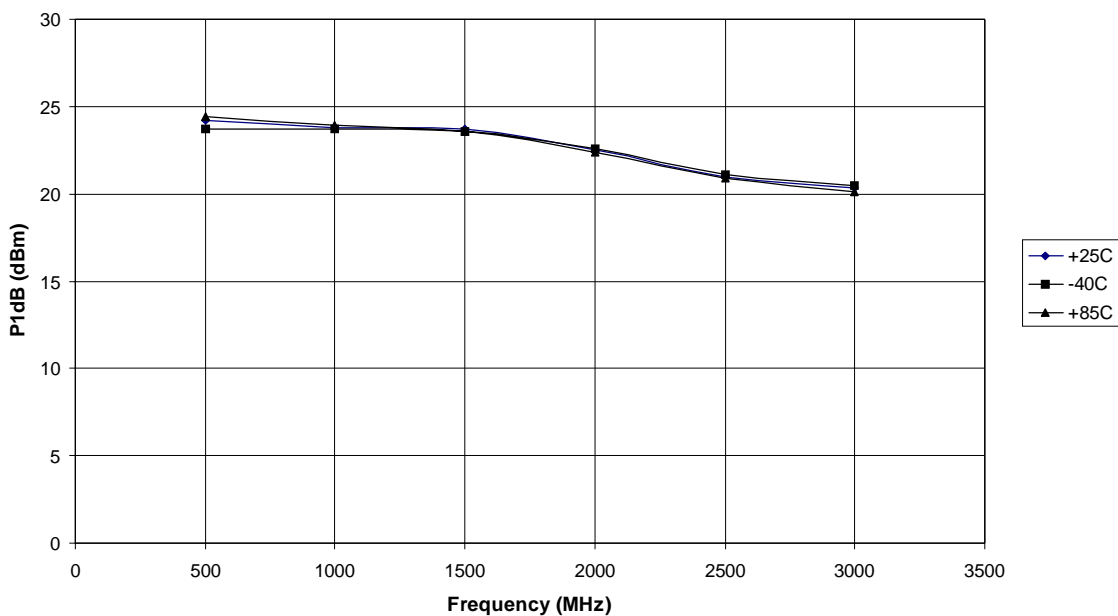


Figure 3

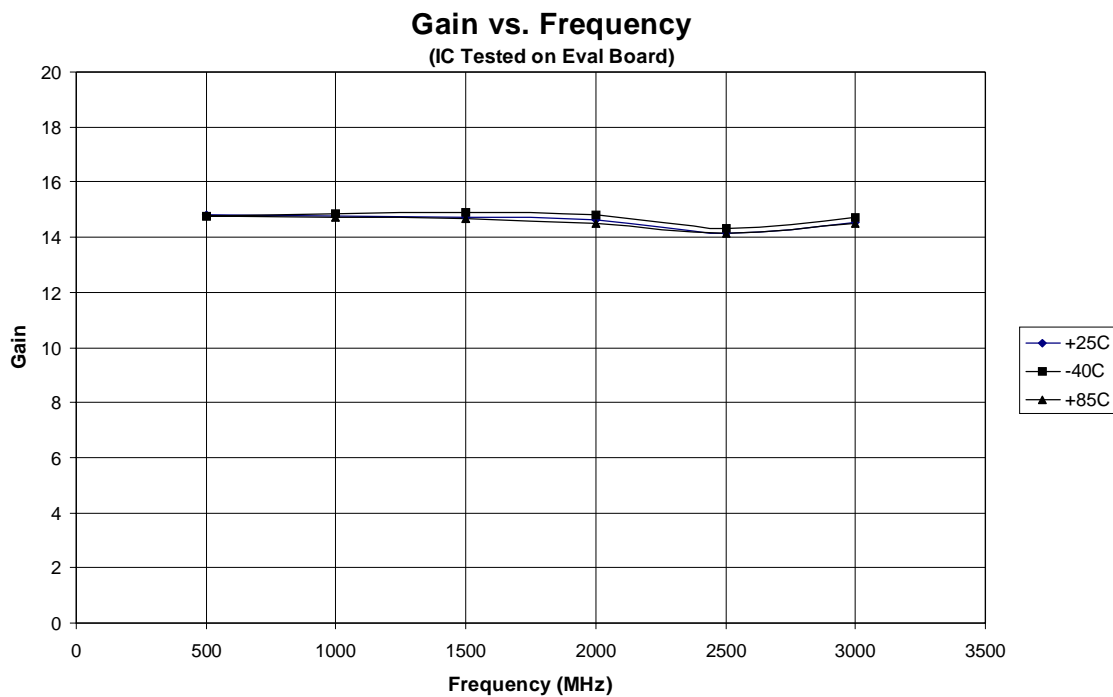


Figure 4

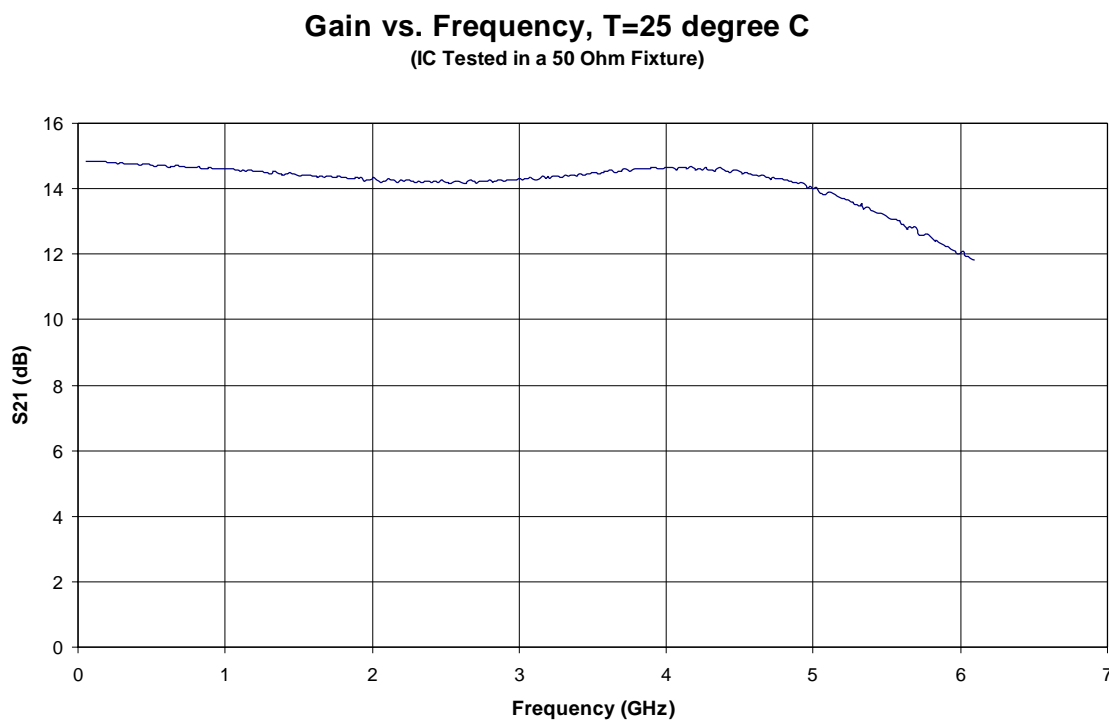


Figure 5

S11, S22 vs. Frequency, T=25 degree C

(IC Tested in a 50 Ohm Fixture)

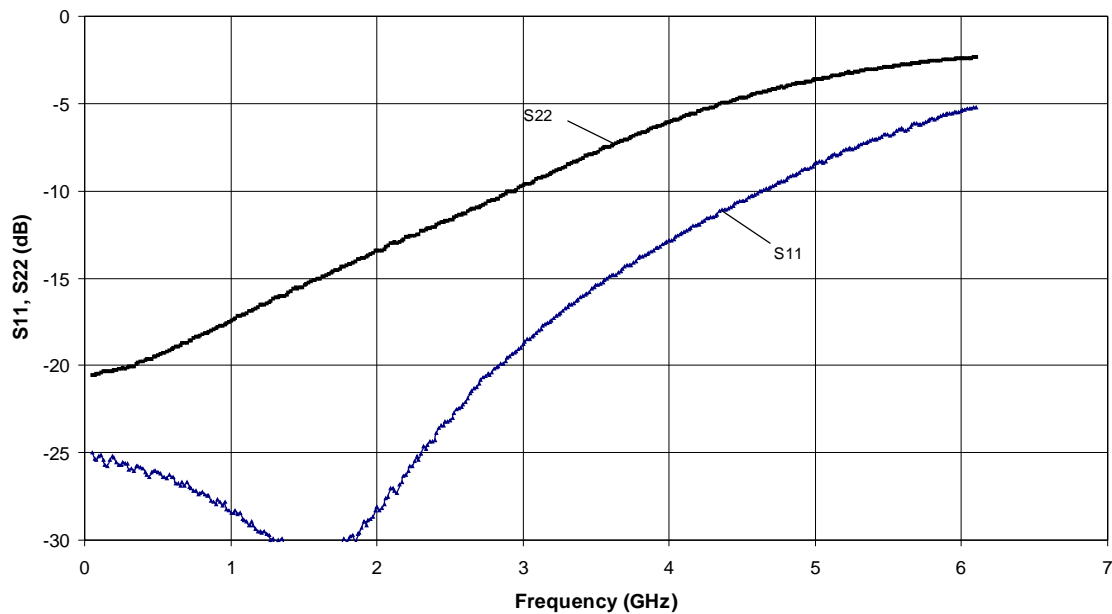


Figure 6

Reverse Isolation vs. Frequency, T=25 degree C

(IC Tested in a 50 Ohm Fixture)

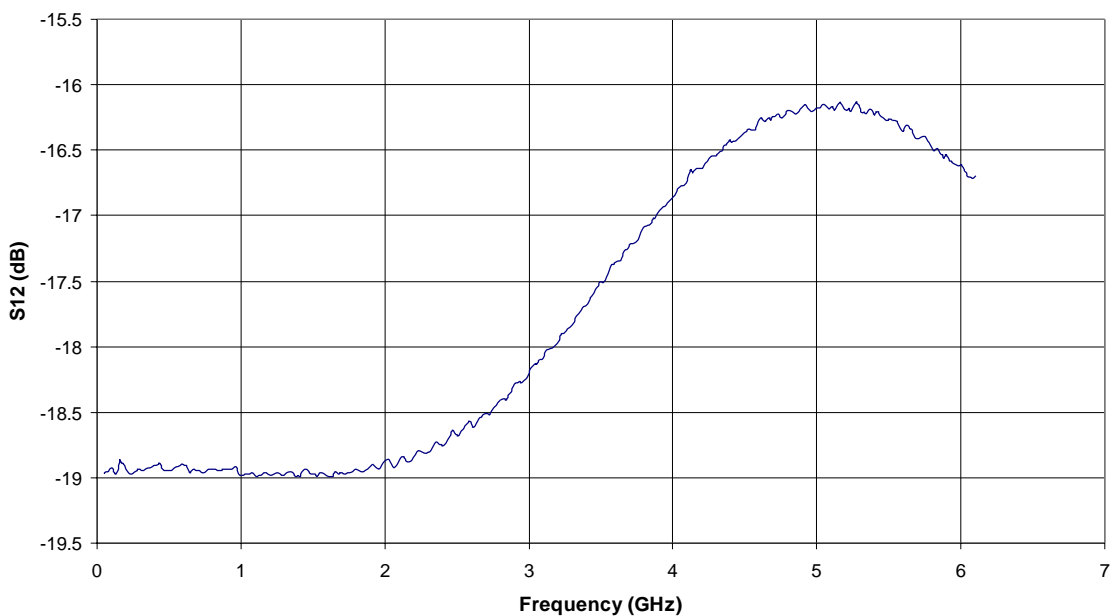


Figure 7

OIP3 vs. Frequency
(IC Tested on Eval Board)

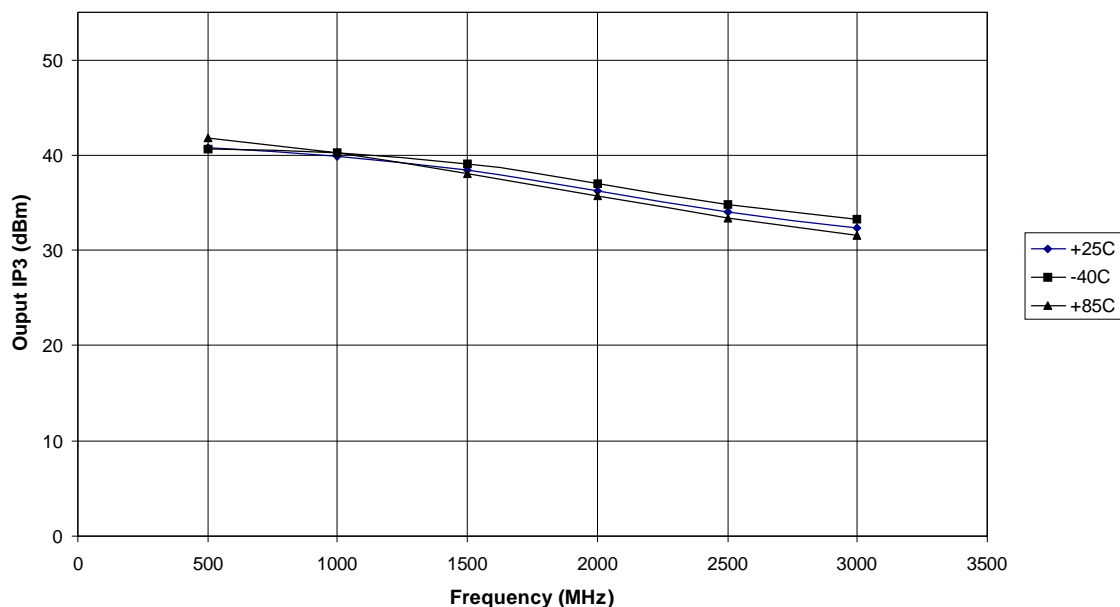
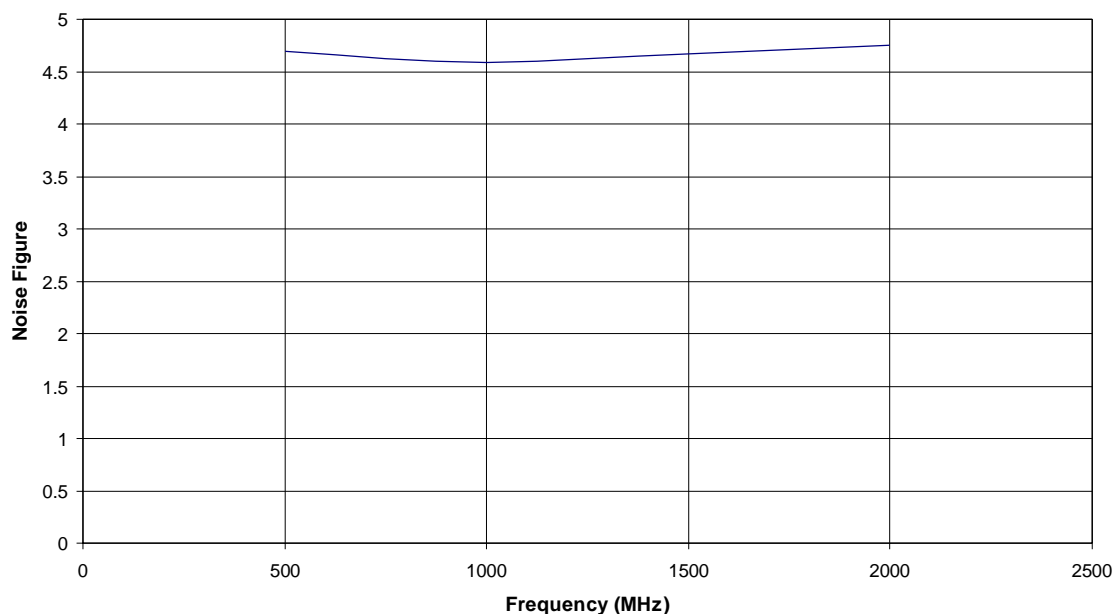


Figure 8

Noise Figure vs. Frequency
(IC Tested on Eval Board)



Application Note:

1. Bias Resistor

Bias resistor is needed for the Darlington type gain blocks. As shown in the I_{cc} vs. V_{de} chart, the curve shifts with temperature as a result of the HBT V_{be} versus temperature. To minimize the impact, dc resistor is required to maintain the gain block operating at the same current range over temperature.

The larger voltage drop across the bias resistor, the more stable operation current will be maintained. 2V or more voltage drop would be sufficient. A table of bias resistor value is given for convenience; user can find their own solution.

The bias resistor size needs to be sufficient to sustain the power dissipation across it.

2. operation frequency

The Darlington type amplifier has direct feedback through resistors. Therefore the low end operation frequency is only limited by the dc blocking capacitors (C1 and C2) and the RF choke (L1).

When the IC is tested in the 50 ohm fixture, the S parameters are measured down to the low end limit by the network analyzer.

3. Gain flatness versus frequency

The plastic package plays an important role in the gain versus frequency, as well as the PCB layout. The package introduces parasitic inductance. The PCB has the ground plane in the backside, and the package is connected to the backside board through PCB via holes. The PCB via holes also introduces inductance. Therefore the IC operates with parasitic grounding inductance which limits the frequency response and reduces the gain into higher frequency. A thick PCB will have large parasitic grounding inductance and will reduce the gain even more at several GHz range.

EiC Gain Blocks Series

Introduction

EiC Gain Block family is made up of a series of high reliability Darlington Amplifier. They are broad band feedback amplifiers matched for 50 ohms operation.

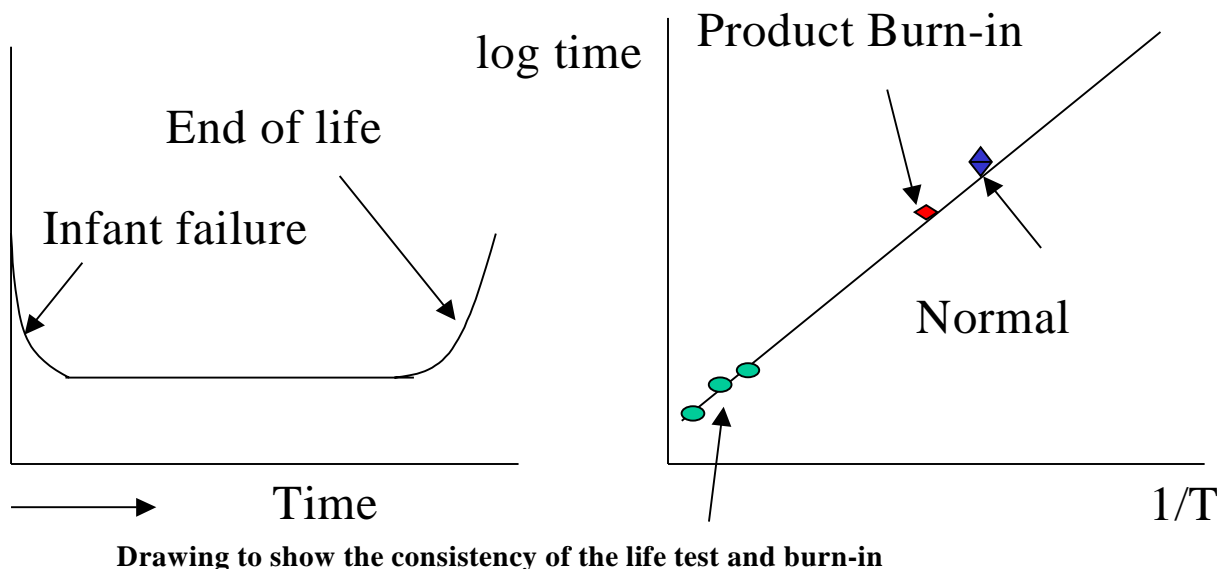
The amplifier series covers from a low 10dBm P1dB to the 23dBm range, with OIP3 up to 40dBm.

They are packaged typically in the plastic micro-X package. The high power amplifiers are in the SOT89 package for better thermal dissipation. All the parts were designed with low thermal resistance to provide low junction temperatures and long lifetime.

I. InGaP HBT offers Reliability and Quality

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

The HBT life test of EiC InGaP HBT has gone through 315°C junction temperature and 50kA/cm² for over 6000 hours (8 ½ months), translating to millions of hours of lifetime at normal operating conditions [1]. **This life test result is far superior to the conventional AlGaAs HBT, as well as many other reported InGaP HBT.**



Product Burn-in time

HBT lifetime ACLT
(Accelerated lifetime testing)

The InGaP HBT product would go through product burn-in test as well. A large sample group, usually 100 pieces, goes through burn-in test at ambient temperature of 125 to 145 °C for 1000 hours. The FIT can be calculated based on the number of failed devices, activation energy, etc. The MTTF is simply 1/FIT. This MTTF should agree with the HBT life test result when HBT is the dominant failure mechanism (not other IC components like resistor, inductor, capacitor, etc).

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 can be flawed.

II. Careful Thermal Design of the Darlington Amplifier

Although the Darlington Amplifier series is not high power (<25dBm), the thermal design is still a key factor affecting the reliability. Even for a low power amplifier, if the HBT cells are closely spaced on the IC die, the transistor junction temperature can still be high, negatively affecting the reliability.

Utilizing EiCs experience on Power Amplifiers, each Darlington Amplifier is carefully designed and laid out to provide a low thermal resistance. The ballasting is also carefully crafted, which is a must for any bipolar transistor (Si BJT, SiGe BJT, AlGaAs/GaAs HBT, InGaP/GaAs HBT, HBT family on InP substrate).

III. High Linearity

HBT is known for its high linearity [3]. Applying this feature to the Darlington Amplifier, a high OIP3 amplifier is made.

Compared with other transistor technology, InGaP HBT has easy process control which allows the OIP3 to be maintained in volume production.

IV. Broad Frequency Band Operation

The Darlington Amplifiers are designed with direct feedback. There is no capacitor on the circuits to limit the operation frequency. The application of the circuit is very simple: dc blocking capacitors at input and output, a choke inductor at the output, followed by a temperature stabilizing resistor.

The low end of the frequency band is limited by the external components: the dc blocking capacitors and the choke. The dc blocking capacitors must have a large value to allow the RF signal to go through: $50\ \text{ohms} \gg 1/(\omega C)$. For example, at 100MHz, a 1000pF capacitor has an impedance of $1/j0.628 \sim -j1.6\ \text{ohms}$, and will allow the RF signal to go through easily; but a 10pF capacitor has an impedance of 160 ohms, effectively blocked the RF signal.

The choke has a similar effect: ωL must be large enough at the low frequency compared with 50 ohms. At 100MHz, a 1000nH will provides a shunt impedance of

j628ohms and is effective as a choke; but a 100nH will have only j62.8ohms, affecting the output matching impedance of the Darlington Amplifier.

The high end of frequency band is determined by the package parasitics and the transistor's own capacitance. The package parasitics is presented as inductance from the pin. The pin inductance at input and output will deviate the impedance from 50ohms. A 1nH pin inductance at 5GHz presents an impedance of j31.4ohms, sufficient to deviate the input and output return loss. The ground pin inductance will have even more profound effect on the amplifier performance.

The transistor has its own parasitic capacitance, which limits the frequency bandwidth as we learned from Electronics 101. A higher power amplifier will need a larger size HBT, and the associated large transistor capacitance will reduce the frequency bandwidth. Therefore the frequency bandwidth of the high power version will be more limited than the low power ones.

Since the amplifier drives 50 ohms load directly, a high power amplifier will need to deliver more RF current and sustain more RF voltage swings. Therefore the high power amplifier will need to be biased at higher voltage and draw more dc bias current.

If an amplifier needs to operate with very broad frequency band, the external components need to be carefully traded off. A large capacitor will have a low self-resonance frequency (SRF), and turns inductive above SRF. Multiple capacitors may need to be used in parallel. It is also true for the inductors.

V. Temperature Stabilization

All bipolar transistors have a negative temperature coefficient for $V_{be}(\text{temperature})$. For Si BJT, it is about $-2\text{mV}/^{\circ}\text{C}$, and for GaAs HBT $-1\text{mV}/^{\circ}\text{C}$. As a result, the I-V curve of the circuit will shift to lower voltage as temperature rises. This is more severe in Si BJT circuit with twice as large a temperature coefficient.

If the amplifier is directly connected to a power supply through a choke, the heating will cause more current to flow into the amplifier, and the higher current causes more heating, more current, more heating, and finally the circuit will reach thermal self-destruction. The solution is very simple: have a resistor inserted between the power supply and the RF choke.

As heating causes more current to flow, the resistor will force the amplifier V_{de} to drop. If the new $V_{de} \cdot I_{cc}$ is lower than original value, the heating is reduced and the overall circuit stabilized. Therefore there is a minimal resistor value for stable temperature operation.

Conclusion

EiC's InGaP HBT Darlington Amplifier Series is a complete family of high reliability, high performance 50 ohm matched gain blocks. Careful thermal design assures a cool operating temperature. Cross-check between the product burn-in and the transistor life test result validates both tests. This series of products will best serve the infrastructure market.

Reference

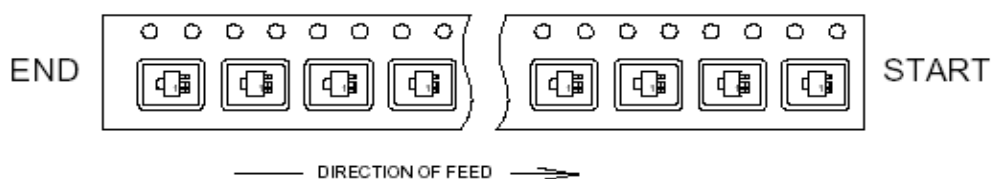
[1]. "InGaP HBTs offer Enhanced Reliability", Barry Lin, Applied Microwave and Wireless. pp 115-116, Dec. 2000

[2] Darrel Hill, John Parsey, "Motorola Digital DNATM Laboratory, 2100 E. Elliot Rd., Tempe, Arizona 85284

[3] N.L. Wang, W.J.Ho, J.A. Higgins, "AlGaAs/GaAs HBT Linearity Characteristics", Trans. Microwave Theory Tech., pp.1845-1850, vol. 42, no.10, Oct. 1994

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4. COMPONENT ORIENTATION.



5. REEL DIMENSIONS

