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# MMIC Amplifiers add Transient Protection for Rugged Performance

**Transient protection is one of many features included in the latest generation of MMIC amplifiers offered by Mini-Circuits**

With their advantages of low cost, small size, and excellent reliability, MMIC (monolithic microwave integrated circuit) amplifiers have displaced discrete component designs in most low power wireless applications. Mini-Circuits offers an extensive line of MMIC amplifiers with a range of performance that accommodates a wide variety of applications. The newest models include transient protection for greater ruggedness and reliability.

Mini-Circuits has improved its MMIC amplifier line with enhanced transient protection

## "Simplicity is a Virtue"

Seasoned engineers hold great appreciation for this old adage. Components that are reliable, easy to use, and operationally robust simplify the job of the design engineer and quickly become favorite components of savvy designers. With this concept in mind, Mini-Circuits designs its MMIC amplifiers to be robust and simple to use, in addition to meeting the performance needs of the latest wireless products. These MMIC amplifiers operate from a single voltage supply, require few external components, and are matched to 50 ohms at input and output over the entire frequency range of operation.

The latest enhancement added to the Mini-Circuits line of MMIC amplifiers is transient protection. Current transients that occur during power-up can cause device damage in any high gain amplifier that uses a Darlington configuration. Using a novel design technique (patent-pending), engineers at Mini-Circuits have now addressed this issue. The result is an amplifier design that is even more rugged, while still providing state-of-the-art performance.

## Product Overview

The MMIC amplifiers are based on InGaP HBT (Heterojunction-bipolar-transistor) technology and achieve wideband high gain performance via a Darlington pair amplifier configuration. HBT technology exhibits many benefits that are not available in commonly-used MESFET devices, namely single supply voltage operation and unconditional stability through the entire amplifier frequency range. Moreover, with their vertically stacked design, HBT devices are very compact, allowing for extremely high yields from a single wafer. The devices are fabricated with proven InGaP on GaAs technology using metal-organic chemical vapor deposition (MOCVD). Fabrication with InGaP on GaAs technology yields wide-

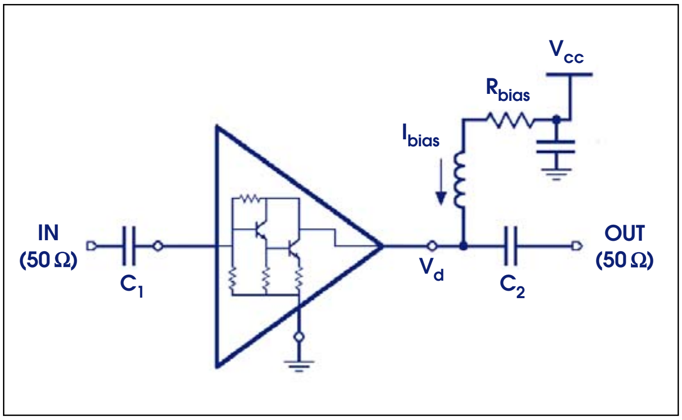


**Figure 1 · Typical biasing configuration of the MMIC amplifier, showing a simplified diagram of the internal Darlington transistor pair, as well as the external coupling and biasing components.**

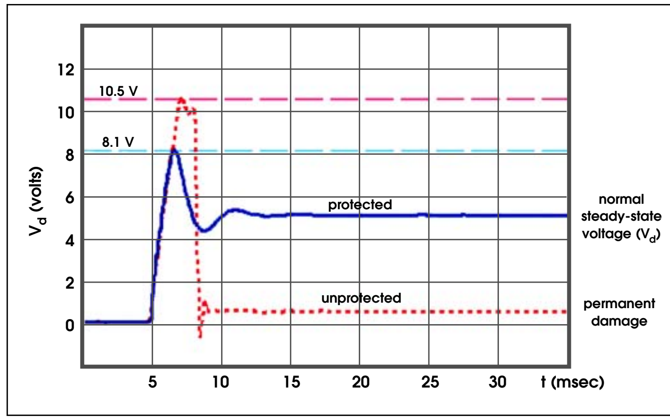


**Figure 2 · Device response to a current transient of 100 mA during power up. The unprotected ERA-5 amplifier (red, dashed) experienced an over-voltage condition and was permanently damaged. The protection circuit of the new ERA-5 (blue, solid) prevents the over-voltage condition and the device settles to its steady state bias level.**

band devices that are significantly more reliable than AlGaAs on GaAs technology.

The amplifiers exhibit high gain, low noise, and high stability. The ERA series amplifiers are supplied in a 4-lead surface mount package, and the GALI series amplifiers are supplied in a 3-lead surface mount package. Both package types provide low thermal resistance for high reliability.

### Transient Protection

The Darlington pair configuration is the most common transistor configuration used for high-gain microwave amplifiers. One unfortunate characteristic inherent to all Darlington amplifiers is their susceptibility to damage from transient currents. The current transient occurs as the device is powered up and the transistors turn on (i.e. enter active mode of operation).

Most of the excess current that occurs during power up is due to the charging of the DC blocking capacitors at the input and output. A typical biasing configuration of the MMIC amp is shown in Figure 1. When the supply voltage is first applied, the voltage at the output of the amplifier, $V_d$, climbs as the output capacitor, $C_2$, charges. The capacitor $C_2$ continues to charge until the Darlington transistor pair inside the amplifier turns on. The voltage on the capacitor $C_2$ can greatly exceed the normal steady state value by the time that the amplifier starts to conduct. Only after the transistors turn on does the output voltage settle to its proper value. If the output voltage exceeds the maximum rated voltage, even for this short period of time, the device experiences permanent damage.

To address this problem, Mini-Circuits added a patent-pending protection circuit to the Darlington pair inside the amplifier. The results are impressive. Figure 2 shows a plot of device voltage ($V_d$) versus time for two amplifiers subjected to a power-on transient. The first amplifier was unprotected, while the second amplifier was protected. The transient caused the first amplifier to fail, but the protected amplifier handled the transient situation unscathed.

### Applications

With their high-gain, wideband performance, and miniature size, the MMIC amplifiers can be used in a wide variety of applications, such as wireless phones, base stations, and instrumentation equipment. Combined with a 1.5:1 wideband transformer, the amps can also be used in 75 ohm systems (e.g. CATV receivers, HDTV receivers, satellite TV receivers and cable modems). Mini-Circuits manufactures a large selection of wideband transformer models, available in miniature surface-mount packaging.

### Supporting Circuitry

The MMIC amplifiers require only five external components, as shown in Figure 1. Coupling capacitors are placed both at input and output for DC blocking. A bias

| MMIC Amplifiers with Transient Protection | | | | | | | | |
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| | | | | At 2 GHz* | | | | |
| | | Gain, dB typ. | | Maximum Power | Noise | Output | VSWR (*n*:1) typ. | |
| Model | Frequency Range | at 100MHz | at Max Freq | Output ($P_{1dB}$) dBm typ. | Figure dB typ. | IP3 dBm typ. | In | Out |
| ERA-1XSM | DC to 8 GHz | 12.5 | 9.0 | +12.5 | 4.3 | +28.0 | 1.3 | 1.4 |
| ERA-2XSM | DC to 6 GHz | 16.5 | 10.6 | +13.0 | 3.3 | +28.0 | 1.3 | 1.4 |
| ERA-3XSM | DC to 3 GHz | 23.2 | 16.3 | +12.0 | 2.6 | +26.0 | 1.2 | 1.3 |
| ERA-4XSM | DC to 4 GHz | 14.7 | 11.3 | +17.0 | 4.2 | +35.0 | 1.2 | 1.3 |
| ERA-5XSM | DC to 4 GHz | 20.5 | 13.7 | +17.8 | 3.1 | +35.0 | 1.2 | 1.4 |
| ERA-6XSM | DC to 4 GHz | 12.9 | 9.8 | +17.1 | 4.5 | +35.0 | 1.2 | 1.3 |

*At 1 GHz for ERA-4XSM, ERA-5XSM, ERA-6XSM

**Table 1 · MMIC amplifier models that include transient protection.**

network is included at the output to deliver power to the amplifier. The bias network consists of a resistor, which sets the bias current to the amp, and an RF choke which prevents coupling of the RF signal to the power supply. The value of $R_{bias}$ is a function of $V_{cc}$, the desired $V_d$ and the particular device's recommended $I_{bias}$. Calculation of the resistor value is simple, and Mini-Circuits provides an application note AN-60-010 to aid the designer [1]. Mini-Circuits also offers both wide-band RF chokes [2] and wide-band bias tees [3] that can be used for implementation of the bias network. Lastly, a bypass capacitor is required for power supply decoupling.

Wideband matching that is internal to the amplifier allows for simple input and output connections to the device. Each amplifier is matched to 50 ohms at input and output over the full frequency range of operation. The amplifiers exhibit excellent input and output VSWRs (see Table 1). Because the amplifiers possess internal matching networks, the devices interface directly with other 50 ohm circuits over the entire operating frequency range with no additional matching circuitry. The amplifiers can be cascaded to achieve higher gain.

To further expedite the design and simulation process, Mini-Circuits provides a suggested layout for each device and publishes full S parameter data [4]. The MMIC amplifiers are priced from $1.19 each (30 qty).

## Notes

1. Application Note AN-60-010 is available online at www.minicircuits. com/appnote/an60010.pdf
2. Information available at: www.minicircuits.com/rfchoke.html
3. Information available at: www.minicircuits.com/bias.html
4. Data available online at: www. minicircuits.com/sparameters.html

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