# Device Qualification Report

# ADM 5929

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## Table of Abbreviations

| | |
|---|---|
| Marki Microwave Incorporated | **MMI** |
| Quad Flat No-Lead Package | **QFN** |
| Pseudomorphic High Electron Mobility Transistor | **PHemt** |
| Gallium Arsenide | **GaAs** |
| High Temperature Operating Life | **HTOL** |
| Electro-Static Discharge | **ESD** |

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# Introduction

Our reliability study utilizes the High Temperature Operating Life device test method to produce a view of a typical component's electrical integrity over its lifetime. The conclusions drawn from this study establishes Marki Microwave's MMIC device's ability to withstand electro-thermal stresses that were imposed by the test method. The GaAs amplifier device used in this study is fabricated using a particular process, "A", that actualizes a configuration of distributed pseudomorphic high electron mobility transistors (PHemt) and is typical of all Marki Microwave MMIC GaAs amplifier devices that feature comparable power dissipation (up to ~1.2W).

This study is based on the planning and practice of a JEDEC standard. The conditions applied to the standard were chosen to encourage our customers' increased confidence in our product's efficacy under environmental conditions likely to be encountered in typical use cases.

## QFN Package

The representative package used in our study was a 4mm x 4mm x 0.9mm gross-leak sealed ceramic QFN containing a GaAs pseudomorphic high electron mobility transistor (PHemt) distributed MMIC amplifier device fabricated using process "A" *.

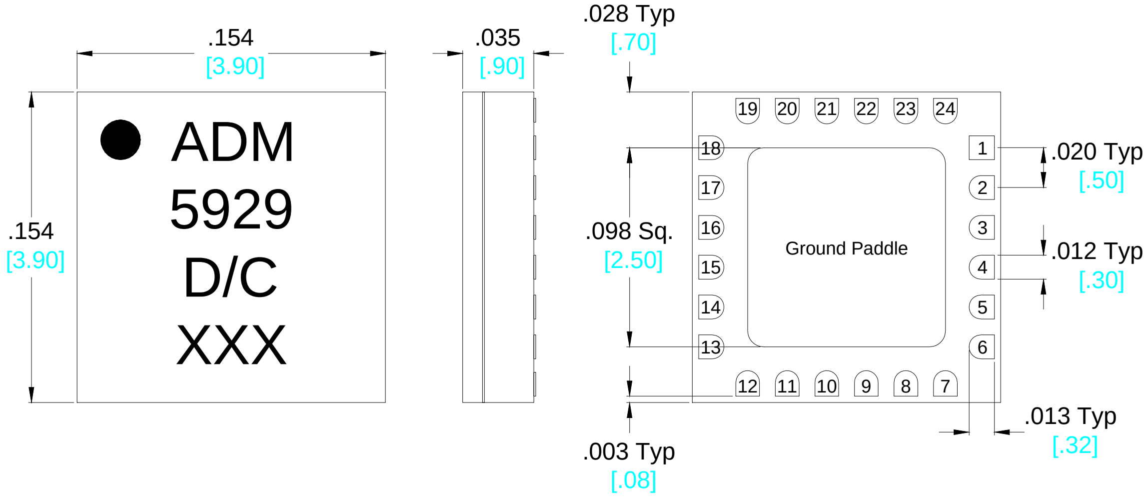


**Figure 1 – A drawing of a 4mm QFN package. Alternate dimensioning: [ mm ]**

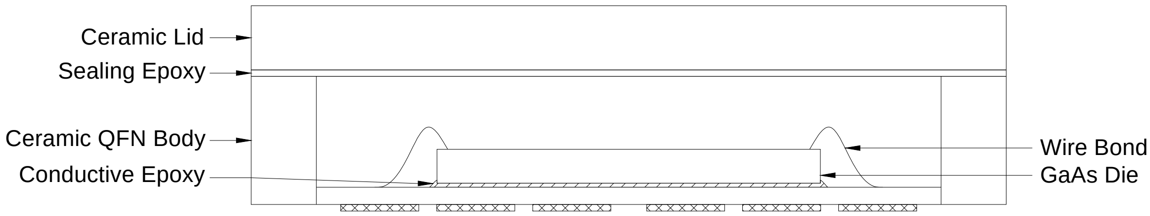


**Figure 2 – A cross-sectional drawing of a typical QFN package with GaAs die and mechanical attachment features.**

## Package Qualification Vehicle

| Marki Microwave Part Number | Report |
|---|---|
| ADM-0026-5928SM | "MMIC Amplifier In QFN Package" |

**Table 1**

## Device Qualification Vehicle

| Marki Microwave Part Number |
|---|
| ADM-0026-5929SM |

**Table 2**

* Contact Marki Microwave for details regarding process "A" and related part numbers.

# Summaries & Declarations

## Test Results

| Test Method | Qty In | Qty Out | Fails | Fail Criteria |
|---|---|---|---|---|
| **HTOL** | 23 | 23 | 0 | 1dB change in gain or 10mA change in $Id_{ss}$ |

**Table 3**

## Performance Variation

| Test Method | Frequency (GHz) | Initial Avg Gain (dB) | Max Gain Change (dB) | Gain Range (dB) | Avg Initial $Id_{ss}$ (mA) | Max $Id_{ss}$ Change (mA) | $Id_{ss}$ Range (mA) |
|---|---|---|---|---|---|---|---|
| **HTOL** | 0.010 – 26.5 | 13.02 | 0.97 | 1.26 | 250 | 9 | 15 |

**Table 4**

## ESD Sensitivity Level

The GaAs Device was not subjected to HBM & CDM ESD testing. Marki Microwave declares the following ESD classifications and recommends the QFN package be handled in a manner that appropriately accounts for high ESD sensitivity.

| Model | Classification | Voltage |
|---|---|---|
| **HBM** | 0A | < 125V |
| **CDM** | C0A | < 125V |

**Table 5**

## Environmental / Operational Maximum Ratings

| Device | |
|---|---|
| **Static Operating Temperature Range** | -55°C to +85°C |
| **Static Storage Temperature Range** | -65°C to +150°C† |

**Table 6**

† **The lower value in the range was not verified in this study**

## Test Method

| Test | Conditions | Duration | Sample Size | Fail Criteria |
|---|---|---|---|---|
| **HTOL** | **$T_j$** = 140°C<br>**$V_{dd}$** = +7V, **$V_{gs}$** = 0V,<br>**$Id_{ss}$** = 250 mA | 1000 Hours | 1 lot of 23 units | 1dB change in gain or 10mA change in $Id_{ss}$ |

**Table 7**

**HTOL:** This test simulates the devices' operating condition in an accelerated way, and is primarily for device qualification and reliability monitoring. Acceleration Factor (AF) & Extrapolated Lifetime were determined. The practice of this test procedure complied with JESD22-A108D, *Temperature, Bias, and Operating Life* & JESD47I, *Stress-Test-Driven Qualification of Integrated Circuits*[**].

# Electrical Test

All RF tests were performed using an electronically calibrated N5242A PNA-X Network Analyzer.

# Test Fixtures

To facilitate RF testing and biasing of the amplifier device, the ADM package was attached to a custom designed test fixture. Table 2 gives a list of materials used in the construction of the test fixture.

| Description / Material |
| --- |
| Aluminum Housing |
| SMA Connector |
| Feed Through Pins |
| Screws |
| Ground Lug |
| RO 4003 PCB |
| Silver Epoxy |
| Solder (SN63) |

**Table 8**

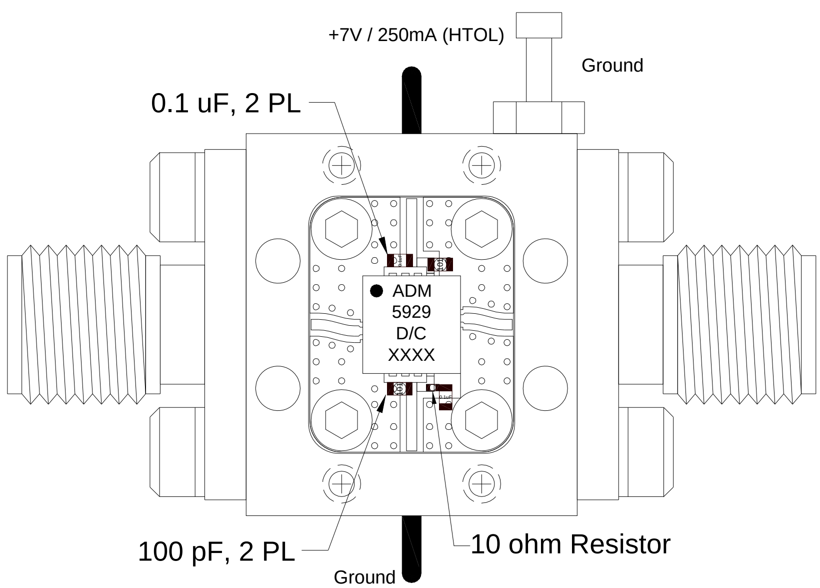


**Figure 3 – A mounted sample in a custom test fixture designed to facilitate HTOL test. Bias voltages used are shown.**

# Performance Plots

**Gain Variation (HTOL)**

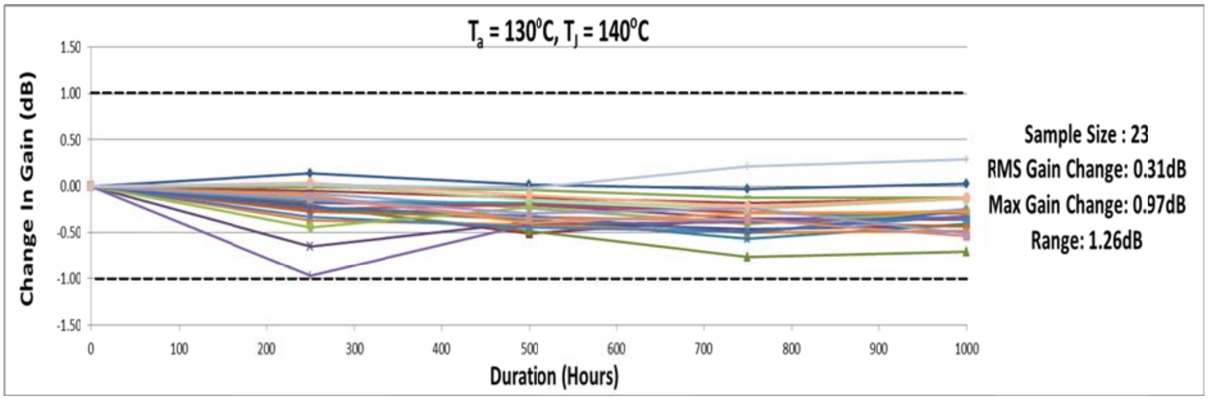


**Figure 4 – Variation in average gain vs duration of environmental stress among all samples.**

**Histogram and Cumulative Distribution of Gain Variation (HTOL)**

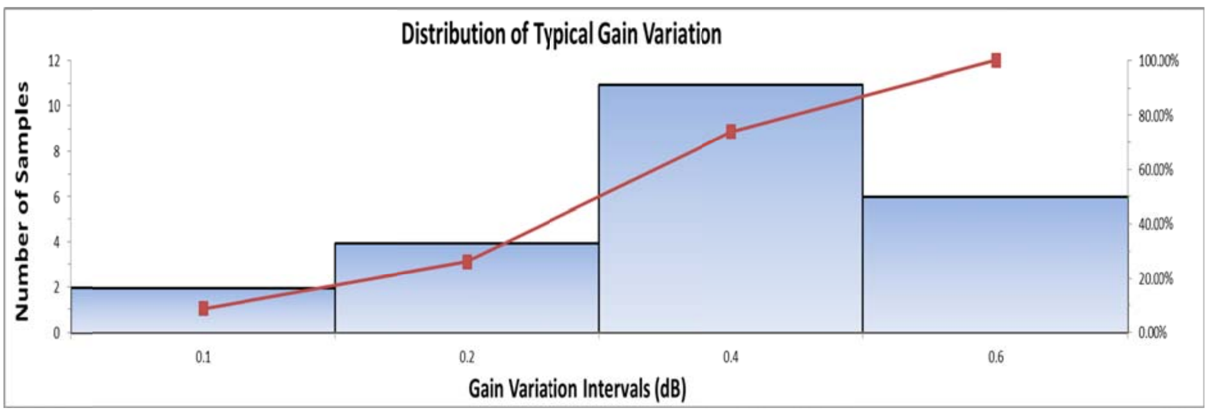


**Figure 5 – Distribution of gain variation gain among all samples; single unit RMS average.**

**Variation in $Id_{ss}$ (HTOL)**

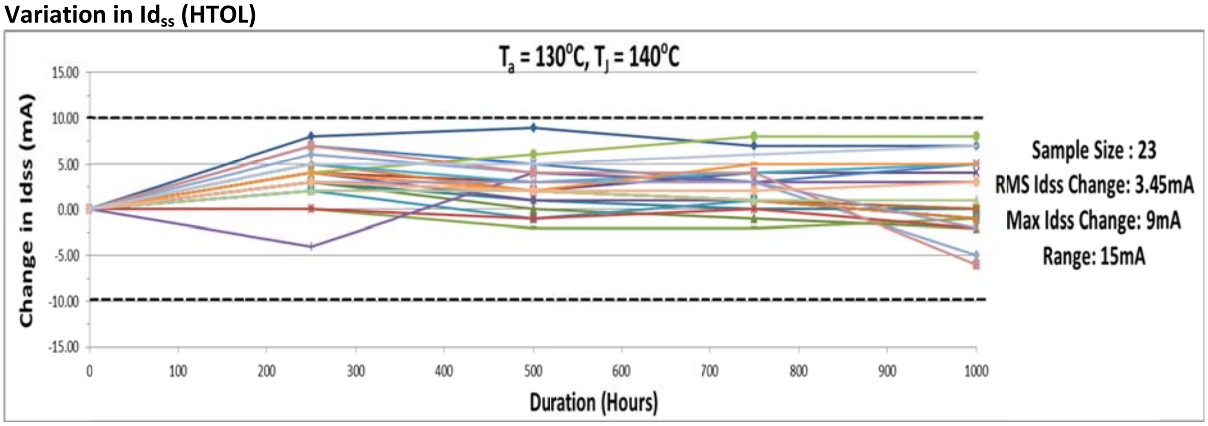


**Figure 6 – $Id_{ss}$ variation vs duration of environmental stress among all samples.**

**Histogram and Cumulative Distribution of Variation in $Id_{ss}$ (HTOL)**

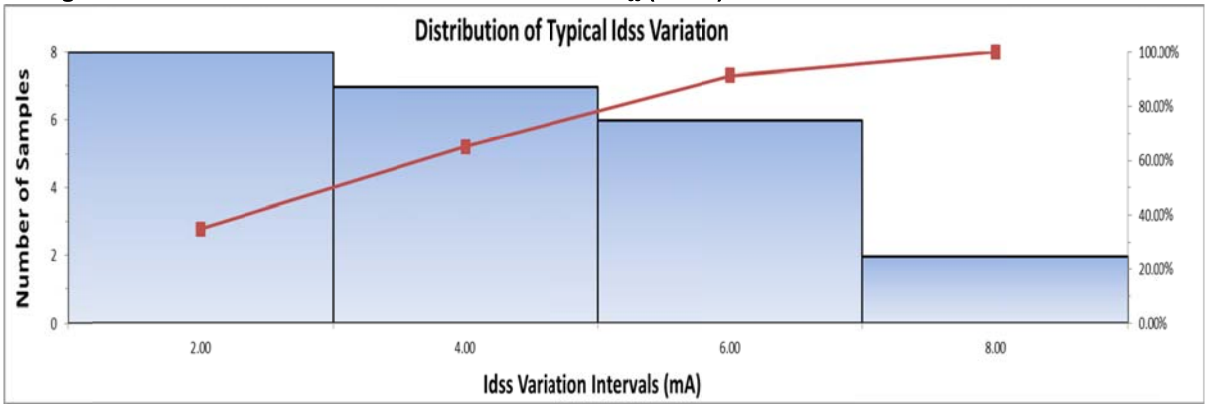


**Figure 7 – Distribution of $Id_{ss}$ variation among all samples; single unit RMS average.**

**Input RL (HTOL)**

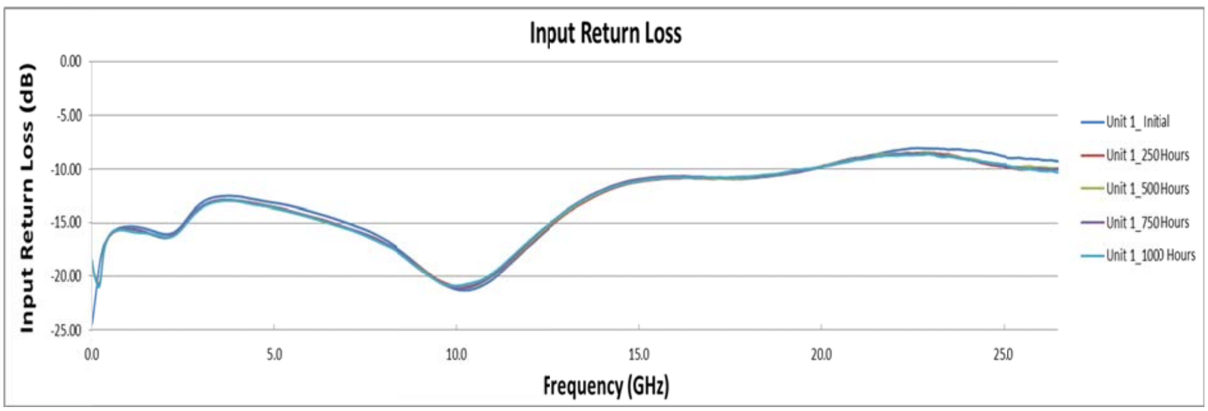


**Figure 8 – Full band input return loss comparison of 1 sample over 1000 hours of stress.**

**Output RL (HTOL)**

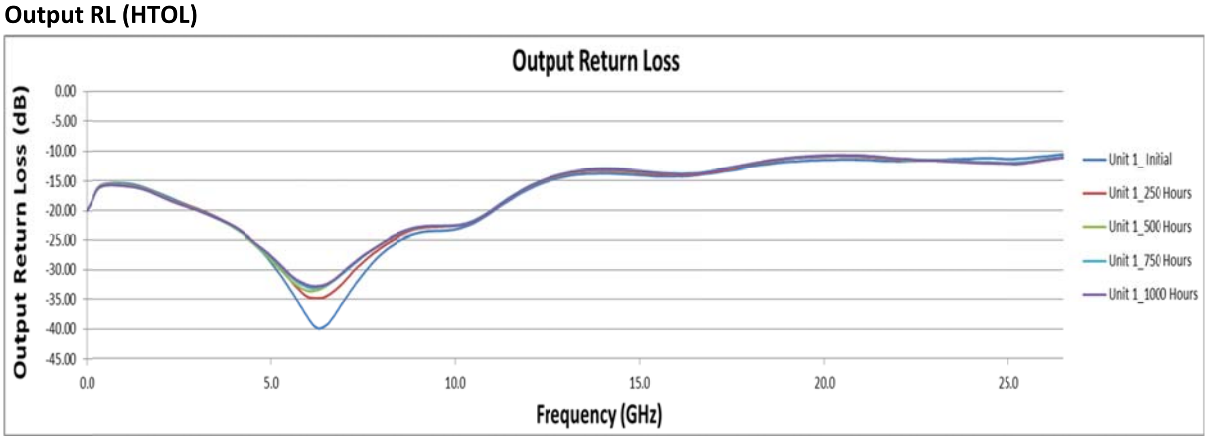


**Figure 9 – Full band output return loss comparison of 1 sample over 1000 hours of stress.**

# Equivalent Hours Calculation (HTOL)

## Identities

| | |
|---|---|
| Device Hours = (Number of Devices) x (Duration of Test) | |
| Equivalent Hours = (Device Hours) x (Acceleration Factor (AF)) | |
| $AF = \exp[\frac{E_A}{K}\left(\frac{1}{T_{use}} - \frac{1}{T_j}\right)]$ | |
| $E_A$ = Activation Energy (J) | K = Boltzmann Constant ($m^2 kg\ s^{-2}\ K^{-1}$) |
| $T_{USE}$ = Operating Temperature (K) | $T_j$ = Junction Temperature(K) |

**Table 9**

## Values Derived From HTOL Test Method

| | |
|---|---|
| $E_A = 236.8 \times 10^{-21}$ J | $K = 1.38 \times 10^{-23}\ m^2\ kg\ s^{-2}\ K^{-1}$ |
| $T_{use}$ = 358.15 K (+85°C) | $T_j$ = 413.15 K (+140°C) |
| Device Hours = 23,000 | AF = 591 |
| Equivalent Hours = $1.36 \times 10^7$ | |

**Table 10**

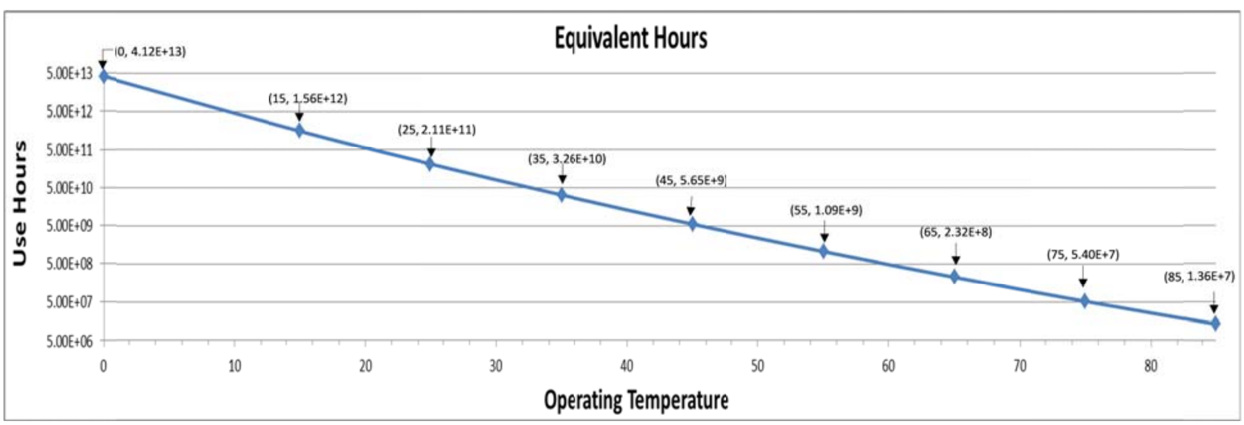


**Figure 10 – The data points on this plot were calculated using the equivalent hours identities & HTOL test method derivations. For each of the data points shown, the acceleration factor (AF) was calculated with a temperature of interest substituted for $T_{USE}$. The device hours calculation was not changed.**