

HMMC-5021/22/26/27 Traveling Wave Amplifier Environmental Data

Application Note # 34

MWTC Marketing
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This application note provides information regarding the operation and performance of the HMMC-5021/22/26 and HMMC-5027 traveling wave amps under a variety of environmental conditions. Included in this application note are:

- HMMC-5021/22/26, HMMC-5027 reliability data.
- Test results in humid and condensing environments.
- Electrostatic discharge damage thresholds.
- RF input power damage.
- Thermal resistance measurements.
- Environmental test check list.

The data is intended to aid the designer in determining the necessary guard bands and precautions required (on reliability, thermal, and environmental issues) to insure a successful end product. This data is supplemental and does not imply any guaranteed specifications.

1.0 High Temperature Operating Life (HTOL) test Results

The HMMC-5021/22/26 and HMMC-5027 TWAs have been subjected to HTOL life tests at the test and bias conditions shown in Table 1. The failure criteria was defined as a ± 1 dB drift in S_{21} measured at 26.5 GHz. The results from these tests show that the failure rate of both the HMMC-5021/22/26 and HMMC-5027 TWAs will be less than 100

FITS (or .01% failure/1000 hours.), after one year of continuous operation at the bias and temperature conditions listed in Table 1.

Table 1: TWA HTOL Reliability Test

Device	Test Conditions			
	V _{ds} (V)	I _{ds} (mA)	T _{ch} (°C)	T _{ch} (°C)
HMMC-5021/22/26	7	150	154*	115
HMMC-5027	8	250	217†	126

* HMMC-5021/22/26: $T_{ch} (°C) = 1.105 T_{bs} + 26.4$ for 1.05 W dc power dissipation, where T_{bs} = backside temperature.

† HMMC-5027: $T_{ch} (°C) = 1.174 T_{bs} + 43.6$ for 2.00 W dc power dissipation.

2.0 Test Results in Humid Conditions

Although MWTC's GaAs ICs are passivated, this passivation does not guarantee hermeticity. The fact that GaAs device can be etched by waters suggests that operation of GaAs devices in humid or condensing environments will impact performance and reliability. As a result, hermetic packaging of GaAs devices and circuits is recommended. Successful application of GaAs devices in non-hermetic environments is a complex function of application-specific variables.

- end use environment
- bias conditions

- thermal design of package
- thermal dissipation

MWTC has characterized the performance of TWAs in a 65°C/95% R.H.¹ environment under three bias conditions:

- high (standard) power dissipation bias in 65°C/95% R.H. after 200 hours.
- low power dissipation bias in 65°C/95% R.H. after 200 hours.

2.1 Unbiased Humidity Test

Over 50 TWA wafers have been subjected to a three day (72 hour) 65°C/95% R.H. soak. S-parameters were measured before and after the humidity soak. S_{21} was the only parameter exhibiting a measurable drift. The change in S_{21} was on the average -0.17 dB, with a standard deviation of 0.08 dB. The cumulative distribution is shown in Figure 1. This drift is recoverable when the wafers are “baked out” at 150°C for 8 hours.

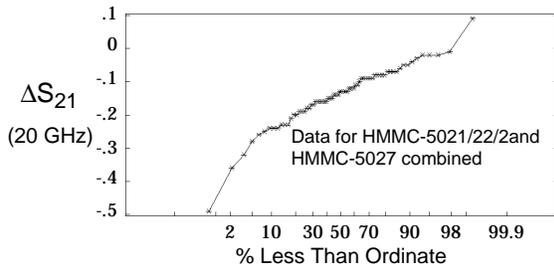
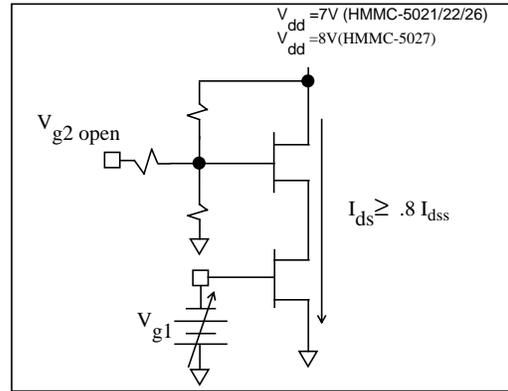


Figure 1

2.2 Biased Humidity Tests

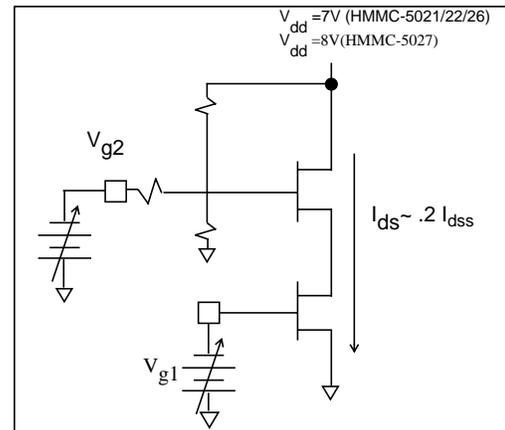
Performance of TWAs under bias, in humidity, was investigated on several wafers. Two bias conditions were tested: high dc power dissipation bias, and low dc power dissipation bias. In standard, or high dc power dissipation bias, the HMMC-5021/22/26 is dissipating approximately 1 watt of dc power (2 watts for the HMMC-5027). In the low bias state the current in the TWA is adjusted, using an externally applied second gate voltage, to approximately 20% of I_{dss} (or ~.2 to .4W

P_{dc} dissipation). See Figures 2 and 3.



Std (or high) Bias

Figure 2



Low Bias²

Figure 3

The low bias state is of particular interest to customers, providing external bias to the second gate of the TWA for AGC or pulse modulation applications. The results of these tests (see Table 2) indicate that TWAs biased at standard or high bias conditions will exhibit the same level of humidity sensitivity, measured by changes in S_{21} , as in the unbiased 65°C/95% R.H. test (i.e., approximately -0.2 dB drift in S_{21}). In the low bias state, catastrophic failures have resulted after several days of exposure to humidity.

It is postulated that the low bias state does not generate enough “self heating” to

¹ R.H. = relative humidity.

² The “low bias” state was achieved during this test by first adjusting V_{g1} to set $I_{ds} \sim 0.8 I_{dss}$. Second, V_{g2} was adjusted until $I_{ds} \sim 0.1$ to $0.2 I_{dss}$.

drive the moisture away from the active areas of the TWA FETs. The combination of high humidity, high voltage differentials and low dc power dissipation can significantly degrade TWA performance and ultimately lead to catastrophic failure. As a result, hermetic packaging is strongly recommended for any TWA applications where operation at low dc power dissipations in humid environments is likely. This is not a problem in non-humid environments.

Table 2: Biased Humidity Results

Atmosphere: 65°C/95% R.H. for 200 hours		
Parameter	Bias Condition	
	Standard (High)	Low
ΔS_{21}	-.2 dB	-3 to -10 dB

3.0 RF Input Power

There are two maximum input power ratings on the HMMC-5021/22/26 and HMMC-5027 TWAs. The Absolute Maximum Input Power rating should be interpreted as the damage level. Applied power equal to or greater than the quoted Absolute Maximum Input Power rating may result in immediate, non-recoverable damage to the IC. The continuous RF Input Power rating represents the maximum input power that can be continuously applied to the device without degradation.³ For both cases the power limiting element on the TWA is the 50Ω thin film termination resistor. The power ratings are shown in Table 3.

Table 3: TWA Power Ratings

Device	Absolute Maximum Input Power	Continuous Maximum Input Power
HMMC-5021/22/26	28 dBm	23 dBm
HMMC-5027	28 dBm	23 dBm

³ These tests were conducted in a dry environment at a 70° C ambient temperature.

4.0 Electrostatic Discharge Sensitivity (ESD)

The ESD damage threshold was characterized on the RF input, output, and auxiliary second gate pads (see Figure 4)

Simplified TWA Schematic

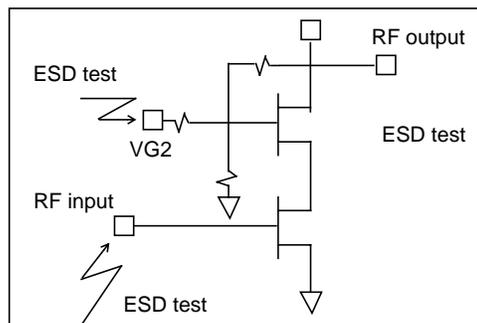


Figure 4

The testing was performed with the source grounded with no drain or gate bias to simulate conditions typically experienced during hybrid assembly. The damage threshold is defined as the voltage required to induce at 10% change in pinch off current or I_{dss} , or a catastrophic open/short, whichever occurs first. Figure 5 is a block diagram of the test system. The results are shown in Table 4.

ESD Test Set Up

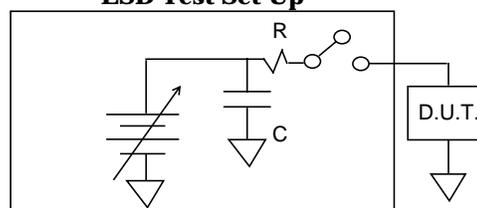


Figure 5

Table 4: ESD Damage Thresholds

Device Type	Voltage		
	RF Input	RF Output	Aux. 2nd Gate (VG ₂)
HMMC-5021/22/26	1100	5500	1500
HMMC-5027	600	7500	700

5.0 Thermal Resistance

The thermal resistance of the HMMC-5021/22/26 and HMMC-5027s was measured using liquid crystal thermography. Thermal resistance measurements are very dependent on the assembly technique and thermal environment surrounding the IC. The assembly technique and materials used for these measurements are shown in Figure 6. The results are shown in Table 5.⁴

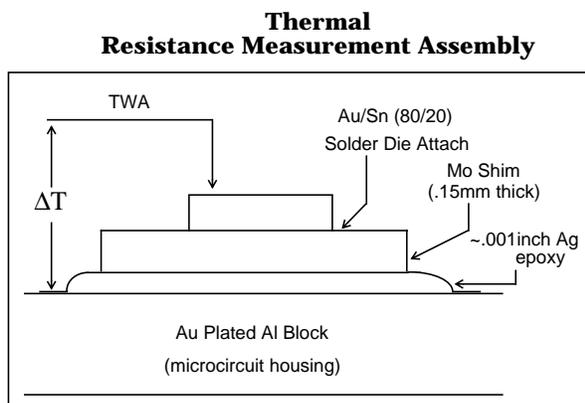


Figure 6

Table 5: Thermal Resistance Measurement Results

Device	Temp. (°C)	Therm. Res. (°C/W)
HMMC-5021/22/26	116	35
HMMC-5027	116	29

6.0 Microcircuit Environmental Qualification Checklist

Most microcircuits designed at HP are subjected to a series of environmental qualification tests. These tests are intended to evaluate how the microcircuit will function under the specified environment. The results will be a complex function of bias condition, thermal design, internal microcircuit components and other application-specific variables. As a result, the performance of a microcircuit under a specific set of environmental conditions can not always be predict-

⁴ These tests were conducted in a dry environment at a 70° ambient temperature.

ed from environmental tests performed on an isolated component used in the microcircuit.

With this qualification in mind, Table 6 lists a number of tests a typical microcircuit is subjected to during production qualification.⁵ Performance of the HMMC-5021/22/26 and HMMC-5027 TWAs is noted for each test as: Passed (in device form); Will Not Pass; or Not Tested.

Table 6: Environmental Checklist

Test	TWA Results
Temperature Cycling Survival	Not Tested
Vibration Survival	Not Tested
Vapor Phase Moisture Test	Will Not Pass
Condensing Moisture Test	Will Not Pass
Operating Temp.	Passed

7.0 References

Else Schmidt, *MWTD MMIC HMMC-5021/22/26 HTOL Reliability Summary (and Summary Amendment)*, September 1988.

Greg Pfeiffer, Robert Close, *HMMC-5021/22/26/HMMC-5027 Thermal Resistance*, January 25, 1990.

Morgan Culver, *Electrostatic Discharge Damage Levels for MMICA Traveling Wave Amplifiers*, February 28, 1991.

Steven Cochran, *A Preliminary Reliability Report for the HMMC-5027*, December 1988.

Greg Pfeiffer, *TWA Reliability Calculations and Notes*, March 1991.

NMD's *Microcircuit Environmental Standard*, Dwg. No. A-5090-3231-1.

For additional information, please call MWTC Semiconductor Marketing, 707-577-2592.

⁵ This test list is derived from NMD's Microcircuit Evaluation Standard (Dwg. No. A-5090-3231-1). Results from other tests, with different test conditions, may vary.