

## MMA-445933H-02 4.4 – 5.9 GHz 2 W High Efficiency Linear Power Amplifier

### Features:

- 30 dB Gain
- 33 dBm P<sub>-1dB</sub>
- OIP3 45 dBm
- 26.0 dBm Linear Pout @ 2.5 % EVM (802.11 64-QAM)
- Fully Matched Input and Output for Easy Cascade
- Internal Bias Tee
- Surface Mount Package
- MTTF > 100 years @ 85 °C ambient temperature

### Description:

The MMA-445933H-02 is a power amplifier with the State-of-the-Art linear power between 4.4 GHz and 5.9 GHz frequency band. Based on advanced robust HFET device technology, the linearity of this power amplifier is 25 dBm linear power at 2.5 % EVM and achieves an ACPR better than -36 dBc. The modulation test pattern is 802.16x 64-QAM. This linear power amplifier also has high gain. Ideal applications include the driver and the output power stage of WiMax and WLAN infrastructures and access points. It also can be used for PTP (Point-To-Point) radio applications for this band.

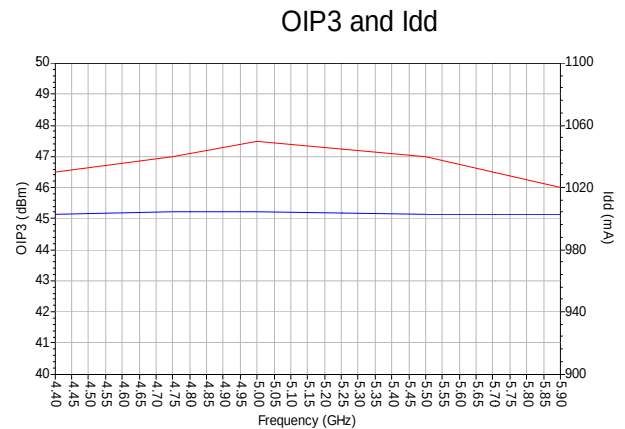
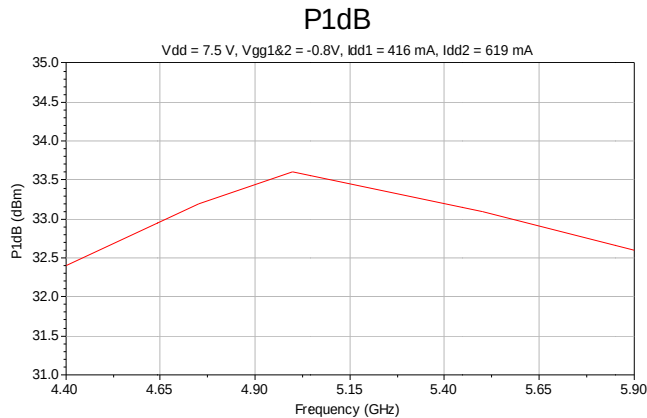
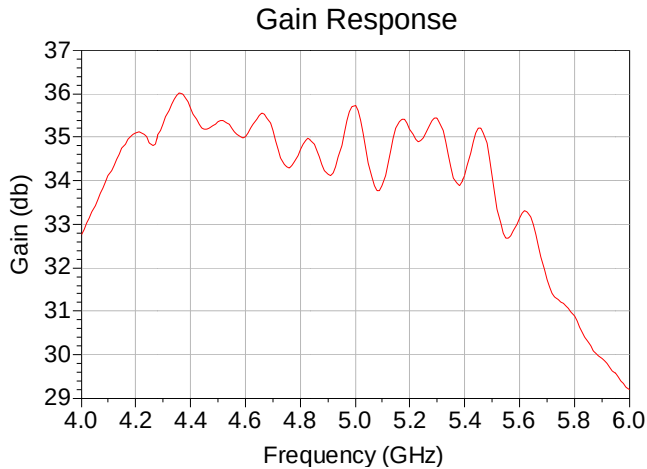
**Typical RF Performance:**  $V_{dd1} = 7.5\text{ V}$ ,  $V_{dd2} = 7.5\text{ V}$ ,  $V_{gg1} = -0.8\text{ V}$ ,  $V_{gg2} = -0.8\text{ V}$ ,  $I_{dq1} = 410\text{ mA}$ ,  $I_{dq2} = 622\text{ mA}$ ,  $T_a = 25\text{ °C}$ ,  $Z_0 = 50\text{ }\Omega$

| Parameter                         | Units  | Typical Data |
|-----------------------------------|--------|--------------|
| Frequency Range                   | MHz    | 4400 - 590   |
| Gain (Typ / Min)                  | dB     | 29 / 33      |
| Gain Flatness (Typ / Max)         | ±dB    | 2.5 / 4.5    |
| Input Return Loss                 | dB     | 10           |
| Output Return Loss                | dB     | 7            |
| Output P1dB                       | dBm    | 33           |
| OIP3                              | dBm    | 45           |
| Pout @ 2.5 % EVM                  | dBm    | 26.0         |
| Operating Current Range           | mA     | 1050         |
| Thermal Resistance (Driver Stage) | °C / W | 20           |
| Thermal Resistance (Output Stage) | °C / W | 16           |

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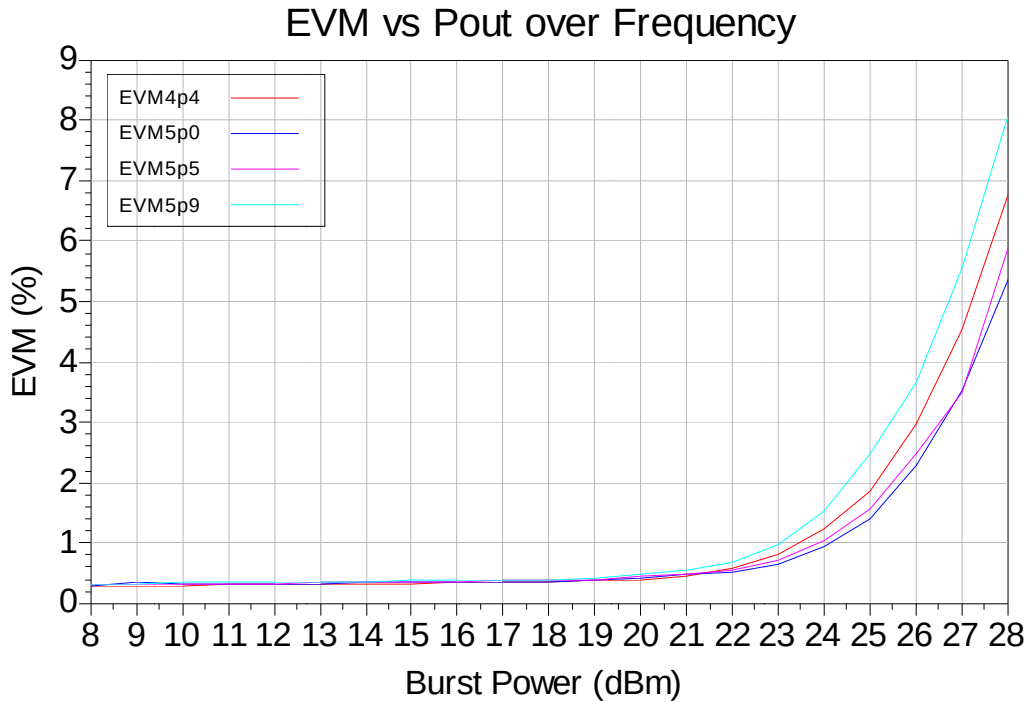
## ESD Caution



High-performance RF integrated circuits are highly sensitive to electrostatic discharge (ESD) and may contain unprotected inputs and outputs. Handling and assembly should be conducted in an ESD-controlled environment. It is recommended that ESD precautions and protocols are adopted to minimise the risk of electrostatic discharge and protect product integrity.

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## Maximum Ratings: ( $T_a = 25\text{ }^{\circ}\text{C}$ )\*

| SYMBOL         | PARAMETERS                        | UNITS | ABSOLUTE MAXIMUM |
|----------------|-----------------------------------|-------|------------------|
| Vdd1           | Drain-Source Voltage Driver Stage | V     | 10               |
| Vdd2           | Drain-Source Voltage Output Stage | V     | 10               |
| Vgg1           | Gate-Source Voltage Driver Stage  | V     | -5               |
| Vgg2           | Gate-Source Voltage Output Stage  | V     | -5               |
| Idq1           | Drain Current Driver Stage        | mA    | 500              |
| Idq2           | Drain Current Output Stage        | mA    | 750              |
| Ig1 and Ig2    | Gate Current                      | mA    | 10               |
| I <sub>p</sub> | Pinch-Off Current                 | mA    | 10               |
| Pdiss          | DC Power Dissipation              | W     | 9.0              |
| Pin max        | RF Input Power                    | dBm   | +10              |
| Toper          | Operating Temperature             | °C    | -40 to +85       |
| Tch            | Channel Temperature               | °C    | 175              |
| Tstg           | Storage Temperature               | °C    | -55 to 150       |

\*Operation of this device above any one of these parameters may cause permanent damage.

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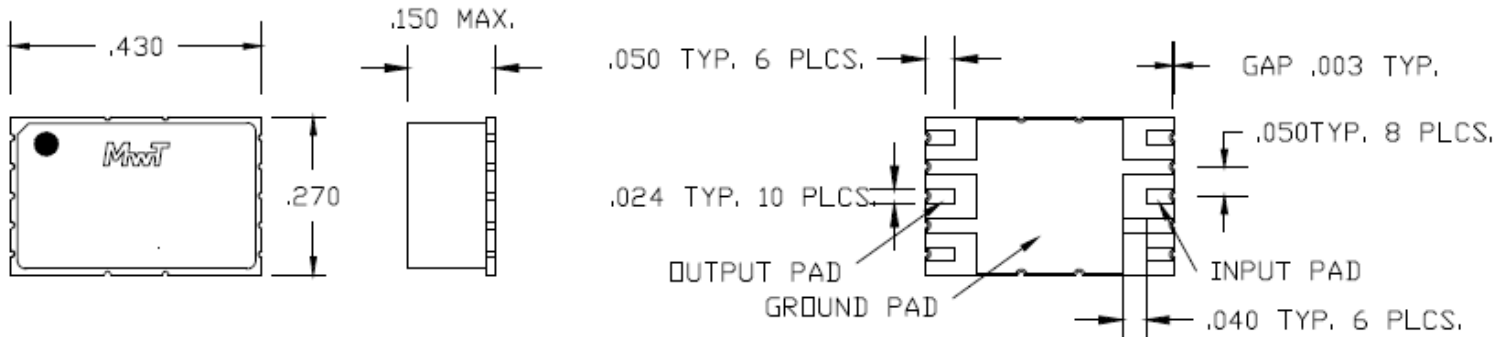
**Typical Scattering Parameters** :  $V_{dd1} = 7.5\text{ V}$ ,  $V_{dd2} = 7.5\text{ V}$ ,  $V_{gg1} = -0.8\text{ V}$ ,  $V_{gg2} = -0.8\text{ V}$ ,  
 $I_{dq1} = 410\text{ mA}$ ,  $I_{dq2} = 620\text{ mA}$ ,  $Z_0 = 50\ \Omega$ ,  $T_a = 25\text{ }^{\circ}\text{C}$

| freq       | magS11 | AngS11   | magS21 | AngS21   | magS12   | AngS12   | magS22 | AngS22  |
|------------|--------|----------|--------|----------|----------|----------|--------|---------|
| 4.000 G... | 0.645  | 32.285   | 43.519 | -99.628  | 0.001    | 97.671   | 0.072  | 22.256  |
| 4.100 G... | 0.583  | 19.241   | 50.770 | -128.986 | 0.001    | 103.298  | 0.029  | 58.433  |
| 4.200 G... | 0.507  | 3.416    | 56.887 | -160.542 | 0.001    | 104.699  | 0.039  | 136.794 |
| 4.300 G... | 0.405  | -13.491  | 58.229 | 171.005  | 0.001    | 99.811   | 0.085  | 155.711 |
| 4.400 G... | 0.303  | -28.862  | 60.835 | 137.356  | 0.001    | 96.209   | 0.141  | 147.883 |
| 4.500 G... | 0.230  | -43.280  | 58.592 | 113.084  | 0.001    | 99.810   | 0.175  | 141.579 |
| 4.600 G... | 0.174  | -60.629  | 56.340 | 89.105   | 0.001    | 97.310   | 0.221  | 137.483 |
| 4.700 G... | 0.126  | -77.940  | 57.163 | 60.090   | 0.001    | 86.109   | 0.265  | 128.530 |
| 4.800 G... | 0.109  | -97.370  | 54.402 | 43.453   | 0.001    | 94.205   | 0.291  | 122.688 |
| 4.900 G... | 0.127  | -120.196 | 51.026 | 18.963   | 0.001    | 128.273  | 0.326  | 119.347 |
| 5.000 G... | 0.154  | -141.350 | 61.098 | -5.354   | 0.001    | 117.399  | 0.386  | 111.612 |
| 5.100 G... | 0.189  | -153.388 | 49.493 | -24.139  | 2.849E-4 | 158.159  | 0.423  | 101.495 |
| 5.200 G... | 0.253  | -162.215 | 57.434 | -52.760  | 0.001    | -171.236 | 0.443  | 91.180  |
| 5.300 G... | 0.316  | -175.950 | 59.113 | -79.554  | 0.001    | -178.476 | 0.463  | 77.581  |
| 5.400 G... | 0.357  | 169.576  | 50.821 | -99.637  | 0.001    | 163.283  | 0.437  | 61.712  |
| 5.500 G... | 0.399  | 158.603  | 50.854 | -137.348 | 0.002    | 176.446  | 0.366  | 48.775  |
| 5.600 G... | 0.435  | 147.247  | 45.402 | -151.993 | 0.002    | 169.971  | 0.294  | 37.350  |
| 5.700 G... | 0.451  | 137.700  | 38.623 | 177.226  | 0.002    | 168.668  | 0.224  | 29.044  |
| 5.800 G... | 0.458  | 131.897  | 35.013 | 157.753  | 0.002    | 169.718  | 0.152  | 25.486  |
| 5.900 G... | 0.462  | 128.232  | 31.307 | 137.326  | 0.002    | 162.603  | 0.084  | 29.234  |
| 6.000 G... | 0.465  | 123.778  | 28.815 | 115.352  | 0.003    | 170.218  | 0.051  | 72.184  |

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## Mechanical Information:



## Package Outline

| Pin Designation (Top View) |             |            |             |
|----------------------------|-------------|------------|-------------|
| Pin Number                 | Signal Name | Pin Number | Signal Name |
| 1 <i>Dot Top Left</i>      | Vgg1        | 10         | Vgg2        |
| 2                          | GND         | 9          | GND         |
| 3                          | RF In       | 8          | RF Out      |
| 4                          | GND         | 7          | GND         |
| 5                          | Vdd1        | 6          | Vdd2        |

All dimensions are in inches

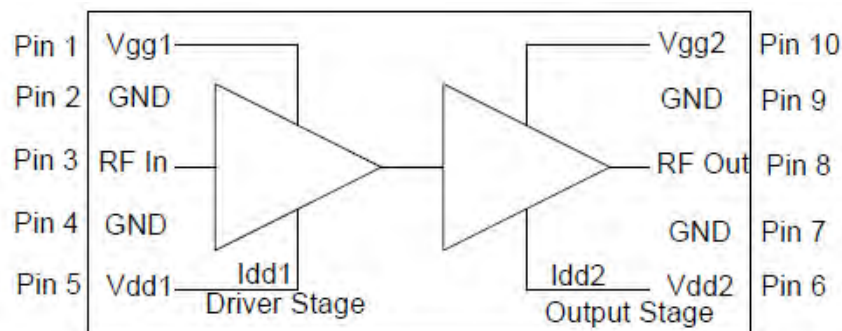


Figure 1 Functional Diagram

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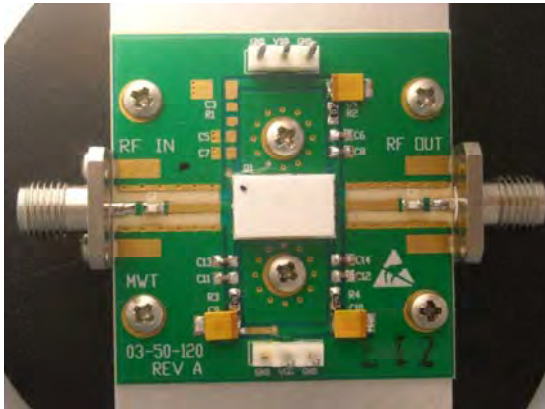


**Figure 1 Evaluation board**

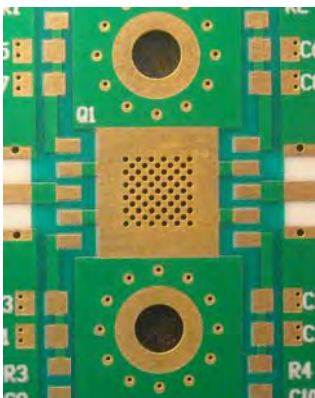


**Figure 2 Hole Layout**

## Application Note

The evaluation board, shown in Figure 1, is fabricated with Rogers 4003 material, 20 mil thick, 2 oz copper weight and includes four DC input connections and two RF lines. The MMA-445933H-02 shown in the center of board is a 2 watt high gain and high linearity amplifier. The MMA-445933H-02 is a 3 stage amplifier assembly die attach to the modified '02' package which includes four bias entries and two RF connections. The bias tees are built-in to the package. Small value bypassing capacitors are included with assembly. Proper bypassing is still required on the DC lines. The amplifier operates over a temperature range of approximately 85 °C.

The PCB requires via holes with a diameter of 20 mils placed uniformly over the center pad for thermal relief and RF ground as shown in Figure 2. The via holes can be back filled with conductive epoxy for best thermal performance. The choice of capacitor bypassing near the amplifier should have a short circuit resonance at the frequency of operation. A small capacitor 3.9 pF 0603 from AVX has a series resonance at 5.5 GHz and will make a good choice for the first bypass capacitor.

Followed up with larger value capacitors, 100 pF or 1000 pF and 2.2  $\mu$ F can be used to maintain voltage stability under peak current conditions. The DC ground via holes should be laid out to minimized inductive returns associated with ground loops. Use of stitch ground via holes can help control the return current and also maintain ground continuity between the top and bottom ground layers. Two mounting holes are used near the PA assembly to secure the board to the chassis; this also minimizes ground current loops and improves thermal conductivity in the absence of sweat soldering the board to the chassis. The internal bias tees inside the PA are quarter-wave stubs at the gate and drain inputs. A 56  $\Omega$  resistor is inserted in series to the gate increasing the effective impedance seen from the Vgs power supply and reducing the risk of video oscillations.

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The MMA-445933H-02 has a noise figure less than 9.0 dB. A plot of noise figure versus frequency at  $I_{dq}$  is shown in Figure 3. The amplifier behaves like a class 'A' amplifier. At small signal levels the amplifier operates at  $I_{dq}$ . A plot of P1dB versus frequency shown in Figure 4 is plotted from 4.4 to 5.9 GHz. The drain current  $I_{dd1}$  and  $I_{dd2}$  increases over a range of 1050 mA to 1100 mA from  $I_{dq} = 1020$  mA. This bias condition for this amplifier is class A. The gain versus temperature has a negative slope of  $-0.07$  dB/°C. Other class operations can be set by adjusting the gate control voltage(s). Such operations as class B is doable by backing off the PA stage controlled by Vgg2 control voltage. The maximum input drive level is 17 dBm.

The two tone linearity shown in Figure 4 is swept across a power range from 15 to 25 dBm per tone at the output of the amplifier from 4.4 to 4.9 GHz. At 22 dBm per tone the IMD3 is 50 dBc and OIP3 is 47 dBm. The Burst power shown in Figure 5 is measured across the frequency range from 4.44 to 4.9 GHz at error vector magnitudes equal to 2% and 2.5%. The modulation is 802.16x and each frame cycle has a 10 msec duration and runs continuously.

Equalization is enabled when measuring EVM performance. The MMA amplifier bias condition is  $V_{dd1} = V_{dd2} = 7.5$  V and the gate voltage is  $V_{gg1} = V_{gg2} = -0.8$  V for an  $I_{dq} = 1020$  mA.

The gain stability over temperature is shown in Figure 6 and 7. The temperature range was taken at 10 °C to 85 °C, and varies 3 dB at a fix frequency.

The EVM versus burst power, shown in Figures 8 and 9 is better than 25.5 dBm for an EVM = 2 % over temperature and is plotted at two spot frequency points 4.4 GHz and 4.9 GHz from 10 °C to 85 °C degrees.

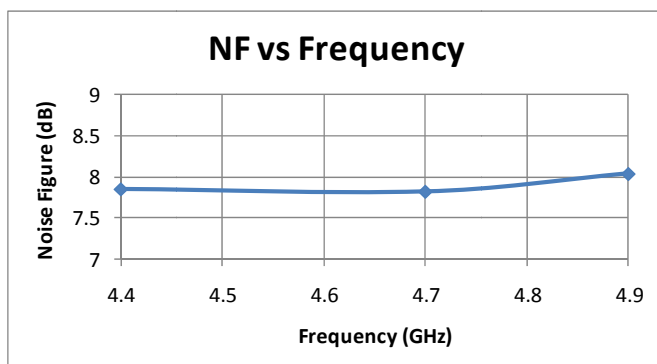


Figure 2 Noise Figure

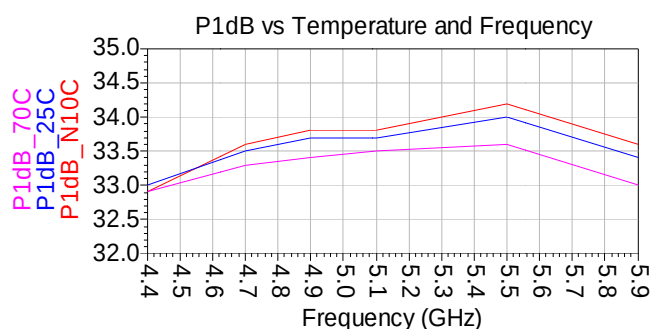


Figure 3 P1dB and Ids

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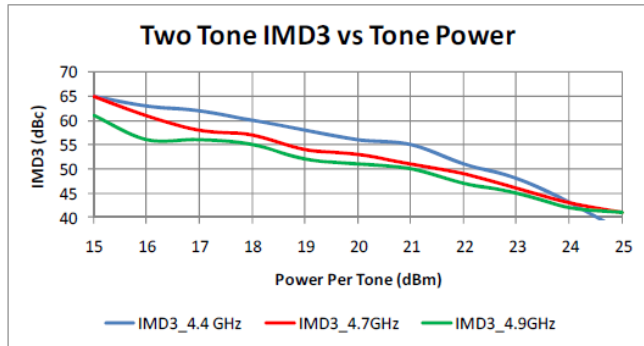


Figure 4 Two Tone

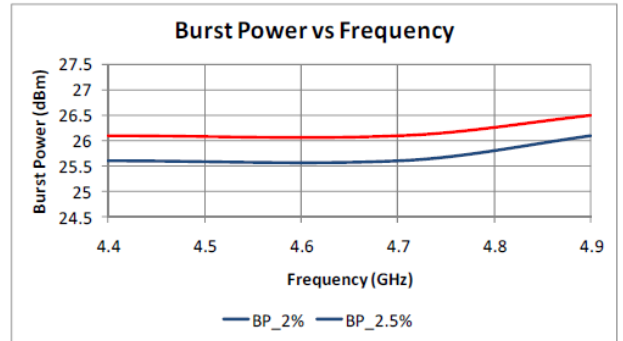


Figure 5 Burst Power

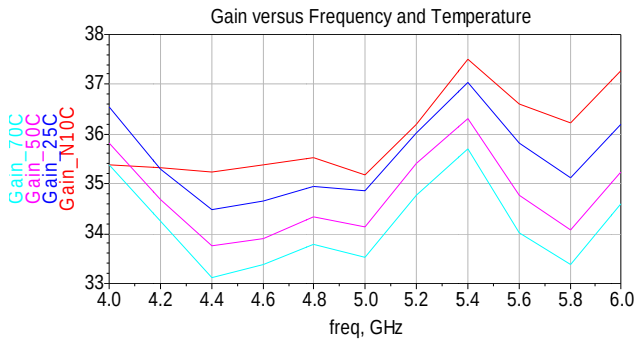


Figure 6 Gain vs Temperature

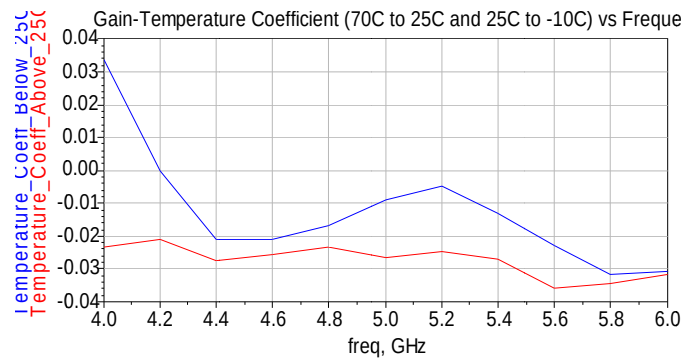


Figure 7 Gain-Temperature Coefficient

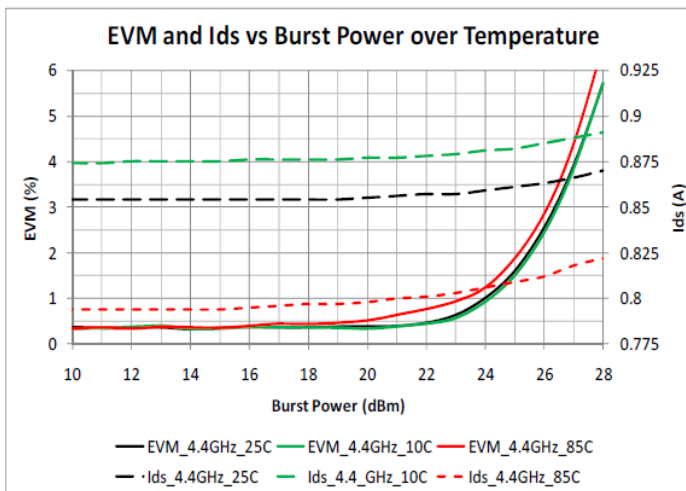


Figure 8 EVM vs Burst Power and Temperature

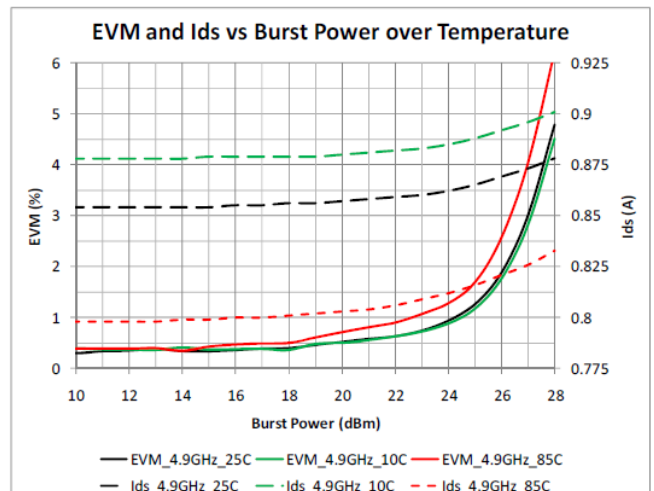


Figure 9 EVM vs Burst Power and Temperature

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### REACH Compliance



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