

Modulated Wideband Driver Amplifier

1 Introduction

The TBMDA2 modulated wideband driver amplifier is designed in order to create an inexpensive signal source for immunity testing of electronic building blocks and products. It is designed to be driven by the tracking generator output of spectrum analyzers. With its 1dB compression point of +27dBm, it can boost the output power of a tracking generator up to 500mW. The TBMDA2 is ideal to drive Tekbox near field probes in order to find the sensitive spot of an electronic circuit or to create electric fields up to 170V/m when driving the Tekbox TEM Cell TBTC0, 100V/m when driving the TBTC1, 50V/m when driving the TBTC2 or 30V/m when driving the TBTC3. Test signals for immunity testing can be CW, AM or PM. Consequently, the TBMDA2 provides built in modulation capability to generate 1 kHz AM or PM signals. In PM mode, the TBMDA2 can also generate a 217 Hz Signal with 12.5% duty cycle in order to simulate mobile phone TDMA noise.



Picture 1 – TBMDA2 modulated wideband driver amplifier, front view



Picture 2 – TBMDA2 modulated wideband driver amplifier, rear view

Modulated Wideband Driver Amplifier

Application:

General-purpose gain block
 Signal source for immunity testing, driving near field probes
 Signal source for immunity testing, driving TEM Cells

Features:

CW amplifier (modulation off)
 1 kHz, 80% AM modulation
 1 kHz, 50% duty cycle pulse modulation
 217 Hz, 12.5% duty cycle pulse modulation

2 Electrical Specifications

Technical Data:

Input / Output: 50 Ohm, SMA female
 Nominal supply Voltage: 5V, typ. 700mA, Mini-USB-B connector
 Maximum supply voltage: 5.5V
 Maximum input power: -8dBm continuous, 0 dBm @ 25°C for 5 minutes max.
 Operating temperature range: -20°C to 50°C
 Frequency range: 10MHz – 1.5 GHz
 1dB output compression point @ 10MHz: +24 dBm typ.
 1dB output compression point @ 100 MHz: +27 dBm typ.
 1dB output compression point @ 1 GHz: +27 dBm typ.
 1dB output compression point @ 1.5 GHz: +26.5 dBm typ.
 Harmonics: < - 30 dBc typ.
 Internal modulation frequency AM: 1 kHz ±10%
 Internal modulation frequencies PM: 1 kHz ±10%, 217 Hz ±20%
 Duty cycle, PM: 50% ±10% @ 1 kHz; 12.5% ±20% @ 217 Hz
 Gain:

| | | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 10 MHz | 25 MHz | 100 MHz | 200 MHz | 300 MHz | 400 MHz | 500 MHz | 600 MHz | 700 MHz |
| 44.2 dB | 46.3 dB | 46.7 dB | 46.6 dB | 45.3 dB | 44.2 dB | 43.8 dB | 42.9 dB | 41.7 dB |
| 800 MHz | 900 MHz | 1 GHz | 1.1 GHz | 1.2 GHz | 1.3 GHz | 1.4 GHz | 1.5 GHz | |
| 39.6 dB | 40.1 dB | 39.3 dB | 38.5 dB | 37.3 dB | 36.8 dB | 35.9 dB | 34.8 dB | |

Table 1 – TBMDA2 gain

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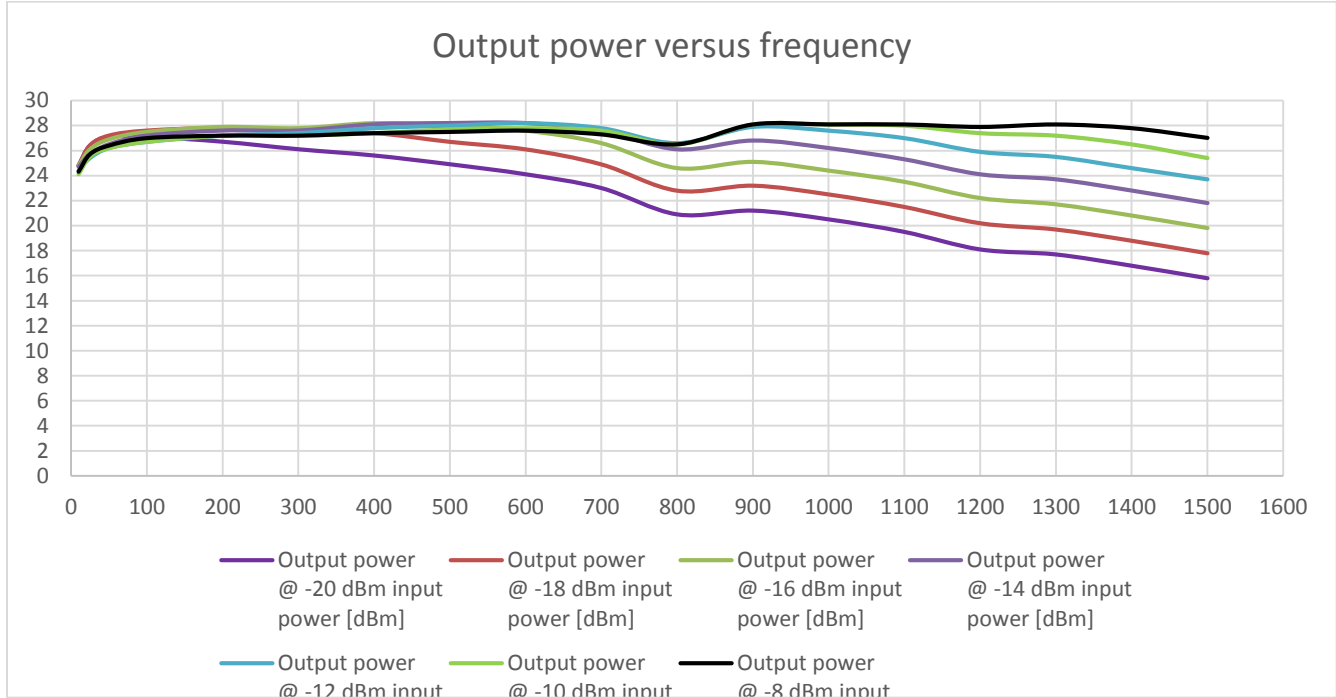


Figure 1 – TBMDA2, output power versus frequency, 10MHz – 1.5GHz

| Frequency [MHz] | Output power @ -20 dBm input power [dBm] | Output power @ -18 dBm input power [dBm] | Output power @ -16 dBm input power [dBm] | Output power @ -14 dBm input power [dBm] | Output power @ -12 dBm input power [dBm] | Output power @ -10 dBm input power [dBm] | Output power @ -8 dBm input power [dBm] |
|-----------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|-----------------------------------------|
| 10 | 24.8 | 24.8 | 24.8 | 24.7 | 24.4 | 24.1 | 24.3 |
| 25 | 26.4 | 26.4 | 26.1 | 25.7 | 25.4 | 25.5 | 25.7 |
| 50 | 27.1 | 27.2 | 26.9 | 26.5 | 26.2 | 26.2 | 26.4 |
| 100 | 27.1 | 27.6 | 27.5 | 27.2 | 26.7 | 26.7 | 27 |
| 200 | 26.7 | 27.8 | 27.9 | 27.6 | 27.2 | 27.2 | 27.2 |
| 300 | 26.1 | 27.5 | 27.8 | 27.6 | 27.4 | 27.2 | 27.2 |
| 400 | 25.6 | 27.4 | 28.2 | 28.1 | 27.8 | 27.4 | 27.4 |
| 500 | 24.9 | 26.7 | 28 | 28.2 | 28 | 27.7 | 27.5 |
| 600 | 24.1 | 26.1 | 27.6 | 28.2 | 28.2 | 27.8 | 27.6 |
| 700 | 23 | 24.9 | 26.6 | 27.6 | 27.8 | 27.6 | 27.3 |
| 800 | 20.9 | 22.8 | 24.6 | 26.1 | 26.6 | 26.5 | 26.5 |
| 900 | 21.2 | 23.2 | 25.1 | 26.8 | 27.9 | 28.1 | 28.1 |
| 1000 | 20.5 | 22.5 | 24.4 | 26.2 | 27.6 | 28.1 | 28.1 |
| 1100 | 19.5 | 21.5 | 23.5 | 25.3 | 27 | 28 | 28.1 |
| 1200 | 18.1 | 20.2 | 22.2 | 24.1 | 25.9 | 27.4 | 27.9 |
| 1300 | 17.7 | 19.7 | 21.7 | 23.7 | 25.5 | 27.2 | 28.1 |
| 1400 | 16.8 | 18.8 | 20.8 | 22.8 | 24.6 | 26.5 | 27.8 |
| 1500 | 15.8 | 17.8 | 19.8 | 21.8 | 23.7 | 25.4 | 27.02 |

Table 2 – TBMDA2 power table

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Frequency response:

The tables above show a 10dB gain variation across the frequency range 10 MHz to 1.5 GHz. When driving the TBMDA2 with the tracking generator of a spectrum analyzer, the TG level can be set to -8 ...-12 dBm to get a flat output power response over the frequency range. This will drive the amplifier into compression for lower frequencies. This is acceptable when using CW or pulse modulation for immunity testing. However, when doing immunity tests with an AM modulated signal, it would clip the AM envelope, as the modulator is in front of the output stage of the TBMDA2.

Hence, when using AM modulation, the input power shall be set to levels where the TBMDA2 is in linear operation.

Linear operation:

You can calculate the drive levels for linear operation using following approximation formula or the table below:

$$P_{\text{input}} [\text{dBm}] = 0.008 * \text{frequency} [\text{MHz}] - 20$$

| Frequency [MHz] | Input power [dBm] | Output power [dBm] | gain [dB] |
|-----------------|-------------------|--------------------|-----------|
| 10 | -19.92 | 24.3 | 44.22 |
| 25 | -19.8 | 26.5 | 46.3 |
| 50 | -19.6 | 27.1 | 46.7 |
| 100 | -19.2 | 27.4 | 46.6 |
| 200 | -18.4 | 27.6 | 46 |
| 300 | -17.6 | 27.7 | 45.3 |
| 400 | -16.8 | 27.4 | 44.2 |
| 500 | -16 | 27.8 | 43.8 |
| 600 | -15.2 | 27.7 | 42.9 |
| 700 | -14.4 | 27.3 | 41.7 |
| 800 | -13.6 | 26 | 39.6 |
| 900 | -12.8 | 27.3 | 40.1 |
| 1000 | -12 | 27.3 | 39.3 |
| 1100 | -11.2 | 27.3 | 38.5 |
| 1200 | -10.4 | 26.9 | 37.3 |
| 1300 | -9.6 | 27.2 | 36.8 |
| 1400 | -8.8 | 27.1 | 35.9 |
| 1500 | -8 | 26.8 | 34.8 |

Table 3 – input drive levels for linear operation

As tracking generator levels usually can only be adjusted in 1dB steps, apply the closest integer value.

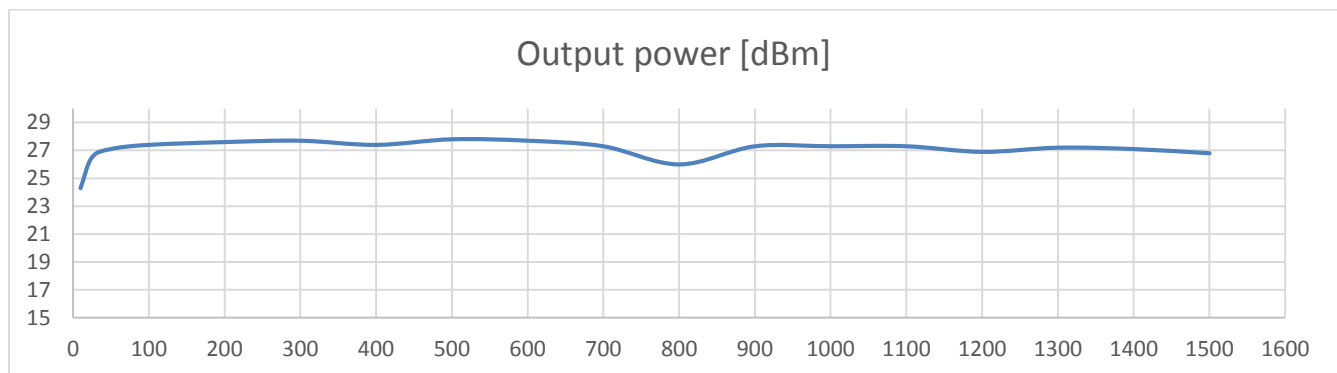


Figure 2 – output power, applying the drive levels given in table3, 10MHz – 1.5GHz

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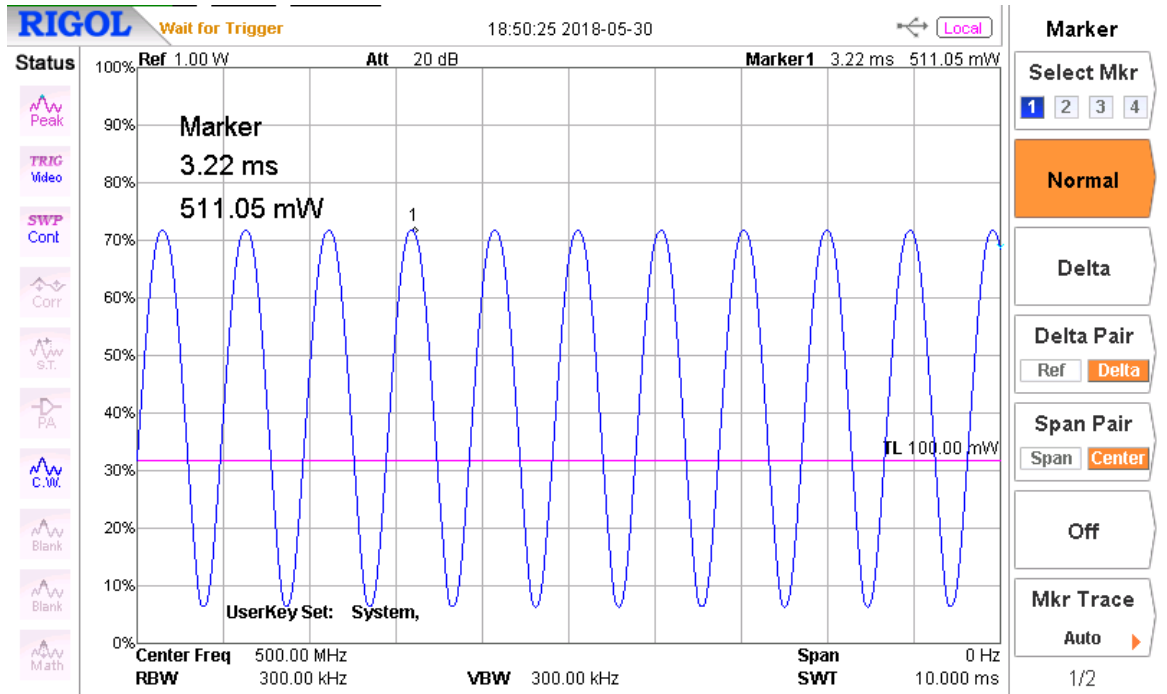


Figure 3 – 1 kHz, 80 % AM envelope, applying the drive levels given in table3, 500 MHz

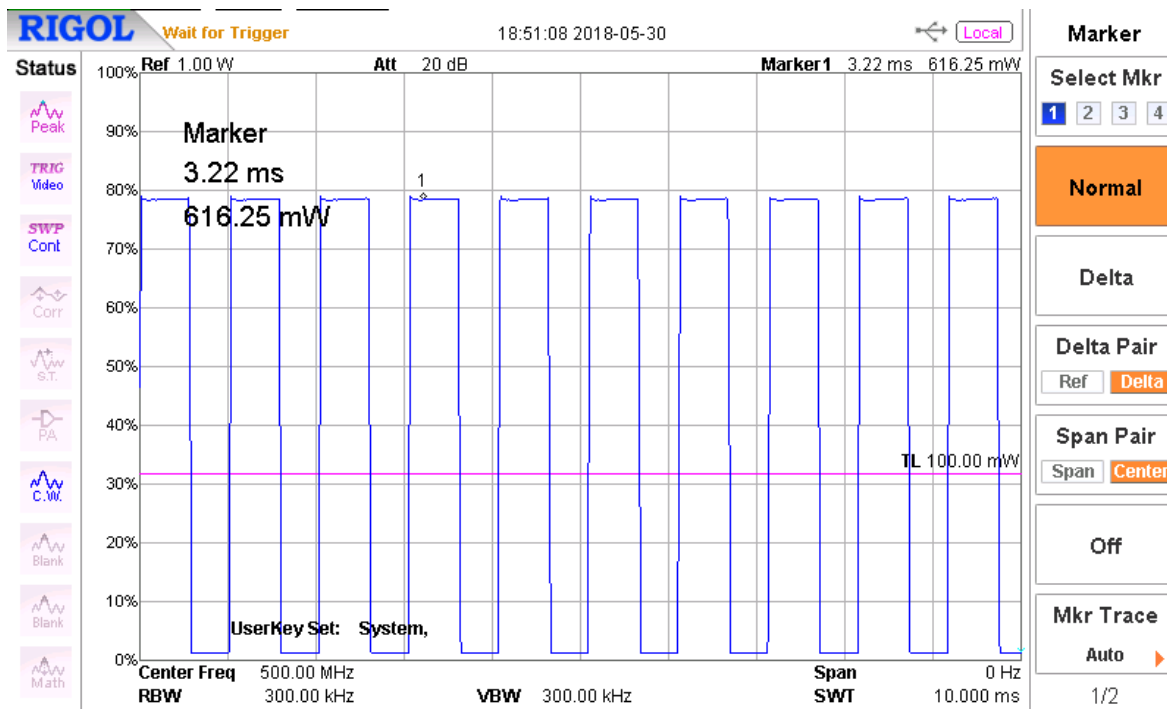


Figure 4 – 1 kHz, 50 % PM envelope, 500 MHz

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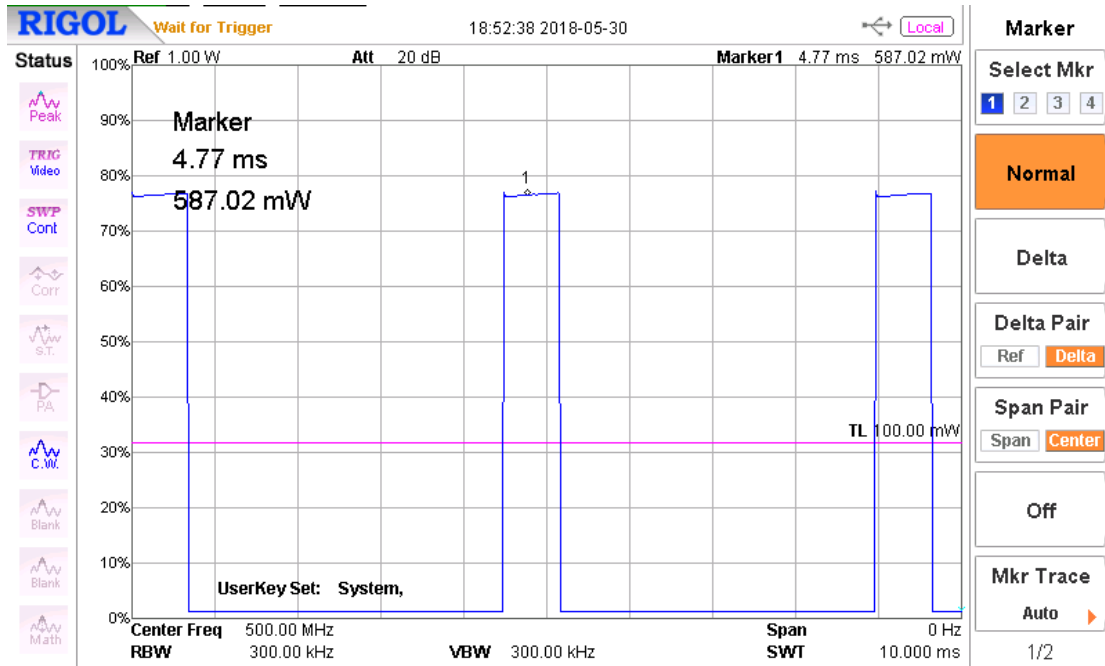


Figure 5 – 217 Hz, 12.5 % PM envelope, 500 MHz

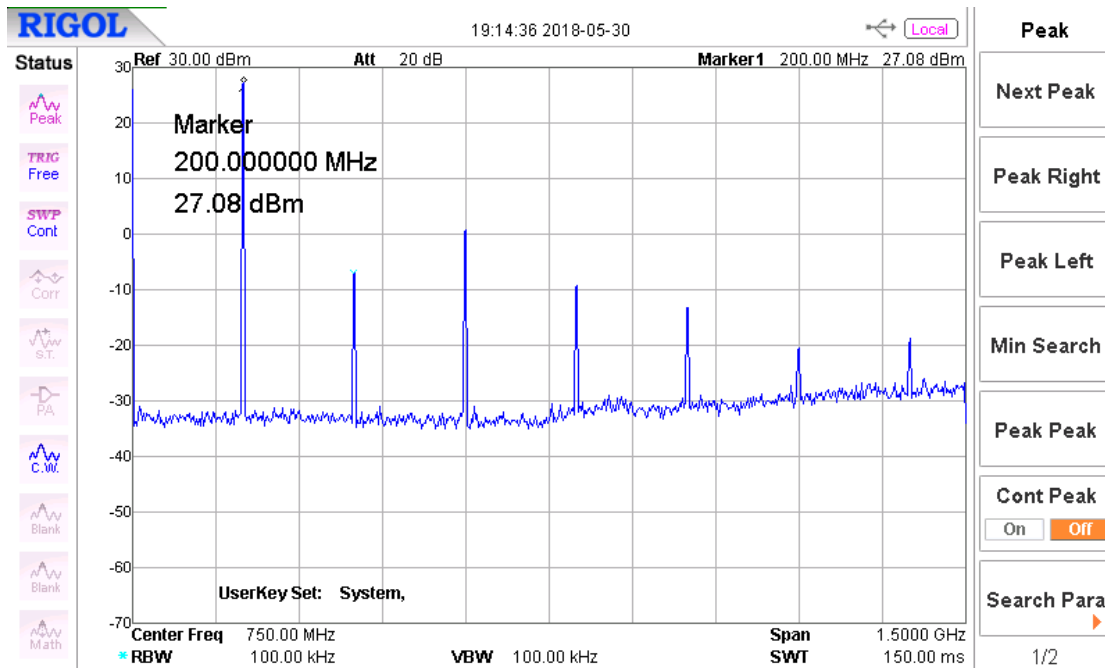


Figure 6 – CW, harmonics, 200 MHz

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3 Power supply

The current consumption of the TBMDA2 is 700mA and consequently exceeds the current limit of USB 2.0 ports. Supply the TBMDA2 through a USB 3.0 port or a mobile phone charger with an output current capability of 1A or higher.

Connector: Mini-USB-B

4 Applications

Immunity testing using a TEM cell

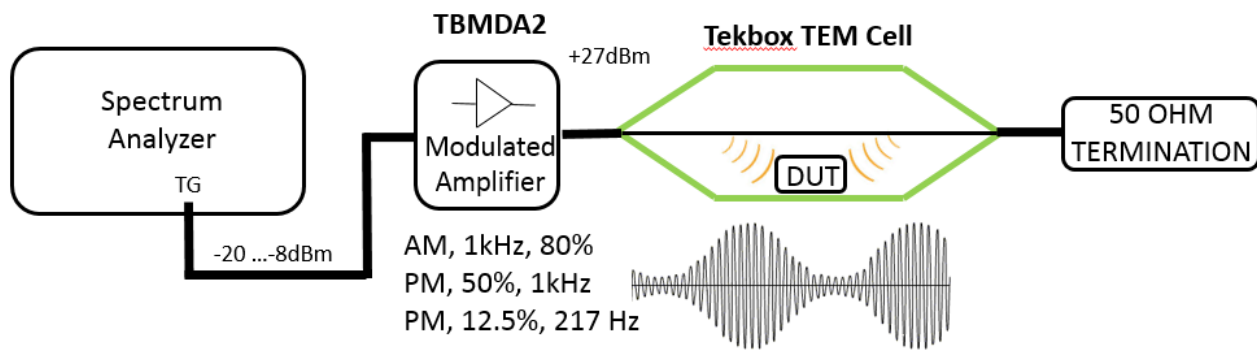


Figure 7 – immunity testing set up

Immunity testing using near field probes

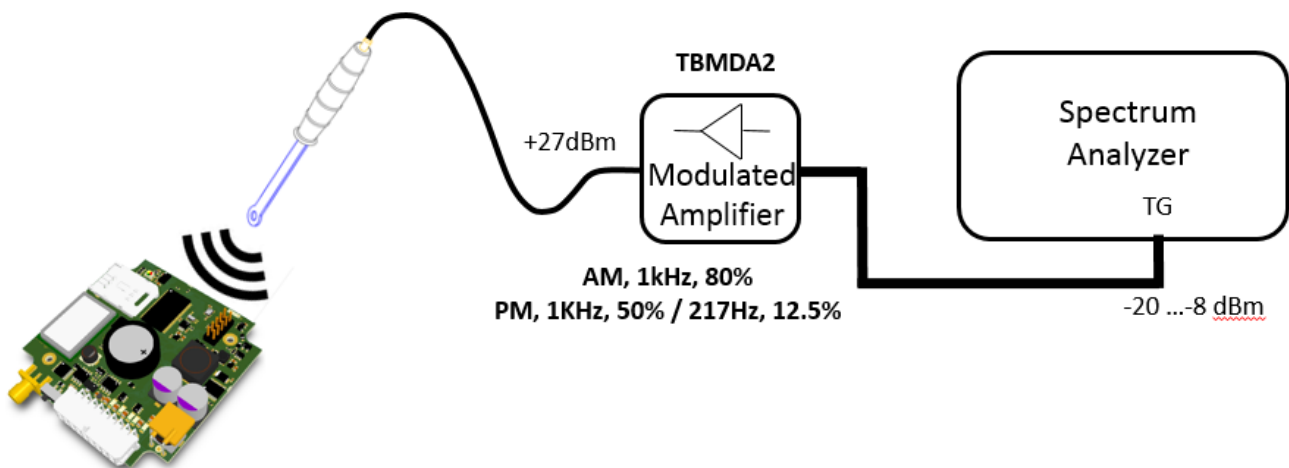


Figure 8 – immunity testing set up

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5 TEM Cell field strength

A typical pre compliance set up for immunity testing is typically not sophisticated enough to measure the real field strength inside the TEM cell. However, the field strength can be approximated mathematically.

The E-field (V/m) between septum and lower (upper) wall of a TEM cell is $E = V/d$ where V is the RMS voltage of the applied signal and d is the distance between septum and lower (upper) wall. This is based on the simplified assumption that the E field would be perfectly homogenous/evenly distributed. A more practical formula is $E = V*Cor/d$ where Cor is a correction factor for the average field strength over the volume of the DUT derived from the analysis of the field distribution over the cross section of the cell.

Assuming the DUT is placed in the center of the cell and in the middle between bottom wall and septum, we can however use the simplified formula with sufficient accuracy.

$$TBTC0: d = 2.8 \text{ cm} \rightarrow E_{[V/m]} = (\sqrt{P*50\Omega}) * 35.7$$

$$TBTC1: d = 5 \text{ cm} \rightarrow E_{[V/m]} = (\sqrt{P*50\Omega}) * 20$$

$$TBTC2: d = 10 \text{ cm} \rightarrow E_{[V/m]} = (\sqrt{P*50\Omega}) * 10$$

$$TBTC3: d = 15 \text{ cm} \rightarrow E_{[V/m]} = (\sqrt{P*50\Omega}) * 6.66$$

The power P in the formulas above has to be entered in [Watt]

$$P_{[W]} = 0.001 * (10^{(P_{[dBm]}/10)})$$

| Frequency [MHz] | Input power [dBm] | Output power [dBm] | Field strength TBTC0 [V/m] | Field strength TBTC1 [V/m] | Field strength TBTC2 [V/m] | Field strength TBTC3 [V/m] |
|-----------------|-------------------|--------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 10 | -19.92 | 24.3 | 131 | 73 | 37 | 24 |
| 25 | -19.8 | 26.5 | 169 | 95 | 47 | 31 |
| 50 | -19.6 | 27.1 | 181 | 101 | 51 | 34 |
| 100 | -19.2 | 27.4 | 187 | 105 | 52 | 35 |
| 200 | -18.4 | 27.6 | 191 | 107 | 54 | 36 |
| 300 | -17.6 | 27.7 | 194 | 109 | 54 | 36 |
| 400 | -16.8 | 27.4 | 187 | 105 | 52 | 35 |
| 500 | -16 | 27.8 | 196 | 110 | 55 | 37 |
| 600 | -15.2 | 27.7 | 194 | 109 | 54 | 36 |
| 700 | -14.4 | 27.3 | 185 | 104 | 52 | 35 |
| 800 | -13.6 | 26 | 159 | 89 | 45 | n.a |
| 900 | -12.8 | 27.3 | 185 | 104 | 52 | n.a |
| 1000 | -12 | 27.3 | 185 | 104 | 52 | n.a |
| 1100 | -11.2 | 27.3 | 185 | 104 | 52 | n.a |
| 1200 | -10.4 | 26.9 | 177 | 99 | 49 | n.a |
| 1300 | -9.6 | 27.2 | 183 | 102 | 51 | n.a |
| 1400 | -8.8 | 27.1 | 181 | 101 | 51 | n.a |
| 1500 | -8 | 26.8 | 175 | 98 | 49 | n.a |

Table 4 – calculated field strength for TBMDA2 driving Tekbox TEM cells

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6 PC Software for immunity testing

The Tekbox EMCview SW is regularly updated and now supports immunity testing with a feature for automated tracking generator control. This significantly simplifies immunity testing, especially in case of repeated testing during validation of DUT modifications/improvements.

Tekbox EMCview currently supports Rigol, Siglent, R&S FPC and FPH series spectrum analyzers.

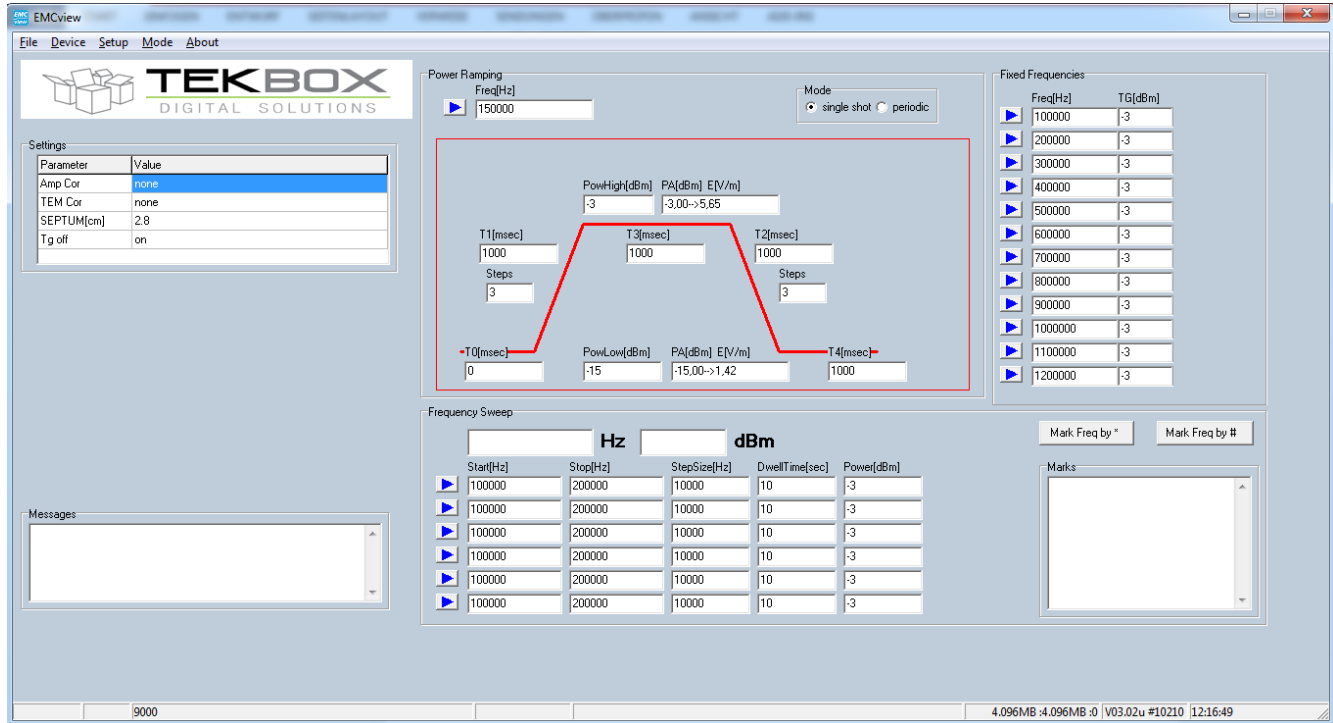


Figure 9 – screenshot of the tracking generator control feature of EMCview

WARNING:

Never connect the output of the TBMDA2 directly to the input of a spectrum analyzer. Check the maximum input ratings of the spectrum analyzer and protect it with an appropriate attenuator.

Example:

Rigol DSA815 – maximum input power rating: +20dBm

Modulated Wideband Driver Amplifier

7 Ordering Information

| Part Number | Description |
|-------------|----------------------------------------------------------------------------------------------------------------------|
| TBMDA2 | modulated driver amplifier, 2 pcs 75cm SMA-male to N-male cables, 1 pc 20dB attenuator with N-connectors, USB cable, |

Table 5 – Ordering Information

8 History

| Version | Date | Author | Changes |
|---------|-----------|------------|--------------------------|
| V1.0 | 31.5.2018 | Mayerhofer | Creation of the document |
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Table 6 – History