Modulated Wideband Power Amplifier

1 Introduction

The TBMDA4 modulated wideband power 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 an input power range of -5 dBm...0 dBm, it can boost the output power of a tracking generator up to 5W. With a frequency range from 100 kHz to 50 MHz, it is an ideal complement to the TBMDA3, which covers 10 MHz to 1 GHz. The TBMDA4 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 550 V/m when driving the Tekbox TEM Cell TBTC0, 300 V/m when driving the TBTC1, 150 V/m when driving the TBTC2 or 100 V/m when driving the TBTC3. Test signals for immunity testing can be CW, AM or PM modulated. Consequently, the TBMDA4 provides built in modulation capability to generate 1 kHz AM or PM signals. In PM mode, the TBMDA4 can also generate a 217 Hz Signal with 12.5% duty cycle in order to simulate mobile phone TDMA noise.

Picture 1 – TBMDA4 modulated wideband driver amplifier, front view

Picture 2 – TBMDA4 modulated wideband driver amplifier, rear view
Modulated Wideband Power Amplifier

**Application:**
General-purpose power amplifier
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, N female
Supply Voltage range: 110 V…240 V
Supply power consumption: 20 W
Operating temperature range: -20°C to 50°C
Frequency range: 100 kHz – 50 MHz

1dB output compression point @ 1 MHz: +35.5 dBm typ.
1dB output compression point @ 10 MHz: +36 dBm typ.
1dB output compression point @ 50 MHz: +36.5 dBm typ.
2\textsuperscript{nd} harmonic, 20 MHz, Pout=36dBm: < -15 dBc typ.
2\textsuperscript{nd} harmonic, 25 MHz, Pout=30dBm: < -20 dBc typ.
3\textsuperscript{rd} harmonic, 25 MHz, Pout=36dBm: < -25 dBc typ.
3\textsuperscript{rd} harmonic, 25 MHz, Pout=30dBm: < -30 dBc typ.
Total harmonic distortion:
6.7% @25MHz, Pout=27dBm typ.
8.5% @25 MHz, Pout=30 dBm typ.
12% @25 MHz, Pout=33 dBm typ.
15% @25 MHz, Pout=36 dBm typ.
Third order intercept point:
+53dBm, @25 MHZ, \Delta f = 200kHz typ.

Noise figure: 9 dB
Modulated Wideband Power Amplifier

Internal modulation frequency AM: 1 kHz ±20%
Internal modulation frequencies PM: 1 kHz ±10%, 217 Hz ±20%
Duty cycle, PM: 50% ±10% @ 1 kHz; 12.5% ±20% @ 217 Hz

**Maximum ratings:**
Maximum input power: 0 dBm
The output of the TBMDA4 is quite tolerant to output mismatch, however open or shorted load is not recommended, potentially can cause damage.

**Small Signal Gain (measured with Pin = - 20 dBm):**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>50 kHz</th>
<th>100 kHz</th>
<th>500 kHz</th>
<th>1 MHz</th>
<th>5 MHz</th>
<th>10 MHz</th>
<th>25 MHz</th>
<th>50 MHz</th>
<th>70 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>39.3 dB</td>
<td>44.9 dB</td>
<td>47.1 dB</td>
<td>47.2 dB</td>
<td>47.3 dB</td>
<td>47.5 dB</td>
<td>48.6 dB</td>
<td>49.9 dB</td>
<td>44.5 dB</td>
</tr>
</tbody>
</table>

*Table 1 – TBMDA4 gain*

**Linear output power:**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>50 kHz</th>
<th>100 kHz</th>
<th>500 kHz</th>
<th>1 MHz</th>
<th>5 MHz</th>
<th>10 MHz</th>
<th>25 MHz</th>
<th>50 MHz</th>
<th>70 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power @Pin = -6 dBm</td>
<td>32.8 dBm</td>
<td>33.9 dBm</td>
<td>34.4 dBm</td>
<td>35.3 dBm</td>
<td>35.5 dBm</td>
<td>35.7 dBm</td>
<td>35.8 dBm</td>
<td>35.8 dBm</td>
<td>33.2 dBm</td>
</tr>
</tbody>
</table>

*Table 2 – TBMDA4, linear output power versus frequency, 50 kHz – 70 MHz*

**Saturated output power:**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>50 kHz</th>
<th>100 kHz</th>
<th>500 kHz</th>
<th>1 MHz</th>
<th>5 MHz</th>
<th>10 MHz</th>
<th>25 MHz</th>
<th>50 MHz</th>
<th>70 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power @Pin = -3 dBm</td>
<td>34.1 dBm</td>
<td>34.9 dBm</td>
<td>35.3 dBm</td>
<td>36.3 dBm</td>
<td>37.3 dBm</td>
<td>37.4 dBm</td>
<td>37.5 dBm</td>
<td>37.6 dBm</td>
<td>36.6 dBm</td>
</tr>
</tbody>
</table>

*Table 3 – TBMDA4, saturated output power versus frequency, 50 kHz – 70 MHz*
Modulated Wideband Power Amplifier

Figure 1 – 1 kHz, 80% AM envelope, 25 MHz

Figure 2 – 1 kHz, 50% PM envelope, 25 MHz

Figure 3 – 217 Hz, 12.5% PM envelope, 25 MHz
3 Applications

Immunity testing using a TEM cell

Immunity testing using near field probes

Figure 4 – immunity testing set up

Figure 5 – immunity testing set up
4 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: $d = 2.8$ cm -> $E_{[V/m]} = (\sqrt{P*50\Omega})*35.7$
TBTC1: $d = 5$ cm -> $E_{[V/m]} = (\sqrt{P*50\Omega})*20$
TBTC2: $d = 10$ cm -> $E_{[V/m]} = (\sqrt{P*50\Omega})*10$
TBTC3: $d = 15$ cm -> $E_{[V/m]} = (\sqrt{P*50\Omega})*6.66$

The power $P$ in the formulas above hast to be entered in [Watt]
$P_{[W]} = 0.001*(10^{(P_{[dBm]}/10)})$

<table>
<thead>
<tr>
<th>Frequency [MHz]</th>
<th>Input power [dBm]</th>
<th>Output power [dBm]</th>
<th>Field strength TBTC0 [V/m]</th>
<th>Field strength TBTC1 [V/m]</th>
<th>Field strength TBTC2 [V/m]</th>
<th>Field strength TBTC3 [V/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>-5</td>
<td>34.2</td>
<td>409</td>
<td>229</td>
<td>115</td>
<td>76</td>
</tr>
<tr>
<td>10</td>
<td>-5</td>
<td>36.3</td>
<td>521</td>
<td>292</td>
<td>146</td>
<td>97</td>
</tr>
<tr>
<td>25</td>
<td>-5</td>
<td>37.4</td>
<td>592</td>
<td>332</td>
<td>166</td>
<td>110</td>
</tr>
<tr>
<td>50</td>
<td>-5</td>
<td>37.3</td>
<td>585</td>
<td>328</td>
<td>164</td>
<td>109</td>
</tr>
<tr>
<td>100</td>
<td>-5</td>
<td>37.2</td>
<td>578</td>
<td>324</td>
<td>162</td>
<td>108</td>
</tr>
<tr>
<td>200</td>
<td>-5</td>
<td>36.5</td>
<td>534</td>
<td>299</td>
<td>149</td>
<td>100</td>
</tr>
<tr>
<td>300</td>
<td>-5</td>
<td>36.1</td>
<td>510</td>
<td>285</td>
<td>143</td>
<td>95</td>
</tr>
<tr>
<td>400</td>
<td>-5</td>
<td>35.6</td>
<td>481</td>
<td>269</td>
<td>135</td>
<td>90</td>
</tr>
<tr>
<td>500</td>
<td>-5</td>
<td>35.4</td>
<td>470</td>
<td>263</td>
<td>132</td>
<td>88</td>
</tr>
<tr>
<td>600</td>
<td>-5</td>
<td>35.1</td>
<td>454</td>
<td>254</td>
<td>127</td>
<td>n.a</td>
</tr>
<tr>
<td>700</td>
<td>-5</td>
<td>34.6</td>
<td>429</td>
<td>240</td>
<td>120</td>
<td>n.a</td>
</tr>
<tr>
<td>800</td>
<td>-5</td>
<td>33</td>
<td>357</td>
<td>200</td>
<td>100</td>
<td>n.a</td>
</tr>
<tr>
<td>900</td>
<td>-5</td>
<td>34.1</td>
<td>405</td>
<td>227</td>
<td>113</td>
<td>n.a</td>
</tr>
<tr>
<td>1000</td>
<td>-5</td>
<td>33.3</td>
<td>369</td>
<td>207</td>
<td>103</td>
<td>n.a</td>
</tr>
</tbody>
</table>

Table 3 – calculated field strength for TBMDA4 driving Tekbox TEM cells
5 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 8 – Screenshot of the tracking generator control feature of EMCview](image)

**WARNING:**

Never connect the output of the TBMDA4 directly to the input of a spectrum analyzer. Check the maximum input ratings of the spectrum analyzer and protect it with an appropriate attenuator. Open or shorted load is not recommended, potentially can cause damage.

**Example:**

Rigol DSA815 – maximum input power rating: +20dBm
6 Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBMDA4</td>
<td>modulated power amplifier, 2 pcs 75cm N-male to N-male cables, 1 pc 30dB / 10W attenuator with N-connectors, power cord</td>
</tr>
</tbody>
</table>

*Table 5 – Ordering Information*

7 History

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Author</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1.0</td>
<td>6.9.2018</td>
<td>Mayerhofer</td>
<td>Creation of the document</td>
</tr>
</tbody>
</table>

*Table 6 – History*