30MHz – 300 MHz Biconical Measurement Antenna

1 Introduction

The TBMA2 is a biconical measurement antenna for EMC radiated emission testing and generating defined field strength. With its affordable price it is an excellent choice for any lab carrying out in house pre-compliance testing.
It is characterized from 30 MHz to 300 MHz and has a directional pattern similar to a dipole antenna.

2 Product overview

The TBMA2 comes with a POM bracket with a ¼ " thread insert for mounting the antenna on standard tripods.

The TBMA2 radiating elements are made of stainless steel parts to avoid the disadvantages of contact degeneration over time, which are associated with non-welded designs using aluminum. The radiating elements are not welded but fastened with grub screws, which makes assembly / disassembly simple and makes the antenna easily storable and transportable. The antenna elements are fed via a 1:4 balun with 100 W power handling capability.

3 Technical specifications

- Type: passive biconical
- Frequency range: 30 MHz– 300 MHz
- Nominal impedance: 50 Ω
- Balun: 1:4
- Maximum continuous input RF power: 100 W
- Connector: N type female
- Isotropic Gain: -12.51 to 0.55, see Figure 2 and Table 1
- Antenna Factor: 10.8 to 26.3, see Figure 3 and Table 1
- Voltage Standing Wave Ratio (VSWR): 1.05 to 38.05, see Figure 4 and Figure 5
- Test standards: FCC, CISPR, SAE, RTCA-DO-160, Mil-STD-461, etc.

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- Length: 138.7 cm (54.6 ") tip-to-tip
- Diameter: 54.2 cm (21.3 ")
- Depth: 80.3 cm (31.6 ") including balun
- Weight of one radiating element: 1.28 kg (2.82 lbs)
- Weight of holder/balun: 0.96 kg (2.12 lbs)

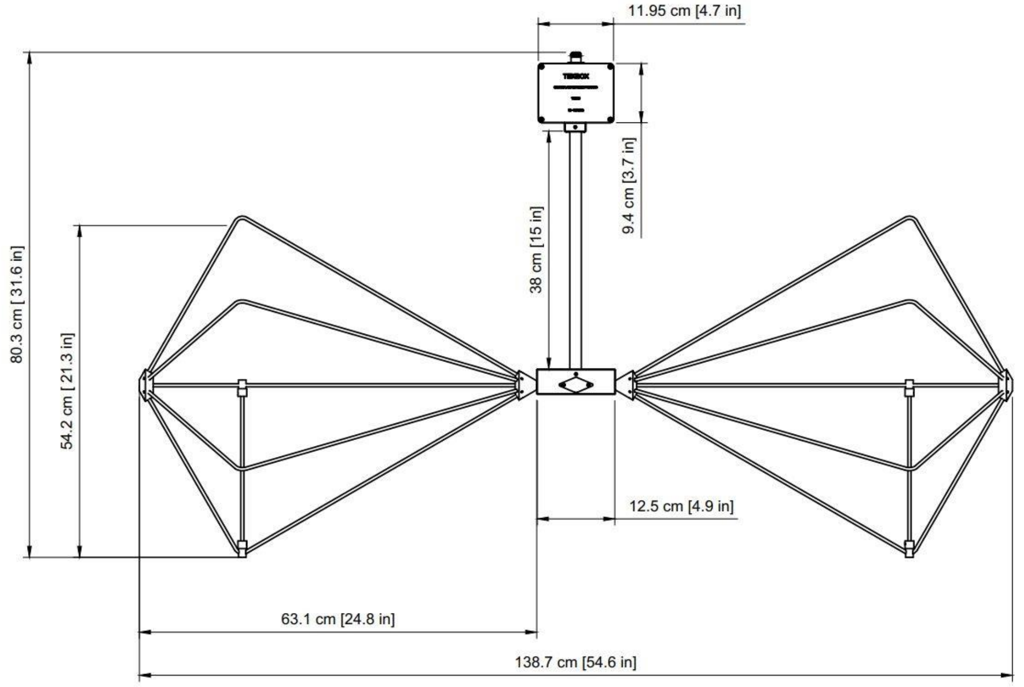

Figure 1: TBMA2 mechanical dimensions

4 TBMA2 Antenna characterization

The TBMA2 has been characterized according SAE-ARP-958 standard by Seibersdorf Laboratories, an accredited Calibration Body for Antennas and Field Probes. The properties of the antenna are documented in the table and plots on the following pages. The test report of the Seibersdorf Laboratories and parameters in Excel format can also be downloaded from our web site.

Every TBMA2 antenna ist tested on the OATS test site of Tekbox for the antenna factor to be within ± 1.5 dB of the results documented in the test report of Seibersdorf Laboratories.

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4.1 Gain & Antenna Factor versus frequency

Frequency [MHz]	Wavelength [m]	Gain (Isotropic) [dBi]	Gain (Dipole) [dBd]	Antenna Factor [dB/m]
30.00	10.00	-12.51	-14.70	12.27
31.00	9.70	-12.28	-14.40	12.32
32.00	9.40	-12.06	-14.20	12.38
33.00	9.10	-11.87	-14.00	12.46
34.00	8.80	-11.62	-13.80	12.47
35.00	8.60	-11.42	-13.60	12.52
36.00	8.30	-11.18	-13.30	12.53
37.00	8.10	-11.00	-13.20	12.58
38.00	7.90	-10.76	-12.90	12.58
39.00	7.70	-10.55	-12.70	12.59
40.00	7.50	-10.39	-12.50	12.65
41.00	7.30	-10.21	-12.40	12.69
42.00	7.10	-10.07	-12.20	12.76
43.00	7.00	-9.85	-12.00	12.74
44.00	6.80	-9.66	-11.80	12.75
45.00	6.70	-9.28	-11.40	12.57
46.00	6.50	-8.96	-11.10	12.44
47.00	6.40	-8.56	-10.70	12.22
48.00	6.20	-8.18	-10.30	12.02
49.00	6.10	-7.80	-10.00	11.83
50.00	6.00	-7.30	-9.50	11.50
51.00	5.90	-6.97	-9.10	11.34
52.00	5.80	-6.64	-8.80	11.18
53.00	5.70	-6.39	-8.50	11.09
54.00	5.60	-6.12	-8.30	10.99
55.00	5.50	-5.78	-7.90	10.80
56.00	5.40	-5.57	-7.70	10.75
57.00	5.30	-5.36	-7.50	10.69
58.00	5.20	-5.27	-7.40	10.76
59.00	5.10	-5.14	-7.30	10.78
60.00	5.00	-5.13	-7.30	10.92
61.00	4.90	-5.07	-7.20	10.99
62.00	4.80	-5.02	-7.20	11.08
63.00	4.80	-4.99	-7.10	11.20
64.00	4.70	-4.94	-7.10	11.28
65.00	4.60	-4.89	-7.00	11.37
66.00	4.50	-4.73	-6.90	11.34
67.00	4.50	-4.57	-6.70	11.31
68.00	4.40	-4.32	-6.50	11.19
69.00	4.30	-4.13	-6.30	11.13
70.00	4.30	-3.87	-6.00	10.99
71.00	4.20	-3.58	-5.70	10.83
72.00	4.20	-3.34	-5.50	10.70
73.00	4.10	-3.09	-5.20	10.57
74.00	4.10	-2.90	-5.10	10.51
75.00	4.00	-2.63	-4.80	10.35
76.00	3.90	-2.47	-4.60	10.30
77.00	3.90	-2.26	-4.40	10.21
78.00	3.80	-2.08	-4.20	10.14
79.00	3.80	-2.00	-4.20	10.18
80.00	3.70	-1.83	-4.00	10.11
81.00	3.70	-1.74	-3.90	10.14
82.00	3.70	-1.60	-3.80	10.10
83.00	3.60	-1.51	-3.70	10.12
84.00	3.60	-1.37	-3.50	10.08
85.00	3.50	-1.33	-3.50	10.14

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Frequency [MHz]	Wavelength [m]	Gain (Isotropic) [dBi]	Gain (Dipole) [dBd]	Antenna Factor [dB/m]
86.00	3.50	-1.27	-3.40	10.18
87.00	3.40	-1.19	-3.30	10.20
88.00	3.40	-1.13	-3.30	10.24
89.00	3.40	-1.04	-3.20	10.25
90.00	3.30	-1.00	-3.20	10.30
91.00	3.30	-0.93	-3.10	10.33
92.00	3.30	-0.93	-3.10	10.42
93.00	3.20	-0.82	-3.00	10.41
94.00	3.20	-0.79	-2.90	10.47
95.00	3.20	-0.78	-2.90	10.55
96.00	3.10	-0.69	-2.80	10.56
97.00	3.10	-0.66	-2.80	10.62
98.00	3.10	-0.61	-2.80	10.66
99.00	3.00	-0.58	-2.70	10.71
100.00	3.00	-0.55	-2.70	10.77
105.00	2.90	-0.58	-2.70	11.22
110.00	2.70	-1.08	-3.20	12.13
115.00	2.60	-2.18	-4.30	13.61
120.00	2.50	-2.63	-4.80	14.43
125.00	2.40	-1.01	-3.20	13.17
130.00	2.30	-0.16	-2.30	12.66
135.00	2.20	-0.01	-2.20	12.84
140.00	2.10	0.07	-2.10	13.07
145.00	2.10	-0.02	-2.20	13.46
150.00	2.00	-0.75	-2.90	14.49
155.00	1.90	-0.10	-2.30	14.12
160.00	1.90	0.07	-2.10	14.23
165.00	1.80	0.25	-1.90	14.32
170.00	1.80	0.31	-1.80	14.52
175.00	1.70	0.50	-1.70	14.58
180.00	1.70	0.55	-1.60	14.77
185.00	1.60	0.55	-1.60	15.02
190.00	1.60	0.45	-1.70	15.35
195.00	1.50	0.22	-1.90	15.80
200.00	1.50	0.11	-2.00	16.13
205.00	1.50	-0.15	-2.30	16.60
210.00	1.40	-0.12	-2.30	16.78
215.00	1.40	-0.27	-2.40	17.14
220.00	1.40	-0.46	-2.60	17.53
225.00	1.30	-0.36	-2.50	17.63
230.00	1.30	-0.44	-2.60	17.89
235.00	1.30	-0.33	-2.50	17.97
240.00	1.20	-0.24	-2.40	18.07
245.00	1.20	-0.16	-2.30	18.17
250.00	1.20	-0.12	-2.30	18.30
255.00	1.20	-0.10	-2.30	18.45
260.00	1.20	-0.02	-2.20	18.54
265.00	1.10	-0.24	-2.40	18.93
270.00	1.10	-0.47	-2.60	19.32
275.00	1.10	-0.96	-3.10	19.96
280.00	1.10	-1.43	-3.60	20.60
285.00	1.10	-2.12	-4.30	21.44
290.00	1.00	-3.14	-5.30	22.61
295.00	1.00	-5.26	-7.40	24.87
300.00	1.00	-6.56	-8.70	26.32

Table 1: TBMA2, gain and antenna factor vs. frequency

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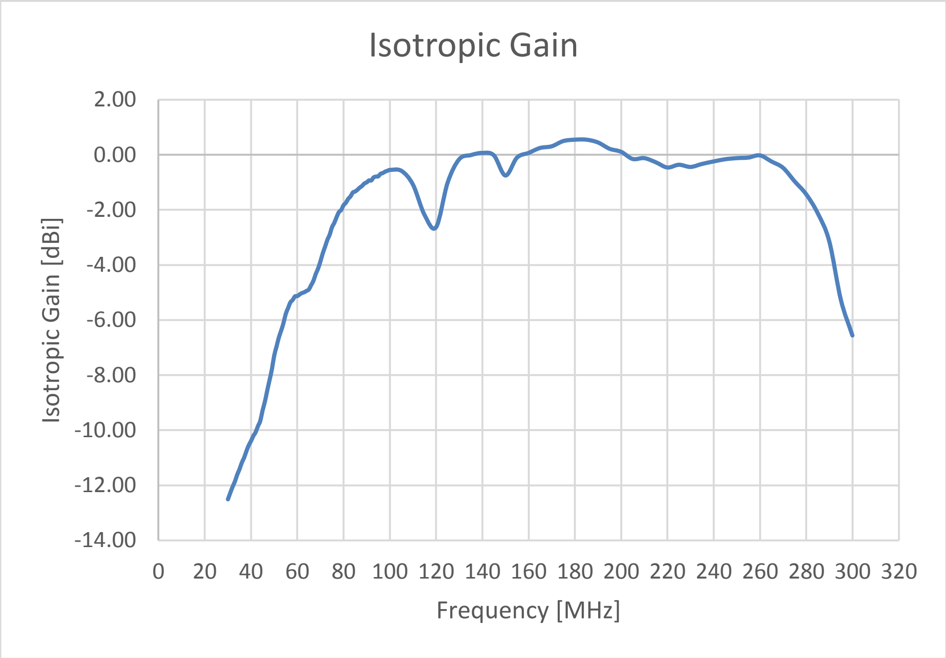

Figure 2: TBMA2 Isotropic Gain (30 MHz…300 MHz)

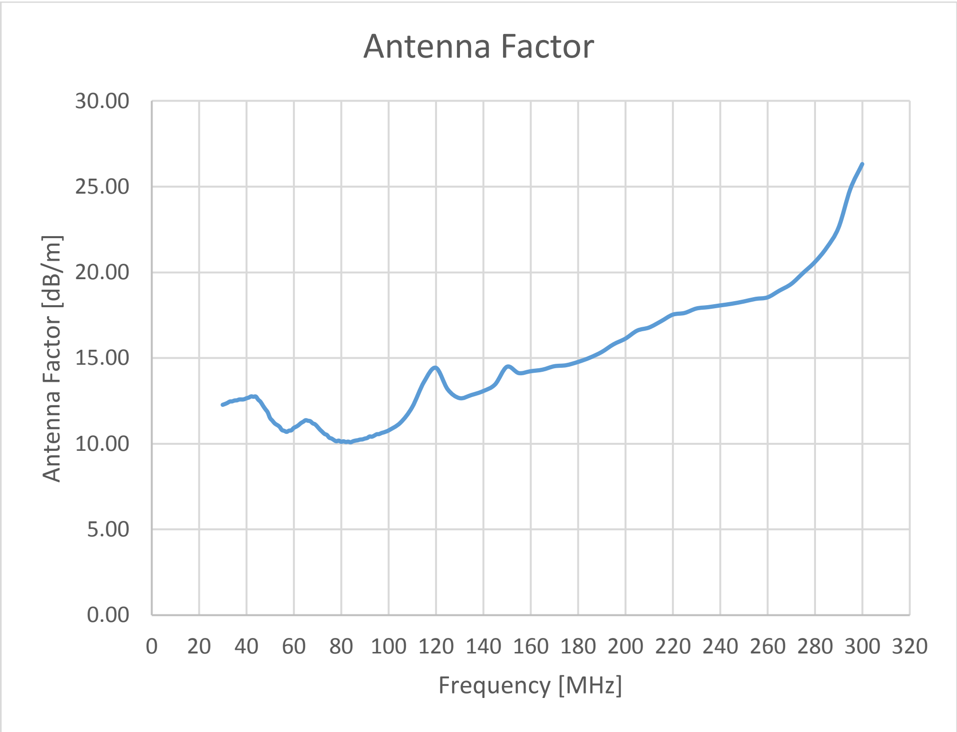

Figure 3: TBMA2 Antenna Factor (30 MHz…300 MHz)

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4.2 TBMA2 Return Loss / VSWR

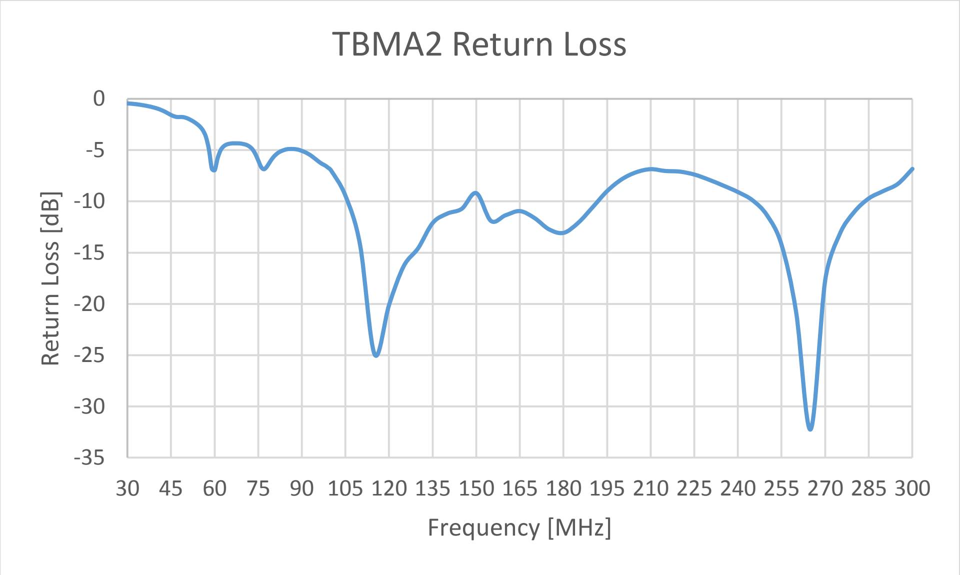

Figure 4: TBMA2 Return Loss 30 MHz … 300 MHz

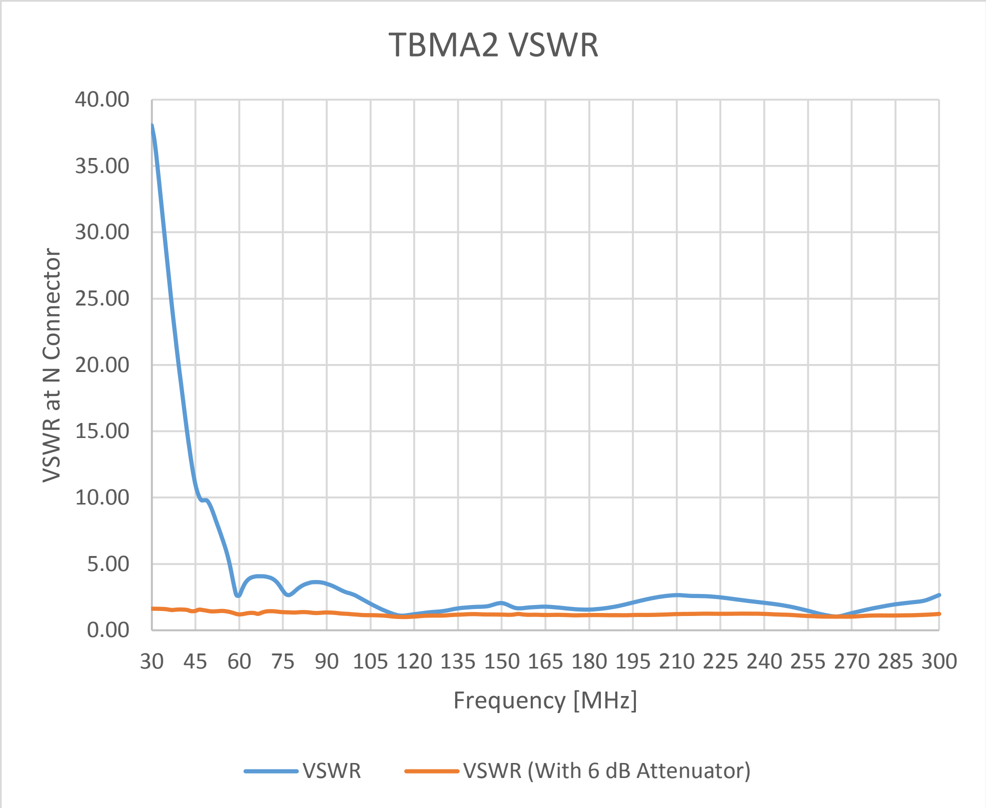

Figure 5: *TBMA2 VSWR 30 MHz … 300 MHz (without/ with 6 dB Attenuator)*

5 Application

The TBMA2 was designed, targeting EMC radiated noise measurements.

To make optimum use of the TBMA2, a few details need to be considered:

The TBMA2 does not contain any filters at the output port. Consequently, high amplitude signals that appear at the RF output, especially when employing external pre-amplifiers might overdrive the spectrum analyzer and the resulting intermodulation will cause measurement errors. In environments with high ambient noise levels, using suitable filters may be of advantage.

The ambient noise level picked up by the antenna in an unshielded environment, combined with the base noise level of the analyzer may already cross the radiated emission limits of certain CISPR standards, even with no DUT present. Consequently, it may be very difficult to differentiate ambient noise and radiated noise from the DUT in an unshielded environment.

Even turning ON/OFF the DUT to identify the radiated noise from the DUT may often not be a solution, given the dynamic characteristics of contemporary sources of ambient noise.

A suitable procedure is first measuring the radiated noise of the DUT in a TEM cell which is placed in a shielded tent or shielded bag. This will give an excellent overview of the emitted noise spectrum of the DUT. You can easily identify the strongest emissions of the DUT and thereafter re-measure it in an open area test site (OATS) with the measurement antenna. You then don´t need to confuse yourself with the entire ambient spectrum. Simply set the center frequency of the analyzer to the critical emission frequencies of the DUT, one by one. Choose a span as narrow as possible to zoom only at the frequency of the investigated DUT spurious. In case that the base noise is still too high, you can use suitable external band pass filters, reduce the resolution bandwidth of the analyzer or move the antenna closer to the DUT until you can clearly identify the DUT spurious and measure its level. As long as you keep your antenna in the far field, you can easily convert from the actual measurement distance to the equivalent level in 3m or 10m distance.

In case that the DUT spurious exceed the limit of the standard, take it back to your lab and use near field probes to locate the origin of the spurious on your DUT PCBA. Take suitable measures to reduce the emissions of your product. Track the effect of the modifications by TEM cell measurements, until the relative improvement measured in the TEM cell matches the relative improvement required to meet the far field limits according to the relevant standard.

Then carry out another OATS measurement of the DUT to validate, if the DUT´s radiated emissions are within the limits when measured with an antenna.

Use following formula to convert the measurement result from the actual measurement distance to the distance specified in the relevant standard:

$$P_s = P_m + 20log\frac{D_m}{D_s} \text{ [dBm]}$$

where D_m is the actual measurement distance and D_s is the specified distance in the relevant standard

P_m is the RF power measured in the actual measurement distance

P_s represents the calculated equivalent RF power in the distance specified in the relevant standard

Alternatively use the conversion table below:

Conversion 1 m to 3 m	subtract 9.5 dB
Conversion 1 m to 10 m	subtract 20 dB
Conversion 2 m to 3 m	subtract 3.5 dB
Conversion 2 m to 10 m	subtract 14 dB
Conversion 3 m to 10 m	subtract 10.5 dB

Table 2: path loss vs. measurement distance conversion

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However, when applying the conversions above, be aware, that even in the set up specified in the standards, the measurement antenna is not in the far field across the entire frequency range. This would physically be impossible, given the size limitations of anechoic chambers.
The following table gives an overview of the near field and far field distances from TBMA2 depending on frequency. As an example, assuming an actual measurement distance of 10 m, the above conversions would become valid between 60 MHz up to 120 MHz.

Frequency	Wavelength	Reactive Near Field Region	Radiative Near Field Region	Transition Zone	Far Field Region
MHz	**m**	**m**	**m**	**m**	**m**
30	10.00	<1.59	1.59 – 10.00	10.00 – 20.00	>20.00
35	8.60	<1.37	1.37 – 8.60	8.60 – 17.20	>17.20
40	7.50	<1.19	1.19 – 7.50	7.50 – 15.00	>15.00
45	6.70	<1.07	1.07 – 6.70	6.70 – 13.40	>13.40
50	6.00	<0.95	0.95 – 6.00	6.00 – 12.00	>12.00
55	5.50	<0.87	0.87 – 5.50	5.50 – 11.00	>11.00
60	5.00	<0.79	0.79 –5.00	5.00 – 10.00	>10.00
65	4.60	<0.73	0.73 – 4.60	4.60 – 9.20	>9.20
70	4.30	<0.68	0.68 – 4.30	4.30 – 8.60	>8.60
75	4.00	<0.64	0.64 – 4.00	4.00 – 8.00	>8.0
80	3.70	<0.59	0.59 – 3.70	3.70 – 7.40	>7.40
85	3.50	<0.56	0.56 – 3.50	3.50– 7.00	>7.00
90	3.30	<0.52	0.52 – 3.30	3.30 – 6.60	>6.60
95	3.20	<0.51	0.51 – 3.20	3.20 – 6.40	>6.40
100	3.00	<0.48	0.48 – 3.00	3.00 – 6.00	>6.00
105	2.90	<0.46	0.46 – 2.90	2.90 – 5.80	>5.80
110	2.70	<0.43	0.43-1.54	1.54-8.95	>8.95
115	2.60	<0.41	0.41-1.57	1.57-9.30	>9.30
120	2.50	<0.40	0.40-1.61	1.61-9.67	>9.67
125	2.40	<0.38	0.38-1.64	1.64-10.07	>10.07
130	2.30	<0.37	0.37-1.67	1.67-10.51	>10.51
135	2.20	<0.35	0.35-1.71	1.71-10.99	>10.99
140	2.10	<0.33	0.33-1.75	1.75-11.51	>11.51
145	2.10	<0.33	0.33-1.75	1.75-11.51	>11.51
150	2.00	<0.32	0.32-1.80	1.80-12.09	>12.09
155	1.90	<0.30	0.30-1.84	1.84-12.72	>12.72
160	1.90	<0.30	0.30-1.84	1.84-12.72	>12.72
165	1.80	<0.29	0.29-1.80	1.80-13.43	>13.43
170	1.80	<0.29	0.29-1.80	1.80-13.43	>13.43
175	1.70	<0.27	0.27-1.70	1.70-14.22	>14.22
180	1.70	<0.27	0.27-1.70	1.70-14.22	>14.22
185	1.60	<0.25	0.25-1.60	1.60-15.11	>15.11
190	1.60	<0.25	0.25-1.60	1.60-15.11	>15.11
195	1.50	<0.24	0.24-1.50	1.50-16.12	>16.12
200	1.50	<0.24	0.24-1.50	1.50-16.12	>16.12
205	1.50	<0.24	0.24-1.50	1.50-16.12	>16.12
210	1.40	<0.22	0.22-1.40	1.40-17.27	>17.27
215	1.40	<0.22	0.22-1.40	1.40-17.27	>17.27
220	1.40	<0.22	0.22-1.40	1.40-17.27	>17.27
225	1.30	<0.21	0.21-1.30	1.30-18.60	>18.60
230	1.30	<0.21	0.21-1.30	1.30-18.60	>18.60
235	1.30	<0.21	0.21-1.30	1.30-18.60	>18.60
240	1.20	<0.19	0.21-1.20	1.20-20.15	>20.15
245	1.20	<0.19	0.19-1.20	1.20-20.15	>20.15
250	1.20	<0.19	0.19-1.20	1.20-20.15	>20.15
255	1.20	<0.19	0.19-1.20	1.20-20.15	>20.15
260	1.20	<0.19	0.19-1.20	1.20-20.15	>20.15
265	1.10	<0.18	0.18-1.10	1.10-21.98	>21.98
270	1.10	<0.18	0.18-1.10	1.10-21.98	>21.98

275	1.10	<0.18	0.18-1.10	1.10-21.98	>21.98
280	1.10	<0.18	0.18-1.10	1.10-21.98	>21.98
285	1.10	<0.18	0.18 –1.10	1.10-21.98	>21.98
290	1.00	<0.16	0.16 – 1.00	1.00-24.17	>24.17
295	1.00	<0.16	0.16 – 1.00	1.00-24.17	>24.17
300	1.00	<0.16	0.16 – 1.00	1.00-24.17	>24.17

Table 3: Near field / Far field vs. frequency

Note that the discontinuity in the above table between 105 MHz and 110 MHz originates from applying two models. The first model applies for antennas physically shorter than half of the wavelength and the second model applies for antennas physically longer than half of the wavelength. Obviously, the formulas for the two models do not smoothly transit into each other.

6 Ordering Information

Part Number	**Description**
TBMA2	30 – 300 MHz biconical measurement antenna, plastic mounting bracket with ¼” thread

Table 4: Ordering Information

7 History

Version	Date	Author	Changes
V1.0	14.8.2020	Mayerhofer	Creation of the document

Table 5: Revision History