

## Active Monopole Antenna

### 1 Introduction

The TBMA5 is an active Monopole Antenna, expanding the Tekbox product range of affordable EMC pre-compliance test equipment.

The monopole antenna is designed for radiated emission measurements within the frequency range 9 kHz – 30 MHz, according to CISPR 16. The monopole antenna has a rod with height of 104 cm and provides sufficient sensitivity to carry out radiated emission measurements as specified in CISPR 25 or MIL-STD-461G.



The TBMA5 consists of an impedance converter, a universal charger, a 10 mm diameter rod, a 60 cm x 60 cm ground plane and a standard 10pF calibration adapter. Furthermore, it includes the coaxial cable with ferrite and grounding equipment required under MIL-STD-461G. The impedance converter is equipped with a 1/4" thread to attach it to conventional tripods.

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### 2 Specification

Characterized frequency range:	9 kHz to 30 MHz
Electric field antenna factor:	+6 to +7 dB/m, typ.
Antenna factor variation:	< ±0.8 dB, typ.
Dynamic Range:	118 dB @ 1MHz, 1 KHz bandwidth
Electric field, lower limit:	12 dBμV/m (4.0 μV/m) @ 1MHz, 1 KHz bandwidth
Electric field, upper limit:	130 dBμV/m (3.15 V/m) @ 1 dB compression
Output VSWR:	1.02 to 1.52 (average:1.06) :1
Output connector type:	N female
Battery type:	6 x NiMH, AA (not included)
Battery life on average:	20 hours
Charger:	Ansmann ACS310
Tripod mount:	¼" thread
Impedance converter dimensions:	185 x 210 x 65 mm, 1.5 kg
Carrying Case:	Aluminum, 75 x 73 x 18 cm, 4 kg



### 3 Antenna factor

The antenna factor AF is an antenna and frequency dependent parameter, which is required to convert the voltage measured at the output of an antenna into the corresponding electric field strength.

For electric field strength:

$$E[\text{dB}\mu\text{V/m}] = V[\text{dB}\mu\text{V}] + AF_E[\text{dB/m}]$$

Where  $AF_E$  is the electric antenna factor in [dB/m]

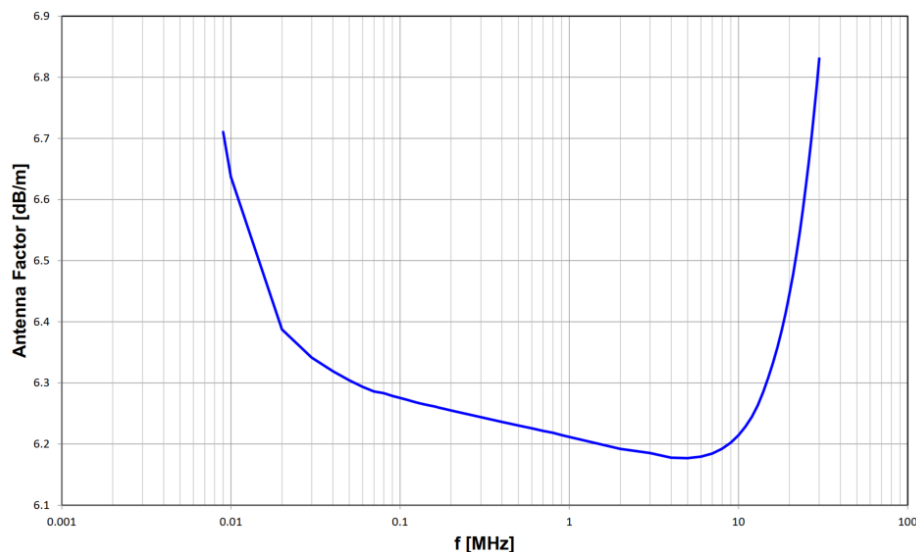


Figure 1: TBMA 5, Antenna Factor, 9 kHz – 30 MHz

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## 4 Antenna factor table

Frequency [MHz]	Electric field antenna factor [dB/m]	Magnetic field antenna factor [dB/Ωm]	Uncertainty [dB]
0,009	6.71	-44.79	±1.00
0,010	6.64	-44.86	±1.00
0,020	6.39	-45.11	±1.00
0,030	6.34	-45.16	±1.00
0,040	6.32	-45.18	±1.00
0,050	6.30	-45.20	±1.00
0,060	6.29	-45.21	±1.00
0,070	6.29	-45.21	±1.00
0,080	6.28	-45.22	±1.00
0,090	6.28	-45.22	±1.00
0,100	6.28	-45.22	±1.00
0,110	6.27	-45.23	±1.00
0,120	6.27	-45.23	±1.00
0,130	6.27	-45.23	±1.00
0,140	6.26	-45.24	±1.00
0,150	6.26	-45.24	±1.00
0,200	6.26	-45.24	±1.00
0,300	6.26	-45.24	±1.00
0,400	6.26	-45.24	±1.00
0,500	6.26	-45.24	±1.00
0,600	6.25	-45.25	±1.00
0,700	6.24	-45.26	±1.00
0,800	6.24	-45.26	±1.00
0,900	6.23	-45.27	±1.00
1,000	6.23	-45.27	±1.00
2,000	6.22	-45.28	±1.00
3,000	6.22	-45.28	±1.00
4,000	6.21	-45.29	±1.00
5,000	6.21	-45.29	±1.00
6,000	6.19	-45.31	±1.00
7,000	6.19	-45.31	±1.00
8,000	6.18	-45.32	±1.00
9,000	6.18	-45.32	±1.00
10,000	6.18	-45.32	±1.00
11,000	6.18	-45.32	±1.00
12,000	6.19	-45.31	±1.00
13,000	6.20	-45.30	±1.00
14,000	6.21	-45.29	±1.00
15,000	6.23	-45.27	±1.00
16,000	6.24	-45.26	±1.00
17,000	6.26	-45.24	±1.00
18,000	6.29	-45.21	±1.00
19,000	6.31	-45.19	±1.00
20,000	6.33	-45.17	±1.00

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21,000	6.36	-45.14	±1.00
22,000	6.39	-45.11	±1.00
23,000	6.41	-45.09	±1.00
24,000	6.45	-45.05	±1.00
25,000	6.48	-45.02	±1.00
26,000	6.51	-44.99	±1.00
27,000	6.55	-44.95	±1.00
28,000	6.58	-44.92	±1.00
29,000	6.62	-44.88	±1.00
30,000	6.66	-44.84	±1.00

Table 1: TBMA5 antenna factors, 9 kHz – 30 MHz, typical values

## 5 VSWR

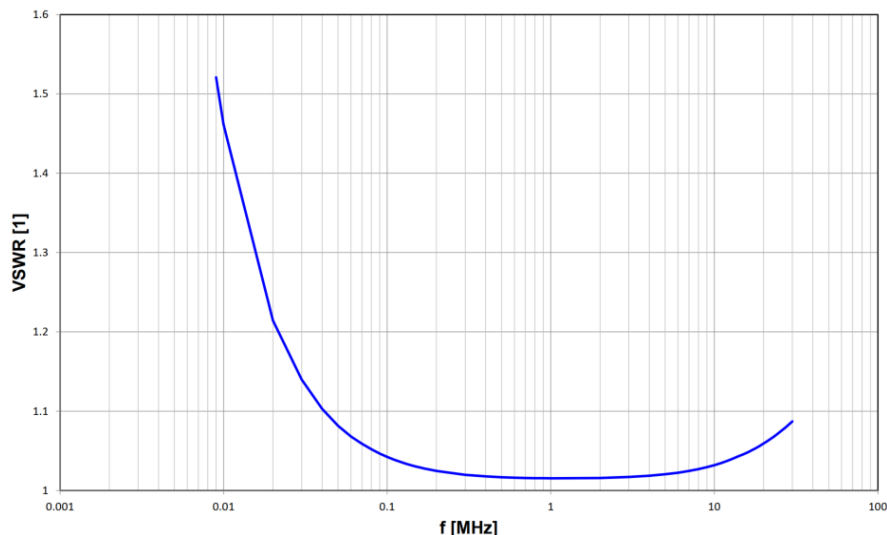


Figure 2: TBMA 5, VSWR at the antenna output, 9 kHz – 30 MHz

## 6 Calibration

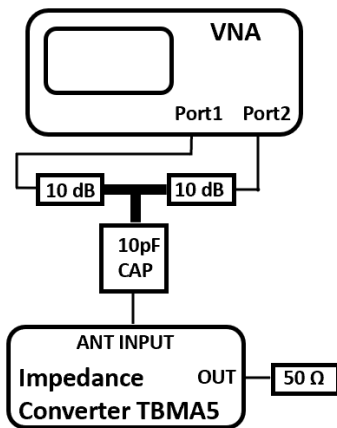
The TBMA5 already comes with a factory calibration protocol. The calibration accessory enables periodic re-calibration or validation of the performance, if required. The calibration process for obtaining the antenna factor is based on the Equivalent Capacitance Substitution Method (ECSM). It is a two-step procedure:

### - Normalizing procedure

As shown in the picture below, both 50  $\Omega$  RF ports of a vector network analyzer/spectrum analyzer are connected to both sides of a coaxial T adapter, combined with two 10 dB N-type

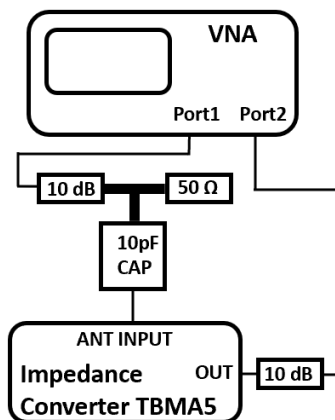
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attenuators in order to improve matching of the VNA ports. The 10 pF calibration capacitor, is attached to the input port of the impedance converter to simulate the high impedance of the 104cm rod element of the TBMA5 antenna. A 50  $\Omega$  termination is connected to the output port of the antenna for the normalization purpose. Next, a  $S_{21}$  Through Calibration is carried out within the frequency range of the antenna.



### - Measurement procedure

For the measurement procedure as shown in the picture below, the RF input port of the vector network analyzer/spectrum analyzer (port 2) is now detached from the coaxial T adapter and is connected to the output port of the TBMA5 antenna while it is still attached to the 10 dB N-type attenuator. The 50  $\Omega$  termination load is now connected to the coaxial T adapter. Next carry out a  $S_{21}$  measurement, which represents the gain of the impedance converter.



Using the described method, the antenna amplifier gain and the active antenna factor can be calculated using the following equations respectively:

$$\text{Amplifier Gain} = S_{21} (\text{Impedance Converter}) [\text{dB}]$$

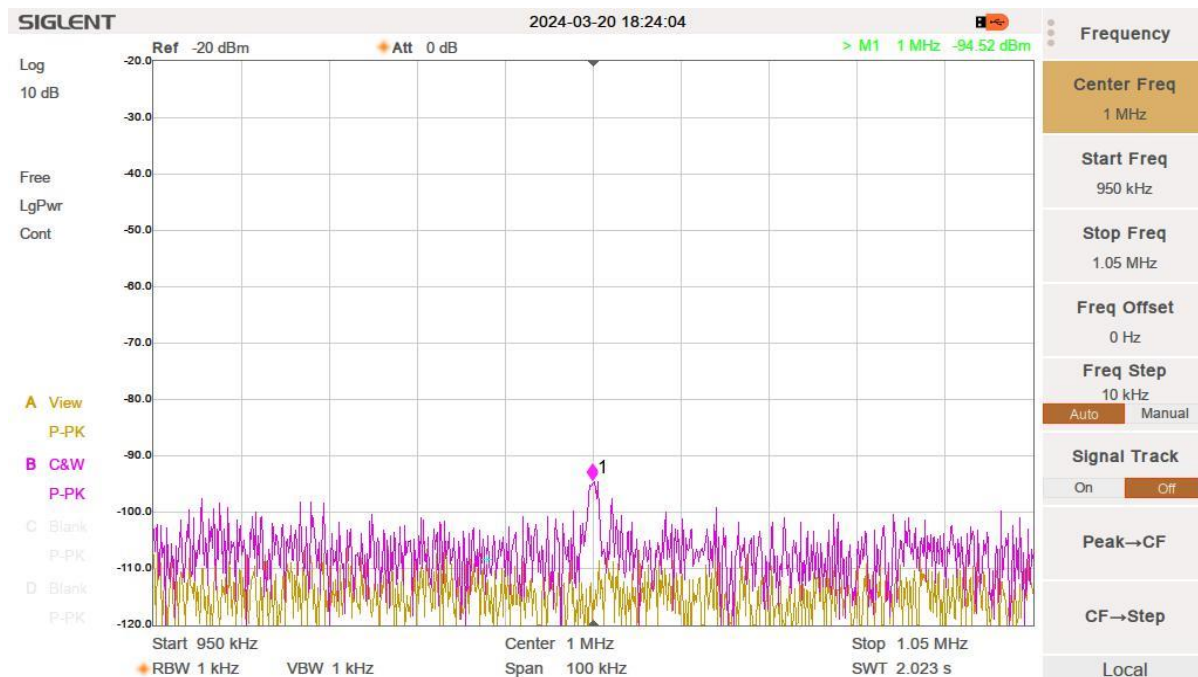
$$\text{Antenna Factor} = 6.02 - \text{Amplifier Gain} [\text{dB/m}]$$

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### 7 Sensitivity

The sensitivity of a radiated noise measurement setup looks at the base noise of the available spectrum analyzer or measurement receiver. Applying the antenna factor gives the resulting minimum detectable electric field for the active monopole antenna. this noise floor has to be at least 6 dB below the emission limits of the applied standard.

To measure the sensitivity of the antenna @ 1MHz and 1KHz RBW, the minimum signal should be at least 6 dB above the noise floor of the available spectrum analyzer /measurement receiver in order to be clearly distinguishable from the noise level according to CISPR 16 standard.



### 8 Accessories

The TBMA5 comes in an aluminum carrying case and includes the impedance converter, a universal charger, a ground panel, a rod, a calibration adapter and a MIL-STD-461G ground bonding kit consisting of a 125cm long coaxial cable with ferrite sleeve and a ground bonding adapter.

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### 9 Inserting / replacing batteries

**Due to airfreight regulations the TBMA5 does not include rechargeable batteries. Before operation, it is necessary to insert 6 pieces standard 1.2V NiMH batteries.**

Remove the four screws at the bottom base plate of the impedance converter housing, lift it, and insert six AA rechargeable 1.2V NiMH batteries. Both the battery compartment and the PCB indicate the polarity. Re-attach the bottom base plate, then tighten the screws.

Before connecting the charger plug to the unit connector, please check that the center tip polarity is shown as (positive) “+”.

**Never connect the charger to the antenna, without batteries inserted.** The universal charger is pulsing with high voltage to detect the battery pack and may damage the internal polyfuse, if no batteries are inserted. Align the charger tip as shown below.



### 10 Ordering Information

Part Number	Description
TBMA5	TBMA5 impedance converter, Ansmann ACS310 universal charger, 104 cm rod, 60 cm x 60 cm ground panel, 10 pF calibration adapter, coaxial T-adapter, 2 pcs 10 dB attenuators, Mil-STD-461 ground bonding kit consisting of a 125 cm long 50 Ohm coaxial cable, a ferrite sleeve and a ground bonding adapter Aluminum carrying case NIST traceable factory calibration certificate & report

## Active Monopole Antenna

### 11 History

Version	Date	Author	Changes
V 1.0	21.03.2024	Mayerhofer	Creation
V 1.1	13.04.2024	Mayerhofer	Chapter 9 updated

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