

Active Monopole Antenna

1 Introduction

The TBMA5B 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 excellent sensitivity to carry out radiated emission measurements as specified in CISPR 25 or MIL-STD-461G.



The TBMA5B 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 ¼" 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: | +5 to +7 dB/m, typ. |
| Dynamic Range: | 117 dB @ 10MHz, 9KHz RBW, AVG |
| Electric field, lower limit: | noise floor at -3 dBμV/m @ 10MHz, 9 KHz RBW, AVG |
| Electric field, upper limit: | 120 dBμV/m (1 V/m) @ 1 dB compression |
| Output VSWR: | 1.04 to 1.6 :1 |
| Output connector type: | N female |
| Battery type: | 12 x NiMH, AA (not included) |
| Battery life on average: | up to 20 hours, depending on the battery capacity |
| Charger: | Mascot 2116 6-12 Cells |
| 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:

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

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

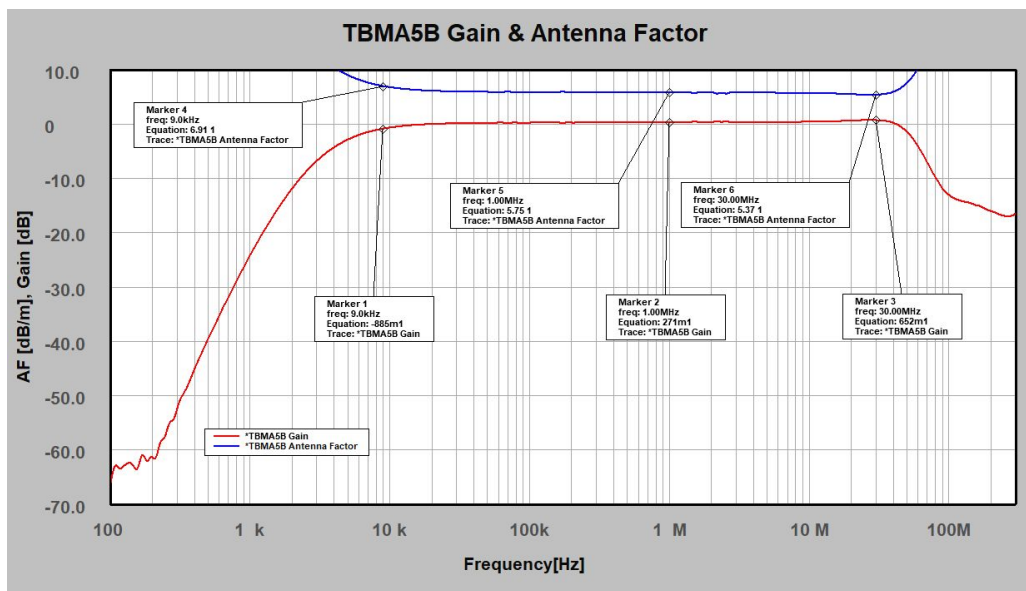


Figure 1: TBMA5B, Gain and Antenna Factor, 100Hz – 300 MHz

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4 VSWR

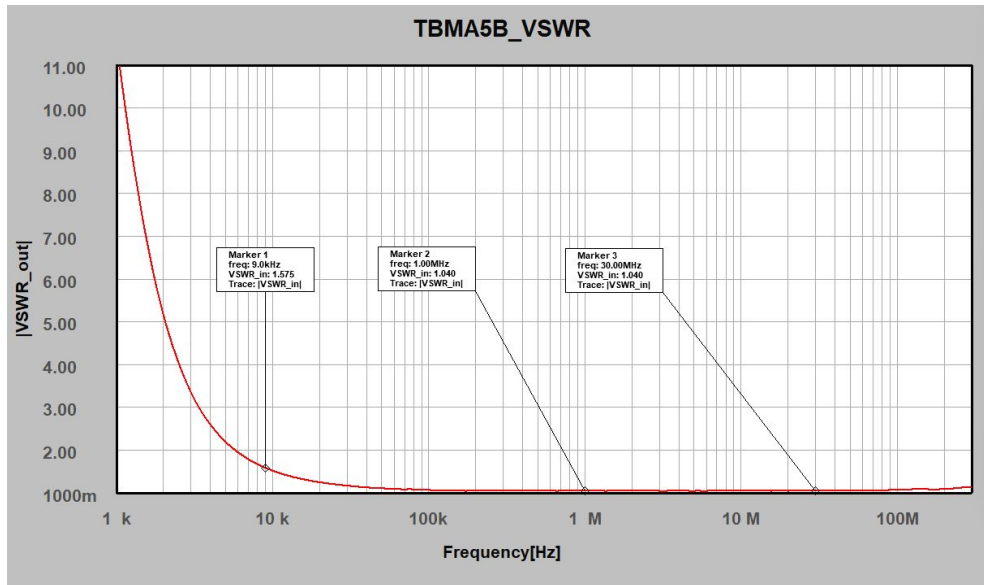


Figure 2: TBMA5B, VSWR at the antenna output, 1 kHz – 300 MHz

5 Antenna factor & VSWR table

| Frequency [MHz] | Electric field antenna factor [dB/m] | Uncertainty [dB] | VSWR | Uncertainty |
|-----------------|--------------------------------------|------------------|------|-------------|
| 0,009 | 6,91 | ±1.00 | 1,57 | ±0.08 |
| 0,010 | 6,73 | ±1.00 | 1,51 | ±0.08 |
| 0,020 | 6,06 | ±1.00 | 1,24 | ±0.06 |
| 0,030 | 5,93 | ±1.00 | 1,16 | ±0.06 |
| 0,040 | 5,89 | ±1.00 | 1,12 | ±0.06 |
| 0,050 | 5,86 | ±1.00 | 1,10 | ±0.06 |
| 0,060 | 5,81 | ±1.00 | 1,08 | ±0.05 |
| 0,070 | 5,89 | ±1.00 | 1,07 | ±0.05 |
| 0,080 | 5,82 | ±1.00 | 1,07 | ±0.05 |
| 0,090 | 5,85 | ±1.00 | 1,06 | ±0.05 |
| 0,100 | 5,84 | ±1.00 | 1,06 | ±0.05 |
| 0,110 | 5,8 | ±1.00 | 1,06 | ±0.05 |
| 0,120 | 5,82 | ±1.00 | 1,05 | ±0.05 |
| 0,130 | 5,81 | ±1.00 | 1,05 | ±0.05 |
| 0,140 | 5,8 | ±1.00 | 1,05 | ±0.05 |
| 0,150 | 5,82 | ±1.00 | 1,05 | ±0.05 |
| 0,200 | 5,82 | ±1.00 | 1,04 | ±0.05 |
| 0,300 | 5,78 | ±1.00 | 1,05 | ±0.05 |
| 0,400 | 5,79 | ±1.00 | 1,04 | ±0.05 |
| 0,500 | 5,78 | ±1.00 | 1,04 | ±0.05 |

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| Frequency [MHz] | Electric field antenna factor [dB/m] | Uncertainty [dB] | VSWR | Uncertainty |
|-----------------|--------------------------------------|------------------|------|-------------|
| 0,600 | 5,77 | ±1.00 | 1,04 | ±0.05 |
| 0,700 | 5,78 | ±1.00 | 1,04 | ±0.05 |
| 0,800 | 5,77 | ±1.00 | 1,04 | ±0.05 |
| 0,900 | 5,77 | ±1.00 | 1,04 | ±0.05 |
| 1,000 | 5,75 | ±1.00 | 1,04 | ±0.05 |
| 2,000 | 5,77 | ±1.00 | 1,04 | ±0.05 |
| 3,000 | 5,73 | ±1.00 | 1,04 | ±0.05 |
| 4,000 | 5,73 | ±1.00 | 1,04 | ±0.05 |
| 5,000 | 5,72 | ±1.00 | 1,04 | ±0.05 |
| 6,000 | 5,7 | ±1.00 | 1,04 | ±0.05 |
| 7,000 | 5,69 | ±1.00 | 1,04 | ±0.05 |
| 8,000 | 5,68 | ±1.00 | 1,04 | ±0.05 |
| 9,000 | 5,67 | ±1.00 | 1,04 | ±0.05 |
| 10,000 | 5,66 | ±1.00 | 1,04 | ±0.05 |
| 11,000 | 5,64 | ±1.00 | 1,04 | ±0.05 |
| 12,000 | 5,62 | ±1.00 | 1,04 | ±0.05 |
| 13,000 | 5,61 | ±1.00 | 1,04 | ±0.05 |
| 14,000 | 5,58 | ±1.00 | 1,04 | ±0.05 |
| 15,000 | 5,57 | ±1.00 | 1,04 | ±0.05 |
| 16,000 | 5,55 | ±1.00 | 1,04 | ±0.05 |
| 17,000 | 5,52 | ±1.00 | 1,04 | ±0.05 |
| 18,000 | 5,49 | ±1.00 | 1,04 | ±0.05 |
| 19,000 | 5,47 | ±1.00 | 1,04 | ±0.05 |
| 20,000 | 5,45 | ±1.00 | 1,04 | ±0.05 |
| 21,000 | 5,42 | ±1.00 | 1,04 | ±0.05 |
| 22,000 | 5,39 | ±1.00 | 1,04 | ±0.05 |
| 23,000 | 5,38 | ±1.00 | 1,04 | ±0.05 |
| 24,000 | 5,37 | ±1.00 | 1,04 | ±0.06 |
| 25,000 | 5,36 | ±1.00 | 1,04 | ±0.06 |
| 26,000 | 5,35 | ±1.00 | 1,04 | ±0.06 |
| 27,000 | 5,35 | ±1.00 | 1,04 | ±0.06 |
| 28,000 | 5,35 | ±1.00 | 1,04 | ±0.06 |
| 29,000 | 5,36 | ±1.00 | 1,04 | ±0.06 |
| 30,000 | 5,37 | ±1.00 | 1,04 | ±0.06 |

Table 1: TBMA5B antenna factors, 9 kHz – 30 MHz, typical values

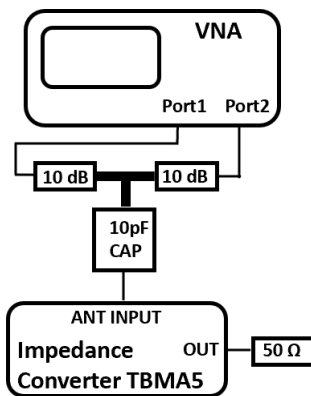
6 Calibration

The TBMA5B 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:

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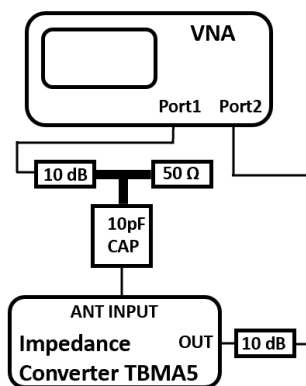
- Normalizing procedure

As shown in the picture below, both 50 Ω 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 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 TBMA5B antenna. A 50 Ω 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 TBMA5B antenna while it is still attached to the 10 dB N-type attenuator. The 50 Ω 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:

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

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

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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. The resulting noise floor has to be at least 6 dB below the emission limits of the applied standard.

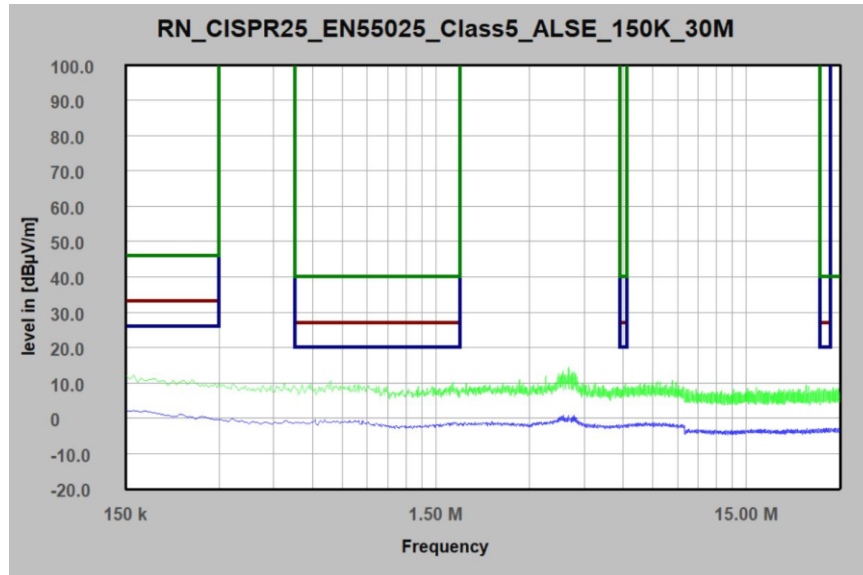


Figure 3: TBMA5B with Tekbox TBMR-110 measurement receiver; base noise versus CISPR 25 Class5 limits; green: Average; blue: Peak

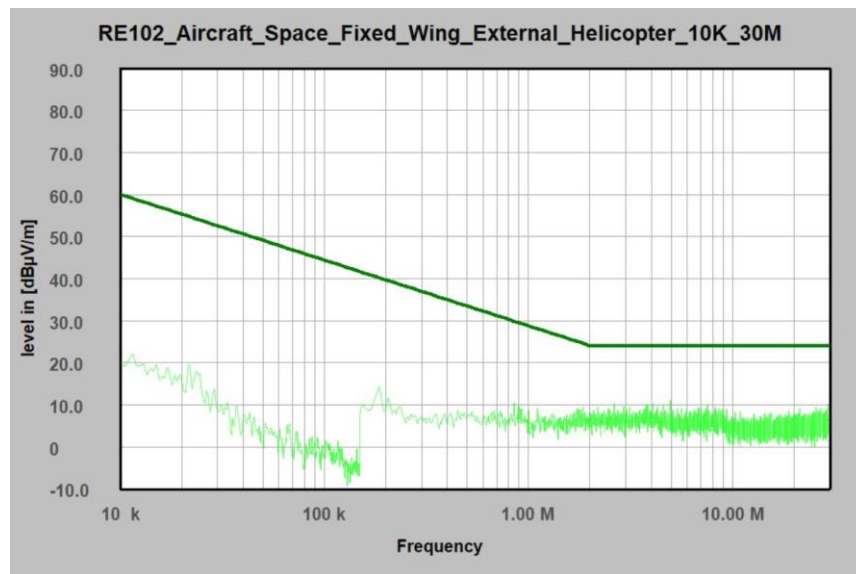


Figure 4: TBMA5B with Tekbox TBMR-110 measurement receiver; base noise versus MIL-STD-451G RE102 limits; Peak detector

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8 Accessories

The TBMA5B 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.

9 Inserting / replacing batteries

Due to airfreight regulations the TBMA5B does not include rechargeable batteries. Before operation, it is necessary to insert 12 pieces standard 1.2V NiMH batteries.

Remove the four screws at the bottom base plate of the impedance converter housing, lift it, and insert twelve pieces 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 trip the internal overvoltage protection circuit, if no batteries are inserted. Align the charger tip as shown below.



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10 Ordering Information

| Part Number | Description |
|-------------|--|
| TBMA5B | TBMA5B impedance converter, Mascot 2116 6-12 Cells 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 |

11 History

| Version | Date | Author | Changes |
|---------|------------|------------|--|
| V 1.0 | 24.09.2024 | Mayerhofer | Creation |
| V 1.1 | 17.10.2024 | Bao Diep | Update part number of charger & pictures |
| | | | |

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