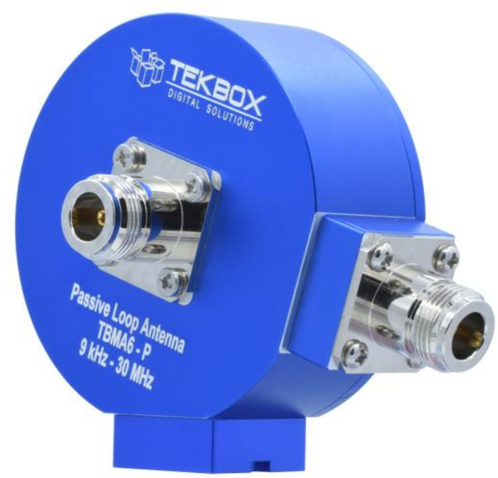
Passive Loop Antenna

# 1 Introduction

The TBMA6-P is a passive Loop Antenna, expanding the Tekbox product range of affordable EMC pre-compliance test equipment.
The loop antenna is designed for radiated emission measurements in the frequency range 9 kHz – 30 MHz, according to CISPR 16. The loop antenna has a diameter of 60 cm and provides sufficient sensitivity to carry out all relevant measurements specified in the corresponding CISPR standards for the frequency range 9 kHz – 30 MHz.




*Picture 1: TBMA6-P passive loop antenna / transducer*

The loop is built from corrugated coaxial cable and attached to the transducer with N-connectors. This construction provides flexibility to use it with various loop diameters. An attachment with a ¼" thread permits connectivity to standard tripods.

# 2 Specification

| | |
|---|---|
| Characterized frequency range: | 9 kHz to 30 MHz |
| Magnetic field antenna factor: | -20 dB/Ωm @ 30 MHz, typ. |
| Electric field antenna factor: | 31,5 dB/m @ 30 MHz, typ. |
| Sensitivity: | -24 dBµA/m @ 30 MHz |
| Dimensions: | Φ 60 cm |
| Weight: | 800 g |
| Connector type: | N female |
| Mount: | ¼" thread |

## 3 Antenna factors

A spectrum analyzer or measurement receiver connected to the antenna will typically display measured power in dBm or voltage in dBµV.

The antenna factor AF is an antenna and frequency dependent parameter, which is required to convert the measured voltage into the corresponding electric or magnetic field strength.
For magnetic field strength:

$$H[\text{dB}\mu\text{A/m}] = V[\text{dB}\mu\text{V}] + AF_H[\text{dB}/\Omega\text{m}]$$

Where $AF_H$ is the magnetic antenna factor in [dB/Ωm] or [dBS/m]
In the far field, the free space impedance $Z_0 = 377\ \Omega$ links electric field strength with magnetic field strength.

$$AF_E[\text{dB/m}] = AF_H[\text{dB}/\Omega\text{m}] + Z_0[\text{dB}\Omega]$$
$$AF_E[\text{dB/m}] = AF_H[\text{dB}/\Omega\text{m}] + 51.5\ \text{dB}\Omega$$

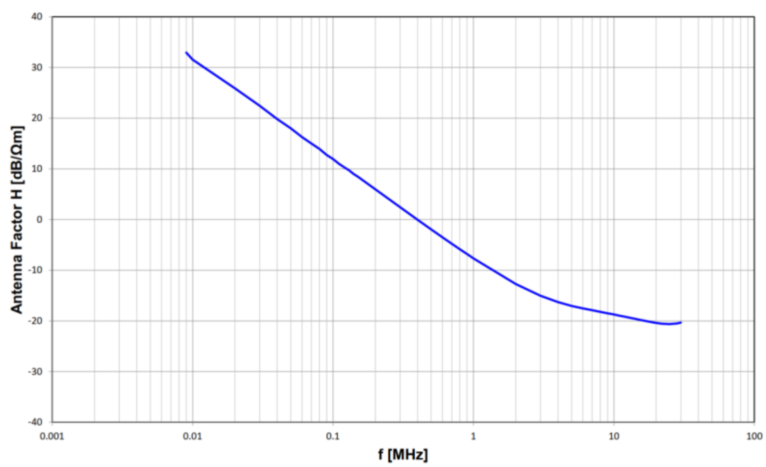



*Figure 1: magnetic field antenna factor, TBMA6-P, 60 cm loop, 9 kHz – 30 MHz, typical data*

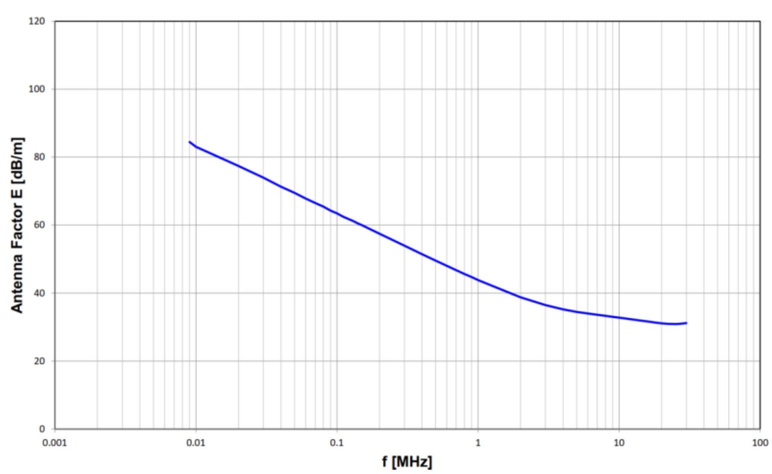



*Figure 2: electric field antenna factor, TBMA6-P, 60 cm loop, 9 kHz – 30 MHz, typical data*

# 4 Antenna factor table

| Frequency [MHz] | Magnetic field antenna factor [dB/Ωm] | Electric field antenna factor [dB/m] | Uncertainty [dB] |
|---|---|---|---|
| 0,009 | 32,934 | 84,454 | ±1,20 |
| 0,010 | 31,540 | 83,060 | ±1,20 |
| 0,020 | 25,870 | 77,390 | ±1,20 |
| 0,030 | 22,444 | 73,964 | ±1,20 |
| 0,040 | 19,803 | 71,323 | ±1,20 |
| 0,050 | 17,970 | 69,490 | ±1,20 |
| 0,060 | 16,273 | 67,793 | ±1,20 |
| 0,070 | 14,999 | 66,519 | ±1,20 |
| 0,080 | 13,928 | 65,448 | ±1,20 |
| 0,090 | 12,754 | 64,274 | ±1,20 |
| 0,100 | 11,944 | 63,464 | ±1,20 |
| 0,110 | 10,982 | 62,502 | ±1,20 |
| 0,120 | 10,297 | 61,817 | ±1,20 |
| 0,130 | 9,694 | 61,214 | ±1,20 |
| 0,140 | 8,994 | 60,514 | ±1,20 |
| 0,150 | 8,463 | 59,983 | ±1,20 |
| 0,200 | 5,956 | 57,476 | ±1,20 |
| 0,300 | 2,441 | 53,961 | ±1,20 |
| 0,400 | -0,045 | 51,475 | ±1,20 |
| 0,500 | -1,960 | 49,560 | ±1,20 |
| 0,600 | -3,492 | 48,028 | ±1,20 |
| 0,700 | -4,772 | 46,748 | ±1,20 |
| 0,800 | -5,882 | 45,638 | ±1,20 |
| 0,900 | -6,825 | 44,695 | ±1,20 |
| 1,000 | -7,681 | 43,839 | ±1,20 |
| 2,000 | -12,731 | 38,789 | ±1,20 |
| 3,000 | -15,043 | 36,477 | ±1,20 |
| 4,000 | -16,287 | 35,233 | ±1,20 |
| 5,000 | -17,039 | 34,481 | ±1,20 |
| 6,000 | -17,525 | 33,995 | ±1,20 |
| 7,000 | -17,898 | 33,622 | ±1,20 |
| 8,000 | -18,215 | 33,305 | ±1,20 |
| 9,000 | -18,488 | 33,032 | ±1,20 |
| 10,000 | -18,736 | 32,784 | ±1,20 |
| 11,000 | -18,967 | 32,553 | ±1,20 |
| 12,000 | -19,179 | 32,341 | ±1,20 |
| 13,000 | -19,376 | 32,144 | ±1,20 |
| 14,000 | -19,560 | 31,960 | ±1,20 |
| 15,000 | -19,734 | 31,786 | ±1,20 |
| 16,000 | -19,890 | 31,630 | ±1,20 |
| 17,000 | -20,037 | 31,483 | ±1,20 |
| 18,000 | -20,173 | 31,347 | ±1,20 |
| 19,000 | -20,296 | 31,224 | ±1,20 |
| 20,000 | -20,398 | 31,122 | ±1,20 |
| 21,000 | -20,482 | 31,038 | ±1,20 |
| 22,000 | -20,549 | 30,971 | ±1,20 |
| 23,000 | -20,592 | 30,928 | ±1,20 |
| 24,000 | -20,613 | 30,907 | ±1,20 |
| 25,000 | -20,626 | 30,894 | ±1,20 |
| 26,000 | -20,591 | 30,929 | ±1,20 |
| 27,000 | -20,555 | 30,965 | ±1,20 |
| 28,000 | -20,494 | 31,026 | ±1,20 |
| 29,000 | -20,423 | 31,097 | ±1,20 |
| 30,000 | -20,334 | 31,186 | ±1,20 |

*Table 1: TBMA6-P, 60cm loop, antenna factors, 9 kHz – 30 MHz, typical values*

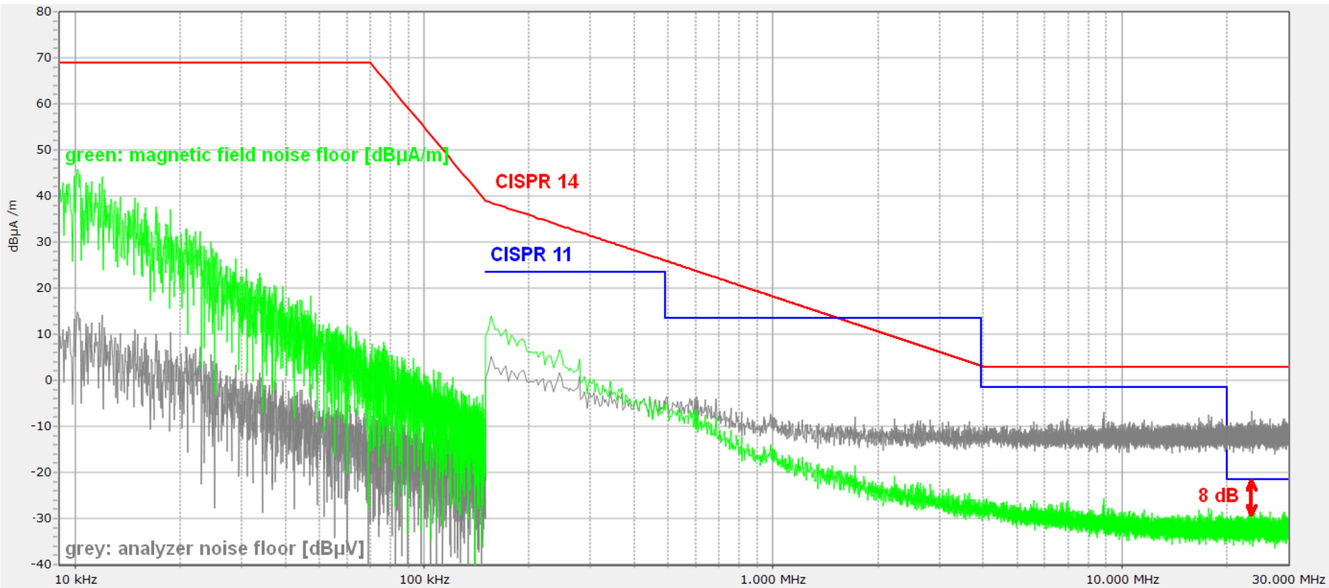
The antenna factors of the 60 cm loop can be used to estimate the antenna factors of loop antennas with different diameter.

| Loop diameter | AF |
|---|---|
| 1 m | +4.5 dB |
| 60 cm | 0 dB |
| 30 cm | -6 dB |
| 25 cm | -8 dB |

*Table 2: antenna factor conversion for different loop diameters*

## 5 Sensitivity

The sensitivity of a radiated noise measurement set up looks at the base noise of the available spectrum analyzer or measurement receiver. Applying the antenna factor gives the resulting noise floor with respect to the magnetic field. According to CISPR 16, this noise floor has to be at least 6 dB below the emission limits of the applied standard.




The above screenshot shows the magnetic field noise floor of a set up consisting of a low-cost spectrum analyzer and the TBMA6-P loop antenna.
Analyzer Model: Siglent SSA3021X-Plus
Internal attenuator: 0 dB; internal pre-amplifier: ON; 9 kHz - 150 kHz: 200 Hz RBW; 150 kHz – 30 MHz: 9kHz RBW; Peak detector; sweep time according to CISPR 16 specification

Red limit line: CISPR 14 Magnetic field strength limits for induction cooking appliances
Blue limit line: CISPR 11 Class A, Group 2, 30 meters, in situ

The blue line represents the toughest limit of all CISPR standards in the range 150 kHz to 30 MHz.
The red line represents the toughest limit of all CISPR standards in the range 9 kHz to 150 kHz.

Comparing the magnetic field base noise with the limit lines shows that the TBMA6-P together with the Siglent SSA3021X-Plus provide sufficient sensitivity for all CISPR specified radiated emission measurements in the range 9 kHz to 30 MHz

## 6 Ordering Information

| Part Number | Description |
|---|---|
| TBMA6-P | TBMA6-P transducer + corrugated, slotted coaxial cable for 60 cm loop + pistol grip tripod; beech wood box for transducer |
| TBMA6-CC30CM-D | corrugated, slotted coaxial cable for 30 cm loop |

## 7 History

| Version | Date | Author | Changes |
|---|---|---|---|
| V 1.0 | 22.9.2022 | Mayerhofer | Creation of the preliminary document |
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| | | | |

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