V1.2

TBCCP1-400K600

COAXIAL RF CURRENT MONITORING PROBE

1 Introduction

The TBCCP1-400K600 is a coaxial RF current monitoring probe, expanding the Tekbox product range of affordable EMC pre-compliance test equipment.
The probe has a typical 3 dB bandwidth from 400 kHz to 600 MHz and a very flat response from 1 MHz to 200 MHz. The transimpedance is characterized over the frequency range from 100 Hz to 600 MHz. The TBCCP1-400K600 is primarily designed as transducer for measurement of RF currents in coaxial cables. Furthermore it can be used as transducer for for passive loop antennas.

Picture 1: TBCCP1-3K100 RF current monitoring probe

The probe is equipped with N-connectors. An attachment with a ¼" thread permits connectivity to standard tripods.

2 Specification

Characterized frequency range:	100 Hz to 600 MHz
Transfer impedance:	22 dB Ohm in a 50 Ohm system
3 dB bandwidth:	400 kHz to 600 MHz, typ.
Dimensions:	76 mm x 102 x 69 mm
Weight:	400 g
Connector type:	N female
Max. primary current (RF):	12 A
Max. core temperature:	125 °C

3 Transfer impedance

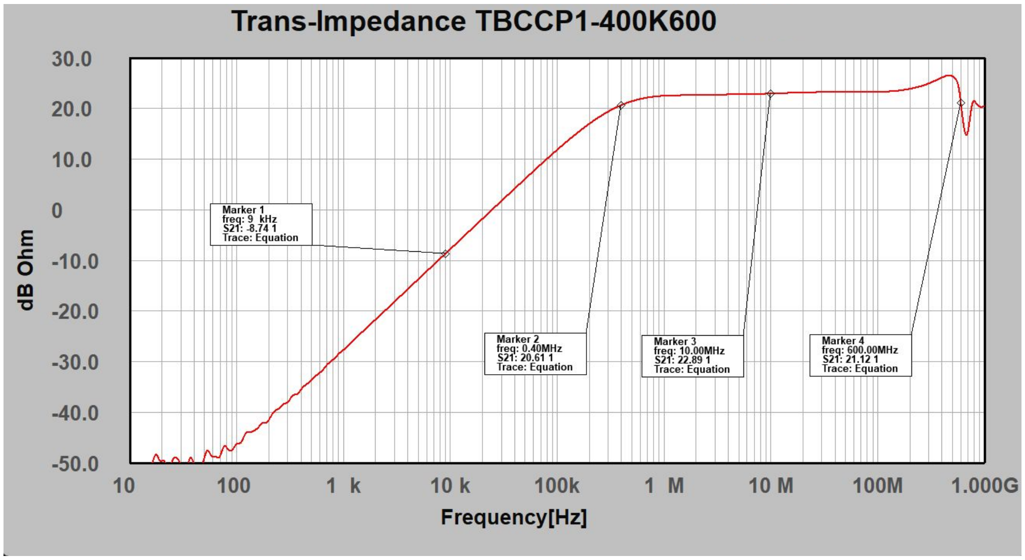

Figure 1: transfer impedance, 10 Hz – 1 GHz, typical data

4 Coaxial Path – Insertion loss (S21)

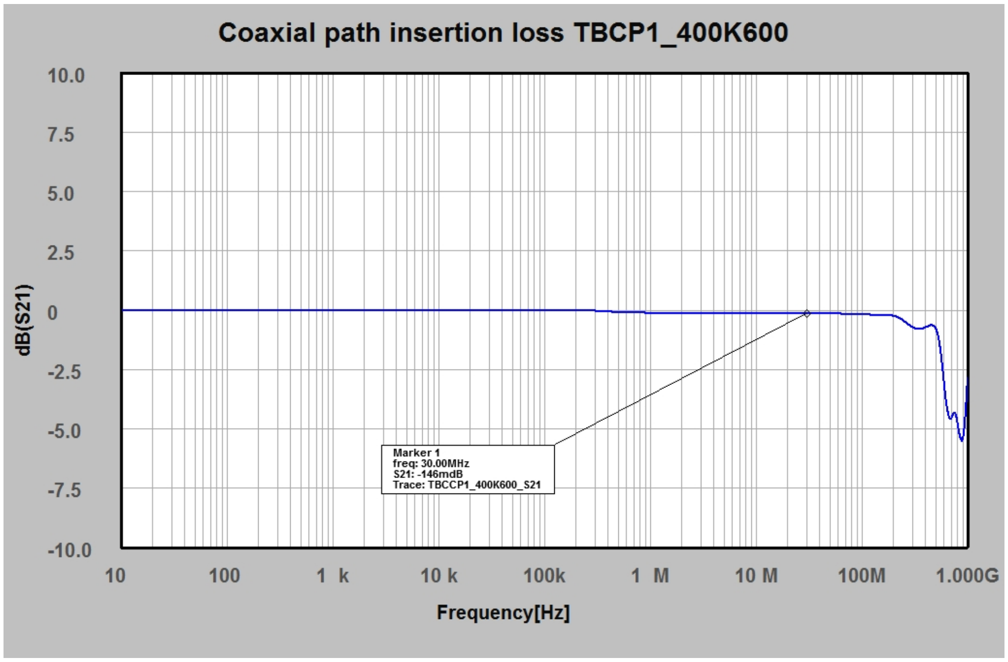

Figure 2: S21, insertion loss of the coaxial path, 10 Hz – 1 GHz, typical data

5 Coaxial Path – Matching (S11)

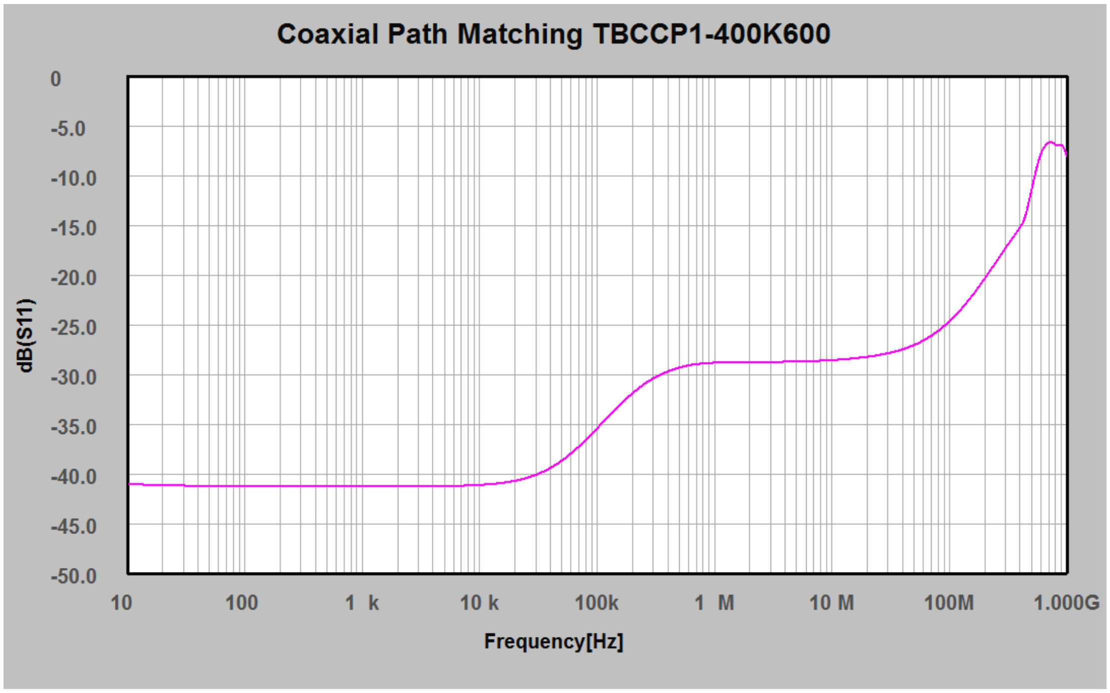

Figure 3: S11, impedance matching of the coaxial path, 10 Hz – 1 GHz, typical data

6 Application

The TBCCP1-400K600 is primarily designed as transducer for measurement of RF currents in coaxial cables. By combining it with a shielded loop, it can also be used as transducer for active or passive loop antennas.

The loop can easily be built from coaxial cable with N-Male connectors on each end. The shield must be separated in the center, removing a section of approximately 5mm length. Use a 185 cm length slotted coaxial cable and the TBCCP1-400K600 to build a passive loop antenna with 60 cm diameter. The magnetic antenna factor will have a value of approximately -8 dBS/m.

When used as transducer for a passive antenna, depending on the base noise of the involved measurement receiver or the spectrum analyzer, the resulting sensitivity is sufficient for most CISPR xx radiated emission measurements in the frequency range from 9 kHz to 30 MHz.

For more details, see chapter the magnetic antenna factor plot of a 60 cm passive loop antenna based on the TBCCP1-400K600 in chapter 8.

7 Typical transfer impedance table

The table below shows typical transfer impedance data of a TBCCP1-400K600 current probe. Each current probe is delivered with its corresponding measurement protocol. This data can be used for the creation of a correction file for EMCview or similar EMC measurement software. The transfer impedance in dBΩ subtracted from the analyzer reading in dBµV gives the corrected reading in dBµA.
Refer to the application notes of EMCview on how to create a current probe correction file, download a file with typical data from the Tekbox website or simply select the file from the installed correction file directory.

Frequency [MHz]	Transfer impedance [dBΩ]	Frequency [MHz]	Transfer impedance [dBΩ]
0.0001	-47,23	10	22,89
0.00025	-40,07	12.5	22,96
0.0005	-33,72	15	23,02
0.00075	-30,44	17.5	23,06
0.001	-28,04	20	23,10
0.0025	-19,97	22.5	23,12
0.005	-13,87	25	23,14
0.0075	-10,35	27.5	23,16
0.009	-8,78	30	23,17
0.01	-7,86	40	23,19
0.025	0,11	50	23,21
0.05	6,04	60	23,20
0.075	9,45	70	23,20
0.1	11,80	80	23,20
0.2	16,94	90	23,21
0.3	19,33	100	23,22
0.4	20,63	150	23,42
0.5	21,38	200	23,80
0.6	21,83	250	24,27
0.7	22,11	300	24,84
0.8	22,28	350	25,49
0.9	22,38	400	26,09
1	22,44	450	26,41
2.5	22,64	500	26,19
5	22,74	550	25,18
7.5	22,81	600	21,01

Table1: Transfer impedance: 100 Hz to 600 MHz, typical data

8 Antenna factors

Frequency [MHz]	Magnetic field antenna factor [dB/Ωm]	Electric field antenna factor [dB/m]	Uncertainty [dB]
0,009	29,24	80,76	±1,20
0,010	28,05	79,57	±1,20
0,020	22,37	73,89	±1,20
0,030	18,70	70,22	±1,20
0,040	16,24	67,76	±1,20
0,050	14,27	65,79	±1,20
0,060	12,74	64,26	±1,20
0,070	11,45	62,97	±1,20
0,080	10,26	61,78	±1,20
0,090	9,24	60,76	±1,20
0,100	8,31	59,83	±1,20
0,110	7,52	59,04	±1,20
0,120	6,80	58,32	±1,20
0,130	6,08	57,60	±1,20
0,140	5,46	56,98	±1,20
0,150	4,85	56,37	±1,20
0,200	2,46	53,98	±1,20
0,300	-0,74	50,78	±1,20
0,400	-2,82	48,70	±1,20
0,500	-4,26	47,26	±1,20
0,600	-5,35	46,17	±1,20
0,700	-6,12	45,40	±1,20
0,800	-6,68	44,84	±1,20
0,900	-7,12	44,40	±1,20
1,000	-7,46	44,06	±1,20
2,000	-8,60	42,92	±1,20
3,000	-8,84	42,68	±1,20
4,000	-8,95	42,57	±1,20
5,000	-9,05	42,47	±1,20
6,000	-9,11	42,41	±1,20
7,000	-9,18	42,34	±1,20
8,000	-9,26	42,26	±1,20
9,000	-9,32	42,20	±1,20
10,000	-9,39	42,13	±1,20
11,000	-9,50	42,02	±1,20
12,000	-9,55	41,97	±1,20
13,000	-9,66	41,86	±1,20
14,000	-9,76	41,76	±1,20
15,000	-9,87	41,65	±1,20
16,000	-9,97	41,55	±1,20
17,000	-10,08	41,44	±1,20
18,000	-10,19	41,33	±1,20
19,000	-10,30	41,22	±1,20
20,000	-10,42	41,10	±1,20
21,000	-10,56	40,96	±1,20
22,000	-10,68	40,84	±1,20
23,000	-10,84	40,68	±1,20
24,000	-10,98	40,54	±1,20
25,000	-11,15	40,37	±1,20
26,000	-11,31	40,21	±1,20
27,000	-11,48	40,04	±1,20
28,000	-11,65	39,87	±1,20
29,000	-11,84	39,68	±1,20
30,000	-12,06	39,46	±1,20

Table2: Antenna factors of a 60 cm passive loop antenna built from a TBCCP1-400K600 transducer and a 184 cm long N-Male / N-Male, corrugated coaxial cable, 9kHz – 30 MHz

COAXIAL RF CURRENT MONITORING PROBE

Radiated emission measurements in the frequency range of 9 kHz to 30 MHz are primarily carried out using shielded loop antennas. A coaxial cable with slotted shield connected to a coaxial RF current monitoring probe forms a shorted loop. The short circuit current induced in such a loop is a frequency independent measure of the magnetic field strength.
The connected spectrum analyzer or measurement receiver 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:

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

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 Ω links electric field strength with magnetic field strength.

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


Picture 2: using corrugated coaxial cable to build a loop antenna

The data in the above antenna factor table can be used to estimate the antenna factors of loop antennas with different diameter. Referring to a 60 cm loop.

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

9 Calibration

Tekbox coaxial RF current probes do not need a calibration fixture for the measurement of the transfer impedance.

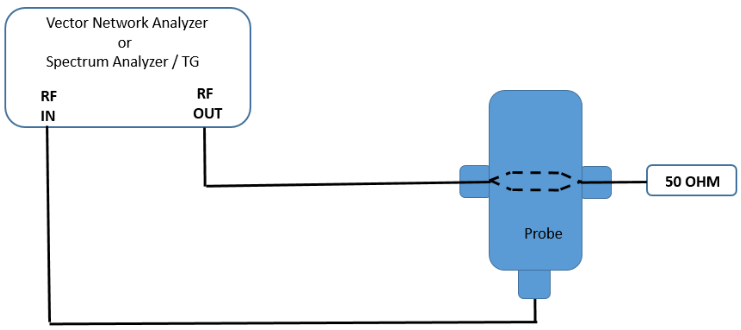

Figure 4: S21, transimpedance measurement set up

Calculate the transfer impedance Z_T using the formula below:

Z_T [dBΩ] = Pin [dBm] – Pprobe [dBm] +34 dB
or simply
Z_T [dBΩ] = S21 [dB] +34 dB

10 Ordering Information

Part Number	Description
TBCCP1-400K600	RF surface current monitoring probe, beech-wood box, trans-impedance plot 100Hz – 600 MHz
TBMA6-CC60CM	Corrugated coaxial cable with N-Male connectors, slotted shield with stiffener sleeve, 184 cm length for 60 cm diameter loop antenna
TBMA6-CC30CM	Corrugated coaxial cable with N-Male connectors, slotted shield with stiffener sleeve, 89 cm length for 30 cm diameter loop antenna

11 History

Version	Date	Author	Changes
V 1.0	1.7.2022	Mayerhofer	Creation of the preliminary document
V 1.1	10.9.2022	Mayerhofer	Antenna factors added
V 1.2	15.9.2022	Mayerhofer	Update of chapter 1

www.tekbox.com
TekBox Digital Solutions Vietnam Pte. Ltd.
Factory 4, F4, Lot I-3B-1, Saigon Hi-Tech Park, Tan Phu Ward, District 9, Ho Chi Minh City, Vietnam