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User Manual

CCM

Contact Current Meter

Updated to Firmware Version:
CCM V1.03
Manual Version:
V1.08

SAFETY NOTES

Read carefully before using the product

MPB works to provide its customers with the best safety conditions available, complying with the current safety standards. The instrumentation described in this manual has been produced and tested in conditions that fully comply with the European standards. To maintain it in safe conditions, ensure the correct use of the product and prevent any danger, these general instructions must be fully understood and applied before any use.

This product is intended for industrial environments and laboratories and should be used by authorized personnel only. MPB disclaims any responsibility for a different use of the device.

Please use the device only after checking the presence and validity of the safety devices (e.g. breakers, differential switches and the conformity of the grounding)

For safety reasons, the *HAND* measurement mode has to be done only **after** the *GROUND PLANE* mode. The latter shall not exceed the limits defined by the 2013/35/EU regulation.

Declaration of Conformity

(in accordance with the Directives: EMC 89/336/EEC and Low Voltage 73/23/EEC)

This is to certify that the product: CCM
(Contact Current Meter)

complies with the following European Standards:
Safety: CEI EN 61010-1 (2001)
EMC: EN 61326-1 (2007)

This product complies with the requirements of the Low Voltage Directive 2006/95/CE, and with the EMC Directive 2004/108/CE.

MPB S.r.l.

Contents

Chapter 1

General Information

Figure 1.1: CCM

1.1 Introduction

CCM was designed to measure the contact current that may be generated when touching electrical/electronic equipment inside a radio frequency field, in a fast and accurate way.

1.2 Description

CCM (Figure 1.1) is a portable measuring device with more than one measurement mode. Depending on the needs, it can measure by means of the *GROUND PLANE* (and the related resistance for closing the circuit on the ground), or it can work without a cable, making use of the impedance level of the user through the conductive area on the handle. In the next chapters we will go more deeply into this subject.

1.3 Composition

The base configuration of this device includes:

- Rigid Case.
- CCM.
- 1,5 V Batteries (2 pcs.).
- sma-sma Cable (M-M) (2 mt.);
- Body Simulation Impedance (Z-2251).
- USB Cable for PC Connection.
- Ground Plane plate.
- USB Key with:
  - User Manual
  - Data Sheet
  - Calibration Certificate

1.4 Optional Kit

CCM-Kit of Calibration, including:

- CCM-JIG
- Resistances (R45)
- RG316 cable (1 mt length) N(M)-sma(M)

1.5 Front

In Figure 1.2 is shown the CCM front panel:

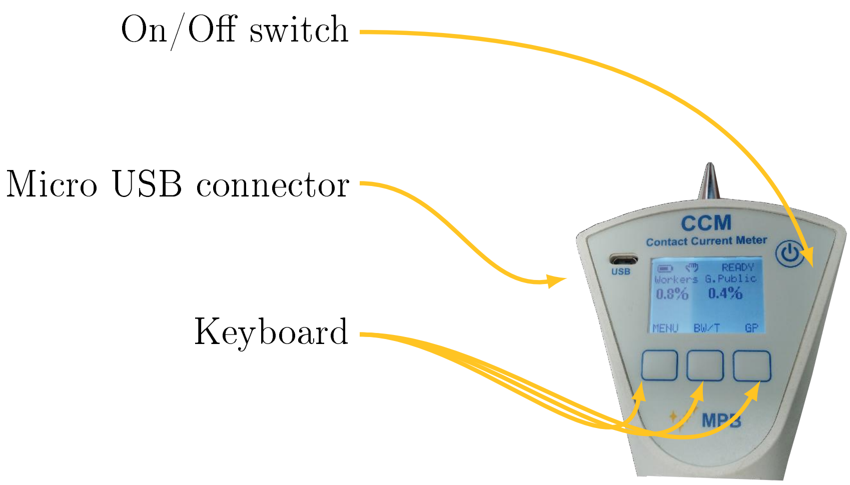

Figure 1.2: CCM front

1.6 Rear

In Figure 1.3 is shown the CCM rear panel:

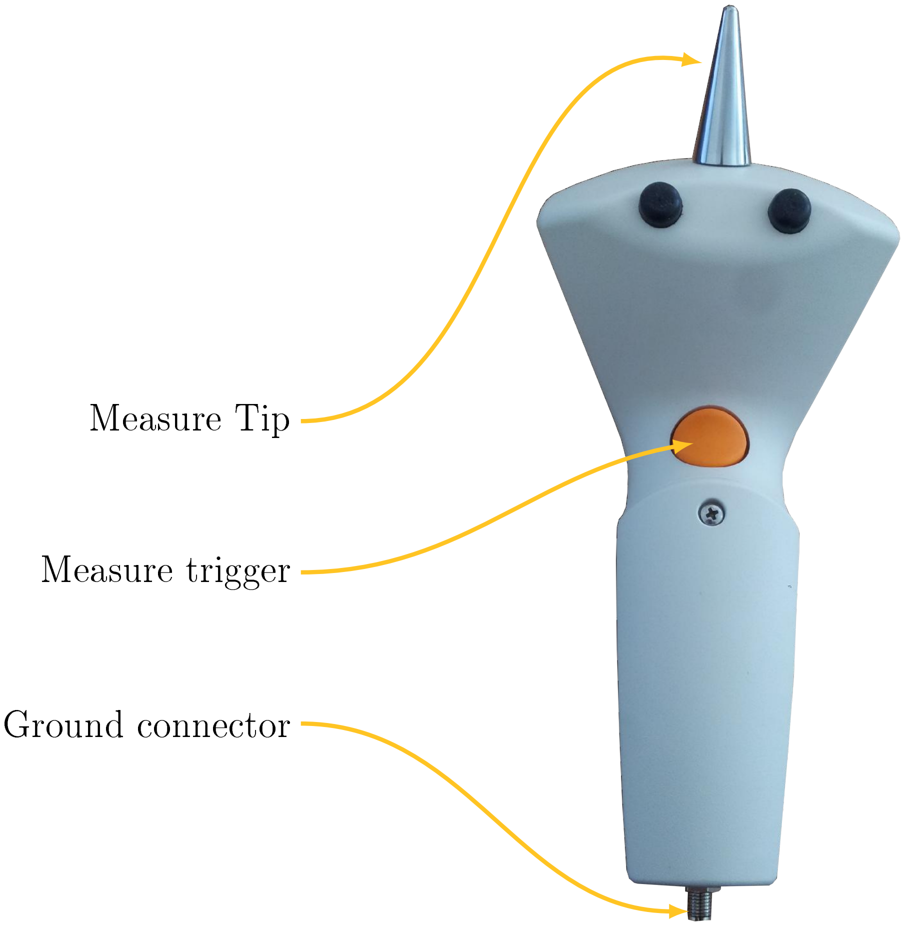

Figure 1.3: CCM rear

1.7 Technical Specifications

Frequency Range	
Low band	40 *Hz* to 2.5 *kHz*
Medium band	2.5 *kHz* to 100 *kHz*
High band	100 *kHz* to 110 *MHz*
Frequency Response	
Low band @ 1 mA	$< \pm$ 1.5 dB
Medium band @ 100%	$< \pm$ 1.5 dB
High band @ 20 mA	$< \pm$ 1.5 dB
Measurement range	
Low Band	
Level range	0.01 to 3 mA (ICNIRP limit 1 mA)
Damage level	100 mA
Resolution	1 nA
Dynamic range @ 500Hz	50 dB
Linearity error @ 500Hz; 0,3...3 mA	$< \pm$ 1 dB
Medium band	
Level range	0 to 300 % (ICNIRP limit 1 to 40 mA)
Damage level	500 %
Resolution	1 nA
Dynamic range @ 25kHz	50 dB
Linearity error @ 25kHz; 10...200 %	$< \pm$ 1 dB
High band	
Level range	0.4 to 120 mA (ICNIRP limit 40 mA)
Damage level	300 mA
Resolution	10 nA
Dynamic range @ 10MHz	50 dB
Linearity error @ 10Mz; 12...120 mA	$< \pm$ 1 dB
Measurement modes	Hand and Ground
Alarm sound	Programmable level
Display	Graphic LCD with led backlight
Detectors	true RMS
Contact tip	Interchangeable
USB Interface	Micro USB connector
Standards	Directive 2004/40/EC
Operating Temperature	+10 °C to +40 °C
Power supply	
Battery	2pcs AA Alkaline
Operation Time	24 hours
Dimension	205 × 90 × 45 mm
Weight	200 g
Recommended calibration interval	24 months
Input signal attenuation over 110 MHz	200 MHz –> 7 dB 300 MHz –> 18 dB 400 MHz –> 31 dB 500 MHz ... 3 GHz –> >45 dB

Chapter 2

Principle of operation

2.1 Logic Schema

The schema shown in Figure 2.1 describes the CCM work flow:

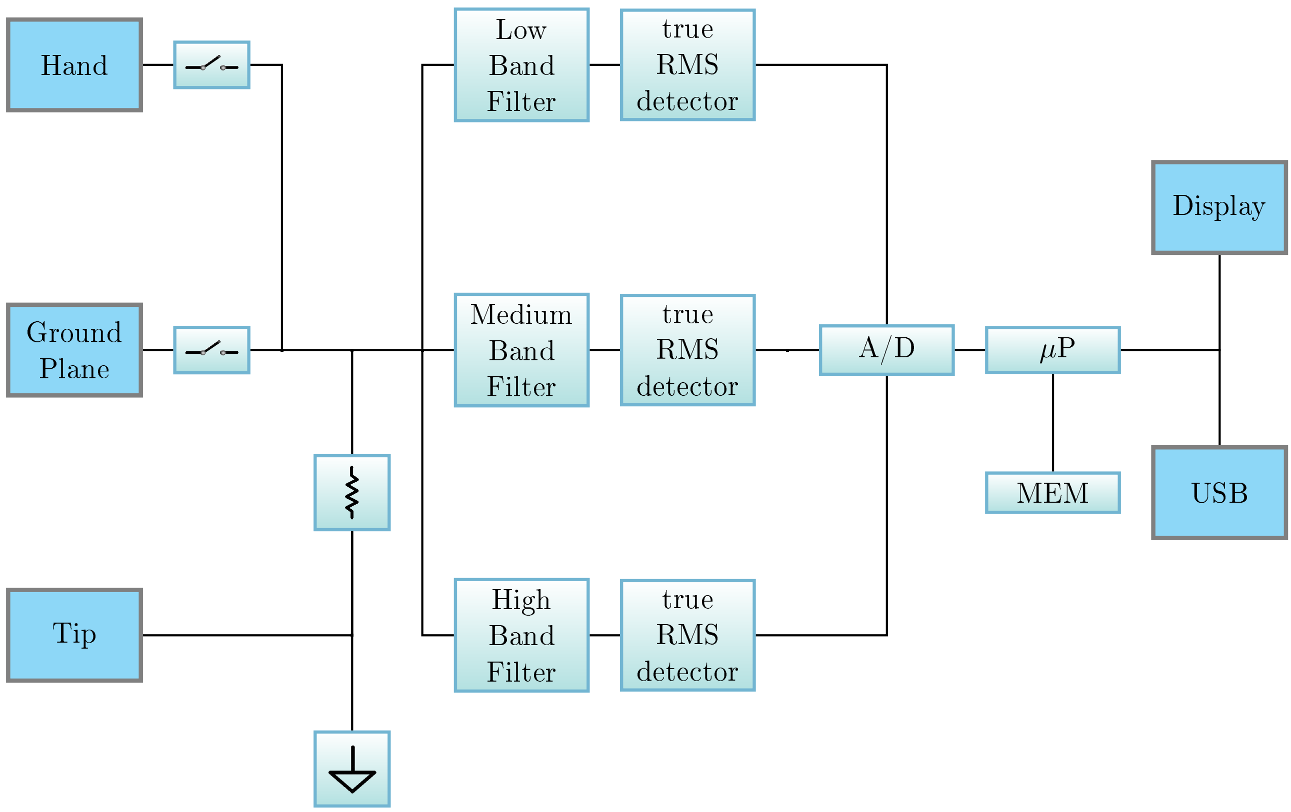

Figure 2.1: CCM Block Diagram

2.2 Measurements

The CCM digital nature allows it to measure contact currents through the true RMS (Root Mean Square) value for all analog signals from 40Hz. The RMS value of a waveform signal is equal to a DC current which provides the same power to the load. The signal measured by the TIP passes through the most suitable filter (Low, Medium and High), then arrives to the true RMS detector, that makes a conversion of the measured current to RMS . The equation is the following:

$$e_{rms} = \sqrt{\frac{1}{T}\int_0^T \mathrm{V(t)}^2\,dt}$$

The actual regulations defines the minimum requirements for the safety of workers in areas of risk, and the limit values for the exposure to contact current.

2.3 Contact Current

The contact current flows when a person or an object serve as electrical conductors when reaching another metallic object immersed in an electromagnetic field: the contact current is expressed in Amperes. The moment right after the contact can imply a discharge of associated currents (First attachment of 2013/35/EU). In the workplace, as well as in the world we live in, the electric and magnetic fields are always present and can have natural or artificial origin. The natural electric fields are, for example, those produced by the accumulation of electric charges during a lightning, while the natural magnetic fields are those that are found in nature, such as the terrestrial one that orients the compass needle North-South. The electric and magnetic artificial fields are produced by artificial devices and systems, such as electrical equipment or systems for the distribution of electricity.

The electromagnetic field can be defined as a physical phenomenon given by the simultaneous presence of an electric field and a magnetic field. Moving from the source of the electromagnetic field, the waves decrease in intensity, it is therefore clear that the intensity is maximum if there is a contact with the object or with the system which is generating the electromagnetic field. A device with metallic shell, if immersed in an electromagnetic field, can become a RF voltage carrier and can accumulate electrical charges. If you come into contact with the device without adequate protection, you can risk that the RF voltage discharges to ground flowing through the limbs and the body. In this case, the electrical charges on the device, immersed in the electric field through the operator's body, have generated a contact current. An electrical equipment not properly shielded can emit electromagnetic waves. When coming into contact with that machinery without adequate protection, even in this case there is a risk that the electromagnetic waves, flowing through the limbs and the operator's body, can generate a contact current.

2.4 Safety

The GP measurement mode has only been developed for safety reasons, since it does not guarantee reliable measurements. Also, for the operator's safety and security please make sure that, when performing GP measurements, the plate is set in the same position as the operator's. For more details please scroll down to 3.3

Chapter 3

CCM Usage

3.1 Turn On

Figure 3.1: Turned On CCM

When the CCM is turned on, it displays the MPB logo and the firmware version (Figure 3.1). After a few seconds a warning message will appear (as in Figure 3.2), and users have to declare to have read this manual and to be aware of the risks involved during the current measurement. In case of negative answer (by pressing "DENY"), the device will automatically turn off.

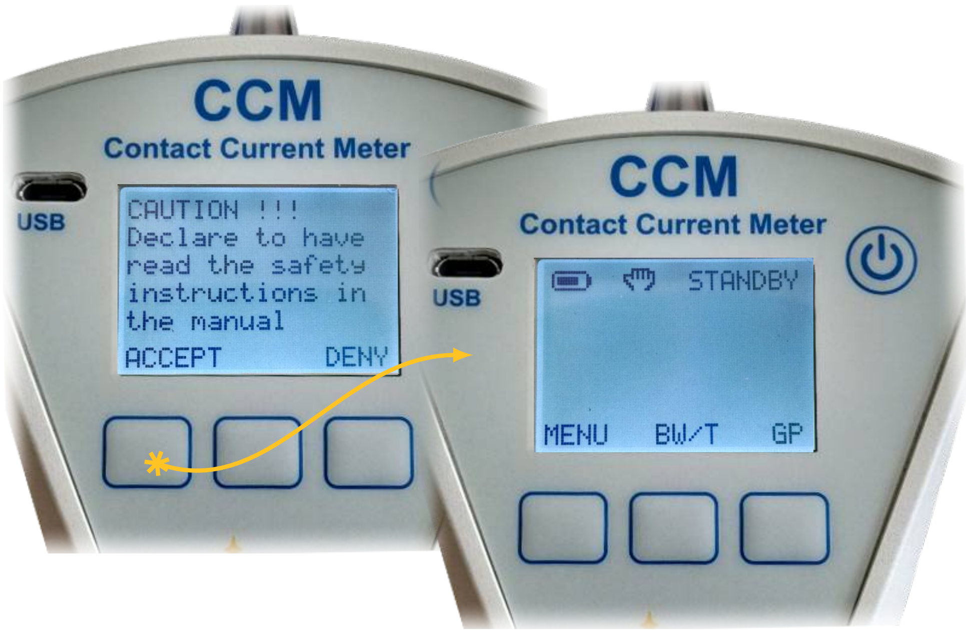

Figure 3.2: CCM Menu

Once you accept the terms of use, the device will remain in the *STANDBY* mode, until you press the trigger to start a measurement.

3.2 Standby Screen

In Figure 3.3 is shown the standby screen. On the top part, you will find:

- *Battery* indicator.
- The *Measurement Mode* shows which kind of circuit is selected in that specific measurement session, and (we'll see that more accurately in next chapter) there are two different measurement modes:

HAND for measurements that use the body impedance of the operator as a reference.

GP (or *GROUND PLANE*) for measurements that concern the supplied metal plate with a standardized impedance as a reference.

- The *State* indicates to the user whether the device is ready to make a measurement or not.

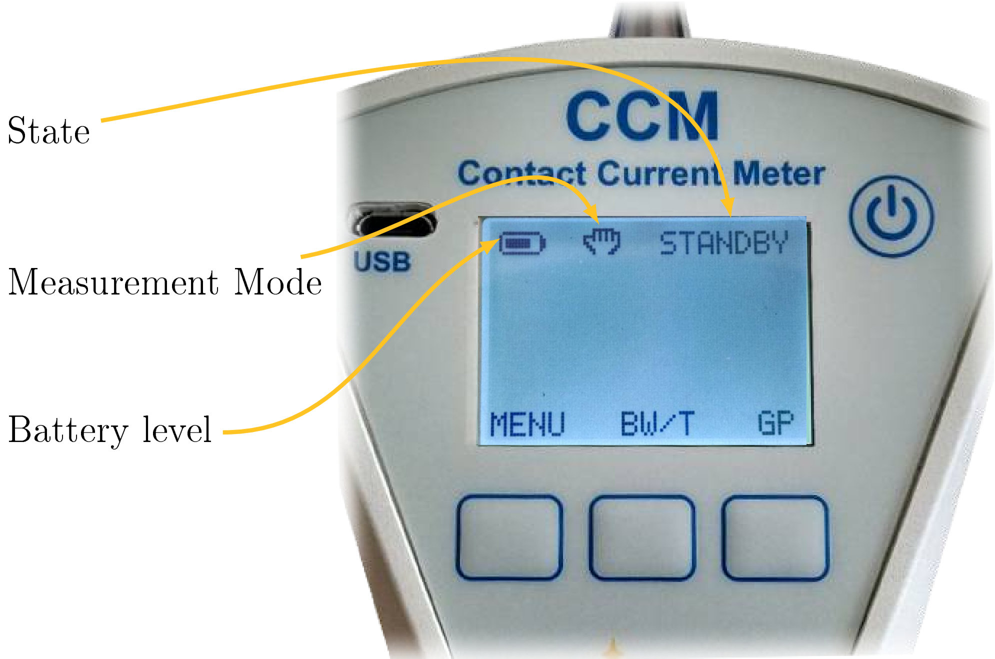

Figure 3.3: First Use

3.3 Hand or GP

Please remember that the GP measurement mode does not guarantee reliable measurements due to safety reasons. Please scroll back to 2.4 for more details.

In the main screen, the key on the right (in this specific case it can be *GP* or *HAND*) allows the user to choose which circuit to use for the measurement (Figure 3.4). It's highly recommended to measure with the Ground Plane **before** doing the *HAND* measurement (so that, in extreme cases, a high current will simply discharge on the ground). In the *Hand* measurement mode the CCM will consider the real impedance value of the human body.

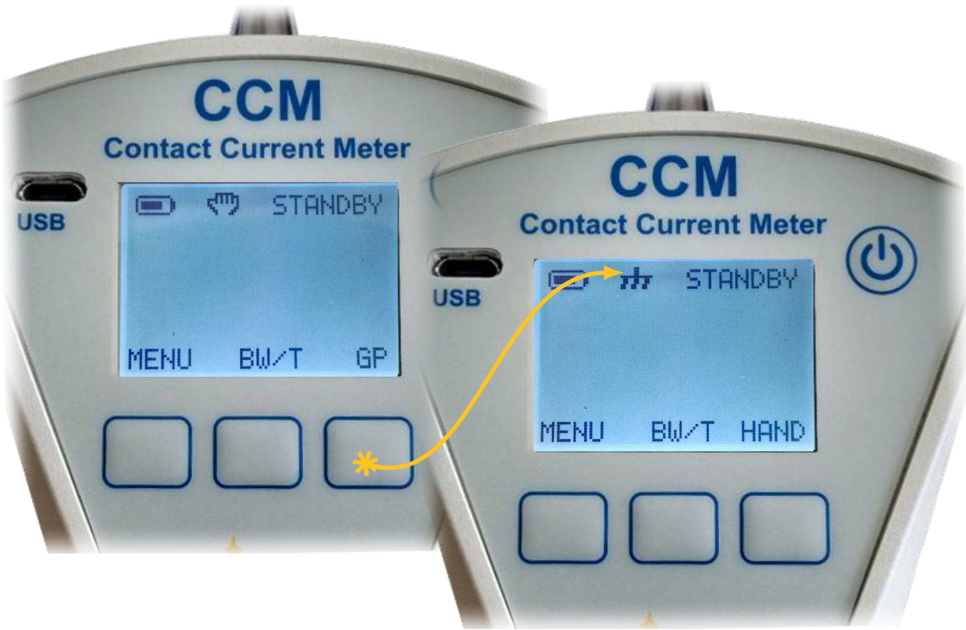

Figure 3.4: Hand or GP

3.4 Bandwidth/Total

the central key, *BW/T*, allows the user to choose the visualization mode:

BANDWIDTH Display of the measurement divided by bands (or selective measurement), with the final result expressed in mA.

TOTAL Overall view of the measured value, in percentage, compared to the ICNIRP limit.

$$\%TOTAL = MAX(\%LF; \%MF; \%HF)$$

You can find the formulas for LF, MF and HF in figure 3.6

$$\%LF(t) = \frac{valLF_{[mA]}(t)}{1_{[mA]}} \times 100$$

$$\%MF(t) = \frac{valMF_{[mA]}(t)}{0,4_{[\frac{mA}{kHz}]} \times f_{kHz}} \times 100$$

$$\%HF(t) = \frac{valHF_{[mA]}(t)}{40_{[mA]}} \times 100$$

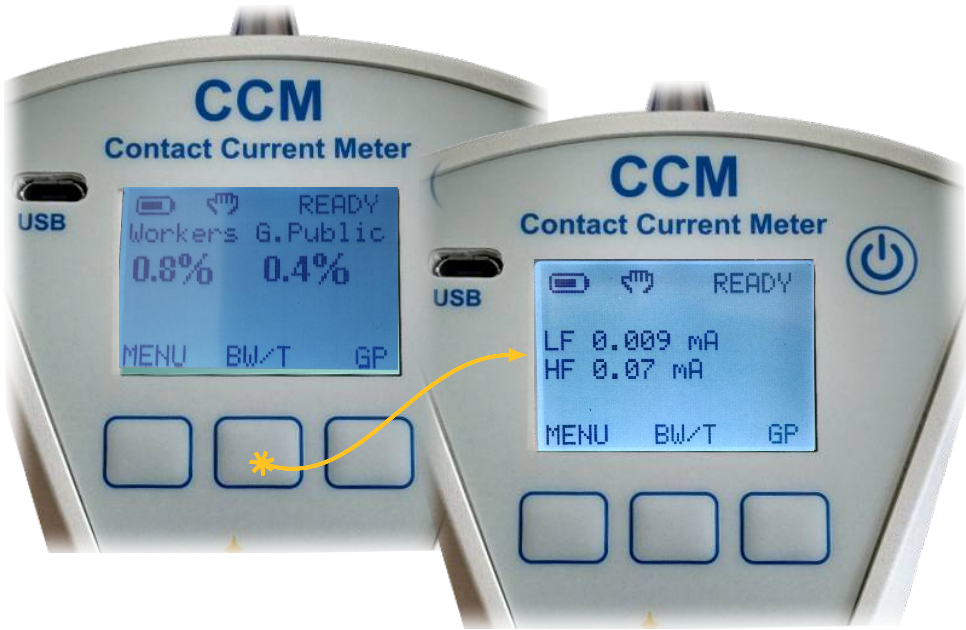

Figure 3.5: BW/T

You can find an example of what happens in Figure 3.5. The *Low band Filter* starts at 40 Hz to 2.5 kHz (IC bound = 1 mA), while the *High band Filter* starts at 0.1 MHz to 110 MHz (IC bound = 40 mA). The value of the contact current in the range of frequencies ranging from 2.5 kHz to 100 kHz is displayed when the values of LF and HF are low. For this reason it is suggested to make the measurement while "displaying" TOTAL and then check in BANDWIDTH at what frequency the limit has been exceeded.

3.5 First Use

If the CCM has just been switched on (or if it's been more than one minute since the last measurement) it is in *STANDBY* mode. By pressing the trigger, the device selects the relay and it actives the *WAIT* mode, which indicates that the device is loading. In the end, the message *READY* is displayed. Before pressing the trigger again, the operator will have to wait for the appearance of the *READY* message on the screen (Figure 3.6). From this moment on, the device is ready to perform the test in real-time.

Before carrying out the measurement, please follow the instructions below:

- *Press the trigger to switch the instrument mode from STANDBY to READY. Only when the READY key appears (please do not press the trigger again) reach the equipment under test with the tip and, only after making contact, press the trigger to start the measurement. You can make single or*

Figure 3.6: Ready for measuring

consequential measurements.

- *With each new measurement, the operator will be warned by an acoustic signal (if enabled) and, simultaneously, by a brighter display illumination. All measures are automatically stored by the CCM.*
- *In both modes the measuring tip of the CCM must never be removed from the equipment under test.*

3.6 CCM Menu

The next part of the manual sequentially shows the possible configurations of the device.

3.6.1 Regulation limits

From the standby screen, by pressing the *MENU* key, you will reach the screen shown in Figure 3.7

This screen is intended as a reminder for the user, since it displays the limit values for which the CCM is designed.

3.6.2 Beep on press

The second page of the menu allows you to enable or disable the beep every time you press the corresponding key. To change this setting enter the page by pressing the key *SET*, as in Figure 3.8.

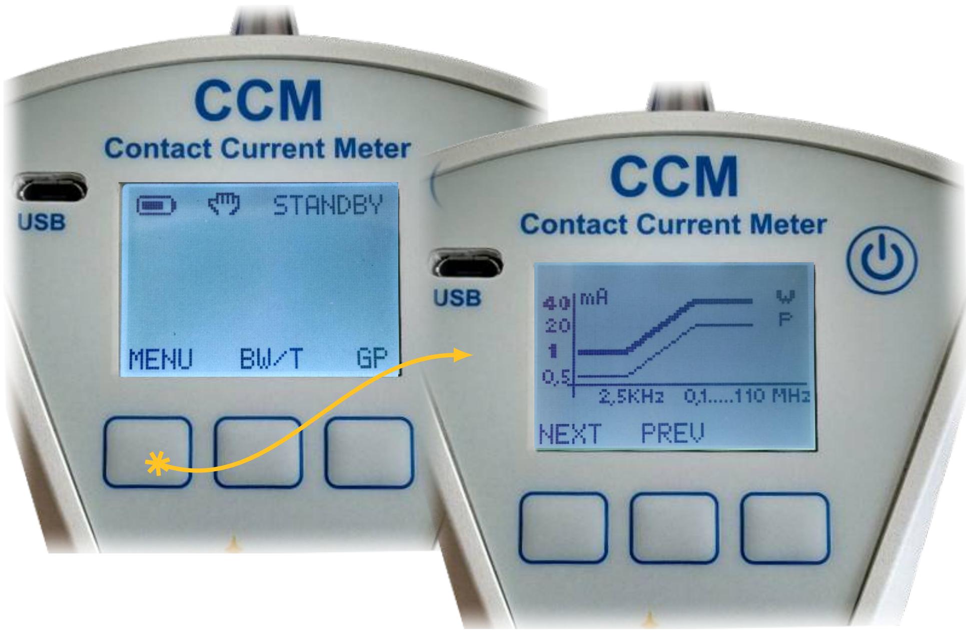

Figure 3.7: Limit

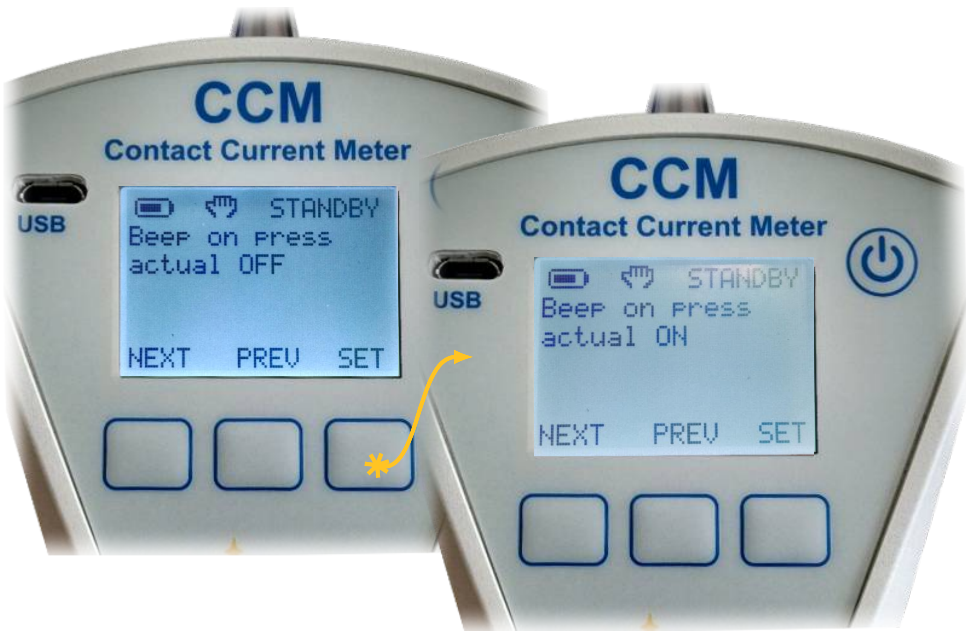

Figure 3.8: Beep on press

3.6.3 Alarm

Scrolling back the menu (always using the *NEXT* key) the third page displayed is the alarm page. This happens when the *SET* key is pressed (as shown in Figure 3.9). By default the alarm is disabled, while, when pressing the *UP* key, the value is incremented by 5% until it reaches the maximum warning threshold of 300%.

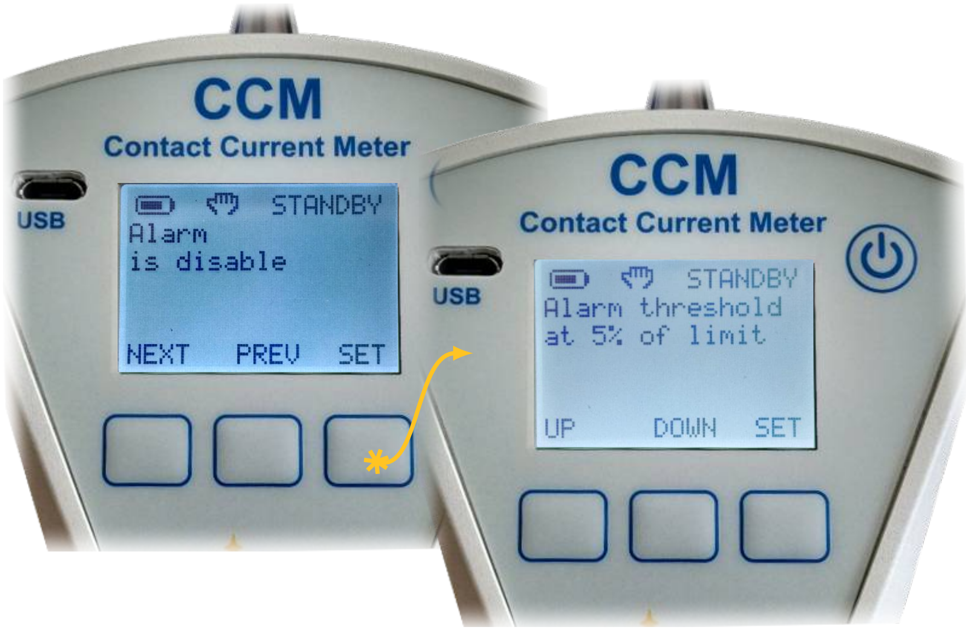

Figure 3.9: Alarm

Please do not forget that the percentage value is parametric with respect to the frequency of the input signal (see the graph shown on the first page of the menu - Chapter 3.6.1).

3.6.4 Auto OFF

Through this setting the user can decide how long after inaction it will take before the device will automatically shutdown. This is the fourth page of the menu, and in Figure 3.10 you can see how, also on this page, the left and center key change usage.

Ranges for this setting vary from 10 minutes to 60 minutes (with a 10 minutes span). You cannot disable this option for battery saving.

3.6.5 Date & Time

The fifth menu item allows you to change the date and time of the device (Figure 3.11). It is important that this information is correct, because the results of the measurements in the downloaded data (csv file generated by the device) are associated with the day and time of the measurements.

The changes of the fields are carried out using the keys *UP* and *DOWN*, and will follow the sequential order of day, month, year, hours, minutes and seconds.

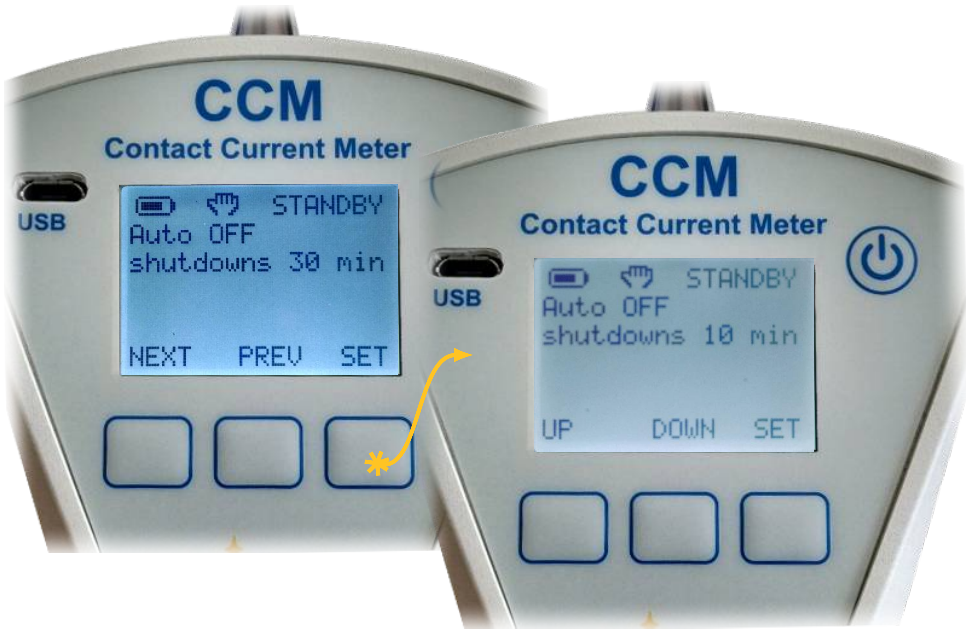

Figure 3.10: Auto Off

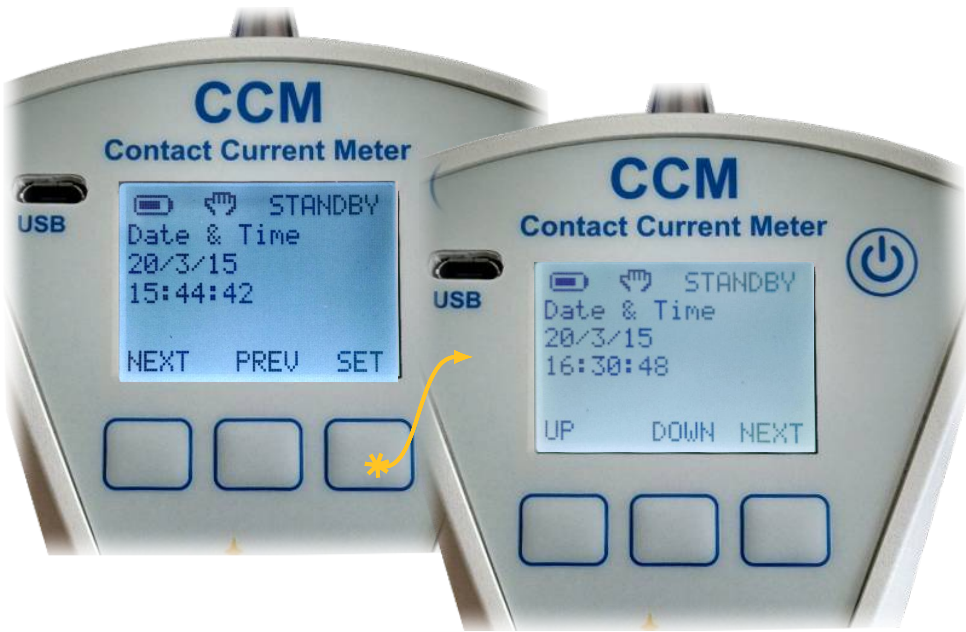

Figure 3.11: Date & Time

3.6.6 Contrast

The sixth page of the menu (Figure 3.12) allows you to change the contrast of the LCD display by using the same keys, *UP* and *DOWN*. By default an intermediate value is already set.

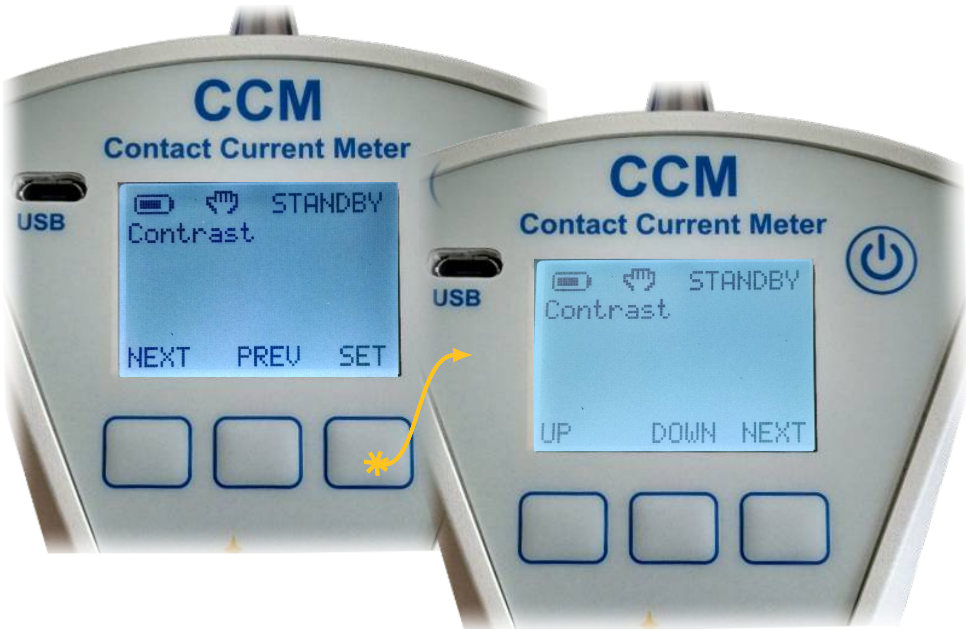

Figure 3.12: Contrast

3.6.7 Clear Data

In this menu, the operator has the possibility to delete all the data stored in the internal memory. If measurements from the previous session have remained, it is possible to clean the memory without a PC. The Figure 3.13 shows how this functionality works.

Figure 3.13: Clear Data

Chapter 4

Data Download

4.1 Connect to PC

The data downloading operation has been designed to improve the speed and simplicity of use. The data generated by the CCM are stored in **csv** (comma separated value), which is a text file with value separators. This allows the user to read, edit and process the downloaded data via various software including *MS Excel*.

When connecting your device, it must be already turned on. At the first connection, through the USB-Micro USB cable supplied with the instrument, the CCM will be recognized by the PC as a mass storage device (Figure 6.7). For this reason there is no need for special drivers, because drivers self-installed by *Windows* OS will be ready to use.

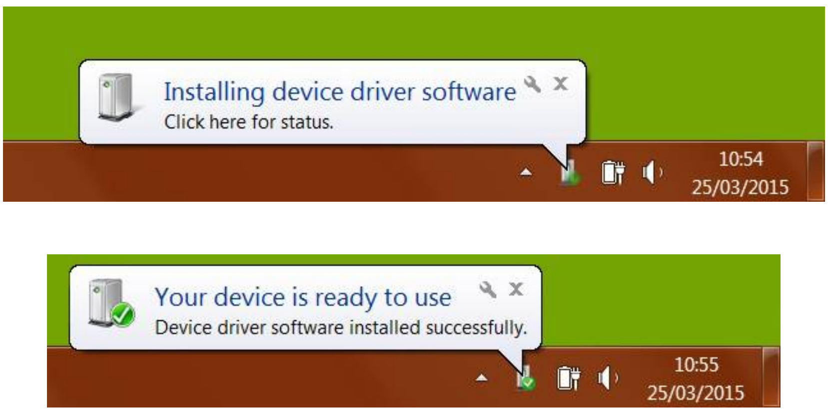

Figure 4.1: Installing

If your PC has enabled the autoPlay, the next window appearing will be the one to access to the new peripheral (Figure 4.2), otherwise it can be accessed by opening "My Computer" and selecting the **MPB (CCM)** marked device

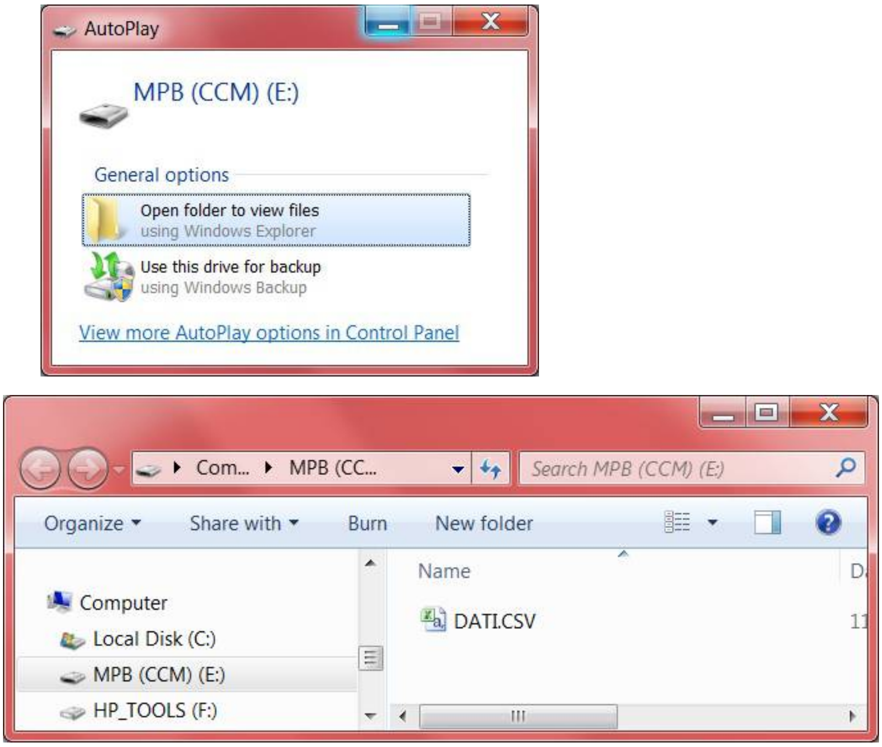

Figure 4.2: Access Data

4.2 Data Format

Measurement by measurement, the device appends into the only data.csv file generated, all the information about a measurement. More specifically, the stored data are ordered as follows:

- Date & Time
- Total value Measurement (expressed in %) For workers.
- Total value Measurement (expressed in %) For general public
- Value in mA from the Low Filter.
- Value in mA from the High Filter.
- Measurement made through *HAND* or *GP*.

To correctly display the date and time, the format to enter is dd:mm:yyyy:hh:mm:ss.

To correctly display the acquired values: the decimal separator is the "." (point), and the digit grouping symbol is a "," (comma)

In case of visualization issues, please change the "Language and region" setting in the control panel

This file, opened with *MS Excel* will appear as in Figure 4.3

MPB CCM FW 1.03					
date time	Workers	G.Public	LF	HF	Input
GG/MM/AAAA hh:mm:ss	%	%	mA	mA	from
05/11/2015 12:55	1.0	0.5	0.010	0.07	hand
05/11/2015 12:55	3.3	1.6	0.033	0.07	hand
05/11/2015 12:55	1.0	0.5	0.010	0.07	hand
05/11/2015 12:55	4.9	2.4	0.049	0.07	hand
05/11/2015 12:55	1.0	0.5	0.010	0.07	hand
05/11/2015 12:55	4.4	2.2	0.044	0.07	hand
05/11/2015 12:55	0.9	0.4	0.009	0.07	hand
05/11/2015 12:55	5.0	2.5	0.050	0.07	hand
05/11/2015 12:55	1.0	0.5	0.010	0.07	hand

Figure 4.3: Data dump

Chapter 5

JIG - General Information

Figure 5.1: CCM and JIG

5.1 Introduction

The JIG was designed to standardize the CCM calibration procedure, and give the final user the possibility to perform calibration whenever he needs to.

5.2 Description

The JIG is built on an iron base, with a connector to be plugged to the CCM's Jig room, an iron locking stirrup designed for the HAND plate, and adaptive connectors designed for the contact current meter. This guarantees a stable support during the test procedure. During the procedure, the user will have to subject the device to RF signals, using the special connectors on the JIG or on the CCM itself.

5.3 Composition

The CCM with the JIG option comes with:

- shaped hard case
- batteries
- Resistances (R45)
- Body Simulation Impedance (Z-2251)
- RG316 cable N-sma (M-M) (length 1 mt.)
- Cable sma-sma(M-M) (length 2 mt.)
- Ground Plane

5.4 Kit Case

In Figure 5.2 is shown the complete Kit for the CCM:

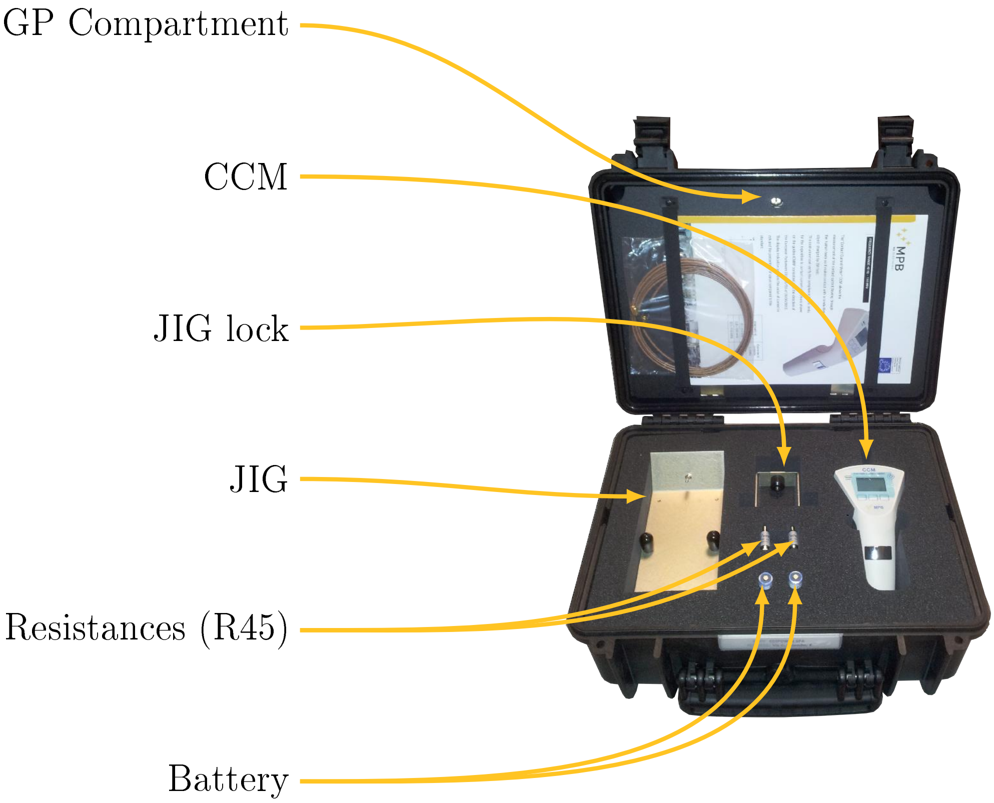

Figure 5.2: Case

In Figure 5.3 is shown the inner compartment of the case:

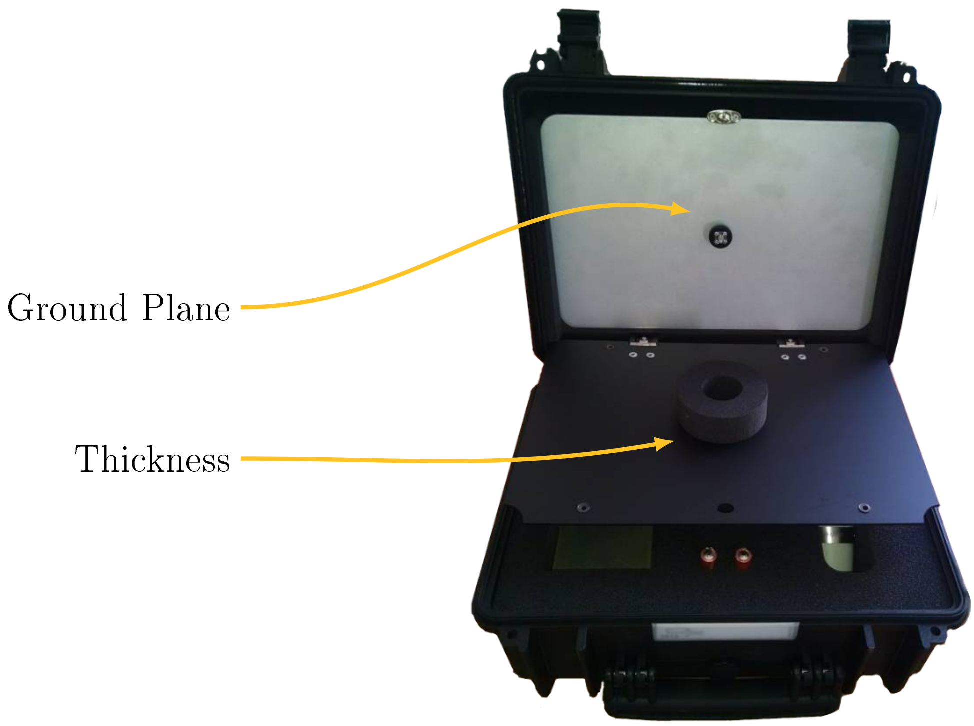

Figure 5.3: Case Compartment

Chapter 6

JIG - Functioning

6.1 Equipment

To use the JIG is necessary to have a signal generator, able to generate sinusoidal signals from 40 Hz to 110 MHz. All the other tools needed for the calibration are supplied with the JIG kit. For the specific connection with the signal generator, a N-sma cable (as in Figure 6.1)and a R45 resistance will be used;

6.1.

Figure 6.1: Cable and resistance

The CCM has an inner resistance of 5 Ohm and, since almost all the signal generators are adapted for 50 Ohm, 45 Ohm must be added to the load. assembling the resistance included on the sma attack of the cable. The connector must be plugged to the generator. In the next paragraphs, we will see different ways of plugging the CCM through this configuration.

6.2 Install the CCM on the JIG

To install the CCM on the JIG in order to be able to make a calibration, first of all we need to remove the TIP from the CCM, simply by sliding it out, as shown in Figure 6.2.

(a) CCM TIP

(b) unplug the TIP

(c) CCM TIP unplugged

Figure 6.2: Remove the TIP

Now the device is ready to be installed on the JIG.
Set the JIG base near your signal generator, and plug the CCM on the JIG through the TIP connector as in Figure 6.3.

Figure 6.3: Set Up the JIG

The next step is to lock down the CCM with the special JIG lock using the knobs, so that the HAND plate will be connected to the lock sma connector (the result is shown in Figure 6.4).

Figure 6.4: Set Up the JIG

It's important to tighten the knobs on the basis, just to ensure a good conductivity between the metal JIG and its lock plate.

6.3 "Ground Plane" Test

As already described on the CCM manual, the GROUND PLANE measure has to be done before the HAND measure. To properly connect the device plane connector to the generator we will use our N-sma cable and the R45 resistance as in Figure 6.5.

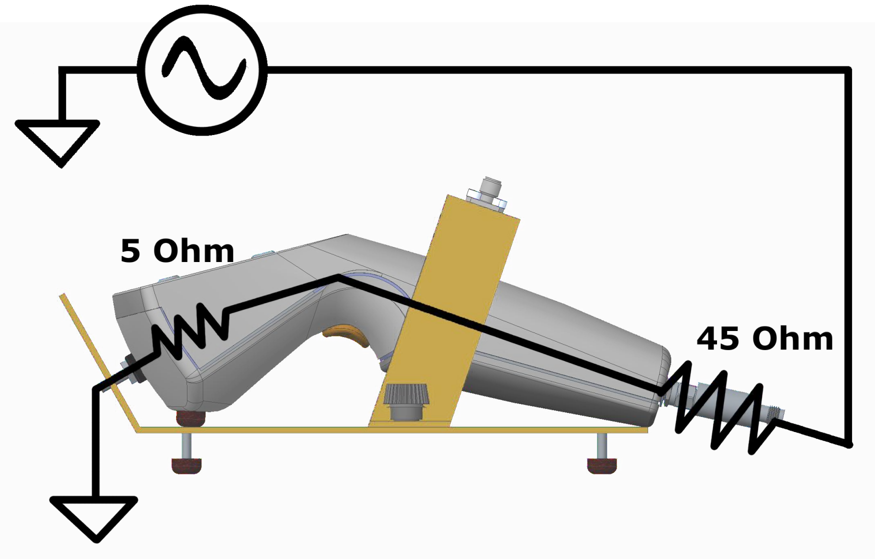

Figure 6.5: Ground Plane Plug

We can now turn on the device and set up the "Ground Plane" mode. Once the signal generator is configured and operating, you can pull the trigger and perform the measurement.

1. plug the R45 adapter to the "SMA" connector in the "GP" input
2. plug the "SMA-N" cable to the adapter and to the signal generator
3. set the generator on the appropriate level
4. turn on the device under test
5. switch to the "GP" modality (see Chapter 3.3)
6. press the "GET" button to perform the measurement

For instructions on how to set the generator please see the examples in 6.5.1, 6.5.2 and 6.5.3.

6.4 “Hand” Test

For the “HAND” measurement you have to plug the R45 resistance to the sma connector on the JIG lock, then the N-sma cable from the impedance to the generator, as shown in Figure 6.6.

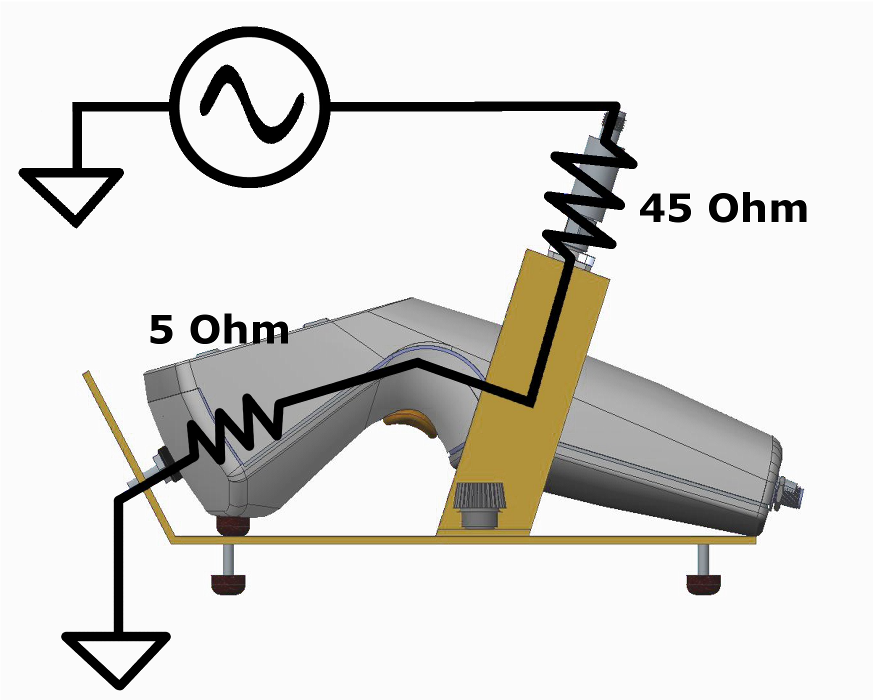

Figure 6.6: Hand Plug

With the device turned on, switch the reading mode to “HAND”. Now you can start to generate the desired signal. When ready please pull the trigger to perform the measure.

1. plug the R45 adapter to the “SMA” connector in the “JIG” input
2. plug the “SMA-N” cable to the adapter and to the signal generator
3. set the generator on the appropriate level
4. turn on the device under test
5. switch to the “HAND” modality (see Chapter 3.3)
6. press the “GET” button to perform the measurement

For instructions on how to set the generator please see the examples in 6.5.1, 6.5.2 and 6.5.3.

6.5 Certificate Measurements

To test the correct functioning of the CCM, make sure your generator is working properly and the grounding is in compliance with the law. Please remember that, as every other device, the CCM is subject to a minimum eventual error. To know the ideal outcome of the device, please appy the folllowing formula:

$$P_{GEN[dBm]} = 10 \times \log_{10}\left(\frac{50_{[\Omega]} \times I_{IN[A]}{}^{2}}{1 \times 10^{-3}{}_{[W]}}\right)$$

Figure 6.7: Formula

6.5.1 Low Band

In this band (from 40 Hz to 2,5 kHz) the limit for workers is 1 mA, so the 100% is equal to 1 mA. To test the correct functioning of the CCM at low frequencies, please set the frequency of the generator at 1 kHz and the power at -13.01 dBm. You will obtain an outcome with accuracy of around 100%, corresponding to 1 mA.
Within this range we suggest to set the "Bandwidth" visualization mode in order to read the result in milliAmpere as well (and not only in percentage compared to the limit)

6.5.2 Medium Band

In this band (from 2,5 kHz to 100 kHz) the limit for workers depends on the frequency with the following rule: mA= 0,4 f where f is expressed in kHz. Within this frequency range the limit varies in function of the frequency of the emitted signal. We will provide three sample frequencies:

- setting the frequency at 10 kHz and the power at −0.97 dBm, you will obtain an outcome with accuracy of around 100%, corresponding to 4 mA.
- setting the frequency at 20 kHz and the power at +5.05 dBm, you will obtain an outcome with accuracy of around 100%, corresponding to a 8 mA.
- setting the frequency at 50 kHz and the power at +13.01 dBm, you will obtain an outcome with accuracy of around 100%, corresponding to a 20 mA.

6.5.3 High Band

In this band (from 100 kHz to 110 MHz) the limit for workers is 40 mA, so the 100% is equal to 40 mA. Within the high frequencies range, setting the frequency at 10 MHz and the power at +19.03 dBm, you will obtain an outcome with accuracy of around 100%, corresponding to a 40 mA. Within this range we suggest to set the “Bandwidth” visualization mode in order to read the result in milliAmpere as well (and not only in percentage compared to the limit)

List of Figures