LANGER
EMV-Technik

IC TEST SYSTEM

User manual
Probe set

P603-1 / P750 set

RF conducted measurement
IEC 61967-4

Copyright © July 2016
LANGER EMV-Technik GmbH

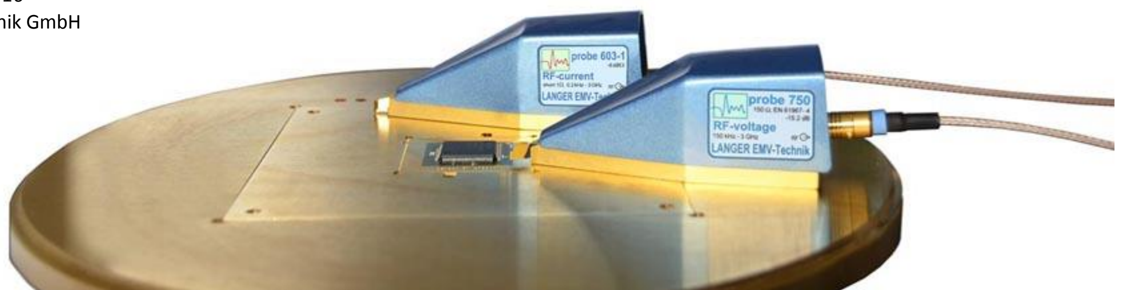

Table of contents: **Page**

1 General description **3**
2 P603-1 probe **8**
2.1 General Description 8
2.2 Design and function of the P603-1 probe 8
3 P750 probe **11**
3.1 General Description 11
3.2 Design and function of the P750 probe 11
4 Measurement set-up **13**
4.1 Performing the measurement 13
4.2 Using the ChipScan-ESA software 15
5 Safety instructions **21**
6 Warranty **21**
7 Technical specifications **22**
7.1 P603-1 probe 22
7.2 P750 probe 23
8 Scope of delivery **24**

1 General description

The ***P603-1*** and ***P750*** probes have been developed to measure conducted emissions from integrated circuits (ICs) with direct 1 Ohm/150 Ohm coupling. The probes can be used to perform measurements on ICs according to IEC 61967-4 (**Figure 1**). The ***P603-1*** probe corresponds to the 1 Ohm RF current probe head. The ***P750*** probe corresponds to the impedance matching network according to IEC 61000-4-6. It has an input impedance of 150 Ohm.
The ***P750*** probe can be used to perform RF voltage measurements and the ***P603-1*** probe can be used for RF current measurements on IC pins.

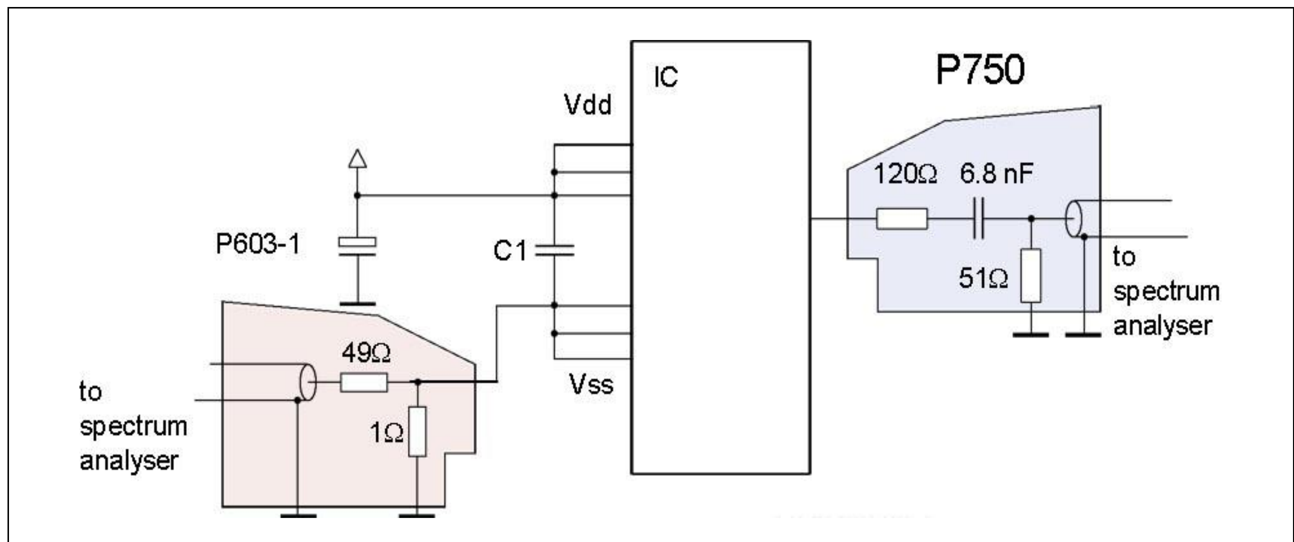

Figure 1 Test set-up according to IEC 61967-4 with the ***P603-1*** 1 Ohm RF current probe head (current measurement) and the ***P750*** impedance matching network (voltage measurement).

The ***P603-1*** and ***P750*** probe can also be used for other measurement tasks:

1. Current measurement (***P603-1***) on concatenated Vdd pins (with external capacity), **Figure 2**
2. Current measurement (***P603-1***) on a single Vss pin, **Figure 3**
3. Current measurement (***P603-1***) on a single Vdd pin (with external capacity), **Figure 4**
4. Voltage measurement (***P750***) on a signal pin while this is in operation, **Figure 5**
5. Current measurement (***P603-1***) on a signal pin while this is in operation (with external capacity), **Figure 6**
6. Voltage measurement (***P750***) on a Vdd or Vss pin, **Figure 7**

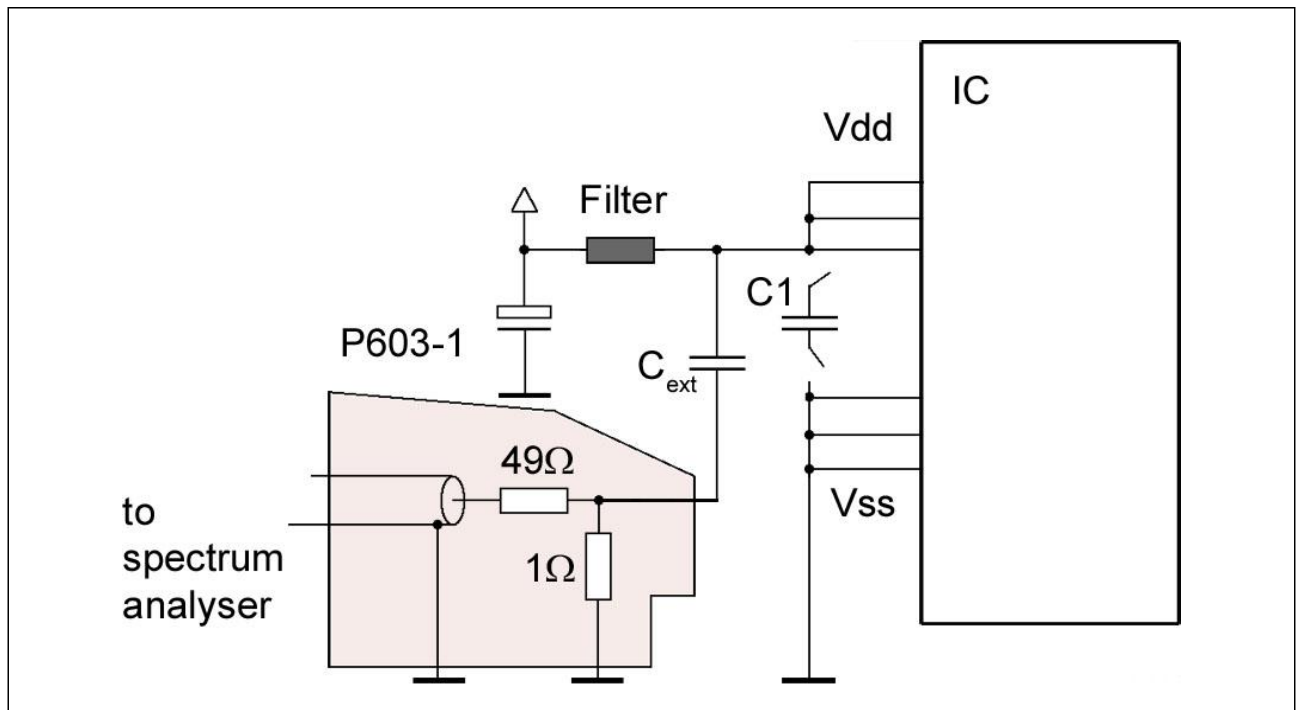

Figure 2 ***P603-1***, current measurement with a direct current block (C_{ext}) on concatenated Vdd pins.

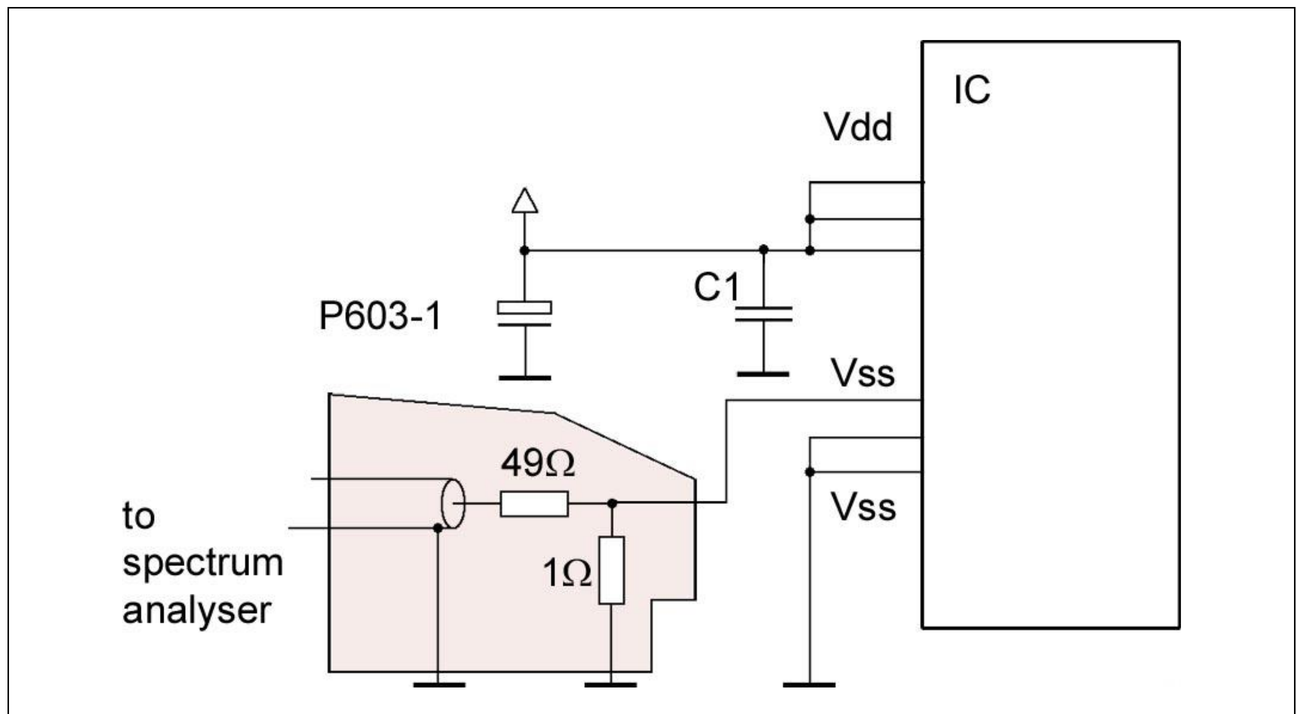

Figure 3 ***P603-1***, current measurement on a single Vss pin.

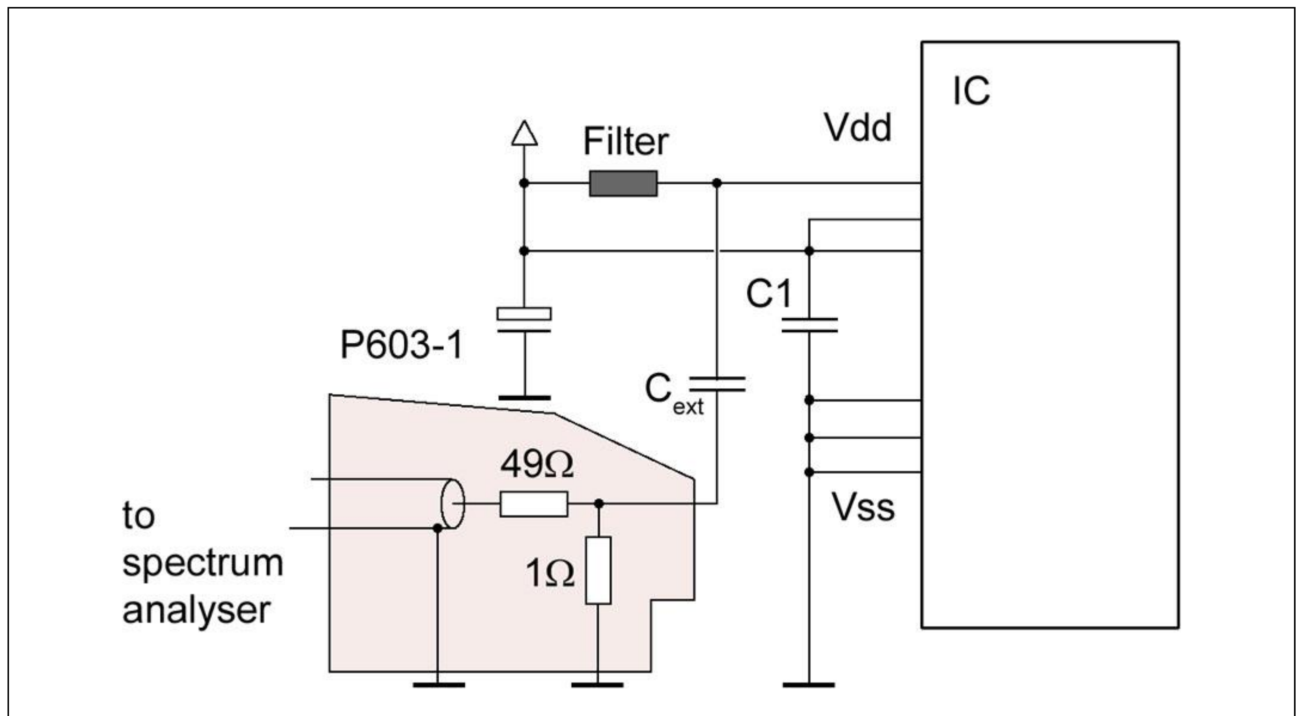

Figure 4 ***P603-1***, current measurement on a single Vdd pin with exteral DC-decoupling..

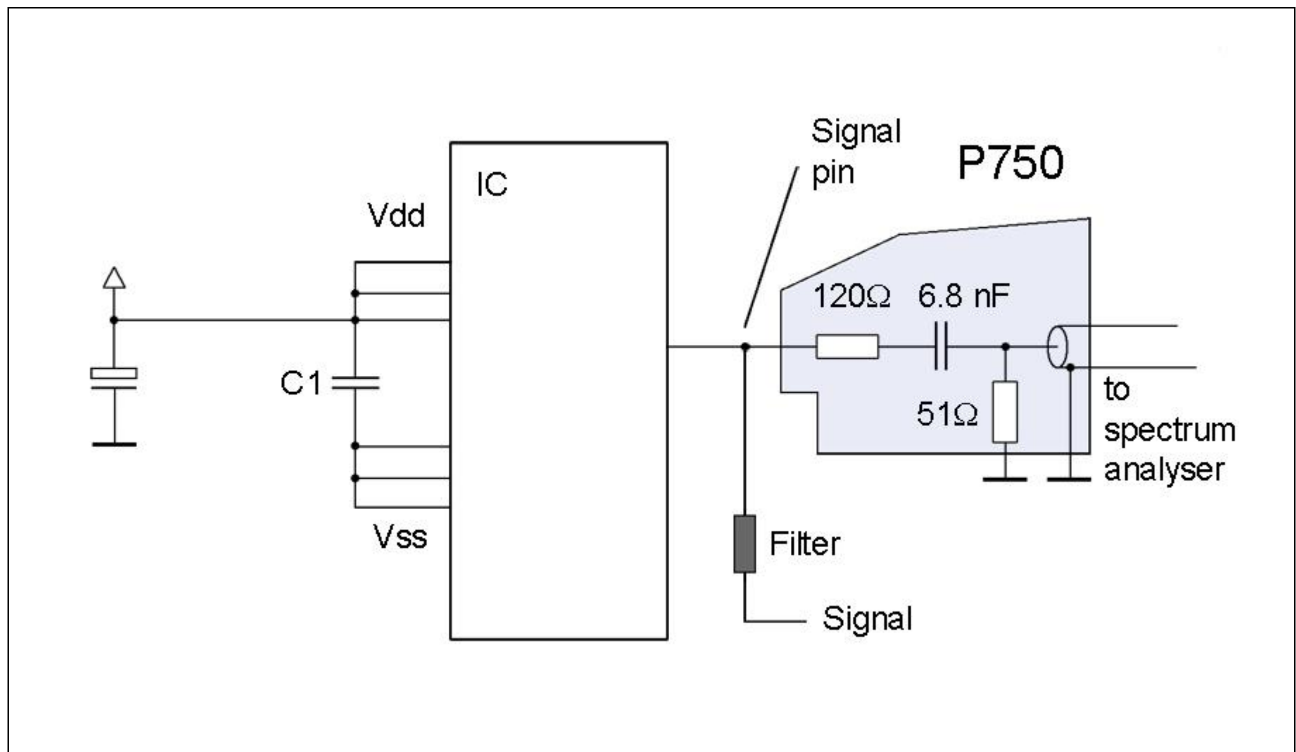

Figure 5 ***P750***, voltage measurement on a signal pin while this is in operation.

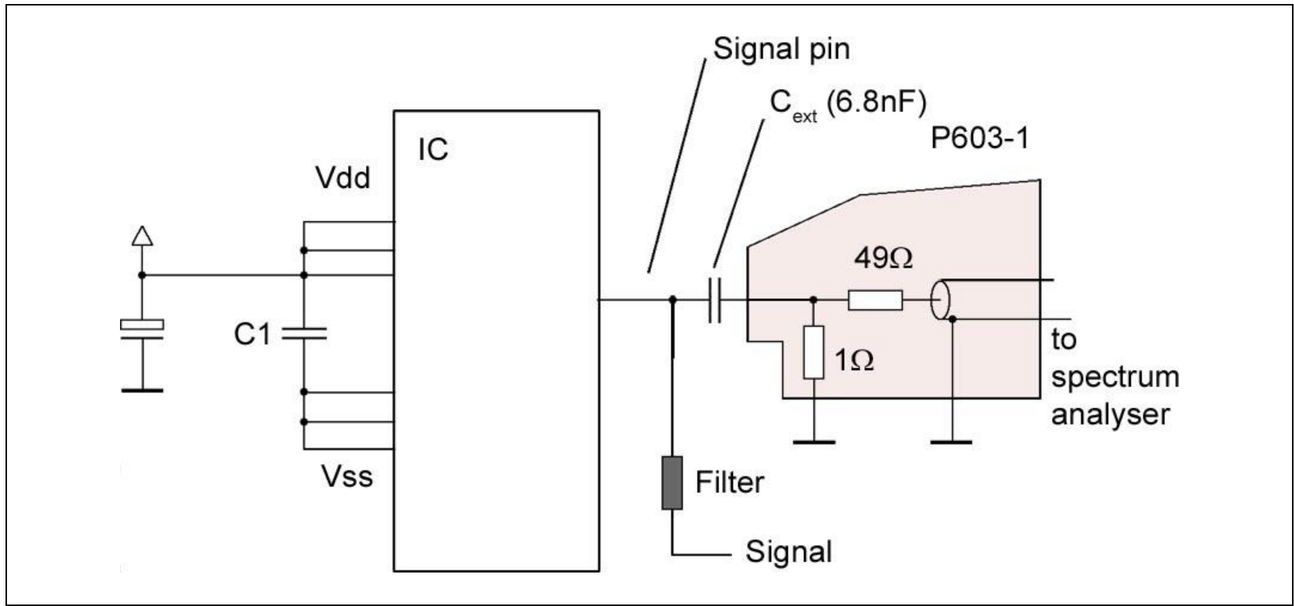

Figure 6 ***P603-1***, current measurement on a signal pin while this is in operation.

The external capacitor C_{ext} can reduce the stress on the signal pin caused by the probe's low impedance (1 Ohm) (**Figure 6**) during current measurements on signal pins.
The impedance of the capacitor C_{ext} should be at least 3 dB smaller than the shunt's 1 Ohm resistance.

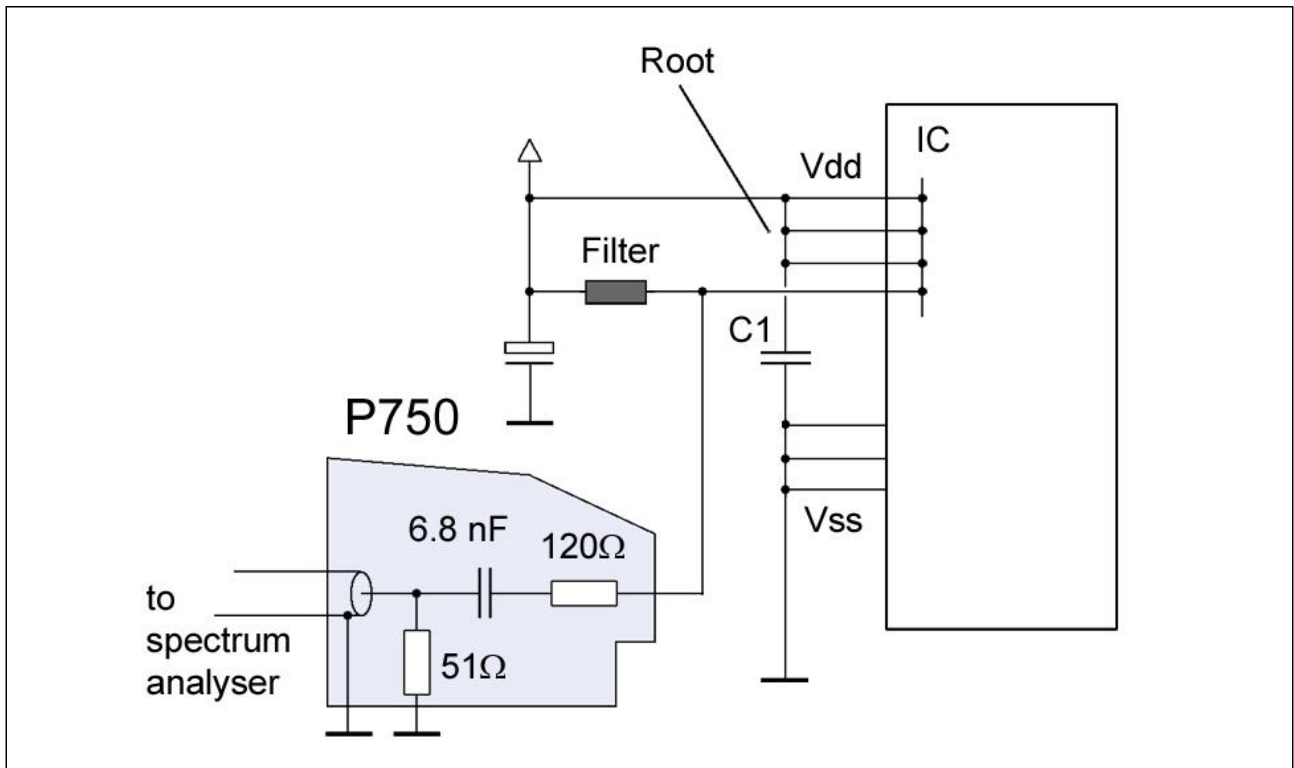

Figure 7 ***P750***, voltage measurement on a Vdd pin

An IC internal connection to other Vdd supply pins is assumed for a voltage measurement on a Vdd pin (**Figure 7**). This measurement enables the determination of voltage dips on the IC's internal Vdd network.

The test IC is soldered to the test board[1] (**Figure 8**). The ***P603-1*** and ***P750*** probes can be moved freely on the ***GND 25*** ground plane or ***GNDA*** ground adapter[2] (**Figure 8**). Unlike the measurement set-up according to IEC 61967-4, this set-up ensures that the ***P603-1*** or ***P750*** probe's pin contact can reach and contact each IC pin. The probes are fixed on the ground plane with magnets. Filter elements and bridges are located on the underside (bottom) of the test board to prepare the measurement set-up for contact with the probe (**Figure 10**).

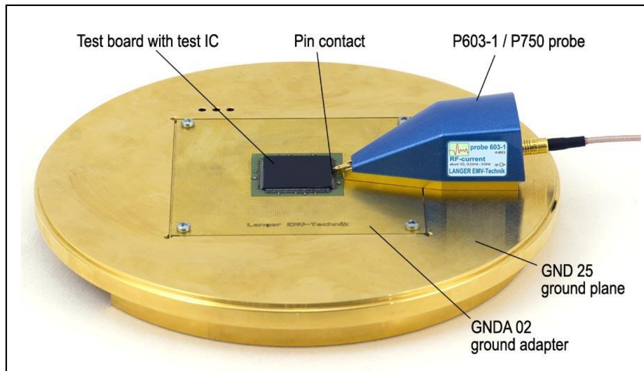

Figure 8 Measurement set-up according to the 1 Ohm method with ***P603-1*** and the 150 Ohm method with ***P750***.

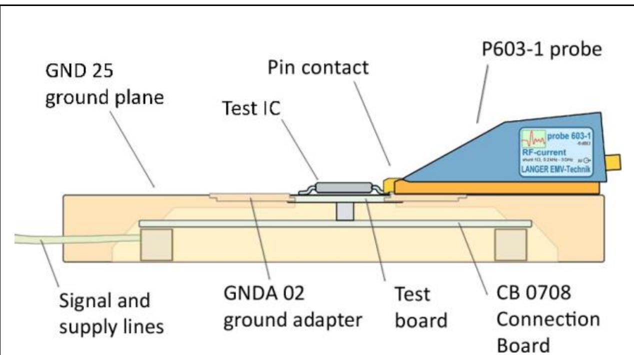

Figure 9 Sectional view of the measurement set-up.

The same test board is used for all measurement methods (1 Ohm, 150 Ohm). Bridges are provided to the Vdd / Vss root at the Vdd / Vss pins in the initial state. The associated bridge to the root is removed and the corresponding filter becomes active if a Vdd / Vss pin is measured.

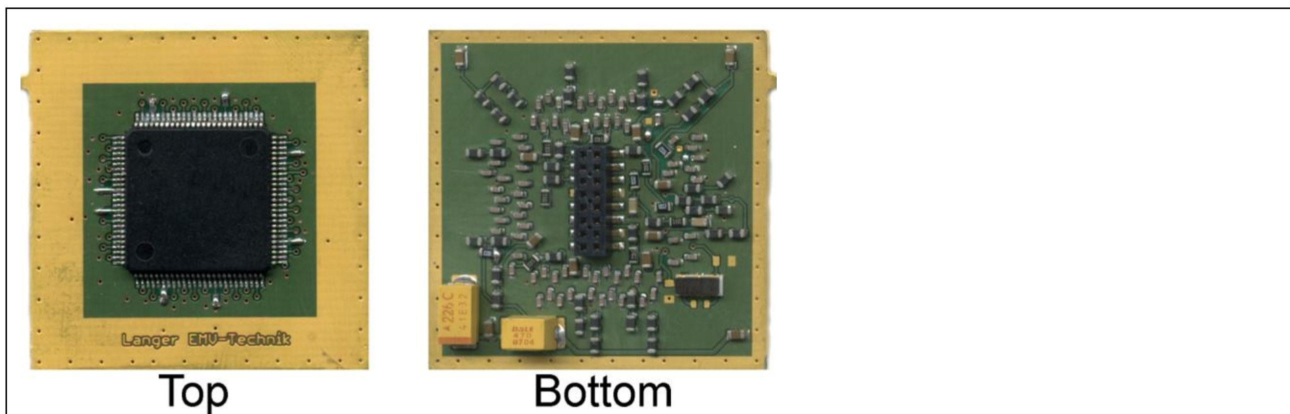

Figure 10 Design of the test board; top with Vss bridges, bottom with back-up capacitors, filters and quartz crystal oscillator circuit.

[1] The test board is described in the "IC test instruction manual", mail@langer-emv.de
[2] ***GNDA 02*** ground adapter and ***GND 25*** ground plane are included in the ***ICE1*** IC test environment. www.langer-emv.de

2 P603-1 probe

2.1 General Description

The ***P603-1*** probe is an RF current probe head to measure conducted RF currents on IC pins according to IEC 61967-4. The measurement is performed with a 1 Ohm shunt.

Figure 11 ***P603-1*** probe

2.2 Design and function of the P603-1 probe

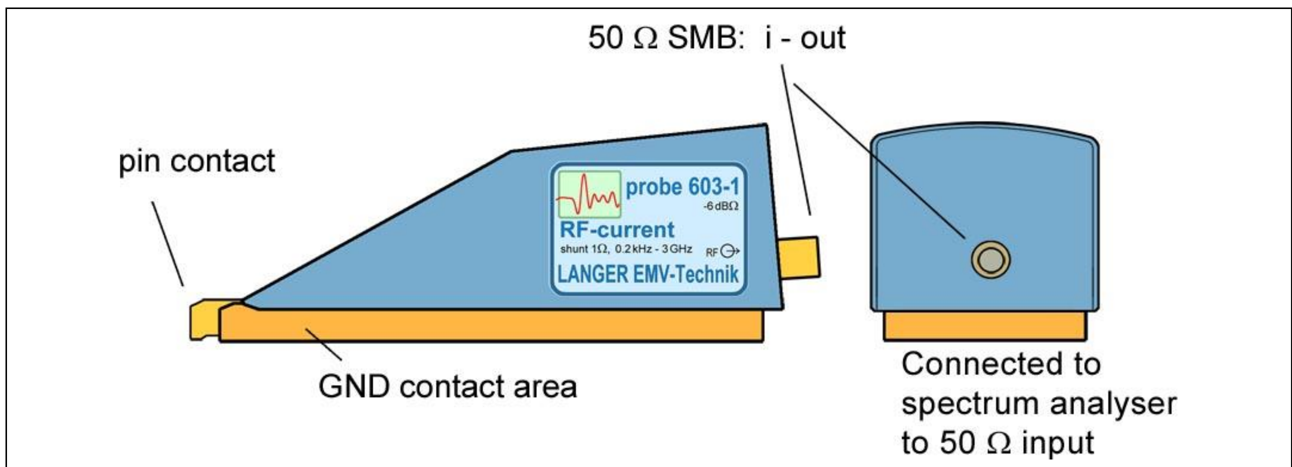

Figure 12 Design of the ***P603-1*** probe

The ***P603-1*** probe contains a 1 Ohm current probe head (IEC 61967-4). The input of the current probe head is connected to the probe's pin contact (**Figure 12**). The output of the current probe head is connected to the 50 Ohm SMB port at the rear end of the probe.
A cable is used to connect the probe's output to a measuring instrument such as a spectrum analyser. The voltage measured is equivalent to the current measured.

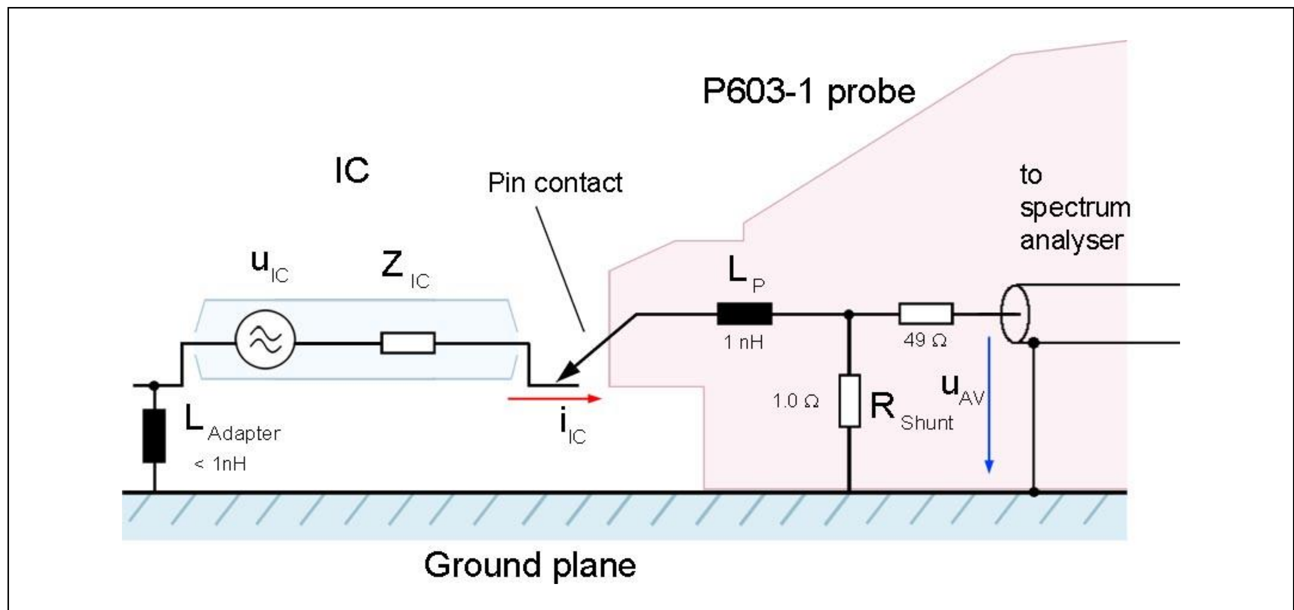

Figure 13 Internal ***P603-1*** design

Figure 13 shows the equivalent circuit diagram of the ***P603-1*** probe. The current probe head comprises a 1 Ohm shunt and a 49 Ohm matching resistor.
An additional capacitor C_{ext} can be inserted between the test IC and the probe to reduce the stress on the signal pins caused by the 1 Ohm shunt. The ***P603-1*** current probe head has an inductance L_P of 1 nH in the line from the tip of the probe contact to the shunt. This value and the associated measurement error are much smaller than the value achieved with the set-up according to IEC 61967-4.
The pin contact of the probe has to be brought into contact with the respective test IC pin to perform the measurement. Please refer to the “ICE1 user manual”[1] and “IC test instructions”[2].

[1] mail@langer-emv.de
[2] mail@langer-emv.de

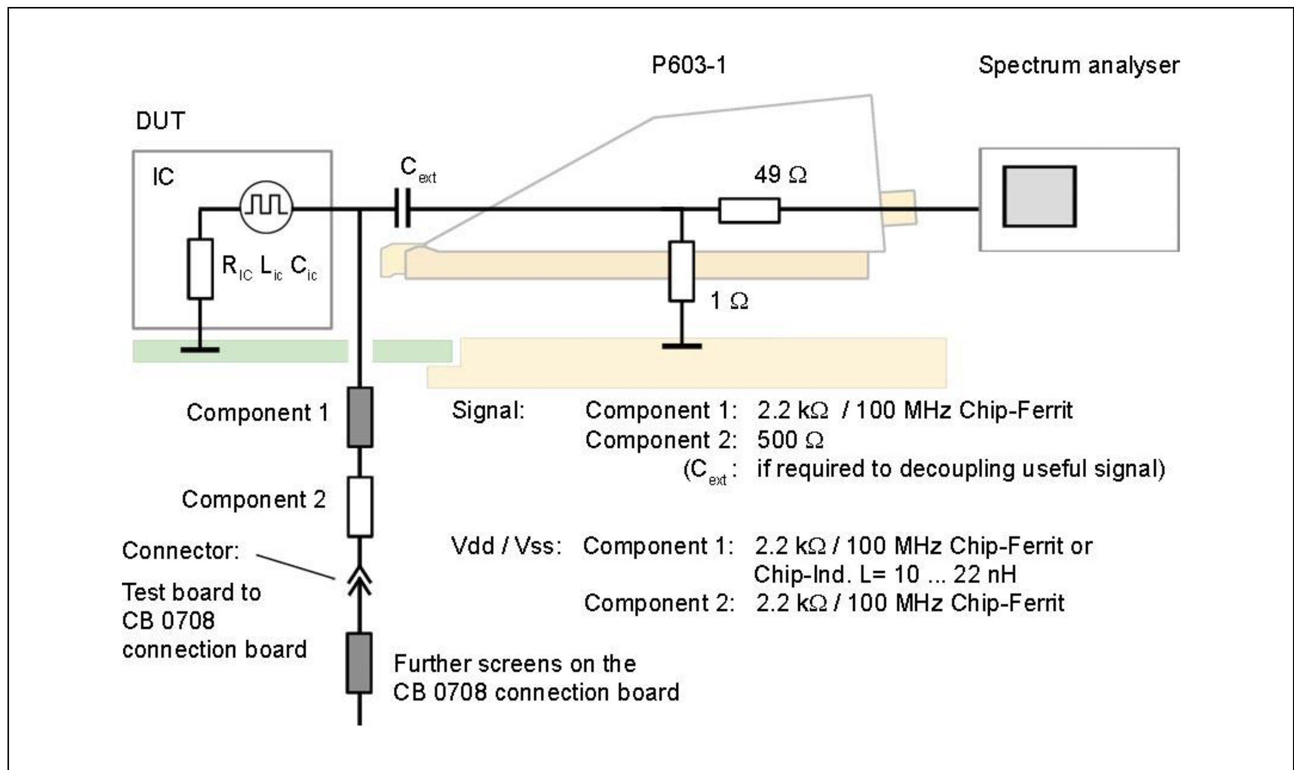

Figure 14 Design of the ***P603-1*** Vdd / Vss and signal pin filters

Figure 14 shows the design of the Vdd / Vss and signal pin filters which are located on the bottom of the test board. Please refer to the “IC test instructions”[1] for a guideline on how to set up a test board.

[1] mail@langer-emv.de

3 P750 probe

3.1 General Description

The ***P750*** probe is a matching network to measure conducted RF voltages on IC pins according to IEC 61967-4.
The ***P750*** has been designed for measurements on supply (Vdd / Vss) and signal pins. The measurement is performed with a 150 Ohm voltage divider.

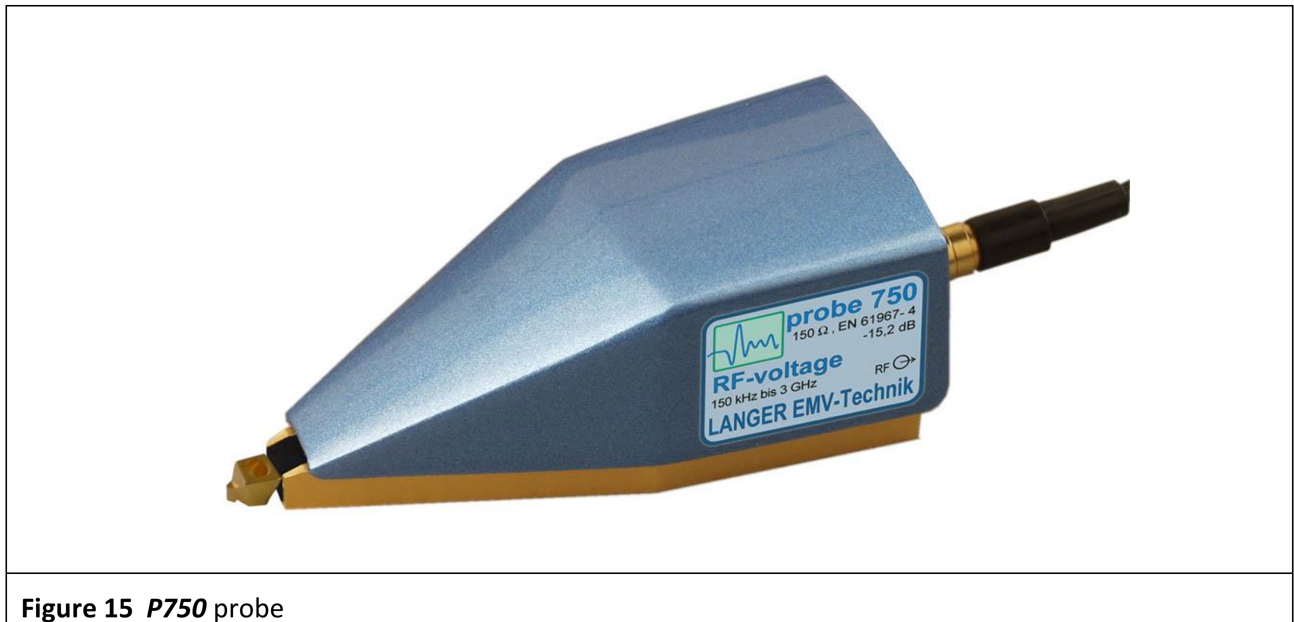

Figure 15 ***P750*** probe

3.2 Design and function of the P750 probe

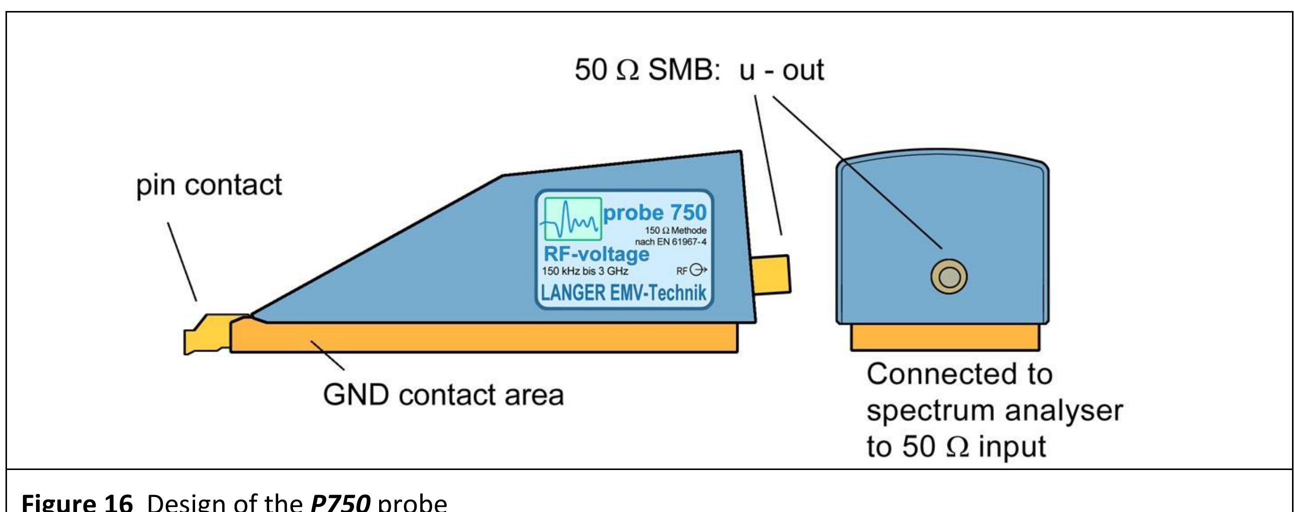

Figure 16 Design of the ***P750*** probe

The ***P750*** probe contains a 150 Ohm matching network (IEC 61967-4). The input of the matching network is connected to the probe's pin contact (**Figure 16**). The output of the matching network is connected to the 50 Ohm SMB port at the rear end of the probe.
A cable is used to connect the probe's output to a measuring instrument such as a spectrum analyser.

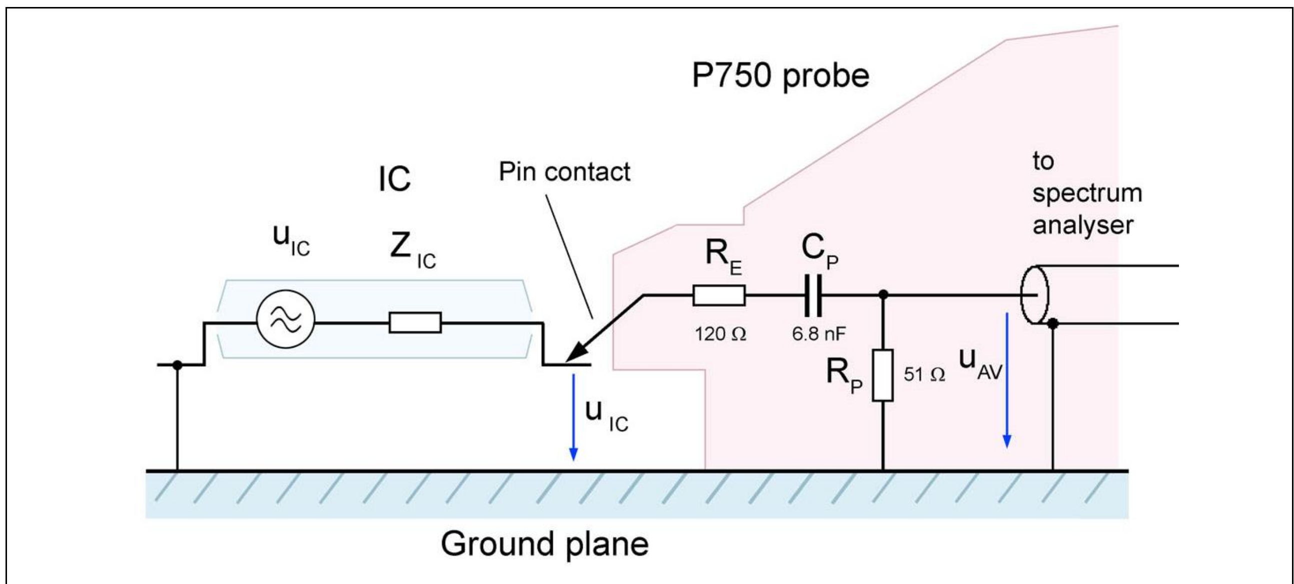

Figure 17 Internal ***P750*** design

Figure 17 shows the equivalent circuit diagram of the ***P750*** probe. The matching network comprises a 120 Ohm – 51 Ohm voltage divider and a 6.8 nF coupling capacitor.
The pin contact of the probe has to be brought into contact with the respective test IC pin to perform the measurement. Please refer to the “ICE1 user manual” and “IC test instructions”[1].

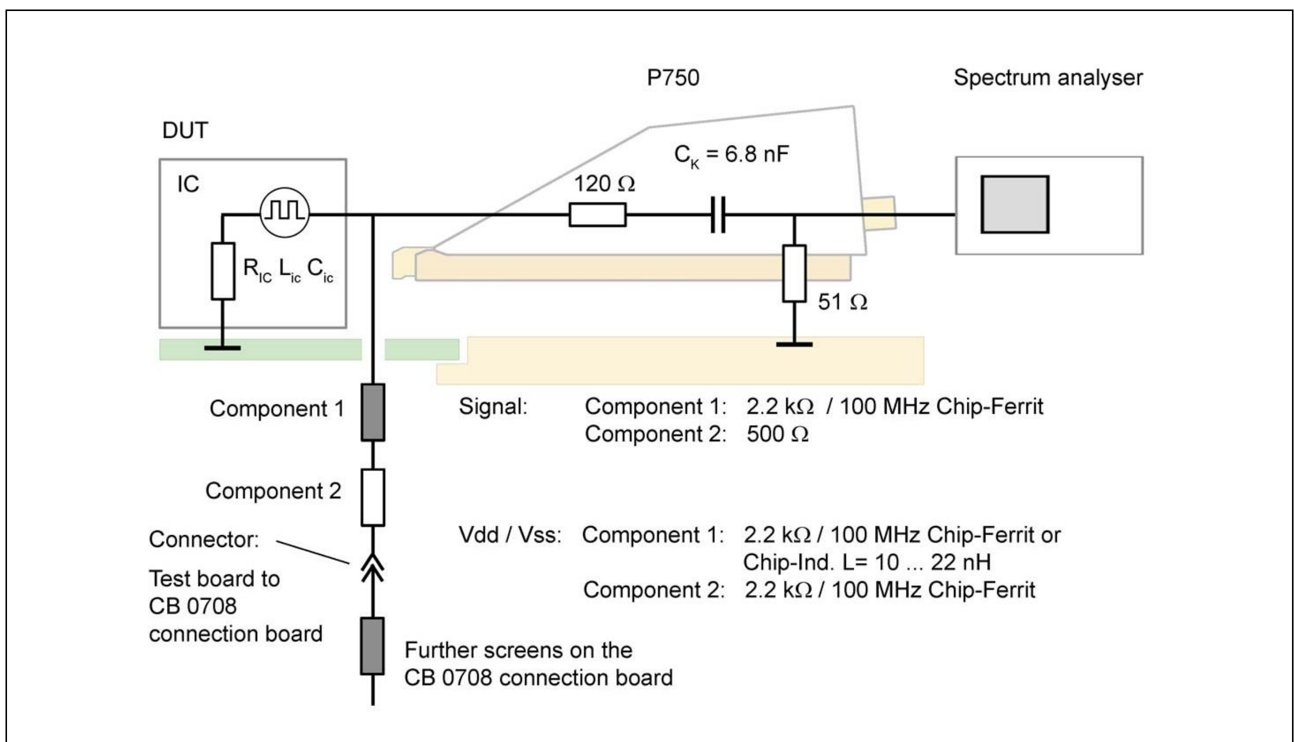

Figure 18 Design of the ***P750*** Vdd / Vss and signal pin filters

Figure 18 shows the design of the Vdd / Vss and signal pin filters which are located on the bottom of the test board. Please refer to the “IC test instructions” for a guideline on how to set up a test board.

[1] mail@langer-emv.de

4 Measurement set-up

4.1 Performing the measurement

Figure 19 shows the measurement set-up to measure conducted emissions from integrated circuits (ICs). The test IC is mounted on the test board. The test board is inserted into the corresponding ground adapter such as ***GNDA 02***[1]. The signal and supply connections to the test IC are established through a plug connector on the test board. The test IC is supplied via the test board and controlled via the connection board. The associated ***Connection Board Control*** software can be used to control and monitor the test IC from a PC.

The ***P603-1*** or ***P750*** probe is placed on the ***GND 25***[2] ground plane with the ***GNDA 02*** ground adapter. The respective pin of the test IC can be contacted with the pin contact by moving the probe manually. The microscope camera (**Figure 19**) optically detects if and when contact is made. The camera's image is displayed on the PC monitor via the ***ChipScan-ESA*** software (**Figure 21**). The video image on the PC monitor enables the user to assess the connection to the respective IC pin. The spectrum analyser displays the RF signal that occurs if and when contact is made. The pins of the test IC can also be contacted automatically if an ***ICT1*** automatic IC tester is available. The ***ICT1*** automatic tester enables automatic measurements.
The AV input of the spectrum analyser is connected to the SMB output of the probe via an SMA-SMB 1 m RF cable.
The ***ChipScan-ESA*** software makes it easy to perform and document the measurements (see also: "ChipScan-ESA operating instructions").

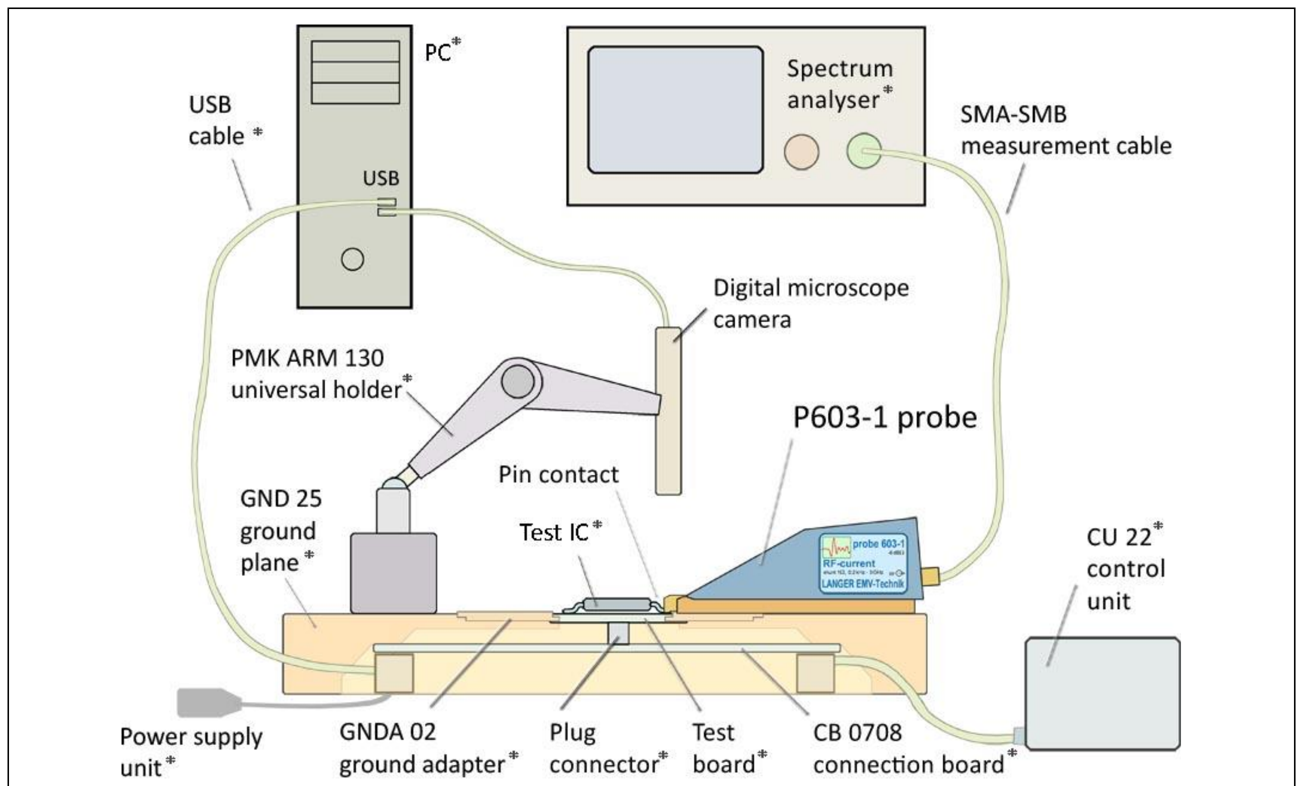

Figure 19 Measurement set-up to measure conducted emissions from integrated circuits (ICs) with the IC test system.

Components marked * are not included in the scope of delivery of the "P603-1 and P750 RF conducted emissions IEC 61967-4" probe set.

[1] The ***GNDA 02*** ground adapter is included in the ***ICE1*** IC test environment. www.langer-emv.de
[2] The ***GND 25*** ground plane is included in the ***ICE1*** IC test environment. www.langer-emv.de

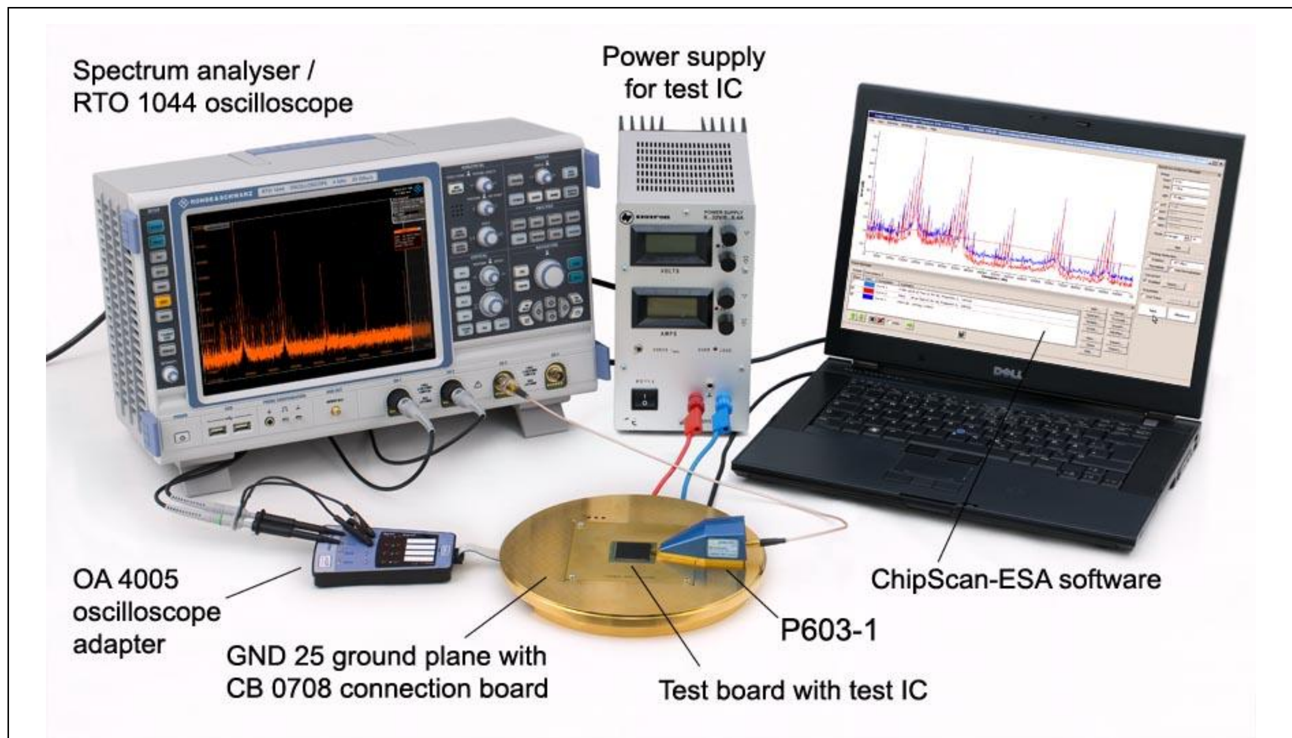

Figure 20 Test set-up with the ***P603-1*** probe set and ***ICE1*** test environment without a control unit and microscope camera.

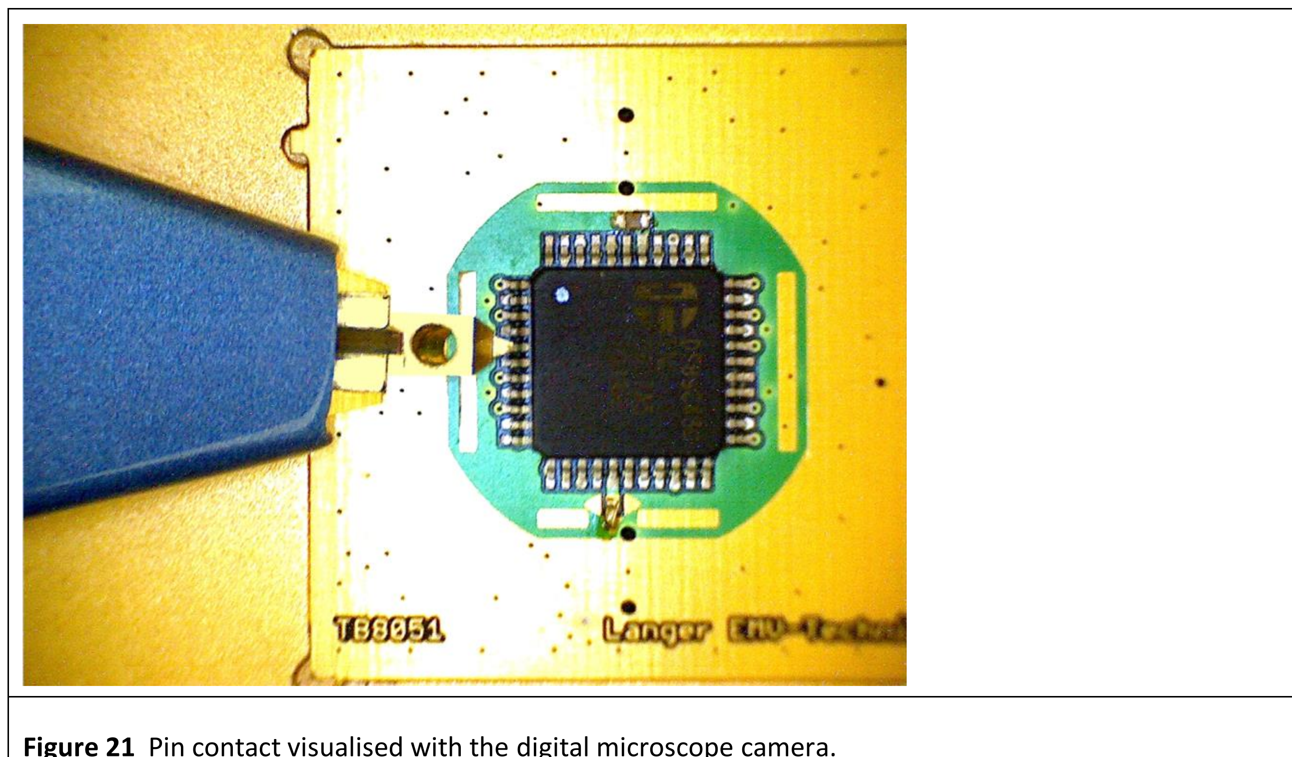

Figure 21 Pin contact visualised with the digital microscope camera.

4.2 Using the ChipScan-ESA software

The spectrum analyser is sought automatically with "Devices/ Devices Manager/ Detected Devices" via the respective interface and connected to the PC (**Figure 23**).

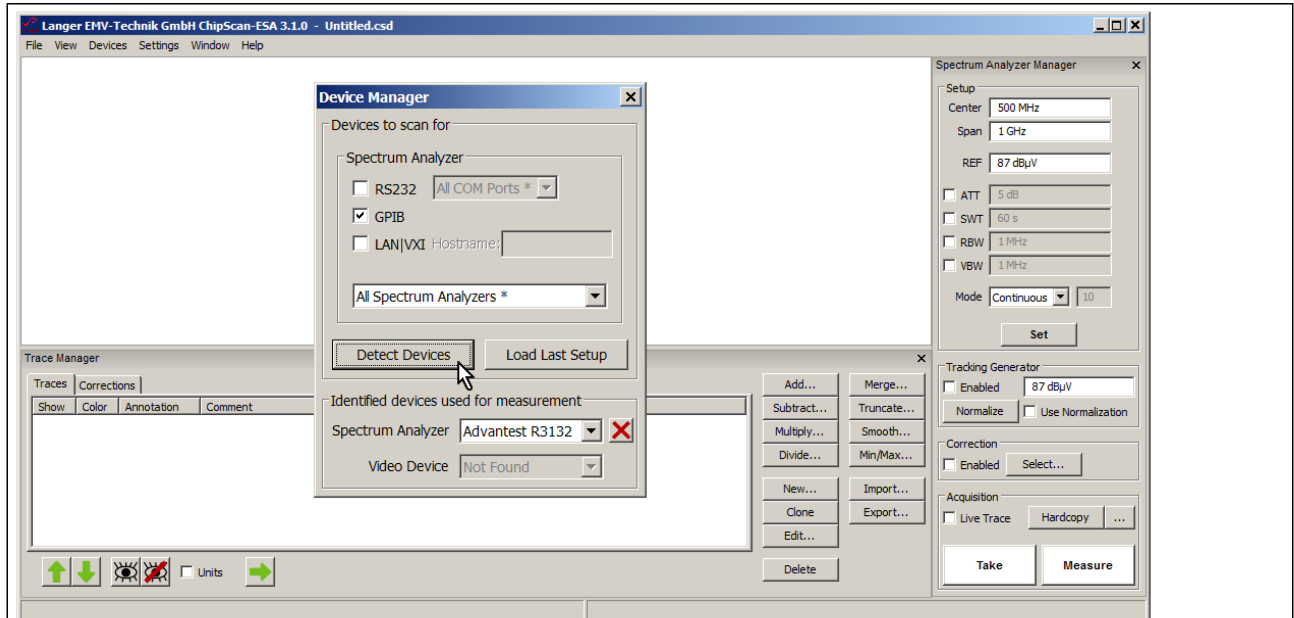

Figure 22 Connecting the spectrum analyser to the PC.

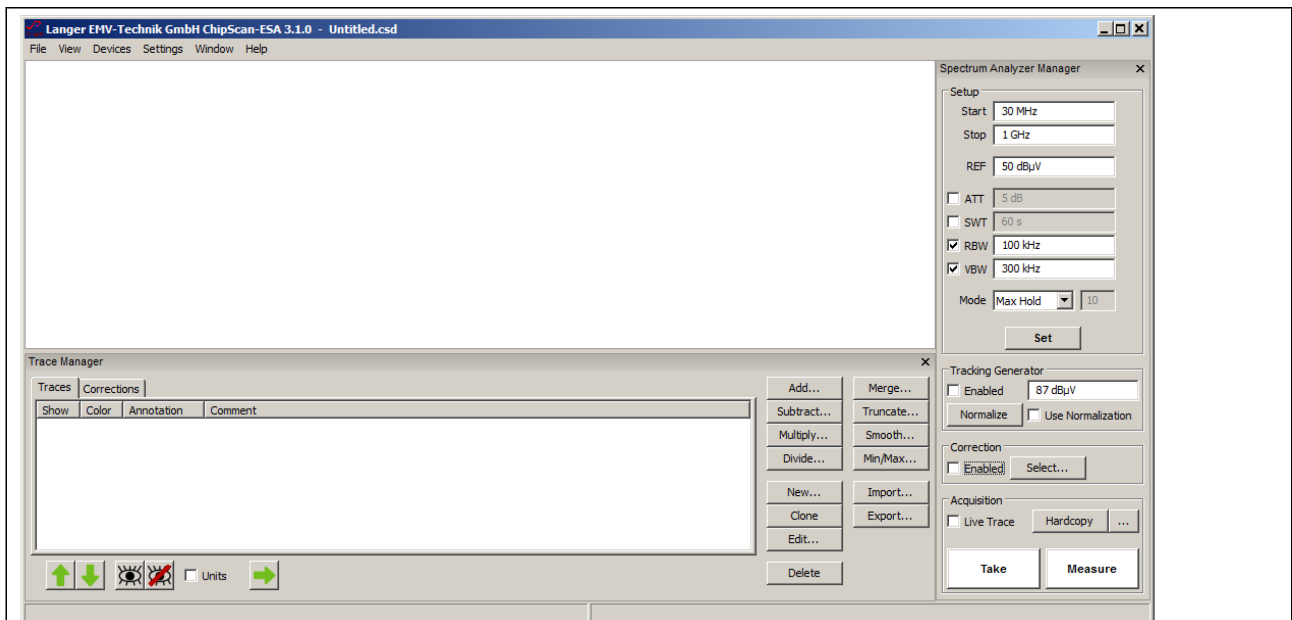

Figure 23 Main settings of the spectrum analyser in the "Spectrum Analyser Manager" (right side).

The main settings of the spectrum analyser have to be defined in the "Spectrum Analyser Manager" (**Figure 23**). The correction curve K603-1 or K750 has to be used to correct the frequency response of $U_{AV}(\omega)$ measured with the ***P603-1*** or ***P750*** probe. $U_{AV}(\omega)$ can be converted to I_{IC} (ω) and $U_{IC}(\omega)$ automatically under "Correction" in the "Spectrum Analyser Manager". The correction curve K603-1 or K750 has to be used for this purpose.

Mathematical functions can also be used (**Figure 24**): division by ω in the time domain, for example. This corresponds to a subtraction of 20 Log ω in the logarithmic form.
You can find the correction curve (- 20 Log ω) in the "Corrections" list of the "Trace Manager".
Click the "Select" button (mouse cursor ① **Figure 24**) under "Correction" in the "Spectrum Analyzer Manager" to select the respective correction curve.

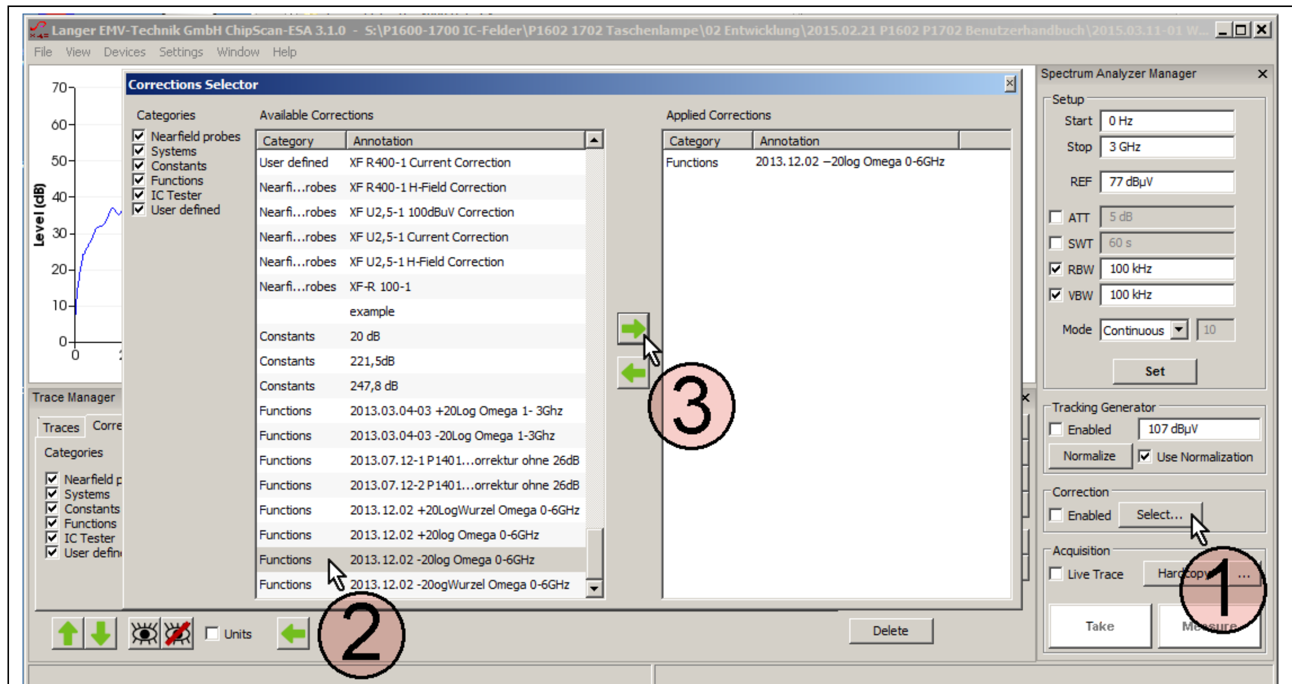

Figure 24 Using mathematical functions by activation in the "Corrections Selector".

The "Corrections Selector" window opens **Figure 24**. Click and activate the correction curve -20 Log ω with the mouse cursor ②. Click the "Arrow right" ③ button to move the correction curve to the "Applied Corrections" list. Other correction factors and correction curves (**Figure 25**) such as K603-1 or K750 can be loaded in the same way or selectively (**Figure 25**).

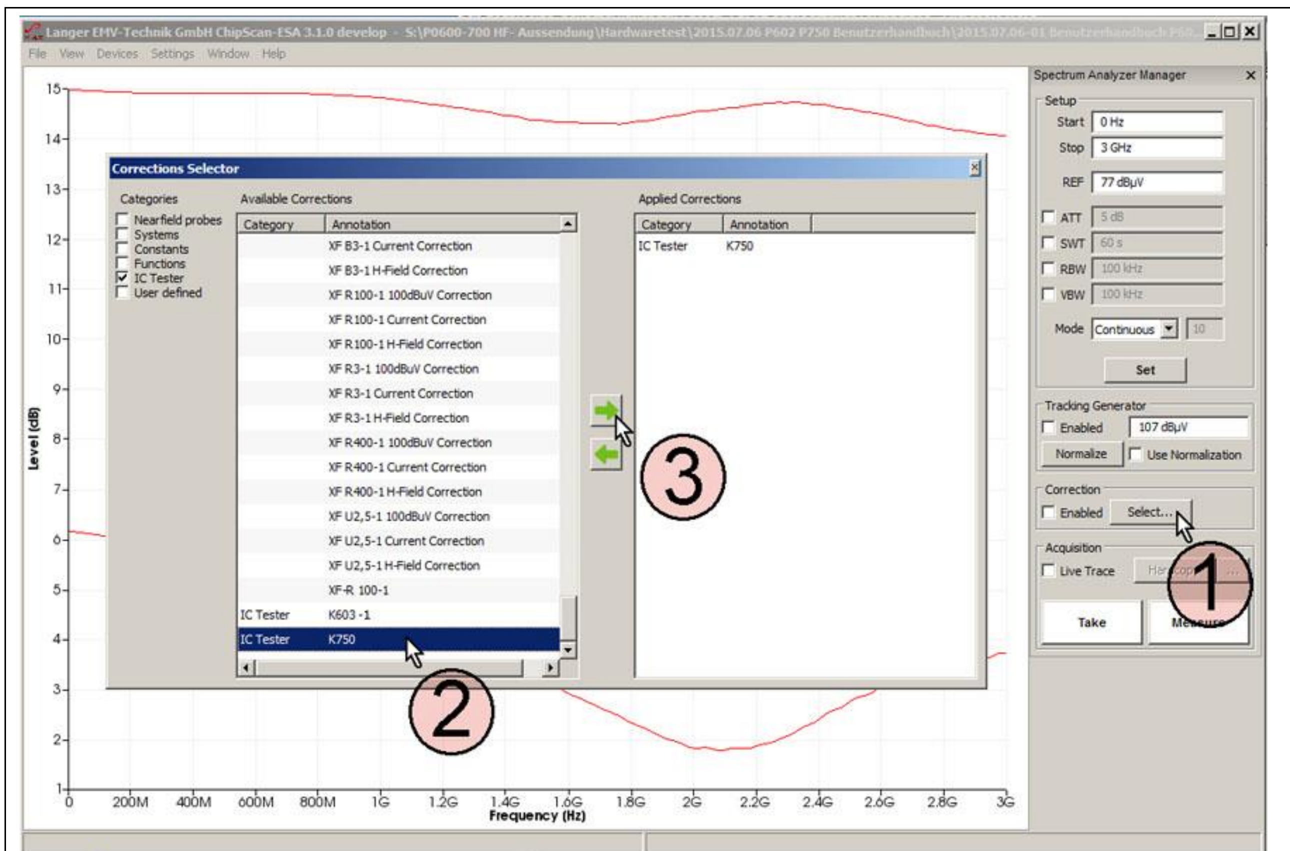

Figure 25 Loading the correction curves K750 to the "Corrections Selector".

The correction curve K603-1 is loaded to the "Corrections Selector" if the ***P603-1*** probe is used for the measurement. Activate the "Enabled" box in the "Correction" field in the "Spectrum Analyzer Manager" with the mouse cursor ① (**Figure 26**). The field ② flashes if the correction is active **Figure 26**. Click "Take" or "Measure" (mouse cursor ③ **Figure 26)** to transfer the current measurement curve ④ $I_{IC}(\omega)$ from the spectrum analyzer to the PC. The calculation: $I_{IC}(\omega) = U_{AV}(\omega)$ +K603-1 is automatically performed at the same time. The curve $I_{IC}(\omega)$ is added to the bottom of the "Traces" list in the "Trace Manager". A measurement log can be kept in the free text field under "Comment".
Delete the check mark from the "Enabled" box if you only want to measure $U_{AV}(\omega)$; the field ② then stops flashing.

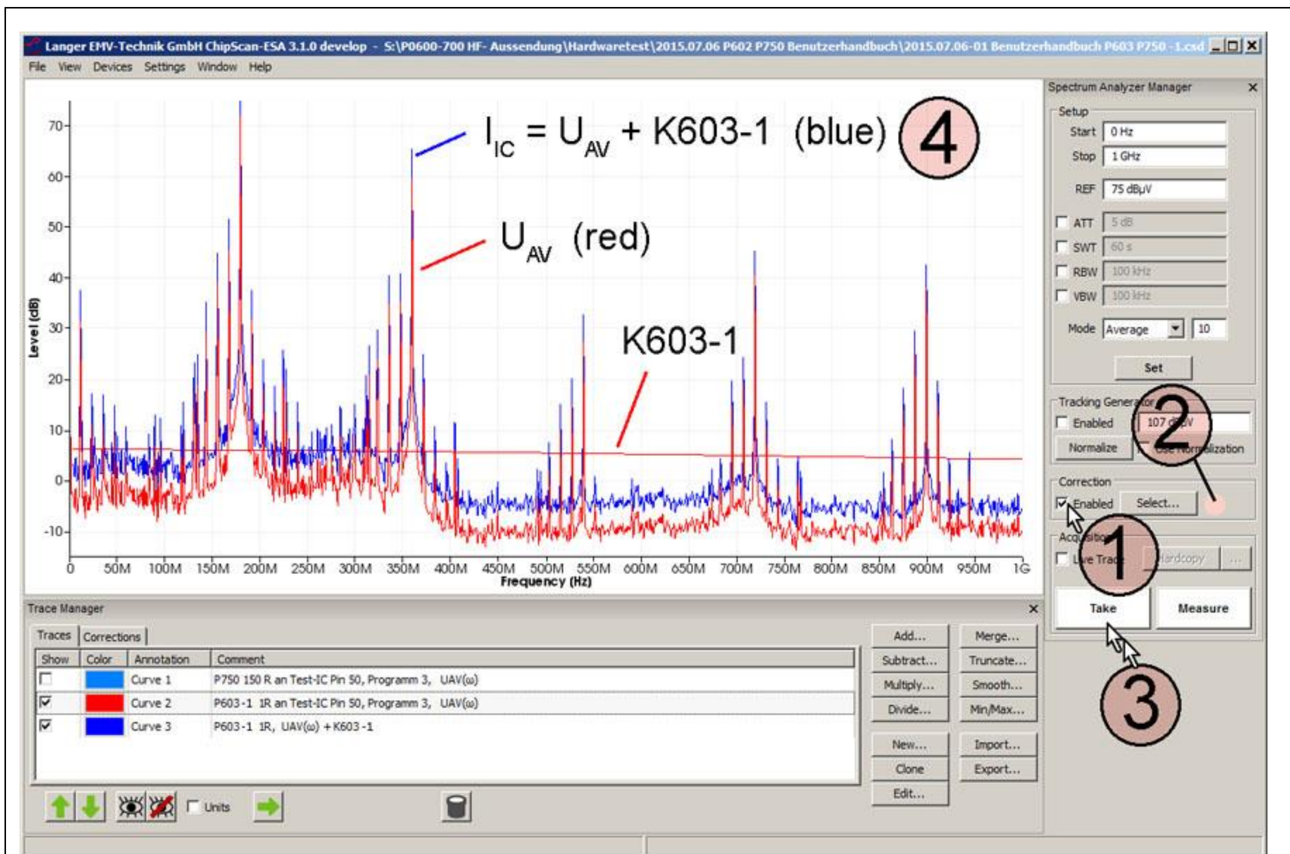

Figure 26 Measurement with the ***P603-1*** RF current probe head using the correction curve K603-1.

The "Curve" number is counted automatically (Curve 3) under "Annotation". The measurement log can be kept in the respective free text field under "Comment".

The correction can also be made later on if the measurement has been carried out using the ***P750*** probe without any correction. The correction curve $U_{IC}(\omega) = U_{AV}(\omega)$ +K750 has then to be added.

You can find the correction curve K750 in the "Corrections" list of the "Trace Manager".
Click the "Select" button (mouse cursor ① **Figure 27**) under "Correction" in the "Spectrum Analyzer Manager" to select the respective correction curve.

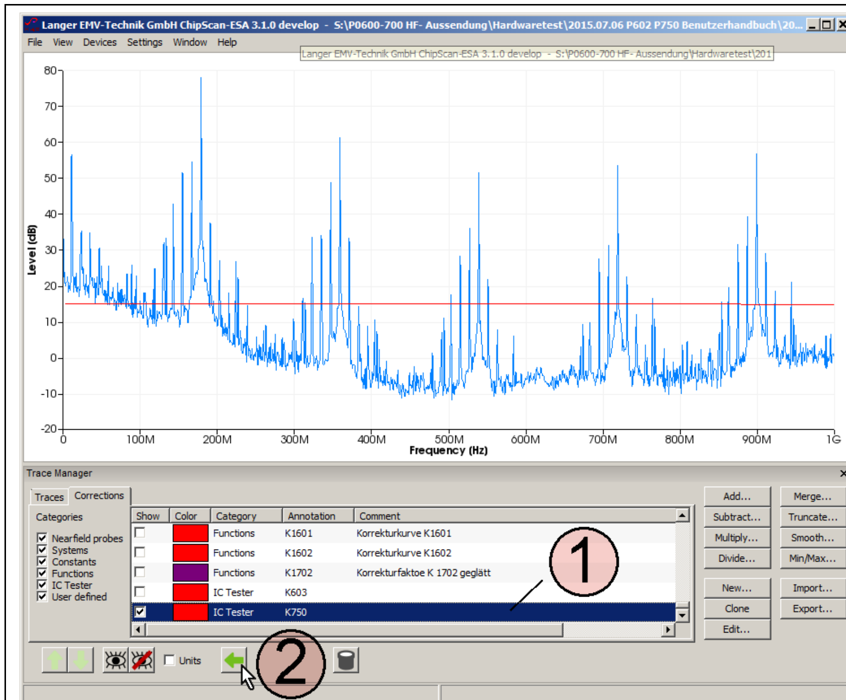

Figure 27 Correction after the measurement; copying K750 from the "Corrections" list to the "Traces" list

Mark the "Curve 1" (U_{AV}) curve and the "K750" curve in the "Traces" list **Figure 28** in the "Trace Manager" with the mouse cursor ①**.** Open the mathematical operation "Add…" (addition) and activate "Sum up all Plots" (**Figure 28** mouse cursor ③). Click OK ④ to perform the addition U_{AV} + K750.

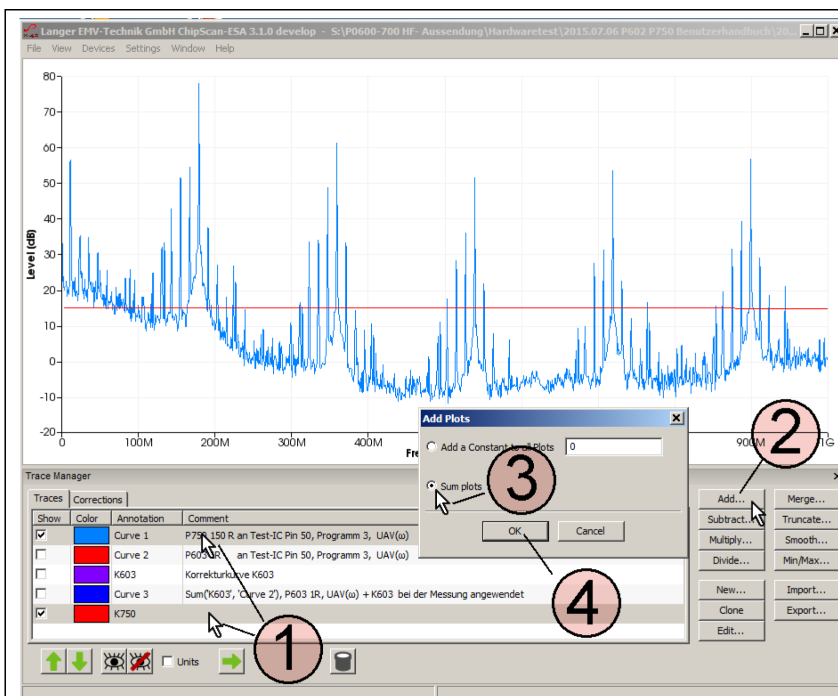

Figure 28 Correction after the measurement; performing the addition U_{IC} = U_{AV} + K750

The calculation creates the entry (① **Figure 29**) at the bottom of the "Traces" list and is displayed as "Curve 5" (② **Figure 29**).

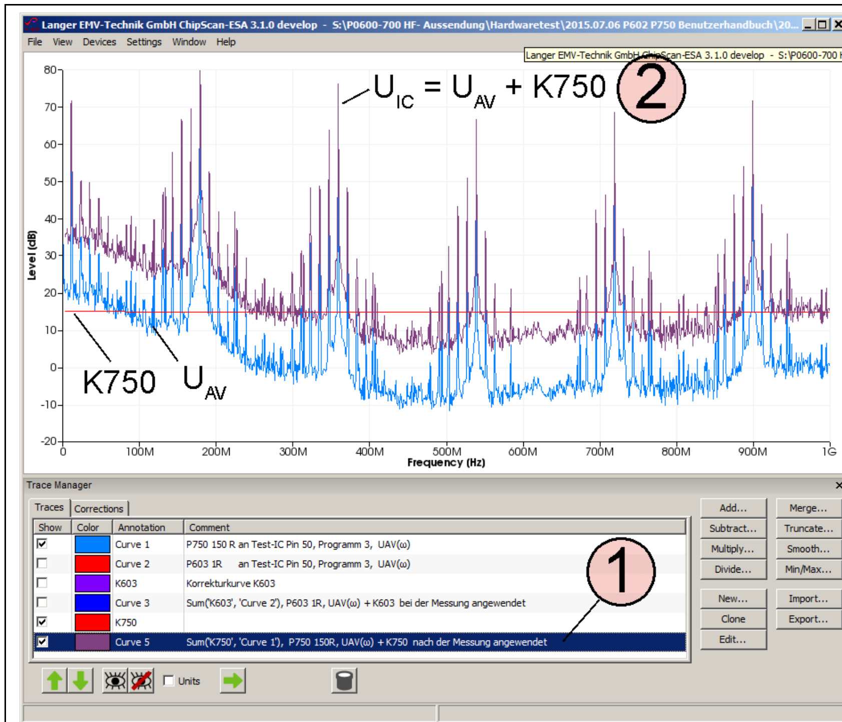

Figure 29 Correction after the measurement; result of the addition $U_{IC} = U_{AV} + K750$

The user manuals for the respective devices are listed in the following table:

Task	**Operating instructions**
• Instructions for the development of the adapter board • Test process	IC test guideline (Langer EMV-Technik GmbH)
• GND 25 ground plane • CB 0708 connection board • OA 4005 oscilloscope adapter • TH 22 probe head holder • Monitoring and controlling the test IC	ICE1 user manual
Table 1	

5 Safety instructions

This product complies with the requirements of the following European Community Directives: 2014/30/EU (Electromagnetic Compatibility) and 2014/35/EU (Low Voltage)

When using the LANGER EMV-Technik GmbH product please observe the following basic safety instructions to protect yourself against electric shock and the risk of injury:

- Read and comply with the operating manual and keep the it in a safe place for subsequent use.
- Only personnel who are qualified in the field of EMC and fit for working under the influence of disturbance voltages and magnetic as well as electric fields may use the device.
- Follow the safety instructions and warnings on the unit.
- Always perform a visual check of the LANGER EMV-Technik GmbH product before use.
- Do not leave the LANGER EMV-Technik GmbH product unsupervised.
- Read the explanation of the symbols on the unit in the operating manual.
- The LANGER EMV-Technik GmbH product is only in use in applications it has been designed for. Any other use is not permitted.
- Do not switch the LANGER EMV-Technik GmbH product on until it has been completely assembled.
- Damaged connection cables must be replaced!

Attention: Function-related near fields and disturbance emissions may develop, particularly in connection with a test set-up while operating the product of the LANGER EMV-Technik GmbH. The user is responsible for measures to ensure that the intended use of products which are installed outside the companys EMC environment is not adversely effected (particularly by disturbance emission).

6 Warranty

Langer EMV-Technik GmbH will remedy any fault due to defective material or defective manufacture, either by repair or by delivery of replacement, during the statutory warranty period.

This warranty is only granted on condition that:
- the information and instructions in the user manual have been observed.

The warranty will be forfeited if:
- an unauthorized repair is performed on the product,
- the product is modified,
- the product is not used according to its intended purpose.

7 Technical specifications

7.1 P603-1 probe

Shunt	1 Ω
Transfer factor V_{out} / V_{in}	-6 dB
Current correction factor R	-6 dBΩ
Max. power dissipation shunt	2.5 W
Inductance of RF input	1 nH
RF measuring output	50 Ω (SMB)
Frequency range	0.2 kHz – 3 GHz

Characteristics of the probe P603-1

Figure 30

P603-1 characteristic

7.2 P750 probe

Transfer factor V_{out} / V_{in}	-15.2 dB
Frequency range	150 kHz to 3 GHz
Input resistance	150 Ω
Max. input voltage for RF	3.5 V
Max. input voltage for DC	50 V
RF measuring output	50 Ω (SMB)

Characteristics of the probe P750

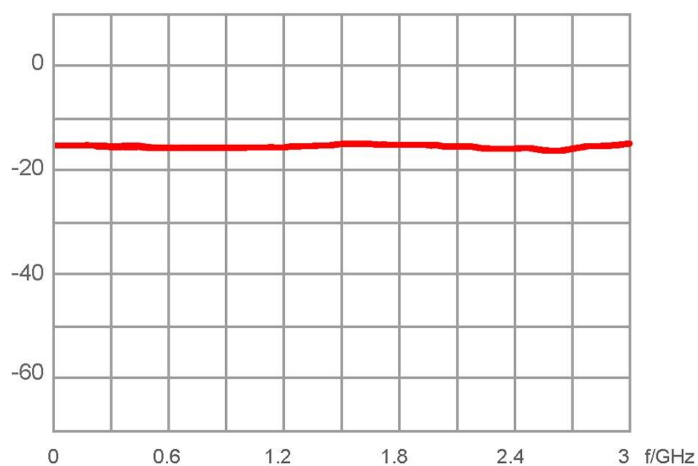

Figure 31

P750 characteristic

8 Scope of delivery

Item	Designation	Type	Quantity
01	RF current probe 1 ohm	***P603-1***	1
02	RF voltage probe 150 ohm	***P750***	1
03	Measurement cable	***SMA-SMB 1 m***	1
04	ChipScan-ESA software	***CS-ESA***	1
05	User manual		1
06	Case insert/Quick guide		1
07	System case		1

Conducted measurement according to IEC 61967-4

This document may not be copied, reproduced or electronically processed, either in its entirety or in part, without the prior written permission of Langer EMV-Technik GmbH. The management of Langer EMV-Technik GmbH assumes no liability for damage that may arise from using this printed information.