

**LANGER**  
EMV-TECHNIK

## Operating Instructions

# Development System - Disturbance Emission ESA1



Measuring disturbances emitted by a module –  
comparative measurements at the developer's workplace

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# 1 Measurement procedure

The ESA1 is suitable for carrying out comparative measurements of disturbances emitted by modules directly at the developer's workplace. Since the effect of any changes to the module becomes evident immediately, the time needed to optimise the unit under test can be dramatically reduced.

Measuring with the ESA1 development system is based on the following considerations:

In most cases, it is not a component or conductor track of a unit under test that directly emits any disturbances, rather the entire metal system of the unit under test is excited through electric or magnetic coupling (i.e. in the near field). This metal system comprises the PCB itself and all connected cables and metal parts such as housings, shielding plates etc. in its immediate vicinity. The system in its entirety acts as an antenna and a source of emission. This excitation is roughly equivalent to the disturbances emitted by the unit under test. To determine this excitation, measure the exciting currents that flow, for instance, from a PCB to any cables connected.

The measurements are performed with a conductive base plate to reduce any influences of the measurement set-up, cable positions and local fields. Inject all exciting currents through short capacitive coupling into the base plate so that you have a small reproducible set-up (Figure 1).

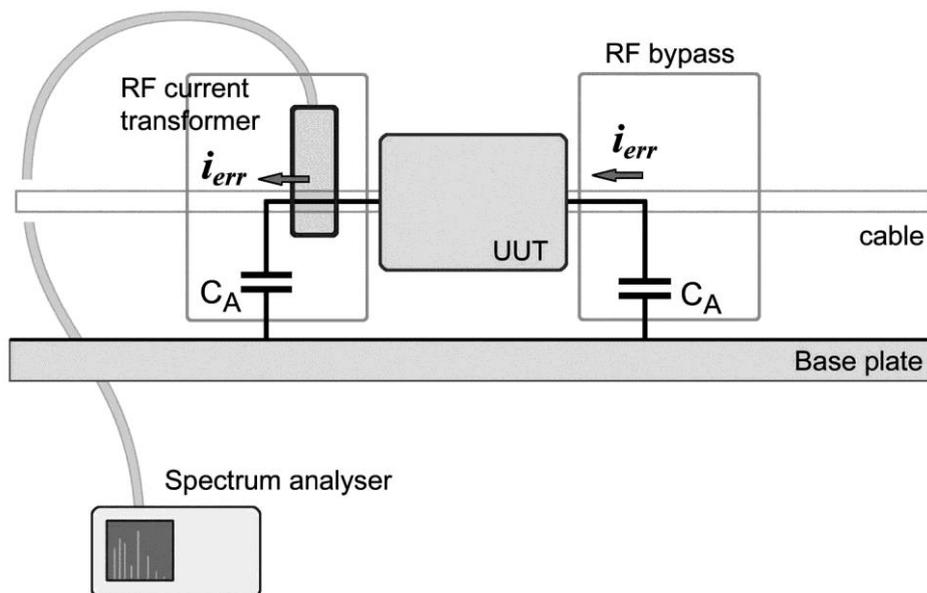


Figure 1

# 2 Description of the components

## 2.1 GP 23 base plate

The GP 23 metal base plate is the reference plate for the measurement set-up. It contains the connectors to supplying the unit under test and preamplifier as well as the output of the latter. (Figure 2).



Figure 2

The nickel-plated surface ensures a steady and reliable conductive connection to the HFW 21 RF current transformer or HFA 21 RF bypass. Figure 3 shows the connections. These are:

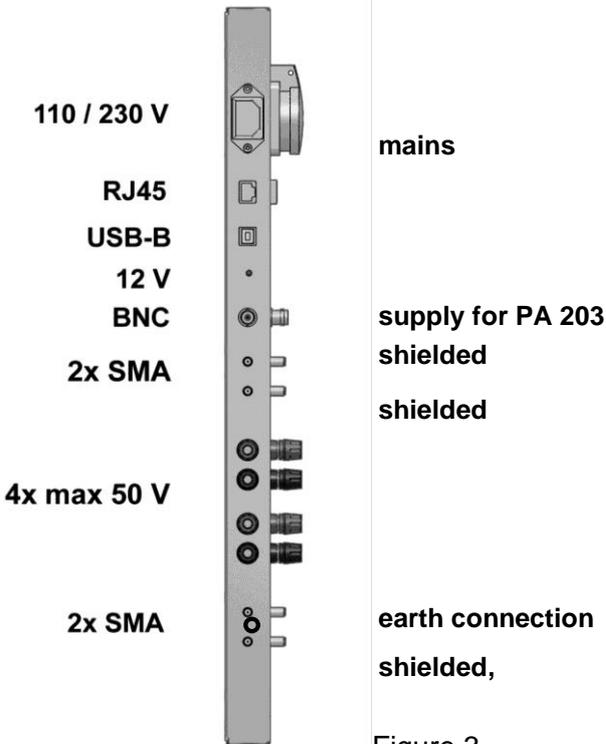


Figure 3

The unit under test and the base plate can be connected at any point via the HFA 21 RF bypass or with copper foil adhesive tape, for instance.

## 2.2 Z23 shielding tent

The shielding tent has been designed to shield the measurement set-up against external RF fields. In case of problems in the VHF range or particularly high demands on the unit under test as in the automobile industry, for instance, a conductive housing has to be used as a shield against ambient disturbance fields. Shielding in the immediate vicinity of the unit under test is possible because all cables to the unit under test are disconnected, coupled to the base plate through capacitive coupling or filtered in a typical ESA1 measurement set-up.

The tent poles are folded upon delivery for ease of transport. Two rubber plugs snap into place in the two rear openings of the base plate to secure the tent against displacement (Figure 4).



Figure 4

To put up the shielding tent, unfold the poles and insert them into the two rear openings of the base plate (Figure 5).



Figure 5

Then pull the Z23 shielding tent over the poles from the back. Flexible magnetic strips are attached to the edges of the shielding tent. Press them against the edges of the base plate to ensure a conductive connection. Two magnetic strips are provided for the connector area: one is fixed to the base plate from the outside, the other one from the top. The front of the shielding tent can be opened and closed separately to ensure quick alternation between measuring and modifying (Figure 6 to Figure 8).



Figure 6

After closing, press the front to the lower edge of the base plate and laterally to the side parts . An uninterrupted connection between the base plate and tent is crucial for an effective shielding.



Figure 7

If the tent is erected as shown in Figure 7, you can see two loops at the upper front edge of the tent. Secure these around the front transverse bar.



Figure 8

You can tilt the whole tent backward for ease of accessibility. The loops stop the tent from sliding down. (Figure 8).

**Attention!** The shielding tent is made from a thin, extremely conductive fabric. Protect the tent against high mechanical stress from sharp-edged or pointed objects, for example! Fold the tent in accordance with the folding instructions contained in the bag!

## 2.3 HFW 21 RF current transformer

The RF current transformer (Figure 9 and Figure 10) measures high-frequency currents of up to 1 GHz on lines and diverts these currents to the base plate.

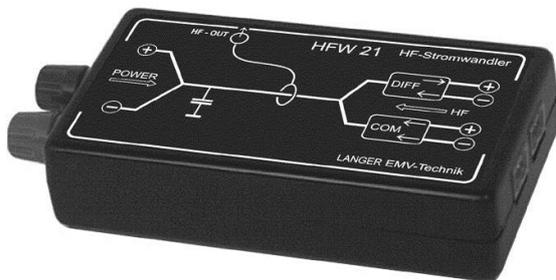


Figure 9

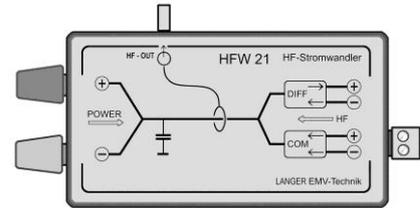


Figure 10

The RF current transformer enables separate measurements of RF common-mode and differential-mode currents. In practice, you can do this by connecting the RF current transformer into the power supply circuit of the unit under test, for example. The supply voltage is connected to the "POWER" socket connector of the current transformer via laboratory cable with a 4 mm plug and the unit under test is connected to the "COM" or "DIFF" output via one of the supplied plugs. The RF currents emitted by the unit under test are thus passed through the transformer, measured (output above the 50 Ohm SMB socket) and diverted to the metal transformer base plate through capacitive coupling.

If the unit under test is connected via the "COM" output, the RF current transformer measures the common-mode currents flowing on both lines whereas the differential-mode currents are measured via the "DIFF" output.

The RF output voltage is independent of the direct current flowing through the transformer if common-mode measurements are carried out. In case of differential-mode measurements, the RF output voltage decreases according to the diagrams shown in section 6.

### **Please note:**

A current surge occurs on switching on depending on how the unit under test is connected. If the electrolytic capacitors, for example, are charged without limiting the current and the unit under test is connected via the HFW 21 differential-mode output, there is a risk of damage to the preamplifier or spectrum analyser input!

Always connect the HFW 21 to the PA 203 or spectrum analyser after the unit under test has been switched on in such cases!

The same thing occurs during a short-circuit in the unit under test if the electrolytic capacitors of the external power supply unit are abruptly discharged. There is no risk if the HFW 21 is operated via the common-mode output because these current pulses are compensated within the transformer.

Current peaks also occur if the supply of the unit under test is connected to earth and thus to the base plate with an external power supply unit and the voltage in the unit under test is short-circuited to the GP 23 base plate during the measurement:

## 2.4 HFA 21 RF bypass

The RF bypass (Figure 11) supplements the RF current transformer by providing another capacitive or conductive connection from the unit under test to the base plate if necessary.



Figure 11

It is mainly used to simulate the data lines connected in normal operation and their capacitance relative to the surroundings. Instead of the data line, a discrete capacitance is connected to the signal output via a measuring line within the HFA 21 (Figure 12). Alternative it is possible to connect each single signal step by step to the capacitance by a Probe tip (Figure 13). Defined RF currents can thus be diverted to the base plate. The HFA 21 contains capacitances from 10 pF to 100 nF.

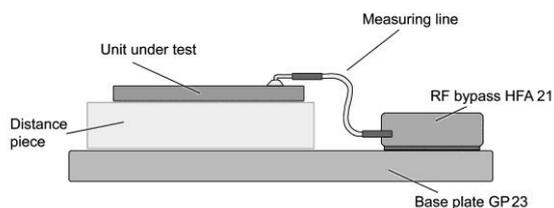


Figure 12

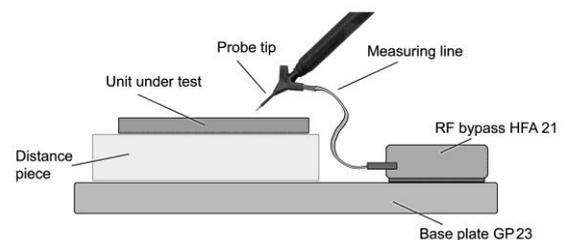


Figure 13

## 2.5 Near field probes

Your ESA1 provides various near field probes for measuring high-frequency magnetic and electric fields depending on its version. The probes are connected to the preamplifier instead of the HFW 21 and enable measurements in the area of the module, on tracks and components. The aim is to find the RF field sources on the module in the unit under test and to detect and understand the respective emission mechanisms. The developer can assess whether there are any RF fields that interfere with neighbouring modules, structural parts or shields and cause disturbance emissions. In practical measurements the HFW 21 current transformer and the near field probes are mostly used alternatively.

A wide range of probes is provided for the various measuring tasks:

The near field probes of the RF type are suitable for measurements to magnetic and electrical fields in the frequency range between 30 MHz and 3 GHz. The probes differ with regard to the probe head's size and design so that you can always select the optimum probe for different measuring jobs. Please refer to the enclosed 6. Technical specification for details about the precise pattern of the field measured by the probe and typical examples for application.

#### **Optional to ESA1:**

The near field probes of the LF type are available for measurements in the frequency range between 100 kHz and 50 MHz. They are particularly suitable in the areas of power supply, converters, drives etc. The RF current paths of individual switching transistors and free-wheeling diodes can be tracked and the respective magnetic fields measured, for example.

## **2.6 PA 203 preamplifier**

The 20 dB preamplifier (Figure 14) operates in the frequency range between 100 kHz and 1 GHz and is suitable for measurements with the RF current transformer and near field probes. The input and output are designed as 50 Ohm BNC plug-and-socket connectors and can thus be operated with any spectrum analyser or oscillograph.



Figure 14

The preamplifier is operated inside the shielding tent during measurements with the ESA1 system (Figure 15). Filters are provided in the GP 23 base plate for the preamplifier's output line and power supply. The output signal reaches the spectrum analyser via the enclosed double-shielded BNC cable. Please use the enclosed plug-in power supply unit to supply power to the preamplifier. Saturation effects will occur if the input level at the preamplifier exceeds 60 dB $\mu$ V. In such a case, the HFW 21 RF current transformer or the near field probe should be directly connected to the BNC socket connector on the base plate without any preamplifier.

#### **Please note:**

There is a risk of destruction during HFW 21 operation when the differential-mode current is measured and electrolytic capacitors are switched on or a short-circuit occurs!

Always connect the HFW 21 to the PA 203 or spectrum analyser only after switching on the unit under test in such cases!

## 2.7 Measurement set-up

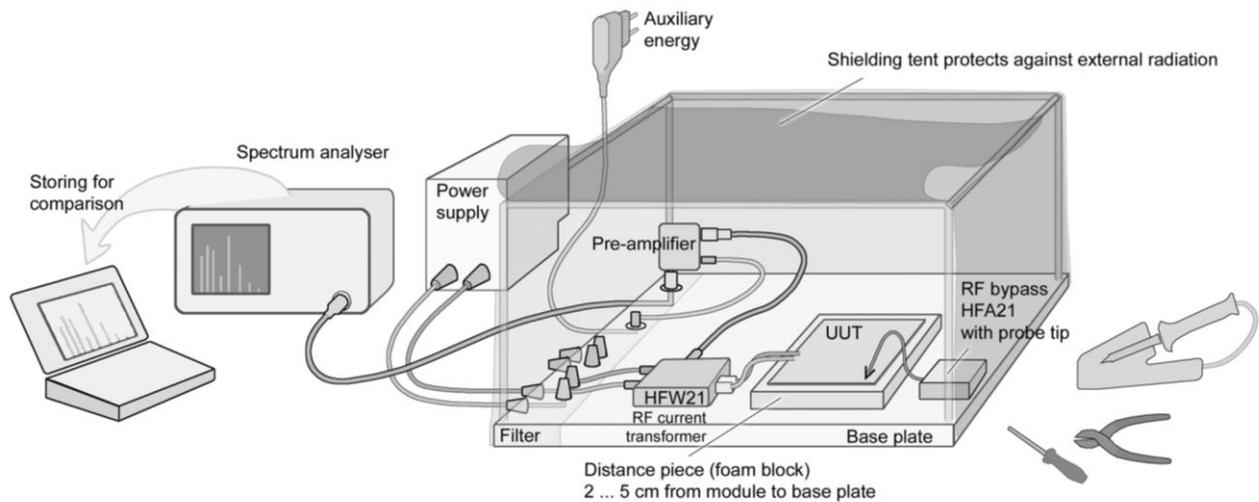


Figure 15

First install the GP 23 base plate with its socket connectors pointing to the left under normal conditions and the shielding tent (description in section 2.2).

Plug the PA 203 preamplifier into the BNC socket on the base plate. Power is supplied via the enclosed plug-in power supply unit; thus plug this unit into the base plate immediately beside the BNC socket from outside. Connect the 12 V input of the PA 203 to the socket connector on the base plate via the enclosed power supply cable (approx. 10 cm long, two power supply plugs) inside the shielding tent. The "ON" LED on the PA 203 must come on. Then connect the HFW 21 RF current transformer or a near field probe via the BNC-SMB connecting cable.

Connect the spectrum analyser to the base plate via the enclosed BNC cable (double-shielded).

## 3 Practical procedure

### 3.1 Measuring with ESA1

The measurements carried out with the ESA1 are relative measurements. It is thus important to define a measurement set-up and document the initial state first.

Measuring results from previous measurements under standard conditions provide crucial information on critical frequency ranges and the extent of necessary improvements. First analyse the measurement set-up required for these measurements:

- How have the PCBs been installed in the unit under test?
- Which connected cables are possible decoupling paths?
- Where are these cables located inside and outside the unit under test (e.g. cable harness in the car in the immediate vicinity of a large metal surface)?
- Which metal parts such as housing, shielding, stud bolts, water pipes etc. are in the immediate vicinity (capacitive coupling)?

These considerations help determine modules and parts of modules as potential RF sources and find the paths by which the high-frequency currents are possibly emitted. This information allows you to design a measurement set-up so that the decisive emitted currents can be measured.

To confirm the measurement set-up, compare your measurement results with the results obtained in far field measurements. There will be deviations of course. However, it is crucial in this comparison to find critical frequencies from far field measurements with the chosen measurement set-up and thus to prove the existence of the suspected sources and associated decoupling paths.

## 3.2 ChipScan-ESA software

ChipScan-ESA is a universal tool in the development of electronic modules which allows the developer to manage the disturbance emission data measured with a spectrum analyser.

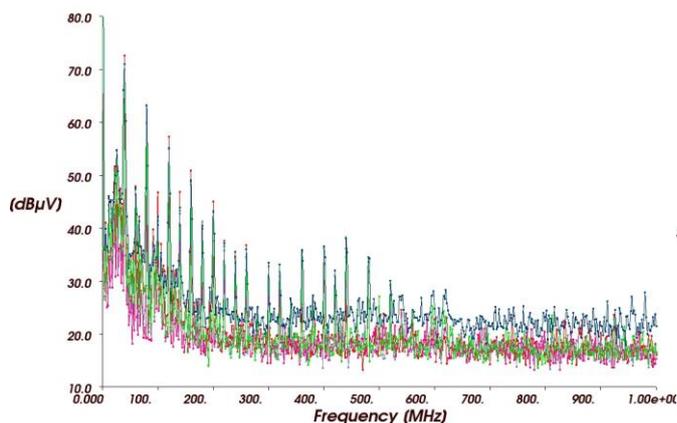
The software enables:

- a quick and easy configuration of spectrum analysers
- the logging of measured data for a quick comparison and for documentation
- the linear / logarithmic plotting of measured data in 2D/3D diagrams
- the storage of measured data for subsequent evaluation and comparison with further measured data if necessary
- the export of measured data as an image for publication, documentation, etc.
- the export of measured data as a .csv file for further processing in Excel, Matlab, Origin, R, etc.

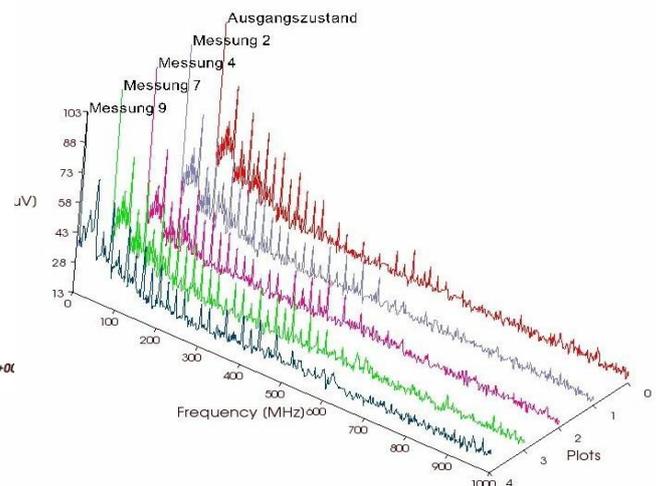
The software's characteristics are described in detail below:

### Easy and flexible portrayal of the measured data

All measured data can be displayed in both a 2D and 3D diagram.



2D diagram



3Ddiagram

It does not matter if the measured data were recorded in different frequency ranges. Individual measurement curves can be shown or hidden and each curve can be assigned a certain colour or description to provide more clarity. Furthermore, gridlines allow the developer to compare measurement curves very precisely in the linear or logarithmic 2D diagram.

	Enable	- P <sub>c</sub>	- P <sub>c</sub>	- P <sub>c</sub>	g Pro	Colour	Anotation
1	<input type="checkbox"/>	000	1000	1000	10000	Red	Ausgangszustand
2	<input type="checkbox"/>	000	1000	1000	10000	Green	Messung 1
3	<input checked="" type="checkbox"/>	000	1000	1000	10000	Blue	Messung 2
4	<input type="checkbox"/>	000	1000	1000	10000	Black	Messung 3
5	<input checked="" type="checkbox"/>	000	1000	1000	10000	Magenta	Messung 4
6	<input type="checkbox"/>	000	1000	1000	10000	Green	Messung 5
7	<input checked="" type="checkbox"/>	000	1000	1000	10000	Red	Messung 8
8	<input checked="" type="checkbox"/>	000	1000	1000	10000	Purple	Messung 6
9	<input checked="" type="checkbox"/>	000	1000	1000	10000	Green	Messung 7
10	<input checked="" type="checkbox"/>	000	1000	1000	10000	Dark Blue	Messung 9

### Storage and export of measured data

Any amount of measured data can be stored in a file. This file can be reloaded from ChipScan-ESA at any time as required. The data can be recorded first and evaluated later. In addition, new measurements can be compared with older ones.

Any number of measurement plots can be exported optionally as an image or a .csv file to edit the measured data for publication or documentation. The .csv export allows the developer to process the measured data using statistical software such as Excel, Matlab, Origin and R.

### Fast and easy handling of spectrum analysers / frequency generators

All important device settings can be conveniently carried out with the ChipScan-ESA software and all supported spectrum analysers can be controlled via a uniform operator interface.

In addition, the device settings can also be stored in configuration files and reloaded. This prevents any operating errors which may occur in measurement logs.

ChipScan-ESA automatically recognises all (footnote: list of supported devices) measuring instruments connected to the PC irrespective of the interface used (RS232, GPIB, VXI) even if several measuring instruments are connected simultaneously. The recognized devices can also be stored in configuration files and reloaded.

### 3.3 Localisation through global changes to the unit under test

The unit under test often allows you to locate the emission sources by changing the measurement set-up. These include

a) geometrical changes

- Changing the distance between the unit under test and base plate
- Use sheet steel to simulate neighbouring modules or housings
- Plugging in and removing cables, changing the cable length and position
- Eliminating individual RF sources by disconnecting individual modules, partial shielding or by using ferrite magnets

b) Changes to the operating procedure

- Using another software or program or program section
- Observing the spectrum when the program is running up
- Switching off individual sections of the unit under test
- Operating the unit under test under permanent reset conditions – only the clock line is maintained

### 3.4 Reason analysis with near field probes

Carry out near field measurements to exactly determine the RF sources that emit disturbances. The aim is to correlate the currents measured with the RF current transformer to the RF fields on the module. You should proceed as shown in Figure 16:

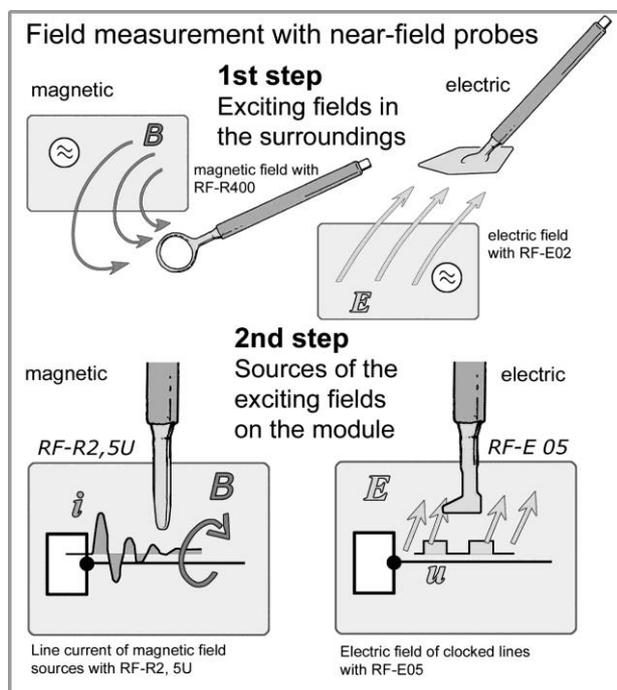


Figure 16

Begin by determining the magnetic and electric fields in the vicinity of the modules. These fields incite the whole metal system of the unit under test to oscillate (exciting fields) and must finally be reduced. You should use near field probes with a bigger probe head, i.e. the probe RF-R 400-1 for magnetic and the probe RF-E 02 for electric fields.

These measurements give you an idea of the respective disturbance emission mechanism.

As a next step, locate the sources of these exciting fields. The probes with smaller probe heads such as the RF-R 3-2 magnetic field probe are particularly suitable for this job.

In each measurement you determine

- the field strength at a certain frequency or within a certain frequency range and
- the direction of the magnetic lines of force by rotating the magnetic field probe in magnetic field measurements.

The following fields should be considered as potential RF sources:

- electric fields above any components such as processors
- electric fields on switched lines and bus systems
- magnetic fields on switched data and clock lines
- magnetic fields on power supply lines

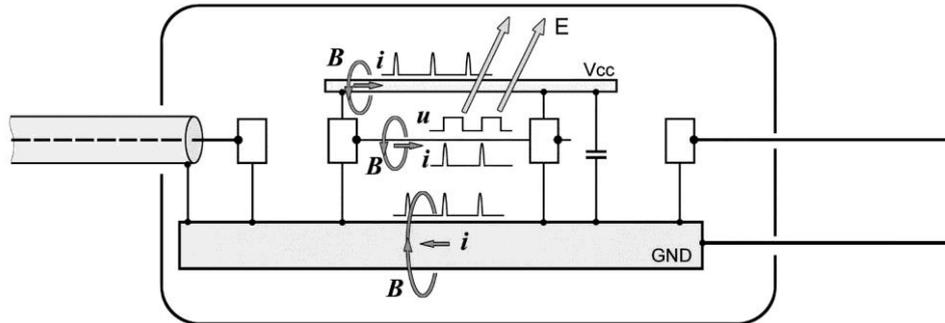


Figure 17

### 3.5 Modification of the module

There are various starting points for modifying a module:

- The module's geometry with regard to
  - plug-and socket connectors and cable connections
  - the layout
  - the surrounding metal system
- Changing the circuitry
  - inserting damping resistors, filters
  - changing the operating procedure

The RF sources have to be modified so that the field strength is reduced (damping) or the lines of force are kept in the immediate vicinity of the source and do not exit the module.

Having detected the potential disturbing fields on the module, you will automatically have ideas and possibilities on how to reduce these fields. Potential modifications are:

- Confining the magnetic fields through metal surfaces
- Shielding electric fields through GND areas
- Inserting damping resistors in signal lines

Perform another measurement with the HFW 21 to check the effect of the implemented modifications. Evaluate the modification, take other measures if necessary and only carry out a further acceptance measurement if there is a decisive improvement in the module.

## 4 Measurement set-up variants

### 4.1 Measurement of the common-mode component

#### 4.1.1 Unit under test with one cable terminal

If only one cable, e.g. the power supply cable, is connected to the unit under test, its leads are filtered first through the GP 23 base plate and then through the HFW 21 (Input: Power and output COM). The RF current flows through the parasitic capacitance between the unit under test and base plate to the base plate and back to the unit under test through the HFW 21 via the power supply cables (Figure 18 and Figure 19).

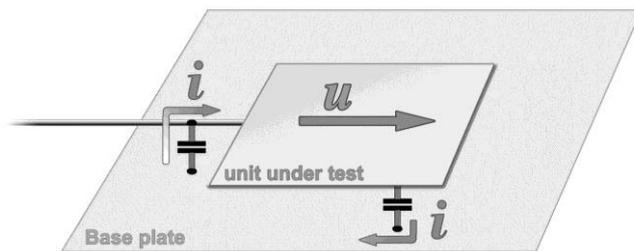


Figure 18

The distance between the unit under test and the base plate influences the magnitude of the RF current:

- If the unit under test is operated in an open space (computer mouse on a wooden table), choose a large distance between the unit under test and base plate (> 5 cm).

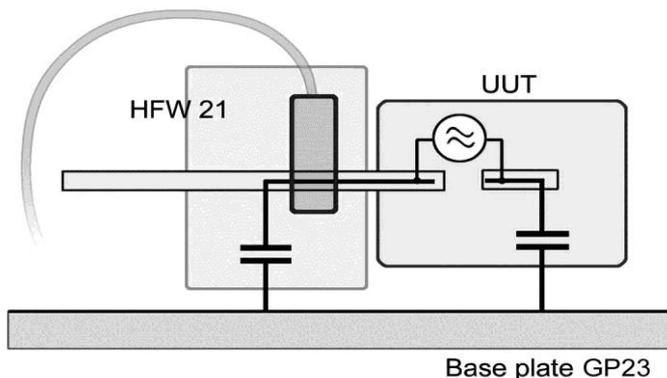


Figure 19

- If the unit under test is installed near a metal surface (control system in a washing machine), simulate this distance.

The scope of delivery includes a foam block (25 mm high) which you can use as a distance piece.

The capacitance between the unit under test and base plate is determined by the size and distance of the unit under test. The RF current flows through this parasitic capacitance. This may be caused by electric fields on the surface of the unit under test which are generated by large-surface clocked bus systems.

In some cases it will not be possible for you to pass the single cable through the current transformer, e.g. if

- more than two wires are needed,
- the current consumption of the unit under test is too high,
- the supply voltage is too high.

In such cases you should connect the unit under test via the usual cable and connect its GND directly to the base plate via the HFW 21 by as short a cable connection as possible. A large part of the RF current which is normally fed to the cable will be diverted via the HFW 21 and measured. You can make this procedure more effective by inserting a choke into the cable.

### 4.1.2 Unit under test with several cable terminals

The aim is a test set-up which is as simple and easily comprehensible as possible. All cables that are not crucial for operating the unit under test are thus disconnected. A restricted function due to missing data, for example, is generally acceptable because essential RF sources on the module, such as the clock line and processor, are still operational in this case even if minor changes arise due to other program sequences, for example. After having found and minimized the main disturbance emissions causes, carry out respective control measurements and, if necessary, connect one cable after the other (Figure 20 and Figure 21).

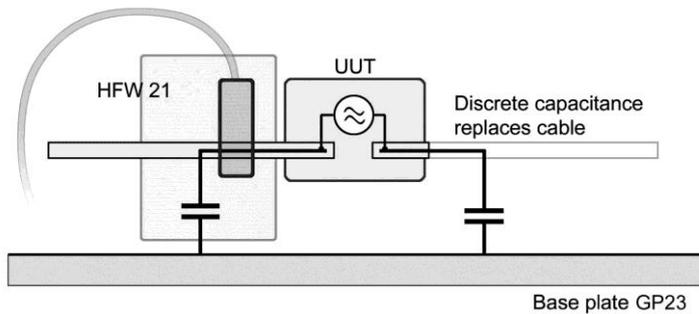


Figure 20

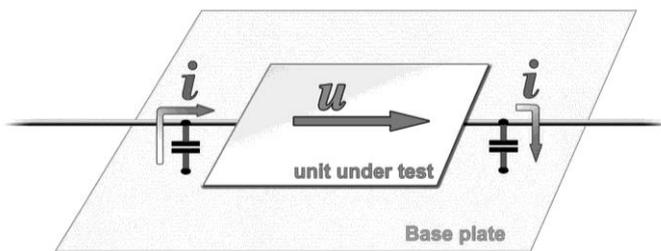


Figure 21

Replacing cables that are not crucial for operation with a link to the base plate:

Establish a direct conductive connection from the GND terminal of the plug-and-socket connector to the base plate instead of the cable in the simplest case.

You can also establish a capacitive connection from GND or Vcc, for example, to the base plate.

Measure the influence of (clocked and operationally static) data lines via a direct capacitive connection from these data lines to the base plate (also see 4.1.5 External data lines).

### 4.1.3 Unit under test with indispensable cables

If you cannot disconnect and simulate cables by an equivalent capacitance or conductive connection for functional reasons, you have to lay and fix the cable on the base plate (Figure 22). If the cable leaves the base plate, use ferrites (still on the base plate) to prevent the cable position and length outside the defined measurement set-up from interfering with the measurement result and interference currents flowing in from the surroundings via these cables from being damped.

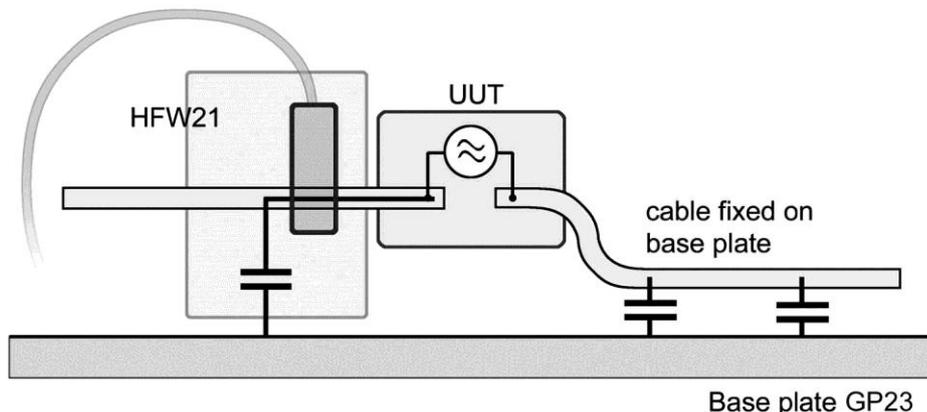


Figure 22

#### 4.1.4 Example: Measurements on a complex unit under test

In many cases, different effects of various RF sources within the unit under test will first be superposed and lead to an amplification or reduction of the RF fields at particular frequencies. It is therefore important for an effective reason analysis, particularly with complex units under test comprising several modules, to dismantle the unit under test and deal with individual modules separately.

The unit under test shown in Figure 23 has several potential disturbance emission sources. We only consider here the interface module plugged on to the basic unit as an example:

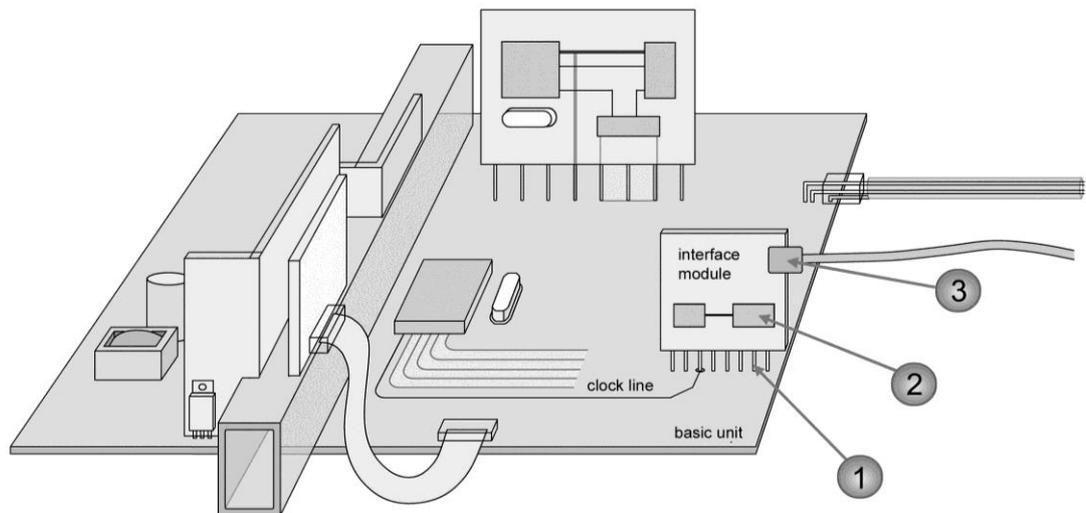


Figure 23

Three RF sources are likely to cause emissions:

- 1) plug-and-socket connector between basic unit and interface module
- 2) electronic components (processor with memory chip) on the interface module
- 3) data streams generated by the interface module and fed into the connected cable

Deal with these three RF sources in succession. You will need measurement set-ups that largely blank out the other RF sources of the unit and those of the basic unit.

##### 1) Plug-and socket connector between basic unit and interface module

###### Assumption:

The basic unit and interface module are connected to each other via data and control lines. These lines are well protected by the basic unit and interface module in the area of the GND systems – but in the area of the plug-and-socket connector they lie in the open air. The high-frequency shares of the signals sent via these lines generate RF magnetic fields which can dissipate freely in the atmosphere and can cause voltage differences between the GND of the basic unit and that of the interface module. These voltage differences drive RF currents into the cable that is connected to the interface module and thus cause emissions (Figure 24).

All other potential RF sources have to be largely eliminated to measure these voltage differences. To do so, make several connections between the GND of the basic unit and the GP 23 base plate with copper foil adhesive tape (mainly in the area of the interface module). The basic unit's GND in the area of the interface module and the base plate are thus equipotential – the voltage differences caused by other sources are short-circuited to the greatest possible extent. Also disconnect the data cable from the interface module provided the data transfer between interface module and basic unit is not dramatically reduced by this measure.

**Measurement:**

Now briefly connect a COM output of the HFW 21 with the GND of the interface module (Figure 24). The voltage difference generated in the area of the plug-and-socket connector causes a compensating current to flow through HFW 21 and its capacitive connection to the base plate back to the GND of the basic unit. This compensating current is measured with the HFW 21 and reflects the amount of the plug-and-socket connector area's share of disturbances being emitted by the whole unit under test. The effect of modifications such as filters or changing the plug assignment are directly measurable.

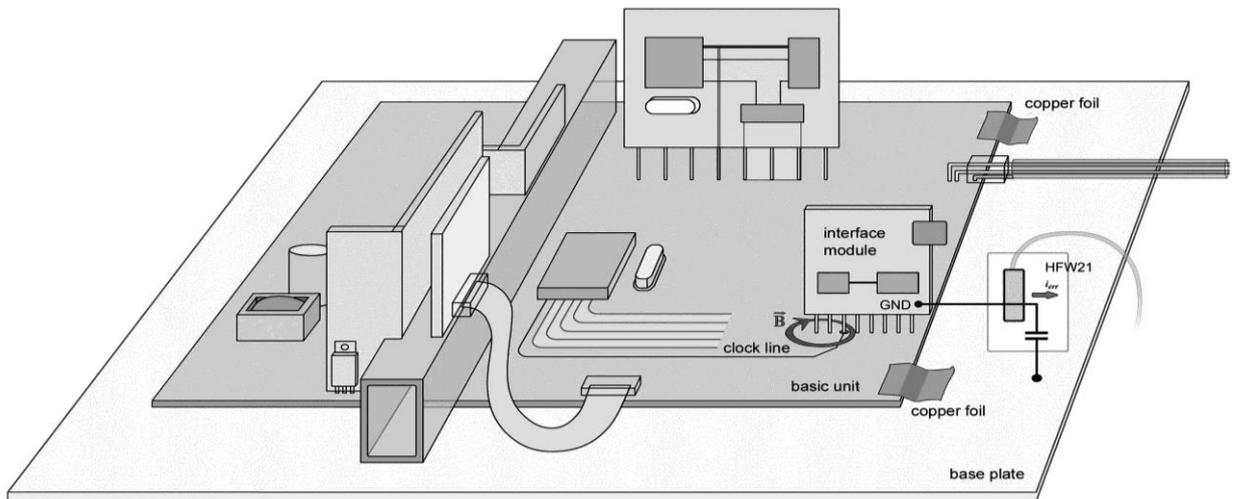


Figure 24

**2) Electronic components (processor with memory chip) on the interface module**

**Assumption:**

The electronic components on the interface module generate currents in the GND system of the interface module which provoke a voltage drop between the connection points of the two plug-and-socket connectors. This voltage difference is decoupled via the data cable and causes disturbance emissions.

**Measurement:**

The basic unit is still connected to the GP 23 base plate. The remaining share of the plug-and-socket connector between interface module - basic unit is dramatically reduced by several large-area GND connections between both GND surfaces (Figure 25).

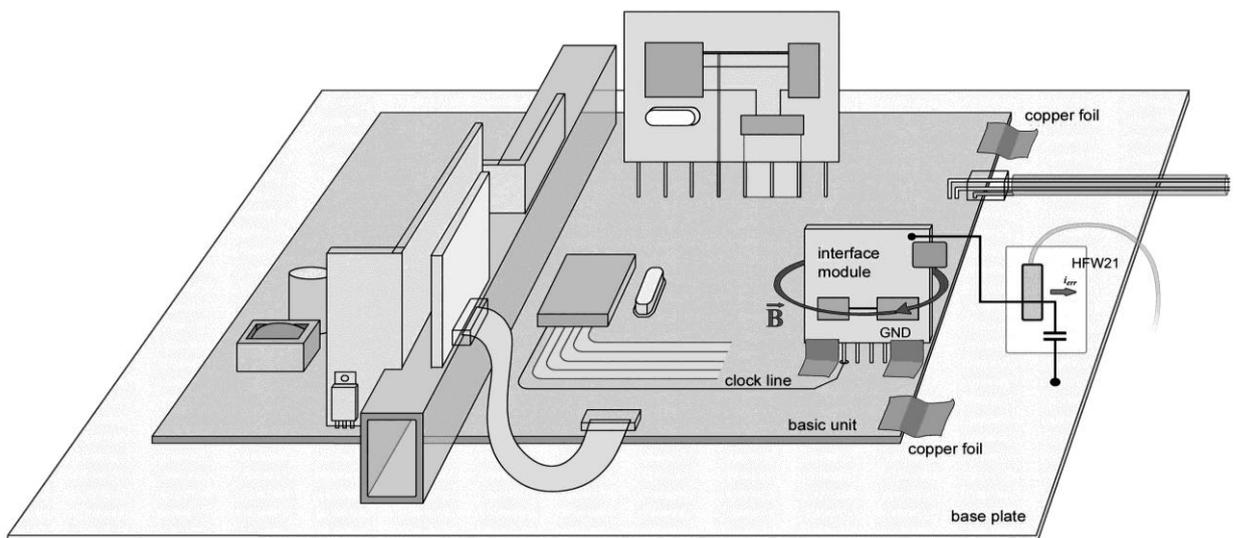


Figure 25

Tap the voltage directly at the GND terminal of the interface plug via a short measuring cable to a COM port of the HFW 21. You can thus evaluate modifications that have been made directly on the interface module.

### 3) Data streams fed into the connected cable

#### Assumption:

The interface driver module feeds a RF current into the signal wires of the data cable. This current couples to the shield via the cable capacitance of signal wire - shield and flows back to the GND of the interface module. It generates a voltage difference between the shield and GND in the area of the shield connection which causes disturbances being emitted.

#### Measurement:

Carry out this measurement without changing the measurement set-up. Simply connect the HFW 21 directly to the shield of the plugged-in data cable (Figure 26). You can thus detect the voltage-drop you are looking for at the same time.

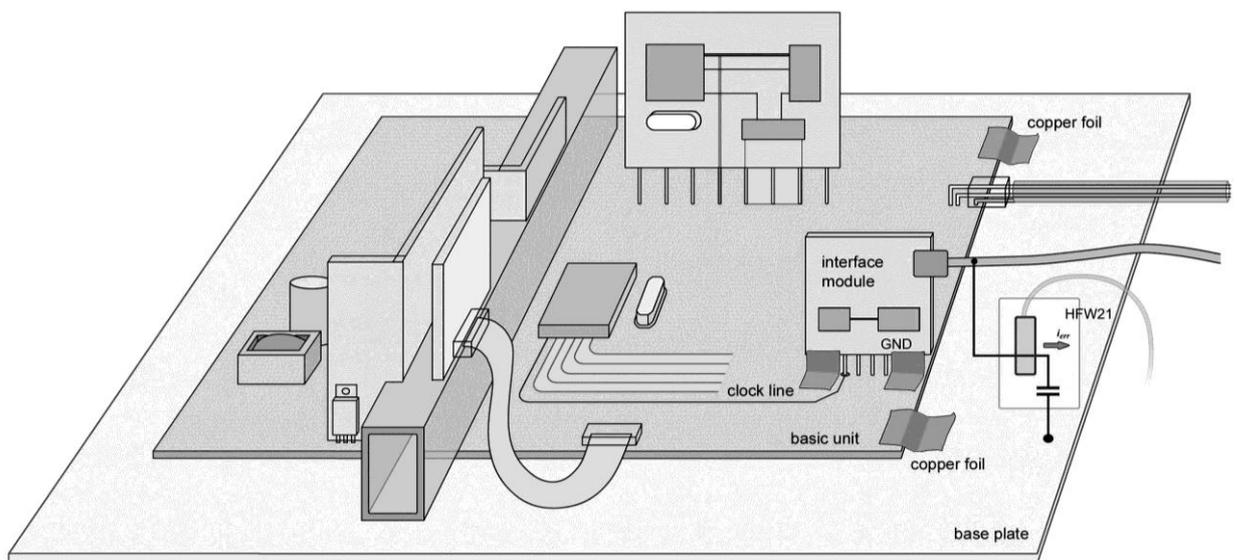


Figure 26

This set-up has a disadvantage: the voltage differences remaining from the areas of the basic unit, plug-and-socket connector and GND of the interface module are measured as well. Wherever functionally possible, you should initially operate the interface module separately without the basic unit (Figure 27). The module's performance characteristics, e.g. without data being sent by the basic unit, will of course differ from those under normal operating conditions. If the clock line functions and the processor is in operation, however,

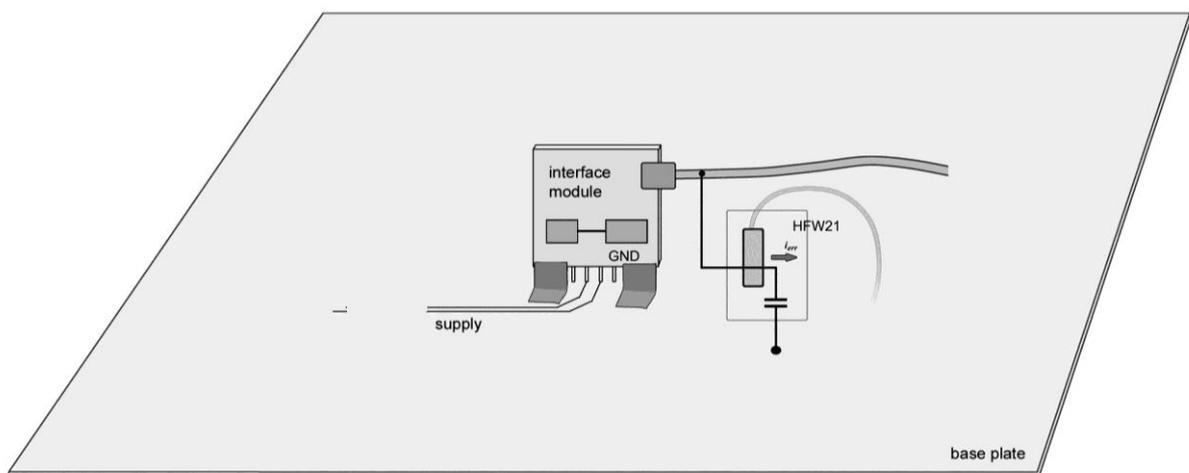


Figure 27

relative measurements of the currents and fields generated by the processor, for example, are possible. You can easily evaluate modifications to the GND and supply systems.

**4.1.5 External data lines**

**Measuring the RF current on data lines**

To measure the RF current on data lines, simulate the capacitance of the line connected under normal operating conditions and lead the RF current through the RF current transformer (Figure 28). The RF current circuit is closed through the capacitance of other lines relative to the base plate or through capacitive or conductive coupling between the unit under test and base plate (e.g. with battery-operated devices). This procedure is particularly suitable for dimensioning data line filters. If the unit under test drives a remote LCD display via a ribbon cable, for example, disconnect the lines to the display on the unit under test side and only connect one line to one of the COM outputs of the HFW 21 via an equivalent capacitance and optimise this line first. Apply the filter circuit you have found to other signal lines later on.

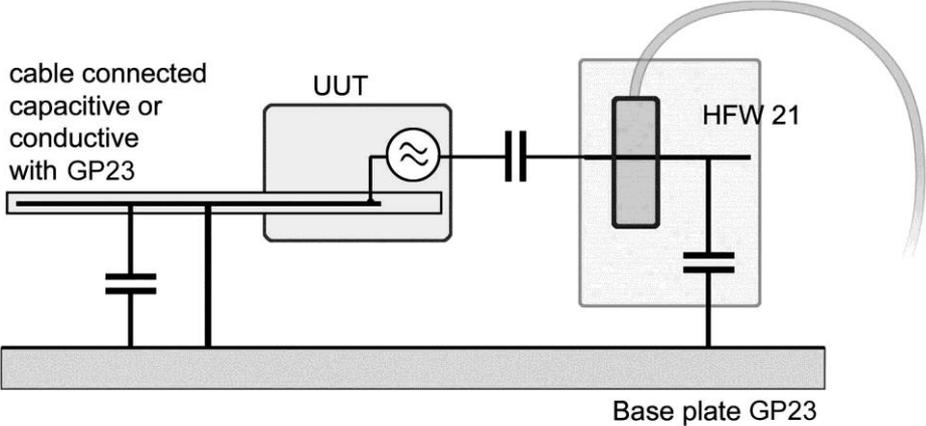


Figure 28

**Measuring the effect on the unit under test**

Simultaneous measuring of the RF current on many lines, such as those of a ribbon cable, is not possible. In such cases you have to carry out the measurement according to Figure 29:

Do not measure the RF current directly on the signal lines but on another cable (e.g. on the opposite power supply connection) or, if there is no other cable present, directly on the GND as described under 4.1.1. Replace the data lines with capacitances relative to the GP 23 base plate .

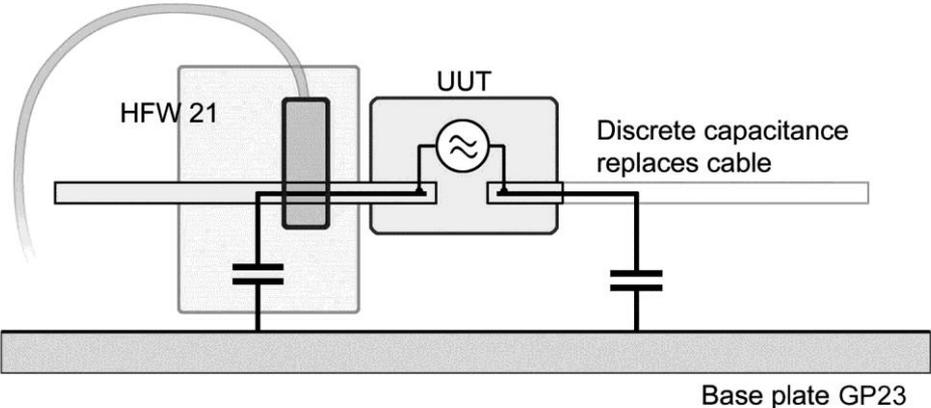


Figure 29

## 4.2 Measurement of the differential-mode component

Beside the common-mode currents measured so far (the RF currents in all wires of a cable travel in the same direction), differential-mode currents, which are mainly generated in the power supply unit of DC/DC converters or by clocked loads (e.g. via PWM) are of interest in the lower frequency range. The RF current transformer enables these measurements via the DIFF port (Figure 30).

According to the disturbance emission mechanism described under 1 Measurement procedure, this differential-mode current does not result in any disturbance emissions. But since it also flows in the chassis-ground or GND connections between different devices, voltage differences develop between these devices. These in turn cause compensating currents (common-mode currents) which cause disturbance emissions.

The differential-mode currents in units under test containing a DC/DC converter or similar device have to be measured and, if necessary, reduced by capacitors or chokes because these currents are partially transformed into critical common-mode currents according to the described mechanism.

The output signal is damped (saturation effect) depending on the power consumption of the unit under test (see point 6) in the frequency range below 10 MHz if the RF differential-mode current is measured on the supply lines of the unit under test. This effect does not occur above this frequency or if the measurement is carried out via the COM common-mode output.

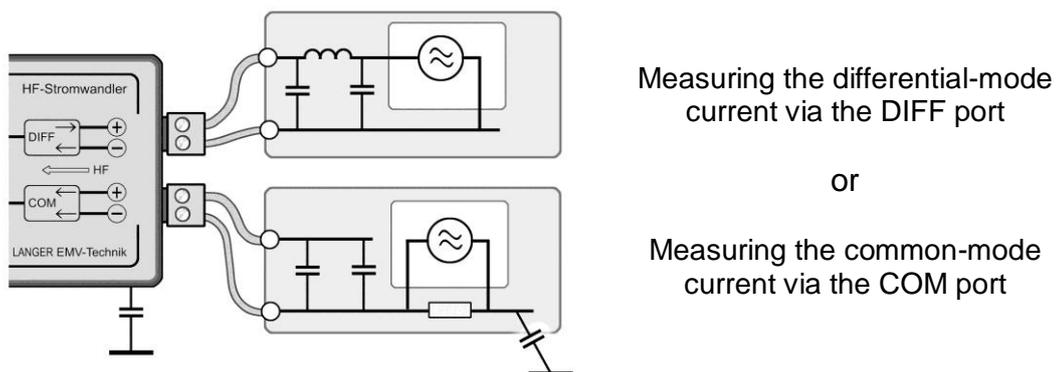


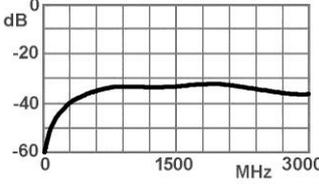
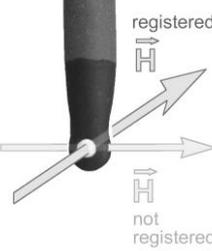
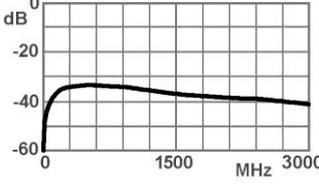
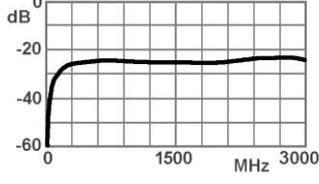
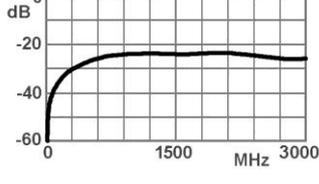
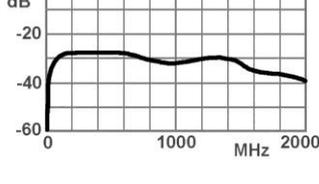
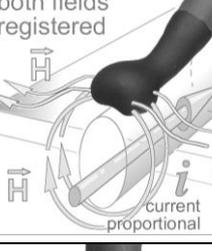
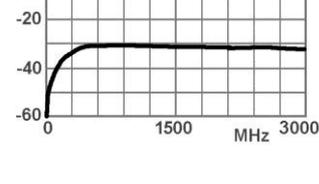
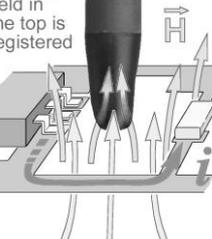
Figure 30

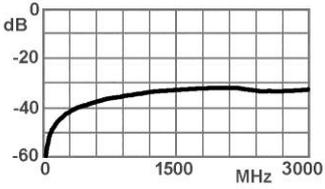
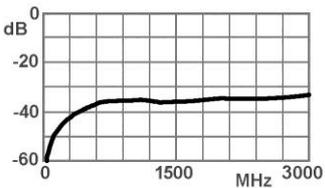
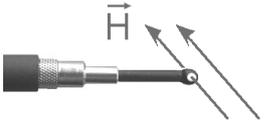
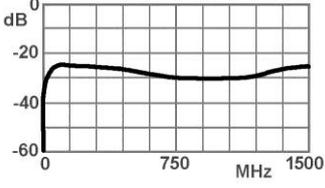
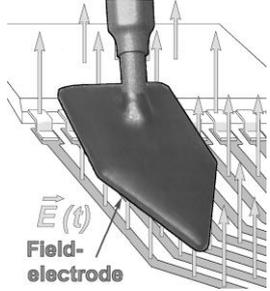
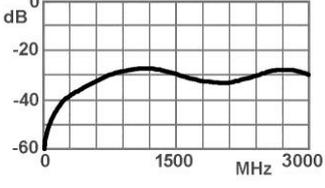
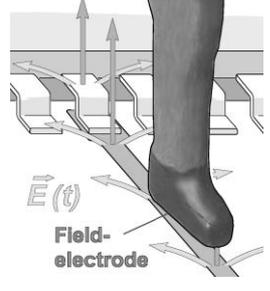
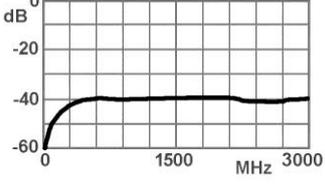
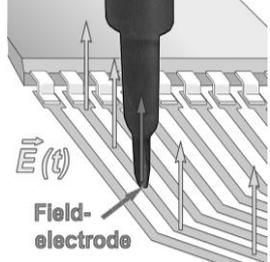
## 5 Safety instructions

- Do not use any damaged or defective devices.
- Pay attention to the operating and safety instructions for each of the devices used (spectrum analyser, measurement receiver etc.).
- Only qualified EMC personnel is allowed to use the devices.

## 6 Technical specification

### Near field probes

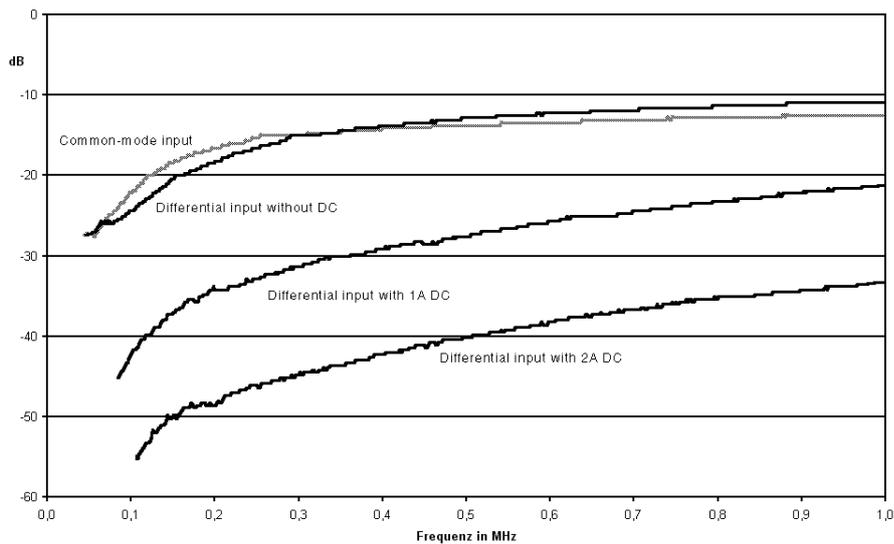
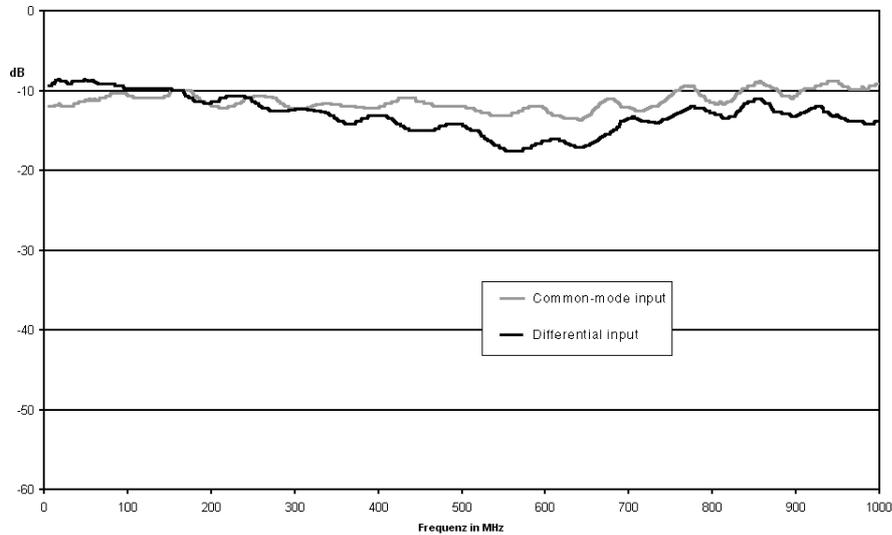
Characteristic	Description	Type
	<p><b>RF-R 3 - 2</b> The near field probe is designed to achieve nearly punctiform detection of HF magnetic fields. The size of the probe enables the resolution of magnetic field distribution within millimetres. Field orientation and distribution can be detected by moving the probe across larger areas or partially between conducting paths, within IC pin areas, bypass capacitors, EMC components, etc.</p> <p><b>Frequency 30 MHz to 3 GHz; Resolution approx. 1 mm</b></p>	
	<p><b>RF-U 2.5 - 2</b> The near field probe is designed for selective detection of the current spectrum in singular small conducting paths and component connections, capacitors, IC pins. The probe head contains a magnetically active curb with a width of approx. 0.5 mm. To achieve measurement the probe with the curb is positioned on conducting paths, IC or capacitor connections.</p> <p><b>Frequency 30 MHz to 3 GHz; Resolution approx. 0.5 mm</b></p>	
	<p><b>RF-R 400 - 1</b> On account of its large diameter (25 mm) the near field probe is the most sensitive and therefore has the lowest resolution. The probe can be used up to a distance of 10 cm from units. The detected field distribution enables the localisation of HF magnetic field sources and deduction with regards to interference.</p> <p><b>Frequency 30 MHz to 3 GHz; Ø approx. 25 mm</b></p>	
	<p><b>RF-R 50 - 1</b> The near field probe has a higher resolution and a lower sensitivity than the R 400-1. It is suitable for measurements up to 3 cm. Interference sources can be localised by detecting the distribution and orientation of the field, therefore enabling a more exact use of higher resolution probes (RF 1 set).</p> <p><b>Frequency 30 MHz to 3 GHz; Ø approx. 10 mm</b></p>	
	<p><b>RF-U 5 - 2</b> The near field probe is designed for detecting surface and circular magnetic fields on very wide conducting paths, metallized surfaces, plug-and-socket connectors, electronic components, cables and component connections. The sources of HF-magnetic fields can be detected and conclusions regarding internal interference currents achieved.</p> <p><b>Frequency 30 MHz to 2 GHz; Resolution approx. 5 mm</b></p>	
	<p><b>RF-B 3 - 2</b> The near field probe is designed for the detection of magnetic fields which are emitted vertically from the surface area of flat units. The probe enables measurement of obstructed parts of the printed-circuit board. It is not possible to conduct measurements of field orientation such as can be done with the RF-R 3 - 2 probe.</p> <p><b>Frequency 30 MHz to 3 GHz; Resolution approx. 2 mm</b></p>	

	<p><b>RF-B 0.3 - 3</b> detects a magnetic field, which enters the probe point vertically. It is therefore suitable for pin-point detection of RF magnetic fields, which are emitted by surfaces. For this, the probe point is applied to the surface in question. Due to its very small construction, magnetic field distributions of under 1 millimeter can be resolved on IC housings and PCB surfaces, for example. The probe enables measurement in hard-to-reach places, such as between components.</p> <p><b>Frequency 30 MHz to 3 GHz      Resolution &lt; 1 mm</b></p>	
	<p><b>RF-R 0.3 - 3</b> serves the high-resolution detection of spatial RF magnetic fields. The loop opening, which is marked by a white dot, is manually turned for the recognition of field orientation and intensity. If the loop opening is orthogonally permeated by the field, a maximum can be determined. The minimum can be determined by pivoting the loop opening 90°. This allows the detection of H field distribution (orientation and intensity) by guiding the probe in the vicinity of components, between and over track runs, in the pin area of ICs, on block capacitors, EMC components, etc.</p> <p><b>Frequency 30 MHz to 3 GHz      Resolution &lt; 1 mm</b></p>	
	<p><b>RF-E 02</b> Bus structures, larger components respectively supply areas couple out electrical fields by their surfaces. These electrical fields may be involved electromagnetic emission. The probe RF-E 02 detect these fields by the probe bottom on an area of 2 cm x 5 cm approximately.</p> <p>For measuring the probe bottom is approached respectively putted on the Unit Under Test.</p> <p><b>Frequency: 30 MHz to 1.5 GHz</b></p>	
	<p><b>RF-E 05</b> By this probe you are able to register selectively electrical fields on layout and component area of flat units. The breadth of the field electrode is about 1 mm. Therefore you can locate electrical fields very exactly. These electrical fields are caused by clocked lines, IC pins and small components.</p> <p><b>Frequency: 30 MHz to 3 GHz</b></p>	
	<p><b>RF-E 10</b> The near field probe detects electrical fields that clocked leads emit via their surface. The probe head tip is only approx. 0.5 mm wide. The integrated screening prevents interference to the measurement result from neighbouring leads. A resolution of approx. 0.2 mm is possible so that each individual track can be evaluated in the layout.</p> <p><b>Frequency 30 MHz to 3 GHz; Resolution approx. 0.2 mm</b></p>	

### HFW 21 RF current transformer:

Max. continuous current: 10 A

Max. operating voltage: 50 V



HFW 21 transfer performance

### HFA 21 RF bypass

Capacitances: 10 pF to 100 nF

Max. operating voltage: 50 V

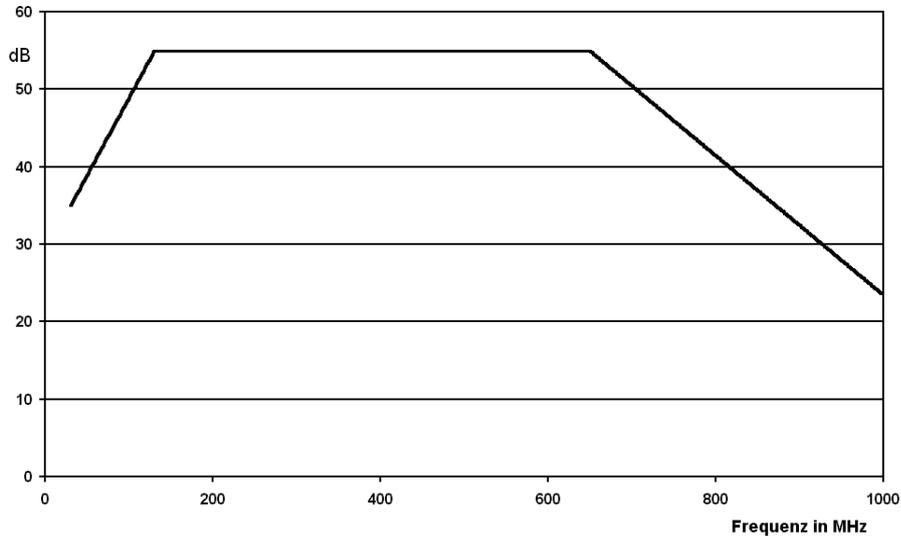
### GP23 base plate

Working area: (900 x 500) mm

	max. continuous current	Damping
Mains	10 A	50 dB at 1 MHz – 1 GHz
DC socket 12 V	2.5 A	40 dB at 1 MHz – 1 GHz
Pole terminal	10 A	50 dB at 1 MHz – 1 GHz

## Z23 shielding tent

	Working room (length x width x height):	Damping:
Z23	(900 x 500 x 400) mm	45 – 50 dB at 30 MHz – 1 GHz
Tent optional	(900 x 500 x 650) mm	45 – 50 dB at 30 MHz – 1 GHz

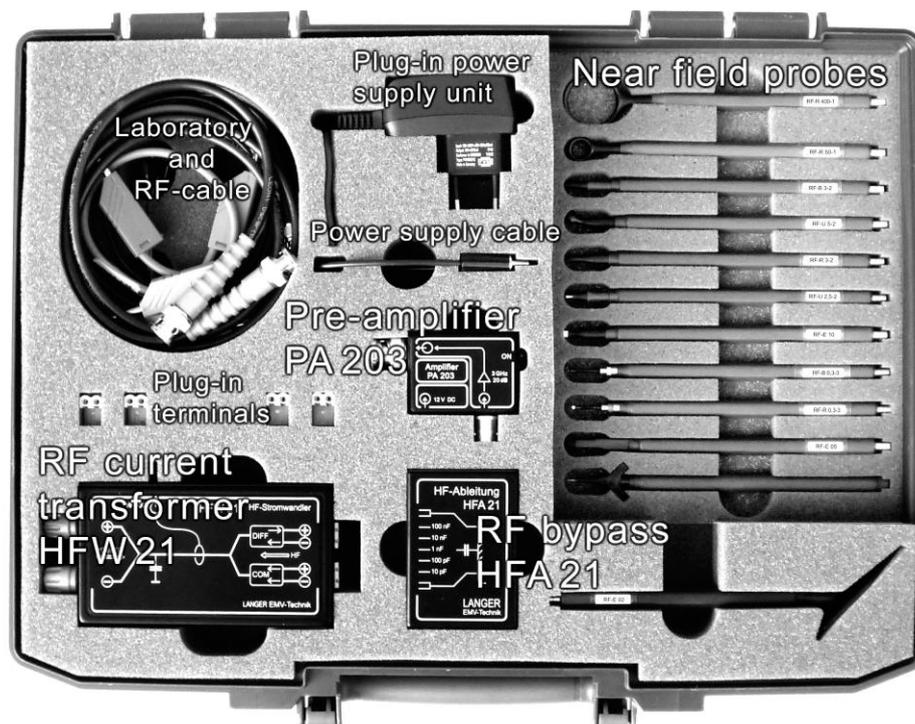


Approximate shield damping with the shielding tent closed

## PA 203 preamplifier

Max. input power	13 dBm
Voltage supply	12 V DC
Current input	50 mA
Amplification	20 dB
Noise figure	4.5 dB

## Overview of the ESA1 case



## 7 Scope of delivery

### Complete ESA1 system

The probes and the preamplifier are not included in the ESA1 basic set (serial no. 06 – 18 ).

Serial no.	Qty.	Part	Code designation
01	1	RF current transformer	HFW 21
02	1	RF bypass	HFA 21
03	1	Tent made from conductive materials	Z23
04	1	Tent poles, collapsible	
05	1	Base plate with filter package	GP 23
06	1	H-field probe	RF-R 400-1
07	1	H-field probe	RF-R 50-1
08	1	H-field probe	RF-R 3-2
09	1	H-field probe	RF-R 0.3-3
10	1	H-field probe	RF-U 5-2
11	1	H-field probe	RF-U 2.5-2
12	1	H-field probe	RF-B 3-2
13	1	H-field probe	RF-B 0.3-3
14	1	E-field probe	RF-E 02
15	1	E-field probe	RF-E 05
16	1	E-field probe	RF-E 10
17	1	Preamplifier for near-field probes	PA 203
18	1	Plug-in power supply unit for preamplifier	
19	1	Power supply cable for preamplifier	PA 203
20	1	Probe tip	
21	1	Laboratory cable 25 cm red	
22	1	Laboratory cable 25 cm blue	
23	2	Plug-in terminal, 2 pole	
24	2	Plug-in terminal, 2 pole, with plug connector	
25	1	RF cable BNC-BNC, double-shielded	
26	1	RF cable SMB-BNC	
27	2	Measuring lines 7 cm red	
28	2	Measuring lines 12 cm yellow	
29	1	Measuring lines 25 cm black	
30	2	Miniature clips	
31	2	Crocodile clamps	
32	1	Insulating material - distance piece for unit under test (foam block 25 mm high)	
33	1	Operating instructions	
34	1	Instruction sheet	
35	1	Case	

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