User Manual

P1401/P1501 set
RF field coupling up to 1 GHz

P1402/P1502 set
RF field coupling up to 3 GHz

- Translation of the original user manual -

Content: **Page**

1 Safety instructions

Read and follow the operating instructions carefully and keep them in a safe place for later consultation. The devices may only be used by personnel who are qualified in the field of electromagnetic compatibility (EMC) and who are eligible to carry out this work.

When using a product from Langer EMV Technik GmbH, please observe the following safety instructions to protect yourself from electric shocks or the risk of injuries and to protect the devices used and the test IC from destruction.

Use a power amplifier that is <u>stable under open-circuit conditions</u> and <u>short-circuit proof</u>.

- Observe the operating and safety instructions for all devices used in the set-up.
- Never use any damaged or defective devices.
- Carry out a visual check before using a measurement set-up with a Langer EMV-Technik GmbH product. Replace any damaged connecting cables before starting the product.
- Never leave a product from Langer EMV-Technik GmbH unattended whilst this is in operation.
- The Langer EMV-Technik GmbH product may only be used for its intended purpose. Any other use is forbidden.
- People with a pace-maker are not allowed to work with these devices.
- The test set-up should always be operated via a filtered power supply.

Attention! Functional interference emissions (near fields and far fields) may occur when the field sources from the P1401/P1501 set or P1402/P1502 set are operated. The user is responsible for taking appropriate measures to protect all electronic devices used in the course of the tests. In particular, the user is responsible for protecting the measuring devices used for the test set-up and all other electronic devices outside the test bench against interference emissions so that their intended function is not impaired. This can be achieved by:

- observing an appropriate safety distance
- use of shielded rooms or enclosures (e.g. shielded tents)

A disturbance field is generated in the field chamber of the field source when operating the test bench. Make sure that the field chamber is not opened under any circumstances during the test for safety reasons (hazard due to RF). The field source may only be operated with the field chamber closed and in accordance with the measurement set-up. The test bench has to be operated in a shielded room or enclosure.

We cannot assume any liability for damage due to improper use.

The disturbances that are injected into the modules can destroy the test IC (latch-up) if their intensity is too high. Protect the device under test by:

- connecting a protective resistor in the IC's incoming power supply
- increasing the disturbance gradually and stopping when a functional fault occurs
- interrupting the power supply to the test IC in the event of a latch-up.

Attention! Make sure that internal functional faults are visible from outside. The test IC may be destroyed due to an increase in the injection intensity if the faults are not visible from outside. Take the following precautions if necessary:

- monitoring representative signals in the test IC
- special test software
- •visible reaction of the test IC to inputs (reaction test of the test IC)

We cannot assume any liability for the destruction of test ICs!

2 Description of the system

2.1 Use

The P1401/P1501 set or P1402/P1502 set can be used to measure the immunity of integrated circuits (ICs) to magnetic and electric fields in the frequency range of up to 1 GHz and 3 GHz, respectively.
The P1401 or P1402 field source is used to generate a magnetic test field and the P1501 or P1502 field source to generate an electric test field. The respective field source is positioned above the test IC by using a spacer ring and its test field is then applied to the IC to measure its immunity to disturbances.

Figure 1 shows the basic set-up for immunity measurements with the P1501 field source as an example. The P1401/P1501 or P1402/P1502 IC test system, the ICE1[1] IC test environment as well as different measuring and test devices[2] are required for the measurement set-up:

Note: The P1401 or P1402 field source is operated under short-circuit conditions and the P1501 or P1502 field source is operated under open-circuit conditions. Any power amplifier that is used to supply the field sources must be designed for this purpose, i.e. it must be stable under open-circuit conditions and short-circuit proof.

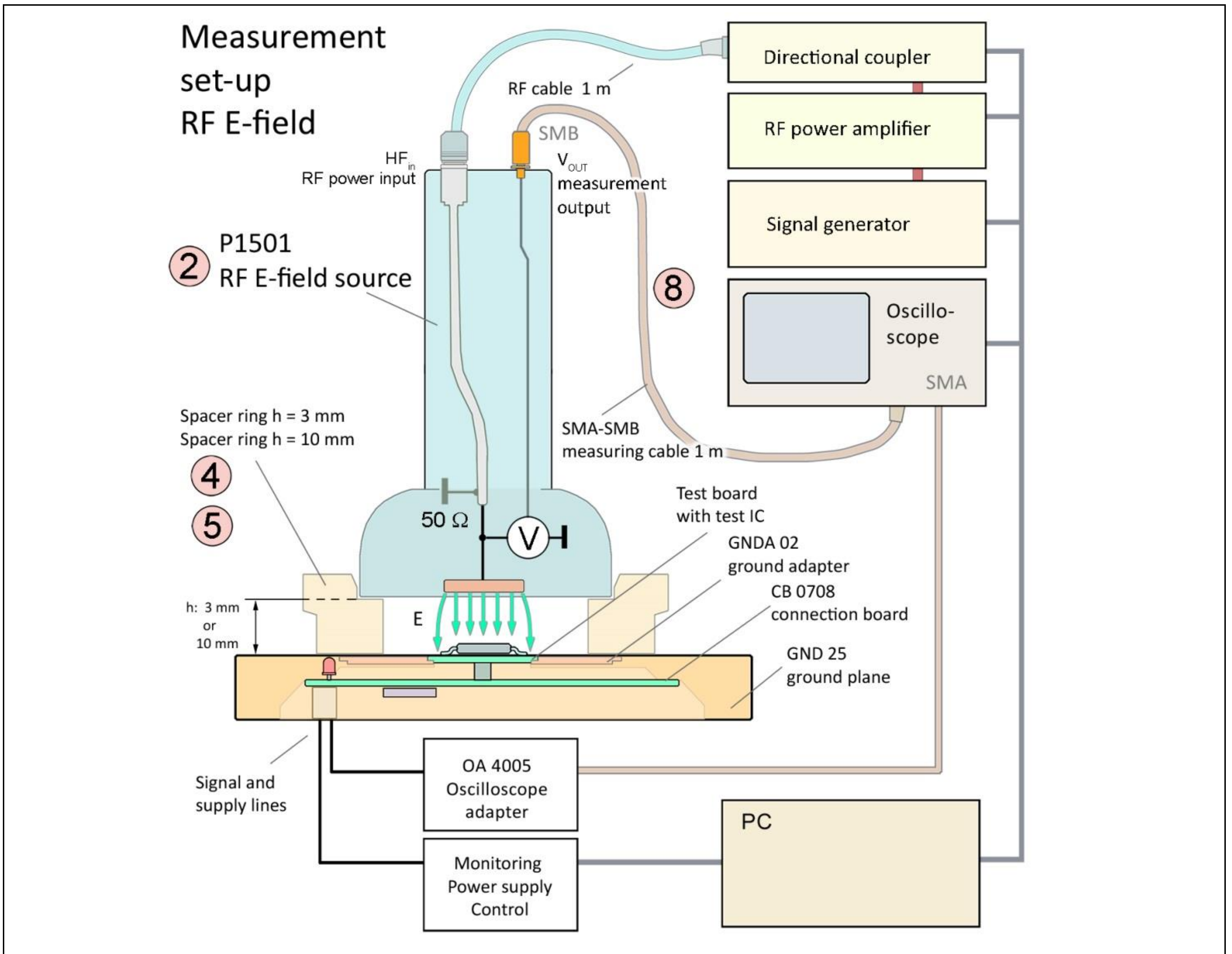

Figure 1 Basic set-up for immunity measurements using the ICE1 IC test environment and P1401/P1501 IC test system (here: P1501 field source)

[1] not included in the scope of delivery
[2] not included in the scope of delivery

No.	Name	Description
1	P1401 (P1401/P1501 set) P1402 (P1402/P1502 set)	RF field source to generate a magnetic test field
2	P1501 (P1401/P1501 set) P1502 (P1402/P1502 set)	RF field source to generate an electric test field
3	FKE 30	Field chamber insert (only for P1402 with D70 h10)
4	D70 h03	Spacer ring, 3 mm
5	D70 h10	Spacer ring, 10 mm
6	EPM 02	Field meter to measure the electric field
7	BPM 02	Field meter to measure the magnetic field
8	SMA-SMB 1 m	Measuring cable

Table 1 Brief description of the P1401/P1501 set; P1402/P1502 set

The following components, not included in the scope of delivery, are also needed:

ICE1 set, IC Test Environment (Langer EMV-Technik GmbH)	- **GND 25** ground plane - **GNDA 02** ground adapter - **CB 0708** connection board - **OA 4005** oscilloscope adapter
Measuring and test devices	- Directional coupler - RF power amplifier - Signal generator - PC - Oscilloscope - Test IC monitoring equipment
Other	- Test board for test IC

The test board together with the test IC is inserted into the ground plane of the measurement set-up. The field source (here P1501) is located above the test IC by using a spacer ring. A signal generator and an RF power amplifier are used to supply the field source. A directional coupler can be used to monitor the forward power.
An oscilloscope and PC are needed to monitor the equipment under test and/or control the measurement set-up. The voltage present on the electrode (P1501/P1502) and/or the current flowing through the electric conductor (P1401/P1402) can be monitored via the field sources' measurement output.

The principal measurement process corresponds to IEC 62132-2:2010.

2.2 P1401 and P1402 field sources

Figure 2 and **Figure 3** show the P1401 and P1402 field source which generate a magnetic test field. Both field sources have two plug connectors, an RF power input (N type) to power the field source and a measurement output (SMB type) at the top. The power input is marked $\mathrm{RF_{in}}$ and the measurement output is marked $\mathrm{i_{out}}$.

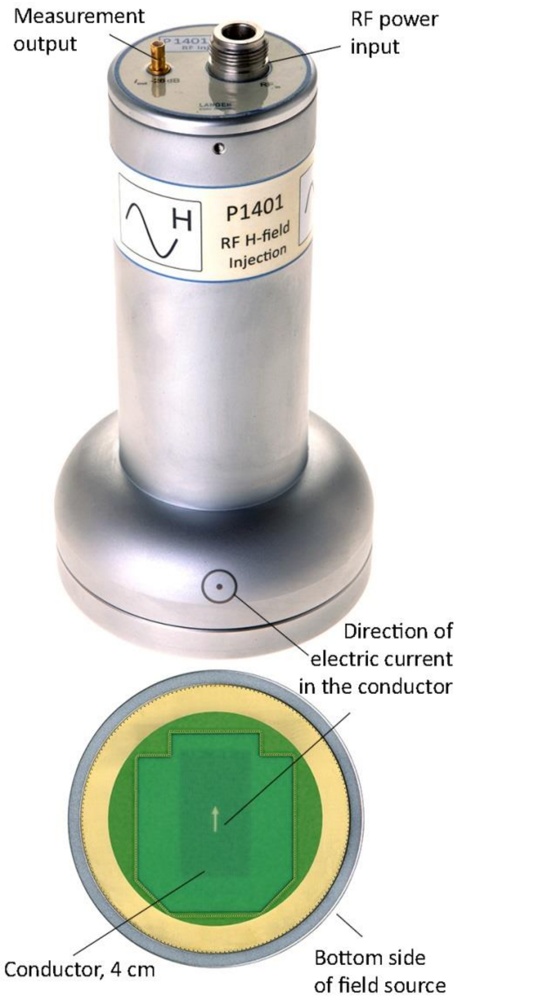

Figure 2 P1401 field source with 4 cm long electric conductor

Figure 3 P1402 field source with 3 cm long electric conductor

On the inside of the field source, the RF power input is connected to the end of the electric conductor located at the bottom of the field source. The other end of the electric conductor is connected to ground of the field source and thus causes a short circuit in the RF current path. The resulting RF current $\mathrm{i_P}$ generates a magnetic field that develops around the electric conductor.

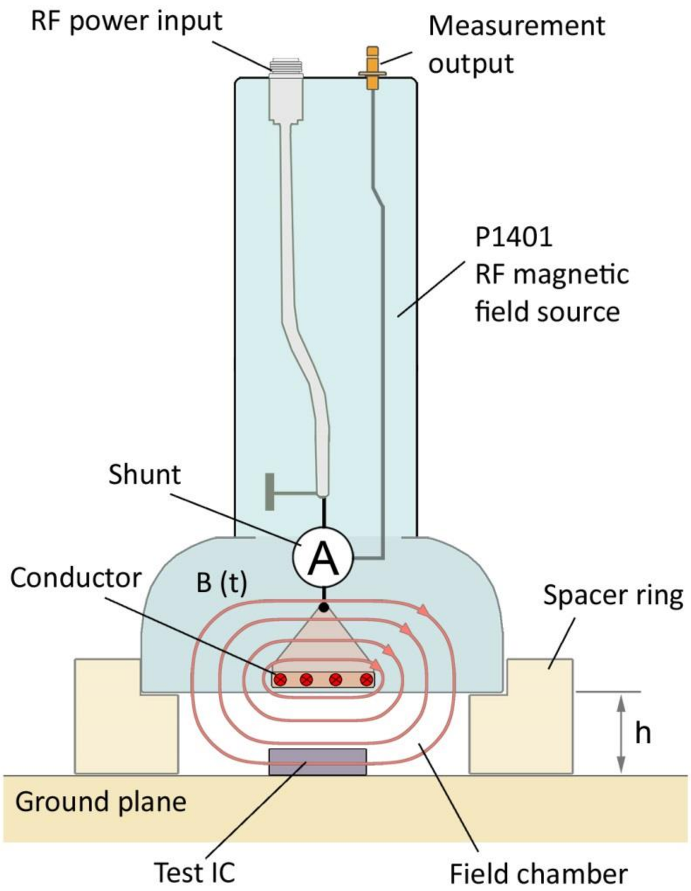

Figure 4 Principle of the immunity measurement using the P1401 or P1402 field source (magnetic field)

Figure 4 shows the basic measurement principle. The field source, the spacer ring and the ground surface with the test board form a field chamber. This field chamber limits and shields the generated magnetic field. The FKE 30 field chamber insert has to be used in connection with the P1402 field source.

Figure 5 FKE 30 field chamber insert for P1402 field source

A current divider (shunt) is located in the current path of the field source to measure the field-generating current i_P. This current can be calculated from the voltage at the field source's measurement output (refer to section 2.4). The measurement output is terminated with 50 Ω inside the field source.

DE-01728 Bannewitz
mail@langer-emv.de
www.langer-emv.com

2.3 P1501 and P1502 field sources

Figure 6 and **Figure 7** show the P1501 and P1502 field source which generate an electric test field. Both field sources have two plug connectors, an RF power input (N type) to power the field source and a measurement output (SMB type) at the top. The power input is marked $\mathrm{RF_{in}}$ and the measurement output is marked $\mathrm{V_{out}}$.

Figure 6 P1501 field source

Figure 7 P1502 field source

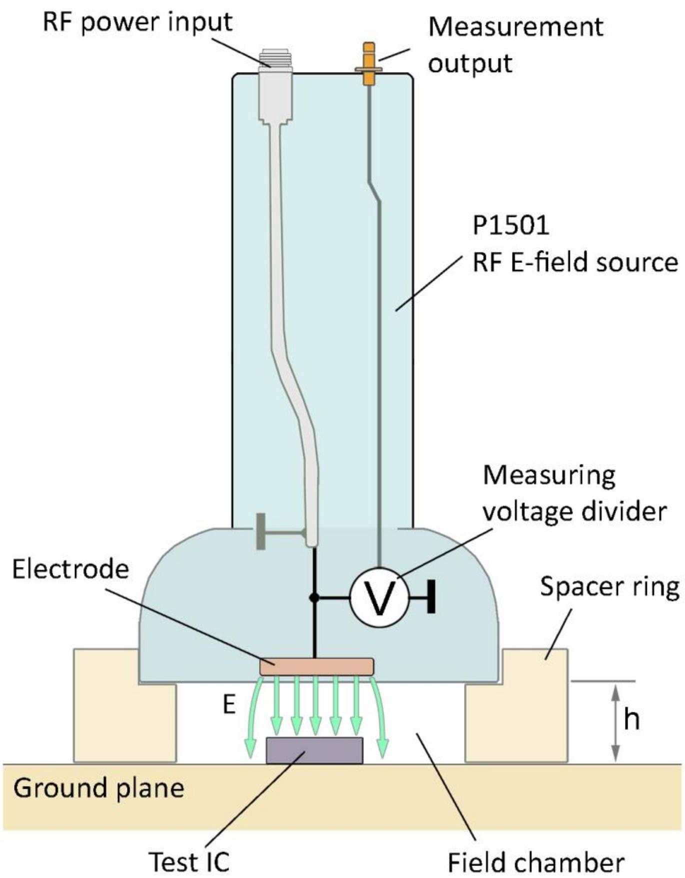

Figure 8 Principle of the immunity measurement using the P1501 or P1502 field source (electric field)

On the inside of the field source, the RF power input is connected to the electrode located at the bottom of the field source. Due to the potential difference between the electrode and the ground surface, an electric field is generated which exits the electrode in the orthogonal direction. **Figure 8** shows the basic measurement principle. The field source, the spacer ring and the ground surface with the test board form a field chamber. This field chamber limits and shields the generated electric field.

An ohmic voltage divider is located at the electrode of the P1501 field source to measure the field-generating voltage u_P. This voltage can be calculated from the voltage at the field source's measurement output (refer to section 2.4). A capacitive voltage meter is used in the P1502 field source instead to measure the field-generating voltage u_P. The respective correction factors are thus different (refer to section 2.4). The measurement outputs of both field sources are terminated with 50 Ω on the inside.

2.4 Measurement outputs of the field sources

The field sources' measurement outputs can be used to calculate the magnetic flux density B or electric field strength E generated by the field sources at the position of the test IC. The voltage $\mathrm{u_{out}}$ has to be measured at the field sources' outputs for this purpose. The respective field quantities can then be calculated using the conversion factors defined in **Table 2**.

P1401/P1402	**P1501/P1502**
$\mathrm{B} = \mathrm{K1} \cdot \mathrm{i_P}$ $\mathrm{i_P} = \mathrm{K4} \cdot \mathrm{u_{out}}$	$\mathrm{E} = \mathrm{K1} \cdot \mathrm{u_P}$ $\mathrm{u_P} = \mathrm{K4} \cdot \mathrm{u_{out}}$

Table 2 Conversion factors of the field sources to calculate the field quantities

2.5 D70 h10 and D70 h03 spacer rings

The D70 h10 and D70 h03 spacer rings are part of the P1401/P1501 and P1402/P1502 IC test systems. The spacer rings have an inner diameter d = 70 mm and a height h = 10 mm or h = 3 mm. The spacer rings are used to position the field sources on the ground surface above the test IC. The height of the spacer ring determines the distance between the field source and the IC. The ground surface, the field source and the spacer ring form a field chamber in which the test field develops.

Figure 9 D70 h03 and D70 h10 spacer rings

2.6 FKE 30 field chamber insert

The FKE 30 field chamber insert is only used together with the P1402 field source and the D70 h10 spacer ring. When using the P1402 field source, the FKE 30 field chamber insert has to be installed at the bottom of the field source as shown in **Figure 10**. The field source can then be positioned on the spacer ring. The field chamber insert is now inside the spacer ring. The field chamber insert ensures a higher suppression of the field's electric component.

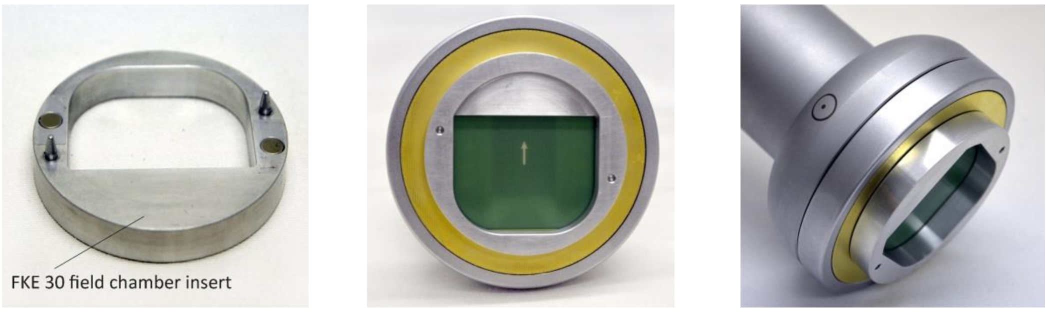

Figure 10 FKE 30 field chamber insert for use with P1402 field source

2.7 EPM 02 and BPM 02 field meters

The magnetic or electric field strength generated by the field sources at the position of the test IC can be measured with the BPM 02 and EPM 02 field meters. To do so, a field meter has to be inserted in the GND 25 ground plane using the GNDA 02 ground adapter. To calculate the magnetic flux density and the electric field strength based on the voltage u_{out} measured at the output of the respective field meter, the conversion factors defined in **Table 3** are used.

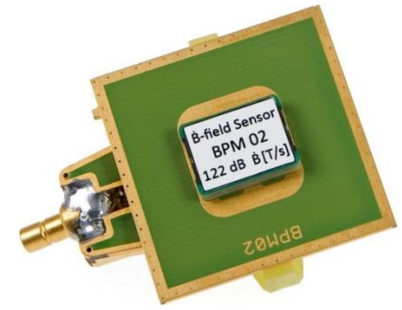

Figure 11 BPM 02 dE/dt field meter

Figure 12 EPM 02 dB/dt field meter

BPM 02	**EPM 02**
$\dot{B} = K \cdot u_{out}$	$\dot{E} = K \cdot u_{out}$
$K = 122\ dB\left(\frac{T}{V \cdot s}\right)$	$K = 251\ dB\left(\frac{1}{cm \cdot s}\right)$
$B = (1/\omega)\ \dot{B}$	$E = (1/\omega)\ \dot{E}$
$B = \dot{B} - 20\ \log_{10}(\omega)$	$E = \dot{E} - 20\ log_{10}(\omega)$

Table 3 Conversion factors of the BPM 02 und EPM 02 field meters

2.8 Orientation of the field sources

Electric field:
The electric field is orthogonal to the ground surface (surface of the test IC) in the area of the test IC (cf. **Figure 13**). Turning the field source on the spacer ring has no significant impact on the direction and the intensity of the electric field. However, we recommend that the orientation is selected for the measurement that was also used to calibrate the measurement set-up. Please refer to section 3.2 for further information on the calibration of the measurement set-up.

Magnetic field:
The magnetic field is oriented in a plane parallel to the ground surface in the area of the test IC (cf. **Figure 14**). Turning the field source on the spacer ring allows the user to vary the magnetic field's direction in this plane. The orientation of the electric conductor is marked at the bottom of the field source as an aid. In addition, there are two marks on the outer margin of the field source that show the orientation of the electric conductor. These are visible in **Figure 2** and **Figure 3** and can be used to adjust the orientation of the field source on the spacer ring. The electric conductor and the magnetic field are perpendicular to each other in the area of the test IC.

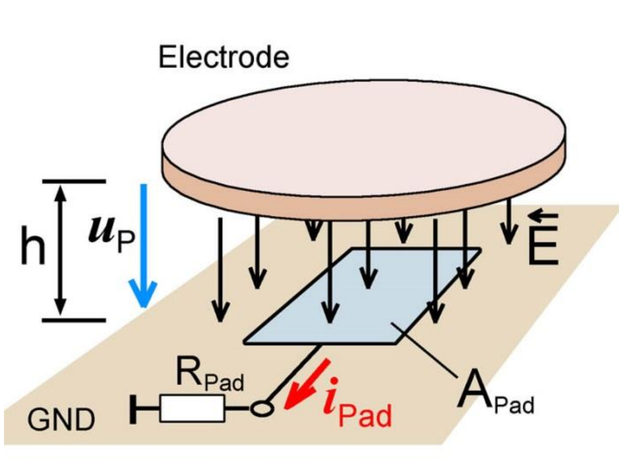

Figure 13 Field coupling principle, electric field

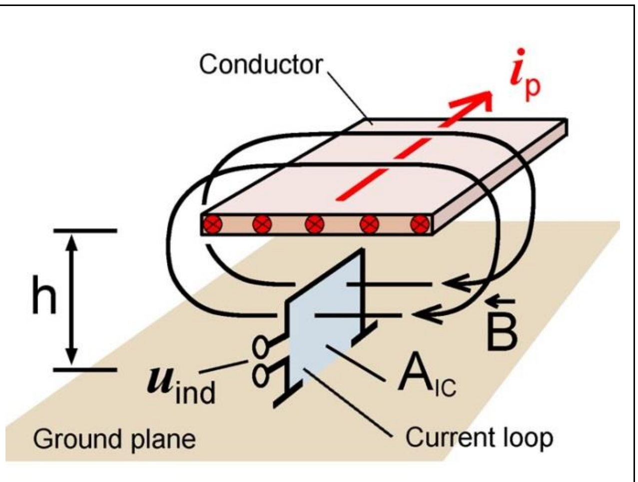

Figure 14 Field coupling principle, magnetic field

3 Start-up and measurement

The P1401/P1501 or P1402/P1502 IC test system can be used to measure the immunity of integrated circuits (ICs) to magnetic and electric fields in the frequency range of up to 1 GHz and 3 GHz, respectively. The immunity to electric fields and magnetic fields is measured separately. The basic measurement set-up, the measurement princple and a description of the individual components of the test systems can be found in section 2.

3.1 Measuring devices

The ICE1 test environment and P1401/P1501 or P1402/P1502 IC test system from Langer EMV-Technik GmbH are used to carry out immunity measurements. In addition, the following devices are needed for the measurement set-up:

- **Signal generator** to generate a test signal
- **RF power amplifier** to generate the required power
- Directional coupler (optional) to measure the forward and reverse power
- Spectrum analyzer (optional) to monitor the signal at the measurement output of the field source
- **Oscilloscope** to monitor the functions and/or signals of the IC
- **PC** to automate the measurement

Note: Since the field sources are operated under short-circuit conditions or under open-circuit conditions, as described in section 2, the power amplifier is terminated and operated with the respective mismatch. The power amplifier used in this set-up must be designed for this purpose, i.e. it must be stable under open-circuit conditions and short-circuit proof.

3.2 Test board

The test IC must be put into operation for the measurement. A test board for the specific IC thus has to be manufactured for the following tasks:

- Provision of the signals and supply voltages required for test IC operation
- Provision of connections for devices such as an oscilloscope to monitor the operation condition and/or detect faults

For further information on manufacturing the test board, please refer to IEC 62132-1 and the "IC test instructions"[3].

[3] available on request (mail@langer-emv.de)

3.3 Calibration of the measurement set-up

The EPM 02 and/or BPM 02 are used to calibrate the measurement set-up. During calibration, the generated field strength is measured and adjusted via the power level of the signal generator to achieve the desired test field. The power level that is required depends on the frequency and has to be determined and stored for the respective frequency range during calibration. The stored values can then be used to measure the test IC's immunity. The field meters are removed and the test board with the IC is installed in the measurement set-up for this purpose.

As an alternative, the voltage can also be recorded at the measurement output of the field source during calibration. The recorded voltage values can then be compared with the values obtained from the ongoing immunity measurements. This comparison allows the user to check if the measurement set-up works correctly.

The EPM 02 is used to check the P1501 or P1502 field source.
The BPM 02 is used to check the P1401 or P1402 field source.

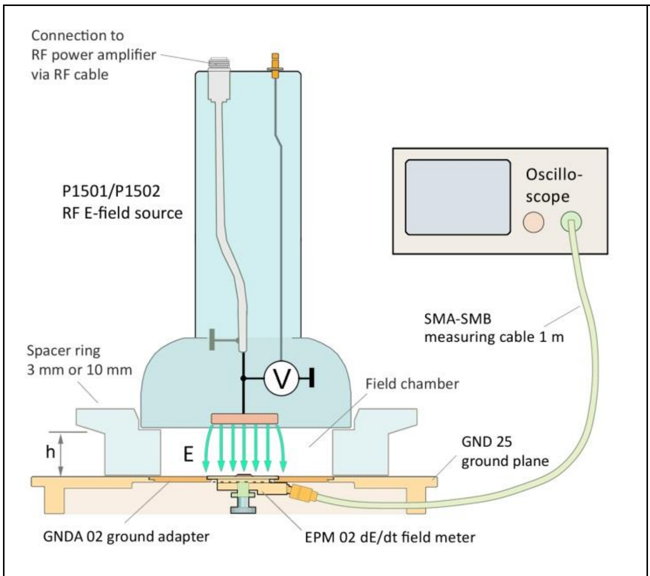

Figure 15 Calibration of P1501/P1502

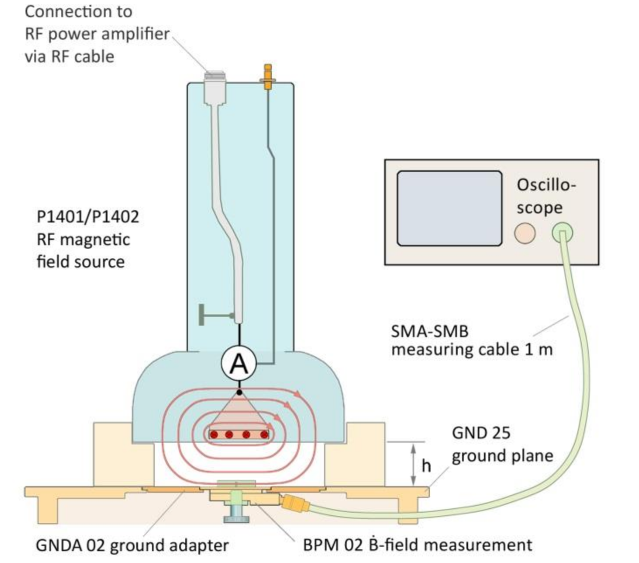

Figure 16 Calibration of P1401/P1402

The basic measurement set-up corresponds to **Figure 1**. The respective field meter is inserted into the ground adapter instead of the test IC. The field strength that is generated by the field source can be determined on the basis of the relations described in section 2.4.

3.4 Measurement set-up

Figure 1 shows the basic set-up for immunity measurements with the P1401/P1501 IC test system and the ICE1 test environment.

The test board together with the test IC is initially inserted into the GND 25 ground plane and connected to the CB 0708 connection board. The IC is supplied with the required input signals via the connection board. At the same time, the test IC's output signals can be monitored during the measurement. Please refer to the user manual of the ICE1 test environment on how to use the connection board.

Use the spacer ring to position and align the respective field source above the test IC when measuring the IC's immunity to disturbances. The field source is then connected to the power amplifier and the signal generator. Additionally, a directional coupler and a power meter can be used to measure the forward and reverse power on the line between the power amplifier and the field source.
The signal generator generates the required test signal. This signal is amplified by the connected power amplifier and transmitted to the field source. The field source converts the input signal into the respective field quantity, in other words into an electric or magnetic field.

3.5 Measurement

The basic measurement can be carried out in accordance with IEC 62132-2:2010, for example:

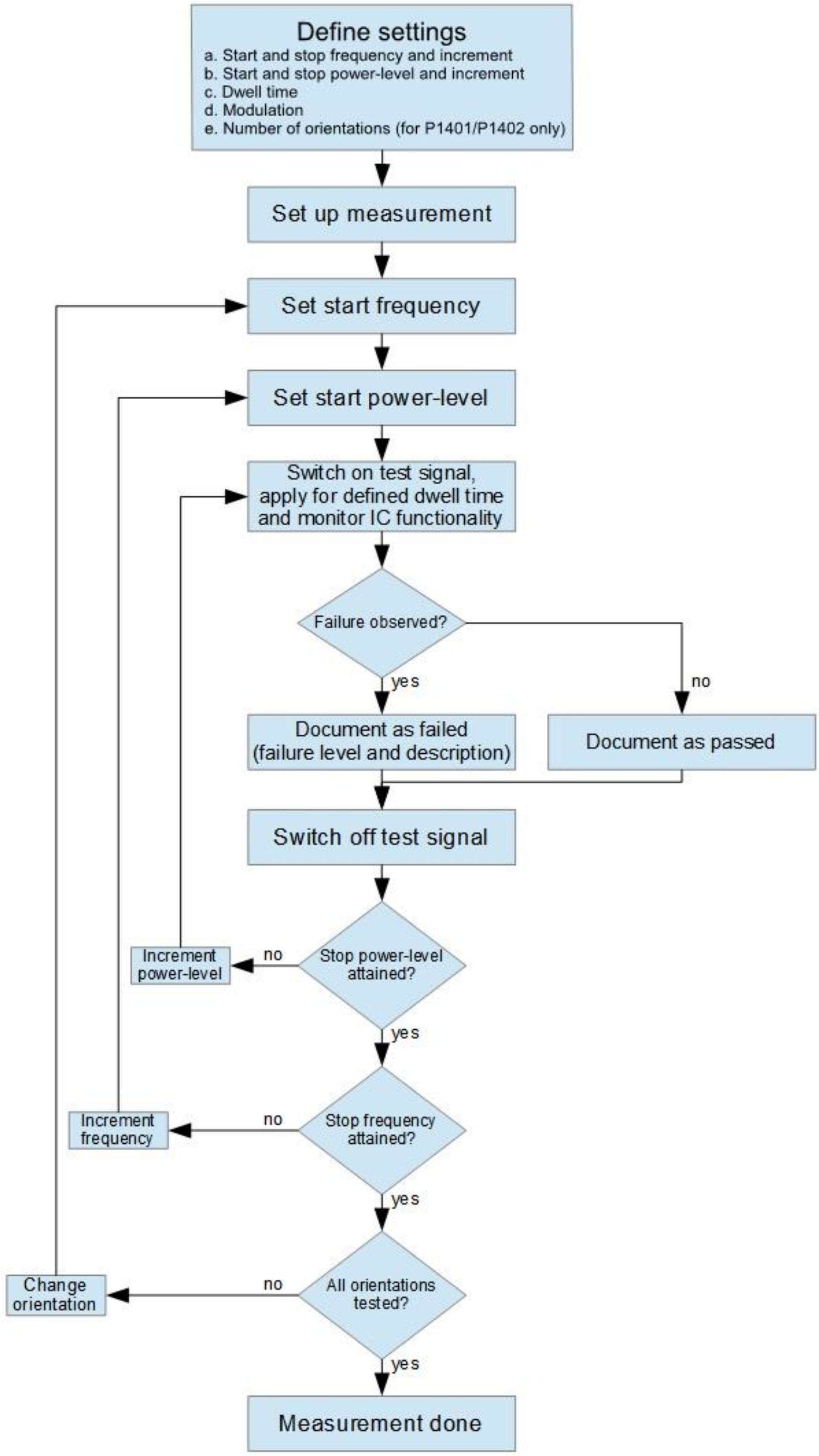

Table 4 Flow chart showing the basic measurement procedure

4 Warranty

Langer EMV-Technik GmbH will remedy any fault caused by defective materials or defective manufacture during the statutory warranty period, either by repair or replacement.

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 for its intended purpose,
- the product has been opened.

5 Technical Parameters

5.1 P1401/P1501

P1401 and P1501 field sources	
Dimensions (height/width/depth)	(180 x 95 x 95) mm
Weight of P1401/P1501	750 g / 700 g
Frequency range	(0 – 1) GHz
Maximum forward power P_{vor}	100 W
Maximum probe current i_P (P1401)	2.8 A
Maximum probe voltage u_P (P1501)	140 V
Internal resistance, P1401/P1501 power input	Operation under short-circuit / open-circuit conditions
Internal resistance, P1401/P1501 measurement output	50 Ω

Table 5 1401 and P1501 field sources – General parameters

P1401 field source – Magnetic flux density B								
P_{vor} in W	0.1	0.5	1	5	10	20	50	100
i_P in A	0.1	0.2	0.3	0.6	0.9	1.3	2	2.8
D70 h03 spacer ring, height h = 3 mm								
B in µT	2.2	4.9	6.9	15.4	21.8	30.9	48.8	69
D70 h10 spacer ring, height h = 10 mm								
B in µT	1.1	2.5	3.5	7.8	11.1	15.7	24.8	35.1

Table 6 P1401 field source – Magnetic flux density generated depending on the forward power P_{vor} and probe current i_P[4]

Bandwidth	1 GHz
Measurement error	approx. 10 %
Attenuator settings	x 20 A / V → 26 dB
Deskew B to v_{out} at measurement output	1 ns

Table 7 Shunt 0.1 Ohm P1401

[4] The values for i_P have to be determined for each measurement set-up (see section 2.4).

DE-01728 Bannewitz
mail@langer-emv.de
www.langer-emv.com

P1501 field source – Electric field strength E								
P_{vor} in W	0.1	0.5	1	5	10	20	50	100
u_p in V	4.5	10	14.1	31.6	44.7	63.2	100	141.4
D70 h03 spacer ring, height h = 3 mm								
E in V/cm	14.9	33.3	47.1	105.4	149.1	210.8	333.3	471.4
D70 h10 spacer ring, height h = 10 mm								
E in V/cm	4.5	10	14.1	31.6	44.7	63.2	100	141.4

Table 8 P1501 field source – Electric field strength generated depending on the forward power P_{vor} and probe voltage u_{P}[5]

Bandwidth	1 GHz
Measurement error	approx. 10 %
Attenuator settings	1000x; → 60dB

Table 9 Voltage divider P1501

[5] The values for u_{P} have to be determined for each measurement set-up (see section 2.4).

5.2 P1402/P1502

P1402 and P1502 field sources	
Dimensions (height/width/depth)	(180 x 95 x 95) mm
Weight of P1401/P1501	750 g / 700 g
Frequency range	(0 – 3) GHz
Maximum forward power P_{vor}	100 W
Maximum probe current i_{P} (P1401)	2.8 A
Maximum probe voltage u_{P} (P1501)	140 V
Internal resistance, P1401 / P1501 power input	Operation under short-circuit / open-circuit conditions
Internal resistance, P1401 / P1501 measurement output	50 Ω

Table 10 P1402 and P1502 field sources – General parameters

P1402 field source – Magnetic flux density B								
P_{vor} in W	0.1	0.5	1	5	10	20	50	100
i_{P} in A	0.06	0.14	0.20	0.45	0.63	0.89	1.41	2.0
D70 h03 spacer, height h = 3 mm								
B in µT	1.5	3.5	4.9	10.9	15.4	21.8	34.5	48.8
D70 h10 spacer, height h = 10 mm								
B in µT	0.8	1.8	2.5	5.5	7.8	11.1	17.5	24.8

Table 11 P1401 field source – Magnetic flux density generated depending on the forward power P_{vor} and probe current i_{P}[6]

Bandwidth	3 GHz
Measurement error	approx. 10 %
Attenuator settings	x 20 A / V → 26 dB
Deskew B to v_{out} at measurement output	1 ns

Table 12 Shunt 0.1 Ohm **P1402**

[6] The values for i_{P} have to be determined for each measurement set-up (see section 2.4).

P1502 field source – Electric field strength								
P_{vor} in W	0.1	0.5	1	5	10	20	50	100
u_{P} in V	3.2	7.1	10	22.3	31.6	44.7	70.7	100
D70 h03 spacer, height h = 3 mm								
E in V /cm	10.5	23.6	33.3	74.5	105	149	236	333
D70 h10 spacer, height h = 10 mm								
E in V /cm	3.2	7.1	10	22.3	31.6	44.7	70.7	100

Table 13 P1501 field source – Electric field strength generated depending on the forward power P_{vor} and probe voltage u_{P}7

Bandwidth	3 GHz
Measurement error	approx. 10 %
Attenuator settings	$246\ \mathrm{dB} - 20\log_{10}\left(\frac{\omega}{\mathrm{Hz}}\right)\ \mathrm{dB}$

Table 14 Capacitive voltage divider **P1502**

7 The values for u_{P} have to be determined for each measurement set-up (see Section 2.4).

5.3 EPM 02 / BPM 02 field meters

BPM 02 dB/dt field meter	
Frequency range	500 kHz - 3 GHz
Magnetic flux density B calculated based on the voltage $\mathrm{u_{out}}$ at the measurement output	$\dot{\mathrm{B}} = \mathrm{K} \cdot \mathrm{u_{out}}$ $\mathrm{K} = 122\ \mathrm{dB}\left(\frac{\mathrm{T}}{\mathrm{V} \cdot \mathrm{s}}\right)$ $\mathrm{B} = (1/\omega)\ \dot{\mathrm{B}}$ $\mathrm{B} = \dot{\mathrm{B}} - 20\ \log_{10}(\omega)$
EPM 02 dE/dt field meter	
Frequency range	500 kHz - 3 GHz
Electric field strength E calculated based on the voltage $\mathrm{u_{out}}$ at the measurement output	$\dot{\mathrm{E}} = \mathrm{K} \cdot \mathrm{u_{out}}$ $\mathrm{K} = 251\ \mathrm{dB}\left(\frac{1}{\mathrm{cm} \cdot \mathrm{s}}\right)$ $\mathrm{E} = (1/\omega)\ \dot{\mathrm{E}}$ $E = \dot{\mathrm{E}} - 20\ log_{10}(\omega)$
Table 15 Conversion factors of BPM 02 and EPM 02	

6 Scope of delivery of the P1401/P1501 set[8]

Item	Designation	Type	Qty.
1	RF Magnetic Field Source	P1401	1
2	RF E-Field Source	P1501	1
3	Spacer Ring, 3 mm	D70 h03	1
4	Spacer Ring, 10 mm	D70 h10	1
5	Measuring Cable	SMA-SMB 1 m	1
6	dB/dt Field Meter	BPM 02	1
7	dE/dt Field Meter	EPM 02	1
8	System Case		1
9	Quick Guide		1
10	User Manual		1
11	CD with conversion factors		1

Figure 17 Case of P1401/P1501 set

[8] The scope of delivery may differ depending on the respective order.

7 Scope of delivery of the P1402/P1502 set[9]

Item	Designation	Type	Qty.
1	RF Magnetic Field Source	P1402	1
2	RF E-Field Source	P1502	1
3	Spacer Ring, 3 mm	D70 h03	1
4	Spacer Ring, 10 mm	D70 h10	1
5	Measuring Cable	SMA-SMB 1 m	1
6	dB/dt Field Meter	BPM 02	1
7	dE/dt Field Meter	EPM 02	1
8	Field Chamber Insert	FKE 30	1
9	System Case		1
10	Quick Guide		1
11	User Manual		1
12	CD with conversion factors		1

Figure 18 Case of P1402/P1502 set

LANGER
EMV-Technik GmbH
Nöthnitzer Hang 31
DE-01728 Bannewitz
www.langer-emv.com
Tel.: +49(0)351/430093-0
Fax: +49(0)351/430093-22
mail@langer-emv.de

9 The scope of delivery may differ depending on the respective order.