IC TEST SYSTEM

User Manual

H4-IC set

EFT/Burst Magnetic Field Source
with BS 06DB-s

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1 Declaration of Conformity

Manufacturer:

Langer EMV-Technik GmbH
Nöthnitzer Hang 31
01728 Bannewitz
Germany

Langer EMV-Technik GmbH hereby affirms, that the product specified below

H4-IC set, EFT/Burst magnetic field source

with BS 06DB-s

agrees with the regulations of EC guidelines:

- Low Voltage Directive 2014/35/EU
- EMC Directive 2014/30/EU
- Restriction of certain Hazardous Substances 2011/65/EU

Applied standards and technical specifications:

- EN 61000-6-1:2007-10 (EMC)
- EN 61000-6-3:2011-09 (EMC)
- DIN EN 50581:2013-02 (Restriction of hazardous substances)

Person authorized to compile the technical file:

Gunter Langer

Bannewitz, 2016-01-25

(Signature)
G. Langer, Geschäftsführer

2 General Information

2.1 Storing the User Manual

This user manual provides the basis for the safe and efficient use of the H4-IC set. It must be kept handy and easily accessible for the user.

2.2 Reading and Understanding the Manual

Read and understand the manual and observe the instructions carefully before using the H4-IC set. Please consult Langer EMV-Technik GmbH if you have any questions or comments.

The user manual must be kept readily available in the immediate vicinity of the product.

2.3 Local Safety and Accident Prevention Regulations

The applicable local general safety and accident prevention regulations must be adhered to.

2.4 Images

Images in this manual facilitate a better understanding, but can deviate from the actual execution.

2.5 Limitations of Liability

The Langer EMV-Technik GmbH is not liable for personal injury or damage to material, if

- the instructions in this user manual were not followed.
- the product was used by personnel who are not qualified in the field of EMC and who are not fit to work under the influence of disturbance voltages and electric and magnetic fields.
- the product was not used as intended.
- the product was arbitrarily modified or technically altered.
- spare parts or accessories were used, that were not authorized by Langer EMV-Technik GmbH.

The actual scope of delivery can deviate from the texts and images in this manual in the case of individual adjustments to the order or recent technical changes.

2.6 Errors and Omissions

The information in this user manual has been checked very carefully and found to be correct to the best of our knowledge; however, Langer EMV-Technik GmbH can assume no responsibility for spelling, typographical or proofreading errors.

2.7 Copyright

The content of this user manual is protected by copyright and may only be used in connection with the H4-IC set. This user manual may not be used for other purposes without the prior consent of Langer EMV-Technik GmbH.

3 Scope of Delivery

Item	Designation	Type	Qty.
1	EFT/burst magnetic field source	**BS 06DB-s**	1
2	High-voltage cable Fischer-SMB	HV FI-SMB 1 m	1
3	System case A5	H4-IC case	1
4	Quick guide	H4-IC qg	1
5	User manual	H4-IC m	1

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

Figure 1: System case (exemplary scope of delivery)

4 Technical Parameters BS 06DB-s

Weight	15 g
Dimensions (L x W x H)	(140 x 8 x 8) mm
Frequency range	0…66 MHz
Maximum supply voltage (IEC 61000-4-4)	4.5 kV
Maximum supply current, peak value I_P	80 A
Waveform and frequency of the injected test pulse	IEC 61000-4-4
Transfer constant K1 (L'), injected current I_P to magnetic field B, $B = K1\ I_P$ at h = 0.2 mm	2.37 mT / A
Low-frequency cut-off f_{UG} [kHz]	0
High-frequency cut-off f_{OG} [MHz]	66 MHz
Diameter D of the field-line bundle at the tip of the probe head	1.8 mm
Cross-section A	2.54 mm²
Self-inductance at I_P = 40 A	9 nH
Self-inductance per unit length at I_P = 40 A	3.6 nH / mm²
Maximum magnetic flux density B_{max} at I_P = 80 A	200 mT
Maximum magnetic flux Φ_{max} at I_{Pmax} = 80 A	540 nVs
E-field suppression Voltage U_F / generator voltage U_{VG} coupled from the tip of the probe head to the test IC	37 dB 11.7 V / 1,000 V

Table 1: Technical parameters of BS 06DB-s field source

5 Safety Instructions

Please observe the following safety instructions when using a product from Langer EMV-Technik GmbH to protect yourself against the risk of electric shocks or injuries.

- 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 this device.
- The test set-up should always be operated via a filtered power supply.
- **Attention! Functional near fields and interference emissions may occur when the field source is operated. The user is responsible for taking appropriate precautions to prevent any interference to the correct function of products outside the operational EMC environment (in particular through interference emissions).**

  This can be achieved by:

  - observing an appropriate safety distance,
  - use of shielded or shielding rooms.

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

- The disturbances that are injected into the modules can destroy the device under test (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 device under test in the event of a latch-up.

Attention! Make sure that internal functional faults are visible from outside. The device under test 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:

- monitor the representative signals in the device under test,
- special test software,
- visible reaction of the device under test to inputs (reaction test of the device under test).

We cannot assume any liability for the destruction of devices under test!

6 Use of the BS 06DB-s Field Source

The BS 06DB-s magnetic field source is used to generate magnetic EFT/burst fields. An EFT/burst generator (IEC 61000-4-4) supplies the field source with an EFT/burst current via an HV cable. The field source generates strong magnetic fields (approx. 200 mT) in very small spaces (2.54 mm²). Thus it is ideal to couple fields to ICs (**Figure 2**).

The BS 06DB-s magnetic field source is typically used

1. in conjunction with the ICS 105 set IC scanner and ICE1 set IC test environment to provide a measurement set-up where ICs can be tested during their development. (**Figure 3** and **Figure 4**).
2. in special measurement set-ups of the user or as a field source for general purposes. The field source can be guided by hand.

The magnetic field emerges vertically from the tip of the field source in a bundle. The field source is usually aligned so that the field-line bundle penetrates the area of the IC housing and thus the die in an orthogonal direction (**Figure 2**). This ensures the highest induction effect in the loops of the die (approx. 30 V/mm²). In practice, however, the interference field is usually parallel to the die surface and thus does not penetrate the die (see “EFT/burst field source probe set” user manual or “P1202-2 ESD magnetic field source” user manual).

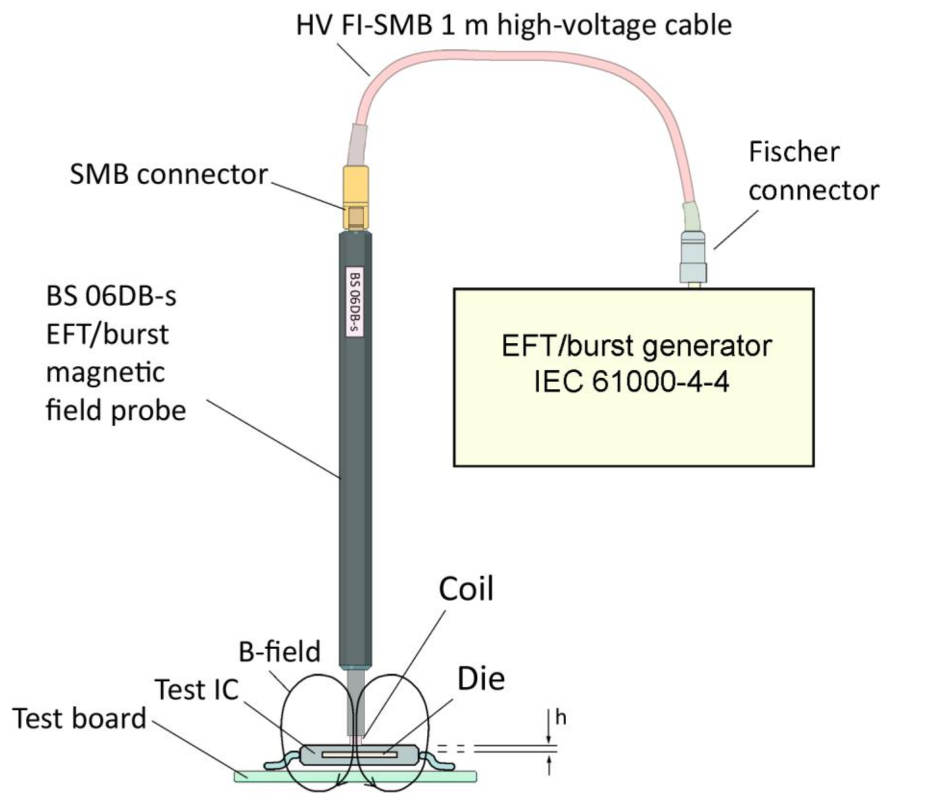

Figure 2: Principal use of the BS 06DB-s EFT/burst magnetic field source

The coordinates of the field source can only be detected with low precision if the field source is guided by hand over the device under test (DUT, such as an IC, component or printed circuit board). A defined point on the IC surface can only be approached roughly and is almost impossible to reproduce. The field source cannot be guided safely enough by hand if the die is exposed. The IC may be damaged.

In order to avoid these disadvantages, the field source can be guided automatically by a positioning system. The ICS 105 IC scanner (**Figure 3**) is such a positioning system that is able to guide the field source precisely, reproducibly and safely.

Figure 3: Use of the BS 06DB-s EFT/burst field source in conjunction with the ICS 105 IC scanner and ICE1 set components

The ICS 105 IC scanner is an integral part of the IC test system (Langer EMV-Technik GmbH). The ICE1 set implements the test environment of an IC test bench. This test bench can be used to perform all important EMC measurements on ICs. Only a single test board has to be designed for all measurements on an IC (**Figure 4**). HF measurements such as field measurements with ICR near-field micro-probes (Langer EMV-Technik GmbH) over the die, conducted measurements acc. to the 1 Ohm method or 150 Ohm method or DPI, EFT/burst measurements can be performed automatically (ICT1 IC tester for automated EMC tests, Langer EMV-Technik GmbH).

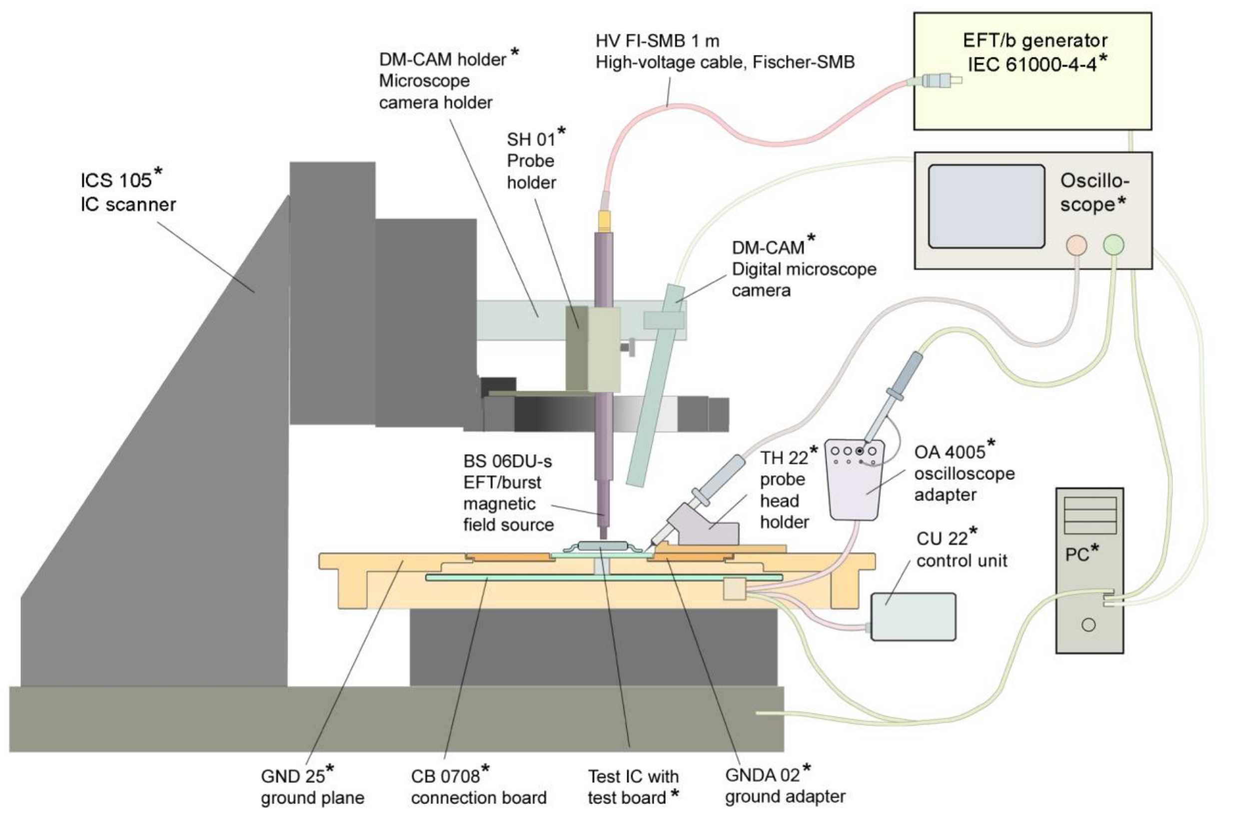

Figure 4: Measurement set-up using the components of the IC test system: ICS 105 IC scanner, ICE1 set and BS 06DB-s EFT/burst field source. Additional devices such as an EFT/burst generator, oscilloscope and PC supplement the measurement set-up. *Items marked with an asterisk (*) are not part of the H4-IC set.*

The field source is attached to the rotary unit of the ICS 105 IC scanner using the SH 01 probe holder (**Figure 5**, **Figure 6**). The probe holder has the function of collision control: If the field source encounters resistance while moving downwards (field source meets the IC), the field source in the probe holder will move upwards. This displacement can be detected by the ICS 105 IC scanner and the movement is stopped.

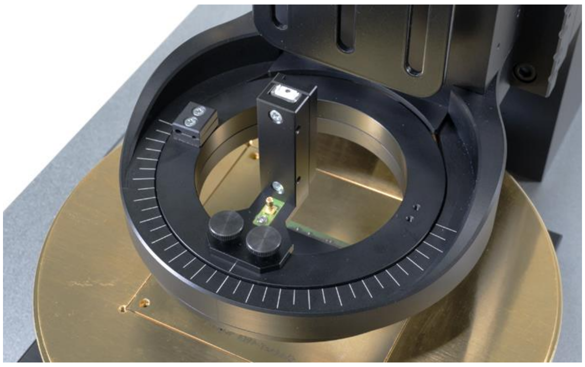

Figure 5: SH 01 probe holder attached to the rotary unit of the IC scanner

Figure 6: Field source attached to SH 01 and connected to IC scanner

7 Design and Function

The BS 06DB-s field source has a coil to generate the magnetic field (**Figure 7**). The coil is supplied by an EFT/burst generator (IEC 61000-4-4) via the HV cable connected to the SMB connector. The shaft of the field source has a sheath current damping to limit interference. Its interior is fully shielded. The magnetic field emerges from the tip of the field source as a field-line bundle. The diameter of this bundle is D = 1.8 mm at the outlet. The field lines of the bundle are returned towards the field probe's shaft and to the coil in a closed circle. The density of the field lines and thus the strength of the magnetic flux density decreases with an increasing distance h from the coil.

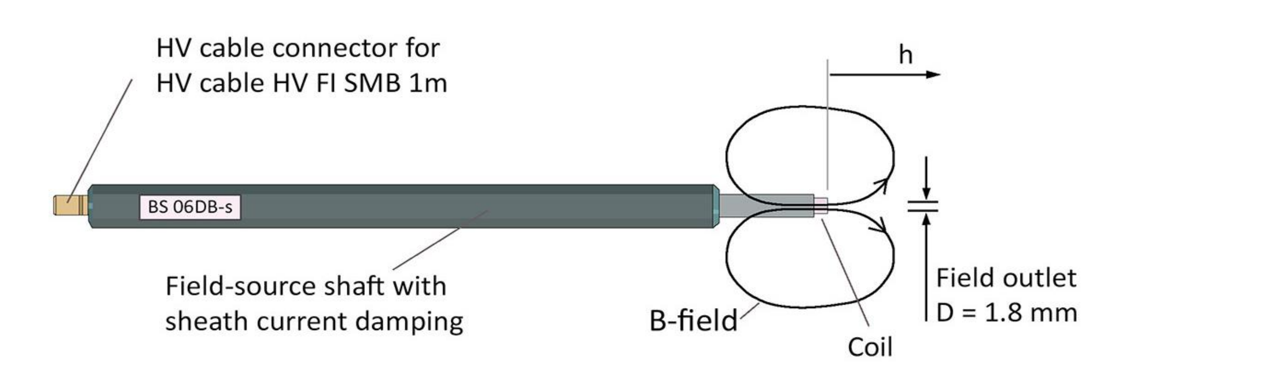

Figure 7: Design of the BS 06DB-s field source

The EFT/burst generator drives a current i_P into the coil of the field source via the HV current path (**Figure 8**). The field source has no terminating resistor. Reflexions (**Figure 9**) develop on the tail of the current pulse depending on the length of the cable (HV FI SMB 1 m). The current is essentially limited by the internal resistance R_G of the EFT/burst generator.

$I_P = U_{VG} / R_G$	Eqn 1

U_{VG} is the peak value of the EFT/burst generator's driving voltage. The internal resistance of the EFT/burst generator is usually 50 Ohm. Thus the peak value I_P of the coil current can be calculated.

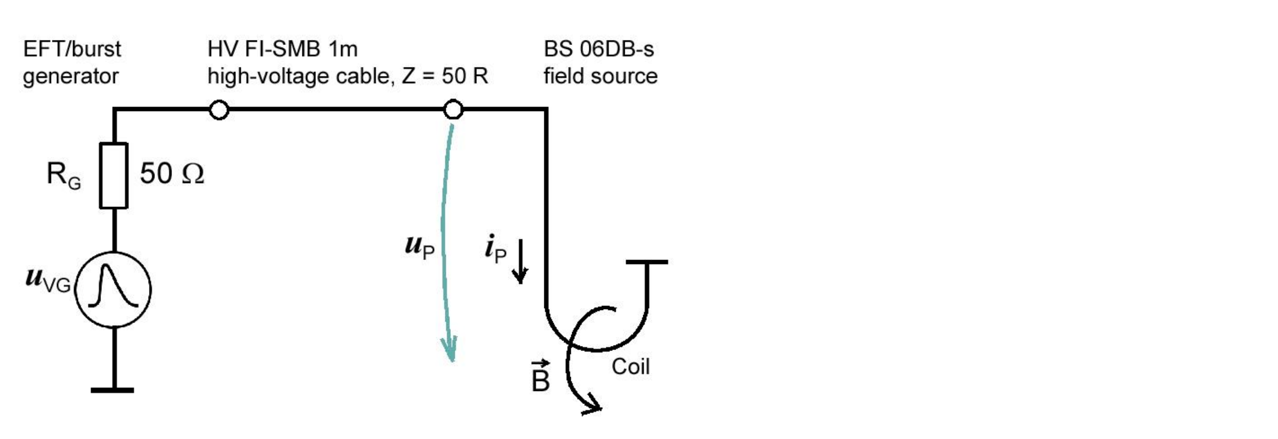

Figure 8: Equivalent circuit diagram with EFT/burst generator (IEC 61000-4-4), HV FI SMB 1 m high-voltage cable and BS 06DB-s field source.

The magnetic flux φ that is generated by the coil of the field source is proportional to the coil current i_P and the inductance L of the coil is the proportionality factor.

$\Phi(t) = L \cdot i(t)$	Eqn 2

If it is assumed that the flux density B is constant across the outlet area A of the field source, the following applies:

$B(t) = \Phi(t) / A = L \cdot i_P(t) / A = L' \cdot i(t)$	Eqn 3

Where

$L' = L / A$	Eqn 4

is the coil's inductance per unit length.

Figure 9 shows the variations of the coil current $i_P(t)$ and flux density B(t) over time that were determined by measurements. The flux density B(t) of the field source was measured at a distance of h = 0.2 mm. The inductance per unit length L' can be calculated on the basis of the measured values:

Figure 7, for h = 0.2 mm, Eqn 3

$L' = B / I_p = 53.74\ \text{mT} / 20\ \text{A} = 2.687\ \text{mH/m}^2 = 2.687\ \text{nH/mm}^2$

The coupling inductance L_h of the field source relative to a loop with a diameter of 1.8 mm can be calculated from:

$L = L' \cdot A = 2.687\ \text{nH/mm}^2 \cdot \pi \cdot (1.8\ \text{mm})^2 / 4 = 6.8\ \text{nH}$

Where the field source is at a distance of 0.2 mm. The value L that was calculated is smaller than the coil's self-inductance (9.0 nH at h = 0).
The inductance L of the field source also depends to a certain extent on the current I_P on account of the field source's ferrite material.

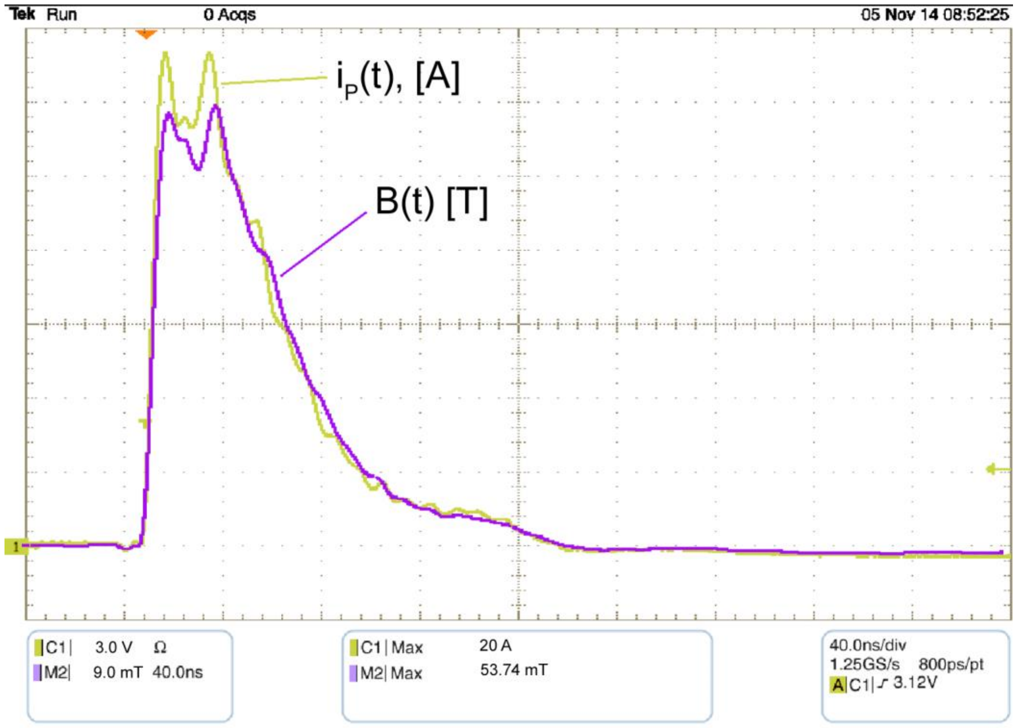

Figure 9: BS 06DB-s, variation of the EFT/burst current and B field over time at I_P 20 A and a height h = 0.2 mm

The magnetic field B(t) (**Figure 9**) does not exactly follow the curve of the current i_P(t). Compared with i(t), B(t) is too small in the peak area due to the material used for the core. **Figure 10** shows the frequency response between the current i_P(t) and the flux density B(t). There is a drop of 3 dB at 66 MHz.

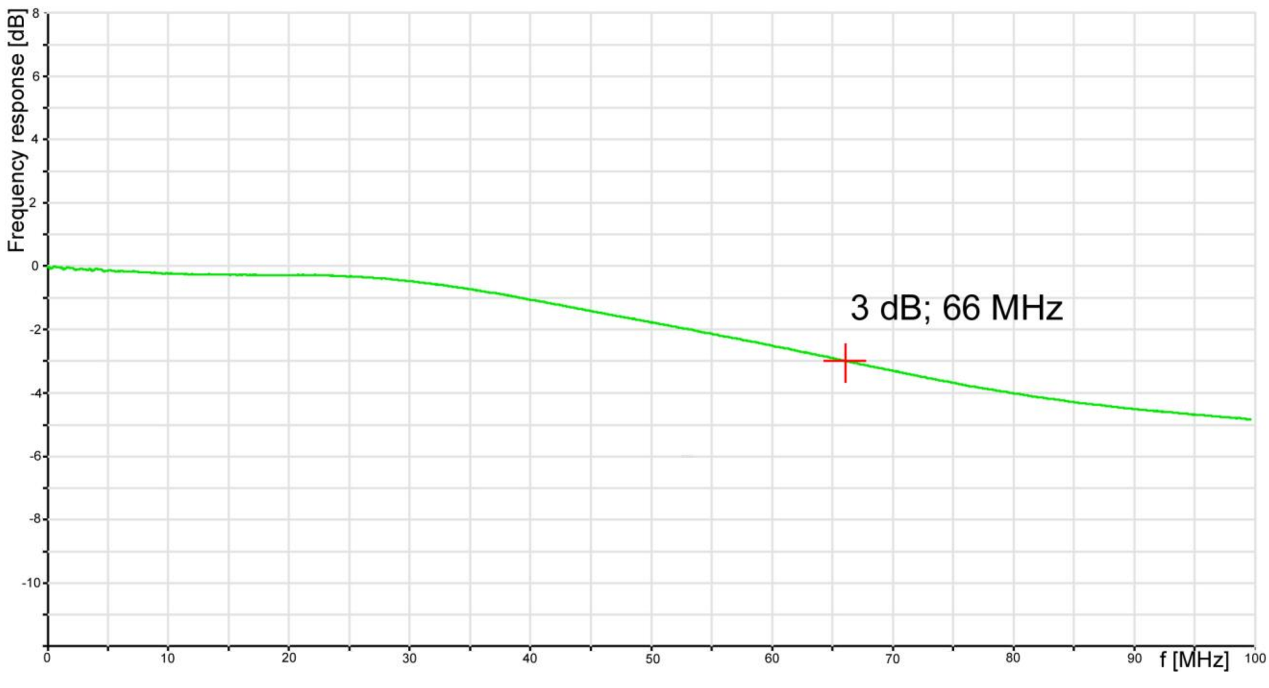

Figure 10: Frequency response of the emitted flux density B

Figure 11 shows the flux density B as a function of the current I_P and the distance h.

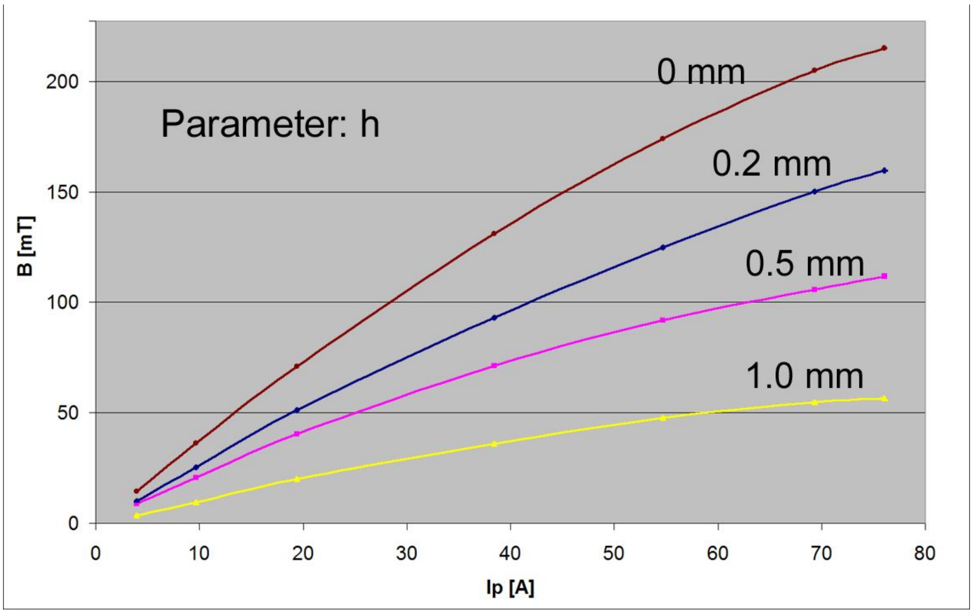

Figure 11: Flux density B provided by the BS 06DB-s field source as a function of the coil current. The distance h of the field source from the measuring point is the parameter.

The effective flux density B can be obtained from the diagram in **Figure 11** for each specific individual case. The required current I_P can be calculated from the voltage U_P that is set at the EFT/burst generator according to Eqn 1. The distance h corresponds to the distance between the IC loop and the field source.
The field source's inductance per unit length can be used for further calculations. The coil / IC loop coupling inductance can be calculated and/or estimated from the area A of the IC loop.

h [mm]	L' [nH / mm²], at I_P = 40 A	L [nH], at I_P = 40 A
0	3.6	9.0
0.2	2.4	6
0.5	1.8	4.6
1.0	0.94	2.4

Table 2: Inductance of the BS 06DB-s field source

The inductance per unit length depends on the distance h to the field source. The inductance also depends on the current I_P on account of the core material. The deviation is up to ±15%. Please refer to **Figure 11** for more precise values.

7.1 Quality Parameters of the Field Source

7.1.1 Parameter that determines the Flux Density produced by the Supply Current Flow and the maximum possible Flux Density B_{max}

Eqn 3 together with I_P and B results in:

$B = L' \cdot I_P$	Eqn 5

The self-inductance per unit length L' is a first parameter that characterizes the field probe's performance.

It determines the flux density B which is produced by the supply current I_P.
L' has to be used for h = 0 to obtain the absolute maximum value B_{max}. The maximum possible flux density B_{max} is provided together with the maximum permissible supply current I_{Pmax}.

B_{max} = 2.75 nH (at 80 A) / mm² 80 A 10^6 mm²/m = 220 mT[1]

7.1.2 Parameter that determines the Flux produced by the Supply Current I_P and maximum possible Magnetic Flux Φ_{max}

Eqn 2 together with I_P and Φ results in:

$\Phi = L \cdot I_P$	Eqn 6

The self-inductance L is a second parameter that characterizes the field probe's performance.

It determines for the magnetic flux Φ that is produced by the supply current I_P.
L has to be used for h = 0 to obtain the absolute maximum value Φ_{max}. The maximum possible flux Φ_{max} is provided together with the maximum permissible supply current I_{Pmax}.

Φ_{max} = 6.75 nH (at 80 A) · 80 A = 540 nVs

[1] B_{max} ist ein theoretisch berechneter Wert.

7.2 Inductive Coupling Mechanism

Figure 12 shows the flux equivalent circuit diagram of the field source's coil and the IC loop.

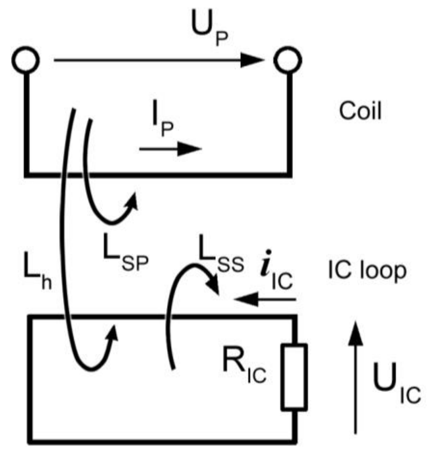

Figure 12: Flux equivalent circuit diagram of the BS 06DB-s field source's coil and the IC loop

The current i_P in the coil generates a vortex magnetic field. The share of the vortex magnetic field which penetrates the IC loop is assigned to the principal inductance L_h. The principal inductance L_h mediates between the current i_P of the field source and the flux Φ which flows through the IC loop.

The following voltage u_{ind} is then induced:

$u_{ind} = - L_h \cdot di_P / dt$	Eqn 7

The IC loop has the self-inductance L_{SS}. The flux equivalent circuit diagram (**Figure 12**) can be transferred to a transformer equivalent circuit diagram (**Figure 13**).
There are two main types of inductive coupling from the coil of the field source to the loops of the test IC.

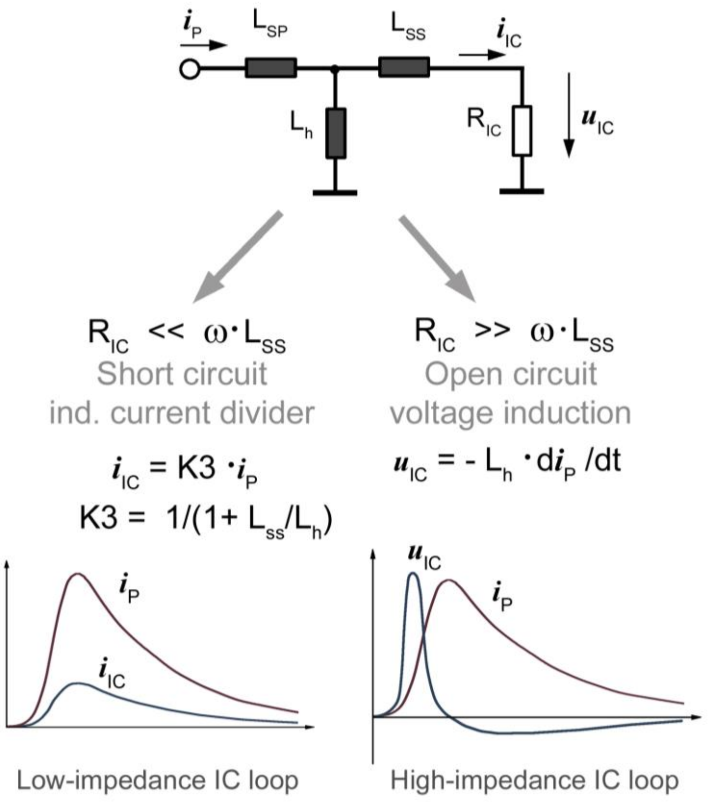

Figure 13: Transformer equivalent circuit diagram of coupling between the electric conductor of the BS 06DB-s field source and the IC loop; main types of coupling by case distinction

Determining the main types of inductive coupling by case distinction:

1. **Current Coupling**

The circuit operates under short-circuit conditions if R_{IC} << ω L_{ss}. The inductances L_h and L_{ss} form a current divider. The currents are divided at the ratio L_h / L_{ss} independent of the frequency (simplification L_{ss} >> L_h: $1/(1+L_{ss}/L_h) = L_h / L_{ss}$). The variation of the current pulse in the IC over time is thus equal to that of the EFT/burst pulse in the electric conductor of the field source. This means that a current pulse i_{IC} of 5/50 ns flows in the IC. The peak value is attenuated by the coupling factor K3 (**Figure 13**). R_{IC} must be in the range of 0.1 Ohm so as to transfer all frequency components of the EFT/burst pulse. This is implemented in Vdd / Vss loops.

2. **Voltage Coupling**

The circuit operates like a voltage transformer under open-circuit conditions if R_{IC} >> ω L_{ss}. The voltage induced on the inductance L_h is present in the IC (open-circuit voltage). It changes depending on the frequency according to the law of induction (Eqn 7, Eqn 8).

$u_{ind} = -\omega \cdot L_h \cdot i_P$	Eqn 8

Current components with a higher frequency generate a higher voltage. The current pulse i_P is differentiated (**Figure 13**). This is particularly important for ESD coupling as the disturbance process takes place at a higher frequency than with EFT/burst. R_{IC} must be in the range of > 5 Ohm to transfer all frequency components of the EFT/burst pulse according to Eqn 8.

7.3 Current Coupling to the IC

The L_h / L_{ss} ratio (reduced from L_{ss} >> L_h: $1/(1+L_{ss} / L_h) = L_h/L_{ss}$) determines the coupling of current to an IC loop (**Figure 13**). L_h is equal to the probe's inductance L if it is assumed in a simplified way that the field source's total flux encircles the IC loop. Only part of the field-line bundle penetrates the IC loop if this is small. Furthermore, coupling depends on the height h of the field source above the IC loop. L_h is determined from the specific inductance L_h' (**Table 2**) of the field source and the surface area A of the IC loop.

$L_h = L_h' \cdot A_{IC}$	Eqn 9

A_{IC} is the effective cross-section of the test IC loop and can be determined on the basis of its design.

The resistance R_{IC} (**Figure 13**) essentially determines the effectiveness of current coupling. Current coupling is effective for supply loops due to their low resistance. L_h can be determined on the basis of the inductance per unit length L' and A_{IC} for calculations. L_{ss} has to be determined on the basis of the IC design. The coupling factor K3 can be calculated from L_h and L_{ss} for the current transfer (Eqn 10).

$i_{IC} = K3 \cdot i_P$	Eqn 10

7.4 Voltage Coupling to the IC

The coil in the field source is coupled inductively to the conductor loop in the test IC. The coupling effect is described by the law of induction (Eqn 7).

L_h is determined from the specific inductance L_h' of the field source and the surface area A of the IC loop.

$L_h = L_h' \cdot A$	Eqn 11

A_{IC} is the effective cross-section of the test IC loop. The cross-sections A_{IC} of the loops in the test IC can be determined on the basis of its design. The voltage which is induced in the loop of the test IC can be calculated from this value, the inductance per unit length and the current differential di_P / dt. These values can be used for a simulation on the IC.

di_P / dt for EFT/burst can be roughly calculated from the rise time of the pulse Δt = 5 ns and the peak value of the current Δi_P:

$\Delta i_P / \Delta t = I_P / 5\ ns$	Eqn 12

di_P / dt can also be measured with an oscilloscope.

The induced voltage can be calculated directly from the flux density in the area of the test IC:

$u_{ind} = - A_{IC} \cdot dB / dt$	Eqn 13

dB / dt can be replaced by:

$\Delta B / \Delta t = B / 5\ ns$	Eqn 14

The equation Eqn 13 establishes a direct relationship between the magnetic field B and the induced voltage u_{ind}.

A voltage u_{ind} (Eqn 13) is induced at a flux density of 160 mT and a loop size of 1 mm²:

$U_{ind} = \Delta B \cdot A / \Delta t = 160\ mT \cdot 1\ mm^2 / 5\ ns = 32\ V$

8 Coupling into IC Loops

The distance h to the IC loop has to be kept small to make coupling as effective as possible. This is achieved by placing the field source vertically on the IC housing (**Figure 14**) or the die. The SH 01 probe holder (**Figure 5** and **Figure 6**) allows the field source to be placed on the device under test with no great exertion of force.

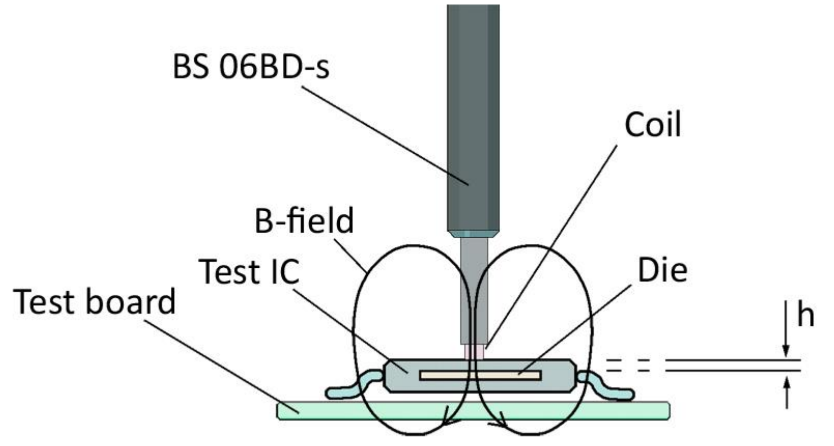

Figure 14: Coupling to the IC

The field-line bundle of the field source penetrates the die in an orthogonal direction (**Figure 14**). Loops that are in the same (horizontal) plane as the die are penetrated by the field-line bundle. Either voltage and/or current are transferred in the loops depending on the type of coupling (**Figure 14**).
The field-line bundle of the field source will also encircle loops that are closed outside the die. The loops are orthogonal to the die and are formed by networks of the test board, IC pins, bonding wires, die, etc. Similar voltages may be induced inside these. Field sources which are larger than the BS 06DB-s field source can induce similar or higher voltages.

9 Guiding the Field Source

The BS 06DB-s field source has to be arranged relative to the IC loops so that an optimal effect is achieved. The emerging flux Φ is a parameter that depends on the supply current according to Eqn 2. The field source produces a magnetic flux Φ(t) that depends on the current or the supply voltage (Eqn 1) of the EFT/burst generator. Based on its internal resistance of 50 Ohm and at an EFT/burst voltage U_{VG} = 2 kV, the EFT/burst generator drives a short-circuit current of 40 A into the field source. The field source produces a flux of:

$\Phi(t) = L \cdot i(t) = 6.8\ \text{nH} \cdot 40\ \text{A} = 270\ \text{nVs}$

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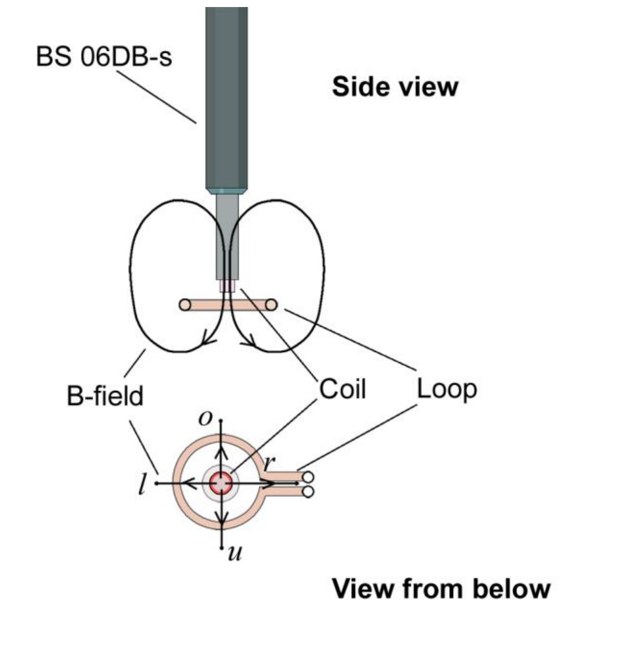
<td>
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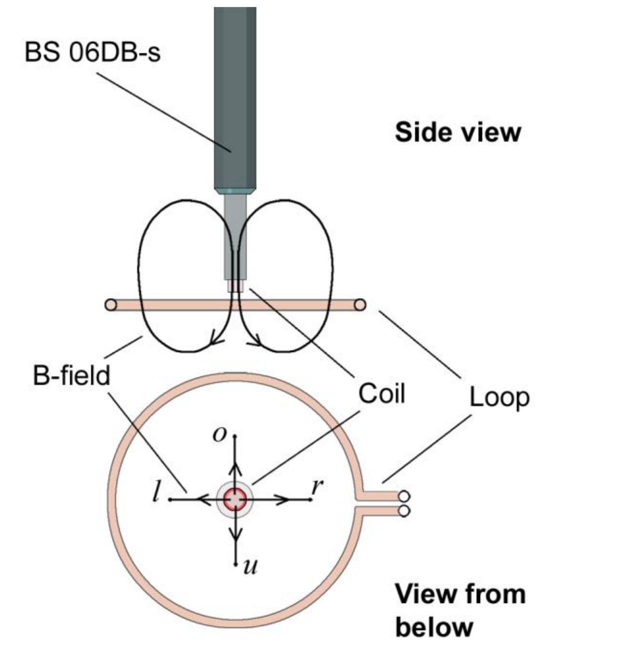
<td>
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<td>Figure 15: Coupling to a horizontal loop. Field lines encircle the conductor of a small IC loop.</td>
<td>Figure 16: Field lines which enter a large loop but also emerge from within its surface area do not induce any voltage.</td>
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</table>

The field-line bundle is homogenous at the outlet area of the field source. The field lines (**Figure 15**) bend outward after leaving the field source. The flux density decreases with an increasing distance h from the coil. The field lines then move up to close the circle in the coil. The field lines that encircle the electric conductor of the IC loop result in a voltage being induced in the IC loop.

Coupling is best if the IC loop approximately corresponds to the diameter of the field source (1.8 mm). If the IC loop becomes too large, the field lines will bend upward within the IC loop (**Figure 16**). These field lines will not encircle the IC loop conductor and thus not result in voltage induction. This may occur if the IC loop is larger than the diameter of the field source. The larger the loop the less field lines are effective.

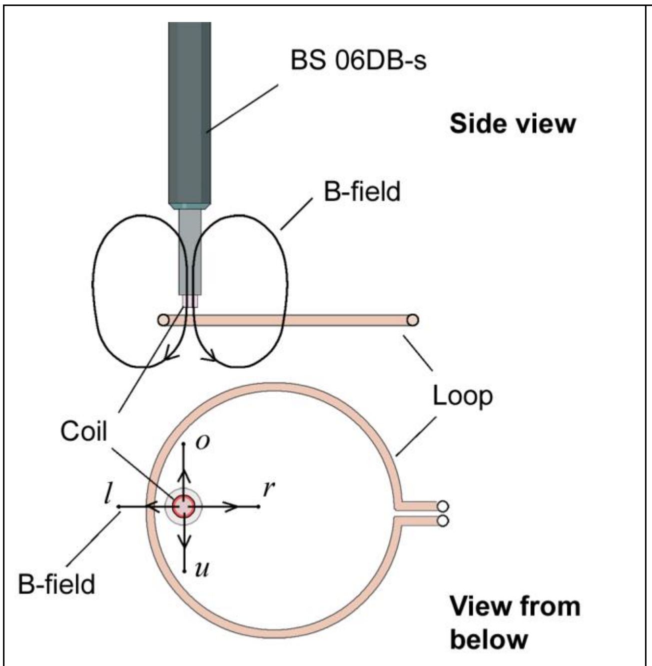

Figure 17: The field source may induce a voltage at the inner perimeter of a large loop

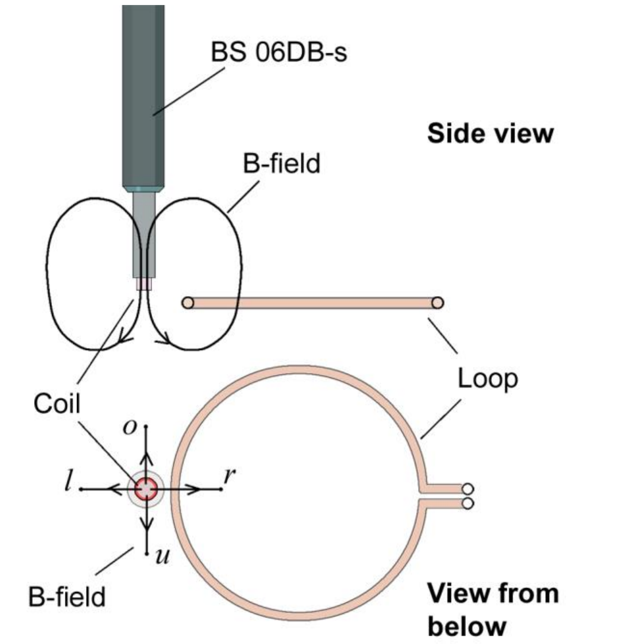

Figure 18: The field source may induce a voltage at the outer perimeter of a large loop

Field lines will encircle the conductor of the IC loop again if the field source is guided to the perimeter of an IC loop. The field source can be guided to the loop's perimeter from the inside (**Figure 17**) or outside (**Figure 18**). The field lines that fully encircle the loop's conductor induce a voltage inside the loop. These interactions also apply to straight conductors.

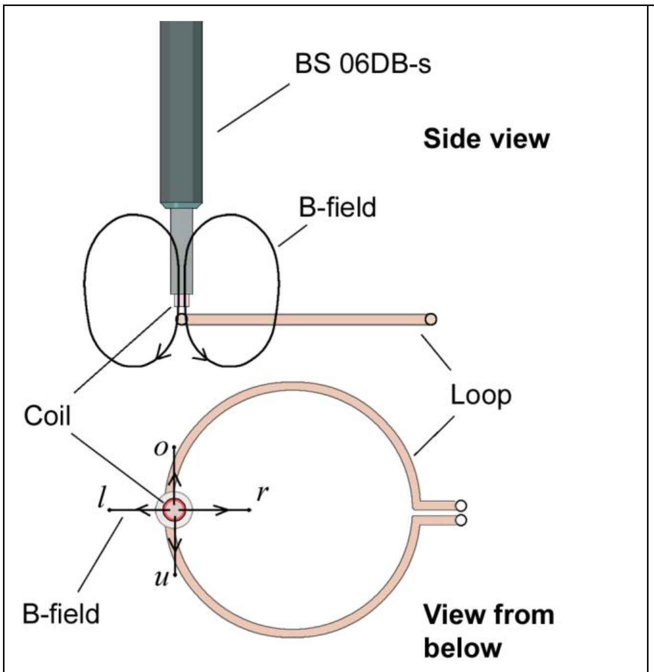

Figure 19: A coil arranged above a conductor does not produce any B-field lines which encircle the conductor

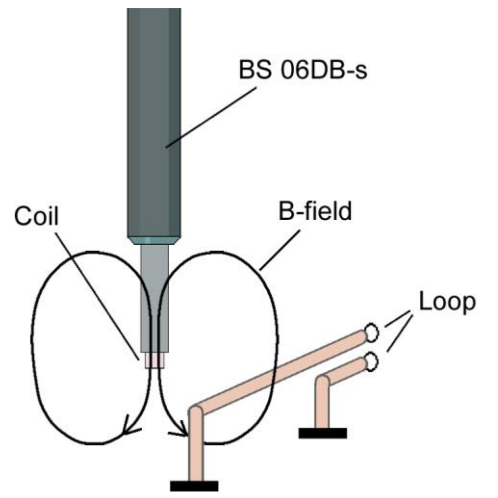

Figure 20: Coupling to a vertical loop / conductor

No field line encircles the conductor if the probe is arranged directly above the conductor of a large loop (**Figure 19**) and the set-up is adjusted with great precision. No voltage is induced. This means the probe does not interfere with the test IC if it is placed directly above the susceptible conductor. Interference with the IC is only possible if the probe is placed to the left or right of the conductor (**Figure 17** and **Figure 18**). Similarly, the field source has to be placed to the left or right of a vertical loop (**Figure 19** and **Figure 20**) to allow the field lines encircle the loop's conductor.

10 E-Field Suppression

The EFT/burst current I_P generates a voltage in the coil of the field source. This voltage cannot be completely shielded. There is a low residual voltage U_F that generates an electric field to GND. When the field source is placed on the IC, the field acts on and may interfere with the die.
The voltage U_F that is reduced by shielding is proportional to the EFT/burst generator voltage U_{VG}.

U_F / U_{VG} = 11.7 V /1000 V

Hence, it follows that the E-field suppression is 37 dB.

11 Warranty

Langer EMV-Technik GmbH will remedy any fault due to defective material or defective manufacture, either by repair or by delivery of spare parts, 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 for its intended purpose.

Documentation:

Task	Instruction manual
• Instructions for the development of the test board • Test process	IC test instruction manual (Langer EMV-Technik GmbH)
• GND 25 ground plane • GNDA 02 ground adapter • Monitoring and controlling the test IC	ICE1 set user manual (Langer EMV-Technik GmbH)
• Positioning of BS 06DB-s	ICS 105 set user manual (Langer EMV-Technik Gmbh)
• Burst generator • Oscilloscope • PC	Operating instructions of the manufacturers

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