LANGER
EMV-Technik

IC TEST SYSTEM

User Manual

H5-IC set

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

CE

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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

H5-IC set, EFT/Burst magnetic field source

with BS 06DU-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, 2020-03-25

(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 H5-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 H5-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

3 Scope of Delivery

Item	Designation	Type	Qty.
1	EFT/burst magnetic field source	BS 06DU-s	1
2	High-voltage cable	HV FI SMB 1 m / SHV-SMB 1 m	1
3	System case	H5-IC set case	1
4	Quick guide		1
5	User manual		1

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

Figure 1: System case (exemplary scope of delivery)

4 Technical Parameters

Weight	15 g
Dimensions (L x W x H)	(140 x 8 x 8) mm
Frequency range	0…560 MHz
Maximum supply voltage (IEC 61000-4-4)	4 kV
Maximum supply current, peak value I_P	80 A
Waveform of the injected test pulse	IEC 61000-4-4
Low-frequency cut-off f_{UG} [kHz]	0
High-frequency cut-off f_{OG} [MHz]	560 MHz
Maximum magnetic flux density B_{max} at I_P = 80 A	150 mT
Maximum magnetic flux Φ_{max} at I_{Pmax} = 80 A	1800 nVs
E-field suppression Voltage U_F / generator voltage U_{VG} coupled from the tip of the probe head to the test IC	26 dB 50 V / 1000 V

Table 1: Technical parameters of BS 06DU-s

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 06DU-s Field Source

The BS 06DU-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. 150 mT) in very small spaces. Thus it is ideal to couple fields to ICs and conductor loops (**Figure 2**).

The BS 06DU-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 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 a circular direction from the tip (**Figure 2**). This ensures the highest induction effect in the loops of the die.

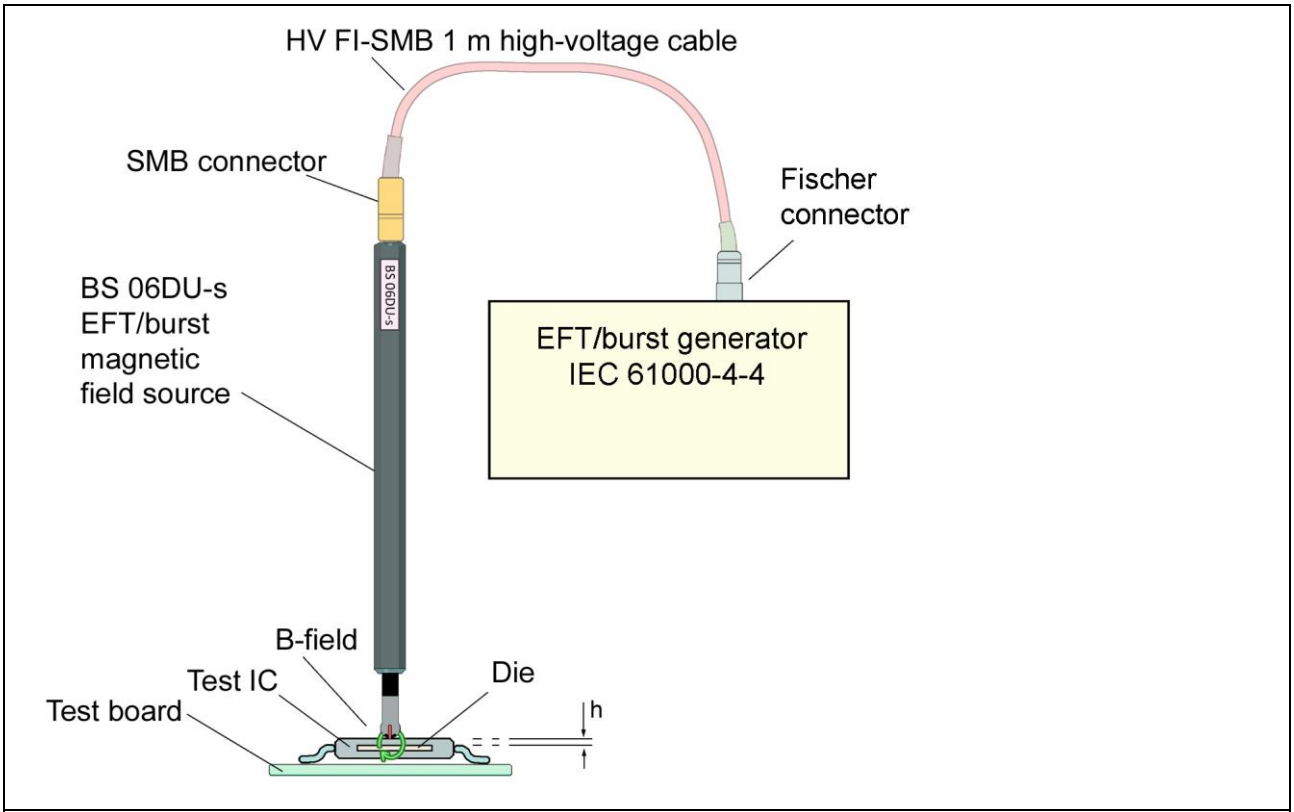

Figure 2: Principal use of the BS 06DU-s EFT/burst magnetic field source

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's 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 06DU-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 microprobes (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).

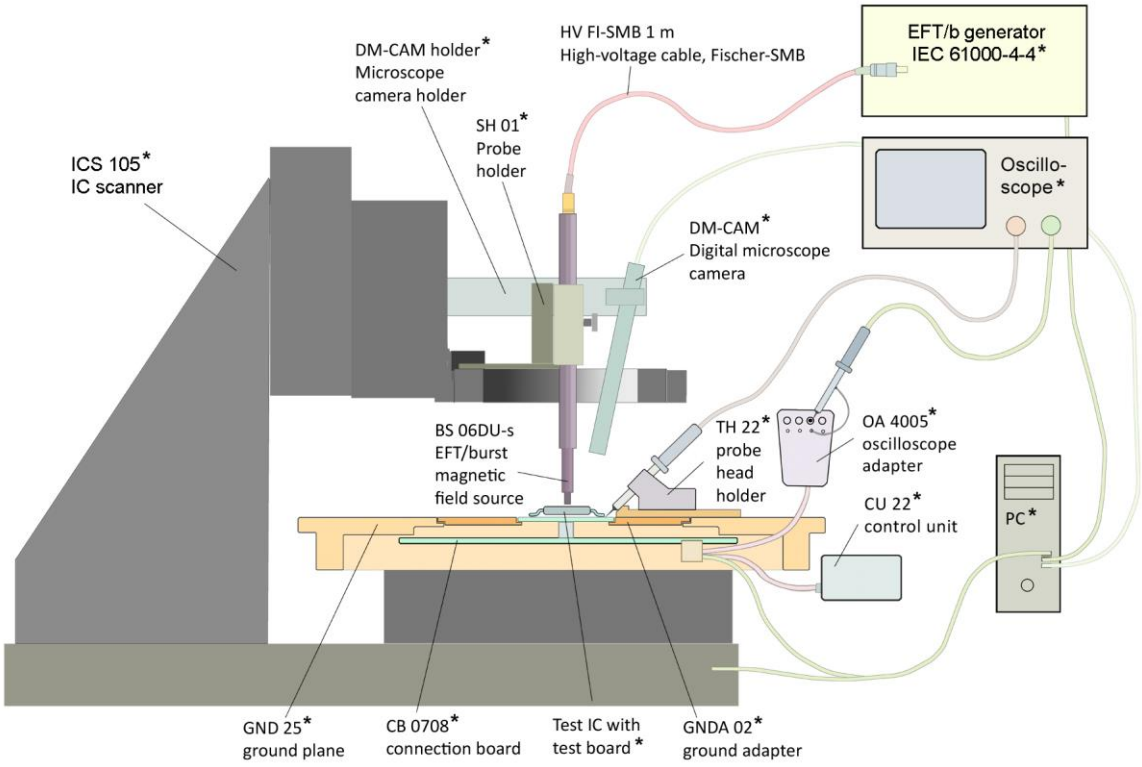

Figure 4: Measurement set-up using the components of the IC test system: ICS 105 IC scanner, ICE1 set and BS 06DU-s EFT/burst magnetic field source. Additional devices such as an EFT/burst generator, oscilloscope and PC supplement the measurement set-up. *Items marked with an asterisk (*) are not part of the H5-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**). 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.

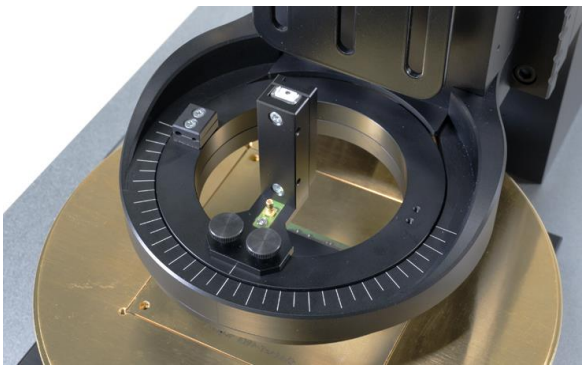

Figure 5: SH 01 probe holder attached to the rotary unit of the IC scanner

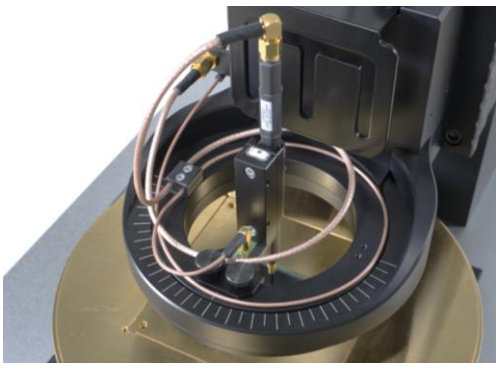

Figure 6: Field source attached to SH 01 and connected to IC scanner

7 Design and Function

The BS 06DU-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 corresponding 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 field lines of the field line bundle run in a circle at the front of the tip (**Figure 10**). They have a closed course. As the distance h from the coil increases, the density of the lines and thus the strength of the magnetic flux density decreases.

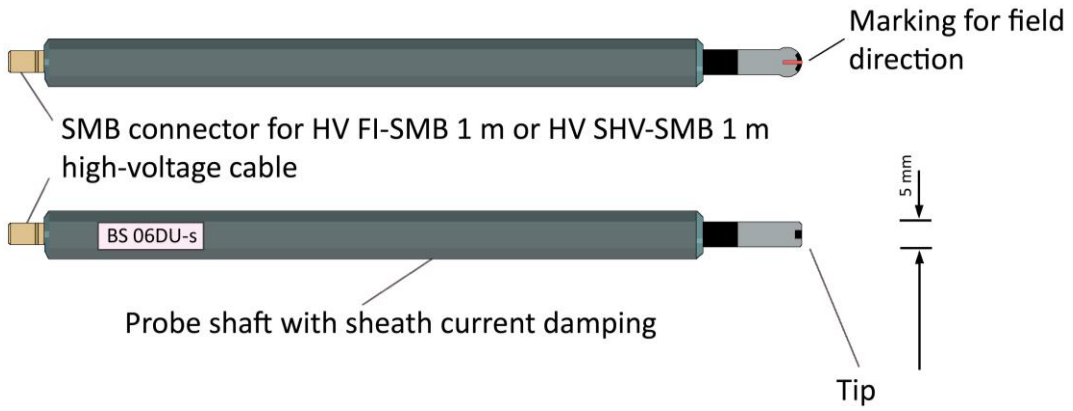

Figure 7: Design of the BS 06DU-s field source

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 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.

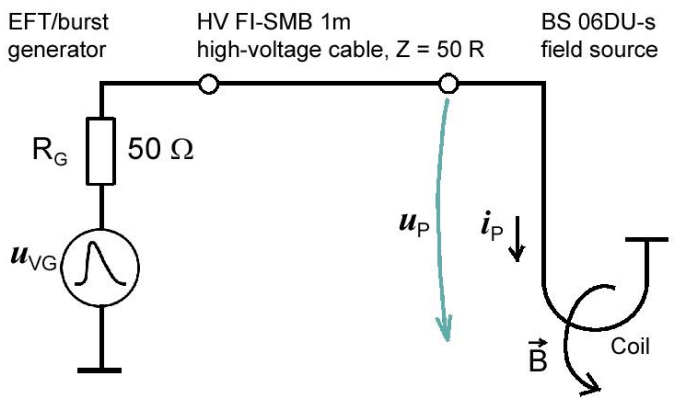

Figure 8: Equivalent circuit diagram with EFT/burst generator (IEC 61000-4-4), HV FI SMB 1 m high-voltage cable and BS 06DU-s field source.

The field source must be able to transmit RF components of the EFT/burst pulse. For this, the frequency response should be constant within a range of 10 MHz – 200 MHz. **Figure 9** shows the frequency response of the field source as the ratio of the induced voltage to the generator voltage. The measurement was carried out on a micro strip line structure.

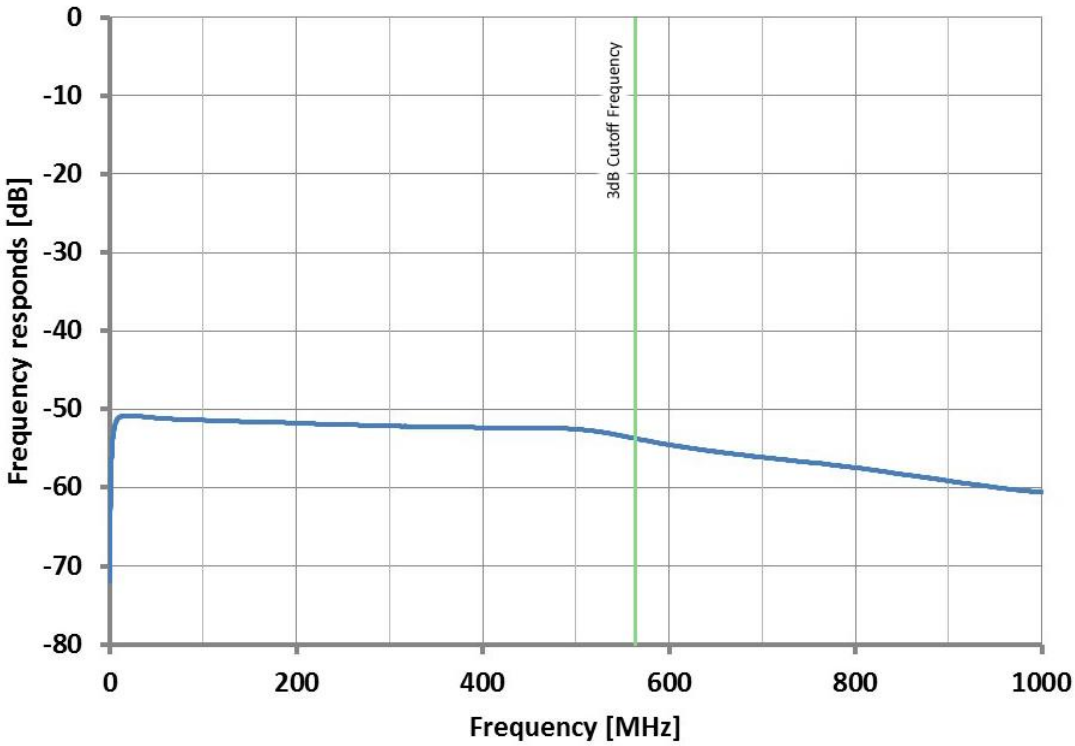

Figure 9: Frequency response of the BS 06DU-s

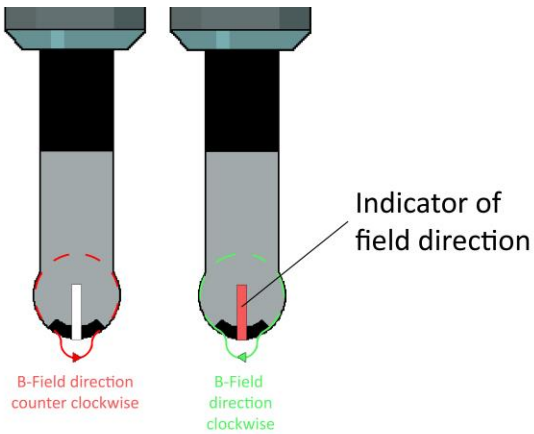

Figure 10: Assignment of the magnetic field direction with positive polarity of the EFT/burst generator

Figure 12 shows the flux Φ as a function of the current I_P and the distance h. Φ is the magnetic flux that comprises a conductor loop at the distance h (**Figure 11**).

The determination of these factors was performed on a conductor loop. **Figure 11** shows a schematic diagram of the measurement set-up.

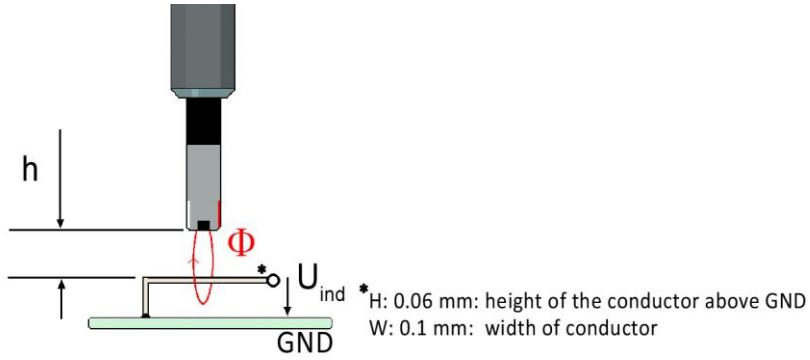

Figure 11: Assignment of the magnetic field direction with positive polarity of the EFT/burst generator

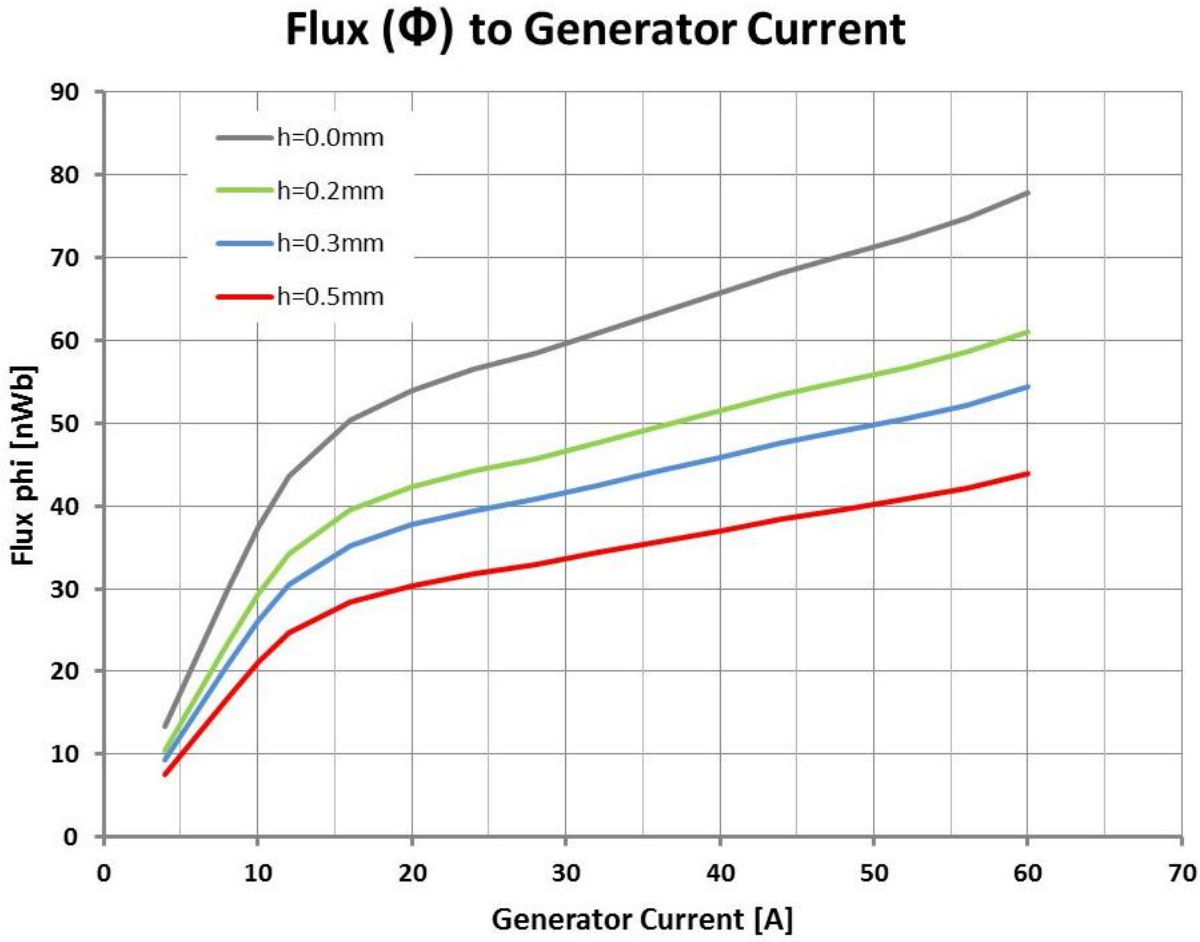

Figure 12: Flux Φ provided by the BS 06DU-s field source as a function of the generator current. Parameter is the distance h of the field source from the conductor.

The effective flux Φ can be obtained from the diagram in **Figure 12** 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.

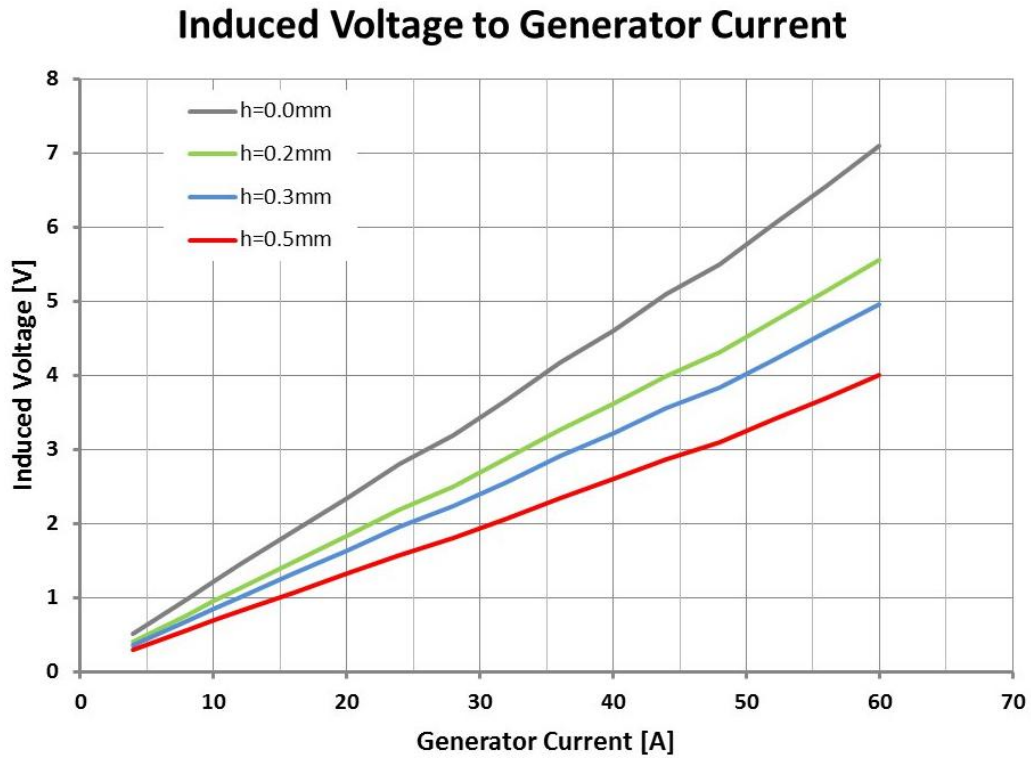

Figure 13: Induced voltage (u_{ind}) of BS 06DU-s as a function of generator current. Parameter is the distance h of the field source from the measuring point.

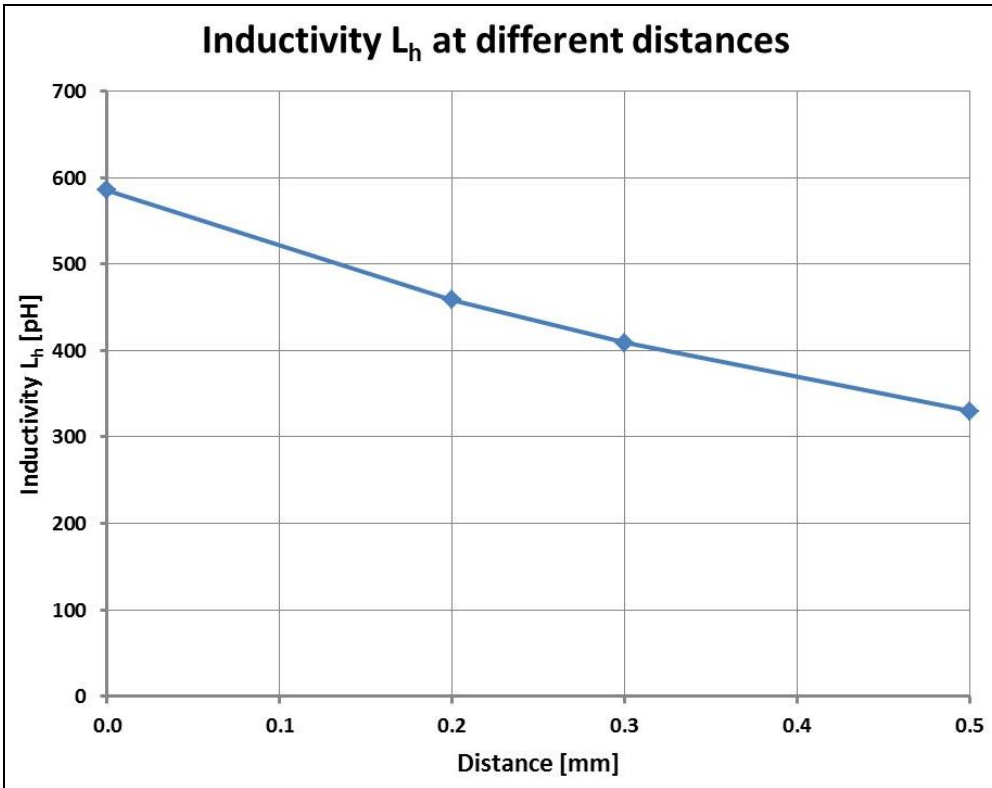

Figure 14: Main inductance L_h of the BS 06DU-s field source dependent on the distance h to the conductor at current i_P of 20 A.

7.1 Inductive Coupling Mechanism

Figure 15 shows the equivalent flux diagram of the field source's coil and the IC loop.

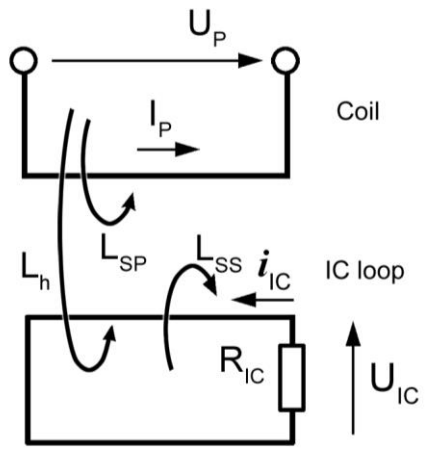

Figure 15: Flux equivalent circuit diagram of the BS 06DU-s field source's coil and the IC loop.

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 2

The IC loop has the self-inductance L_{ss}. The flux equivalent circuit diagram (**Figure 15**) can be converted to a transformer equivalent circuit diagram consisting of concentrated elements (**Figure 16**). There are two main types of inductive coupling of the field source coil with loops of the test IC.

Determining the main types of inductive coupling by case distinction:

1. Current coupling

The circuit operates under short-circuit conditions if $R_{IC} << \omega L_{ss}$. 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 16**). 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.

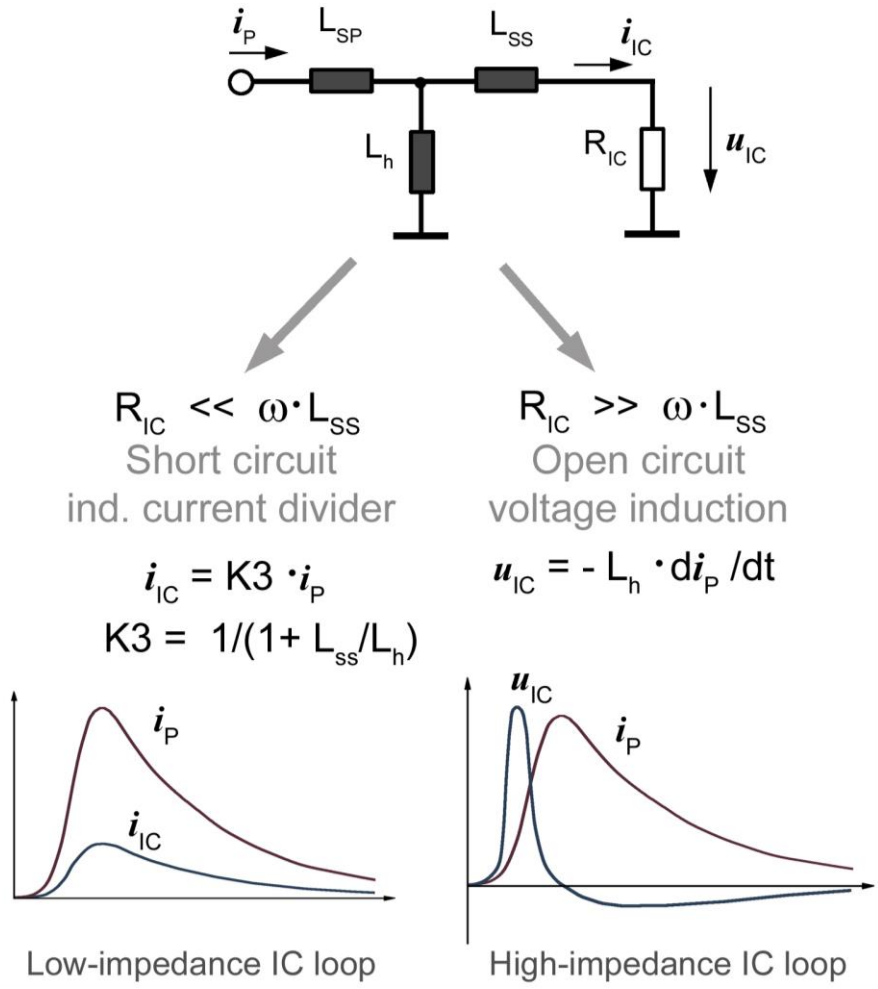

Figure 16: Transformer equivalent circuit of coupling between the electric conductor of the BS 06DU-s field source and the IC loop; main types of coupling by case distinction

2. Voltage coupling

The circuit operates like a voltage transformer under open-circuit conditions if $R_{IC} >> \omega L_{ss}$. 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 3 and Eqn 4).

$u_{ind} = -L_h \cdot d_{iP} / dt$	Eqn 3

$u_{ind} = -\omega \cdot L_h \cdot i_P$	Eqn 4

Current components with a higher frequency generate a higher voltage. The current pulse i_P is differentiated (**Figure 16**). 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 4.

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 17**) 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.

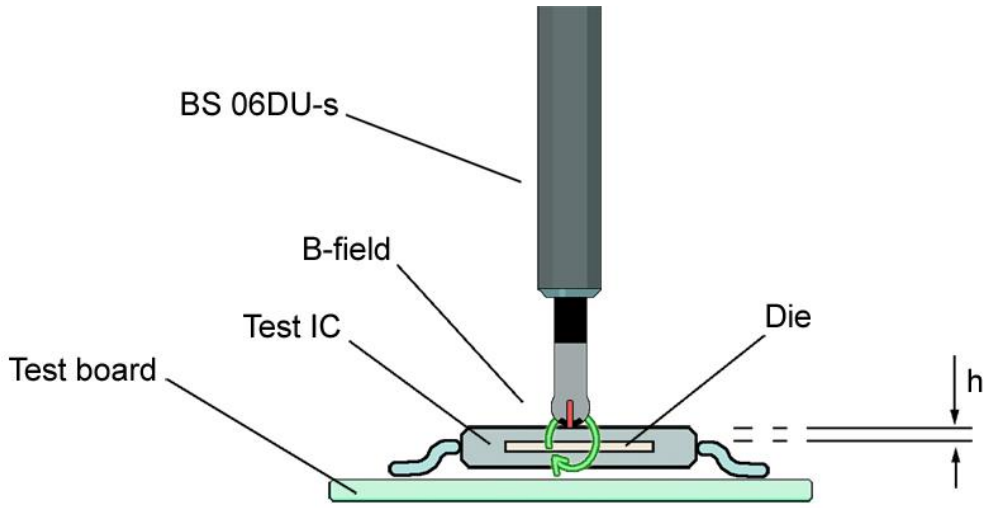

Figure 17: Coupling into the IC

The field-line bundle of the field source penetrates the die in an orthogonal direction (**Figure 17**). In particular loops that are orthogonal to the plane of the die (vertical) are penetrated by the field line bundle. Either voltage or current is transferred in the loops depending on the type of coupling (**Figure 17**).
Due to the small-scale field formation, loops outside the die are hardly flooded. The field-line bundle of the field source will also encircle loops that are closed outside the die. Loops outside the die are orthogonal to the die and are formed by networks of the test board, IC pins, bonding wires, the die, etc. Similar voltages may be induced inside these networks. Field sources which are larger than the BS 06DU-s field source can induce similar or higher voltages.

9 Guiding the Field Source

The BS 06DU-s field source has to be arranged spatially corresponding to the IC loops in order to achieve an optimal effect. The emerging flux Φ is according to $\Phi(t) = L \cdot i(t)$, a parameter that depends on the supply current. 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.

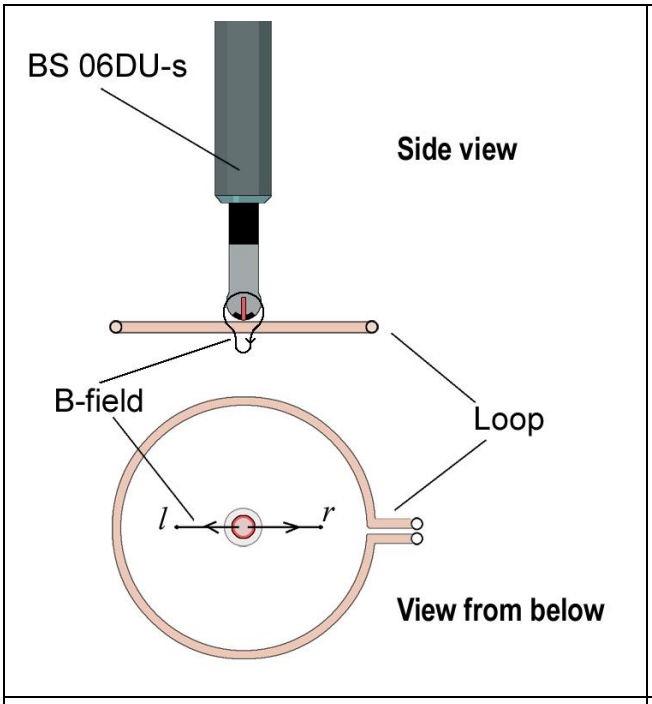

Figure 18: The field source arranged in the middle of the conductor loop does not produce any B-field lines which encircle the conductor.

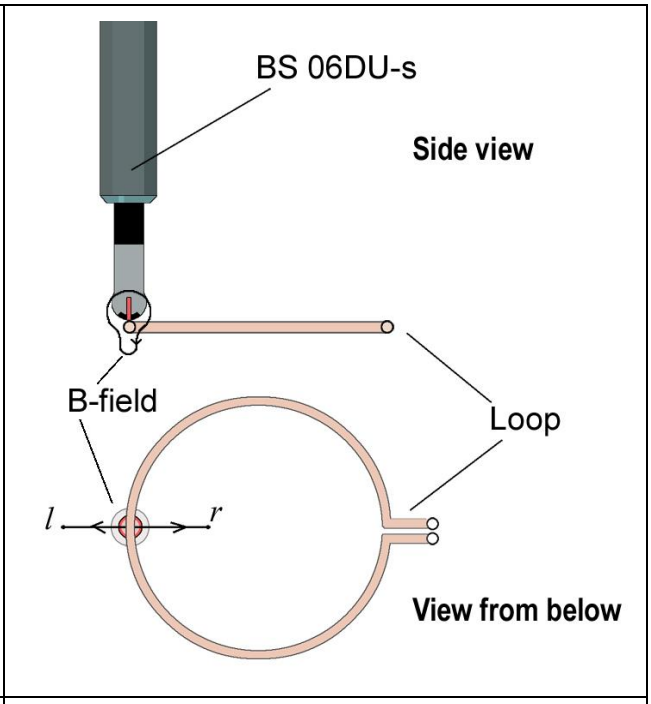

Figure 19: The field source arranged above the conductor produce maximum of B-field lines which encircle the conductor.

The field-line bundle is inhomogeneous at the outlet area of the field source. The field lines first run vertically downwards over a small area and below the exit point horizontally to the surface of the DUT. The flux density decreases with an increasing distance h from 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 field source is directly above the conductor of the IC loop (**Figure 18**).
If the distance of the field source to the conductor becomes larger, less field lines encircle the IC loop and thus do not result in voltage induction. This may occur if the IC loop is larger than the diameter of the field source.

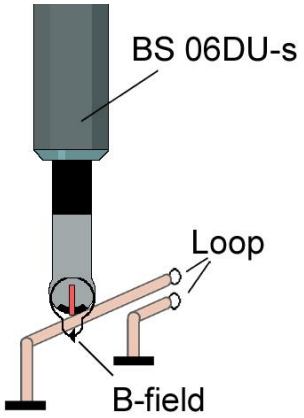

Figure 20: Coupling to a vertical loop / conductor

Similarly, the field source has to be placed nearly to the vertical loop (**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 the die and may interfere with it.
The voltage U_F that is reduced by shielding is proportional to the EFT/burst generator voltage U_{VG}.

U_F / U_{VG} = 50 V /1000 V

It follows from this, that the E-field suppression is 26 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.

Documentations:

Task	**Instruction manual**
• Instructions for the development of the test board • Test process	Guideline EFT immunity (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 06DU-s	ICS 105 set user manual (Langer EMV-Technik GmbH)
• Burst generator • Oscilloscope • Computer	Operating instructions of the manufacturers

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