SCHWARZBECK MESS-ELEKTRONIK
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Nahfeldsonden / *Near Field Probes*

♦	**H-Feld *(Magnetic-Field)***	**9 kHz-30 MHz**	**HFSL 7101**
♦	**H-Feld *(Magnetic-Field)***	**4 MHz-1 GHz**	**HFSH 7102**
♦	**E-Feld *(Electric-Field)***	**9 kHz-1 GHz**	**EFS 7103**
♦	**Weiche *(Separator)***	**9 kHz-1 GHz**	**EW 7110**

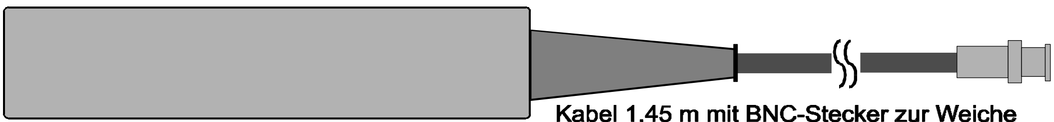
Diese aktiven Sonden eignen sich durch ihre kleinen Abmessungen, ihre hohe Empfindlichkeit und ihre hohe Aussteuerbarkeit zur Messung von elektrischen und magnetischen Feldern in Geräten und auf Platinen.
Im Gegensatz zu passiven Sonden mit und ohne Nachverstärker ergeben ihre in weiten Frequenzbereichen konstanten Wandlungsfaktoren ein getreues Abbild der Feldstärken auf Störmeßempfängern oder Spektrum-Analysatoren.
Die zusätzlich erhältlichen Normalisierungssonden HSS 7121 (0-1 GHz, H-Feld) und ESS 7122 (0-1 GHz, E-Feld) erlauben zusammen mit Meßsendern oder Mitlaufgeneratoren die Normalisierung des Restfrequenzganges und die Überprüfung des Wandlungsfaktors durch Substitution.
Die Sonden werden über das Koaxialkabel mit Spannung versorgt. Zur Trennung von Hochfrequenz und Versorgungsspannung dient die Weiche EW 7110, die direkt auf die N-Buchse des Empfängers aufgeschraubt werden kann. Die Stromversorgung kann dem Empfänger oder dem optionalen Steckernetzteil entnommen werden.

Their small size, high sensitivity and good large signal handling makes these active probes a good choice for measurement of magnetic and electric fields in electric and electronic equipment and on pc-boards.

Unlike passive probes with or without separate amplifiers, their conversion factors are constant over many frequency decades and give a perfect image of the field strength using interference measuring receivers or spectrum analysers.
Using the optional normalising probes HSS 7121 (H-Field) and ESS 7122 (E-Field) together with signal generators or tracking generators, the small influence of the frequency on the conversion factor may be eliminated by substitution.

Supply current comes via the coaxial cable. The separator EW 7110 is used to separate RF and supply voltage. The EW 7110 may be mounted directly on the N - connector of the receiver.

The supply voltage is delivered by the receiver or the optional power supply.



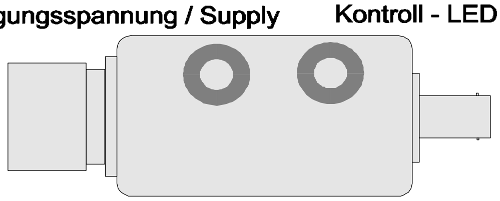
Kabel 1,45 m mit BNC-Stecker zur Weiche
Cable with BNC - Connector to Separator

Sonde *Probe* (zylindrisch 85 x 23 mm)

Buchse für Versorgungsspannung / Supply

Kontroll - LED / *LED for ON/OFF Indication*

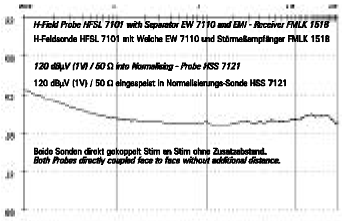
N - Stecker
zum Empfänger
to receiver



BNC - Buchse für
Sondenkabel
to probe

Weiche *Separator* 50 x 30 x 30 mm

H-Feld-Sonde *H-Field-Probe*
9 kHz-30 MHz HFSL 7101



Prinzip, *Principle of operation:*
Sondenspule mit extrem niederohmigem Verstärker für möglichst frequenzunabhängigen Wandlungsfaktor. *Probe-loop with Low-Impedance - Amplifier for frequency independent conversion factor.*

Frequenzbereich, *Frequency Range:*
Spezifiziert, *specified:* 9 kHz-30 MHz
Übersichtsber., *Overview:* 1 kHz-100 MHz

Ausgangsimp., *Output Imp.:* 50 Ω nom.

Wandlung, *Conversion:*
G [dBµA/m] = U [dBµV] +10 dB

Kleinste nachweisbare magn. Feldstärke unter Störmeßbedingungen, s*mallest signal to measure under practical EMI-conditions*
F=1 MHz, Quasipeak, ΔF=9 kHz:
<26 dBµA/m (20 µA/m)
Kleinere Bandbreiten und Mittelwertdetektor ergeben entsprechend bessere Werte, s*maller bandwidth and average detector lead to better results.*

Maximale Meßfeldst., ein Signal, F=1 MHz:
Maximum Field Strength, one signal only:
>124 dBµA/m (1.44 A/m)

Stromverbrauch incl. Weiche, *supply current including separator:* 45 mA

Gehäuse, *Dim.:* 85x23 mm Rohr, *Tube*

Gew. mit Kabel, *Weight incl. cable: 110 gr.*

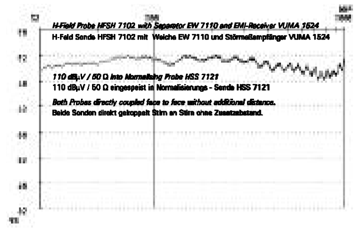
Weiche für Sonden, *Separator for Probes* EW 7110

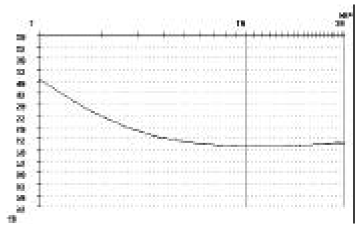
Eingang Versorgungsspannung, *Input Supply Voltage:* 10 V-15 V DC
Ausgang Versorgungsspannung, *Output Supply Voltage:* 7 V DC
Frequenzb., *Frequ. Range:* 9 kHz-1 GHz nom.
Impedanz Eingang, Ausgang, *Impedance Input, Output:* 50 Ω nom.
Sondenb., *Probe Connector:* BNC
Zum Empfänger, *to receiver:* N

EIN/AUS-Anz. über LED,
ON/OFF Ind. by LED
Gehäuse, *Dimensiones:* 50 x 30 x 30 mm

Kompletter Satz mit allen 3 Sonden, Weiche und Stromversorgung im Koffer, *complete set of all 3 probes incl. separator and power supply in a case*: **FS-SET 7100**

H-Feld-Sonde *H-Field-Probe*
4 MHz-1000 MHz HFSH 7102





Prinzip, *Principle of operation:*
Abgeschirmte Sondenspule mit extrem niederohmigem Verstärker mit GaAs-MMICs für möglichst frequenzunabhängigen Wandlungsfaktor. *Shielded Probe-loop with Low-Impedance-Amplifier using GaAs-MMICs for nearly frequency independent conversion factor.*

Frequenzbereich, *Frequency Range:*
Spezifiziert, *specified:* 4 MHz-1000 MHz
Übersichtsber., *Overview:* 1 MHz-1,5 GHz

Ausgangsimpedanz, Output Imp.: 50 Ω nom.

Wandlung, *Conversion:*
G [dBµA/m] = U [dBµV] -5 dB (30 MHz)

Kleinste nachweisbare magn. Feldstärke unter Störmeßbedingungen. *Smallest signal to measure under practical EMI-conditions:*
F=30 MHz, Quasipeak, ΔF=120 kHz:
<20 dBµA/m (10 µA/m)
Kleinere Bandbreiten und Mittelwertdetektor ergeben entsprechend bessere Werte. *Smaller bandwidth and average detector lead to better results.*

Maximale Meßfeldstärke, ein Signal, *Maximum Field Strength, one signal only* F=30 MHz:
>110 dBµA/m (0.32 A/m)

Stromverbrauch incl. Weiche, *supply current including separator: 85 mA*

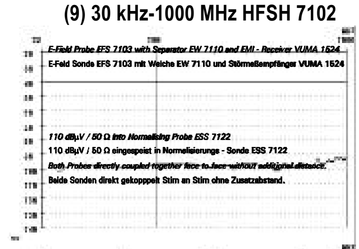
Gehäuse, *Dimensions:* 85 x 23 mm Rohr, *Tube*

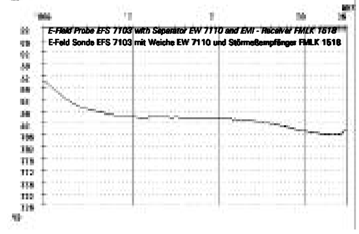
Gew. mit Kabel, *Weight incl. cable 110 gr.*

Normalisierung-Sonden, *Normalising-Probes*

Option zur Überprüfung des Wandlungsfaktors und zur eventuellen Normalisierung des Frequenzganges. *Option to check the conversion factor and to eventually normalise it.*
E-Feld-Normalisierungssonde ESS 7122
H-Feld-Normalisierungssonde HSS 7121

E-Feld-Sonde *E-Field-Probe*
(9) 30 kHz-1000 MHz HFSH 7102





Prinzip, *Principle of operation:*
Sondenkapazität mit extrem hochohmigem Verstärker mit GaAs-MMICs zur Reduzierung der Frequenzabhängigkeit des Wandlungsfaktors. *Probe-Capacity with High-Impedance-Amplifier using GaAs-MMICs to reduce the influence of the frequency on the conversion factor.*

Frequenzbereich, *Frequency Range:*
Spezifiziert, *specified:* 30 kHz-1000 MHz
Übersicht, *Overview:* 9 kHz-1,5 GHz

Ausgangsimp., Output Imp.: 50 Ω nom.

Wandlung, *Conversion:*
F [dBµV/m] = U [dBµV] +5 dB (1 MHz)

Kleinste nachweisbare el. Feldstärke unter Störmeßbedingungen. *Smallest Signal to measure under practical EMI-conditions:*
F=1 MHz, Quasipeak, ΔF=9 kHz:
<20 dBµV/m (10 µV/m)
Kleinere Bandbreiten und Mittelwertdetektor ergeben entsprechend bessere Werte. *Smaller bandwidth and average detector lead to better results.*

Maximale Meßfeldstärke, ein Signal, *Maximum Field Strength, one signal only,* F=1 MHz:
>120 dBµV/m (1 V/m)

Stromverbrauch incl. Weiche, *supply current including separator: 85 mA*

Gehäuse, *Dim.:* 85 x 23 mm Rohr, *Tube*
Gew. mit Kabel, *Weight incl. cable: 110 gr.*
Sondenmessungen sind nicht genau spezifiziert.
Die Angaben sind daher nur typisch. Genauere Angaben sind bei vereinbartem Prüfaufbau möglich.

Stromversorgungskabel
Power Supply Cable

Optional, entsprechend den Möglichkeiten des Empfängers oder Analysers.
Optional, according to receiver or analyser.

Steckernetzeil, *Power supply*

Option, wenn keine andere Versorgung möglich ist.
Option, if no other source available.

♦ Messung von elektrischen und magnetischen Feldern mit Nahfeldsonden

Anders als beim Rundfunk, wo durch die großen Abstände zwischen Sende- und Empfangsantenne immer Fernfeldbedingungen herrschen und damit elektromagnetische Felder bestehen, müssen bei den kurzen Meßentfernungen der Nahfeldsonden elektrische und magnetische Felder getrennt betrachtet werden.

Magnetische und elektrische Sonden zeigen daher hohe Empfindlichkeit für ihre jeweilige Feldart und hohe Unterdrückung für die andere.

Während in einem Meßaufbau sehr reine nur-elektrische oder nur-magnetische Felder erzeugt werden können, werden in der Praxis in komplexen Geräten mit vielen Bauteilen und Baugruppen Gemische auftreten. So stellt zwar der große Halbleiterchip eines Mikroprozessors mit seiner Fläche eine Kapazität dar und die dort gegen die Umgebung bestehenden Spannungen verursachen ein elektrisches Feld, aber auf den Betriebsspannungsanschlüssen fließen Ströme (bis zum nächsten Abblockkondensator nach Masse), deren Verlauf Ähnlichkeit mit dem der Spannungen hat. Werden die den Feldstärken proportionalen Ausgangsspannungen der Sonden nun zum Beispiel einem Störmeßempfänger (oder Spektrumanalysator) zugeführt und aufgezeichnet, so zeigen sich oft Ähnlichkeiten. Je komplexer die Geräte sind, desto weniger können jedoch Vorhersagen dazu gemacht werden. Sicherheit gibt nur die Messung beider Feldarten. Die folgenden Beispiele wurden in einem PC gemacht und geben erste Anhaltspunkte.

Alle Messungen wurden mit den Schwarzbeck Störmeßempfängern FCKL 1528 für den Bereich 9 kHz-30 MHz und FCVU 1534 für den Bereich 30 MHz-1000 MHz gemacht. Da bei den Frequenzen 150 kHz und 30 MHz normgemäß ZF-Bandbreiten und Detektorzeitkonstanten umgeschaltet werden, treten dort Pegelunterschiede auf.

♦ *Measuring electric and magnetic fields with near field probes*

Looking at the classic am broadcasting with large distances between transmitting and receiving antenna we have only to consider the electromagnetic field. Near field probes however are very close to the "transmitting antenna" and so we have to consider electric and magnetic fields separately.

It is for this reason that near field probes are especially developed for high sensitivity concerning the wanted field and high suppression of the unwanted field.

In a laboratory environment, extremely "clean" magnetic or electric field can be generated. In the real world of electronic equipment with many components and pc - boards there will be a mixture.

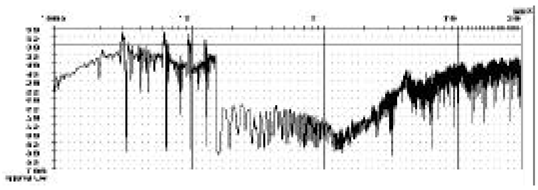
A microprocessor with its relatively large chip area is a capacitor and the voltages on the chip surely will generate an electric field. On the other hand there are the power supply lines with the current flowing to ground (via the next bypassing capacitor). They surely produce a magnetic field with similarities to the electric field.

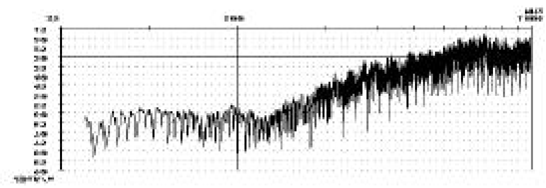
If we connect the probes to the EMI-receiver or spectrum analyser, these similarities are visible.

The more complex the unit under test, the more difficult or impossible it will be to predict similarities. It is always good practice to measure both fields to be sure.

The following examples were made inside a standard Personal Computer with Schwarzbeck EMI-receivers FCKL 1528 for 9 kHz-30 MHz and FCVU 1534 for 30 MHz-1000 MHz.

According to the standards on the frequencies 150 kHz and 30 MHz both i.f.-bandwidth and detector time constants are changed. This may result in different measuring levels.

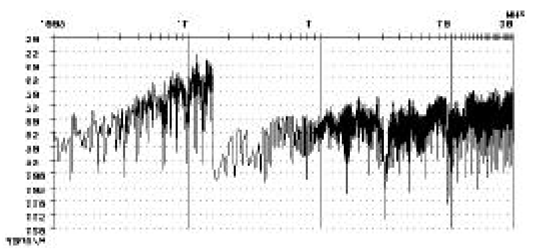
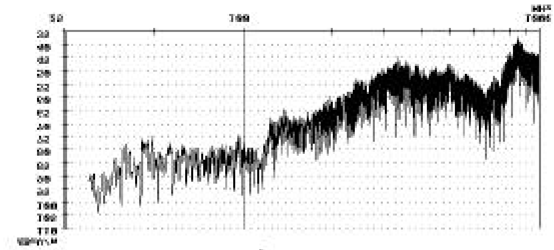




Messung der magnetischen Feldstärke am Boden eines Standard - Graphíkprozessors auf einer Graphikkarte in einem PC.
Measurement of the magnetic field strength on the bottom of a standard graphic processor as part of a vga-adapter in a PC.
H-Feld - Sonde im Bereich, *Near field probe in the frequency range* 9 kHz-30 MHz: HFSL 7101
H-Feld - Sonde im Bereich, *Near field probe in the frequency range* 30 MHz-1000 MHz HFSH 7102

Im unteren Frequenzbereich zeigen sich hauptsächlich die VGA-Frequenz bei 31 kHz und deren Oberwellen. Eine weitere Spektrallinie erscheint bei 3 MHz. Die Oberwellen dieser beiden Frequenzen sind bis zum Meßende bei 1000 MHz feststellbar, obwohl ihre Amplitude stark abnimmt.

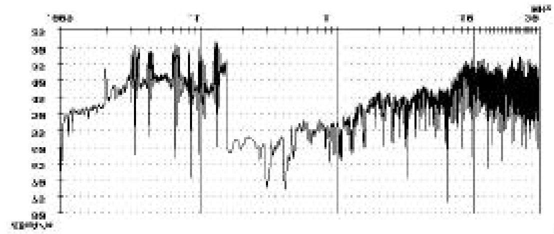
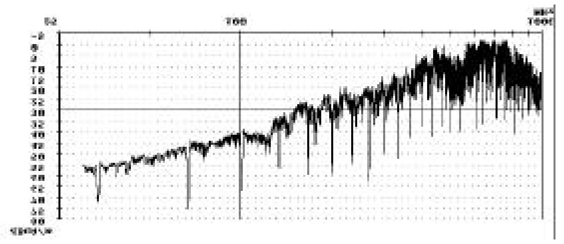
In the lower frequency range the vga-frequency and harmonics dominate the spectrum. A second line appears near 3 MHz. The harmonics of both frequencies are present until the end of the measurement at 1000 MHz, though the amplitude decreases rapidly

Messung der elektrischen Feldstärke am Boden eines Standard - Graphíkprozessors auf einer Graphikkarte in einem PC.
Measurement of the electric field strength on the bottom of a standard graphic processor as part of a vga-adapter in a PC.
E-Feld-Sonde im Bereich, *Near field probe in the frequency range* 9 kHz-1000 MHz: EFS 7103

Die E-Feld-Messung hat Ähnlichkeit zur H-Feldmessung . Die Spektrallinien der VGA-Freq. heben sich jedoch vom Grundpegel weniger gut ab.

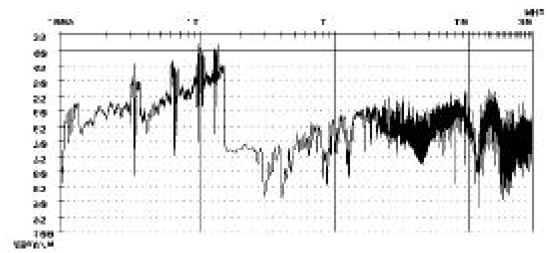
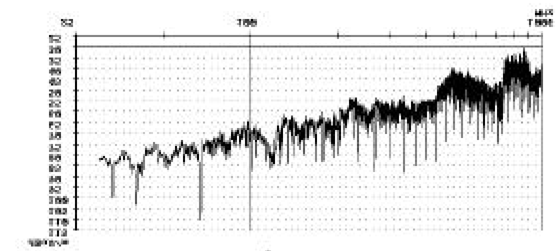
E-Field and H-Field show a certain similarity, but the measurement of the electric field seems to be more "noisy".

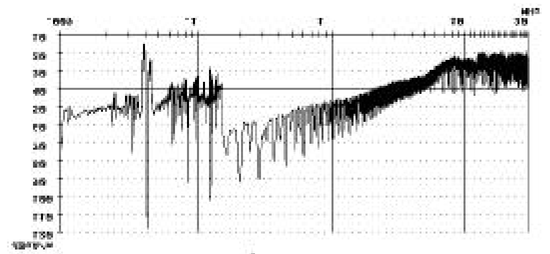
Messung der mag. Feldstärke auf einem 80486 Prozessor mit den H-Feld-Sonden HFSL 7101 (9 kHz-30 MHz) und HFSH 7102 (30 MHz-1000 MHz)
Measurement of the mag. field strength on a 80486 processor with H - Field Probes HFSL 7101 (9kHz-30 MHz) and HFSH 7102 (30 MHz-1000MHz)

Im unteren Frequenzbereich zeigen sich hauptsächlich die VGA-Frequenz bei 31 kHz und die Schaltfrequenz des Netzteiles bei 40 kHz. Im oberen Bereich bis 1000 MHz dominiert der Prozessortakt bei 33 MHz.

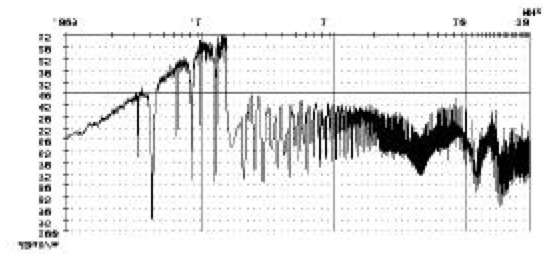
In the lower frequency range the vga-frequency and the switching frequency dominate the spectrum. The upper range to 1000 MHz is dominated by the 33 MHz processor clock frequency.

Messung der elektrischen Feldstärke auf einem 80486 Prozessor mit der E-Feld-Sonde EFS 7103 (9 kHz-1000 MHz)
Measurement of the electric field strength on a 80486 processor with E-Field Probe EFS 7103 (9 kHz 1000 MHz



HFSL 7101 außerhalb des Gehäuses nahe beim Trafo. Dominierend sind Netzteil-Schaltfrequenz und VGA-Frequenz mit Oberwellen. Magnetische Feldstärke eines PC-Schaltnetzteiles mit der H-Feldsonde.
Magnetic field-strength outside a PC power supply measured with magnetic probe HFSL 7101. Most important signals are switching frequency and vga-frequency and their harmonics.



Wie linke Seite, aber elektrisches Feld gemessen mit E-Feld-Sonde EFS 7103. Oberhalb 1 MHz zeigt sich ein hoher Grundsockel durch eine Vielzahl von Spannungen auf dem Netzteilgehäuse.
See left side, but measuring electric field strength with E-Field-Probe EFS 7103. Beyond 1 MHz a multitude of voltages on the shielding box pushes up the baseline.

Manual for Schwarzbeck Near Field Probes

List of content

1. Warnings

Extreme care has to be taken when measuring in the vicinity of components with high voltage.

High voltage components should be carefully covered with high quality insulating material before measuring.

The probes are housed in tubing of insulating material, but some parts are conductive.
Touching components with these conductive parts has to be avoided, because of danger to user and components. The rear metal cover of the probe is connected to the shielding of the coaxial cable. Via the separator and the measuring receiver or spectrum analyser a connection to safety ground may exist.
A short circuit to components can occur when touched with metal parts of the probe.

If no safety ground exists, the shielding of measuring equipment will be lifted to the voltages of the components which are touched.

The probes are made very small to avoid negative influence on the fields to be measured.

The probes do not radiate any fields. When working in electric or magnetic fields, limits and regulations have to be observed.

2. O v e r v i e w

The Probe Set FS-SET 7100 consists of

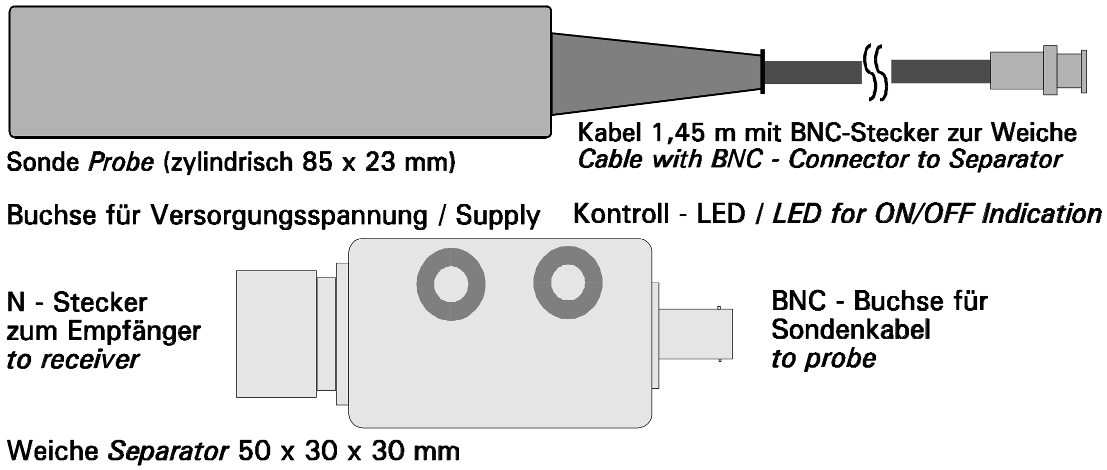
H-Field-Probe	9 kHz-30 MHz	HFSL 7101
H-Field-Probe	4 MHz-1 GHz	HFSH 7102
E-Field-Probe	9 kHz-1 GHz	EFS 7103
Separator	9 kHz-1 GHz	EW 7110

and wall-plug-power-supply or power-supply-cable in a plastic box.
Normalising Probes are available as an ***option.***

H-Field-Probe	0-1 GHz	HSS 7121
E-Field-Probe	0-1 GHz	ESS 7122

These normalising probes act as transmitting antennas to eliminate the frequency dependent conversion factor for highest precision.

3. F i r s t s t e p s



3.1 Separator

To use a single coaxial cable for both r.f. and supply current, a separator is used.
The advantage of this single coaxial cable solution is, that longer distances can be achieved easily by simply adding standard coaxial cable. There is no need for expensive customised cable.

Special care has to be taken because of the fact that the bnc-connector of the separator in direction to the probe is conducting voltage. Under no circumstances this bnc-connector should be connected to a receiver or spectrum analyser, because this could damage the input attenuator or mixer.
It is good practice to connect first the probe cable to the bnc-connector of the separator.

The n-connector on the other side of the separator will usually be directly connected to the n-connector of the receiver or spectrum analyser.
An adapter can be used for receivers with bnc-connectors.
This is often the case with receivers for the frequency range up to 30 MHz.

3.2 Options for power supply:

a) Wall plug power supply 230 V AC/12 V DC

In this way the supply is independent of the receiver or analyser.
The supply is plugged into the mains socket and the low voltage d.c. output is connected to the d.c. connector of the separator.

b) Power supply cable to connect auxiliary connector of the Schwarzbeck Receiver to the d.c. input of the separator.

Schwarzbeck receivers have a 25-pin sub-d-connector on the rear panel for auxiliaries.
There is a special cable available to connect this sub-d-connector to the separator.

c) Many receivers have special connectors for auxiliaries. Any d.c.-voltage in the range +9 V to +15 V/80 mA is sufficient for the probes. Therefore the separator uses a 7-V-regulator that makes the probes independent of a special voltage.

Control-LED

If the power supply is OK, the red led will be on. Shining of the red led only indicates that the power supply is OK, not more. It will shine with or without a probe connected to the separator.

3.3 Probes

Connect the bnc-connector of the probe to the separator. The probe is now ready to use. For a first test, pc-boards or equipment including microprocessors and clock oscillators are very useful, because they provide many strong signals.

Especially the electric field probe EFS 7103 shows good results for first steps, because it is very broad band.

For first steps up to 30 MHz a Schwarzbeck measuring receiver can be adjusted to 30 dBµV for centre of the instrument. This presetting makes sure that even weak signals can be detected. Increase input attenuation when strong signals occur.

> Whenever spectrum analysers are used, the first 10 db step of the attenuator should be used to protect the input. Most often this is part of the default set-up. Using an external 10-dB-attenuator is even better to protect the vulnerable input circuitry.

Look for a processor or a crystal with known frequency on the pc-board and tune the receiver or spectrum analyser to this frequency.

Now approach the probes to these components and register the amplitudes in order to see how practical components behave.

The variation in amplitude increases with decreasing distance to object.
For this reason there is a 5 mm plastic stopper in the front part of the probes to ensure that there is always a minimum distance from the electric or magnetic pick-up to the object.

4. Electric and magnetic fields, near field

Contemporary EMI-measurement concentrates on the frequency range from 9 kHz to 1 GHz. The corresponding wave lengths are between 30 km to 30 cm. Even at distances usually given for measurement with antennas we have near field conditions for frequencies from 9 kHz to more than 100 kHz. If we consider 3 m distance from the antenna to the E. u. T., even some MHz will show near field effects.

Under these near field conditions, electric and magnetic components have to be measured separately. It is only in the far field that E and H have the same phase and are related by the field impedance of the free area.

These considerations are already important considering a 3-m-distance for antenna measurement. They are extremely important considering the extremely small distances commonly used with near field probes.

Example 1: Current is conducted through a piece of wire. The piece of wire is low impedance and therefore even a significant current produces only a small difference in voltage between the ends of the wire. The current results in a strong magnetic field. The electric field is limited by the small voltage drop and the distance between the wire ends. Using the probes at small distances from the wire, we have to consider the near field conditions. Electric and magnetic fields are separate.

No electro-magnetic field is present.

The magnetic probe will show a strong magnetic field, the electric probe will show only a small electric field.

Example 2: A metal holder intended to fix a pc-board to a plastic cabinet shows high interference voltage measured against the main chassis. A strong electric field is present. Because of the fact that the holder is fixed to non conductive plastic at one side, there is no substantial current flow. So the magnetic field is weak.

Again the distance is small. An electro-magnetic field is not yet established.

In this special case the electric probe will show strong signals, but the magnetic probe nearly nothing.

In the ideal world we think about equipment creating only electric or only magnetic field. In the real world even a standard pc-board contains a variety of both electric and magnetic field sources, which are related to each other. This leads to the strange result, that sometimes measurement of electric and magnetic field looks very much alike, knowing that at small distances this should not happen. Why?

In the real world of pc-boards these extremes mentioned above very seldom really exist. Very low impedance parts (low voltage, high current, mainly magnetic field) and very high impedance parts (low current, high voltage, mainly electric field) are more or less exemptions. Common pc-boards use middle impedance components and wiring. Characteristic impedance is well between 100 Ω to some kΩ. Voltages in the range of some volts lead to currents in the range of some mA and vice versa. Integrated circuits or metal cooling blocks with voltage to ground and coils or cables conducting current are nearly always present. Voltages and currents often have the same clock frequencies. This relation in time domain results in similar frequency spectrum.

Despite the fact that the spectra look like electromagnetic fields at distances $>\lambda/2\pi$, we always have to keep in mind that in fact two different kinds of field are generated on a pc board.

5. The probes as a help in the every day EMI-work

Goal of all efforts made to decrease the level of conducted and radiated interference is to keep the E.u.T. well beneath the limits given in the standards.
These limits are only valid for the specified type of measurement.
The specified measurements are made with L.I.S.N.s for conducted voltage, with absorbing clamps for radiated power and with antennas for radiated field strength.
The limits in the standards are not given for near field probes.
Radiated field strength f. e. is measured at a 10-m-distance from the E.u.T. with antennas.
The limits are only valid if measured in that way.
Probe measurement is done at a very small distance in quite a different way. It is absolutely impossible to convert results of probe measurement in such a way that the limits given for antenna measurement could be used. This is somewhat disappointing but very important to avoid frustrating set-backs.
Probe measurement is not a substitute for antenna measurement, but probes help to find signals on pc-boards, which were detected in the antenna measurement before. Therefore it is very important to look for special fingerprints of signals while measuring with antennas in order to find them later on with the probes.
Such fingerprints are:
a) Characteristic frequencies:
Common microprocessors use well known clock frequencies.
Graphic adapters use standardised frequencies in different graphic modes.
Switching power supplies use frequencies which can be detected by oscilloscopes.
b) Modulation:
Classic "am radio" has its name from the kind of modulation used, amplitude modulation. The audio frequency source controls the magnitude of the radio frequency. "Fm radio" uses frequency modulation, audio frequency deviates the carrier frequency.
These expressions are so common that people often are not aware of the physical background.
Besides this strictly am or fm modulation, many forms of mixed modulation are in use.
Modern fm stereo multiplex signals are enhanced with a variety of signals for traffic information, background music and so on using a complex mixture of modulation techniques.

Most of the interference signals generated by an E.u.T. carry also characteristic modulation.
Interference measuring receivers usually have a loudspeaker and one or more demodulators.
Standard is the amplitude demodulator, because it detects the amplitude of a signal just like the measuring detectors.
Frequency demodulators and B.F.O.s to detect CW-signals are also very useful. B.F.O.s will detect the exact carrier frequency and even smallest frequency shift. Often a 50 or 60 Hz hum or multiples can be monitored. PCs with monitors generate signals changing with the kind of graphic displayed on the screen. Even the blinking cursor may be heard.
The multitude of different signals is greater than those found with radio transmitters, which are related to international standards. These standards oblige the radio transmitters to generate narrow and clean signals. For example a standard am radio uses only 9 kHz of bandwidth.
Interference signals cover a range from very small to extremely broad bandwidth.
Extremely small bandwidth is common with very clean crystal oscillators.
Extremely broad signals are mostly pulse spectrums, sometimes wide band fm modulation occurs.
Acoustic control by loudspeaker is still the easiest and best method to monitor such fingerprints.
If not available as with most analysers, the signal can be "zoomed" for amplitude and frequency until the spectrum will be clearly seen.
This method is second best compared to acoustic control and quite insensitive, but often the only way out.
Interference signals identified in this way will now be reduced as good as possible.
This is the only reasonable way but success is not guaranteed.
Sometimes an improvement achieved on board level is not the same when measured with antennas.
It could even get worse.
If the basic problems are not recognised, such as poor shielding, unsatisfactory grounding, noisy power lines, coupling by cables and so on, improvements on board level are probably only "black magic".
Never make expensive modifications only based on probe measurement on board level.
Wait until antenna or L.I.S.N measurement shows the truth.

6. The Magnetic Field Probe 9 kHz - 30 MHz HFSL 7101

6.1 Basics

Basic configuration of a magnetic probe is a simple loop connected to the receiver via a coaxial cable.
The advantage of this passive design is the use in both receiving and transmitting direction and high overload capability.
To improve the poor sensitivity, an external preamplifier can be used.
A disadvantage is the poor conversion factor, which depends on the frequency. Beginning at low frequencies, the conversion factor rises by 20 dB/decade up to a maximum, when the loop impedance approaches 50 Ω.
Wide band matching of the frequency dependent impedance of the loop to 50 Ω is impossible without attenuation. This complicates the scaling of the amplitude axis of a spectrum analyser in field strength units.
A preamplifier improves the conversion factor, but does not eliminate the frequency dependence.

6.2 Principles

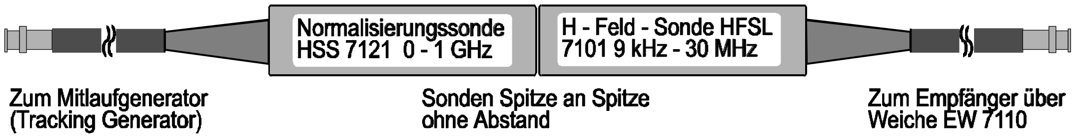
The magnetic field probe HFSL 7101 uses a principle which is widely used in laboratory magnetic field strength meters to keep the conversion factor independent of the frequency over many decades.
This principle uses the fact, that the short circuit current of the receiving loop is independent of the frequency. In order to measure this short circuit current, a very low impedance amplifier loads the loop.
This loading of the loop is only successful when both loop and amplifier are combined in the probe.
An external preamplifier cannot do this job in the same way.
Because of some limitations it is impossible to cover the whole frequency range from 9 kHz - 1 GHz in one combination loop-amplifier.
Using two probes gives better performance and a broad overlap.
Beneath and beyond the specified edges there is no sharp cut off, but a smooth frequency response.
So both probes can be used with minor errors outside their main frequency band.

6.3 Directivity

An ideal magnetic probe would have no directivity at all.
Expensive laboratory equipment uses three orthogonal loops with separate amplifiers.
A probe with limited space and cost cannot use this high end principle.
The probe uses one loop with a common axis for both the loop and the holder.
Measuring a loop with the same axis gives maximum reading.
Measuring the magnetic field of a wire gives minimum reading when the head of the probe is directly centred over the wire.
This effect is very useful to find the centre of a line conducting interference current (direction-finding using the minimum reading).
If the probe is kept in such a way that its axis is a tangent to the magnetic field lines encircling the wire, a maximum is measured.
The wire is then not at the front of the probe, but about 10 mm away in direction to the rear end.
In the real world of a crowded pc-board, complicated networks of magnetic field strength generators create random patterns.
The measurement should therefore be judged with reasonable care.

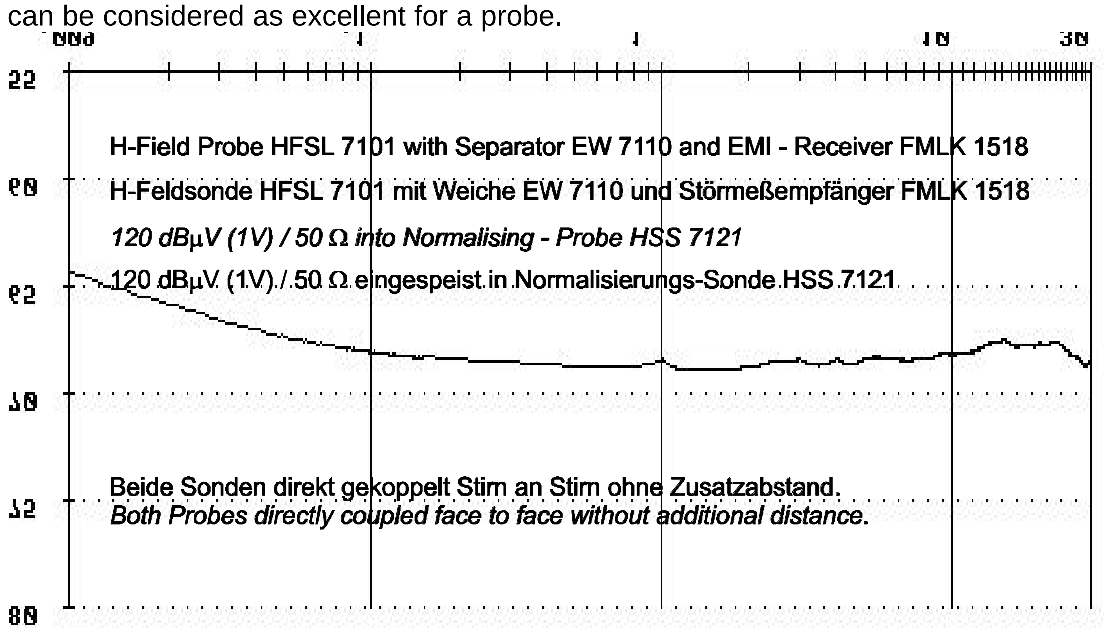
6.4 Frequency dependent conversion factor

Measuring the frequency dependent conversion factor has to be made under specified measuring conditions. For this type of measurement, the optional magnetic normalising probe HSS 7121 from 0 to 1 GHz is used. This probe uses an electrically shielded one-winding-loop.
A series resistor keeps the loop current independent of the frequency.
A parallel resistor matches to 50 Ω cable impedance.
This basic passive circuit design avoids any frequency dependent influence, as long as the diameter of the winding is small. Any variation of the conversion plotted as a function of frequency is caused by the receiving probe.



Probes head against head without distance To receiver via separator

Both probes are coupled front to front. The normalising probe is connected to the tracking generator, the receiving probe to the spectrum analyser.
A wooden table is recommended. Metal is not permitted in the vicinity.
The diagram shows less than +-2.5 dB of deviation over the frequency range of 9 kHz -30 MHz.
From 100 kHz-30 MHz less than +-0,75 dB is achieved.
This can be considered as excellent for a probe.



It has to be kept in mind, however, that measurement on a pc-board is influenced by many factors, which can cause substantial errors.
In special cases it may be justified to eliminate this small frequency error by normalising.
Most spectrum analysers use normalising routines to do this job. Please read the manual.
Measuring receivers use transducers factors.
Probes can be handled as antennas.
The normalising factors are put into the receiver step by step.

6.5 Antenna factor

The antenna factor for this probe is +10 dB.
You can calculate the magnetic field strength reading the voltage from the receiver:

G [dbµA/m] = U [dBµV] +10 dB

It is not correct to calculate the fictitious electric field strength using the magnetic field strength at distances <$\lambda/2\pi$, this is only possible in the far field.
At close distances electric field strength has to be measured with the probe for electric field.

6.6 Sensitivity

The lowest magnetic field strength level to be measured with this probe under realistic EMI-conditions is <26 dBµA/m (20 µA/m).
The receiver uses a bandwidth of 9 kHz (-6 dB) and the CISPR Quasi-Peak-Detector. Measuring frequency is 1 MHz.
A qualified EMI-receiver must be used for such a measurement.
This lowest measuring limit is sufficient to monitor your local am-stations using the probe as antenna (consider the directivity).
Also some of the EMI-limits at a 3-m-distance can be measured, when a qualified EMI-receiver is used.
The lowest limit can be even more extended when smaller bandwidth and the average detector are used.

6.7. Maximum field strength

The maximum field strength for the probe is 124 dBµA/m.
Higher field strength causes saturation and errors.
When more signals are present, the amplitude of each signal has to be decreased in order to keep the complete spectrum under the saturation limit.
Spectrum analysers contribute to saturation, when no input filtering is present.
The graphic of the spectrum on the screen should be monitored carefully to notice the signs of intermodulation and saturation.
When completely "new" signals occur, or when signals are not growing when the probe distance is reduced, care should be taken.

6.8 Side effects

Just like laboratory field strength meters the suppression of the unwanted electric field sensitivity is limited.
This should not be a problem in everyday work, but has to be taken in account in some special cases.
Potential errors occur, when a very weak magnetic field is measured in the presence of a very strong electric field.
In this case the decoupling from the electric field must be improved.
This can be done with a different direction of the probe or some electric shielding.
For frequencies below 20 kHz the noise floor produced by the probe increases.
This is due to the increasing amplification of the loop amplifier which is needed to keep the conversion factor constant.
These frequencies are usually measured with 200 Hz bandwidth, which reduces the effect of broad band noise significantly.

7. The Magnetic Field Probe 4 MHz - 1 GHz HFSH 7102

7.1 Basics

Basically this probe is the same as HFSL 7101 but for a different frequency range.
The same considerations show that the inherent frequency dependent conversion factor of the passive design is far from ideal for everyday work.
The active design solves the problem.

7.2 Principles

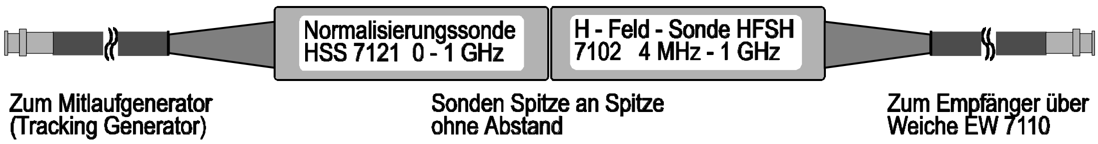
The magnetic field probe HFSH 7102 uses a principle which is widely used in laboratory magnetic field strength meters to keep the conversion factor independent of the frequency over many decades.
The principle uses the fact, that the short circuit current of the receiving loop is independent of the frequency. In order to reach 1 GHz, the loop is one winding with a small diameter.
To reject the unwanted electric field, this winding is electrically shielded.
The amplifier senses the current, which is independent of the frequency.
Below 4 MHz, the input impedance is not low enough to load the loop effectively.
This leads to a frequency dependent conversion factor towards lower frequencies.
The roll off is rather smooth, so overview measurement is still possible.

7.3 Directivity

The same considerations as for HFSL 7101 are valid.

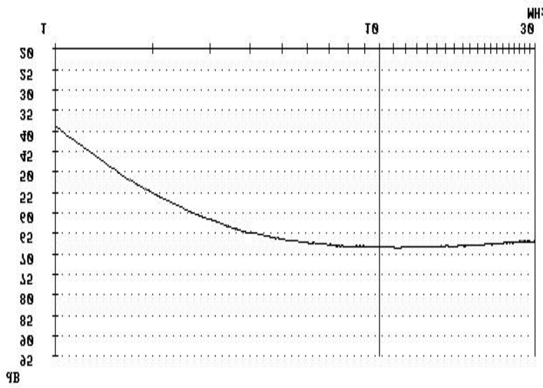
7.4 Frequency dependent conversion factor

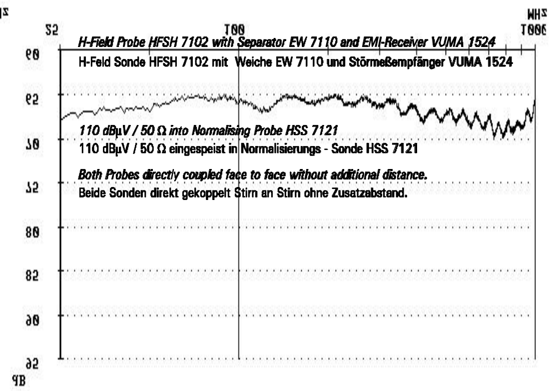
Measuring the frequency dependent conversion factor has to be made under specified measuring conditions. For this type of measurement, the optional magnetic normalising probe HSS 7121 from 0 to 1 GHz is used.
This probe uses an electrically shielded one-winding-loop.
A series resistor keeps the loop current independent of the frequency.
A parallel resistor matches to 50 Ω cable impedance.
This basic passive circuit design avoids any frequency dependent influence, as long as the diameter of the winding is small.
Any variation of the conversion plotted as a function of frequency is caused by the receiving probe.



Probes head against head without any distance   To receiver via separator

Both probes are coupled front to front.
The normalising probe is connected to the tracking generator, the receiving probe to the spectrum analyser.
A wooden table is recommended. Metal is not permitted in the vicinity.
The diagram shows less than +-2.5 dB of deviation over the frequency range of 3 MHz - 1 GHz.





It has to be kept in mind, however, that measurement on a pc-board is influenced by many factors, which can cause substantial errors.
In special cases it may be justified to eliminate this small frequency error by normalising.
Most spectrum analysers use normalising routines to do this job.
Please read the manual. Measuring receivers use transducers factors.
Probes can be handled as antennas.
The normalising factors are put into the receiver step by step.

7.5 Antenna factor

The antenna factor for this probe is -5 dB.
You can calculate the magnetic field strength reading the voltage from the receiver:

G [dBµA/m] = U [dBµV] -5 dB

It is not correct to calculate the fictitious electric field strength using the magnetic field strength at distances $<\lambda/2\pi$, this is only possible in the far field.
At close distances electric field strength has to be measured with the probe for electric field.

7.6 Sensitivity

The lowest magnetic field strength to be measured with this probe under realistic EMI-conditions is <20 dBµA/m (10 µA/m).
The receiver uses a bandwidth of 120 kHz (-6 dB) and the CISPR Quasi-Peak-Detector.
Measuring frequency is 30 MHz.
A qualified EMI-receiver must be used for such a measurement.
This lowest measuring limit is sufficient to monitor local radio stations using the probe as antenna (consider the directivity).
Using smaller bandwidth and the average detector improves sensitivity significantly.

7.7. Maximum field strength

The maximum field strength for the probe is 110 dBµA/m.
Higher field strength causes saturation and errors.
When more signals are present, the amplitude of each signal has to be decreased in order to keep the complete spectrum under the saturation limit.
Spectrum analysers contribute to saturation, when no input filtering is present.
The graphic of the spectrum on the screen should be monitored carefully to notice the signs of intermodulation and saturation.
When completely "new" signals occur, or when signals are not growing when the probe distance is reduced, care should be taken.

7.8 Side effects

Just like laboratory field strength meters the suppression of the unwanted electric field sensitivity is limited. This should not be a problem in every day work, but has to be taken in account in some special cases.
Potential errors occur, when a very weak magnetic field is measured in the presence of a very strong electric field.
In this case the decoupling from the electric field must be improved.
This can be done with a different direction of the probe or some electric shielding.

8. The Electric Field Probe 9 kHz - 1 GHz EFS 7103

8.1 Basics

In contrast to the two probes described before this probe was designed for the electric field. Also in this case a passive design is possible with a small conductive plate connected to the inner conductor of the coaxial cable.
Disadvantage of this simple design is poor sensitivity and frequency dependent conversion factor.
Matching the very high impedance of the plate to the low impedance of the coaxial cable is difficult and lossy.
An external preamplifier will improve sensitivity but cannot overcome the disadvantage of the frequency dependent conversion factor.

8.2 Principles

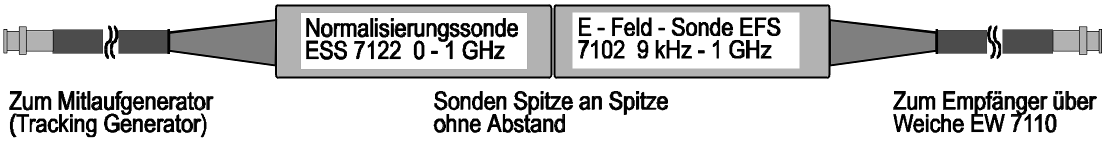
The electric field probe EFS 7103 uses a principle also used in laboratory field strength meters to keep the conversion factor independent of the frequency over many decades.
This is done by connecting the tiny conductive plate to an extremely high impedance amplifier. If there is practically no load on the capacitive probe, the voltage does not depend on the frequency.
More amplifier stages are used for further amplification and matching.
For better performance, GaAs-MMICs are used.

8.3 Directivity

The plate has an area of only a few mm^2 and is positioned directly behind the white stopper. Maximum reading leads you to the component by simply moving the probe.

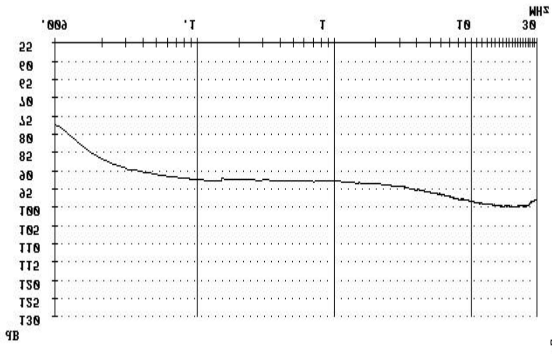
8.4 Frequency dependent conversion factor

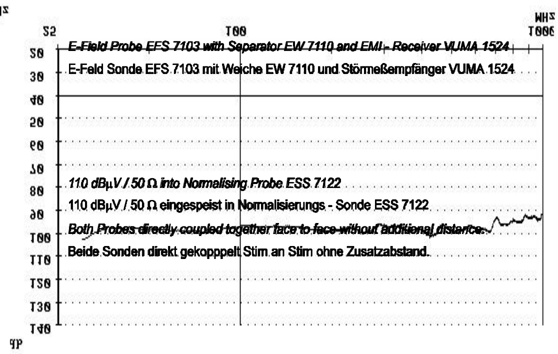
Measuring the frequency dependent conversion factor has to be made under specified measuring conditions. For this type of measurement, the optional electric normalising probe ESS 7122 from 0 to 1 GHz is used. It uses a small conductive area as a plate which is connected to the inner conductor of the coaxial cable. A 50 Ω-resistor matches the plate to the cable.
The plate is driven with a constant voltage and generates an electric field which is independent of the frequency.



Probes head against head without distance To receiver via separator

Both probes are coupled front to front. The normalising probe is connected to the tracking generator, the receiving probe to the spectrum analyser. A wooden table is recommended. Metal is not permitted in the vicinity. A broad copper band should be used to connect the grounding screws at the rear of the probes.
The diagram shows less than +-5 dB deviation in the frequency range from 30 kHz to 1 GHz. Below 30 kHz the sensitivity decreases and is 15 dB down at 9 kHz.





In special cases it may be justified to eliminate this small frequency error by normalising.
Most spectrum analysers use normalising routines to do this job.
Please read the manual.
Measuring receivers use transducer factors.
Probes can be handled as antennas.
The normalising factors are put into the receiver step by step.

8.5 Antenna factor

The antenna factor for this probe is +5 dB.
You can calculate the electric field strength reading the voltage from the receiver:

F [dbµV/m] = U [dBµV] +5 dB

8.6 Sensitivity

The lowest electric field strength level to be measured under realistic EMI-conditions is <20 dBµV/m (10 µV/m)). The receiver uses a bandwidth of 9 kHz (-6dB) and the CISPR Quasi-Peak-Detector. Measuring frequency is 1 MHz. A qualified EMI-receiver must be used for such a measurement. This lowest measuring limit is sufficient to monitor local radio stations using the probe as antenna.
Using smaller bandwidth and the average detector improves sensitivity significantly.

8.7. Maximum field strength

The maximum field strength for the probe is 120 dBµV/m (1 V/m). Higher field strength causes saturation and errors. When more signals are present, the amplitude of each signal has to be decreased in order to keep the complete spectrum under the saturation limit. Spectrum analysers contribute to saturation, when no input filtering is present. The graphic of the spectrum on the screen should be monitored carefully to notice the signs of intermodulation and saturation. When completely "new" signals occur, or when signals are not growing when the probe distance is reduced, care should be taken.

8.8 Side effects

Just as laboratory field strength meters the suppression of the unwanted magnetic field sensitivity is limited. This should not be a problem in every day work, but has to be taken in account in some special cases. Potential errors occur, when a very weak electric field is measured in the presence of a very strong magnetic field. In this case the decoupling from the magnetic field must be improved. This can be done with a different direction of the probe or some magnetic shielding.