Another EMC resource
from EMC Standards

Cost-effective uses of close-field probing Pt 1

Helping you solve your EMC problems

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Webinar: Cost-effective uses of close-field probing
Part 1, November 20, 2013
By Keith Armstrong

ITEM interference technology

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Close-field probing series
Webinar #1 of 2, November 20, 2013

Cost-effective uses of close-field probing in every project stage: emissions, immunity and much more

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interference technology

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Cost-effective uses of close-field probing

1
Introduction

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Close-field EMC probing (often called near-field probing) is difficult to do accurately

But it is an excellent qualitative technique

It can quickly identify emissions problems, when used with a spectrum analyser ('receiver')…

It can quickly reveal weak points for immunity, when used with transient and/or radio-frequency (RF) generators…

And it can help design PCBs, shielding, and much else

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Close-field EMC probing is low-cost and very useful

We can easily make close-field probes…
even from a paper clip…

– and they can be used to great effect with spectrum analysers costing as little as £800…

– or with oscilloscopes that we already have (it helps to be able to do Fourier transforms in our heads!)

Once people learn to use close-field probes…

– they wonder how they ever managed without them!

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Cost-effective uses of close-field probing

2

Making our own close-field probes

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Easily make two kinds of close-field probes

The magnetic field probe...

– a 'shorted turn' shielded from electric fields, sometimes called a 'loop' probe

The electric field probe...

– a very short 'whip' antenna

The largest probe dimension should be less than 1/6th of the wavelength at the highest frequency to be measured (e.g. < 1GHz: < 50mm dia.)

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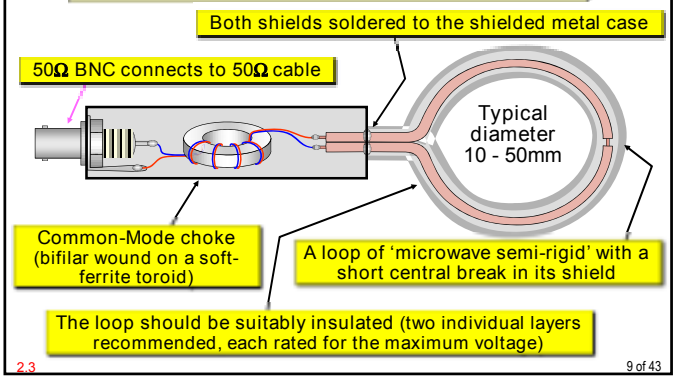
Construction of a good-quality close-field magnetic probe



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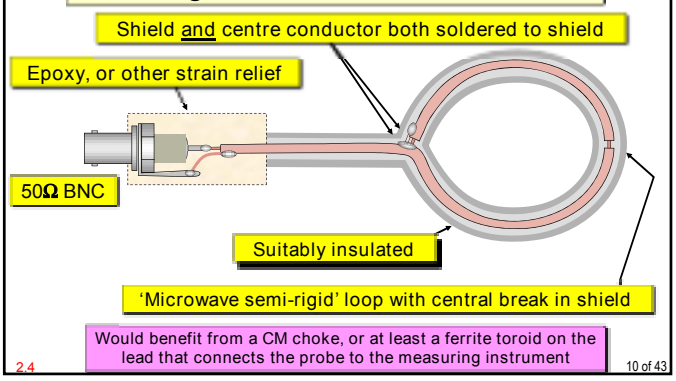
An easier magnetic field probe design (but lower performance)



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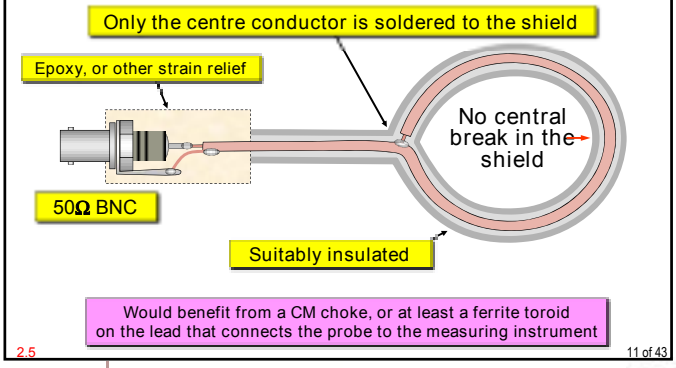
An even easier magnetic field probe (with even lower performance)



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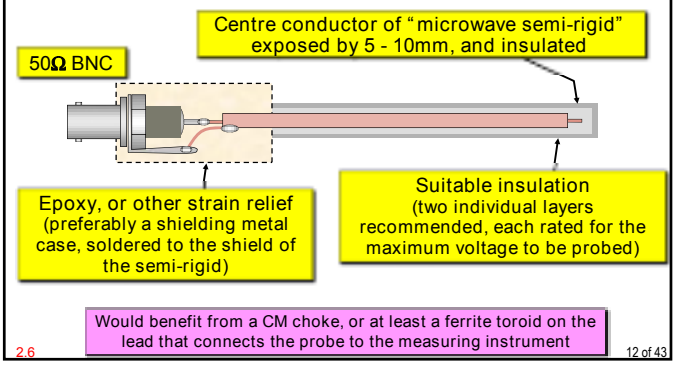
Construction of an electric field probe



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Unshielded loop probes

Close-field probing using magnetic-field probes will not detect electric fields…

– and an electric-field probe will not detect magnetic fields

So, sometimes a simple loop of unshielded wire can be helpful…

– this will detect both magnetic and electric fields…

– can save time in locating problem areas when the nature of the source is unknown

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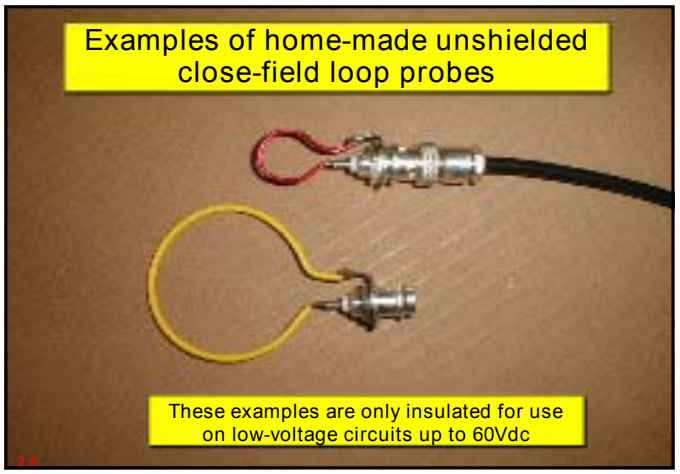
Examples of home-made unshielded close-field loop probes



These examples are only insulated for use on low-voltage circuits up to 60Vdc

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Many close-field probes are circular

But rectangular probe shapes can be more convenient…

– for testing flat items such as printed-circuit boards (PCBs)

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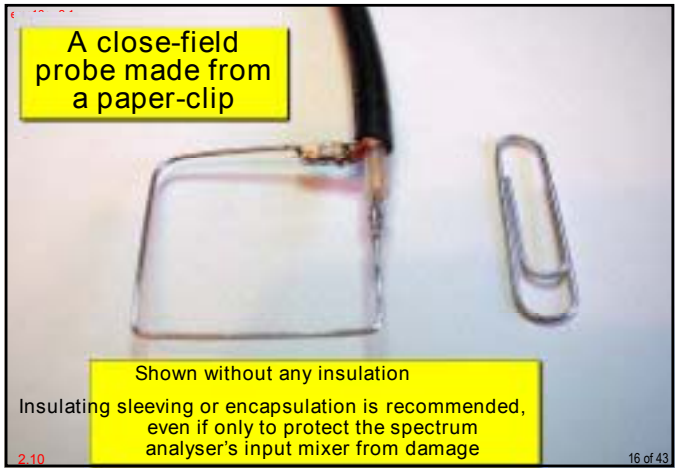
A close-field probe made from a paper-clip



Shown without any insulation

Insulating sleeving or encapsulation is recommended, even if only to protect the spectrum analyser's input mixer from damage

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A variety of other probe designs are possible

Multi-turn coils have more sensitivity…

– but resonate at lower frequencies than a single-turn coil of the same diameter…

due to the capacitive coupling between the turns

Some people wind tiny coils on the sharpened points of pencils, for measuring up to 30GHz…

– the resulting tiny cone-shaped multi-turn winding helps reduce resonances whilst increasing sensitivity

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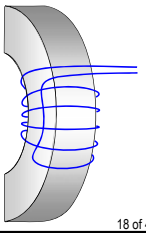
A variety of other probe designs are possible continued…

Some people use half of an RF ferrite cylinder or toroid and put a turn or two around it…

– the ferrite acts as an antenna for magnetic fields…

– commercial products based on this principle are often called 'surface current probes'



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POLL QUESTIONS

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Cost-effective uses of close-field probing

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Buying close-field probes and low-cost spectrum analysers

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Commercially-available close-field probes

There are a number of suppliers of close-field probes…

- most of them have built-in amplifiers, or are too weak for other reasons, so must not be used for immunity testing…
  - because they won't work, and they will be damaged…
- and some are calibrated in dBμA/m (H-field) or dBμV/m (E-field)

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Aaronia AG, E & H near-field probe set DC - 9GHz, PBS2 preamplifier

Laplace Instruments RF-100

ETS-Lindgren 7405 with optional preamplifier

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Some of the many close-field probe kits from Langer EMV-Technik 100kHz to 6GHz, E & H field

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Agilent 11945A kit, H-field 9kHz-30MHz H-field 30MHz-1GHz plus preamp Low price for 2nd-user (ebay, etc.)

Agilent N9311X-100 set, H-field 30M-3GHz (looks like Langer RF2 !)

Teseq NFPS1 set, H-field 9kHz-30MHz H-field 30MHz-1GHz E-field 9kHz-1GHz built-in preamps

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Hameg HZ530
E & H probes

Com-Power PS-500
E & H probes

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Rigol 'near-field probe set'
£250

Aim I-prober 520

- Non-contact probe: observe/measure current in PCB traces, component leads, ground planes
- Dynamic range: 10mA to 20A pk-pk
- DC to 5MHz

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A wide variety of low-cost spectrum analysers are available

Used with close-field probes (or current probes, see later) to check conducted or radiated emissions…

and for design diagnoses/assessments

There are expensive models with a variety of sophisticated functions…

including CISPR Quasi-Peak and Average detectors…

– and there are medium and low-cost models…

available to over 6GHz

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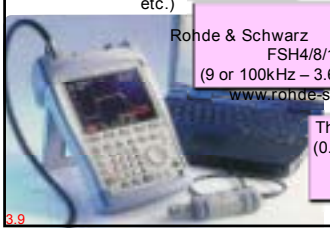
Agilent E7400A Series (portable)
www.agilent.com
Low prices for 2nd-user (ebay, etc.)

Agilent N9342C-N9344C up to 20GHz
www.agilent.com



Rohde & Schwarz
FSH4/8/13 or 20
(9 or 100kHz – 3.6/8/13 or 20GHz)
www.rohde-schwarz.com

Thurlby-Thandar PSA1301T
(0.1MHz -1.3GHz) PSA2701T
(1MHz-2.7GHz) www.tti-test.com

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Rigol DSA 815, 9kHz – 1.5GHz
Add: Tracking Generator
Add: CISPR bandwidths and Q-Pk detector
Add: Advanced Measurement control software

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Cost-effective uses of close-field probing

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Current probes and pin probes

These are not close-field probes, but are also very useful for cost-effectiveness in all lifecycle stages

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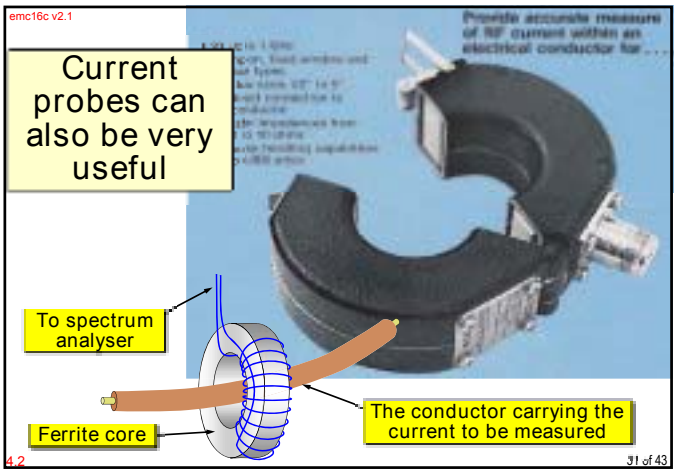
emc16c v2.1
Current probes can also be very useful
To spectrum analyser
Ferrite core
The conductor carrying the current to be measured
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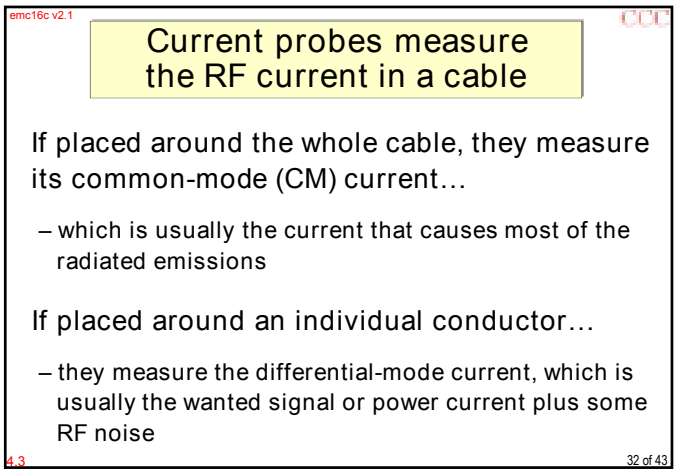
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Current probes measure the RF current in a cable
If placed around the whole cable, they measure its common-mode (CM) current…
– which is usually the current that causes most of the radiated emissions
If placed around an individual conductor…
– they measure the differential-mode current, which is usually the wanted signal or power current plus some RF noise
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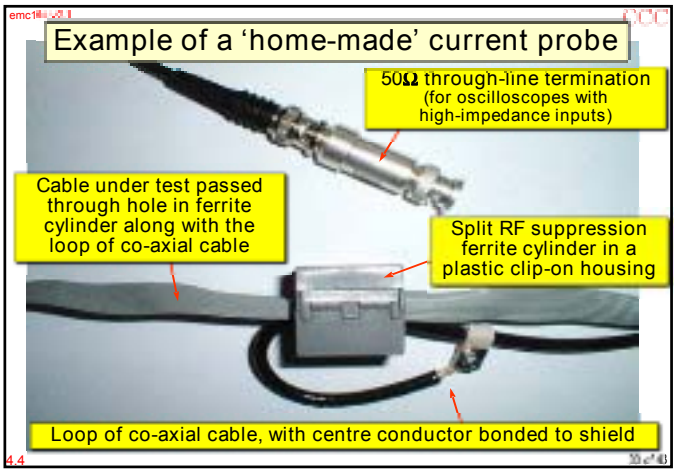
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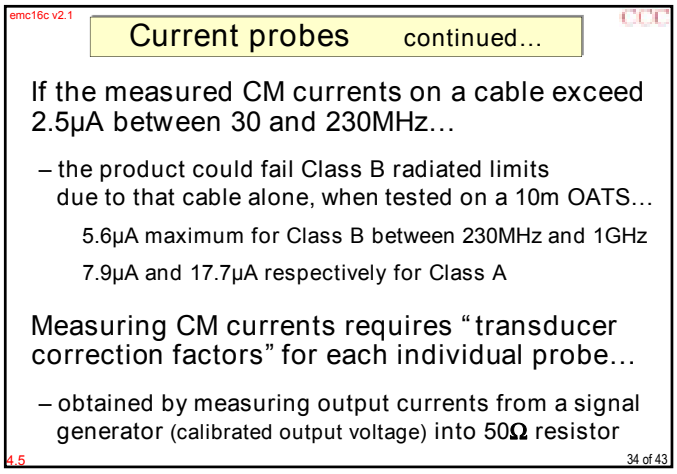
Example of a 'home-made' current probe
50Ω through-line termination (for oscilloscopes with high-impedance inputs)
Cable under test passed through hole in ferrite cylinder along with the loop of co-axial cable
Split RF suppression ferrite cylinder in a plastic clip-on housing
Loop of co-axial cable, with centre conductor bonded to shield
4.4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Current probes continued…
If the measured CM currents on a cable exceed 2.5μA between 30 and 230MHz…
– the product could fail Class B radiated limits due to that cable alone, when tested on a 10m OATS…
5.6μA maximum for Class B between 230MHz and 1GHz
7.9μA and 17.7μA respectively for Class A
Measuring CM currents requires "transducer correction factors" for each individual probe…
– obtained by measuring output currents from a signal generator (calibrated output voltage) into 50Ω resistor
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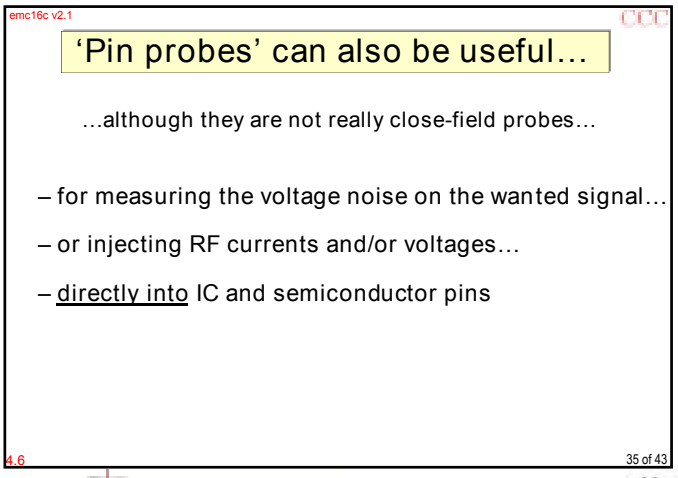
emc16c v2.1
'Pin probes' can also be useful…
…although they are not really close-field probes…
– for measuring the voltage noise on the wanted signal…
– or injecting RF currents and/or voltages…
– directly into IC and semiconductor pins
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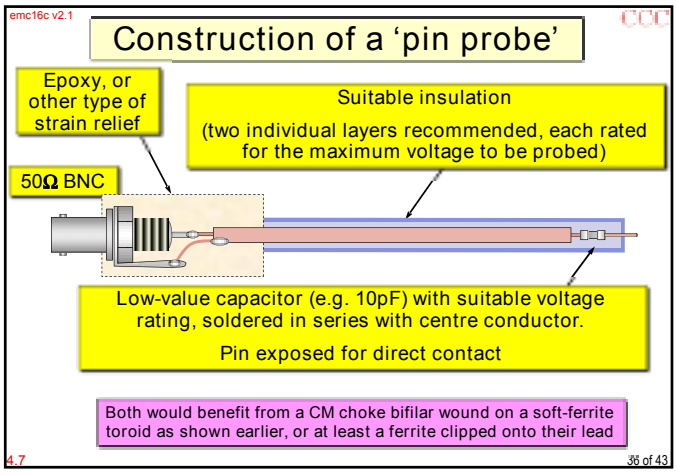
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Construction of a 'pin probe'
Epoxy, or other type of strain relief
Suitable insulation
(two individual layers recommended, each rated for the maximum voltage to be probed)
50Ω BNC
Low-value capacitor (e.g. 10pF) with suitable voltage rating, soldered in series with centre conductor.
Pin exposed for direct contact
Both would benefit from a CM choke bifilar wound on a soft-ferrite toroid as shown earlier, or at least a ferrite clipped onto their lead
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Cost-effective uses of close-field probing

5

Using close-field probes

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The most important issues

Don't damage the spectrum analyser, or the equipment being probed !!!

e.g. by touching a conductor with a part of a probe

Don't electrocute yourself, or others !!!

Only use probes that are insulated to withstand the maximum possible voltage of the circuits to be probed…

– i.e. which comply with all relevant parts of both IEC 61010-1 and IEC 61010-031…

– and don't have any damage to their insulation

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Using close-field probes
continued…

The probes are sensitive to near-field signals…

– so tend to ignore ambient RF noise…

– making it easier to identify EMC problems

They must be held very close to an item to operate, and are usually used to probe...

– seams and apertures in shielding enclosures… –

cables and connectors…

– PCB traces, ICs, transistors and heatsinks

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Using close-field probes
continued…

Some regions of some types of probes are more sensitive than others…

– so for repeatability it is important to use the probe the same way each time

Loop probes (magnetic-field) are polarised…

– they pick-up or emit magnetic fields more strongly when the fields are perpendicular to the plane of the loop…

– so orienting the loop can help identify where a problem is located

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Close-field probes are all different

It is difficult to make comparisons between the results of different designs of close-field probes…

– and there is no direct comparison between close-field probe test results and the results of 'proper' EMC tests

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Close-field probes are all different
continued…

But if we keep using just a few particular probes with specific items of test equipment (spectrum analyser, signal generator, etc.)…

– and use them to test equipment that has passed (or failed) full-compliance EMC tests…

– we soon become familiar with how our probes' results compare with 'proper' EMC testing

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