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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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1 of 43

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2 of 43

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Contents

3 of 43

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Cost-effective uses of close-field probing

1
Introduction

1.1

4 of 43

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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

1.2

5 of 43

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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!

1.3

6 of 43

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Cost-effective uses of close-field probing

2

Making our own close-field probes

2.1 7 of 43

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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.)

2.2 8 of 43

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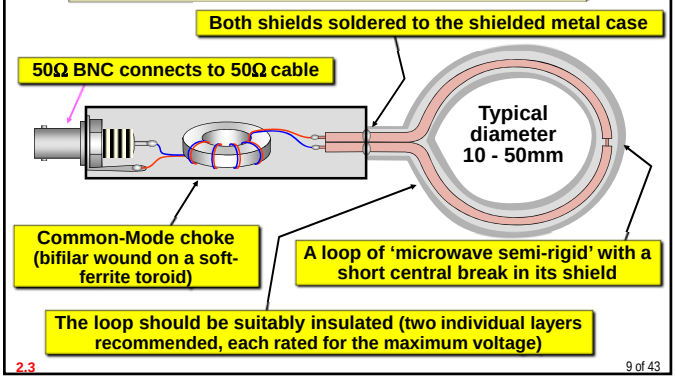
Construction of a good-quality close-field magnetic probe



2.3 9 of 43

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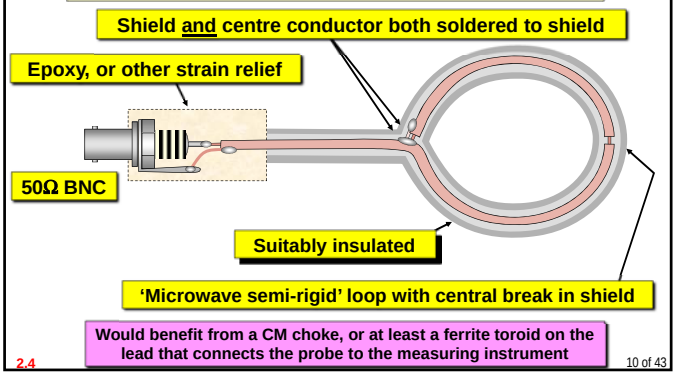
An easier magnetic field probe design (but lower performance)



2.4 10 of 43

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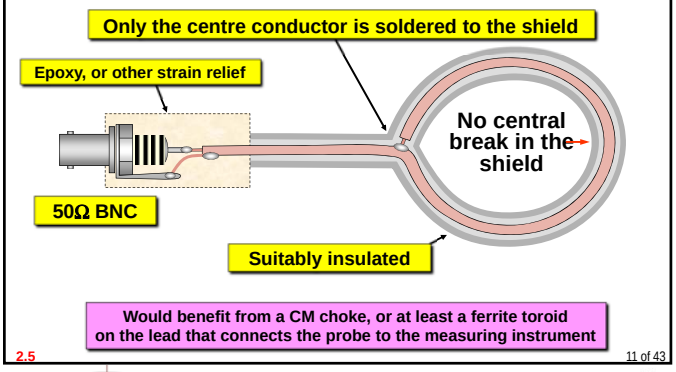
An even easier magnetic field probe (with even lower performance)



2.5 11 of 43

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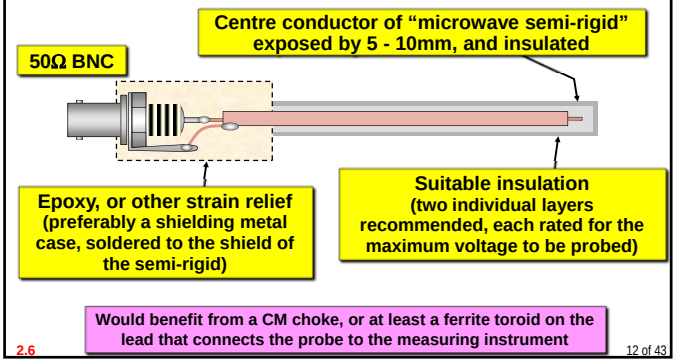
Construction of an electric field probe



2.6 12 of 43

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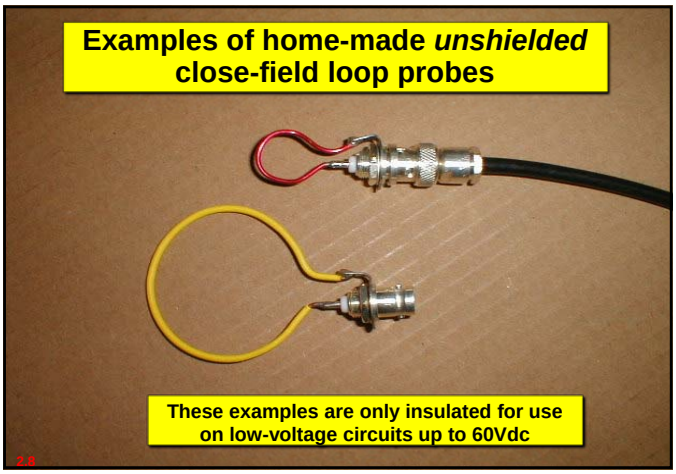
Unshielded loop probes

- 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

2.7 13 of 43

Examples of home-made *unshielded* close-field loop probes



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

2.8

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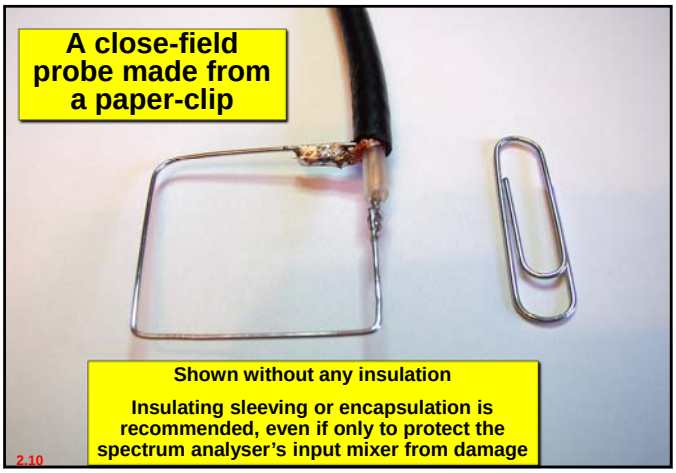
Many close-field probes are circular

- But rectangular probe shapes can be more convenient…
  - for testing flat items such as printed-circuit boards (PCBs)

2.9 15 of 43

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

2.10

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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

2.11 17 of 43

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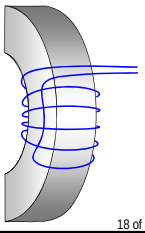
A variety of other probe designs are possible continued…

- 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'



2.12 18 of 43

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POLL QUESTIONS

19 of 43

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Cost-effective uses of close-field probing

3

Buying close-field probes and low-cost spectrum analysers

3.1

20 of 43

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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)**

3.2

21 of 43

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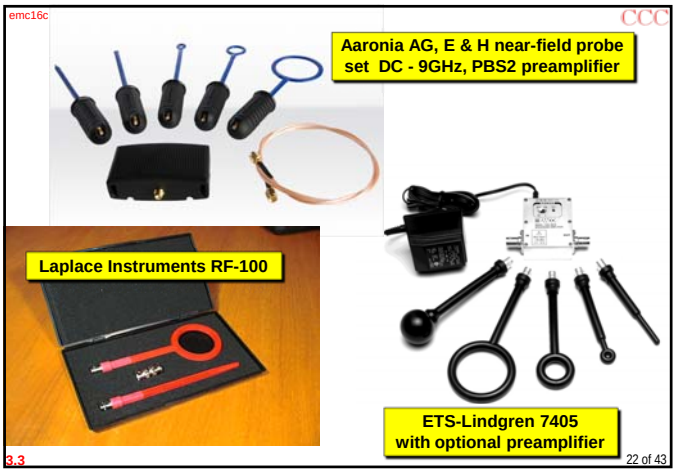

3.3

22 of 43

3.4

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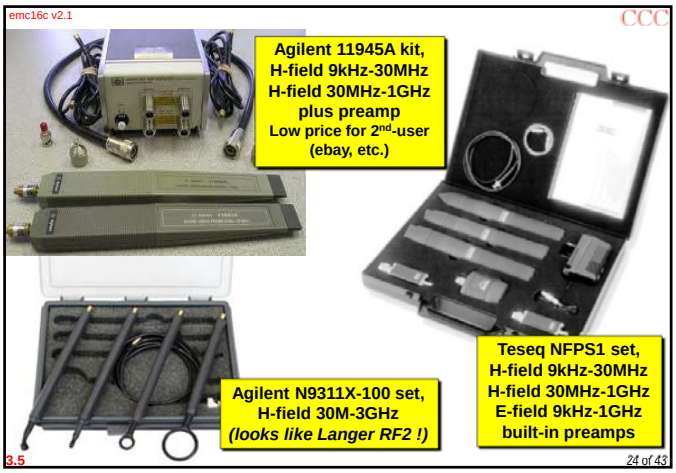

3.5

24 of 43

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Hameg HZ530
E & H probes

Com-Power PS-500
E & H probes

3.6 25 of 43

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Rigol 'near-field probe set'
£250

Aim I-prober 520 Positional Current Probe
PCB Track - Touch & Measure

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

3.7 26 of 43

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A wide variety of low-cost spectrum analysers are available

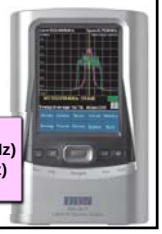
- **Used with close-field probes** (or current probes, see later) **to check conducted or radiated emissions…**
  - **and for design diagnoses/assessments**
- **There are expensive models with a variety of sophisticated functions…**
  - **including CISPR Quasi-Peak and Average detectors…**
  - **and there are medium and low-cost models…**
    - **available to over 6GHz**

3.8 27 of 43

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

3.9

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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

3.10 29 of 43

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Cost-effective uses of close-field probing

4

Current probes and pin probes

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

4.1 30 of 43

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Current probes can also be very useful

To spectrum analyser

Ferrite core

The conductor carrying the current to be measured

4.2 31 of 43

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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

4.3 32 of 43

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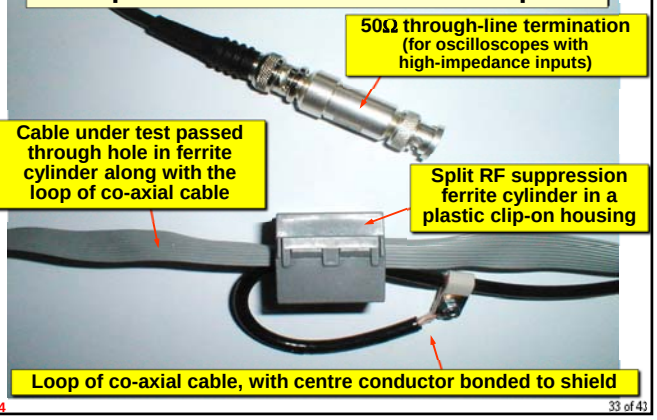
Example of a 'home-made' current probe



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 33 of 41

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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

4.5 34 of 43

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'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…
  - <u>directly into</u> IC and semiconductor pins

4.6 35 of 43

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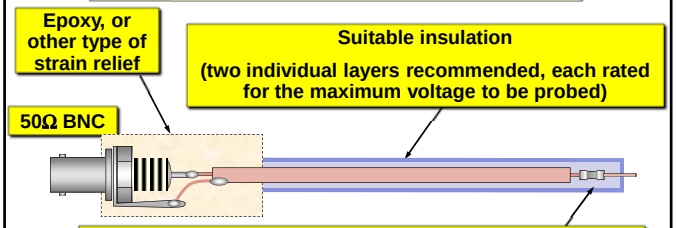
Construction of a 'pin probe'



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

4.7 36 of 43

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Cost-effective uses of close-field probing

5

Using close-field probes

5.1 37 of 43

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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

5.2 38 of 43

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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

5.3 39 of 43

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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

5.4 40 of 43

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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

5.5 41 of 43

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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

5.6 42 of 43

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the end
of the 1st part

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43 of 43