Demonstration of:

A shielding effectiveness test method.

by Roy Ediss, Ediss Electric Ltd.

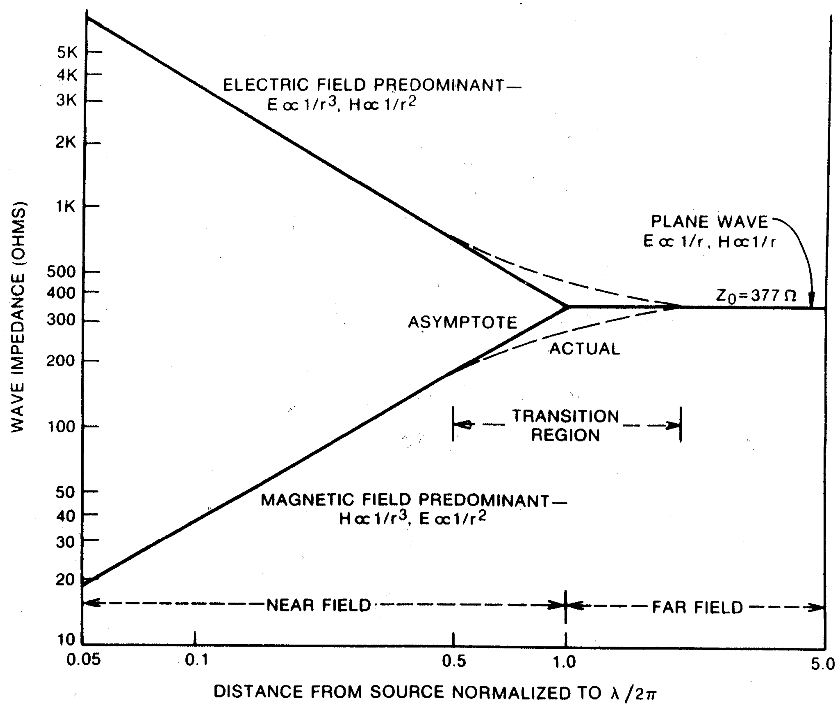
Field characteristics.

Interaction of fields and shielding materials.

Magnetic field sensing probes.

The test method using two probes.

Electric, magnetic and electromagnetic fields.



Electric, magnetic and electromagnetic fields.

The type of source, the distance away and the transmission medium determine *near-field and far-field characteristics*.

Up to a distance of $\frac{\lambda}{2\pi}$ metres

the near-field may be predominantly electric or magnetic depending on the source. The wave impedance Z_w is the ratio E/H of electric to magnetic field, it is variable with distance but with respectively high and low value.

$$Z_w = \frac{E}{H} \text{ ohms}$$

In the far field, where a plane wave is formed, this ratio of E/H is constant and equals the characteristic impedance of the medium Z_o, which for air is 377ohms. A matched situation then exists for propagation. $Z_w = Z_o$.

for insulators $Z_o = \sqrt{\frac{\mu}{\varepsilon}}$ ohms

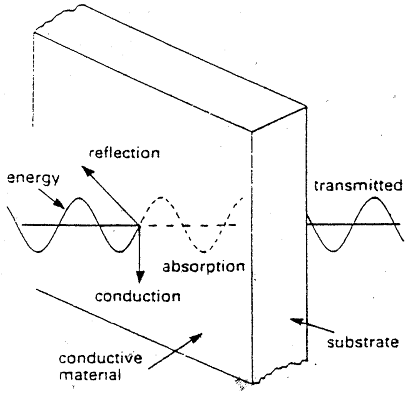
where μ is permeability
and ε is dielectric constant or permittivity

So for air where $\mu_o = 4\pi \times 10^{-7}\,Hm^{-1}$, $\varepsilon_o = 8.85419 \times 10^{-12}\,Fm^{-1}$

$$Z_o = \sqrt{\frac{\mu_o}{\varepsilon_o}} = \sqrt{\frac{4\pi \times 10^{-7}}{8.85419 \times 10^{-12}}} = 377 \text{ ohms}.$$

The field wave impedance varies with distance from the source as described. This shielding demonstration is performed in the near-field.

The shielding effectiveness of various materials.



Dissipation of radiated EM energy

		Result:
High Wave Impedance (Electric field) →	Low Material Impedance (Metal)	MISMATCH and tendency for reflection

		Result:
Low Wave Impedance (Magnetic field) →	Low Material Impedance (Metal)	Less reflection more absorption

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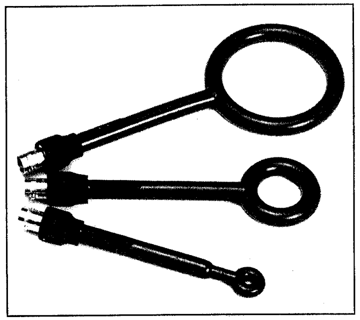


Figure 2. These probes are highly selective of the H field while being relatively immune to the E-field.

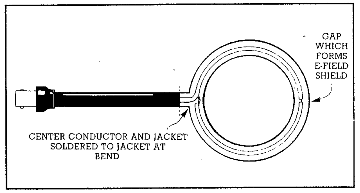


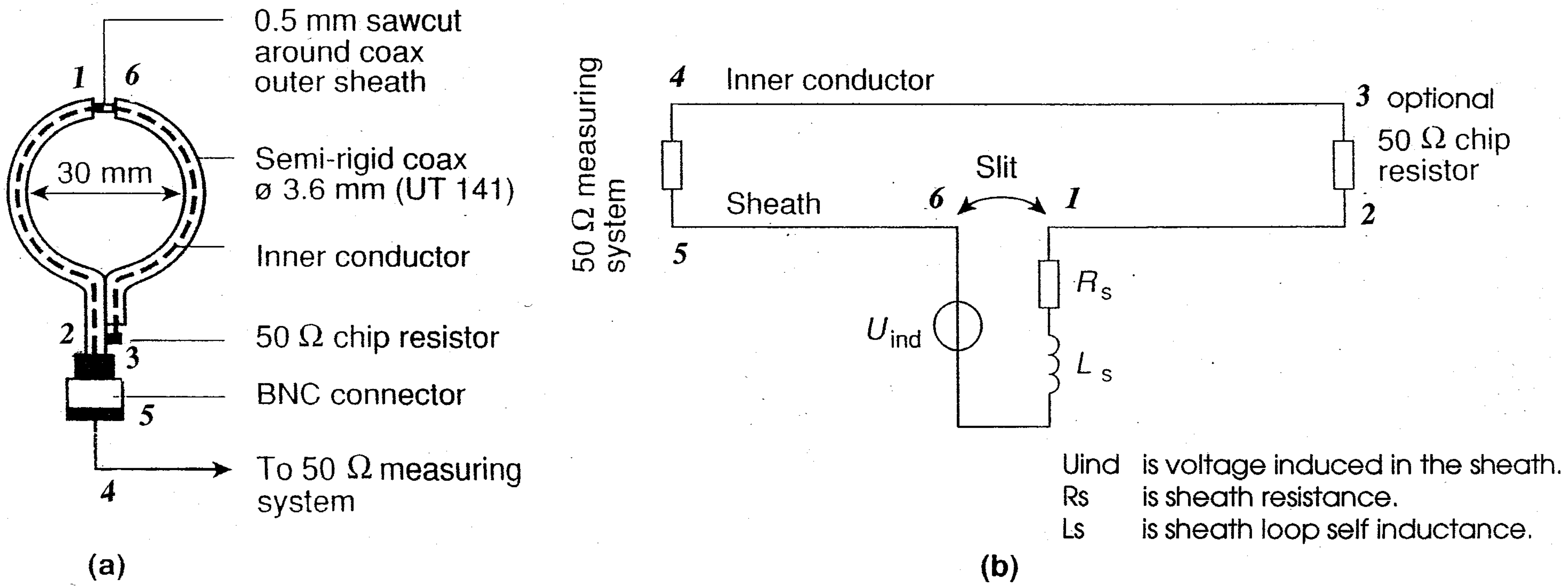
Figure 3. H-field Probe

D. PROBE TECHNICAL DATA

Model Number	Probe Type	Primary Sensor Type	E/H or H/E Rejection	Upper Resonant Frequency
901	6 cm Loop	H-Field	41 dB	790 MHz
902	3 cm Loop	H-Field	29 dB	1.5 GHz
903	1 cm Loop	H-Field	11 dB	2.3 GHz
904	3.6 cm Ball	E-Field	30 dB	2.3 GHz
905	6 mm Stub Tip	E-Field	30 dB	23.6 GHz

Figure 7-11. Probe Characteristics.

Commercial magnetic probes are available but they can be easily made.



(a) Do-it-yourself *H* field sensor; (b) equivalent circuit diagram.
(Corresponding points are numbered 1 to 6.)

How the magnetic field probe works.

Refer to the diagram of the H-field loop probe and its equivalent circuit diagram. The probe is made from 50 Ohm semi-rigid coaxial cable. Corresponding points are numbered 1 to 6.

Electric fields may impinge on the outer sheath of the probe but are shielded from the inner signal line.

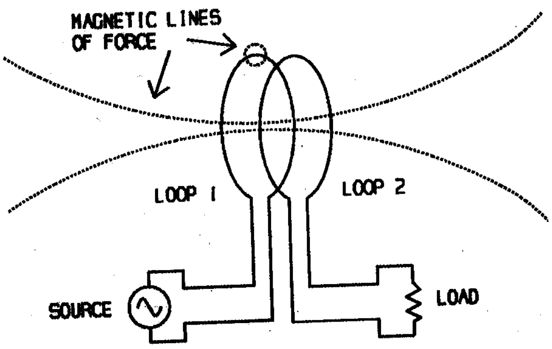
A magnetic field passing through the probe loop generates a voltage. Faradays law states that the induced voltage is proportional to the total time changing magnetic flux through a circuit loop. A voltage is therefore in fact induced in the outer sheath loop, and this appears across the sheath gap (points 1 & 6). The 50 Ohm transmission line, formed by the sheath and the inner conductor, is then driven by this voltage and is terminated by the 50 Ohm measurement system (points 4 & 5) and the optional 50 Ohm chip resistor (points 2 & 3). (The chip resistor will reduce the probe sensitivity when it is used as a pick-up connected to a measuring instrument. In reality this terminator is only desirable when the probe is used as a local transmitting source fed from a signal generator.)

The probes have a self-resonant frequency due to loop inductance and parasitic capacitance; the smaller the probe loop, the higher this frequency. For a 20 mm by 20mm square loop this resonance occurs at around 1.3GHz.

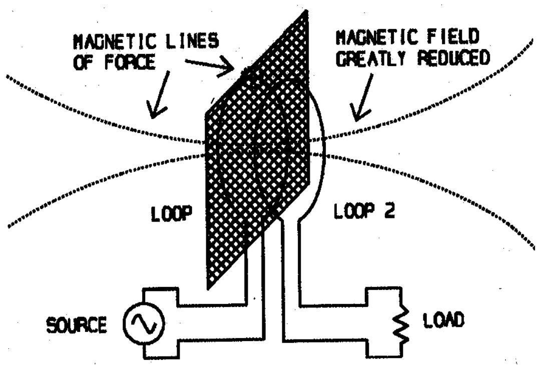
The test method using two probes.

Refer to "A method of accurately measuring shielding effectiveness of materials in electronic products" by Douglas C. Smith. EMC Compliance Journal, Issue 43, Pg. 17-20. November 2002. Available at http://www.compliance-club.com/Archive.aspx

The diagrams below indicate the test methodology.



Transmission Between Loops



Shielding Material Placed Between the Loops