Ground Parameters For Hams

Do we have a problem and can we do something about it?

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Note

- Copies of this presentation are available on my web site: www.antennasbyN6LF.com
- Because of time limitations this presentation is very short but a detailed multi-page discussion of the issues, equipment examples, test data, calibration information, etc, etc, is available on my web site.
- Both are in .pdf format.

NEC Modeling

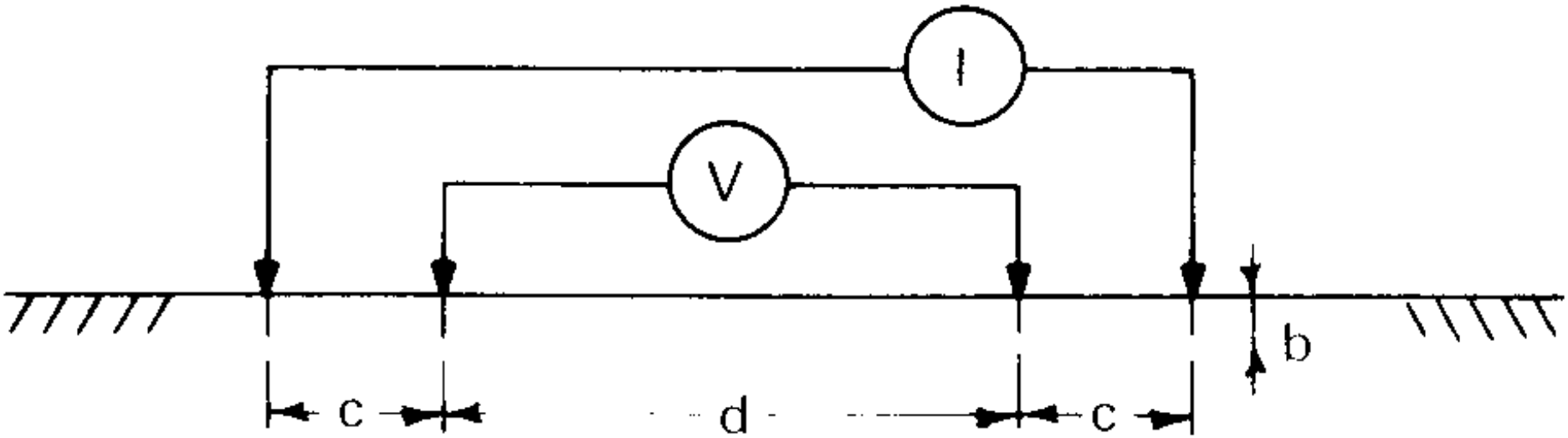
- Antenna modeling on a computer has assumed an important role in antenna design.
- The values for ground conductivity (sigma) and relative permittivity (Er) are key inputs especially for verticals.
- However, there are some problems:
  - most of the time the values selected are little more than a wild guess,
  - fixed "typical" values are used which do not reflect reality as the frequency is changed,
  - and it is seldom appreciated that for a given sigma, there may be a wide range of Er values.

A major problem

- Soil parameters by nature vary widely:
  - from site to site
  - laterally within a site
  - vertically
  - soil is often stratified
  - over time due to rainfall and dry seasons
- Can we actually make useful measurements?

Conventional idea

- Simple low frequency sigma measurements with something like a Wenner array represent a good approximation to sigma on the lower HF bands.



The idea is based on

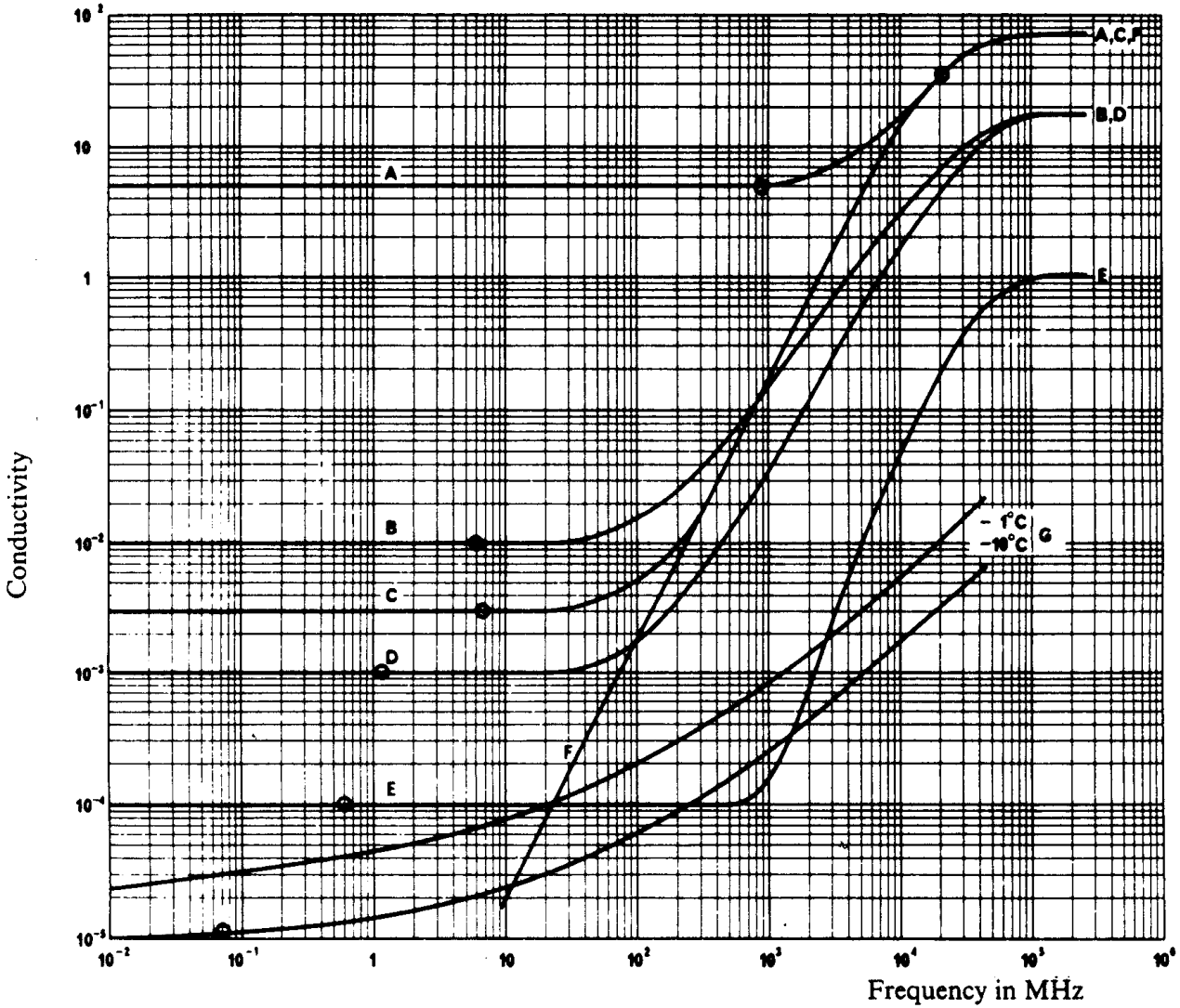
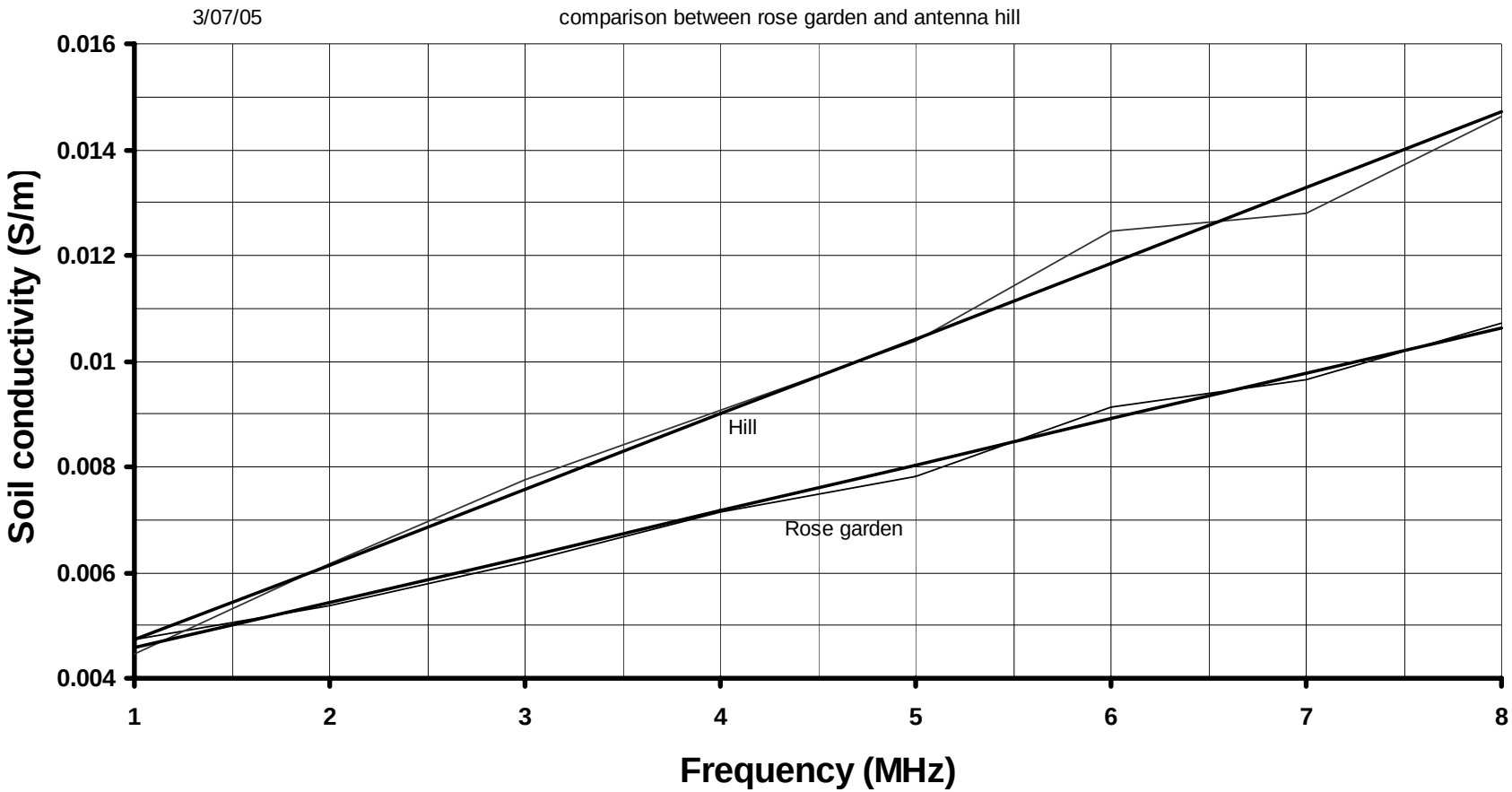


Fig. 3.1 Permittivity ε and conductivity σ of the Earth's surface: A: sea water (mean salinity), 20°C; B: humid soil; C: fresh water, 20°C; D: moderately dry soil; E: very dry soil; F: pure water, 20°C; G: ice (fresh water); ring: transition frequency.

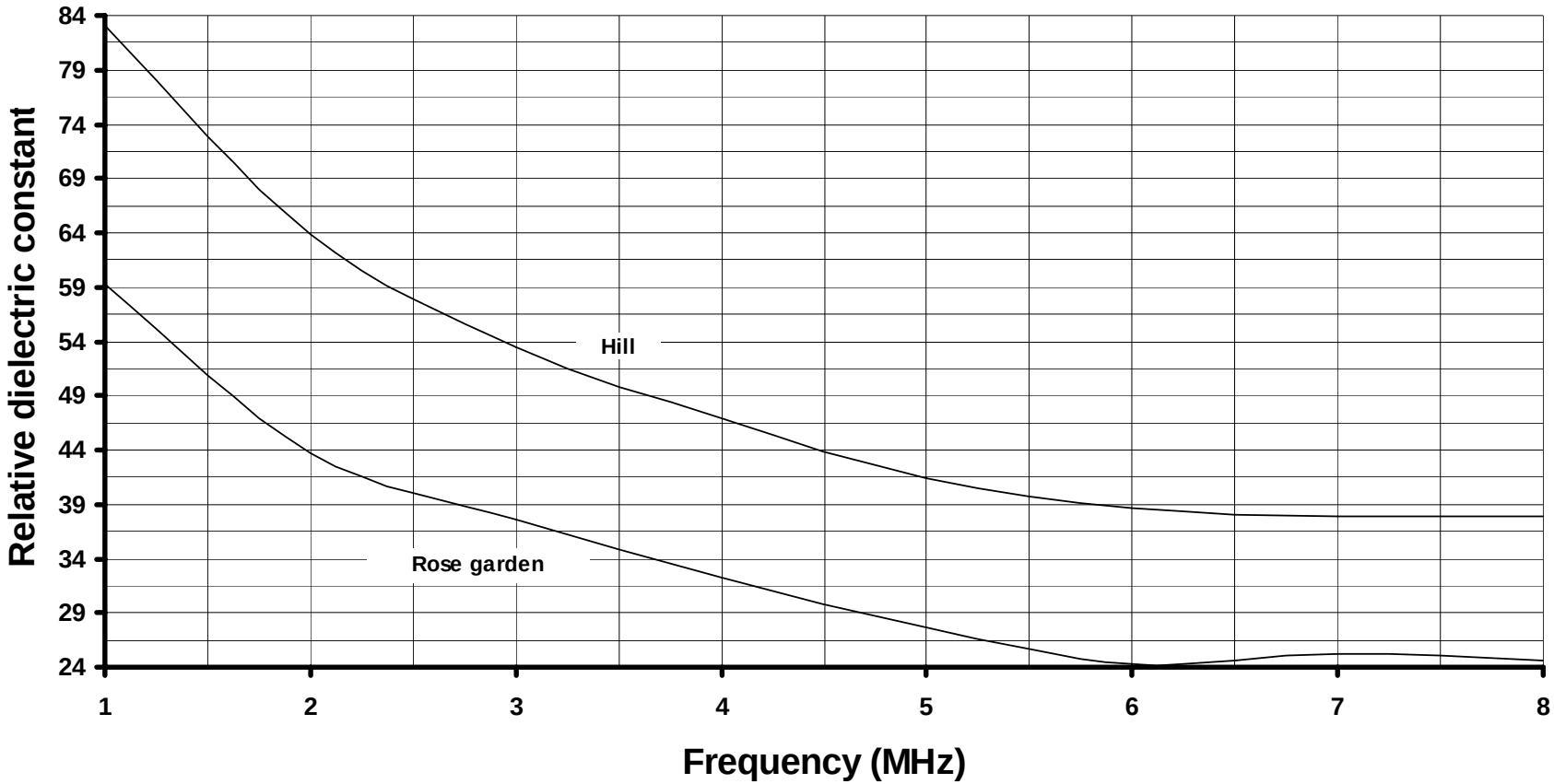
IEEE Std. 356-2001 comment

- **"The curves of conductivity and relative permittivity in ITU-R Recommendation 527-3 exhibit no dispersion in the band 3-30 MHz, whereas measured values show significant dispersion in the band for which surface soils typically can show characteristics from lossy conductors to lossy dielectrics ..... Therefore, the ITU values for the HF band are inconsistent with the results of complex variable theory and are in error."**

Typical HF conductivity plots



Typical HF Er plots



Comment on high Er values

- **The following quote is from the King and Smith, Antennas In Matter.**
- **"For some time, the high values of permittivity and the dispersion at these lower frequencies were thought to be artifacts of the measuring procedure; that is, it was thought that they were caused by electrochemical effects at the interface between the metallic electrodes and the sample of rock or soil. Measurements made using several different materials for the electrodes, however, indicate that there is a high permittivity associated with the geological material apart from any electrode effects."**

Ground measurements for hams

- Whatever scheme is adopted for ground measurements by hams has to have certain attributes:
  - it has to use simple and low cost mechanical apparatus
  - and
  - the instrumentation should be no more advanced than an MFJ or AEA or similar impedance analyzer
  - the measurement procedure must be quick and easy with data reduction on a spreadsheet.
- Vector network analyzers, like that by N2PK which are appearing in many shacks, are great but should not be required.

Comments on measurement accuracy

- For horizontally polarized antennas more than ¼-wave above ground, the ground parameters are not critical.
- However, for verticals, close to ground, the parameters are important.
- Fortunately we do not need 1% accuracy.
- +/- 25 % is just fine!

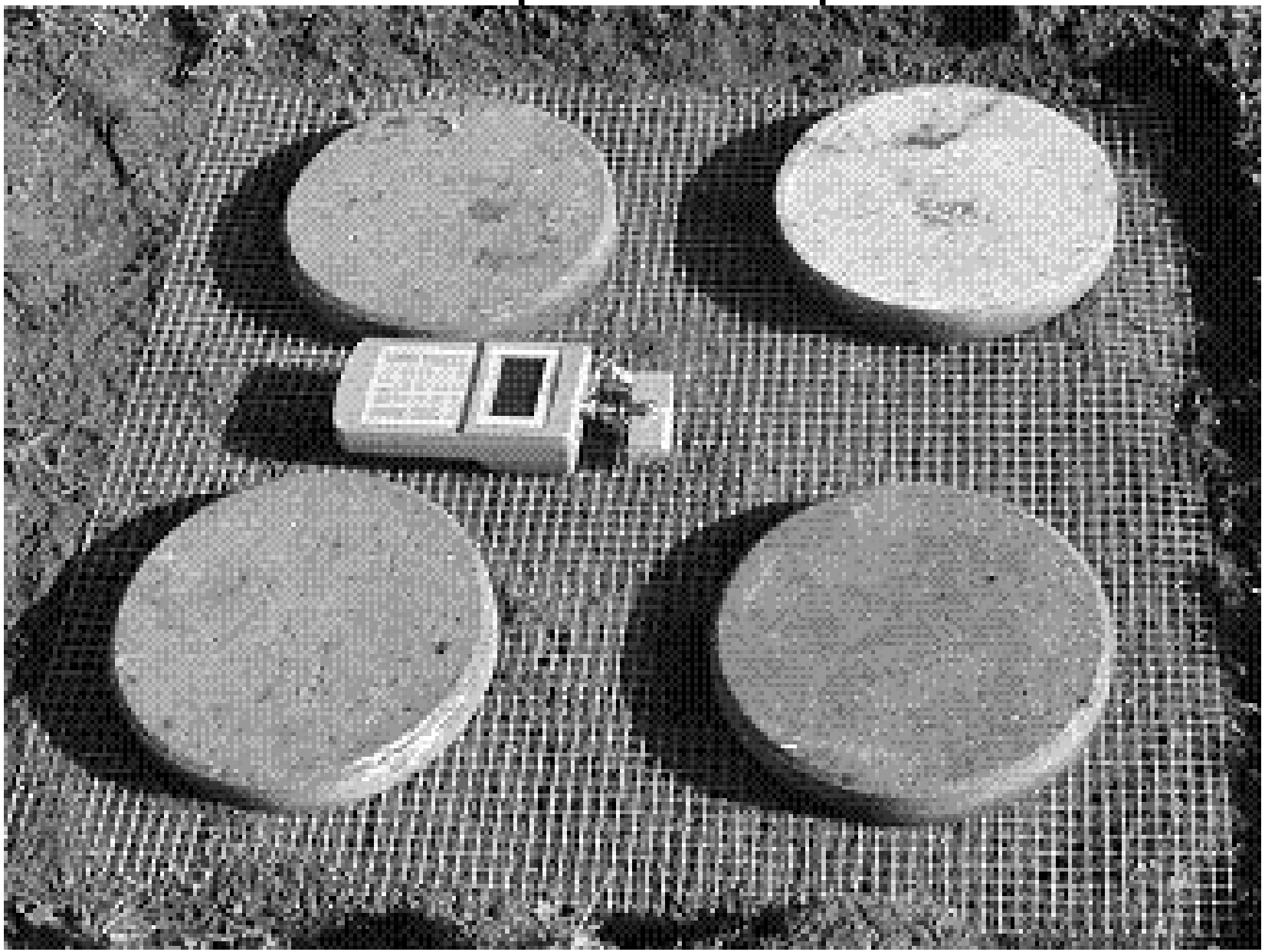
Using the decay rate of the E-field

- It is very common in the BC field to measure the rate of decay of the electric field along a radial line away from an antenna.
- For soils dominated by resistivity this can give a reasonable average value for conductivity by curve fitting to the data.
- However,
  - at HF where the capacitive component matters, there are often several different combinations of sigma and Er that fit the curve
  - in addition this approach doesn't give good resolution close to the antenna

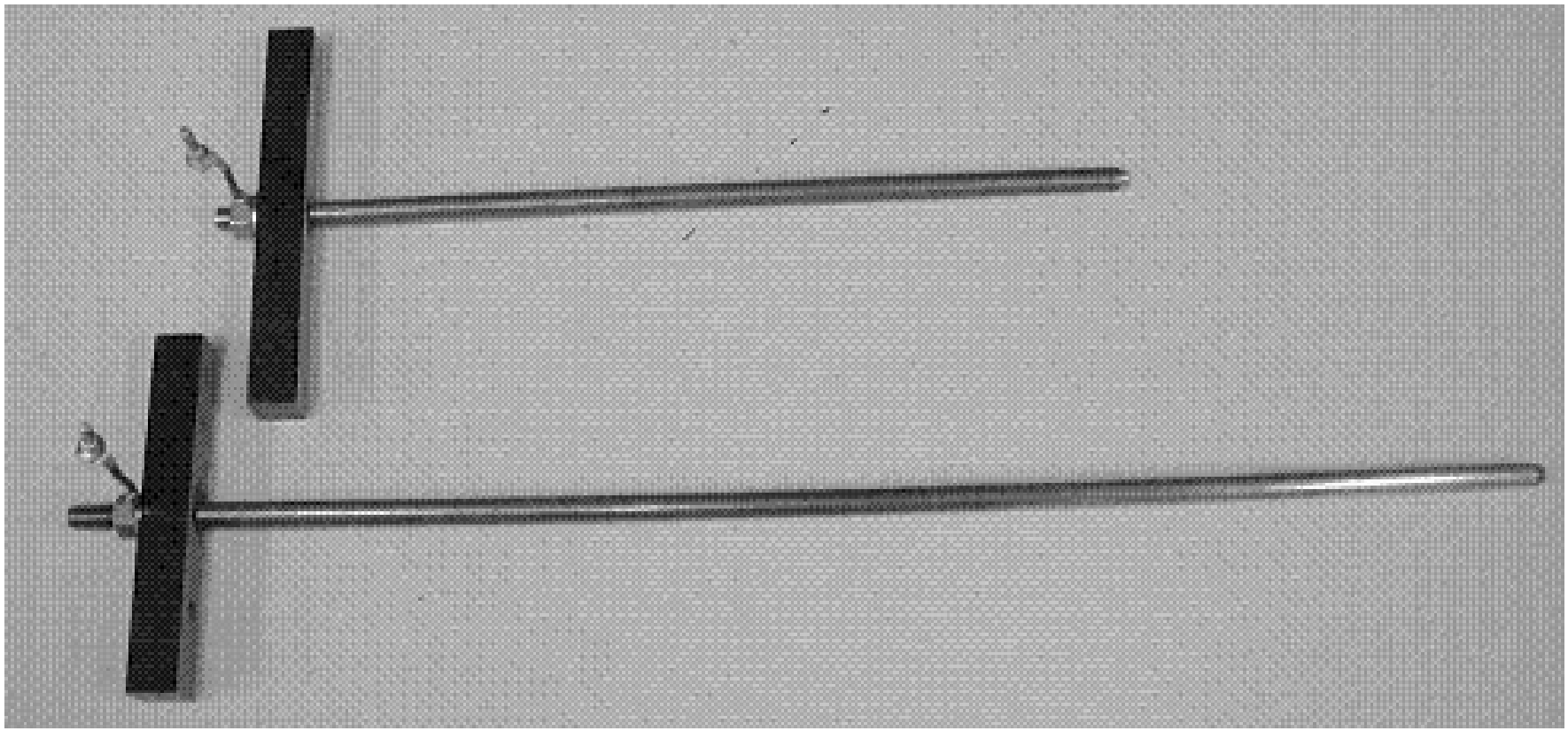
Soil probe technique

- It is possible to insert a probe into the soil and measure the impedance of the probe to determine soil parameter.
- The idea is that the probe can be represented as either a simple capacitor or an antenna in the soil and soil parameters can be deduced from the impedance.
- There are many kinds of probes but the two most commonly used are:
  - a single rod inserted into the soil with a ground screen, called a monoprobe
  - and
  - a two conductor open transmission line, called an OWL.

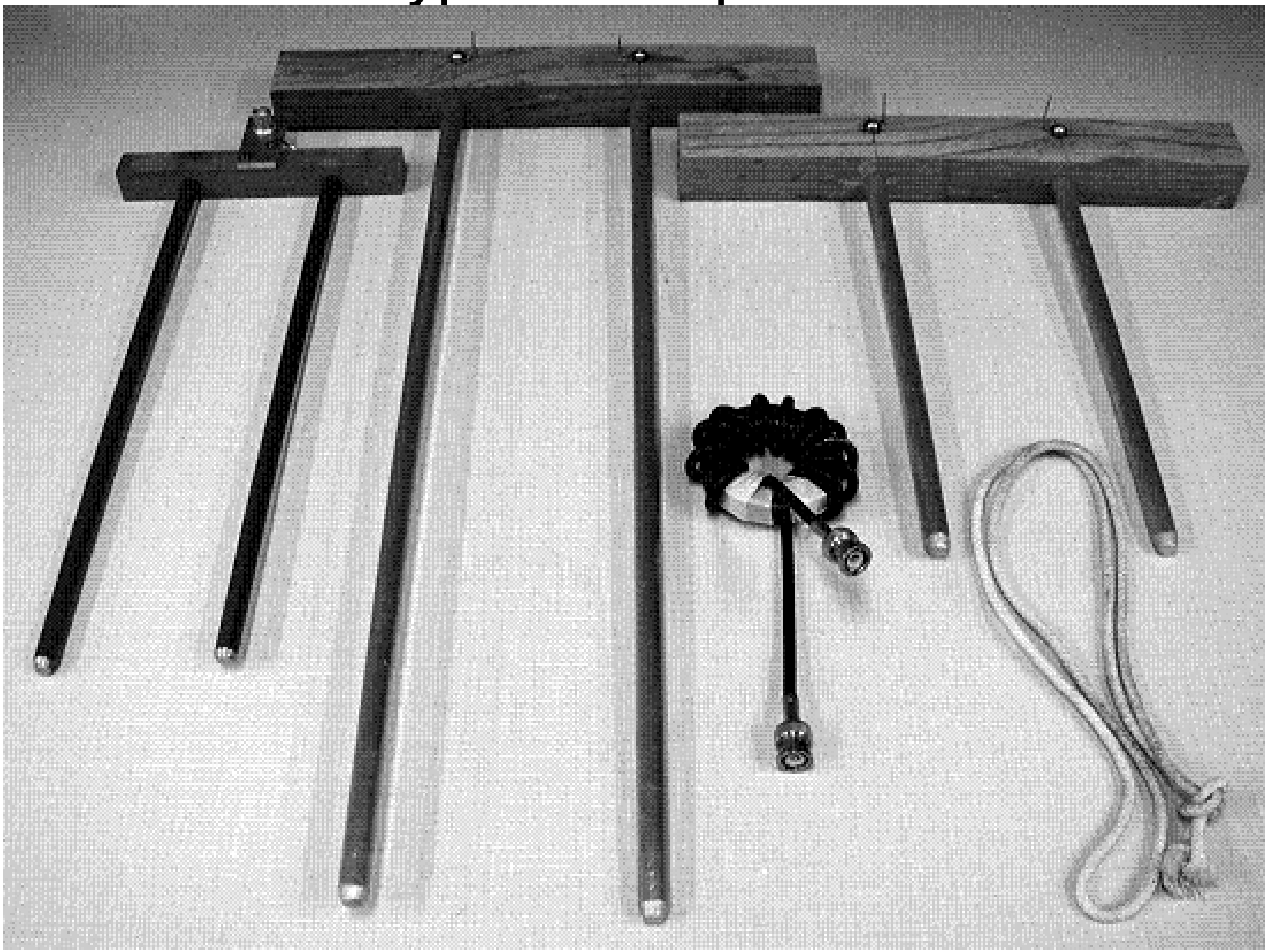
Monoprobe example



Typical ground probes



Typical OWL probes



Advantages and limitations of probes

- Both the monoprobe and the OWL can give quite accurate values for conductivity and Er.
- In practice the measurements are quick and easy.
- But these values are only for a cylinder of soil surrounding the probe and a short distance below it
- The longer the probe the deeper you can go but in most cases you can't get down a full skin depth as you would like.
- The longer the probe, the lower the maximum frequency for simple calculations.
- What you are measuring are the properties of a skin of earth.

The bottom line!

- Are ground measurements with ground probes worth doing?
- Do they give us any useful information?

- I believe they are vastly better than nothing and are worth doing at least up through 40 m.
- But we must not fool ourselves into thinking they are more than a rough guide.