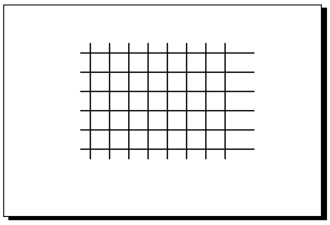
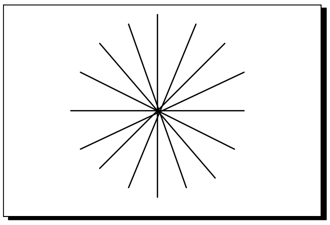
Forms of near-field scanning

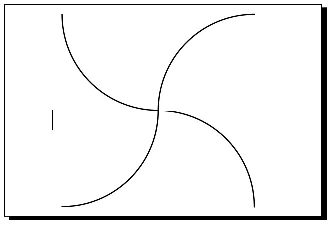
Three main forms of near-field scanning exist each with a different co-ordinate system in which the measurements are made. Below in diagram the three systems can be seen.



Plane rectilinear



Plane polar



Plane bi-polar

Plain-polar

The plane polar geometry for measuring antenna radiation patterns in the near-field is the most recent. Plane polar scanning involves taking measurements over a polar grid. Incremental samples are taken over polar angle ϕ and radial displacement r. The advantage of plane-polar scanning is that there is a reduced mechanical complexity, single linear probe trajectory is required. However, again an increased computational complexity results in transforming data co-ordinate systems, however a FFT / Bessel or a Jacobi-Bessel series representation is available.

The test antenna and probe are orientated such that they always point in a vertical direction. This has the benefit of allowing gravitationally sensitive space antennas to be accurately measured. It must be noted that neither Spherical or Cylindrical near-field scanners can be used in such a way since the necessary antenna rotation can not be tolerated by such gravitationally sensitive space antennas.

The antenna rotation is avoided by using the antenna in a transmit mode and the probe which is mounted on the carriage of a linear scanner consists of a corrugated feed and a orthomode transducer. The rotation of the probe is avoided by the orthomode transducer and by successively measuring the two orthogonal polarisation's at every scan point.

The limiting factor for frequency range is the isolation between the two ports of the orthomode transducer. The isolation at the design frequency is currently $\approx$ 40dB and would need to be greater if better accuracy is required.

An alternative to the usual fast Fourier transform can be employed. A FFT / Bessel approach can be utilised instead. This approach avoids the interpolation onto a Cartesian grid and then processed by the standard FFT. It must be recognised that as a result of such a manipulation a degree of phase drift will be introduced, which can be as severe as 50° in a six hour scan.

Plane-bipolar

Plane bi-polar is similar to plane-polar except the probe sweeps out an ark in two dimensions and not just one. Mechanically it is the simplest to construct since only two rotary connections are required to connect the RF output from the probe to the input of the network analyser with no variation in phase over the scan plane. For this reason this design is very cost effective and so become popular. Early designs suffered from a low high frequency limit, typically x band, however with improved rotary connectors this has to a great extent been overcome.

Again some data manipulation is required so that the results can be passed to the two dimensional Fourier transform algorithm having been laid out in a Cartesian grid.

Plane-rectilinear

Accuracy depends on the accuracy of the synthesised plane waves which in turn depend upon the constancy of the near field probe amplitude, phase and polarisation as it moves thorough the plane of the free space port.

The near field probe does not emit a perfect spherical wave and therefore must be calibrated in order to determine its true radiation pattern. The pattern of the near field probe is measured in amplitude, phase and polarisation and used to compensate the calculated far field pattern and gain of the antenna under test.

Accuracy in amplitude, phase and polarisation depends upon the spacing of the measurement or the excitation points in the free space port.

It can be seen that as the near field spacing for the planar case approaches one half wavelength the separation distance between the antenna under test and the measurement plane is increased beyond ten wavelengths.

The area of the measurement plane is also important. An angle of 71° can be obtained using a planar surface located two wavelengths from the antenna and over scanning the antenna aperture by six wavelengths on each side. Hence the measurement area for high gain microwave antennas is not much larger than the aperture of the antenna and so is ideally suited to planar rectilinear near-field scanning.

A thorough investigation into this field has been carried out by the National Institute of Standards and Technology, the Technical University of Denmark and the Georga Institute of Technology.

Ultimately the required accuracy depends on the desired accuracy of the various far field pattern quantities.