WIDEBAND DUAL POLARIZED OPEN–ENDED WAVEGUIDE

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ABSTRACT

Wideband dual polarized probes are often used for modern high precision measurement systems. A desired feature of a good probe is that the useable bandwidth should exceed that of the antenna under test so that probe mounting and alignment is performed only once during a measurement campaign [1]. This paper describes a new field probe taking full advantage of the 1: 4 bandwidth of the Ortho Mode Junction (OMJ) overcoming the aperture size problem by applying different apertures on the same field probe. The apertures are circularly symmetric so the exchange of apertures can be performed rapidly without the need to repeat calibration and alignment procedures for the full probe.

Keywords: wideband antennas; open- ended waveguides; dual polarized antennas; antenna measurements.

INTRODUCTION

Dual polarized probes for modern high precision measurement systems have strict requirements in terms of pattern shape, polarization purity, return loss and port-to-port isolation. A desired feature of a good probe is that the useable bandwidth should exceed that of the antenna under test so that probe mounting and alignment is performed only once during a measurement campaign [1]. As a consequence, the probe selection/design is a trade-off between performance requirements and the usable bandwidth of the probe.

Recently, a new OMJ and probe technology has been developed capable of achieving as much as 1:4 bandwidth while maintaining the high performance standards of traditional probe designs [2–9]. The development, test and performance details of these probes has been reported in [7]. At the lower frequencies the aperture diameter of these probes is about 0.7λ making this probe design highly useful for any measurement application. However, the aperture diameter in terms of wavelengths increases with frequency and becomes close to 3λ on a 1:4 frequency range.

Increased probe aperture size leads to increased coupling between the probe and the Antenna Under Test (AUT). The large aperture at the higher frequencies also leads to a directive main beam and the appearance of sidelobes within the forward hemisphere. For measurement applications with limited distance between the AUT and the probe, like in a planar near field range, both phenomena are incompatible with the requirements for good measurements. A good field probe for these antenna measurement applications should have an aperture diameter below 1.3λ.

The solution to this problem is shown in Figure 1. Taking advantage of a single 1:4 bandwidth OMJ with a fixed aperture size and by using different apertures with varying flare angle the effective aperture dimension of the overall probe is varied with the frequency. The apertures are circularly symmetric so the exchange of apertures can be performed rapidly without the need to repeat calibration and alignment procedures for the full probe.

The radiation pattern of the probe is nearly identical to traditional circular open ended waveguides exited with the fundamental mode so probe calibration can be omitted and close-form pattern prediction formulas can be used in the probe correction. The wideband dual polarized open-ended waveguide design is available in different frequency bands [2-6]GHz, [6-20]GHz and [18-40]GHz.

Figure 1: Dual Polarized probe with interchangeable apertures. Frequency band [6-20] GHz.

PROBE TECHNOLOGY

Traditional dual polarized field probes are generally based on an OMJ with externally balanced feeding as shown in Figure 2 (left). The OMJ structure is completely symmetrical using two pairs of excitation pins, one pair for each polarization. The pins are fed from a pair of high precision 3dB, 0º / 180º hybrids in order to ensure the correct matching and to maximize the cross polar performance [7].

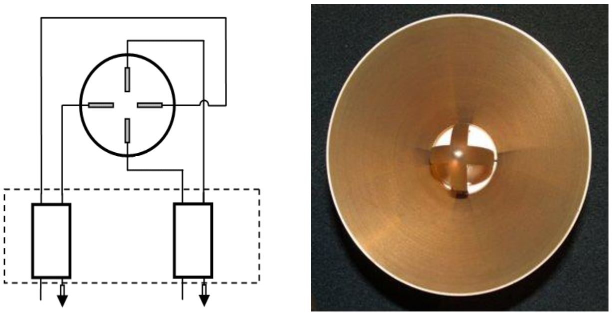

Figure 2: Left - Block diagram of four excitation pin polarizer network for L/Ka-band orthomode junction. Right - Front view of the probe topology showing the inverted quad ridge structure of the probe.

The advantage of this technique is the simplicity and the fact that the excitation can be performed directly in a circular wave guide avoiding complicated transitions from other wave guide geometries. High precision hybrids are also available with very large bandwidths. However, there are two main disadvantages of this approach:

1) Even small excitation errors will excite higher order modes at frequencies where these modes are allowed to propagate. This limits the useable bandwidth of a simple circular wave guide to a maximum of 1:1.5.
2) The frequency dependence of the wave guide excitation impedance makes it difficult to achieve good matching on bandwidth larger than 1:1.5.

A ridge wave guide is the solution to both the above problems, since the ridge geometry can be designed with mono mode propagation in a very wide frequency bandwidth and the excitation impedance is much more stable with frequency than for the circular wave guide case. Unfortunately, the traditional ridge is not very adapted for balanced excitation which is also why the traditional quad ridge horns operating in dual orthogonal polarization have such a poor port-to-port isolation and cross polar performance.

The solution is to use an inverted quad ridge structure as shown in Figure 2 (right). The inverted ridge structure provides four symmetrical feeding points for external balanced feeding and stabilizes the frequency dependence of the OMJ. With the above feeding scheme, frequency band-width of up to 1:4 can be achieved [7]. The diameter of the OMJ and inverted quad ridge is tapered to become the most suitable radiating aperture for such a wide band-width, which is the small flare angle circular aperture.

The 6-20GHz probe consists of the radiating apertures, OMJ, standoff structure, mechanical interface plate with means for optical alignment and detachable absorbers plates as shown in Figure 3. All probe components have been optimised to obtain a highly symmetric radiation pattern with low directivity and low cross-polar levels within the pertinent field of view.

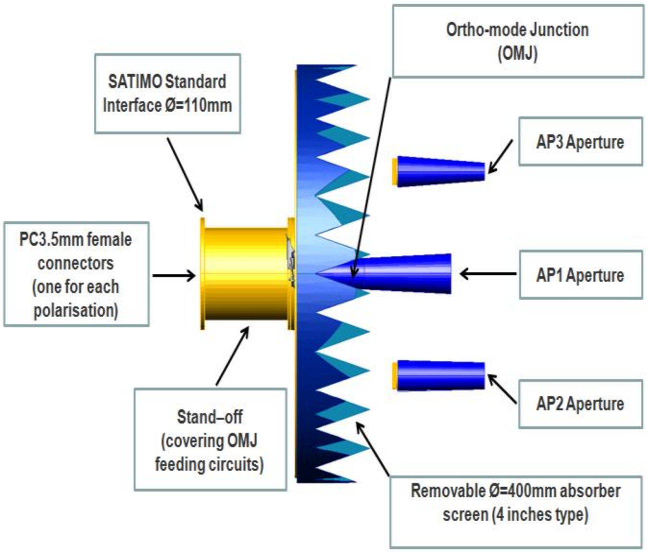

Figure 3: Dual linear polarized probe covering the entire 6GHz to 20GHz frequency bandwidth with three interchangeable apertures (6-9GHz, 9-13.5GHz & 13.5-20GHz).

The probe has three interchangeable apertures covering the nominal frequency ranges of 6-9GHz, 9-13.5GHz & 13.5-20GHz. The apertures are circularly symmetric and screwed directly onto the probe OMJ and interface assembly so the exchange of apertures can be performed rapidly without the need to repeat calibration and alignment procedures for the full probe.

MEASURED PROBE PERFORMANCE

The bore sight gain performance of the probe with each of the three different apertures are shown in Figure 4. The peak gain remains between 7 and 11 dBi leading to an operational frequency bandwidth of each aperture of at least 1:1.8.

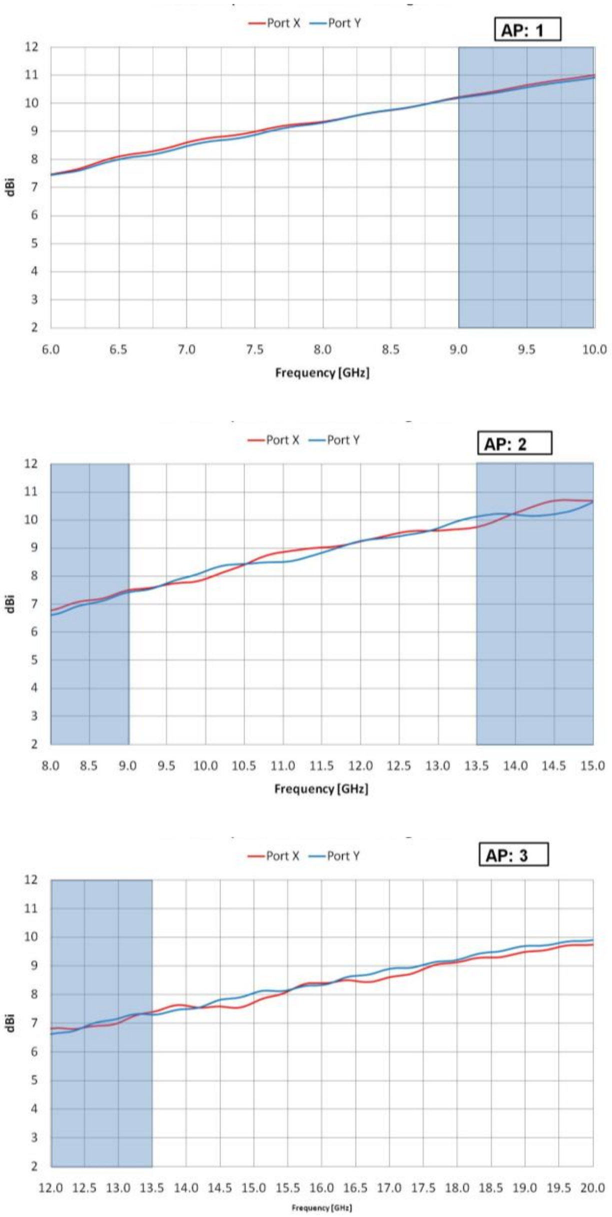

Figure 4: Boresight gain with frequency - (AP1: 6-9GHz, AP2: 9-13.5GHz & AP3: 13.5-20GHz).

The measured return loss and isolation are shown in Figure 5. Due to the high accuracy machining and the high performance 3dB/90° hybrids the measured matching performance is better than -10dB within the operational bandwidth and the port-to-port coupling is better than -50dB for all apertures on the full 6-20GHz bandwidth.

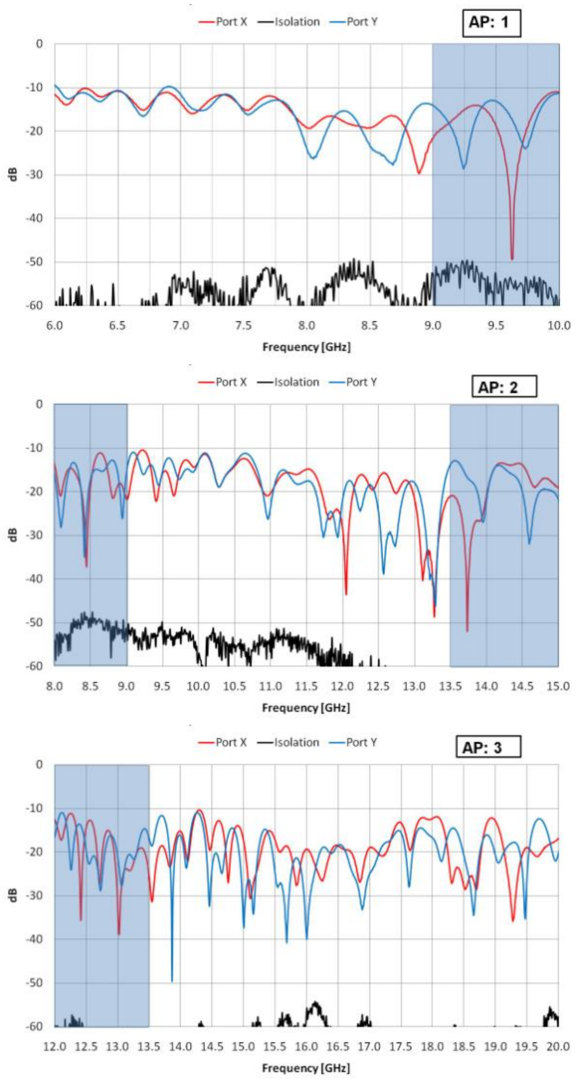

Figure 5: Measured return loss and isolation with frequency - (AP1: 6-9GHz, AP2: 9-13.5GHz & AP3: 13.5-20GHz).

It can be seen how each aperture has its well defined matching and gain bandwidth well beyond the nominal bandwidth for each aperture.

The probe with only the first aperture AP1 mounted can also be used as a single aperture probe on the full 6-20GHz bandwidth and this antenna is in effect identical to the SP6000 antenna presented in [6, 7] with the same identical bandwidth. In this case the probe gain is a monotone increasing function of the frequency as can be expected for a fixed size aperture exited with the fundamental waveguide mode. This probe configuration conserve all the nice electrical performance figures wrt matching, port-to-port coupling and cross polar as the original probe.

The 3dB beam widths of each of the apertures are shown in Figure 6 for the E, H and diagonal plane. The beam widths are within 50° to 80° within each nominal frequency bandwidth. Each of the apertures have a very nice symmetry within and beyond the nominal bandwidth. The apertures can therefore be used on a much wider frequency band.

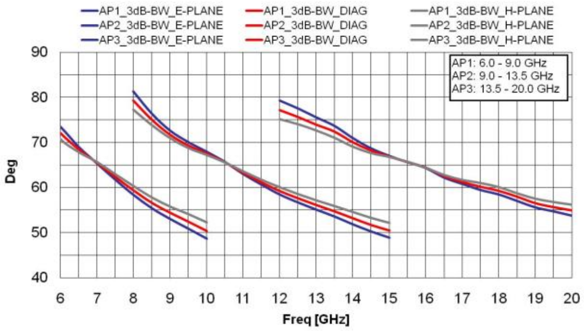

Figure 6: 3dB Beamwidth with frequency (AP1: 6-9GHz, AP2: 9-13.5GHz & AP3: 13.5-20GHz).

The directivity radiation patterns of the probe for the three aperture at the lower and the upper limits of the 6 – 20 GHz frequency band are shown in Figure 7 to Figure 12.

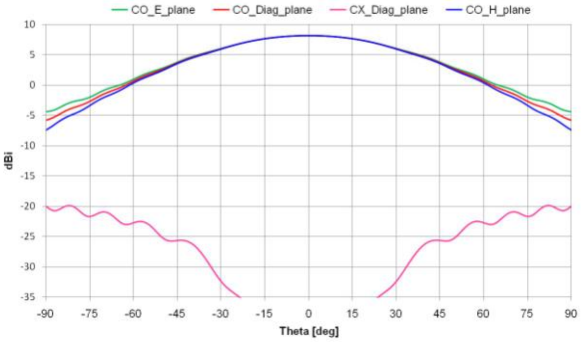

Figure 7- Directivity radiation patterns AP1: @6GHz.

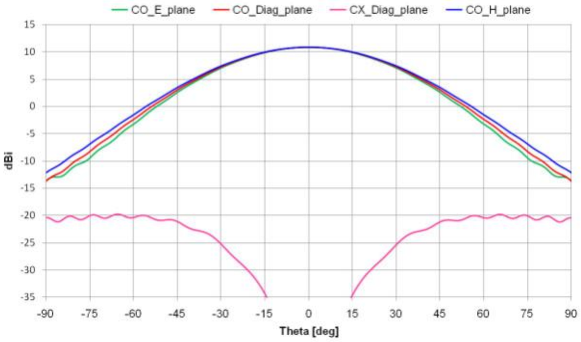

Figure 8- Directivity radiation patterns AP1: @9GHz.

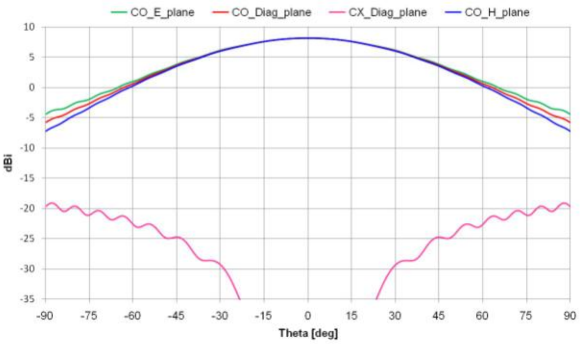

Figure 9- Directivity radiation patterns AP2: @9GHz.

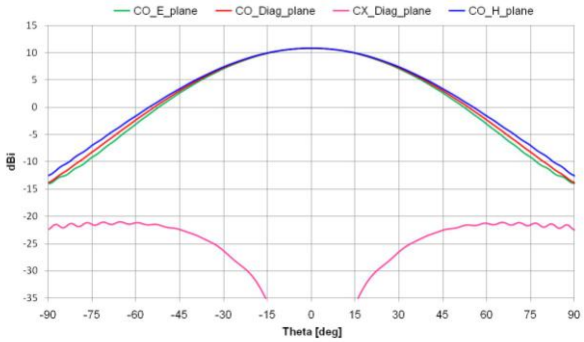

Figure 10- Directivity radiation patterns AP2: @13.5GHz.

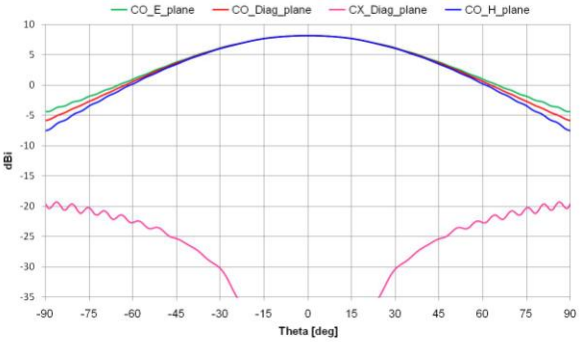

Figure 11- Directivity radiation patterns AP3: @13.5GHz

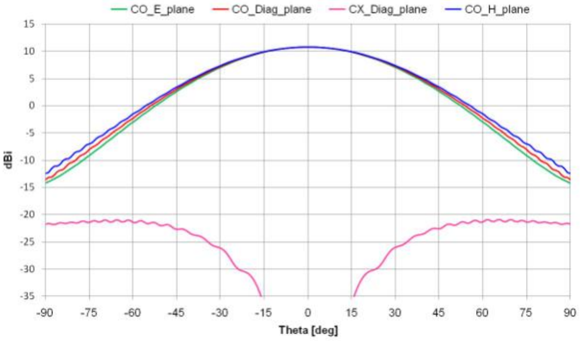

Figure 12- Directivity radiation patterns AP3: @20GHz

CONCLUSION

A new field probe taking full advantage of the available 1: 4 bandwidth of existing OMJ designs and overcoming the aperture size problem by applying different apertures on the same OMJ has been presented. The apertures are circularly symmetric and screwed directly onto the OMJ/interface assembly so the exchange of apertures can be performed rapidly without the need to repeat calibration and alignment procedures for the full probe.

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