Wide Band Dual Polarized Probes for Near and Farfield Measurement Systems

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1. 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 usable bandwidth should exceed that of the antenna under test so that probe mounting and alignment is performed only once during a measurement campaign.

As a consequence, the probe design is a trade-off between performance requirements and the usable bandwidth of the probe. A new probe technology has been developed capable of achieving 1:4 bandwidth while maintaining the high performance of traditional probe designs [1–4]. This paper describes the new probe technology and discusses the application of these probes in spherical near field and traditional far field measurement systems.

An example of a field probe covering the frequency range from 800MHz to 3.0GHz is shown in figure 1. The mechanical and electrical probe requirements have been derived from a trade-off on the particular needs of high accuracy dual polarized near field measurement systems. The trade-off also took into account the achievable performance considering different state-of-the-art probe technologies [1], [2] and inputs from potential clients with far field and near field systems. The mechanical probe performance specification requires a robust but compact design with low mass to allow for easy handling during mounting and alignment procedures.

![Figure 1: Dual linear polarized probe covering from 800MHz to 3.0GHz.](image)

Specifically for the 0.8-3GHz probe the requirements of total mass below 5Kg was a significant manufacturing challenge. The low mass was achieved through a very accurate machining of the internal ridge shape where only the electrically significant parts where maintained together with a thin outer horn throat.
2. Probe Technology

Traditional dual polarized field probes are generally based on an Ortho Mode Junction (OMJ) with externally balanced feeding as shown in Figure 2. The OMJ structure is completely symmetrical using two pairs of excitation pins, one pair for each polarization. The pins are feed from a pair of high precision 3dB, 0º / 180º hybrids in order to ensure the correct matching and to maximize the cross polar performance [1-2].

![Figure 2: Block diagram of four excitation pin polariser network for L to X-band orthomode junction (OMJ).](image)

![Figure 3: Front view of the probe topology showing the inverted quad ridge structure of the OMJ.](image)

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 3. 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 [2]. 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.
3. Measured Probe Performance

The radiated performances has been measured in two spherical near field systems. The SATIMO range (Paris) and the DTU range (Copenhagen), Figure 4 and 5. During the measurements in DTU the interface plate and positioner was covered by absorbers.

Figure 4: Measurements in the SATIMO spherical near field range in Paris.

Figure 5: The 800MHz to 3.2GHz probe configuration during measurements in the DTU spherical near field range.

The measured return loss for both ports vs. frequency is shown in Figure 6. Although the resulting port matching is the combination of the probe ports, feeding cables and hybrid couplers, the overall matching of the two ports are very similar in the entire bandwidth. The matching is better than -12dB in the bandwidth from 950MHz to 3350MHz.

The measured port-to-port coupling vs. frequency is shown in Figure 7. The coupling is better than -55dB above 950MHz and better than -43dB @ 800MHz. The degradation at the lower frequency is due to the performance of the hybrids.

Figure 6: Measured return loss of dual polarized horn.

Figure 7: Measured port-to-port coupling of dual polarized horn

The measured on-axis gain for both ports vs. frequency is shown in Figure 8 with a frequency step of 100MHz. The gain variation between the two orthogonal polarized ports is minimal. Both ports show the expected smoothly increasing boresight gain vs. frequency, but with a slow variation with frequency imposed. This variation is due to interaction between the aperture and the interface plate in the measured configuration without absorbers.

The measured Co polar patterns in the E / H planes @ 1.1, 2.0 and 3.0GHz are shown in Figure 9 to 11. The probe pattern is symmetric throughout the operating frequency band.

Circular symmetry is maintained in the lower frequency range as seen in Figure 9, but around 2GHz the effective size of the aperture is such that some difference in the E and H plane patterns appears as seen in Figure 10. The differences in the E and H plane are very minor within a +/-20deg angular range from boresight as can be seen in Figure 9 to 11.
4. Conclusions

An example of a field probe covering the frequency range from 800MHz to 3.0GHz has been presented. This antenna is part of a family of standard dual polarized probes covering the frequency bands: 0.8-3.0GHz, 2.6-8.2GHz, 6-18GHz and 18-40GHz. The performance and wide bandwidth makes the field probe suitable for both spherical near field and far field measurement systems.

References