On Selecting the Most Suitable Range for Antenna Measurements in the VHF-UHF Range

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Abstract—**It is desirable to have a single facility to serve all the antenna measurement needs of an organization of company. However, there is not a one-size-fits-all antenna measurement facility to meet all antennas and frequency ranges. Trying to design and operate a Jack-of-all-trades facility is unrealistic. Such facilities may be ideal for testing part of the frequency range and types of antennas but may not be the ideal solution for certain applications. In this papers suggestions and recommendations are given for specific types of antennas mainly operating in the 30 to 3000 MHz range.**

Keywords—Antenna Ranges, Measurements, Range Design.

I. Introduction

Antenna Measurement ranges can be divided into two main groups. The first set is outdoor ranges and the second set is indoor ranges. Outdoor ranges include, Elevated ranges, Ground reflection ranges and slanted ranges [1]. Indoor ranges are anechoic or partially anechoic facilities. Indoor ranges may be based on a far-field measurement of the pattern or a near-field acquisition where the far-field is computed by post-processing the near field data [2]. These may be shielded or not depending on the type of antennas that are to be measured. The critical thing is to understand that not a single one type of these types of ranges can accurately, that is with a low level of uncertainty, be used to measure every type of antenna over all the possible frequency ranges. In this paper the range selection for VHF and UHF ranges is explored.

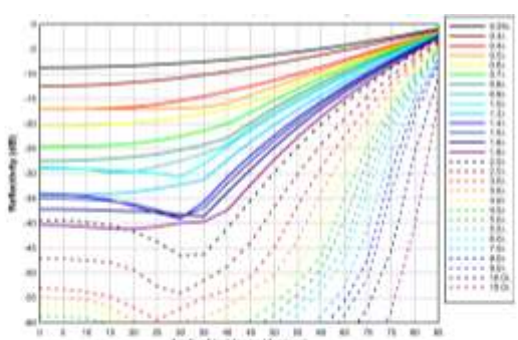

Fig 1. Computed absorber reflectivity versus angle of incidence for different electrical sizes of pyramidal absorber.

II. RF Absorber and Indoor ranges

Indoor ranges require the use of RF absorber on their internal surfaces to minimize reflections [3]. In [4] a series of numerical exercises where performed to develop a series of equations to describe the performance of typical RF pyramidal absorber.

Figure 1, shows that to get at least about 30dB of absorption the pyramidal absorber covering the indoor range must be at least one wavelength (λ) in height. A quick survey of absorber suppliers shows that the largest type of pyramid that is manufactured ranges from 96 inches (2.44 m) and 45 inches (1.14 m) That places the lowest frequency for absorber to operate efficiently between 123 MHz and 263 MHz. It is true that there are some RF absorbers available to can achieve better absorptions that the ones shown in fig. 1 [5]. These hybrid absorbers described in [5] however, never exceed the levels of absorption of traditional absorbing materials at frequencies over 1 GHz. In general, they are not suitable for measuring highly directive antennas and their limited absorption at frequencies above 1 GHz limits the accuracy of gain and side-lobe level due to the higher reflected signal levels [1].

In general, for frequencies below 200 MHz users are better served with an outdoor range given the limitations of current absorber technology. The reader should understand that indoor ranges below 200 MHz are possible. These require either customized absorber or special treatments that are costly. Unless there are specific reason for desiring an indoor range (such as shielding for secure or safety reasons), outdoor facilities (either far field, compact range or near-field) are a more economical approach.

III. Indoor Ranges from 200 MHz to 3 GHz

As it was described in section II. Above 200MHz it is possible to construct an indoor range. The type of indoor range is, in part related to the type and electrical size of the antenna under test (AUT) and the RF Absorber technology. Reference [3], describes the different approaches for different size antennas for indoor ranges.

A. Rectangular Far-Field Ranges

For frequencies ranging from 100MHz to 500 MHz only antennas smaller than 2 wavelengths are recommended as suitable for measurement in an indoor far field range. If we look

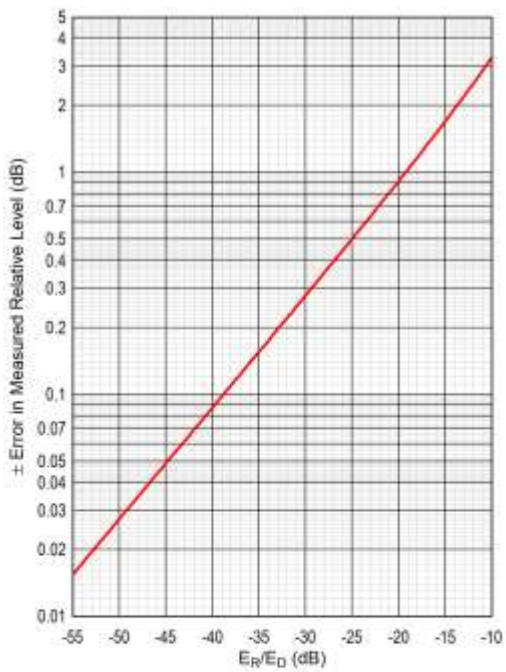

Fig. 2. Potential error of measured relative level due to reflected energy levels.

at Fig. 1. It can be seen, that at θ=60°, for a 2λ absorber the reflectivity is about -18 dB. Reference [1] provides a plot similar to the plot Fig 3. In this plot we see that for the level of reflected to direct energy a potential error of ±1.17dB is possible. At 200 MHz that means that the side wall absorber must be about 3m. It is true that the directivity of the source antenna must be low. If we assume a dual ridge antenna like the one described in [6] then the reduction on the signal incident on to the absorber at 200 MHz is less than 5dB. At However, a 2λ absorber at 200 MHz (3m) is not commercially available. The lowest frequency at which a 2λ absorber is available is at 333 MHz (typical 72-inch pyramid is available). Even then, the range size should be about 14.41 m long by 7.76 m by 7.76 m, using the equations in [3]. This is a physically large chamber for testing antennas that are at a maximum 2λ or 1.82m in maximum size.

B. Far-Field Taper Anechoic Ranges

For those frequencies between 200 MHz and 3 GHz it is possible to use a taper range [7]. One of the features of the Taper range is that the reflectivity is mainly dependent on the end wall absorber. At 200MHz, the typical 72-inch pyramidal has a normal incidence reflectivity of about -28dB. That level places the potential measurement error due to the reflected signals as low as ±0.2dB. That level is much smaller than the one expected for a rectangular chamber. Such a range could be as small as 10.8m tall by 10.8m wide by 32m long, if we use the rules mentioned in [3]. Hence, the taper chamber allows us to do measurements at lower frequencies with smaller potential error. At 333 MHz the taper chamber designed to operate down to 200MHz, could be used to measure antennas as large as 3λ. And the error, based on the 72-inch absorber performance at 333MHz could be potentially smaller than ±0.1dB (a reflectivity of -40 dB).

It should be understood, that the taper range is still a far field range. However, the taper range is not a free space range. The illumination of the AUT is done using some of the reflected waves from the absorber. If properly designed the reflected waves and the direct wave propagated from the horn will add to create a nice amplitude taper across the AUT and provide a phase variation that is similar to the free-space phase distribution. This is important because any method to measure gain based on the Friis transmission equation, such us the three-antenna or the two-antenna method [1], cannot be applied in a taper range. Gain measurements in a taper range must be done using a gain substitution method [1].

Another important limitation in taper, and rectangular far field ranges, is that the test distance or path length (PL) is fixed. That is, only antennas whose far field distances are smaller or equal to the fixed test distance. Hence, as the frequencies increase (the λ decreases) the size of the antenna D is reduced in order to maintain the far field limitation

$$PL \geq \frac{2D^2}{\lambda} \quad (1)$$

C. Near-Field Ranges

It is recommended in [3] that for larger antennas (i.e. 2 to 5λ a near-field approach can be used to measure such antenna in an indoor range. There are some points that should be considered. First, at 200 MHz a 5λ antenna is 7.5m across, hence it is a very large antenna to rotate in two axis, hence it is desirable to have the antenna rotated on one single axis while the probe moves around the orthogonal axis. Second, the probe used in the near field measurement must be at least 3λ from the minimum sphere encompassing the AUT, hence it may be required to have a gantry system with a radius of 8.5 m. This is a very large gantry. The addition of the absorber and the enclosure make for a very large indoor range. In some cases, it may be desirable to forgo the anechoic chamber and have an out-door near-field range. Figure 3 shows one such gantry used for out-door near-field measurements. The AUT or vehicle is placed on a turntable

Fig. 3. A large in-door near field gantry for on-vehicle antenna measurements. A Standard Gain Horn (SGH) is being measured.

while the gantry swings a probe measuring along the θ direction while the turntable rotates the AUT on φ.

D. Compact Ranges

Compact range reflectors are typically not used at frequencies below 1 or 2 GHz. The Reflector itself must be electrically range, so at frequencies below 1 GHz the reflector starts to be physically very large. In addition, the edge treatment used must to be designed for the lowest frequency. For serrated edge reflectors this calls for serrations in the order of 4λ to 5λ [8]. The collimation nature of the reflector reduces the amount of energy incident onto the lateral surfaces, hence the performance is related to the quality of the reflector and the end

Figure 4. A Compact range designed to operate down to 700MHz for base station antenna testing

wall absorber, much like in the taper range. Rolled edge reflectors have a higher level of energy incident onto the lateral surfaces of the range [8], but even in those absorber that is 1λ is sufficient to have a good performing indoor range. Compact ranges have been designed for frequencies as low as 500 MHz. However, these are usually for large antennas as large as 8λ where the far field is in excess of 100λ away. Figure 4 shows a low frequency serrated edge compact range, notice the length of the serrations compared to the reflector body.

E. Combined Ranges

As it has been shown, there is not an ideal approach to test all types of antennas at all frequencies. While taper ranges can be used to do measurements with small errors, the size of the antennas that can be tested is limited by the path length. A way to work this is to do a combined range like the one described in in [9]. That range combines a taper range, that is ideal for operation from 200 MHz to 2GHz with a spherical Near Field Range for testing from 700 MHz to 18 GHz. An additional planar range was added for testing high gain antennas at frequencies potentially above 18GHz. Figure 5 shows a picture of this range. The SNF is perpendicular to the Taper range. The picture shows the conical taper range to the left of the AUT positioner. The conical taper concept was introduced in [9].

IV. Conclusion

There is not a single “magic bullet” that will be ideal for all type of antennas. In this paper it has been shown that for indoor

Figure 5. A combined SNF and Taper range. The AUT positioner is being shown from the near field probe stand. To the left the conical taper section is shown. The ranges are perpendicular to each other sharing the AUT positioner

ranges in the VHF-UHF there is not a single recommendation that will be ideal for all types of antennas and frequencies. Far field approaches while simple and fast can be economically unfeasible for some large antennas and in those cases a near-field system may be a better solution. At these frequencies the sampling required is rather sparse and the measurement may not take a long time. Taper ranges, although usually shorter may still require a large real estate to fit the long taper necessary. Combined systems of taper and near-field provide flexibility within the same range and should be consider in some cases.

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