Field Calibration of Un-calibrated Antenna

Z Technology Application Note No: 42

Background
In a DriveTest situation of measuring several frequencies in a single drive a challenging issue can be what antenna to use and what is the antenna factor for that antenna at the measurement frequencies. Often times it makes sense to use an antenna that has not been calibrated on an antenna calibration range. This would be an Un-calibrated antenna. Un-calibrated are generally more durable than calibrated traceable antennas.

A Calibrated Traceable Dipole antenna requires that its adjustable elements be set at specified lengths specified frequencies. Antenna factors are called out in the Calibration table for those settings and frequencies.

Un-calibrated antennas generally have a fixed length element which means different element lengths are not required for different frequencies. However because its length may not be optimum its efficiency will be different resulting in a different Antenna Factor for the measured frequency. This application note is intended to help the user understand the procedure to calibrated in the Field an un-calibrated antenna using a Calibrated antenna as a reference.

Once an un-calibrated antenna has been Field Calibrated, it can be used to make accurate measurements on multiple frequencies in a single drive.

Un-calibrated Antennas

A typical Un-calibrated antenna may be a magnetic Mount Whip Antenna like the unit pictured below.

![Figure 1: Un-calibrated Magnetic Mount Vertical Whip Antenna](image-url)
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The un-calibrated antenna may also be the dipole antenna that comes with a calibration table which includes element lengths and corresponding Antenna Factors, but is being used at a non-specified element length. For instance, an engineer would like to make measurements on two frequencies 400 MHz and 600 MHz. Both frequencies can be measured with a Z Technology TV-2 or AA1-B4 calibrated antenna. Both antennas have a calibrated measurement range of 325 MHz to 1000 MHz. Data from the Calibration table at the frequencies of interest are listed below.

<table>
<thead>
<tr>
<th>Model: TV-2 10 Meter Calibration Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (MHz)</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>600</td>
</tr>
</tbody>
</table>

According to the Calibration table for measurements at 400 MHz the engineer would set the element lengths 7 1/8 inches, the corresponding Antenna Factor is 21.2 dB/m.

At 600 MHz the engineer would set the element lengths 4 3/8 inches, the corresponding Antenna Factor is 25.2 dB/m.

To measure signals at both 400 MHz and at 600 MHz in a single drive the engineer may elect to set the antenna elements to a mid length 5 3/4 inches. At this length the antenna is un-calibrated for measurements at 400 MHz and 600 MHz. There is no corresponding Antenna Factor for those frequencies at that length, but the antenna can be “Field Calibrated” to determine Antenna factors for 400 MHz and 600 MHz using an mid element length of 5 3/4 inches.

![Figure 2: TV-2 Antenna at "Calibrated" settings and "Un-calibrated" setting](image-url)

The procedure for determination of Field calibration tables for both the Un-calibrated Vertical Whip Antenna, and the TV-2 Un-calibrated mid length setting is the same.
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This application note will describe the procedure to field calibrate a un-calibrated Whip.

**Field Calibration Overview**
The Field Calibration process determines Antenna Factors for an un-calibrated antenna using broadcast signals as a signal source, and a Calibrated Antenna as a reference.

The process requires that the user be able to set up the reference antenna (a Calibrated Dipole antenna such as the TV-1 or TV-2 or one of the AA1 Baluns) on a non-conductive stand such as a wooden or plastic tripod in an open area at about the same height that the un-calibrated antenna will ride on the test vehicle. If the un-calibrated antenna will be used in a vertical orientation, the calibrated dipole should be set up with the balun of the calibrated dipole at the test vehicle roof top level as shown in the photo below.

![Figure 3: Reference Dipole Antenna and Un-calibrated Whip at vehicle roof top level](image)

The field calibration process will consist of the following steps for each frequency to be measured:

1) Calibrated Dipole on Tripod, Elements adjusted to specified lengths for frequency, make 10 measurements, check that measurements are all within 5 dB (preferable 3 dB). Measurements should be made with the meter set for dBuV units. Average the measurements. The average is the reference level for that frequency. Let us say we the reference average calculated to be 45.1 dBuV.

2) Move the tripod out of the way, move the test vehicle with the Un-calibrated antenna to the location the tripod was with the un-calibrated antenna in as close to the exact location as the Dipole Antenna was. Make 10 measurements. Average the measurements. The average is the un-calibrated level. Let us say the un-calibrated level average calculated to be 42.5 dBuV.
3) Add the Antenna Factor from the antenna calibration chart and the Cable loss from the Cable Calibration table for the cable connected between the Dipole antenna and the Meter. The result is the signal level in dBuV/m at the measurement location.

4) Example at 400 MHz Antenna Factor for dipole is 21.2 dB/m, cable loss from Cable calibration table is 1.06. The total is $21.2 + 1.06 = 22.26$ dB. If the Reference average of 0 measurements was 45.1 dBuV, then the Reference signal level in dBuV/m is

$$45.1 \text{ dBuV} + 22.26 = 67.36 \text{ dBuV/m}.$$  

5) The Antenna factor for the un-calibrated whip (with it’s included cable) can now be determined. Since the signal strength at the measurement location presumably has not changed the measured signal with the uncalibrated antenna plus its Antenna Factor (cable Included) should equal 67.36 dBuV/m.

$$42.5 \text{ dBuV} + \text{new Antenna Factor} = 67.36 \text{ dBuV}$$

Therefore new Antenna Factor $= 67.36 - 42.5 = 24.86$ dB/m

**Extrapolating Antenna Factors from Antenna Cal Tables**

The frequency of interest may not be listed in the Antenna Cal Table. In that case an antenna factor can be calculated by extrapolating between adjacent values that are above and below the frequency of interest. Extrapolation can be done mathematically or if its is a simple extrapolation it can be done mentally.

Example:

**Frequency of Interest 412.25 MHz**

<table>
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<tr>
<th>Model: TV-2 10 Meter Calibration Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency (MHz)</strong></td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>425</td>
</tr>
</tbody>
</table>

In this case it is easy to mentally to the extrapolation. 412.25 MHz is about half way between 400 MHz and 425 MHz with antenna factors of 21.2 and 21.4 respectively. So the antenna factor for 412.25 MHz is half way between 21.2 and 21.4 which is 21.3 dB/m.

**Extrapolating Element Lengths from Antenna Cal Tables**
Like the Antenna factor for the frequency of interest, the Element Length for the dipole can be interpolated between adjacent table values to derive a correct Element Length for the reference dipole measurements.

Example:

Frequency of interest  412.25 MHz

Element length for 400 MHz is 7 1/8 inches, for 425 MHz is 6 9/16 inches. 412.25 MHz is about half way between 400 MHz and 425 MHz therefore the element length should be about half way between 7 1/8 inches and 6 9/16 inches. It is fairly easy to mentally calculate $(7 \frac{1}{8} + 6 \frac{9}{16}) / 2 = 6 \frac{7}{8}$ inches.