Comparing ground plane coupling effects for bicon/log hybrid antennas with or without capacitively loaded bowtie elements

Removable loading elements can benefit radiated immunity tests while minimizing the coupling for emissions measurement.

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The bicon/log hybrid antenna was developed by the University of York in 1993. It has gained great popularity due to the fact that a single sweep of the antenna can cover the whole frequency range of 30 MHz to 1 GHz. The antenna was originally designed for emissions measurement which could also handle limited immunity measurements.[1] However, due to the small size of the antennas at low frequencies (less than a quarter of a wavelength below 50 MHz), the voltage standing wave ratio (VSWR) of these antennas is on the order of 50:1. This means that for immunity measurements, more than 90% of the input power is reflected. Capacitive loading was later applied on the bowtie elements of some hybrid antennas (T- or L-shaped end caps) to reduce the mismatch. Although the capacitive loadings are effective for reducing the high reactance at these frequencies (thus gaining better match), these loading elements can interact negatively with the ground plane. It will be shown in this paper that the influence from a conducting ground plane can change the antenna factor by as much as 5 dB. For the emissions measurement, the loading elements should be removed, while the loading elements can be left on for the immunity tests to gain the better match (Figure 1).

HEIGHT-DEPENDENT ANTENNA FACTORS FOR HYBRID ANTENNAS WITHOUT CAPACITIVE LOADING

Radiated emissions measurements as defined in ANSI C63.4[2] or CISPR 22[3] are based on an open area test site with a conducting ground plane. The height of the receive antenna varies between 1 and 4 m to receive the maximum electric field. It has been shown[4] that the antenna factors (AFs) will change depending on the height of the antenna

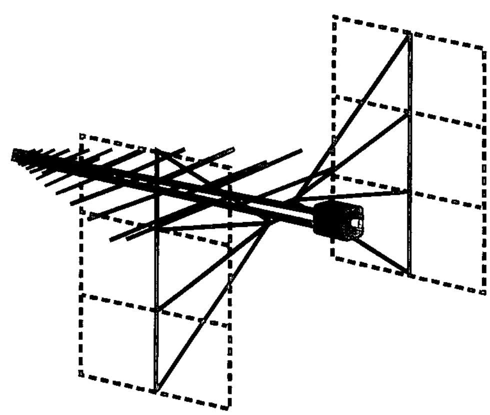

Figure 1. A bicon/log hybrid antenna for both emissions and immunity measurement—(dashed parts removed for radiated emissions measurement, or dashed parts installed for radiated immunity test).

above the ground due to the mutual coupling between the antenna and its image. Depending on the physical size, shape, height, and polarization, this coupling effect is different.

Figures 2 and 3 show the height influences on the AFs for a traditional bicon/log hybrid antenna (no end loading) above a conducting ground plane. Figure 2 is for horizontal polarization, while Figure 3 is for vertical polarization. It is clear that the couplings are the strongest at lower height and frequencies where the antenna is close to the ground plane in terms of wavelength. The coupling of this type of antennas is also larger for the horizontal polarization than for the vertical one. For a horizontally polarized hybrid without end-loading, the maximum variation is 2 dB when the height is changed from 1 m to 4 m in height. In a vertical polarization, the maximum variation is about 1 dB. This is easily explainable since the antenna pattern of this type is at a null at the two ends (in line with the antenna). There are minimal electromagnetic fields in the direction of the ground plane for a vertically polarized antenna. Compared to the AFs variation above ground plane for a biconical antenna,[5] the behavior of the traditional bicon/log hybrid is very similar at these lower frequencies.

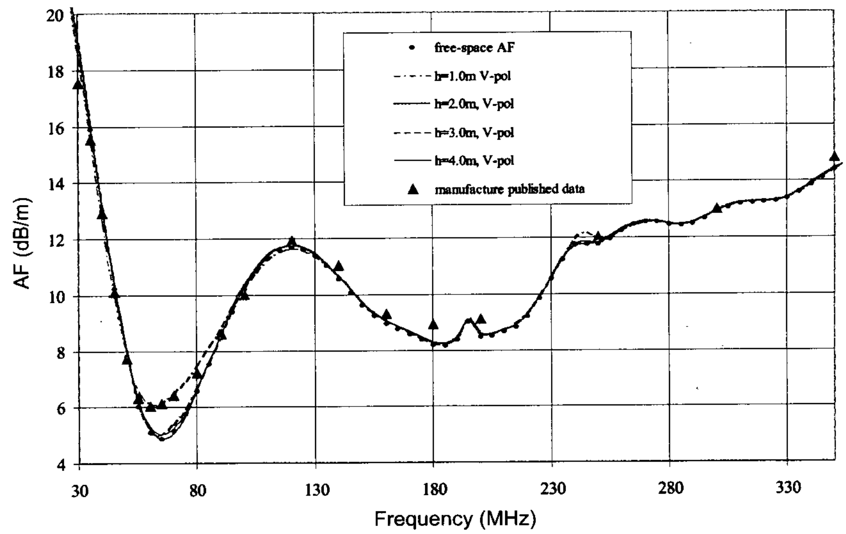

Figure 3. Vertical AFs of a traditional bicon/log hybrid antenna at different height above a conducting ground plane.

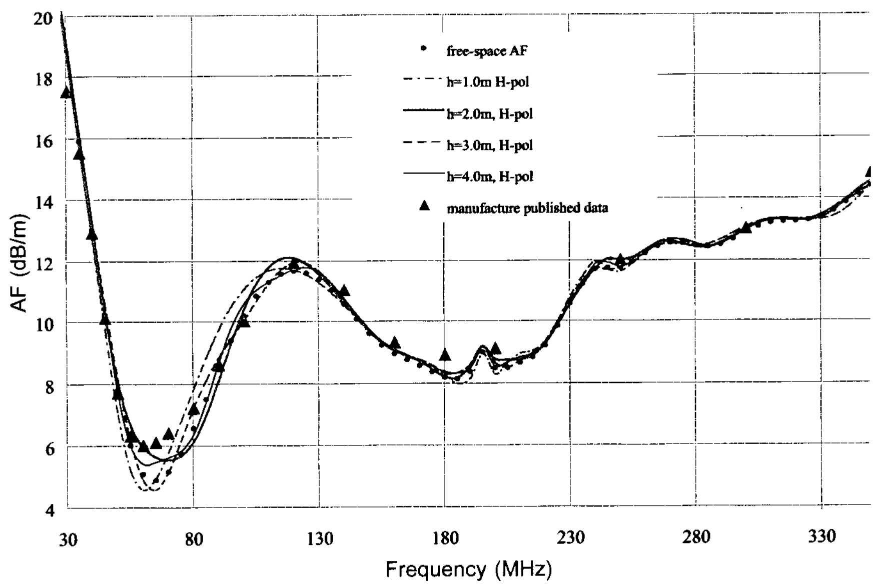

Figure 2. Horizontal AFs of a traditional bicon/log hybrid antenna at different heights above a conducting ground plane.

CAPACITIVE LOADING AND ITS IMPLICATIONS

The AF of the hybrid antenna is similar in magnitude to existing biconical and log antennas. However, the VSWR of these antennas is high in a 50-ohm system. As shown in Figure 4, the VSWR is about 50:1 at 30 MHz. For a radiated immunity test, this means more than 90% of the forward power is reflected back to the amplifier. Not only does this necessitate a high power amplifier to generate a moderate electric field level, but many amplifiers simply cannot absorb the large amount of energy reflected back, and will quit functioning. To compensate for mismatch and still maintain a modest physical size, capacitive loadings are applied to some of the hybrid antennas. Mechanically, these are frames perpendicular to the bowtie elements forming either T-shaped or L-shaped junctions. The VSWR of the capacitively loaded hybrid antenna is greatly improved (Figure 4).

One question that needs to be answered is, if the same improvement made for an immunity test is still applicable for an emissions test. For an emissions test, it is highly desirable to have an AF which is insensitive to the surroundings. It is unavoidable, as shown in Figures 2 and 3, that AFs are dependent on the heights and polarizations above a conducting ground plane due to the mutual coupling. However, this coupling needs to be minimized, since any

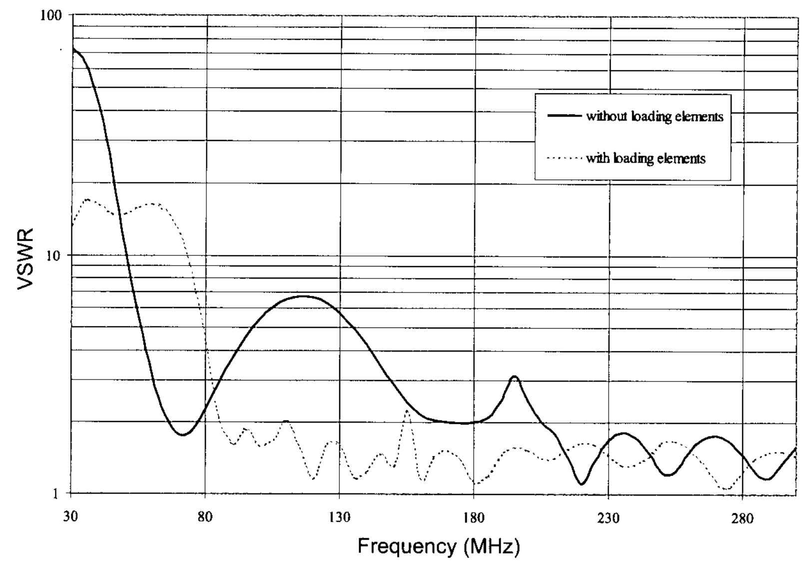

Figure 4. Numerically modeled voltage standing wave ratio of a traditional bicon/log hybrid antenna and a bicon/log hybrid antenna with capacitive loading elements

AF variation due to the height eventually becomes part of the total measurement uncertainties in an emissions measurement. Figure 5 shows the AF variation for a vertically polarized antenna with L-shaped capacitive loading elements. The L-shaped loading elements are variations of the T-shaped loading shown in Figure 1. The AFs can change by about 5 dB at different heights at certain frequencies. It would not be acceptable for a typical emissions measurement.

The far-field patterns of such antennas with loading elements are still similar to that of half-wave dipoles or biconical antennas. However, currents distributed on the loading elements strongly couple with the ground plane in the near field. This is the case when antennas are close to the ground plane at these frequencies.

Another question needs to be answered is, if the effect of these loading elements is still acceptable for an immunity test since they affect the antenna the same way when transmitting. For an immunity test, the transmit antenna is stationary. As long as the field level can be characterized by a field probe at given spatial positions (and the field's uniformity and levels, etc. meet the requirement), the coupling between the antenna and its image is not an issue. In addition, radiated immunity tests are normally conducted in fully lined anechoic chambers, or over partially absorber-lined ground planes where the coupling is not as significant. The capacitive loadings, which improve the mismatch between the antennas and the amplifiers, can considerably benefit the immunity tests (in some cases improve the gain of the antennas by 5–8 dB).

SOLUTIONS FOR EMISSIONS MEASUREMENTS

The end loading should be made removable. For emissions measurement, the capacitive loadings can be taken off. The antenna would perform just like a regular bicon/log hybrid antenna. As shown in this paper (Figures 2 and 3), the ground plane influence on the regular bicon/log hybrid is similar to the biconical or dipole antennas. For performing an immunity test, the loadings can be added back. The antenna only needs to be calibrated without the capacitive loading elements, since immunity tests do not require calibration. This solution would save the cost of having two separate antennas for emissions and immunity tests.

CONCLUSIONS

A capacitively loaded bicon/log hybrid antenna is not suitable for a

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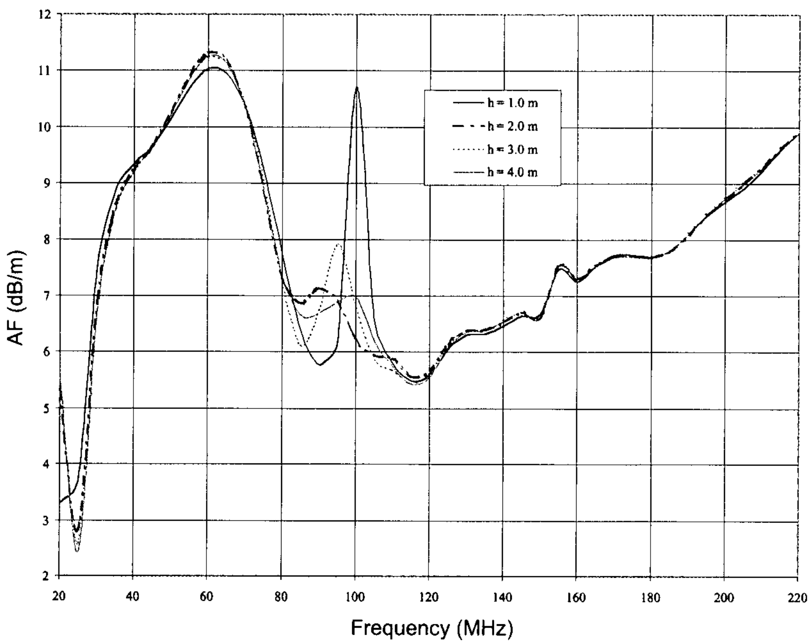

Figure 5. Numerically modeled AF for a vertically polarized bicon/log hybrid with L-shaped capacitive-loading.

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typical radiated emissions measurement due to the strong coupling between the loading elements and the conducting ground plane. On the other hand, for radiated immunity tests, this loading helps the matching of the antenna to a 50-W system, thus reducing the power requirement or, in some cases, making tests possible. Removable loading elements can benefit the radiated immunity tests while minimizing the coupling for emissions measurement.

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