Concealment Solutions for the Wireless Cellular Industry

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INTRODUCTION

The wireless cellular industry is one of the fastest growing industries globally. Technology driving growth in the industry has evolved rapidly from analog to digital, voice to multimedia services, from a single standard to multiple standards and from regional to global systems. These trends are creating daily deployment challenges for site professionals to obtain new sites for the infrastructure required to meet customer quality and service demands.

Buildings in certain locations have the required height for adequate coverage, making these building the perfect candidate for a cell site. However, the antenna structure of the base station site can be aesthetically unacceptable and become an "eyesore" to local communities and authorities. Figure 1 shows an unaesthetic antenna structure with multiple antennas on a rooftop. Communities and local authorities have thus advocated for restrictions on the construction of unappealing antenna structures. Therefore antenna concealments are essentially important applications in the base station industry to address the safety, aesthetic and community issues without prohibiting the growth of wireless mobile communication. Antenna concealment is a system that prevents antennas from being seen or discovered without creating any obtrusive visual impact. This is accomplished by means of enclosing and blending structures that hold antennas; also known as camouflage or concealment solutions.

Figure 1: Base station antenna structure on a roof top

In a true concealment design, a careful observer should not be able to notice the enclosure as what it appears to be. This enclosure is designed to blend with the surrounding environment and building such as an exhaust vent, chimney, rooftop screening, water tank and so forth.

CONCEALMENT DESIGN

In any concealment design, the design methodology should meet balance criteria that include cost-effectiveness, structural integrity, RF transparency, and cosmetic appeal. To achieve these balance criteria, the design considerations are as follow:

- Type of concealment
  - Visual consideration of blending the concealment structure to the building (e.g. chimney, signage, parapet wall and etc.)
- Antenna factor
  - Size, type, azimuth, number of antennas and operating frequency
- Design Configuration
  - Structure design behind and in front of the antennas
- Building material
  - Galvanised steel, Fiber glass Reinforce Plastic (FRP) and Concealment panel.

During the site survey, the profile of the site needs careful observation. The profile includes the history of the site, residents and local authority concerns, building structure and surrounding environment. Various angles of the site and the surrounding area are captured as reference. An appropriate design for concealment is proposed based on the antenna factor and site profile. Concealment designs are limited by the antenna factor, for instance a large number of antennas with too much of variation on their azimuth will lead to low performance in electrical properties. Selections of concealment design that maintain the electrical performance while blending with the site profile need careful consideration. For instance, redesigning the site and separating RF antennas and microwave dish to different structures or implementing polarisation diversity antennas rather than space diversity antennas system are solutions suitable for certain sites.

Design configuration and concealment material determine the structural integrity, and RF transparency of the end solution. The design configuration should limit structural material to fiberglass reinforced plastic (FRP) and concealment panel in front of the antenna or in close proximity to it. Galvanized steel structures are then placed behind the antennas for structural integrity. This is to ensure the transmission loss and reflectivity is minimal. RF transparent panels are a very important element in concealment solutions. Materials that are RF transparent are the key building material in concealment as they give the greatest impact on electrical performance. Therefore, the concealment panel needs to be carefully designed so that it offers not only good electrical properties but also structural integrity.

RF TRANSPARENCY

RF transparent or concealment panels are designed and developed based on the radome concept. A radar dome or radome is a protective dielectric enclosure to protect antennas from adverse environments in ground-base, shipboard, airborne and aerospace application while having insignificant effect on the electrical performance. Concealment solution is one of the variations of radome applications in which radome material is regarded as concealment material.

Table 1: Propagation properties of concealment panels

Properties	Multiple substrate (CSW1)	Monolithic (CSW2)	Radius Multiple substrate (RCS)
Transmission Attenuation (TA)			
• RF (GSM 900, GSM 1800 & 3G)	< -0.5 dB	< -0.5 dB	< -1.0 dB
• @ 7 GHz	< -1.1 dB	< -2.0 dB	< -2.0 dB
• @ 13 GHz	< -0.2 dB	< -0.5 dB	< -3.0 dB
• @ 15 GHz	< -0.8 dB	< -0.5 dB	< -3.5 dB
• @ 18 GHz	< -1.5 dB	< -1.0 dB	< -2.0 dB
Enhanced Gain due to Superstrate Effect for RF Applications	√	√	√
Polarization distortion	Minimal	Minimal	Minimal
Reflection	Minimal	Minimal	Minimal

Notes:
1. CSW™ Concealment System for Wideband and RCS™ Radius Concealment System are trademark of AnsComm Sdn Bhd.
2. The propagation properties changes with the incident angle, site environment and panel surface treatment at particular operating frequency.

Any enclosure of the antenna will change the electrical performance of the antenna due to reflections and refractions at interfaces between material media and loses in the material itself. The changes in the electrical performance include pattern distortion, polarisation distortion, transmission attenuation, VSWR and etc. Excessive reflections from the concealment will cause impedance mismatch to the antenna. Excessive losses in the concealment material may increase its temperature to a point where its structural properties and electrical performance are degraded.

The concealment material effect can be understood and explained in terms of plane wave propagation as shown in Figure 2 as given below.

Ideally, a concealment panel should be designed to transmit the entire energy incident upon it and reflect nothing. Therefore, the electrical thickness of low loss dielectric sheet should be carefully chosen to ensure that the reflections from the front and back would cancel each other (they are equal in amplitude but with opposite phase.) and leave the phase difference unchanged. This will ensure that maximum energy is transmitted and minimum energy is reflected.

CONCEALMENT PANEL

After extensive research on material properties and RF characteristics, concealment panels were successfully researched, designed and developed by AnsComm Sdn. Bhd. A well-designed composite material (multiple substrates) with structural members made of two stiff, strong skins separated by a lightweight core was developed for wideband applications. The separation material between the skins is a low-density core, the skins carry the load, and this configuration increases the strength and stiffness of the beam/panel with little increase in weight, producing an efficient structure. The inner skin and outer skin are identical and thin with respect to wavelength. The thickness of the core is carefully chosen so that the reflected wave from the second skin cancels the reflected wave from the first skin. A radius panel was also designed and developed using multiple substrates. An alternative design is using monolithic configuration that comprises of a thin thermoplastic. However, this configuration requires more structure frames for structural integrity.

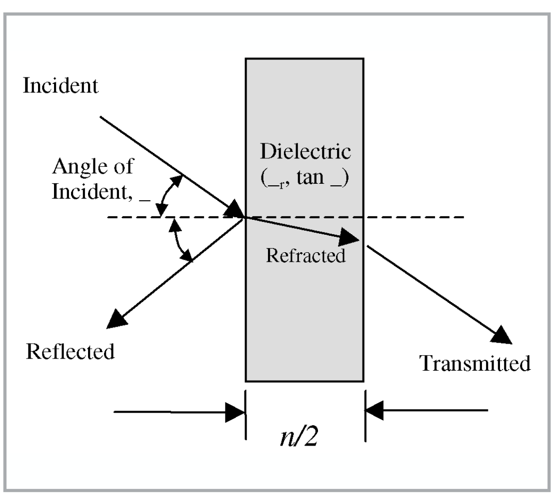


Figure 2: Plane wave propagation

The electrical properties (transmission attenuation, radiation pattern distortion and isolation) of the RF transparent panels were tested in an indoor far field region (anechoic chamber) at Multimedia University, Malaysia. Figure 3 shows an image of the measurement setup in the anechoic chamber. Table 1 shows the propagation properties of the concealment panels.

IMPLEMENTATION

In 2005, AnsComm successfully implemented a concealment trial site for DIGI in Malaysia. Figure 4 shows the concealment design implementation of a rooftop site based on chimney concealment. This site has been restricted twice due to obtrusive visual impact of the microwave dish antenna on the building rooftop. By concealing the antenna, the concept of "out of sight, out of mind" is fulfilled.

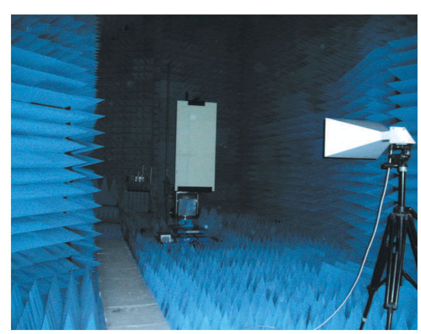
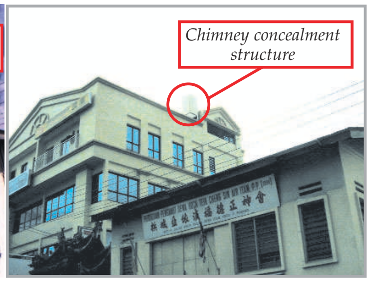


Figure 3: Measurement setup in an anechoic chamber at MMU

(a)



(b)

Figure 4: A chimney concealment structure is enclosing a microwave dish (a) before and (b) after concealment

CONCLUSION

Concealment solutions are essentially important in the wireless industry due to the demand of aesthetic visual impact of the base station site and restriction from the communities and local authorities. Concealment solutions enclose the antennas to make it appear as part of building structure to the observer. To design concealment for a site, balance criteria that include cost-effectiveness, structural integrity, RF transparency, and cosmetic appeal are essential considerations. ■

REFERENCES

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