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**Report R-1284-2-1**

**Client: GBX Technology/Christie Lites**

**Project: Active tag system**

**Subject: Performance of tag antennas**

**Summary**

This document provides the results of measurements of efficiency, radiation patterns and gain of 2.4 GHz tag antennas in free space and mounted on a cable.

**1 Test environment**

The antenna was measured in the SATIMO Stargate-64 3-D chamber at Quy, Cambridge, owned by Cambridge Consultants Ltd. Results were plotted using CCL’s Stargate Visualiser software. The chamber was maintained and calibrated by Satimo earlier in 2018.

**2 Physical arrangement**

The device under test was mounted on a Styrofoam platform on top of the central column in the chamber with the face with the logo on top. For the second measurement the tag was attached to a 600-mm horizontal length of RG-8 coaxial cable (braid diameter 7.5 mm). The axis arrangement is shown in Fig. 1.

The coaxial feed cable in the chamber was connected directly to the DUT, so the stated gains and efficiency need no correction for additional connecting cables. The radial scale on the radiation patterns is absolute gain (dBi).

Efficiency plots show the polarisation components separately and summed together. The plotted efficiency is the terminal efficiency, including the effects of reflection loss caused by imperfect matching as well as dissipative losses.

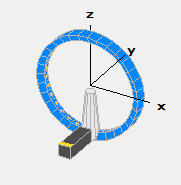


Fig. 1: Arrangement of axes. The grey access platform extends to the chamber door.

**3 Results**

**3.1 Performance in free space**

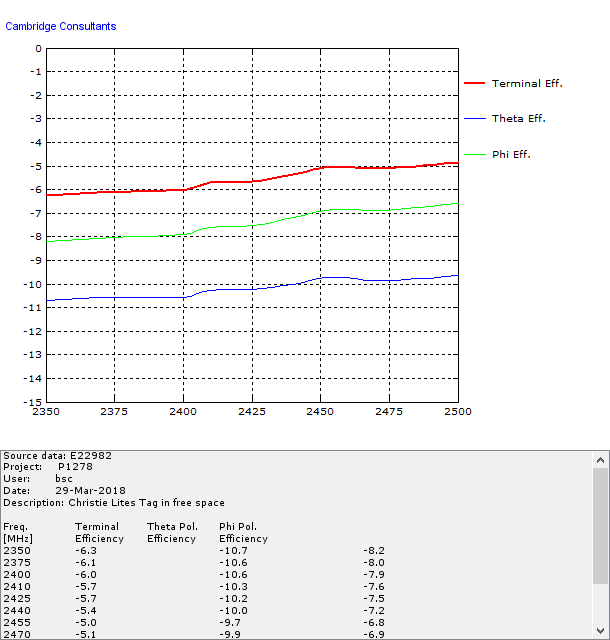
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Fig. 2: Efficiency in free space (red) showing difference between horizontally polarised component (green) and vertically polarised component (blue).

**3.2 Radiation patterns in free space**

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Fig. 3: Free space radiation patterns. 3-D pattern at 2440 MHz (Top left), Azimuth patterns (top right), Elevation patterns in plane across tag (lower left) and along tag (lower right)

**3.3 Performance when strapped to a cable with a cable tie**

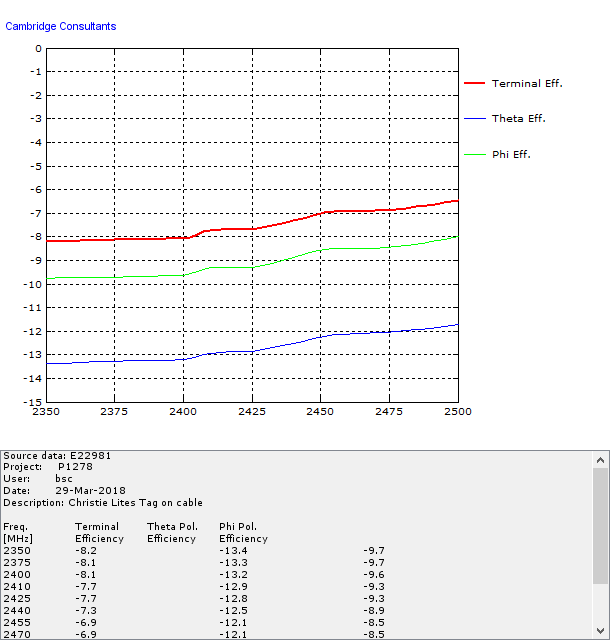
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Fig. 4: Efficiency when strapped to a cable (red) showing difference between horizontally polarised component (green) and vertically polarised component (blue).

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Fig. 5: Radiation patterns when attached to a cable patterns. 3-D pattern at 2440 MHz (Top left), Azimuth patterns (top right), Elevation patterns in plane across tag (lower left) and along tag (lower right)

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| Fig. 6: Cumulative probability functions showing the the gain on the horizontal axis is exceeded in a specified proportion of directions in 3-D space (on the vertical axis) for a tag on a cable. The separate graphs relate to the two orthogonal polarisations, looking down at the tag strapped to a wire. The colours identify the measurement frequencies. | |

**4 Comments on results**

The efficiencies are on the lower side of expectations, but it is already known that the antennas were not well matched, so the efficiency can be improved.

The radiation patterns are generally of the same form as the patterns of a dipole oriented along the long axis of the tag PCB. When tags are placed horizontally the nulls are in the horizontal plane, so they should not affect discovery by a reader overhead. The radiated polarisation is horizontal, as expected.

From Fig. 6 we can see that the median gain (ie in 50% of directions relative to the tag) is typically -10 dBi in one polarisation plane and -14 dBi in the orthogonal plane. At 99% probability these become approximately -27 dBi and -34 dBi. At 99.9% probability the figures are -35 dBi and < -35dBi (at which point the dynamic range of the measurement system is exceeded). It is worth remembering that these figures relate to a tag lying in full view and not hidden under other objects. Fortunately the presence of multi-path signals in the warehouse environment will help to fill these nulls in the patterns of the tags; signals emitted in other directions may be reflected to fill the null areas.

Measurements and report by Brian Collins, BSc(Eng), CEng, FIET, SMIEEE

v1, 02 April, 2018