EMC Testing of Traffic Law Enforcement Devices, specifically relating to potential TETRA and GSM interference

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Introduction

In October 2000 the Defence Evaluation and Research Agency (DERA), now QinetiQ, was awarded a Contract to investigate the risks of interference to Traffic Law Enforcement Devices (TLEDs) from primarily TETRA and GSM radio transmissions. This multi-year Contract was awarded to QinetiQ by the Police Information Technology Organisation (PITO) on behalf of the Home Office with the project reaching it's conclusion this summer.

A new radio service, called Airwave, is gradually being introduced across all police forces in England, Wales and Scotland to replace the current radio systems in use. This radio service uses a new advanced digital trunked system based on a European standard called TETRA (Terrestrial Trunked Radio) providing the Police with a more effective and secure communication system. Because TETRA radios, like GSM phones, can transmit automatically to their network base stations without any action on behalf of the user, potential interference problems with TLEDs needed to be addressed.

Equipment Required for Testing

In 2000, QinetiQ (DERA) began an intensive programme of EMC testing of all 54 of the current type approved TLEDs. These TLEDs consisted of the following equipment types:

1. Speedmeters
    - Hand-held radar speed measuring devices
    - Tripod mounted radar speed measuring devices
    - Pneumatic tube sensor speed measuring devices
    - Piezo sensor speed measuring devices
    - Laser speedmeters
    - Fixed radar speed cameras
    - Automatic distance over time speedmeters
    - Mobile distance over time speedmeters
2. Fixed red light cameras
3. Roadside breath alcohol screening devices
4. Evidential Breath Test Instruments (EBTI)

Fig 1 QinetiQ's Reverberation Chamber

Facilities and Capabilities Used

Because of the field strengths required and the potential area required to effectively exercise some the devices under test, all of the devices were tested in a large (10m x 8m x 7m) Reverberation Chamber at QinetiQ Farnborough (Fig 1) and in a large screened Test Chamber at QinetiQ's Chertsey site.

The Reverberation Chamber subjected the TLEDs to RF fields over the band 100MHz to 18GHz at 100 frequencies per decade with varying modulations. These tests were conducted in accordance with the draft standard IEC 61000-4-21. This test has been chosen as it is the most thorough and repeatable commercial immunity test procedure currently available. Additionally, QinetiQ has been in the forefront of the development of this test technique and therefore has an in-depth understanding of the techniques and methodologies required to achieve meaningful results. As a result QinetiQ now was able to call on a number of reverberation chambers including one of the largest in the world.

Test Equipment

In the Chertsey Chamber, the TLEDs were subjected to TETRA and GSM frequencies (380-400MHz & 890-915MHz) at varying power levels and at distances ranging from 0.05 to 10 metres. The generator chosen to produce the actual waveforms was a very capable multi-purpose vector signal generator (SMIQ), manufactured by Rhode and Schwarz. In order to guarantee that the complex waveforms were generated precisely as per the ETSI Specifications, the SMIQ had to be upgraded. This upgrade included the addition of the B11 data generator card enabling the SMIQ to generate representative TETRA and GSM waveforms. This upgrade also facilitated more advanced features such as power ramping, discontinuous transmission control, and the adjustment of both frequency and power levels. Measurements were taken on these waveforms prior to use and found to be within acceptable tolerances of the appropriate ETSI standards (EN300 392-2 and EN 300 396-2 for TETRA).

Understanding the EUT Exercising Requirements

To ensure that each individual EUT was tested for completely for each mode of operation, QinetiQ had to develop innovative ways to simulate operation of the speed measuring devices; an example of this is shown in Fig 2. The simulator was designed to activate speed TLEDs which use pressure sensitive pneumatic tubes as their sensing element. The simulator consists of a wheel mounted on a 2-metre arm rotated on a circular track via a motor. The pneumatic strips were laid across the track to register the pulse generated by the wheel as it crosses them. The indicated speed is a function of the spacing between the individual pneumatic tubes and the speed of rotation of the arm.

Pneumatic actuators were used to remotely control the TLEDs under test. The advantage of using the pneumatic actuators was to eliminate the intrusive effects that would occur if electromechanical devices were used. It proved possible to control all of the device switches by use of pneumatic rams mounted on suitable brackets.

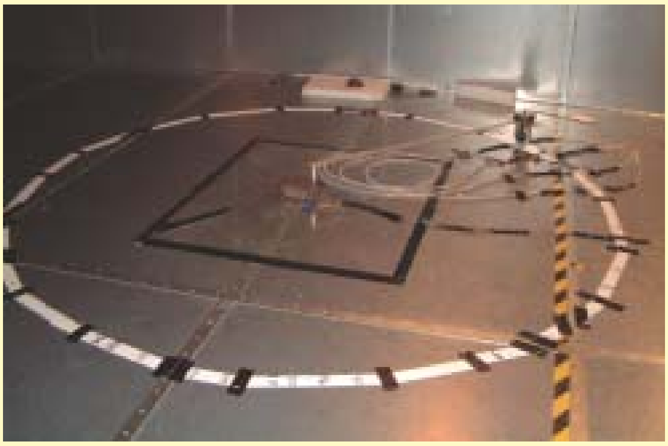

Fig 2 Vehicle simulator for Speed TLEDs with pneumatic sensors

The importance of accurate simulation of the EUT cannot be overstated, this affects the test methods used especially when the EUT has a long duty cycle. For example, if the complete cycle of an EUT is 3s from start to finish of its operation, under normal test procedures a large part of the frequency spectrum could be covered. However, to ensure that the TLED is not susceptible at a specific frequency point at any part of its cycle, then the susceptibility signal must dwell at each frequency point for the duration of 1 cycle of the equipment. This has a significant effect on the length of the tests but is the only way to verify if the equipment is susceptible at any time during it's operation.

To simulate the effect of the human beings during the TETRA and GSM tests, two human simulants (phantoms) were obtained from the UK Defence Science and Technology Laboratories (DSTL) based at Porton Down, Wiltshire. The TETRA/GSM antennas were mounted on the standing Phantom, the second was sitting to represent a police officer operating an EBTI.

The human simulant is an RF dosimetry phantom, which consists of a hollow fibreglass dummy filled with muscle simulant designed to represent the dielectric properties of the human body. Compared to other body tissues, most of which have high water content, muscle is accepted as an adequate approximation for a homogenous body. In this case the muscle simulant formulation was selected from a table of formulations for different frequencies. From the table the muscle simulant formulation for 433 MHz was selected as being the closest formulated mixture to the frequencies of the TETRA signal. It was therefore specifically matched to TETRA. The mixture comprised fine polythene powder 15.4%, salt 1.0%, TX151 gelling agent 8.4% and water 75.1%.

To determine the correct level of field strength to which the TLEDs should be tested under this programme of work, QinetiQ undertook a series of controlled measurements to determine the true radiated power levels from a range of purchased TETRA radios. Mean and peak powers were measured over a range of temperatures, frequencies and supply voltages for each model of TETRA terminal. These measurements helped to provide a draught new specifications tor type approval of future TLEDs.

Test Procedure

Because we were using two very different chambers for this research programme, different test procedures needed to be developed, these are outlined below.

1. Reverberation Chamber

The test procedure followed the following steps at each test frequency:

- The paddle wheel was set to rotate at a speed commensurate with the TLED's response time. In the case of a device which had an acquisition time of about 30 seconds, the paddle wheel was rotated at 1.8 rpm. Two complete revolutions were made at each test frequency with the maximum field applied. Another device which may have an acquisition time of 70 secs would mean the paddle wheel rotation speed had to be reduced down to 0.8 rpm; the longer the acquisition time the slower the test.
- The field was increased in the following steps - 5V/m, 10V/m, 15V/m and 20V/m. At each test level the paddle wheel was rotated for at least one revolution. The appropriate modulation was applied.
- If no effect was observed, the maximum field strength applied was recorded, the power removed and the frequency changed to the next test frequency.
- If an effect was observed, the threshold was determined by slowly reducing the applied field. The threshold was then recorded, the power removed and the frequency changed to the next test frequency.

2. Chertsey Screened Room

- Each TLED was irradiated at up to the full power level at distances of 10, 5, 3, 2, 1, 0.5, 0.2, 0.1 and 0.05 metres when using the phantom and at distances of 10, 5, 3, 2, 1 and 0.5 metres when using a simulated vehicle. The distances of 0.2 and less were only used for the portable devices.
- The TLED was deployed in the normal mode with a phantom placed to simulate the TLED operator. The appropriate operational simulator was used to exercise the TLED and adjusted until stable readings were obtained on the TLED when operated.
- Any controls that needed manipulation to make the TLED operate were operated using pneumatic actuators operated from the control room.
- The output screen of the TLED was monitored using a hardened CCTV system.
- The TLED was subjected to RF fields emanating from two separate sources, transmitting independently, the threat phantom and the simulated vehicle.
- The TLED was exercised at each combination of signal source and distance.
- The RF power applied to the various simulator antennas was increased in 6dB steps
- If a susceptibility was found at any frequency, the power was reduced and then slowly increased until the onset of the susceptibility was found.

Conclusions

Testing was scheduled to be completed in August 2002 with a report being issued through the Home Office. Several devices have shown various types of vulnerability and QinetiQ has been working with the manufacturers of the devices to reduce this vulnerability.

However, it is evident that this type of equipment needs to be tested as extensively as possible to ensure that the users, manufactures or operators of facilities within which they are used know that they will operate correctly when a GSM or TETRA signal is nearby.

This testing is significantly more than the usual required for CE marking and could be viewed as significantly increasing the

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