Tetra the noise source – who cares?

Abstract

TETRA (TErrestrial Trunked RAdio) systems deployment is gathering pace. Dolphin have deployed a pan-European Public Access Mobile Radio (PAMR) network for professional users. Most European public safety organisations are deploying their own Private Mobile Radio (PMR) networks. There are two features of TETRA that make it a particularly annoying source of radio interference: (A) its relatively slow frame rate (17 frames per second) and (B) its spectrum allocation (adjacent to all major European ISM bands). This paper investigates Tetra as a noise source and asks who should worry about Tetra and what can they do to eliminate Tetra interference. The paper concludes that manufacturers and users of electronic equipment should be aware of Tetra as a potential noise source. Furthermore manufacturers of short range, license exempt, radio-communications devices will have to take additional steps to prevent TETRA signals disrupting or completely blocking the operation of their products.

What is TETRA?

TETRA is a European standard for professional digital mobile radio communications. It was developed by ETSI[1] as a harmonised digital replacement for the many conflicting analogue mobile radio standards currently in use. It has been aimed at two target markets:

(i) Public safety users (police, fire, ambulance). Currently these users employ analogue radios that can easily be overheard by criminals and don't inter-work properly (or at all) even on a regional basis. The Tetra standard facilitates pan-European roaming and inter-working and also employs strong encryption techniques to prevent eavesdropping.

(ii) Professional fleet users (public utility, private company). Tetra's large cell size and relatively low roll-out costs allow operators to offer fleet users very significant discounts compared with GSM technology. Furthermore Tetra supports features such as group calls and broadcast calls that are not supported by the GSM standard.

Tetra utilisation (handsets per kM^2) was always going to be lower than GSM, which has mass-market consumer appeal. For this reason frequency allocations were sought lower down the spectrum were cell sizes can be much larger and therefore network rollout costs significantly reduced. After much debate harmonised allocations around 400 MHz were finally secured. Currently further allocations circa 450 and 900 MHz are being considered[3].

Tetra was designed to be interleaved with existing analogue PMR and PAMR systems operating in the same frequency band allowing for a gradual replacement of the latter with the former[2]. The TETRA standard[1] achieves this goal by:

(i) Employing a 25 KHz channel separation compatible with analogue systems,
(ii) Placing severe limitations on adjacent channel power.

These requirements dictate a narrow-band modulation technique (DQPSK) combined with highly linear transmitter circuitry. In practice manufacturers use Cartesian loop feedback to combine linear performance with low current operation.

The narrow bandwidth dictated a slow frame rate for maximum data payload efficiency. A rate of 17 frames per seconds was chosen. This worsens interference in some electronics equipment over equivalent GSM radiation[4]. More worrying is Tetra's frequency allocations which are adjacent to the popular and crowded license exempt ISM bands[5]. These concerns will now be explored in more detail.

Tetra Spectrum Allocations

TETRA radio spectrum allocations (recommended) are given in figure 1.

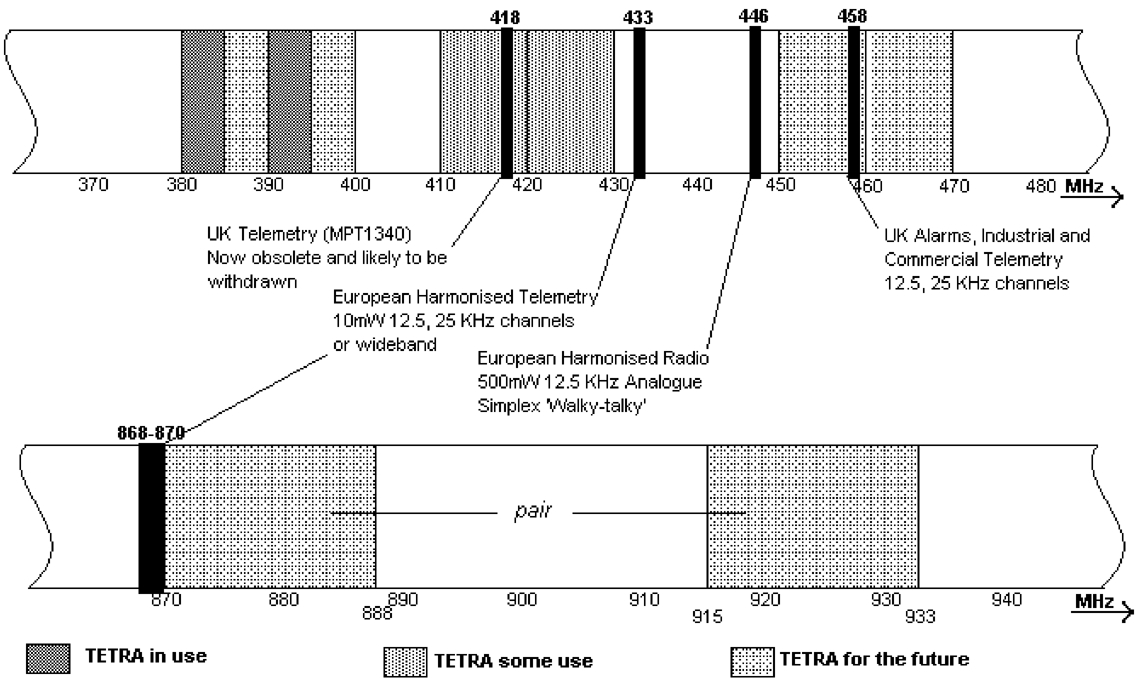

Figure 1 – TETRA Spectrum Allocations

All UK TETRA installations currently use the 380-385 and 390-395 MHz frequency pairs. The European regulatory body CEPT has allocated all the spectrum from 380 to 400 MHz for Tetra but the current spectrum holder (UK MOD) has yet to release the upper 5 MHz.

In Europe take up of the 410-420 and 420-430 MHz is underway. The remaining bands ear-marked for Tetra have yet to be released. Only a few TETRA OEMs have 900 MHz equipment and this author knows of only one 900 MHz contract that has been let (Marconi, Saudi Arabia).

As can be seen this part of the spectrum is already crowded. Worst still all TETRA allocations seem to either overlap with or appear adjacent to both UK and European ISM bands.

Why is TETRA a Noise Source?

There are three main reasons:

(i) It operates on frequencies adjacent to consumer license exempt telemetry (ISM) bands and traditionally these products are very poor at rejecting near frequency interference (they are easily blocked).

(ii) It utilises relative high power transmissions: 3 watts (portable), 10 watts (mobile fitted in vehicle), 25 watts (base-station).

(iii) It uses Time Division Multiplexing (TDMA) with relatively long burst periods. This induces unwanted low-frequency components in some electronics apparatus, these components being difficult if not impossible to filter out.

So What, Who Cares?

1 Consumers should care, especially if they can't get into their cars after driving into a TETRA cell.
2 Designers and manufacturers of license exempt telemetry products should care and take additional steps to prevent blocking.
3 Designers and manufacturers of safety critical /life support equipment should care as a TETRA handset can induced RF fields in excess of those used to test such products[6].

Tips for Electronics Equipment Manufacturers

TETRA's long frames induce low-frequency components in a wide variety of electronics equipment that are hard to filter out. In a recent study on the effects of Tetra signals on safety critical medical equipment a simulated TETRA signal was shown to have more damaging interference effects than the equivalent GSM signal[4]. This could be a real problem in a hospital environment where GSM phones are banned near to intensive care wards. Ambulance staff and paramedics will increasing be wearing TETRA handsets in these areas posing an even greater threat to the safe operation of life critical equipment.

The radiated power levels of both TETRA and GSM handsets can create near field RF levels greatly in excess of the current European class A limit of 10 V/M[6], which forms the basis of immunity requirements for industrial and safety critical equipment. Equipment manufacturers need to take additional EMC design steps to provide immunity from TETRA handsets operated in close proximity. This is particularly true of measuring equipment, which usually contains sensitive analogue electronics working down to low signal levels (a few millivolts).

Many books and articles have been written on the 'how to' of designing for RF immunity[7][8] including one article dealing specifically with sensitive analogue electronics written by this author[9]. An explanation of these techniques is beyond the scope of this paper.

Tips for Low Power Radio Equipment Manufacturers

TETRA and the increasing crowding of the radio spectrum have effectively ended the days of the cheap and cheerful wideband license exempt telemetry systems such as the key fob controlled central locking /immobiliser mechanism fitted to your car.

The UK Radiocommunications Agency are soon to withdraw the old wideband MPT1340 specification[10] used in the UK for these devices at 417.900 MHz to 418.100 MHz. As can be seen from figure 1 this allocation now sits inside a TETRA allocation that is beginning to be taken up throughout Europe. Pause for thought next time you take your car to the continent!

The bands currently being offered by the agency are 433.050 to 434.790 and 868 to 870 MHz. Wideband receiver apparatus is being discouraged in favour of narrow band channelised operation in either 12.5 or 25 KHz channels.

This change will force manufacturers to use crystals with tighter temperature tolerances and will drive up the costs of transmitter fobs. Nevertheless crystals with coefficients as low as 10ppm can be obtained in volume at prices as low as 33.5p (1/4 million part per annum).

The main impact is on receiver design however. Traditionally receiver characteristics have not been examined before granting type approval for a license exempt radio product. The R&TTE directive[11] further de-regulates type examination requirements for these products. In response to these factors the Low Power Radio Association[12] (LPRA) and others have formed the RadioMark scheme[13], which will set standards for receiver performance.

In order to prevent TETRA signals from blocking low power radio receivers, designers should employ the following techniques:

(i) Avoid using SAW filters employing Lithium alloy substrates such as Lithium Niobate and Lithium Tetra-Borate. These filters have poor temperature stability (30-100 ppm/°C). Given the extremes of temperature common with automotive applications there is a very real risk of such SAW filters drifting from their desired operating frequency into an occupied TETRA band with obvious results.

(ii) Use SAW filters employing quartz as a substrate, which is stable (<1 ppm/°C). These filters are optimised for narrow band applications, which is exactly what the DTI-RA and LPRA are recommending.

(iii) Employ additional IF filtering rather than rely on a single down conversion process and thereby on the characteristics of a single SAW filter. Low cost transceiver chips with 1 and 2 IF stages are now becoming common places and will directly interface to low cost 10.7 MHz and 455 KHz ceramic filters. Examples are Thompson CSF TRX01 and RFMD RF2905 both of these devices operate at 433 and 868 MHz and the former is fully synthesised.

About the Speaker

Tim Jarvis is Senior Design Consultant with KTL. He advises the company and its clients on the technical aspects of designing electronic products for compliance with European directives. He manages the development group within KTL Hull. The group specialises in designing and developing products and sub-assemblies for European and world markets. Tim has worked in the electronics industry since 1983 and sits on the Tetra MOU SFPG Committee. tjarvis@ktl.com. KTL are a member of the TETRA MOU, the Low Power Radio Association (LPRA) and the RadioMark scheme the company is also a notified body for regulatory testing of radiocommunications products.

References:

1 - ETS 300 392 Tetra standard, source ETSI TC-RES F-06921 Sophia Antipolis CEDEX – France.

2 - ETR 300-1 Part 1 Overview, technical description and radio aspects, source ETSI EP-TETRA F-06921 Sophia Antipolis CEDEX – France.

3 - Current and future spectrum for TETRA – A consultative document from the DTI and the Radiocommunications Agency. December 1997. www.radio.gov.uk/document/misc/traneuro/traneuro.htm

4 - Electromagnetic Compatibility Aspects of Radio-based Mobile Telecommunications Systems. Final Report. LINK Personal Communications Programme. DTI & EPSRC. University of York, University of Hull, ERA Technology Limited, Cambridge Consultants Limited 1999.

5 - Short Range Devices – Information Sheet. Radiocommunications Agency 1999. www.radio.gov.uk/document/ra_info/ra114/ra114.htm

6 - Radiated Electric Field Susceptibility, IEC 61000-4-3 (EN 55024 : 1998)

7 - EMC for Product Designers (Newnes Oxford 1992), ISBN 0-7506-1264-9.

8 - Design techniques for EMC parts 1-6, Eur Ing Keith Armstrong, CEng MIEE MIEEE, UK EMC Journal nos 21-26. Published by Nutwood UK Limited Jan 99.

9 - Improving the RF Immunity of Sensitive Analogue Electronics, T.P.Jarvis BSc CEng MIEE & I.R.Marriott BEng. UK EMC Journal nos 9. Published by Nutwood UK Limited Feb 97.

10 - MPT 1340 PERFORMANCE SPECIFICATION Transmitters and receivers for use in telemetry, telecommand and in-building security equipment operating in the frequency band 417.900 MHz to 418.100 MHz and in-vehicle equipment including radio keys in the frequency band 433.720 MHz to 434.120 MHz Revised and reprinted December 1997. Radiocommunications Agency.

11 - European Directive 1999/5/EC.

12 - www.lpra.org

13 - www.radiomark.org