TETRA MEASUREMENT CHALLENGES OF A NEW DIGITAL PMR SYSTEM

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What is TETRA?

TErrestrial Trunk RAdio (TETRA) is a radio system being defined by the European Telecommunications Standards Institute (ETSI) as a digital radio suitable for replacing existing Professional Mobile Radio (PMR) and Public Access Mobile Radio (PAMR) for wide area networks.

The first users of TETRA systems will be public safety organisations (police, fire, ambulance, border patrol) at frequencies between 380 MHz and 400 MHz where there is a need for a radio system which provides high levels of interoperability and connectivity to other networks such as the PSTN. However, the new facilities and the high spectral efficiency of TETRA will result in other users adopting the standard. In due course TETRA is likely to replace current systems based on MPT 1327. The cumulative size of the emergency service market for Europe alone is 1 million users including the UK home office with 100,000 users and 400,000 in Germany from police and fire services.

ETSI will also ensure that TETRA forms part of the concept of the Universal Mobile Telecommunications System (UMTS) where seamless operation between various communications system will be provided. UMTS will include Digital European Cordless Telephone (DECT), Global System for Mobile Communication (GSM) and European Messaging System (ERMES).

The GSM system has become a de facto global standard for cellular communication (even in parts of north America), and it is the objective of the supporters of TETRA that it also becomes a global standard.

A Memorandum of Understanding (MoU), similar to the one used to promote GSM, has been signed by major manufacturers, operators and government organisation which commits each signatory to support TETRA as the preferred solution to future digital trunked radio.

The progression to TETRA

TETRA satisfies the need of both public and private network operators. The TETRA standard is offered as a voice plus data version or a packet data optimised version.

The first clear change towards international standardisation was the introduction of the analog MPT 1327 trunked radio standard that lead to a market success in most parts of the world. The lack of a common frequency allocation has however prevented MPT 1327 from extending beyond national/regional boundaries. MPT 1327 systems have evolved differently as a consequence and through a lack of rigorous standard.

TETRA offers a real opportunity for multivendor systems to be configured. The air interface specification ensures interoperability. Other interface specifications for terminal equipment interfacing and inter system interfacing are written in such a way to further promote this principle.

Who uses TETRA

Any application for radio communication currently supported by analog PMR is a target for TETRA. A driving force behind the standard development has been the exacting needs of emergency services, such as fire, ambulance and police. The police will benefit from improved security and the ability to send and receive data relating to suspects, such as finger printing. Fire services will benefit from direct mode operation

in areas unlikely to have good coverage and to receive data concerning hazardous substances or building blue prints.

Who uses TETRA (cont'd)

The medical service, as suggested above may be able to provide more effective treatment at the scene of accidents and to pass medical history to where it's needed. But TETRA may also be used in other areas, the railway networks could use TETRA for voice communication and signalling. Taxi firms may provide credit card debiting through TETRA.

Transport companies may adopt TETRA for vehicle location. TETRA may in fact be used for applications unconnected with normal PMR such as radio microphones and other low power applications.

Frequencies

TETRA has been granted by NATO a European wide frequency allocation between 380 and 400 MHz for emergency services. National authorities have allocated two 5 MHz bands in this 20 MHz band.

Currently, spectrum is being made available for commercial services between 410 MHz and 430 MHz, hopefully as a European wide, common allocation so that roaming may be possible. Other potential bands exist, such as 870 MHz to 921 MHz and 450 MHz to 470 MHz.

Two licences have been awarded in the UK for commercial networks.

TETRA standard is written so that potentially TETRA may be used within any 25 kHz channel space currently occupied by analog systems giving an immediate four-fold increase in capacity. This attribute of TETRA is what potentially makes it attractive as a world wide digital standard.

In other countries throughout the world different frequencies may be allocated. Some countries are talking of systems up to 900 MHz.

What is different about TETRA

TETRA uses a digital modulation technique to provide high quality speech from a speech codec and uses air interface encryption. Even without encryption the modulation technique and codec ensures that messages cannot be overheard by a casual eavesdropper without access to a TETRA receiver (existing PMR systems use analog voice signals which can be listened to by general purpose receivers). The air interface encryption ensures that even if an eavesdropper has access to a TETRA receiver, the lack of access to a cipher key ensures that casual eavesdropping is not possible.

How does TETRA differ from GSM

There are clear distinctions between TETRA and GSM., the two systems are not designed to compete with one another. The GSM system is essentially a telephone system and has features and attributes usually associated with telephones. TETRA has all the features that are expected of a PMR system and many unique features not currently available on analog PMR systems.

TETRA Air Interface

TETRA uses phase offset differential quadrature phase shift keying modulation with a symbol rate of 18k symbols/s and root raised cosine (Nyquist) filters in the transmitter and the receiver to give an overall raised cosine modulation filter. The RF carriers uses 4 time slots to provide access for 4 simultaneous conversations or data paths. The RF carriers are spaced at 25 kHz intervals to provide an effective 6.25 kHz channels spacing.

In traditional PMR operation is usually done on a simplex basis i.e. only one transmitter is active at a given time. The TETRA standard allows simplex or duplex operation.

The TETRA standard has been specified to allow the system to coexist with analog radio systems. The migration from analog PMR to TETRA demands that TETRA can be displace analog channels. This in turn requires that TETRA systems do not interfere with existing analog channels. The TETRA adjacent channel power specification is therefore very demanding when compared to other digital communication systems.

Testing TETRA Radios

The conformance tests are the basis of any production test requirement. Manufacturers will choose which subset of tests to perform and which test methodology to adopt following satisfactory completion of type approval radio acceptance tests on the design. The test performed in manufacturing will follow closely those carried out for type approval especially when the product is ultimately aimed at public safety organisations.

The test methodology may be simplified where it is otherwise time consuming or requires lots of specialist equipment.

Power Measurements

The power output of TETRA equipment varies depending on the class of equipment and whether it is a mobile or fixed terminal. The output power is a maximum, the actual level is under the control of the base station and is dependent upon received signal strength.

The bursted nature of TETRA makes it a difficult parameter to measure. In addition the modulation results in a non constant envelope.

The requirement to ramp the power levels up and down in a TDMA system results in additional spread of the transmitted spectrum at times determined by the TETRA base stations. Controlling the spectral spread is significantly easier than on GSM since the rise and fall time of the signal is relatively slow on TETRA.

Consequently the limit masks on the TETRA signal power ramps are relatively straight forward.

A non active timeslot occurs normally between successive TETRA bursts. Only when the equipment is first switched on or off does the non TX state occur. The measurement of non active timeslot power requires a large dynamic range to be accommodated. First the nominal level must be measured as per the previous slide.

TETRA Unwanted Emission Performance

The requirement to allow analog coexistence and the relatively unplanned nature of PMR operation has resulted in the TETRA specification requiring low levels of unwanted emission - much more difficult than those used in cellular systems.

The generation of power ramps must not be allowed to compromise the spectral purity of the transmitted output. Amplifiers must be switched on slowly. This parameter is distinct from adjacent channel power due to modulation which results from non ideal filter characteristics by virtue of amplifier non linearity.

TETRA place high demands upon broadband generated noise again in an effort to ensure compatibility with existing analog systems.

Vector Accuracy

Vector accuracy is defined as a circle about the decision point in which the trajectory of the carrier has to be. Two values are specified, the peak value and the rms average value. In both cases the radius of the error circles are expressed as a proportion (or %) of the distance from the origin of the decision point.

Measuring Sensitivity

Measuring the sensitivity of a TETRA radio is in principle similar to that of an analog radio but instead of performing SINAD measurements, a bit error rate (BER) measurement is performed. An additional complication is that a radio should be tested under conditions found in real applications where the signal exhibits fading characteristics. The TETRA standard includes tests with faded and static receiver signals.

An additional complication to the sensitivity is that there is nothing very graceful about the degradation of a digital radio as the signal level drops. With analog systems the noise levels steadily increase as the RF level falls. However, with digital radios the error correction algorithms keep correcting the output until the point at which they can no longer cope and the radio produces virtually meaningless output signals.

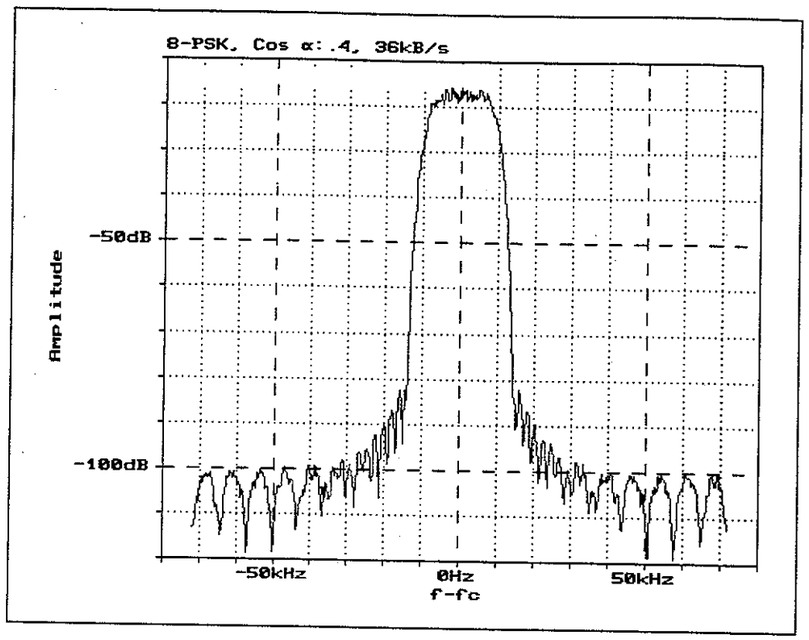
Selectivity can broadly include adjacent channel selectivity, co channel selectivity, intermodulation rejection and blocking.

The above slide refers to adjacent channel selectivity. The transmitter of TETRA radios is specified for adjacent channel power of less than -60 dBc at first channel offsets and -70 dBc for second and third adjacent channels. TETRA receivers must therefore accommodate these levels but also other rogue transmissions without degradation of reception quality.

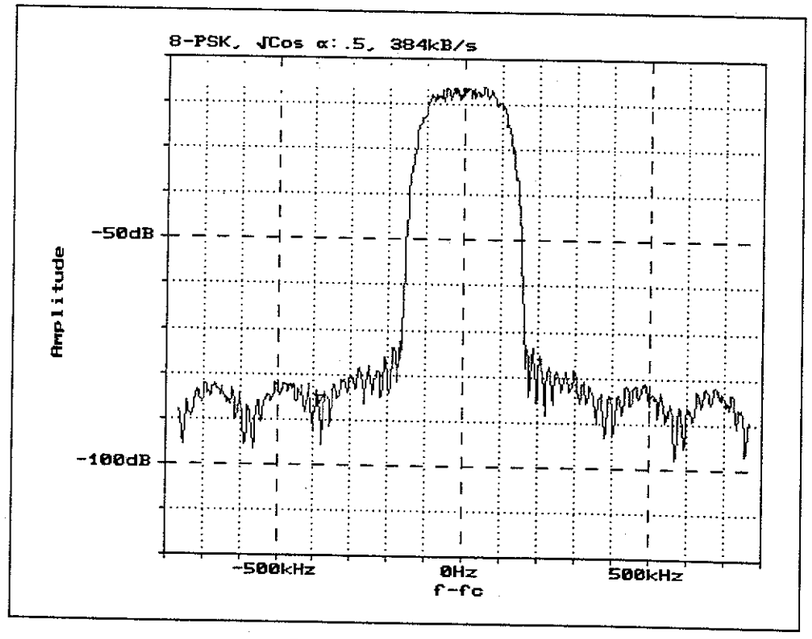
Both the in channel and interfering signals may be subject to terrain fading which requires the use of a fading simulator. In the case of Marconi's 2050 and 2050T generators a Rayleigh fading model is supplied internally. This has a characteristic close to the required TETRA TU50 terrain models although it is a single path and not a two path model.

Intermodulation rejection uses three signals. In receiver stimulus (T1) a modulated interferer (T2) with low adjacent channel power and a CW interferer. The internally generated intermodulation products of the receiver front end will occur at the wanted

channel frequency providing the interferers are correctly set. The intermodulation products will cause degradation of received BER performance.



TETRA



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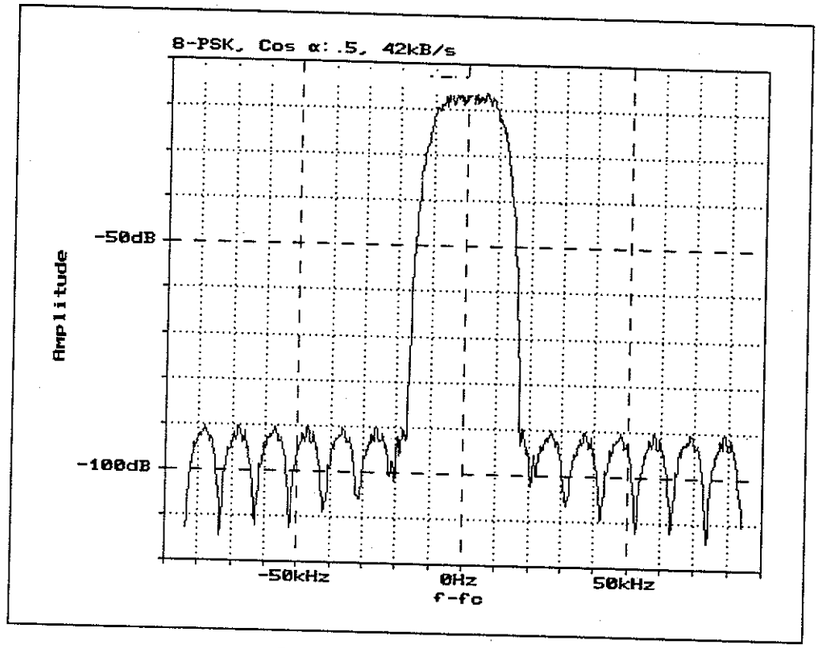
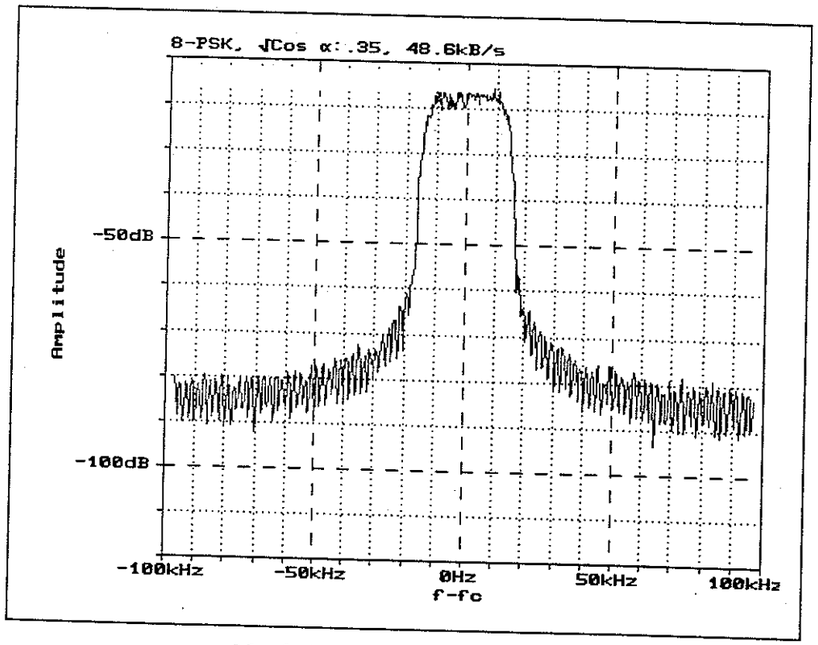


Japanese Digital Cellular



North American Digital Cellular