SPECTRACOM
SYNCHRONIZING CRITICAL OPERATIONS™

APPLICATION NOTE

# Synchronization of Tetra

## Introduction

The TETRA (TErrestrial Trunked RAdio) is the International standard for digital Private Mobile Radio (PMR). This standard has been developed by the European Telecommunications Standardization Institute (ETSI) (EN 300 392-2 V2.1.1).

TETRA is aimed at markets that range from very large regional and national public and emergency service networks to on-site systems such as the Millennium Dome in London. Customers include network providers, police forces, fire and ambulance services, security services, gas, water and electric utilities, mass transit authorities and operators, airports, ports and the general professional radio market.

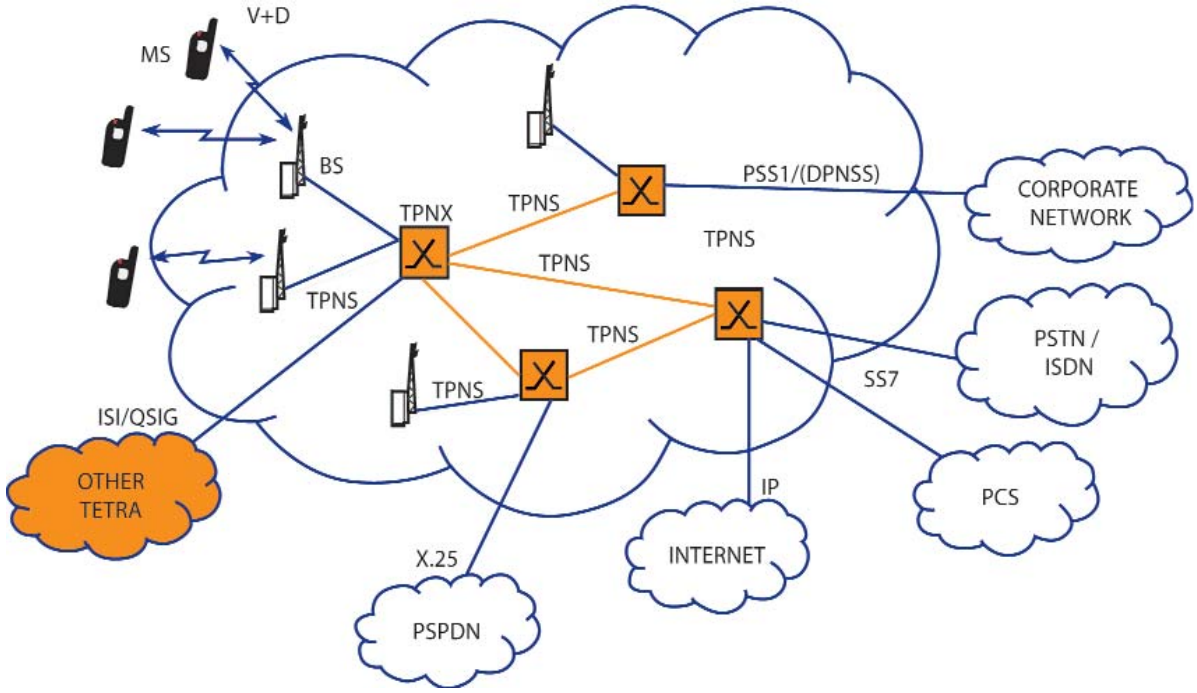
The aim of this application note is to answer 4 questions:

- How TETRA works?
- What are the synchronization needs?
- How to synchronize?
- What are the solutions offered by TEMEX to synchronize TETRA?

## How Tetra Works?

The system is based on TDMA (Time Division Multiple Access). The TDMA is a digital transmission technology that allows a number of users to share a single radio-frequency (RF) channel without interference by allocating unique time slots to each user within each channel. The TETRA digital transmission scheme multiplexes 4 traffic or control channels per radio frequency. Each communication link (voice or data) can use up to the four time slots allowing in this last case a maximum data rate of 28.8 kbit/s.

The figure below represents architecture of the TETRA system. The big cloud is the TETRA wireline network with the exchange nodes (TPNX), the lines (TPNS) and the base stations (BS). Around this main cloud, the links with Mobile station (MS), other TETRA networks, Public Telephone Network, and the Internet are also represented. The MS can be either a handset system or a data terminal.

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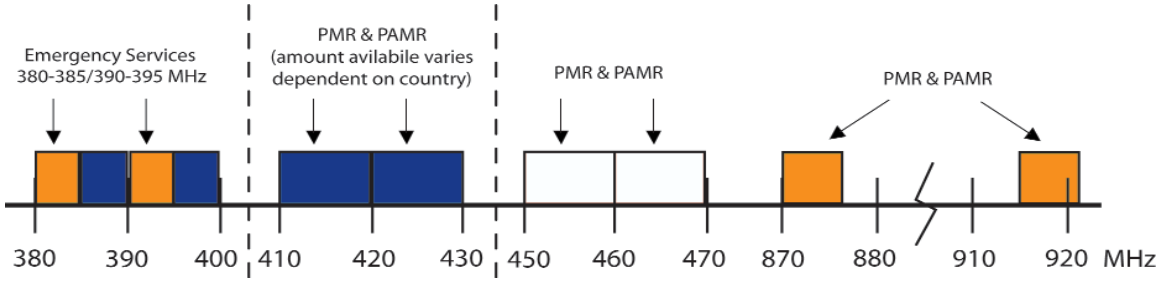
The following figure represents the Frequency bands attributed to TETRA in most of European countries for Emergency Services, PMR (Private Mobile Radio) and PAMR (Public Access Mobile Radio)




## What are the Synchronization Needs?

In telecommunication industry the term synchronization applies to time synchronization and also to frequency accuracy. It is important to distinguish these two types of synchronization and the type of stations (Base or Mobile).

### Frequency Accuracy

The Base Stations (BS) shall use a single frequency source for both RF frequency generation and clocking the time base. All carriers of the BS shall use the same source. The BS specification of relative frequency accuracy is up to .

Note: The carrier frequency of the MS shall be accurate to within ±100 Hz compared to signals received from the BS (these signals may have an apparent frequency error due to BS frequency error and Doppler shift). For this purpose the MS slaves its local oscillator to BS.

### Time Synchronization

In terms of Time synchronization, all the channels of different carriers transmitted by one BS shall be synchronized together, i.e. controlled by the same set of counters. The timing difference between the different frequency channels is specified to be less than 13.9 µs (¼ symbol duration).

It is optional whether the time base counters of the different BS are synchronized together. In case of timesharing of the same frequency channel by different BS, the timing difference between the time base references of two any such BS shall be less than 27.8 µs (½ symbol duration).

Note: The MS shall adjust its internal time base in line with that of signals received from the BS. If the MS determines that the timing difference exceeds ¼ symbol duration (13.9 µs), it shall adjust its time base in steps of not greater than ¼ symbol duration. This adjustment shall be performed at intervals of not less than 1 second and not greater than 3 seconds until the timing difference is less than ¼ symbol duration. In determining the timing of signals from the BS, the timings shall be estimated in such a way that the timing assessment error is less than 1/8 symbol duration (6.9 µs).

## How to Synchronize?

### Frequency Accuracy

To synchronize the frequency it is necessary to have a clock reference, which complies to the accuracy goal. Hydrogen Maser or cesium beam frequency is very stable and accurate, much more than the needs but is too expensive for this application. A rubidium atomic clock is compliant to the needs for the lifetime of a BS but it is a little bit too expensive as well. A quartz oscillator is much cheaper but to reach the needs an OCXO need to be calibrated at each starting procedure and to be recalibrated at least 2 to 3 time a year. Furthermore, the quartz oscillator must be replaced every 3 years, because the drift after this time may exceed the tuning range. So, even though the purchasing cost is very low, the ownership cost can be very high. The best solution is to choose a GPS clock based solution, which needs no calibration.

### Time Synchronization

Furthermore a GPS based solution is linked to an international time scale (UTC), which is very useful for dating a message. Of course for applications with timesharing of the same carrier, a reference to an absolute time scale is mandatory and a GPS solution is so strongly recommended.

The spread spectrum signal of CDMA2000 requires sophisticated broadcast power management and "soft hand-offs" between base stations (BS). This requires that the BS be precisely timed. The basic synchronization requirement is that each BS must maintain its frequency to within one part in 1010 and the time offset between BS must be within ±10 µs.

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## Temex Solutions to Synchronize Tetra Network

As a conclusion, an operator wishing to deploy an optimally synchronized Tetra Network has to take into account the total ownership cost (purchasing + operation + maintenance) for a period of at least 10 years. A solution based on GPS is therefore strongly recommended.

This could be achieved by Tetra BS equipment with GPS receiver (built-in or external) and good performance oscillator (such as quartz OCXO, single or double oven). Three Spectracom products answer these needs:

The **EPSILON BOARD® OEM II** is specially designed to be integrated in a customer built-in system. It delivers one 1 PPS TTL and one 10MHz sine wave signals and Time of Day via a serial interface.

Aimed to supply Tetra BS manufacturers.

The **EPSILON CLOCK® 1S** is a low-cost compact and stand-alone GPS clock with one 1 PPS TTL and one 10MHz sine wave signals and Time of Day via a serial interface.

Aimed to externally secure or upgrade a BS site/network


All these products provide synchronization solutions with accurate and stable Time and Frequency signals. They are synchronized by UTC-GPS reference, broadcast by the GPS satellite constellation all over the world. Time – Receiver Autonomous Integrity Monitoring (T-RAIM) is achieved to discard faulty GPS satellites and then ensures Time
integrity.

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