Application Note

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Performance of a TETRA base station using 3250 Series Spectrum Analyzer

A TETRA network is only as good as the performance of the radio equipment which is used on it. Testing TETRA radio equipment presents difficult challenges to test equipment. Of course the Aeroflex 3920 Digital Radio Test set and 2310 TETRA Signal Analyzer are available to provide the gold standard in TETRA test, but in many cases such as base station test, it can be effective to use a more general purpose instrument such as the 3250 Series Spectrum Analyzer.

Conventional swept frequency spectrum analysis is useful to inspect the TETRA signal and to identify gross impairments. But a spectrum analyzer alone is inadequate for TETRA signal analysis.

Most transmitter measurements will be made using a modulation analyzer. Difficult measurements such as ACP and non-active power require high dynamic range and an accurate implementation of the TETRA Root Nyquist filter. This needs to be very precise and requires a digital filter with a minimum length of 30 symbols

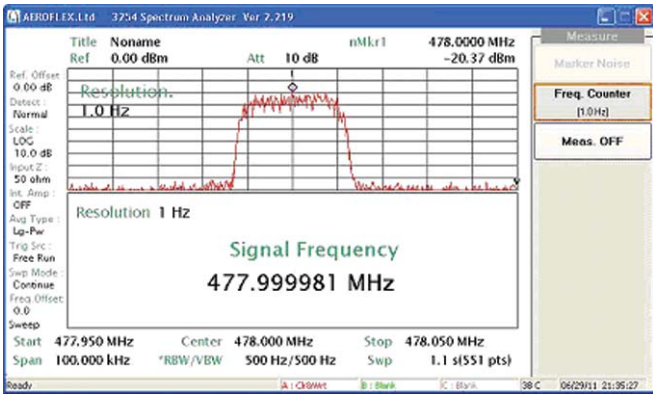
Measurement of Adjacent Channel Power and non-active power, where the radio under test is required to achieve 70 dB dynamic range or better, requires the test equipment to achieve at least 80 dB.

The Aeroflex 3250 Series Spectrum Analyzers include a 30 MHz IQ Digitizer with more than 80dB dynamic range. Using this vector digitizer, the 3250 can be used to make very accurate measurements and is ideally suited for the measurement of TETRA base station equipment. The 3250 modulation analysis package includes the TETRA root Nyquist filter as standard.

One of the most critical radio performance parameters is power level accuracy. Efficient use of radio spectrum depends on re-use of frequencies in cells; typically cell sizes are reduced as network roll-out progresses and use density increases. Control of cell size depends on both mobiles and base stations using the correct power level.

Inadequate power restricts the reach of a transmitter and excessive power can cause interference in a distant cell re-using the frequency, as well as shortening battery life in a mobile.

TETRA radio systems define radio channels which are 25 kHz wide. In real life, all radio transmitters produce a degree of interference outside of the allocated channel. A TDMA system such as TETRA also has the potential for interference due to the switching transients as it ramps up and down the power for each burst.



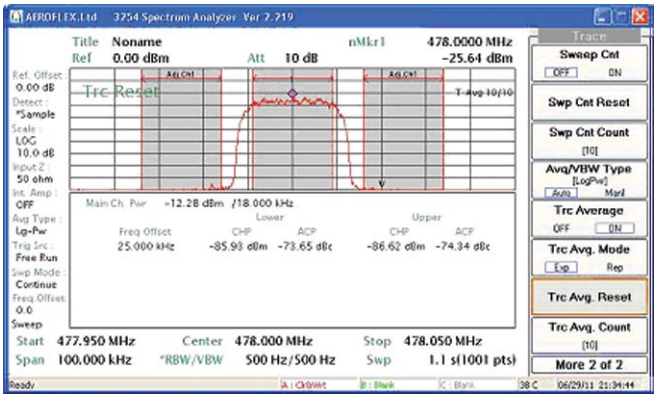
Frequency count is accurate even with a modulated signal (Reference Generator: 478.000000 MHz)

The DQPSK modulation and TETRA filter are designed, in theory, to avoid spectral spread into adjacent channels. In practice, modulator and transmitter impairments result in a certain amount of power appearing in the adjacent channels. Transmitter non-linearity can cause an increase in adjacent channel power and TETRA permits occasional increases in ACP for the purposes of linearity correction.

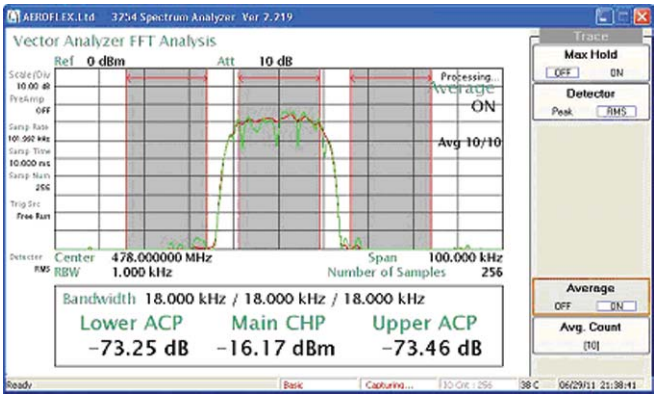
In order to avoid problems between TETRA and analogue radio users, or indeed between TETRA users, the TETRA specifications include some very demanding requirements for transmitter performance. To measure this performance imposes demanding requirements on the test equipment.

The TETRA Adjacent Channel Power (ACP) specifications have proved to be particularly demanding, requiring close attention to transmitter linearity, modulation accuracy and the implementation of the TETRA filter. Power in the first adjacent channels (±25 kHz) must not exceed - 60 dB relative to the allocated channel. Power in the second and third adjacent channels (±50 kHz and ±75 kHz) must not exceed -70 dB

The 3250 Spectrum Analyzer can perform this measurement in either Spectrum mode or Vector mode. As shown below, the performance of the analyzer in both modes when measuring the output of a TETRA reference generator exceeds the TETRA requirement.

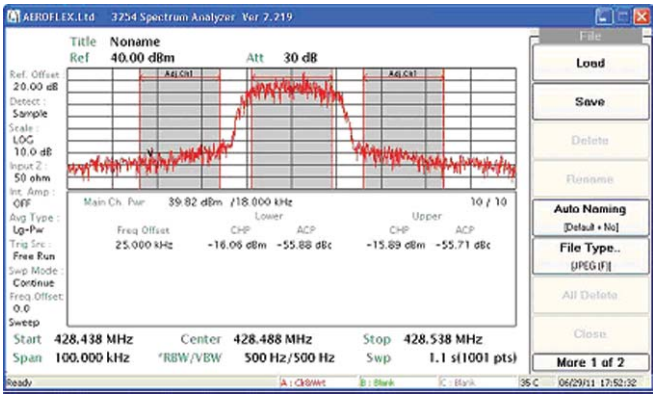


ACP measurement of TETRA Reference Generator 3413 with averaged trace in spectrum analyzer mode



ACP measurement of TETRA Reference Generator 3413 with averaged trace in vector analyzer mode

Used to measure the output from a TETRA base station, the 3250 Spectrum Analyzer will correctly identify many of the discussed above which lead to the bleeding of power into adjacent channels.

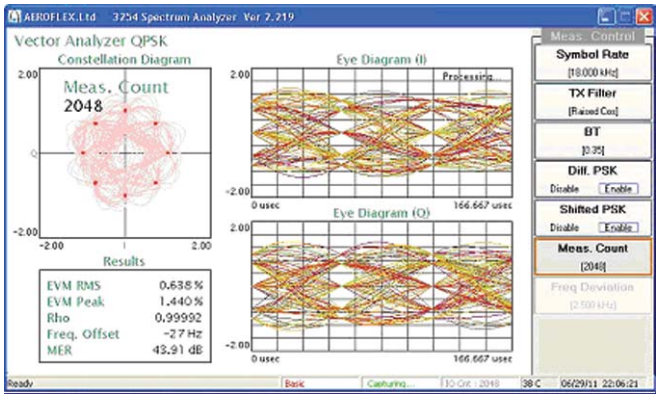


ACP measurement of real TETRA base station in spectrum analyzer mode

TETRA transmitter measurements are complicated. Most transmitter measurements require capture of a burst transmission with the measurement period time-aligned to the active period of the burst. Many measurements require much finer alignment such that the measurement is only made at the decision points of the modulation symbols. This applies even to average power measurement. Accurate results require a trigger derived from the base station

A TETRA radio implements a TETRA filter (Root Nyquist or Root Raised Cosine) filter in both the transmitter and the receiver, such that the overall transmit receive response is Nyquist filtered. For making valid TETRA transmitter measurements, the test equipment must emulate a TETRA receiver by Root Nyquist filtering the measured signals. The Nyquist filter restricts the spectral spread of the signal without introducing inter-symbol interference (ISI).

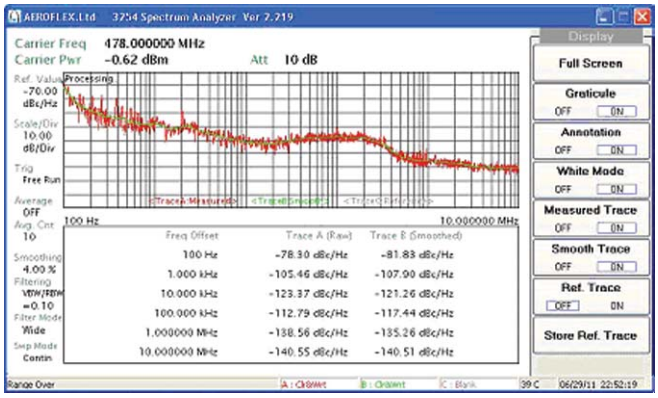
The modulation analyzer in the 3250 implements both raised cosine and root raised cosine filter which matches the TETRA specification when BT is set to 0.35. Therefore the instrument can be set to correctly match the transmitter.



Analysis of TETRA Reference Generator 3413. Set symbol rate of 18 kHz; Enable Differential PSK and Shifted PSK

The measures of EVM, Modulation Error and frequency offset are presented by the Vector Analyzer in a table of numeric results. Eye diagrams on the quadrature signals are also shown.

Note, the number of acquisition points should be high enough to exceed the length of a frame cycle.

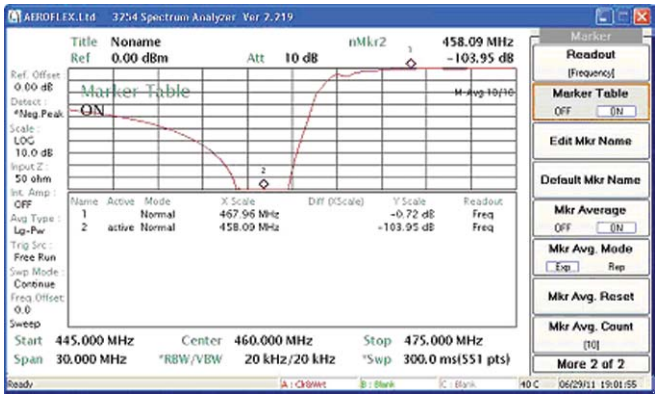


Analysis of the phase noise of a reference CW signal.

The 3250 Spectrum Analyzer offers excellent phase noise performance and a useful phase noise analysis screen which sets up the analyzer, measures and displays the phase noise measurement in graphical and tabular formats.

Analysis of the phase noise of a reference CW signal at 478 MHz shows the residual phase noise performance of the instrument to be <-120 dBc/Hz at 10 kHz offset. This means that the 3250 is well suited to the characterization of the TETRA base station.

One more test for which the 3250 proves to have an excellent performance is measurement of the duplexer filter used to separate the high power transmit signals from the low power receive signals in the base station.



Duplexer filter with the tracking generator at 0 dBm max

Setting the Tracking Generator to its maximum output of 0 dBm provides highest measurement dynamic range.

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