TETRA - Design Proving, Testing and Maintenance

Author: Steve Gledhill
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Steve Gledhill of IFR reviews the test and measurement challenges of the new TETRA communication system and examines some of the solutions available. Since TETRA is a digital system many radio workshops will require radically different test equipment.

The majority of users of radio communications equipment will only be aware of the testing which is carried out to maintain it when there are faults. Before examining this aspect in more detail it is instructive to review the other aspects of testing which are carried out at the design and manufacturing stages. Measurements need to be made on all the constituent parts of the system including the mobile handsets, base stations and direct mode terminals.

At the design validation stage the critical assessments made are those that verify that the radio system performance conforms to the requirement specifications. The TETRA standard is rigorously defined in a range of documents published by ETSI - the European Telecommunications Standards Institute.

The next crucial stage is conformance testing; this entails a selection of hardware tests and software evaluations to check for compliance with the standards. Having evaluated and proved the performance of representative production or pre-production samples, the next phase is to measure the performance of products throughout the manufacturing cycle. Additionally the system will undergo further tests at system installation and commissioning. Testing does not stop there; service workshops require test and measurement equipment for maintenance and repair.

Methods of Testing

Two main methods are prescribed for TETRA terminal testing. These are known as T1 Test mode and TETRA Test mode. T1 test mode entails the application of a suite of RF test signals to the antenna connector of the terminal. These are decoded by the terminal and passed to the test system where receiver performance measurements are made. The decoded data is output by the terminal using either a specially provided test connector, or by using RF Loop Back to re-transmit the received data using the antenna connector. The T1 test mode is principally confined to conformance testing.

TETRA Test mode tests the TETRA terminal in near-normal operation, permitting registration and call set-up to be performed, whilst avoiding the need for authentication. For security reasons, TETRA Test mode must be manually enabled and will only operate with a control channel using reserved test values for Mobile Country Code and Mobile Network Code. With a call set up, RF Loop Back can be selected and de-selected for performing receiver error rate tests.

Conformance Testing

Conformance type tests are generally only carried out at the design and manufacturing approval stages, although routine quality checks of production equipment will take place. This scenario means that although relatively few systems will be assessed for conformance, the tests have to be made to a very high standard. A certain degree of automation will be required, but there is less demand than for the mass testing required at manufacturing and maintenance.

Test equipment manufacturers have had to produce highly specialised testers especially for TETRA conformance testing. Receiver tests require two specialised signal generators and transmitter tests require a system specific modulation analyzer.

TETRA Signal Generator

In research and development and manufacturing test a dedicated TETRA Signal Generator is essential for receiver testing and evaluation. The IFR 2050T (fig 1) Signal Generator provides a P /4 DQPSK (Differential Quaternary Phase Shift Keyed) vector modulated test signal. The 2050T is vital for TETRA receiver design proving because it generates an interfering test signal with the very low adjacent channel power of -70 dBc required for both conformance and manufacturing testing. Additionally power ramps can be generated with greater than 70 dB dynamic range to simulate a TDMA (Time Division Multiple Access) burst.

The IFR 2050T TETRA Signal Generator provides a vector modulated test signal and very low adjacent channel power for receiver evaluation.

TETRA Signal Analyzer

Transmitter measurements in a TETRA system demand a new type of signal analyzer which can measure a wide range of parameters. These include transmitter power, power profile, adjacent channel power due to modulation and switching as well as power in a non-active slot, frequency accuracy and modulation accuracy.

This dedicated TETRA Signal Analyzer (fig 2), with a patented digital IF, incorporates very low noise receiver and local oscillators combined with excellent linearity in order to meet the very demanding tests required at design proving and conformance stages.

Transmitter measurements in a TETRA system demand a new type of signal analyzer. The 2310 TETRA Signal Analyzer graphically displays all the vital transmitter parameters.

The Testing Challenge, repair and maintenance

Testing the traditional two-way radio in a maintenance workshop was originally a relatively simple task. An AM or FM signal generator to test receiver sensitivity and a modulation meter, power meter and frequency counter for transmitter testing were generally sufficient to trouble shoot a faulty radio and to adjust it to meet specification. As systems became more complex, and narrow-band synthesized systems were introduced, the demands on test equipment grew. In the early 1980s sophisticated "all-in-one" radio test sets appeared on the market, the most renowned one being the 2955 from Marconi Instruments.

The company, now known as IFR since parting from GEC in early 1998, has pioneered the "all-in-one" approach to TETRA testing with its model 2968 Radio Test Set (fig 3). As well as a signal generator, modulation analyzer and a variety of other test functions the instrument also includes a spectrum analyzer. Most importantly the instrument carries out additional tests which are specific to TETRA testing. Since TETRA is a digital radio system using TDMA, additional and radically new test techniques are required.

Although the 2968 is engineered to test the latest digital technology it still provides the full range of traditional PMR and MPT 1327 trunked radio tests. In addition it can also tests GSM and analogue cellular radio systems so that other equipment in use is supported.

Radio workshops will need to be re-equipped with TETRA-specific integrated testers. IFR's 2968 tests
TETRA base stations, terminals and direct mode mobiles as well as providing full test facilities for traditional PMR radios as well as analogue and GSM cellular radios.

Transmitter testing

Instead of FM deviation or AM modulation tests, which are carried out on analogue systems tests, TETRA necessitates different types of transmitter measurements. The modulation quality is measured by comparing the calculated and measured values of the signal magnitude and phase and calculating a percentage error. This measures the performance of the IQ modulators and baseband circuits. Graphical displays with constellation, phase trajectory and rotated vector diagrams are incorporated. To assist with the alignment and adjustment of IQ modulators the amplitude and phase errors are displayed on one diagram.

To test the transmitter power the tester provides a graphical time domain display. This shows the rise and fall times of the TETRA burst profile against the limits set by ETSI. These limits are stored in the instrument's memory. If a transmitter has an incorrect burst profile there may be errors in transmitted data, and interference generated for other users, which, in the extreme, can give system failure.

Receiver Testing

Analogue receivers are tested by measuring the signal to noise performance with low level RF signals at the receiver input. This is usually known as the SINAD measurement. With TETRA different parameters, BER (Bit Error Rate) or MER (Message Erasure Rate) are the critical measurements. These parameters compare the data transmitted by the test set to the unit under test (UUT) with that received by the UUT. and returned to the Test set, using the loopback test facility. A poor BER/MER performance will indicate that noise introduced in the receiver is interfering with the modulated signal to produce errors in the digital bit stream. The TETRA system does utilise error-correcting routines but these only operate up to a certain critical level of degradation. For safety critical systems it is essential to ensure that there is adequate stand-off and that the receiver is not at the edge of its performance capabilities. This could mean failure in adverse operating conditions or degradation due to time

To measure BER the tester generates a range of T1 test signals (T1 Test mode) or control and traffic channels (TETRA Test mode), which synchronize the mobile and control its operation BER is assessed by applying a test stimulus which is a closely defined Pseudo Random Binary Sequence (PRBS). Mobiles may not implement a T1 Test mode beyond conformance testing, so the tester also needs to generate Main Control Channel (MCCH) and Traffic Channel (TCH) signals which simulate the real network and permit calls to be set up. Additionally the TETRA loopback specification enables the terminal to be tested without any knowledge of the encryption algorithms employed in the system.

System Testing

Testing and aligning the transmitters and receivers of a TETRA system is necessary and important, but what is vital is the overall test of performance and integrity. To be certain that a radio is fully working when it leaves the workshop after service or repair the test system needs to evaluate call processing, check burst timing and burst profile and verify synchronisation.

Call processing can include many different parameters and functions. Typical checks will include the following:

- Mobile registration
- Call placement and clear down in both simplex and duplex modes
- Speech talkback for subjective audio quality assessment

Conclusion

The introduction of TETRA, which utilizes digital modulation, has generated a number of major challenges to Test and Measurement manufacturers. Specialized instruments have been developed in close consultation with the TETRA manufacturers. To assist workshops that will need to re-equip to cater for TETRA radios, a multipurpose, versatile radio test set is now available for repair and maintenance of TETRA radios as well as traditional PMR, trunked radios and cellular radios.

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