Application Note

AEROFLEX
A passion for performance.

The 2975 - An advanced P25 and Analog Test System

by Rob Barden

This application note provides P25 testing professionals with an in-depth view of the 2975's capabilities, design concept and exclusive features. It is designed to highlight the features of the 2975 P25 Radio Test Set and describe its contribution to the support and maintainability of equipment conforming to the Project 25 standard.

Concept

The IFR 2975 is a new concept in radio test. Within the confines of its RF parametric performance, the 2975 is a software radio platform, with the added functionality of providing highly accurate measurement capabilities of RF systems. The platform was designed primarily for FDMA systems, particularly the P25 land mobile radio standard.

The ability to handle complex P25 digital modulation formats is enhanced by the 2975's base-band digital signal processing capabilities. The system incorporates modern FPGA (Field Programmable Gate Array) and DSP (Digital Signal Processing) technology to accomplish much of what was previously a hardware task. This includes programmable IF bandwidths that allow the system to emulate real world conditions faced by operators of P25 and FM communication systems.

In addition to real time base-band processing of the RF signal, the 2975 adds another distinct feature compared to conventional radio test sets. The system architecture incorporates a fully functional PC environment that allows unique control and application support for expanded test functionality. This aspect of the 2975 allows for fast development of application software for user specific requirements as well as Internet and LAN (Local Area Network) capabilities for creating remote instrumentation over the Internet or support of ethernet connections for real time Remote Command Interface (RCI).

Architecture

Although the system architecture of the 2975 is proprietary, we can disclose some of the capabilities of the 2975 and thus, the reason for its flexibility. The unit consists of 4 high speed (currently 100 MIPS) DSPs to support the RF parametric analysis, audio functions, spectrum analysis and the receive/transmit capabilities of the unit. In addition to the DSPs, the unit incorporates a FPGA as well as programmable up and down conversion.

The receiver system downconverts to an IF at 10.7 MHz. Calibration factors are loaded into the unit to digitally offset hardware fluctuations and temperature variations of the unit. This allows very accurate generation and recovery of RF signals.

The system processor is a Pentium Class embedded computer. This processor is running at less than 10% utilization and provides over 10,000 times the processing capabilities of conventional and competitive equipment on the market (most being based on the Motorola 68 K processor).

Although the instrument maintains an internal computer, nothing keeps the user from hooking up a more powerful external computer to control the unit. Some competitors have suggested that the 2975 is limited to the internal computer, which is not correct. Any external computer can be used to control the instrument, just as with any service monitor. However, the internal computer provides much more flexibility in future expansion and test capabilities.

The unit also includes sufficient RAM to control system functions (64 MB) and a 20 GB hard-drive for virtually unlimited storage of setups and configurations. Current settings allow for 1,000 unique setup locations.

The operating system includes an open-source application layer that allows users to custom design specific test sequences as well as the "look" of the instrument for specialized testing. The TCL/TK application layer provides both mathematical and graphical manipulation of the unit to provide unique applications for the user.

Since the instrument digitizes the RF signal after the down-conversion process, the system can provide base level symbols directly to the user for analysis. This is shown by the unit's ability to provide raw symbols, decoded octets and fully decoded system messages in the P25 digital trunking mode. This base-band demodulation capability of digital signals allows for great flexibility in the protocol domain in the encoding and decoding of digital messages for protocol analysis.

User Interface

Test equipment has always been complex to operate, often with the user being the last concern of equipment designers. This has been due to the designer's focus on accuracy of measurement, and the complexity of the various technologies that are to be supported in the test system.

IFR, in the design of the 2975, focused on both accuracy and the user interface equally during the design phase of the instrument. This was due to a number of factors:

1. The complex nature of new digital modulation formats.
2. The rapid deployment of P25 systems that put a significant learning "ramp" on engineers and technicians.
3. The lack of competent technical personnel to test new digital systems.
4. The previous history of complexity of test instruments dictated a quantum leap in complexity for new digital systems. Something had to "give" in order to make this useable for the market.

Although nothing will surpass the inherent knowledge of RF systems and digital modulation technology, the 2975 goes a long way to minimize the complexity of these systems for the average user.

The 2975, in base configuration, supports the following unique characteristics for ease of use:

1. A unique windowing system that allows the user to quickly configure the instrument the way he desires. Expand and minimize functions of the window or "tile" adds to the user's ability to quickly and accurately assess problems.
2. Exclusive "All Instrument" save capabilities that stores the entire "state" of the instrument for future recall. This feature dramatically reduces the required setup and inherent knowledge required to use the instrument. A "master" technician or engineer can define various setups for the systems he or she is responsible for testing, and then store these into memory. This allows for "standardization" of the test procedures for roll out to the technician "base". This eliminates technician competency and test equipment "interpretation" issues.
3. Exclusive on-line help. The system utilizes on-line help functions that instruct the user on the use of a particular feature or function. Since the help function is HTML based,

future revisions will allow users to customize help functions to particular setups that the user defines.

4. Full color LCD display. With excellent contrast and brightness, this screen allows the user to easily see problems and errors when testing radios.

5. Mouse and keyboard operation. Since the system incorporates a PC, the instrument allows the user to use a PS2 mouse and keyboard to quickly access the unit's test capabilities.

6. Fast test recall. The unit allows for custom setup of specialized test and then also provides the ability to "walk" through the various tests quickly through a fast recall function. This allows the user to quickly access stored setups in any sequence and then walk through a series of tests.

7. Click and tune spectrum analyzer. The 2975, with the mouse function, allows for quick analysis of spectral performance with the ability to "click" on a spectral anomaly and quickly ascertain the frequency and level of the interfering signal.

8. Pass/Fail parameters. The 2975 allows the user to quickly establish pass/fail parameters on the various meter "tiles" or "windows". With these tests, the user can audibly and visually ascertain if the radio under test is within the pass/fail limits established. This is accomplished by a user enabled audible warning (beep) and the following graphic representation of pass/fail performance:

A. Red. Over-limit condition.

B. Green. In-limits condition or "Green for Good".

C. Blue for an Under-limit condition.

And, the optional Autotest program allows for even simpler operation of the radio through an integrated, stand alone test system that automatically tests the radio, with user prompts when human intervention, if any, is required.

System Test Capabilities

The 2975 provides a wide range of test capabilities for AM, FM, SmartNet/Zone and P25 systems. The following is a quick recap of the 2975's test capabilities for each of these formats supported.

1. AM: Full support for AM testing functions included in the base unit.

A. High Accuracy Modulation from 30% to 90%

B. 1% Resolution

C. 0 to -137 dBm range

D. Wideband and Narrowband Power Meters

2. FM: Full support for FM testing functions including Tone Signaling, CTCSS, DPL, and Tone Remote included in the base unit.

A. High Accuracy Modulation from 50Hz to 20kHz

B. 3% Accuracy

C. +10 to -137 dBm range

D. IF Filters of 12.5, 25, 60 and 200 kHz

E. Full range of High Pass, Low Pass and Band Pass filters

F. Wideband and Narrowband Power Meters

3. P25 Conventional testing included in the base unit.

A. Highly accurate C4FM modulation

B. Exclusive C4FM FSK Error Meter (Modulation Fidelity)

C. Downlink Protocol Selection Capabilities

D. Uplink Protocol Analysis

E. Exclusive Test Patterns including 1011, Speech and TIA/EIA-102 CAAA test bit patterns

4. SmartNet/SmartZone optional test capabilities.

A. Full Analog Test Capabilities

B. P25 Digital Mode Capabilities

C. Exclusive SmartNet/Zone scanner finds control channels

D. Exclusive OSW and LSD logger

E. True Repeater Functionality

F. VHF/UHF/800/900MHz operation

5. P25 Trunking optional test capabilities.

A. VHF/UHF/700/800MHz operation

B. Downlink Protocol Selection Capabilities

C. Uplink Protocol Analysis

D. Control Channel Logging Capabilities

E. True Repeater Functionality

Unique Features

The 2975 has a variety of unique features. The following is a recap (some items are available as options):

A. Modulation Fidelity (C4FM) Meter. This unique function allows true analysis of C4FM modulation for verification of P25 radio modulation accuracy and is standard on all 2975's.

B. Highly accurate C4FM modulation (typically .4% C4FM FSK Error versus 2% for the R2670B). High levels of C4FM FSK error in a modulation source can cause improper alignment of P25 radios due to the high-induced BER in the generated signal. The main concern is what is causing high BER, the receiver or the generator. The 2975 provides this level of accuracy as standard equipment.

C. Exclusive Internet Remote capability. Allows the user to create a virtual instrument using the supplied Ethernet support and IP addressing abilities. This allows for unique remote monitoring of P25 systems and remote training features through the Internet. In addition, training programs can be quickly realized through the use of Windows™ based word processing and graphics programs (Microsoft Word and Powerpoint, as examples) where the user can directly copy the front screen display into a document for training and informational purposes. The 2975 provides this support as a standard feature.

D. P25 Phase II support, with highly accurate CQPSK modulation and demodulation in a 6.25 kHz bandwidth.

E. Exclusive Error Vector Magnitude (EVM) and CQPSK constellation display option, which allows engineers and technicians to quickly verify transmitter performance characteristics. Support for both Linear Simulcast Modulation (LSM) with an Alpha of .35 and P25 Phase II CQPSK systems with an Alpha of .2, without the need to spend an additional $20,000 (USD) for test systems to test CQPSK modulation parameters.

F. Frequency Error, Phase Error, Magnitude Error and Origin Offset for CQPSK support for Linear Simulcast Modulation and P25 Phase II systems.

G. The New KVL key-loader option supports DES and new AES keys to be directly loaded into the 2975 for test and analysis using the KVL-3000+ and the P25 Keyloader protocol. Includes the ability to load and manage individual keys, multiple keys and key groups.

H. Support for the new Advanced Encryption System (AES) option for higher security features as well as continued support for the current DES (Digital Encryption System) Type III encryption currently used in existing P25 systems.

I. Exclusive Manual Key Loading functions including the ability to load and manage keys separate from the KVL-3000+.

J. VHF/UHF and 700 MHz P25 Trunking option capability for new system deployments utilizing P25 technology in existing VHF/UHF bands and the newly approved 700 MHz band for PMR applications.

K. Exclusive Control Channel Logging function for P25 Trunked operations allows users to verify interoperability with various P25 radio systems offered by a number of manufacturers.

L. P25 Trunking Protocol Capabilities. With the ability to optionally set P25 OSP messages for control channel and decode of ISP messages from user radios, the 2975 provides users with the ability to verify protocol operation of radios on P25 networks.

M. "Try before you buy" options/features. IFR now allows 2975 owners to test all 2975 options for up to 30 days before making an investment on these features which can be installed directly from IFR via the Internet in the field.

N. Expanded test setups with the new standard 20GB internal hard-drive allow virtually unlimited logging functions of the control channel, with future expansion up to 10,000 radio test setup storage.

O. The 2975 includes TIA/EIA-102.CAAA Standard Patterns. The 2975 provides this support as a standard feature.

P. The 2975 includes a Click and Tune Spectrum Analyzer. The 2975 provides this support as a standard feature.

Q. The 2975 goes to 2.7 GHz for better analysis of harmonics. The 2975 provides this support as a standard feature.

R. IFR has a 5x better Time Base than the competition. The 2975 provides this as a standard feature.

Service and Warranty

IFR provides service centrally at the Wichita, Kansas, U.S. location. In addition, we support third party service organizations. The unit comes with a 2 year warranty standard, with 1-3 year extensions available for service contracts.

A Discussion on Auto-Test and Auto-Align

The P25 test market has requested the ability to perform Auto-Test functions using the 2975. The two primary features of Auto-Test have been the ability to:

A. Perform a quick analysis of radio parameters for transmitter and receiver performance.

B. Align radios using automated software to interface with the radio control equipment and then command the radio to align the radio automatically.

IFR believes in supporting a wide range of radio manufacturers. We believe that the ability to design specialized "fast" analysis of radio parameters with minimal user interface provides the user with a low cost, low complexity solution to testing a wide range of radio manufacturers. We also believe that this capability will give the user the ability to handle virtually all of the radio test and alignment requirements faced on a daily basis.

Disadvantages of the Old

It is possible, using some of the older field alignment procedures which rely on analog measurement technology, to degrade the radio's operation in the digital mode to such an extent that performance is compromised.

Using an out-dated auto-alignment has inherent problems. These include:

A. Errors in the interconnect between the computer controlling the interface to the radio. These include RS-232 baud rate errors, windows, DOS and hardware setup problems and constant vigilance required to support firmware upgrades to the radio.

B. Errors in the interconnect between the test instrument and the computer controller. In many instances, particularly GPIB operation, the computer and the instrument interface requires the use of "wait states". These wait states are required to allow the test instrument to complete a test measurement, process it and report it to the computer. Problems occur when the instrument is commanded or polled for results before it is complete or when the instrument is in the process of completing a measurement which can result in erroneous reports.

Without a complete understanding of the latency of the instrument the exact timing required for measurements to be completed, and the exact delays associated with the computer hardware and the interface, no one can guarantee exact measurement accuracy.

That is why test programming experts continuously re-request data to eliminate possible errors associated with latency issues. This adds precious time to any test. (Interestingly, many of these issues can be resolved with an instrument that has an internal PC where latency issues are dramatically minimized).)

Advantages of the New

IFR believes that the 2975's flexibility in supporting "in instrument" auto-tests with minimal user intervention, versus full auto-alignment, provides the following advantages:

A. Covers 98% of test requirements.

B. Is a much faster way to test radios: typically less than a minute. (Feedback indicates that competitive auto-align procedures require each radio to go through a 17-23 minute alignment procedure.)

C. With the TCL/TK open source application layer, the 2975 can continuously be redefined for many types of auto-test applications.

D. Help files can be developed with the 2975's html based help menu structure.

E. Provides a history of radio performance.

Conclusion

The 2975 is a versatile, high performance platform for testing analog and P25 radio systems. The unit was designed with ease of use, speed and accuracy all considered equally. As part of a multi-faceted test equipment company (Aeroflex), IFR has the knowledge, ability and commitment to providing on-going P25 market support, both now and in the future.

CHINA
Tel: [+86] (21) 6282 8001
Fax: [+86] (21) 6282 8002

EUROPE
Tel: [+44] (0) 1438 742200
Fax: [+44] (0) 1438 727601

FRANCE
Tel: [+33] 1 60 79 96 00
Fax: [+33] 1 60 77 69 22

HONG KONG
Tel: [+852] 2832 7988
Fax: [+852] 2834 5364

SCANDINAVIA
Tel: [+45] 9614 0045
Fax: [+45] 9614 0047

SPAIN
Tel: [+34] (91) 640 11 34
Fax: [+34] (91) 640 06 40

UNITED KINGDOM
Tel: [+44] (0) 1438 742200
Toll Free: [+44] (0800) 282 388 (UK only)
Fax: [+44] (0) 1438 727601

USA
Tel: [+1] (316) 522 4981
Toll Free: [+1] (800) 835 2352 (US only)
Fax: [+1] (316) 522 1360

AEROFLEX
A passion for performance.

www.aeroflex.com
info-test@aeroflex.com

Our passion for performance is defined by three attributes represented by these three icons: solution-minded, performance-driven and customer-focused.

Part No. 46891/916, Issue 2, 07/03