THE FLEXIBLE INTEROPERABLE TRANSCEIVER DATA LINK STANDARD - A SOLUTION FOR INTEROPERABILITY AND SPECTRAL EFFICIENCY FOR THE T&E AND TRAINING RANGES

Eddie M. Meadows
AEgis Technology Group, Inc.

Terrance J. Hill
Nova Engineering, Inc.

ABSTRACT

The greatest threat to the DOD Test and Training Test Centers is the loss of the Radio Frequency (RF) spectrum used in transmitting digital data generated by the test instrumentation during the evaluation of weapon systems. The T&E ranges use the RF spectrum for data generated by status reporting, GPS/TSPI, telemetry, target control, range safety, situational awareness, video, voice communication, etc. In the past the ranges developed their data links independently of one another. The Flexible Interoperable Transceiver (FIT) Data Link Standard identifies protocols and technology that provides for interoperability and spectral efficiency, and can be applied to most RF transmission requirements at the test ranges and training centers.

KEY WORDS

Data Link, Protocols, Spectral and Bandwidth Efficiency, Interoperbility, Instrumentation

INTRODUCTION

Over forty different types of RF data links are used today at DOD test and training ranges, for position status reporting, situational awareness, and control of assets. Twenty-eight (28) T&E and twenty-two (22) training ranges were surveyed for their data link capabilities and applications. It was concluded that most of the data link requirements could be satisfied with a single type of data link, appropriately tailorable and flexible. The Flexible Interoperable Transceiver (FIT) project was chartered by DOD Central Test and Evaluation Investment Program (CTEIP) to develop a standard that defines that common data link. The FIT project is one of two OSD directed projects providing solutions for the frequency encroachment problem.

THE FIT DATA LINK STANDARD

The FIT project has develop a Joint (Mutual) Data Link Standard that identifies signals, formats and protocols for interoperability of transmitting digital data via radio networks from ground-to-ground, ground-to-air and air-to-air. It also incorporates advanced, but cost-effective, techniques for improving spectral efficiency. The datalinks developed from this standard will provide general purpose common RF capability that can be used in a wide variety of military test and training applications such as reporting time-space position information (TSPI), transmitting vehicle data information, target control signals, flight termination commands, video transmissions, telemetry data, timing and voice communication. The transceivers procured using the FIT Standard will be highly tailorable in both hardware and software to optimize each application, provide the latest technologies for spectrum efficiency and assure efficiency and interoperability at and between ranges.

To achieve interoperability, the FIT Data Link Standard identifies the protocols/parameters necessary to allow one FIT configured transceiver to “talk” to another FIT configured one. The high-level interoperability protocols/parameters are (1) modulation type, (2) error coding, (3) header format/structure, (4) message format/structure, (5) timeslot architecture, and (6) relying/controlling scheme. To achieve spectrum efficiency, the Standard specifies the following techniques: (1) Shaped Offset Quadrature Phase Shift Key (SOQPSK) modulation, (2) error detection and forward error correction coding, (3) Time Division Multiple Access, (4) time/frequency/spatial diversity.

The following are brief explanations of the Standard’s high-level interoperability protocols/parameters:

1. Modulation type - The modulation defines the method by which the data causes the amplitude, phase, or frequency of the RF carrier to vary. Use of a single modulation type is required among transceivers that are meant to “talk” to each other. The modulation makes the signal very distinctive and will only be received with a radio that has an identical modulation type.
2. Error coding - this is method to insert and then “read” redundant information into the data stream which the receiver process to detect and/or correct transmission errors.
3. Header structure - headers are configured to a total finite bit length with specific information in various bit lengths inside the header. Only other receivers configured with similar header format can receiver the message
4. Message structure - each message that is transmitted is configured with common structure and control fields. The message can contain different amounts of information but must have the same segments in same sequence to be recognized by the receiver.
5. Timeslot Architecture - The timeslot architecture is into a certain number of time slots per second. Each time slot is assigned to a particular user or terminal in the network.
6. Relying/controlling scheme - Through the controlling software, each transceiver is assigned relay task. These are program dependent and can be configured to the mission scenario.

The following are brief explanations of the techniques in the Standard for spectrum efficiency:

1. SOQPSK modulation - this constant envelope modulation technique based on MIL-STD 188 is at least 2 time more efficient than the MSK or other similar types used at the DOD ranges. SOQPSK has excellent sidelobe falloff allowing packing adjacent signals with out interference. (See Figure 1)
2. Forward error correction - This improves the quality of the received data and can allow using reduced power or higher information transmission rate.
3. TDMA - eliminates interference between users or terminals operating on the same frequency channel.
4. Time/Frequency/Spatial diversity - this allows duplication of a single message at more than one time or frequency. Diversity is very effective in mitigating multipath, antenna screening, and other forms of data dropouts.

The FIT Data Link Standard also requires that transceivers be designed in modular form with programmable software. This allows the transceivers to be extremely flexible and can be configured for specific program needs. Transceivers can tune over several wide bands (e.g. 200-450 MHz, 1350-1525 MHz), selectable by choice of RF heads.

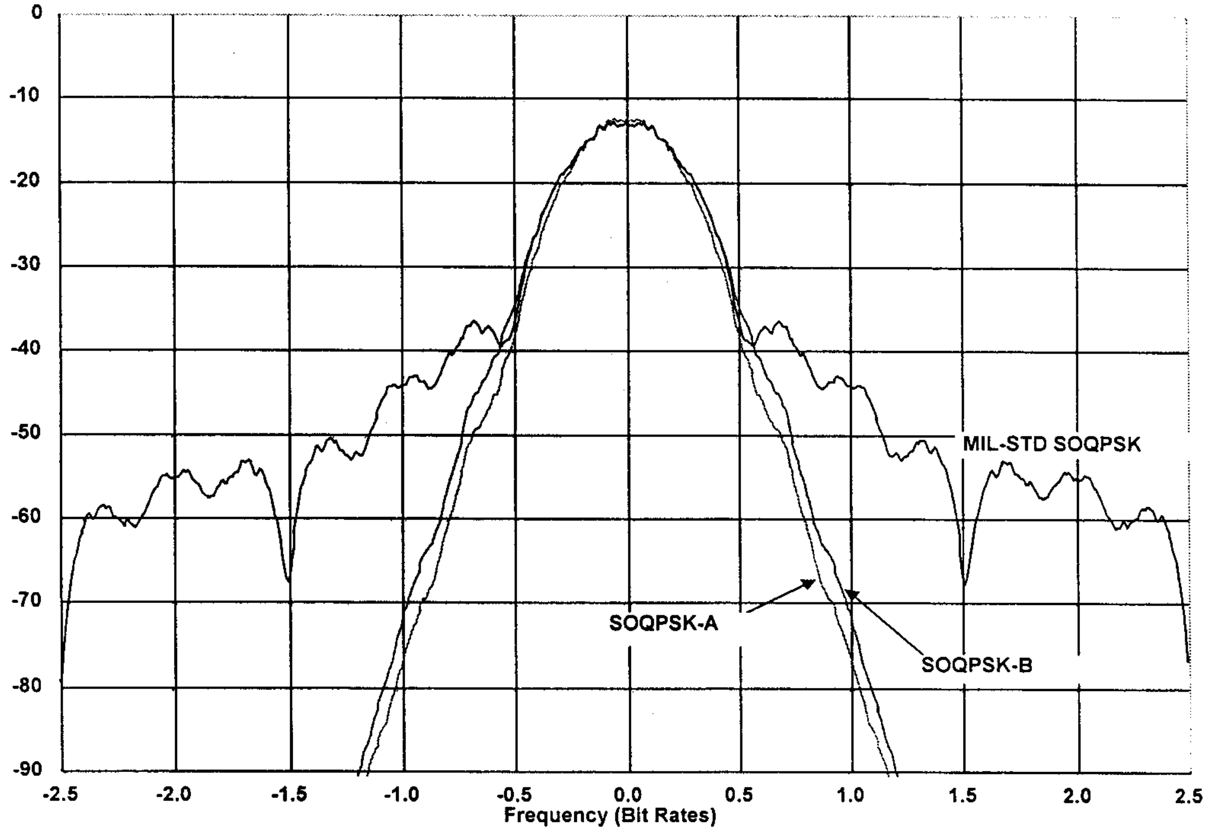


Figure 1. Power Spectral Density Curve

Nova Engineering in Cincinnati, Ohio has validated the Standard. They first developed an engineering model and engineering model and two breadboard transceivers built to the protocols and technologies specified in the FIT Standard and demonstrated point-to-point transmissions. During this phase they also developed the Shaped Offset Quadrature Phase Shift Key (SOQPSK) modulation that improves efficiency over twice of now fielded units [details of this modulation technique can be found in the ITC 2000 Proceedings, Session 2, Advanced Data Links 00-02-05, titled: An Enhanced Constant Envelop Interoperable Shaped Offset QPSK (SOQPSK) Waveform for Improved Spectral Efficiency]. Below is a comparison between SOQPSK, the proprietary Feher-patented QPSK and the presently used MSK (Figure 2).

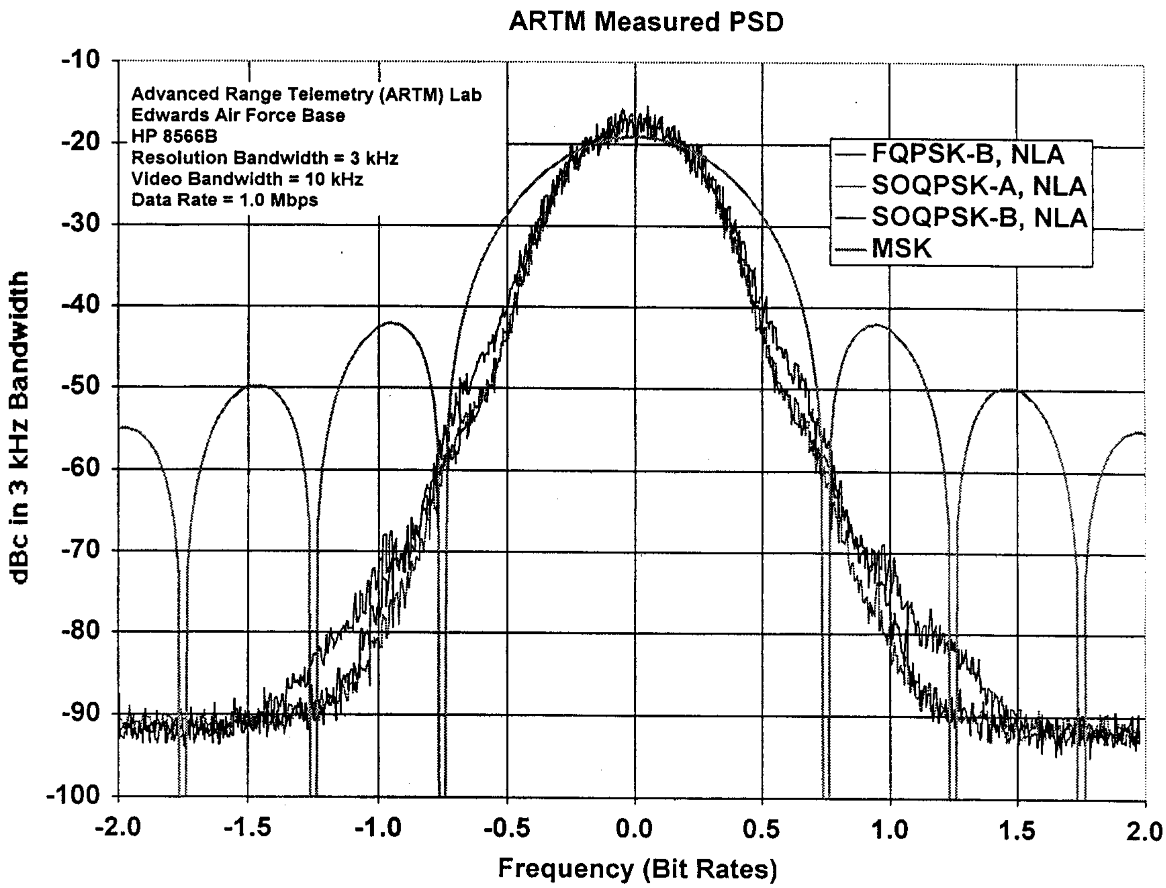
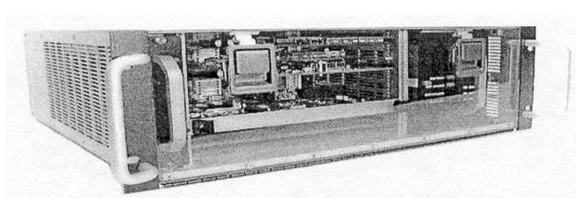
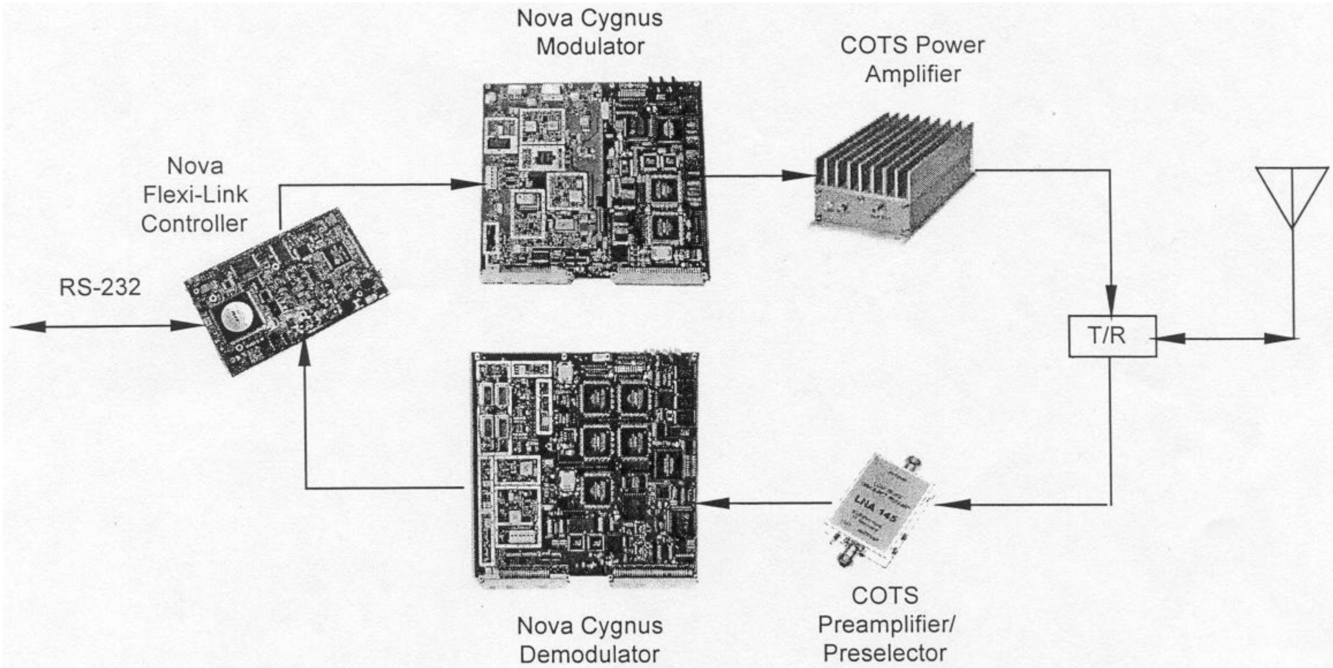


Figure 2. Compared Power Spectral Density Curves

In the next phase, Nova developed the controlling software and fabricated 3 more breadboards. This allowed them to demonstrate the relaying/networking capabilities of the Standard with 6 "players" at their facility in Cincinnati, Ohio. Testing in "real world environments" will follow using all of the fabricated prototype transceivers. Below is a picture of the FIT rack mounted breadboard FIT compliant transceivers:



Below are the components in the above rack that make up the FIT breadboard prototype transceivers:



THE FIT COMPLIANT TRANSCEIVERS

The transceivers that are fabricated using the techniques and protocols of the Fit Data Link Standard will have the following characteristics:

1. Layered Transceiver Architecture - Modular: multiple RF heads, I/O interfaces, power supplies; custom software; high degree of automated control, over-the-air reconfiguration
2. Multi-band and Tunable - Use of different RF heads allow unlimited tuning range
3. Spectrally Efficient: Narrow signal bandwidth; efficient modulation with excellent sidelobe rolloff, highly automated to sense and react to EMC problems
4. Time Division Multiple Access and TX/Rx Switching
5. Tailorable Space, Frequency, Time and Antenna Diversity
6. Variable output Power levels/Ranges
7. Automatic or Pre-configured relaying and control

NEW RCC DATA LINK STANDARD

The Electronic Trajectory Measurements Group (ETMG) of the Range Commanders Council (RCC) are converting the FIT Data Link Standard into a (RCC) Standard. It will be updated and maintained by them. They also will add procedures and acceptance checks that will assure compliance to the RCC created Standard. When a range would need a new or updated transceiver, it would develop systems specifications from its user requirements, add the FIT/RCC Standard as part of the RFP and procure a radio that would have the protocols and techniques incorporated in its design. Any transceiver that was procured in this method would have to pass the checks in the RCC Standard before it would be accepted and become part of the DOD systems.

CONCLUSIONS

The FIT Data Link/RCC Standard is the only DOD developed procedure to help the T&E and Training community address the continuing battle of requiring more data through put transmitted in the ever-limited RF spectrum. The use of the FIT Data Link Standard to construct new transceivers for use at the test & training ranges will result in new levels of versatility and interoperability that will be several time more efficient than present equipment. The unit and life cycle cost will be reduced as well as being more efficient in the limited spectrum available for DOD.

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