FREEDOM
Communication Technologies

Test and Maintenance of P25 Phase II Subscriber Units

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Motivation

A diligent maintenance program is required to maximize the reliability and range of a P25 phase II radio network. This is particularly important in Public Safety systems. Proper performance of subscriber units can be guaranteed through the measurement of transmit metrics such as output power, output carrier frequency, modulation fidelity, and deviation, and receive metrics such as BER and sensitivity. This is commonly accomplished using a Communications Analyzer such as Freedom Communication's R8000. The balance of this paper will discuss the P25 Phase 2 measurements now available in the R8000 radio test set.

P25 Phase II Overview

P25 Phase II is an update to P25 Phase I and offers improvements such as higher bandwidth efficiency and more channels. The higher bandwidth efficiency combined with the use of TDMA results in channels providing an effective bandwidth of 6.25 kHz rather than the previous 12.5 kHz. It should be noted that Phase II systems operate in a trunked only mode. Phase II uses different modulations on the outbound versus inbound channels. This simplifies the requirements for Subscriber Units (SU's) while taking advantage of the increased capabilities of the base stations. The base station outbound modulation is, Harmonized Differential Quaternary Phase Shift Keying, (HDQPSK) which requires a linear power amplifier. The base station inbound modulation is Harmonized Continuous Phase Modulation (HCPM). The HCPM modulation transmitted by the SUs allows some degree of nonlinearity in the SU power amplifiers allowing for the same power amplifiers used in Phase I SUs. The Phase II control channel uses the same 4FSK, 4 level Frequency Shift Keying as Phase I. Phase II vocoders are half rate compared to the full rate vocoders of Phase I. Phase II systems and components are intended to be backwards compatible. This allows the construction of hybrid systems that use both newer Phase II SUs and older Phase I SUs.

HCPM modulation

HCPM is used to transmit from the SU to the base station. It is a form of continuous phase modulation with h = 1/3. It has the memory inherent in CPM plus memory introduced by the symbol filter which spans 5 symbols. (See figure 1)Ideal demodulation requires a sequence demodulator. An optimal sequence demodulator is the Viterbi algorithm. Note HCPM is constant modulus. The physical channel symbol rate is 6 kHz resulting in a bit rate of 12 Kbits. Time Division Multiple Access is used to distribute this data between two logical channels.

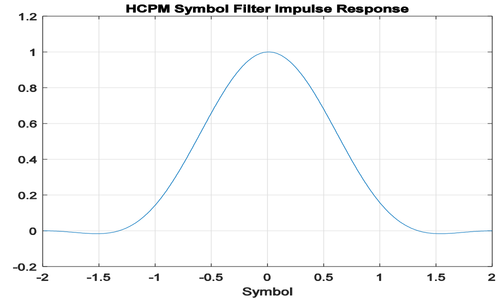

Fig 1

HDQPSK modulation

HDQPSK is used to return data from the SU to the base station. This is a form of pi/4 Quaternary Phase shift keying. The symbols are filtered with a Root Raised Cosine filter with alpha = 0.35. (See figure 2) The physical channel has a symbol rate of 6 kHz. Two logical channels are mapped into the one physical channel data stream.

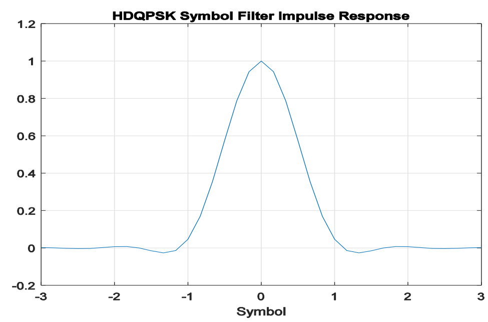

Fig 2

It is interesting to note the HDQPSK symbol filter has very minor symbol interference, which results in a ragged peak for each symbol in the distribution plot. (see figure 3). The reader may be unaccustomed to seeing this interference, expecting to see a "cleaner" peak. This is because unlike the Freedom Communication Technologies R8000, which was used to generate this plot, most radio test sets do not have the required resolution to properly display HDQPSK distribution plots.

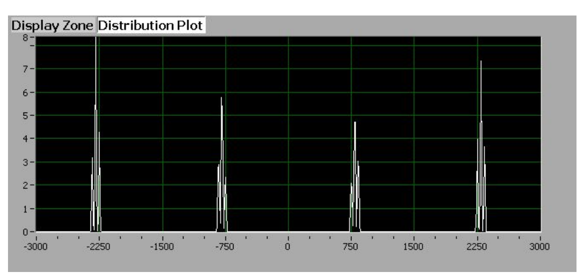

Fig 3 HDQPSK Distribution Plot

SU Transmitter testing

These tests measure performance metrics specified in the TIA specifications [1][2][3] or metrics that are implied by these specifications. The tests, both transmit and receive are performed using a Communications Analyzer such as the Freedom R8000 and a laptop running radio configuration software to put the SUs into test mode.

First on the list of parameters to verify are output power, carrier frequency, and total deviation. (see figure 4)

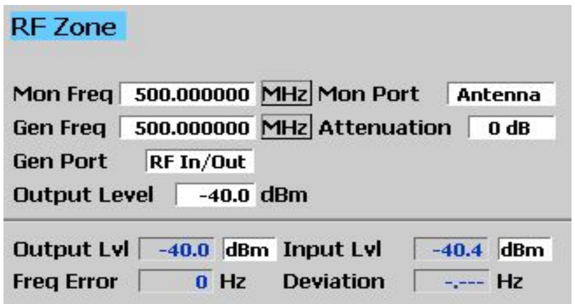

Fig 4 Transmit Power

The next area of interest is signal quality. (See figure 8) Modulation fidelity is a measure of distortion in the transmitted waveform. The transmitter waveform is compared to a reference version generated from the recovered transmitted symbols.

Although signal quality is completely constrained by correct carrier frequency, modulation fidelity and total deviation, displays such as distribution plots and eye diagrams provide added insight into the operation of the transmitter.

The distribution plot (see figure 5) illustrates the symbols associated frequencies. It is interesting to note, seven “virtual” symbols are displayed rather than the four message symbols. This is due to the intersymbol interference built into the HCPM signal. This intersymbol interference helps to constrain the bandwidth of the signal and in conjunction with a sequence demodulator provides improved performance.

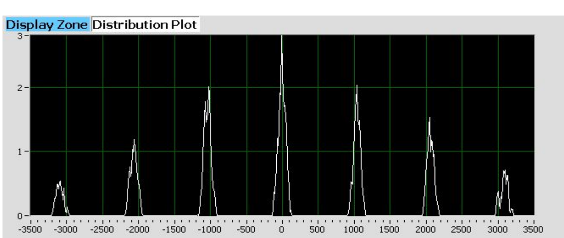

Fig 5 HCPM Symbol Distribution

The eye diagram (see figure 6) displays the variation in the frequency of the transmitted signal as a function of time. Once again "virtual" symbols are what is transmitted and displayed.

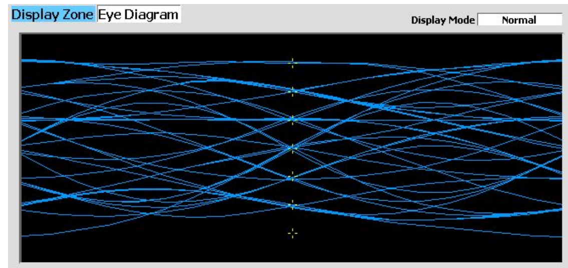

Fig 6 HCPM eye diagram

Another area of interest is the power profile (see figure 7). This is the transmitter’s power as a function of time. This is used to visualize how the SU's transmitter power ramps up and down and stays within its intended time slot.

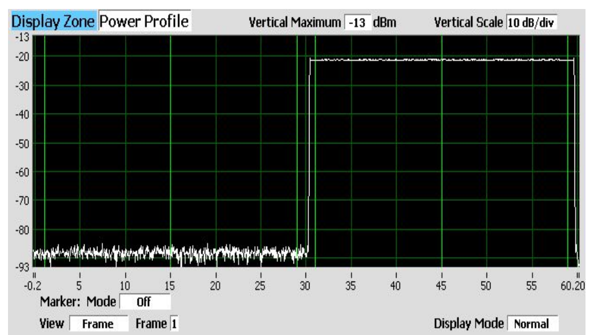

Fig 7 HCPM Power profile

SU Receiver testing

Correct functioning of the receiver can be determined by measuring its sensitivity. SU receiver testing is performed using HDQPSK modulated waveforms generated by the analyzer and feeding these into the receiver at predetermined levels, then measuring Bit Error Rate (BER) (see figure 8). The lowest level at which a receiver generates low BER determines its sensitivity.

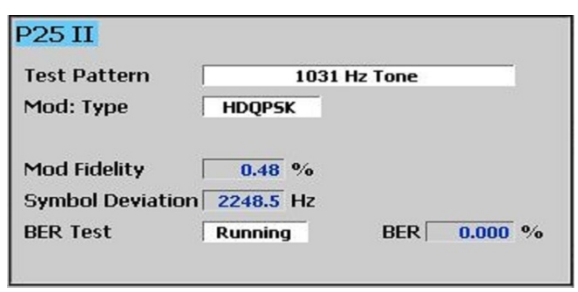

Fig 8 Modulation Fidelity and BER

Conclusions

Correct operation of a P25 Phase II network can be enhanced by periodically testing and aligning the SUs. This is most easily accomplished using a Communication Analyzer such as Freedom Communication's R8000. This allows detection of potential SU failures such as misalignment or failing transmitter power amps to be identified before actual failure thereby insuring the reliable operation of the radio network.

References

1) TIA-102.BBAB Project 25 Phase 2 Two-Slot Time Division Multiple Access Physical Layer Protocol Specification.

2) TIA-102.CCAB-A Project 25 Two-Slot Time Division Multiple Access Transceiver Performance Recommendations.

3) TIA-102.CCAA Two-Slot Time Division Multiple Access Transceiver Measurement Methods.

External Links

1) www.project25.org