Data Radio Standard Test Methods

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Abstract

The Data Radio Standard Test Methods document is introduced and explained. The document consists of a number of standardized test methods, written in a clear, step-by-step format. Each test method is designed to be easy to perform, yet yield meaningful results. The rationale and organization of the DRSTM are discussed, including the proposed DRSTM database of measurement data.

Introduction

With the ever-increasing demands of modern packet networks upon the radios being used, there exists no standardized group of test procedures for these radios, or even a list of which radio characteristics are important, and why. If we are to maximize the efficiency of the shared radio networking environment we use, then we must have a better understanding of the significant characteristics of the radios being used. In an effort to resolve this apparent lack of information, VE2BMQ began writing the Data Radio Standard Test Methods in August 1994. In October 1994, the Board of the North East Digital Association endorsed this effort as beneficial to advancing the radio art, and encouraged other organizations to do so as well. In November 1994, the Board of the Radio Amateur Telecommunications Society also endorsed the DRSTM. In this paper, these efforts will be summarized.

Why do we need this?

Recently, a test report of radios advertised as "9600 Baud ready" appeared in QST [May 1995, pp 24-291. The author, Jon Bloom KE3Z, provided a detailed analysis of the bandwidth considerations for proper operation at 9600 baud, also briefly mentioning deviation and its effects. He then provided test results of the Bit Error Rate (BER) for a few radios, a critical yardstick of data radio performance. However, the BER is measured in a continuous data stream, without the normally found pauses between groups of packets. These pauses, which are set by TXDelay (transmit delay) can significantly affect the overall performance of a packet radio link.

As an example, compare two commonly used 70 cm radios: The TEKK T-Net Mini (Model KS-900L) and the ICOM IC-449A. The TEKK has a RX/TX turnaround time of less than 12 milliseconds, while the ICOM has been measured at over 410 milliseconds. At 9600 baud, this translates to a loss of data capacity on the order of 80%. From the table below, we can see that a 2400 baud link with a TXDelay of 40 mS has a higher throughput capacity than a 56 kb link with a TXDelay of 500 mS!

Baud	Byte	Throughput (bps) given a TXDelay of:				
Rate	Time	0mS	40mS	250mS	350mS	500mS
1200	6.67mS	127	121	99	91	81
2400	3.33mS	254	233	163	143	121
4800	1.67mS	506	431	241	199	158
9600	.833	1015	750	316	248	187
56k	.104	8131	2124	435	316	223

[Reprinted from NEDA 1994 Annual, pg.8 1. Assumptions: 230 Byte data per 256 byte transmission, 16 byte acknowledgement, both transmitters have same TXD]

The point is that one parameter that was not even measured in the test has a huge influence upon the performance of a data radio in a real packet network. If such a serious omission can be found in a technically competent journal such as QST, it can be said that most amateurs have an incomplete understanding of the parameters affecting data radio performance.

Organization

The Data Radio Standard Test Methods (DRSTM) is organized much like the published procedures of large standards organizations, such as the ASTM, IEEE or SAE. Each test method first defines the parameter to be measured, then explains its importance to data transmission. A detailed, step-by-step test procedure is then provided, along with set-up diagrams and a standardized form for recording and interpreting the test results. This ensures that all test results, whatever their source, are as reliable as possible. Efforts are taken to use commonly available test equipment wherever possible. This allows as many people as possible to perform the tests. The tests themselves are kept as simple as possible, while still yielding meaningful results, which allows a wide range of radio equipment to be tested. While we believe that many radio users would not actually perform measurements, just knowing how a particular parameter is measured can offer insight to its effects.

In addition, the DRSTM manual contains a detailed Glossary, a thorough explanation of the database structure, and performance requirements for all test equipment.

The scope and significance of each test that has been written so far is summarized below:

DRSTM-01 Transmitter Power-on Time Delay

Scope: This test procedure is intended to measure the time from the start of the transmitter keying (Push-To-Talk or PTT) line becoming active until the RF output has risen to 90% of its final value.

Significance: The time delay that a radio transmitter's power output has when it is keyed can range from microseconds to hundreds of milliseconds. A transmitter that is keyed but not putting out RF power can create a serious 'hidden transmitter' problem. In addition, in the case of a synthesized transmitter, a significant difference between the Transmitter Power-on Time Delay and the Transmitter Power On-frequency Time Delay (see DRSTM-02) would indicate the possibility of serious interference to users on other nearby frequencies.

DRSTM-02 Transmitter Power On-frequency Time Delay, Frequency Stability Time Delay, and Modulation Stability Time Delay

Scope: This test procedure will measure three Data Radio characteristics:
1. Time from PTT becoming active to the RF output appearing within the designated passband of a test receiver.
2. Time delay until the transmitter output frequency has stabilized to within 5% of the channel bandwidth relative to its final stable frequency, or until the PLL loop tone or any other extraneous signal has decayed to less than 10% of the normal system modulation level, whichever is longer.
3. The time delay until the transmitter's modulation envelope has reached 90% of its final stable value.

Significance: The time delay until a transmitter's output frequency appears within its intended channel can range between microseconds and hundreds of milliseconds. Any difference between the Power Output Time Delay (see DRSTM-01) and the Power Output On-frequency Time Delay would indicate the possibility of serious interference to users on nearby frequencies. Any substantial delay in the appearance of the transmitter output signal in the receivers of other users on the same channel can result in a serious 'hidden transmitter' problem.

The additional delay of waiting for the frequency to settle down, or signals that have a significant amount of non-data modulation (such as the damped oscillation of a PLL oscillator feedback loop immediately following lockup) can have a serious effect on decoding the data signal. This could require a much longer TXDelay setting for usable operation.

Similarly, the time delay for the modulation envelope to settle down to its final stable value can also affect proper data recovery at the beginning of a data transmission. This rare condition has been observed in certain radios such as the Motorola MOCOM 35, where a large RC time constant in the reactance modulator retards the modulation envelope by several hundred milliseconds.

DRSTM-03 Transmitter Short-term Frequency Stability

Scope: This test procedure is intended to measure the transmitter and receiver frequency changes that occur when the radio is exposed to extreme temperature and supply voltage conditions.

Significance: Excessive changes of either the transmitter or receiver channel frequency can cause failure or degradation of packet radio links, if the change forces the signal beyond the passband of the received at either end. This information is important to designers of packet network facilities where equipment may be housed in unheated enclosures, as well as builders of emergency response networks that must not fail under extreme conditions.

It must be recognized that the quartz crystal used as the primary channel element or as a reference for a PLL is a major factor in frequency stability. Amateur radio users often use crystals from suppliers that may not follow the manufacturer's specifications. testing radios using such crystals can lead to more appropriate selection of crystals for particular radios.

DRSTM-04 Receiver Detector/Frequency/Squelch Recovery Time Delay

Scope: This test procedure measures:
1. The time between when PTT is released until a signal is received at the detector output
2. The time between when PTT is released until the receiver center frequency is within 5% of its design bandwidth relative to its final stable receive frequency, or until the PLL loop tone or other extraneous signal has decayed to within 10% of the normal demodulated data signal amplitude, whichever is longer
3. The time between when PTT is released until the receiver squelch circuit (and all preceding circuits) begin to pass a demodulated signal.

Significance: A useful data signal cannot be recovered from a received signal until the detector and all RF/IF/LO circuits ahead of it have recovered following a period of transmission.

Radios which take a long time for their frequency to stabilize, or that have considerable 'non-data' signals (such as the damped oscillation of a PLL oscillator feedback loop immediately following lockup) can have a serious effect on decoding the data signal. This could require a much longer TXDelay setting for usable operation.

Radio squelch circuits which take a long time to open following a transmit period would present decoding difficulties when the TNC or modem is connected after the squelch circuit (such as at the speaker jack). This would also require a longer setting for TXDelay.

DRSTM-05 Receiver Squelch Turn-on Time Delay

Scope: This test procedure measures the time between the start of a test signal until the squelch circuit in the radio opens and passes demodulated audio.

Significance: When using a TNC or modem connected after the squelch circuit, the time it takes for the squelch circuit to open and pass audio affects operation. If there is a significant time delay in opening the squelch, the TNC could decide to transmit before it realized the channel was occupied. This would cause a 'hidden transmitter' like problem.

DRSTM-OS Receiver Output Level, Impedance, Demodulated Frequency Slope (De-emphasis) 'and Demodulation 6dB Cutoff Bandwidth.

Scope: This test procedure measures:
1. The voltage level of the demodulated data signal output, per unit modulation level.
2. The impedance at the point where the demodulated audio output signal is connected.
3. The amount of audio output signal variation with frequency (De-emphasis slope) measured where the output is connected, expressed as dB per octave.
4. The audio frequency at which the demodulated signal drops to one-half the voltage on both the higher and lower sides of the normal operating frequency range.

Significance: The level and impedance of the demodulated audio signal from a data radio receiver is useful information when designing data systems and interfacing TNCs and modems. The de-emphasis response of a receiver affects TNC or modem operation. Most TNCs and modems require a flat frequency response while most radios offer some pre- and de-emphasis to improve voice quality. For optimum performance, these responses should be matched. The high side frequency response helps determine the maximum usable bit rate, while the low side frequency response is important with certain direct FM modulation systems (such as the G3RUH modem).

DRSTM-09 Transmitter Modulation Drive Requirements, Input Impedance, Impedance Response Slope, Pre-emphasis Slope, Maximum Deviation and Modulation Frequency Capability.

Scope: This test procedure measures:
1. The voltage level of the modulation signal per unit of transmitter deviation.
2. The input impedance of the modulation circuit.
3. The response characteristics of the modulator input impedance, as it varies with audio frequency.
4. The variation in the deviation when the modulating frequency is changed @e-emphasis).
5. The maximum deviation capability without distortion.
6. The highest modulating frequency which does not reduce the first modulation sideband by more than 20dB.

Significance: The level and impedance of the modulator is useful when designing data systems and interfacing TNCs and modems. The modulator frequency response characteristic should be matched with the receiver response to obtain an overall 'flat' system response. A non-flat system response will distort data signals. The impedance variation of the modulator with frequency can also affect the modulator's frequency response characteristic. The maximum modulation (deviation) capability without distortion is useful when designing data systems and interfacing TNCs and modems. The maximum modulating frequency is useful in determining the maximum capabilities of a higher-speed data link, as well as in avoiding the radiation of wide sidebands produced by computer clock noise, etc. FM transmitters with direct connections to their modulators have been found radiating 10 MHz wide sidebands, caused by leakage of the TNCs 5 MHz CPU clock.

Database

An integral part of the DRSTM concept is a database containing the measurement results obtained by the DRSTM users. Each DRSTM enables the user to make the same measurements, consistently, and provides a form on which to record all measurements. It is well known that radios have differing characteristics for many parameters, even radios of the exact same type and of consecutive serial numbers. It is anticipated that, by providing an international clearinghouse and database of all measurements, that the amateur community would be better served. this may also provide an incentive for radio manufacturers to either publish the data-relevant parameters, or at least design radios with data transmission in mind. While no firm plans have been developed, it is expected that the database would be available on-line in some fashion, with free access for all.

Conclusion

The establishment of standards for various radio characteristics having significance in data transmission will eliminate much of the confusion and misinformation in the area today. These standard test methods, used to measure the performance of data radios, could be used by anyone having reasonable experience with common electronic test equipment. The international database would disseminate this collected data and, as manufacturers noticed that certain radios were unsuitable for data use, convince radio designers to modify their designs to acommodate data transmission. In this manner, the authors hope to improve the radio art.

It is the author's hope that other knowledgeable persons would step forward and offer their expertise in either writing standard methods, suggesting new tests, evaluating existing tests, or performing tests and disseminating their findings. At this time, these standard tests should be considered tentative. If you can help in any way, please contact the authors.