



## Tech Notes

### **BER vs. Eb/No Performance**

The [M5 Waterfall Graphs](#) and newer [M500 Waterfall Graphs](#) linked show the performance of our M5 series and new M500 Series Modems in the form of Bit Error Rate (BER) vs. Eb/No over a range of common Eb/No values. All of our modems perform within 0.3 dB of theoretical, and are typically between 0.1 and 0.2 dB of theoretical performance. The graphs show actual measured typical performance data.

The M500 series currently in production uses more sophisticated Viterbi and Reed-Solomon processes which are now embodied in FPGAs. The optimization possible over the older fixed ICs allows a typical 0.1 to 0.4 dB improvement in performance. The M500 series graphs currently show only TPC performance in the 10 "CT" modes of operation.

When viewing the graphs note the tabs at the bottom of the screen. These tabs are used to change which performance curves or data are viewed. The tabs will perform differently in a Netscape or Opera browser and may not highlight as they do in the MSIE browser.

### ***M500 Turbo Product Codes FEC Highlites:***

These newly added graphs currently show the performance for the new Turbo Product Codes CT mode FEC available in the M500 series of modems. This FEC is available in 3 variations. First with the same 4k block IC used in the M5 series, second with the newer 16k block device only for the M500 series and a third version that contains both chips. The CT mode is used for compatibility with other manufacturer's modems and per convention the CT mode operates with a 4k processing block in all modes except Rate 7/8. CT Rate 7/8 only operates in the 16k block device mode. The 16k block device is capable of operating at higher data rates than the 4k block IC in all modes. TPC offers excellent performance compared to the common Viterbi and Reed-Solomon FECs available. Several notable points to be garnered from these performance curves are:

TPC-CT Rate 7/8 which operates in 16k block mode shows a much steeper performance curve and better performance which extends to higher BERs than the 4k modes.

TPC-CT offers a Rate 0.95 which gives very low occupied bandwidth if your system can tolerate the higher required Eb/No (representing more power required). In 8PSK and 16QAM modes which are more susceptible to phase noise than QPSK, and in 16QAM which is susceptible to amplifier non-linearity that may present a problem however.

The data page also shows the relative bandwidth for each TPC-CT and modulation mode expressed as bps/Hz.

### ***M5 Turbo Product Codes FEC Highlites:***

These graphs have recently been expanded to include the new Turbo Product Codes FEC performance Data. The TPC has excellent performance comparable to other FECs available. Several notable points to be garnered from these performance curves are:

TPC Rate 1/2 has performance approximately 3 dB better than normal Viterbi Rate 1/2. TPC Rate 7/8 will perform better than Viterbi Rate 1/2, but uses approximately 57% of the bandwidth.

TPC Rate 3/4 has performance approximately equal to a concatenated Viterbi Rate 1/2 plus Reed-Solomon Codec, but uses approximately 60% of the bandwidth. In addition the bit delay for the TPC link would be 44 ms at 64 kbps, while the Reed-Solomon/Viterbi coding would result in a 75 ms end to end delay. (Some other manufacturers spec over 200 ms of delay in the same case).

Datum Systems' selectable "Short Block TPC" uses a smaller block size optimized for low latency. The Short Block delay in the above example of Rate 3/4, 64 kbps is approximately 14.8 ms.

Datum Systems' implementation of TPC outperforms other manufacturers performance by 0.3 to 2 dB depending on the Rate settings.

TPC can provide better performance than 8PSK with Trellis Code Modulation and concatenated Reed-Solomon as per IESS-310. For example TPC in QPSK mode at Rate 7/8 uses less than 5% more bandwidth but 1.2 dB less power at a BER of 1 part in  $10^{-7}$ . QPSK is also much less sensitive to phase noise and can operate successfully at lower data rates than 8PSK.

### ***Measurement Notes:***

Viterbi measurements are all made with differential encoding enabled and the standard V.35 scrambler.

Viterbi concatenated with Reed-Solomon coding measurements are all made with differential encoding enabled and the Reed-Solomon specific IESS-308 synchronous scrambler. Reed-Solomon is based on IESS-308 standard settings of  $n=126$ ,  $k=112$ , depth of 4.

TPC measurements are all made with the Turbo specific synchronous scrambler and no differential encoding.

The raw data used to produce these graphs is shown in the table on the last tab of the charts. Note that this chart and data are measured in accordance with the IESS 308/309 standard methods.