DATUM SYSTEMS

Appendix TPC

M500 Turbo Product Codes FEC Addendum

1.0 Optional Turbo Product Codes FEC Overview

The installation of the optional Turbo Product Codes FEC Card provides the M500 Class modems (PSM-500/500H/500L and variants) with a greater level of functional capability. This optional FEC card is designed to fit into one of the two FEC card slots on the main modem assembly. In order to conserve the available slots in the M500 modem the card also contains the capability of running the Viterbi and Reed-Solomon FECs, and therefore only one card is required for all standard and TPC functions. Turbo Product Codes offers very high coding gain and performance as compared to Viterbi either alone or concatenated with Reed-Solomon.

The TPC FEC decoder is built using industry standard FEC ASIC "chips". There are two chips in common usage: the first is a relatively low speed, 5 Mbps version which is capable of all standard TPC functions except a standard rate 7/8 in a 16k byte processing block. This is the same chip as used in the PSM-4900 series of modems. The second chip is a newer but more expensive chip that contains a 16k byte processing block and is capable of operating to the full speed of the modem's processing, which is approximately 29.52 Mbps. This newer 16k chip is also capable of operating in the 4k block modes for compatibility with the 4k chip except for two PSM-4900 compatible modes at rate ¾ and 7/8. These operating mode exceptions are a limitation in the chips themselves and not in the Datum Systems' implementation. For this reason we offer multiple variations of the TPC FEC option card.

The M500 TPC is available in 3 variations listed here and shown in Table 1:

- TPC-4k – Base Viterbi, R-S card with added TPC-4k chip capable of operating to approximately 5 Mbps depending on modulation, code rate and interface.
- TPC-16k – Base Viterbi, R-S card with added TPC-16k chip capable of operating to approximately 20+ Mbps depending on modulation, code rate and interface.
- TPC-20k – Base Viterbi, R-S card with both TPC-4k and 16k chips added, capable of operating in all available TPC modes to approximately 20+ Mbps depending on modulation, code rate and interface.

Table 1 - TPC FEC Card Variations

FEC Module	Part Number	Vit	R-S	TPC-4k	TPC-16k	Max Data Rate
Viterbi/R-S	DRA05-002-01	**X**	**X**			29.52 Mbps
TPC-4k	DRA05-002-02	**X**	**X**	**X**		5 Mbps
TPC-16k	DRA05-002-03	**X**	**X**		**X**	29.52 Mbps
TPC-20k	DRA05-002-04	**X**	**X**	**X**	**X**	29.52 Mbps

The Turbo Product Codes FEC is described in more detail in the following sections. The abbreviation "TPC" is used interchangeably with "Turbo Product Codes FEC" throughout the rest of this document. There are 2 versions of the M500 Turbo Product Codes option available, the TPC4k and TPC16k referring to the maximum block size as described below.

- "***TPC***" This is the short form or abbreviation for Turbo Product Codes. *(Note: There is also a Turbo Convolutional Code FEC which is not block oriented, but generally not currently suitable for satellite communications.)*
- "***TPC4k***" This is the short form or abbreviation for a Turbo Product Codes using a decoder with a maximum 4,000 byte processing block. This TPC option is compatible with the TPC used in the previous PSM-4900 (M5) modem series. It is limited to a maximum data rate of approximately 5 Mbps.

- "***TPC16k***" This is the short form or abbreviation for a Turbo Product Codes using a decoder with a maximum 16,000 byte processing block. This TPC option is backward compatible with the TPC used in the previous PSM-4900 modem series. It is also capable of higher performance because of its larger processing block size. The larger block size also presents longer latency, or processing time. It is capable of a maximum data rate of approximately 20+ Mbps.

For the purposes of the remainder of this appendix the conventions for naming the different rates of data entering and leaving the modem are:

- "***Aggregate***" data rate. The data rate that the modem transmit and receive is operating at. This rate is always the same as or higher than the terrestrial data rate and is the rate that includes the terrestrial rate plus the multiplexer overhead plus the FEC overhead.
- "***Terrestrial***" data rate. The data rate presented on the main modem rear panel data interface connector for connection to the DTE line side.
- "***ES to ES***" or "**ESC**" data rate. The overhead channel rate presented as a service or overhead channel on the modem rear panel connector J4.

Bit time delays introduced by the two variations of Turbo Product Codes FEC functions are given in the Unit Specifications, Appendix A.

The Term "M5" refers to the PSM-4900, 4900H, 4900L and its variants, while the Term "M500" refers to the PSM-500, 500H, 500L and its variants. The Turbo Product Codes FEC described here is only unique to and only for use with M500 series of satellite modems.

1.1 Overview - Quick Start Guide

The main point to insure in setting up the Turbo Product Codes FEC is that the two ends of the link must be set up in a complementary fashion. That is, whatever parameters on set on the transmit at one end of the link must also be set the same for the receive on the other end.

- If the option card is not already installed see the "Installation" section at the end of this Appendix. The TPC option requires software version 0.20 or greater. Go to the Datum Systems web site or Contact Datum Systems If your modem requires a firmware upgrade.
- The Turbo Product Codes FEC can be individually selected in each direction (transmit and receive) via the **<Mod:Data - FEC>** settings for the transmit direction and the **<Dem:Data - FEC>** settings for the receive direction. Then the Code Rate is set in the **<Mod:Data – Code Rate>** settings for the transmit direction and the **<Dem:Data – Code Rate>** The same settings must be used on both ends of the link in each direction, but the two directions may be different, one perhaps not even using TPC.
- Choose a mode of operation suitable for the service desired. In most cases where M5 series modem compatibility is required the TPC "Full" mode provides basic full capabilities taking advantage of the special features built into the modem. When communicating with another M500 series or some Comtech modems using the same chips, then the "CT" modes offer the most compatibility plus operation at 8PSK and 16QAM modulation modes.
- See the Turbo Product Codes FEC Descriptions in Sections 2.1 of this Appendix for more information on refining the settings to optimize them for a particular application.
- The Turbo Product Codes FEC can be used in conjunction with the IBS Multiplexer, but the Reed-Solomon option cannot be enabled with TPC as it could actually decrease performance. The Reed-Solomon is disabled automatically when the TPC is enabled. The IBS Multiplexer options such as AUPC and overhead channels are all still available when used in conjunction with the Turbo Product Codes FEC.

1.1.1 Overview - Modes of Operation

Turbo Product Codes FEC

The TPC option provides the following modes of operation. Note that the Viterbi and Reed-Solomon operating modes are also shown because the TPC cards also provide Viterbi/TCM.

Table 2 - PSM-500 Series FEC Option Table

FEC Type	Sel #	FEC Type Option	Sel #	Code Rates Available	Sel #	R-S Option	Modulation Modes (see notes)						
							BPSK	QPSK	OQPSK	8PSK	8QAM	16QAM	16APSK
None	0	N/A	0	N/A	0		●	●	●				
Viterbi	1	Normal	0	1/2	0	●	●	●	●			●	·
				3/4	1	●	●	●	●			●	
				5/6	2	●	●	●	●			●	
				7/8	3	●	●	●	●			●	
		Swap C0/C1	1	1/2	0	●	●	●	●			●	
				3/4	1	●	●	●	●			●	
				5/6	2	●	●	●	●			●	
				7/8	3	●	●	●	●			●	
		CT	2	3/4	1	●◆	·	·	·			●	
				7/8	2	●◆	·	·	·			●	
TCM	2		0	2/3	0	●				●			
TPC	4	Advanced	0	0.453-16k	0		●	●	●	·	·	●	
				1/2-16k	1		●	●	●	·	·	●	
				1/2-4k	2		●	●	●	·	·	●	
				3/4-16k	3		●	●	●	●	·	●	
				3/4-4k	4		●	●	●	●	·	●	
				7/8-16k	5		●	●	●	●	·	●	
				7/8-4k	6		●	●	●	●	·	●	
				0.922-16k	7		●	●	●	●	·	●	
				0.950-4k	8		●	●	●	●	·	●	
		M5 Full	1	1/2	0		●	●					
		*TPC4k Only		3/4	1		●	●					
				7/8	2		●	●					
		M5 Short	2				·	·					
				3/4	1		●	●					
		*TPC4k Only		7/8	2		●	●					
		M5 Legacy	3										
				3/4	1		●	●					
				7/8	2		●	●					
		CT	4	5/16	0		●						
				21/44	1		●	●	●				
				3/4	2		●	●	●	●	●	●	
		*TPC16k only		7/8	3		●	●	●	●	●	●	
				0.95	4		●	●	●	●	●	●	

Notes:

1. 8QAM and 16APSK modes to be determined.
2. The TPC M5 Full, Short and Legacy modes are intended for PSM-4900 Compatibility.
3. Not yet shown are S-Tec or other FECs in development.
4. TPC 4k/16k restrictions apply to that line and Code Rate only.
5. TPC4k Max data rate limits see below.
6. TPC16k operates up to 20+ Mbps depending on Feature Set and modulation.
7. The Viterbi, Rate 3/4 & 7/8, 16QAM CT mode only for Comtech modem compatibility as they only operate in this mode with R-S at 220, 200, depth of 4. R-S is auto-enabled.
8. TPC CT Rate 7/8 is currently the only mode that utilizes the full 16k block processing in the TPC16k chip. All others utilize the 4k block size.

TPC4k M5 Mode Limits: Rate 1/2 = 2.46 Mbps, Rate 3/4 or 7/8 = 4.92 Mbps.
TPC4k CT Mode Limits: Rate 5/16 = 2.048 Mbps, Rate 21/44 = 3.2 Mbps, Rate 3/4 = 5 Mbps, Rate 0.95 = 6.6 Mbps.

1.2 TPC Framing Overview

Framing of data is required for the Turbo Product Codes FEC functions of this card and FEC type. That is because TPC functions are “block” oriented and synchronization to particular locations in the bit stream are necessary. Generally the TPC processor operates on a complete block of data at a time.

The TPC codecs are capable of multiple block sizes, and three block sizes are used in the current implementation, depending on the chip used. The standard block size is approximately 4k bytes intended to optimize the TPC performance and provide compatibility with the M5 series of Datum Systms modems plus many competitive modems. The alternate Datum Proprietary “Short” block is intended for special applications that require minimal bit delay or latency. The latency of the short block is approximately 1/3 of that for the standard block. The FEC decoder in the receive channel is normally the largest bit delay in the end-to-end link.

The TPC16k chip can use either of these two block sizes and in addition has a larger block size of approximately 16k bytes. By convention this larger block is only used for the CT mode rate 7/8. The Datum Systems’ proprietary “Advanced” mode offers both 4k and 16k block sizes for most code rates, allowing the maximum flexibility with either chip. The 16k chip is capable of using either block size in Advanced mode and selecting the larger block size will improve performance at the expense of latency.

Additionally note that the TPC16k chip is not capable of operating in the M5 Full mode at rate 3/4 or the M5 Short mode at rate 7/8. These are limitations in the chip itself.

1.3 TPC Inter-Operability and Compatibility

Although the Intelsat IESS-315 describes the use of TPC in satellite links it does not specify many of the actual parameters used for a particular manufacturer or service. The result is that very few different modem manufacturers use the same set of parameters in configuring the TPC operation. Of primary importance to Datum Systems is insuring optimal performance in links, then compatibility and interoperability with its own modems, and last compatibility with other manufacturers modems. The TPC modes named “M5” are only known to be compatible with other M5 or M500 series of Datum Systems’ modems. The “CT” or Competative Technology modes are specifically designed to be compatible with at least the Comtech CDM570 and CDM600 modems. The TPC Advanced modes are proprietary optimizations by Datum Systems and are only known to be compatible with other PSM-500 series modems.

2.0 Turbo Product Codes FEC Description and Operation

The addition of a Turbo Product Codes FEC places a new Forward Error Correction (FEC) process replacing (in parallel with) the existing Viterbi FEC. The two FECs are considered alternate, and only one or the other can be selected at any one time. The two directions of a link are indepent however and the FEC used in each direction may be different. Of course the transmit encoder and receive decoder in any one direction must match exactly.

The performance improvement achieved by the Turbo Product Codes FEC is significant, even as compared to concatenated Reed-Solomon plus Viterbi FEC. For example, the BER vs. Eb/No performance of concatenated Viterbi rate 3/4 coding with R-S is better than Viterbi rate 1/2 alone, and it uses less bandwidth than the Viterbi rate 1/2 alone.

Like Reed-Solomon, Turbo Product Codes uses “block” framing which allows the use of a synchronous scrambler and descrambler resulting in slightly improved performance relative to the self-Synchronized scrambler normally used. See the scrambler use in Section 2.2 of this Appendix

A simplified block diagram of the modem baseband processinga and where the TPC Codec is applied is shown in Figure 1 below.

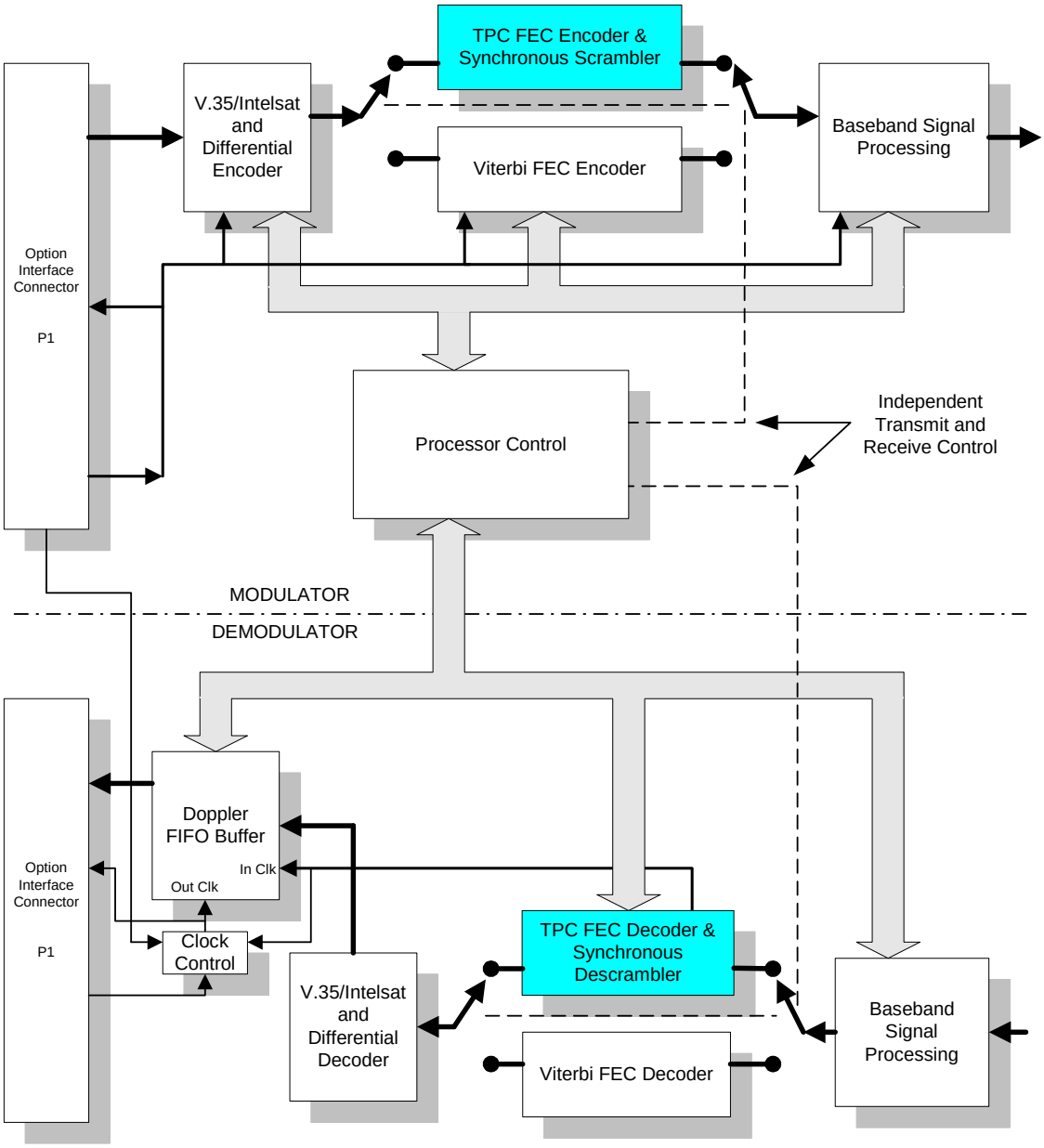


Figure 1 - M500 Modem TPC Diagram

The Turbo Product Codes FEC function can be turned on and off under software control from either the front panel or remote control.

2.1 Controlling the Optional Turbo Product Codes FEC Functions

The PSM-500 Modems automatically recognize the presence of the optional capabilities when this option card is installed. Any of the Turbo Product Codes FEC properties can be programmed from the front panel or remote control interface. Like other properties of these modems the latest configuration of the TPC are saved in non-volatile memory and re-instated on power up.

The TPC FEC function is designed to replace or serve as an alternate to the modem's built-in Viterbi/convolutional Codec. The TPC option actually allows one of several alternate TPC

functions to be used; the TPC4k can operate in standard “Full” and a low latency “Short” version. the TPC16k can operate in standard “Extended” (16k block size) standard “Full” (4k block size) and a low latency “Short” (~2k block size) version. The CT mode only uses the larger 16k block size for improved performance in the rate 7/8 case, but provides the higher data rate capability in all modes.

The same FEC Code Rate parameters options of Rate ½, ¾ and 7/8 apply to any of these codecs just as with the standard Viterbi Codec. Rate ½ is not available with the “Short” block version of TPC. The occupied bandwidth of the RF signal is identical between a Viterbi and TPC Codec at the same FEC “Rate”.

The “CT” compatibility mode of the TPC provides specific compatibility with some Comtech modems equipped with TPC. Currently these include the CDM550T, CDM570 and the CDM600. We cannot guarantee absolute compatiblility with other manufacturers modems since their operating modes may change at any time.

> *NOTE:*
> *The user does not have to compute aggregate data rates for operation with the TPC options. The terrestrial data rate is maintained when features that require adjusting the aggregate rate are added or deleted. The modem internal software automatically computes the proper aggregate rate and sets the modem accordingly.*
>
> *NOTE:*
> *The data rate entry at the front panel or remote control is the “Terrestrial” or user data rate that the physical interface operates at, not the modem’s aggregate rate.*

The TPC function has the same restrictions on maximum data rate as the standard Viterbi Codec does at each FEC Code Rate. Attempts to program the data rate higher than possible at each FEC Code Rate results in the modem sounding a warning beep and setting the data rate to the maximum possible.

Selecting FEC operating modes is slightly more complex in the PSM-500 series of modems than previous versions due to the large number of FECs supported. The 500 series uses 3 parameters to determine the FEC operation: Type, Option and Code Rate, each represented by an integer selection value as shown in Table 2 above. The PSM-500 modem leads the user through selecting all of the parameters necessary when changing the FEC type to insure that a valid mode is selected.

2.1.1 Scrambler Selection

The M500 modems have a new preferred scrambler setting of “Auto”. This selection provides the optimal scrambler setting for all FEC modes for the modulator and demodulator. These modes automatically select the proper scrambler to use typically resulting in standard Intelsat IESS 308 or 309 modes. There is no IESS Standard covering the new Turbo Product Codes FEC, and this auto mode follows specific guidelines to insure compatibility.

Remember that the scrambler and descrambler may be set independently in each link direction.

The synchronous TPC scrambler is synchronized to the processed block itself. No lock time or bit latency penalty is incurred by use of the synchronous scrambler, but a performance gain of approximately 0.2 dB is realized relative to the self-synchronizing “V.35/Intelsat” scrambler.

IESS-308 Scrambler Mode Operation

- With no mux or RS then the self-synchronizing Intelsat scrambler is enabled.
- With just the IBS Mux enabled then the IBS synchronous scrambler is used
- With just the R-S enabled then the R-S synchronous scrambler is used

- With both IBS Mux and R-S enabled then the IBS synchronous scrambler is used.

IESS-309 Scrambler Mode Operation
The operation is the same as the IESS-308 option with the exception that

- With just R-S enabled then the self-synchronizing Intelsat scrambler is used.

Fixed Scrambler Mode Operation
The V.35 and Intelsat scrambler modes use the V.35 and Intelsat self-synchronizing scramblers respectively in all modes.

Alternate Scrambler Mode Operation
The alternate V.35 and alternate Intelsat scrambler mode performs a data inversion required by some “Comstream” modems.

2.2 Turbo Product Codes FEC Performance

Turbo Product Codes performance is one of the best possible of currently available FECs. TPC offers a significant performance improvement over even concatenated Reed-Solomon FEC performance.

Turbo Product Codes FEC Highlights:

- 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 Code 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.
- The new M500 “CT” modes not only provide compatibility with common Comtech modems, but extend TPC operation into the new M500 series 8PSK and 16QAM modulation modes.
- The best TPC performance is achieved at the CT mode rate 7/8 using the TPC16k chip. This is because that is the only current mode that uses the full 16k block size of this chip set. The delay or latency when using this mode is however significantly increased.

The data and graphs below shows the typical performance of a Turbo Product Codes equipped M5 class modem as compared to the typical performance of the standard Viterbi FEC.

2.2.1 TPC M5 Compatible Modes

The Table below shows TPC performance in modes compatible with the M5 series of modems for BPSK and QPSK operation. All shown modes are available up to 5 Mbps using the TPC-4k variation FEC card. Viterbi Performance is shown for comparison purposes.

The Eb/No values shown are those referenced to the customer data rate at the decoder output. Performance would appear improved if measured relative to the decoder input (i.e. at the satellite data rate). All values shown are using the synchronous TPC scrambler.

TPC M5 Compatible Modes

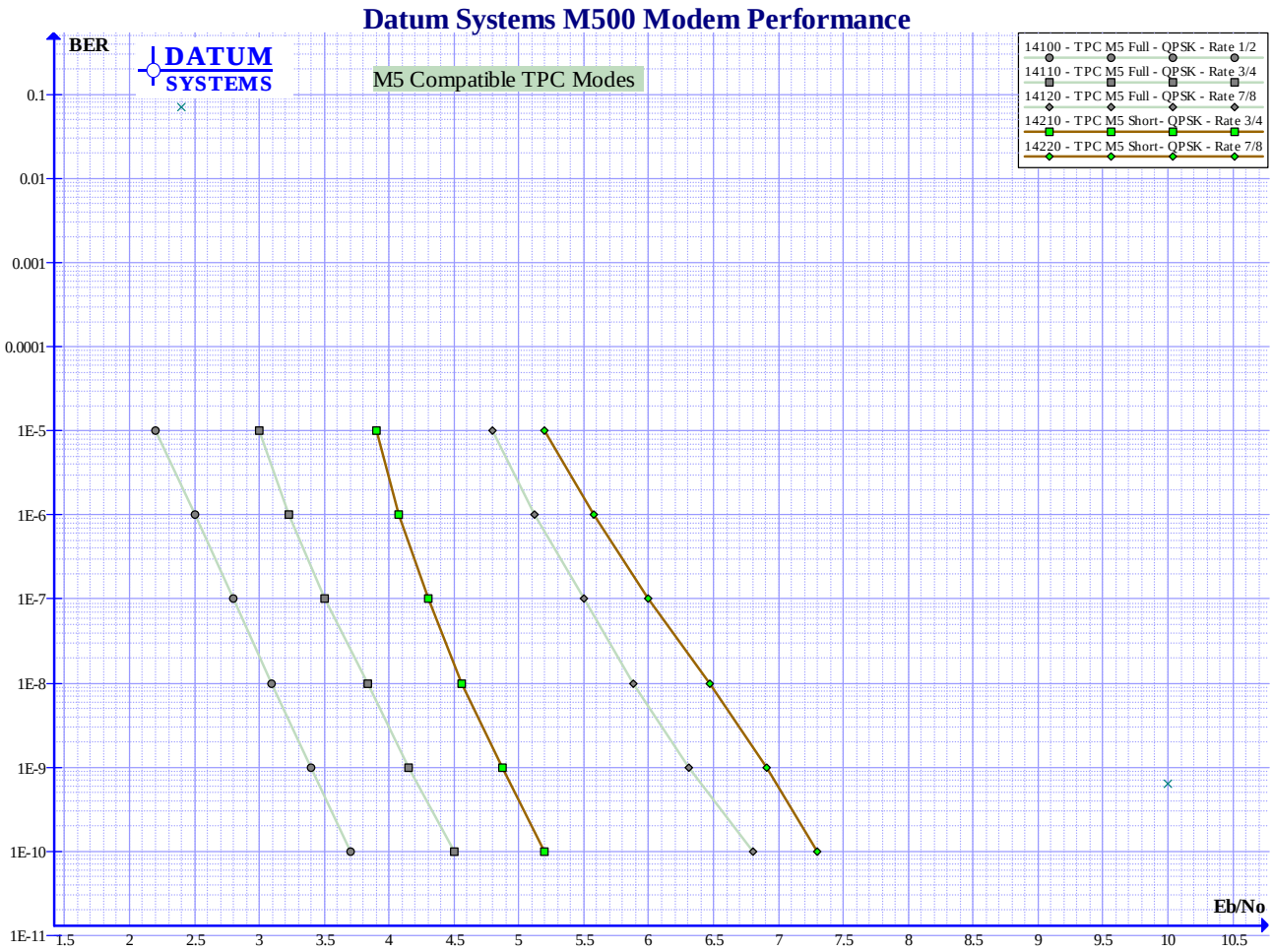
Turbo Product Codes FEC M5 Full Mode Typical Performance Data			
	Rate ½	Rate ¾	Rate 7/8
MTOCR	14100	14110	14120
BER	Eb/No	Eb/No	Eb/No
10^{-4}			
10^{-5}	2.20	3.00	4.80
10^{-6}	2.50	3.23	5.12
10^{-7}	2.80	3.50	5.50
10^{-8}	3.09	3.84	5.88
10^{-9}	3.40	4.15	6.31
10^{-10}	3.70	4.50	6.80

Turbo Product Codes FEC M5 Short Block Mode Typical Performance Data			
	Rate ½	Rate ¾	Rate 7/8
MTOCR	14200	14210	14220
BER	Eb/No	Eb/No	Eb/No
10^{-4}			
10^{-5}		3.90	5.20
10^{-6}		4.07	5.58
10^{-7}		4.30	6.00
10^{-8}		4.56	6.47
10^{-9}		4.87	6.91
10^{-10}		5.20	7.30

Turbo Product Codes FEC M5 Legacy Mode Typical Performance Data			
	Rate ½	Rate ¾	Rate 7/8
MTOCR	14300	14310	14320
BER	Eb/No	Eb/No	Eb/No
10^{-4}			
10^{-5}		3.2 dB	4.6 dB
10^{-6}		3.3 dB	4.7 dB
10^{-7}		3.5 dB	4.8 dB
10^{-8}		3.6 dB	5.0 dB
10^{-9}		3.7 dB	5.3 dB
10^{-10}		3.9 dB	5.5 dB

TPC M5 Compatible Modes Waterfall Curves

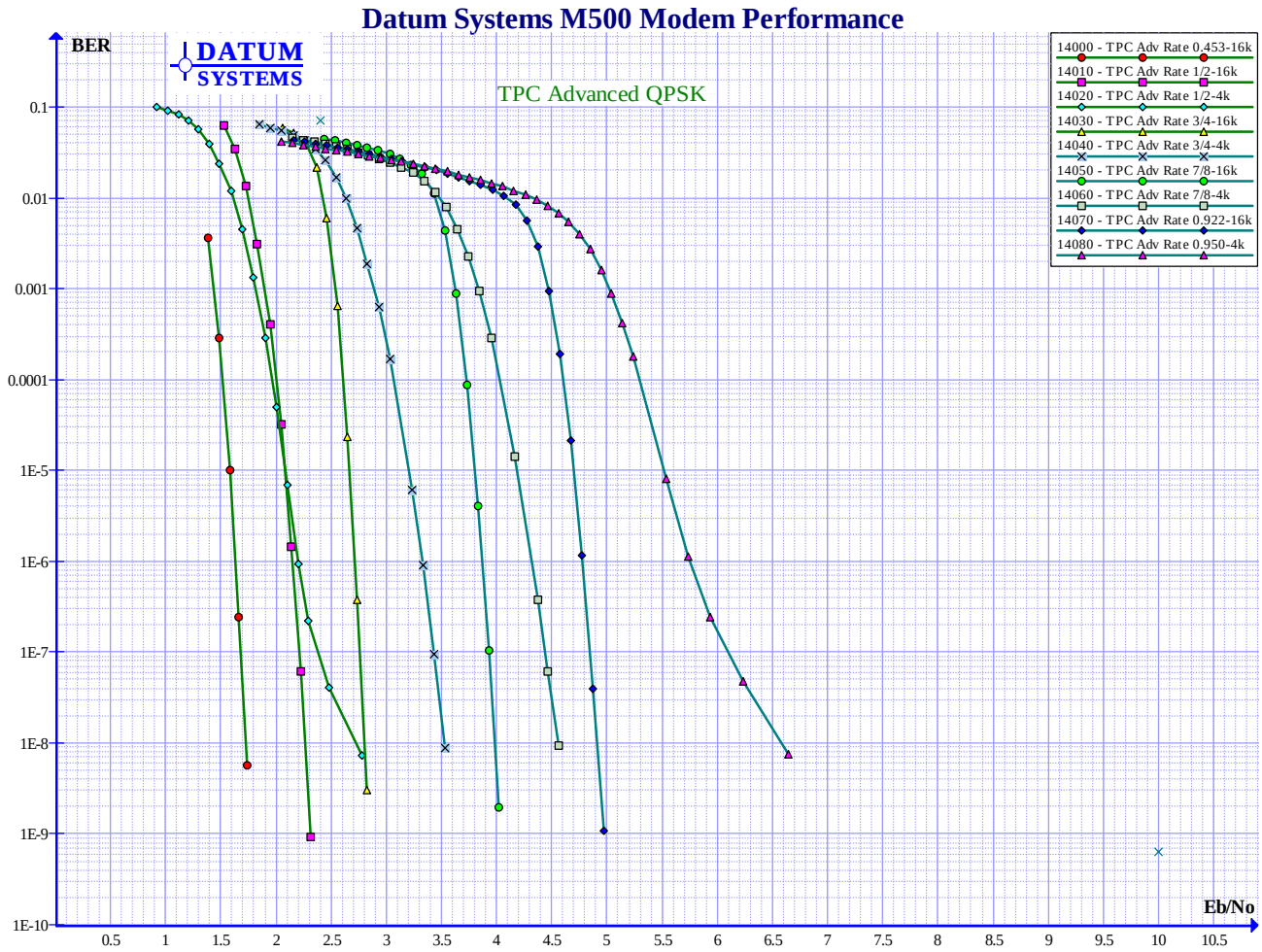
Note: M5 Legacy mode not shown



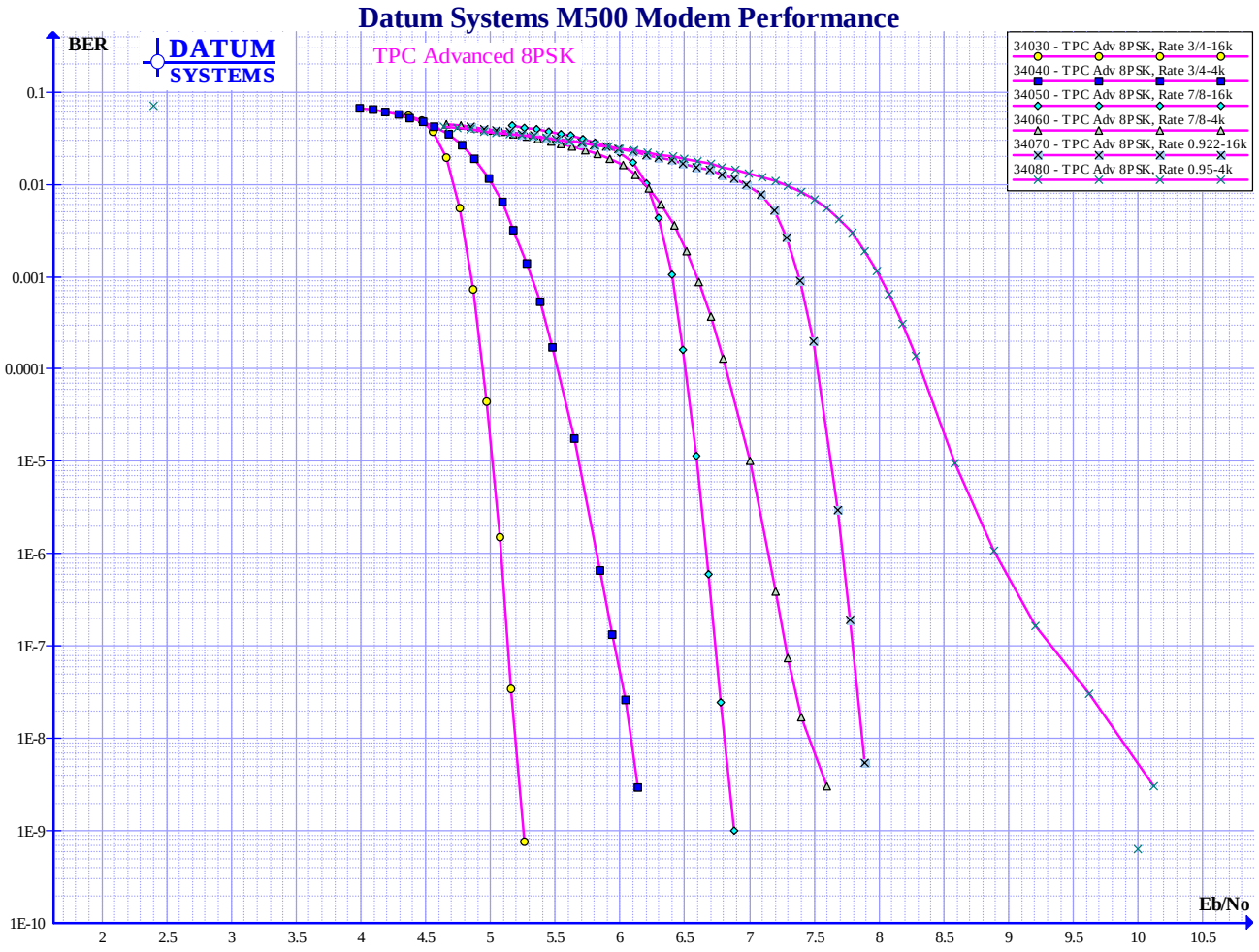
2.2.2 TPC CT Compatible Modes

The TPC Advanced FEC option is a new TPC implementation proprietary to Datum Systems. These specific modes were optimized for optimized performance covering a broad range of system needs. They will typically outperform any TPC modes by any modem manufacturer.

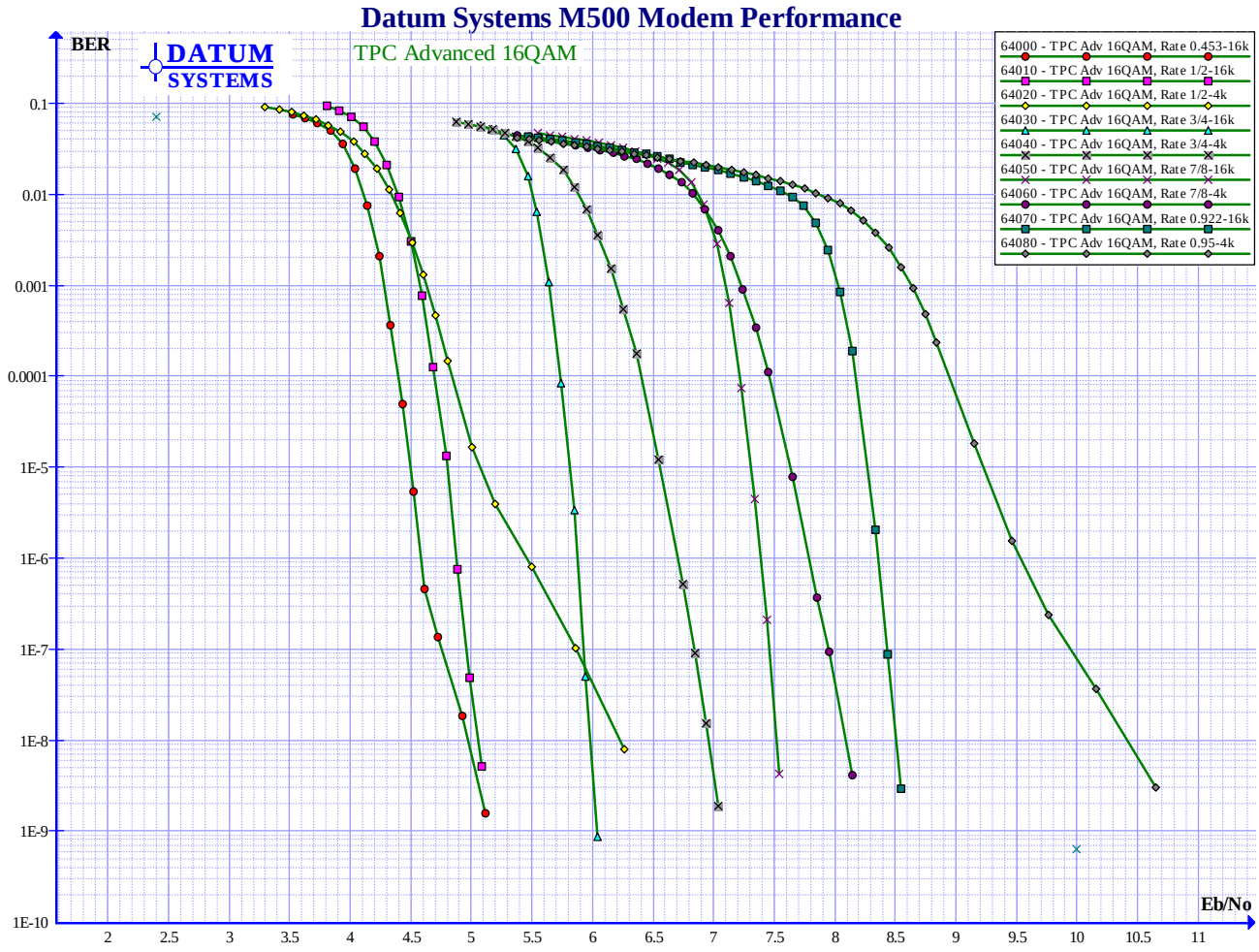
TPC Advanced FEC Performance for BPSK, QPSK and OQPSK Required Eb/No in dB									
Rate -->	**0.453-16k**	**1/2-16k**	**1/2-4k**	**3/4-16k**	**3/4-4k**	**7/8-16k**	**7/8-4k**	**0.922-16k**	**0.95-4k**
BER	**14000**	**14010**	**14020**	**14030**	**14040**	**14050**	**14060**	**14070**	**14080**
1.00E-03	1.44	1.90	1.82	2.54	2.89	3.62	3.83	4.47	5.02
1.00E-04	1.51	2.01	1.97	2.61	3.06	3.72	4.02	4.60	5.30
1.00E-05	1.58	2.08	2.09	2.67	3.20	3.80	4.18	4.70	5.52
1.00E-06	1.63	2.15	2.20	2.72	3.32	3.87	4.31	4.77	5.75
1.00E-07	1.68	2.22	2.38	2.76	3.43	3.93	4.44	4.84	6.10
1.00E-08	1.73	2.27	2.72	2.81	3.52	3.98	4.56	4.91	6.59
1.00E-09	1.78	2.32	3.12	2.85	3.62	4.04	4.68	4.97	7.10



TPC Advanced FEC Performance for 8PSK Required Eb/No in dB						
Rate -->	3/4-16k	3/4-4k	7/8-16k	7/8-4k	0.922-16k	0.95-4k
BER	34030	34040	34050	34060	34070	34080
1.00E-03	4.85	5.31	6.40	6.59	7.38	8.00
1.00E-04	4.94	5.52	6.51	6.82	7.52	8.32
1.00E-05	5.01	5.68	6.59	7.00	7.63	8.58
1.00E-06	5.08	5.82	6.66	7.14	7.72	8.90
1.00E-07	5.13	5.96	6.74	7.28	7.80	9.33
1.00E-08	5.19	6.08	6.81	7.46	7.87	9.86
1.00E-09	5.25	6.19	6.88	7.73	7.94	10.36



TPC Advanced FEC Performance for 16QAM Required Eb/No in dB									
Rate -->	0.453-16k	1/2-16k	1/2-4k	3/4-16k	3/4-4k	7/8-16k	7/8-4k	0.922-16k	0.95-4k
BER	64000	64010	64020	64030	64040	64050	64060	64070	64080
1.00E-03	4.28	4.57	4.63	5.64	6.19	7.10	7.23	8.02	8.63
1.00E-04	4.40	4.69	4.84	5.73	6.40	7.22	7.46	8.17	8.94
1.00E-05	4.49	4.80	5.08	5.81	6.56	7.31	7.63	8.27	9.23
1.00E-06	4.58	4.88	5.46	5.88	6.71	7.39	7.78	8.36	9.53
1.00E-07	4.75	4.96	5.86	5.93	6.84	7.46	7.95	8.44	9.94
1.00E-08	4.98	5.06	6.22	5.98	6.96	7.52	8.09	8.51	10.41
1.00E-09	5.15	5.16	6.59	6.04	7.07	7.58	8.23	8.59	10.86

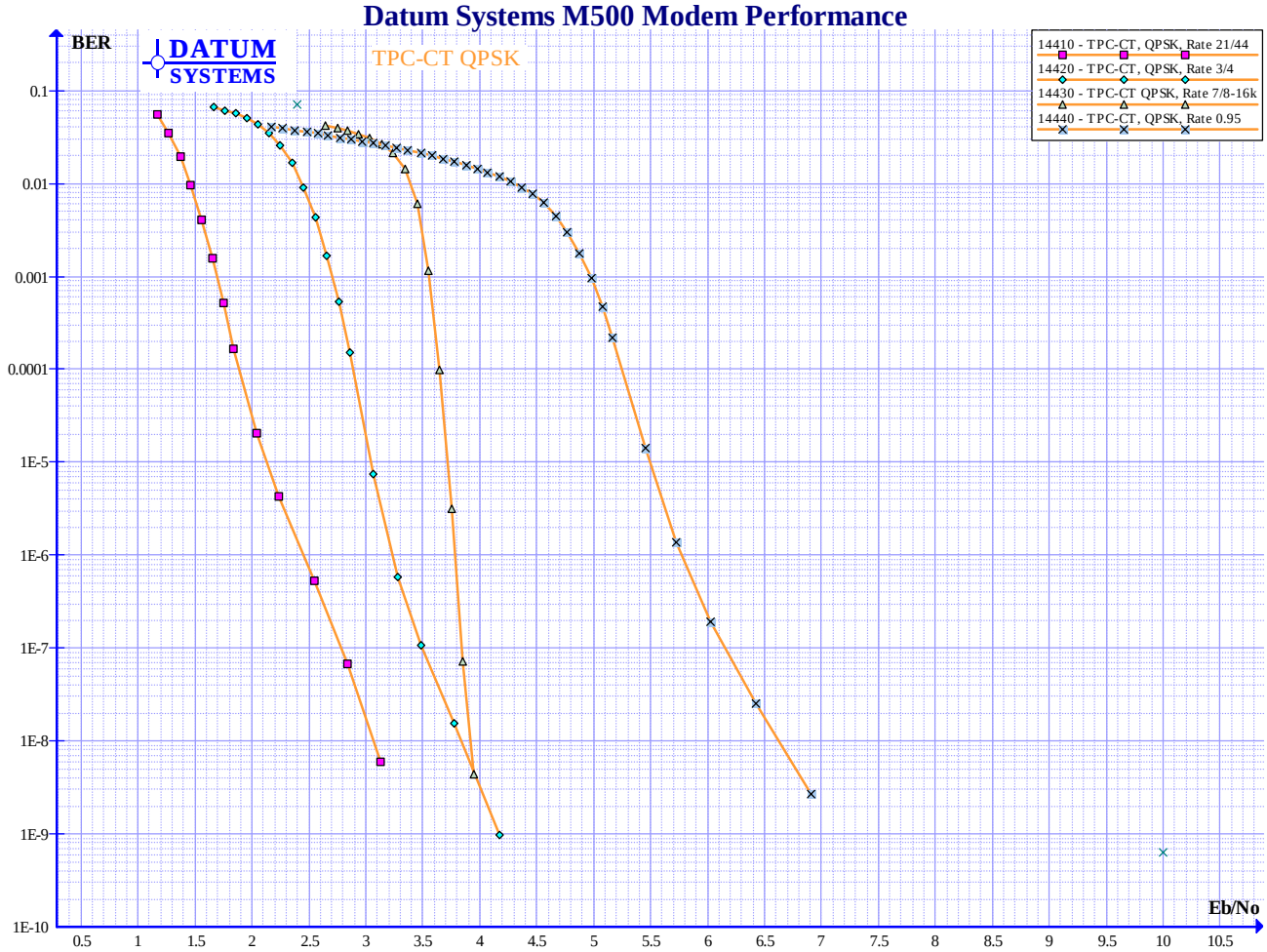


2.2.3 TPC CT Compatible Modes

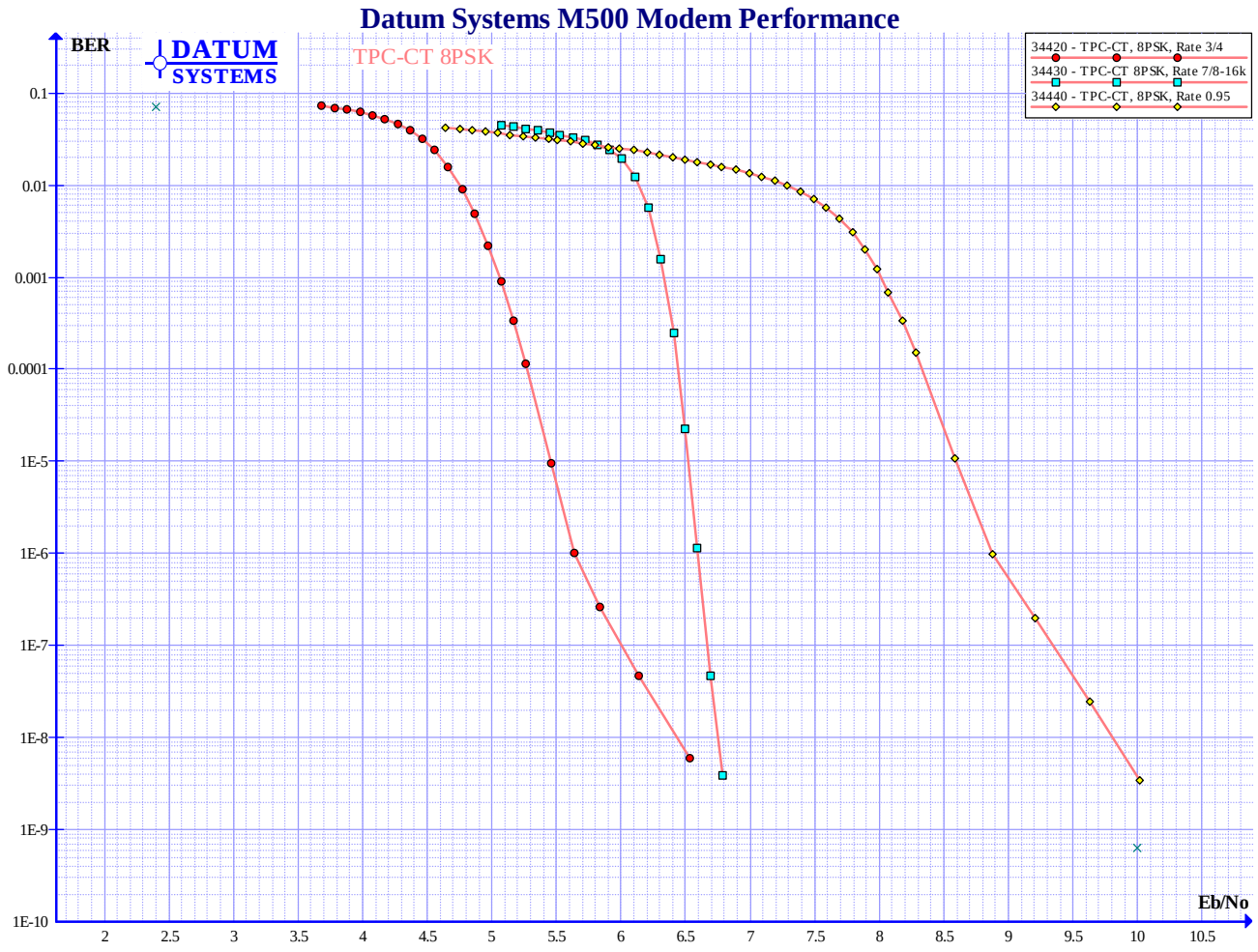
The “CT” compatible modes are specifically intended to provide maximum compatiblitlity with competing satellite modems such as the Comtech CDM5xx and 600 series.

You will notice in each of these data sets that the performance at Rate 7/8 is improved over the other rates. That is because by convention Rate 7/8 is only available and uses the 16k block mode, providing better performance. All other rates use the 4k block mode only, but if set with the TPC16k chip version of the FEC card will be capable of up to the full 20 Mbps rate of the modem.

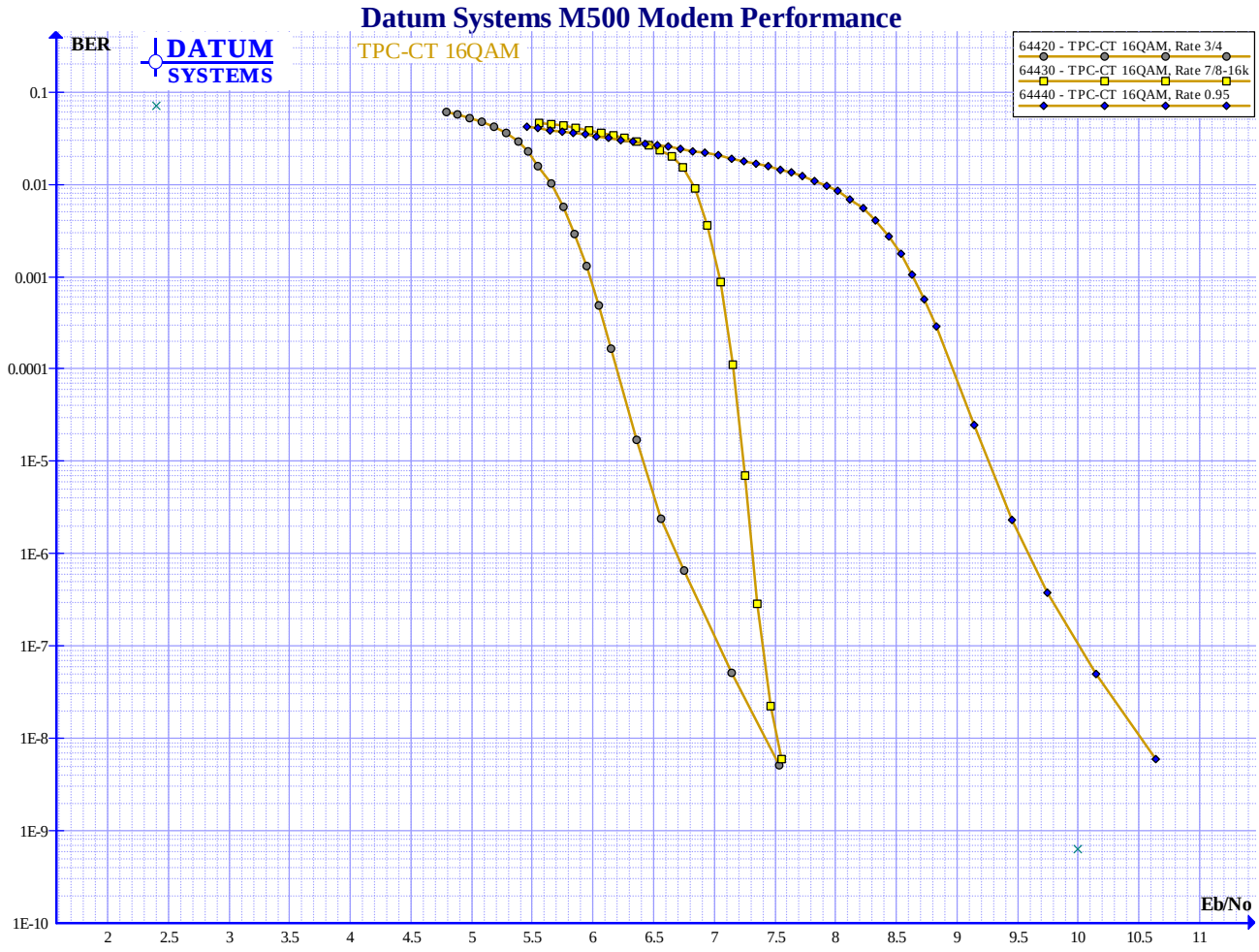
TPC CT FEC Performance for BPSK, QPSK and OQPSK Required Eb/No in dB					
Rate -->	**5/16**	**21/44**	**3/4**	**7/8**	**0.95**
BER	**14400**	**14410**	**14420**	**14430**	**14440**
1.00E-03		1.69	2.70	3.56	4.97
1.00E-04		1.89	2.89	3.65	5.25
1.00E-05		2.13	3.05	3.72	5.50
1.00E-06		2.45	3.24	3.78	5.78
1.00E-07		2.79	3.49	3.84	6.16
1.00E-08		3.07	3.84	3.92	6.63
1.00E-09		3.34	4.17	4.00	7.12



TPC CT FEC Performance for 8PSK Required Eb/No in dB			
Rate -->	3/4	7/8	0.95
BER	34420	34430	34440
1.00E-03	5.06	6.33	8.01
1.00E-04	5.27	6.44	8.33
1.00E-05	5.45	6.52	8.60
1.00E-06	5.64	6.59	8.88
1.00E-07	6.01	6.67	9.35
1.00E-08	6.43	6.75	9.81
1.00E-09	6.87	6.85	10.27



TPC CT FEC Performance for 16QAM Required Eb/No in dB			
Rate -->	3/4	7/8	0.95
BER	64420	64430	64440
1.00E-03	5.98	7.04	8.64
1.00E-04	6.20	7.15	8.96
1.00E-05	6.42	7.24	9.26
1.00E-06	6.69	7.31	9.59
1.00E-07	7.04	7.40	10.01
1.00E-08	7.42	7.52	10.52
1.00E-09	7.80	7.70	11.05



3.0 Installation

The Turbo Product Codes FEC Option is normally factory installed, but can be field installed by technical personnel. The option card itself is an approximate 2.1-inch by 3.9 inch printed circuit board with an SO-DIMM form factor and connector as used commonly for memory in laptop computers. The modem main board has two mating connectors capable of handling two different FEC cards.

As shown in Table 1-1 any TPC card also contains the standard Viterbi, TCM and Reed-Solomon functions and therefore only one card is required unless an S-Tec or some other type of FEC is also used in the modem. If a TPC card is installed in a modem which currently has the standard Viterbi, TCM, R-S card, that card may be removed and full functionality is still maintained.

Installation requires removal of the modem unit cover, plugging the option card onto the main modem assembly and then replacing the modem unit cover.

When installed the PSM-500 main processor automatically recognizes the presence of the card and its capabilities. It also adds appropriate front panel and remote control settings to allow programming the added functionality provided. This is transparent to the user, who needs take no action other than installation and setting for desired parameters.

> *Note that the FEC card itself holds the software and firmware required to operate. The main modem software may need to be updated however to recognize and use a newer FEC card. Software versions after 0.43 recognize all TPC variations.*

3.1 Installing a Turbo Product Codes FEC Option Card

Remove the modem unit from service before installation of the TPC option. Unplug the modem unit and remove the power cord from the rear for safety.

WARNING: Failure to remove power from the modem unit before removal of the cover can expose the operator to hazardous voltages and result in harm to personnel and equipment.

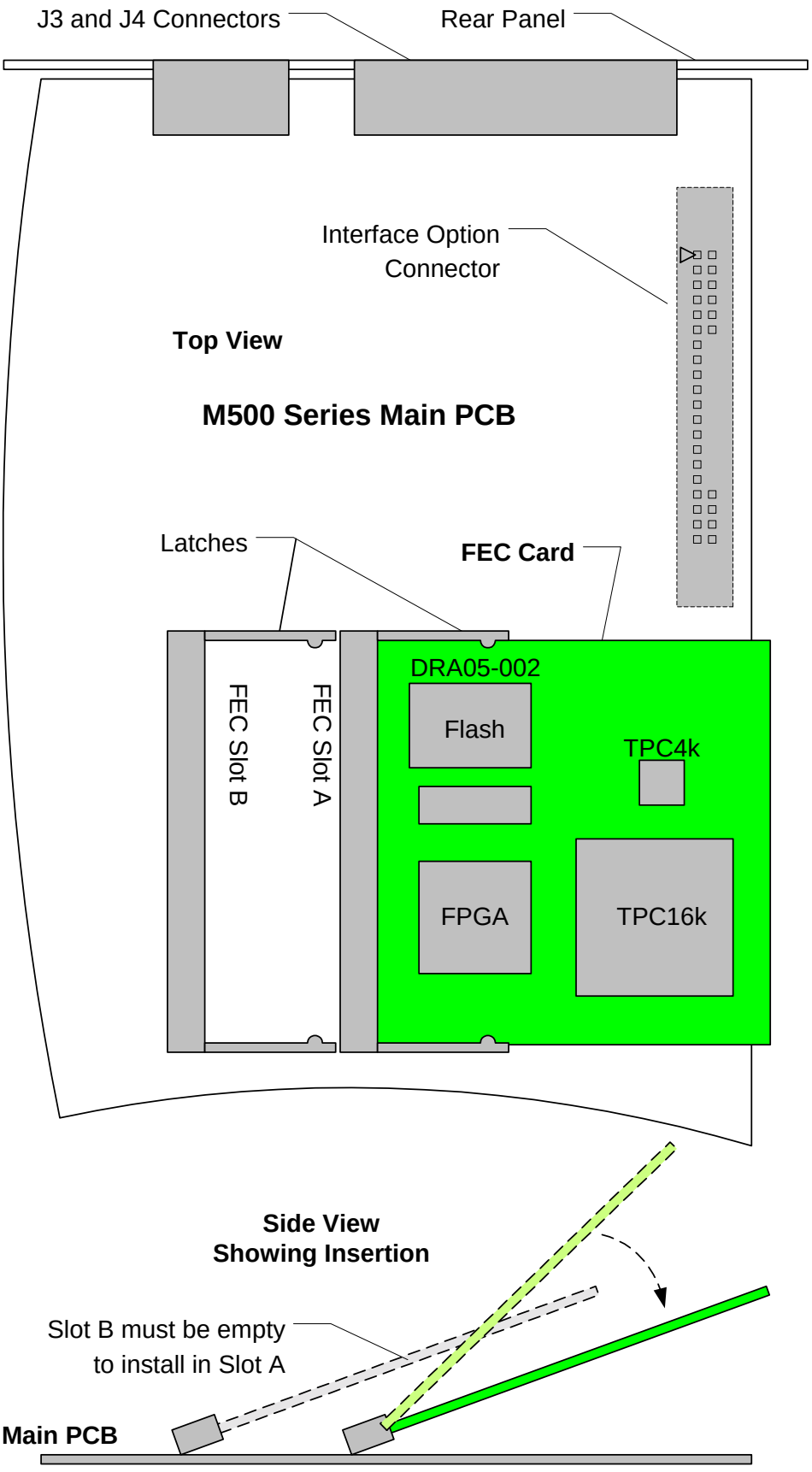
Place the unit on a flat surface and remove the 8 flathead screws holding the cover to the main chassis using a number 2 Philips screwdriver. The location for the option card installation is shown in the diagram below.

FEC Option cards are built on a SO-DIMM 144 pin platform basis, and installation is similar to installing memory in computers that use this type of connector system. The PSM-500 has two FEC slots available and the connectors for each are adjacent and on a 22.5 degree angle from the main board surface. The two slots are intended to be identical except that the one closest to the center of the main board is called “B” and the other is called “A”.

Position the new card to be installed into an empty slot at an approximate 45 degree angle to the main board surface and push the edge fingers int the connector making certain that it is properly seated. There are alignment cutouts on the card which insure that it can only be put in one way. Then rotate the card down toward the main board surface until the latches snap into place holding the board in that position.

Use extreme care in insuring that the pins are properly aligned between the option card and the main board connector.

Re-install the cover and plug the unit in. Using the front panel arrow keys scroll down to the interface parameter and verify that the modem recognizes the newly installed card. The modem is now ready to be put into service.


J3 and J4 Connectors
Rear Panel
Interface Option Connector
Top View
M500 Series Main PCB
Latches
FEC Card
DRA05-002
FEC Slot B
FEC Slot A
Flash
TPC4k
FPGA
TPC16k
Side View
Showing Insertion
Slot B must be empty
to install in Slot A
Main PCB