2114 West 7th Street
Tempe, AZ 85281 USA
Voice +1.480.333.2200
E-mail sales@comtechefdata.com
Web www.comtechefdata.com

Symbol Rate Calculation for the DMD2050E Satellite Modem

Symbol rate calculation of STANAG 4486 Edition 3 turbo forward error correction modes in the DMD2050E satellite modem

January 2014

1. Abstract

The DMD2050E Satellite Modem implements a framing structure defined by STANAG 4486 Edition 3 when operating in the turbo forward error correction (FEC) modes defined by this standard. The framing structure defined by STANAG 4486 Edition 3 for the turbo modes is complex and adds overhead. The modem symbol rate depends on the programmed data rate, nominal code rate, and other operational parameters.

This white paper discusses the STANAG 4486 Edition 3 turbo FEC framing structure, and provides equations to calculate the symbol rate given the relevant configuration parameters when operating in turbo FEC modes.

2. DMD2050E Processing Flow Overview

The DMD2050E supports Serial, Ethernet and External Overhead user interface options, and uses an internal Embedded Channel for modem-to-modem communication required for TRANSEC and Information Throughput Adaptation (ITA). The processing flow for these functions is illustrated in Figure 1.

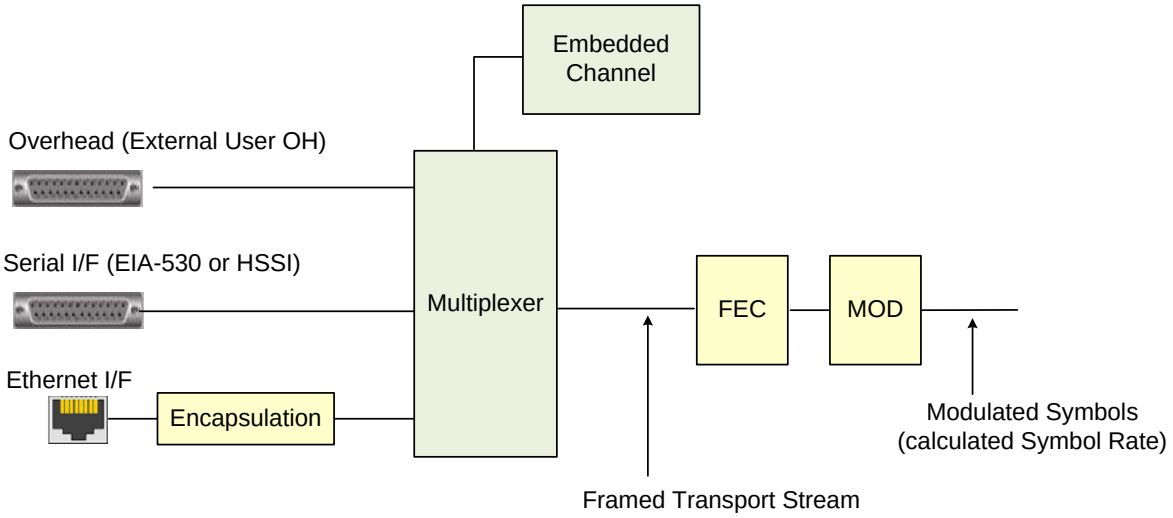

Figure 1: DMD2050E Processing Flow

The symbol rate S_R is given in terms of the programmed user bit rate R_b^u by the equation

$$S_R = \frac{R_b^u}{N_{ub/sym}} \quad [1]$$

where

R_b^u = User bit rate[1]
= Programmed Serial (EIA-530 or HSSI) data rate if serial interface is configured [2]
= Programmed Encapsulated Ethernet data rate if Ethernet interfaced is configured

$N_{ub/sym}$ = Number of User Bits per Symbol. For traditional FDMA modems this value is simply the stated code rate times the modulation order[2]. In STANAG 4486 turbo FEC modes, this is a more complex calculation. Please see Section 3. [3]

[1] The symbol rate calculation provided in this white paper is exact when either serial or Ethernet user interfaces are separately configured. In the case where the both serial and Ethernet interfaces are multiplexed together, the symbol rate calculation is still approximately correct if one considers the User Bit Rate to be the sum of the configured serial and Ethernet rates. However, the multiplexed case adds another layer of complexity, and the exact calculated symbol rate can differ somewhat from this approximation due to second-order multiplexer effects. Since the serial/Ethernet multiplexed mode is not likely to be commonly used in practice, the exact symbol rate calculation is omitted from this paper. A spread sheet calculator that includes this case can be obtained from CEFD.

[2] This is still the case for legacy MIL-STD-188-165A modes, and for Comtech proprietary turbo modes supported by the DMD2050E. For these DMD2050E modes, kindly refer to standard calculations of symbol rate.

3. User Bits-Per-Symbol Calculation

3.1. Symbols Per Frame

The STANAG 4486 Edition 3 framing structure is shown in Figure 2 [3]

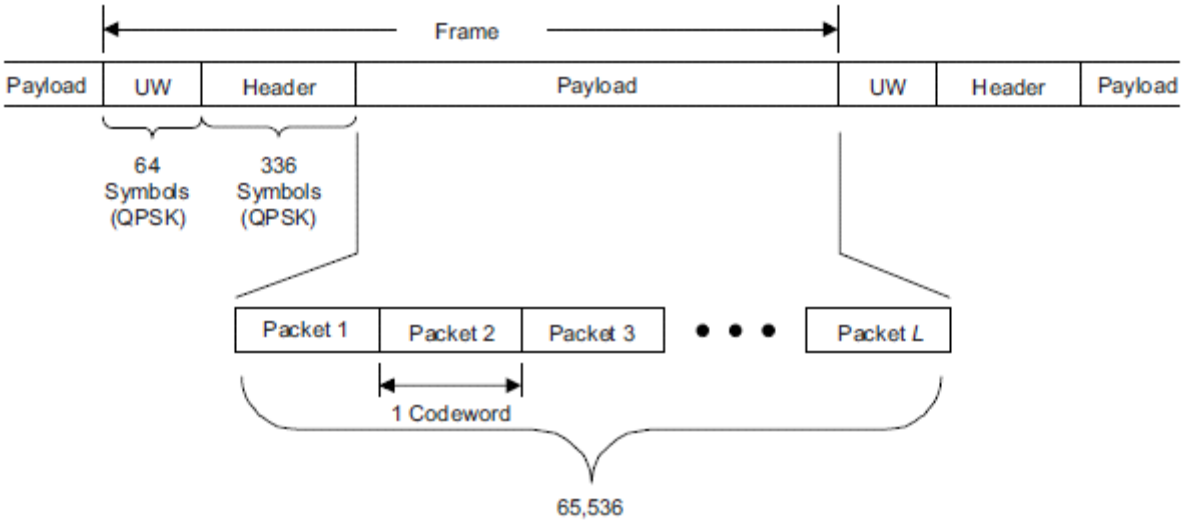

Figure 2: STANAG 4486 Edition 3 Framing Structure

As seen in Figure 2, a turbo FEC Frame contains a UW/Header field of 400 symbols prepended to multiple packets, where each packet is a FEC codeword. A Frame always contains 65,536 FEC information bits. The number of FEC information bits per codeword, K and number of codewords per frame, L depends on the sum data rate S_{dr}, as shown in Table 1.

Info bits / Codeword (K)	Sum Data Rate (S_{dr}) (kbps)	Codewords / Frame (L)
1024	$1024 > S_{dr}$	64
4096	$1024 \leq S_{dr} < 4096$	16
16384	$S_{dr} \geq 4096$	4

Table 1: Codeword Information Bits (K) and Codewords per Frame (L) Given Sum Data Rate S_{dr}

where S_{dr} is the sum of the external and embedded channel data rates

$$S_{dr} = R_b^u + R_b^{ohd} + R_b^{ec} \quad [4]$$

with R_b^u the user bit rate as defined in Equation [2] and

R_b^{ohd} = Programmed data rate of optional external Overhead Channel. [5]
= Constrained to 8 kbps multiples (0, 8, 16, 24, 64 kbps)

R_b^{ec} = Embedded Channel data rate [6]
= 4 kbps if TRANSEC is enabled (nominal rate)
= 0 if TRANSEC is not enabled[4]

[3] This Figure is taken directly from Figure E/A-6 from the STANAG 4486 Ed. Specification "Super High Frequency (SHF) Military Satellite Communications (MILSATCOM) Frequency Division Multiple Access (FDMA) non-EPM Modem for Services Conforming to Class-B of STANAG 4484 STANAG 4486 Edition 3", 13 February 2008

[4] The Embedded channel is also present when Information Throughput Adaptation (ITA) is enabled. However, when ITA is enabled, the symbol rate (rather than the user bit rate) is directly programmed by the operator.

The number of symbols per codeword, N_{sym} depends on both the nominal FEC code rate and the sum data rate. Values for each supported mode are tabulated in the STANAG 4486 Edition 3 specification[5]. These are repeated below in Table 2.

		Code Rate Label				
Mod	**Sum Data Rate S_{dr} (kbps)**	**1/2**	**2/3**	**3/4**	**7/8**	**19/20**
BPSK	$1024 > S_{dr}$	2048	1536	1368	1172	1080
BPSK	$1024 \leq S_{dr} < 4096$	8192	6144	5464	4684	4312
BPSK	$S_{dr} \geq 4096$	32768	24576	21848	18728	17248
QPSK	$1024 > S_{dr}$	1024	768	684	586	540
QPSK	$1024 \leq S_{dr} < 4096$	4096	3072	2732	2342	2156
QPSK	$S_{dr} \geq 4096$	16384	12288	10924	9364	8624
8-PSK	$1024 > S_{dr}$	684	512	456	392	360
8-PSK	$1024 \leq S_{dr} < 4096$	2732	2048	1822	1562	1438
8-PSK	$S_{dr} \geq 4096$	10924	8192	7282	6242	5750
16-APSK	$1024 > S_{dr}$	512	384	342	294	270
16-APSK	$1024 \leq S_{dr} < 4096$	2048	1536	1366	1172	1078
16-APSK	$S_{dr} \geq 4096$	8192	6144	5462	4682	4312

Table 2: Symbols per Codeword (N_{sym}) Given Sum Data Rate S_{dr} and Nominal FEC Code Rate

A given modem configuration defines the sum data rate S_{dr} and FEC code rate. Given these parameters, look-up values of L in Table 1, and N_{sym} in Table 2, enable the number of symbols per frame, N_{frame} to be calculated as

$$N_{sym/frame} = L*N_{sym} + 400 \quad [7]$$

3.2. User Information Bits Per Frame

The STANAG 4486 Edition 3 turbo FEC codeword structure is shown in Figure 3. [6]

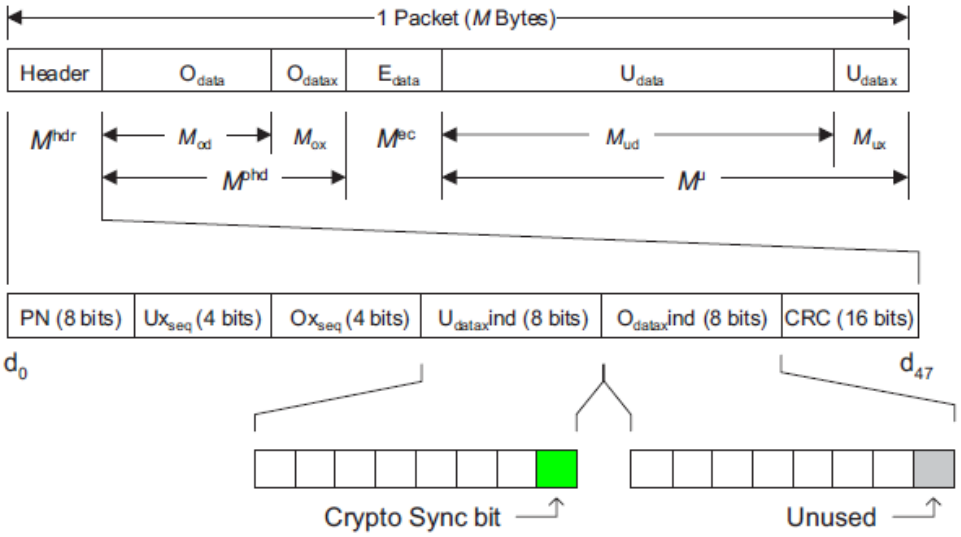

Figure 3: Structure of Codeword

[5] TABLE E/A-10 of 13 February 2008 STANAG Edition 3 Specification

[6] From FIGURE E/A-2 of 13 February 2008 STANAG Edition 3 Specification

As seen in Figure 3, the number of user data bytes M^u is given by

$M^u = M - M^{hdr} - M^{ohd} - M^{ec}$ [8]

where

M = Number of total FEC information bytes in a codeword

= K/8, K given in Table 1 [9]

M^{hdr} = 6, (from Figure 3) [10]

$$M^{ec} = \left\lceil \frac{R_b^{ec}}{R_b^u + R_b^{ohd} + R_b^{ec}} \left(M - M^{hdr} \right) \right\rceil$$ if TRANSEC enabled, $\lceil \bullet \rceil$ = ceiling function [11]

= 0 otherwise

$$M^{ohd} = \left\lceil \frac{R_b^{ohd}}{R_b^u + R_b^{ohd}} \left(M - M^{hdr} - M^{ec} \right) \right\rceil$$ [12]

The number of user information bits in a frame is then given by

$N_{ubits/frame} = 8*L*M^u$ [13]

3.3. User Information Bits Per Symbol

Given the number of symbols per frame $N_{sym/frame}$ (Equation [7]) and user bits per frame (Equation [13]), the number of user bits per symbol is

$$N_{ub/sym} = \frac{N_{ubits/frame}}{N_{sym/frame}}$$ [14]

4. Ethernet Packet Encapsulation

When an Ethernet interface is used, an additional source of overhead is necessary to encapsulate the packets into the transport stream. The DMD2050E operates in bridged mode, where Ethernet packets received from the external interface are encapsulated.

Unpublished versions of STANAG 4486 Edition 3 define the Ethernet encapsulation mechanism to always add 11 bytes, as shown in Figure 4.

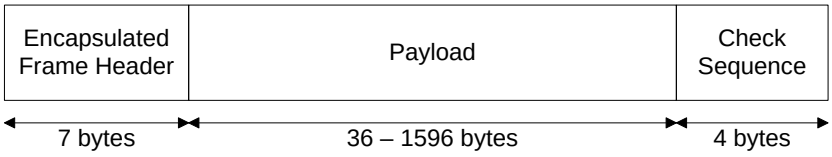

Figure 4: STANAG 4486 Edition 3 Ethernet Encapsulation

The encapsulation overhead reduces the effective throughput of packet bits relative to the programmed modem data rate. The packet throughput data rate, in packet bits/second is

Packet Throughput Data Rate = (Programmed Modem Ethernet Data Rate)* F_E [3]

where

$$F_E = \frac{P}{P + 11}$$ [4]

and P = the Ethernet packet size in bytes. Expressed as a percent overhead of the programmed modem date rate, the encapsulation overhead is

Encapsulation OH [%] = $(1- F_E)*100$ [5]

= $\frac{11}{P+11}*100$

Encapsulation overhead ranges from approximately 15% for P=64 to approximately 0.7% for P=1518.

5. Conclusions

The DMD2050E supports STANAG 4486 Edition 3 turbo FEC modes. The symbol rate calculations for STANAG 4486 Edition 3 turbo FEC modes are complex, and depend on the nominal FEC code rate, the programmed modem data rates, and whether the embedded channel used in conjunction with the TRANSEC option is enabled.

Equations for calculating symbol rate given the relevant modem operating parameters are provided for understanding and reference.

For additional information, please contact us.

Email: sales@comtechefdata.com
Voice: +1.480.333.2200
Fax: +1.480.333.2540
Web: www.comtechefdata.com