DATUM SYSTEMS

Appendix MUX

M500 Framing/Multiplexer Addendum

Revision History
Rev 0.9   6-17-2007   Initial Release.
Rev 0.8   12-12-2006   Draft Release.

1.0   Framing/Multiplexer Overview

The Multiplexer function is built into all standard M500 Class modems (PSM-500 and variants) and when enabled provides these modems with several useful capabilities. Since it is virtually identical to the implementation in the M5 Class modems (PSM-4900) then it is compatiple in all coincident modes. The multiplexer is part of the main modem assembly and use the J4 "Aux", (Auxiliary) connector for Input and Output at the rear panel

The Framing and Multiplexer are described in more detail in the following sections. The Framing Multiplexer functions may be enabled or disabled independently in each link direction.

For the purposes of the remainder of this document 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 Reed-Solomon 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 Multiplexer functions are given in the Unit Specifications, Appendix A.

The Terms "M5" refer to the PSM-4900 modems and their variants. The Term "M500" refers to the PSM-500 and its variants. The IBS Multiplexer described here is that built into the M500 Modems modems, but is identical to that in the M5 modem IBS option except where noted.

1.1   Overview - Quick Start Guide

The most important point to insure in setting up the Multiplexer 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. This is not strictly true for the ESC port rates in all cases, but it is true for most other parameters.

- The IBS Multiplexer can be individually enabled or disabled in each direction (transmit and receive) via the **<Mod:Mux - Mode>** settings for the transmit direction and the **<Dem:Mux - Mode>** settings for the receive direction. The same settings must be used on both ends of the link in each direction.

- Choose a mode of operation suitable for the service desired. In most cases the Multiplexer "Enhanced" mode provides basic full capabilities taking advantage of the special features built into the modem.

- See the Multiplexer Descriptions in Sections 2.03 and 2.1 of this Appendix for more information on refining the settings to optimize them for a particular application.

1.1.1 Overview - Modes of Operation

IBS Multiplexer

The Multiplexer provides the following modes of operation. They are described more fully in later sections of this Appendix.

Mode	Standard/ Compatibility	Overhead Ratio	Notes
Disabled	N/A	1/1	
Standard	IESS-309	16/15	Fixed synchronous ESC, No AUPC, No MCC
Enhanced	Modified IESS-309	16/15	M4 compatible ESC and AUPC (limited MCC).
Custom	Modified IESS-309	Variable	Full ESC and MCC including AUPC, Remote Modem Control, 2 one=bit control channels. Also variable data load per frame.

1.2 Framing Overview

Framing of data is required for the Multiplexing functions. That is because multiplexing functions are "block" oriented and synchronization to particular locations in the bit stream are necessary. In a standard modem all the bits are considered the same. But for a multiplexer the function must know that certain bits belong to the main terrestrial through data and others belong to the overhead channel and still others are for control purposes. The frame synchronizes the data by placing special detectable flags in the data stream that can be recovered at the receive end to separate or "un-frame" the data.

In contrast to previous Datum Systems' M4 Multiplexer functions, the later M5 and M500 multiplexer provides for variable and programmable modes of operation. The M5 and M500 versions are fully compatible within the limits of compatible data rate range.

The multiplexer variability is accomplished by modifying the number of data load bytes within the frame. Thus in "Custom" mode the input to output ratios varying from approximately 1/2 to 255/256 (standard IBS multiplexers use a fixed rate of 15/16). These ratios represent the ratio between the main channel terrestrial data rate and the aggregate rate (exclusive of the Reed-Solomon). Thus a 15/16 ratio means that 15 out of 16 transmitted bits are actual data bits. The 16th bit contains the framing and all the other information multiplexed onto the data stream. Looking at the standard IESS frame structure below you will note that it is actually arranged into bytes, where there are 4 bytes of framing/multiplexer information and 60 bytes of data. The M500 Custom framing allows the number of data bytes per frame byte to vary from 4 to 1020.

2.0 Framing/Multiplexer Description and Operation

The framing convention used in the M500 Multiplexer adheres to the Intelsat IESS-309 standard. Three possible modes of operation are provided for that include various uses for the available framing bits:

1. "Standard" – Provides usage in accordance with the IESS Standard.
2. "Enhanced" – Provides added capabilities proprietary to the M5 and M500 class modems.
3. "Custom" – Provides added capabilities proprietary to the M5 and M500 class modem plus variable terrestrial to framing ratios. This mode is not compatible with M4 class modems.

The framing/multiplexer is capable of multiplexing a (usually) low speed overhead channel and pieces of control information onto the terrestrial data stream resulting in a slightly higher combined or "aggregate" data rate through the modem.

There are two specific channels that the PSM-500 IBS Multiplexer can add to the terrestrial data stream. The data for the channels is contained within the framing bytes themselves.
- The "ESC" channel available in all modes.
- The control or "MCC" channel available in the proprietary "Enhanced" and "Custom" modes.

The multiplexed channels are recovered and separated from the terrestrial data at the far end of the link.

The ESC channel is termed variously an overhead channel, Engineering Service Channel (ESC), "asynch" channel or in Intelsat IESS terminology an "ES to ES data channel" (for Earth Station to Earth Station). This document and the modem front panel refer to this channel as the "ESC". A simplified block diagram of the data multiplexer is shown in Figure MUX-1 below. Normal operation of the multiplexer may be either uni or bi directional and most parameters of the multiplexer may be set independently in each direction. The ESC channel appears at the rear panel connector J4 on the modem.

In addition to the ESC various other information is transferred between the two ends of the link. This information consists of status represented by fixed bits within the frame structure. The "Frame" is the method used to synchronize information at each end, allowing recovery of the separate channels that are multiplexed or "mixed" together for transmission. The standard Intelsat IESS frame structure is shown below in figure MUX-2 below.

The MCC or Modem Control Channel is proprietary to Datum Systems' Modems, and provides added valuable facilities. For the M500 class modems the MCC can provide:
- AUPC – Automatic Uplink Power Control in Enhanced and Custom modes.
- RMC – Remote Modem Control in Enhanced and Custom modes. (Not compatible with M4 Modems)
- RFC – Remote Facility Control in Custom mode only.

The MCC facilities are generated using specific normally unused bits in the framing structure. It provides an independent channel by which the two modems themselves may communicate, providing the capability for Automatic Uplink Power Control (AUPC) and Remote Modem Control (RMC) without the necessity of a separate multiplexer. This document and the modem front panel refer to this channel as the "MCC", standing for Modem Control Channel.

The PSM-500 multiplexer MCC also provides two "single line" backward alarm channels, termed a Remote Facility Control or "RFC". These two independent RFC channels can accept a voltage or contact closure type input on one end and provide a form "C" relay contact presence on the far end. These can be used for alarms and simple commands. One example might be to light an indicator at a hub site when the door is opened at a remote site. The reverse direction of this bit might be used to lock the door electronically. One other possible use for such data transfer would be to provide a "backward" alarm from an unattended site giving the status of the transmit and receive outdoor converter and amplifier equipment.

The AUPC and RMC information is used internally by the modem and does not appear on the rear panel at J4. The RFC "backward alarm" channels do appear on J4. For the pin connections refer to the "Installation" Section 3 of this Appendix.

> ***Note: The ESC is available in all modes when the IBS Multiplexer is enabled. The MCC is available only in the Enhanced and Custom Multiplexer modes described below.***
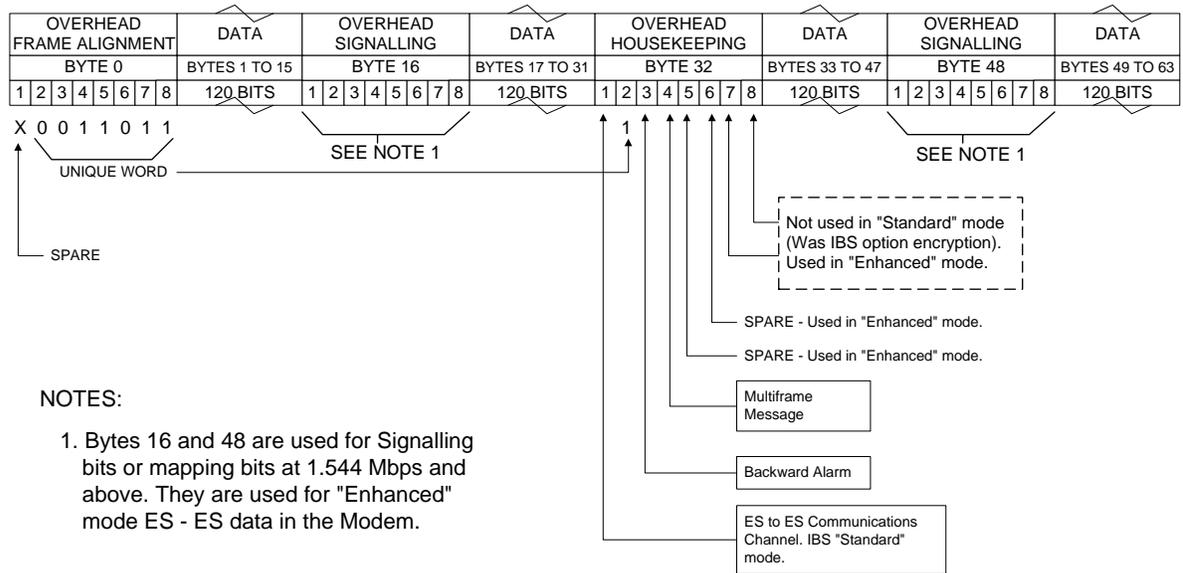
Figure MUX- 1
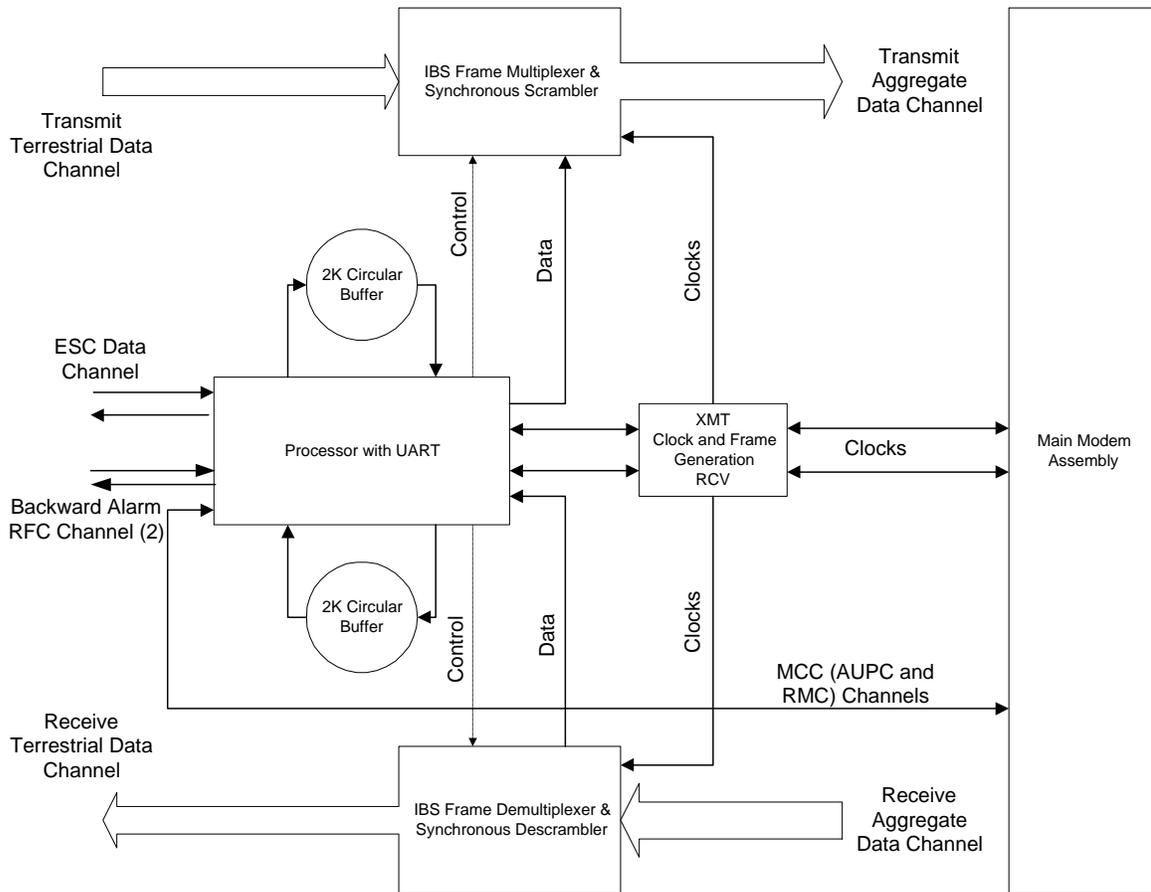
IBS Multiplexer Simplified Block Diagram

One advantage of the framing of serial terrestrial data is that a "synchronous" scrambler can be employed. This type of scrambler overcomes the slight loss of performance due to the standard V.35 type self-synchronized scrambler normally used.

The basic frame structure used by the multiplexer is that specified in the IESS-309 standard, Page 60, Figure 10, resulting in a 16/15 aggregate to through data ratio. Most of the IESS Framing Structure diagram is shown here in Figure MUX-2 below.

Figure MUX- 2

OVERHEAD FRAME ALIGNMENT	DATA	OVERHEAD SIGNALLING	DATA	OVERHEAD HOUSEKEEPING	DATA	OVERHEAD SIGNALLING	DATA
BYTE 0	BYTES 1 TO 15	BYTE 16	BYTES 17 TO 31	BYTE 32	BYTES 33 TO 47	BYTE 48	BYTES 49 TO 63
1 2 3 4 5 6 7 8	120 BITS	1 2 3 4 5 6 7 8	120 BITS	1 2 3 4 5 6 7 8	120 BITS	1 2 3 4 5 6 7 8	120 BITS

X 0 0 1 1 0 1 1   1

UNIQUE WORD ────────────── SEE NOTE 1   SEE NOTE 1

SPARE

Not used in "Standard" mode (Was IBS option encryption). Used in "Enhanced" mode.

SPARE - Used in "Enhanced" mode.

SPARE - Used in "Enhanced" mode.

Multiframe Message

Backward Alarm

ES to ES Communications Channel. IBS "Standard" mode.

NOTES:

1. Bytes 16 and 48 are used for Signalling bits or mapping bits at 1.544 Mbps and above. They are used for "Enhanced" mode ES - ES data in the Modem.

IBS FRAME STRUCTURE

Overhead signaling bytes 16 and 48 are not implemented as signaling or mapping bits. Three software controlled modes are designed into the multiplexer to best utilize the available bits; "Standard IBS", "Enhanced" and "Custom". The characteristics of the channel interface are also determined by the standard or enhanced mode.

2.0.1   Standard IBS Multiplexer Mode

In the first or "Standard" mode, all bit assignments are per the IBS standard. The bits of Overhead Housekeeping byte 32 are implemented as shown below:

Bit 1 - *ES to ES Data Channel* Channel. Its the   This bit is routed directly to the ES to ES (ESC) Data data rate is 1/512th of the aggregate rate (or $1/480^{th}$ of through terrestrial data rate), and is normally used to super-sample an asynchronous data channel.

Bit 2 -   Part of the Frame Alignment word.

Bit 3 - *Backward Alarm*   Transmit and Receive with main processor to activate main alarm/LED

Bit 4 - *Multiframe Message*   As per IBS

Bits 5 and 6 - *Spare*   Not currently Utilized

Bits 7 and 8 - *Encryption Utilization*   Not currently Utilized

The ratio of the through terrestrial data channel rate to the aggregate rate is 15/16.

The standard transmit and receive channels of the ESC data channel in standard IBS mode are raw channels operating at the specific bit rate as controlled by the data channel rate, without buffering. Synchronous clocks are provided with the ESC channel in the standard mode when set to RS-232 I/O. The transmit and receive ESC clocks are both outputs from the modem as the timing is specifically set by the IESS standard as a fixed ratio to the terrestrial data rate. These clocks are not provided when operating in the RS-485 mode.

2.0.2   Enhanced Multiplexer Mode

The "Enhanced" Multiplexer mode provides alternate proprietary usage for the basic framing structure allowing enhanced useful capabilities not provided in the standard mode. Note that all of the capabilities of the Enhanced Multiplexer mode are also available in the "Custom" mode described below. One main purpose of the Enhanced mode is to provided backward compatibility with the M4 class (PSM-2100) modems, specifically the operation of the AUPC function.

Since many of the frame bits in the standard IBS mode are not used, an "Enhanced" multiplexer mode has been implemented that can be engaged under software control. Since this mode changes the use of many of the framed non-data bits, this mode is only usable when a PSM-500, PSM-4900 or PSM-2100 is at both ends of a link and each is set to the same modes. In this mode, the overhead signaling bytes 16 and 48 can be used to implement a significantly higher speed ESC Data Channel under software control. When implemented, this rate is 16 times that of the normal IBS standard, or 1/30th of the terrestrial data rate (1/32nd of the aggregate rate). In addition, spare bit 1 of Byte 1 and bits 1, 5, 6, 7 and 8 of Byte 32 are typically used to implement a secondary ES-ES modem channel dedicated to communications between the two modems-on a link for Status and Automatic Uplink Power Control (AUPC) applications. This secondary channel is called a Modem Control Channel or MCC.

One of the main advantages to the Enhanced (or Custom) mode of multiplexer operation is to provide buffering of the ESC, which then allows using standard asynchronous format and rate operation.

> ***NOTE: The Enhanced or Custom IBS mode MUST be selected for true Asynchronous channel operation to be available.***

The main processor and the option card logic performs software/hardware assignment of bits to specific purposes in the enhanced mode and buffers the ESC Data Channel to standard asynchronous data rates. The secondary or MCC modem control channel should normally be at 300 bps minimum in order to maintain a sufficient loop response time when using Automatic Uplink Power Control. Therefore, if the aggregate rate results in an MCC modem channel rate less than 300 bps minimum (approximately 25 Kbps aggregate) then the Overhead Signaling bytes are commandeered for this purpose. The primary ESC channel then uses the six spare and unused bits, which is still six times the rate of standard IBS. Note that this occurs in the enhanced mode whether the AUPC is enabled or not.

The processor-controlled ESC channel contains both transmit and receive data buffers which are 2048 bytes in length. These act as long FIFOs on the data in each direction. No data is lost if the actual ESC data channel and the buffered user data rates are different, unless the sustained user data rate causes the buffer to overflow. Buffer overflow results in purging the entire buffer contents. Gaps between characters or messages do not use the buffer and thus can be used to prevent overflow. If the user data rate is less than the data channel rate, then there are simply gaps between characters, which is normal in asynchronous communications. The transmit and receive data rates at either end do not have to be the same, so one end of the link could, for example, have 19.2 kbps transmit and receive while the other end may have 1.2 kbps transmit and receive rates. Note that this could easily result in overflow if the sustained rate exceeded 1.2 kbps.

The MCC channel also contains buffers, 1024 bytes in this case, that allow the processor to write AUPC and Remote Modem Control messages which flow at the normal MCC overhead rate. If the buffers are full the processor receives a message to that effect and can resend the message later.

2.0.3   Custom Multiplexer Mode

This is the most flexible mode available in the multiplexer. In both the Standard and Enhanced modes the ratio of framing bytes to data bytes are fixed at 1 framing byte per 15 data bytes, and a

frame length of 64 bytes total. Note that there are 4 framing bytes per complete frame. In the Custom mode the framing bytes remain as previously described, but the number of data bytes in a frame is variable from 4 to 1020. Thus the ratio of data to framing bytes are variable from 1 to 255 yielding mux ratios of 1:2 to 255:256. Like the "Enhanced" multiplexer mode the "Custom" mode uses the unused frame bits in the standard IBS mode. It also provides all of the features of the "Enhanced" mode, plus the variable data "load". In addition the Custom mode provides for two single line control or backward alarm type channels, complete with logic inputs and relay outputs. These are termed Remote Facility Control (RFC) channels.

> ***NOTE: The Custom IBS Multiplexer mode is NOT compatible with M4 class modems.***

The Custom Multiplexer Mode provides the capability of very low overhead penalty at one extreme of setting to the capability for an overhead channel that is close to the rate of the through data channel at the other extreme of its settings.

> ***NOTE: The Custom or Enhanced IBS mode MUST be selected for true Asynchronous ESC channel operation to be available.***

> ***NOTE: Both ends of a link (in each direction) MUST be set to the same mode, that is the transmit on one end of the link and receive at the other end. The two directions may however be set to different modes.***

The processor on the main board performs software/hardware assignment of bits to specific purposes in the Custom mode. The ESC Data Channel is buffered to standard asynchronous data rates.

The user does not have to compute data framing variables to use the Custom Multiplexer Mode. When placed in this mode the entry parameters are the ESC and MCC channel "overhead" rates selected from standard asynchronous data rates (300 to 38,400 bps). The modem then computes the proper relationship between the framing and terrestrial data rates to achieve the proper operation. The modem also displays the terrestrial data to aggregate ratio.

The Custom ESC and MCC Overhead rates determine the frame resources that are allotted to the ESC and MCC channels. The overhead rate selected is different from the ESC port rate, which determines the rate that the rear panel ESC port actually operates at. The difference between the two in Custom mode must be absorbed by the ESC transmit and receive buffers, just as in the Enhanced mode.

The ESC channel and the MCC channel can be individually disabled by setting the **<Mod:Mux – ESC Overhead>** or **<Mod:Mux - MCC Overhead>** to "Disable". The companion Demodulator settings must be used on the other end of the link.

2.0.3.1   Custom Multiplexer Mode Setup Guide and Example

In the Custom mode it can be difficult to determine how to properly set the ESC/MCC overhead rates and port rates to efficiently use the satellite link. Several guidelines are set out here as a sequence to arrive at good initial settings, using a hypothetical case as an example.

1. Determine that an ESC and MCC are required.
   We assume here that it is.
2. Determine the desired ESC port rate.
   Example – two computers that will talk at 9600 baud
3. Determine the approximate duty cycle of the ESC.
   Example – our computers only communicate approximately 25% of the time.

4. Compute approximate required ESC and MCC Overhead rates.
   The ESC overhead rate would be 9600 times 25% = 2400 bps. AUPC and very occasional remote modem control are required; therefore the MCC is set at the minimum needed by the AUPC, 300 bps.

When the above settings are combined with several terrestrial data rates the resulting ratios of terrestrial data to aggregate rates are shown in the table below:

ESC Configuration Example with Percentages of Overhead Used						
ESC Port Rate in bps.	Approx. Activity %	ESC Overhead Rate in bps	Terrestrial Data Rate (kbps)	Mux Ratio Including 300 bps MCC	Overhead percentage of Terr. Rate	Aggregate Rate
9600	25%	2400	9.6 kbps	2:3	50%	14.4 kbps
9600	25%	2400	32	7:8	14.3%	36.57143
9600	25%	2400	64	14:15	7%	68.57143
9600	25%	2400	128	29:30	3.5%	132.4138
9600	25%	2400	256	58:59	1.7%	260.4138
9600	25%	2400	1000	229:230	.4%	1004.367

As a first estimate formula for the total overhead percentage of the terrestrial data rate this could be expressed as:

Overhead % = ((ESC Port Rate X ESC Activity Factor) + (MCC Overhead Rate) +2000) / Terrestrial Rate

The Aggregate data rate is then <u>approximately</u> 1 + Overhead percentage times the terrestrial data rate. The aggregate rate is <u>exactly</u> the terrestrial data rate times 1/Mux ratio (as read from modem front panel). In the example above, at 128 kbps the aggregate rate would be 128 X (30/29) or 132.4138 kbps.

In practice the maximum rate of ESC plus MCC cannot be greater than approximately 68% of the through terrestrial data rate.

The ESC activity factor is obviously just a guess in most cases, but often the usage can be very low, as in the case of occasional command information. Since the buffers on the ESC channel are relatively large (2 kbytes at both the transmit and receive ends), the ESC Overhead rate can be set very low to minimize the aggregate data rate. The transmit and receive ESC buffers are circular, thus If the buffer(s) overflow the oldest ESC data is overwritten.

2.0.3.2   Custom Multiplexer Examples and Limitations

The overhead percentage formula given above is an approximation. A more exact computation of the bits used in the Custom mode shows the limitations and more exact ratios as computed by the modem's processor.

As shown in Figure MUX-2, the IBS Frame stucture uses 4 bytes out of each frame, 32 bits. Of those 32 bits 10 are used for frame synchronization and housekeeping. The remaining 22 bits are then available for the MCC and ESC channels. The mux ratio is controlled by adjusting the number of terrestrial data bytes put between each of the four frame bytes. That ratio of data to frame bytes can be adjusted in the custom mode from 1:2 to 255:256.

At one extreme where you want the maximum overhead capacity compared to the terrestrial data rate the mux ratio is set to 1:2. Then the multiplex frame is 8 bytes (64 bits) long. 32 of those bits are the main data channel. Of the remaining 32 bits that are overhead, 22 bits are available for the MCC and ESC channels and 10 bits are frame synchronization, backward alarms and

scrambler synchronization. The MCC and ESC are each assigned an integer number of those 22 bits where the combined total has to always be 22.

At a terrestrial rate of 9.6 kbps and the custom mux configured to 1:2 ratio (terrestrial to data channel rate) the total aggregate bit rate is 19.2 kbps. 19200 / 64 bits per frame means the frame rate is 300 frames per second. Therefore each bit in the frame provides 300 bits per second. If the MCC function is turned off that leaves all 22 bits for the ESC. 22 x 300 bps is 6600 bps. If the MCC is turned on at the lowest setting of 300 bps it will use at least 1 of those 22 bits leaving 21 bits (or fewer depending on the actual ratio of the ESC to MCC) for the ESC. So with the MCC configured at 300 bps the maximum internal ESC rate is 21 x 300 bps = 6300 bps.

In addition the internal MCC and ESC channels both have one extra stop bit added to minimize extraneous data characters from being generated due to false start bits from data errors over the satellite. If the ESC is configured for "N81" async format (a total of 10 bits, 1 start, 8 data and 1 stop) the internal ESC channel sends 11 bits internally for every 10 bit async character received at the ESC interface. This means there's an additional 10% internal overhead. So if the MCC is set to 300 bps the remaining 6300 bps available to the internal ESC will effectively be 5727 bps at the ESC user interface. If the ESC physical interface is set to 9600 baud and you send continuous ESC data eventually the ESC input 2k byte buffer will overflow unless flow control is enabled or the data has sufficient gaps between async characters to allow the slower internal channel to catch up. At 4800 baud it would never overflow and would not need flow control.

The MCC channel is only required if you want to use automatic uplink power control (AUPC) or want to remotely monitor and control the far end modem via the MCC. At lower terrestrial data rates 300 bps for the MCC is sufficient for the AUPC to operate properly.

At a terrestrial rate of 64 kbps and the custom mux configured to 1:2 ratio the total aggregate bit rate is 128 kbps. 128000 / 64 bits per frame means the frame rate is 2000 frames per second. Therefore each bit in the frame provides 2000 bits per second. If the MCC function is turned off that leaves all 22 bits for the ESC. 22 x 2000 bps is 44000 bps. If the MCC is turned on at the lowest setting of 300 bps it will use 1 of those 22 bits leaving 21 bits for the ESC. So with the MCC configured at 300 bps the maximum internal ESC rate is 21 x 2000 bps = 42000 bps.

If the MCC is set to 300 bps the remaining 42000 bps available to the internal ESC will effectively be 38182 bps at the ESC user interface due to the internally added stop bit. If the ESC physical interface is set to 38400 baud and you send continuous ESC data eventually the ESC input 2k byte buffer will overflow unless flow control is enabled or the data has sufficient gaps between async characters to allow the slightly slower channel to catch up. At 19200 baud it would never overflow. If the MCC is turned off all 22 bits would be available to the ESC, 22 x 2000 = 44000 and would be effectively 40000 bps and would support 38400 at the physical ESC interface continuously.

2.0.4   ESC Channel Port Characteristics

The ESC (ES to ES) Data Channel can be set under software-control to operate in either RS-232 mode, or RS-485 4 Wire mode, RS-485 Drvr On or 485 2 Wire mode. The pin assignments for both modes are shown in the Installation section of this Appendix. The RS-485 Transmit Data Drivers can be set to "RS-485 4 Wire" or "RS-485 Driver ON" when in "Enhanced" or "Custom" mode. The "ON" setting forces the driver continuously on while the "RS-485 4 Wire" setting controls the output into tri-state when the modem is not transmitting data, allowing multiple modem outputs to be connected together typical of a multi-drop control system. In the standard IBS mode only the "RS-485 ON" mode is available.

In Enhanced or Custom mode the RS-485 2 Wire receive operating mode can be selected for the receive data into the ESC channel. In this mode the receive input is muted while the transmit data output is active. In 4 wire mode the receive is always enabled. In the standard IBS mode only the

4-wire mode is available. Note that the transmit and receive pairs are physically separate wires and must be connected together if true RS-485 2 wire connectivity is desired.

Note that the RS-232 connection in standard IBS mode is synchronous. This is due to the IBS frame structure resulting in unbuffered data at a fixed rate relative to the terrestrial data rate. The Enhanced and Custom modes offer full transmit and receive buffering allowing true asynchronous operation at standard data rates. These modes also offer full control signals.

The Mux - ESC port rate, port (RS-232/RS-485 and 2 wire/4 wire) and format controls appear in both the Mod and Demod pages and are coupled. A change in one side results in the same change in the other. The driver/receiver selected is a physical device and must be the same in both ESC transmit and receive.

2.0.4.1   ESC Flow Control Operation

When using the RS-232 ESC I/O mode it is possible to activate (or ignore) the standard asynchronous control signals under front panel or remote control. These control signals are normally used for flow control of the ESC, and include RTS/CTS, DSR/DTR.

The RTS/CTS are normally used on the sending end to prevent buffer overflow. When the buffer on sending end of the ESC reaches ¾ full (1536 bytes) then the CTS control line is dropped. It is raised again when the buffer is reduced to ¼ or less (512 bytes).

DSR/DTR are normally used on the receiving end to notify the end equipment of traffic status. If the user drops the DTR the receive data output will stop and the buffer will start filling. The DTR can be used for flow control but the buffer is the responsibility of the user. The DSR control line operation is similar to that of a DCD. That is when data is incoming the DSR goes active meaning that data is present and being transmitted.

Control options allow forcing the Modulator ESC CTS active, while Normal permits flow control. The Demodulator ESC DSR can be forced active or set to Normal, which follows the DTR line and shows the presence of data. The Normal DSR setting will also drop on loss of lock or Multiplexer hardware alarm. With the DTR set to Nrormal it is used for receive flow control, while ignore will ignore the DTR line, eliminating flow control.

2.0.5   Modem Control Channel (MCC)

The MCC is available in both the Enhanced and Custom Multiplexer modes. In the Enhanced mode the MCC provides for an AUPC and Remote Modem Control channel. In the Custom mode the MCC provides for the AUPC plus the Remote Modem Control (RMC) Channel and the Auxiliary Remote Facility Control lines or RFC (sometimes called backward alarms).

2.0.5.1   AUPC Control Channel (part of MCC)

When the modem is placed into either the "Enhanced" or "Custom" modes the AUPC control channel becomes available. The AUPC operation itself is under control of the modem while the AUPC facility in the MCC provides the channel for the information. This channel provides a minimum 300 baud control channel in each direction to allow the modems at two ends of a link to interactively maintain the receive Eb/No by controlling the power output at the transmit site.

Refer also to the AUPC operation description of the main manual in section 3.8 titled "*Automatic Uplink Power Control (AUPC)" Operation.*

2.0.5.2   Remote Modem Control Channel (RMC)

When the modem is placed in the "Enhanced" or "Custom" mode the Remote Modem Control channel becomes available. This channel allows the control of a far end modem from the near end site. This control is not however allowed from the near end front panel, but only via the

remote control interface port. The command protocol for remote unit control is explained in Appendix B*, "Remote Control Protocol".*

> ***Note: Remote Modem Control is only available between two M5 or M500 class modems.***

Note that the Automatic Configuration Recovery or ACR is partially designed as a safety feature to be used with the remote programming of modems. It can help prevent "losing" the modem at an unattended site. Refer to the ACR section of the main manual in 3.14 "*Automatic Configuration Recovery".*

2.0.5.3   Far End Modem Control via the MCC (RMC) and M5 Compatibility

The M5 and the M500 series protocols contain the ability to relay control packets and responses via the Modem Control Channel, or MCC, from a local to a single far end modem. The PSM-500 modem can interoperate with the previous generation of M5 modem series, the PSM-4900. To aid in mixed systems containing both M500 and M5 series modems the M500 series has almost complete M5 series protocol capabilities. This exists side by side with the newer protocols described in this addendum, but are limited naturally to the capabilities of the M5 series. For further information on the M5 series protocol, please see the M5 Appendix B available on the web stie.

As noted before the M5 series of protocols use a "Mode" byte value of "1" to indicate a local packet, and a value of 2 to indicate a far end packet. The M500 series uses a value of "5" for local and "6" for far end packets. Far end packets look just like local packets in all other respects. When a modem receives a valid control packet with a mode byte value of 2 or 6 (M500) or 2 (M5) then it retransmits that packet to the far end modem via the MCC.

M500 series protocol compatibility with the M5 series extends to the use of the Modem Control Channel to send and receive far end packets. That means that a local M500 series modem can be set up to link to and control either another M500 modem or an M5 series modem at the far end. The M500 series has a built in multiplexer, but the multiplexer is an option in the M5 series. See the respective manuals for information on setting up the link and multiplexers to allow this type of control. The following link packet protocols can be used.

MCC Channel Far End Control Modes			
Controller End Modem	**Far End Modem**	**Mode Byte**	**Possible?**
M500	M500	6	Yes
M500	M500	2	Yes
M500	M5	2	Yes
M5	M500	2	Yes
M5	M500	6	No

The last case is not currently possible because the previous M5, PSM-4900 series modems do not know how to process a newer M500 protocol mode byte.

A far end designated packet is not evaluated or processed by the local modem except that its source and destination addresses are removed. When the response is returned by the far end modem, the addresses are inserted into the response before returning it to the original calling controller.

2.0.5.4 MCC Channel Timing

A packet sent to the far end via the MCC channel may take quite a while before a response is returned to the original caller. The timing also varies depending on the overhead rate assigned to the MCC channel. For example, a 9 byte request with a 50 byte response and a 9600 baud MCC channel overhead would take approximately 9 mS for local receipt, plus 9 mS to send via the MCC, plus 250 mS satellite time, then for the response, approximately 6 mS processing time, 50 mS to send, plus 250 mS satellite return time, plus 50 mS to retransmit to the originator. That is a total of approximately 624 mS. If the MCC overhead rate was lowered to 1200 baud then the time would increase to approximately 1237 mS! The originating controller must be set up to accept this order of delay.

2.0.5.5 Far End Modem Control via the ESC

The M500, and the M5 series modems equipped with the multiplexer, also have an overhead channel or Engineering Service Channel (ESC), which can be used to relay multiple types of control messages from one station to another. Although it requires more connecting cables, this method has several additional configurations not possible using the MCC.

The ESC is an asynchronous overhead channel capable of being formatted as either RS-232 or RS-485 physically. To use the ESC for control of one or more modems at a far end, the ESC locally is connected to a controlling computer. The ESC at the far end of the link is looped back into the modem's normal control port at J6. To control a single far end modem the physical connection could be either RS-232 or RS-485, but if RS-485 is chosen then multiple modems at a remote location can be controlled by simply daisy chaining the RS-485 to each modem. The ESC at the two ends of the link do not have to be the same physical protocol or even the same data rate since the ESC channel contains buffering at both ends.

Since the ESC channel is simply a link, and knows nothing about the information being carried, it can also be used to control a single far end modem using the VT100 control mode. This mode is limited to a single modem however since that method does not use addresses to point to a particular modem. The VT100 mode has the advantage that all of the programming required is contained within the modem. The controller simply needs to be a dumb terminal or a PC running a terminal emulation program like Hyperterminal in a Windows OS PC.

For information on building the cables needed to connect a computer or a modem's control port to the ESC port connections on the modem's Aux Port (J4), see Appendix C, Cabling, Section 3.

2.0.5.6 Remote Facility Control Channels (RFC)

When the Multiplexer is placed into the "Custom" mode the auxiliary control RFC channels becomes available. These consist of two single line or "one-bit" control channels that can be used to send control information independently in both directions over the link. The input signals on these channels can be either a contact closure or a logic type signals while the output is a form C relay contract set whose state depends on the state of the input signal. The low input logic level is 0 to 0.8 VDC, while the logic high level can be from 2.0 to approximately 5 VDC. This includes normal "TTL" logic levels. The input is current limited to accept temporary inputs up to approximately 20 VDC without damage. Higher voltages may damage the inputs however and caution should be exercised.

The RFC input has an approximate 1 mA pull-up and can therefore also accept a contact closure as the input signal.

When modem power is removed or the demodulator is unlocked the output relay state will be in the Normally Open state. When locked a logic 1 input will result in a Normal Open state. A logic 0 or contact closure on the input will result in the output relay being driven to the Normally Closed state.

2.2 Controlling the Optional Multiplexer Functions

Any of the Multiplexer properties can be programmed from the front panel or remote control interface. Like other properties of these modems the latest configuration of the Multiplexer are saved in non-volatile memory and re-instated on power up.

Optional parameters for operation of the multiplexer are added to the front panel display as required. For example if both multiplexer are disabled then the only parameter available is the one to enable these functions, as well as the Unit Status read only parameter that indicates that the modem is so equipped. When the multiplexer is enabled new options become available in the front panel matrix allowing setting of the "Standard", "Enhanced" or "Custom" multiplexer operating modes, and the optional ESC channel format. Parameter settings for the Multiplexer functions appear in the "Mux" columns when either the "Mod" or "Dem" front panel buttons are pressed.

> *NOTE:*
> *The user does not have to compute aggregate rates for operation with either of these 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.*

There is an exception to automatic setting; that is when the aggregate rate would exceed the maximum data rate capacity of the modem. For example, if a PSM-500 modem with feature set M505 (very close to a Standard PSM-4900) is operating at 4.8 Mbps and the multiplexer is enabled in either standard or Enhanced mode then the aggregate rate required would be 4.8 Mbps times 16/15 or 5.12 Mbps. Since this exceeds the maximum aggregate rate of 5 Mbps (4.92 for a PSM-4900) then the modem will sound 4 quick beeps and set the modem to the maximum possible terrestrial rate of 4.92 times 15/16 or 4.6125 Mbps.

2.2.1 Scrambler Selection Notes

Four main scrambler options are provided in the M500 modem plus some alternatives for special cases. In normal operation we recommend the "Auto" option, which adjusts automatically for the types of features enabled in the Reed-Solomon as shown below. The Auto selection is not available in any of our previous modems, and is an attempt at making selection from the ever increasing list of scramblers easier.

The PSM-4900 IESS-308 Scrambler is closest to the new PSM-500 Auto scrambler, but less competent. In normal interoperation between a PSM-500 and a PSM-4900 the PSM-500 would be set to Auto while the PSM-4900 would be set to IESS-308. The exception to this is when the FEC is in a TPC mode. The PSM-500 is left in Auto (which will automatically select a TPC sync mode while in the Auto mode), while the PSM-4900 will be set itself to "TPC Sync" and should be left there.

The synchronous scrambler is synchronized by a special "multi-frame" bit that occurs every 64 frames, or approximately every 32 k bits. If the synchronous scrambler is turned off the IBS decoder can usually lock in 2 frames. If the synchronous scrambler is enabled then frame lock will take 64 times as long. At low data rates and in the custom mode this can take significantly longer to lock the modem.

Auto Scrambler Mode Operation
The new PSM-500 Auto scrambler mode is the equivalent of a combined IESS-308 selection plus a IESS-309 selection plus a TPC Sync selection. The automatic select even extends to "CT" or

comptetitive technology FEC modes, where the same scrambler setup as the competitive modem uses is automatically selected. In other words it automatically selects the optimum and standard scrambler for other operation mode settings. When a PSM-500 series modem in linked to another PSM-500 series modem it is recommended to leave the Auto mode enabled.

Fixed Scrambler Mode Operation
The PSM-500 also permits setting a fixed scrambler from the following selection if desired.

- ❑ **V.35** - The standard self synchronized scrambler.
- ❑ **Intelsat** - Another standard self synchronized scrambler.
- ❑ **Alt V.35**
- ❑ **Alt Intelsat**
- ❑ **EFD**
- ❑ **IBS Sync**
- ❑ **Disabled**

V.35 and Intelsat scrambler modes use the V.35 and Intelsat self-synchronizing scramblers respectively in all modes. The alternate V.35 and alternate Intelsat scrambler mode performs a data inversion required by some "Comstream" modems.

2.2 *Using the Multiplexer Function with the Turbo Product Codes Option*

There is no restriction on the use of the IBS Multiplexer with any current FEC.

3.0 Connections

3.1 *Connector J4 Pin Assignments for the IBS Multiplexer*

The IBS Multiplexer function requires connections for the ESC overhead communications channel and the available RFC one-bit transfer/alarm input and output. These are brought out on the "AUX" DB37 male connector, J4, on the modem's rear panel as shown below. Note that when the multiplexer is used in the "Standard" IBS mode no buffering is provided and therefore the only way to synchronize the data is via the provided clocks. The proprietary "Enhanced" and "Custom" modes provide buffering to standard asynchronous data rates and therefore do not require clocks.

> RS-232 Standard Mode Connection (synchronous)
> > RS-232 Transmit on pin 4 (input to modem, sampled on rising clock edge)
> > RS-232 Receive Clock on pin 13 (output from modem)
> > RS-232 Receive on pin 6 (output from modem, changes on falling clock edge)
> > RS-232 Transmit Clock on pin 7 (output from modem)

> RS-232 Enhanced/Custom Mode Connection:
> > RS-232 Transmit on pin 4 (input to modem)
> > RS-232 Receive on pin 6 (output from modem)
> > RS-232 CTS on pin 7 (output from modem)
> > RS-232 RTS on pin 9 (input to modem)
> > RS-232 DSR on pin 11 (output from modem)
> > RS-232 DTR on pin 12 (input to modem)
> > RS-232 DCD on pin 13 (output from modem)

RS-485 Connection:
> RS-485 Transmit A on pin 11 (output from modem)
> RS-485 Transmit B on pin 6. (output from modem)
> RS-485 Receive A on pin 12 (input to modem)
> RS-485 Receive B on pin 4. (input to modem)

User Remote Facility Control channel A
> Pin 33 - RFC channel A Input (TTL, Internal 1mA Pull-Up)
> Pin 34 - RFC channel A Form-C Common
> Pin 35 - RFC channel A Form-C N.C.
> Pin 16 - RFC channel A Form-C N.O.

User Remote Facility Control channel B
> Pin 15 - RFC channel B Input (TTL, Internal 1mA Pull-Up)
> Pin 17 - RFC channel B Form-C Common
> Pin 18 - RFC channel B Form-C N.C.
> Pin 36 - RFC channel B Form-C N.O.

Grounds
> Pins 14, 19, 20, 32, 37

Caution: The RFC relay outputs are designed for low voltage control signals and are not intended for AC or power line switching.

***** End of Appendix MUX *****