Appendix RS

Framing/Multiplexer/Reed-Solomon Codec Addendum

1.0   Optional Framing/Multiplexer/Reed-Solomon Codec Interface Card

The installation of the optional Interface Card provides the PSM-512/1500/2100 (both 70 MHz and L-band versions) modems with a greater level of functional capability. It is provided in two possible configurations:

1)   Framing and IBS Multiplexer, and

2)   2) Framing and IBS Multiplexer with Reed-Solomon Codec.

The Reed-Solomon codec may be added later to a multiplex-only card. The following are general descriptions of the characteristics of each of these cards. A common clock generator circuit is used to support both the multiplexer and Reed-Solomon codec. Because of this it is not possible to purchase a Reed-Solomon option by itself. However, when equipped with both capabilities, either may be enabled independently.

For the purposes of the remainder of this document the conventions for naming the different rates of data entering and leaving the modem are:
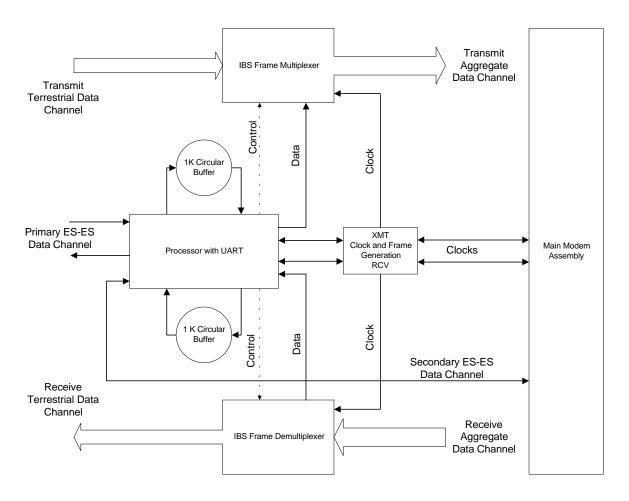
- "*Aggregate*" data rate. The data rate that the modem transmit and receive is operating at. This rate is always the same as or higher than the terrestrial data rate and is the rate that includes the terrestrial rate plus the multiplexer overhead plus the Reed-Solomon overhead.
- "*Terrestrial*" data rate. The data rate presented on the main modem rear panel data interface connector for connection to the DTE line side.
- "*ES to ES*" data rate. The overhead channel rate presented as a service or overhead channel on the modem rear panel ES to ES connector.

Bit time delays introduced by the Multiplexer and Reed-Solomon functions are given in the Unit Specifications, Appendix A.

1.1   Framing/Multiplexer Capability

The framing/multiplexer is capable of multiplexing a relatively low speed overhead channel onto the terrestrial data stream resulting in a slightly higher combined or aggregate data rate through the modem. The overhead channel is recovered at the far end. This added channel is termed variously an overhead channel, service channel, "asynch" channel or in Intelsat IESS terminology an "ES to ES data channel" (for Earth Station to Earth Station). A simplified block diagram of the data multiplexer is shown in Figure RS-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.
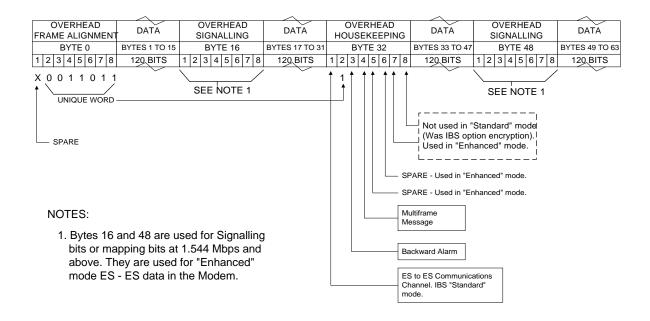
In addition to the overhead channel various other information is transferred between the two ends of the link. This information consists of status represented by fixed bits within the frame structure. The "Frame" is the method used to synchronize information at each end, allowing recovery of the separate channels that are multiplexed or "mixed" together for transmission. The frame structure is shown below in figure RS-2 below. One set of bits is also used to provide an independent channel by which the two modems themselves may communicate, providing the capability for Automatic Uplink Power Control (AUPC) without the necessity of a separate multiplexer.

IBS Frame Multiplexer

Transmit Terrestrial Data Channel

Transmit Aggregate Data Channel

1K Circular Buffer

Control

Data

Clock

Primary ES-ES Data Channel

Processor with UART

XMT Clock and Frame Generation RCV

Clocks

Main Modem Assembly

1 K Circular Buffer

Control

Data

Clock

Receive Terrestrial Data Channel

Secondary ES-ES Data Channel

IBS Frame Demultiplexer

Receive Aggregate Data Channel

IBS Multiplexer Simplified Block Diagram

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 RS-2 below.

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   SEE NOTE 1   1   SEE NOTE 1

UNIQUE WORD

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 as the unit does not operate at a 1544 or 2048 Kbps data rate. Two software controlled modes are designed into the card to best utilize the available bits; "Standard IBS" and "Enhanced". The characteristics of the channel interface are also determined by the standard or enhanced mode.

The ES to ES Data Channel can be set under software-control to either RS-232 or RS-485 mode. The pin assignments for both modes are shown in Table RS-1. The RS-485 Transmit Data Drivers can set to "RS-485" or "RS-485 ON" when in "enhanced" mode. The "ON" setting forces the driver continuously on while the "RS-485" setting controls the output into tri-state when the modem is not transmitting data, allowing multiple modem outputs to be connected together. In the standard IBS mode only the "RS-485 ON" mode is available.

In Enhanced mode a 2 wire receive operating mode can be selected for the receive data into the ES-ES 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.

Table RS-1. RS-232/RS-485 Pin Functions

DB9 Pin	Function
1	RS-485 Transmit Data B (+)
2	RS232 Transmit Data
3	RS232 Receive Data
4	
5	GND
6	RS-485 Transmit Data (A) -
7	
8	RS-485 Receive Data B (+)
9	RS-485 Receive Data A (-)

1.1.1   Standard IBS Mode

In the first or "Normal" 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* Its the	This bit is routed directly to the ES to ES Data Channel. 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 ES to ES data channel in standard IBS mode are raw channels operating at the specific bit rate as controlled by the data channel rate, without buffering. Also no clocks are provided with this channel. Since it would be rare that the data rate provided was exactly that required for a standard rate device, the only method of communicating using this channel is to allow it to super-sample the user data. The ES to ES data channel rate should normally then be a minimum of 3 times the desired asynchronous rate to work properly, while 4 times the desired rate would have fewer errors.

1.1.2   Enhanced Multiplexer Mode

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 the PSM-2100 is at both ends of a link. In this mode, the overhead signaling bytes 16 and 48 can be used to implement a significantly higher speed ES to ES Data Channel under software control. When implemented, this rate is 16 times that of the normal IBS standard, or $1/30^{th}$ 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.

> NOTE: The Enhanced IBS mode MUST be selected for true Asynchronous channel operation to be available.
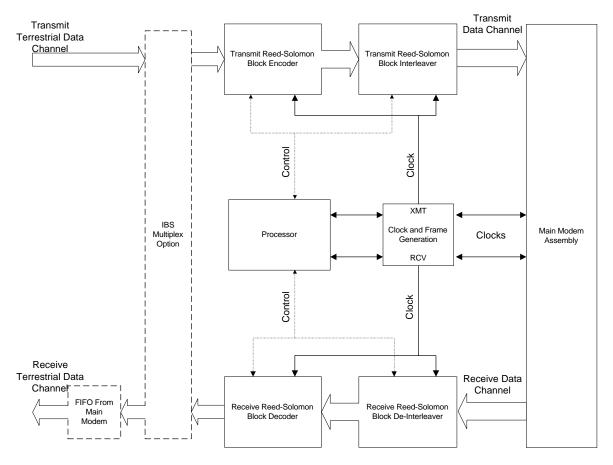
The microprocessor on the interface board performs software/hardware assignment of bits to specific purposes in the enhanced mode and buffers the ES to ES Data Channel to standard asynchronous data rates. The secondary ES-ES modem channel should normally be at 300 bps minimum in order to maintain a sufficient loop response time when using Automatic Uplink Power control. Therefore, if the aggregate rate results in a secondary ES-ES modem channel rate less than 300 bps minimum (approximately 25 Kbps) then the Overhead Signaling bytes are commandeered for this purpose. The primary ES-ES 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 primary and secondary ES-ES channels each contain both transmit and receive data buffers which are 1024 bytes in length. These act as long FIFOs on the data in each direction. No data is lost if the actual ES-ES 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 4.8 Kbps receive while the other end may have 9.6 Kbps receive and 1.2 Kbps transmit. Needs diagram.

1.2 Reed-Solomon Codec Capability

The addition of a Reed-Solomon codec places a second Forward Error Correction (FEC) process outside of and in series with the existing Viterbi FEC. The two FECs are thus considered "Concatenated". In addition, the data between the two FECs is "interleaved" which effectively reduces the possibility of multiple consecutive errored block symbols, thus improving the Reed-Solomon Codec performance. The performance improvement achieved by this combination is significant. 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.

A simplified block diagram of the Reed-Solomon Codec is shown in Figure RS-3 below.

Reed-Solomon Codec Simplified Block Diagram

The clock generation for the RS Codec is accomplished in the same Framing/Multiplexer circuits used for the IBS Multiplexer and ES to ES Data Channel. The R-S codec uses a single block format of 126,112,7. The ratio of encoded to un-encoded transmission is 9/8.
The Reed-Solomon Codec function can be turned on and off under software control, and is independent of the IBS ES to ES Data Channel enabling.

1.3 Controlling the Optional Multiplexer and R-S Functions

The PSM-512, PSM-1500 and PSM-2100 Modems Automatically recognize the presence of the optional capabilities when this interface card is installed. Any of the Multiplexer and Reed-Solomon (when equipped) properties can be programmed from the front panel or remote control

interface. Like other properties of these modems the latest configuration of the Multiplexer and R-S are saved in non-volatile memory and re-instated on power up.

Optional parameters for operation of the multiplexer and R-S are added to the front panel display as required. For example if both multiplexer and R-S are disabled then the only parameter available is the one to enable these functions, as well as the interface status read only parameter that indicates that the modem is so equipped. When the multiplexer is enabled new options become available allowing setting of the "standard" or "enhanced" multiplexer operating modes, and the option to ES to ES channel format.

> *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 this automatic setting when the aggregate rate would exceed the maximum data rate capacity of the modem. For example, if a PSM-2100 is operating at 2.048 Mbps and the multiplexer is enabled then the aggregate rate required would be 2.048 times 16/15 or 2.184533 Mbps. Since this exceeds the maximum aggregate rate of 2.10 Mbps then the modem will sound 4 beeps and set the modem to the maximum possible terrestrial rate of 2.10 times 15/16 or 1.96875 Mbps.

1.4   Configuring the Interface Standard

The Interface can be configured for 1 of 3 standard types: RS-449, RS-232 or V.35. Configuring the interface consists of inserting the correct driver/receiver ICs into sockets on the board and installing the correct cable/connector between the interface board and the rear panel. The table below and the following pictorial of the interface card shows the appropriate IC and cable installation for each standard.

IC	RS-449	RS-232	V.35
U1	26LS32	Not Installed	Not Installed
U2	26LS31	Not Installed	Not Installed
U3	26LS31	Not Installed	Not Installed
U4	26LS32	Not Installed	Not Installed
U5	Not Installed	Not Installed	LTC1345
U6	Not Installed	MAX231EPD	MAX231EPD
U7	Not Installed	MAX231EPD	Not Installed
U8	Not Installed	MAX231EPD	Not Installed
Interface Cable	DB37 to P1	DB25 female to P3	DB25 female to P2

Note that the RS-232 is a synchronous RS-232 standard intended for special applications. It is not the same as asynchronous RS-232 commonly used on personal computers.

1.4.1   Installing a Multiplexer/Reed-Solomon Interface Card

Assuming that the modem is already equipped with a standard Interface card, then the procedure for changing to a Multiplexer/Reed-Solomon Interface card is very straightforward. First remove the standard interface card by removing the 40-pin ribbon cable connection to the main modem assembly, then removing the data and overhead channel cables at the interface card end. Ejector latches are provided on the card end to facilitate removal. Note the location of the cables on removal.

Next remove the 4 screws and lock washers holding the interface card to the chassis base. The new card should have the proper interface chips installed for the interface protocol desired. Refer to the section above on "Configuring the Interface Standard" and the card diagram below for particulars.

Install the new Multiplexer/Reed-Solomon Interface card by the reverse of the above procedure, insuring that the 4 screws are at approximately 200 in-oz torque.

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.

1.4.2   Adding Reed-Solomon to a Multiplexer Interface Card

Interface cards originally configured as Multiplex only can be converted to add Reed-Solomon codec capability by adding the proper ICs to the interface card. These parts are fairly specialized and can be obtained as a "kit" from the manufacturer. The following figure shows the Integrated Circuits concerned. Carefully install the ICs insuring that they are correctly oriented and fully seated. Double check your work, then reinstall 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 parts by showing "IBS & RS Interface". The modem is now ready to be put into service.

DSA96-003 REV( )

U25

U16

U15

U12, U15
and U16
Installed in
R-S Option

MAX489

MAX231

U13

U12

H/O

P4

U6

U7

U8

MAX231 X 3

RS232

U5

LTC1345

P3

P2

V.35

26LS32

U4

U3 26LS31

U2 26LS31

U1 26LS32

RS449

P1

P5

IBS/R-S Interface

■ = RS-449
● = V.35
▲ = RS-232