STAR EMC Tower FEE Crate to Tower Data Collector
Data Transmission Specification
Draft 10/4/99

In order to meet the STAR EMC requirements a unidirectional glass fiber optic data transmission scheme was chosen, which provides the needed bandwidth, total ground isolation, and high noise immunity. Raw data transmission specifications are as follows:

Fiber Cable	62.5/125um glass SIECOR cable 001K38-311
Fiber Conectors	ST style SIECOR ceramic unicam 95-000-51
Optical Wavelength	1300nm
Optical Transmitter	HP HFBR-1119T, CTS 1261BCE, etc.
Optical Receiver	HP HFBR-2119T, CTS 1361BCE, etc.
Data Baud Rate	187 Mbaud NRZ (20 x RHIC clock)
Data Word Rate	18.7 Mbytes/sec (12 bit ADC data will be split into 2 bytes)
Data Serial Encoder	Cypress CY7B923 "HOTLink" used in encoded mode
Data Serial Decoder	Cypress CY7B933 "HOTLink" used in encoded mode

Since the standard Cypress "HOTLink" chips have a bit rate of 160-330 Mbps, and since FEE ADC data must be transferred synchronized with the RHIC clock, a simple scheme of transferring each 12 bit ADC value at the RHIC clock rate in 2 successive "HOTLink" bytes was chosen. This results in a byte rate for the "HOTLink" chips at 2 x RHIC, and an encoded baud rate of 187 Mbaud.

Bit alignment for HOTLink chip transmission

CHIP D7-0:	7	6	5	4	3	2	1	0
1st byte	7	6	5	4	3	2	1	0
2nd byte					11	10	9	8

Bit 0 is least significant, and bit 11 is most significant.

These 2 bytes will map directly into the 12 bit wide TDC memory. The unused 4 bits of the second byte will be ignored since there is no memory bits to store them. This is true for all parts of the transmission protocol.

FEE to TDC byte transmission protocol description

The full transmission protocol follows (last page), which includes header information and HOTLink special characters. HOTLink special characters will signal Event Start, Data Start, and Event End or Event Abort. If no data or command needs to be sent, then the HOTLink chip automatically inserts a sync word (K28.5), and the TDC ignores the sync characters. Also sync characters may be inserted and any time during the transmission as desired by the state machine driving the HOTLink TX chip.

The transmission begins with an Event Start, followed by a 8 byte header, a Data Start, 160 12 bit ADC words (split into 320 bytes), and ends with an Event End. Header information containing the Crate number, The Token number sent with the Event will be checked against the Token number received from Trigger and one of Error Flag bits set if they do not match. Trigger Command will provide for diagnostic information once the data is transferred to DAQ. The Crate number can be useful to determine if the proper FEE crate is connected to the desired input channel of the TDC. Since the TDC has 30 identical fiber input channels, there is a possibility of mixing up the fiber cables. The Token number and Trigger Command verify that the FEE crate decoded the trigger correctly.

FEE to TDC event semaphores

Four reserve bytes allow the TDC to add semaphore information before the event transmission and after event transmission. The TDC will set these bytes to FF hex, when it receives a Trigger for that Token number. This flags that TDC token data as invalid, because the memory locations contain the old data from the previous time the TDC wrote data to that Token number. When the FEE sends new data to the TDC, the new data stream will overwrite these bytes with 00 hex, which flags that the data is valid, but is in the process of being received by the TDC. When the transmission is complete, the TDC will overwrite these bytes again with a link word count, and error flags. Note that the 2^{nd} and 4^{th} transmission bytes are only nibbles.

Contents of Reserved Bytes:	1^{st}	2^{nd}	3^{rd}	4^{th}
TDC gets new Trigger	FF	F	FF	F
FEE reception begins	00	0	00	0
FEE reception ends	Received Word Count	0	Error Flag bits	0

FEE to TDC transmission before and after delays

Implementing semaphores requires that the TDC have time to write data to the TDC memory with proper timing with respect to the FEE to TDC event transmission. So the FEE to TDC protocol has delays before and after the Event body. The delay before transmission is given as 7 sync characters (about 370nS). This is a minimum time and is measured from the Trigger 5 x RHIC clock edge that contains the last nibble of the L0 trigger (all 20 bits), to the HOTLink clock edge that latches the “Event Start” C1.0 character into the TX chip. The delay after transmission is given as 5 sync characters (about 267nS). The STAR trigger busy should not be released until completion of this delay. This delay allows the TDC to write the “Received Word Count” and “Error Flag Bits” before another L0 trigger can appear.

Three Token readout for PP running

The above delays are sufficient so that the FEE to TDC events may appear back to back.

STAR Trigger Busy

Proper TDC operation requires that busy be asserted immediately after a given L0 trigger, so that no other L0 trigger will appear until the FEE to TDC transmission is complete.

FEE to TDC byte transmission protocol template

Delay before allows the TDC to write “New Token” semaphore:

Sync K28.5	Sync K28.5	Sync K28.5	Sync K28.5	Sync K28.5	Sync K28.5	Sync K28.5

The header protocol for a single event:

Event Start C1.0	Reserved Must be 0	Reserved Must be 0	Reserved Must be 0	Reserved Must be 0	Token # LSB	Token # MSN	Crate #	Trigger Command nibble

Immediately followed by the data protocol:

Data Start C2.0	ADC0 LSB	ADC0 MSN	ADC1 LSB	ADC1 MSN	ADC2 LSB	ADC2 MSN	……..

Repeating ADCn until:

……	ADC159 LSB	ADC159 MSN	Event End C 3.0

Or transmission may be aborted after the “Data Start” with:

…… …	Event Abort C 4.0

Final delay allows the TDC to write “Received” semaphore:

Sync K28.5	Sync K28.5	Sync K28.5	Sync K28.5	Sync K28.5

LSB = Least Significant Byte (8 bits)
MSN = Most Significant Nibble (4 bits)
Cx.0 = HOTLink special character codes where x is 1 to 3

Notes: Each box represents one byte sent by the HOTLink chip.
HOTLink chip sync=s (K28.5) can be added between any bytes at any time during the event.

The overall transmission has 320 bytes for the 160 12 bit ADC values, 8 bytes for the header, 3 command bytes, and 12 sync’s. The resulting timing is 343 bytes at 18.74 MHz which is 18.3uS.

This transmission scheme results in a 18.3uS transmission time from FEE crates to TDC