ConnTech 2000

# Introduction to ESCON and the ConnTech2000 Link/Bert Tester

IBM's Enterprise System Connection Architecture (ESCON) I/O interface provides an optical fiber communication link between host channels and control units that implement the Enterprise Systems Architecture/390. The ESCON I/O interface has the following key attributes over the parallel I/O interface.

- Higher data rates (10MB vs 4.5MB)
- Greater distance (3km vs 400ft)
- Lower bulk and weight
- Improved error isolation
- Optical I/O

## ESCON Components

An ESCON communication system consists of a number of different components, some of which are listed below.

### ESCON Channel

The ESCON Channel is the host-based channel connection that supports the ESCON architecture. It directs the flow of information between devices and host main storage and provides common controls for the attachment of different I/O devices

### Control Unit

An ESCON control unit provides the logical capability necessary to operate and control one or more I/O devices (cluster controller, tape drive, DASD) that can connect directly to an ESCON channel or Director port.

### ESCON Director

The Director, sometimes referred to as a "dynamic switch" is a switch that acts as a communications hub for ESCON channels. It provides the capability to physically interconnect any two links that are attached to it. Such a connection between two ports provides simultaneous two-way information transfer. When a connection is established the two ports and their respective point-to-point links are connected so that frames received by one of the ports is passed transparently to the other port. Such a connection can be either static or dynamic. A dynamic connection is set up and removed by delimiters or sequences in the flow of data through the ports; that is, when a connection is to be made addressing information in the frame determines to which port the incoming data should be routed. Start-of- Frame (SOF) and End-of-Frame (EOF) delimiters are used to initiate and remove dynamic connections.



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### Fiber Link

An ESCON fiber link is a full duplex, point to point, fiber optic connection between a control unit and a channel, a channel and a Director, a control unit and a Director, or a Director and another Director.

## Information Formats

The serial-I/O interface uses two distinct transmission units for sending information on the link: the frame and the sequence.

The major unit of transmission is the frame. Frames are used to transfer control information, data, commands, or status between a channel or control unit. A frame consists of an addressing field, a control field, and an optional informational field.

Sequences, including the idle sequence, are special groups of encoded characters used to indicate certain conditions that cannot be indicated using the protocols associated with the sending and receiving of frames. For example the idle sequence is sent out over the link when no other information is being sent.

## Protocols

Two levels of frame protocol are defined for ESCON connections: the link level and the device level. These levels represent logical collections of protocols for transferring information over a channel path. Refer to Figure 1.

### Link Level Facility

The link level facility manages the attached link, including all associated hardware communication protocols.

### Device Level Facility

The device level facility manages the execution of I/O operations for specific I/O devices. The device level facility allows transfer of information related to an I/O operation.

### Addressing

Two different levels of addressing are used for link level and device level protocols. Link level addressing identifies the physical path within a channel path to be used for communication between a channel and control unit. Device level addressing identifies an I/O device to the channel or control unit once the physical path and image are determined.



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## ESCON Channel Protocol Description

The ESCON channel protocol can be divided into three distinct protocols for transferring information over a channel path. The protocols are:

- Sequence protocol level
- Link protocol level
- Device protocol level

**Link and Device Protocol Frame Structure**

Both link level and device level frames use the same basic frame format which consists of a fixed length link header field, a variable length information field, and a fixed length link trailer. Every frame is bounded by a SOF delimiter, which is part of the link header and an EOF delimiter, which is part of the link trailer. Refer to Figure 2 and 7.

**Link Header**

The link header consists of four fields: SOF delimiter, destination address, source address, and link control field. Refer to Figure 3 and 7.

- Destination Address field identifies the link level facility of a channel or control unit that is the destination for the frame.

- Source Address field identifies the sending link level facility

- Link Control field indicates the type a format of the frame.

**Information Field**

For a link-control frame the length of the information field is from 0 to 104 bytes. For a device frame the length of the information field is from 5 to 1028 bytes. The information field of every device frame consists of a device header and a device information block (DIB). The device header is the first four bytes of the information field. Refer to Figure 4 and 7.

**Link Trailer**

The link trailer consists of a two-byte CRC field followed by the EOF delimiter. Refer to Figure 5 and 7.



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## Sequence Protocol Structure

**Idle function**

Idle characters are sent on the link to perform the idle function whenever no other frame or sequence is to be sent on the link. A minimum of 4 consecutive idle characters is required between frames to allow a dynamic switch to adjust (add or drop up to 2 idle characters) the number of idle characters between frames. This method is used to ensure that a frame-overrun condition does not occur at the switch due to the data recovery and resynchronization that is done at the same transmit and receive frequency.

**Not Operational Sequence (NOS)**

The not operational sequence is sent when a link failure is recognized because of conditions other than recognition of receiving the NOS sequence. The NOS sequence is also sent when performing an offline procedure and waiting to recognize the offline sequence.

**Connect Start-of-Frame delimiter (CSOF)**
**Passive Start-of Frame delimiter (PSOF)**

The start-of–frame delimiter is the first string of transmission characters of a frame. There are two types of SOF delimiters, the connect-SOF which is used to initiate the making of a dynamic connection, and the passive-SOF which causes no action with respect to a dynamic connection.

**Passive End-of Frame delimiter (PEOF)**
**Disconnect End-of Frame delimiter (DEOF)**
**Abort End of Frame delimiter (AEOF)**

The end-of–frame delimiter is the last string of transmission characters of a frame. There are three types of EOF delimiters, the disconnect-EOF which is used to initiate the removal of a dynamic connection, and the passive-EOF which causes no action with respect to a dynamic connection, and the abort-EOF which is used to prematurely terminate the transmission of a frame.

**Unconditional Disconnect sequence (UD)**

The unconditional disconnect sequence is sent when a dynamic connection between the link and any other link is to be removed after certain abnormal conditions.

**Unconditional Disconnect Response sequence (UDR)**

The unconditional disconnect response sequence is sent when the link level facility receives and recognizes the UD sequence.



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**Offline sequence (OLS)**

The offline sequence is sent when the link level facility must inform the other end of the link to not recognize link errors or link failure. The OLS sequence is also sent when the NOS sequence is received and recognized.

### *Link Protocol Level*

Link protocol level processing provides the means by which the physical paths that make up a channel path and the elements interconnected by them are initialized and maintained in an operational state. Link control frames are used to establish and maintain the physical and logical paths over which I/O operations are executed.

### *Device Protocol Level*

Information associated with the operation of an I/O device is transferred between a channel and control unit in the information field of a device frame. The information field of every device frame consists of a device header and a device information block

**Device Header**

The device header is the first four bytes of the information field that identifies the I/O device for which the contents of the information field are intended along with other types of identifiers. Refer to Figure 6 and 7.

**Device Information Block (DIB)**

Data is transferred between a channel and control unit in the DIB of the data frame. The number of bytes of data sent in the DIB is determined by the parameters established at the start of the execution of the transfer.



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# ESCON Physical Layer

## Data Transmission

The data transmitted over a link is based on an 8-bit/10-bit nonreturn-to-zero code. Information to be transmitted is encoded eight bits at a time into a 10 bit transmission character sent serially across the link. In the 8B/10B transmission code the high optical power level designates a one bit while the low optical power level designates a zero bit. The data transmission rate is at 200 +/-0.04 megabits per second.

## ESCON Multimode Physical Layer

The multimode physical layer allows links to extend up to 3 kilometers (1.87 miles) using 62.5/125um multimode fiber cable or up to 2 kilometers (1.24 miles) using 50/125um multimode fiber cable.

## ESCON Multimode Transmit Interface Specification

Optical Output Power = Min -21dBm, Typical -17.7dBm, Max -14.5dBm
Rise Time = Typical 1.2ns, Max 1.7ns
Fall Time = Typical 1.2ns, Max 1.7ns
Center Wavelength = Min 1285nm, Typical 1325nm, Max 1355nm

## ESCON Multimode Receiver Interface Specification:

Optical Saturation Level = Max -14.5dBm
Optical Sensitivity = Min -31dBm, Max -14.5dBm

## ESCON Single-Mode Physical Layer

The single-mode physical layer allows links to extend up to 20 kilometers (12.4 miles) using dispersion-unshifted single-mode fiber cable.

## ESCON Single-Mode Transmit Interface Specification

Optical Output Power = Min –9.0dBm, Typical –6.5dBm, Max –2.7dBm
Rise Time = Typical 1.5ns, Max 1.7ns
Fall Time = Typical 1.5ns, Max 1.7ns
Center Wavelength = Min 1270nm, Typical 1310nm, Max 1340nm

## ESCON Single-Mode Receiver Interface Specification:

Optical Saturation Level = Max –2.7dBm
Optical Sensitivity = Typical -27dBm, Max –24.6dBm



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## ConnTech2000 Overview

The ConnTech "Link/BERT Tester" application will generate ESCON frames enveloped (or encapsulated) by valid ESCON "Start of Frame" and "End of Frame" delimiters. The ConnTech Link/BERT Tester uses the "Passive Start of Frame" and "Passive End of Frame" delimiters to envelope the frames. The ConnTech2000 does not allow/support the modification of the ESCON header values. The value of the "header positions" will be that of the selected "Data type". Refer to Figure 8. The "Data Rate" selection within the "Setup Options" window selects the amount of idle sequences that will be inserted in between each ESCON frame. This produces the over all data rate that is being transmitted with respect to the ESCON frame payload (payload is defined as only the Data Information Block within the frame, this omits any ESCON overhead protocol).

If the 19.6 MB data rate is selected there are a total of 4 idle sequences inserted between each frame, this is true for any "Data Size" selected within the "Data Options" window. Refer to Figure 9. If 14 MB is selected there are a larger number of idle sequences inserted between frames to insure the desired data rate is met.
This is also true for the 2.1 MB selection. The "Data Rate", "Data Size", and "Data Type" selections will determine what type of data transitions occur at the output stream and how often they will occur.

Bandwidth can be calculated by using the following equation:

$$\text{Bandwidth (MB/sec)} = \frac{\text{Payload size}}{\text{Payload size + Overhead}} \times \frac{\text{Speed (Mbaud)}}{10}$$

ConnTech2000 Full Rate Bandwidth calculation:

$$\frac{1015 \text{ bytes}}{1035 \text{ bytes}} \times \frac{200\text{Mb}}{10} = 19.613\text{MB}$$

The output of the two transmitters will send a continuous 8b/10b encoded 200Mb stream. Both RX1 and RX2 independently monitor for and report any ESCON error condition detected (CRC, Delimiter, Code Violation, Consecutive Idle errors, Link Status, etc). The difference between the RX1 and RX2 ports is that RX1 not only detects the standard ESCON error conditions it also has the ability to verify the data pattern for bit errors. RX2 cannot verify the data patterns for bit errors it only detects and reports the standard ESCON error conditions. Refer to the ConnTech2000 User's Guide Chapter 6.

When running the Link/BERT Test application the "Single" button selected in the "Inject Error" section of the window causes a single bit error to be injected into one of the ESCON frames. At this point the Rate and Count fields react to the detection of a bit error coming in on RX1. The bit error will not create a "CRC" error due to the fact that the bit error is injected before the CRC calculation and becomes part of the result. The "Inject Error" (single, 10-3, 10-6) function is only available when running at the full 19.6Mbyte rate. Refer to the ConnTech2000 User's Guide Chapter 7.



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The ConnTech "Generate Frames" application allows the user to create and detect all of the ESCON Ordered Sequences. Also it gives the user the ability to generate a single custom ESCON frame with or without a forced error condition. If an error condition is selected when the frame is launched the specific error condition will be reported when the frame and error is detected. Refer to the ConnTech2000 User's Guide Chapter 6.

The ConnTech "Analyzer/Trace" application monitors the IBM ESCON Channel running Native "S" Channel traffic between an "Control Unit" and a "Channel" device. In the analyzer mode the ports act as an active "pass though" tap that supports full duplex operation from an IBM native "S" channel control unit and channel device. The ConnTech has the ability to monitor and trigger on specific ESCON patterns. Both RX1 and RX2 independently monitor for and report any ESCON error condition detected. Refer to the ConnTech2000 User's Guide Chapter 5.

**ConnTech2000 Error Reporting Definition**

CRC Error - CRC (cyclic redundancy check) error has been detected at the receiver logic block of the ConnTech2000. If this flag is set the data within an ESCON frame has been corrupted

Code Violation - an 8b/10b code violation has been detected by the receiver logic block of the ConnTech200. If this flag is set an encode error has occurred within an ESCON frame, an ESCON delimiter, or an ESCON Ordered Sequence.

SOF Error - an unexpected ESCON Start of Frame delimiter was detected at the receiver logic block of the ConnTech2000. If this flag is set the SOF character sequence of the ESCON frame has been corrupted.

EOF Error - an unexpected ESCON End of Frame delimiter was detected at the receiver logic block of the ConnTech2000. If this flag is set the EOF character sequence of the ESCON frame has been corrupted.

Cons Idle - the ConnTech2000 detected less than 4 valid consecutive idle characters have been sent between ESCON frames. The report does not necessarily indicate an error condition. This condition is dependent on the link configuration.

Ord. Seq - the ConnTech2000 detected less than 8 valid consecutive UD or UDR sequence characters have been transmitted between ESCON states. The report does not necessarily indicate an error condition. This condition is dependent on the link configuration.



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## ConnTech2000 ESCON Physical Interface

All the components used in the transmitter and receiver front end of the ConnTech are IBM ESCON compliant. The transmitter of the ConnTech uses a Type 2, second-order PLL filter. When the transmitter is fed by a low jitter clock source, typical output jitter will be less then 20ps (RMS) and 200ps (peak-peak). The ConnTech supports 2 physical interfaces, single-mode and multi-mode. Two separate Line Interface cards support the interfaces.

### ConnTech2000 Single Mode Physical Layer Interface

ConnTech2000 Transmitter Performance:

Data Rate = 200Mb Typical
Optical Output Power = Min -8.0dBm, Typical -5.0dBm, Max -2.0dBm
Rise Time = Min 0.5ns, Max 1.0ns
Fall Time = Min 0.5ns, Max 1.0ns
Center Wavelength = Min 1285nm, Typical 1310nm, Max 1355nm

ConnTech2000 Receiver Performance:

Data Rate = Min 10Mb, Max 200Mb
Optical Saturation Level = Max -14.0dBm
Optical Sensitivity = Min -32dBm, Max -14.0dBm
Optical Wavelength = Min 1270nm, Max 1380nm

Local Loop back testing at the box level will require an optical attenuator since the output level of the laser exceeds the max input level of the receiver. An attenuator of 15 dB will be sufficient.



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**ConnTech2000 Multi Mode Physical Layer Interface**

ConnTech2000 Transmitter Performance:

Data Rate = 200Mb Typical to 220Mb Max
Optical Output Power = Min -19.5dBm, Typical -16.0dBm, Max -14.0dBm
Rise Time = Min 0.6ns, Max 1.7ns
Fall Time = Min 0.6ns, Max 1.7ns
Center Wavelength = Min 1285nm, Typical 1320nm, Max 1355nm

ConnTech2000 Receiver Performance:

Data Rate = Min 10Mb, Max 200Mb
Optical Saturation Level = Max -14.0dBm
Optical Sensitivity = Min -32dBm, Max -14.0dBm
Optical Wavelength = Min 1270nm, Max 1380nm

The ConnTech2000 meets or exceeds the IBM Escon optical physical layer specifications as defined in the IBM Enterprise Systems Architecture/390, Escon I/O Interface, Physical Layer Document SA23-0394-00.

The ConnTech2000 generates Escon Data Frames and Escon Ordered Sequences that comply with the Link Level Transmission and Reception of Characters as defined in the IBM Enterprise Systems Architecture/390, Escon I/O Interface Document, SA22-7202.



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