IBM 4680 Store System

4680 SERIAL INPUT/OUTPUT ARCHITECTURE

Product Attachment Information

Contents

Link Definition

Multi-Point Network

1. All data transfers between control and device - no device to device data transfer
2. Control messages seen by all devices
3. Device must be polled to transmit data, status, or responses

Scope of Document

1. Control for data exchange between the Serial I/O Access Method/ Control Logic and the device 8051 Serial I/O microcode is defined
2. Device Access Method interface to the device functions is the subject of another document
3. All functions defined only for the delivery and verification of the delivery of data and control

Format of Data/Control/Status

1. All data, device control, and status transferred in a block designated as a frame
    a. Frames are numbered
    b. Frames require numbered responses
2. Control has capability to broadcast control or data to all devices simultaneously via unnumbered frames

″N on 1″ Considerations

1. Roundtop program/control logic has the capability to drive
    a. Its own cluster of attached devices
    b. One set of clustered devices attached to a Copper and appearing as two terminals to the operators
2. Each cluster has its own addressable link, but there is only one set of control logic driving the two clusters
3. The poll address contains two bytes
    a. Byte One (port address) selects the set of devices
    b. Byte Two selects the specific device on the link

Character Structure

Twelve Bit Asynchronous

1. Bit 1 = Start Bit
2. Bits 2 to 9 = Data Bits 0 to 7
3. Bit 10 = Address Bit
4. Bits 11 and 12 = Stop Bits(minimum)

Bit Rate = 187.5 Kbits per second

Intel 8051 Bit Definition

1. Up Level = ″1″ Bit
2. Down Level = ″0″ Bit

Transmission Order

All characters transmitted low order bit first (Data Bit Zero)

Framing Characters

1. All frames, except polls, begin with an address character with Data Bit Seven set to ″zero″ and terminate with a Flag Character
2. Polls are an address character with Data Bit Seven set to ″one″
3. End of Poll is a single character response to a poll when the device has no frames to transmit
4. Bit format
    a. Bit 1 = Start Bit (zero)
    b. Bits 2 to 9 = Framing byte
        1) Flag (7 to 0) = 01111110 X′7E′
        2) End of Poll (7 to 0) = 01011010 X′5A′
    c. Bit 10 = Address Bit (one)
    d. Bits 11 and 12 = Stop Bits (one)

Address Characters

1. Address characters are twenty-four bits long minimum
2. Bits 11 through 24 are Stop bits
3. Long address character used to provide receive setup processing time at the device
4. Length of address characters determined via the ″Address Wait Time″ parameter

Reserved Addresses

1. Broadcast Address (X′7A′)
    a. Used to transmit non-sequenced frames to all Serial I/O attached devices on a given port
    b. Bit structure (7 to 0) - 01111010
2. Idle Poll (X′B2′)
    a. Transmitted by Crystal during bring up for problem determination
    b. Bit structure (7 to 0) - 10110010

Training Sequence

When entering transmit mode twelve ″one″ bits must be transmitted to condition the receiver for the Start Bit of the first character

SDLC-Like Frame Structure

Use of Address Bit

1. Expands code table to 512 characters
2. Address bit = ″one″ defines Flag character, End of Poll character, and addresses
3. Address bit = ″zero″ defines data bytes, link control byte, and CRC bytes
4. Bit stuffing not required

Frame Checking

1. SDLC CRC polynomial (SDLC implementation rules to be observed)
2. CRC checking on the eight data bits
3. Frame rejected if
   a. Address bit = 1 and character is not address, Flag, or End of Poll
   b. First character and last character of the frame do not have Address bit = 1

Control Frame Formats

1. Poll - |24 ″one″ bits|Poll Address|24 ″one″ bits|Poll Address|
2. Data - |Address|Control| Data |CRC|CRC|FLAG|
3. Response - |Address|Control|CRC|CRC|FLAG|

Device Frame Formats

1. Data - |Address|Control| Data |CRC|CRC|FLAG|
2. Response - |Address|Control|CRC|CRC|FLAG|
3. Poll response (no data or status to transmit) - |EOP|

Framing in the Asynchronous Environment at the Device

1. Search for address character without regard to state of Data Bit Seven
2. Detect address
   a. If address has Data Bit Seven set to ″zero″
      1) Take data into receive buffer
      2) Terminate receive with the receipt of Flag character
   b. If address has Data Bit Seven set to ″one″
      1) Store address byte
      2) Continue search for address
      3) If next address received compares with stored address
         a) Send frame if device has one ready
         b) Send End of Poll character if no frame ready
   c. If not address, continue searching for address
3. Address with Data Bit Seven set to ″zero″ seen twice with no intervening Flag character

a. Abort previous partial frame if any

b. Start new frame if address

Receive Mode Timeout at Control Station

1. Start timeout when entering receive mode
2. Receive mode entered after each transmission of the poll address
3. Reset and restart with each received character
4. Reset on Flag or End of Poll
5. Length of timeout = 1.3 milliseconds
6. If timeout completes, timeout status, port address, and device address are posted to the program

Maximum Data Field Length in a Message Frame

1. 256 data bytes
2. Exceptions to this limit negotiated on an individual device basis

Control Character Definition

Commands (Control to Device)

1. Information (I)
    a. Used to send data, device control, status request
    b. Expected Responses
        1) Receive Ready is the normal response
        2) Information frame allowed as a response
        3) Frame accepted if receive count of the response equals the current control send count
    c. Only one Information frame can be sent to a given device at a time
    d. Included send/receive counts in the control byte are the current control send/receive counts
    e. Bit structure (7 to 0) - RRR0SSS0
2. Receive Ready (RR)
    a. Sent in response to an Information frame with no checking errors detected
    b. Implies ability to accept another Information frame
    c. Does not require a response
    d. Included receive count is the current control receive count
    e. Bit structure (7 to 0) - RRR00001
3. Non-Sequenced Information (NSI)
    a. Sent to broadcast commands or data to all devices (e.g. system commands such as ″software power on reset″)
    b. Required response is Non-Sequenced Acknowledge (NSA)
        1) Response is not permitted to a frame with a broadcast address
        2) System command ″Software Power On Reset″ does not require a response
        3) Request on Line (ROL) is expected reaction to ″Software Power On Reset″
    c. Does not alter any send or receive counts
    d. Bit structure (7 to 0) - 00000011
4. Set Normal Response Mode (SNRM)
    a. Sent to bring device on to the channel, usually after receipt of Request on Line from the device
    b. Resets send/receive counts to zero for that device at both the device and the control
    c. Required response is Non-Sequenced Acknowledge (NSA)
    d. Bit structure (7 to 0) - 10000011

Responses (Device to Control)

1. Information (I)
    a. Used to send data, status
    b. Expected responses
        1) Receive Ready is the normal response
        2) Information frame is allowed as a response
        3) Frame accepted if receive count of the response equals the current device send count
    c. If no response, retransmit the frame on every poll
    d. Device may transmit only one frame on any given poll cycle
    e. Included send/receive counts are the current device send/receive counts
    f. Bit structure (7 to 0) - RRR0SSS0
2. Receive Ready (RR)
    a. Sent in response to an Information frame with no checking errors detected
    b. Implies ability to receive another Information frame
    c. Does not require a response
    d. Included receive count is the current device receive count
    e. Bit structure (7 to 0) - RRR00001
3. Non-Sequenced Acknowledge (NSA)
    a. Sent in response to Set Normal Response Mode (SNRM)
    b. Sent in response to Non-Sequenced Information (NSI) if address of the frame is not a broadcast address
    c. Implies acceptance of the control byte received
    d. Bit structure (7 to 0) - 01100011
4. Request on Line (ROL)
    a. Sent to indicate that initialization of the device is complete and the device is ready to get on the channel
    b. Retransmit this frame on every poll cycle until Set Normal Response Mode (SNRM) is received from control
    c. Only frames accepted when in the ROL transmitting mode are SNRM and system commands broadcast in an Non-Sequenced Information (NSI) frame
    d. No frames received in this mode, whether accepted or not, are responded to
    e. Bit structure (7 to 0) - 00001111
5. Command Reject (CMDR)
    a. Sent to indicate that the received control byte is not valid
    b. Sent on every poll cycle until Set Normal Response Mode is received from control
    c. Bit structure (7 to 0) - 10000111

Sequence Counts

1. Send count
    a. Incremented after each Information frame is transmitted
    b. Decremented at the start of retransmission of a frame
    c. Program increments send count when Information frame is given to the control logic to transmit, not when it is placed in the transmit queue
2. Receive count - Incremented after receipt of a frame that:
    a. Contains no checking errors
    b. The send count in the received Information frame is equal to the current receive count
    c. Information frames in the transmit queue and in the timeout queue have their receive counts updated prior to release to the control logic for transmission
3. Responses
    a. Appropriate response is generated whether or not another Information frame can be accepted
    b. When generating the response, attach the current receive count
    c. Acceptance of a frame is signalled by the receive count contained in the response, not the response itself

Action on Received Information Frames with no Checking Errors

1. Frame send count is equal to current receive count
    a. Accept the frame
    b. Generate the Receive Ready response
    c. Increment the receive count
    d. Include the incremented receive count in the response
2. Frame send count is not equal to the current receive count
    a. Device action taken
        1) Discard the frame
        2) Generate the Receive Ready response
        3) Do not alter the receive count
        4) Include the current receive count in the response
    b. Control action taken
        1) Frame send count is one less than the current receive count

            Action taken is same as the device action
        2) Frame send count not equal to or one less than the current receive count
            a) Discard the frame
            b) Post a sequence error to be logged
            c) Transmit Set Normal Response Mode (SNRM)
3. If an unacknowledged Information frame has been transmitted when this frame is received
    a. Frame receive count is equal to the current send count

1) The unacknowledged Information frame has been acknowledged and is released

2) Proceed to compare the frame send count to the current receive count to determine if the frame can be accepted

b. Control determines that the frame receive count is not equal to the current send count

1) Do not release the unacknowledged Information frame

2) Proceed to compare the frame send count to the current receive count to determine if the frame can be accepted

c. Device determines that the frame receive count is not equal to the send count

1) Discard the received frame

2) Retransmit the unacknowledged Information frame on the next poll cycle

Polling Scheme

Control Logic Polls Continuously

Program Has Open/Close Capability with the Control Logic

Polling List

1. Each entry in the poll list is a two byte address
    a. Byte One defines the port
    b. Byte Two defines the device on the port
        1) A given device always has the same address, independent of the link (port) to which it is attached
        2) Any device only sees the addresses for its link
2. Given to control logic by the program
3. Stored in the shared memory of the program and the control logic
4. Program can add to/delete from list at any time
5. Each device, not each adapter, is assigned an address
6. Polling goes through the list sequentially
7. Polling stops when:
    a. Message frame received from a device
    b. Message frame to transmit from the program
    c. Receive mode timeout completes
    d. Close command received from the program
8. Poll cycle in process completes before polling stops
9. Polling resumes at the next address in the list

Responses to a Poll

1. EOP - Device is operational, but has no data or status to transmit
2. Message Frame - Device data or status received
3. Receive Mode Timeout (No Response)
    a. Program given status of timeout with address used on the poll cycle
    b. Polling continues at next address in the list

Program Control of the Polling List

1. Single receive mode timeout does not imply an error condition - device/8051 may be too busy to respond
2. Sixteen consecutive timeouts on the same device is considered an error condition - the program may remove that device from the poll list

Message Frame Transmission - Control to Device

Program Generates Message for the Device

1. Message contains port address, address wait time parameter, device address, link command, device or system command, data, and CRC bytes
2. Program issues transmit request to control logic
3. Control logic completes poll cycle in progress
4. Control logic grants control of the shared buffer to the program
    a. Program processes any received frame in the shared buffer
    b. Program transfers message to the transmit buffer
    c. Send count incremented by the program
5. Program awaits a response

Control Logic Transmits the Message Frame

1. Removes the port address from the message block
2. Removes address wait time parameter from the message block
3. Pauses after transmission of the address character
    a. Length of pause determined by value of address wait time parameter
    b. Address wait time parameter allows idle time on the link between the address character and the link command for the device code to set up for a receive operation
    c. Unless device requires more time, parameter should be set to allow twelve (12) bits of idle time
4. End Flag inserted after the CRC bytes
5. Response received on a subsequent poll of this device
6. Control logic passes response to the program

Device Responses to a Message Frame

1. Receive Ready (RR)
    a. Correct receive count
        1) Message frame has been delivered
        2) Clear the buffer
        3) Process next queued message or resume polling
    b. Incorrect receive count
        1) Message frame has not been delivered
        2) Retransmit message at the program's discretion
2. Response timeout (Program controlled)
    a. Message has not been delivered
    b. Retransmit message at the program's discretion

c. Length of timeout = 300 milliseconds

Broadcast Frame to all Devices

1. Non-Sequenced Information command used
2. Broadcast address used - bit structure (7 to 0) = 01111010 (X′7A′)
3. No response is allowed to a frame with a broadcast address

Message Frame Transmission - Device to Control

Control Logic Receives Message Frame in Response to a Poll

Frame Checking

1. Frame begins with an address character; ends with a Flag
2. CRC checking detects no error
3. No characters other than Flag and address have the Address Bit set to ″one″
4. Send count is proper

Program Generates Response to be Transmitted

1. Receive Ready with correct receive count if no checking errors
2. If checking detects any error
    a. Discard the frame
    b. Do not generate a response

When the Device Receives the Response

1. Response indicates frame has been delivered
    a. Frame has been delivered
    b. If next frame is ready, transmit the next frame when polled
2. Response indicates the frame has not been delivered
    a. Retransmit the frame on each poll until response is correct or program transmits SNRM frame
    b. Set status if undeliverable
3. No response received prior to the next poll - retransmit the frame until correct response is received or SNRM frame is received

Device Adapter Groundrules

Transmit Only When Polled

Poll Address

1. Nothing to transmit - send EOP
2. Data or status to transmit - send message frame
3. No response received to previously transmitted frame - resend the frame
4. Response to transmit - send response frame

Message Frame

1. No errors detected - send Receive Ready with proper receive count when polled
2. CRC error or other check condition - do not respond
3. Device status condition preventing further receipt of frames
    a. Set status condition
    b. Transmit Receive Ready when polled
    c. Report status condition in I format frame on next poll

Response After Transmitting a Message Frame

1. Response indicates frame has been accepted - clear buffer
2. Response indicates frame was not accepted - resend frame when polled
3. No response - retransmit frame when polled until correct response received or SNRM frame received

Timeouts

1. None required for link control purposes
2. Device dependent for service requirements if required
    a. Set visual indication of the problem
    b. Do not transmit without Control permission (polled)

Control Segment Groundrules

Poll Responses

1. EOP - go to next poll address
2. Message frame - perform checking and send status and frame to the program
3. Receive mode timeout - inform program and append address of the polled device

Received Message Frame Responses

1. No CRC error or other check condition - program generates Receive Ready with proper receive count
2. CRC error or other check condition - do not respond

Program Action on Responses to Transmitted Message Frame

1. Receive Ready with proper receive count - resume polling or transmit queued frame as instructed by the program
2. Receive Ready with incorrect receive count
    a. Program retransmits the frame if the count is one less than the current receive count
    b. Program transmits Set Normal Response Mode (SNRM) if count is other than one less than the current receive count
3. Program timeout - retransmit the frame

Error Control

CRC Checking

Address Bit Checking

Send/Receive counts

Timeouts at the Control Segment Only

1. Receive mode timeout (Control Logic)
2. Response timeout (program)

Frame Receipt/Delivery When Error Occurs

1. Retransmission of frames
2. Status set if message frames cannot be delivered

Device Error Recovery

1. 8051 must not get lost due to ESD, PLD, EMC, etc.
2. Hardware timer or equivalent function is required
    a. Timer must be reset periodically by 8051 microcode
    b. If timer completes, 8051 is brought back to the ″Power on Reset″ state
    c. 8051 transmits Request On Line when polled
    d. Control brings device to the point where interrupted so that the operation can complete
3. 8051 must at least be able to reestablish Serial I/O communication after a hit

Control Segment - Program/Hardware Interface

Program and Control Logic Interface to Each Other via a Shared Buffer

Transmitting to a Device

1. Program
    a. Generates eight bit bytes including
        1) Port address
        2) Address wait time parameter
        3) Device address
        4) Control byte
        5) Data
        6) CRC bytes
    b. Issues transmit request to the control logic
2. Control logic
    a. Completes the poll cycle in progress
    b. Suspends polling
    c. Notifies program if a frame has been received on the completed poll cycle
    d. Issues a transmit grant to the program
3. Program
    a. Processes the received frame, if any
    b. Updates the send and receive counts if a frame received
    c. Inserts current send/receive counts for the device in the message block
    d. Releases the message block to the transmit buffer for transmission by the control logic
4. Control logic
    a. Removes the port address from the block
    b. Removes the address wait time parameter
    c. Generates the idle time after the address on the link defined by the address wait time parameter
    d. Adds the Flag character after the CRC bytes at the end of the block
    e. Logic converts eight bit bytes to twelve bit asynchronous character format by appending
        1) Start bit
        2) Address bit
        3) Two Stop bits
    f. Transmits frame
5. Following frame transmission, the control logic resumes polling at the next sequential address or processes another transmit request from the program

Interrupt to Program During Polling Operation

1. Frame received
    a. Control logic performs frame checking - generates checking status
    b. Control logic removes Start bit, Address bit, Stop bits (converts back to eight bit byte format)
    c. Control logic appends the port address
    d. Port address, device address, control byte, data, CRC bytes, and checking status transferred to the program
2. Receive mode timeout - control logic transfers port address, device address, and timeout status to the program
3. EOP response to poll - no interrupt generated

Device Dependencies

Character Generation by the Program

1. Provided for printers and displays (not CRT)
2. Program transfers full line of print/display to the device

Overrun Conditions Detected in the Devices

Unique Device Keys (Paper Advance, e.g.)

1. Located on the device itself
2. Keyboard does not include unique keys for other devices

Output Devices Providing Feedback on Operation Completion

1. Information frame causes buffer full condition
    a. Update receive count
    b. Generate Receive Ready response with the updated receive count included
    c. When operation has completed, send Information frame with status
    d. Control may now transmit next Information frame
    e. Examples of these type devices are printers,hard totals
    f. Device cannot accept another I format frame until the Operation Complete I format frame has been transmitted
2. Information frame does not cause buffer full condition
    a. Update receive count
    b. Generate Receive Ready response with the updated receive count
    c. Control may transmit next Information frame after receipt of Receive Ready

Unique Device Requirements

1. Keyboard
    a. Buffer for up to six characters provided to ease poll cycle requirements
    b. Transmit whatever characters are available when polled rather than wait until the buffer is full
2. Feature Adapters
    a. Poll list may contain an address for each external input/output interface
    b. If multiple devices attached to interface
        1) Device addressing is responsibility of adapter or application program
        2) Serial I/O addressing does not extend beyond the interface

System Requirements on Devices

Devices must accept at any time

1. Set Normal Response Mode (SNRM) frames
2. Frames containing system commands

Implementation Example: Control (Program) to Device

CONTROL Send	CONTROL Rcv	CONTROL Transmit	DEVICE Transmit	DEVICE Send	DEVICE Rcv	Comments
0	0			0	0	Initial condition
1	0	--I(0,0)->		0	1	Counts incremented
1	0		<-RR(1)--	0	1	Device responds
2	0	--I(1,0)->		0	2	Counts incremented
2	0		<-RR(2)--	0	2	Device responds
2	0	--I(2,0)		0	2	Control puts frame in queue, does not increment count
2	1		<-I(0,2)--	1	2	Status frame transmitted
3	1	--I(2,1)->		1	3	Queued frame transmitted*
3	1		<-RR(3)--	1	3	Device responds
4	1	--I(3,1)->		1	4	Counts incremented
4	1		<-RR(4)--	1	4	Device responds

* Device receives frame and accepts frame as the receive count in the received Information frame acknowledges the acceptance by control of the device's transmitted Information frame.

Groundrules:

1. Interlock between the program and the control logic guarantees send/ receive counts are not updated until the frame leaves the transmit queue. The control logic cannot poll after granting the program a transmit request. The program will process any frame received as a result of a poll cycle which was in progress when transmit request was issued prior to removing the frame to be sent from the transmit queue.
2. If the device has an unacknowledged Information frame, the receive count in the received Information frame is compared to the current send count of the device. If these counts compare, the frame is accepted. The device's transmitted frame is acknowledged. If these counts are not equal, the frame is rejected and the unacknowledged Information frame is retransmitted on the next poll cycle for the device.

Implementation Example: Input Device to Control (Program)

CONTROL			DEVICE			
Send	Rcv	Transmit	Transmit	Send	Rcv	Comments
0	0			0	0	Initial condition
0	1		<-I(0,0)--	1	0	Counts incremented
0	1	--RR(1)->		1	0	Control responds
0	2		<-I(1,0)--	2	0	Counts incremented
0	2	--RR(2)->		2	0	Control responds
0	2	--I(0,2)		2	0	Control puts frame in queue, does not increment count
0	3		<-I(2,0)--	3	0	Counts incremented
1	3	--I(0,3)->		3	1	Queued frame transmitted*
1	3		<-RR(1)--	3	1	Device responds
1	4		<-I(3,1)--	4	1	Counts incremented
1	4	--RR(4)->		4	1	Control responds

* Input device accepts an Information frame from control when it has an unanswered Information frame it has transmitted if the receive count in the received frame verifies delivery of the unanswered device frame.

Groundrule:

Control Program always accepts an Information frame when the frame send count is equal to the current receive count. If the control has an unacknowledged Information frame in the timeout queue, this frame is released if the received frame receive count equals the current send count. If this compare indicates the counts are unequal, the receive count is updated on the frame in the timeout queue and it is retransmitted with the updated receive count when the timeout completes.