

IBM 1401 Tape Channel Analyzer  
Specification  
Version 0.3  
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## Change History:

### Version 0.3:

Major additions were made in this version.

- The division of work between the Adapter hardware, Adapter firmware, Application Communications Daemon, and Applications is described and ready for design review.
- The Adapter Section now contains sufficient detail to warrant a design review. The use of PIC hardware facilities (I/O ports, Interrupts, and Timers) is described. Firmware functionality is outlined and assigned to interrupt levels.
- The Application software and GUIs are described in sufficient detail to present a good understanding of how users will interact with the overall system, but are not ready for design review. Screen layouts and controls still need work. For example, the Tape Channel Analyzer Application GUI only displays the state of a single tape drive, it needs to display the status of all drives being monitored or emulated.
- The function of the Adapter Communications Daemon is only described at a very high level and is not ready for review.
- It is likely that there are contradictions in this document between early text and text that reflects more recent thinking. If you detect any of these contradictions, please notify me of their locations.

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## 1 Overview of Major Components

The components of the IBM 1401 to PC Interface Adapter are:

- The Adapter (the USB peripheral controller module, supporting logic, and firmware). The lowest level of the design.
- The Windows driver that enables the above and below items to communicate.
- The Adapter Application Programs. The highest level of the design.

The design strategy for this subsystem is to focus on simplicity and to push required complexity to a high of a level as possible. Since this is a one of a kind design, unit materials cost is secondary to design complexity cost.

### 1.1 *The Adapter*

The Adapter consists of:

- a USB peripheral chip
- a microcontroller (maybe included in the USB module) and its firmware
- a data buffer large enough to hold an entire tape record (max record size is 2000 characters)
- microcontroller parallel ports that map to the tape channel signals to be controlled and monitored
- voltage level translation circuits
- support circuitry for to make the above work

This is the lowest level of design. All interface functionality that requires "microsecond" response times needs to be handled at this level. This means that "Tape Read" and "Tape Write" block data transfers must occur within this level. Due to relative difficulties in observing and controlling the behavior of the Adapter, the simplicity of this level is the highest priority.

The Adapter shall have two major functions, that of a TAU bring-up tool and a multiple tape drive emulator. The bring-up tool function is described under the heading "Tape Channel Analyzer". When performing this function, Adapter monitors the tape channel, recognizes specific activity on the tape channel for which it has been configured to respond, and respond to the activity as instructed. The response could be stimulation of the tape channel and/or recording data to be uploaded to the PC for display. For its emulation function, the Adapter shall emulate the relevant functionality of a bank of IBM 729 Model V tape drives. Data written to the emulated tape drives is uploaded to the PC. Data to be read from emulated tape drives is downloaded from the PC.

### 1.2 *Windows Driver*

The Driver handles the interface between the Adapter and the Adapter Application Program. Ideally, the Adapter will register with Windows as a standard USB serial or parallel port device and therefore no special driver will be needed. However, a better understanding of the design may require the use of a special driver. This document assumes that a standard Windows driver will be used.

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## 1.3 Adapter Application Programs

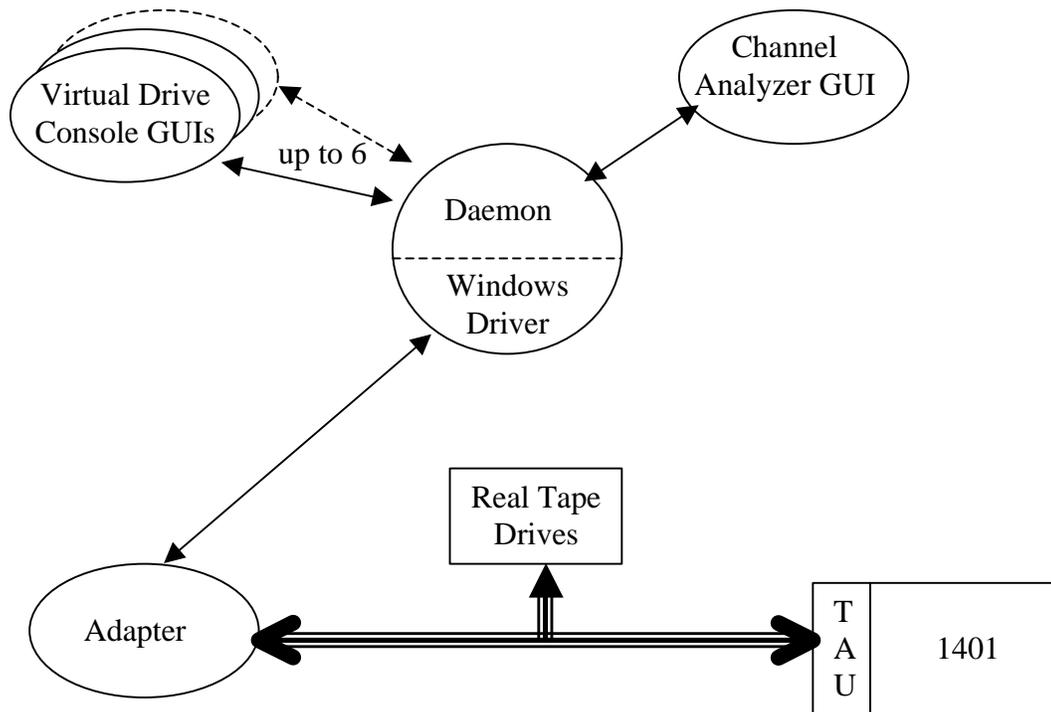
It is envisioned that the Application Programs consist of:

- an Adapter Communications Daemon
- a Tape Channel Analyzer GUI (Graphic User Interface)
- a Virtual Tape Drive Console GUI (up to 6 copies may run in parallel)

The Adapter Daemon acts as the communications multiplexer combining streams destined for the Adapter into a single stream; and as a demultiplexer routing segments of the stream coming from the adapter to the targeted GUI.

The Tape Channel Analyzer GUI should provide two types of functionality; a Logic Analyzer like set of controls and display; and a Tape Channel CE Panel set of indicators and switches used to configure the responses of the Adapter.

The Virtual Tape Drive Console GUI should represent the operator control panel of the IBM 729V drive as closely as reasonable. This GUI provides traditional Tape Drive Operator Panel indicators and buttons, as well as a mechanism to associate a PC file with the Virtual Tape Drive. Data written from the 1401 to the tape drive will appear in this file. When the 1401 reads from the tape drive, the data from this file will be supplied to the 1401. If the associated file contains a bootable object program or a "boot loader", programs from the tape can be loaded into the 1401 and executed by pressing the "Load" button on the 1401 Operators Console. This eliminates the need to punch all programs to card decks before they can be run.



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Note that this architecture permits the GUI interfaces to run on different computers than the Adapter Communications Daemon. This could be important in the future; if classes are taught related to the 1401. The GUI application could run on classroom computers or could be an applet running inside a browser environment. Due to timing requirements, the Adapter Communications Daemon must be run on the computer that is USB connected to the Adapter.

## ***1.4 Communication between levels***

It should be assumed that the PC with which the Adapter is communicating has not been specially prepared and therefore can not be used for "hard real time" control. Even if the user only has Virtual Tape Drive Console Application windows open, background services will still interfere with the PC's ability to service Adapter interrupts. Interrupt latency in a normal Windows PC can vary from 100 microseconds to 10 milliseconds.

In general, communication from a higher level to its adjacent lower level is initiated by issuing a "Command"; and communication from a lower level to its adjacent higher level is initiated by signaling an "Event". When a Command is issued, the lower level executes the command and returns a response. The signaling of an "Event" is a one way communication, no response is returned.

## 2 The Adapter

The functional elements of the Adapter are:

- the IBM 1401 tape channel interface
- the data buffer
- the microcontroller
- the USB buffer
- the USB peripheral interface engine
- the USB interface

The Adapter monitors activity on the USB interface and on the tape channel interface. Activity on either side may invoke action by the Adapter.

### 2.1 IBM 1401 Tape Channel Interface

The 1401's Tape Adapter Unit (TAU) controls the tape channel. The 1401 CPU makes "calls" to the TAU based in the instruction being executed and the TAU translates the "call" into "tape channel operations". The overall system was designed to make the tape drive units as simple (low logic card count) as possible. As a result, much of the complex logic that is found in modern tape drives, is performed by the TAU. This was economical because the logic in the TAU benefited all of the tape drives. This architecture also makes our job of emulating a tape drive easier.

#### 2.1.1 1401 Tape Channel Operations

Defined Tape Channel Operations are:

- Read Tape
- Write Tape
- Backspace Record
- Skip and Blank Tape
- Rewind Tape
- Rewind and Unload Tape
- Sense Status (No-Op)

All of the 1401 instructions that effect the Tape I/O Channel map into one of the above channel operations. Tape oriented conditional branch instruction do not effect the Tape I/O Channel, but rather they sense status that has been set in the 1401 Tape Adapter Unit (TAU) as a result of previous channel operations. Interlocks within the TAU enforce that only one channel operation may be in progress at a time. This makes the difference between emulating one drive and multiple drives small.

Magnetic tape is a sequential file medium. When writing a record to a tape it is/was considered "poor programming practice" to assume that there is valid data beyond the point on the tape where this record is written. Due to stretching and contraction of the tape medium, tape speed tolerance and variations in tape start and stop timing, attempting to update a record on a tape could corrupt records that follow it. Given the above, we will make the simplifying assertion that writing a record to a tape erases all data beyond that

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record. Note that even with this assumption, it is allowed to mix read, write, and backspace operations to the same tape. The requirement is that the tape is never read beyond the location of the last write. If an attempt is made to read beyond the last write the Adapter will respond by indicating End-Of-Reel.

Before the TAU switches a tape drive from Write mode to Read mode, it advances the tape forward a short distance so that noise caused by turning off the write head would not corrupt previously written data. The tape advance causes erasure of any data that abutted the last block written. As a result, 1401 non-write tape instructions like Tape Rewind actually begin with a short Write operation (no data is transferred).

The timing information in the below "tape operation" descriptions are for an IBM 729V. The timings may vary for other drives. See the "Critical Timings Table" has complete timing information on all supported drives.

## 2.1.2 Tape channel operation phases

A tape channel operation session will pass through one or more of the below phases.

- Selection Phase
- Start Phase
- Execution Phase
- Stop Phase

*Note that the below describes the operation of the full implementation of Adapter functionality. Initially a subset of this functionality will be implemented to support Tape Channel Analyzer needs for TAU bring-up. The full implementation is described to assure that the Adapter's architecture can support anticipated future expansion.*

Each operation begins with the tape reels stopped; and ends with either the tape reels stopped or the tape drive entering "Manual Control" mode. Tape channel operations can have four phases. The "selection phase" begins a channel operation session with a Virtual Tape Drive. The "start phase" provides several milliseconds for tape movement to start and achieve a stable speed. The "execution phase" performs the specified operation. And, the "stop phase" provides a few milliseconds for tape movement to stop.

A tape channel operation session begins with the TAU activating one of its six Select lines. The Adapter will monitor the levels of the Select lines for which it has been configured to respond. If the Adapter is configured to respond to a specific Select line, it is said to have a "Virtual Tape Drive" defined for that line. If a Virtual Tape Drive is selected, the Adapter will emit status for that Virtual Tape Drive on its output signal lines. The values being emitted will be updated as changes in the Virtual Tape Drive state occurs. The TAU ends a channel operation session by deactivating the Select line.

Once the channel operation session is established, if tape movement is needed, the TAU will initiate tape movement by activating the "Go" signal. The activation of the "Go" signal begins the "Start" phase of the channel operation. The "Delay Counter" in the TAU controls the length of the "Start" phase. The TAU determines the type of tape drive it is

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communicating with by examining the tape drive's status that it received during the Selection phase. The Adapter will provide status to the TAU that describes it as an IBM 729 Model V. This delay time permits tape to start moving and obtain a stable speed. The Adapter will use this delay time to exchange information with the PC.

At the end of the "Start" phase, if the tape operation is a Read Tape, Write Tape, or Backspace operation, the "Execution" phase begins. During this phase, data is transferred between the TAU and the Adapter. Because of the real time workload demand on the Adapter during "execution phases", it does not communicate with the PC during this phase. This restriction requires the Adapter to have sufficient memory to buffer any block data transfer that is likely to occur. The Adapter will provide buffering for at least 2K byte tape records. This seems to be a reasonable restriction, given the maximum memory capacity of the 1401 is 16K bytes.

After the record data has been transferred, the TAU deactivates the Go signal to begin the "Stop" phase. The deactivation of the Go signal tells the tape drive to stop tape movement. The TAU again uses the "Delay Counter" to provide a time interval appropriate for the type of tape unit with which it is communicating. The Adapter uses this interval to exchange data with the PC. At the completion of this time interval, the TAU deactivates the Select signal, thus ending the tape operation session.

## 2.1.3 Read Tape Operation

The 1401 instructions that map to this operation are "Read Tape", "Read Tape with Word Marks", and "Diagnostic Read". The uniqueness of the specific instructions is known only by the TAU and is not communicated to the tape drive.

This operation transfers data from the selected tape drive to the TAU. The TAU will begin this tape operation session with the Adapter by activating a Select signal and proceed through all four phases. During the "Selection Phase", the TAU sets the Adapter to read mode and then moves to the "Start Phase" by activating the Go signal. The Backward signal is inactive while GO is active for the Read operation. If it is active, the Backspace Record tape operation is being performed, rather than the Read..

A drive is at its "load point" if it is fully rewound so that the load point reflective spot is under the "load point photo detector". If the Virtual Tape Drive is not indicating that it is at its "load point", the TAU will start monitoring for the appearance of data on the Read Bus 6.6 milliseconds after Go is activated. If the drive is indicating that it is at its "load point", the TAU will start monitoring for data 24 milliseconds after Go. {I could not find any reference to the maximum amount of time the TAU will wait for the first character of a block to be delivered. Some CE manuals indicate that the transfer of the first character read should occur 10.5 milliseconds after Go. I expect that this is the typical timing that occurs when the tape is not at its "load point".} The Adapter transitions into the "Start Phase" when the TAU activates the Go signal. During this phase the Adapter must request and receive the record to be read from the PC. The Adapter will wait xxx milliseconds {for now lets use 10.5 milliseconds} for the PC to respond with the record data to be read. If the data was received, the Adapter moves to the "Execution Phase".

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Otherwise, the Adapter will report an "End-of-Reel" condition to the TAU, a data "Underflow" event to the PC, and enter the "Selection Phase". Warning: Most programs will not expect this "End-of-Reel" condition to occur and will crash if it does.

During the "Execution Phase", the Adapter will send read data to the TAU. Character transfers will occur at fixed intervals based upon the density under which the data on the tape was written. For simplicity purposes, all read operations will be performed at 800 characters per inch density. {If we have problems at this data rate, we could drop back to a lower density.} This results in a new character being emitted every 16.7 microseconds.

Data being transferred will be encoded in Non-Return-to-Zero-Invert-ones (NRZI) format as it is placed on the bus. The Adapter will also compute a Longitudinal Redundancy Check (LRC) character for the block. The LRC character is transmitted to the TAU after the last character in the buffer is sent.

Every time the TAU receives a data character it resets its "Delay Counter". The TAU will recognize the end of the block transfer by 37 microseconds elapsing without a new character being received. Once it detects the end of the block transfer, the TAU will expect the LRC character to be sent. It will wait an additional 96 microseconds for the LRC to be received. The TAU will deactivate the Go signal 200 microseconds after the last data character is received. The operation thus moves into the "stop phase". No "stop phase" Adapter actions are needed for this operation.

The "Stop Phase" is initiated by the deactivation of the Go signal. The TAU will deactivate the Select signal 2.1 milliseconds after the deactivation of Go, thus ending the "Stop Phase" and the tape operation. During this phase the Adapter will notify the PC of successful data transfer by issuing a "Record Read" event.

## 2.1.4 Write Tape Operation

The 1401 instructions that map to this operation are "Write Tape", "Write Tape with Word Marks", "Write Tape Mark", and "Diagnostic Write". The uniqueness of the specific instructions is known only by the TAU and is not communicated to the tape drive.

When the 1401 executes a "Skip and Blank Tape" instruction no tape channel operation takes place, but it impacts the next "Write Tape" operation by lengthening the period between the "Go" signal and the presentation of the first character to be written. Since we are not moving physical tape, it does not effect operation of the adapter.

The Write operation transfers data from the 1401 TAU to the selected tape drive. The TAU will begin this tape operation session by activating a Select signal and proceed through all four phases. During the "Selection Phase", the TAU sets the Adapter to write mode. It then activates the Go signal and the Adapter moves to the "Start Phase".

Once "Go" is signaled and the Virtual Tape Drive is write enabled, the Adapter informs the PC that a Write Tape operation has begun using a "Write Prepare" event. If the

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Virtual Tape Drive is not indicating that it is at its "load point", the TAU will move to the "Execution Phase" 7.5 milliseconds after Go is activated. If the drive is indicating that it is at its "load point", the TAU will move to the "Execution Phase" 48 milliseconds after Go is activated.

When the Adapter is in the "execute phase" it waits for characters to arrive from the TAU. As characters arrive from the TAU, the Adapter will store them in a RAM buffer and update the running LRC character. The Adapter recognizes a character on the tape channel interface by detecting the activation of the Write Pulse signal. After the last data character is transferred the TAU activates the Write Check Character signal. This signal causes the tape drive to write the accumulated LRC character to the tape.

Each received character and the LRC character is echoed in NRZI format to the Read Data bus after a 4 millisecond delay (emulates the travel distance between the tape head's write and read gaps).

The TAU signals the end of the "Execution Phase" by deactivating the "Go" signal, thus the operation session advances to the "stop phase".

Once in the "stop phase", the Adapter sends a "Write Upload Request" event to the PC. Since the TAU may send the Adapter into another "Execution Phase" in 12.6 milliseconds, the PC must respond with an Upload command and complete the upload of the buffer in that amount of time. Failure to meet this timing may result in data from the next Tape Write operation being lost. If this occurs, the Adapter will report an "End-of-Reel" condition to the TAU and a data "Overflow" event to the PC. Warning: Most programs will not expect this condition to occur and will crash if it does.

## 2.1.5 Backspace Record Tape Operation

The Backspace Record operation moves the tape backward by one record. During this operation, the drive performs a read operation with the tape moving in the backward direction. The characters transmitted to the TAU on the Read Bus are neither passed to the CPU nor error checked. However, the transmission of the characters is necessary so that the TAU can detect when to stop the tape.

If the drive is indicating that its tape is positioned at the load point, the TAU will not issue the Backspace operation. If during the Backspace operation, the drive detects the "Load Point" reflective spot, the operation is ended.

If the drive is in Write mode, the tape is first advanced forward before the mode is changed to Read. This is done to guarantee a full inter-record gap after the last written record. In this case, this first part of the Backspace operation will appear to the tape drive as a Tape Write operation that transfers no data (erase). Therefore, the remainder of this description assumes the drive is in Read mode.

The TAU will begin this tape operation session by activating a Select signal and proceed through all four phases. During the "Selection Phase", the TAU sets the Adapter to read

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mode and activates the Backward signal. It then activates the Go signal and the Adapter moves to the "Start Phase".

The TAU starts the Start Phase by ignoring the Read Data bus for 3 milliseconds. This permits the drives read head to move away from any tape noise caused by changing the drive from write to read mode. The Adapter will wait 3.5 milliseconds and then enter the execution phase.

During the "Execution Phase", the Adapter will send read data to the TAU. The TAU does not interpret the characters on the Read Bus. It just searches for an inter-record gap. Since the Adapter will send 100 NRZI encoded "0" (zero) characters to the TAU in using the appropriate Read Bus frame timing. (For a 75ips drive using 800 bpi density the character frame is 16.7 microseconds.) No LRC character is sent. The Adapter will then stop transmitting and wait for the TAU to respond. The TAU detects an inter-record gap by 0.6 milliseconds elapsing after the last character is received. It then deactivates the GO signal and enters the Stop Phase 5.7 milliseconds after the last character is received.

The "Stop Phase" is initiated by the deactivation of the Go signal. The Adapter transmits a Backspace Event to the PC. The TAU ends this phase and the operation by deactivating Select.

## **2.1.6 Skip and Blank Tape Operation**

This operation is described under the Write Tape Operation.

## **2.1.7 Rewind Tape Operation**

This operation consists only of a Selection phase. The TAU selects the tape drive and activates the "Rewind" signal. In response to this, the drive the Select activates the "Select and Rewind" output signal to indicate that the tape has begun rewinding. While the tape is rewinding, it becomes "not ready" and all output signals that require the drive to be ready are deactivated. When the drive detects the Load Point reflective spot, the drive turns off the "Select and Rewind" output signal, reenters the Ready state, activates the "Select and At Load Point" output signal, deactivates the "Select and Not At Load Point" output signal. The TAU then deactivates the Select signal, and reactivates other ready dependent signals as appropriate.

After the Adapter activates the "Select and Rewind" output signal, it sends a Rewind Event to the PC, waits one second and sets the Virtual Drive's "Tape Position" state element to zero to indicate that the tape is positioned at its Load Point".

## **2.1.8 Rewind and Unload Tape Operation**

This operation consists only of a Selection phase. The TAU selects the tape drive and activates the "Rewind and Unload" signal. In response to this, the drive the Select activates the "Select and Rewind" output signal to indicate that the tape has begun rewinding. While the tape is rewinding, it becomes "not ready" and all output signals that require the drive to be ready are deactivated. When the drive detects the Load Point reflective spot, it remains in the "not ready" state as it removes the tape from the vacuum

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columns and opens its access windows. The drive is now in "manual control mode" and must be made ready by the operator pressing the "Load Rewind" button and then the "Start" button, before it will again respond to the TAU.

When the TAU detects the activation of the "Select and Rewind" signal, it deactivates Select thus ending the operation. Note that the TAU does not wait for the tape to rewind to its Load Point.

After the Adapter activates the "Select and Rewind" output signal, it clears the drive's "Mechanically\_Ready" and "Electrically\_Ready" state elements, sets the drive's "Tape Position" state element to zero, and sends an Unload Event to the PC.

## 2.1.9 Tape Channel I/O Signals

The interface is physically represented by the below input and output signals.

**Table 1. Tape Channel Inputs**

Input Name	Level	Description
Select [1:6]	+P	Selects the addressed tape drive. The rotating address switch on the drive's Operator's Panel selects the address to which the drive will respond. Although the switches on the 729 drives have positions 0 through 9, the 1401 TAU can only address 1 through 6. If a drive is not selected, it will ignore the below input signals.
Set Hi Density	+P	Sets drive to write in "high density" mode.
Set Lo Density	-N	Sets drive to write in "low density" mode.
Turn On TI	-N	Sets the Tape Indicator flip-flop.
Turn Off TI	+P	Resets the Tape Indicator flip-flop
Set Read Status	+P	Sets the Read-Write flip-flop to Read.
Set Write Status	-N	If the tape is not write protected, sets the Read-Write flip-flop to Write.
Go	+P	Activating this signal starts the tape moving. Deactivating this signal begins the braking process to slow and stop movement.
Backward	-N	ANDed with "select and ready" to produce "reverse" which controls the direction of tape movement. The backward line is also ANDed with "non at load point" to prevent backspacing when the tape is at its load point.
Rewind	-N	Initiates a rewind operation.
Rewind & Unload	+P	Initiates a rewind operation followed immediately by an unload operation.
Write Bus [0:6]	-N	Data to be written to the tape.
Write Pulse	-N	Strobe to indicate valid data is on the Write Bus.

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Write Check Character	-N	Tells the drive to write the accumulated LRC character to the tape.
Process Meter	-N	Not connected. Supposed to run the use time meter on the tape drive.
<b>Summary</b>		
	+P	11 signals
	-N	14 signals, not counting Process Meter.
	Total	25 signals

**Table 2. Tape Channel Outputs**

Output Name	Level	Description
Select and Ready Mod 2	+P	Indicates that the selected tape drive is a 729II or 729V, mechanically ready, and electrically ready. (These drives move tape at 75 ips.)
Select and Ready Mod 4	+P	Indicates that the selected tape drive is a 729IV or 729VI, mechanically ready, and electrically ready. (These drives move tape at 112.5 ips.)
Mod 5 or 6	+P	Indicates that the selected tape drive is either a 729V or a 729VI. (These tape drives support all densities up to 800 bpi.) This signal when analyzed with the above two signals completely identifies the model drive being used.
Select and At Load Point	+P	Indicates that the selected drive's tape is positioned at its load point.
Select and Not At Load Point	+P	Indicates that the selected drive's tape is not positioned at its load point.
Select and Rewind	-N	Indicates that the selected drive is rewinding.
Select and TI Off	-N	Indicates that the selected drive's Tape Indicator state element is off.
Select and TI On	-N	Indicates that the selected drive's Tape Indicator state element is on.
Sel Ready and Read	+P	Indicates that the selected drive is ready and its Write_Mode state element is set to Read (off).
Sel Ready and Write	+P	Indicates that the selected drive is ready and its Write_Mode state element is set to Write (on).
Hi-Lo Density	+P	Indicates that the selected drive's Hi_Density state element is set to on.
Write Echo Pulse	-N	This seems to be the conditional wrap back of the Write Pulse input. If any of the Write Data bits are set to one, then the Write Pulse is sent back to the TAU using this signal. (All legal 1401 BCD characters will have at least two bits on.)

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Read Data [0:6]	NRZI	Data transmitted from the selected drive to the TAU.
<b>Summary</b>		
	+P	8 signals
	-N	4 signals
	NRZI	7 signals
	Total	19 signals

## 2.2 Adapter State

The Adapter state consists of the state elements needed to emulate a tape drive and the state elements needed for Tape Channel Analyzer configuration. Note that six sets of Tape Drive State elements are maintained one for each drive that may be being emulated.

### 2.2.1 Tape Drive State

The below state elements are maintained for each emulated and monitored drive. The state elements may be modified by the PC application or by the effects of Tape Channel operations.

State Element	Description
Mechanically_Ready	Set means that a tape is mounted on the drive and the access window is closed.
Electrically_Ready	Set means the drive is not in manual control mode.
Write_Mode	Set means the drive is in Write mode. Reset means the drive is in Read mode.
Hi_Density	Set means that the drive will write in its High Density Mode. Note that density is completely controlled by the TAU. This seems to just be for a light on the Operator's Panel.
Tape Indicator	This bit can be read and written by 1401 assembler instructions. It is also set as a side effect of exceptions occurring during tape operations.
LRC[0:6]	This is a set of 7 elements corresponding to the accumulated LRC character for Write Data that was received for the current record
Byte Count	For Read and Backspace Operations - The number of data characters to be sent to the TAU. This field decrements as characters are sent. For Write Operations - The number of data bytes received from the TAU. This field increments as characters are received.
Tape Position	This is the number of records from the start of the tape to the current position. A value of zero means that the tape is at its "Load Point". This value is

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represented as a signed 32-bit integer.

## 2.2.2 Tape Drive Configuration

This information is set up by the application software for each emulated drive and used but not modified by the Adapter. See the "Adapter Microcontroller Timer Use" section for specific timer values.

Configuration Variable	Description
Emulation_Enabled	Set means the Adapter will respond to interface transactions for this drive address.
Read, At LP, GO to 1 <sup>st</sup> Char Interval	Time in pre-scaled ticks between detection of an active going GO transition and Adapter's writing its 1 <sup>st</sup> character to the Read Bus on Read Operations, if the Virtual Tape is positioned at its Load Point.
Read, Not at LP, GO to 1 <sup>st</sup> Char Interval	Time in pre-scaled ticks between detection of an active going GO transition and Adapter's writing its 1 <sup>st</sup> character to the Read Bus on Read Operations, if the Virtual Tape is not positioned at its Load Point.
Backspace, GO to 1 <sup>st</sup> Char Interval	Time in pre-scaled ticks between detection of an active going GO transition and Adapter's writing its 1 <sup>st</sup> character to the Read Bus on Backspace Operations.
Write, Ignore after GO Interval	Time in pre-scaled ticks between detection of an active going GO transition and the Adapter's enabling the receiving of data from the Tape Channel Write Data Bus.
Read Timeout	The time limit in pre-scaled ticks between the Adapter's writing its 1 <sup>st</sup> character to the Read Bus and the completion of the Read Operation. If this time interval is exceeded, than the operation may be hung.
Backspace Timeout	The time limit in pre-scaled ticks between the Adapter's writing its 1 <sup>st</sup> character to the Read Bus and the completion of the Backspace Operation. If this time interval is exceeded, than the operation may be hung.
Write Timeout	The time limit in pre-scaled ticks between the expiration of the "Write, Ignore after GO Interval" and the completion of the Write Operation. If this time interval is exceeded, than the operation may be hung.
Rewind Delay	The time in pre-scaled ticks between the drive becoming "not ready" due to the detection of an active going "Rewind" transition and the completion of the Rewind Operation. This is the time it takes the emulated tape to rewind.
Unload Delay	The time in pre-scaled ticks between the drive becoming "not ready" due to the detection of an active going "Rewind & Unload" transition and the completion of the Unload Operation. This is the time it takes the emulated tape to rewind.

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	At the end of this delay, if the drive is still selected by the TAU, then the drive will return to the selected but not ready state. Otherwise, the drive will return to the idle state.
High Density Read Char to Char	The time in system ticks between data character presentations on the Read Bus during High-Density Read Bus data transfer operations. Used by Read Operation, Backspace Operation, and by the echo function of the Write Operation.
High Density Read Pulse Width	The time in system ticks between turning on bits in the Tape Channel Pulse Register and turning them off. The initial implementation will use the same timing for both High and Low density operation. Separate fields are provided as a contingency.
High Density Read Char to LRC Delay	The time in system ticks between presentation of the last data character and the LRC character during High-Density Read Bus data transfer operations. Used by Read Operation and by the echo function of the Write Operation.
Read Data Source	0 = The data source for Read data will be the PC. (via "Download Record" commands) 1 = The data source for Read data will be the Analyzer's Data Generator.
File Protected	False = The drive is not file protected. (The drive's tape has its write enable ring installed.) True = The drive is file protected. (The drive's tape has its write enable ring removed.)

## 2.2.3 Tape Channel Analyzer State

The below states have been added to permit the Tape Channel Analyzer to alter the responses from emulated drives and monitor the tape channel activity from any drive, real or emulated.

State Element	Description
Monitor_Drives[1:6]	These bits correspond with the Select [1:6] inputs. A bit being set configures the Analyzer to monitor Tape Operations addressed to the corresponding tape drive. Monitoring is a passive function and will not effect channel operation.
Respond_Drives[1:6]	These bits correspond with the Select [1:6] inputs. A bit being set configures the Analyzer to respond to Tape Operations addressed to the corresponding drive. All drives selected in this element must also be selected in the Monitor_Drives element.
<b>Only one instance of each of the below state elements exists in the adapter. The value of these state elements will be used for all drives selected in the Respond_Drives element.</b>	
Force_Not_Ready	If this bit is set, the controlled drives will be forced to and held

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	in the "Electrically Not Ready" state.
Inhibit_Echo_Pulse	Inhibits output of the "Write Echo Pulse". (Used only in Write operations.)
Drive_Model	Tells the analyzer to respond as a specific model tape drive. Valid values are 729V (default), 729II, 729IV, and 729VI. Note that this only effects the "Select_and_Ready_Mod 2", "Select_and_Ready_Mod_4", and "Mod_4_or_5" output signals. Critical timings are controlled separately.
Force_LRC_Error	Complements the LRC character that is echoed on the Read Data lines. (Used only in Write operations.)
Force_VRC_Error	Complements the check bit of each Write Bus character as it is echoed on the Read Bus. (Used only in Write operations.)
Force_Echo_Error	Complements the units and check bit of each Write Bus character as it is echoed on the Read Bus. (Used only in Write operations.)
Generate LRC	1 = The Adapter will generate and transmit a LRC character on the Read Bus during Read operations after each record is sent. This assumes that the LRC character is not included in the data record. If "Read Data Source" is the data generator, the LRC will be transmitted as character "Gened Record Length"+1. 0 = The Adapter does not generate a LRC character. The LRC is assumed to be that last character in the data record. These values apply regardless of the selected data source.
Nominal Gain [C,B,A,8,4,2,1]	The 4-bit track amplitude setting for each track of the Read Bus during normal operation.
Test Gain [C,B,A,8,4,2,1]	The 4-bit track amplitude setting for each track during the presentation of "Test" data on the Read Bus. Note that "Test Gain" applies even if the selected data source is the PC. The LED signal will be turned on during the presentation of test data to enable the triggering of test equipment.
Test Delay	See the description of the Tape Channel Analyzer's Data Generator for a description of how this field is used. (In the Tape Channel Analyzer / Functionality section of this document. The record's length preempts this setting, it does not persist to the next record.
Test Duration	See the description of the Tape Channel Analyzer's Data Generator for a description of how this field is used. (In the Tape Channel Analyzer / Functionality section of this document. The record's length preempts this setting, it does not persist to the next record. The LED signal will be turned on during the presentation of test data to enable the triggering of test equipment.
Test Repeats	The number of times that "Test Data Delay" and "Test Data Duration" is to be repeated in a record. The record's length preempts this setting, it does not persist to the next record.

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	<p>Example: If "Test Data Delay"==1, "Test Data Duration"==1, and "Test Data Repeats"==100; then for up to 200 characters, starting with the second character in a record, every other character will be transmitted using the "Test Gain" settings.</p>
Generated Record Length	<p>If "Read Data Source" selects the data generator, this is the size of the records that will be generated. (Not including any generated LRC character.) See the description of the Tape Channel Analyzer's Data Generator for a description of how this field is used. (In the Tape Channel Analyzer / Functionality section of this document.)</p>
Test Data Char	<p>If "Read Data Source" selects the data generator, this seed character used to generate "Test Data". See the description of the Tape Channel Analyzer's Data Generator for a description of how this field is used. (In the Tape Channel Analyzer / Functionality section of this document.)</p>
Filler Data Char	<p>If "Read Data Source" selects the data generator, this character is presented on the Read Bus when the presentation of "Test" data is delayed or has a duration shorter than required to meet the record length specification. Filler characters are always transmitted at "Nominal Gain". See the description of the Tape Channel Analyzer's Data Generator for a description of how this field is used. (In the Tape Channel Analyzer / Functionality section of this document.)</p>
Data Generator Mode	<p>Repeat (0) = The "Test Data Char" seed is repeated without alteration.</p> <p>BCD Inc (1) = The next higher character in the BCD tape character collating sequence is used each time the "Test" data is transmitted. This sequence wraps from the higher character in the collating sequence to the lowest. (It is reinitialized to the seed character at the beginning of each record.)</p> <p>Binary Rotate (2) = The "Test Data Char" is rotated right by one bit each time it is transmitted. (It is reinitialized to the seed character at the beginning of each record.)</p> <p>When the "Test Data Char" is altered using any of the above modes, a valid even parity C-bit is generated.</p> <p>Note that Binary operations may result in bit patterns that are not valid BCD tape characters.</p>

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## **2.3 Adapter to PC Interface Commands and Events**

### **2.3.1 Windows Driver to Adapter Command Interface**

Command = Full Reset

Parameters = None

Meaning = All ongoing operations are aborted. The Adapter is set to its Power-On-Reset state. If the 1401 is in session with the Adapter, this could cause the 1401 to detect an error.

Response = adapter status

Command = Define Virtual Drive

Parameters = drive address, virtual tape drive configuration data, virtual tape drive initial state data

Meaning = Tells Adapter to emulate this drive, if 1401 tries to communicate with a drive at this address.

Response = virtual drive status

Command = Download Record

Parameters = drive address, record data

Meaning = Move the record data from the PC to the Adapter

Response = virtual drive status

Command = Upload Record

Parameters = drive address

Meaning = Move the record data from the Adapter to the PC

Response = record data, LRC character, and virtual drive status. LRC character should be zero, otherwise an error exists.

Command = Undefine Virtual Drive

Parameters = drive address

Meaning = Abort ongoing operations on this drive, "undefine" the virtual drive.

Response = virtual drive status

Command = State Inquiry

Parameters = drive address

Meaning = Upload Adapter state.

Response = virtual drive state followed by analyzer state.

Command = Set Virtual Drive State

Parameters = drive address, virtual tape drive state data

Meaning = Set the addressed Virtual Drive's state. This may reset the drive and or abort ongoing operations.

Response = none

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Command = Set Analyzer State

Parameters = tape channel analyzer state element values

Meaning = Set the Tape Channel Analyzer's state.

Response = none

## 2.3.2 Adapter to Windows Driver Event Interface

Event = Read Request

Parameters = drive address, virtual drive status

Meaning = 1401 is trying to read the tape. Driver has 10 ms to respond with a "Download Record" command

Event = Read Underflow

Parameters = drive address, virtual drive status

Meaning = 1401 is trying to read the tape, but the Adapter prematurely ran out of data. An error was sent to the 1401. This event should not occur.

Event = Write Request

Parameters = drive address, virtual drive status

Meaning = 1401 is has written data to the tape. Driver has xx ms to respond with a "Upload Record" command.

Event = Write Overflow

Parameters = drive address, virtual drive status

Meaning = 1401 is trying to write the tape, but the driver did not upload data fast enough, so the write buffer overflowed. An error was sent to the 1401. This event should not occur.

Event = Backspace

Parameters = drive address, virtual drive status

Meaning = 1401 has moved the tape backwards by 1 record. The new tape position is specified in the "virtual drive status".

Event = Rewind

Parameters = drive address, virtual drive status

Meaning = 1401 has commanded the drive to rewind its tape to the "load Point". Note that the "Tape Position" in the presented "virtual drive status" is not valid. It should be interpreted as zero.

Event = Unload

Parameters = drive address, virtual drive status

Meaning = 1401 has commanded the drive to rewind and unload its tape.

Event = Status Change

Parameters = drive address, virtual drive status

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Meaning = 1401 or a console button did something to cause the virtual drive status to change. For example it could have issued the "Unload" command to set the drive into "manual control mode".

Event = Read Timeout

Parameters = drive address, virtual drive status

Meaning = An excessive amount of time has elapsed since the start of this operation.

Event = Backspace Timeout

Parameters = drive address, virtual drive status

Meaning = An excessive amount of time has elapsed since the start of this operation.

Event = Write Timeout

Parameters = drive address, virtual drive status

Meaning = An excessive amount of time has elapsed since the start of this operation.

Event = Channel Transaction

Parameters = drive address, virtual drive status of the drive that triggered the event, and "Channel I/O" status.

Meaning = If the Tape Channel Analyzer is enabled, one of these events is transmitted every time a Tape Channel control input or output signal changes state. Note that changes on the Tape Channel Read Bus, Write Bus, and data bus strobes will not cause this event.

## **Virtual Drive Status is defined as:**

```
int tape_position;           // the number of records from the beginning of the tape
                             // to the current position. 0 = tape is at the load point
short bufferByteCount;     // After a Write op., the number of chars to be uploaded.
boolean selected;          // TAU is in session with this drive
boolean mech_ready;        // mechanically ready
boolean elect_ready;       // electrically ready
boolean write_mode;        // drive is in write mode
boolean density;           // 'H' = true or 'L' = false;
boolean tapeIndicator;     // see console indicator description
                             // After a Read op., the number of chars not transferred.
char spare;                // reserved
// 8 bytes
```

## **Adapter Status is defined as:**

```
int healthCondition; // 0 = OK, Other codes TBD.
boolean[1:6] drives; // 1 = drive is defined and Adapter will respond to 1401
```

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## **Channel I/O Status is defined as:**

```
// The "Free Running Timer" provides time stamp for this event. The time stamp
// value is in scaled system ticks which are units of about .3 milliseconds.
// See the description of this timer for more information.
int time_stamp;
// The next field contains the count of characters in the read/write data buffer.
short buffer_count;
// Samples contents of the Adapter's Select Register (Port D encode 0)
// and the A, B, C, E, and H Port registers.
byte select_reg, port_A, port_B, port_C, port_E, port_H;
// The next field contains the current state of the operations state machine.
byte machine_state;
// The next field has bits that are ORed on when a "Write Pulse" or "Write Check
// Character" input becomes active.
byte read_write_flags;
// bits 7-1 unused
// bit 0 write character received on Write Bus
// 14 bytes
```

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## 2.4 Adapter Microcontroller Port Register Assignments

Port A	Dir	7 bits -- Not used.
0	I	Select and TI On (Monitoring)
1	I	Select and TI Off (Monitoring)
2	I	HiLo Density (Monitoring)
3	I	Select and Rewind (Monitoring)
4	I	(open drain)
5	I	Unused
6	IM	Not brought out.

Port B	Dir	8 bits, interrupting -- Interrupting Signals
0		
1	I	SELECT_CHANGE - Tape channel select signals have changed state since they were last read.
2	IM	FT245-RXF# (internal to module)
3		
4	IM	FT245-TXE# (internal to module)
5	IM	SWVCC (internal to module)
6	I	TGO - Tape channel signal
7		

Port C	Dir	8 bits -- Channel State Change Requests
0	I	TSETHDEN - Set Hi Density from tape channel.
1	I	TSETLDEN - Set Lo Density from tape channel.
2	I	TSETTI - Turn On TI from tape channel.
3	I	TRESETTI - Turn Off TI from tape channel.
4	I	TSETREAD - Set Read Status from tape channel.
5	I	TSETWRITE - Set Write Status from tape channel.
6		
7		

Port D	Dir	8 bits, multiplexed -- Data Bus to 2 <sup>nd</sup> Level Components
7:0	I/O	DB - Bi-directional data bus. Connected to: FT245 FIFO (internal to module), Latched Select[1:6] - latched Channel Select Signals, Read Channel Polarity Reg. (on analog card), Read Channel Pulse Reg. (on analog card), Read Channel Amplitude Regs A-D (on analog card)

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Port E	Dir	8 bits -- Channel Inputs and Data Bus Address Encode
2:0	O	DBSEL[2:0] - Selects register that is to receive data from Port D data bus. Selection encodes are: 0 = FT245 FIFO 1 = SELREGOE - Select Register output enable 2 = SELRCDR - Read Channel Polarity (Direction) Register 3 = SELRCPR - Read Channel Pulse Register 4 = SELRCAA - Read Channel Amplitude A Register 5 = SELRCAB - Read Channel Amplitude B Register 6 = SELRCAC - Read Channel Amplitude C Register 7 = SELRCAD - Read Channel Amplitude D Register
3	I	TBACKWARD - Tape Channel's Backward signal
4	I	TREWIND - Tape Channel's Rewind signal
5	I	TREWUNLD - Tape Channel's Rewind and Unload signal.
6	I	TWRITELRC - Tape Channel's Write Check Character signal.
7	I	TWRITEPULSE - Write Pulse from tape channel.

Port F	Dir	8 bits -- Tape Channel Write Data and Echo Pulse
6:0	I	TWRITEDATA - Tape Channel Write Data.
7	O	WRITEECHO -- Write Echo Pulse

Port G	Dir	5 bits -- Strobe Signals
0	O	SELSTROBE - Select Register Write Strobe
1	OM	FT245-RD# (internal to module) - Read next byte from FIFO.
2	OM	FT245-WR# (internal to module) - Write byte into FIFO.
3	O	ANALOGSTRB - Write strobe to the Analog Module
4		FT245-SNDWUP
5	I	Unused

Port H	Dir	8 bits -- Virtual Drive Configuration
0	O	MOD2 - Ready Mod 2
1	O	MOD4 - Ready Mod 4
2	O	MOD5OR6 - Mod 5 or 6
3	I	Mod 5 or 6 (Monitoring)
4	I	Sel Ready & Write (Monitoring)
5	I	Sel Ready & Read (Monitoring)
6	I	Sel Ready & At Load Point (Monitoring)
7	I	Sel Ready & Not At Load Point (Monitoring)

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Port J	Dir	8 bits -- Virtual Drive State
0	O	SELECTED - The Adapter is selected
1	O	READY - The Adapter is mechanically and electrically ready.
2	O	WRITE - The Adapter is in Write mode.
3	O	TAPEIND - The drives Tape Indicator (TI).
4	O	HIDENSITY - The drive is in Hi density write mode.
5	O	MODULE_LED# , TRIGGER_ANLZR
6	O	LOADPT - The drive's tape is at the load point.
7	O	REWINDING - The Tape is rewinding.

Mplxed D (encode 0)	Dir	FT245 USB Peripheral Chip (requires additional Port B controls)
7 : 0	I/O	USB data FIFO

Mplxed D (encode 1)	Dir	Select Register
0	I	Select & Ready Mod 2 (Monitoring)
1	I	SELECT REG[1]
2	I	SELECT REG[2]
3	I	SELECT REG[3]
4	I	SELECT REG[4]
5	I	SELECT REG[5]
6	I	SELECT REG[6]
7	I	Select & Ready Mod 4 (Monitoring)

Mplxed D (encode 2)	Dir	Read Channel Polarity (Direction) Reg. (on Analog board)
6 : 0	O	Mapped to Read Channel bits CBA8421 respectively.
7	O	Unused

Mplxed D (encode 3)	Dir	Read Channel Pulse Reg. (on Analog board)
6 : 0	O	Mapped to Read Channel bits CBA8421 respectively
7	O	Unused

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<b>Mplxed D (encode 4)</b>	<b>Dir</b>	<b>Read Channel Amplitude A Reg. (on Analog board)</b>
3 : 0	O	Gain control for Read Channel Bit 1
7 : 4	O	Gain control for Read Channel Bit 2

<b>Mplxed D (encode 5)</b>	<b>Dir</b>	<b>Read Channel Amplitude B Reg. (on Analog board)</b>
3 : 0	O	Gain control for Read Channel Bit 4
7 : 4	O	Gain control for Read Channel Bit 8

<b>Mplxed D (encode 6)</b>	<b>Dir</b>	<b>Read Channel Amplitude C Reg. (on Analog board)</b>
3 : 0	O	Gain control for Read Channel Bit A
7 : 4	O	Gain control for Read Channel Bit B

<b>Mplxed D (encode 7)</b>	<b>Dir</b>	<b>Read Channel Amplitude D Reg. (on Analog board)</b>
3 : 0	O	Gain control for Read Channel Bit C
7 : 4	O	Unused

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## 2.5 Adapter Microcontroller Timer Use

Four hardware timers are used on the microcontroller. All of the timers are run off the microcontroller clock. A 6 MHz. crystal oscillator driving a 4x multiplying Phase Locked Loop creates the microcontroller clock. The resulting clock rate is 24 MHz. The internal microcontroller clock received by the timers is  $F_{OSC}/4$  (6 MHz.).

### 2.5.1 Frame Timer

The "Frame Timer" is used during Read, Backspace, and Write operations to determine when to place a character on the 1401 Tape Channel Read Data Bus. Time intervals between 16 microseconds to 150 microseconds are programmed.

**Table 2: Frame Timer Specification.**

Model =	729 II & V	729 II & V	729 V	729 IV & VI	729 IV & VI
Speed(ips) =	75	75	75	112.5	112.5
Density(bpi)=	200	556	800	200	556
Char to Char (uSec)	66.6	24.0	16.7	44.5	16.0
Char to LRC (uSec)	150	54	37	100	36

PIC18LF8720's Timer2 implements this timer. The input to the timer is the microcontroller's internal clock. The timer's prescaler is set to 1:4. The timer's postscaler is set to 1:1. Interrupts from this timer are configured to occur at the "Low" priority level.

The above configuration yields a timer tick of 0.667 microseconds and a full range value of 170.6 microseconds. The below tick values should be used to program this timer. Adjustments to the below table may be necessary to account for average interrupt latency time.

**Table 3: Frame Timer - Actual Values.**

Model =	729 II & V	729 II & V	729 V	729 IV & VI	729 IV & VI
Speed(ips) =	75	75	75	112.5	112.5
Density(bpi)=	200	556	800	200	556
Char to Char (ticks)	100	36	25	67	24
Char to Char (uSec)	66.7	24.0	16.7	44.7	16
Char to LRC (ticks)	225	81	56	150	54
Char to LRC (uSec)	150	54	37.3	100	36

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## 2.5.2 Read Pulse Width Timer

The "Read Pulse Width Timer" is used to control the NRZI pulse widths on the 1401 Tape Channel Read Bus. The target pulse width is 8 microseconds regardless of the tape drive model or tape density being emulated.

PIC18LF8720's Timer4 implements this timer. The input to the timer is the microcontroller's internal clock. The timer's prescaler is set to 1:1. The timer's postscaler is set to 1:1. Interrupts from this timer are configured to occur at the "High" priority level.

The above configuration yields a timer tick of 0.167 microseconds and a full range value of 42.6 microseconds. To achieve an 8-microsecond pulse width, the tick count of 48 should be used. An adjustment to this value may be necessary to account for average interrupt latency time.

## 2.5.3 I/O Polling Timer

The "I/O Polling Timer" is used to check for changes in 1401 Tape Channel control input signals. The most critical of these signals are wired to interrupt producing microcontroller pins. State changes occurring to the less critical signals must be discovered by polling. Currently, a polling interval of about one millisecond is deemed sufficient. Whenever the "I/O Signal Polling" interrupt service routine is entered, this timer is reset to its "start" value.

PIC18LF8720's Timer3 implements this timer. The input to the timer is the microcontroller's internal clock. The timer's prescaler is set to 1:8. Interrupts from this timer are configured to occur at the "Low" priority level.

The above configuration yields a timer tick of 1.33 microseconds and a 16-bit full range value of 87 milliseconds. To achieve a one-millisecond timeout, a start value of -750 ticks is used.

## 2.5.4 Alarm Timer

The "Alarm Timer" is used to signal the end of specific timed intervals that are important to the operation of the 1401 Tape Channel Interface.

PIC18LF8720's Timer0 implements this timer. The input to the timer is the microcontroller's internal clock. The timer's prescaler is set to 1:256. Interrupts from this timer are configured to occur at the "Low" priority level.

The above configuration yields a timer tick of 42.6 microseconds and a 16-bit full range value of 2.8 seconds. Note that this timer increments and interrupts on the transition from 0xffff to 0x0000. Therefore the complement of the below tick values plus 1 needs to be loaded into the counter.

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**Table 4: Alarm Timings (milliseconds / tick value)**

Model =	729 II & V	729 IV & VI
Speed(ips) =	75	112.5
Density(bpi) =	All	All
Read At LP: GO to 1 <sup>st</sup> Char	48 / 1125	32 / 750
Read Not At LP: GO to 1 <sup>st</sup> Char	10.5 / 246	6.7 / 157
Backspace: Go to 1 <sup>st</sup> Char	3.1 / 73	2.1 / 49
Write: Ignore after GO	6.6 / 155	4.4 / 103
Read Timeout	2.8 sec / 64k	2.8 sec / 64k
Backspace Timeout	2.8 sec / 64k	2.8 sec / 64k
Write Timeout	2.8 sec / 64k	2.8 sec / 64k
Rewind Delay	2.8 sec / 64k	2.8 sec / 64k
Unload Delay	2.8 sec / 64k	2.8 sec / 64k

## 2.5.5 Free Running Timer

The "Free Running Timer" is used as a time base by the Adapter's "Tape Channel Analyzer" function. When the "Tape Channel Analyzer" function is enabled, this timer is started and runs continuously. "Channel State Change" events are stamped with this timer's value so that PC based software can track relative timings of interface signal transitions. The desire is that the resolution of this timer be less than 1 millisecond and will not wrap during a debugging session.

The "Free Running Timer" is implemented using the PIC18LF8720's Timer1 (16-bit hardware timer) with a 3-byte extension of RAM memory. Every time the timer interrupts the RAM extension is incremented by one. The Timer is sampled as a four-byte integer consisting of the three bytes of RAM extension followed by the high order byte of the hardware timer. The input to the hardware timer is the microcontroller's internal clock. The timer's prescaler is set to 1:8. Interrupts from this timer are configured to occur at the "Low" priority level.

The above configuration yields a hardware timer tick of 1.33 microseconds. The RAM extension is incremented every 87.4 milliseconds and the RAM extension will wrap after approximately 17 days. When the timer is initialized, the RAM extension is set to 0x8000 so that arithmetic overflow is delayed as long as possible. The resolution of the 32-timer (3 bytes of RAM plus the upper byte of the hardware timer) is 0.34 milliseconds.

The sampling of this timer's value must be performed in a way that avoids roll over errors. Sampling this timer should be performed in the following manner:

1. Copy the 3 byte RAM extension to the work area. (bytes 1 through 3, low order first)

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2. Read the low order byte of the hardware timer to cause the high order byte to be latched.
3. Copy the high order byte of the hardware timer to byte 0 of a work area.
4. Read and save the timer's interrupt flag.
5. Read the low order byte of the hardware timer to cause the high order byte to be latched.
6. Compare the high order byte of the hardware timer to byte 0 of a work area. If they differ then go to step 3.

Check the saved copy of the timer's interrupt flag. If it is on, then increment the work area copy of the RAM extension.

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## **2.6 Adapter Microcontroller Interrupt Level Use**

The Microcontroller supports two priority levels thus permitting code execution on three levels, the background level, the low priority level, and the high priority level.

### **2.6.1 Background Level Firmware**

Background level software executes at the lowest priority. It runs only when no interrupt software is active. Typically, the "Main Program" is executed at this level. The "Main Program" initializes the execution environment, initializes the interrupt service routines, enables interrupts, and starts performing work.

The work performed on this level is the communication to and from the USB controller. Work is initiated from two sources, inbound USB messages, and posts to the outbound message queue. The firmware on this level alternates checking for inbound USB messages and outbound postings.

Inbound USB messages are detected by polling the USB peripheral chip. When the chip indicates that inbound data is present, the command message is received, executed, and a response is sent. See the "Adapter to PC Interface Commands and Events" section for message definitions. All commands are defined to be executed and responded to without waiting for peripheral actions to be performed. When the last byte of a command message is received, it is responded to before the "Outbound Message Queue" is checked for new messages.

Outbound messages (Events) are posted to the "Outbound Message Queue" by interrupt service routines running at the low priority level. When a posted message is detected, it is sent to the USB chip. Due to the nature of priority level execution, if the firmware on this level detects the presence of a message in the queue, it is guaranteed that entire message has been placed into the queue. Also, when a message is detected in the "Outbound Message Queue", all messages in the queue are sent before the USB chip is examined for inbound messages.

### **2.6.2 Low Priority Level Firmware**

Work on this level is initiated by interrupts caused by 1401 Tape Channel Interface signal changes and microcontroller timers. Six low priority interrupts are defined; the "Frame Timer", the "Free Running Timer", the "Select Change Interrupt", the "Go Changed Interrupt", the "Alarm Timer", and the "I/O Polling Timer".

#### **Frame Timer Interrupts**

Interrupts from the "Frame Timer" are routed to its service routine. The occurrence of this interrupt indicates that it is time to transmit a character on the Tape Channel Read Bus. It is used during:

- tape channel Read operations to transmit the read data on the Read Bus
- tape channel Backspace operations to transmit generated data on the Read Bus
- tape channel Write operations to echo Write data on the Read Bus

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The occurrence of this interrupt means that it is time to transmit the next character on the Read Bus. This service handler shares the low priority level with other interrupts, but the other interrupts should not occur during the Read, Backspace, or Write block data transfers unless the actions of this handler need to be terminated.

The first part of this service routine is extremely timing sensitive. The other part is less sensitive time sensitive.

In the first part of the service routine, the work performed is:

- 1) The interrupt flag is cleared.
- 2) The timer is restarted for the next Read Frame.
- 3) Four bytes of pulse amplitude data are moved to the Read Channel Amplitude Registers.
- 4) The next\_data\_character to be sent is XORed with the LRC.
- 5) The LRC is moved to the Read Channel Direction Register.
- 6) The next\_data\_character is moved to the Read Channel Pulse Register.
- 7) The "Read Pulse Width Timer" is started.

The time interval from step 1 to step 7 should be a fixed number of microcontroller instruction cycles. All branching has been eliminated in order to accomplish this goal. It also must be executed in less than one half of a Read Data Bus Frame (target is 5 microseconds for the highest density read operations).

In the other part of the service routine, the work performed is:

- 1) Determine and make ready the Amplitude settings to be used for the next character to be transmitted.
- 2) Determine and make ready the next character to be transmitted. (Tape Channel Analyzer read data character generation occurs here.)
- 3) If Operation State == Read, then:
  - a) If the current character is the LRC, then:
    - i) Post "Read Complete".
    - ii) Stop the Read Frame Timer.
  - b) Else if the LRC is the next character to be sent, then:
    - i) Add the difference in frame times to the Read Frame Timer.
- 4) Else if Operation State == Backspace, then:
  - a) If the current character was the last to be sent, then:
    - i) Post "Backspace Complete".
    - ii) Stop the Read Frame Timer.
- 5) Else if Operation State == Write, then:
  - a) If the current character is the LRC, then:
    - i) Post "Write Complete".
    - ii) Stop the Read Frame Timer.
  - b) Else if the LRC is the next character to be sent, then:
    - i) Add the difference in frame times to the Read Frame Timer.
- 6) Return from Interrupt.

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The other part is not time sensitive except that both parts of the service routine must be executed in less than one frame time (16 microseconds for the highest supported densities), including time spent responding to the "Read Pulse Width Timer" and the "Write Pulse" or "Write Check Character" high priority interrupts. The Read Pulse Width Timer interrupt will always occur sometime during the execution of the second part of the service routine.

## **Free Running Timer Interrupts**

Interrupts from the "Free Running Timer" are routed to its service routine. The occurrence of this interrupt indicates that the hardware timer has overflowed and the timer's RAM extension needs to be incremented.

This service handler shares the low priority level with other interrupts and it is essential that it cause as little timing interference as possible.

The work performed is:

- 1) The interrupt flag is cleared.
- 2) Increment the low order byte of the RAM extension.
- 3) Branch no carry to step 7.
- 4) Increment the middle byte of the RAM extension.
- 5) Branch no carry to step 7.
- 6) Increment the high order byte of the RAM extension.
- 7) Return from interrupt.

## **Other Low Priority Interrupts**

A common service routine handles interrupts from the "Select Change Interrupt", the "Go Changed Interrupt", the "Alarm Timer", and the "I/O Polling Timer". The specific work to be done by this level is selected via a "current operation's state / input branch table".

The operation states are:

- Idle - No virtual drive is selected. In this state the adapter will ignore all input transitions except for the activation of a select signal that corresponds to a configured virtual tape drive.
- Selected\_NR - The TAU is in session with a configured virtual tape drive, but the drive is not ready to process TAU commands.
- Selected\_Rdy - The TAU is in session with a configured virtual tape drive, and the drive is ready to process TAU commands.
- Pre\_Read - The virtual tape is moving forward while the drive is in Read state, no read data has been transferred.
- Pre\_Backspace - The tape is moving backwards while the drive is in Read state, no read data has been transferred.
- Pre\_Write - The tape is moving forward while the drive is in Write state, no write data has been transferred.
- Read - The selected virtual drive is performing a Read block transfer.
- BackwardsRead - The selected virtual drive is performing a Backspace block transfer.
- Write - The selected virtual drive is performing a Write block transfer.

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- Post\_Read - The last byte (LRC) of a record has been sent to the TAU, waiting for GO to deactivate.
- Post\_Backspace - The last byte of a backspace data has been sent to the TAU, waiting for GO to deactivate.
- Post\_Write - The last byte (LRC) of a record has been received from the TAU, waiting for GO to deactivate.
- Rewinding - The Adapter has signaled the TAU that the drive is rewinding as part of a Rewind operation.
- Unloading - The Adapter has signaled the TAU that the drive is rewinding as part of a Rewind & Unload operation.

When a low priority interrupt occurs the work performed is:

- 1) Stop the "I/O Polling Timer".
- 2) If the "Alarm Timer" has interrupted, then stop it and clear its interrupt flag.
- 3) Clear interrupt flags for the "Select Change Interrupt", the "Go Changed Interrupt", and the "I/O Polling Timer".
- 4) Sample and save the Free Running Timer value (see the sampling instructions under this timer's description), the Select Register (Port D encode 0) and the A, B, C, E, and H Port registers. Input changes are detected by comparing these saved ports with an old copy of the saved ports that was made on the previous entry of this interrupt handler.
- 5) Handle virtual drive functions. Switch on current state:
  - a) Idle:
    - i) If the Select signal to a Virtual Drive has become active then:
      - (1) Load the context for the selected tape drive.
      - (2) initialize operations status.
      - (3) Set current state to "Selected\_NR".
      - (4) Go to Step 6.
    - ii) Exit the virtual drive function switch block.
  - b) Selected\_NR:
    - i) If the drive is "Electrically Ready" and "Mechanically Ready" and Force\_Not\_Ready is not asserted, then:
      - (1) Set current state to "Selected\_Rdy".
      - (2) Go to Step 6.
    - ii) If the virtual drive's Select signal has become inactive, then:
      - (1) Set current state to "Idle".
      - (2) Exit the virtual drive function switch block.
    - iii) Exit the virtual drive function switch block.
  - c) Selected\_Rdy:
    - i) If "Turn Off TI" has become active, then:
      - (1) Set the "Tape Indicator" state element to false.
    - ii) If "Turn On TI" has become active, then:
      - (1) Set the "Tape Indicator" state element to true.
    - iii) If "Set Lo Density" has become active, then:
      - (1) Set the "Hi\_Density" state element to false.
    - iv) If "Set Hi Density" has become active, then:
      - (1) Set the "Hi\_Density" state element to true.

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- v) If "Set Read Status" has become active, then:
  - (1) Set the Write\_Mode state element to false.
- vi) If "Set Write Status" has become active and the Read\_Protect state element is inactive, then:
  - (1) Set the Write\_Mode state element to true.
- vii) If the virtual drive's Select signal has become inactive, then:
  - (1) Set current state to Idle.
  - (2) Exit the virtual drive function switch block.
- viii) If the virtual drive's Rewind signal has become active, then:
  - (1) Set the current state to Rewinding.
  - (2) Set the "Tape Position" state element to zero.
  - (3) Set the "Mechanically\_Ready" state element to false.
  - (4) Set the "Alarm Timer" to the "Rewind Delay".
  - (5) Post a Rewind event to the PC.
  - (6) Exit the virtual drive function switch block.
- ix) If the virtual drive's "Rewind & Unload" signal has become active, then:
  - (1) Set the current state to Unloading.
  - (2) Set the "Tape Position" state element to zero.
  - (3) Set the "Mechanically\_Ready" state element to false.
  - (4) Set the Alarm\_Time to the "Unload Delay".
  - (5) Post an Unload event to the PC.
  - (6) Exit the virtual drive function switch block.
- x) If the GO signal has become active and the Backward input is inactive and the Write\_Mode state element is false, then:
  - (1) If the read data record has not been downloaded, then exit the virtual drive function switch block. (Does detecting the end-of-reel reflective spot make the drive "Not Ready"?)
  - (2) Set current state to Pre\_Read.
  - (3) If the datasource is the PC, then Post a "Read Request" to the PC.
  - (4) Set the Alarm\_Time to the "Read: GO to 1<sup>st</sup> Char" delay for the virtual drive's model, density setting, and "At Load Point" state.
  - (5) Initialize read data transfer fields to deliver the first read character.
  - (6) Exit the virtual drive function switch block.
- xi) If the GO signal has become active and the Backward input is active and the Write\_Mode state element is false, then:
  - (1) Set current state to Pre\_Backspace.
  - (2) Set the Alarm\_Time to the "Backspace: GO to 1<sup>st</sup> Char" delay for the virtual drives model and density setting.
  - (3) Initialize read data transfer fields to deliver the first read character.
  - (4) Exit the virtual drive function switch block.
- xii) If the GO signal has become active and the Backward input is inactive and the Write\_Mode state element is true, then:
  - (1) If the last record has not been uploaded, then Set the "Tape Indicator" to true, post a "Write Overflow" event, and exit the virtual drive function switch block. (Does detecting the end-of-reel reflective spot make the drive "Not Ready"?)

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- (2) Set current state to Pre\_Write.
  - (3) Set the Alarm\_Time to the "Write: Ignore after GO" delay for the virtual drives model and density setting.
  - (4) Initialize read data transfer fields to deliver the first read character.
  - (5) Exit the virtual drive function switch block.
- d) Pre\_Read:
- i) If the virtual drive's GO signal has become inactive, then:
    - (1) Set current state to Post\_Read.
    - (2) Go to Step 6.
  - ii) If the virtual drive's Select signal has become inactive, then:
    - (1) Set current state to Idle.
    - (2) Exit the virtual drive function switch block.
  - iii) If the Alarm\_Time has expired, then:
    - (1) If the datasource is the PC and the record has not been downloaded, then:
      - (a) Post a "Read Underflow" to the PC
      - (b) What dies a 729 do when the reflective spot is detected while reading?
    - (2) Set current state to Read.
    - (3) Set the Alarm\_Time to the "Read Timeout" delay.
    - (4) Initialize and start the Frame\_Timer with the appropriate frame time for the virtual drive's model and density setting.
- e) Pre\_Backspace:
- i) If the virtual drive's GO signal has become inactive, then:
    - (1) Set current state to Post\_Backspace.
    - (2) Go to Step 6.
  - ii) If the virtual drive's Select signal has become inactive, then:
    - (1) Set current state to Idle.
    - (2) Exit the virtual drive function switch block.
  - iii) If the Alarm\_Time has expired, then:
    - (1) Set current state to Backspace.
    - (2) Set the Alarm\_Time to the "Backspace Timeout" delay.
    - (3) Initialize and start the Frame\_Timer with the appropriate frame time for the virtual drive's model and density setting.
- f) Pre\_Write:
- i) If the virtual drive's GO signal has become inactive, then:
    - (1) Set current state to Post\_Write.
    - (2) Go to Step 6.
  - ii) If the virtual drive's Select signal has become inactive, then:
    - (1) Set current state to Idle.
    - (2) Exit the virtual drive function switch block.
  - iii) If the Alarm\_Time has expired, then:
    - (1) Set current state to Write.
    - (2) Set the Alarm\_Time to the "Write Timeout" delay.
    - (3) Enable "Write Pulse" and "Write Check Character" interrupts.
    - (4) Initialize but don't start the Frame\_Timer with the appropriate echo delay time for the virtual drive's model and density setting.
- g) Read:

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- i) If the Read has been posted as complete, then:
  - (1) Increment the "Tape Position" state element by 1.
  - (2) Set current state to Post\_Read.
  - (3) Go to Step 6.
- ii) If the virtual drive's GO signal has become inactive, then:
  - (1) Stop the "Frame Timer".
  - (2) Set current state to Post\_Read.
  - (3) Go to Step 6.
- iii) If the virtual drive's Select signal has become inactive, then:
  - (1) Stop the "Frame Timer".
  - (2) Set current state to Idle.
  - (3) Exit the virtual drive function switch block.
- iv) If the "Alarm Timer" expired, then:
  - (1) Stop the "Alarm Timer".
  - (2) Post a "Read Timeout" event to the PC.
  - (3) Go to Step 6.
- h) Backspace:
  - i) If the Backspace has been posted as complete, then:
    - (1) Decrement the "Tape Position" state element by 1.
    - (2) Post a Backspace event to the PC.
    - (3) Set current state to Post\_Backspace.
    - (4) Go to Step 6.
  - ii) If the virtual drive's GO signal has become inactive, then:
    - (1) Stop the "Frame Timer".
    - (2) Set current state to Post\_Backspace.
    - (3) Go to Step 6.
  - iii) If the virtual drive's Select signal has become inactive, then:
    - (1) Stop the "Frame Timer".
    - (2) Set current state to Idle.
    - (3) Exit the virtual drive function switch block.
  - iv) If the "Alarm Timer" expired, then:
    - (1) Stop the "Alarm Timer".
    - (2) Post a "Backspace Timeout" event to the PC.
    - (3) Go to Step 6.
- i) Write:
  - i) If the Write has been posted as complete, then:
    - (1) Disable "Write Pulse" and "Write Check Character" interrupts.
    - (2) Stop the "Frame Timer".
    - (3) Increment the "Tape Position" state element by 1.
    - (4) Post a "Write Request" event to the PC.
    - (5) Set current state to Post\_Write.
    - (6) Go to Step 6.
  - ii) If the virtual drive's GO signal has become inactive, then:
    - (1) Disable "Write Pulse" and "Write Check Character" interrupts.
    - (2) Stop the "Frame Timer".
    - (3) Set current state to Post\_Write.

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- (4) Go to Step 6.
- iii) If the virtual drive's Select signal has become inactive, then:
  - (1) Disable "Write Pulse" and "Write Check Character" interrupts.
  - (2) Stop the "Frame Timer".
  - (3) Set current state to Idle.
  - (4) Exit the virtual drive function switch block.
- iv) If the "Alarm Timer" expired, then:
  - (1) Stop the "Alarm Timer".
  - (2) Post a "Write Timeout" event to the PC.
  - (3) Go to Step 6.
- j) Post\_Read:
  - i) If the virtual drive's GO signal has become inactive, then:
    - (1) Set current state to Selected\_Rdy.
    - (2) Go to Step 6.
  - ii) If the virtual drive's Select signal has become inactive, then:
    - (1) Set current state to Idle.
    - (2) Exit the virtual drive function switch block.
- k) Post\_Backspace:
  - i) If the virtual drive's GO signal has become inactive, then:
    - (1) Set current state to Selected\_Rdy.
    - (2) Go to Step 6.
  - ii) If the virtual drive's Select signal has become inactive, then:
    - (1) Set current state to Idle.
    - (2) Exit the virtual drive function switch block.
- l) Post\_Write:
  - i) If the virtual drive's GO signal has become inactive, then:
    - (1) Set current state to Selected\_Rdy.
    - (2) Go to Step 6.
  - ii) If the virtual drive's Select signal has become inactive, then:
    - (1) Set current state to Idle.
    - (2) Exit the virtual drive function switch block.
- m) Rewinding:
  - i) If the "Alarm Timer" has expired, then:
    - (1) Set current state to Selected\_Rdy.
    - (2) Set the "Mechanically\_Ready" state element to true.
    - (3) Go to Step 6.
  - ii) If the virtual drive's Select signal has become inactive, then:
    - (1) Set current state to Idle.
    - (2) Invalidate the Alarm\_Time.
    - (3) Set the "Mechanically\_Ready" state element to true.
    - (4) Exit the virtual drive function switch block.
- n) Unloading:
  - i) If the "Alarm Timer" has expired, then:
    - (1) Set current state to Selected.
    - (2) Go to Step 6.
  - ii) If the virtual drive's Select signal has become inactive, then:

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- (1) Set current state to Idle.
- (2) Invalidate the Alarm\_Time..
- (3) Exit the virtual drive function switch block.
- 6) If the state machine has changed state OR "Select" signal from a Monitored drive is active and any input or output has changed state since the last interrupt OR the Select signal from a Monitored drive has just become inactive OR the read\_write\_flag is non-zero, then:
  - a) Post a "Channel I/O Status" event to the PC.
- 7) Replace the old copy of the saved ports with the current saved copy.
- 8) Write the virtual drives state to the appropriate output port pins.
- 9) Set the "I/O Polling Timer" to its normal interval.
- 10) Start the "I/O Polling Timer".
- 11) Return from interrupt.

## 2.6.3 High Priority Level Firmware

Work on this level is initiated by the "Read Pulse Width Timer", the "Write Pulse" input signal, the "Write Check Character" input signal, error exceptions, and potentially, debug actions. It is a design goal to perform as little work as possible on this level. It is also a requirement that non-error related interrupt service routines on this level must exit (return from interrupt) in less than 5 microseconds.

### Read Pulse Width Interrupts

Interrupts from the "Read Pulse Width Timer" are routed to its service routine.

1. Clear the interrupt flag.
2. Store zeros in the Read Channel Pulse Register.
3. Return from Interrupt.

### Write Pulse Interrupt

Interrupts from the "Write Pulse" input signal are routed to its service routine.

- 1) Clear the interrupt flag.
- 2) Read the character from the "Tape Channel Write Data" Register.
- 3) If the Frame Timer is not running (this is the first character to be echoed), then:
  - a) Initialize the Frame Timer to 4 milliseconds and start it.
- 4) Store the received character in the read buffer and increment the received character count.
- 5) Set the "write character received" bit in read\_write\_flags to 1.
- 6) Return from Interrupt.

### Write Check Character Interrupt

Interrupts from the "Write Check Character" input signal are routed to its service routine.

- 1) Clear the interrupt flag.
- 2) Read the character from the "Tape Channel Write Data" Register.
- 3) If the Frame Timer is not running, then:
  - a) Initialize the Frame Timer to 4 milliseconds and start it.

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- 4) Store the received character in the read buffer and increment the received character count.
- 5) Disable "Write Pulse" and "Write Check Character" interrupts.
- 6) Post "Write Complete".
- 7) Return from Interrupt.

## 3 The Adapter Daemon

The Adapter Daemon:

- is a Java program that communicates with the Adapter via the Windows driver.
- acts as the "data model" for Tape Channel Analyzer and Virtual Tape Drive Console GUIs.
- enables the user to define up to six Virtual Tape Drives
- enables the user to dispose of defined Virtual Tape Drives
- associates a control input stream, a status output stream, and a data input/output stream with each of the defined Virtual Tape Drives. These streams are used by Virtual Tape Drive GUIs.
- associates a control input stream and a data output stream with the Adapter's Tape Channel Analyzer function. The Tape Channel Analyzer GUI uses these streams.
- permits, but not necessarily implements mechanisms by which the GUIs could be bypassed and allow external programs to drive the associated input and output streams (this "hook" is architected to permit the potential expansion of this application to be connected to the internet)

### 3.1 *Functionality*

TBD.

### 3.2 *Console Application to Adapter Daemon Command Interface*

Command = Start ("Start" button pressed)

Parameters = "virtual tape drive select address" (1-6) and "associated file path".

Response = Success (returns Adapter's virtual drive status) or Error (unable to open file, Adapter does not respond)

Command = Reset ("Reset" button pressed or Frame closed)

Parameters = "virtual tape drive select address" (1-6)

Response = Success (returns Adapter's virtual drive status) or Error (Adapter does not respond)

Command = Set File Protect ("File Protect" button pressed)

Parameters = "virtual tape drive select address" (1-6), file protection state.

Response = Success (returns Adapter's virtual drive status) or Error (Adapter does not respond)

Command = Load Rewind ("Load Rewind" button pressed)

Parameters = "virtual tape drive select address" (1-6), file upload data

Response = Success (returns Adapter's virtual drive status) or Error (Adapter does not respond)

Command = Unload ("Unload" button pressed)

Parameters = "virtual tape drive select address" (1-6)

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Response = Success (returns Adapter's virtual drive status) or Error (Adapter does not respond); file download data.

Command = Change Density ("Change Density" button pressed)

Parameters = "virtual tape drive select address" (1-6)

Response = Success (returns Adapter's virtual drive status) or Error (Adapter does not respond)

Command = Inquiry (issued every few seconds to update status display)

Parameters = "virtual tape drive select address" (1-6)

Response = Success (returns Adapter's virtual drive status) or Error (Adapter does not respond), Virtual Drive Status

Virtual Drive Status is defined as:

(See Adapter to Daemon interface definition.)

## **3.3 Adapter Daemon to Console Application Interface**

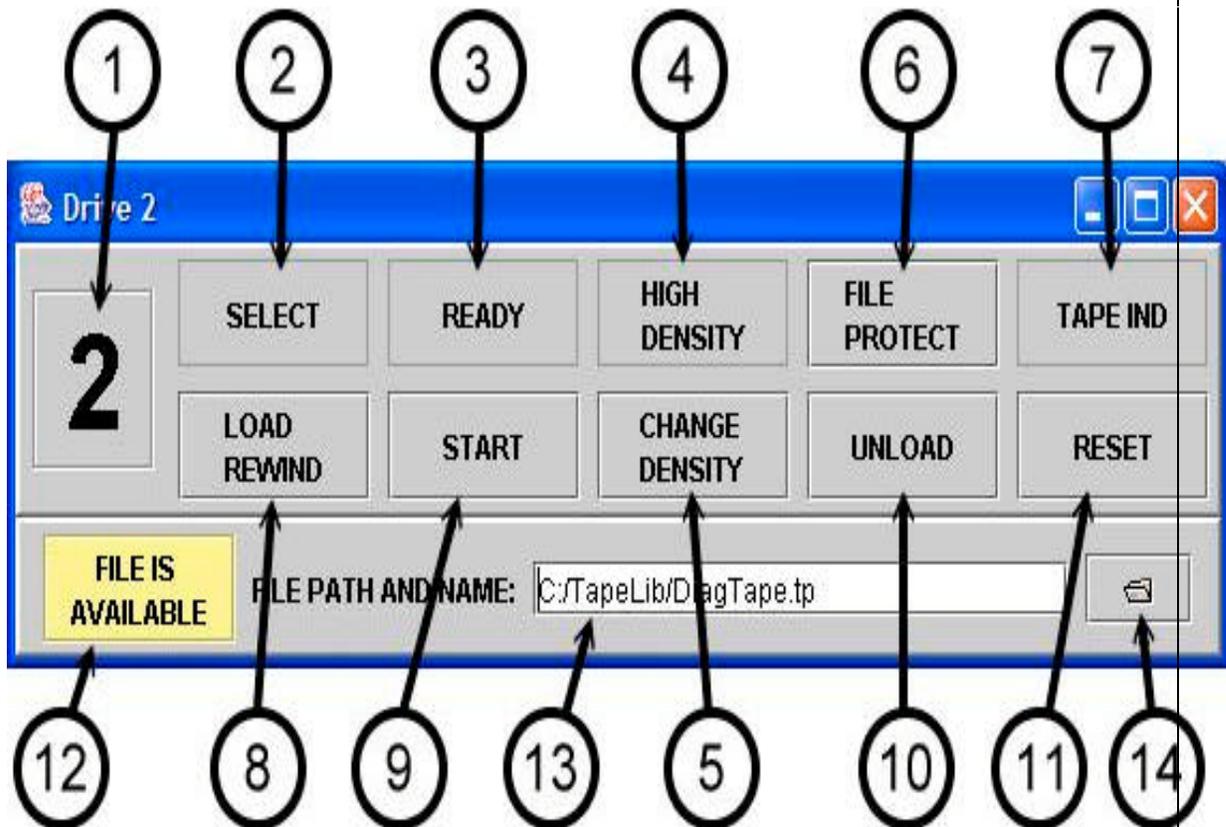
TBD.

## 4 Virtual Tape Drive Console Application

The Virtual Tape Drive Console Application is a subset of the Tape Channel Analyzer Application. It provides basic status visibility and control of the virtual drive. Since the objective of this application is to emulate 1401 era tape drives and priority is being given to restoration of the IBM 729 Model V tape drives, the GUI should represent a IBM 729 Model V drive as closely as reasonable. One instance of this application will be created for each emulated tape drive.

### 4.1 Functionality

The console should emulate the operator panel of a 729V tape drive. The GUI displays the operator controls and indicators in a "JFrame" (non-Java readers should substitute the term "Window"). Each virtual tape drive must have a unique address. Legal addresses are 1 through 6. The address must be user specifiable.



- 1) The "Drive address" indicates the tape channel drive address that is associated with the Frame.
- 2) Select Indicator - "On" indicates that the 1401 has selected the virtual drive and is in session with the Adapter.
- 3) Ready Indicator - "On" indicates that the Adapter is Mechanically and Electrically ready. "Off" indicates that the drive is in manual control mode.

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- 4) High Density Indicator - "On" indicates that the TAU will perform Write Operations using the "High Density" timings for the model drive that is addressed. (Write Operation timing is determined completely by the TAU's interpretation of the "Select and Ready Mod x", "Mod 5 or 6", and "Hi-Lo Density" response signals.) For Read Operations on real drives, this density indicator is meaningless. The density of Read Operations is predetermined by the data on the tape.  
For Virtual Tape Drive emulation, Write Operations will be performed in the same manner. For Read Operations, the Adapter will use the state of this indicator to select the timings that it will use to present data to the TAU. If the drive is configured as a 729 V, then read data is transferred using 800 bpi timing when in high density mode and 556 bpi timings when in low density mode.
- 5) Change Density Button - Toggles tape drive between high and low density. The TAU can also set the drive to the high or low density state.
- 6) File Protect Indicator / Button - "On" indicates that the drive will not accept Write Operations. On a real drive, this state is determined by the absence of the "write ring" being present on the tape reel. Under emulation, this indicator also functions as a button to toggle the "File Protect" state. However, if a file is associated with the Virtual Drive (see #13) and the file has the "file protect attribute" set, then the "File Protect" state is forced to "On". This button is inoperative unless the drive is in manual control mode.
- 7) Tape Indicator - "On" indicates that the Adapter's "Tape Indicator" state bit is on. The Adapter's "Tape Indicator" state bit can be turned on/off by 1401 interface signals. Reading a "tape mark" character will also turn it on. Pressing the "Unload" console button or a TAU initiated Unload operation will also make the Adapter turn it on.
- 8) Load Rewind Button - Emulates closing the drive's access window and positioning the tape at its "Load Point". Upon pressing this button, this application will also use the pressing of this button to:
  - a) Verify the validity of the "file association field" (see #13). If the field is not valid, the pressing of the button is ignored and the user is informed that the field is not valid.
  - b) Make "file association field" uneditable.
  - c) If a file is specified, a copy of the file is sent to the Adapter Communications Daemon.
  - d) The file availability indicator (see #13) is set to "IN USE".  
This button is inoperative unless the drive is in manual control mode.
- 9) Start Button - Pressing the start button places the drive in "ready" status if tape is loaded (file is associated or CE Panel Data Generator is enabled) and the access door is closed (Load Rewind was pressed). This button is inoperative unless the drive is in manual control mode and the above conditions are met. "Ready" status takes the drive out of manual control mode.
- 10) Unload Button - Emulates rewinding the tape, pulling the tape out of the vacuum columns, and opening the drive's access window. When this button is pressed, the Adapter:
  - a) If data was written to a file, then the file is closed and transferred from the Adapter Communications Daemon to this application.
  - b) The "file association field" is made editable.

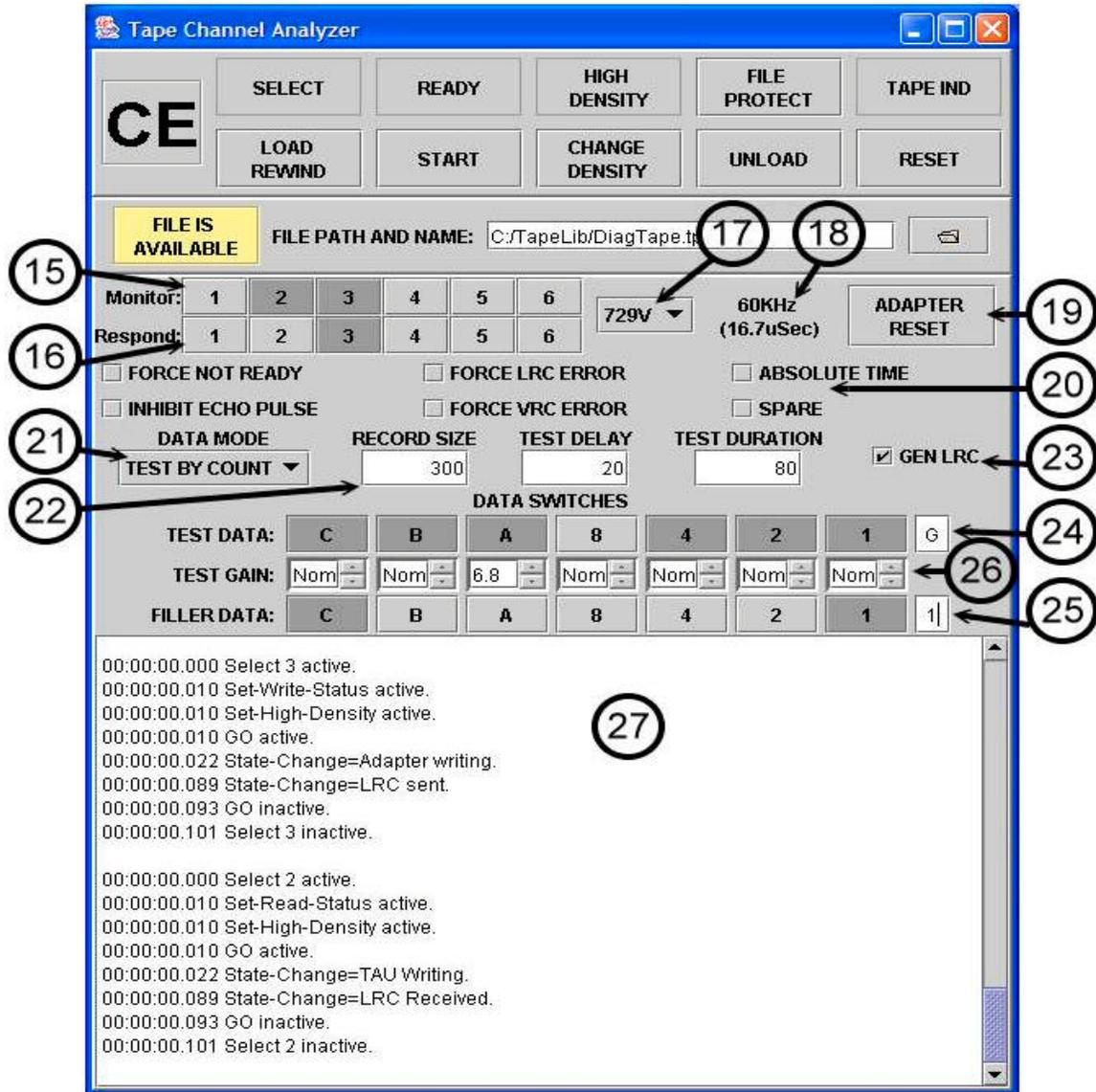
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- c) The file availability indicator (see #13) is set to "AVAILABLE". This button is inoperative unless the drive is in manual control mode. The TAU may also initiate these actions by issuing a "Rewind & Unload" operation.
- 11) Reset Button - Aborts any ongoing operation and sets the tape drive in "manual control mode".
  - 12) File availability indicator - This indicator changes state between "IN USE and "AVAILABLE" (a change in background color would help denote the state difference). The indicator state of "IN USE" means that the application's copy of the associated file may be out of sync with the copy of the file held by the Adapter Communications Daemon and may not contain the data written by the TAU. The local copy of the file can be synchronized by pressing the "UNLOAD" button or the TAU issuing a "Rewind & Unload" operation.
  - 13) File association field - To associate a PC file with the emulated tape reel, the fully qualified path/name of the file should be specified in this field. The field may be blank if the CE panel has its Data Generator enabled. If the field is not blank, it must contain a valid file path/name. The standard Java file path format is used. (The forward slash ("/") separator is used rather than the Windows backslash separator ("\").) Specifying a valid file name for a file that does not exist indicates the mounting of a blank tape. If this field specifies a file which is Windows write protected, then the "File Protect" state will be forced "On".
  - 14) File chooser button - Pressing this button will activate a "File Chooser" pop-up window to help the user locate the file path/name to select for the "file association field".

## 5 Tape Channel Analyzer Application

This application presents a GUI with the look and feel of a CE Panel and a logic analyzer. Switch controls override normal Adapter responses. A waveform display window is not specified, but may be a good enhancement.

### 5.1 Functionality



The top portion of the CE Panel operates as described in the previous section, except as described below.

15) Monitor Toggle Switches - The switches indicate which tape channel drive addresses the Adapter monitors. If a drive address is "monitored", then tape channel transaction to that address are recorded and displayed in the "Channel Trace" pane (see #27).

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- 16) Respond Toggle Switches - The switches indicate the tape channel drive addresses to which the Adapter will emulate (respond).

The actions of the below controls apply to all Virtual Drives selected by the "Respond Toggle Switches".

- 17) Drive Model Selector - Selects the model drive that will be emulated. Valid Selections are 729V (default), 729II, 729IV, and 729VI.
- 18) Frame Rate Display - The data transfer rate resulting from the above "Drive Model Selector" and density settings.
- 19) Adapter Reset - Fully resets the Adapter. Any ongoing operations are aborted.
- 20) Check Box Controls - These controls enable or disable specific features of the Tape Channel Analyzer.
- a) Force Not Ready - The Adapter will respond to all TAU operations as "Not Ready". The Virtual Drive state is forced and held "Electrically\_Not\_Ready".
  - b) Inhibit Echo Pulse - When Write Operations occur, the Adapter will not respond to write data with echo pulses.
  - c) Force LRC Error - The Adapter's LRC character will be complemented before it is transmitted. This applies to all transmitted LRC characters including those for Read Operations and the echo function of the Write Operations.
  - d) Force VRC Error - The Adapter will complement the "C"-bit of all data characters that are transmitted. LRC characters will be calculated using the complemented data. This applies to all transmitted data characters including those for Read Operations and the echo function of the Write Operations. This switch does not effect LRC characters.
  - e) Absolute Time - Normally timestamps displayed in the "Trace Pane" (see #27) are displayed using time relative to the previous active transition of a monitored Select signal. If "Absolute time" if checked, then absolute timestamps (relative to the last Adapter Reset) will be displayed. This facilitates the examination of Tape Channel timing across multiple operations.
- 21) Data Generator Mode - The Tape Channel Analyzer can generate several types of data streams. This control selects the type of data stream that is generated.
- a) Force Test - The character represented by the "Test Data" switches at the gain level established by the "Test Gain" switches will be transmitted whenever a character is to be sent on the Tape Channel Read Bus.
  - b) Alternate - Characters in the generated data stream will alternate between the character represented by the "Test Data" switches and the character represented by the "Filler Data" switches. Whenever the "Test Data" character is transmitted, the gain level established by the "Test Gain" switches will be applied. Whenever the "Filler Data" character is transmitted, the nominal gain levels will be applied.
  - c) Test By Count - The generated data stream will consist of records that are "Record Size" (see #22) characters in length. In each of these records, the first part of the record will consists of the "Filler Data" character. The "Test Delay" field contains the number of "Filler Data" characters to be inserted. Then a block of "Test Data" characters will be transmitted at the "Test Gain" level. The "Test Duration" field contains the number of "Test Data" characters in this block. If

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- "Record Size" is greater than "Test Delay" plus "Test Duration", the remainder of the record is composed of "Filler Data" characters at nominal gain levels.
- d) Test+1 - Same as "Test by Count" except that the "Test Data" character is the first character of the "Test Data" block. Subsequent characters in the block generated by selecting the next character in the BCD tape character collating sequence.  
Example: A block of 5 characters starting with "7" is "7", "8", "9", blank, and "."
  - e) Test Rotate - Same as "Test by Count" except that the "Test Data" character is the first character of the "Test Data" block. Subsequent characters in the block generated by rotating the bits of that character one position to the right. Note that this may generate characters that are not valid BCD tape characters.
- 22) Count fields - The "Record Size", "Test Delay", and "Test Duration" fields are numeric text entry fields that contain data that may be used by some "Data Generator" modes. (see #21)
  - 23) Gen LRC - If checked and Data Generator is the selected data source, the Tape Channel Analyzer's Data Generator will generate a valid LRC character and transmit it after the last data character of the record. This character will be in addition to the count specified in the "Record Size" field.
  - 24) Test Data Toggle Switches - The character represented by these switches is known as the "Test Data" character. See "Data Generator Mode" (#22) for a description of how the character is used. If the character is entered via the switches, then the text representation of the character is displayed in the right side text field. If the character is entered via the right side text field, then the bit representation is set in the switches.
  - 25) Filler Data Toggle Switches - The character represented by these switches is known as the "Filler Data" character. See "Data Generator Mode" (#22) for a description of how the character is used. If the character is entered via the switches, then the text representation of the character is displayed in the right side text field. If the character is entered via the right side text field, then the bit representation is set in the switches.
  - 26) Test Gain Spinner Switches - Each of these switches indicates the gain level to be used for the corresponding bit of "Test Data". These switches only apply to the transmission of "Test Data". The transmission of "Filler Data" always occurs at nominal gain levels.
  - 27) Trace Pane - This pane displays a textual representation of the Tape Channel Analyzer's trace file. Recorded Tape Channel control and control response signal transitions are displayed in this pane. Each transition is displayed as a line preceded by a timestamp. The timestamps may be displayed as absolute or relative (see #20).