CAUTION!!!
Incorrect assembly or connecting of the Mimeo Cassette Interface can cause fatal damage to the interface and/or the motherboard. Double and triple check your connections before powering on. Pay special attention to orientation of the card when you plug it into the motherboard’s expansion slot. Plugging it in backwards will result in damage to the card and/or motherboard.

Forward
In the mid 1970’s, around the time the Apple 1 was developed, the only reasonably affordable interface for home computer hobbyist was repurposing an ordinary cassette recorder as a data storage device. Soon after the introduction of the Apple 1, Apple Computer released the Apple Cassette Interface (ACI) for the Apple 1. This small card had a list price of $75 and turned out to be the only peripheral card that Apple ever released for the Apple 1. The Mimeo Cassette Interface is a clone of Apple’s original ACI, duplicating the form, fit and function of the original ACI in exacting detail. This manual refers to the board as the ACI, since that is the name Apple used and for all intents and purposes the implementations and operation are identical.
Reliability

Reliability of the ACI card, in its stock form, is not very good by 21st century standards. Apple made improvements to the cassette interface circuit when it came out with the Apple II. I have spent considerable effort looking for improvements in reliability, without altering the design of the original ACI printed circuit board. In the end, I have found two items that can help with reliability.

One of these involve changing the value of the input coupling capacitor. I am providing parts that can used to build the board with either original component value or with a component that will improve reliability. Because of the reliability problems with the original design, I recommend building this kit with the components that improve reliability. Look and feel of the board is not affected but reliability is improved quite a bit. Even with these changes, reliability is not perfect, but the system will be more reliable.

The second reliability improvement I recommend, is using an Apple recommended cassette recorder. I have had great difficulty with a different vintage cassette recorder that works quite well with an Apple II. The good news is that a modern variation of the original Apple recommended recorder happens to remain on the market. This is a Panasonic RQ-2102. There may be other cassette recorders that perform as well or better than the RQ2102, but I don’t have the time or resources to investigate the possibilities.

Chapter 1 – Assemble Components, Tools, and Equipment

1. **Recommended Tools and Equipment**
   - Quality soldering station - I use a Weller WES51. Whatever you use, I recommend that it has some kind of temperature controlled tip. This will help prevent damage to the PCB when soldering. Soldering irons that do not have a temperature controlled tip can overheat and damage the PCB or component being soldered
   - Solder - use quality solder - thinner solder is vastly easier to work with than fat solder. The fat stuff sold at hardware stores is not suitable for these sort of electronics projects
   - Wire cutters – for trimming component leads and cutting wire to length
   - Wire strippers - for stripping ends of jumper wire
   - Your favorite PCB cleaning agent - Isopropyl Alcohol will dissolve many kinds of soldering resin. Windex will also help with cleaning PCBs
   - Ohm meter - to check for good connections and shorts
   - Logic probe or oscilloscope – handy if you are having trouble with bring up
   - Your host computer schematics or hardware interfacing guide – Direction for connecting to Mimeo 1 computers are provided in this manual

2. **Additional Components (not included)**
   - Cassette Recorder - I strongly recommend the Panasonic RQ-2102
   - Cassette Tapes - ordinary 30 or 60 minute tapes work well
   - Two mono to mono 1/8” audio cables. One end plugs into the ACI, the other into jacks on the cassette recorder
### 3. Compare Received Components With Parts List

Examine and identify all parts provided with the kit.

<table>
<thead>
<tr>
<th>PART</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>PRESENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 pin socket</td>
<td>For PROMs</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>14 pin socket</td>
<td>For 74LS parts</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>8 pin socket</td>
<td>For LM311</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>LM311</td>
<td>Voltage comparator</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>74LS02</td>
<td>Quad 2 input nor gate</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>74LS10</td>
<td>Triple 3 input nand gate</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>74LS74</td>
<td>Dual D type flip flop</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7474</td>
<td>no longer supplied - original 74LS74 works better</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6301 - APPLE-A3</td>
<td>256x4 PROM - location A3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6301 - APPLE-A4</td>
<td>256x4 PROM - location A4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>.01uF capacitor</td>
<td>Input coupling capacitor</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>.1uF capacitor</td>
<td>Reliability improvement replacement for .01uF</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>100 ohm</td>
<td>brown-black-brown Low part of voltage divider for tape output &amp; current limiter for LED input monitor</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3K resistor</td>
<td>orange-black-red Voltage comparator feedback</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10K resistor</td>
<td>brown-black-orange-gold High part of voltage divider for tape output</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10K 1% resistor</td>
<td>brown-black-orange-black-brown Voltage dividers for inputs to voltage comparator</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>47K resistor</td>
<td>yellow-violet-orange Voltage comparator feedback</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>100K resistor</td>
<td>brown-black-yellow Sense resistor for input monitor LED</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>PCB</td>
<td>Printed circuit board</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>MPS3704</td>
<td>Sense transistors for input monitor LED</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>RED LED</td>
<td>Read level indicator</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Audio Jacks</td>
<td>Switchcraft #41</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Jumper wire for Jacks</td>
<td>Apple used bare wire - use cut lead from a resistor</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**PARTS COUNT**

32

**COUNT OF TYPES**

23
Chapter 2 – Solder In Components

1. Overview
The key thing here is to check orientation and make sure that you don’t put the sockets or transistors in wrong. For the IC sockets, make sure that the parts are oriented correctly with pin 1 of the socket or chip near the edge of the PCB that contains the gold fingers. All components go on the front of the board (the side with the words “Apple Cassette Interface 1” etched in copper.

Make sure the socket or chip is fully seated. I accomplish this by resting the socket upside down on a small object with the board on top. The weight of the board should keep the socket or chip completely seated. Then tack down a couple of corner pins and recheck orientation and seating. Then finish soldering the rest of the pins.

Take your time and enjoy the process, double checking orientation of devices as you go. The red or blue arrows indicate places to pay special attention when placing components.

2. Check for Power and Ground Shorts on PCB
Easiest way to do this is to use an ohm-meter to make sure that there is no connection between +5 volts, -12 volts and ground. The Ohm meter should show no connections between any of these nets. A convenient place to use to check for shorts, is this area on the back of the board (red arrows above).
3. Solder in All Components Except 1/8” Phono Jacks

[Table]

<table>
<thead>
<tr>
<th>PART</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>COMPLETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 pin socket</td>
<td>A-3 and A-4 - pin 1 toward gold finger edge</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>14 pin socket</td>
<td>A-2, A-5, A-6 - pin 1 toward gold finger edge</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>8 pin socket</td>
<td>A-1 - pin 1 toward gold finger edge</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>capacitor</td>
<td>Input coupling capacitor - topmost device in row of components at A-1. Use .1uF (104) capacitor for better read reliability. Use .01uF (103) capacitor to exactly replicate original design.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>100 ohm</td>
<td>brown-black-brown Top of row at A4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>100 ohm</td>
<td>brown-black-brown Next to gold fingers in row A1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3K ohm</td>
<td>orange-black-red Vertically mounted - left of 8 pin dip in row A-1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10K resistor</td>
<td>brown-black-orange-gold Top of row at A-3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10K 1% resistor</td>
<td>brown-black-orange-black-brown Four in a row below cap in row A-1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>47K resistor</td>
<td>yellow-violet-orange Just above 8 pin dip in row A-1.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>100K resistor</td>
<td>brown-black-yellow just below two 1/8” jacks</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>MPS3704</td>
<td>Below two 1/8” jacks - flat side toward top of board (middle pin goes in hole closer to top of board)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>RED LED</td>
<td>Long lead (anode) on right</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

front view of board (components are mounted on front side of board)
4. **Install 1/8” Phono Jacks**

After mounting the jacks, a short wire must be connected from tab on jack to PCB hole to connect read and write circuits to the jacks. See the illustrations above for locations.

<table>
<thead>
<tr>
<th>PART</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>COMPLETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read and Write Jacks</td>
<td>The jack is mounted with the receptacle facing the front of the board (the same side as the components). Firmly tighten the nut, but not so tight that you risk damaging the PCB. Ground is through this connection. Use two short lengths of wire left over from cutting off resistor leads. They only need to be long enough to reach from the tab on jack to the hole in the PCB. Original ACIs had no insulation on these short lengths of wire. From the back of the board, solder one end to tab on jack and the other to the appropriate hole in the PCB. There are two tabs. Be sure to connect the wire to the tab that connects to the tip of the plug.</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

5. **Recheck for Power and Ground Shorts on PCB**

Easiest way to do this is to use an ohm-meter to make sure that there is no direct connection between +5 volts, -12 volts and ground. With the resistors now soldered in, you should note about 9.6K ohms resistance between +5 volts and ground. -12 volts should have no connectivity with either +5 volts or ground.
6.  Install ICs

<table>
<thead>
<tr>
<th>PART</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>COMPLETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM311</td>
<td>8 Pin Socket at A-1. Pin 1 toward gold fingers</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>74LS74</td>
<td>14 Pin Socket at A-2. Pin 1 toward gold fingers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROM A-3</td>
<td>16 Pin Socket at A-3. Pin 1 toward gold fingers. Prom is printed with &quot;APPLE A-3&quot; on top of the package and has an A3 label on the bottom.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROM A-4</td>
<td>16 Pin Socket at A-4. Pin 1 toward gold fingers. Prom is printed with &quot;APPLE A-4&quot; on top of the package and has an A4 label on the bottom.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>74LS02</td>
<td>14 Pin Socket at A-5. Pin 1 toward gold fingers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>74LS10</td>
<td>14 Pin Socket at A-6. Pin 1 toward gold fingers.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.  Clean PCB of Rosin and By-products of Soldering

Once soldering is complete, clean the back of PCB of excess flux and rosin. 90% or higher isopropyl alcohol. IPA will dissolve soldering resin. Note that the IPA will also remove the APPLE-AX printing on the PROMs so keep it away from these parts. Spray it on the back of the board and lightly scrub with a very soft brush that will not scratch the surface of the PCB. Soak up the IPA and contaminates with a clean soft cloth before the IPA evaporates in order to remove the by products of soldering. I have also discovered that “Windex” window cleaner can help remove the by-products from the soldering job. Removing contaminates is important as many kinds of rosins are corrosive. Let dry overnight. Position a fan to blow over the board to make sure that all remaining moisture evaporates.

8.  Check Board for Solder Bridges and Cold Solder Joints

While the board is drying, you should carefully check your work for bad solder joints and solder bridges.

Chapter 3 – Installation, Operation and Help

1.  Installation and Operation

Completely read and understand the original Apple Cassette Interface Manual reproduced in appendix C for installation and operation instructions.

2.  Troubleshooting and Help

A good job of soldering the components into place should eliminate most if not all trouble. First step, in case of trouble, should be to check for bad solder joints or bridges.

Refer to my Apple II repair page at www.willegal.net for some general troubleshooting hints.

Feel free to send email to: mike@willegal.net if you run into difficulties.
**Appendix A - Using an iPod With the ACI**

An iPod may be used in place of a cassette player with the ACI. Almost any iPod can be used for loading programs with the same cable that is used for reading from a cassette player. Programs must be put into AIFF format prior to loading. I have listed several programs already in that format on this web page: http://www.willegal.net/appleii/apple1-software.htm

This same page has the source code for a UNIX shell program that will convert programs in Apple monitor format into AIFF files, so that you can convert your own programs to be loaded from an iPod.

Writing to the iPod requires an iPod that supports microphone input, a special cable and an iPad application that uses a lossless recording format. A detailed write up on the process can be found here.
http://www.apple1notes.com/Home/Notes.html

**Appendix B Replica 1 Notes**

At the time of this printing, the ACI has not been tested with a Briel Computer Systems Replica 1. Watch my blog at www.willegal.net/blog for updates on the results of this planned testing. I do not expect issues with this testing. If you do try it before I get the chance, remember that because the ACI requires -12volts, the Replica 1 must be powered by an ATX power supply.

The Achatz replica does not have a provision for -12 volts, so the ACI will not work with that system.

**Appendix C - Apple’s Original ACI Manual**

Appendix C is a digitized reproduction of the original eight page Apple Cassette Interface manual. Fonts and layout are similar to the original, but not exact reproductions. *Disregard warranty, address, phone number information - this data is left in place, so the complete manual is preserved.*

Unlike what the manual indicates, performance with various cassette recorders can vary from not functional to works pretty well. I use and recommend a Panasonic RQ-2102. The best volume setting for read operations on my recent production Panasonic RQ-2102 is around a 4.

The LED circuit is configured to turn on at about 1.2 volts, which I have found, is too high a level for reliable data recovery. Don’t rely on the LED to set your playback volume.

Finally, it is my opinion is that the reliability of the ACI is not as good as the manual suggests. In fact, with the stock .01uF capacitor in place, I have experienced very unreliable operation. Operation improves substantially with the .1uF capacitor, which is why I have included it in the kit. This is not unique to reproductions, as I know of an owner of an original Apple 1 that had to resort to bridging the existing .01uF cap with a .1uF cap before he could read files from an cassette player during his efforts to restore the unit to operation.

Except for these points, the manual contains accurate and useful information for installation and operation of the ACI and should be read and understood prior to installing and operating your ACI.

**Appendix D – ACI Source Code Listing**

Appendix D is the source code listing for the 256 byte PROM bank that exists on the ACI card.
APPLE-1
CASSETTE INTERFACE
INTRODUCTION

The Apple Cassette Interface [ACI] is a peripheral device for the Apple Computer which enables the user to store and retrieve information (data and programs) using a standard audio grade cassette recorder. The ACI attaches directly to the Apple Computer and jacks are provided on the ACI board to connect to the cassette recorder. The ACI reads and writes data at the rate of approximately 1500 baud (depending upon the data), All the ACI timing is done in software, resulting in extreme accuracy, no adjustments, and consistency between units.

TAPE RECORDERS & TAPE

Almost any cassette recorder will work well with the ACI. As a recommendation, we have found the least expensive (under $40) Panasonic to be very reliable and of good quality, although it is not equipped with a tape counter, which is useful (though not essential) for locating files within a tape. (An alternative method of discerning files is to record a voice identification between files.)

Among the ‘under $25’ cassette recorders there may be variations in head alignment and internal electronics, resulting in the inability to accurately read a tape that has been recorded on a different machine. However, if the same unit is used for both recording and reading, even the cheapest of cassette recorders will work reliably.

Most tapes available in the $2-$4 category work well for data storage. You may experience an occasional tape which ‘loses bits’ which is caused by severe oxide thickness variations on the tape and cannot be corrected. Special leaderless tapes need not be used as the ACI automatically transmits a ten second ‘header’ of all ones before transmitting the data, which insures that the leader will have passed.

JUMPERS

For operation of the ACI, a permanent jumper must be placed between ‘R’ and ‘C’ in the block select area of the main board (B9,10). This jumper from ‘R’ which is connected to enable the ACI, to ‘C’ selects the ACI when the 12th 4K block (‘C’) is addressed.

Also, for running Apple Basic in the 2nd 4K band of on-board memory, it is necessary to break the solder jumper between ‘W’ and ‘1’ and then jumper ‘W’ to ‘E.’ This moves the 2nd 4K bank from the ‘1’ block to the ‘E’ block, which is where Apple Basic resides.
INSTALLATION

Install the ACI board into the connector on the main board with the components on the ACI board facing away from the main board (the jacks to the edge of the main board). SEE FIGURE 1. The system power should be OFF whenever installing or removing the ACI board.

Install cables from the ACI jack marked “TO TAPE” to the recorder microphone input and from the ACI jack marked “FROM TAPE” to the recorder earphone output. One cable can be appropriately switched between the two paths if necessary.

USING THE ACI

The Cassette program is contained in two PROMS on the ACI board and runs at C100. When entered, the program should echo an “*.” The format for specifying the memory address ranges to be either stored (write) or deposited into (read) is identical to the standard monitor format: Beginning . End , suffixed with either a ‘W’ (write) or an ‘R’ (read). Execution will start following a carriage return (CR). The cassette program will return control to the system monitor upon completion of a read or write. Illegal characters (or the absence of characters) in the address line will return control to the system monitor without execution, following a carriage return.

MULTIPLE RANGES

The ACI is capable of reading and writing multiple address ranges. The format is: A.BW C.DW (R for read). Again, spaces are ignored. The ACI will write a ten second header, the first range, another header and the second range. 100.200W 300.500W will write a header, 100 in 200, a second header, and 300 to 500. When reading a multiple range tape. YOU MUST USE THE SAME ADDRESS INCREMENTS AS WERE USED IN WRITING THE TAPE. This does not mean the same absolute addresses, but rather the same increments.
The procedure for reading from a tape into memory is:

**C100R (RET)** This enters the cassette program and should echo an ‘*’

**E000 . EFFF R** This will load the tape data into memory locations E000.EFFF. ‘R’ denotes a read, and spaces are ignored. [Don’t hit ‘return’ yet.]

**Start the Tape**

**Hit ‘RETURN’** A carriage return will start execution of a read. The ‘return’ can be hit immediately, however, it must be hit within 5 seconds after the start of tape motion.

When the last location (EFFF in this example) has been loaded, the program will print a ‘/’ and return control to the monitor.

The procedure for a write is identical except the suffix 'W' is substituted for 'R' in the address line. For both read and write, the tape should always be moving before hitting the RETURN.

**LEVEL**

The Cassette recorder output level should be set to where the LED on the ACI is just fully lit. Increase the level from zero until the LED glows fully. If you experience a bad read, try it a LITTLE higher. The LED indicator is operational even when the cassette program is not executing, and the level should be set prior to reading a tape, NOT during the reading of a tape.

**SPEED**

The ACI uses the technique of recording a whole cycle of either a 1kHz cycle (representing a ‘one’ data bit) or a 2 kHz cycle (representing a ‘zero’ data bit). Therefore, with an average data mix of one’s and zero’s, data will be recorded at 1500 baud. A ten second header of all ones will automatically be recorded on the tape prior to memory data. This is to insure that the clear leader portion of the tape will have passed. See schematic for further details.
NOTE:
1. IN CHIP SELECT AREA (B9 · B10 ON MAIN BOARD), 7R7 MUST BE PERMANENTLY JUMPERED TO 7C7 FOR OPERATION OF THE CASSETTE INTERFACE.
WARRANTY

Apple Computer Company hereby warrants each of its products, and all components therein contained, to be free from defects in materials and/or workmanship for a period of thirty (30) days from date of purchase. In the event of the occurrence of malfunction, or other indication of failure attributable directly to faulty workmanship and/or material, then, upon return of the product to the Apple Computer Company at 770 Welch Road, Palo Alto, California 94304 (postage prepaid), the Apple Computer Company will, at its option, repair or replace said products or components thereof, to whatever extent Apple Computer Company shall deem necessary, to restore said product to proper operating condition. All such repairs or replacements shall be rendered by Apple Computer Company without charge to the customer.

The responsibility for the failure of any Apple Computer product, or component thereof, which, at the discretion of the Apple Computer Company, shall have resulted either directly or indirectly from accident, abuse, or misapplication of the product, shall be assumed by the customer and the Apple Computer Company shall assume no liability as a consequence of such events under the terms of this warranty.

While every effort, on the part of Apple Computer Company, is made to provide clear and accurate technical instruction on the use, implementation, and application of its products, the Apple Computer Company shall assume no liability in events which arise from the application of such technical instruction, nor shall the Apple Computer Company be held liable for the quality, interconnection, or application of peripheral products, which may have been recommended by Apple Computer Company, but which have not been supplied as part of the product.

This warranty contains and embodies the limits of responsibility of the Apple Computer Company with regard to its products, and no other liability is expressed, implied, or should be assumed by the purchaser, and in no event shall the Apple Computer Company be held liable for the loss of time, effort, or transportation costs, nor for loss of potential profits or other consequential losses which might arise from the purchase, assembly, use, application, or subsequent sale of the products of Apple Computer Company, nor from any instructions and/or mechanical information thereto related.
Apple Computer Company
770 Welch Road, Suite 154
Palo Alto, California 94304
Phone: (415) 326-4248
c00 PROCESSOR 50

;-------------------------------------------------------------------------
; The WOZ Apple Cassette Interface for the Apple 1
; Written by Steve Wozniak somewhere around 1976
;-------------------------------------------------------------------------
ORG $C100

; Memory declaration
;-------------------------------------------------------------------------

;-------------------------------------------------------------------------
 ;  Memory declaration
 ;-------------------------------------------------------------------------

ORG $C00

;-------------------------------------------------------------------------
;  Constants
 ;-------------------------------------------------------------------------

;-------------------------------------------------------------------------
;  Let’s get started
 ;-------------------------------------------------------------------------

a9 aa WOZACI LDA #$AA ;Print the Tape prompt “*”
a0 ef ff          JSR ECHO
a0 ff         LDX #- ;Initialize parse buffer pointer

--- FILE wozaci.asm LEVEL 1 PASS 2
D-
Start parsing first or a new tape command

; Clear begin and end values
LDA #0
STA HEX1L
STA HEX1H

; Read command? “R”
CMP #$D2
BEQ READ

; Write command? “W”
CMP #$D7
BEQ WRITE

; Separation? “.”
CMP #$AE
BEQ SEP

; End of line?
CMP #CR
BEQ GOESC

; Ignore spaces: “ ”
CMP #$A0
BEQ NEXTCHR

; Map digits to 0-9 “0”
ADC #$88
CMP #$FA
BCC WOZACI

; Hex digit to MSD of A
ASHL
ASHL
ASHL

; Hex digit left, MSB to carry
ASHL
ROL HEXL
ROL HEXH

; Done 4 shifts?
DEY
BNE HEXSHIFT

; Handle next character

; Return to monitor, prints \ first

; Separating “.” found. Copy HEX1 to Hex2. Doesn’t clear HEX1!!!

; Copy hex value 1 to hex value 2
LDA HEX1L
STA HEX2L
LDA HEX1H
STA HEX2H

; Always taken!
BCS NEXTCHR
; Write a block of memory to tape
;a9 40 WRITE LDA #36 ;Write 10 second header
20 cc c1 JSR WHEADER
88 WRNEXT DEY ;Compensate timing for extra work
a2 00 LDX #0 ;Get next byte to write
a1 26 LDA (HEXL,X)
a2 10 WBITLOOP LDX #8*2 ;Shift 8 bits (decremented twice)
a0 8 ASL ;Shift MSB to carry
20 db c1 JSR WRITEBIT ;Write this bit
d0 fa BNE WBITLOOP ;Do all 8 bits!
a0 1e JSR INCADDR ;Increment address
a0 e LDX #0 ;Compensate timer for extra work
a2 10 WRNEXT JSR FULLCYCLE ;Synchronize with full cycle
20 f1 c1 JSR INCADDR ;Increment address
90 ec WRNEXT JSR INCADDR ;Increment address
a6 28 RESTIDX LDX SAVEINDEX ;Restore index in input line
b0 98 BCS NEXTCMD ;Always taken!

; Read from tape
;a9 16 LDA #22 ;Introduce some delay to allow
20 cc c1 JSR WHEADER ;the tape speed to stabilize
20 cc c1 JSR FULLCYCLE ;Synchronize with full cycle
a0 1f NOTSTART LDY #31 ;Try to detect the much shorter
20 bf c1 JSR CMELEVEL ; start bit
b0 f9 BNE NOTSTART ;Start bit not detected yet!
a0 3a LDY #58 ;Set threshold value in middle
a2 08 RDBYTE LDX #8 ;Receive 8 bits
48 RDBIT PLA ;Roll new bit into result
20 bf c1 JSR CMELEVEL ;Wait for 2nd phase of start bit
a0 39 LDY #57 ;Set threshold value in middle
ca DEX ;Decrement bit counter
d0 f5 BNE RDBIT ;Read next bit!
81 26 STA (HEXL,X) ;Save new byte
20 f1 c1 JSR INCADDR ;Increment address
a0 35 LDY #53 ;Compensate threshold with workload
90 ea BCC RDBYTE ;Do next byte if not done yet!
b0 cd BCS RESTIDX ;Always taken! Restore parse index

;FULLCYCLE CMELEVEL ;Wait for two level changes
88 DEY ;Decrement time counter
ad 81 e0 LDA TAPEIN ;Get Tape In data
c5 29 CMP LASTSTATE ;Same as before?
f0 1e BEQ CMELEVEL ;Yes!
85 29 STA LASTSTATE ;Save new data

c0 80 CPY #128 ;Compare threshold
Write header to tape

The header consists of an asymmetric cycle, starting with one phase of approximately (66+47)x5=565us, followed by a second phase of approximately (44+47)x5=455us.

Total cycle duration is approximately 1020us ~ kHz. The actual frequency will be a bit lower because of the additional workload between the twoloops.

The header ends with a short phase of (30+47)x5=385us and a normal phase of (44+47)x5=455us. This start bit must be detected by the read routine to trigger the reading of the actual data.

:-------------------------------------------------------------------------

8 WHEADER STX SA SAVEINDEX ;Save index in input line
A0 HCOUNT LDY #66 ;Extra long delay
20 JSR WDELAY ;CY is constantly 1, writing a 1
D0 JSR WDELAY ;Do this * 5 time!
69 ADC #-2 ;Decrement A (CY=1 all the time)
B0 BCS HCOUNT ;Not all done!
A0 LDY #30 ;Write a final short bit (start)

:-------------------------------------------------------------------------

20 e0 c1 WRITEBIT JSR WDELAY ;Do two equal phases
A0 LDY #44 ;Load 250us counter - compensation
8 WRITEBIT LDY BNE WDELAY ;Delay 250us (one phase of 2kHz)
D0 BNE WDELAY ;Write a '1' (2kHz)
90 BCC WRITE1 ;Additional delay for '0' (kHz)
B0 DEY ;(delay 250us)
8 WRITEBIT0 LDY #47 ;Write a final short bit (start)
D0 BNE WDELAY0 ; (delay 250us)
20 WRITE LDY FLIP,X ;Flip the output bit
A0 LDY #41 ;Reload 250us cntr (compensation)
8 DEX ;Decrement bit counter
60 RTS

:-------------------------------------------------------------------------

20 e0 c1 WRITEBIT JSR WDELAY ;Do two equal phases
A0 LDY #44 ;Load 250us counter - compensation
8 WRITEBIT LDY BNE WDELAY ;Delay 250us (one phase of 2kHz)
D0 BNE WDELAY ;Write a '1' (2kHz)
90 BCC WRITE1 ;Additional delay for '0' (kHz)
B0 DEY ;(delay 250us)
8 WRITEBIT0 LDY #47 ;Write a final short bit (start)
D0 BNE WDELAY0 ; (delay 250us)
20 WRITE LDY FLIP,X ;Flip the output bit
A0 LDY #41 ;Reload 250us cntr (compensation)
8 DEX ;Decrement bit counter
60 RTS

:-------------------------------------------------------------------------

A5 INCADDR LDA HEX2L ;Compare current address with
C5 CMP HEX1L ; end address
A5 LDA HEX2H
E5 SBC HEX1H
E6 INC HEX2L ;And increment current address
D0 BNE NOCARRY ;No carry to MSB!
E6 INC HEX2H
60 NOCARRY RTS

:-------------------------------------------------------------------------