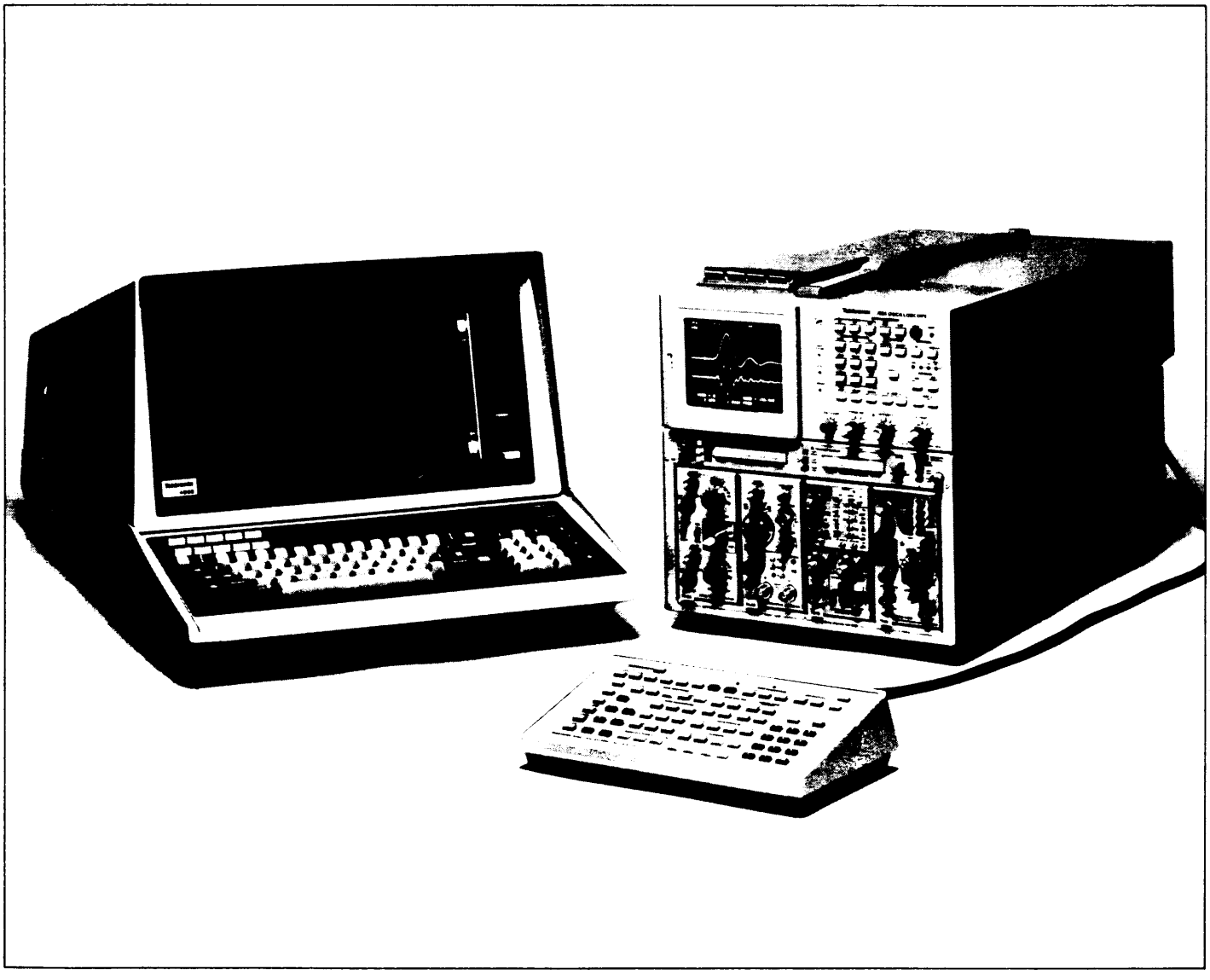
USING THE 7854 IN A GPIB CONFIGURATION



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Introduction

The Tektronix 7854 Oscilloscope combines high-performance analog capabilities with digital storage, waveform processing, keyboard programmability, and General Purpose Interface Bus (GPIB) interface.

This powerful measurement tool can improve measurement quality; provide push-button solutions to common waveform problems; offer system interface; and dramatically reduce the time from initial display to final calculation.

All the information displayed on the 7854 (except real-time waveforms) can be transferred or received via GPIB interface. This includes stored waveforms and constants, user programs, and other alphanumeric text. Any keystroke command may be remotely issued over the bus, including vertical and horizontal mode select switches. GPIB interface can be used to transfer information for external storage and documentation, for further processing, or to connect with an interactive system that informs the operator of the present status of the system procedure.

As a GPIB system component, the 7854 opens the door to *distributive processing*. The 7854 can be used to perform complete decision-making tasks and send the answer, instead of raw data, over the bus. This allows the GPIB controller to coordinate a more efficient and faster measurement system, and relieves the host computer of processing all the data for a given measurement.

Common bus transfers are essentially transparent to the user, in that the actual data and handshake lines are controlled by a higher level user language. Since single commands will initiate and conduct information transfers, the user need not know the design specifications of the bus or the details of communication transactions.

This application note shows how the 7854 can be interfaced via GPIB with a graphic terminal or a tape unit. Detailed program examples are given. Equipment used in the examples, in addition to the 7854, are the Tektronix GPIB compatible 4052 Graphic Computing System and 4924 Tape Drive. *All examples written in BASIC are also compatible with both the Tektronix 4051 and 4054 Grahic Computing Systems.*

7854 Specifications Summary

The 7854 is a conventional oscilloscope with powerful waveform processing capabilities.

As a conventional oscilloscope, the 7854 offers:

- Dc to 400 MHz bandwidth at 10 mV/div.
- Calibrated sweep rates to 500 ps.
- A choice of more than 30 compatible 7000-Series plug-in units.

With digital storage and waveform processing, the 7854:

- Stores repetitive waveforms up to 400 MHz.
- Reduces noise through signal averaging.
- Stores single shot events (50 μs/div fastest sweep with 7B87 Plug-in).
- Pretrigger (with 7B87 Plug-in).
- Common waveform parameters at the touch of a key.
- Resolution up to 0.01 div on stored data.
- A choice of 128, 256, 512, or 1024 points per waveform.
- Keystroke programming (up to 1000 lines).
- GPIB interface.

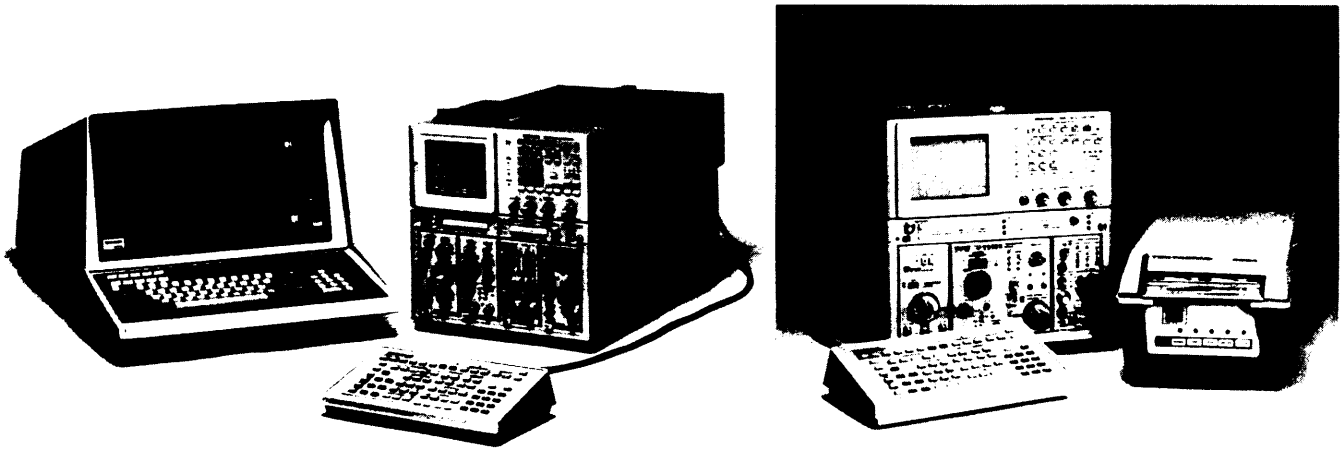

Figure 1. The Tektronix 7854 Oscilloscope shown interfaced with the 4052 Graphic Computing System (left), and with the 4924 Digital Cartridge Tape Drive (right).

Basic Configurations

Two basic GPIB configurations are available with the 7854 Oscilloscope. The first consists of a 7854 interfaced to a mass storage device without any intervention from the controller. For applications requiring permanent storage of 7854-user programs and displayed waveforms, the addition of a GPIB compatible tape drive unit provides an economic GPIB system. No additional software is needed to operate this system.

The second configuration involves the use of a GPIB controller or external computer. For applications that also need full hard copy documentation of further information processing, a GPIB compatible computer and graphics display unit such as the 4052 may be interfaced to the 7854.

Communication Mode

Three GPIB communication modes can be selected: TALK ONLY, LISTEN ONLY, and TALK-LISTEN. In TALK-LISTEN, the end of message terminator can be selected as either EOI ONLY or EOI or LF. This

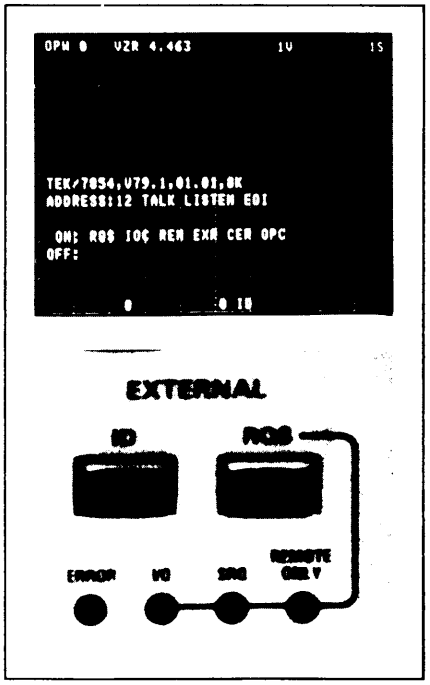

Figure 2. CRT display of the 7854 shows the ID readout obtained by pressing the ID button.

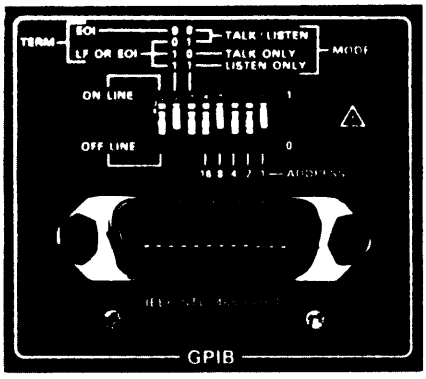

Figure 3. DIP switches and GPIB connector are located on the rear panel of the 7854.

choice easily permits interfacing with most controllers.

The TALK ONLY and LISTEN ONLY modes permit use of a peripheral device, such as a tape drive, for external storage without a controller to coordinate the bus transfers.

Installation and Device Settings

Before making any changes in the rear panel selectors, press the "ID" key on the 7854 mainframe (see Figure 2). The message displayed includes the primary address, the communication mode, and the end of message terminator. If the 7854 is off line (rear selectable) the "OFF LINE" is displayed in place of the mode and message terminator.

If the settings require changing, follow these steps:

Step 1. Locate the GPIB connector and DIP selector switch on the 7854 upper rear panel. (See Fig. 3.)

Step 2. Set switches 2 and 3 to the desired transmission mode.*

Step 3. Set the device's primary address, switches 4-8.

Step 4. Attach the GPIB cable.

*The selector switches 2 and 3 enable four possible types of transmission. Code 00 and 01 are designed for TALK/LISTEN operation with a controller. Code 00 is for use with TEK controllers such as the 4052. Code 01 allows for differences in the end of message terminator as implemented by other companies. Code 10 is for TALK ONLY, which allows only the transmission of data from the 7854. Code 11 is for LISTEN ONLY, which allows only the reception of data into the 7854.

External Storage to Mag Tape

Manually operating the 4924 Tape Drive, 7854 user programs, waveforms, and numeric constants can be transmitted to magnetic tape without a controller. In this communication, the addresses selected on both 7854 and 4924 are irrelevant.

To insure proper operation with early 4924's, they must be upgraded with the latest firmware. Field modification kits are available. For serial numbers B010100 through B019999, order kit number 050-0860-02; for B020000 through B039999, order kit number 050-0942-01; and for B04000 and above, no changes are necessary.

```
000 L01
001 BOTH UNDALT HMDA
002 L02
003 AQR
004 11 LBL GSB
005 1 WFM 11 LBL GSB
006 X<>Y CLX -
007 20.5EEXCHS9
008 IFY>X 2 LBL GOTO
009 STOP 1 LBL GOTO
010 L11
011 CRS1 0 >HCRD
012 MAX VCRD - CRS2-1 >VCRD
013 DELAY
014 RTN
```

Figure 4. Displayed keystroke program list from the 7854 Oscilloscope.

Programs

Programs are saved on tape by the following procedure:

Step 1. Set the 7854 GPIB switches 2 and 3 (rear panel) to Code 10 (TALK ONLY). Press the ID key to verify if desired.

Step 2. Set the 4924 to off line.

Step 3. Load a tape into the 4924 Tape Drive.

Step 4. Advance the tape to the desired file location manually. (REWIND will return to the start of the tape, FORWARD will advance one file at a time, and REVERSE will back up one file.)

Step 5. Press SAVE on the 7854.

Step 6. Press LISTEN on the 4924.

The entire program record will be sent and stored on tape. Similarly, a previously stored program can be loaded into the 7854 by the following steps:

Step 1. Set the GPIB select switch for Code 11 (LISTEN ONLY). Press the ID key to verify.

Step 2. Load the tape into the 4924.

Step 3. Advance to the desired tape file manually.

Step 4. Press PROGRAM ENTRY on the 7854 if in SCOPE, STORED, or BOTH.

Step 5. Press TALK on the 4924.

When manually operating the 4924 tape drive, the easiest way to locate a file is to press the REWIND button, then use the FORWARD button to advance the tape, one file at a time. To find the first file, press the FORWARD button once. If, for example, the fifth file is desired, press the FORWARD button five times following the REWIND. *All tapes used on the 4924 must be premarked to a specific file length by a 4050-Series computer.* A file length of 10,000 bytes is typically more than enough for most applications. This length will vary depending upon the record transmitted (see appendix for transmission format specifications). If the tape is to be read by a 4050-Series computer, refer to the 4924 Operator Manual for the correct rear panel setting before recording data.

Waveforms and Constants

Waveforms and constants are sent and received with the SENDX and READX commands. The procedure is similar to that for storing programs on magnetic tape. Simply place the desired constant or waveform number in the X-register, then press LISTEN on the 4924 and SENDX on the 7854.

To receive data back into the 7854, press READX, then TALK on the 4924. Remember when using the 4924 Tape Unit that the 7854 must be set to TALK ONLY to send information from the 7854 to the 4924, and LISTEN ONLY to receive information from the 4924.

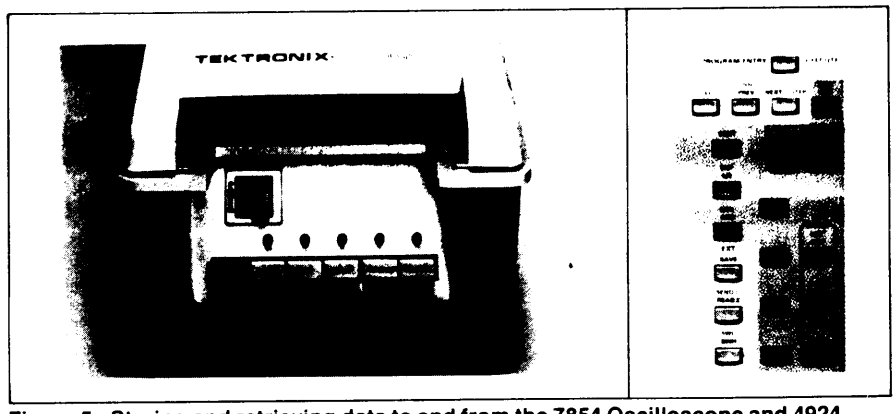

Figure 5. Storing and retrieving data to and from the 7854 Oscilloscope and 4924 Tape Drive is done using the PROGRAM ENTRY, SAVE, READX, and SENDX on the 7854 and TALK and LISTEN on the 4924.

I/O Procedures Using a Controller

When using the Tektronix 4052 Graphic Computing System as a controller, all keystroke commands can be sent to the7854 through the GPIB. The 7854 will react as if the commands were issued from the waveform calculator or the measurement keyboard. Commands can be sent to the 7854 from the waveform calculator, the measurement keyboard, the GPIB, or any combination of the above. (When a controller is in use, pressing any key on either 7854 keyboard generates a local rtl message).

To send a command to the 7854 address through the GPIB, send the command mnemonic (or numeric command) in the same way that you would enter the command from either of the 7854 keyboards, separating each equivalent 7854 keystroke with a space.

Similarly, multiple commands may be grouped as one message by separating each command with a space.

Example 4052 code:

PRINT @ 10:"VMDL HMDA AQR RISE"

where 10 is the address selected on the 7854.

This code will select the left vertical compartment of the 7854 (VMDL), select the A Horizontal compartment (HMDA), acquire a waveform (AQR), and compute its risetime (RISE). Such a statement may be executed by a BASIC program on the 4052, or may be manually typed in and executed only once as a calculator command.

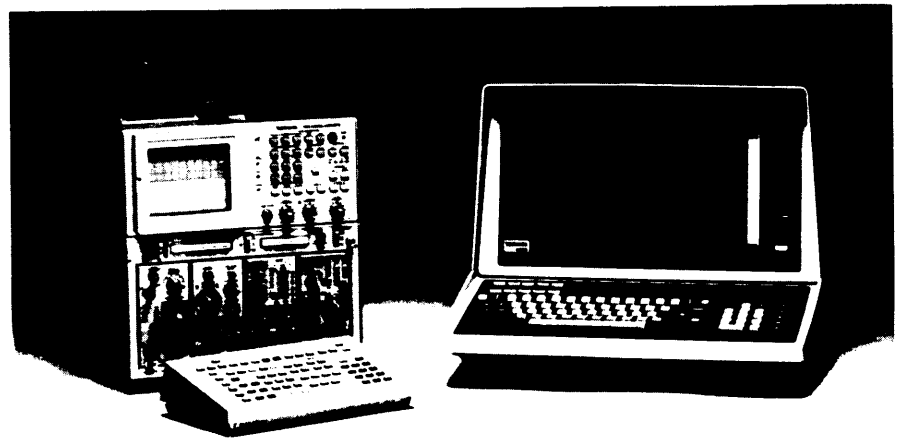

Figure 6. I/O procedures can be carried out on the 7854 Oscilloscope using the 4052 graphic Computing System as a GPIB compatible controller. Tektronix offers an integrated WP1310 Signal Processing System featuring the 7854 and the 4052. For additional information, see System Specification of the WP1310.

Note: No more than ten commands should be grouped following an I/O command in the same message. The 7854 will buffer up to ten commands following an I/O command, and will execute them on completion of the I/O command. More than ten commands will cause the I/O command to be aborted and all commands following the I/O command to be ignored.

In additon to the measurement commands, the 7854 has commands designed specifically for data transfers through the GPIB. Some of the commands are listed below. (See appendix for complete listing.)

Primary Input/Output Commands

SAVE Outputs the 7854 program memory contents to the GPIB. All program lines are transmitted, from the edit prompt through the end of the program.

SENDX Outputs X-register contents to the GPIB. If the information is a numeric, then that number is sent. But if the information is a waveform number, such as 2 WFM, then the entire waveform record is sent.

READX Inputs a number or waveform from the GPIB and places it in the X-register. Waveform data is stored as Ø WFM.

>TEXT Inputs up to 12 lines of text (40 character maximum for each) from the GPIB for display on the 7854 crt (in STORED, SCOPE, or BOTH modes).

TEXT Outputs a copy of all 16 lines of the currently displayed text to the GPIB.

The SAVE, SENDX, READX, TEXT and >TEXT commands comprise the primary data transfer command set. On the 4052, additional simple BASIC programming statements will be needed to capture incoming data, recall and send data, and handle some of the overhead involved, such as defining and dimensioning variables and responding to a 7854 service request with a serial poll.

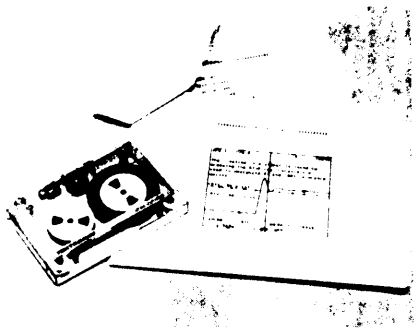

Figure 7. Data transferred through the 7854 GPIB interface includes programs, numeric values, waveforms, and text strings. With the 4052, hard copy and tape storage are available.

Data Transfers

Data that can be sent through the GPIB includes programs, numeric values, waveforms, and text strings. The format for all output from the 7854 allows the same data to be sent back into the 7854 without any intermediate processing or loss of information. (The only exception is when the 7854 is set for EOI/LF as the message terminator in the TALK-LISTEN mode and waveform data is being sent. In this case a carriage return and line feed separate the waveform preamble and curve data. The line feed must be deleted before sending the data back to the 7854. Select EOI when using the 4052.)

Programs

To send a program from the 7854 through the GPIB to a controller for permanent storage on tape or disc, move the edit prompt to the beginning of the program and issue the SAVE command. The program will be send line-by-line as one record, with the NEXT command and a carriage return appended to the end of each program line. The line numbers are removed from the program as it is sent, and line labels will appear as **LNN a b** where a and b are single digit integers.

These format changes allow the program to be easily re-entered into the 7854 program memory, and the *carriage returns* allow the controller to transfer the program *line-by-line* to tape or disc.

The following 4052 BASIC program example (Program 1) will set the 7854 edit prompt at line zero and retrieve and store the program line-by-line on the 4052 magnetic tape.

To retrieve a stored program from tape and send it to the 7854, the 7854 must be in the PROGRAM ENTRY state. Incoming commands

Note: The 7854's device address is 10. The target variable for the incoming data is the ASCII string L$. The 4052 magnetic tape file is designated by the variable F.

```
100  REM * TRANSFER 7854 PROGRAM TO 4050 TAPE FILE
110  REM * 7854 IS GPIB DEVICE #10
120  REM *
130  REM * STORE PROGRAM ON FILE NUMBER: F
140  REM *
150  ON SRQ THEN 260
160  S=0
170  PRINT @10:"EXECUTE 0 GOTO PROGRAM SAVE"
180  IF S<>208 THEN 180
190  FIND F
200  ON EOI THEN 240
210  INPUT @10:L$
220  PRINT @33:L$
230  GO TO 210
240  PRINT @33:L$
250  END
260  POLL D,S;10
270  RETURN

     LINE BY LINE COMMENTS:
     150  Enable SRQ interrupt handler at 260
     160  Clear status flag
     170  Command 7854 to send entire program
     180  Wait for 'SAVE' service request status byte
     190  Position 4050 tape to file F
     200  Enable EOI interrupt handler at 240
     210  Input next line of program from 7854
     220  Save line of program on tape
     230  Continue until EOI
     240  On EOI save last line of program on tape
     250  Stop
     260  Serial poll 7854; S = status byte
     270  Return from SRQ interrupt handler
                                                2873 306
```

Program 1: Data format compatible with Program 2.

will be entered the same as if manually pressed on the waveform calculator. The operator may append a program from tape to an existing program in the 7854 or delete an existing program and load another from tape. The following 4052 BASIC program will delete the existing 7854 program and load in another from the mag tape.

Program 2 functions as the inverse of the previous example. So this will load the same program as the one saved in the previous example.

To append a program to an existing program, remove CLP NEXT from program 2. Position the edit prompt, >, to the location at which you wish to append.

```
100  REM *TRANSFER PROGRAM FROM 4050 TAPE FILE TO 7854
110  REM *7854 IS GPIB DEVICE #10
120  REM *
130  REM *LOAD PROGRAM FROM FILE NUMBER: F
140  REM *
150  ON SRQ THEN 250
160  S=0
170  PRINT @10:"PROGRAM CLP NEXT"
180  IF S<>66 THEN 180
190  FIND F
200  ON EOF (0) THEN 240
210  INPUT @33:L$
220  PRINT @10:L$
230  GO TO 210
240  END
250  POLL D,S;10
260  RETURN

     LINE BY LINE COMMENTS:
     150  Enable SRQ interrupt handler at 250
     160  Clear status byte
     170  Command 7854 to accept a new program
     180  Wait for operation complete status byte
     190  Position 4050 tape to file F
     200  Enable end-of-file interrupt handler at 240
     210  Input next line of program from tape file
     220  Send line of program to 7854
     230  Continue until end-of-file
     240  Stop
     250  Serial poll 7854; S = status byte
     260  Return from SRQ interrupt handler
```

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Program 2: Data format compatible with Program 1.

SENDX (Numeric Values)

Numeric values (constants) can be transferred from the 7854 over the GPIB by placing the number in the X-register and then executing the SENDX command. The numerical value may be the result of a waveform calculation such as MAX (maximum vertical value), cursor coordinates, or a plug-in's readout (Program 3). See note.

An advantage of sending a calculated result such as MAX is that it relieves the controller or host computer of processing an entire array of waveform data, since the 7854 was designed to make waveform measurements. The result, a single numeric constant can be transferred much faster than an entire array of raw data, making the operation even more efficient.

```
100  REM*TRANSFER CONSTANT (MAX) FROM 7854 TO 4050 VARIABLE
110  REM*7854 IS GPIB DEVICE #10
120  REM *
130  REM*INPUT CONSTANT INTO VARIABLE: M
140  REM *
150  ON SRQ THEN 210
160  S=0
170  PRINT @10:"MAX SENDX"
180  IF S<>210 THEN 180
190  INPUT @10:M
200  END
210  POLL D,S;10
220  RETURN

     LINE BY LINE COMMENTS:
     150  Enable SRQ interrupt handler at line 210
     160  Clear status flag
     170  Command 7854 to send the 'MAX' value
     180  Wait for 'SENDX' service request status byte
     190  Input constant (MAX) from 7854 into variable M
     200  Stop
     210  Serial poll 7854; S = status byte
     220  Return from SRQ interrupt handler
```

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Program 3: Note—The X-register has four digit resolution. To preserve values of greater than four digits, such as from a 7D15 plug-in, use the TEXT command.

READX (Numeric Values)

Numeric values can be transferred back to the 7854 and placed in the X-register by executing the READX command and then sending the number to the 7854 over the GPIB (Program 4).

Alternately, a numeric value may be transferred as individual keystrokes with each command digit separated by a space. This may be more convenient for known constants than for computed variables. For example, to change the points per waveform to 256, send the string "2 5 6 > P/W." The READX may be used, but a simple task like this is performed faster by individual keystroke entries.

```
100  REM *TRANSFER 4050 VARIABLE TO 7854'S X REGISTER
110  REM *7854 IS GPIB DEVICE #10
120  REM *
130  REM *OUTPUT CONSTANT FROM VARIABLE: M
140  REM *
150  ON SRQ THEN 210
160  S=0
170  PRINT @10:"READX"
180  IF S<>211 THEN 180
190  PRINT @10:M
200  END
210  POLL D,S,10
220  RETURN

     LINE BY LINE COMMENTS:
     150  Enable SRQ interrupt handler at 210
     160  Clear status flag
     170  Command 7854 to accept data
     180  Wait for 'READX' service request status byte
     190  Output variable M to 7854
     200  Stop
     210  Serial poll 7854; S = status byte
     220  Return from SRQ interrupt handler
```

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Program 4

Waveforms

Waveform data is sent as one message (Table 1): the waveform preamble, a separator, and the curve data. The waveform preamble *contains information such as points/waveform, volts/division, time/division, and offset voltage. The* separator *is either a carriage return (Message Terminator Code 00 set to EOI) or a carriage return and line feed (Message Terminator Code 01 set to LF or EOI). The* curve data *contains the actual vertical ordinate (in divisions ±5) of each point of the waveform relative to the center crt graticule. The curve data consists of the header (CURVE) followed by a space and then one ASCII coded decimal number for each point of the waveform. Each number is separated by a comma and represents the vertical distance of that point from the center graticule line, measured in graticule divisions (negative if below center). All trailing zeroes are deleted and not sent.*

Waveform Preamble: A typical preamble is shown below:

WFMPRE ENCDG:ASC,NR.PT:512,PT.FMT:Y,XZERO:0,XINCR:9.766E-06, XUNIT:S,YZERO:2.704,YMULT:1,YUNIT:V;

The abbreviations in the waveform preamble are as follows:

WFMPRE[1]	waveform preamble (header)
ENCDG:ASC[1]	curve data encoded ASCII decimal
NR.PT:(P/W)	number of points/waveform
PT.FMT:Y[1]	point format (curve data in vert. div.)
XZERO:0[1]	no horizontal offset
XINCR:[10*HSCL/(P/W)]	horizontal increment between points
XUNIT:S	horizontal scale factor units (S=seconds)
YZERO:[-(VSCL*VZR)]	vertical zero offset
YMULT:(VSCL)	vertical scale factor
YUNIT:V	vertical scale factor units (V=volts)

[1]Fixed value, cannot be changed.

Curve Data: A typical curve data (partial) is shown below:

CURVE 1.3779,1.3777,1.3778,1.3777,...,1.3777,-2.6953,-2.6955,-2.6954, -2.6955,-2.696,-2.7

Table 1

SENDX (Waveforms)

To send stored waveform information from the 7854 through the GPIB, the waveform number (i.e., 3 WFM) must be placed in the X-register. The waveform data can then be sent by giving the SENDX command (Program 5).

The ASCII string format is especially useful for direct storage to mag tape. In this format, the data may be sent back without any intervening processing or reformatting by the controller. The ASCII format is also easy to interpret visually, since it is in a language that can be readily understood by the user.

To facilitate such data manipulation as plotting and further processing, waveform records may easily be input to an array in the 4052. With the 4052 INPUT statement, string variables are converted "on the fly" to array elements as each byte is received. *Any non-numeric character is ignored so the 4052 BASIC program automatically extracts the numeric data from the alphanumeric string.**

Since the data being sent from the 7854 is in a fixed format, the 4052 INPUT statement need only have its variables arranged in the same order (Program 6).

Once the waveform data is transferred to the array, further processing may be performed. Special signal processing ROM packs are available for 4050 Series computers that can provide, for instance, FFT analysis of the waveform to reveal its spectral components and their phase relations. And because these ROM packs operate on an entire array, the processing speed is very fast.

*Other controllers may require you to read in the header information and decode the numeric data. The header CURVE is separated from the first data point of the array by a space, and therefore the header must be extracted from the array.

```
100  REM *TRANSFER WAVEFORM #0 FROM 7854 TO 4050 ASCII STRINGS
120  REM *7854 IS GPIB DEVICE #10
130  REM *
140  REM *INPUT WAVEFORM PREAMBLE INTO ASCII STRING: P$
150  REM *INPUT WAVEFORM CURVE INTO ASCII STRING: W$
160  REM *
170  DIM P$(200),W$(8200)
180  ON SRQ THEN 250
190  S=0
200  PRINT @10:"0 WFM SENDX"
210  IF S<>210 THEN 210
220  INPUT @10:P$
230  INPUT @10:W$
240  END
250  POLL D,S;10
260  RETURN
```

LINE BY LINE COMMENTS:

170 Dimension ASCII strings P$ & W$
180 Enable SRQ interrupt handler at line 250
190 Clear status flag
200 Command 7854 to send waveform #0
210 Wait for 'SENDX' service request status byte
220 Input waveform preamble from 7854 to P$
230 Input waveform curve from 7854 into W$
240 Stop
250 Serial poll 7854; S = status byte
260 Return from SRQ interrupt handler

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Program 5: Data format compatible with Program 7. (Waveforms as ASCII strings)

```
100  REM *TRANSFER WAVEFORM #0 FROM 7854 TO 4050 VARIABLES & ARRAY
110  REM *7854 IS GPIB DEVICE #10
120  REM *
130  REM *INPUT WAVEFORM PREAMBLE INTO VARIABLES: N,Z1,X,Z2,Y
140  REM *          N = POINTS/WAVEFORM
150  REM *          Z1 = HORIZONTAL ZERO
160  REM *          X = HORIZONTAL INCREMENT BETWEEN POINTS
170  REM *          Z2 = VERTICAL ZERO
180  REM *          Y = VERTICAL SCALE FACTOR
190  REM *INPUT WAVEFORM CURVE INTO ARRAY: W
200  REM *
210  ON SRQ THEN 300
220  S=0
230  PRINT @10:"0 WFM SENDX"
240  IF S<>210 THEN 240
250  INPUT @10:N,Z1,X,Z2,Y
260  DELETE W
270  DIM W(N)
280  INPUT @10:W
290  END
300  POLL D,S;10
310  RETURN
```

LINE BY LINE COMMENTS:

210 Enable SRQ interrupt handler at line 300
220 Clear status flag
230 Command 7854 to send waveform #0
240 Wait for 'SENDX' service request status byte
250 Input waveform preamble arguments into N,Z1,X,Z2,Y
260 Delete Array W
270 Dimension array W to size N (N = Points/Waveform)
280 Input waveform curve into array W
290 Stop
300 Serial poll 7854; S = status byte
310 Return from SRQ interrupt handler

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Program 6: Data format compatible with Program 8. (Waveforms as numeric arrays)

READX (Waveforms)

To copy a waveform back into the 7854, issue the READX command and send the waveform preamble and curve data to the 7854 address. The waveform preamble and curve data must be sent as a single message with no line feed between the two strings. The waveform will become the operational waveform (Ø WFM) in the 7854 and can then be copied to another waveform memory address if desired.

This program requires data formatting in two string variables, the Preamble (P$) and the Curve (W$). The first program used with the "SENDX" for waveforms (Program 5) should be used with this READX program (Program 7) to insure the proper data formats.

If the data is not in a suitable format for transmitting to the 7854, the user must reconstruct the Preamble and Curve. If the waveform points are in an array and properly scaled, they may be sent as an array from the 4052 without being converted to an ASCII string.

*When constructing the Preamble it is not necessary to have the exact arrangement of parameters.**

The 7854 will accept the paramaters in random fashion provided they agree with the basic format (i.e., NR.PT: 512,). Not all of the preamble must be sent back, but it must contain "WFMPRE" as the first word, "XINCR," "YZERO," and "YMULT" and their respective values to fully specify the waveform. If not transferred, default values are assigned (1 for scaie factors and 0 for offset values).

Program 8 constructs a proper waveform preamble from numeric values. These values are converted to string variables and concatenated into a preamble string (P$). The array (W) is sent without any conversion.

This program's data format is compatible with the second program used with the SENDX command for transferring waveforms (Program 6).

*However, the header CURVE followed by a space must preceed the data.

```
100  REM * TRANSFER 4050 ASCII STRINGS TO 7854'S WAVEFORM #0
110  REM * 7854 IS GPIB DEVICE #10
120  REM * OUTPUT WAVEFORM PREAMBLE FROM ASCII STRING: P$
140  REM * OUTPUT WAVEFORM CURVE FROM ASCII STRING: W$
150  REM *
160  ON SRQ THEN 220
170  S=0
180  PRINT @10:"READX"
190  IF S  211 THEN 190
200  PRINT @10:P$;W$
210  END
220  POLL D,S;10
230  RETURN
       LINE BY LINE COMMENTS:
         160  Enable SRQ interrupt handler at 220
         170  Clear status flag
         180  Command 7854 to accept data
         190  Wait for 'READX' service request status byte
         200  Output waveform from P$ & W$ to 7854
         210  Stop
         220  Serial poll 7854; S = status byte
         230  Return from SRQ interrupt handler
                                                    2873-312
```

Program 7: Data format compatible with Program 5. (Waveforms as ASCII strings)

```
100  REM *TRANSFER 4051 VARIABLES AND ARRAY TO 7854's WAVEFORM #0
110  REM *
120  REM *OUTPUT WAVEFORM PREAMBLE FROM VARIABLES: N,Z1,X,Z2,Y
130  REM *          N = POINTS/WAVEFORM
140  REM *          Z1 = HORIZONTAL ZERO
150  REM *          X = HORIZONTAL INCREMENT BETWEEN POINTS
160  REM *          Z2 = VERTICAL ZERO
170  REM *          Y = VERTICAL SCALE FACTOR
180  REM *OUTPUT WAVEFORM CURVE FROM ARRAY: W
190  REM *
200  DIM P$(200)
210  ON SRQ THEN 460
220  REM *BUILD WAVEFORM PREAMBLE
230  P$="WFMPRE ENCDG:ASC,NR.PT:"
240  T$=STR(N)
250  P$=P$&T$
260  P$=P$&",PT.FMT:Y,XZERO:"
270  T$=STR(Z1)
280  P$=P$&T$
290  P$=P$&",XINCR:"
300  T$=STR(X)
310  P$=P$&T$
320  P$=P$&",XUNIT:S,YZERO:"
330  T$=STR(Z2)
340  P$=P$&T$
350  P$=P$&",YMULT:"
360  T$=STR(Y)
370  P$=P$&T$
380  P$=P$&",YUNIT:V;CURVE "
390  S=0
400  PRINT @10:"READX"
410  IF S<>211 THEN 410
420  REM *THE COMMA(,) BETWEEN P$ AND W IN LINE 440 IS REQUIRED,
430  REM *A SEMICOLON (;) WILL NOT WORK
440  PRINT @10:P$,W
450  END
460  POLL D,S;10
470  RETURN

       LINE BY LINE COMMENTS:
         200  Dimension ASCII string P$
         210  Enable SRQ interrupt handler at line 460
         230 through 380:
              Build waveform preamble in P$
         390  Clear status flag
         400  Command 7854 to accept data
         410  Wait for 'READX' service request status byte
         440  Send waveform to 7854
         450  Stop
         460  Serial poll 7854; S = status byte
         470  Return from SRQ interrupt handler
                                                    2983-313
```

Program 8: Data format compatible with Program 6. (Waveforms as numeric arrays)

TEXT (Display Message to the 7854 CRT)

Up to 12 lines of text (of up to 40 characters each) may be send to the 7854 for display on the crt along with the waveform(s). This text can include operator prompts, additional information for documenting photographs, or any comments the programmer may wish to display on the 7854 crt.

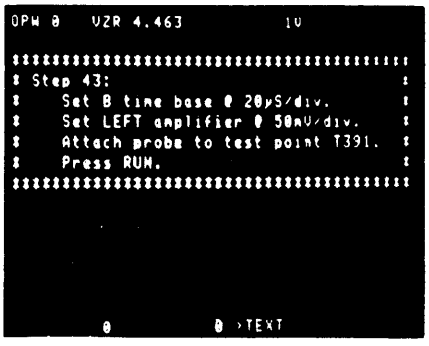

Figure 8. TEXT message instructing the 7854 Oscilloscope operator to perform a task.

To send text to the 7854, give the >TEXT command, followed by a single string of text with carriage return codes (ASCII decimal 13) inserted at the line breaks (see Program 9). The text display remains until another >TEXT command is given, a crt display command is given (STORED, SCOPE, BOTH, or ID), or the 7854 is put into PROGRAM Mode.

```
100  REM * TRANSFER TEXT FROM 4050 TO 7854 CRT
110  REM * 7854 IS GPIB DEVICE #10
120  REM *
130  REM * BUILD TEXT IN STRING: T$
140  REM *
150  ON SRQ THEN 340
160  DIM T$(12*41)
170  PRINT "↵INPUT TEXT AS IT IS TO BE DISPLAYED ON 7854"
180  PRINT "↵<SPACE><RETURN> FOR A BLANK LINE"
190  PRINT "<RETURN> ONLY TO END INPUT↵"
200  T$=""
210  C$=CHR(13)
220  FOR I=1 TO 12
230  PRINT "-->";
240  INPUT L$
250  IF LEN(L$)<1 THEN 290
260  T$=T$&L$
270  T$=T$&C$
280  NEXT I
290  S=0
300  PRINT @10:"EXECUTE >TEXT"
310  IF S<>213 THEN 310
320  PRINT @10:T$
330  END
340  POLL D,S;10
350  RETURN
```

```
LINE BY LINE COMMENTS:
150  Enable SRQ interrupt handler at line 340
160  Dimension ASCII string T$ (12 lines of 41 characters)
170 through 190:
     Prompt 4050 user to input text
200  Null T$
210  Define C$ as <CARRIAGE RETURN>
220  Loop to accept maximum of 12 lines
230  Issue line input prompt
240  Input next line of text
250  If only <CARRIAGE RETURN> then done inputting
260  Concatenate text onto T$
270  Concatenate a <CARRIAGE RETURN> after each line
280  Continue accepting text
290  Clear status flag
300  Command 7854 to accept text for display
310  Wait for '>TEXT' status byte
320  Send text to 7854
330  Stop
340  Serial poll 7854; S = status byte
350  Return from SRQ interrupt handler
```

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Program 9

The text to be displayed may include characters not found on the ASCII code chart (see appendix). Table 5 in the appendix lists the additional special characters which may be displayed on the 7854 crt and the codes used to represent them. For example, to display a μ symbol, send ESC followed by CTRL-S.

All 16 lines of text being displayed on the 7854 can be sent back to the controller for editing or inspection by giving the TEXT command. This text includes all text previously sent to the 7854 via the > TEXT command (lines 3 through 14), and all *crt readout text (lines 1-2 and 15-16).**

To capture the readout of line 16 of the display, the line must be retrieved before the TEXT command is issued. Otherwise, it will be altered by the TEXT command itself. By using the "SRQ?" command (accessible through the GPIB only), the entire readout of line 16 is returned so that processor status, X and Y registers, and the last executed command may be examined (Program 10). A complete list of GPIB only commands is included in the appendix.

*This crt readout may be either the "SCOPE" or "STORED" displayed characters. When using 7000 Series plug-ins that generate readout of greater resolution than four digits, it is necessary to use the TEXT command while in the "SCOPE" mode to accurately report the readout. This will be required for plug-ins such as the 7D15, 7D13A, 7D12/M2, and the 7D11.

```
100  REM * TRANSFER TEXT FROM 7854 DISPLAY TO 4050
110  REM *
120  ON SRQ THEN 280
130  PAGE
140  PRINT @10:"SRQ?"
150  INPUT @10:S$
160  S=POS(S$,"SRQ ",1)
170  S$=SEG(S$,S+4,LEN(S$)-S-3)
180  S=0
190  PRINT @10:"TEXT"
200  IF S<>212 THEN 200
210  FOR I=1 TO 15
220  INPUT @10:L$
230  PRINT L$
240  NEXT I
250  PRINT S$
260  INPUT @10:L$
270  END
280  POLL D,S;10
290  RETURN

     LINE BY LINE COMMENTS:
     120  Enable SRQ interrupt handler at line 280
     130  Page 4050 crt screen
     140  Use 'SRQ?' querie to get line #16 of 7854's readout
     150  Input line #16
     160  Find position of substring 'SRQ' in response
     170  Remove querie header
     180  Clear status flag
     190  Command 7854 to send readout
     200  Wait for 'TEXT' service request status byte
     210  Loop to input first 15 lines of text
     220  Input line of text
     230  Display line of text on 4050
     240  Continue inputting first 15 lines
     250  Use 16th line from 'SRQ?' querie
     260  Clear last line of text from 7854
     270  Stop
     280  Serial poll 7854: S = status byte
     290  Return from SRQ interrupt handler
```

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Progam 10

Conclusion

All information stored in the 7854 is accessible. With the proper steps, a complete copy of the 7854 crt display (STORED) can be reproduced on the 4052 including additional messages for complete documentation.

By combining the preceding program segments, any I/O sequence for a 4052/7854 (WP1310) system can easily be implemented. Augmented by the graphics and computing capabilities of the 4052, the 7854 Oscilloscope becomes a total waveform measurement system.

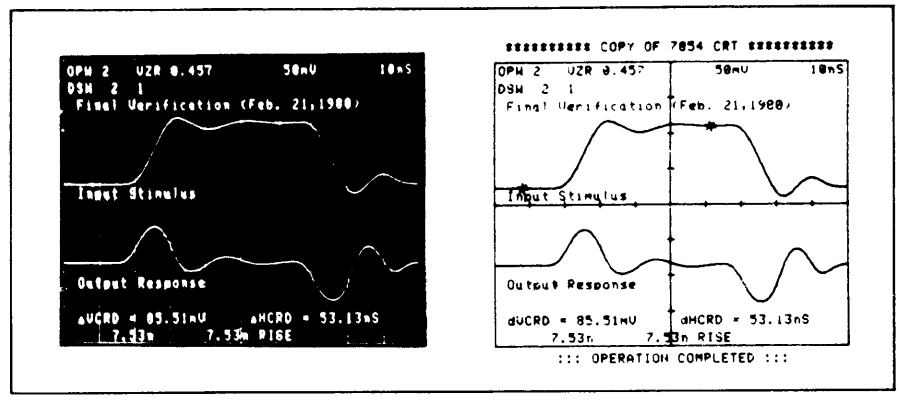

Figure 9. All of the stored information in the 7854 can be accessed and a duplicate display can be generated by the 4052.

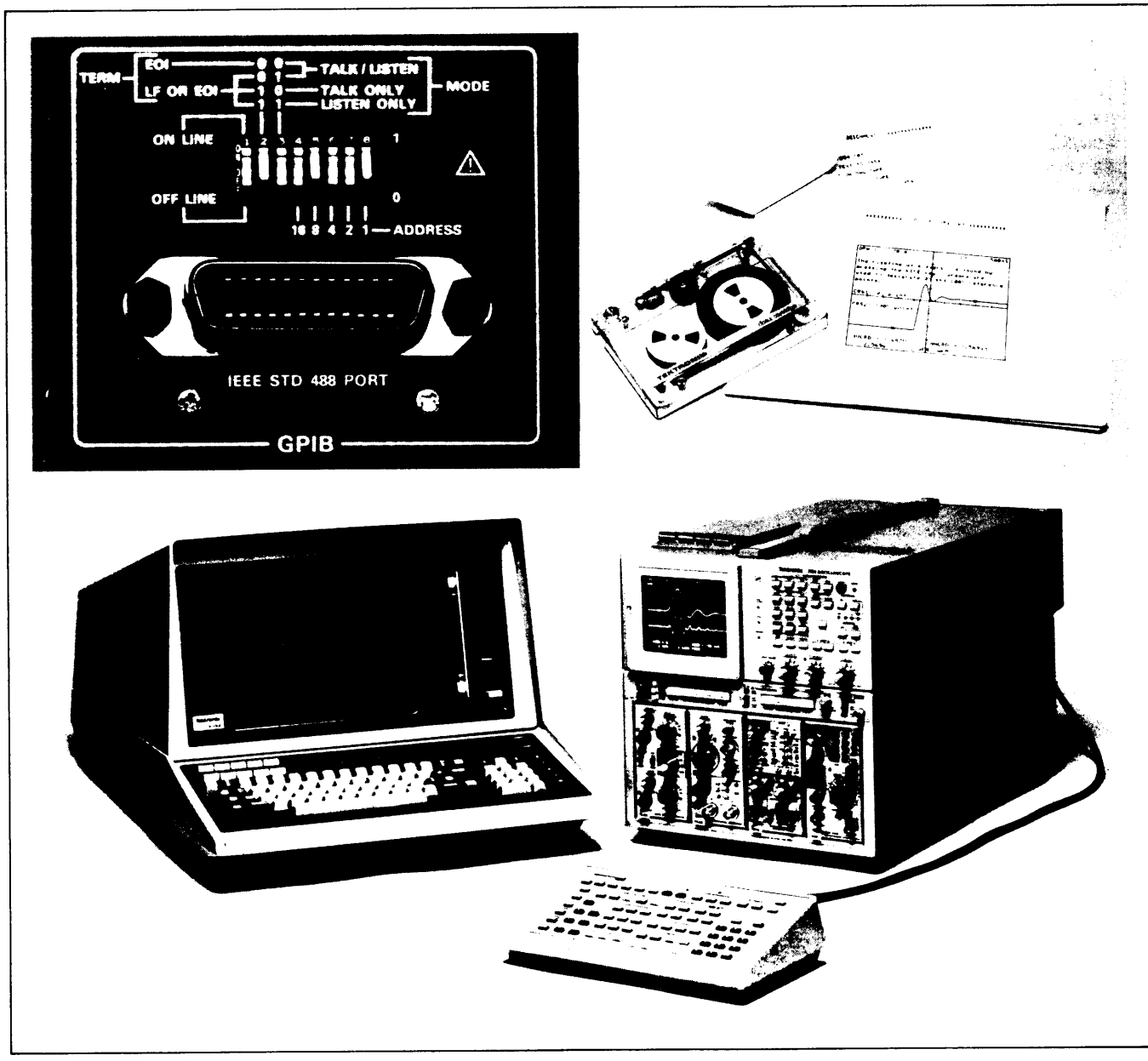

Figure 10. Combining program segments to implement the desired I/O sequence for a 4052 controller can take full advantage of the 7854 as a total waveform measurement system. (See WP1310 Specifications.)

Appendix

Service Request

The service request function allows the 7854 to keep the GPIB controller informed of its status. This is done by asserting SRQ (Service Request) and then sending a status byte to the controller when polled. The status byte is an eight-bit binary number representing the status of the 7854. If status information is not required for a particular application, all SRQ's can be disabled except the Power-On SRQ asserted on completion of the 7854 self-test (if the 7854 is ON LINE when power is applied). Any service request can be cleared by performing a serial poll of the 7854.

The status bytes sent by the 7854, and their meanings, are listed in Table 2.

When the 7854 is on line, an SRQ is activated when powered up. This SRQ must be cleared via a POLL command from the controller. The returned status byte will indicate whether the 7854 powered up in a normal condition or with an internal error detected by its self-test routine. This service request is not selectable by the controller. If the 7854 is set to the off-line condition before power-up, the SRQ is not activated.

Enable Requests

If IOC is set to on (IOCON), an SRQ is activated after a SAVE, SENDX, READX, TEXT, or >TEXT command is initiated. The controller must respond with a POLL command to begin the I/O transfer.

If OPC is set to on (OPCON), an SRQ is activated after a 7854 programmed STOP or END OF PROGRAM is encountered or at the completion of a command group. Such a group may be a single command or sequence of commands resident in the 7854 temporary command buffer.

If EXR is set to on (EXRON), an SRQ is activated when an execution error occurs with the 7854 user program.

If CER is set to on (CERON), an SRQ is activated when an external command error occurs via the GPIB or when the 7854 is "talked" with nothing to say.

7854 Status Bytes

Condition	Status Byte 8765 4321	Decimal Equivalent
Normal	ØØØX ØØØØ[a]	(Ø,16)
Ext. command group complete[1]	ØXØØ ØØ1Ø[b]	(2,66)
End of program[1]	ØXØØ ØØ1Ø[b]	(2,66)
Execution error[2]	ØX1Ø ØØ1Ø[b]	(34,98)
External command error[3]	ØX1Ø ØØØ1[b]	(33,97)
Power On	Ø1ØX ØØØ1[a]	(65,81)
Power on check failure	Ø11X ØØ11[a]	(99,115)
RQS command executed[4]	Ø1Ø1 ØØØØ	(8Ø)
SAVE command initiated[5]	1XØ1 ØØØØ[b]	(144,2Ø8)
SENDX command initiated[5]	1XØ1 ØØ1Ø[b]	(146,21Ø)
READX command initiated[5]	1XØ1 ØØ11[b]	(147,211)
TEXT command initiated[5]	1XØ1 Ø1ØØ[b]	(148,212)
>TEXT command initiated[5]	1XØ1 Ø1Ø1[b]	(149,213)

[1]**OPCOFF command will disable this service request.**
[2]**EXROFF command will disable this service request.**
[3]**CEROFF command will disable this service request.**
[4]**REMOFF command will disable this service request.**
[5]**IOCOFF command will disable this service request.**

[a]**bit 5 true (1) indicates busy condition.**
[b]**bit 7 true (1) indicates active service request.**

NOTE

The RQSOFF command will disable all SRQ's except power on. Therefore, for any other service request to function, the RQSON command must be given, along with the command to enable that service request.

Table 2.

Polling

The serial poll allows the GPIB controller to check the status of any or all instruments on the bus. When the 7854 is polled, it sends the appropriate status byte and, if the 7854 was asserting SRQ, clears its service request. The status byte can then be used to initiate corrective action, proceed with the program, or send a message to the operator (Program 11).

```
100  REM*SERIAL POLL SUBROUTINE #1
110  REM*
120  POLL D,S;10
130  RETURN
140  REM*SERIAL POLL SUBROUTINE #2
150  REM*
160  WBYTE @95,63,24,74:
170  RBYTE S
180  WBYTE @95,25:
190  RETURN

     LINE BY LINE COMMENTS:
100  Use 4050 POLL command if 7854 is requesting service
120  S = status byte
130  End of subroutine #1
140  Use 4050 WBYTE and RBYTE commands if 7854 is not
     requesting service
160  95 = Send GPIB UNTalk command (UNT)
     63 = Send GPIB UNListen command (UNL)
     24 = Send GPIB Serial Poll Enable command (SPE)
     74 = Send 7854's talk address
170  Input status byte (S)
180  95 = Send GPIB UNTalk command (UNT)
     25 = Send GPIB Serial Poll Disable command (SPD)
190  End of subroutine #2
```

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Program 11

GPIB Only Commands: Queries

To receive the response from a query command, use an INPUT statement on the 4052 to a string variable (i.e., Q$). This INPUT statement should immediately follow the query statement. For example, the 4052 program statements to generate an "SRQ?" and receive the 7854 output would be:

```
PRINT @ 10:"SRQ?"
INPUT @ 10:Q$
```

where 10 is the 7854 GPIB address and Q$ is the string variable receiving the information (See Table 3.)

Queries

ERR?	Outputs error status; **ERR 00** if no error exists or **ERR 01** if an error does exist.
ID?	Outputs a copy of the 7854 identification display to the GPIB. (**ID TEK/7854,V79.I,XX.YY,ZK** where XX is the ROM version, YY is the ROM revision, and Z is 2, 4, or 8, indicating the number of kilobytes of RAM installed.)
SRQ?	Outputs a copy of the bottom line of the calculator display. (**SRQ XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX** where XXXX... is the bottom line of the display.)

NOTE

Do not send a query (ERR?, ID?, or SRQ?) to the 7854 following an I/O command (SAVE, SENDX, TEXT, >TEXT, or READX) until the I/O command is completed. A query will interupt the I/O command and cause unpredictable I/O. (Use a serial poll to determine I/O-command status, if necessary. Status byte > 127 indicates I/O in progress.)

Table 3.

Record Lengths for Mag Tape Files

Programs:

The maximum 7854 program will not exceed 29 kilobytes in a 4050 Series format. The length is given by,

Length = (total number of displayed characters + spaces) + (total number of lines) *(5+18)

The 5 bytes account for the NEXT command and a space which are not displayed. The 18 bytes are added by the 4052 as each line is stored.

Waveforms:

The maximum record length for waveforms varies with the different points per waveform (P/W) values. The required lengths are: for P/W = 1024, 8400 bytes; for P/W = 512, 4300 bytes; for P/W = 256, 2300 bytes; and for P/W = 128, 1200 bytes.

The maximum length is given by,

Preamble length = 150 bytes

Curve length = (Number of points per waveform) *8+24

Approximate GPIB Transfer Times				
Waveform Record	4052 (4054)		4051	
	Array	String	Array	String
128 points	0.83 sec	0.33 sec	2.5 sec	1.0 sec
256 points	1.6 sec	0.6 sec	4.8 sec	1.8 sec
512 points	3.2 sec	1.2 sec	9.6 sec	3.5 sec
1024 points	6.5 sec	2.6 sec	19.4 sec	7.1 sec

Table 4.

Special >TEXT Characters

In addition to the standard ASCII character set of the 4052, the 7854 may display the special characters listed below:

Special Character Codes			
Special Character	ASCII Code	(decimal)	4050 Commands
β (cap beta)	SOH	1	ESC CTRL-A
γ (gama)	STX	2	ESC CTRL-B
η (eta)	EOT	4	ESC CTRL-D
□ (box)	ENQ	5	ESC CTRL-E
▯ (rectangle)	ACK	6	ESC CTRL-F
δ (delta)	BEL	7	ESC CTRL-G
° (degree)	BS	8	ESC CTRL-H
α (alpha)	HT	9	ESC CTRL-I
Δ (cap delta)	SØ	14	ESC CTRL-N
π (pi)	SI	15	ESC CTRL-O
ρ (rho)	DLE	16	ESC CTRL-P
σ (sigma)	DC1	17	ESC CTRL-Q
τ (tau)	DC2	18	ESC CTRL-R
μ (mu or micro)	DC3	19	ESC CTRL-S
ν (nu)	DC4	20	ESC CTRL-T
Ω (cap omega)	SYN	22	ESC CTRL-V
ω (omega)	ETB	23	ESC CTRL-W
√ (square root)	EM	25	ESC CTRL-Y
→ (right arrow)	SUB	26	ESC CTRL-Z
← (left arrow)	ESC	27	ESC CTRL-[
↓ (down arrow)	FS	28	ESC CTRL
↑ (up arrow)	GS	29	ESC CTRL-]

Table 5.

Reset States

Device Clear

The 7854 responds to a DCL (Device Clear) or SDC (Selected Device Clear) message by executing a STOP command, aborting any input/output or waveform acquisition command in progress, and clearing all SRQ's. If an external input command (READX or >TEXT) is in progress, the partially filled data area is cleared (Ø WFM data points = 0, X-register = 0, or any text input is deleted) and a warning is displayed. If an external output command (SAVE, SENDX, or TEXT) is in progress, it is terminated and a warning is displayed.

Interface Clear

The IFC (Interface Clear) message interrupts any data input or output. If the 7854 is talking, it will continue from that point when it is again addressed as a talker. If the 7854 is listening, it will continue inputting data when it is again addressed as a listener.

Stop Key

If the 7854 is in the talk-listen mode, pressing the 7854 keyboard STOP key will abort an I/O (Input/Output) command (SAVE, TEXT, >TEXT, SENDX, READX) if the 7854 is not yet addressed as a talker or listener. If data transmission has already started, the STOP command is buffered until the I/O command is finished.

If the 7854 is in the TALK ONLY or the LISTEN ONLY mode, the STOP command will abort an I/O command even if data transmission has started.

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