the R1340 Data Coupler

Complete testing of today's complex integrated circuits, printed circuit boards and other such products is a formidable task. To accomplish it, an equally formidable array of signal sources, power supplies, test fixtures and measuring devices are brought together to form automatic measurement systems. Some of the more sophisticated systems also include a computer.

How well we accomplish the testing task depends, to a large extent, on the ease with which the various elements of the system "communicate" with each other and with the computer.

The new TEKTRONIX R1340 Data Coupler could be called a "systems communication expert". The coupler is designed to multiplex data inputs and outputs of various system components to a common TTL data bus. This data bus can, in turn, be interfaced to a computer, data receiver, or data source. Using optional interface circuit cards, nearly any form and format of data can be applied to, or acquired from, the R1340. The unit can perform such functions as input/output level conversion, serial-to-parallel and parallel-to-serial format conversion and temporary storage of data in latching registers.

The unit is designed primarily for use with TEKTRONIX Automated Measurement Systems. However, it can serve just as well as an important building block in your system. Here are some of the chores it can perform:

- Provide the interface to bring your system under computer control.
- Couple the system to data-logging equipment.
- Interface the computer to registers, DVMs, test fixtures and other programmable instruments in the system.
- Digitize high-speed waveforms for computer analysis.

The R1340 consists of a rackmount cabinet with power supply, space for twelve plug-in cards and eighteen wired connectors providing a total of 648 input/output lines. Combinations of from one to twelve plug-in cards within the R1340 perform the various functions desired.

The block diagram in Fig. 1 shows four major application areas using the R1340. (Type numbers of TEKTRONIX instruments used in our automated measurement systems are shown in the appropriate blocks.) Although not apparent from the diagram, data logging from a system using the 230 and 240 can be performed through the R1340 without using the computer. Data is logged on computer-compatible magnetic or punched paper tape.

INTERFACE OPTIONS

Since different applications or functions require different interfaces, we should discuss the various interface options available for the R1340 before getting into specific applications. An option consists of a package which includes one or more plug-in circuit cards, interconnecting cables and an instruction manual. Several options (up to a total of 12 cards) can be accommodated in the unit at one time. There are ten options presently available with several more in the design stage. Briefly they are:

1. R1340 to PDP-8/L Computer Interface
2. R1340 to IBM 1800 Computer Interface
3. R1340 to R230/R240 Interface
4. R1340 to Paper Tape Punch/Reader Interface
5. R1340 Data Logging Interface
6. 16-bit Input/16-bit Output Interface
7. 32-bit Input Interface
8. 32-bit Output Interface
9. R568 to R1340 Waveform Digitizing Interface
10. Vertical and Horizontal Signal References Interface.

The waveform digitizing and the signal reference interfaces merit special consideration since they bring new capability to automated testing.

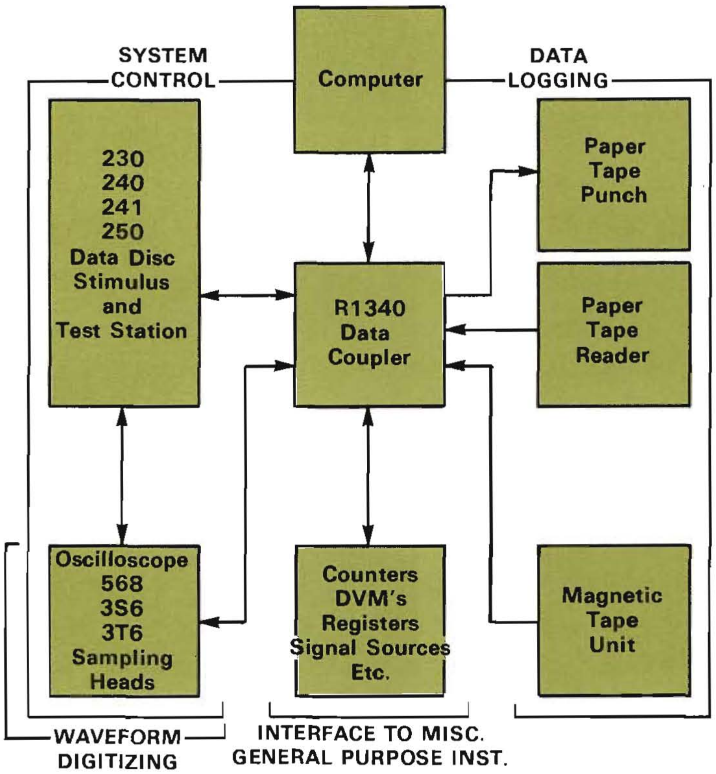

Fig. 1 Four major application areas of the R1340 include system control, data logging, waveform digitizing and interfacing to many general purpose instruments.

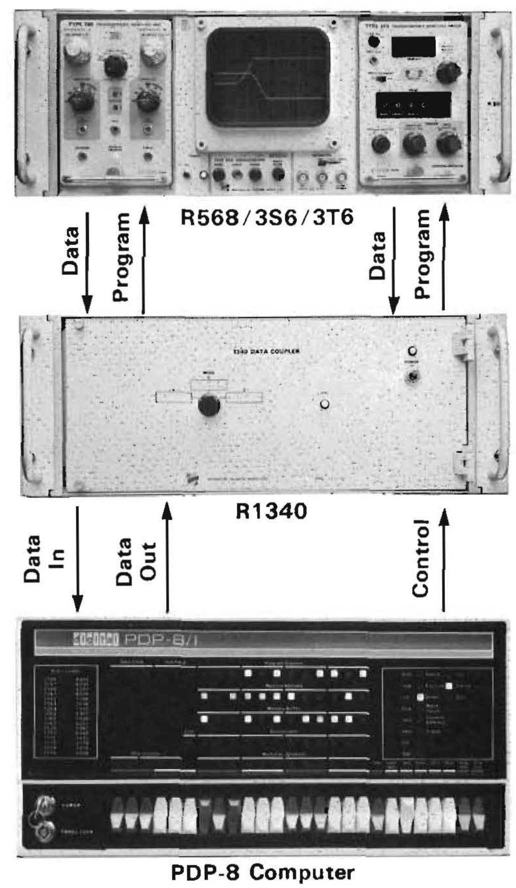

Fig. 2 A basic waveform digitizing system consisting of the R1340 Data Coupler, an R568/3S6/3T6 Oscilloscope and a DEC PDP-8 minicomputer.

WAVEFORM DIGITIZING

Waveform digitizing, as the name implies, is a means of converting an analog waveform into its digital equivalent. A computer can then be used to measure whatever parameters are desired such as risetime, pulse width, period, or delay between two pulses. Smoothing or noise reduction can be performed to improve measurement accuracy or to extract a low-level signal from noise.

A block diagram of the basic waveform digitizing system is shown above. It consists of the R568/3S6/3T6 programmable oscilloscope, the R1340 and a PDP-8 minicomputer. A total of seven interface cards reside in the R1340. Three cards are required to interface the computer to the R1340, two cards program the R568 and plug-ins, and the remaining two cards are the digitizer interfaces.

One of the digitizer interface cards has two, 10-bit A-D converters, buffers and control logic to convert the 3S6 channel A and B analog information to binary numbers. These numbers are then made available to be read by the computer under software control.

The other card consists of a buffered 10-bit D-A converter which outputs an analog voltage to the 3T6 to determine the time position of a particular sample. It, in essence, generates the analog ramp for the sampling sweep unit. Both cards rely on computer-generated operating instructions.

WAVEFORM DIGITIZER LOGIC

Three operating modes are available for the waveform digitizer. One is called the SCAN, SAMPLE and HOLD mode, wherein the horizontal sweep is stepped across the screen in 1023 increments. This is like the normal sampling scope operation with one important difference. The sweep is prevented from going to the next time position until the data in one or both of the A-D buffers has been read by the computer. This enables the memory location itself to be used as a time position pointer for that data word.

The second operating mode is called PARK, SAMPLE and HOLD. In this mode, the self-incrementing operation of the register driving the D-A converter is disabled and now becomes a simple 10-bit latch which will accept a data

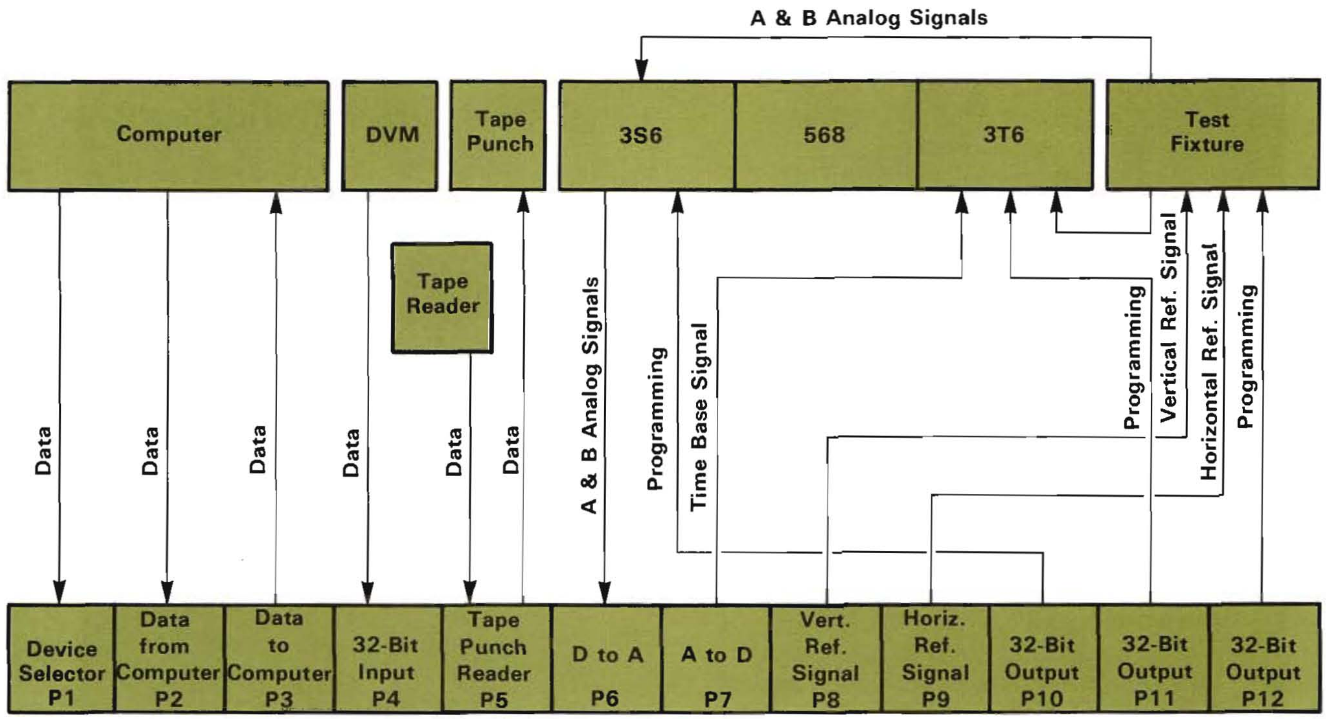

Fig. 3 Block diagram of a computer-controlled system which includes waveform digitizing and vertical and horizontal reference signals.

word from the computer. The sampler now makes samples at any one of 1023 time positions on the waveform being measured. Any number of samples desired may be read at that single time location by the computer. A new word may be loaded into the D-A register at any time to select a new time position or the mode may be changed back to SCAN, SAMPLE and HOLD. Thus, any segment or segments of a waveform may be stored in core, or multiple measurements at single-time locations may be stored for use in noise reduction.

The third operating mode is called SCAN, FREE RUN. Here the sweep D-A operates in the self-increment mode and the logic loop requiring the computer to read the A-D converter before allowing the D-A to move to the next time position, is disabled. This mode is most useful for initial setup of the package since in the SCAN, SAMPLE and HOLD mode, only one sweep can be seen, and in the PARK, SAMPLE and HOLD mode, only a single dot can be seen on screen.

Any of those three modes can be entered via computer, while the SCAN, FREE RUN mode may also be entered by a front panel control on the R1340.

APPLICATION CONSIDERATIONS

Of the two data acquisition modes discussed, the SCAN, SAMPLE and HOLD mode offers the greatest flexibility in the range of measurements that can be made. However, it requires up to 2048 words of computer memory to store a complete sweep of data from channels A and B. Since most standard minicomputers have only 4K of memory, the user would almost certainly have to add storage capacity to accommodate a comprehensive program package.

It should be apparent that a great deal of redundant information is contained in a typical oscilloscope display. This leads to a second type of acquisition routine which uses the PARK, SAMPLE and HOLD mode. It requires somewhat more sophisticated software but has several important advantages over the first method.

Prior to the data acquisition stage, the user specifies the type of measurement and what points must be measured on the waveform. For example, suppose we want to measure risetime, amplitude and channel A to channel B delay. These measurements require 0%, 10%, 50%, 90% and 100% points of the pulses on both channels to be stored.

A 0% zone is established by parking the sweep at the left edge of the screen and then reading the channel A and B samples. Next, the sweep is parked a few tens of increments to the right, samples read and compared with the first ones. A zero slope area is quickly found by stepping the time position around as necessary. Once a suitable time-position is established, several readings of the A-D converters at that one time position are averaged and then stored as the 0% locations for channels A and B. Similarly, to locate the 100% time and amplitude, the time position (sample) is programmed to the right edge of the screen then moved to the left or backward in time. Now the 50% voltage value is calculated and the sampling time position moved around until this value, or something near it, is found. Multiple A-D readings are then made at adjacent time positions with each time location given some average value of these readings. These noise-reduced values are then used to calculate the time position of the "smoothed" 50% crossing. The 10% and 90% points are found in a similar way.

The required parameters of the two vertical channels are stored in only 20 memory locations (10 amplitude and 10 time) compared to 2048 memory locations for storing the complete waveform. Furthermore, the noise level and, hence, repeatability of the measurement have been greatly enhanced, and the whole process carried out with fewer than 100 samples, depending upon the number of samples used for noise reduction purposes.

VERTICAL AND HORIZONTAL SIGNAL REFERENCE INTERFACE

Designed to be used with the Waveform Digitizing Interface, a programmable time standard and programmable voltage standard are available as plug-in cards for the R1340. These standard signals are made available at the system measurement fixture so that all combinations of sampling heads, channel A or B, and 3S6 sensitivity will have a calibration coefficient tabulated in the computer memory. Similarly, a calibration table can be stored for all sweep rates of the 3T6 between 500 ms/div and 1 ns/div. Time and amplitude measurements can thus be made to better than 1% with traceability to NBS.

COMPUTER-CONTROLLED WAVEFORM DIGITIZING SYSTEM

Pictured on the preceding page is a block diagram of a computer-controlled system using the Waveform Digitizer and the Vertical and Horizontal Reference interfaces. The computer has master control over all of the cards in the coupler via Pl, the Device Selector.

The Device Selector takes data from the computer, converts it from a binary number to a selection code and uses it to select one or more cards in the data coupler. The selected card immediately transfers data to or from the interface bus in the R1340. The computer generates a strobe pulse when it sends or receives data.

The Device Selector also receives a signal from each card which indicates the status of that card. When the computer is ready for data from the coupler, it looks for a signal from the Device Selector and then handles the data as the computer program requires.

SOFTWARE

No software is presently available as part of the R1340 except as part of an operating S3150 system, and that software is in a language closely related to the particular hardware in the system.

Existing hardware interfaces used in the R1340 for the DEC PDP-8/L and IBM 1800 computer are well documented and allow machine-language drivers to be easily written. Hardware interfaces for other computers (including the DEC PDP-11) are under development. Special software, a high-level language written in DEC PDP-11, FORTRAN IV, will be available in 1972. The TEKTRONIX programming language being developed for the PDP-11 will allow interactive English-language control of computer peripherals and test instruments interfaced through the R1340. Digitized waveform data acquired by the Waveform Digitizing Interface can be computer processed through measurement routines for determining such parametric data as risetime, pulsewidth, etc. Measurement routines may be interactively altered or extended for unusual applications by writing FORTRAN routines to perform special functions. Arithmetic, data-logging, instrument programming and display operations are to be included.

CONCLUSION

The R1340 Data Coupler greatly expands system flexibility with or without the use of a computer. Through waveform digitizing and accurate voltage and timing references it brings new measurement capability to dynamic testing. Your TEKTRONIX field engineer can help you apply the R1340 to solving your measurement problems.