Portable Analyzer Speeds Test and Service of Microprocessor-Based System

An Automatic Video Signal Parameter Measuring Instrument with Logging Capabilities

Developing a Practical Automatic Television Parameter Measuring and Logging System

New Products

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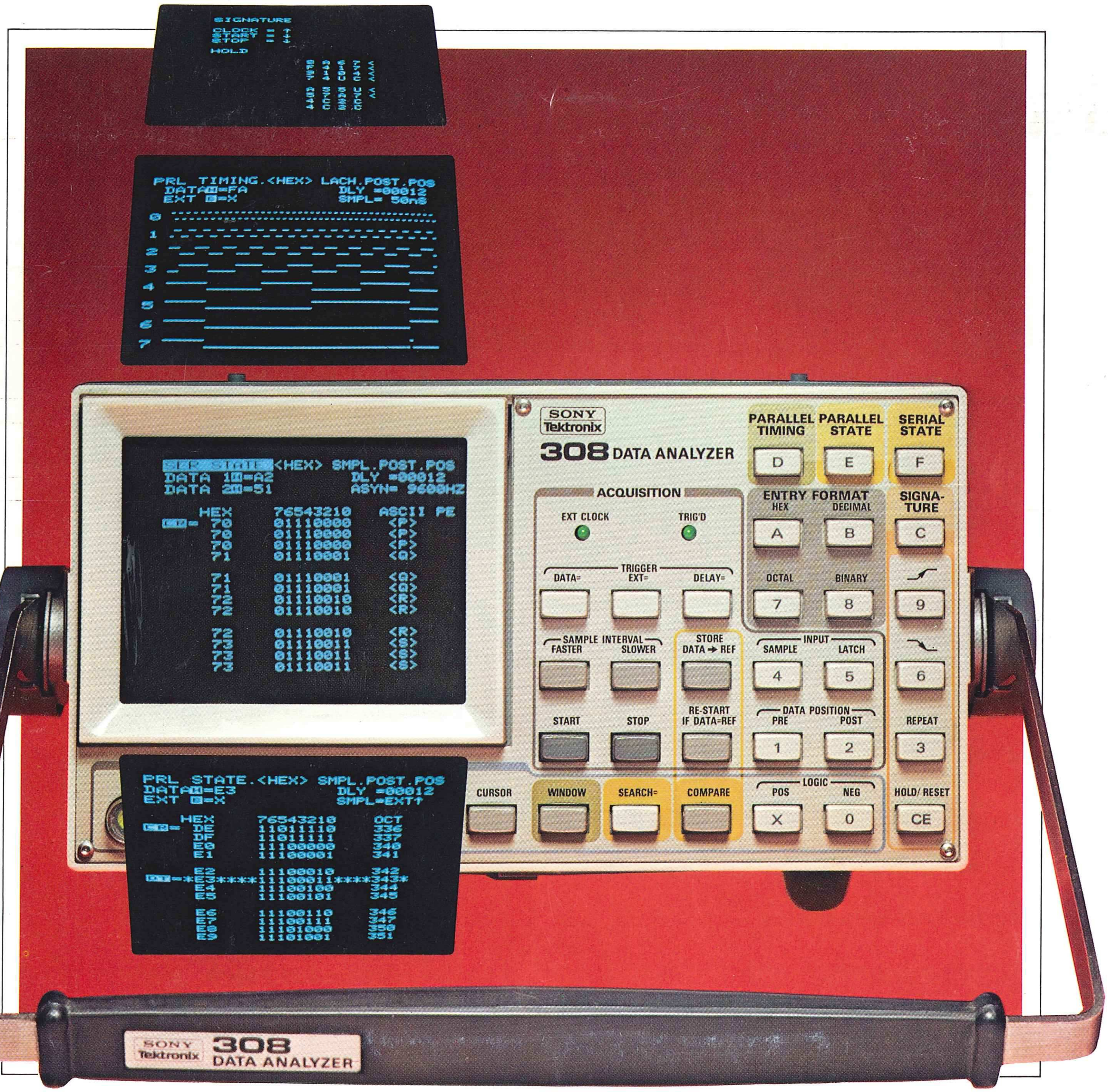
Tekscope



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Customer information from
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Beaverton, Oregon 97077

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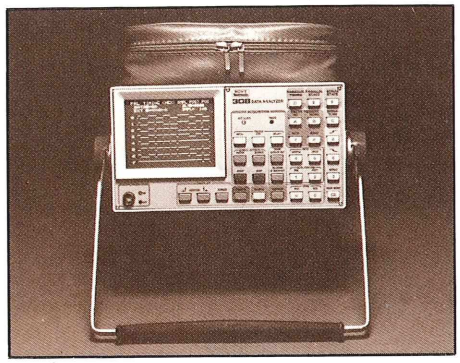
The Sony/Tektronix 308 Data Analyzer combines parallel timing analysis, parallel state analysis, serial state analysis, and signature analysis in a single, compact, lightweight instrument that is cutting dollars and hours from digital test and service functions.

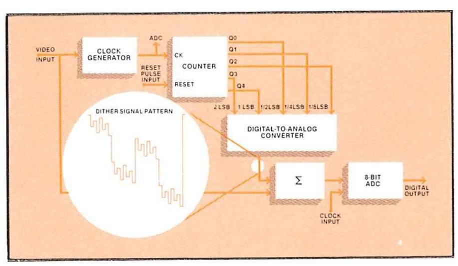


An Automatic Video Signal Parameter Measuring Instrument with Logging Capabilities

Monitoring and logging television transmitter performance is a tedious, time consuming job. Now it can all be done, automatically and unattended, by the Tektronix 1980 ANSWER. This microprocessor-based instrument digitizes the video signal and uses unique signal-processing techniques to make measurements more quickly and accurately than is possible by conventional means.

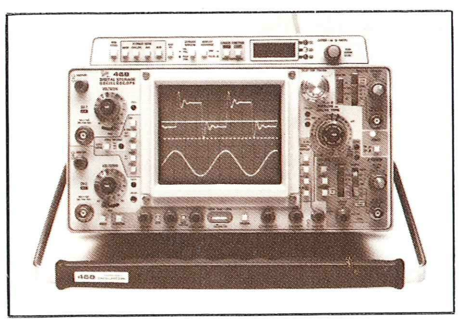
Developing a Practical Automatic Television Parameter Measuring and Logging System

Digitizing the broadcast video signal with sufficient accuracy to allow measurements to broadcast standards provided some interesting challenges. High speed A/D and D/A converters developed in-house are coupled with precision offset and dither signals to provide resolution and accuracies equivalent to 11-bit digitization.



New Products

A host of new products including digital scopes, a digital television test signal generator, a state-of-the-art distortion analyzer, and a programmable oscilloscope calibrator apply the power of the microprocessor to meet your test and measurement needs for today, and tomorrow.



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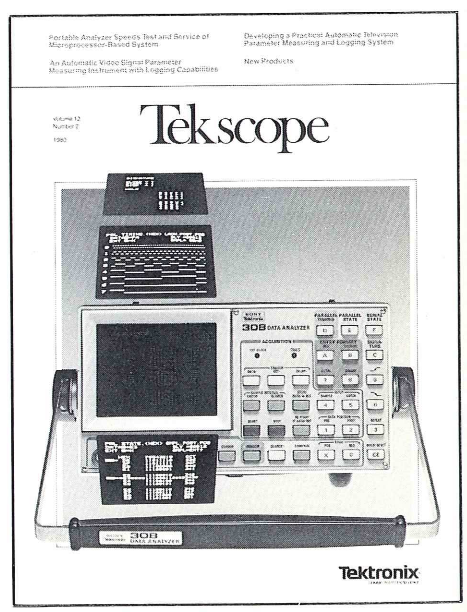
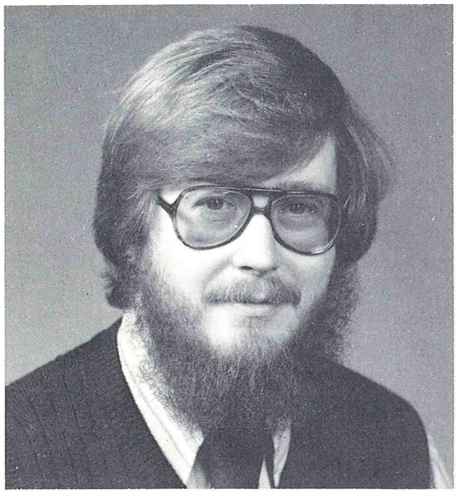
Tekscope is a bimonthly publication of Tektronix, Inc. In it you will find articles covering the entire scope of Tektronix' products. Technical articles discuss what's new in circuit and component design, measurement capability, and measurement technique. A new products section gives a brief description of products recently introduced and provides an opportunity to request further information.

Cover: The four displays in this photo show only the basic capability of the Sony/Tektronix 308 Data Analyzer. This small, lightweight instrument packs more measurement power than you could normally carry using both hands.



Portable Data Analyzer Speeds Test and Service of Microprocessor-Based Systems



Ed Averill joined Tektronix three years ago after completing his BSEE and a year of post-graduate studies at the University of Nebraska. His work on the 308 included evaluation of both electrical and firmware design, which entailed spending three months in Japan. He is writing the thesis for his MSEE, and is studying to improve his Japanese. Ed enjoys camping, hiking, and outdoor photography. He processes both color and black and white in his own darkroom.

John Huber started his electronics career in the United States Navy as a Fire Control Technician. Since joining Tek in 1973, he has performed diverse functions from quality control of large-screen storage display monitors to on-site service of complex semiconductor test systems. Currently, he is an applications engineer for Logic Analyzer Marketing. John is completing work on his BSEE at the University of Portland. For recreation, he enjoys racquet ball, golf, and woodworking.

New microprocessor-based products are announced almost daily. Hundreds more are in the design stage. The circuit complexity and diversity of signals present in these products complicate their manufacture and maintainability. It is imperative, therefore, to have an effective, efficient means of testing and servicing such products.

Figure 1 depicts a typical microprocessor-based system. Three major categories of signal are present: input and output signals in serial logic, address and data bus signals in parallel logic, and timing and control signals such as CLOCK, READ, WRITE, RESET, etc.

To test such a system effectively, each type of signal must be monitored in an optimum manner and analyzed differently. For example, the relationship of the clock and control signals is best analyzed using a parallel timing display. Bus transactions are usually observed using parallel state analysis, and serial data through the communications port using serial state analysis. Signature analysis compresses sequential data into a four character alphanumeric code for quick GO/NO GO information. Modes that can be observed as clocked data can be tested using signature analysis.

Usually several different instruments would be needed to acquire and display the varied signals in the desired format. Now, all of these capabilities — parallel timing, parallel state, serial state, and signature analysis — are combined in one lightweight, portable instrument, the Sony/Tektronix 308 Data Analyzer.

The operation of the 308 is controlled from a front-panel keyboard, which greatly simplifies mode and parameter selection. Within the four basic operating modes, there are several subfunctions available. For example, in the parallel timing mode you can select the menu timing display, timing cursor display, or timing window display. In the parallel and serial state modes there is a choice of four displays: menu, cursor,

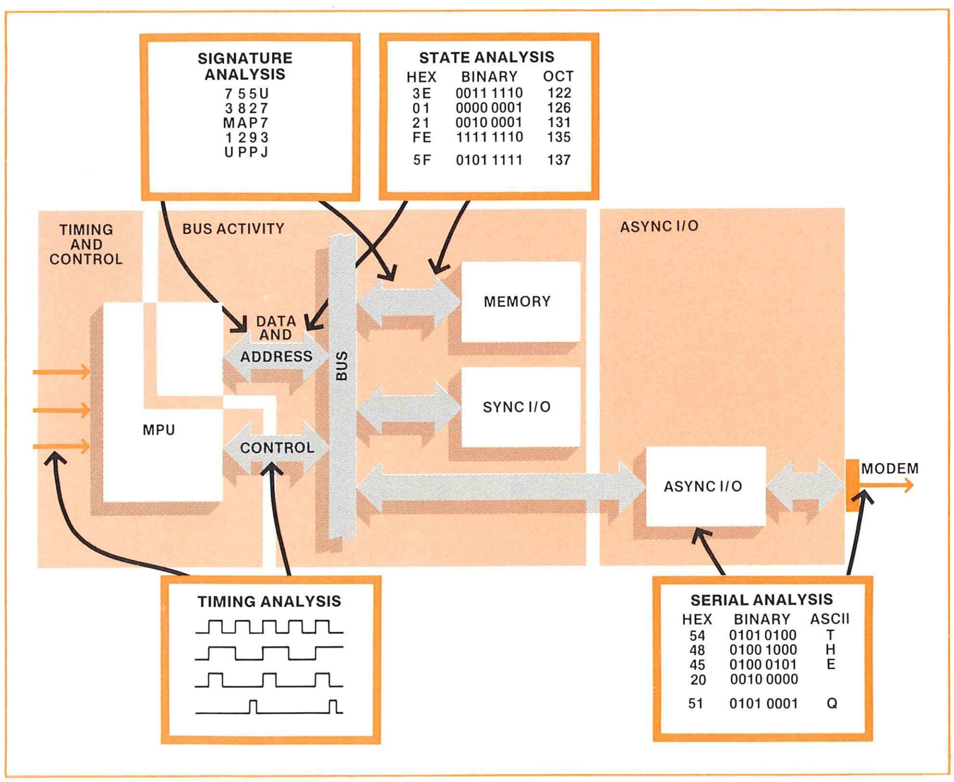


Fig. 1. Typical microprocessor-based system requires varied data acquisition techniques for thorough analysis of its activities.

search, and compare. In the signature mode you can select either hold or repeat modes. In addition, there are several diagnostic displays available for self-checking the 308's operation.

A menu displayed in the upper portion of the screen lists the operating mode selected and the operating parameters to be set from the keyboard. The data entry format selected (hexadecimal, octal, binary, or decimal), sample or latch mode, pre or post-trigger display, trigger word, source, and delay, and other pertinent parameters are included in the menu. It serves to direct the operator in setting up the 308 and lets one know, at all times, the current setup.

Acquiring data

Data and trigger inputs are located at the side of the 308 to keep the front panel clear for operating ease. An eight channel data probe provides inputs for acquiring parallel data at rates up to 20 MHz. Serial data and signature inputs are via a single, high-impedance probe. Serial word lengths of 5, 6, 7 or 8 bits can be selected and data acquired at rates from 50 to 9600 baud.

Acquired data is stored in an 8 x 252 bit Data Memory. Stored data can then be copied into a Reference Memory and be available for a Compare function. However, only the contents of Data Memory can be displayed. In the Compare mode, differences in the two memories are highlighted by display in inverse video. If the two memories match, the 308 can automatically restart data acquisition and continue until a difference in data is detected. The restart feature allows an automatic search for an intermittent problem. A count of the number of times the memories match is displayed at the bottom of the screen.

Trigger versatility

Quick, easy selection of a variety of trigger modes is in keeping with the other attributes of the 308. The trigger word is defined from the keyboard and can be programmed in hexadecimal or other of the data entry modes. Eight inputs to the trigger are provided by the Data Acquisition probe. These can be augmented by an optional 16-bit Word Recognizer probe. An external trigger qualifier input adds a bit for a total trigger word length of 25 bits. A word recognizer trigger output is provided for triggering an oscilloscope or other external equipment.

When triggering internally from the serial probe input, the menu calls for defining two consecutive data bytes as the trigger word (figure 3). External triggering can be accomplished by a single bit via channel 0 of the Data Acquisition probe. A programmable trigger delay of up to 65,535 counts or words is available in parallel and serial operating modes. Data displays can be either pre or post delayed trigger. In the pre mode the delayed trigger is positioned at the 240th position in the 252 byte data memory; in the post mode it is positioned at the 13th position. Data acquisition can be stopped manually at any time by pressing a STOP key. The last 239 bytes acquired are then displayed.

Fig. 2. Versatility, operating ease, and small size make the 308 useful in a wide range of applications. Here the 308 is being used to analyze graphic terminal operation.

Data display

Once the data is acquired and stored, it can be displayed in one of several formats. In the parallel timing format up to 168 eight-bit words can be viewed simultaneously. A window mode provides a magnifying effect for close analysis of timing relationships, by displaying only 84 or 42 words. The window can be positioned anywhere in the 252-byte memory by the horizontal position control.

For parallel state display, data is conveniently displayed in three formats simultaneously — hexadecimal, octal, and binary. The same applies to serial state displays except that octal is replaced by ASCII. Up to twelve lines of data are displayed at one time. The vertical position control allows the operator to step forward and backward through memory.

In addition to the usual menu display modes, several special displays are available. These include cursor modes, window, compare, search, and extended serial displays. Each display meets a specific need, enabling the operator to view the desired data in an optimum manner.

In signature analysis mode, the 16-bit words are converted to a four-character alphanumeric signature and displayed

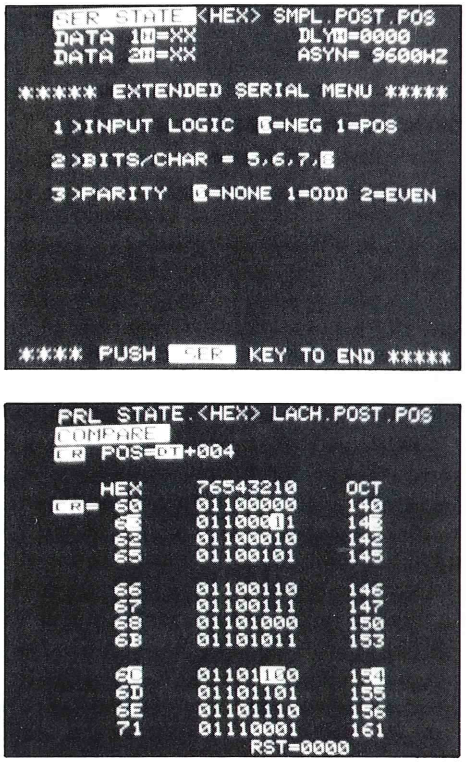


Fig. 3. Some of the many displays available on the 308. Changing from one display to another is accomplished by one or two keystrokes.

in one of two formats. In the hold mode, a signature is acquired and displayed each time the HOLD/RESET key is pressed. Up to eight signatures can be displayed at one time, with a < symbol indicating a change in signature.

In the repeat mode, signatures are repeatedly acquired. If a change in signature is detected, a FAULT sign is flashed momentarily and the new signature is displayed. This is a very useful mode for isolating intermittent malfunctions.

Acquisition and display synergism

One of the many unique functions in the 308 allows data acquired in one mode to be displayed in another. For example, when using parallel acquisition, the display can be done with serial displays that will analyze parity and decode ASCII.

When using serial acquisition, the parallel displays can be used to show octal information, and the parallel timing displays can show a summary of trends over long sequences of data. An example of the latter would be analysis of the parity bit. The activity of bit 7 can be shown along one line in the timing display with up to 168 bytes in the display at one time.

In performing signature analysis, correct information depends on both the gate formation signals and the data they frame for the signature. A faulty signature can be caused by a faulty signal on any of the lines — START, STOP, CLOCK, or DATA. The clock-sampled START and STOP lines can be observed using parallel display modes, without changing any probe connections (just press the appropriate keys). Parallel modes are useful in identifying a stuck START line, an unstable START/STOP line, etc. By applying one of the parallel data input probes to the signature analyzer data point, the data pattern can be observed relative to the gating information.

As the serial and signature data memories are identical, a comparison can be made between data acquired in each mode. Thus, a reference memory can be obtained from a data bus, and compared to test points on the other side of a USART (communications interface) and its line drivers.

A microprocessor-based system

The versatile acquisition and display capability of the 308 is accomplished through use of a microprocessor controller. Some features are the result of firmware residing in ROM, while others are highly dependent on groups of hardware components. The simplified block diagram in figure 4 shows some of the details. The key factor in determining which features require additional hardware is the speed with which each function must be performed. This differs for each of the subinstruments.

The powerful displays, and their ability to help the user understand the data, are the result of firmware. Over 18,000 bytes of program are used. The basic instrument control is designed as a state machine, with transactions between states controlled by keystrokes. Each

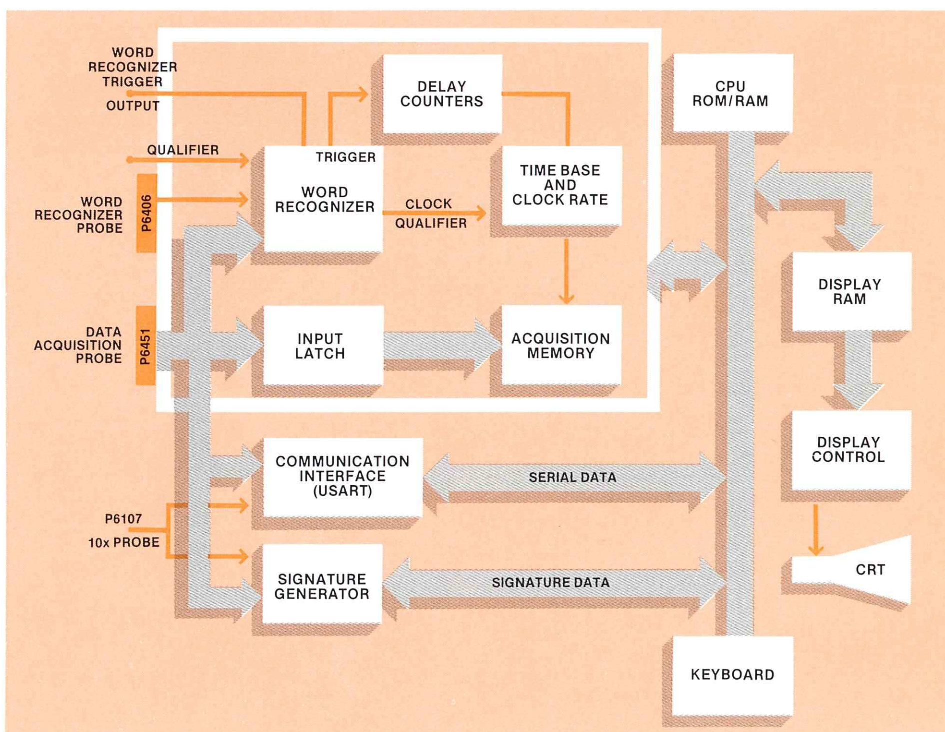


Fig. 4. Simplified block diagram of the 308. The data paths for the three subinstruments start at the probes, pass through separate high-speed circuits, then merge at the microprocessor controller for processing and display.

state has its unique display form. Within each display state, fields of the display can be controlled with different keystrokes. For example, positioning of the cursor or window. The three acquisition systems can be invoked from any of their associated display states simply by pressing the START key.

The parallel logic functions are required to work at speeds up to 20 MHz. Thus, all of the decisions needed to store a full acquisition have to be made at hardware speeds; decisions like do I have a trigger, have I delayed to the delayed trigger point, was the acquisition terminated with a full data memory, etc.

An interesting part of the parallel acquisition circuitry is data latching. In SAMPLE mode, data is accepted by normal setup and hold rules. In the latch mode, however, each sample period records any change from the previous sample period's recorded value without regard to when the change occurred. This is important when trying to observe changes in data that are not occurring near clock edges. Examples are glitches in the middle of sample intervals and other nonsynchronous activity, such as observing patterns with periods much longer than could be recorded synchronously.

In the serial data acquisition system, data speeds are much slower. The hardware is used to interpret the bit-to-byte transformation protocol. After that, the bytes of information are completely handled by firmware. The firmware determines if a trigger has been received, counts the delay to the delay trigger, senses protocol errors, reorients the acquired data into the main data memory, etc. Finally, the displays are formed by the firmware in a way similar to those of the parallel logic analyzer.

In the signature analyzer, the data input rates are, again, 20 MHz. Thus, the signature gate formation and data manipulation must be done with hardware up to the point where a signature is formed. Signatures are then moved into the microprocessor control system where they are processed for fault information and displayed.

The input circuitry is chosen to make a few probes serve many purposes. Where several signals are going to be used together, a multiple input probe is used. Where changing from one test point to another is important, a single input probe is used.

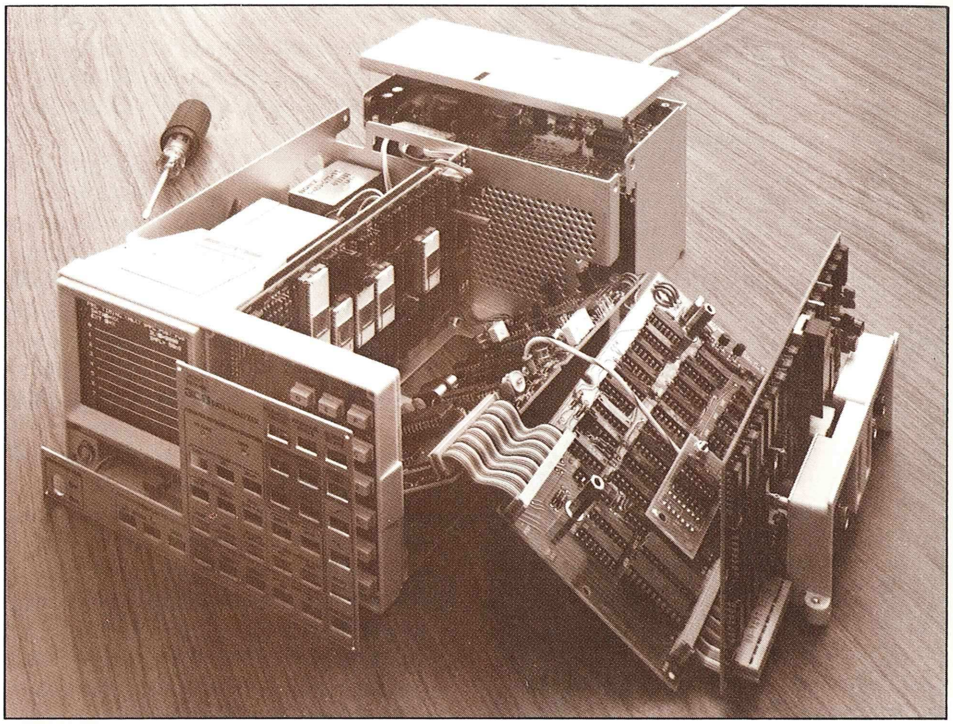


Fig. 5. Easy access to circuitry even with the 308 powered up facilitates calibration and servicing.

The data paths for the three sub-instruments start at the probes, pass through separate high-speed acquisition circuits, and then merge at the microprocessor controller for processing and display. Note the parallel acquisition circuit contains delay counters, and a word recognizer. The serial acquisition has the same functions, but they do not appear in circuitry. Instead, the microprocessor controller performs the serial word recognition and delay counting functions.

Self-test diagnostics

In many instances, valuable time is lost trying to fix defective equipment with a test instrument which is, itself, faulty. A set of diagnostic routines resident in the 308 precludes the probability of this happening to a 308 user.

A self-test procedure is invoked each time the instrument is powered up. The display informs the operator that a self-test is in progress and then indicates OK if no errors are formed. If an error is detected, a code denoting the type of error detected is displayed. A series of six user-initiated diagnostics can then be called up to help in locating the source of the problem. A seventh routine designed specifically for the service technician is also resident.

The 308 is mechanically designed for easy access to components, and can be operated and fully calibrated while spread open (figure 5). Modularity and the use of ribbon cable connections allow quick, easy replacement of subassemblies or component parts.

Summary

The task of testing and servicing the myriad of microprocessor-based products entering the marketplace is of increasing importance. The Sony/Tektronix 308 Data Analyzer combines in one compact, lightweight instrument the data acquisition and display capabilities needed to effectively test and service such products. Microprocessor-based, itself, the 308 provides a low-cost, yet versatile solution to many of today's digital instrument problems.

An Automatic Video Signal Parameter Measuring Instrument with Logging Capabilities

Jim Capps is a Program Manager in Television Products Marketing. During his six years at Tektronix, he has applied his programming skills to various areas including Manufacturing Planning, Manufacturing Engineering, and the Mechanical Products group. Jim is single and enjoys fly fishing, back-packing, and outdoor photography.

The "vital signs" of every television broadcasting system must be monitored and logged at frequent intervals. It is required by government regulations to ensure that equipment is set up and operating properly. Of equal importance, is the opportunity such monitoring affords for early detection of subtle changes in the transmission system which, if uncorrected, could eventually result in major failure.

The 1980 Automated Video Signal Measurement Set is a microprocessor-controlled digital instrument capable of making and recording, automatically, the majority of common video measurements. It has been designed to alleviate most of the problems associated with video measurement.

The standard video signal contains vertical synchronizing pulses, horizontal synchronizing pulses, and active picture elements. The time between synchronizing pulses, the shapes and risetimes of the pulses, and the peak-to-peak amplitude of the signal are relatively easy to measure while actual broadcasts are in progress. The problem is that there are many additional factors affecting picture quality that require special test signals to measure. These parameters include frequency response, delay of the chrominance with respect to the luminance, differential gain, differential phase, etc. Because these parameters affect the quality of the broadcast picture so dramatically, it is important that they be measured during the course of actual broadcasting, especially when it is considered that the broadcasting day may now be up to twenty-four hours long. In fact, the FCC requires that many of these parameters be measured during actual broadcasting.

Special test signals help

There are obvious disadvantages to broadcasting test signals, such as color bars, at frequent intervals during the day while long sequences of measurements are made. Therefore, there are special signals that are inserted in the video signal during the vertical interval, the time when the beam of a television receiver is "blanked" as it returns from the bottom of the picture tube to the top. These are called vertical interval test signals, or VITS. The vertical interval

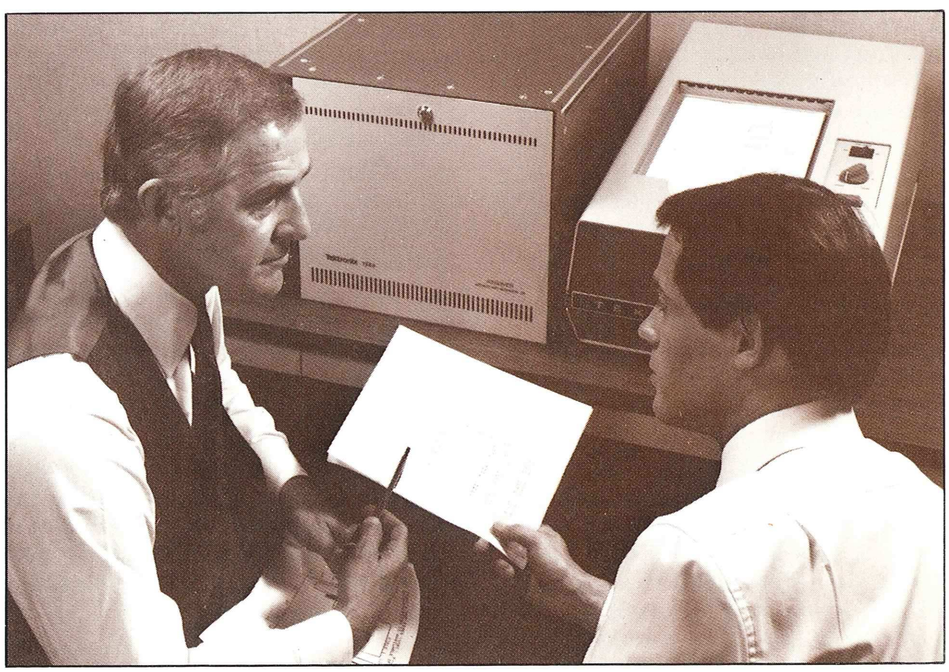


Fig. 1. The Tektronix 1980 ANSWER Automatic Video Measurement Set with companion hard copy unit. Measurements are made and results logged automatically to provide proof-of-performance with unparalleled ease and accuracy.

occurs sixty times a second and lasts for approximately 1.3 milliseconds, or about the same time as 21 scan lines of regular picture. This interval may also contain the VIR signal (Vertical Interval Reference) which can be used for automatic correction of certain signal parameters, as well as information such as the origin of the program material, the time of day, and captioning for the deaf. The VIT signals allow accurate determination of how the signal has been affected as it passed through distribution amplifiers, telephone lines, microwave links, switchers, and the transmitter. Generally, measurement of VIT signals is made using two special types of oscilloscope: a waveform monitor, and a vectorscope.

Signal measurement using these two special instruments involves certain difficulties, however. Accuracy and repeatability of these measurements are limited by factors such as operator interpretation and the presence of noise on the signal. It is difficult to record the results, as this requires photographing the signal and recording the settings of the measuring equipment. Instrument controls must be changed several times during the course of a set of measurements and highly trained personnel must make the measurements.

In contrast, the 1980 automatic video measurement set makes a complete set of standard operating video measurements in just a few minutes. Results of these measurements are printed on a terminal or printer that may be located many miles from the site of the measurement taking. Because the measurement results are simply printed numbers, there is no operator interpretation of waveforms, and because the 1980 is almost all digital, the results are accurate and repeatable. Since the results of the measurements can be logged on a printer, there is no need to record the measurements, or waveforms, with a camera. Best of all, the 1980 can be run totally unattended so there is no need for a skilled operator to spend many hours at a repetitive task.

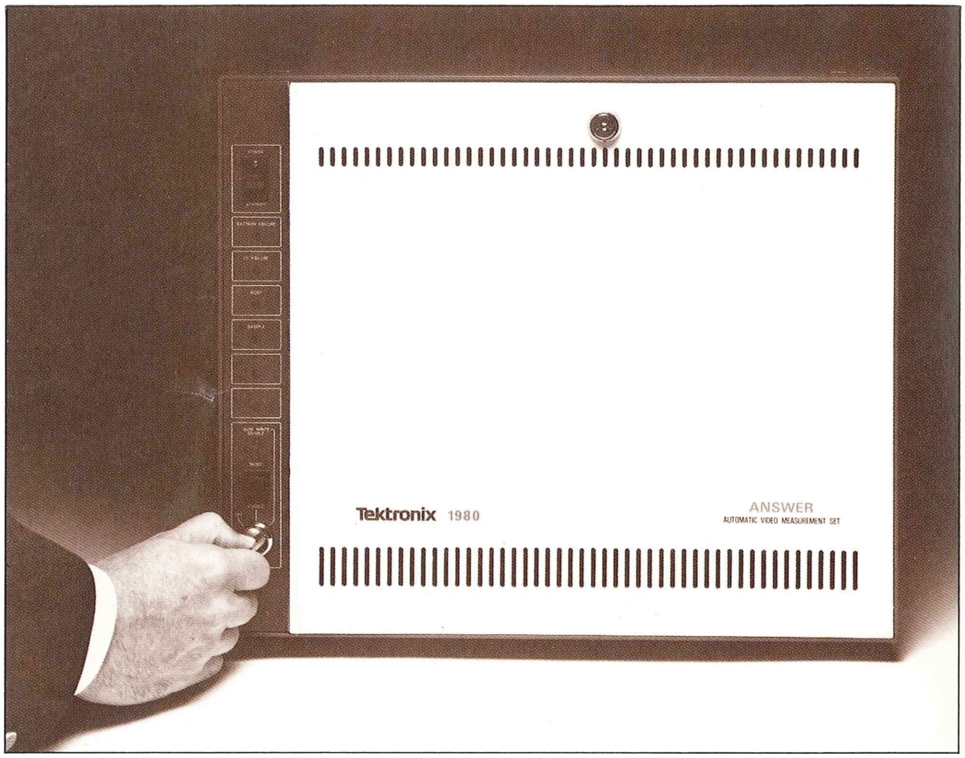


Fig. 2. A front-panel keylock switch controls what happens when power is applied to the 1980. In one position, the 1980 will start itself, run a set of diagnostic programs, and enter its normal monitoring mode. Other positions allow programming the instrument and changing configuration parameters.

These features make the 1980 ideally suited for use as an off-air transmitter monitoring device. When combined with the Tektronix 1450 precision demodulator, the 1980 can be used to monitor both the output of the transmitter and the video signal arriving at the transmitter via the STL (studio transmitter link). Two video inputs, automatically switchable, are provided. The 1980 can be set up to make its measurements continually and only report the results when a set of limits are exceeded, or at fixed times of day, or both. In a typical transmitter application, the 1980 would be set up to report on the broadcast signal every three hours, continuously monitor both the incoming and outgoing video, and generate an alarm signal when either of these exceeded predetermined limits.

The limits are set up for each video source that the 1980 is monitoring, and there are two pairs of limits associated with each measurement parameter. The first pair, the broader of the two, are called alarm limits and are usually set so that they correspond to what is legally prescribed. The other pair, tighter in their tolerance, are called caution limits and signify that the signal is not of the quality that is should be although it is still within legal limits. Usually the 1980 would be set up so that it would print a measurement report when the inner or caution limits are exceeded, and to generate an alarm signal at the studio when the outer, or alarm, limits were exceeded. The 1980 can be set up to monitor and compare a full set of measurements against these limits, or make partial sets of measurements; for instance, to monitor the blanking intervals (the timing of the signal).

Microprocessor-based versatility

The great versatility of the 1980 is achieved by digitizing the video signal and using a microprocessor to measure it. The 1980 is programmed in TEK ANSWER BASIC, a programming language very similar to TEK SPS BASIC. TEK ANSWER BASIC has a set of measurement commands added to it that reduces the complexity of programming video measurements. There are special commands to digitize the video signal and store the values in a waveform array. A waveform array is a collection of eight-bit numbers (ranging from 0 to 255) that can be interpolated by a program to find the original peak amplitude, phase, and other characteristics of a digitized signal. Measurement commands do things such as find the amplitude of a sine wave with a single BASIC statement. Many of the measurement commands are specifically designed around video measurements.

This programmed adaptability makes the 1980 suitable for use in almost any transmitter monitoring application. The VIT signals do not have to be in any specific location within the vertical interval, nor do all of the FCC and Network Transmission Committee Report 7 VIT signals have to be present. The 1980 will scan the entire vertical interval and locate the VIT signals that are there, then make the appropriate measurements for each of the signals it finds, including the VIR signal.

The remoteness of many transmitters from the studio makes it very desirable to be able to make video measurements from a distance. Sending the signal back to the studio for measurement may introduce distortions in the signal that are not present at the transmitter. In some cases, off-air reception of the broadcast signal at the studio is not possible, especially when one studio is broadcasting on several transmitters. The 1980 solves these problems by providing the capability of making the measurements at the transmitter and sending the results back to the studio by telephone. The 1980 has five RS-232-C interface ports that may be connected to modems to send measurement results in ASCII code, over a standard telephone line, to a terminal or printer located in the studio. An optional RS-366 interface will allow the 1980 to dial the phone and call the terminal or printer at the studio to report problems at the transmitter.

The key to assurance

The 1980 has a keylock switch on the front panel that controls what happens when power is applied to the instrument. With the keylock switch in one position, the 1980 will start itself when power is applied, run a complete set of diagnostic programs, and enter its normal monitoring mode of operation. Other positions of the switch allow programming the instrument and changing the configuration parameters — operations that are infrequent. The 1980 contains a battery that keeps the real-time clock operating for about one month without external power. Another preserves information stored in the non-volatile memory. This is important because the memory contains relatively constant information about the configuration of a particular installation. It includes things such as the number and type of terminals, the limits files, the phone number of the studio, and possibly even small customer-written programs.

The 1980 also has a feature called ATR (Automatic Timeout Reset) that takes control of the processor whenever sixteen minutes have gone by without the execution of a BASIC command. This is in case of a failure in the instrument. ATR restarts the instrument and runs a complete set of diagnostic routines before re-entering the monitoring mode. The diagnostic programs in the 1980 run special test procedures to ensure that the instrument is operating correctly. The results of these diagnostics are printed on the master terminal, and in most cases it is possible to determine on which circuit board a failure has occurred, simply by looking at the diagnostic printout on the terminal.

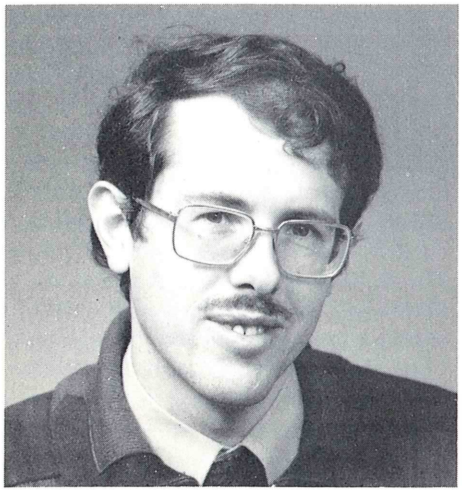
Broadcasting requires service from an instrument up to twenty-four hours a day, 365 days a year, so the 1980 has been designed with a long mean-time-between-failure (MTBF) and a short mean-time-to-repair (MTTR). Serviceability has been designed-in from the start with resident diagnostic programs that detect and isolate almost any fault. The instrument has been designed so that all of the circuit boards may be slipped out of their guides through the front of the instrument and replaced in a few seconds. The I/O board and power supply are the only exceptions. They are removed from the rear because of the cabling connections on them. All of the circuit boards in the 1980 may be removed without removing the instrument from its rack.

The 1980's digital design, customer-set limits, versatility, phone line compatibility, ATR, self-diagnosis, and other features have all been designed to make unmanned, remote, continuous transmitter monitoring a realistic, economical possibility.

Acknowledgements

Many people were involved in the development and completion of the 1980. Phil Crosby, Project Manager, also did much of the design work on the high-speed A/D and D/A converters. John Lewis was the Hardware Manager, with Dale Jordan performing a similar function for software. Earl Matney made substantial contributions in designing the digital feedback and memory controller circuitry. Jim Prouty did the applications software and Larry Morandi, the debug board, operating system, and diagnostics.

Developing a Practical Automatic Television Parameter Measuring and Logging System



John Lewis received his B.Sc(Eng.) from London University in England and upon graduation joined the British Broadcasting Corporation. Most of his ten years with BBC were spent in the TV Measurement Section of their Engineering Designs Department. He emigrated to the U.S. and joined Tektronix in 1976. John is married, has two young sons, and spends most of his leisure time with his family and in local church activities.

Earl Matney started his electronics career in the United States Navy. Electronics training was followed by submarine school and nuclear power school. Completing an extended tour of duty, Earl brought his family to the Portland area, joining Tek in 1974. His off-work hours are devoted to family activities, hunting, fishing, and studying.

Automatic measurement and logging of the television broadcast signal has been a long-sought-after goal. Prior to the introduction of large-scale integration and the microprocessor, however, attempts to automate the measurement process encountered serious drawbacks: such systems had limited capability, required frequent calibration, occupied a lot of space, and were very expensive. Now, with the availability of new components, the long-sought-after goal has become a reality in the new Tektronix 1980 ANSWER Automatic Video Measurement Set.

Typically, television signal measurements are made manually using analog instruments such as waveform monitors, vectorscopes, etc. The process requires highly skilled personnel and is time-consuming. Design goals for the 1980 were to make these same measurements automatically, with greater speed and accuracy, and at reasonable cost. Measurement results were to be logged automatically, on site or remotely. The instrument was to allow easy selection of individual tests, or series of tests, and provide for adding new tests. Reliability, of course, was essential.

Digitizing the signal

The key to developing an automatic video test set lay in finding a suitable high-speed analog-to-digital converter (ADC) for digitizing the video signals. With the video signal digitized, a microprocessor could be used to make almost any measurement desired.

Sampling theorem implies that if a bandlimited signal, such as broadcast video, is sampled at a frequency greater than twice the highest frequency component of the sampled signal, the original signal waveform can be accurately reconstructed by mathematical manipulation of the sampled values.

Investigation revealed a sampling frequency of four times the color subcarrier (14.32 MHz for NTSC, 17.72 MHz for PAL) affords some very significant performance advantages for the particular measurements to be made. Reviewing the commercially available ADCs it became apparent that to achieve our performance and cost goals we would have to develop the ADC in-house.

A simplified block diagram of the Tek-developed 8-bit, 20-MHz ADC is shown in figure 1. The converter uses a two-stage parallel conversion technique

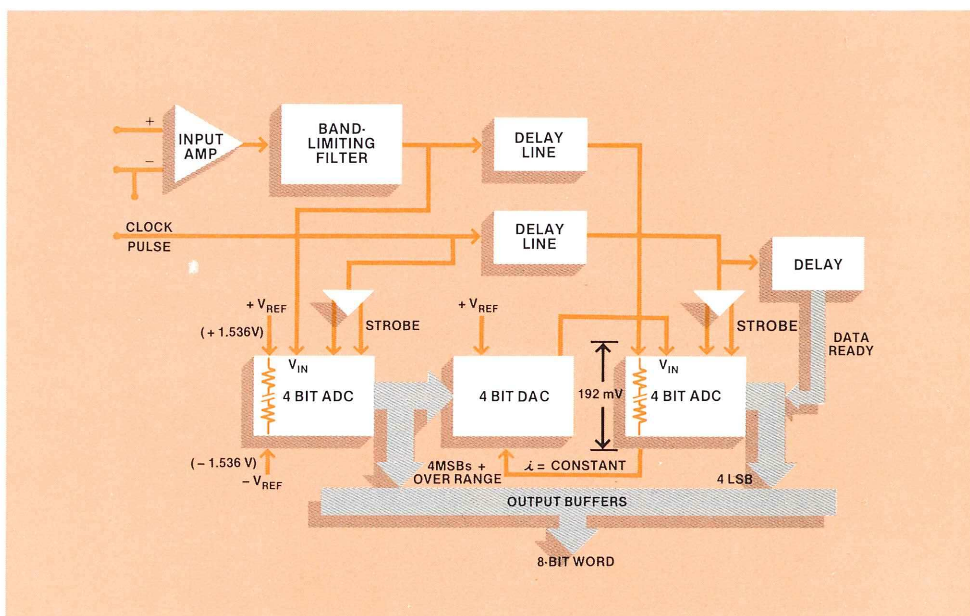


Fig. 1. The 8-bit, 20-MHz analog-to-digital converter uses two-stage parallel conversion, substantially reducing the number of comparators required.

which affords significant economies over the full parallel approach. For example, the number of comparators required is reduced from 255 to only 30. In two-stage parallel conversion, the first 4-bit ADC is biased so that it converts the four most significant bits.

The output of the first ADC drives a very fast digital-to-analog converter (DAC), also Tek designed. The analog output of this DAC is subtracted from the input video signal, and the difference signal is applied to the second 4-bit ADC to produce the four least significant bits (LSB).

In conventional two-stage parallel ADCs, a sample-and-hold circuit usually precedes the conversion process to ensure that the signal level does not change during the time between the two conversions. Because sample-and-hold circuitry is not readily integrated onto an IC chip, an alternate approach was developed. The input analog signal is delayed by 32 nanoseconds before being applied to the second 4-bit ADC. The strobe pulse is also delayed by precisely the same amount. As the ADC process occurs in each converter at the instant the strobe pulse is applied, both converters convert at the same point on the input signal waveform.

Development of both a 4-bit ADC and DAC as integrated circuits makes possible the high-speed conversion needed and provides other benefits. Linearity is improved by integrating the tapped voltage divider into the IC device containing the comparators, and laser trimming each resistor to optimally bias each comparator. Having all 15 comparators in a common thermal environment also improves the linearity of the conversion process over a range of temperatures. All of these factors result in an 8-bit, 20-MHz analog-to-digital converter with an accuracy of ±0.25 LSB.

Improving the resolution

To take full advantage of the dynamic range and inherent accuracy of the ADC, three significant elements are added during input signal processing — dynamic offset, dynamic gain, and dither (see figure 2).

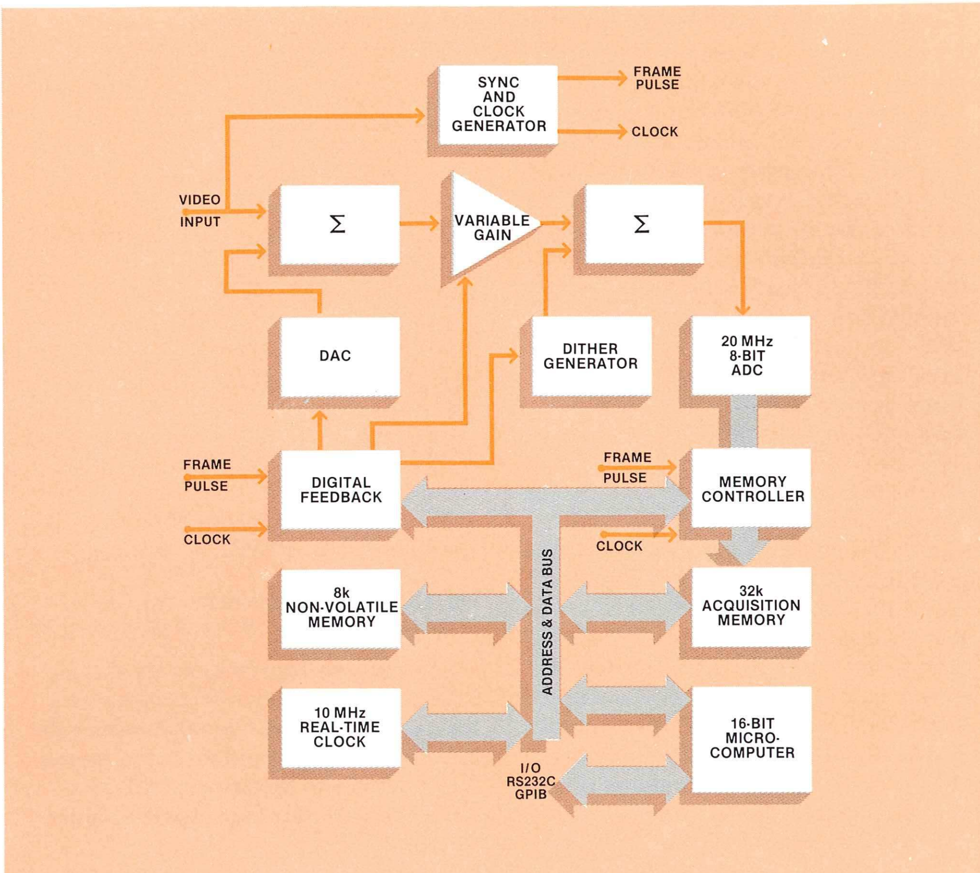


Fig. 2. Simplified block diagram of the 1980. Considerable signal processing is done to achieve maximum resolution and accuracy. Programmable memory controller provides great flexibility in selecting portion of video signal to be stored.

Dynamic offset is applied by summing a precision offset waveform with the input video signal. The offset pattern is digitally generated by the microcomputer and stored in the digital feedback memory. The contents of the memory are read out in sychronism with the video input signal, and applied to a precision (0.01% accuracy) DAC. The resultant analog output is then summed with the input video signal.

The output of the summing amplifier is applied to a digitally-programmable, variable-gain amplifier. This amplifier is controlled by the digital feedback memory which has been loaded with the appropriate gain pattern by the microcomputer. Figure 3 shows the effect of applying dynamic offset and gain to a linearity test signal. In this example, the resultant chroma portion of the input

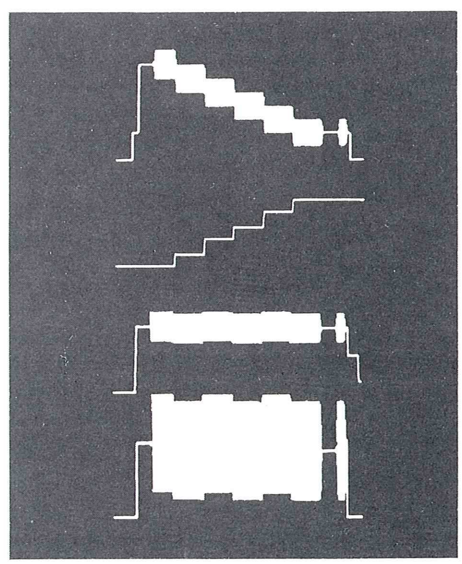


Fig. 3. Offset and variable gain applied to linearity test signal greatly enhances resolution and accuracy of measurement.

video signal is amplified by about three times to take full advantage of the dynamic range of the ADC.

Finally, a dither signal that causes successive waveform repetitions to have a slightly different dc term is combined with the video signal. The proprietary digital dither generator used in the 1980 provides a complex analog dither signal designed to improve both the accuracy and resolution of the quantization process.

A simplified block diagram of the dither system is shown in figure 4. The input video signal is coupled to a summing amplifier and to a clock generator which generates a clock pulse at the end of each repetition period of the input signal. The output of the clock generator, gated by an output of the feedback board, is connected to the input of a 5-bit counter. A reset pulse coupled to the reset input of the counter initializes the system. The counter outputs are coupled to the data inputs of a DAC whose output is then summed with the original input video signal. The resultant signal is then applied to the waveform digitizer. After 32 repetitions of the video input signal (32 television lines), the counter is reset and the process is repeated. Stepping the analog dither signal through 32 dc levels yields a resolution equivalent to that achieved if an 11-bit ADC were used.

The controller regulates the flow of sampled data to the acquisition memory. It can be programmed to sample any line or group of lines (up to 32) in the television field or frame; it can sample the same line in 32 successive frames; or, it can sample part of a line, skip several frames, and sample that part of the same line again. The latter capability is useful, for example, in conducting bounce tests or transmission links. Sampled data is stored sequentially, eight bytes at a time, in shift registers and then transferred in parallel to the acquisition memory. The acquisition memory has the capacity to store up to 32 lines.

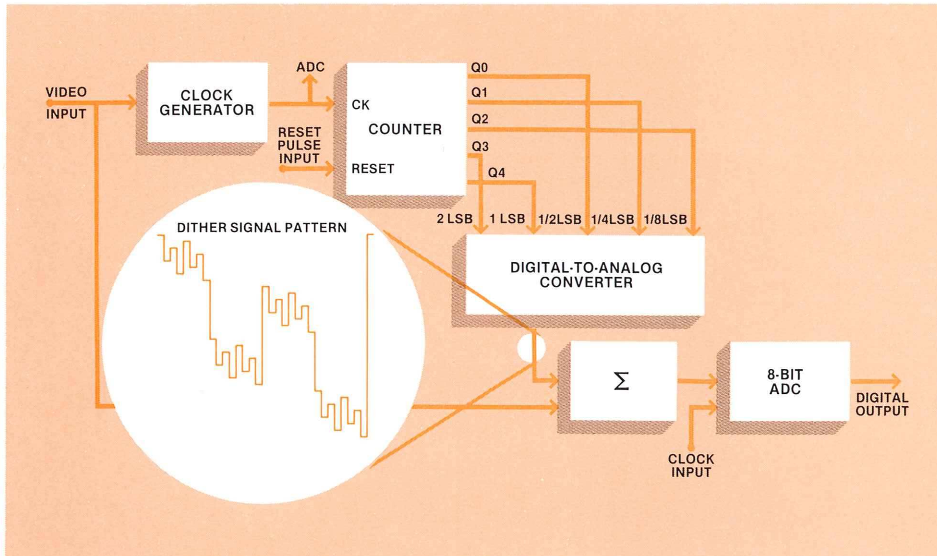


Fig. 4. Digital dither generator produces thirty-two precision levels which are summed with video input signal to enhance resolution and accuracy of digitizing process.

For many measurements, the test signal data is averaged over 32 successive frames (one line per frame) to reduce the masking effects of random noise. Averaging results in an apparent 15 dB enhancement in the video signal-to-noise ratio.

The microcomputer

The microcomputer in the 1980 is designed around the TMS 9900 16-bit microprocessor, with extended addressing capability. Several memories reside in the microcomputer section. The operating system occupies 44k words of ROM, an application memory has 40k of PROM, and there is 32k of RAM for the main memory. These are all 16-bit memories. In addition, there is 8k of non-volatile memory powered by stand-by batteries should power be interrupted. This non-volatile memory may be used to store the parameter limit files and other configuration information usually entered from the keyboard.

There are several clocks used in the 1980. The sync and clock generator associated with the input video signal basically controls the front-end circuitry — phase lock, digital feedback, etc. The realtime clock (4-MHz) provides time-of-day, date, and automatic timeout reset. A user can substitute an external 1 MHz clock to lock the time information to the station master clock if desired. The main clock controls the processor and associated computer circuits.

User interaction with the 1980 is provided by multiple RS-232, CCITT V.24 input/output ports, allowing connection to various types of terminals, printers, modems, etc. An extended form of BASIC was developed to efficiently handle input/output communications and deal with the special requirements of processing the video signal.

Designed for reliability

The 1980 is designed for remote or unattended operation as well as operation where the intended use is to relieve engineering personnel from time-consuming, routine testing. In both applications, reliability is of paramount importance. Accordingly, much effort was expended in both electrical and mechanical design to ensure reliability.

All critical semiconductors undergo a 96-hour burn-in at 125°C before use in the 1980. In addition, the entire instrument undergoes several hours of burn-in at elevated temperatures to weed out infant mortalities.

New Products

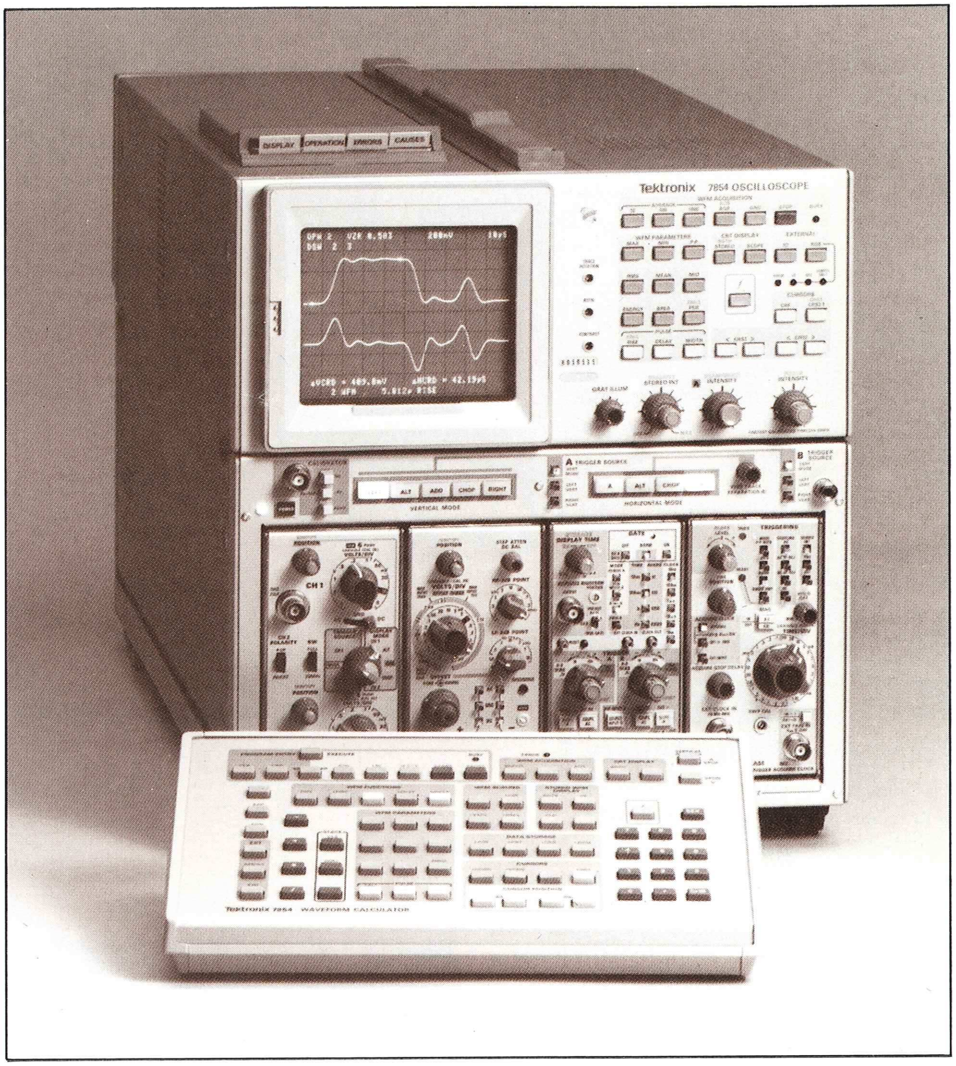
Digital Storage of Repetitive Signals to 400 MHz

To assure the operator that the 1980 is working properly, extensive self-check diagnostic routines are activated each time the instrument is powered up. Some of these routines are accessible by BASIC so the operator can program the 1980 to perform a self-check routine each time a measurement error is detected.

The instrument is mechanically and electrically configured for easy trouble-shooting. The design incorporates the ability to use signature analysis as an aid in quickly isolating faulty components or circuitry.

Summary

There is no longer any need to spend valuable engineering time making routine measurements and logging the results. The 1980 is designed to do this for you — to provide fast, accurate, automatic measurement of television signal amplitude, phase, and timing parameters. As an example, the 1980 can automatically run and log a complete in-service NTC No. 7 measurement routine in less than one minute, with worst-case accuracies of ±0.5%/0.5°C for most measurements. The instrument is easily programmed to meet special requirements and future needs.



The 7854 Oscilloscope

A new 7000-Series Oscilloscope combines 400 MHz analog performance with microprocessor-based waveform processing to greatly simplify waveform measurements and improve measurement quality.

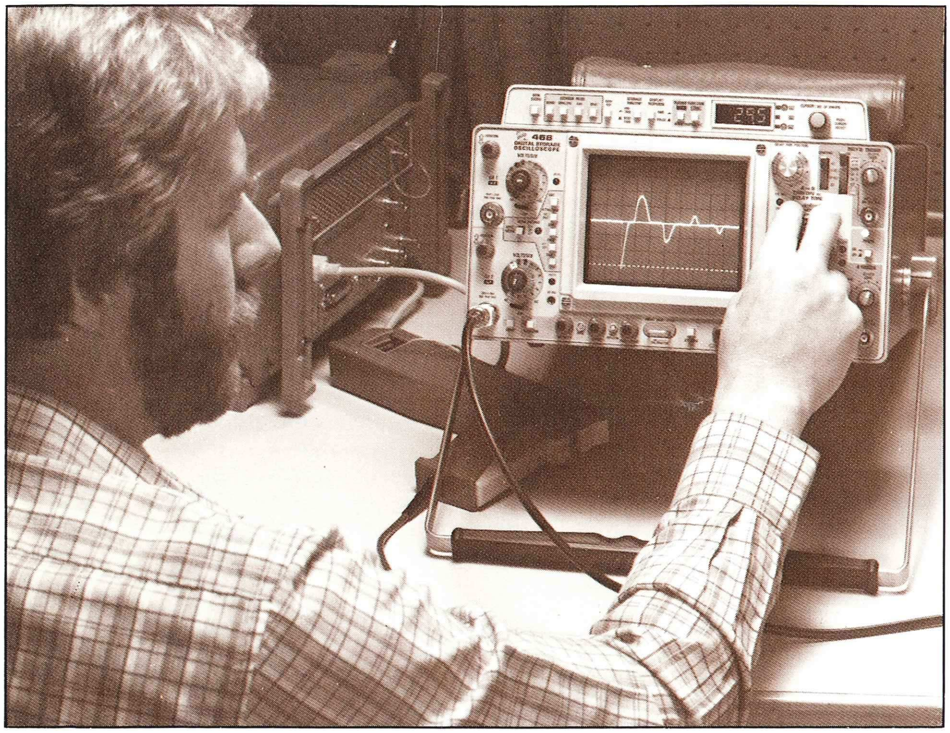
The 7854 is preprogrammed to make common measurements such as rise time, fall time, pulse width, peak-to-peak, RMS, and other measurements at the touch of a button. Through averaging, signals buried in noise can be recovered and measured with improved accuracy. Averaging also gives increased resolution, with differences as small as 0.01 division recorded in the digital storage process.

The 7854 can store repetitive waveforms up to 400 MHz and single-shot events at sweep speeds up to 50 μs/division. A choice of 128, 256, 512, or 1024 horizontal points is provided to allow storage of multiple waveforms. With optional memory, the 7854 can digitize and store up to 40 waveforms.

A GPIB interface is provided for customers requiring additional processing, data storage, or coordination of the oscilloscope with other instruments.

As a conventional oscilloscope, the 7854 operates like a 7904 or 7704A. The choice of more than 30 compatible plug-in units affords the same versatility enjoyed by users of other 7000-Series instruments.

A Digital Storage Scope with a Familiar Face



468 Digital Storage Oscilloscope ↑

The new Tektronix 468 Digital Storage Oscilloscope looks just like the industry-standard 465B, 100-MHz Portable Oscilloscope, and for good reason. The 468 "drives" just like the 465B, and in the non-storage mode has the same characteristics.

Switching to digital storage, the 468 uses state-of-the-art technology advances to extend digital storage bandwidths, simplify detection of aliased signals, and overcome envelope error and display jitter — all problems plaguing earlier digital storage efforts.

The 468 uses a 25-MHz, 8-bit digitizer and a unique display interpolation technique to achieve a 10 MHz "useful storage bandwidth." To accommodate a wide range of applications, both sine and pulse interpolation is included. An envelope mode provides dual digitizing rates useful in catching glitches and detecting aliasing.

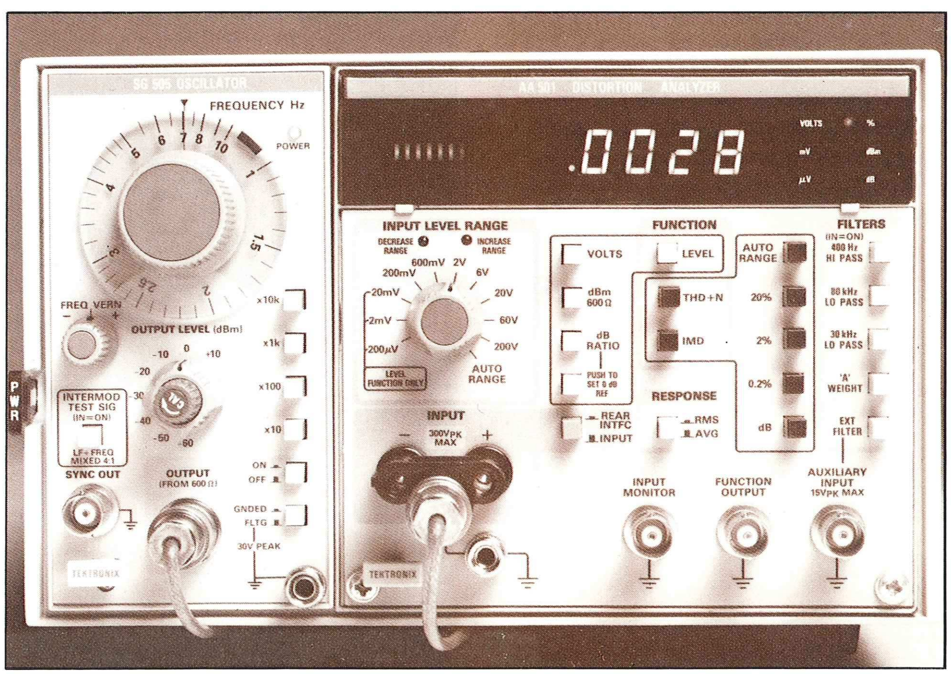
Operating ease and measurement resolution is enhanced by signal averaging, and cursors for measuring both time and amplitude differences. In addition to the signal averaging option, a GPIB option is available for waveform transmission.

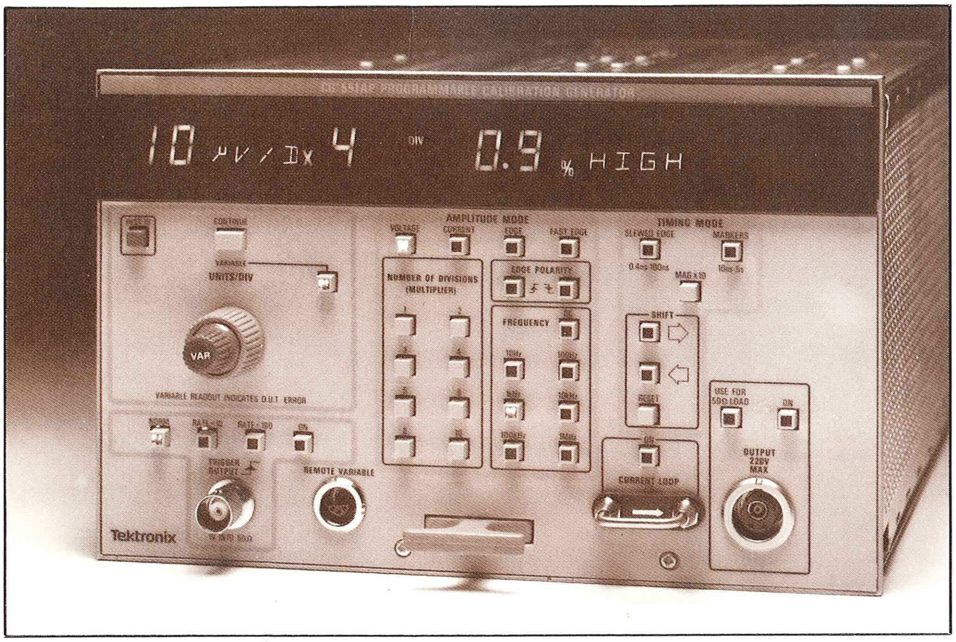
Fully Automatic Distortion Analysis

With the introduction of the Tektronix AA 501 Distortion Analyzer and SG 505 Oscillator, complex distortion measurements become a totally automated process. Steps such as level setting, tuning, and nulling which previously required several minutes of skilled operator time, are now done quickly, precisely, and automatically by the AA 501's internal circuitry.

The AA 501 and SG 505 combination permits harmonic distortion, intermodulation distortion, frequency response, gain/loss, and signal-to-noise ratio measurements to be accomplished with minimal skill level. At the same time, both instruments feature state-of-the-art performance in residual noise and distortion. The system provides a total residual distortion of less than 0.0025% (−92 dB), residual noise of less than 3 microvolts, and fully differential input with a CMRR of 50 dB at 50 Hz. The SG 505 Oscillator gives a significant boost to measurement accuracy with ultra-low distortion, 0.0008% (20 Hz to 20 kHz). In addition, it features an extremely flat frequency response, within 0.1 dB from 10 Hz to 20 kHz, 0.2 dB from 20 kHz to 200 kHz.

↓ AA 501 Distortion Analyzer with SG 505





CG 551AP Programmable Calibration ↑ Generator

The Tektronix CG 551AP is a fully programmable, microprocessor-based oscilloscope calibration generator. It can be used as part of a computerized system for the calibration and verification of major oscilloscope parameters, including the following:

- Vertical gain
- Horizontal timing and gain
- Vertical bandwidth/pulse characteristics
- Probe accuracy and compensation
- Current probe accuracy
- Calibrator output accuracy

A diversity of functions, manually selectable from the front panel, are all programmable through a controller via the GPIB (General Purpose Interface Bus, IEEE-488). Many of the functions represent a new state-of-the-art in calibration performance.

The CG 551AP is compatible with any Tektronix 4050 Series or other controller operating on the GPIB. A typical system would include the CG 551AP, a Tektronix 4052 Graphics Computing Controller and a hard copy unit such as the Tektronix 4631 or a matrix printer such as the Tektronix 4642 for permanent documentation.

The 1900 Digital Test Signal Generator and VITS Inserter is designed for state-of-the-art performance testing of NTSC television systems and equipment. Available in four different versions, the 1900 supports a wide range of transmitter, studio, common carrier, and equipment manufacturing applications.

Standard, full-field signals: modulated ramp, field square wave, window, convergence, and VIRS are included in each version. In addition, each version provides a special test signal complement tailored to the specific application.

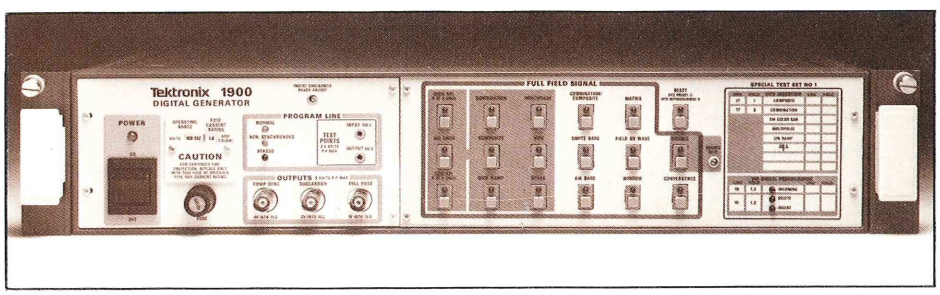
The generator's functions are controlled by an internal microprocessor and its associated PROM memory. Test signals are stored as 10-bit digital words and converted to analog form by a 10-bit precision DAC to ensure signal accuracy and long-term stability.

Since the 1900's signals are stored in PROM, test signal format changes are accomplished by replacing the appropriate test signal memory. No recalibration is required, and changing industry test signal standards will not cause obsolescence.

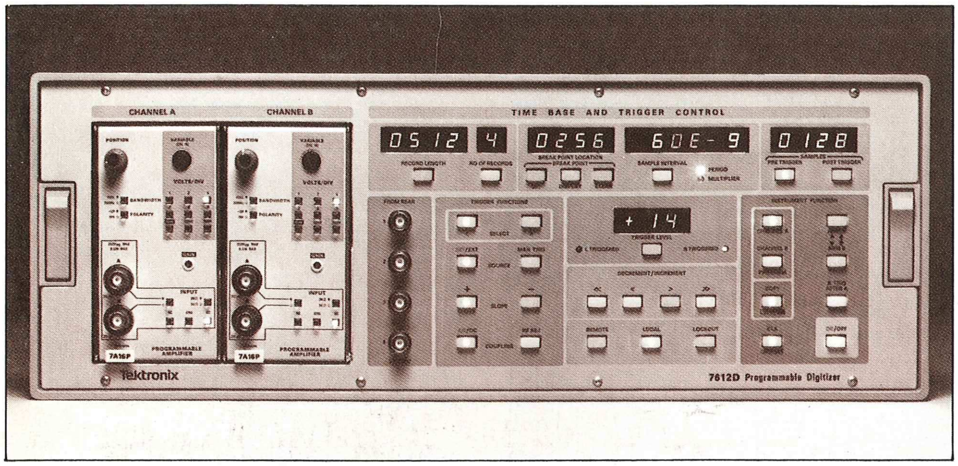
RS-232-C and ground closure interfaces allow wide-ranging remote control functions and applications versatility.

The 1900 is available for the NTSC television standard only.

↓ 1900 Digital Generator



A New Standard in Automatic Waveform Measurement



7612D Programmable Digitizer

The 7612D is a dual-channel/dual-time base programmable waveform digitizer. It is, essentially, two digitizers in one cabinet. Each channel accepts a 7000-Series vertical plug-in amplifier (fully programmable with two 7A16Ps), and each channel has its own built-in digital time base.

Sampling intervals, derived from an accurate, crystal-controlled clock, are selectable on each channel from five nanoseconds to one second. Analysis of single-shot signals shorter than one microsecond in duration is possible at the faster sampling rates. Samples are stored as 8-bit words in a 2,048 byte memory for each channel. Each memory may be partitioned into multiple sections of 1024, 512, or 256 words.

The 7612D features the ability to switch sample rates at specified time locations within a record. This allows increased resolution of fast waveform components, or skipping of unwanted waveform portions.

All the functions of the instrument are programmable over the GPIB bus through simple mnemonic commands. The 7612D is compatible with the 4050-Series and SPS PDP-11 based controllers.

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