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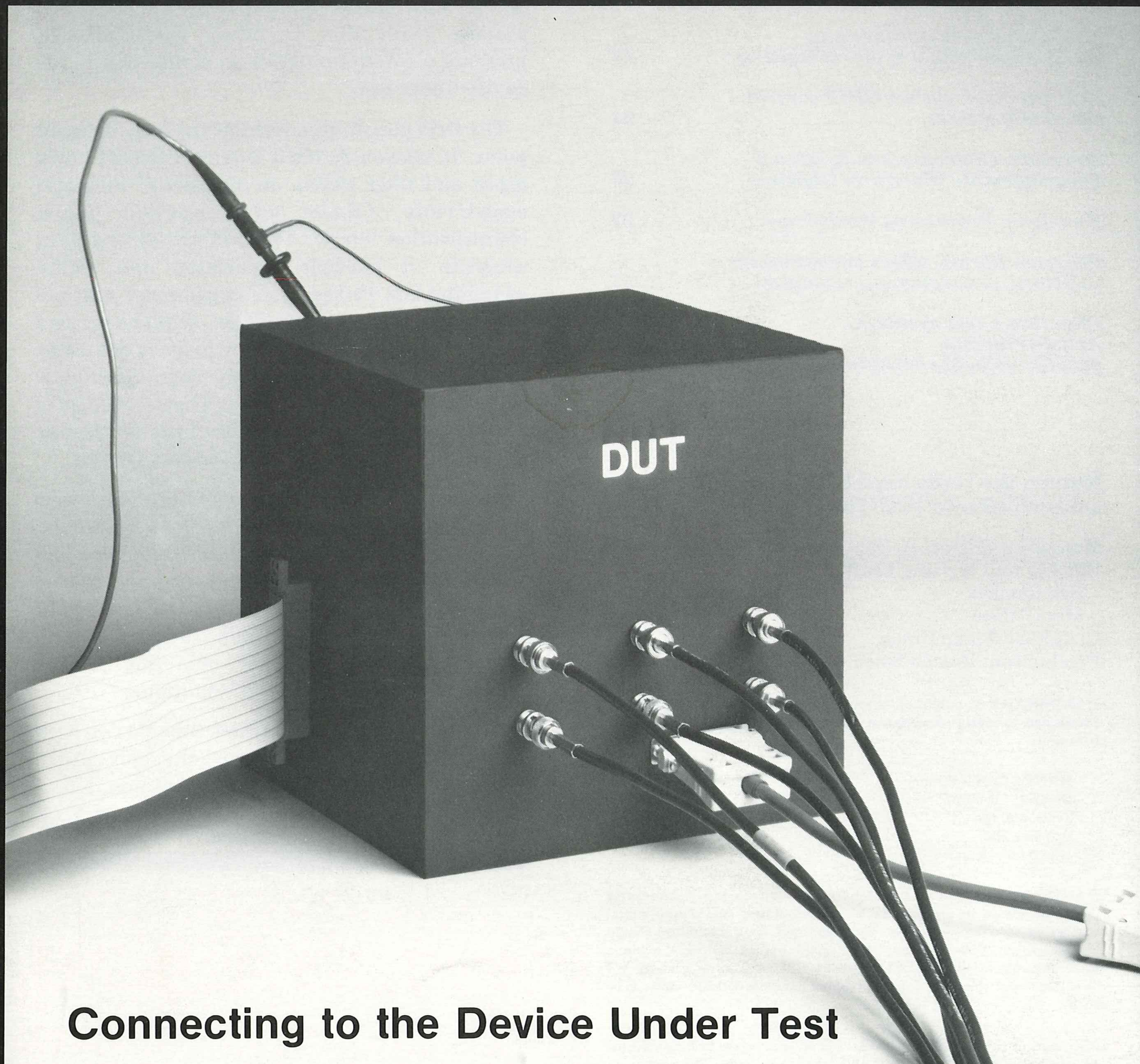
HANDSHAKE

NEWSLETTER OF SIGNAL PROCESSING AND INSTRUMENT CONTROL



Connecting to the Device Under Test

Tektronix®
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HANDSHAKE
NEWSLETTER OF SIGNAL PROCESSING AND INSTRUMENT CONTROL

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Managing Editor: A. Dale Aufrecht
Editing and Writing Staff:
Bob Ramirez
Mark Tilden
Graphics: Joann Crook
Production: Brenda Smethers

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HANDSHAKE Editor
Group 157 (54-016)
Tektronix, Inc.
P.O. Box 500
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In this issue

Those measurement errors...could they be from the test probe?

How you connect to a test signal or test point can be the most important part of the measurement process. With this in mind, HANDSHAKE presents a three-part series on connection to the device under test.

The first part begins right at the measurement point. It takes a detailed look at different probe types and their effects on signal rise time and amplitude. (Have you checked probe compensation lately?) Then, in the second part, concepts of multiple connection and signal switching are looked at. For example, you can automate complex probing sequences and eliminate the human tendency to leave out a step now and then. Broadening the connection topic even further, Part III looks at various concepts of multifunction interfacing—very little is immune to control from your GPIB-based test system.

And finally, there are two important new waveform digitizers available from Tektronix. They are the 7D20 Programmable Digitizer Plug-In for 7000-Series oscilloscopes and the 390AD Programmable Digitizer. This HANDSHAKE covers both briefly in introductory articles and provides a reply card for obtaining further technical and application information.

Of course, if this is the first time you've seen HANDSHAKE, we hope you use the reply card to obtain a free HANDSHAKE subscription, too.

Connecting to the device under test:

Part I—Probes

No doubt there have been times when the signal you've captured with a waveform digitizer hasn't measured up to expectations. After checking the device under test from another aspect, perhaps you began casting a suspicious eye on your waveform digitizer. But, before suspecting the acquisition instrument, did you stop to consider the connection to the device under test as the possible culprit?

Is an unterminated 50-ohm coax being used when a high-impedance probe is really needed?

Or if a probe is being used:

- Is it properly compensated for the digitizer input impedance?
- Does it have an attenuation factor that the digitizer or acquisition software needs to take into account?
- Are you using the best probe for the specific application?

The function of the ideal probe, or any other type of connection for that matter, is to couple the signal of interest to the acquisition instrument without affecting the signal source or signal waveshape. But there is no ideal probe for all applications. That's why oscilloscope and waveform digitizer manufacturers provide a selection of probe types. Most are either passive voltage probes or active voltage probes. However, there is an additional special purpose class of current probes, too. Understanding how each type of probe affects your measurement will help you pick the best probe for your application.

Moreover, an understanding of probe basics is important in other areas of test connection. The same properties of probes and considerations of circuit loading apply as well to test fixturing and signal switching, actually anything that attaches to the device under test. The goal is always to make test connections such that there is minimum disturbance to the normal operation of the device or phenomenon being measured.

Passive voltage probes

Passive probes come in a variety of sizes and shapes with differing electrical characteristics. The typical probe consists of a probe assembly, a ground lead, and a shielded cable with a suitable connector for attaching to an oscilloscope or waveform digitizer.

A unique feature of most Tektronix probes is a patented coaxial cable with a resistance wire center conductor. This distributed resistance suppresses ringing that can be impressed on fast pulses as a result of mismatches between the probe cable and its terminations.

The digitizer's input circuit

Most waveform digitizers have analog input circuitry similar to an oscilloscope's. In fact, several Tektronix digitizers use the same 7000-Series vertical plug-in amplifiers as used in TEKTRONIX 7000-Series Oscilloscopes. Therefore, the input impedances are the same as typically found in oscilloscopes, and many of the standard oscilloscope probes are compatible with those inputs.

Low- and medium-frequency digitizers typically have one-megohm inputs shunted by 15 to 50 picofarads of capacitance. Those designed for use above 200 MHz often have a 50-ohm input impedance. Some are switchable between 50-ohm and one-megohm inputs.

In most cases, the input connector is a BNC type. This makes it especially tempting to use 50-ohm coax as a test lead, particularly when the device under test has a BNC connector, too. This is a generally acceptable practice when working in a 50-ohm system. However, be cautious about just picking up any piece of coax and using it—75-ohm coax looks a lot like 50-ohm coax.

In most situations, the measurements desired will be those made under minimum circuit loading conditions. For this, you'll want a high input impedance digitizer and a high-impedance probe. The choice of a specific probe will also depend on the type of measurement being made and the degree of circuit loading that can be tolerated.

Probes load the circuit

When any instrument is attached to a device under test, the input capacitance and resistance of the instrument loads the device. This loading can alter the signal being acquired. It can even substantially alter the device's operation. Using the appropriate probe can minimize these loading effects.

If the signal amplitude permits, an attenuator probe can reduce loading. But remember in later processing of a digitized signal, you'll have to take the probe attenuation factor into account. This is simplified with probes that provide attenuation readout information back to the scope or digitizer. In other cases, attenuation factors must be kept track of by the system operator or programmer.

Figure 1 shows a schematic model of a probe and digitizer input. They essentially form an RC divider. Since R_1C_1 must equal R_2C_2 for equal attenuation at all frequencies, C_1 must decrease as R_1 increases. Thus, you can obtain lower values of capacitance at the probe tip by using higher values of attenuation. Common probe attenuations are 10X and 100X, with some probes having the provision for switching between 1X and 10X attenuation. Typical capacitance is 10 picofarads for 10X probes and 3 picofarads for 100X probes.

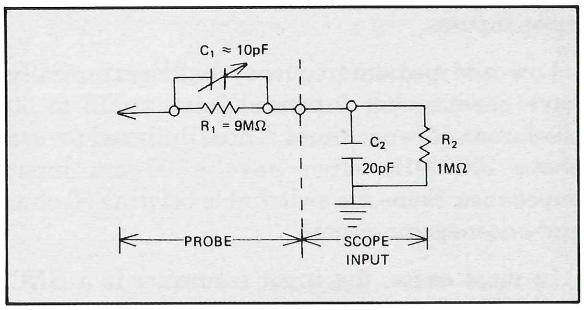


Fig. 1. *Schematic of a typical 10X attenuator probe and digitizer input.*

The impedance of the test point on the device or circuit under test is a primary consideration in a probe's affect on the acquired signal. In modern circuitry, signal source resistance varies from a fraction of an ohm to hundreds of kilohms and more. Source capacitance can be from 1 picofarad to more than 100 picofarads. To reduce probe loading, pick the point of lowest impedance to acquire signals from.

Another factor to consider in dealing with probe loading is the type of signal being acquired. There are two major types—pulse or step functions where amplitude, rise time, and transient response are the major concerns and sinusoidal signals where amplitude and phase distortion are the major concerns. Often, each must be dealt with differently.

Compensation

In acquiring pulses with high-impedance passive probes, the probe should be properly compensated. This consists of trimming the probe's compensation capacitor to provide equal attenuation over all frequencies in the specified bandwidth.

Compensation can be checked over a wide band of frequencies by acquiring a calibrator square wave such as provided at a front-panel connector on many instruments. Alternatively, a high-quality 1-kHz square-wave generator can be used. If the acquired calibrator square wave is rounded or has overshoot, a need for probe compensation is indicated. Typically, compensation is done on high-impedance passive probes via either a screwdriver adjustment or by twisting two probe barrel sections. Consult your probe manual for the precise method to use.

Measuring pulses

To understand the effects of applying a probe to a device, consider the pulse signal source shown in Fig. 2a. If the generator has a t_r of 0, the output, t_{r1}, is limited by the integration network of R_s and C_s. The rise time equals $2.2R_sC_s$. This is 8.8 nanoseconds for the values given in Fig. 2a.

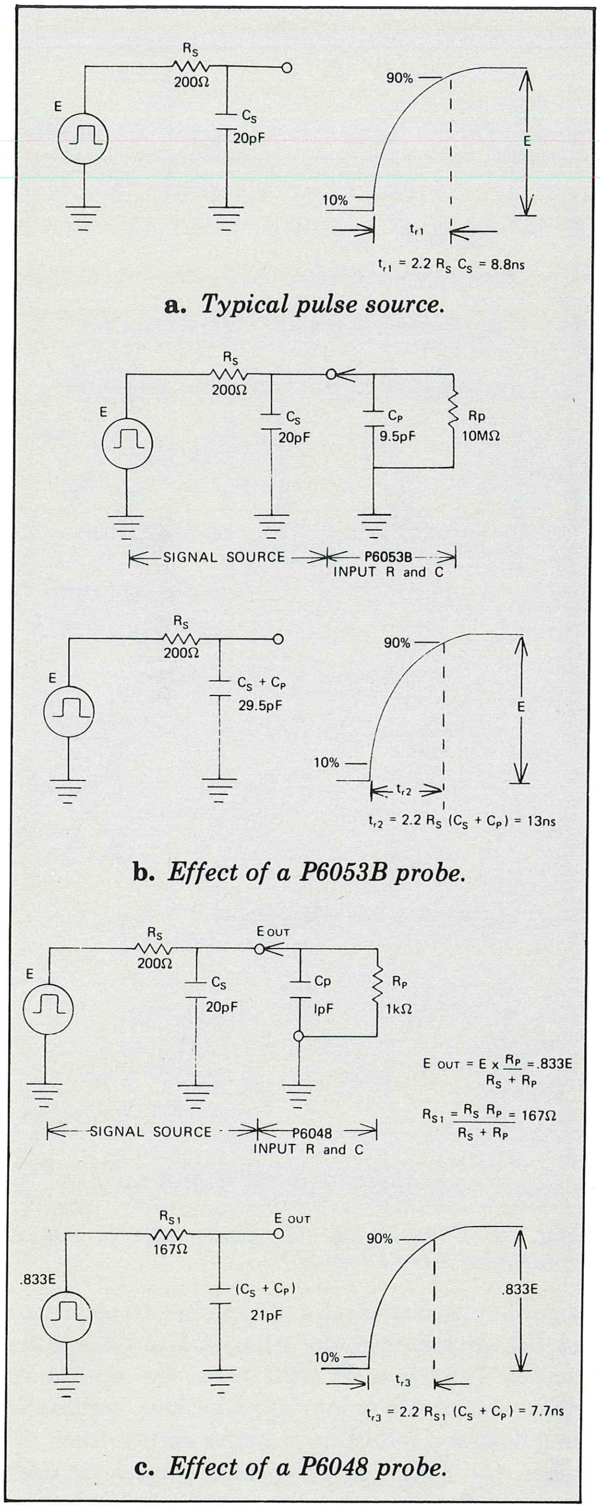
When a probe is used on a pulse circuit, the probe's input resistance and capacitance are added to the circuit. This is demonstrated in Fig. 2b, where a passive attenuator probe (P6053B, 10X, 9.5 picofarads, 10 megohms input) is used. Since the resistance of the probe, R_p, is much greater than the source resistance, R_s, R_p has negligible effect and can be disregarded. C_p is important, though, and using the rise time formula, $2.2R_s(C_s+C_p)$, the circuit rise time, t_{r2}, becomes 13 nanoseconds.

The loading effect on the signal source in this case is the percentage change in rise time and is given by,

$$\frac{t_{r2}-t_{r1}}{t_{r1}} \times 100 = \frac{13\text{ns}-8.8\text{ns}}{8.8\text{ns}} \times 100 = 48\%$$

When probe resistance is large compared to the source resistance, the percentage change is directly related to added capacitance and can be expressed as,

$$\frac{C_p}{C_s} \times 100 = \frac{9.5\text{ pF}}{20\text{ pF}} \times 100 = 48\%$$



a. *Typical pulse source.*

b. *Effect of a P6053B probe.*

c. *Effect of a P6048 probe.*

Fig. 2. *Comparison of probe effects on a pulse signal source.*

Now, consider the effect of a different probe on the same signal source. A P6048 (10X, 1 picofarad, 1 kilohm) is shown in use in Fig. 2c. In this instance, however, R_p is not ten times greater than R_s and must be considered as having an effect. R_p and R_s form a divider, reducing the amplitude and modifying the source impedance. Using Thevenin's theorem, the new generator source voltage and resistance (Fig. 2c) can be calculated. The rise time now becomes $t_{r3}=2.2R_{s1}(C_s+C_p)=7.7$ nanoseconds. Notice the percent change now,

$$\frac{7.7\text{ ns} - 8.8\text{ ns}}{8.8\text{ ns}} \times 100 = -12\%$$

is significantly less than that caused by the previous probe.

It's also interesting to note that rather than slowing the rise time, the probe in Fig. 2c modified the source resistance and decreased the rise time. It has become faster than it should be. And look at the output amplitude. It has been decreased to 83.3% of its unloaded value. This drop is due to the divider formed by R_p and R_s, whereas, in the previous example, there was minimal change in the signal source amplitude when the probe was applied.

By comparing the two examples of Fig. 2b and c, it can be seen that the choice of probe depends to some extent on which signal parameter you wish to measure. Generally, low capacitance is desired for measuring rise time. But high resistance is more important when measuring amplitude. Choosing a low impedance test point is necessary in either case since minimum circuit loading is always the desired end.

Measuring sinusoidal signals

Now, consider the effects of using the same probes and source impedance while the generator supplies a sinusoid instead of a pulse. Here, the concern is with amplitude changes and phase relationships.

In studying probe effects, bear in mind that specified probe input capacitance and resistance are low-frequency values, below 1 MHz. As signal frequency increases, the equivalent probe input impedance changes. This is illustrated in Fig. 3.

Figure 4a shows E_{out} of a 10-MHz source before probing to be 97% of the generator voltage. Figure 4b shows the effect of attaching a P6053B probe (10X, 9.5 picofarads, 10 megohms). Actual probe impedance at 10 MHz can be found from the graph in Fig. 3. It's composed of 35 kilohms of probe resistance and 1.7 kilohms of reactance. The capacitive reactance is predominant and, paralleled with the source capacitive reactance,

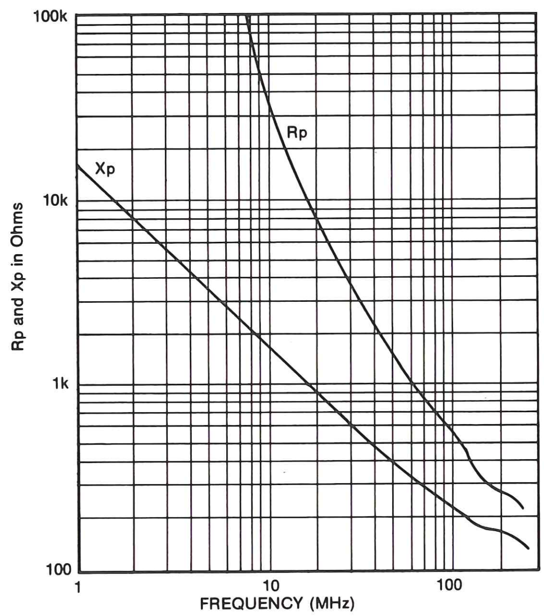


Fig. 3. *P6053B probe (3.5 foot cable), typical variation of out of phase (X_P) and in phase (R_P) impedance components with frequency.*

equals 545 ohms. The influence of this impedance on signal amplitude is to decrease it to 94%, a 3% change from the unloaded 97% level.

Applying a different probe—the P6048 (10X, 1 picofarad, 1 kilohm)—has an even greater effect on amplitude. This is shown in Fig. 4c, where the output drops to 81% of the generator voltage.

Several conclusions can be drawn by comparing these sinusoidal examples with the preceding pulse examples (Fig. 2b and c and Fig. 4b and c). For rise time measurements, the low-capacitance P6048 yields better results than the P6053B. But, for sinusoidal amplitude measurements, the DC loading of the P6048 causes a larger error than the capacitive loading of the P6053B. In either case, however, minimum loading of the circuit being measured is still the first concern since excessive loading can alter the circuit's performance, affecting both rise time and amplitude.

Phase relationships

Since most attenuator probes have a capacitive element, some signal phase shift will be introduced by the probe. The impedance appearing at the point of probe attachment is an important factor in the amount of phase shift that will occur.

For an example of phase shift effects, consider an amplifier driven by a 10-MHz, 50-ohm source. This is shown in Fig. 5a. Figures 5b and c show

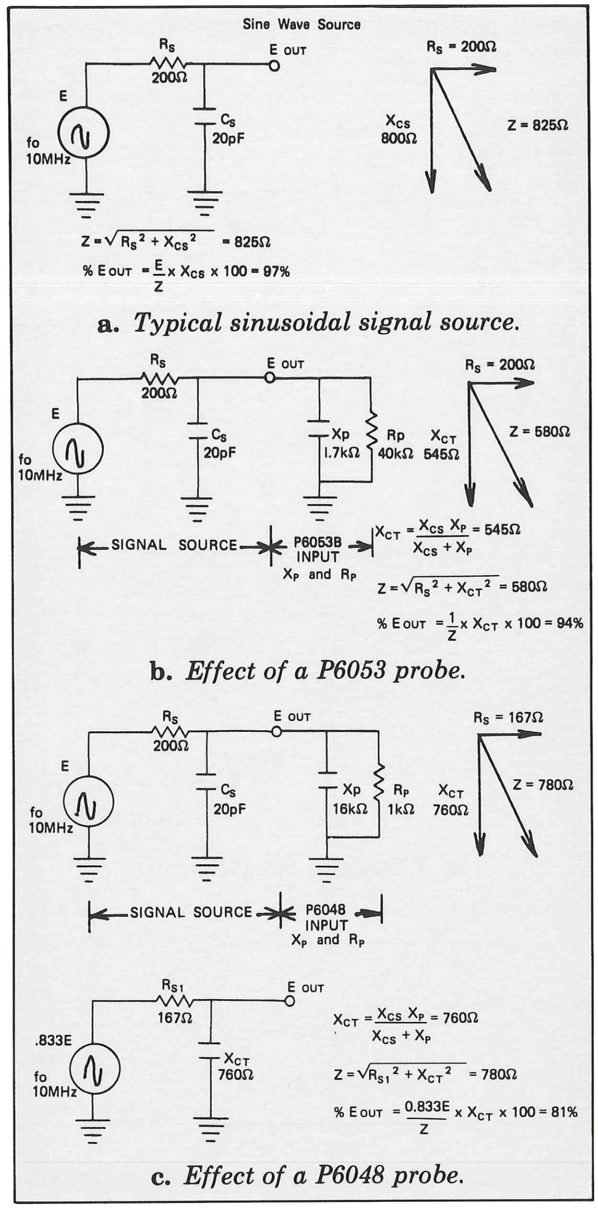
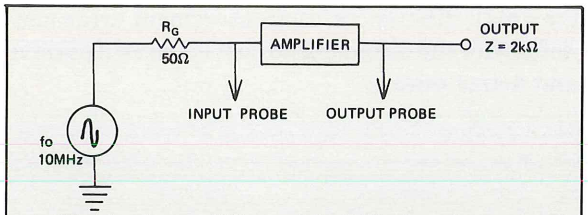


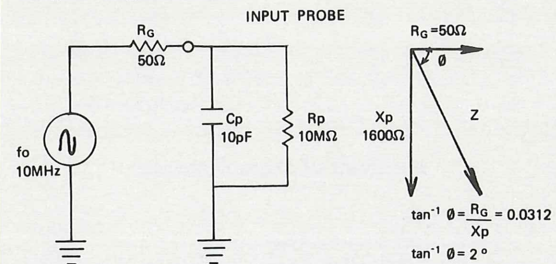
Fig. 4. *Comparison of probe effects on a sinusoidal signal source.*

what happens when two 10-megohm, 10-picofarad probes are attached, one to the input and one to the output. There is a 49° shift due to the impedance difference in the points being probed. Figures 5c and d show a reduction in phase shift to about 2° when two 1-kilohm, 1-picofarad probes are used instead. But there is also a 67% amplitude loss from resistive loading.

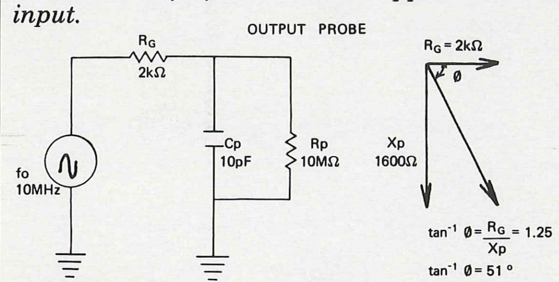
Depending on your application, it may be best to select a probe offering a better compromise between the extremes shown here. This will generally be the case where conditions require you to capture and digitize various signals with one



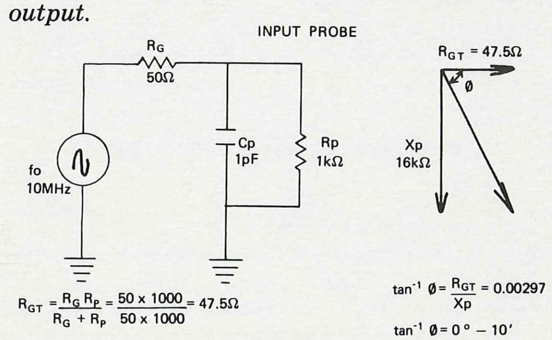
a. *Typical amplifier with differing input and output impedances.*



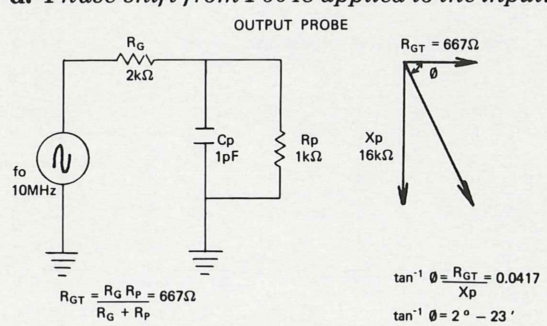
b. *Phase shift from P6053B applied to the input.*



c. *Phase shift from P6053B applied to the output.*



d. *Phase shift from P6048 applied to the input.*



e. *Phase shift from P6048 applied to the output.*

Fig. 5. *The effects of two different probes on sinusoidal input and output signals.*

probe or where various parameters must be measured from a single acquisition. On the other hand, for cases where you can make individual acquisitions and measurements, you may want to select different probes optimized for each measurement—rise time, amplitude, phase.

Guidelines for passive probes

Here are some general rules for improving data acquired with probes:

1. Always check probe compensation by acquiring a calibrator square wave and adjusting out overshoot or rounding of leading edges.

2. Acquire signals from the lowest impedance point possible.

3. For rise time measurements:

a. Use a probe with low C and an impedance suitable to the impedance appearing at the test point.

b. Instrument and probe rise times need to be short relative to the rise time being measured.

c. Measured rise time will be approximately the square root of the sum of the squares of the system rise times. This includes the rise time of the signal source, the specified rise times of the probe and instrument, and the calculated rise time of the instrument-probe combination along with the effects of source impedance.

4. For amplitude measurements:

a. With sinusoids, remember loading error changes with frequency, so use the probe having the highest input impedance at the frequency of interest.

b. With pulses, use a probe having large input resistance relative to the source impedance; probe input C is of little concern if pulse duration is five times longer than the input RC.

Active voltage probes

Active voltage probes have two primary features. First, they provide higher impedance between the test point and the acquisition instrument. This allows high input resistance and low capacitance to be achieved. And, second, they typically provide full bandwidth without input signal attenuation.

The typical active probe uses a FET input and contains AC coupling and voltage offset capabilities for capturing signals riding on DC.

Most are also compatible with either 1-megohm or 50-ohm instrument inputs without using external adapters. For 50-ohm systems, standard 50-ohm cable can be used to extend probe length without increasing capacitive loading.

Pulses and active probes

With the same signal source used in the passive probe examples, let's look at the effects of an active probe. A P6201 active probe is used here. It has a FET input, a probe-only bandwidth of DC to 900 MHz, and a rise time of 0.4 nanoseconds or less. The effect of applying this probe, with its 10X attenuator head (1.5 picofarads, 1 megohm), to the signal source is shown in Fig. 6b.

For the signal source in Fig. 6a, P6201 capacitive loading increases pulse rise time from 8.8 to 9.5 nanoseconds. Stating loading effect as percent change in rise time, loading effect is—

$$\frac{t_{r3}-t_{r1}}{t_{r1}} \times 100 = \frac{9.5-8.8}{8.8} \times 100 = 8\%$$

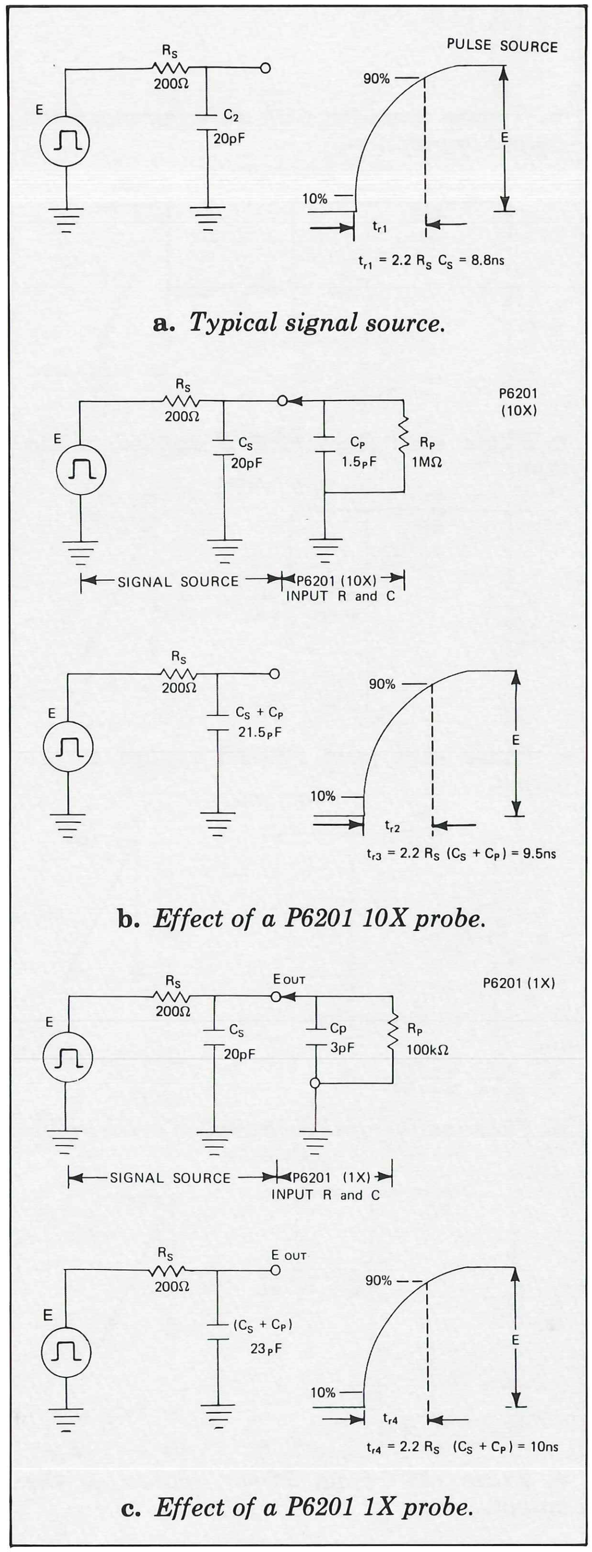
This is a considerable improvement over the 48% increase in rise time caused by the typical high-impedance 10X passive probe. It's also somewhat better than the 12% decrease caused by the low-resistance, low-capacitance P6048 demonstrated in Fig. 2c.

Measuring low-level signals

As noted before, one of the prime advantages of an active probe is full bandwidth at 1X attenuation with minimum circuit loading. This is essential when viewing fast signals in the millivolt region.

Using the P6201 1X probe as an example, Fig. 6c shows what happens to rise time and amplitude. The 100-kilohm, 3-picofarad input of the P6201 causes rise time to increase from 8.8 to 10 nanoseconds. That's a loading effect of 14%. Though somewhat greater than the 8% of the P6201 with 10X attenuation, 14% is comparable to the 12% error caused by the low-resistance, low-capacitance P6048 passive probe. But, just as importantly, note that the P6201 1X probe has negligible effect on signal amplitude.

The graph in Fig. 7 makes a further comparison between passive and active probe performance. The graph shows that an active probe provides more accurate rise time measurements over a wider range than a passive probe. However, at low values of source impedance or slower rise times, the small differences in measurement error may not justify the difference in cost between a passive and active probe.



a. *Typical signal source.*

b. *Effect of a P6201 10X probe.*

c. *Effect of a P6201 1X probe.*

Fig. 6. *Comparative effects of a P6201 active probe in the 10X and 1X attenuator modes.*

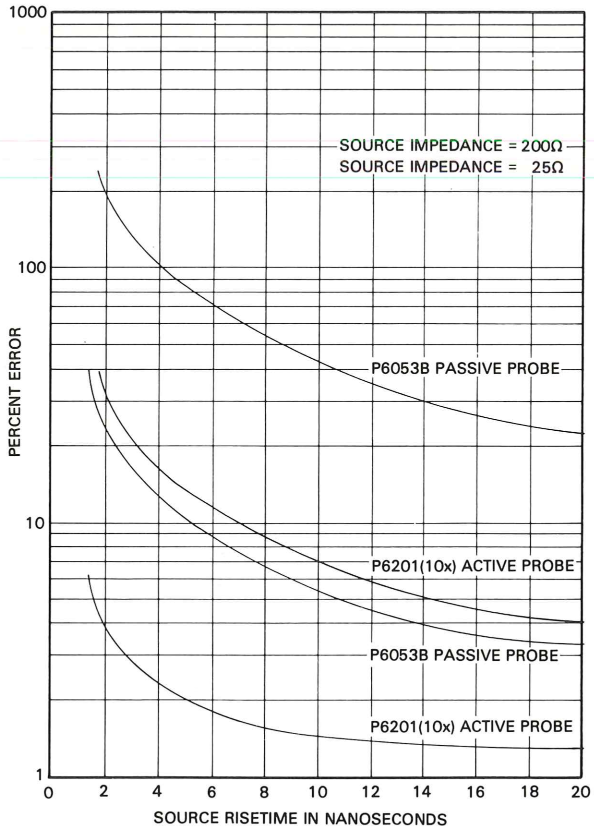


Fig. 7. *Relative performance of the P6201 active probe and P6053B passive probe when measuring various rise-time signals from 200-ohm and 25-ohm sources.*

Sinusoids and active probes

Figure 8 shows an active probe applied to a 10-MHz sinusoidal source. The P6201 10X probe causes loading by 1-megohm resistance and 11-kilohms capacitive reactance. By comparison, the typical high-impedance passive probe presents an input of only 40-kilohms resistance and 1.7-kilohms reactance at 10 MHz.

Going through the loading calculations as indicated in Fig. 8, the P6201 active 10X probe drops signal output only slightly to 97% of the unloaded output. Even increasing the signal frequency to 50 MHz results in only a 3% change with the P6201 10X probe, while the typical passive probe would cause a change on the order of 20%. This is because an active probe's resistive component of impedance does not decrease as rapidly with increasing frequency as that of a passive probe. Because of the sustained high input R and low input C, active probes cause the least error in rise time and amplitude.

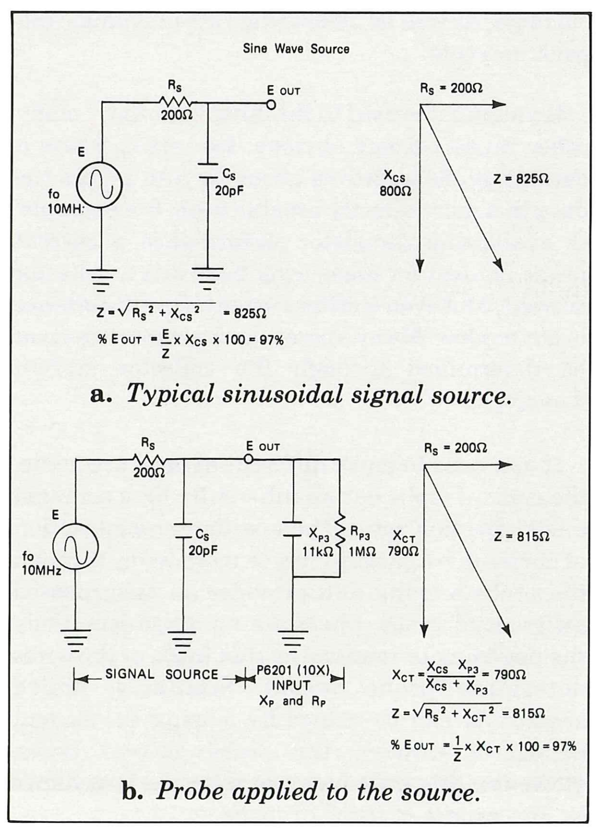
Current probes

Current probe measurements are particularly applicable to high-impedance circuits or points where a voltage probe would significantly alter the circuit characteristics. The current probe offers the lowest circuit loading of any available probe.

Insertion impedance

While a current probe offers low circuit loading, there is, however an element of impedance reflected into the circuit under test. This reflected impedance consists of a series resistance shunted by a small inductance and limits rise time to 2.2 L/R. The amount of inserted impedance depends on the design of the current sensing unit in the probe head.

For example, in the TEKTRONIX A6302 DC-50 MHz current probe, insertion impedance is 0.1 ohm at 5 MHz. For an amplitude measurement error of less than 2%, the signal source should be 50 times the insertion impedance. That's a 5-ohm minimum source required for the example of the A6302 probe.



a. *Typical sinusoidal signal source.*

b. *Probe applied to the source.*

Fig. 8. *Effect of an active probe on a sinusoidal signal source.*

A second consideration in using a current probe is the capacitive coupling from the probe to the circuit. This coupling is the only shunt loading placed on the circuit by the probe, and it varies with the size and type of material used for the current conductors. For example, with No. 20 AWG wire the capacitance is about 0.6 picofarad and with No. 14 AWG about 1.5 picofarads. The majority of this is to a shielding can on the current sensing unit, and its effect can be reduced by using the probe ground lead when working around large voltage swings or high-frequency signals. Another method is to monitor current at points with minimum voltage swing, for example on the DC supply side of a load resistor.

Think current

A few of the many areas better suited to current probe measurements include transformer design, where the current distribution is the most important parameter; the design of electric motors and generators, including looking at starting currents, generating transients, and checking cummutation currents; and numerous SCR-oriented applications, including balancing SCR currents, as well as measuring rate-of-change and peak currents.

If you become used to thinking "current," many other areas become obvious, too, areas where a current probe improves accuracy and places the data in a more directly useable form. For example, in evaluating transistor performance, a current probe is ideal for measuring base drive, collector current, and even emitter current if the impedance is not too low. Many operating characteristics can be determined through the collector current waveform.

If you need to make differential measurements, the current probe has an inherently high common mode rejection ratio. The addition or subtraction of currents by passing two or more wires through the probe sensing unit provides an unsurpassed differential probe. There are no amplifiers. Only the opposing or reinforcing flux fields of the wires determine probe output. Similarly, added sensitivity can be gained by looping the current conductor through the probe several times. However, this does increase reflected impedance by the square of turns or loops.

Another application is making simultaneous voltage probe and current probe measurements. This allows you to determine in-circuit capacitive or inductive characteristics.

Though the use of a current probe may require a slight change in thinking, the advantages offered in certain measurement situations can make the effort worthwile. Here are some major considerations favoring current probes:

- The current probe can be considered complementary to the voltage probe in that, where a voltage probe requires low-impedance points for measurement accuracy, the current probe requires high-impedance points.
- Current probes exhibit less capacitive loading than voltage probes, which implies minimum amplitude attenuation and reduced rise-time error.
- Where current supply requirements are being studied, especially into capacitive elements, a current probe is almost a necessity.

Making the choice

While passive voltage probes are by far the most commonly used probes, both the active probe and the current probe can extend your capabilities. They can yield more accurate measurement data than passive voltage probes in many instances, and sometimes they provide the only means of making a measurement. Often a measurement problem can be solved just by changing to a more appropriate probe type.

The TEKTRONIX Products Catalog contains a full description of available probes along with a probe selection chart. Your local Tektronix Field Office can supply you with further information on specific probe types for your instrumentation and applications.

*Adapted from a two part series by Riley Stock, Tektronix, which originally appeared in **Tekscope**, Vol. 6, Nos. 2 & 3.*

Connecting to the device under test:

Part II—Signal switching

While a great many measurements can be made from a single connection to a device or circuit, or even two connections through a dual-channel instrument, this is certainly not sufficient for all measurements. This is particularly true for functional testing of complex circuits or boards. Many stimulus signal and measurement connections may need to be made to a board for running it through its paces as well as acquiring verification data. Also, automated test may require these connections to be switched or scanned across several devices for efficient parts handling.

Besides meeting the standard requirements of low-noise, low insertion-loss connections, a switcher should also provide flexible configuration and be programmable. Flexibility is necessary for meeting various switching or scanning requirements. Programmability is necessary for quick and repeatable scanning through a given configuration and for changing quickly to new sequences.

As a final consideration in the area of programmability, the switcher should be programmable via one of the standard instrument interfaces. Most often, this will be the General Purpose Interface Bus (GPIB). This is the interface conforming to the IEEE-488 instrument interfacing standard and the most commonly used one in test instrument systems. CAMAC and RS-232C are the other established, but less often used, instrument interfacing schemes. In any case, the switcher needs to be interface compatible with the test system it is going to serve.

Basic switch configuration

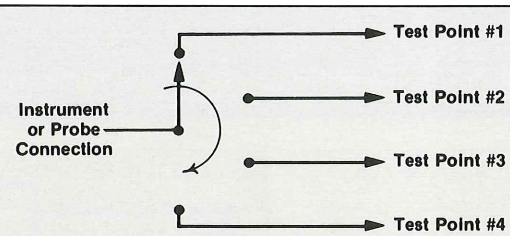
There are two ways switching can be looked at. A single signal or test connection can be switched to several destinations. Or several signals or test connections can be switched across a single point. Both concepts are illustrated in Fig. 1.

The concept in Fig. 1a is probably the most familiar. An instrument or probe is scanned across several test points. There are a variety of cases where this is useful. One example is scanning edge connector outputs in board testing. Another example is in scanning the same measurement across several devices sequestered in a test chamber.

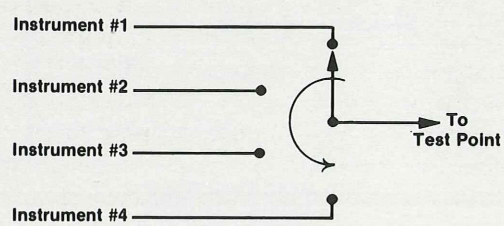
Although possibly not as familiar, the concept in Fig. 1b is equally important and useful. In this second case, switching allows the test point to be scanned across several instruments.

The test point in Fig. 1b could be, for example, the output of a device, and the instruments scanned could include a DVM, a frequency counter, a spectrum analyzer, a waveform digitizer, or any other combination of special instruments. All of these instruments could be connected simultaneously to the test point. However, that puts the instrument input impedances in parallel, resulting in possible loading problems at the test point. Switching to each instrument individually eliminates this potential problem. And, for productivity, switching offers a time advantage in that only one connection need be made to the device under test for access to a variety of instrumentation. Having scanning and the instruments run under program control over the GPIB presses the time advantage further—an operator merely connects and disconnects devices while the system scans and tests.

Carrying the idea of program controlled switching a step further, Fig. 2 shows both switching concepts in use. In this case, a device with multiple inputs and a single output is under test. The test signal or stimulus is scanned across the inputs while the output is scanned across various instruments for measuring or analyzing



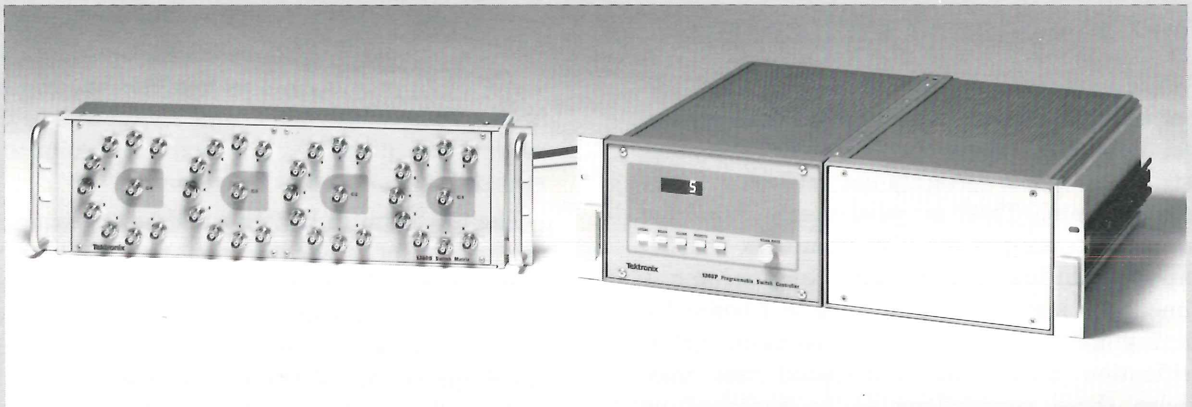
a. *Scanning across test points.*



b. *Scanning tests across a point.*

Fig. 1. *Two basic scanning concepts.*

1360P/1360S Programmable Signal Multiplexer



- GPIB Compatible
- Software Configurable
- 250-MHz Bandwidth
- Rackmount or Benchtop
- Up to 16 Nine-Pole Coaxial Switches

The 1360P/1360S Programmable Signal Multiplexer is a microprocessor-based switching system consisting of two primary modules. There is a 1360P Programmable Switch Controller module and a 1360S Switch Matrix module. Each is standard rackmountable. Bench top options are available.

The 1360P contains the microprocessor and firmware for GPIB interfacing and driving the coaxial switches housed in the 1360S. An LED display is provided for monitoring pole selection and error status. Each 1360P Programmable Switch Controller can drive from one to four 1360S Switch Matrix modules.

Each 1360S Switch Matrix contains four nine-pole coaxial switches. The ninth pole of each switch set is used as a feed-through contact to another switch set. This allows a single 1360S to be configured for multiplexing either inputs or outputs as—

4 groups of 9 channels
2 groups of 17 channels
1 group of 33 channels

With four 1360S units operating off of a single 1360P, the possible group configurations expand to—

4 groups of 33 channels
2 groups of 65 channels
1 group of 129 channels

Switching system impedance is 50 ohms. Bandwidth is 250 MHz (one switch). Also, each switch is rated at 250 volts DC or 250 milliamperes, with a 10 watt maximum power rating per switch.

To find out more about the 1360P/1360S Programmable Signal Multiplexer, contact your local Tektronix Field Office. Outside of the United States, contact the Tektronix sales representitive serving your country.

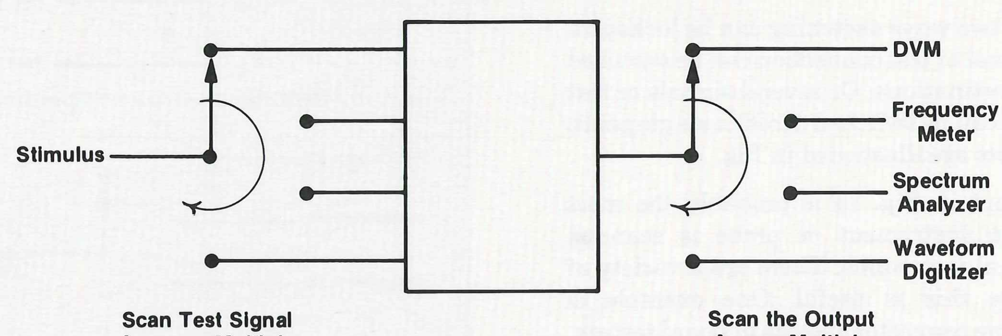


Fig. 2. *Both switching concepts used in one test configuration.*

different signal parameters. A computer program would control switch sequencing, providing one complete instrument scan for each step of the input signal switch. The program could also be used to automatically log data from each instrument so that full advantage could be taken of scanning speed.

Of course, a skilled technician with a single instrument such as a standard oscilloscope could duplicate the measurement situation portrayed in Fig. 2. It would be a matter of the technician connecting the stimulus signal to the first input, examining and interpreting the output for various parameters, recording the parameters, switching the stimulus to the next input, examining and interpreting the output, and so on for all inputs. This is a perfectly efficient approach...as long as the test situation is an occasional one out of a wide variety encountered on a day-to-day basis. But, in a production or even a research monitoring situation where rapid repeatability is crucial, automating with programmed switching and GPIB compatible instruments is the more efficient approach.

Expanding the configuration

Thus far, the switching configurations illustrated have been oversimplified. This simplification helps clarify the basic concepts. But for true efficiencies, more switch contacts and contact arrangements are necessary. Figure 3 shows an example of what is typically needed for practical configurations.

One thing that can't be missed in Fig. 3 is that the number of contacts is increased over the four shown in Figs. 1 and 2. Figure 3 shows 16 contacts arranged in groups of four with an additional common contact per group. The wiring arrangement is such that the common contacts can be set individually to select four groups of four contacts, two groups of eight, or one group of sixteen. Also, unlike the examples in Figs. 1 and 2, more than one contact can be made at a time to set up either branching or converging signal paths.

Even more switchable signal paths are available with the TEKTRONIX 1360S Switch Matrix. Figure 4 shows a schematic of one of the two BNC switching cards in the 1360S. Each card contains two sets of nine connectors, 0 through 8, with an additional common connector for each set of nine. With two cards per 1360S, this arrangement allows matrixing of 1 output with 33 inputs, 2 ganged outputs with 17 inputs, or 4 ganged outputs with 9 inputs.

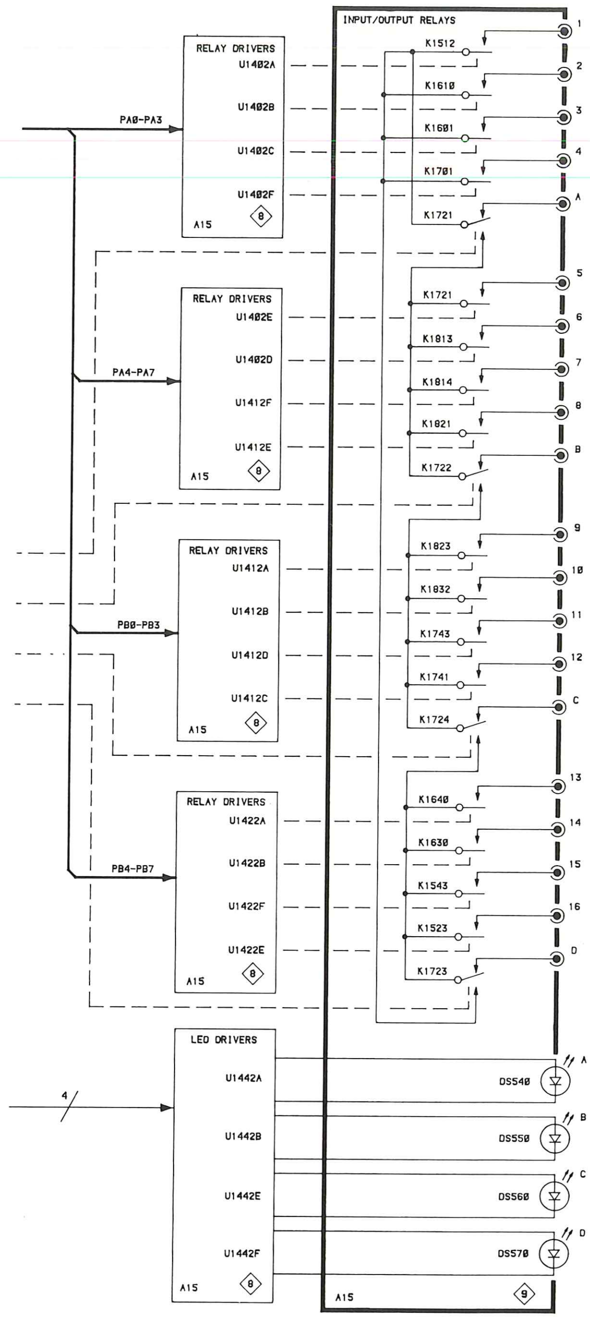


Fig. 3. *Switching arrangement in the TEKTRONIX SI 5010 Programmable Scanner.*

The 1360S Switch Matrix is only half the story, though. A 1360P Programmable Switch Controller is used for computer interfacing and control of the 1360S. The 1360P can control up to four 1360S units, providing multiplexing of up to 1 output with 129 inputs, 2 ganged outputs with 65 inputs, or 4 ganged outputs with 33 inputs.

For most cases, you probably won't need 1 output to as many as 129 inputs. But it's nice to

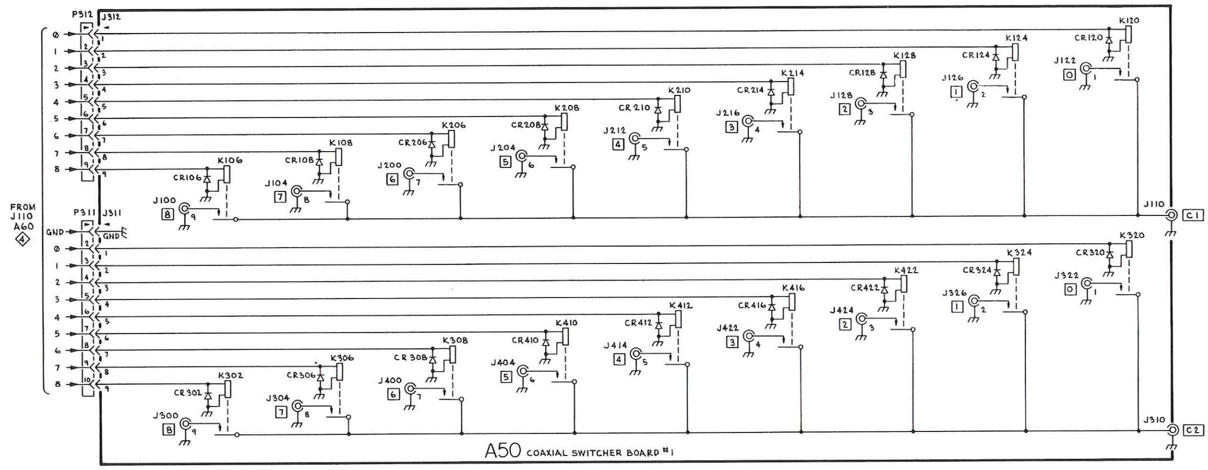


Fig. 4. *One of the two switching boards showing the relay arrangement used in the TEKTRONIX 1360S Switch Matrix.*

know that the capability exists off-the-shelf should the need for it ever arise.

Configure with specifications in mind

General purpose signal switchers are typically designed to present an unterminated 50-ohm characteristic impedance and are usually specified for VSWR on a per channel basis. Other transmission specifications, such as rise time and bandwidth, are also generally specified on a per channel or per switch basis. These specifications presume a proper termination matching the switcher's characteristic impedance.

When configuring a signal switcher, keep in mind that per channel or per switch specifications may degrade in some configurations. Generally, this is due to open-switch capacitance adding in parallel to the channel. Using the TEKTRONIX SI 5010 Programmable Scanner as an example, rise time is specified at 1 nanosecond for groups of 4 individual channels. However, for a configuration combining channels into one group of 16 channels, the rise time specification becomes 4 nanoseconds.

Switch pull-in and release times are also important to consider for programmed scanning operations. It takes a certain amount of time for a scanner switch to pull-in or become fully closed after an activation voltage is applied. The same is true for opening or releasing a switch; it takes some time for the contacts to break after the signal or command is given. A programmed sequence for closing a scanner switch, taking a measurement, and opening the switch must allow enough time for each physical process to take place.

And, as always, consideration must also be given to impedance and circuit loading effects. Probes and test points used in scanning must still be selected with the same care and guidelines covered by Part I of this article series.

With these considerations taken care of, let's look at some application areas where signal switching can multiply your measurement capabilities.

Switching for research

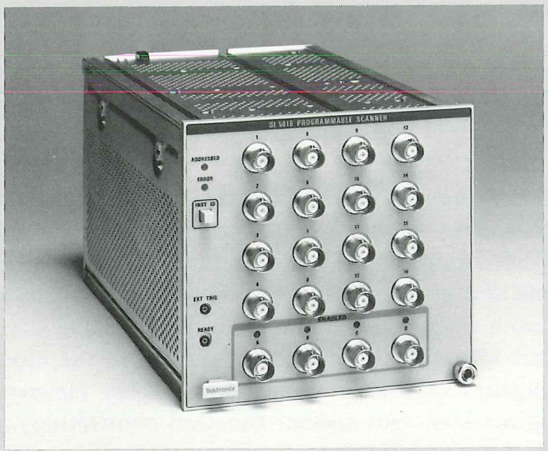
For research and evaluation, programmable switchers offer an economical solution to data collection. Where personnel or equipment duplication may have once been required for monitoring multiple transducer placements, a switcher and controller can now beused to quickly scan transducers and log data. And, if the controller has a clock function, scanning can be done on a timed basis without operators present.

Scanning arrays of strain gauges is one possible application of switchers in research and evaulation. Or, instead of strain guages, you could be using multiple placements of other types of transducers for pressure, flow, vibration, whatever. The point is that a scanning switcher under computer control can be used with a minimum of instrumentation to automatically monitor a number of test points or local test stations.

Switching for automation

Scanning tests across components or assemblies can be a key factor in increasing production test throughput. As an example, consider functional testing of assembled circuit boards.

SI 5010 Programmable Scanner



- GPIB Compatible (IEEE 488-1978)
- Software Configurable
- Built-In Real Time Clock
- 350-MHz Bandwidth (1-ns Rise Time)
- External or Software Triggerable

The SI 5010 Programmable Scanner is a two-wide TM 5000 plug-in. It provides programmable scanning and switching of 16 different signal channels. Scanning or switching can be across individual channels or various combinations of channels. The general configurations are—

4 groups of 4 channels
2 groups of 8 channels
1 group of 16 channels

Each SI 5010 channel has a characteristic impedance of 50 ohms, and signal degradation is minimal when configured for one or more groups of four individual channels. Channel rise time for groups of four individual channels is approximately one nanosecond and increases to about four nanoseconds for one group of 16.

The SI 5010 has built-in microprocessor intelligence and a command buffer for storing from 80 to 300 commands, depending on command length. The buffered commands are sequenced in order and can be paced with a built-in real-time clock, a built-in wait timer, an external hardware trigger, or a software trigger from the system controller.

For more information on the SI 5010 please contact your local Tektronix Field Office. Outside of the United States, contact the Tektronix sales representative for the country you are in.

If the boards are designed with edge contacts, they can be inserted into edge connectors by the test system operator. There are a variety of ways that loaded edge connectors can then be fed to the system. For example, the connectors could be attached to a conveyor that advances them one or two at a time to wiper contacts. The wiper contacts would, in turn, go to the switcher which would scan various test signals and measurements across each connector.

By using two conveyors, testing could be underway on one set of boards while the other conveyor steps the next set of boards into another set of wiper contacts. Alternately stepping boards into place and switching test scans between them would allow a near continuous stream of boards through the system. Capacity could be added by more switchers and conveyors in parallel.

Switching for programmability

A programmable switcher can also be an economical approach to adding programmable settings to a variety of instruments. Perhaps the simplest example is creating a programmable attenuator. This can be done simply by connecting fixed attenuators to the switch matrix output connectors. Going a step further, selected attenuators or dividers could be used in conjunction with a switcher to provide programmable range selection for the input channels of waveform digitizers and other instrumentation.

Switching for economy

It would be easy to go on with more examples of how switchers and scanners can save time and money. However, the best example is your own application needs.

Have you done a system sketch? Are there routing problems that could be solved by a switcher? How about duplicate instruments or functions? Could one instrument be used on a time shared basis via a signal switcher?

To help you answer questions like these, Tektronix has skilled Application Engineers placed at selected Field Offices. To find out more about availability of Application Engineers, contact the Sales Engineer at your local Tektronix Field Office. Or if you like, use the reply card bound into this issue of HANDSHAKE. Just check the box asking for a Sales Engineer contact.

by Bob Ramirez,
HANDSHAKE Staff

Connecting to the device under test:

Part III—Multifunction interfacing

As devices and test situations become more complex, connection to devices under test can become more complex, too. In production testing, for example, the requirements usually go beyond providing test signals and measurement connections. You may also have to interface the test system and measurement sequences to a parts handler. There are also cases where the device requires digital words—rather than sinusoids, square waves, etc.—for stimulus or control. Such cases that go beyond simple test connections form a rather broad area that can be referred to as multifunction interfacing.

Controlling relays, motors, and other electromechanical devices associated with the device under test or with positioning it for testing is one aspect of multifunction interfacing. Another aspect is providing digital input/output capabilities between the device and the test system. This can be either as a direct test of a digital device or for controlling a device while it undergoes test. A third aspect of multifunction interfacing is the rather general aspect of providing a specific functional atmosphere for the device under test.

For GPIB-based systems, the problem is somewhat simplified. One side of multifunction interfacing looks to the system like any other GPIB instrument. It's standardized. The other side of multifunction interfacing is specialized to match requirements outside of the GPIB system. This situation is further illustrated in the block diagram of Fig. 1 which shows relay closures, digital I/O, and special function connections to the device under test.

Relay closures

Relay closures can be grouped into two major application categories. The first is the general category of signal routing. Closures for equipment control is the other general category. In actual practice, these two may overlap considerably.

The concepts of signal routing have already been covered in Part II of this article series. However, as a matter of general classification for here, closures for signal routing are of the type

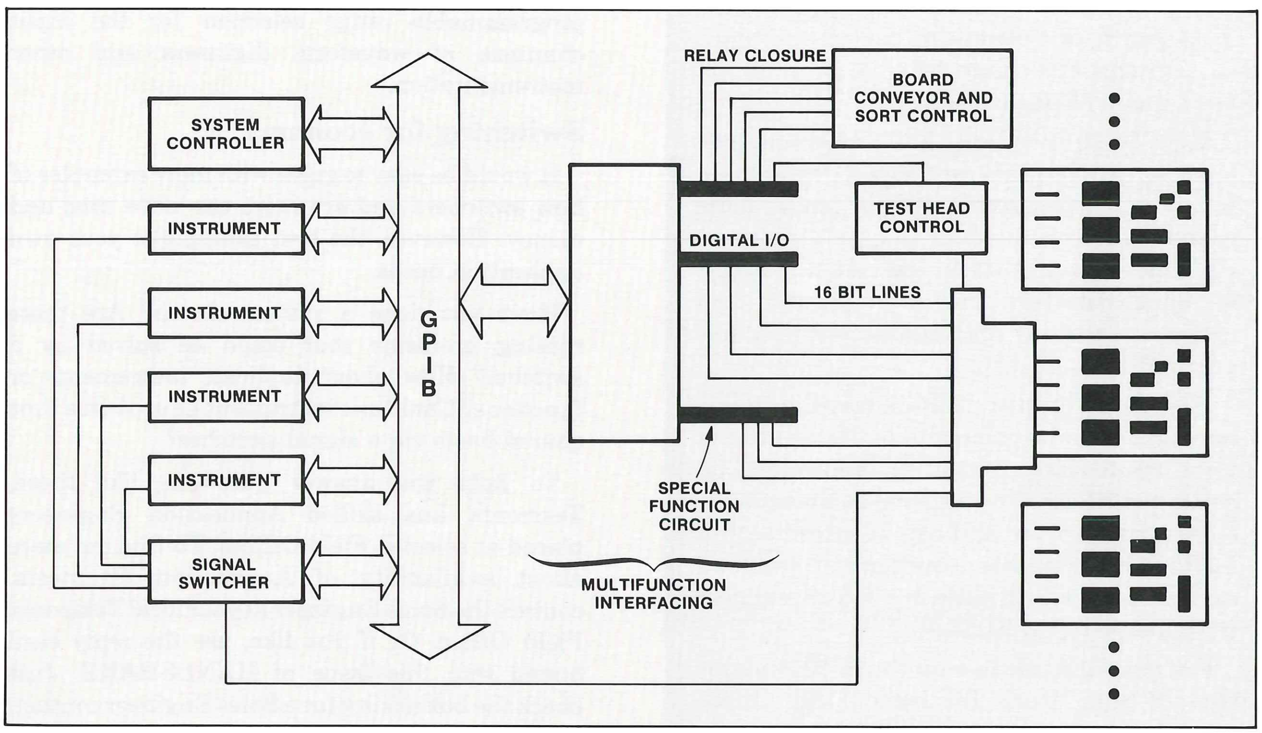


Fig. 1. *GPIB-based test system with multifunction interfacing to provide relay closures, digital I/O, and special function support to the device under test and its test environment.*

where bandwidth and noise level are major concerns. The primary goal is to route or switch signals between various points while maintaining signal fidelity. For broadband applications, this generally means using some type of coaxial switching such as employed in the switchers discussed previously in Part II.

In terms of multifunction interfacing—connection to or controlling devices beyond the GPIB system—signal switchers offer a means of routing control signals to various points. One example of use is in process control. Small DC levels or multitone signals may be used as control signals to activate remotely located valves, gates, motors, etc. In some cases, even modulated RF may be used as a control signal. A GPIB system with a programmable signal switcher offers a means of routing such signals under program control as well as automatically testing or monitoring various process parameters.

On the other hand, equipment control may simply be a matter of completing a circuit. This could be a switch closure in the ground lead of a relay coil. Or it could be a closure to activate an SCR. For these types of closures, the voltage and current ratings of the switch contacts become more important than high bandwidth. Accordingly, mercury-wetted relays are often used rather than coaxial switches. These generally provide enough voltage and current capacity for most applications. And, where more power capacity is needed, heavy-duty relays can be activated by the switcher's mercury-wetted relays.

Activating and sequencing switch closures is done by an application program stored in the GPIB system controller. The nature of the program depends, of course, on the application. It is also dictated in part by the system needs and capabilities. In general, though, sequencing can be keyed to sensing an event with the instruments in the test system, or it can be keyed to a clock if one is provided in the system. An example of clocked sequencing is illustrated in Fig. 2.

The clocked switching sequence diagrammed in Fig. 2 is based on the TEKTRONIX MI 5010 Programmable Multifunction Interface with a 50M40 Programmable Relay Scanner Card installed. The 50M40 relay closures can be executed in immediate mode over the GPIB by commands from a program in the system controller. Alternatively, commands can be stored in the MI 5010 buffer for execution independent of the system controller.

Figure 2 lists the MI 5010 commands necessary to run the diagrammed sequence. These commands are sent to the MI 5010 over the GPIB interface in the same format used for other device-dependent messages. When they are received by the MI 5010, the commands are either executed immediately or stored in the MI 5010 for later execution. In the case of the command sequence listed in Fig. 2, the TIME command executes immediately, causing the clock to be set to the specified time. The UNTIL also executes immediately, setting a time for comparison to by a later WAIT UNTIL command. However, all of the commands following the BUF ON and up to the BUF OFF are not executed immediately. They are, instead, stored in the MI 5010's buffer for later execution.

```
TIME Ø7:ØØ:ØØ    } Executed immediately
UNTIL 14:ØØ:ØØ   }
BUF ON;
  WAIT UNTIL;    }
  CLOSE 1;       }
  WAIT 12Ø;      }
  OPEN 1;        } Stored in MI 5010 buffer
  CLOSE 2;       }
  WAIT 12.5;     }
  OPEN 2;        }
BUF OFF;
EXEC -1;         } Executes buffered commands
                   repeatedly
```

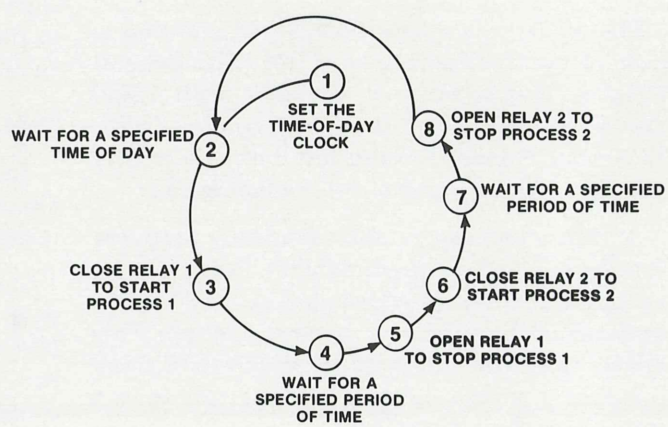
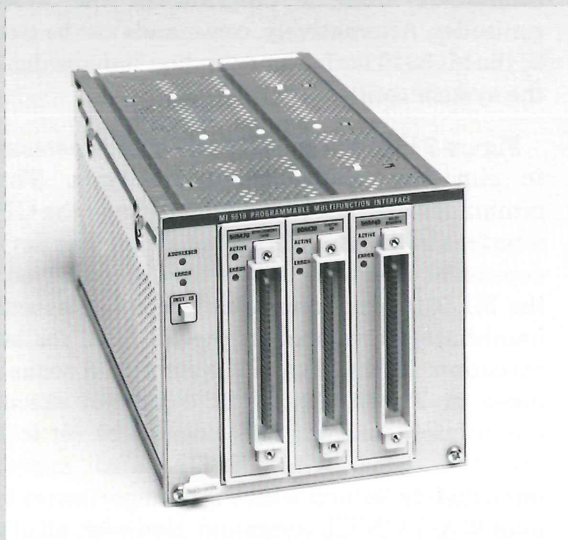


Fig. 2. *Example of a clocked switching sequence executed from the command buffer of the TEKTRONIX MI 5010 Programmable Multifunction Interface.*

Multifunction interfacing from Tektronix

Multifunction interfacing allows you to extend GPIB control and programming to non-GPIB devices. It's a concept that broadens the scope of possibilities for connection to a device under test, controlling the device under test, and even connecting to and controlling the device's environment. To support this concept, Tektronix offers a GPIB compatible MI 5010 Programmable Multifunction Interface unit and several function cards. An MX 5010 Multifunction Interface Extender is also available for increasing the number of function cards that can be controlled through the MI 5010.



MI 5010 Programmable Multifunction Interface

The MI 5010 Programmable Multifunction Interface

The MI 5010 is a two-wide plug-in unit that is part of the Tektronix line of TM 5000 General Purpose Instruments. It complies with IEEE Standard 488-1978. It also complies with Tektronix Standard Codes and Formats to give you the highest degree of programming ease.

A Microprocessor and firmware provide interfacing and programmability. Additionally, an internal buffer provides storage for 80 to 300 commands, depending on command length. This allows controller independent execution of small interface routines. Longer routines can be run from the system controller.

Interfacing operations—relay scanning, digital I/O, etc.—are determined by the function cards used in the MI 5010. Up to three function cards can be plugged into the front of the unit. Each card has its own ROM and set of device-dependent programming commands. Communication with the MI 5010 microprocessor is through each card's backplane connector. Each card also has a front-panel connector for ribbon cable connection to the application or device under test or control.

MX 5010 Multifunction Interface Extender

The MX 5010 extender is a two-wide plug-in identical to an MI 5010 with the microprocessor control board removed. The MX 5010 allows three additional function cards to be controlled from the MI 5010 for a total of six function cards.

50M20 Programmable Digital-to-Analog Converter Card

The 50M20 allows conversion of digital data to an analog signal. Data for conversion can be fed to the 50M20 from the GPIB, directly or through the MI 5010 command buffer, or data can be input externally through the front-panel connector.

Required data format is 12 bits sent in two sequential 7-bit words. Six bits of each word are data to be converted; the seventh bit indicates high order or low order group. Firmware on board the 50M20 converts commands and data to the proper format for digital-to-analog conversion.

Total conversion time is 20 microseconds (max to plus or minus LSB) for data input through the front panel connector. The analog output can be either a voltage (-10.240 to +10.235 volts) or a current (-20.48 to +20.47 milliamps) proportional to the digital data. Voltage or current output is switch selectable on the card.

50M30 Programmable Digital I/O Card

The 50M30 provides 16 digital input and 16 digital output lines. Four additional lines are also included for I/O handshaking.

The digital input lines accept TTL level data from push buttons, switches, relay closures, or other devices capable of supplying TTL levels. The output lines transmit digital data at TTL levels for controlling devices, instruments, etc. that accept TTL input. Internal jumpers also allow setting the output lines for open-collector outputs when an external power source is used.

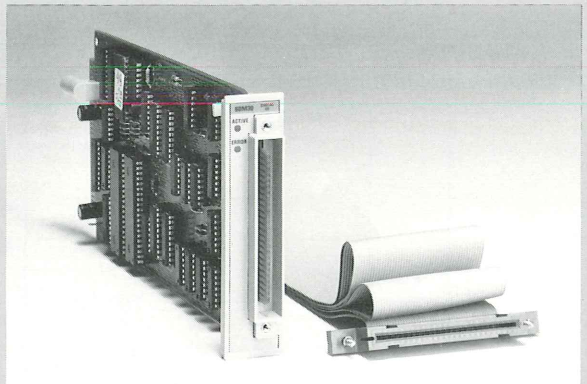
50M40 Programmable Relay Scanner Card

The 50M40 provides 16 normally open, mercury-wetted relay contacts. Jumpers allow selection of various contact configurations—for example, 4 groups of 4 contacts, 2 groups of 8 contacts, or 1 group of 16. Scanning sequence and contact closure is accomplished under program control.

50M70 Programmable Development Card

The 50M70 is a general purpose card for people needing to design special purpose functions and interface them to the GPIB. Some examples of things that the 50M70 might be used to implement include a keypad entry port, LED or LCD displays, programmable filters, joystick port, etc.

A 4x4-inch breadboard area is provided on the 50M70 card as the special function design area. The card comes standard with a ROM and firmware for GPIB communication. Other standard features are programmable I/O data registers, programmable trigger conditions, and programmable data transfer, register configuration, status, and interrupts.



Function card for the MI 5010

For specifications on the MI 5010 Multifunction Interface and its function cards, consult your Tektronix IEEE-488 System Instruments Catalog (75-AX-4545). Or call your local Tektronix Field Office or the Tektronix sales representative for your country and ask about multifunction interfacing from Tektronix.

Executing commands from the MI 5010 buffer is done with the EXEC statement followed by an argument specifying the number of times the buffered command sequence is to be executed. In the case of Fig. 2, a -1 is used for EXEC. This causes repeated execution of the sequence until halted by a STOP or other command from the controller.

Each execution follows the same path. There is a WAIT UNTIL that suspends further command execution until the clock reaches the time specified by a previous UNTIL statement. Then CLOSE 1 causes relay 1 to close. There's a WAIT for 120 seconds. Relay 1 is opened, and so on until the cycle completes and goes into its WAIT UNTIL again.

The same switching sequence could also be executed from a program stored in the controller rather than the interface buffer. However, if this were done, the WAIT UNTIL would have to be replaced by a routine that would start the relay sequence by recognizing a data condition or instrument interrupt.

Figure 2 is just one example of implementing a relay sequence. Actual methods and the number of closures used will vary with the application. Also, whether or not the switcher or interface has command buffering will determine to some extent the implementation approach.

Digital I/O

A switch closure is the simplest case of digital I/O. For example, a foot pedal or push button can provide a closure. If this closure can be sensed or otherwise communicated to the GPIB system, it can be used to control or initiate measurement sequences through other bus connected devices. The relay sequencing example in Fig. 2 could be initiated, for instance, by such a switch closure instead of the clock and WAIT UNTIL function.

A foot pedal or push button is a simple 1-bit, open-or-closed form of digital input. An equally simple case of digital output is the act of turning an indicator light on or off from the GPIB system. A digital "1" could be the signal to turn the light on, a "0" to turn it off.

For such simple cases of digital I/O, only one data line for input or output is needed. Most digital I/O needs, however, require more data lines as well as some additional lines for handshaking the data exchange (see Fig. 3). Eight input lines (DI0-DI7) and output lines (DO0-DO7) would be nice for many applications. But 16 input and output lines

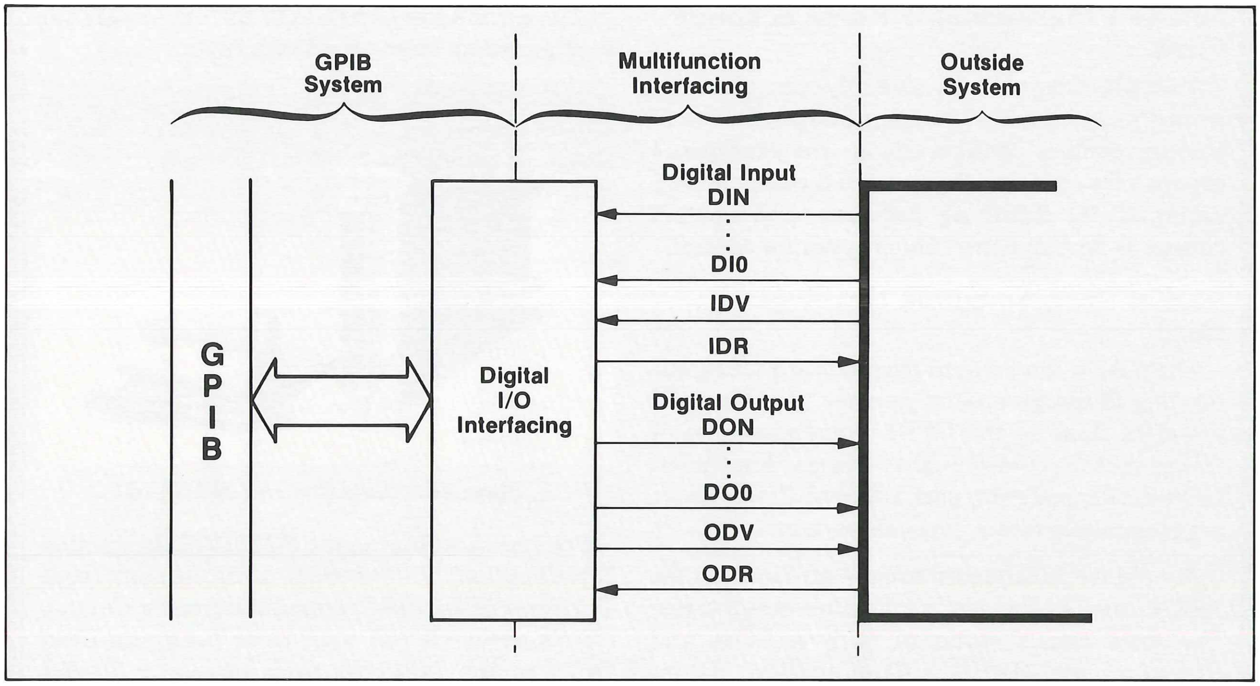


Fig. 3. *Digital I/O with data handshake lines; the same handshake can be used with any number of I/O lines.*

would cover an even wider variety of cases. For applications requiring a lesser number of bits or lines, the unneeded higher order bit lines can be ignored. For any number of lines or bits, however, the two input and two output handshake lines are sufficient.

The handshake lines illustrated in Fig. 3 are used in data exchange between the GPIB system and the non-GPIB outside world. They are not the same lines, or even the same process, used for GPIB handshaking between bus connected devices.

For digital input to the system, the IDV and IDR lines provide a simple handshake. When the external device (parts handler, shaft encoder, or whatever), sends data to the GPIB system via a multifunction interface, the device puts data on the line and then asserts the Input Data Valid (IDV) line. Asserting IDV tells the Digital I/O Interface that data is ready for input. The I/O Interface reads the data into its buffer and asserts the Input Data Received (IDR) line. Normally, on receiving IDR, the external device should unassert IDV and leave it unasserted until new data is put on the data lines.

Once data has been input to the Digital I/O Interface buffer, the data can be transferred via standard GPIB procedures to any other GPIB connected device. Conversely, any GPIB connected device can send data outside the system through the Digital I/O Interface. The Digital I/O Interface uses the Output Data Valid (ODV) line to signal an external device that data is ready to be read. The Output Data Received (ODR) line allows the external device to acknowledge receipt of the data from the Digital I/O Interface.

Special function interfacing

Beyond standard relay closures and digital I/O functions, there is a variety of special functions or circuits that you may need to interface to a GPIB system. In many cases, you'll also want these to be GPIB programmable.

Some typical functions include analog-to-digital conversion, digital-to-analog conversion, keypad entry port, joystick port, logarithmic amplifier, filtering, and circuits for testing hybrids or ICs. Some of these functions are available commercially as GPIB devices. However, for narrow or specialized applications, it may be cheaper to design and build the function yourself. For example, a simple filter that's programmable for a few slightly different cutoff points might be more economical to construct than buy. There may also be cases where designing the function is mandatory, either for proprietary reasons or because the function simply isn't commercially available. An example of the latter might be a programmable circuit for testing a special hybrid or IC.

To simplify the design and interfacing task of providing special functions, Tektronix offers a 50M70 Programmable Development Card. This card is part of the TEKTRONIX MI 5010 Programmable Multifunction Interface series of cards. Essentially, what the Development Card does is provide a GPIB interface for any circuit you design. Firmware is included on the card to control the GPIB interface. Control and data lines, as well as data and address buffers, are provided for interconnection between your circuit and the card's GPIB interface. The control and data lines are brought out to a 4x4-inch breadboard area on the card which can be used for implementing your special circuits.

The 50M70 Programmable Development Card plugs into the MI 5010 Programmable Multifunction Interface unit. The MI 5010 provides the final link to the GPIB.

There is room in the MI 5010 for three function cards. These can be development cards that you've built, or they can be standard cards provided by Tektronix. Currently, a digital I/O card, a relay scanner card, and a digital-to-analog converter are available in addition to the development card. An MX 5010 Interface Extender is also available for use with the MI 5010 to provide three additional function card slots.

To find out more about how these multifunction interfacing devices can benefit you, contact your local Tektronix Field Office or the Tektronix sales representative for your country.

By Bob Ramirez
HANDSHAKE Staff

New system automates scope calibration, program generation

The new F7601A1 Programmable Scope Calibration System offers increased productivity for your calibration lab. Program controlled system set up and calibration procedures increase technician efficiency, allowing as much as a fourfold increase in throughput. Even calibration program development is automated with SCPDA, the ScopeCal Procedure Development Aid software provided with the system. With SCPDA, you don't have to be a programmer to implement programmed calibration.

The F7601A1 system comes complete with all the equipment needed for automated oscilloscope calibration. The system controller is the TEKTRONIX 4052A Graphic Computing System with full graphics capability and BASIC software installed. SCPDA software is provided on a magnetic tape. The main calibration generator is the TEKTRONIX CG 5001 Programmable Calibration Generator. Three other generators for leveled sine waves from 5 Hz to 1050 MHz are also supplied with the system. Also, the necessary pulse head, cables, accessories, and complete manuals are provided.

The key calibration features of the F7601A1 system come from the CG 5001 Programmable Calibration Generator. This microprocessor-based instrument can be used manually or under full program control for calibration and verification of such major oscilloscope parameters as:

- Vertical Gain
- Vertical Bandwidth
- Pulse Characteristics
- Horizontal Timing and Gain
- Probe Accuracy and Compensation
- Calibrator Output Accuracy

Basic voltage and current amplitude accuracy for the CG 5001 is plus or minus 0.25%. Timing Mode accuracy is plus or minus 0.01% with a plus or minus 0.0003% option available. All CG 5001 front-panel modes are controllable over the GPIB. Additionally, the CG 5001 automatically computes error percentages or deviations. These are displayed on the CG 5001 front panel as well as made available to the GPIB port for transfer to the 4052A controller.

The 4052A controller monitors and controls the test sequence. Calibration generator settings can be made automatically by the controller. Proper settings for the oscilloscope being calibrated can be conveyed to the technician via the 4052A screen. Calibration data (error or deviation) from the CG 5001 is compared to specifications stored in the 4052A, and out-of-tolerance items are flagged for further action. A permanent record of the entire maintenance or calibration procedure can also be output from the controller to a peripheral hard copy unit or printer.

For developing calibration control and output routines, the SCPDA software provides user prompts on the 4052A screen. The operator's answers to these prompts are used to construct a specialized program from the SCPDA's routine library. User prompts and responses are in the form shown in Fig. 1. An example of user input compiled into a calibration step is shown in Fig. 2, and examples of output are shown in Figs. 3 and 4. Even the final step of the calibration sequence—documenting the results—is automated.

To find out more about the TEKTRONIX F7601A1 Programmable Scope Calibration System and how it can streamline oscilloscope maintenance, contact your local Tektronix Field Office. Outside of the United States, please contact the Tektronix Sales Representative serving your country.

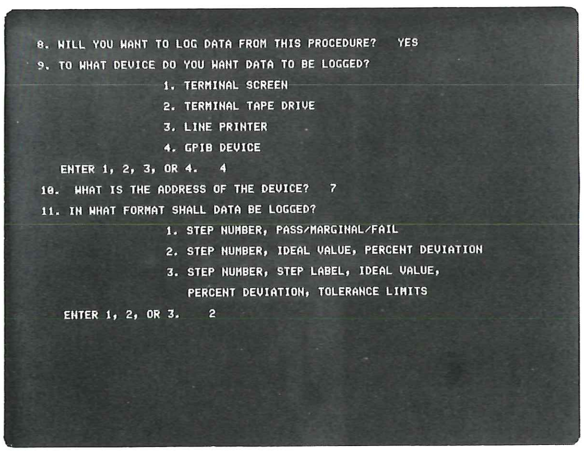


Fig. 1. *SCPDA user prompts help you build calibration programs for specific oscilloscope types and calibration lab needs.*

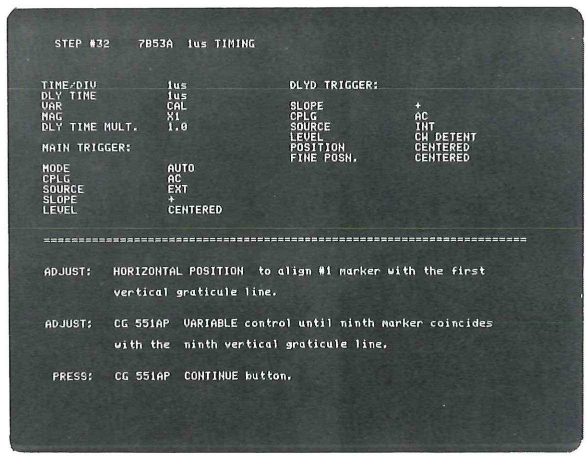
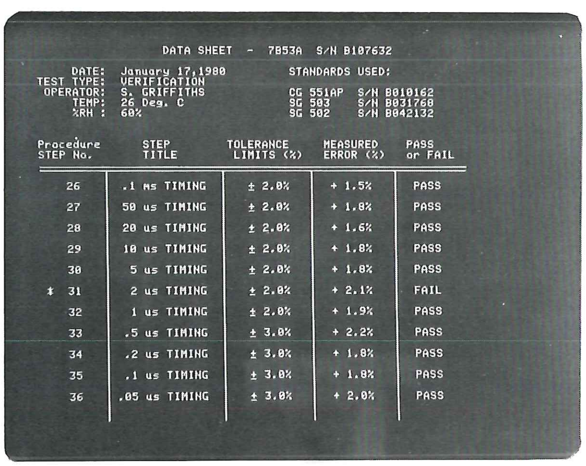


Fig. 2. *Instructions output by the system for a single calibration step.*



Procedure STEP No.	STEP TITLE	TOLERANCE LIMITS (%)	MEASURED ERROR (%)	PASS or FAIL
26	.1 ms TIMING	± 2.0%	+ 1.5%	PASS
27	50 us TIMING	± 2.0%	+ 1.8%	PASS
28	20 us TIMING	± 2.0%	+ 1.6%	PASS
29	10 us TIMING	± 2.0%	+ 1.8%	PASS
30	5 us TIMING	± 2.0%	+ 1.8%	PASS
* 31	2 us TIMING	± 2.0%	+ 2.1%	FAIL
32	1 us TIMING	± 2.0%	+ 1.9%	PASS
33	.5 us TIMING	± 3.0%	+ 2.2%	PASS
34	.2 us TIMING	± 3.0%	+ 1.8%	PASS
35	.1 us TIMING	± 3.0%	+ 1.8%	PASS
36	.05 us TIMING	± 3.0%	+ 2.0%	PASS

Fig. 3. *Calibration data and results are stored by the 4052A and can be displayed on its screen.*

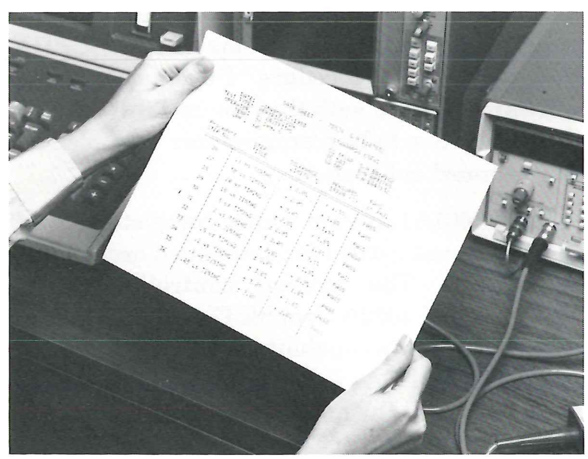
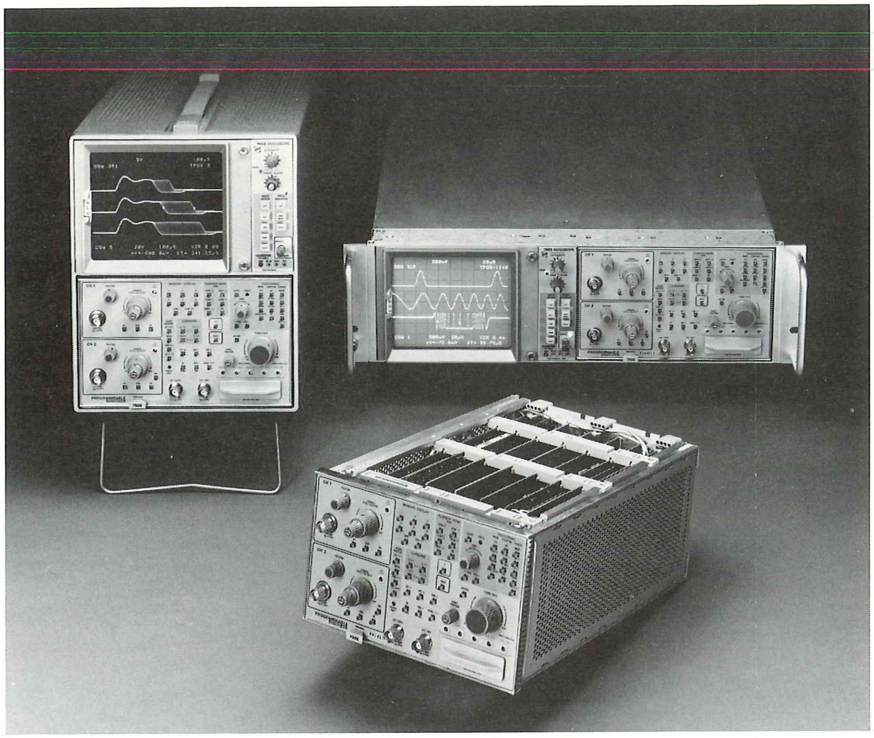


Fig. 4. *Logged data can also be output to a peripheral hard copy device for permanent calibration records.*

7D20 turns oscilloscopes into GPIB compatible waveform digitizers



The new 7D20 Programmable Digitizer plug-in is designed to significantly enhance your oscilloscope measurement capabilities. This three-wide plug-in unit provides dual-channel waveform digitizing, storage for six waveforms, and GPIB compatibility and programmability for automated test systems. It operates with any of the long standing line of Tektronix 7000 Series oscilloscopes (except the 1-GHz 7104 scope), and gives you access to a number of capabilities not found in traditional analog oscilloscopes.

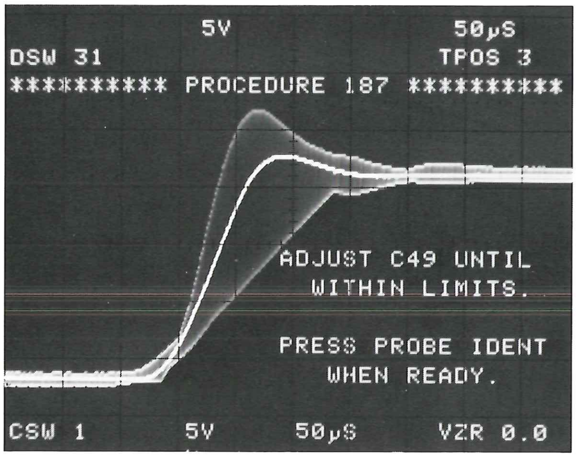
State-of-the-art dual channel digitizing offers a variety of enhancements in acquiring and viewing waveforms. Simultaneous acquisition from both channels provides capabilities comparable to those of a dual-beam oscilloscope. Single-shot sampling at a 40-MHz rate allows capture and storage of transient events as narrow as 50 nanoseconds. And, for repetitive signals, equivalent time sampling provides a bandwidth of 70 MHz.

Pre- and post-triggering capabilities are included in the 7D20 for investigating events before or long after triggering. And because of digital storage, waveforms can be expanded, contracted, and moved about the display for better viewing and easier comparisons.

Further measurement enhancements include signal averaging for cleaning up noisy signals, cursors with readout for fast and accurate amplitude and time measurements, and enveloping for monitoring changing signals. Add to this the ability to store six waveforms and call them up for comparison and the ability to store six complete front-panel setups, and you have an extremely powerful and flexible measurement tool.

Yet there is no confusion for all this added power and flexibility. The 7D20 front-panel layout is straightforward. The controls are all clearly labeled and they are functionally grouped in a layout following the tradition of standard 7000 Series plug-in layout. It's quick and easy to learn, quick and easy to use.

The same ease-of-use philosophy is carried over into 7D20 programming. The 7D20 complies with Tektronix Standard Codes and Formats. This means you can program it over the GPIB with direct, English-like commands. All 7D20 settings

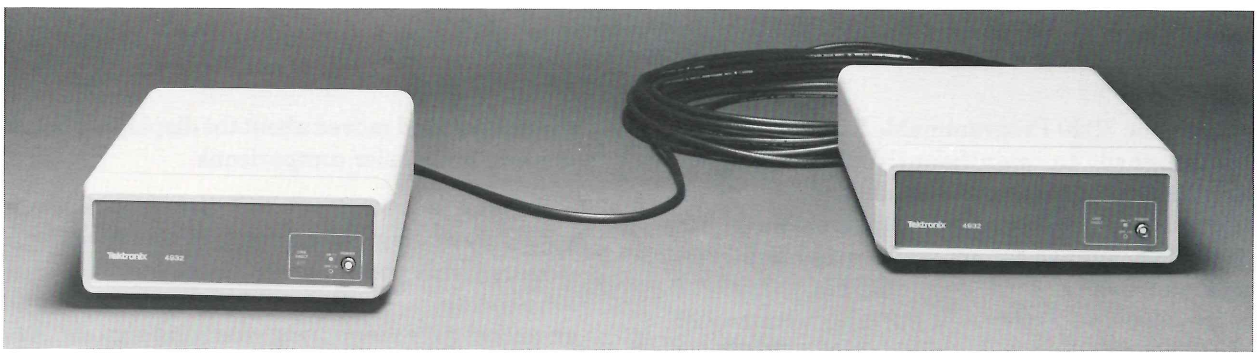


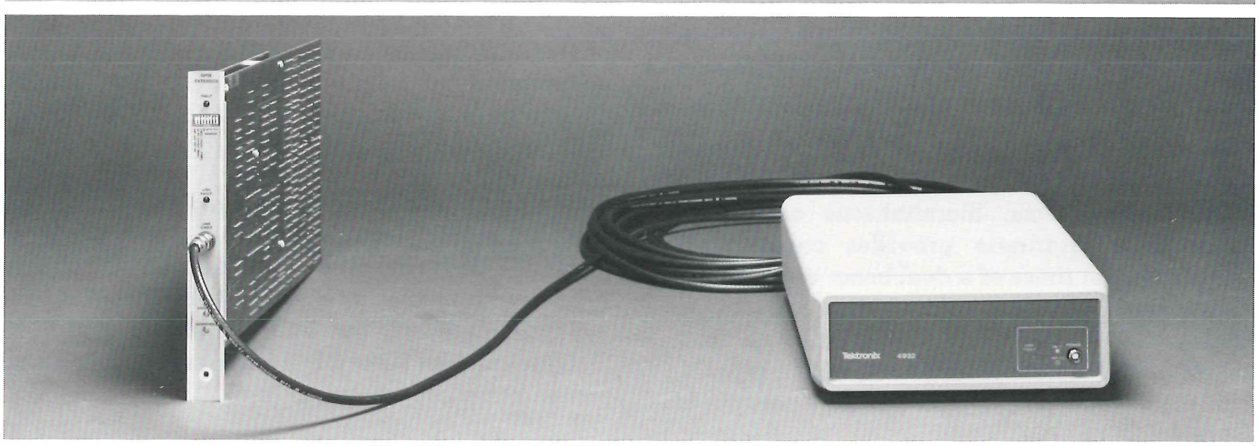
Use of the 7D20 in a semi-automated test application. When the capacitor adjustment has been made, pressing the identify button on the probe advances the program to the next step.

and operating modes, except Variable V/div and Horizontal Position, are programmable. Waveforms can also be transferred out of 7D20 memory to a GPIB controller or peripheral for further processing or mass storage. Waveform transfer format is selectable for high-speed BINARY or standard ASCII format.

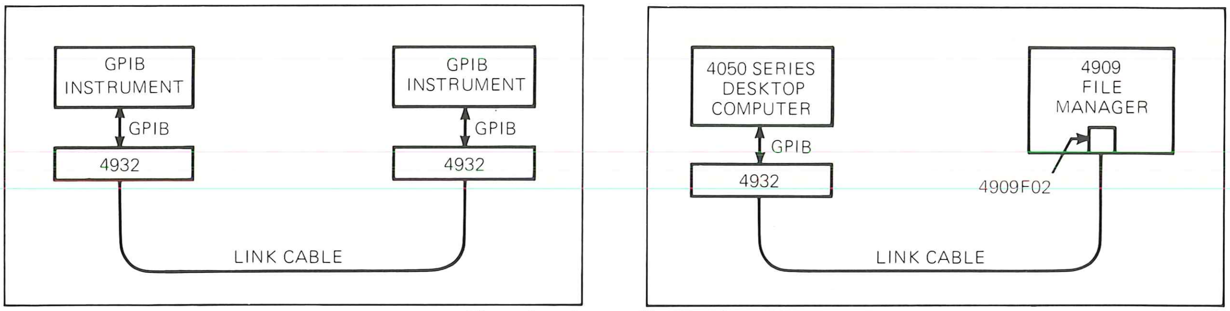
From enhanced stand-alone capabilities for R&D to GPIB system compatibility for production test, the 7D20 Programmable Digitizer plug-in puts a whole new generation of capabilities into your Tektronix 7000 Series oscilloscope. To find out more about these capabilities contact your local Tektronix Field Office or the Tektronix sales representative in your country. Or use the reply card in this copy of HANDSHAKE to request a data sheet.

New extender pushes GPIB control out to 500 meters

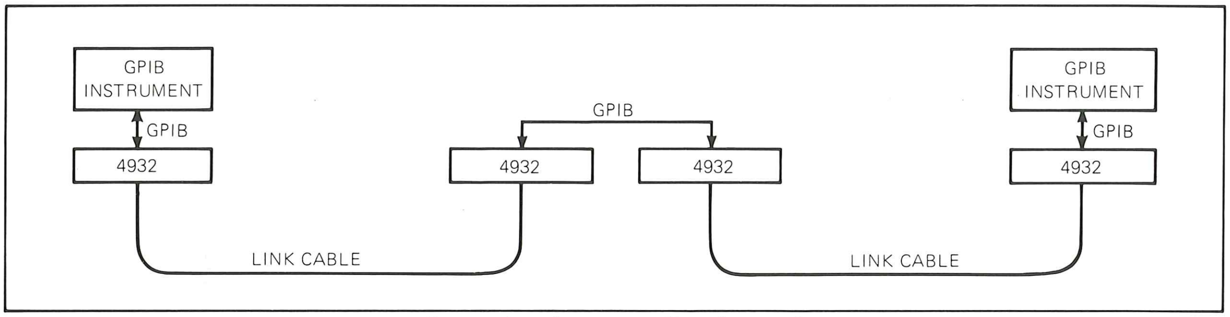




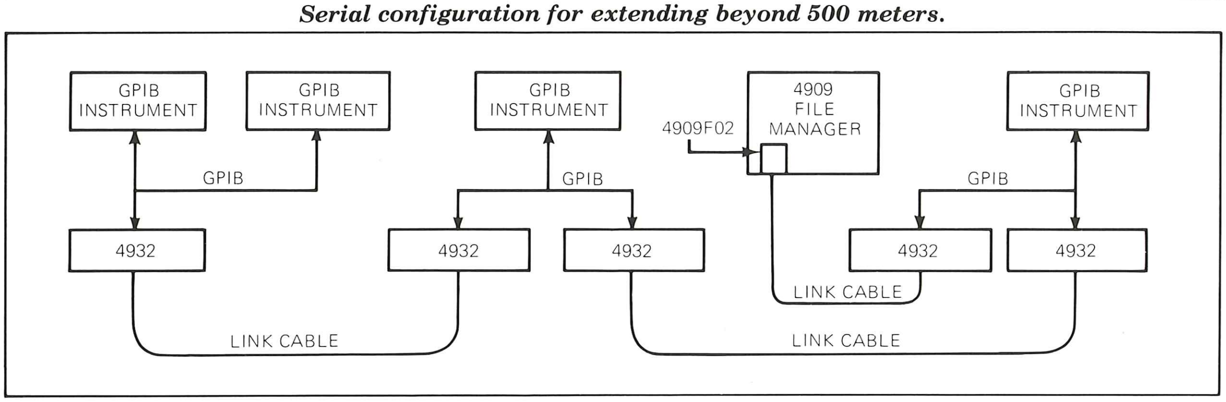
To serve your remote instrument control needs, Tektronix has introduced a new GPIB Extender. You no longer have to be limited to the IEEE 488 Standard's restriction of 2 meters per instrument and 20 meters maximum bus length. GPIB control and data transfer can now be extended to 500 meters and beyond.



Two basic configurations.



Serial configuration for extending beyond 500 meters.



Tree configuration allowing maximum flexibility in GPIB interconnection, including use of more than 15 GPIB devices per system.

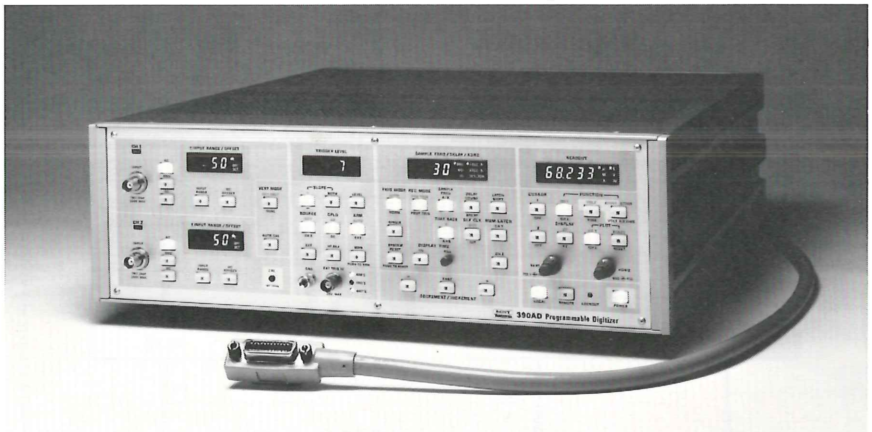
The extension capability comes from a data conversion and use of coaxial cable. An extender unit on the bus converts data from the GPIB parallel mode to a serial mode. The serial data is transmitted over a coaxial "link" cable (75-ohm RG6/U) to a second remote extender unit which converts the data back to a parallel GPIB format. Full GPIB compatibility, except for parallel poll capability, is maintained.

The coaxial "link" can be any length up to 500 meters. Data rate does, however, depend on length. At 300 meters, the rate is 20 kilobytes/second; at 500 meters, it is 5 kilobytes/second. The 500-meter length can be extended further by using two more extender units and another "link" cable. The tradeoff for additional length, though, is further reduction in data rate.

There are two versions of the GPIB Extender. The basic extender consists of two 4932 GPIB Extender units, one for each end of the "link" cable. The alternate version consists of a 4932 unit and a 4909F02 Plug-In Interface. The 4909F02 is especially designed for use with the TEKTRONIX 4909 Multi-User File Management System. The 4909 system provides hard-disk multi-user capabilities for 4050 Series GPIB controllers from Tektronix.

Several configurations using both versions of the GPIB Extender are shown in the accompanying illustrations. For further information on the 4932/4909F02 GPIB Extender, please contact your local Tektronix Field Office or the Tektronix sales representative for the country you are in.

Sony and Tektronix join in 390AD Programmable Waveform Digitizer



Available in Japan since 1980, the SONY/TEK 390AD Programmable Waveform Digitizer is now available on a world-wide basis. This GPIB compatible, 10-bit digitizer was designed specifically for applications requiring automated waveform capture in the DC to 15 MHz range. Added to dynamic range and bandwidth are long record length capabilities that make the 390AD especially effective in acquiring ultrasonic, mechanical, biomedical, seismic, and other similar waveforms.

The SONY/TEK 390AD is a monolithic, dual-channel digitizer that further expands the already large family of GPIB system products from Tektronix. Following on tradition, a well organized front panel makes instrument setup quick and easy to learn. XYZ monitor and plotter outputs offer convenient operator viewing of waveforms for setup or test monitoring. And, like all GPIB products from Tektronix, the SONY/TEK 390AD conforms to Tektronix Standard Codes & Formats—our assurance to you of interfacing and system operating ease.

An internal crystal-reference clock provides the 390AD with selectable sampling rates from 5 Hz to 30 MHz in dual-channel operation (60 MHz for single-channel operation). Sample rates can be switched during conversion time. Pre- and post-triggering capabilities are provided, with post-triggering covering an extended range of up to 9998 samples.

Digitizing is done with two-stage flash conversion. This provides 10-bit resolution with excellent dynamic range and accuracy. Separate converters are used for each of the two input channels. Waveform storage for each channel is 2048 words, with the entire 4096-word memory available for single-channel operation.

Digital readout and cursors are standard and allow some basic waveform analysis from the 390AD front panel. The cursors can be positioned and used, one alone or as a pair, for absolute or differential measurements of voltage and time. Results are displayed on the front panel and can be transferred over the GPIB to a system controller.

Of course, entire waveforms can be transferred to a controller as well. And the entire instrument setup can be programmed over the bus.

The SONY/TEK 390AD is available now for state-of-the-art waveform capture. For further specifications, prices, and ordering information, contact your local Tektronix Field Office or the Tektronix sales representative in your country.

Waveform Processing Workshops

A series of workshops on waveform processing is being made available by Tektronix at key locations throughout the continental United States. Through a balanced program of classroom lecture and hands-on laboratory exercises, participants will be able to quickly grasp basic system concepts and build system operating skills.

Included in the Waveform Processing series are the—

Signal Processing Workshop, 5 days in length

4052 Based Waveform Processing Workshop, 5 days in length

7854 Based Waveform Processing Workshop, 2 days in length

Since specific systems are used in each workshop, the training is particularly valuable to new owners of Tektronix systems. But each workshop is also a quick and economical means of gaining practical experience and knowledge prior to making an equipment purchase decision.

Free Attendance

Starting December 1, 1982, with the purchase of each Tektronix Waveform Processing System or 7854 Oscilloscope, you are entitled to one tuition-free attendance at any of the regularly scheduled workshops.

To find out more about content, schedules, and tuition, use the reply card in this issue of HANDSHAKE to request a workshop catalog. Outside of the United States, please contact a Tektronix Sales Representative for information on systems training and workshops available in your country.

Program library offers measurement solutions, programming examples

A variety of programs are available at no cost from the HANDSHAKE Applications Program Library. The programs are written in various Tektronix signal processing and instrument control languages, which are mostly enhanced BASIC. Application areas covered vary widely but include waveform graphics, automated calibration, frequency domain analysis, pulse analysis, and many others. All programs are provided free of charge as hard copy listings.

Available programs are described in the HANDSHAKE Applications Program Library Catalog. The catalog also includes a convenient program order form. For a copy of this catalog, check the appropriate box on the HANDSHAKE reply card in this issue.

Planning a test system?... Article reprints provide valuable background

Planning a test system with GPIB instruments? Two article reprints are available from Tektronix to help you. Both reprints provide valuable background, whether you are just now specifying system components or are at the stage of putting the system together and writing instrument handling routines.

One article is about waveform digitizer specifications. It provides useful insight into digitizer specifications and how they affect waveform acquisition. If you are thinking about using a waveform digitizer as part of your system, you'll want to read this article. It originally appeared in the September 1981 issue of **Electronics Test**. However, in case you missed it, article reprints are available.

The other article more recently appeared in **EDN** as a two part series (June 9 and August 4, 1982, issues). This two-part series is an in-depth treatment of GPIB system concepts from the user's viewpoint. Such items as defining the system's purpose, selecting system components, and getting the system up and running are covered in the first part. The second part takes a look at GPIB software configuration and covers power-up processing, reading status bytes, polling devices, and techniques of sending messages and data over the bus. Also included is a System-Configuration Checklist covering the important points of getting a system up and running.

For a reprint of either article, check the appropriate box on the reply card in this issue of HANDSHAKE.

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