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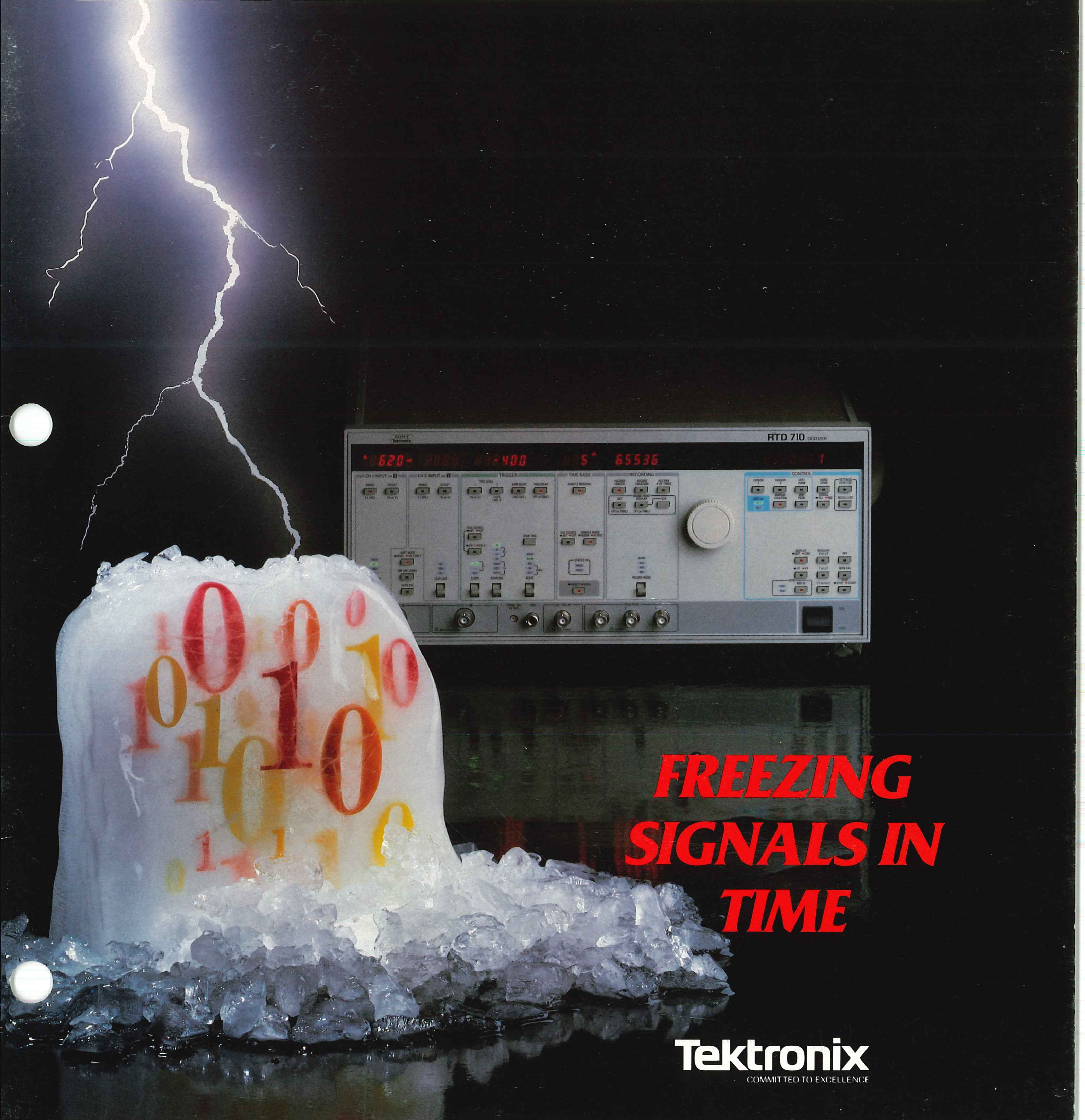
HANDSHAKE

NEWSLETTER OF INSTRUMENTATION AND INSTRUMENT SYSTEMS



FREEZING SIGNALS IN TIME

Tektronix
COMMITTED TO EXCELLENCE

Twelve years and still going

Twelve years may not seem like a long time, but in the world of corporate publishing that can be more than a lifetime. Budget changes, management changes, organizational changes, and technology changes all add up to potential challenges to the longevity of any corporate-sponsored newsletter.

But thanks to you, our loyal readers, and thanks to our many supporters within the marketing, sales, and engineering groups at Tektronix, **HANDSHAKE** proudly begins its twelfth year of publication. Our commitment remains the same — to bring you the latest information on how Tektronix measurement products can make your measurements faster, better, more accurately, or easier.

As the next few issues unfold, we'll be presenting some new ways to help you learn about making measurements along with information about some exciting new products and applications which will help with these measurements. Watch upcoming issues for these new features.

And by the way, **HANDSHAKE** is intended as a forum for our readers. We welcome articles on measurement applications and concepts. If you have an idea that you feel would be of interest to other readers of **HANDSHAKE**, send us a short summary or outline of the article. Or check the box on the **HANDSHAKE** reply card. Either way, we'll get in touch with you to help turn your idea into a finished article.

One final comment. The sincerest complement you can give us is to recommend **HANDSHAKE** to a friend or fellow worker. Please pass your copy along or give them a reply card so they can request their own subscription. Thank you in advance!

What is a handshake?

Some of you may wonder why we chose the name **HANDSHAKE** for our newsletter. Well, wonder no more.

Twelve years ago when we planned the first issue of the newsletter that became **HANDSHAKE**, we looked for a name that would be both unique and expressive of our intent. The **HANDSHAKE** name, as well as the handshake symbol which was later derived from it, have met those original goals well.

First and foremost, a handshake implies a friendly greeting. We hope that each issue of **HANDSHAKE** is received as that friendly greeting from Tektronix — a way of our showing that we are here to solve your measurement problems and to help with your measurement needs.

The second meaing of a handshake comes from the establishment of communication between a computer or controller and a measurement instrument. In that sense, **HANDSHAKE** strives to establish communication between you, our customers, and ourselves. Through this, the purpose remains the same — to help with your measurement needs. Look at this newsletter as an extension of your local Tektronix Sales Engineer or representative.

As you receive each new issue of **HANDSHAKE**, consider it our way of saying a friendly "hello" and simply asking "How are you doing? Can we help you?"

We're here to help! Let us know what we can do for you.

New "scope" for HANDSHAKE

Since it's beginning, the goal of **HANDSHAKE** has been to help you make measurements — faster, better, more accurately, or easier. We've done this through articles on new Tektronix products that advance the state-of-the-art, applications for both new and existing products, and tutorials on measurement concepts.

But these articles featured only a portion of the measurement instruments available from Tektronix — our charter was restricted to programmable measurement products — and overlooked traditional oscilloscopes. In the process, we missed a few products along the way which would help you in the overall challenge of making measurements.

With this issue, we expand our coverage to all products of the Instruments Group of Tektronix. This includes both plug-in and modular oscilloscopes, programmable and manual instruments, semiconductor curve tracers, as well as the accessories and software that allow these products to work more efficiently.

Our goal is not to abandon our original purpose but, instead, to expand upon it. To this end, note our new purpose statement on the front cover — **NEWSLETTER OF INSTRUMENTATION AND INSTRUMENT SYSTEMS.** Systems — those instruments which either feature an internal processor or work with an external controller to provide signal processing and enhanced measurements — are still at the center of our focus. In fact, most of the instruments being introduced today take advantage of these features. Those that don't, rely upon many of the same measurement principles already described in these pages.

Overall, our goal remains to help you make measurements. And we hope you find our new "scope" helpful.

FOR MORE INFORMATION: Readers in the United States can use the postpaid reply card in this issue to request a free subscription to **HANDSHAKE** or more information on products described in this issue. International readers please contact the Tektronix Sales Representative for your country. To find the address of your representative, contact the following Tektronix area offices:

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A look inside

Freezing signals in time — that's the purpose for all digitizers. The new RTD 710 provides some new ways of meeting this goal. See the article **RTD 710 — state-of-the-art in high-resolution waveform** digitizing for details on the many features of this new digitizer from Sony/Tektronix.

Another new digitizer from the Instrument Systems Integration Division (ISI) is featured in the article **7912HB — Realtime digitizing to 750 MHz**. This new instrument is part of the 7912 family of digitizers — one of the first digitizers produced by Tektronix and still going strong in this latest version.

An application article on **Modeling for EMP** shows how a digitizing oscilloscope and the companion computer can be used to accurately predict performance of a device under test.

Other new products featured in this issue include the 7F10 Optical-Electrical Converter plug-in for the Tektronix 7000-Series, new software support for the Tektronix 11000-Series, and new software packages to extend the performance of the Digital Camera System.

To round out this issue, we provide an index to the past four issues of **HANDSHAKE**. Use this index to locate articles of interest or to request back issues which you may have missed.

As always, we invite you to contact your local Tektronix Field Office or Tektronix Sales Representative for your country for more information on any of the products described in this issue or for help with your signal measurement needs. And be sure to tell them you saw it in **HANDSHAKE**.

Use the reply card in this issue to request a free subscription to **HANDSHAKE**.

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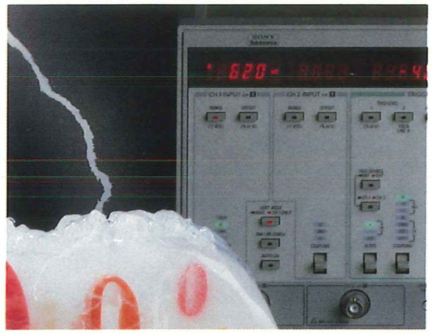

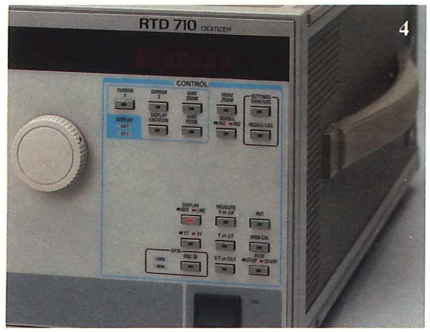

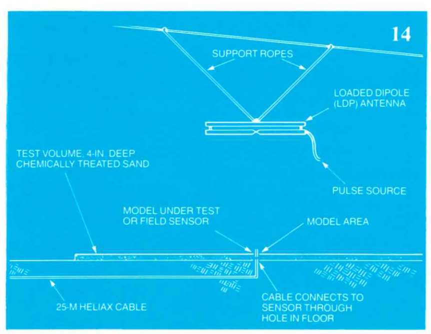

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The RTD 710 — state-of-the-art in high-resolution waveform digitizing

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Tektronix, France

The Sony/Tektronix RTD 710 Waveform Digitizer combines real-time, 200-MS/s, 10-bit waveform digitizing with record lengths to 64K words and extensive built-in triggering modes and signal processing capabilities.

There's a new standard of comparison in high-resolution, real-time waveform digitizing. It's called the Sony/Tektronix RTD 710 Waveform Digitizer.

You only need to look at four basic specifications to see that the RTD 710 is something special among waveform digitizers. The RTD 710 can digitize at rates up to 200 Megasamples/second (MS/s). It does this with 10-bit resolution and ±0.4% amplitude accuracy. And it can do it into records as long as 65,536 words, one word per waveform sample.

Digitizing versatility

A 64K record (65,536 words) and 200 MS/s — that's over 300 microseconds of continuous real-time digitizing with 5-nanosecond resolution. Or, at the slowest internally clocked rate, digitizing can span more than 3.5 hours with 200-millisecond resolution. If you don't need all of that record length, you can partition memory into as many as 64 records. Or you can share the waveform memory between the two analog-to-digital converter sections for simultaneous, dual-channel digitizing to 100 MS/s.

That's the RTD 710's pure digitizing power! Beyond that, the RTD 710 offers a wide variety of triggering modes to ensure capture of complex or obscure waveform features. Waveform capture is further supported by signal averaging, enveloping, reference envelope comparison, measurement cursors, and full programmability over a high-speed GPIB interface. And, unlike other transient digitizers, features of the RTD 710 can be accessed directly and easily from the front-panel. This allows it to serve equally well as a powerful bench-top instrument and as a GPIB component in automated test systems.

Back to the basics — Sampling and resolution

The features of any waveform digitizer are only as good as the data they work on. That means everything hinges on sampling rate, resolution, and accuracy. Basic digitizing capability — that's the heart of the matter.

The heart of the RTD 710 is a 10-bit, dual-stage flash converter (actually there are two of them, one for each signal input channel). Figure 1 shows the basic elements of the analog-to-digital (A/D) converter.

The signal for A/D conversion is first sampled by a sample-and-hold circuit. The sample is then applied to a 5-bit flash converter, which is used to obtain the five most significant bits of the signal's digital representation. These same five bits are also converted back to analog by a 10-bit D/A and subtracted from a delayed version of the original analog sample. The delay used on the original analog sample is precisely timed so that the 10-bit D/A result is in exact synchronism with the analog sample. Thus, the result of subtracting the original and the 10-bit reconstruction is an analog representation of the quantizing error left over from the first 5-bit A/D conversion. This quantizing error signal is amplified and applied to a second 5-bit A/D converter. The 5-bit conversion of the residual from the first converter results in the five least signifi-

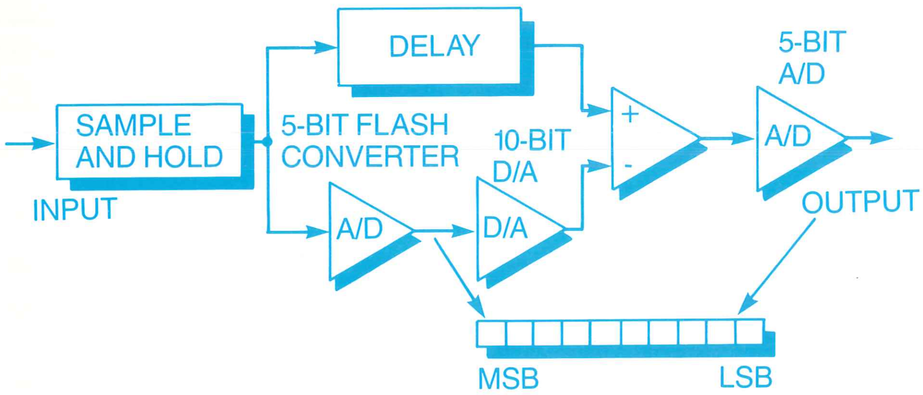


Figure 1. *High-resolution digitizing in the RTD 710 begins with a 10-bit, dual-stage flash converter that can be clocked at rates up to 100 Megasamples/second.*

cant bits of the signal, which are stored in memory beside the originally obtained five most significant bits. This, in total, provides high-speed 10-bit A/D conversion of the original sample.

The RTD 710 uses two dual-stage, 10-bit flash converters, one for each input channel. This arrangement (Figure 2) allows simultaneous, dual-channel digitizing into 32K-words of memory per channel. Simultaneous 100-MS/s clocking of the A/D section for each channel is provided by two clock signals derived from a 200-MHz, ±0.001% crystal-controlled oscillator.

When operated in the single-channel, high-speed mode, the full 200-MS/s capability can be applied to the Channel 1 input. This arrangement is achieved by interleaving the sampling clock from the Channel 2 A/D section with the Channel 1 clock (single-channel connections between blocks shown with shaded lines in Figure 2). The single-channel mode also borrows 32K words of memory from Channel 2 for a total of 64K words of memory.

The secret to interleaved sampling in the high-speed, single-channel mode lies in the Autocal capabilities of the RTD 710.

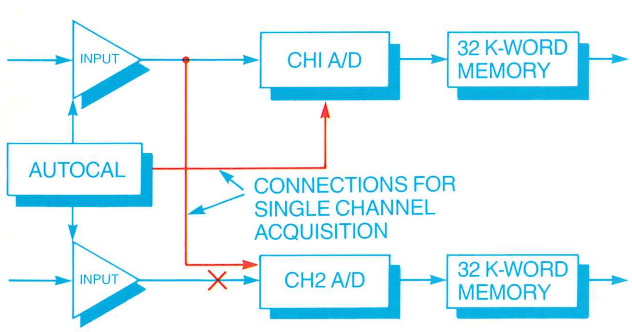


Figure 2. *Simultaneous, dual-channel waveform capture is supported by two A/D sections with coherent 100-MS/s clocking and 32K words of waveform memory per channel.*

In dual-channel mode, the Autocal circuit precisely matches the amplifiers to the A/D converter input. This provides a ±0.4% gain accuracy and ±0.2% DC drift specification. This same Autocal process is used in the single-channel mode and includes precise 180-degree phase shifting of the Channel 2 100-MS/s clock for precise interleaving with the Channel 1 A/D clock. The result is high accuracy 200-MS/s real-time digitizing for the Channel 1 high-speed mode. Moreover, this digitizing can be sustained continuously for the duration provided by the available 64K-words of waveform memory.

Sample-rate switching for maximum memory efficiency

The 64K-words of available memory proves to be more than sufficient for most waveform acquisition needs. But there are always those special cases that beg for more memory. These applications are typified by transient events with extremely fast wavefronts and long, slow decays. Or perhaps the event is actually a major event followed by post-event reverberation bursts. Because such events are transient (single-shot) there are no second chances for capture. All of the information must be taken in a single acquisition — in real-time.

Sampling such waveforms at a high rate to achieve time resolution on the fast portions automatically means wasted high-speed sampling (as well as wasted waveform memory) during slow or non-active portions of the waveform. Submicrosecond events with millisecond decays or inter-event dead times use up available memory long before the total event is over if standard sampling techniques are employed.

To prevent loss of data from inefficient memory use, the RTD 710 offers an alternative mode called sample-rate switching. This allows the A/D sample rate to be changed on the fly up to five times within a record. You can define five zones within a record, each with a completely independent and different sampling rate. This proves to be extremely important when dealing with complex or multi-rate signals.

For example, a fast-rise signal with an exponential decay can be captured in its entirety, without compromising resolution or over-running memory, by simply specifying RTD 710 capture over two zones with two different sample rates. A high sampling rate is used initially for the fast wavefront. Then the sampling is switched to a slower rate for the waveform decay. The result of this sample-rate switching on an exponential transient is shown in Figure 3. The top trace, captured with a 10-microsecond sample interval, lacks detail of leading-edge phenomena. Using sample-rate switching (bottom trace), the same signal can be recorded with a 100-nanosecond sampling interval during the fast-rise portion and then switched to a 10-microsecond sampling interval on the decay. This mode captures all information with the appropriate resolution throughout the single-shot signal.

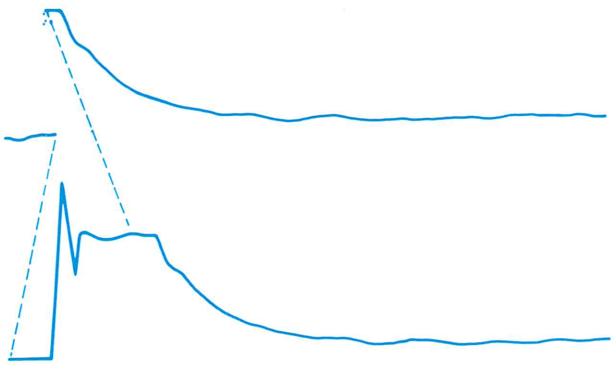


Figure 3. *A decaying signal captured at a constant sample interval (top trace) misses data on the leading edge. Using sample-rate switching (bottom trace) all information is captured with appropriate resolution throughout the single-shot signal.*

Pulse echo signals, such as those occurring in ultrasonic non-destructive testing or radar applications, present a similar capture situation. The pulse and echo (or multiple echoes) need to be captured with high resolution sampling. Yet substantially less resolution is required for the inter-pulse dead time. With sample-rate switching, the first pulse can be captured at a high sample rate. Then sampling is slowed during dead time and switched again to a high rate to capture the subsequent echo pulse.

Figure 4 shows the result. Because of the high accuracy sampling and coherent sample rate switching of the RTD 710, all of the information is captured with appropriate resolution. Also, precise timing measurement accuracy is maintained between the two captured pulses.

Besides sample-rate switching, the total RTD 710 memory (32K words in dual-channel or 64K words in single-channel) can be partitioned into multiple records as listed in Table 1. Partitioning can be taken to the extent of providing up to 64 individual 1K-word records (32 per channel in dual-channel, or 64 records for single-channel operation). These partitioned records can each be used on an individual basis for capturing and holding many diverse waveforms. Additionally, sample-rate switching can be used within all of these records, with up to five sample rate changes per record.

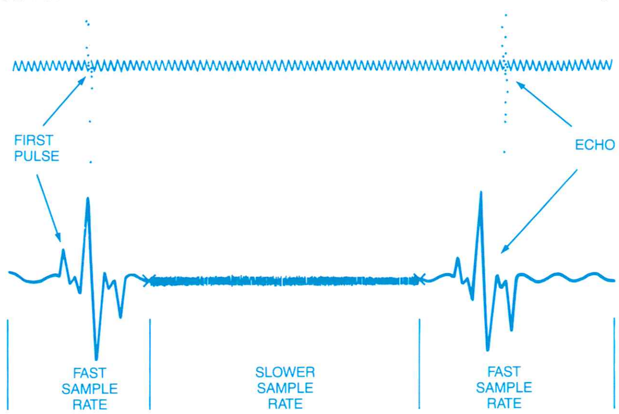


Figure 4. *A signal with two echoes recorded at a uniform sampling rate (top trace). The same signal recorded with sample rate increased during each echo (bottom trace) to capture echo detail with increased resolution and sample rate decreased between echoes to conserve memory.*

Table 1
Allowable RTD 710 Memory Partitions

Number of memory blocks per channel	Dual-channel block length	Single-channel block length
1	32,768	65,536
2	16,384	32,768
4	8,192	16,384
8	4,096	8,192
16	2,048	4,096
32	1,024	2,048
64	—	1,024

Auto advance for more versatility

The Auto Advance recording mode allows a sequence of events to be automatically captured into a series of record partitions (Figure 5). This provides another way to save memory over single-record capture approaches.

The Auto Advance mode is particularly useful for capturing random events in sequential memory segments. A typical application is in lightning experiments where it is necessary to capture all of the fast micro-discharges occurring during the event. Without Auto Advance (as well as the additional capability of sample-rate switching within each record), capturing all of the random high-speed detail would require a memory length in excess of 200 megawords. Through efficient capture methods and memory usage, the RTD 710 can compress the same information into a very manageable 64K-words of memory.

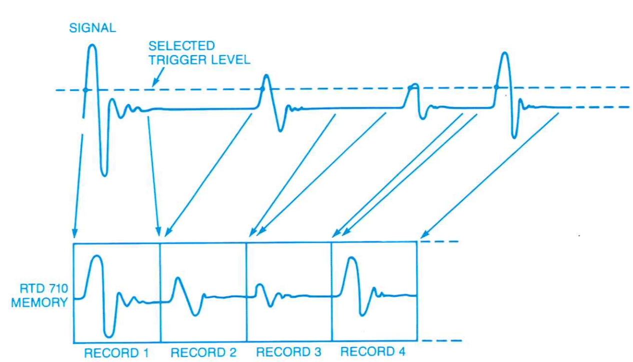


Figure 5. *Auto Advance mode provides minimum rearm time between events to automatically capture and store a series of events in sequential memory records.*

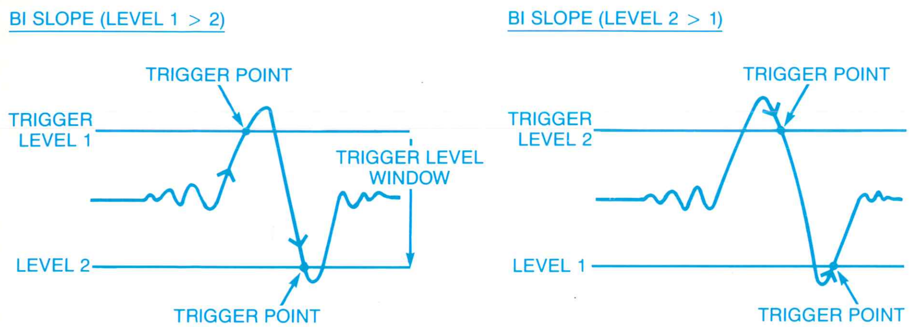


Figure 6. *Bi-Slope triggering allows capture of any signal that goes outside of (left) or enters (right) a trigger level window defined by two individual level selections. In both cases, the Level 1 setting recognizes a positive slope, and Level 2 recognizes a negative slope.*

And for those special cases ...

These special recording modes along with 64K of available memory cover the vast majority of complex waveform capture needs. But, as always, there's the occasional extreme case — the case that can't be covered by special recording modes or even 64K of memory. For these cases, the RTD 710 responds with yet another special feature. The A/D outputs for both channels are available from a rear-panel connector. This allows continuous, uninterrupted digitized points to be fed from the RTD 710 directly to an external mass-storage device (at rates and modes determined by the front-panel settings). A major benefit of this feature is that available record length is now extended to the capacity of the external memory. With the advanced high-density, high-speed storage technology available today this means record-lengths of megawords — perhaps even gigawords!

Advanced triggering modes

Of course, all of this digitizing and record length capability presumes that you can trigger on precisely the event (or events) you want to capture. This hasn't always been possible with conventional waveform digitizers and digital storage oscilloscopes. But that's changed with the RTD 710 which offers a collection of the most advanced triggering capabilities developed to date.

Auto advance triggering and more. Auto Advance recording, for random event capture into sequential records, has already been discussed. This mode, as well as conventional triggering modes (normal, single, pre- and post-triggering) are all provided on the RTD 710. Triggering is further simplified by precision trigger level setting with a direct LED readout of trigger level in 1% increments over ±99% of full scale. Moreover, triggering can be set and displayed in either percent or volts.

But that's just the beginning. You can also set up triggering so it ignores or triggers on certain waveform attributes. The simplest case is selection of plus or minus trigger slope. And, if you're not sure what the slope will be, Bi-Slope triggering allows triggering on either slope.

Bi-slope triggering. While Bi-Slope triggering, isn't new, the RTD 710 carries it substantially further than previous implementations. With the RTD 710, you can also set two individual trigger levels that operate in conjunction with Bi-Slope operation. The simplest application of this is catching signals of either polarity (slope) as shown in Figure 6. In the first case with the Trigger 1 level set for a positive signal and Trigger 2 for a negative signal, triggering occurs whenever the signal goes outside of the Level-1/Level-2 triggering window. For the opposite case with Level 2 triggering set higher than Level 1, triggering occurs when the signal enters the window.

Hysteresis triggering. Hysteresis triggering is another RTD 710 triggering mode that uses two trigger level settings. In this mode, the trigger level settings control trigger sensitivity by varying the hysteresis width. This is very useful, for example, in obtaining stable triggering on noisy or high aberration signals. The various modes of + and − hysteresis triggering are illustrated in Figure 7.

Referring to Figure 7A, positive-hysteresis triggering works in the following manner. When a positive-going signal crosses the trigger Level 1 setting, a trigger pulse is generated. After this, triggering will be reset only when a negative-going signal transition crosses trigger Level 2. Once reset, the next trigger occurs when Level 1 is crossed again by a positive-going signal transition. The effect of this in Figure 7A is to reduce trigger sensitivity to avoid triggering on the second aberration peak of the signal. On the other hand, sensitivity could be increased by setting Level 2 just below Level 1. This would allow

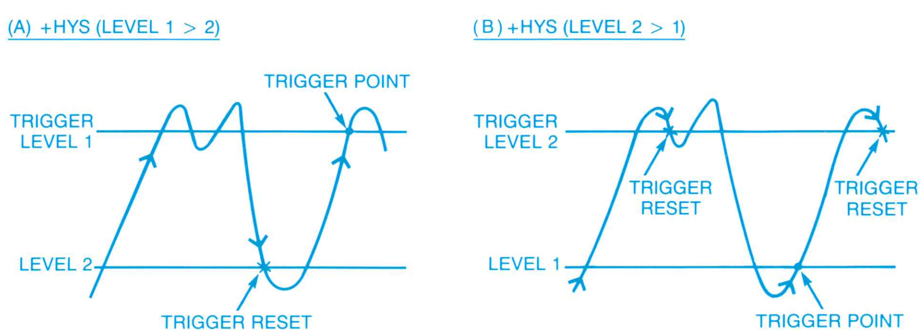


Figure 7. *Hysteresis triggering allows trigger sensitivity to be set for noise and aberration immunity (or sensitivity).*

reset to occur on the negative-going peak aberration, and triggering would then occur on the next immediate peak. Figure 7B shows the effect when Level 2 is set higher than Level 1.

Compare mode triggering. Compare Mode triggering provides further triggering versatility. In the strictest since, this isn't a triggering mode, but in operation it appears to "trigger" the capture of a compare event. In this mode, the input signal is digitized and compared against a stored waveform template or envelope. If the input signal crosses the bounds of this template at any point, the signal causing the boundary violation is automatically stored as a Compare Mode event.

There are actually two Compare Modes, Compare Out and Compare In. The Compare Out mode captures any event that goes outside of the limits envelope bounds. This is useful for example in monitoring a DC power bus for switching spikes or for droop or surge from load changes. The normal DC signal is centered within the boundary envelope, and Compare Out monitors the signal and captures any glitch, droop, or surge conditions that go outside of the boundary.

Compare In operates in the opposite manner. In this mode, some part of the monitored signal is normally outside of the compare envelope or template. If the waveform should ever be completely within the envelope zone, that occurrence is automatically captured as a Compare In event. This can be used, for example, as feedback for robotic adjustment stations.

This built-in automatic monitoring and capture capability of the Compare Out and Compare In modes extends the usefulness of the RTD 710 as a standalone bench tool. The RTD 710 can be left unattended for as long as needed to capture infrequent events. In the same manner, the Compare Modes also increase the efficiency of the RTD 710 as an automatic test system component. For example, limits envelopes (test templates) can be downloaded from the system controller to RTD 710 memory. Then the RTD 710 can act in an independent monitoring and capture mode using the appropriate Compare Mode. This frees the system controller from the task of continuous digitizer waveform transfers and limits analysis. The RTD 710 does the work and only interrupts the controller when it has a captured compare event to transfer.

Still other modes and options

All of the capabilities discussed thus far are further enhanced by other RTD 710 modes. External triggering is provided of course. But along with it (as well as with internal triggering) an external trigger arming mode can be used to delay or hold off triggering. For example, an external arming pulse could be the output of an event counter, or it could be a logical combination of events (ANDed, ORed, etc.), a word recognizer output, or any other qualifier for delaying triggering until a desired count or condition is reached.

As an option, the RTD 710 can be ordered with TV triggering capabilities. This is in addition to the standard triggering features described above, and it gives the RTD 710 the ability to provide stable triggering on a specified line of any type of video signal. You can select field one or field two and trigger within a field on any line number from 1 to a maximum of 1280.

The TV Trigger option along with the 100-MHz bandwidth and 200-MS/s sampling (5-nanosecond time resolution) combine to make the RTD 710 ideal for high-resolution video research, engineering, or production. These capabilities allow digitizing of a complete line into 12,800 points for very precise measurement on signals such as 2T pulses or modulated 20T pulses like those shown in Figure 8.

Measurement capability

With all this acquisition capability, the important test still is making measurements on the acquired signal. The RTD 710 has both manual measurement capability using cursors and on-board signal processing for automated applications.

Cursor measurements. When the RTD 710 is used with an external X-Y monitor, cursors can be displayed to give absolute and relative time, voltage, and frequency measurements. If cursor 1 is used, time and frequency measurements are referenced to ground. If both cursors 1 and 2 are used, all measurements are referenced from cursor 1 to cursor 2, giving the delta between the cursors. Measurements can be made with one cursor on the channel 1 waveform and the other cursor on the channel 2 waveform.

Internal signal processing. There are several signal processing commands built into the RTD 710. The commands available are: MAX, MIN, TOP, PEAKTOPEAK, NCROSS (find negative crossing), and PCROSS (find positive crossing). The measurements can be windowed using either cursors or computer control so the answers returned are in relation to the points of interest. These commands can also be used to segment a waveform for transfer to the computer for further analysis.

Need more information?

Unfortunately, there just isn't enough room in this article to fully describe all of the capabilities of the RTD 710. Some of the major features have been touched on here along with some brief application examples. The following RTD 710 Technical Notes provide additional information and technical details:

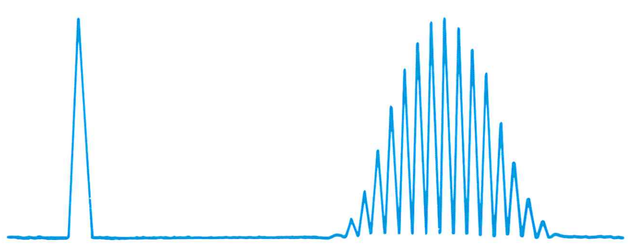


Figure 8. *Examples of 2T and modulated 20T pulses acquired by using the TV Trigger option. Acquisition was done with a sampling rate of 200 MS/s, allowing timing measurements to 5-nanosecond resolution.*

- 45W-6591 — High-Resolution Waveform Capture with the RTD 710 Advanced Recording Modes
- 45W-6592 — Synchronizing the RTD 710 with External Events: General Concepts
- 45W-6593 — RTD 710 Advanced Triggering Techniques
- 45W-6594 — Introduction to the RTD 710 Waveform Digitizer and Its Front Panel Features

To obtain any of these Technical Notes, or for further technical or application information on the Sony/Tektronix RTD 710 Digitizer, contact your local Tektronix Field Office or representative. For a brochure and data sheet or for copies of all available technical notes, check the appropriate boxes on the **HANDSHAKE** reply card.

Editing and consulting for this article provided by Robert W. Ramirez, Signal Processing Consultant, North Plains, OR.

7000-Series scopes "see the light"

7F10 Optical-Electrical Converter allows fiber-optic signals to be measured directly with a 7000-Series oscilloscope.

The Tektronix 7F10 Optical-Electrical Converter plug-in allows Tektronix 7000-Series oscilloscopes to literally "see the light". The 7F10 plugs into a single vertical compartment, converting any Tektronix 7000-Series mainframe into an optical oscilloscope. Input range is 700 to 1550 nanometers, offering a bandwidth of 10 KHz to 750 MHz (in 7104 Oscilloscope) for either single-mode or multi-mode fibers. An optical attenuator providing attenuation of up to 37.5 dB in 2.5 dB steps is built in. Both the deflection factor and attenuation are displayed on the screen using the 7000-Series readout system.

Measuring light

The 7F10 opens a variety of new measurement opportunities to oscilloscopes. An obvious application is the design and test of fiber-optic communications equipment. Another area is testing the transmission quality of fiber-optic cables — both during manufacture and after installation.

Direct monitoring of the output from lasers which operate within the range of the 7F10 is another application. This converts the optical output of the laser to measurable electrical phenomena, allowing easy monitoring of amplitude, frequency, and waveshape.

Capitalizing upon the low susceptibility of fiber-optic transmission systems to electro-magnetic interference (EMI) and its high-speed data transmission capabilities, the 7F10 can be used to monitor tests under high-noise conditions (Figure 1). The test signals are sensed at the source, converted to light impulses, and launched into the fiber by an optical transmitter. At the receiving end, the 7F10 converts the optical signal to an electrical signal for display and measurement on the oscilloscope CRT. When used with a programmable digitizer, this signal can also be captured for further analysis.

An added benefit of this fiber-optic data transmission is data security. The data in a fiber-optic system cannot be monitored in an unauthorized manner unless the transmission line itself is compromised. This intrusion can be easily detected using optical TDR techniques.

For more information

Can the 7F10 Optical-Electrical Converter solve an optical measurement problem for you? For further information, contact your local Tektronix Field Office or representative. For a data sheet, check the appropriate box on the **HANDSHAKE** reply card.

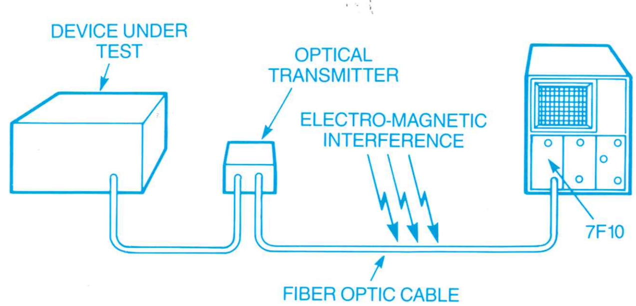
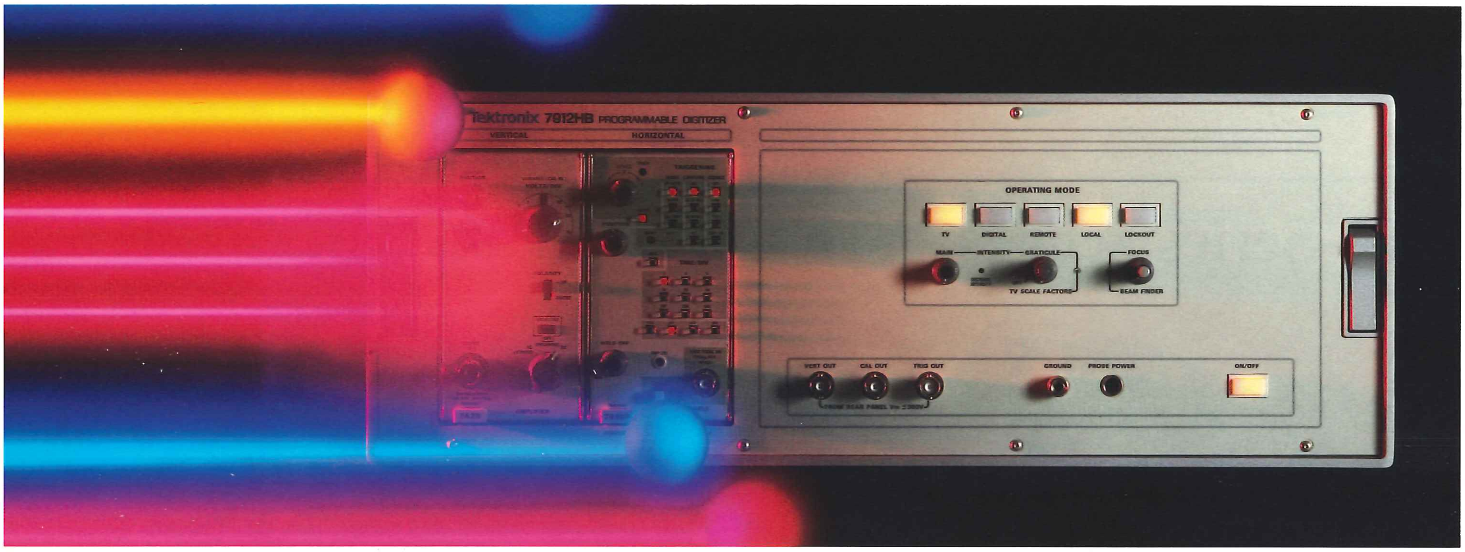


Figure 1. *The 7F10 can be used to monitor test signals in high-noise environments.*

7912HB — Real-time digitizing to 750 MHz

Craig Bulmer
ISI Digitizer Marketing
Instrument Systems Division
Tektronix, Inc.



The Tektronix 7912HB Programmable Transient Waveform Digitizer offers a 750-MHz mainframe bandwidth with 9-bit real-time digitizing and time resolution to 10 picoseconds/point.

The 7912HB is the newest member of the 7912 Programmable Digitizer family. The "HB" in this new instrument version stands for High Bandwidth, and the 7912HB delivers that with real-time digitizing capability to 750 MHz for single-shot events.

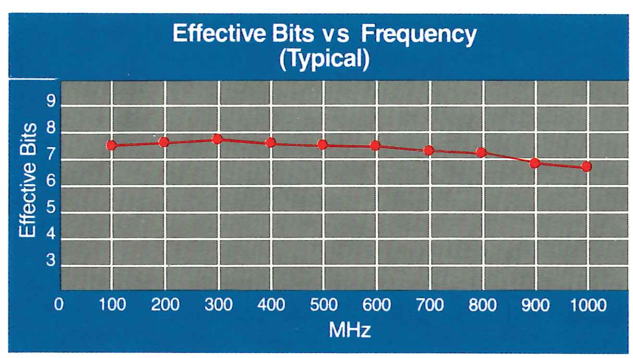
This expanded bandwidth offers extended sub-nanosecond resolution — to 10 picoseconds/point — for a variety of applications in both defense and private sector research. Areas sure to benefit from this additional bandwidth include:

- Laser research
- High energy physics
- Fluorescence decay
- Fiber optics
- EMP and lightning strike studies
- Semiconductor research
- Pulse/echo studies (ultrasonics, LIDAR, high-speed stimulus/response, etc.)

High-speed 9-bit scan conversion

A Tektronix-developed scan converter provides real-time digitizing for the 7912HB (see sidebar entitled **Scan Conversion**). The result is single-shot capture capability for signals to 750 MHz (−3 dB point) with high resolution for amplitude and time information. This scan converter provides exceptional dynamic accuracy over a broad range of frequencies (Figure 1). The scan converter's electron beam, driven by the waveform being captured, traces the waveshape onto a 512 x 512 diode-array target by discharging array diodes. This stores the waveshape in the target array, all in a single real-time sweep.

Waveform data can be read from the target diode array by one of two methods. One method is TV mode scanning, which allows direct display of the waveform data on a TV monitor. The other method is the digitizing mode, which reads the raw target data into an internal memory. Internal processing can be used to provide either a data envelope or averaged-to-center-trace results representing 512-point, 9-bit digitizing of the original waveform.



Note: Effective Bits (Typical) determined by least squares sine wave fit. Amplitude 50% full scale, Amplifiers 7A29 (vertical) and 7B90P (Horizontal). ATC Data, data has not been software corrected for geometry nor timing.

Figure 1. *The 7912HB dynamic accuracy, expressed as effective bits.*

While this scan conversion technique is the optimum method for capturing high-speed transients, it's also just as effective for capturing repetitive waveforms. The high bandwidth of the 7912HB and its 10-picosecond/point resolution assure exceptional definition on both transient and repetitive waveforms. Additionally, the built-in signal averaging can be applied to repetitive waveforms for improved definition and signal-to-noise ratio.

Plug-in selection to 525 picoseconds

Several input amplifier plug-ins can be selected for the 7912HB, depending on input bandwidth and risetime needs. The vertical amplifiers provide the signal conditioning needed to support a wide range of signal amplitudes while maintaining signal integrity. Table 1 lists these recommended plug-in amplifiers and their bandwidth/risetime specifications when used in the 7912HB.

Table 1
7912HB Performance with
Various Plug-In Vertical Amplifiers

Plug-In Amplifier	Bandwidth (-3 dB)	Risetime
7A16P	200 MHz	1750 ps
7A19	500 MHz	750 ps
7F10 (optical input)	500 MHz	750 ps
7A29	700 MHz	525 ps

In addition to a vertical amplifier plug-in, a time base is also required for 7912HB operation. The 7B90P, 7B92A, or 7B10 are the recommended time base plug-ins. Each provides calibrated sweeps to 500 picoseconds/division, with the 7B90P having the advantage of programmability.

Full programmability

The 7912HB mainframe is programmable via the standard GPIB interface, allowing access to internal data processing functions and waveform transfers from its internal memory to an external controller. When used with 7B90P Programmable Time Base and 7A16P Programmable Amplifier plug-ins, the 7912HB becomes fully programmable over the GPIB (IEEE 488) interface. Highest performance, however, is obtained with the 7A29 vertical plug-in, which provides 700-MHz bandwidth and 525-picosecond rise time.

Except for the addition of an instrument mainframe initialization command, the command set used for the 7912HB is the same as used for the 7912AD. Thus, if you are currently using a 7912AD, you can move directly to the higher performance provided by the 7912HB without rewriting instrument control programs.

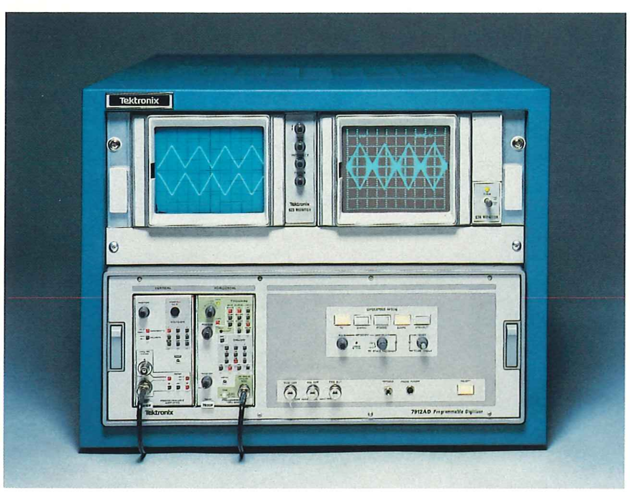
Ready-made systems

For either standalone or system applications, the 7912HB is also available in several measurement packages (Figure 2). The MP 1101 package includes the 7912HB with plug-ins (7A16P and 7B90P) and monitors (620 and 634). Cables, mounting hardware, and a cabinet are provided for configuring the equipment into a single measurement package. This package can be used as a standalone, high-bandwidth storage oscilloscope, or it can be connected to an instrument controller via the GPIB interface.

A second package, the MP 2101, adds a 4205 Color Graphics Terminal, a 4041 System Controller, and special MP software. This software provides waveform acquisition, storage, and analysis capabilities (min, max, FFT, convolve, correlate, etc.) through simple menu selections.

For more information

To find out more about the new 7912HB, its measurement packages, and applications, contact your local Tektronix Field Office or sales representative. For a data sheet on the 7912HB, check the appropriate box on the **HANDSHAKE** reply card included in this issue.



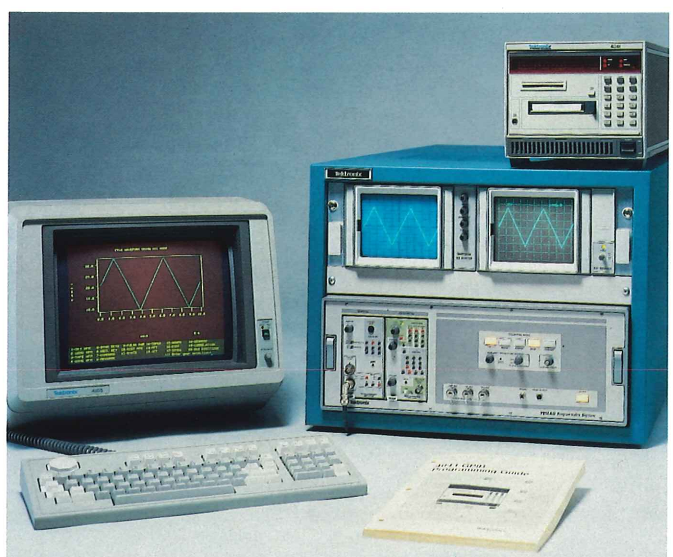


Figure 2. *7912HB is available as part of several measurement packages. Left, MP 1101 Programmable Digitizer package; Right, MP 2101 Acquisition/Processing Measurement package.*

Scan conversion

Scan conversion converts a signal from one data rate to another. In the 7912HB, scanning converts a very high speed analog input signal to one of two output formats — TV or digital.

The 7912HB uses two scanning systems to convert the input signal to the desired output signal. Figure A shows the T7910 scan-converter tube which consists of two facing electron guns with a scan-converter target positioned between them. This is conceptually the same as two CRTs joined at the target.

The input signal is applied to the high-bandwidth writing gun which functions similar to a high-performance oscilloscope CRT. The writing gun has a 1 GHz bandwidth with the vertical plates driven by the input signal and the horizontal plates driven by a triggered sweep ramp from the time base. The reading gun operates similar to a video camera, scanning the target either at a TV scan rate or a rate optimized for digital data transfer.

The target is a 512 x 512 array of diodes formed on a silicon wafer (Figure B). The low-speed reading beam continuously scans the target. This scanning reverse biases each diode in the array.

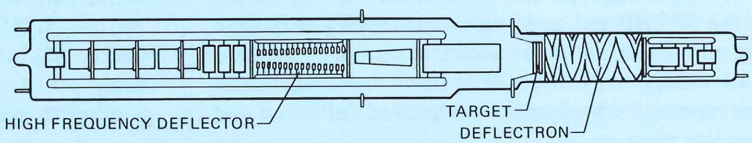


Figure A. *The T7910 scan converter tube.*

When a high-speed input signal is applied to the 7912HB, the writing gun writes the waveform on the target by forward biasing the target diodes. Then, as the reading gun scans one of these "written" diodes, more beam current is required to reverse bias the diode. This change in beam current is sensed and the resulting signal is used to reconstruct a low-speed representation of the high-speed input signal. This arrangement of a shared target between a fast writing gun and a slower reading gun results in a fast input, slow output digitizer which allows high analog bandwidth (750 MHz) with high amplitude and time resolution.

Scan rate of the reading gun is determined by the output format desired. For TV format, the target is scanned horizontally (Figure C) at a standard 525-line rate (625-line rate with Option 13). This allows the high-speed input signal to be viewed on a relatively low-frequency TV monitor. In the digital format, the target is scanned vertically in a 512 x 512 point format. This signal can be processed by a computer to produce a digital representation of the input signal.

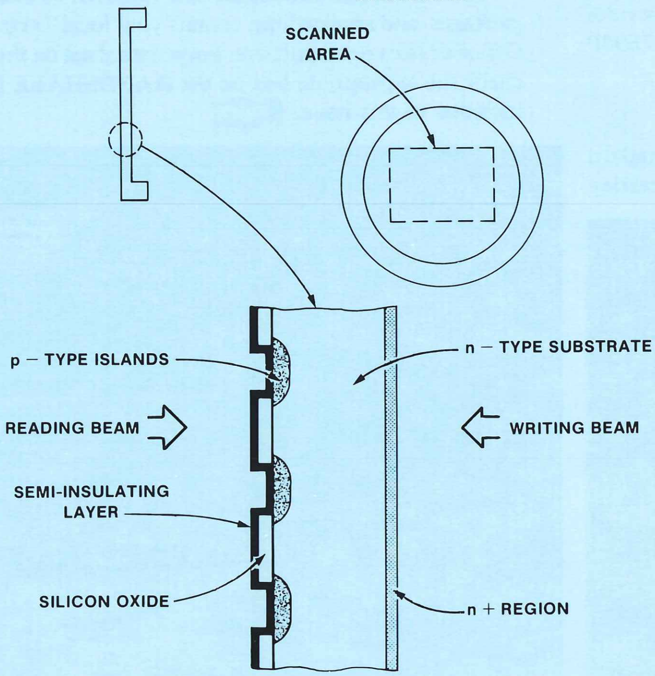


Figure B. *The read and write beams scan a 1.3 x 0.95 centimeter area of the target. The target density is about 800 diodes per square centimeter.*

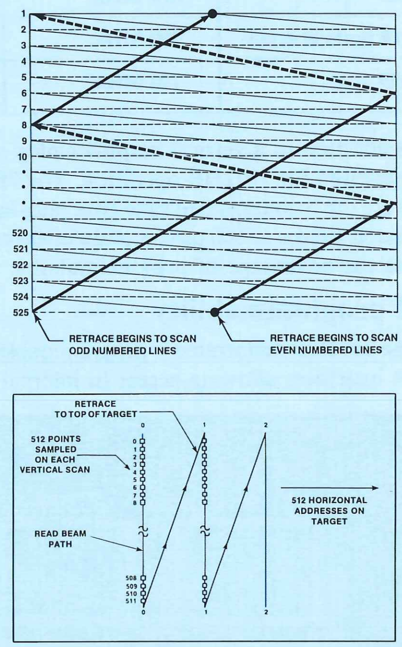


Figure C. *Reading gun scans target horizontally at a 525-line rate (optionally 625-line rate) in TV mode (top). In digital mode, target is scanned vertically in a 512 x 512 point format (bottom).*

Software support for the Tektronix 11000-Series

Three new software products supporting the Tektronix 11000 Oscilloscope family are now available. Two of these products provide basic utility functions for the 11300 and 11400 Oscilloscopes. The third provides support for the 11400-Series when used with the ASYST software package — a product of the MacMillan Software Company (see **Get an assist in your signal processing measurements** in the Fall 1986 **HANDSHAKE**).

If you would like to know more about the 11000 Series Oscilloscopes, see the Winter 1986/87 **HANDSHAKE**.

11000-Series Utility Software

The two utility software packages are function-key driven software products for the IBM PC, PC/XT, PC/AT, or compatibles, in support of either the 11301/11302 Programmable Oscilloscope or the 11401/11402 Digitizing Oscilloscope. They each consist of a stand-alone executable program, sample waveform and measurement data files, and source code that is compatible with either IBM BASIC Compiler Version 2.0 or Microsoft QuickBASIC Version 2.0. Communication with the oscilloscopes is available either through an optional GPIB card or the standard RS-232 communication port, COMM1.

These software packages provide an easy to use interface to the most desired instrument utility functions. Waveforms or instrument front-panel settings can be archived to floppy or hard disk. Instrument-based measurements (such as maximum, minimum, frequency, etc.) can be acquired and automatically logged to disk files. Logging can occur at selected time intervals, on operation complete, or by user selection through activation of a probe-tip button or the RQS icon). Maximum, minimum, standard deviation, most frequent value, and mean value are computed from logged measurement data files. Waveforms and histograms of measurement data can be graphed and hardcopy dumped to a standard graphics printer. ASCII-language interface commands can be transmitted over the RS-232 or GPIB interfaces.

In addition, the 11400-Series Utility Software provides for the acquisition of waveforms in average, envelope, % fill, or single-trigger modes. The 11300-Series Utility Software also provides for the creation, storage, and down loading of "template" waveforms.

Measurement data files are easily imported as ASCII text files to such software packages as Lotus 1-2-3 and Framework for incorporation into spreadsheets for further analysis, graphing, or inclusion in reports.

An ASYST for the 11400-Series

The 11400 Series Driver for ASYST is a function-key driven software package supporting the 11401/11402 Digitizing Oscilloscopes in the ASYST software operating environment. Written in the ASYST source language, the 11400-Series Driver Software for ASYST provides an easy, menu-oriented interface to some of the more commonly needed instrument functions. ASYST modules 1, 2, and 4 are required for operation.

Function-key access is provided for archival storage of waveforms and front-panel settings, acquisition of 11400-Series measurements and subsequent logging to disk files, screen graphing of either waveform or measurement data files, hardcopy dump of screen graphics, transmission of ASCII language interface commands from the keyboard, and computation of FFT and display of frequency spectrum.

Instrument interfacing is either through an optional GPIB card or the standard RS-232 interface in the computer. Acquired waveform or measurement data is left in a format that can be easily analyzed using normal ASYST commands.

Ordering information

To order any of these software products, call the Tektronix National Marketing Center 1-800-426-2200 (in Oregon, call 627-9000 collect). Or contact your local Tektronix Field Office or sales representative. And be sure to tell them you saw it in **HANDSHAKE**.

For data sheets describing these products, use the **HANDSHAKE** reply card included in this issue.

Modeling for EMP

A method of predicting the field radiated by a pulse-driven antenna

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Measurement overview

The radiated free field, as measured from a pulse-driven antenna, is normally recorded as a waveform. The measured peak amplitude is then compared to a calculated value. To perform the calculation, the variables of antenna impedance, applied peak voltage, and the distance from the antenna to the measurement point are required. A possible error source for this calculation is the antenna impedance value which varies as a function of the antenna geometry and length.

For this application, a computer-based system using a digital processing oscilloscope was used to apply the measurement techniques of time domain sampling, signal averaging, and time shifting, resulting in a waveform which is representative of the antenna feed-point impedance as a function of geometry and length. By also measuring and recording the time domain variations of the pulse applied to the antenna, it is possible to predict the radiated nonground-reacted field as a function of time by substituting the impedance and pulse-applied waveforms in the formula and performing the calculations in the computer for each instant in time.

Predicting response with scale modeling

Harry Diamond Laboratories conducts electromagnetic scale modeling to predict the responses of the external receptors of various Army systems to a simulated field. This is a scale representation of conditions that result from a high-altitude nuclear explosion. The high-altitude electromagnetic pulse (HEMP) field simulation is created by radiating a pulsed field from a biconical-dipole antenna. The resulting field induces currents on the receptors of the model under test, which are sensed and coupled to recording equipment housed in a shielded enclosure (see Figure 1).

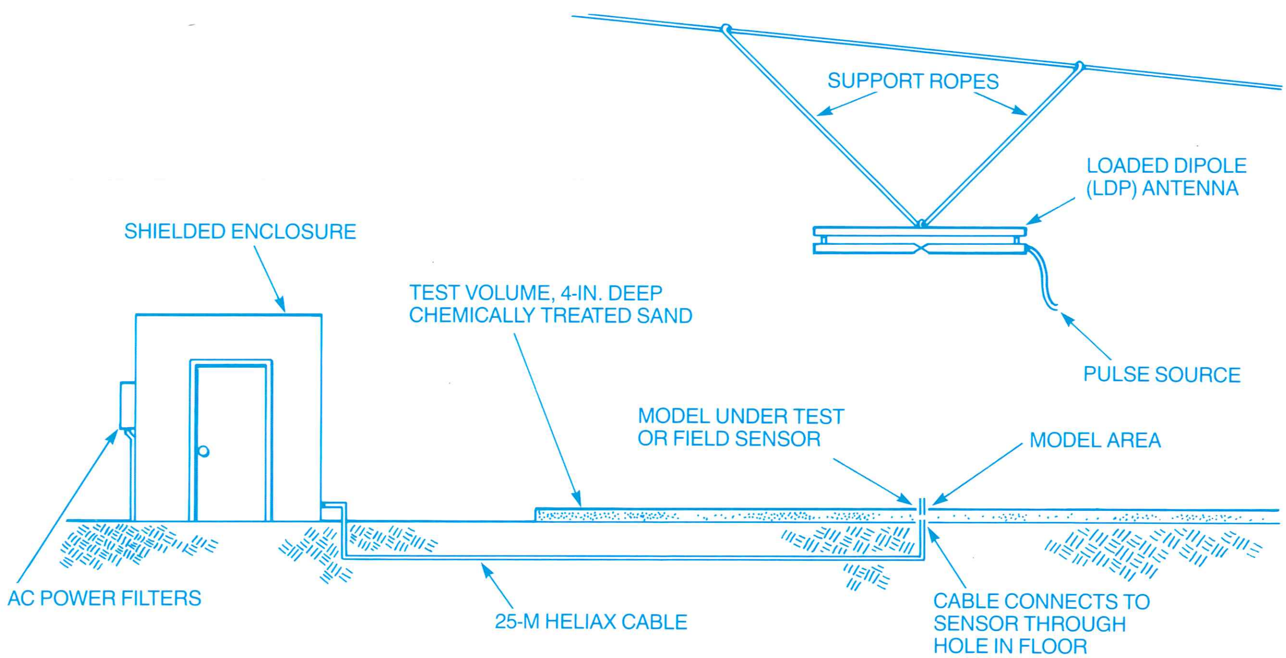


Figure 1. *Physical setup for model under test.*

The repetitively pulsed field, with a rise-time in the sub-nanosecond region, induces fast-rising responses in the model. To adequately record these fields and model responses, a measurement system with an effective bandwidth of 10 GHz is required. This is achieved by using a computer to control a digital processing oscilloscope which is capable of time domain sampling. Computer control yields the further benefit of signal averaging for these repetitive, but quite small, responses. Averaging greatly increases the effective signal-to-noise ratio of the measurement system. The computer may also be used to process the captured waveforms in other ways.

The measurement system used consisted of a Tektronix Digital Processing Oscilloscope with a 7S12 TDR/Sampler, S-6 Sampling Head, and S-53 Trigger Recognizer. A Tektronix 7M11 Delay Line provides a trigger for the 7S12. The system is controlled by a computer running TEK SPS BASIC software.

Making the measurements

It's a relatively simple matter to record the pulsed field which is radiated by the biconical/dipole antenna shown in Figure 1. The electric and magnetic fields produced by this antenna are sampled by the appropriate sensor and transmitted to the recording instruments by a high-quality coaxial cable. To assure that these measured values are correct, a calculation is made which predicts the theoretical peak free-field amplitude of the electric field (see Figure 2). The formula applied is:

$$E_{pk}^{inc} = \frac{V_o}{r\, Z_k(\sin\theta)} \qquad [1]$$

where:

V_o = driving voltage peak at the bicones
r = radial distance in meters
Z_k = antenna impedance in ohms
$\sin\theta$ = sine of angle (theta), relative to the equatorial plane of the antenna

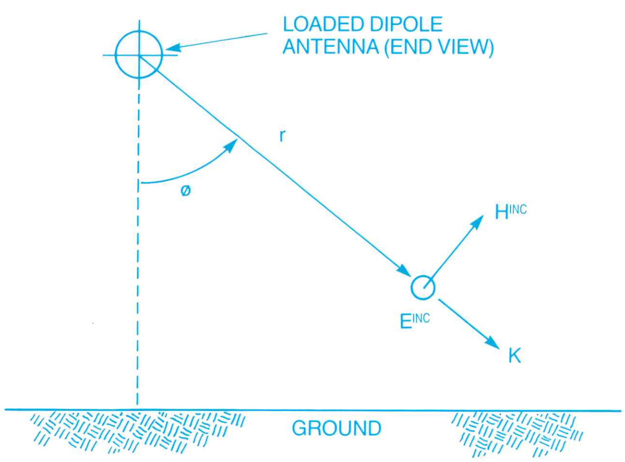


Figure 2. *Physical relationship of field quantities to antenna and ground (k = propagation vector).*

The sine term becomes 1 by making the measurement in the equatorial plane (the plane normal to the axis of the antenna bicone feed point), and the distance term is simply obtained by measuring from the point in space (sensor position) to the antenna. The peak voltage of the driving pulse may be measured as seen in Figure 3. Note, however, that this value is not the applied voltage, V_o.

The actual voltage applied to the loaded dipole antenna (LDP) is dependent upon the impedance mismatch which occurs at the interface of the coaxial cable and the bicone feed point. The need to know the antenna impedance is therefore two fold, in that the mismatch will effect the applied voltage term in the numerator, and is further required in the denominator as the Z_k value.

The theoretical characteristic impedance of a bicone antenna of fixed geometry and infinite length may be found in many antenna text books. For the leading edge of the applied pulse and a very short time afterwards, the LDP antenna may be considered to approximate a bicone with an impedance of about 330 ohms. The bicones have a half-angle of 7.5 degrees and the theoretical impedance may be calculated or found in tabular form in several publications on antennas.[1] Once this impedance is known, the output voltage (V_o) may be found by:

$$V_o(t) = V_a(t) + V_{ref}(t) \qquad [2]$$

where:

$V_{ref}(t)$ = reflected voltage at the mismatch as a function of time.

or:

$$V_o(t) = V_a(t) + [(Z_l - Z_o)/(Z_l + Z_o)] * V_a(t) \qquad [3]$$

where:

Z_l = Z_k = 330 ohms

Z_o = 50 ohms (coaxial cable impedance)

As an example, at time (t) when the applied votage is at its peak value of 420 volts, the output voltage would be approximately:

$$V_o = 420 + [(330 - 50)/(330 + 50)] * 420 = 730 \text{ volts}$$

From this and formula [1], the electric field may be estimated by:

$$E_{pk}^{inc} = (60 * 730)/(1.8 * 330)$$

where:

1.8 = radial distance in meters and the sine term has a value of one.

This yields an approximate peak electric field of 74 volts/meter.

[1] *e.g., John D. Kraus, Antennas, 1st Edition, McGraw Hill, New York, 1950, pg 222.*

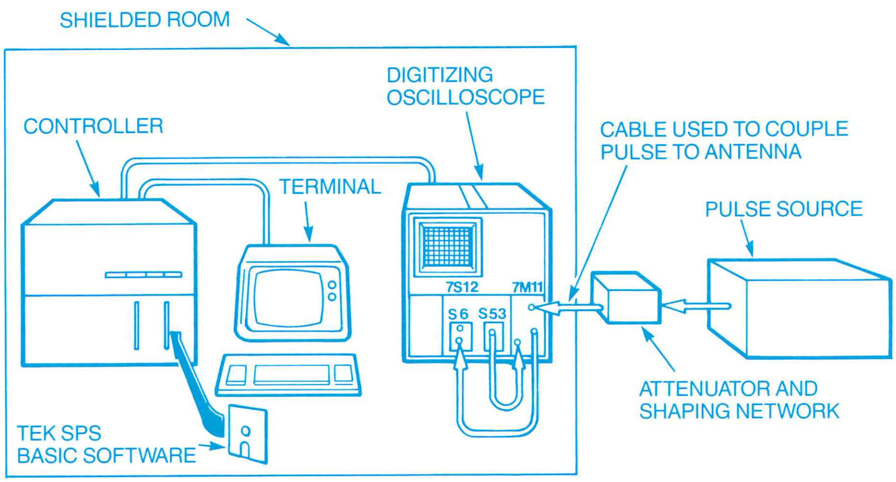


Figure 3. *Equipment setup for measuring the applied source.*

Reconciling the differences

In a recent modeling effort, the calculated (using the above method) and the measured fields were found to not be in close agreement — the calculated value being some 30% less than the measured. It was reasoned that, since the instrumentation provides for time domain reflectometry and A/D conversion with digital format waveform storage, we could create programs for the computer which would more accurately approximate the field. The result desired was a waveform representing the free field at a given point in space.

This calculated waveform is obtained by applying the values found in the driving pulse and the antenna impedance to the formula, with the calculation being made for each instant in time for both variables. The first step is to observe and record the LDP feed-point impedance.

A BASIC language program was written to make use of the TDR capabilities of the digitizing oscilloscope. This program converts the observed reflection at the bicone-to-coaxial cable interface to a waveform in which the impedance is recorded. The results (see Figure 4) show that the impedance does not achieve the theoretical value until some seven nanoseconds have passed (about eight nanoseconds from time zero).

> **NOTE:** *Program listings not included for brevity. For a copy of the program, write to the* **HANDSHAKE** Group.

Next, the coaxially-coupled pulse (V_a) is measured and recorded as it was at the antenna end of the drive cable. This waveform (Figure 5) is seen to have a peak value of about 423 volts, which is achieved in something less than one nanosecond. Note that both the impedance and applied pulse waveforms are recorded for identical time windows of 10 nanoseconds and that they both begin their base line transitions at the same time.

Since the stated formula for the electric field may be expressed as a function of time and the two variables (V_a, Z_k) were recorded as a function of time, the calculation may be performed in a program. Calculations are made for each of the 512 points in the arrays, for times of zero to 10 nanoseconds.

The impedance waveform affects each calculation in both the numerator and denominator since the output voltage, V_o, varies directly as the antenna reflection coefficient. In addition, the electric field varies as the inverse of the antenna impedance. Each calculated value is stored sequentially in a 512-point array, which is provided with the same sampling interval as the voltage and impedance waveforms (about 1.9 E–11 seconds), vertical units of volts/meter (V/M), and horizontal units of seconds. The results of these calculations may be seen as the computer-developed waveform of Figure 6A.

The actual measured field from the LDP antenna is shown in Figure 6B. This waveform is the recorded response from an EG&G, Inc., type MGL-7 B-dot sensor. The waveform was

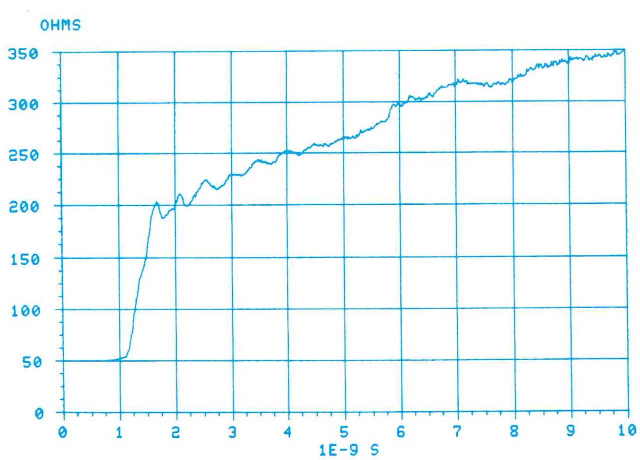


Figure 4. LDP antenna feed-point impedance as a function of time.

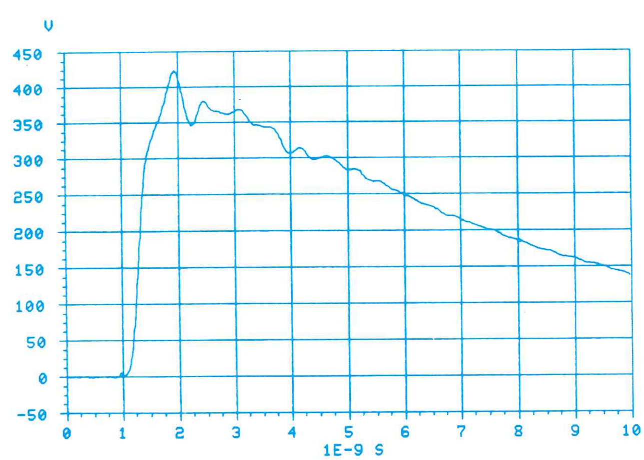


Figure 5. *Drive pulse for LDP antenna.*

signal averaged, integrated, and converted to read as the electric field using the relationship of E/H = 377 ohms. This processing was done by the computer under program control (routine for processing not presented here).

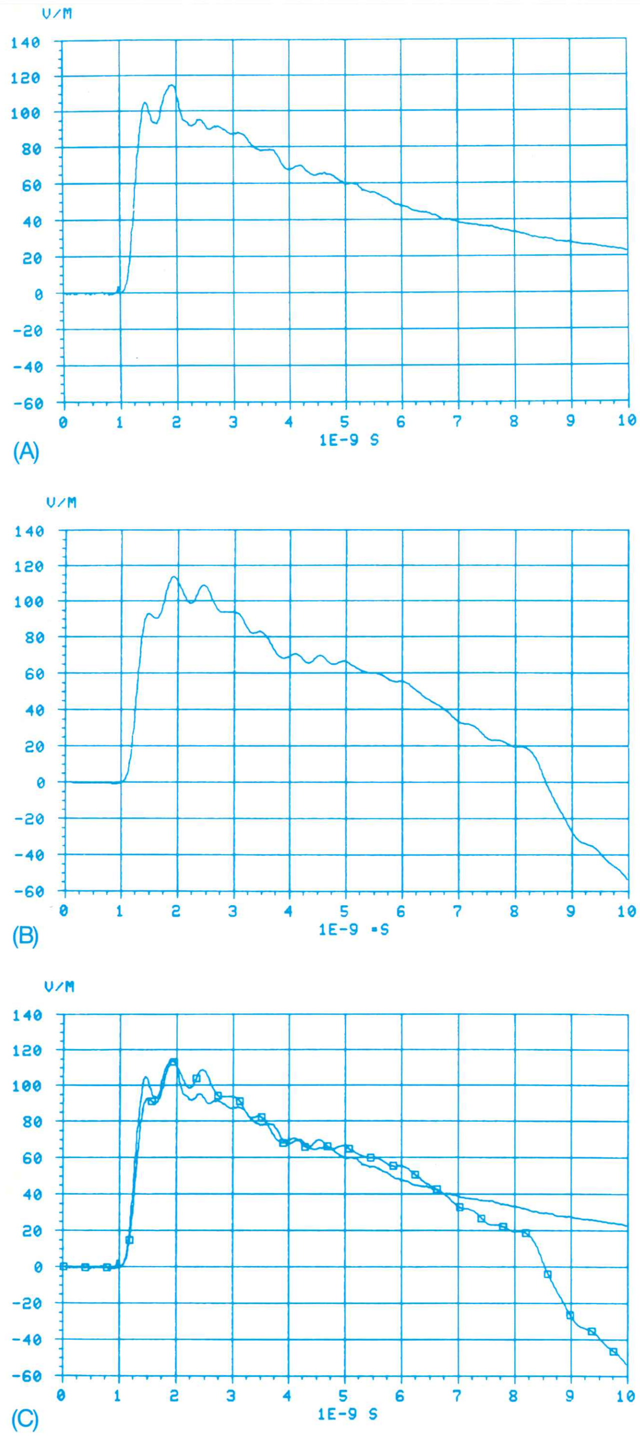


Figure 6. *(A) A computer-generated radiated waveform from LDP antenna produced by field prediction routine. (B) Measured radiated waveform from LDP antenna. (C) Overlay of predicted and measured waveforms for LDP antenna.*

As may be observed, the predicted (Figure 6A) and the measured (Figure 6B) compare very well until time equals approximately eight nanoseconds (see overlaid waveforms in Figure 6C). The departure of the measured data at approximately eight nanoseconds, is due to the method of measurement. Lacking a free-field sensor, the type employed required mounting on a ground plane. Physical spacing and time constraints imposed by the test then being done, precluded the use of a very large ground plane. In fact, the measured data departure coincides well with the physical end of the ground plane being reflected and sensed by the MGL-7.

Conclusion

This application can be used to predict the nonground-reacted radiated waveshape and amplitude of an antenna intended as a pulse radiator in the equatorial plane. This can be obtained either through physical measurement or mathematical (computer) calculation with equal confidence. All that is needed is a description of the antenna in terms of its impedance versus length and geometry. This information is useful in the design of new pulse radiators or in the modification of those in existence.

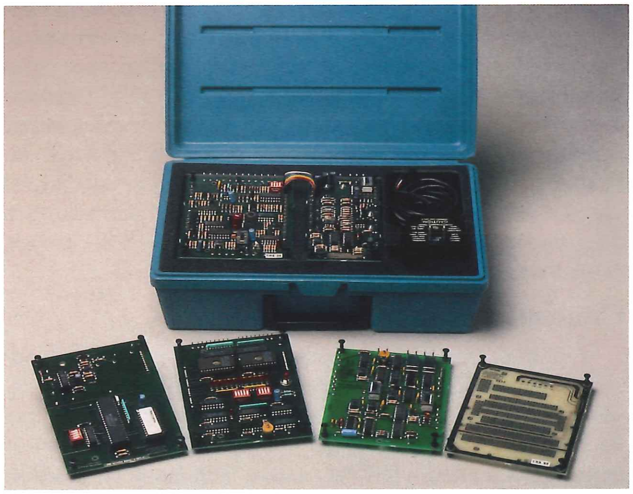
For the Harry Diamond Laboratories measurement system purchased from Tektronix, Inc., the system software includes an FFT algorithm. With the assumption that the predicted waveshape will yield greater high-frequency amplitudes than those measured, it is possible to evolve a "lumped" transfer function to compensate for losses in both the coaxial cable and the sensor. This "correction factor" may be applied to the measured transforms, which would then be inverse transformed to the time domain.

With appreciation to Jim Kassebaum, programming consultant, Newberg, OR, for technical assistance in preparing the waveforms for publication.

EDITOR'S NOTE

The Tektronix Digital Processing Oscilloscope used in this application is no longer being manufactured. However, several digitizers from Tektronix will perform this function. Contact your local Tektronix Field Office or representative for assistance in choosing the digitizer best suited for your application. For a selection chart listing the specifications of all digitizers currently available from Tektronix along with a tutorial on choosing a digitizer, check the Tektronix Digitizer Chart box on the **HANDSHAKE** *reply card.*

A signal for all reasons



The CRS101 Basic Training Lab provides a convenient signal source for the classroom or laboratory.

How many times have you needed a specific signal to demonstrate a measurement concept in a classroom setting and couldn't find the right source? Or how many times have you needed a unique signal to test an application but the signal source was miles away? If you've found yourself in either of these situations, then the Tektronix CRS101 Basic Training Lab and Signal Boards from Tektronix are for you.

The CRS101 Basic Training Lab provides an integrated source of signals to teach concepts such as risetime, pulse width, frequency, digital troubleshooting, and video measurements. It's suitable for beginning through advanced courses in electrical engineering, electronics, engineering technology, or physics. The CRS101 can also be an invaluable tool for both laboratory demonstrations and student lab stations.

The CRS101 is provided in a compact carrying case. It consists of the following modules and can be ordered either as a unit or each module can be ordered separately. A comprehensive instruction manual is available to aid in the application of the CRS101.

CRS10 Power Unit consists of a power/clock board powered from an external transformer. The transformer provides 24 volts AC, which is below the level considered hazardous by Underwriters Laboratory. The transformer, power/clock board, and a signal board can be stored and operated in a tray in the carrying case. There is also room to store additional signal boards below the tray.

CRS30 General Purpose Board is designed to exercise most oscilloscope functions by providing a variety of digital and analog signals. This board has proven extremely useful in the training of beginning through advanced students in many technical disciplines such as field service, calibration, and design.

Digital signals are available at ECL, TTL, and CMOS levels. Digital signals include logic, a variable pulse train, a low-frequency square wave, a variable stairstep generator (D-to-A converter), and fast trigger signals.

Analog signals include a sine wave with glitch, a voltage-to-frequency converter, a low-frequency triangle waveform, and a waveform with variable frequency, amplitude, and slope. All signals are available at test points around the board edge.

CRS50 Video Signal Board is primarily for understanding video measurement signals and techniques. This board generates NTSC interlaced video signals which demonstrate TV triggering capabilities of oscilloscopes. It can also be used to display pictures on a video monitor. This board is extremely valuable for facilities where an NTSC generator is not available.

CRS70 Digital Pattern Board was designed specifically to demonstrate use of the word recognizer, delay by events, and boolean trigger functions on the 2445A/2465A Oscilloscopes equipped with the counter/trigger/timer option.

The circuitry on this board generates a repeating series of 16-bit words. These digital patterns can be signal-stepped or driven by the 1-MHz clock. Series length can be set to a maximum of 4096 in multiples of 256 bits. Both the starting and ending addresses can be set from their respective end-of-series in 256-bit increments.

The patterns generated by this board are contained in EPROMs. They are entirely arbitrary and can be changed by installing a different set of EPROMs. An additional circuit provides a variable glitch at a 1 kHz rate. This is useful in demonstrating the glitch-capture features of advanced digital oscilloscopes.

CRS72 Digital Fault Board is a demonstration aid for Tektronix oscilloscopes equipped with microchannel-plate CRTs. Most conventional oscilloscopes will not be able to display the signal faults generated by this board.

Circuit-timing errors generated by this board replicate those found in real-life situations, but in a more repeatable form. The type of errors include noise and timing-margin violations, clock corruption, and faulty state transitions.

CRS90 Builder Board has a grid pattern of holes, along with access to the signals and power supply voltages provided by the power/clock board. This board provides a simple method of building your own test or demonstration circuits.

Ordering information

To order the CRS101 Basic Training Lab, call the Tektronix National Marketing Center, 1-800-426-2200 (in Oregon call 627-9000 collect). Or contact your local Tektronix Field Office or sales representative. And be sure to tell them you saw it in **HANDSHAKE**.

For a brochure describing the CRS101, check the box on the **HANDSHAKE** reply card in this issue.

New software packages extend Digital Camera System performance

Two new software packages, the first of many planned enhancements, are available to extend the usefulness and functionality of the Digital Camera System (see **New scope camera digitizes waveforms to 12 bits at 1 GHz** in the Fall 1986 **HANDSHAKE**, Vol 11 No. 3). These new software packages are the S58DC01 Functional Library and the S58DC03 SPD Driver.

S58DC01 Functional Library

Using the S58DC01 Functional Library, users of the Digital Camera System (DCS) can now create their own customized software programs for the DCS. The functions provided in this package relieve the user from having to deal with the hardware intricacies required to perform simple functions. In addition, routines are provided to allow up to eight Digital Camera Systems to be controlled by a single PC. Figure 1 shows a block diagram of a multiple-input system using three Digital Camera Systems.

Majority of the functions in the DCS-LIBRARY are written in the high-level "C" language. A working knowledge of the "C" language as well as the Microsoft "C" Compiler are required for software development. Also, any changes to the S58DC01 assembly language requires the use of the Microsoft Assembler.

Included in this package is all of the source code for the DCS-LIBRARY and a large memory model library. Source code is provided in disk format. The functions in this library do not use floating-point data; therefore the optional PC co-processor is not required.

Some of the general functions that can be done with this library are:

1. Define where and how many Digital Camera Systems are available to the computer system.

2. Define how input data from the video camera system should be translated when storing data in the Frame Store Board.

3. Specify when to begin acquiring a video image and when to freeze an image in the Frame Store Board.

4. Switch between video memory images in real time (two standard, up to eight optional using a daughter board).

5. Control the amplitude and frequency of the built-in calibrator.

6. Sum incoming video with the video memory (additive).

7. Define a delta mask, either with live video or statically, via program control. In addition, this delta mask can be used to cause a triggered status to occur.

8. Poll an external signal for any transition.

9. Toggle an external signal line to control external devices.

10. Read or write values anywhere in video memory. This is done on a column-by-column basis.

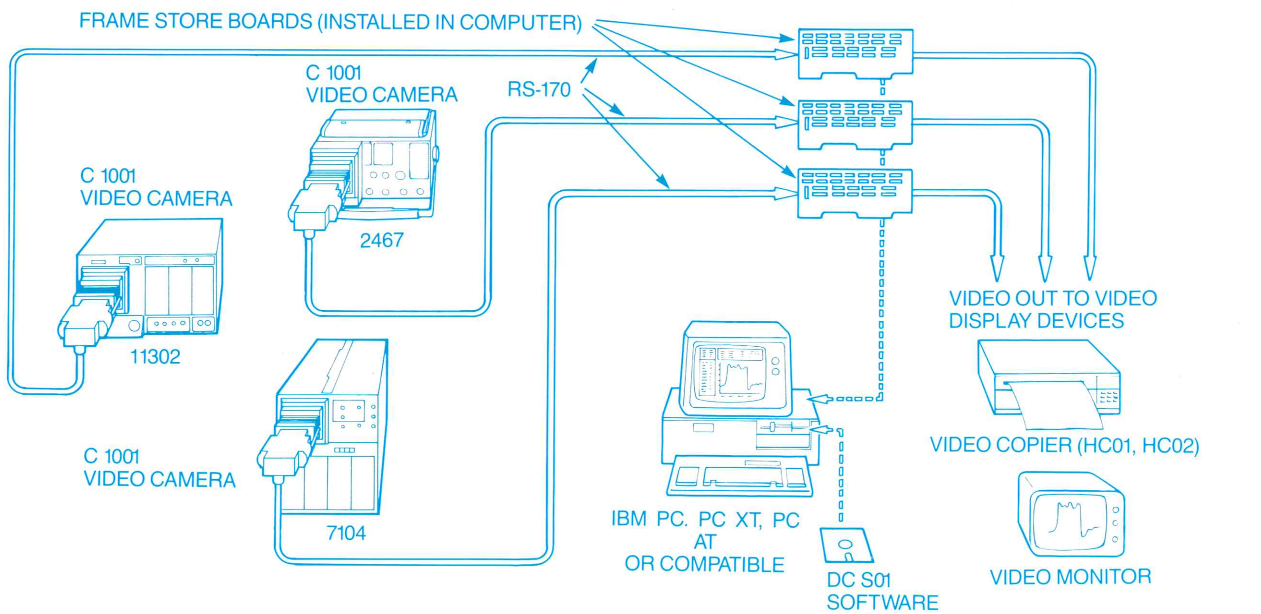


Figure 1. *Multiple Digital Camera Systems can be controlled by a single PC using routines in the S58DC01 Functional Library.*

11. Read or write values anywhere in the delta mask video memory. Again, this is done on a column-by-column basis.

12. Calculate a centroid or median position of each column of video data stored within the video memory.

S58DC03 SPD Driver

The S58DC03 SPD Driver provides easy access to waveforms acquired by the Digital Camera System using Tektronix Signal Processing and Display Software (see **Signal processing tools for your IBM PC** in the Fall 1986 **HANDSHAKE**, Vol 11 No. 3). DCS-acquired waveforms are written as SPD-format files, providing a link between the Digitizing Camera System and SPD software. This allows use of the many SPD Menu Functions including FFT, convolution, correlation, and waveform statistics.

Ordering information

To order either of these software products, call the Tektronix National Marketing Center 1-800-426-2200 (in Oregon, call 627-9000 collect). Or contact your local Tektronix Field Office or sales representative. And be sure to tell them you saw it in **HANDSHAKE.**

For data sheets describing these products, use the **HANDSHAKE** reply card included in this issue.

HANDSHAKE article index for Volume 11

Here for your reference is an index to the past four issues of **HANDSHAKE.** For copies of any of these back issues, please use the **HANDSHAKE** reply card in this issue (availability subject to stock on hand).

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Tektronix offers classes and workshops for the convenience of Tektronix customers with application, operational, or service training needs. Here's the schedule of classes and workshops to be offered in the near future.

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Call Tektronix Service Training, 1-800-835-6100 (in Oregon, call 629-1407) to register for the following classes.

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2465A Portable Oscilloscope	Atlanta	Jul 20-31
7904/7633 Laboratory Storage Oscilloscopes	Irvine Atlanta	Aug 10-21 Dec 7-18
TM 500 Calibration Package	Chicago	Jul 6-10
7912AD Programmable Digitizer	Beaverton	Oct 26- Nov 6
TM 5000 Programmable Instruments	Beaverton	Call for schedule

In addition to classroom instruction, Tektronix Service Training has a variety of training packages and videotapes available for self-study. Classes are also available for maintenance of other Tektronix products. Call for further information.

Workshop sizes are limited. We recommend that you enroll early. Other classes are planned beyond this schedule. For more information or to register, call the numbers listed above.

We retain the option to cancel or reschedule classes or workshops.

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Using a 4041 System Controller	Beaverton Washington	Jul 28-30 Aug 25-27
Using the PC as a Controller	St. Paul Woodbridge Santa Clara Lexington Dallas	Jul 18 Jul 31 Aug 28 Sep 18 Sep 25
7912AD/7612D Advanced Waveform Processing with TEK SPS BASIC	Albuquerque Woodbridge	Sep 15-18 Nov 17-20
2230 Digital Storage Measurements	St. Paul Woodbridge Santa Clara Lexington Dallas	Jul 15 Jul 28 Aug 25 Sep 15 Sep 22
2430A Advanced Digital Measurements	St. Paul Woodbridge Cleveland Santa Clara Lexington Dallas	Jul 16-17 Jul 29-30 Aug 11-12 Aug 26-27 Sep 16-17 Sep 23-24
7854 Waveform Processing	Orlando Woodbridge	Aug 26-27 Sep 22-23
11301/11302 Measurement and Analysis	Washington Philadelphia Dallas Indianapolis Las Vegas Lexington	Jul 16 Jul 30 Aug 13 Aug 28 Sep 10 Sep 23
11301/11302 Advanced Measurement and Analysis	Beaverton Los Angeles	Oct 22-23 Nov 5-6
11401/11402 Waveform Measurements	Washington Philadelphia Dallas Indianapolis Las Vegas Lexington	Jul 15 Jul 29 Aug 12 Aug 27 Sep 9 Sep 22
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