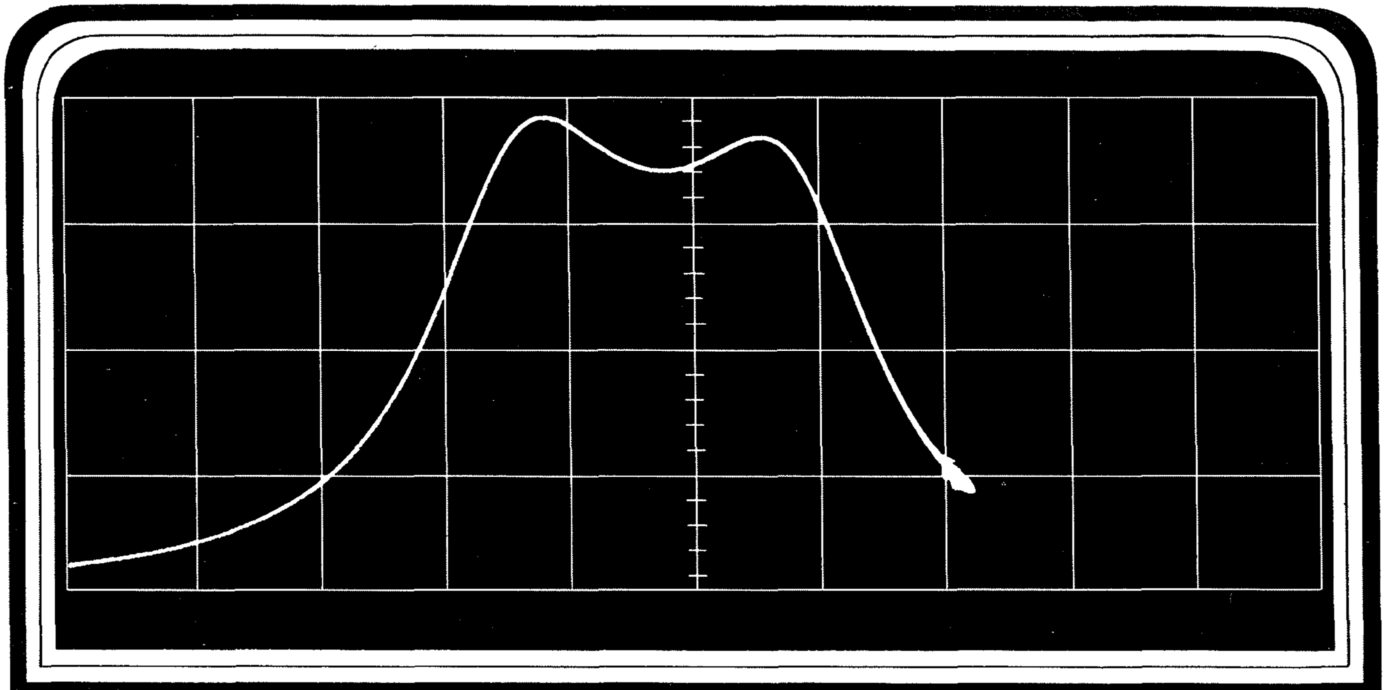
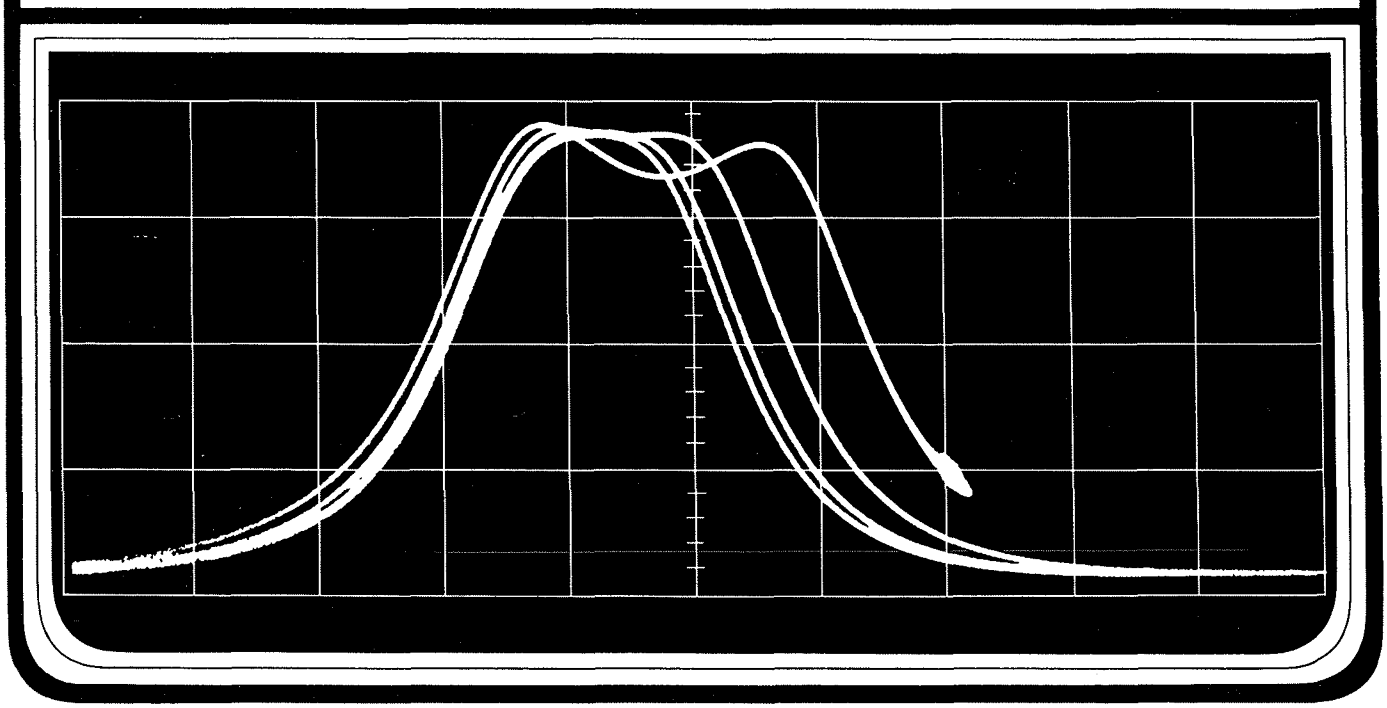
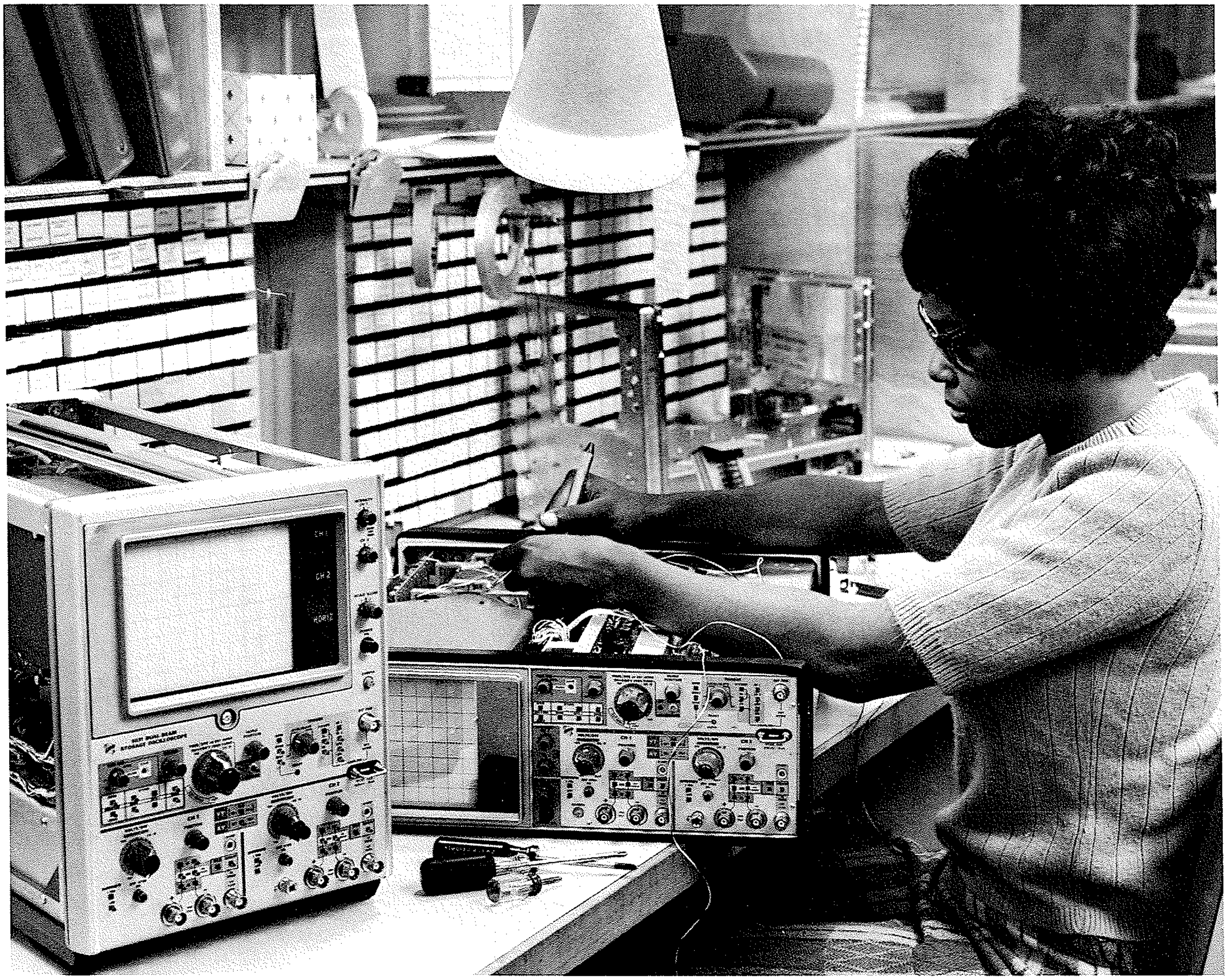
TEKTRONIX

TEKSCOPE

APRIL 1970







A DUAL-BEAM FAMILY

Now both dual-beam storage and non-storage oscilloscopes are available with large screen and auto scale-factor readout. Measurement ease and accuracy are increased by human engineering and performance features.

COVER—Long-term changes in a voltage controlled filter response curve are plotted by both beams of the 5031 Split-Screen Storage Oscilloscope. This instrument is holding and simultaneously displaying "history" as new information is recorded and erased.

LARGE SCREEN AND READOUT

The new, 50% larger screen area plus scale-factor readout displays more information than previously possible. These unique features provide new measurement ease in this complete family of dual-beam oscilloscopes. All six instruments have a display area of approximately 10 x 12.5 centimeters. The internal graticule is scaled in an 8 x 10 division format on the 6½-inch dual-beam

A cabling change is installed by Prototype Technician, Sandra Lowe. Superior construction starts early in Tektronix instruments.

CRT and the large-screen area of the 5030 and 5031 oscilloscopes allows generous separation of displays. For example, a display of two waveforms, each occupying 4 centimeters, will be separated by 2 centimeters.

This dual-beam series uses no time sharing as is required in a dual-trace instrument. The possible errors in time correlation between traces in dual-trace alternated modes are eliminated and true simultaneous dual displays are established. No resort to special control setups and trigger sources is necessary. Each independent beam has its own vertical amplifier and separate intensity control, and one time base drives both beams simultaneously.

The 5030/5031 Series uses fiber optic readouts to ease interpretation of deflection factors for both visual observation and photographic recording. The large fiber optic readout panel (located just to the right of the CRT) places each scale factor in the logical place; where the operator is looking. The user is not distracted by searching for scale factors near the knobs where most instruments locate this information.

Each readout is activated by the amplifier and time-base controls that affect changes in calibration and modes of deflection. Voltage, current and time units are *all* automatically selected by the same switches that control the internal circuitry used for these three modes. The automatic display of scale factors includes indication of an uncalibrated condition during the use of a variable time or deflection sensitivity control. When an operator wants to use a variable control, he pushes the recessed control causing it to pop out to an active position. An active variable will be indicated by a greater than sign (>) just to the left of the appropriate readout. A second push removes the > sign from the readout and restores calibrated operation.

The user will see a crisp, high-resolution display over the full screen for both beams, as a sharp presentation is maintained at varied intensity settings with no adjustment. There are no front panel focus or astigmatism controls to contend with. Deflection defocus is less than 1.5 to 1 on any axis. To assure display accuracy, an additional deflection element has been added to the CRT. This element is driven by an active geometry circuit that corrects geometry dynamically with beam position information.

CONTROL LOGIC

A versatile, single-beam instrument has many modes of operation. A versatile, dual-beam scope should have more modes than a single-beam unit. The 5030/5031 Series has this mode versatility, but it does not add complexity to the operator's tasks.

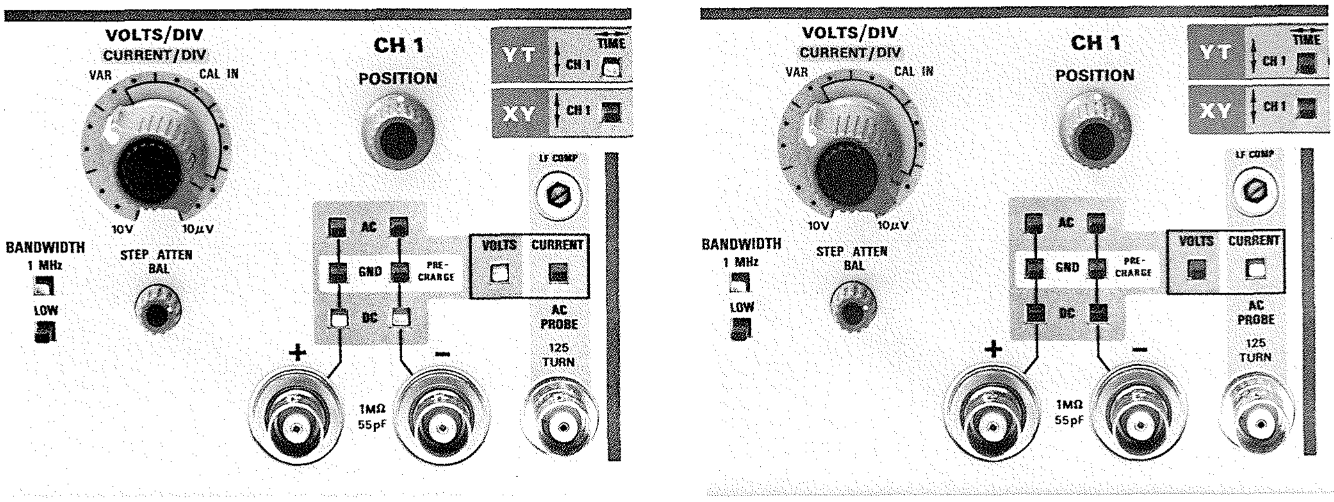
Instrument design evolves over a period of time and reflects the original objectives and inspirations of the people involved. This design effort in the 5030/5031 Series is reflected by the logic of each control and the grouping of controls. The operator using these controls gets results quickly and without ambiguity. The design effort in the 5030/5031 Series has produced fewer controls, each with maximum usability and simplicity, while increasing the number of operational modes.

Operating modes are not always easily identified in some instruments. A control can mislead an operator when it is not in use. If a control looks no different, active or inactive, the user may be uncertain as to what mode is really in use. The 5030/5031 instrument group positively identifies the mode in operation. The user does not sense any ambiguity of control meaning when making measurements with this series.

Four methods of identification are used in the 5030/5031 Series:

1. The CRT Display
2. Panel Indicator Lights
3. The Fiber Optic Readout
4. Illuminated Push Buttons

Panel lights are common to many instruments. The usual applications of scope panel lights are in warning indicators such as "uncal". The 5030/5031 Series uses only one panel light, the magnifier "on" indicator. The important indication of "uncal" has been moved from the panel to the display area where it logically belongs. The use of a variable control places a greater than sign (>) where the user needs it, in front of the appropriate fiber optic scale-factor readout.



Mode Identification

Push buttons quickly establish the mode needed for a measurement. Illumination of the push buttons activated complete the identification of mode.

An example of mode identification and control usage is revealed by a look at the front panel and the display area. Channel 1 and Channel 2 are readily switched from a voltage to a current mode. When operating in a *voltage* configuration, the push-button switches in use will be illuminated and the scale-factor readout will indicate voltage units. Pushing the *Current* button will extinguish illumination of all switches unique to voltage, change the scale-factor readout to current units, and illuminate the current button. Switches common to both current and voltage remain illuminated when active after mode change.

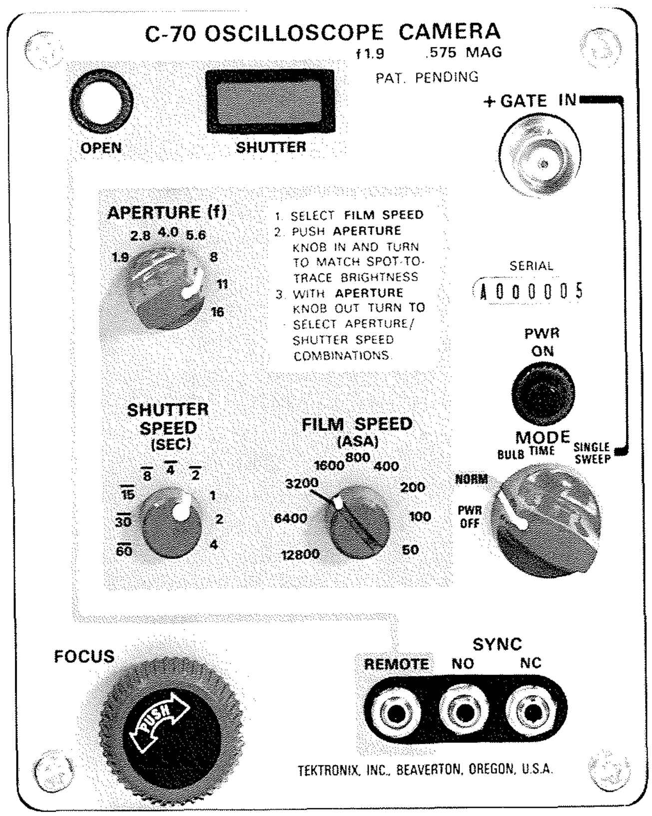
Scale-factor readout, control illumination and color keying allows the new user of the 5030/5031 Series to rapidly feel at home because ease has been designed into this dual beam measurement system.

NEW CAMERA EASE

Reduction of photographic errors and adjustment effort have been achieved in a new camera. Prior to the introduction of all the new Tektronix cameras, waveform photography could require considerable trial and error setup efforts. Several new approaches have been incorporated in this new camera series to minimize focus and exposure errors.

The C-70 is designed for the 5030/5031 and other Tektronix instruments with 6½-inch CRT's. The C-70 does not require a focus plate. This camera uses two adjustable bars of light projected onto the CRT to simplify adjustment. Alignment of the light bars with one focus control quickly sets the camera for sharp results.

With an easy adjustment of a projected photometer spot to match the trace intensity, the C-70 camera user can set the correct lens opening for proper exposures. This photometer spot is new to oscilloscope cameras and plays an important part in the quick and error-free set-up of all the new Tektronix cameras. After setting exposure, any subsequent adjustment of shutter speed or f-stop, automatically adjusts the complementary control to maintain correct exposure value.



The C-70 Oscilloscope Camera adjustments are made here. Correct exposure and sharp focus are quickly set with no film waste.

TIME BASE AND TRIGGER

Any YT display requires a stable location of the T_o reference. This point is established by triggering. Early triggered-sweep instruments required five distinct steps to establish a triggered time base and the desired T_o point.

Step 1.	Set Sweep Stability
Step 2.	Select Trigger Source
Step 3.	Select Trigger Coupling
Step 4.	Select Trigger Slope
Step 5.	Set Trigger Level

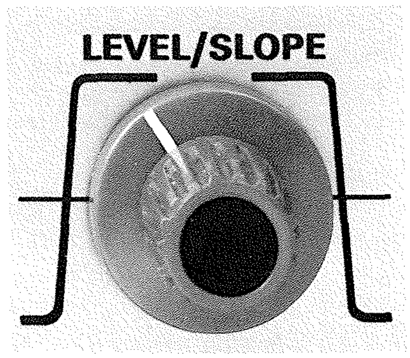
If the operator was inexperienced or rushed, he encountered difficulties. Even when he strived for optimum front panel control settings, he could be frustrated by marginal performance resulting from component aging effects and improper internal adjustment.

An ideal scope would automatically establish T_o without resorting to control use. Circuit design would eliminate aging effects and the need for internal adjustments. Tektronix engineering efforts in the 5030/5031 Series have resulted in a significant step towards an ideal triggering and time base system.

After selection of source and coupling, most scopes require slope selection with a separate single-pole, double-throw switch. Then, the operator searches for a point for sweep start on the trigger waveform. This is commonly done by varying a trigger level control over a fixed voltage range to provide a comparator with an input that is equal to the desired trigger point on the incoming waveform.

Oscilloscopes ordinarily provide some form of automatic operation based on a zero comparison voltage. This allows triggering on all signal levels including low level noise and other sources of display jitter. When level selection is provided along with automatic operation, a level can be selected that eliminates noise triggering. The level selected may also exceed a triggerable point causing loss of stable display.

The 5030/5031 Series features fully automatic, hands-off triggering. After a source is selected, activation of the new PEAK-TO-PEAK AUTO mode will present stable displays on virtually all triggerable waveforms without adjustment. The simplified triggering of the 5030/5031 Series is the result of two lines of parallel development aimed at usability. One—a simplification of control; two —the minimization of internal adjustments and aging effects.



This one knob selects both slope polarity and triggering level.

The Peak-to-Peak mode uses the trigger signal itself to set the limits of triggering level. Peak detectors set the upper and lower DC voltages available to the level selector so that the level control cannot select a trigger point above or below the available trigger signal amplitude.

The 5030/5031 instruments, when operated in the Peak-to-Peak Auto mode, can be set for any trigger point from peak negative through peak positive. Simple rotation of the continuous 360° turn Level/Slope control selects all the possible level and slope triggering points. The user cannot exceed the trigger level range and he does not have to stop to select slope. Slope is "selected" by relays at the 6 and 12 o'clock positions of the trigger/slope control. In the absence of a triggering signal, the time base will "free run" to provide a high-duty-cycle, bright baseline.

The Peak-to-Peak Auto mode control is activated by pressing a push-button switch located with the other trigger push buttons in a color grouped area of the panel. All active mode controls are illuminated.

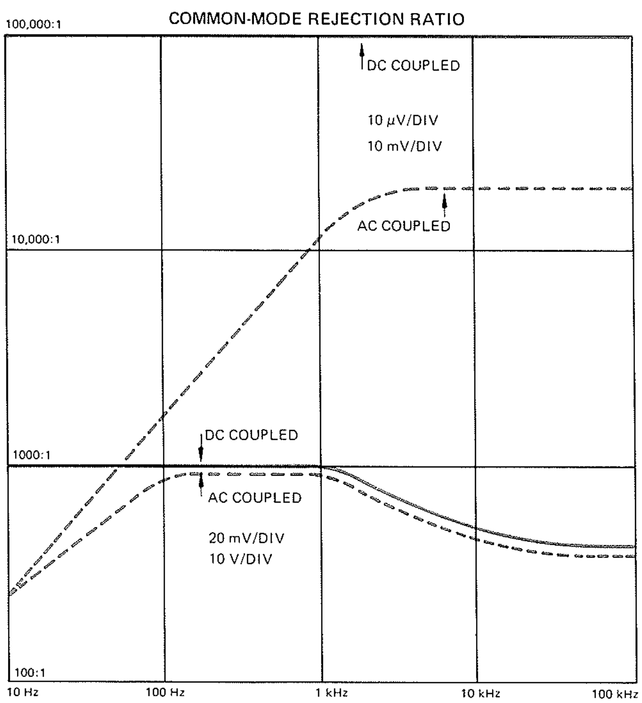
Two unique Tektronix integrated circuits and six transistors perform all functions of triggering and time base generation. Only two adjustments are required to calibrate the time base and center the trigger level recognition response. The built-in circuit stability minimizes time base and trigger problems.

TEN MICROVOLTS PER DIVISION

An instrument with 10 microvolts per division sensitivity must reflect concern with the low-level measurement environment. Noise and drift in the display must be minimized. The amplifier must be capable of rejecting unwanted common-mode signals that often exceed the desired input in amplitude. While being used, its own operational requirements must not detract from the user's measurement efforts.

This series has a tangential noise specification of less than 15 microvolts in voltage modes and less than 200 microamps in current modes. Trace stability is excellent and is specified as less than 10 microvolts or 0.1 divisions per hour after 2.5 hours warm up. Less than 5 microvolts per minute drift is achieved after only one hour warm up.

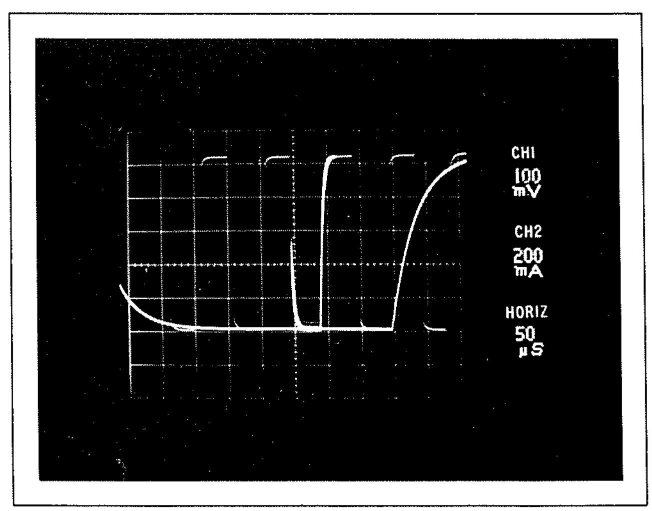
Common-Mode Rejection, a vital specification of a differential amplifier, must be considered over a range of input voltages at varying frequencies. The 5030/5031 instrument group maintains at least a 100,000:1 ratio when DC coupled up to 100 kHz at 10 microvolts per division to 10 millivolts per division. The ratio is still at least 500:1 at 100 kHz when AC coupled at 20 millivolts per division to 10 volts per division. The same attention to the circuit design that resulted in excellent noise and drift performance has achieved excellent CMRR. Another feature representative of the attention to operational ease in this series removes a common annoyance from AC coupled operation. An input capacitor can often cause a trace drift-in period before a measurement can be made. When operating in the sensitive ranges, the charging of the input capacitor from a test point may require a long wait for the trace to stabilize. The necessary charge time can now be eliminated by using the *Precharge* Position of the vertical input. This will allow the input coupling capacitor to charge during the base line zero volts reference check. Use of the AC push button after precharge will now present a drift-free trace.



Specified Common Mode Rejection Ratios of both Channel 1 and Channel 2.

NEW MAGNIFIER DISPLAY

A novel approach to identifying magnified sweep display is included in the 5030/5031 instruments. Magnification is an expansion of a portion of a time-base display by increasing the gain of the horizontal amplifier. In either of the "Mag On" or "Mag Off" conditions, what is centered horizontally in the display area should be the same. This centering is an identification aid common to most scopes. To further aid the operator in identifying the location of the magnified display in time on the unmagnified display, a special LOCATE button is provided. Pressing this button will restore an unmagnified time base when operating "Mag On" with an *Intensified* portion that identifies the location of the portion of the sweep magnified.



The intensified area of the slower display identifies the time interval magnified. The faster display is that time interval expanded by magnification. Double exposure is used to represent this feature photographically.

5030/5031 Series Displays

YT Dual Beam	Channel 1	Voltage vs Time or Current vs Time
		and
	Channel 2	Voltage vs Time or Current vs Time
XY Dual Beam	Channel 1	Volts vs Volts or Current vs Volts
		and
	Channel 2	Voltage vs Volts or Current vs Volts
XY Single Beam	Channel 1	Volts vs Channel 2 Volts or
	Channel 1	Current vs Channel 2 Volts or
	Channel 1	Current vs Channel 2 Current or
	Channel 1	Volts vs Channel 2 Current
Z Axis		Both beams have separate inputs that function in all modes.

XY

Oscilloscope users usually think first of a voltage-vs-time plot (YT) when selecting an instrument. This display is the most used mode. YT usefulness is the reason that most scopes are designed primarily to achieve optimum performance in that mode. XY modes in most instruments are usually compromised in X-axis performance because of YT considerations. Sensitivities, bandwidth, phase characteristics, control logic usefulness are often less than that found in the Y-axis.

The XY mode in the 5030/5031 Series is treated as equal in importance to a voltage-vs-time (YT) display. The user has available at a touch a 10-μV per division differential X-axis amplifier with the same characteristics as the Y system. This X-axis amplifier is the Channel 2 amplifier switched into X-axis by a push button. Channel 2's X-axis performance is equal to Channel 1's Y-axis characteristics. In the XY mode, phase difference between X and Y is only 1° at 200 kHz and is still better than 4° at 1 MHz.

An unusual mode available in this line of instruments is the plot of two variables against a third. Channel 1 and 2 are plotted against a common X-axis amplifier with 20 millivolts to 500 millivolts per division sensitivities in 1, 2, 5 steps. Activation of this separate X-axis amplifier is a function of the time-per-division control. This combined control use eliminates the need for separate controls for X-axis mode selection. Inadvertent selection of a voltage X-axis is prevented by a positive press activated clutch. Any use of X-axis modes is clearly indicated to the user by control illumination and automatic scale-factor readout.

DUAL-BEAM STORAGE

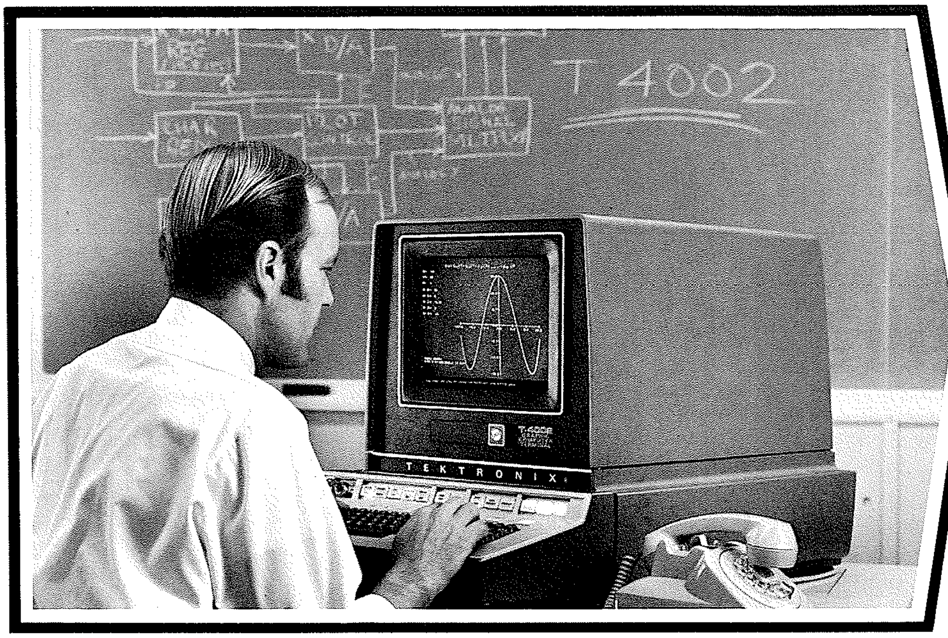
The 5031 and R5031 are the new storage scopes in the 5030/5031 Dual-Beam Family. They feature all the modes of the non-storage instruments (5030 and R5030) plus Tektronix bistable storage. Tektronix features such as split screen and long-term storage at full stored intensity are prominent in this pair of instruments. Stored writing speed is specified as greater than 20 divisions per millisecond.

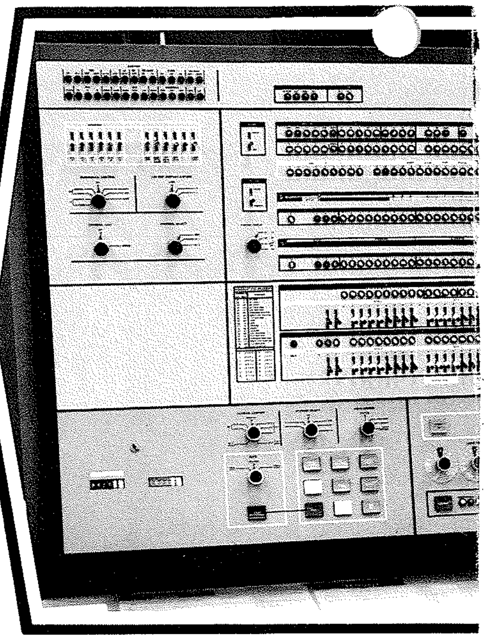
The split screen allows Tektronix storage tubes to store a representative or standard waveform on one half screen while tracing other repetitive information in a conventional non-stored mode for comparison on the other half screen. Another split screen use is for the display of a signal, single-sweep stored and periodically automatically erased on one screen area, while the other area is used to store several displays. This creates a short-term "history" of what has happened. The inclusion of auto erase, remote erase, as well as front panel erase for each screen area multiplies storage application possibilities.

The AUTO ERASE mode is often used to monitor changing information while looking for some significant display worth saving. The user may desire to stop auto erase action and view a particular stored display. Pressing the VIEW control "saves" the stored display for a long term look.

When using an oscilloscope to plot time in periods of 10 milliseconds or greater, flicker becomes a viewing factor. Storage scopes can present a flicker-free display by operating in store and auto erase after sweep modes. Since the time needed to erase becomes a significant factor in such displays, the 5030/5031 Series storage scopes have reduced erase periods to 2 milliseconds. No information is lost during this erase because the period is usually shorter than sweep retrace times.

Each screen can be separately or individually erased automatically or remotely from an electrical input, as well as manually from the front panel, or remotely by use of an optional accessory.





DATA COMMUNICATION BASICS

by Emory Harry, Tektronix Field Engineer

The high rate of information transfer possible with the T4002 Graphic Computer Terminal places increasing emphasis on the considerations of using *voice-grade* data communication channels. Further development of techniques currently available offers promise of much higher data rates in this basic communication building block.

BAUD VS BIT

A bit (BInary digiT) is a digit (0, 1) in a numbering system with a base of two. The term baud refers to a unit of signaling speed. Baud is usually defined as the reciprocal in time of the shortest code element. ONLY under one set of circumstances (all code elements equal in time with two level signaling) are bit rate and baud identical. Although they are often used interchangeably, if the code elements are not equal in time or if multi-level signaling is used, significant differences may exist.

Data Communication is normally considered to be communication of anything other than voice or video. In the United States, over 2,000 common carriers offer communication facilities and services for the transmission of voice, data, video, facsimile, telemetry, etc. These companies are regulated by federal (interstate), state (intrastate), and in some states, municipal agencies.

The tariff structure is very complex and it is usually necessary to contact the sales office of the local common carrier to determine the exact charges for the service you require. Differences between intrastate tariffs and interstate tariffs vary widely throughout the country, and thus, the wise user looks closely at all alternatives in designing a Data Communication System.

Several grades of communication channels are presently available for data communication.

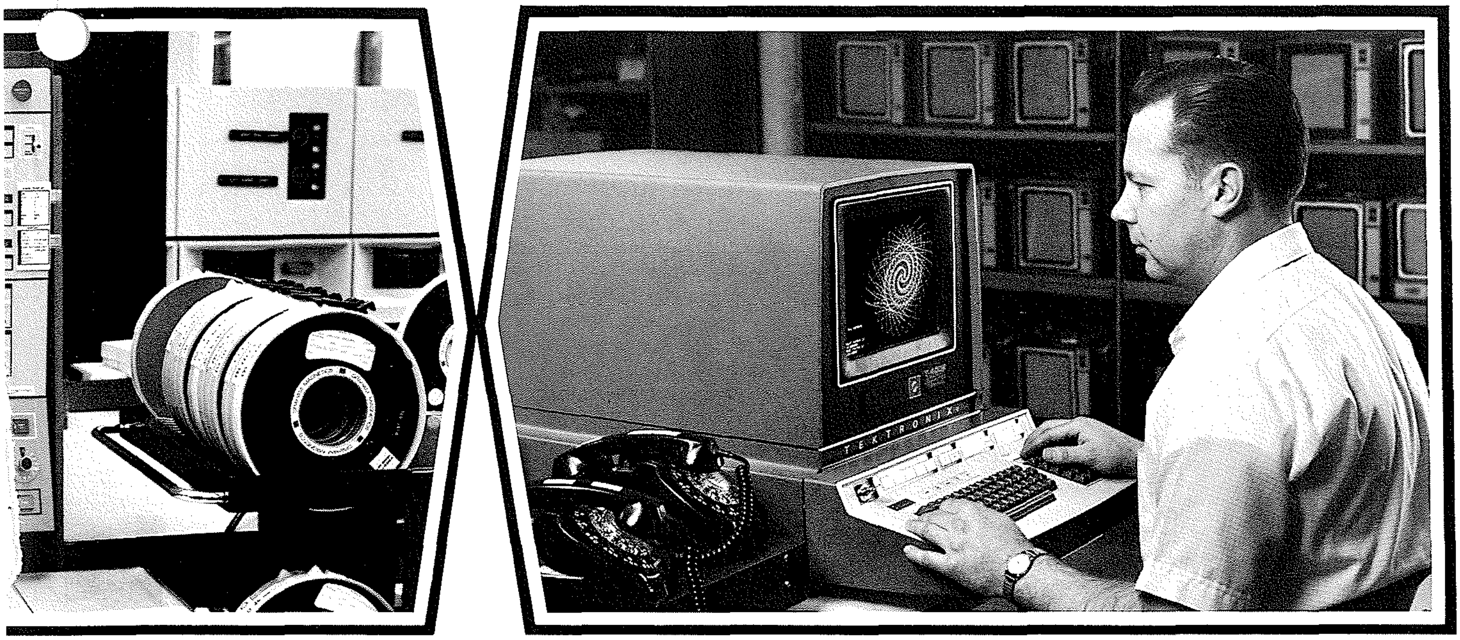
Telegraph Grade Channels — 45 to 75 Baud

Sub Voice Grade Channels — 110 to 600 Baud

Voice Grade Channels — 300 to 2400 Baud

Broad Band Channels — up to about 1 Mega Baud

There are two basic types of voice grade channels: DDD (Direct Dial Distance) and Leased (Private). The bandwidth is similar (300 Hz to 3000 Hz), but other characteristics differ measurably. Leased lines avoid local central office switching equipment and are much less subject to noise. Several levels of line conditioning are usually available on leased lines to compensate for the undesirable characteristics such as envelope delay, frequency distortion, etc. Although line conditioning is more expensive, higher transmission rates are possible. 9600 Baud is currently practical on voice-grade, conditioned, leased lines.

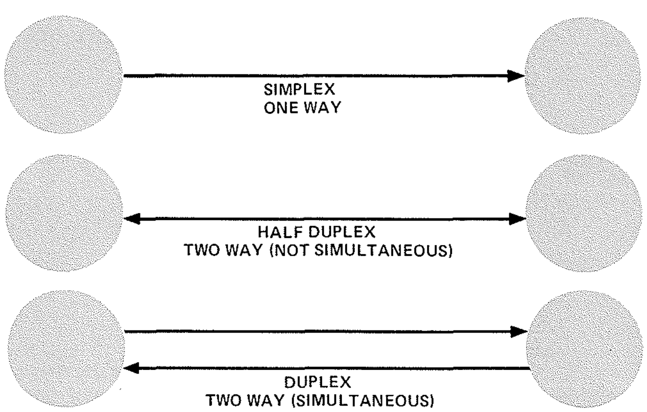


The Tektronix T4002 Graphic Computer Terminal provides interactive displays in a time-sharing environment. At left, Emory Harry in a classroom application. At right, Ken Nordling checks a graphic mode.

BASIC COMMUNICATION

Communication channels may be categorized as simplex, half-duplex, or full duplex. These transmission modes refer basically to whether the channel can transmit data in one direction only, one direction at a time, or both directions simultaneously as shown in the drawing. A two-wire circuit may be used for full duplex operation by employing frequency division multiplexing (a different portion of the channel's frequency spectrum is used to transmit in each direction).

Full duplex or half-duplex does not mean that the channels are symmetrical or of equal bandwidth in both directions. If the data transmitted in one direction is originating from a keyboard, the slow transmission makes it wasteful to divide a voice grade channel equally. Modems are available which transmit full duplex at the rate of 110 bits per second in one direction (keyboard) and 1200 bits per second in the opposite direction (computer).



Basic Data Transmission Methods

Supervisory Channel describes a very low bandwidth reverse channel that is used only to send control information. This Supervisory Channel is sometimes as slow as five bits per second. A channel which transmits data in one direction and supervisory information simultaneously in the other is not normally considered full duplex.

Echo-plexing is not another mode, but its operation is similar. Echo-plexing describes the operation whereby data is transmitted in one direction and is then turned around and sent back to its source for verification. Echo-plexing is being employed if data is sent out from the terminal keyboard, goes to the computer or interface, and then is sent back to the terminal where it goes to the character generator and is displayed. If an error occurs in communication, the operator detects it since the letter on the display is different from the keyboard input.

Echo suppressors are used in long distance transmission to reduce the effects of channel discontinuities on voice communication by introducing attenuation in the line opposite to the direction which the voice is traveling. Echo suppressors are switched by voice detectors, and should be out of the circuit when data is being transmitted. They can be switched out of the circuit by transmitting energy solely in the band from 2000 Hz to 2250 Hz. After the switching, transmission may utilize the entire frequency spectrum of the channel, but if energy is interrupted, the echo suppressor is automatically switched back into the line.

SERIAL VS PARALLEL

Transmission of data falls into two basic categories: serial and parallel transmission. In parallel transmission, several code elements are transmitted simultaneously through individual channels. For example, a five-level teletype code would require five separate channels; a seven-level ASCII code would require seven channels. Using multiple voice-grade lines provides a very high data transfer rate, but for most purposes, this approach is excessively expensive. The same results can be achieved by frequency-multiplexing a single voice grade channel and using a separate portion of the frequency spectrum for each code element. However, because perfect filters are not attainable, frequency multiplexing wastes bandwidth. Parallel transmission is not practical for terminal applications unless the transmission distance is very short, making it unnecessary to use telephone lines.

In serial transmission, the code elements are sent sequentially with each element occupying its own time slot in a form of time multiplexing. Although serial transmission normally requires more expensive hardware, the cost is more than offset by the fact that a single communications channel can be used. Serial transmission results in a much lower rate than is possible with multiple channels in parallel transmission.

Data transmission may be further divided into two categories: asynchronous and synchronous. Asynchronous transmission is used by most devices whose code elements are not generated uniformly in time. For example, the data rate output at a keyboard is a function of the speed at which the operator types.

When using asynchronous (start/stop) transmission, extra elements are sent with the data to identify and synchronize it. An extra element or bit is sent ahead of the data bits (start bit) and either one or two bits are sent after the data bits (stop bits). The group of bits that form each character has no definite time relationship with the previous or succeeding group of bits.

When transmitting synchronously, the characters have a definite time relationship to one another. Normally, a character is sent immediately after the preceeding character with no time lag between them. This type of transmission is generally more practical for devices that generate a continuous flow of data.

In synchronous transmission, it is necessary to periodically interrupt the data flow to send synchronizing information. Because the ratio of synchronizing bits to data bits is much lower in a synchronous system, the information transfer rate is proportionally higher. Codes have been developed that are self-synchronizing and require no synchronization bits to be transmitted, but these codes are not commonly used because of the expensive hardware required.

The T4002 can be used with modems (modulator demodulators) designed for either synchronous or asynchronous operation. When employing a synchronous modem, however, start and stop bits are still required.

MODULATION TECHNIQUES

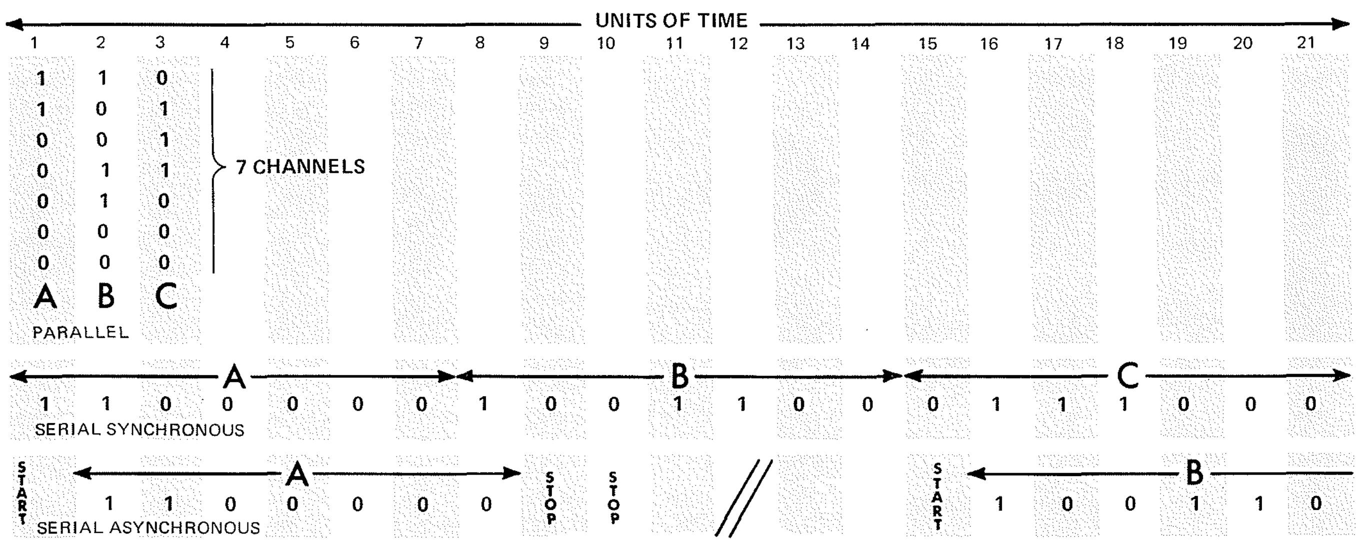
Modems are necessary to efficiently transmit data since the basic transmission medium, telephone lines, is not ideally suited to the transmission of data. The bandwidth of a voice-grade channel is normally from about 300 Hz to about 3 kHz. Modulation maximizes data transmission rate while minimizing the effects of noise, distortion, etc.

A number of considerations are important when selecting the type of modulation. Error control, equipment cost and complexity, available bandwidth, signal-to-noise ratio of channel, and type of code, all enter into the modulation system selection. Amplitude, frequency or phase modulation may be used, with some systems combining these techniques.

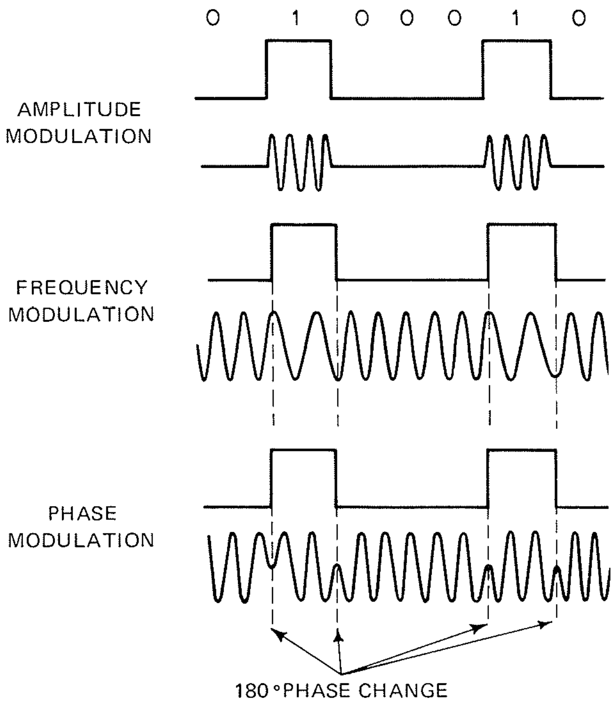
Frequency modulation, where frequency varies as a function of input code, is used on many lower-speed modems. Usually, a specific type of frequency modulation called frequency shift keying (FSK) is used in which one frequency represents a binary zero and another represents a binary one.

Many of these modems are designed to cradle the telephone handset and are called acoustic couplers. The signal is acoustically coupled from the telephone handset to a transducer in the modem, rather than the connection being made physically. Though this approach is convenient for low-speed communications, high-speed communications require a different approach.

Amplitude modulation, where amplitude varies as a function of input code, is used on many higher speed modems. Usually,a specific type of amplitude modulation called vestigial sideband is used.



Basic Communication Methods



Basic Modulation Techniques

Phase modulation is used on many of the higher speed synchronous modems, e.g., the Bell 201 Series. These multilevel modems generally do not employ more than four levels (each 90° of phase representing a level) because of noise and distortion limitations. When four increments of 90° are used, each level represents a two bit pair called a dibit. The Bell 201 Series that transmits four dibits (00, 01, 10, 11) is capable of data transmission rates of 2400 Baud. As the number of levels goes up, the modem becomes increasingly complex and expensive and the amount of line conditioning becomes impractical.

Modems are available which have their own adjustable conditioning or equalization networks. In addition, others are available with automatic equalizers which allow the modem to adjust to changing line conditions. As the degree of sophistication increases, however, so does the cost of the hardware.

Many variations and combinations of these three basic forms of modulation may be used in the future.

MULTIPLEXING

Multiplexing is a term used to describe the techniques used when combining several signals for transmission through a single channel.

Frequency multiplexing is the most common method in data communications. It is characterized by shifting of signal spectra so that no two spectra overlap. Shifting is usually accomplished by heterodyning. For example, a single voice grade channel can be divided into two frequency bands, one from 500 Hz to 1400 Hz and another from 1700 Hz to 2600 Hz. This creates two effective channels that can be used to send data in both directions simultaneously. Each channel uses less than half of the original bandwidth since a guard band is necessary between channels because of filtering limitations.

Time multiplexing is characterized by the interlacing in time of input data samples. Much less of the original bandwidth is lost using this technique than with frequency multiplexing because the time between channels can be very short.

Other forms of multiplexing such as Linear Addition Multiplexing, Orthogonal Multiplexing, and Polarization Multiplexing may all find wider use in the future.

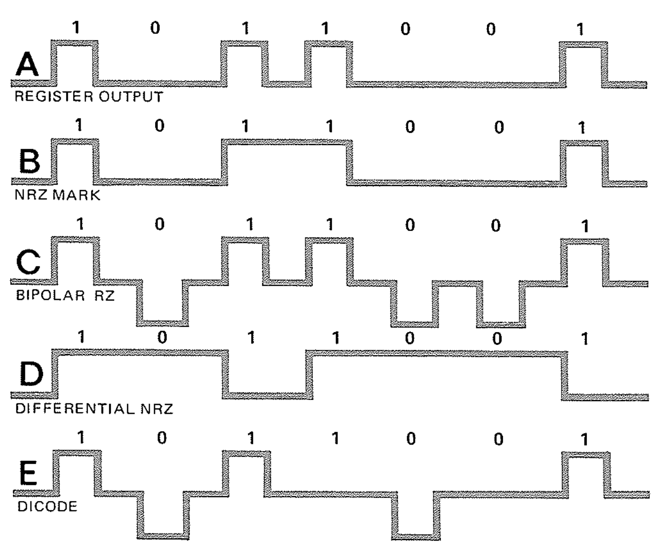
BIT CODING TECHNIQUES

A wide range of techniques are currently available for coding bits. Assume that a series of 7 bits has 4 true and 3 false bits. A, B, C, D, and E are five different bit coding methods that might be employed. Each technique (and the many others that are not represented) have characteristics which will make them desirable in one application and not in another.

Sequence A illustrates the pulses at the output of a computer register. In most FSK modems, the train appears as B where 1 is transmitted at f1 and 0 is transmitted at f2. The modulator shifts between frequencies depending on whether the bit is 1 or 0. This technique is sometimes called NRZ Mark (Non-return to Zero Mark). (One and zero have long been referred to in telegraphy as mark and space.) Note that there are fewer transitions in a given length of time and thus bandwidth is conserved.

C is a code that might be used if more synchronization information is required than is inherent in B. In C, there are always 2 transitions made in each unit of time. This code is usually called bipolar RZ (Return to Zero).

D is a code where bandwidth is of major consideration. A transition is made for each logic "1." This code is normally called differential NRZ.



Bit Coding Techniques

E is a code where a bipolar bit occurs on each new series of pulses. Each time the bit changes from 1 to 0 or 0 to 1, a pulse, either negative for 0 or positive for 1, is sent. This code is good for conserving bandwidth if long series of 1's or 0's are anticipated.

There are many different bit coding schemes that offer advantages and disadvantages depending upon the application. Bandwidth, synchronization, cost of coding and decoding hardware, and power consumed are all important characteristics of any system chosen.

CHARACTER CODING

A large number of character coding schemes are currently used, such as the Baudot, EBCDIC, and ASCII Codes. The most universal code is the USASCII (United States American Standard Code for Information Interchange) shown in the diagram, 7 bits with 128 permutations. These codes are generally termed quiet channel codes as they are designed for channels with relatively high signal-to-noise ratios.

Error detecting and error correcting coding techniques are accomplished by adding redundancy to the code. The amount and type of redundancy designed into a code is usually determined by how serious the effect of errors is. If the data is perishable, a large amount of redundancy may be designed into the code. In most computer terminal applications, where the channel is a phone line, the major source of errors is the operator, not the hardware, and thus, little redundancy is designed into the standard Data Communication code. Usually, a single parity bit is added to each character which makes the total number of bits in the character either odd or even. This allows most errors to be detected, but not corrected. When poorer signal-to-noise ratios are encountered, or when it is necessary to correct as well as detect errors, more sophisticated coding techniques are employed. One such technique is simply the addition of more than one parity bit.

Adding additional parity bits allows a larger number of errors to be detected, or permits the same number with a lower signal-to-noise ratio. When parity bits are added in sufficient numbers, the correction of most errors is feasible. Of course, the higher the level of error control, the higher the cost and the lower the information transmission rate.

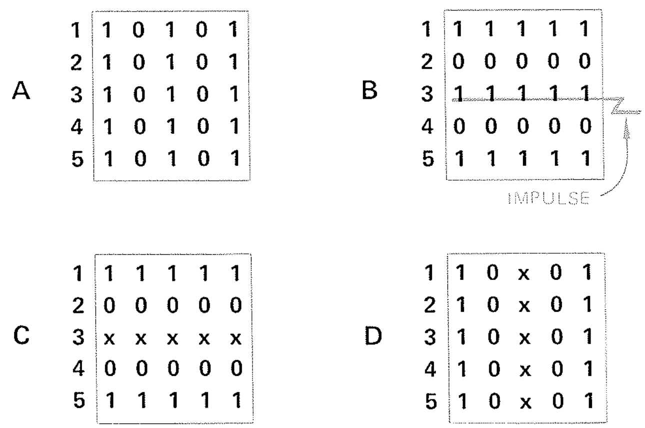
b_7 b_6 b_5 →					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_4	b_3	b_2	b_1	COLUMN → / ROW ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

USASCII Code

INTERLACING

This is a term which is used to describe a technique which is similar to time multiplexing and is used to effectively normalize impulse noise, a form of noise that is the largest source of data communication errors. Each character (7 bits, if the code is USASCII) plus 4 parity bits is stored in some form of storage device such as a flip-flop register. When as many characters are stored as there are bits in the code, in this case 11 characters, then the information is read out, but not as it was stored. One bit from each of the eleven characters is transmitted. For example, bit one from each of the eleven characters is sent together, then bit two from each of the eleven characters, until all 121 bits are sent. If an impulse should occur during transmission that would normally destroy one character, now only one bit from each character is lost and the one-bit error can be detected and corrected.

This is a very effective technique, particularly if multiple parity bits are also transmitted so that error detection and error correction are both possible at the receiving end. The technique is not as useful for asynchronous as for synchronous transmission.



Five words are read in horizontally (A). The five words are scanned vertically and transmitted as in B. If a noise impulse strikes word three, the data appears as C when received. Vertical scanning C constructs five words with one error bit (D). If the code has sufficient redundancy, the original words (10101) can be reconstructed.

STANDARDIZATION

Attempts have been made at standardizing on a universal code. This code is the ASCII Code, American Standard Code for Information Interchange. The USASCII discussed earlier is that which has been found to be the most universally accepted. The ISO (International Standardization Organization) has proposed both 6 and 7 bit character sets for international information processing interchanges.

The Electronic Industries Association Standard RS232B (Interface Between Data Processing Terminal Equipment and Data Communications Equipment) is a standard which specifies such things as connector type, pin assignments, voltage levels, impedance, etc. EIA RS232C is a new standard which attempts to make compatible RS232B and the CCITT (Consultative Committee for International Telephone and Telegraph) Standards.

SERVICE SCOPE

Troubleshooting Sampling Systems

By Charles Phillips
Product Service Technician, Factory Service Center

Confidence and knowledge enable a service technician to complete his services with best results. Confidence in servicing sampling scopes is sometimes prevented by unnecessary awe of subnanosecond region instrumentation. With normal preparation, you will find much of your knowledge and experience with real-time scopes is of direct value when working on these "fast" scopes.

This article will discuss adjustments and troubleshooting in vertical systems with particular emphasis on the *Sampling Loop*. All Tektronix Sampling Oscilloscopes* use an error or difference detecting technique. Since they use this technique, you will find a similarity in the various sampling systems. These similarities allow us to work in this article with a "composite sampling scope" and make some generalized statements about samplers. These generalizations should not be used in place of specific information included in your instrument's instruction manual. That manual's calibration section should be your source of specific adjustment information. Your Tektronix Field Engineer can aid you further with your individual requirements.

A display visible on screen is the most valuable aid available to you. Here are a few ideas on getting that trace.

*N unit exception.

> *Sampling Notes* and *Sampling Oscilloscope Circuits* by John Mulvey are two publications available from your Tektronix Field Engineer that are valuable sources of sampling facts.

We should start with the output of the vertical system. Output circuitry is straightforward. It amplifies the output of the *Sampling Loop* to drive the vertical deflection system. It can be isolated from the Sampling Loop by sliding the NORM/INVERT switch to its center. This blocks the input to the output circuits and will allow you to localize the off-screen problem to the "loop" or the "output".

After you have the "output" functioning, set the NORM/INVERT switch to NORM. If no trace is on screen, you should suspect the loop. Try the following:

1. Apply a 25-kHz squarewave of approximately 300 mV to the input. Use 200-mV/div sensitivity.
2. Free run or trigger the time base and use about 10 dots per division, zero the offset (use meter at output jack) and the *Position* control should bring the display on screen. If the position control does not do the job, center it at about 12 o'clock.
3. If step 2 does not produce a display, vary each of the internal adjustments in the "loop" and sampling gating pulse generator full range, one at a time, remembering the original settings. If an adjustment does not reveal a display, return it to its original setting and proceed to the next one. If any adjustment brings the display on screen, attempt to achieve a correct response by using your manual. If all adjustments fail, leave them in their original position and proceed to the troubleshooting information.

SOME INFORMATION ON ADJUSTMENTS

The section of the sampling system that is located within the *Sampling Loop* has the most effect on waveform, risetime, aberrations, and vertical trace position. The adjustments we will discuss often interact and may appear to have the same function. This interaction and similarity of results on screen should be explored to get the "feel" of the system. This "feel" cannot be derived from any written material.

No harm will result if you try extreme range combinations of the adjustments. By this exploration of extreme settings, you rapidly build confidence by gaining knowledge and experience.

Memory

Memory Balance—Purpose: To adjust for no trace shift when "smoothing" (front panel) is operated. Effect: See purpose.

Memory Gating Pulse Width—Purpose: To allow memory to respond to the full input signal. Effect: Will cause "rounded corners" of signal at one extreme (gain <1) or oscillation (gain >1).

Amplifier

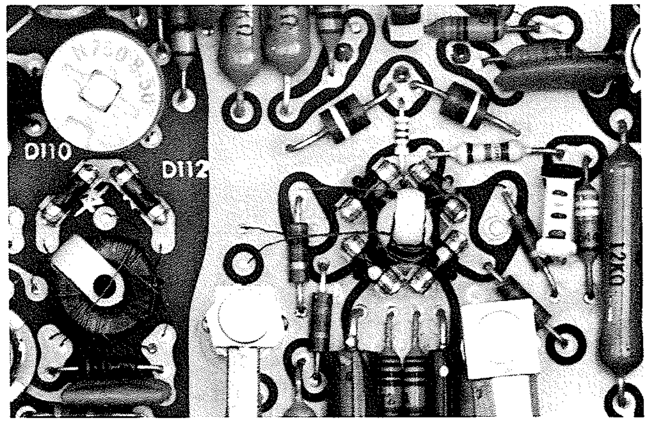
Loop Gain—Purpose: To adjust for maximum signal to the memory. Effect: Will cause "rounded corners" of signal at one extreme or oscillation at the other. May also be located in the memory.

Dot Response—Purpose: A front panel adjustment to maintain a loop gain of 1 after internal adjustments have been set. Effect: Similar to loop gain (very evident when using a random sampling system).

Smoothing—Purpose: A front panel control for minimizing noise. Effect: Similar to loop gain, but usually its effect varies from unity gain to less than 0.5 gain.

Sampling Gate

Sampling Gate Volts—Purpose: To set voltage across gate diodes, normally about 2 volts for proper display risetime and dynamic range. Effect: Risetime is changed as adjustment is made.



Here's where most of the fast action occurs. A four-diode bridge makes the sub-nanosecond voltage sample. The two-diode memory gate accepts processed sample and holds the information for CRT vertical deflection.

Sampling Gate Balance—Purpose: To neutralize trace shift as mV/div switch is rotated. Effect: See purpose.

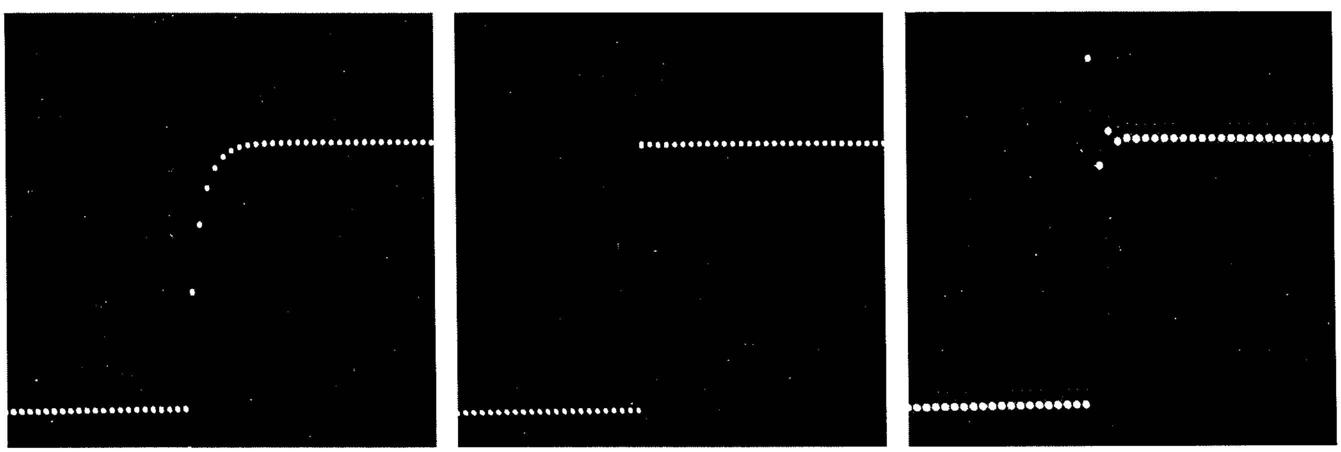
Blowby Compensation—Purpose: To neutralize capacitance in the sampling gate. Effect: Will change aberrations in the 2-μs interval after risetime.

Strobe Pulse Generator

Snap-off Current—Purpose: Adjusts strobe pulse for best resulting display risetime. Effect: Has the most significant control over risetime.

Avalanche—Purpose: To drive the sampling strobe source with minimum noise and jitter. Effect: In addition to noise and jitter effect, there are some risetime effects.

All the adjustments in the loop and strobe generator will have some loop gain effects. It is usually worthwhile to recheck for unity gain using your manual information after completing adjustments.



The sampling gate is unable to fully charge the amplifier input capacity with one sample. Feedback after the gate completes the charging process. Adjustments in the "Loop" produce (1) less than full charge (gain <1) (2) full charge (gain $= 1$) (3) more than full charge (gain >1).

SOME SOLUTIONS

Problem: Dot transient response difference between plus and minus signals.

Check: If more than 10% difference, sampling gate should be replaced.

Problem: Baseline shift with change of trigger frequency.

Check: Set front panel controls for a free-running trace at 2 mV/div (or highest sensitivity). Change time/div through entire range. Trace shift should be less than 2 divisions. If more, the sampling gate diodes should be interchanged. Replace diodes if necessary.

Problem: Memory slash (vertical elongation of dot at low trigger rates).

Check: Trigger sweep at 10 Hz; if slash is more than 0.6 divisions, interchange memory diodes or replace them. Other sources of slash are tubes and FET's.

Problem: Noise, microphonics, level changes, gain changes.

Check: Sampling gate diodes seated with proper clip tension. Grounds solidly made, soldered properly and mechanically tight. Input connectors tight. Input 50-Ω resistors should not be discolored and should be within ±1 Ω. Nuvisor socket should have sufficient tension in tab slots for good grounds.

Problem: Display tilt.

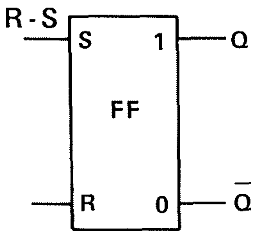
Check: If problem is most noticeable at about 1 MHz, the sampling gate is most suspect. Try blowby adjustment, then gate diodes. If interaction between both channels is noticeable, especially at certain positions on screen, check output amplifier tubes and channel switching diodes.

BREAKING THE LOOP

The feedback in the Sampling Loop can be disabled to further localize problems. Isolation of the memory can be easily accomplished by lifting one end of the memory gating diodes. Some instruments use built-in clips for resistor insertion for isolation. If this provision is made, see your instruction manual.

The sampling gate may be isolated by disconnecting the center arm of the sampling gate balance. This will allow you to check for proper voltages around the gate circuits. You may wish to remove the diodes to check for proper bridge voltage before replacing the gate diodes.

CORRECTION



Input		Output	
R	S	Q	$\bar{Q}$
LO	LO	No change	
LO	HI	HI	LO
HI	LO	LO	HI
HI	HI	Undefined	

Frankly, our truth tables are a pack of lies! In the December Issue, the article "A Basic Logic Review" had a mistake in the R-S Flip-Flop Truth Table. A corrected table is shown above. Our thanks to our readers for notifying us and our apologies for not detecting it.
The Editor

INSTRUMENTS FOR SALE

1—Type 511AD. In operating condition. Contact: Bruce Blevins, Box 2012, Socorro, New Mexico 87801. Telephone: (505) 835-5555.

1—Type 514AD. Good condition. Will accept reasonable offer. Contact: M. R. Sparks, 104 Ward Street, Oxford, North Carolina 27565.

7—Type 535A/CA. 1—Type 543B. Other 530/40 Series with plug-ins. Contact: Mr. Posner, Pacific Engineering Company. Telephone: (213) 225-6191.

1—Type 547, SN 11965. 1—Type 1A1, SN 24603. Both brand new. Contact: Mr. G. Schneider, Space Electronics, 40 Cottontail Lane, Irvington, New York 10533. Telephone: (914) 591-8681 or 8774.

1—Type 1A1, SN 016111. 1—Type 1A2, SN 006740. 1—Type 516, SN 004789. Contact: Bob Smith, Interactive Data Systems, P. O. Box A-O, Irvine, California 92664. Telephone: (714) 549-3329.

1—Type 516. Just calibrated and in excellent condition. Price: $600. Contact: Heinz Frederick, Data Products Corp., 6219 De Soto Street, Woodland Hills, California 91364. Telephone: (213) 887-8219.

1—Type 581, SN 966. 1—Type 82, SN 7944. 1—Type C-40, SN 10639. Reconditioned by Tektronix one and one half years ago. Lot Price: $1900. Contact: Ken Marich, Stanford Medical Center, Room 230, Stanford, California 94304. Telephone: (415) 321-2300 Ext. 6071.

1—Type 546/1A1. Good condition, small amount of use. Price: $1900. Contact: Don R. Green, Ferson Optics, P. O. Box 629, Ocean Springs, Mississippi 39564.

1—Type 575 Mod 122C and 1—Type 202-2. Used approximately 30 hours. Price: $1000. Contact: Mrs. Wainwright, I-Tel Corp., 10504 Wheatley Street, Kensington, Maryland 20795. Telephone: (301) 946-1800.

1—Type 545, SN 15990. 1—Type CA, SN 9652. Price: $1250. Contact: Les, 575 South Barrington, Apt. 202, Los Angeles, California 90049. Telephone: (213) 472-0882.

1—Type 541, SN 693. Best offer. Contact: Mr. Greg Jigamian, Hanson Hawk, Inc., 20327 Nordhoff St., Chatsworth, California 91311. Telephone: (213) 882-9600.

4—Type RM503, SN 001848; SN 001651; 00905; and SN 001866. Price: $450 each. Contact: Stuart Ex, 14827 Cohasset, Van Nuys, California 91405. Telephone: (213) 786-7672 or 873-7672.

INSTRUMENTS WANTED

1—Type 2B67 Time Base. Contact: F. O. Wiseman, T. B. Woods & Sons Co., Chambersburg, Pennsylvania 17201. Telephone: (717) 264-7161.

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TEKSCOPE

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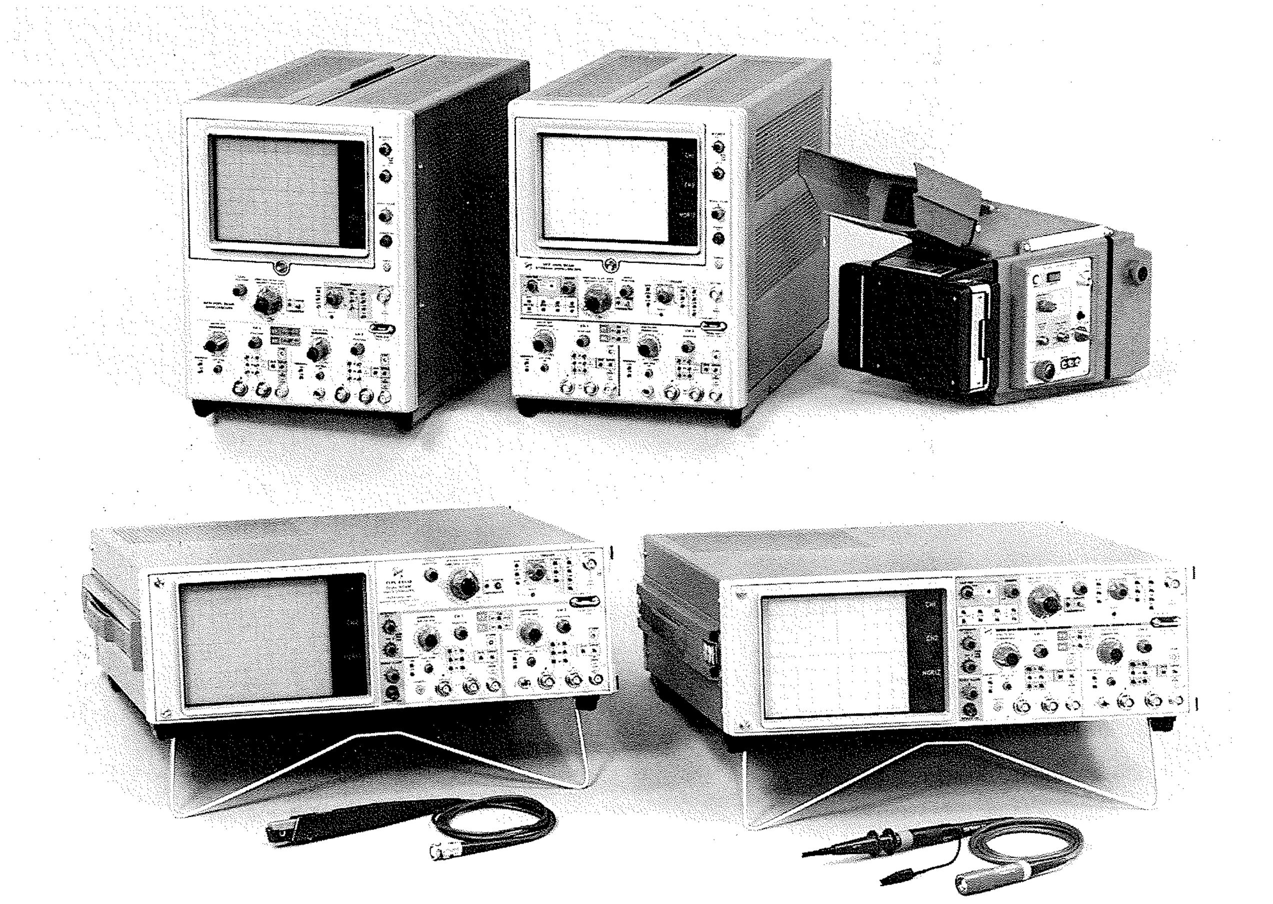

A DUAL-BEAM FAMILY

SCALE FACTOR READOUT

Control settings, probe attenuation values, and magnifier settings are all taken into consideration and electronically read out in the CRT viewing area. A > symbol is provided for uncalibrated settings.

NEW CAMERA SYSTEM

The C-70, with its electronic shutter, eliminates much of the film waste normally associated with oscilloscope photography. Range finder focusing is combined with a trace-brightness photometer to simplify and improve oscilloscope photography.

NEW LARGE-SCREEN OSCILLOSCOPE

More than 50% greater viewing area (over an 8 x 10 cm display) is available in the 5030/5031 Family. 1-MHz dual-beam oscilloscope also provides a fiber optic display of scale-factor readout.

ADVANCED COMPONENT TECHNOLOGY

Tektronix oscilloscopes make extensive use of Tektronix developed and manufactured components to provide the user with the most reliable components currently available. Low torque cam switches, miniature illuminated push buttons, relays, custom integrated circuits, ceramic cathode-ray tubes, and a number of other unique components contribute to superior instrument performance.

NEW DUAL-RANGE ATTENUATOR PROBE

The P6052 is easily switched from X1 to X10 attenuation. Probe attenuation factor is sensed and automatically controls scale-factor readout to display total system deflection factor.

CURRENT PROBE

The P6021 current probe is used without adapter or external amplifier to allow easy current waveform display.