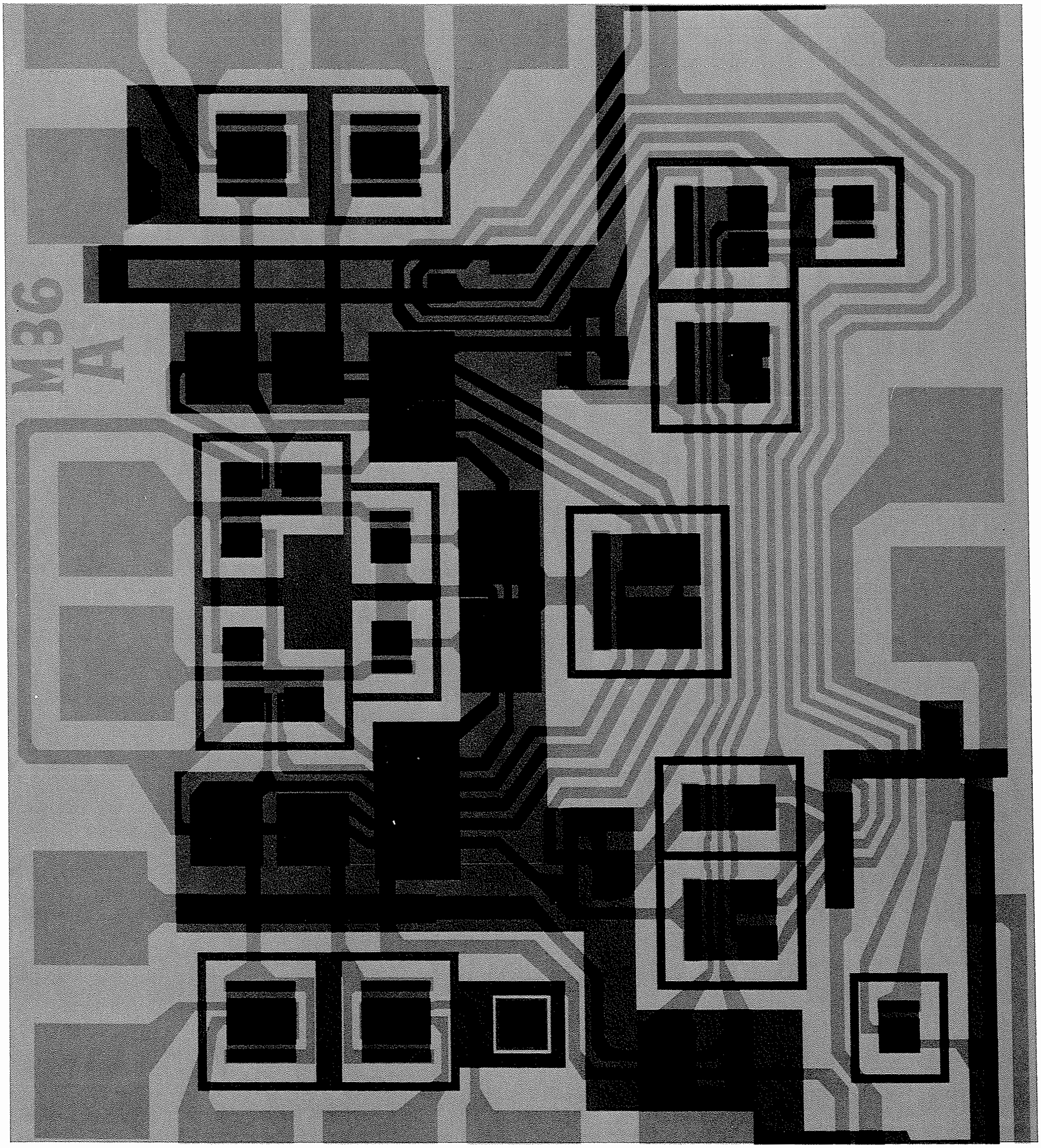
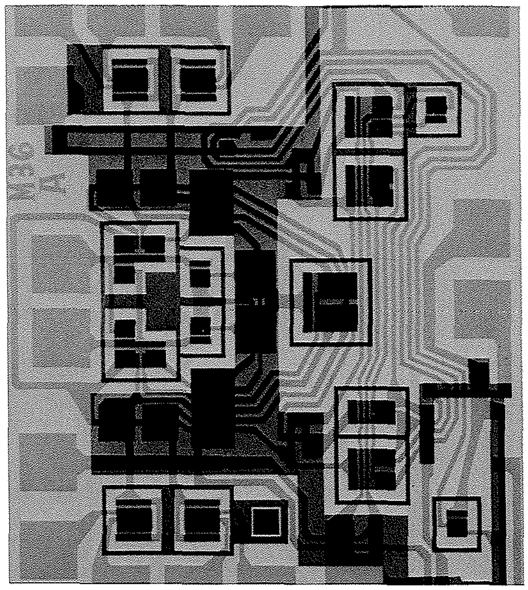
TEKTRONIX

TEKSCOPE

DECEMBER 1969



New Logic for Oscilloscope Displays • **Basic Logic Review** • **Service Scope**



a new logic for oscilloscope displays

Placing the mode switching function in the oscilloscope mainframe, where it logically belongs, greatly enhances the flexibility of the plug-in concept. This new development, coupled with an instrument design that accepts up to four plug-in units and provides an 8 x 10 cm display, offers unprecedented versatility in oscilloscope performance.

The new Tektronix 7000 Series provides the most versatile oscilloscope switching to date. Historically, vertical switching has taken place in the plug-in instead of in the oscilloscope. By placing the switching capability in the mainframe, many of the typical limitations are overcome and a number of advantages are available. No longer is the user limited to a choice of any one of two or three dual-trace plug-in units. A wide selection of multi-trace options is provided, since switching is between plug-in units and therefore performance parameters may vary greatly. Thus, the user can select the two vertical plug-ins most appropriate for his measurement, and *still* have multi-trace performance.

COVER—The composite mask of the MO36 Channel Switch IC symbolizes the versatility provided by the mainframe switching capability of the 7000 Series. See back cover.

MAINFRAME LOGIC

There are 20 possible combinations of VERTICAL MODE and HORIZONTAL MODE switch settings. The total number of possible display configurations is multiplied further by: (1) the variety of plug-ins available for use with this instrument (i.e., voltage amplifiers, current amplifiers, sampling units, etc.), (2) the interchangeability of plug-ins (i.e., an amplifier or time-base unit can be installed in either of the vertical or horizontal compartments or both) and (3) the capabilities of the plug-in units which are used in these instruments (e.g., a dual-trace vertical unit can be used in either of the two single-channel modes, in either dual-trace modes, or added algebraically; a delaying time base may be used either for a normal sweep or for delayed sweep). The table at right illustrates the combinations available for single-channel vertical and horizontal units used in the conventional Y-T mode.

The mainframe logic accepts the plug-in outputs and time-shares the CRT to provide the appropriate display. Thus, the operation of each plug-in is continuous and independent. The mainframe sequentially selects and applies plug-in outputs to the vertical and horizontal deflection plates respectively. The time interval and sequence in which plug-in outputs are displayed depends on which combinations of display modes are used.

The basic system is set up to sweep-slave the middle two plug-ins and the outer two plug-ins together (VERT MODE—ALT and HORIZ MODE—ALT or CHOP).

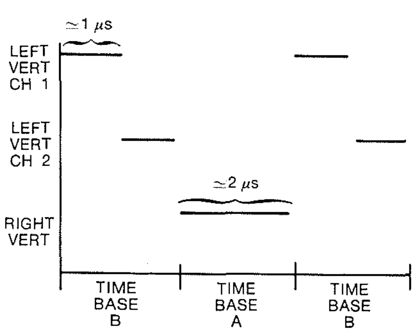
SWITCHING LOGIC

VERTICAL MODE	HORIZONTAL MODE	SOURCE OF DEFLECTION	DISPLAY
LEFT	A B	Vertical—single unit; horizontal—single unit.	Single-trace.
	ALT CHOP	Vertical—single unit; horizontal—two units.	Dual-trace—independent dual time-base—simultaneous DELAYING and DELAYED sweep.
ALT	A B	Vertical—two units; horizontal—single unit.	Dual-trace.
	ALT CHOP	Vertical—two units; horizontal—two units. Sweep slaving between LEFT VERT and B HORIZ plug-ins and RIGHT VERT and A HORIZ plug-ins.	Dual-trace—independent "dual-beam" operation—X-Y, Y-T—dual-trace delaying sweep—dual-beam X-Y (CHOP ONLY).
ADD	A B	Vertical—algebraic summation of two units; horizontal—single unit.	Single-trace—algebraic addition of two or more signals—dual-trace delaying sweep—raster capability.
	ALT CHOP	Vertical—algebraic summation of two units; horizontal—two units.	
CHOP	A B	Vertical—two units; horizontal—single unit.	Dual-trace.
	ALT CHOP	Vertical—two units; horizontal—two units.	Four-trace—each vertical displayed at two sweep speeds—dual-beam X-Y.
RIGHT	A B	Vertical—single unit; horizontal—single unit.	Single-trace.
	ALT CHOP	Vertical—single unit; horizontal—both units.	Dual-trace—independent dual time-base—simultaneous DELAYING and DELAYED sweep.

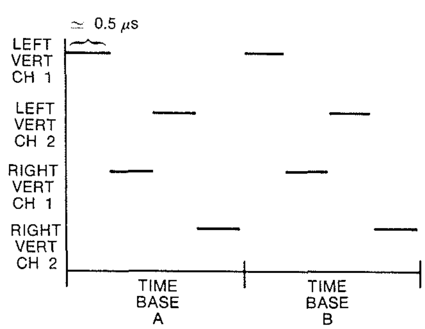
Thus, the right vertical plug-in is displayed at the sweep rate of the A horizontal plug-in and the left vertical plug-in is displayed at the sweep rate of the B horizontal plug-in (non-delayed sweep only). One reason for this particular choice is to allow for the possibility of multiple width plug-ins for the future. Since there are no vertical dividers in the plug-in compartment, maximum future flexibility is provided.

For delayed-sweep operation, a different display sequence occurs. First, the LEFT VERT unit is displayed at the sweep rate of the time-base unit in the A HORIZ compartment (delaying sweep) and then at the sweep rate of the time-base unit in the B HORIZ compartment (delayed sweep). The vertical display then shifts to the RIGHT VERT unit and is displayed consecutively at the delaying and delayed sweep rate. The figures below show three of the possible switching configurations.

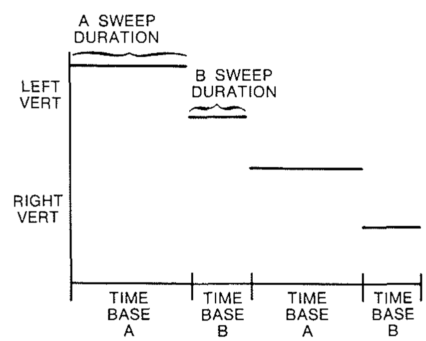
The CHOP HORIZ mode provides a display that has not been possible before. In this mode, the outputs of the A and B horizontal plug-ins are continuously switched and displayed on the CRT. If the two horizontal plug-ins are time bases, then the CHOP mode displays both at what appears to be the same time. The chopping is not normally discernible since the sweep switching occurs nonsynchronously with the sweep.



VERTICAL MODE—ALT HORIZONTAL MODE—CHOP
ONE DUAL-TRACE (CHOP) AND ONE SINGLE-CHANNEL PLUG-IN
TWO TIME-BASE PLUG-INS (CHOP)



VERTICAL MODE—CHOP HORIZONTAL MODE—CHOP
TWO DUAL-TRACE VERTICAL PLUG-INS (CHOP)
TWO TIME-BASE PLUG-INS

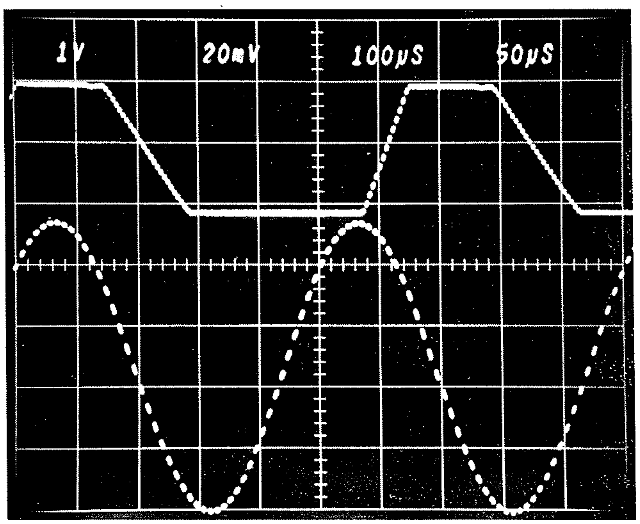


VERTICAL MODE—ALT HORIZONTAL MODE—ALT
TWO SINGLE-TRACE VERTICAL PLUG-INS
TWO TIME-BASE PLUG-INS (DELAYED-SWEEP OPERATION)

Three of the many possible switching configurations are shown above.

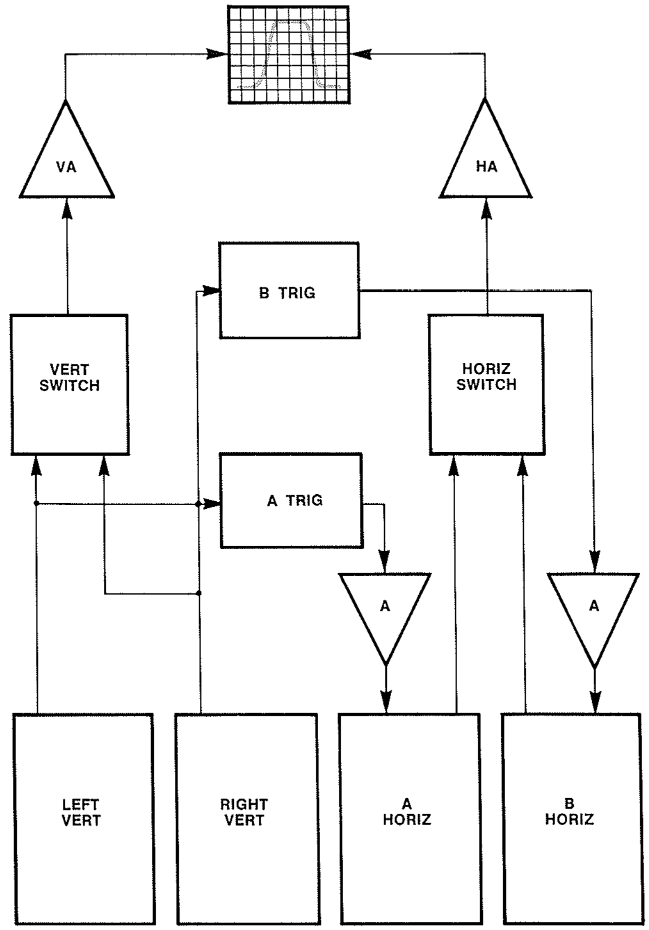
The CHOP horizontal configuration provides the ability to obtain an equivalent dual-beam single-sweep capability. The maximum sweep speed limitation is dependent upon the horizontal chop rate. Since the horizontal chop rate requires a 2-μs segment for each plug-in and the vertical chop rate requires ≃ a 0.5-μs segment, the fast sweep limitation is basically the horizontal chop rate. Thus, two simultaneous single events may be monitored at sweep speeds as fast as 50 μs/div. The photo below illustrates this capability.

A second advantage of the CHOP horizontal configuration is that the intensity level of different sweep speeds may be more closely matched. Because the sweep-speed ratios may be quite diverse (2,500,000,000:1 is available in calibrated sweeps with the 7B70 Time-Base Unit), the Alternate mode in many cases can have too great an intensity level difference to display the faster sweep. Chopping, however, helps a great deal to balance the different sweep intensities.



The horizontal CHOP mode monitors two independent single-occurrence events ***simultaneously*** *and provides a dual-beam capability to approximately 50 μs/div.*

Selection of internal trigger signals for both sweeps is provided on the front panel. For most applications, these switches can be set to the VERT MODE positions. This position is the most convenient since the internal trigger signal is automatically switched as the VERTICAL MODE switch is changed or as the display is electronically switched between the LEFT VERT and RIGHT VERT plug-ins in the ALT position of the VERTICAL MODE switch. It also provides a usable trigger signal in the ADD or CHOP positions of the VERTICAL MODE switch, since the internal trigger signal in these modes is the algebraic sum of the signals applied to



The unique mainframe switching of the 7000 Series provides a new versatility in signal and triggering processing.

the vertical plug-in units. This technique prevents the time base from triggering on the vertical CHOP signal. The VERT MODE ensures that the time-base units receive a trigger signal regardless of the VERTICAL MODE switch setting, without the need to continually change the trigger source selection.

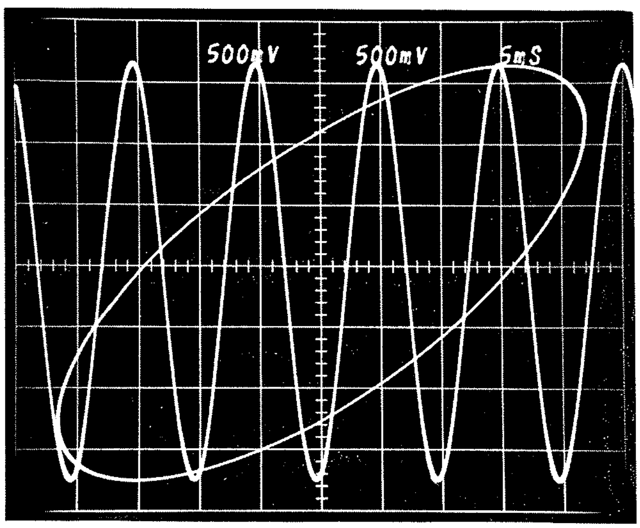
If correct triggering for the desired display is not obtained in the VERT MODE position, the trigger source for either the A HORIZ or B HORIZ time-base unit can be changed to obtain the trigger signal from either the LEFT VERT or RIGHT VERT plug-in. The internal trigger signal is obtained from the selected vertical compartment whether or not the plug-in in that compartment is selected for display on the CRT.

One of the most unique aspects of the NEW 7000 Series is the ability to simultaneously use different methods of analyses. Thus, the identical signal can be observed both X-Y and Y-T. A sampling display (X-Y or Y-T) may be compared against a high-impedance conventional display, and a raster display (T-T) may be displayed *simultaneously* with an X-Y or Y-T display, or both.

A unique Z-axis configuration available on 7000-Series instruments enhances this multiple display capability. Two inputs are provided for maximum user versatility in Z-axis modulation applications. HIGH SPEED requires 60 volts peak-to-peak to provide trace modulation over the full intensity range from DC to 100 MHz (7704). HIGH SENS requires only 2 volts peak-to-peak to provide full intensity range from DC to 2 MHz.

Three outputs are provided on the front panel of the 7000 Series. A positive sawtooth output provides a sample of the sawtooth signal from either of the plug-in time bases. The rate of rise of the signal is approximately 50 mV/div into a 50-Ω load or approximately 1 volt/div into a 1-MΩ load.

The + GATE output provides a positive-going rectangular output pulse from either A or B time base, on the delayed gate from an A delaying time-base unit. The amplitude of the + GATE is approximately 0.5 volts into 50 Ω or approximately 10 volts into 1 MΩ.



The 7000 Series allow simultaneous use of different methods of analyses. Thus, both X-Y and Y-T presentations may be monitored to obtain additional information from the display.

The SIG OUT connector provides a sample of the vertical deflection signal. The source of signal is determined by the position of the B trigger source. In the VERT MODE position, the output signal is determined by the setting of the VERTICAL MODE switch. In the ALT position of the VERTICAL MODE the output signal switches between vertical units along with the CRT display. CHOP and ADD both provide a composite signal output. The output voltage into 50 Ω is approximately 25 mV/div of the CRT display. Into a 1-MΩ load, the output voltage is approximately 0.5 V/div. The bandwidth of the output signal is determined by the combination of plug-in and oscilloscope. The 7704 and 7A11 or 7A16 provide a DC-60 MHz vertical signal output capability.

AMPLIFIER PERFORMANCE

The initial offering of 13 plug-ins contains 7 amplifier units (including a sampling amplifier). Up to four amplifier units may be displayed (dual X-Y displays), but the most common configuration is two amplifier units in the LEFT VERT and RIGHT VERT compartments. The wide range of units available include wide-band amplifiers, dual-trace amplifiers, differential comparators, current probe amplifiers, and high gain differential amplifiers.

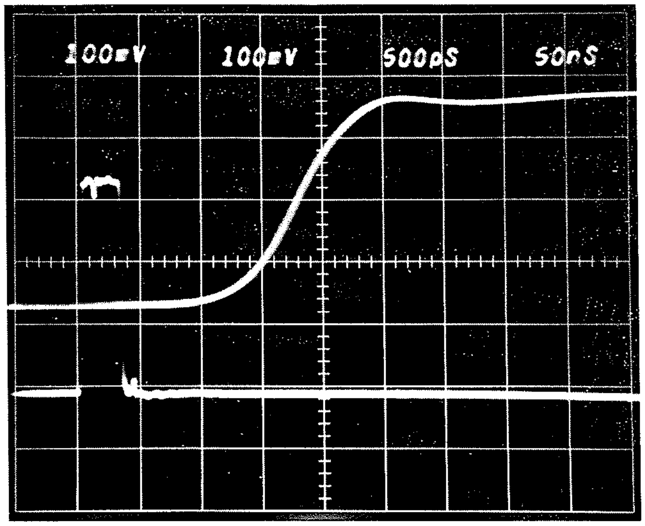
The basic accuracy of most amplifier units is specified at 2% over the temperature range of 0° to 50° C. The exceptions to this are 1½% for the differential comparator unit and 3% for the sampling amplifier unit. All amplifier units contain an INVERT position and an IDENTIFY button which deflects the trace slightly and identifies the appropriate Auto Scale-Factor Readout area.

An X-Y compensation option is available for applications requiring precise phase measurements. The option consists of a network to compensate for the differences in vertical and horizontal delays allowing phase shift to be adjusted to less than 2° from DC to 2 MHz.

The 7A11 amplifier is a new concept in high input impedance (1 MΩ) amplifier FET probe design offering 5-mV, 150-MHz performance in the 7704 and 5-mV, 90-MHz performance in the 7504. Capacitance is a function of the attenuators and is 5.8 pF from 5 mV to 50 mV/div; 3.4 pF from 0.1 V to 1 V/div; and 2.0 pF from 2 V to 20 V/div. One volt (±) of DC offset is provided as well as an output jack for monitoring of the offset voltage.

A unique captive probe design that is an integral portion of the plug-in allows a design much easier to use than present FET probes. Two stacked attenuators and a FET amplifier are contained in the probe and are relay-switched by the front-panel VOLTS/DIV control.

The result is a FET probe that is small in size with no bulky amplifier to mount to the oscilloscope. The probe cannot be made to clip or limit the signal on the CRT by an incorrect combination of input attenuator and plug-in sensitivity. The operator is thus freed from concern with manual plug-on attenuators and dynamic signal range. If the signal can be positioned or offset to fall within the viewing area, the amplifier is operating linearly. The sensitivity at the probe tip may be read directly from the front panel or from the auto scale-factor readout on the CRT.



Lower trace—conventional display. Upper trace—sampling display provides increased time resolution.

A second mode of operation is provided via a BNC connector on the front panel. When the full capability of the system is not required, the probe is stored internally and is accessible via a front panel BNC connector. In this mode, approximately 1 pF is added to the input capacitance.

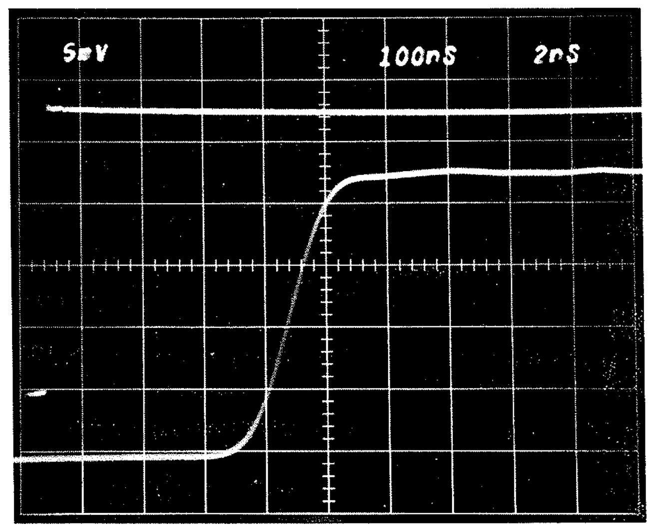
The 7A12 is a 1-MΩ, 5-mV dual-channel plug-in amplifier that is the basic building block for two, three and four-trace operation. The 7A12 provides 105-MHz performance in the 7704, and 75 MHz in the 7504, with an accuracy of 2% over the 5-mV/div to 5-V/div deflection factor range. In addition to the 5 display modes (Channel 1, ALTERNATE, CHOP, ADD, Channel 2), a trigger source allows selection of either Channel 1 or Channel 2. An additional position is included for operator convenience. In this position, the trigger source is automatically locked to the display mode. Thus, when Channel 1 is selected as the display mode, Channel 1 is automatically selected as the trigger source. The only exception to this is in CHOP, where the triggering is the same as in the ADD mode.

A feature new to dual-trace operation is the volts DC offset provided to allow ±1000 cm of offset on all ranges for both channels. Thus, the user can make DC-coupled measurements of low-amplitude signals that "ride" on DC levels. This DC offset makes the 7A12 truly a versatile instrument.

The 7A13 is a differential comparator plug-in amplifier that incorporates a number of performance features in the same instrument. As a conventional 1-MΩ input impedance amplifier, the 7A13 maintains constant bandwidth (100 MHz in the 7704, 75 MHz in the 7504) over a 1 mV/div to 5 V/div deflection factor range. A 5-MHz bandwidth position is provided to minimize noise in the lower frequency applications. As a differential amplifier, the 7A13 maintains its conventional features, and provides a CMRR of 20,000:1 from DC to 100 kHz, decreasing to 1000:1 at 10 MHz.

The 7A13 features an in-line digital readout of comparison voltage. The decimal point for the comparison voltage is coded by the probe in use and automatically indicates the correct voltage as referenced to the probe tip. The ±10 volts of offset provides an effective 10,000-centimeter display on the 1 mV/div range, of which any 8-cm "window" can be displayed.

A V_c REF button applies the comparison voltage to both input gates. The "null" is established using V_c instead of a ground reference, and results in a simplified method of obtaining a zero reference.



The 7704 and the 7A16 Amplifier provide a 5-mV, 2.4 ns capability. Note the excellent long-term and short-term response characteristics.

The 7A14 is an AC current probe amplifier which provides constant bandwidth (dependent on the current probe and mainframe) over the 1-mA/div to 1-A/div calibrated deflection factor range. Both the P6021 and P6022 AC current probes may be used with the 7A14. A special BNC input connector senses the type of current probe, and switches in the proper internal compensation circuit. An invert switch on the plug-in allows an inversion of the current waveform and eliminates the need to physically reverse the probe.

Two current probes are presently offered for use with the 7A14. The P6021 is optimized for low-frequency response. It has a lower −3 dB point of 30 Hz and an upper −3 dB point of 45 MHz in the 7504 and 50 MHz in the 7704. The P6022 is designed for high-frequency response. The lower frequency −3 dB point is 250 Hz with an upper −3 dB point of 75 MHz in the 7504 and 105 MHz in the 7704.

The 7A16 is a wideband amplifier with a deflection-factor range of 5 mV/div to 5 V/div. 150-MHz performance is provided in the 7704 and 90-MHz performance in the 7504. The unit provides a 1-MΩ, 15-pF input and employs a thick-film drum attenuator for excellent frequency response. Bandwidth is selectable at FULL or 20 MHz for user convenience.

The 7A22 is a high-gain differential amplifier with 10-μV, 1-MHz performance characteristics. The displayed noise (tangentially measured) at full bandwidth is held to 16 μV. Drift is held to less than 5 μV/min and 10 μV/h. Both HF −3 dB points and LF −3 dB points may be selected from the front panel to reduce the displayed noise for any given measurement. An offset feature provides ± 1 volt at small deflection factors, ± 10 volts midrange, and ± 100 volts at large deflection factors. The CMRR of the instrument is 100,000:1 from DC - 100 kHz.

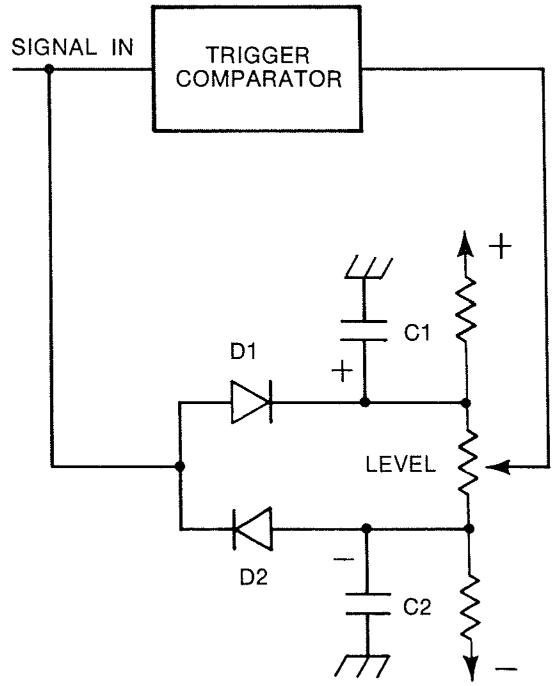
TIME-BASE PERFORMANCE

Four time-base units are presently available for use in the 7000-Series Oscilloscopes. All four make extensive use of push buttons for simplified operation. For the most commonly used mode, it is only necessary to depress the upper push button in each row. Twelve push buttons control MODE, SOURCE, and COUPLING. The 7B50/51 were primarily designed for the 7504 and the 7B70/71 were primarily designed for the 7704. The primary differences between the 7B50/51 and 7B70/71 are maximum sweep speed and trigger bandwidth (5 ns, 100 MHz or 2 ns, 200 MHz). The plug-in front panels are identical except for the fastest sweep speed range. Any time base may be used in any mainframe although maximum calibrated sweep speed may become a factor. For example, the 2-ns position of the 7B70/71 would not be calibrated if used in the 7504. A notation on each mainframe labels the fastest calibrated TIME/DIV.

The 7B50 and 7B70 are typically used as delayed-sweep units and also contain provision for external horizontal operation, 25 mV/div or 250 mV/div.

The 7B51 and 7B71 are typically used as delaying-sweep units and contain delay-time multiplier circuitry with a jitter specification of 1 part in 50,000.

A new trigger circuit is featured that greatly simplifies trigger operation. The peak-to-peak auto trigger circuit detects the peak-to-peak excursions of the displayed waveform, stores the value in the peak-to-peak memories, and matches the range of the level control to the range of the displayed signal. Should the amplitude change, the memories will automatically respond. Thus, positive triggering is ensured for all positions of the LEVEL/SLOPE control regardless of signal amplitude. In addition, trigger level and slope are incorporated into one control with the slope being relay-switched as the LEVEL/SLOPE control passes through 0° and 180°.



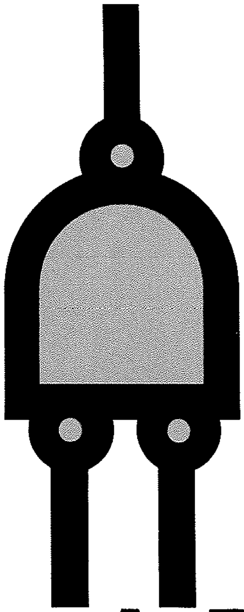
The repetitive signal input forward-biases the peak detectors (D1 and D2) and allows peak-to-peak memories C1 and C2 to become positively and negatively charged, respectively. This level is impressed across the LEVEL control and allows full sensitivity for all amplitudes of trigger signal within the sensitivity limits.

With the trigger in the peak-to-peak auto position, the operator can go through the maximum excursions on either slope and never reach an untriggerable position on the control knob.

The 7S11 Sampling Amplifier, the 7T11 Sampling Time-Base Unit, the 7M11 Dual Delay-Line and a complete line of sampling heads provide a complete sampling capability. The ability to mix conventional displays against sampling displays offers a unique new measurement capability. The 7S11 accepts any one of five plug-in sampling heads to cover the impedance/bandwidth spectrum from 1 MΩ/350 MHz to 50 Ω/14 GHz. In addition, the random sampling mode of the 7T11 allows the triggering event to be displayed without pretrigger or delay lines. February's TEK-SCOPE will discuss in detail the performance of these new sampling instruments.

The Tektronix 7504 and 7704, with their initial complement of 13 plug-ins, represent an excellent investment for the future and a hedge against obsolescence. Placing the mode switching capability in the mainframe results in a new standard of oscilloscope versatility and performance.

For further information on the Tektronix 7000 Series refer to the August 1969 New Products Supplement and consult your local Tektronix Field Engineer.



A BASIC LOGIC REVIEW

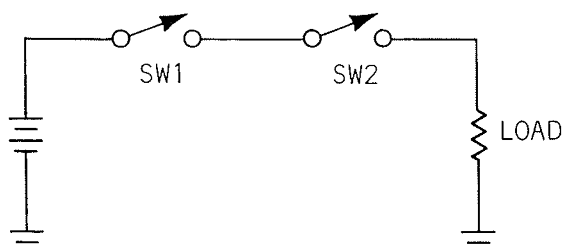
The latest Tektronix instruments are using digital logic functions extensively. This review is a brief discussion of the common symbols and terms used to explain some of the basic logic functions.

All new Tektronix instruments are standardizing on the use of positive logic. Positive logic refers to the use of a 1 to represent the true or more positive level and a 0 to represent the false or less positive level (0 volt). A convenient method of converting the HI-LO logic convention to a 1-0 notation is to disregard the first letter of each state. Thus:

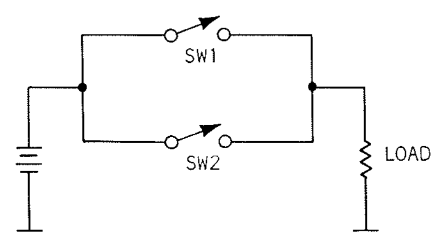
HI = 1
LO = 0

Input/output (truth) tables are used with logic diagrams to show the input combinations which are of importance to a particular function, along with the resultant output conditions. The tables can be given either for an individual device or for a complete logic stage.

The basic logic circuit is the AND gate. The AND gates contain two or more inputs and a single output. The output of an AND gate is HI only when all of the inputs are at the HI state. A LO signal on any of the input terminals produces a low signal at the OUTPUT. Thus, the AND gate performs the logical operation of producing a true output signal only when all the input signals are simultaneously true. The circuit drawing illustrates a circuit in which no voltage is delivered to the load unless both switches are closed.



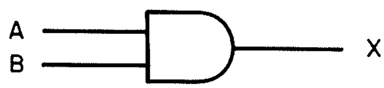
A second basic logic circuit is the OR gate. OR gates contain two or more inputs and a single output. The output of an OR gate is HI when one or more of the inputs are at the HI state. Thus, the OR gate performs the logical operation of producing a true output for the time duration that one or more of its inputs are true, and a false output for the time durations in which none of its inputs are true. The circuit drawing illustrates a circuit in which voltage is delivered to the load where either or both switches are closed.

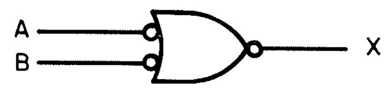


BASIC LOGIC DIAGRAMS

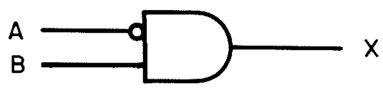
GATES

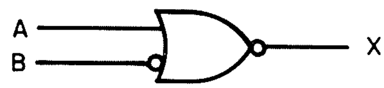
AND / OR / A B X



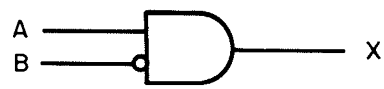


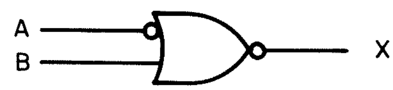
A	B	X
HI	HI	HI
HI	LO	LO
LO	HI	LO
LO	LO	LO



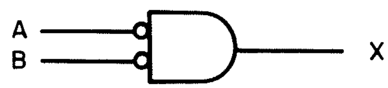


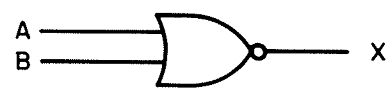
A	B	X
HI	HI	LO
HI	LO	LO
LO	HI	HI
LO	LO	LO



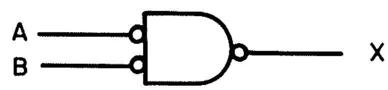


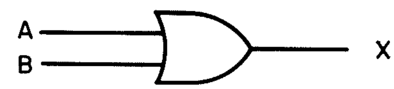
A	B	X
HI	HI	LO
HI	LO	HI
LO	HI	LO
LO	LO	LO



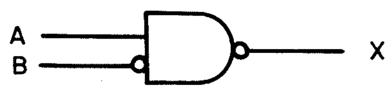


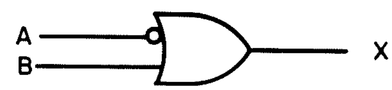
A	B	X
HI	HI	LO
HI	LO	LO
LO	HI	LO
LO	LO	HI



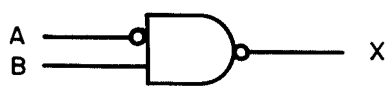


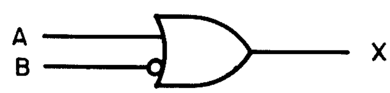
A	B	X
HI	HI	HI
HI	LO	HI
LO	HI	HI
LO	LO	LO



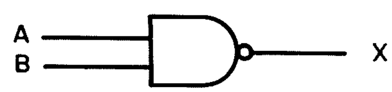


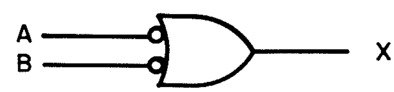
A	B	X
HI	HI	HI
HI	LO	LO
LO	HI	HI
LO	LO	HI





A	B	X
HI	HI	HI
HI	LO	HI
LO	HI	LO
LO	LO	HI

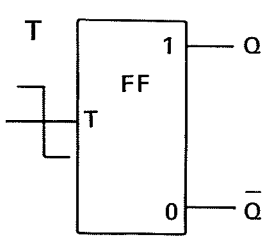




A	B	X
HI	HI	LO
HI	LO	HI
LO	HI	HI
LO	LO	HI

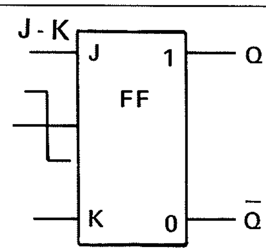
FLIP-FLOPS

T



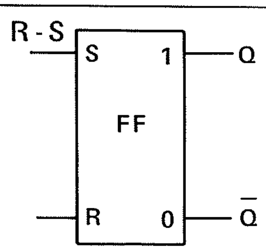
Input Condition before trigger pulse		Output Condition after trigger pulse	
Q	Q̄	Q	Q̄
LO	HI	HI	LO
HI	LO	LO	HI

J - K



Input		Output	
J	K	Q	Q̄
LO	LO	No change	
LO	HI	LO	HI
HI	LO	HI	LO
HI	HI	Comple-ment	

R - S



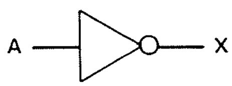
Input		Output	
R	S	Q	Q̄
LO	LO	No change	
LO	HI	LO	HI
HI	LO	HI	LO
HI	HI	Undefined	

FLIP-FLOP INPUTS

SET .... Shown by the letter S
RESET (or CLEAR) .. Shown by the letter R
TOGGLE .... Shown by the letter T
J and K ..... Shown by the letters J and K
DELAY .... Shown by the letter D

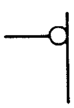
Cut along dotted line.

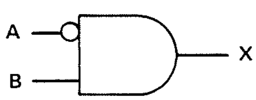
The inverter amplifier is a device with one input and one output that is used to invert the sense of the signal. The output of an inverter provides the complement of the input. Thus, the inverter amplifier performs the logical operation of not producing a true output (HI) for the time duration that the input is true.



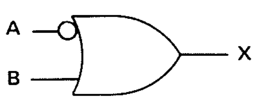
A	X
LO	HI
HI	LO

Logic diagrams make extensive use of the LO-state indicator. A small circle at the input or output of a symbol indicates that the LO state is the significant state. The absence of a circle indicates that the HI state is the significant state. For example, an AND gate with LO-state indicator at the input is shown below. The output of this gate is only HI when the A input is LO and the B input is HI. A second example is the OR gate shown with a LO-state indicator at the A input. Note that the output of this gate is HI if either the A input is LO or the B input is HI.



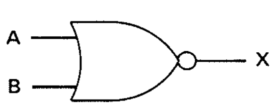


A	B	X
LO	LO	LO
LO	HI	HI
HI	LO	LO
HI	HI	LO



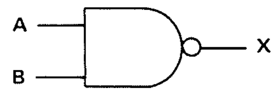
A	B	X
LO	LO	HI
LO	HI	HI
HI	LO	LO
HI	HI	HI

A NOR gate is functionally equivalent to an OR gate followed by an inverter. The NOR gate fulfills the logical function of producing a HI at the output only when all the input signals are simultaneously LO. A HI applied to any input results in a LO output.



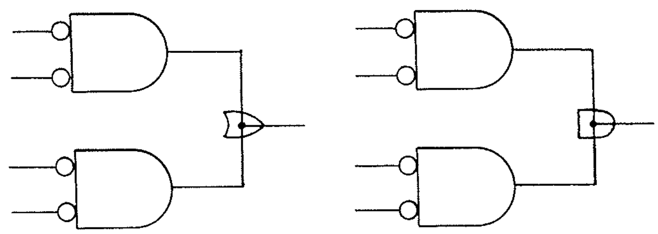
A	B	X
LO	LO	HI
LO	HI	LO
HI	LO	LO
HI	HI	LO

A NAND gate is functionally equivalent to an AND gate followed by an inverter. The NAND gate performs the logical function of producing a LO at the output only when all the input signals are HI. The inverted output of the NAND gate provides level restoration in addition to performing a logical function.

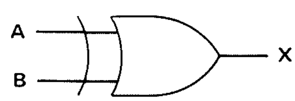


A	B	X
LO	LO	HI
LO	HI	HI
HI	LO	HI
HI	HI	LO

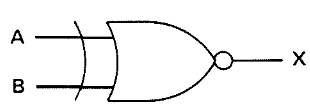
Occasionally, circuits can be combined according to AND (or OR) function simply by having the outputs connected. This configuration is called a phantom OR (sometimes called a wired OR). Two examples are presented below.



An EXCLUSIVE OR gate produces a true output when the input states are not identical. The output is false if the inputs are identical. Thus, the EXCLUSIVE OR gate fulfills the logical function of producing a HI if one and only one input is LO. A second configuration of the EXCLUSIVE OR (COINCIDENCE) produces the complement.



A	B	X
LO	LO	LO
LO	HI	HI
HI	LO	HI
HI	HI	LO



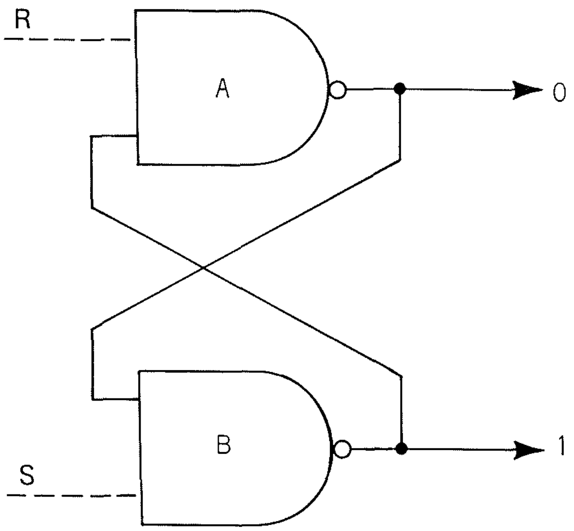
A	B	X
LO	LO	HI
LO	HI	LO
HI	LO	LO
HI	HI	HI

The flip-flop is a bistable device with one or more inputs and two outputs which performs the logical operation of storage. A flip-flop is a bistable circuit that will remain in its last state until an input causes it to change into its output state. Because of this ability to store a bit of information, the flip-flop is the basic building block in digital logic. The state of the flip-flop is available on the output line and a particular flip-flop is generally identified by which function is stored within it. Nearly all flip-flops have a second output line on which the complement (e.g., $\overline{Q}$)

of the stored function is available. The other terminals of a flip-flop are input terminals and may receive either level or pulse signals, depending on the particular circuit.

A basic flip-flop can be drawn using two NAND gates connected as show below. To understand operation, assume the two inputs shown as dotted lines do not exist. When power is applied, opposite states will appear on the outputs.

For example, assume that the output of gate A is LO. This LO will be applied to the input of gate B whose output will then become HI. When this HI is applied



to the input of gate A, a LO will remain on the output of gate A. Thus, the gates are latched into a stable state.

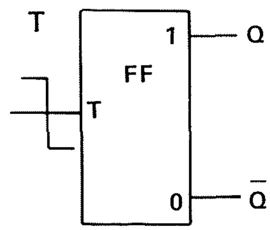
Next, connect R and assume it is HI. The state of the gates can be changed by applying a LO to input R. The flip-flop flips to the state where A is HI and B is LO. (NAND gate—if either input is LO, the output is HI.) Since the input of A is now LO from gate B, there is no way to return to the original state through the use of R. The LO input will now keep the output of gate A HI, regardless of the R input state.

By connecting S, the state of the flip-flop can be changed by applying a LO to the R or S where output is LO and the flip-flop is fully controlled. Thus, a basic flip-flop consists of two NAND gates with outputs cross-coupled to the inputs.

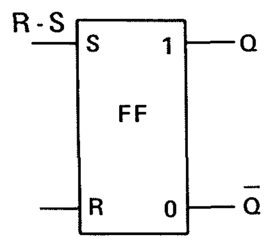
Flip-flops may be either clocked or unclocked. In a clocked flip-flop, the outputs respond to the inputs only when clocked. In an unclocked flip-flop, the outputs respond to the inputs as the inputs change.

A common configuration is the toggle flip-flop (TFF). The TFF is a bistable device with one input line and two output lines which changes states from one stable state to the other state with each trigger. Either or both of the complementary outputs may be used. A major shortcoming of the TFF is that the state of the FF after a trigger is applied cannot be accurately known unless the present state is known.

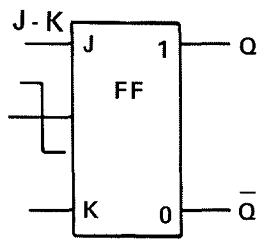
Another common FF is the set-reset flip-flop (RS FF). The RS FF is a bistable device with two input lines and two output lines. The output lines are complementary and change states in response to the states at the input. Two rules for R-S flip-flops are "set to 1 and reset to 0". Set to 1 means an input signal to the set terminal switches the circuit to a known condition (HI). Reset to 0 means that an input signal to the reset input switches the flip-flop to the opposite condition (LO). Inputs at both the R and S inputs are forbidden since the device can never be in both states simultaneously. The R-S flip-flop is used in logic situations which do not include the possibility of simultaneous set and reset inputs.



Input		Output	
Condition before trigger pulse		Condition after trigger pulse	
Q	$\bar{Q}$	Q	$\bar{Q}$
LO	HI	HI	LO
HI	LO	LO	HI



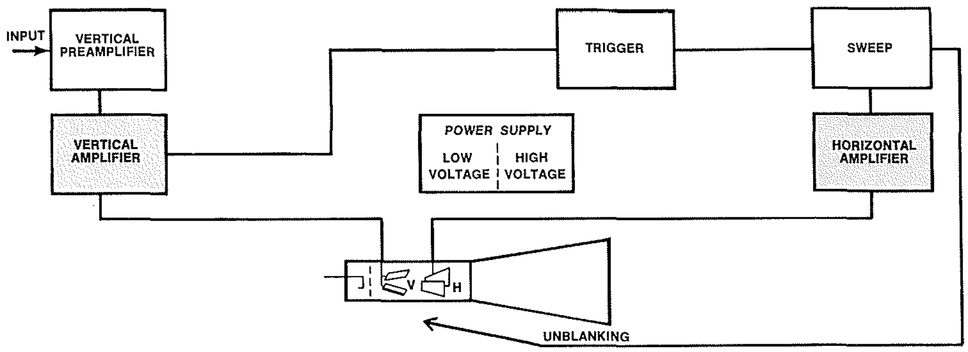
Input		Output	
R	S	Q	$\bar{Q}$
LO	LO	No change	
LO	HI	LO	HI
HI	LO	HI	LO
HI	HI	Undefined	



Input		Output	
J	K	Q	$\bar{Q}$
LO	LO	No change	
LO	HI	LO	HI
HI	LO	HI	LO
HI	HI	Complement	

The J-K flip-flop has no ambiguous states and is a commonly used configuration. The J-K flip-flop has two inputs and two outputs. When a HI is applied to the J, the flip-flop is switched to the HI state. With a HI at K, the flip-flop is switched to the LO state. If HI's are applied to both the J and K terminals, the FF switches to its complement state. Many J-K flip-flops are supplied with two or more J inputs and two or more K inputs. As a result, frequently one J and one K input are connected together for use as a clock input.

SERVICE SCOPE



TROUBLESHOOTING THE AMPLIFIERS

By Charles Phillips
Product Service Technician, Factory Service Center
Contribution by Dave Colbert

This fifth article in a series discusses troubleshooting techniques in the vertical and horizontal amplifier circuits of Tektronix instruments. For copies of the preceding four TEKSCOPE articles, please contact your local Tektronix Field Engineer.

For effective troubleshooting, examine the simple possibilities before proceeding with extensive troubleshooting. The following list provides a logical sequence to follow while troubleshooting both the horizontal and vertical amplifier circuitry:

1. Observe CRT display characteristics.
2. Check control settings.
3. Isolate trouble to block.
4. Thorough visual check.
5. Check voltages and waveform.
6. Check individual components.

Note: **Always** return the original component to its place if the problem remains.

GENERAL

Neon indicator lights and trace finders usually provide sufficient information to indicate which side of the vertical or horizontal amplifier is causing the trouble, or whether both sides are. If the trace-finder button brings the trace back on the screen, then by varying the position control we can observe whether we have position control on both sides. If we have position to one side only, this will tell us that we have an unbalance in one of the amplifiers. If we have no position, then it could be a defective stage completely.

If a vertical or horizontal amplifier is badly out of balance, a clip lead can be used to short the collectors of the output transistors (or plates of output tubes) to ensure that the spot is centered. (The deflection plates themselves may be shorted to verify the true electrical center of the instrument.) The shorting strap is then moved to the base (or grid) of the output stage and the amount of difference in the spot position noted. The position difference indicates the amount and direction of unbalance in the output stage. By applying this technique, stage by stage back to the input, the amount of unbalance may be determined. Switch the input transistors of the output amplifier when the unbalance is over 0.5 centimeter. A defective stage is indicated by the shorting strap not centering the trace on the CRT. It's a good idea to switch transistors around to obtain an unbalance less than that figure. This will ensure a well balanced vertical system and minimize compression or expansion.

The Type 576 Curve Tracer presents a convenient way to locate difficult problems in push-pull or complementary circuitry. The AC Collector Mode is ideal for comparing the impedance of various circuit points against similar impedance points. Any substantial difference in displays indicates a probable incorrect circuit impedance for the test point. Use sufficient voltage to turn on nearby junctions for maximum insight into the test circuit. Open and shorted diodes are easily found this way as well as much more difficult conditions, including in-circuit leakage problems. Be certain that the power is OFF on the scope under test.

This approach is useful whenever suspected stages may be compared against a known good stage. The technique is particularly valuable when troubleshooting feedback circuitry. By setting the initial display to approximately a 45° positive slope, meaningful comparisons can be quickly made.

A convenient method of determining which component in a string is noisy is to use a differential comparator unit. Usually, if such a problem is observed single-ended, it is difficult to localize the faulty resistor. By monitoring the problem differentially and bucking out the voltage, the noisy component is quickly and easily located. The same technique will often work to a lesser degree with add algebraic or ordinary differential amplifiers.

HORIZONTAL AMPLIFIERS

The horizontal amplifier develops a push-pull version of the input ramp from the time-base generator. These simultaneous positive and negative going ramp voltages are then applied to the right and left horizontal deflection plates, respectively, causing the CRT spot to move across the screen. Thus, equal increments of distance represent equal increments of time, and the sweep can be calibrated.

Many horizontal amplifiers include magnifier circuitry that decreases the amount of negative feedback and increases the gain accordingly. Such magnifiers are usually X5 or X10 and effectively increase the sweep rate by that amount. Most oscilloscopes also provide an external input to the horizontal amplifier. In this position, the internally generated sawtooth is disconnected and an external signal may be connected to the external horizontal input terminal. Often a compensated 10X attenuator is used with the external horizontal circuitry to provide a wider range of signal inputs.

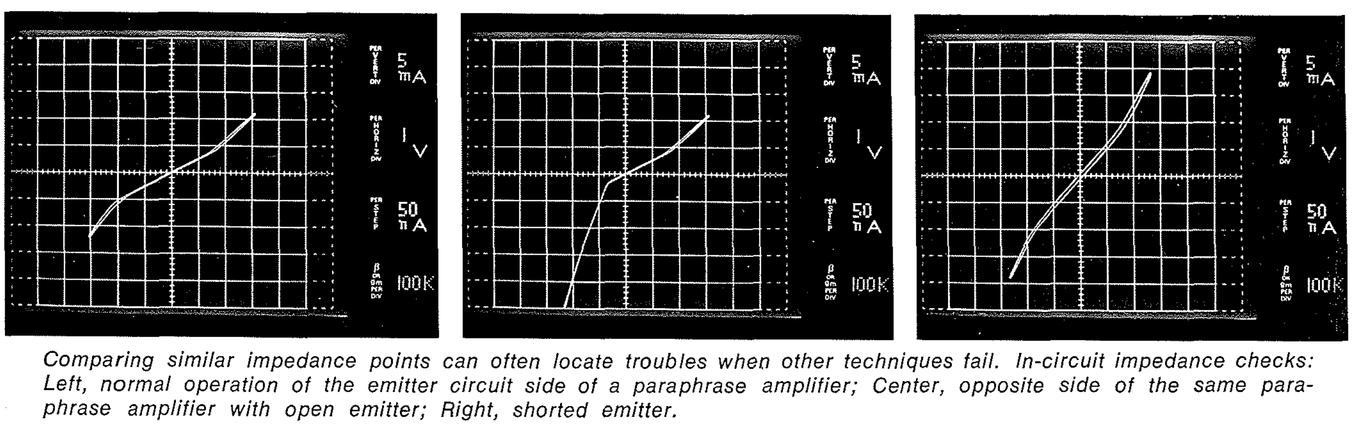
When the oscilloscope has a second sweep, this may be used to check for normal operation. A calibrator signal to the external horizontal input checks the operation of a portion of the horizontal amplifier. If the instrument has a plug-in horizontal, removing the plug-in unit should automatically center the spot. This is of additional assistance with oscilloscopes using deflection blanking. Deflection blanking positions the spot offscreen, except during sweep time, and no spot can be seen by overriding the intensity control.

Switching to the external input disconnects the sweep and is a means of determining whether a problem is associated with the horizontal amplifier. At the same time, it can indicate the condition of the unblanking circuitry.

VERTICAL AMPLIFIERS

The vertical amplifier develops a push-pull version of the input signal from the vertical preamplifier. These simultaneous positive and negative going amplified signal voltages are then applied to the upper and lower vertical deflection plates, deflecting the CRT spot as it traverses the screen. Thus, an accurate amplified reproduction of the original signal is displayed on the CRT. In addition, many oscilloscopes provide a vertical signal output which allows the amplified signal to drive other devices.

No stage where distributed amplifiers are used should contribute more than 2-mm unbalance. In addition, tubes should be switched so the total unbalance of the distributed amplifiers does not exceed 2 mm. Never mix different brands of distributed amplifier tubes. If a distributed amplifier tube fails and a replacement is needed, the trigger pickoff tube makes an excellent aged replacement. The trigger pickoff tube may then be replaced with a different brand.



Comparing similar impedance points can often locate troubles when other techniques fail. In-circuit impedance checks: Left, normal operation of the emitter circuit side of a paraphrase amplifier; Center, opposite side of the same paraphrase amplifier with open emitter; Right, shorted emitter.

TYPICAL HORIZONTAL PROBLEMS

Problem: Sweep shortening at fast sweep speeds. Nonlinearity and sometimes sweep compression to the right.

Solution: This problem is typically caused by an open collector (or plate) load to one of the stages. An open decoupling resistor will also cause this problem.

Problem: Compression or expansion of the sweep as it is positioned from one side to the other.

Solution: This problem is typically caused by the diode network between the bases (or grids) of the amplifier. Check for leaky diodes.

Problem: Horizontal shift exceeds 1 cm as line voltage is varied from 105-125 V.

Solution: Change tubes or transistors.

Problem: Horizontal sweep control center position is shifted and control is nonlinear.

Solution: Check for an open circuit in the center tapped plate load resistors of the output amplifier.

Problem: Nonlinear sweep.

Solution: Gassy HF capacitance driver tube. A faulty input CF tube may also cause a similar problem.

Problem: Insufficient HF timing range and gain or position effect.

Solution: Check the horizontal output amplifier for weak tubes.

Problem: Position range off-centered.

Solution: Check the input compensated divider of the input CF.

TYPICAL VERTICAL PROBLEMS

Problem: Unbalance greater than 0.5 cm.

Solution: Switch tubes to bring within 0.5 cm of electrical center. **NOTE—TURN OFF POWER WHEN SWITCHING INPUT TUBES.**

Problem: No internal triggering capability.

Solution: Open plate load inductance of trigger pickoff amplifiers.

Problem: Bump in display 0.25 μs from beginning.

Solution: Check for open or defective termination network.

Problem: DC shift.

Solution: Check to be sure that the plate load resistor is correct for the brand of tubes being used. (Resistor value varies with tube manufacturer other than original.) If the problem still remains, check the filter capacitors.

Problem: Cathode-Interface—front end of pulse varies as line voltage is varied from 105-125 V.

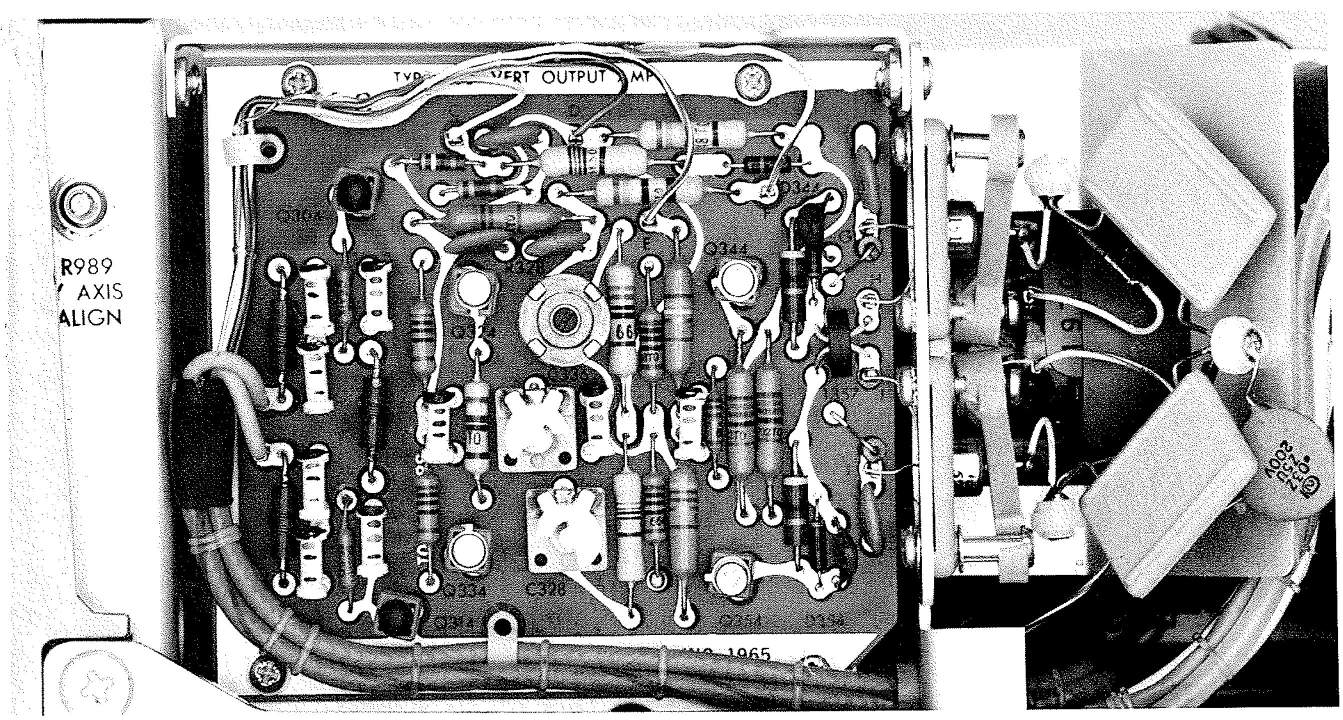
Solution: Replace input tubes. If problem still remains, retube the distributed amplifier.

Problem: Overshoot and ringing.

Solution: Check collector load resistor for out-of-tolerance components. If problems remains, check gain potentiometers. Non-Tektronix made gain pots may not have the right amount of inductance.

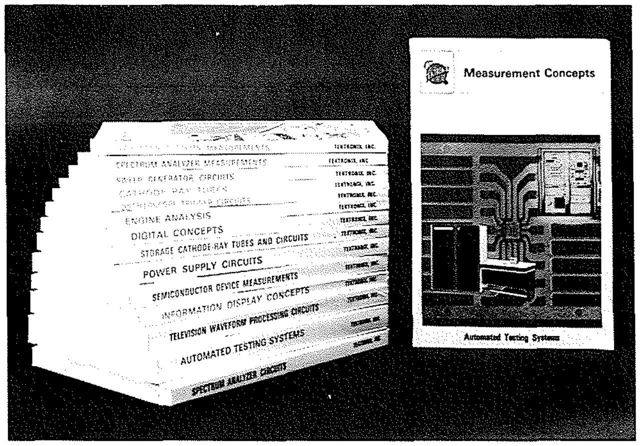
Problem: Compression.

Solution: Check diodes in base circuits for a shorted diode.



Type 422 Vertical Amplifier circuit board. Note that transistor sockets are used where possible for servicing convenience.

NEW CONCEPTS BOOKS



Four new titles have been added to the concepts series of books published by Tektronix. A total of 14 concepts books are now available from your Tektronix Field Engineer. Eight circuit concepts books and six measurement concepts books are presently in print.

"Sweep Generator Circuit" is the addition to the circuits concepts series and discusses sawtooth waveform characteristics, the gated clamp-tube generator control circuit, bootstrap sweep generators, Miller integrators, and sweep generator control circuits.

Three new titles are available in the measurement concepts series: "Spectrum Analyzer Measurements", "Engine Analysis", and "Automated Testing Systems". "Spectrum Analyzer Measurements" discusses concepts of RF spectrum tuning, RF modulation systems, spectrum analyzer terms, spectrum analyzer characteristics and their relationships, spectrum analyzer functional considerations, CW signal measurement, amplitude-modulation measurement, single-sideband measurements, pulsed RF carrier measurements, swept frequency measurements, fluid velocity measurements, and waveform analysis. "Engine Analysis" consists of ignition systems, ignition waveform analysis, magnetic transducers, rotational function generators, vibration transducers, and pressure transducers. "Automated Testing Systems" discusses the memory and control blocks (data disc, punched tape, tape readers and perforators, the Type 240 program control unit, the Type 250 auxiliary program unit, and the Type 241 programmer unit); the measurement block (sampling review, the Type R568 oscilloscope—Type 3S6 vertical and Type 3T6 sweep, the Type 230 digital unit, testing systems options); the stimulus block (the Type R116 programmable pulse generator, the Type R293 programmable pulse generator and power supply, and programmable power supplies); and the fixture block, a discussion of fixturing and problems.

INSTRUMENTS FOR SALE

1—Type 535A, SN 24917 and 1—Type CA, SN 30061. Price: $1,225. 1—Type 535A, SN 25772 and 1—Type CA, SN 30364. Price: $1,225. 1—Type 545, SN 8225 and 1—Type B, SN 14320. Price: $1,200. Recently reconditioned and recalibrated. Contact: Mr. Weiss, Communications Radio, 150 Jerusalem Avenue, Massapequa, New York 11758. Telephone: (516) 798-7342.

1—Type 661/4S1/5T1A. Good condition, small amount of use. Contact: Carl Gruber or Dr. Hixson, Electrical Engineering Dept., South Dakota School of Mines and Technology, East St. Joe Avenue, Rapid City, South Dakota 57701. Telephone: (605) 394-2291.

1—Type 535, SN 489. 1—Type L, SN 010273. 1—Type 53C, SN 730. 1—Type G, SN 006777. Contact: Mr. E. Thomas, The Budd Co., 12141 Charlevoix, Detroit, Michigan 48215. Telephone: (313) 822-7000 Ext. 229.

1—Type 561A/3A3/2B67. Used only 20 hours. Price: $1,400. Contact: Dick Hahn. Telephone: (914) 232-5891.

1—Type CA, SN 38575. Price: $150. 1—Type T, SN 2782. Price: $150. Contact: William H. Greenbaum, V.P., Unilux, Inc., 48-20 70th Street, Woodside, New York 11377. Telephone: (212) 651-2258.

1—Type 422, AC Model. Used less than 25 hours. Price: $1,000. Contact: J. M. Edelman, M.D., 4550 North Boulevard, Baton Rouge, Louisiana 70806. Telephone: (504) 927-3553.

1—Type 575. Three years old. Will calibrate prior to sale. Price: $900. Contact: L. M. Buckler, Intech, Inc., 1220 Coleman Ave., Santa Clara, California 95050. Telephone: (408) 244-0500.

1—Type 524D, SN 1186. In operating condition. Best reasonable offer. Contact: Jerry Berger, Minneapolis Moline, 301 Ninth Avenue South, Hopkins, Minnesota 55343. Telephone: (612) 935-5181 Ext. 306.

1—Type 575, SN 010866. Three years old. Price: $950. Contact: Mobilscope, Inc., 17734½ Sherman Way, Reseda, California 91335. Telephone: (213) 342-5111.

1—Type 422, SN 003693. Good condition. Price: $1000. Contact: Robert Blessing, National Supply Company, Drawer H, Gainesville, Texas 76240. Telephone: (817) 465-2811.

1—Type 514, SN 2907. 1—Type 517, SN 280 with Duty Cycle Limiter Modification. Contact: R. A. Kern, Link-Belt Div. of FMC Corp., P. O. Box 346, Indianapolis, Indiana 46206. Telephone: (317) 632-5411 Ext. 337.

1—Type 575, SN 002669. Reconditioned. Price: $850. Contact: Mobilscope, Inc. 1734½ Sherman Way, Reseda, California 91335. Telephone: (213) 342-5111.

1—Type 545B, SN 2529. 1—Type 1A1, SN 2029. And 015-0062-00 TV Sync Separator. Price: $1,750. Contact: Robert Brown, Everett Cablevision, 2507 Broadway Avenue, Everett, Washington 98201. Telephone: (206) 259-3171.

1—Type 1A1. Price: $400. Contact: Mr. Dean Maloney, 832 Busse Highway, Park Ridge, Illinois 60068.

1—Type 575 Mod 122C, SN 12941. One year old. Price: $995. Contact: Alfred Gomez, Computer Components International, Inc., 3804 Burns Road, Palm Beach Gardens, Florida 33404. Telephone: (305) 842-4216.

1—Type 545S6, SN9388. Price: $900 or best offer. Contact: Mr. M. Stepanski, Deltron, Inc., Wissahickon Avenue, North Wales, Pennsylvania 19454. Telephone: (215) 699-9261.

INSTRUMENTS WANTED

1—Type 515A or 516. Any condition. Contact: Ray Harland, Route 1, Box 745A, Escondido, California 92025. Telephone: (714) 746-4584.

1—10 to 20 MHz scope, either single or dual channel. Contact: John Ricker, 1570 Meade Street, Denver, Colorado 80204. Telephone: (303) 623-6002.

1—C-12 Camera. Contact: Mr. Dean Maloney, 832 Busse Highway, Park Ridge, Illinois 60068.

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TEKSCOPE

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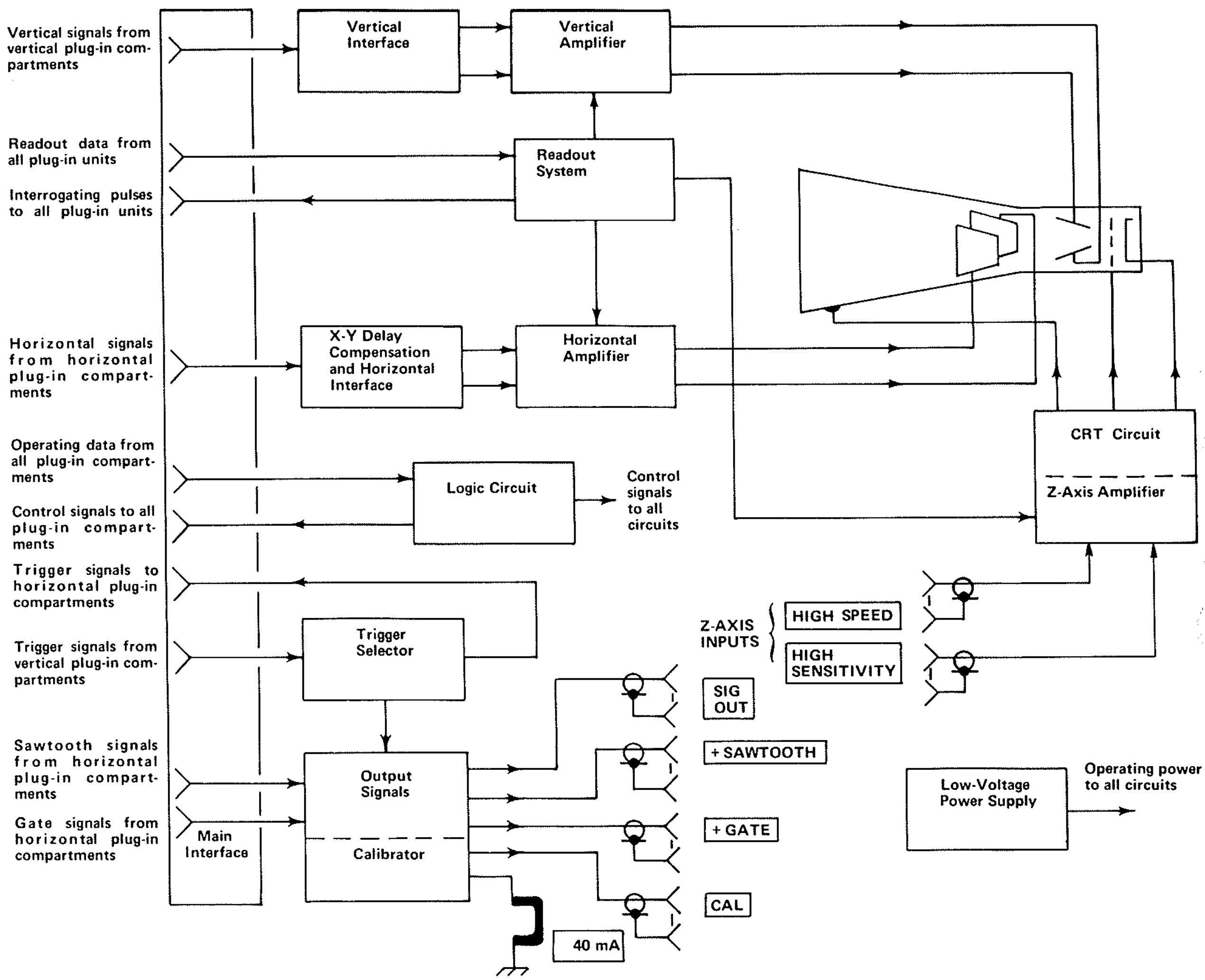
Editor: Rick Kehrli Artist: Nancy Sageser For regular receipt of TEKSCOPE contact your local field engineer.

7000-SERIES BLOCK DIAGRAM



The Tektronix developed and manufactured M036 Channel Switch IC was developed to fill the need for a fast, clean switch with good isolation characteristics. The switch is housed in a 14-pin, dual-in-line package and is the key to much of the versatility of mainframe switching in the NEW 7000 Series. One M036 is used in both the Vertical Interface and Horizontal Interface and two are used in the Trigger Selector block.

The channel switch selects one or mixes two analog input signals in response to a digital input. In its simplest application, it is a double-pole, double-throw selector of one of two balanced input signals. Its more sophisticated role is in providing signal steering in dual-trace vertical and horizontal amplifiers.

The MO36 is designed for two balanced input signals of 25 mV/division into 50 Ω per side (0.5 mA/div). Side-to-side diodes are included inside the IC for limiting the differential voltage swing of the output. The risetime of the switch is less than 1 ns and switching time is 20 ns maximum. The IC is also very clean from chopping transients.

1968-1969 TEKSCOPE INDEX

BACK ISSUES—Although some back issues of listings in this index are out-of-print, most issues are available upon request from your local Tektronix Field Engineer.

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TEKSCOPE LABEL INSIDE →

SUBJECT INDEX

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SUBJECT INDEX (SERVICE INFORMATION)