## TEKTRONIX



INSTRUCTION MANUAL

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## INSTRUMENT DESCRIPTION

The 5B31 Digitally Dly'd Time Base provides Delay by Time, Delay by Events, and Normal sweep operations. These operations are obtained with only one sweep generator system. The 5B31 is complementary to the 5400 Series oscilloscope mainframes and 5A30 Series vertical amplifier plug-in units.

Time delay is controlled by a highly accurate 1 MHz clock. Delay time is selected in 1 microsecond steps from 0 to 99,999 microseconds (inclusive). Event Delay is from 0 to 99,999 events (inclusive). Delay time or the number of events to be counted before the delayed sweep starts is set by a 5 -digit thumb-wheel switch.

A DLY'D GATE output connector is provided on the front panel. The output signal is a voltage rise occurring at the end of the delay interval and is TTL compatible.

Calibrated sweep rates from $5 \mathrm{~s} /$ DIV to $0.2 \mu \mathrm{~s} /$ DIV are available, with a variable sweep rate control extending the sweep rate to at least 12.5 s/DIV. All sweep speeds can be magnified by a factor of 10 . When the 5B31 is used in a mainframe with readout capabilities, the sweep rate is displayed on the cathode-ray tube (crt). Single sweep operation is also provided.

Although designed for use in a right hand (sweep) compartment of the oscilloscope mainframe, the 5 B31 will operate in the vertical compartments to produce vertical sweeps or DLY'D GATE output signals.

Horizontal amplifier operation is provided when the sweep rate selector is set to the AMPL position. The signal input to the horizontal amplifier is selected by the triggering source switches.

## PREPARATION FOR USE

The 5B31 is calibrated and ready for use when received. Fig. 1-1 shows installation-removal procedure. Refer to the CONTROLS and CONNECTORS illustration in the foldout pages for a complete description of the front panel. To quickly produce a sweep trace on the crt, set the 5 -digit, thumb-wheel switches to read 00000 and center the horizontal POSITION control. Set and adjust the EVENT TRIG LEVEL and MAIN TRIG LEVEL controls for + SLOPE triggering. Push the AUTO TRIG pushbutton
(in). All other pushbuttons should be out. Apply power with the mainframe POWER switch and center the INTENSITY control. When a trace appears, adjust the INTENSITY and FOCUS controls on the mainframe for the best defined trace. Set the SEC/DIV control on the 5B31 for any arbitrary sweep rate. For this procedure, no input signals are applied and the sweep is triggered internally by pulses produced by an automatic triggering circuit.


Fig. 1-1. 5B31 Installation-Removal Procedure.

## BASIC OPERATION

## Sweep Mode Definitions

For purposes of this manual, four modes of sweep operation are defined as follows:

1. Normal mode-The $\mu \mathrm{s}$, EVENT, and DLY'D pushbuttons are set to the OUT position. The sweep start is not delayed. The sweep is not intensified for any arbitrary setting of the 5-digit thumb-wheel switch.
2. Locate mode-The $\mu \mathrm{s}$ or EVENT pushbutton is pushed IN. The DLY'D pushbutton is set to the OUT position. The thumb-wheel switch setting must be greater than 00000. The Sweep start is not delayed. The sweep is intensified at the end of the delay interval (or event count) when the total sweep time is greater than selected delay.
3. Delayed mode-The $\mu \mathrm{s}$ or EVENT pushbutton is pushed IN. The DLY'D pushbutton is also IN. The start of the sweep is delayed by time interval, or event count, as selected by the thumb-wheel switch (greater than 00000). Intensification begins at the start of the sweep.

## Triggered Display (Normal Sweep Mode)

With the 5B31 properly installed in the sweep compartment and either a single channel or dual-trace vertical amplifier unit installed in the left compartment, apply power to the mainframe. Apply an input signal to the vertical amplifier unit. For this explanation, a 1 kHz square-wave signal is used. Adjust the vertical amplifier controls for a centered 2-division display and set the 5B31 SEC/DIV control to display at least 5 cycles of the input signal ( $.5 \mathrm{~ms} /$ div sweep rate for 1 kHz ). Release the AUTO TRIG pushbutton and push the LEFT trigger source switch. All other 5B31 pushbuttons should be out and the thumb-wheel switch reading 00000 . Adjust the MAIN TRIG LEVEL control until the display appears and the sweep is starting on the positive slope of the input signal. Rotate the MAIN TRIG LEVEL control from stop to stop and note that the display appears only when triggered and disappears over most of the control's rotation range. Push the AUTO TRIG button and repeat the rotation of the MAIN TRIG LEVEL control. Note that the display stabilizes only when triggered on the positive slope of the input signal and that the sweep free runs over most of the MAIN TRIG LEVEL control rotation range. Release the AUTO TRIG pushbutton and stabilize the display with the MAIN TRIG LEVEL control.

Press the sweep MAG button and note that the sweep speed increases by a factor of 10 . This is shown on the SEC/DIV dial and (if applicable) crt readout. Release the MAG button.

Push the LINE trigger source switch. The display will not be stabilized unless the input signal is line-frequency related. The signal activating the trigger circuits in this triggering mode is derived from the power line. Release the LINE button by pushing the LEFT trigger source switch. The display should again be stabilized.

External signals may be applied to the HORIZ AMPL connector to externally trigger the sweep. External trigger signals must be time related to the vertical input signal or the display will drift across the crt screen. Use a BNC Tconnector and a coaxial cable to apply the same signal to both the vertical and HORIZ AMPL inputs and push the EXT button. The MAIN TRIG LEVEL control may need readjustment for a stable display.

## External Horizontal Amplifier Mode

With the same square-wave signal applied to the vertical input and 5B31 HORIZ AMPL connector, set the SEC/DIV control to AMPL position. The display should be two dots separated horizontally by an amount proportional to the peak-to-peak signal amplitude applied to the HORIZ AMPL connector. The 5B31 is internally calibrated for a $50 \mathrm{mV} / \mathrm{div}$ horizontal deflection factor. Push the LINE and LEFT trigger source switches, in sequence, and note the displays for other input signals to the horizontal amplifier.

With the LEFT trigger source switch remaining in, reset the SEC/DIV control to again display about 5 cycles of vertical input signal ( $.5 \mathrm{~ms} /$ div for 1 kHz ) and reset the MAIN TRIG LEVEL control for a stable display. Disconnect the signal to the HORIZ AMPL connector.

## Single Sweep (Normal Sweep mode)

With a stable display, position the trace so that the start of the sweep is visible. Note that the TRIG-READY light is on. This light serves both as a "sweep triggered" indication and as an indicator that the sweep circuits are ready to accept a trigger pulse when operating in a Single Sweep mode. Disconnect the vertical input signal. The READY light should be off. Depress the SINGL SWP button. Push and release the RESET button. The READY light should turn on. Watch the crt screen and reconnect the vertical input signal. If the intensity is high enough, a fast, single trace will be visible and the READY light will extinguish. Remove the vertical input signal and depress, then release, the RESET button. The READY light will again be visible and the sweep is rearmed. Reconnect the vertical input signal, release the SINGL SWP button and obtain the original stable display.

## Dual-Trace Display Switching Mode

The DISPLAY button labeled CHOP on the 5B31 selects the switching mode for dual-trace vertical plugins. With the button out, the switching is done in ALTERNATE mode (one channel is displayed for one full sweep, then the other channel is displayed). This can be demonstrated by using a dual-channel vertical plug-in and slowing the 5B31 sweep speed to about $50 \mathrm{~ms} / \mathrm{div}$. Pushing the button in produces the chopped mode, wherein the sweep is switched between the two vertical channels at about a 500 kHz rate. Use the chopped mode for viewing slower dual-trace displays and the alternate mode for faster displays. Refer to instruction manual for dual-trace vertical amplifier unit for further information.

## Locate and Delayed Modes (Time Delay)

Obtain a centered two-division triggered display according to instructions given under Triggered Display (Normal Sweep mode) and be certain that Normal Sweep is being triggered on the positive slope of the signal from the left vertical plug-in. With a 1 kHz square-wave input signal and 5B31 set for a $.5 \mathrm{~ms} /$ div sweep rate the display should be about 5 cycles.

## Operating Instructions-5B31

Depress the $\mu$ s button and set the thumb-wheel switch for a reading of 01750. Use the horizontal POSITION and mainframe INTENSITY controls to set the start of the nonintensified portion of the sweep to the left-most vertical graticule line (Zero reference, see Fig. 1-2a). The start of the intensified zone should be midway between the third and fourth division vertical graticule lines, indicating a selected time delay of $1,750 \mathrm{microseconds}$ for a 1 kHz signal. Vary the thumb-wheel switch settings and note that the start of the intensified zone varies with the selected time delay settings. In order to view the time delay selection in unit steps, it will be necessary to increase the sweep speed to $1 \mu \mathrm{~s} / \mathrm{div}$ and reduce the selected thumbwheel switch setting to less than 00010. Return to the original setting of 1,750 microseconds. Rotate the EVENT TRIG LEVEL control from stop to stop and note that it has no effect on the display.

(A) Area of graticule used for time measurements.

(B) Measuring the time duration between points on a waveform.

Fig. 1-2. Graticule reference lines and direct time measurement.

Reset the thumb-wheel switch to read 00000 and note the return to Normal Sweep mode. A return to Normal Sweep mode can also be accomplished by leaving the thumb-wheel switch at any setting and pushing the EVENT pushbutton just enough to release the $\mu$ s pushbutton (both buttons out-Counter RESET).

Reset the thumb-wheel switch to read 01750 and again depress the $\mu$ s button to locate the start of the intensified zone for a 1 kHz signal. Depress the DLY'D button and note that the intensified portion of the sweep moves to the zero reference vertical graticule line. The 5B31 is now operating in a Delay by Time mode (delayed sweep). Press the sweep MAG button and notice that the sweep expands. Rotate the horizontal POSITION control to locate the start of the delayed sweep. Release the sweep MAG button and horizontally center the display. Reset the thumb-wheel switch to read 00000 . Release the $\mu$ s pushbutton.

## Locate and Delayed Modes (Event Delay)

Obtain a centered 2-division triggered display according to instructions given under Triggered Display (Normal Sweep mode) and be certain that the Normal Sweep (non-intensified) is being triggered on the positive slope of the signal from the left vertical plug-in. With a 1 kHz square-wave input signal and the $5 B 31$ set for a $.5 \mathrm{~ms} / \mathrm{div}$ sweep rate, the display should be about 5 cycles. Set the thumb-wheel switch for 00000 delay. Center the EVENT TRIG LEVEL control and use + Slope triggering. All other pushbuttons should be out.

## NOTE

Event trigger signal can only be obtained from the left vertical plug-in.

After obtaining a Normal Sweep display, depress the EVENT button and note that the sweep becomes intensified. Adjust the EVENT TRIG LEVEL control so that the sweep intensification starts on the leading edge of the first pulse. Slowly increase the units digit on the thumb-wheel switch to 5 (00005) and note that the start of the intensification jumps to the right one pulse at a time. This procedure has located (or identified) the number of events (or pulses) to be counted before the start of the delayed sweep. Depress the DLY'D button and note that the start of the intensified portion moves to the zero reference vertical graticule line. The 5B31 is now operating in a Delay by Events mode and is counting five events (pulses) that have occurred since Main Trigger recognition. Main Trigger recognition is considered to be time zero ( $\mathbf{t}_{0}$ ).

The trigger recognition point ( $t_{0}$ ) is determined by the setting of the MAIN TRIG LEVEL control. This control selects the amplitude level on either the + or-Slope of the input signal to produce a trigger recognition pulse to start the event count. The trigger recognition pulse also starts the sweep in the Locate and Normal Sweep modes. In the Delay by Events or Delay by Time mode, the sweep is started and intensified by pulses produced by the counter and delay control circuitry. The trigger recognition point and the effects produced by various settings of the MAIN TRIG LEVEL and EVENT TRIG LEVEL controls can easily be observed if a triangular or sinusoidal waveform is used as an input signal.

To aid in further understanding the 5B31 operation in the Delay by Events mode, return to Normal Sweep mode and reset the thumb-wheel switch to read 01000. Push the

EVENT and DLY'D buttons and notice that the display occurs (flashes) at one second intervals. Using a 1 kHz signal, an event occurs once every millisecond. The 5B31 counts 1000 of these events and then produces a sweep. After the sweep has ended, the internal counter circuitry is reset and the event counting process repeats. For low pulse (event) repetition rates and large integral counts, a storage oscilloscope should be used to display the desired signal.

## Delayed Gate Output

The DLY'D GATE OUT signal, coincident with the selected time delay or event count, can be observed by using a dual-trace vertical amplifier unit (or two single channel units) and applying the DLY'D GATE OUT signal to a separate vertical channel (see Dual-Trace Display Switching).

## BASIC APPLICATIONS

## Direct Time Measurements

The 5B31 sweep (time base) is calibrated so that horizontal distance represents real time. Time intervals between two or more events may therefore be measured directly on the crt graticule. For direct measurements, use the following procedure.

1. Obtain a triggered display using the Normal Sweep mode.
2. Measure the horizontal distance between two displayed events.
3. Multiply the distance measured (in divisions) by the SEC/DIV control readout to obtain the apparent time duration. The CAL knob concentric with the SEC/DIV control must be fully clockwise (detent position).

Example: Assume that the distance between measurement points is 5.0 horizontal divisions. The SEC/DIV control reads $50 \mu \mathrm{~s} / \mathrm{div}$ with the sweep MAG button pushed in.

Apparent time duration $=$ Horizontal distance $X$ SEC/DIV readout (divisions

$$
\begin{aligned}
& =5 \times 50 \mu \mathrm{~s} \\
& =250 \mu \mathrm{~s}
\end{aligned}
$$

Refer to Fig. 1-2 for the definition of vertical graticule lines and a simulated display for direct time measurements.

## Arbitrary Sweep Rates

To establish an arbitrary horizontal sweep rate based on a specific reference frequency, use the following procedure.

1. Connect a reference signal to the vertical input connector and obtain a stable display.
2. Set the SEC/DIV switch and CAL control so that 1 cycle of the reference signal covers an exact number of horizontal divisions. Do not change the CAL control after obtaining the desired deflection. This display can be used as a reference for frequency comparison measurements.

NOTE
The repetition rate of the reference signal must be known. If it is not known, it can be determined by making a differential time delay measurement.
3. Divide the repetition rate of the reference signal by the product of the horizontal deflection established in step 2 (divisions) and the SEC/DIV switch readout to obtain a Deflection Conversion Factor (DCF).

$$
\begin{aligned}
& \text { Deflection } \\
& \text { Conversion }=\frac{\text { Reference signal repetition rate }}{\text { Factor }} \begin{array}{l}
\begin{array}{l}
\text { Horizontal } \\
\text { deflection } \\
\text { (divisions) }
\end{array} \times \quad \begin{array}{c}
\text { SEC/DIV } \\
\text { switch } \\
\text { readout }
\end{array}
\end{array} \text { (2) }
\end{aligned}
$$

Example: Assume a reference signal frequency of 455 Hz (repetition rate, 2.19 ms ), and a SEC/DIV switch readout of .2 ms , with the CAL control adjusted to provide a horizontal deflection of 8 divisions for 1 complete cycle;

$$
\mathrm{DCF}=\frac{2.19 \mathrm{~ms}}{8 \times .2 \mathrm{~ms}}=1.37
$$

4. After an arbitrary sweep rate has been established and is being used to display signals whose time characteristics are unknown, the DCF must be used in calculating direct time interval measurements.

| Unknown |
| :--- |
| Signal |
| Repetition |
| Rate |$=$| SEC/DIV |
| :---: |
| switch |
| readout |$\times$ DCF $\times$| Horizontal |
| :--- |
| deflection |
| (divisions) |

Example: With the SEC/DIV switch readout of $50 \mu \mathrm{~s}$ and the CAL control not moved from the position set in step 2, an unknown signal completes 1 cycle in 6.2 horizontal divisions as displayed on the arbitrary eight division sweep;

## Unknown

Signal Repetition $-50 \mu \mathrm{~s} \times 1.37 \times 6.2=424.7 \mu \mathrm{~s}$ Rate

This answer can be converted to frequency by taking the reciprocal of the repetition rate.

## Differential Time Delay Measurements

The accuracy of time interval measurements can be increased by using the 5B31 to make a differential measurement (see Fig. 1-3). For differential measurements, use the following procedure.


#### Abstract

NOTE The numerical quantities listed for this procedure are for example only and were obtained for a period measurement. Essentially the same procedure is used for pulse width measurements, or measurements made between any two events as displayed on the crt.


1. Obtain a Triggered Display (Normal Sweep mode). Use a calibrated sweep rate that results in the 2 events to be measured being separated by at least 1 or more major horizontal divisions. Use the horizontal POSITION control to set the sweep starting point (trigger recognition) on the zero reference vertical graticule line. Do not reset this control throughout the measurement procedure.
2. First Measurement-Use the Locate mode of operation for Time Delay and adjust the thumb-wheel switches to set (locate) the start of the sweep intensification just before the first point to be measured. Note the thumb-wheel setting. Push the DLY'D button and increase the sweep speed. Adjust the delay time, if necessary, to keep the measurement point on screen. Continue to increase the sweep speed consistent with signal rate of change, jitter, and repetition rate. If the original sweep rate for the Locate mode was $0.1 \mathrm{~ms} /$ div and the final sweep rate for the DLY'D mode is $1 \mu \mathrm{~s} / \mathrm{div}$, the effect is an apparent sweep magnification by a factor of 100. This apparent sweep magnification is dependent on the ratio of the sweep rate used for the Locate mode to the final sweep rate used for the DLY'D mode. If time jitter from the source is excessive, reduce the ratio of the two sweep speeds.

Adjust the units digit on the thumb-wheel switch to set the first event to be measured as close as possible to the center graticule line. The final switch reading, for example, may be 00149. This means that the delayed sweep is starting on the zero reference line $149 \mu$ s after trigger recognition.

For the DLY'D mode and faster sweep rates, make a direct time measurement from the zero reference line to the point of interest. For example; 5.0 horizontal divisions times $1 \mu \mathrm{~s} / \mathrm{div}$ is $5 \mu \mathrm{~s}$. This value must be added to the thumb-wheel switch reading to obtain the time delay for the first measurement (154 $\mu \mathrm{s})$.

(A) First measurement. Total delay for first measurement $149 \mu \mathrm{~s}+5 \mu \mathrm{~s}=154 \mu \mathrm{~s}$.

(B) Second measurement. Total delay for second measurement $849 \mu \mathrm{~s}+5 \mu \mathrm{~s}=854 \mu \mathrm{~s}$.

Fig. 1-3. Differential time delay measurement. Period equals $854 \mu \mathrm{~s}-154 \mu \mathrm{~s}$, or 700 microseconds.
3. Second Measurement-To locate the second event to be measured, repeat the procedure given for the first measurement. Use the DLY'D mode to make a second direct time measurement for the second event. For example, a final thumb-wheel switch reading of 00849 plus 5.0 horizontal divisions is 854 $\mu \mathrm{s}$.
4. Subtract the final value obtained for the first measurement from the final value obtained for the second measurement to obtain the differential time delay ( $854 \mu \mathrm{~s}-154 \mu \mathrm{~s} \div 700.00 \mu \mathrm{~s}$ ).

## Operating Instructions-5B31

Differential delay accuracy is specified to be within 2 parts in $10^{5}$, which is equivalent to $.002 \%$ of the measurement made. When making direct time measurements in the delayed mode at sweep rates of $10 \mu \mathrm{~s} / \mathrm{div}$ or slower, there is no need to take into account sweep errors because the resolution obtained with the 5B31 is greater than can be obtained from the crt graticule. At sweep rates of $5 \mu \mathrm{~s} / \mathrm{div}$ or faster (delayed mode), the event to be measured should be set with the thumb-wheel switches to be somewhere between the first and ninth division vertical graticule lines. The choice of vertical graticule line is irrelevant as long as the events are set as close as possible to the same vertical graticule line for both measurements.

## Pulse Jitter Measurements

In some applications it is necessary to measure the amount of time jitter for the leading or trailing edge of a pulse, or jitter between pulses. The following procedure allows this measurement to be made and can also be used to note changes in pulse width or period. Refer to Fig. 1-4.


Fig. 1-4. Measuring pulse jitter.

1. Use the Locate mode for time delay to set the start of the intensified portion of the sweep just before the leading or trailing edge of the pulse of interest. Push the DLY'D button and increase the 5B31 sweep speed to its fastest practical calibrated rate. Use the thumb-wheel switches to set the desired pulse area of interest near the center of the graticule. Measure the time jitter using the direct method of time measurement. The 5B31 contributes only about 10 nanoseconds (or less) plus $.00001 \%$ of the indicated delay to the pulse jitter measurement.
2. If the pulse width or signal period changes, this effect can be noted by observing a change in the position of the displayed signal relative to the measurement point.

## Delay by Events (Complex Waveforms)

Complex signals often consist of a number of individual events of differing amplitudes. Because the trigger circuits are amplitude sensitive, a stable display for the Normal Sweep mode can be obtained only when sweep is triggered by the event having the greatest amplitude. However, this may not produce the desired display of a lower amplitude event that follows the trigger recognition point (see Fig. 1-5). The Delay by Event mode of operation can be used to delay the sweep start so that the lower amplitude signals in the display can be observed. Use the following procedure.

(A) This portion of display cannot be viewed adequately because sweep is triggered on larger amplitude signals at start of display (Normal sweep mode).

(B) Area of interest displayed by using the Delay by Event mode.

Fig. 1-5. Displaying a complex signal using Delay by Event mode of operation.

1. Use the Locate mode with the EVENT button pushed in. Set the MAIN TRIG LEVEL controls to recognize the highest amplitude at burst start. Adjust the EVENT TRIG LEVEL control for an intensified trace that starts 1 or 2 events before the signal area that needs to be observed.
2. Push the DLY'D button and increase the sweep speed slightly (if necessary).

The Delay by Event mode of operation can be used for counting (or delaying) events that occur at repetition rates up to 20 MHz . This mode is useful in stabilizing the display when signals are aperiodic, or contain instability (jitter).

Delaying by Events rather than time removes display jitter caused by mechanical speed variances in rotating memory devices for computers. It also allows the operator to know exactly where the display starts by direct observation of the number of events displayed on the thumb-wheel switches. For example; by delaying an exact number of clock or index pulses, the operator can elect to observe a particular track or sector on a memory device.

Delaying by Events is also useful to observe cycle activity in a non-synchronous system, where the system or processing clock is not time coherent with a peripheral clock. Signal viewing for operations of this type is facilitated by using one, dual-trace vertical amplifier plug-
in (such as a 5 A 48 or 5 A 38 ) with a second vertical amplifier, which may be either a single- or dual-trace plugin.

Connect the signal used as the reference pulse to the right vertical input and the signal to be counted to the left vertical input. In each case, the trigger source selector on the vertical plug-in, if any, should select the appropriate input. Choosing ALT or CHOP sweep switching, as appropriate, allows both the main trigger and event signals to be viewed without changing trigger selectors. Other signals may be connected to the remaining vertical inputs, while the MAIN and EVENT triggering signals are removed from the display by using the vertical amplifier mode selector. Do not remove signals by grounding inputs as triggers will be lost.

## Counter Reset

The Delay counter circuits are not reset automatically until after the sweep has been completed. When operating with low event rates and large integral counts, use the Counter RESET feature to stop the count when it is desired to select a new event delay.

## ELECTRICAL CHARACTERISTICS

## Introduction

The electrical characteristics listed in this section are valid over the temperature and environmental range listed for the 5400 Series oscilloscope mainframe units, unless otherwise stated. The instrument must be calibrated at an ambient temperature of $+20^{\circ} \mathrm{C}$ to $+30^{\circ} \mathrm{C}$ after a 30 -minute warmup time.

## Sweep Accuracy

Sweep accuracy is measured in a 5400 Series oscillscope over the center eight divisions. The accuracies listed are valid for 100 divisions of the magnified sweep after the first 30 ns .

|  | $+15^{\circ} \mathrm{C}$ to $+35^{\circ} \mathrm{C}$ |  | $0^{\circ} \mathrm{C}$ to $+50^{\circ} \mathrm{C}$ |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Unmag | Mag | Unmag | Mag |
| $1 \mathrm{~s} / \mathrm{div}$ to <br> $0.5 \mu \mathrm{~s} / \mathrm{div}$ | $3 \%$ | $4 \%$ | $4 \%$ | $5.5 \%$ |
| $5 \mathrm{~s} / \mathrm{div}, 2 \mathrm{~s} / \mathrm{div}$ <br> and $0.2 \mu \mathrm{~s} /$ div | $4 \%$ | $5 \%$ | $5 \%$ | $6.5 \%$ |
| Any 2 divisions <br> within the center <br> 8 divisions | $6.5 \%$ | $6.5 \%$ | $8 \%$ | $8 \%$ |

## Variable Range

The range is continuously variable between calibrated sweep rates. This extends the sweep rate to at least 12.5 s/div.

## Operating Instructions-5B31

## Single Sweep

This has the same requirements as the main sweep.

## External Horizontal Amplifier

Internally calibrated for a horizontal deflection factor of $50 \mathrm{mV} / \mathrm{div}$.

Input R and C: $1 \mathrm{M} \Omega$ within $2 \%$, paralleled by approximately 24 pF .

## Bandwidth.

DC Coupled: dc to $\geqslant 2 \mathrm{MHz}$.
DC Coupled: $\leqslant 50 \mathrm{~Hz}$ to $\geqslant 2 \mathrm{MHz}$.

Maximum Input Voltage. 350 V dc + peak ac, 350 V peak-to-peak ac at $\leqslant 1 \mathrm{kHz}$.

## Triggering Requirements

Triggering from Internal Sources.
Frequency Range:
DC to 35 MHz . Frequency range is also affected by bandwidth limits of the vertical amplifier plug-in unit.

Minimum Required Signal:
DC Coupled: 0.4 division of deflection, minimum, dc to 10 MHz ; increasing to 1.0 division at 35 MHz .
AC Coupled: Same as dc coupled, except that the requirements increase below 50 Hz .
Useful to 60 MHz with 1.5 divisions displayed from 5A40-Series.

Polarity:
$\pm$ Slope selection. The Displayed slope (at selected MAIN TRIG LEVEL) is equal to or greater than 1 $\mathrm{div} / \mu \mathrm{s}$ for specified jitter and delay accuracy. Slower signals will trigger the 5B31 with reduced delay accuracy and increased jitter.

## Main Trigger Level Range:

$\geqslant \pm 8$ divisions.

## Auto Triggering:

The sweep is triggered by internal circuitry if the time between input signals is more than 0.2 second (less than 5 Hz ). The Auto Triggering function is disabled when operating in the DLY'D modes.

Line Triggering:
The sweep is triggered at frequency of main power line.

## Triggering From External Sources.

The signal is applied to HORIZ AMPL input connector.

The maximum Input Voltage and Input RC are the same as those listed for EXTERNAL HORIZONTAL AMPLIFIER.

> Main Trigger Level Range: $\pm 2 \mathrm{~V}$.

Minimum Required Signal:
DC Coupled: 100 mV for frequencies from dc to $10 \mathrm{MHz} ; 400 \mathrm{mV}$ for frequencies from 10 MHz to 35 MHz .
AC Coupled: Same as dc coupled, except that requirements increase below 50 Hz .

## Polarity:

+ Slope Selection. The input slope must be equal to or greater than $50 \mathrm{mV} / \mu \mathrm{s}$ for specified jitter and delay accuracy.


## Delay

## Delay By Time.

Delay Range: 0 to $99,999 \mu$ s (inclusive).

Delay Increment:
$1 \mu \mathrm{~s}$.

Differential Delay Accuracy:
2 parts in $10^{5}$ after one-half hour warmup. Z-axis intensification starts within 55 ns after the end of delay when the 5B31 is operated in a Locate mode.

Differential Delay Drift:
Less than 1 part in $10^{5}$ per month ( $0.001 \% /$ month).

Delay Jitter:
10 ns plus 1 part in $10^{7}$ ( 10 ns plus $0.00001 \%$ of selected delay)

Insertion Delay:
100 ns minimum; 140 ns maximum.

## Delay By Events.

Delay Range:
0 to 99,999 events (inclusive)

Delay Increment: 1 event.

Delay Jitter:
Less than 10 ns . This is applicable only to signals with a displayed slope (at the selected EVENT TRIG LEVEL) equal to or greater than $1 \mathrm{div} / \mu \mathrm{s}$.

Insertion Delay:
Less than 25 ns between non-delayed and delayed modes.

Counter Reset:
This occurs during sweep holdoff or when both $\mu \mathrm{s}$ and EVENT pushbuttons are released (out).

## Event Triggering:

From left vertical plug-in only.
Frequency Range:
dc to 20 MHz . Frequency range is also affected by the vertical amplifier installed in the left vertical compartment.

Minimum Pulse Width: 20 ns

Minimum Required Signal:
0.4 division of deflection minimum, dc to 10 MHz ; increasing to 1.5 divisions at 20 MHz .

```
Event Trigger Level Range:
    \geqslant \pm 8 \text { divisions.}
Trigger Coupling:
    Direct coupled.
Polarity:
    \pm \text { Slope selection.}
```


## Output Signals

DLY'D GATE (front panel):
This is a positive-going signal at the end of delay interval and a negative-going signal at end of sweep.

Output Impedance: Approximately $50 \Omega$

Logic Levels:
Into open circuit: Low $\approx-0.3 \mathrm{~V}$, High $\approx+2.5 \mathrm{~V}$. Into $50 \Omega$ Load: Low $\approx 0.0 \mathrm{~V}$, High $\approx+1.25 \mathrm{~V}$.

TTL Capability:
One standard load (2 mA maximum).
Risetime:
Approximately 50 ns .

Accuracy:
Rises between 50-80 ns after the end of delay interval.

## THEORY OF OPERATION

## Introduction

Refer to the block diagram and the circuit diagrams indicated by the diamond enclosed numbers as the 5B31 Theory of Operation is read. These diagrams are on pullout pages at the rear of this manual.

## Main Trigger Generator $\langle 1$

The purpose of the trigger source and coupling circuitry is to allow the operator to select the desired signal source and to reject unwanted signals during various modes of operation. The LEFT, RIGHT, LINE and EXT source switches are self-cancelling.

When the LEFT vertical plug-in is selected as a trigger source, the emitters of Q165 and Q180 are connected through R185 and R186 to the -15 V supply. The circuit operates with Q175 as a unity-gain feedback buffer amplifier to isolate the Main Trigger system from the Event Trigger system. When RIGHT, LINE, or EXT sources are selected, the output from the buffer amplifier is grounded.

When ac-coupling from internal sources is selected, C204 is inserted in series with R210. C206 ac-couples signals from external sources. The adjustment of C210 frequency compensates the EXT input voltage divider composed of R200 and R210.

Q215 and Q220 is a totem-pole amplifier circuit that isolates all trigger sources from the Main Trigger Comparator and External Horizontal Amplifier circuitry. The adjustment of R220 sets the current through Q220, which develops a voltage drop across R215 that compensates for the reverse-bias between the gate and source of Q215. The drain terminal of Q220 is normally at a quiescent level of zero volts. CR215 and VR215 operate as limiting devices for overdrive protection.

For all SEC/DIV switch settings (other than AMPL), the Main Trigger Comparator circuit, Q225 and Q235 operates as a voltage comparator that determines the voltage level on the waveform where Normal Sweep triggering occurs. Operator adjustment of the Main Trigger Level control R245 sets the dc level at the base of Q235 to which the signal level on the base of Q225 is compared. Positive slope, Normal Sweep triggering is selected by pushing the + SLOPE selector button, which grounds pin 1 of U245.

U245 accepts signals from the Main Trigger Comparator and processes them to produce emitter-coupled logic levels (High $\approx 4.2 \mathrm{~V}$, Low $\approx 3.2 \mathrm{~V}$ ) at output pins 3 and 4. The application of a positive-going pulse to pins 6 and 10 of U245 at the end of sweep time forces a high at pin 4 and a low at pin 3 , establishing a trigger holdoff condition for U245 during a sweep holdoff period. Pins 4 and 3 change their logic level on the next trigger signal after sweep holdoff has ended. The occurrence of a low at pin 4 simultaneously with a high at pin 3 of U245 is called Main Trigger recognition.

## Event Trigger Generator $\langle 1$

The output of the LEFT vertical plug-in is connected directly to the Event Trigger Comparator circuit, Q100 and Q110. The circuitry for Q100 and Q110 operates essentially in the same manner as the Main Trigger Comparator. Event Trigger Level control R125 allows the operator to choose event triggering levels independent of the Main Triggering Level. Signals from the Event Trigger Comparator are applied to pin 4 of U130A. Positive slope, event triggering is established by setting a high at pin 5 of U130A, which operates as an inverting amplifier with a gain of about five for low amplitude analog signals. A low at pin 5 of U130A causes it to operate as a noninverting amplifier for negative slope event triggering. The output of U130A drives Exclusive-OR gates U130B and U130C. These gates are connected as a Schmitt trigger generator to produce rectangular waveforms with fast rise and fall times at pin 10 of U145C.

## 1 MHz Clock and Event Gates〈1>

Because the time delay for the 5B31 is controlled by a crystal oscillator, the 1 MHz reference clock circuit (U145D) operates continuously with the negative transition on pin 15 significant in the Delay by Time mode of operation. The network containing R155, C155, R156 and R158 maintains pin 12 of U145D at the correct voltage for linear operation.

## Theory of Operation-5B31

In the case of two-input positive-logic NOR gate (such as U145B and U145C), if one of the inputs is held high, the output will be low regardless of the switching levels on the other input (a lock-out state). If the same input is held low, the output transitions are inverted with respect to the switching levels on the other input (a gated operation).

Delay by Time mode of operation is selected by setting a low on pin 7 of U145B ( $\mu$ s selector button pushed in). For Delay by Events mode, a low is set on pin 11 of U145C (EVENT button pushed in). The wired-OR junction (output terminals of U145C and U145B) is a common point for the 1 MHz reference clock signal from U145D or event triggers produced at pin 10 of U145C. The $\mu \mathrm{s}$ or Event pushbuttons are self-cancelling and when either mode of operation is selected, a high is restored to the control terminal of the opposite gate. For example, a low on pin 11 of U145C simultaneously, with a high on pin 7 of U145B, locks out the 1 MHz reference clock signals from the wired-OR junction, allowing the 5B31 to operate in a Delay by Event mode.

U145A is gated on when Main Trigger recognition occurs (pin 5 goes low). The negative transition of the gated signal (event or 1 MHz clock) at pin 2 of $U 145 \mathrm{~A}$ is significant to counter operation in both modes of operation.

When the 5B31 is not delaying by events or time (both $\mu \mathrm{s}$ and Event buttons out), the wired-OR junction remains low. This enables U145A, allowing its output (pin 2) to go high when Main Trigger recognition occurs. Pin 2 of U145A remains high during total sweep time.

CR132 is connected to +5 V in a Delay by Time mode to lock the output terminal of U130A to a high, preventing event triggers from switching the Event Trigger Schmitt circuit.

## Sweep Gate Generator (General) <2

The Sweep Gate Generator circuit must produce a Sweep Gate (start) signal on pin 3 of U270B when the instrument is operated in either a Normal Sweep or Locate mode (see Section 1 for definition of these modes). The circuit must also produce an Intensify Gate and DLY'D GATE output signal after the selected time delay or event count has been completed.

When operating in a Delayed Sweep mode, the circuit must also originate Sweep Gate, Intensify Gate and DLY'D GATE signals that occur simultaneously after the selected delay.

For a Normal Sweep mode, pin 7 of U270B is held to a low by grounding the cathode of CR275. The output of U270B then goes high with every trigger signal that has been processed by the Main Trigger circuits. No Intensify Gate or DLY'D GATE signal is produced in a Normal Sweep mode; the crt is unblanked by circuits in the Sweep Generator section.

If the DLY'D button only is pushed in and the thumbwheel switches are set to 00000, pin 7 of U270B is held to a low through CR276. This action causes the sweep to be triggered with zero delay (same as Normal Sweep). With the EVENT and $\mu \mathrm{s}$ buttons both out, Normal Sweep triggering (zero delay) is obtained with any arbitrary setting of the thumb-wheel switches.

When the thumb-wheel switches are set to 00000 and the $\mu \mathrm{s}$ button only is pushed in, Normal Sweep triggering occurs with zero delay and the Intensify Gate or DLY'D GATE signals are not generated. However, if the thumbwheels are at 00000 and the EVENT button only is pushed in, the Intensify Gate and DLY'D GATE signals are produced and occur with the first event after Main Trigger recognition. More detailed information concerning Delay by Event and Delay by Time operation is discussed under separate headings.

## Delay Generator (General) 1$\rangle\langle 2\rangle\langle 3$

When selected by S145A or S145B, 1 MHz clock or event signals from pin 2 of U145A are applied to the emitter of Q380, with R380 and R382 providing a high-speed termination. The Clock Translator circuit (Q380 and Q390) is a negative feedback amplifier circuit that translates emitter-coupled logic signal levels to TTL levels to drive the counter chain composed of $\cup 430, \cup 435$, U440, U445, and U450.

All the counters use an $8,4,2,1 \mathrm{BCD}$ code and are preset to a specific selected count by the five programming thumb-wheel switches (S450). A switch contact closure connects a counter input line to ground (logical low $=0$ ), while an open switch contact allows appropriate counter input lines to be set to a logical high (=1) through an associated $10 \mathrm{k} \Omega$ pull-up resistor. Each input line to a counter has its own pull-up resistor ( $5 \times 4=20$ total). Ten of the pull-up resistors are directly connected to +5 V for the 2 and 4 coding input lines. The 1 and 8 coding input lines are connected through the remaining pull-up resistors to a bus line that is common to all counters. The common bus is connected to the base of Q465 and through R464 to +5 V .

Q465 is a zero sense detector. When the thumb-wheel switches are set to 00000, the 1 and 8 coding input lines to the counters have an open switch contact and little or no current flows from ground through the common bus. Consequently, the voltage drop across R464 is approximately zero and Q465 is essentially cut off, with its collector pulled down toward 0 volts through R465. However, if the EVENT button is pushed in, the cathode of CR418 is grounded and current through R418 and R464 disables the zero sensing operation. Q465 is turned on and its collector is at a logical TTL high. Consequently, the Intensity Gate and DLY'D GATE signals are produced by U280A (Sweep Gate Generator circuit) on the first event occurrence after Main Trigger recognition even though the thumb-wheels indicate 00000 and the counter-chain in the Delay Generator system is not counting. This is done because the zeroth event is defined as the first event after Main Trigger recognition and it must be made observable on the crt screen. See Delay by Event Operation for a more detailed discussion of U280A.

With the collector of Q465 at zero volts (zero sensing), pin 4 of $U 460 B$ is low, locking out any input signals on pin 3 and setting pin 6 to a high. This high level is transmitted through VR460 and CR387 to cut off the Clock Translator circuit (Q380 and Q390). The low at the collector of Q465 also forward biases CR276 and CR302 in the Sweep Gate Generator circuit to cut off a differential current switch (Q300 and Q302) and gates on U270B to allow Normal Sweep triggering.

The BCD information programmed by the thumbwheel switches is loaded into the counter chain only when the data storage line (pin 1 of each counter and the collector of Q415) goes low. A counter preset signal is generated during sweep hold-off period by a Preset Monostable circuit (Q400 and Q410). The input signal to the base of Q400 goes high at the start of holdoff and low at
the end of holdoff. Only the positive transition triggers the monostable circuit. Consequently, the collector of Q410 is high for only a $1.5 \mu$ s period, which is shorter than the shortest hold-off period. This $1.5 \mu \mathrm{~s}$ high level period causes the collector of Q415 to go low and preset the counters.

The counters are loaded (preset) with the 9's complement of the number to be counted. If a counter is to count zero, it is loaded with the binary number equivalent to a decimal 9. For a count of one, it is loaded with data equivalent to decimal 8 ; for a count of two, it is loaded with a 7 , etc. This is done because the end of a count is determined by sensing when all of the counters have a count of 9. A selected count of 00001 means that U450, U445, U440, and U435 are preset to binary 9 , while U430 would be preset to binary 8 . One clock pulse then changes $\cup 430$ to a count of 9 which would then be sensed as the end of the count and the count would be stopped.

The state of the counters is sensed by U455, U460C, and U460A. Pin 5 of each counter is the 1 output and pin 12 is the 8 output. A high is set on every input line to the sensing gates when pins 5 and 12 of each counter goes high (a counter full state) and pin 12 of U460A goes to a low at the end of a selected count. If the thumb-wheels are not at 00000 , the transition to a low on pin 12 of U460A is gated through U460B with inverted polarity to perform two functions: cut off the Clock Translator circuit (Q380 and Q390) and applies an End Count signal to the Sweep Gate Generator circuit.

Counter Reset is accomplished by releasing both the $\mu \mathrm{s}$ and EVENT buttons to the out position. This generates a +5 V control signal through R413 to the base of Q415, causing its collector to remain low for counter reset (forces counters to be loaded). With both $\mu \mathrm{s}$ and Event buttons out, the base of Q465 is also forced high through CR413, which deactivates the zero sensing operation. The collector of Q465 is always low with both buttons out. Pushing either button in removes the +5 V control signal, allowing the counters to count and generate an End Count signal.

A Counter Transition Detector circuit, composed of U470D, U470C and U470A develops a signal that controls a $1 \mu \mathrm{~s}$ Ramp Generator in the Sweep Gate Generator section. The output signal on pin 2 of U470A is utilized only during Delay by Time operation.

The 1 output line of the high-speed counter, pin 5 of U430, is connected to +5 V through a voltage divider composed of R470, R472 and R473. The resistor values are chosen such that both input terminals of the Counter Transition Detector are set slightly below their threshold levels for a low level at pin 5 of U430. R472 also sets pin 10

## Theory of Operation-5B31

of U470C slightly more positive than pin 13 of U470D. When a low occurs at pin 5 of U430, both inputs to the Counter Transition Detector are considered to be low, setting the wired-OR junction at pin 4 of U470A to a high.

When pin 5 of U430 changes from a low to a high, pin 10 of $U 470 \mathrm{C}$ is the first input terminal to rise above its threshold level and produces a momentary low on pin 4 of U470A. The momentary low is inverted by U470A to a momentary high. When the input level to pin 13 of U470D crosses the threshold level going in a positive direction, the wired-OR junction is reset to a high. When pin 5 of U430 changes from a high to a low, pin 13 of U470D will be the first terminal to go low, producing another momentary low at the wired-OR junction. When the input terminal of U470C goes through its threshold level in a negative direction, the wired-OR junction is reset to a high. The momentary low levels are produced at the wired-OR junction and inverted to momentary highs by U470A each and every time the counter changes state.

## Delay By Event Operation<1><2><3>

With the EVENT button pushed in and the thumbwheels not at 00000, the junction of CR276 and CR302 is logically high, but the cathode of CR301 is grounded, which cuts off differential current switch (Q300 and Q302) in the $1 \mu$ s Ramp Generator. Therefore, the Ramp Hold signal on pin 12 of U280B has no effect (not used) when delaying by events. The base of Q310 is also held high through CR145 and R310. With Q310 on, no voltage rise (ramp) can occur across C315. When the SEC/DIV switch is set to the AMPL position, the base of Q310 is held high through R311. CR280 is reverse-biased (cut off) when delaying by events.

Pin 3 of U270B is a wired-OR junction. For a Locate mode the DLY'D button is out and the sweep has already been started by a Main Trigger signal. The wired-OR junction is already high, requiring only that Intensify Gate and DLY'D GATE signals be generated at the proper time. For a Delayed Sweep mode, the DLY'D button is pushed in and the Trigger Bypass gate (U270B) locks out the Main Trigger signal. After a sweep has ended (for either the Locate or Delayed Sweep mode) pin 5 of U280A goes high to set the wired-OR junction to a low (no sweep).

When the End of Count signal from U460B and VR460 goes high, the output of U270C goes low. A low on pin 6 of U280A enables an internal clock gate. Nongated event signals from pin 14 of U145C are applied to pin 9 of U280A. Pins 2 and 3 of U280A change state on the next event signal after the end of the count. The counter-chain is not involved with the last count, thus there is a very small delay between the last count and sweep gate operation. The last event count sets pin 3 of U280A to a high and pin 2 to a low. The transition to a low is transmitted through Q350 (a nonsaturated, grounded-base amplifier) and is inverted by
both Q360 and Q365 to intensify the remaining portion of the total sweep. The diodes in the collector circuits of Q350 and Q365 prevent these transistors from operating in a saturated mode.

Q370 is an emitter-follower circuit for the DLY'D GATE output signal. R370 combines with the internal emitter resistance of Q370 to set a $50 \Omega$ source impedance for a coaxial cable. This output stage has a current sinking capability of about 2 mA (one TTL load $=1.6 \mathrm{~mA}$ ). LR370 and C370 decouple current surges.

## Delay By Time Operation〈 1$\rangle\langle 2\rangle$

With the $\mu$ s button pushed in and the thumbwheels not at 00000 , the same conditions as described for Delay by Event Operation are established at the wired-OR junction (pin 3 of U270B).

When delaying by time, the EVENT button is out and a logical high is set at the junction of CR280 and CR301. With CR280 forward-baised (on), pin 6 of U280A is locked to a high level, disabling the internal clock gate. It is not possible for U280A to change state with a nongated, 1 MHz reference clock signal on pin 9.

Before Main Trigger recognition occurs, the nottriggered logic levels on the base and emitter of Q290 cause this transistor to be in a conducting state. This action holds the base of Q310 to a high level (as long as the 5B31 is not triggered), ensuring that a voltage rise across C315 will always start from the same level when the 5B31 is triggered. When delaying by time, R310 is grounded through CR145, and CR301 is reverse biased (off). Q290 turns off at the instant of Main Trigger recognition.

Before Main Trigger recognition occurs, the differential current switch (Q300 and Q302) is off, with the base of Q302 at a logical high and the base of Q300 at a logical low (no charge on C315). These logic states require that pin 15 of U280B to be low and pin 12 of U270D to be high. Also, before Main Trigger recognition, pin 11 of U280B is low. Pin 10 of U280B is the D terminal for this type Flip-Flop and the data on pin 10 is always low. Therefore, the nongated 1 MHz clock signal on pin 9 is gated through the internal gate to ensure that pin 15 is always in a low state before trigger recognition. After trigger recognition, the 1 MHz clock signal is locked out by the logical high on pin 11 of U280B. Another condition that exists before trigger recognition is that a logical low is established at the junction of CR285, CR286, R340, and VR340.

At the instant of Main Trigger recognition, pin 12 of U270D goes low (pin 13 is already low). This sets a low on the base of Q302 and a high on the base of Q300, turning on the differential current switch to start charging C315. If
the 5B31 is in a Locate mode, the sweep is also started; for a Delayed Sweep mode, pin 3 of U270B will not go high to start the sweep until after the selected delay.

While the counter-chain counts, the Ramp Hold signals (momentary highs) are applied to pin 12 of U280B from the Counter Transition Detector. The first Ramp Hold signal sets pin 15 of U280B to a high. The second and all other Ramp Hold signals (for the associated delay period) have no effect, because pin 15 of U280B is already high. The logical high on pin 13 of U270D sets pin 9 to a high and pin 15 to a low. These logic levels to the bases of the differential current switch turn on Q300 and cut off Q302, disconnecting the charging current path for C315. Whatever voltage level that has been developed across C315 up to this point in time remains at this level until the occurrence of the End of Count signal (counter-chain is full of 9 's).

When the End of Count signal goes high, pin 15 of U280B is set to a low. Pin 13 of U270D also goes low, causing pin 9 to go low and pin 15 to go high. This cuts off Q300 and turns on Q302, reconnecting the charging current path for C315. The voltage developed across C315 again continues its rise toward a higher voltage level. The held ramp signal is applied through a source-follower circuit (Q320A and Q320B) to the noninverting input terminal of Ramp Comparator U330. When the Ramp voltage crosses the voltage level set on pin 3 of U330 by the adjustment of R325, the output terminal (pin 7) goes high. R336 provides a slight amount of positive feedback to improve the risetime. The fast transition to a logical high is level shifted by VR340 and applied to the anodes of CR285 and CR286.

The transition to a high at the end of the held Ramp period pulls up on the anode of CR286 to set pin 13 of U270D to a high, stopping the voltage rise across C315. The Reset (clear) terminal (pin 4) of U280A is also driven high, which sets pin 2 to a low and pin 3 to a high to start a delayed sweep. The wired-OR junction will already be high for a Locate mode. Intensify Gate and DLY'D GATE signals are generated in the same manner as described for the Delay by Event Operation.

There is a random time interval between the occurrence of a 1 MHz clock transition and the Main Trigger event on pin 12 of U270D. This random time interval can be anywhere between zero and $1 \mu$ s and may or may not be the same for the generation of each sweep. The purpose of the held Ramp is to absorb this random relationship. The ramp first runs during a random time interval between the Main Trigger event and the first occurrence of the clock (or Ramp Hold) signal. See Fig. 2-1. The ramp is then turned off during the count and resumes its run-up at the end of the count to complete a $1 \mu$ s period. Thus, the total time delay is the delay counted by the counter-chain plus an additional $1 \mu \mathrm{~s}$ due to the held ramp.


Fig. 2-1. Held ramp(s). Random hold levels due to random time relationship between Main Trigger recognition and 1 MHz clock. Output of Ramp Follower. Three microsecond delay. Test oscilloscope sweep rate $0.2 \mu \mathrm{~s} / \mathrm{div}$.

After a sweep has been completed, Q290 turns on to drive the base of Q310 to a logical high. This resets the held ramp voltage across C315 to a near zero level. The 1 MHz clock signal on pin 9 of U280B also resets pin 13 of U270D to a low. The system is now ready for another cycle of operation.

## Sweep Generator and Sweep Control 4>

The Sweep Gate signal (a transition to a logical high) is applied to the emitter of Q500 and pin 1 of U485. Q500 and its associated components translate emitter-coupledlogic levels down to signals levels that swing between ground and about 2.5 volts. The collector of Q500 goes high to start the sweep and goes low at end of sweep. The negative transition is applied to the base of emitterfollower Q520 and differentiated by C518 and R518 to provide an Alternate Drive signal to the mainframe circuits. The Sweep Gate signal is also applied to the base of an inverting, nonsaturating amplifier (Q510) to unblank the crt Z-axis slightly before the start of the sweep. If the 5B31 is operated in a horizontal AMPL mode, the collector of Q510 is locked to a logical high by the application of a 5 $\checkmark$ level to the junction of R505 and R506.

U485, with additional external circuitry, controls the Sweep Generator. In the automatic triggering mode, pin 19 of U485 is grounded. Pins 1 and 2 of U485 sense the absence of a Sweep Gate signal from the Sweep Gate Generator circuitry. If no Sweep Gate signal is received for a period of time set by the time constant of R532 and C532, the output of pin 3 of U 485 goes negative to drive the base of Q500. The output on pin 3 is a square-wave signal as long as no external signal is applied to the 5B31 or if the period of the external signal is greater than about 0.2 second.

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In the Single Sweep mode, pin 12 of U485 is connected to +5 V and pin 19 is ungrounded. This connects a current path through pin 11 to turn on the READY-TRIG light. One Sweep Gate signal disconnects the current path, extinguishing DS490. For another sweep, the RESET button must be pushed to reconnect the current path. Reset action is accomplished by applying +5 V to pin 15 through R490. Automatic reset action for storage applications is applied through CR490. In a triggered mode, a Sweep Gate signal on pin 1 of U485 connects a current path through pin 7 to turn on the READY-TRIG light.

When pin 18 of $\cup 485$ is set to a logical high, pin 17 goes high to lock out trigger signals through U245 (Main Trigger Processor). Therefore, the sweep cannot be triggered when pin 18 is high because Sweep Gate signals are not present at the emitter of Q500. Also, the sweep cannot be started by delayed Sweep Gate signals because the counter-chain cannot count without a gated signal through U145A (Clock Gate). Pin 18 of U485 is set to a logical high (about +5 V ) by a mainframe signal through CR495 for storage applications, or through CR494 when the instrument is operated in a horizontal AMPL mode.

Pin 1 of U545 goes high to start the sweep ramp. The ramp drives the horizontal amplifiers from pin 8. Timing resistors $R_{1}$ and timing capacitors $C_{1}$ determine the slope of the ramp. R565 and R566 set an internal comparator reference level on pin 6 of about 10 V . When the ramp voltage level passes through the comparator reference level, pin 4 goes high to provide end of sweep information through CR500 to pin 16 of U485. Sweep hold-off time starts when pin 16 of $\cup 485$ reaches about 2.4 V .

Pin 17 of U485 goes high at start of sweep holdoff to lock out trigger signals from the Main Trigger Processor (U245) and to trigger the Preset Monostable circuit (Q400 and Q410). The hold-off period is determined by R539 and four capacitors connected to pin 8 of U485, (dependent on the sweep speed selected). The collector of Q500 and pin 1 of U545 go low at the start of holdoff (sweep lockout). A mainframe signal for storage applications is applied through CR496 to lock out the sweep and gate off the Zaxis unblanking circuit. At the end of sweep retrace pin 16 of $U 485$ has been reset to a low. Pin 17 is set to a low at the end of holdoff. The Sweep Generator system is now ready to accept another Sweep Gate signal.

## Horizontal Amplifiers $\langle 5$

When the AMPL mode is selected, the signal input to the Main Trigger Comparator circuit (Q225 and Q235) is disconnected and applied to the base of Q585. A current shunt path through CR582 and R582 is also disconnected from the emitters of Q585 and Q595 when operating in the AMPL mode. Q585, Q595, and Q590 operate as an operational amplifier circuit with differential inputs and a gain of about three. The noninverting input on the base of

Q585 is driven by external signals, while the inverting input on the base of Q595 is driven by a dc voltage level from the horizontal POSITION control. The amplifier gain is set by R594, R596, and R600. When the 5B31 is operated in a sweep mode, the emitters of Q585 and Q595 are reverse biased by connecting CR582 and R582 to +5 V .

The sweep ramp signal on pin 8 of $\cup 545$ is processed by differential output amplifier Q645 and Q615, with Q625 providing a constant-current source. The ramp input signal is divided down by R642, R644 and R645 to drive the base of Q645. R614 and R615 set the quiescent bias level on the base of Q615. The junction of R612 and R610 is grounded when the 5 B31 is operated in a horizontal AMPL mode. In a sweep mode, this ground is removed and horizontal POSITION information drives the base of Q615 through R610. The X1 gain of the differential amplifier is set by the adjustment of R630. Output signals at the collectors of Q645 and Q615 are developed across R649 and R619. R619 is grounded in a sweep mode by a switch contact (S545-2), which shorts the other end of the coaxial cable center conductor and shield. For External Horizontal Amplifier operation, the center conductor is disconnected from the shield. The differential amplifier circuit does not amplify external horizontal signals.

In a magnified sweep mode, R635 and R633 are connected in parallel with the X1 gain setting resistors, reducing the emitter degeneration of Q645 and Q615. This results in a X10 increase in gain. The collectors of Q645 and Q615 are current starved and their voltage excursions in a sweep mode are limited to about 1.2 V maximum by clamping diodes located in the mainframe circuitry.

## Readout and Switch Details <6

The SEC/DIV, CAL and SWP MAG switches have contacts wired into the readout circuitry. A zero to -15 V pulse, approximately $125^{\circ} \mu \mathrm{s}$ in duration is applied at different times to all of the rear interface connections associated with the readout circuitry, except the column (pin 28A) and row (pin 28B) output lines. The readout circuitry, in the 5B31, sets the correct amounts of row and column current during an input pulse time for the particular character that needs to be generated and displayed on the crt. Refer to 5400-Series Oscilloscope System instruction manual for detailed information on time slot and currents required for each character.

Opening S545-17 in the horizontal AMPL mode disables the sweep readout. When the SWP MAG button is pushed in, DS720 will be turned on and the readout will show that the time per division has been reduced by a factor of 10 . When the CAL knob is not in its detent position, S 710 is closed, generating an uncalibrated sign $(>)$ in front of the sweep readout data on the crt. Diodes CR700 through CR708 and CR710 decouple noise pulses (or overshoot spikes) which may appear on the time slot input lines.

Timing capacitors and resistors are connected according to various positions of the SEC/DIV switch as illustrated on the schematic diagram. The CAL potentiometer R560 varies the timing resistance for any sweep mode position of the SEC/DIV switch. The connections at the junctions of a voltage divider composed of R559, R557, R556, and R555 are for a 1, 2, 5 sequence, with R558 and

R554 compensating for different source impedances for the timing chain. The remaining timing resistors and capacitors connected to the summing junction (pin 9 of U545) are for decade timing, with the highest sweep speed calibrated by the adjustment of C555. C566, R569, and C569 connected to pin 9 of U545 (Sweep Generator circuit) are for oscillation suppression.

## SYMBOLS AND REFERENCE DESIGNATORS

Electrical components shown on the diagrams are in the following units unless noted otherwise:

$$
\begin{aligned}
\text { Capacitors }= & \text { Values one or greater are in picofarads }(\mathrm{pF}) . \\
& \text { Values less than one are in microfarads }(\mu \mathrm{F}) . \\
\text { Resistors }= & \text { Ohms }(\Omega)
\end{aligned}
$$

Symbols used on the diagrams are based on ANSI Y32.2-1970.
Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following special symbols are used on the diagrams:


External Screwdriver adjustment.


External control or connector.

Clockwise control rotation in direction of arrow.

Refer to diagram number indicated in diamond.

Refer to waveform number indicated in hexagon.


P1O circuit board

# REPLACEABLE <br> ELECTRICAL PARTS 

## PARTS ORDERING INFORMATION

Replacement parts are avaitable from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

## SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number
00X
Part removed after this serial number

## ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

## ABBREVIATIONS

| ACTR | ACTUATOR | PLSTC | PLASTIC |
| :--- | :--- | :--- | :--- |
| ASSY | ASSEMBLY | QTZ | QUARTZ |
| CAP | CAPACITOR | RECP | RECEPTACLE |
| CER | CERAMIC | RES | RESISTOR |
| CKT | CIRCUIT | RF | RADIO FREQUENCY |
| COMP | COMPOSITION | SEL | SELECTED |
| CONN | CONNECTOR | SEMICOND | SEMICONDUCTOR |
| ELCTLT | ELECTROLYTIC | SENS | SENSITIVE |
| ELEC | ELECTRICAL | VAR | VARIABLE |
| INCAND | INCANDESCENT | WW | WIREWOUND |
| LED | LIGHT EMITTING DIODE | XFMR | TRANSFORMER |
| NONWIR | NON WIREWOUND | XTAL | CRYSTAL |

## CROSS INDEX MFR. CODE NUMBER TO MANUFACTURER

| MFR.CODE | MANUFACTURER | ADDRESS | CITY,STATE,ZIP |
| :---: | :---: | :---: | :---: |
| 00853 | Sangamo Electric Co., S. Carolina Div. | P. O. Box 128 | Pickens, SC 29671 |
| 01121 | Allen-Bradley Co. | 1201 2nd St. South | Milwaukee, WI 53204 |
| 01295 | Texas Instruments, Inc. |  |  |
|  | Semiconductor Group | P. O. Box 5012 | Dallas, TX 75222 |
| 04713 | Motorola, Inc., Semiconductor |  |  |
|  | Products Div. | 5005 E. McDowell Rd. | Phoenix, AZ 85036 |
| 07126 | Digitran Co., The | 855 South Arroyo Parkway | Pasadena, CA 91105 |
| 07263 | Fairchild Semiconductor, A Div. of |  |  |
|  | Fairchild Camera and Instrument Corp. | 464 Ellis St. | Mountain View, CA 94042 |
| 07910 | Teledyne Semiconductor | 12515 Chadron Ave. | Hawthorne, CA 90250 |
| 08806 | General Electric Co., Miniature |  |  |
|  | Lamp Products Dept. | Nela Pk. | Cleveland, OH 44112 |
| 12697 | Clarostat Mfg. Co., Inc. | Lower Washington St. | Dover, NH 03820 |
| 15818 | Teledyne Semiconductor | 1300 Terra Bella Ave. | Mountain View, CA 94040 |
| 18324 | Signetics Corp. | 811 E. Arques | Sunnyvale, CA 94086 |
| 24931 | Specialty Connector Co., Inc. | 3560 Madison Ave. | Indianapolis, IN 46227 |
| 56289 | Sprague Electric Co. |  | North Adams, MA 01247 |
| 71590 | Centralab Electronics, Div. of Globe-Union, Inc. | 5757 N. Green Bay Ave. | Milwaukee, WI 53201 |
| 72982 | Erie Technological Products, Inc. | 644 W. 12th st. | Erie, PA 16512 |
| 73138 | Beckman Instruments, Inc., Helipot Div. | 2500 Harbor Blvd. | Fullerton, CA 92634 |
| 75042 | TRW Electronic Components, IRC Fixed Resistors, Philadelphia Division | 401 N. Broad St. | Philadelphia, PA 19108 |
| 80009 | Tektronix, Inc. | P. O. Box 500 | Beaverton, OR 97077 |
| 80031 | Electra-Midland Corp., Mepco Div., |  |  |
|  | A North American Phillips Co. | 22 Columbia Rd. | Morristown, NJ 07960 |
| 86577 | Precision Metal Products of Malden, Inc. | 41 Elm St. | Stoneham, MA 02180 |
| 90201 | Mallory Capacitor Co., Div. of |  |  |
|  | P. R. Mallory Co., Inc. | 3029 E. Washington St. | Indianapolis, IN 46206 |


| Ckt No. | Tektronix <br> Part No. | Serial/Model No. Eff Dscont | Name \& Description | Mfr <br> Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Al | 670-3227-00 |  | CKT BOARD ASSY:MAIN | 80009 | 670-3227-00 |
| A2 | 670-3228-00 |  | CKT BOARD ASSY:TRIGGER | 80009 | 670-3228-00 |
| Cl05 | 290-0527-00 |  | CAP.,FXD, ELCTLT: 15UF, 20\%, 20V | 90201 | TDC156M020FL |
| Cl09 | 281-0513-00 |  | CAP. ,FXD, CER DI: $27 \mathrm{PF},+/-5.4 \mathrm{PF}, 500 \mathrm{~V}$ | 72982 | 301-000P2G0270M |
| C115 | 290-0527-00 |  | CAP.,FXD, ELCTLT: $15 \mathrm{UF}, 20 \%$, 20V | 90201 | TDC156M020FL |
| C130 | 290-0527-00 |  | CAP, FXX, ELCTLT:15UF, 20\%, 20V | 90201 | TDC156M020FL |
| C145 | 290-0527-00 |  | CAP.,FXD, ELCTLT: $15 \mathrm{UF}, 20 \%, 20 \mathrm{~V}$ | 90201 | TDCl56M020FL |
| Cl50 | 281-0204-00 |  | CAP.,VAR,PLSTC: $2-22 \mathrm{PF}, 100 \mathrm{~V}$ | 80031 | COIOEA-20E |
| C152 | 281-0578-00 |  | CAP.,FXD, CER DI:18PF, 5\%,500V | 72982 | 301-000C0G0180J |
| C155 | 283-0000-00 |  | CAP., FXD, CER DI: $0.001 \mathrm{UF},+100-0 \%, 500 \mathrm{~V}$ | 72982 | 831-516E102P |
| C168 | 290-0527-00 |  | CAP.,FXD, ELCTLT: 15UF,20\%,20V | 90201 | TDC156M020FL |
| C185 | 290-0527-00 |  | CAP.,FXD,ELCTLT: $15 \mathrm{UF}, 208,20 \mathrm{~V}$ | 90201 | TDC156M020FI |
| C193 | 283-0002-00 |  | CAP.,FXD,CER DI: $0.01 \mathrm{UF},+80-20 \%, 500 \mathrm{~V}$ | 72982 | 811-546E103z |
| C200 | 281-0510-00 |  | CAP. ,FXD, CER DI : $22 \mathrm{PF},+/-4.4 \mathrm{PF}$, 500 V | 72982 | 301-000COG0220M |
| C204 | 283-0002-00 |  | CAP., FXD, CER DI: $0.01 \mathrm{UF},+80-20 \%, 500 \mathrm{~V}$ | 72982 | 811-546E1032 |
| C206 | 283-0002-00 |  | CAP.,FXD,CER DI: $0.01 \mathrm{UF},+80-20 \%, 500 \mathrm{~V}$ | 72982 | 811-546E103Z |
| C210 | 281-0204-00 |  | CAP.,VAR,PLSTC:2-22PF,100V | 80031 | COIOEA-20E |
| C212 | 290-0527-00 |  | CAP.,FXD, ELCTLT : 15UF, 20\%, 20V | 90201 | TDC156M020FL |
| C 220 | 290-0527-00 |  | CAP., FXD, ELCTLT: 15UF,20\%, 20 V | 90201 | TDC156M020FL |
| C227 | 281-0524-00 |  | CAP.,FXD, CER DI: 150 PF , +/-30PF, 500 V | 72982 | 301-000x5U0151m |
| C230 | 290-0527-00 |  | CAP., FXD, EICTLT: 15UF, 20\%,20V | 90201 | TDC156M020FL |
| C237 | 290-0527-00 |  | CAP. ,FXD, ELCTLT: 15UF, 20\%, 20V | 90201 | TDC156M020FL |
| C242 | 283-0000-00 |  | CAP. ,FXD, CER DI: 0.001UF, +100-0\%, 500 V | 72982 | 831-516E102P |
| C250 | 281-0549-00 |  | CAP., FXD, CER DI:68PF, 10\%,500V | 72982 | 301-000U2J0680K |
| C270 | 290-0527-00 |  | CAP. ,FXD, ELCTLT : 15 UF , 20\%, 20V | 90201 | TDC156MO20FL |
| C280 | 290-0527-00 |  | CAP.,FXD, ELCTLT: 15UF,20\%,20V | 90201 | TDC156MO20FL |
| C315 | 285-0918-00 |  | CAP.,FXD, PLSTC:0.001UF,5\%,200V | 56289 | LP66A1Cl02J002 |
| C330 | 283-0000-00 |  | CAP., FXD, CER DI: $0.001 \mathrm{UF},+100-0 \%, 500 \mathrm{~V}$ | 72982 | 831-516E102P |
| C334 | 283-0023-00 |  | CAP., FXD, CER DI: $0.1 \mathrm{UF},+80-20 \%, 10 \mathrm{~V}$ | 56289 | 20c374 |
| C370 | 283-0003-00 |  | CAP., FXD, CER DI: $0.01 \mathrm{UF},+80-20 \%, 150 \mathrm{~V}$ | 72982 | 855-547E103Z |
| C400 | 281-0513-00 |  | CAP., FXD, CER DI: $27 \mathrm{PF},+/-5.4 \mathrm{PF}, 500 \mathrm{~V}$ | 72982 | 301-000P2G0270M |
| C 403 | 281-0518-00 |  | CAP.,FXD, CER DI:47PF, +/-9.4PF, 500V | 72982 | 301-000U2J0470M |
| C425 | 290-0527-00 |  | CAP, FXD, ELCTLT: 15UF, 20\%, 20V | 90201 | TDC156M020FL |
| C470 | 290-0527-00 |  | CAP. ,FXD, ELCTLT: 15UF,20\%, 20V | 90201 | TDC156M020FL |
| C485 | 290-0527-00 |  | CAP. ,FXD, ELCTLT: 15UF, 20\%, 20V | 90201 | TDC156M020FL |
| C490 | 290-0534-00 |  | CAP. ,FXD, ELCTLT: 1 UF , 20\%, 35V | 56289 | 196D105X0035HAl |
| C500 | 281-0518-00 |  | CAP. FXD, CER DI : $47 \mathrm{PF},+/-9.4 \mathrm{PF}, 500 \mathrm{~V}$ | 72982 | 301-000U2J0470M |
| C506 | 283-0000-00 |  | CAP., FXD, CER DI:0.001UF, +100-0\%,500V | 72982 | 831-516E102P |
| C518 | 281-0546-00 |  | CAP.,FXD, CER DI:330PF, 10\%,500V | 72982 | 301-000x5P0331K |
| C532 | 290-0523-00 |  | CAP. ,FXD, ELCTLT: 2.2UF, 20\%,20V | 56289 | 196D225X0025HAl |
| C535 | 281-0513-00 |  | CAP. ,FXD, CER DI: $27 \mathrm{PF},+/-5.4 \mathrm{PF}, 500 \mathrm{~V}$ | 72982 | 301-000P2G0270M |
| C537 | 290-0534-00 |  | CAP.,FXD,ELCTLT: $1 \mathrm{UF}, 20 \%, 35 \mathrm{~V}$ | 56289 | 196D105X0035HAl |
| C538 | 283-0003-00 |  | CAP., FXD, CER DI:0.01UF, +80-20\%, 150V | 72982 | 855-547E103Z |
| C539 | 283-0060-00 |  | CAP. ,FXD, CER DI: $100 \mathrm{PF}, 5 \%, 200 \mathrm{~V}$ | 72982 | 855-535U2J101J |
| $\begin{aligned} & \mathrm{C} 545 \\ & \text { C550 } \end{aligned}$ | 290-0527-00 |  | CAP. FXD, ELCTLT:15UF, $20 \%, 20 \mathrm{~V}$ | 90201 | TDCl56M020FL |
| $\left.\begin{array}{l} \mathrm{C} 551 \\ \mathrm{C} 552 \end{array}\right] 1$ | 295-0143-00 |  | CAP., SET, MTCHD: 10UF, 0.1UF,0.001UF | 80009 | 295-0143-00 |
| C554 | 283-0631-00 |  | CAP.,FXD,MICA D:95PF,1\%,100V | 00853 | D151E950F0 |
| C555 | 281-0207-00 |  | CAP., VAR, PLSTC:2-18PF,100V | 80031 | HTl0EA-218 |
| C565 | 283-0000-00 |  | CAP.,FXD, CER DI: $0.001 \mathrm{UF},+100-0 \%, 500 \mathrm{~V}$ | 72982 | 831-516E102P |
| C566 | 281-0523-00 |  | CAP.,FXD, CER DI:100PF, + /-20PF, 350V | 72982 | 301-000U2MO101M |

${ }^{1}$ Individual timing capacitors in this assembly must be ordered by the 9 -digit part number, letter suffix and tolerance printed on the timing capacitors to be replaced. The letter suffix and the tolerance should be the same for all of the timing capacitors in this assembly.

EXAMPLE:
285-XXXX-XX F-

Electrical Parts List-5B31.


| Ckt No. | Tektronix Part No. | Serial/Model No. Eff Dscont | Name \& Description | Mfr Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| LR230 | 108-0245-00 |  | COIL, RF: 3.90 H | 80009 | 108-0245-00 |
| LR237 | 108-0245-00 |  | COIL, RF:3.9UH | 80009 | 108-0245-00 |
| LR270 | 108-0245-00 |  | COIL, RF: 3.9UH | 80009 | 108-0245-00 |
| LR280 | 108-0245-00 |  | COIL, RF:3.9UH | 80009 | 108-0245-00 |
| LR370 | 108-0245-00 |  | COIL, RF: 3.9UH | 80009 | 108-0245-00 |
| LR425 | 108-0245-00 |  | COIL, RF: 3.9UH | 80009 | 108-0245-00 |
| LR470 | 108-0245-00 |  | COIL, RF: 3.9 UH | 80009 | 108-0245-00 |
| LR485 | 108-0245-00 |  | COIL, RF: 3.9UH | 80009 | 108-0245-00 |
| LR545 | 108-0245-00 |  | COIL, RF:3.9UH | 80009 | 108-0245-00 |
| 2100 | 151-0190-00 |  | TRANSISTOR:SILICON, NPN | 04713 | 2N3904 |
| 2110 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 04713 | 2N3904 |
| Q165 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 04713 | 2N3904 |
| Q175 | 151-0188-00 |  | TRANSISTOR:SILICON, PNP | 04713 | 2N3906 |
| Q180 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 04713 | 2N3904 |
| Q215 | 151-1042-00 |  | SEMICOND DVC SE:MATCHED PAIR FET | 80009 | 151-1042-00 |
| Q220 | 151-1042-00 |  | SEMICOND DVC SE:MATCHED PAIR FET | 80009 | 151-1042-00 |
| Q225 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 04713 | 2N3904 |
| Q235 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 04713 | 2N3904 |
| Q290 | 151-0188-00 |  | TRANSISTOR:SILICON, PNP | 04713 | 2N3906 |
| Q300 | 151-0220-00 |  | TRANSISTOR:SILICON, PNP | 80009 | 151-0220-00 |
| Q302 | 151-0289-00 |  | TRANSISTOR:SILICON, PNP | 04713 | SS106 |
| Q310 | 151-0283-00 |  | TRANSISTOR:SIIICON,NPN | 07263 | S032790 |
| Q320A, B | 151-1044-00 |  | TRANSISTOR:SILICON,JFE,N CHAN. | 15818 | 2N3955 |
| Q350 | 151-0220-00 |  | TRANSISTOR:SILICON, PNP | 80009 | 151-0220-00 |
| Q360 | 151-0341-00 |  | TRANSISTOR:SILICON,NPN | 07263 | 2N3565 |
| Q365 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 04713 | 2N3904 |
| 2370 | 151-0190-00 |  | TRANSISTOR:SILICON,NPN | 04713 | 2N3904 |
| Q380 | 151-0220-00 |  | TRANSISTOR:SIIICON, PNP | 80009 | 151-0220-00 |
| Q390 | 151-0220-00 |  | TRANSISTOR:SIIICON, PNP | 80009 | 151-0220-00 |
| Q400 | 151-0341-00 |  | TRANSISTOR:SILICON,NPN | 07263 | 2N3565 |
| 2410 | 151-0341-00 |  | TRANSISTOR:SILICON,NPN | 07263 | 2N3565 |
| Q415 | 151-0341-00 |  | TRANSISTOR:SILICON,NPN | 07263 | 2N3565 |
| Q465 | 151-0219-00 |  | TRANSISTOR:SILICON, PNP | 07263 | SS22650 |
| Q500 | 151-0188-00 |  | TRANSISTOR:SILICON, PNP | 04713 | 2N3906 |
| Q510 | 151-0190-00 |  | TRANSISTOR:SILICON, NPN | 04713 | 2N3904 |
| Q520 | 151-0188-00 |  | TRANSISTOR:SILICON, PNP | 04713 | 2N3906 |
| Q585 | 151-0341-00 |  | TRANSISTOR:SILICON,NPN | 07263 | 2N3565 |
| Q590 | 151-0342-00 |  | TRANSISTOR:SILICON, PNP | 07263 | 2N4249 |
| Q595 | 151-0341-00 |  | TRANSISTOR:SILICON,NPN | 07263 | 2N3565 |
| Q615 | 151-0188-00 |  | TRANSISTOR:SILICON, PNP | 04713 | 2N3906 |
| Q625 | 151-0188-00 |  | TRANSISTOR:SILICON, PNP | 04713 | 2N3906 |
| 2645 | 151-0188-00 |  | TRANSISTOR:SILICON, PNP | 04713 | 2N3906 |
| R100 | 315-0331-00 |  | RES. ,FXD, COMP:330 OHM,5\%,0.25W | 01121 | CB3315 |
| R102 | 315-0390-00 |  | RES. ,FXD, COMP : 39 OHM, 5\%, 0.25W | 01121 | CB3905 |
| R105 | 315-0512-00 |  | RES. ,FXD, COMP:5.1K OHM, 5\%,0.25W | 01121 | CB5125 |
| R107 | 315-0390-00 |  | RES. , FXD , COMP : 39 OHM, 5\%, 0.25 W | 01121 | CB3905 |
| R112 | 315-0301-00 |  | RES.,FXD, COMP : 300 OHM, 5\%, 0.25 W | 01121 | CB3015 |
| R115 | 315-0271-00 |  | RES. FXX , COMP: 270 OHM , 5\%,0.25W | 01121 | CB2715 |
| R120 | 315-0331-00 |  | RES. ,FXD, COMP:330 OHM, 5\%,0.25W | 01121 | CB3315 |
| R122 | 321-0159-00 |  | RES. FXX, FILM: 442 OHM, $18,0.125 \mathrm{~W}$ | 75042 | CEATO-4420F |
| R124 | 321-0300-00 |  | RES.,FXD,FILM: 13K OHM, 1\%,0.125W | 75042 | CEATO-1302F |
| R125 1 | 311-1192-00 |  | RES., VAR, NONWIR:10K OHM, 20\%,1W | 71590 | 381-CM39695 |

[^0]| Ckt No. | Tektronix Part No. | Serial/Model No. Eff Dscont | Name \& Description | Mfr Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| R132 | 315-0102-00 |  | RES., FXD,COMP:1K OHM, 5\%,0.25W | 01121 | CB1025 |
| R134 | 315-0470-00 |  | RES., FXD, COMP:47 ОHM, 5\%,0.25W | 01121 | CB4705 |
| R136 | 315-0331-00 |  | RES. , FXD , COMP:330 ОHM, 5\%, 0.25 W | 01121 | CB3315 |
| R138 | 315-0222-00 |  | RES., FXD, COMP:2.2K OHM,5\%,0.25W | 01121 | CB2225 |
| R140 | 315-0102-00 |  | RES., FXD, COMP : 1 K OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB1025 |
| R150 | 315-0102-00 |  | RES. ,FXD,COMP:1K OHM , 5\%,0.25W | 01121 | CB1025 |
| R152 | 315-0222-00 |  | RES.,FXD, COMP:2.2K OHM,5\%,0.25W | 01121 | CB2225 |
| R155 | 315-0182-00 |  | RES.,FXD, COMP:1.8K OHM,5\%,0.25W | 01121 | CB1825 |
| R156 | 315-0182-00 |  | RES., FXD, COMP:1.8K OHM,5\%,0.25W | 01121 | CB1825 |
| R158 | 315-0203-00 |  | RES. , FXD, COMP : 20 K OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB2035 |
| R165 | 321-0078-00 |  | RES., FXD,FILM:63.4 OHM, 18,0.125W | 75042 | Ceato-63R40F |
| R168 | 315-0301-00 |  | RES., FXD, COMP: 300 OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB3015 |
| R170 | 315-0101-00 |  | RES., FXD, COMP:100 ОНm, 5\%,0.25W | 01121 | CBl015 |
| R180 | 315-0101-00 |  | RES. , FXD, СОMP: 100 ОНM, 5\%, 0.25 W | 01121 | CB1015 |
| R185 | 315-0332-00 |  | RES., FXD,COMP:3.3K OHM,5\%,0.25W | 01121 | CB3325 |
| R186 | 315-0101-00 |  | RES. ,FXD, COMP:100 OHM, 58, 0.25 W | 01121 | CB1015 |
| R190 | 321-0078-00 |  | RES. ,FXD,FILM: 63.4 OHM, 18, 0.125 W | 75042 | Ceato-63R40F |
| R192 | 315-0563-00 |  | RES., FXD, COMP:56K OHM,5\%,0.25W | 01121 | CB5635 |
| R193 | 315-0103-00 |  | RES., FXD, COMP:10K OHM, 5\%,0.25W | 01121 | CB1035 |
| R200 | 322-0464-00 |  | RES.,FXD,FILM:665K OHM, 1\%,0.25W | 75042 | CEBT0-6653F |
| R210 | 321-0435-00 |  | RES.,FXD,FILM:332K OHM, 18, 0.125 W | 75042 | CEAT0-3323F |
| R212 | 315-0101-00 |  | RES., FXD, COMP:100 ОНM, 5\%,0.25W | 01121 | CB1015 |
| R215 | 315-0220-00 |  | RES., FXD, COMP: 22 OHM, 5\%,0.25W | 01121 | CB2205 |
| R217 | 315-0153-00 |  | RES., FXD, COMP:15K OHM, 5\%,0.25W | 01121 | CB1535 |
| R220 | 311-1568-00 |  | RES., VAR, NONWIR:50 OHM, 20\%,0.50W | 73138 | 91A50R00m |
| R222 | 315-0101-00 |  | RES., FXD, COMP:100 ОHM, 5\%, 0.25W | 01121 | CB1015 |
| R225 | 315-0101-00 |  | RES. , FXD, COMP : 100 OHM, 5\%,0.25W | 01121 | CB1015 |
| R227 | 315-0220-00 |  | RES. , FXD , COMP : 22 OHM , 5\%,0.25W | 01121 | CB2205 |
| R229 | 315-0101-00 |  | RES. , FXD , COMP: 100 OHM, 5\%, 0.25W | 01121 | CB1015 |
| R230 | 315-0201-00 |  | RES., FXD, COMP:200 OHM, 5\%, 0.25W | 01121 | CB2015 |
| R232 | 315-0101-00 |  | RES. , FXD, COMP:100 OHM, 5\%,0.25W | 01121 | CB1015 |
| R235 | 315-0220-00 |  | RES. , FXD, COMP: 22 OHM, 5\%,0.25W | 01121 | CB2205 |
| R237 | 315-0302-00 |  | RES. , FXD, COMP : 3 K OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB3025 |
| R240 | 315-0101-00 |  | RES. , FXD, COMP: 100 OHM, 5\%, 0.25 W | 01121 | CB1015 |
| R242 | 321-0175-00 |  | RES., FXD, FILM:649 OHM, 1\%,0.125W | 75042 | CEATO-6490F |
|  | 321-0300-00 |  | RES.,FXD,FILM:13K OHM,1\%,0.125W |  | CEATO-1302F |
| R245 | 311-1192-00 ${ }^{1}$ |  | RES., VAR,NONWIR:10K OHM, 20\%,1W | 71590 | 381-CM39695 |
| R250 | 315-0362-00 |  | RES., FXD, COMP:3.6K OHM,5\%,0.25W | 01121 | CB3625 |
| R252 | 315-0102-00 |  | RES. .FXD, COMP:1K OHM, 5\%,0.25W | 01121 | CB1025 |
| R254 | 315-0182-00 |  | RES., FXD, COMP:1.8K OHM, 58,0.25W | 01121 | CB1825 |
| R260 | 315-0470-00 |  | RES. , FXD, COMP:47 ОHM, 5\%, 0.25 W | 01121 | CB4705 |
| R262 | 315-0470-00 |  | RES., FXD, COMP : 47 OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB4705 |
| R270 | 315-0102-00 |  | RES. FTXD, COMP : 1 K OHM $, 5 \%, 0.25 \mathrm{~W}$ | 01121 | CB1025 |
| R272 | 315-0822-00 |  | RES., FXD, COMP:8.2K OHM 58.0 .25 W | 01121 | CB8225 |
| R280 | 315-0102-00 |  | RES. ,FXD, COMP : 1 K OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB1025 |
| R282 | 315-0102-00 |  | RES. ,FXD,COMP: 1 K OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB1025 |
| R285 | 315-0332-00 |  | RES. ,FXD, COMP: 3.3 K OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB3325 |
| R287 | 315-0102-00 |  | RES., FXD, COMP: 1 K OHM,5\%,0.25 | 01121 | CB1025 |
| R290 | 315-0392-00 |  | RES., FXD, COMP:3.9K OHM, 5\%, 0.25 W | 01121 | CB3925 |
| R292 | 315-0151-00 |  | RES. , FXD, COMP: 150 OHM, 5\%,0.25W | 01121 | CB1515 |
| R294 | 315-0332-00 |  | RES.,FXD, COMP:3.3K OHM, 5\%,0.25W | 01121 | CB3325 |
| R296 | 315-0102-00 |  | RES., FXD, COMP: 1 K OHM, 58,0.25 | 01121 | CB1025 |
| R298 | 315-0102-00 |  | RES.,FXD,COMP:1K ОНM,5\%,0.25W | 01121 | CB1025 |

$\mathrm{I}_{\text {Furnished }}$ as a unit with S 245 .

| Ckt No. | Tektronix <br> Part No. | Serial/Model No. Eff <br> Dscont | Name \& Description | Mfr Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| R300 | 315-0432-00 |  | RES. , FXD, COMP: 4.3 K OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB4325 |
| R301 | 315-0102-00 |  | RES.,FXD, COMP:1K OHM, 5\%,0.25W | 01121 | CB1025 |
| R310 | 315-0273-00 |  | RES.,FXD,COMP:27K OHM, 5\%,0.25W | 01121 | CB2735 |
| R3I1 | 315-0272-00 |  | RES., FXD, COMP:2.7K OHM, 5\%,0.25W | 01121 | CB2725 |
| R320 | 315-0511-00 |  | RES.,FXD, COMP:510 OHM, 5\%,0.25W | 01121 | CB5115 |
| R322 | 315-0511-00 |  | RES., FXD, COMP:510 OHM, 5\%,0.25W | 01121 | CB5115 |
| R324 | 315-0182-00 |  | RES. ,FXD, COMP : 1.8 K OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB1825 |
| R325 | 311-1563-00 |  | RES.,VAR,NONWIR:1K OHM, 20\%,0.50W | 73138 | 91A-10000M |
| R326 | 315-0182-00 |  | RES.,FXD, COMP:1.8K OHM,5\%,0.25W | 01121 | CB1825 |
| R330 | 315-0153-00 |  | RES. ,FXD, COMP: 15 K OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB1535 |
| R336 | 315-0393-00 |  | RES.,FXD, COMP : 39 K OHM, 5\%,0.25W | 01121 | CB3935 |
| R340 | 315-0332-00 |  | RES., FXD, COMP : 3.3 K OHM, 5\%, 0.25 W | 01121 | CB3325 |
| R345 | 315-0471-00 |  | RES., FXD, COMP : 470 OHM, 5\%,0.25W | 01121 | CB4715 |
| R346 | 315-0131-00 |  | RES.,FXD, COMP: 130 OHM, 5\%,0.25W | 01121 | CB1315 |
| R347 | 315-0681-00 |  | RES.,FXD,COMP :680 OHM, 5\% , 0.25W | 01121 | CB6815 |
| R350 | 315-0102-00 |  | RES., FXD, COMP:1K OHM, 5\%, 0.25W | 01121 | CB1025 |
| R352 | 315-0222-00 |  | RES.,FXD, COMP : 2.2 K OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB2225 |
| R355 | 315-0132-00 |  | RES.,FXD, COMP:1.3K OHM, 5\%,0.25W | 01121 | CB1325 |
| R356 | 315-0271-00 |  | RES.,FXD, COMP:270 OHM, 5\%,0.25W | 01121 | CB2715 |
| R358 | 315-0751-00 |  | RES. ,FXD, COMP : 750 OHM, 5\%,0.25W | 01121 | CB7515 |
| R360 | 315-0222-00 |  | RES.,FXD, COMP : 2.2 K OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB2225 |
| R364 | 315-0222-00 |  | RES.,FXD, COMP : 2.2 K OHM, 5\%,0.25W | 01121 | CB2225 |
| R366 | 315-0222-00 |  | RES.,FXD,COMP:2.2K OHM,5\%,0.25W | 01121 | CB2225 |
| R370 | 315-0180-00 |  | RES.,FXD, COMP:18 OHM, 5\% ,0.25W | 01121 | CB1805 |
| R372 | 315-0822-00 |  | RES. ,FXD, COMP:8.2K OHM,5\%,0.25W | 01121 | CB8225 |
| R380 | 315-0301-00 |  | RES. ,FXD, COMP: 300 OHM, 5\%, 0.25W | 01121 | CB3015 |
| R382 | 315-0201-00 |  | RES. ,FXD, COMP: 200 OHM, 5\%,0.25W | 01121 | CB2015 |
| R385 | 315-0681-00 |  | RES., FXD, COMP:680 OHM,5\%,0.25W | 01121 | CB6815 |
| R387 | 315-0272-00 |  | RES.,FXD,COMP:2.7K OHM,5\%,0.25W | 01121 | CB2725 |
| R390 | 315-0102-00 |  | RES. ,FXD, COMP: 1 K OHM,5\%,0.25W | 01121 | CB1025 |
| R392 | 315-0223-00 |  | RES. ,FXD, COMP : 22 K OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB2235 |
| R394 | 315-0102-00 |  | RES., FXD, COMP : 1 K OHM, 5\%,0.25W | 01121 | CB1025 |
| R400 | 315-0472-00 |  | RES., FXD, COMP:4.7K OHM,5\%,0.25W | 01121 | CB4725 |
| R401 | 315-0683-00 |  | RES.,FXD, COMP : 68 K OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB6835 |
| R403 | 315-0102-00 |  | RES. ,FXD, COMP: 1 K OHM, 5\%,0.25W | 01121 | CB1025 |
| R405 | 315-0202-00 |  | RES., FXD, COMP: 2 K OHM, 5\%,0.25W | 01121 | CB2025 |
| R408 | 315-0682-00 |  | RES. ,FXD, COMP:6.8K OHM, 5\%,0.25W | 01121 | CB6825 |
| R410 | 315-0681-00 |  | RES., FXD, COMP:680 OHM, 5\%,0.25W | 01121 | CB6815 |
| R412 | 315-0102-00 |  | RES.,FXD, COMP:1K OHM,5\%,0.25W | 01121 | CB1025 |
| R413 | 315-0472-00 |  | RES., FXD, COMP:4.7K OHM, 5\%,0.25W | 01121 | CB4725 |
| R415 | 315-0472-00 |  | RES. ,FXD, COMP: 4.7 K OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB4725 |
| R418 | 315-0822-00 |  | RES., FXD, COMP:8.2K OHM,5\%,0.25W | 01121 | CB8225 |
| R430 | 315-0103-00 |  | RES., FXD, COMP:10K OHM,5\%,0.25W | 01121 | CB1035 |
| R431 | 315-0103-00 |  | RES.,FXD, COMP:10K OHM, 5\% , 0.25 W | 01121 | CB1035 |
| R432 | 315-0103-00 |  | RES.,FXD, COMP:10K OHM, 5\%, 0.25 W | 01121 | CB1035 |
| R433 | 315-0103-00 |  | RES. ,FXD, COMP : 10 K OHM, 5\%, 0.25W | 01121 | CB1035 |
| R435 | 315-0103-00 |  | RES.,FXD, COMP:10K OHM, 5\%,0.25W | 01121 | CB1035 |
| R436 | 315-0103-00 |  | RES.,FXD, COMP:10K OHM, 5\%,0.25W | 01121 | CB1035 |
| R437 | 315-0103-00 |  | RES., FXD, COMP: 10 K OHM, 5\%, 0.25 W | 01121 | CB1035 |
| R438 | 315-0103-00 |  | RES. ,FXD, COMP : 10 K OHM, 5\%, 0.25 W | 01121 | CB1035 |
| R440 | 315-0103-00 |  | RES. ,FXD, COMP:IOK OHM, 5\%, 0.25 W | 01121 | CB1035 |
| R441 | 315-0103-00 |  | RES., EXD, COMP:10K OHM, 5\%,0.25W | 01121 | CB1035 |
| R442 | 315-0103-00 |  | RES. FXX, COMP:10K OHM, 5\%,0.25W | 01121 | CB1035 |


| Ckt No. | Tektronix Part No. | Serial/Model No. Eff Dscont | Name \& Description | Mfr <br> Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| R443 | 315-0103-00 |  | RES.,FXD, COMP:10K OHM, 5\%,0.25W | 01121 | CB1035 |
| R445 | 315-0103-00 |  | RES. FXX, COMP: 10 K OHM,5\%,0.25W | 01121 | CB1035 |
| R446 | 315-0103-00 |  | RES. ,FXD, COMP:10K OHM, 5\%,0.25W | 01121 | CB1035 |
| R447 | 315-0103-00 |  | RES. ,FXD, COMP:10K OHM,5\%,0.25W | 01121 | CB1035 |
| R448 | 315-0103-00 |  | RES. ,FXD, COMP:10K OHM, 5\%,0.25W | 01121 | CB1035 |
| R450 | 315-0103-00 |  | RES. ,FXD, COMP: 10 K OHM, 5\%, 0.25W | 01121 | CB1035 |
| R451 | 315-0103-00 |  | RES. ,FXD, COMP:10K OHM, 5\%,0.25W | 01121 | CB1035 |
| R452 | 315-0103-00 |  | RES.,FXD, COMP:10K OHM,5\%,0.25W | 01121 | CB1035 |
| R453 | 315-0103-00 |  | RES. , FXD, COMP: 10 K OHM, 5\%,0.25W | 01121 | CB1035 |
| R464 | 315-0472-00 |  | RES.,FXD,COMP:4.7K OHM,5\%,0.25W | 01121 | CB4725 |
| R465 | 315-0302-00 |  | RES., FXD, COMP:3K OHM, 5\%,0.25W | 01121 | CB3025 |
| R468 | 315-0182-00 |  | RES. ,FXD,COMP:1.8K OHM, 5\%,0.25W | 01121 | CB1825 |
| R470 | 315-0242-00 |  | RES. , FXD, COMP $: 2.4 \mathrm{~K}$ OHM, $5 \%, 0.25 \mathrm{~W}$ | 01121 | CB2425 |
| R472 | 315-0511-00 |  | RES., FXD, COMP:510 OHM, 5\%, 0.25W | 01121 | CB5115 |
| R473 | 315-0182-00 |  | RES. ,FXD, COMP:1.8K OHM, 5\%,0.25W | 01121 | CB1825 |
| R475 | 315-0102-00 |  | RES. ,FXD, COMP: 1 K OHM,5\%,0.25W | 01121 | CB1025 |
| R477 | 315-0102-00 |  | RES., FXD, COMP:1K OHM,5\%,0.25W | 01121 | CB1025 |
| R487 | 321-0207-00 |  | RES. ,FXD,FILM:1.4K OHM, 1\%,0.125W | 75042 | CEAT0-1401F |
| R489 | 321-0253-00 |  | RES. FXX, FILM:4.22K OHM, 1\%,0.125W | 75042 | CEATO-4221F |
| R490 | 315-0102-00 |  | RES. FXD, COMP:1K OHM, 5\%,0.25W | 01121 | CB1025 |
| R493 | 315-0180-00 |  | RES. ,FXD, COMP: 18 OHM, 5\%,0.25W | 01121 | CB1805 |
| R495 | 315-0472-00 |  | RES., FXD, COMP:4.7K OHM,5\%,0.25W | 01121 | CB4725 |
| R497 | 321-0193-00 |  | RES.,FXD,FILM:1K OHM, 1\%,0.125W | 75042 | CEATO-1001F |
| R498 | 321-0253-00 |  | RES., FXD, FILM 4.22 K OHM, $1 \%$, 0.125 W | 75042 | CEATO-4221F |
| R500 | 315-0102-00 |  | RES., FXD, COMP: 1 K OHM, 5\%,0.25W | 01121 | CB1025 |
| R502 | 315-0102-00 |  | RES. ,FXD, COMP: 1 K OHM, 5\%,0.25W | 01121 | CB1025 |
| R505 | 315-0682-00 |  | RES. ,FXD, COMP:6.8K OHM,5\%,0.25W | 01121 | CB6825 |
| R506 | 315-0242-00 |  | RES. ,FXD, COMP : 2.4 K OHM, 5\%,0.25W | 01121 | CB2425 |
| R510 | 315-0751-00 |  | RES. ,FXD, COMP: 750 OHM, 5\%, 0.25 W | 01121 | CB7515 |
| R511 | 315-0271-00 |  | RES. ,FXD, COMP:270 OHM, 5\%, 0.25W | 01121 | CB2715 |
| R512 | 315-0152-00 |  | RES. ,FXD, COMP: 1.5 K OHM, 5\%, 0.25W | 01121 | CB1525 |
| R514 | 315-0202-00 |  | RES. , FXD, COMP : 2 K OHM, 5\%,0.25W | 01121 | CB2025 |
| R518 | 315-0152-00 |  | RES. ,FXD, COMP: 1.5 K OHM, 5\%,0.25 W | 01121 | CB1525 |
| R520 | 315-0562-00 |  | RES. ,FXD, COMP:5.6K OHM,5\%,0.25W | 01121 | CB5625 |
| R525 | 301-0391-00 |  | RES. , FXD, COMP : 390 OHM, 5\%, 0.50W | 01121 | EB3915 |
| R527 | 315-0681-00 |  | RES. ,FXD, COMP:680 OHM,5\%,0.25W | 01121 | CB6815 |
| R529 | 315-0131-00 |  | RES. ,FXD, COMP : 130 OHM, 5\%,0.25W | 01121 | CB1315 |
| R530 | 315-0471-00 |  | RES. ,FXD, COMP : 470 OHM, 5\%, 0.25 W | 01121 | CB4715 |
| R532 | 315-0334-00 |  | RES. ,FXD, COMP : 330 K OHM, 5\%,0.25W | 01121 | CB3 345 |
| R539 | 315-0154-00 |  | RES.,FXD, COMP:150K OHM, 5\%,0.25W | 01121 | CB1545 |
| R542 | 315-0332-00 |  | RES. ,FXD, COMP:3.3K OHM, 5\%,0.25W | 01121 | CB3325 |
| R544 | 315-0682-00 |  | RES. ,FXD, COMP : 6.8 K OHM, 5\%,0.25W | 01121 | CB6825 |
| R547 | 315-0473-00 |  | RES., FXD, COMP: 47 K OHM, 5\%,0.25W | 01121 | CB4735 |
| R548 | 315-0102-00 |  | RES. ,FXD, COMP:1K OHM, 5\%,0.25W | 01121 | CB1025 |
| R550 | 323-0498-03 |  | RES. ,FXD,FILM:1.5M OHM, 25\%, 0.5W | 80031 | MF7CCl. 5MC |
| R551 | 323-0498-03 |  | RES.,FXD,FILM:1.5M OHM, 25\%,0.5W | 80031 | MF7CCl.5MC |
| R552 | 321-0917-03 |  | RES. ,FXD,FILM: 27.2 K OHM, $0.25 \%, 0.125 \mathrm{~W}$ | 75042 | CEAT227.2KC |
| R553 | 321-0856-03 |  | RES. ,FXD,FILM:333K OHM, 0.25\%,0.125W | 75042 | CEAT2330KC |
| R554 | 321-0200-00 |  | RES.,FXD,FILM:1.18K OHM, $28,0.125 \mathrm{~W}$ | 75042 | CEATO-1181F |
| R555 | 321-0230-00 |  | RES.,FXD,FILM:2.43K OHM, 18,0.125W | 75042 | CEATO-2431F |
| R556 | 321-0827-03 |  | RES.,FXD,FILM:3.61K OHM, 0.25\%,0.125W | 75042 | CEAT-2401C |
| R557 | 321-0268-03 |  | RES.,FXD,FILM $: 6.04 \mathrm{~K}$ OHM, $0.25 \%, 0.125 \mathrm{~W}$ | 75042 | CEATO-6041C |
| R558 | 321-0234-00 |  | RES.,FXD,FILM:2.67K OHM, 1\%,0.125W | 75042 | CEATO-2671F |


| Ckt No. | Tektronix Part No. | Serial/Model No. Eff Dscont | Name \& Description | Mfr <br> Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{R}^{5} 591$ | 315-0124-00 |  | RES. , FXD, COMP : 120 K OHM, 5\%, 0.25 W | 01121 | CB1245 |
| R560 | 311-1426-00 |  | RES.,VAR,NONWIR:PNL, 20K OHM, O. 5W,W/SW | 01121 | GS-831 |
| R561 | 321-0289-00 |  | RES.,FXD,FILM:1OK OHM,1\%,0.125 | 75042 | CEAT0-1002F |
| R562 | 321-0164-00 |  | RES. ,FXD,FILM:499 OHM, 1\%,0.125W | 75042 | CEATO-4990F |
| R565 | 321-0358-00 |  | RES.,FXD,FILM:52.3K OHM, 1\%,0.125W | 75042 | CEAT0-5232F |
| R566 | 321-0385-00 |  | RES.,FXD,FILM: 100 K OHM, 1\%,0.125W | 75042 | CEATO-1003F |
| R569 | 315-0101-00 |  | RES.,FXD, COMP:100 OHM, 5\%,0.25W | 01121 | CB1015 |
| R570 | 315-0621-00 |  | RES. ,FXD, COMP:620 OHM, 5\%,0.25W | 01121 | CB6215 |
| R580 | 315-0223-00 |  | RES.,FXD, COMP : 22 K OHM, 5\%, 0.25 W | 01121 | CB2235 |
| R582 | 315-0621-00 |  | RES.,FXD, COMP:620 OHM, 5\%, 0.25 W | 01121 | CB6215 |
| R584 | 315-0472-00 |  | RES., FXD, COMP $=4.7 \mathrm{~K}$ OHM, $58,0.25 \mathrm{~W}$ | 01121 | CB4725 |
| R587 | 315-0911-00 |  | RES.,FXD, COMP:910 OHM, 5\%,0.25W | 01121 | CB9115 |
| R590 | 315-0221-00 |  | RES. ,FXD, COMP : 220 OHM, 5\%, 0.25 W | 01121 | CB2215 |
| R592 | 315-0121-00 |  | RES. ,FXD, COMP: 120 OHM, 5\%, 0.25W | 01121 | CB1215 |
| R594 | 321-0208-00 |  | RES.,FXD,FILM:1.43K OHM, 1\%,0.125W | 75042 | CEATO-1431F |
| R596 | 321-0172-00 |  | RES.,FXD,FILM:604 OHM, 18,0.125W | 75042 | CEATO-6040F |
| R600 | 311-1566-00 |  | RES., VAR,NONWIR:200 OHM, 20\%, 0.50 W | 73138 | 91A-200R0M |
| R602 | 315-0472-00 |  | RES., FXD, COMP:4.7K OHM, 5\%,0.25W | 01121 | CB4725 |
| R604 | 321-0338-00 |  | RES.,FXD,FILM:32.4K OHM, 1\%,0.125W | 75042 | CEATO-3242F |
| R605 | 311-0310-01 |  | RES., VAR, NONWIR:PNL, 5 K OHM, 0.5W | 01121 | W-7350B |
| R610 | 321-0261-00 |  | RES.,FXD,FILM:5.11K OHM, 1\%,0.125W | 75042 | CEATO-51l1F |
| R612 | 321-0172-00 |  | RES.,FXD,FILM:604 OHM, 1\%,0.125W | 75042 | CEATO-6040F |
| R614 | 321-0257-00 |  | RES.,FXD,FILM:4.64K OHM, 1\%,0.125W | 75042 | CEAT0-4641F |
| R615 | 321-0217-00 |  | RES.,FXD,FILM:1.78K OHM,1\%,0.125W | 75042 | CEATO-1781F |
| R617 | 321-0259-00 |  | RES.,FXD,FILM:4.87K OHM,1\%,0.125W | 12697 | MFF1816G48700F |
| R619 | 321-0098-00 |  | RES.,FXD,FILM:102 OHM, 1\%,0.125W | 75042 | CEA1020 |
| R622 | 315-0101-00 |  | RES.,FXD, COMP: 100 OHM, 5\%, 0.25W | 01121 | CBl015 |
| R624 | 321-0229-00 |  | RES.,FXD,EILM:2.37K OHM, 1\%,0.125W | 75042 | CEATO-2371F |
| R627 | 321-0222-00 |  | RES.,FXD,FILM:2K OHM, 1\%,0.125W | 75042 | CEATO-2001F |
| R629 | 321-0231-00 |  | RES.,FXD,FILM:2.49K OHM,1\%,0.125W | 75042 | CEATO-2491F |
| R630 | 311-1562-00 |  | RES.,VAR,NONWIR:2K OHM, 20\%,0.50W | 73138 | 91A-20000M |
| R633 | 321-0108-00 |  | RES.,FXD,FILM:130 OHM,1\%,0.125W | 75042 | CEATO-1300F |
| R635 | 311-1568-00 |  | RES., VAR, NONWIR:50 OHM, 20\%, 0.50 W | 73138 | 91A50R00M |
| R639 | 321-0222-00 |  | RES.,FXD,FILM:2K OHM, 1\%,0.125W | 75042 | CEATO-2001F |
| R642 | 321-0230-00 |  | RES.,FXD,FILM:2.43K OHM, 1\%,0.125W | 75042 | CEATO-2431F |
| R644 | 321-0302-00 |  | RES.,FXD,FILM:13.7K OHM, 1\%,0.125W | 75042 | CEATO-1372F |
| R645 | 321-0233-00 |  | RES.,FXD,FILM:2.61K OHM, 1\%,0.125W | 75042 | CEAT0-2611F |
| R647 | 321-0259-00 |  | RES.,FXD,FILM:4.87K OHM,18,0.125W | 12697 | MFF1816G48700F |
| R649 | 321-0098-00 |  | RES.,FXD,FILM:102 OHM, 1\%,0.125W | 75042 | CEA1020 |
| R700 | 315-0513-00 |  | RES.,FXD, COMP:51K OHM, 5\%,0.25W | 01121 | CB5135 |
| R701 | 315-0513-00 |  | RES.,FXD, COMP:51K OHM, 5\%,0.25W | 01121 | CB5135 |
| R702 | 315-0753-00 |  | RES.,FXD, COMP:75K OHM,5\%,0.25W | 01121 | CB7535 |
| R703 | 315-0154-00 |  | RES.,FXD,COMP:150K OHM, 5\%,0.25W | 01121 | CB1545 |
| R704 | 321-0344-00 |  | RES.,FXD,FILM:37.4K OHM, 18,0.125W | 75042 | CEATO-3742F |
| R705 | 315-0154-00 |  | RES.,FXD, COMP : 150 K OHM, 5\%,0.25W | 01121 | CB1545 |
| R706 | 315-0154-00 |  | RES., FXD, COMP : 150 K OHM, 5\%,0.25W | 01121 | CB1545 |
| R707 | 315-0753-00 |  | RES.,FXD, COMP:75K OHM,5\%,0.25W | 01121 | CB7535 |
| R708 | 315-0753-00 |  | RES., FXD, COMP:75K OHM, 5\%,0.25W | 01121 | CB7535 |
| R709 | 315-0753-00 |  | RES.,FXD, COMP:75K OHM, 5\%,0.25W | 01121 | CB7535 |
| R710 | 315-0133-00 |  | RES.,FXD, COMP: 13 K OHM, 5\%,0.25W | 01121 | CB1335 |
| R711 | 315-0154-00 |  | RES., FXD, COMP $: 150 \mathrm{~K}$ OHM, 5\%, 0.25W | 01121 | CB1545 |
| R712 | 315-0154-00 |  | RES., FXD, COMP : 150 K OHM, 5\%,0.25W | 01121 | CB1545 |
| R713 | 315-0154-00 |  | RES.,FXD, COMP:150K OHM, 5\%,0.25W | 01121 | CB1545 |
| ${ }^{\text {Furnishe }}$ | d as a unit | th s710. |  |  |  |

Tektronix Serial/Model No. Mfr

| Ckt No. | Tektronix Part No. | Serial/Model No. Eff Dscont | Name \& Description | Mfr Code | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| R714 | 321-0344-00 |  | RES. ,FXD,FILM: 37.4 K OHM, $18,0.125 \mathrm{~W}$ | 75042 | CEATO-3742F |
| R720 | 315-0913-00 |  | RES.,FXD,COMP:91K OHM, 5\%,0.25W | 01121 | CB9135 |
| S130 ${ }^{1}$ | 311-1192-00 |  | RES., VAR,NONWIR:10K OHM, 20\%,1W | 71590 | 381-CM39695 |
| S145 | 260-1724-00 |  | SWITCH, PUSH: DELAY | 80009 | 260-1724-00 |
| S180 | 260-1725-00 |  | SWITCH, PUSH:TRIGGER | 80009 | 260-1725-00 |
| S245 ${ }^{2}$ | 311-1192-00 |  | RES., VAR,NONWIR:10K OHM, 20\%,1W | 71590 | 381-CM39695 |
| S450 | 260-1650-00 |  | SWITCH, ROTARY: | 07126 | 23-5-1 |
| 5485 | 260-1723-00 |  | SWITCH, PUSH:SWEEP CONTROL | 80009 | 260-1723-00 |
| S545 | 263-1102-00 |  | ACTR ASSY,CAM S:FRONT,TIME/DIV | 80009 | 263-1102-00 |
| S635 | 260-1209-00 |  | SWITCH, PUSH: 4PDT | 71590 | 2KAB001000-358 |
| $5710^{3}$ | 311-1426-00 |  | RES., VAR,NONWIR:PNL, 20K OHM, $0.5 \mathrm{~W}, \mathrm{~W} / \mathrm{SW}$ | 01121 | GS-831 |
| S725 | 260-1211-00 |  | SWITCH, PUSH :DPDT, PUSH-PUSH | 71590 | 2KAB010000-357 |
| U130 | 156-0295-00 |  | MICROCIRCUIT,DI:MECL 1OK OHM,TRIPLE 2-INPUT | 04713 | MC10107L |
| U145 | 156-0205-00 |  | MICROCIRCUIT, DI :QUAD 2-INPUT NOR GATE | 04713 | MC10102L |
| U245 | 155-0109-00 |  | MICROCIRCUIT,LI:MONOHTNIC,TRIG,M-120 | 80009 | 155-0109-00 |
| U270 | 156-0205-00 |  | MICROCIRCUIT, DI:QUAD 2-INPUT NOR GATE | 04713 | MC10102L |
| U280 | 156-0230-00 |  | MICROCIRCUIT,DI:DUAL D MA-SLAVE FLIP-FLOP | 04713 | MC10131L |
| U330 | 156-0013-00 |  | MICROCIRCUIT, DI: DIFF COMPARATOR | 07263 | U5B7710393 |
| U430 | 156-0097-00 |  | MICROCIRCUIT,DI:DIV BY 2 AND 5 RIPPLE CNTR | 18324 | M8290A |
| U435 | 156-0091-00 |  | MICROCIRCUIT,DI:DIV BY 2 AND 5 RIPPLE CNTR | 18324 | N8292A |
| U440 | 156-0091-00 |  | MICROCIRCUIT,DI:DIV BY 2 AND 5 RIPPLE CNTR | 18324 | N8292A |
| U445 | 156-0091-00 |  | MICROCIRCUIT,DI:DIV BY 2 AND 5 RIPPLE CNTR | 18324 | N8292A |
| U450 | 156-0091-00 |  | MICROCIRCUIT,DI:DIV BY 2 AND 5 RIPPLE CNTR | 18324 | N8292A |
| U455 | 156-0035-00 |  | MICROCIRCUIT, DI:SGL 8-INPUT POS NAND GATE | 01295 | SN7430N |
| U460 | 156-0047-00 |  | MICROCIRCUIT,DI:3-INPUT NAND GATE | 01295 | SN7410N |
| U470 | 156-0205-00 |  | MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE | 04713 | MC10102L |
| U485 | 155-0049-01 |  | MICROCIRCUIT,DI:MONOLITHIC,SWEEP CONTROL | 80009 | 155-0049-01 |
| U545 | 155-0042-03 |  | MICROCIRCUIT,LI:MILLER INT,DELAY AND PICKOFF | 80009 | 155-0042-03 |
| VR215 | 152-0278-00 |  | SEMICOND DEVICE:ZENER,400MA,3V,5\% | 07910 | 1N4372A |
| VR330 | 152-0217-00 |  | SEMICOND DEVICE:ZENER, $400 \mathrm{MW}, 8.2 \mathrm{~V}, 5 \%$ | 07910 | 1N756A |
| VR334 | 152-0278-00 |  | SEMICOND DEVICE:ZENER,400MA, 3V,5\% | 07910 | 1N4372A |
| VR340 | 152-0278-00 |  | SEMICOND DEVICE:ZENER,400MA, 3V,5\% | 07910 | 1N4372A |
| VR460 | 152-0278-00 |  | SEMICOND DEVICE:ZENER, 400MA , 3V,5\% | 07910 | 1N4372A |
| VR525 | 153-0059-00 |  | SEMICOND DEVICE,DI:4.75V,5\% AT 5MA | 80009 | 153-0059-00 |
| Y150 | 158-0079-00 |  | XTAL UNIT,QTZ:1 MHZ,+/-0.001\% | 80009 | 158-0079-00 |

[^1]
## Services Available

Tektronix, Inc. provides complete instrument repair and adjustment services at local Field Service Centers and and adjustment services at local Field Service Centers and
at the Factory Service Center. Contact your local Tektronix Field Office or representative for further information.

## Maintenance

Refer to 5400 Series Oscilloscope System mainframe instruction manual for general information

## NOTE

If it becomes necessary (for repair only) to remove the Trigger Circuit Board from its mountings to gain Boards, the instrument can be operated in a Normal Sweep mode by using a plastic Accessory Tool, PN 003-0742-00, to hold four switch contacts in their proper positions. These switch contacts are located on the under side of the Trigger Circuit Board. install the Accessory Tool so that three swid.

## Test Equipment and Accessories Required

For calibration and a complete accuracy check of the B31, the following equipment is required.
5400 Series Oscilloscope
ime Mark Generator; Tektronix TG 501 (Option 1), or equivalent.
Calibration Generator; Tektronix PG 506, or equivalent.
Dual-Trace Amplifier plug-in unit; Tektronix 5A38, or equivalent.
al cable with BNC connectors; Tektronix PN 012-0057-01
$50 \Omega$ feed-through termination; Tektronix PN 011-004901
Adapter, BNC Female to BSM Male; Tektronix PN 103-0036-00. Used only to connect DLY'D GATE OUTPUT to coaxial cable.

## Preparation

Remove both side covers from the 5B31 and the right side cabinet panel from the 5400 Series oscilloscope mainframe. Insert the 5B31 in the right hand plug-in plug-in compartment. The center plug-in compartment must be empty to allow access to left side of 5B31. Apply power and allow 30 minutes warmup time. Make ad justments at an ambient temperature between $+20^{\circ} \mathrm{C}$ and $+30^{\circ} \mathrm{C}\left(+68^{\circ} \mathrm{F}\right.$ and $+86^{\circ} \mathrm{F}$ ) for best accuracy

1. Adjust External Horizontal Balance (R220)

Set the SEC/DIV switch to 1 m and the thumb-wheels for a reading of 00000 . Push the AUTO TRIG and EXT buttons. All other buttons should be out and no input signal applied. Obtain a visible free-running trace and use the trace in the graticule area. Adjust the INTENSITY the trace in the graticule area. Adjust the INTENSITY
control on the display module for normal brightness. control on the display module for normal brightness. Adjust the 5B31 horizontal POSITION control so that the trace starts at the extreme left vertical graticule line. Set
the SEC/DIV switch to the AMPL position. Reduce the INTENSITY control, if necessary, to prevent burning the phosphor. Adjust R220, Bal, to horizontally position the dot at the exact center of the graticule area. R220 is located on the left side of the 5B31.

## 2. Adjust External Horizontal Gain (R600)

Apply a $0.5 \mathrm{~V}, 1 \mathrm{kHz}$ square-wave signal from the Calibration Generator through the coaxial cable to the divisions of horizontal deflection. R600 is located on the left side of the 5B31. Use the 5B31 POSITION control to position the dots to the extreme right and left vertical graticule lines while making this adjustment.

## 3. Adjust External Input Attenuator Compensation

 (C210)With signal applied as in step 2, use the 5B31 POSITION control to set the dots on the extreme left and right vertical graticule lines. Adjust C210, Atten Comp, undershoot (well-defined dots, no smearing). Disconnect the 1 kHz signal from the HORIZ AMPL connector.


## 4. Adjust 1 ms Timing (R630)

Apply 1 ms markers from the Time Mark Generator to the vertical amplifier unit. Set the 5B31 SEC/DIV switch to the 1 m position and push the LEFT triggering source button. Obtain a stable display by adjusting the MAIN TRIG LEVEL control. Vertical deflection of the markers should be at least one major division. Be certain that the CAL knob concentric with the SEC/DIV switch is rotated clockwise to its detent position. Adjust R630, Sweep, (right side of 5B31) for a spacing of one time mark per vertical graticule line (over the center 8 divisions).

## 5. Adjust Fast Sweep Timing (C555)

Set the SEC/DIV switch to the $.5 \mu$ position. Apply $0.5 \mu \mathrm{~s}$ markers to the vertical amplifier unit. Obtain a stable display. Adjust C555, Timing, (right side of 5B31) for one time mark per vertical graticule line. Check the $.2 \mu$ position of the SEC/DIV switch using the correct time markers, for accuracy within specifications. It may be necessary to return to the $.5 \mu$ position of the SEC/DIV switch and compromise the adjustment of C555 so that both sweep rates are within specifications.

## 6. Adjust Sweep Magnification (R635)

Change the SEC/DIV switch to the 1 m position. Apply 0.1 ms markers to the vertical amplifier unit. Obtain a stable display. POSITION the trace horizontally in the graticule area. Press the SWP MAG button. Adjust R635, Mag (right side of 5B31) for one time mark per vertical graticule line. Release the SWP MAG button.

## 7. Adjust Held Ramp (R325)

This step determines the Insertion Delay for the Delay by Time mode. Change the SEC/DIV switch to the $.2 \mu$ position and apply $1 \mu \mathrm{~s}$ markers from Time Mark Generator to the vertical amplifier unit. Obtain a stable display of three markers. POSITION the display horizontally within the graticule area. Push the SWP MAG button for a $20 \mathrm{~ns} /$ div sweep rate. Use the 5B31 POSITION control to align the $50 \%$ level on the leading edge of the single displayed marker (non-delayed pulse) with the eighth-division vertical reference line. Set the thumbwheel switches for $00001 \mu$ s delay. Press the $\mu$ s and DLY'D buttons. The delayed marker must shift to the left. Adjust

R325, Micro (right side of 5B31), so that the $50 \%$ level of the delayed marker is aligned with the second-division vertical reference line. Use the 5 B31 POSITION control to reset the $50 \%$ level of the delayed marker to the fifthdivision vertical reference line before proceeding to step 8.

## 8. Adjust 1 MHz Clock (C150)

This procedure determines the Differential Delay Accuracy. For Non-storage Display Modules a crt viewing hood may be needed for this step. For Storage Modules use the INTEGRATE function. Initial control settings for the 5B31 and time marks used depends on the final settings called out in step 7 . Set thumb-wheel switches for $10001 \mu$ s delay. Adjust C150, Osc Adj (left side of 5B31), so that the $50 \%$ level of the delayed marker is aligned with the fifth-division vertical reference line. Vary the left-most thumb-wheel digit from 1 through 9 (10001-90001). The delayed marker should not move from the fifth-division vertical reference line. If a shift is observed for any selected digit, readjust C 150 to return the delayed marker to the fifth-division vertical reference line. The final adjustment of C150 must result in no shift of the delayed marker from the fifth-division vertical reference line when the left-most thumb-wheel digit is varied over its complete range from 0 through 9 (00001-90001).

## 9. Check Delay Jitter

Reset thumb-wheels to 10001. Check for no more than 1 division of delayed pulse jitter. This completes the internal adjustment procedure for the 5B31. Disconnect all external equipment.

[^2]

| CKT. <br> NO. | $\begin{aligned} & \text { GRID } \\ & \text { LOC. } \end{aligned}$ | CKT. <br> NO. | $\begin{aligned} & \text { GRID } \\ & \text { LOC. } \end{aligned}$ | CKT. NO. | $\begin{aligned} & \text { GRID } \\ & \text { LOC. } \end{aligned}$ | CKT. NO. | $\begin{aligned} & \text { GRID } \\ & \text { IOC } \end{aligned}$ | CKT. NO. | $\begin{aligned} & \text { GRID } \\ & \text { LOC. } \end{aligned}$ | $\begin{aligned} & \text { CKT. } \\ & \text { NO. } \end{aligned}$ | $\begin{aligned} & \text { GRID } \\ & \text { LOC. } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| C270 | K6 | CR520 | E6 | R300 | L4 | R447 | E1 | R569 | C5 | U485 | G5 |
| C280 | J5 | CR527 | E5 | R301 | L4 | R448 | D1 | R570 | D5 | U545 | C5 |
| C315 | M4 | CR700 | B3 | R310 | K1 | R450 | C2 | R610 | E5 |  |  |
| C330 | K4 | CR702 | B3 | R311 | L5 | R451 | D2 | R612 | C5 |  |  |
| C334 | K4 | CR703 | B3 | R320 | L3 | R452 | D1 | R614 | C5 | VR330 | L3 |
| C370 | J4 | CR704 | B3 | R322 | L3 | R453 | C2 | R615 | B5 | VR334 | L4 |
| C400 | K3 | CR705 | B3 | R324 | L2 | R464 | E2 | R617 | B4 | VR340 | K4 |
| C403 | K3 | CR706 | B3 | R325 | K3 | R465 | 13 | R619 | B5 | VR460 | 13 |
| C425 | J1 | CR708 | B3 | R326 | L3 | R468 | L2 | R622 | B5 | VR525 | F5 |
| C470 | 11 | CR710 | B3 | R330 | L3 | R470 | J2 | R624 | B5 |  |  |
| C485 | G6 | CR710 |  | R336 | L3 | R472 | J1 | R627 | B4 |  |  |
| C490 | G5 | LR270 | K5 | R340 | L4 | R473 | J1 | R629 | B4 |  |  |
| C500 | G6 | LR280 | J5 | R345 | H5 | R475 | J2 | R630 | B3 |  |  |
| C506 | D5 | LR370 | J4 | R346 | H5 | R477 | K2 | R633 | B4 |  |  |
| C518 | E5 | LR425 | J1 | R347 | H5 | R487 | F5 | R635 | B3 |  |  |
| C532 | G6 | LR470 | J1 | R350 | H5 | R489 | F5 | R639 | B4 |  |  |
| C535 | H3 | LR485 | G6 | R352 | 15 | R490 | 15 | R642 | C4 |  |  |
| C537 | H2 | LR545 | C6 | R355 | 15 | R493 | L6 | R644 | B5 |  |  |
| C538 | H2 |  |  | R356 | 15 | R495 | F5 | R645 | B5 |  |  |
| C539 | H2 | P450 | 11 | R358 | H5 | R497 | E5* | R647 | B4 |  |  |
| C545 | D6 | P451 | F1 | R360 | 14 | R498 | F5 | R649 | B5 |  |  |
| C550 | E3 | P452 | D1 | R364 | 14 | R500 | F5 | R700 | B2 |  |  |
| C551 | G3 |  |  | R366 | 14 | R502 | E6 | R701 | B1 |  |  |
| C552 | F3 | Q290 | L6 | R370 | J4 | R505 | D4 | R702 | B2 |  |  |
| C554 | H3 | Q300 | L5 | R372 | J4 | R506 | D5 | R703 | B2 |  |  |
| C555 | H3 | Q302 | M4 | R380 | 13 | R510 | D5 | R704 | B1 |  |  |
| C565 | D5 | Q310 | L5 | R382 | 13 | R511 | D5 | R705 | B2 |  |  |
| C566 | D5 | Q320 | L4 | R385 | 13 | R512 | E5 | R706 | B2 |  |  |
| C569 | C4 | Q350 | 15 | R387 | 13 | R514 | A6 | R707 | B1 |  |  |
| C570 | D5 | Q360 | 15 | R390 | J3 | R518 | E5 | R708 | B2 |  |  |
| C610 | C5 | Q365 | 15 | R392 | J3 | R520 | D6 | R709 | B1 |  |  |
| C633 | C3 | Q370 | J5 | R394 | J3 | R525 | F6 | R710 | B2 |  |  |
| C730 | B6 | Q380 | 13 | R400 | K2 | R527 | E5 | R711 | B1 |  |  |
|  |  | Q390 | J3 | R401 | L2 | R529 | F5 | R712 | B1 |  |  |
| CR145 | J3 | Q400 | K3 | R403 | K2 | R530 | F5 | R713 | C3 |  |  |
| CR275 | J2 | Q410 | K3 | R405 | K2 | R532 | G6 | R714 | B1 |  |  |
| CR276 | J3 | Q415 | H2 | R408 | K3 | R539 | H5 | R720 | B6 |  |  |
| CR280 | K4 | Q465 | J2 | R410 | K3 | R542 | E5 |  |  |  |  |
| CR285 | K4 | Q500 | E6 | R412 | 13 | R544 | D6 | S485 | K2 |  |  |
| CR286 | L4 | Q510 | D6 | R413 | 12 | R547 | C4 | S545 | G4 |  |  |
| CR301 | K4 | Q520 | E6 | R415 | D2 | R548 | C4 | S635 | C4 |  |  |
| CR302 | K3 | Q615 | B4 | R418 | J2 | R550 | H3 | S710 | C4 |  |  |
| CR346 | H5 | Q625 | B4 | R430 | 11 | R551 | H4 | S725 | D3 |  |  |
| CR356 | 14 | Q645 | B4 | R431 | 12 | R552 | G2 |  |  |  |  |
| CR387 | 13 |  |  | R432 | 11 | R553 | G3 |  |  |  |  |
| CR413 | 12 | R270 | L4 | R433 | H2 | R554 | F3 | U270 | K5 |  |  |
| CR418 | J2 | R272 | J3 | R435 | F1 | R555 | E3 | U280 | J6 |  |  |
| CR465 | 13 | R280 | K4 | R436 | G2 | R556 | E3 | U330 | K4 |  |  |
| CR490 | B4 | R282 | J5 | R437 | G1 | R557 | F3 | U430 | 12 |  |  |
| CR494 | D4 | R285 | K4 | R438 | F2 | R558 | F4 | U435 | G2 |  |  |
| CR495 | D4 | R287 | J6 | R440 | E2 | R559 | C4 | U440 | F2 |  |  |
| CR496 | D4 | R290 | K3 | R441 | F2 | R560 | C4 | U445 | D2 |  |  |
| CR500 | D4 | R292 | K6 | R442 | F1 | R561 | D4 | U450 | C2 |  |  |
| CR506 | D5 | R294 | K4 | R443 | E1 | R562 | B5 | U455 | G2 |  |  |
| CR512 | D5 | R296 | L4 | R445 | D2 | R565 | C5 | U460 | H2 |  |  |
| CR518 | B4 | R298 | L4 | R446 | E2 | R566 | C5 | U470 | J2 |  |  |

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## CONTROLS \& CONNECTORS

DISPLAY
Selects mode of multiple trace switching.

## POSITION

Positions trace horizontally on crt.

## LEFT

Button in selects trigger signal from plug-in in. stalled in left vertical compartment.

RIGHT
Button in selects trigger signal from plug-in in. stalled in right vertical compartment.

LINE
Button in selects power line voltage as trigger signal.

EXT
Button in connects HORIZ AMPL jack to trigger circuits for sweep modes or connects signals through External Horizontal Amplifier when 5B31 is operated in AMPL mode.

AC COUPL
Button in ac couples trigger signals from either internal or external sources. Button out for dc coupling.

CAL
Continuously varies sweep rate to at least 2.5 times slower than SEC/DIV switch setting.

HORIZ AMPL
Input jack for triggering sweep externally or applying signals to an External Horizontal Amplifier.
$\mu \mathrm{s}$
Button in selects Delay by Time mode. With DLY'D button out, instrument is in a Locate mode.

## EVENT

Button in selects Delay by Events mode. With DLY'D button out, instrument is in a Locate mode.

DLY'D
Button in causes start of sweep to be delayed until the selected Time Delay or Event Delay (Count) has been completed.

EVENT TRIG
LEVEL/SLOPE
Selects slope and amplitude point of signal (from left vertical plug-in) where Events Start count is initiated.

SEC/DIV
Selects sweep rate and AMPL mode.

SWP MAG
Button in increases sweep speed by a factor of ten.

## AUTO TRIG

Button in causes sweep to be triggered by internal circuitry when sweep is not triggered by other signals.

SINGLE SWP
Push to place 5B31 in Single Sweep mode.

RESET
Push to re-arm sweep in Single Sweep operation.

## MAIN TRIG

LEVEL/SLOPE
Selects slope and amplitude point on input signals where Main Trigger recognition occurs (sweep start).

DLY'D GATE OUT
Positive-going at end of delay interval and negative-going at end of sweep.

READY-TRIG
Light indicates sweep armed or triggered.

PARTS LOCATION GRID

 \&界 $\AA$ KONOM $\qquad$


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Scan by Zenith








## REPLACEABLE MECHANICAL PARTS

## PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

## SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number
00X Part removed after this serial number

## FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

## INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

12345
Name \& Description
Assembly and/or Component
Attaching parts for Assembly and/or Component

-     -         - *--

Detail Part of Assembly and/or Component
Attaching parts for Detail Part
-.-*.-.
Parts of Detail Part
Attaching parts for Parts of Detail Part

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol---*---indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

## ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

| $"$ | INCH | ELCTRN | ELECTRON |
| :--- | :--- | :--- | :--- |
| \# | NUMBER SIZE | ELEC | ELECTRICAL |
| ACTR | ACTUATOR | ELCTLT | ELECTROLYTIC |
| ADPTR | ADAPTER | ELEM | ELEMENT |
| ALIGN | ALIGNMENT | EPL | ELECTRICAL PARTS LIST |
| AL | ALUMINUM | EQPT | EQUIPMENT |
| ASSEM | ASSEMBLED | EXT | EXTERNAL |
| ASSY | ASSEMBLY | FIL | FILLISTER HEAD |
| ATTEN | ATTENUATOR | FLEX | FLEXIBLE |
| AWG | AMERICAN WIRE GAGE | FLH | FLAT HEAD |
| BD | BOARD | FLTR | FILTER |
| BRKT | BRACKET | FR | FRAME OR FRONT |
| BRS | BRASS | FSTNR | FASTENER |
| BRZ | BRONZE | FT | FOOT |
| BSHG | BUSHING | FXD | FIXED |
| CAB | CABINET | GSKT | GASKET |
| CAP | CAPACITOR | HDL | HANDLE |
| CER | CERAMIC | HEX | HEXAGON |
| CHAS | CHASSIS | HEX HD | HEXAGONAL HEAD |
| CKT | CIRCUIT | HEX SOC | HEXAGONAL SOCKET |
| COMP | COMPOSITION | HLCPS | HELICAL COMPRESSION |
| CONN | CONNECTOR | HLEXT | HELICAL EXTENSION |
| COV | COVER | HV | HIGH VOLTAGE |
| CPLG | COUPLING | IC | INTEGRATED CIRCUIT |
| CRT | CATHODE RAY TUBE | ID | INSIDE DIAMETER |
| DEG | DEGREE | IDENT | IDENTIFICATION |
| DWR | DRAWER | IMPLR | IMPELLER |


| IN | INCH |
| :--- | :--- |
| INCAND | INCANDESCENT |
| INSUL | INSULATOR |
| INTL | INTERNAL |
| LPHLDR | LAMPHOLDER |
| MACH | MACHINE |
| MECH | MECHANICAL |
| MTG | MOUNTING |
| NIP | NIPPLE |
| NON WIRE | NOT WIRE WOUND |
| OBD | ORDER BY DESCRIPTION |
| OD | OUTSIDE DIAMETER |
| OVH | OVAL HEAD |
| PH BRZ | PHOSPHOR BRONZE |
| PL | PLAIN Or PLATE |
| PLSTC | PLASTIC |
| PN | PART NUMBER |
| PNH | PAN HEAD |
| PWR | POWER |
| RCPT | RECEPTACLE |
| RES | RESISTOR |
| RGD | RIGID |
| RLF | RELIEF |
| RTNR | RETAINER |
| SCH | SOCKET HEAD |
| SCOPE | OSCILLOSCOPE |
| SCR | SCREW |


|  |  |
| :--- | :--- |
| SE | SINGLE END |
| SECT | SECTION |
| SEMICOND SEMICONDUCTOR |  |
| SHLD | SHIELD |
| SHLDR | SHOULDERED |
| SKT | SOCKET |
| SL | SLIDE |
| SLFLKG | SELFLOCKING |
| SLVG | SLEEVING |
| SPR | SPRING |
| SQ | SQUARE |
| SST | STAINLESS STEEL |
| STL | STEEL |
| SW | SWITCH |
| T | TUBE |
| TERM | TERMINAL |
| THD | THREAD |
| THK | THICK |
| TNSN | TENSION |
| TPG | TAPPING |
| TRH | TRUSS HEAD |
| V | VOLTAGE |
| VAR | VARIABLE |
| W/ | WITH |
| WSHR | WASHER |
| XFMR | TRANSFORMER |
| XSTR | TRANSISTOR |
|  |  |

## CROSS INDEX MFR. CODE NUMBER TO MANUFACTURER

| MFR.CODE | MANUFACTURER | ADDRESS | CITY,STATE,ZIP |
| :---: | :---: | :---: | :---: |
| 00000C | Gettig Engineering and Manufacturing Co. |  | Springmill, PA 16875 |
| 00779 | AMP, Inc. | P. O. Box 3608 | Harrisburg, PA 17105 |
| 01295 | Texas Instruments, Inc., |  |  |
|  | Semiconductor Group | P. O. Box 5012 | Dallas, TX 75222 |
| 05820 | Wakefield Engineering, Inc. | Audubon Road | Wakefield, MA 01880 |
| 07126 | Digitran Co., The | 855 South Arroyo Parkway | Pasadena, CA 91105 |
| 08261 | Spectra-Strip Corp. | 7100 Lampson Ave. | Garden Grove, CA 92642 |
| 12360 | Albany Products Co., Div. of Pneumo |  |  |
|  | Dynamics Corp. | 351 Connecticut Ave. | South Norwalk, CT 06856 |
| 12697 | Clarostat Mfg. Co., Inc. | Lower Washington st. | Dover, NH 03820 |
| 15912 | Ansley Electronics Corp., A Sub of |  |  |
|  | Thomas and Betts Corp. | 2828 N. Figueroa At. | Los Angeles, CA 90065 |
| 22526 | Berg Electronics, Inc. | Youk Expressway | New Cumberland, PA 17070 |
| 23499 | Gavitt Wire and Cable, Division of |  |  |
|  | RSC Industries, Inc. | 455 N. Quince St. | Escondido, CA 92025 |
| 24931 | Specialty Connector Co., Inc. | 3560 Madison Ave. | Indianapolis, IN 46227 |
| 45722 | USM Corp., Parker-Kalon Fastener Div. | 1 Peekay Drive | Clifton, NJ 07014 |
| 71159 | Bristol Socket Screw, Div. of |  |  |
|  | American Chain and Cable Co., Inc. | 40 Bristol St. | Waterbury, CT 06720 |
| 71590 | Centralab Electronics, Div. of |  |  |
|  | Globe-Union, Inc. | 5757 N. Green Bay Ave. | Milwaukee, WI 53201 |
| 71785 | TRW Electronic Components, Cinch |  |  |
|  | Connector Operations | 1501 Morse Ave. | E1k Grove Village, IL 60007 |
| 73743 | Fischer Special Mfg. Co. | 446 Morgan St. | Cincinnati, OH 45206 |
| 74445 | Holo-Krome Co. | 31 Brook St. West | Hartford, CT 06110 |
| 74868 | Bunker Ramo Corp., The Amphenol RF Div. | 33 E. Franklin St. | Danbury, CT 06810 |
| 78189 | Illinois Tool Works, Inc. Shakeproof Division | St. Charles Road | Elgin, IL 60120 |
| 78471 | Tilley Mfg. Co. | 900 Industrial Rd. | San Carlos, CA 94070 |
| 78584 | Stewart Stamping Corp. | 630 Central Park Ave. | Yonkers, NY 10704 |
| 79807 | Wrought Washer Mfg. Co. | 2100 s. O Bay St. | Milwaukee, WI 53207 |
| 80009 | Tektronix, Inc. | P. O. Box 500 | Beaverton, OR 97077 |
| 83309 | Electrical Speciality Co., Subsidiary of |  |  |
|  | Belden Corp. | 213 E. Harris Ave. | South San Francisco, CA 94080 |
| 83385 | Central Screw Co. | 2530 Crescent Dr. | Broadview, IL 60153 |
| 83501 | Gavitt Wire and Cable, Division of |  |  |
|  | RSC Industries, Inc. | Central St. | Brookfiela, MA 01506 |
| 97464 | Industrial Retaining Ring Co. | 57 Cordier St. | Irvington, NJ 07111 |

Fig. \&

| Index No. | Tektronix Serial/Model No. <br> Part No. Eff Dscont | Qty | 2345 Name \& Description | $\begin{gathered} \text { Mfr } \\ \text { Code } \end{gathered}$ | Mfr Part Number |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1-1 | 337-1399-00 | 2 | SHLD, ELECTRICAL:SIDE | 80009 | 337-1399-00 |
| -2 | 366-1317-00 | 1 | KNOB:RED WITH SETSCREW | 80009 | 366-1317-00 |
|  | 213-0153-00 | 1 | . SETSCREW:5-40 x 0.125 INCH, HEX SOC STL | 74445 | OBD |
| -3 | 366-1575-00 | 1 | KNOB: SEC/DIV | 80009 | 366-1575-00 |
|  | 213-0153-00 | 2 | . SETSCREW:5-40 x 0.125 INCH,HEX SOC STL | 74445 | OBD |
| -4 | 366-1391-00 | 2 | KNOB:GRAY WITH SETSCREW | 80009 | 366-1391-00 |
|  | 213-0239-00 | 2 | . SETSCREW:3-48 X 0.062 INCH, HEX SOC STL | 71159 | OBD |
| -5 | 366-1023-05 | 2 | KNOB: GRAY, VAR, $0.127 \mathrm{ID}, 0.392 \mathrm{OD}, 0.466 \mathrm{H}$ | 80009 | 366-1023-05 |
|  | 213-0246-00 | 2 | . SETSCREW:5-40 x 0.125 INCH,HEX SOC STL | 74445 | OBD |
| -6 | 366-1023-01 | 1 | KNOB:GRAY | 80009 | 366-1023-01 |
|  | 213-0246-00 | 1 | . SETSCREW:5-40 x 0.093 INCH L, HEX SOC | 71159 | OBD |
| -7 | 366-1257-27 | 1 | PUSH BUTTON:--AC COUPL | 80009 | 366-1257-27 |
| -8 | 366-1257-24 | 1 | PUSH BUTTON:GRAY--EXT | 80009 | 366-1257-24 |
| -9 | 366-1257-23 | 1 | PUSHBUTTON:GRAY--LINE | 80009 | 366-1257-23 |
| -10 | 366-1257-58 | 1 | PUSHBUTTON:GRAY--RIGHT | 80009 | 366-1257-58 |
| -11 | 366-1257-57 | 1 | PUSHBUTTON:GRAY--LEFT | 80009 | 366-1257-57 |
| -12 | 366-1257-31 | 1 | PUSH Button:CHOP | 80009 | 366-1257-31 |
| -13 | 366-1257-30 | 1 | PUSH BUTTON:GRAY--RESET | 80009 | 366-1257-30 |
| -14 | 366-1257-29 | 1 | PUSH BUTTON:GRAY--SINGLE SW | 80009 | 366-1257-29 |
| -15 | 366-1257-26 | 1 | PUSH BUTTON:GRAY--AUTO TRIG | 80009 | 366-1257-26 |
| -16 | 366-1257-25 | 1 | PUSHBUTTON:GRAY--SW MAg | 80009 | 366-1257-25 |
| -17 | 366-1286-02 | 1 | KNOB: LATCH | 80009 | 366-1286-02 |
|  | 214-1840-00 ( 1 PIN, KNOB SECRG: ${ }^{\text {(ATACHING PARTS) }}$ |  |  |  |  |
| -18 |  |  |  | 80009 | 214-1840-00 |
| -19 | 366-1512-00 | 3 | push button:gray, 0.18 SQ x 0.83 Inch le | 80009 | 366-1512-00 |
| -20 | ----- ----- | 2 | . RESISTOR,VARTABLE:(SEE R125,R245 EPL) (ATTACHING PARTS FOR EACH) |  |  |
| -21 | 210-0583-00 | 1 | NUT,PLAIN, HEX.:0.25-32 $\times 0.312$ INCH,BRS | 73743 | 2x20319-402 |
| -22 | 210-0940-00 | 1 | WASHER,FLAT:0.25 ID X 0.375 INCH OD,STL | 79807 | OBD |
| -23 | ----- ----- | 1 | . RESISTOR,VARIABLE (SEE R605 EPL) (ATTACHING PARTS) |  |  |
| -24 | 210-0583-00 | 2 | NUT,PLAIN, HEX.:0.25-32 $\times 0.312$ INCH,BRS | 73743 | 2x20319-402 |
| -25 | 210-0940-00 | 1 | WASHER,FLAT: 0.25 ID X 0.375 INCH OD, STL | 79807 | OBD |
|  | 210-0046-00 | 1 | WASHER,LOCK: INTL, 0.26 "ID X 0.40 OD OSTL | 78189 | 1214-05-00-0541C |
| -26 | 131-0955-00 | 1 | CONNECTOR, RCPT, :BNC, FEMALE | 24931 | 28JR200-1 |
|  |  |  | (ATTACHING PARTS) |  |  |
|  | 210-0207-00 | 1 | TERMINAL,LUG:0.375 INCH DIANETER | 12697 | 01136902 |
| -27 | 131-0282-00 | 1 | CONNECTOR,RCPT, | 74868 | 74300 MB |
|  | (Attaching parts) |  |  |  |  |
| -28 | 210-0269-00 | 1 | TERMINAL,LUG:NON LOCKING,0.257" MTG HOLE | 78584 | OBD |
| -29 | (ATTACHING PARTS) |  |  | 80009 | 358-0029-00 |
| -30 |  |  |  | 73743 | 2x28269-402 |
| -31 | 210-0978-00 | 1 | WASHER, FLAT:0.375 ID x 0.50 INCH OD,STL | 78471 | OBD |
| -32 | 344-0195-01 | 1 | CLIP, GROUNDING: | 80009 | 344-0195-01 |
| -33 | 260-1650-00 | 1 | SWITCH, ROT: THUMBWHEEL | 07126 | 23-T-1 |
| -34 | 426-0681-00 | 10 | FR, PUSH BUTTON:GRAY PLASTIC | 80009 | 426-0681-00 |
| -35 | 426-1072-00 | 3 | FR,PUSHBUTTON: | 80009 | 426-1072-00 |
| -36 | 333-1971-00 | 1 | PANEL, FRONT: | 80009 | 333-1971-00 |
| -37 | 214-1513-01 |  | LCH, PLUG-IN RET: <br> (ATtAChing PARTS) | 80009 | 214-1513-01 |
| -38 | 213-0254-00 | 1 | SCR,TPG,THD CTG:2-5680.25"100 DEG,FLH STL | 45722 | OBD |
| -39 | 337-1430-00 | 2 | Shield, elec: | 80009 | 337-1430-00 |
| -40 | 136-0431-00 | 2 | LIGHT, INDICATOR | 80009 | 136-0431-00 |
| -41 | 386-3125-00 | 1 | SUBPANEL, FRONT: | 80009 | 386-3125-00 |
|  | (AtTACHING PARTS) |  |  |  |  |
| -42 | 213-0229-00 | 4 | SCR,TPG,THD FOR:6-20X0.375 100 DEG,FLH STL | 83385 | OBD |

Fig. \&


Fig. \&
$\begin{array}{ccc}\text { Index } & \text { Tektronix Serial/Model No. } \\ \text { No. } & \text { Part No. Eff } & \text { Dscont }\end{array}$

| Qty | $12345 \quad$ Name \& Description | Mfr <br> Code | Mfr Part Number |
| :---: | :---: | :---: | :---: |
| 21 | . . Contact, Eiec:0.365 inch long | 22526 | 47357 |
| 7 | . SOCket,plug-in 14 Contact,LOW Clearance | 01295 | C931402 |
| 3 | . . SOCket,plug-in:16 Contact,Low clearance | 01295 | C931602 |
| 1 | . . heat Sink,ELEC:XSTR,0.72 OD X 0.375 H | 05820 | OBD |
| 1 | . . SOCKEt,rlug-in: 8 Contact round | 71785 | 133-98-12-062 |
| 1 | . SOCKET, PLUG-IN:10 CONTACT,ROUND | 71785 | 133-99-12-064 |
| 1 | . SKT,dUAL ASSY: | 80009 | 136-0366-00 |
| 1 | . SWITCH, PUSH: DELAY | 80009 | 260-1724-00 |
| 1 | . SWITCH,PUSH:SWEEP CONTROL | 80009 | 260-1723-00 |
| 1 | . SWITCH, PUSH:4PDT | 71590 | 2KAB001000-358 |
| 10 | . . SPACER, SLEEVE: | 80009 | 361-0573-00 |
| 1 | FR SECT, PLUG-IN:TOP | 80009 | 426-0725-02 |
| 2 | CONTACT, Elec: | 80009 | 131-1372-00 |
| 1 | FR SECT, PLUG-IN:BOTTOM | 80009 | 426-0724-02 |
| 1 | HOIDER,TERM.CON:5 WIRE RED | 80009 | 352-0163-02 |
| 1 | HOLDER,TERM.CON: 6 WIRE,BROWN | 80009 | 352-0164-01 |
| 1 | HOLDER, TERM.CON:10 WIRE BLACK | 80009 | 352-0168-00 |
| 21 | CONTACT, ELEC: 0.48 L , 22-26 AWG WIRE | 22526 | 47439 |
| FT | WIRE, ELECTRICAL: 3 WIRE RIBBON, 0.417 FT | 08261 | TEK-175-0826-00 |
| FT | WIRE, ELECTRICAL: 5 WIRE RIBBON, 0.917 FT | 23499 | TEK-175-0828-00 |
| FT | WIRE,ELECTRICAL: 6 WIRE RIBBON, 0.583 FT | 83501 | TEK-175-0829-00 |
| FT | WIRE, ELECTRICAL: 10 WIRE RIBBON,0.750 FT ACCESSORIES | 23499 | TEK-175-0833-00 |
| 1 | MANUAL, TECH: INSTRUCTION(NOT SHOWN) | 80009 | 070-1805-00 |

REPACKAGING



[^0]:    ${ }^{1}$ Furnished as a unit with sl30.

[^1]:    ${ }^{1}$ Furnished as a unit with R125.
    ${ }_{3}^{2}$ Furnished as a unit with R245.
    $3_{\text {Furnished }}$ as a unit with R560.

[^2]:    note
    The Operating Instructions (Section 1) of this manual contains data and information that allow checking the Delay by Event mode and other functional characteristics.

