BK PRECISION®
MAXTEC INTERNATIONAL CORP.

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Chicago, Illinois 60635

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INSTRUCTION MANUAL

BK PRECISION

MODEL 2501

10 M Sample/Second Dual Channel DIGITAL STORAGE ADAPTER

BK PRECISION®

TEST INSTRUMENT SAFETY

WARNING

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must often be performed where exposed high voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts dc or ac rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltage poses an even greater threat because such voltage can more easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly in the equipment under test. Remove housings and covers only when necessary. Turn off equipment while making test connections in high-voltage circuits. Discharge high-voltage capacitors after removing power.

2. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.

3. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; make certain such surfaces are not damp or wet.

4. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.

5. When using a probe, touch only the insulated portion. Never touch the exposed tip portion.

6. When testing ac powered equipment, remember that ac line voltage is usually present on some power input circuits such as the on-off switch, fuses, power transformer, etc. any time the equipment is connected to an ac outlet, even if the equipment is turned off.

7. Some equipment with a two-wire ac power cord, including some with polarized power plugs, is the "hot chassis" type. This includes most recent television receivers and audio equipment. A plastic or wooden cabinet insulates the chassis to protect the customer. When the cabinet is removed for servicing, a serious shock hazard exists if the chassis is touched. Not only does this present a dangerous shock hazard, but damage to test instruments or the equipment under test may result from connecting the ground lead of most test instruments (including this oscilloscope) to a "hot chassis". To make measurements in "hot chassis" equipment, always connect an isolation transformer between the ac outlet and the equipment under test. The **B & K-Precision** Model TR-110 or 1604 Isolation Transformer, or Model 1653 or 1655 AC Power Supply is suitable for most applications. To be on the safe side, treat all two-wire ac powered equipment as "hot chassis" unless you are sure it has an isolated chassis or an earth ground chassis.

8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

NOTES

Instruction Manual

for

BK PRECISION

Model 2501

10 M Sample/Second

Dual Channel

DIGITAL STORAGE ADAPTER

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NOTES

INTRODUCTION

The Model 2501 Digital Storage Adapter is a versatile, dual channel, 10 M sample/second digitizer that greatly expands the capablities of a conventional dual-channel oscilloscope. Because it does not include most of the hardware contained in oscilloscopes, it is considerably less expensive than most Digital Storage Oscilloscopes (DSO's). It allows the user the freedom to continue using his own oscilloscope with which he is probably quite familiar. The Digital Storage Adapter's applications include capturing and viewing of extremely slow signals, capturing and comparing waveforms, capturing and viewing of one time events, hard copying of display (through the rear panel plotter outputs), and capturing and viewing of events that occur before the trigger signal.

The sampling rate of 10 million samples per second allows the Adapter to be used to capture one time events with durations as short as 1 µs (this allows a minimum resolution of 10 samples, enough for most applications). In addition, because the Adapter is connected to an external oscilloscope, expansion of the waveform is not limited to the typical X10 sweep magnification. The X10 sweep magnification feature of the oscilloscope can be enabled or the sweep speed setting of the oscilloscope can be increased to provide the desired magnification (although magnification higher than about 50 will result in the viewing of less than 10 samples). Unlike many low cost DSO's, after the waveform has been stored, the oscilloscope's controls can be used to maneuver the waveform vertically in addition to horizontally (the Adapter's controls allow you to maneuver the waveform horizontally even after it has been stored).

A memory capacity of 2 K x 8 bits/channel allows high resolution of stored waveforms. The horizontal oscilloscope display contains 2048 samples; 200 samples per division plus 48 extra (allowing for some "overscan" past the edge of the oscilloscope graticule). Vertical resolution is 1 in 256, or a minimum of about 25 dots per division (allowing for a deflection of 10 divisions - 8 divisions for a standard oscilloscope display plus 2 extra for display outside of the graticule).

The Digital Storage adapter also allows selectable trigger level, slope, and source. The trigger source can either be the channel 1 signal itself (internal), or an externally applied (to a rear panel jack) TTL level signal. Trigger level for the channel 1 signal is set with a front panel control and either positive or negative-going slope can be selected.

The Adapter allows the user to store both the channel 1 and channel 2 signals or store only the channel 2 signal. This allows the stored channel 2 signal to be compared to a continuously updated (refreshed) channel 1 display. When both signals are stored, the waveform(s) can be outputed to a plotter for a hard copy.

The signal shot storage feature allows the capture of one-time events that would be difficult if not impossible to view on a conventional oscilloscope. In addition, when using the single shot storage mode, 0%, 50%, or 100% of the display and memory can be used for storing and viewing events that occur before the trigger point is reached.

The Model 2501 Digital Storage Adapter uses digital technology to perform functions previously impossible with conventional oscilloscopes. It is recommended that the entire instruction manual be read before operating the Digital Storage Adapter.

FEATURES

Dual Channel
Model 2501 has two vertical input channels for displaying and storing two waveforms simultaneously.

2048 x 8 Bit Memory
Vertical resolution of 1 in 256 (approximately 25 steps/division) and horizontal resolution of 1 in 2048 (200 samples/div).

10 Msample/sec Sampling Rate
Allows capture of one time events with pulse widths of 1 µs or greater. Allows capture of repetitive waveforms of up to 1 MHz.

Capturing Pretrigger Information
Allows selection of 0%, 50%, or 100% of the stored waveform to be pretrigger information.

Single Shot Mode
In the Single Shot mode of operation, the Adapter begins storing information on trigger and continues through entire sweep.

Roll Mode
In the Roll mode of operation, the trace moves across the oscilloscope CRT from right to left like a strip chart recorder. Ideal for capturing very slow events and pretrigger information.

Calibrated Voltage Measurements
Accurate voltage measurements in Store mode (±5%) on 10 calibrated ranges from 5 mV/div to 5 V/div.

Calibrated Time Measurements
Accurate time measurements in Store mode. Model 2501 has 21 calibrated ranges from 80 s/div to 20 µs/div.

Two Trigger Sources
Two trigger source selections, channel 1 or external (TTL level).

Plotter Output
Rear panel output and pen lift signal allow a stored waveform to be fed to an analog printer.

WARRANTY SERVICE INSTRUCTIONS
(For U.S.A. and its Overseas Territories)

1. Refer to the MAINTENANCE section of your **B & K-Precision** instruction manual for adjustments that may be applicable.

2. If the above-mentioned does not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred in U.S.A.) to the nearest **B & K-Precision** authorized service agency (see list enclosed with unit).

If your list of authorized **B & K-Precision** service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

B & K-Precision, Factory Service Department
Maxtec International Corporation
6470 West Cortland Street
Chicago, Illinois 60635
Tel (312) 889-1448

Also use this address for technical inquiries and replacement parts orders.

asing because Aliasing can only occur with repetitive waveforms.

FREQUENCY LIMITATIONS

A common misconception with digital storage devices is that the usable bandwidth is the same as the sampling rate. Trying to view a 10 MHz waveform with a 10 M samples/second digital storage device would produce a useless display. If the digital storage device is sampling 10 million times every second (10 M samples/second), and the waveform being stored was at a frequency of 10 MHz, there would only be one sample taken every cycle. This would definitely not be very useful (it would also be quite likely that aliasing would occur). If however, a 1 MHz waveform were being stored (with the sampling rate still at 10 million samples per second), there would be 10 samples for every cycle. For most applications this would allow usable resolution. A general rule when using a digital storage device is to limit its maximum stored frequency to 1/10 the sampling rate. As in the above example, the maximum frequency of a stored waveform for this adapter should be limited to 1 MHz.

SPECIFICATIONS

VERTICAL AMPLIFIERS

Number Of Channels:
Two.

Sensitivity:
5 mV/div to 5 V/div in 1-2-5 sequence.

Accuracy:
±5% in STORE mode, ±30% in NON-STORE mode.

Input Resistance:
1 MΩ.

Input Capacitance:
25 pF.

Input Coupling:
AC or DC.

Maximum Input Voltage:
300 V (dc + ac peak).

SWEEP SYSTEM

Sweep Speed:
80 s/div to 20 µs/div.

TRIGGERING

Mode:
Normal.

Source:
Channel 1 or external (TTL compatible).

Coupling:
DC.

Level:
Front panel adjustable; permits selection of triggering at any point on the positive and negative slope of the displayed waveform.

Slopes:
+/-.

DIGITAL FACILITIES

Storage Word Size:
2048 x 8 bits/channel (2 k/channel).

Vertical Resolution:
1 in 256, approximately 25 steps/div.

Sampling Rates:
10 M samples/sec to 2.5 samples/sec, reduced in proportion to time base.

Digital Display Modes:
Roll:
Stored data and display updated continually (80 s/div to 5 msec/div sweep times).
Refresh:
Stored data and display updated by triggered sweep (80 s/div to 20 µs/div sweep times).
Hold:
Freezes channel 1 and channel 2 data immediately.
Save CH 2:
Freezes channel 2 data immediately.
Pretrigger Storage:
Available in SINGLE SHOT mode only, switchable for 0%, 50%, or 100% of full store pre-trigger.

PLOT OUTPUT

CH 1 and CH 2 Outputs:
Selected by PLOT pushbutton. Output via channel 1 and channel 2 output jacks on rear panel. Amplitude 0.2 V/div (2 V maximum).

Output Sweep Rate:
Selected by 10 x TIME/DIV control. Range of 800 s/div 0.2 ms/div.

Pen Lift Output:
Available at SCOPE TRIGGER (PEN LIFT) jack on rear panel. TTL high, pen up. TTL low, pen down (front panel indicator on).

OTHER SPECIFICATIONS

Power Requirements:
120 or 240 V ±10%, 50/60 Hz,
approximately 15 W.

Dimensions (W x D x H)(Including Handle):
260 x 260 x 97 mm (10.24 x 10.24 x 3.82").

Weight:
1.8 kg (3.96 lbs).

Operating Environment:
0° C to $+40^{\circ}$ C.

Storage Environment:
-25° C to $+55^{\circ}$ C.

SUPPLIED ACCESSORIES:
Schematic Diagram And Parts List.
Spare Fuse.

OPTIONAL ACCESSORIES:
10:1/Direct Probe (PR-37).
10:1 Probe (PR-46).
100:1 Probe (PR-100).
BNC-to-BNC Cable (CC-41).

APPENDIX I

UNIQUE CHARACTERISTICS OF DIGITAL STORAGE DEVICES

Digital Storage Devices (including DSO's and Digital Storage Adapters) use a digital sampling technique to convert analog input signals to a series of digital words that can be stored in memory. Since digital sampling has disadvantages as well as advantages, it is important to be aware of these unique characteristics of Digital Storage Devices.

ALIASING

This Digital Storage Adapter uses Real Time Sampling whenever it is in the **STORE** mode of operation. Real Time Sampling simply means that samples of the input signals are taken at equal spaces (e.g., every 0.25 ms when the 50 ms/div range is selected). With Real Time Sampling, a phenomena called "Aliasing" can occur when the input signal is not sampled often enough. This causes the digitized signal to appear to be of a lower frequency than that of the input signal. Unless you have an idea what the input signal is supposed to look like, you will usually be unaware that Aliasing is occuring.

Aliasing Example

To see what actually occurs when a Digital Storage Device is Aliasing, perform the following example.

1. Apply a 10 kHz signal to the input jack and set the sweep **TIME/DIV** control to 50 µs/div. You should see about 5 cycles of the waveform on the display. Since the Adapter samples the input waveform 200 times per division, each cycle is sampled 400 times.

2. Now change the sweep **TIME/DIV** control to 5 ms/div. The display should look crowded. Because the Adapter takes 200 samples per division, the sample points are 25 µs apart. Since the input signal is at a frequency of 10 kHz, it is being sampled 4 times per cycle. The resulting display is too crowded to be useful, however, it is not incorrect (it is similar to what you would see on a conventional oscilloscope).

3. Change the sweep **TIME/DIV** setting to 20 ms/div. Vary the frequency a slight amount (until the display is readable) to obtain as few cycles as possible on the CRT. If you were to calculate the frequency of the signal from the display, you would come up with a much lower frequency than that of the actual frequency of the signal at the input jack. If 3 cycles are displayed, the calculated frequency would be approximately 15 Hz. This is obviously incorrect. This occurs because the Digital Storage Adapter is taking one sample every 0.1 ms and a 10 kHz signal has one cycle every 0.1 ms. What is actually happening is that the frequency is off (not perfectly 10 kHz) by just enough to cause the Digital Storage Adapter to take one sample at a slightly different place on each cycle of the waveform. It is also possible to have the Adapter sample the waveform at exactly the same point on every cycle. This causes the Digital Storage Adapter to display what looks like a dc voltage. Obviously, this is also incorrect.

Avoiding Aliasing

Aliasing is not limited to the above example. This phenomena can occur anytime that at least two samples per cycle are not taken (whenever the sweep **TIME/DIV** setting is much too slow for the waveform being applied to the input). Whenever the frequency of the signal is unknown, always begin with the fastest sweep speed (20 µs/div).

NOTE

Viewing of one time events poses no problem with Ali-

8. Adjust C104 for the same waveform as obtained in step 4 (as shown in Fig. 17).

9. Connect the oscilloscope calibrator output to the **CH 2** input through the dummy probe circuit shown in Fig. 18. Using a "T" connection also connect the calibrator directly to the **CH 1** input to keep the display constantly "refreshed". The dummy probe circuit provides isolation between CH 1 and CH 2 to avoid capacitance loading of CH 2 during this adjustment.

10. Readjust the trimmer capacitor in the dummy probe circuit for the best quality square wave presention on CH 2 at 50 mV sensitivity.

11. Select 1 V/div sensitivity on the Adapter and set the oscilloscope calibrator for 5 or 6 divisions of amplitude.

12. Adjust C204 for the same waveform as obtained in step 9 (as shown in Fig. 17).

13. Change the **CH 2 V/DIV** control setting to **0.1 V** and adjust the calibrator output level for 5 divisions of amplitude (if necessary, reduce the **CH 1 V/DIV** control setting to obtain a triggered display).

14. Adjust C202 for the same waveform as obtained in step 9 (as shown in Fig. 17).

INSTRUMENT REPAIR SERVICE

Because of the specialized skills and test equipment required for instrument repair and calibration, may customers prefer to rely upon **B & K-Precision** for this service. We maintain a network of **B & K-Precision** authorized service agencies for this purpose. To use this service, even if the oscilloscope is no longer under warranty, follow the instructions given in the WARRANTY SERVICE INSTRUCTIONS portion of this manual. There is a nominal charge for instruments out of warranty.

CONTROLS AND INDICATORS

FRONT PANEL CONTROLS AND INDICATORS

1. **POWER Indicator.** Lights when power is turned and unit is plugged in.

2. **TRIG'D Indicator.** Lights when sweep is triggered. Shows when trigger level is properly set.

3. **ARMED Indicator.** Lights when the **SINGLE SHOT** switch has been pressed until an adequate trigger signal has been provided and the waveform is stored. Also lights whenever the **REFRESH** operating mode is selected.

4. **TIME/DIV Control.** Provides step selection of sweep rate. Control has 21 steps from 20 µs/div to 80 s/div. Once a waveform has been digitized and stored, changing the **TIME/DIV** control will have no effect on the stored waveform.

5. **CH 2 Input Jack.** Vertical input for channel 2.

6. **CH 2 POSITION Control.** Rotation adjusts vertical position of channel 2 trace. Once a waveform has been digitized and stored, changing the **CH 2 POSITION** control setting will have no effect on the stored waveform.

7. **CH 2 V/DIV Control.** Vertical attenuator for channel 2. Vertical sensitivity is calibrated in 10 steps from 5 volts/div to 5 mV/div. Once a waveform has been digitized and stored, changing the **CH 2 V/DIV** control setting will have no effect on the stored waveform.

8. **CH 2 AC/DC Switch.** Selects input coupling for channel 2 signal. When switch is engaged (**AC** position), the channel 2 input signal is capacitively coupled and any dc component is blocked. When the switch is disengaged (**DC** position), the channel 2 input signal is direct coupled and both the ac and dc component produce vertical deflection.

9. **CH 1 AC/DC Switch.** Selects input coupling for channel 1 signal. When switch is engaged (**AC** position), the channel 1 input signal is capacitively coupled and any dc component is blocked. When the switch is disengaged (**DC** position), the channel 1 input signal is direct coupled and both the ac and dc component produce vertical deflection.

10. **CH 1 Input Jack.** Vertical input for channel 1.

11. **CH 1 POSITION Control.** Rotation adjusts vertical position of channel 1 trace. Once a waveform has been digitized and stored, changing the **CH 1 POSITION** control setting will have no effect on the stored waveform.

12. **CH 1 V/DIV Control.** Vertical attenuator for channel 1. Vertical sensitivity is calibrated in 10 steps from 5 volts/div to 5 mV/div. Once a waveform has been digitized and stored, changing the **CH 1 V/DIV** control setting will have no effect on the stored waveform.

13. **NON-STORE/STORE Switch.** Selects digitizing (**STORE**) or analog (**NON-STORE**) operating mode. When this switch is engaged (**NON-STORE** position), the Digital Storage Adapter is in the analog mode of operation and all input signals are fed directly through the Adapter's amplifier (the only Digital Storage Adapter controls that have an effect on the oscilloscope display are the **V/DIV**, **POSITION**, and **AC/DC** controls). When the switch is disengaged (**STORE** position), the Digital Storage Adapter is in the digital mode of operation and all input signals are digitized before being fed to the rear panel output jacks.

14. **PEN DOWN Indicator.** Works in conjunction with the **PLOT** switch. Indi-

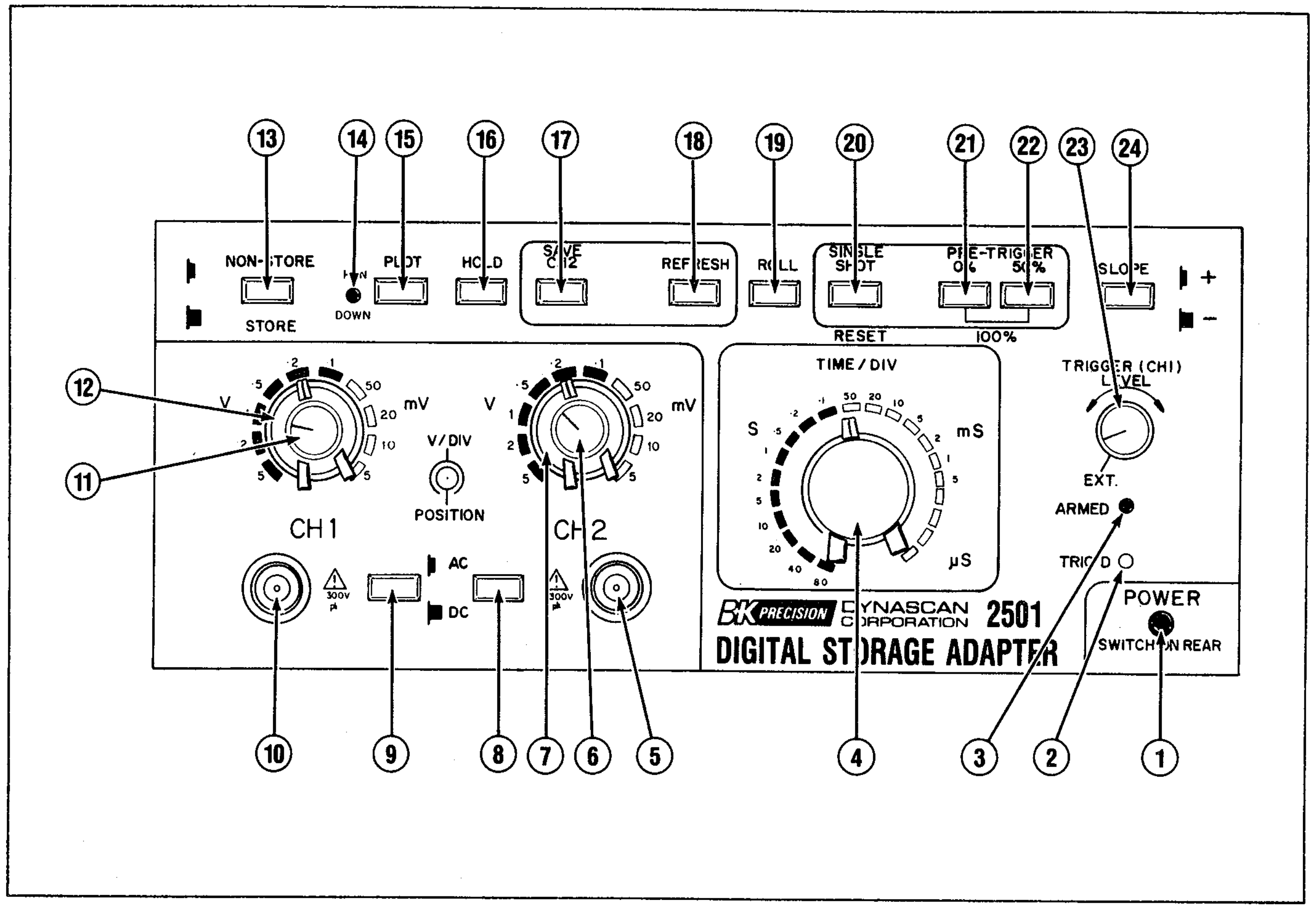

Fig. 1. Front Panel Controls And Indicators.

cates when TTL signal at rear panel **SCOPE TRIGGER (PEN LIFT)** jack is at logic low. When the TTL signal is at logic low and the **SCOPE TRIGGER (PEN LIFT)** signal is connected to a plotter, the plotting pen is down.

15. **PLOT Switch.** Works in conjunction with the **SCOPE TRIGGER (PEN LIFT)** output jack on the rear panel. When this switch is engaged (**PLOT** position), and the **SCOPE TRIGGER (PEN LIFT)** output is connected to the pen lift input of a plotter, the plotter pen will be on the paper for the duration of one output frame from the **CH 1** and **CH 2** outputs.

16. **HOLD Switch.** When in the **STORE** mode of operation, engaging this switch freezes and stores the channel 1 and channel 2 trace immediately. The display and memory cannot be updated until this switch is released.

17. **SAVE CH 2.** When in the digitizing and **REFRESH** modes of operation, engaging this switch freezes and stores the channel 2 trace immediately. The channel 2 display cannot be updated until this switch is released or the **ROLL** or **SINGLE SHOT** mode are selected.

18. **REFRESH Switch.** When this switch is engaged and the **NON-STORE/STORE** switch is in the **STORE** position, the Digital Storage Adapter is in the **REFRESH** mode of operation. In the **REFRESH** mode, the trace moves across the CRT from left to right and the display is updated each time an adequate trigger signal is supplied.

19. **ROLL Switch.** When this switch is engaged and the **NON-STORE/STORE** switch is in the **STORE** position, the Digital Storage Adapter is in the **ROLL** mode of operation. In the **ROLL** mode,

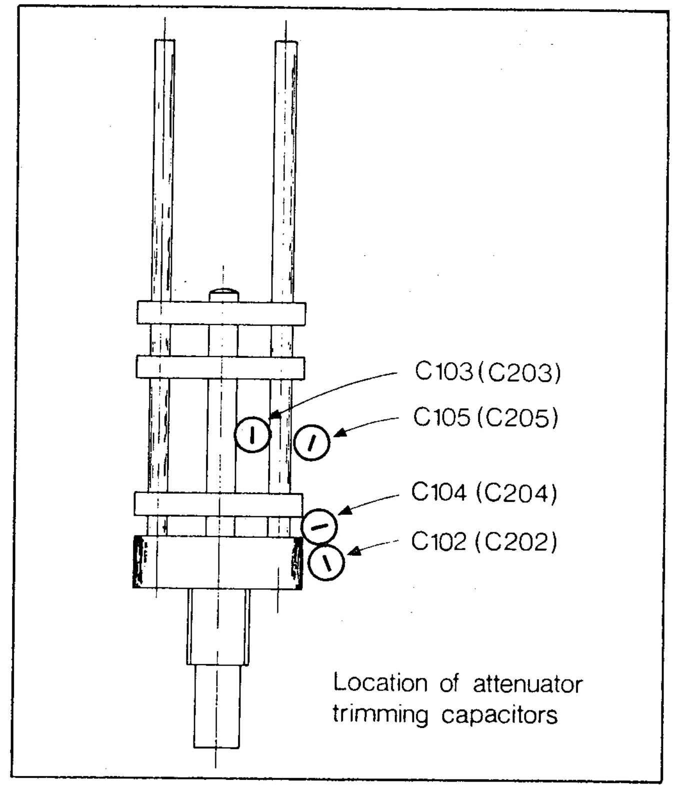

Fig. 19. Location Of Input Trimmers.

Input Attenuator Frequency Compensation

1. Perform the "Calibration Set-Up" instructions.

2. Set the Adapter for **REFRESH** operating mode and set the **TIME/DIV** control to **20 μs.** Set the **CH 1 V/DIV** control to **0.1 V** and the **CH 2 V/DIV** control to **1 V.**

3. Set the oscilloscope calibrator for a 10 kHz squarewave and connect it to the CH 1 input of the Adapter. Adjust the calibrator so that the waveform occupies between 5 and 6 divisions vertically and adjust the Adapter **TRIGGER (CH 1) LEVEL** control for a stable display.

4. Adjust C103 for the best square wave presentation (as shown in Fig. 17).

5. Set the Adapter **CH 1 V/DIV** control to **1 V** and increase the output level of the oscilloscope calibrator so that the waveform occupies between 5 and 6 divisions vertically.

6. Adjust C105 for the best square wave presentation (as shown in Fig. 17).

7. Connect the oscilloscope calibrator output to the CH 2 input and use a "T" to also connect the signal to the **CH 1** input (so that the display will be constantly "refreshed").

8. While observing the 5 to 6 vertical divisions of waveform, adjust C205 for the best square wave presentation (as shown in Fig. 17).

9. Set the **CH 1** and **CH 2 V/DIV** control to **0.1 V** and reduce the output level of the calibrator so that the display again occupies 5 to 6 vertical divisions.

10. Adjust C203 for the best square wave presentation (as shown in Fig. 17).

Input Capacitance Frequency Adjustment

1. Perform the "Calibration Set-Up" instructions.

2. Set the Adapter for the **REFRESH** operating mode and set the **TIME/DIV** control to **0.2 ms.** Set the **CH 1 V/DIV** control to **50 mV** and the **CH 2 V/DIV** control to **1 V.**

3. Set the oscilloscope calibrator for a 1 kHz square wave and connect it to the **CH 1** input through a 1 MΩ ±1% resistor in parallel with a 4-40 pF variable capacitor (as shown in Fig. 18).

4. Adjust the calibrator output level for 5 divisions amplitude and set the Adapter **TRIGGER (CH 1) LEVEL** control for a stable display. Adjust the variable capacitor in the load (shown in Fig. 18) for the best square wave presentation (as shown in Fig. 17).

5. Set the Adapter **CH 1 V/DIV** control to **0.1 V** and adjust the output level of the calibrator for 5 divisions amplitude.

6. Adjust C102 for the same waveform as obtained in step 4 (as shown in Fig. 17).

7. Increase the Adapter **CH 1 V/DIV** control setting to **1 V** and readjust the output level of the calibrator for 5 divisions of amplitude on the CRT.

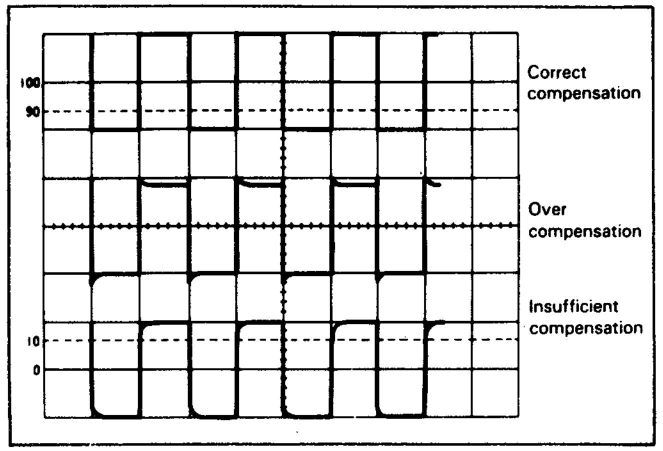

Fig. 17. Proper Input Compensation.

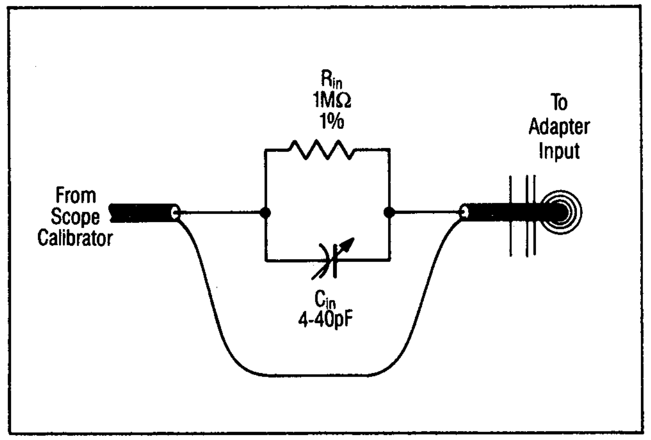

Fig. 18. Network For Input Capacitance Adjustment.

3. Set the oscilloscope calibrator controls for a 10 kHz squarewave output with an amplitude of 1 V.

4. Check the oscilloscope for a stable display with 5 divisions of amplitude on both channels. Check for good quality square wave presentation (as shown in Fig. 17) and adjust the oscilloscope if necessary.

5. Set the oscilloscope calibrator for a 1 kHz squarewave output with an amplitude of 1 V.

6. Check the oscilloscope for a stable display with 5 divisions of amplitude on both channels. Check for good quality square wave presentation (as shown in Fig. 17) and adjust the oscilloscope if necessary.

7. Follow the "Initial Set-Up" procedure in the OPERATING INSTRUCTIONS section of this manual. That is, connect the output of the Adapter to the oscilloscope. Select the **ROLL** mode of operation; all other switches should be disengaged.

8. Allow the Adapter to "warm-up" for at least 20 minutes.

9. Remove the Digital Storage Adapter case.

DC Balance Adjustment

1. Perform the "Calibration Set-Up" instructions.

2. Set the Adapter **TIME/DIV** control to 20 ms.

3. With no input to the Adapter, switch the Adapter **CH 1 V/DIV** control between **5 mV** and **50 mV** and adjust R124 so that there is no vertical shift in the trace when switched between these ranges.

4. With no input to the Adpater switch the **CH 2 V/DIV** control between **5 mV** and **50 mV** and adjust R224 so that there is no vertical shift in the trace when switched between these ranges.

Amplifier Gain Adjustment

1. Perform the "Calibration Set-Up" instructions.

2. Set the Adapter **TIME/DIV** control to **5 ms** and the **CH 1** and **CH 2 V/DIV** controls to **10 mV.**

3. Set the oscilloscope calibrator for a 1 kHz square wave with 50 mV of amplitude and connect it to the Adapter **CH 1** input.

4. Adjust R140 for exactly 5 divisions of signal amplitude on the CRT.

5. Connect the oscilloscope calibrator 1 kHz, 50 mV square wave signal to the Adapter **CH 2** input.

6. Adjust R240 for exactly 5 divisions of signal amplitude on the CRT.

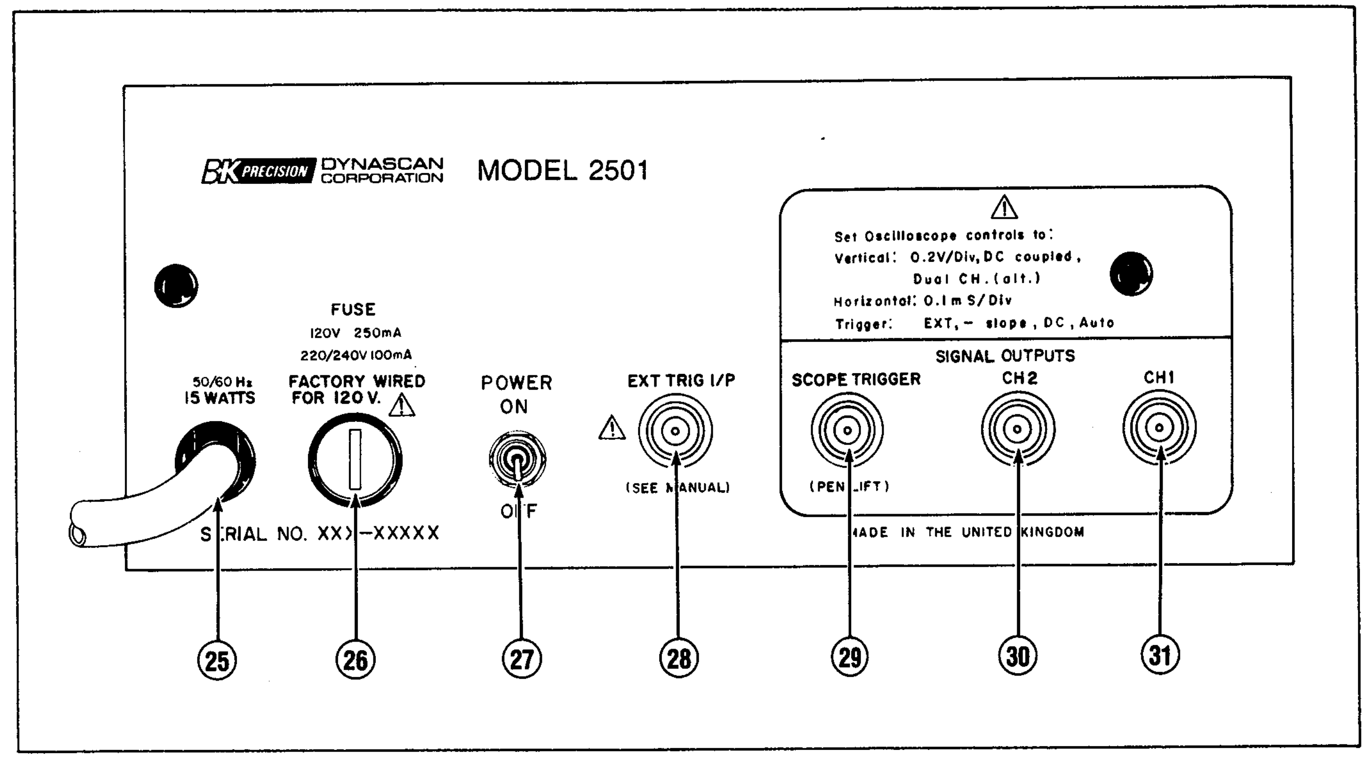

Fig. 2. Rear Panel Controls.

the trace moves across the CRT from right to left like a strip chart recorder (opposite conventional oscilloscope operation) and the display is continually updated.

20. **SINGLE SHOT Switch.** When this momentary action switch is pressed the Digital Storage Adapter arms for storage. The signals at the **CH 1** and **CH 2** input jacks will be stored at the next adequate trigger signal.

21. **PRE-TRIGGER 0% Switch.** Works in conjunction with the **PRE-TRIGGER 50%** switch to select 100% pretriggering. When both this switch and the **PRE-TRIGGER 50%** switch are engaged and the **SINGLE SHOT** operating mode is selected, all 100% of the stored waveform(s) will be pretrigger information. When the **PRE-TRIGGER 50%** switch is not engaged or the the **SINGLE SHOT** operating mode is not selected, this switch has no effect.

22. **PRE-TRIGGER 50% Switch.** When this switch is engaged, the **SINGLE SHOT** operating mode is selected, and the **PRE-TRIGGER 0%** switch is not engaged, 50% of the stored waveform(s) will be pretrigger information. If the **PRE-TRIGGER 0%** switch is also engaged (and the **SINGLE SHOT** operating mode is selected), 100% of the stored waveform(s) will be pretrigger information. If the **SINGLE SHOT** operating mode is not selected, this switch has no effect.

23. **TRIGGER (CH 1) LEVEL Control.** Trigger level adjustment, determines point on channel 1 waveform where sweep is triggered. Rotation in counterclockwise direction selects more negative point of triggering, and rotation in clockwise direction selects more positive point of triggering. Complete counterclockwise rotation (**EXT** position) selects external trigger source (applied to rear panel jack).

24. **SLOPE +/- Switch.** When this switch is engaged (- position), sweep is triggered on trigger signal's negative going slope. When this switch is disengaged (+ position), sweep is triggered on trigger signal's positive going slope.

REAR PANEL CONTROLS

25. **Line Cord.**

26. **Fuse Holder.** Contains line fuse.

27. **POWER ON/OFF Switch.** Turns power on and off.

28. **EXT TRIG I/P Jack.** TTL compatible input for external trigger source. Signal is selected by complete counterclockwise rotation of **TRIGGER (CH 1) LEVEL** control.

29. **SCOPE TRIGGER (PEN LIFT) Jack.** Output jack for TTL level oscilloscope trigger signal. Can also be used as pen lift signal for use with an external plotter.

30. **CH 2 Output Jack.** Channel 2 output signal. To be connected to the channel 2 input of the oscilloscope or plotter.

31. **CH 1 Output Jack.** Channel 1 output signal. To be connected to the channel 1 input of the oscilloscope or plotter.

WARNING

The following instructions are for use be qualified service personnel only. To avoid electrical shock, do not perform any servicing other than contained in the operating instructions unless you are qualified to do so.

Remember that ac line voltage is present on line voltage input circuits any time the instrument is plugged into an ac outlet, even if turned off. Unplug the Adapter before performing servicing procedures.

FUSE REPLACEMENT

If the fuse blows, the pilot light will go out and the Adapter will not operate. The fuse should not normally open unless a problem has developed in the unit. Try to determine and correct the cause of the blown fuse, then replace only with the correct value fuse. For 120 V operation a 250 mA, V, 5 x 20 mm fuse is used (Dynascan part number 194-019-9-001) and for 220/240 V operation a 100 mA, 250 V, 5 x 20 mm fuse is used (Dynascan part number 194-020-9-001). The fuse is located on the rear panel (see Fig. 2).

LINE VOLTAGE SELECTION

The Model 2501 can operate on 120 V or 220 V/240 V line voltage. The unit is factory wired for 120 V operation. To select 220 V/240 V line voltage perform the following:

1. Remove the two 120 V jumping resistors (labeled "120 V") located on the pc board next to the power transformer.

2. Solder one of the jumping resistors to the pc board where it is labeled "240 V".

3. Replace the fuse with a 100 mA, 250 V, 5 x 20 mm fuse.

4. To return the unit to 120 V operation, remove the 240 V jumping resistor, replace both 120 V jumping resistors, and replace the fuse with a 250 mA, 125 V, 5 x 20 mm fuse.

CALIBRATION PROCEDURE

This unit was carefully checked and calibrated at the factory prior to shipment. Readjustment is recommended only if repairs have been made in a circuit affecting calibration. The location of the input attenuator frequency compensation trimmers and the input capacitance frequency response trimmers is shown in Fig. 19. The other trimmers should be easily located. Keep in mind that some calibration procedures require high precision test instruments. Those adjustments should be attempted only if the proper test equipment is available and you are experienced in its use. The following test equipment is required for complete recalibration:

Oscilloscope Compatible with Digital Storage Adapter Model 2501 (must be completely calibrated).

Oscilloscope Calibrator (must produce 1 kHz squarewave at 50 mV, 0.5 V, 1 V, and 5 V ±0.5%; and 10 kHz squarewave at 0.5 V, 1 V, and 5 V; both signals must have risetime of less than 100 ns).

Calibration Set-Up

The following steps are necessary to ensure that the oscilloscope is properly calibrated. Failure to do this could result in improper calibration of the Digital Storage Adapter.

1. Connect the oscilloscope calibrator directly to the oscilloscope channel 1 and 2 inputs.

2. Set the oscilloscope input attenuator for 0.2 V/div and the time base for 20 µs/div.

TIME/DIV controls to appropriate settings. Set the Adapter trigger controls so that the when the ac power is cut off, the sweep will be triggered.

3. Press the **SINGLE SHOT** switch before the power is cutoff. The event will then be stored when the triggered sweep is completed.

4. Use the oscilloscope horizontal position control to adjust the point where the ac power was cut off to coincide with a major vertical graduation line and measure the horizontal distance in divisions between the point where power was cut off and the point where the battery back-up took over. Multiply this by the sweep **TIME/DIV** setting and also by 1/10 if the oscilloscope times 10 sweep magnification was used.

The measurement is summarized by the following equation:

Take-over Time =

Hor div x sweep **TIME/DIV**

(x 1/10 if sweep magnification is used)

For the example shown in Fig. 16, the horizontal distance is 4.0 divisions. The sweep **TIME/DIV** setting is **2 ms.** The take-over time is calculated as follows:

Take-over Time =

4.0 (div) x 2 (ms/div) x 1/10

= 0.8 ms

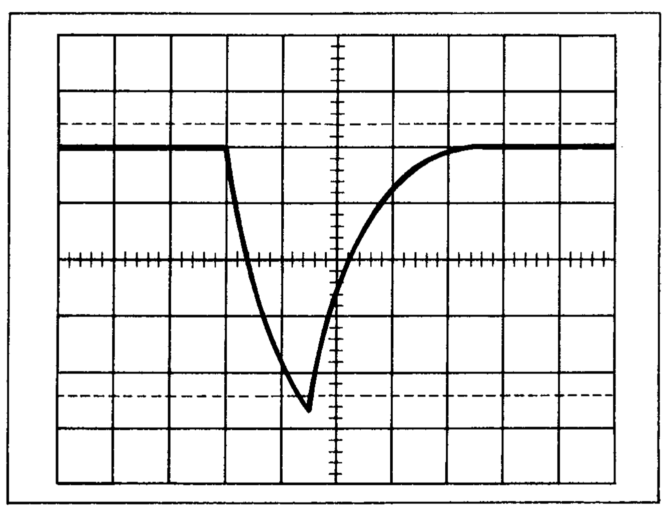

Fig. 16. Battery Back-Up Take-Over Time Measurement

RECORDING LIGHTNING INDUCED SURGES ON POWER LINES

Like switching spikes, lightning surges can cause serious malfunctions to occur in electrical and electronic equipment. This Adapter can be set up to record such an event even if the user is not present.

1. Connect a probe to the **CH 1** input on the Adapter and connect the probe tip to the power line.

   NOTE

   Make sure that the probe is of sufficient rating to withstand the voltage produced by a surge. Also make sure that the voltage present on the Adapter side of the probe will not exceed the maximum input rating of the Adapter (300 V dc + ac peak).

2. Set the Adapter **V/DIV** and sweep **TIME/DIV** controls to appropriate settings and set the trigger controls so that the desired event will trigger the sweep.

3. If you wish to capture pretrigger information, select the desired amount of pretrigger information using the **0%** and **50%** switches and press the **SINGLE SHOT** switch. The event will automatically be stored when the triggered sweep is completed.

4. If you do not wish to capture pretrigger information, disengage the **0%** and **50%** switches and press the **SINGLE SHOT** switch. The event will then be stored when the triggered sweep is completed.

   NOTE

   The Adapter and oscilloscope can now be left unattended. When the surge occurs, the Adapter will automatically store the waveform and hold it for later use (if the trigger controls have been set properly).

5. To obtain a hard copy of the display, connect a plotter to the plotter outputs on the rear panel, press the **HOLD** switch, select the appropriate sweep time for the plotter being used, and press the **PLOT** switch.

SAFETY PRECAUTIONS

WARNING

The following precautions must be observed to prevent electric shock.

1. When the adapter is used to make measurements in equipment that contains high voltage, there is always a certain amount of danger from electrical shock. The person using the adapter in such conditions should be a qualified electronics technician or otherwise trained and qualified to work under such circumstances. Observe the TEST INSTRUMENT SAFETY recommendations listed on the inside front cover of this manual.

2. Do not operate this adapter with the case removed unless you are a qualified service technician.

3. The ground wire of the 3-wire ac power plug places the chassis of the adapter at earth ground. Use only a 3-wire outlet, and do not attempt to defeat the ground wire connection or float the adapter; to do so may pose a great safety hazard.

4. Special precautions are required to measure or observe line voltage waveforms with this adapter or any oscilloscope. Use the following procedure:

   a. Do not connect the ground clip of the probe to either side of the line. The clip is already at earth ground and touching it to the hot side of the line may "weld" or "disintegrate" the probe tip and cause possible injury, plus possible damage to the scope or probe.

   b. Insert the probe tip into one side of the line voltage receptacle, then the other. One side of the receptacle should be "hot" and produce the waveform. The other side of the receptacle is the ac return and no waveform should result.

EQUIPMENT PROTECTION PRECAUTIONS

CAUTION

The following precautions will help avoid damage to the adapter and the oscilloscope being used with it.

1. Never allow a small spot of high brilliance to remain stationary on the oscilloscope screen for more than a few seconds. The screen may become permanently burned. A spot will occur when the scope is set up for **X-Y** operation and no signal is applied. Either reduce the intensity so the spot is barely visible, apply a signal, or switch back to normal sweep operation. It is also advisable to use low intensity when a stored waveform is displayed for long periods. A high intensity trace at the same position could cause a line to become permanently burned onto the screen.

2. Do not rest the Adapter or any other objects on top of the oscilloscope or otherwise obstruct the ventilating holes in the case, as this will increase the internal temperature.

3. Excessive voltage applied to the input jacks may damage the adapter. The maximum ratings of the inputs are as follows:

   CH 1 and **CH 2:**
   300 V dc + ac peak.
   Ext Trig I/P:
   5 V dc + ac peak.

   Never apply external voltage to the adapter or oscilloscope output jacks.

4. Always connect a cable from the ground terminal of the oscilloscope to the chassis of the equipment under test. Without this precaution, the entire current for the equipment under test may be drawn through the probe clip leads under certain circumstances. Such conditions could also pose a safety hazard, which the ground cable will prevent.

5. The probe ground clips are at oscilloscope and adapter ground and should be connected only to the common of the equipment under test. To measure with respect to any point other than the common, use subtract operation. Use this method even if the reference point is a dc voltage with no signal.

INITIAL SET-UP

The Digital Storage Adapter must be used in conjunction with an oscilloscope with the following features:

Dual Channel
Vertical Sensitivity Of 0.2 V/Div
Timebase Of 0.1 ms/div
External Trigger Input
Negative Trigger Slope

The oscilloscope controls should be set as follows:

All Variable Controls - Calibrated
Vertical Input - Dual Channel (ALT sweep if selectable)
Input Coupling - DC
Input Attenuator - 0.2 V/Div
Sweep Mode - A or Main (if selectable)
Sweep Speed - 0.1 ms/Div
Sweep Magnification - Off (If present)
Trigger Source - External
Trigger Coupling - AC or DC
Trigger Mode - Auto
Trigger Level - Mid Position
Trigger Slope - Negative
Intensity - Mid Range

1. Turn on the oscilloscope and the Digital Storage Adapter (the power switch on the Digital Storage Adapter is on the rear panel).

2. With no connections yet made to the oscilloscope, adjust the vertical position controls on the oscilloscope so that both traces are at the bottom of the CRT (not the center as for standard operation).

3. Set the trigger mode on the oscilloscope to normal (triggered sweep) operation. Both traces will disappear.

4. Connect the **CH 1** and **CH 2** output jacks of the Digital Storage Adapter to the channel 1 and channel 2 input jacks of the oscilloscope.

5. Connect the **SCOPE TRIGGER (PEN LIFT)** output jack of the adapter to the external trigger input of the oscilloscope.

6. Press the **ROLL** button and release all other buttons of the Digital Storage Adapter.

7. Set the adapter **TIME/DIV** control to 0.1 s/div.

8. Set the **CH 1 POSITION**, and **CH 2 POSITION** controls on the Adapter to mid position.

9. Adjust the trigger level control on the oscilloscope for a triggered display.

NOTE

Without any signal applied to the adapter, both traces will be straight lines even though the oscilloscope is set for triggered sweep. This is because the Digital Storage Adapter generates the trigger signal.

10. The oscilloscope should now be displaying two traces. It should be possible to move these two traces completely off the bottom and top of the CRT using the Digital Storage Adapter **POSITION** controls. If the traces cannot be moved completely off the top and bottom of the CRT, adjust the oscilloscope position controls accordingly. Once these controls have been set properly, do not further adjust them.

3. With the telephone connected to a telephone line or telephone line simulator, connect the telephone (at the telephone line) to the **CH 1** input of the Adapter.

NOTE

Remember that dialing on an actual telephone line will be accepted by the telephone exchange and dialing a complete number will result in a connection being made.

4. Observe the voltage on the oscilloscope display. An on hook telephone should have about -48 volts dropped across it. When the telephone is taken off hook, the voltage should be approximately -12 volts. As the telephone is dialed, there should be negative going pulses that drop all the way down to the telephone line voltage (the voltage dropped across the on hook telephone). The pulses will roll across the screen from right to left.

NOTE

With some telephone exchanges, the voltage may actually go to -70 volts.

5. At any time the pulses can be stored by pressing the **HOLD** switch. The groups of pulses can then be more closely examined by selecting the sweep magnification function on the oscilloscope. The number of pulses should directly correspond with the number dialed (i.e., when "2" is dialed there should be two pulses, when "6" is dialed there should be six pulses, and when "0" is dialed there should be ten pulses).

6. If you wish to examine the pulses more closely, select a faster Adapter **TIME/DIV** setting that will allow pulse rate, make time, break time, and interdigit time to be measured.

EVALUATING SWITCHING DEVICES

Spikes generated by switches, relays, and circuit breakers, often cause malfunctions to occur in electrical or electronic equipment. This Adapter can be used to capture such spikes. It can be triggered from either a "make" or a "break" in the circuit path and it can also capture the transient charactersitic that occured prior to the trigger. In addition, its ability to store and display two waveforms simultaneously, allows pole synchronization tests to be made.

1. Connect a probe to the **CH 1** input jack and touch the probe tip to the relay contact, switch, or circuit breaker.

2. Set the Adapter **V/DIV** and **TIME/ DIV** controls to appropriate settings and set the **TRIGGER (CH 1) LEVEL** and **SLOPE** controls so that the desired event will trigger the sweep.

3. If you wish to capture pretrigger information, select the desired amount of pretrigger using the **0%** and **50%** switches and press the **SINGLE SHOT** switch before the event occurs. The event will then be stored when the triggered sweep is completed.

4. If you do not wish to capture pretrigger information but still wish to store the spike, disengage both the **0%** and **50%** pretrigger switches and press the **SINGLE SHOT** switch before the event occurs. The event will then be stored when the triggered sweep is completed.

5. To obtain a hard copy of the display, connect a plotter to the plotter outputs on the rear panel, press the **HOLD** switch, select the appropriate sweep time for the plotter being used, and press the **PLOT** switch.

TESTING BATTERY BACK-UP SYSTEMS

Using the Digital Storage Adapter it is possible to measure the time between when ac power is cut off and when the battery back-up takes over.

1. Connect a probe to any point that is powered by both the ac line voltage and the battery back-up system and connect the probe to the **CH 1** input jack on the Adapter.

2. Select the **ROLL** mode of operation and set the Adapter **V/DIV**, **POSITION**, and

the Adapter **TIME/DIV** control is **0.1 ms**, the sweep coefficient is caluculated as follows:

$$\text{sweep coefficient} = \frac{1.75\ \text{kHz}^{-1}}{5\ (\text{div}) \times 0.1\ (\text{ms/div})}$$

$$= 1.143$$

For the example in Fig. 15B, the width of the unknown signal is 7 divisions, and the previously calculated sweep coefficient is 1.143. If the Adapter **TIME/DIV** setting is **0.2 ms**, the period is calculated as follows:

$$\text{Unknown Period} =$$

$$7\ (\text{div}) \times 0.2\ (\text{ms/div}) \times 1.143\ (\text{sweep coef})$$

$$= 1.6\ \text{ms}$$

VIEWING ONE-TIME EVENTS

1. Connect a probe to the **CH 1** input on the Digital Storage Adapter and touch the probe tip to the point in the circuit where the glitch or other one-time event is present.

2. Press the **REFRESH** switch on the Adapter and set the Adapter **V/DIV**, **TIME/DIV**, **POSITION**, **AC/DC**, **SLOPE**, and **TRIGGER (CH 1) LEVEL** controls as desired. When setting the **SLOPE** and **TRIGGER (CH 1) LEVEL** controls, keep in mind that the one-time event that you wish to store should trigger the sweep.

3. If pretrigger information is desired, select the desired amount of pretrigger information using the **0%** and **50%** switches.

4. Press the **SINGLE SHOT** switch (the **ARMED** indicator should light until a sufficient trigger is applied) and wait for the glitch or other one time event to trigger the oscilloscope. Upon completion of the sweep (after triggering) the oscilloscope will automatically store the event (and any pretrigger information if selected).

VIEWING VERY SLOW SIGNALS

Slow signals are difficult to observe on an analog oscilloscope. Below 20 Hz the display flickers or becomes a dot moving across the screen. The Digital Storage Adapter permits easy viewing of slow waveforms (down to 13-1/3 minutes, or 800 seconds, per occurance).

1. Connect a probe to the **CH 1** input on the Digital Storage Adapter and touch the probe tip to the point in the circuit where the signal that you wish to observe is present.

2. Select the **REFRESH** operating mode (**ROLL** operating mode may be selected if prefered) and select **DC** input coupling on the Adapter. Set the Adapter **V/DIV** and **TIME/DIV** controls to appropriate settings and set the Adapter **SLOPE** and **TRIGGER (CH 1) LEVEL** controls so that the signal will trigger the sweep.

3. The waveform should now be displayed on the screen and should refresh the display each time a new sweep is triggered. It can be stored at any time by pressing the **HOLD** switch.

CAPTURING TELEPHONE DIAL PULSES

The relatively slow speed of pulse dial telephones combined with the fact that the dialing pulses are non-repetitive, make it almost impossible to view the pulses with a conventional oscilloscope. The extremely slow sweep speeds of this Digital Storage Adapter allow the capture and analysis of dialing pulses from a pulse dial telephone.

1. Set the oscilloscope for channel 1 display and press the **ROLL** switch on the Adapter. Set the Adapter **SLOPE** switch to **–**, the **V/DIV** control to **10 V**, the **TIME/DIV** control to **1 s**, and the **AC/DC** switch to **DC**.

2. With no signal applied to the Adapter input yet, use the Adapter **POSITION** control to move the trace up to the second horizontal graduation line from the top.

SINGLE TRACE DISPLAY

Usually, channel 1 should be used for single-trace operation. Because the Digital Storage Adapter is usually set to trigger off the channel 1 signal, in order to have a properly triggered display, channel 1 must be used. However, because the oscilloscope uses the external trigger input, either channel may be displayed individually by switching the oscilloscope from a dual trace display to either channel 1 or channel 2 display. It is also possible to use the **EXT TRIG I/P** in conjunction with either the **CH 1** or **CH 2** input (but the **EXT TRIG I/P** jack can only accept a TTL level signal). The following instructions are for true single trace operation using only the **CH 1** input.

1. Perform the steps of the "Initial Set-Up" section.

2. Press the **REFRESH** switch on the Digital Storage Adapter.

3. Connect the probe to the **CH 1** input jack on the Adapter.

4. Set the oscilloscope for single channel display of channel 1.

5. Connect the probe ground clip to the chassis or common of the equipment under test. Connect the probe tip to the point of measurement.

6. If no waveforms appear, increase the sensitivity by turning the Digital Storage Adapter **CH 1 V/DIV** control to a position that gives 2 to 6 divisions vertical deflection on the oscilloscope CRT.

7. The display may not be updating (if the green **TRIG'D** indicator on the adapter does not light). Refer to the TRIGGERING paragraphs in this section for procedures on setting triggering and sweep time controls to obtain a continuously updating display showing the desired number of waveforms.

DUAL TRACE DISPLAY

In observing simultaneous waveforms on channel 1 and 2, the waveforms are usually related in frequency, or one of the waveforms is synchronized to the other, although the basic frequencies are different. If the two waveforms have no phase or frequency relationship there is seldom reason to observe both waveforms simultaneously. However, using the Digital Storage Adapter, two waveforms not related in frequency or period can be simultaneously stored.

1. Perform the steps of the "Intial Set-Up" section.

2. Connect probes to both the Digital Storage Adapter **CH 1** and **CH 2** input jacks.

3. Press the **REFRESH** switch on the Digital Storage Adapter.

4. Connect the ground clips of the probes to the chassis or common of the equipment under test. Connect the tips of the probes to the two points in the circuit where waveforms are to be measured.

5. Set the Digital Storage Adapter **CH 1** and **CH 2 V/DIV** controls to a position that gives 2 to 3 divisions of vertical deflection for each trace.

6. The display may not be updating (if the green **TRIG'D** indicator on the adapter does not light). Refer to the TRIGGERING paragraphs in this section for procedures on setting triggering and sweep time controls to obtain an continuously updating display showing the desired number of waveforms.

TRIGGERING

TRIGGER (CH 1) LEVEL And SLOPE Controls

(Refer to Fig. 3)

A sweep trigger is developed when the trigger source signal crosses a preset threshold level. Rotation of the **TRIGGER (CH 1) LEVEL** control varies the threshold level. In the clockwise direction the triggering threshold shifts to a more positive value, and in the counterclockwise direction, the triggering threshold shifts to a more negative value. When the control is centered, the threshold level is set at approximately zero volts. Proper adjustment of this control causes the display to be continually updated (refreshed each time the trigger threshold is crossed) in the **REFRESH** mode and the green **TRIG'D** indicator on the adapter to light each time the trigger signal crosses the threshold.

The **TRIGGER (CH 1) LEVEL** control adjusts the start of the sweep to almost any desired point on a waveform. On sine wave signals, the phase at which sweep begins is variable. Note that if the **TRIGGER (CH 1) LEVEL** control is rotated toward its extreme settings, no sweep will be developed because the triggering threshold exceeds the peak amplitude of the sync signal (the **TRIG'D** indicator will not light).

When the slope (+/-) switch is set to the (+) position, the sweep is developed from the trigger source waveform as it crosses a threshold level in a positive-going direction. When the slope (+/-) switch is set to the (-) position, a sweep trigger is developed from the trigger source waveform as it crosses the threshold level in a negative-going direction.

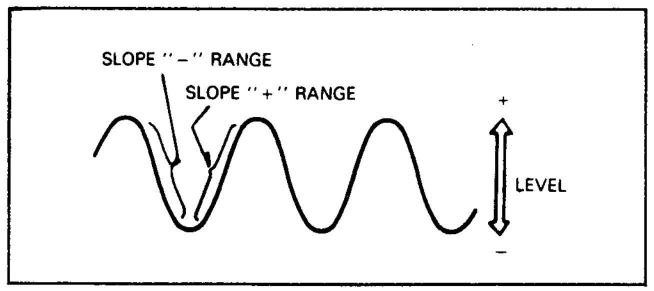

Fig. 3. Function of Slope and Level Controls.

Trigger Source

The Digital Storage Adapter allows you to select either the channel 1 signal or an external TTL level signal (applied to the rear panel **EXT TRIG I/P** jack) as the trigger level source. When the channel 1 signal is selected, the **TRIGGER (CH 1) LEVEL** control and slope control give you full control over triggering point and slope. Virtually any signal of adequate level can be applied to the **CH 1** input jack and adjusted to trigger the sweep. The external trigger signal is limited to TTL level and only the slope can be adjusted (because TTL signals are fixed level square or pulse waves, no level adjustment is necessary or possible). The signal applied to the **EXT TRIG I/P** jack is selected as trigger when the **TRIGGER (CH 1) LEVEL** control is rotated completely counterclockwise (the signal applied to the **CH 1** input jack is selected when the **TRIGGER (CH 1) LEVEL** control is at any position other than fully counterclockwise).

Sweep TIME/DIV Control

To help avoid Aliasing (see APPENDIX I), always start with the fastest sweep speed (20 µs/ div). If only a line is displayed (or too few cycles), try a slower sweep time. When the sweep time is faster than the waveform being observed, only part of the waveform will be displayed. This may appear as a straight line for a square wave or pulse waveform.

MAGNIFIED SWEEP OPERATION

Since merely shortening the sweep time to magnify a portion of an observed waveform can result in the desired portion disappearing off the screen, such magnified display should be performed using the sweep magnification feature of your oscilloscope.

If your oscilloscope has a sweep magnification feature (e.g., X5 MAG or X10 MAG), turn it on. Using the oscilloscope horizontal position control, adjust the desired portion of the waveform to the center of the CRT. For this type of display the sweep time is the **TIME/DIV** setting divided by the magnification factor of the oscilloscope (generally 10).

If your oscilloscope does not have a sweep magnification feature, it is still possible to magnify the display but you will only be able to view a part of the stored waveform. To magnify the oscilloscope display, simply increase the sweep speed setting of the oscilloscope. Note, however that you will have no control over which portion of the stored waveform you can view. Always remember to return the oscilloscope sweep speed control to the 0.1 ms/div position, when you are through magnifiying the waveform.

5 V, the unknown signal is 7.5 V p-p; which was calculated as follows:

Unknown Voltage =

3 (div) x 5 (V/div) x 0.5 (vert coef)

= 7.5 V

NOTE

It is preferable that the reference voltage be the peak-to-peak value, as in the previous example. The measurement holds true for all waveforms if a p-p reference is used. It is also possible to use an rms value for the reference voltage. The unknown voltage value will also be in rms, but the measurement holds true only if both the reference and unknown signals are undistorted sine waves.

Relative Period Measurements
(refer to Fig. 15)

1. Apply the reference signal to the Adapter **CH 1** input jack and adjust the Adapter controls for an easily observed waveform display. Using the Adapter **TIME/DIV** and oscilloscope variable sweep speed controls, adjust one cycle of the reference signal to occupy a fixed number of horizontal divisions. After this is done, be sure not to disturb the oscilloscope variable sweep speed control setting.

2. Calculate the sweep (horizontal) calibration coefficient using the following equation:

$$\text{Sweep coefficient} = \frac{F}{G \times H}$$

Where:
F = Period of reference signal (seconds).
G = Horizontal width of reference signal (divisions).
H = sweep **TIME/DIV** setting.

3. Remove the reference signal and apply the unknown signal to the **CH 1** input jack, using only the Adapter **TIME/DIV** control to adjust the width of the display (do not disturb the oscilloscope variable sweep speed setting).

4. Measure the width of one cycle of the displayed waveform, in divisions. Multiply the number of divisions by the Adapter **TIME/DIV** setting and the sweep coefficient from above to find the period of the unknown waveform.

The measurement is summarized by the following equation:

Unknown Period = Horizontal divisions x

sweep **TIME/DIV** x sweep coefficient

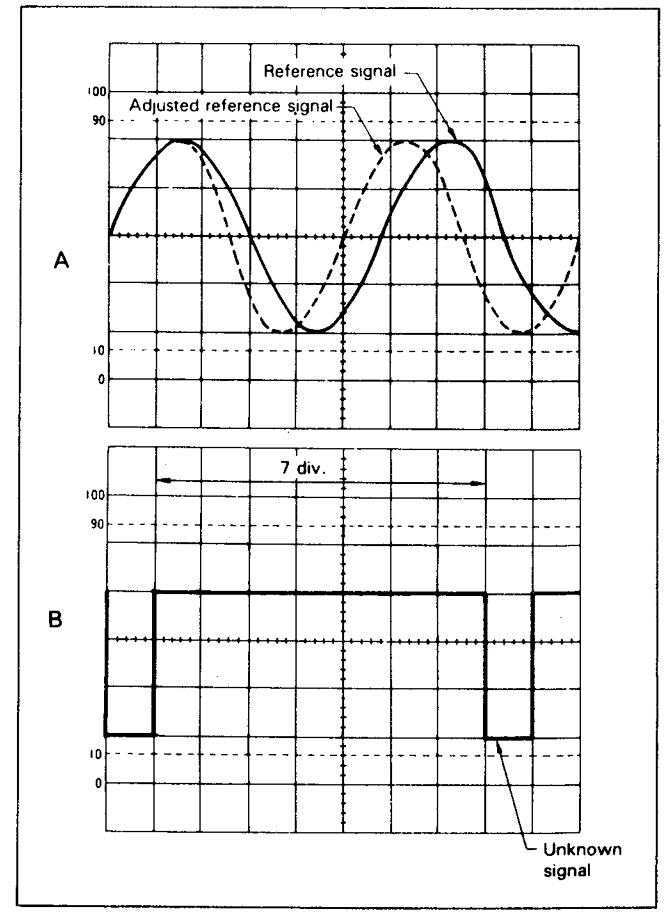

Fig. 15. Period Measurement, Relative Method.

For the example in Fig. 15A, the oscilloscope variable sweep control is adjusted so the reference signal occupies 5 horizontal divisions. If the reference signal is 1.75 kHz, and

RELATIVE MEASUREMENTS

If the amplitude and period of some reference signal are known, an unknown signal may be measured for amplitude and period without the oscilloscope variable attenuator and variable sweep controls set to the calibrated position. The measurement is made in units relative to the reference signal.

Relative Voltage Measurements
(refer to Fig. 14)

1. Apply the reference signal to the Adapter **CH 1** input jack and adjust the Adapter controls for a normal waveform display. Adjust the Adpater **V/DIV** and oscilloscope variable attenuator controls so that the amplitude of the reference signal occupies a fixed number of divisions. After adjusting, be sure not to disturb the setting of the oscilloscope variable attenuator control.

2. Calculate the vertical calibration coefficient as follows:

$$\text{vertical coefficient} = \frac{C}{D \times E}$$

Where:
C = Amplitude of reference signal (in volts).
D = Amplitude of reference signal (in divisions).
E = Adpater **V/DIV** setting.

3. Remove the reference signal and apply the unknown signal to the Adapter **CH 1** input jack, using only the Adapter **V/DIV** control to adjust the amplitude for easy observation (do not disturb the oscilloscope variable attenuator setting).

4. Measure the amplitude of the displayed waveform, in divisions. Multiply the number of divisions by the **V/DIV** setting and the vertical coefficient from above to find the value of the unknown voltage.

The measurement is summarized by the following equation:

$$\text{Unknown Voltage} = \text{Vert div} \times \textbf{V/DIV} \times \text{vert coefficient}$$

For the example shown in Fig. 14, the oscilloscope variable attenuator control is adjusted so the amplitude of the reference signal is 4 divisions. If the reference signal is 2.0 volts p-p, and the Adapter **V/DIV** setting is **1 V**, the vertical coefficient is 0.5; which was calculated as follows:

$$\text{vertical coefficient} = \frac{2\ (V)}{4\ (div) \times 1\ (V/div)} = 0.5$$

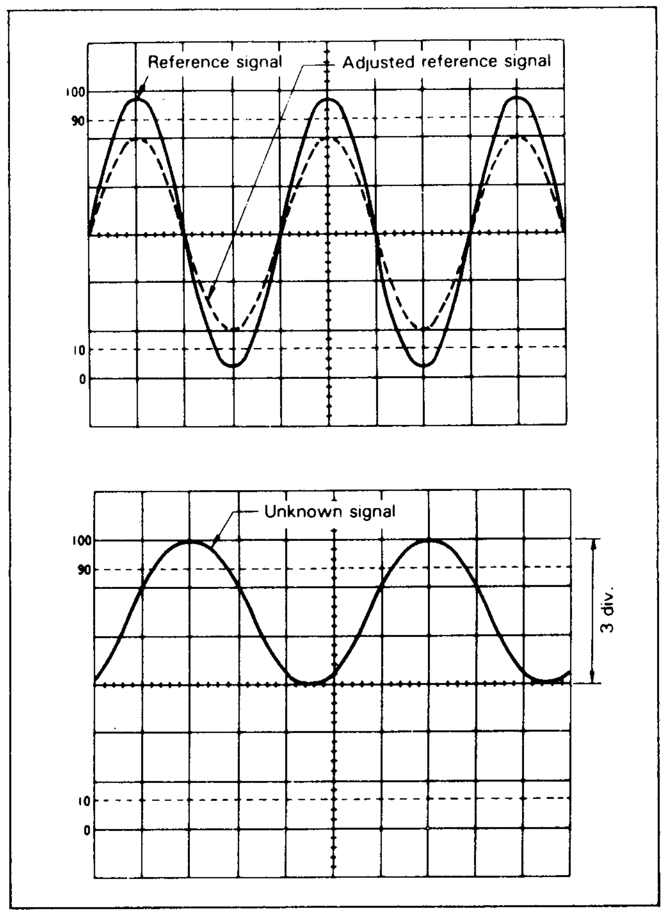

Fig. 14. Voltage Measurement, Relative Method.

For the example shown in Fig. 14, the amplitude of the unknown signal is 3 divisions, and the previously calculated vertical coefficient is 0.5. If the Adapter **V/DIV** setting is

SINGLE SHOT OPERATION

The **SINGLE SHOT** mode of operation is an ideal way to capture one-time (single-shot) events or pre-trigger information.

Storing Post-Trigger Information

1. Perform the steps of the "Initial Set-Up" section.

2. Press the **REFRESH** switch on the Adapter. Make sure that the **PRE-TRIGGER 0%** and **PRE-TRIGGER 50%** switches are disengaged.

3. Select the desired **TIME/DIV, CH 1** and **CH 2 V/DIV, CH 1** and **CH 2 POSITION,** and trigger control settings while viewing the waveform to be stored.

4. Press the **SINGLE SHOT** switch (the yellow **ARMED** indicator will light until the waveform is stored). As soon as the **TRIG'D** indicator lights, the Adapter begins storing the waveform. The display will be blanked from the time that the **SINGLE SHOT** switch is pressed until the waveform is stored. The amount of time varies according to the sweep speed and the length of time before a trigger occurs. That time can vary from imperceptible (for high sweep speeds) to more than 13 minutes (for the 80 s/div sweep speed).

5. To update the display, press the **SINGLE SHOT** switch again. This will store the waveform at the next trigger in the memory and update the display. To return to continuously updating operation, press the **REFRESH** switch.

Storing Pre-Trigger Information

1. Perform the steps of the "Initial Set-Up" section.

2. Press the **REFRESH** switch on the Adapter.

3. Select the desired amount of pre-trigger.

   a. If you wish to fill half of the memory (and display) with pre-trigger information, press the **PRE-TRIGGER 50%** switch.

   b. If you wish to all of the memory (and display) with pre-trigger information, press both the **PRE-TRIGGER 0%** and **PRE-TRIGGER 50%** switches.

4. Select the desired **TIME/DIV, CH 1** and **CH 2 V/DIV, CH 1** and **CH 2 POSITION,** and trigger control settings while viewing the waveform to be stored.

5. Press the **SINGLE SHOT** switch (the yellow **ARMED** indicator will light until the waveform is stored). The instant that the **SINGLE SHOT** switch is pressed, the Adapter will begin loading the memory with the waveform present at the **CH 1** and **CH 2** input jacks. The display will be blanked from the time that the **SINGLE SHOT** switch is pressed until the waveform is stored. The amount of time varies according to the sweep speed and the length of time before the trigger occurs. That time can vary from imperceptible (for high sweep speeds) to more than 13 minutes (for the 80 s/div sweep speed).

   a. If 50% pre-trigger operation is selected, the adapter will continue filling the memory with the signal(s) obtained from the input jack(s) for 1024 (1 K) counts after the trigger (the memory contains a total of 2048 counts - if half of the memory, 1024 counts, is pre-trigger information, then the other half, the other 1024 counts, is post-trigger information).

   b. If 100% pre-trigger operation is selected, the adapter will stop filling the memory with the signal(s) obtained from the input jack(s) the instant that the trigger occurs (all 2 K of memory will contain events immediately before the trigger).

NOTE

Occasionally, when storing 50% or 100% pre-trigger information, part of the display may contain useless information. This happens when the trigger occurs before the memory contains all of the desired pre-trigger information (1024 counts for 50% pre-trigger operation, 2048 counts for 100% pre-trigger operation). When this occurs, part of the information (display) will be data stored from previous operation.

In order to prevent this undesirable event from occuring, the Digital Storage Adapter must be armed for a period of time equal to or greater than the pre-trigger time (figured with the following equation).

$$\text{Time} = \frac{\text{PRE-TRIG \%}}{100} \text{ X TIME/DIV X } 10.24$$

If the Adapter is set for **50% PRE-TRIGGER** and the **TIME/DIV** control is set at **1 ms,** the pre-trigger time is calculated as follows:

$$\text{Time} = \frac{50}{100} \text{ X 1 ms X } 10.24$$

$$\text{Time} = 5.12 \text{ ms}$$

In this example at least 5.12 ms of new signal must elapse between the time that the **SINGLE SHOT** switch is pressed and the time that the first adequate trigger signal occurs.

6. To update the display, press the **SINGLE SHOT** switch again. This will store the waveform and pre-trigger information in the memory and update the display at the next trigger. To go back to a continuously updating display, press the **REFRESH** switch.

ROLL OPERATION

In the **ROLL** operating mode, the waveform rolls across the CRT from the right side of the screen to the left (as opposed to standard oscilloscopes which have the trace moving from left to right) in the same manner as most strip chart recorders. This is convenient for viewing very slow events and for users that are familiar with the use of strip chart recorders rather than oscilloscopes. The **ROLL** mode is not a triggered sweep operation and therefore the **TRIGGER (CH 1) LEVEL** and **SLOPE** controls have no effect on the display.

1. Perform the steps of the "Initial Set-Up" section.

2. Make sure that the **ROLL** switch is engaged and set the **TIME/DIV, V/DIV, POSITION,** and trigger controls as desired.

NOTE

While it is possible to use the **ROLL** mode of operation with sweep speeds up to 5 ms/div, sweep speeds faster than about 0.1 s/div generally make it difficult to view the display because it "rolls" across the CRT at such a rapid rate. For most "roll" applications, sweep speeds should be limited to 0.1 s/div or slower.

LONG TERM WAVEFORM STORAGE

Once a waveform is digitized it can be stored in long term memory by pressing the **HOLD** switch. The **HOLD** switch immediately freezes the display and stores both the channel 1 and channel 2 waveforms. Once waveforms are stored by engaging the **HOLD** switch, the waveforms will be stored until the **HOLD** switch is disengaged or the power is turned off.

COMPARING WAVEFORMS

One of the primary advantages of using a digital storage device is the ability to store a waveform and compare it to another stored or continuously updated waveform. Using the Digital Storage Adapter, a waveform can be stored in the channel 2 memory and compared to the channel 1 signal (stored or continuously refreshed display).

izontally (see Fig. 12). The Adapter **TRIGGER (CH 1) LEVEL** and oscilloscope horizontal position controls are also useful in achieving this display. The display should be as shown in Fig. 12, where one division now represents 45^o in phase.

4. Measure the horizontal distance between corresponding points on the two waveforms. Multiply the distance (in divisions) by 45^o per division to obtain the phase difference.

The measurement is summarized by the following equation:

$$\text{Phase difference} = \text{Hor div x } 45^o/\text{div}$$

For the example shown in Fig. 12, the horizontal distance is 1.7 divisions. Thus, the phase difference is calculated as follows:

$$\text{Phase difference} = 1.7 \text{ x } 45^o/\text{div} = 76.5^o$$

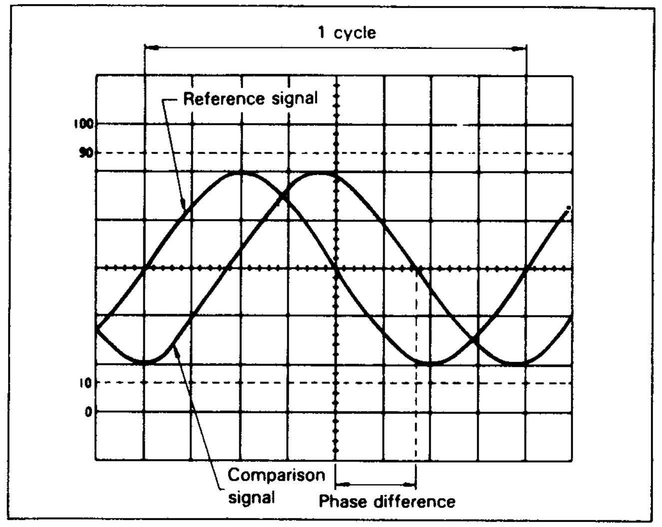

Fig. 12. Phase Difference Measurement.

Method No. 2
(Refer to Fig. 13)

The previous procedure allows 45^o per division, which may not give the desired accuracy for small phase differences.

If greater accuracy is required, the Adapter **TIME/DIV** setting may be changed to expand the display as shown in Fig. 13, but the oscilloscope variable sweep setting must not be touched. If necessary, the **TRIGGER (CH 1) LEVEL** may be readjusted. For this type of operation, the relationship of one division to 45^o no longer holds. Instead the following equation must be used:

$$\text{Phase diff} = \text{Hor div x } 45^o/\text{div x } \frac{A}{B}$$

Where:
A = New sweep **TIME/DIV** setting.
B = Original sweep **TIME/DIV** setting.

A simpler method of obtaining more accuracy quickly is to simply use the oscilloscope times 10 sweep magnification for a scale factor of 4.5^o/division.

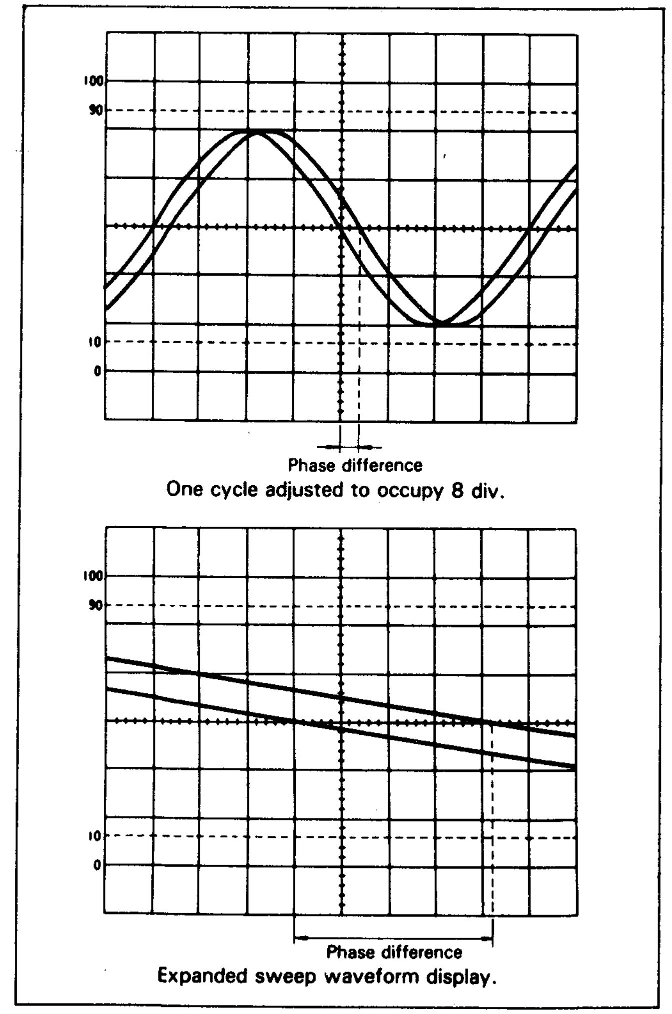

Fig. 13. Measuring Small Phase Difference.

Pulse Width =

4.6 (div) x 0.2 (ms/div) x 1/10

= .092 ms or 92 µs

TIME DIFFERENCE MEASUREMENTS
(Refer to Fig. 11)

This procedure is useful in measurement of time difference between signals that are synchronized to one another but skewed in time.

1. Apply the two signals to the Adapter **CH 1** and **CH 2** input jacks. Connect the faster of the two signals to the **CH 1** input so that it will be the trigger source.
2. Set the oscilloscope for dual trace display and use the Adapter **V/DIV** and sweep **TIME/DIV** controls to obtain an easily observed display.
3. Use the Adapter **POSITION** controls to superimpose both waveforms to intersect the center horizontal graduation line as shown in Fig. 11. Use the oscilloscope horizontal position control to set the reference signal coincident with one of the vertical graduation lines.
4. Measure the horizontal distance between the two signals and multiply this distance (in divisions) by the Adapter **TIME/DIV** setting. If times 10 magnification is used on the oscilloscope, multiply this again by 1/10.

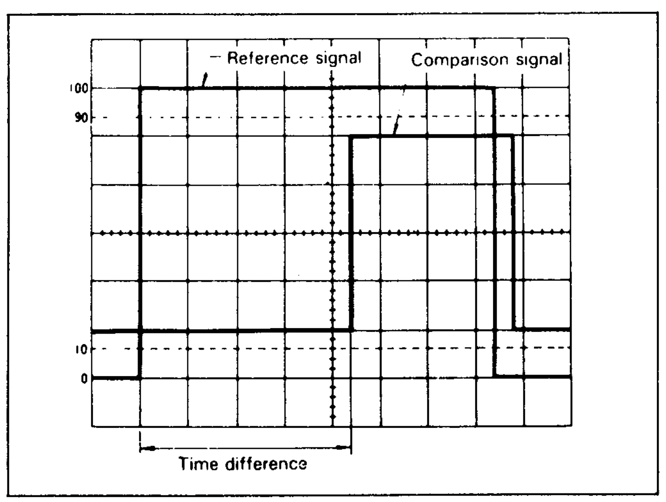

Fig. 11. Time Difference Measurement.

The measurement is summarized by the following equation:

Time = Hor div x sweep **TIME/DIV**

(x 1/10 if sweep magnification is used)

For the example shown in Fig. 11, the horizontal distance measured is 4.4 divisions. If the Adapter **TIME/DIV** setting is **0.2 ms** and sweep magnification is not used, the time difference is calculated as follows:

Time = 4.4 (div) x 0.2 (ms/div)

= 0.88 ms or 880 µs

PHASE DIFFERENCE MEASUREMENTS

Method No. 1
(Refer to Fig. 12)

This procedure is useful in measuring the phase difference of signals of the same frequency.

1. Apply the two signals to the Adapter **CH 1** and **CH 2** input jacks. Connect the signal which is leading in phase to the **CH 1** input so that it becomes the trigger source.
2. Set the oscilloscope for dual trace display and use the Adapter **V/DIV** and the oscilloscope step and variable vertical attenuator controls to adjust the two waveforms so they are equal in amplitude.

NOTE
Make sure that the oscilloscope vertical attenuator controls are not adjusted to the point where the waveform(s) being observed is clamped.

3. Use the Adapter **POSITION** controls to position the waveforms in the vertical center of the screen. Use the Adapter **TIME/DIV** control and the oscilloscope step and variable sweep controls to adjust the display so one cycle (360°) of the reference signal occupies 8 divisions hor-

1. Perform the steps of the "Initial Set-Up" section.
2. Press the **REFRESH** switch on the Adapter.
3. Adjust the Adapter controls as desired for optimum viewing of the channel 2 waveform.
4. Press the **SAVE CH 2** switch on the adapter. The channel 2 signal is now stored in memory and can be compared to the channel 1 signal. If the channel 1 signal is continuously refreshed (**REFRESH** operation with adequate trigger signal present), the channel 1 signal can be manipulated as desired using the **CH 1 V/DIV** and **POSITION** controls. It is also possible to manipulate the channel 2 (or channel 1 if desired) waveform using the oscilloscope controls (make certain that after the waveforms have been compared, the oscilloscope controls are returned to the same settings as before the storage operation).
5. To return the Adapter to **REFRESH** operation, release the **SAVE CH 2** switch. Once the **SAVE CH 2** switch is released, the channel 2 display will again be refreshed on each trigger.

X-Y OPERATION

Unlike many Digital Storage Oscilloscopes (DSO's), the Digital Storage Adapter allows you to use the X-Y function of your oscilloscope (many DSO's only allow you to use the X-Y function in the analog mode of operation). This allows you to perform many measurements not possible with conventional sweep operation. The CRT display becomes an electronic graph of two instantaneous voltages. The display may be a direct comparison of the two voltages such as vectorscope display of video color bar patterns. However, the **X-Y** mode can be used to graph almost any dynamic characteristic if a transducer is used to change the characteristic (frequency, temperature, velocity, etc.) into a voltage. One common application is frequency response measurements, where the Y axis corresponds to signal amplitude and the X axis corresponds to frequency.

1. Set-up the oscilloscope for X-Y operation. Generally in this mode, channel 1 becomes the X axis input and channel 2 becomes the Y axis input (some oscilloscopes may vary however - keep in mind that the Digital Storage Adapter **CH 1** output signal must be applied to one axis input and the **CH 2** output must be applied to the other). For these instructions, it is assumed that on the oscilloscope being used, channel 1 is the X-axis and channel 2 is the Y-axis.
2. Press the **ROLL** switch on the Digital Storage Adapter.
3. The X position is now adjusted using the adapter **CH 1 POSITION** control and the Y position is adjusted using the oscilloscope horizontal position control (do not use the adapter **CH 2 POSITION** control to adjust the Y position - the control has very little range of adjustment when used for X-Y operation and will "clamp" the signal if overadjusted).
4. Adjust the amount of horizontal (X axis) deflection with the **CH 1 V/DIV** control.
5. Adjust the amount of vertical (Y axis) deflection with the **CH 2 V/DIV** control.
6. When using the Digital Storage Adapter to view an X-Y display, it is best to try several different sweep speeds (on the Adapter) while observing the waveform (pick the one that produces a waveform most like that you would see on a conventional oscilloscope). It should be noted however, that it will almost never be possible to produce a waveform identical to that seen when feeding the signals directly to a conventional oscilloscope. Usually at least one bright dot will be present on the waveform (for some sweep speeds and applications several bright dots may appear).

USING THE PLOTTER OUTPUT

The Digital Storage Adapter provides facilities for driving an analog plotter. The following instructions explain how to store and output a waveform. Since plotters vary greatly, only general instructions have been given, consult the manual for the plotter to be used for more specific operating instructions.

1. Preform the steps of the "Initial Set-Up" section.

2. Select **ROLL** or **REFRESH** mode of operation as desired.

3. Adjust the trigger, **V/DIV**, **TIME/DIV**, and vertical position controls on the Adapter as desired.

4. Press the **HOLD** switch on the Adapter.

5. Connect the **CH 1** and/or the **CH 2** output jack(s) (at the rear panel of the Adapter) to the signal input jack(s) of the plotter.

6. Connect the **SCOPE TRIGGER (PEN LIFT)** jack (also at the rear of the Adapter) to the pen lift jack of the plotter.

7. After the waveform has been stored, the Adapter **TIME/DIV** control can be set for a "sweep speed" that is correct for the plotter that is being used.

8. Press the **PLOT** switch on the Adapter. The yellow **PEN DOWN** indicator will light when the **PEN LIFT** output to the plotter is at a TTL low level. For most plotters, a TTL low signal causes the pen to drop to the paper. When the indicator is off, the **PEN LIFT** output is at a TTL high level. Conversely, this will cause the pen to lift on most plotters. The **PEN LIFT** output will be low for the duration of the time that it takes to "dump" its memory at the output (equal to 10.24 times the **TIME/DIV** setting).

NOTE

The design of the Digital Storage Adapter causes the **PEN LIFT** output to be high for a period of time equal to the time that it is low. When the **PLOT** switch is first pressed, the **PEN LIFT** output could be at either a high or low level (the level and point at which the **PEN LIFT** signal is at are random). Therefore, the plotter may have to wait for the "pen down" signal for a period of time equal to 10.24 times the **TIME/DIV** setting. This period could be as long as 13.65 minutes (819.2 seconds).

When capturing the entire waveform is necessary, nothing can be done to eliminate this wait. However, because the output time is so long for very low sweep speeds, missing the very beginning of the waveform should not be significant for many applications. If the beginning of the waveform is not needed, the **TIME/DIV** setting can be increased to about the **1 s/div** setting (this will cause the maximum delay to be only 10.24 seconds) until the **PEN DOWN** indicator first lights. The instant that you observe the **PEN DOWN** indicator turn on, decrease the sweep speed back to the desired setting.

DELAYED (DUAL) SWEEP OPERATION

The Digital Storage Adapter is specifically designed to work with a basic, "no-frills", dual-trace oscilloscope. However, it can still be used with more expensive "full featured" oscilloscopes. The delayed (or dual) sweep function that such oscilloscopes offer is an excellent way to magnify the waveform. In many ways it is actually better than the sweep magnification feature that many oscilloscopes offer. This is because you can control the amount of magnification (controlled by the delayed or B sweep control), view both the unmagnified and magnified waveform simultaneously, and magnify any point desired on the waveform.

If must be remembered when using the delayed sweep function of an oscilloscope that

calculate the time span. Multiply the reciprocal of this value by the number of cycles present in the time span. If sweep magnification is used on the oscilloscope, multiply this further by the magnification factor (usually 10). Note that errors will occur for displays having only a few cycles.

The measurement is summarized by the following equation:

$$\text{Freq} = \frac{\text{No of cycles (x 10 for sweep mag)}}{\text{Hor div x sweep TIME/DIV}}$$

For the example shown in Fig. 9, there are 10 cycles within 7 divisions. If the Adapter **TIME/DIV** setting is **50 µs** and sweep magnification is not used, the frequency is calculated as follows:

$$\text{Freq} = \frac{10 \text{ (cycles)}}{7 \text{ (div) x } 50 \text{ (µs)}} = 28.57 \text{ kHz}$$

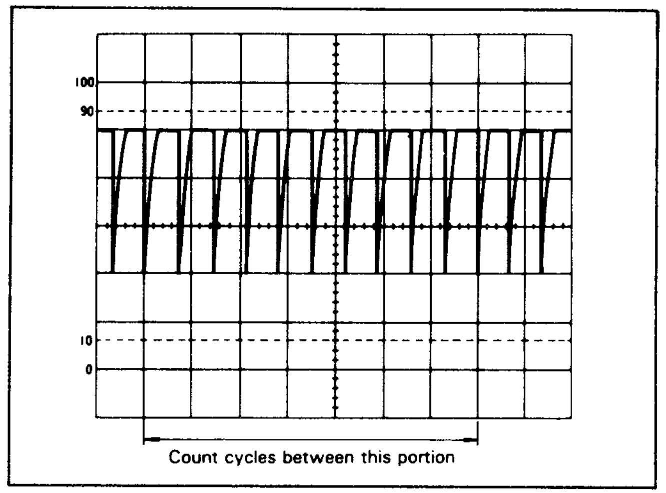

Fig. 9. Alternate Method of Frequency Measurement.

PULSE WIDTH MEASUREMENTS

(Refer to Fig. 10)

1. Connect the pulse signal to be measured to the **CH 1** input jack on the Adapter, set the oscilloscope to display the channel 1 signal, and press the **REFRESH** switch on the Adapter.

2. Use the Adapter **V/DIV** control to adjust the display so the waveform is easily observed. Use the Adapter **POSITION** control to position the pulse over the center horizontal graduation line. Use the oscilloscope horizontal position control to align the leading edge of the pulse with one of the vertical graduation lines.

3. Measure the distance between the leading edge and trailing edge of the pulse (along the center horizontal graduation line). Be sure that the oscilloscope variable sweep control is set to the calibrated position. Multiply the number of horizontal divisions by the Adapter **TIME/DIV** setting, and if the oscilloscope times 10 sweep magnification is used, further multiply this value by 1/10.

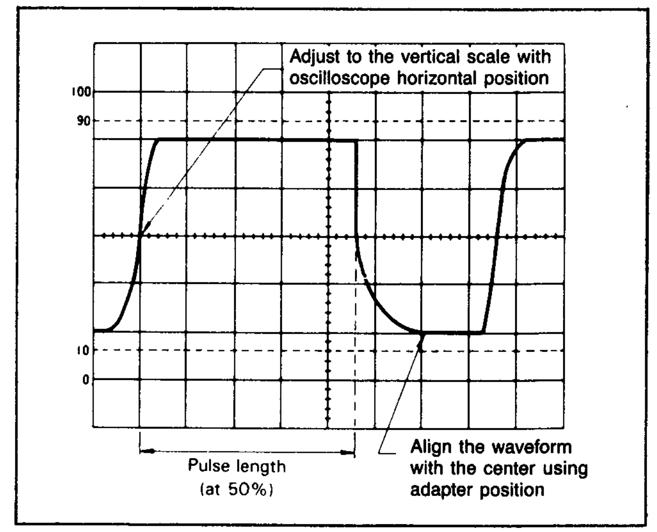

Fig. 10. Pulse Width Measurement.

The measurement is summarized by the following equation:

Pulse Width = Hor div x sweep **TIME/DIV**

(x 1/10 if sweep magnification is used)

For the example shown in Fig. 10, the pulse width at the center of the pulse is 4.6 divisions. If the Adapter **TIME/DIV** setting is **0.2 ms** and the oscilloscope sweep magnification is used, the pulse width is calculated as follows:

The measurement is summarized by the following equation:

$$\text{Time} = \text{Hor div} \times \text{sweep } \mathbf{TIME/DIV}$$

$$(\times\ 1/10 \text{ if sweep mag is used})$$

For the example shown in Fig. 7, the horizontal distance between the two points is 5.4 divisions. If the **TIME/DIV** setting is **0.2 ms** and the oscilloscope sweep magnification is not used, the time period is calculated as follows:

$$\text{Time} = 5.4 \text{ (div)} \times 0.2 \text{ (ms/div)}$$

$$= 1.08 \text{ ms}$$

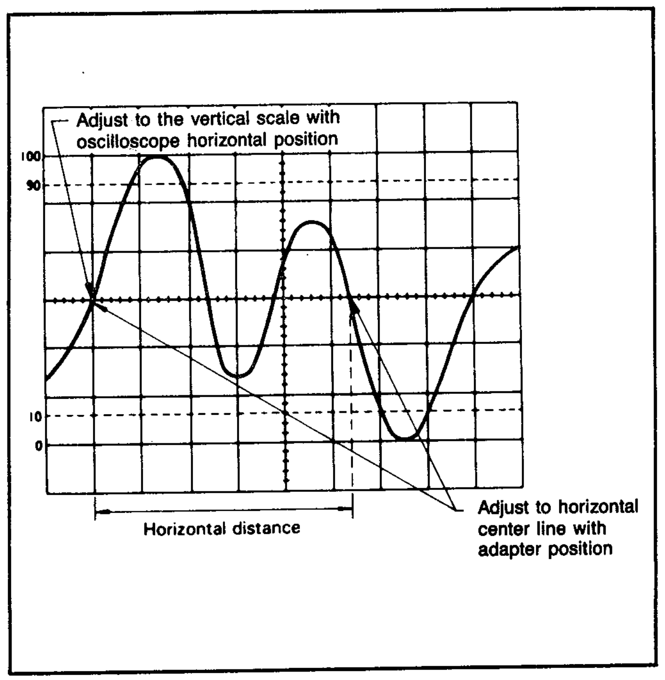

Fig. 7. Time Measurement.

FREQUENCY MEASUREMENTS

Method No. 1
(Refer to Fig. 8)

Frequency measurements are made by measuring the time period of one cycle of waveform and calculating the frequency, which equals the reciprocal of the time period.

1. Set up the adapter and the oscilloscope to display one cycle of the waveform (see Fig. 8).

2. Measure the time period of one cycle and calculate the frequency as follows:

$$\text{Freq} = \frac{1}{\text{Period}}$$

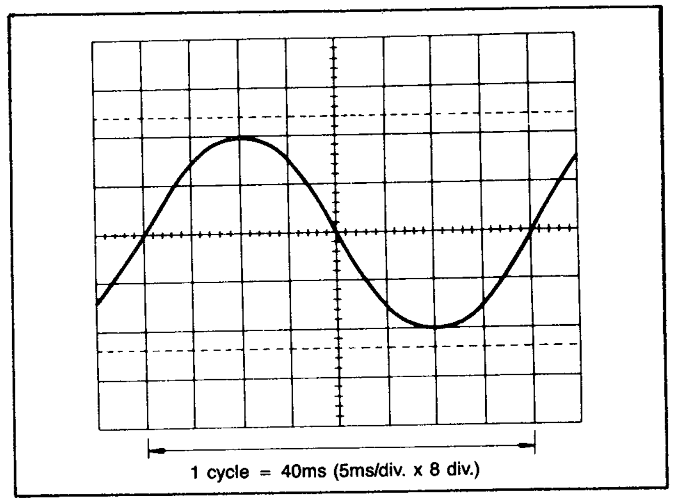

Fig. 8. Frequency Measurement.

In the example shown in Fig. 8, a period of 0.4 ms is observed. Substituting this value into the above equation, the frequency is calculated as follows:

$$\text{Freq} = \frac{1}{0.4 \times 10^{-3}}$$

$$= 2.5 \times 10^{3}$$

$$= 2.5 \text{ kHz}$$

Method No. 2
(Refer to Fig. 9)

While the previously described method relies upon direct period measurement of one cycle, the frequency may also be measured by counting the number of cycles present in a given time period.

1. Set up the Adapter and oscilloscope to display several cycles of the waveform.

2. Count the number of cycles of waveform between a chosen set of vertical graduation lines (see Fig. 9).

3. Multiply the number of horizontal divisions by the Adapter **TIME/DIV** setting to

the actual sweep speed of the delayed (or B) sweep is not simply the setting of the delayed (B) sweep time/div control on the oscilloscope. To figure the actual sweep speed of the waveform being viewed, divide the delayed (B) sweep speed setting of the oscilloscope by the main (or A) sweep speed setting (this should normally be 0.1 ms/div) of the oscilloscope. Multiply this value by the **TIME/DIV** setting of the Adapter. The actual sweep speed (Time/Div) setting of the delayed sweep is computed by the following equation:

$$\text{Actual Time/Div} = A \times \frac{B}{C}$$

where:

A = sweep speed (**TIME/DIV**) setting of Adapter.
B = Delayed (or B) sweep speed setting of oscilloscope.
C = Main (or A) sweep speed setting of oscilloscope (always 0.1 ms/div).

If a 100 Hz signal is applied to the Adapter, the Adapter is set for a sweep speed of **10 ms/div**, and the delayed sweep speed of the oscilloscope is set at 1 µs/div, the sweep time is calculated as follows:

$$\text{Actual Time/Div} = 10 \text{ ms} \times \frac{1\ \mu s}{0.1 \text{ ms}}$$

$$\text{Actual Time/Div} = 0.1 \text{ ms}$$

This number should always be faster than the sweep speed setting of the Adapter. While with some oscilloscopes it may be possible to select a slower sweep speed for the delayed (B) sweep than the main (A) sweep, this type of display would have no advantage. In fact, because the Adapter does not feed the waveform to the oscilloscope except immediately following a sync pulse, the display would show a "blanking period" between each "memory content" as shown in Fig. 4 (the memory content is what you would see on one complete display with the oscilloscope set for 0.1 ms/div). There are no practical applications for this type of signal.

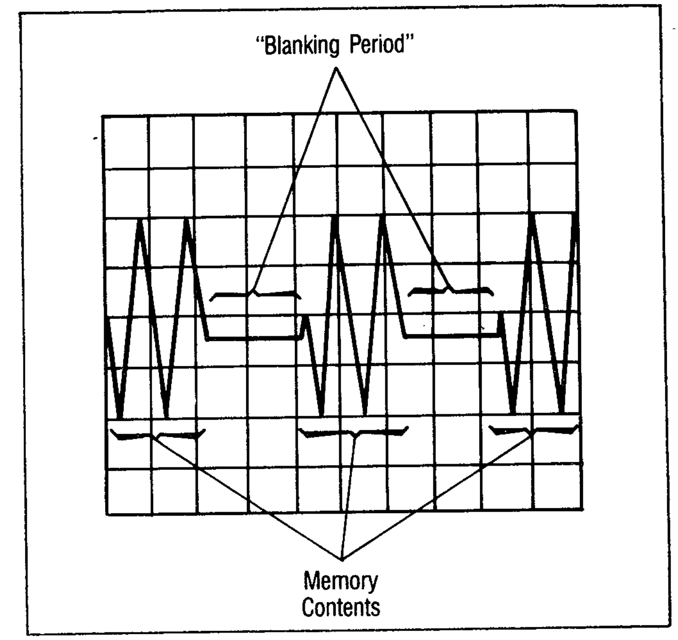

Fig. 4. Incorrect Display When Sweep Speed Is Set Too Low.

NON-STORE OPERATION

The **NON-STORE** switch on the Digital Storage Adapter allows the digital storage circuitry to be bypassed for a quick check of the waveform in analog form. The only controls on the Adapter that effect the display in the **NON-STORE** mode are the **V/DIV, POSITION,** and **AC/DC** switches. Because the Adapter **TIME/DIV** and triggering controls have no effect on the display, the oscilloscope must be switched to trigger off the channel 1 or channel 2 signal and the trigger level and sweep speed must be adjusted on the oscilloscope.

The **NON-STORE** operating mode is only intended for checking signal presence and for checking the general appearance of the waveform. Because the accuracy of the Digital Storage Adapter is ±30% in the **NON-STORE** mode, no measurements should be made while in this mode. If you wish to measure or analyze a purely analog (non digitized) signal, the signal should be connected directly to the oscilloscope. Remember to return the oscilloscope controls to the proper settings before returning to the **STORE** operating mode.

DC VOLTAGE MEASUREMENTS
(Refer to Fig. 5)

The following technique may be used to measure the instantaneous dc level at any portion of a waveform, or to measure a dc voltage where no waveform is present.

1. Connect the signal to be measured to the **CH 1** input jack on the Adapter and set the oscilloscope to display the channel 1 signal. Press the **REFRESH** switch on the Adapter, set the Adapter **AC/DC** switch to the **DC** position (to observe the waveform and its dc component), and set the Adapter **V/DIV** and sweep **TIME/DIV** controls to obtain a normal display of the waveform to be measured.

2. Remove the signal from the input of the **CH 1** input jack on the Adapter and press the **ROLL** switch. This will establish a zero volt reference (the Adapter must be placed in the **ROLL** mode because with no trigger applied, the display cannot be updated in the **REFRESH** mode).

3. Using the Adapter **CH 1 POSITION** control, adjust the trace to the desired reference level position, making sure not to disturb this setting once made.

4. Apply the signal to the Adapter **CH 1** input again and press the **REFRESH** switch. If an inappropriate reference level position was selected in step 3 or an inappropriate **V/DIV** setting was made, the waveform may not be visible at this point (deflected completely off the screen). This is especially true when the dc component is large with respect to the waveform amplitude. If so, reset the Adapter **V/DIV** control and repeat steps 2 through 4 until the waveform and the zero reference are both on the screen.

5. Use the oscilloscope horizontal position control to bring the portion of the waveform to be measured to the center vertical graduation line of the graticule scale.

6. Measure the vertical distance from the zero reference level to the point to be measured (at least 3 divisions desirable for best accuracy). The reference level can be rechecked by momentarily removing the signal from the input of the Adapter and switching back to the **ROLL** operating mode.

7. Multiply the distance measured above by the Adapter **V/DIV** setting and the probe attenuation ratio as well. Voltages above the reference level are positive and voltages below the reference level are negative.

The measurement is summarized by the following equation:

DC level = Vert div x **V/DIV** x Probe

For the example shown in Fig. 5, the point being measured is 3.8 divisions from the reference level (ground potential). If the Adapter **V/DIV** control is set to **0.2 V** and a 10:1 probe is used, the dc voltage level is calculated as follows:

DC level = 3.8 (div) x 0.2 (V/div) x 10

= 7.6 V

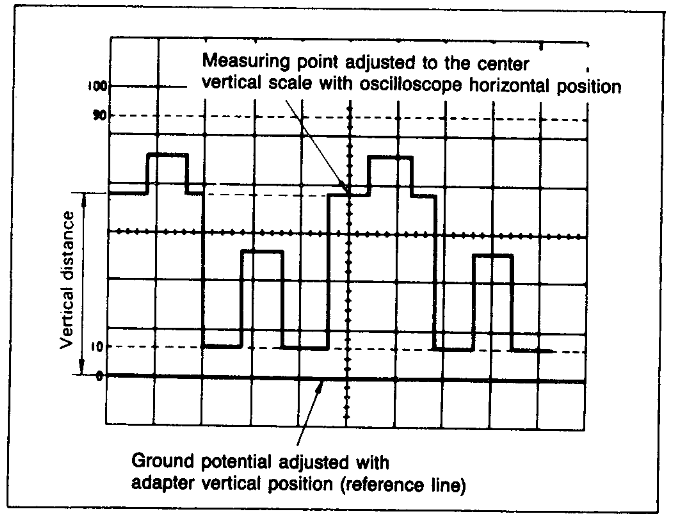

Fig. 5. DC Voltage Measurement.

MEASUREMENTS OF VOLTAGE BETWEEN TWO POINTS ON A WAVEFORM
(Refer to Fig. 6)

This procedure may be used to measure peak-to-peak voltages, or for measuring the voltage difference between any two points on a waveform.

1. Connect the signal to be measured to the **CH 1** input jack on the Adapter and set the oscilloscope to display the channel 1 signal. Press the **REFRESH** switch on the Adapter and set the Adapter **AC/DC** switch to **AC.** Set the Adapter **V/DIV** and sweep **TIME/DIV** controls to obtain a normal display of the waveform to be measured.

2. Using the Adapter **CH 1 POSITION** control, adjust the waveform position such that one of the two points falls on a major horizontal graduation line on the CRT.

3. Using the oscilloscope horizontal position control, adjust the second point to coincide with the center vertical graduation line on the CRT.

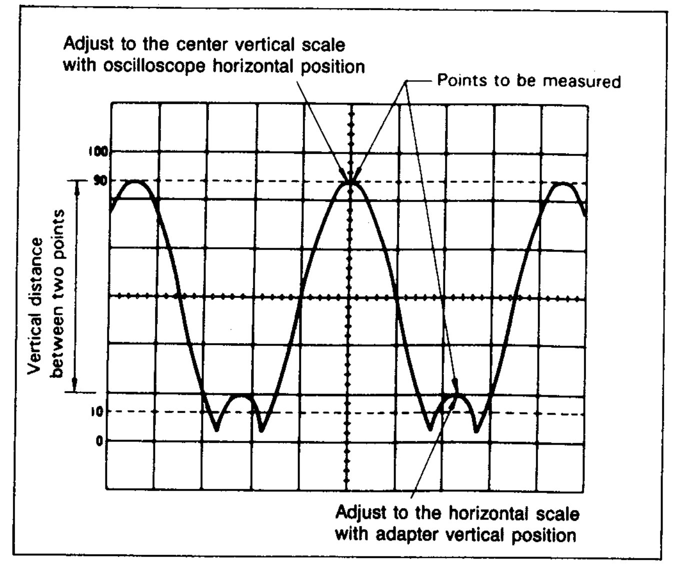

Fig. 6. Voltage Measurement.

4. Measure the vertical distance between the two points (at least 3 divisions desirable for best accuracy). Multiply the number of divisions by the setting of the Adapter **V/DIV** control. If a probe is used, further multiply this by the probe attenuation ratio.

The measurement is summarized by the following equation:

Voltage = Vert div x **V/DIV** x probe

For the example shown in Fig. 6, the two points are separated by 4.4 divisions vertically. If the Adapter **V/DIV** setting is **20 mV** and a 10:1 probe is used, the voltage is calculated as follows:

Voltage = 4.4 (div) x 20 (mV/div) x 10

= 880 mV

TIME MEASUREMENTS
(Refer to Fig. 7)

This is the procedure for making time (period) measurements between two points on a waveform. The two points may be the beginning and ending of one complete cycle if desired.

1. Connect the signal to be measured to the **CH 1** input jack on the Adapter and set the oscilloscope to display the channel 1 signal. Press the **REFRESH** switch on the Adapter and set the Adapter **V/DIV** and sweep **TIME/DIV** controls to obtain a normal display of the waveform to be measured.

2. Using the Adapter **CH 1 POSITION** control, set one of the points to be used as a reference to coincide with the horizontal center line. Use the oscilloscope horizontal position control to set this point at the intersection of any vertical graduation line.

3. Measure the horizontal distance between the two points (at least 4 divisions desirable for best accuracy). Multiply this by the setting of the Adapter **TIME/DIV** control to obtain the time between the two points. If times 10 magnification is used on the oscilloscope, multiply this further by 1/10.