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INSTRUCTION MANUAL

BK PRECISION®

MODEL 2522

20 MHz, 10 MSample/sec DIGITAL STORAGE/ANALOG OSCILLOSCOPE

Patent Pending

BK PRECISION®

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MODEL 2522 SPECIFICATIONS

CRT:

Type:
Rectangular with internal graticule.

Display Area:
8 x 10 div(1 div = 1 cm).

Accelerating Voltage:
2 kV.

Phosphor:
P31.

VERTICAL AMPLIFIERS (CH 1 and CH 2)

Sensitivity:
5 mV/div to 5 V/div in 1-2-5 sequence, 10 steps. Vernier control provides fully adjustable gain between steps and increases maximum sensitivity to 1 mV/div (at reduced bandwidth).

Accuracy:
±3%.

Input Resistance:
1 MΩ ±2%.

Input Capacitance:
35 pF ±5 pF.

Frequency Response:
5 mV to 5 V/div (calibrated):
DC to 20 MHz (-3 dB).
1 mV/div (uncalibrated):
DC to 10 MHz (-3 dB).

Rise Time:
Approximately 17.5 ns.

Operating Modes:

CH 1:	CH 1, single trace.
CH 2:	CH 2, single trace.
ALT:	dual trace, alternating.
CHOP:	dual trace, chopped.
ADD:	algebraic sum of CH 1 + CH 2.

Polarity Reversal:
CH 1 only.

Maximum Input Voltage:
400 V dc + ac peak.

Maximum Undistorted Amplitude:
DC-to-20 MHz: 4 divisions.
DC-to-10 MHz: 8 divisions.

HORIZONTAL AMPLIFIER
(Input through channel 2 input)

X-Y mode: switch selectable using X-Y switch.
CH 1: Y axis.
CH 2: X axis.

Sensitivity:
Same as vertical channel 2.

Accuracy:
Y-Axis: ±3%.
X-Axis: ±6%.

Input Impedance:
Same as vertical channel 2.

Frequency Response:
DC to 2 MHz typical (-3 dB) to 6 divisions horizontal deflection.

X-Y Phase Difference:
Approximately 3^{o} at 50 kHz.

Maximum Input Voltage:
Same as vertical channel 2.

SWEEP SYSTEM

Sweep Speed:
0.5 µs/div to 0.2 s/div in 1-2-5 sequence, 18 steps. Vernier control provides fully adjustable sweep time between steps.

Accuracy:
±3%.

Sweep Magnification:
10X, ±6%.

TRIGGERING

Trigger Modes:
AUTO (free run) or NORM.

Trigger Source:
CH 1, CH 2, ALT, EXT, LINE.

Maximum External Trigger Voltage:
200 V dc + ac peak.

Trigger Coupling:

AC	30 Hz to 30 MHz.
TV H/HF	Used for triggering from horizontal sync pulses. Low frequencies attenuated.
TV V	Used for triggering from vertical sync pulses.
DC/LF	High frequencies attenuated. Direct coupled.

Trigger Sensitivity:

Internal:	0.5 division.
Extenal:	500 mV.

DIGITAL STORAGE FACILITIES

Storage Word Size:
2048 x 8 bits/channel (2 k/channel with direct sampling, 1 k/channel with equivalent time sampling).

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

Horizontal Resolution:
1 in 2048, approximately 200 samples/div.

Sampling Rate:
10 M samples/sec to 10 samples/sec, reduced in proportion to time base. Direct sampling at time base settings of 20 µs/div and slower, equivalent time sampling at time base settings of 10 µs/div and faster.

Time Base Expander:
For storage of slow time events, time base steps 10 ms/div and slower have selectable 1/1 or 1/100 rate. 1/100 rate expands time base from 1 sec/div to 20 sec/div in 1-2-5 sequence.

Equivalent Time Sampling Bandwidth:
20 MHz for repetitive waveforms.

Dot Joining:
Linear interpolation between samples.

Digital Display Modes:
Roll:
Stored data and display updated continually.
Refresh:
Stored data and display updated by triggered sweep.
Hold:
Freezes channel 1 and channel 2 data immediately.
Save CH 2:
Freezes channel 2 data immediately.
Pretrigger Storage:
Available in single shot mode, switchable to 0% or 50%.

PLOT OUTPUT
Analog output of the stored display.

CH 1 and CH 2 Outputs:
Selected by PLOT switch on rear panel. Output via CH1 OUTPUT and CH2 OUTPUT jacks on rear panel. Amplitude 0.2 V/div (2 V maximum).

Output Sweep Rate
Output sweep rate is 1/10 of TIME/DIV setting (and 1/100 switch when applicable).

Pen Lift Output:
Available at PEN DOWN jack on rear panel. TTL high, pen up. TTL low, pen down.

INDICATIONS

Trigger:	Green LED
Arm:	Red LED
Pen Down:	Red LED

OTHER SPECIFICATIONS

Y Output (on rear panel):

Output Voltage:
50 mV/div (nominal into 50-ohm load).

Output Impedance:
Approximately 50 ohms.

Frequency Response:
20 Hz to 10 MHz, -3 dB into 50 Ω.

Cal/Probe Compensation Voltage:
0.2 V p-p ±2% square wave, 1 kHz nominal.

Power Requirements:
120 V/220 V ±10%, 50/60 Hz, Approximately 60 W.

Dimensions: (H x W x D)
5-3/4 x 13-3/8 x 17" (146 x 340 x 430 mm).

Weight:
Approx. 22 lb. (10 kg).

Environment:

Within Specified Accuracy:
+10° to +35° C, 85% maximum relative humidity.

Full Operation:
0° to +40° C, 85% maximum relative humidity.

Storage:
-20° to +70° C.

ACCESORIES SUPPLIED
Two 10:1 Probes.
Instruction Manual.
AC Power Cord.

CONTROLS AND INDICATORS

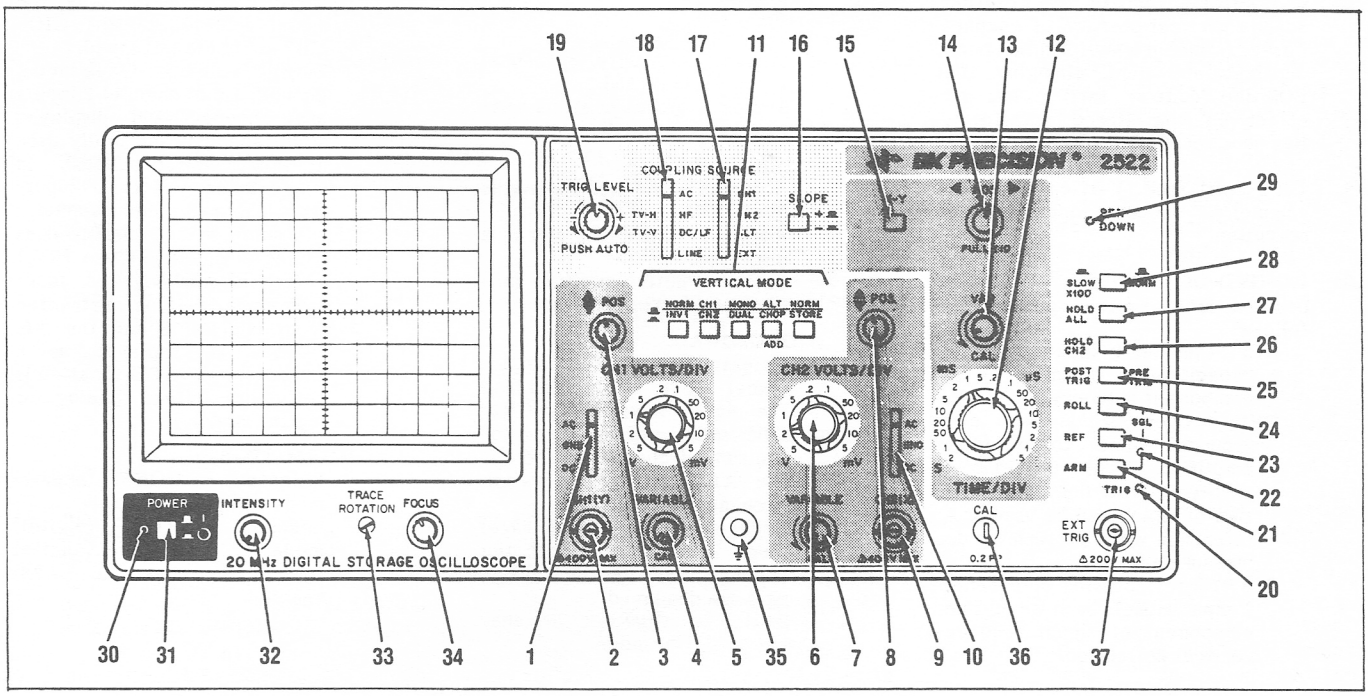

Fig. 1. Front Panel Controls and Indicators.

VERTICAL CONTROLS

CHANNEL 1 CONTROLS

1. **AC-GND-DC Switch.** Three-position lever switch operates as follows:
   - **AC:** Channel 1 input signal is capacitively coupled; dc component is blocked.
   - **GND:** Opens signal path and grounds input to vertical amplifier. This provides a zero-volt base line, the position of which can be used as a reference when performing dc measurements.
   - **DC:** Direct coupling of channel 1 input signal; both ac and dc component of signal produce vertical deflection.

2. **CH 1 Input Jack.** Vertical input for channel 1. Y-axis input for X-Y operation.

3. **▲ POSition Control.** Rotation adjusts vertical position of channel 1 trace. In X-Y operation, rotation adjusts vertical position of display. Once a waveform has been digitized and held, changing the POS control setting has no effect on the stored waveform.

4. **VARIABLE Control.** Rotation provides vernier adjustment of channel 1 vertical gain. In fully counterclockwise CAL position, the vertical attenuator is calibrated at the minimum gain point. Clockwise rotation increases gain, fully clockwise provides X5 gain. In X-Y operation this control becomes the vernier Y-axis gain control. Once a waveform has been digitized and held, changing the VARIABLE control setting has no effect on the stored waveform.

5. **VOLTS/DIV Control.** Vertical attenuator for channel 1. Provides step adjustment of vertical sensitivity. When channel 1 VARIABLE control (4) is set to CAL, vertical sensitivity is calibrated in 10 steps from 5 mV/div to 5 V/div in a 1-2-5 sequence. In X-Y operation, this control provides step adjustment of Y-axis sensitivity. Once a waveform has been digitized and held, changing the VOLTS/DIV control setting has no effect on the stored waveform.

CHANNEL 2 CONTROLS

6. **VOLTS/DIV Control.** Vertical attenuator for channel 2. Provides step adjustment of vertical sensitivity. When channel 2 VARIABLE control (7) is set to CAL, vertical sensitivity is calibrated in 10 steps from 5 mV/div to 5 V/div in a 1-2-5 sequence. In X-Y operation, this control provides step adjustment of X-axis sensitivity. Once a waveform has been digitized and held, changing the VOLTS/DIV control setting has no effect on the stored waveform.

7. **VARIABLE Control.** Rotation provides vernier adjustment of channel 2 vertical gain. In the fully counterclockwise CAL position, the attenuator is calibrated at the minimum gain point. Clockwise rotation increases gain, fully clockwise provides X5 gain. In X-Y operation this control becomes the

vernier X-axis gain control. Once a waveform has been digitized and held, changing the VARIABLE control setting has no effect on the stored waveform.

8. ▲ **POSition Control.** Rotation adjusts vertical position of channel 2 trace. Once a waveform has been digitized and held, changing the POSition control setting has no effect on the stored waveform. Has no effect in X-Y operation.

9. **CH 2 Input Jack.** Vertical input for channel 2. X-axis input in X-Y operation.

10. **AC-GND-DC Switch.** Three-position lever switch operates as follows:
   AC: Channel 2 input signal is capacitively coupled; dc component is blocked.
   GND: Opens signal path and grounds input to vertical amplifier. This provides a zero-volt base line, the position of which can be used as a reference when performing dc measurements.
   DC: Direct coupling of channel 2 input signal; both ac and dc component of signal produce vertical deflection.

VERTICAL MODE SELECTOR

11. **VERTICAL MODE Switches.** Row of five pushbuttons select vertical mode of display as follows:

NORM/INV 1:
Released - polarity of channel 1 signal is normal.
Engaged - polarity of channel 1 input is inverted.
Switch is active in either analog or digital mode.

CH1/CH2:
Released - channel 1 signal is displayed.
Engaged - channel 2 signal is displayed.
Switch is active in either analog or digital mode.

MONO/DUAL:
Released - MONO (single-trace) mode is selected and the signal selected by CH1/CH2 switch is displayed (or the sum of channels 1 and 2 if the ALT/CHOP/ADD switch is engaged).
Engaged - DUAL (dual-trace) mode is selected. Both the channel 1 and channel 2 signals are displayed.
Switch is active in either analog or digital mode.

ALT/CHOP/ADD:
Released - In dual-trace mode, channel 1 and channel 2 traces are alternately displayed (normally used at faster sweep speeds). In single-trace mode, only the signal selected by the CH1/CH2 switch is displayed.
Engaged - in dual-trace mode, channel 1 and channel 2 inputs are chopped and displayed simultaneously (normally used at slower sweep speeds). In single-trace mode, inputs from channel 1 and channel 2 are summed and displayed as a single signal. When INV 1 switch is also engaged, input from channel 1 is subtracted from channel 2 and the difference is displayed as a single signal. ADD function is active in either analog or digital mode.

NORM/STORE:
Released - NORM (analog) mode of operation.
Engaged - STORE (digital) mode of operation; digital control switches (21 - 28) enabled.

HORIZONTAL AND SWEEP CONTROLS

12. **TIME/DIV Control.** Provides step selection of sweep rate. When the VARiable sweep control (13) is set to CAL, sweep rate is calibrated in 18 steps from 0.5 µs/div to 0.2 s/div, in a 1-2-5 sequence. In digital STORE mode, settings of 20 µs/div and slower provide direct sampling, while 10 µs/div and faster use equivalent time sampling. Also in STORE mode, settings of 10 ms/div and slower (shaded in grey) can be expanded to 100 times slower via the SLOW X100/NORM control (28). Once a waveform has been digitized and held, changing the sweep TIME/DIV control setting has no effect on the stored waveform; however, the sweep is magnified by two if the TIME/DIV control is switched from direct sampling ranges into equivalent time sampling ranges.

13. **VARiable Sweep Control.** Rotation provides vernier adjustment of sweep rate. In fully counterclockwise (CAL) position, sweep rate is calibrated. When in the digital (STORE) mode, this control can only be used when in the Equivalent Time Sampling TIME/DIV ranges. Once a waveform has been digitized and held, changing the VARiable sweep control setting has no effect on the stored waveform.

14. ◄► **POSition/PULL X10 Control.**
◄► **POSition:** Horizontal position control for all modes (X-Y, CH 1, DUAL etc.). Also controls horizontal position in STORE mode (even after a waveform has been stored, the horizontal position can be changed).
PULL X10: Selects ten times sweep magnification when pulled out, normal when pushed in. Active in all analog and digital modes.

15. **X-Y Switch.** Selects X-Y mode. Channel 1 becomes the Y-axis and channel 2 becomes the X-axis. Triggering controls are disabled. The X-Y mode cannot be used in the digital (STORE) mode of operation.

TRIGGERING CONTROLS

16. **SLOPE Switch.** When this switch is released (+ slope position), sweep is triggered on positive going slope; when switch is engaged (- slope position), sweep is triggered on negative going slope.

17. **SOURCE Switch.** Selects source of sweep trigger. Four-position lever switch with the following positions:
   CH1: Channel 1 input signal becomes sweep trigger regardless of the display mode.
   CH2: Channel 2 input signal becomes sweep trigger regardless of the display mode.
   ALT: Trigger source follows the CH1/CH2 switch (11) setting for single-trace operation.

For dual-trace operation, trigger source alternates between channel 1 and channel 2. This permits each waveform viewed to become its own trigger signal. However, this type of triggering is not possible in CHOP dual-trace mode.

EXT: Signal from EXT TRIG jack (37) becomes sweep trigger.

18. **Trigger COUPLING Switch.** Four-position lever switch selects trigger coupling as follows:
    - **AC:** Trigger is capacitively coupled; dc component is blocked.
    - **TV H:** Used for triggering from horizontal sync pulses. Also serves as high-pass (low frequency reject) trigger coupling.
    - **TV V:** Used for triggering from vertical sync pulses. Also serves as low-pass (high frequency reject) trigger coupling. Trigger is dc coupled.
    - **LINE:** Signal derived from input line voltage (50/60 Hz) becomes trigger.

19. **TRIG LEVEL/PUSH AUTO Control.**
    - **TRIG LEVEL:** Rotation is trigger level adjustment; determines the point on the triggering waveform where the sweep is triggered. Rotation in the (-) direction (counterclockwise) selects more negative point of triggering, and rotation in the (+) direction (clockwise) selects more positive point of triggering.
    - **PUSH AUTO:** When pushed in, automatic triggering is selected. In automatic triggering mode, sweep is generated in absence of adequate trigger signal; automatically reverts to triggered sweep operation when adequate trigger signal is present. When pulled out, normal triggering is selected. In normal triggering mode, sweep is generated only when adequate trigger signal is present.

DIGITAL (STORE) MODE CONTROLS

All digital mode controls are enabled when the NORM/STORE switch is engaged (STORE mode), and all digital mode controls are disabled when the NORM/STORE switch is released (NORM mode).

20. **TRIGgered Indicator.** Lights when a suitable trigger signal is sensed in digital mode.

21. **ARM Switch.** Momentary action switch that arms the oscilloscope for storage of the waveform on the next adequate trigger signal. Note: pushing the ARM switch releases the REFresh (23) and ROLL (24) switches and selects SGL "single-shot" operation.

22. **Armed Indicator.** LED which lights after ARM switch (21) is pushed, and remains lit until an adequate trigger signal is received. Once such a signal is received, the scope stores the waveform and this indicator goes out.

23. **REFresh Switch.** Places the oscilloscope in the "refresh" mode of storage, in which it updates the stored waveform each time an adequate trigger signal is received (if the previous update has been completed).

24. **ROLL Switch.** Places the oscilloscope in the "roll" mode of operation, in which the trace moves across the CRT from right to left like a strip chart recorder (opposite of conventional oscilloscope operation) and the display is continuously updated. This update takes place even in the absence of any trigger signal. The rolling speed equals the TIME/DIV control setting (and SLOW X100 if engaged).

    SGL ("Single Shot") Mode. When the REFresh (23) and ROLL (24) switches are both released, the "single shot" mode is selected. These switches are released by pressing the ARM switch (21).

25. **POST TRIG/PRE TRIG Switch.** Selects post-trigger or pre-trigger storage mode. In post-trigger mode, the waveform is displayed with the trigger point at the extreme left of the display, as in a conventional analog scope display. In pre-trigger mode, the trigger event is positioned in the center of the displayed waveform; events that occurred prior to the trigger event can be observed on the screen by studying the left half of the display. Pre-trigger mode is active only in single-shot operation (not in "roll" or "refresh" modes).

26. **HOLD CH2 Switch.** In the digital mode, engaging this switch freezes and stores the channel 2 trace immediately. The channel 2 display and memory cannot be updated until this switch is released.

27. **HOLD ALL Switch.** In the digital mode, engaging this switch freezes and stores the channel 1 and channel 2 traces immediately. The display and memory cannot be updated until this switch is released. Engaging this switch also enables the PLOT ON-OFF switch.

28. **SLOW X100/NORM Switch.** In the digital mode, engaging this switch (SLOW X100 position) expands the five time bases shaded in grey on the TIME/DIV control (12) by a factor of 100. For example, the 10 ms/div setting becomes 1 sec/div when SLOW X100 is selected.

29. **PEN DOWN Indicator.** Lights when output at PEN DOWN jack (39) on rear panel is TTL low.

MISCELLANEOUS CONTROLS

30. **Power On Indicator.** Lights when unit is turned on.

31. **POWER Switch.** Turns unit on and off.

32. **INTENSITY Control.** Adjusts brightness of trace.

33. **TRACE ROTATION Control.** Adjusts (by screwdriver) trace tilt.

34. **FOCUS Control.** Adjusts sharpness of trace.

35. **Ground Jack.** Banana plug connected to chassis ground of scope;

also connected to earth ground via ac power cord.

36. **CAL 0.2 p-p Terminal.** Provides a 0.2-volt peak-to-peak square wave signal at approximately 1 kHz. This is useful for probe compensation adjustment and a general check of oscilloscope calibration accuracy.

37. **EXT TRIG Jack.** External trigger input.

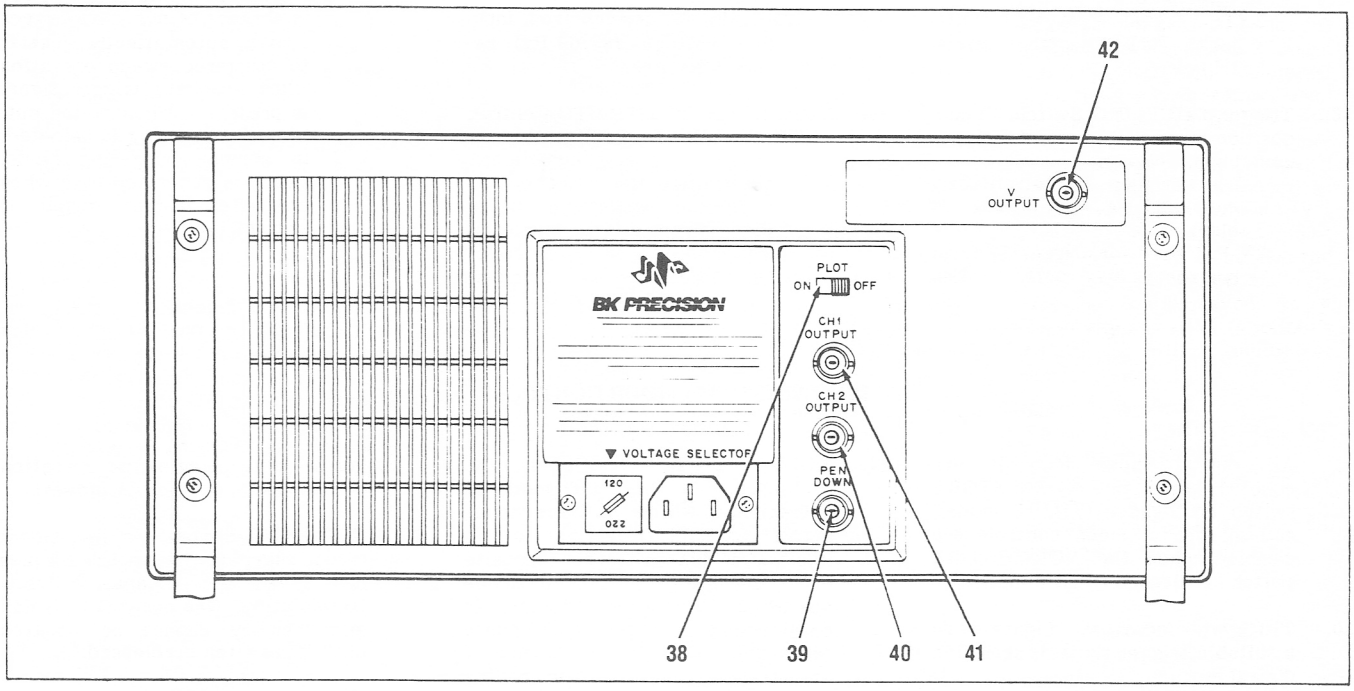

Fig. 2. Rear Panel Controls and Facilities.

REAR PANEL CONTROLS

38. **PLOT ON/OFF Switch.** When enabled by the HOLD ALL switch, the ON position of this switch activates the plot mode by permitting the PEN DOWN output (39) to go low at regular intervals. When the switch is OFF, the PEN DOWN output remains at a constant high.

39. **PEN DOWN Output.** TTL open collector output to raise and lower plotter pen. Plotter information is output at the CH1 (41) and CH2 (40) output jacks starting at each positive and negative transition of PEN DOWN. The TIME/DIV switch sets the period of this output.

40. **CH2 OUTPUT Jack.** Supplies channel 2 digital storage contents for use with an analog plotter.

41. **CH1 OUTPUT Jack.** Supplies channel 1 digital storage contents for use with an analog plotter.

42. **Y OUTPUT Jack.** Output terminal where sample of channel 1 analog signal is available. Amplitude of output is 50 millivolts per division of vertical deflection seen on CRT when terminated into 50 ohms. Output impedance is 50 ohms.

SAFETY PRECAUTIONS

WARNING

The following precautions must be observed to prevent electric shock.

1. When the oscilloscope 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 oscilloscope in such conditions should be a qualified electronics technician or otherwise trained and qualified to work in such circumstances. Observe the TEST INSTRUMENT SAFETY recommendations listed on the inside front cover of this manual.

2. Do not operate this oscilloscope with the case removed unless you are a qualified service technician. High voltage up to 2,000 volts is present when the unit is operating with the case removed.

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

4. Special precautions are required to measure or observe line voltage waveforms with 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 oscilloscope.

1. Never allow a small spot of high brilliance to remain stationary on the 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 with AUTO triggering and no signal applied or 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 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 oscilloscope. The maximum ratings of the inputs are as follows:

   CH1 (Y) and CH2 (X):
   400 V dc + ac peak.
   EXT TRIG:
   200 V dc + ac peak.

   Never apply external voltage to 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 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 CH 2 - CH 1 subtract operation (ADD mode and INV 1 switch engaged), with the channel 2 probe to the point of measurement and the channel 1 probe to the point of reference. Use this method even if the reference point is a dc voltage with no signal.

OPERATING TIPS

The following recommendations will help obtain the best performance from the oscilloscope.

1. Always use the probe ground clips for best results, attached to a circuit ground point near the point of measurement. Do not rely solely on an external ground wire in lieu of the probe ground clips, as undesired signals may be induced.

2. Avoid the following operating conditions:
   a. Direct sunlight.
   b. High temperature and humidity.
   c. Mechanical vibration.
   d. Electrical noise and strong magnetic fields, such as near large motors, power supplies, transformers, etc.

3. Occasionally check trace rotation, probe compensation, and calibration accuracy of the oscilloscope using the procedures found in the MAINTENANCE section of this manual.

4. Terminate the output of a signal generator in its characteristic impedance at the oscilloscope and use an interconnecting cable of the same impedance. This precaution will minimize ringing, especially if the signal has fast edges such as square waves or pulses. For example, the typical 50 Ω output of a square wave generator should be terminated into an external 50 Ω terminating load at the oscilloscope and connected to the oscilloscope with 50 Ω coaxial cable.

5. Probe compensation adjustment matches the probe to the input of the scope. For best results, compensation should be adjusted initially, then the same probe always used with the same channel. Probe compensation should be readjusted when a probe from a different oscilloscope is used.

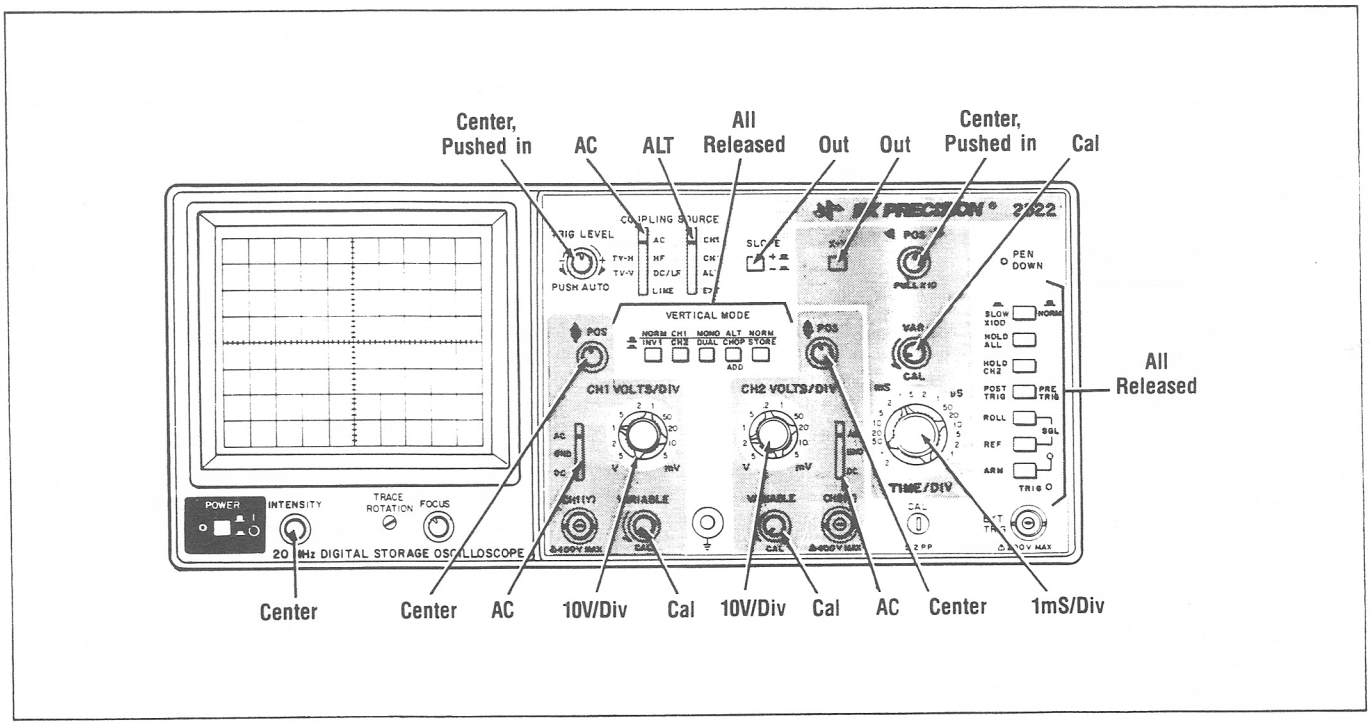

Fig. 3. Recommended Initial Settings.

INITIAL STARTING PROCEDURE

Until you familiarize yourself with the use of all controls, the settings shown in Fig. 3 may be used as a reference point to obtain a trace on the CRT in preparation for waveform observation.

1. Press the POWER switch; the unit will be turned on and the pilot light will be illuminated.
2. The CH1/CH2 switch should be set to CH1 (released), the TRIG LEVEL control should be set to AUTO (pushed in), and the STORE/NORM switch set to NORM.
3. A trace should appear on the CRT. Adjust the trace brightness with the INTENSITY control, and the trace sharpness with the FOCUS control.

SINGLE TRACE DISPLAY

Either channel 1 or channel 2 may be used for single-trace operation. The advantage of using channel 1 is that the waveform on the display can be inverted if desired with the INV 1 switch.

1. Perform the steps of the "Initial Starting Procedure" with the CH1/CH2 switch set to CH1.
2. Connect the probe to the CH1(Y) input jack.
3. Connect the probe ground clip to the chassis or common of the equipment under test. Connect the probe tip to the point of measurement.
4. If no waveforms appear, increase the sensitivity by turning the CH1 VOLTS/DIV control clockwise to a position that gives 2 to 6 divisions vertical deflection.
5. The display on the CRT may be unsynchronized. Refer to the "Triggering" paragraphs in this section for procedures on setting triggering and sweep time controls to obtain a stable 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, when the trigger SOURCE switch is set to the ALT position, two waveforms not related in frequency or period can be simultaneously viewed in either the analog (NORM) or digital (STORE) mode.

1. Connect probes to both the CH1 and CH2 input jacks.
2. 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.
3. When the MONO/DUAL switch is set to MONO and the ALT/CHOP/ADD switch is set to ADD, the algebraic sum of CH1 + CH2 is displayed as a single trace. When the INV 1 switch is also engaged, the algebraic difference of CH2 - CH1 is displayed.
4. To view both waveforms simultaneously, set the MONO/DUAL switch to DUAL and select either ALT (alternate) or CHOP with the ALT/CHOP/ADD switch.
5. In the ALT mode, one sweep displays the channel 1 signal and the next sweep displays the channel 2 signal in an alternating sequence. Alternate sweep is normally used for viewing high-frequency or high-speed waveforms at sweep times of 1 ms/div and faster, but may be selected at any sweep time.
6. In the CHOP mode, the sweep is chopped and switched between channel 1 and channel 2. One channel does not have to "wait" for a complete swept display of the other channel. Therefore, successive portions of each channel's waveforms are displayed until the

entire traces are displayed. Chop sweep is normally used for low-frequency or low-speed waveforms at sweep times of 1 ms/div and slower.

a. If chop sweep is used at sweep times of 0.2 ms/div and faster, the chop rate becomes a significant portion of the sweep and may become visible in the displayed waveform. However, you may select chop sweep at any sweep time for special applications. For example, the only way to observe simultaneous events on an analog dual-trace scope at any sweep rate is with chop sweep.

b. Note that this oscilloscope is not intended to be used with the CHOP display mode and the ALT triggering source selected simultaneously. It may be impossible to synchronize the display with this combination. Use the ALT display mode instead or select a trigger SOURCE of CH1 or CH2.

7. Adjust the channel 1 and channel 2 ⇕ POSition controls to place the channel 1 trace above the channel 2 trace.

8. Set the CH1 and CH2 VOLTS/DIV controls to a position that gives 2 to 3 divisions of vertical deflection for each trace. If the display on the screen is unsynchronized, refer to the "Triggering" paragraphs in this section of the manual for procedures for setting triggering and sweep time controls to obtain a stable display showing the desired number of waveforms.

TRIGGERING

The Model 2522 Oscilloscope provides versatility in triggering, allowing a stable, jitter-free display to be presented over a wide range of conditions. The proper settings depend upon the type of waveforms being observed and the type of measurement desired. An explanation of the various controls which affect synchronization is given to help you select the proper setting over a wide range of conditions.

PUSH AUTO Switch

1. The pulled out position provides normal triggered sweep operation. The sweep remains at rest until the selected trigger source signal crosses the threshold level set by the TRIG LEVEL control. The trigger causes one sweep to be generated, after which the sweep again remains at rest until triggered. In the normal triggering mode, there will be no trace unless an adequate trigger signal is present. In the ALT VERTICAL MODE of dual trace operation with the SOURCE switch also set to ALT, there will be no trace unless both channel 1 and channel 2 signals are adequate for triggering. Typically, signals that produce even 1/2 division of vertical deflection are adequate for normal triggered sweep operation.

2. In the AUTO position, automatic sweep operation is selected. In automatic sweep operation, the sweep generator free runs to generate a sweep without a trigger signal. However, it automatically switches to triggered sweep operation if an acceptable trigger source signal is present. The AUTO position is handy when first setting up the scope to observe a waveform; it provides sweep for waveform observation until other controls can be properly set. Once the controls are set, operation is often switched back to the normal triggering mode, since it is more sensitive. Automatic sweep must be used for dc measurements and signals of such low amplitude that they will not trigger the sweep.

NOTE

In the X-Y mode, the sweep generator and triggering circuits are disconnected and have no effect.

Trigger SOURCE Switch

The trigger SOURCE switch (CH1, CH2, etc.) selects the signal to be used as the sync trigger.

1. If the SOURCE switch is set to CH1 (or CH2) the channel 1 (or channel 2) signal becomes the trigger source regardless of the VERTICAL MODE selection. CH1 or CH2 are often used as the trigger source for phase or timing comparison measurements.

2. When the ALT position is selected, the trigger source is dependent upon the VERTICAL MODE selection. In this manner, each waveform being observed becomes its own trigger signal.

   a. When the VERTICAL MODE is changed from CH1 to CH2, the trigger source is also changed from CH1 to CH2, and vice versa. This is very convenient for single trace operation.

   b. When the ALT dual-trace VERTICAL MODE is selected, the trigger source alternates between channel 1 and channel 2 with each sweep. This is convenient for checking amplitudes, waveshape, or waveform period measurements, and even permits simultaneous observation of two waveforms which are not related in frequency or period. However, this setting is not suitable for phase or timing comparison measurements. For such measurements, both traces must be triggered by the same sync signal.

   c. When the CHOP dual-trace VERTICAL MODE is selected, synchronization of the display is not always possible. Use the ALT mode instead, or change the SOURCE switch setting to CH1 or CH2.

3. If the SOURCE switch is set to the EXT position, the signal applied to the EXT TRIG jack becomes the trigger source. This signal must have a timing relationship to the dipslayed waveforms for a synchronized display.

TRIG LEVEL and SLOPE Controls
(Refer to Fig. 4)

A sweep trigger is developed when the trigger source signal crosses a preset threshold level. Rotation of the TRIG LEVEL control varies the threshold level. In the (+) direction, the triggering threshold shifts to a more positive value, and in the (-) direction, it shifts to a more negative value. When the control is centered, the threshold level is set at the approximate average of the signal used as the triggering source. Proper adjustment of this control usually synchronizes the display.

The TRIG 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 TRIG LEVEL control is rotated toward its extreme (+) or (-) setting, no sweep will be developed in the normal trigger mode because the triggering threshold exceeds the peak amplitude of the sync signal.

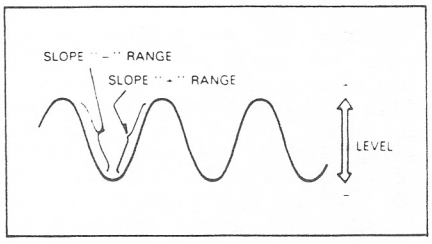

Fig. 4. Function of Slope and Level Controls.

When the SLOPE control is set to the (+) position (released), the sweep is developed from the trigger source waveform as it crosses a threshold level in a

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

Trigger COUPLING Switch

1. Use the AC position for viewing most types of waveforms. The trigger signal is capacitively coupled and may be used for all signals from 30 Hz to 20 MHz.

2. The TV H and TV V positions are primarily for viewing composite video waveforms. Horizontal sync pulses are selected as trigger when the trigger COUPLING switch is set to the TV H position, and vertical sync pulses are selected as trigger when the trigger COUPLING switch is set to the TV V position. The TV H and TV V positions may also be used as low frequency reject and high frequency reject coupling respectively (with a cut-off frequency of about 400 Hz). Additional procedures for observing video waveforms are given later in this section of the manual.

Sweep TIME/DIV Control

Set the sweep TIME/DIV control to display the desired number of cycles of the waveform. If there are too many cycles displayed for good resolution, switch to a faster sweep time. If only a line is displayed, try a slower sweep time. When the sweep time is faster than the waveform being observed, only part of it will be displayed, which 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 magnified sweep.

Using the ◀▶ POSition control, adjust the desired portion of waveform to the center of the CRT. Pull out the PULL X10 knob to magnify the display ten times. For this type of display the sweep time is the sweep TIME/DIV setting divided by 10. Rotation of the ◀▶ POSition control can then be used to select the desired portion of the waveforms.

X-Y OPERATION

X-Y operation permits the oscilloscope 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 stereoscope display of stereo signal outputs. 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. Press the X-Y switch. In this mode, channel 1 becomes the Y axis input and channel 2 becomes the X axis input. All VERTICAL MODE switches should be disengaged for X-Y operation.

2. The X and Y positions are now adjusted using the ◀▶ POSition and the channel 1 ▲▼ POSition controls respectively.

3. Adjust the amount of vertical (Y axis) deflection with the CH1 VOLTS/DIV and VARIABLE controls.

4. Adjust the amount of horizontal (X axis) deflection with the CH2 VOLTS/DIV and VARIABLE controls.

VIDEO SIGNAL OBSERVATION

Setting the COUPLING switch to the TV H or TV V position permits selection of horizontal or vertical sync pulses for sweep triggering when viewing composite video waveforms.

When the TV H mode is selected, horizontal sync pulses are selected as triggers to permit viewing of horizontal lines of video. A sweep time of about 10 µs/div is appropriate for displaying lines of video. The VARiable sweep control can be set to display the exact number of waveforms desired.

When the TV V mode is selected, vertical sync pulses are selected as triggers to permit viewing of vertical fields and frames of video. A sweep time of 2 ms/div is appropriate for viewing fields of video, and 5 ms/div for complete frames (two interlaced fields) of video.

At most points of measurement, a composite video signal is of the (-) polarity; that is, the sync pulses are negative and the video is positive. In this case, use (-) SLOPE. If the waveform is taken at a circuit point where the video waveform is inverted, the sync pulses are positive and the video is negative. In this case, use (+) SLOPE.

DIGITAL (STORE MODE) OPERATION

Digitizing Repetitive Waveforms

While the most powerful feature of a digital storage oscilloscope (DSO) is its ability to capture one-time events, a DSO can also digitize conventional repetitive waveforms, such as those observed on a standard analog scope. An analog/digital unit such as the Model 2522 allows the user to set up sensitivity, sweep, and triggering in a familiar analog setting, and then switch to the digital mode. This is a good way to gain familiarity with the digital features of the instrument. You may wish to pursue this method as described below in the "Refresh Mode" paragraph.

Also, some repetitive signals can be viewed and measured much more effectively in the digital store mode than in the analog mode. One example is slow signals below 60 Hz. Signals that appear as a flickering waveform or just a moving dot on the screen in the analog mode are displayed as a bright, non-flickering, easily viewed entire waveform in the digital store mode.

The digital store mode also improves viewing and measurement of repetitive signals with low trigger repetition rates relative to the sweep rate. In the analog mode, such waveforms may be too faint for viewing. In the digital store mode, the display is equivalent to a CRT with infinite persistence. The waveform can be easily viewed.

Refresh Mode

In the refresh mode, the waveform is digitized and displayed on the screen. After the complete waveform is digitized, the next trigger causes the stored waveform to be replaced (refreshed) by a new waveform.

1. Set up the oscilloscope to view a periodic waveform in the analog operating (NORM) mode. Adjust the trigger, VOLTS/DIV, sweep TIME/DIV, and vertical position controls as desired.

2. Initially, disengage all of the digital control switches (the group of 7 switches at the extreme right of the front panel) and set the PLOT switch on the rear panel to OFF.

3. Select digital storage operation by setting the NORM/STORE switch to STORE (engaged). Select the "refresh" mode of operation by depressing the REFresh switch. The waveform should appear on the display, relatively unchanged from the previously displayed analog version. In the "refresh" mode, the display is continually updated as long as a suitable trigger signal remains present.

4. Once a waveform is digitized it can be stored in long term memory by pressing the HOLD ALL or HOLD CH2 switches. The HOLD CH2 switch immediately stores the channel 2 waveform. The HOLD ALL switch immediately freezes the display and stores both waveforms. Once a waveform is stored by engaging either of these switches, it will be stored until the switch is disengaged or the power is turned off.

NOTES

Any of the operating modes previously discussed in analog operation (e.g. DUAL, ADD, etc.) can be used in digital mode, except for X-Y operation.

Time base settings of 10 µs/div and faster result in a display that is accquired through "time equivalent sampling". This process develops the digitized image over many cycles of the repetitive signal; therefore, these higher sweep speeds can not be used for capture of one-time events. Time-equivalent sampling is discussed in detail in Appendix II, "Unique Characteristics of Digital Storage Oscilloscopes".

Digitizing One-Time Events

One of most powerful features of a digital storage oscilloscope (DSO) is its ability to capture one-time events. To capture one-time events, single-shot operation is employed. This is done through the use of the ARM switch. When pushed, this switch releases the REFresh or ROLL switches if previously engaged, and readies the digital storage circuit to receive a trigger signal - presumably the event to be captured or some other time-related occurrence. When the event arrives, it is stored in the memory and displayed. The procedure is as follows.

1. Set the oscilloscope to run in analog mode (NORM/STORE switch to NORM). Set the TRIG LEVEL control to normal triggering (pulled out), and adjust the level so that the unit triggers on the event to be captured.

2. Set the oscilloscope to digital (STORE) mode by engaging the NORM/STORE switch.

3. Initially, set the POST TRIG/PRE TRIG switch to PRE TRIG (disengaged). A more detailed discussion of pre- and post-triggering is given later in this section of the manual.

4. Press the ARM switch. The Armed indicator (red LED next to the ARM switch) will momentarily light, as the scope awaits the arrival of the trigger signal. When that trigger occurs, the TRIGgered indicator (green LED) will light, and the event being monitored will roll to the center of the display and stop.

NOTES

Depending on the sweep TIME/DIV setting, the anticipated event may roll to the center of the screen very rapidly, or very slowly, after the TRIGgered indicator lights.

Single-shot mode can be used in the presence of very rapidly occuring events, even continuous waveforms if desired. In that case, the period between pushing of the ARM switch and the arrival of the trigger may be very short or almost instantaneous. As a result, the Armed Indicator may light for only a very short time, perhaps not being visible at all.

Pushing the ARM switch automatically disengages both the REFresh and ROLL switches, which are continuous modes.

5. Once the waveform is captured, it can be stored in long term memory through the use of the HOLD CH2 or HOLD ALL switches.

Pre- and Post-Trigger Capture

Another powerful feature of a DSO is its ability to display "pre-trigger" information, that is, events occuring before the arrival of a trigger event. On the Model 2522, pre-trigger operation is available in single-shot mode, by setting the POST TRIG/PRE TRIG switch to PRE TRIG (disengaged). As shown in the above section on "Digitizing One-Time Events", when pre-trigger operation is selected, the event to be captured is situated in the center of the memory (roughly the center of the display) after storage. The waveform to the left of center represents activity which occurred before that trigger arrived.

If the POST TRIG/PRE TRIG switch is set to POST TRIG (engaged), then no pre-trigger information is stored, and the trigger event rolls to the extreme left of the display. In this case, all the information displayed on the screen represents activity after the trigger event. You may wish to use post-trigger operation first, to observe where the trigger is occurring on the waveform of interest, and then switch to pre-trigger mode.

Roll Mode

In this mode of operation, the waveform rolls across the CRT from right to left (as opposed to standard oscilloscopes which have the trace moving from left to right) in the same manner as most strip chart recorders. It is most commonly used for viewing very slow events.

1. Set up the oscilloscope in analog mode so that the event to be observed is properly positioned on the display. You may wish to use AUTO triggering so that the scope continues to draw a trace even if the event is especially slow.

2. Switch to digital mode (NORM/STORE switch to STORE), and depress the ROLL switch. Select a TIME/DIV setting that produces a roll at the desired speed. As the sweep speed is decreased, the waveform will move across the screen more slowly and the Roll feature will become more apparent. It can also be slowed by a factor of 100 on some ranges; see the discussion in the next section.

3. The rolling display can be frozen at any time by pressing the HOLD CH2 or HOLD ALL switches (as discussed in the section on "Digitizing Repetitive Waveforms").

NOTE

ROLL mode cannot be used on sweep speeds greater than 50 µs/div.

Expanded Sweep Settings - SLOW x100 Mode

In digital mode, the five TIME/DIV ranges shaded in grey can be expanded by a factor of 100 by depressing the SLOW x100/NORM switch. For example, the 10 ms/div setting becomes 1000 ms (1 sec)/div when this switch is engaged. This time base expansion is extremely useful for observing very slow events. With it, the scope is capable of recording an event up to 200 seconds in duration (.2 sec/div x100 becomes 20 sec/div).

Using Plotter Output

The Model 2522 oscilloscope provides facilities for driving an analog plotter. The following instructions explain how to output a waveform; however, since plotters vary greatly, only general instructions have been given. Consult the manual for the particular plotter for more specific instructions. Also, it is recommended that you read this entire procedure first, because some steps may need to be performed in a different sequence, depending on the plotter.

1. Initially, set the PLOT ON/OFF switch on the rear panel to OFF.

2. Use any of the digital modes described above to obtain a digitized display to be plotted. Once the desired display is obtained, freeze it using the HOLD ALL switch.

3. Connect the plotter's Y (vertical) input to either the CH1 or CH2 OUTPUT jack on the rear panel of the oscilloscope, depending on which channel display you wish to plot.

4. Connect the plotter's pen lift control input to the PEN DOWN output jack on the rear of the scope.

5. Momentarily disable external up/down control of the plotter pen; that is, set the pen to be permanently lifted from the paper surface. This will allow you to exercise initial "trial and error" sweeps without using up excessive ink. Consult the manual for the particular plotter for details.

6. Set the PLOT ON/OFF switch on the rear of the scope to ON. This will gate a TTL-level square wave through to the PEN DOWN output jack. The repetition rate of this square wave is controlled by the front panel TIME/DIV control. The relationship is as follows. Each low or high portion of the square wave represents the output of one screen, i.e. ten divisions of waveform (10.24 divisions to be more exact). This output takes place at a rate that is 1/10th that of the TIME/DIV setting. For example, if the TIME/DIV setting is 10 ms/div, the plotter output sends out waveform information at a rate of 100 ms/div. For the full 10.24 divisions of screen, this means a total interval of 1.024 second. Thus, the square wave has low and high portions that are each 1.024 second long. The PEN DOWN indicator on the front panel of the oscilloscope lights during each low portion.

NOTE

Though many plotters use a TTL-low level as the "pen down" signal, and technically only require plotting information during that low portion, this oscilloscope outputs a full screen of data on both the low and high intervals of the square wave. This discussion assumes a plotter using TTL low as the "pen down" command.

When the PLOT ON/OFF control is set to OFF, the PEN DOWN output is at a constant TTL high.

Engaging the SLOW X100 switch slows the plot output by a factor of 100 on the five TIME/DIV settings shaded in grey.

7. With the plotter's pen control input still disabled, observe the PEN DOWN indicator on the scope to determine the repetition rate of the square wave. Adjust as desired using the TIME/DIV control. It will be necessary to use the plotter's own time base to move its pen in the horizontal (X) direction. If possible, set that movement to begin on the high-to-low transition of the PEN DOWN signal. Through trial and error, with the pen still up, run the plotter horizontally to determine the speed that produces the desired plot width during the PEN DOWN interval as observed on the LED. Also adjust the vertical deflection and offset for the desired height.

8. Finally, during the high portion of the square wave (PEN DOWN indicator off), re-enable external pen control on the plotter. At the next transition of PEN DOWN to low, the plotter should produce the desired results.

NOTE

If you are not able to trigger the horizontal plotter sweep from the PEN DOWN signal, you may have to enable that sweep manually, using the PEN DOWN indicator as a timing guide.

APPLICATIONS

Analog Oscilloscope Applications

B & K-Precision offers a "Guidebook to Oscilloscopes", which describes numerous analog oscilloscope applications for this instrument and important considerations about probes. It also includes a glossary of oscilloscope terminology and an understanding of how oscilloscopes operate. It may be obtained free of charge by filling out and mailing the postage-free coupon card enclosed with this instrument.

Digital Oscilloscope Applications

The following examples illustrate cases where a DSO can perform measurements which would be difficult or impossible using a conventional scope.

Capturing Telephone Dial Pulses

The relatively slow speed of pulse dial telephones, combined with the fact that the dialing pulses are not repetitive, make it almost impossible to view the pulses with a conventional oscilloscope. The extremely slow sweep speeds of the Model 2522, however, allow the capture and analysis of dialing pulses from these phones.

1. With the telephone connected to a telephone line or telephone line simulator, connect the telephone (at the line) to the input of the oscilloscope, using a 10:1 probe.

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.

2. Set the following controls:

TRIG LEVEL: pulled out (normal triggering).
SLOPE: - (pushed in).
STORE/NORM: STORE.
ROLL: pushed in.
SLOW X100: pushed in.
TIME/DIV: 10 mS.
Channel 1 VOLTS/DIV: 1 V.
Channel 1 AC/GND/DC: GND.

3. Use the channel 1 ▲▼ POSition control to move the trace up to the second horizontal graticule line from the top. Set the channel 1 AC/GND/DC switch to DC and observe the voltage on the oscilloscope. 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.

4. The pulses can be stored at any time by pressing the HOLD ALL switch. The groups of pulses can then be more closely examined by pulling the ◄► POSition switch out (x10 horizontal magnification). The number of pulses should directly correspond with the number dialed (e.g. when "2" is dialed there should be two pulses, when "6" is dialed there should be six, and when "0" is dialed there should be ten).

5. The pulses can also be examined more closely by disengaging the SLOW X100 switch and pushing the ◄► POS switch back in. Then

select one of the other TIME/DIV settings shaded in grey. Because the x100 factor has been eliminated, most of these actually represent faster sweep speeds than the one initially recommended. Select the speed appropriate for measuring pulse rate, make time, break time, and interdigit time.

Testing Battery Back-Up Systems

Using the Model 2522 it is possible to measure the time interval required for a battery back-up system to take over after ac power has been cut off.

1. Connect a probe to any point that is powered by both the ac line voltage and the battery back-up system.

2. Set the VOLTS/DIV and TIME/DIV to appropriate settings, according to the levels and time intervals anticipated.

3. Set the scope for normal triggering (TRIG LEVEL pulled out), and set the level to trigger on the "power off" occurrence. As with all single-shot events, this may require several "trial and error" efforts with the scope still in analog mode.

4. Set the NORM/STORE switch to STORE. If you wish to capture pre-trigger information, leave the POST TRIG/PRE TRIG button out.

5. Press the ARM button, and initiate the "power off" event.

6. If POST TRIG/PRE TRIG was left disengaged, the event will be stored at roughly the center of the display, as shown in Fig. 5. Use the ◄► POSition control to adjust the initial cut-off to coincide with a major graticule line. You can then measure the 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 X10 horizontal magnification was used. For example, in Fig. 5, the horizontal distance is 4 divisions. If the sweep TIME/DIV setting is 2 mS, and x10 magnification is used, the take-over time is:

Take-over Time =
4.0 (div) x 2 (ms/div) x 1/10 =
0.8 ms.

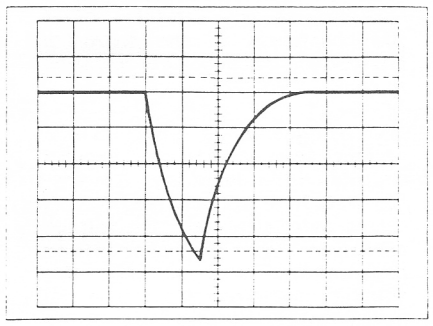

Fig. 5. Battery Back-Up Take-Over Time Measurement.