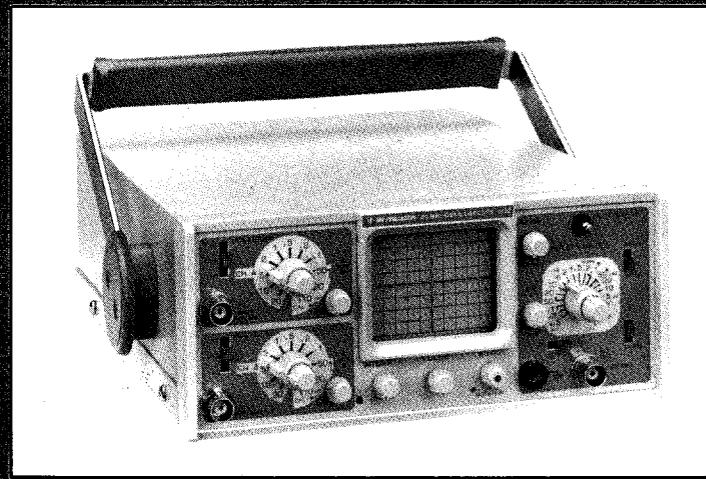


INSTRUCTION MANUAL



MODEL 1422

20 MHz, AC/DC/Battery
Dual-Trace
MINI-SCOPE



TEST INSTRUMENT SAFETY

WARNING

Normal use of this instrument 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 it 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.

(Continued on inside of back cover)

Instruction Manual
for

 **BK PRECISION®**

Model 1422

20 MHz, AD/DC/Battery
Dual-Trace Mini-Scope



MAXTEC INTERNATIONAL CORP.

6470 W. Cortland St. • Chicago, IL 60635

INTRODUCTION

The **B & K-Precision** Model 1422 Dual Trace Mini-Scope is a miniature, lightweight instrument for observing and measuring waveforms in electronic circuits. In addition to its portability, it offers the high performance features usually found only in laboratory-quality scopes.

The compact Model 1422 will fit easily into a standard attache case with plenty of room left over for the probes and other accessories and tools, even a digital multimeter. The instrument weighs only 8 pounds with battery installed. This is a major convenience when the Mini-Scope must be carried to an equipment site. For full versatility in its field service role, the unit operates from almost any power source.

Dual-trace operation permits two waveforms to be viewed simultaneously, or each may be viewed independently. The chop method of dual-trace operation is automatically selected at sweep times of 1 ms/division and slower, alternate sweep at all faster sweep speeds. The matched, dual vertical amplifiers can be switched to provide vertical and horizontal deflections in X-Y operation, at the same calibrated sensitivities.

With internal triggering, any signal that produces at least 1 division of vertical deflection is adequate for sweep triggering. A variable trigger threshold level and choice of negative or positive slope permit triggering at any desired point on a waveform. In internal triggered dual-trace operation, the channel A signal is the trigger source. An AUTO mode generates a sweep without an

input trigger. For viewing video waveforms, a selectable built-in sync separator permits triggering from vertical or horizontal sync pulses. Vertical or horizontal sync pulse triggering is automatically selected by the sweep time control at sweep speeds appropriate for viewing frames or lines of video.

Convenience features include a built-in square wave generator for probe compensation adjustment, and a sturdy carrying handle that also serves as a tilt stand with a choice of several angles of tilt. The conveniently grouped and well identified controls contribute to ease of operation. Solid state, integrated construction contributes to reliability and dependability, as well as the low power consumption of 16 watts.

The 1422 Mini-Scope is ideal for applications where portability and performance are both important, such as field engineering and field service of high technology products. In many cases, the performance characteristics of this Mini-Scope also meet the requirements for laboratory and bench service diagnostics. Typical applications include field engineering and service of mini computers, computer terminals, microprocessor controlled products, CCTV systems, cable television networks, and mobile and studio broadcast and recording equipment. The Mini-Scope is well suited to installation, maintenance, and adjustment of communications systems, including mobile units, dispatching base stations, remote site equipment, and tower mounted equipment.

FEATURES

PORTABILITY

MINISIZE

Its compact size, light weight, rugged construction, and convenient carrying handle enhance portability. Designed to fit easily in an attache case. Weighs only 8 pounds with battery.

AC/DC/BATTERY OPERATION

The Mini-Scope operates anywhere from 120 V, 60 Hz ac, 220 V, 50/60 Hz ac, 10-16 VDC, or internal battery.

VOLTAGE REGULATION

Maintains calibration accuracy over entire 105 to 130 VAC or 210 to 260 VAC or 10 to 25 VDC range.

LOW BATTERY INDICATION

Pilot light flashes to warn of low battery.

BATTERY CHARGING

Battery recharges when the oscilloscope is connected to ac, and scope is turned off. Will not overcharge.

PERFORMANCE

DUAL-TRACE

Two input waveforms can be viewed either singly or simultaneously, as desired. Individual

vertical sensitivity and positioning controls are provided for completely independent adjustment of the two signal amplitudes.

20 MHz BANDWIDTH

Guaranteed dc to 20 MHz bandwidth at -3dB. Smooth roll-off makes scope usable well above 20 MHz.

17.5 ns RISE TIME

Assures distortion-free, high resolution presentation at high frequencies, and at fast switching rates.

10 mV/div SENSITIVITY

Permits the low-capacitance, high-impedance, 10:1 attenuation probes to be used for virtually all measurements, thus assuring minimum circuit loading.

TRIGGERED SWEEP

Fully adjustable trigger threshold allows the desired portion of the waveforms to be used for triggering. In dual-trace operation, can be synchronized to the signal displayed on channel A or to an external sync trigger. Selectable automatic triggering mode provides sweep in absence of triggering signal.

VIDEO SYNC

A selectable built-in sync separator circuit is included specifically for viewing composite video signals. A sync separator is needed for observing waveforms in computer terminal displays, CCTV, cable TV, television circuits, etc. Horizontal sync pulses are automatically selected for triggering at sweep times of 50 $\mu\text{s}/\text{div}$ to 1 $\mu\text{s}/\text{div}$ for viewing horizontal lines of video. At sweep times of .1 ms/div and slower, vertical sync pulses are selected for viewing vertical frames.

**11 CALIBRATED
VOLTAGE
SCALES**

Accurate measurements of instantaneous voltages on 11 different attenuator ranges for both channel A and channel B (10 mV/div to 20 V/div).

**18 CALIBRATED
SWEEP SPEEDS**

Accurate measurements on 18 sweep speed ranges of 1.0 $\mu\text{s}/\text{div}$ to 0.5 s/div in a 1, 2, 5 sequence.

**X10 SWEEP
MAGNIFICATION**

A ten times (10X) magnification of the horizontal sweep allows close-up examination of any portion of the waveform. In

addition, the 10X magnification provides a maximum sweep speed of 0.1 $\mu\text{s}/\text{div}$ (100 ns/div).

X-Y OPERATION

Selectable from front panel without changing input connections. Channel A becomes vertical (Y axis) and channel B becomes horizontal (X axis) deflection. The dual matched channel A and B amplifiers provide the same calibration accuracy for both vertical and horizontal deflection.

**CALIBRATION
SOURCE**

A built-in calibrated, 1 volt-peak-to-peak square wave permits probe compensation adjustment and a general check of calibration accuracy.

**SIMPLIFIED
OPERATION**

All controls are front panel mounted. Controls are logically grouped and labeled for ease of operation. Dual-trace chop-alternate and video frame-line selection is automatic with sweep time selection, which speeds and simplifies set-up.

SPECIFICATIONS

VERTICAL AMPLIFIERS (CH A and CH B)

Deflection Factor	10 mV/div to 20 V/div, $\pm 5\%$, in 11 ranges, each with vernier adjustment.
Frequency Response	DC: dc to 20 MHz (-3dB). AC: 10 Hz to 20MHz (-3dB).
Risetime	17.5 nanosecond or less.
Overshoot	3% or less.
Input Impedance	1 megohm $\pm 5\%$, shunted by approximately 26 pF.
Max. Input Voltage	300 V (dc + ac peak) or 600 V p-p.
Operating Modes	Channel A only. Channel B only. Dual: Trace automatically chopped at all sweep times of 1 ms/div and slower; alternate trace automatically selected for all faster sweep times.
Chop Frequency	100 kHz $\pm 20\%$.
Channel Separation	Better than 60 dB @ 1 kHz.

SWEEP CIRCUITS (Common to CH A and CH B)

Sweep system	Triggered and automatic. In automatic mode, sweep is obtained without input signal.
Sweep Time	1 μ s/div to 0.5 s/div $\pm 5\%$ in 18 ranges, in 1-2-5 sequence. Vernier control provides fully adjustable sweep time between steps.
Magnifier	X10 $\pm 10\%$. Extends maximum sweep rate to 100 ns/div.
Linearity	3% or less distortion, $\pm 5\%$ for X10 magnification.

TRIGGERING

Source	INTERNAL. Channel A trigger in CH A mode. Channel B trigger in CH B mode. Channel A trigger in DUAL mode. EXTERNAL.
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Type	Normal, automatic. In automatic mode, the sweep triggers automatically without an input signal.
Coupling	AC, 20 Hz-20 Mhz.
Slope	Positive or negative.
Level	Continuously variable, pull for AUTO.
VIDEO Sync	Vertical and horizontal sync separator circuit provided so that any portion of composite video waveform can be synchronized and expanded for viewing. LINE (horiz) and FRAME (vert) sync switched automatically by SWEEP TIME/DIV switch. Frame 0.5 s/div to 0.1 ms/div; line 50 μ s/div to 1.0 μ s/div.
Trigger Sensitivity	INT: 20 Hz to 20 MHz-1 division. EXT: 20 Hz to 20 MHz-1.0 V p-p.
External Trigger Input	Maximum input voltage: 50 V p-p max or 24 V dc + ac peak. Input Impedance: 100 k Ω nominal, 35 pF nominal.

HORIZONTAL AMPLIFIER
(Horizontal input thru CH B input)

Deflection Factor 10 mV/div to 20 V/div \pm 5%.

Frequency Response	DC: dc to 1 MHz (-3dB). AC: 10 Hz to 1 MHz (-3dB).
Input Impedance	1 megohm \pm 5%, shunted by 22 pF (\pm 3 pF).
Input Protection	300 V (dv + ac peak) or 600 V p-p.
X-Y Operation	With SWEEP TIME/DIV switch in X-Y position, the CH A input becomes the Y input (vertical) and the CH B input becomes the X input (horizontal). The CH B position control becomes the horizontal position control.

CALIBRATION VOLTAGE

Internal 1 V p-p \pm 3% square wave @ 1 kHz nominal.

POWER REQUIREMENTS

AC	120 VAC, 60 Hz or 220 VAC, 50/60 Hz, 18 watts. 120 VAC or 220 VAC adapter supplied.
External DC	10-16 VDC, 16 watts. Reverse polarity protection.
Internal battery (Not Supplied)	12 V lead - acid rechargeable battery. Battery drain, 16 watts.

SPECIFICATIONS

Battery Charging Full charge time, 16 hours. Overcharge protection. Battery charges when oscilloscope is connected to external power, and scope is off.

Low Battery Indication Pilot light flashes at 10 V.

MISCELLANEOUS

Operating Environment 0 to +45°C.

CRT Rectangular 4 cm x 5 cm. P31 phosphor. Mumetal shield.

Accelerating Voltage 1.0 kV.

Scale 8 x 10 division; 1 division=0.5 cm.

Dimensions (HxWxD) 89 x 225 x 305 mm (3-1/2 x 8-7/8 x 12") with handle.
89 x 197 x 280 mm (3-1/2 x 7-3/4 x 11") without handle.

Weight 3.6 kg (8 lbs) with optional battery.

Probe Input Impedance: 10 MΩ. BNC connector.

ACCESSORIES SUPPLIED

Two 10:1 probes with accessory tips.

120 VAC, 60 Hz Adapter or 220 VAC, 50/60 Hz Adapter.

Instruction Manual.

Schematic Diagram & Parts List.

OPTIONAL ACCESSORIES

MODEL BP-14 BATTERY PACK

This rechargeable battery pack provides operation in field locations where ac or external dc power is not readily available. Battery pack mounts totally inside oscilloscope case. Battery charger (standard feature built into Model 1422 Mini-Scope) automatically recharges the battery whenever scope is connected to external ac or dc power source and scope is off. Battery is fully charged over night (16 hours), and charger automatically tapers to trickle charge as needed.

MODEL CC-20 DC POWER CABLE

For operation from 12-volt negative ground vehicle electrical system, cigar lighter plug.

MODEL LC-21 PROBE POUCH

Heavy man-made leather pouch attaches securely to top of scope. Holds two probes and instruction manual.

MODEL LC-22 DELUXE CARRYING CASE

Rugged man-made leather carrying case affords protection and convenience for field service applications. Front panel protector folds open to permit use of scope without removal from case. Shoulder strap included, but may also be carried by scope handle.

INSTRUMENT CONNECTING CABLES

Model CC-41. 36" RG/58U with a BNC connector on each end. Model CC-42. 36" RG/58U with a BNC connector and UHF connector (PL-259).

MODEL PR-32 RF DEMODULATOR PROBE

This probe permits display and analysis of the modulation envelope of RF signals to 250 MHz (-6 dB @ 250 MHz). Input impedance is 30 k Ω minimum, shunted by 4.5 pF maximum. Internal shielding protects against stray RF pickup.

MODEL PR-33 10:1/DIRECT PROBE

The Model PR-33 is the standard replacement probe, with 50 MHz bandwidth, for **B & K-Precision** oscilloscopes.

MODEL PR-37 DELUXE 10:1/DIRECT PROBE

The Model PR-37 is the deluxe replacement probe, with 100 MHz bandwidth, for **B & K-Precision** oscilloscopes. Accessories included with the Model PR-37 are a spring-loaded retractable tip cover, insulating tip, BNC tip adapter, IC tip and insulated compensation capacitor adjustment tool. The PR-37 is available in both grey and red colors. Model PR-37G is grey and PR-37R is red. The PR-37 and accessories come in convenient zippered vinyl case.

CONTROLS AND INDICATORS

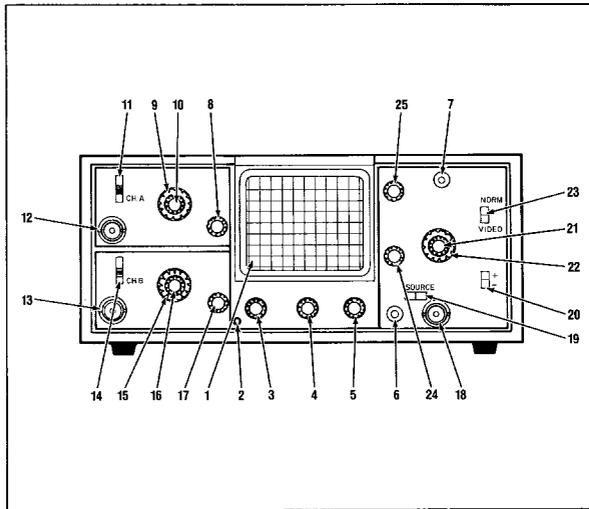


Fig. 1. Front Panel Controls.

CRT CONTROLS (1-7)

1. **Cathode Ray Tube (CRT).** This is the screen on which the waveforms are viewed. An 8 x 10 division graticule is used.

2. **Pilot Light.** Lights when Mini-Scope is turned on. When operating from battery, flashes when battery needs recharging (10 V).
3. **INTENSITY Control.** Fully counterclockwise rotation of this control (OFF position) turns off Mini-Scope. Clockwise rotation turns on Mini-Scope. Further clockwise rotation of the control increases the brightness of the trace.
4. **FOCUS Control.**
5. **ASTIGmatism/TRACE ROTATION Control.** Concentric control. Outer knob is astigmatism control, used in conjunction with FOCUS and INTENSITY for optimum spot roundness; center screwdriver adjustment is TRACE ROTATION, which adjusts trace to eliminate tilt.
6. **Terminal.** Chassis ground.
7. **CAL 1 kHz 1 V p-p Terminal.** Provides 1 kHz, 1-volt peak-to-peak square wave signal. This is useful for probe compensation adjustment and a general check of Mini-Scope calibration accuracy.

CHANNEL A CONTROLS (8-12)

8. **POS Control.** Rotation adjusts vertical position of channel A trace. In X-Y operation, rotation

adjusts vertical position of display. OFF position disables channel A (fully counterclockwise). Dual-trace operation is enabled when both channel A and B are turned on.

9. **VOLTS/DIV Switch.** Vertical attenuator for channel A; provides step adjustment of vertical sensitivity. When VARIABLE control (10) is set to CAL, vertical sensitivity is calibrated in 11 steps from 10 mV/div to 20 V/div.
10. **VARIABLE Control.** Rotation provides fine control of channel A vertical sensitivity. In the fully clockwise (CAL) position, the vertical attenuator is calibrated.
11. **AC-GND-DC Switch.** Three-position slide switch which operates as follows:
 - AC Capacitive coupled input of channel A input signal.
 - GND Opens signal path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing dc measurements.
 - DC Direct coupled input of ac and dc component of channel A input signal.
12. **INPUT Jack.** Vertical input for channel A trace. Vertical input for X-Y operation. Maximum input rating 300 volts dc + ac peak or 600 volts peak-to-peak.

CHANNEL B CONTROLS (13-17)

13. **AC-GND-DC Switch.** Three-position slide switch which operates as follows:
 - AC Capacitive coupled input of channel B input signal.
 - GND Opens signal path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing dc measurements.
 - DC Direct coupled input of ac and dc component of channel B input signal.
14. **INPUT Jack.** Vertical input for channel B trace in normal sweep operation. External horizontal input in X-Y operation. Maximum input rating 300 volts dc + ac peak or 600 volts peak-to-peak.
15. **VOLTS/DIV Switch.** Vertical attenuator for channel B; provides step adjustment of vertical sensitivity. When VARIABLE control is set to CAL, vertical sensitivity is calibrated in 11 steps from 10 mV/div to 20 V/div. In X-Y operation, this control provides step adjustment of horizontal sensitivity.
16. **VARIABLE Control.** Rotation provides fine control of channel B vertical sensitivity. In the fully clockwise (CAL) position, the vertical attenuator is calibrated. In X-Y operation, this control becomes the fine horizontal gain control.

17. **◆ POS Control.** Rotation adjusts vertical position of channel B trace. In X-Y operation, rotation adjusts horizontal position of display. OFF position disables channel B (fully counterclockwise). Dual-trace operation is enabled when both channels A and B are on.

SWEEP AND TRIGGERING CONTROLS (18-25)

18. **EXT TRIG Jack.** Input terminal for external trigger signal. Maximum input rating is 24 volts dc + ac peak.

19. **SOURCE Switch.** Two-position slide switch selects triggering source for sweep.

INT Internal sync. Waveform being observed triggers sweep. Channel A signal triggers sweep in dual-trace operation. Any signal of at least 1 division amplitude is capable of triggering the sweep.

EXT External sync. Sweep is triggered by signal applied at EXT TRIG jack.

20. **SLOPE Switch.** Two-position slide switch with the following positions:

- (+) Sweep is triggered on positive-going slope of waveform, or with positive sync pulse of composite video waveform.
- (-) Sweep is triggered on negative-going slope of waveform, or negative sync pulse of composite video waveform.

21. **SWEEP TIME/DIV Switch.** Horizontal coarse sweep time selector. Selects calibrated sweep times of 1 μ s/div to 0.5 s/div in 18 steps when sweep time VARIABLE control is set to CAL position (fully clockwise). In the channel B position, this switch disables the internal sweep generator and permits the channel B input to provide horizontal deflection (X-Y operation).

22. **Sweep Time VARIABLE Control.** Fine sweep time adjustment. In the extreme clockwise (CAL) position the sweep time is calibrated.

23. **NORM-VIDEO Switch.** Two-position slide switch selects type of trigger signal.

NORM Used for viewing all waveforms except composite video signals.

VIDEO Used for viewing composite video signals. Interconnects video sync separator to permit the sync pulses to trigger sweep. Vertical sync pulses automatically selected at sweep times appropriate for viewing FRAMES, .5 s/div to .1 ms/div. Horizontal sync pulses automatically selected at sweep times appropriate for viewing LINES, 50 μ s/div to 1 μ s/div.

24. **TRIG LEVEL Control.** Trigger level adjustment, determines point on waveform where sweep starts. "0" (center of rotation) selects zero-crossover, or average, of waveform, and is the most sensitive setting. Rotation in minus (-) direction selects more negative point of triggering, and rotation in

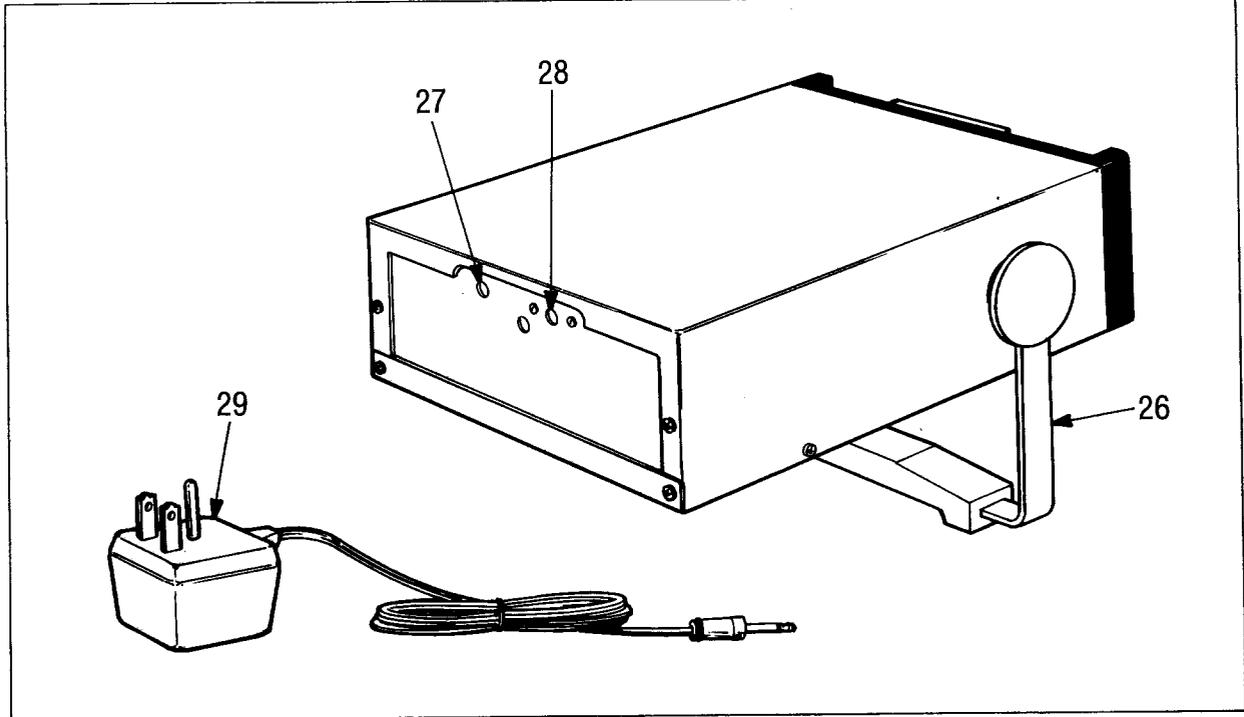


Fig. 2. Rear Panel and Miscellaneous Controls.

plus (+) direction selects more positive point of triggering. Push-pull switch selects automatic triggering when pulled out (PULL AUTO). With automatic triggering, a sweep is generated automatically (free runs) in the absence of trigger signal; reverts to triggered sweep operation in the presence of adequate trigger signal.

25. ◀▶ **POS Control.** Rotation adjusts horizontal position of trace (both traces in dual-trace operation). Alternate action (push-push) switch selects X10 sweep magnification when knob is released (PUSH X10 MAG). Rotation selects portion of sweep to be viewed, ccw to view left end of trace, cw to view right end of trace. X10 magnification increases sweep rate 10 times, to 100 ns/div maximum. Push again to latch knob in for standard non-magnified sweep.

ADDITIONAL FACILITIES (FIG. 2)

26. **Carrying Handle/Tilt Stand.** The Mini-Scope rests on rubber feet when the handle is folded upward. When the handle is folded downward, it elevates the front of the Mini-Scope to a convenient viewing angle. Handle locks at each $22\text{-}1/2^\circ$ angle of rotation.
27. **AC Input Connector.** Accepts output from 120 VAC or 220 VAC adapter.
28. **DC Input Connector.** Accepts external dc source of 10 to 16 volts. Center pin is positive.
29. **AC Adapter.** Converts 120 VAC (Model BE-20) or 220 VAC (Model BE-21) input to 16 VAC rms for ac input connector.

OPERATING INSTRUCTIONS

PRECAUTIONS**Safety****WARNING**

The following precautions must be observed to prevent electric shock.

1. When this Mini-Scope is used to make measurements in equipment that contains high voltage, there is always a certain amount of danger from electric 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. When operated from ac power or internal battery, the chassis and the housing of the Model 1422 Mini-Scope is floating (isolated from earth ground). Always connect a cable from the \perp terminal of the Mini-Scope to a good earth ground before making any other connections to the equipment under test. See item 6 on the inside of this manual for a full explanation of the hazard.
3. One of the most commonly encountered shock hazards is testing of "hot chassis" transformerless ac powered equipment (see item 5 on the inside front cover for a full explanation of the hazard). Never attempt to make oscilloscope measurements in such equipment without first connecting an isolation transformer between the ac power line and the equipment under test. To be on the safe side, treat all equipment as "hot chassis" unless you are it has an isolated chassis or earth ground chassis.
4. Special precautions are required to measure or observe line voltage waveforms with any oscilloscope. Use the following procedure:
 - a. First, connect the ground clip of the probe to earth ground. Do not connect the ground clip of the probe to either side of the line. If the "hot" side is contacted, the chassis and the case of the scope also become "hot" and pose a serious electrical shock hazard. If the chassis is already grounded touching the "hot" side of the line may "weld" or "disintegrate" the probe ground clip and cause possible injury, plus possible damage to the scope and the 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

a waveform. The other side of the receptacle should be grounded and no waveform will result.

Equipment Protection

CAUTION

The following precautions will help avoid damage to the oscilloscope.

1. Never allow a small spot of light of high brilliance to remain on the screen for more than few seconds. The screen may become permanently burned. A spot will occur only 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, or switch back to normal sweep operation when no signal is applied.
2. Never apply more than the rated 300 volts dc + ac peak or 600 volts peak-to-peak (212 volts rms for sine wave) to the oscilloscope inputs. When using 10:1 attenuation probes, the voltage at the scope input is only 1/10 of that at the point of measurement, however, do not exceed the probe's voltage rating at the point of measurement.
3. When operated from external dc power, the chassis and the housing of the Mini-Scope is common with the negative polarity of the power source. Make sure the ground cable for the Mini-Scope and the ground clips of the probes are also connected to points that are common with the negative polarity of the power source. Without this precaution, the

equipment under test may be shorted through the probe clip leads or ground cable, resulting in possible damage to the equipment under test or the Mini-Scope.

OPERATING TIPS

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

1. Always use the probe ground clips for best results. Do not use an external ground wire in lieu of the probe ground clips, as undesired signals may be introduced.
2. Operation adjacent to equipment which produces strong ac magnetic fields should be avoided where possible. This includes such devices as large power supplies, transformers, electric motors, etc., that are often found in an industrial environment. Strong magnetic fields can exceed the practical CRT magnetic shielding limits and result in interference and distortion.
3. Probe compensation adjustment matches the probe to input of the scope. For best results, compensation of both probes should be adjusted initially, then the same probe is always used with channel A and channel B respectively. Probe compensation should be readjusted whenever a probe from a different scope is used, or the channel A and B probes are interchanged. Adjust the compensation trimmer on each probe for the best quality wave-shape (minimum overshoot, rounding off, and tilt), while observing the calibration square wave from the CAL 1 kHz 1.0 V p-p terminal.

4. Occasionally check trace rotation, dc balance, astigmatism, and calibration accuracy of the scope using the procedures found in the OPERATOR MAINTENANCE section of this manual.

BATTERY INSTALLATION (refer to Fig. 3)

The Model 1422 Mini-Scope is shipped without a battery. The Model BP-14 Battery Pack is available as an optional accessory for users desiring the convenience of a rechargeable battery that mounts inside the unit. This reduces instrument cost for those users not requiring battery operation. For those requiring the accessory, it assures a fresh battery when you are ready to use the Mini-Scope as a battery-powered instrument.

1. To prevent electric shock, disconnect all external power and turn off the Mini-Scope (INTENSITY control fully counterclockwise) before removing the case.
2. Remove the six screws securing the top cover; two on each side and two at the rear panel.
3. Lift off the top cover.
4. Remove and save the long screw, washer and spacer.
5. Remove the screw from the right side of the external dc power jack. Loosen the left screw and tilt up the right edge connector body to allow the battery to easily slide into the battery compartment.

6. Slide the battery into position under the connectors so that the positive (red) terminal is located to the right as shown in Fig. 3. Be sure not to damage any wires.
7. Connect the red wire to the positive terminal and the black wire to the negative terminal.
8. Insert the long screw and spacer (from step 4) through the rear panel and tighten to secure the battery in position.
9. Replace and tighten the mounting screws which attach the external dc power jack.
10. Reinstall the top cover.

BATTERY POWERED OPERATION

Initially, the Mini-Scope should be operated from ac power to assure that the battery is fully charged. Allow up to 16 hours to fully recharge a battery that has discharged to the point of 10 volts. This point is indicated by the flashing pilot light.

1. Turn on the Mini-Scope.
2. If the pilot light glows brightly, the battery is charged and the Mini-Scope is ready to use. A fully charged battery will typically give 45 minutes of continuous operation. To extend battery life, turn off the Mini-Scope when not actually making measurements.

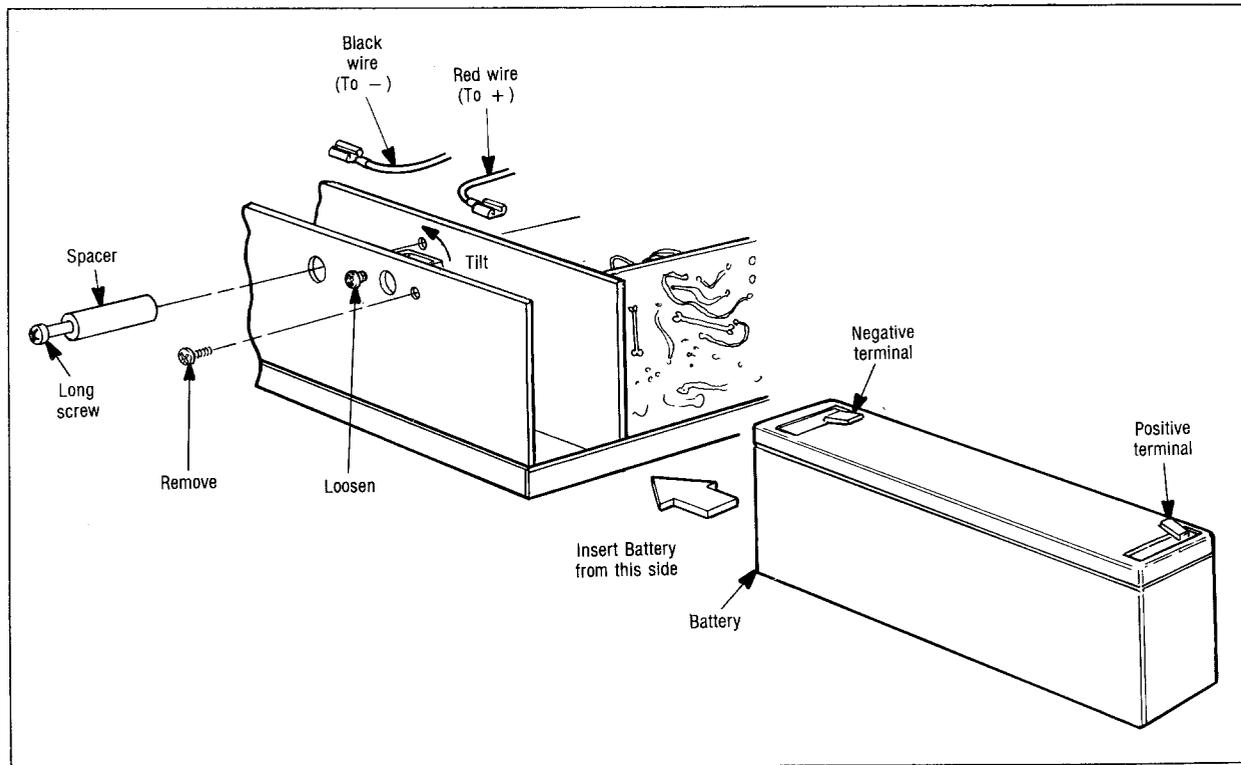


Fig. 3. Battery Installation

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3. If the pilot light flashes, the battery is discharged to 10 volts. Measurement accuracy is sharply degraded below 10 volts. To continue operation, the scope must be connected to ac or external dc power. If possible, recharge the battery.
4. The battery is recharged when ac power is applied and the scope is turned off. An internal circuit inhibits charging when the Mini-Scope is operating. Recharging also occurs when external dc power is applied and the Mini-Scope is turned off, but only if the external dc voltage is at least 3 volts higher than the battery voltage. Thus, a minimum voltage of 17.5 volts is required to fully charge the battery. Normally, only ac power is used for battery charging.
5. If you anticipate the need for prolonged battery operation, you may wish to carry a fully charged spare battery. Another alternative is to carry a heavy duty external battery. The considerations for selecting and using such an external battery pack are fully explored in the Appendix.
6. At sites without ac power, a source of external dc power is often available for powering the equipment being serviced. Any dc power source of 10 to 16 volts (up to 25 volts peak) and 16 watts of reserve capacity will power the Mini-Scope and conserve the battery.

AC POWERED OPERATION

1. Connect the ac power adapter (BE-20 for 120 VAC, 60 Hz operation or BE-21 for 220 VAC, 50/60 Hz operation) to an ac outlet and the ac

input receptacle on the rear panel of the Mini-Scope.

2. Turn on the Mini-Scope.
3. The pilot light should glow, indicating that the Mini-Scope is ready for use.
4. If the optional battery is installed, it will recharge when the INTENSITY control is turned OFF (fully counterclockwise), so long as the Mini-Scope remains connected to the ac power source.

EXTERNAL DC POWERED OPERATION

CAUTION

1. For use with negative-ground electrical systems only.
2. Never connect an external dc power source and the ac adapter at the same time. Possible damage may result.

The Model 1422 Mini-Scope is guaranteed to operate from external dc power sources of 10 to 16 volts. However, it will withstand and operate from voltage as high as 25 volts peak or continuous. We do not recommend operation from nominal 24-volt dc power sources; peak voltage in such systems is usually 28 to 32 volts. If external dc power is taken from the equipment under test, make sure its power supply can furnish 16 watts of additional drain for powering the Mini-Scope without performance degradation of the equipment being tested.

1. Connect a dc power cord from the rear panel dc input receptacle to a negative-ground 12-volt dc power source (10 to 25 VDC), such as a vehicle cigarette lighter, or an external marine type battery. Observe proper polarity; the Mini-Scope is protected against reverse polarity damage, but will not operate if polarity is reversed.
2. Turn on the Mini-Scope.
3. The pilot light should glow, indicating that the Mini-Scope is ready for use. The pilot light will flash if the external dc voltage drops to 10 volts or less.
4. If the internal battery is installed, the battery is charging during the time the Mini-Scope is connected to the external dc source, if the voltage exceeds the internal battery voltage by at least 3 V and the Mini-Scope is turned off. An internal circuit inhibits charging when the scope is operating.

INITIAL STARTING PROCEDURE (refer to Fig. 4)

1. Prepare oscilloscope for ac-powered, external dc-powered, or battery-powered operation as previously described.
2. Set CH A \blacktriangleleft POS control (8), CH B \blacktriangleleft POS control (17), and \blacktriangleleft POS control (25) to the centers of their ranges.
3. Pull TRIG LEVEL control (24) to the AUTO position.
4. Set CH A AC-GND-DC switch (11) and CH B AC-GND-DC switch (13) to the GND positions.

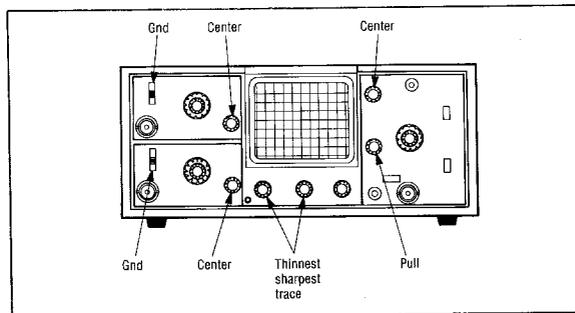


Fig. 4. Initial Control Settings.

5. Wait a few seconds for the cathode ray tube (CRT) to warm up. Two traces should appear on the face of the CRT.
6. If no trace appears, increase (clockwise) the INTENSITY control (3) setting until the trace is easily observed. If a spot appears, select any SWEEP TIME/DIV setting except CH B.
7. Adjust FOCUS control (4) and INTENSITY control (3) for the thinnest, sharpest trace.
8. Readjust position controls (8, 7 and 25) if necessary, to center the traces.
9. Check for proper adjustment of ASTIG control (5). The oscilloscope is now ready for making waveform measurements.

CAUTION

Never allow a small spot of high brilliance to remain stationary on the screen more than few seconds. The screen may become permanently burned. Reduce intensity or keep the spot in motion by causing it to sweep.

SINGLE-TRACE WAVEFORM OBSERVATION

Either channel A or channel B can be used for single-trace operation. Channel A is used for following instruction.

1. Perform the steps of the "Initial Starting Procedure" with the CH B \blacktriangle POS control set to OFF position. Then connect the probe to the channel A INPUT jack (12).
2. Set AC-GND-DC switch (11) to AC or DC position for desired measurement.
3. Connect ground clip to chassis of the equipment under test. Connect the tip of the probe to the point in the circuit where the waveform is to be measured.
4. Set CH A VOLTS/DIV switch (9) and the VARIABLE control (10) to a position that gives 2 to 6 divisions of amplitude reading on the CRT screen.
5. Set SOURCE switch (19) to INT position for internal triggering or EXT position if you desired to use an external triggering source by connecting it to the EXT TRIG jack (18).
6. Set NORM-VIDEO switch (23) to the VIDEO position for observing television composite video waveforms or to the NORM position for all other types of waveforms.
7. Adjust TRIG LEVEL control (24) to obtain a synchronized display and a clean waveform. If there is inadequate signal to trigger the sweep, such as when measuring dc or very low amplitude waveforms, pull the control out (PULL AUTO) for automatic triggering.
8. To obtain and view certain portions or several numbers of the waveform adjust SWEEP TIME/DIV switch (21) and VARIABLE control (22) to obtain desired display on the screen.
9. After obtaining the desired display, as in step 8, it is sometimes desirable to make final adjustment of TRIG LEVEL control (24). The (-) direction selects a more negative point of the waveform at which the sweep triggering will occur and the (+) direction selects a more positive point on the waveform at which sweep triggering will occur. The control may be adjusted to start the sweep on any desired portion of the waveform.
10. For a close-up view of a portion of the waveform, push to release \blacktriangleleft POS control (25). This expands the sweep by a factor of ten (10X magnification) and displays only the center portion of the sweep.

To view a portion to the left of center, turn the ◀ POS control counterclockwise. To view a portion to the right of center, turn the control clockwise. Push again on the control to latch control in and return the sweep to the normal, non-magnified condition.

DUAL-TRACE WAVEFORM OBSERVATION

1. For dual-trace waveform observation repeat the steps for "SINGLE-TRACE WAVEFORM OBSERVATION", except set both CH A and CH B ⚡ POS controls to "on". Two traces will appear.

2. Adjust the separation between traces as required with the CH A ⚡ POS and CH B ⚡ POS controls.
3. The CH A signal becomes the trigger or EXT trigger may be selected.

APPLICATIONS

Several helpful hints on oscilloscope operation and applications are contained in "B & K-Precision's Guidebook to Oscilloscopes". A free copy is available to all purchasers of Model 1422 Mini-Scopes. To obtain your free copy, return the postage paid card that was packaged with your oscilloscope.

WARNING

To prevent electric shock, do not perform servicing that requires removal of the covers unless you are qualified to do so. High voltage, up to 1,000 volts, is present when covers are removed.

PERIODIC ADJUSTMENTS

All adjustments which require removal of the top cover or bottom plate are described in the CALIBRATION section of this manual and should be performed by qualified personnel only.

The following operator adjustments only need to be checked and adjusted occasionally. The ASTIG and TRACE ROTATION controls are accessible without removing the top cover or bottom plate.

Trace Rotation

If the trace is not exactly parallel with the horizontal lines of the graticule scale, it may be readjusted with the TRACE ROTATION control on the front panel.

1. Set Mini-Scope controls to produce a horizontal trace with no input signal (PULL AUTO position of TRIG LEVEL switch).

2. Use POSITION controls as required to position the trace along a horizontal line of the graticule scale.
3. Adjust TRACE ROTATION with a small, thin flat blade screwdriver so trace is parallel with the reference line on the graticule scale.

Astigmatism

1. Set SWEEP TIME/DIV switch to CH B position and channel A and channel B AC-GND-DC switches to GND position. This will produce a spot on the screen.
2. With INTENSITY control set about mid-range, adjust both the ASTIG and FOCUS controls for the sharpest, roundest spot. Do not readjust ASTIG control after this step. If the normal setting for the front panel ASTIG control approaches its limit, an internal adjustment can be set to re-center the range of adjustment. Refer to the SERVICING section for procedure.

CAUTION

Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may be permanently burned.

Probe Compensation

Probe compensation adjustment matches the probe to the input of the scope. For best results, compensation of both probes should be adjusted initially, then the same probe always used with channel A and channel B respectively. Probe compensation should be readjusted whenever a probe from a different oscilloscope is used, or the channel A and B probes are interchanged.

1. Connect probes to both INPUT jacks. Connect ground clip of probes to Mini-Scope ground terminal and touch tips of both probes to CAL 1 kHz 1 V p-p terminal.
2. Select single trace operation of channel A, then channel B, for steps 3 and 4.
3. Set Mini-Scope controls to display 3 or 4 cycles of CAL square wave at 5 or 6 divisions amplitude.

4. Adjust compensation trimmer on probe for optimum square wave (minimum overshoot, rounding off, and tilt).

CALIBRATION CHECK

A general check of calibration accuracy may be made by displaying the output of the CAL 1 kHz 1 V p-p terminal on the screen. This test signal has been factory adjusted to provide a square wave of 1.0 V p-p amplitude ($\pm 3\%$) and approximately 1 millisecond time duration per cycle (uncalibrated). However, a calibration signal of 0.5% accuracy is required for recalibration adjustment of the instrument.

At 20 mV/div (using 10:1 probes) the CAL jack should produce five divisions of vertical deflection on channel A or channel B, or five divisions of horizontal deflection in X-Y operation when the VARIABLE controls are set to CAL.

WARNING

1. The following instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the OPERATOR MAINTENANCE section unless you are qualified to do so.
2. High voltage up to 1000 volts dc is present on the CRT and high voltage power supply when the scope is operating. Always observe caution when the top cover or bottom plate is removed from the unit. Contacting exposed high voltage could result in fatal electric shock.

REMOVING THE CASE

The case is removed in two sections as shown in Fig. 6. The top cover can be lifted off after removing six Phillips-head screws from the top and sides of the case. The bottom plate can be lifted off after removing six Phillips-head screws from the bottom of the case.

FUSE REPLACEMENT (Refer to Fig. 5)

Fuse F1 is in series with the ac input at P1 and dc input at P2. Fuse F2 is in series with the internal battery. If fuse F1 blows when operating on ac or dc, or

fuse F2 blows when operating on the internal battery, the pilot light will go out and the scope will not operate. The fuses 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 a fast blow fuse of proper current rating and type; 2 amp, 7AG for both fuses. The fuses are located on the power supply circuit board. When operating on external ac or dc the F2 fuse can be used as a spare. When operating on internal battery the F1 fuse can be used as a spare.

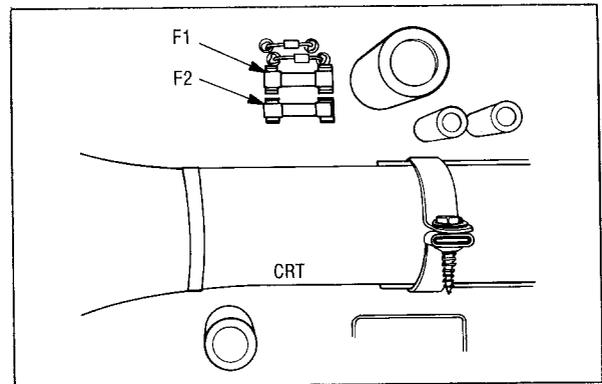


Fig. 5. Fuse locations.

1. Disconnect external power source from unit if used.
2. Remove six screws holding top cover and lift off cover.
3. Pull out the fuse from the fuse clip. The fuse fits very tightly into the clips, and it may be necessary to hold the circuit board in place while pulling.
4. Replace with a fuse of the correct voltage and current rating and type; 2 amp, 32 volt, 7 AG.

CALIBRATION ADJUSTMENTS

The following procedures include only those not requiring specialized skills and test equipment. Sweep time compensation, frequency compensation, and input capacitance should be adjusted only by experienced, skilled personnel with proper test equipment.

Initial Preparation

All adjustments should be performed in the sequence listed in this manual. Touch-up adjustment of unrelated adjustments can be performed independently. All adjustments are affected by the 8 V reference; if 8 V is readjusted, complete calibration must be performed.

1. Disconnect any external power source.
2. Set INTENSITY to the full counterclockwise (OFF) position.

3. Remove top cover and bottom plate.
4. Place Mini-Scope bottom side up on workbench.
5. Use an external ac or dc power source to assure accuracy and connect to appropriate rear panel connector.
6. Set front panel controls to initial positions in Table 1.

Test Equipment Required

DC Voltmeter: 1% or better accuracy, 1 V to 100 V, 10 M Ω input impedance (B & K-Precision Model 2831 or equivalent).

High Voltage Multiplier Probe: Input impedance 100 M Ω or greater (B & K-Precision Model PR-28 or equivalent).

AC voltmeter: 0.5% or better accuracy at 200 Hz, 10 M Ω input impedance (B & K-Precision Model 2831 or equivalent).

Frequency Counter: 0.5% or better accuracy, 10 Hz to 10 MHz (any B & K-Precision frequency counter).

Sine wave generator: 1% or less distortion at 200 Hz. (B & K-Precision Model 3025 or equivalent).

8 V Adjustment

The 8 volt adjustment R27 is located on the power supply as shown in Fig. 7.

SWITCH CONTROL

SWEEP TIME/DIV
Sweep time
VARIABLE
◀ POS/PUSH
10X MAG
INTENSITY
FOCUS
NORM/VIDEO
SLOPE
TRIG LEVEL/
PULL AUTO
SOURCE
CH A ▲ POS
CH A AC-GND-DC
CH A VOLTS/DIV
CH A VARIABLE
CH B ▲ POS
CH B AC-GND-DC
CH B VOLTS/DIV
CH B VARIABLE

POSITION

1 mS
CAL

Mechanical
Center/released
3 o'clock
Optimum focus
NORM
+
Mechanical Center/
pull out
INT
Mechanical center
AC
10 mV
CAL
Mechanical center
AC
10 mV
CAL

Table 1. Initial control settings for calibration adjustment.

1. Set voltmeter to measure dc.
2. Connect dc voltmeter between 8 volt bus and ground.
3. Set 8 V Adjust (R27) for a reading of 8.00 volts dc.

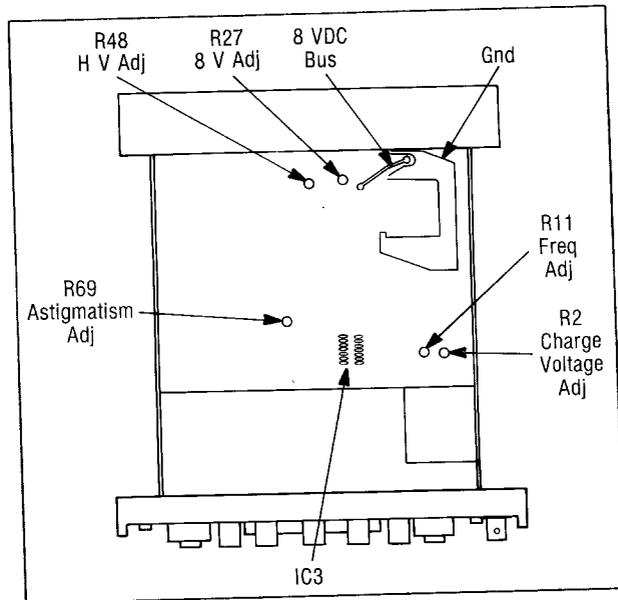


Fig. 7. Calibration Adjustments, Bottom of Scope.

DC-DC Converter Frequency Adjustment

The dc-to-dc converter frequency adjustment (R11) is located on the power supply board as shown in Fig. 7.

1. Connect frequency counter to IC3 pin 10.
2. Adjust Freq Adj (R11) for reading of 20.0 kHz.

High Voltage Adjustment (R48)

The high voltage adjustment is located on power supply board Fig. 7.

1. Turn INTENSITY control to OFF position.
2. Set dc voltmeter with minimum 100 M Ω input impedance for 1000 volt range (with 1000:1 multiplier, use 1 volt range).
3. Connect (+) to CRT Cathode (pin 4) and (-) to chassis ground.
4. Turn INTENSITY control clockwise to turn on Mini-Scope.
5. Adjust H.V. Adjust (R48) for -1000 volts dc (-1.000 volts with 1000:1 multiplier).

Charge Voltage Adjustment

The charge voltage adjustment R2 is located on the power supply board Fig. 7. This adjustment sets the maximum charge voltage for the rechargeable battery. This adjustment does not need to be performed on units not using the rechargeable battery pack.

1. Connect ac adapter and turn off scope.

2. Disconnect leads from terminals of rechargeable battery.
3. Connect a 1 k Ω , 1/2 W resistor between the + and - leads disconnected in step 2.
4. Connect a dc voltmeter across the resistor.
5. Adjust (R2) for a reading of 14.4 volts dc charge voltage.

Astigmatism Range Adjust

The astigmatism range adjustment (R69) is located on the power supply board Fig. 7. This adjustment is set so that the front panel ASTIG control is approximately centered for proper astigmatism setting.

1. Set SWEEP TIME/DIV switch to CH B position and channel A and B AC-GND-DC switches to GND. This will produce a spot on the screen.
2. With INTENSITY control and front panel ASTIG control set about mid-range, adjust FOCUS control and astigmatism range control (R69) for the sharpest, roundest spot. Leave front panel ASTIG control centered while performing this adjustment.

CAUTION

Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may be permanently burned.

DC Balance

The dc balance controls (R235 for channel A, R237 for channel B) are located on the vertical board, Fig. 8.

1. Set scope controls for a single horizontal trace on channel A with the channel A AC-GND-DC switch set to GND position

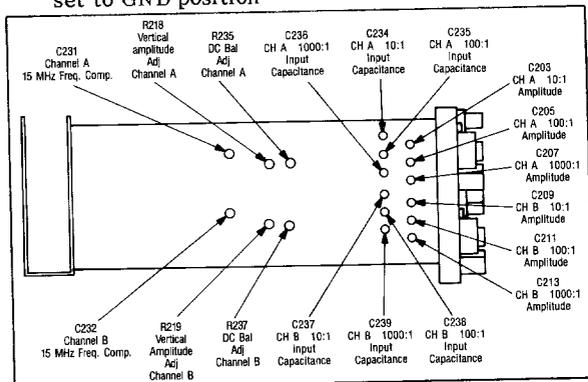


Figure 8. Calibration Adjustments, Left Side of Scope.

2. Rotate the Channel VOLTS/DIV control back and forth through the 10, 20, and 50 mV positions while observing the trace.
3. If the trace moves vertically, adjust R235 for minimum or zero movement when performing step 2.

4. Repeat the entire procedure for Channel B, adjusting R237.

Vertical Amplitude Adjustment

The vertical amplitude adjustments (R218 for channel A, R219 for channel B) are located on the vertical board, Fig. 8.

1. Set VOLTS/DIV for both channel A and B to 1 V position.
2. Set VARIABLE controls for both channel A and B fully clockwise to CAL.
3. Set AC-GND-DC controls for both channel A and B to AC position.
4. Use a sine wave generator (1% or less distortion at 200 Hz) and connect directly to channel A input, without 10:1 attenuation probes.
5. Set \blacktriangledown POS control for channel B to OFF position.
6. Measure level of sine wave signal with an ac voltmeter. Meter must be accurate (0.5% at 200 Hz). Adjust signal generator for a 1.77 V rms output.
7. Adjust R218 for a peak-to-peak output of exactly 5 divisions (5 V p-p).
8. Rotate channel A \blacktriangledown POS control counterclockwise to OFF and channel B \blacktriangledown POS control clockwise out of the OFF position.

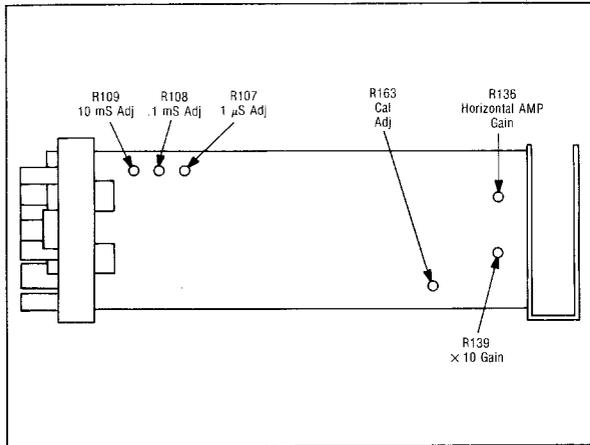


Figure 9. Calibration Adjustments, Right Side of Scope

9. Connect signal generator to channel B input.
10. Adjust R219 for a peak-to-peak output of exactly 5 divisions (5 V p-p).

CAL Adjustment

The CAL adjustment (R163) is located on the horizontal board, Fig. 9.

1. Immediately after performing vertical amplifier calibration, connect the output of the CAL 1 kHz, 1 V p-p terminal to the channel A input with 10:1 probe.
2. Using 20 mV/div sensitivity, adjust R163 for exactly 5 divisions amplitude on the CRT.

INSTRUMENT REPAIR SERVICE

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

APPENDIX-EXTERNAL POWER PACK CONSIDERATIONS

The Model BP-14 Battery Pack typically gives 45 minutes of continuous operation for the Model 1422 Mini-Scope. However, where longer battery operation may be required occasionally, some users prefer to also carry an external power pack. This usually consists of a moderate to heavy duty 12-volt rechargeable battery, such as a marine type, and an adapter cable for connecting the battery to the Mini-Scope. The pilot light on the Mini-Scope still warns of low voltage conditions by flashing, just as when the BP-14 Battery Pack is used. Following items should be considered for selecting and using an external battery pack:

1. To protect against spillage of battery acid, a dry type is recommended. Ni-Cad or lead-acid gel-cell types are preferred.
2. The most important factor for selecting a battery is the maximum number of hours of operation to be expected from a fully charged battery. Excess battery capacity should be avoided. A battery giving 8 to 12 hours continuous operation should meet the most rigorous requirements. The required battery capacity can be readily calculated as follows:
 - a. The Mini-Scope dissipates about 16 watts. Therefore, the average current drain on a 12-volt battery is about 1.3 amp.
 - b. Multiply the maximum hours of operation expected times the average current drain of 1.3 amp to determine the required battery capacity. For example, 10 hours of operation times 1.3 amps equals 13 ampere-hours battery capacity. Check the battery derating specification at a current drain of greater than 1 amp; it may significantly affect the total hours of operation per charge.
3. If the internal battery is used until the pilot light flashes before connecting the external battery pack, the external battery may start to recharge the internal battery when the scope is turned off. To prevent this discharge disconnect the external dc jack as soon as the scope is turned off.
4. The external battery will not be automatically recharged if the Mini-Scope is connected to ac power. In fact, serious damage may result since there is only diode isolation between the ac input and external dc input jacks. Never connect external dc power and ac power at the same time.
5. Use the battery manufacturer's recommendation for selecting the battery charger. It will limit current and voltage to values that give the longest battery life, and with reasonable recharge time.
6. Do not attempt to wire the battery charger circuit of the Mini-Scope to recharge the external battery. This charger is designed for the BP-14 Battery Pack and does not have adequate capacity for a larger external battery pack.

WARRANTY SERVICE INSTRUCTIONS

(For U.S.A. and its overseas territories)

To send in 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, Maxtec International Corporation
Factory Service Operations
6470 West Cortland Street
Chicago, Illinois 60635
Tel (312) 889-1448
Telex: 25-3475

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

TEST INSTRUMENT SAFETY

(Continued from inside of front cover)

5. 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 many test instruments 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.
6. The housing and chassis of the Model 1422 Mini-Scope is isolated from earth ground (floating). This poses no safety hazard for normal measurements, where the chassis of the equipment under test is at earth ground. However, it is recommended safety practice to always connect a cable from the $\text{---}\frac{\square}{\perp}$ terminal of the scope to an earth ground before starting measurements. Without this cable, touching the ground clip of a probe to a "hot chassis" or live voltage point floats the entire housing and chassis of the scope to that potential. The separate earth ground connection prevents the scope from becoming "hot", even if high voltage appears at an unexpected point or the safety precautions for "hot chassis" equipment (item 5, above) are ignored.
7. 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.
8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.