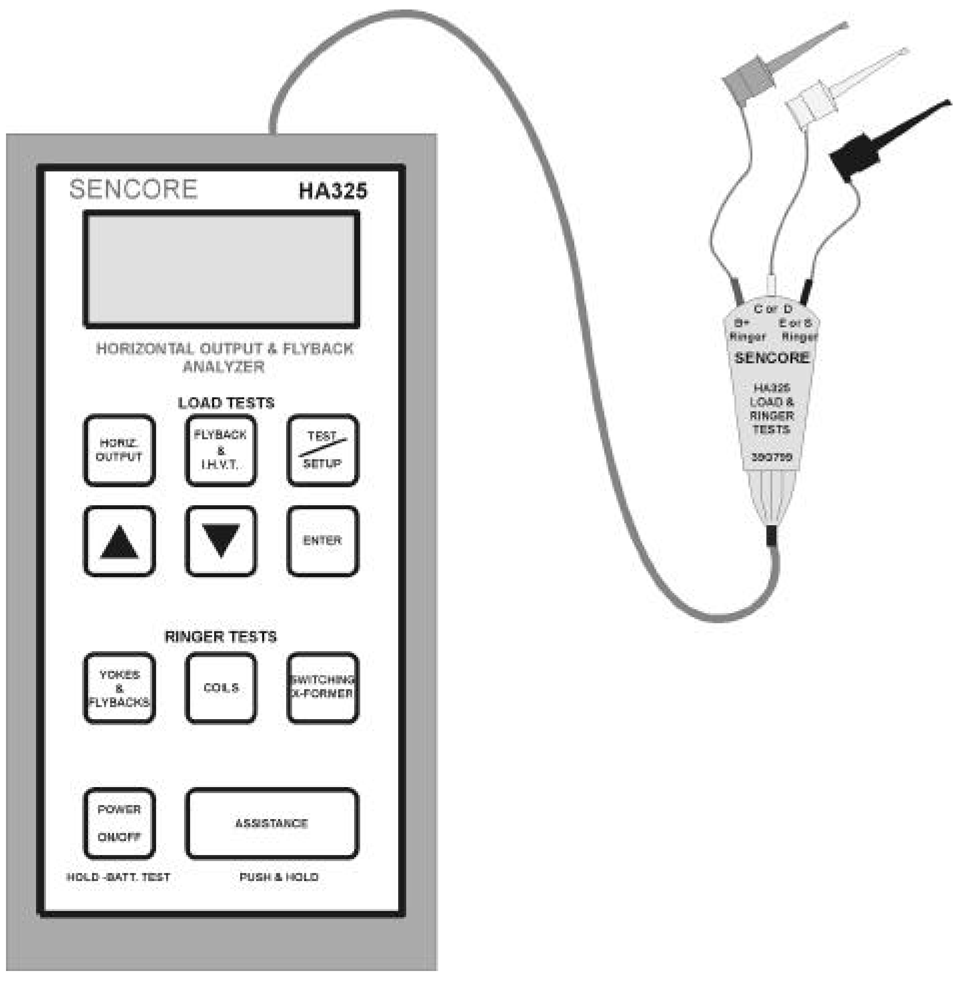
HA325

HORIZONTAL OUTPUT & FLYBACK ANALYZER

Operation and Application Manual



SENCORE

3200 Sencore Drive, Sioux Falls, South Dakota 57107

WARNING

PLEASE OBSERVE THESE SAFETY PRECAUTIONS

There is always a danger present when using electronic test equipment. Unexpected voltages can be present at unusual locations in defective equipment and distribution systems. Become familiar with the equipment with which you are working and observe the following safety precautions.

Every precaution has been taken in the design of the HA325 to insure that it is as safe as possible. However, safe operation depends on you, the operator.

1. **Never exceed the limits of this instrument** as given in the specifications section and the additional special warnings in this manual.

2. **A severe shock hazard can result** if the chassis of the equipment being serviced is tied to the "hot" side of the AC line. An isolation transformer should always be used with hot-chassis equipment. Also be sure that the top of your workbench and floor underneath it are dry and made of non-conductive materials.

3. **Remove the circuit power before making connections** to high voltage circuits or circuit points.

4. **Discharge filter capacitors** (after removing power) before connecting to any part of the circuit requiring power to be removed.

5. **Be sure your equipment is in good order.** Broken or frayed test leads can be extremely dangerous and expose you to dangerous voltages.

6. **Remove the test lead immediately** after the test has been completed to reduce the possibility of shock.

7. **Do not work alone when working on hazardous circuits.** Always have another person close by in case of an accident.

8. **Improper Fuse(s) Void Warranty.** Fuses are for your protection, so always replace fuse with the proper type and current rating. Type and ratings are listed near the fuse holder. On units with more than one fuse, be sure you are replacing the proper fuse value in the fuse holder.

9. **Study the procedures in this manual carefully and note special warnings and cautions before using this test instrument.**

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DESCRIPTION

INTRODUCTION

There are many display monitors today in computer, medical, security, design, gaming and industrial applications. These displays operate at many different horizontal scanning frequencies and picture resolutions. Some operate at a single scanning frequency while others switch to properly display video at many scanning frequencies.

All CRT (cathode ray tube)-based displays have a horizontal output stage to produce high voltage and deflection. This can be done with a single horizontal output stage or separate horizontal output stages. Despite the wide range of horizontal operating frequencies and uses, several basic horizontal output stage configurations are used and can be analyzed using universal tests.

Horizontal output stages and their related circuits account for many defects and difficult-to-troubleshoot symptoms. Close interaction between stages, momentary voltages, high currents, repeat component failures and the inability to reduce the output voltage from a switch mode power supply are to blame.

Video displays that operate at multiple scanning frequencies maintain proper high voltage and deflection by switching in components in the horizontal output stage and/or using high voltage or deflection regulator stages. These circuits and switched components add further complexity and troubleshooting difficulty.

FEATURES

The HA325 provides exclusive analyzing tests of horizontal output stages, flyback/IHVT transformers, inductors, and switching transformers to localize horizontal circuit defects faster than conventional methods. Its exclusive Load Tests and Ringer Tests isolate defects that previously required many hours of expensive troubleshooting or component swapping.

The HA325 provides a "chassis off" Load Test of the horizontal output stage to determine if the stage is free of severe defects or if problems exist. The Load Test simulates the operation of the horizontal output stage at or near 1/10 of its normal level and analyzes the resulting current and voltages. The Horizontal Output Load Test is valuable in determining if defects are in the horizontal output stage or the main power supply and/or if circuit problems caused the horizontal output transistor to fail. It's also helpful in isolating horizontal defects that would cause component damage or high voltage shutdown if AC power were applied to the display.

The HA325 provides a test of integrated high voltage transformers (IHVTs) or flyback transformers to determine if primary to secondary shorts, loading/efficiency defects or integrated multiplier section defects exist. The Flyback & IHVT Load Test establishes a test circuit in which the flyback or IHVT is placed into a tuned horizontal output stage at either a TV or high scan frequency. In a manner similar to the Horizontal Output Load Test, a setup is established and the currents and voltages analyzed to identify flyback or IHVT defects.

The Flyback & IHVT Load Test can also be used in-circuit to isolate a loading defect to the flyback and its secondary load circuits or to the primary circuitry of the horizontal output.

The HA325 Ringer Test is a component analyzing test of a flyback or IHVT transformer, coil or switching transformer. These components commonly fail from one or more internal wire turns shorting together. A shorted turn lowers the Q of the inductor and performance of the circuit, but is difficult to confirm, as it causes little change to the inductor value or winding resistance of the coil. A Ringer Test identifies inductor or transformers with shorted turns for confident diagnosis and replacement.

The small battery operated HA325 is well suited to take to the home or commercial site to help in isolating horizontal or power supply related symptoms in HD- ready televisions, CRT video projection systems, display monitors, gaming monitors and the like. It's also well suited to pass from bench to bench or from technician to technician to get the maximum return on your test equipment investment.

SPECIFICATIONS

HORIZONTAL FREQUENCY GENERATOR

FUNCTION: Square wave generator for Load Tests
FREQUENCY RANGE (HORIZ. OUTPUT): 15 kHz to 125 kHz (.5kHz steps)
FREQUENCY RANGE (IHVT/FLYBACK SETUP): 15-40kHz (1kHz steps)

LOAD TEST B+ POWER SUPPLY

VOLTS RANGE: 0 - 18 VDC (.1 volt steps)
CURRENT LIMIT: 200 mA ± 10%
PROTECTION: 200 V (DC + Peak)

LOAD TEST SETUP

EXCITATION DRIVE: Square wave 50% duty-cycle ± 2%
FREQ. READOUT ACCURACY: ± 250 Hz
DCV READOUT ACCURACY: ± .2 volts
VPP RANGE: auto-ranged 0 - 300 VPP
VPP RESOLUTION: 1 volt
VPP ACCURACY: ± 1%, ± 2 counts (20 kHz)
VPP FREQ. RESPONSE: 10 kHz - 125 kHz ± 1 dB
SETUP OPTIONS (HORIZ. OUTPUT):
- AUTO: Automatically selects setup
- TV: Frequency = 16kHz, VDC=13V
- HD1080 33kHz: Frequency = 33 kHz, VDC = 11.5V
- HD720 45kHz: Frequency = 45 kHz, VDC = 12V
- VESA 38 kHz: Frequency = 38 kHz, VDC = 10V
- VESA 48 kHz: Frequency = 48 kHz, VDC = 10V
- VESA 64kHz: Frequency = 67 kHz, VDC = 10V
- VESA 75kHz: Frequency = 75 kHz, VDC = 12V

VESA 88 kHz: Frequency = 88 kHz, VDC = 12 V
MANUAL: Adjustable beginning 30 kHz, 1V
SETUP OPTIONS: (FLYBACK & IHVT)
AUTO: Automatically selects setup
TV: Frequency = 16 kHz, VDC = 13V
HI-SCAN: Frequency = 25 kHz, VDC = 13V
MANUAL: Adjustable beginning 20 kHz, VDC = 1V

LOAD TEST
B+ mA RANGE: 0 - 200 mA (HORIZ. OUTPUT)
B+ mA RESOLUTION: 1 mA
B+ mA ACCURACY: ± 1%, ± 2 counts
TIME µS RANGE: .1 µS - 40 µS
TIME µS ACCURACY: ± 1%, ± 2 counts
TIME µS RESOLUTION: .1 µS
TIME µS TRIGGER LEVEL: 5% ±1% of pos.
pulses with PPV > 10 VPP
EFFICIENCY RANGE: 0 - 99%
EFFICIENCY ACCURACY: ± 2%, ± 1 count
EFFICIENCY RESOLUTION: 1%
PROTECTION: Diode & Fuse, 400 volts (DC + Peak)

RINGER TEST
FUNCTION: Approximate coil Q determined by exciting
coil and counting ringing cycles to a damped level.
INDUCTOR RANGE: 10 µH or higher, non-iron core
EXCITATION VOLTAGE: 5 volts
SENSITIVITY LEVEL: Yokes & flybacks -25%, Coils 5% (Ref. first cycle)
ACCURACY: ± 1 count from 8 to 13 rings
PROTECTION: 200 volts (DC + Peak)

General
CASE SIZE: 2” x 5” x 10.5”
WEIGHT: ~ 2 lbs.
DISPLAY: LCD (20 X 4 row characters)
POWER: 105-125VAC (AC/DC Adapter 14V, 700 mA (Sencore PA273)
BATTERY: Rechargeable Nickel Metal Hydride Pack (7.2V 1500 AH)
TEMPERATURE: 5-35 degree C.
HUMIDITY: 0-90% no condensation
WARMUP: All specifications allow for 20 minute warm-up and are guaranteed at 5-35º C.

FRONT CONTROLS AND SIDE PANEL FEATURES

1. **DIGITAL DISPLAY –** Displays setup options & values, user information, test results and assistance messages.

2. **LOAD TEST FUSE –** Protects the HA325 test circuitry from an energized circuit or stored circuit charge.

3. **LOAD & RINGER TEST LEAD –** Provides connection for the Load & Ringer Test Lead.

4. **RS232 INTERFACE BUS –** Provides computer connection to update firmware.

5. **AC POWER ADAPTER INPUT –** Provides input for connecting the power adapter (PA273) to the HA325.

6. **TEST/SETUP pushbutton -** Switches the display between the SETUP display window or LOAD TEST display window during the HORIZ. OUTPUT and FLYBACK & IHVT Load Tests.

7. **ENTER pushbutton -** Enters a setup option, kHz value, or VDC value when incrementing with the UP ARROW and DOWN ARROW pushbuttons.

8. **RINGER TESTS SWITCHING XFORMER pushbutton –** Selects the Ringer Test designed to test switching transformers for a shorted turn.

9. **ASSISTANCE pushbutton –** Provides assistance messages while performing setups or tests.

10. **POWER ON/OFF pushbutton –** Provides or removes power and provides a battery test.

11. **RINGER TESTS COILS pushbutton –** Selects the Ringer Test designed to test inductors and coils for a shorted turn.

12. **RINGER TESTS YOKES & FLYBACKS pushbutton -** Selects the Ringer Test designed to test yokes and flybacks for a shorted turn.

13. **DOWN ARROW pushbutton -** Moves the display cursor downward to select from the SETUP OPTIONS during setup of the Horiz. Output or Flyback & IHVT Load Tests. Decreases kHz or VDC values in the SETUP display during a manual setup.

14. **UP ARROW pushbutton –** Moves the display cursor upward to select from the SETUP OPTIONS during setup of the Horiz. Output or Flyback & IHVT Load Tests. Increases kHz or VDC values in the SETUP display during a manual setup.

15. **LOAD TEST HORIZ. OUTPUT** pushbutton – Selects the Horizontal Output Load Test and initiates the setup process.

16. **LOAD TEST FLYBACK & IHVT pushbutton –** Selects the Flyback & IHVT Load Test and initiates the setup process.

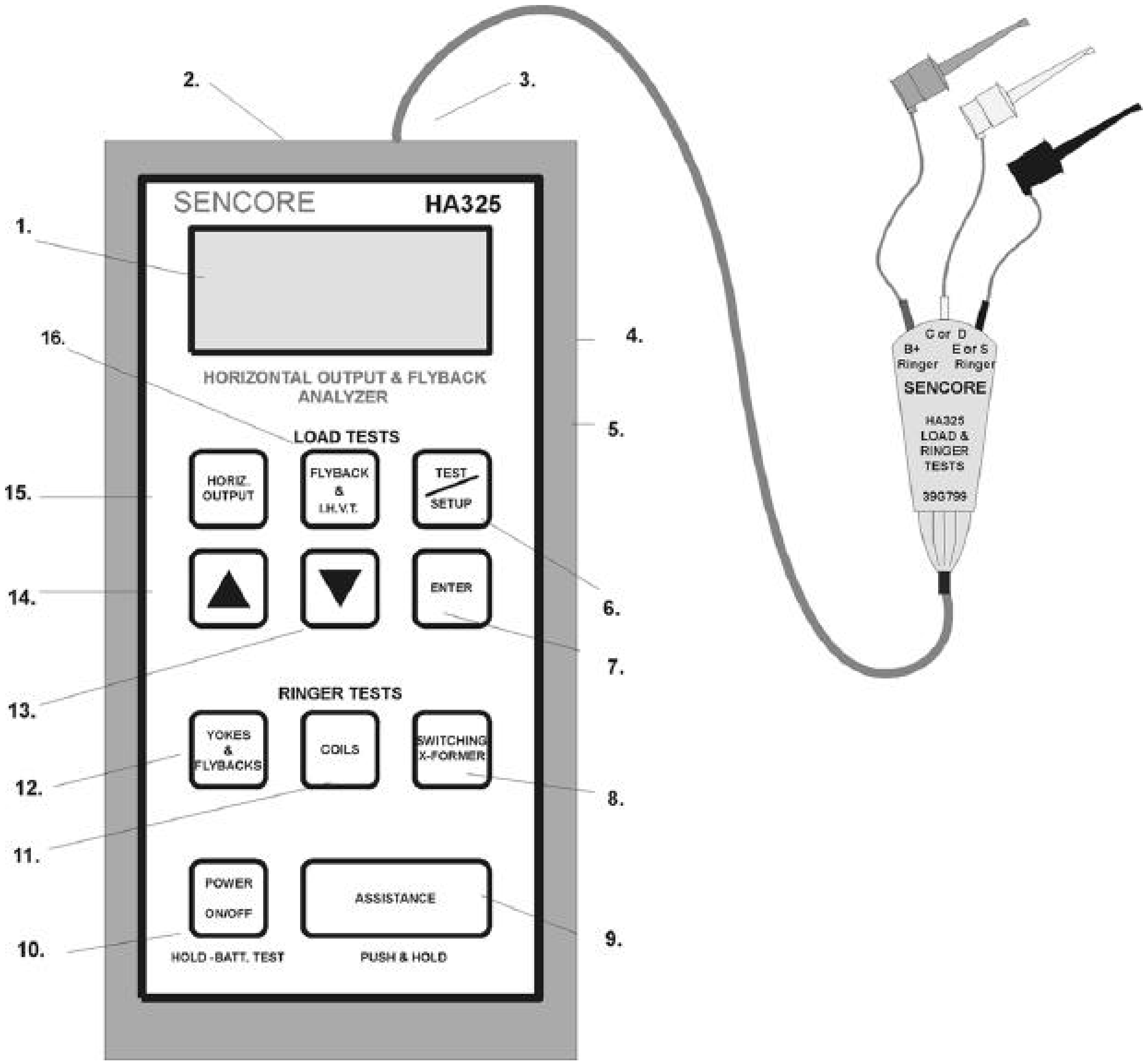


Fig. 1: Front panel controls and side panel features.

ACCESSORIES

17. TP212 X10 Multiplier probe: Increases a 15 megohm impedance DC meter to 150 megohms for measuring flyback or IHVT output voltages during the Load Test. (Optional)

18. AC POWER ADAPTER/CHARGER (Part #PA273) – Plugs into the DC Input jack to recharge the battery or provide AC operation. (Provided)

19. PROTECTIVE/STORAGE COVER: (Part #CC296) Provides a protective cover and a convenient storage pouch to store the attached LOAD & RINGER TEST CABLE. (Optional)

20. FUSED DC POWER LEAD: (**Part # 39G355)** Plugs into the DC Input Jack to power the unit from any 12 volt negative-ground vehicle lighter. (Optional)

21. NULL-MODEM COMMUNICATIONS CABLE: (**Part #39G523)** Connects between the communications port of a computer and the RS232 Interface Bus connector (4). (Optional)

Fig. 2: Accessories

OPERATION

INTRODUCTION

You should take a few minutes to read this section of the manual before operating the HA325. It explains how its unique tests work, along with how to use and interpret the tests. This section of the manual includes 4 main sections: 1) Preparation For Use, 2) Horizontal Output Load Test, 3) Flyback & IHVT Load Test and 4) Ringer Tests.

Once you become familiar with the tests, you can operate the HA325 from the display window and assistance messages provided. The APPLICATIONS section of this manual provides more information on using and interpreting the HA325 tests. The MAINTENANCE section of this manual covers firmware updates and internal battery, transistor and lead replacement.

PREPARATION FOR USE

The HA325 is ready for use when you remove it from its packing material. The test lead is attached to the HA325 so it cannot be lost during portable applications. The AC Power Adapter/Charger and the Operation & Application Manual is shipped with the HA325. Additional product and company support information may also be included. Carefully unpack the HA325 and confirm you have received these supplied items.

Power Connection

The HA325 is powered from an internal battery or an external AC Power Adapter/Charger to convert the standard 105-125 VAC, 50/60 Hz AC line voltage to 14 VDC. The AC Power Adapter/Charger (Sencore #PA273) is detachable from the HA325.

To power the HA325 with the AC Power Adapter/Charger connect it to a 105-125 VAC power receptacle. Attach the AC Power Adapter/Charger's miniature plug to the AC Adapter Input Jack located on the side panel. The unit is powered for normal operation by momentarily pressing the POWER ON/OFF button in the bottom left corner of the HA325. The digital display will illuminate, indicating the HA325 is powered on.

When powered on, pressing & holding down the POWER ON/OFF pushbutton will display a "CHARGING" display message, indicating the Power Adapter/Charger is powering the HA325 and charging its internal battery. A battery symbol in the upper right corner of the display increments upward, providing a continuous indication that the power adapter is connected and is charging the internal battery.

Battery Testing & Charging

The HA325 has an internal battery compartment containing a standard rechargeable Nickel Metal Hydride battery pack. The battery pack requires no special maintenance, however some care in operating procedures can optimize the battery life.

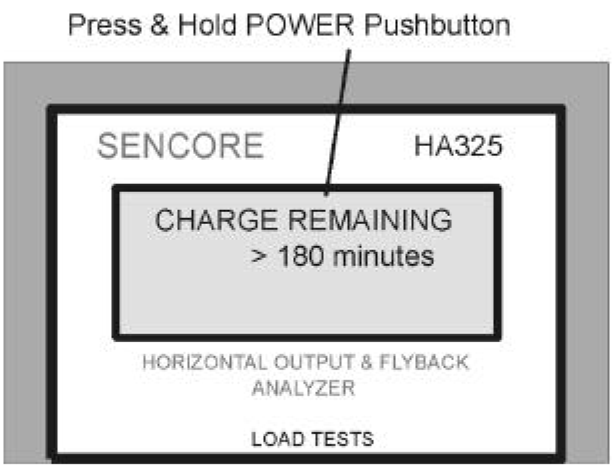
The HA325 battery condition may be tested when the AC Power Adapter/Charger is not plugged into the AC Adapter Input Jack. With the unit power on, press and hold down the POWER ON/OFF pushbutton. The battery condition is shown in the digital display. Release the POWER ON/OFF pushbutton to return to normal instrument use.

The battery condition is indicated as an estimate of the remaining minutes of operating time. A full charge is indicated by a display reading of approximately 3.5 hours or a message indicating “>180 minutes.” When remaining time readouts indicate 30 minutes or less, the battery pack is nearing full discharge. At low remaining time readouts the reduced battery voltage may cause the HA325 to turn off automatically. This occurs to prevent unreliable test readings.

A battery symbol shown continuously in the upper right corner of the digital display provides an indication of the battery condition. A full charge is indicated by a fully blackened battery symbol. As the battery discharges the inside of the symbol becomes void of black starting from the top to the bottom. When the inside of the battery symbol is nearing white to the bottom, the battery needs charging.

While the HA325 has an approximate 3.5 hour continuous battery life, you should expect this time to vary. Intermittent use and the battery power management features of the HA325 will extend the total operating battery life. Prolonged troubleshooting using the Load Test with high mA readings will substantially reduce the battery life.

Nickel Metal Hydride batteries provide a larger storage capacity with less size and weight compared to other battery types. The care of these batteries is different when compared to NiCad batteries. Routinely charging the Nickel Metal Hydride battery pack is beneficial and will not cause the “memory” effect associated with NiCad batteries. Faster charging rates are also beneficial. For maximum charging current, leave the HA325 powered off while charging with the AC Power Adapter/Charger. When possible, avoid prolonged charging of the battery pack. A full charge is obtained in 4 to 5 hours if the battery is fully discharged and the HA325 is not being used during this time.



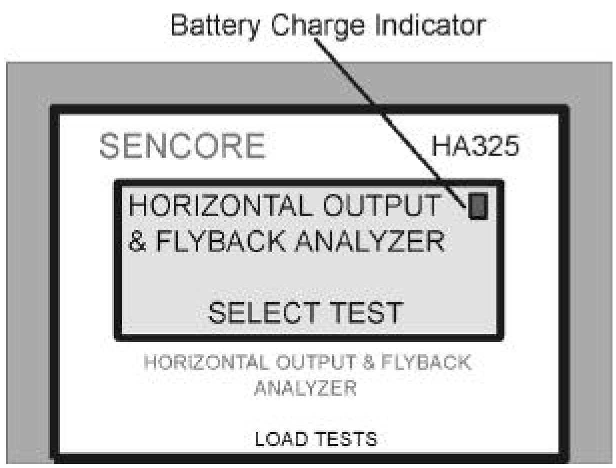


Fig. 3: A battery test indicates remaining battery charge as a time estimation. A battery symbol in the upper right of the display also indicates battery charge.

Battery Power Management

The HA325 provides several battery power management features during battery operation to extend the useable time provided by each battery charge cycle. Battery power management features reduce the battery power being consumed by the HA325 when the instrument is powered on but is not being used for testing. The HA325 includes three levels of power management including: 1) display back light disable, 2) standby mode and 3) power shutdown. The power management functions are defeated when the AC Power Adapter/Charger is connected to the HA325.

The first level of power management disables the back light of the digital display if no front panel pushbuttons are pushed in 60 seconds. All HA325 test functions remain active. Pressing a front panel button will select the function pressed and restore the display light. To restore the light while performing a Load Test without changing functions, press the TEST/SELECT pushbutton twice, which toggles between setup and test windows. You may also momentarily press the up arrow, down arrow, ENTER or ASSISTANCE pushbuttons to restore the display back light without disrupting the test.

The second level of battery power management is a standby mode, initiated when no front panel pushbutton is pressed for 5 minutes. Standby removes the test voltage of the Load Test and reduces internal power drain on the battery. "STANDBY" readout is shown on the display to indicate a standby mode. Standby operation is preceded by audio tones at 2 minutes remaining (3 beeps), 1 minute remaining (2 beeps) and standby begins (1 beep). If you have completed testing, the beeps remind you to turn the

HA325 off to extend the battery life. Pressing any of the front panel pushbuttons in the Standby mode, except the POWER pushbutton, restores the previous test or setup function.

The final level of battery power management is power shutdown. Power shutdown occurs after approximately 5 minutes in the standby mode if no front panel pushbuttons are pressed. An audio beep is produced by the HA325 each minute in the standby mode. Once power is shutdown the POWER button must be pressed to again turn the HA325 on for normal use.

Load Test Fuse Replacement

A fuse protects the Load Test circuitry of the HA325 from voltages and charges that may be present in the chassis or components being tested. For ease of replacement, the fuse is located on the top side panel of the HA325 near the Load & Ringer Test Lead input. The fuse is a 1 amp 3AG fast blow fuse.

The Load Test fuse is monitored by internal circuits of the HA325 to detect when it has opened. This prevents wasted time and possible errors performing the Load Test when the fuse is bad. If the fuse opens or is missing, the digital display indicates "REPLACE LOAD TEST FUSE 1AMP. FAST- BLOW."

To replace the Load Test Fuse:

1. Remove the Load & Ringer Test lead clips from the circuit or component being tested.
2. Turn the POWER off to the HA325.
3. Use a small blade screwdriver to turn the fuse holder counterclockwise until the fuse releases.
4. Replace the fuse.
5. Use the screwdriver to gently press inward while turning the fuse holder clockwise back into place.
6. Turn the POWER on to begin operation.

Note: *If fuse replacement fails to restore normal operation, contact the Sencore Service Department.*

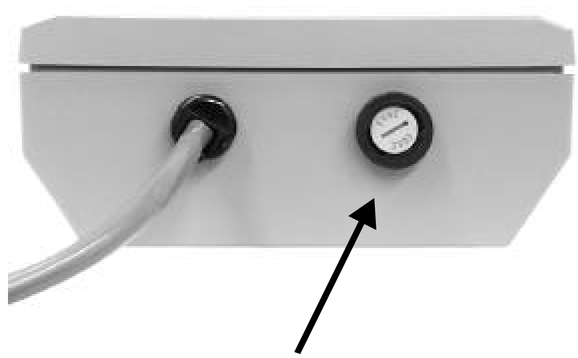


Fig. 4: The Load Test fuse protects the internal test circuits from circuit voltages.

Assistance Display Messaging

The HA325 contains a library of help messages to assist the user in operating the HA325 when setting-up tests, performing tests and interpreting test results. The assistance messages also provides some suggestions on what circuit component to test under certain test conditions. These messages are contained in memory within the HA325.

The front panel ASSISTANCE pushbutton on the HA325 accesses the assistance messages for display, depending upon the display window and current setup or testing values being displayed. To access these messages, press and hold down the ASSISTANCE pushbutton. Releasing the ASSISTANCE pushbutton resumes the normal testing or setup function.

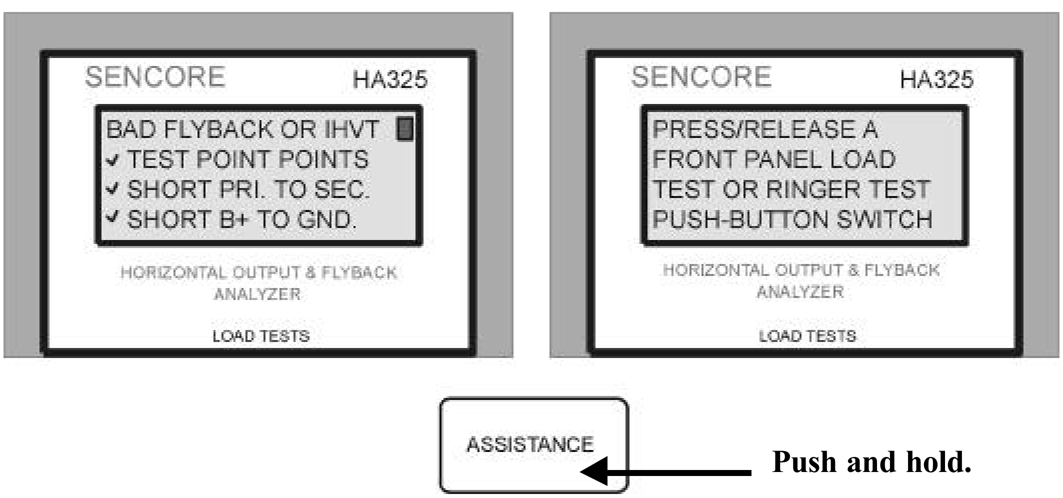


Fig. 5: Helpful assistance messages guide you during setup, testing and troubleshooting with the HA325.

HORIZONTAL OUTPUT LOAD TEST

The Horiz. Output Load Test provides a functional test of the horizontal output stage with no AC applied to the chassis. The Load Test quickly confirms if the horizontal output stage is free of severe defects or if problems exist. The Load Test is useful in determining repair costs, troubleshooting horizontal output stage defects and determining when it is safe to apply AC voltage to the chassis.

This section familiarizes you with the Horiz. Output Load Test. It explains how to properly setup and perform the Load Test and further explains the three readouts displayed during the Load Test.

Load Test Display Windows

The HA325 has three digital display windows that are used when performing the HORIZ. OUTPUT and FLYBACK & IHVT Load Tests. Three display windows used by the HA325 step you through the setup and testing process. The display windows include: 1) SETUP OPTIONS, 2) SETUP and 3) TEST display windows.

The SETUP OPTIONS display window is shown immediately after selecting a Load Test by pressing the HORIZ. OUTPUT or FLYBACK & IHVT front panel pushbutton. This display window shows a list of options for establishing a horizontal test frequency and DC voltage to the horizontal output stage or flyback/IHVT being tested. Options include a fully automatic setup (AUTO), preset options (TV, etc.) or a manual (MANUAL) setup.

The SETUP display window shows the resulting frequency and DC voltage being applied to the horizontal output stage or flyback/IHVT as a result of the option selected in the SETUP OPTIONS display window. A VPP readout is also shown indicating the resulting flyback pulse amplitude being produced by the applied setup. The SETUP display window follows the SETUP OPTIONs window when a MANUAL setup is selected. With all other setup options, a SETUP display may be selected by pressing the TEST/SETUP pushbutton when the TEST display window is shown.

The TEST display window shows test measurements (mA, % EFF, µS) in either the Horiz. Output or Flyback & IHVT Load Tests. This display follows all setup option choices when entered during the SETUP OPTIONS display window. This display window also follows all SETUP display windows when the TEST/SETUP pushbutton is pressed.

Fig. 6: Three display windows used for the HA325 Load Tests

Understanding the HORIZ. OUTPUT Load Test

The Horizontal Output Load Test simulates the actual operation of the chassis horizontal output stage at its normal frequency but at 1/10 its normal B+ voltage level. Measurements taken during the simulation are displayed to indicate the conditions of the chassis horizontal output stage. To simulate the actual operation of a horizontal output stage without power to the chassis requires three things:

1. A B+ or DC voltage applied to the chassis horizontal output transformer.
2. A horizontal output transistor to provide a switched current path to energize the output transformer.
3. A drive signal to this horizontal output transistor to switch it on and off at the proper frequency.

The HA325 satisfies these three requirements. A variable DC power supply inputs a B+ voltage to the horizontal output stage. The DC voltage is selected with the setup options, or can be adjusted using the manual setup option to a voltage that is near 1/10 the chassis normal B+ voltage. This is the VDC value displayed in the SETUP display window.

A switching power MOSFET transistor inside the HA325 acts like the chassis horizontal output transistor providing the switching action to energize the chassis horizontal output stage. The HA325 internal horizontal frequency generator provides the horizontal drive signal to the gate of the switching transistor. This frequency may be selected by the HA325 with the AUTO setup option or may be set to a specific frequency by entering a setup option in the SETUP OPTIONS display window. The frequency can be manually selected and adjusted using the manual setup option.

During the SETUP and TEST display windows, if the chassis horizontal output stage is operational, alternating currents and induced voltages or flyback pulses are produced. Since the Load Test VDC voltage is 1/10 of the chassis normal B+, the current and voltages are approximately 1/10 of normal, providing a low level and safer test. However, the LC or resonant timing of the chassis horizontal output stage is the same no matter what the level of applied voltage. This means the flyback voltage pulse duration is nearly the same during the Load Test as it is during chassis operation.

The HA325 Load Test is active in the SETUP and TEST display windows. In the SETUP display window, three readouts are simultaneously displayed. The readouts help you establish a 1/10 level simulation of the horizontal output stage being tested. The TEST display window shows the results of three measurements, which determine whether the horizontal output stage is operating normally or contains a defect.

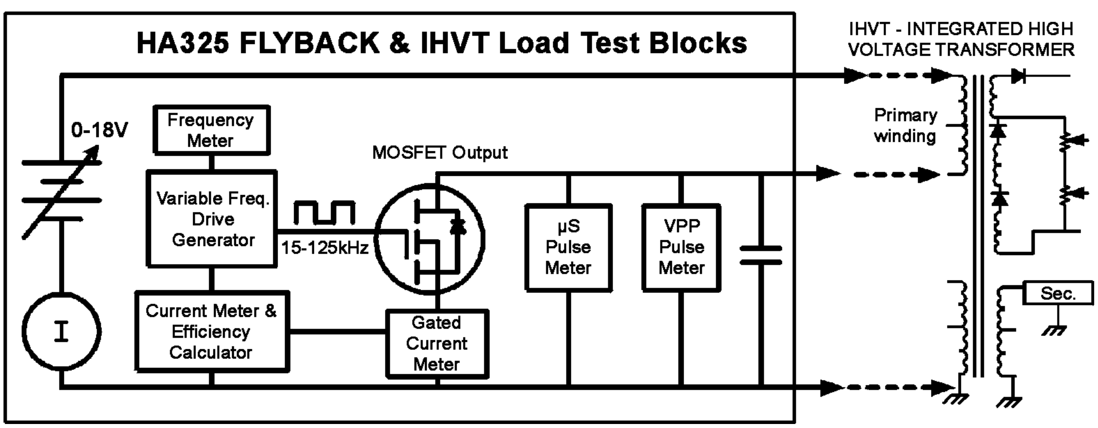


Fig. 7: The HORIZONTAL OUTPUT Load Test operates a horizontal output stage at 1/10 power and at its normal frequency to analyze its operation.

Horizontal Frequency Generator

The HA325 chassis-off Load Test requires an internal horizontal test signal. An internal horizontal square wave generator produces the horizontal test signal. The frequency of the generator can be selected from a display of predetermined frequencies available in the SETUP OPTIONS display window. When an AUTO setup option is selected, the frequency of the generator is automatically selected by the HA325 to match the resonant timing of the horizontal output stage being tested. When a MANUAL setup option is selected, the frequency of the generator may be selected in the SETUP display window using the UP ARROW and DOWN ARROW pushbuttons.

Horizontal output stages found in CRT video displays operate at many different horizontal frequencies, ranging from 15.7 kHz to over 100 kHz. When performing the HA325 Horizontal Output Load Test, the horizontal test frequency must be near the chassis normal horizontal operating frequency for reliable test results. For example, the horizontal test frequency for a video graphics array (VGA) computer monitor should be approximately 31.5 kHz. For video displays that operate at multiple horizontal frequencies, test near the chassis highest horizontal operating frequency.

The horizontal frequency of the HA325 internal generator is shown in the SETUP HORIZ. OUTPUT display window when a Horiz. Output Load Test is selected. The SETUP FLYBACK/IHVT display window indicates the internal generator frequency when a setup option is selected for performing the Flyback & IHVT Load Test.

The Load Test VDC Power Supply

The Load Test uses a variable DC power supply to provide the 1/10 of normal voltage to the horizontal output stage or flyback/IHVT being tested. The voltage is variable from near 0 volts to approximately 18 volts. The positive voltage is output to the orange clip of the LOAD & RINGER TESTS lead with the black clip at ground in the SETUP VALUES or LOAD TESTS display windows.

The Load Test VDC voltage is displayed in the center row of the SETUP display window. When performing the Load Test with a MANUAL setup option, the DC voltage should be set to approximately 1/10 of the chassis normal B+ voltage. This DC voltage yields a VPP readout of approximately 100 VPP for most horizontal output or flyback/IHVT Load Tests.

The Load Test VDC supply is current limited to approximately 200 mA in the HORIZ. OUTPUT Load Test and FLYBACK & IHVT Load Test. A circuit short during the Load Test or during the SETUP VALUES display window causes a current limiting condition. A current limiting condition prevents the VDC voltage from reaching its preset level or from increasing to the desired level during an auto setup or a manual setup in the SETUP display window.

The HA325 contains a diagnostic software routine to determine if the cause of high current flow to the horizontal output stage or flyback or IHVT is caused by a DC defect (direct current path from the VDC supply to ground) or if it is a result of an AC defect.

AC loading defects affect the alternating currents produced in the horizontal output stage. AC shorts include a shorted turn in the flyback or yoke, short on a flyback secondary, or leakage in a component. High current diagnostic tests are performed when the current exceeds 100 mA in the Horiz. Output Load Test and 50 mA in the Flyback & IHVT Load Test.

High Load Test current conditions are noted in the display by "DC LOAD", "AC LOAD", "DC SHORT" or "AC SHORT" readouts. These readouts occur to the right of the mA readout in the LOAD TEST display and to the right of the DCV readout in the SETUP Display. The "DC SHORT" or "AC SHORT" message indicates a Load Test current over 150 mA.

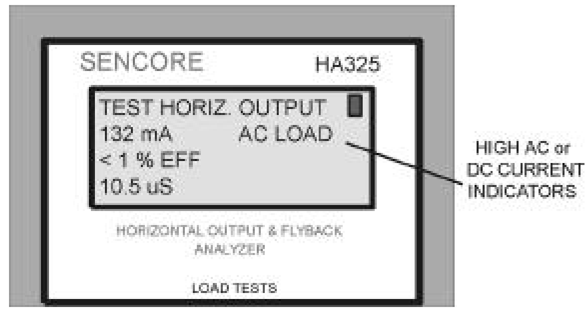


Fig. 8: High current conditions are indicated on the display as a DC LOAD, DC SHORT, AC LOAD or AC SHORT.

Test Lead Connection – Horiz. Output Load Test

To perform the Load Test you must connect the three LOAD & RINGER TEST LEAD connector clips to the proper circuit points of the chassis horizontal output stage. Before connecting the LOAD/RINGER TEST LEAD to the chassis horizontal output stage, be sure to unplug or remove AC power to the chassis being tested. The HA325 contains internal protection circuitry, but to remove any chance of damaging either the analyzer or the chassis always unplug the AC line cord to the chassis before connecting the test clips.

CAUTION

Perform the Load Test **ONLY** with AC power to the chassis removed.

The HORIZ. OUTPUT Load Test produces current and inductive voltage pulses in the chassis horizontal output stage. Be careful not to come into contact with these energized circuit points while performing the load test or when connecting or disconnecting the test clips. Connect the test clips to circuit test points before entering an option from the SETUP OPTION display window. Push the HORIZ. OUTPUT or POWER pushbuttons to remove voltage to the chassis before removing the test clips.

CAUTION

Do not come in contact with energized horizontal output circuits points during the Load Test. For added safety connect or disconnect the test clips with the HA325 powered off or with the HA325 in the SETUP OPTIONS display.

The clips on the LOAD/RINGER TEST LEAD are labeled and color-coded for easy identification as follows. The labels indicate where the clips are connected to the chassis horizontal output stage to perform the Load Test.

Clip Color	Lead Label	Description of Circuit Connection Point
Orange	**B+**	**B+ Input to Horiz. Output stage transformer or coil**
Yellow	**C or D**	**Collector or Drain of Horizontal Output Transformer**
Black	**E or S**	**Horizontal Ground or H.O.T emitter or source lead**

Connect the black test clip to horizontal ground commonly available at the emitter or source lead of the horizontal output transistor. Connect the orange test clip to the B+ voltage input of the horizontal output stage transformer primary or coil winding. Connect the yellow test clip to the collector or drain of the horizontal output transistor.

The Load Test can be performed with or without the chassis horizontal output transistor in the circuit. If the transistor is leaky or shorted, the Load Test Setup may display a “DC SHORT” or “DC LOAD” message indicating a severe output stage problem. If you suspect a shorted horizontal output transistor, remove it from the chassis and repeat the Load Test.

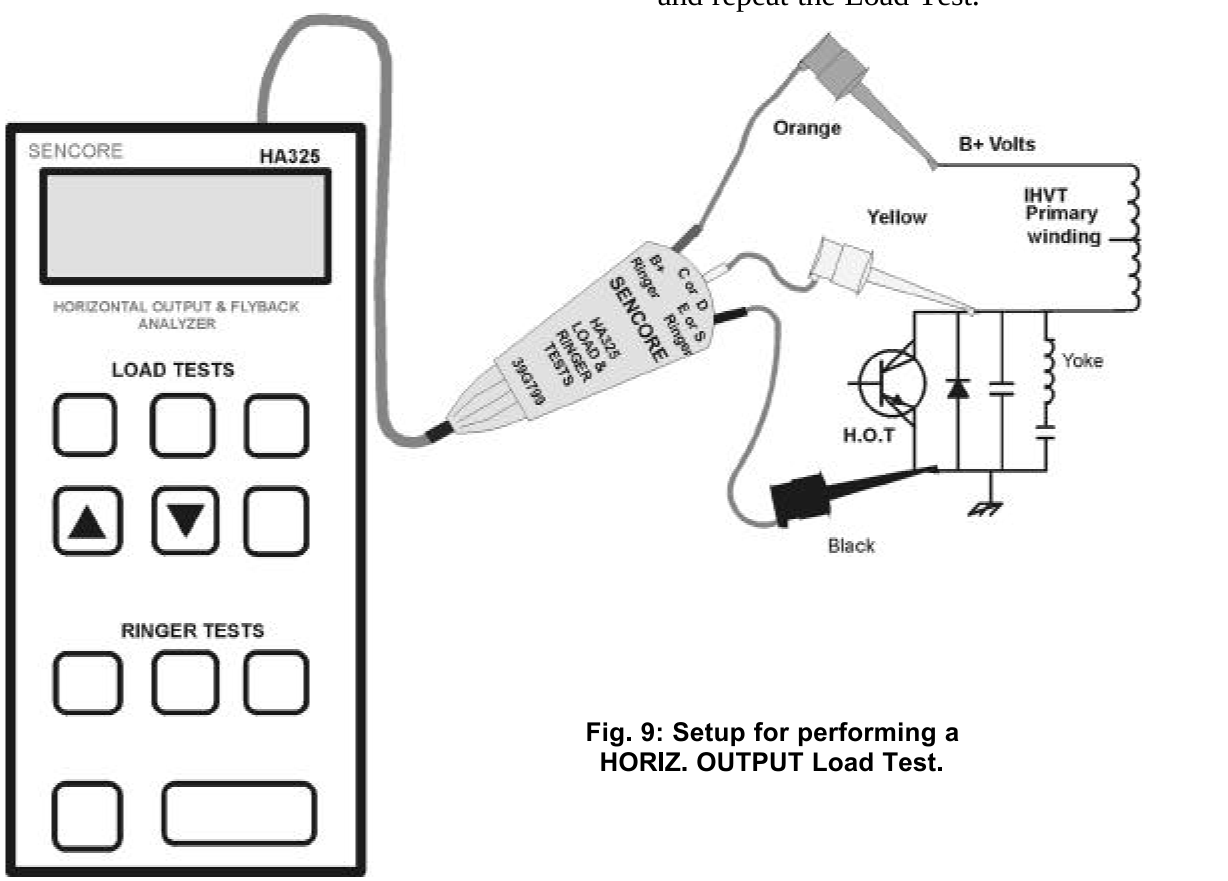


Fig. 9: Setup for performing a HORIZ. OUTPUT Load Test.

Selecting a Setup Option - HORIZ. OUTPUT Load Test

When the HORIZ. OUTPUT Load Test function is selected, a list of setup options is displayed. The top line in the digital display is titled SETUP OPTIONS-HOR. These setup options provide ease in establishing a test frequency and DC voltage to the horizontal output stage to be tested with the Horiz. Output Load Test. Select the option that provides the fastest or most accurate manner to obtain an appropriate frequency to test the horizontal output stage and a DC voltage to simulate operation at 1/10 of the normal level.

In the SETUP OPTIONS-HOR. display window a cursor block on the left side of the display allows user selection of one of the setup options. There are more setup options available than can be viewed at one time on the display. Pushing the UP ARROW and DOWN ARROW pushbuttons brings more options into view. The arrow indicators above and/or below the cursor block indicate more options are available below and/or above the cursor that cannot be currently shown on the three line display.

To select one of the setup options, position the cursor to the left of the desired setup option and press the ENTER pushbutton. Entering the setup begins the auto setup routine or applies the test frequency and voltages for the option selected. If the MANUAL option is entered, the SETUP HORIZ. OUTPUT display window is displayed for adjustment of the frequency and VDC values beginning at 30 kHz and 1 VDC.

SETUP OPTIONS (HORIZ. OUTPUT)	FREQUENCY	VDC
AUTO	Auto selected	Auto selected
TV 16 kHz	Fixed 16 kHz	Fixed 13 VDC
HD1080 33 kHz	Fixed 33 kHz	Fixed 11.5 VDC
HD720 45 kHz	Fixed 45 kHz	Fixed 12 VDC
VESA 38 kHz	Fixed 38 kHz	Fixed 10 VDC
VESA 48 kHz	Fixed 48 kHz	Fixed 10 VDC
VESA 64 kHz	Fixed 67 kHz	Fixed 10 VDC
VESA 75 kHz	Fixed 75 kHz	Fixed 12 VDC
VESA 88 kHz	Fixed 88 kHz	Fixed 12 VDC
MANUAL	Adjust from 30 kHz	Adjust from 1V

Chart 1: Setup options for performing the HORIZ. OUTPUT Load Test.

The AUTO setup works well to quickly find a setup for testing most horizontal output stages. Defects in the horizontal output stage that dramatically change the timing of the generated flyback pulse may result in inappropriate auto setup values. Pushing the TEST/SETUP pushbutton following the auto setup routine displays the setup values established by the auto setup. Changes to the values default the setup to a MANUAL setup mode.

Use the TV setup options for testing most television horizontal output stages. The frequency and VDC is consistent with the majority of TV horizontal output stages and provides reliable setup. Use the HD1080 or HD720 setup option for testing HD-ready horizontal output stages.

Use VESA setup options to test computer monitors. Select the setup option that is nearest to the monitor's highest horizontal scanning frequency mode. Use the MANUAL setup option when you desire to more closely duplicate the test frequency or DCV level to operate at 1/10 of normal operation.

To select a SETUP OPTION for the HORIZ. OUTPUT Load Test:

1. Press the HORIZ. OUTPUT Load Tests pushbutton.
2. Push UP ARROW or DOWN ARROW pushbuttons to position the cursor beside the desired selection.
3. Press the SELECT/ENTER pushbutton to enter the selection.

(Auto routine begins or setup values are applied to the horizontal output stage.)

Using Setup Values – SETUP HORIZ. OUTPUT

The SETUP display provides information regarding the operation of the Load Test. Three parameters are metered and displayed in the SETUP display window. They include: 1) kHz (horizontal test frequency), 2) VDC (B+ voltage) and 3) VPP (volts peak-to-peak).

The horizontal test frequency is determined by the auto routine or selected from the options within the SETUP OPTIONS-HOR. display window. The frequency indicated can be adjusted with the UP ARROW and DOWN ARROW pushbuttons. When these pushbuttons are pressed, the setup is changed to MANUAL mode. The test frequency should be appropriate for the horizontal output stage being tested. TV requires approximately 16 kHz, VGA-only monitors approximately 32 kHz, HD-ready displays approximately 33 kHz and monitors require a test frequency near the highest operating frequency they can display.

The DCV readout indicates the HA325 DC voltage applied to the horizontal output stage being tested. The VDC value may be automatically selected by the auto setup routine or selected from the options within the SETUP OPTIONS-HOR. display window. The VDC voltage indicated may be adjusted with the UP ARROW and DOWN ARROW pushbuttons. When adjusted, the setup changes to MANUAL mode. The VDC value should simulate the operation of the horizontal output stage at 1/10 of its normal level.

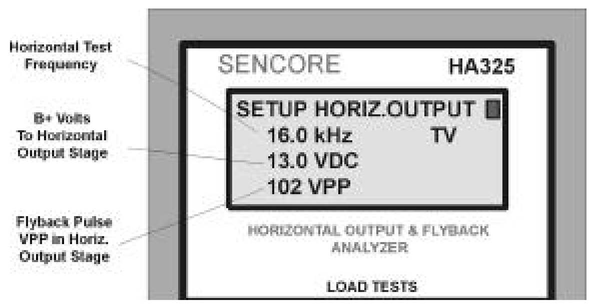


Fig. 10: Setup values indicate Load Test frequency, DC or B+ voltage and flyback pulse VPP in the horizontal output stage being tested.

The SETUP display window indicates a VPP (Volts-Peak-to-Peak) readout indicating the amplitude of the induced voltage pulses produced by the horizontal output stage being tested.

When properly connected, a functional horizontal output stage produces induced voltage pulses relative in amplitude to the selected frequency and VDC voltage applied. A VPP readout in the range of 50-150 VPP confirms an active test simulation.

A VPP reading that is 1/10 of the chassis normal indicates a proper setup. Most horizontal output stages use bipolar transistors, in which the voltage pulses produced during normal operation range from 800 to 1100 volts peak-to-peak. In the SETUP VALUES display window the VPP readout should read in the range of 80 to 110 VPP. A VPP reading of 100 VPP serves as a good reference setting when the normal level is unknown.

Some horizontal output stages use MOSFET transistors. Flyback pulses in these stages commonly range from 500 to 800 VPP. When testing a MOSFET horizontal output stage establish a VPP reading 1/10 or normal or between 50 and 80VPP. To manually adjust Frequency (kHz) and VDC:

1. Apply POWER & Press the HORIZ. OUTPUT Load Tests pushbutton.
2. Push the DOWN ARROW pushbutton to position the cursor beside the MANUAL selection.
3. Press the ENTER pushbutton. (kHz blinks awaiting adjustment)
4. Press Down Arrow or Up Arrow pushbuttons to increment the test frequency (kHz).
5. Press the ENTER pushbutton. (Enters kHz -VDC blinks awaiting adjustment)
6. Press Down Arrow or Up Arrow pushbuttons to increment VDC value.
7. Press ENTER (Enters VDC – kHz blinks awaiting adjustment)
   Note: *VPP should read 1/10 of chassis normal – 100 VPP typical.*

Performing the HORIZ. OUTPUT Load Test

In the TEST HORIZ. OUTPUT display window, the HA325 simultaneously meters and displays three automatic measurements. The measurements reflect the operation of the horizontal output stage being tested. The measurements are used to determine whether the horizontal output stage is normal or contains a defect. The three measurements are summarized in Chart 2.

Load Test	**Display Readout**	**Description of Test**
B+ Current	**____ mA**	**The current supplied by the Load Test B+ power supply to the horizontal output stage under test.**
Efficiency	**____ % EFF**	**The percentage of the current input to the horizontal output stage at the beginning of the horizontal cycle that is returned to the power supply at the end of the cycle.**
Pulse Time	**____ µS**	**The duration of the induced voltage pulse produced by the horizontal output stage.**

Chart 2: Description of the three measurements performed during the Load Test.

The three Load Test measurements accurately reflect the operation of the horizontal output stage under test. The “mA” readout indicates the current being drawn by the horizontal output stage from the Load Test DC power supply. This current reflects the current drawn by the horizontal output stage from the chassis B+ power supply. In other words, this is the power supply load current to the horizontal output stage. Since the Load Test DC supply is approximately 1/10 of normal chassis B+ voltage, the "mA" readout is approximately 1/10 of the normal chassis power supply load current. The "mA" readings typically range from 10 to 75 mA in normal operating horizontal output stages. When severe loading problems exist in the horizontal output stage, the "mA" readings rise significantly.

The "% EFF" readout measures what percentage of the input energy or current to the output stage is returned to the B+ power supply at the end of the horizontal cycle. Horizontal output stages are primarily tuned LC circuits with energy alternating between the magnetic fields of the flyback and/or yoke and capacitance of the output stage. At the end of the horizontal cycle the magnetic fields collapse, returning stored energy back to the power supply. Defects add power losses, greatly reducing the efficiency of the horizontal output stage and the percentage of energy returned to the power supply. Efficiency readouts typically range from 50 to 90% in normal horizontal output stages and decrease dramatically in problem horizontal output stages.

The "µS" readout is an automatic measurement of the pulse duration or time of the inductive voltage produced in the horizontal output stage being tested. The Load Test measures the time of the pulse from the start of its rising edge to the end of its falling edge.

The pulse time is determined by the stage inductance, retrace timing capacitor(s), yoke, and yoke series components. The "µS" readout provides an indication of the LC timing of the horizontal output stage. The timing influences the flyback pulse amplitude, which determines the amount of yoke deflection and CRT high voltage.

To perform the HORIZ. OUTPUT Load Test:

1. Apply POWER to the HA325, press the HORIZ OUTPUT pushbutton.
2. Select a SETUP OPTION using UP and DOWN ARROW keys.
3. Press the ENTER pushbutton
   Note: *In "MANUAL" select frequency and VDC values and press the TESTS/SETUP pushbutton.*
4. Read the "mA", "µS", and "% EFF" readouts in the LOAD TESTS display window.
5. Compare readout results to typical ranges. Press and hold the ASSISTANCE pushbutton for helpful messages during the testing process.

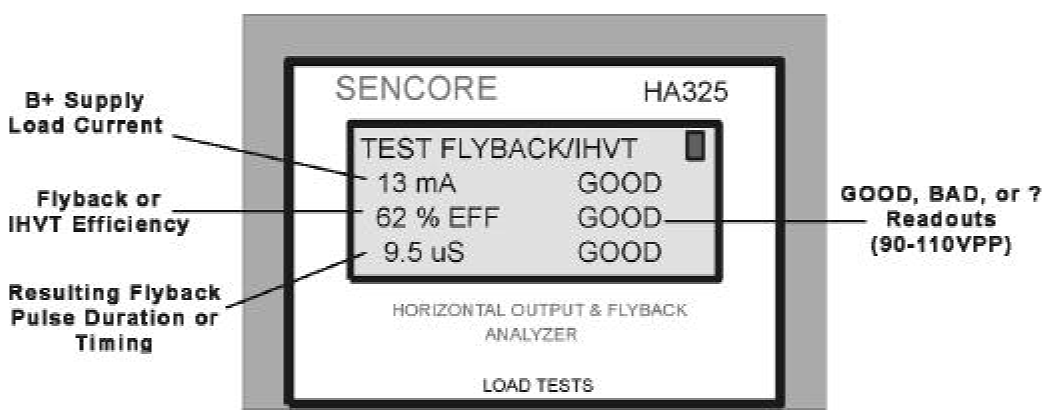


Fig. 11: The Horiz. Output Load Test measurements include mA, % EFF and µS readings.

Interpreting Horiz. Output mA, % EFF and µS Readings:

The HA325 accompanies the Horiz. Output Load Test mA, % EFF and µS numeric readings with a “Good”, “?” or “Bad” indication. These are shown on the right side of the display window. These indications are shown when the Load Test is active and flyback pulses in the range of 80-110 VPP are present in the horizontal output circuit being tested.

The normal mA readout varies among horizontal outputs depending upon if the stage is a high voltage, deflection or combination HV and deflection output. It also varies with the size of the CRT as more horizontal yoke current and HV is required from the horizontal output stage. The mA readout commonly ranges from 10-75 mA.

The Good/?/Bad mA ranges are shown in Chart 3. Readings from 5-35 mA are considered “Good” and readings over 76 mA are considered “Bad.” Readings from 36-75 mA are considered “?” by the HA325. This range of current is normal for some horizontal output stages but is excessive for others. All HV-only horizontal outputs and those in a 13 inch TV or monitor should be considered bad if the Load Test current exceeds 35 mA. Horizontal Output stages with CRTs increasing to 27 inch commonly range to about 55 mA. Horizontal Output stages with larger CRTs commonly range to 75 mA.

HORIZ. OUTPUT LOAD TEST GOOD/?/BAD mA, µS RANGES

Parameter	Good	?	Bad
mA	5-35 mA	36-75 mA	> 76 mA
% EFF	55-100%	46-54%	< 45%, 1%, 0%
µS	Based upon setup option and test frequency		< 1%

Chart 3: Horiz. Output Load Test Good/?/Bad ranges.

Efficiency readings that range from 55-100% are considered “Good” by the HA325. Readings of 0-45% are considered “Bad” and indicate a likely setup frequency error or an excessive power loss associated with the horizontal output stage. Readings from 46 to 54 are considered “**?**.” If a questionable reading is accompanied by a higher than normal mA reading, a defect is likely. If the questionable reading is accompanied by a normal mA reading the horizontal output stage is likely good.

Flyback pulse times, indicated by the Load Test µS readout, vary among displays. The normal µS range can be determined with the horizontal blanking interval of the video signal to be displayed and the display’s over-scan or under-scan characteristics. In multi-format monitors it is the video signal with the shortest horizontal blanking interval, typically the highest horizontal scanning frequency, that dictates the displays retrace time and therefore the µS pulse time.

The HA325 defines a typical µS range, based upon the video format's horizontal blanking interval and under vs. over-scan display characteristic. The Good/?/Bad µS ranges for the fixed frequency and VDC setup options of the HA325 are shown in Chart 4. The Good/?/Bad µS ranges for the manual or auto setup options are shown in Chart 5.

HORIZ. OUTPUT LOAD TEST – µS Ranges Good/?/Bad (Setup Options)

Preset:	Good	?	Bad
TV:	11.0-13.9 µS	10.8-10.9, 14.0-14.9 µS	0.1-10.7, >14.9 µS
HDTV 1080	3.7 - 6.0 µS	3.5 - 3.6, 6.1 - 6.3 µS	0.1 - 3.4, > 6.0 µS
HDTV 720	3.7 - 6.0 µS	3.5 - 3.6, 6.1 - 6.3 µS	0.1 - 3.4, > 6.0 µS
VESA 38	4.0 - 6.9 µS	3.7 - 3.9, 7.0 - 7.1 µS	0.1 - 3.7, > 7.1 µS
VESA 48:	2.8 - 5.5 µS	3.5 - 3.7, 5.6 - 5.7 µS	0.1 - 3.5, > 5.7 µS
VESA 64:	2.8 - 5.0 µS	2.6 - 2.7, 5.1 - 5.3 µS	0.1 - 2.5, > 5.3 µS
VESA 75:	2.5 - 4.3 µS	2.2 - 2.4, 4.4 - 4.6 µS	0.1 - 2.1, > 4.6 µS
VESA 88	2.0 - 3.4 µS	1.8 - 1.9, 3.5 - 3.6 µS	0.1 - 1.7, > 3.6 µS

Chart 4: Good/?/Bad µS ranges for setup options of the HA325.

HORIZ. OUTPUT LOAD TEST – µS Ranges Good/?/Bad (Manual & Auto Frequency)

Man. Freq.	Auto	Good	?	Bad
15-17.9 kHz	16 kHz	11.0-13.9 µS	10.8-10.9, 14.0-14.9 µS	0.1-10.7, >14.9 µS
18 - 30 kHz	25 kHz	7.0-10.9 µS	6.5 - 6.9, 10.9-11.5 µS	0.1 - 6.4, >11.5 µS
31 - 40 kHz	35 kHz	3.7 - 6.9 µS	3.5 - 3.6, 7.0 - 7.2 µS	0.1 - 3.4, > 7.2 µS
41 - 49 kHz	n/a	3.8 - 5.5 µS	3.6 - 3.7, 5.6 - 5.7 µS	0.1 - 3.7, > 5.7 µS
50 - 59 kHz	60 kHz	3.2 - 5.0 µS	3.0 - 3.1, 5.1 - 5.2 µS	0.1 - 2.9, > 5.2 µS
60 - 75 kHz	75 kHz	2.6 - 4.3 µS	2.4 - 2.5, 4.4 - 4.5 µS	0.1 - 2.3, > 4.5 µS
76 - 95 kHz	85 kHz	2.0 - 3.4 µS	1.8 - 1.9, 3.5 - 3.6 µS	0.1 - 1.7, > 3.6 µS
> 95 kHz	100 kHz	1.5 - 2.8 µS	1.3 - 1.4, 2.9 - 3.0 µS	0.1 - 1.2, > 3.0 µS

Chart 5: Good/?/Bad µS ranges for manual and auto setup options.

FLYBACK & IHVT LOAD TEST

The FLYBACK & IHVT Load Test analyzes flyback transformers and integrated high voltage transformers to determine if they are free of defects or if problems exist. The Flyback & IHVT Load Test verifies if the flyback or IHVT is the cause of problems when the Horiz. Output Load Test indicates a severe horizontal output stage defect. The Flyback & IHVT Load Test can also be used to isolate AC Loading defects in the horizontal output stage to the primary circuit components or to the flyback & secondary circuit loads.

This section familiarizes you with the Flyback & IHVT Load Test and explains how to properly "setup" and perform the tests. The applications section of this manual shows how to use the FLYBACK & IHVT Load Test to isolate AC loading problems.

Understanding the FLYBACK & IHVT Load Test

The Flyback & IHVT Load Test analyzes flyback transformers and integrated high voltage transformers (IHVT) for defects using the HA325 Load Test circuitry. The primary winding of the flyback or IHVT being tested is tuned with a timing capacitor to ground, internal to the HA325, forming a horizontal output stage. The HA325 switching transistor and horizontal drive generator simulate the operation of this horizontal output stage containing the flyback or IHVT being tested in a manner similar to performing the Horiz. Output Load Test.

The HA325 simulates the operation of test circuit containing the flyback or IHVT to be tested at approximately 1/10 of the normal current and voltages. The timing of the horizontal output stage is determined by the inductance of the flyback or IHVT being tested and typically varies from 10-18 µS with TV flybacks and 5-10 µS with high frequency monitor flybacks.

The HA325 applies a variable DC voltage or B+ to the primary of the flyback transformer. The HA325 internal frequency generator and switching transistor energizes the flyback or IHVT producing AC currents. The frequency may be selected automatically with the auto setup option, be preset to a specific frequency with the TV or Hi-scan setup options or be manually selected.

During the SETUP and TEST display windows, the Flyback & IHVT simulation is active and the flyback or IHVT being tested produces flyback pulses. The SETUP FLYBACK/IHVT display window shows three readouts to help you determine if the setup is accurately simulating a 1/10 voltage and current level. The TEST FLYBACK/IHVT display window shows the results of three measurements, which determine if the flyback or IHVT is good or contains a defect.

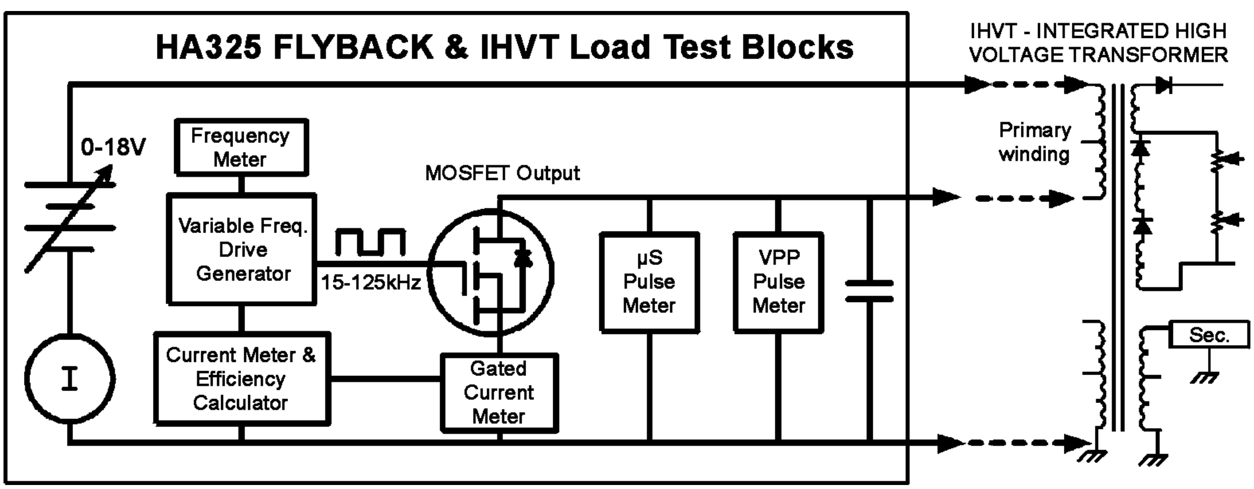


Fig. 12: The Flyback & IHVT Load Test forms a horizontal output stage with the IHVT being tested and simulates it operation at 1/10 of normal power.

Test Lead Connections - FLYBACK/IHVT Load Test

To perform the FLYBACK & IHVT Load Test, you must connect the three colored connector clips of the LOAD & RINGER TEST LEAD to the proper flyback or IHVT pins before connecting the LOAD & RINGER TEST LEAD clips.

The FLYBACK & IHVT Load Test produces current and inductive voltage pulses. Be careful not to come into contact with these energized component points while performing the Load test or when connecting or disconnecting the test clips. Connect the test clips before entering an option from the SETUP OPTION display window. Push the FLBYACK & IHVT or POWER pushbutton to remove voltage to the IHVT before removing the test clips.

CAUTION
Do not come in contact with the flyback or IHVT pins, focus, anode, or G2 leads during the FLYBACK & IHVT Load Test.

The clips on the LOAD/RINGER TESTS LEAD are labeled and color-coded for easy identification. Connect the leads to the flyback or IHVT as listed.

Clip Color	Lead Label	Description of Circuit Connection Point
Orange	**B+**	**Primary winding pin of flyback or IHVT where B+ voltage is input.**
Yellow	**C or D**	**Primary winding pin of flyback leading to Collector or Drain of the Horizontal Output Transformer**
Black	**E or S**	**Ground pin of the flyback or IHVT**

Connect the black test clip to one of the ground pins of the flyback transformer or IHVT. Connect the orange test clip to the B+ voltage input pin to the flyback or IHVT primary winding. Connect the yellow test clip to the other side of the primary. The primary pin leads to the collector or drain of the horizontal output transistor.

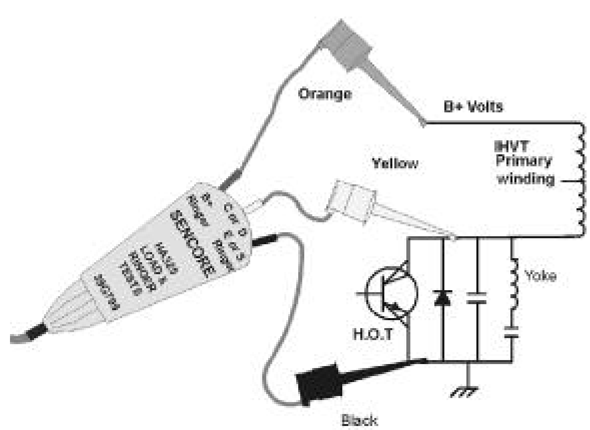


Fig. 13: Setup for using the Flyback & IHVT Load Test.

Selecting a Setup Option - FLYBACK/IHVT Load Test

When the FLYBACK & IHVT Load Tests pushbutton is pressed and released, a list of setup options are displayed. The top line in the digital display is titled SETUP OPTIONS-FLY. These setup options for the FLYBACK & IHVT Load Test provide ease in establishing a test frequency and DC voltage to the IHVT or flyback to be tested. Select the option that provides an appropriate frequency to test the flyback or IHVT and a DC voltage to simulate operation at 1/10 of the normal level, typically 100 VPP.

In the SETUP OPTIONS-FLY display window a cursor block on the left side of the display allows user selection of one of the setup options. There are more setup options available than can be viewed at one time on the display. Pushing the UP ARROW and DOWN ARROW pushbuttons brings more options into view. The arrow indicators above and/or below the cursor block on the display screen indicate more options are available below and/or above the cursor that cannot be currently shown on the display.

To select one of the setup options, position the cursor to the left of the desired setup option and press the ENTER pushbutton. This begins the auto setup routine or applies the test frequency and voltages for the option selected. If the MANUAL option is entered, the SETUP FLBYACK/IHVT display window is displayed for adjustment of the frequency and VDC values beginning at 20kHz and 1 VDC.

SETUP OPTIONS (FLYBACK & IHVT)	FREQUENCY	VDC
AUTO	Automatic selected	Automatic selected
TV	Fixed 20 kHz	Fixed 12 VDC
HIGH SCAN	Fixed 30 kHz	Fixed 8 VDC
MANUAL	Adjustable from 20 kHz	Adjustable from 1V

Chart 6: Setup options for performing the HORIZ. OUTPUT Load Test.

The AUTO setup works well to quickly find a setup for testing most flybacks and IHVTs. Defects that dramatically change the timing of the generated flyback pulse may result in inappropriate setup values. Pushing the TEST/SETUP pushbutton following the auto setup routine displays the setup values established by the auto setup. Changing the values of the frequency or VDC values shown after the AUTO setup defaults the setup to MANUAL mode.

Use the TV setup options for testing television flyback and IHVTs. The frequency and VDC is consistent with the majority of TV horizontal output stages and provides reliable setup. Use the HI-SCAN setup option for testing flyback or IHVTs found in HD-ready TVs, multi-media, computer monitor and high-resolution displays. Use the MANUAL setup option when you desire to change the test frequency or DCV level to simulate 1/10 of normal operation.

To select a setup option for the FLYBACK & IHVT Load Test:

1. Press the FLYBACK & IHVT Load Tests pushbutton.
2. Push UP ARROW or DOWN ARROW pushbuttons to position cursor beside desired selection.
3. Press the ENTER pushbutton to enter the selection.
   (Auto routine begins or setup values are applied to the flyback or IHVT.)

Using Setup Values - SETUP FLYBACK/IHVT

The SETUP FLYBACK/IHVT display widow provides information regarding the operation of the Load Test. Three parameters are shown or metered in the SETUP FLYBACK/IHVT display window. They include: 1) horizontal test frequency, 2) VDC (B+ voltage) and 3) volts peak-to-peak (VPP).

The horizontal test frequency indicated is determined by the auto routine or selected from the options within the SETUP OPTION-FLY display window. The frequency indicated can be adjusted with the UP ARROW and DOWN ARROW pushbuttons. When these pushbuttons are pressed, the setup is changed to MANUAL mode. The test frequency should be appropriate for the flyback or IHVT being tested. TV flybacks should be tested at 16kHz with the HA325. Flyback and IHVTs in displays operating at frequencies above 30 kHz should be tested at 25kHz.

The VDC readout indicates the DC voltage applied to the flyback or IHVT being tested. The VDC value indicated may be automatically selected by the auto setup routine or selected from the options within the SETUP OPTIONS display window. The VDC voltage indicated may be adjusted with the UP ARROW and DOWN ARROW pushbuttons. When adjusted, the setup changes to MANUAL mode. The VDC value should simulate the operation of the flyback or IHVT to produce voltages and currents at approximately 1/10 of normal.

The SETUP FLYBACK/IHVT window displays a VPP (Volts-Peak-to-Peak) measurement, indicating the amplitude of the induced voltage pulses produced by the test circuit contain the flyback or IHVT. If properly connected, a functional flyback or IHVT produces induced voltage pulses relative in amplitude to the selected frequency and VDC voltage applied. A VPP reading that is 1/10 of the chassis normal indicates voltages and currents within the flyback or IHVT are approximately 1/10 of the normal circuit levels. Most horizontal output stages use bipolar transistors, in which the voltage pulses produced during normal operation range from 800 to 1100 volts peak-to-peak. In the SETUP FLYBACK/IHVT display window, a VPP readout should read from 80 to 110 VPP. A VPP reading of 100 VPP serves as a good reference setting when the normal level is unknown.

Some horizontal output stages use MOSFET transistors. Flyback pulses in these stages commonly range from 500 to 800 VPP. When testing a flyback or IHVT that uses a MOSFET horizontal output transistor, establish a VPP reading 1/10 of normal, or between 50 and 80VPP.

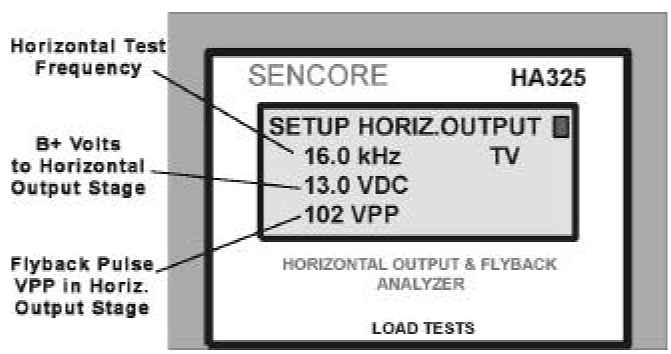


Fig. 14: The kHz, VDC and VPP values indicate the FLYBACK & IHVT Load test frequency, applied DC voltage and resulting flyback pulse peak-to-peak voltage.

Performing the FLYBACK & IHVT Load Test

The FLYBACK & IHVT Load Test simultaneously meters and displays the same three automatic measurements as shown in the HORIZ. OUTPUT Load Test. The measurements reflect the operation of the flyback or IHVT in the simulated horizontal output circuit. The measurements are used to determine if the flyback or IHVT is normal or contains a defect.

The three Load Test measurements accurately reflect the operation of the flyback or IHVT in the horizontal output test circuit. The “mA” readout indicates the current being drawn by the flyback or IHVT from the HA325 DC power supply. This is the power supply load current to the flyback or IHVT. The “mA” readings typically range from 3 - 15 mA with a good flyback or IHVT. The “mA” readings rise significantly when defects exist with the flyback or IHVT.

The % EFF readout measures what percentage of the input energy or current to the flyback or IHVT in the simulated horizontal output stage is returned to the B+ power supply at the end of the horizontal cycle. Flyback or IHVT defects add power losses, greatly reducing the efficiency of the horizontal output test circuit and the percentage of energy returned to the power supply. Efficiency readouts typically range from 60 to 90% when the flyback or IHVT contains no defects.

The “µS” readout is an automatic measurement of the pulse duration of the inductive voltage produced by the flyback or IHVT in the horizontal output test circuit. The Load Test measures the time of the pulse from the start of its rising edge to the end of its falling edge. The pulse duration is determined by the inductance of the flyback or IHVT. Therefore, the resulting µS time will vary between flybacks or IHVTs. The “µS” timing will typically vary from 10-16 µS with TV flybacks and from 5-10 µS with high scanning frequency monitors.

<u>To perform the FLYBACK & IHVT Load Test:</u>

1. Apply POWER to the HA325, press the FLYBACK & IHVT pushbutton.
2. Select an appropriate setup option using the UP ARROW and DOWN ARROW pushbuttons.
3. Press the ENTER pushbutton.
   Note: *In MANUAL setup, select VDC and frequency values and press the TEST/SETUP pushbutton.*
4. Read the “mA”, “µS”, and “% EFF” readouts in the digital display.
5. Compare readout results to typical ranges. Press and hold ASSISTANCE pushbutton for helpful messages during the testing process.

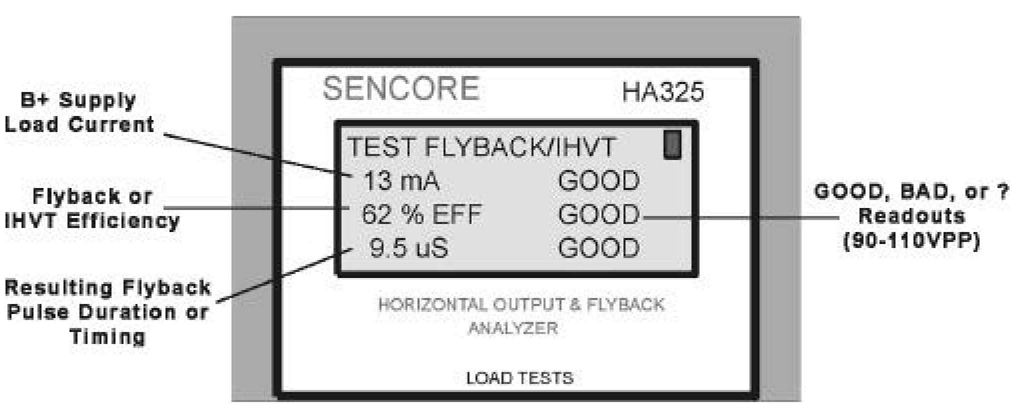


Fig. 15: Three measurements during the Flyback & IHVT Load Test analyze its operation.

Interpreting Flyback/IHVT mA, % EFF and µS Readings:

The HA325 accompanies the FLYBACK & IHVT Load Test mA, % EFF and µS numeric readings with a “Good”, “?” or “Bad” indication on the right side of the display window. These indications are shown when the Load Test is active and flyback pulses in the range of 80-110 VPP are present in the horizontal output circuit being tested.

The Good/?/Bad mA ranges of the Flyback & IHVT Load Test are shown in Chart 7. Readings from 3-15 mA are considered “Good” and readings over 20 are considered “Bad.” Readings from 16-20 are considered “?” by the HA325. Most flyback transformers with Load Test mA readings exceeding 15 mA are defective. However, a few less efficient flyback transformers or IHVTS have normal Load Test currents ranging from 15-20 mA. Testing at a reduced test frequency can also increase current readings into the questionable range.

Efficiency readings that range from 60-100% are considered “Good” by the HA325. Readings of 0-49% are considered “Bad” and indicate a likely defect with the flyback transformer or IHVT. Readings in the range of 50-59% are considered questionable. The flyback or IHVT is likely defective if a questionable % EFF reading is accompanied by a higher than normal mA reading.

Readings from 6-15 µS are considered “Good” when performing the Flyback & IHVT Load Test. The µS reading or timing of the HA325 Load Test circuit will not agree with the timing of the circuit in which the flyback or IHVT was removed. Therefore, the µS reading is not used to determine if the Flyback or IHVT is defective. However, if the µS reading is considerably different than the “Good” 6-15 µS range, a defect is likely.

Flyback & IHVT Good/?/Bad Ranges

Test Parameter	Good	?	Bad
mA	**3-15 mA**	**16-20 mA**	**>20 mA**
% EFF	**60-100%**	**50-60%**	**<1-49%**
µS	**6-15 µS**	**5.0-5.9, 15.1-15.9 µS**	**0.1-4.9 >15.9 µS**

Chart 7: Good/?/Bad ranges for the Flyback & IHVT Load Test.

RINGER TESTS

The HA325 Ringer Tests are used to locate a shorted turn in a yoke, flyback, coil or switching transformer. The Ringer Test checks the coil's quality or “Q” and locates shorted turns that cannot be detected with other troubleshooting tests. The test dynamically checks all the windings in a yoke, flyback, a non-iron core transformer or coil for a shorted turn(s). A single shorted turn causes all of the other windings that share the common core to also ring bad. Therefore you need to ring only the primary winding of a flyback or non-iron core transformer.

Three Ringer Test options including 1) Yokes And Flybacks, 2) Coils and 3) Switching Transformers are provided, allowing the HA325 to automatically check different inductor types. In each case, connecting the Ringer Test leads to the coil places a capacitor in parallel with the coil. The HA325 applies energy to the cap/coil combination and automatically ranges the capacitor value to produce the highest number of oscillations or rings. The digital display indicates the number of times the coil rings before it dampens out.

A Ringer Test reading of “10” or more means the coil does not contain a shorted turn. A reading of less than 10 indicates the coil or transformer contains a shorted turn(s) between windings. Note that the number “10” is merely a good/bad reference point. A coil that rings 35 is not better than a coil that rings 20.

Yokes & Flybacks - Use this Ringer Test to test deflection yokes, flybacks and the flyback portion of IHVTs.

Coils - Use this Ringer Test to test coils and inductors found in horizontal stages or in other electronic stages. These coils or transformers typically have a lower Q than yokes and flybacks and need to be tested to a different damping level threshold.

Switching Transformers – Use this Ringer Test to test transformers found in switching mode power supplies.

To perform the Ringer Tests:

1. Press POWER to apply power to HA325.
2. Remove or isolate the component to be tested from the circuit.
3. Connect the orange and black LOAD & RINGER Lead clips to the yoke, flyback coil, or switching transformer.
4. Push & release the appropriate RINGER TEST pushbutton of the yoke, flyback, coil or switching transformer.
5. Read the ring count result in the digital display.

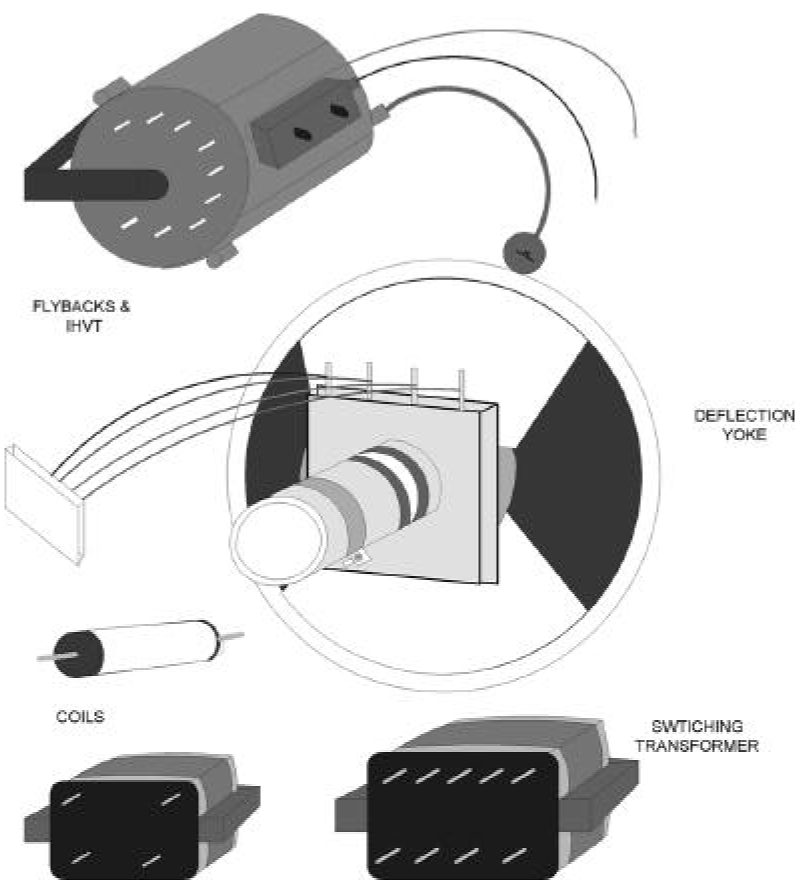


Fig. 16: The RINGER TESTS identify shorted turn(s) in yokes, flybacks, coils, or switching transformers.

APPLICATIONS

INTRODUCTION

The applications section helps you understand horizontal stages. It includes examples of typical applications to provide you with an understanding of how to use and interpret the HA325 analyzing tests. It further provides you with ideas on how to use the HA325 to take advantage of its full potential.

Understanding Horizontal Stages of a CRT Video Display

Horizontal stages are part of every CRT-based video display. The horizontal stages produce flyback transformer current to generate high voltage required by the CRT. The horizontal stages produce alternating current in the horizontal yoke to deflect the CRT's electron beam side to side.

The horizontal and related stages can be broken into six major functional areas. They include:

1. **Horizontal Output Stage**
2. **B+ Power Supply**
3. **High Voltage/ Deflection Regulator**
4. **Horizontal AFC/OSC/BUFFER**
5. **Horizontal Driver**
6. **x-ray Shutdown**

The horizontal output stage produces alternating currents in the flyback transformer and yoke. The currents result from the B+ voltage applied to the stage and the on/off switching action of the horizontal output transistor as it is driven by the horizontal drive signal.

The B+ power supply provides the power (volts X current) for the horizontal output stage. The output voltage of the B+ power supply is constant over a range of AC voltage and horizontal output load current variations. B+ power supplies typically output voltages between 30 and 190 volts depending upon the chassis design. Switching power supplies are commonly found in multi-frequency CRT video displays.

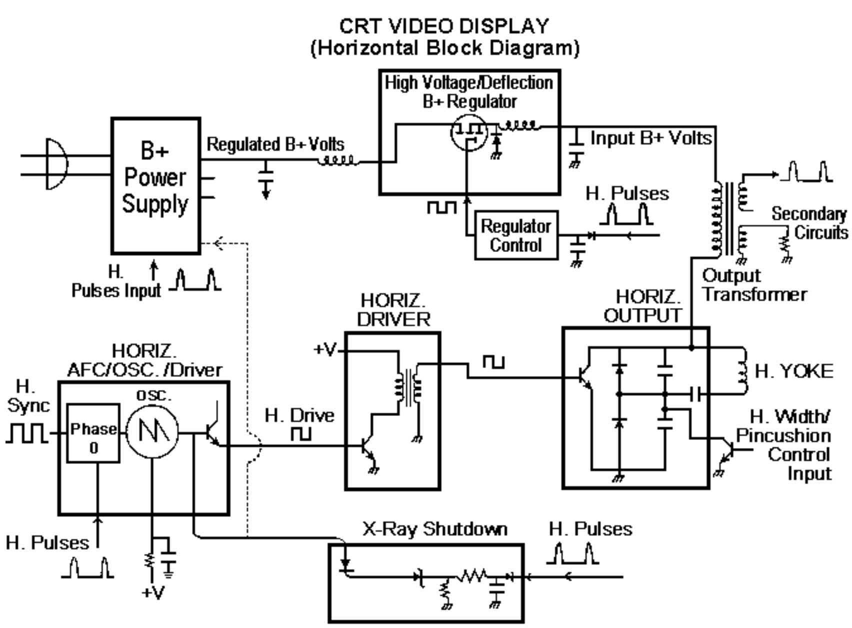


Fig. 17: Horizontal Output and related stages in a multi-frequency CRT video display.

The high voltage/deflection regulator varies the B+ voltage to the horizontal output stage to keep the high voltage and/or deflection constant with changes in scanning frequencies. The high voltage/deflection regulator may be a linear regulator or a “buck” or “boost” switching type. The “buck” switching type is the most common. It uses a switching MOSFET transistor driven with a pulse width drive signal from a regulator control stage. The regulator control varies the drive according to feedback from the horizontal output stage to increase or decrease the B+ voltage to the horizontal output stage.

The horizontal oscillator produces the drive signal required for on/off switching of the horizontal output transistor. The horizontal oscillator stage is commonly part of an integrated circuit. The oscillator uses discrete components such as a crystal or resistor and capacitor. Multi-frequency displays commonly use resistors and capacitors that can be switched or varied to change the oscillator frequency. The oscillator is locked to the frequency of the video's horizontal sync pulses and adjusted in phase to center the picture on the CRT by an automatic frequency control (AFC) stage. A buffer amplifier in the IC shapes the oscillator signal into a square-wave output that is applied to the horizontal driver stage.

The horizontal driver stage amplifies the weak horizontal drive waveform. The horizontal driver stage for a bipolar horizontal output transistor includes an amplifier with a current step-up transformer to produce the proper drive current. The horizontal driver stage for a MOSFET horizontal output transistor uses an amplifier to provide a changing voltage to the MOSFET's high impedance gate.

All CRT-based video displays include over-voltage or x-ray shutdown protection. This stage disables the horizontal output stage to shutdown the chassis if the high voltage increases to an unsafe level. The horizontal output stage is disabled by removing B+ or horizontal drive either of which stops the output stage from producing high voltage. Causes of excessive high voltage and shutdown include too much B+ voltage to the horizontal output stage, a horizontal output stage timing problem, or a reduced horizontal drive frequency.

Understanding Horizontal Troubleshooting Difficulties

Much of the difficulty in troubleshooting horizontal related problems and symptoms of a CRT video display can be understood by studying figure 17. Each stage develops an output, based upon inputs or voltages produced by other stages. It is the interaction and inter-dependence of each horizontal stage on the other stages that make symptoms and defects difficult to isolate.

To better understand this, consider the horizontal output stage and B+ power supply. The B+ power supply outputs a normal voltage when the current demand or load of the horizontal output stage is within a normal range. An abnormal increase in current in the output stage can cause a decrease in the output B+ supply voltage. Also, gating pulses from the horizontal output stage transformer are commonly used for switching or syncing of the B+ power supply. A lower than normal B+ voltage can be caused by defects in the supply or horizontal output stage.

The interaction between the horizontal output stage and the B+ power supply is most apparent when the horizontal output stage develops severe timing or excessive current demands (power supply loading). The severe conditions place immediate high current stress on horizontal output transistors, high voltage/deflection regulators and B+ power supply components. These severe horizontal output stage problems can cause immediate damage to replacement horizontal output transistors and power supply components, if not isolated before applying AC power.

The secondaries of the horizontal output transformer interact with the horizontal output stage. Shorts in the secondary circuits cause an abnormal increase in current in the horizontal output stage and load the B+ power supply input. These conditions are not evident with resistance tests in the horizontal output stage.

In multi-frequency monitors, a high voltage and/or deflection regulator adjusts the B+ voltage to the output transformer to produce normal high voltage and/or deflection. Feedback voltage pulses from the output transformer to the regulator control block form a closed loop regulator. Defects in the circuit loop cause improper operation of the output stage and high voltage/deflection regulator. Since all the stages of the loop are altered, it is difficult to isolate the problem to the stage and component.
The x-ray or high voltage shutdown circuits closely interact with the horizontal output stage. The shutdown circuit detects excessive high voltage and immediately shuts down the operation of the horizontal output stage by interrupting horizontal drive or B+ voltage. Since conditions are momentary, conventional voltage measurements cannot be made to isolate the problem.

Voltage or gating pulses from the horizontal output transformer feed the horizontal AFC or phase detectors and may be used to power the horizontal driver stages. Feedback from the output transformer to horizontal phase or driver stages may cause problems with the horizontal drive signal and output stage operation. Once again, the closed circuit loop makes troubleshooting difficult.

Guide To The HA325 Tests

The unique analyzing tests of the HA325 provide effective troubleshooting capabilities to isolate horizontal and related chassis symptoms. The HA325 tests are performed with the chassis power off and include the HORIZ. OUTPUT and FLYBACK & IHVT Load Tests. The HA325 also provides a Ringer Test optimized for testing yokes, flybacks, IHVTs, coils and switching transformers. A guideline as to when to use each HA325 test is shown in Chart 8.

HA2500 test	When to use	What it tells you
HORIZ. OUTPUT LOAD TEST	Full AC cannot be applied: B+ supply dead or bad. H.O.T heats or fails. B+ supply squeals, burns-up components or blows fuses. X-ray shutdown symptom.	Output stage functions. Short/Load on B+ supply. Output stage pulse timing. Output stage efficiency.
FLYBACK & IHVT LOAD TEST	HORIZ. OUTPUT Load Test is abnormal (High mA, low %).	Flyback/IHVT functions. Flyback/IHVT mA load. Flyback/IHVT efficiency.
(The FLYBACK & IHVT Load Test may be used in-circuit to isolate AC loading defects to horizontal output stage primary components or flyback/IHVT and/or secondary components.)		
FLYBACK & IHVT EXTENDED TESTS	Flyback/IHVT has improper HV focus, G2, or secondary output.	Flyback/IHVT secondary defect. IHVT multiplier defect. IHVT focus/G2 divider defect.
RINGER TEST	Load Tests is abnormal. Suspect flyback, yoke, or horizontal coil defect.	Confirm if yoke, coil, transformer is bad from shorted turn(s).

Chart 8: Guide to HA325 Horizontal Analyzing Tests.

Connecting the Load Tests Leads Without a Schematic

To connect the Load Test clips without the aid of a schematic diagram, first locate the horizontal output transistor or transistors. There may be one or two horizontal output stages. When two horizontal output stages are used, one produces high voltage while the other produces horizontal deflection.

A single horizontal output stage produces both high voltage and deflection. Horizontal output transistor(s) are normally located near the flyback transformer or yoke connector plug on the circuit board. Most horizontal output transistors are variations of a TO-3P case style and are mounted to a large metal heat sink. The circuit path of the collector or drain should lead to a pin of the flyback, or yoke transformer or coil.

If you are unsure if the transistor is a horizontal output type, use a semiconductor cross reference book to match the transistor number and identify a replacement transistor. Check the uses specified for the replacement transistor and the breakdown voltage rating BVceo. Most horizontal output bipolar transistors have a rating greater than 1000 volts (typically 1500V) and MOSFET transistors greater than 800 volts (typically 800 or 1000V).

Once you have identified the horizontal output transistor(s), connect the yellow test clip to the center lead (collector or drain). Identify the ground for the horizontal output circuitry. Horizontal ground typically connects to the emitter or source lead of the horizontal output transistor directly, or through a parasitic inductor or small value resistor. The ground circuit path on the board typically has a large trace size. It may also be recognized as the trace on the circuit board that the negative lead of many polarized capacitors shares.

Some horizontal output transistor emitters are connected to the driver transformer. Typically the base lead contains a resistor or diode leading back to the driver transformer while the emitter lead does not. In this configuration the Load Test black clip may be connected to either the emitter of the output transistor or horizontal ground.

To identify the B+ input to the horizontal output stage, trace the circuit path from the collector or drain of the horizontal output transistor to the output transformer or coil. This is one side of the primary winding of the output transformer, typically the flyback, or coil in the HV-only horizontal output stage. With an ohmmeter, identify pin or pins that have continuity to the collector pin of the transformer. Typically one or two pins may be identified. The B+ input pin may be identified on the circuit board for you. If not, the B+ input typically has an electrolytic capacitor to ground with a coil or low value resistor leading to the B+ power supply or regulator. A second transformer pin that may have continuity to the primary winding likely has a diode connected to it to develop a voltage for the CRT.

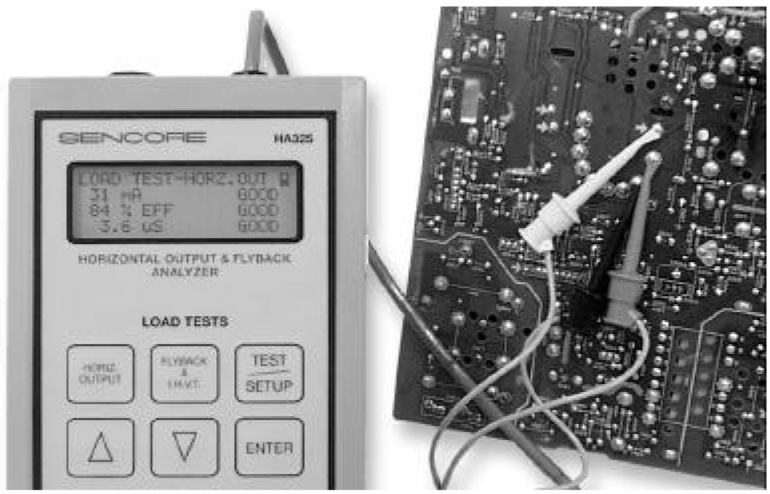


Fig. 18: With a few simple steps you can connect and perform the Load Tests without a schematic.

If you are unsure of the B+ input, you can use a trial and error method to identify the B+ input using the Load Test. Select an appropriate preset option from the SETUP OPTIONS-HOR display window for the horizontal output stage you are testing. In the TEST HORIZ.OUTPUT display window, alternately connect the B+ or orange test clips to pins of the transformer which may be the B+ input while monitoring the Load Test results. The connection which produces Load Test readings that are normal or closest to normal, is likely the proper B+ input. Improper connections will show high levels of mA readouts, loading or short indications, unusual µS readings or other unusual test results.

Understanding the Auto Setup - HORIZ. OUTPUT Load Test

The HA325 provides several options to quickly establish a horizontal test frequency and DC voltage to the horizontal output stage to be load tested. These options are available in the SETUP OPTIONS-HOR display window. An AUTO option is also available as a setup option. This section familiarizes you with the flowchart the HA325 uses to establish an appropriate test frequency and DC voltage automatically for the horizontal output stage being load tested.

When the AUTO setup option is selected by pushing the ENTER pushbutton, the HA325 begins the auto setup process. The process begins by applying a switching frequency of 25 kHz and slowly incrementing the DC voltage. Initially the AUTO setup flowchart relies on the horizontal output circuit being load tested to begin producing flyback pulses, approaching 25VPP with only a few volts DC applied. When the flyback pulses are sensed, the µS meter measures the duration of the pulses.

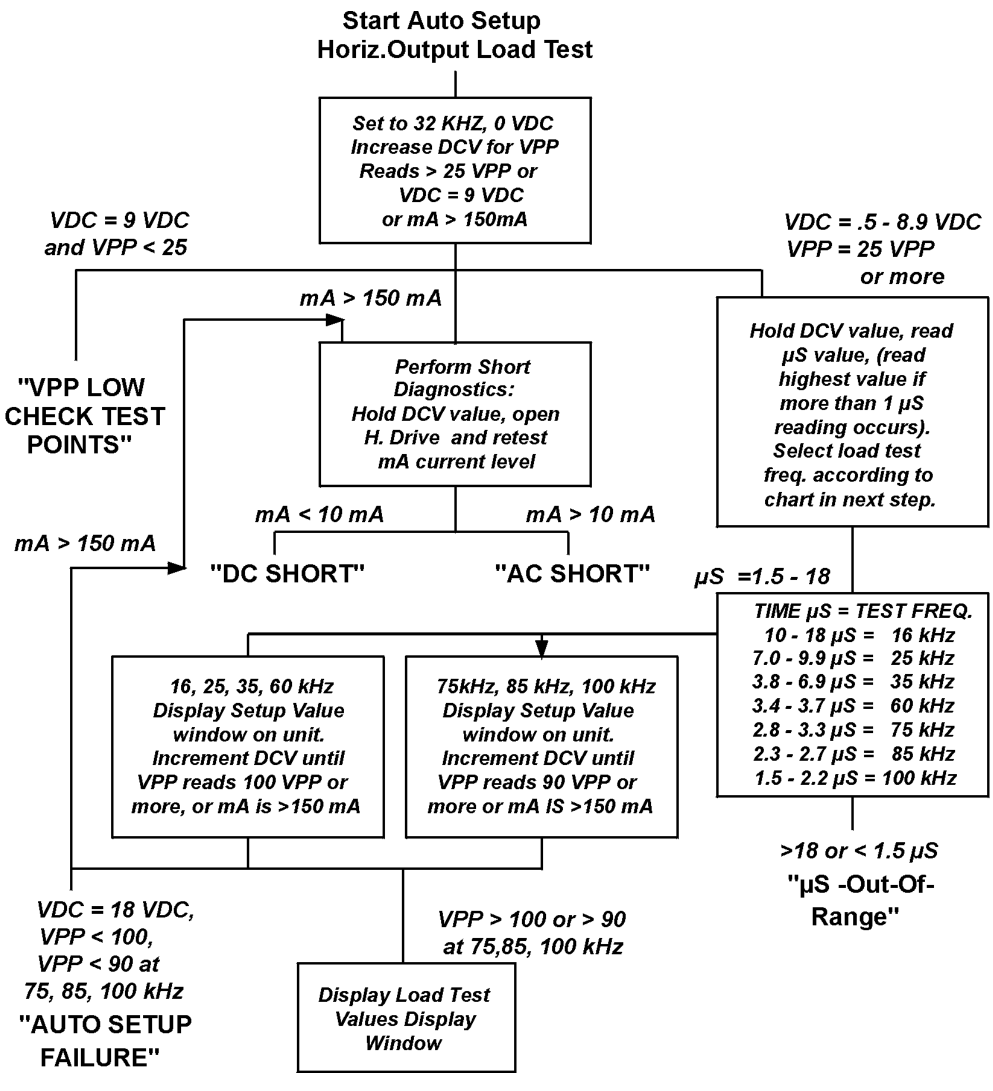


Fig. 19: The auto setup flowchart for the Horiz. Output Load Test.

The duration of the flyback pulses is the key to determining a suitable test frequency for the auto setup. TVs and CGA monitors have flyback pulse durations exceeding 10µS. High definition TV displays and VGA monitors have flyback pulse durations in the range of 4-7 µS. Higher resolution displays have shorter and shorted flyback pulse durations.

The HA325 chooses a test frequency, based upon the pulse time. Once the new test frequency is selected, based upon the µS reading, the DC voltage is increased until the VPP reading nears 100VPP. Upon reaching 100VPP, the auto setup is complete and the Load Test results are displayed.

As with any automated process, failure to achieve the required criteria in each flowchart block results in an unsuccessful setup. Improper connections to the horizontal output stage being tested or severe defects in the stage are the most common cause of automatic setup failures. The blocks in figure 19 show the HA325 AUTO setup flowchart. If the auto setup routine fails, a brief message indicating the reason is displayed. The HA325 then returns to the SETUP OPTIONS display window.

Interpreting the Load Test mA Readout

The Load Test "mA" reading is the amount of B+ current drawn from the Load Test VDC power supply by the horizontal output stage being tested. The mA reading reflects the horizontal output stage current load on the chassis B+ power supply. Since the Load Test is performed near 1/10th the normal B+ voltage of the chassis, the B+ current displayed by the Load Test is approximately 1/10 of the chassis normal.

A normal or typical range of Load Test mA readings varies with high voltage-only, deflection-only or combination horizontal output stages. Typical mA ranges further depend on the CRT size. Larger CRT sizes require increased yoke current and high voltage, resulting in greater horizontal output stage power demands.

A high voltage-only horizontal output stage typically demands 10 to 40 watts of power to produce normal high voltage. The power demand of the horizontal output stage is provided by the B+ power supply (Volts X Current = Power). If the chassis B+ voltage is 100 volts, the B+ supply delivers 400 mA to the output stage to deliver the needed 40 watts. If the HA325 Load Test was performed using 10 volts B+ (1/10 of normal), the mA readout should be near 40 mA. If another chassis requiring 40 watts uses a B+ voltage of 125 volts, the power supply current is 325 mA, corresponding to a Load Test current of 32 mA. A 70 volt B+ supply would need to output 570 mA for the same 40 watts. Considering a power range of 10 to 40 watts, a typical B+ voltage range, Load Test mA readings in the range of 10 to 60 mA are typical in a high voltage-only horizontal output stage. Although rare, slightly higher Load Test mA readouts may be encountered if the output stage operates at B+ voltages below 70 volts and/or has power demands exceeding 40 watts.

Deflection-only and combination horizontal output stages require more power and subsequently more B+ power supply current. See Chart 2. The added power demand increases the normal mA readings during the Load Test. Combination horizontal output stages in TVs with CRT sizes less than 26 inch or multi-frequency monitors with CRT sizes less than 16 inches, typically have Load Test mA currents ranging from 10 to 50 mA. Deflection-only horizontal output stages, typically found in multi-frequency monitors with larger CRT sizes, typically have Load Test mA currents ranging from 10 to 70 mA. This range is also typical of combination horizontal output stages in TVs with CRT sizes exceeding 25 inches and multi-frequency monitors with CRT sizes exceeding 15 inches.

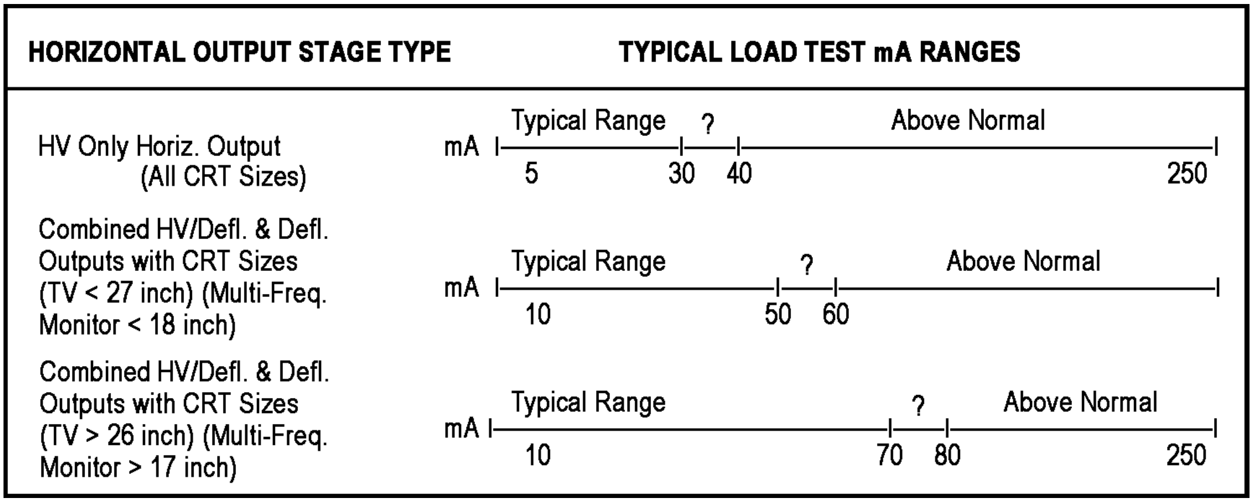


Chart 9: The normal or typical Load Test mA ranges of horizontal output stages.

Load Test mA readings in the typical range indicate a normal current load on the B+ power supply. Check the µS and % EFF reading to confirm that the horizontal output stage has no other defects.

Load Test mA readings below 10 mA are unusually low. Readings below 10 mA usually indicate an invalid Load Test or improper setup condition. An improper setup can result from improper circuit clip connections, unusually low B+ voltage, unusually high test frequency or an open in the horizontal output circuit. Check for proper circuit connections and the Load Test Setup Values to confirm a proper B+ voltage and test frequency is being applied.

Load Test mA readings greatly exceeding the typical current range for the horizontal output stage type and CRT size indicate a heavy current demand in the horizontal output stage or flyback secondary. The heavy current demand will likely load down the high voltage or deflection regulator and B+ power supply stressing components when AC voltage is applied. Isolate the problem and confirm normal Load Test results before applying AC voltage.

Load Test mA readings that are slightly above the typical current range are questionable. It may be normal for a certain chassis to slightly exceed the normal mA range if its B+ voltage is lower than the norm or its power requirements are slightly higher. Current readings exceeding the typical range may indicate a subtle horizontal output stage problem or result from using a slightly higher than normal Load Test B+ voltage or lower than normal test frequency.

When a mA reading just above the typical range is encountered, check the VPP reading in the SETUP VALUES display window. A VDC voltage higher than the 1/10 level causes an increase in output stage power demand and load on the B+ supply. Reduce the VDC until the VPP is approximately 100 VPP (bipolar output transistor) and 80VPP (MOSFET output transistor. This may reduce the mA reading into the typical range. Next, check the remaining Load Test µS and % EFF readouts. If either or both tests indicate unusual readings, a horizontal output stage defect is likely. If both tests indicate normal, the horizontal output stage does not have a severe defect and AC power may be applied for further testing.

Interpreting The Load Test % EFF Readout

The Load Test “% EFF” readout measures what percentage of the input energy or current to the output stage is returned to the B+ power supply at the end of the horizontal cycle. Horizontal output stages are primarily tuned LC circuits, which return a large share of energy back to the power supply at the end of each cycle. Defects add power losses, greatly reducing the efficiency of the horizontal output stage and the percentage of energy returned at the end of each cycle.

The Efficiency measurement is based upon the ratio of two current measurements, reflecting the efficiency of the horizontal output stage under test. A gated conduction current measurement is made of both the Load Test horizontal output transistor and the Load Test “mA” or B+ power supply current. The gated current measurement captures the horizontal output transistor conduction current representing the total input of energy to the inductors (coil, flyback and/or yoke) of the horizontal output stage. The “mA” or B+ supply current represents the current needed to replenish the output stage to satisfy its current demand each cycle. The supply current represents the energy or current consumption of the output stage and transformer secondaries.

The ratio of these currents represents what percentage of the input energy or current is returned to the output stage during each horizontal cycle. Normal horizontal output stages return a substantial amount of unused energy to the B+ supply at the end of each horizontal cycle. Defects cause the horizontal output stage to have increased losses, greatly reducing the output stage efficiency and the ratio between the Load Test currents.

At the beginning of the horizontal cycle, the Load Test horizontal output transistor conducts, producing a current buildup in the horizontal output stage's transformer or coil. The current buildup is the energy input to the horizontal output stage being tested. The input current energizes the stage, producing a magnetic field in the transformer or coil. During the remainder of the horizontal cycle, current alternates in the stage, transferring the input energy from a magnetic field to a capacitive charge and finally back to a magnetic field. At the end of the cycle the energy remaining in the magnetic field is returned to the power supply.

If all the input energy to the horizontal output stage were returned at the end of the cycle, no B+ supply current would be needed after the first cycle. The B+ supply current would be zero, and some level of conduction current would exist in the output stage. The horizontal output stage would be 100% efficient. But, all horizontal output stages have some inefficiencies or losses. Power is induced into the flyback transformer secondaries and used to produce CRT currents and gating pulses to other stages. Other energy is dissipated in the inherent losses of the components in the horizontal output stage. For this reason the % EFF readout is always less than 100%.

The % EFF readout varies among horizontal output stages, depending on the level of power transfer to secondaries and the horizontal output stage configuration. High voltage-only horizontal output stages typically are 60-95% efficient. Deflection-only and combination horizontal output stages typically range from 50-95% efficient. Overall, expect efficiency readings to be higher than 50% for the majority of horizontal output stages.

Occasionally, an efficiency reading slightly less than 50% may be encountered. This can occur from a design inefficiency in the horizontal output stage or in one of its components. If the mA readout is in a typical range, the efficiency is simply a reflection of a circuit inefficiency. If the mA reading is questionable or high, press the TEST/SETUP pushbutton and check the VPP and frequency setup values. The frequency should be near the highest horizontal frequency capability of a multi-frequency or multi-mode display. The VPP should be 1/10 of the chassis normal or approximately 100VPP for most displays.

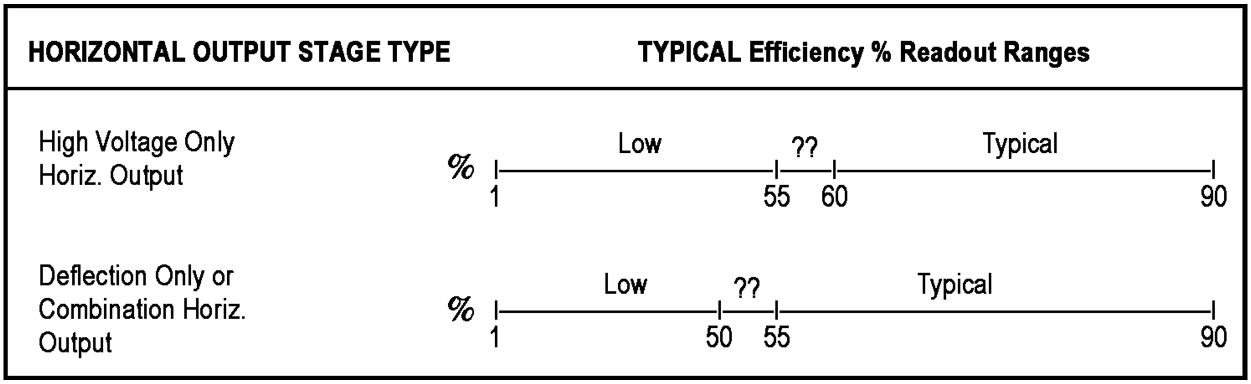


Chart 10: Typical "% EFF" readout ranges of horizontal output stage configurations.

A % EFF readout in the typical range indicates the horizontal output stage and transformer secondaries are exhibiting a normal range of energy losses and transfer. Efficiency readouts considerably below the typical range for the horizontal output stage configuration indicate a substantial increase in circuit power losses or power transfer to a secondary. Low efficiency readouts usually accompany high mA test results when severe horizontal output stage problems exist.

The "% EFF" test is especially useful when testing multi-frequency monitors. An error in setting the Load Test B+ voltage and/or test frequency may cause the "mA" readout to be above the normal range. In these instances the "% EFF" readout provides an additional analysis of the horizontal output stage to indicate if excessive circuit losses or inefficiencies exist. If the % EFF is in a normal range, a higher than normal "mA" readout is likely a result of too much applied B+ voltage for the test frequency chosen.

Note: *The efficiency test is mostly independent of the applied Load Test B+ voltage and frequency. Only extreme B+ voltage or frequency settings cause substantial changes in the "% EFF" Therefore, the efficiency readout can indicate output stage losses or defects that may be missed due to improper Load Test B+ or Frequency settings. It can also help differentiate questionable "mA" results when you are unsure of the proper Load Test B+ voltage.*

Interpreting The Load Test µS Readout

All horizontal output stages produce an inductive flyback voltage pulse, typically at the collector or drain of the horizontal output transistor. The voltage pulse occurs during horizontal blanking time and coincides with the yoke retrace period. The pulse time duration is determined by the inductance or capacitance of the flyback or coil primary, retrace timing capacitor(s), yoke, and yoke series components.

The "µS" readout during the Load Test measures the pulse duration with the chassis off. The measurement is triggered at approximately the 5% levels of the voltage pulse for pulses exceeding 10 VPP. The "µS" readout closely duplicates the pulse time of the chassis horizontal output stage when powered to its full B+ voltage.

The pulse time is important for proper operation of the horizontal output stage. The LC timing of the output stage determines the amplitude of the induced voltage pulse in the output stage. The amplitude of the pulse reflects the energy induced to the yoke to produce deflection and energy induced into the flyback transformer to produce high voltage. The pulse time also reflects the time in which retrace must be performed and video blanked.

The normal pulse time or µS reading varies between horizontal output stages depending on the display's capabilities. The pulse time must begin and end relative to the video's horizontal blanking interval. If the picture is over-scanned, such as in NTSC television, the pulse duration is typically 0-30% greater than the approximately 11uS blanking interval. Since the video is over-scanned on the CRT, the voltage pulse begins just before the start of the horizontal interval and ends slightly after the horizontal interval. This produces typical µS pulse durations of 11 to 14 µS on NTSC-compatible television displays. HDTV is also over-scanned, resulting in a µS pulse duration slightly longer than the 3.77 µS (1080i) blanking interval.

On under-scanned video displays, the voltage pulse does not begin until the start of the blanking interval and ends before active video begins at the end of the horizontal interval. This is because video blanking and retrace cannot occur during active video visible on the CRT edges. Therefore, the video's horizontal blanking time serves as an approximate maximum µS pulse time in these displays. The minimum µS time in an under-scan display is typically not less than 70% of the blanking interval time. This produces typical µS pulse durations from 70-100% of the horizontal blanking time. This range applies to deflection-only horizontal output stages, combination horizontal output stage and most high voltage-only horizontal output stages.

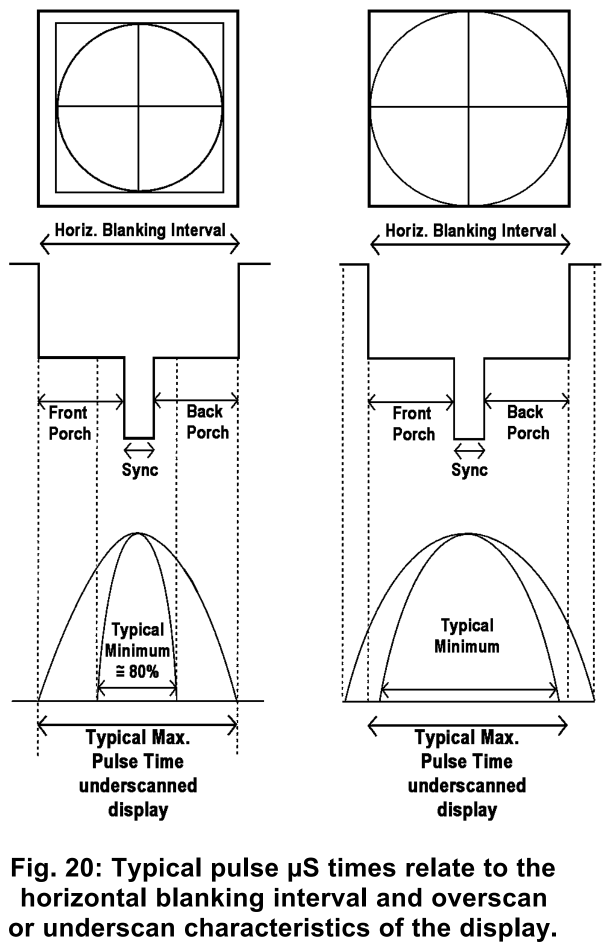


Fig. 20: Typical pulse µS times relate to the horizontal blanking interval and overscan or underscan characteristics of the display.

For example, several monitor format frequencies and horizontal blanking intervals are shown in Chart 11. A VGA computer monitor operating at 31.5 kHz displays a common video format with a horizontal blanking time of 6.35 µS. The typical horizontal pulse µS timing found among VGA monitors ranges from approximately 4.5uS (Approx. 70% of 6.35 µS) to 6.5 µS (video blanking 6.35 µS). A monitor designed to display a higher resolution VESA format at 60 kHz displays a video with a horizontal blanking interval of 3.56 µS. Monitors designed to display this video format would have horizontal pulse µS timing ranging from approximately 2.5 to 3.8 µS.

Chart 11 shows that as the resolution and horizontal scanning frequency increase, the video's horizontal blanking time decreases. As the horizontal blanking interval decreases, so does the normal range of horizontal pulse or µS readings. To determine if a measured µS reading is normal, reference the horizontal scanning frequency and/or horizontal blanking interval to a section shown in Chart 11 or compare to the HA325Good/?/Bad µS ranges.

A multi-frequency monitor has the ability to display different video formats with various horizontal scanning frequencies and blanking intervals. The horizontal voltage pulse or µS timing is limited by the video format containing the shortest horizontal blanking interval, which is usually the highest scan frequency. To determine the typical µS pulse time of a multi-frequency display, reference the monitor's highest frequency capability and the video's horizontal blanking time. The horizontal voltage pulse time should be equal or shorter than the horizontal blanking interval but typically not less than 70% of the blanking time.

Scan Format	Horiz. Freq.	Horiz. Blanking Time	Typical µS Range
TV-NTSC	15.7 kHz	11 µS	11.0 - 15 µS
VGA	31.5 kHz	6.35 µS	5.0 - 7.0 µS
VESA	38 kHz	6.1 µS	4.8 - 7.0 µS
XGA	35.5 kHz	5.3 µS	4.2 - 6.0 µS
VESA	46.88 kHz	5.17 µS	4.1 - 5.5 µS
VESA	60.02 kHz	3.56 µS	2.8 - 4.5 µS
VESA	63.98 kHz	3.78 µS	3.0 - 4.5 µS
VESA	75.0 kHz	3.46 µS	2.8 - 4.0 µS
VESA	79.98 kHz	3.0 µS	2.4 - 3.5 µS
VESA	81.25 kHz	3.2 µS	2.5 - 3.5 µS
VESA	93.75 kHz	2.765 µS	2.2 - 3.5 µS
VESA	106.25 kHz	2.44 µS	2.0 - 3.5 µS

Chart 11: The typical µS horizontal pulse time range found among video displays of different frequency and horizontal blanking times.

A horizontal output stage pulse time that is in the range shown in Chart 11 for the video display's frequency and blanking capabilities indicates proper timing and resonant action in the horizontal output stage.

A pulse time outside the typical range indicates questionable timing or a horizontal output stage defect. Readings slightly below the typical range may simply indicate the monitor is capable of slightly higher resolutions than was anticipated. Readings below the typical range for the monitors known highest frequency capability indicate a problem in the horizontal output stage. Readings below the typical range may cause excessive high voltage shutdown and/or horizontal output transistor failure.

Troubleshooting High mA & Low % EFF Load Test Readouts

The Load Test Setup and the Load Test can be used to isolate defects in the horizontal output stage. If the Load Test readings indicate high current and/or low efficiency and/or bad µS readings, a problem exists in the horizontal output stage. You can use the Load Test Setup and Load Test readouts to help isolate the defect. Chart 12 shows common combinations of Load Test readouts and possible causes.

Load Tests Readouts mA	%	µS	Likely Causes
High mA	Very Low <6%		Improper connection DC leakage. (see Fig. 21)
High mA	Low % 6 - 50%		Horiz. Out Defect - Shorted inductor turn(s), secondary short, leaky or open component.
Normal mA	Low %	Near Normal or low µS	Load Test Freq. High or B+ Low Horiz. Out Defect - Shorted inductor turn(s), sec. short, leaky component. (see Fig.22)
Normal mA	Normal %	Low µS	Horiz. Out Timing - Retrace capacitor. Display runs higher resolution or frequency.
Low mA	Normal %	High µS	Yoke or series components.

Chart 12: Common Load Test combination of readouts and likely causes.

There are commonly three types of shorts or leakage problems that cause extra B+ supply current (loading). The Load Test can determine the type of short or leakage (loading) problem and help you isolate it. The three types include:

1. A low resistance path for direct current (DC short to ground) on the B+ supply.
2. A DC leakage (higher resistance short) on the B+ supply.
3. An AC short or leakage path in the horizontal output stage.

The Load Test mA and % EFF readouts can be used to determine what type of loading problem exist and provide feedback while you isolate the defect. A readout of approximately 200 mA with a "--- %" readout indicates a low resistance DC short to ground on the VDC or B+ power supply. The HA325 accompanies this readout with a "DC SHORT" message. This is the maximum current that can be produced by the Load Test VDC power supply. Before assuming a circuit short, check the test lead connections to be sure your have connected to the proper B+ circuit point.

There are many possible DC short paths. A DC short or leakage path can be caused by a leaky filter capacitor, diode or regulator component in the chassis B+ path. Defects may also be from shorts or leakage paths in the horizontal output stage or other stages connected to the B+ power supply path. See figure 21. To isolate a DC short or leakage path, first open the B+ supply circuit path back to the power supply and other circuits powered by the B+ supply. Hook the "B+" (orange) test lead directly to the B+ side of the flyback transformer primary winding. Leave the Collector (yellow) lead open and compare the Load Test mA readout to the earlier reading. A DC current greater than 10 mA indicates a DC leakage or short in the horizontal output stage.

The most likely cause of a DC short on the VDC or B+ supply is a shorted horizontal output transistor. Disconnect the orange test clip and remove the chassis horizontal output transistor. Connect the test clip and repeat the Load Test, noting the Load Test mA reading. If the mA reading is "--- mA" or below 5 mA you have confirmed that the horizontal output transistor is shorted.

Caution: *The Load Test energizes the horizontal output circuit. Remove the orange test clip or return to the SETUP OPTION – HOR. display when unsoldering or testing components.*

If opening the horizontal output transistor does not remove the short, continue to open possible short paths. The opened component or current path that reduces the mA reading to near zero identifies the short.

Note: *The Horiz Output Load Test can be performed with the horizontal output transistor and/or damper in or out of circuit. These components, if good, will not change the mA, % or µS readouts.*

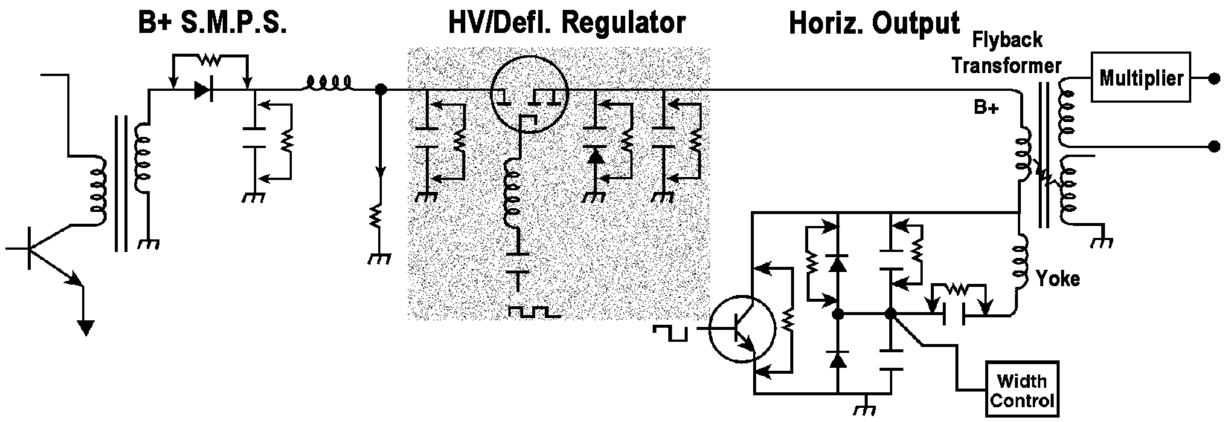


Fig. 21: Possible DC short or leakage paths, which can load down the TV's B+ power supply.

Loading problems, which are not low resistance DC shorts, produce high mA readouts and low efficiency readouts. The first step in isolating the loading problem is to determine if added load current is caused by DC loading or by AC loading.

The Horiz. Output Load Test can be used to isolate DC loading from AC loading by disconnecting the “Collector or Drain” yellow test clip from the horizontal output stage being tested. Removing the yellow clip stops the switching action removing any alternating sawtooth currents in the output stage and all power transferred to the flyback secondary circuits and shorted turns which may exist in the flyback or yoke. With the yellow lead opened, the Load Test Setup VPP reads near 0 and the % EFF and µS readouts show dashed lines.

With the yellow clip open, select a proper setup option or manually set the Load Test B+ to approximately 1/10 of the chassis normal B+. The Load Test mA readout indicates the current to circuits powered by the Load Test VDC power supply. This includes the horizontal output stage and perhaps the horizontal driver stage and others. These stages typically draw less than 5 mA of DC current from the Load Test B+ supply with the yellow clip open. If the current is much higher than this, suspect a DC short or leakage path on the B+ power supply.

Note: *Some horizontal output stages use a small DC current for horizontal yoke centering which may be seen during this DC current test.*

If the current readout is much higher than the typical range for the horizontal output stage being tested, but is normal when the yellow clip is removed, the high current is a result of a severe AC current load in the horizontal output stage. The current demand may be caused by shorted turns in the inductors of the output stage or yoke or caused by a short or leakage on any of the secondary circuits of the flyback. It is also possible for the horizontal output transistor or damper diode to be breaking down during the test.

The HA325 contains a diagnostic routine that automatically opens the yellow clip lead internally, opening the Load Test switched output during high current (high mA) loading conditions. When the mA current exceeds 100 mA the HA325 momentarily opens drive and tests for existing DC current. If the current exists with the drive opened, the current is DC current and "DC LOAD" or "DC SHORT" is shown in the display.

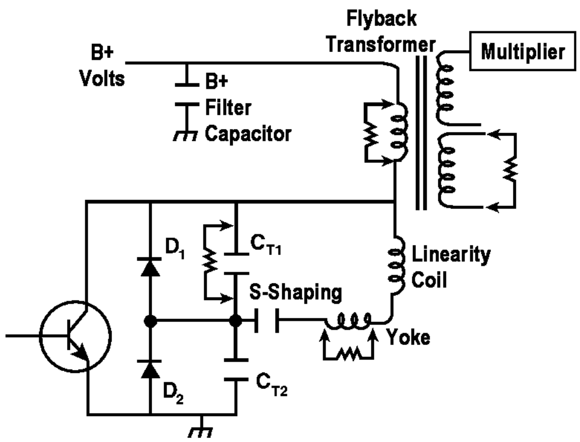


Fig. 22: Possible AC shorts or leakage paths in a horizontal output stage.

An effective method of isolating AC loading symptoms is to use the HA325 FLYBACK & IHVT Load Test in-circuit. See the Flyback & IHVT Load Test Application section of this manual.

Troubleshooting Unusual µS Readouts

If the Load Test µS readout is outside the typical range, or fluctuating by several µS, a timing problem in the horizontal output stage is indicated. If the Load Test also shows high mA and low % EFF readouts, ignore the unusual µS readout and isolate the excessive loading problem first. Most loading problems cause the µS readout to decrease or fluctuate. There are commonly three types of problems in the horizontal output flyback circuits, which will be evident on the µS readout.

1. **A"---- µS" readout:** Dashed lines in the µS readout indicate that the flyback pulses normally produced during the Horiz. Output Load Test are not present. Confirm that the Load Test lead connections and Load Test Setup parameters are proper. It is likely that the Load Test Setup VPP also reads "---VPP". An improper lead connection or an open circuit path from B+ through the flyback primary to ground is likely. You can use an ohmmeter to isolate the open.

2. **Stable µS readout above or below the typical range:** A steady µS readout outside the normal range indicates a value change in one of the critical timing components in the horizontal output stage. If the µS readout is above the typical range, an open yoke current path and its series components are likely suspects. If the µS readout is below the typical range and the mA reading is normal, check the display's frequency and resolution capabilities. Check the retrace timing capacitors for reduced value.

   A reduced µS readout is common in horizontal output stages with a shorted flyback turn or shorts on the flyback secondary circuits. These faults effectively decrease the transformer or inductance value, causing the µS readout to fall to the bottom of or below the typical normal range. Shorted flyback turns and secondary loading problems cause higher than normal Load Test mA readings and low % EFF readings.

3. **µS readouts fluctuating by several µS:** Readings that are changing values by several µS indicate that the waveshape of the flyback pulse is abnormal. The waveshape may have multiple flyback

pulses per cycle or abnormal pulse shape or ringing. Severe output stage problems or loading problems in the flyback secondaries are likely causes. High mA and low % EFF Load Test results commonly accompany fluctuating readings.

When troubleshooting timing problems and unusual µS readouts, it is sometimes helpful to use an oscilloscope to view the pulse at the collector or drain of the horizontal output transistor. Test horizontal output stage components, yoke and its series components, flyback and flyback secondary circuits to isolate the problem and correct the timing.

Understanding IHVT Failures

Integrated high voltage transformers are a complex component or module. They contain a transformer with multiple secondary windings, a high voltage multiplier section and a focus/screen resistive voltage divider. If any of these sections fail, the IHVT must be replaced.

The complexity of the IHVT results in multiple failure modes and various display symptoms. Any of these failures requires that the IHVT be replaced. The possible IHVT failure modes are listed below.

1. Shorted adjacent turn(s) in a primary or a secondary winding.
2. Short or leakage between a primary and an isolated secondary winding.
3. Short or leakage between a secondary and another isolated secondary winding.
4. Open turn in a primary or secondary winding.
5. Defect in the high voltage multiplier section.
6. Open or increased resistance in the focus/screen voltage divider.

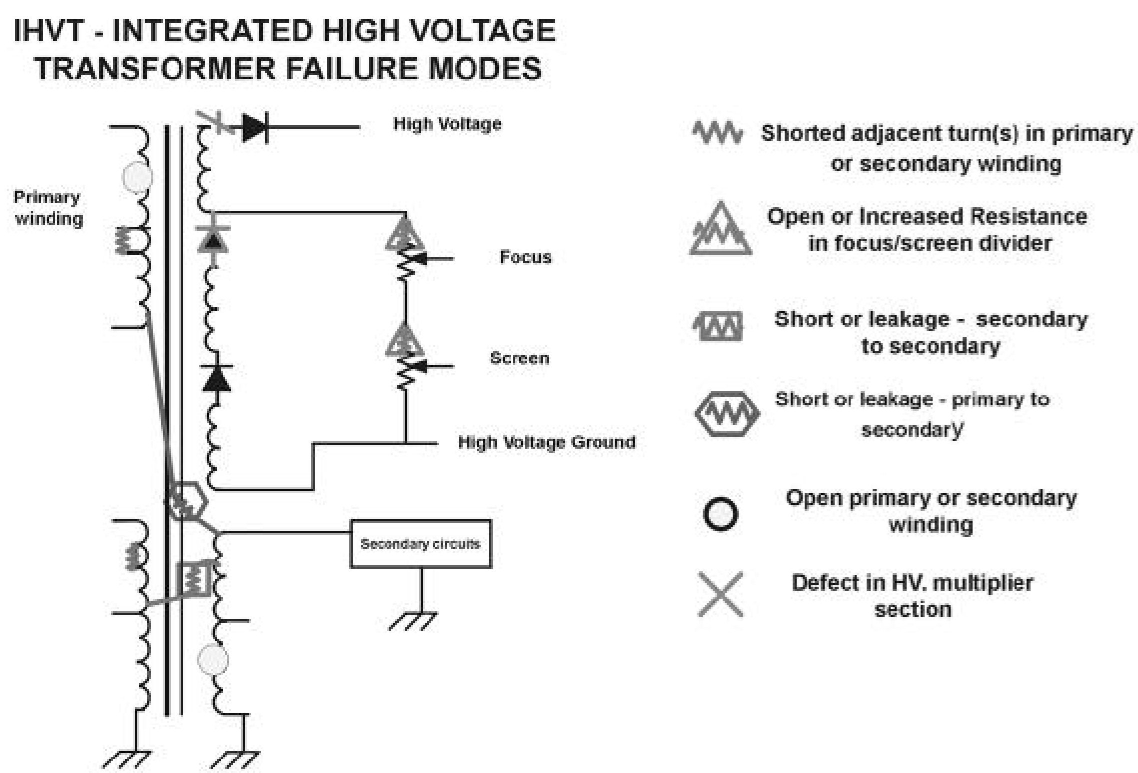


Fig. 23: An IHVT can fail in 6 different ways.

Analyzing a Flyback or IHVT for a Shorted Turn(s)

A common failure of a flyback transformer is shorts between adjacent wire turns or windings of the transformer. Flyback or IHVT primary and secondary windings are wound around a core. The wire windings consist of several layers of wire separated electrically by the lamination or insulation coating of the wire. If the lamination insulation breaks down a leakage or short path develops between the adjacent wire turns. High voltage, high currents, humidity, heating/cooling and manufacturing shortcomings can all lead to shorted turns.

A short between adjacent turns of a coil dramatically alters the quality of the transformer. The transformer becomes very inefficient and cannot perform its circuit function. A shorted turn in the IHVT or flyback transformer results in a current demand from the chassis B+ power supply of 2 to 4 times the normal level. The horizontal output stage becomes very inefficient as it attempts to satisfy the normal circuit loads plus the additional load caused by the shorted turn. Often the B+ power supply is damaged by the added load current.

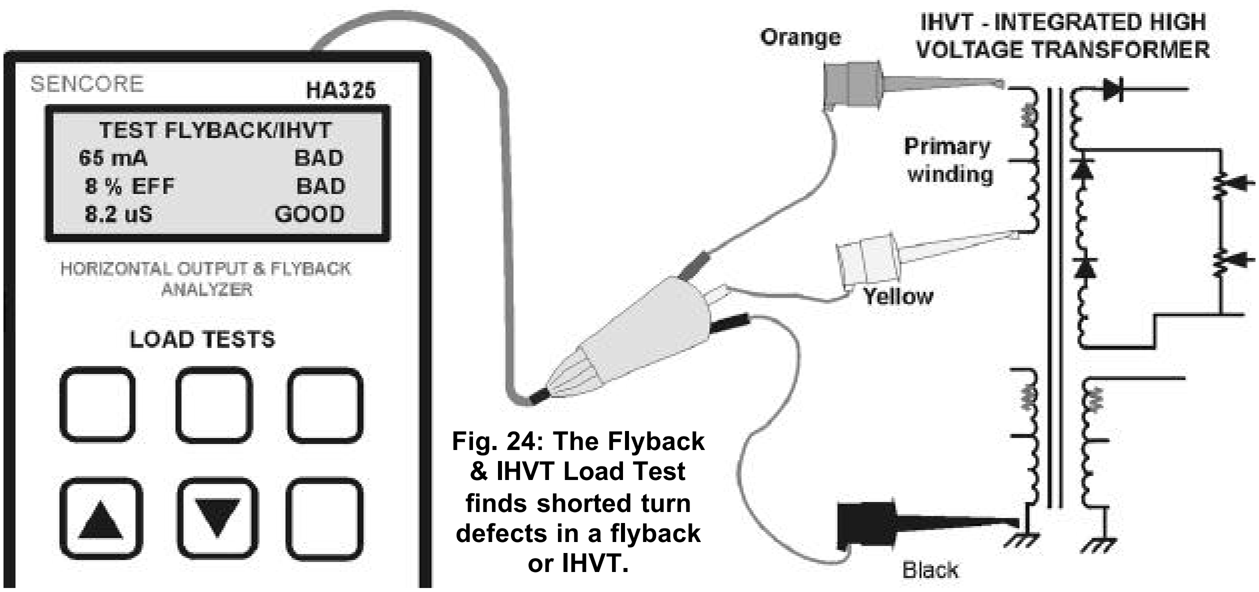


Fig. 24: The Flyback & IHVT Load Test finds shorted turn defects in a flyback or IHVT.

Shorted adjacent turns in the flyback or IHVT are not evident with ohmmeter checks of the winding resistance. Inductance value measurements of the primary or secondary windings are also of little use because the shorted turn has little effect on the inductance value.

The Flyback & IHVT Load Test detects shorted turns in flybacks or IHVTs. The Flyback & IHVT Load Test places the flyback or IHVT in a simulated horizontal output stage at 1/10 of the normal power level. The Load Test mA readout indicates the B+ or load current draw of the flyback or IHVT from the B+ power supply. The Load Test % EFF readout gauges the efficiency of the flyback or IHVT.

To test a flyback or IHVT for shorted turns with the Flyback & IHVT Load Test, properly connect the Load & Ringer Test Lead clips to the flyback or IHVT. Select an appropriate setup option and establish a Vpp setup of 1/10 of the chassis normal, typically near 100 VPP. Select TEST and note the Load Test mA and % EFF readings.

Good flybacks or IHVTs typically draw 3-20 mA of current and have efficiencies over 55%. If the flyback or IHVT has Load Test measurements in this range, it does not have a shorted turn. If the chassis exhibits horizontal output problems, check the flyback or IHVT for other failures as explained in this section of the manual.

A shorted turn(s) typically causes the current to increase to over 30 mA and the % EFF to fall below 50%. Because of the severe nature of a shorted turn defect, it is not uncommon for the current to increase above 50 mA and the % EFF to be below 10%.

To test a flyback or IHVT for shorted turns:

1. Properly connect the Load & Ringer Test Lead clips to the flyback or IHVT.
2. Apply POWER to the HA325; press the FLYBACK & IHVT pushbutton.
3. Select an appropriate setup option using the up and down arrow pushbuttons.
4. Press the ENTER pushbutton. Press TEST/SETUP to confirm setup near 100 VPP.
5. Press TEST/SETUP to read the "mA" and "% EFF" readouts in the digital display.

Analyzing a Flyback or IHVT for Primary to Secondary Shorts

A flyback transformer or IHVT may develop a short between turns of the flyback winding to a turn of a secondary winding. This defect causes an increase in DC current from the B+ power supply to flow through a secondary winding to ground.

The Flyback & IHVT Load Test detects shorts from the primary winding to isolated secondary windings. These defects are shown by an increase in the mA reading and a decrease in the % EFF reading. Shorts from primary to secondary are indicated by a Load Test mA reading near 200 mA, accompanied by a "DC SHORT" readout. DC leakage between the primary and secondary windings ranging from 50-150 mA with the Flyback & IHVT Load Test will be accompanied by a "DC LOAD" readout.

To test the flyback or IHVT for a primary to a secondary winding short or leakage, properly connect the Load & Ringer Test lead clips to the flyback or IHVT. Select an appropriate setup option and establish a Vpp setup of 1/10 of the chassis normal, typically near 100 VPP. Select TEST and note the Load Test mA and % EFF readings.

Good flybacks or IHVTs typically draw 3-20 mA of current and have efficiencies over 55%. If the flyback or IHVT has Load Test measurements in this range, it does not have a short between primary and a secondary.

A typical flyback or IHVT has multiple secondary windings that are electrically isolated from each other. To check for leakage from the primary to each of the isolated secondary windings, remove the black clip lead and move it to one of the pins of each isolated secondary winding. Check the Load Test mA and % EFF readings as the black lead is connected to each isolated secondary. The mA and % EFF readings should remain in the good range. An increase in the mA reading or a mA reading that is accompanied by a "DC LOAD" or a "DC SHORT" readout indicates a short or leakage from the primary to secondary.

Note: *The primary winding of the flyback or IHVT may have a tap. Connecting the black clip to this tap would result in a high mA and "DC SHORT" readout. This is normal.*

To test a flyback or IHVT for primary to secondary shorts:

1. Properly connect the Load & Ringer Test Lead clips to the flyback or IHVT.
2. Apply POWER to the HA325; press the FLYBACK & IHVT pushbutton.
3. Select an appropriate setup option using the up and down arrow pushbuttons.
4. Press ENTER pushbutton.
5. Read the "mA" and "% EFF" readouts.
6. Move the black clip to a pin on each of the isolated flyback secondaries while checking the Load Test mA and % EFF readouts.

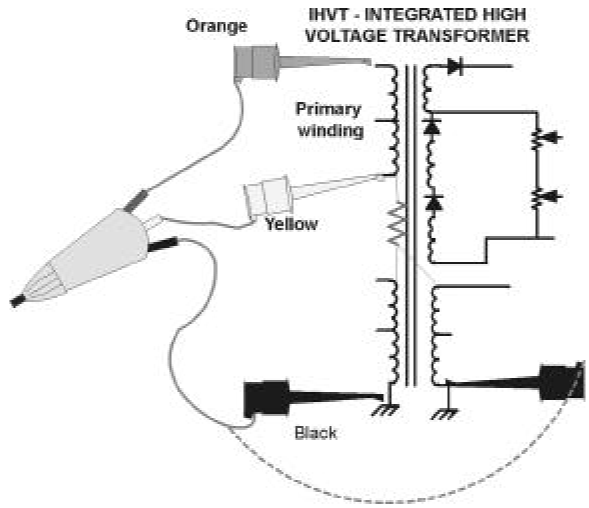


Fig. 25: Move the black clip to each isolated secondary to test for high mA primary to secondary leakage or shorts.

Analyzing the IHVT's HV Multiplier Section

The HA325 Flyback & IHVT Load Test, combined with a high impedance DCV meter, provides additional analyzing capabilities or extended testing of an IHVT. An IHVT contains a HV multiplier section, consisting of multiple secondary windings cascaded with HV diodes and capacitor filtering. The windings multiply and output the HV DC potential needed by the CRT anode. The HV potential exists at the HV anode lead with respect to the flyback HV ground return. This HV return or HV ground pin may also be called the aquadag ground.

An open in any of the HV section windings or an open HV diode causes little or no HV output. Minor defects in this section may reduce the output HV to a fraction of normal. With these defects, the horizontal output stage works normally and the Horiz. Output Load Test shows normal operation, but the HV output is low or missing.

The Flyback & IHVT Load Test and a high impedance DCV meter can be used to analyze the output HV. Since the Flyback & IHVT Load Test operates the IHVT at approximately 1/10 of the normal power level, the output HV produced during the test is approximately 1/10 of normal.

Proper voltage measurement of HV requires the use of a high impedance DC voltmeter. The typical input impedance DCV meter (10-15 megohms) loads the HV output, reducing the metered voltage. Proper measurement of HV can be achieved by increasing the input impedance of the DC meter to 100 megohms or more.

The Sencore TP212 is a X10 multiplier probe that increases the DC input impedance of a 15 megohm DC meter to 150 megohms. The multiplier probe divides the voltage by 10, causing the DC meter to read 1/10 of the voltage present at the probe tip. Use the Sencore TP212 with the DC meters on Sencore analyzers such as the Sencore VA62, TVA92, HA2500, SC3100 etc.

The Sencore DVM models DVM500 and DVM501 have a 10 megohm input impedance. Using a Sencore TP212 will reduce the normal 1/10 output DC voltage to the meter by approximately 30%. These lower voltages will complicate test interpretation. A X10 multiplier probe for a 10 megohm impedance meter is available from Probe Master to extend the input impedance to 100 megohms. (See www.probemaster.com)

To test the HV multiplier section of an IHVT, connect and set up the HA325 to perform the Flyback & IHVT Load Test. Establish a setup to produce a VPP that is approximately 1/10 of the chassis normal VPP. Use 100 VPP if you are uncertain of the chassis normal flyback pulse amplitude (VPP). The Load Test mA, % EFF and µS readings should be in the Good or ? range. If the Load Test measurements indicate a shorted turn, open primary, or short from primary to secondary, the IHVT is defective and no IHVT multiplier testing is necessary.

With proper setup and Load Test measurements confirmed, connect the DC meter ground to the HV ground return pin of the IHVT. Connect the X10 multiplier probe to the DC meter probe. Set the DVM to the DCV function and probe the HV anode lead of the IHVT.

The voltage measured on the DC meter is the HV output of the IHVT. This voltage is reduced by a factor of 100 compared to the actual output voltage of the IHVT in the chassis; 1/10 by the Load Test and 1/10 by the multiplier probe of the DC meter. Multiply the DC measured on the DVM by 100 for direct comparison to the HV required by the CRT or reference in the schematic. For example, an IHVT that produces 26 kV in a chassis may measure in the range of 240-280 VDC, depending on the accuracy of the 1/10 level and Load Test frequency used. If the VDC measured is near the 1/100 level, the HV multiplier section is functioning normally.

If the high impedance DC meter reads a lower than normal 1/100 high voltage level, a defective multiplier section is likely. Check connections of the Flyback & IHVT Load Test to the primary winding of the IHVT. Switching the orange clip and yellow clip alters the current polarity of the primary, greatly reducing the HV output, with little effect on the HA325 Load Test results.

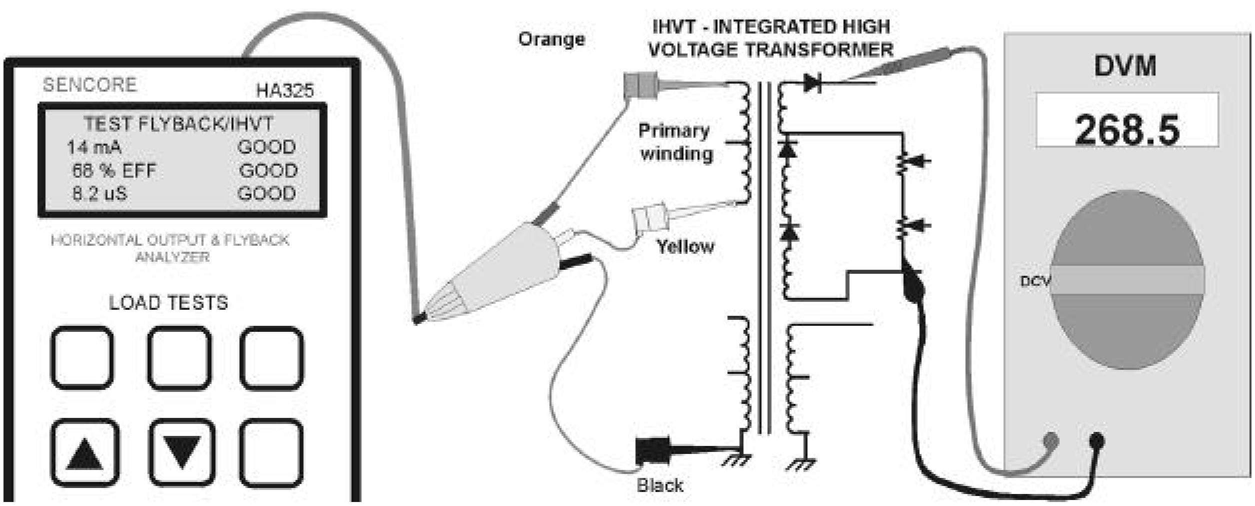


Fig. 26: The Flyback & IHVT Load Test and high impedance DCV meter can detect failures in the IHVT's HV multiplier.

To Test the HV Multiplier Section of an IHVT:

1. Properly Connect the Load & Ringer Test Lead clips to the IHVT.
2. Apply Power to HA325. Select Flyback & IHVT Load Test.
3. Select an appropriate setup option. Press ENTER.
4. Perform TEST FLYBACK/IHVT and note mA, % EFF, µS readings.
5. Press SETUP and manually adjust for 1/10 chassis VPP (Typically 100 VPP)
6. Connect DC meter ground to the HV ground return of the IHVT.
7. Connect X10 multiplier probe to DC meter. Probe HV anode lead output of IHVT.
8. Read DC volts. Multiply DC volts by 100 and compare to the expected chassis HV.

A missing or low DC voltage (IHVT HV output) indicates a defective IHVT multiplier section.

Analyzing the IHVT's Focus & Screen Divider Section

Most IHVTs contain a section that taps high voltage from the high voltage windings. The high voltage is applied to a high resistance voltage divider network to limit the current flow. The network is connected to the HV ground return pin of the IHVT, often called the CRT or aquadag ground return. The voltage divider resistor are commonly tapped to supply variable output voltages at levels required by the CRT for focus and G2 (screen) grid operation.

The high value resistors used in the divider commonly open, increase in resistance, or become intermittent, causing a decrease in the focus or screen output voltages. When this occurs, the CRT goes dark and/or the focus control cannot be turned far enough to achieve good focus. There may also be some interaction between controls and output voltages. Since a weak electron gun can also cause these symptoms, you should confirm proper electron gun low and high level emission currents with a CRT tester, such as the Sencore CR7000.

The Flyback & IHVT Load Test and a high impedance DCV meter can be used to analyze the output voltages of the focus and screen resistive divider. Since the Flyback & IHVT Load Test operates the IHVT at approximately 1/10 of the normal power level, the output HV produced during the test is approximately 1/10 of normal.

Proper voltage measurement of focus and screen voltages requires the use of a high impedance DC voltmeter. The typical input impedance DCV meter (10-15 megohm) loads the HV output, reducing the metered voltage. Accurate measurement of focus and screen voltages requires increasing the input impedance of the DC meter to 100 megohms or more. Use a X10 multiplier probe such as the Sencore TP212 for DC meters with a 15 megohm input impedance.

To test the focus/screen divider section of an IHVT, connect and set up the HA325 to perform the Flyback & IHVT Load Test. Establish a setup to produce a VPP that is approximately 1/10 of the chassis normal VPP. Use 100 VPP if you are uncertain of the chassis normal flyback pulse amplitude (VPP). The Load Test mA, % EFF and µS readings should be in the Good or ? range. If the Load Test measurements indicate a shorted turn, open primary, or short from primary to secondary, the IHVT is defective and no IHVT multiplier testing is necessary.

With proper setup and Load Test measurements confirmed, connect the DC meter ground to the HV ground return pin of the IHVT. Connect the HV multiplier probe to the DC meter probe. Set the DVM to the DCV function and probe the focus and screen voltage outputs of the IHVT. These are typically red and white wires that lead to the CRT circuit board. Other HV dividers with taps are sometimes used for feedback to HV regulators, HV shutdown circuits etc. You may also test the DC voltage on these pins. You may vary the focus control(s) or G2 (screen) control and observe the change in voltage range provided by the adjustment.

The voltage measured on the DC meter is the focus, G2, or tapped high voltage output of the IHVT. These voltages should be approximately 1/100 of the actual output voltages of the IHVT in the chassis under normal operation. The DC voltage on the meter is reduced 1/10 by the Load Test and 1/10 by the multiplier probe. Multiply the DC measured on the DVM by 100 for direct comparison to the focus, screen, or tapped voltages required by the CRT or referenced in the schematic. For example, an IHVT that produces a range of 6-8 kV for focus in the chassis may measure in the range of 55-85 VDC, depending on the accuracy of the 1/10 level and Load Test frequency used. If the VDC measured provides the proper range or 1/100 level, the focus and screen divider section is functioning normally.

If the high impedance DC meter reads a lower than normal 1/100 voltage level as the control is varied, exhibits a jumpy output voltage as the control is varied, or has interaction between controls, a defective focus/screen divider is likely. Check connections of the Flyback & IHVT Load Test clips to the primary winding of the IHVT. Switching the orange clip and yellow clip alters the current polarity of the primary, greatly reducing the focus and screen output voltage with little effect on the HA325 Load Test results.

To test the IHVT's focus & screen divider output voltages:

1. Properly Connect Load & Ringer Test Lead clips to the IHVT.
2. Apply Power to HA325. Select Flyback & IHVT Load Test.
3. Select an appropriate setup option. Press ENTER.
4. Perform TEST FLYBACK/IHVT and note mA, % EFF, µS readings.
5. Press SETUP and manually adjust for chassis 1/10 VPP (Typically 100 VPP)
6. Connect DC meter ground to the IHVT HV ground return.
7. Connect a X10 Multiplier probe to the DC meter. Probe the focus and G2 (Screen) outputs of IHVT.
8. Read meter DC volts. Multiply DC volts by 100 and compare to the expected chassis HV.
9. Vary the focus and G2 controls and test for normal voltage ranges.

The G2 or Screen voltage is sensitive to the impedance level of the DC meter. Its actual output DC voltage in a chassis is largely determined by G2 current drawn from the IHVT by the CRT. Testing with a high impedance DC meter commonly produces higher than expected output DC voltages. Higher than expected voltages that can be varied through a voltage range indicate a normal screen output voltage and good screen voltage divider.

Testing An IHVT for HV Multiplier to Secondary Shorts

An IHVT may fail because a secondary winding develops leakage or a short to another secondary winding. Secondary windings are typically insulated from each other by the lamination of the wire that makes up each winding. However, these wires are wound on top of each other around the flyback core. A breakdown of the lamination causes leakage current or a short to develop between formerly isolated windings. Shorts from a winding in the HV multiplier section to another secondary winding are common due to high voltage potentials.

Shorts between an HV winding and an isolated secondary winding of the IHVT place high voltage potentials on the isolated secondary winding(s) with respect to the high voltage ground. These high voltage potentials commonly cause arcing on the circuit board or burn out components on these secondaries, as they are not designed to withstand these higher voltage potentials. The Flyback & IHVT Load Test combined with a high impedance DC voltmeter can be used to test for shorts between the high voltage section and other isolated secondary windings.

To detect HV winding to secondary shorts/leakage connect the Flyback & IHVT Load Test to the IHVT. Set up the Load Test for 1/10 of the normal flyback pulse amplitude, typically around 100 VPP. Use a DC voltmeter with a high impedance multiplier probe to increase the input impedance of the DC meter to 10 megohm or greater. The multiplier probe reduces the voltage that is measured by the DC meter by 10.

Note: *The Sencore TP212 increases Sencore 15 megohm input impedance meters to 150 megohms. Multiply DC voltages measured by 10.*

With the Flyback & IHVT Load Test set for 100 VPP, you can identify shorts or leakage to these normally isolated secondaries by measuring for high voltage potentials on these windings. Connect the ground of the high impedance DC meter to the HV aquadag ground. Measure the focus and/or screen voltage to be sure you have connected and set up the HA325 properly and the DC meter is properly measuring high voltage potentials.

Probe the secondary windings with the multiplier probe and note readings on the DC meter. DC voltage readings should be low or near zero. It is common for a high input impedance DC meter to read some random but lower voltage readings. Random but low voltage readings indicate no shorts or leakage from the HV section to the primary winding. Probe other isolated secondaries to confirm that no high voltage potential exists with respect to HV ground.

DC voltage measurements that are near or equal to DC voltages measured at the HV anode, focus, and G2 (screen) outputs of the IHVT indicate high voltage potentials leaking to the isolated secondary.

To Test an IHVT for HV multiplier to secondary shorts/leakage:

1. Properly connect Load & Ringer Test Lead clips to the IHVT.
2. Apply Power to HA325. Select Flyback & IHVT Load Test.
3. Select an appropriate setup option. Press ENTER.
4. Perform FLYBACK/IHVT TEST and note mA, % EFF, µS readings.
5. Press SETUP and manually adjust for chassis 1/10 VPP (Typically 100 VPP)
6. Connect the DC meter ground to the IHVT HV ground return.
7. Connect a X10 multiplier probe to the DC meter. Probe the focus and G2 (Screen) outputs of the IHVT.
8. Probe isolated secondary pins of the IHVT and note DCV readings.

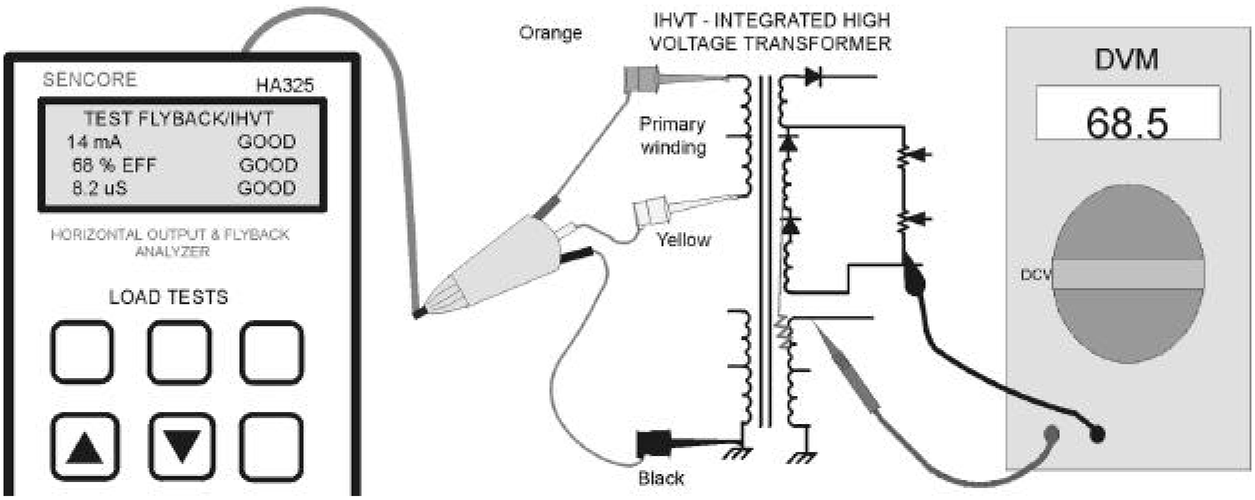


Fig. 27: The Flyback & IHVT Load Test and high impedance DC meter can detect leakage or shorts from the HV multiplier to the secondary.

Troubleshooting Horiz. Output Stage AC Loading Defects

The Horiz. Output Load Test analyzes the horizontal output stage for loading or timing defects. A loading defect typically results in high mA readings and low % EFF readings. Readings may be accompanied by "AC LOAD" or "AC SHORT" display indicators when the current exceeds 100 mA and 150 mA respectively.

When a defect is indicated by the Horiz. Output Load Test, a problem could exist in the horizontal output stage components, flyback, or flyback secondary circuitry. Isolating the defective circuit area reduces troubleshooting time, especially for AC loading defects that are not evident with ohmmeter tests.

The FLYBACK & IHVT Load Test can isolate AC loading defects to the horizontal output stage or primary components or to the flyback & its secondary load circuitry. The primary circuitry includes the yoke and its current path, timing components, and any width/pincushion components. The flyback and secondaries includes the IHVT/flyback, secondary circuits, CRT, HV blocks, etc.

The Flyback & IHVT Load Test effectively substitutes the horizontal output stage circuitry or primary components of the flyback. During the Flyback & IHVT Load Test, a timing capacitor tunes the primary of the flyback or IHVT. The setup process establishes an operating horizontal output stage with the flyback or IHVT primary, resulting in flyback pulses approximately 1/10 of normal or typically near 100 VPP.

This unique ability makes it possible to easily isolate AC loading defects to the primary circuitry/components or to the IHVT and secondaries. Once the AC loading problem is isolated further tests can pinpoint the loading defect.

Isolating AC loading defects with the FLYBACK & IHVT Load Test requires opening the circuit path connecting the flyback primary winding to the horizontal output circuitry/components. Typically you can unsolder the primary pin of the flyback isolating it from the circuit board and traces leading to the collector of the horizontal output transistor, timing capacitors, yoke etc. Occasionally a tap on the primary may contain yoke or timing circuitry/components. Be sure to open other primary winding pins that may contain timing capacitors or primary components.

With the horizontal output stage circuitry isolated from the flyback primary, connect the FLYBACK & IHVT Load Test clips. The black clip lead connects to ground, orange clip lead to the B+ input of the flyback primary, and yellow clip to the primary pin which is unsoldered/isolated from the circuit board. Perform the Flyback & IHVT Load Test and note the mA, % EFF and µS readings with a typical 100 VPP setup. To confirm that the primary circuitry is opened, move the yellow clip to the collector of the horizontal output transistor and compare measurement readings. The same load test readings indicate the flyback pin is not completely unsoldered or isolated.

With the primary circuitry isolated from the test, the Flyback & IHVT Load Test measurements indicate the condition of the flyback and secondary circuitry. A normal range of mA, % EFF and µS indicates a good flyback and secondaries, concluding a primary component defect. High mA and low % EFF readings indicate an AC Loading defect associated with the IHVT or a secondary load.

You can further isolate high mA and low % EFF readings caused by the IHVT or secondary loads. Open secondary circuit paths and repeat the Flyback & IHVT load test, noting changes to the readings. For example, open connections to a HV block in projection systems, HV anode leads, remove CRT board from CRT, open scan diodes etc. A defective load and associated circuitry is indicated when the Load Test readings dramatically drop to normal levels. Abnormal Load Test readings with most or all secondary loads open indicate a likely IHVT defect. Remove the IHVT completely from the chassis and confirm with the Flyback & IHVT Load Test.

With the horizontal output primary circuitry isolated, good Flyback & IHVT Load Test readouts indicate a defect associated with the primary circuitry/components. Connect the primary circuitry to the flyback/IHVT primary and repeat the Horiz. Output Load Test as you open the horizontal output transistor, damper diode, and yoke plug. Remember to disconnect the orange clip lead as you open components. A component that greatly reduces the mA reading is the likely cause of the loading. If the mA drops dramatically with the yoke plug opened, use the Ringer test to check the horizontal yoke winding for a shorted turn. Use a capacitor analyzer, such as the Sencore LC103 to analyze the yoke S-shaping capacitor(s).

To isolate AC loading defects – Flyback & IHVT Load Test:

1. Unsolder the IHVT primary pin, opening the circuit path to horizontal output components.
2. Connect Load & Ringer Test clips.
3. Apply Power to HA325. Select Flyback & IHVT Load Test.
4. Select the appropriate setup option. Set up for approx. 100 VPP.
5. Perform TEST FLYBACK/IHVT and note mA, % EFF, µS readings.

Note: *Confirm open primary circuitry by moving the yellow clip to the collector of the horizontal output transistor and noting different readings. Same readings indicate the primary circuitry is not opened.*

High mA and low % EFF indicate Flyback/IHVT or secondary load defect. Good mA and % EFF indicate a primary component defect.

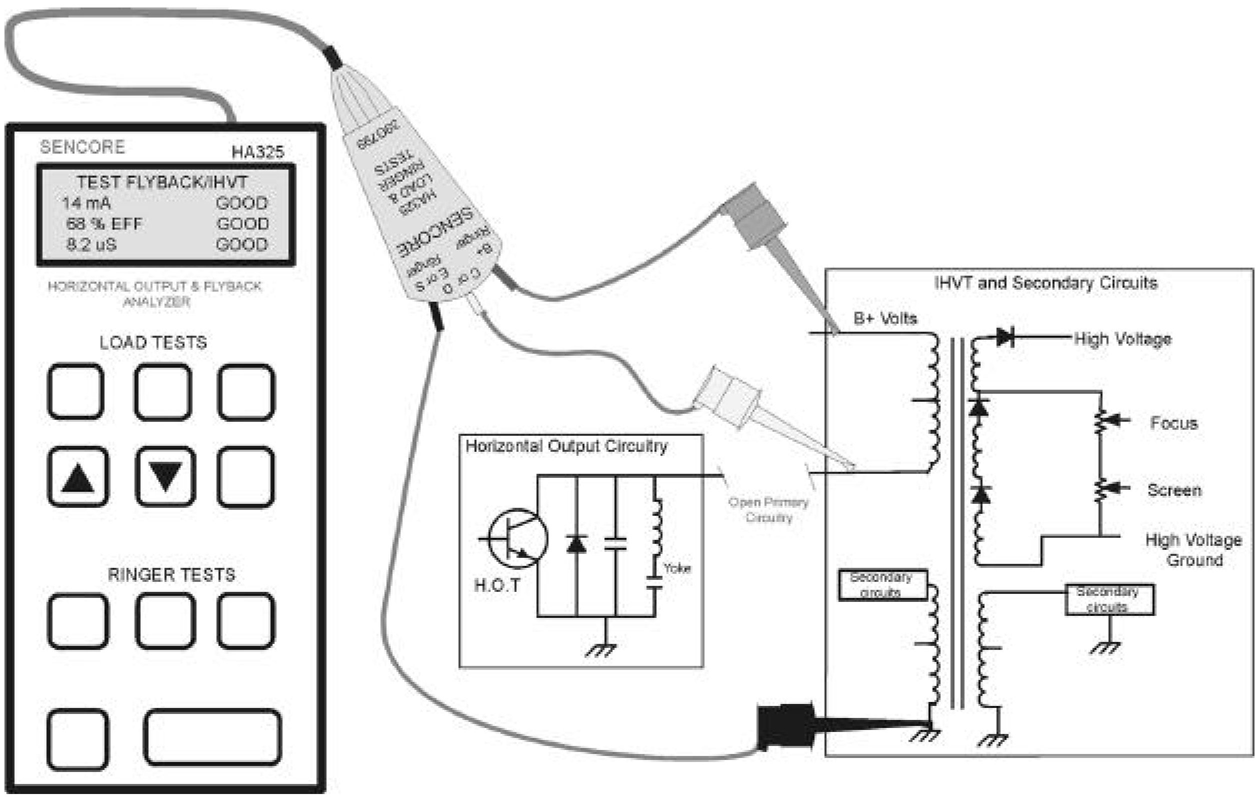


Fig. 28: With the primary circuitry isolated from the test, the Flyback & IHVT Load Test measurements indicate the Condition of the flyback and secondary circuitry.

MAINTENANCE

Introduction

The HA325 is designed for long term reliability. However, with a high percentage of portable use anticipated, along with the rigors of transport and multiple battery charge/discharge cycles, several key components of the HA325 are designed for easy replacement. This section covers how to replace the battery pack, Load Test switching transistor and Load/Ringer test lead.
It further covers how to update the unit's operating software, should a factory update become available.

Replacing components requires opening the HA325 case enclosure to reveal the internal circuit boards and components. Remove the HA325 from the padded cover if it is being used. The case is held together by four case screws which are located on the back of the instrument, near each of the four corners. A small Philips screwdriver is required for removal. Place the instrument on a bench or table covered with a soft cloth or padded surface. Remove the screws, placing them to the side. Be sure to note which screws are on the top and which are on the bottom, as they are different lengths. Be sure to use the longer screws near the top end of the HA325 during re-assembly. ***SEE CAUTION BELOW***

-------------------------------------CAUTION---
There are two lengths of screws. The two longer screws are used near the top of the instrument and the two shorter screws at the bottom. Using the longer screws at the bottom can result in damage to the case, as the longer screw length is excessive for the bottom locations.

Place the instrument on its back and gently lift the front side of the instrument up, separating it from the back. Hinge the front portion of the instrument open and gently place the front side flat on the padded surface, beside the case back. This reveals the inside circuitry and components of the HA325.

To open the HA325 case enclosure:
1. Place on front on padded bench surface.
2. Remove the four rear screws.
3. Place on back on padded bench surface
4. Gently lift front side, separating it from the back.
5. Hinge front side open, placing it face down on the padded bench surface.

Replacing the Internal Battery Pack

When the battery no longer holds a charge or provides adequate use time, it can be easily replaced. A replacement battery of the same type and voltage is available from the Sencore Service Parts department (Sencore #17A49). Replace only with a battery supplied by Sencore.

To replace the battery pack, follow the instructions to open the HA325 case enclosure. The battery is located near the bottom of the instrument. The battery is connected to the circuit board with a removable connector. The battery is held in place by the case covers, circuit boards and metal edging.

When replacing the battery, be sure the unit is powered off. Unplug the battery connector from the circuit board and gently lift the battery from its compartment. Install the new battery by reversing the process.

To replace the battery pack:

1. Be sure unit is powered OFF
2. Unplug battery connector from the circuit board.
3. Remove battery pack from its compartment.
4. Install new battery pack.
5. Assemble case enclosure.

Replacing the Internal Load Test Switching Transistor

The main output transistor used by the HA325 Load Test is installed into a socket so that the transistor can be easily removed and replaced. While this transistor is fuse protected, leaving the Load Test leads connected to a live display chassis or encountering a large flyback pulse amplitude or B+ charge may cause it to short. A replacement transistor is available from the Sencore Service Department.

Note: *The most likely failure of the Load Test output transistor is a short. You can test for a shorted Load Test transistor by connecting a 1000 ohm resistor between the yellow and orange test clips of the HA325. The black clip is not used for this simple check. Select the Horiz. Output Load Test and select the "TV 16 kHz" setup function. Normally in this configuration, the Load Test readout indicates 6 – 7 mA and approximately 30-32 µS. If you obtain these readings, the Load Test is functioning normally and the transistor is good. A reading of 12-14 mA indicates a shorted Load Test output transistor.*

The Load Test switching output transistor is Q9. It is located just behind the Load Test fuse on the back panel circuit board. The transistor may be removed by carefully removing the screw holding the transistor to its heat sink. Remove the transistor from the circuit board socket. Obtain a replacement transistor for installation and reverse the process to install the new transistor.

The Load Test output transistor is an N-channel MOSFET transistor, number MTP6N60 (Sencore #19G230). You can obtain a replacement from the Sencore Service Parts Department. Do not use a general replacement, as it will alter the measurement accuracy of the Load Test mA and % EFF measurements.

To Replace the Load Test Switching Transistor:

1. Follow the procedure to open the case enclosure.
2. Locate Q9, a 6N60 socketed transistor.
3. Remove the screw holding the transistor to its heat sink.
4. Remove the transistor from the socket.
5. Replace the transistor with an identical replacement.
6. Reassemble the case enclosure.

Replacing the Load & Ringer Test Lead

The Load & Ringer Test Lead is designed for easy repair. The clips and other parts may be purchased from the Service Department. The test lead cable is a durable cable that has been cycle tested at the factory and should provide many years of service. However, should it become damaged or frayed, the complete test lead can be removed and replaced without returning the HA325 to the factory. The complete Load & Ringer Test Lead Assembly (Part #39G799) may be ordered from the Sencore service parts department.

The test lead is connected to the main circuit board with two removable connectors. These connectors are small enough to enable removal through the lead entry hole in the case enclosure.

To replace the complete lead cable assembly, open the case enclosure and remove the connectors attaching the test lead to the circuit board. Use proper-sized needle nose pliers to compress and push the cable-retaining clip outward, releasing the test lead assembly from the case enclosure. Pass the connectors outward through the case enclosure hole to separate the lead assembly from the HA325.

Reverse the process to install the new test lead.

To replace the HA325 test lead:

1. Follow the procedure to open the case enclosure.
2. Unplug the two connectors attaching the test lead to the circuit board.
3. Use a proper-sized needle-nosed pliers to remove the cable at the case enclosure hole.(Pinch the retaining part of the holder while gently pushing outward)
4. Reverse the process to install the new cable.

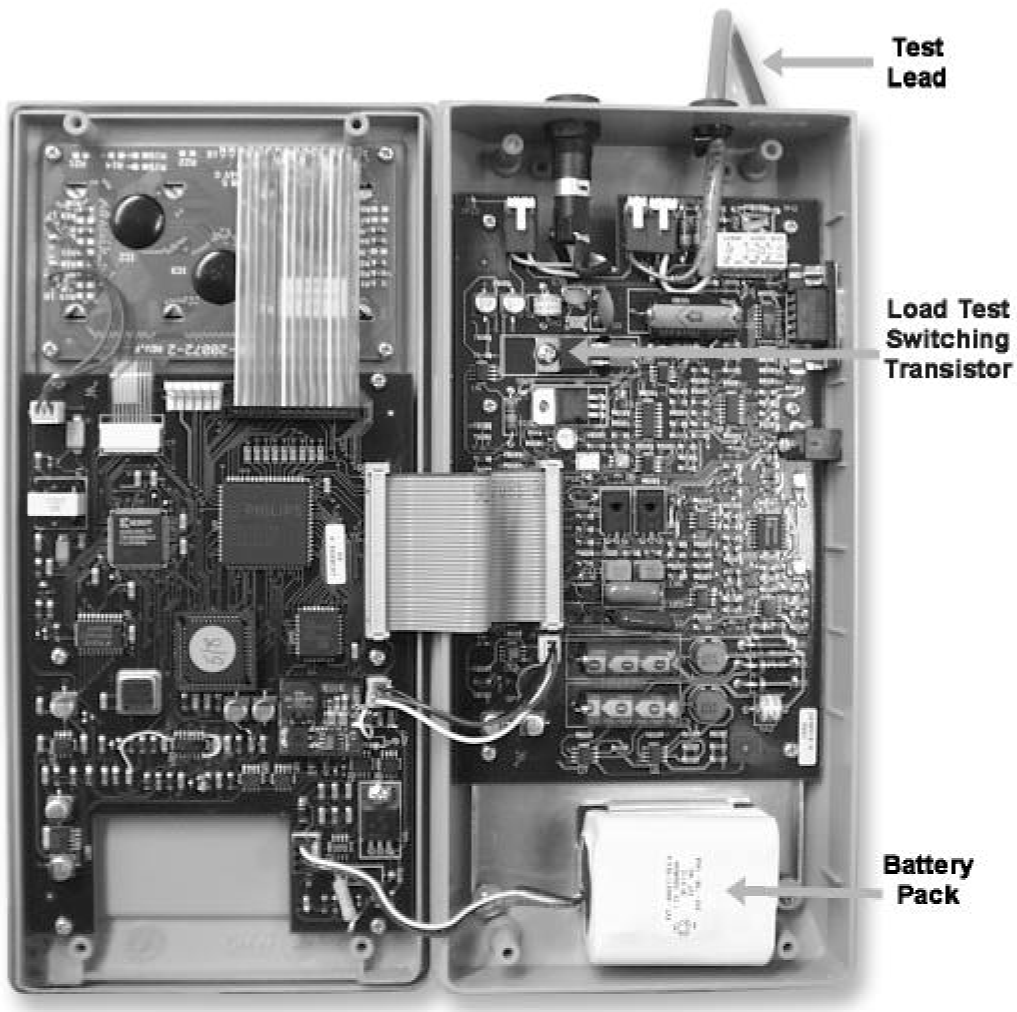


Fig. 29: The battery pack, Load Test switching transistor and Load/Ringer test lead are field replaceable.

Updating the HA325 Operating Firmware

The HA325 includes a communications port for interface to a computer. The port enables the HA325 operating software to be updated, using a computer running a communications program, should an upgrade in the software program become available from the factory. A terminal communications program, such as HyperTerminal supplied with Windows 95, 98 and WinNT4.0, Terminal, supplied with Win3.1, or any other terminal emulation program can be used to transmit the upgrade file to the HA325 RS232 port.

Connect an RS232 null modem cable from the computer serial port of the to the HA325 RS232 Interface Port. Apply power to the HA325, using the supplied AC Adapter/Charger. Open the communications program to be used and establish a communications link using the following settings.

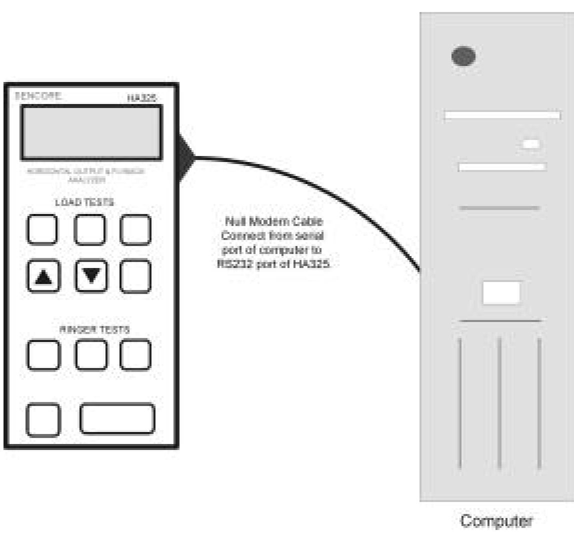


Fig. 30: The HA325 operating software can be updated with factory updates, using a computer connected to the HA325 communications port.

Communications Settings:
Baud: 9600
Data Bits: 8
Parity: None
Stop Bits: 1
Flow Control: Hardware
(Set to echo typed characters locally)

To upgrade unit firmware:

1. Connect null-modem cable (Sencore #39G523) from HA325 to Computer serial port.
2. Apply Power to the HA325. The PA273 Power Adapter/Charger should be connected.
3. Type ERASE and press <ENTER> on the computer keyboard. (HA325 Display goes blank)
4. The message "ARE YOU SURE? Y/N" is displayed. Type Y
5. The current firmware is erased followed by "READY FOR DATA" message.
6. Click on Transfer – Send Text File
7. Change Files of Type to show All Files (*.*)
8. Navigate to the file HA325.hex and click Open.
9. Firmware update begins followed by three beeps and "SUCCESS" message when complete.
10. Remove the null-modem cable.

The firmware loading time varies with different computers and software. In most cases, the firmware will be loaded in less than 10 minutes.

WARRANTY & SERVICE INFORMATION

WARRANTY

Your Sencore instrument has been built to the highest quality standards in the industry. Each unit has been tested, aged under power for at least 24 hours, then every function and range was re-tested to insure it met all published specifications after aging. Your instrument is fully protected with a 1 year warranty and Sencore's exclusive 100% Made Right Lifetime Guarantee in the unlikely event that a defect was missed. Details are covered in a separate document included with your instrument.

SERVICE

The Sencore Factory Service Department provides all in and out-of-warranty service and complete re-calibration services for Sencore instruments. No local service centers are authorized to repair Sencore instruments. Factory service assures you of the highest quality work, the latest circuit improvements and the fastest turnaround time possible. Most service repairs are completed within 72 hours of receipt.

Re-packing For Shipment

Save the original shipping carton and packing material for reuse should you ever need to ship your Sencore instrument or return it to the Sencore factory for repair. If the original materials are unavailable or unfit for reuse, repack the HA325 according to the following guidelines.

1. Use a corrugated cardboard shipping container with adequate test strength and dimensions of at least 10” X 17” X 20” (HWD).

2. Please call the Sencore Service Department and obtain a Return Verification Authorization number (RUA). Enclose the following information: Owners address, billing information, purchase order (if applicable), name and phone number of contact person, description of problem and reason for return.

3. Enclose the unit inside a plastic bag to protect its finish and prevent foreign material from getting inside.

4. Cushion the unit equally on all sides with a minimum of 3 inches of padding material. Pack the padding tightly enough to prevent the unit from shifting during shipment.

5. Seal all seams on the container with strapping tape.

6. Send the packed unit to the address listed below (we recommend shipping via United Parcel Service).

A separate schematic and parts list is available should you wish to repair your own instrument. Parts may be ordered directly from the Service Department. Any parts not shown in the parts list may be ordered by description.

We reserve the right to examine defective components before an in-warranty replacement is issued.

SENCORE FACTORY SERVICE
3200 Sencore Drive
Sioux Falls, SD. 57107
Toll Free: 1-800-Sencore
FAX 605-335-6379
www.Sencore.com

Fill in for your records:
Purchase Date: ____________ Serial Number:____________ Run Number:___________

Note: *Please refer to the run number if is necessary to call the Sencore Factory Service Department. The run number may be updated when the unit is serviced.*

3200 Sencore Drive
Sioux Falls, SD 57107
Call 1-800-SENCORE (736-2673)
www.sencore.com

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Form 7151

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