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tech tips

Understanding The HA2500 Horizontal Output Load Test

Horizontal output stages are part of every CRT video display including closed circuit monitors, computer monitors, video games, medical monitors, TVs. HDTVs, IDTVs, and the like. The horizontal output stage produces CRT high voltage and/or horizontal yoke current to deflect the CRT's electron beam side to side.

The Load Tests detect problems in high voltage, deflection, or combination horizontal output stages and enables troubleshooting. This Tech Tip explains when to use the Load Test and how it works. It explains how to properly "set up" and perform the Load Tests. Tech Tip #220 explains how to interpret the LOAD TESTS Readouts.

WHEN TO USE THE LOAD TESTS	WHAT IT TELLS YOU
• Full AC volts cannot be applied without component damage • B+ supply is dead or bad ▪ Horiz. output dead or suspect ▪ H.O.T. heats or fails ▪ Display dead or won't start ▪ B+ supply squeals, burns-up components or blows fuses ▪ X-ray shutdown symptom ▪ Estimating repair costs	▪ If horiz. output stage function is normal or abnormal ▪ If short or high current load exists on B+ power supply ▪ If horiz. output stage pulse timing is normal or abnormal ▪ If horiz. output stage is efficient or inefficient (high losses)

Why Use The Horizontal Output Load Test

Many problems involving the horizontal stages and B+ power supply are difficult to isolate with AC power applied to the chassis. Many defects in the horizontal output stage, B+ power supply or HV/deflection regulators reduce the B+ power supply voltage to the horizontal output stage. Since the stages interact so closely, the defect is not easily isolated.

The horizontal output stage may load the B+ supply, placing high current stress on horizontal output, high voltage/deflection regulator and B+ power supply components. Damage to replacement horizontal output transistors and B+ supply components often results when the problem is not isolated before applying AC power.

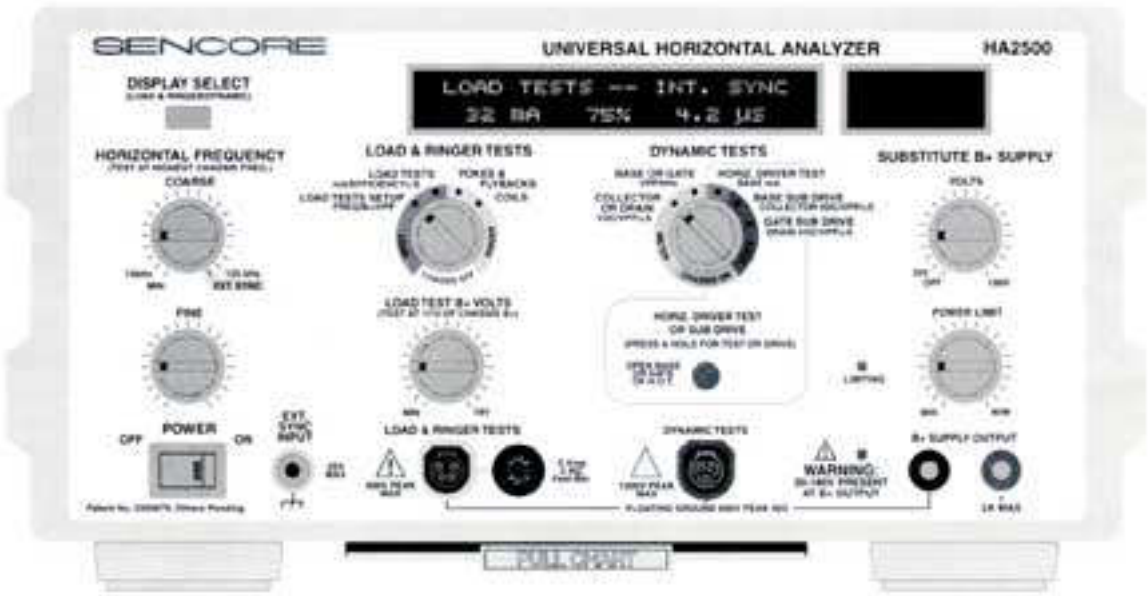

Fig. 1: The Load Tests of the Sencore HA2500 Universal Horizontal Analyzer test horizontal output stages with no AC power applied to the chassis.

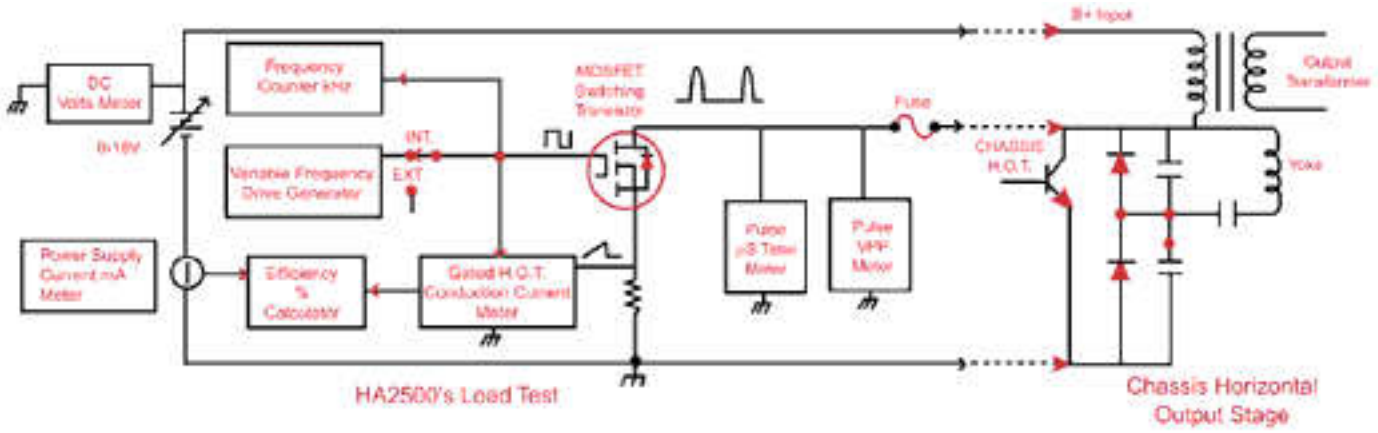

Fig. 2: Block diagram of the Load Test and connections to a horizontal output stage.

Especially difficult to detect is a shorted flyback turn or a defect in a flyback derived secondary circuit. These problems cause an abnormal increase in current in the horizontal output stage loading the B+ power supply. This type of short or loading cannot be detected with resistance tests in the horizontal output stage.

The X-Ray or high voltage shutdown circuits immediately defeat 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 to the B+ power supply. HV/deflection regulator, horizontal output or shutdown circuits.

In the past. many of these difficult symptoms could be isolated using a variable AC power supply to reduce the AC voltage to the chassis. Reducing the AC voltage lowered the B+ voltage to the horizontal output stage permitting conventional measurements. However, the B+ voltage output from a switching mode power supply cannot be reduced when the AC voltage is lowered. Therefore. a variable AC power supply is ineffective in troubleshooting horizontal, Bt supply. startup, and shutdown symptoms in chassis with a switch mode power supply.

The HA2500's Horizontal Output Load Test provides a functional test to quickly confirm if the horizontal output stage is free of severe defects or if problems exist. It quickly determines if the horizontal output stage is the cause of problem symptoms. The Load Test is useful in determining potential repair costs or to troubleshoot defects in the horizontal output stage. It protects replacement parts by verifying when horizontal output stage problems have been corrected and it is safe to apply AC voltage.

Understanding the Load Test

The Load Test simulates the operation of the horizontal output stage at its normal operating frequency and 1/10 its normal B+ voltage. The test energizes the horizontal output stage producing alternating currents in the flyback and/or yoke just as if the chassis was operating. 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 or coil.

3. A drive signal to this horizontal output transistor at the proper frequency and duty cycle to switch it on and off properly.

The HA2500 satisfies these three requirements. For a better understanding, refer to the Load Test block diagram and horizontal output stage in Fig. 2.

To functionally test the chassis horizontal output stage with no AC power to the chassis requires that the B+ voltage to the horizontal output stage be supplied. A variable DC power supply 0 - 18 volts provides the voltage for the Load Tests. The DC power supply is adjustable with the front panel LOAD TEST B+ VOLTS control. The positive voltage is output to the orange clip of the LOAD & RINGER TESTS lead in respect to the black clip or ground. The power supply current is limited to 250 mA to provide short circuit protection.

A MOSFET transistor serves as the chassis horizontal output transistor providing the switching action to energize the chassis horizontal output stage. The HA2500's internal horizontal frequency generator provides the proper horizontal drive signal to the gate of the transistor. The drive frequency is adjusted with the front panel COARSE and FINE controls to match the frequency of the chassis horizontal output stage. Drive may also be decoded from an external sync signal applied to the HA2500's Ext. Sync Input Jack.

During the Load Test, if the chassis horizontal output stage is operational, alternating currents and induced voltages or flyback pulses are produced. Since the Load Test B+ voltage is 1/10 of normal, 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 Load Test is active in the LOAD TESTS SETUP and LOAD TESTS positions of the LOAD & RINGER TESTS Switch. Measuring circuits indicate parameters during the Load Tests Setup and Load Tests functions.

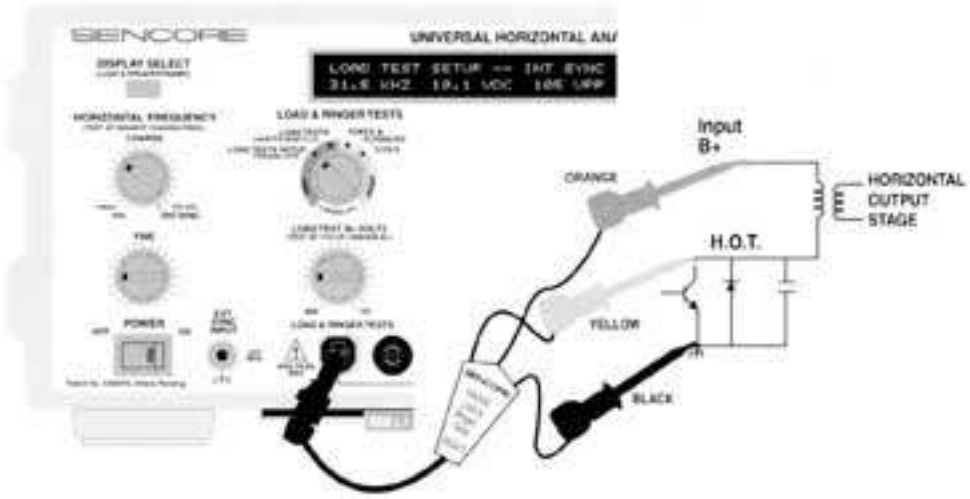

Fig. 3: Setup for performing the horizontal output stage Load Tests.

Connecting The Load & Ringer Test Lead

Performing the LOAD TEST requires connecting the three colored clips of the supplied LOAD & RINGER TEST LEAD to the chassis horizontal output stage. Before connecting the LOAD & RINGER TEST LEAD clips, be sure to unplug or remove AC power to the chassis being tested. The HA2500 contains internal protectron circuitry, but to remove any chance of damage to the analyzer and chassis, always unplug the chassis AC line cord before connecting the test lead clips.

CAUTION

Only perform the LOAD TEST with AC power to the chassis removed.

Also be careful not to come into contact with circuit points while performing the load test or when connecting or disconnecting test clips. The LOAD TEST produces current and inductive voltage pulses in the chassis horizontal output stage. It is a good idea to reduce the LOAD TESTS B+ voltage to minimum when connecting or disconnecting test clips or before unsoldering components in the horizontal output stage.

CAUTION

Do not come in contact with energized horizontal output circuits points during the LOAD TEST. Reduce the LOAD TEST B+ volts for added safety when connecting or disconnecting test lead clips.

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.

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

The Load Tests 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 "LIMITING" message or indicate a severe output stage problem. If you suspect a shorted horizontal output transistor, remove it from the chassis and repeat the Load Tests Setup.

Connecting The Load & Ringer Test Lead Clips Without A Schematic

To connect the LOAD TEST LEAD 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 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 BVce. Most horizontal output bipolar transistors have a rating greater than 1000 volts (typically 1500 V) and MOSFET transistors greater than 800 volts (typically 1000 V).

Once you have identified the horizontal output transistor(s), connect the yellow test lead 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. In some instances the emitter connects through several windings of the driver transformer to ground. 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 share.

To identify the B+ voltage input point 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 or coil in the horizontal output stage. With an ohmmeter, identify a pin or pins that

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.

Fig. 4: Use the Load Tests Setup to set the frequency and B+ for an accurate Load Test.

have continuity to the collector pin of the transformer. Typically, one or two pins may be identified on a flyback transformer. 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 shown continuity to the primary winding likely has a diode connected to it as it is commonly used as a 200 to 300 volt power supply to the CRT.

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 Setup Alternately connect the B+ or orange test clips to pins of the transformer which may be the Bt input while monitoring the Load Tests Setup readouts. The connection which produces Load Tests Setup and Load Tests results that are normal or closest to normal is likely the proper input Improper connections will show unusual Load Tests Setup and Load Tests results.

Understanding The Load Test Setup

The Load Tests Setup guides you in setting the horizontal frequency and B+ volts for the Load Test and confirms proper chassis connections. An improper horizontal frequency and/or B+ voltage can cause Load Tests results that are outside of the typical range for a particular chassis. Perform the Load Tests Setup before analyzing the Load Tests mA, %, and µS readouts. If you change the horizontal test frequency or B+ volts while performing the Load Tests, repeat the Load Test Setup.

During the Load Tests Setup, three parameters are simultaneously metered and displayed in the center fluorescent display. They include the following.

1. Load Test Horizontal Frequency (kHz) — Variable with the HORIZONTAL FREQUENCY COARSE and FINE controls.

2. Load Test B+ voltage (DCV) — Variable with the LOAD TEST Bt VOLTS control.

3. Peak-to-Peak (PPV)- Amplitude of induced voltages in the chassis horizontal output stage resulting from an active LOAD TEST at the frequency and B+ selected.

These three parameters guide you to the proper setup for performing the Load Tests at the chassis 1/10 level and achieving the most accurate test results. The frequency readout indicates the horizontal frequency for the Load Tests selected with the HORIZONTAL FREQUENCY COARSE and FINE Controls. When the COARSE control is set to "EXT". the test frequency is determined by the frequency of the applied sync to the EXT. SYNC INPUT Jack.

The DCV readout indicates the HA2500's Load Test B+ power supply voltage applied to the horizontal output stage. The voltage is adjustable with the LOAD TEST B+ VOLTS Control. Adjust the LOAD TEST B+ VOLTS Control until the display indicates a DC voltage that is approximately 1/10 of the normal B+ voltage to the horizontal output stage being tested.

To "Setup" For The LOAD TESTS (LOAD TESTS SETUP)

1. Remove AC power to the chassis.

2 Reduce the LOAD TEST B+ voltage to "MIN."

3. Connect the LOAD & RINGER TEST LEAD clips to the proper circuit points.

4. Set the LOAD & RINGER TESTS Switch to "LOAD TESTS SETUP."

5. Set the HORIZONTAL FREQUENCY COARSE and FINE Controls to the horizontal operating frequency For multi-frequency monitors. select the highest horizontal operating frequency.

6. Increase the LOAD TEST B+ VOLTS control to approximately 1/10 of the normal B+ voltage to the chassis horizontal output stage.

7. Read the VPP readout in the digital display.

The LOAD TESTS SETUP VPP (Volts-Peak-to-Peak) readout Indicates the amplitude of the Induced voltage pulses produced by the horizontal output stage being energized by the Load Test. If properly connected, a functional horizontal output stage produces induced voltage pulses relative in amplitude to the selected test frequency and applied B+ voltage. In horizontal output stages using bipolar transistors. VPP readings typically range from 80 to 120 VPP. In horizontal output stages using MOSFET transistors, VPP readings during the Load Tests Setup range from 50 to 80 PPV.

To achieve the most accurate Load Tests of multi-frequency CRT video displays, set the horizontal frequency to match the highest horizontal frequency the display can produce. While a precise frequency is not important, avoid being more than 10 kHz below the monitor's highest frequency. Low test frequencies increase the mA readings often above the typical normal range because mode switched components are removed from the horizontal output stage.

If you are unsure of the chassis normal B+ voltage, Increase the LOAD TEST B+

Load Tests Frequency (kHz)	Setup Readouts VDC	VPP	Most Likely Causes
Display's Highest Horiz. Freq.	1/10 normal B+ (Highest Display Freq.)	90 -110VPP (Bipolar type)	Proper Load Test Setup
	Can't increase DCV	0.0 VPP Low VPP	Load Test mA ~ 250 mA "Current Limiting" Severe B+ Load.
Display's Highest Horiz. Freq.	1/10 normal B+	0.0 VPP	Improper connections Open inductor/flyback circuit path.
Display's Highest Horiz. Freq	1/10 normal B+	Low VPP	Load Test B+ too low. Load Test Freq. too high.
Display's Highest Horiz. Freq.	1/10 normal B+	High VPP	Load Test B+ too high. Load Test Freq. too low.

Chart 1: Likely causes of Load Test Setup Readouts.

VOLTS Control while monitoring the VPP readout. Increase the voltage until the VPP readout is near 110 VPP (bipolar transistor) or 80 VPP (MOSFET transistor). This establishes a satisfactory 1/10 level for Load Testing most horizontal output stages.

Occasionally problems in the horizontal output stage, improper circuit connections, or an improper test frequency or B+ voltage do not permit a normal Load Test Setup. If the Load Test B+ voltage cannot be increased beyond a certain DCV readout, it is likely the power supply is current limiting to 250 mA. This condition is indicated by a "Limiting" readout in the digital display and a Load Tests mA reading near 250 mA. Common causes include an error in the B+ connection and a DC short or severe AC load in the horizontal output stage.

A 0.0 VPP readout during setup with a normal VDC applied indicates no inductive voltage pulses are being produced by the horizontal output stage. This may be caused by an improper connection or open in the horizontal output stage. Low VPP readouts may be caused by lower than normal B+ volts, a higher than normal horizontal test frequency, or an output stage loading or timing defect. Higher than normal VPP readouts indicate higher than normal B+ volts, a lower than normal horizontal test frequency, or a timing problem in the horizontal output stage.

Severe horizontal output stage problems may prevent normal Load Test Setup. This does not prohibit you from using the Load Tests. Set the Load Tests Setup as close to normal VPP as you can and perform the Load Tests. Use the Load Test readouts to help determine the nature of the horizontal output stage defect or setup problem. (See Chart 1)

Performing The Load Tests

In the LOAD TESTS position of the LOAD & RINGER TESTS Switch, the HA2500 simultaneously meters and displays three automatic measurements. The measurements accurately reflect the operation of the horizontal output stage being tested and indicate if the horizontal output stage is normal or contains a defect. The three LOAD TEST measurements are summarized in Chart 2.

The "mA" readout Indicates the current being drawn by the horizontal output stage from the Load Test's B+ power supply. This current reflects the current drawn by the horizontal output stage from the chassis Bt power supply. In other words, this is the power supply load current to the horizontal output stage. Since the Load Test B+ supply is approximately 1/10 of chassis normal Bt voltage, the "mA" readout is approximately 1/10 of the chassis normal. Readings typically range from 10 to 70 mA in normal operating horizontal output stages and rise significantly when severe loading problems exist in the horizontal output stage.

The Efficiency "%" readout measures what percentage of the input energy or current to the output stage is returned back 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 % of energy returned to the power supply. Efficiency % readouts typically range from 55 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 duration or time is determined by the

Load Test	Display Readout	Description of Test
B+ Current	milliamps (mA)	The current supplied by the Load Test B+ power supply to the horizontal output stage under test.
Efficiency	percent (%)	The % 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	microseconds (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.

Fig. 5: The Load Tests indicate if the horizontal output stage contains a defect.

inductance or capacitance of the flyback or coil primary, 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 deflectron and CRT high voltage.

To perform the LOAD TEST:

1. Perform the LOAD TESTS SETUP.
2. Set the LOAD & RINGER TESTS switch to "LOAD TESTS"
3. Read the "mA", "µS", and "Eff." readout of the digital display.
4. Compare readout results to typical ranges listed in the Pull Chart.

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