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tech tips

Understanding The HA2500's Dynamic "METER" Tests

The HA2500's "METER" Dynamic Tests are designed to analyze parameters of the horizontal output stage with the chassis powered on. Horizontal output stage measurements quickly tell you if the horizontal output stage is operating properly or not. When the output stage is not working properly, measurements quickly indicate if input voltages or drive signals are improper and help formulate possible horizontal output stage defects.

Conventional test instruments are damaged by high voltages and currents in the horizontal output stage. However, the HA2500 is designed with adequate protection to perform automatic measurements in the horizontal output stage to isolate horizontal symptoms. The "Meter" Dynamic Tests may be used on high voltage only, deflection only, and combination horizontal output stages with grounded emitter or source horizontal output transistors. This Tech Tip provides information on how to use and interpret the HA2500's COLLECTOR OR DRAIN and BASE OR GATE measurements.

Understanding The COLLECTOR OR DRAIN And BASE OR GATE Tests

The first position of the DYNAMIC TESTS Switch is the "COLLECTOR OR DRAIN DCV/uS/VPP" meter. This Dynamic Test provides three automatic measurements of the parameters at the collector or drain of the horizontal output transistor. The measurements include the DC voltage (DCV), the duration in microseconds (uS) of the inductive voltage pulse, and the peak-to-peak amplitude (VPP) of the inductive voltage pulse produced by the horizontal output stage. All three measurements are displayed simultaneously in the center fluorescent display panel.

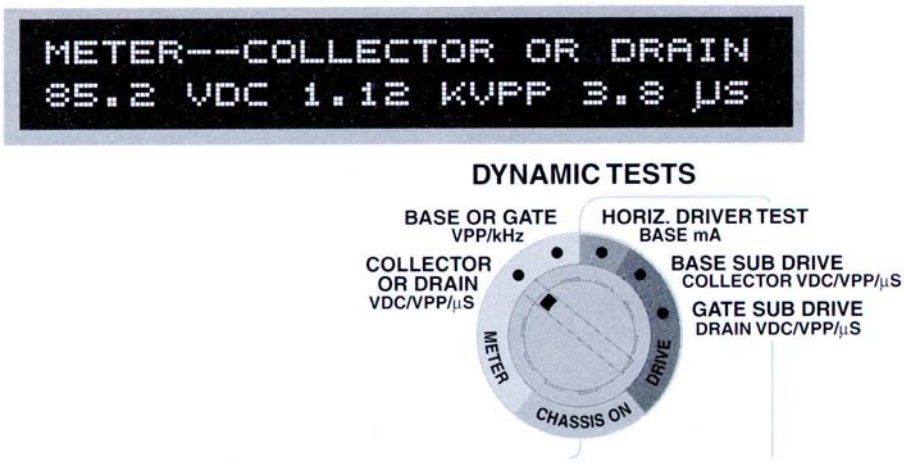

Fig. 1. The COLLECTOR OR DRAIN and BASE OR GATE "Meter" tests analyze parameters in the horizontal output stage.

The second position of the DYNAMIC TESTS Switch is the "BASE OR GATE VPP/FREQ." meter. This switch position provides two automatic measurements of the parameters at the base or gate of the horizontal output transistor. The measurements include the peak-to-peak voltage (VPP) and frequency (kHz) of the horizontal drive signal to the base or gate of the horizontal output transistor. The measurements are displayed simultaneously by the center fluorescent display panel.

The "METER" Dynamic Tests may be used in bipolar or MOSFET horizontal output transistor stages. Measurements are accurate with the horizontal output transistor in the chassis or removed. However, the horizontal output stage cannot operate and produce voltage pulses with the transistor removed. Therefore, the COLLECTOR OR DRAIN uS and PPV readouts indicate near 0 or show "---" in the display. BASE OR GATE measurements may also change slightly with the transistor removed.

Before using any of the Dynamic Tests on suspect horizontal output stage problems, it is a good idea to perform the HA2500's horizontal output Load Tests. The Load Tests identify severe output stage problems and help you troubleshoot them. Applying AC power to the chassis with severe output stage problems could stress and damage chassis components.

Connecting The Dynamic Test Lead

The COLLECTOR OR DRAIN and BASE OR GATE measurements in the horizontal output stage use the specially designed DYNAMIC TEST LEAD supplied with the HA2500. Three clip connections are required to the leads of the horizontal output transistor. If the horizontal output transistor is removed, the connections are made to the circuit points corresponding to the transistor elements.

Insert the DYNAMIC TEST LEAD plug into the DYNAMIC TESTS Jack on the front panel of the HA2500. The plug locks into the front panel jack to prevent unwanted disconnection during use. To remove the plug from the front panel jack,

push inward on the release tab of the plug and remove.

CAUTION:
Always remove AC power to the chassis before connecting or disconnecting the DYNAMIC TEST LEAD clips.

The DYNAMIC TEST LEAD is labeled and color coded for easy connection. The yellow clip connects to the collector or drain of the horizontal output transistor. The blue clip connects to the base or gate and the black lead connects to horizontal ground typically at the emitter or source (see Fig. 2).

To Perform The "METER" Dynamic Tests

The "COLLECTOR OR DRAIN" or "BASE OR GATE" Dynamic Tests are performed with AC applied to the chassis. Measurements result from the operation of the horizontal stages and stages which supply input signals and voltages. To avoid damaging the chassis or HA2500, always follow these precautions.

Always follow these precautions to prevent chassis or instrument damage:

1. Always remove power to the chassis before connecting or disconnecting to the horizontal output transistor or circuit. Do not remove AC power to the HA2500.
2. Always remove the LOAD/RINGER TEST LEAD clips from the chassis before applying AC power to perform any of the DYNAMIC TESTS.
3. Always attach the DYNAMIC TEST LEAD clips securely so they do not become detached during testing. If necessary, solder small test points or component leads to circuit points to provide secure connections. Remove AC power to the chassis if a lead(s) becomes detached.
4. When using the SUBSTITUTE B+ SUPPLY to sub for the chassis B+ voltage, always reduce the VOLTAGE control to "OFF" befor e connecting or disconnecting lead clips.

Lead Connections For Dynamic Tests:

Lead Clip Color	*Lead Label*	*Connect to:*
Black	E or S	Emitter or Source of H.O.T
Yellow	C or D	Collector or Drain of H.O.T
Blue	B or G	Base or Gate of H.O.T

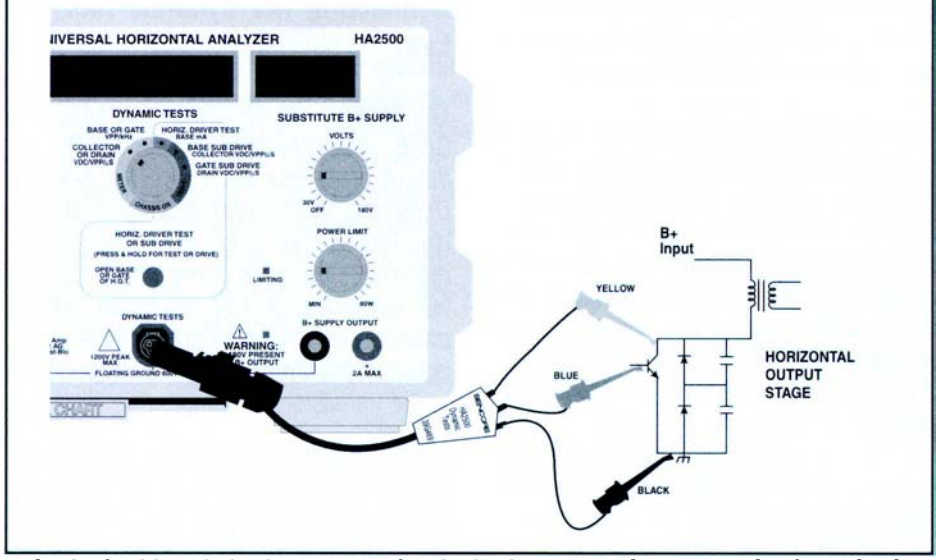

Fig. 2: The COLLECTOR OR DRAIN and BASE OR GATE Dynamic Tests require three simple DYNAMIC TEST LEAD connections to the horizontal output transistor.

To Perform The "COLLECTOR OR DRAIN" Or "BASE OR GA TE" Dynamic Tests:

1. Remove AC voltages to the chassis.
2. Connect the DYNAMIC TEST Lead.
3. Set the DYNAMIC TESTS switch to "COLLECTOR OR DRAIN DCV/uS/VPP"
4. Push DISPLAY SELECT button.
   Note: Changing the DYNAMIC TESTS switch automatically selects Dynamic Tests readout.
5. Apply AC volts to the chassis.
6. Read the DCV, VPP, and uS readouts in the center fluorescent panel.
6. Set the DYNAMIC TESTS switch to "BASE OR GA TE FREQ/VPP".
7. Read the VPP and FREQ. readouts in the center fluorescent panel.

Interpreting The COLLECTOR OR DRAIN DCV Readout

The Collector Or Drain DCV readout measures the DC voltage at the collector or drain of the horizontal output transistor in respect to ground. The DC voltage is the B+ power supply voltage applied to the horizontal output stage. The DC voltage measurement is designed to measure the full range of B+ voltages found in video displays ranging from 0 to 400 volts.

The DCV readout should closely agree with the schematic or the B+ voltage known to be normal for the chassis being tested. DC voltage readings that vary considerably from the normal indicate a change in the normal load current to the horizontal output stage. It may also be an indication of a problem with the B+ power supply. In multi-frequency displays, it may indicate a problem with the high voltage or deflection B+ regulator

If without a schematic, you can estimate the normal B+ voltage. While the normal B+ voltage varies among TVs and multi-frequency displays, there are some common trends in B+ voltage depending on the display's frequency and resolution capabilities. Color televisions with CRT sizes of 13" or mor e commonly have B+

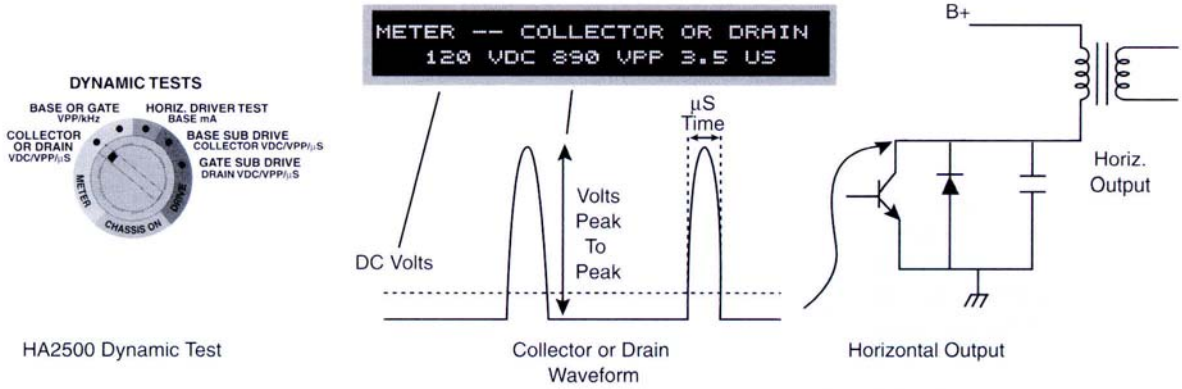

Fig. 3 The COLLECTOR OR DRAIN "Meter" tests analyze the DC voltage, pulse VPP and duration at the collector or drain of the hor izontal output transistor.

voltages ranging from 115 volts to 140 volts. A VGA only monitor commonly uses a B+ supply voltage of 75-95 volts. A multi-frequency display that operates from VGA through a range of frequencies commonly changes the B+ supply voltage to the horizontal output depending on the frequency of operation. At VGA (31.5 kHz), the B+ voltage may be approximately 80 volts and increase to 130 volts as operating frequencies near 60 kHz. As you use the Collector Or Drain Dynamic Tests, you will gain further insight on normal B+ voltages among displays.

A missing B+ voltage results in a very low or 0 VDC reading. Missing B+ voltage prevents the horizontal output stage from producing alternating currents in the inductor, flyback transformer, or yoke. Missing B+ voltage commonly results from an open or circuit defect within the B+ supply or high voltage/deflection regulator. Voltage readings near 0 VDC may also be caused by a short in the horizontal output stage.

A lower than normal B+ voltage causes reduced currents in the horizontal output stage and less high voltage and/or deflection. Reduced B+ voltage may be an indication of an excessive load or current demand from the horizontal output stage. Use the HA2500's Load Test to identify and isolate horizontal output stage shorts or loading problems. If the Load Tests indicate normal, the B+ power supply or HV/deflection regulator is suspect. You may use the Substitute B+ Supply to further isolate the defect.

A higher than normal B+ voltage causes increased currents in the horizontal output stage and increased high voltage and/or deflection. If the voltage is considerably higher than normal, safety shutdown circuits will "shutdown" the horizontal output stage. Higher than normal B+ voltage indicates a B+ power supply regulation problem or in multi-frequency displays a HV/deflection regulator problem.

Higher than normal B+ voltage to the horizontal output stage is often normal when the horizontal output stage is not operational or is not drawing current from the B+ supply or high voltage/deflection regulator. This commonly occurs when the horizontal drive is missing to the horizontal output stage. Missing drive results in no currents in the horizontal output stage and no current draw from the B+ supply.

Interpreting The COLLECTOR OR DRAIN VPP Readout

The alternating currents in the horizontal output stage produce an inductive voltage pulse, commonly called a flyback pulse. The amplitude or volts peak-to-peak (VPP) of the voltage pulse provides useful information about the operation of the horizontal output stage. The HA2500's Collector Or Drain VPP readout measures the VPP of the flyback pulse produced at the collector or drain of the horizontal output stage. The VPP measurement is automatic and requires no range selection from 0 volts to 1500 VPP. While most horizontal output stage voltage pulses are positive, the VPP meter also measures negative peaks for an accurate VPP reading.

A VPP reading indicates the presence of flyback pulses in the horizontal output stage. Flyback pulses indicate B+ voltage is present, horizontal drive is switching the horizontal output transistor, and alternating currents are being produced in the horizontal output stage. The amplitude of the flyback pulses or VPP readings reflect the level of current alternating in the horizontal output stage. Normal VPP readings indicate the horizontal output stage current is proper to produce normal high voltage and/or deflection.

The collector or Drain VPP readout should agree closely with waveform amplitudes at the collector or drain of the horizontal output transistor shown in the service literature. Most horizontal output stages with bipolar output transistors and B+ voltage >35 volts produce voltage pulses ranging from 800 to 1,200 VPP. Horizontal output stages with MOSFET output transistors produce voltage pulses ranging from 500 to 850 VPP. It is not unusual for VPP readings to vary 50 VPP from the schematic or between chassis of the same model. However, if the readings are considerably different than the normal, a change in the amount of current or rate of current change alternating in the horizontal output stage is indicated.

The absence of flyback pulses produce VPP readings below 50 VPP or a "0.0" VPP reading. Missing flyback pulses indicate the horizontal output stage is not operational or is not producing alternating currents. The B+ voltage may be missing or there may not be drive to the base or gate of the horizontal output transistor. Use the Collector Or Drain DCV readout to confirm B+ voltage. Use the Base Or Gate

VPP/kHz Dynamic Test to check for the presence of horizontal drive. If these are normal, an open horizontal output transistor, output stage component, or circuit path exists.

Lower than normal VPP readings result from decreased currents in the horizontal output stage. Decreased currents commonly result from a decrease in the B+ voltage to the horizontal output stage, a change in the resonant timing of the output stage or insufficient base drive or transistor beta. Reduced B+ voltage likely indicates a defect in the B+ power supply or HV/deflection regulator. A timing defect caused by an increase in the inductance or capacitance of the stage slows the rate of current change reducing the VPP readout. An open in the yoke current path alters the timing in this manner. Use the Collector Or Drain uS readout to confirm a resonant timing change in the output stage. Reduced VPP readouts can be caused by insufficient base drive to the horizontal output transistor or reduced output transistor gain (beta). Use the Base Or Gate and Horiz. Driver Test to confirm proper horizontal base drive.

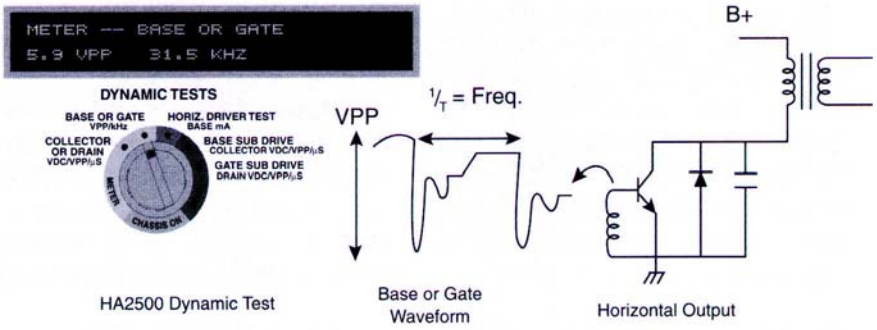

Fig. 1: The Base or Gate Meter tests analyze the peak-to-peak voltage and frequency of the horizontal input drive to the H.O.T. base or gate.

An increase from the normal VPP results from an increase in current alternating in the horizontal output stage. The most common cause is an increase in the B+ voltage to the horizontal output stage caused by B+ supply or HV/deflection regulator defects. A timing defect in the horizontal output stage may also cause increased VPP readings. Timing problems are commonly caused by a flyback internal shorted turn, an added current load on a flyback secondary, or a decrease in a output stage timing capacitor value. Use the Collector Or Drain uS readout to identify a change in the resonant timing of the horizontal output stage.

COLLECTOR/DRAIN READOUTS	PROBABLE CAUSES
VDC = 0	No ACV, Bad B+ power supply, Open HV/Defl. regulator, Shorted H.O.T.
VDC = lower than normal	Bad HV/Defl. regulation, B+ supply defect, Severe load or short in Horiz. Output.
VDC = higher than normal	B+ Supply Regulation, Shorted or bad HV/Defl. regulator, No load current to Horiz. Output.
VPP = 0.0 VPP or <5VPP	Little or no B+ volts, No Horiz. Drive, Open H.O.T or inductor in Horiz. Output.
VPP lower than normal	Low B+, Open yoke path, Insufficient Drive, Increased value-retrace capacitor or inductor.
VPP higher than normal	High B+, reduced value-retrace capacitor or inductor, Horiz. Output stage loading.
µS = - - - µS	Little or no B+ volts, No Horiz. Drive, Open H.O.T. or inductor in Horiz. Output.
µS = lower than normal	Display capable of higher resolution? Reduced value-retrace capacitor or stage inductor. Flyback shorted turn or sec. load.
µS = higher than normal	Open yoke or its series components.

Chart 1. Probable causes of the measurement results using the COLLECTOR OR DRAIN Dynamic Tests.

Interpreting the COLLECTOR OR DRAIN uS Readout

The COLLECTOR OR DRAIN uS readout measures the duration of time in microseconds of the voltage pulse produced at the collector or drain of the horizontal output transistor. The uS time is measured between the 5% level of the voltage peak for pulses greater than 20 VPP. This provides an automatic pulse time measurement with reasonable accuracy for all pulses >100 VPP.

The voltage developed by the horizontal output stage corresponds to the charge and discharge of the retrace capacitor(s). This time reflects the resonant timing of the horizontal output stage and relates to the inductance and capacitance values of the components in the output stage. The duration or time of the voltage pulse provides useful information about the normal resonant operation of the horizontal output stage.

The normal pulse uS timing of the horizontal output stage depends on the shortest horizontal blanking time of the highest frequency video that the display is capable of reproducing. Furthermore, the uS timing is influenced by the

overscan and underscan characteristics of the display. To determine what a normal uS reading is for a particular horizontal output stage, reference the Typical uS Pulse Time Range Chart used for the Load Tests. The Load Test uS readout and Collector Or Drain uS readout should closely agree when analyzing a particular horizontal output stage.

Schematics usually do not specify the flyback pulse duration, but it can sometimes be estimated from the horizontal output's collector or drain waveform shown by the service literature. If the graticules of the scope are shown with the waveform and the scope's sweep rate setting is listed, multiply the number of scope divisions included from the beginning to the end of pulse times the scopes uS setting. This provides a rough estimate of the pulse time in microseconds.

A normal pulse time indicates the resonant timing of the horizontal output stage is appropriate to produce normal PPV pulses and proper high voltage and deflection. It also confirms normal timing to properly blank the video during retrace.

A pulse time that is shorter than the anticipated normal uS range may indicate the display and horizontal output stage is designed to handle higher display resolution with video containing faster horizontal blanking times. Investigate the display's highest frequency horizontal capabilities and the video format display capabilities to confirm if the uS is normal or too narrow.

A pulse time that is confirmed shorter than the normal uS range indicates a reduced inductance or capacitance value of the horizontal output stage. The inductance of the flyback or coil can be reduced by a shorted turn or loading of a secondary winding. A reduced retrace capacitance value also causes a shorter than normal uS reading. Shorter than normal uS readings usually result in increased PPV readings with the normal B+ voltage applied to the horizontal output stage.

A pulse time that is longer than the anticipated uS range may be an indication that the display is not capable of displaying the resolution and horizontal frequency you thought. Investigate the display's highest horizontal operating frequency and the highest video blanking interval of the display to confirm the normal uS range.

A pulse time that is longer than the normal uS range indicates the timing of the horizontal output stage is reduced. The inductance or capacitance of the horizontal output stage has been effectively increased. The likely cause of this in combination high voltage/deflection horizontal output stages is an open in the yoke or its series components. Longer than normal uS readings usually result in decreased PPV readings with the normal B+ voltage applied to the horizontal output stage.

Interpreting The BASE OR GATE VPP Readout

The BASE OR GATE Dynamic tests analyze the peak-to-peak voltage and frequency of the horizontal drive waveform at the base or gate of the horizontal output transistor. The BASE OR GATE FREQ/PPV measurements are designed to be used in either bipolar or MOSFET horizontal output stages. Measurements are valid and accurate with the horizontal output transistor in the chassis or removed.

The BASE OR GATE VPP readout measures the amplitude or peak-to-peak voltage (PPV) of the horizontal drive signal input to the base or gate of the horizontal output transistor. The PPV measurement is automatic for both positive or negative polarity voltage peaks.

Normal VPP readings at the base or gate of the horizontal output transistor vary slightly between output stages and output transistor types. FET horizontal output stages have base input drive voltages typically ranging from 5 to 18 volts peak-to-peak. Zener diodes from the gate to source limit the maximum drive voltage to prevent damage to the FET output transistor. Bipolar horizontal output stages have drive peak-to-peak voltages ranging from 4 to 20 VPP. While the VPP readings may change when the horizontal output transistor is removed, the VPP readings should remain in the typical ranges listed.

Base Or Gate VPP readings in the typical range indicate the presence of proper drive voltage to the base or gate of the horizontal output transistor. The presence of drive indicates the horizontal oscillator and driver stages are functioning. Perform the Base Or Gate kHz test and the Horiz. Driver Test when bipolar output transistors are used to further confirm normal horizontal oscillator and driver stage operation.

VPP readings that are higher than the typical range shown likely do not indicate a circuit problem. The high VPP readings are likely due to positive and negative switching spikes caused by the normal switching action of the horizontal output transistor.

VPP readings that are lower than the typical range likely indicate a drive signal problem. VPP readings near 0 indicate that there is no input horizontal drive signal or the horizontal output transistor is shorted preventing any substantial VPP at the base or gate. Open the base or gate or remove the horizontal output transistor and repeat the Base Or Gate VPP test. Normal VPP readings confirm the output transistor

Typical Base Or Gate VPP Ranges

Horiz. Output Stage/Transistor Type	Typical VPP Range
HV Only Horiz. Output With Bipolar H.O.T	3 - 15 VPP
Combined HV/Deflection Or Deflection Only Horiz. Outputs With Bipolar H.O.T.	4 - 20 VPP
All Horiz. Output Stages With FET H.O.T	5 - 18 VPP

Chart 2. Typical ranges of Base or Gate VPP measurements

defective while low or missing VPP readings indicate a horizontal oscillator or driver stage defect.

VPP readings below the typical range (less than 4 VPP) may indicate that drive is weak or missing. For questionable VPP readings (2-5 VPP) in horizontal output stages using bipolar horizontal output transistors, use the Horiz. Driver Test to confirm normal or insufficient drive current levels.

BASE OR GATE TEST RESULTS	PROBABLE CAUSES
Freq. = 0.0 kHz	• No Horiz. Drive
Freq. = lower than normal	• Horiz. Osc., Horiz. Drive Distortion, Mode Select Defect, Missing Sync
Freq. = higher than normal	• Horiz. Osc., Mode Select, Sync, Unwanted Osc/Driver Distortion
VPP = 0.0 VPP	• No Horiz. Drive, Shorted H.O.T.
VPP = lower than normal	• Missing or Weak Drive, Shorted H.O.T.
VPP = higher than normal	• Likely no fault

Chart 3 Probable causes of the measurement results using the BASE OR GATE Dynamic Tests.

Interpreting The BASE OR GATE kHz Readout

The Base Or Gate kHz readout indicates the frequency of the horizontal drive signal input to the base or gate of the horizontal output transistor. The automatic horizontal drive frequency measurement is accurate both when the horizontal output transistor is in the chassis or removed, or with either bipolar or FET horizontal output stages.

The Base Or Gate kHz measurement tests the frequency of the horizontal oscillator. The oscillator generates a drive signal which is amplified by the horizontal driver stage to the base or gate of the horizontal output transistor. Measuring the frequency of the horizontal drive waveform provides an indirect measurement of the horizontal oscillator frequency.

For normal operation, the horizontal output stage must be driven with the proper horizontal frequency. In a multi-frequency display, the B+ voltage and mode selecting components in the output stage are chosen depending on the operating frequency. An improper drive frequency in relationship to the applied B+ and mode selected components causes improper horizontal output stage operation. To much or to little high voltage or deflection is produced or the timing of the output stage pulse is incorrect for the video's retrace time requirements.

The normal frequency is determined by the horizontal scan rate of the video to be displayed by the monitor. If the horizontal output stage is in a television receiver, the horizontal oscillator typically free-runs near 16 kHz. If a TV video signal is input and displayed, the horizontal oscillator locks to the video's sync signal resulting in an oscillator frequency and readout of 15.7 kHz. In a VGA monitor, the horizontal oscillator runs near 31.5 kHz and locks to this frequency when synced to a VGA input signal.

To accurately test the horizontal oscillator (drive frequency) and horizontal sync circuits of a display, apply the proper video test signal and frequency from a generator to the inputs of the display. The Base Or Gate kHz readout should agree with the horizontal sync frequency of the applied video signal if the display is capable of displaying the applied video format. The horizontal oscillator and sync circuits of the display are working properly if the kHz readout agrees with the generator frequency.

Note: *The Base Or Gate kHz readout may not be exactly the same as the frequency displayed by the generator even when they are synced or locked. The generator may be outputting a slightly different frequency than it's displaying or the frequency meters have slightly different resolutions and accuracy.*

If the Base Or Gate kHz readout is considerably higher or lower than expected with no input signal to the display, check the display's horizontal frequency and resolution capabilities.

A kHz readout near the applied generator frequency, but not the same, indicates the horizontal oscillator is not being synchronized with the horizontal sync signal. You can remove the generator signal while monitoring the FREQ. readout to confirm the oscillator is not locking or changing frequency. If the frequency does not change as the generator signal is applied, the display's horizontal sync circuits or mode control circuits are suspect. If the frequency changes but just not quite enough, the horizontal oscillator components or frequency mode control input voltage to the oscillator are suspect.

On occasion, the FREQ readout may be considerably higher than the normal operating horizontal frequency or proper input horizontal sync frequency from a generator. Use an oscilloscope to measure the horizontal oscillator frequency to the input of the driver stage. If the frequency and waveform look normal, analyze the waveform at the base or gate of the horizontal output transistor for unwanted waveform variations or ringing. Unwanted drive signal variations can cause unwanted horizontal output transistor on/off switching in the middle of the horizontal cycle causing noise and horizontal output transistor failures.

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SENCORE
3200 Sencore Drive, Sioux Falls, SD 57107
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