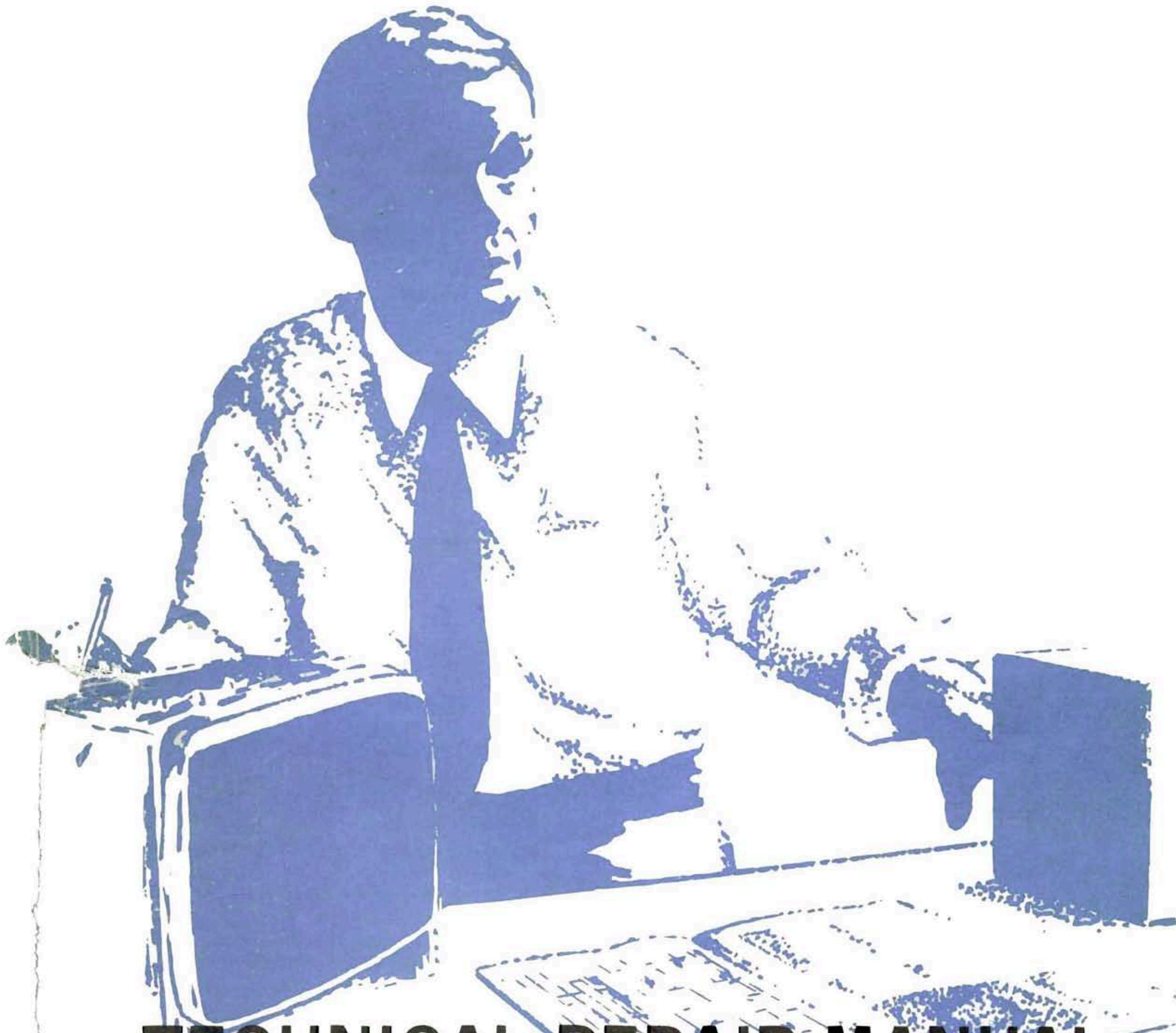


TECHNICAL REPAIR MANUAL
SOLID STATE MONITOR
XM SERIES

MOTOROLA INC.

Display Systems

WEST CHICAGO, IL. 60185
PART NO. 68P65130A74–2

SAFETY WARNING

CAUTION: NO WORK SHOULD BE ATTEMPTED ON AN EXPOSED MONITOR CHASSIS BY ANYONE NOT FAMILIAR WITH SERVICING PROCEDURES AND PRECAUTIONS.

1. SAFETY PROCEDURES should be developed by habit so that when the technician is rushed with repair work, he automatically takes precautions.

2. A GOOD PRACTICE, when working on any unit, is to first ground the chassis and to use only one hand when testing circuitry. This will avoid the possibility of carelessly putting one hand on chassis or ground and the other on an electrical connection which could cause a severe electrical shock.

3. Extreme care should be used in HANDLING THE PICTURE TUBE as rough handling may cause it to implode due to atmospheric pressure (14.7 lbs. per sq. in.). Do not nick or scratch glass or subject it to any undue pressure in removal or installation. When handling, safety goggles and heavy gloves should be worn for protection. Discharge picture tube by shorting the anode connection to chassis ground (not cabinet or other mounting parts). When discharging, go from ground to anode or use a well insulated piece of wire. When servicing or repairing the monitor, if the cathode ray tube is replaced by a type of tube other than that specified under the Motorola Part Number as original equipment in this Service Manual, then avoid prolonged exposure at close range to unshielded areas of the cathode ray tube. Possible danger of personal injury from unnecessary exposure to X-ray radiation may result.

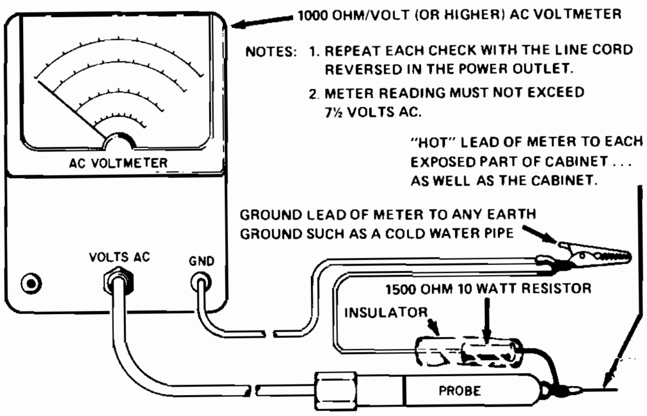
4. An ISOLATION TRANSFORMER should always be used during the servicing of a unit whose chassis is connected to one side of the power line. Use a transformer of adequate power rating as this protects the serviceman from accidents resulting in personal injury from electrical shocks. It will also protect the chassis and its components from being damaged by accidental shorts of the circuitry that may be inadvertently introduced during the service operation.

5. Always REPLACE PROTECTIVE DEVICES, such as fishpaper, isolation resistors and capacitors and shields after working on the unit.

6. If the HIGH VOLTAGE is adjustable, it should always be ADJUSTED to the level recommended by the manufacturer. If the voltage is increased above the normal setting, exposure to unnecessary X-ray radiation could result. High voltage can accurately be measured with a high voltage meter connected from the anode lead to chassis.

7. BEFORE RETURNING A SERVICED UNIT, the service technician must thoroughly test the unit to be certain that it is completely safe to operate without danger of electrical shock. DO NOT USE A LINE ISOLATION TRANSFORMER WHEN MAKING THIS TEST.

In addition to practicing the basic and fundamental electrical safety rules, the following test, which is related to the minimum safety requirements of the Underwriters Laboratories should be performed by the service technician before any unit which has been serviced is returned.



Voltmeter Hook-up for Safety Check

A 1000 ohm per volt AC voltmeter is prepared by shunting it with a 1500 ohm, 10 watt resistor. The safety test is made by contacting one meter probe to any portion of the unit exposed to the operator such as the cabinet trim, hardware, controls, knobs, etc., while the other probe is held in contact with a good "earth" ground such as a cold water pipe.

The AC voltage indicated by the meter may not exceed 7½ volts. A reading exceeding 7½ volts indicates that a potentially dangerous leakage path exists between the exposed portion of the unit and "earth" ground. Such a unit represents a potentially serious shock hazard to the operator.

The above test should be repeated with the power plug reversed, when applicable.

NEVER RETURN A MONITOR which does not pass the safety test until the fault has been located and corrected.

NAEPC–00798
+ BEPC–00149

INTRODUCTION

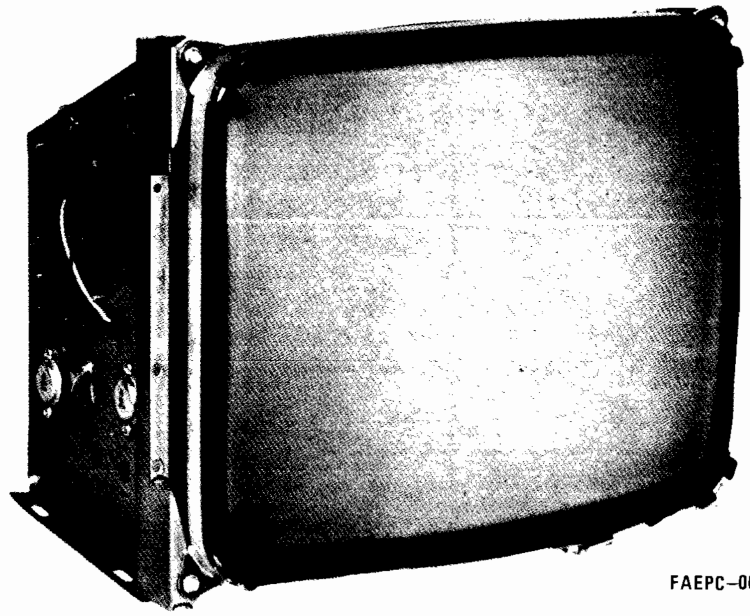
The information in this manual is presented as a tool to provide engineers and technicians with a general working knowledge of CRT displays. It will aid in developing a procedure for rapid and professional analysis of service problems that may arise.

The material presented is not specific to any particular model, but will attempt to provide a detailed overview of the Motorola Display Products XM Series line.

Motorola Display monitors are primarily intended for use in the display of alphanumerics. However, since the monitor will reproduce at least 10 levels of grey scale, analog (or combinations of analog and digital video), signals as generated by camera or tape can be accurately displayed. Motorola Display monitors are offered in a variety of chassis designs, display (CRT) sizes, and systems of operations. These features are coupled with the total serviceability concept of Motorola's solid state technology.

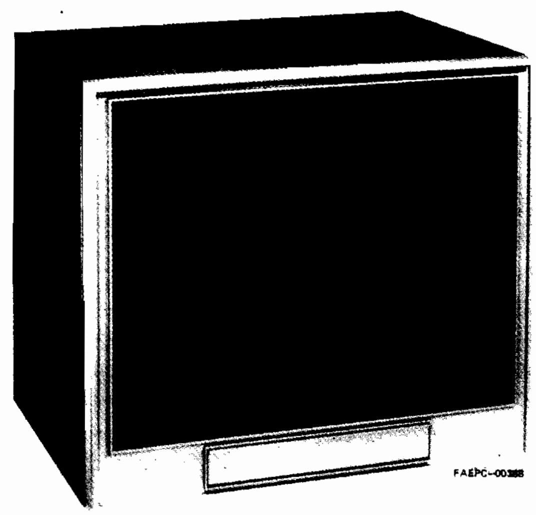
Currently we produce CRT Display sizes in 9", 12", 14", 19" and in 23". Due to flexibility of design, customer controls are located in a variety of locations. Displays may be self contained in their own cabinetry or rack mounted in single or multiple installations.

Motorola displays are fully solid state. They operate from either internal or external power supplies, and some AC powered models include switch selection of 115 or 230 volts 50/60 Hz. Power supplies in AC powered models are regulated.



FAEPC–00144

Typical Monitor Chassis



Typical Cabinet Model with Concealed Front Controls

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DISPLAY BLOCK DIAGRAM

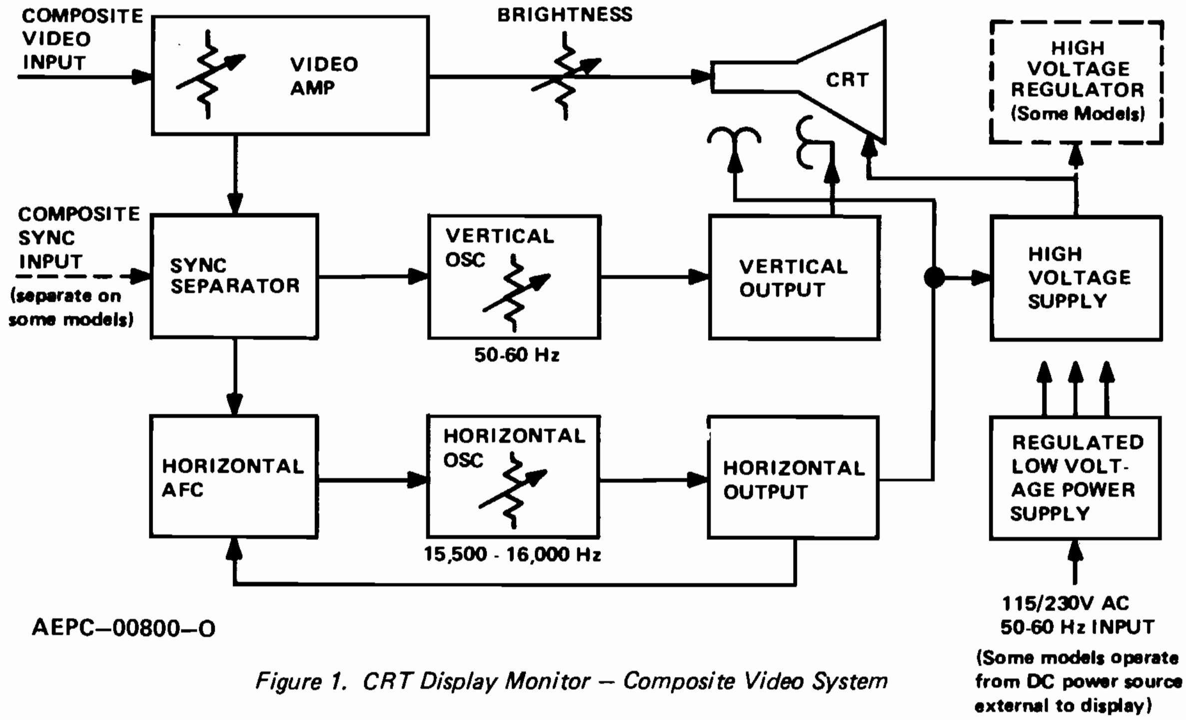


Figure 1. CRT Display Monitor — Composite Video System

SIGNAL REQUIREMENTS

Basically the XM series display monitors operate in one of two modes; composite video or transistor/transistor logic (TTL). An understanding of these two modes and their differences is necessary because the input signals determine the monitor input circuitry design, the amount of circuitry needed, and the application for which the monitor can be used. A brief discussion and comparison of each mode follows:

1. Composite Video (Figure 1)

Monitors operating in this mode utilize a single input with video, horizontal sync and vertical sync inputs all combined and coupled to the video amplifier. These signals appear periodically across the input and must be electronically separated to be usable. Extraction of the horizontal and vertical sync signals from video is performed by the sync separator. Figure 2 is a partial display of a monitor raster, showing several horizontal scan lines that make up a non-interlace vertical frame.

Figure 3, page 5, illustrates one non-interlace vertical frame of a composite "alphanumeric" character video signal at a vertical (refresh) rate. A non-interlace frame consists of an even number of 262 horizontal scan lines. An interlace frame consists of an odd number of 525 horizontal scan lines. For the purpose of clarity, only the non-interlace format will be described here. Several new terms are apparent in Figure 3 and are defined as follows:

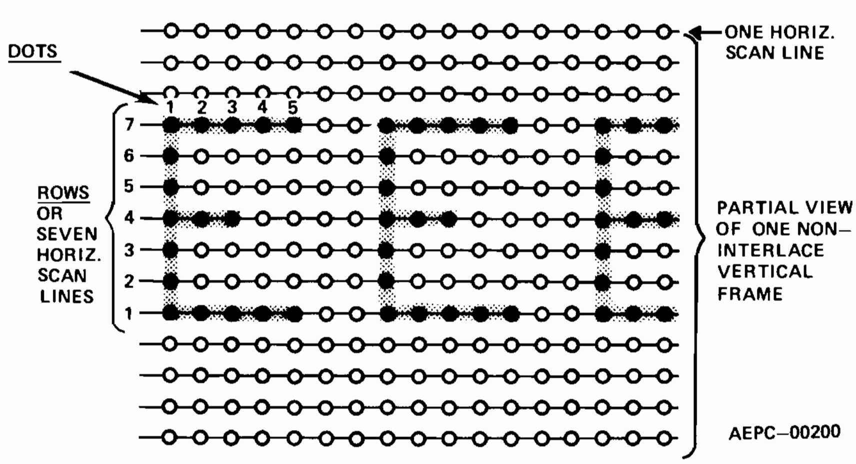


Figure 2. 5 x 7 Character "E" Displayed on Monitor (50% Duty Cycle Shown for Clarity)

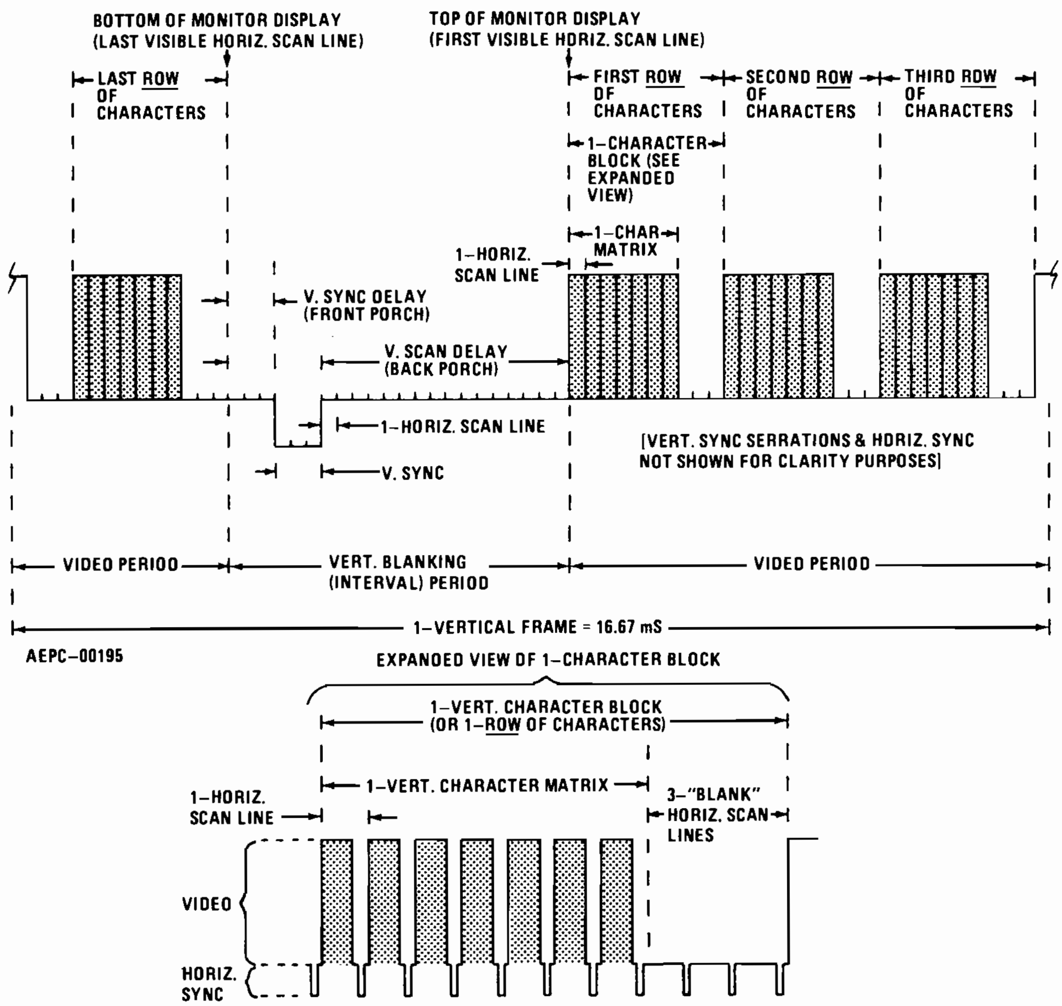


Figure 3. Terminology of a Composite "Alphanumeric Character" Video Signal at a Vertical Rate

V. (Vertical) Sync Delay – commonly called a front porch in standard TV phraseology.

V. (Vertical) Scan Delay – commonly called a back porch.

Character Matrix
Character Block
Rows of Characters

These three terms represent the structure and spacing of the alpha numeric characters which occur during the video period (as shown in Figure 3). The expanded view illustrates a further breakdown of one vertical character block, which also represents one (1) row of characters. In addition, horizontal sync pulses are shown.

Time durations shown are scaled proportionately for one typical non-interlace vertical frame. Figure 4 illustrates the same non-interlace composite "alphanumeric character" video signal, except it is now shown at a horizontal rate. The expanded view illustrates a further breakdown of one horizontal character block with the terminology that is used. Time durations shown are scaled proportionately for one typical horizontal scan line.

2. TTL (Figure 5)

Monitors utilizing TTL input require separate video, vertical and horizontal sync signals coupled directly to their respective amplifier circuits. This precludes the necessity of a sync separator circuit.

TTL sync signals are pulses of a duration similar to that of composite video sync and, as with composite video, TTL sync sets the horizontal and vertical frequencies by edge triggering oscillators in the respective deflection circuits. Figure 6 gives TTL sync timing information. Note that the video information is illustrated for reference only; it does not appear on the same wire pair as the sync.

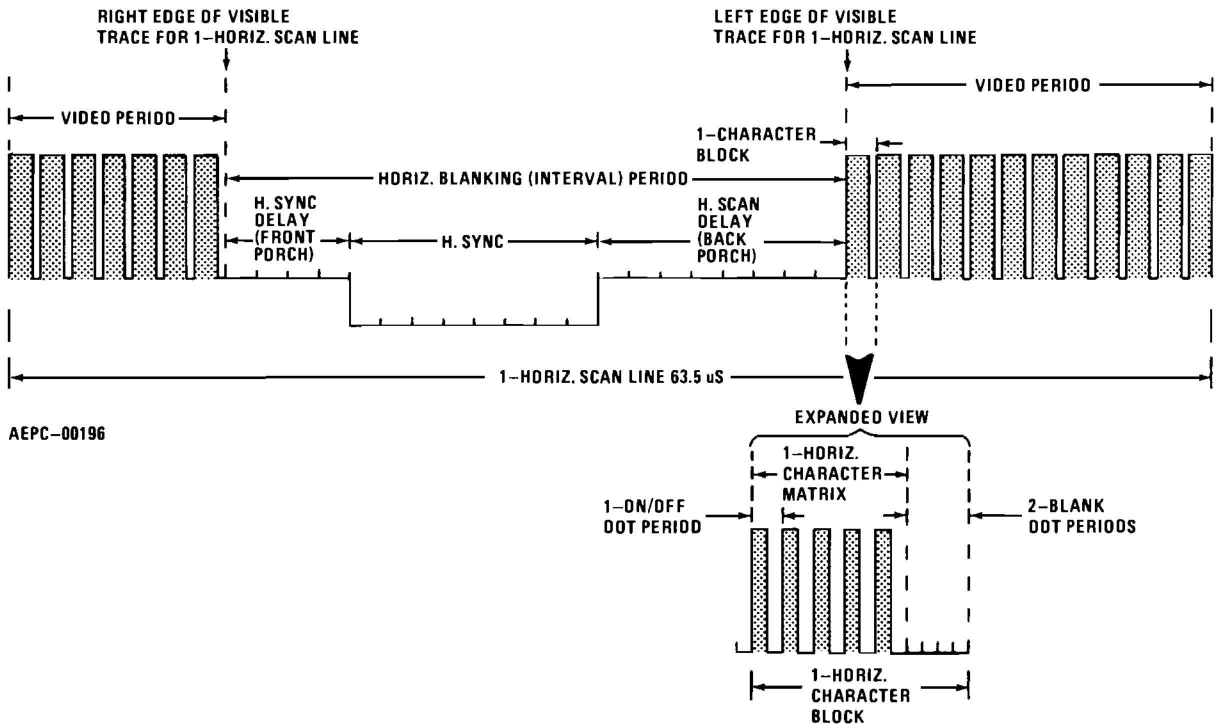


Figure 4. Terminology of a Composite "Alphanumeric Character" Video Signal at a Horizontal Rate

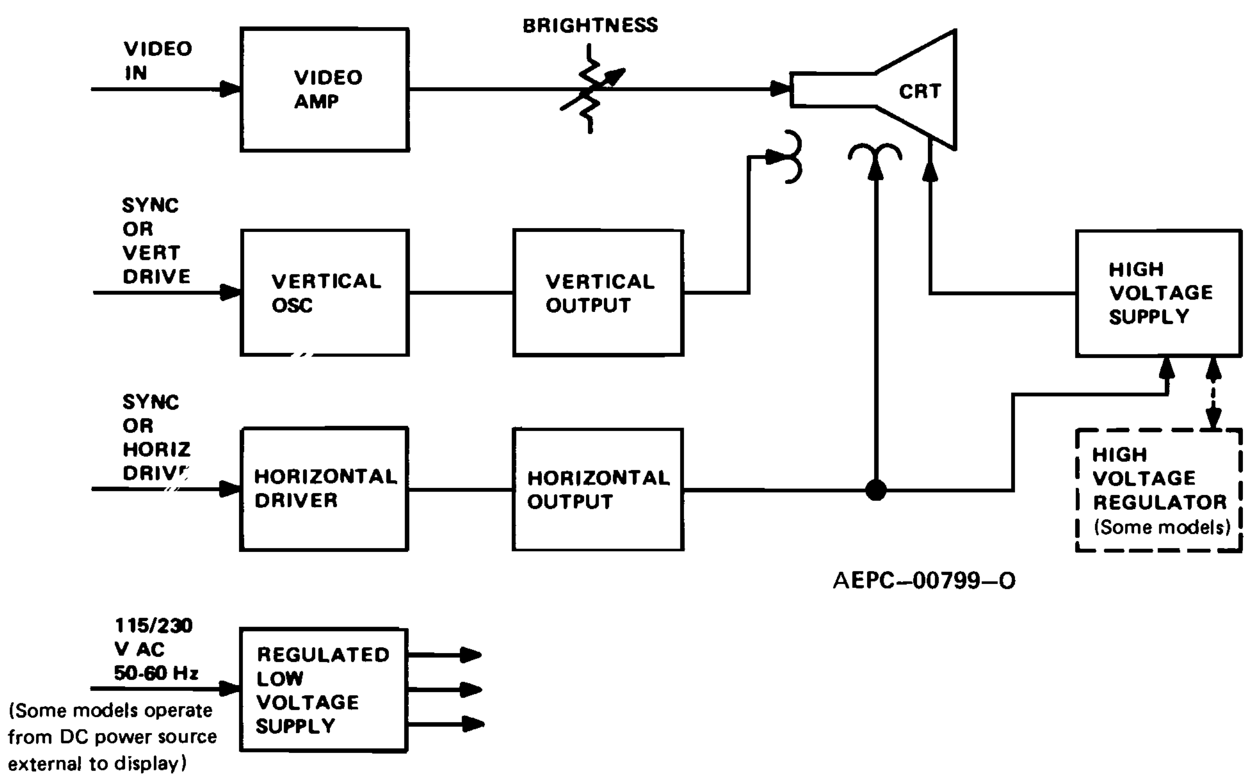


Figure 5. CRT Display Monitor – TTL Compatible System

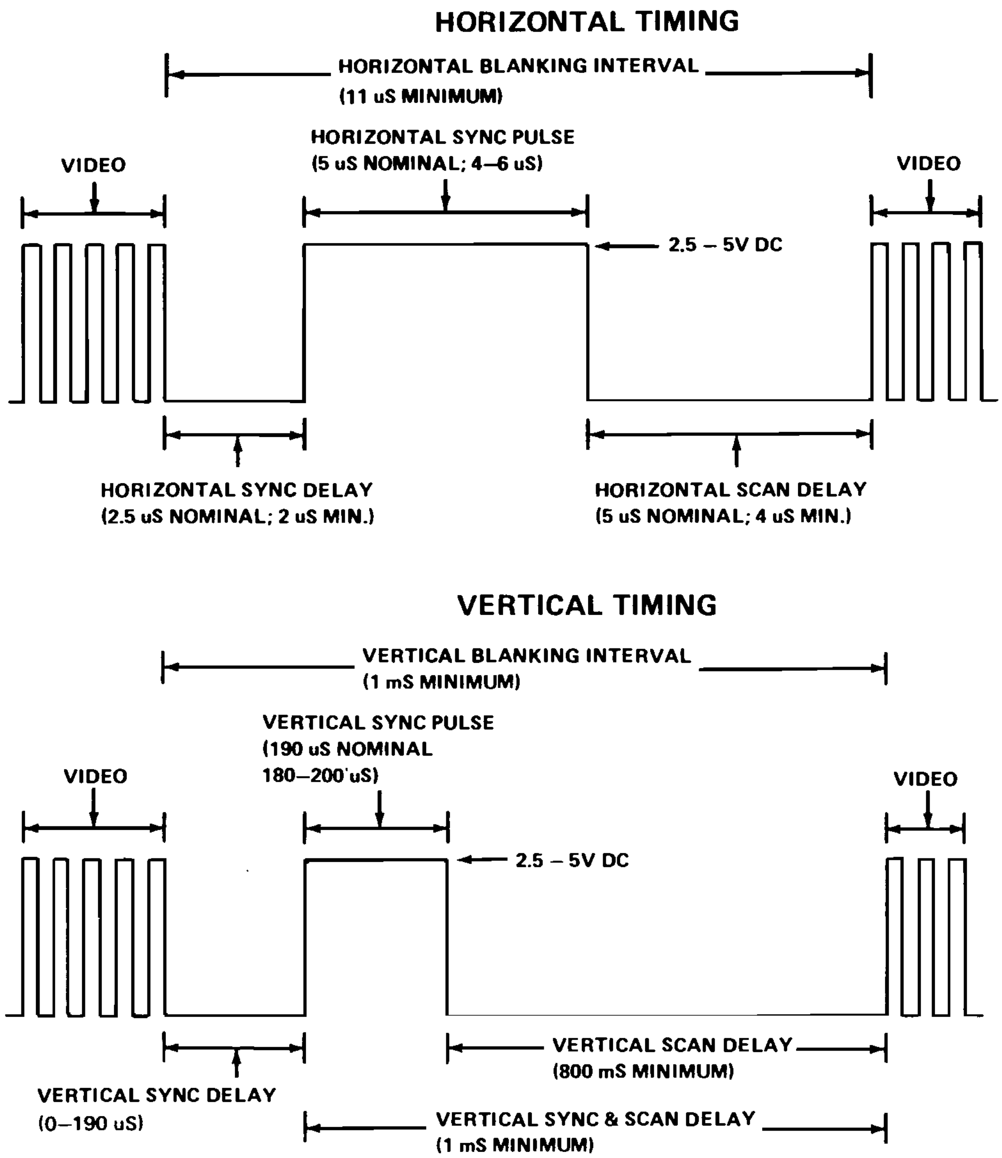


Figure 6. TTL Sync Timing

THEORY OF OPERATION

POWER SUPPLY 73V VERSION (Figure 7A)

Two basic power supplies are used in Motorola Display modules: a 73V supply for large screen applications and a 12V supply for small screen (9 inch) monitors. THE MOST COMMON TYPES WILL BE EXPLAINED HERE.

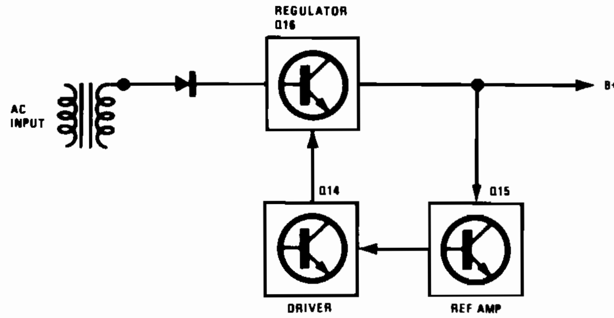
The power supply is a transformer operated, full wave, regulated supply which maintains constant output voltage with input variations of $\pm$15%. A switch (SW1) is provided to allow operation from 115/230 volts, 50/60 Hz AC. The regulator is a series pass circuit. Q16 is the series pass transistor, Q15 the reference amplifier and Q14 the output driver.

The output voltage of the regulator appears at the emitter of Q16. This voltage is divided between R71, R74 and R73. The voltage appearing on the arm of potentiometer R74 is a reference input to the base of Q15.

A temperature compensated Zener diode (D6) is used to establish a fixed reference voltage at the emitter of Q15. R72 provides a bias current for D6, establishing its operating point.

An increase in output voltage results in an increase of voltage at the base of Q15. Since the emitter of Q15 is held at a fixed reference voltage, the change in base voltage will turn Q15 on harder, reducing its collector voltage. This reduces forward bias for Q14 resulting in less emitter current and less base current for Q16. Q16 will conduct less, lowering the output voltage.

R79 provides a shunt current path for Q16 allowing it to run cooler, improving reliability. C44 is an RF noise filter.



Power Supply Block Diagram

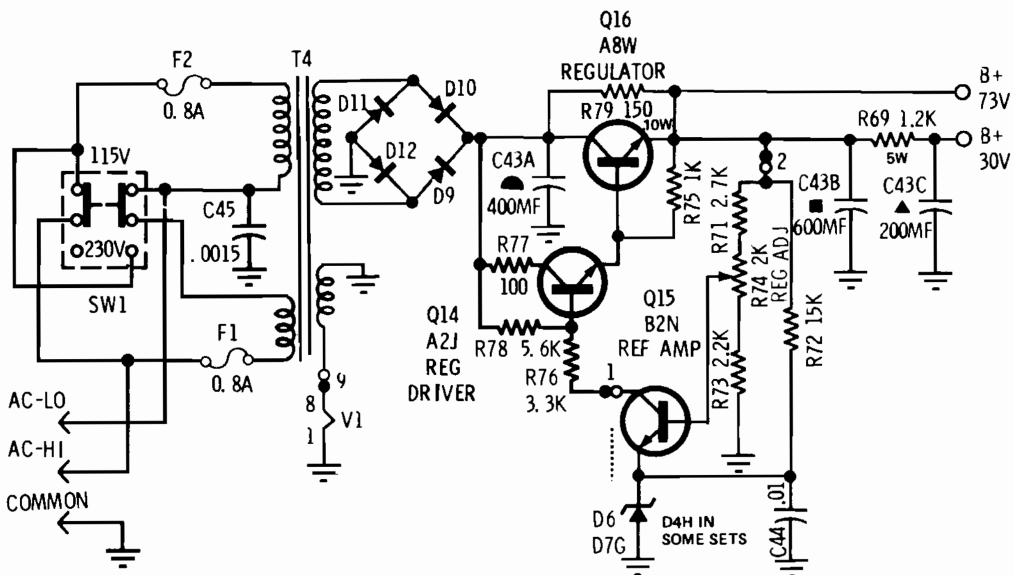


Figure 7A. Power Supply (+73V Version)

POWER SUPPLY 12V VERSION (Figure 7B)

Operationally the 12 volt supply is similar to the 73 volt version just discussed.

The IC replaces the temperature compensated Zener diode, reference and regulator driver circuitry. Its IC operating voltage is supplied by diode D105 and capacitor C101 and the power transformer winding.

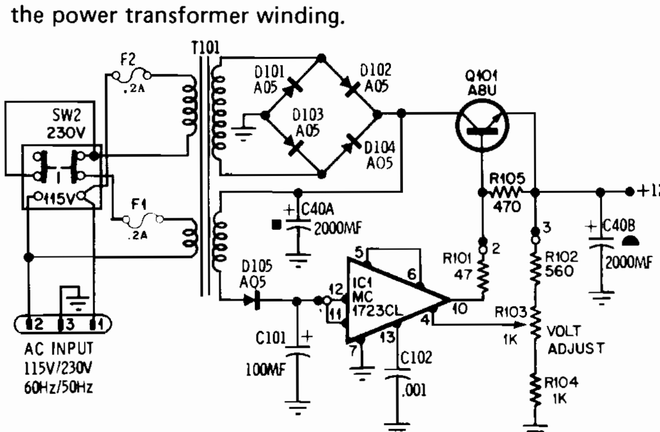
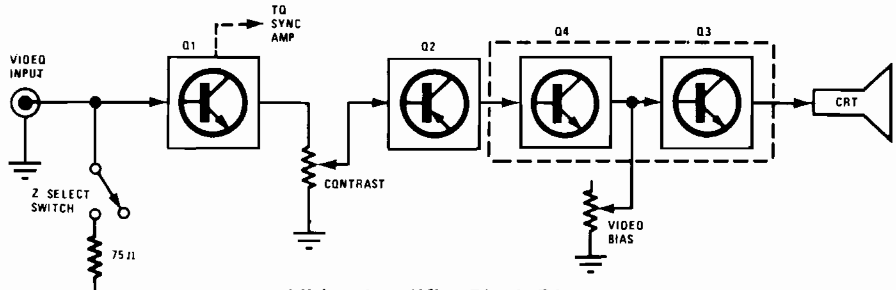


Figure 7B. Power Supply (12V Version)

VIDEO AMPLIFIER (Figure 8A & 8B)

The video circuit is a wide band transistorized amplifier utilizing up to four stages with a capability of 60 volts output for .5 volts input, (2.5V P-P Max). On some models the input impedance is switch selected for 75 ohms terminated or 12K unterminated. The high impedance operation permits use of bridging connections to drive a number of monitors from a common signal source. The frequency response within 3 db from 10 Hz to 15 MHz and, depending on CRT type, is capable of up to 800 lines resolution at the CRT center.

The first stage (Q1) is an emitter follower. It provides impedance matching and couples the input to the low impedance load. Its emitter resistor R5 is a low resistance control which provides an adjustable low impedance drive signal without the need for frequency compensation. On composite video models, sync information is removed at the collector, and C3 provides high frequency roll off to limit the collector bandwidth to the synchronizing signals, (50/60 Hz vertical and up to 20 kHz horizontal). C1 provides DC blocking, permitting Q1 to be base biased. The



Video Amplifier Block Diagram

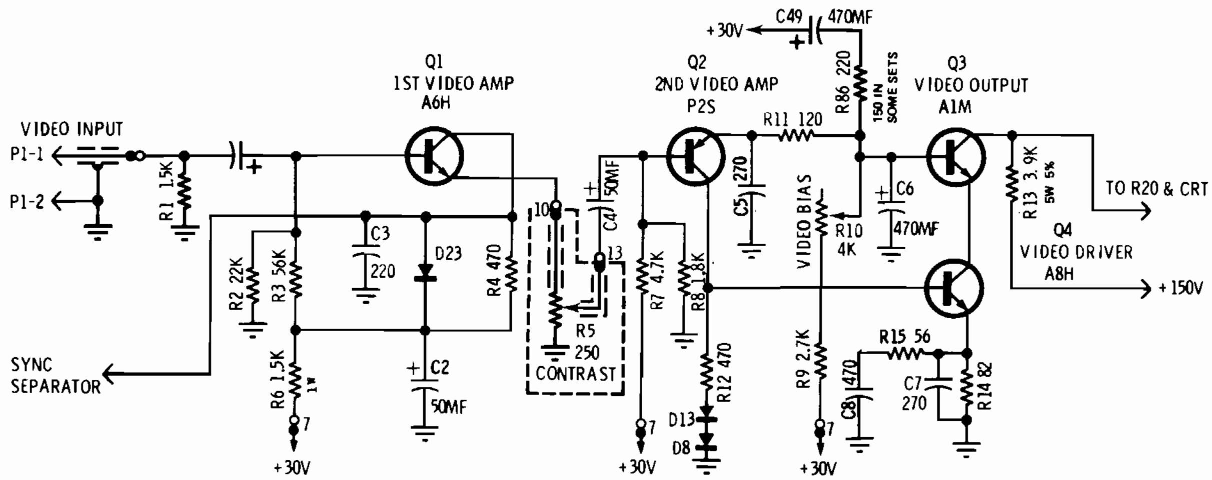


Figure 8A. Video Amplifier Composite Input

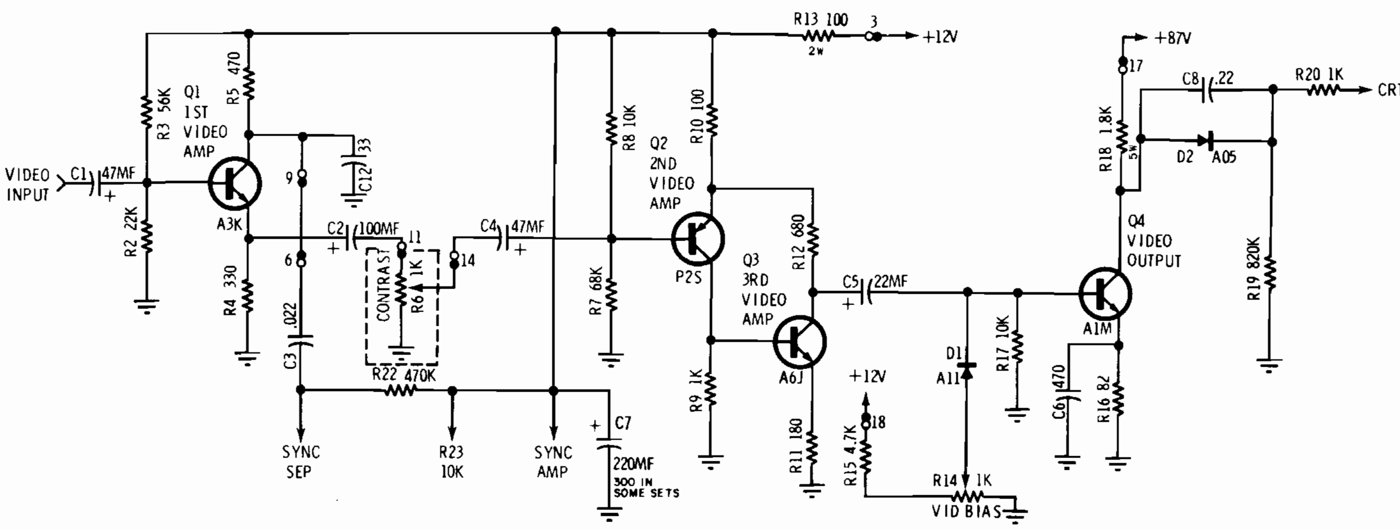


Figure 8B. Alternate Video Amplifier

video signal is coupled from the contrast control by C4 to the base of amplifier Q2 which is operated common emitter. The emitter of Q2 and base of Q3 are AC grounded by capacitor C6. Bypass capacitor C5 is used for frequency compensation increasing Q2 gain at high frequencies. The output is DC coupled to the base of the common emitter stage Q4. The output stages Q3 and Q4 form a Cascode pair which is used in place of a single output stage to obtain a high gain bandwidth by reducing the input capacity or "Miller effect". As a result of an increase in temperature, the emitter base drop of Q4 decreases, causing an increase of collector current. The forward drop of D8 and D13, both silicon diodes, decreases with an increase in temperature. This results in a lower base voltage for Q4, cancelling variations of Q4 collector current with temperature. The video bias control R10 is used to set the quiescent collector voltage of the output stage.

DC restoration is accomplished by setting this control so the sync tips, which are negative going at the collector of Q3, just go into saturation. Variations in the video drive will result in variations of Q2 base current during sync time due to the low load reflected back to Q2 when Q3 is saturated. The charge on C4 will depend on the amplitude of

INPUT IMPEDANCE (Z) SELECTOR SET Z SWITCH ON MONITOR TO:

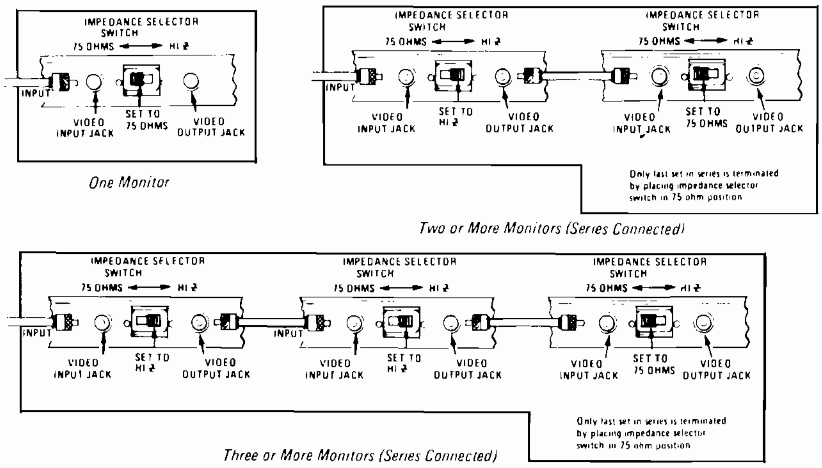


Figure 9. Impedance Switch Arrangement

Q3 collector current during sync time. The result is a clamping action which holds the sync tips at a constant level despite video input signal variations. The output is DC coupled to the CRT through R18 which isolates the output stage from transients should they occur as a result of CRT arcing. C5, C7, C8 and R15 are used for high frequency compensation.

NOTE: Some models differ from the above circuit in the number of stages, CRT coupling, absence of the input switch or contrast control. The sync take off is not used on models with external sync input. (See Figure 8B.)

VIDEO INPUT Z SWITCH (ON MODELS DESIGNED FOR SERIES INSTALLATION) (Figure 9)

The impedance switch provides a means of selecting input impedance for one or more monitors if used in series. Set impedance switch to position shown for number of monitors used as illustrated in Block Diagram.

Resistor R100 (75 ohms) is switched in to terminate last set.

SYNC SEPARATOR (Figure 10)

The function of the sync separator is to receive the composits video signal and separate the sync pulses, discarding all other information. When a signal is applied to the base of Q5, it is driven positive causing electrons to flow from emitter to base, charging C11. As the input signal drops, a charge remains on C11 because its only discharge path is through the high resistance of R24, since the transistor is cut off at this time and its base has stopped drawing current. When the next sync pulse arrives it must overcome the residual charge voltage on C11 which is holding the transistor in cutoff. Between pulses (horizontal scan time) some of the charge will be lost through R24, but it is somewhat less than the height of the sync pulse. The amount of charge lost by C11 will determine when the transistor is turned on. Q5 conducts only when C11 is charging, while video information is blocked by C11's residual voltage which is holding Q5 in cutoff at that time. The charge amplitude depends on the peak-to-peak input to Q5 and thus makes the bias for Q5 track the amplitude of the input signal, allowing only the positive peaks (sync pulses) to be amplified.

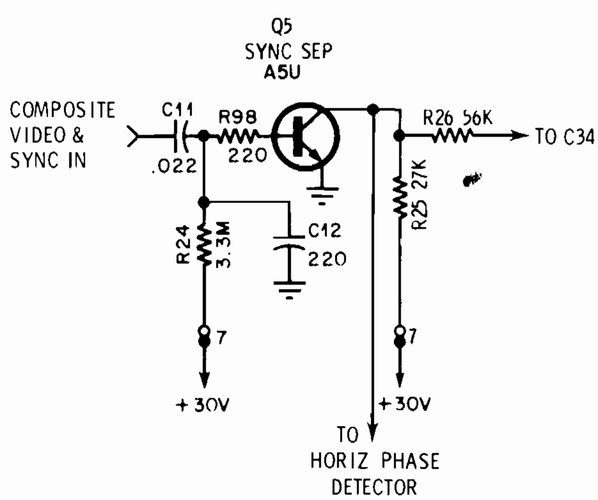
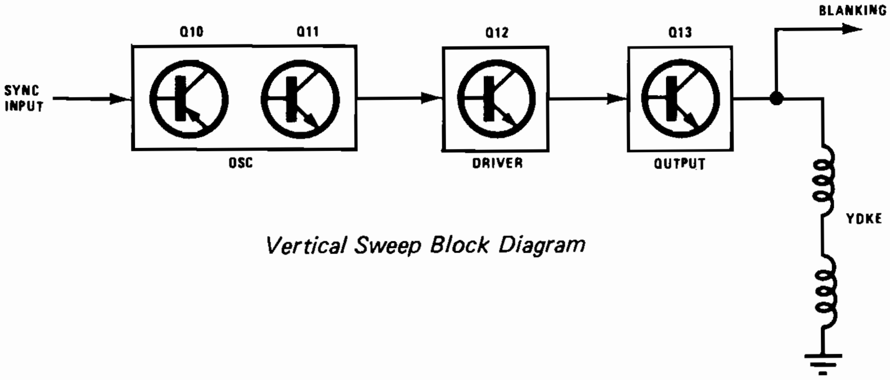
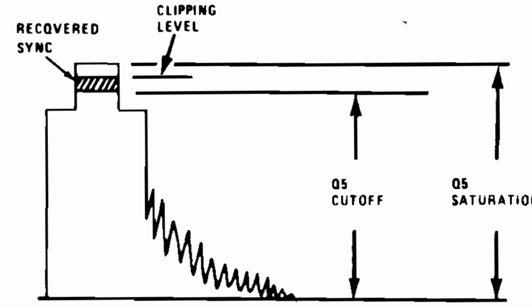


Figure 10. Single Stage Sync Circuit



Vertical Sweep Block Diagram



Sync Waveform Analysis

VERTICAL CIRCUITRY (Figure 11)

Sync pulses from the collector of sync separator Q5 are integrated by R26 and C35; then applied to the base of VERT. OSC 1, Q10, as negative-going pulses. Transistor Q10, along with Q11 (VERT. OSC 2), are connected as a regenerative switch. To start operating, the series combination of capacitors C37 and C38 charges through R65, R56, R58, D3, and R99 until Q10 turns on. This occurs when the charge voltage applied to the emitter of Q10 exceeds its base voltage. The resultant current flow to the base of Q11 turns that device on. With both Q10 and Q11 conducting, C37 and C38 discharge to near zero, which causes Q10 and Q11 to turn off. At this point the cycle will repeat. The repetition rate for the charge and discharge of C37 and C38 is controlled by the bias on the base of Q10, which is the result of the VERT. HOLD control (R83) setting.

The waveform applied to the base of Q12 is a positive-going ramp or sawtooth with a fast retrace to zero. VERTical SIZE control R65 varies the P-P amplitude of the sawtooth. Diode D3 provides a small incremental voltage above ground to compensate for the base-emitter voltage drop of Q12, which keeps Q13 from being driven too far into cutoff.

Transformer T3 matches the collector of Q13 to the vertical deflection yoke. When Q13 is cut off during vertical retrace, a high voltage positive pulse is developed across the primary of T3. To limit this pulse to a safe value, varistor R81 is connected across the primary of T3, with R66 and C41 providing damping. Since the primary impedance of T3 decreases with current, the degree to which the primary shunts the reflected load impedance varies with collector current. This would result in severe vertical non-linearity unless some compensation is employed.

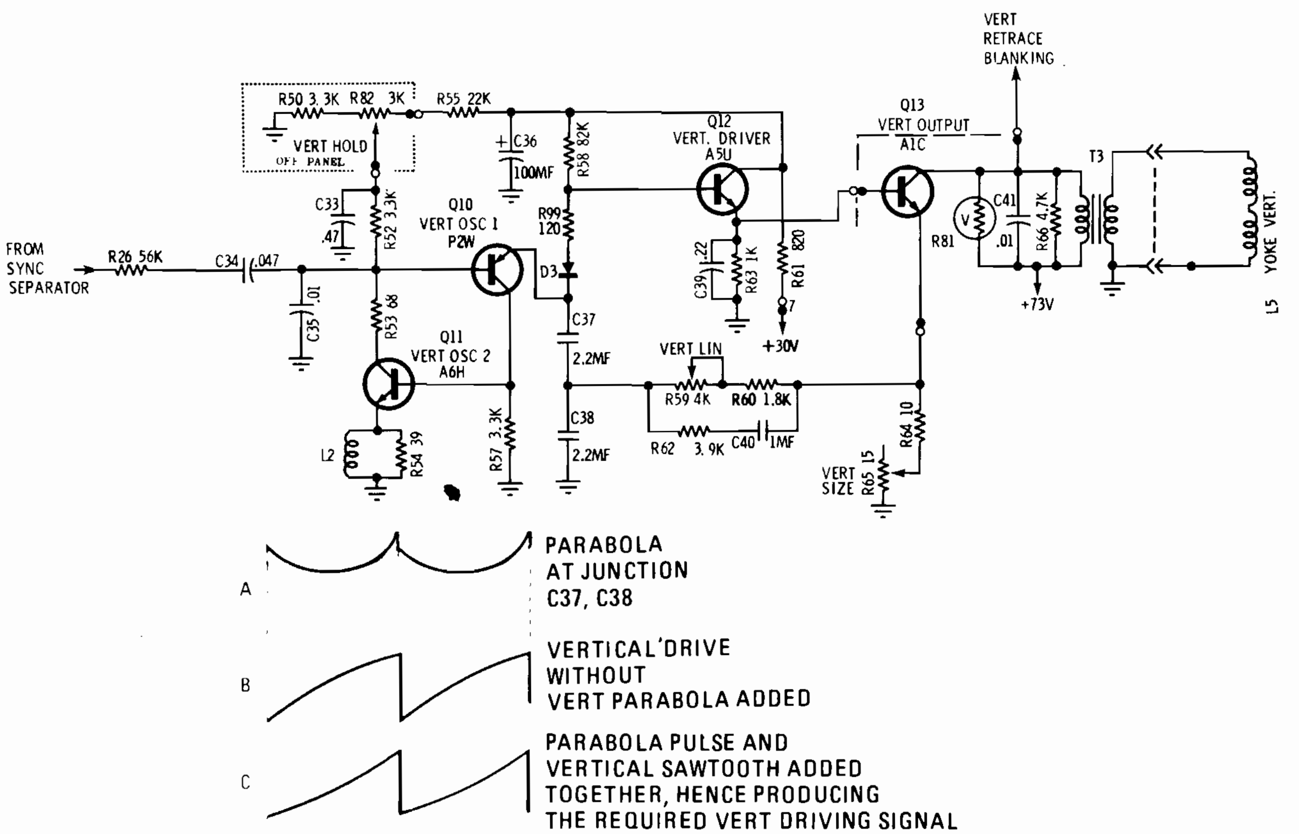


Figure 11. Vertical Circuit

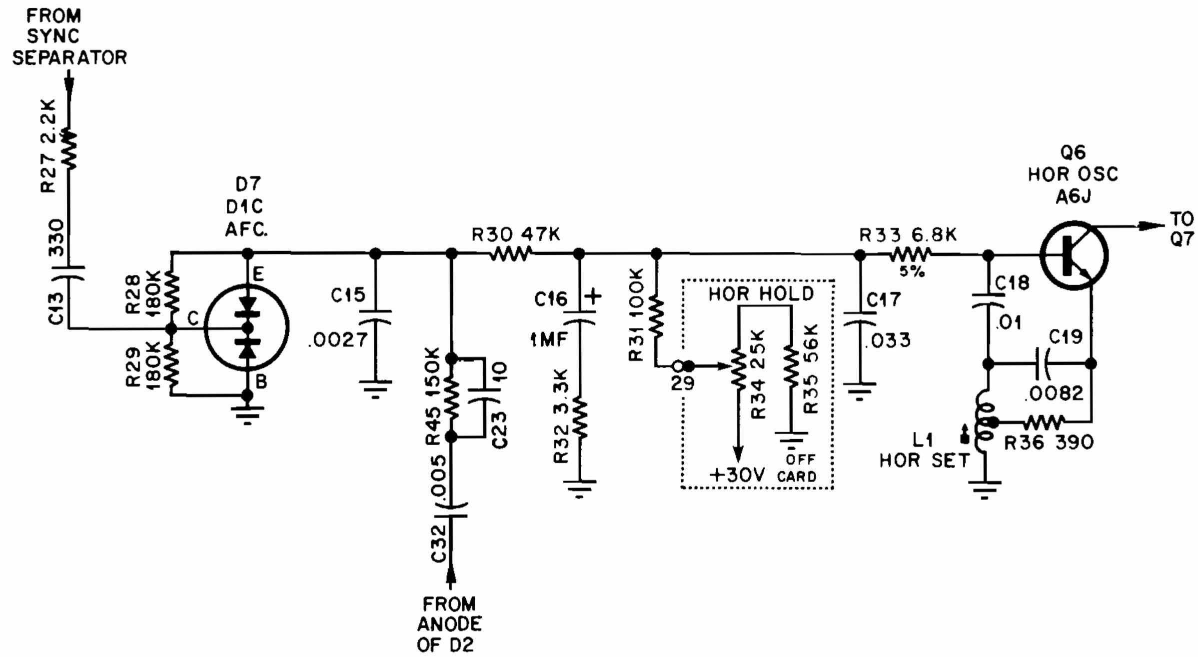


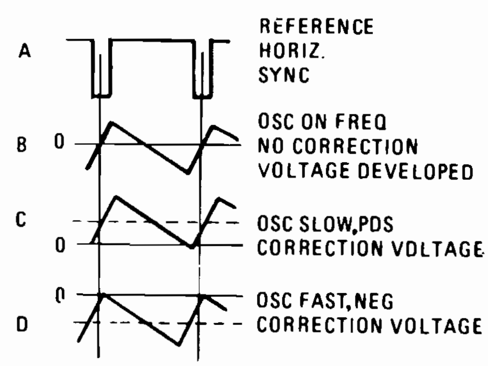
Figure 12. AFC and Horizontal Oscillator Circuit

Part of the sawtooth voltage waveform, from the emitter of Q12 is coupled back to the junction of C37 and C38 via R59 and R60. Since this path is resistive, the waveform will be integrated into a parabola waveform by C38 (waveform A). Ths results in a predistortion of the drive sawtooth (waveform C). (Waveform B illustrates the drive sawtooth without parabola shaping.) Parabola shaping is necessary to compensate for the non-linear charging of C37 and C38 and the changing impedance in the primary of T3. An additional feedback path through R62 and C40 serves to optimize the drive waveshape for best linearity.

HORIZONTAL CIRCUITRY

Phase Detector (AFC) (Refer to Figure 12)

The phase detector consists of two diodes in a keyed clamp circuit. Two inputs are required to generate the required output, one from the sync separator, Q5, and one from the horizontal output circuit, Q9. The required output must be of the proper polarity and amplitude to correct phase differences between the input horizontal sync pulses and the horizontal time base. The horizontal output (Q9) collector pulse is integrated into a sawtooth by R45 and C15. During horizontal sync time, both diodes in D7 conduct, which shorts C15 to ground. This effectively clamps the sawtooth on C15 to ground at sync time. If the horizontal time base is in phase with the sync (waveform A), the sync pulse will occur when the sawtooth is passing through its AC axis and the net charge on C15 will be zero (waveform B). If the horizontal time base is lagging the sync, the sawtooth on C15 will be clamped to ground at a point negative from the AC axis. This will result in a positive DC charge on C15 (waveform C). This is the correct polarity to cause the horizontal oscillator to speed up to correct the phase lag. Likewise, if the horizontal time base is leading the sync, the sawtooth on C15 will be clamped at a point positive from its AC axis. This results in a net negative charge on C15, which is the required polarity to slow the horizontal oscillator (waveform D). Passive components R30, C17, C16 and R32 comprise the phase detector filter. The bandpass of this filter is chosen to provide correction of horizontal oscillator phase without ringing or hunting. Capacitor C23 times the phase detector for correct centering of the picture on the raster.

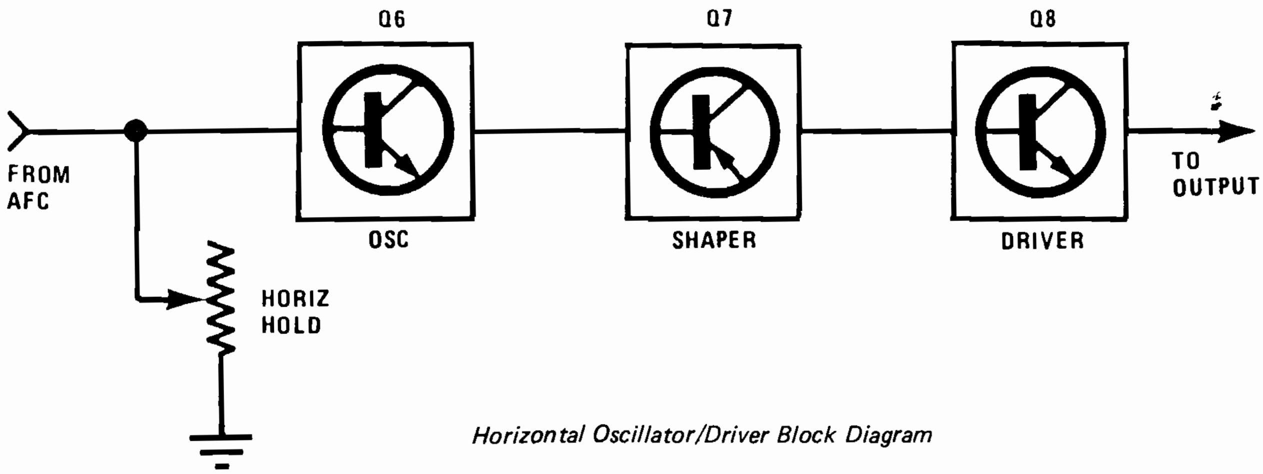


Horizontal Oscillator (See Figure 12)

The horizontal oscillator consists of Q6, which is employed as a modified type of Hartley oscillator. The operating frequency of this oscillator is sensitive to its base input voltage. This permits control by the output of the phase detector and the setting of the HORIZ. HOLD control, R34. Resistor R31 provides DC bias to turn on Q6 and start the oscillator. The free-running horizontal frequency is adjusted with the HORIZ. SET coil, L1.

– NOTE –

Some models utilize an integrated circuit (IC) being essentially a voltage controlled oscillator with variable mark-space ratio (duty cycle) and internal voltage reference. The output of the IC is a square wave of proper frequency and duration and is applied to the base of the horizontal driver.



Horizontal Oscillator/Driver Block Diagram

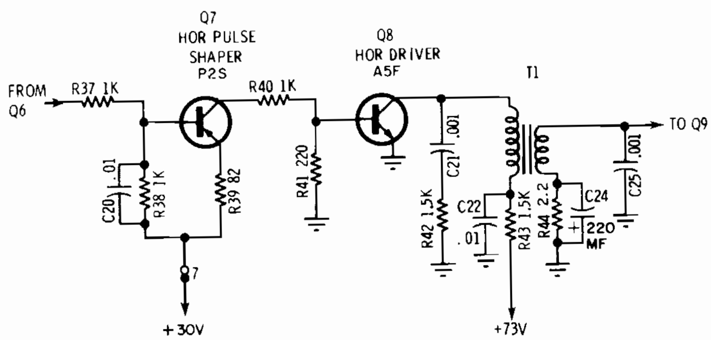


Figure 13. Pulse Shaper and Horizontal Driver

Pulse Shaper & Horizontal Driver (Figure 13)

Transistor Q7 is a buffer stage between the horizontal oscillator and horizontal driver. It provides isolation for the horizontal oscillator as well as a low impedance drive for the horizontal driver. Components R38 and C20 form a time constant that shapes the oscillator output to the required duty cycle, approximately 50%, to drive the horizontal output circuitry. The horizontal driver stage, Q8, operates as a switch to drive the horizontal output transistor (Q9) through T1. Because of the low impedance drive and fast switching times furnished by Q7, very little power is dissipated in Q8. Components C21 and R42 provide damping to suppress ringing in the primary of T2 when Q8 goes into cutoff.

HORIZONTAL OUTPUT (Figures 14 A & B)

This stage must be capable of developing both a sawtooth of current thru the horizontal deflection coils and a high voltage pulse for the high voltage rectifier (not shown). In order for a transistorized horizontal output stage to perform these functions properly, we must drive it with a

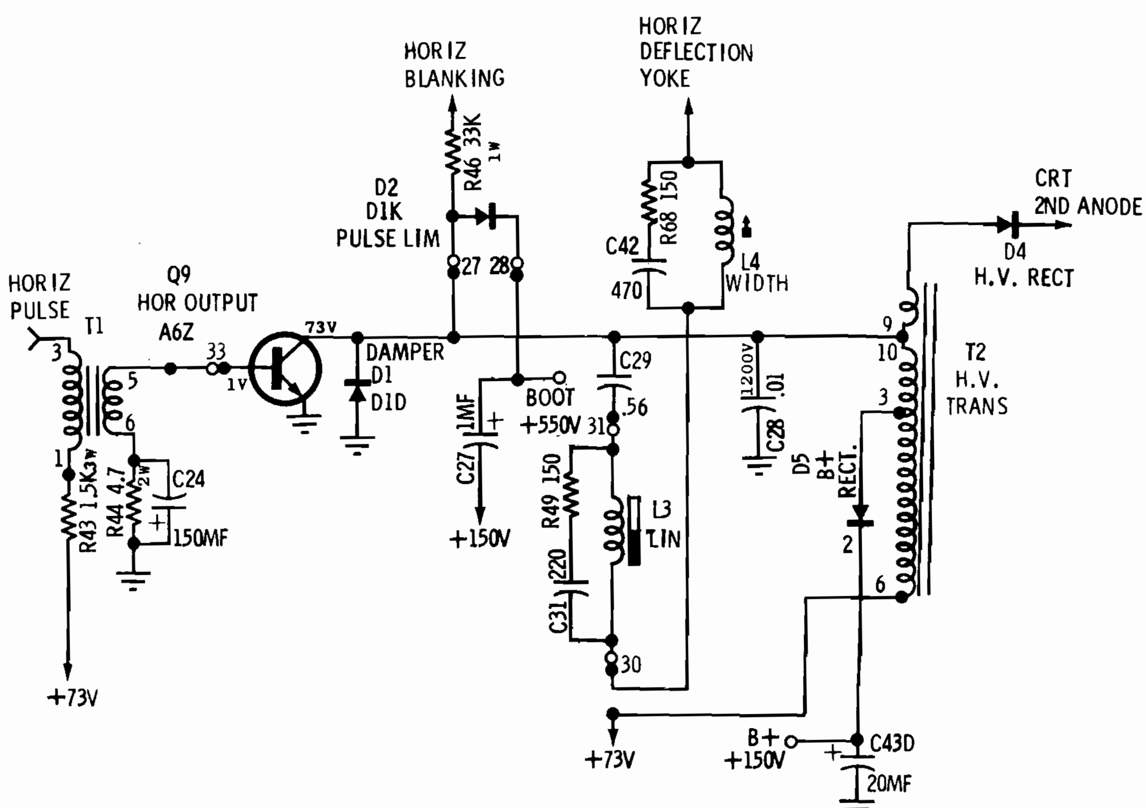


Figure 14A. Complete Horizontal Output Circuit

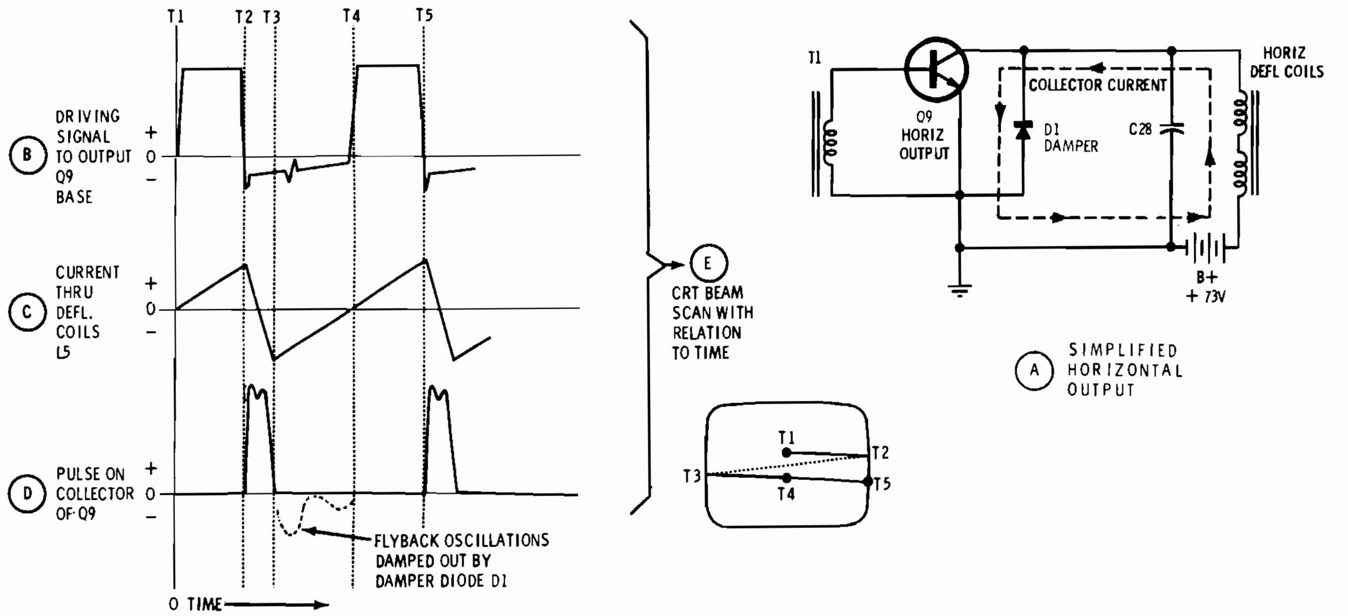


Figure 14B. Waveform Analysis of Horizontal Output Circuit

square wave of voltage. A square wave is needed because the circuit is almost purely inductive. The circuit is virtually absent of resistance because the output transistor, Q9 exhibits only a fraction of an ohm when driven into saturation by the driving signal. Since the only impedance left in the circuit now is the yoke and flyback (high voltage transformer), the circuit is primarily inductive.

Q9, the horizontal output transistor, is simply a switch which is turned on and off at a horizontal scan rate by the driving signal applied to its base. Shown with respect to time, (B) driving signal applied to base of Q9, (C) current thru deflection coils, (D) pulse appearing on collector of Q9 during retrace and (E) CRT scan relative to time.

A simplified diagram of the horizontal output showing collector current when the output transistor Q9 is turned on is illustrated in Figure 14B.

(B) shows the drive voltage applied to the base of Q9. From T1 to T2, the input signal turns on Q9 and drives it into saturation. In this condition, the emitter/collector resistance is reduced to a fraction of an ohm, thus simulating a closed switch. During this time (C) illustrates the flow of current from zero to maximum through the yoke (horizontal deflection coils) in a direction to move the beam from the center of the screen to the right side.

At T2, Q9 is driven sharply into cutoff, thereby initiating horizontal retrace. Between T2 and T4, Q9 is driven into cutoff, and the current supplied to the deflection coil ceases. However, an induced voltage appears across the deflection coils as the magnetic field collapses and an oscillation then occurs between the deflection coils and C28. The damper diode, D1, then conducts on the negative ring of this oscillation and the beam is returned to the center of the screen at a linear rate.

It is important to note here that Q9 conduction causes scan which starts at the CRT center to the right edge and damper D1 conduction causes scan from the left edge to the CRT center.

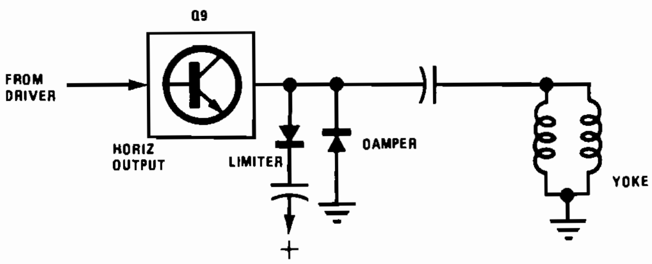
From T2 to T3, the direction of current through the yoke is shown in (C). During horizontal retrace, the current rises to a high value in the reverse direction causing retrace which quickly returns the beam to the left side of the screen. Then, from T3 to T4, the yoke current gradually decreases to zero during damper conduction allowing the beam to return to the center of the screen. The beam movement relative to time is illustrated in (E).

From T4 to T5, Q9 is turned on by the driving signal on its base, thus causing current to rise (C) at a sawtooth rate. This rising current produces an increasing magnetic field in the yoke which will deflect the beam from the center of the screen to the right side.

When the beam reaches the right side of the screen, Q9 is abruptly cut off causing retrace and again, repeating the sequence of events.

(D) indicates the collector voltage waveform of Q9. The instant Q9 is switched off, the collapsing magnetic field produces a positive pulse. This pulse is stepped up by the flyback transformer (not shown) and rectified to produce the required high voltage to accelerate the CRT beam toward the screen.

Transistors require bias to turn on and, if you will note, the horizontal output stage has no DC voltage paths to its base to form the required emitter/base forward bias for turning on. Q9 will turn on when the driving signal on its base is positive enough to forward bias it, therefore, no harm will



Horizontal Output Block Diagram

be done to the horizontal amplifier stage in the event we lose drive. This is a good thought to keep in mind when servicing the horizontal sweep system.

The secondary of T1 provides the required low drive impedance for Q9. R44 and C24 form a time constant for fast turn-off of the base of Q9. The transition of time between saturation and cut off is very critical. If this time is too long, the maximum collector dissipation would be exceeded. To alleviate this undesirable condition, we incorporate this network in the base circuit.

Q9 operates as a switch which, once each horizontal period, connects the supply voltage across the parallel combination of the horizontal yoke and the primary of T2. The required sawtooth of deflection current through the horizontal yoke is formed by the L-R time constant of the yoke and output transformer primary. The damper diode, D1, conducts during the period between retrace and turn on of Q9. A second diode, D2, is employed as a pulse limiter/boost rectifier. The horizontal retrace pulses charge C27 through D2 providing a DC supply voltage for use at the CRT. Should momentary transients appear at the collector of Q9, they will be limited to the voltage on C27 since D2 will conduct if the collector voltage rises to this value.

C28 is used to tune the retrace pulse to the proper frequency. C43D is charged through D5 developing the video output supply voltage. D4 serves as the high voltage rectifier supplying the DC voltage for the CRT 2nd anode. The capacity of the CRT is used to filter this voltage. Since the low side of the deflection coils are connected to ground, a capacitor, C19, is in series with the yoke, blocking DC which would decenter the raster.

The linearity of scan is critical in a monitor due to its application in reproduction of a fixed image. Two circuits are included to control linearity and width of the horizontal sweep. The width coil, L4, is adjustable and in series with the yoke. By changing the inductance of the width coil, the amount of deflection current flowing through the yoke is varied and the raster size (scan without picture information) changes in a horizontal direction. The linearity coil, L3, is a factory adjusted magnetically biased coil which shapes the deflection current for optimum trace linearity. If the yoke was a pure inductance, a sawtooth current through it would be adequate. However, to compensate for its internal resistance, the linearity coil reshapes the sweep current to compensate for system losses which could cause right side compression. C31, R49, C42 and R68 form damping network components for the linearity and width coils.

HIGH VOLTAGE REGULATOR (NOT IN ALL UNITS) (Figure 15)

In some applications, the monitor is used to reproduce information which alternates from a bright to dark picture. The horizontal output supplies the current for both scan and high voltage, and as the CRT electron beam is switched on and off, it causes changes in the loading of output trans-

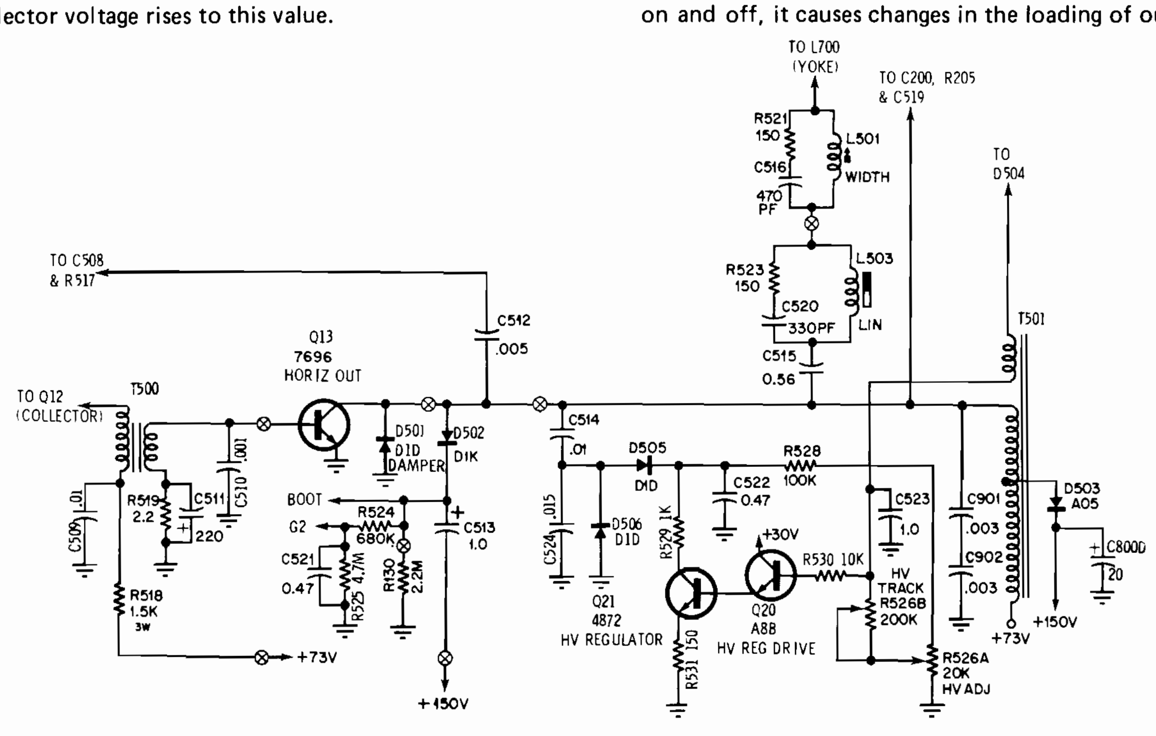


Figure 15. High Voltage Regulator

former and yoke. This can result in raster size changes (or blooming).

The regulator transistors Q20 and Q21 function as a switch and are controlled by beam current changes, and in turn control high voltage by varying horizontal retrace time. C514 and C524 are connected across Q13. The pulse voltage at the capacitor junction is rectified by D505 and D506 and is the source voltage for Q21. Sensing voltage is developed by returning the high voltage transformer secondary to ground through R526 A and B. Since CRT beam current flows through these resistors, lower beam currents will develop an increase in high voltage and also a positive voltage at the arm of R526B which is DC coupled to the base of Q20 turning it on. Since Q21 is DC coupled to the emitter of Q20 it is also turned on. Conduction of Q21 gates diode D505, effectively connecting C522 across C524. The amount of current conducted by Q21 determines the degree that C522 shunts C524. This capacity change widens the retrace pulse, reducing the high voltage. The regulator is capable of maintaining the high voltage within 200V over a 300 uA current change.

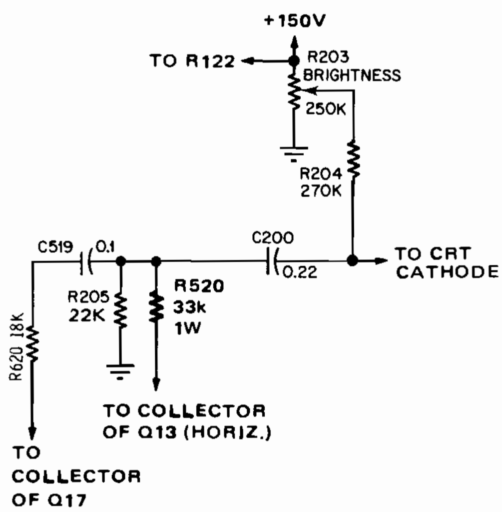


Figure 16. Retrace Blanking

RETRACE BLANKING (Figure 16)

Both vertical and horizontal retrace blanking are provided by positive pulses applied to the CRT cathode. The collector pulse from the horizontal output transistor is placed across R205 through R520. The vertical collector voltage is differentiated by C519 to remove the sawtooth portion of the waveform. The remaining pulse appears across R205. The mixed vertical and horizontal pulses on R205 are coupled to the CRT cathode by C200 and R206.

DYNAMIC FOCUS (Figure 17)

Due to the geometry of a CRT, the electron beam travels a greater distance when deflected to a corner as compared to the distance traveled at the center of the CRT screen. As a result of these various distances traveled, optimum focus can be obtained at only one point. For general applications, an adequate adjustment can be realized by setting the focus while viewing some point midway between the center of the CRT screen and a corner, thus optimizing the overall screen focus. When an application requires a tighter specification, one of the simplest methods for improvement is to modulate the focus voltage at a horizontal sweep rate. Now optimum focus voltage is made variable on the horizontal axis of the CRT, which compensates for the beam travel along this axis.

The AC component focus voltage is developed by a series resonant circuit consisting of L6 and C55. This voltage is an 80V P-P horizontal rate pulse from a tap on the horizontal output transformer, T2. The normal DC component of the G4 focus voltage is set by adjusting the FOCUS control, R17. When the DYNAMIC FOCUS coil, L6, is optimized for best edge focus, a sinusoidal voltage of approximately 200V P-P is developed across C55. This mixed AC and DC voltage results in a waveform of proper phase and amplitude, which is coupled through isolating resistor R20 to the CRT focus anode.

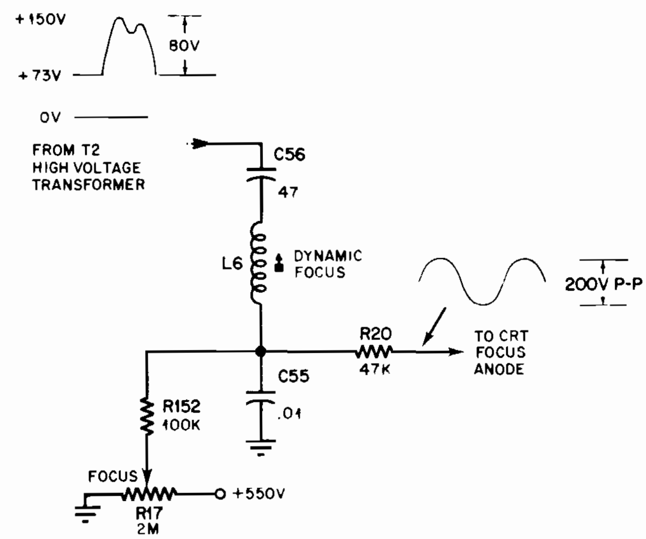


Figure 17. Dynamic Focus

LOW VOLTAGE LOGIC POWER SUPPLY (Figure 18)

An available option for some models is the low voltage logic power supply. It is used when a remote power source is required for logic interface circuitry at the CRT monitor installation site.

The power supply is capable of delivering three separate full-wave bridge, regulated output voltages with separate and/or common ground bus (two 12V outputs and one 5V output). The 5V output includes an overvoltage protection (crowbar) circuit.

+5 VOLT SUPPLY

When the output of the 5V supply attempts to increase, the voltage at pin 2 of IC1 attempts to rise also through the divider network D8, R4, R5 and R42. The voltage at pin 3 of IC1 is maintained at a constant 3 volts lower than supply voltage by zener diode D9. Therefore, a greater potential difference will exist between pins 2 and 3 of IC1. The re-

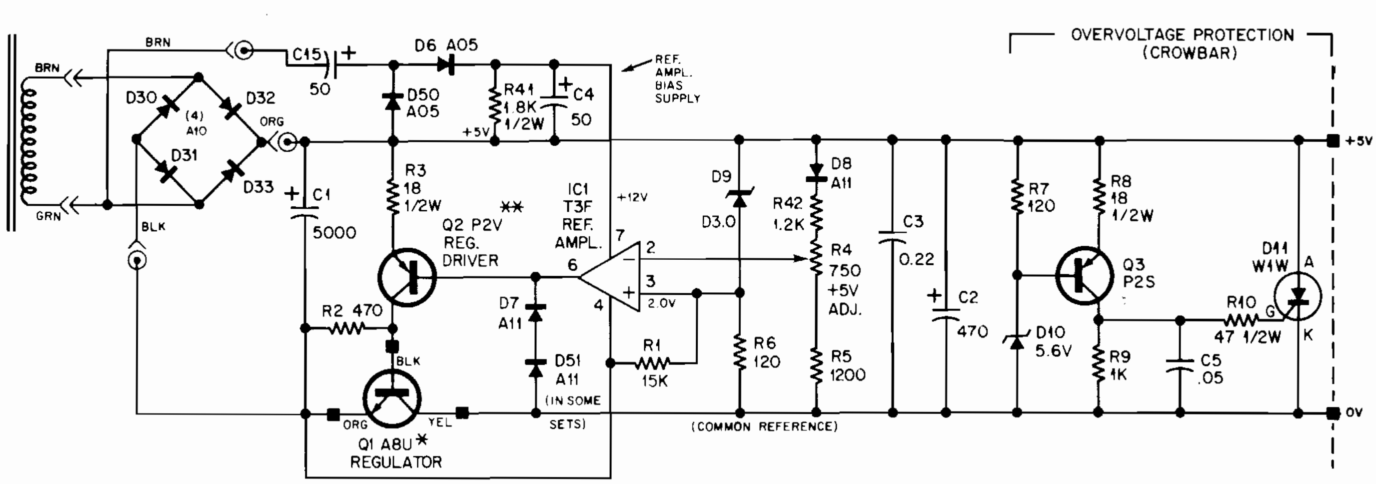


Figure 18. Low Voltage Logic Power Supply

ference amplifier will register a decrease in voltage at pin 6 and the base of Q2, causing Q2 to conduct less. The resulting decrease in emitter current will create a larger voltage drop across R3 and, consequently, a lower voltage at the base of Q1. This reduces the bias of Q1, causing it to conduct less, and producing a larger voltage (collector to emitter – VCE) on Q1. This voltage on Q1 will correspond directly to the attempted increase in output voltage. Therefore, the voltage at the output terminals will remain constant.

Conversely, a decrease in supply voltage produces the opposite effect.

R2 provides the collector load for Q2 while C3 filters high frequencies from the supply voltage and C2 acts as a low frequency filter.

Overvoltage Protection Circuit (Crowbar)

Transistor Q3 will turn on when the output of the supply exceeds both the zener diode voltage (D10), and the base-to-emitter voltage of Q3. The collector current that flows through R9 will cause a positive voltage to be present at the gate of D11. The SCR will "Latch" on, shunt a portion of the output current to the supply return buss, and cause the supply voltage to decrease to approximately one volt.

The overvoltage circuitry will "reset" itself when the power to the supply is removed.

Short Circuit Mode Protection

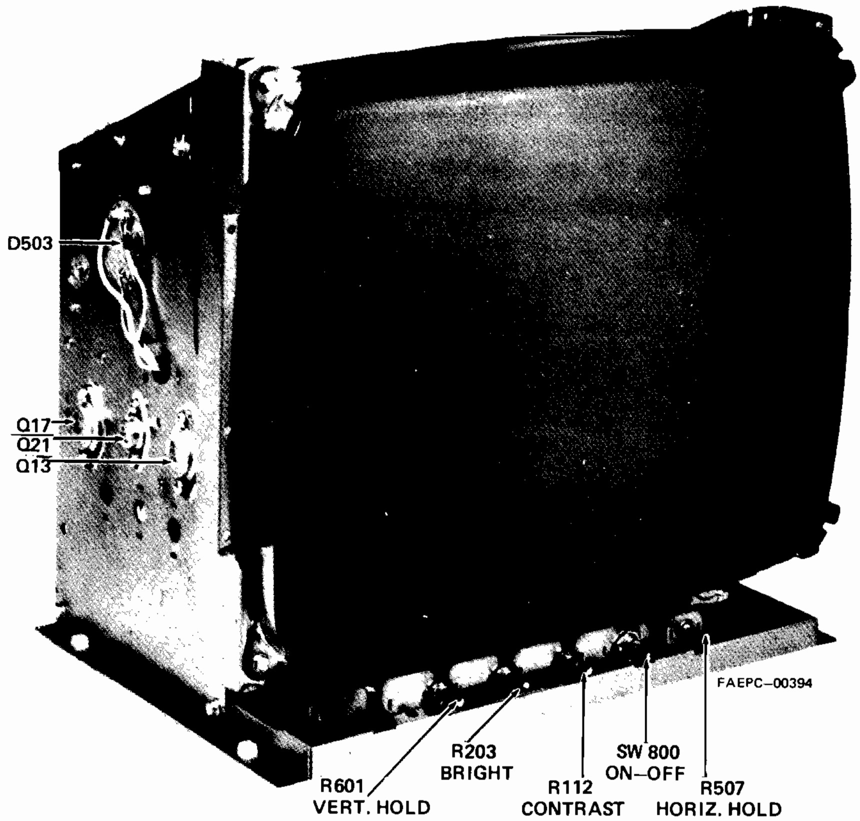
Should a short be present at the output terminals of the supply, the Reference Amplifier will tend to turn transistor Q2 off and Q1 on. Diodes D7 and D51 will clamp the voltage at pin 6 of IC1 to 1.4 volts below the negative buss and limit the forward bias of Q1 and, hence, the amount of short circuit current that will flow through the transistor.

Diode D51 (on some sets) is used when a large capacitance load is inherent to some logic circuitry. The filter capacitors present an instantaneous short across the supply when the supply is first turned on. The magnitude of the short circuit current for this condition is such that Q2 will tend to remain off and Q1 on. The series combination of D51 and D7 prevents Q2 from remaining off during the time when the logic circuitry capacitors are charging.

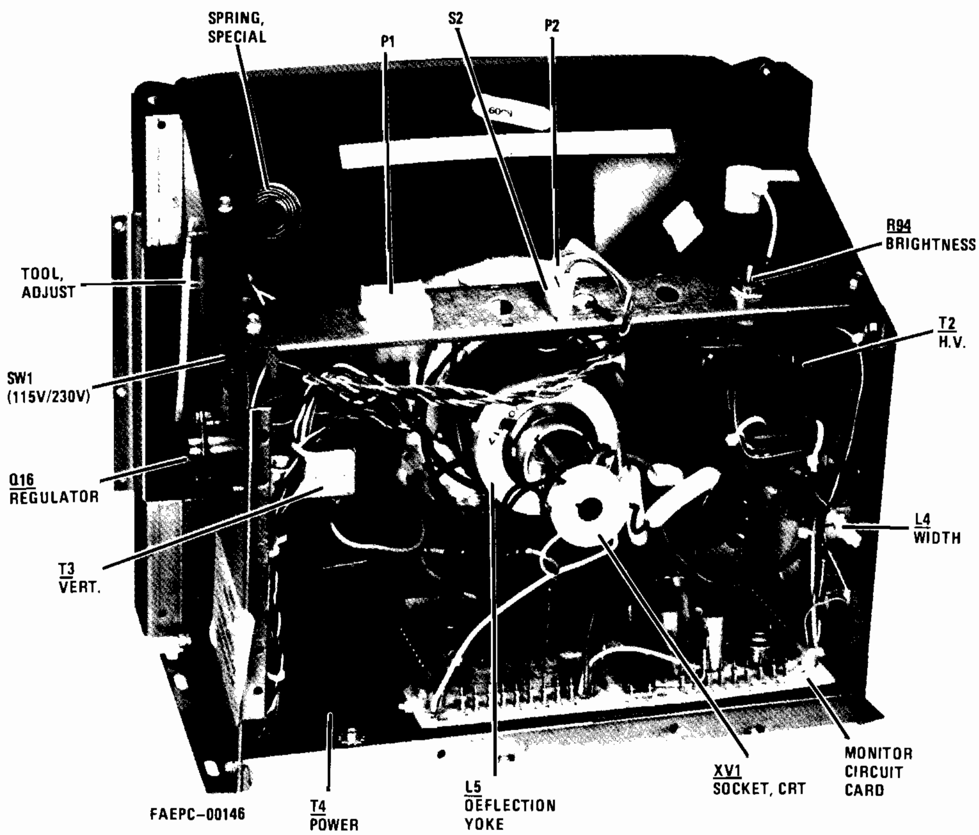
Output Voltage Adjustment

The 5 volt adjust, R4, is initially adjusted for the proper output voltage with the designed load across the output terminals.

• • •



Typical Chassis (Front View)



Typical Chassis (Rear View)

SERVICING . . .

Two important aspects of any electronic product are reliability to keep you "in business" and Serviceability to minimize your "down time".

Motorola's commitment to serviceability includes: plug in panels, quick replacement CRT, plug in power transistors, and easy access test points which are all incorporated into the design on most models.

The Motorola Display is also backed by factory service and parts . . .information and parts direct to you . . . when you need it.

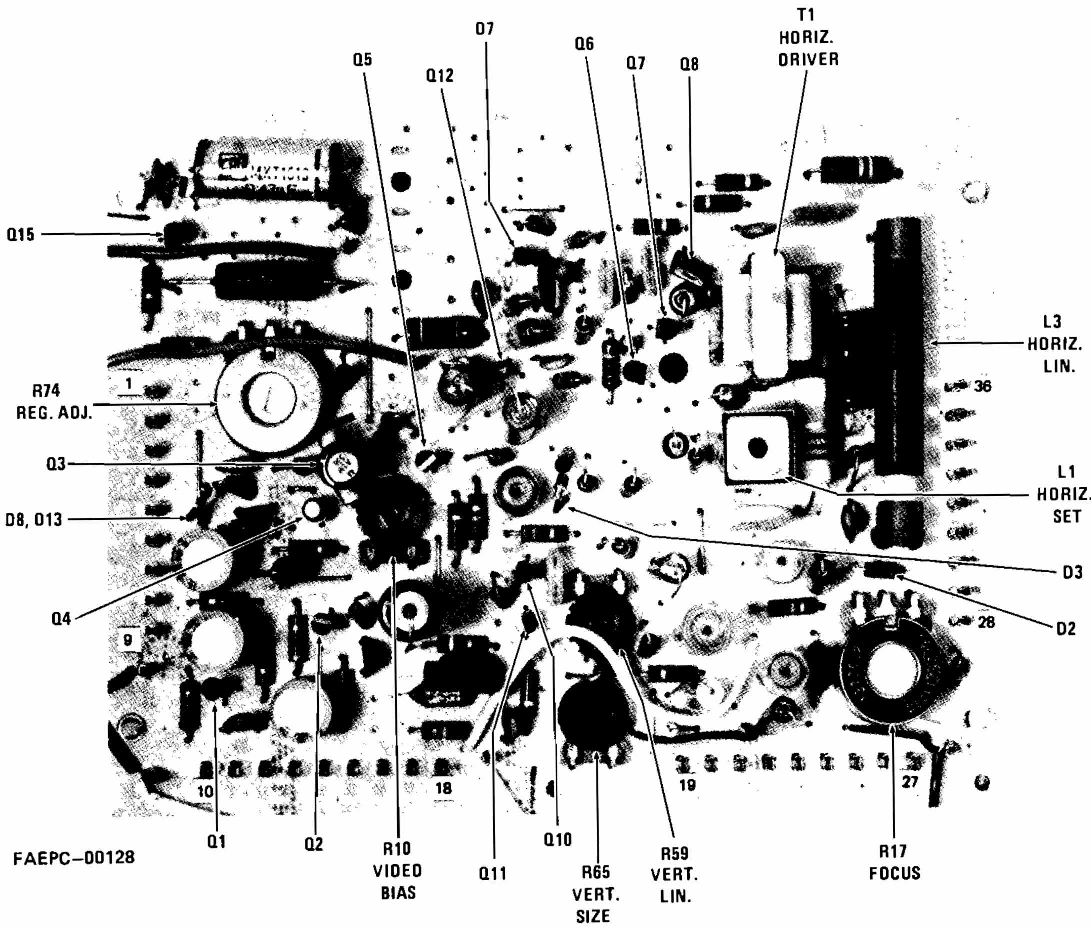
Address your requests to:

Motorola Display Products
1155 Harvester Drive
West Chicago, Illinois 60185

Attention: Parts and Service

TWX: 910–230–3117
Phone: (312) 231–4400

Shown is Motorola's unique Plug–In Circuit Panel (used on most models). Over 80% of the display module circuitry is contained on the panel. This feature provides the fast and easy servicing required in computer related equipment. Motorola maintains a circuit panel repair and update service which provides the customer with a fast and economical source for replacements. Panels returned to Motorola are not only repaired, but up-dated to include the latest reliability and performance improvements.



FAEPC–00128

THE "DOWN TIME" MINIMIZER PLUG-IN CIRCUITS
. . . . A REAL TIME SAVER!

SERVICE NOTES

ETCHED BOARD CIRCUIT TRACING

Component reference numbers are printed on top and bottom of the plug-in circuit board to facilitate circuit tracing.

Transistor elements are identified as follows:

E – emitter, B – base, and C – collector.

COMPONENT REMOVAL

Removing components from the etched board is facilitated by the fact that the circuitry (plating) appears on one side of the board only and the component leads are inserted straight through the holes and are not bent or crimped.

It is recommended that a solder extractor be used to aid in component removal. An iron with a temperature controlled heating element is desirable since it reduces the possibility of damaging the board due to over-heating.

The nozzle of the solder extractor is inserted directly over the component lead and when sufficiently heated, the solder is drawn away, leaving the lead free from the copper plating. This method is particularly suitable in removing multi-terminal components.

POWER TRANSISTOR REPLACEMENT

When replacing any "plug-in" transistor, i.e., the regulator, horizontal or vertical output, please observe the following precautions:

1. The transistor sockets are not "Captive", that is, the transistor mounting screws also secure the socket. When installing the transistor, the socket must be held in its proper location. This location is indicated by flanges on the socket which fit into the heat sink.

2. When replacing the output and regulator transistors, silicone grease (Motorola Part No. 11M490487) should be applied evenly to both sides of the mica insulator.

3. All transistor mounting screws must be tight before applying power to the receiver. This insures proper cooling and electrical connections.

NOTE: Use caution when tightening transistor mounting screws. If the screw threads are stripped by excessive pressure, a poor electrical and mechanical connection can result.

NON-COMPLIANCE WITH THESE INSTRUCTIONS CAN RESULT IN FAILURE OF THE TRANSISTOR AND/OR ITS RELATED COMPONENTS.

VIDEO AMPLIFIER BIAS ADJUSTMENT

Adjust video bias control R10 to voltage specified for your model on collector of video output transistor Q3 with no signal input (30V DC nominal). Disconnect cable from video input jack if necessary to eliminate noise.

CRT REPLACEMENT

Use extreme care in handling the CRT as rough handling may cause it to implode due to atmospheric pressure. Do not nick or scratch glass or subject it to any undue pressure in removal or installation. Use goggles and heavy gloves for protection.

Disconnect the CRT socket and second anode lead.

Remove CRT from chassis by loosening screws at corners of CRT.

Remove retaining band if present.

Remove deflection yoke from tube. Apply tape to replacement tube before banding. If no new tape is available, reuse tape from old tube.

Mount deflection yoke on replacement tube before installing.

Install tube and secure screws.

REGULATOR ADJUSTMENT (on applicable models)

Misadjustment of the low voltage regulator, or the horizontal oscillator may result in damage to the horizontal output transistor or pulse limiter diode. The following procedures are recommended to insure reliable operation:

1. Connect monitor to AC line supply. Adjust supply to 120 volts (240 on some models).

2. Apply test signal(s) to proper input(s). Test signal(s) should be of same amplitude and sync rate as signal(s) used when monitor is in service.

3. Adjust vertical and horizontal oscillator controls until display is synced.

NOTE: If horizontal oscillator coil is replaced or requires adjustment, follow procedure outlined on this page.

4. Connect the digital voltmeter or other precision accuracy voltmeter to the emitter of the regulator output transistor.

5. Adjust the regulator control for the output specified for your model. **Do not "run" the regulator control through its range or damage to the monitor may result (73V DC typical).**

6. When adjustment is complete, vary the AC line supply (between 105 and 130 volts) to check for proper regulator operation. With regulator operating properly, changes in display size should be negligible.

HORIZONTAL OSCILLATOR ADJUSTMENT (on applicable models)

1. Set the horizontal hold potentiometer to mid-range (if applicable).
2. Adjust core of horizontal hold coil L1 until the horizontal blanking lines are vertical.
3. Rotate horizontal hold potentiometer through its full range. Display should go out of sync in each direction and hold in sync at the center of its range. Retouch oscillator coil as necessary to center the hold range.

NOTE: To adjust horizontal frequency on chassis not equipped with a potentiometer, perform step 2 only.

CENTERING ADJUSTMENT

Rotate centering magnets on CRT neck either individually or as a unit while observing display. Display can be moved horizontally, vertically or any angle depending on position of magnets.

VERTICAL SIZE AND LINEARITY

1. Set up crosshatch video pattern on screen.

2. Adjust vertical size and linearity controls alternately to obtain raster which fills the screen to correct height, with uniformly spaced horizontal lines over entire screen.

FOCUS

1. Set up display or pattern on screen and adjust for normal brightness.

2. Adjust focus control for sharpest detail over entire screen.

HORIZONTAL SIZE

1. Adjust pattern for normal brightness and contrast.

2. Adjust horizontal size coil to obtain correct horizontal size. Core is adjusted by rotating captive plastic insert.

SERVICE EQUIPMENT

When servicing a Motorola display (or any professional piece of electronic equipment), it is recommended that precision test equipment be used. Adjustments that may be required are critical to the performance and reliability of the display.

For final testing it is important that a "test signal" be equivalent to the "in service" signal.

The following equipment is essential to insure professional servicing of the display:

- Digital voltmeter (1% accuracy)
- Oscilloscope
- Isolated Variable AC/DC supply
- Test signal or signal generator (use Motorola model DG-100 shown below or equivalent).

MODEL DG100HA

TEST CHARACTER GENERATOR

GENERAL

The DG100HA is designed for use in testing display modules and closed-circuit television monitors. The flexibility of adjustment incorporated in the design allows it to be used for testing monitor linearity, resolution, focus, and horizontal and vertical timing. In addition, this equipment can be used to establish character display formats and character fonts.

The DG100HA produces a raster of the same character in each of the character locations. The unit has a built-in variable frequency oscillator which covers 1 - 25 mHz in four ranges. Most raster scan alphanumeric character generating systems can be simulated with this equipment.

Interlaced video signals can be generated at horizontal rates of from 8 kHz to 20 kHz. The interlace mode is selected by a front panel control.

Additional flexibility is provided by rear panel connections. Dot input and row output connectors allow interfacing to character generating ROM's.

StepScan output is available. Modulated half intensity, TTL and 75 ohm variable video are provided. Composite as well as vertical and horizontal sync outputs allow interfacing with non-composite video display equipment.

SPECIFICATIONS

Clock Rate:	1 - 25 mHz in four bands
Horizontal Dots Per Character:	2 - 16
Characters Per Row:	1 - 99
Delay Before and After Horizontal Sync:	1 - 99 Character Times
Horizontal Sync Width:	1 - 99 Character Times
Scan Lines Per Row of Characters:	1 - 99
Rows of Characters:	1 - 99
Delay Before and After Vertical Sync:	1 - 99 Scan Lines
Vertical Sync Width:	1 - 99 Scan Lines

The character format is selected by adjusting digital read out thumb wheel switches.

OUTPUTS:

Composite Video	BNC (Front Panel)
Half Intensity Video	BNC (Rear Panel)
Video (RRL or 75 ohms Variable)	BNC (Rear Panel)
Horizontal Sync (Both Polarities)	BNC (Rear Panel)
Vertical Sync (Both Polarities)	BNC (Rear Panel)
Composite Sync (Both Polarities)	BNC (Rear Panel)
StepScan	BNC (Rear Panel)
16 Dot Inputs	Cinch Connector
20 Decoded Scan Line Outputs	Cinch Connector
Clock Rate	Cinch Connector
Horizontal Blanking	Cinch Connector
Vertical Blanking	Cinch Connector

TEST CHARACTER GENERATOR

CONTROLS

Band Select (4 positions)

Tuning

Interlace Frequency Adjust

Interlace In-Out

Interlace Adjust (Potentiometer)

Video Polarity

Dot Duty Cycle (50 or 100%)

60 Hz Test (pushbutton switch)

Power — On and Off Switch

POWER INPUTS:

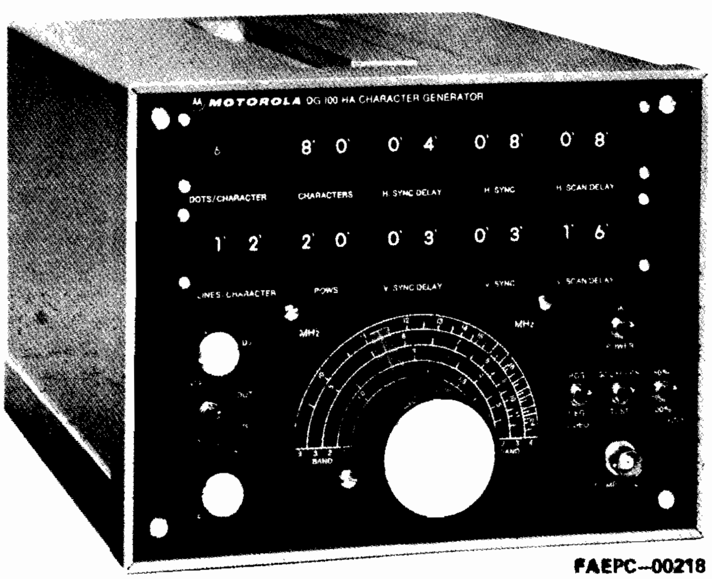
15 Watts nominal. 100-140 Volt DC
50-60 Hz

SIZE:

6" High, 8" Wide, 11" Deep

WEIGHT

10 lbs.



FAEPC—00218

TROUBLESHOOTING HINTS

FIELD SERVICE REPAIR PROCEDURE

VIDEO SECTION: Replace panel; if trouble remains, remove CRT monitor.

VERTICAL SECTION: Replace panel; next replace vertical output transistor. If trouble remains remove CRT monitor.

HORIZONTAL SECTION: If fuse(s) is open, check for defective B+ regulator or horizontal output transistor, or damper diode. Replace panel, next replace high voltage rectifier. If trouble remains, remove CRT monitor.

SYNC SECTION: Replace panel. If trouble remains, remove CRT monitor.

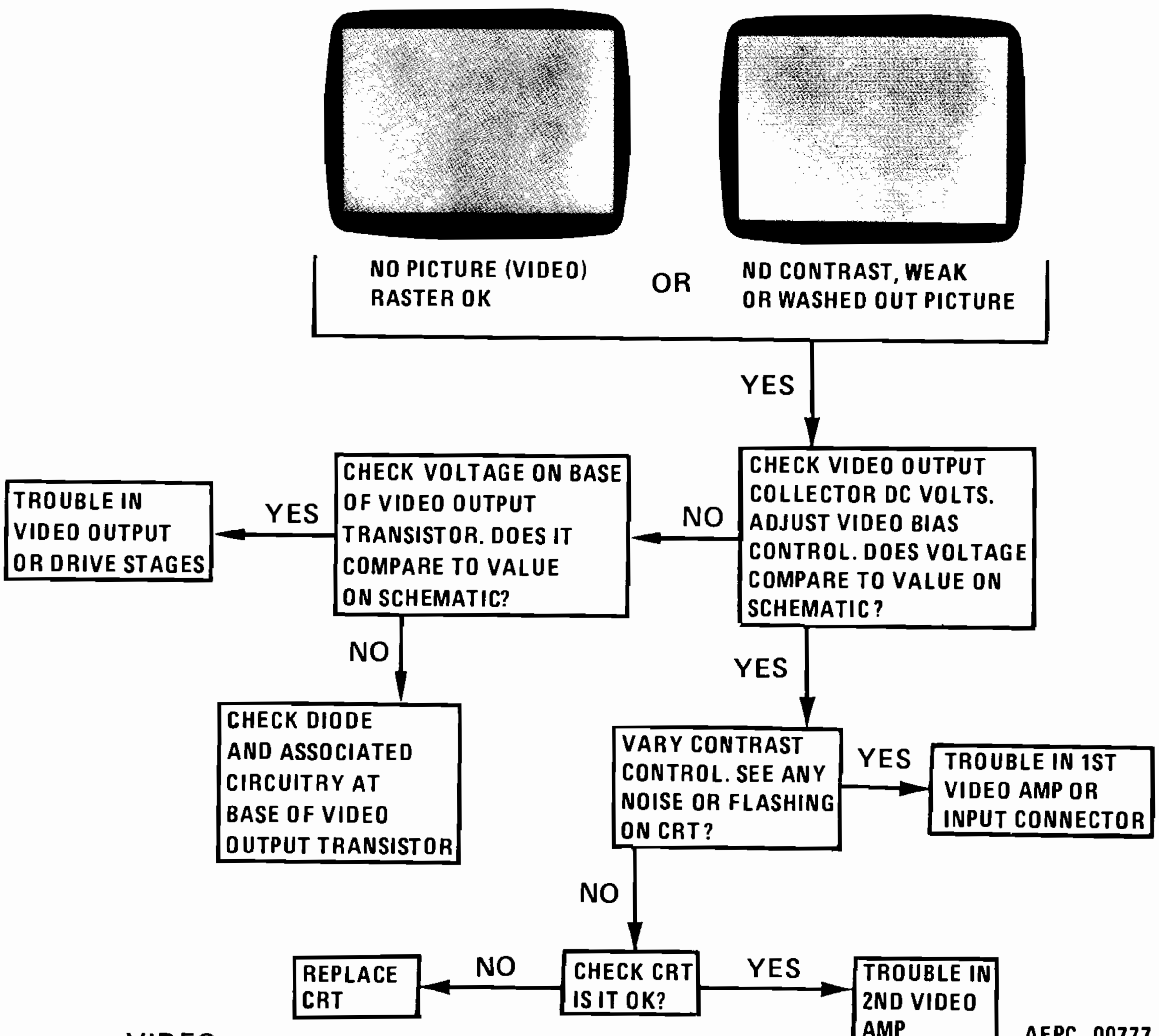
POWER SUPPLY SECTION: Check fuse(s), replace regulator transistor. If fuse opens repeatedly, check under horizontal above. Replace panel. If trouble remains, remove CRT monitor.

If the module is removed for service, refer to the following procedure.

ISOLATING THE DEFECTIVE STAGE

When troubleshooting a display monitor, it is necessary to observe the symptoms carefully for use in classifying the trouble to its logical section. The following flow charts are one form of a systematic approach in isolating the defective stage. Not all troubles will be located with these charts; however, they will identify common faults and help in isolating the problem stage.

VIDEO



VIDEO

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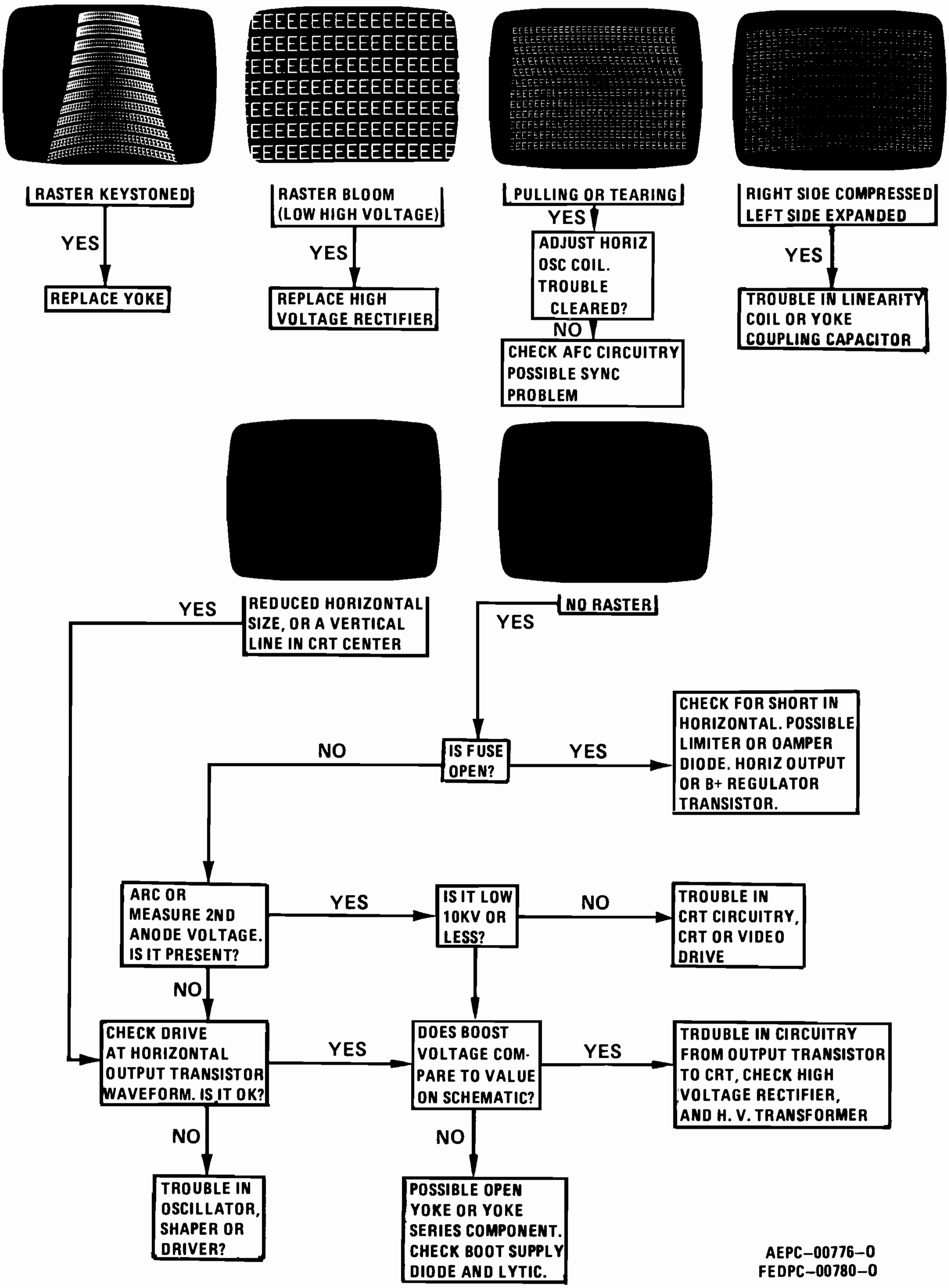
FDEPC–00780–0

NOTE: IF PROCEDURE FAILS TO LOCATE PROBLEM, CHECK VIDEO TRANSISTORS FOR LEAKAGE OR LOW BETA. LOOK FOR LOSS OF SIGNAL WITH OSCILLOSCOPE.

HORIZONTAL



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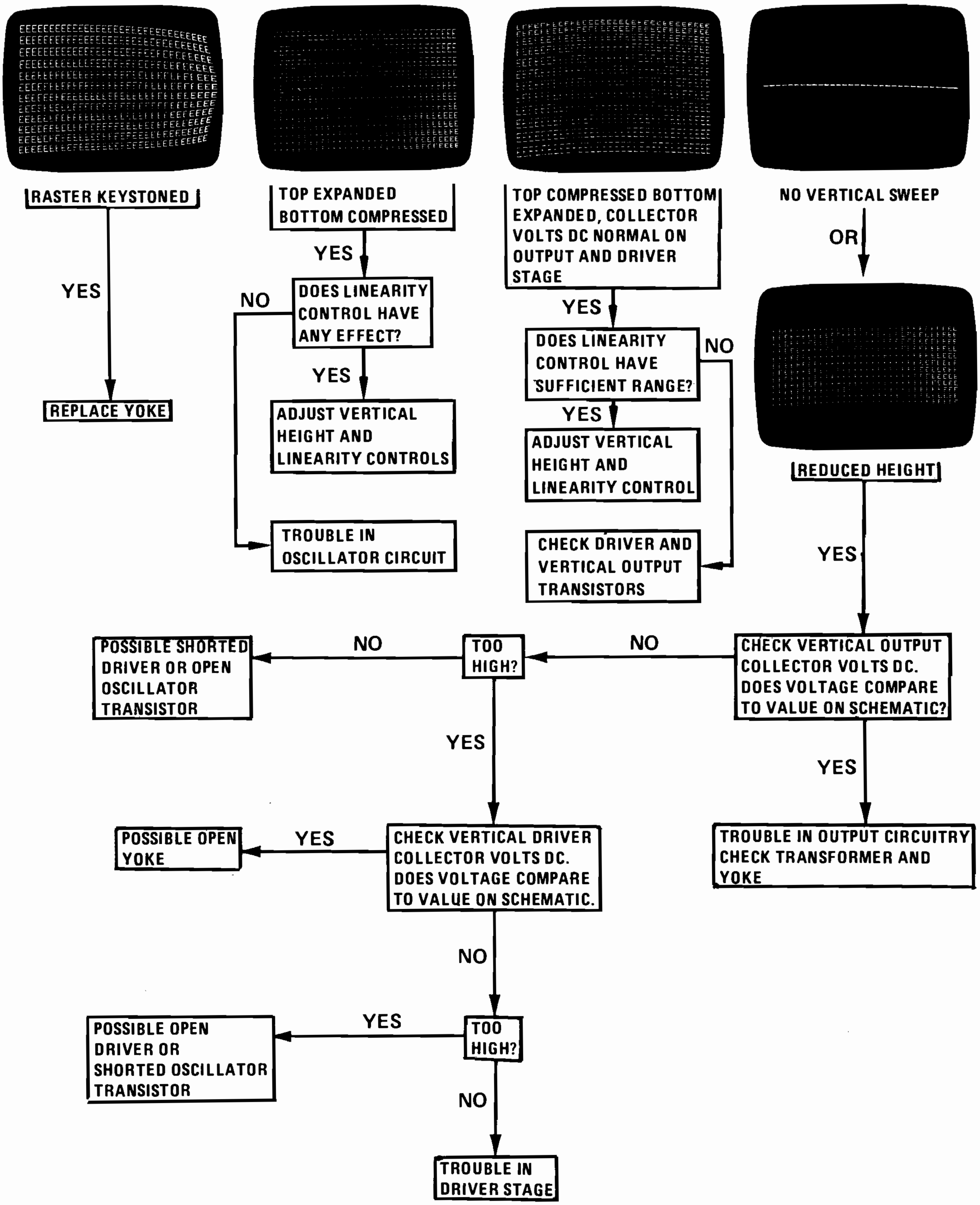
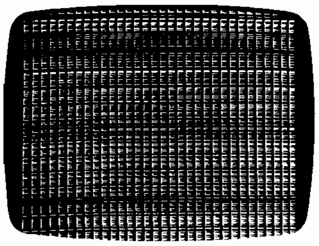
VERTICAL


RASTER KEYSTONED
YES
REPLACE YOKE
TOP EXPANDED BOTTOM COMPRESSED
YES
DOES LINEARITY CONTROL HAVE ANY EFFECT?
NO
YES
ADJUST VERTICAL HEIGHT AND LINEARITY CONTROLS
TROUBLE IN OSCILLATOR CIRCUIT
TOP COMPRESSED BOTTOM EXPANDED, COLLECTOR VOLTS DC NORMAL ON OUTPUT AND DRIVER STAGE
YES
DOES LINEARITY CONTROL HAVE SUFFICIENT RANGE?
NO
YES
ADJUST VERTICAL HEIGHT AND LINEARITY CONTROL
CHECK DRIVER AND VERTICAL OUTPUT TRANSISTORS
NO VERTICAL SWEEP
OR
REDUCED HEIGHT
YES
CHECK VERTICAL OUTPUT COLLECTOR VOLTS DC. DOES VOLTAGE COMPARE TO VALUE ON SCHEMATIC?
NO
TOO HIGH?
NO
POSSIBLE SHORTED DRIVER OR OPEN OSCILLATOR TRANSISTOR
YES
YES
TROUBLE IN OUTPUT CIRCUITRY CHECK TRANSFORMER AND YOKE
CHECK VERTICAL DRIVER COLLECTOR VOLTS DC. DOES VOLTAGE COMPARE TO VALUE ON SCHEMATIC.
YES
POSSIBLE OPEN YOKE
NO
TOO HIGH?
YES
POSSIBLE OPEN DRIVER OR SHORTED OSCILLATOR TRANSISTOR
NO
TROUBLE IN DRIVER STAGE

SYNC



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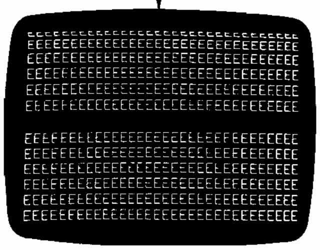
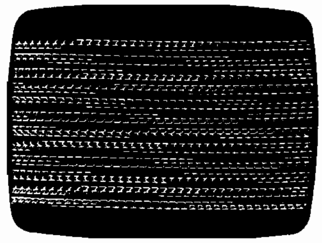


LOSS OF VERTICAL SYNC

YES

ADJUST VERTICAL HOLD, CHECK HEIGHT AND LINEARITY CONTROL SETTING OR ....

TROUBLE IN VERTICAL INTEGRATOR OR OSCILLATOR. CHECK SYNC SEPARATOR



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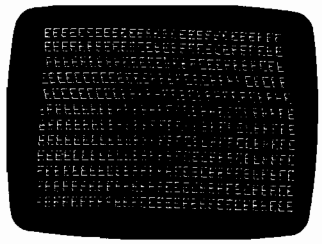
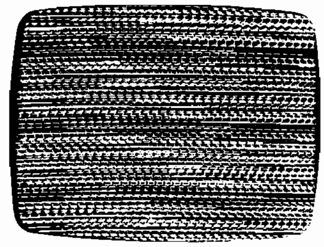


LOSS OF HORIZONTAL SYNC

YES

ADJUST HORIZONTAL HOLD CONTROL OR ....

TROUBLE IN HORIZONTAL OSCILLATOR OR AFC. CHECK SYNC SEPARATOR



LOSS OF BOTH VERTICAL AND HORIZONTAL SYNC

YES

ADJUST VERTICAL AND HORIZONTAL HOLD CONTROLS OR ....

TROUBLE IN SYNC SEPARATOR OR INPUT TO SEPARATOR SA-5397

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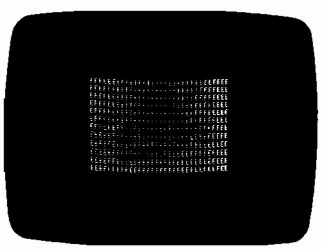
FDEPC–00780–0

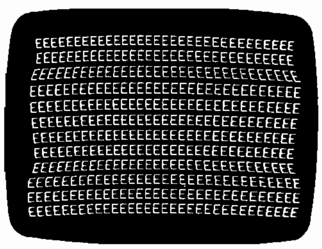
POWER SUPPLY



REDUCED SIZE BOTH HORIZONTALLY AND VERTICALLY

YES

CAUSED BY DECREASE IN B+. CHECK REGULATOR ADJUSTMENT



WEAVE OR HUM

YES

ADJUST LOW VOLTAGE REGULATOR. DOES IT VARY? CAN YOU SET TO 73 VOLTS?

NO

DEFECT IN LOW VOLTAGE CIRCUITRY. CHECK REGULATOR TRANSISTORS.

YES

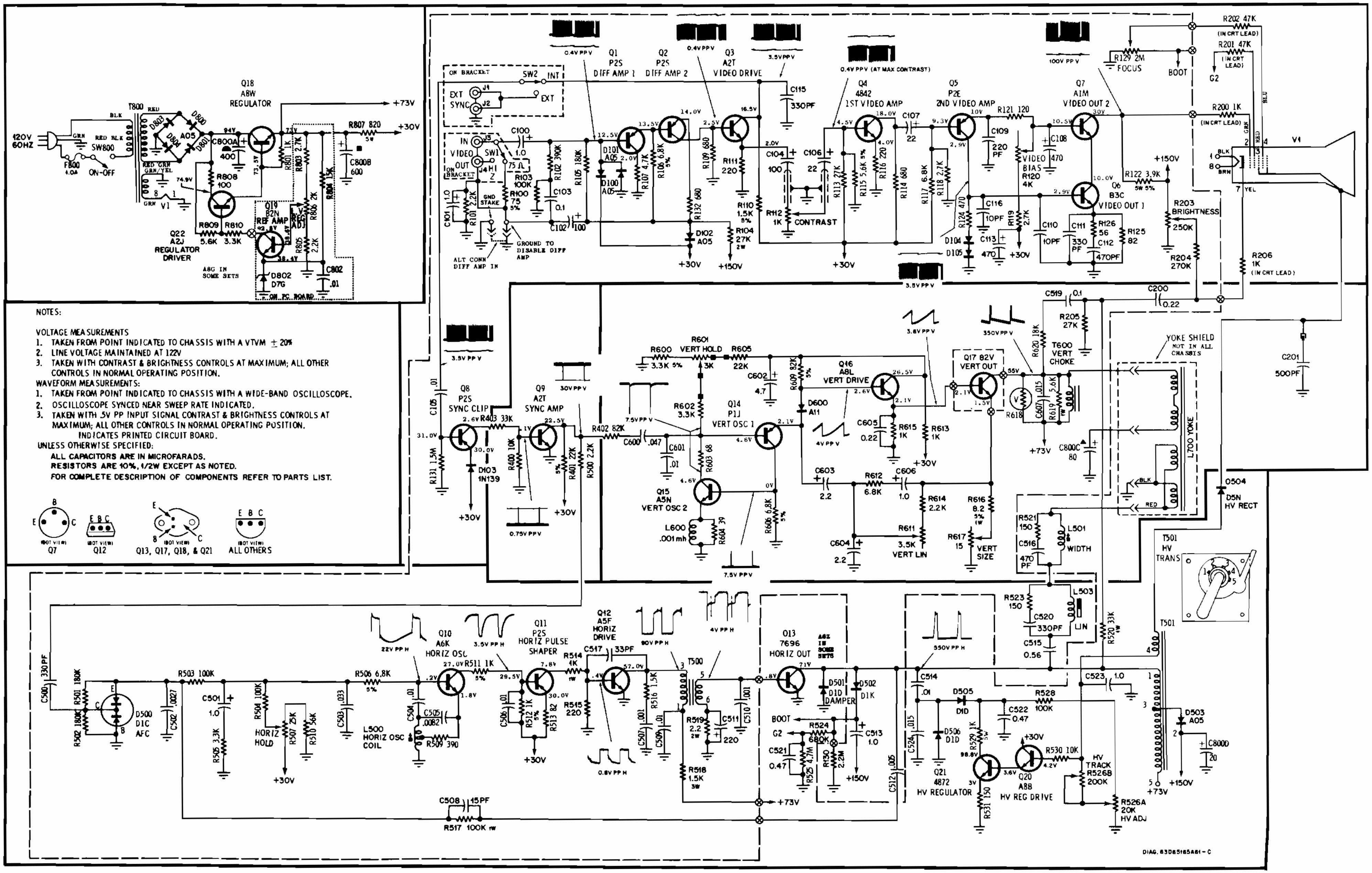
CHECK FOR OPEN ELECTROLYTIC CAPACITOR IN POWER SUPPLY OR ON B+ BUSS FEED POINTS. POSSIBLE DEFECTIVE ZENER DIODE.

NO RASTER

YES

CHECK FOR OPEN FUSE. SEE SAME SYMPTOM IN HORIZONTAL SECTION. SA5393

AEPC–00774–0
FDEPC–00780–0



NOTES:

VOLTAGE MEASUREMENTS

1. TAKEN FROM POINT INDICATED TO CHASSIS WITH A VTVM ± 20%
2. LINE VOLTAGE MAINTAINED AT 122V
3. TAKEN WITH CONTRAST & BRIGHTNESS CONTROLS AT MAXIMUM; ALL OTHER CONTROLS IN NORMAL OPERATING POSITION.

WAVEFORM MEASUREMENTS:

1. TAKEN FROM POINT INDICATED TO CHASSIS WITH A WIDE-BAND OSCILLOSCOPE.
2. OSCILLOSCOPE SYNCED NEAR SWEEP RATE INDICATED.
3. TAKEN WITH .5V PP INPUT SIGNAL CONTRAST & BRIGHTNESS CONTROLS AT MAXIMUM; ALL OTHER CONTROLS IN NORMAL OPERATING POSITION.

INDICATES PRINTED CIRCUIT BOARD.

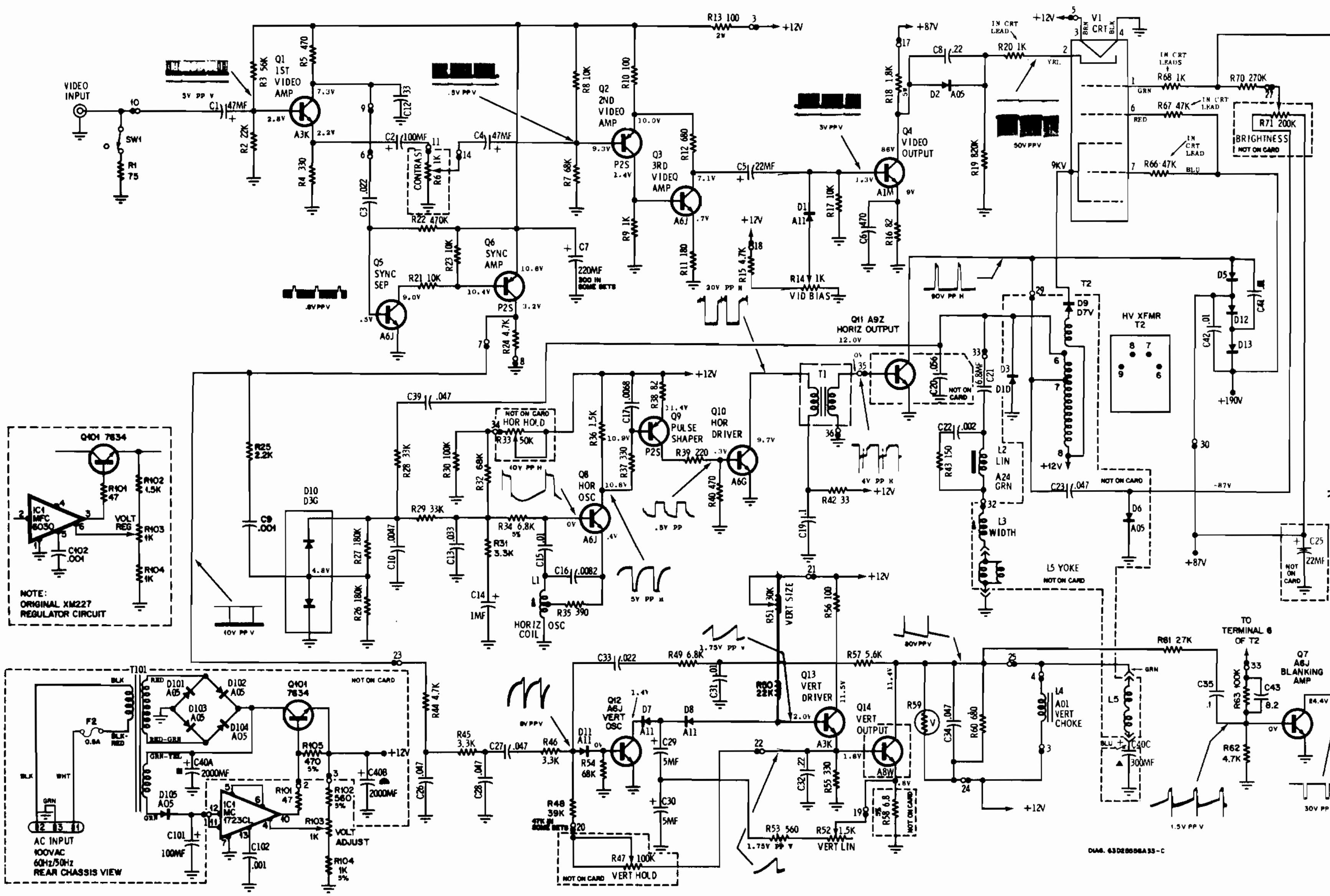
UNLESS OTHERWISE SPECIFIED:

ALL CAPACITORS ARE IN MICROFARADS.

RESISTORS ARE 10%, 1/2W EXCEPT AS NOTED.

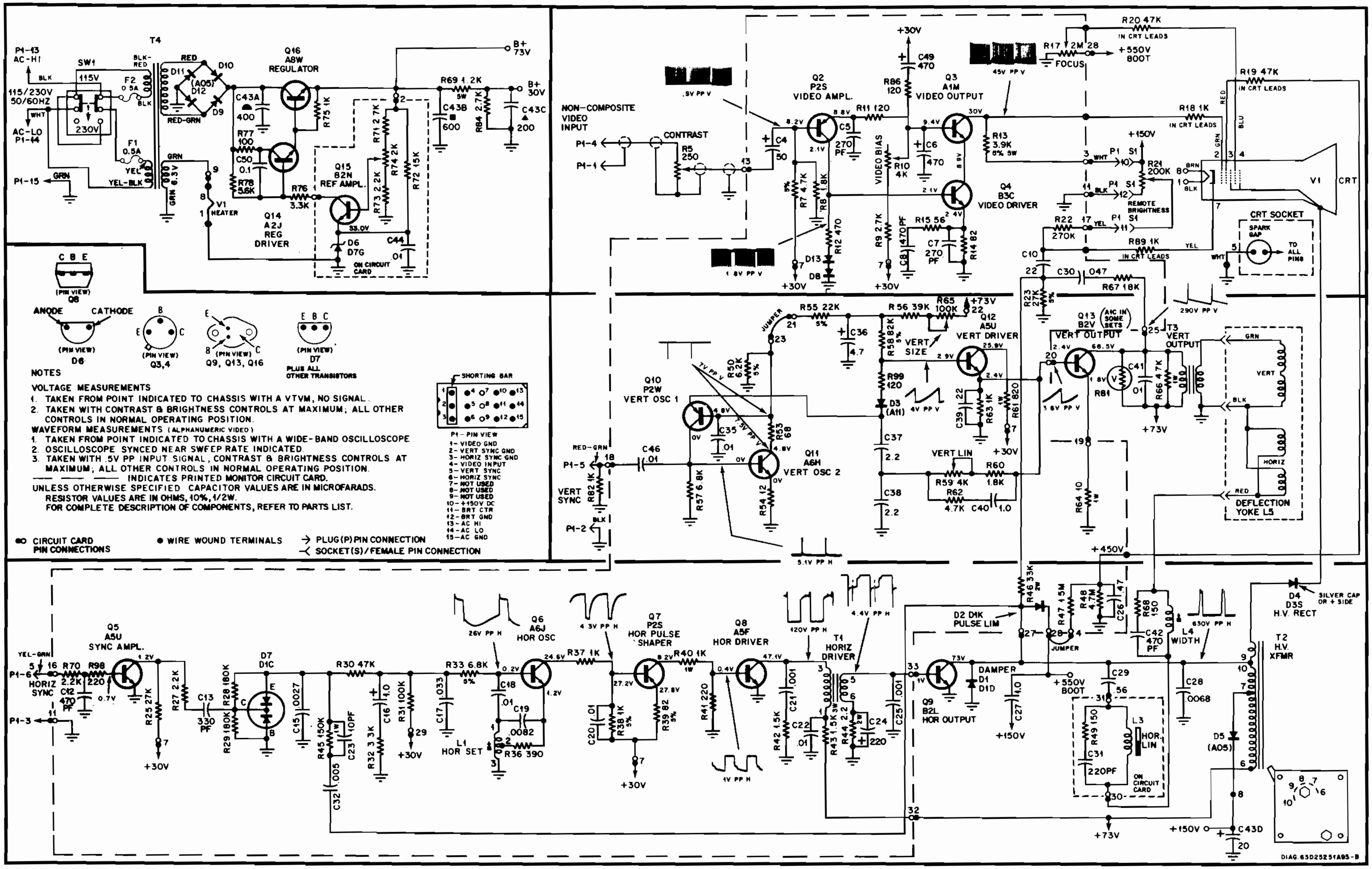
FOR COMPLETE DESCRIPTION OF COMPONENTS REFER TO PARTS LIST.

Illustrative Schematic of 73V B+ Models with Composite Input

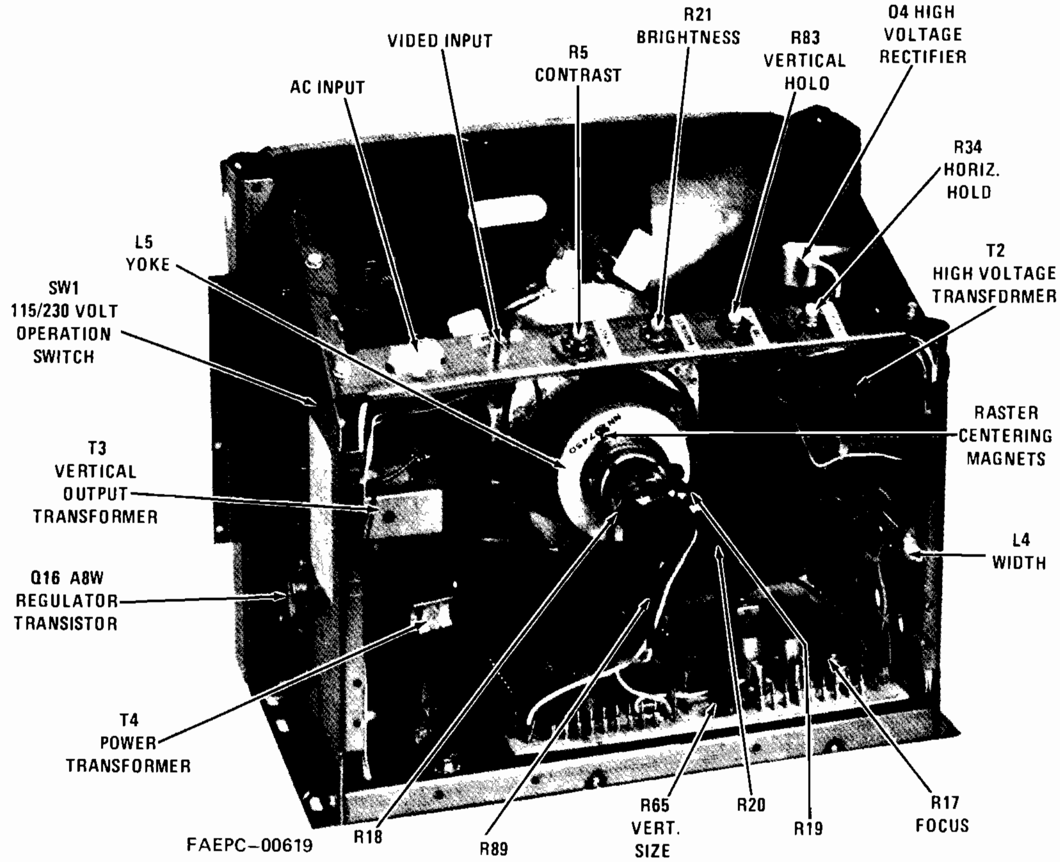


NOTES:
PARTS WITHIN DASHED LINES, AND CRT ARE NOT ON P. C. PANEL.
VOLTAGE MEASUREMENTS:
1. TAKEN FROM POINT INDICATED TO CHASSIS WITH A VTVM, NO SIGNAL.
2. TAKEN WITH CONTRAST & BRIGHTNESS CONTROLS AT MAXIMUM; ALL OTHER CONTROLS IN NORMAL OPERATING POSITION.
WAVEFORM MEASUREMENTS:
1. TAKEN FROM POINT INDICATED TO CHASSIS WITH A WIDE-BAND OSCILLOSCOPE.
2. OSCILLOSCOPE SYNCED NEAR SWEEP RATE INDICATED.
3. TAKEN WITH .5V PP INPUT SIGNAL CONTRAST & BRIGHTNESS CONTROLS AT MAXIMUM; ALL OTHER CONTROLS IN NORMAL OPERATING POSITION.
UNLESS OTHER WISE SPECIFIED: CAPACITORS DECIMAL VALUES IN MF, ALL OTHERS PF. CAPACITANCE VALUES ONLY ARE SHOWN ON SCHEMATIC DIAGRAM. FOR COMPLETE DESCRIPTION OF CAPACITORS, REFER TO PARTS LIST.
RESISTORS ARE 10% 1/2W

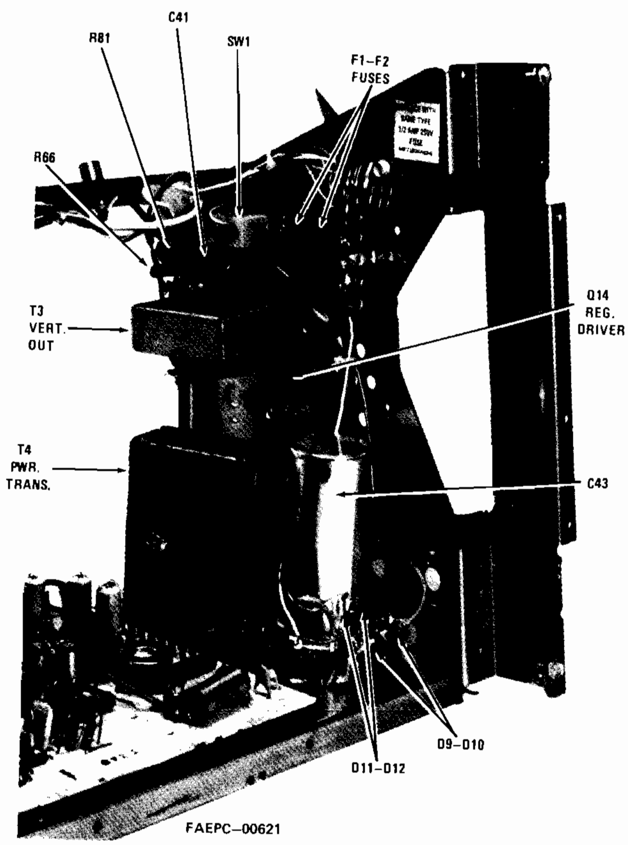
Illustrative Schematic of 12V B+ Models with Composite Input

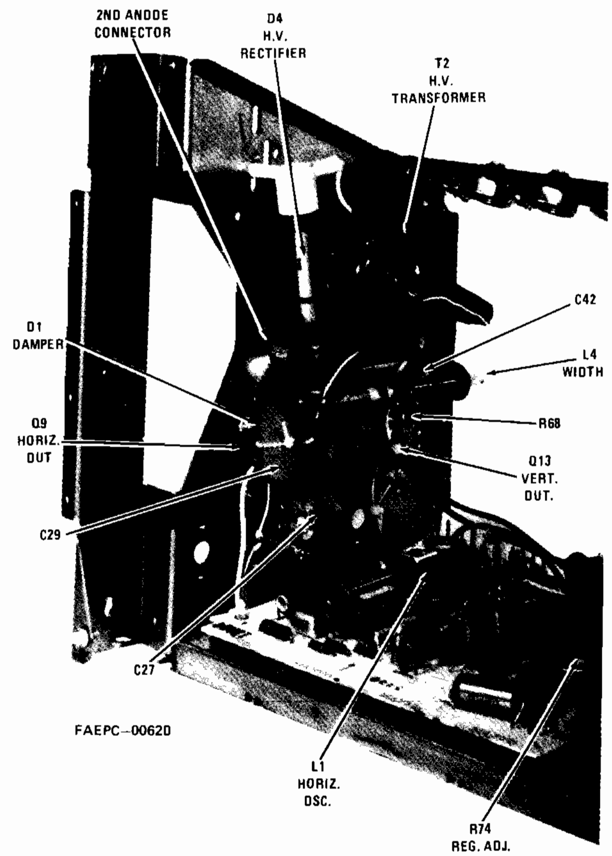


Illustrative Schematic of 73V B+ Model with TTL Input



Typical Chassis Rear View — Component Location





Typical Chassis Partial Front Views — Component Location

SOLDER SIDE SHOWN

PICTORIAL SCHEMATIC DIAGRAM SHOWING RELATION BETWEEN COMPONENTS LOCATED ON/OFF THE PANEL. (TYPICAL DISPLAY SHOWN)