SWITCHED MODE POWER SUPPLY

The Switched Mode Power Supply used in the C8 Series Chassis is a self oscillating, transformer-coupled, voltage regulator (Figure 7). The Switched Mode Transformer, T401, is driven from the ac line derived +155Vdc. Line isolation for the chassis is provided by the Switched Mode Transformer and the Opto-Isolator, IC404. The +155Vdc is applied to the transformer primary and controlled via the Switched Mode Regulator transistor, Q400. Magnetic energy is stored in the transformer during the On time of the transistor and is transferred to the secondary during the Off time interval. This collapsing magnetic energy replenishes the voltage lost by the storage capacitors to the load during the On time period. The amount of energy transfer is controlled by the self-oscillating frequency and the On/Off time of the transistor switch to maintain the proper voltage output. The self-oscillating frequency of the power supply under normal load conditions will range from 20kHz to 40kHz. Depending upon the load, the frequency can range from 10kHz to 60kHz.

AC voltage is continuously applied to the power supply in remote sets. It is necessary to provide a method to degauss the picture tube in these configurations. Degaussing is performed by the circuitry of Triac, SCR401. AC voltage is applied across the Degauss Coil, Thermistor R401, and Triac SCR401. When the remote chassis is first powered On, pulses in the secondary winding 1-2 are rectified by D402 and filtered by C402. This voltage turns On SCR401 allowing ac voltage to flow through the degauss coil until Thermistor, R401, opens degaussing the picture tube.

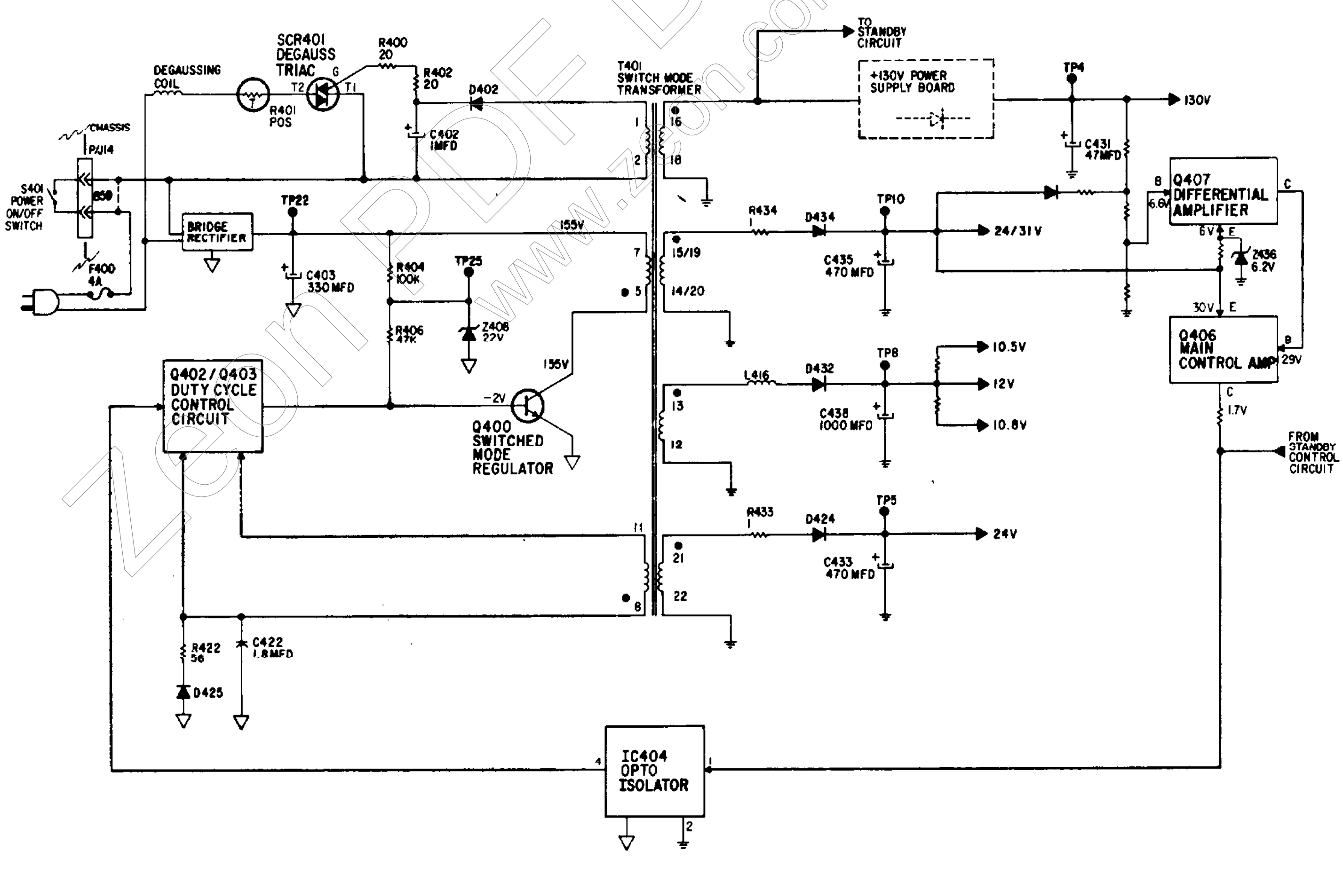

Figure 7 — SMPS Block Diagram

The Differential Amplifier, Q407, monitors the output voltage, compares it to a +6.2 volt reference provided by Zener, Z436, and develops a dc correction voltage (Figure 8). This correction voltage is inverted by the Main Control Amplifier, Q406, and fed back to the Opto-Isolator, IC404. The change to Pin 1 of IC404 is proportional to the change of the 130V source. If the 130V increases, the light emitting diode section of the Opto-Isolator conducts more, creating more voltage at Pin 4. The increase at Pin 4 adds to the charge voltage on C420, thereby causing Q403/Q402 to turn On earlier. This action causes Q400 to turn Off earlier, lowering the output voltage. The control circuitry varies the duty cycle and/or frequency to maintain the output at the preset level. Therefore, the output voltage is maintained by the input to the transformer and the On/Off ratio of the Switched Mode Regulator.

START UP

The initial requirement for start up is to provide forward bias voltage for Q400. When ac power is applied, base voltage is provided from the bridge rectified +155Vdc through the 22Vdc zener supply, R404, Z408, and R406. The +155Vdc is applied across the primary of the transformer and collector current starts to flow when Q400 turns On. A voltage is also induced into secondary winding Lb, providing a positive voltage for the base drive for Q400 via Pin 11, R421, D416, and C418. During this On time, a negative voltage from T401, Pin 8, is charging C422 with a negative charge. Q400 stays turned On until C420 charges positive enough to forward bias the Duty Cycle Control transistors, Q403/Q402, which applies the negative voltage from C422 to the base of Q400, turning it Off. Diode D416 blocks the start up voltage from flowing through the secondary winding, Lb. During the Off period of Q400, the voltage from T401 Pin 11 becomes negative and this negative charge on C418 is limited by the conduction of D414. By limiting the negative charge on C418, the positive charge of C418 can be accomplished more quickly. C418 controls the start up frequency during the period of time that the output voltage is building up to its operating level of +130 volts.

The start up procedure repeats for several cycles until the dc voltage from the Differential Amplifier and Main Control Amplifier via the Opto-Isolator takes over control by adding to or subtracting from the voltage developed by C420. During the On time of Q400, a negative voltage (-5.3V) has developed across the network of R422 and C422. This voltage provides a negative voltage for turning Q400 Off when the Duty Cycle Control transistors, Q403/Q402 turns On. When normal output voltage (+130V) has been achieved, the turn On base voltage is then supplied by secondary winding Lb via D416 and R421.

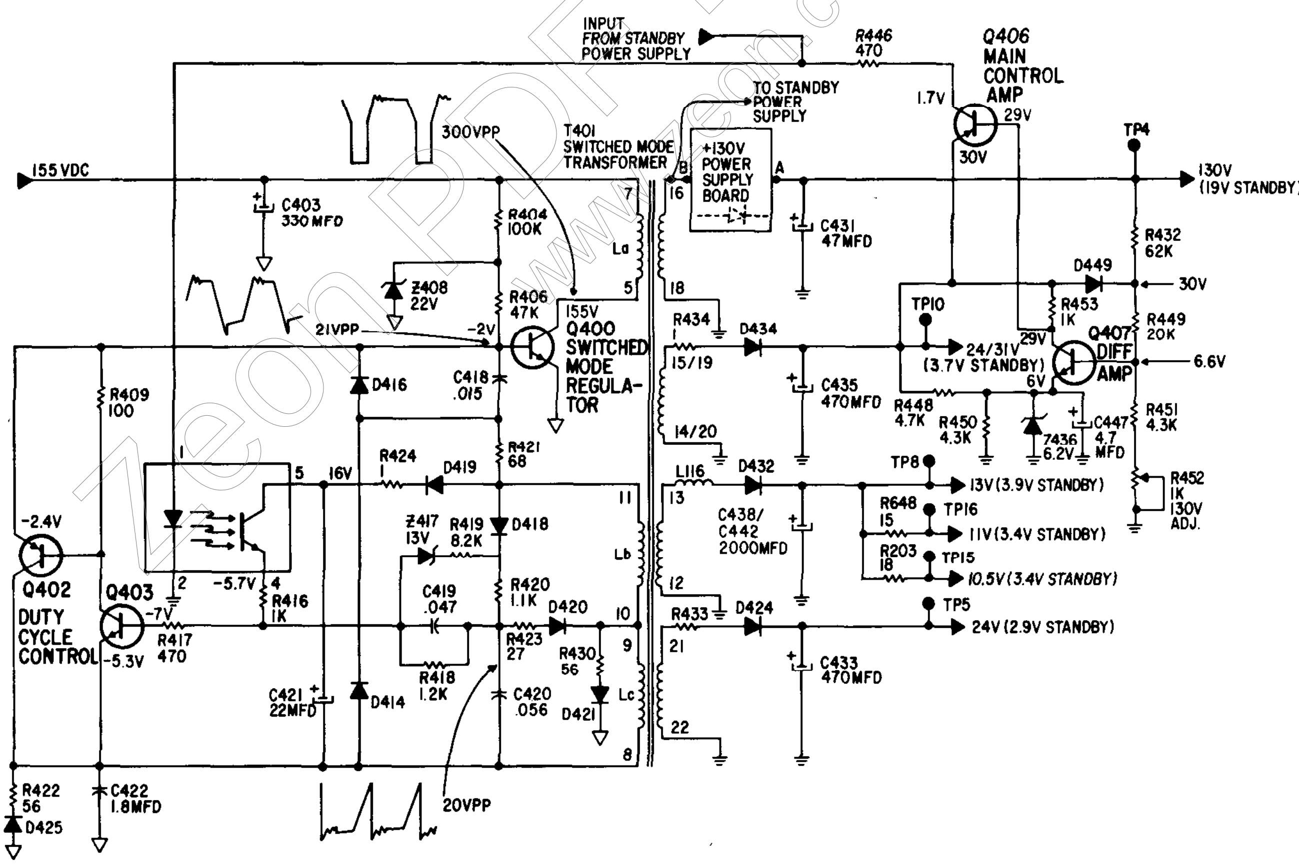

Figure 8 — SMPS Control Circuitry

CONTROL CIRCUITRY

The +130 output voltage is monitored by the Differential Amplifier, Q407, and compared with the reference voltage (+6.2V) derived by Zener Diode, Z436, through the divider network of R432, R449, R451, and R452 connected between the +130V source and ground. Diode D449 is connected to the +24/31V source and provides an alternate path of current in case of failure of the +130V supply. This helps to maintain the other supplies at a regulated level during such a failure.

The Differential Amplifier drives the Main Control Amplifier, Q406, which in turn sources the LED portion of the Opto-Isolator, IC404, generating an output proportional to the dc error voltage. When current increases through the Opto-Isolator diode, the increased light output causes an increase of current flow in the transistor portion. The Opto-Isolator feedback modifies the voltage developed across R418 and C419 from C420 that controls the turn On of the Duty Cycle Control transistors, Q403 and Q402. The source of the voltage for the Opto-Isolator is produced by winding Lb, Pin 11, rectified by D419 and applied to Pin 5 of Opto-Isolator, IC404. The output of the Opto-Isolator is from Pin 4 through R416 to the base circuit of Q403. Along with the voltage across C420, this voltage will adjust the trip point for the Duty Cycle Control transistors proportional to the error voltage, thus advancing or delaying the turn Off of Q400.

The maximum On time for Q400 is controlled by the RC time constant of R420 and C420. The induced voltage of winding Lb charges C420 via D418 and R420. The voltage developed across R418 and C419 is then added to this voltage, resulting in a shift in the turn Off point for the Switched Mode transistor, Q400. When the sum of these voltages builds up enough to forward bias Q403, the Duty Cycle transistors turn On and Q400 turns Off. During this Off time, C420 will discharge through R423, D420, and through the lower winding Lc. Additional control is provided by Zener, Z417 (13V) and R419, which become a controlling factor when the voltage across Lb exceeds the zener voltage of Z417. The voltage across C420 is made up of two components, a positive portion and a negative portion. The positive portion is through R420 and D418; the negative portion is developed by R423, D420, R430, and D421 during the Off period of Q400.

At maximum load, the On time for Q400 will be at its maximum as determined by the voltage on C420. Q400 will remain On until C420 charges from its negative condition to a level sufficient to turn On Q403. Therefore, the maximum On time occurs when the power supply is loaded at its maximum rated output. Feedback current from the Opto-Isolator is zero and the voltage across R418 and C419 will remain at zero as long as maximum load (short circuit) is on the output.

NORMAL OPERATION

Regulation during normal operation is maintained by changing the duty cycle as well as the frequency. An output load change affects frequency, and ac line voltage changes affect the duty cycle. The frequency change occurs because the power supply is self-oscillating. The frequency will change rapidly with a change in power output, whereas a change in ac line voltage will produce a more gradual correction in output voltage.

OVERLOAD AND SHORT CIRCUIT PROTECTION

The current through the transistor portion of the Opto-Isolator, IC404, approaches zero as the output load reaches maximum (full load). The bias voltage from Pin 4 of IC404 is no longer contributing to the turn On of Q403 because the error voltage is too low to light the LED. The transistor now depends solely on the voltage across C420 for base bias. A longer time is required for Q403 to reach forward bias, resulting in an increase in conduction time for Q400.

The output voltage (130V) will start to decrease as the load is further increased, creating an overload condition. The Opto-Isolator feedback can no longer compensate for the output voltage change, because the light from the LED portion was already at minimum. The input to Pin 1 of the Opto-Isolator is proportional to the change in the 130 volts. The decrease in the +130 volt output causes the negative charge on C420 to become more positive during the Off time of Q400, which results in a reduced On time for Q400 proportional to the output voltage level, or inversely proportional to the output load. This process prevents the output power from exceeding the maximum design limit and provides current protection as the output approaches a short circuit.

The current from the 155Vdc source is also reduced when the supply is overloaded. This causes an increase in the pulse voltage at the cathode of D418 during Q400 On time which activates the control circuit of Z417 and R419. This action will increase the voltage across R418 and C419, causing Q403 to turn On earlier, which will reduce the On time of Q400. The turn On time for Q400 continues to reduce as the output voltage approaches zero. Just prior to a short circuit, at a very low output voltage, the start up circuit will attempt to turn On Q400, but it will be turned Off almost immediately. This will not provide any supply voltage for the 130V output. Only a small current will build up in the transformer and normal oscillation can not be maintained due to the failure in build up of the output voltage. Q400 is held Off for the duration of time the secondary diodes are conducting, until the current in the transformer reduces to zero. This cycle will repeat until the condition is corrected. With a complete short on the 130V output and 120Vac applied to the chassis, the On time for Q400 reduces to a series of very short spikes (approximately 10 usec every 160 usec). The On time is then controlled by the small start up current which together with C418 determines the cycling time. Start up can not be obtained until the short is removed and the output voltage level is allowed to build up.

STANDBY/FULL POWER CIRCUIT

The Standby/Full Power circuit enables the SMPS to provide standby voltage for the Microcomputer in Remote versions. Previous TV Sets used a separate power supply for standby power because standby power was needed continuously. But now, standby power is only used during the time full power is not needed, making the TV Set more economical to operate.

Operation of the Standby/Full Power circuit maintains low-level operation of the SMPS. In the remote sets, a wire staple is placed in position B59 keeping the power supply alive all the time (see Figure 7). This jumper is connected across the On/Off Switch as used in a non-remote set. Any time a remote set is plugged into ac power, the SMPS begins running in the standby mode. This operation is accomplished by taking the square wave pulses from T401, Pin 16, and applying them to two places (Figure 9). First, the pulses are applied to Diode D433, where they are rectified to provide 13Vdc for the Standby Control Switch, Q431/Q432. Second, the pulses are coupled across the network of C439, R439, and C444 to the base of Q432 to turn the Standby Control Switch On. With Q431/Q432 turned On, the rectified dc voltage (approximately 13V) is applied to the 5V Regulator, IC309, keeping the standby circuits active.

With the 5V supplied to the Microcomputer, it remains active to the input commands of the Remote Control transmitter or Customer Keyboard. A High output at Pin 8 of the Microcomputer turns On the Power On/Off transistor, Q60. With Q60 turned On, the base of the Mode Switch, Q410, is held Low, keeping it turned Off. Q410 is the central controlling factor in the Standby Power supply. If Q410 is turned On, the path for the pulses to the base of Q432 is interrupted (grounded), therefore the SMPS is allowed to come up to full power. With Q410 held Off, the pulses from T401, Pin 16, are allowed to pass to the base of Q432 and the dc voltage developed by D433 is coupled via D437 to the 5V Regulator. The 13V at the emitter of Q432 is also applied to Zener, Z435, which forward biases the zener, supplying voltage to the LED portion of the Opto-Isolator.

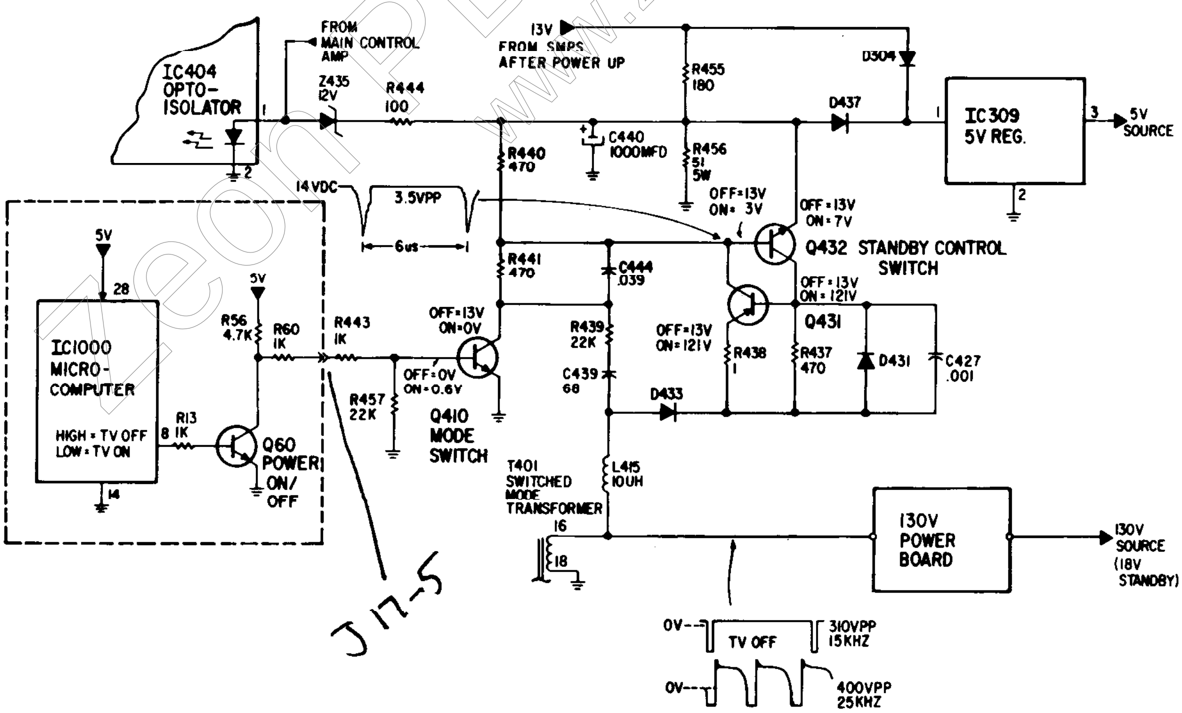

Figure 9 — Standby/Full-Power Circuit

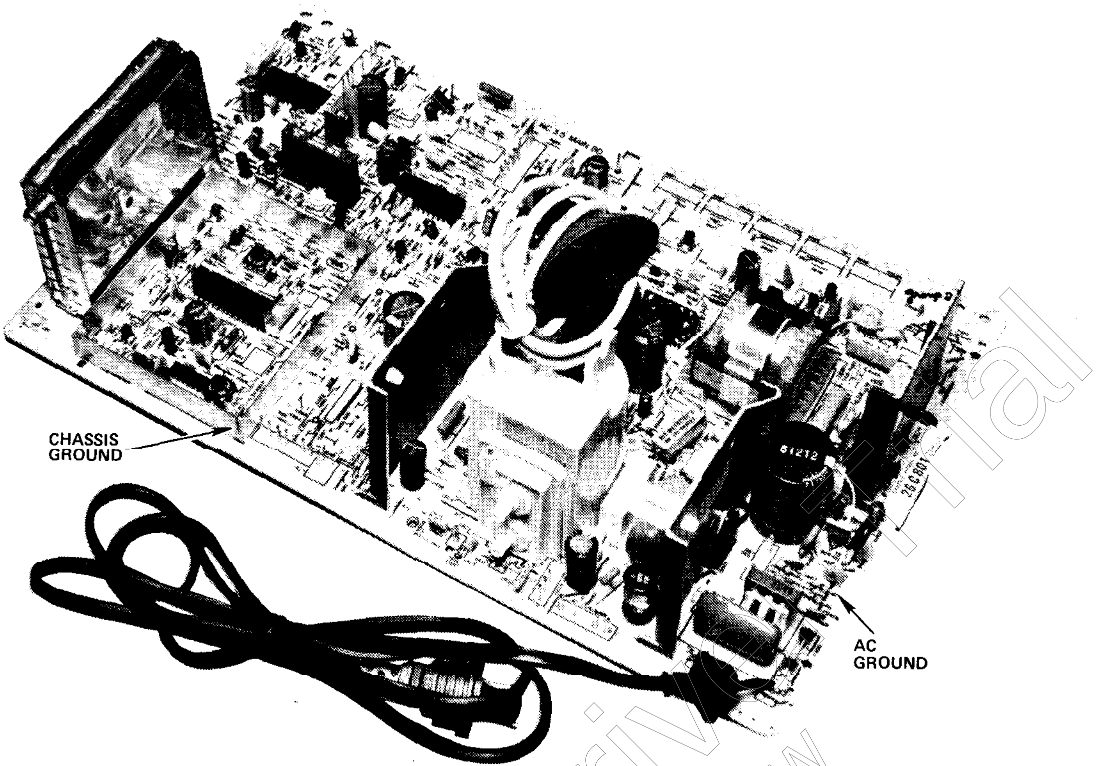

Figure 10 — C8 Chassis Ground Connections

TROUBLESHOOTING THE STANDBY/FULL POWER CIRCUIT

The waveforms and voltages shown in Figure 9 can help in troubleshooting the Standby Circuit. The rest of the circuitry involves switching stages which are either On or Off. The SMPS can be analyzed by the use of the Standby Mode. The voltage of the various dc supplies for the standby mode are shown in Figure 8.

TROUBLESHOOTING THE SWITCHED MODE POWER SUPPLY

Troubleshooting power related problems in the C8 chassis will most likely be performed within the SMPS circuitry. Most of the voltages for the chassis are developed in the SMPS, except a 200 volt source developed from the horizontal scan system.

NOTE: THERE ARE TWO GROUND SYSTEMS ON THIS CHASSIS; THEREFORE, USE CARE IN CHOOSING THE CORRECT GROUND FOR THE TEST EQUIPMENT AND ALWAYS USE AN ISOLATION TRANSFORMER.

Chassis (signal) ground connection can be made to the IF area shield and Hot (ac ground) ground can be made to the anode of D404 or D405 (Figure 10). THE HEATSINKS SHOULD NOT BE USED FOR GROUND CONNECTIONS.

Circuits Notes:

1. A blown fuse, F400, will almost always point to a defective Switched Mode Regulator transistor, Q400.
2. A shorted Q400 can create a short or open circuit in the Bridge Diodes, D404 through D407.
3. The Switched Mode Regulator transistor will be destroyed without the function of the feedback circuit of the Duty Cycle Control transistors, Q403/Q402. Therefore, any failure of Q400 will require checking Q403 and Q402.
4. If either of the Duty Cycle Control transistors are shorted, the start-up of the SMPS can not be accomplished because the base of Q400 is always returned to a negative voltage.
5. If the Duty Cycle Control circuit is open, the Switched Mode Regulator transistor, Q400, will be destroyed as soon as the chassis is powered On.
6. If any of the above conditions are found, verify the value of R434. R434 is the fusible resistor for the 23V/31V source. If it is open, supply an external 23V supply to the circuit and troubleshoot to facilitate a repair before troubleshooting the SMPS. The 23V/31V source is necessary for the operation of the Opto-Isolator, IC404, and the feedback loop from the Differential Amplifier, Q407, through the Main Control Amp, Q406.

Check Points:

The following ohmmeter checks should be made before applying power.

ENSURE THAT THE CHASSIS IS REMOVED FROM ANY POWER SOURCE WHILE PERFORMING THESE TESTS.

1. Check Fuse, F400.
2. Check Switched Mode Regulator, Q400.
3. Check the Duty Cycle Control transistors, Q403 and Q402.
4. Check the Differential Amplifier, Q407, and the Optic Coupler, IC404.
5. Check the fusible resistors in the secondary, R433/R434.
6. Check the rectifier diodes, D404-D407, D424, D432, D434, and D422.

Troubleshooting the Power Supply can be performed best with the chassis removed from the TV cabinet. Remove ALL plugs and modules (Stereo Decoder, CRT Board, and Microcomputer) from the chassis. Place the chassis on a non-conductive working surface or work bench with the copper side facing up (Figure 11).

CAUTION: THE NEXT STEP IS VERY IMPORTANT **Remove R513 from the chassis** for safety. This will prevent the high voltage from coming up.

The following tools and test equipment are required to perform this type of maintenance:

Voltmeter
Oscilloscope
Variable ac supply (Variac)
AC Ammeter (5A)
Isolation transformer
Load resistor (200 ohm, 100W)*
Jumper wires
Hand tools

* An insulated light bulb socket with pigtails and a 60 watt bulb may be substituted with slight changes in the reading.

DURING THE FOLLOWING TEST, THE POWER SUPPLY WILL BE OPERATED WITHOUT A LOAD ON THE 130V SUPPLY

1. Place a jumper in B59 to complete the Power Switch circuit (A remote set will already have a jumper in this location).
2. Place a jumper wire from TP14 to J17, Pin 5 (disables the Standby Power supply).
3. Plug the isolation transformer into the ac outlet.
4. Plug the variable ac supply into the isolation transformer.
5. Connect a dc voltmeter to the 130Vdc source (TP4).

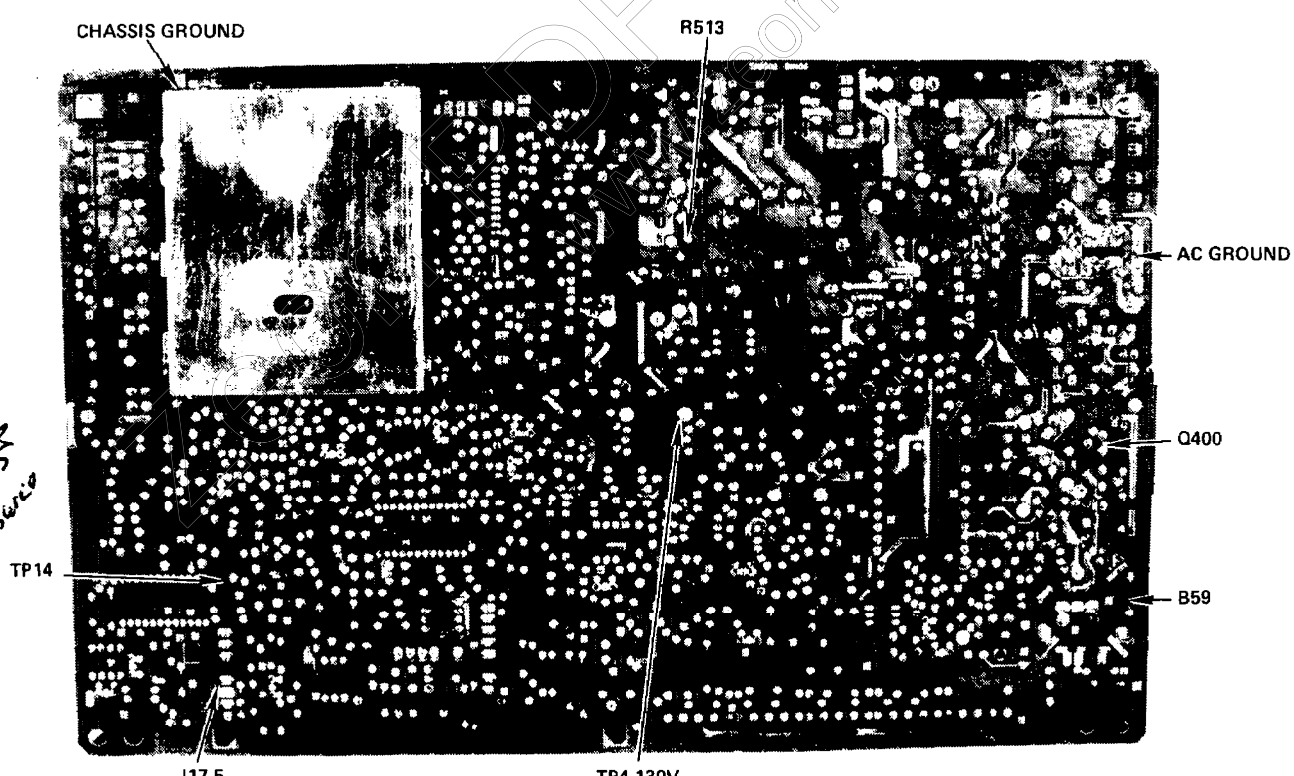

Figure 11 — C8 Chassis Copper Side

6. Use the ac ground for the oscilloscope ground.
7. Connect the oscilloscope probe to the collector of Q400.
8. Turn the variable ac supply to minimum.
9. Plug the AC Line Cord into the variable ac supply.

NOTE: MAKE ABSOLUTELY SURE THAT R513 IS DISCONNECTED!!

10. Turn On the variable ac supply and slowly increase the ac voltage while monitoring the 130Vdc and the ac ammeter.

Note: There will be an inrush of current until regulation is achieved and very little current is necessary to maintain the 130Vdc.

CONCLUSION: IF THE AC AMMETER DOES NOT PEAK AND START BACK IN THE OTHER DIRECTION, OR IF THE 130Vdc SUPPLY CONTINUES BEYOND THE 130Vdc REGULATION POINT, A DEFECT IS PRESENT IN THE CHASSIS (EXCLUDING THE HORIZONTAL DRIVER, OUTPUT, AND IFT AREA).

An increase beyond the 130Vdc level indicates an OPEN in the feedback circuit of Q407, Q406, and IC404. With a normal working Power Supply and chassis, the ammeter will reach a peak around 700mA and develop the 130Vdc regulated source at approximately 40Vac input to the chassis. Continued increase of the ac supply voltage will allow the ac current to decrease to approximately 220mA at 60Vac. Further increase of the ac supply voltage will begin to increase the current at 90Vac and the ac ammeter reading will be 500mA at 120Vac input.

11. Return the variable ac supply to zero volts output.

DURING THE FOLLOWING TEST, THE POWER SUPPLY WILL BE OPERATED WITH A 200 OHM, 100 WATT LOAD ON THE 130Vdc SUPPLY SIMULATING A TV CHASSIS LOAD. A 60 WATT LIGHT BULB MAY BE USED FOR THE LOAD.

1. Connect the load resistor between the 130Vdc source (TP4) and chassis ground (IF Shield).
2. Place a jumper in B59 to complete the Power Switch circuit (A remote set will already have a jumper in this location).
3. Place a jumper wire from TP14 to J17, Pin 5 (disables the Standby Power supply).
4. Plug the isolation transformer into the ac outlet.
5. Plug the variable ac supply into the isolation transformer.
6. Connect a dc voltmeter to the 130Vdc source (TP4).
7. Use the ac ground for the oscilloscope.
8. Connect the oscilloscope probe to the collector of Q400.
9. Turn the variable ac supply to minimum.
10. Plug the AC Line Cord into the variable ac supply.

NOTE: MAKE ABSOLUTELY SURE THAT R513 IS DISCONNECTED!!

11. Turn On the variable ac supply and slowly increase the ac voltage while monitoring the 130Vdc and the ac ammeter.

Note: There will be an inrush of current until regulation is achieved and very little current is necessary to maintain the 130Vdc.

CONCLUSION: IF THE AC AMMETER DOES NOT PEAK AND START BACK IN THE OTHER DIRECTION, OR IF THE 130Vdc SUPPLY CONTINUES BEYOND THE 130Vdc REGULATION POINT, A DEFECT IS PRESENT IN THE CHASSIS (EXCLUDING THE HORIZONTAL OUTPUT AND IFT AREA).

An increase beyond the 130Vdc level indicates an OPEN in the feedback circuit of Q407, Q406, and IC404. With a normal working Power Supply and chassis, the ammeter will reach a peak around 2.4 amps and develop the 130Vdc regulated source at approximately 90Vac input to the chassis. Continued increase of the ac supply voltage will allow the ac current to decrease to approximately 1.4 amps at 120Vac.

12. Return the variable ac supply to zero volts output.

DURING THE FOLLOWING TEST, THE POWER SUPPLY WILL BE OPERATED WITH A SHORT ON THE 130V SUPPLY

1. Connect a jumper wire from the 130Vdc source (TP4) to chassis ground.
2. Place a jumper in B59 to complete the Power Switch circuit (A remote set will already have a jumper in this location).
3. Place a jumper wire from TP14 to J17, Pin 5 (disables the Standby Power supply).
4. Plug the isolation transformer into the ac outlet.
5. Plug the variable ac supply into the isolation transformer.
6. Connect a dc voltmeter to the 130Vdc source (TP4).
7. Use the ac ground for the oscilloscope.
8. Connect the oscilloscope to the collector of

10. Plug the AC Line Cord into the variable ac supply.

NOTE: MAKE ABSOLUTELY SURE THAT R513 IS DISCONNECTED!!

11. Turn On the variable ac supply and slowly increase the ac voltage while monitoring the 130Vdc and the ac ammeter.

CONCLUSION: THE AC AMMETER WILL NOT MOVE UP SCALE MUCH IN THIS TEST BECAUSE THE SMPS WILL SENSE THIS SHORT AND WILL NOT OUTPUT ANY VOLTAGE (THIS IS OVERCURRENT SHUTDOWN).

12. The ac current does increase a slight amount as the ac voltage approaches 120Vac. It can read as much as 600mA at 120Vac, but should not exceed this value.
13. Return the variable ac supply to zero volts output.
14. Restore the chassis to its normal condition.

HORIZONTAL CIRCUIT

The IF/Sync/Sound Processor, IC201, generates the Horizontal/Vertical drive signals, a three-level Sandcastle Output pulse, coincidence voltage output, and processes the Video IF. The circuit in IF/Sync/Sound Processor IC.

The Horizontal Oscillator begins running when 10.5 volts is applied to Pin 7 of IC201. The composite video signal, which comes from the IF Processing section of IC201, exits the IC via Pin 17. A 4.5MHz Filter removes any Sound IF products before the composite signal is buffered by Q244 and applied to Pin 25 of IC201. The Horizontal Oscillator is synchronized to the incoming TV signal via Pin 25. When synchronization is attained, the coincidence output from IC201, Pin 22, is High (9V) and when out of sync, the output at Pin 22 is Low (1.5V). The coincidence signal is applied to the tuning system to advise the tuning system that the sync system is locked onto the proper signal. The Sync Separator circuit passes the horizontal sync signals to the Gating and Phase One Detector where a dc voltage is developed and fed from Pin 24 back into Pin 23 to control the frequency of the Horizontal Oscillator. Also connected to Pin 23 is the Horizontal Frequency Adjust control, R233. An output from the Horizontal Oscillator is fed to the Sandcastle Generator, which outputs on Pin 27 a three level signal that includes Burst Keying, Horizontal Blanking, and Vertical Blanking pulses. The horizontal pulse feedback is input via Pin 27 to provide phase control for the Phase Two Detector in the Horizontal circuit.

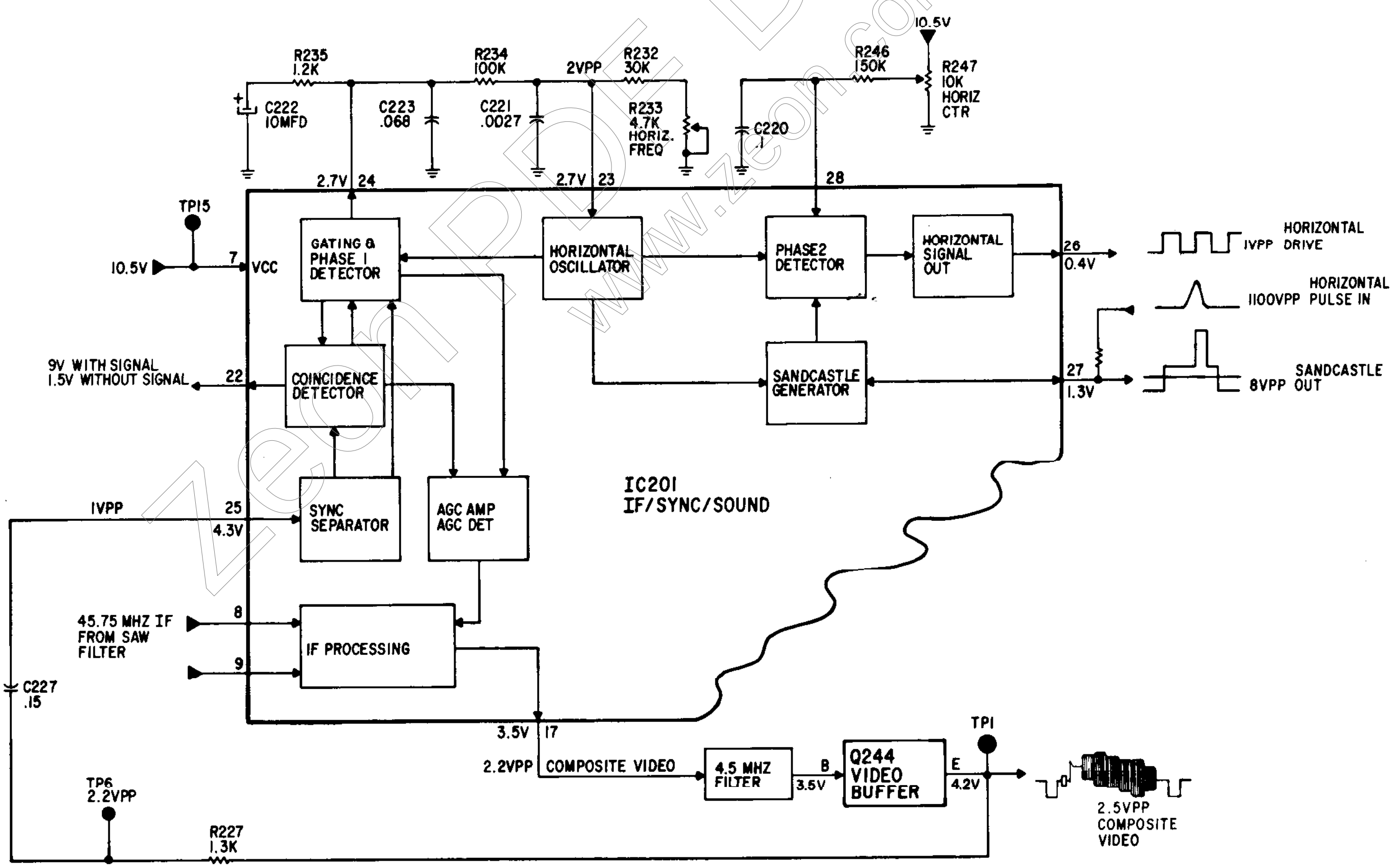

Figure 12 — Horizontal Signal Generation