Safety Leakage

If the "HOT" ground of the power supply becomes electrically connected to exterior metal parts of the cabinet housing, the electronic system poses a shock hazard. Should a user touch this exposed part of the cabinet and at the same time have a good contact with earth ground, AC leakage current flows. The resistance between the HOT ground and exposed metal determines how much leakage current can flow and determines if the user gets a slight annoying tingle, strong jolt or lethal shock.

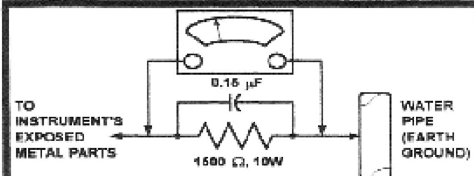
There are several ways that electric paths from the HOT ground to exposed metal on the cabinet can occur:

- Using longer metal cabinet screws
- Leaky AC Line filtering & isolation capacitors
- Improper installation of parts
- Foreign objects falling into the chassis

Fig. 5 - AC leakage presents a dangerous shock hazard for the user

In service manuals, manufacturers include a Leakage Current Check section as part of the Safety Precautions. The "LEAKAGE CURRENT CHECK" section instructs the servicer to measure the leakage current that flows from any exposed metal part of the cabinet to a known earth ground. These instructions shift the responsibility of proving the product safe from electrical shock hazards to the servicer. If an unsafe condition exists after you have serviced the product, even if a leakage problem resulted from no fault of yours, you may be held liable.

To protect yourself and your business you should verify that each electronic system you service does not pose a shock hazard. After you have repaired the power supply and remainder of the system, perform a Safety Leakage Current check. The Sencore PR570 provides for safety leakage tests without the need for a known earth ground.



Leakage Current Hot Check

1. Do not use an isolation transformer for this test. Plug the completely reassembled unit directly into the ac outlet.
2. Connect a 1.5K, 10W resistor paralleled by an .015uF capacitor between each exposed metal cabinet part and a good earth ground such as a water pipe, as shown above.
3. Use an ac voltmeter with at least 5000 ohms/volt sensitivity to measure the potential across the resistor.
4. The potential at any point should not exceed 0.75 volts. A leakage current tester may be used to make this test; leakage current must not exceed 0.5 milliamps. If a measurement is outside of the specified limits, there is a possibility of shock hazard. The chassis should be repaired and rechecked before returning it to the customer.
5. Repeat the above procedure with the ac plug reversed. (Note: An ac adapter is necessary when a polarized plug is used. Do not defeat the polarizing feature of the plug.)

Fig. 6 - Typical Manufacturer leakage measurement instructions

Full Wave Rectification

To understand how a bridge rectifier and filter (Raw DC Supply) works, we will examine the current paths during one AC cycle, as illustrated in Figure 7. During the positive alternation, diodes D1 and D3 conduct and charge capacitor C1 to the positive voltage peak (120 X 1.414 = 169V). During the negative alternation, diodes D2 and D4 conduct, and recharge capacitor C1 to the negative peak voltage of 169 V.

As capacitor C1 discharges to supply current to the remainder of the power supply and load circuits, the voltage across it falls. This charging and discharging action produces a sawtooth waveform across C1 with a ripple frequency of 120 Hz . The amplitude of the sawtooth waveform is determined by how much the capacitor discharges. Under a "no load" condition the capacitor does not discharge, and no AC ripple waveform is present. As the load and discharge current increases, the ripple waveform amplitude increases.

The raw DC output voltage measured across C1 is influenced by the load and waveform amplitude, as illustrated in Figure 7. With no discharge current (no load) the DC voltage nears the peak AC line voltage of 169 volts. As the load current increases, the DC voltage decreases. Under typical loads the DC voltage of the raw DC power supply ranges from 150 to 165 volts.

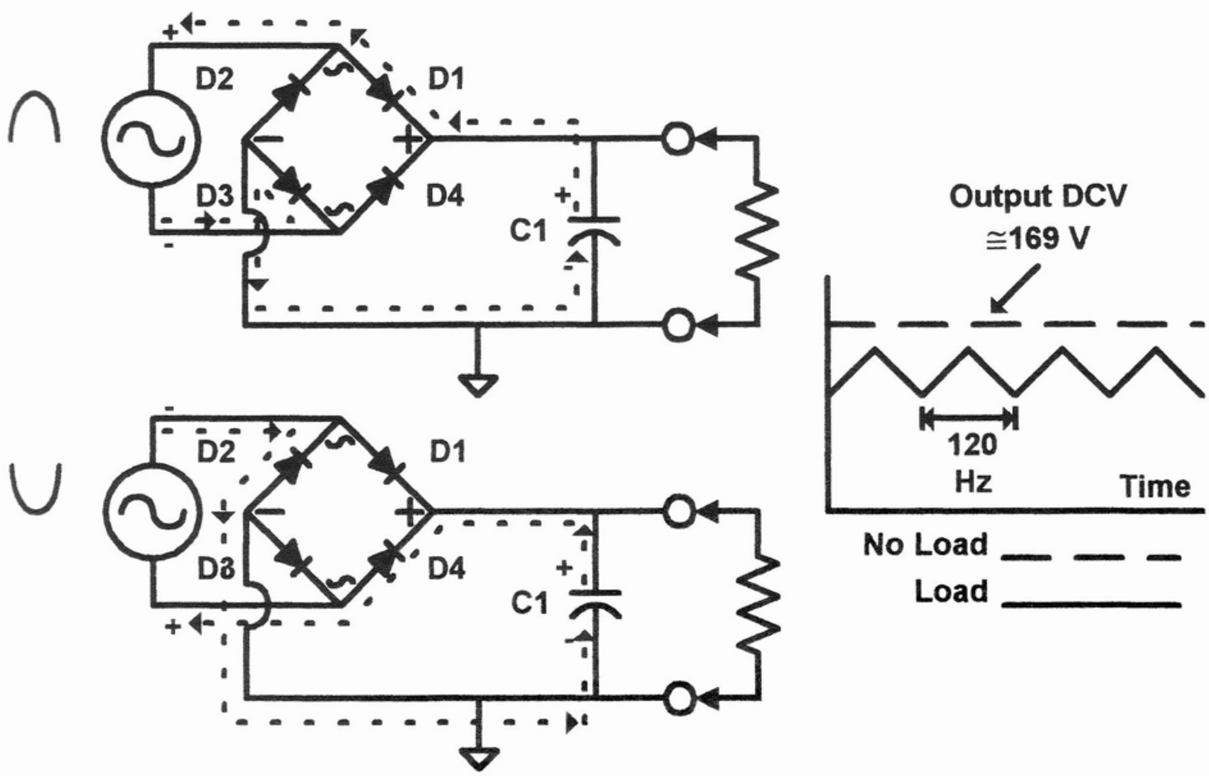


Fig. 7 - Each half cycle of the 60Hz AC input voltage turns on different diodes in the bridge rectifier

All switching power supplies include the basic operational blocks shown in Figure 8. A SMPS includes a raw DC power supply, a switching device, step up/down transformer, drive generator, and feedback/regulation control. The 120 VAC is converted to DC using a conventional AC line-derived DC supply. The raw unregulated DC voltage is applied to the primary of a switching transformer primary. A switching transistor serves as an on/off switch providing a path for current flow through the primary of the transformer.

The switching current flow in the primary of the transformer produces an expanding and collapsing magnetic field that induces voltage in to the secondary windings. The secondaries have different turns ratios, and produce various amplitude voltages. The AC output of each secondary winding is rectified with high speed diodes and filters to produce a DC output voltage.

The secondary windings of the transformer are mutually coupled to the transformer's magnetic field. If more power (current) flows in the primary, all the secondary output voltages increase. Changing the conduction time of the switching transistor or its switching rate controls the primary power and the resulting secondary output voltages.

The switching transistor in a SMPS is turned on and off with a drive signal applied to its base or gate. Two main types of switch mode power supplies are illustrated in Figure 9. They differ in how the drive to the switching transistor is developed.

The drive signal may be produced with an oscillator circuit, usually part of an IC. This is called an IC drive, or Pulse Width drive.

Another method of producing drive is to configure feedback components with the switching transistor and transformer to form an oscillator. By self-oscillating, the switching supply develops its own sustaining drive while transferring power to the transformer secondaries. This type of SMPS is called a Self Oscillator, or Pulse Rate drive.

These two methods of producing drive differentiate between the two basic SMPS designs. Both types will be examined in this Tech School.

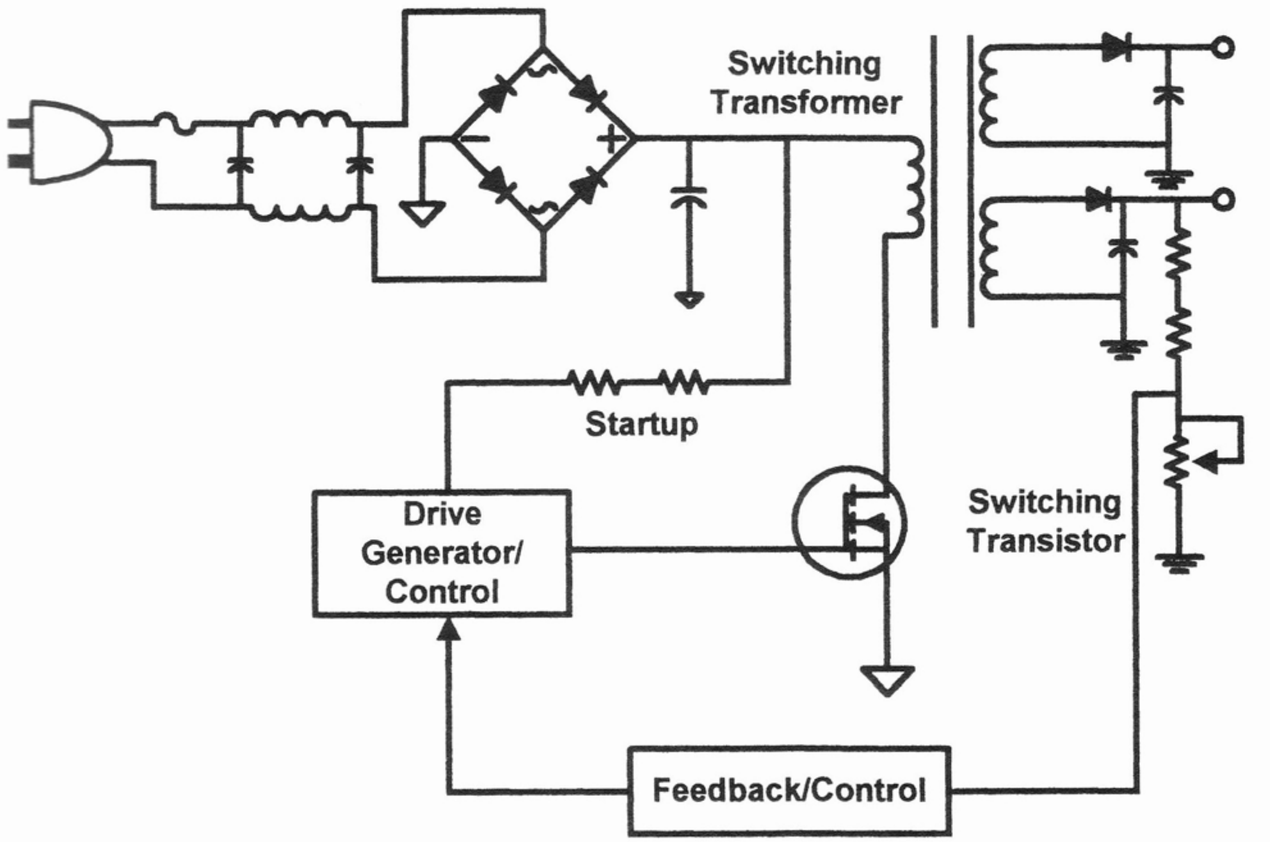
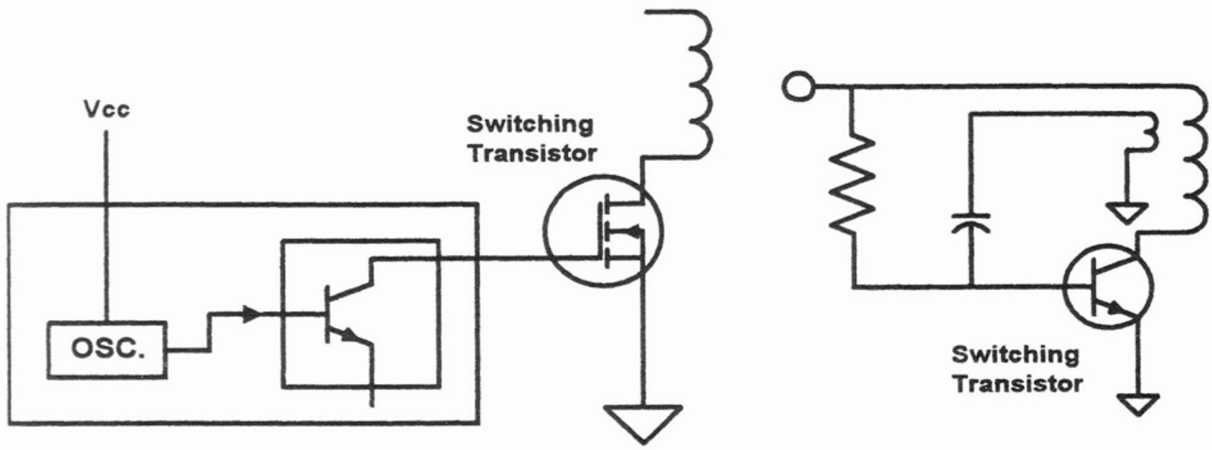


Fig. 8 - Simplified switch mode power supply block diagram



Type: Pulse Width Switching Supply

Drive: IC Oscillator

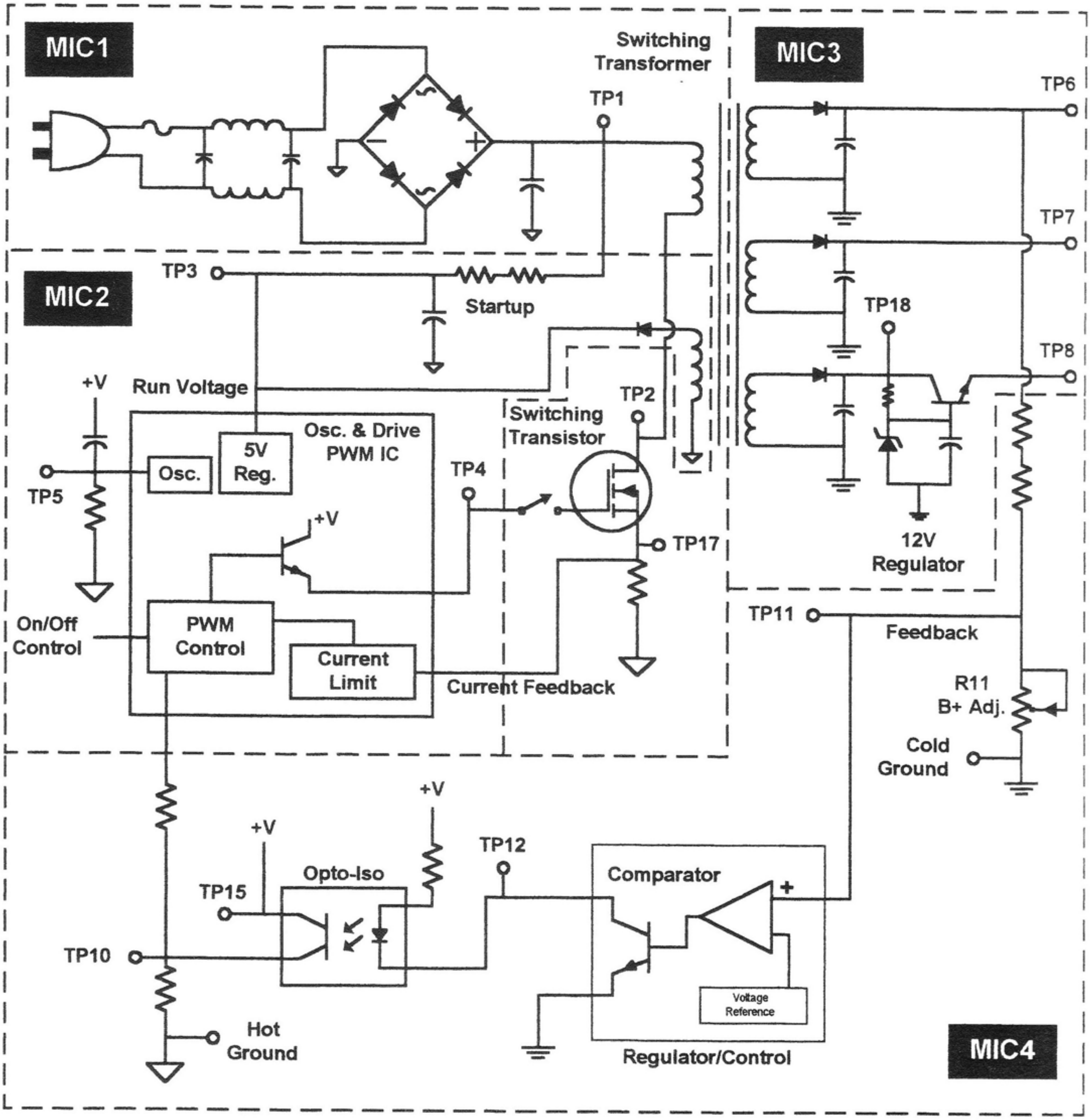
Type: Pulse Rate Switching Supply

Drive: Self-Oscillation

Fig. 9 - Two common SMPS types and how drive is produced in each

Pulse Width SMPS

Simplified Schematic



Pulse Width SMPS

Trainer Familiarization

Caution: You are working with a Hot Chassis
Connect the TT400's AC plug to the PR570

OBJECTIVE:

- Become familiar with normal voltages and waveforms in a Pulse Width Switching supply

SETUP:

- Turn the TT400 Trainer power switch to the "OFF" position
- Ensure that all Problem and Gate Drive switches are set to "Norm"
- Turn the TT400 Trainer power on (the LED on the power supply should illuminate)

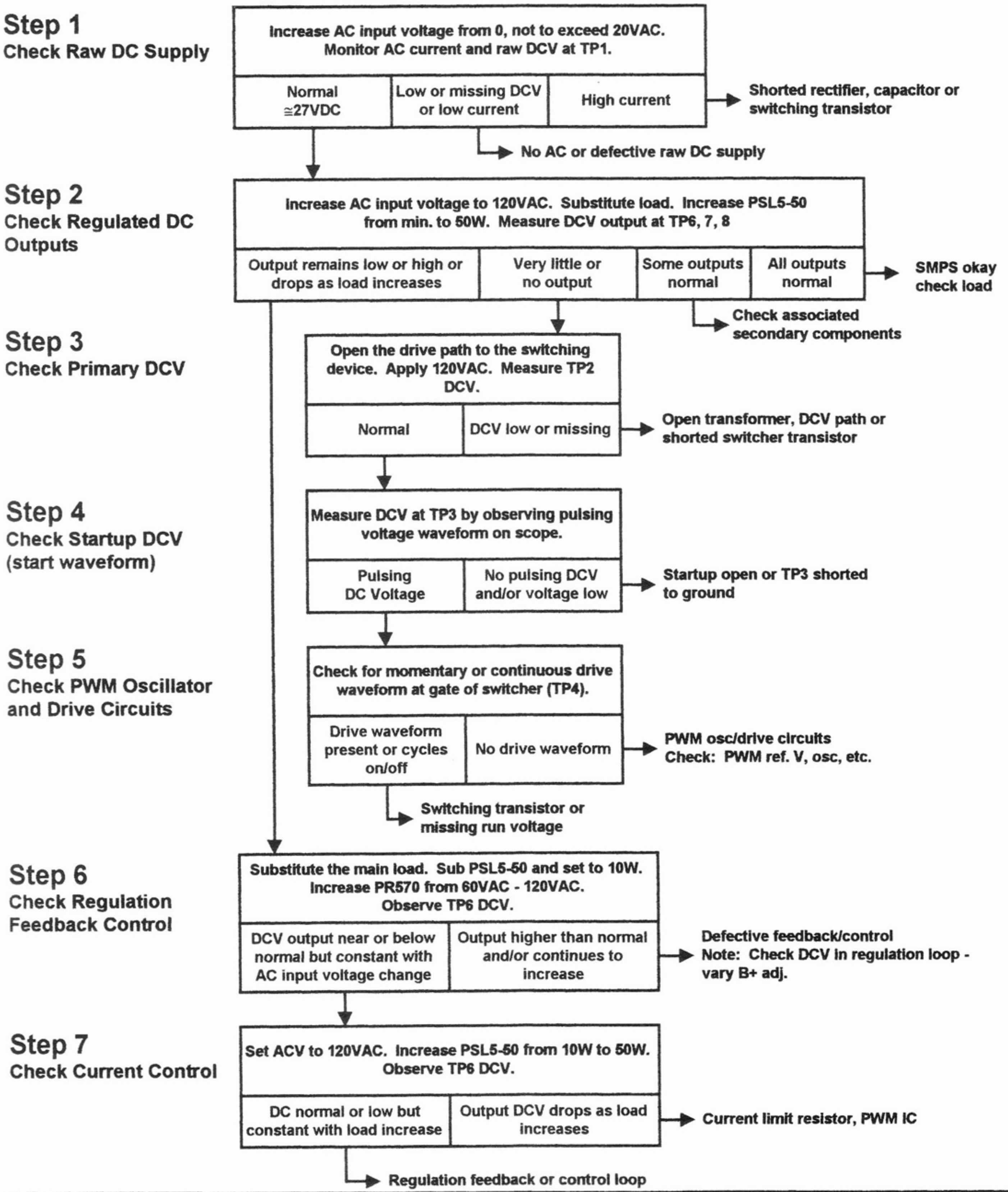
PROCEDURE:

- Connect the PSL5-50 to TP6 and cold ground and increase the load to approximately 25 Watts
- Record the DCV and waveform parameters at the test points indicated
  (Use the SC3100 Delta Frequency function when measuring frequency to ensure accuracy)

Test Point	Ground	DCV	VPP	Frequency	Timebase	Waveform
TP1	HOT	______	______	______	2mS	______
TP2	HOT	______	______	______	10uS	______
TP3	HOT	______	______	None	None	None
TP4	HOT	______	______	______	10uS	______
TP5	HOT	______	______	______	10uS	______
TP10	HOT	______	______	None	None	None
TP17	HOT	______	______	______	10uS	______
TP6	COLD	______	______	None	None	None
TP7	COLD	______	______	None	None	None
TP8	COLD	______	______	None	None	None
TP11	COLD	______	______	None	None	None
TP12	COLD	______	______	None	None	None
TP18	COLD	______	______	None	None	None

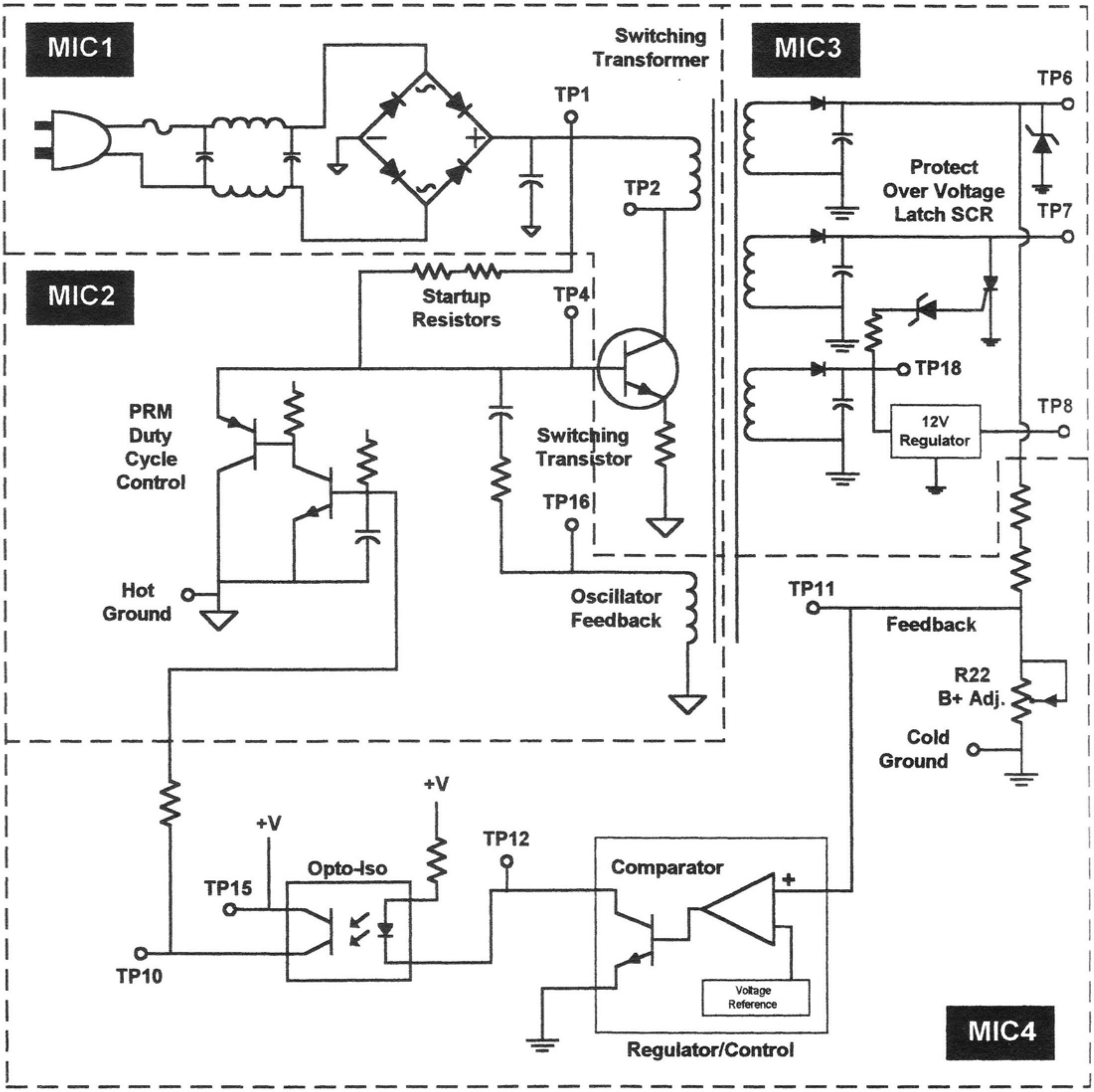
Troubleshooting Tree

Pulse Width SMPS



Pulse Rate SMPS

Simplified Schematic



Pulse Rate SMPS

Trainer Familiarization

Caution: You are working with a Hot Chassis
Connect the TT400's AC plug to the PR570

OBJECTIVE:

- Become familiar with normal voltages and waveforms in a Pulse Rate Switching supply

SETUP:

- Turn the TT400 Trainer power switch to the "OFF" position.
- Carefully remove the PWM SMPS from the TT400 and insert the PRM SMPS
- Ensure that all Problem switches are set to "Norm"
- Turn the TT400 Trainer power on (the LED on the power supply should illuminate)

PROCEDURE:

- Connect the PSL5-50 Load to TP6 and cold ground
- Increase the load to approximately 25 Watts
- Record the DCV and waveform parameters at the test points indicated

Test Point	Ground	DCV	VPP	Frequency	Timebase	Waveform
TP1	HOT	________	________	________	2mS	________
TP2	HOT	________	________	________	5uS	________
TP4	HOT	________	________	________	5uS	________
TP10	HOT	________	________	None	None	None
TP15	HOT	________	________	None	None	None
TP16	HOT	________	________	________	5uS	________
TP6	COLD	________	________	None	None	None
TP7	COLD	________	________	None	None	None
TP8	COLD	________	________	None	None	None
TP11	COLD	________	________	None	None	None
TP12	COLD	________	________	None	None	None
TP18	COLD	________	________	None	None	None

Troubleshooting Tree

Pulse Rate SMPS