SENCORE® Means Success In Electronic Servicing — tech tips

Troubleshooting SMPS Problems (PWM Type)

Switch Mode Power Supplies (often called "choppers", switchers" or simply "SMPS") are used extensively in many AC-powered devices, such as computers, monitors, television receivers, and VCRs. This Tech Tip provides a 6-step procedure to use for isolating problems in the PWM type of SMPS that are typically used in consumer electronic equipment. Tech Tip #203 explains how SMPS operate.Tech Tip #204 provides information on how to determine whether the SMPS is the cause of an inoperative chassis.

Why SMPS Troubleshooting Is Different Than Linear Supplies

Conventional linear power supplies usually continue to supply an output, even if a load shorts, a filter capacitor opens, or half of the bridge quits. Isolating the defective component in a linear supply usually consists of tracking too low, too high or lost DC voltages. The SMPS, on the other hand, requires a different troubleshooting process. Here's why:

First, replacing a burnt resistor, shorted diode or bad transistor in a SMPS does not guarantee a fix as with the linear supply. Simply fixing the SMPS supply by replacing a burned part often causes the same components to burn up again.

Secondly, when troubleshooting a linear supply, a variac is used to slowly bring up the AC line voltage while you monitor the current draw. Not so with most SMPS. You have virtually no chance to back off the AC power once the SMPS kicks in. It either puts out no current or full current.

Perhaps the biggest difficulty with troubleshooting a SMPS is a direct result of one of the SMPS benefits - it's ability to protect itself from over-voltage or over-current conditions by shutting down. Most SMPS component failures or load changes cause the SMPS to completely shut down and produce a "dead chassis" symptom. This can make troubleshooting difficult and confusing. Is the shutdown caused by too much high voltage?; the B+ being pulled down?; too much load current?; a supply component failure?; or a defective safety circuit?

Without a logical procedure, SMPS troubleshooting can be frustrating. But you can break the SMPS shutdown loop and quickly isolate the defective area in 6 easy steps.

The Four Key Circuits

Before we look at these six steps, let's briefly review the four general sections (most important circuits or MICS) that make up a SMPS, as shown in Figure 1. (Refer to Tech Tip #203 for a complete explanation of each MIC).

MIC #1 - Unregulated B+ - This circuit includes the linear power supply, standby supply, primary of the switching transformer, and the switching transistor.

MIC #2 - Startup & Drive - This section provides the control signal for the switching transistor. The heart of MIC #2 is the driver circuit. It can be a single stage transistor or a current mode controller IC.

MIC #3 - Secondary Circuits - The secondary circuits include the secondary winding of the switching transformer and the components (diodes capacitors, etc.) that provide power to the loads. Most SMPS have 2 to 5 loads.

MIC #4 - Feedback & Control - Most PWM SMPS feedback loops provide four functions:

- Output voltage sampling for regulation
- High voltage monitoring
- System control micro for power ON/OFF
- Ground isolation through opto-isolators

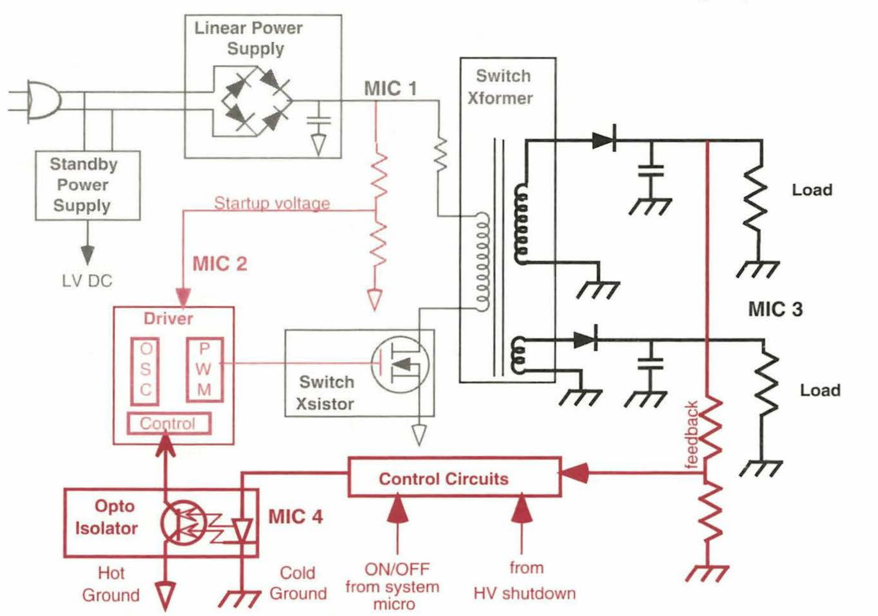

Fig. 1: A SMPS contains four key circuits.

6-Step Troubleshooting Procedure

The following six steps are proven to be a safe, effective method of isolating the problem to a specific MIC. Combining these steps with dynamic component analyzing will get even the toughest SMPS up and running.

WARNING:

Always use an Isolation Transformer. All SMPS contain both hot and chassis (floating) grounds. You will cause damage to the SMPS and/or your test equipment if you connect test equipment to a hot ground, or attempt to tie the hot and cold grounds together.

Keep the following things in mind when performing the SMPS troubleshooting procedure:

• Always use the correct ground reference when making a measurement. Using the wrong ground reference will result in an incorrect reading.

• Hot grounds are usually found on the primary side of the switching transformer. Use this ground for all MIC 1 measurements.

• Chassis grounds are found on the secondary side of the switching transformer. Use this ground for MIC 2, 3 & 4 measurements.

• The opto isolator input (from the control circuits) is measured with respect to chassis ground.

• The opto isolator output (to primary side driver or controller stage) is measured with respect to hot ground.

• Be Prepared to Make All Parameter Measurements. Efficient troubleshooting depends on your ability to quickly measure different signals and voltages: DC from tenths of a volt to 160V; signal voltages from 2 VPP to >400 VPP; and frequencies from 40 kHz to 150 kHz.

We recommend using the SC61, SC3080 or SC3100 Waveform Analyzer, since they allow you to make all measurements with just one probe connection.

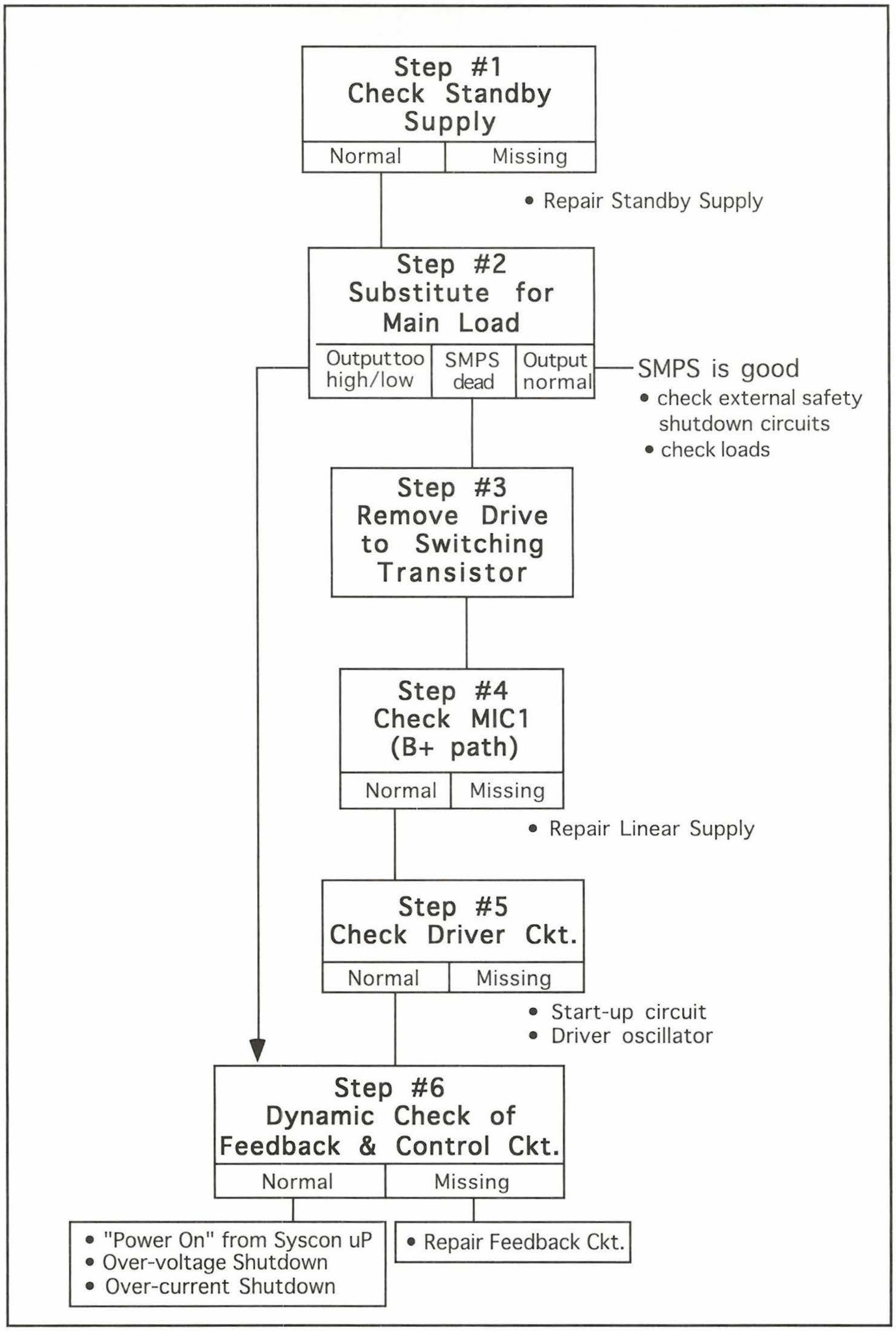

Fig. 2: Follow these steps to quickly and safely isolate SMPS problems

The flow chart in Figure 2 outlines the six troubleshooting steps. Perform the steps in order. Each step funnels the problem to a specific MIC and suspect components. Any one of the troubleshooting steps may isolate the SMPS problem. Often, you may not need to do all 6 steps because the problem is found in one of the first steps. Following is an explanation of each step.

#1 - Check The Standby Supply

The standby voltages to the driver and microprocessor must be correct before the SMPS can operate. (Not all SMPS have standby supplies). Check for standby voltage with the chassis plugged into an isolation transformer set for an output of 117VAC, (such as the PR57 POWERITE) but with the chassis power (chassis ON/OFF switch) turned off.

Some chassis use a second, smaller SMPS as the standby supply. The fact that the standby supply is working eliminates many suspect components. The IC Driver in MIC #2 is always a suspect in a shut-down condition, and is often needlessly replaced. The standby switcher is physically smaller, and has lower power handling capabilities than the main switcher, but it is driven by the same Driver IC as the main switcher. Therefore, if the standby switcher is running the Driver IC is likely OK. The shutdown condition is caused by something else that preventing the Driver IC from supplying a control signal to the main switching transistor.

If the standby supply voltage is correct, but the main SMPS is still not operating, move on to step #2.

#2 - Substitute For The Main Load

An important step in troubleshooting SMPS problems is to separate the SMPS output from the rest of the chassis. This helps you determine if the shut down supply symptom is due to the SMPS supply itself, or if the symptom is due to an outboard circuit or load. (A similar procedure is given in Tech Tip #204 for isolating problems to the SMPS or external circuitry).

Most PWM SMPS will not operate without an adequate load current. Therefore you can not simply disconnect the loads. Instead, most manufacturers recommend replacing the main load with a light bulb that has approximately the same wattage rating. The light bulb provides current limiting and provides a suitable, constant load for the SMPS.

The main B+ load is the output of the SMPS that contains the feedback divider network. In a television receiver or monitor this is the output that powers the collector of the horizontal output transistor. By substituting for this load you effectively disable the safety shutdown controls that come from the external circuits.

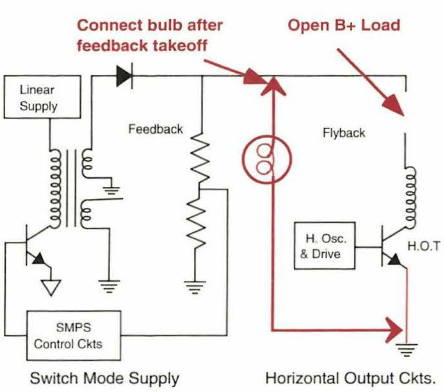

Fig. 3: Use a light bulb as a substitute load for the B+ output of the SMPS. Disconnect the normal B+ load, then connect the bulb after the feedback takeoff point.

The size of bulb you use depends on the load you are substituting. For example, if you are substituting for the load on the 130 VDC B+ supply in a television receiver or monitor, use a standard 60 watt, 120 VAC light bulb. If you are substituting for the 15 volt B+ output in a VCR supply, use a 12 or 18 volt bulb.

You will need to open the circuit path to remove the normal load. Make sure to break the circuit after the feedback take off point. Removing the horizontal output transistor in a television or monitor will break the circuit, but do not connect the bulb in place of the horizontal output transistor. The primary of the flyback is not designed to handle a continuous current. Connect the light ahead of the primary, as shown in Figure 3.

After you substitute for the load, you will see one of four conditions when you turn on the SMPS:

- **Bulb lights and measured voltage is normal**

This means that the SMPS is working properly. Something external to the SMPS is causing the shutdown. Possibilities include excessive HV, excessive current draw by one of the loads, or a defective safety circuit.

- **Light bulb doesn't light (SMPS doesn't start)**
- **Light comes on but goes out (SMPS starts but goes into shutdown)**
- **Light is very bright (indicates possible regulation problems)**

These last three conditions indicate that something is wrong with the SMPS. Continue with the remaining steps until you locate the problem.

#3 - Remove the Drive Signal from the Main Switching Transistor

Open the signal path between the Drive and the gate or base of the switching transistor. You can easily do this by unsoldering and lifting any one of the components in the signal path. Disconnecting the input signal to the main switching transistor allows you to safely troubleshooting the SMPS circuits, while the chassis is turned on, without accidentally producing an output from the SMPS.

#4 - Check MIC 1 Circuits

MIC #1 includes all the B+ path from the output of the linear supply to the ground point of the emitter or source of the switching transistor. Begin by checking for B+ voltage at the switching transistor:

1. Connect the Waveform Analyzer to the switching transistor's drain or collector. Set it to measure DC voltage.

2. Set the PR57 to zero volts AC output. Press the "0-1.5A/175W" output current monitor button.

3. Gradually increase the PR57's AC output while monitoring the output current.

You will observe one of the following conditions:

- **Low current, normal B+ (approximately 160 VDC) with PR57 output at 117 VAC.**

This means that the B+ supply is good. But there still might be a problem in the MIC 1 circuity:

Check the switching transistor to make sure it is not open. Use a dynamic transistor, such as the TF46 "Super Cricket.check

Also check the resistor(s) in the emitter or source lead of the switching transistor. If you suspect they may have changed in value, replace them with the manufacturer's exact replacement. These resistors are precise tolerance, and are critical to safe operation of the SMPS.

If the transistor and resistors are good, proceed to Step #5.

- **No DC and no AC current draw**

There is an open in the B+ supply. Check the fuses, safety resistors, diodes, and switching transformer primary.

- **No (or low) DC & increasing AC current**

Low or missing DC voltage along with increasing AC current is caused by a short in the B+ supply itself, or some-where within MIC #1. Check the switching transistor, bridge, and filter capacitor. Also check the primary winding of the switching transformer for a DC short to the core or to another winding.

#5 - Check Driver Circuit

First, confirm that the Driver IC has start-up voltage. In most switch mode power supplies the start-up voltage is obtained from a resistor divider network off the linear unregulated B+ supply. Always check for start-up voltage before checking if the oscillator is running. Connecting a probe to the oscillator test point can "kick-start" the oscillator.

Secondly, check all of the oscillator test point waveform parameters: DC, PPV, and frequency. The oscillator frequency must run at the switch mode supply frequency. If the frequency reads high (the oscillator waveform may be noisy and contain with glitches) confirm the frequency using the Delta Frequency function on the waveform analyzer. If the frequency is more than 10% too high, the controller IC is defective.

NOTE: Usually a current mode controller will not output a drive signal to the switcher with the SMPS disabled. Make your measurements at the oscillator test point on the controller IC)

#6 - Perform a Dynamic Check of The Feedback & Control Circuit

This final troubleshooting step confirms proper operation of the Feedback and Control circuits, MIC 4. Often failures in MIC #4 are caused by a defective transistor which shuts down the entire feedback loop. This dynamic feedback circuit check will quickly isolate any problem in MIC 4.

To check these circuits you will need to apply an external voltage (equal to the normal, main B+ output of the SMPS) and confirm that the circuits respond properly to it. Use a variable, current limited DC power supply, such as the leakage power supply in the Sencore LC102 "AUTO Z".

1. Disconnect the substitute light bulb load from main B+ output of the SMPS.

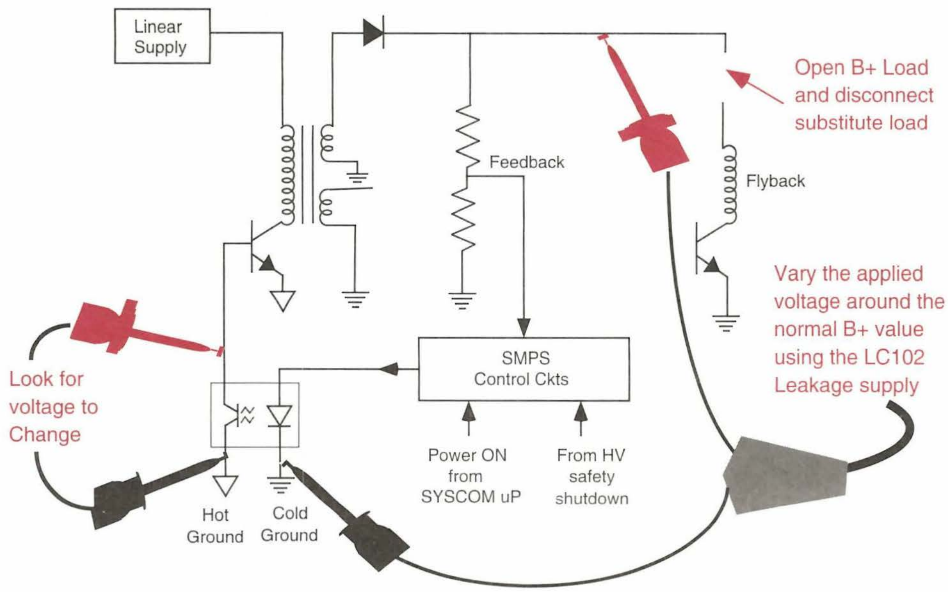

Fig. 4: Apply an external DC voltage to the feedback circuit to confirm the operation of MIC 4.

2. Connect the LC102 power supply to the B+ point, after the feedback divider network. (The same point where the light bulb was connected).

3. Connect the Waveform Analyzer to the control input of the Driver. (Output of the Opto Isolator) Press the "DCV" function.

4. Set the PR57 to 117 VAC output and turn the chassis on.

5. Vary the LC102 supply voltage from five volts below the normal B+ voltage to five volts above the normal B+ voltage, while monitoring the DC reading on the Waveform Analyzer.

If the feedback circuitry is working, you will see an increase in the DC voltage at the Driver input as you increase the applied voltage above the normal B+ level. A 1 VDC change in the applied voltage typically may only show a .1 VDC change at the Driver.

If there is no change at the Driver input, check the opto isolator. (Remember to reference the correct ground.) With a changing DC into the opto isolator there should be corresponding change in the output DC voltage. Continue checking the MIC #4 feedback loop until the defect is located. This includes the "Power On" command from the system control microprocessor, and the output from the safety circuits, such as over-voltage and over-current shutdown. Be sure to check the electrolytic capacitors for ESR.

SMPS Component Analyzing Tips

Don't use general replacement parts.
The switching transistors and diodes used in SMPS must operate effectively at high currents and high frequencies. The most reliable results are achieved using the manufacturers' original parts.

ESR is a critical capacitor parameter.
Due to the high operating frequency of SMPS, ESR (equivalent series resistance) is a common failure mode of electrolytic capacitors used in SMPS. High ESR causes an array of symptoms, from shutdown to wrong regulation. Replacing a suspect cap with an off-the-shelf part may only make matters worse.Test any suspect capacitors with an ESR tester, such as the Sencore LC102.

Test the Switching Transformer
SMPS switching transformers, like flyback transformers, are high Q transformers. They are responsible for transferring a large amount of energy in a short period of time. A single turn short will shut down the SMPS. Be sure to use the patented Sencore ringing test to test any suspect switching transformer.

For More Information,
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3200 Sencore Drive, Sioux Falls, SD 57107

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