SAM GOLDWASSER
SERVICE EDITOR

Monitor Power-Supply Problems

THIS MONTH WE'LL BEGIN OUR DISCUSSION OF ACTUAL MONITOR FAILURES BY DEALING WITH PROBLEMS WITH THE LOW-VOLTAGE POWER SUPPLY. UNFORTUNATELY, THERE ARE SO MANY VARIATIONS IN MONITOR DESIGNS AND POTENTIAL problems that this series can touch on only a small fraction of the possibilities. However, the most common ones are still going to be shorted/blown parts and bad connections.

With a half-dozen or more separate voltages required by the typical SVGA monitor, a dead monitor is only one of the possible symptoms of a low-voltage power-supply problem. If one of these voltages is missing or incorrect, a number of systems can be affected-and in unexpected ways.

The Series Light Bulb Trick

Before we get into the gory details of monitor troubleshooting, here is possibly the single most-useful and inexpensive gadget you can use when servicing power electronics. This is one of several of my "Incredibly Handy Widgets(tm)!"

When powering up a TV or monitor that has had work done on any power circuits, it is desirable to minimize the chance of blowing your newly installed (and likely expensive) parts should there still be a fault. There are two ways of doing this-use a Variac to bring up the AC line voltage gradually or use a series current limiter. One device that is great as a series current limiter is a common incandescent light bulb-they are readily available and inexpensive, and also provide a nice visual indication. If you go that route, here is what you'll see and what it means:

- Full brightness: a short circuit or extremely heavy load-a fault probably is still present.
- Initially bright, then fading to a reduced brightness: this is what is expected if operation is normal-the brightness drops as the filter capacitors charge.
- Pulsating: the power supply is trying to come up but shutting down due to an overcurrent or overvoltage condition. It is also possible that the wattage of the light bulb may be too low for the equipment.

Note: for a TV or monitor, unplug the internal degauss coil as it represents a heavy initial load that could prevent the unit from starting up with the light bulb in the circuit.

The following are suggested starting wattages for the bulbs: 40 watts for a VCR or laptop-computer switching power supplies; 100 watts for small (i.e., B/W or 13 -inch color) monitors or TVs; and 150 to 200 watts for large color monitors or projection TVs. You may need to go to a higher wattage with some equipment, but don't be tempted to remove it entirely until you are absolutely sure that the fault is no longer present.

Unfortunately, some monitors simply will not power up at all with any useful-sized series load (in terms of wattage). The microcontroller apparently senses the drop in voltage and shuts down. However, these seem to be the exceptions.

Power-Supply Fundamentals

Monitors require a variety of voltages (at various power levels) to function. The function of the low-voltage power supply is to take the AC line input of either 115 VAC, 60 Hz (220 to 240 VAC, 50 Hz or other AC power in Europe and elsewhere) and produce some or all of those DC voltages.

- In all cases, the B+ (B+ refers to the main DC voltage that powers the horizontal deflection system of most monitors) to the horizontal output transistor or (HOT) is obtained directly from the low-voltage power supply.
- With small video monitors that operate at a fixed scan rate (e.g., TV monitors), many or most of the low voltages may be derived from secondary windings on the flyback (LOPT) transformer.
- The typical SVGA autoscan monitor will use one or more switchmode power supplies (SMPSs) to provide most or all of the low voltages-the flyback isn't used for this purpose.
- There are also various (and sometimes convoluted) designs using combinations of any or all of the above.

Figure 1 shows the complete schematic for the switchmode power supply (SMPS) from a small "I guarantee you never heard of the brand name" SVGA color monitor. The AC line-input and degauss components are at the upper left; the SMPS chopper, its controller, and feedback optoisolator are in the lower left/middle; and the secondaries-some with additional regulation components-occupy the entire right side of the diagram. Even for relatively basic application such as this, the circuitry is quite complex. There are more than a half-dozen separate outputs regulated in at least three different ways!

For large high-performance autoscan monitors, it becomes even worse as highly-stable voltages need to be pro-

grammed based on a wide range of scan rates. Several common design approaches are used to generate the required variable regulated B+ voltage:

1. A separate programmable SMPS generates the B+. This is done by selecting its reference voltage or the fraction of the output voltage that is fed back to the regulator.

2. A voltage from the main SMPS is fed through an additional series switch-mode or linear regulator that drops it down to the required value.

3. One of several fixed post-regulators is selected based on scan rate.

Technique 2 is used by the power supply in Figure 1. The circuitry is located in the upper right-hand comer of the schematic.

Power-Supply Components

All monitor low-voltage power supplies will have:

1. A power switch, relay, or triac to enable main power.

2. Various line-filter, RFI, and surge-suppression components (coupled inductors, LCL filter networks, MOVs, etc.).

3. A set of rectifiers-usually in a bridge or doubler configuration-to turn the AC into DC.

4. One or more large filter capacitors to smoothe the unregulated DC (usually 150 to 160 or 300 to 320 VDC depending on design).

5. A discrete, hybrid, IC, or switch-mode regulator to provide B+ to the horizontal deflection.

6. Some means of generating the various other DC voltages required by the monitor's analog and logic circuitry.

7. Zero or more voltage dividers and/or regulators to produce additional voltages directly from the line power.

8. A degauss-control circuit. Monitors having manual degauss buttons will include additional circuitry.

9. A startup circuit for booting the horizontal deflection if various voltages to run the monitor are derived from the flyback. This may run off a non-isolated voltage or the standby power supply, or it may be derived from the video input (mostly small video monitors, not auto-scan types). However, the SMPS itself will have a startup circuit!

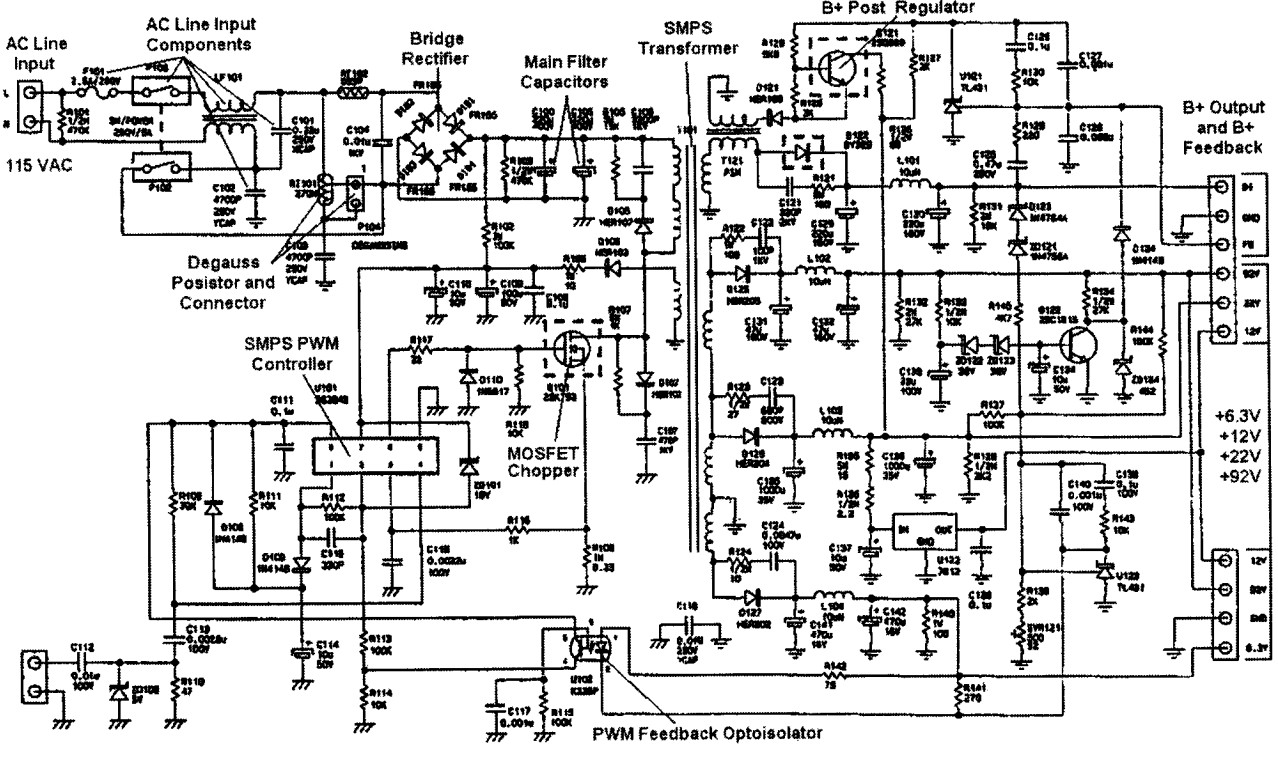
10. A standby power supply if the monitor doesn't use a latching power switch.

Items 1 to 6 might be part of a separate low-voltage power supply module or located on the main board.

Power-Supply Symptoms

Low-voltage power-supply problems can manifest themselves in an almost unlimited number of possibilities, but the following probably cover the most likely:

- Monitor is as dead as a concrete block-no picture or raster, no LEDs lit, no sounds of life (like degauss) of any kind. Most likely causes: No power at AC outlet or outlet strip, bad or loose line cord, bad power switch, blown fuse due to internal short or overload.
- No picture but unusual sounds like a whine, periodic clicks, tweets, or flubs, and/or possibly flickering or flashing front-panel LEDs. Most likely causes: Excessive load or short on output of power supply (shutdown or cycling due to overcurrent) or loss of horizontal drive (cycling from overvoltage due to lack of load).
- Unusual aromas, smoke, or six-foot flames coming from inside the case. Most likely causes: Failed parts in low-voltage power-supply, deflection, or high-voltage sections. Actually, while burning smells and even smoke aren't that unusual when parts overheat as a result of a short circuit, actual fire is quite unlikely due to regulatory design requirements for mate-



Typical Switchmode Power Supply for Small SVGA Color Monitor

FIG. 1—HERE'S THE SCHEMATIC of a typical switchmode power supply found in small SVGA computer monitors.

rials and protection devices UNLESS safety systems have been tampered with or the monitor has been operated in an environment where there is lots of flammable dust.

- Jittering, vibrating; or unstable picture. Most likely causes: External magnetic interference or power-line noise, hum in various power-supply voltages resulting from dried-up main-filter capacitor(s) or other capacitors, resistors out of tolerance-all affecting power supply regulation.
- Loss of video, deflection, geometry or size problems, or some or all adjustments have no effect. Most likely causes: Failure of one or more power-supply voltages, selection circuitry not selecting properly (autoscan monitors), bad connections.
- Monitor doesn't power up immediately. Most likely causes: Dried up electrolytic capacitors in power supply or bad connections.
- Interaction of adjustments (for example, turning up the brightness results in a loss of sync or a wavy raster). Most likely causes: Poor power-supply regulation due to bad capacitor, resistor, regulator, or other component, or bad connections.

Note that the underlying cause of any of the above might not be in the low-voltage power supply itself, but might actually be elsewhere-a shorted horizontal output transistor or deflection yoke, for example. This results in either the power-supply shutting down, becoming extremely unhappy, blowing a fuse, or just plain dying. Thus, we cannot really limit our investigation to only the power supply! In fact, with so many interconnected systems in a monitor, particularly a high-performance SVGA model-it can require the services of a master sleuth to identify the perpetrator! Therefore, before you break out the socket wrenches and DMM (or 10 pound hammer!)-or call Scotland Yard-double check that:

- Your AC outlet is live, the power cord is intact (not chewed by the dog), the plug is firmly seated, and the monitor is switched on.
- You have a valid video signal, the video cables are securely attached to the proper connectors, and/or there are no bent pins.
- The monitor isn't being commanded to go into a power-savings mode because your computer thinks it is smarter than you!
- You have the front-panel switches and controls set properly and the video-source selection is correct. Reset it to factory defaults.

If possible, try the monitor with another known-good video input that is compatible with its scan rates and signal levels, or substitute a known-good monitor for the suspect unit. In other words, try to rule out external problems and "cockpit error."

Monitor Power-Supply Problems

WARNING: You should always use an isolation transformer when working on a monitor, but this is especially important-for your safety-when dealing with the non-isolated line-operated power-supply section. Read and follow the safety guidelines presented last month and at my Web site. If there is anything you are unsure of, or if you are not familiar with the hazards and procedures required when dealing with potentially lethal voltages, stay out and get a professional's help!

The following can cause symptoms of a dead or mostly dead monitor:

1. Shorted horizontal-output transistor (HOT). This will usually blow a fuse or fusable resistor as well if fed directly from the AC line. However, when fed by a SMPS, the result may just be a soft audible whine or periodic tweet or flub, possibly accompanied by flashing front-panel LEDs. Here, the failure is not in the power supply itself but may result in damage to it or other components, especially if it continues to run in this state.

2. Shorted output rectifier diodes can load down the outputs to the point of shutting down or resulting in the same audible symptoms as item 1 above.

3. The flyback transformer can have shorted windings or shorts in the focus/screen divider network which load down the output. Those (and particularly shorts in the primary) could cause the horizontal-output transistor to fail as well. That is a common problem with older Macintosh computers and video terminals. Some secondary faults might not be instantly destructive, but result in little or no high voltage and eventual overheating.

4. Some load, or even the CRT, could be shorted leading to similar behavior or blowing fuses or fusable resistors, which then result in no power to that circuitry.

5. A failure in horizontal-drive chain; that includes the horizontal oscillator, driver, or driver transformer. Without drive, there will be no deflection and that will either result in no high voltage directly (when it is derived from the horizontal deflection) or cause it to be shut down to prevent CRT screen bum (from a stationary spot or line). When powered by an SMPS, there may be an audible ticking from the SMPS cycling on overvoltage due to lack of a load.

6. Failure of an SMPS to start. There can be any number of causes, though dried-up electrolytic capacitors and open high-value startup resistors are high on the list if the chopper transistor is not blown.

7. Cold solder joints or other bad connections; monitors tend to have these as a result of temperature cycling and-with all too many-poor manufacturing-quality control. It is possible that no parts have been damaged-at least not yet. Resoldering may be all that is needed.

Troubleshooting The Switchmode Power Supply

If the SMPS is a separate module, it may be possible to unplug its output connector and test it for proper operation independently of the monitor circuitry. However, a minimum load might be needed-at least on the output that is used for regulation feedback-and there could be other interlocks that will complicate your testing.

The most common failures in a monitor SMPS are:

- Main chopper transistor; in a monitor, this is often an expensive power MOSFET.
- Other shorted semiconductors, particularly high-speed rectifiers on the secondary side of the high-frequency transformer.
- Dried-up electrolytic capacitors leading to startup and regulation problems.
- Open high-value startup resistors resulting in no initial drive to chopper.
- Bad connections.

Detailed troubleshooting instructions are beyond the scope of this series of "Service Clinic" columns on monitor repair. However, we will have a complete series on the SMPS in the future, including those found in monitors and PCs.

Common Problems

Here are just a few of the common problems that you might come across:

Power button on monitor is flaky: If the on/off (or other button) on the monitor itself behaves erratically, then the most likely cause is the obvious-the button or switch is dirty or worn.

Believe it or not, that isn't as unusual as you might think. On a momentary pushbutton, if you can get at it, some contact cleaner could help. Replacement with a common pushbutton or toggle-type switch (as appropriate) might be much easier than attempting to locate the original part!

Dead monitor: That means there is absolutely no evidence of anything happening when the power switch is activated. The most likely causes are:

- Outlet isn't live, or the power cord is loose or defective. Try something else in the outlet, and inspect/replace the power cord.
- Bad power switch. With plug pulled, check for continuity in the on or pressed position.
- Blown fuse or fusable resistor (probably from shorted parts in power supply or elsewhere like the HOT).
- Bad power supply (not starting up or just dead), bad connections. However, degauss would likely still operate in this case.

Monitor blows fuse: If the fuse really blows absolutely instantly with no indication that the circuits are functioning (e.g., no static on the screen), then this points to a dead short somewhere quite near the AC power input. The most common places would be:

- Degauss Posistor.
- Shorted parts in the AC-input line-filter capacitors and MOVs.
- Diode(s) in main bridge.
- Main filter capacitor(s).
- SMPS chopper (usually a MOSFET) if there is a line-operated SMPS or HOT (if there is a deflection derived power supply).

You should be able to eliminate those one by one using a multimeter to check for short circuits/low resistance. For everything but the HOT or chopper, replacing the bad parts should be all that is needed-those rarely fail due to OTHER parts going bad.

However, if the HOT or chopper tests bad, it is possible (though not always the case) that something downstream is causing an excessive load that caused the part to fail. Therefore, don't put the cover back on just yet!

Instead, install a new transistor and power the monitor using your series light bulb. If the bulb flashes once and then settles down to a low brightness level, the monitor might be fine. Even a pulsating light bulb might just mean that the light bulb is too small for the monitor power requirements. It might be safe to try a higher wattage bulb.

However, if the bulb glows at close to full brighmess, there is probably still some fault elsewhere. Don't be tempted to remove the light bulb just yet. There is still something wrong. Continue to search for shorted parts.

Fuse replaced (doesn't blow) but monitor is still nearly dead: There might be a click indicating that the power relay is engaging (there could be bad contacts, though this isn't that likely) and the degauss is probably working now. Since the fuse doesn't blow now (you did replace it with one of the same ratings, right?), you need to check for:

- Other blown fuses. Occasionally there is more than one in a monitor.
- Open fusable resistors. Those are usually low values (a few ohms or less) and are in big rectangular ceramic power-resistor cases or smaller blue or gray-colored cylindrical power resistors. They are supposed to protect expensive parts like the HOT, but often blow at the same time, or the expensive HOT or SMPS chopper sacrifices itself to save the 25-cent resistor. Anyway, if any of these test open, they will need to be replaced with flameproof resistors of the same ratings. However, you can substitute an ordinary resistor for testing purposes ONLY as long as you don't leave the monitor unattended.

If you find one bad part, still check everything else, as more than one part may fail; and just replacing one might cause it to fail again. There may also be bad connections that are the cause of the original failure. So, always inspect for those.

Power-on "tick-tick-tick" or "click-click-click" but no other action: A variety of problems can result in this or similar behavior. Possibilities include:

- Lack of horizontal drive. The main regulator is cycling on overvoltage due to very little load.
- Excessive load or faulty power-supply cycling on its overcurrent protection circuit. The sound in this case may be more like a "tweet-tweet-tweet" or "flub-flub-flub," however-see below.
- HV shutdown, or some other system detecting an out-of-regulation condition. However, in this case, there should be some indication (like a momentary high-pitched deflection whine, static on the screen, etc.) that the deflection and HV is attempting to come up.
- A dried-up main filter capacitor or other filter capacitor in the low-voltage power supply that is producing an out-of-regulation condition.
- A problem with the microcontroller, relay or its driver, or standby power supply.

Dead monitor with audible whine, periodic tweet or flub, and low-low voltage: A monitor that appears to be dead except for an audible whine or a once-a-second or so tweet or flub coming from the SMPS usually indicates an overload fault in the power supply itself or a short in one of its load circuits. The power (or other) LED may be weak or flashing as well. Here is a summary of the possible causes:

- Shorted rectifiers or capacitors on secondary side of SMPS.
- Other problems in the power supply or its controller, like bad capacitors.
- Shorted HOT
- Flyback with shorted turns or a breakdown in the focus/screen divider network.
- A short or excessive load on the secondary supplies fed from the flyback.
- Short in horizontal yoke windings.
- Bad solder connections.

Note that a whine may be perfectly normal for your monitor if there is no video input-confirm that there is a signal that is compatible with the monitor's scan rate(s) and type of sync (e.g., separate, composite, or sync-on-green). Assuming you know that the input is valid, that may indicate an overloaded low-voltage switching power supply. The whine is caused by the switching power supply's chopper frequency dropping down due to the overload. The periodic tweet or flub is caused by the SMPS attempting to come up, sensing the excessive load, and restarting.

Test the B+ input to the flyback. If it is near zero, test the HOT for shorts and replace but continue testing with a series light bulb and/or Variac. There may be something causing the HOT to go bad, like a shorted flyback or bad damper diode or snubber capacitor.

If the voltage is not zero but is low (e.g., it should be 120 volts but is only 60 volts) or fluctuating in time with the tweet or flub, there may be a problem with the SMPS itself, the flyback, the deflection yoke, an excessive load somewhere else, or improper drive to the HOT

Reduced width picture and/or hum bars in picture: The most likely cause is a dried-up main filter capacitor. Once the effective capacitance drops low enough,

120-Hz (or lOO-Hz in countries with 50-Hz power) ripple will make its way into the regulated DC supply (assuming full-wave rectification).

Another likely cause of similar symptoms is a defective low-voltage regulator allowing excessive ripple. The regulator IC could be bad or the filter capacitor following the IC could be dried up.

wiggling or jiggling picture: Depending on the frequency of the instability relative to the scan rate in use, the symptoms might be that the entire picture is vibrating, that ripples are moving up or down the screen, or something else. There may also be variations in brightness-hum bars-in the picture.

First, eliminate the possibility of external magnetic interference, power-line noise, or a video-card/computer problem. Try the monitor in another location and on another computer if possible. Or, try another similar monitor in its place.

Once these causes have been ruled out, the most likely ones are:

- Dried-up electrolytic capacitors in the power supply.
- A resistor or other component has changed value in the B+ (or other) regulator. For example, one very common monitor-the Gateway CS 1.5 72FS-uses a 91K, l-watt resistor (R331) to set its 180-volt B+ output. Invariably with use and age, that device's resistance increases in value, leading to a vibrating raster and eventual failure of other parts.
- Bad connections.

Monitor doesn't power up immediately: The monitor might do nothing, cycle on and off for a while, power up and then shut down in an endless cycle-or at least for a while. Then it comes on and operates normally until it is turned off. A couple of possibilities here:

1. The main filter capacitor or other filter capacitors in the low-voltage power supply is dried up, and this can cause all kinds of regulation problems. Other regulating components might be marginal. That might be allowing excessive voltage to reach the output of the power supply, and then the X-ray protection circuitry shuts things down.

2. Bad connections might be preventing the power supply from operating normally until the main board or components heat up a bit.

Adjustment or picture interactions: This describes problems such as turning up the brightness causes a loss of sync; adjusting height also affects width

or produces a wavy raster; or a bright picture or opening a bright window results in a significant change in picture size, wiggly edges, or in the monitor shutting down!

Those might be caused by poor regulation in one or more low-voltage power supphes or an interaction between the high-voltage and low-voltage power supplies, which in turn could be caused by a dried-up capacitor if the unit is relatively old, bad connections, or another faulty component. Measure the B+ to the horizontal deflection (to the flyback, not the horizontal output transistor). If it is changing with the problem, then a regulation problem is confirmed. If that voltage is solid, you will need to check the others to see which one is actually changing.

Wrap Up

That's it for now. Next month we'll explore the exciting world of deflection system failures! Until then, check out my Web site, www.repairfaq.org. I welcome comments (via e-mail only at sam@stdavids.picker.com, please) of all types and will reply promptly to requests for information. See you next time! ❑