BASIC CONVERTER

This supply is an off-line, voltage-fed, half-bridge, switch-mode power supply. This topology first converts the AC power mains to DC, This DC is then chopped to a quasi-square wave. This quasi-square wave is used to drive the primary of an inverter transformer. The secondaries are converted to low voltage DC by using rectifiers and low-pass filters

EMI FILTER COMPONENTS

All power entering the power supply passes through an EMI filter. The filter is comprised of C1f C2f C3, CM and L1.

> *If hit by lightning or some other strange surge any of these could be destroyed. One possible fix is to replace with the newer PC power socket that has a built in filter.*

FUNCTION

The main function of this filter is to reduce conducted emissions emanating from the power supply to a point where it complies with the regulatory agencies.

LINE TRANSIENT SUPPRESSOR

MOV 1 is a surge suppressor. Its function is to attenuate high voltage transients from entering the power supply.

> *I have seen these become a short when hit by lightning. Any typical 120/130 VAC MOV should work.*

POWER MAINS TO DC CONVERSION COMPONENTS

CR1, RT1, RT2, C5, C6 and R1-R4 form the AC-to-DC conversion circuit.

> *RT1,2 are Thermisters, and should read about 5 ohms when cold, as shown on the schematic.*

115 VAC OPERATION

When the 115/230 switch is closed, this circuit is configured in a voltage doubler mode. Each half-power line cycle, C5 and C6 are alternately charged to 1.414 times the rms line voltage. Since the load is across the two capacitors, the voltage is two times the voltage across each capacitor. (Note: The two lower diodes of 6Rf are not used in this mode.)

230 VAC OPERATION

When the 115/230 switch is open, the AC-to-DC conversion circuit is configured in a full-wave bridge mode. How C5 and G6 are charged in series each half cycle. The load "sees11 the same DC voltage regardless of the power line voltage selected.

> *There is a plug/jack connection from the switch to the points as indicated in the drawing. If there is an open in the plug or switch you will not get the proper voltage doubling and no output.*

INRUSH LIMITING

Thermistor RT1 and RT2 limit power line inrush when the supply is first turned on.

If much higher than about 5 ohms they are probably no good.

MAINS DISCHARGE

Resistors R1-R4 discharge C5 and C6 when the supply is turned off (UL requirement).

DC TO QUASI-SQUARE WAVE CONVERSION

OPERATION AND COMPONENTS

Transistors Q1 and Q2 form two active switches that "chop" the DC, They operate 180 degrees out of phase. They are driven through driver/isolation transformer, T1. Diodes CR2, CR3, CR4 and CR5 and C11 and C12 form two turn-off enhancement circuits. When Q1 or Q2 is forward biased, C11 or C12, respectively, charges up to approximately 1.2 volts. When the drive circuit signals either transistor to turn off, it does this by effectively shorting out the primary of transformer T1. Since the secondaries are now effectively shorted, the last charged capacitor is placed across the emitter-base junction of the forward biased transistor.
Therefore, at the first instant, the emitter-base junction is reverse biased to approximated 1.2 volts. This supplies not only sufficient IB2, but keeps the transistors reverse biased to prevent false turn on.

Q1 and/or Q2 was bad in my P/S. I could not find the 2N6740 anywhere. I replaced them with a NTE379. This is a higher voltage, higher current device. I had to adjust the output voltage down after repair, so it may have a better gain also. Since these are in a push-pull arrangement, replace both. (Or go back and fix the thing again in a few weeks/months.)

CATCH DIODES

Diodes CR6 and CRT are "catch" diodes that return any inductive energy to the input capacitors, C5 and C6. They also protect Q1 and Q2 from reverse breakdown. R5 and C13 form a "snubber" network. This circuit limits the "ringing" due to leakage inductance in T3 and T4.

BASE DRIVE SCHEME - TRANSFORMER

The base drive scheme is a proportional type. The three-turn winding of T1 has the entire primary current of inverter transformers, T3 and T4, circulating through it. As the output load is increased, so does the amount of base drive to Q1 and Q2. This provides optimum drive under all load conditions

BASE DRIVE SCHEME - ACTIVE COMPONENTS

Transistors Q5 through Q8 form a "push-pull" inverter drive circuit. Transistors Q5 and Q7 provide the turn-on signal to its respective inverter transistor. Transistors Q6 and Q8 provide the turn-off signal to its respective inverter transistor. Diodes CR36 and CR38 allow the current to commutate during turn off. Transistors Q3 and QU act as logic inverters between the switching regulator IC1 and the inverter drive circuit.

INTEGRATED SWITCHING REGULATOR - OPERATION

Diodes CR20, CR21, CR22 and CR23 and C37 Provide a sort of "bootstrap" startup circuit to get 12 volts to IC1 so the rest of the circuit can start working. Verify that you have ~ +12 volts here if there is no output on any of the other outputs.

Since you will be testing this out of circuit, make a dummy load by soldering a 6 volt 18 watt lamp to the 5 volt pins on a floppy disk connector (available at many computer parts dealers) then attach this connector to one of the leads that go to the P/S. You must have this load to make the P/S work. Without this load, even if nothing is broke, you will get some voltage on the outputs but they will not be the correct voltage other than on the 12 volt supply.

The switching regulator control is IC1. Resistors R28 and C30 determine the clock frequency. The inputs to the error amplifier portion of the control 1C are pins 1 and 2. Pin 16 is an internal reference of approximately 5 volts. Approximately 2.5 volts is applied to pin 2 by dividing down the reference through resistors R21,R22, and R23. C29 is a noise-decoupling capacitor. The +5 volt output is divided down to approximately 2.5 volts to be applied to pin 1 through R17 and R18. Pin 9 is the output of the error amplifier. Frequency compensation, for proper roll-off and phase margin, is provided by C26, C43, and R19

IC1 is a SG3524. Read the data sheet to get a better idea of its circuit operation, then re-read this section. I could not get a "frequency" reading with a FLUKE V/M that has a frequency scale - do not know why.

CROSS CONDUCTION PROTECTION

To prevent cross conduction of inverter transistors Ql and Q2, at any time, a "dead time" limiting circuit is incorporated. R24, R25 and CR26 form this circuit. R2M and R25 form a 2.5 volt voltage divider off the 4-5 volt internal reference. If the output of the error amplifier ever attempts to slew above this 2.5 volt level, CR26 is forward biased. This clamps the output. The result is the maximum duty ratio attainable is approximately 90%.

SLOW START CIRCUIT

Diodes CR24 and CR25, R20 and C27 form the slow start circuit. This circuit prevents the output from the supply from overshooting on turn-on. The circuit also limits the amount of current the inverter transistors must sustain during turn-on.
At turn-on, C27 is at zero volts. Diode CR25 clamps the output of the error amplifier to one diode drop. Through IC1 logic, this forces Q3, Q4, Q6f and Q8 to conduct- This prevents Q1 or Q2 from switching. Now C27 is charged through R20. This allows the output of the error amplifier to rise. Eventually, IC1 allows a minimal on-time to occur on one of the inverter transistors. A short time later, the other inverter transistor conducts for the same duration. Now, the outputs begin to rise. This process of "walking" up the outputs continues until the inputs of the error amplifier are equal. At this point, the "loop" is closed. Capacitor C27 continues to charge to the internal reference voltage and CR25 is reverse biased. Diode CR2*J resets the slow-start capacitor, C27, when the supply is turned off.

OUTPUT STAGES

I found it fairly easy to remove the diodes and diode-pack for all four outputs and then test each and test the capacitors for shorts, excess leakage, etc. and to verify that the transformer was not shorted/open. I got approximately 30-50 ohms on each winding.

These sections work just like the typical analog circuit.

+5 VOLT OUTPUT

Diode CR9 comprises a full-wave Schottky rectifier that changes a secondary quasi-square wave to a positive polarity square wave for the -4-5 volt output. L2 and C1M form a low-pass filter to convert the square wave to DC, H6 is a discharge resistor. C21 is a high frequency by-pass capacitor.

+12 VOLT QUASI-REGULATED OUTPUT

Diode CR10 comprises a full-wave rectifier that changes a secondary quasi-square wave to a positive polarity square wave for the +12 volt output. L3 and C17 comprise a low-pass filter to convert the square wave to DC. R76 is a discharge resistor. C22 is a high frequency by-pass capacitor. R56, R57, C39 and C40 are two snubber networks to dampen the ringing due to the leakage inductance of T3.

+8 VOLT OUTPUT

Diode CR8 comprises a full-wave Schottky rectifier that changes a secondary quasi-square wave to a positive polarity square wave for the + 8 volt output. L6 and C16 form a low pass filter to convert the square wave to DC. R7 is a discharge resistor. C20 is a high frequency by-pass capacitor.

+16 VOLT OUTPUT

Diodes CR12 and CR1M comprise a full wave rectifier that changes a secondary quasi-square wave to a positive polarity square wave for the +16 volt output. LM and C18 form a low-pass filter to convert the square wave to DC. R77 is a discharge resistor. C23 is a high frequency by-pass capacitor* The DC fan for the supply is ran off this line through RT3. (This is so the fan will not run faster if the box gets too hot.) This output is also used for "boot strapping11 the bias supply through CR33* The purpose of this is twofold. One reason is to maintain the bias voltage once the power to the supply is turned off for output carryover* The second purpose is to allow the use of a small bias transformer, T5, which is used only on start up.

Another use of the +16 volt output is the power source for the + 12 volt regulated output. The operation of this regulator is described in the +8 Volt Output section.

VOLT REGULATOR OPERATION

The +12 volt linear regulator is made up of discrete transistors Q9 thru Q11. The +5 volt output, used as a reference, is applied to the emitter of Q9.

Since, at the first instant, the +12 regulated output is zero, 09 is off. B5*J pulls the base of Q11 high. Since Q10 and Q11 are in a Darlington configuration, both Q10 and Q11 are turned on, The +12 regulated output begins to rise until Q9 becomes forward biased through voltage divider R50 and R51. At this point, the circuit is in equilibrium. The dynamic resistance of Q10 drops the +16 volt line to the +12 volt regulated output potential.

-16 VOLT OUTPUT

Diodes CR11 and CR13 form a full-wave rectifier that changes a secondary quasi-square wave to a negative polarity square wave for the -16 volt output. L5 and C19 form a low pass filter to convert the square wave to DC. H10 through R13 are discharge resistors as well as a minimum load to ensure that the filter inductor remains critical at all times. R58, H59» C41, and C*J2 are two snubber networks used to dampen the "ringing" due to the leakage inductance of T4.

PROTECTION CIRCUITS

CURRENT LIMIT PROTECTION

Transformer T2 is a current-sense transformer that monitors primary current. H14 provides a load for the transformer. This converts current to a voltage. Full-wave bridge, CR15 through CR18, converts this quasi-square wave voltage to a positive polarity square wave. R15 is adjusted to extract the amount of voltage that would constitute an overcurrent condition. R16 and C25 is a low-pass filter and time delay* The time delay prevents false shutdowns for momentary transients. CR19 resets C25 every time primary current falls to zero- During dead time, CR30 is an isolation diode, since the remainder of this circuit is shared with the overvoltage protection circuit. If the voltage of C25 is of sufficient amplitude to exceed the 5~volt reference on the inverting input of comparator IC2Cf the output will go high. This forward biases CR30 and CR29; the thyristor, CR29, will latch into conduction pulling its cathode high. This will also pull pin 10 of IC1 high. A high on pin 10 will inhibit all switching action and the outputs will fall to zero. To recover from this condition, the AC power must be removed from the power supply, the overcurrent condition corrected, and the power returned to the power supply.

OVERVOLTAGE PROTECTION

IC2A is the overvoltage comparator. A 2.5 volt reference is applied to the inverting input of the comparator. The +5 volt output is applied to the non-inverting input of the comparator. The 4.5 volt output is applied to the non-inverting input of the comparator through voltage divider R39 and R40. If the +5 volt output exceeds approximately 6,2 volts, the output of the comparator will go high, forward biasing CR32. This will, similar to an overcurrent, forward bias CR29. CH29 will latch and pull pin 10 of IC1 high. Once again, all outputs will fall to zero. The supply will not restart until the overvoltage condition has been corrected and the power line recycled*

+12 VOLT REGULATOR OVERCURRENT PROTECTION

IC2B is used as an overcurrent comparator on the 4-12 volt regulated output. If the voltage on the output side of RU5 drops too low because of an excessive current drain, the output of IC2B will go high, forward biasing CR3U This will, similar to an overcurrent, forward bias CR29. CR29 will then latch and pull pin 10 of IC1 high* Once again all outputs will fall to zero. The supply will not restart until the overcurrent condition has been corrected and the power line recycled. This condition on the 4-12 volt regulated output could destroy Q10 without activating the primary overcurrent circuit.