UNDERSTANDING PLANT AMPLIFIER POWER SUPPLIES

THE SERIES REGULATOR

All power supplies can be broken down into four basic parts: (1) the rectifier, (2) the filter, (3) the regulator, and (4) the reference voltage. Some power supplies also include an option, the current limiter, which we shall discuss in depth later.

Rectifier

The AC input voltage is first fed to a silicon diode which is used to rectify (or convert) the sine-wave AC to a pulsating DC. The most basic form of rectifier is shown in Figure 2, a half-wave rectifier. Half-wave rectifiers are quite widely utilized in CATV amplifiers for two reasons: (1) they do not require a bulky (or expensive) transformer, and (2) they allow you to design a circuit with just a B+ and ground power system. However, they do have some draw backs, the largest of which is that current is drawn through the power supply during only 50% (1/2) of the AC sine-wave cycle. This means that only 1/2 of the power available is utilized.

Three basic approaches have evolved for satisfying the limitations of the half-wave rectifier:

by:

S.K. Richey
Richey Development Company
Oklahoma City, Oklahoma

(1) Use a bridge rectifier (see Figure 3) to develop full-wave rectification. If you use a bridge rectifier *without a transformer*, the negative side of the rectified AC cycle must be run *throughout* the amplifier, where you could otherwise connect to ground through bias resistors you must connect to the B- line from the power supply. See Figure 4.

(2) Use a bridge rectifier with a transformer (see Figure 5). This avoids the B- line complications and now bias connections can go directly to the ground plane on the amplifier circuit.

(3) Or, there is an alternative method that can be used to obtain full-wave rectification, rectifying both sides of the AC sine-wave (see Figure 6) with individual (a pair) of half-wave rectifiers. Both the B+ and B- sides must be individually regulated, and separate B+ and B- lines must be run to the amplifier stages.

All techniques are utilized in CATV equipment; each has its advantages

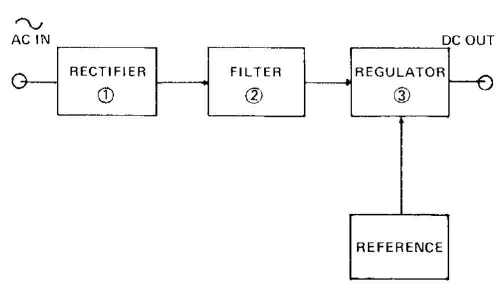

FIGURE 1

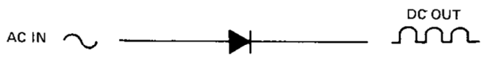

FIGURE 2

and disadvantages, and each is utilized by the design engineer where the individual circuit needs call for different requirements.

Filter

The basic job of the filter capacitor is to *charge up* during the maximum voltage swing (see Figure 7) and to *discharge* during the minimum voltage swing. This procedure results in a *leveling* of the DC output voltage, which usually has less than 5% ripple at this point in the circuit.

Regulator

The regulator transistor is the heart of the series regulator (see Figure 8). Here is how the regulator transistor works. Voltage from the basic supply (i.e. the rectifier and the filter) is fed into the collector of the regulator transistor and any current that is drawn by the load (i.e. the CATV amplifier) will be drawn from the collector. However, *the voltage of the regulator transistor emitter is a representation of the voltage applied to the base.* For example, if we apply 30 volts on the collector, and 5.7 volts to the base, we will see a voltage of 5.0 volts on the emitter (there is a 0.7 volt drop between the base and the emitter). If the 5.7 volts

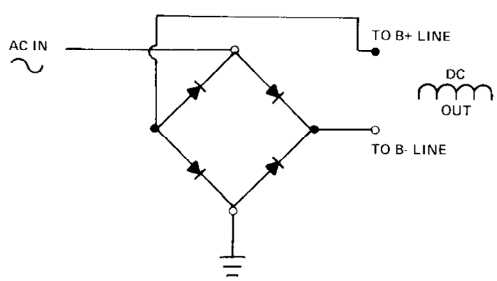

FIGURE 3

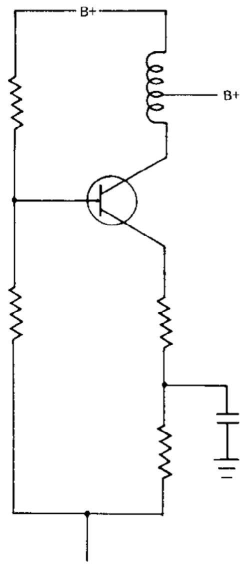

FIGURE 4

are stable at the base, the collector voltage could drop to 9.0 volts or rise to 40.0 volts, and the output would remain stable at 5.0 volts.

Reference Voltage

The reference voltage fed into the base is developed by "dropping resistors" R1 and R2 and by a zener diode (see Figure 9). The function of the zener diode at the base is to maintain the reference voltage to exactly the rated zener voltage level. It accomplishes this by increasing or decreasing the amount of current drawn through resistors R1 and R2 (Figure 9).

It is worth noting with a series regulator that voltage at the emitter will

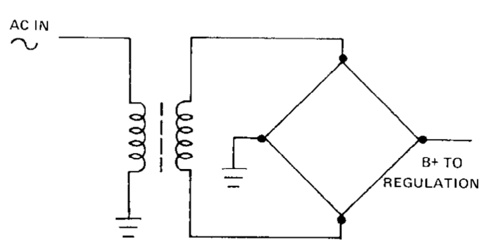

FIGURE 5

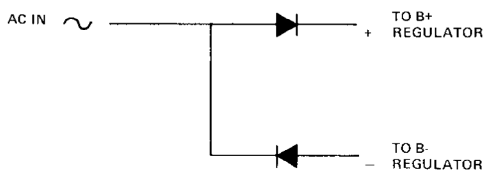

FIGURE 6

have basically the *same amount of hum* (i.e. unwanted distortion products on the power supply line) *as the transistor base voltage,* although the collector of the transistor may have considerably greater hum present. This is because resistors R1 and R2, along with capacitor C2, provide very clean (no ripple) DC to the base.

Current Limiting

If the output of the series regulator is shorted, or a large load is suddenly placed across the power supply output, the series regulator transistor can be destroyed. To avoid this unwanted fuse-action, a circuit such as shown in Figure 10 is often employed.

As long as there is a load of 1 amp the voltage at the output of the 1 ohm resistor is *higher* than the voltage drop across diodes D1, D2, and D3. However, if the load *increases* to 2 amps the output voltage would drop to 13 volts and thus *appear negative* to diodes D1, D2, D3. At this point these diodes would begin to conduct, drawing additional current through resistors R1, R2. This lowers the base voltage and the emitter voltage, and effectively reduces the current output capability to under 2 amps, thereby protecting the series regulator transistor.

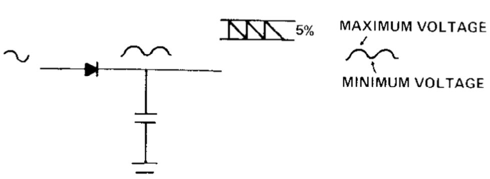

FIGURE 7

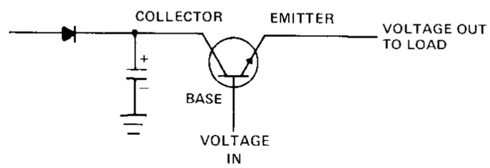

FIGURE 8

Switching Regulator

Switching regulators are becoming more and more popular, due to their *high operating efficiency and low heat problems.* A basic switching regulator is outlined in Figure 11.

The power source which feeds the regulator is the same as we have previously discussed. The output to the electronic switch/pass transistor is where the change takes place. Instead of regulating the *output* of the transistor to a constant voltage, the output of the transistor is *turned on and off* to produce a square wave at the output. The square wave output (i.e. pulsed output) is then passed through a low pass filter which basically converts the output back to a DC voltage. At this point, the output is sampled and compared in voltage to a fixed reference (zener diode). If the output voltage is lower than the reference voltage, the Schmitt trigger is turned on, which activates the electronic switch. The output is *constantly being compared* to the reference voltage, and if the output begins to rise above the reference voltage, the trigger shuts off and so does the electronic switch.

This sequence happens again and again, many hundreds (thousands) of times per second, and the result is a

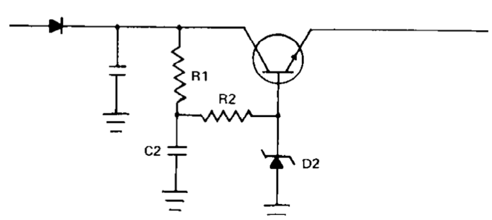

FIGURE 9

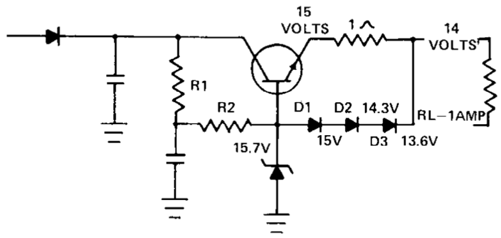

FIGURE 10

regulated output with little heat generated by the power supply.

There are many other ways of accomplishing the same thing. In the supply described, both the frequency and the duty cycle of the square wave are varied with the load and input voltage. There are other designs which only vary the duty cycle while the frequency remains constant.

Synopsis

CATV power supplies are basically voltage suppliers to the power requirements of the solid state active devices in our amplifiers. In the process, the power supplies generate heat (unwanted) and are subjected to sudden *variations* in their input voltages (rare), and their current loads (quite

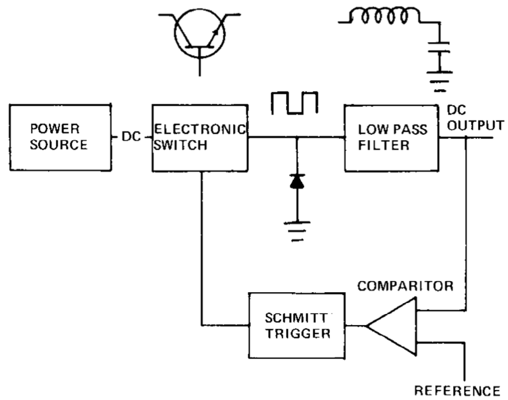

FIGURE 11

common). Heat must either be disposed of (heat destroys parts directly and cause operating parameters to change drastically); input voltage changes must be tamed before component parts are destroyed. And sudden increases in current loads must be caught before the supplies are operating beyond their own current output capabilities and burn up.

Understanding how the supply functions is a leg-up on the correction of faults and preventing supplies from breaking down at an inappropriate time.