AN-725
Application Note

A LOW-COST 80 V - 1.5 A COLOR TV POWER SUPPLY

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A full-wave SCR power supply is proposed for application in line operated color television receivers. Economy of design is maintained while providing good regulation against line, load and temperature changes.

MOTOROLA *Semiconductor Products Inc.*

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The power supply circuit described in this report was designed to meet the real needs of today's 19-inch color TV market. The most important design goal is low cost, although the savings may be masked by circuit complexity demanded by the stringent performance requirements. First the power supply will stay within 2% output voltage over a line-voltage range of 105 V to 140 V. This is important considering the lower line voltages that may be encountered during brown-outs. Secondly, the need to conserve energy demands an efficient regulator which the phase-controlled switching regulator circuit provides. SCR's are used in this design because they are more rugged than transistors and offer cost savings as well. A bridge rectifier circuit is used because of the additional cost advantage of the smaller filtering requirement. This circuit is designed with an 80 V output for use with a 700 V flyback horizontal system.

The circuit can be divided into three sections as shown in Figure 1. The SCR bridge rectifier actually does two functions at once: it rectifies the ac line and also controls the amount of output voltage.

The control function is accomplished by a variable duty cycle. Figure 2 shows the effect of low-line voltage (85 V). The waveforms show the voltage across the two SCRs. Notice that the SCR turns on at an early point in the sine wave, and stays on until the ac input sine wave crosses zero. When the line voltage is high (140 V), Figure 3, the SCR turns on at a later point in the cycle. This is called "phasing back" in SCR terminology.

The line-filter chokes and 0.01 μF capacitors filter out the fast voltage spikes caused by the quick turn-on of the SCRs, and this filter network is also used to keep the horizontal scan frequencies from radiating back into the ac power line. These chokes should be constructed with a minimum wire size of #20.

A programmable unijunction transistor (PUT) is used for the regulator and SCR gating function. The PUT is a negative resistance type device that is easily used in low-frequency sawtooth oscillators. The time constant of the 36 kΩ resistor and 0.1 μF capacitor determine the angle or pitch of the sawtooth waveform. The firing point of the PUT is set by the gate voltage. By increasing the gate voltage, the PUT will fire or trigger later. This action causes the SCRs to fire later in the ac cycle, which decreases the output voltage. The opposite effect occurs when the PUT's gate voltage decreases; the PUT triggers quickly and turns on the SCRs for a longer period allowing more voltage to the output.

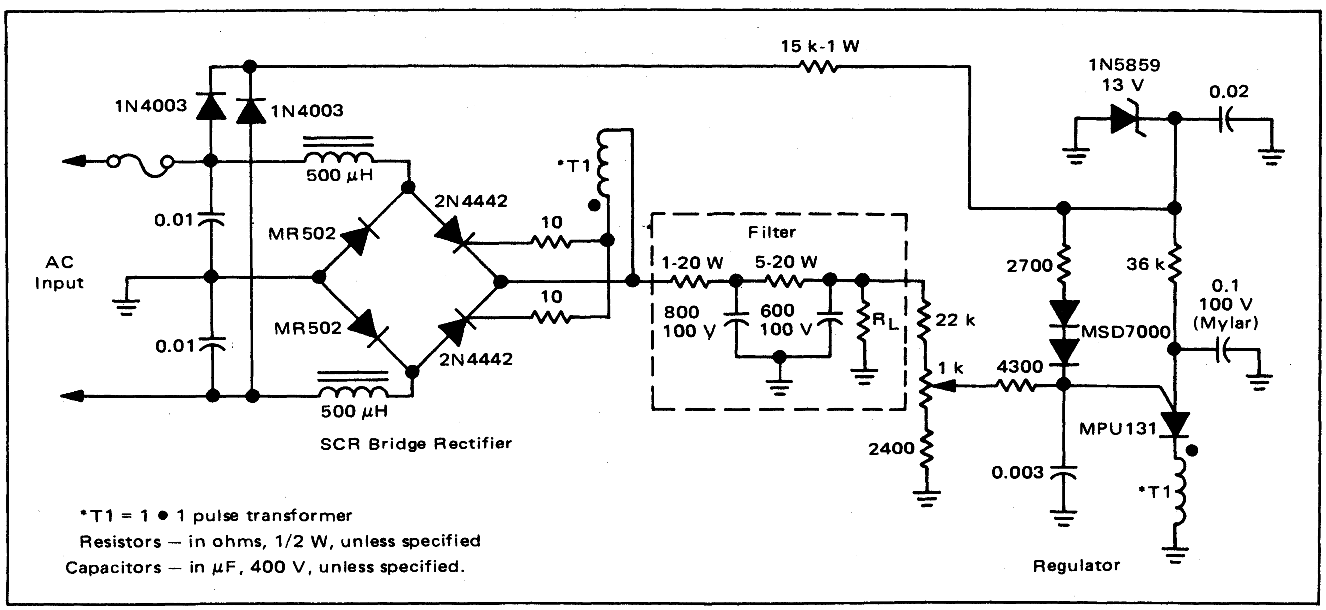

FIGURE 1 — 80 V — 1.5 A Power Supply

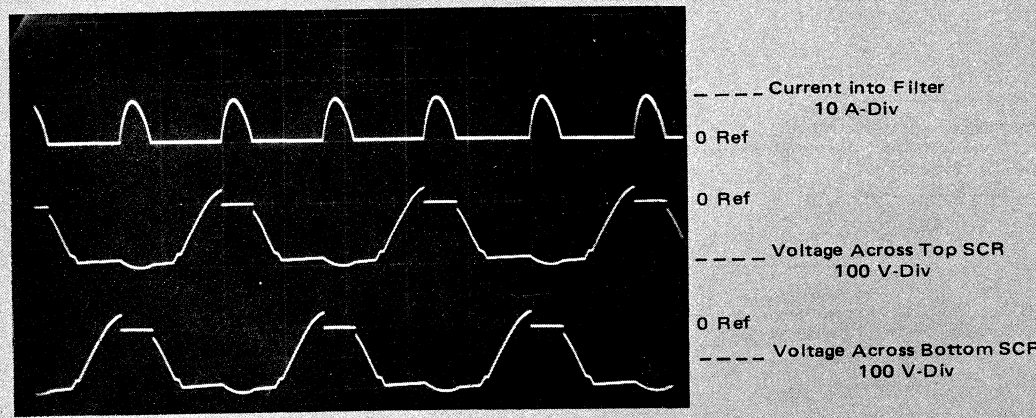

FIGURE 2 – Effects of Low Line Voltage

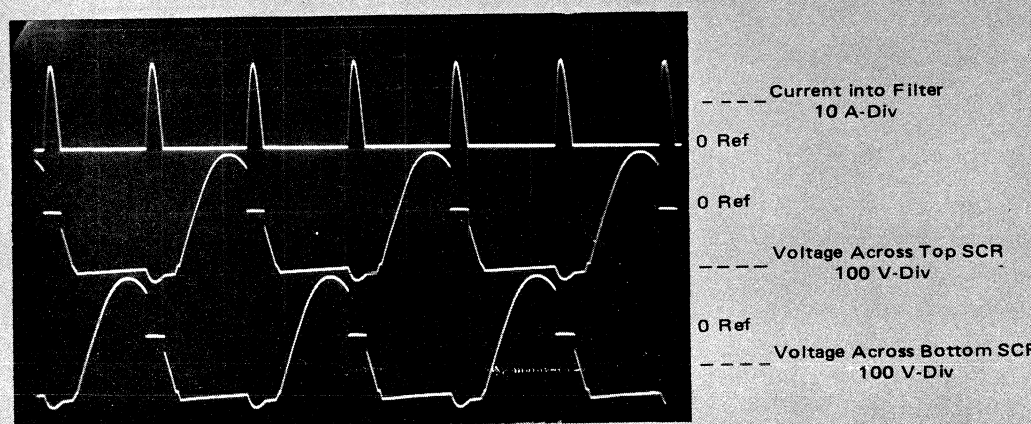

FIGURE 3 – Effects of High Line Voltage

Figure 4 shows the sawtooth waveform present at the anode of the PUT. Figure 5 is the same except with a high ac line voltage. When the PUT fires, the charging capacitor (0.1 μF) is discharged rapidly through the PUT and pulse transformer. This pulse is narrow in width, approximately 2 μs, and provides sufficient energy to gate the SCR "on" via the pulse transformer. Figure 6 shows the voltage waveform across the primary winding of the 1:1 pulse transformer. When the SCR is gated "on" with the narrow pulse from the PUT, it will remain in the "on" state until the ac voltage input crosses zero. Figure 7 shows this effect. The 10 Ω resistors used in the SCR

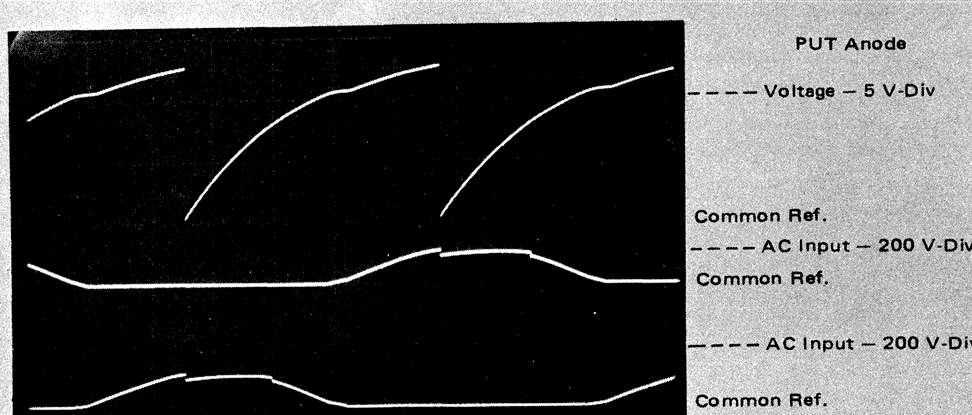

FIGURE 4 – Low Line Voltage At Anode of PUT

gates insure equal gate current sharing from the pulse transformer. The PUT oscillator is synchronized with the line by the bridge rectifiers' unfiltered dc output. This bridge uses the two rectifiers in the SCR bridge circuit plus two additional smaller diodes tied back to the ac line input. The zener diode clamps this unfiltered dc to 13 V, and the 0.02 μF capacitor filters out any fast spikes that may cause erratic operation of the PUT oscillator. Figure 8 shows the voltage waveform across the zener and the sawtooth waveform across the PUT anode. The PUT gate voltage, also shown, is set by the 2.7 kΩ, 4.3 kΩ, 2.4 kΩ resistors, and the MSD7000 dual diodes. The 1 kΩ potentiometer allows this voltage to be varied. The 22 kΩ resistor feeds back the dc output voltage to the PUT gate and varies the PUT firing time with respect to the output voltage.

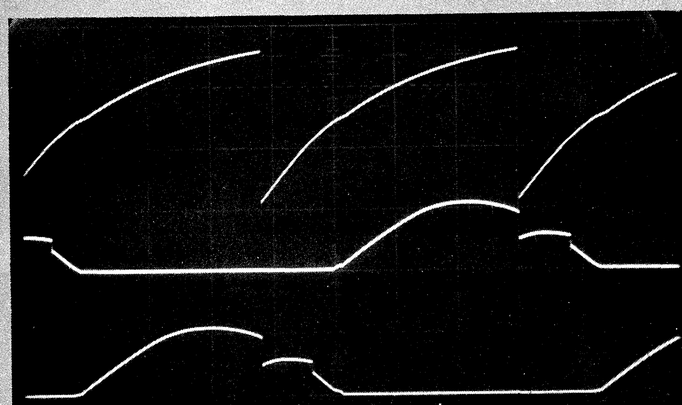

FIGURE 5 – High Line Voltage at Anode of PUT

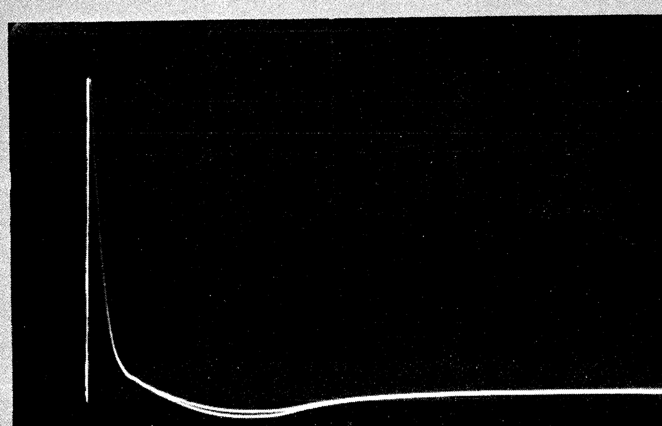

FIGURE 6 – Waveform at Winding of 1:1 Pulse Transformer

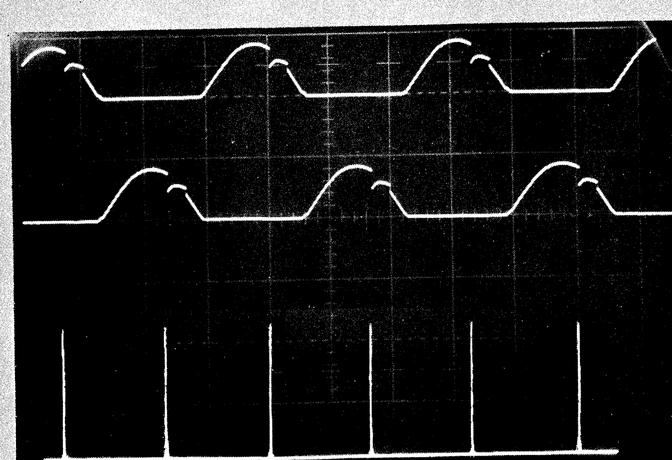

FIGURE 7 – SCR with Narrow Pulse From the PUT

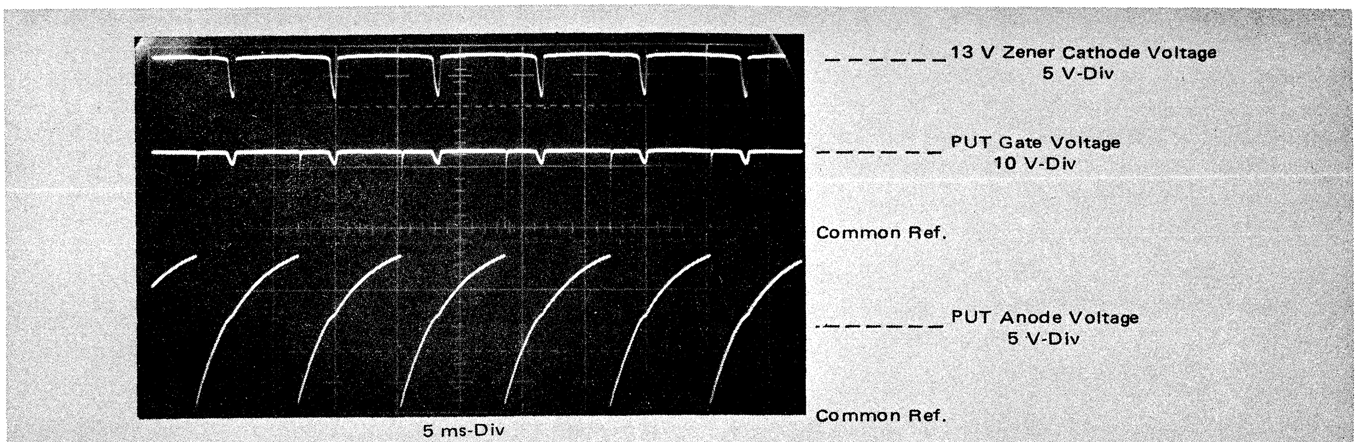

FIGURE 8 — Voltage Waveform Across Zener Diode Sawtooth Waveform Across PUT Anode

Figure 9 shows the line and load regulation. Figure 10 shows the peak-to-peak ripple as the load and line voltage is varied.

Figure 11 shows one method of powering a color TV receiver utilizing the 80 V power supply.

There are some design considerations when using an SCR type power supply that should be allowed. One, is the high peak currents flowing from the ac line through the SCRs and into the filter capacitors. The interconnecting wiring between these components should be short and no smaller than #18 wire. The capacitance of the filter network can be made too large, which causes such a long phase shift that the PUT oscillator loses sync with the line frequency and gates the SCRs at the wrong phase angle.

The SCRs will not operate without a load of at least 200 mA. The SCRs need to be thermally connected to a 15°C/W heat sink and care taken not to bend their leads excessively. The PUT is somewhat temperature sensitive, and the operating temperature of the chassis should be stabilized before setting the 80 V output. Figure 12 shows the output voltage over a temperature range. The dual diode MSD7000 provides temperature compensation, and should be mounted very close to the MPU131 to insure good thermal tracking.

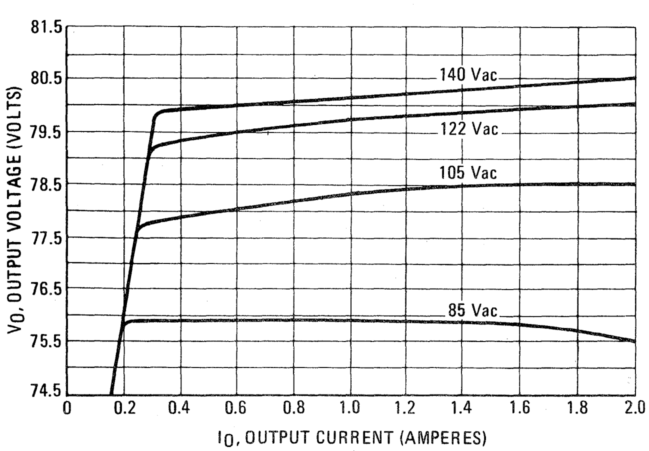

FIGURE 9 — Line and Load Regulation

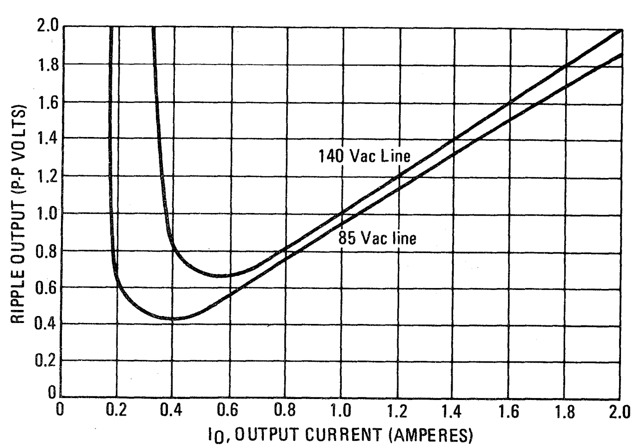

FIGURE 10 — Ripple Output

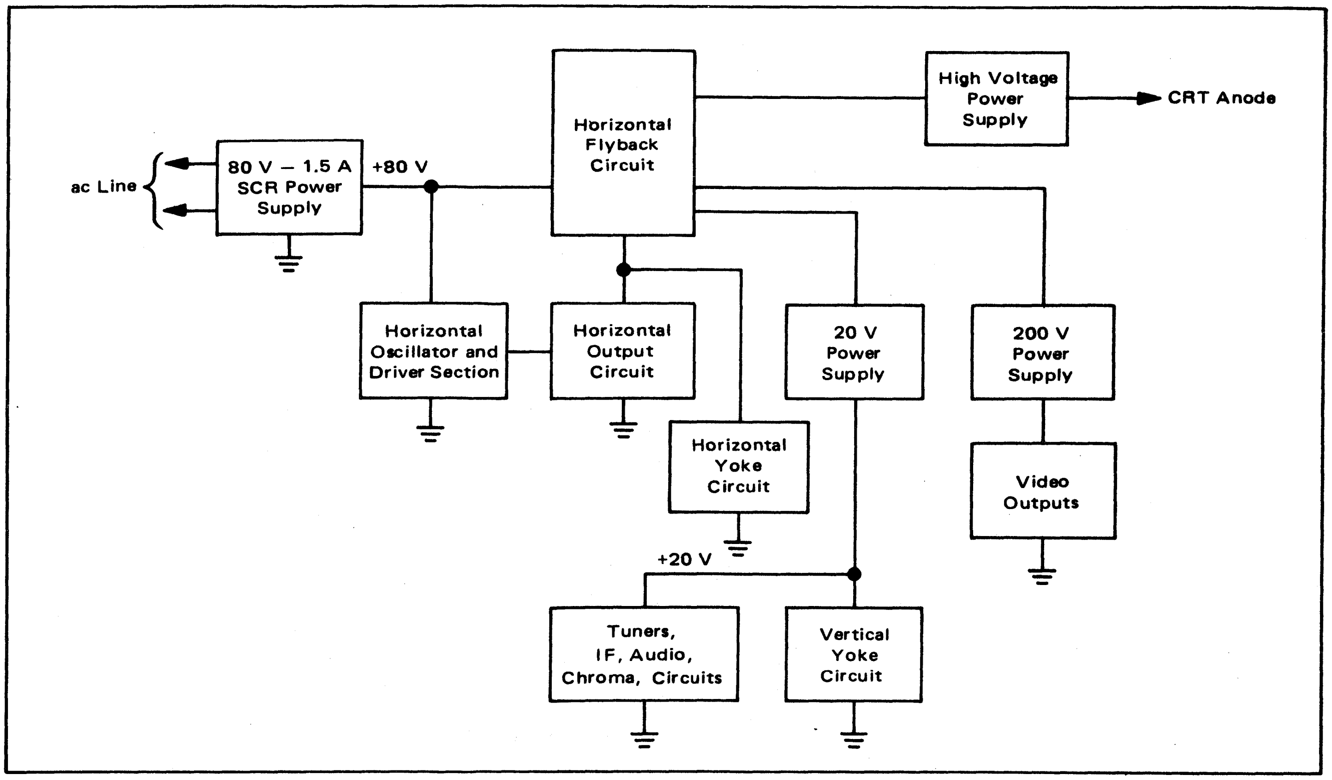

FIGURE 11 — Powering A Color TV Receiver Diagram

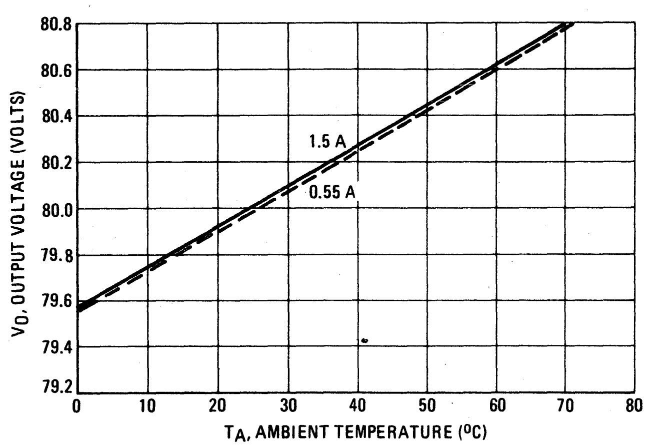

FIGURE 12 — Output Voltage

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1. Applications Engineering, "SCR Power Control Fundamentals", Motorola Applications Note AN-240.
2. Larry Wing, "Mounting Procedure for, and Thermal Aspects of, Thermopad Plastic Power Devices", Motorola Applications Note AN-290B.
3. R. J. Haver and B. C. Shiner, "Theory, Characteristics and Applications of the Programmable Unijunction Transistor", Motorola Applications Note AN-527.

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