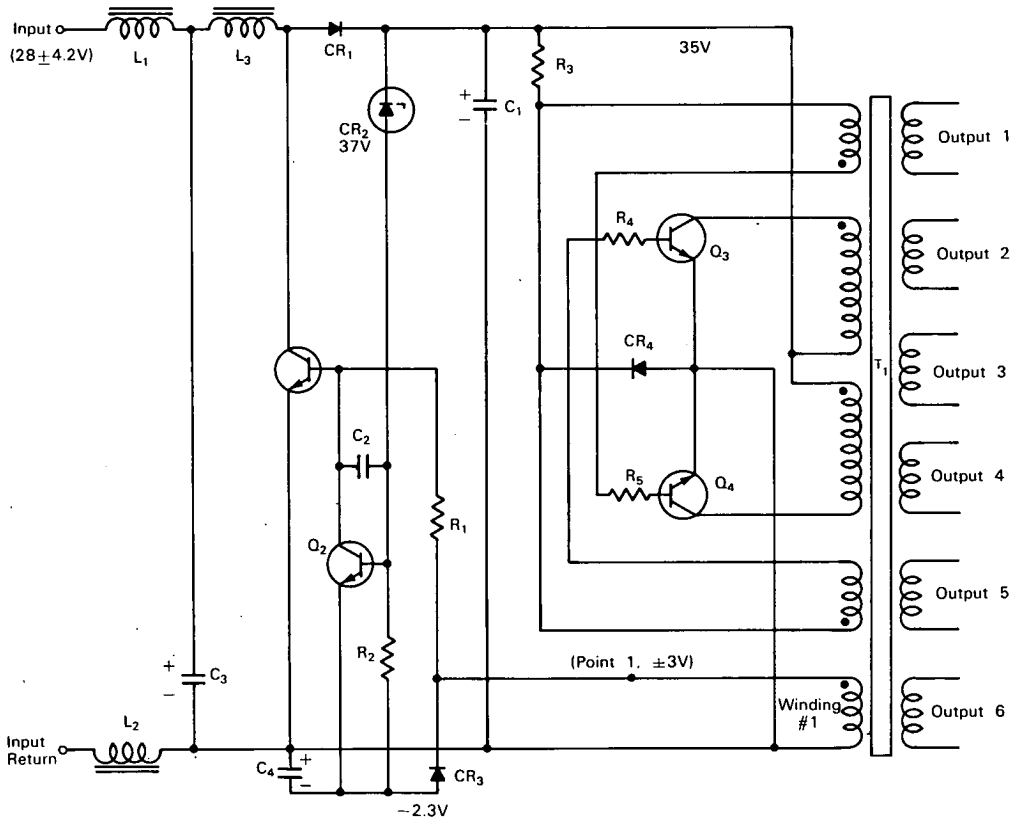
NASA TECH BRIEF

High-Efficiency Step-Up Regulator



Power supplies for telemetry equipment must be of compact design and operate with high efficiency. An improved step-up regulator has been developed for a power supply that operates from an input of 28±4.2 volts (23.8 to 32.2 volts). The step-up regulator provides a constant output of 35 volts from the variable input and accomplishes the conversion with an efficiency of 97 percent. Choppers used alone as power supplies had excessive losses. Single-ended switching regulators, although operating with increased efficiency, cause large undesirable voltage spikes to appear on the output signal. The single-ended step-up regulator-chopper power supply (employing conventional chopper circuitry) combines the advantages of the chopper and switching regulator circuits.

A schematic of the power supply incorporating the step-up regulator is shown above. With 28±4.2

(continued overleaf)

volts applied to the input, the chopper (Q_3–Q_4) will start oscillating. Winding 1 of transformer T_1 develops a 3 volt square wave, and since one side of this winding is grounded, the other side (point 1) goes from 3 volts positive to 3 volts negative at the frequency of the chopper. Assume point 1 has just gone positive and turned Q_1 on through R_1. Q_1 will now stay on until point 1 goes negative. While Q_1 is on, current is flowing through L_3 to ground, charging L_3. When Q_1 is turned off by point 1, the charge in L_3 must dissipate, and it does this by forward biasing CR_1. The current flows through CR_1 and charges capacitor C_1 slightly. The voltage on C_1 increases. Point 1 again goes positive and turns Q_1 on again and off again. This time, the potential on C_1 is raised a little higher and reaches 35 volts. CR_2 and Q_2 prevent the potential on C_1 from exceeding 35 volts. Assuming the 35 volt line is at a potential slightly above 35 volts, CR_2 will conduct and turn Q_2 on while Q_1 will be held off. When point 1 goes positive it will not yet be able to turn Q_1 on. There will be a slight delay until the 35 volt line drops just below 35 volts and CR_2 stops conducting. At this point, Q_1 will now come on, charging L_3. L_3 will in this case not get a whole charge, as the charging time was shortened. During periods of full load on the output of the supply, the charging time of L_3 will be long. During no-load conditions, the charging time will be greatly shortened.

The 35 volts will generally be held within plus or minus 0.25 volt. There are spikes on the 35 volts, and this voltage could not normally be used without further filtering. In this case the 35 volts are applied directly to the chopper. The inductance of the transformer in the chopper tends to eliminate the spikes from the preregulator and they are not seen on the outputs.

Capacitor C_2 is adjusted to a minimum value just large enough to cause the circuit to operate smoothly in PDM. The combination of L_1, L_2, and C_3 makes up a filter which minimizes the ripple fed back to the bus. At the instant Q_1 is turned on, there is no current, due to the inductance of L_3; therefore, Q_1 can be turned on slowly. At the instant Q_1 is turned off, there is a maximum of current in Q_1, and Q_1 needs to be turned off as rapidly as possible. Point 1 pulls the base of Q_1 to a minus 3 volt potential, turning Q_1 off in nanoseconds. By having the chopper operate on 35 volts instead of the customary 18 volts, the current in the primary of T_1 is halved, causing less heating and giving better efficiency. Multiple isolated outputs can be taken off of T_1. The minus 2.3 volt potential is obtained from point 1 as it goes 3 volts negative. The application of the 35 volts to the chopper can result in multiple isolated outputs (No. 1 to No. 6), and the voltage drop across the series regulators in the output circuits can be maintained at one volt plus or minus several millivolts. In presently used power supplies the drop is usually 1 to 8 volts.

Note:

No additional documentation is available. Questions may be directed to:

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Reference: B68-10432

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: L. Ray Lister
of Sperry Rand Corporation
under contract to
Marshall Space Flight Center
(MFS-20049)