Add Kelvin Sensing and Parallel Capability to 3-Terminal Regulators

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Paralleling of 3-terminal regulators is generally not recommended because the devices do not share current equally. If, for instance, you try to make a 3 amp regulator using three 1 amp regulators, the device with the highest output could be carrying 2.5 amps in a current limit mode. The regulator with the second highest output would be carrying only 0.5 amps, and the third regulator would be totally off. The reliability of such a system is poor because of the combination of high temperature and high current in the first regulator. A simple way to improve sharing is to insert a low value resistor in series with each output. The problem with this approach is that load regulation is very poor if the resistors are made large enough to ensure adequate sharing.

A new technique for current sharing overcomes the load regulation problem and, as an added bonus, provides remote sensing capability not available in the standard 3-terminal regulators. This is a great advantage when the regulators must be mounted off-card with their outputs fed through a connector. Total cost of added components is less than 50¢.

Figure 1 shows the new Kelvin sense scheme using the LM338 5 amp adjustable regulator. A1 forces a voltage drop across R3 equal to the voltage across the parasitic resistance, r_s. The current through R3 flows into the output of A1 and out the negative supply pin. This creates a voltage drop across R4 just equal to the voltage across r_s, cancelling the effect of r_s on load regulation. There is an error in V_{OUT} created by the quiescent current of A1, but for a 5V output, this error is only about 0.7%. Voltage loss across r_s must be limited to 300 mV to avoid current limiting in A1. If larger drops must be accommodated, R3 and R4 will have to be increased. C1 is necessary only if intermediate values of capacitance (2 μF–20 μF) are put directly across the load. Any of the positive adjustable regulators may be used in place of the LM338.

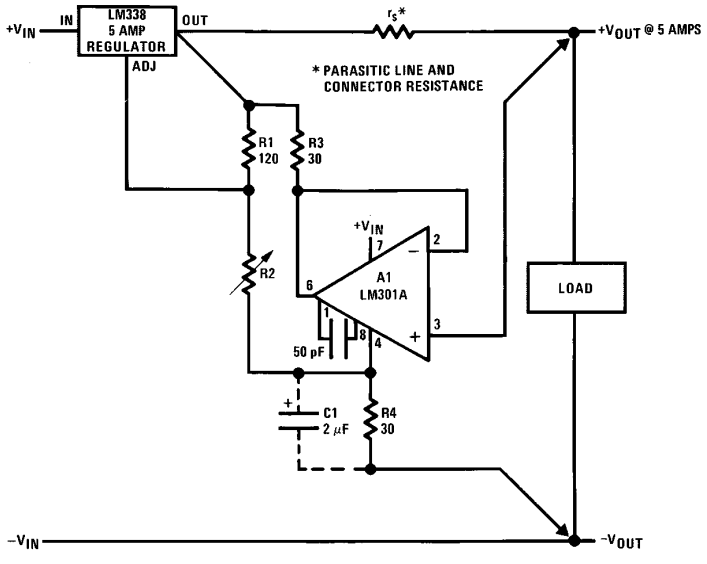

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FIGURE 1

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Figure 2 combines Kelvin sensing with paralleling, where the voltage loss across the current sharing resistors is corrected by the sensing connection. r_{s1} through r_{s3} are equal lengths of #22 gauge lead wire which act as ballasting resistors. These resistors can be kept small because LM338 adjustment pins are paralleled, forcing the outputs to track to within about 60 mV. r_{s4} consists of the parasitic resistance of any additional output lead plus connector loss. The total loss for r_{s4} may be up to 0.25V without loss of proper Kelvin sensing. Note that if U1 has the lowest reference voltage of the three regulators, full Kelvin sensing might not become effective until output current has increased above a threshold value of several amps. If this is undesirable, the adjustment pin of U1 may be connected to a 5Ω tap on R1, increasing its effective reference voltage by 50 mV. The current load for U1 would be 1.5 amps higher, however.

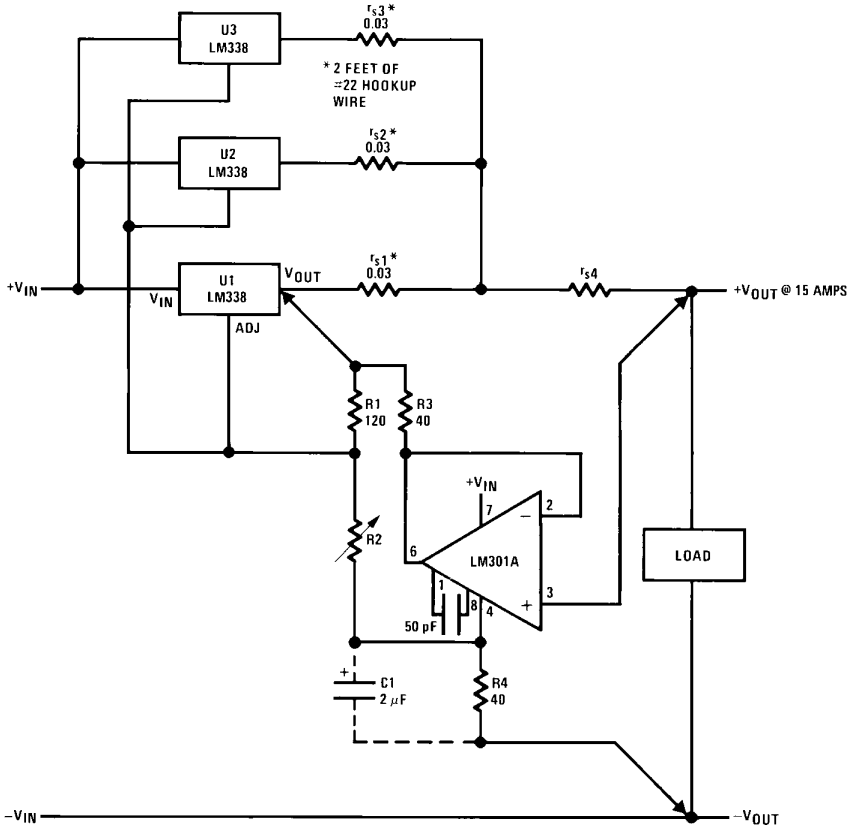

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FIGURE 2

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