

#### Summary of the Idea

For multi-output power supplies, an active shunt regulator and pre-load circuit may be used to prevent rising output voltages under unbalanced loading conditions.

#### Description

In the world of line-voltage-AC to low-voltage-DC switching power supplies, the flyback is one of the most popular topologies used. One reason for this is the cost effectiveness with which multiple output voltages can be provided by simply adding additional windings to the secondary side of the transformer.

Typically, feedback is taken from the output requiring the tightest output tolerance. That output then defines the turns-per-volt for all other secondary output windings. Due to the effects of leakage inductance, it is not always possible to achieve the required output voltage cross regulation, especially when a given output may be unloaded or only lightly loaded while other outputs are fully loaded.

Post regulators or pre-loads may be used to prevent an output's voltage from rising under those conditions. However, the higher cost and the reduction in efficiency that post regulators and pre-loads cause have made them less attractive, especially with respect to the recent regulatory requirements for low/no-load and/or standby input power consumption in many consumer applications. The active shunt regulator shown in Figure 1 addresses the regulation problem while minimizing impacts on cost and efficiency.

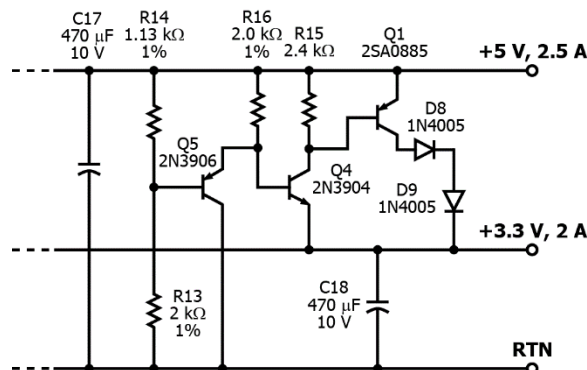
The circuit shown in Figure 1 operates as follows. While the outputs of the power converter are both within regulation, resistor divider R14 and R13 bias transistor Q5 on, which keeps

transistors Q4 and Q1 turned off. When in this mode of operation, the current through Q5 acts as a small pre-load for the 5 V output.

The nominal difference between the 5 V output and the 3.3 V output is 1.7 V. When the load demands additional current from the 3.3 V output without the same increase in load current being drawn from the 5 V output, the output voltage for the 5 V output will increase with respect to that of the 3.3 V output. As the difference between the two outputs exceed 100 mV, transistor Q5 is biased off, which turns on transistors Q4 and Q1 and allows current to flow from the 5 V output to the 3.3 V output. This current lowers the voltage of the 5 V output and reduces the voltage difference between the two outputs.

The amount of current that flows in transistor Q1 is determined by the difference between the two voltages. Therefore, the circuit shown in Figure 1 helps to keep both outputs in regulation, regardless of their loading; even under worst case conditions where the 3.3 V output is fully loaded while the 5 V output is unloaded. The arrangement of transistors Q5 and Q4 also provide temperature compensation, because the VBE temperature variations of each transistor cancel the other out. Diodes D8 and D9 are optional and can be used to reduce the dissipation of transistor Q1, and may potentially remove the need for transistor Q1 to have a heatsink.

As the circuit only reacts to relative voltage differences between the two outputs, it is largely inactive at both full load and light load because the shunt is connected from the 5 V output to 3.3 V output. The active dissipation of the circuit is reduced by 66% when compared to a shunt regulator that is connected to ground. The result is that efficiency remains high at full load and light-to-no-load power consumption is kept low.



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Figure 1. Active shunt regulator for a multiple output flyback converter.