New Applications for a New Architecture Linear Regulator

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With the introduction of the LT3080, the architecture of linear regulators has changed. This regulator throws away the voltage reference and uses a reference current to set the output. As shown in Figure 1, a single resistor sets the output for a voltage follower in the regulator. The output voltage can be adjusted down to zero or up to within about a volt of the input supply. Since the voltage at the set-pin and the output are equal, these regulators can be easily paralleled to share current using only a small piece of a circuit board as a ballast resistor. That allows heat to be spread across the board, eliminating heat sinks. Additionally the collector of the output transistor comes out separately, allowing a dropping resistor to be inserted in series with the collector. This puts some of the power dissipation from the IC regulator to a resistor on the board, further spreading the heat and eliminating the need for a heat sink to dissipate all the power in one spot. Table 1 gives the basic specifications for this regulator.

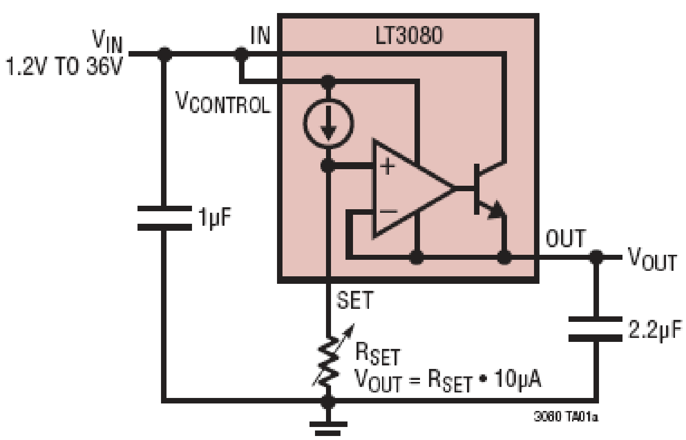

Fig. 1 Basic operation of the LT3080

Table 1

Parameter	Min	Typ	Max	Units
Load reg Iout =10mA to1.1A		<1		mV
Line Reg 2V to 40V input		<1		mV
Adjust Pin Current	-1%	10	1%	µA
Min Load Current		0.3		mA
Offset Adj to Output		1.5		mV
Operating Temp Range	-55		125	Deg C
Dropout (3 Terminal) 1.1A		1.3		V
Dropout (4 Terminal) 1.1A		0.3		V
Ripple rejection (120Hz)		75		dB

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A paralleled regulator pair is shown in Figure 2. Although only two regulators are shown, any number of regulators can be paralleled for higher output current. All the regulators have their inputs, their set pin and their outputs are tied together. Inserted in series with the output is a small piece of PC trace to act as a ballast resistor. Ten to fifteen milliohms of resistance is adequate to ballast the outputs of the regulator and provide good current sharing. An output capacitor is needed for stabilization of the regulator since several devices are now paralleled. The output voltage is adjusted in the same way, with a resistor to ground, but instead of 10 microamps there are now Nx10 microamps where N is the number of regulators in parallel. For two regulators in parallel, this gives an output voltage of 1Volt for every 50k of resistance to ground.

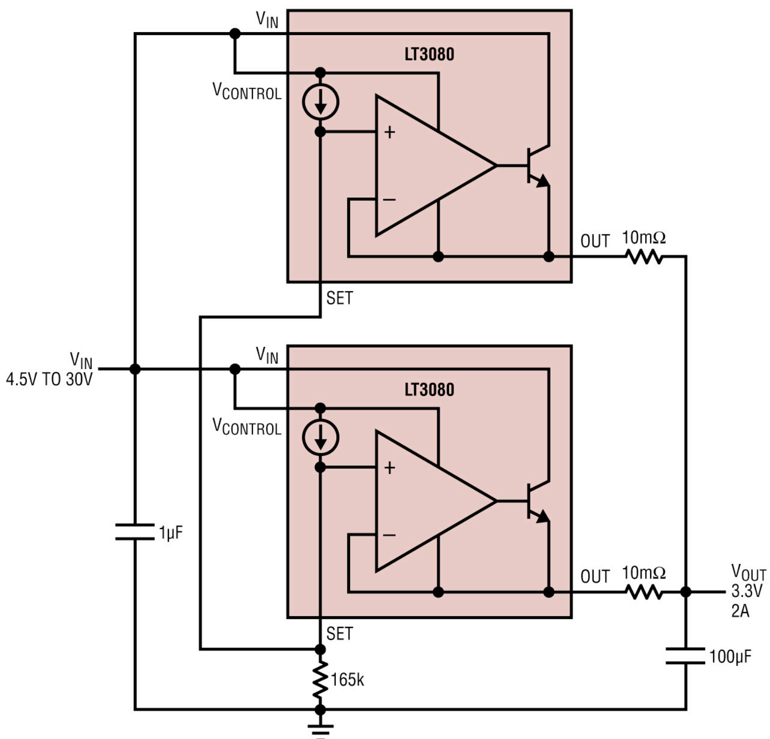

Figure 2 Parallel operation of the LT3080

The LT3080 may also be paralleled with fixed output regulators (linear or switching) to supplement the output current of a single device. This is useful when the single device does not provide sufficient current or a simple system modification is needed to increase the power supply current because of system changes.

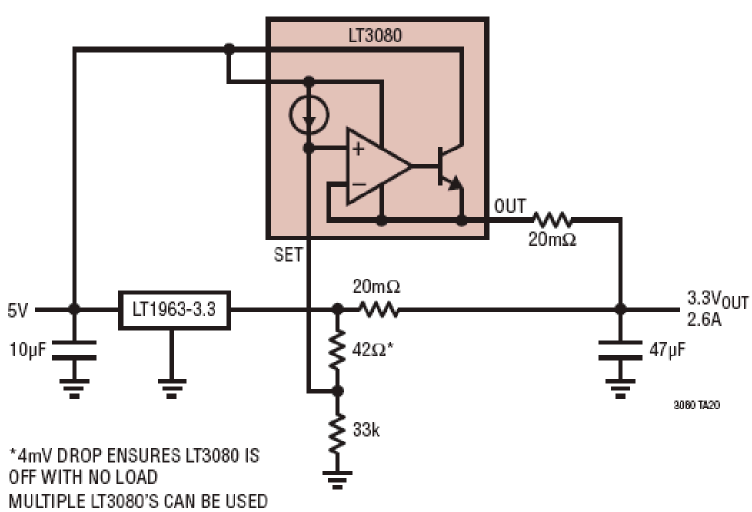

Figure 3. Boosting the output current of a fixed regulator

Again it is necessary to use 15 to 20 milliohms of ballast resistance to cause the two ICs to share. But since the fixed regulator, the LT1963-3.3, does not have a “set pin,” we must provide a point for connecting the set pin of the LT3080. A divider from the output of the fixed regulator provides a voltage about 4 milivolts lower then the fixed output. This 4 milivolt drop is needed to ensure that the output current of the LT3080 is zero under a no load condition. Without this offset, the LT3080 could supply current, forcing the output high under a light load or no load situation.

At light loads, the set pin of the LT3080 is held negative with respect to the output. This indicates to the feedback circuitry in the LT3080 that the output is “high,” and not to supply any current. As the load is increased on both the fixed regulator and the LT3080, the drop across the ballast resistors slowly turns on the LT3080, such that it provides a portion of the output current. The ballast resistance in this case should be slightly larger then paralleling direct LT3080s since the offset of 4 millivolts is greater than the LT3080 native offset. A resistance of 20 milliohms will give 20 millivolts of ballast at 1 amp output current. At a 2 volt output, this drop only degrades the load regulation by less than one percent. With 20 milliohms of ballast resistance and a 2 amp total output current, the LT3080 is supplying approximately 75% to 80% of the output current. For closer matching of output currents the ballast must be increased.

Current sources are useful components in many types of applications. The LT3080 can provide a two-terminal current source with very good DC performance. The requirement that the LT3080 include an output capacitor to provide frequency compensation makes the device slightly less useful since it cannot be used as an AC current source. However the very high gain of the LT3080 allows small voltage drops to set up the output current and produce very high DC output impendence.

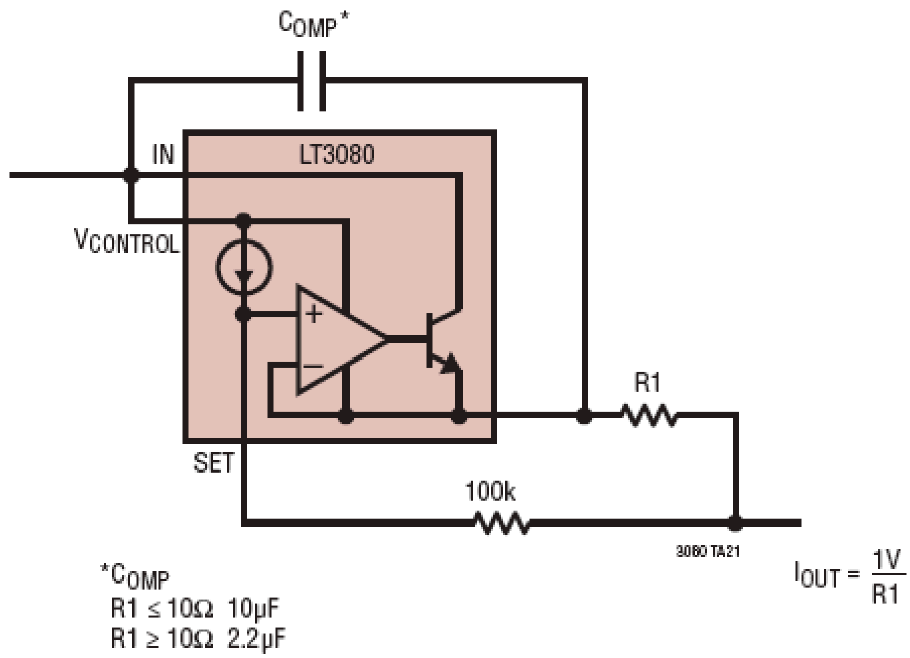

Figure 4 shows 2 “two terminal” current source configurations for the LT3080.

Approximately 100 millivolts is dropped across the set resistor with a 10k value. The 100 millivolts appears across the current-setting resistor as well, and sets the total output current to 0.1 volts divided by the output setting resistor (plus 10 microamps). Higher drops can be used to improve accuracy if needed.

Frequency compensation is achieved with a capacitor from the input pin to the output. By configuring the frequency compensation as shown, the current through the capacitor (for relatively low frequency input changes) is included within the feedback loop and does not appear as capacitance across the device. If the input voltage changes, current flows through the capacitor due to voltage change. When the current in the capacitor approaches the DC current, the loop will not be able to compensate for the AC current and the AC output impedance will decrease. The low set current of the LT3080 as well as the very high gain of the regulation loop make this an excellent current regulator. With a low quiescent current of only 0.3 milliamps, this circuit is suitable for current sources down to one milliamp or up to one amp. The temperature coefficient of the current is the temperature coefficient of the regulator plus whatever drift comes from the resistor change with temperature.

The ability of the LT3080 to operate down to zero volts makes it attractive to use this for general-purpose lab supplies. However the power dissipation for a lab regulator can become very high if the operating voltage range is high. The circuit in Figure 5 shows a switching preregulator connected to the LT3080 to keep the power dissipation down to about 1.5 watts by controlling the input voltage to approximately 1.5 volts above the output.

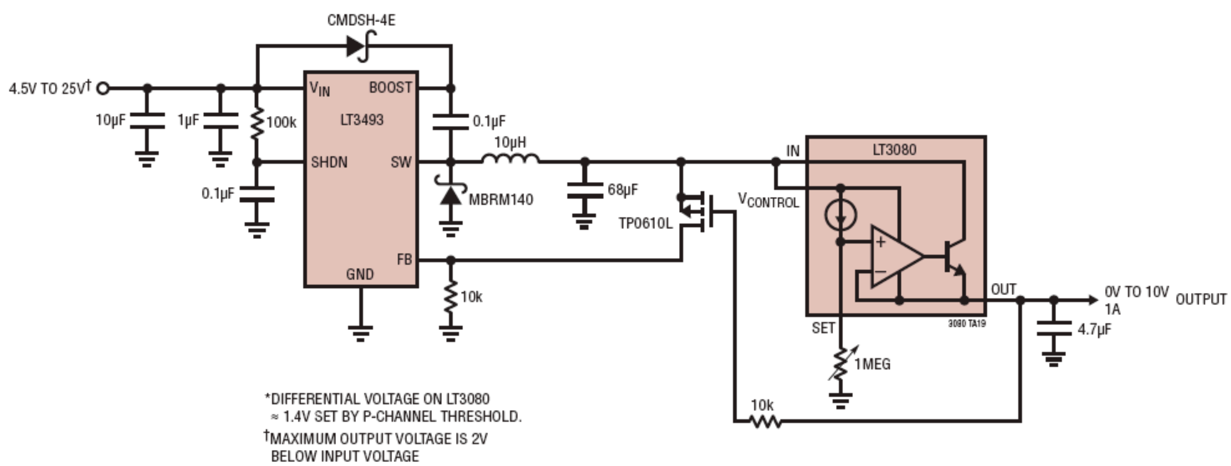

Figure 5 Tracking preregulator for general-purpose supply

The LT3080 is connected to the gate and source of a P-channel FET. The “on” threshold of the P-channel sets the dropout voltage across the LT3080. The drain of the P-channel is tied to the feedback pin of a switching regulator.

When the circuit is turned on, the switching regulator output rises until the current through the P-channel is sufficient to bring the feedback pin (FB) up to 1.2 volts. The feedback pin rises to 1.2 volts, reducing the output of the switching regulator. The LT3080 then is operating with about a MOS threshold voltage across it. Adjusting the set resistor of the LT3080 sets the output voltage and the input voltage tracks at 1.5 volts above the output.

An even lower dissipation switching regulator is shown in Figure 6. Here the emitter–base voltage of a PNP is used rather then the threshold of a P-channel. When several LT3080 devices are paralleled for high current, this keeps the dissipation even lower. This circuit requires the input pin of the LT3080 to be connected to the input voltage to ensure there is sufficient operating voltage across the control circuitry. A PNP emitter–base voltage then sets the voltage across the output transistor of the LT3080 at 0.6 Volts with a power dissipation at 1 amp of only 0.6 watts. Again the switching regulator tracks the output and the output is adjustable down to zero.

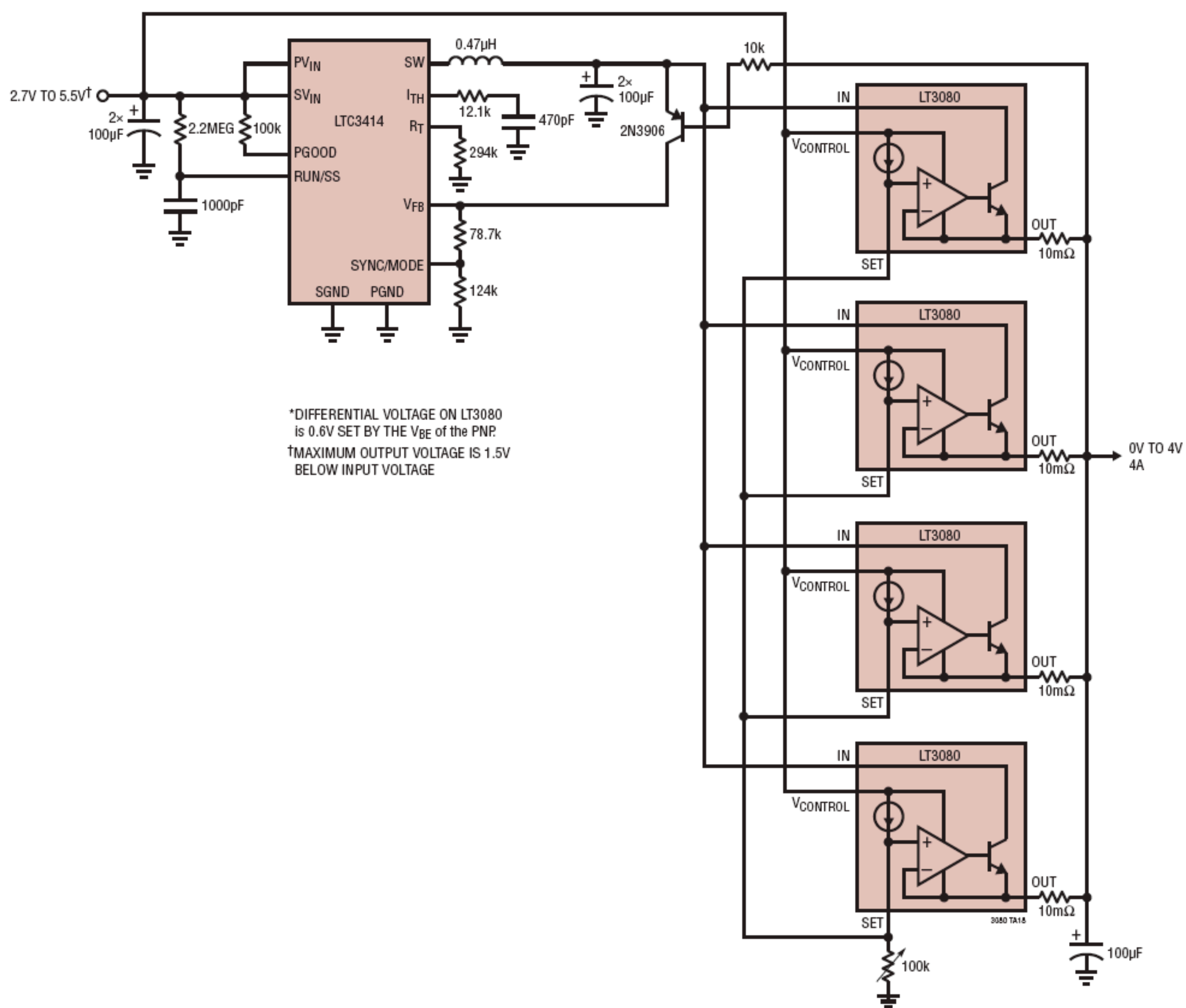

Figure 6 Preregulator for higher current supply

Conclusions

The new regulator is extremely versatile and offers applications not available with any other existing regulator architecture. Paralleling, adjustable output down to zero and the ability to divert some of the power dissipation out of the regulator make it extremely useful in new applications. The precision current used as a reference allows soft starting, shut-down, and tracking with no external parts. Other inherent features in this device make it the architecture of choice for linear regulators.