Techview

LEAP FROG

Monolithic Programmable Constant Current Source Is A New Basic Buildi...

Linear Technology's LT3092 is a 0.5- to 200-mA, two-terminal, low-temperature-coefficient, constant-current-source IC. Conceptually, it's simple, but there has never been an IC like it. You can build various circuits to provide the same functionality, yet never before could you have bought a standalone IC that does the job so simply and elegantly.

Questions arise. What's it good for? Why didn't anybody make one before this? How did Linear come to develop the device? The person best equipped to answer those questions is Linear chief technology officer and Silicon Valley legend Robert Dobkin. So I asked him.
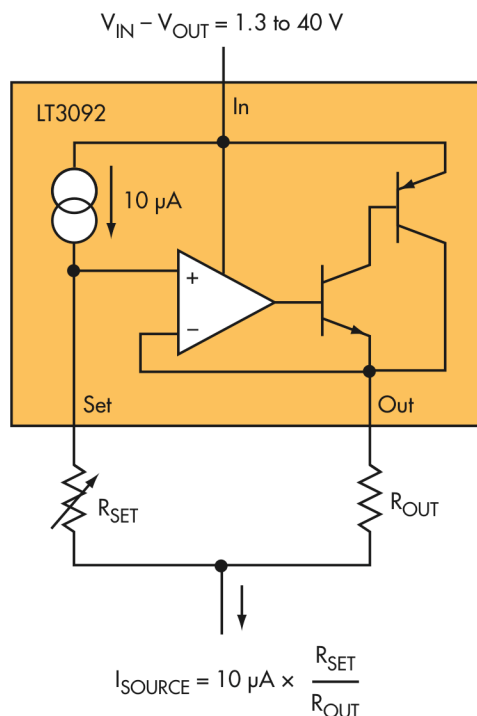
The LT3092 is a three-terminal bipolar device. It comes in several small-outline package variants. Inside, there is a precision 10-µA current source and a voltage-follower circuit *(see the figure)*. The terminal designations are INPUT, SET, and OUT. The current source is between the INPUT and SET. The SET node is also the input to the voltage follower, which is set up so whatever voltage appears on the SET node also appears on the OUT pin. The only external components required are two resistors.

As Dobkin describes the operation, it starts with any dc voltage up to 40 V on the INPUT pin. "Put a resistor in series with the SET node," he explained. "You're putting 10 µA through that resistor. If it's a 20-kΩ resistor, you'll see 200 mV across it."

The second resistor goes between the OUT node and whatever you want to drive with a constant current. It's the other part of setting that current level. "If you tie the bottoms of the resistors together, the voltage follower drives the voltage on OUT to the same value as the voltage on SET. In my example, that means there's 200 mV across the resistor on the OUT pin. If that resistance is 1 Ω, you've set the current through it to 200 mA. If it's 10 Ω, that's 20 mA. If it's 100 Ω, that's 2 mA. The regulation is better than 10 ppm per volt," Dobkin said.

"The resistor absolute values aren't too critical," he added. "Making the voltage caused by the precision current source and the SET resistor 200 mV leads to the error in the current from the current source and the offset of the op amp being about equal. If you make the voltage drop across the SET resistor bigger, the op-amp offset introduces less error."

Note that no bypass capacitors are required. None. That's where the Linear engineers spent their development effort. "We were developing another part with an internal regulator and we found it didn't need much bypass capacitance," Dobkin said. "And we kept on working on it until it didn't need any—across the full range of voltage, current, and temperature ranges. When we first started, I didn't know we could get to zero capacitance, but we did."

$$V_{IN} - V_{OUT} = 1.3 \text{ to } 40 \text{ V}$$

LT3092 — In — 10 µA — Set — Out — R_{SET} — R_{OUT}

$$I_{SOURCE} = 10 \text{ µA} \times \frac{R_{SET}}{R_{OUT}}$$

Linear Technology's LT3092 uses a constant current source and a voltage follower to drive the OUT terminal to the same potential as SET. The resistor ratio determines output current.

What do you do with a constant current source? Obviously, it's what you want to drive sensors and bridges in industrial control apps. Presently, engineers have various ways of doing that with discretes. "You can make a current source with a depletion-mode FET and a resistor, but it will have big variations with production and a high temperature coefficient. Or you can make a little circuit out of some Zener diodes and transistors that will give you a couple of percent, but it's much more expensive and you have to assemble it. Or you can make a current source with an op amp and a transistor, but it's one-sided. It's not floating," Dobkin said. "The LT3092 is fully floating. You can tie your loads on the top side or the bottom side." In almost every case, he said, the LT3092 does the job better, with fewer parts, for much less than $2.00, even at low-volume pricing.

More specific applications—battery charging and LED driving come to mind—will come. When I talked to Dobkin, he was taking time out from Linear's annual meeting of its global Field Applications Engineering corps. One of the tasks the engineers was assigned was to go wild with potential applications.

To wrap things up, I asked Dobkin what else was cool about the part that might not be obvious at first glance. "I kinda like the fact that if you need more power, you can just parallel them. It's like two Zeners, where, if you want more voltage, you put them in series. Then, you know, this is a small package, but you can go up to 40 V on the input and 200 mA to your load. That's 8 W," he said.

"What you do to bring the in-package dissipation down to something it can handle is put a resistor across the package, so that, at high voltage, most of the current goes through the resistor, and at low voltage, most of the current goes through the devices in the package. In the middle, you make the currents equal, so you wind up with four times less power dissipation in the IC," he noted.

"Let's say you did have that 8 W, with 200 mA at 40 V. Now your worst-case point is at 20 V, and at 20 V, we have 200 mA split between the device and the resistor. So the dissipation is 2 W, and we can handle that with one IC," Dobkin said.

The LT3092's datasheet specs include 0.5- to 200-mA output current with 1.0% initial current accuracy and 10-ppm/V current regulation from an input voltage range of 1.2 to 40 V dc. Safety features include reverse battery and reverse current protec-tion, along with overcurrent limiting and thermal shut-down. Thousand-piece pricing starts at $1.65 and $1.83 for the dual-flat no-lead (DFN) and SOT-23 packages, $1.75 and $1.94 for the SOT-223 package, and $4.73 for the SOT-223.

LINEAR TECHNOLOGY
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10GE CONTROLLER TRANSFORMS DATA CENTERS WITH VIRTUALIZED I/O AND UNIFIED NETWORKING

The 82599 10-Gbit/s dual-port Ethernet controller from Intel is designed to address some of the trends driving data-center upgrades. For example, it includes hardware optimization for I/O virtualization and supports unified networking, allowing local-area network (LAN), storage-area network (SAN), and Internet Protocol communications (IPC) traffic to share the same Ethernet network.

With data-center traffic continuing to grow, IT departments are implementing server virtualization with multicore servers with higher bandwidth and network storage. IT managers want to consolidate multiple Gigabit Ethernet ports into a single 10-Gbit/s network for lower cost and complexity.

The 82599 is designed to work with Intel's Xeon processor 5500 series platform. The combination can produce performance that is more than twice the total I/O throughput of previous-generation servers. When the 5500 series is using a network interface card (NIC) with an 82599, performance data shows that the combination can handle bidirectional Ethernet traffic exceeding 50 Gbits/s whereas previous generation servers could only handle up to 17 Gbits/s.

Basic features include PCI Express 2.0 interfaces and intelligent queue support optimized for multicore processors. Intel's Virtualization Technology for Connectivity (VT-c) helps reduce I/O bottlenecks, boost throughput, and reduce latency. The Virtual Machine Device Queues improve performance by offloading the data-sorting burden from the virtual-machine manager (VMM) to the network controller. The Virtual Machine Direct Connect provides near native performance by facilitating direct assignment of a virtual function on an Ethernet port.

Also, the 82599 allows multiple traffic types to share a single Ethernet connection. It features Fibre Channel over Ethernet offloads, iSCSI support for SAN and LAN sharing of the network, and data-center bridging that enables Ethernet to support mixed LAN and storage workloads.

The 82599 is designed for NICs, server blades, LAN on motherboard (LOM), and mezzanine card implemen-

Intel's 82599 dual-port 10-Gbit/s Ethernet controller targets data-center upgrades by optimizing the hardware for I/O virtualization and unified networking. It's designed to work with Intel's Xeon processor 5500 series.