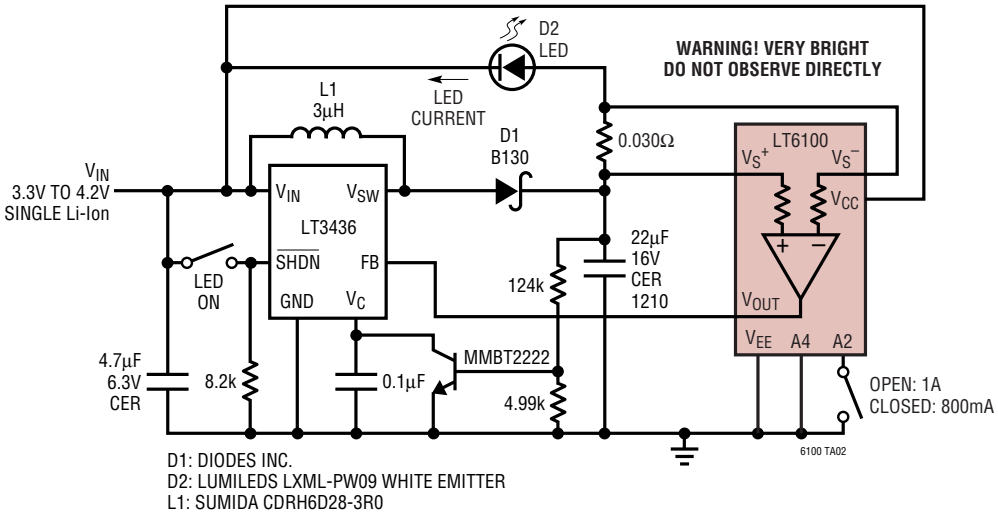
Current Control

This chapter collects a variety of techniques useful in generating controlled levels of current in circuits.

To see other chapters in this Application Note, return to the Introduction.

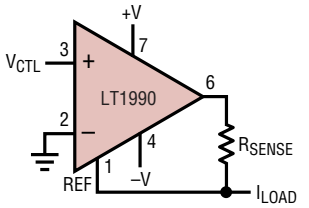
800 mA/1A White LED Current Regulator



D1: DIODES INC.
D2: LUMILEDS LXML-PW09 WHITE EMITTER
L1: SUMIDA CDRH6D28-3R0

The LT6100 is configured for a gain of either 40V/V or 50V/V depending on whether the switch between A2 and V_{EE} is closed or not. When the switch is open (LT6100 gain of 40V/V), 1A is delivered to the LED. When the switch is closed (LT6100 gain of 50V/V), 800mA is delivered. The LT3436 is a boost switching regulator which governs the voltage/current supplied to the LED. The switch "LED ON" connected to the SHDN pin allows for external control of the ON/OFF state of the LED.

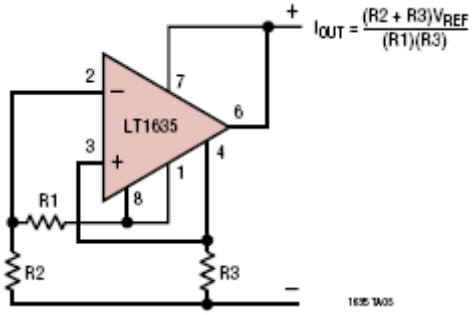
Bidirectional Current Source



$I_{LOAD} = V_{CTL}/R_{SENSE} \leq 5mA$
EXAMPLE: FOR R_{SENSE} =100Ω,
OUTPUT IS 1mA PER 100mV INPUT

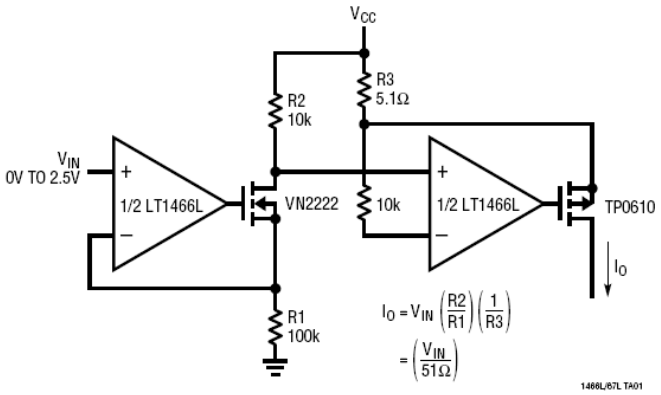
The LT1990 is a differential amplifier with integrated precision resistors. The circuit shown is the classic Howland current source, implemented by simply adding a sense resistor.

Two Terminal Current Regulator



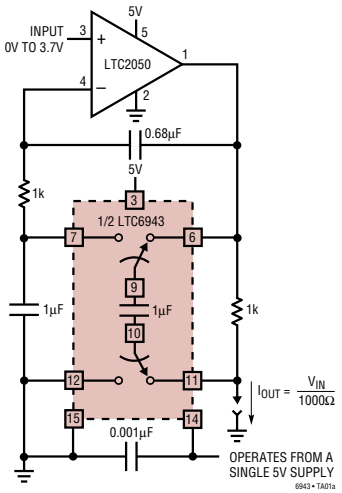
The LT1635 combines an op amp with a 200mV reference. Scaling this reference voltage to a potential across resistor R3 forces a controlled amount of current to flow from the +terminal to the –terminal. Power is taken from the loop.

Variable Current Source



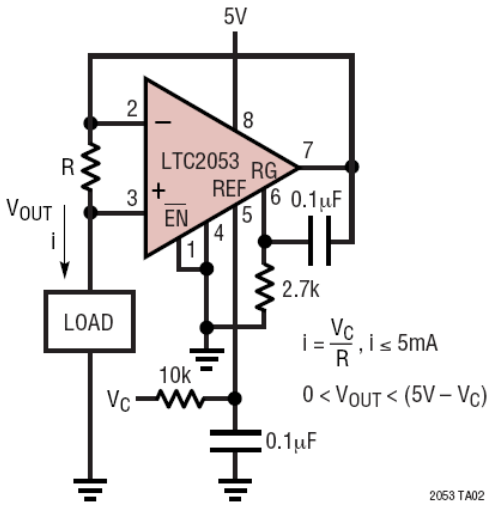
A basic high-side current source is implemented at the output, while an input translation amplifier section provides for flexible input scaling. A Rail-to-Rail input capability is required to have both amplifiers in one package, since the input stage has common-mode near ground and the second section operates near V_{CC}.

Precision Voltage Controlled Current Source with Ground Referred Input and Output



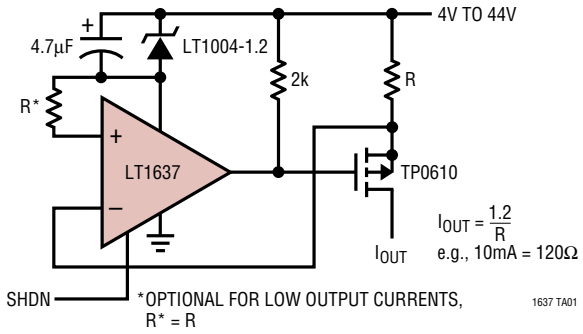
The LTC6943 is used to accurately sample the voltage across the 1kΩ sense resistor and translate it to a ground reference by charge balancing in the 1µF capacitors. The LTC2050 integrates the difference between the sense voltage and the input command voltage to drive the proper current into load.

Precision Voltage Controlled Current Source



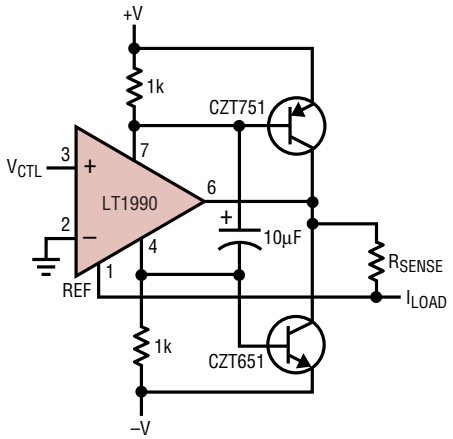
The ultra-precise LTC2053 instrumentation amplifier is configured to servo the voltage drop on sense resistor R to match the command V_C. The LTC2053 output capability limits this basic configuration to low current applications.

Switchable Precision Current Source



This is a simple current-source configuration where the op amp servos to establish a match between the drop on the sense resistor and that of the 1.2V reference. This particular op amp includes a shutdown feature so the current source function can be switched off with a logic command. The 2kΩ pull-up resistor assures the output MOSFET is off when the op amp is in shutdown mode.

Boosted Bidirectional Controlled Current Source

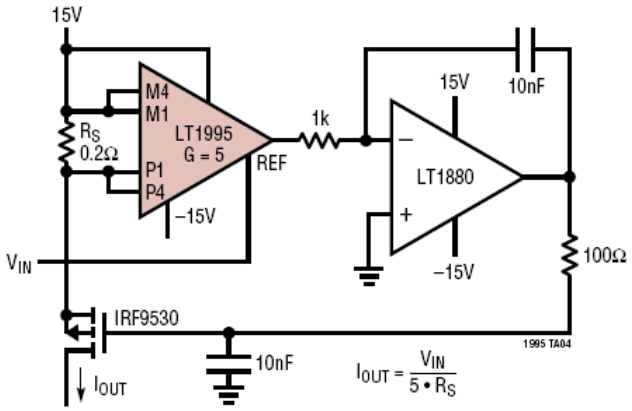


$I_{LOAD} = V_{CTL}/R_{SENSE} \leq 100mA$
EXAMPLE: FOR $R_{SENSE} = 10\Omega$,
OUTPUT IS 1mA PER 10mV INPUT

1990 AI04

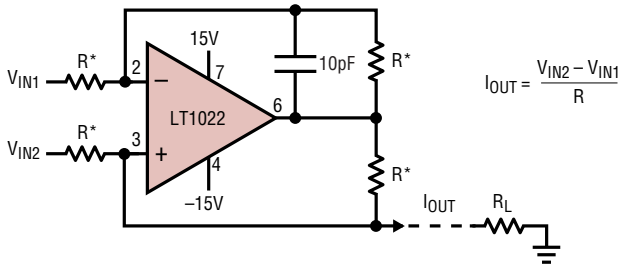
This is a classical Howland bidirectional current source implemented with an LT1990 integrated difference amplifier. The op amp circuit servos to match the RSENSE voltage drop to the input command VCTL. When the load current exceeds about 0.7mA in either direction, one of the boost transistors will start conducting to provide the additional commanded current.

0A to 2A Current Source



The LT1995 amplifies the sense resistor drop by 5V/V and subtracts that from V_{IN}, providing an error signal to an LT1880 integrator. The integrated error drives the PMOSFET as required to deliver the commanded current.

Fast Differential Current Source

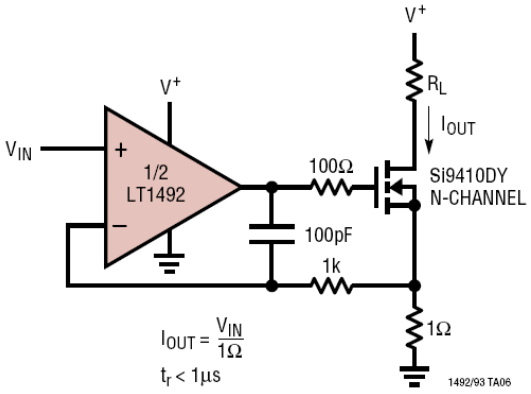


*MATCH TO 0.01%
FULL-SCALE POWER BANDWIDTH
= 1MHz FOR $I_{OUT}R = 8V_{P-P}$
= 400kHz FOR $I_{OUT}R = 20V_{P-P}$
MAXIMUM $I_{OUT} = 10mA_{P-P}$
COMMON-MODE VOLTAGE AT LT1022 INPUT = $\frac{I_{OUTP-P} \bullet R_L}{2}$

LT1022 • TA07

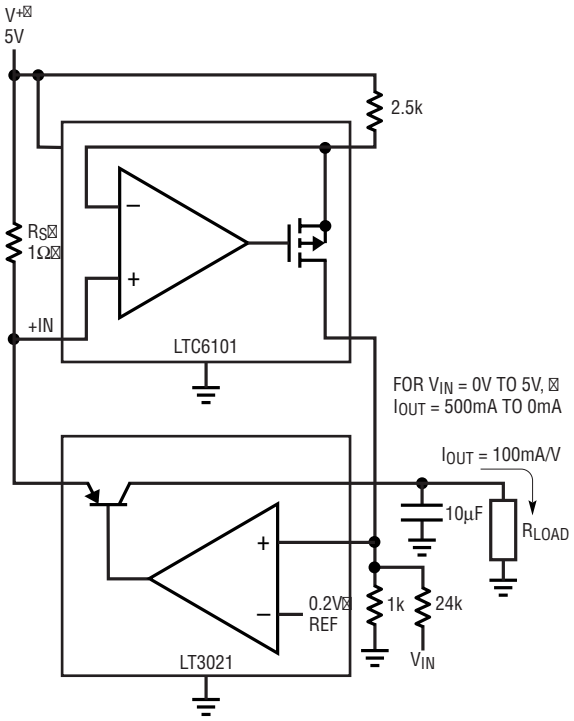
This is a variation on the Howland configuration, where load current actually passes through a feedback resistor as an implicit sense resistance. Since the effective sense resistance is relatively large, this topology is appropriate for producing small controlled currents.

1A Voltage-Controlled Current Sink



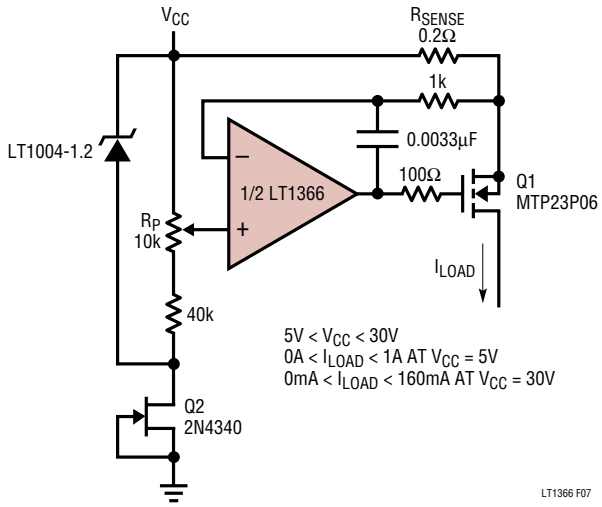
This is a simple controlled current sink, where the op amp drives the NMOSFET gate to develop a match between the 1Ω sense resistor drop and the V_{IN} current command. Since the common-mode voltage seen by the op amp is near ground potential, a “single-supply” or Rail-to-Rail type is required in this application.

Voltage Controlled Current Source



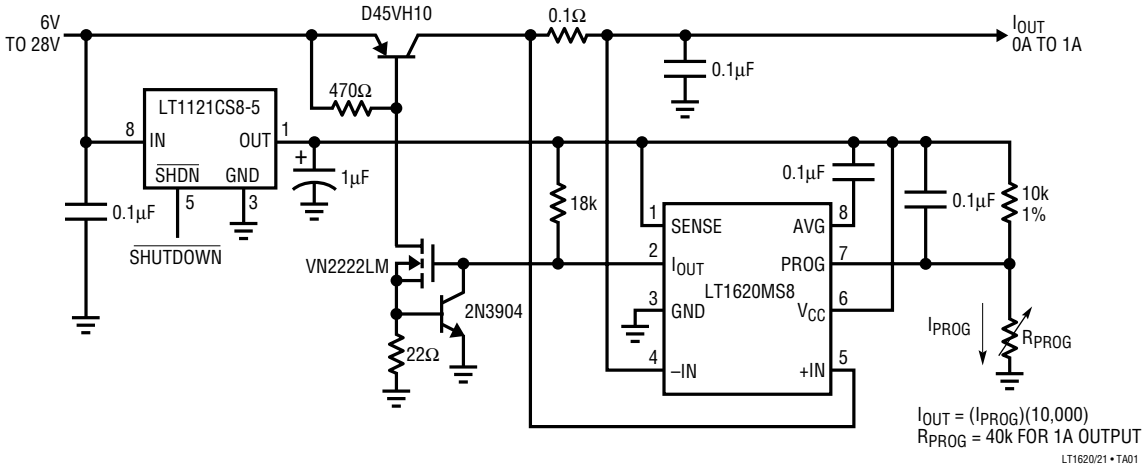
Adding a current sense amplifier in the feedback loop of an adjustable low dropout voltage regulator creates a simple voltage controlled current source. The range of output current sourced by the circuit is set only by the current capability of the voltage regulator. The current sense amplifier senses the output current and feeds back a current to the summing junction of the regulator's error amplifier. The regulator will then source whatever current is necessary to maintain the internal reference voltage at the summing junction. For the circuit shown a 0V to 5V control input produces 500mA to 0mA of output current.

Adjustable High-Side Current Source



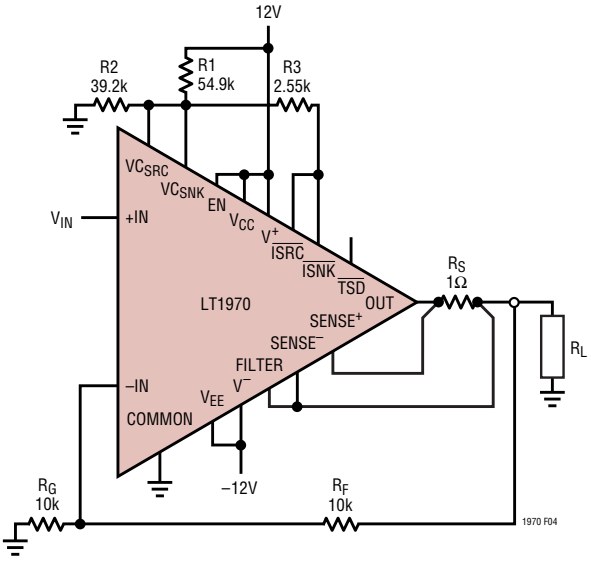
The wide-compliance current source shown takes advantage of the LT1366's ability to measure small signals near the positive supply rail. The LT1366 adjusts Q1's gate voltage to force the voltage across the sense resistor (R_{SENSE}) to equal the voltage between V_{DC} and the potentiometer's wiper. A rail-to-rail op amp is needed because the voltage across the sense resistor is nearly the same as V_{DC}. Q2 acts as a constant current sink to minimize error in the reference voltage when the supply voltage varies. At low input voltage, circuit operation is limited by the Q1 gate drive requirement. At high input voltage, circuit operation is limited by the LT1366's absolute maximum ratings.

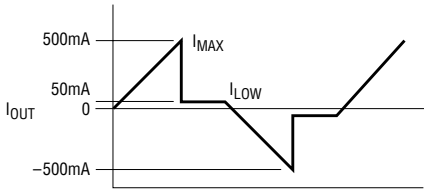
Programmable Constant Current Source



The current output can be controlled by a variable resistor (R_{PROG}) connected from the PROG pin to ground on the LT1620. The LT1121 is a low-dropout regulator that keeps the voltage constant for the LT1620. Applying a shutdown command to the LT1121 powers down the LT1620 and eliminates the base-drive to the current regulation pass transistor, thereby turning off I_{OUT}.

Snap Back Current Limiting





$$I_{MAX} \approx \frac{V_{CC} \bullet R2}{(R1 + R2) \bullet 10 \bullet R_S}$$

$$I_{LOW} \approx \frac{V_{CC} \bullet (R2||R3)}{[R1 + (R2||R3)] \bullet 10 \bullet R_S}$$

The LT1970 provides current detection and limiting features built-in. In this circuit, the logic flags that are produced in a current-limiting event are connected in a feedback arrangement that in turn reduces the current limit command to a lower level. When the load condition permits the current to drop below the limiting level, then the flags clear and full current drive capability is restored automatically.