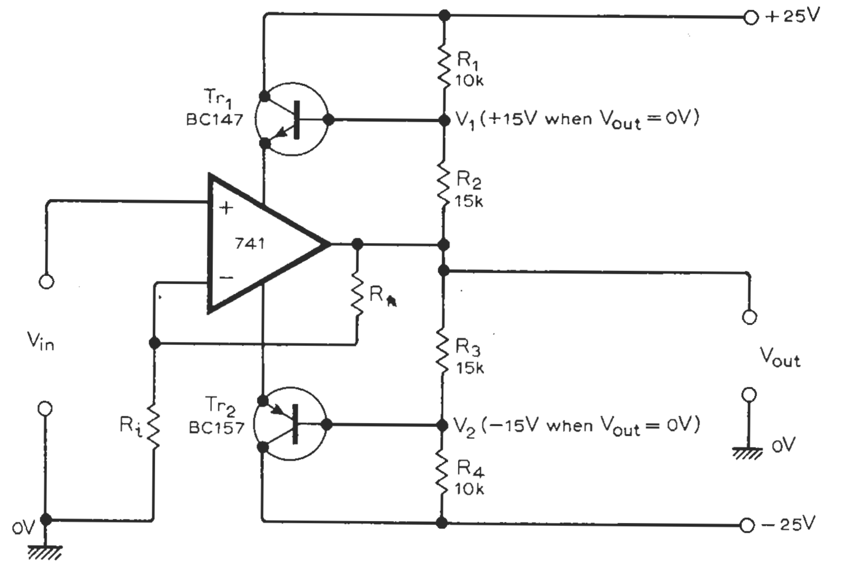
Circuit Ideas



Increased output voltage for op-amps

The circuit shown uses a 741 i.c. and will produce a typical peak to peak output voltage swing of 37V using a ±25V supply. Power is supplied to the i.c. by Tr_1 and Tr_2 whose bases are kept 30V apart by the divider chain. As the output voltage varies, the current in one half of the divider chain increases and the current in the other half decreases by the same amount. This causes the potential between the bases of Tr_1 and Tr_2 to remain constant and allows the power supply for the i.c. to vary between the limits of ±Vcc in sympathy with the output signal. For the non-inverting amplifier shown

$$\frac{R_1}{R_2}=\frac{(+V_{cc})-V_1-V_{out}}{V_1-V_{out}}$$

and $$\frac{R_4}{R_3}=\frac{(-V_{cc})-V_2-V_{out}}{V_2-V_{out}}$$

and gain $$=\frac{V_{out}}{V_{in}}=\frac{R_f+R_i}{R_i}$$

The gain must not exceed a value dependent upon the output voltage swing otherwise the input voltage will exceed the power supply voltage of the i.c. Therefore,

$$\text{Gain}\leqslant\frac{V_{out\,pk}}{\dfrac{R_4\,(V_{out\,pk}-(-V_{cc}))}{R_3+R_4}+a+(-V_{cc})}$$

for positive half cycles, and

$$\text{Gain}\leqslant\frac{V_{out\,pk}}{\dfrac{R_1\,(V_{out\,pk}-(+V_{cc}))}{R_1+R_2}-a+(+V_{cc})}$$

for negative half cycles, where $-a$ is absolute maximum input voltage – input voltage range (3V typical) and $V_{out\,pk}$ is peak output voltage.

Further restrictions are imposed if the amplifier is connected in the inverting mode because the i.c. inputs are always at 0V and therefore the power supply voltage can only swing by ±12V.

Colin D. Ride,
Mickleover,
Derby.

Extending the range of a low-cost op amp

by Bob Darling
Department of Physics and Astronomy, Rutgers University, Piscataway, N. J.

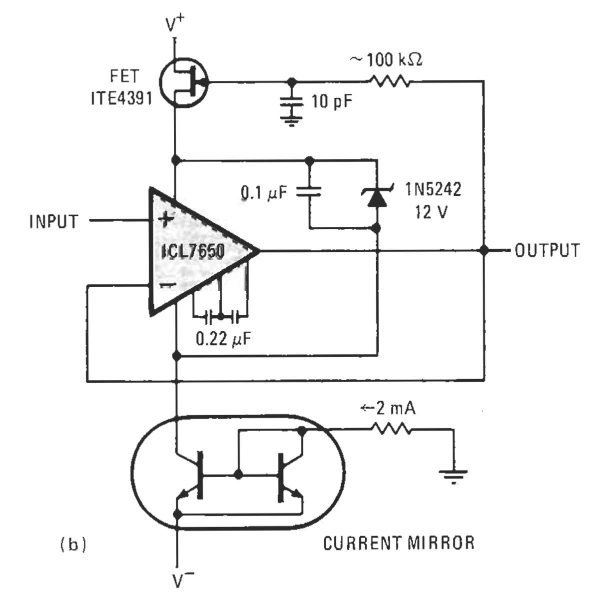
Low-cost operational amplifiers often have limited power-supply and common-mode voltage ranges. This is the case with the recently introduced ICL7650CPD from Intersil Inc., a device with otherwise very good specifications that sells for under $3 in 100-piece quantities. The 7650 has a typical offset voltage of under 1 microvolt, drift of only a few nanovolts per degree Celsius, bias current in the low picoampere range, and a bandwidth of 2.5 megahertz.

However, its applicability is limited because its maximum supply voltage of 18 volts and its common-mode voltage range V^- to $V^+ - 2.7$ V yields a maximum allowable common-mode input of about 15 V. The circuit in (a) greatly extends the common-mode range in the follower mode.

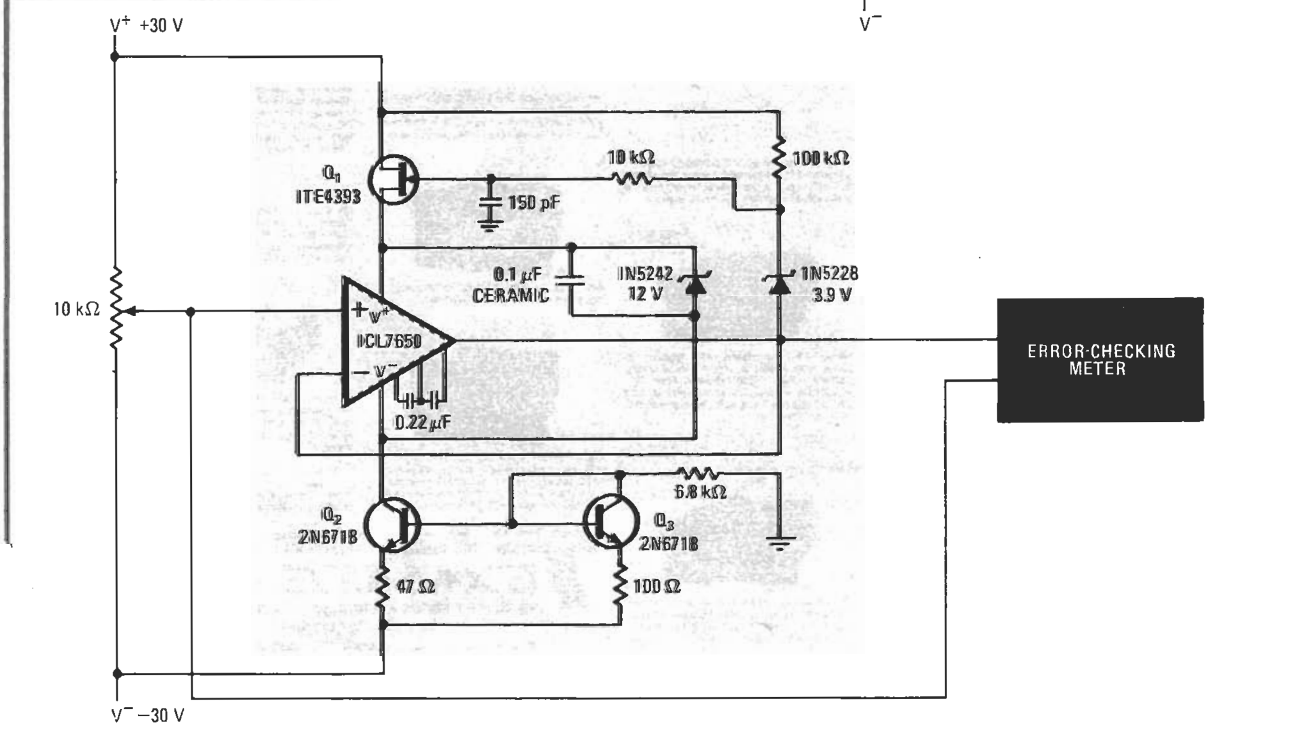
The idea is to bootstrap the power supply of the 7650, limit the supply voltage on the integrated circuit with a zener diode, and float the complete package on a current source or another floating voltage source.

The 7650 has a maximum rated supply current of 4 milliamperes, so a current source capable of 5 mA was chosen. Transistors Q_2 and Q_3 (2N6718) provide a current mirror yielding the 5 mA current source. The 1N5242 zener diode limits the supply voltage to 12 V dc, and the 1N5228—a 3.9-V zener diode—plus the gate-source voltage of the ITE4393 field-effect transistor is used to provide the greater-than-4-V bootstrap voltage needed for V^+ of the IC.

Bias for the 1N5228 comes through a 100-kilohm resistor, and the 10-kΩ, 150-picofarad filter stabilizes the circuit against high-frequency oscillations. Because the FET has a gate-source breakdown voltage (BV_{GSS}) of more than 60 V, the circuit has a common-mode range of −29 V to +25 V. In addition, the circuit can follow a 40-V peak-to-peak signal of over 20 kilohertz into a 50-kΩ load.



Ranging out. Bootstrapping the power supply, as well as limiting the supply voltage with a zener, helps extend the common-mode range of the inexpensive ICL7650 operational amplifier (a). Minimum parts version (b) of the extender circuit uses a commercially available 2:1 current mirror and a selected ITE4391 as the booster FET.



A minimum parts version of the first circuit is shown in (b). The current source is a 2:1 current mirror (from Texas Instruments), and the booster FET is a selected ITE4391 with a gate-source breakdown voltage (BV_{GSS}) greater than 60 V dc and a drain current greater than 5 mA when the gate-source voltage is equal to -3 V. The 100-kΩ and 10-pF stabilizing network is adjustable for maximum frequency response.

This type of circuit can be used to more than 100 V by substituting bipolar transistors or high-voltage FETs. And it can be built to be fully floating by replacing the current source with a pnp amplifier or p-channel FET □