Converter in feedback loop improves voltage regulation

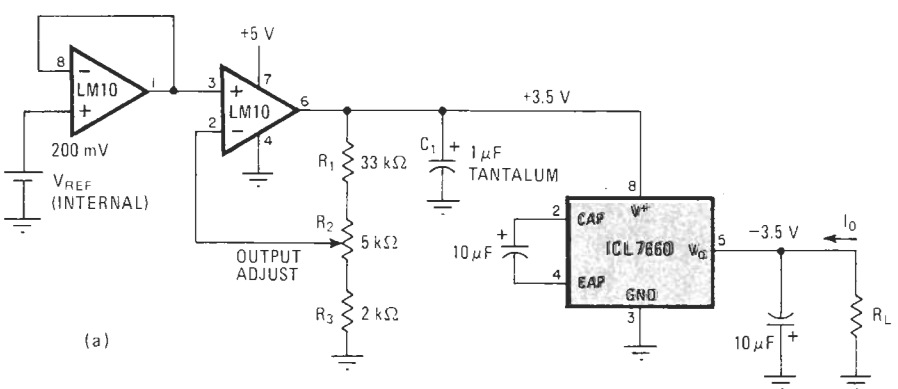
by David Abrams
Winchester, Mass.

One of the most frustrating experiences a designer faces is to discover that his TTL or complementary-MOS circuit, which he intended for single-supply operation, actually requires a minus potential at some miniscule current for one or two of its integrated circuits. A new chip, Intersil's 7660 voltage converter, now enables the designer to obtain the minus voltage at low currents from a positive supply without the need for a transformer or other complicated inverter circuitry, and at low cost. In addition, placing the converter in a feedback loop that includes the chip's power—or driving—source permits a degree of voltage regulation that is not possible with the conventional stand-alone driver configuration.

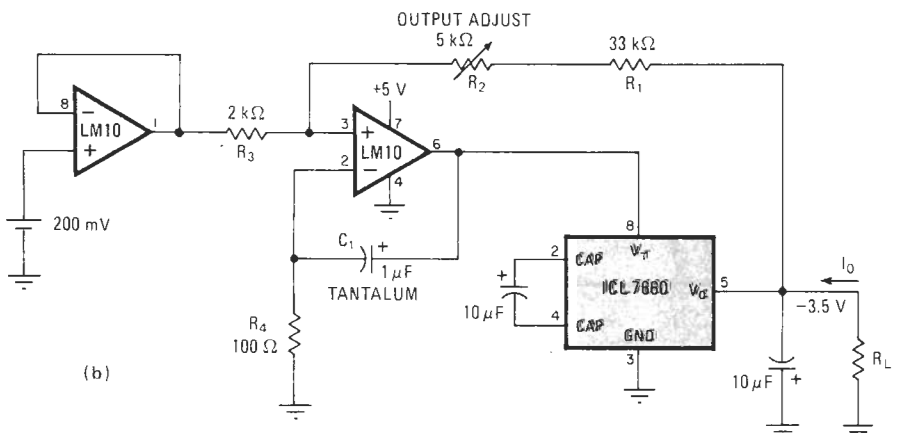
As shown in (a), the 7660 can supply −3.5 volts to a single chip in a C-MOS or TTL system. The chip requires +3.5 V, which is generated by the LM10 operational amplifier from the +5-V supply. Although some other low-voltage op amp and an external reference could be substituted, the LM10 will run off a single supply, has its own reference, and has an output stage that can swing within ½ V of the supply while delivering −20 milliamperes to the 7660.

Though this circuit performs well at very low load currents, its output voltage drops rapidly as load currents increase (see table) because its output impedance is fairly high. At a no-load output voltage of −3.5 V the converter exhibits an output resistance of about 100 ohms, but it will increase 50% for V_{out} = 2 V. This value will render the 7660 useless in systems where more then a few milliamperes are required.

By adding a single resistor and configuring the circuit to the topology in (b), however, the converter can be made to perform much as an ideal voltage source for



R_L (kΩ)	I_O (mA)	V_O
∞	0	3.50
10	0.34	3.45
6.8	0.47	3.37
4.7	0.74	3.36
3.3	1.02	3.34
2.2	1.60	3.30
1.5	2.22	3.26
1.0	2.97	3.20
0.68	4.48	3.08
0.47	6.12	2.94
0.33	8.23	2.73
0.22	10.38	2.48
0.15	13.50	2.06



R_L (kΩ)	I_O (mA)	V_O
∞	0	3.50
4.7	0.76	3.50
3.3	1.06	3.50
1.5	2.35	3.50
1.0	3.20	3.50
0.68	5.06	3.52
0.47	7.02	3.42
0.33	9.38	3.19
0.22	12.13	3.02
0.15	17.42	2.81

Regulatory loop. Intersil's 7660 voltage inverter provides a negative output from a positive source without transformers (a), but voltage regulation is poor. Placing the 7660 in a feedback loop that includes the driving source (b) improves operation markedly.