MAX660 INVERTER/DOUBLER

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A small circuit is described that inverts a positive voltage into a negative one or doubles its level. It does not use inductors and is based on a single Type MAX660 chip.

THE power supply for a battery-operated design can often cause a few headaches as regards the level of the voltage or whether a symmetrical supply should be used. The latter, for instance, normally means a doubling of the number of batteries, which take twice the space originally allowed for and increase the weight: two undesirable factors. The obvious solution is a switch-mode supply, but the construction and/or dimensions of the inductor required for that is another unwelcome element.

There is, however, another solution, provided the output current is not required to be larger than 100 mA: the Type MAX660 integrated circuit. This IC needs only a few capacitors and a diode to provide, from a positive supply, a negative voltage at the same level or double the voltage. It is, of course, possible to use a number of these ICs to increase the output current or voltage, but the proposed design is based on just one.

The circuit

The internal of the MAX660 circuit is shown in Fig. 1; Fig. 1a is a design for a voltage inverter and Fig. 1b, for a voltage doubler. Within the IC, one of two pairs of CMOS switches is opened or closed by the internal

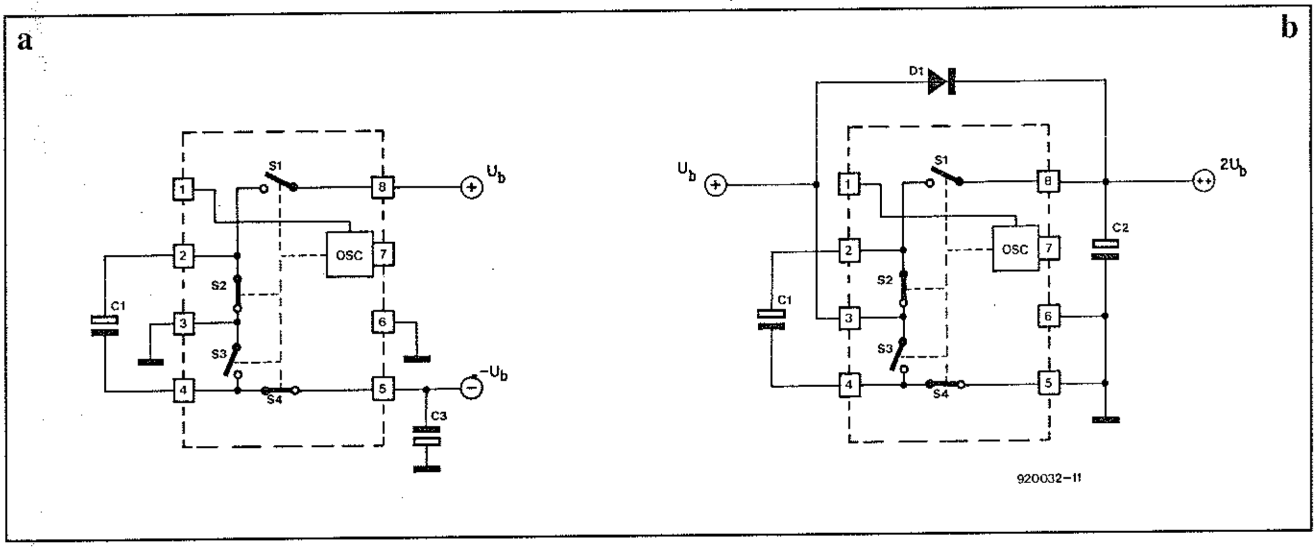

Fig. 1. Basic circuit of a voltage inverter (a) and a voltage doubler (b) based on a Type MAX660 integrated circuit.

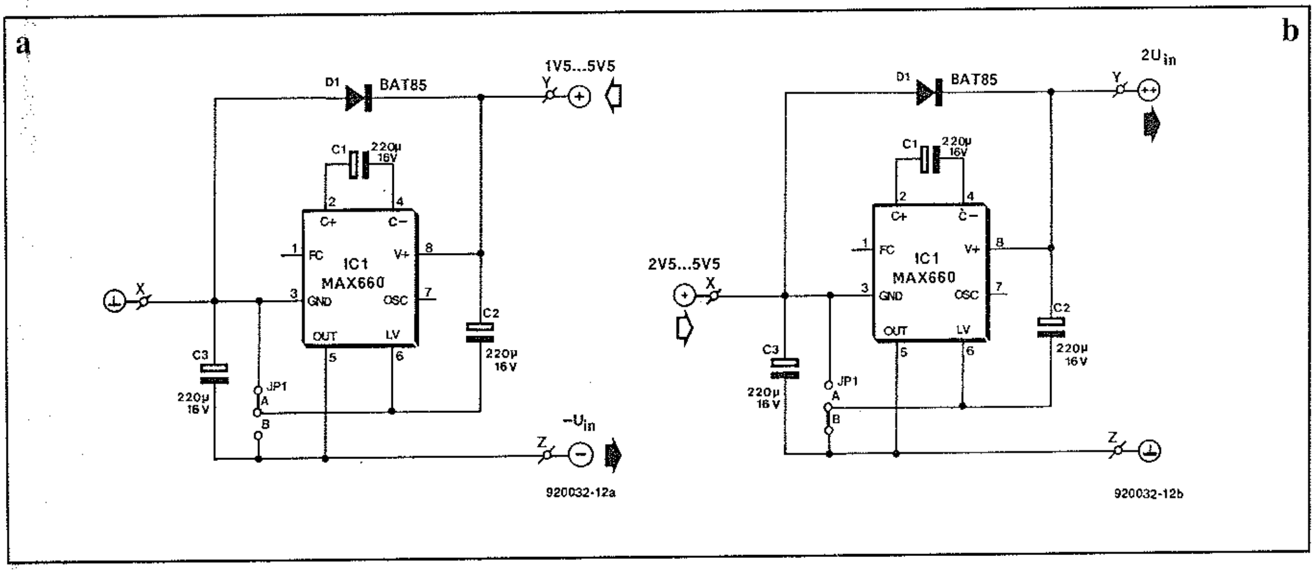

Fig. 2. The two circuits of Fig. 1 can be combined into one that can serve either as an inverter or as a doubler.

TABLE 1
Connections

	inverter	doubler
JP1	A	B
X	ground	in (2.5–5.5 V)
Y	in (1.5–5.5 V)	out
Z	out	ground

TABLE 2
Function of various components

component	inverter	doubler
C1	pump	pump
C2	input buffer	output reservoir
C3	output reservoir	input buffer
D1	polarity protection	start up

TABLE 3
Measurement results

U_{in} (V)	R_L (Ω)	I_{in} (mA)	U_{out} (V)	U_{ripple} (mV_{pp})	Efficiency (%)
Inverter					
2.5	∞	0.1	−2.5	5	
2.5	22	80	−1.8	100	74
5.0	∞	0.2	−5.0	5	
5.0	47	97	−4.5	100	89
Doubler					
2.5	∞	0.1	5.0	5	
2.5	47	178	4.1	100	80
5.0	∞	0.3	10.0	5	
5.0	100	190	9.5	100	95
Maximum output current = 100 mA.					

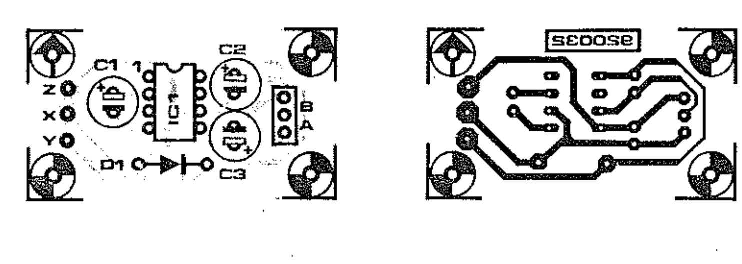

Fig. 3. Printed-circuit board for the inverter/doubler

oscillator that operates at 10 kHz.

If, in Fig. 1a, S_1 and S_3 are closed (S_2 and S_4 are then open), C_1 will be charged. When these switches change over, C_1 and C_3 are in parallel, whereupon charge is transferred from C_1 to C_3. Also, the polarity of C_1 with respect to earth is reversed (pin 2 was connected to ⊕ U_b and is now connected to earth, while pin 4 was connected to earth and is now connected to pin 5). The voltage across C_3 will thus be negative with respect to earth. In the absence of a load, a negative voltage will arise across C_3, whose level is equal to that of ⊕ U_b. When the circuit is loaded, that negative voltage will not only decrease, but will also have a ripple. This is, of course, because C_1 can transfer only a limited charge, smaller than the one required, per unit time. On average, there will remain a smaller charge in C_3, so that the voltage across this capacitor will drop.

When the switches are connected as in Fig. 1b, and a diode, D_1, is added, the IC will double the input voltage. When the supply is switched on, C_2 is charged immediately to the supply voltage (less the forward voltage of the diode) via D_1. This is necessary to ensure a supply to the oscillator. Furthermore, the charge need not be transferred via the IC. Here again, C_1 is the reservoir. It is charged when the switches are in the position shown. When the position of the switches is reversed, C_1 is in series with the supply voltage, U_b, so that the potential across it is $2U_b$. At the same time, C_2 is connected, so that charge is transferred from C_1 to C_2. In that way, and provided the the circuit is not loaded, a voltage arises across C_2 that is twice U_b. As in Fig. 1a, when a load is connected to the circuit, the output voltage, $2U_b$, will decrease in proportion to the load (see Table 3). Bear in mind that the input current will be twice as large as the output: the energy has to come from somewhere.

The circuits in Fig. 1a and Fig. 1b can be combined as shown in Fig. 2. The position of jumper JP1 and the connections to X, Y and Z are given in Table 1. Table 2 shows the function of each of the external components. When the circuit serves as voltage inverter, D_1 is not really required, but, together with a 160 mA fuse, it serves as protection against polarity reversal. Should the supply voltage be connected with incorrect polarity, it will be short-circuited by D_1, whereupon the fuse blows.

The minimum input voltage to the doubler circuit cannot be as low as to the inverter circuit, because, in that configuration, the oscillator has difficulty in starting at too low a voltage. This happens particularly at input voltages below 3.5 V; above that level, the oscillator starts readily at all times.

Although the circuit is perfect for building into an existing design, there may be applications where it is used by itself and for those a printed circuit board—see Fig. 3—is provided. ■

PARTS LIST

Capacitors:
C1–C3 = 220 µF, 16 V, radial

Semiconductors:
D1 = BAT85
IC1 = MAX660