Dc-dc converter supplies dual voltages

by Steven Sarns
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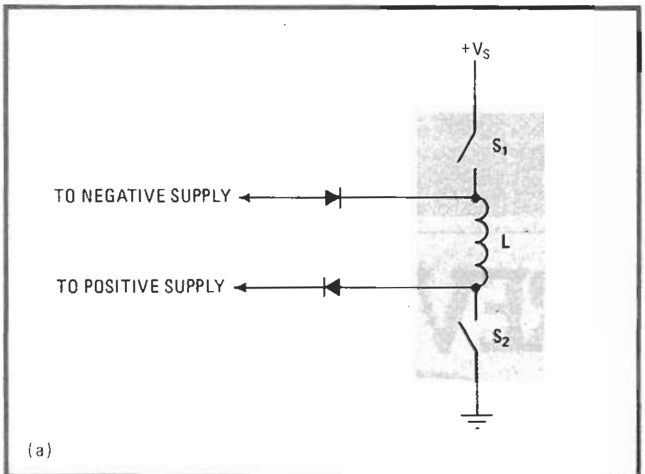
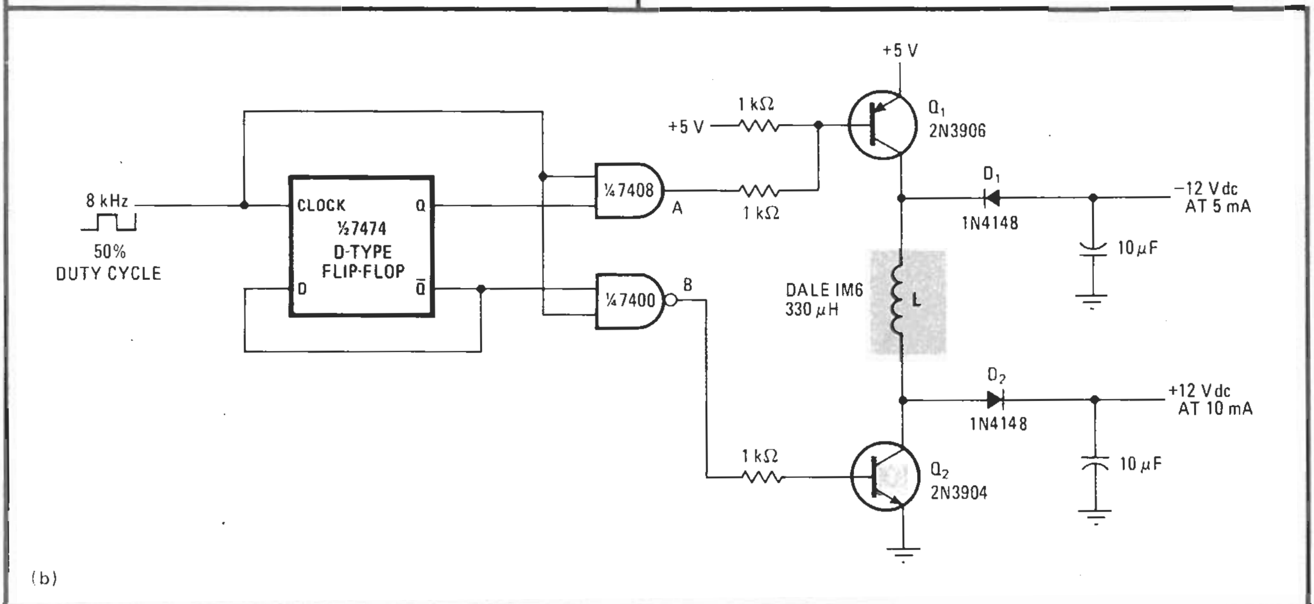
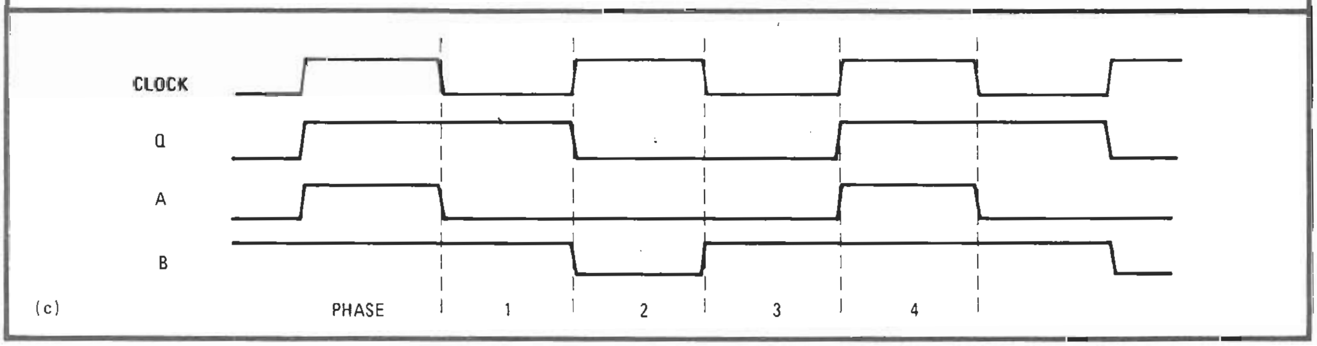
Transmitting RS-232-C line data is just one of the many applications that often need a small card to supply them with both positive and negative voltages. This circuit uses a few discrete components to fulfill this need and substantially lowers the parts count normally required by acting as both a step-up and an inverting flyback converter.

A four-phase clock, an inductor, and two switches form the basis of this dc-dc converter (a). During the first phase of the clock, inductor L is energized through switches S_1 and S_2. Switch S_2 is opened during the second phase and the energy is transferred to the positive supply rail. The two switches are then closed during the third phase and energize the inductor once again. This energy is now transferred to the negative supply rail by opening S_2 during the final phase of the clock.

In the practical circuit (b), D-type flip-flop U_1 generates the four-phase clock, and transistors Q_1 and Q_2 perform the switching actions. The circuit uses an input clock frequency of 8 kilohertz to provide ±12 volts dc to an RS-232-C line driver. In addition, the timing diagram (c) depicts the four phases of the clock. □







Positive and negative. Inductor L in conjunction with a four-phase clock and two switches forms the fundamental dc-dc–converter circuit that supplies dual-polarity voltages (a). The practical design (b) employs D-type flip-flop U_1 to generate the four-phase clock and transistors Q_1 and Q_2 to perform switching functions. A dc voltage of ±12 V is provided by the circuit. In addition, the four-phase clock and the driving inputs for the transistors are as shown in (c).

On-chip transistors extend audio amp's design flexibility

by Jim Williams
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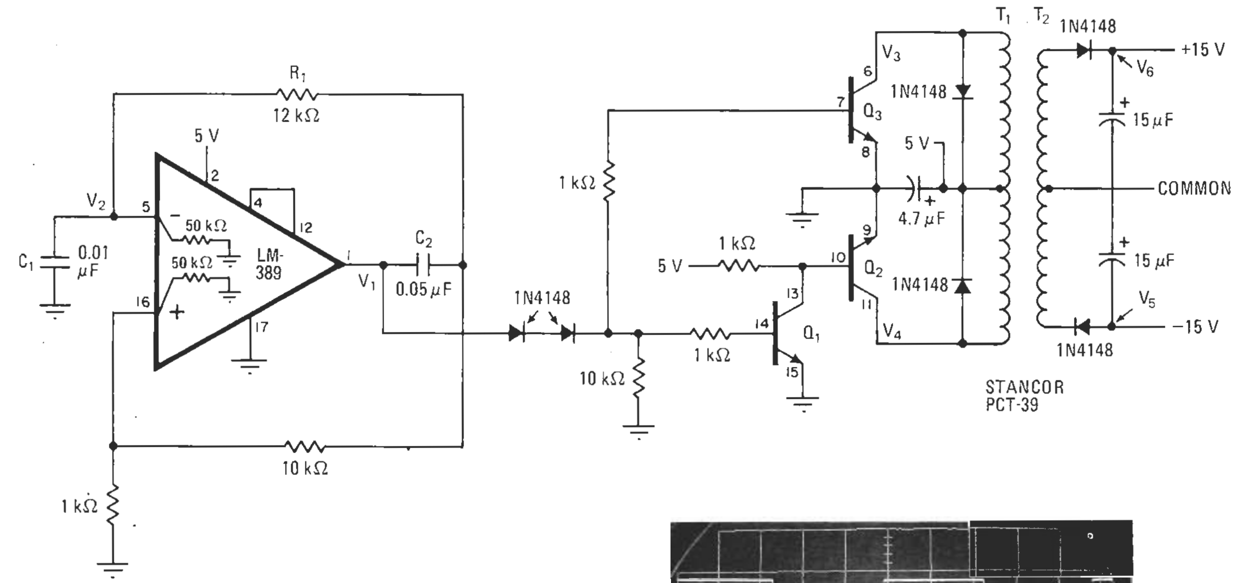
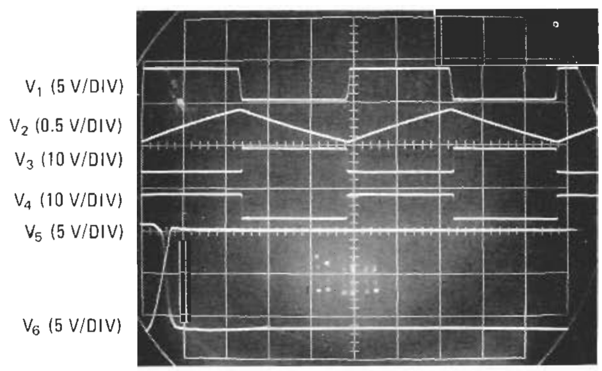
The availability of extremely low-cost audio-amplifier integrated circuits with on-chip transistor arrays, such as National's LM389, gives designers a great deal of flexibility in designing audio circuits. They make it much easier to develop low-cost versions of circuits unrelated to basic audio amplification, such as dc-dc converters, touch switches, stabilized frequency standards, scope calibrators, low-distortion oscillators, and logarithmic amplifiers. The designs of the often-needed converter, a bistable touch switch, and a tuning-fork frequency standard are discussed here in the first part of this two-part presentation.

The LM389 contains a 250-milliwatt audio amplifier and an array of three npn transistors, each of which is uncommitted. The amp has differential inputs and separate pins for setting its gain (from 20 to 200) via a resistor and runs off a single supply that may range from 4 to 15 volts. The three transistors have a minimum current-handling capability of 25 milliamperes and a minimum current gain of 100 for $V_{ce\,max} = 12$ V and for a wide range of collector currents. The chip is therefore ideal for general use.

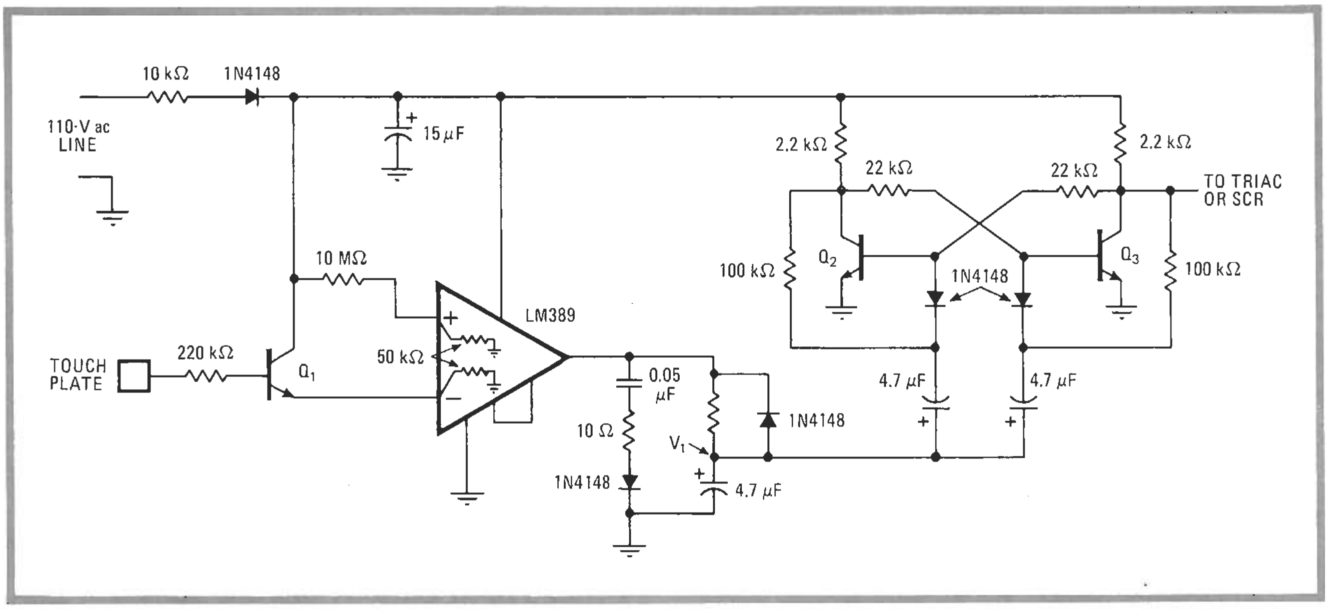
One area in which the chip will be useful is in dc-dc switching conversion. The device in Fig. 1 is intended for use as a power supply in a digital system where it is necessary to supply ±15 V to a low-power load. As can be seen from the oscilloscope photograph, the LM389 switches at 20 kilohertz. That rate is determined by the triangular-wave feedback signal, whose time constant is set by $R_1C_1C_2$, and its square-wave output is applied to transistors Q_1 and Q_3. The series diodes ensure clean turn-off for Q_1 and Q_3.

Q_1's inverted output drives one half of the transformer primary through Q_2, while Q_3 drives the other half. The diodes across Q_2 and Q_3 suppress spikes. Thus there is an

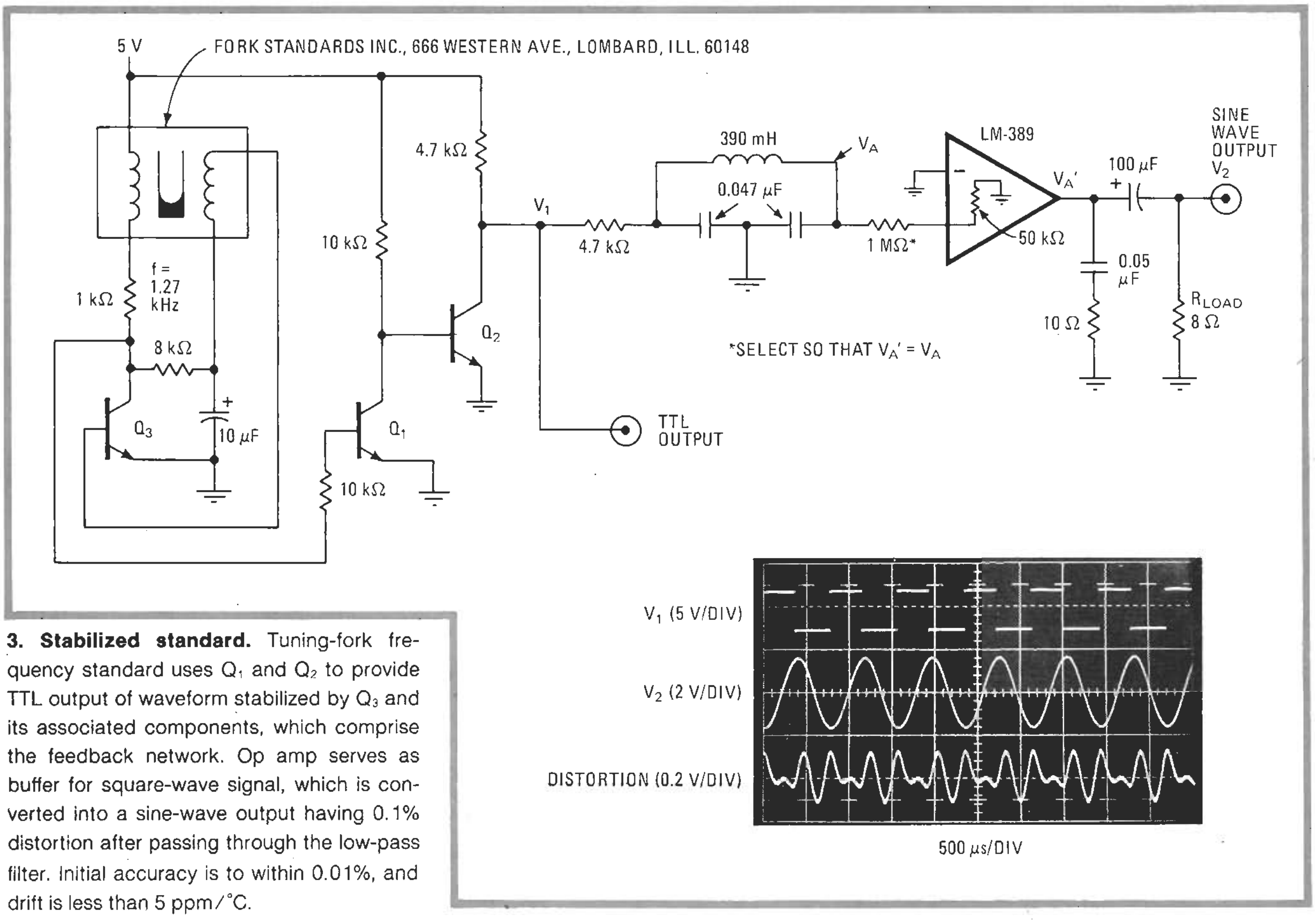




1. Condensed converter. Op amps with an on-chip transistor array, such as National's LM389, make inexpensive one-chip switching converters. Costing under $10, unit shown provides ±1.5 mA at ±15 V for instrumentation amplifier. Scope photo displays waveforms at various points in circuit. Use of diodes in driver side of circuit allows spike suppression, plus clean switching.



2. Simple switching. Simple bistable touch switch may be similarly constructed. Op amp works as comparator and trigger for flip-flop Q_2–Q_3, which changes state each time plate is contacted. Thus, SCR at output may be alternately fired and switched off on command.



3. Stabilized standard. Tuning-fork frequency standard uses Q_1 and Q_2 to provide TTL output of waveform stabilized by Q_3 and its associated components, which comprise the feedback network. Op amp serves as buffer for square-wave signal, which is converted into a sine-wave output having 0.1% distortion after passing through the low-pass filter. Initial accuracy is to within 0.01%, and drift is less than 5 ppm/°C.

efficient step-up of voltage across T_2. This ac signal is rectified and filtered to produce complementary output voltages that may be used to power the desired linear components, in this case delivering ±1.5 mA, enough to power an operational or instrumentation amplifier.

The bistable touch switch (Fig. 2) allows a line-powered load to be controlled from a touch plate by means of a thyristor. Each time the plate is contacted, emitter-follower Q_1 conducts, permitting a fraction of the 60-hertz input signal to be applied to the inverting input of the amplifier. Consequently, the normally high output of the op amp follows the 60-Hz line input, causing V_1 to drop sharply.

This negative transition triggers a toggling flip-flop formed by Q_2 and Q_3. In this manner, the output of the flip-flop changes state each time the touch plate is contacted, prompting the firing of the silicon controlled rectifier or triac that switches ac power to the load.

Figure 3 shows a tuning-fork frequency standard that is stabilized by appropriate feedback. Both sine-wave and TTL-compatible outputs are available. As the circuit needs only 5 V, it can run off a battery.

The tuning fork proper supplies a low-frequency output that is very stable (typically to within 5 ppm/°C) and has an initial accuracy of within 0.01%. Moreover, it will withstand vibration and shock that would fracture a quartz crystal. Here, Q_3 is set up in a feedback configuration that forces the fork to oscillate at its resonant frequency. Q_3's output is squared up by Q_1 and Q_2, which provide a TTL-compatible output. When passed through an LC filter and the op amp, which provides a low-impedance (8-ohm) output, the signal is converted into a sine wave having less than 1% distortion, as shown in the figure.

Several other useful circuits also can be built. The second part of this article will deal with the chip's use in a portable scope calibrator, a low-distortion oscillator, and as a logarithmic amplifier. □

Capacitive voltage doubler forms ±12-to-±15-V converter

by Tom Durgavich
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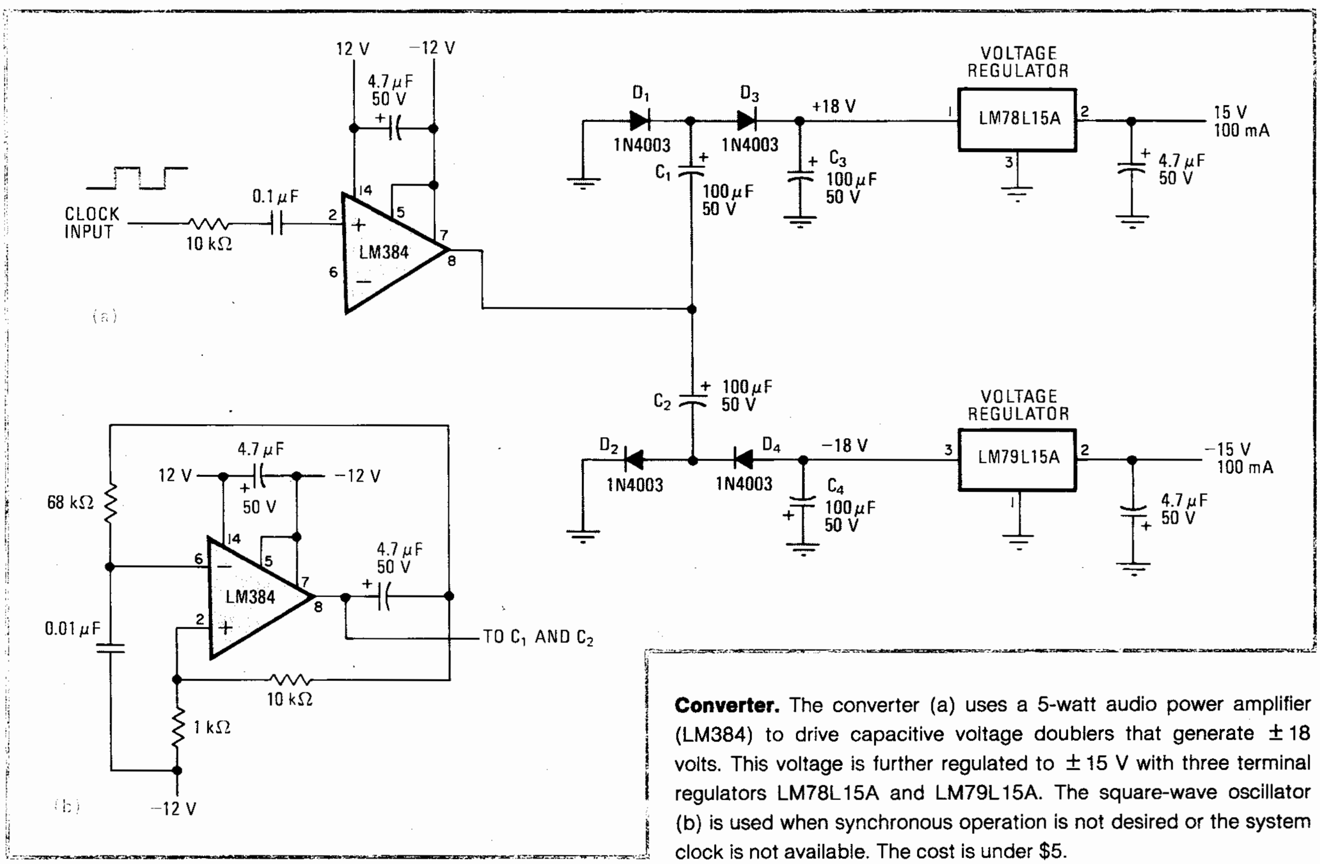
Pairing a capacitive voltage doubler with a regulator provides a simple solution to the problem of converting ±12 volts dc into ±15 V dc. Such a conversion is often required in systems using Intel's Multibus, for example, which puts out only ±12 V dc. Such a conversion is often tional amplifiers and data converters to a guaranteed voltage swing of ±10 V. Unlike conventional dc-to-dc converters, this approach is inexpensive and occupies little board space.

The circuit (a) uses a 5-watt audio power amplifier (LM384) to drive capacitive voltage doublers that generate ±18 V. One doubler, consisting of capacitors C_1 and C_3 and diodes D_1 and D_3, generates +18 V and the other, consisting of C_2 and C_4 and D_2 and D_4, −18 V. The saturation voltage of the 384 op amp along with the voltage drop across the diodes prevents these voltages from ever reaching ±24 V.

The power-amplifier clock input derived from the system clock keeps the switching waveform synchronous and random noise to a minimum. The clock input voltage and frequency can vary from 2 to 12 V peak to peak and 3 to 20 kilohertz, respectively. The 7-kHz square-wave oscillator (b) is used when the system clock is not available or synchronous operation is not desired.

The output current of this converter is limited to 100 milliamperes but can be slightly increased by providing the op amp with a good heat sink. The ±18 V unregulated voltages may be increased to greater then ±30 V by connecting diodes D_1 and D_2 to +12-V and −12-V sources instead of to a ground connection. □

Engineer's notebook is a regular feature in *Electronics*. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $75 for each item published.



Converter. The converter (a) uses a 5-watt audio power amplifier (LM384) to drive capacitive voltage doublers that generate ±18 volts. This voltage is further regulated to ±15 V with three terminal regulators LM78L15A and LM79L15A. The square-wave oscillator (b) is used when synchronous operation is not desired or the system clock is not available. The cost is under $5.