Three-level inverter conserves battery power

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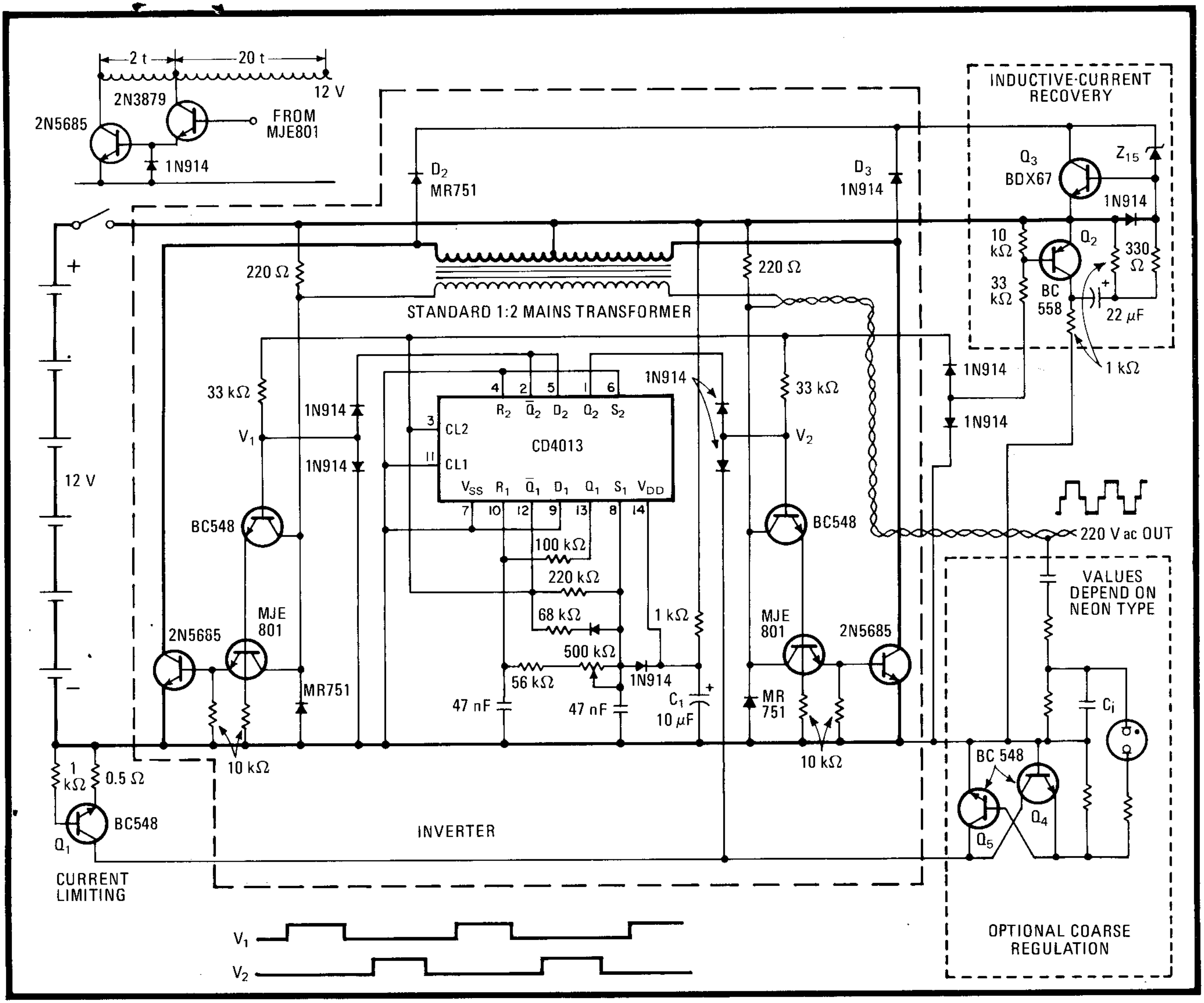
Converting 12 volts dc into a well-regulated 220 v ac at high efficiency is especially desirable when the input power source is derived from solar cells or a car battery. Often, too, output harmonics generated by the conventional square-wave inverter must be reduced to a point where it does not create other practical drawbacks. These design requirements are met with this inverter, which maintains efficiency and reduces harmonics at all power levels by ensuring that the driving current is almost linearly proportional to the output power and by producing a three-level output waveform that more closely approximates a sine wave.

As shown, the CD4013 dual flip-flop generates a 100-hertz pulse train (duty cycle is 1/6) and a 50-Hz square wave (the oscillator is easily modified for 60 Hz), both of which are independent of input voltage and load variations. The AND gates formed by the diode-resistor networks at the output of the flip-flops apply these signals to the power transistor drive circuitry (BC548, MJE801, etc.), which, configured in a two-phase switched-mode arrangement that sends a pulse through the primary of the line transformer every quarter cycle at 50 Hz, generates a three-level waveform.

Because the positive and negative output swings each last one third of a cycle, separated by sixth-period intervals at the zero crossings, third-harmonic attenuation is theoretically reduced to zero. By appropriate modulation



Cell saver. Switched-mode inverter attains high efficiency and low harmonic distortion over a wide range of power levels, thus conserving solar cells and batteries. Output frequency is independent of input fluctuations. Current limiting and voltage regulation are provided.

of these zero-voltage intervals, good regulation is achieved at low loss without reintroducing excessive third harmonic energy. Although this method is not as elegant as the transformerless method of summing phase-shifted square waves or stepped sine waves,' it is much simpler.

D1 and C1 ensure reliable startup. Current limiting is provided by Q1, which diverts drive current if output current soars. Output impedance is kept virtually constant during all parts of the cycle, including zero-voltage periods, where Q2 saturates Q3, thus feeding an inductive current back into the battery via diodes D2 and D3. The zener diode provides spike suppression. A neon lamp or similar symmetrical-breakdown device allows simple voltage regulation. When V_{out} soars, Ci attains breakdown before the normal zero-voltage period, and Q4 or Q5 diverts current.

Because this is a switched-mode inverter, efficiency is excellent at nominal output power. But, in contrast to other inverters, its high-efficiency characteristic extends down to very low output-power levels. This is achieved by forcing output current to flow not only through the transformer's secondary, but also through the base-emitter junctions of the 2N5685 power transistors. Thus, base drive closely tracks the output power requirements. As long as the transformer winding ratio is compatible with the gain needed to saturate the power transistors, significant power can be saved at the lower power levels. Efficiency exceeds 88% at 120 volt-amperes, 75% at 175 VA, and 50% at 15 VA. No-load loss is only 12 watts.

Still better performance can be obtained by adopting the power Darlington configuration, as shown at the upper left. Using the Darlington, the inverter's efficiency will be 89% at 150 VA, 70% at 225 VA, and 50% at 15 VA. Lower transformer step-up ratios further improve performance, because the output transistors switch more totally into saturation. Thus, 12-v dc-to-110-v ac and 24-v-dc-to-220-v-ac designs are more efficient than this 12-v-dc-to-220-v-ac circuit. □

References

1. Geert J. Naaijer. "Transformerless inverter cuts photovoltaic system losses," *Ekectronics,* Aug. 14. 1980, p. 121