Build a quartz-crystal-controlled digital clock with only six ICs

A quartz-crystal-controlled 12-hour digital clock requires only six CMOS MSI circuits for timing and counting. During power-line interruptions the clock continues to run on a single small dry-cell battery.

To conserve power during stand-by battery operation, voltage is automatically removed from the output display. The oscillator, timing and counting circuits, however, continue to operate from the battery without interruption, consuming only about 50 mW of power. When line power is restored, the correct time is automatically redisplayed without need to reset the clock.

The oscillator uses a CR-18/U crystal unit, which operates at a frequency of 2.236962 MHz. The oscillator frequency is divided by two cascaded 14-stage binary counters (IC$_5$ and IC$_6$ in the figure) to produce one pulse a minute. These pulses are totaled in four additional cascaded decade counters (IC$_1$ through IC$_4$) with 10 decoded outputs, producing the discrete minute and hour signals for the display.

To provide the proper counting and decoding sequence in the hour decades, the unit hours decade counter IC$_2$, together with its display circuit, is wired in an offset fashion, as shown in the diagram. In a 12-hour clock, the hour decades must go from a display of "12" hours to "01" (rather than "00"). Both hour counters are reset to zero (displayed as "01" hours) after a displayed hours count of "13" is reached. This occurs within a few microseconds after the undesired display of "13" is reached, so that the displayed hours count appears to move directly from "12" to "01" hours.

This hours counting and display scheme also requires that the carry to the tens of hours decade must come from the digit nine in the units hours decade rather than the usual carry output terminal. In a similar fashion, the tens of minutes decade is reset to "0" after a count of "6" is reached. The connection sequence is summarized in the accompanying table.

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UNIT HOURS DECODING										
UNIT HOURS COUNTER DECODED OUTPUT	0	1	2	3	4	5	6	7	8	9
CONNECT TO DISPLAY NUMERAL	1	2	3	4	5	6	7	8	9	0
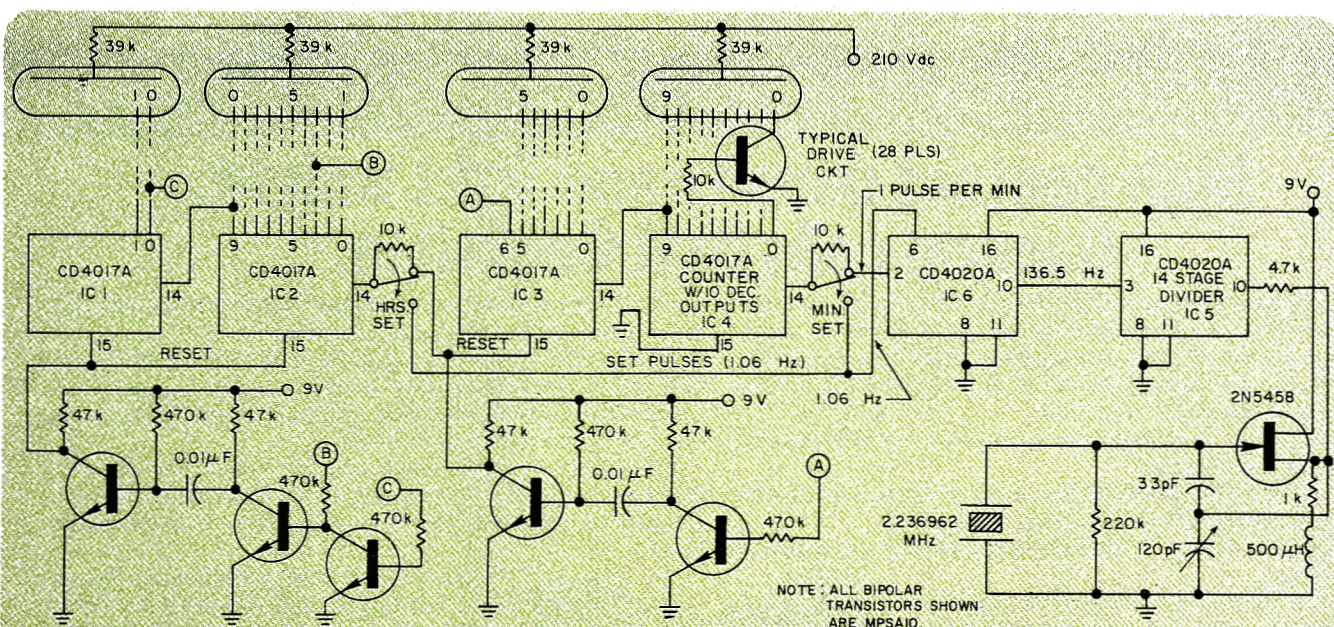
Four digital displays exhibit hour and minute outputs from four CMOS cascaded decade counters IC$_1$ through IC$_4$. The table shows the connection sequence to the displays.