Simplifying sum-correction logic for adding two BCD numbers

by Robert D. Guyton
Mississippi State University, Mississippi State, Miss.

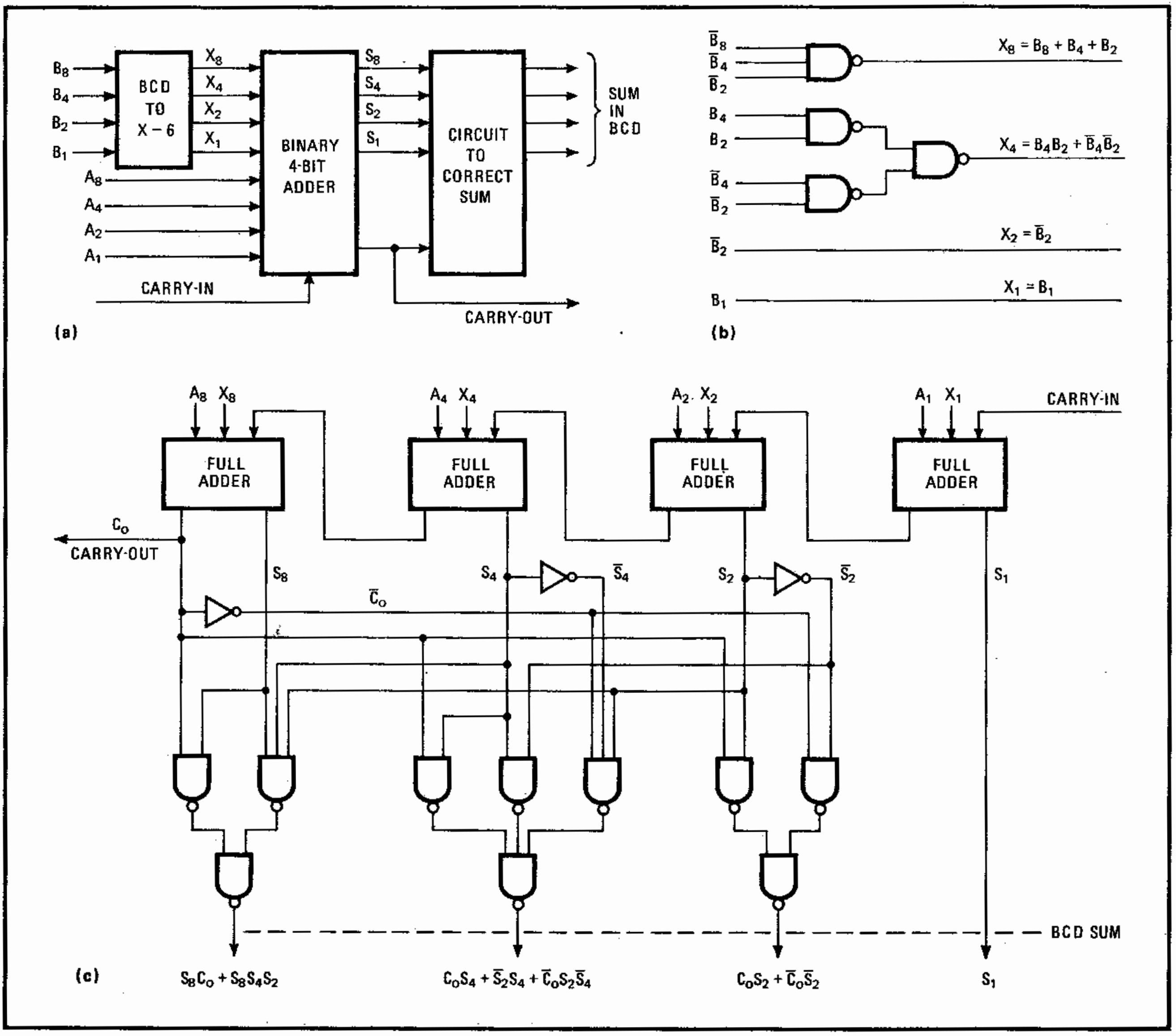
To add two numbers in binary-coded decimal form, much less logic hardware is needed if one of the numbers is converted to the excess-6 binary code before the addition is done. The other number remains unchanged.

The block diagram of (a) outlines the approach. One BCD input is converted to the excess-6 code by a second-level logic circuit, which is drawn in (b). This translated number and the unchanged BCD number are then added by a 4-bit binary adder. The resulting output carry is correct, but the sum must still be corrected—and can be corrected by a simple second-level logic circuit, rather than a multilevel type of logic circuit based on half and full adders.

The BCD-to-excess-6 translator circuit needs four NAND gates and three inverter gates. The rest of the over-all addition circuit is shown in (c): the four-bit binary adder requires four full adders, while the sum-correction circuitry requires 10 NAND gates and three inverter gates.

The complete excess-6 addition circuit, therefore, consists of 14 NAND gates, six inverter gates, and four full adders. As against an addition circuit based on excess-3 code conversion, that's a savings of six NAND gates, three inverter gates, one full adder, and two half adders. □

Conserving logic hardware. The circuit for adding two binary-coded-decimal numbers can be implemented with fewer devices by changing one of the BCD numbers to the excess-6 code format. When this conversion is done, simple logic gates can be used to perform the necessary sum correction. The figure shows the circuit's block diagram (a), the excess-6 code translator (b), and the complete circuit (c).


B_8
B_4
B_2
B_1
BCD TO X − 6
X_8
X_4
X_2
X_1
A_8
A_4
A_2
A_1
BINARY 4-BIT ADDER
S_8
S_4
S_2
S_1
CIRCUIT TO CORRECT SUM
SUM IN BCD
CARRY-IN
CARRY-OUT
(a)
$\overline{B}_8$
$\overline{B}_4$
$\overline{B}_2$
$X_8 = B_8 + B_4 + B_2$
B_4
B_2
$\overline{B}_4$
$\overline{B}_2$
$X_4 = B_4B_2 + \overline{B}_4\overline{B}_2$
$\overline{B}_2$
$X_2 = \overline{B}_2$
B_1
$X_1 = B_1$
(b)
A_8 X_8
A_4 X_4
A_2 X_2
A_1 X_1
CARRY-IN
FULL ADDER
FULL ADDER
FULL ADDER
FULL ADDER
C_o
CARRY-OUT
S_8
S_4
$\overline{S}_4$
S_2
$\overline{S}_2$
$\overline{C}_o$
S_1
BCD SUM
(c)
$S_8C_o + S_8S_4S_2$
$C_oS_4 + \overline{S}_2S_4 + \overline{C}_oS_2\overline{S}_4$
$C_oS_2 + \overline{C}_o\overline{S}_2$
S_1