Decimal ALU

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Introduction

The decimal number system is used in many commercial applications, such as financial analysis, banking, tax calculation, currency conversion, insurance and accounting. With the explosively increasing amount the data to be proposed, computers are introduced to help deal with it. However, in digital Arithmetic Logic Unit (ALU) circuit systems, the binary number system is widely used for its simplicity and easy realization in physical layout. This project aims at constructing an ALU that contains decimal additions, subtractions and multiplications using binary coded decimal (BCD) on a binary system platform.

BCD Operations

A	0010 0101 0111 0101
B	+ 0011 0100 0010 1000
Sum 1	0101 1001 1001 1101
Correction 1	+ 0000 0000 0000 0110
Sum 2	0101 1001 1010 0011
Correction 2	+ 0000 0000 0110 0000
Sum 3	0101 1010 0000 0011
Correction 3	+ 0000 0110 0000 0000
Result	0110 0000 0000 0011

Figure 1 Conventional BCD addition

A	0010 0101 0111 0101
B	0011 0100 0010 1000
Speculated Correction	+ 0110 0110 0110 0110
Sum	0111 0111 0011 1011
Carry	+ 0010 0100 0110 0100
Compressed Sum and Carry	1100 0000 0000 0011
Final Correction	- 0110 0000 0000 0000
Result	0110 0000 0000 0011

Figure 2 Adding 6 along with the addition

A	B	Cin		
G	P	H		
K	L	S₁	C₁	
Cout		S₂	S₄	S8

$$S_1 = (A_1 \oplus B_1) \oplus C_{\text{in}} = H_1 \oplus C_{\text{in}} = H_1\bar{C}_{\text{in}} + \bar{H}_1 C_{\text{in}}$$

$$S_2 = H_2 \oplus C_1 \oplus C_{\text{out}} = H_2\bar{C}_1\bar{C}_{\text{out}} + H_2 C_1 C_{\text{out}}$$
$$+ \bar{H}_2 C_1 \bar{C}_{\text{out}} + \bar{H}_2 \bar{C}_1 C_{\text{out}}$$

$$S_2 = H_2\bar{C}_1\bar{K} + H_2 C_1 L + \bar{H}_2 C_1 \bar{L} + \bar{H}_2 \bar{C}_1 K$$

$$S_4 = \bar{P}_4 G_2 + \bar{P}_8 H_4 \bar{P}_2 + (\bar{P}_8\bar{P}_4 P_2 + G_4 G_2 + P_8 P_4)C_1$$
$$+ (G_8 + H_4 H_2)\bar{C}_1$$

$$S_8 = (G_8 + H_4 H_2)\bar{H}_8 C_1 + L\bar{K}\bar{C}_1$$

Figure 3 One-digit CLA BCD addition

		A3	A2	A1	A0
×					B0
		M03	M02	M01	M00
+	C03	C02	C01	C00	
=		PP04	PP03	PP02	PP01	PP00

				A3	A2	A1	A0
×				B3	B2	B1	B0
			PP04	PP03	PP02	PP01	PP00
+			PP14	PP13	PP12	PP11	PP10
+		PP24	PP23	PP22	PP21	PP20	
+	PP34	PP33	PP32	PP31	PP30		
= P7	P6	P5	P4	P3	P2	P1	P0

Figure 4 BCD Multiplications