ISSN: 2414-1895
DOI: 10.6919/ICJE.202103_7(3).0014

Design of 8-bit Adder and Subtractor Based on Digital Chip

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Abstract

The adder is very important to improve the convenience and safety of modern operations. In order to meet the needs of increasing working speed and reducing power consumption, the design adopts the integrated chip advance bit adder 74LS283 and exclusive OR gate 74LS86 to form a combinational logic circuit, and uses the function of the logic gate circuit to design an 8-bit adder and subtractor to achieve two Addition and subtraction of an 8-bit binary number. By controlling the switch to close the analog data input and selecting the adder and subtractor, according to the number system operation of the digital circuit, it can be known that the subtraction operation can be converted into the addition operation by adopting the form of complement. Therefore, in order to simplify the circuit structure of the arithmetic unit, there is no need. In addition, the subtractor is designed, but the subtraction operation is changed into the addition operation to process, that is, by adopting the form of adding complement, the design can perform both addition operation and subtraction operation.

Keywords

Advance Bit Adder; Binary Number; Combinational Logic Circuit; Adder and Subtracter.

1. Introduction

The 21st century is the era of rapid development of integrated circuits. The rapid development of information industries such as computers has promoted the integrated circuit industry. Most VLSIs have gradually entered people's daily lives, improving people's lives and becoming indispensable to people's lives. In part, in these widely used operations, the basic unit of these operations is the adder. In high-performance microprocessors and digital signal processors, the operation of the adder is very important. The operation of the adder is usually in the critical path of the arithmetic components of the high-performance processor, especially in the arithmetic logic unit. The speed plays a decisive role.

2. System overall design

This article uses the logic functions of the 74LS283 and 74LS86 chip logic gate circuits to design a combinational logic circuit to realize the addition and subtraction of two 8-bit binary numbers, and control the switching of the adder and subtractor through the switch, so that the circuit can perform addition operations. And can perform subtraction. The system block diagram is shown in Figure 1. The adder-subtractor is composed of an addition and subtraction module, a control module, and a display module. Use a self-locking switch to control the light-emitting diode as the input signal represents binary 0 and 1, the output signal is output with carry, the calculation result is displayed on the light-emitting diode, the light-emitting diode is on to indicate high level, and the light-emitting diode is off to indicate low level . The role of the resistor exclusion used in the 8-bit adder-subtractor circuit is to stabilize current and limit the current, protect the LED, so as not to burn the LED due to excessive current. Compared with ordinary resistors, the advantage of using exclusion is to simplify

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the PCB The layout, installation, reduce space and ensure welding quality. Because the subtraction operation can be transformed into an addition operation in the form of adding one's complement code, in order to make the design system simpler and save the cost to the maximum extent, no additional subtractor is provided here.

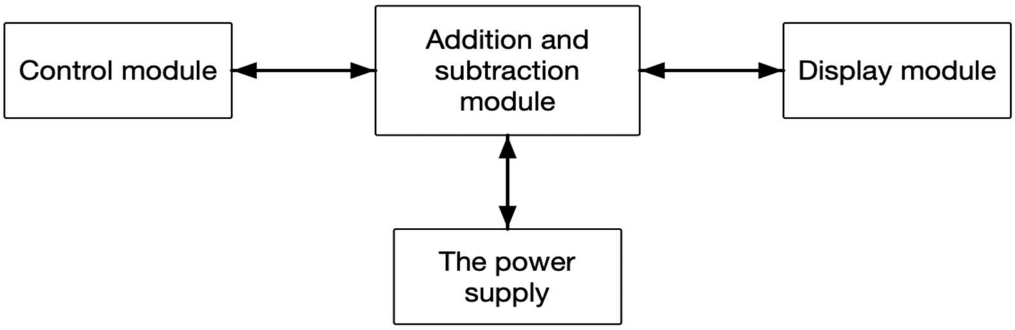

Figure 1. System block diagram

3. System implementation

3.1 Design of control circuit

Taking into account that a single-open switch may not get a low level, unless the pull-down resistance is small, the power consumption will be large when it is turned on. In order to overcome this problem, the design of the control circuit of this part is composed of a self-locking switch, an RS latch composed of a NAND gate, and a light-emitting diode. This part also uses a resistor, and the function here is to limit current. Because the storage circuit formed by the SR latch has a memory function, it can prevent the circuit from flipping twice and obtain accurate 0 and 1 states. In this design, each time the switch changes, the latch only flips once, and there is no jitter. When the control signal M=1, that is, the state of the latch Q=1, the circuit performs subtraction; when M=0, that is, when Q=0, the circuit performs addition. The specific circuit design is shown in Figure 2 below.

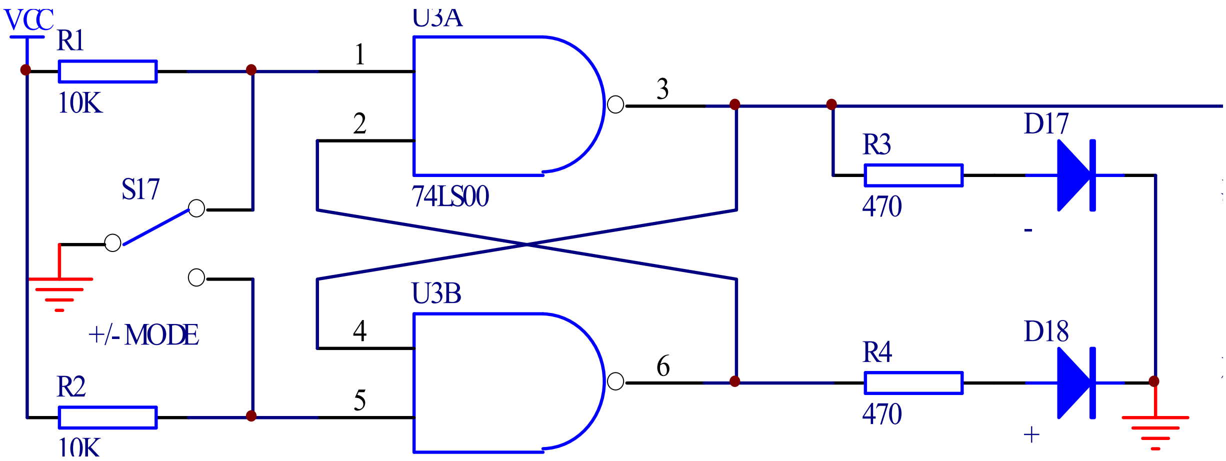

Figure 2. Addition and subtraction control circuit

3.2 Design of adder and subtractor circuit

In the design of the adder, the integrated chip advanced forward bit adder 74LS283 is used. 74LS283 is a four-bit binary advanced forward bit adder. In order to obtain an 8-bit binary adder, two 74LS283 chips are needed for off-chip expansion, because 74LS283 There is a serial carry between slices, so connect the carry output of the lower chip to the carry input of the higher chip to get an 8-bit binary

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number adder. That is to say, the four-bit addend and the low-order bits of the four-bit addend are implemented on the same 74LS283, and the high-order bits are implemented on the same 74LS283. Then the low-order carry output is connected to the high-order carry input, and finally the The output terminal outputs a 9-bit binary number, which is read from left to right. As mentioned earlier, in order to simplify the circuit structure, the design of the subtractor can be implemented in the form of adding complement, namely: A-B=[A] complement +[-B] complement. 74LS283 realizes the operation of the adder-subtractor, because the complement of B is its complement plus 1, and the complement of B can be implemented with the exclusive OR gate 74LS86. After getting the inverse code, use the four-bit binary full adder 74LS283 to realize the inverse code of A+B, and make the least significant carry bit 1. Summarized as follows, use the full adder integrated chip 74LS283 and exclusive OR gate 74LS86 to design a subtractor, two numbers are subtracted, taking a four-digit binary number as an example, A3A2A1A0 minus B3B2B1B0 is equal to B3B2B1B0 plus 1 and rounding up, such as using 4 Bit two's complement is calculated as 5-2, (5-2)'s complement = (5)'s complement + (-2)'s complement=0101+1110=[1]0011, here we automatically discard the 1 in the brackets, because in the circuit In processing, 1 means that there is no borrow in the subtraction process, that is, the result of the subtraction is a positive number. According to the knowledge of addition and subtraction in the digital circuit, two numbers are subtracted. If the borrow signal is 0, then the difference is the original code of the difference; if the borrow signal is 1, then the difference is the difference Complement. The pin diagram of 74LS283 is shown as in Fig. 3.

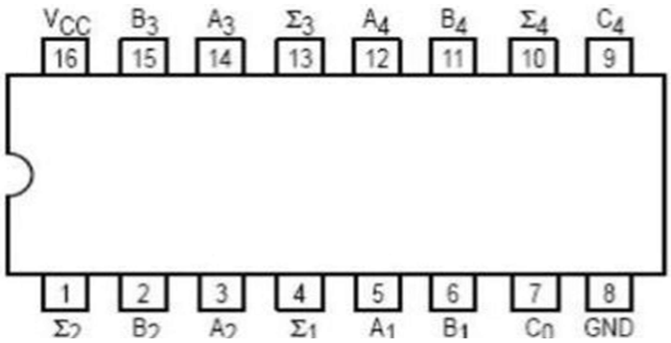

Figure 3. The pin diagram of the full adder 74LS283

3.3 Design of LED display circuit

The circuit consists of a self-locking switch, a buffer and a light-emitting diode. In addition, a resistor is used. The role of the resistor here is to input current to the device when used as a pull-up resistor, and output current to the device when used as a pull-down resistor. It is clamped at high or low level by exclusion, and at the same time acts as a current limiter. The light-emitting diode has two functions in the system: one is to control the input of analog data of the light-emitting diode through the closing of the self-locking switch, and the light-emitting diode is turned on and off logically into binary numbers 0 and 1; the other is through the self-locking switch Close the control light-emitting diode, and the light-emitting diode is used as an indicator light to instruct the circuit to perform addition or subtraction. Connect the light-emitting diode and the exclusion resistor in series, and the resistor acts as a step-down and current-limiting function to prevent the excessive current at both ends of the diode from being burned out. The on and off of the light-emitting diode is controlled by the opening and closing of the self-locking switch. The logic is: the light-emitting diode is on or the switch is closed, which means the binary number "1", and the light-emitting diode is off or the switch is off, which means the binary number "0". This means the input of binary numbers. When the green light is on, the circuit performs addition; when the blue light is on, the circuit performs subtraction. Buffer 74LS240 is connected to the 16 input terminals, because 74LS240 has three-state gates, which has strong driving ability and can be used for circuit driving. The specific circuit design is shown in the figure below. The LED display circuit design is shown in figure 4.

Volume 7 Issue 3, 2021
DOI: 10.6919/ICJE.202103_7(3).0014

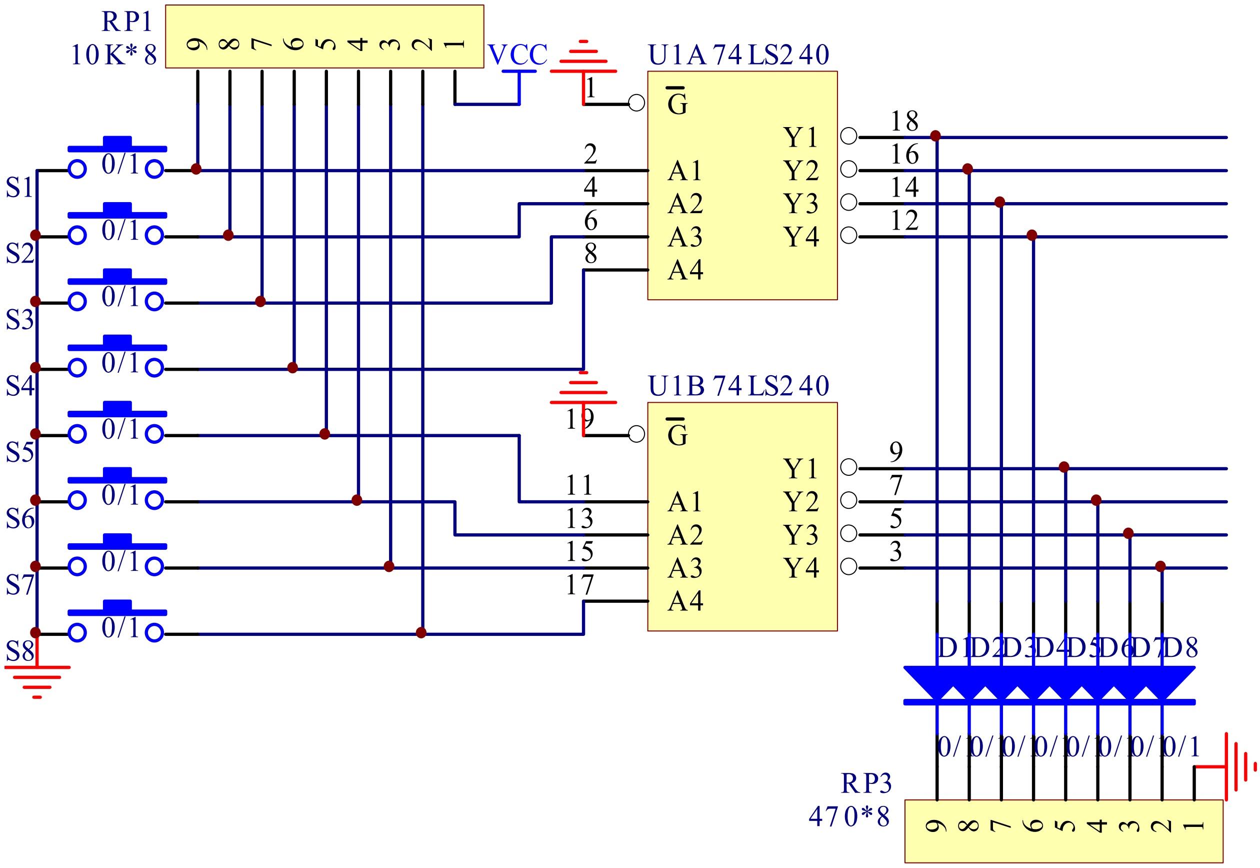

Figure 4. Schematic diagram of LED display circuit

3.4 Design of power supply circuit

The power circuit is composed of a +5V power interface and a power filter circuit. The capacitor plays a role of filtering and decoupling in the circuit. The specific circuit design is shown in Figure 5. The power supply circuit design is shown in Figure 5.

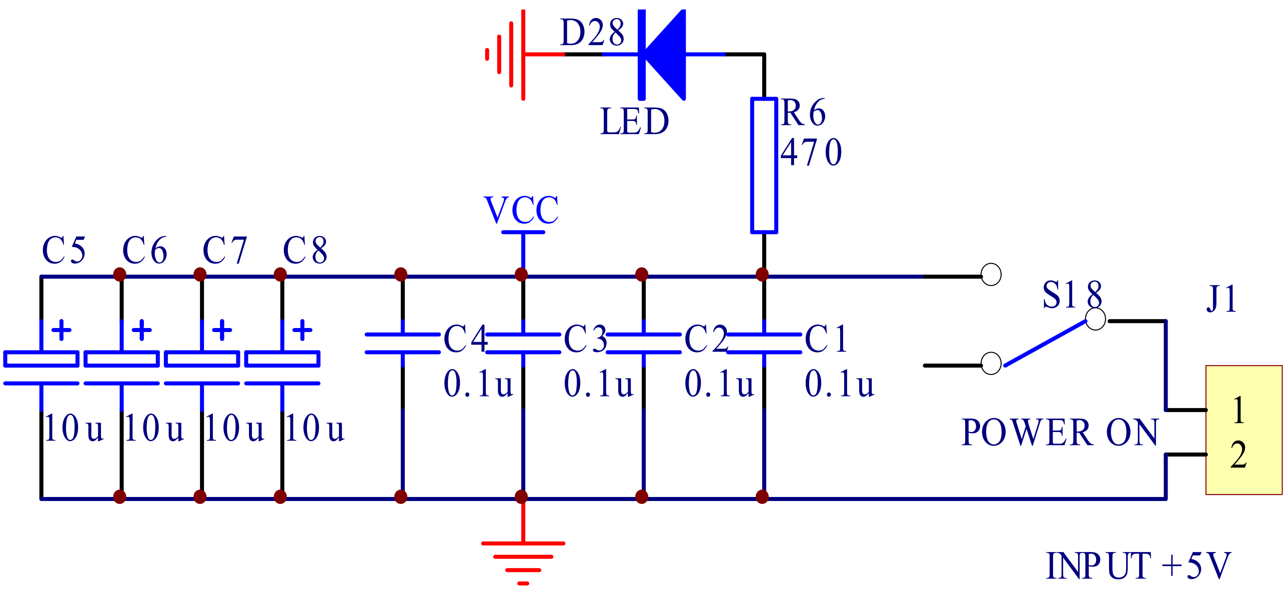

Figure 5. Schematic diagram of power supply circuit

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4. Simulation and testing

The simulation circuit diagram of the addition operation is shown in Figure 6.

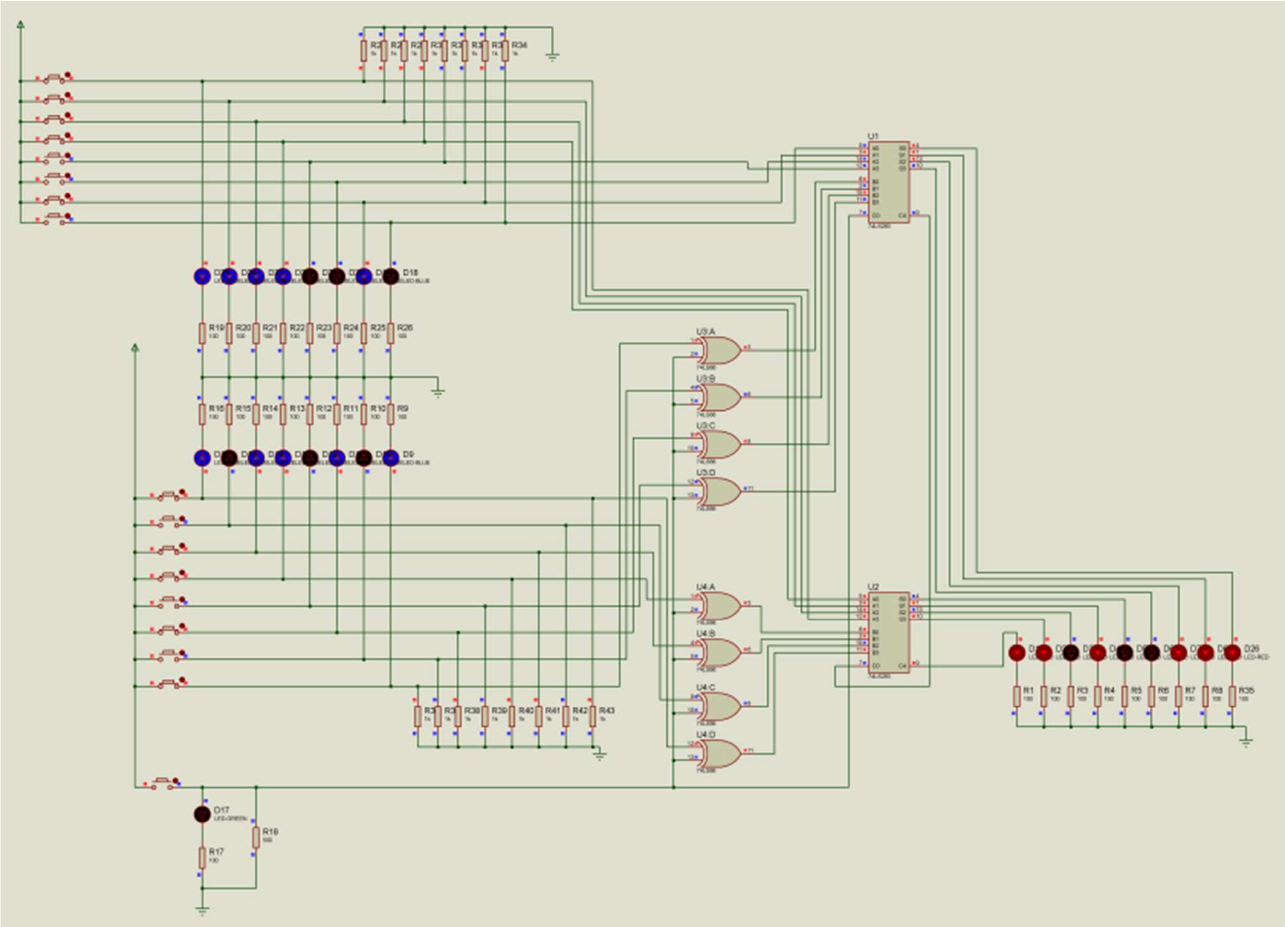

Figure 6. Simulation of addition operation

When used as a subtractor, it is divided into two cases, the first case is A>B, and the second case is A<B.

First discuss the case of A>B. Input the binary numbers "0010 0101" and "0001 0110", that is, the decimal numbers "37" and "22", and set the M terminal to "1", that is, high level to make it perform subtraction , It can be observed that the output result is "1 0000 1111". It can be seen from the addition and subtraction operation of two's complement that in the circuit processing, the highest 1 in the output result indicates that there is no borrow in the subtraction process, that is, the result of the subtraction is positive Number, the "1" here should be automatically discarded, and 37-22=15. It can be seen that the circuit can satisfy the subtraction operation and realize the function of the subtraction operation. In summary, the design of A>B subtractor is successful.

Discuss the case of A<B again, input the binary numbers "0011 1010" and "0100 1111", that is, the decimal numbers "58" and "79", set the M terminal to "1", which is high level, and make it perform subtraction , It can be observed that the output result is "0 1110 1011". It can be seen from the addition and subtraction operation of two's complement that in circuit processing, the highest bit of 0 in the output result indicates that there is a borrow in the subtraction process, that is, the subtraction result is The complement of the resulting value. It can be seen that the circuit can satisfy the subtraction operation and realize the function of the subtraction operation. In summary, the design of A<B subtractor is successful.

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5. Summary

Enter several groups of two 8-bit binary numbers arbitrarily on the Proteus simulation software to perform addition and subtraction operations. Observe the comparison between the results displayed by the light-emitting diodes and the actual calculation results to verify the correctness of the design circuit. According to the simulation results and calculations The comparison of the results proves that the system can realize the addition and subtraction of two 8-bit binary numbers, achieve the expected purpose, and the circuit design is successful.

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