

# Designing Digital Circuits by Contactor Control Circuit

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**Abstract:** Today, digital Systems play a significant role in human's life. And it is the reason to call existing technology, "The Digital Age". Digital circuits are utilized in industry, trade and science. The most commonly used electronic devices like computers, cell-phones, digital cameras, televisions,... are designed by digital circuits. Digital circuits are composed of smaller circuits titled logic gates. It seems confusing to design huge digital circuits by logic gates. A procedure will be presented in this paper to design digital circuits with logic gates by contactor control circuits. This method can be useful for skilled persons in designing contactor control circuits. And it will be beneficial in controlling power circuit in low-noise environments, since it can lead to decrease size and expenses.

**Keywords:** contactor, circuit, digital, designing, logic gate, control circuit

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## 1. Introduction

Control contactor circuits are designed by N.O (normally open) and N.C (normally close) contacts of magnetic contactors. The magnetic contactor (MC) is a device which switches the load by opening and closing the contact point by exciting and degaussing the magnetic coil [1].

PLC's were developed in the late 1960's to eliminate the large cost involved in changing complicated relay based machine control systems [2]. Before introducing PLC technology, control systems were designed by relays and magnetic contactors. The more complicated control system is, the more devices contacts will be required. These systems' big problem was their huge sizes. Also it was hard to change the logic of the circuit's function. Development in industries will lead to development in the size of control contactor panels too. And this means extra expenses in circuits' repair, maintenance and troubleshooting. Through improving digital science, processors were entered into the control contactor systems. In the beginning, power systems were controlled by IPCs, but they were replaced by DCSs progressively. DCSs developed in 1975 and consisted of distributed microprocessor based single loop controllers [3]. DCS system is complex and expensive but provides different control functions [4]-[6].

The next generation of DCSs were PLCs. PLC is a programmable Logic Controller utilized for controlling and operating manufacturing process and machinery [7]. It can also be defined as "a digitally operating electronic apparatus which uses a programmable memory for the internal storage

of instructions [8]. PLCs can hold data for a long time [9]. They have less size and it is easy to change their logical functions.

It seemed that there was no chance for old control contactor systems' existence through PLCs' appearance, but there is, because of PLCs' extreme prices.

So, designing non-programmable digital circuits and substituting them for control contactor circuits in low-noise environments may decrease the huge size of such circuits, even though they are not changeable. The mentioned circuits can even reduce expenses of adding auxiliary contacts to contactors and utilizing auxiliary contactors. Agreeing with the explanation, the presented method in this paper can probably be useful in turning control contactor circuit into digital one by AND, OR and NOT logic gates.

## 2. The Significance Of The Problem

Designing electronic boards for controlling power system not only can reduce the size of control contactors and the price of providing contacts and auxiliary contactors but also will cover one of the moot points in electrical systems, i.e. operator's safety against electrical current. Thus control circuits with 5V supply activate the related output. Then they identify connection status to AC or DC contactor by a relay or a transistor respectively. In this way electronic circuits, which are used for controlling system, can reduce the probability of appearing electrical injuries for operators for using low voltage DC.

In the other way, the electrical students in power field may be skillful in designing control contactor circuits, but have some problems in designing digital ones. The procedure which will be presented in this article may assist them in solving the problem.

### 3. The Study

In contactor circuits, control circuit includes the contacts that can identify the connection or disconnection status in special circumstances. These contacts can be normally open (N.O) or normally close (N.C). The N.O contacts are closed while the related device operates and they are opened when the device

doesn't operate. But N.C contacts are reversed. A device can be a contactor or even a push-button.

To design an equivalent digital circuit of a contactor control circuit, making the contacts and connections between them (series or parallel) equivalent as logic gates is necessary.

Equivalent of a close contact in a contactor control circuit is a NOT gate in the related device's route. For example, the close contact of device C1 can be shown as Figure 1. It is obvious that the output of this circuit like a closed contact is active when C1 is inactive.

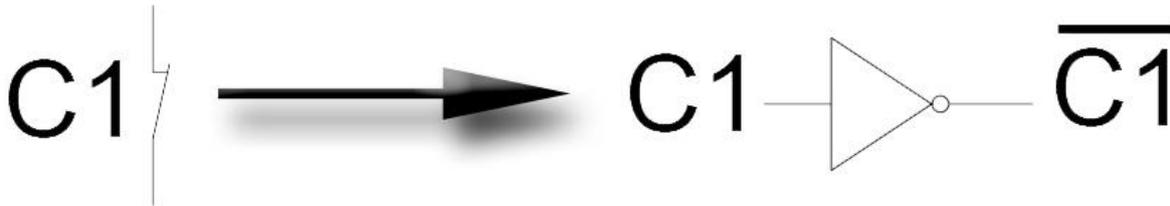


Figure1: The equivalence of close contact

It is clear that the equivalence of open contact C1, is C1, which activates just when C1 is active.

To activate the output, all of the series contacts should be active. So to design the equivalent digital circuit of a contactor control circuit, series elements are connected through AND gate (Figure 2).

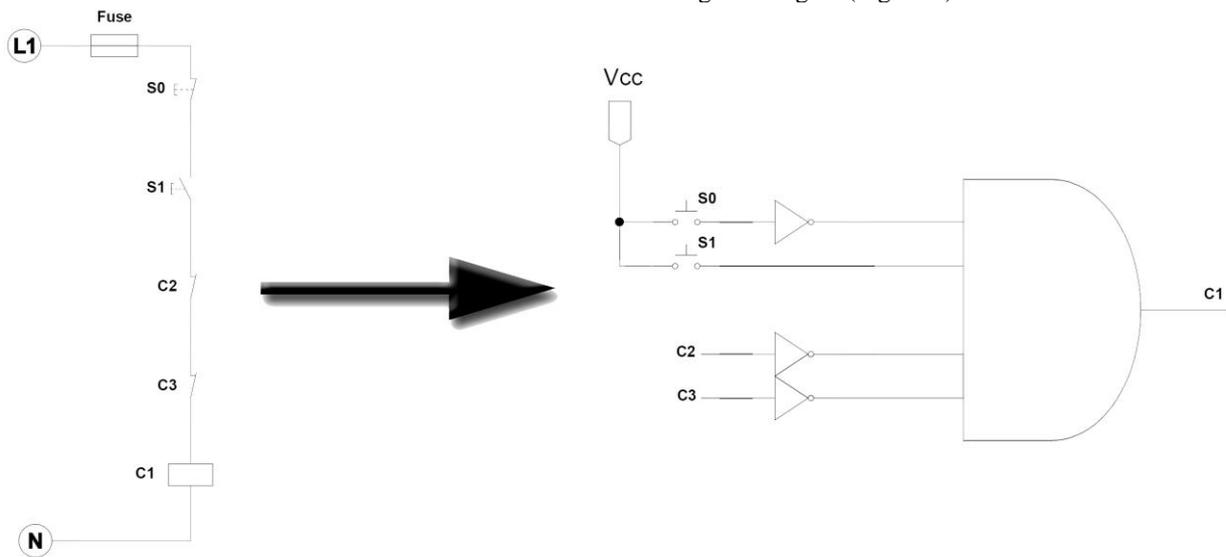
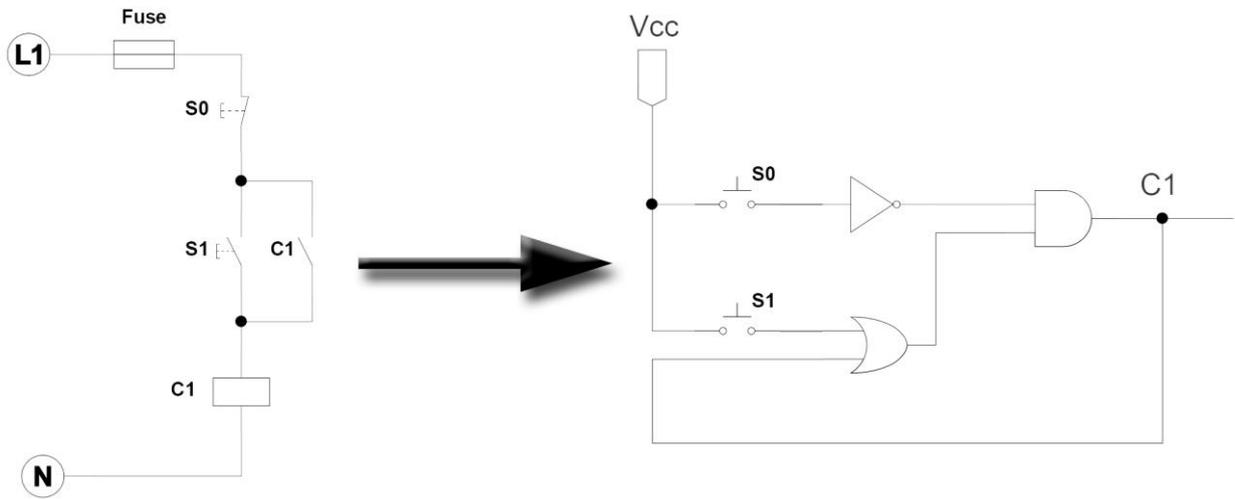


Figure2: Digital equivalence of series circuit

Also to close the current route and to activate the output, at least one of the parallel contacts should be

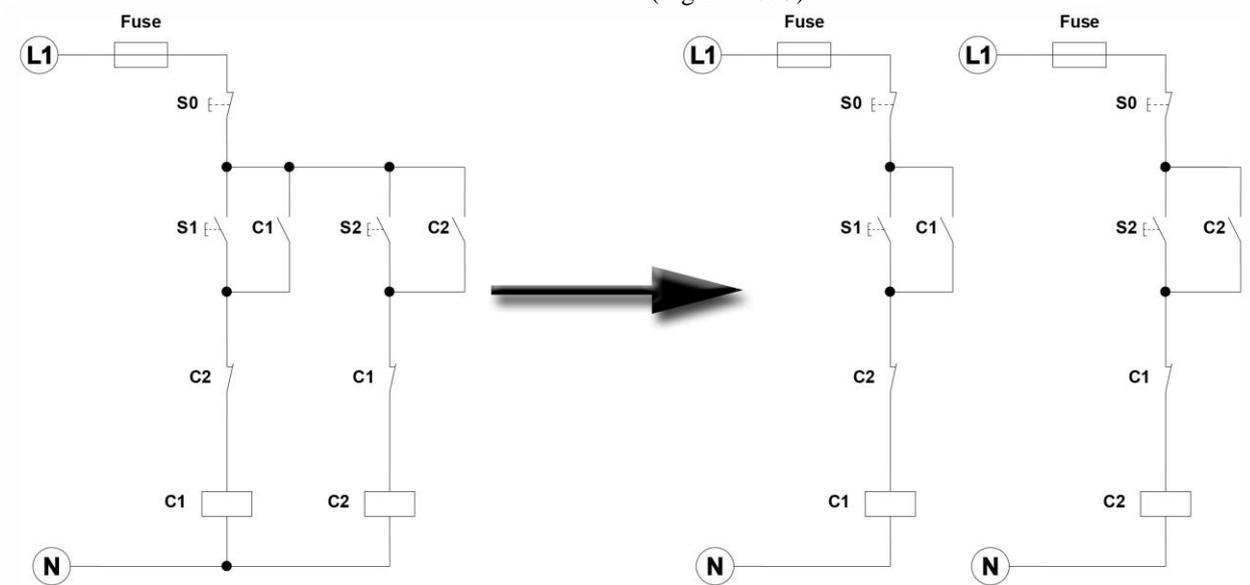
activated. So, parallel elements are connected through OR gate (Figure 3)



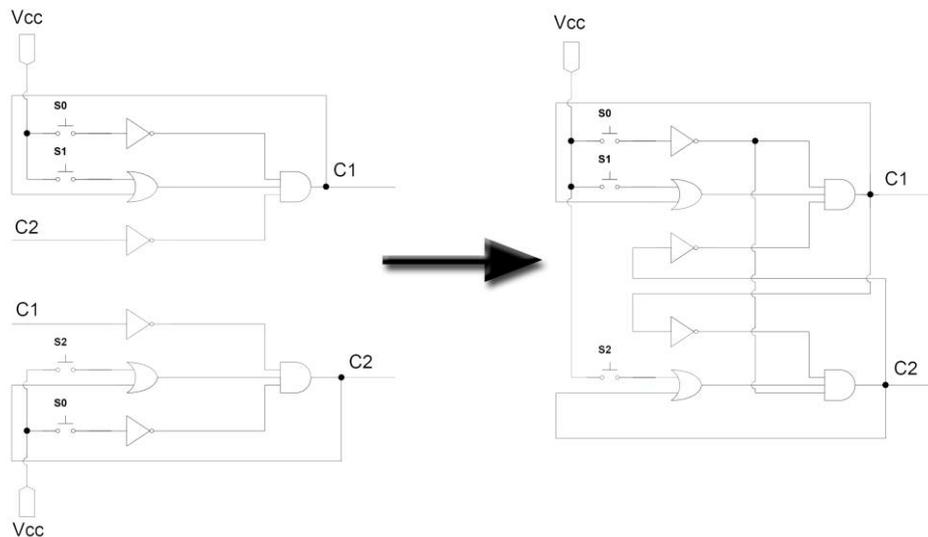
**Figure3:** Digital equivalence of series-parallel circuit

If a NOT gate is placed in the output of an OR gate, we can use a NOR logic gate instead of the collection of OR and NOT gates. Also, if a NOT gate is placed in the output of an AND gate, we can utilize a NAND gate instead of the collection of AND and NOT gates.

For circuits with multi-outputs, the circuit should be turned into multi-circuits with one output. Then the equivalent digital circuit for each one will be designed separately. It means that the common part of the original circuit (S0 in Figure 4) should exist in all of the sub-circuits (Figure 4 & 5).



**Figure4:** Turning a circuit with multi-outputs into multi-circuits with one output



**Figure5:** The equivalent digital circuit of Figure 4

In electro-magnetic contactors, after coil's function, N.C contacts are opened firstly. Some minutes later, N.O contacts will be closed. This feature of contactors is beneficial in different circuits. In fact, the circuit may not function well without this feature. Since NOT gate output changes while input varies, it should be noted that just the circuits in which the delay between connection of closed contacts and disconnection of open contacts doesn't have any effect on circuit's function can be made equivalent by logic gates.

#### 4. Conclusion

Those are large assemblies of logic gates which make digital electronic circuits. Utilizing digital circuits are widespread recently because a digital circuit in spite of an analog circuit can transmit digital signals without degradation due to noise [10]. So designing digital circuits is highly significant nowadays.

In the other hand, the most important programming language which is common in all PLCs is LAD. In fact, this program is a contactor circuit which is implemented in a ladder. In this paper a procedure was presented to design digital control circuit, based on control contactor circuit that can be useful for PLC users in designing digital circuits. In this method, N.O and N.C contacts of contactor and series and parallel connections between them were made equivalent by logical gates.

The stages of designing digital circuit are:

Firstly, a single circuit with multi-outputs turned into multi-circuits with single output. Then the following steps were done for each of the sub-circuits:

- 1) N.C contacts were made equivalent by NOT logical gate.
- 2) Parallel elements were connected through OR gate.
- 3) Series elements were connected through AND gate.

Then the input of each circuit were connected to their homonymous outputs in the other circuits.

Using XOR and XNOR logic gates will reduce the complexity of the circuit and assist in better understanding of it. Therefore, it is suggested to study on making equivalents for XOR and XNOR logic gates.

It is predicted that this procedure can be an appropriate solution for designing complicated digital

circuits by power circuits' designers. Changing the logic of performance in control contactor and digital circuits requires changing the prepared hardware. It is expected to do new studies on converting these circuits to the programs in C, C++, etc. programming languages to make replacing digital and contactor circuits with microcontroller-based circuits possible. Since changing the performance of logic of circuits is possible just by changing the program in microcontroller circuits, this leads to reducing expenses of system changing or probable system developing in the future.

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