

Digital Monitoring Circuit for Controlling A Limit Based Parameter Value

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ABSTRACT

Industrial Revolution 4.0 relates to many digital devices, machines or applications that integrates with internet and needs to be controlled on one or two of its parameter values regarding the importance of output in order to function correctly. Those parameter values have standard limitation and essential automation procedures should be taken for keeping the good operation of devices, machines or system. Controlling a limit based parameter is difficult if done manually and needs full concentration. Digital monitoring circuit would be very helpful for doing that controlling with the support of digital technology development nowadays. The usage of monitoring circuit currently applied in many fields especially for monitoring the condition of a patient in a hospital bed. Regarding health management and digitalization, digital monitoring circuit becomes very important and needs continued improvement.

Based on the problem above, this paper is conducted a research to design a digital monitoring circuit for the purpose of controlling a limit based parameter value for patient medication. The research methodology contains literature study, analysis and logic simulation. The outcome derives a reliable digital logic circuit that could be implemented into a real digital circuit or Integrated Circuit (IC) components to help people controlling the condition of a patient based on limit parameter value and support medical industries to improve their devices, machines or system performance to work more accurately and give out best medical services.

Keywords: Logic Circuit; Digital Electronics; Parameter Control; Medical Tool; Medication.

1 INTRODUCTION

Currently Indonesia is facing the era of Industrial Revolution 4.0 or we called it Revolusi Industri 4.0. This era applies automation concept for machines that do not required man power in their applications. Today industrial evolution continues the previous Industrial Revolution 3.0 that becomes startup for a digital revolution by combining innovations and creativities in Electronics and Information Technology field. Automation and Digital are parts of the essential concepts in Industrial Revolution and are putted as an important role for controlling and organizing the works of a device or a machine or an application to meet the operational tasks. Automation sometimes deals with one or few parameters which are needed to be measured from their limitation. These kinds of value mainly have a limit value that considered important to be set up for alarm and better performance. Not every device or machine or application has limit based parameter value and should be controlled,

but surely there are some of them that truly need a control handling to notice the limit and get the right procedure for improvement.

The examples of device or machine or system that have a limit based parameter value e.g. patient monitor, chemical substance production, data traffic, voltage or current measure, and etc. Based on the importance reason of automation and supported by digital technology improvement and development, in this research author learned how to design a digital monitoring circuit for controlling a limit based parameter. Author designed and derived a principle common logic circuit that could be applied with any sensor although it might need an analog-digital converter for the input.

This research came from the problem discussed in University of Michigan. It talks about how to design a sequential circuit for monitoring the condition of a patient in a hospital bed [5]. This Problem then was brought into digital system classroom and determined the solution by author so students can learn more about the course, know exactly how the combinational and sequential circuits work and how they can be implemented or integrated as one to build a logic circuit.

Learning from the basic concept of digital system and doing proper analysis, author managed to derive a digital logic circuit for that patient monitor problem and reflected a digital monitoring circuit that logically can be designed and applied commonly and putted into fabrication by electronics factory or electronics industry.

2 Research Methodology

For this research, author conducted three procedures: literature study, analysis and logic simulation. The output concludes a design of digital monitoring circuit that can be used for controlling a limit based parameter value of a Patient Monitor. This logical design can be applied in the form of algorithm using microcontroller or other computer devices.

3 Literature Study

The digital monitoring circuit was designed using combinational and sequential circuits i.e. logic gates and flip-flops which are very familiar to students, scientists and circuit designers. It is easy to understand how the logics work. The future works of this research bring out the implementation of digital circuit into electronic component or digital IC or software algorithm. The future research can be done by electronics industry or university.

As been explained previously, the idea of this research came from a digital system problem discussed in course. The problem stated about designing a sequential circuit patient monitor, a circuit for monitoring the condition of a patient in a hospital bed as being described and explained in figure 1 [5].

This is an application problem that caught author attention to bring and solve it into classroom learning at the end of the digital system course. With this application and the solution given, students can understand the theory of combinational and sequential circuits more easily and improve their point of views.

Design a sequential circuit that monitors the condition of a patient in a hospital bed. The input to the circuit is a binary number n that ranges from in value from 1 to 7 and indicates the patient's condition. The expected value of n is 3, but values of 3 and 4 are not considered abnormal. A new value of n is sent to the monitor automatically every 5 seconds. If n goes below 2 or above 4, the monitor should activate an alarm at a nurse's station. The nurse responds by administering medication to the patient and resetting the monitor. Construct a suitable state table and corresponding circuit.

Figure 1. Problem or Question that Builds the Idea

From this patient monitor problem, author tried to learn and learn and did research to derive a solution, a digital monitoring circuit for controlling a limit based parameter value. So the digital logic circuit does not only can be used for patient monitor, but it also can be used for other applications that need controlling on their parameter value.

The research studied about combinational and sequential circuits that were related to logic components such as logic gates and flip-flops.

3.1 Logic Gate

Logic gate is the fundamental logic component that builds digital technology. The basic concept started from binary number that only has logic 0 and logic 1.

These simple logic creates the logical thinking for computers or digital devices so they can think and work structurely with the help of program instructions. There are 8 (eight) logic gate components: NOT gate, BUFFER gate, AND gate, NAND gate, OR gate, NOR gate, XOR gate and XNOR gate. These gates works logically according to their logic truth table [1-4].

3.2 Flip-Flop

Flip-Flop is a basic component of combinational logic circuit and sequential logic circuit, mostly used to build a counter or register circuit. The design for flip-flop comes from logic gate circuits. D Flip-Flop is one of the main flip-flops that normally functions as a latch. It has an input and two outputs [1-4].

3.3 Register

Register is a type of sequential circuit mainly for storing information. There are three common types of register, right shift register, left shift register and parallel register. Shift register is built from a group of flip-flops, usually D-FF, connected in a loop so that the output from one flip-flop becomes the input of the next flip-flop, and so on [3,9]. The input is serial and shifted from the left side to the right side or from the right side to the left side. A right shift register is shown in figure 8. All flip-flop components are driven by a common clock, and they are set or reset simultaneously. Parallel register has similar logical task except it is in parallel connection.

3.4 Counter

Counter is another type of sequential circuit mainly for counting binary data or information. There are two common types of counter: synchronous and asynchronous counter. Synchronous counter would be selected if we need a common clock that triggers the flip-flop output simultaneously, while asynchronous counter would fit best if in design we need asynchronous source of clock for each flip-flops.

Asynchronous Counter is a sequential logic circuit function which all the inputs of flip-flop components are connected together to logic 1 (standard high dc voltage). The first clock is connected to a clock source, while the other clocks need to be connected to output Q from previous flip-flop. The number of bit depends on number of flip-flop being used. For example, to have a design of output values in 4-bit length we use 4 (four) flip-flops [6-8,10].

4 Analysis and Observation

4.1 Analysis

Based on the previous background, author conducted analysis to derive the block diagram of digital monitoring circuit. According to the standard design procedure for logic circuit, digital monitoring circuit have three parts: input, process and output [3].

Both input and output are digital information, so whatever comes to input should be in binary value and the output also will be in binary and if necessary can be converted into analog value.

The input which is expected to go inside the digital monitoring circuit is a parameter value. If we use analog sensor, we need to change the analog value into digital value using Analog to Digital Converter (ADC). In process, this binary information from input will be stored in register and stays there until a specific timing and will be retrieved for output processing. The length of input depends on the sensor specification and digital monitoring circuit standard fabrication, for example 8-bit or 16-bit. Each string of bits is relate to a specific value. The logical block diagram is derived in figure 2.

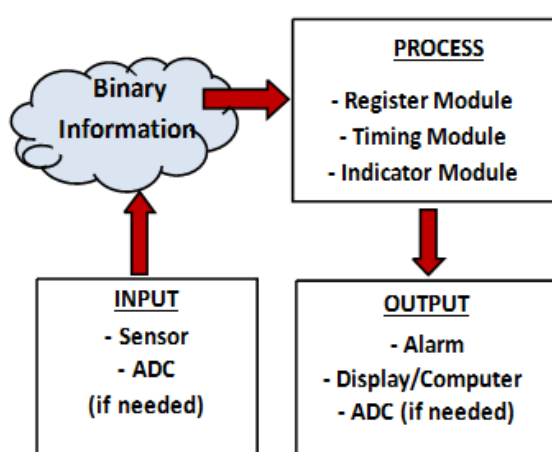


Figure 2. Logical Block Diagram of Monitoring Circuit

4.1.1 Register Module

For analysis, author used 3-bit binary information as input, named ABC and a parallel register module as described in figure 3.

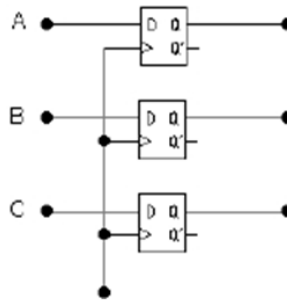


Figure 3. Parallel Register Circuit from D-FFs

When the binary inputs are detected from a sensor, they will reach the register input and stored in it until the clock being triggered for retrieving the data output and displaying into monitor.

4.1.2 Timing Module

The next module is the timing circuit. This circuit sets the time for controlling a limit based parameter value. This circuit will trigger the register's clock then drive all the inputs into outputs. It could be built from counter circuit (JK-FFs) or used IC that accommodate the source of clock for timing.

For analysis, author used a 3-bit asynchronous counter circuit as given in figure 4. This counter counts up from 0 to 7 as explained in table 1.

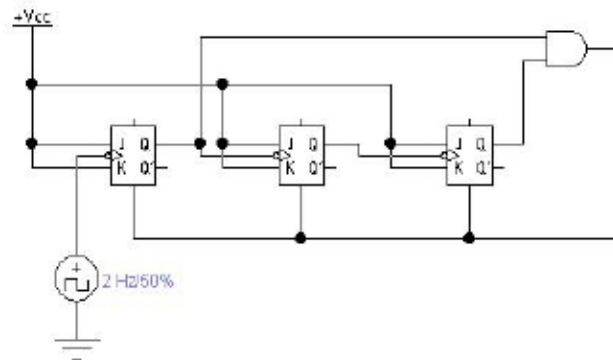


Figure 4. a 3-bit Asynchronous Counter

Suppose we need a system to automatically check the machine's limit based parameter value every 2 minutes. Timing circuit should be designed appropriately to meet the controlling time requirement by given a logic signal to trigger register's clock every 2 minutes. If more time is needed, modify the frequency or program instructions.

Table 1. Truth Table of a 3-bit Asynchronous Counter

OUTPUTS		
Q	Q	Q
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

4.1.3 Indicator Module

The third module is the indicator circuit that will be connected with the output monitor. For analysis, author used combinational circuit built from logic gates as shown in figure 5.

Using truth table, an indicator circuit was designed in relation to a parameter value. If the output reach the limit value then a notification will be given to the output monitor. The output monitor can be performed as an alarm, digital display or feedback to the system or device.

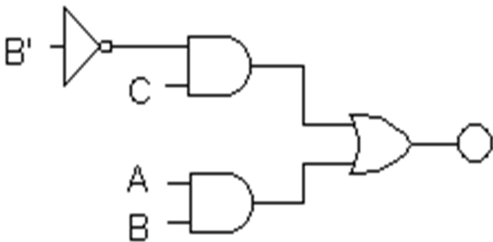


Figure 5. Indicator Circuit

Table 2. Truth Table of an Indicator Alarm

A	B	C	
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

From the given logic truth table in table 3, it is clearly stated that the indicator circuit is related to parameter value: 1,5,6 and 7. This logic combinational design shall be different for different limit based parameter values.

4.2 Simulation and Observation

For simulation, the three modules were combined and connected together to represent the digital monitoring circuit which functions as a controller for checking a limit based parameter value. In this research author used software Electronics Workbench 5.12 to stimulate and check the output and performance of the circuit design.

The register's output was connected to the input of indicator circuit while the output of counter was connected to register's clock as shown in figure 6.

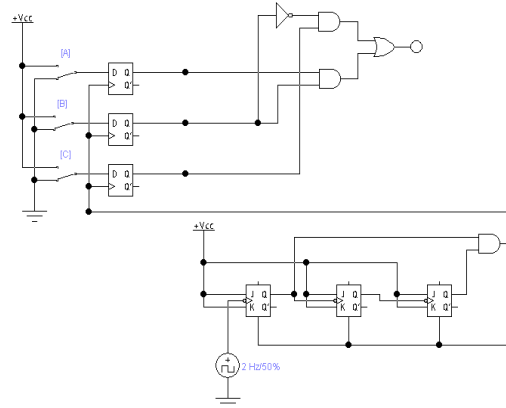


Figure 6. Digital Monitoring Circuit Schematic Diagram

When the digital monitoring circuit was activated, it would be in initial condition. The sensor input detected value 3 that is considered normal (had not reach the limit) but the output still in initial condition (value 0) because the timing circuit had not triggered the clock yet. When the timing circuit triggered the clock, it would be the time for sending data from register input to the register output or time for changing or updating the output of register. The indicator showed value 3, similar to the input value.

The indicator circuit indicates normal condition (in this simulation, the indicator was a probe that lighted on if the parameter value reached the limit) as given in figure 7.

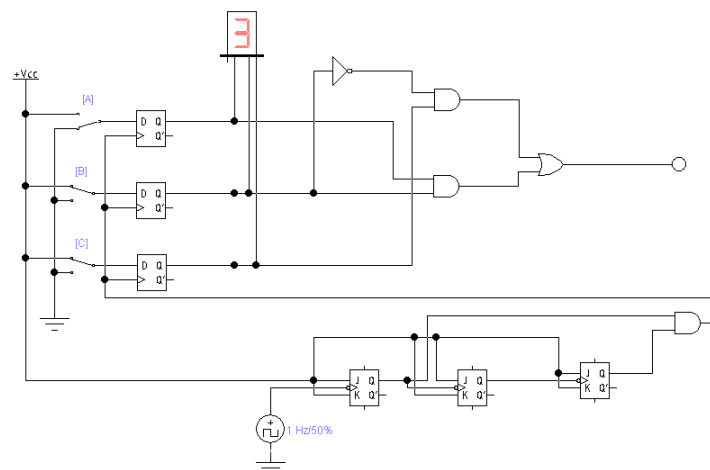


Figure 7. Data being Transferred to Register Output and shows Normal Condition

When the condition of limit based parameter value was changed because of any circumstance and special unknown factors, the digital monitoring circuit would detect again the input and wait for the timing circuit to re-trigger and support a new data transfer.

When the timing circuit sent signal to input clock, a new data were transferred to the register's output and new output will be displayed and checked by indicator circuit. For example, value 7 was considered the limit value, hence the circuit showed red signal as given in figure 8 that indicated the device, machine or system is out of its good performance. When indicator gave this limit sign, the device, machine or system can be resetted or inputted to other devices which then return as a feedback for troubleshooting and correction.

The automation controlling worked automatically everytime the timing circuit sent signal to register clock.

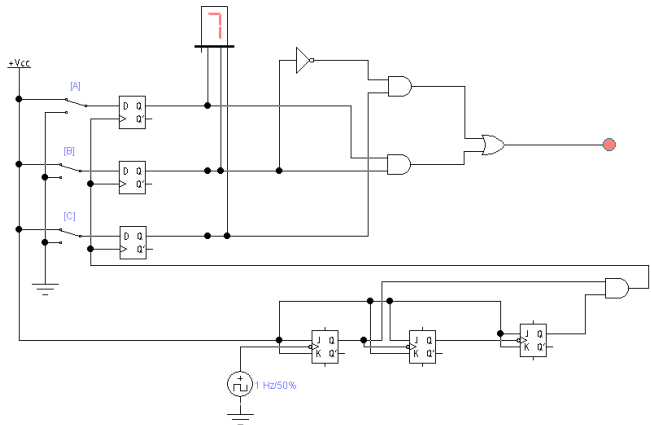


Figure 8. New Data being Transferred to Register Output and shows Out of Normal Condition

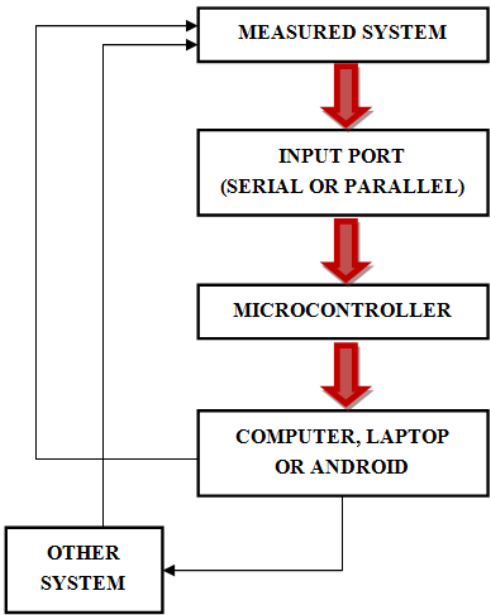


Figure 9. Logical Block Diagram of Monitoring Circuit using Microcontroller

The logic design of digital monitoring circuit shown in figure 9 becomes the fundamental knowledge of designing a more complex monitoring circuit that can solve human problems in controlling a limit based parameter value. Many advantages could be reached with this basic knowledge of design including the implementation of Internet of Things (IoT) for human life in the next generation era and creating better environment.

Microcontroller and electronic component fabrication will make the logical circuit development easier and reliable to be implemented.

The n-bit data input will need a microcontroller that support an n-parallel register. The sensor shall be connected to the input port, could be serial or parallel according to specification and available converter. The output from microcontroller is connected to a computer, laptop, android or other digital device for indicator and monitoring. Those system's user equipment analysis the data value and will return an operation or instruction to the measured system with or without other system assistance.

5 Conclusion

The research derived a basic concept of digital monitoring circuit logical design that can be used for controlling a limit based parameter value. It has three important modules: register module, timing module and indicator module. Specification of sensor and output monitor will affect the number of components in each module but would not too baffle to damage the whole design.

The digital monitoring circuit was flexible in design and can be embedded into digital IC components or applied in Microcontroller programming. It could be produced in a simple to complex design according to consumer's need.

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