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Smart Programmable Timer

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Abstract: **The Electronic Industrial Timers are used in the industries to control the process/operation with specified time interval of repetitive nature. They find applications in the control of sequential functions of industrial machinery at varying time intervals for plastic industries, pharmaceutical industries, petro-chemical industries, steel industries, power plants etc. Electronic timers are manufactured today to meet the complex function of Industries but these timers are available in limited operating modes that may be 8/16/20 maximum and hence if your application does not fit in that operating modes then you have to give order for customizing the timer. So this paper gives you a universal solution where you can build any mode as per your requirement that to very easily.**

Keywords: **Timers, Operating modes, Signal sensing, Timing accuracy, EMI protection.**

I. INTRODUCTION

A timer is a specialized type of clock for measuring time intervals and performing action according to condition. The electronic timer is a device which has driving circuit and a digital display system with a facility depends on the application for connecting the output to individual machinery/system to control the operation at predetermined time interval. Simple timers with an on/off arrangement to sophisticated electronic timers are manufactured today to meet the specification of the industry. Timers [5] may be free-standing or incorporated into appliances and machines. Their operating mechanism may be mechanical (typically clockwork), electromechanical, or purely electronic/digital (counting cycles of an electronic oscillator). Timing functionality can be provided by software in digital timer. Mechanical timers use mechanical clockwork to measure time elapsed. Manual timers are typically set by turning a dial to the time interval desired; turning the dial stores energy in a mainspring to run the mechanism. A very basic mechanical timer is shown in fig 1. This kind of timer do support only single mode and were used only in early days. Now a day's electronic timers are available in market which supports 8/16/20 operating modes.

Figure 1 Typical Mechanical Timer

The problem with these timers is that you cannot build your own mode for your application. For example suppose a timer supports a mode which is called signal On delay [2]. In signal On delay mode ,time commences as supply (U) is present. When input signal is removed, the timing is stopped. The output(R) is switched ON at the end of the preset time duration (T). When output is ON if signal is removed the output is switched OFF. The timing diagram of signal On delay is shown in fig. 2, where U represent power supply, S represent external signal and R represents output. Now suppose in the below mode you want the timing should pause when signal is removed instead of returning to zero then it's not possible with the existing timers.

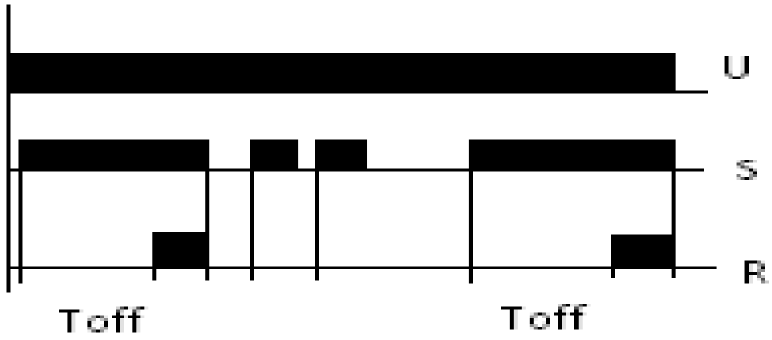

Figure 2 Timing diagram of Signal On delay

The solution to the problem is to order a customized timer but that is not possible for every Industries. So this paper focuses on the design of Universal timer for Industrial applications.

II. OVERALL DESIGN OF UNIVERSAL TIMER

Before going through the concept of universal timer we will see the requirements of industrial timer. The industrial timer should have following properties:-

a) Accurate in time

b) Robust

c) Multifunction (i.e. operating modes)

d) Noise immunity should be very high (EMI/EMC related)

e) Easy to use and cheap

Each electronic industrial timer represents a custom implementation. It contains different subsystems connected in a unique way, has a unique hardware schematics and software structure. This means that each control system requires hardware and software design, highly qualified and expensive work. A universal hardware and software platform can lead to lower costs of such a system [UNI IEEE paper].

A. Overall Software flow of Universal timer

In electronic timer, the operating modes completely depend on software structure inside the controller. In the development process of electronic timer, hardware and software aspects require most of available resources (accurate time and highly qualified workforce) - EMI hardware design (immunity to perturbations) of printed circuit board and cabling and firmware (software running on microcontroller) design. The firmware of electronic timer is divided mainly into two modes such as default and custom modes.

1. Default mode

The concept of universal timer is to fulfill the application by building your mode but if your application fulfills in existing modes so you don't need to go for customized mode. So the universal electronic timer has a provision where if your application is existing in the default modes then just select the respective number and run the profile. For example a timer manufacturer has numbered the operating modes as follows, then by selecting 00 the timer will work in on delay mode in this mode output gets ON after the preset time.

Mode number	Operating mode
00	Off Delay mode
01	Cyclic On/Off
02	Cyclic Off/On
03	Signal On delay

Table. 1 Mode description

Now existing timer you need to do configuration setting in which select number of output one or two, select default mode and enter the operating mode number , then choose up counting or down counting and run your profile.

2. Customized mode

As shown in fig 2 in signal On delay mode it was not possible to pause the timing if the signal is removed the solution the solution to such problem is discussed in this section. This part of paper concentrates on the enhanced version of electronic timer where you have the right to build the mode of timer if it does not exist in the default modes. The below section emphasis on universal solution for customizing the timer according to user application. The controller will be interfaced with keys where you can either select default mode or build the customized mode. The flow of timer is divided into two sections, power On based and signal based. Power On based timers output totally depends on the power supply of timer unit whereas in signal based output depends on external signal, here the hardware should be such that its able to sense both AC and DC signal. The signal input from an proximity sensor is an example of external signal. The step wise execution of power based and signal based is as follows:-

-Select custom mode.

-Then select whether you want your output to be dependent on power supply or any external signal.

1. Only power based (Without any external signal)

As shown in flowchart fig. 4 below power On based timer has following procedure to build a custom mode.

- Output status when power comes On or Off
- If On then continue/time
- If Off then continue/time
- Load time for opposite action and select whether you want to repeat the cycle.

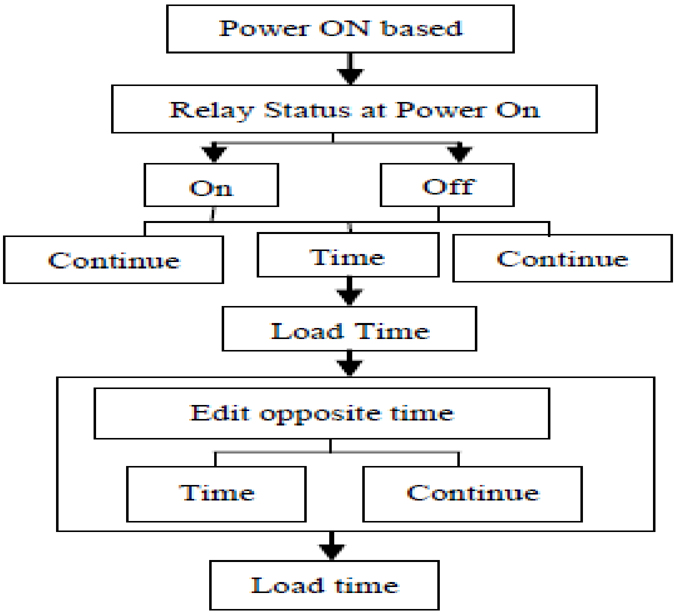

Figure 4 Flowchart for Power On based

2. Signal based

Whenever your application is dependent on any external signal and this mode is not available in default modes then you need to build your own custom mode follow the following steps to build any mode.

The proposed universal timer signal based is as follows,

1) Select output status when signal comes On or Off.
2) Select whether you want to action on signal present or signal absent.
3) Now select the action i.e. whether On or Off or On-Off or Off-On.
4) Select time or continue and load time if applicable.
5) Consider the action during timing, either ignore signal change or take action on signal absent (SA) or signal present (SP).
6) Action after time over can be No (no action) or relay Off or reload the time or a new time.
8) If new time and reload then same as step 5 of signal based.
9) Select whether you want to repeat signal sensing or not.

Above is all possible condition and just by using keys you can program it. It's also possible through a GUI which will make the timer remotely accessible just select steps and build your own mode and fulfill your application through remote location. Here by following steps it's possible to pause the timing in Signal On delay mode which is not possible with default mode.

B. Hardware overview

Industrial processes require rigorous monitoring and control of many parameters. The control systems for such processes must be accurate, fast in response, reliable and also inexpensive. Digital control systems offer comparable performance with analog counterparts but are more flexible in communication and data processing issue and, most important, have lower costs.

A decrease in development costs can be achieved only using a universal hardware and software platform, adapted to specific issues of controlled process. So the hardware solution for such an electronic timer is main control circuit may consist of seven segment display, keys (up, down, enter, escape), signal sensing circuit, output i.e. relay or SSR, serial support for downloading the code via GUI and a driving circuit for relay. As the universal timer will be used in industries these timers should be very much robust and hardware should pass all EMI/EMC related tests [3].Seven segment displays are used in this kind of electronic timer mainly because of its intensity so that it can be viewed from a distance and its cost is also less. A 16 bit microcontroller is used with which seven segment displays, keys and signal sensing circuit is interfaced is shown in fig.5. To avoid interface problems like voltage spikes generated due to switching in industrial environments MOV (Metal Oxide Varistor) is used. A varistor (MOV) is an electronic component with a "diode-like" nonlinear current–voltage characteristic. Varistors are often used to protect circuits against excessive transient voltages by incorporating them into the circuit in such a way that, when triggered, they will shunt the current created by the high voltage away from sensitive components.

The block diagram for the electronic timer is as below,

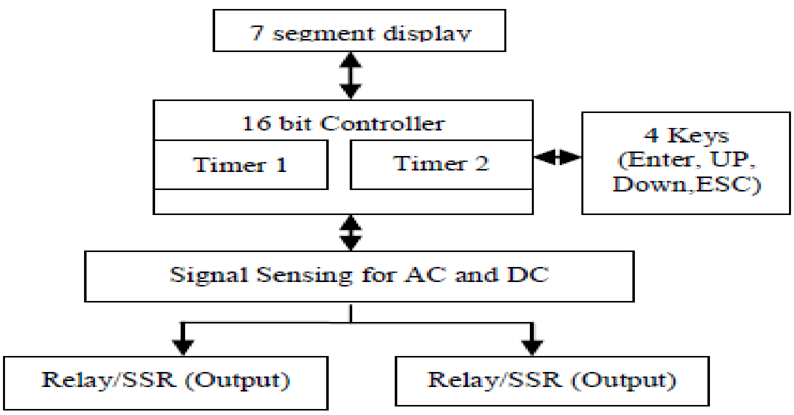

Fig. 4 Block diagram of Universal timer

C. Timing Accuracy

Timers play a very vital role for automation in industry this is because of their timing accuracy; if the designed timer is in accurate then it's of no use. The accuracy of the electronic timer depends on crystal connected to controller or the internal crystal frequency. For instance if we consider Crystal frequency 4 MHz and 40 ppm frequency then the time accuracy calculation is given as below,

Actual frequency= 4000000(Hz)

40 ppm frequency = 4000000-40

= 3999960

Actual frequency per day =4000000*3600*24

= 345600000000

40 ppm error frequency per day = 3999960*3600*24

= 345596544000

Error frequency per day = 345600000000– 345596544000

= 3456000 Hz/per day

Error in time = 3456000/1000000 =3.456sec

So this is the error for above condition and it's very lower than the 0.01% within a day.

III. CONCLUSION

The proposed design approach gives the freedom to build their own mode if needed, so this universal timer has wide range of scope in small scale industries where they cannot go for customizing their application.

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