MICROCONTROLLER FOR SMART PROCESS CONTROL SYSTEM

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Abstract: Present article deals with selection and study of microcontroller required for the construction of smart process control system. Construction of process control system requires parts like data convertor, sensors, relay and microcontroller. They are used as signal and data convertors, switch, data manipulation and analysis devices. In addition to the above essential parts, if the device for data communication is included then that improves the performance of process control system. In the present work, we have focussed on the modern low cost microcontroller which includes many of above parts like data conversion, data manipulation and communication. It is easy to include some intelligence by use of such microcontroller, so that the system is smart enough to improve its parameters and performs self diagnosis. Furthermore, the short range wireless communication using Bluetooth allows wireless control of process parameters. Present study is helpful to the beginners working in the field of smart instrumentation and process control.

Index Term: **Microcontroller, Bluetooth, process control.**

I. INTRODUCTION

Process is a term used in some industries where the work or task for making some product is carried out in sequence of steps. Such steps are interrelated either in linear or loop path which are known as open and closed loop processes. To control the path of process is called a process control (PC).(Johnson 2015). Process control not only controls the path but also controls rate, quality and performance. Process control helps to minimize the manual involvement if it is automatic, which is not only cost effective but also helps in quality improvement. Process control has some benefits as well as limitations which are given in table 1.

Table 1: Benefits and limitations of process control system

Sr No	Benefits	Limitations
1	Maintains a comfortable indoor environment suitable for workers and the machinery	PC is not yet fully mature field and its main drawback is poor design
2	Safe human machine interaction.	PC is manufactured by one industry and installed in another industry and most of the time installation is not as per the designed system.
3	Allow more than one systems to operate cooperatively.	Some steps of the process have random response and difficult to include in PC.
4	System is operational only on demand. Self diagnosis and load management improves the life of machinery.	The electronic circuit of PC needs appropriate operating conditions like temperature, humidity, etc and they change with climatic condition
5	Provides feedback data for monitoring performance, benchmarking, energy efficiency, and planning or scheduling maintenance.	Operation and maintenance requires skilled workers.
6	Ensures the integration of entire system	PC requires basic infrastructure such as dust free rooms, clean water and load shedding free electricity.
7	Optimizes the use of available infrastructure and hence minimises the machinery cost.	PC requires many complex computers programs for proportional (P), integrating (I), derivative (D) and their combinations such as PI and PID.
8	The resources like electricity, water, etc are optimally used that reduces the expenses.	Measurement and control at set point as well as to optimize the system is a complex process.
9	Automatic system minimises the involvement of operators and reduces the production cost.	Difficulty in sensing process dynamics.

Process control is an application of electronics which needs to be upgraded continuously to improve benefits and reduce limitations. In the present article, we have discussed the one such electronic component i.e microcontroller for this purpose. The article is divided into following sections. Requirement of process control is discussed in section II. Suitable microcontroller for process control is discussed in section III. Finally, conclusions are presented in section IV.

II. Requirement Of Process Control

Control of process has three parts namely measurement, control and feedback. Measurement section includes measurement of either a physical or electrical parameters. The common physical parameters are temperature, light intensity, moisture, pressure, pH, conductivity and so on. There are only two electrical measurable parameters and they are voltage and current. The physical parameter needs to be converted into electrical by use of sensor which is either passive or active. For instance, light is converted into electrical parameter either by passive, photoconductive, LDR or active photovoltaic photodiode. A generalised block diagram of measurement system is shown in figure 1. Ones the physical parameter is converted into electrical then it is amplified, calibrated by the signal conditioning circuit. The result of measurement circuit is generally called a measured value which is the observable and it is compared with some constant i.e the set point required by the process. The main purpose of process control circuit is to compare set and measured values and if they are mismatched then it tries to match them by controlling the desired parameter of process. Following examples elaborate the function of process control system.

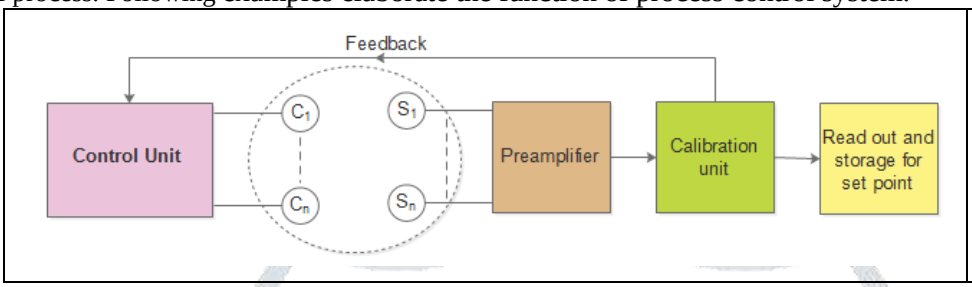

Figure 1: Block Diagram of measurement system

2.1 Light intensity control for calibration of photometer

Photometer is a simple device used for measurement of optical density (OD) of a medium. It is generally calibrated before its use at 0 and 1 OD, which is equivalent to 100% and 0% transmission of light respectively. This is a simple example of process control which includes only one process as shown in figure 2.

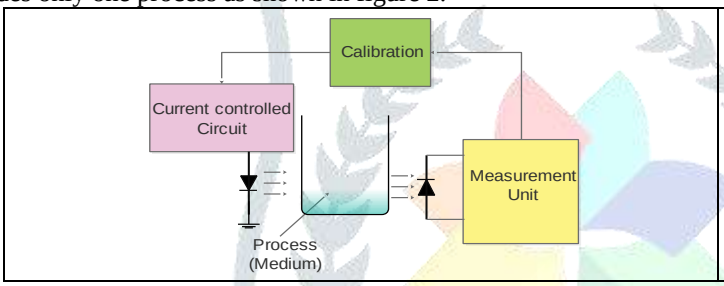

Figure 2: Block Diagram of Intensity Control of Photometer.

This simple photometer has one measurement unit and one control unit. Measurement is carried out by a light sensor like LDR or photodiode and control of light intensity is carried out by controlling the electric current passing through a light source such as filament bulb or light emitting diode. Here, the set points are 0 or 1 OD, if measured OD is not equal to the set value then the light intensity is adjusted by the feedback circuit constructed using operational amplifier, transistor or pulse width modulator. (Pule, et.al, 2017)

2.2 Control of pH in dairy industry

Dairy industry is an ideal example where the process control system can be successfully implemented. One of the important parameter of the process is pH at various stages of milk product processing, such as raw cow milk, intermediate stages, packed milk. In the dairy industry, pH is a critical parameter and process control system should maintain it in a narrow limit. For example, raw cow milk should have pH in a narrow range from 6.5 to 6.7. The quality of product is directly proportional to the width of limit. Figure 3 shows the block diagram of milk process control system. In milk product industry, pH is controlled at two three stages by changing the acidic level of milk.

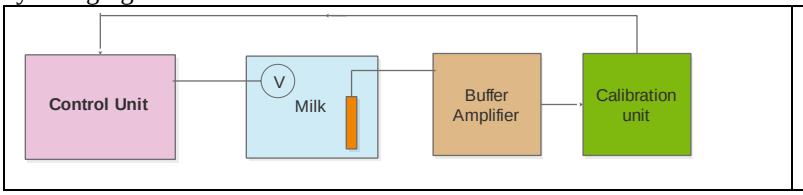

Figure 3: Block Diagram of Milk Process Control System

III. Role of Microcontroller In Smart Process Control System

Process control system is an electronic circuit constructed using components like sensor, operational amplifier, microcontroller, relay, motor, thyristor. Each of above component is essential part of PC system and even absence of a single component will not complete the system. Sensor is a state convertor i.e. it converts physical parameters into electrical signal. Sensor could be passive or active type depending on the type of physical parameters to be sensed. For example a photoconductive LDR is a passive sensor required for converting physical parameter light intensity into electrical signal. On the other hand glass electrode is an active sensor that converts ion concentration into electrical signal. The common physical parameters in process control are temperature,

pH, light intensity, moisture, etc and each of them requires different sensors. Figure 4a and b shows the passive and active sensors. Almost all the sensor produce week electrical signal that should be amplified, modified and calibrated into some measuring unit. The best possible electronic circuit for this work is operational amplifier which can be used for all above three purposes. Figure 4 c shows the basic operational amplifier circuit. Relay, thyristor and motor are part of control unit necessary for either On Off action or speed control of electric motor and valve. Figure 4d shows the basic use of this controlling devices.(Zabala et.al,2018) Sensor and relay are just like the input and output devices and there is a need of some unit which can control them. Microcontroller is one of such device which can be used not only as a control but also as a measuring unit.

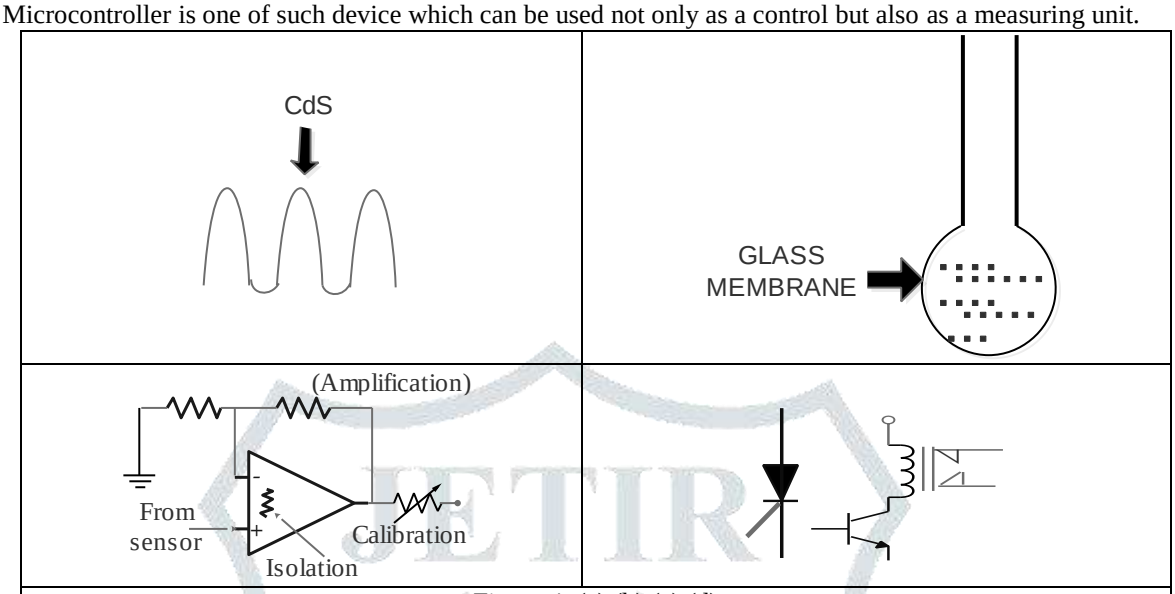

Figure 4: (a) (b) (c) (d)
(a)Passive sensor (b)Active sensor (c)Use of operational amplifier in process control (d)Electrically operated switch.

Advantages of using microcontroller are: makes system compact, automatic, low cost and reprogrammable. Selection of particular microcontroller depends on the type of PC system. If the system is very large then many microcontrollers are used in master/slave configuration, but for a small system. Microcontroller along with operational amplifier and relay can be used for following PC functions Proportional (P), Integrator (I) and Derivative (D) and their combinations. Figure 5a shows the microcontroller suitable for PC system. Figure 5b shows proportional control system.

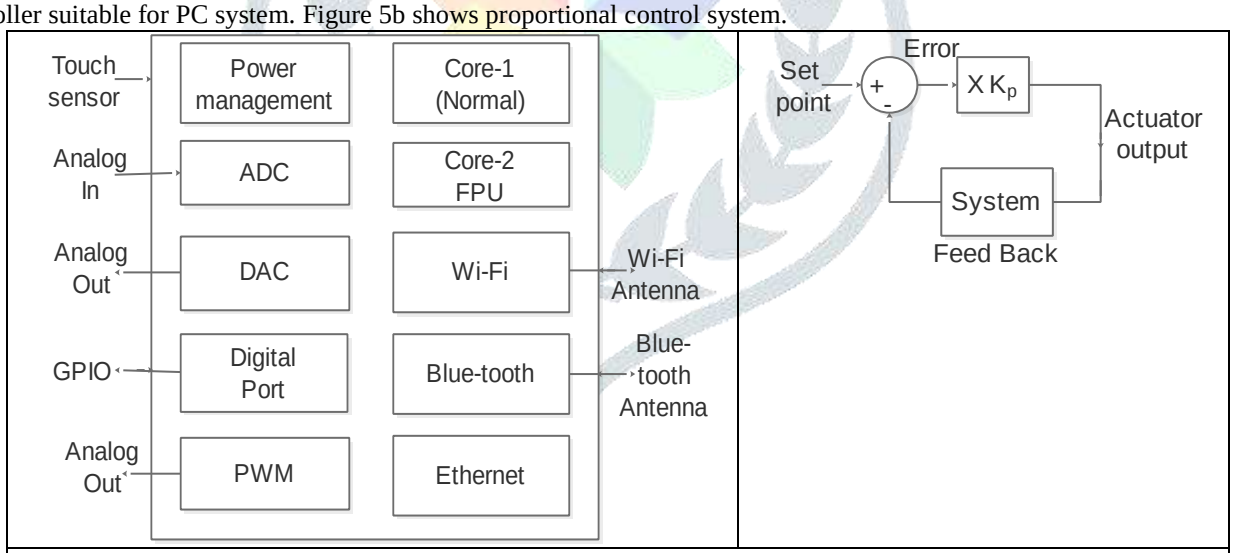

Figure 5: (a) (b)
(a)Block diagram of mixed RF signal microcontroller (b)Proportional control system

In recent days, PC system are significantly improved. Now they are more intelligent and can be included in the category of smart electronic devices like other devices such as smart phone and smart television. The smart devices are generally programmable and the programs take care of various activities that make that device smart and intelligent. A smart PC system has features like automation, sensing, machine learning and remote accessibility. There are many microcontrollers available in the market, manufactured by different industry like Microchip, Atmel and Analog Devices, and some of them can be used in PC system for satisfying the need of smartness. There are three types of microcontrollers namely digital, mixed signal and mixed RF signal. Digital microcontrollers are not suitable for PC, because of lack of analog data convertor. Most of the present day PC system use mixed signal i.e analog and digital signal handling microcontrollers.

In future the third type of microcontroller i.e mixed RF signal one will be suitable for PC systems. For example the microcontroller ESP32 manufactured by Shanghai based silicon chip manufacturing company Espressif seems to be promising

and suitable for PC system required for small scale industry. The general block diagram of ESP32 is shown in figure 5a. Its distinct feature is that it integrates the communication protocols like Bluetooth and wifi along with the other units of microcontroller. Some of its features and their contribution in the PC system are given in table 2.(Kolban,2017)

ESP 32 is recently launched in a market. Its main feature is inclusion of RF section on the same microcontroller chip. RF section includes RF oscillator, modulator, demodulator and antenna. At present it is one of the widely used microcontroller by the hobbyist and students of electronics. They have developed many domestic applications of it like home automation and robotics. In future, this microcontroller will have good scope in the industrial application such as process control.

Table 2: Important features of ESP32

Sr No	Feature	Contribution in PC	Advantage to PC
1	10 Touch sensor	User interface	Long life
2	Temperature sensors	Measurement of temperature	Precision measurement
3	Hall effect sensor	Measurement of magnetic field	Precision measurement
4	12bit ADC	Data convertor	Miniaturization
	Preamplifier	Signal conditioning	Low noise
5	8 bit DAC	Signal injection	Miniaturization
6	Dual core processor	Core-1 regular , core-2 floating point operation	More accuracy
	32 bit data bus	More data size	Less code size
7	Clock frequency 240 MHz	High speed computation	Faster decision in P, I and D
	600 DMIPS	More instruction per second	Faster computation
8	Slave controller	Master slave	Cooperative system
9	PWM	Speed control of motor	Miniaturization
10	SPI, I2C, UART, CAN	Wired communication	supports wired protocol
11	Wifi 802.11b/g/n	IOT	Wireless internet assisted system
12	Bluetooth v4.2 BR and BLE	PAN	Short range wireless system
13	ethernet	Internet	Wired internet assisted system
14	Power management	Power saving	Power saving in idle state

IV Conclusions And Future Scope

Modern microcontroller has many features such as high speed, floating point coprocessor, mixed signal processing, sensors and wireless communication. These types of microcontrollers make the process control system smart and intelligent. The main features of such system are longer life, self diagnosis, low power consumption, security, precise measurement and control, etc. Moreover, such system can be managed from remote place due to availability of wifi and Bluetooth protocols. Present study gives guidelines to the beginners and the students of electronics working in the field of industrial automation and process instrumentation.

There is a wide future scope in this field for improvement of process control system which includes optimisation of performance parameters, development of new software utilities, benchmarking, etc. The scope can be extended by use of wired and wireless communication protocols such as Ethernet and wifi that utilises various tools of IOT.

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