DESIGN AND DEVELOPMENT OF ANDON SYSTEM FOR MACHINING MACHINE AT FKP LAB

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Report submitted in partial fulfillment of the requirement
for the award of the degree of
Bachelor of Manufacturing Engineering

Faculty of Manufacturing Engineering
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

ABSTRACT

Andon system is a visual and audible response notification tool and widely used in manufacturing industry. From this concept, one project is conducted to develop an andon system to monitor the status of machine in Faculty of Manufacturing Engineering (FKP) laboratory. This system used indicator lights *(green, red and yellow color)* and the light was control by using wireless connection. The aims of this project is to design and develop an andon system for better visual management at FKP laboratory. There are three phases in this system. Phase I cover the design of the transmitter board and receiver board. Phase II is the programming installation into the PIC16F88 microcontroller. The programming are build using Proton IDE software. Phase III is the fabrication of the andon system. To validate the system, the light was observed and the results shows this system work efficiency. Green lights show the machine in operation condition, yellow lights for idle condition and red lights when then machine stop the operation. Efficiency test are conduct to evaluate the application's efficiency with the computing environment. hundred test has been run and the results show efficiency is in range of 90% to 100%. From the results it shows that this system run well and provide a consistent application and hardware environments to application developer. By implementing this system at FKP laboratory, it will help students to identify the condition of the machine.

ABSTRAK

Sisyem andon adalah alat pemberitahuan balas visual dan boleh didengar dan digunakan secara meluas dalam industri pembuatan. Dari konsep ini, satu projek telah dijalankan untuk membangunkan satu sistem andon untuk memantau status mesin di makmal Fakulti Kejuruteraan Pembuatan (FKP). Sistem ini akan menggunakan lampu penunjuk (warna hijau, merah dan kuning) dan cahaya itu dikawal dengan menggunakan sambungan tanpa wayar. Tujuan projek ini dijalankan adalah untuk mereka bentuk dan membangunkan sistem andon untuk pengurusan visual yang lebih baik di makmal FKP. Terdapat tiga fasa dalam sistem ini. Fasa I meliputi reka bentuk penghantar dan penerima. Fasa II adalah pemasangan pengaturcaraan ke dalam mikropengawal PIC16F88. Pengaturcaraan yang dibina ialah dengan menggunakan perisian Proton IDE. Fasa III adalah fabrikasi sistem andon itu. Untuk mengesahkan sistem, cahaya diperhatikan dan keputusan ini menunjukkan system bekerja secara efisyen. Lampu hijau menunjukkan mesin dalam keadaan operasi, lampu kuning untuk keadaan rehat dan lampu merah apabila kemudian mesin berhenti beroperasi. Ujian kecekapan adalah kelakuan untuk menilai kecekapan aplikasi dengan persekitaran pengkomputeran. Seratus ujian telah dijalankan dan keputusan menunjukkan kecekapan adalah dalam lingkungan 90% hingga 100%. Dari keputusan itu menunjukkan bahawa sistem ini berjalan dengan baik dan menyediakan aplikasi yang konsisten dan persekitaran perkakasan kepada pemaju aplikasi. Dengan melaksanakan sistem ini di makmal FKP, ia akan membantu para pelajar untuk mengenal pasti keadaan mesin tersebut.

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LED	Light Emitting Diode
PIC	Peripheral Interface Controller

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Andon is derived from the Japanese word for paper lantern. Liker (2004) has stated that andon is a term for a visual control system using an electric light board (or other signal device) hung in a factory, so that worker can call for help and stop the line. In a study on quantitative analysis of a transfer production line with andon (Jingshan Li & Dennis E. Blumenfeld, 2006), andon is originates from Toyota Production System and has been used in many Japanese and American manufacturing plants as an effective approach to improve product quality The idea of andon is that worker can pull the so-called andon cord, triggering the light and/or music as a call for help and stopping the line when a defect is discovered. It has been claimed that, although productivity is lost due to line stoppages, the overall system performance improves (Liker, 2004).

The alert can be activated manually by a worker using either pullcord or button, or it can also be activated automatically by the production equipment itself. The system may include means to stop production so the issue can be corrected.

Some modern alert systems incorporate audio alarms, text, or other display. For this design, buttons will be used as the indicator to activate the lights.

Derick Bailey (2008) has stated that an andon system is one of the principal elements of the Jidoka quality-control method pioneered by Toyota as part of the Toyota Production System and therefore now part of the Lean approach. It gives the worker the ability, and the empowerment, to stop production when a defect is found, and immediately call for assistance. Common reasons for manual activation of andon are part shortage, defect created or found, tool malfunction, or the existence of a safety problem. Work will be stopped until a solution has been found. The alerts may be logged to a database so that they can be studied as part of a continuous-improvement program.

As Jingshan & Dennis E. Blumenfeld (2006) carried their study, the current literature on andon contains many popular articles that provides qualitative and quantitative analysis on how andon system improves product quality and quantity. By implementing andon, problems are not hidden anymore, but it can be detected and also can be fixed so that good quality can be achieved the first time. The system typically indicates where the alert was generated, and may also provide a description of the trouble.

Modern andon systems can include text, graphics, or audio elements. Audio alerts may be done with coded tones, music with different tunes corresponding to the various alerts, or pre-recorded verbal messages. The most common type of andon system is the three-light tower. Three colored lights (red, yellow, and green) are mounted on a pole by a work station with a switch to allow the operator to quickly change the status if anything goes wrong. The typical andon light color-coding schema is red = stop and green = go (or running). Yellow may stand for not running at rate, ‘need help’, or something similar.

These andon lights can also be mounted to machines or equipment and automatically change color based on a signal from the machine. These are especially handy when the machines are running with no operator.

Another more complex version of the andon light is the andon board. This is where several indicators are mounted on the same board to centrally locate the visual system. These are common in lean factories that have multiple production lines. This allows anyone to look at a glance how the plant is running and its current status.

A pull cord is another style of andon. If an operator is having difficulties or wants to signal management that there is a problem, they pull the andon cord (Liker, 2004). This is just like pulling the cord on a city bus to signal to the driver that you want to get off at the next stop or in a hospital room where there is a cord to pull if you need the nurse.

Even audible signals can be thought of as a type of andon. An alarm, bell or buzzer gets attention when something is wrong or is trying to warn you about a situation. In the old days, at department stores the chimes heard overhead were actually signals to floor managers to contact the office. The number of chimes, the sequence or sound was designated to different managers. This way a manager could be notified without disturbing the customers with an annoying announcement. In some lean facilities they even use the pace or rhythm of the sound to indicate if there is a problem.

In any process, information is critical – it allows people to know where they are, where they are going and if problems are occurring that could be prevented. No one would consider driving a car without a dashboard, and few would operate a machine that wasn't equipped with the appropriate indicator lights, panel meters and LCD touchscreens. However, like a car's dashboard, panel meters and touchscreens are only for a single operator. While both are forms of visual management, they lack some of the phenomenon that occurs by having the information publicly available.

By having key performance indicators on display, the operators know what their performance is, but more importantly, they know that everyone else knows what their performance is. This allows the operator to take pride of ownership in their contribution to the company. It also provides actionable information to supervisors, allowing them to determine, in real time, areas that are in need of improvement. Andon messages that communicate process problems across a facility ensure that everyone is aware of a given issue, drastically reducing downtime.

The typical andon system is a manual system. It often consisting of a simple series of lights or flags to indicate that an area is experiencing a problem and requires assistance. It requires constant monitoring by support personnel and/or management. It requires personnel to perform further investigation to determine the nature of the problem or assistance required. It also will save time and resources. It gives support personnel & management an “at-a-glance” view of in-work status. It reduces the need for technicians to interrupt their work, in order to acquire assistance. It give instant notifications. It notifies only the appropriate personnel and it will differentiate between emergent and scheduled needs.

The advantages of using andon systems are it can removes errors associated with manual data collection and input, minimizes production losses by facilitating real-time problem analysis and correction and can removes costs associated with manual data collection and input. To be sure, they allow a supervisor or team lead to quickly spot a problem before it escalates. For example, if a supervisor wants to know the status of six different work cells in an area, he would have to walk to each one and look or ask an operator the status. Unfortunately, while the supervisor is in the back area trying to find out what is going on, a work cell in the front has a malfunction and the supervisor doesn’t even know about it. By installing andon lights at each of the work cells, the supervisor can visually see that status and proceed to the work cell that needs assistance. andon lights are a low cost solution versus people waiting or not knowing the current status if work.

1.2 PROBLEM STATEMENT

There are several types of machine such as milling machines, turning machine and grinding machines used by the lecturers and students in Fakulti Kejuruteraan Pembuabtan (FKP) laboratory, however, some of the machines like milling machine doesn't have andon system attach to the machines. Lecturers and students hard to identify which machines are available to use and which machine are in maintenance condition due to lacking of andon system. Andon system is important because it is one of the safety approach to avoid any accident happened.

The system is very important in terms of safety and also as a guide or warning to the machines users about the condition of the machine. This system can help users to identify the machine status whether it is in use, idle, available or breakdown.

1.3 OBJECTIVES

The objectives for this research are as follow:

i. To design and develop an andon system at FKP labarotary.
ii. To verify and analyze an andon system via lights observation test and efficiency test.

1.4 SCOPE OF PROJECT

This research is about the design of andon system that can be implemented in the FKP lab. It is because some of the machines in the FKP lab such as milling machine and grinding machine does not have andon system attached to them.

The andon system can be controlled using wireless connection that can be triggered using switches. The signal will be given by the XBEE.

To show the visual control of the andon system, light emitting diode (LED) are used to show the current situation of the machine. The LED have three different color which are red, yellow and green. For this project, a prototype is constructed to represent the andon system. Since this is only the prototype, the andon would prefer to represent a motor as a machine in real situation.

For the programming of andon system, C program will be used as the coding method. This program will be installed into the PIC16F88 microcontroller.

CHAPTER 2

LITERATURE REVIEW

2.1 THE ANDON SYSTEM

Andon is an extremely simple system of visual management for helping teams identify when there is a problem with a process or machine. Originally they were developed as part of the Jidoka quality-control method within the Toyota Production System and have now been incorporated into standard lean manufacturing practice.

Originally andon lamps were used to notify teams of a quality problem, and more frequently we see them installed on continuous flow lines to help inform operators of why machines have stopped. For example if it have an operator running two packaging machines and one of the machines stop, a simple andon light stack can instantly tell the operator if he has a problem (and has to intervene) or if the machine has just run out of product.

There has been major research about the impact of productivity and profitability in andon and no-andon System. A research has been made on good-job throughput in a production line with andon and no-andon system (Robert R. Inman and Dennis E. Blumenfeld, 2009)

Using a work team model to characterize the response to workers' calls for help (Blumenfeld and Inman, 2009) they optimize the team size for assembly lines with and without an andon system. With andon, if a worker cannot finish the task, he or she will pull the andon cord and stop the line. This preserves quality at the expense of throughput (Li and Blumenfeld 2006) provide more general models of andon system policies. Without andon, if the team leader cannot help a worker in need, the job may leave the station incomplete – increasing the chance of a quality defect. These impacts are illustrated in the following for the two systems.

2.1.1 No Andon System

To clarify their work team model of a no-andon system, Figure 2.1 displays an example section of the line in a series of six snapshots taken every 12 seconds. (For simplicity, Figure 2.1 treats the line as an index line that holds the vehicles stationary for one minute then instantaneously advances them all one station.) Vehicles are shown as rectangles and workers as circles. The example 10-station section has one worker per station (labelled A through J) supported by one team leader (labelled T). The following narrative accompanies Figure 2.1 (Robert R. Inman et al, 2009).

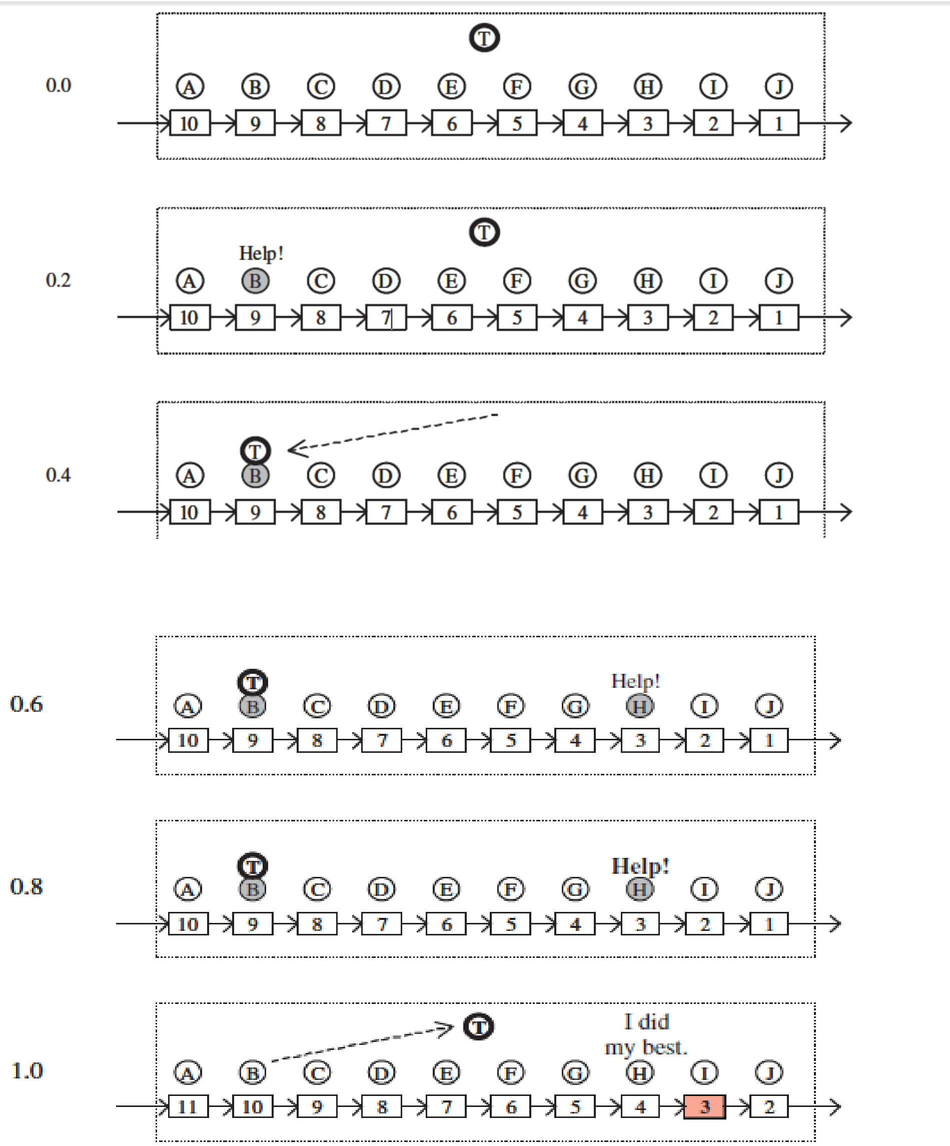

Figure 2.1 : Team leader responds to worker's call for assistance.

(R.R Inman et al, 2009)

Table 2.1 : Time and narrative for no andon system (Robert R. Inman et al, 2009)

Time	Narrative
0.0 minutes	Each station has a vehicle (labelled 1 through 10).
0.2 minutes	Worker B encounters a problem and calls for the team leader, T, for help.
0.4 minutes	The team leader has reached B's station and begins to assists B
0.6 minutes	The team leader continues helping B.
0.8 minutes	The team leader continues helping B Worker H calls for help again, but the team leader is still busy helping B.
1.0 minutes	The team leader has finished helping B and has returned to the on-call position, and all vehicles have advanced one station.

Vehicle 3 that worker H had difficulty with enters worker I's station, even though worker H is not sure the tasks were completed correctly.

Hence, vehicle 3 is depicted with a pattern denoting a potential quality defect.

2.1.2 Andon system

Figure 2 displays how the andon system works on Figure 2.1's example. This scenario is very similar to that of Figure 1 but instead of worker H allowing vehicle 3 to move out of station unfinished, worker H pulls the andon cord and stops the line. Figure 2.2's narration below has new narrative shown in bold.

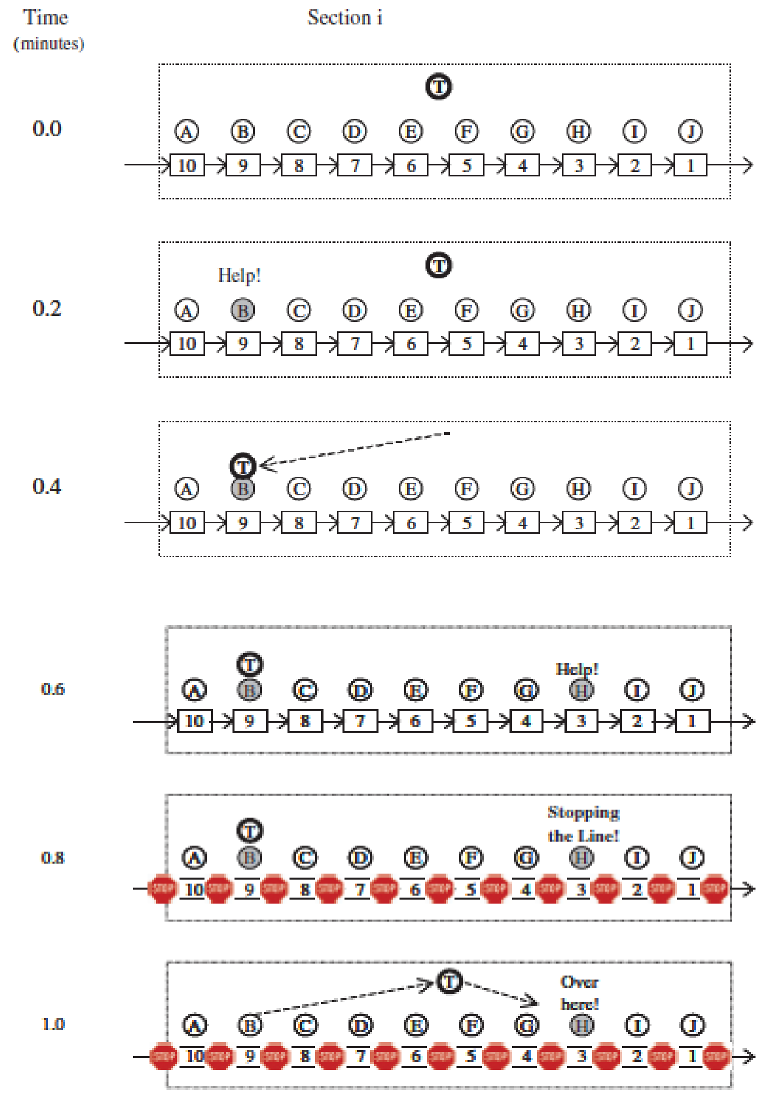

Figure 2.2: Two workers needing help on a section with andon.

(R.R Inman et al, 2009)

Table 2.2 : Time and narrative for andon system
(Robert R. Inman et al, 2009)

Time	Narrative
0.0 minutes	Each station has a vehicle (labelled 1 through 10).
0.2 minutes	Worker B encounters a problem and calls for the team leader, T, for help.
0.4 minutes	The team leader has reached B's station and begins to assists B
0.6 minutes	The team leader continues helping B.
0.8 minutes	The team leader continues helping B Since the team leader has not responded to worker H's call for help (because the leader is still busy helping B), worker H pulls the Andon cord and stops the line.
1.0 minutes	The team leader has finished helping B and walks to help worker H. The vehicles do not advance because the line has been stopped by worker H pulling the Andon cord.

After worker H and the team leader complete worker H's tasks on vehicle 3, the team leader restarts the line and the vehicles advance one station.

Then they calculate the average number of defects per job, D by using this equation:

$$D = \frac{Wfr}{J} \times \frac{(N-1)rt}{1+(N-1)rt} \qquad \text{———————— (1)}$$

Number of good-jobs per unit time, G by using this equation:

$$G = J\left(1 - \frac{N(N-1)(rt)}{1+(N-1)rt}\right) \qquad \text{———————— (2)}$$

Where:

f Fraction of unanswered calls that result in a defect.

D Average number of defects per job.

J Line rate (jobs per unit time).

W Total number of trained workers (¼number of work stations on the line).

T Number of teams on the line (W/N).

G Throughput of good jobs (good jobs per hour).

P Productivity (good jobs per hour per worker).

After doing some and calculation estimation based on the equation to the good-job throughput in the No-Andon and Andon cases, respectively, as a function of team size N, Figure 4 displays the results. As the team size gets larger, the team leader must support more line workers and is less able to respond to calls for help. Hence more defects creep in and the throughput of good jobs decreases.

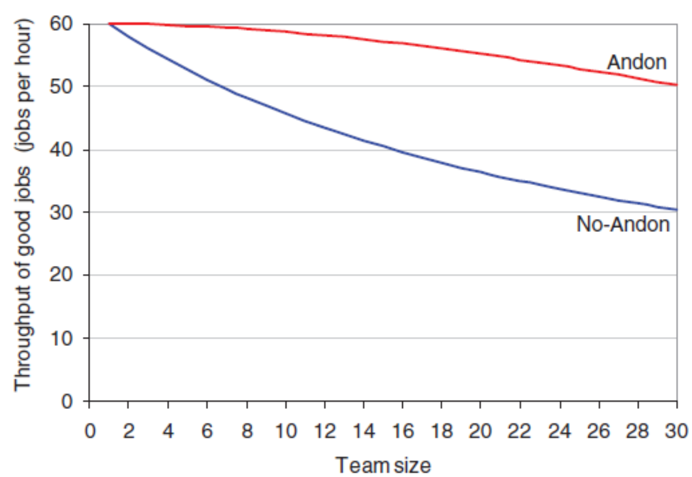

Figure 2.3 : Throughput of defect-free jobs versus team size for Andon and Non-Andon System (Blumenfeld and Inman, 2009)

As the result, in the Andon case, the line is stopped to prevent defects so the total throughput is the same as the good-job throughput (because these models only consider the defects resulting from calls for help that were not responded to). The Andon system's total throughput is less than the No-Andon's, but the Andon's good-job throughput is much higher for larger team sizes.

2.2 THE CONCEPT OF ANDON SYSTEM

To design the Andon system, first the PIC16F88 microcontroller has been decided as the connecting device between the machine and LED. The PIC16F88 microcontroller has been programmed with C Programming command installed in it.

2.3 LIGHT EMITTING DIODE (LED)

Light emitting diode (LED) are the main component in the andon system. It is commonly used on equipment in industrial manufacturing and process control environments to provide visual indicators of a machine state or process event to machine operators, technicians, production managers and factory personnel.

For this project, LED has been decided as the device of Andon lights. The LED's have three different colors which are red,yellow and green. Red is to indicate that the machine is stop, yellow is to indicate that the machine is under maintenance and green is to indicate the machine are being used.

This LEDs will be attach at the top of the machine as the visual warning system to the users. The LEDs are programmed to light whenever the machine are being used. When the user switch on the machine, the green light is on and it will indicates that the machine is being used, so others users cannot used that machine.

While the green light is on but there is no activity (no push button) on the machine for 10 seconds, the yellow light will on and it shows that the machine is under maintenance or stop for a while.

When there is an emergency case happen to the machine, user will push the STOP button and the red light will be on. This indicates that the machine is stop because of breakdown.

2.4 PIC16F88 MICROCONTROLLER

A microcontroller is an electronic device that includes three components Microprocessor, Memory and I/O on a single semiconductor unit called an Integrated Circuit (Karthick Kumar Reddy et al. 2011). In addition to these components, the microcontrollers include many supporting devices as shown in Figure 2.4. In this paper, PIC16F88 is use and is available in 18-pin PDIP, SOIC and the features are summarized in Table 2.3.

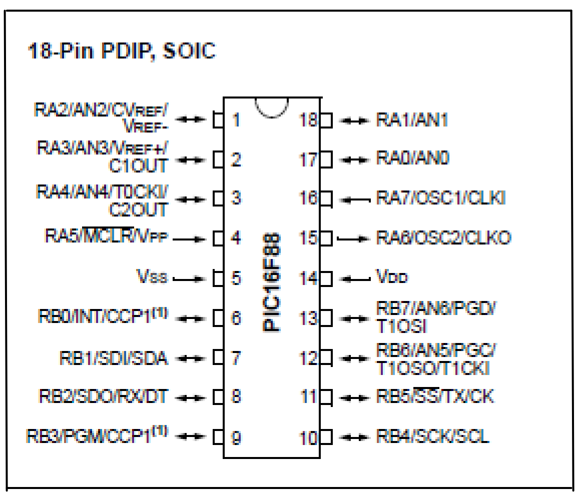

Figure 2.4 : PIC16F88 Microcontroller 18 Pin