International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Special Issue 31(September, 2015), PP. 77-79

DEVELOPMENT OF MICROCONTROLLER BASED COUNTER UNIT FOR LEVEL GAUGE

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***Abstract*-- A level gauge based on gamma radiation was used to detect the level of liquid in any cylinder. Gamma radiation was used because of its penetration power to pass through metal and liquid. The change in gamma intensity is a measure of liquid level. The processed signal from detector corresponding to gamma intensity was available. The aim was to develop microcontroller based intelligent counter and display unit that can automatically warn the user about the absence of liquid in the cylinder by giving alarm, and thus indicate the level of liquid present in the cylinder. The paper describes the selected hardware for the counter unit, the flow chart of the program and the obtained results of the testing. It is concluded that the counter unit was developed and tested successfully. The work was carried out in BARC during summer training in May-July 2015.**

I. INTRODUCTION:

Many times we come across the situations where it becomes essential to know the level of the liquid present in the cylinder. One such situation is Cargo ships, which travel long distance equipped with large number of fire extinguishers (bank of CO_2 cylinders) as a precautionary measure. Before sailing, it is ensured that each cylinder is full of CO_2 or else it is replaced. Checking each and every cylinder with traditional way (weighing method) is time consuming and requires lot of manpower. The work can be carried out using hand held portable level gauge based on gamma radiation very easily. The gauge is based on a gamma transmission principal. When gamma rays passed through different materials, they attenuated by different levels depending upon material [1, 2]. This is given by following equation

$$I = I_0 e^{-\mu t} \qquad (1)$$

Where, μ is attenuation constant, t is thickness, I_0 is Initial intensity and I is transmitted Intensity (after attenuation).

It shows that intensity of transmitted radiation depends on the thickness and attenuation coefficient (μ). When the thickness of material is constant, it depends only on μ which is function of material density. Thus to detect liquid level, the intensity of transmitted radiation passing through cylinder is measured keeping source of gamma radiation at one side and detector on the opposite side as shown in the fig 1(a) below. The transmitted gamma intensity measured will be less when liquid is present (fig 1-b) and it will be more if liquid is not present (fig 1-c) as density of air is less than water.

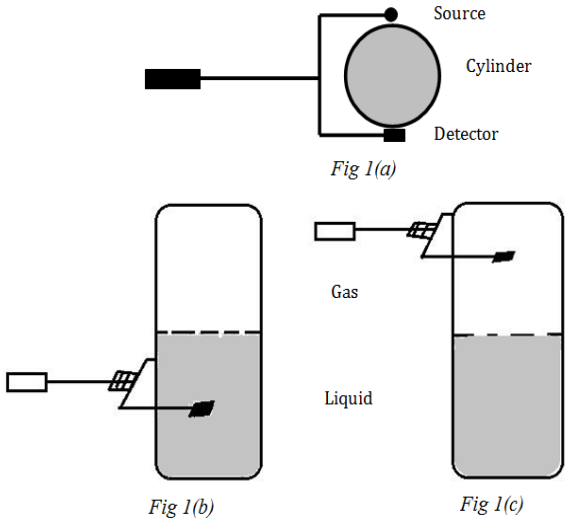

Fig 1 source detector arrangement of Level gauge

Level gauge consists of gamma source and GM detector placed opposite to each other. The block diagram of level gauge is shown in fig 2 below.

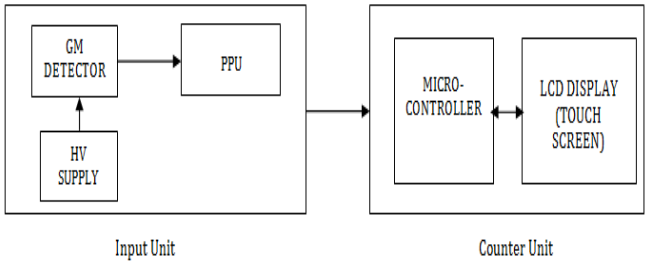

Fig 2 Block Diagram of Level gauge

It consists of two units, input unit and counter unit. The input unit contains a GM (Geiger Muller) detector powered by a HV source and a PPU (Pulse Processing Unit). The function of input unit is to detect transmitted gamma intensity and convert it to 5V rectangular pulses suitable to interface with microcontroller. The amount (number) of pulses produced is proportional to the intensity of radiation detected. The function of counter unit is to measure the pulse rate, display it and decide when to trigger

alarm. The counter unit based on a microcontroller was designed as described henceforth.

II. HARDWARE

The counter unit developed was across PIC32 microcontroller [3]. It is a 32-bit microcontroller having 512K Flash Memory and 32K RAM. It consists of 85 I/O Pins as seven 32-bit ports (Port A- Port G), oscillators and clock circuits along with five 16-bit timers T1-T5, four of which can be used as 32- bit timers. Development was carried out using Mikromedia PIC32MX Development board, which is a Compact high-quality multimedia development platform for PIC32 device. It has numerous on-board modules that help with multimedia applications and fully supported by mikroC compiler for PIC32 and pre-programmed with fast USB HID bootloader. Further it has an audio module, SD card slot and an USB connection [4]. The main requirement of counter unit was a counter and a timer. The four 16 bit timers of microcontroller (T2, T3, T4 and T5) are set to work as a 32 bit timer (T2 and T3) and as another 32 bit counter(T4 and T5). The 32 bit timer(T2 and T3) is used to keep track of 1 sec counting time where as 32 bit counter (T4-T5) used to count pulses coming from input unit of level gauge. This was achieved by programming the control word of microcontroller as T2CON/T4CON =0X00000078 i.e. $(0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0111\ 1000)_2$

III. SOFTWARE:

The main challenge is to develop software to count the input pulses for 1 second (counts per second-cps) and display it. Also it is required to trigger alarm when the count rate (count per second or cps) is more than the set threshold. The threshold countrate is set well above the countrate obtained when liquid is present.
In the beginning a graphic user interface was designed using visual TFT software as shown in fig 3 below.

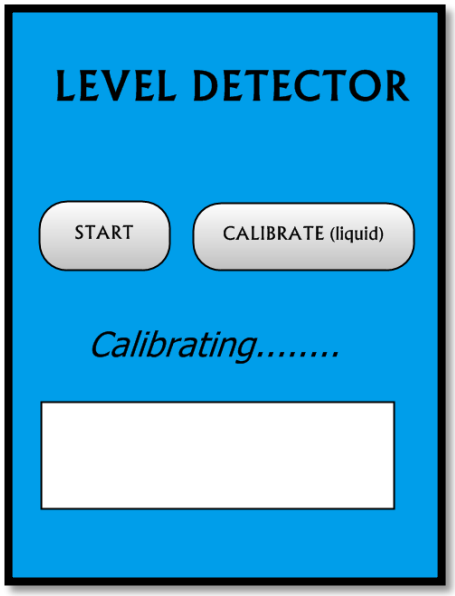

Fig 3 Level Detector display screen

It facilitates the user to set the threshold value of countrate using '*CALIBRATE*' button and detect level using '*START*' button. The value of countrate is displayed in the rectangular white box on blue background. Next, the coding was done in mikroC software. Fig 4 shows the flow chart giving programming logic. The code was developed in C compiler and compiled to generate hex file. The hex file then uploaded in the microcontroller using microbootloader software.

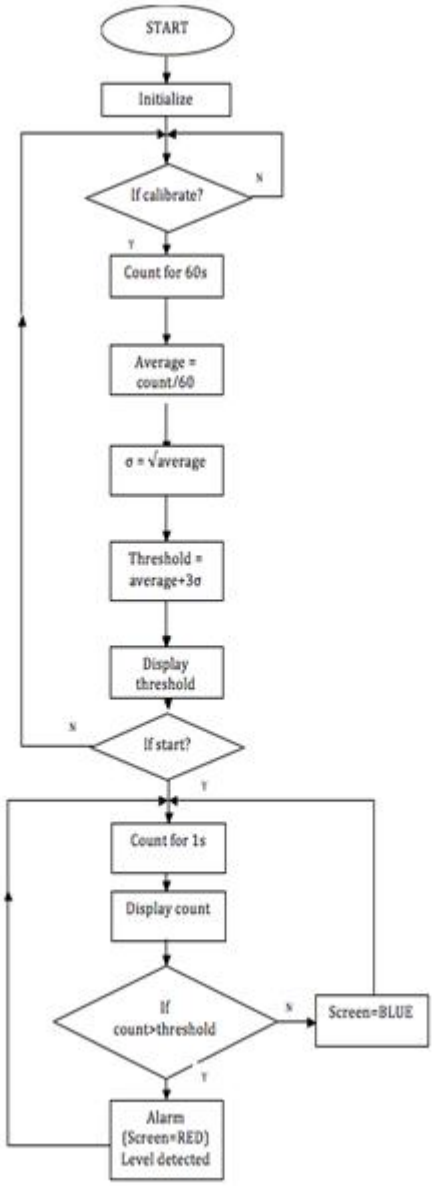

Fig 4 flow chart giving programming logic

IV. TESTING

Testing of the microcontroller based counting unit was done using a 0.5mCi Co-60 source on a half filled cylinder of CO_2. Readings obtained when the cylinder was scanned from bottom to top is noted in table 1 below.

TABLE 1: READINGS OF LEVEL GAUGE

Position	Count rate (cps)	Remark
Bottom of cylinder	50-70	Liquid
Top of cylinder	110-140	Air

First the threshold value was calculated at liquid level by pressing calibrate button which set threshold value as 91cps. Then the start button pressed to start gauge operation. It displayed value between 50-70 cps at bottom. The gauge is then moved up at the top portion. It displayed value between 110-140 cps. It was found that until the countrate was below the threshold the screen remained blue. As soon as countrate crossed threshold value, the visual alarm was triggered, i.e. the screen turned red, indicating the detection absence of liquid. Hence the counter unit is tested successfully.

V. CONCLUSION

A microcontroller based counter unit is developed successfully. It measures and displays countrate (cps). A simple GUI is designed, considering it may be used by a layman. It is successfully tested to automatically warn the user about the absence of liquid in the cylinder by giving alarm, and thus indicating the level of liquid present in the cylinder.

ACKNOWLEDGEMENT

Authors thankfully acknowledge Dr. Ashutosh Dash and Dr. Umesh Kumar from BARC for giving opportunity to carry out the work in Bhabha Atomic Research Centre (BARC), Mumbai. We are also thankful to Shri Parag Walinjkar and Shri Anant Mitra for providing facility and guidance.

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