Counting the signals received from scintillator detector/Gamma ray spectrometer

Electronics lab Project(PH-525P)

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0.1 Aim

Arduino has been used to calculate the number of signal received from the scintillator detector which represents how much ionising radiation has passed through the detector.

0.2 Introduction

In the scintillator detector scintillating material is present.This material has the property of producing photons whenever high energy photons/Ionizing radiation falls on it.The photons produced are of low energy which then falls on photocathode which then emits an photo electron when it is illuminated by photons.This photo electron then gets multiplied when it falls on photo multiplier crystals and is accelerated throughout the whole photo multiplier tube.Then all the electrons are collected and converted into electrical signal from light signal.The strength of the signal produced is proportional to energy of incident photon.So it can be told how many ionizing radiations is produced by counting the no of electrical signals.

Now various different electronics circuits like mono-stable vibrator,amplifier are used to make a circuit which can count the no of electrical signal coming detector. At the end Arduino will be used to do computing part.

0.3 Arduino

Arduino board is an Italian device.There are a number of Arduino boards that have different specification.The number of different applications that can be done depends on one's own thinking.For this work the simplest one Arduino uno is used.It is made up of a number of microprocessors and controllers,transistors gates and many more other components.This board has a number of analog and digital pins.These pins are used to read digital and analog signal.It can also be used to generate a signal.Basically this board is used with different sensors to complete the different purposes.This board has USB serial bus also through which it can connected to a computer and it can be programmed as one's need.

It operates on a voltage 5 volts.It has inbuilt ground port also that can be used for reference purpose.It's input recommended voltage is between 7-12 V and limit is 6-20V.It has an flash memory of 32KB and a static ram of 2KB.Though the storage seems to be very less but it can store thousands of lines of codes.Also it has an additional EPROM of 1KB.It clock has max speed

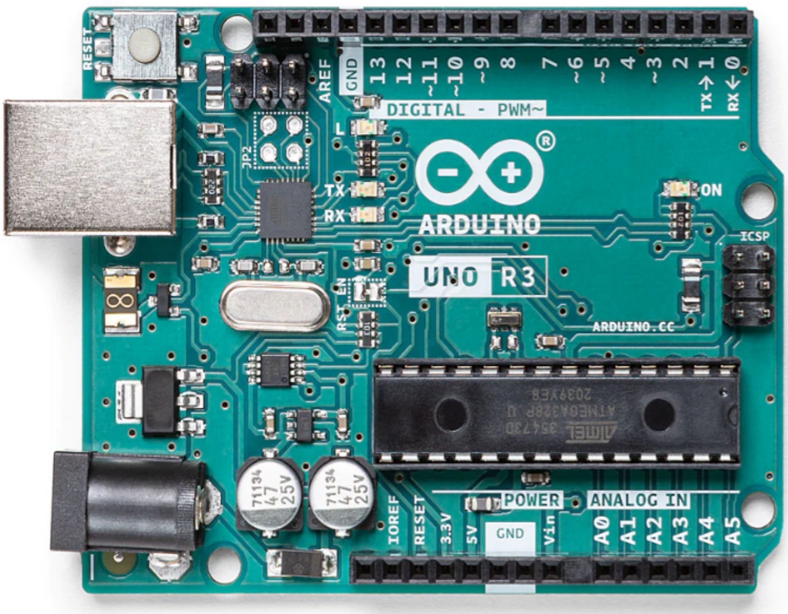


Figure 1: Arduino uno picture from top.IT can be seen how much components are installed on just a single board.This board is 68.6 mm long and 58.4 mm wide.

of 16MHz. It also has an inbuilt LED at pin number 13.Even after having these much component it weighs only 25g.

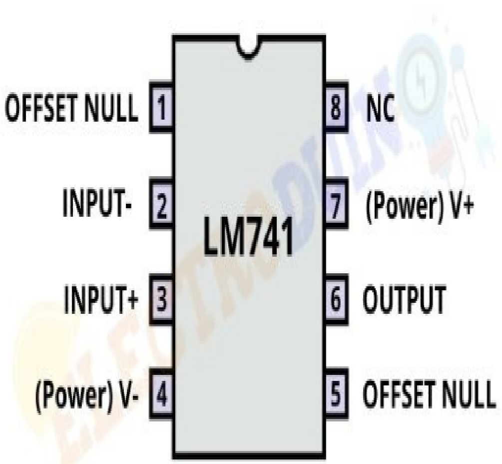
It will keep counting the no of signals and give us the signal count.

0.4 Underlying working principle

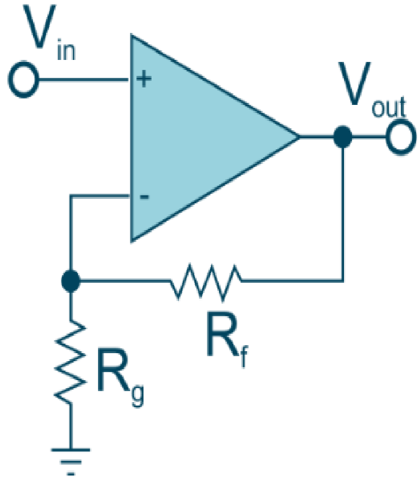
Now after putting source radioactive source in the detector we are getting signals which we need to count.However the signal which coming from detector is very low.So to make it of any use it first needs to be amplified.For this purpose an operational amplifier has been used which will serve the purpose.

After the signal is amplified it can be used for further analysis.The principle behind counting the no of signals is this signal will be passed through a mono-stable vibrator which will create square pulses for every signal.A mono-stale vibrator is a vibrator with one stable state which 0 volt that is ground.If this vibrator is given a trigger it will shift to high voltage state and when the signal is gone it will again come back to the ground stable state.It is implemented using 555 timer IC. by the use of figure 3

So for every signal this mono-stable vibrator will make a square pulse which can be calculated using Arduino.For this work Arduino uno is used though any Arduino can be used.



(a) Pinout of IC-741



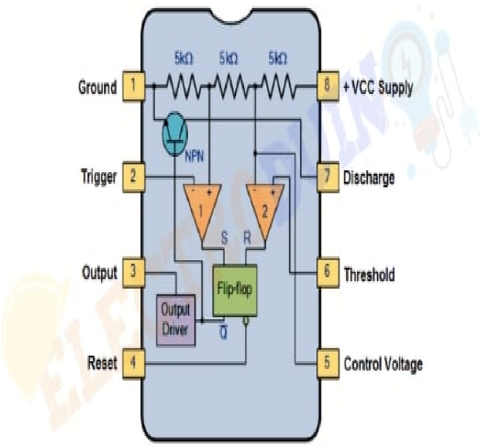
(b) Non inverting Amplifier schematic diagram used for amplifying the signal

Figure 2: The 555 timer IC pin-out diagram and the schematic diagram of mono-stable vibrator

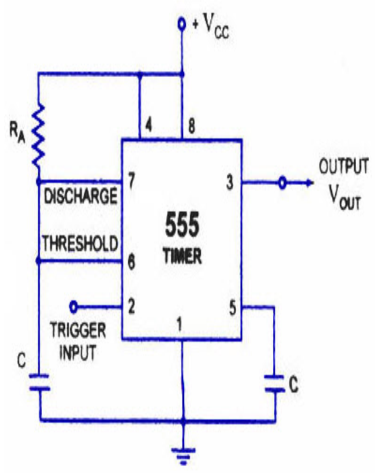
For this the Arduino will be connected to the output of mono-stable vibrator.First the width of square pulses will be calculated from the Digital storage oscilloscope.A DSO is multi purpose device used in electronics lab generally for observing the output waveform coming from some electronic device.It can also be used as a function generator, a trigger pulse generator and for many other purposes.For this work it will be used to observe the output coming from different sections like amplifier,mono-stable vibrator and getting frequency ,amplitude of initial and amplified signal.And also for measuring the width of the square pulses generated by the Arduino.

After connecting the Arduino with the output of the mono-stable vibrator work can be done further.One thing must be taken care of is that the input applied to the Arduino should not be greater than volts,otherwise it may lead unexpected functioning or even damage the Arduino. In the Arduino now programming is to be done so that it can work as required.First of all a serial connection need to established between the Arduino and the serial monitor so that number of counts can be obtained.So Serial.begin(9600) function is to be added inside the void setup().

There are to function that in the Arduino.One is void setup().Lines written inside this block is read only once by the compiler.Other one is void loop().Lines written in this block are executed repeatedly until the Arduino is on. First a variable needs to be defined to store the number of counts.Then a pin is selected as the input pin say pin number 5 and use it in read mode.Then the voltage is



(a) 555 timer IC



(b) Mono-stable vibrator schematic diagram

Figure 3: The 555 timer IC pin-out diagram and the schematic diagram of mono-stable vibrator

read from pin number 5 and stored in another variable.Then a condition needs to implemented which will according to which if the voltage at pin number 5 is not zero then compiler will increase the count.This process is repeated after the pulse width of square pulse otherwise for a single pulse many counts will be done.These counts then is to be displayed on the serial monitor for observation.

often the signal we get from the scintillator is a mixture of signal and noise as the signal we are getting is very rapid.So we need to filter out this signal.This work is also done using Arduino.For this the program will be different.But almost the same.The analog signal from the amplifier will be applied to one of the the analog pins of the Arduino.The signal input is read.Again it should be noticed that the analog pins of Arduino generate 10 bit digital output in the range 0-5 volts.Then the digital output can be converted to analog voltage signal.So the input voltage to Arduino should not exceed 5 volts or it will damage the Arduino.Then the particular the output signal be formed only when the signal is having a particular a voltage.fortunately this signal filtering process will by itself generate a square pulse.These square pulses can be again counted by the use of Arduino and thus the purpose of this work will be full-filled.

0.5 Measurement

After setting up the instrument measurements need to be done.Switch on the electronics devices used in making up of whole circuit/instrument.First counting was done for dummy source that is no source placed in the detector.This was done to avoid any potential errors introduced from the device itself.After taking the measurement form the dummy source then measurement was done using gamma source.Counting was done and recorded.Then it the number of signal counts were subtracted form the signal counts obtained from the dummy source.

0.6 Result/Conclusion

The counts from the Scintillator detector/Gamma ray spectrometer were counts successfully.However there might be uncertainty involved in the counts as the signal obtained from the detector was completely drenched in noise.To increase the accuracy the signal needs to filtered precisely and amplification only as much as is required.