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Microcontroller Based Blood Irradiator System

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Abstract - Irradiation of blood and blood products by gamma rays is a proven and safe method to inhibit T- Lymphocyte Proliferation and eliminate the risk of post transfusion graft versus host disease (T-GVHD). Transfusion-associated graft-versus-host disease (TA-GVHD) is a rare, but usually fatal, complication of transfusion. The risk associated with an individual transfusion depends on the number and viability of contaminating lymphocytes, the susceptibility of the patient's immune system to their engraftment and the degree of immunological disparity between donor and patient. This paper aims to acknowledge the importance of blood irradiator.The mainstay of prevention is gamma irradiation, which inactivates T lymphocytes whilst preserving the function oother blood cells. Leucodepletion by current filtration technology is inadequate [unproven] for this purpose. Gamma irradiation of cellular blood components is the best current technology to reduce the risk of T-GVHD to the recipients as confirmed by research and therefore being widely practiced world over in hospitals and blood banks as a life saving approach to this problem. Blood is usually irradiated in standard blood bags in dedicated blood irradiators using cobalt –60 or caesium –137 radioactive source. Thus this paper aims to contribute to the development of a control system is a based system microcontroller used for controlling the various input and output devices. The unit can be installed in a room without any additional shielding.

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MICROCONTROLLER BASED BLOOD IRRADIATOR SYSTEM

Strictly as per the compliance and regulations of:

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I. Introduction

a) Blood Irradiator System

Blood irradiators are widely used for the irradiation of blood samples and also for various research studies like mutation breeding, radiation sterilization etc. The compact self-shielded cobalt-60 gamma irradiators provide an irradiation dose of 9KGy/hr. The sample for irradiation is to be placed inside the sample chamber. The motorized drive and its associated mechanism enable precise position of the sample chamber at the centre of the radiation field inside the chamber. The recommended dose limit for blood sample ranges from 15Gy to 30Gy

b) Main Features of BI-2000

- Safe and self shielded: No additional shielding is required. The radiation field on the external surface of the unit is much below the permissible level.
- Dose uniformity: Sample rotation mechanism and stationary source pencils symmetrically placed in a cylindrical cage ensure good uniformity of radiation field within 25% variation or better.
- Computerized calculations of dose and termination of irradiation based on time as well as dose modes with Cobalt-60 source decay correction.
- Sample chamber door inter lock for safety operation.

c) Blood Irradiation

Blood is a specialized bodily fluid that delivers necessary substances to the body's cells such as nutrients and oxygen – and transports waste products away from those same cells. Blood consists of many components (constituents). These include: Plasma, White Blood Cells, Red Blood Cells, Platelets, Lymphocytes, Erythrocytes, Leucocytes and thrombocytes. Lymphocytes, Basophiles, Europhiles and Monocytes.

d) T-GVHD

Transfusion –associated graft versus host disease is a complication of blood transfusion in which the donor T-Lymphocytes mounts an immune response against the recipient's lymphoid tissue. Donor lymphocytes are identified as foreign and destroyed by the recipient's immune system. These donor lymphocytes proliferate and damage target organs, especially bone marrow, skin, liver and gastrointestinal tract. The risk associated with an individual transfusion depends on the number and viability of contaminating lymphocytes, the susceptibility of the patient's immune system to their engraftment and the degree of immunological disparity between donor and patient. However, in situation where recipient are immune deficient such as cancer patients and those who are going organ transplantation are not able to destroy the donor lymphocytes. This result in T-GVHD.T-GVHD is developing four to thirty days after transfusion

II. Need of Blood Irradiator

When blood is given to patients who are immuno- deficient such as cancer patients or patients being operated for organ transplants, blood needs to be irradiated with low dose of radiation to inhibit T-Lymphocyte proliferation. Without this, these Lymphocytes may tend to take over the immune system of the recipient and attack the healthy organs resulting in T-GVHD or Transfusion induced graft versus host disease. This may lead to complications and may be fatal. Even in the case of immuno sufficient patients, this can take place, if the donor happens to be a close first degree relative due to the lymphocytes getting past the immune system of the recipient undetected

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like a Trojan horse. Treating of the blood with radiation is considered a sure way to prevent such complications.

III. System Design

After getting the required dose the sample is lifted out of the chamber using the control drive mechanism automatically. The microcontroller based fully automated system accurately adjust the irradiation time and generates control signals for activating different output devices and take appropriate control action by reading the inputs from various input devices.

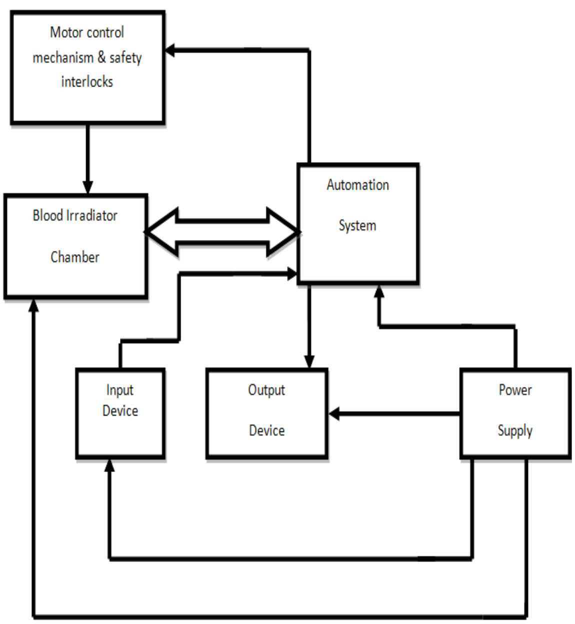

Fig I: Block Diagram of control system.

a) Input Devices

Keypad

The 4x3 matrix keypad is a general-purpose keypad. It consists of 16 switches arranged in 4 rows and 4 columns. It can connect to the MCU 8-bit port directly. Is provide o choose between different options and to select different operation settings by the user. It's provided to enter the parameters for irradiation like dose rate, initial activity. This is our keypad module which has the following keys:

- Increment Key
- Decrement Key
- Right shift Key
- Left Shift Key
- OK Key

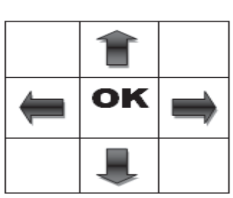

Fig II: Keypad

b) Output Devices

LED

A light-emitting diode (LED) is a semiconductor diode that emits incoherent narrow-spectrum light when electrically biased in the forward direction of the p-n junction, as in the common LED circuit.

LCD

The user interface is developed through the LCD display.

- Display various menus for the user.
- Displays the parameters and different modes of operation the operator has selected.
- Guide the user to interactively choose different menus and select different parameters for taking decisions.

Automation Devices

The automation system consists of a microcontroller (Atmel AT89C52 microcontroller) based fully automated system. The peripherals are interfaced with the microcontroller and the communication is done through the IO ports. Accurately adjusts the irradiation time and generating control signals for different input & output devices.

Power supply

This unit will supply the various voltage requirements of each unit. A variable regulated power supply is used to continuously adjust the output voltage to the requirements. This unit consists of transformer, rectifier, filter, regulator and power LED. Transformer rating is 30VA (2A current rating). Rectifier will be center tap rectifier. Filter value is 2200μF. Regulator is 7805.

Microcontroller

- The automation system consists of a microcontroller (Atmel AT89C52 microcontroller) based fully automated system.
- The peripherals are interfaced with the microcontroller and the communication is done through the IO ports.

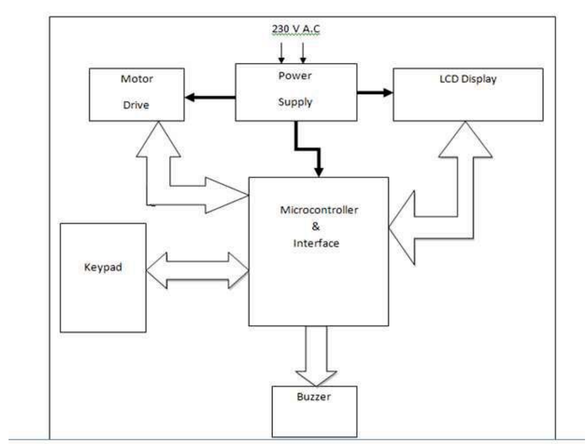

Fig III: Automation system

• Accurately adjusts the irradiation time and generating control signals for different input & output devices.

• Generates control signals for different input & output devices to precisely place the sample to the centre of the source.

• Automatically removes the sample after irradiation for the calculated time.

• It is programmed to read the dose rate of the sample then calculate the exact irradiation time.

Motor drive Mechanism

• The motorized drive mechanism is a D.C Motor whose speed is 100 r.p.m and its associated drive mechanism enables precise positioning of the irradiation chamber at the centre of the radiation field inside the sample chamber.

• This becomes an important mechanism as the position of the chamber should be accurate such that the sample is accurately exposed to the radiations. These radiations should accurately fall on the sample chamber in order to remove the impurities.

• Stationary source pencils, symmetrically placed in a cylindrical cage ensure good uniformity of radiation field in the sample chamber. In addition a mechanism is also provided for rotating/stirring samples during irradiation.

• Sample chamber door interlocks are provided for safety operation such that during the irradiation time the doors should not open as they may hamper the whole process and also expose the harmful gamma radiations to the environment and the operator.

The DC motor that we have used serves the following purpose:-

• For controlling the position of the sample in the gamma chamber we use to interface dc motor with microcontroller to a port which will give high or low logic to rotate the motor in any of the direction.

• Here to lower the sample in to the chamber we use to convert the angular motion of motor in to liner motion.

• For controlling the vertical motion of actuator we have use to limit switch know as upper and lower limit switch.

• The rating of the motor is 24V/1A.

• Rating of microcontroller 5v/10mA

IV. Development tools

a) *Embedded (Keil) C*

The use of C language to program microcontrollers is becoming too common. And most of the time it's not easy to build an application in assembly which instead you can make easily in C. So it is important that you know C language for microcontroller which is commonly known as Embedded C. As we are going to use Keil C51 Compiler, hence it is called as Keil C.

b) *Orcad package*

OrCAD is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly to create electronic prints for manufacturing of printed circuit boards, by electronic design engineers and electronic technicians to manufacture electronic schematics and diagrams, and for their simulation.

c) *Operation*

The control system is built for controlling the irradiation time for a sample as per required. The keypad provided is use to control the process as denoted on screen. When we switch on the circuit following screens are displayed in a sequence:-

• The first screen will display the title of the project is display

• In the second screen we have to enter the dose rate which we have to give according the quantity of the sample. The following operations are performed by the key as they are pressed. Increment the values when "UP" Key is press similarly when "DOWN" Key is press it will decrement the values and store the values invariable. Move the cursor right or left according to the direction of key pressed. "OK" key is used to store the data and go to next operation.

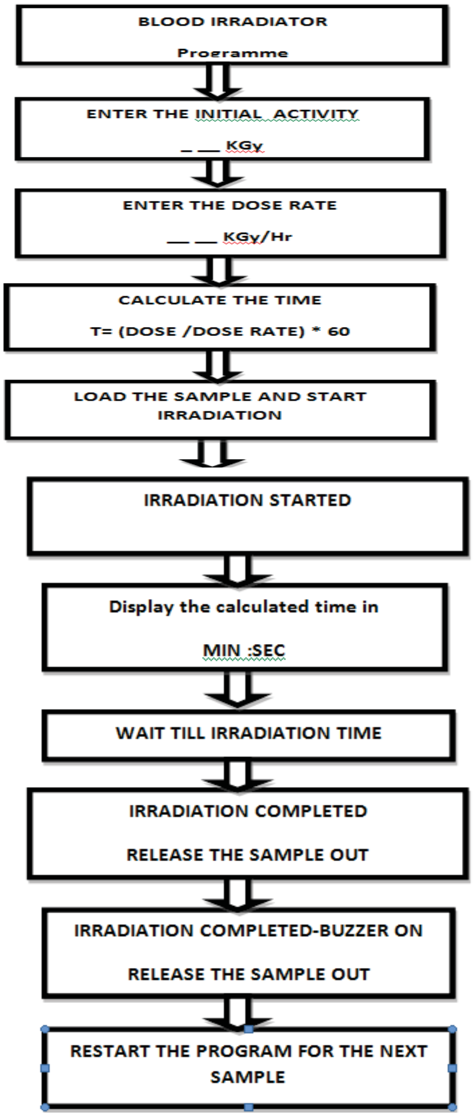

Fig V: Flowchart sequence of events

- In the third screen we have to enter the dose rate which we have to give according the quantity of the sample. The above operations will be performed by the key as they are pressed
- Calculate the time of irradiation by formula Time= (initial activity/dose rate) *60
- After calculating the time the dc motor will rotated in clockwise direction and as the mechanical link the sample holder will move in up direction. As the sample holder is move up, place the sample and press "OK" key to move to next operation. As the key is pressed the dc motor rotated in anti- - -clockwise direction and as the mechanical link the sample holder will move in down direction. Here as the sampled is loaded to the irradiation chamber the controller will ask the user whether to start the irradiation then press "OK" Key after a delay of few millisecond the controller will go to next screen.
- As soon as the sample is loaded irradiation starts and the calculated time is displayed on the screen. The time is display and start decrementing as down counter first sec followed by min. This countdown can be stop by pressing "OK" key in mid of time As the irradiation time hit zero this screen appear indication that irradiation completed and after pressing "OK" key the dc motor will rotated in clockwise direction and as the mechanical link the sample holder will move in up direction. Now after the irradiation time is completed the buzzer will be ON to indicate irradiation is complete. Now the sample can be removed.

V. Conclusion

The Gamma Chamber is very effective, as compared to other systems for Blood Irradiation. The radiation from Gamma chamber degrades the intensity of T- Lymphocytes which is the main cause for TA-GVHD disease in low immune patients. The irradiation can be controlled effectively by microcontroller which accurately calculates the time with the initial activity and dose rate entered by the user. The position of the sample in the chamber is precisely controlled by microcontroller by means of interfacing with DC motor.

VI. Future scope

The same concept can be used for the following requirements:-

- Sterilization of healthcare products
- Cancer Treatment
- Irradiation of water
- Microbial decontamination of spices, herbs and vegetable seasonings
- Food and food product preservation
- Inhibition of sprouting in onions and potatoes
- Gemstone Coloration & enhancement
- Radiation effect of materials
- Mutation breeding
- Food preservation
- Radiation sterilization

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