

*Original Research Article*

# PLC automation of circular sll-02 type 50kci cobalt 60 irradiator

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Abstract

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A Siemen Logo 12/24 RC Programmable Logic Controller (PLC) was used to model and design an automation for the Circular SLL-02 type 50kCi cobalt 60 irradiator, which is category IV wet storage, installed at Radiation Technology Centre (RTC). The reason this project was carried out is; to avoid difficulty face in: integrated circuit based control system for the irradiator, importation of expertise in repairing the facility and thereby reducing the down time of the gamma irradiator. It was designed to provide automatic initial conditions checks, motor rolled the radiation source up, monitor the irradiation process and finally retiring the source to its storage after irradiation. The PLC monitors the inputs and outputs signals of the facility and energized or the de-energized the respective relays according to the written program installed in its memory. The Light Emitting Diodes (LEDs) in the project gave the indications of the satisfied conditions and when output relay has been energized and is de-energized. By implementation of the design down time of the facility would be reduced.

**Keywords:** Automation, down time, gamma, irradiator, model design, programmable logic controller, radiation

## INTRODUCTION

The 50kCi cobalt 60 Gamma irradiator was manufactured by the Hungarians. It was supplied by the IAEA. It is wet storage category II type. It consists of 20 source pencils, stored in a pool of de-ionized water; 2mx3mx5.7m. The de-ionized water helps prevent rust. It was installed by the Hungarians in 1994 at the Radiation Technology Centre (RTC) of the Ghana Atomic Energy Commission, and commissioned in 1995 by the Ghana Government (Alpha Omega Technologies. Inc. 1992; International Atomic Energy Agency, 2008; Emi-Reynolds et al 2006).

The electronic control system of the gamma irradiator at the Radiation Technology Centre of the Ghana Atomic Energy Commission is integrated circuits based system design. (Alpha Omega Technologies. Inc. 1992). The cost and time spent to bring in an expert to repair the facility always result in long down time of the facility. Aside

above mentioned challenges the rapid breakdown facility due to component failure and finding their replacement, also lead to long down time of the irradiator. Workings on the main circuit boards are also difficult. This is because repairs on them cause more damage on the circuit tracks. Lastly, many aspects of the facility are manual based. The above reasons necessitate the need to automate the Gamma irradiator using the Siemens Logo PLC 12/24 RC. The PLC is used for controlling and operating of industrial machinery. (Siemens Logo manual, 2005). This will eliminate the system long down time and other bottle necks including those explained earlier associated with the main boards, thereby increasing efficiency. The PLC based gamma irradiators are more advantageous. The advantages of PLC-automated irradiator system reside in the fact that it is; rugged and designed to withstand

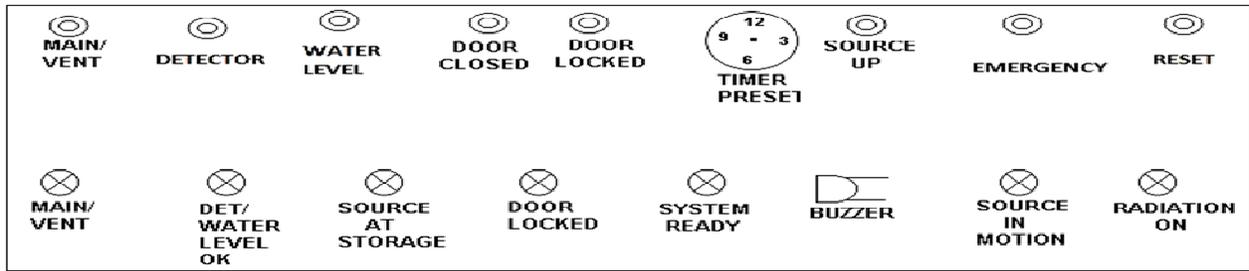


Figure 1. Positional Sketch of the modeled automated Circular SLL-02 type 50kCi cobalt 60 irradiator

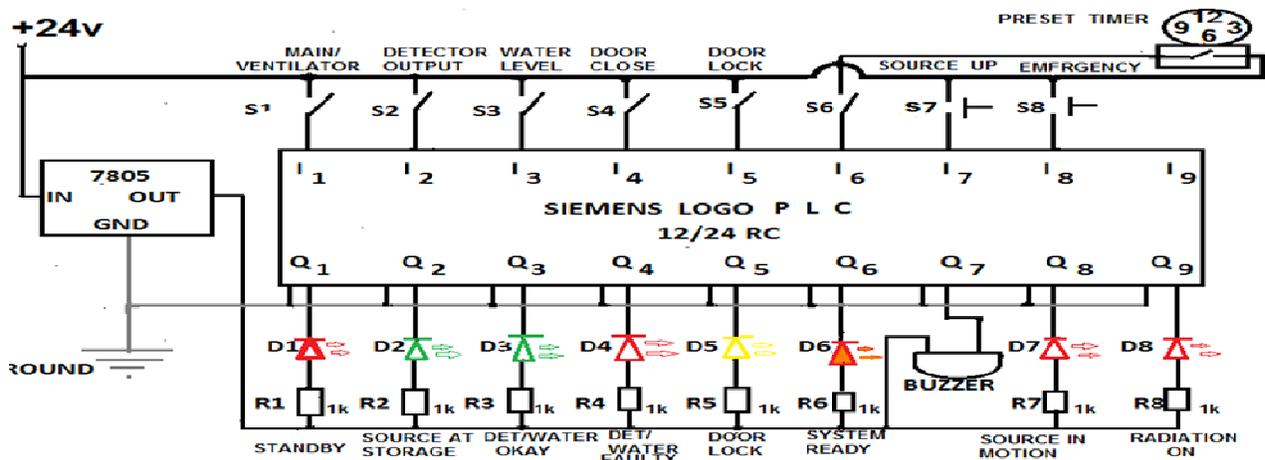


Figure 2. Circuit diagram of the modeled automated Circular SLL-02 type 50kCi cobalt 60 irradiator

vibrations, temperature, humidity and electrical noise. (Alpha Omega Technologies. Inc.1992)

It is user friendly and can easily be programmed. The programming language simply deals with logic and switching operation. (Petruzella, 1998; Webb et al. 2003).

To modify a control system all that is necessary is for an operator to key in a different set of instructions. There is no need to re-wire. The result is flexible and cost effective.

The success of the automation would greatly reduce the cost of bringing in foreign experts to repair the system since it would locally be repaired. The memory size of the PLC is 2 Kilobytes with 12 I/Os. The type of software language used is functional block diagram (FBD) which can easily be converted to ladder language using the facility provided in the PLC. (Siemens Logo manual, 2005).

## MATERIALS AND METHODS

The components such as: LEDs, Switches, Circuit board, PLC Logo (SIEMENS 12/24 RC), Preset timer, Resistors

and Flexible wires, and Voltage Regulator (7805) for the project were collected from Engineering Services Center of Ghana Atomic Energy Commission. Control requirements were generated, positional sketch was made as shown in the figure1 and allocation was plotted as shown in Table1 Flowchart was developed as shown in fig.4 and the software program figure.5 was written on the computer using Siemens LOGO comfort and simulated before transferred to the PLC. (Alpha Omega Technologies. Inc.1992; International Atomic Energy Agency, 2008).

## Control requirements

Below is the control requirement that gives the action to be initiated and the resulting indication.

1. Press main push button to put the system on standby. Indication - main and vents lights comes on.
2. When detector/water level is OKAY; 5.7 above the bottom of the storage tank. Indication - Detector/water level LED comes on.
3. When door is closed and locked. Indication - Door lock

Table 1. Allocation list

Address	Symbol	Comment
I <sub>1</sub>	Main/Vent	ON/OFF switch for system standby
I <sub>2</sub>	DET Signal	For detection of test source radiation
I <sub>3</sub>	Water Level	For checking water level
I <sub>4</sub>	Door closed	Door safe
I <sub>5</sub>	Door locked	Door safe
I <sub>6</sub>	Preset timer	For the setting of the desired radiation time
I <sub>7</sub>	Source up (START)	To start the radiation process
I <sub>8</sub>	Emergency push button	To stop the radiation when problem occurs
Q <sub>1</sub>	RED LED	MAIN/VENT Indicator
Q <sub>2</sub>	GREEN LED	Source at storage Indicator
Q <sub>3</sub>	GREEN LED	Detector/Water Level OK
Q <sub>4</sub>	RED LED	Detector/Water Level Faulty
Q <sub>5</sub>	AMBER LED	Door Locked
Q <sub>6</sub>	RED LED	System Ready
Q <sub>7</sub>	BUZZER	Alarm
Q <sub>8</sub>	RED LED	Source in motion
Q <sub>9</sub>	RED LED	Radiation On

LED comes on.

4. When the preset timer is set to desired time, Indication - system ready LED comes on.

5. Press start or source up push button and buzzer comes on

6. When buzzer is on for 5 seconds then source begins to move upwards.

7. When source moves for 15 seconds radiation LED indicator comes on.

8. When preset time elapses source returns to storage. [Webb et al. 2003]

#### Positional Sketch

The positional Sketch gives the location of various input switches and output terminals as shown figure 1

#### Allocation List

The addresses and symbols including various comments for the input and output pins are tabulated Table 1 above.

Function of each component of the Block Diagram of the modeled automated gamma irradiator

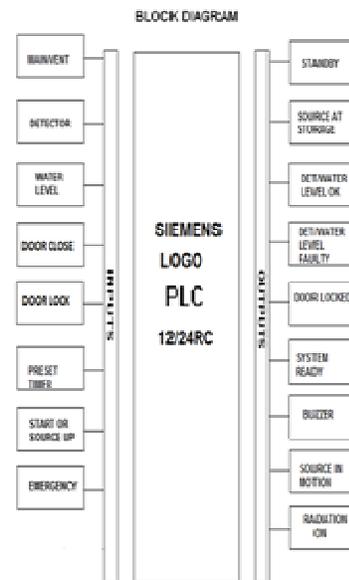


Figure 3. Block diagram of the modeled automated Gamma irradiator

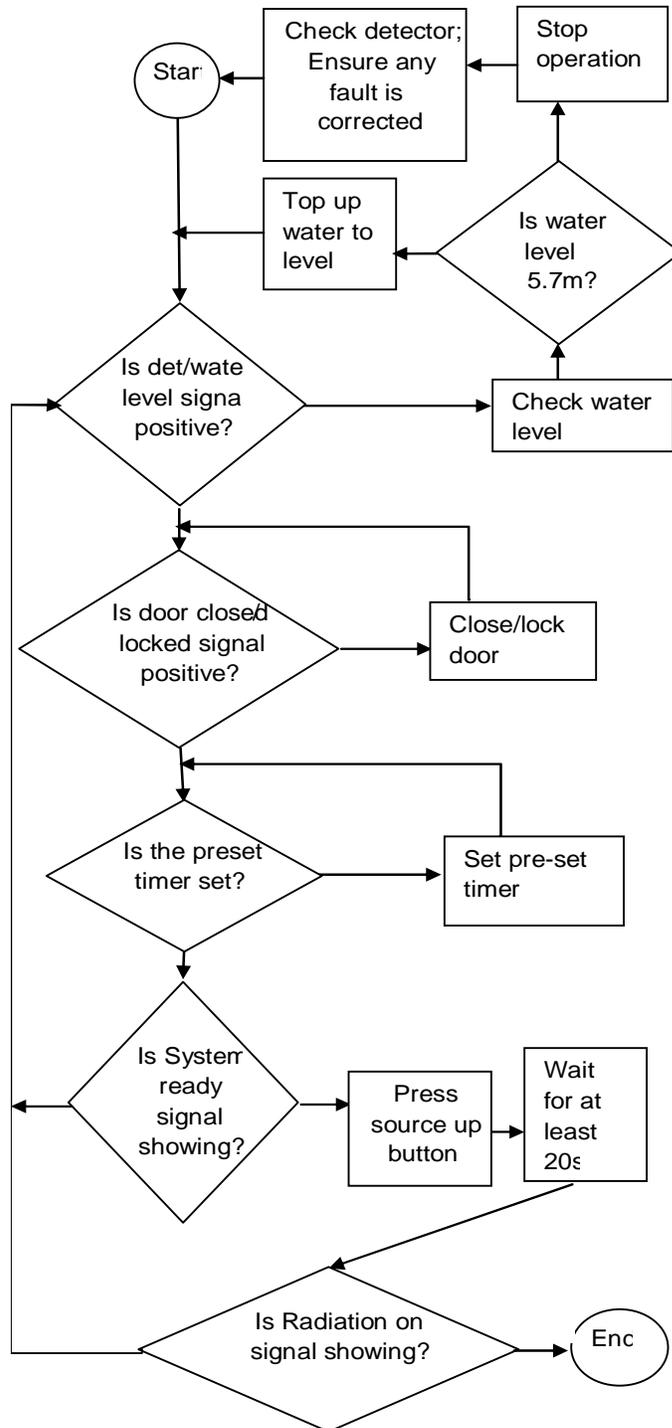


Figure 4. Operation flowchart for PLC controlled gamma irradiator – to guide the operator

MAIN: This block put or powers the system as well as the ventilator on.

DETECTOR: It is used to measure the test source and

the radiation level

WATER LEVEL: With the help of micro switch connected is to give logic high or low to the input of the PLC.

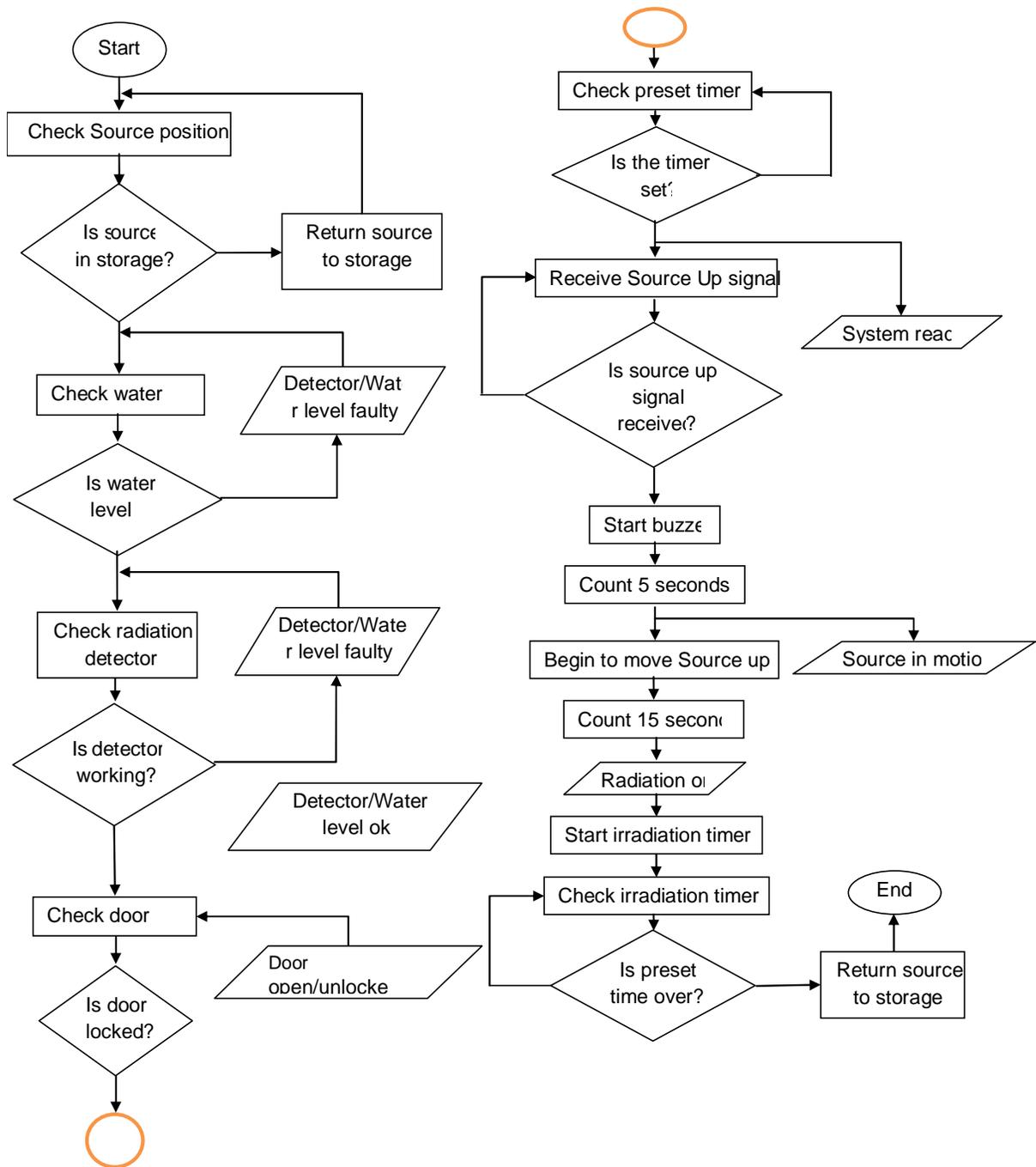


Figure 5. Flow Chart of the modeled automated gamma irradiator.

DOOR CLOSE: The door must be closed to give logic high, if not then a logic low.  
 DOOR LOCK: The door must be locked to give a logic high, if not then a logic low.  
 PRESET TIMER: It is used to set the desired radiation time.

SOURCE UP: It is used to start the radiation process.  
 EMERGENCY: It is used to immediately halt the radiation process, thereby sending the source from radiation level back to storage.  
 STANDBY: The PLC checks if the source is at storage, the detector/water level are okay, and give an output light

**Figure 6.** Pulse generator

indication.

**DOOR LOCK:** The door locked LED comes on when the door is locked.

**SYSTEM READY:** It comes on when the preset timer is set.

**BUZZER:** It gives an audible alarm when source is about to move.

**SOURCE IN MOTION:** It LED comes on when the source starts moving.

**RADIATION ON:** Comes on when the source is at radiation position.

### **Flow chart**

Operation Flowchart; shown in figure 4 is quite a comprehensive guide to the operator of the gamma irradiator. The operator uses feedback from the plc controller to assess operation status and take necessary action some of which are commands to the plc and others action to correct faults indicated by the plc through its outputs connected to the LEDs.

PLC program flowchart; this flowchart (Figure. 5) seeks to show what inputs the PLC receives and processes and the output signals it gives. Some of its inputs are the outputs of the detectors set up in the irradiator system for various functions – water level assessment, detector functionality, whether door is closed or locked, etc. Other inputs include command signals from manual switches which the operator actuates in order to effect particular actions required for the irradiation process – e.g. ‘source up’ switch which is actuated when the system checks are completed and certified by the PLC control system through one of its

LEDs. The output signals are used to light. It is based on this flowchart the program in figure 6 was written uploaded into PLC.

If source up fails then start the whole routine, but if source up responds then start radiation till the desired radiation time is over.

### **Pulse generator**

It used to generate an adjustable pulse. (Figure 6)

## **RESULTS AND DISCUSSION**

### **The explanation of the software**

The PLC responds to an input condition and switch on a particular output depending on the software program stored in its memory. The input conditions are: the main switch should be able to put the system on standby, detector/water level must be okay, the door must be closed and locked, the preset timer must be set to the desired radiation time.

The outputs are, the standby/ventilator LED, detector /water level okay LED, detector/water level faulty LED, source at storage LED, system ready LED, door locked LED, buzzer , source in motion LED, radiation on LED must respond to their respective inputs conditions

When the main/ventilator switch is pressed, the program starts running. The detector and the water level are fed in an AND Gate to give an output HIGH when the, detector/water level is okay. When detector or water level or any one of them is low, the detector/water level faulty

is indicated. Similarly, the door close and door lock are also fed into an AND Gate to give an output, which is the door locked indication. The

preset timer, source up, detector/water level okay and faulty are fed through an AND Gate and their output is inverted. In this case when detector/water level is faulty the source will not go up, likewise the door close and lock and as such no radiation. The on delay has its input from a flip flop; the signal at its input is delayed based on the program set time before an output is received. The two on delay timers controls the buzzer and source in motion time, whilst the two off delay timers controls the buzzer sounding time and the source motion time. The output of the off delay timers switches on and off at the set time.

The signal generator block is used to set the blinking time of the radiation ON LED and the buzzer beeping time. The buzzer beeps continuously when the source is in motion, but when radiation is on, it beeps intermittently, hence the two signal generators.

After developing the software program in functional block diagram, a simulation test was performed, and the program worked according to the control rules which have been written. When the program was transferred to the PLC it also worked as expected.

## Principles of operation

The principles of operation of the circuit diagram in Fig 2 are as follows. The operation mode serves for the automatic completion of the stated irradiation. After the irradiation time has been elapsed this mode sends the radiation sources into the storage position. Manual intervention is not possible except the EMERGENCY button.

With the main switched on, the system goes to standby, while it puts on the ventilator and then checks the detector and water level circuit. The power/ventilator Light Emitting Diode (LED) comes on together with the detector/water level LED and the source at storage LED.

When the door is closed and locked, two micro switches are activated and the door locked LED comes on. Preset timer is set to a desired radiation period to allow the system in ready state. Source up switch, when switched on, powers the buzzer for 10 seconds before the motor starts running. When motor running time is up the radiation ON LED comes on, the buzzer and the motor are then switched off. The source goes back to storage when preset time elapses. The emergency allows the source to immediately go back to storage.

The conditions that were met before the source to move to radiation position are:

1. The water should be at the appreciable level.
2. The detector circuit should be okay by checking with the standard source.
3. The source should be at storage.
4. The door should be closed and locked.
5. The preset timer should be set. (Operational Manual of SLL-02 Gamma Irradiation facility, 1993).

By using the modeled PLC-automation of the Gamma irradiator it was realized that the down time of the irradiator was reduced because PLC is robust device which can withstand harsh environmental conditions. To incorporate the design in the real system would just involve replacing the LED at the output pins with appropriate mechanical or solid state relay and also modification can be done at any time by just changing the program. Most samples for irradiation contain high level of moisture giving rise in the humidity level of the gamma environment. PLC-based automation could cope with wide range of ambient temperature and humidity.

Programming in functional block diagram is very easy as compared to other programming languages, but is limited when dealing with complex circuit diagrams. (Siemens Logo manual, 2005).

## CONCLUSION

A prototype PLC- automation of the Gamma irradiator has been successfully modeled and designed using the Siemens LOGO! PLC. The result shows PLC-based control system has significantly smaller control panel and because the PLC is robust, the durability of the control circuitry is not in doubt. Therefore, it can be confidently said, the down time of the facility would be reduced when the ICs based are replaced with the designed PLC based one.

In the near future works would be done on transportation of cells and vent.

## ACKNOWLEDGMENT

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