Automatic light regulating systems to minimize power consumptions

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Abstract

Operating light sources in the room consumes a lot of energy while it works at maximum power. During the day, when there is sufficient ambient lighting, tube lights are not required to operate at maximum output. By controlling the current supplied to the tube lights, we can save a great deal of energy. Previous projects have included light regulators that alter the light's intensity. When the lights are dimmed or brightened, the dimmer switches change the direction of the electrical flow. Always alternating between positive and negative, the flow of electricity automatically turns on or off the circuit. Other projects included automatically turning on or off the street lights based on the time of day (day time and night time). At night, the street lights remained off until they detected the presence of people or vehicles. In our project, we've created an automatic regulator that monitors the room's ambient lighting conditions. We have programmed both automatic and manual modes in our project. In manual mode, the user can adjust the light intensity to his liking. Whereas in automatic mode a threshold luminous value is set for the room. A photo cell monitors the room's brightness and transmits the information to the microcontroller. The microcontroller then determines whether the value exceeds the threshold. If this condition is met, the tube light remains off, otherwise, the regulator's resistance is varied until the threshold value is reached.

Keywords

Smart rooms, photocell, light regulators

Flow-Chart

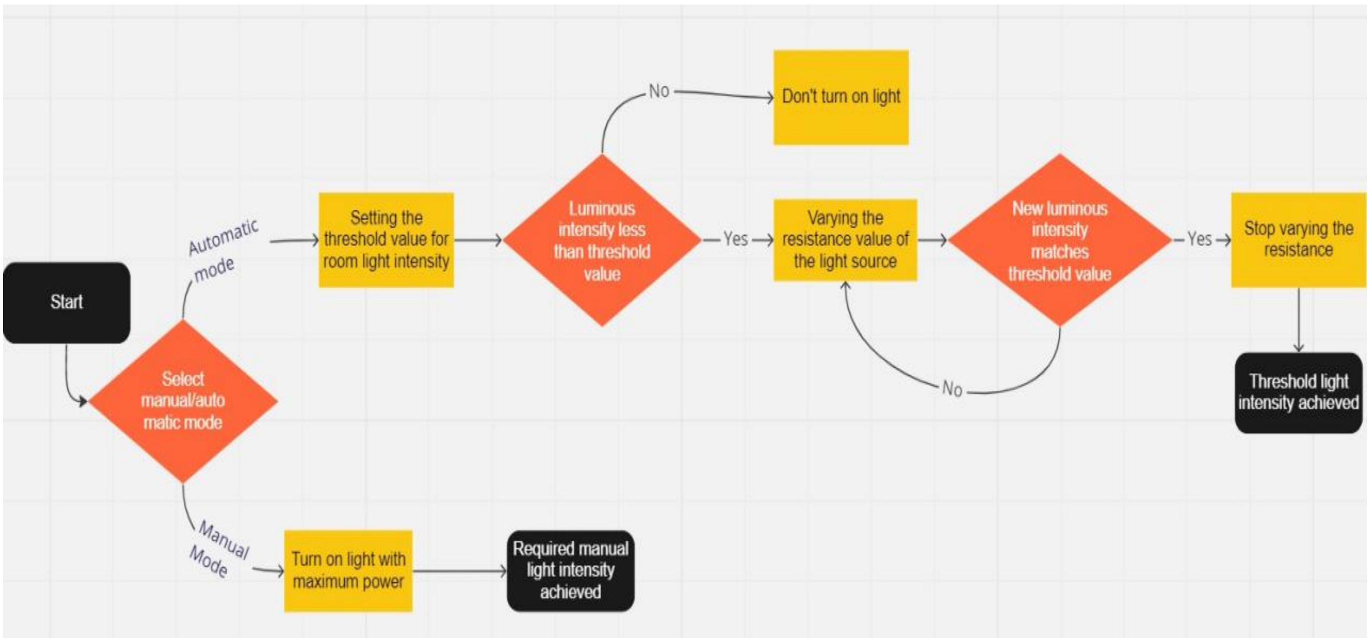

Fig. 1 Flow-chart of how light regulating systems work.

Introduction

An 8051 microcontroller is a very small computer like device which is integrated in various bigger embedded systems and devices such as various motors, sensors and appliances.

Due to the minimal size and cost, low latency, power efficiency and high reliability and robustness, microcontrollers have played a huge role in the automotive industry, consumer electronics, robotics, home applications and much more

We have created an ambient light regulator that consists of a luxmeter that detect the amount of natural light in a room and communicate with a controller that adjusts the brightness of the artificial lights accordingly. For example, if there is enough natural light in the room, the system may dim the lights or turn them off completely to save energy. Conversely, if the natural light is insufficient, the system may increase the brightness of the artificial lights to ensure that the room is well-lit.

An automatic light brightness room system can be particularly useful in spaces where natural light varies throughout the day, such as offices, classrooms, and homes with large windows. By automatically adjusting the light levels, the system can help reduce energy costs and create a more comfortable environment for occupants.

Methodology

Firstly, we tried to derive a relation between the power consumption of the tube light and illuminance. We set the optimum lighting conditions required for a classroom to 600 lux. Other necessary parameters are the area of the room, number of tube lights and lumen rating of each tube light. The lumen rating of each tube light is used to convert the illuminance delivered by each tube light per unit of power. The current brightness of the room is measured using a lux meter. The difference in the current brightness and the optimum brightness is calculated and it is used to power the tube lights accordingly.

In our project we have configured ports P1 and P3 as input ports. They are connected to the lux meter. The lux meter gives 16-bit number, which denotes the current brightness of the room in lux. This data is then processed in the microcontroller, where 16-bit subtraction and 16-bit division operations are done on the data and the parameters. The calculated result is the resistance value of the external circuit to change the power consumption of the tubelights. This data is sent to the externally connected digital potentiometer via port P0 and P2. The potentiometer manipulated the resistance thus changing the brightness (power of operation) of the tube lights.

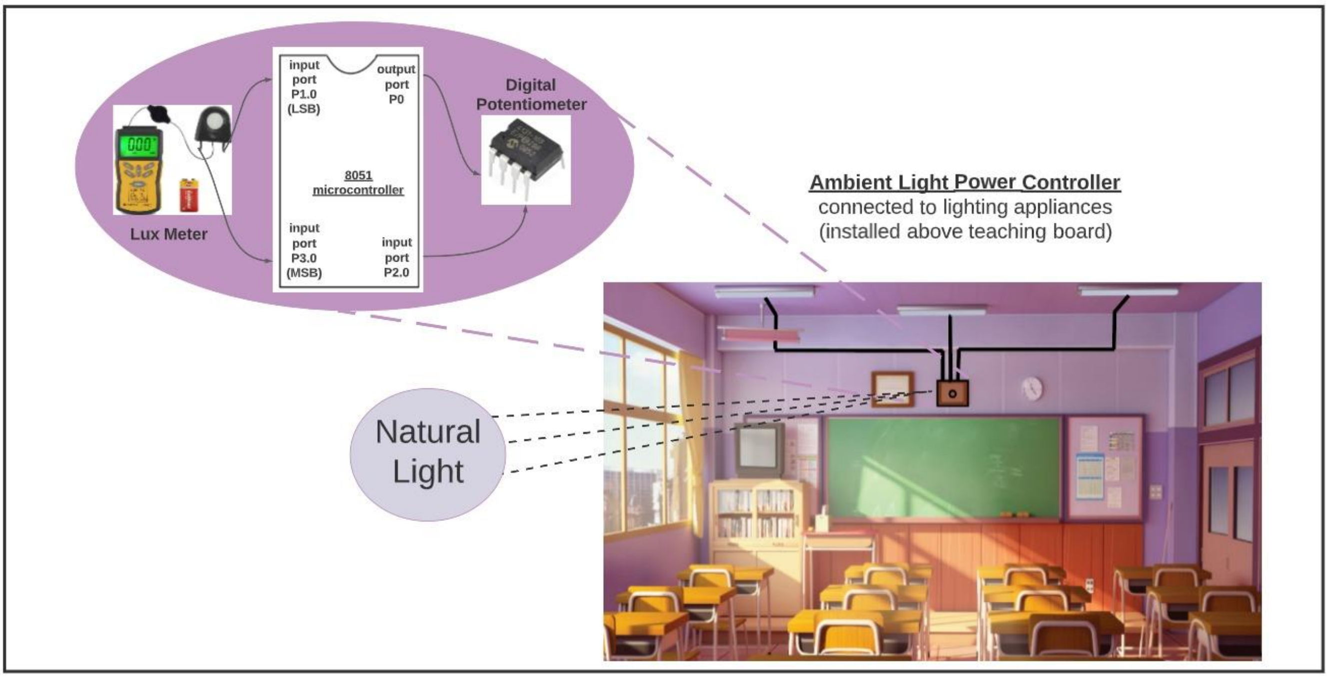

Fig. 2 A rough diagram of light regulating system is depicted

Calculation

Assuming the required brightness of room be B_0

$$B_0 = 600lx \tag{1}$$

Area of the room be A

$$A = l \times b = 5 \times 10 = 500m^2 \tag{2}$$

Lumen Rating of the tube light be T_r

$$T_r = 50lumen / watt \tag{3}$$

Number of tube lights $n = 4$ (4)

Let the current brightness of the room that got detected by the sensor be B. Therefore, the difference in brightness can be given by

$$B_0 - B = (600 - B)lx \tag{5}$$

Lumens required will be given by

$$(B_0 - B) \times A = (600 - B) \times 500 \tag{6}$$

Power required per tube light

$$P = \frac{(B_0 - B) \times A}{T_r \times n} \tag{7}$$

Substituting the values and simplifying it

$$P = \frac{(600 - B) \times 500}{50 \times 4}$$

$$P = (600 - B) \times 25 \tag{8}$$

Power P also has the formula

$$P = \frac{V^2}{R} \tag{9}$$

Resistance required per tube light can be given by

$$R = \frac{V^2}{P}$$

The voltage rating of the rooms is 220V. From (8)

$$R = \frac{220 \times 220}{(600 - B) \times 25}$$

$$R = \frac{1936}{(600 - B)} \tag{10}$$

The current brightness in the room (B) will be thus captured by the lux meter and is sent to the 8051 microcontroller. The microcontroller calculates the value of the required resistance (R) to be given to the tube light and sends the data to the digital potentiometer connected to each tube light.

Code

In **Fig. 3**, Port P1 and P3 are configured as input port, so as to receive the current brightness of the room through lux meter connected to ports. Using serial communication, the user gives input of choosing the mode on which the system should work.

Modes	Function
Mode 0	Manual
Mode 1	Automatic

In manual mode, the power supplied to the tube lights are max as the sensor is kept off. In automatic mode, the power is varied according to the brightness in the room.

```
ORG 0000H

MOV P1, #0FFH       ;LSB OF SENSOR
MOV P3, #0FFH       ;MSB OF SENSOR

;TO CHOOSE THE MODE FROM KEYBOARD UART
MOV TMOD, #21H      ;TIMER 1 MODE 2 -> SET THE BAUD RATE && TIMER 0 MODE 1 -> TIME DELAY
MOV TH1, #-3        ;BAUD RATE SET = 9600
MOV SCON, #50H      ;SERIAL COMM. MODE 1
HERE:SETB TR1
TRANSFER: JNB RI, TRANSFER
MOV A,SBUF          ;A HAS THE MODE. EITHER 0 OR 1
MOV R2, #48
SUBB A, R2          ;TO CONVERT ASCII TO NUMERAL
JZ MANUAL

;AUTOMATIC OR MODE 1:
SJMP CALC


;MANUAL OR MODE 0
MANUAL:
MOV P0, #00         ;TO SEND MAX POWER IN MANUAL MODE, SEND 0 RESISTANCE IN POTENTIOMETER
MOV P2, #00         ;TO SEND MAX POWER IN MANUAL MODE, SEND 0 RESISTANCE IN POTENTIOMETER
ACALL DELAY
CLR A
SJMP HERE
```

Fig 3. Code for taking input of mode and sensor

```
;CALCULATION OF SENDING RESISTANCE VALUE FOR AUTOMATIC MODE
CALC:
;SUBTRACTION
MOV 20H, #58H
MOV 30H, #02H
MOV 40H, P1          ;LSB OF SENSOR
MOV 50H, P3          ;MSB OF SENSOR
CLR C
MOV A, 20H
SUBB A, 40H
MOV 60H, A          ;LSB AFTER SUBTRACTION
MOV A, 30H
SUBB A, 50H
MOV 70H, A          ;MSB AFTER SUBTRACTION

MOV R0,#90H         ;36
MOV R1,#07H         ;19   (220 X 220) = 1936
MOV R3,70H
MOV R2,60H
```

Fig 4. Code for calculation (1)

```
;DIVISION
UDIV16: MOV R7, #0  ;CLEAR PARTIAL REMAINDER
MOV R6, #0
MOV B, #16          ;SET LOOP COUNT
DIV_LOOP: CLR C     ;CLEAR CARRY FLAG
MOV A, R0           ;SHIFT THE HIGHEST BIT OF
RLC A               ;THE DIVIDEND INTO...
MOV R0, A
MOV A, R1
RLC A
MOV R1, A
MOV A, R6           ;THE LOWEST BIT OF THE
RLC A               ;PARTIAL REMAINDER
MOV R6, A
MOV A, R7
RLC A
MOV R7, A
MOV A, R6           ;TRIAL SUBTRACT DIVISOR
CLR C               ;FROM PARTIAL REMAINDER
SUBB A, R2
MOV DPL, A
MOV A, R7
SUBB A, R3
MOV DPH, A
CPL C               ;COMPLEMENT EXTERNAL BORROW
JNC DIV_1           ;UPDATE PARTIAL REMAINDER IF BORROW
MOV R7, DPH         ;UPDATE PARTIAL REMAINDER
MOV R6, DPL

DIV_1: MOV A, R4    ;SHIFT RESULT BIT INTO PARTIAL
RLC A               ;QUOTIENT
MOV R4, A
MOV A, R5
RLC A
MOV R5, A
```

Fig 5. Code for calculation (2)

```
DJNZ B, DIV_LOOP
MOV A, R5           ;PUT QUOTIENT IN R0, AND R1
MOV R1, A
MOV A, R4
MOV R0, A
MOV A, R7           ;GET REMAINDER, SAVED BEFORE THE
MOV R3, A           ;LAST SUBTRACTION
MOV A, R6
MOV R2, A


MOV P2, R0          ;TRANSFER REQUIRED RESISTANCE (LSB) TO DIGITAL POTENTIOMETER
MOV P0, R1          ;TRANSFER REQUIRED RESISTANCE (MSB) TO DIGITAL POTENTIOMETER

ACALL DELAY
CLR A
SJMP HERE


;TIME DELAY OF 9 SECONDS
DELAY:
MOV 25H,#0FFH
LOOP:
MOV TL0,#00H
MOV TH0,#00H
SETB TR0
AGAIN: JNB TF0, AGAIN
CLR TF0
CLR TR0
DJNZ 25H,LOOP
CLR TF0
CLR TR0
RET

END
```

Fig 6. Code for calculation (3) and Time delay of 9 seconds

Fig. 4, **Fig.** 5, **Fig.** 6 has the code that calculates the value of resistance. **Fig.** 6 also contains a time delay of 9 seconds. Thus, after every 9 seconds, the new resistance for the updated lumens in the room is calculated and sent to the potentiometer.

Result and Observation

Assume the following data is used for testing of the code.

Mode	Luxmeter value (input)	Resistance value (output)
Mode 1	$(012C)_{16}$ or 300	$(0006)_{16}$ or 6
Mode 1	$(01F6)_{16}$ or 500	$(0013)_{16}$ or 19
Mode 0	-	$(0000)_{16}$ or 0

First, the value of luxmeter is fed into port P1 and P3. The mode is selected by giving the value 0 or 1 into the UART.

After the delay of 9 seconds, the resistance value is displayed in port P0 and P2. If another input is given the resistance thus changes in the next 9 seconds. Fig. 7 and 8 shows the value of resistance in Mode 1.

To change the mode, the code has to be run again. 0 is fed to the UART and the resistance is displayed in P0 and P2 shown in Fig. 9.

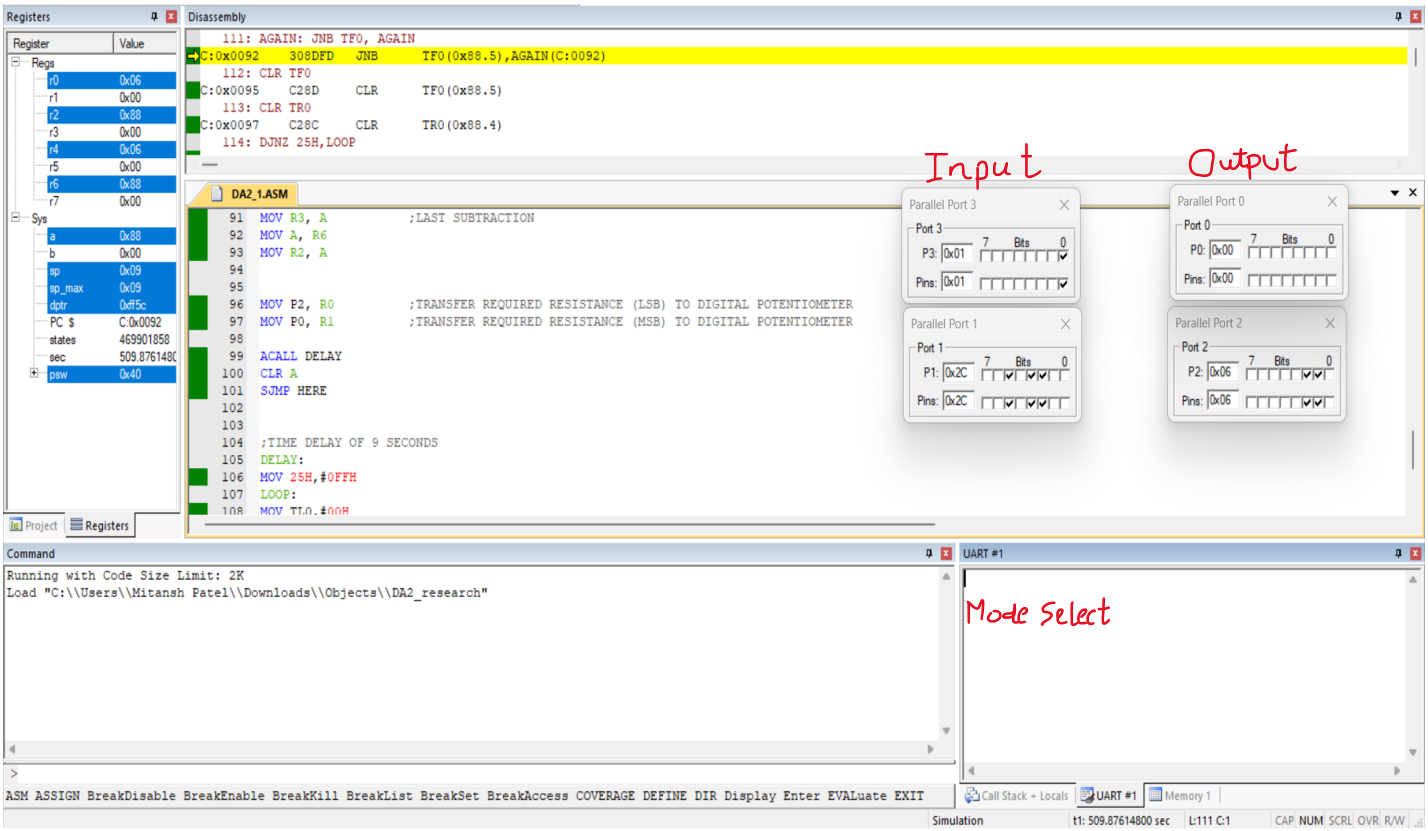

Fig. 7 Simulation of Mode 1 when luxmeter input is 012C in Keil µVision

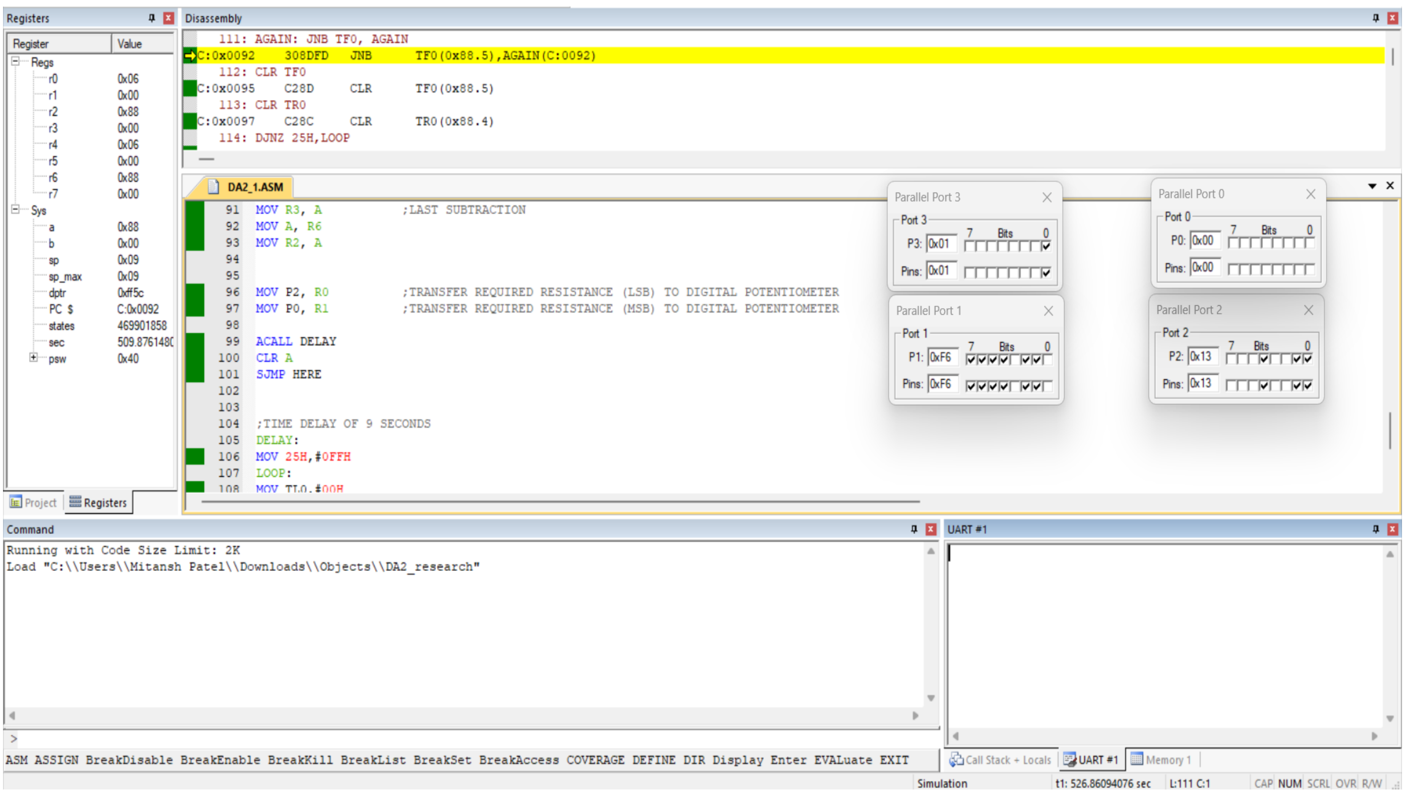

Fig. 8 Simulation of Mode 1 when luxmeter input is 01F6 in Keil µVision

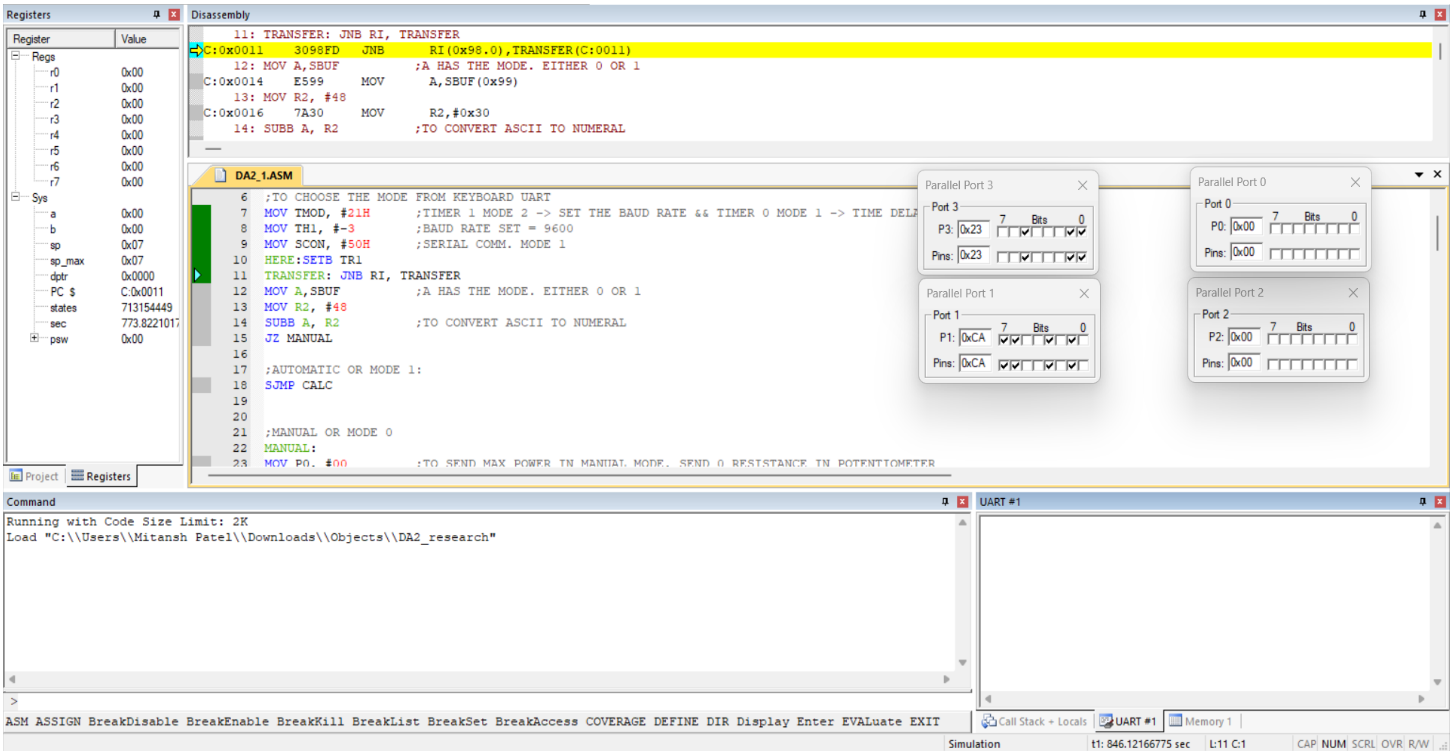

Fig. 9 Simulation of Mode 0

Conclusion

We observed that when the luxmeter showed a value of 500 lux the resistance was adjusted to 19.36 ohms and showed similar changes in resistance with varying values of luxmeter

hence we have created a sustainable method for the conservation of light energy resources by the help of light sensors and microcontroller.