STEMSEL LCD Project 4 : Radiation Counter

Problem

When we are in an environment with radiation, we want to make sure the level of the radiation is in the safe range. What can we do to determine the radiation level?

Background

When we think about radiation, we often think of things like nuclear weapons and accidents like those at the Chernobyl or Fukushima nuclear reactors. However, low levels of radiation are all around us every day, from the sun to building materials and even in our food! Brazil nuts and bananas are two foods quite well known for being slightly radioactive. Don't worry about eating too much of such foods though; you could not eat enough of them to cause any health problems (You should always try and eat a good amount of fruit anyways!).

Radiation is also very useful in many applications; many smoke detectors use a tiny amount of radioactive Americium to detect the smoke. Radiation is often used in medicine as well, including in the treatment of some cancers and viewing the inside of the body using X-rays (radiography), radio-opaque dyes, and nuclear medicine procedures. Radioactive substances can also be used in scientific research. Radiography is also used in many industries for quality control or to analyse the internal working of machinery. We also use radioactive elements to power nuclear power plants, submarines and satellites. The Curiosity Mars rover is not only powered by radioactive elements, but also uses them for analysing rock and soil samples it finds on the red planet.

However, radiation can be very dangerous for living things. The effects on the human body of receiving too much radiation vary, depending on which areas of the body were exposed and how much radiation was absorbed. Radiation damages and kills the cells that make up our bodies, and may therefore cause burns (sunburn is caused by UV radiation), loss of white blood cells, haemorrhaging (bleeding), fatigue and weakness, and even cancer. If radiation damages vital organs like the brain, heart, lungs, digestive tract etc., then the effects will be more severe than if only the surface of your skin or your hand was affected.

Despite these dangers people must sometimes enter dangerous radioactive zones. For example, people cleaning up the areas around the Fukushima nuclear reactor in Japan. Or when working in places where radioactive compounds are used or stored such as a research centre or even in outer space. They often carry measuring devices like Geiger counters to help them measure how much radiation they have been exposed to. It is important to consider the level of radiation they have been exposed to, as well as the length of time they were exposed. If there was only a low radiation level, you could stay in the area for a longer time without any negative effects than if the radiation level was higher. For today's project, we will implement a counter to keep track of the total amount of radiation we have been exposed to. We will be using a safer type of radiation though, simply measuring the amount of light.

Note: Yes, (visible) light is a type of radiation. Much like radio waves, microwaves, infrared and x-rays are all radiation and are part of the electromagnetic spectrum. The danger in radiation generally comes with how short the wavelength for the type is. Types with longer

wavelengths such as radio waves are safer than gamma waves or x-rays, which have significantly shorter wavelengths and have more energy per packet of light.

Ideas
How can we measure the radiation (light) level? How can the microchip tell the user if the level is high or low? How can we make our device count up faster the more radiation is detected? Is a visual warning like the LCD enough, or would additional method be advantageous? What kind of thresholds might be good? Is there any other information that might be good to display on our LCD?

Plan
We can use a LDR as our light sensor, and display the level on the LCD. A buzzer and LED can also be used and made to flash/beep faster the more radiation is detected. This means the user doesn't have to be constantly looking at the screen, and can concentrate on their task and surroundings. This is why Geiger counters make their recognizable clicking sound.
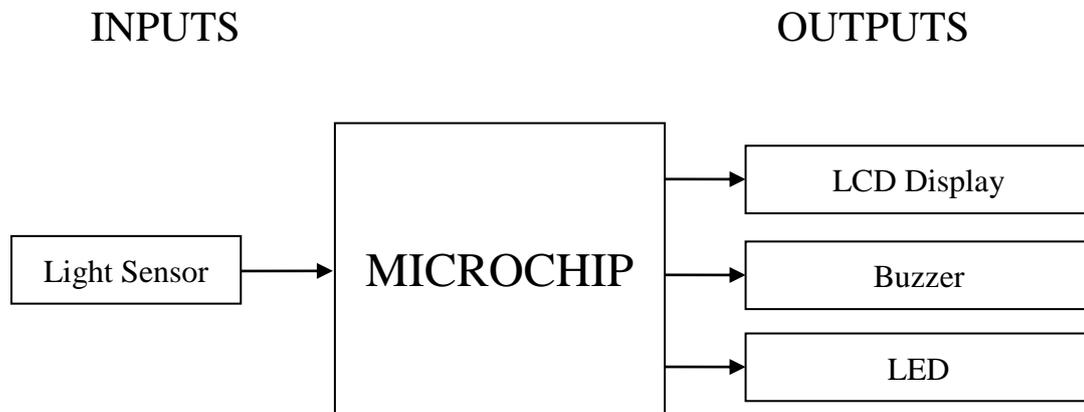
INPUTS   OUTPUTS

Figure 1: Inputs and Outputs

When programming, we will need several different threshold levels, and to vary the beep/flash rate accordingly as the light level increases past them. We need to consider what may be good ranges for these.
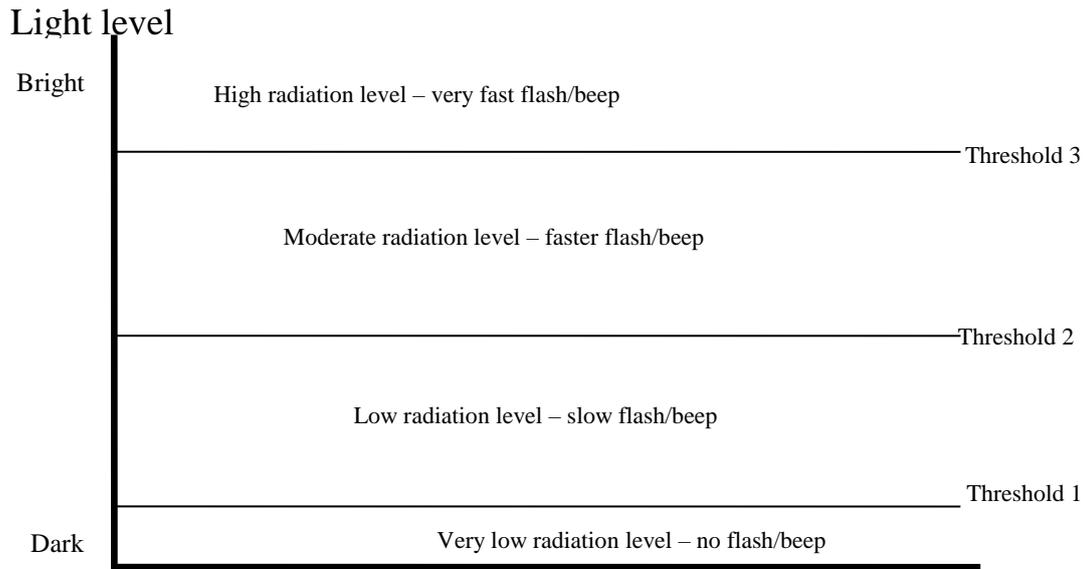
Light level

Figure 2 – threshold diagram

Design

Begin a new STEMSEL project in ezCircuit Designer and add a LDR light sensor and rename it Rad_Detector, an LCD, a buzzer and an LED to the design, as specified in our plan. The completed design should look like the following:
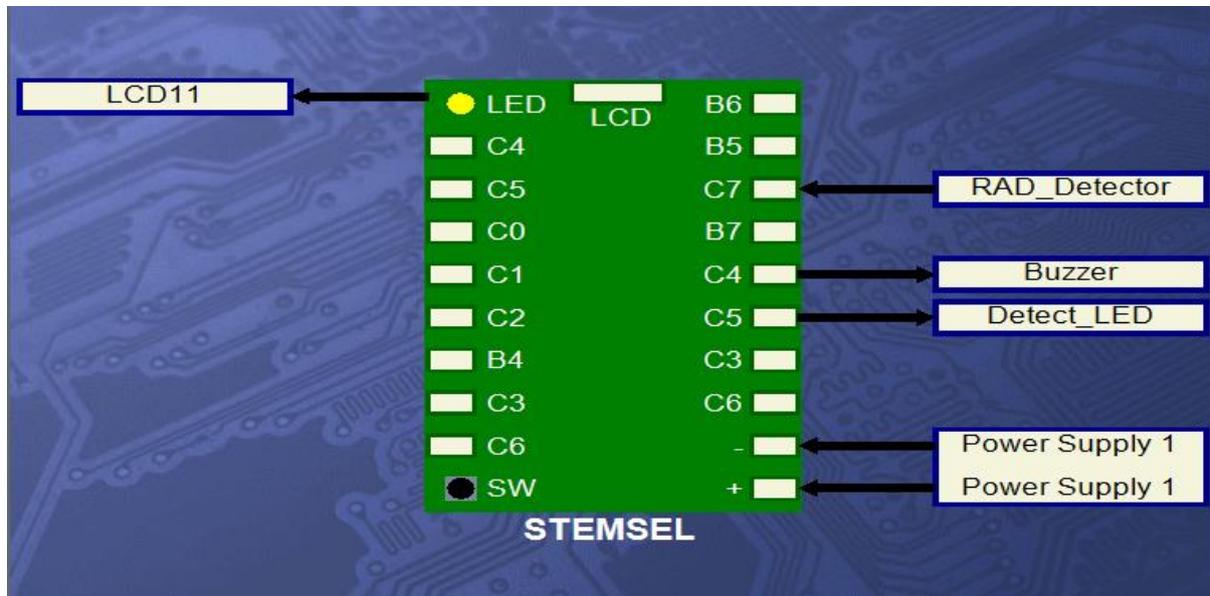

Figure 3: Circuit Design

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Build

Now, it's time to assemble the circuit using the kit. Put all of the black wires into the negative (-) port and insert the red lead of the light sensor into the positive (+) port. The white wires go into the ports specified in the design. The LCD connects to the 10-pin connector near the top of the STEMSEL Controller board.
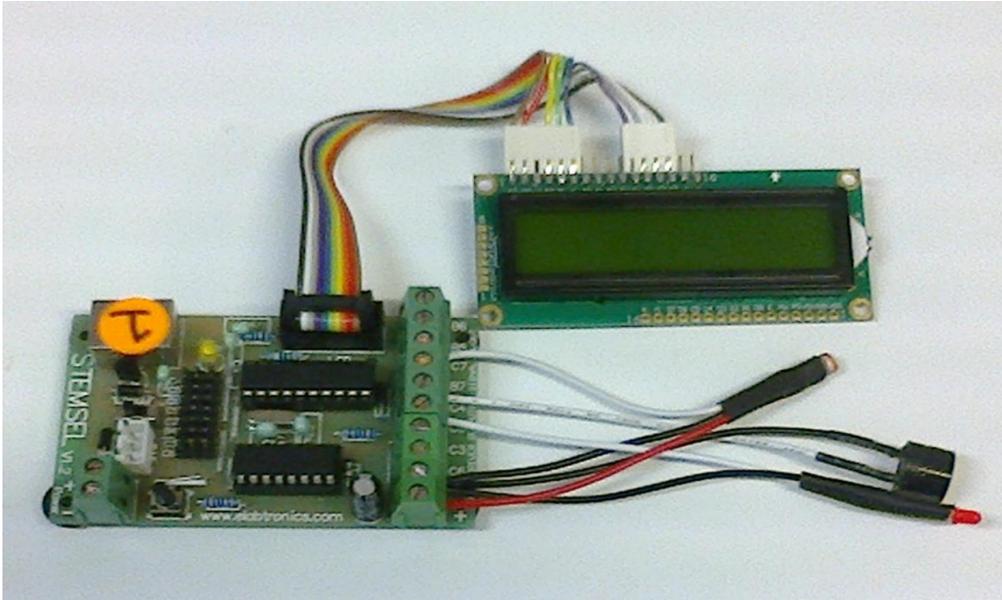

Figure 4: Circuit

Programming

Once the circuit has been assembled, send the design to CoreChart by clicking the "Send to CoreChart" button, and then send the generated test program to the STEMSEL controller board by clicking the "Send Program To Chip" button. Once you have verified that the outputs are working, delete the test routines so we can start writing our program.

1. Our first step is to set up our counting variable. Use a Set_Number icon to set a variable called Rad_counter to 0.

2. We do not want to reset this variable every time we loop through our program, so create an address called Check_Loop.

3. Use an Analog_In icon to check the Rad_Detector, saving the value as Rad_Level.

4. Use a Compare icon to check if the Rad_Level is below 0.25V. If so, there is minimal radiation and we can leave our buzzer and LED off. Group these together to "No_Radiation" so that they fit under the decision.

5. Use a CompBetween icon to see if the Rad_Level is between 0.25V and 1.5V. This will be our low radiation range, so we will use OnOffPin and TimeDelay icons to flash the LED and beep the buzzer using 1 second time delays. We will also use an Add icon to add one to our Rad_Counter. Don't forget to group the OnOffPin, Timedelay and Add icons together into a group so they fit beneath the decision.

6. Now we will do the same for the medium range, using a CompBetween to see if the Rad_Level is between 1.5V and 3V, adding 1 to our Rad_Counter, and flashing the LED and beeping the buzzer, this time using a delay of 50 hundredths.

7. Finally, add the high radiation level by using a Compare icon to see if the radiation level is above 3V. Increment the Rad_Counter, flash the LED and beep the buzzer with time delay of 25 hundredths.

8. Display the value of your Rad_Counter on the LCD, first by using a LCDFormat icon to clear the LCD using the default 1/3sec delay, then adding a DispNumberLCD iconto display Rad_counter.

9. Finally, add a GoTo icon to return to the Check_Loop address we added before. Send the program to the microchip and test it with various light levels.
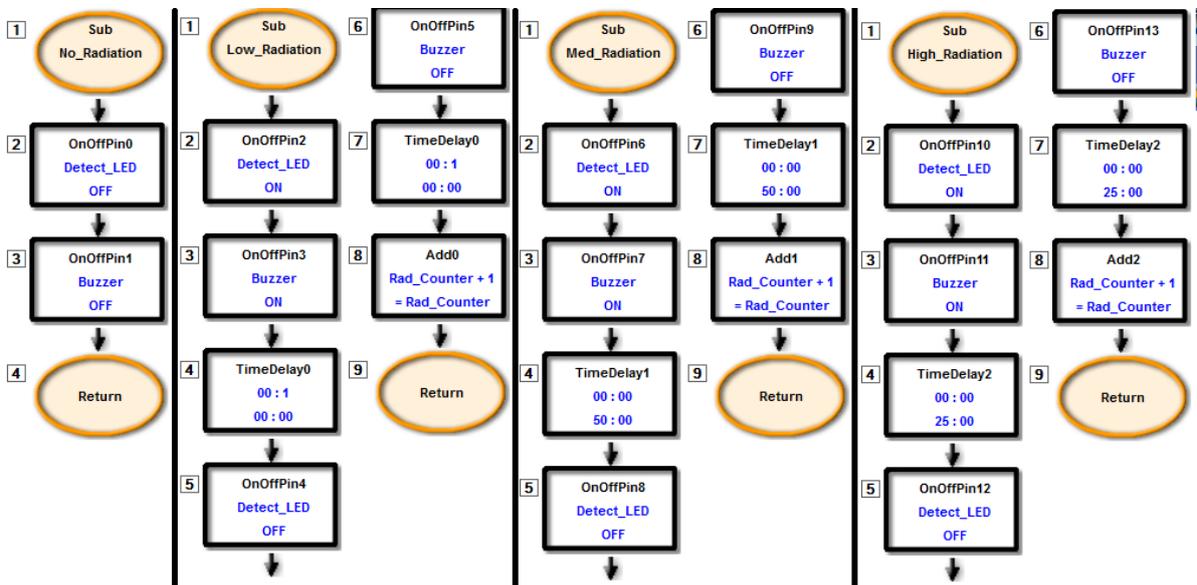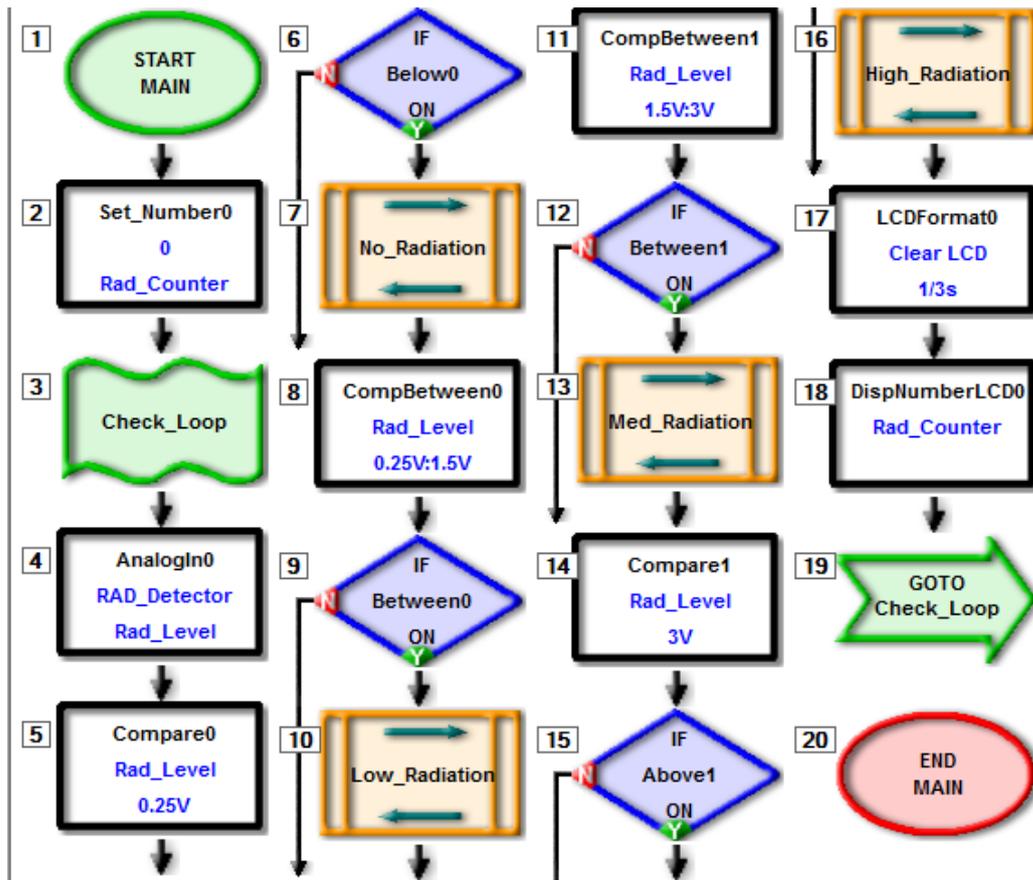
Figure 5: Initial Program with Groups

For our project, people can only work in the irradiated zone until a count of 100. Once the device reaches that count, it should inform the user to leave, while also continuing to monitor the radiation level and count.

1. After displaying the radiation count use a Compare icon to check if Rad_Counter is above 99.
2. If so, we need to use an LCDFormat icon to move the cursor to the second line, then place an LCDMessage icon to display an appropriate message on the LCD, like "Leave NOW".
3. Keep in mind that the LCD can only display 16 characters right now. Don't forget to group these into a group called "Limit Reached" so they fit beneath the decision.
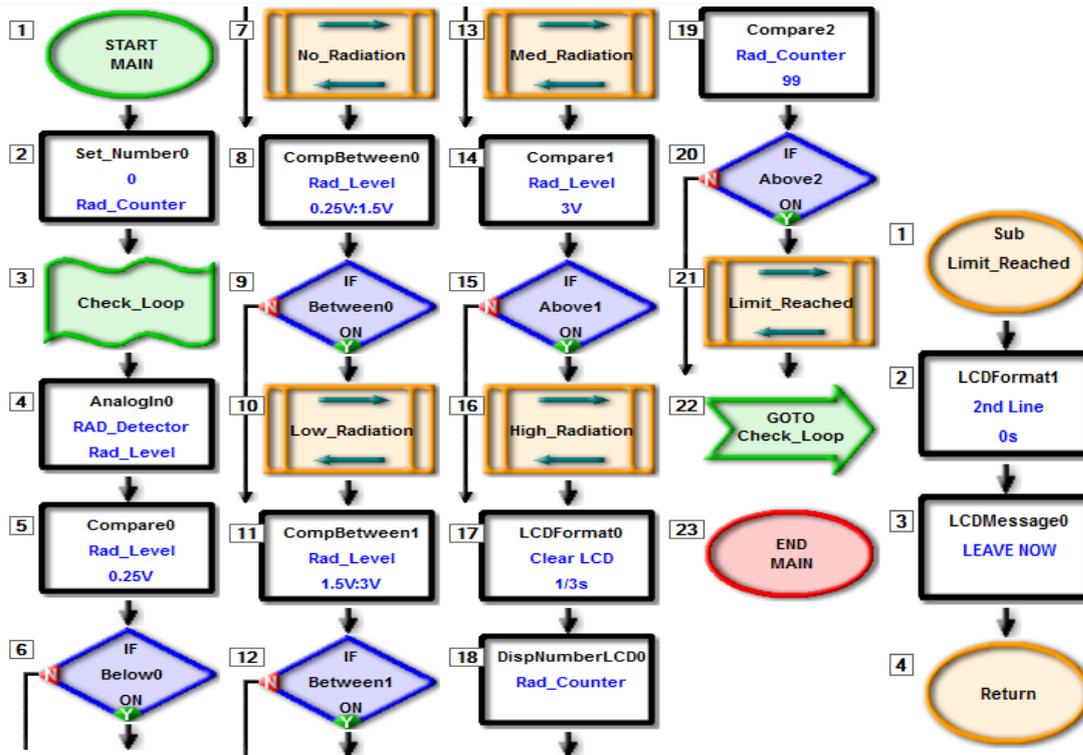

Figure 6: Final Program with Danger Message

Extensions

Can you think of further improvements for our device? These may include:
- Adding additional warning levels, for example "Warning" at a count of between 80 and 90, and "Prepare to leave" at a count of between 90 and 100.
- Add an extra warning if the radiation level detected by the light sensor goes too high. For example, display "Get back" or "Danger" if the level goes above 3V. (i.e. if the radiation level is in our High_Radiation zone)
- Use the buzzer or LED to also warn the user that they need to leave the irradiated area.

Summary

We are surrounded by radiation every day and although it is useful, radiation can cause serious and ongoing health problems. We need to be careful of how much radiation we are exposed to, so people working in areas with high radiation need to monitor their exposure with devices similar to the one we made in this project.

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