LDR_Light_Switch1 -- Overview

Mukesh Soni
Product Marketing Manager
Basic Scopes Product Line
Tektronix

Tektronix

OBJECTIVES

After performing this lab exercise, learner will be able to:

- Understand the functionality of Light Dependent Resistor (LDR)
- Use LDR (Light Dependent Resistor) to measure the light intensity variation in terms of voltage at the LDR output
- Program Arduino board to digitize and capture voltage across LDR
- Relate the digitized value of voltage across LDR with value measured on oscilloscope
- Use digital oscilloscope to:
  - Measure the signal amplitude
  - Trigger on input channel

EQUIPMENT

To carry out this experiment, you will need:

- TBS1KB-Edu Digital Oscilloscope from Tektronix
- Arduino Duemilanove or Uno board
- Voltage probe (provided with oscilloscope) / BNC cables
- Breadboard and connecting wires
- Simple circuit components – LDR, Resistor 10k Ohms


THEORY

Key points:

- A photoresistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits.
- A photoresistor or light-dependent resistor (LDR) or photocell is a light-controlled variable resistor.
- A photoresistor is made of a high resistance semiconductor. In the dark, a photoresistor can have a resistance as high as a few megaohms (MΩ), while in the light, a photoresistor can have a

resistance as low as a few hundred ohms.

- If incident light on a photoresistor exceeds a certain frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electrons (and their hole partners) conduct electricity, thereby lowering resistance.
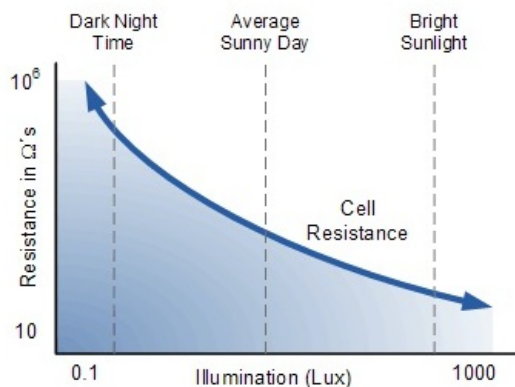
- Change in resistance can be converted in to voltage variation by voltage divider implemented using LDR and a fixed resistor.

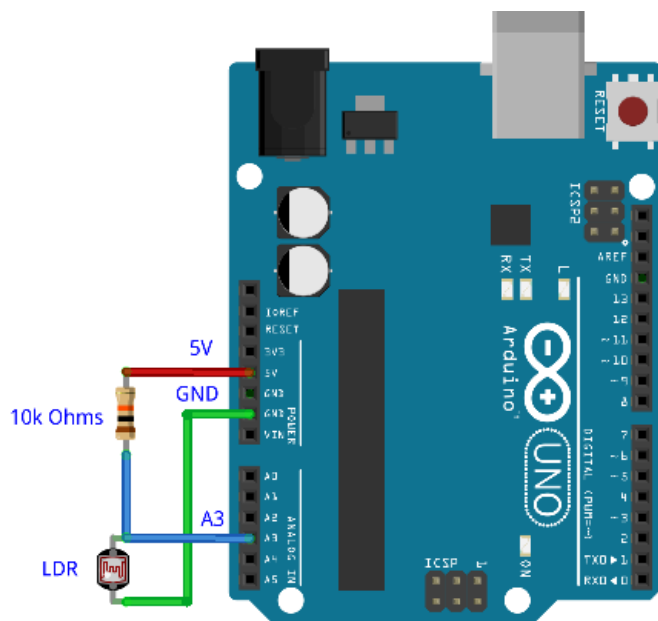$$V_{out} = V_{in} \times \frac{R_{LDR}}{R + R_{LDR}}$$
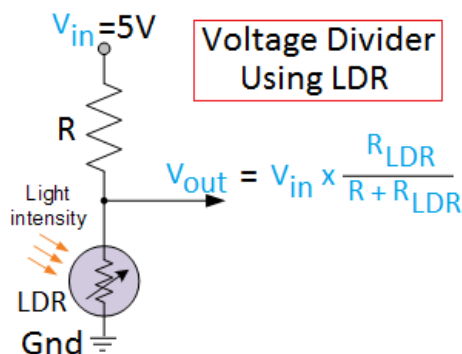
- The voltage across LDR can be measured using oscilloscope or digitized/recorded using Arduino - The voltage is proportional to darkness (%) -
  - ~5V = 100% darkness
  - ~0V = 0% darkness

LDR_Light_Switch1 -- Procedures

Step 1

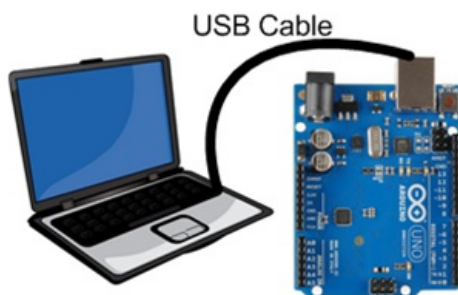### DUT Setup: Arduino-LDR Circuit

Prepare the circuit (using LDR, Resistor and Arduino) as shown below:

Step 2

DUT Setup: Connecting Arduino with Computer

- Connect the Arduino to computer using USB cable.

- Launch Arduino IDE and ensure correct USB port number and Board name for establishing the connection.

Step 3

DUT Setup: Programming Arduino

- Program the Arduino board with code - "Ligh_Switch_1.ino"
- Once the program is uploaded and running on Arduino, open serial monitor


```
LDR Output: 701 | Volts =  3.27 | Darkness =  68 % | Brightness =  32 %
LDR Output: 701 | Volts =  3.27 | Darkness =  68 % | Brightness =  32 %
LDR Output: 701 | Volts =  3.27 | Darkness =  68 % | Brightness =  32 %
LDR Output: 701 | Volts =  3.27 | Darkness =  68 % | Brightness =  32 %
LDR Output: 701 | Volts =  3.27 | Darkness =  68 % | Brightness =  32 %
LDR Output: 701 | Volts =  3.27 | Darkness =  68 % | Brightness =  32 %
LDR Output: 701 | Volts =  3.27 | Darkness =  68 % | Brightness =  32 %
```

Step 4

Scope and DUT Connection:

Connect channel 1 of the oscillosocope to LDR output. Probe at A3 pin of Arduino.

Step 5

Scope Settings: Horizontal / Vertical Scale & Trigger

Do autoset (or manually set) and ensure following settings:

- Horizontal scale 1ms/div
- Vertical scale 1V/div
- Vertical position at -3V (-3 divisions)

Step 6

Scope Settings: Measurements

Using 'measure' menu, add following measurements to CH1:

- RMS
- Mean
- Maximum

Step 7

Check the measurement value on the oscilloscope and compare it with "Volts" value on the serial monitor. The value in "Volts" should match the "Mean" value reported by oscilloscope.

Step 8

Change the light intensity around LDR - Cover the LDR to increase darkness. Again check the measurement value on the oscilloscope and compare it with "Volts" value on the serial monitor. The value in "Volts" should match the "Mean" value reported by oscilloscope.

Step 9

You can verify the output of LDR (readings on scope and Serial Monitor) matches for different light conditions around LDR.

LDR_Light_Switch2 -- Overview

Mukesh Soni
Product Marketing Manager
Basic Scopes Product Line
Tektronix

Tektronix

OBJECTIVES

After performing this lab exercise, learner will be able to:

- Use LDR (Light Dependent Resistor) to measure the light intensity variation in terms of voltage at the LDR output
- Program Arduino board to:
    - Digitize and capture voltage across LDR
    - Compare it against a fixed threshold and
    - Switch a relay / LED connected to a digital output pin
- Use digital oscilloscope to:
    - Trigger on input channel
    - Measure the signal amplitude
   - Measure delay using cursors

EQUIPMENT

- To carry out this experiment, you will need:
- TBS1KB-Edu Digital Oscilloscope from Tektronix
- Arduino Duemilanove or Uno board
- Voltage probe (provided with oscilloscope) / BNC cables
- Breadboard and connecting wires
- Simple circuit components – LDR, Resistor 10k/470 Ohms, LEDs

THEORY

Key points:

- LDR changes its resistance based on the light intensity incident on it. Higher the light, lower will be resistance and vice versa.

- Change in resistance can be converted in to voltage variation by voltage divider implemented using LDR and a fixed resistor.

Voltage Divider Using LDR

$$V_{out} = V_{in} \times \frac{R_{LDR}}{R + R_{LDR}}$$
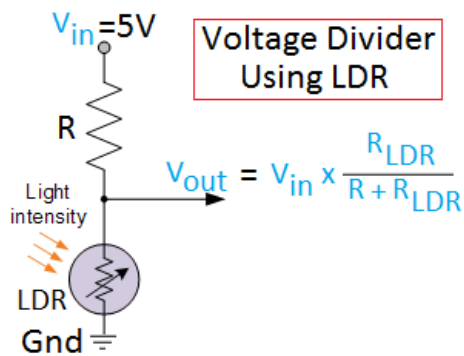
- The voltage across LDR can be measured using oscilloscope or digitized/recorded using Arduino - The voltage is proportional to darkness (%) -
  - ~5V = 100% darkness
  - ~0V = 0% darkness
- We can define a fixed 'darkness' threshold (in volts or ADC levels) for switching. If the LDR output crosses this level, Arduino should turn one of its digital pin ON (High).
- An LED or relay can be used at the digial output pin for indicating switching action.

LDR_Light_Switch2 -- Procedures

Step 1

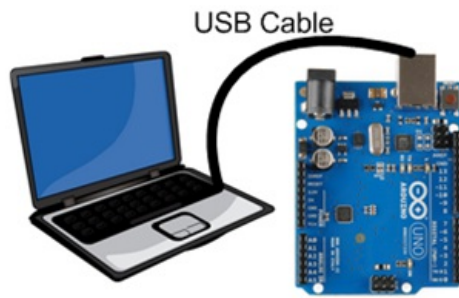## DUT Setup: Arduino-LDR Circuit

Prepare the circuit (using LDR, Resistor and Arduino) as shown below:
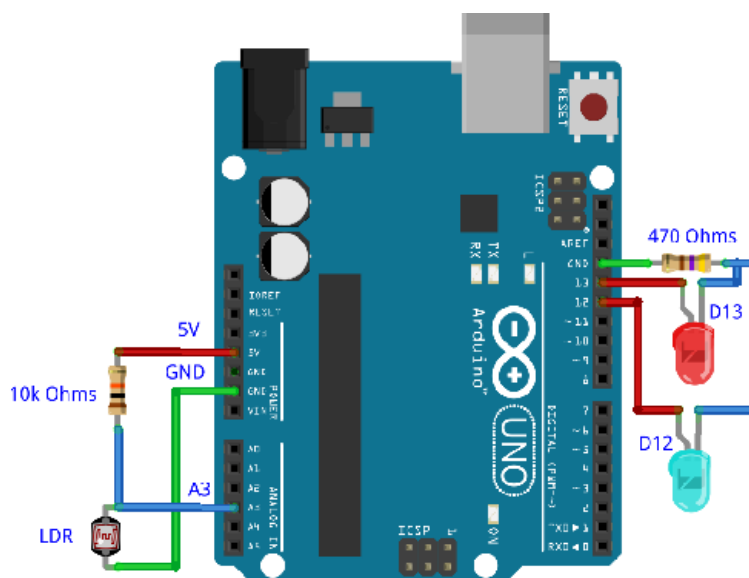
Step 2

DUT Setup: Connecting Arduino with Computer

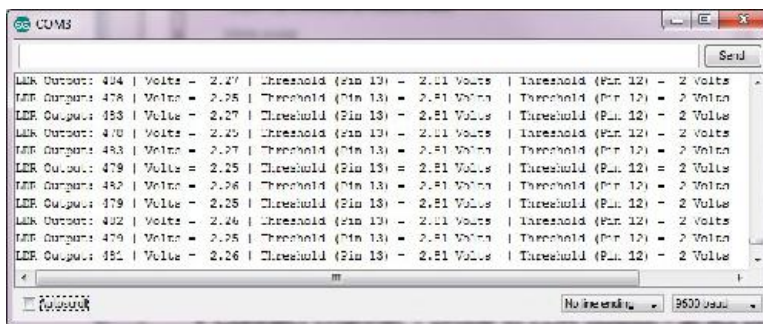- Connect the Arduino to computer using USB cable.

USB Cable

- Launch Arduino IDE and ensure correct USB port number and Board name for establishing the connection.

Step 3

DUT Setup: Programming Arduino

- Program the Arduino board with code - "Ligh_Switch_2.ino"
- Once the program is uploaded and running on Arduino, open serial monitor

- Read the Threshold level for LEDs connected at Pin 12 and Pin 13 of Arduino.

Step 4

Scope and DUT Connection:

- Connect channel 1 probe to LDR output - at A3 pin of Arduino.
- Connect channel 2 probe to pin 13 (digital output) of Arduino

Step 5

Scope Settings: Horizontal / Vertical Scale & Trigger

Do autoset (or manually set) and ensure following settings:

- Horizontal scale = 50 ms/div
- Channel 1:
  - Vertical scale = 1V/div
  - Vertical position = -2V (-2 divisions)

- Channel 2:
    - Vertical Scale = 1V/div
    - Vertical Position = -3 div
- Edge Trigger on CH2, Trigger level = 2.5V
- Single Trigger

Step 6

Scope Settings: Measurements

Using 'measure' menu, add following measurements to CH1:

- RMS
- Mean
- Maximum

Step 7

- Press SINGLE from front panel on the scope
- Vary the light condition around LDR till the LED on pin 13 glows -- start with higher light and then reduce it to create darkness.

Step 8

- Verify that when CH1 (LDR output) crosses the threhsold of 2.81V (same as trigger level), the LED on Pin 13 glows and voltage goes to 5V (low to high transition)

Step 9

- Do you see a delay between CH1 (LDR output) crossing the threshold of 2.81V and CH2 (LED on Pin 13) making Low to High transition?
- Using vertical (time) cursors, measure this delay.
- Can you tell why is this delay?

Step 10

- The delay is caused due to 'Serial.Print' code in the program - Serial writing takes sometime and hence causes the delay.
- Next, comment all the serial printing code and re-run the program on Arduino.
- Repeat the steps 7-9.
- Does the delay vanish now?

Step 11

Modify the probing point:

- Connect channel 1 probe to LDR output - at A3 pin of Arduino.
- Connect channel 2 probe to pin 12 (digital output) of Arduino

Step 12

- Verify the switching for another LED connected to Pin12, having a different threshold (2V).
- Again aquire signal (SINGLE acquisition) while you vary the light condition around LDR till LED on pin 12 glows -- start with higher light and then reduce it to create darkness.

Step 13

- You can play around with changing light intensity around LDR and you would see the LED flashing the moment LDR output crosses the threshold. Take a screenshot of it.
- Verify the switching against threshold crossing.

LDR_Light_Switch3 -- Overview

Mukesh Soni
Product Marketing Manager
Basic Scopes Product Line
Tektronix

Tektronix

OBJECTIVES

After performing this lab exercise, learner will be able to:

- Use LDR (Light Dependent Resistor) to detect light intensity variation and detect threshold crossing
- Define threshold dynamically using a potentiometer
- Program Arduino board to:
    - Digitize and capture voltage across LDR
    - Read another analog input to comparision with LDR output
    - Switch a relay / LED connected to a digital output pin
- Use digital oscilloscope to:
    - Trigger on input channel
    - Measure the signal amplitude
    - Work with reference waveforms

EQUIPMENT

To carry out this experiment, you will need:

- TBS1KB-Edu Digital Oscilloscope from Tektronix
- Arduino Duemilanove or Uno board
- Voltage probe (provided with oscilloscope) / BNC cables
- Breadboard and connecting wires
- Simple circuit components – LDR, Resistor 10k & 470 Ohms, LEDs and Potentiometer 100K ohms

THEORY

Key points:

- LDR changes its resistance based on the light intensity incident on it. Higher the light, lower will be resistance and vice versa.
- Change in resistance can be converted in to voltage variation by voltage divider implemented using LDR and a fixed resistor.

Voltage Divider Using LDR

$V_{in} = 5V$

$V_{out} = V_{in} \times \dfrac{R_{LDR}}{R + R_{LDR}}$
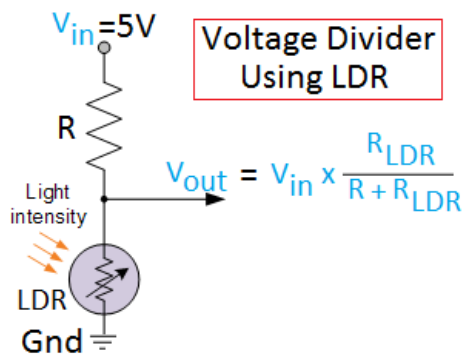
- The voltage across LDR can be measured using oscilloscope or digitized/recorded using Arduino - The voltage is proportional to darkness (%).
- We can dynamically provide 'darkness' threshold (in volts or ADC levels) using another potentiometer for switching. If the LDR output crosses this level, Arduino should turn one of its digital pin ON (High).
- An LED or relay can be used at the digial output pin for indicating switching action.

LDR_Light_Switch3 -- Procedures

Step 1

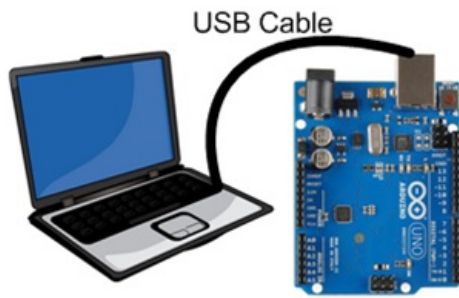### DUT Setup: Arduino-LDR Circuit

Prepare the circuit (using LDR, Resistor, Potentiometer, LEDs and Arduino) as shown below:
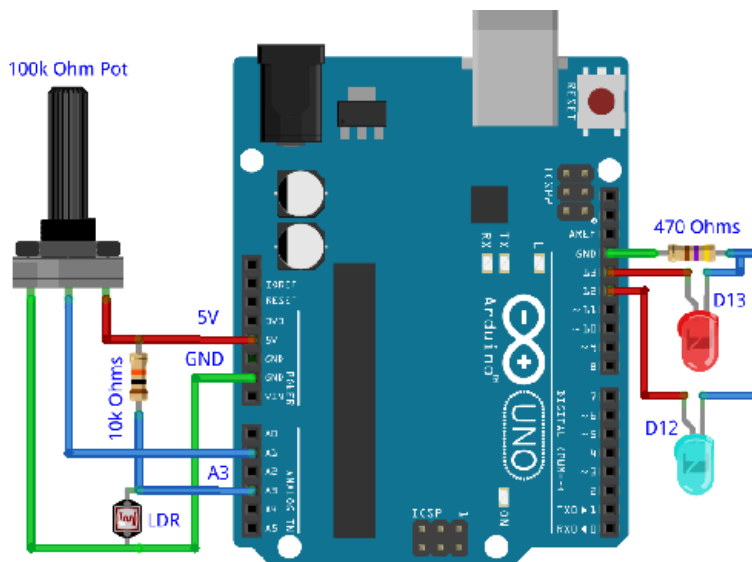
Step 2

DUT Setup: Connecting Arduino with Computer

- Connect the Arduino to computer using USB cable.

USB Cable

- Launch Arduino IDE and ensure correct USB port number and Board name for establishing the connection

Step 3

DUT Setup: Programming Arduino

- Open the code - "Ligh_Switch_3.ino" - in Arduino IDE.
- Compile and upload the program on Arduino board for execution

Step 4

Scope and DUT connection:

- Channel 1 probing at LDR output (pin A3 of Arduino)
- Channel 2 probing at Potentiometer output (pin A1 of Arduino)

Step 5

Scope Settings: Horizontal / Vertical Scale
Do autoset (or manually set) and ensure following settings:

-
- Horizontal scale = 50 ms/div
- Channel 1 & 2:
  - Vertical scale   = 1V/div
  - Vertical position = -3V (-3 divisions)

Step 6

Scope Settings: Measurements
Using 'measure' menu, add following measurements to CH1 and CH2:

- RMS
- Mean

Step 7

Looking at the Mean/RMS value of CH2, vary the potentiometer till it reaches the mean value of 3.5V.

Step 8

Once CH2 reaches 3.5V, save CH2 as Reference Waveform Ref A. Press Save/Recall button from the front panel and do following settings:

- Save/Recall > Action setting = Save Waveform
- Save To = Ref
- Source = Ch2
- To = Ref A
- Press Save

Step 9

Turn on Ref A: You would see white trace (horizontal line @ 3.5V, where CH2 was)

- Press Ref (R) button on front panel
- Ref A = On

Step 10

Now change the probing for CH2 – connect CH2 to Pin D13 (LED output)

Step 11

Scope Settings: Trigger

- Trigger source = CH2,
- Edge = Rising
- Trigger Level = 2.5V

Step 12

- Vary the light incident on LDR (you can use mobile flash light or torch) and acquire signal using Single Acquisition.
- Verify that you LED glows (CH2 goes to 5V) only when CH1 (LDR output) crosses the threshold (Ref A)

Step 13

Now your light controlled switch is ready for use. You can set your light controlled switch –

- Create the darkness level you want to have your LED on for
- Now adjust the potentiometer that it turns the LED off
- Now rotate the pot in other direction slowly till it just switches on the LED
- You've just defined / set the darkness threshold for switching on the LED. If there is more light than this, LED will turn off and vice versa.

LDR_Light_Switch4 -- Overview

Mukesh Soni
Product Marketing Manager
Basic Scopes Product Line
Tektronix

Tektronix

OBJECTIVES

After performing this lab exercise, learner will be able to:

- Interface a pushbutton with Arduino
- Program Arduino board to:
  - Detect switch (push button) press
  - Count the seconds elapsed while switch is pressed
- Use digital oscilloscope to measure the pulse width (duration)

EQUIPMENT

To carry out this experiment, you will need:

- TBS1KB-Edu Digital Oscilloscope from Tektronix
- Arduino Duemilanove or Uno board
- Voltage probe (provided with oscilloscope) / BNC cables
- Breadboard and connecting wires
- Simple circuit components – Resistor 10k & 470 Ohms, LEDs and Push button (switch)

THEORY

Key points:

- A push button is a switch that changes state (Normally open to close or vice versa) with the button press. The state change is retained till switch is kept pressed. Upon release of the switch, it comes back to its normal switching position.

- A switch can be interfaced with Arduino by making use of 'internal pull-up resistor' of a digital IO pin. Without pressing the switch, the value at digital input pin remains HIGH (5V) due to pull-up resistor. When switch is pressed, the input is connected to ground and voltage becomes 0V.
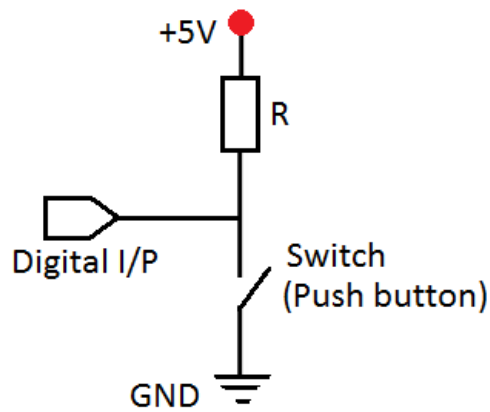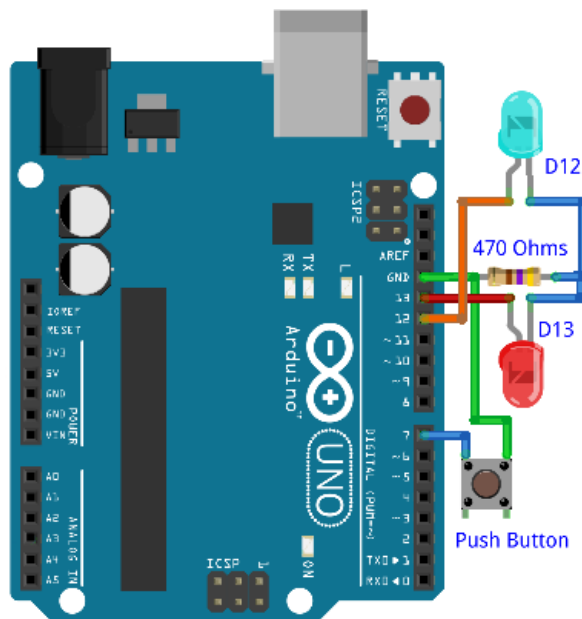
- Arduino can read the input pin level (HIGH or LOW) and detect the switch press.

LDR_Light_Switch4 -- Procedures
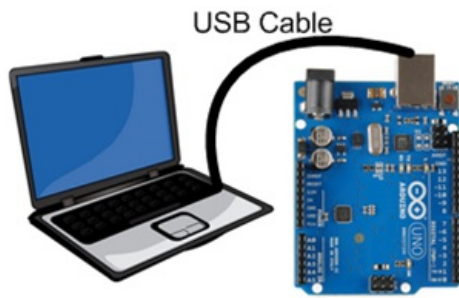
Step 1

DUT Setup: Arduino - Push Button Circuit
Prepare the circuit (using push button, LEDs, Resistor and Arduino) as shown below:

Step 2

DUT Setup: Connecting Arduino with Computer

- Connect the Arduino to computer using USB cable.

USB Cable

- Launch Arduino IDE and ensure correct USB port number and Board name for establishing the connection.

Step 3

DUT Setup: Programming Arduino

- Open the code - "Ligh_Switch_4.ino" - in Arduino IDE
- Compile and upload the program on Arduino board for execution
- Once the program is uploaded and running on Arduino, open serial monitor
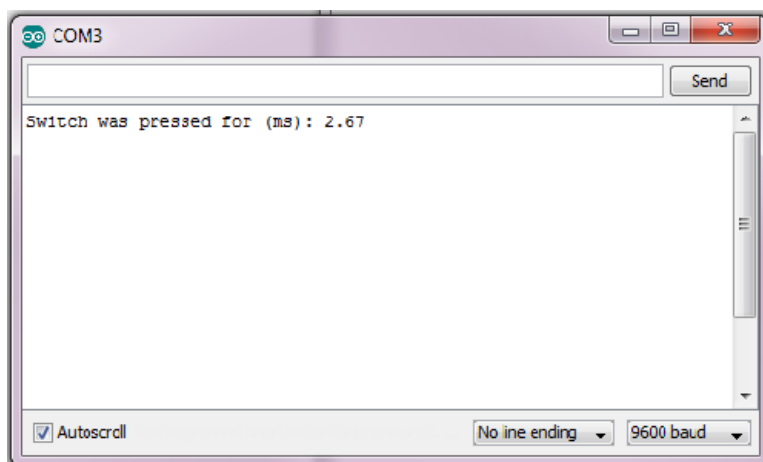
Step 4

Scope and DUT Connection:

- Channel 1 probing at Push Button (pin D7 of Arduino)
- Channel 2 probing at LED output (pin D13 of Arduino)

Step 5

Scope Settings: Horizontal / Vertical Scale & Trigger

- Horizontal scale = 500 ms/div
- Channel 1 & 2:
  - Vertical scale   = 1V/div
  - Vertical position = -3V (-3 divisions)

- Trigger on CH1, Falling Edge
- Horizontal Position (Pre-trigger) = 10% (1st div from left side)
- Take Single Acquisition (no free run)

Step 6

Scope Settings: Measurements

Using 'measure' menu, add following measurements to CH2:

- Positive Width

Step 7

- Ensure that Serial Monitor is turned on, press SINGLE (on the scope front panel)
- Press the 'push button' - keep it pressed for 2-3 seconds (approximately) and then release it. the LED at pin 13 would glow while push button is pressed.

Step 8

When the push button is released, Serial Monitor will print the time for which the push button was pressed. Verify this value (from Serial Monitor) against the Positive Width measurement on CH2 (= LED on period).

Step 9

You can try pressing the button for different interval of time and verify the value indicated by Arduino Serial monitor against scope's Positive Width measurement.

LDR_Light_Switch5 -- Overview

Mukesh Soni
Product Marketing Manager
Basic Scopes Product Line
Tektronix

Tektronix

OBJECTIVES

After performing this lab exercise, learner will be able to:

- Interface LDR and pushbutton with Arduino to make light controlled switch
- Program Arduino board to:
  - Measure LDR output as light intensity variation
  - Detect switch (push button) press and measure duration
  - Calibrate switching threshold with current LDR output using button press
- Use digital oscilloscope to measure the pulse width (duration) and burst width

EQUIPMENT

To carry out this experiment, you will need:

- TBS1KB-Edu Digital Oscilloscope from Tektronix
- Arduino Duemilanove or Uno board
- Voltage probe (provided with oscilloscope) / BNC cables
- Breadboard and connecting wires
- Simple circuit components – LDR, Resistor 10k & 470 Ohms, LEDs and Push button (switch)


THEORY

Key points:

- LDR (photo-resistor) changes its resistance with intensity of light falling on it. More the light, lesser is the resistance.
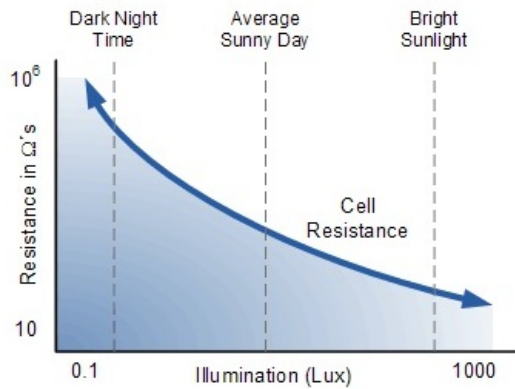
- The light variation can be 'measured' by using LDR with another resistor as voltage divider circuit. ADC of Arduino can be used to measure the voltage change (due to variation in intensity of light on LDR).

Voltage Divider Using LDR

$$V_{out} = V_{in} \times \frac{R_{LDR}}{R + R_{LDR}}$$
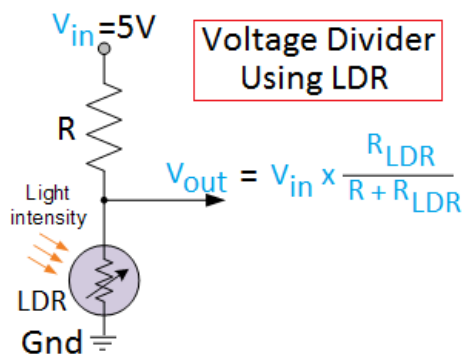
- A push button can be interfaced with Arduino's digital input pin using a pull-up resitor. Arduino can programmed to detect the switch press which will be used for calibration of threshold.
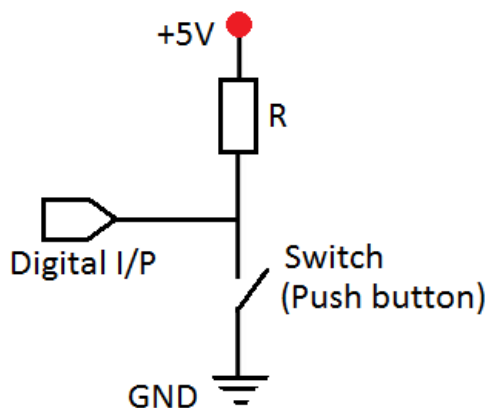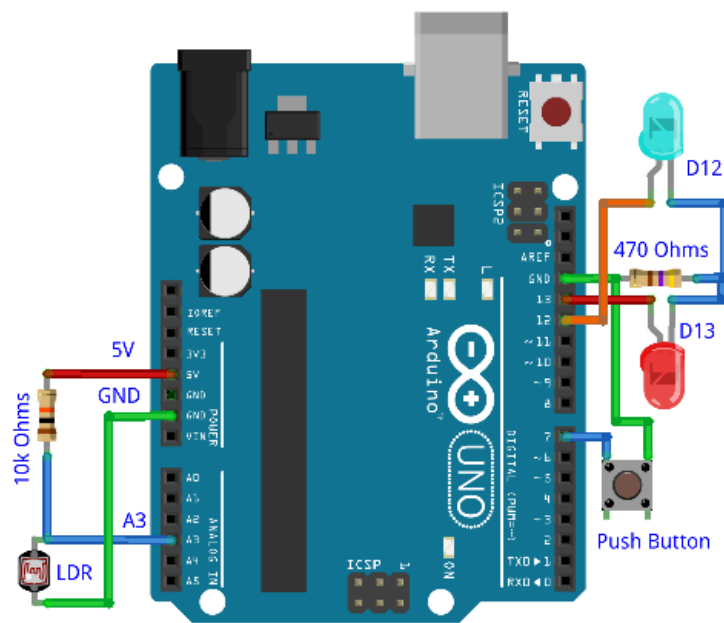

- When "calibrate" switch is pressed for over 2 seconds, the current value of LDR output can be assigned as Threshold.
- When switch is released, instantaneous LDR output is compared against the Threshold and switching is performed.

LDR_Light_Switch5 -- Procedures

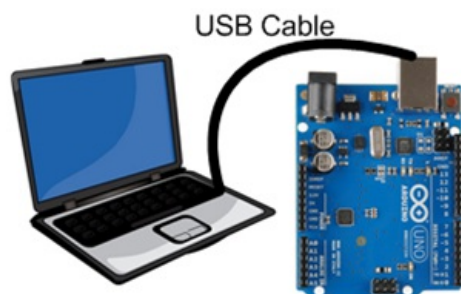## Step 1

DUT Setup: Arduino-LDR Circuit

Prepare the circuit (using LDR, Resistor and Arduino) as shown below:

Step 2

DUT Setup: Connecting Arduino with Computer

- Connect the Arduino to computer using USB cable.

- Launch Arduino IDE and ensure correct USB port number and Board name for establishing the connection.

Step 3

DUT Setup: Programming Arduino

- Open the code - "Ligh_Switch_5.ino" - in Arduino IDE.
- Compile and upload the program on Arduino board for execution

Step 4

Scope and DUT Connection:

- Channel 1 probing at Push Button (pin D7 of Arduino)
- Channel 2 probing at 'calibrate' LED (pin D12 of Arduino)

Step 5

Scope Settings: Horizontal / Vertical Scale & Trigger
Do autoset (or manually set) and ensure following settings:

- Horizontal scale = 250 ms/div
- Channel 1 :
  - Vertical scale   = 2V/div
  - Vertical position = +2V (+1 divisions)
- Channel 2 :
  - Vertical scale   = 2V/div
  - Vertical position = - 6V (-3 divisions)
- Trigger on CH1, Falling Edge
- Horizontal Position (Pre-trigger) = 10% (1st div from left side)
- Take Single Acquisition (no free run)

Step 6

Scope Settings: Measurements
Using 'measure' menu, add POS WIDTH and BURST WIDTH measurements to CH2

Step 7

- Ensure that Serial Monitor is turned on, press SINGLE (on the scope front panel)

Step 8

- Create darkness that you want to have switching at (threshold definition).
- Press the 'push button' - Calibrate LED will glow.
- Keep the button pressed till LED is on. Release it once the LED turns off.

Step 9

- You can verify the burst width measurement to be close to 2s.
- How's the CH2 (Calibrate LED output) - Smooth pulse of 2s or burst of square wave / pulses with burst width of 2s?
- We expected a smooth pulse of 2s as LED output. Without scope we could not figure it out that we have so many switchings till push button is pressed (2s).
- Can you debug the code and correct it?

Step 10

- The corrected code is "Light_Switch_5a.ino". Upload this code and run Arduino.
- Repeat step 8 & 9 to verify you get a smooth 2s pulse now.

Step 11

Now your Light switch is ready -

- You can define light intensity for switching by creating that exact darkness and pressing the Calibrate switch for 2s (till calibrate LED glows)
- Once the threshold is defined through calibration, main output LED (pin 13) will glow when the darkness is more than defined threshold.