Department of Electrical and Electronic Engineering
ELEN90066 Embedded System Design

Workshop Three (W03)

Interfacing sensors to the myRIO platform

Welcome to Workshop 3 for Embedded System Design. In this workshop you will learn about the principles of operation of Infra-red (IR) range finders, and apply calibration techniques using multiple measurements in order to interface it with the myRIO embedded platform. Applications of an IR range finder include ranging and object detection for robots, proximity sensing, and contact-less switches.

Pre-workshop background

An Infra-red (IR) range finder uses a beam of reflected infrared light to sense the distance between the sensor and a reflective target. The range to an object is proportional to the reciprocal of the IR range finder's output voltage.

Interface circuit: The SHARP GP2Y0A21YK0F IR range finder creates an output voltage V_O that varies in inverse proportion with range to a reflective target. Study the video IR Range Finder Interfacing Theory (9:59) to learn more about the IR range finder including features, principle of operation, calculating range from sensor voltage based on the geometric principle of similar triangles, and calibrating the sensor with single- or multi-measurement techniques.

LabVIEW programming: Study the video Analog Input Express VI (2:00) to learn how to use Analog Input Express VI to measure the voltage divider's primary output.

LabVIEW IR Range Finder demo: Study the video IR Range Finder Demo Walk-Through (3:51) to learn the design principles of IR Range Finder demo.

Pre-workshop questions

1. What is the stated distance measuring range of the SHARP GP2Y0A21YK0F IR range finder sensor? (**Hint:** See data sheet on LMS).
2. (a) What is the typical output voltage range for the SHARP GP2Y0A21YK0F IR range finder sensor (i.e. the voltage outputs at both ends of its stated measuring range)?
   (b) Why would calibrating the sensor data directly from these datasheet measurements potentially lead to inaccurate measurements?

Workshop Exercises

The following tasks reference files that are distributed on the LMS as a `.zip` file. You need to download and extract these files to a folder with write permissions in order to complete this workshop. All file paths given are with respect to the top-level folder of the downloaded archive file.

You will need the following equipment and software to complete this lab, in addition to equipment used in prerequisite workshops (if applicable):

- Computer with Windows 10
- National Instruments LabVIEW 2018 myRIO Toolkit
- National Instruments myRIO 1900
- 12V DC power supply
- USB cable
- SHARP GP2Y0A21YK0F IR range finder sensor

In this workshop you will do the following:

- Wire up the IR range finder to the myRIO and read the sensor data using the "IR Range Finder demo" LabVIEW project. **(TASK 1 - 5 marks)**
- Fit an affine function for the sensor data over the approximate linear range of operation of the sensor and determine the sensitivity and bias values **(TASK 2 - 10 marks)**
- Modify a LabVIEW project to add additional features to the IR sensor panel. **(TASK 3 - 10 marks)**

There are 25 marks available for successful completion of all tasks in this workshop, worth 1% of your final mark in the subject.

Task 1: Read the IR sensor data

1. **Build the interface circuit:** Refer to the schematic diagram and recommended wiring layout shown in Figure 1. The interface circuit requires three connections to NI myRIO MXP Connector B :

   (a) 5-volt power supply → B/+5V (pin 1)

   (b) Ground → B/GND (pin 6)

   (c) Output signal → B/AI0 (pin 3)

2. **Run the demonstration VI:**

   (a) Download the workshop software files and unzip the contents to a convenient location;

   (b) Open the project `IR Range Finder demo.lvproj` contained in the `src\LabVIEW\IR Range Finder demo` folder;

   (c) Expand the hierarchy button (a plus sign) for the "myRIO-1900" item and then open `Main.vi` by double-clicking;

   (d) Confirm that the NI myRIO is connected to your computer; and

   (e) Run the VI either by clicking the Run button on the toolbar or by pressing Ctrl+R.

   Expect to see a "Deployment Process" window showing how the project compiles and deploys (downloads) to NI myRIO before the VI starts running.

   Hint: You may wish to select the "Close on successful completion" option to make the VI start automatically.

3. **Expected results:** The demo VI displays both the IR range finder output voltage and the range in centimetres to a reflective target. Use a tape measure to measure the distance from the back side of the sensor to a reflective target placed somewhere between 0 cm and 80 cm. Compare the measured range to the known range; how well do these values match?

   Use a smartphone camera to view the IR range sensor. Infrared light appears blue on such a digital image sensor. Which side of the sensor is the IR emitter?

   Click the Stop button or press the escape key to stop the VI and to reset NI myRIO; a myRIO reset causes all of the digital I/O pins to revert to input mode.

TASK 1 Show that you have successfully wired the IR range finder to the myRIO and can read the sensor data using the "IR Range Finder demo" LabVIEW project.

Note : Your demonstrator will assess this task once you have finished it.

There are 5/25 marks for successful completion of this task.

Troubleshooting tips: Not seeing the expected results? Confirm the following points:

- Glowing power indicator LED on NI myRIO
- Black Run button on the toolbar signifying that the VI is in run mode
- Correct MXP connector terminals – ensure that you are using Connector B and that you have the correct pin connections.

Task 2: Calibrating the IR range finder sensor

1. **Estimate the sensor parameters:** Record the sensor voltage V_O when the target is placed at a known range R of between 10 cm and 40 cm, calculate the calibration scale factor $K_{scale} = R \times V_O$, and then enter this value into the K_{scale} [cm-V] front-panel control. Repeat your earlier range measurements; do you observe improved measurement accuracy?
2. **Explore the range of readings:** Try moving the target to ranges closer than 10 cm. You should observe that the measured range begins to increase even though the target is obviously very close to the sensor. You can mitigate this non-ideal behaviour by ensuring that the sensor is mounted at least 10 cm from the nearest target. With a robot platform, for example, mount the sensor towards the interior of the platform rather than at the edge.

TASK 2 Take a range of sensor measurements (V_O) over the IR sensor's operating range (10cm-80cm). Plot the range measurements R versus the reciprocal output voltage $1/V_O$ (see the first video in the pre-workshop section for an example) and fit an affine function for the data over the approximate linear range of operation of the sensor (e.g. using MATLAB or Excel) such that

$$R = K_s \left(\frac{1}{V_O} \right) + K_o$$

where K_s is the *sensitivity* and K_o is the *bias* of the sensor. Record these values as you will be using them in the Front Panel to calibrate the sensor.

Note : Your demonstrator will assess this task once you have finished it.

There are 10/25 marks for successful completion of this task.

Task 3: Modify the Main VI

Now that you have calibrated measurements for the sensitivity and bias of the IR sensor, make these modifications to the block diagram of `Main.vi`:

1. Add a Boolean control to disable or enable the averaging function.
2. Add a proximity detection feature: activate an onboard LED when the range is lower than a threshold value entered on the front panel.
3. Add an "out of range" Boolean indicator when the range exceeds 80 cm.
4. Add an enhanced proximity detection feature: one of three onboard LEDs to indicate "in range", "too close", or "too far".

TASK 3 Show your modified `Main.vi` to your demonstrator, highlighting the features added above.

There are 10/25 marks for successful completion of this task.

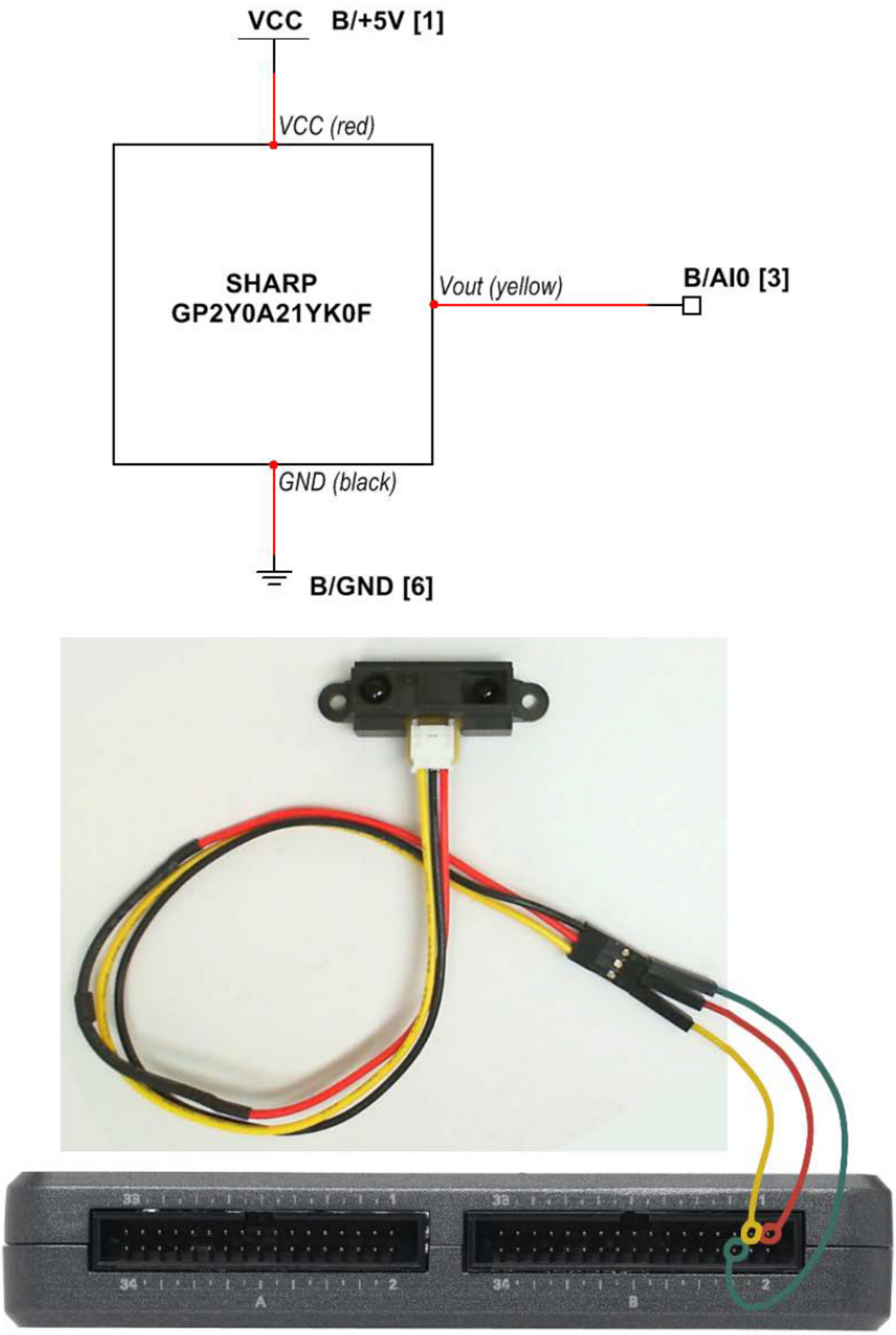

Figure 1: Setup for rangefinderIR connected to NI myRIO MXP Connector B