Lab 2: Characterization of a Reflective Object Sensor and K60 Serial Port

Rochester Institute of Technology
Department of Computer Engineering

EECC 560 Interface and Digital Electronics
Fall 2011-1

Introduction

Optical measurement and isolation has the advantage that it does not require physical contact with a system, and thus is much less likely to disturb the system being measured. For example, it is possible to use optical measurements to measure the distance between two objects, eliminating the need for a physical "measuring tape". Opto-isolators are useful when physical isolation between two systems is required. Isolation may be required when:

1. An application requires safe, accurate measurement of DC and low frequency voltage or current in the presence of high common-mode voltage.
2. It is necessary to receive/transmit signals at high impedance in noisy environments.
3. An application must perform a measurement, and, for safety reasons, must guarantee that voltage and current leakage will remain below certain thresholds.

Opto-isolators are a common element found in medical electronic equipment, power plants, automated test equipment, industrial controls, and portable field equipment.

Communication interfaces allow systems with different architectures to communicate with each other. The Universal asynchronous receiver/transmitter (UART) peripheral in the Kinetis K60 allows the use standards such as RS-232. This can be used for communication between the K60 and a computer.

Objectives

For this lab, you are to characterize the OPB745 photo-transducer included in your lab kit, testing both its ability to accurately measure the distance to a reflecting surface and its ability to perform as an opto-isolator. Several components of this lab experiment are open-ended—there is no one right way of doing this lab. It will be up to you to develop and define certain elements to complete this lab.

The second part of this Lab involves configuring the Universal asynchronous receiver/transmitter (UART) on the K60 to transmit and receive data from the 9-pin RS232 Serial Port. You will use a terminal to echo input from a keyboard back out to the terminal.

Relevant Reference Manual Chapters

- Chapter 10: Signal Multiplexing and Signal Descriptions
- Chapter 11: Port control and interrupts (PORT)

- Chapter 51: Universal asynchronous receiver/transmitter (UART)

Pre-Lab

For Part 1, calculate the resistor value Rf for Parts 1A and 1B. The resistor value for 1B will not be the same due to the buffer's output range. Show these values to the Lab Instructor or TA before beginning the Lab. There is no Pre-Lab for Part 2.

Procedure

Part 1: Characterization of a Reflective Object Sensor

A. Design and build a test environment for the OPB745 that will isolate the sensor from external lighting and will allow you to accurately adjust the distance between a reflective surface and the OPB745's sensor head. An example housing is described in Figure 1: Example Test Environment The key characteristics of the test environment are:
   i. Isolation from all ambient light sources—the OPB745 should be the only source of lighting within the environment.
   ii. The ability to accurately measure the distance between the OPB745's sensor head and the reflective surface (accuracy defined as within ±0.5 mm).
   iii. The ability to adjust the distance between OPB745 and reflecting surface.

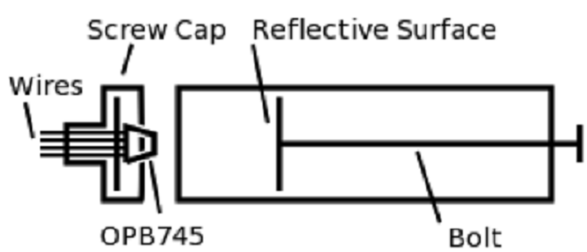

Figure 1: Example Test Environment

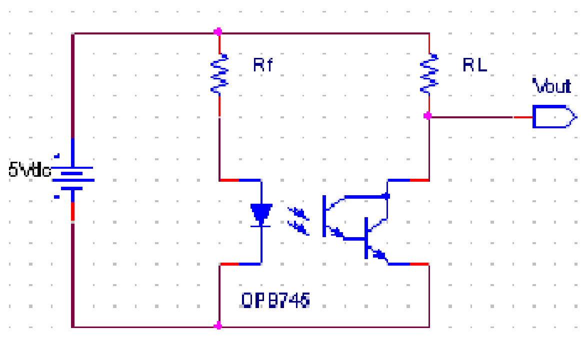

Figure 2: Circuit Schematic for OPB745

Using this test environment, you are to wire the OPB745 in the circuit described in Figure 2: Circuit Schematic for OPB745 and then record values for the following table. Graphing these values will allow you to visualize the distance/voltage output relationship for the OPB745, and this graph should reflect the “Normalized Collector Current vs. Object Distance” graph given in the OPB745 datasheet.

You should perform this experiment twice: once with RL equal to 10 kΩ and once with RL set to 20 kΩ. For RF you should use a resistor value that allows ≈35 mA through the LED. To figure out the appropriate resistance, you will need to consult the OPB745 datasheet.

	R_{L1} =		R_{L2} = 2 R_{L1}	
Distance (mm)	V_{out} (V)	I_{RL} (mA)	V_{out} (V)	I_{RL} (mA)
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
15				
20				
25				
30				
35				
40				
45				
50				

B. For the second part of this exercise you will be building an experiment that will allow you to determine the maximum frequency at which the OPB745, acting as an opto-isolator, is able to transmit a TTL logic binary signal. Using the test environment you designed and built for part A, modify your circuit to match the circuit shown in Figure 3.

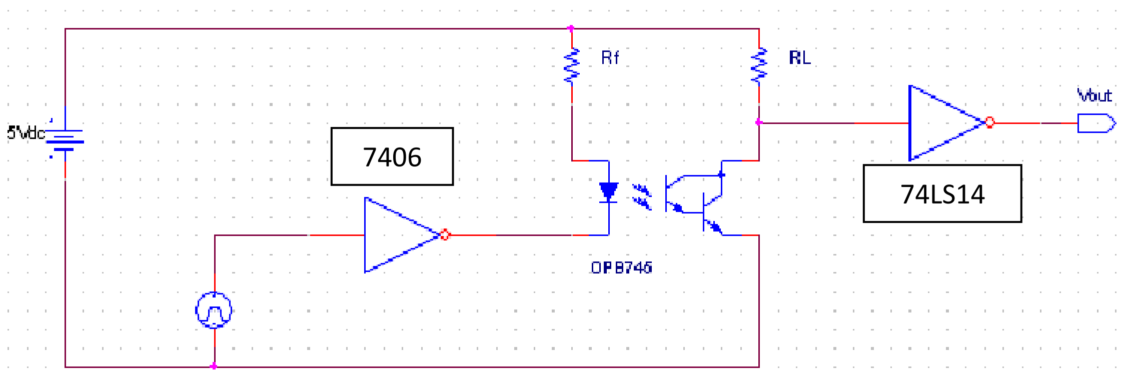

Figure 3: Maximum Throughput Test Circuit

Using this circuit, you are to generate a 50% duty cycle, TTL logic level square wave as the input to the first inverter and measure the output of the second inverter. Your goal is to find, f_{max}, the maximum frequency at which the OPB745 is able to reliably and usefully transmit the input square wave. It is up to you to come up with a quantitative definition for "reliably and usefully transmit". For example, "doesn't look good" is not a quantitative definition. You will know that your definition is good if you can give it and your circuit to someone else, and they will come up with the same value for f_{max}. Capture f_{max} using the oscilloscope. Include the input and output waveforms and frequency measurements in the capture.

Part 2: K60 Serial Port

For the second part of this Lab, you will be writing a UART driver for the K60. You will need to write the methods for initialization, writing a character, reading a character, and checking if a character is present.

1. Create a new project in CodeWarrior 10.1.
2. Download the provided code for Lab 2 and add it to the project.
    a. There should be 8 files. io.c, io.h, main.c, mcg.c, mcg.h, printf.c, uart.c, and uart.h.
3. Find the UART module that is connected to the 9-pin RS232 connector. You will need this to know which UART registers to use. (Hint: Find the RS232 connector and trace the signals back to the K60 MCU. Or look at the code provided.)
    a. The K60 has a total of Five UARTs
    b. Each UART may be assigned to multiple pins.
4. Fill in the methods uart_init(), uart_putchar(char), uart_getchar(), and uart_getchar_present() in uart.c.
    a. Use 115200 Baud rate. 8 Data bits, No Parity, 1 Stop bit
    b. Read 51.8.3 for initialization procedure.
    c. Read 51.4.3 for Baud Rate Generation (System is clocked at 50 MHz).
    d. Registers you will need to use: SIM_SCGC4, UARTx_BDH, UARTx_BDL, UARTx_C1, UARTx_C2, UARTx_C4, UARTx_S1, and UARTx_D.
5. Modify main.c to print your name and your partner's name to the terminal.
6. Connect the Serial port to the TWR-SER board.
7. Open HyperTerminal (Start menu -> Programs -> Accessories -> Communication)
    a. Type in any name for the new connection and click Ok.
    b. Select the Serial Port (which should be COM1).
    c. Set the Baud Rate, Start, Stop, and Parity bits. Set flow control to off.
8. Run the software on the K60 and demonstrate to the TA to be checked off.

Lab report

Follow the Lab Report Guidelines on myCourses.

1. Title Page
2. Short Abstract
3. Procedures / Methodology
4. Results
    a. A graph of the data recorded while measuring the relationship between distance and output voltage.

b. A graph of the data recorded while measuring the relationship between distance and current.
c. Oscilloscope captures taken while finding f_{max}, showing both the input and output of your circuit. These captures must include frequency measurements of both channels.

5. Conclusion