University of Colorado Denver, Fall 2021

MECH 4428/5228, ELEC 4804/5804

Homework 2 Solutions: Serial Communication - Arduino and pySerial

**Design Questions**

For each of the problems below, assume

* one bit per baud, i.e. baud rate is equivalent to bits per second.
* one start bit, 8 data bits, no parity, and one stop bit for each byte.

*Show your work where appropriate.*

1. What is the Arduino worst-case transmission time for a 20-element array of four-byte unsigned integers? Assume the baud rate is 115200.

**Transmitted using serial.println().**

**unsigned int array[20];**

**for(int k = 0; k < 20; ++k)**

**Serial.println(array[k]);**

The serial print functions transmit data as characters. The range of values for a 4-byte unsigned number is 0 to 2^32 – 1 or 0 to 4294967295. The worst case is transmitting a number greater than or equal to 1,000,000,000 which has 10 digits.

There are 20 elements in the array, with a worst case that each number contains 10 digits. Each digit will be transmitted as a character.

Serial.println(array[k]) transmits 10 characters to represent the number and then appends the characters ‘\r’’\n’, transmitting a total of 12 characters for each array element.

20 array values \* (12 characters/array value) = 240 characters

Each character has 8 data bits. One start bit and one stop bit are added to each character transmission for a total of 10 bits/character.

240 characters \* 10 bits/character = 2400 bits

A baud rate of 115200 baud that transmits one bit per baud, transmits 115,200 bits per second.

Transmission time for 2400 bits is 2400 bits / (115200 bits/sec) = 0.02083333 seconds or 20.833 millseconds.

**Transmitted with serial.write**

Serial.write transmits the data in a binary format, one byte at a time. A 20 element array of four-byte unsigned integers contains 80 data bytes. There are 8 bits in each data byte. Serial transmission adds one stop bit and one start bit to each data byte, transmitting a total of 10 bits per data byte.

20 array elements \* 4 bytes/array element = 80 byte

80 bytes \* 10 bits/byte = 800 bits.

A baud rate of 115200 baud that transmits one bit per baud, transmits 115,200 bits per second.

Transmission time for 800 bits is 800 bits / (115200 bits/sec) = 0.00694444 seconds or 6.944 millseconds.

2. Suppose a sensor’s measurement rate can be set at 5, 10, 25, or 75 Hz. The measurement rates correspond to the number of sets of measurements that are produced each second.

Examples:

* When the sensor rate is set to 5 Hz, the sensor produces 5 sets of measurements each second.
* When the sensor rate is set to 10 Hz, the sensor produces 10 sets of measurements each second.

Each set of sensor measurements contains 382 bytes.

1. What is the minimum allowable baud rate that allows a sensor to transmit measurements at a rate of 75 Hz?

Sensor rate of 75 Hz produces 75 measurement sets/sec

75 sets/sec \* 382 bytes/set \* 10 bits/byte = 286,500 bits/sec

(286,500 bits/sec) \* 1 baud/bit = 286,500 baud rate mininum

1. If the only serial transmission rate available is 57600 baud, what is the maximum sensor rate setting to ensure complete transmission of all data in one second?

57600 baud = 57600 bits/sec

382 bytes/set \* 10 bits/byte = 3820 bits/set

57600 bits/sec / 3820 bits/set = 15.08 set/sec

The closest sensor measurement rate at or under 15.08 set/sec is 10 Hz.

3. Modify the Lesson 5 Arduino example to transmit binary values of x and y. You may only use Arduino Serial.write functions for transmission (no print, println functions). Modify the python program to receive the binary data. The python program should print the received x, y values as it does in lesson 5. Name the Arduino program hw23.ino and the python program hw23.py.

See folder hw23 for Arduino and python programs.

4. Timing serial data transmission

Compare the performance of binary versus ASCII character serial transmission using the Serial write, print functions. Write an Arduino program that serially transmits the range of values from 0 to 2^16-2 to a python program.

Compare total number of bytes transmitted for the range 0 to 2^16-2.

Submit a brief written explanation/analysis of your methodology and results. Include all source code used to obtain the results.

See hw24.ino

**Grading**

|  |  |  |
| --- | --- | --- |
| Problem | Points Possible | Points Earned |
| 1 | 5 |  |
| 2 | 8 |  |
| 3 | 12 |  |
| 4 | 20 |  |
| Total | 45 |  |