

Control and Navigation 6 – Signal Multiplexing

Cornerstone Electronics Technology and Robotics III

- **Administration:**
 - Prayer
- **Signal Multiplexing:**
 - In Lesson 21, we learned that it is impractical for a sophisticated ROV with a long tether to have a separate wire pair for each electrical device onboard; the tether would be thick and unmanageable. Signal multiplexing makes it possible to replace all of the separate wires with a single pair power cable and one small control wire. In this lesson, we will learn how to send several signals over a single fiber-optic cable using time-division multiplexing.
 - Time-Division Multiplexing: Signals take turns being sent over the same wire or channel. Low-bit-rate data streams can be merged into one high-bit-rate multiplexed data stream. See Figure 1.

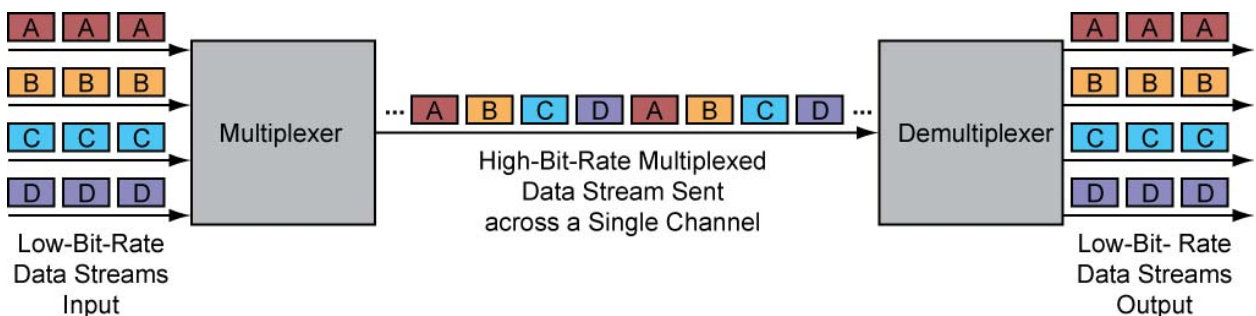


Figure 1: Time-Division Multiplexing

- In Signal Multiplexing Lab 1, each input from the four switches is assigned to its own variable (A,B,C,and D) by the transmitting PIC16F88. The values (1 or 0) of these four variables are sent through the single fiber-optic cable to the receiving PIC16F88 which controls four output pins to power the attached LEDs. See Figure 2.

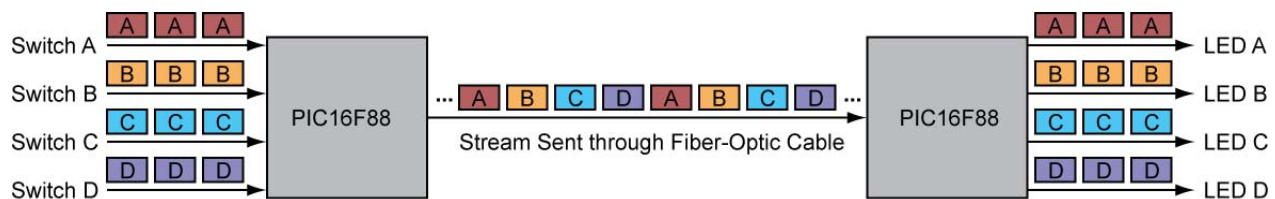


Figure 2: Lab 1 Multiplexing

- Perform Signal Multiplexing Lab 1 – ON/OFF Control 1. Before we continue to the explanation of Lab 2, let's cover how to label bits of an 8-bit variable. An 8-bit variable A has eight bits that are labeled A.0 through A.7. See Figure 3. Each bit can be either a 1 or 0.

A = %00000000

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑
 A.7 A.6 A.5 A.4 A.3 A.2 A.1 A.0

Figure 3: Bit Positions of Variable A

- Signal Multiplexing Lab 2 performs the same task as Lab 1, but rather than using four variables to send the state of the four switches, it only uses one variable.
 - Lab 2 uses the least significant four bits of one 8-bit variable to send the ON/OFF information to the receiver PIC. For example, if all four switches are pressed (ON), then the 8-bit variable, A, would equal %00001111. If none of the switches are pressed, the 8-bit variable, A, would equal %00000000.
 - The input from each switch is assigned to one bit of the variable A. Switch 1 is now assigned to bit A.0. Likewise, Switch 2 is allocated to A.1, Switch 3 to A.2, and Switch 4 to A.3.
 - The program starts with A = %00000000. It then adds each bit value to A (A.0 to A.3) to give the final value of A. Refer to Figure 4. The program continuously cycles through to update the value of A, sending the renewed state of all four switches.

Starting value of variable A	A = %00000000
If Switch A is pressed, A.0 = 1	A = A + %00000001, so A = %00000001
If Switch B is not pressed, A.1 = 0	A = A + %00000000, so A = 00000001
If Switch C is not pressed, A.2 = 0	A = A + %00000000, so A = %00000001
If Switch D is pressed, A.3 = 1	A = A + %00001000, so A = %00001001
The final value of variable A	A = %00001001

Figure 4: Each Bit Value Is Added to A to Give the Final Value of A

- We could control up to eight ON/OFF functions on an ROV with one 8-bit variable.
 - Thanks to G. Spencer for developing this technique of switch control.
- Perform Signal Multiplexing Lab 2 – ON/OFF Control 2.
- Perform Signal Multiplexing Lab 3 – PWM Motor Control

Electronics Technology and Robotics III

Control and Navigation 6 LAB 1 – ON/OFF Control 1

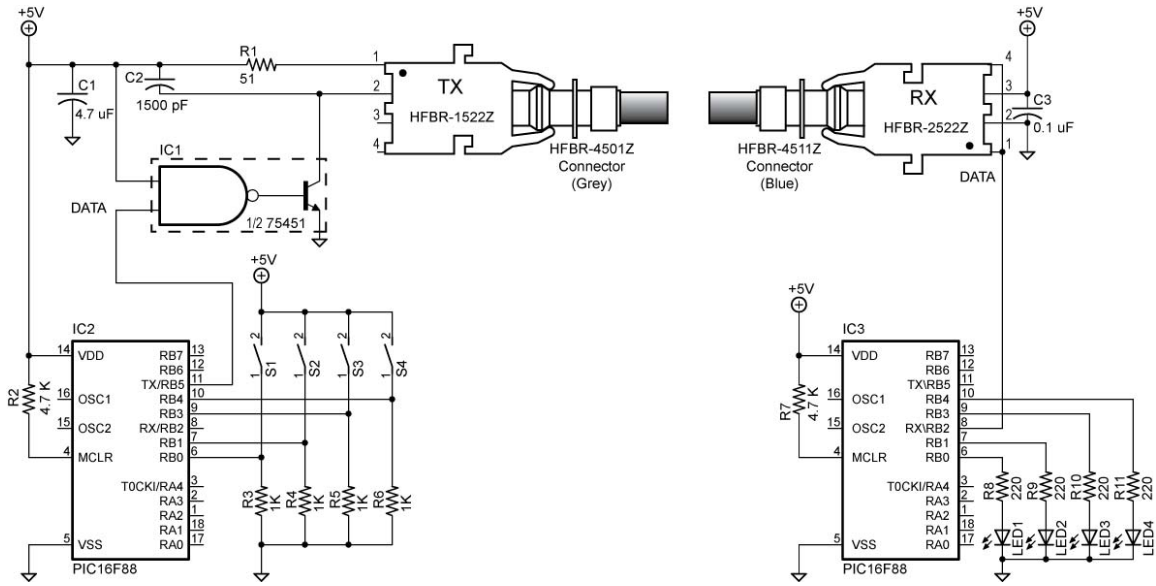
- **Purpose:** The student assembles the hardware and uses software to simultaneously control several ON/OFF functions over a single fiber-optic cable using four 8-bit variables.
- **Apparatus and Materials:**
 - 1 – Breadboard with +5V supply or an Analog/Digital Trainer
 - 1 – HFBR-1522Z Fiber-Optic Transmitter
 - Source: <http://www.digikey.com/product-detail/en/HFBR-1522Z/516-2044-ND/1990442>
 - Datasheet: <http://www.avagotech.com/docs/AV02-1501EN>
 - 1 – HFBR-2522Z Fiber-Optic Receiver
 - Source: <http://www.digikey.com/scripts/DkSearch/dksus.dll?lang=en&keywords=516-2063-nd&WT.srch=1&cur=USD>
 - Same datasheet as above
 - 1 – HFBR-4501Z Grey Fiber-Optic Connector
 - Source: <http://www.digikey.com/product-search/en?x=0&y=0&lang=en&site=us&KeyWords=516-2071-ND>
 - Datasheet: <http://www.avagotech.com/docs/AV02-1508EN>
 - 1 – HFBR-4501Z Blue Fiber-Optic Connector
 - Source: http://www.digikey.com/scripts/DkSearch/dksus.dll?WT.z_header=search_go&lang=en&keywords=hfbr-4511z&x=0&y=0&cur=USD
 - 1 – Fiber-Optic Cable, 1 mm Fiber Diameter, 2.2 mm Jacket (Insulation) Diameter
 - Source: http://www.digikey.com/scripts/DkSearch/dksus.dll?WT.z_header=search_go&lang=en&keywords=FB140-1-ND&x=0&y=0&cur=USD
 - 1 – 75451 Dual Peripheral Driver
 - Source: http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?freeText=75451+&langId=-1&storeId=10001&productId=51027&search_type=jamecoall&catalogId=10001&ddkey=http:StoreCatalogDrillDownView
 - Datasheet: <http://www.jameco.com/Jameco/Products/ProdDS/51027.pdf>
 - Substitution: 1 – 74LS00 Quad 2-Input NAND Gate and 1 – 2N222A NPN Transistor
 - 2 – PIC16F88 Microcontrollers
 - 4 – NO Momentary Switches
 - 1 – 51 Ohm Resistor
 - 4 – 220 Ohm Resistors
 - 2 – 4.7K Resistors
 - 4 – 1K Resistors
 - Apparatus and Materials continued on the next page.

Apparatus and Materials Continued:

- 1 – 4.7 uF Capacitor
- 1 – 0.1 uF Capacitor
- 1 – 1500 pF (0.0015 uF) Capacitor
- 4 – LEDs

• Procedure:

- Wire the circuit below.



Multiplex_tx_rx1

- Program the transmit PIC (IC2) with multiplex_tx1.pbp
- Program the receiver PIC (IC3) with multiplex_rx1.pbp
- Press the four buttons connected to the transmit PIC and observe the LEDs connected to the receive PIC.
- Review programs with the instructor.

Electronics Technology and Robotics III Control and Navigation 6 LAB 2 – ON/OFF Control 2

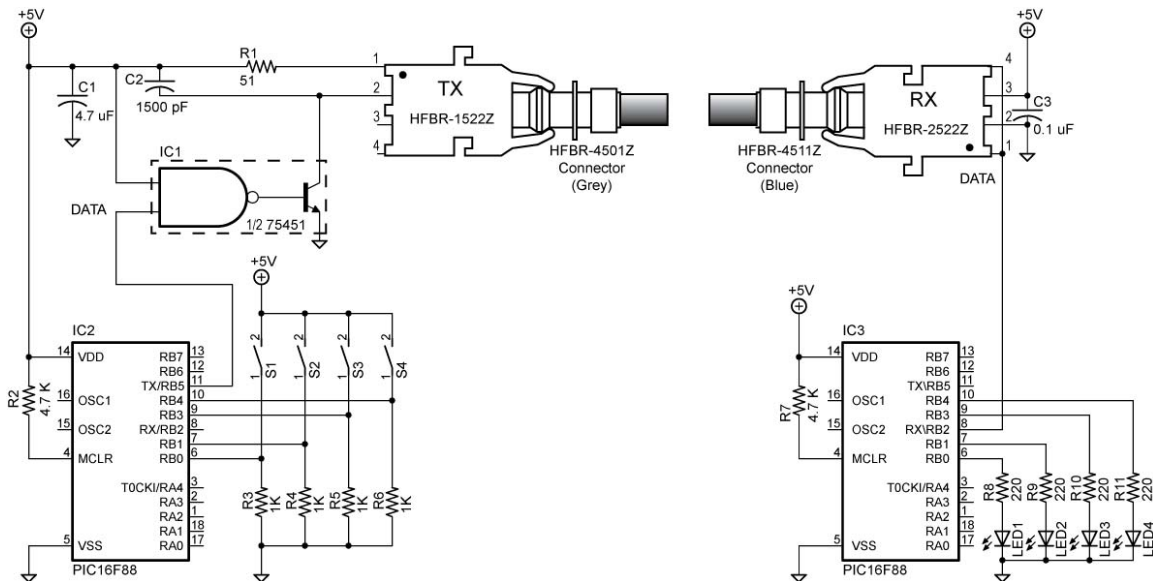
- **Purpose:** The student assembles the hardware and uses software to simultaneously control several ON/OFF functions over a single fiber-optic cable using one 8-bit variable.
- **Apparatus and Materials:**
 - 1 – Breadboard with +5V supply or an Analog/Digital Trainer
 - 1 – HFBR-1522Z Fiber-Optic Transmitter
 - Source: <http://www.digikey.com/product-detail/en/HFBR-1522Z/516-2044-ND/1990442>
 - Datasheet: <http://www.avagotech.com/docs/AV02-1501EN>
 - 1 – HFBR-2522Z Fiber-Optic Receiver
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 - Same datasheet as above
 - 1 – HFBR-4501Z Grey Fiber-Optic Connector
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 - Datasheet: <http://www.avagotech.com/docs/AV02-1508EN>
 - 1 – HFBR-4501Z Blue Fiber-Optic Connector
 - Source: http://www.digikey.com/scripts/DkSearch/dksus.dll?WT.z_header=search_go&lang=en&keywords=hfbr-4511z&x=0&y=0&cur=USD
 - 1 – Fiber-Optic Cable, 1 mm Fiber Diameter, 2.2 mm Jacket (Insulation) Diameter
 - Source: http://www.digikey.com/scripts/DkSearch/dksus.dll?WT.z_header=search_go&lang=en&keywords=FB140-1-ND&x=0&y=0&cur=USD
 - 1 – 75451 Dual Peripheral Driver
 - Source: http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?freeText=75451+&langId=-1&storeId=10001&productId=51027&search_type=jamecoall&catalogId=10001&ddkey=http:StoreCatalogDrillDownView
 - Datasheet: <http://www.jameco.com/Jameco/Products/ProdDS/51027.pdf>
 - Substitution: 1 – 74LS00 Quad 2-Input NAND Gate and 1 – 2N2222A NPN Transistor
 - 2 – PIC16F88 Microcontrollers
 - 4 – NO Momentary Switches
 - 1 – 51 Ohm Resistor
 - 4 – 220 Ohm Resistors
 - 2 – 4.7K Resistors
 - 4 – 1K Resistors
 - Apparatus and Materials continued on the next page.

Apparatus and Materials Continued:

- 1 – 4.7 uF Capacitor
- 1 – 0.1 uF Capacitor
- 1 – 1500 pF (0.0015 uF) Capacitor
- 4 – LEDs

- **Procedure:**

- Wire the circuit below.



Multiplex_tx_rx2

- Program the transmit PIC (IC2) with multiplex_tx2.pbp
- Program the receiver PIC (IC3) with multiplex_rx2.pbp
- Press the four buttons connected to the transmit PIC and observe the LEDs connected to the receive PIC.
- Review programs with the instructor.

Electronics Technology and Robotics III Control and Navigation 6 LAB 3 – PWM Motor Control

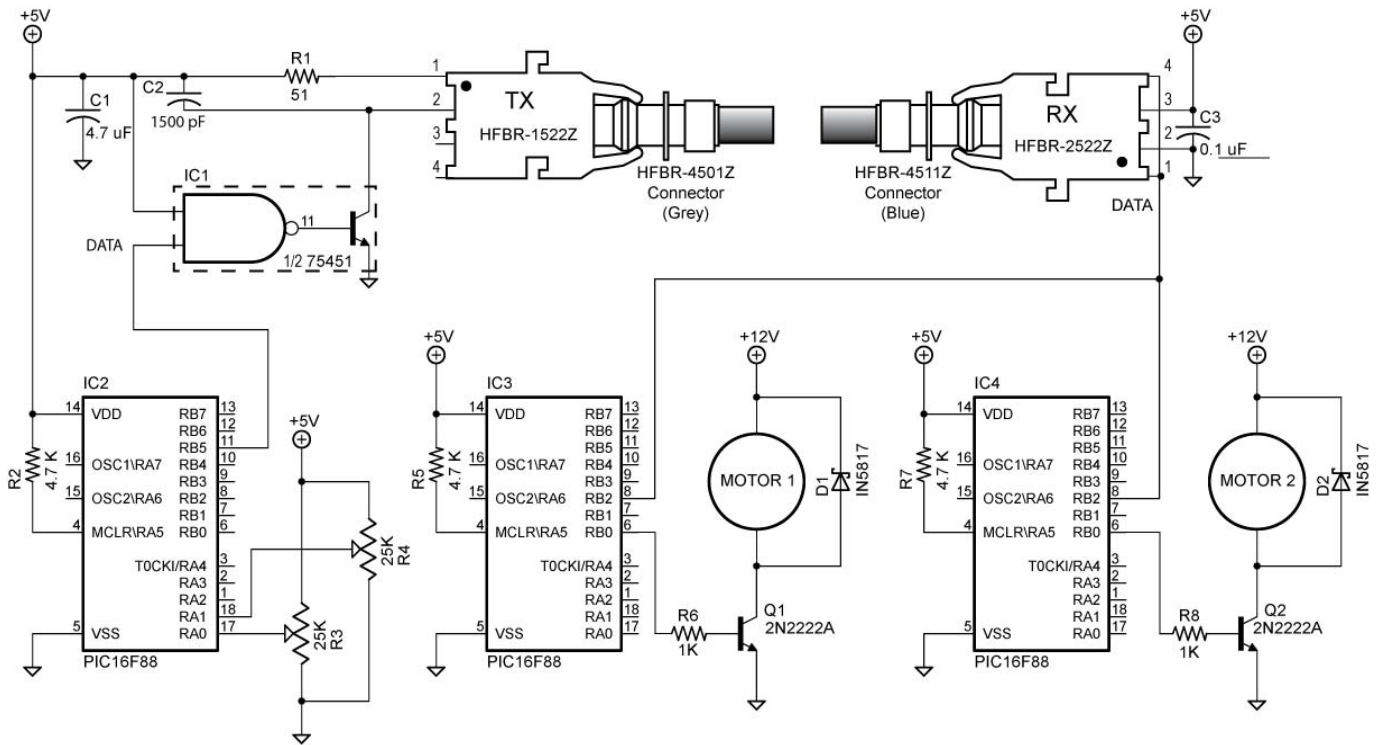
- **Purpose:** The student assembles the hardware and uses software to control two motors' speed with two potentiometers over a fiber-optic cable.
- **Apparatus and Materials:**
 - 1 – Breadboard with +5V and +12V supply or an Analog/Digital Trainer
 - 1 – HFBR-1522Z Fiber-Optic Transmitter
 - Source: <http://www.digikey.com/product-detail/en/HFBR-1522Z/516-2044-ND/1990442>
 - Datasheet: <http://www.avagotech.com/docs/AV02-1501EN>
 - 1 – HFBR-2522Z Fiber-Optic Receiver
 - Source: <http://www.digikey.com/scripts/DkSearch/dksus.dll?lang=en&keywords=516-2063-nd&WT.srch=1&cur=USD>
 - Same datasheet as above
 - 1 – HFBR-4501Z Grey Fiber-Optic Connector
 - Source: <http://www.digikey.com/product-search/en?x=0&y=0&lang=en&site=us&KeyWords=516-2071-ND>
 - Datasheet: <http://www.avagotech.com/docs/AV02-1508EN>
 - 1 – HFBR-4501Z Blue Fiber-Optic Connector
 - Source: http://www.digikey.com/scripts/DkSearch/dksus.dll?WT.z_header=search_go&lang=en&keywords=hfbr-4511z&x=0&y=0&cur=USD
 - 1 – Fiber-Optic Cable, 1 mm Fiber Diameter, 2.2 mm Jacket (Insulation) Diameter
 - Source: http://www.digikey.com/scripts/DkSearch/dksus.dll?WT.z_header=search_go&lang=en&keywords=FB140-1-ND&x=0&y=0&cur=USD
 - 1 – 75451 Dual Peripheral Driver
 - Source: http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?freeText=75451+&langId=-1&storeId=10001&productId=51027&search_type=jamecoall&catalogId=10001&ddkey=http:StoreCatalogDrillDownView
 - Datasheet: <http://www.jameco.com/Jameco/Products/ProdDS/51027.pdf>
 - Substitution: 1 – 74LS00 Quad 2-Input NAND Gate and 1 – 2N2222A NPN Transistor
 - 3 – PIC16F88 Microcontrollers
 - 2 – 25K Potentiometers
 - 1 – 51 Ohm Resistor
 - 2 – 1K Resistors
 - 3 – 4.7K Resistors
 - 2 – 12 Volt DC Motors
 - Apparatus and Materials continued on the next page.

Apparatus and Materials Continued:

- 2 – 1N5817 Schottky Diodes
- 2 – 2N2222A NPN Transistors
- 1 – 4.7 uF Capacitor
- 1 – 0.1 uF Capacitor
- 1 – 1500 pF (0.0015 uF) Capacitor

• Procedure:

- Wire the circuit below.



multiples_tx_rx3

- Program the transmit PIC (IC2) with multiplex_tx3.pbp
- Program the receiver PIC (IC3) with multiplex_rx3x.pbp
- Program the receiver PIC (IC4) with multiplex_rx3y.pbp
- Turn the potentiometers and observe the motor speeds.
- Review programs with the instructor.