IRISHWAVY
ACCEPTANCE TESTS

Spring 2014

Thomas Irish
ENEE440 – Final Project

Table of Contents

1. Initial State

Some tests will assume that the program is in its initial state before beginning. Rather than forcing the tester to reboot, the program can easily be returned to its initial state. Figure 1 illustrates the initial state of the program, as reflected by the LEDs. The program begins at a frequency of 100, amplitude of 100, waveform source set to sinusoid, operation mode set to repetitive, seven segment display showing the frequency and the run status set to On. The USART waveform buffer is also assumed to be empty. The rotary encoder is assumed to be notched, with the flat surface facing the seven segment display (not at any angle).

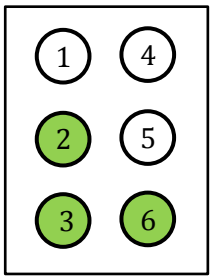

Figure 1: LED initial state

2. Mode Changing

The following tests are the barebones tests, which the tests will build upon. All tests assume the program is in its initial state.

2.1 Variable Selection

The test demonstrates how to select what value is being displayed on the seven segment display. Only the seven segment display, LED2 and LED5 should change over the course of this test.

1. Note the display reads 0100 initially, and LED2=Green and LED5=Off. This indicates frequency is currently being displayed and is set to 100
2. Press Switch 11 once. The display should still read 0100, but now LED2=Off and LED5=Green. This indicates amplitude is currently being displayed and is set to 100.
3. Press Switch 11 once. The display should now read 0000, LED=Off and LED5=Off. This indicates the first read-only value is being displayed, which happens to be configured to the size of the USART waveform buffer, which is initially zero.
4. Press Switch 11 once. The display should now be counting rapidly, with the first two digits counting too quickly to recognize. Also, LED2=Off and LED5=Red. This indicates that the second read-only value is being displayed, which happens to be configured to a counter being incremented within a service call.

5. Press Switch 11 once. The display should now read 0000, LED2=Red and LED5=Off. This indicates that the third read-only value is being displayed, which happens to be configured to nothing and should always read 0000.
6. Press Switch 11 once. The display should still read 0000, LED2=Red and LED5=Red. This indicates that the fourth read-only value is being displayed, which happens to be configured to nothing and should always read 0000.
7. Press Switch once. The display should now read 0100, LED2=Green and LED5=Off. This indicates frequency is again being displayed and still set to 100. Note the program is back in its initial state, so you can continue tests from this point.

2.2 Waveform Source

This test demonstrates how to select what waveform source/type is currently selected. Only LED1 and LED4 should change over the course of this test. If oscilloscope probe is connected to PA5, changes will also be noticed on the oscilloscope.

1. Note LED1=Off and LED4=Off initially. This indicates that the sinusoid waveform is currently selected. The oscilloscope should display a sinusoid at 100Hz.
2. Press Switch 9 once. Now LED1=Off and LED4=Green. This indicates that the triangle waveform is currently selected. The oscilloscope should display a triangle wave at 100Hz.
3. Press Switch 9 once. Now LED1=Green and LED4=Off. This indicates that the square waveform is currently selected. The oscilloscope should display a square wave at 100Hz.
4. Press Switch 9 once. Now LED1=Green and LED4=Green. This indicates that the USART waveform is currently selected. The oscilloscope should display a flat line, as the USART waveform buffer should currently be empty.
5. Press Switch 9 once. Now LED1=Off and LED4=Off. This indicates that the sinusoid waveform is once again selected. The oscilloscope should display a sinusoid at 100Hz. Note the program is back in its initial state, so you can continue tests from this point.

2.3 Operation Mode

This test demonstrates how to select the operation mode for the waveform. Only LED3 should change over the course of this test. If oscilloscope probe is connected to PA5, changes will also be noticed on the oscilloscope.

1. Note LED3=Green initially. This indicates that repetitive mode is currently selected. The oscilloscope should display a continuous sinusoid at 100Hz.
2. Press Switch 10 once. Now LED3=Red. This indicates that triggered mode is currently selected. The oscilloscope should display a flat line, as no trigger is being given.
3. Press Switch 10 once. Now LED3=Off. This indicates that single mode is currently selected. The oscilloscope should display a flat line, but a glimpse of a period immediately after pressing the switch.
4. Press Switch 10 once. Now LED3=Green. This indicates that repetitive mode is once again selected. The oscilloscope should display a continuous sinusoid at 100Hz. Note the program is back in its initial state, so you can continue tests from this point.

2.4 Run Status

This test demonstrates how to turn the program On and Off. Only LED6 should change over the course of this test. If oscilloscope probe is connected to PA5, changes will also be noticed on the oscilloscope.

1. Note LED6=Green initially. This indicates the program is currently running. The oscilloscope should display a sinusoid at 100Hz.
2. Press Switch 13 once. Now LED6=Red. This indicates that the program is currently stopped. Since this stop is done by preventing new data from entering the DAC, the oscilloscope should display a flat line at some level (the last value to be sent to the DAC).
3. Press Switch 13 once. Now LED6=Green. This indicates that the program is once again running. The oscilloscope should display a sinusoid at 100Hz. Note the program is back in its initial state, so you can continue tests from this point.

3. SVC Demonstration

This test assumes the program is currently displaying the frequency(LED2=Green & LED5=Off) but makes no other assumptions.

1. Note the frequency value being displayed.
2. Press Switch 11 three times. Now LED2=Off and LED5=Red. The seven segment display should show a number counting rapidly, with least significant two digits being impossible to recognize. This number is being incremented by a service call that is being called from the SysTick interrupt handler, which uses the SVC interrupt to queue the service for PendSV. Then, in the PendSV interrupt handler, the service is being removed from the queue and run. This number incrementing is a demonstration of the functionality of the SVC and PendSV interrupts. This also serves a secondary demonstration of the functionality of SysTick.
3. Press Switch 11 three times. Now LED2=Green and LED5=Off. The seven segment display should display the frequency value that was displayed just before beginning this test.

4. Variable Modification

The following tests demonstrate how to modify the writeable values using the seven segment display, Switches 1 to 8 and the Rotary encoder. All tests assume the program is in its initial state.

4.1 Frequency

This test demonstrates how to modify the frequency using the switches and the rotary encoder. Only the seven segment display should change over the course of this test. If oscilloscope probe is connected to PA5, changes will also be noticed on the oscilloscope.

1. Press Switch 7 once. The display should now read 0101. This indicates the frequency is now set to 101, and pressing Switch 7 added one to it. This change is likely too small to notice any change on the oscilloscope.
2. Press Switch 8 twice. You will see the display go from 0100 to 0099. This indicates the frequency is now set to 99 and pressing Switch 8 subtracted one from it for each press. This change is likely too small to notice any change on the oscilloscope.
3. Press Switch 5 three times. You will see the display go from 0109 to 0119 to 0129. This indicates the frequency is now set to 129 and pressing Switch 5 added 10 to it for each press. This change should be visible on the oscilloscope, which should now display a sinusoid at 129Hz.
4. Press Switch 6 twice. You will see the display go from 0119 to 0109. This indicates the frequency is now set to 109 and pressing Switch 6 subtracted 10 from it for each press. The oscilloscope should now display a sinusoid at 109Hz.
5. Press Switch 3 once. The display should now show 0209. This indicates the frequency is now set to 209 and pressing Switch 3 added 100 to it. The oscilloscope should now display a sinusoid at 209Hz.
6. Press Switch 4 once. The display should now show 0109. This indicates the frequency is now set to 109 and pressing Switch 4 subtracted 100 from it. The oscilloscope should now display a sinusoid at 109Hz.
7. Press Switch 1 once. The display should now show 1000. This indicates the frequency is now set to 1000 and has reached its maximum value. In actuality, Switch 1 should add 1000, but since the maximum frequency is 1000, the frequency simply maxes out. The oscilloscope should now display a sinusoid at 1kHz.
8. Press Switch 2 once. The display should now show 0001. This indicates the frequency is now set to 1 and has reached its minimum value. In actuality, Switch 2 should subtract 1000, but since the minimum value is 1, the frequency bottoms out. The oscilloscope should now display a sinusoid at 1Hz.
9. Press Switch 3 once. The display should now show 0101. Now press Switch 8. The display should now show 0100. This indicates the frequency is once again at 100. The oscilloscope should now display a sinusoid at 100Hz.
10. (Rotary Encoder Test) Turn the rotary encoder clockwise until you feel it stop resisting and reach a notch. As you turn, notice the least significant digit increase slowly. After reaching the notch, the display should now show 0104. This indicates that each clockwise notch adds four to the frequency and each clockwise step between the notches adds one. This change is likely too small to notice any change on the oscilloscope.
11. Turn the rotary encoder counterclockwise until you feel it stop resisting and reach a notch. As you turn, notice the least significant digit decrease slowly. After reaching the notch, the display should now show 0100. This indicates that each counterclockwise notch subtracts four from the frequency and each counterclockwise step between the notches subtracts one. This change is likely too small to notice any change on the oscilloscope. Note the program is back in its initial state, so you can continue tests from this point.

4.2 Amplitude

This test demonstrates how to modify the amplitude using the switches and the rotary encoder. Only the seven segment display, LED2 and LED5 should change over the course of this test. If oscilloscope probe is connected to PA5, changes will also be noticed on the oscilloscope.

1. Press Switch 11 once. The seven segment display should still read 0100 but now LED2=Off and LED4=Green. This indicates amplitude is currently being displayed and is set to 100%. The oscilloscope should still show a sinusoid at 100Hz and unchanged (full) amplitude.
2. Press Switch 8 once. The seven segment display should now read 0099. This indicates the amplitude is now set to 99% and pressing Switch 8 decreased it by 1%. This change may be too small to notice any change on the oscilloscope, but the sinusoid's peak should have moved downward slightly.
3. Press Switch 6 once. The seven segment display should now read 0089. This indicates the amplitude is now set to 89% and pressing Switch 6 decreased it by 10%. The oscilloscope should now show a sinusoid at 100Hz with an even lower peak.
4. Press Switch 4 once. The seven segment display should now read 0100. This indicates the amplitude went out of bounds and defaulted back to full amplitude, 100%. In actuality, Switch 4 decreased the amplitude by 100%, but because of the bounds handling it acts as a toggle switch between 100% and 1%.
5. Press Switch 4 once. The seven segment display should now read 0001. This further indicates the behavior of Switch 4, in that it toggles between 100% and 1%. The oscilloscope should now show a nearly flat line, as the sinusoid should only be at 1% of the maximum amplitude.
6. Press Switch 2 once. The seven segment display should now read 0100. This indicates the amplitude went out of bounds and defaulted back to full amplitude, 100%. In actuality, Switch 2 decreased the amplitude by 1000%, but because of the bounds handling it simply defaults to full amplitude.
7. Press Switch 6 twice. The seven segment display should go from 0090 to 0080. This indicates the amplitude is now set to 80%. The oscilloscope should now show a sinusoid at 100Hz with a peak at 80% of the maximum.
8. Press Switch 1 once. The seven segment display should now read 0100. This indicates the amplitude went out of bounds and defaulted back to full amplitude, 100%. In actuality, Switch 1 increased the amplitude by 1000%. The oscilloscope should now show a sinusoid at 100Hz with a peak at 100% of the maximum.
9. Press Switch 6 twice. The seven segment display should go from 0090 to 0080. Now press Switch 7 once. The seven segment display should now read 0081. This indicates the amplitude is now set to 81% and that pressing Switch 7 increased it by 1%. The oscilloscope should now show a sinusoid at 100Hz with a peak at 81% of the maximum.
10. Press Switch 5 once. The seven segment display should now read 0091. This indicates the amplitude is now set to 91% and that pressing Switch 5 increased it by 10%. The oscilloscope should now show a sinusoid at 100Hz with a peak at 91% of the maximum.
11. Press Switch 3 once. . The seven segment display should now read 0100. This indicates the amplitude went out of bounds and defaulted back to full amplitude, 100%. In actuality,

Switch 3 increased the amplitude by 100%, but because of the bounds handling it simply defaults to full amplitude.

12. (Rotary Encoder Test) Turn the rotary encoder counterclockwise until you feel it stop resisting and reach a notch. As you turn, notice the least significant digit decrease slowly. After reaching the notch, the display should now show 0096. This indicates that each counterclockwise notch subtracts four from the amplitude and each counterclockwise step between the notches subtracts one. The oscilloscope should now show a sinusoid at 100Hz with a peak at 96% of the maximum.
13. Turn the rotary encoder clockwise until you feel it stop resisting and reach a notch. As you turn, notice the least significant digit increase slowly. After reaching the notch, the display should now show 0100. This indicates that each clockwise notch adds four to the amplitude and each clockwise step between the notches adds one. The oscilloscope should now show a sinusoid at 100Hz with a peak at 100% of the maximum. Note to return to the initial state simply press Switch 11 five times, at which time LED2=Green and LED5=Off.

5. Operation Mode

These tests demonstrate the alternate operating modes for the waveforms, which are Single and Triggered modes. Only LED3 should change over the course of these tests. These tests assume the program is in its initial state. If oscilloscope probe is connected to PA5 (recommended), changes will also be noticed on the oscilloscope.

5.1 Single Mode

This test is intended to demonstrate the functionality of the Operation Mode for outputting a single period.

1. Press Switch 10 twice. Notice LED3=Red then LED3=Off, this indicates the Operation Mode changed to Triggered then Single. Immediately after LED3=Off, the oscilloscope should have shown a brief flash of a single period of the 100Hz sinusoid. At this point, the program's Operation Mode is set to Single and waiting for user input to send another period. After the brief flash, the oscilloscope should show a flat line.
2. (Watch oscilloscope closely) Press Switch 12 once. On the oscilloscope, notice a single sinusoid period flash on the screen then the signal return to a flat line. Press Switch 12 several times and observe a time period flash per press. Each press of Switch 12 resets a flag that goes high once a full period has been read.
3. Press and hold Switch 12. Notice only a single period is flashed on the oscilloscope before returning to a flat line. All switches on the board are passed through an edge detection/debouncing filter to verify the switch press, therefore holding the switch will have no added effect.

4. Press Switch 10 once. Notice LED3=Green and the oscilloscope is once again displaying a continuous sinusoid at 100Hz. This indicates the program is again in repetitive operating mode. Note the program is back in its initial state, so you can continue tests from this point.

5.2 Trigger Mode

This test is intended to demonstrate the functionality of the Operation Mode for outputting based on a trigger input. The default input pin is PB15, and is configured for a high value to be considered On for the signal. The trigger will be treated as some external switch that can be toggled on and off, and is connected to PB15. If PB15 is not available as in input, see Maintainer document in the Alternate Configuration section to modify the trigger pin. The trigger is assumed to be Off (low value) at the start of this test.

1. Press Switch 10 once. Now LED3=Red. This indicates the program is now in triggered mode and is awaiting a trigger on the trigger pin. The oscilloscope should now show a flat line (due to a lack of a trigger).
2. Toggle the trigger on. The oscilloscope should now show a sinusoid at 100Hz, indicating the trigger is being received.
3. Toggle the trigger off. The oscilloscope should now show a flat line, indicating the trigger is no longer being received.
4. To return to the initial state, press Switch 10 twice. Notice LED3=Green.

6. USART Waveform

This test is intended to demonstrate the functionality of the USART. This test assumes a serial communication terminal is running and a connection between it and the board has been made. For the proper serial communication configuration see either the User Manual or Maintainer document in the section Serial Communication Overview. This test assumes the program is in its initial state. Only the seven segment display, LED1, LED2, LED4 and LED5 should change over the course of this test. If oscilloscope probe is connected to PA5 (recommended), changes will also be noticed on the oscilloscope.

1. Press Switch 9 three times. Now LED1=Green and LED4=Green, indicating the waveform source has been set to the USART waveform buffer. The oscilloscope should show a flat line, as the waveform buffer is empty.
2. Press Switch 11 twice. Now the seven segment display should read 0000, LED2=Off and LED5=Off, indicating that the first read-only value is being displayed on the seven segment display. Since the first read-only value is configured to the size of the USART waveform buffer, this also indicates that the waveform buffer is empty.
3. In the communication terminal, type the characters “h” and “i”. Notice the characters show up, indicating they have been sent back as confirmation. The seven segment display should still read 0000 and no change should be observed on the oscilloscope.

4. In the communication terminal, type the characters “f”, “f” and “f”. Notice the characters show, indicating they have been sent back as confirmation. Also notice, the cursor for the terminal has advanced to the next line, indicating a 12-bit number has been parsed and sent to the waveform buffer. The seven segment display should now read 0001, indicating one value has been saved to the waveform buffer. The oscilloscope should not be showing a flat line at the maximum voltage, this is because the single value of 0xfff is making up the entire period of the waveform.
5. In the communication terminal, type the characters “f”, “h”, “f”, “j”, and “f”. Notice the characters show, indicating they have been sent back as confirmation. Also notice, the cursor for the terminal has advanced to the next line after the last “f”, indicating a 12-bit number has been parsed and sent to the waveform buffer. This shows that the valid hex characters do not need to be consecutive, as non-hex characters will merely be sent back as confirmation with no other action taken. The seven segment display should now read 0002, indicating two values are now in the waveform buffer. The oscilloscope should still show a flat line at the maximum voltage, because the entire period is the waveform is currently two 0xfff values.
6. In the communication terminal, type the characers “e”, “e”, “e”, “e”, “e”, and “e” (total of six). Notice after each batch of three characters, the cursor for the terminal advanced to the next line. The seven segment display should now read 0004, indicating four values are now in the waveform buffer. The oscilloscope should now be showing a waveform with two different steps repeating (the timescale may need to be adjusted).
7. In the communication terminal, type the character “x”. Notice the cursor for the terminal has advanced to the next line, and character “:” is at the beginning of the line. This indicates the waveform buffer has been cleared. The seven segment display should now 0000, indicating the waveform buffer is now empty. The oscilloscope should now show a flat line at the minimum voltage (zero).
8. In the communication terminal, hold down the key for character “f”. Notice after each batch of three characters, the cursor for the terminal advanced to the next line. Also notice the number on the seven segment display steadily increasing. Continue to hold the key until the number on the seven segment display is no longer changing or until a “!” is character is seen in the communication terminal. This indicates that the waveform buffer is full and the values are no longer being accepted into the buffer. The seven segment display should read 0256, indicating the maximum size of the waveform buffer is 256. The oscilloscope should show a flat line at the maximum voltage, as the entire period is comprised of 0xfff values.
9. Note that the USART waveform is treated like any other waveform and is therefore subject to the amplitude and frequency adjustments. This can be verified by populating the USART waveform buffer then going through the Frequency and Amplitude tests in a previous section. Note to return the program to its initial state, enter an “x” character in the communication terminal, you should now see 0000 on the seven segment display, then press Switch 11 four times. Now LED2=Green and LED5=Off. Now press Switch 9 once, LED1=Off and LED4=Off.