Software Development - 3K04

Assignment 3 - Pacemaker Testing

Instructor: Dr. Alan Wassyng

December 12, 2017

Group 7 - "Group 4"

Adam Cool	400032857	coola
Andrew Rehkopf	001412499	rehkopaz
Evan Gagich	400027794	gagiche
Ibrahim Tannir	001204850	tanniri
Michael Henry	400011728	henrym1
Michael Soosaipillai	400034820	soosaipm
Moshiur Howlader	001316948	howlam

Contents

1 Introduction

Testing is performed to check the completeness of code based on a specific list of requirements or specifications. The overall goal is not to fix every single bug in the program but to find situation that could negatively affect the program. Testing helps finds defects created by the programmer during development, gain confidence in and provide information about the quality of the program. Testing and verification can also lead to the ability to maintain code and find potential problematic error before they become harmful. The expected values of the output should come from your requirements. Testing is conducted in a variety of settings including LabView's myRIO or Matlab simulation.

2 Testing on FRDM-K64F

2.1 Overview

All tested using heart rates of 30, 35, 45, 60, 65, 75, 90, 95, 105, 120 with lower rate at 60 and 90, and high rate at 120 and 150 respectively. Rate adaptive are tested at low rate, and then moved to achieve higher rates. These rates were used to give a wide range of both high and low heart rates as well as odd heart rates that fall between the usually tested ones. All modes and rates were changed using the DCM, so no out of boundary conditions can be tested since the DCM will not allow uploading of out of boundary condition.

Due to an issue with the shield, no modes that require the atrium to pulse work correctly, this is a result of the capacitor not discharging through the atrium line and all tests on the Atrium mode will be excluded and all fail before the test.

2.2 Pace Modes

The following test cases test the functionality of each pace mode. Note that the results for atrium only modes are identical and as such, only one of their associated modes is included.

Input - Lower rate: 60, Upper rate: 120. myRIO induced rates of 30, 35, 45, 60, 65, 75, 90, 95, 105, 120

Mode	Expected Output	Actual Output	Result
VOO	Constant ventricle rate of 60 beats per minute, 1 beat every 1 second.	Constant ventricle rate of 60 beats per minute, 1 beat every 1 second.	Pass
VVI	Does not beat during any beat rate higher than 60. The beat rates of 30, 35, and 45 all have 1 beat 1 second after the pulse.	Does not beat during any beat rate higher than 60. The beat rates of 30, 35, and 45 all have 1 beat 0.99 seconds after the pulse.	Pass
DOO	Constant rate of 60 beats per minute, 1 atrium beat followed by a ventricle beat every 1 second. 60 beats of the atrium, 60 beats of the ventricle.	Constant rate of 60 beats per minute, 1 ventricle beat every 1 second. Atrium does not work.	Pass for the ventricle, Fail for atrium.
DDD	Does not beat during any beat rate higher than 60. The beat rates of 30, 35, and 45 all have 1 atrium beat followed by a ventricle beat 1 second after the pulse.	Does not beat during any beat rate higher than 60. The beat rates of 30, 35, and 45 all have a ventricle beat 0.99 seconds after the pulse. Atrium does not work.	Pass for the ventricle, Fail for atrium.

Input - Lower rate: 60, Upper rate: 120. myRIO induced rates of 30, 35, 45, 60, 65, 75, 90, 95, 105, 120

Mode	Expected Output	Actual Output	Result
VOOR	Constant ventricle rate of 60 beats per minute, 1 beat every 1 second. After motion the ventricle rate increases to 120 beats per minute, 1 beat every 0.5 seconds before lowering down.	Constant ventricle rate of 60 beats per minute, 1 beat every 1 second. After motion ventricle rate increases to 120 beats per minute, 1 beat every 0.5 seconds before lowering down to 90 beats per second, and then 60.	Pass
VVIR	Does not beat during any beat rate higher than 60. The beat rates of 30, 35, and 45 all have 1 beat 1 second after the pulse. After motion the ventricle does not beat for any beat rate higher than 120. The beat rates of 30, and 35 both have 3 beats every 0.5 seconds after the pulse. The beat rate of 45 will have 2 beats after the pulse. The beat rates of 60, 65, 75, 90, 95, and 105 will all have 1 beat after the pulse.	Does not beat during any beat rate higher than 60. The beat rates of 30, 35, and 45 all have 1 beat 0.99 seconds after the pulse.	Pass
DOOR	Constant rate of 60 beats per minute, 1 atrium beat followed by a ventricle beat every 1 second. 60 beats of the atrium, 60 beats of the ventricle. After motion the beat rate increases to 120 beats per minute, 1 beat every 0.5 seconds before lowering down.	Constant ventricle rate of 60 beats per minute, 1 beat every 1 second. After motion ventricle rate increases to 120 beats per minute, 1 beat every 0.5 seconds before lowering down to 90 beats per second, and then 60. Atrium does not work.	Pass for the ventricle, Fail for atrium.
DDDR	Does not beat during any beat rate higher than 60. The beat rates of 30, 35, and 45 all have 1 atrium beat followed by a ventricle beat 1 second after the pulse. After motion there are no pulses for any beat rate higher than 120. The beat rates of 30, and 35 both have 3 beats after the pulse. The beat rate of 45 will have 2 beats after the pulse. The beat rates of 60, 65, 75, 90, 95, and 105 will all have 1 beat after the pulse.	Does not beat during any beat rate higher than 60. The beat rates of 30, 35, and 45 all have a ventricle beat 0.99 seconds after the pulse. After motion there are no pulses for any beat rate higher than 120. The beat rates of 30, 35, and 45 all have 2 beats after the pulse. The beat rates of 60, 65, 75, 90, 95, and 105 will all have 1 beat after the pulse. Atrium does not work.	Pass for the ventricle, Fail for atrium.
Atrium Mode	Atrium beats according to input and pacing mode	Atrium failed to pace	Fail for atrium modes

Further testing of pace modes with different input parameters
Input - Lower rate: 90, Upper rate: 150. myRIO induced rates of 30, 35, 45, 60, 65, 75, 90, 95, 105, 120

Mode	Expected Output	Actual Output	Result
VOO	Constant ventricle rate of 90 beats per minute, 1 beat every two thirds of a second.	Constant ventricle rate of 90 beats per minute, 1 beat every two thirds of a second.	Pass
VVI	Does not beat during any beat rate higher than 90. The beat rates of 30, 35 all have 2 every beats two thirds of a second after the pulse. 45, 60, 65, and 75 will all have 1 pulse two thirds of a second after the pulse.	Does not beat during any beat rate higher than 90. The beat rates of 30, 35 all have 2 beats two thirds and 1 and one third seconds after the pulse. 45,60,65, and 75 will all have 1 pulse two thirds of a second after the pulse.	Pass
DOO	Constant rate of 90 beats per minute, 1 atrium beat followed by a ventricle beat every two thirds of a second. 90 beats of the atrium, 90 beats of the ventricle.	Constant rate of 90 beats per minute, 1 ventricle beat every 2/3 second. Atrium does not work.	Pass for the ventricle, Fail for atrium.
DDD	Does not beat during any beat rate higher than 90. The beat rates of 30, 35 all have 2 beats two thirds and 1 and one third seconds after the pulse. 45, 60, 65, and 75 will all have 1 pulse two thirds of a second after the pulse.	Does not beat during any beat rate higher than 90. The beat rates of 30, 35 all have 2 beats two thirds and 1 and one third seconds after the pulse. 45,60,65, and 75 will all have 1 pulse two thirds of a second after the pulse. Atrium does not work.	Pass for the ventricle, Fail for atrium.
VOOR	Constant ventricle rate of 90 beats per minute, 1 beat every two thirds of a second. After motion the ventricle rate increases to 150 beats per minute, 1 beat every two fifths of a second before lowering down.	Constant ventricle rate of 90 beats per minute, 1 beat every two thirds of a second. After motion the ventricle rate increases to 150 beats per minute, 1 beat every two fifths of a second before lowering down to 120 beats per minute, and then 90.	Pass
VVIR	Does not beat during any beat rate higher than 90. The beat rates of 30, 35 all have 2 beats every two thirds of a second after the pulse. 45, 60, 65, and 75 will all have 1 pulse two thirds of a second after the pulse. After motion the beat rates of 30 and 35 will have 4 beats every two fifths of a second after the pulse. The beat rate of 45 will have 3 beats every two fifths of a second after the pulse. The beat rates of 60, and 65 all have 2 beats every two fifths of a second after the pulse. The beat rates of 75, 90, 95, and 105 will all have 1 pulse two thirds of a second after the pulse.	Exactly as stated in the expected results	Pass

Input - Lower rate: 90, Upper rate: 150. myRIO induced rates of 30, 35, 45, 60, 65, 75, 90, 95, 105, 120

Mode	Expected Output	Actual Output	Result
DOOR	Constant rate of 90 beats per minute, 1 atrium beat followed by a ventricle beat every two thirds of a second. 90 beats of the atrium, 90 beats of the ventricle. After motion the beat rate increases to 150 beats per minute, 1 beat every two fifths of a second before lowering down.	Constant rate of 90 beats per minute, 1 ventricle beat every two thirds of a second. After motion the beat rate increases to 150 beats per minute, 1 beat every two fifths of a second before lowering down to 120 beats per minute, and then 90. Atrium does not work.	Pass for the ventricle, Fail for atrium.
DDDR	Does not beat during any beat rate higher than 90. The beat rates of 30, 35, and 45 all have 1 atrium beat followed by a ventricle beat every two thirds of a second after the pulse. After motion the beat rates of 30 and 35 will have 4 beats every two fifths of a second after the pulse. The beat rate of 45 will have 3 beats every two fifths of a second after the pulse. The beat rates of 60, and 65 all have 2 beats every two fifths of a second after the pulse. The beat rates of 75, 90, 95, and 105 will all have 1 pulse two thirds of a second after the pulse.	Does not beat during any beat rate higher than 90. The beat rates of 30, 35, and 45 all have 1 ventricle beat every two thirds of a second after the pulse. After motion the beat rates of 30 and 35 will have 4 beats every two fifths of a second after the pulse. The beat rate of 45 will have 3 beats every two fifths of a second after the pulse. The beat rates of 60, and 65 all have 2 beats every two fifths of a second after the pulse. The beat rates of 75, 90, 95, and 105 will all have 1 pulse two thirds of a second after the pulse. Atrium does not work.	Pass for the ventricle, Fail for atrium.
Atrium Mode	Atrium beats according to input and pacing mode	Atrium failed to pace	Fail for atrium modes

2.2.1 Conclusion

It is evident that the appropriate functionality occurs for ventricle pacing however atrium pacing fails in all test cases. Rate adaptivity appears to be working for ventricle however it is unclear whether it is correct for atrium as no pace can be observed.

2.3 Rate Adaptivity

Additional cases probed using the Oscilloscope. These tests were conducted on all rate adaptive modes

Test Case	Expected Output	Actual Output	Result
60 BPM lower rate, 120 BPM upper rate (VOOR), 2 ms PW	Pace should occur at lower rate until stimulation applied then raise to medium rate then upper rate	Pace and LED indicator rate increases with stimulation.	Pass for rate adaptivity.
60 BPM lower rate, 120 BPM upper rate (AOOR), 2 ms PW	Pace should occur at lower rate until stimulation applied then raise to medium rate then upper rate	LED indicator rate increases however no paces seen	Pass for rate adaptivity.
60 BPM lower rate, 120 BPM upper rate (VVIR), 2 ms PW	Pace should occur at lower rate until stimulation applied then raise to medium rate then upper rate, no pace should occur upon detection of simulated pace	LED indicator rate increases, pace rate increases upon stimulation appears to react to simulated paces	Pass
60 BPM lower rate, 120 BPM upper rate (AAIR), 2 ms PW	Pace should occur at lower rate until stimulation applied then raise to medium rate then upper rate, no pace should occur upon detection of simulated pace	LED indicator rate increases upon stimulation still no pace seen on oscilloscope	Pass for rate adaptivity.
60 BPM lower rate, 120 BPM upper rate (DOOR), 2 ms PW	AV pace should occur at lower rate until stimulation applied then raise to medium rate then upper rate.	LED indicator rate increases upon stimulation no atrium pace seen on oscilloscope	Pass for rate adaptivity.
60 BPM lower rate, 120 BPM upper rate (DDDR), 2 ms PW	AV pace should occur at lower rate until stimulation applied then raise to medium rate then upper rate, no pace should occur upon detection of simulated pace	LED indicator rate increases upon stimulation no atrium pace seen on oscilloscope	Pass for rate adaptivity.

2.3.1 Conclusion

It is evident that the appropriate functionality occurs for ventricle pacing however atrium pacing fails in almost all test cases. Rate adaptivity appears to be working for ventricle however it is unclear whether it is correct for atrium as no pace can be observed.

2.4 Pulse Amplitude

The following tests are conducted to determine the correctness of the outputted pace amplitude. **Input - Pulse Width 1ms**

Pulse Amplitude	Expected Output	Actual Output	Result
2.5 V	Pulses that are 1 ms long and spike up to a maximum of 2.5 V.	The pulses produced by the pacemaker were 1ms in duration but were slightly under 2.5V at max.	Pass
3.75 V	Pulses that are 1 ms long and spike up to a maximum of 3.75 V.	The pulses produced by the pacemaker were 1ms in duration but were slightly under 3.75V at max.	Pass
5.0 V	Pulses that are 1 ms long and spike up to a maximum of 5.0 V.	The pulses produced by the pacemaker were 1ms in duration but were slightly under 5.0V at max.	Pass

2.4.1 Conclusion

This inability of the pacemaker to not reach the desired voltage is caused by imperfections in the parts, and was small enough that the difference would be insignificant and can be ignored.

2.5 Serial Receive Testing

These tests were conducted using the coded board and the DCM particular rates and modes were set to LEDs so that the result of the serial transmission can be confirmed to be right.

Test Case	Expected Output	Actual Output	Result
Change mode to AAO from start up of VVO	LED turns red to blue	LED turns red to blue	Pass
Change mode to VVOR from start up of VVO	LED remains blue and flashes green upon pace (rate adaptivity is visible)	Mode change and rate adaptivity working	Pass
Check that correct upper rate of 120 is received	LED Turns green	Green LED on	Pass
Check that correct amplitude of 4500 mv is received	LED Turns green	Green LED on	Pass
Check that amplitude of 4500 mv is converted to PWM right	LED Turns green	Green LED on	Pass
Check that BPM of 60 is converted to beat period of 1000 ms	LED Turns green	Green LED on	Pass
Check that pacing is done at correct rate which was sent as 60 BPM	Pace every 1000ms	Pace occurs roughly every 2000 ms	Fail

2.5.1 Conclusion

All elements of serial receiving occurs properly however the serial receive block appears to destroy the accuracy of pacing rates (nearly halves them).

3 Simulation Testing

These tests were conducted using Matlab Simulink simulation and results were probed using the scope function block. The purpose is essentially to confirm that the atrium pacing would work if the shield were functional.

Test Case	Expected Output	Actual Output	Result
Pace mode VVO, 60 BPM, 2 ms PW	Pace of 2ms width every 1000ms	Ventricle pace occurs at 1000ms for 2 ms	Pass
Pace mode AAO, 60 BPM, 2 ms PW	Pace of 2ms width every 1000ms	Atrium pace occurs at 1000ms for 2 ms	Pass
Pace mode VVI, 60 BPM, 2 ms PW Induced pace all the time	No paces	No paces	Pass
Pace mode VVI, 60 BPM, 2 ms PW No induced paces	Pace of 2ms width every 1000ms	Ventricle pace occurs at 1000ms for 2 ms	Pass
Pace mode AAI, 60 BPM, 2 ms PW Induced pace all the time	No paces	No paces	Pass
Pace mode AA, 60 BPM, 2 ms PW No induced paces	Pace of 2ms width every 1000ms	Atrium pace occurs at 1000ms for 2 ms	Pass
Correct Pacing mode and settings (VVO 60 BPM, 2 ms PW) at start-up	Pace of 2ms width every 1000ms	Pace occurs at 1000ms for 2 ms	Pass
Probe all PWM settings to ports for correctness	Proper amplitudes and threshold voltages should be seen	The correct amplitudes are seen	Pass
Probe all calculated beat rates in milliseconds (ex. 60 BPM = 1 Second)	Correct beat period	Beat period of 1000ms seen for 60 BPM	Pass

3.0.2 Conclusion

All elements of design are working correctly in simulation.

4 Conclusion of Testing of Pacemaker

All implemented modes of the pacemaker pass testing with the exception of atrium pacing which due to a fault in the shield, will not work under any circumstance. Simulation testing indicates that the atrium paces would work if the shield were functional.