Assignment 2 Part 1

Simulinkers
Group 8
November 27, 2017
SFWR ENG 3K04

Table of Contents

Introduction 2

1: Requirements Likely to Change 2

2: Design Decisions Likely to Change 3

3: Simulink Diagram 4

- **Explanation of Simulink:** 9
- **Simulink Testing:** 10

Introduction

This assignment is the intermediate step in the process of our pacemaker project. This assignment just like the previous consists of two major sections. The first section involves implementing working modes of: VOO, AOO, VVI, and AAI into the prior Simulink model. In addition, the model was designed to support rate adaptive functionality and allowing the DCM to dynamically change between modes to without restarting the device. The second part involves expanding the Device Controller Monitor (DCM) to accommodate the newly added modes. The major functionality applied to the DCM was serial communication, which allows the DCM and pacemaker to transmit and receive information.

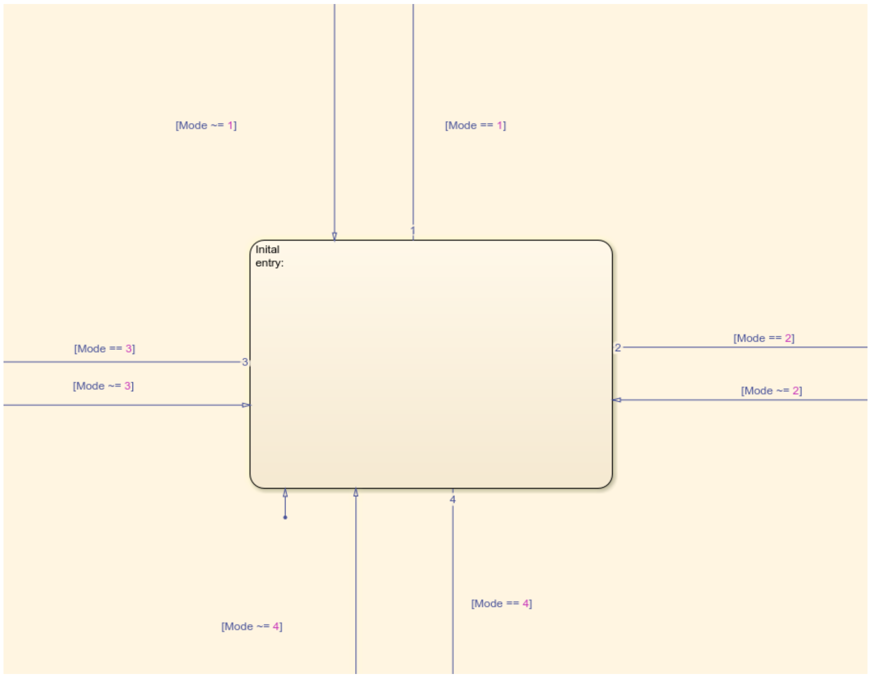
1: Requirements Likely to Change

From the first part of this assignment, an additional two modes have been added to the state flow. The two modes added were VVI and AAI. These two modes essentially monitor the patient’s heartbeat sensing the ventricle or atrial and are inhibited by a sensed event. Such an event would lead the pacemaker to send out a signal to contract the heart again if a pulse wasn’t detected between the specified time intervals. An additional functionality included in this assignment was the rate-adaptive pacing, which is designed to increase the heart rate according to metabolic needs during physical, mental or emotional activity. The DCM was implemented to dynamically change between modes without restarting the device. This will allow the user to input the required specification for each mode and Simulink will determine which state to perform. The next step of this project would be to implement DDDR (Dual chamber rate adaptive) which has a sensor that records a demand for a higher cardiac output and can adjust the heart rate accordingly.

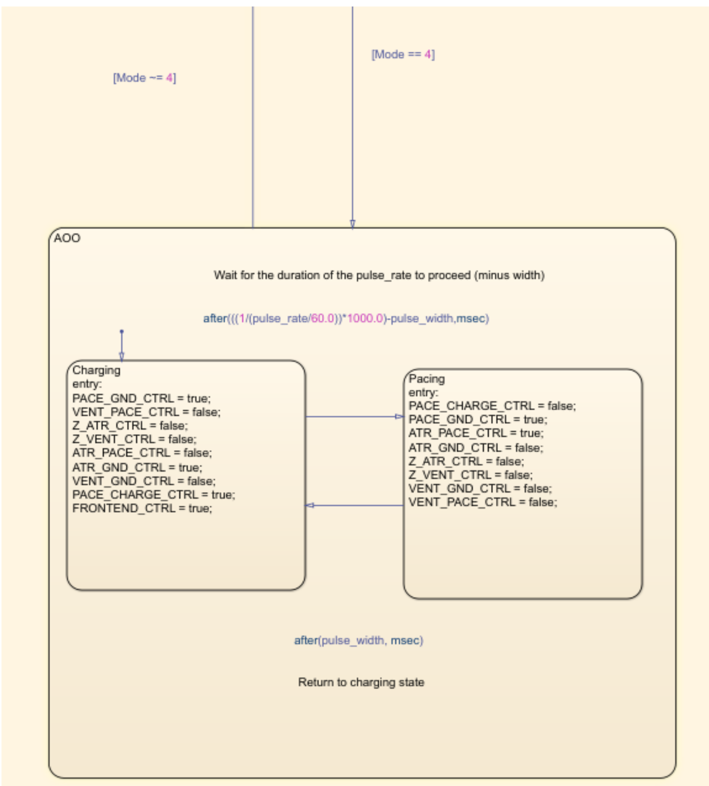
2: Design Decisions Likely to Change

Numerous design changes were made to this section of the assignment. The biggest change overall would be adding extra state flows for each mode and implementing the DCM serial communication. Essentially the DCM would send out an array that would contain the mode, lower rate limit, amplitude, pulse width and the refractory period. Simulink would use this information to determine the appropriate action to implement in the pacemaker. DDDR pacemaker marks atrial and ventricular rates and senses both chambers of the heart. If the heart natural pacemaker function is failing, DDDR pacemaker can take over their role and ensure further smooth functioning of the heart. Sometimes they are referred to a dual chamber pacemaker with adaptability, and can be adapted to the special needs of every patient who needs this type of pacemaker.

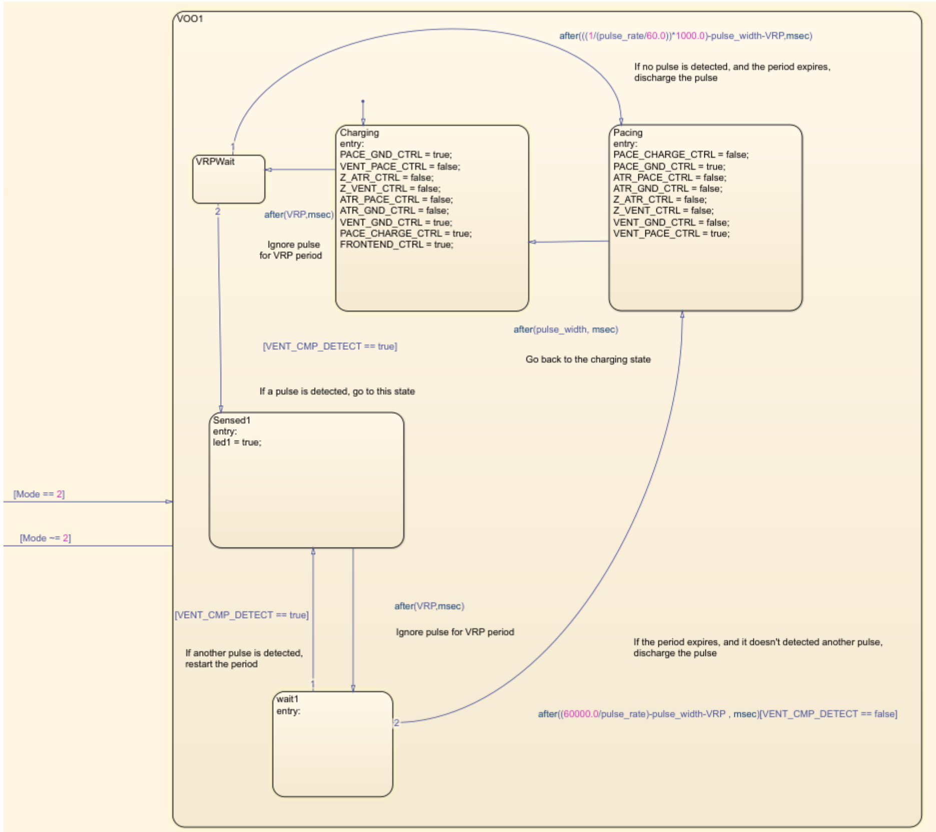
3: Simulink Diagram



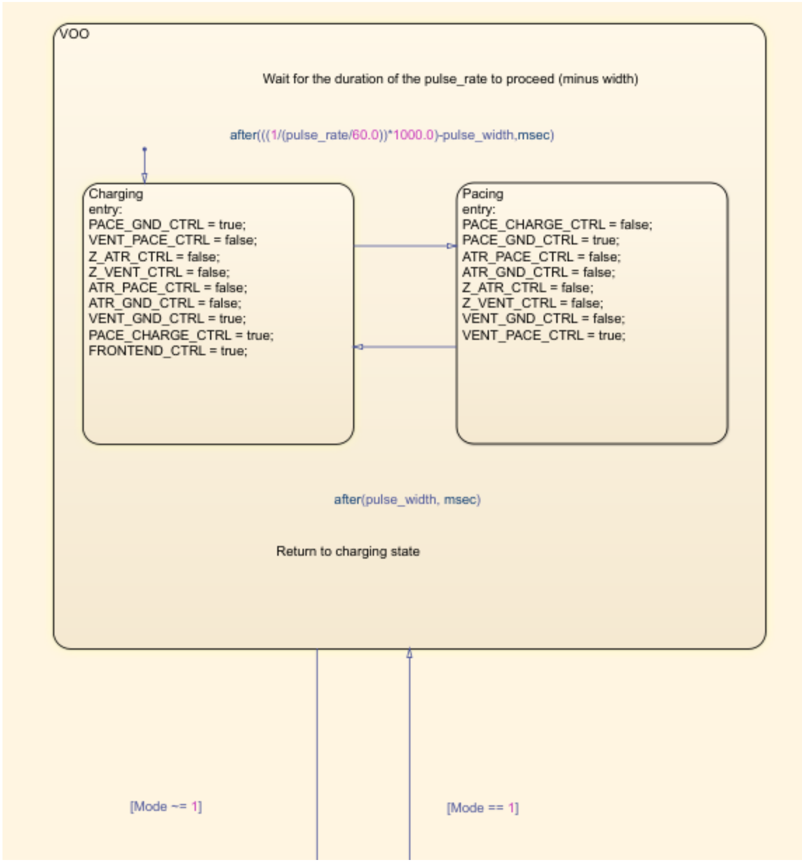
Center Box



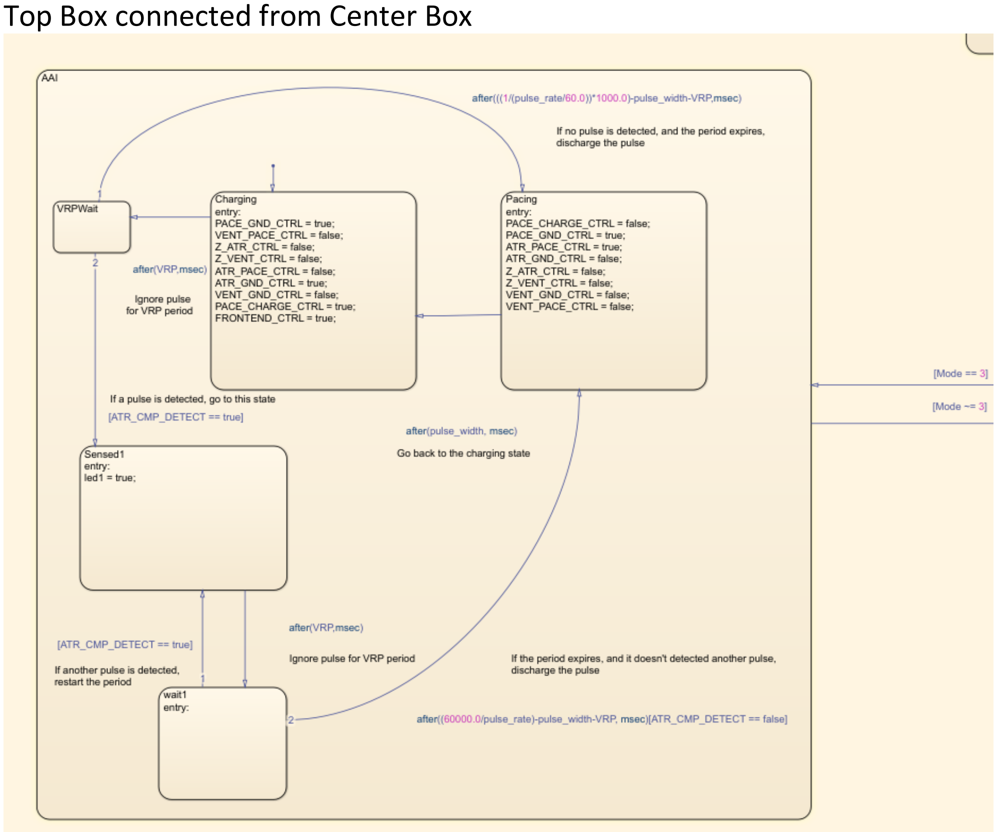
Lower Box connected from Center Box



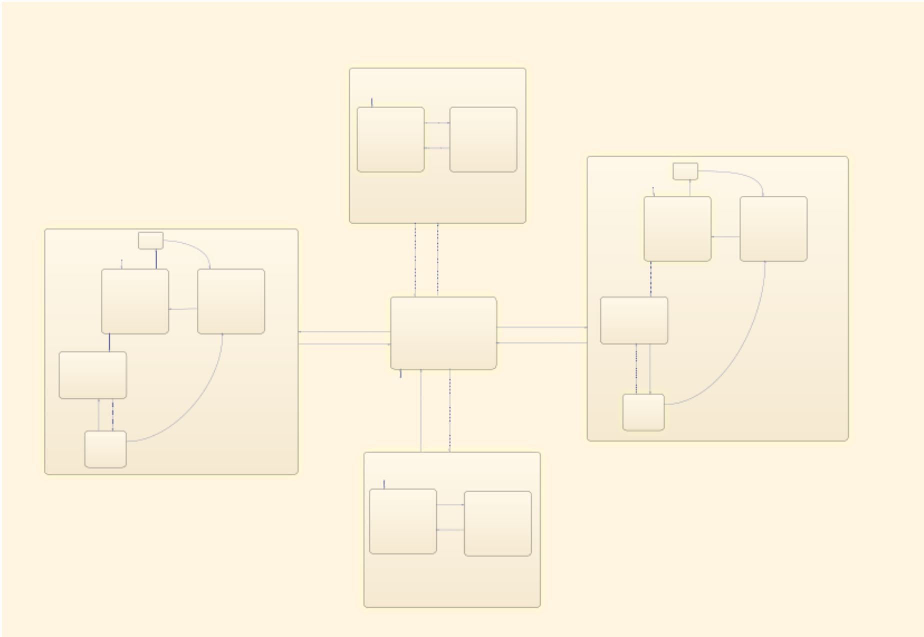
Right Box connected from Center Box



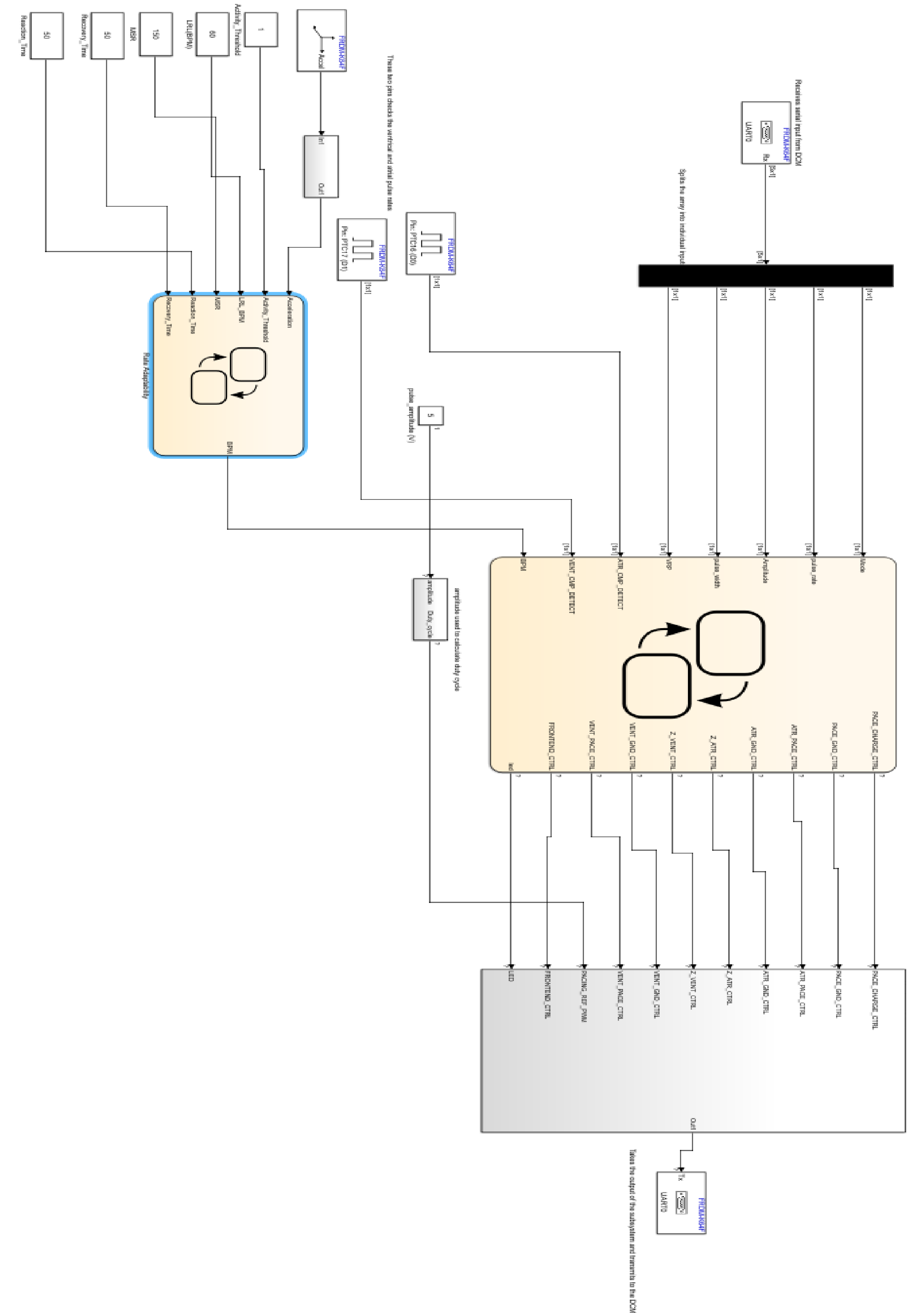
Top Box connected from Center Box



Left Box connected from Center Box



Full Diagram



Receives serial input from DCM
UART0
Rx
Splits the array into individual input
Mode
pulse_rate
Amplitude
pulse_width
VRP
ATR_CMP_DETECT
VENT_CMP_DETECT
BPM
State Input
State Output
PACE_CHARGE_CTRL
PACE_GND_CTRL
ATR_PACE_CTRL
ATR_GND_CTRL
Z_ATR_CTRL
Z_VENT_CTRL
VENT_GND_CTRL
VENT_PACE_CTRL
FRONTEND_CTRL
led
These two pins checks the ventrical and atrial pulse rates
Pin: PTC16 (D0)
Pin: PTC17 (D1)
pulse_amplitude (V)
amplitude used to calculate duty cycle
amplitude
Duty_cycle
Accel
In1
Out1
Activity_Threshold
LRL(BPM)
MSR
Recovery_Time
Reaction_Time
Acceleration
LRL_BPM
Rate Adaptability
LED
PACING_REF_PWM
Takes the output of the subsystem and transmits to the DCM
Tx

Explanation of Simulink:

From the DCM, an array of five values (1x5) is passed through to the demux block in Simulink. The demux block separates this array into individual values to pass as inputs. A design decision was made for the first element in the array to be an integer between one and four with each integer corresponding to one of the four modes: VOO, AOO, AAI and VVI. Two other inputs are from the two pins on the board that detect if the ventricle and atrium pulsed. The final input is BPM which accounts for rate adaptability.

The rate adaptability module has hardcoded values as well as the acceleration of the board and it outputs the BPM value. The acceleration is calculated within a subsystem. This subsystem takes in the 1x3 array that contain the acceleration in the x, y and z plane and passes it through a demux to separate the accelerations. The magnitude of the acceleration is found through calculations.

In the main chart, a few functions are happening. For the VOO and AOO mode, the states switch from charging and discharging as whether or not the heart beats is irrelevant for these modes. For VVI and AII, it is more complicated. It enters the charging state and then checks whether or not it detects the heart beats through VENT_CMP_DETECT for VVI and ATR_CMP_DETECT for AAI. If there is detection, it does not go to the discharge state. It flows to a sensed state and a LED turns on and then flows to a waiting state. If there is another detection, it loops back to the sense state. If not, it flows to the discharge state.

Simulink Testing:

Throughout this project we encountered numerous occasions to test if our Simulink state flows were working properly. LEDs were used to test the rate adaptive functionality. When the pacing was increased, the LEDs would blink at a faster rate to match it. Likewise, when the pacing was slowed down, so would the blinking of the LEDs. Another instance of using LEDs was in VVI and AAI mode. When VENT_CMP_DETECT and ATR_CMP_DETECT were true (a heartbeat was detected) the LED would flash on. Furthermore, LabView was used to test if the output of the Simulink system works properly. The expected outputs were tested for four different test cases. The actual output matched the expected output.