**SFRWENG 3K04**

Assignment 1

Part 2: Hardware Hiding

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1. **Introduction**

The pacemaker design's hardware-hiding components are all included in Part 3 of Assignment 1. One component was created for each pacemaker mode to deal directly with the hardware pins and share streamlined information with the main software implementation only when necessary. This method of hardware concealing was made possible by realizing that all pacemaker modes use the identical pacing and sensing mechanism.

1. **Variables**
   1. Measured Variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Units/Type** | **Range** | **Description** |
| t | ms |  | Time period since the pulse is started |
| Pul\_detect\_in\_atr | Boolean | {True, False} | Atrium Pulse Detected |
| Pul\_detect\_in\_ven | Boolean | {True, False} | Ventricle Pulse Detected |
| s\_atrialPaceStart | Boolean | Commencement of atrial pulse | {True, False} |
| s\_ventricularPaceStart | Boolean | Commencement of ventricular pulse | {True, False} |
| s\_paceStart | Boolean | Output will be paceStart regardless of Atrium or Ventricle | {True, False} |

* 1. Constant Variables (Programmable Parameters)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Units/Type** | **Description** | **Value/Range/ToI** |
| p\_pacingMode | int | Pacing mode | {AAO, VOO, AAI, VVI} |
| p\_ventricularPulseAmplitude | V | Desired amplitude of a ventricular pace | 0.5-0.7 ± 12% |
| p\_ventricularPulseWidth | ms | Desired width of a ventricular pace | 0.05-1.9 ± 0.2ms |
| p\_atrialAmplitude | V | Desired amplitude of a ventricular pace | 0.5-0.7 ± 12% |
| p\_atrialPulseWidth | ms | Desired width of a ventricular pace | 0.05-1.9 ± 0.2ms |

2.3 Controlled Variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Units/Type** | **Description** | **Range** |
| s\_atrialPaceStart | Boolean | Commencement of atrial pulse | {True, False} |
| s\_ventricularPaceStart | Boolean | Commencement of ventricular pulse | {True, False} |
| s\_paceStart | Boolean | Output will be paceStart regardless of Atrium or Ventricle | {True, False} |

1. **Interfaces**
   1. Pacing
      1. *Description*

The pacing component regulates the control signals and the pacing reference pulse width modulation in the pacing circuitry. s\_atrialPaceStart and s\_ventricularPaceStart, both of which are typically false, are its two input signals. The correct control signals are programmed to pace the correct chamber when a 1 ms pulse is detected on either.

* + 1. *Variables*
       1. *Measured*

|  |  |  |
| --- | --- | --- |
| **Name** | **Abbreviation** | **Reference** |
| t | - | 2.1 |
| s\_atrialPaceStart | - | 2.1 |
| s\_ventricularPaceStart | - | 2.1 |

* + - 1. *Constant Variables (Programmable Parameters)*

|  |  |  |
| --- | --- | --- |
| **Name** | **Abbreviation** | **Reference** |
| p\_pacingMode | - | 2.2 |
| p\_ventricularPulseAmplitude | - | 2.2 |
| p\_ventricularPulseWidth | - | 2.2 |
| p\_atrialAmplitude | - | 2.2 |
| p\_atrialPulseWidth | - | 2.2 |

* + - 1. *Controlled Variables*

|  |  |  |
| --- | --- | --- |
| **Name** | **Abbreviation** | **Reference** |
| s\_atrialPaceStart | - | 2.3 |
| s\_ventricularPaceStart | - | 2.3 |
| s\_paceStart | - | 2.3 |

* + 1. *Initial Values*

|  |  |  |
| --- | --- | --- |
| **Name** | **Initial Value** | **Reference** |
| p\_pacingMode | OFF | 2.2 |
| p\_ventricularPulseAmplitude | 3.5 | 2.2 |
| p\_ventricularPulseWidth | 0.4 | 2.2 |
| p\_atrialAmplitude | 3.5 | 2.2 |
| p\_atrialPulseWidth | 0.4 | 2.2 |

* + 1. *Requirements*

= false

= false

|  |  |
| --- | --- |
| **p\_PacingMode** |  |
| AOO | p\_atrialAmplitude /0.05 |
| VOO | p\_ventricularPulseAmplitude /0.05 |
| AAI | p\_atrialAmplitude /0.05 |
| VVI | p\_ventricularPulseAmplitude /0.05 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **s\_atrialPaceStart** | **s\_ventricularPaceStart** | **s\_atrialPaceStart** | **s\_ventricularPaceStart** |  |  |  |  |  |
| false | false | false | true | true | false | false | false | true |
| true | false | true | false | false | true | false |
| true | X | X | false | false | true | false | false |
| true | false | X | X | false | true | false | false | false |
| true | X | X | ILLEGAL INPUTS | | | | |

### *State Transitions*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | initial | C22charge | buffer | A\_Pacing | C21Discharge\_A | V\_Pacing | C21Discharge\_V |
| initial | – | Automatic | – | – | – | – | – |
| C22charge | – | – | ~s\_atrialPaceStart  ~s\_ventricularPaceStart | – | – | – | – |
| buffer | – | – | – | s\_atrialPaceStart | – | s\_ventricularPaceStart | – |
| A\_Pacing | – | – | – | – | t= p\_atrialPulseWidth | – | – |
| C21Discharge\_A | – | Automatic | – | – | – | – | – |
| V\_Pacing | – | – | – | – | – | – | t=p\_ventricularPulseWidth |
| C21Discharge\_V | – | Automatic | – | – | – | – | – |

*3.1.6 State details*

|  |  |
| --- | --- |
| **State** | **Description** |
| initial | Defines initial values |
| C22charge | Pacing capacitor starts to charge |
| buffer | Waits until pace start signals are low |
| A\_Pacing | Defines atrium which is pacing |
| C21Discharge\_A | Blocking capacitor begins to discharge through atrium |
| V\_Pacing | Defines ventricle which is pacing |
| C21Discharge\_V | Blocking capacitor begins to discharge through ventricle |

* + 1. *Future Changes*

The state flow diagrams will be modified eventually as dual pacing modes have to implemented in the future.

* + 1. *Design details*

The significance of buffer state is to make sure that pacing does not start looping.

* + 1. *Stateflow*
    2. *Testing*

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Cases** | **Expected Result** | **Actual Result** | **Pass/Fail** |
| p\_pacingMode: AOO  p\_lowrateinterval: 60 BPM | Pacing at 60 BPM | Pacing at 60 BPM | Pass |
| p\_pacingMode: VOO  p\_lowrateinterval: 60 BPM | Pacing at 60 BPM | Pacing at 60 BPM | Pass |

Test 1

HEARTVIEW SS

Test 2

HEARTVIEW SS

* 1. Sensing

*3.2.1 Description*

The control signal for the sensing circuitry as well as the atrial and ventricular comparator reference pulse width modulations are controlled by the sensing component.

*3.2.2 Variables*

*3.2.2.1 Measured variables*

|  |  |  |
| --- | --- | --- |
| **Name** | **Abbreviation** | **Reference** |
|  | - |  |
|  | - |  |
|  | - |  |

*3.2.2.2 Constant variables*

|  |  |  |
| --- | --- | --- |
| **Name** | **Abbreviation** | **Reference** |
| p\_pacingMode | - | 2.2 |
| p\_ventricularPulseAmplitude | - | 2.2 |
| p\_atrialAmplitude | - | 2.2 |

*3.2.2.3 Controlled variables*

|  |  |  |
| --- | --- | --- |
| **Name** | **Abbreviation** | **Reference** |
|  |  |  |
|  |  |  |
|  |  |  |

*3.2.3 Initial Values*

There are no initial values for sensing.

*3.2.4* *Requirements*

|  |  |  |  |
| --- | --- | --- | --- |
| **p\_Pacingmode** |  |  |  |
| AOO | 0 | 0 | False |
| VOO | 0 | 0 | False |
| AAI | p\_atrialAmplitude /0.05 | 0 | True |
| VVI | 0 | p\_ventricularPulseAmplitude/0.05 | True |

*3.2.5 Future Changes*

It is essential to keep a track of both ventricular and atrial paces for dual sensing modes. Therefore, we have to implement more modes in the future.

*3.2.6 Design details*

The discrete clock requires that the PWM ON time be computed, rounded to the nearest number of clock cycles, and then deducted from the PWM period in order to prevent rounding mistakes from affecting the period.

* + 1. *Stateflow*
    2. *Testing*

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Cases** | **Expected Result** | **Actual Result** | **Pass/Fail** |
| p\_Pacingmode: AAI  p\_lowrateInterval: 60 BPM  Atrium PW: 10.0 ms  Heart Rate: 60 BPM | No pacing | No pacing | Pass |
| p\_Pacingmode: VVI  p\_lowrateInterval: 60 BPM  Ventricle PW: 10.0 ms  Heart Rate: 60 BPM | No pacing | No pacing | Pass |

Test 1

HEARTVIEW SS

Test 2

HEARTVIEW SS