Pacemaker DCM Documentation

MECHTRON 3K04

Group 13

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## **DCM**

1. Requirements that are likely to change
   1. Number of testable modes
   2. Number of programmable parameters
   3. DCM to Device communication
   4. Displayable e-gram outputs
2. Design Decisions that are likely to change
   1. Window sizing
   2. Grid sizing
   3. Element placements
   4. Complete transfer to an object-oriented programming style
   5. Use of python serial communication
   6. Use of plotting libraries
   7. Use of some other libraries (do we need to list them all out cause idk what they are yet)
3. For the register.py module
   1. Purpose of Module
      1. Creates “register” window for new users to create an account
      2. Max 10 users
   2. The “secret ingredient”
      1. Love
   3. Public Functions
      1. register\_window(root, login\_database)
         1. Parameters
            1. root – master window in which the register window stems from. In this case, it is the welcome page
            2. login\_database – JSON file containing all of the login information for all users. This file is modified in this module when a new user is created
      2. create\_user():
   4. Entering an input into the “username” and “password” entry boxes will result in the register window destroying itself if the entries are both valid. The entries are then saved locally in login\_database.json. If either or both entry boxes are left empty, the resulting output will be an error message to the user to fill in the boxes. If the username entered is already taken, an error message will be outputted to the user to pick a new username.
   5. State Variables (\*\*All data structures are unique to the tkinter library)
      1. Register\_window
         1. The register window that all the GUI elements are placed on
      2. Reg\_canvas
         1. Creates grid for precise GUI element placement
      3. Register\_label
         1. Label displayed at top of window
      4. Create\_user\_response
         1. Label used to output the error messages
      5. Create\_creds\_btn\_text
         1. Text message displayed on the create\_creds button
         2. Tkinter StringVar data structure
      6. Create\_creds\_btn
         1. Button to be pressed to validate inputs
         2. Calls create\_user function
      7. New\_username\_entry
         1. Entry box for username input
      8. New\_username\_label
         1. Label displaying “New Username: “
      9. New\_password\_entry
         1. Entry box for the password input
      10. New\_password\_label
          1. Label displaying “Password: “
   6. No private functions
   7. Function Internal Behaviour
      1. register\_window(root, login\_database)
         1. Generates the window for user registration
         2. Instantiates all of the labels, buttons, and grid used for the visual aspects of the GUI
      2. create\_user():
         1. Function called when “sign-up” button is clicked
         2. Checks if entry boxes are empty. Returns error if they are
         3. Checks if username already exists in login\_database. Returns error if username already exists
         4. If the entries for username and password are acceptable, they are saved as a dictionary to the login\_database JSON file and the register window destroys itself

## **AOO**

## **VVI**

* 1. *Inputs*
     1. *Beats per Minute (BPM)*

The BPM input parameter is the rate at which the pacemaker will ensure pacing. For example, if set to 60, and the natural heart rate is not present, this input will result in 60 pulses per minute. Additionally, if the natural heart rate is too slow (bradycardia), the BPM input will ensure that there are enough pulses to reach the desired heart rate. For example, if BPM is set to 60 but the natural heart rate is 30, the pacemaker will pulse halfway in between each natural pulse to ensure a heart rate of 60.

* + 1. *Amplitude*

The amplitude input parameter is used to program the desired amplitude of the pacemaker pulses. For example, an input of 2.5 will output a pulse of 2.5V (approximately) from the pacemaker.

* + 1. *Refractory Period*

The ventricular refractory period (VRP) is an input time interval to the system (in ms) which follows a ventricular event. In this time interval, sensing will not inhibit or trigger pacing.

* + 1. *Pulse Width*

The pulse width input parameter is a programmable amount of time between discharging capacitor (C22) and recharging it, which ultimately results in the width of each pulse produced.

* + 1. *Ventricular Sensing Pin (D1)*

The ventricular sensing pin is an input to the pacemaker which reads the output from the heart. Using the output from the heart, this input compares the value to a threshold (section 3.2.3). If the value is greater than it returns a value of HIGH to the system, if the value is lower than the threshold it returns a value of LOW. This input will be used to inhibit or trigger pacing.

* 1. *Outputs*
     1. *Charging Output Pins*

Similar to the VOO mode, the charging state sets a variety of values to specific output pins to charge capacitor C22. The output pins and their values for the charging state are shown below. The block capacitor is also discharged in this state. A variety of the same pins are used in the Pacing state with different values.

|  |  |
| --- | --- |
| Output Pin | Value |
| ATR\_PACE\_CTRL (D8) | LOW |
| VENT\_PACE\_CTRL (D9) | LOW |
| PACING\_REF\_PWM (D5) | Duty Cycle = (5/Amplitude) \* 100 |
| PACE\_CHARGE\_CTRL (D2) | HIGH |
| PACE\_GND\_CTRL (D10) | HIGH |
| Z\_ATR\_CTRL (D4) | LOW |
| Z\_VENT\_CTRL (D7) | LOW |
| ATR\_GND\_CTRL (D11) | LOW |
| VENT\_GND\_CTRL (D12) | HIGH |

* + 1. *Pacing Output Pins*

As with the VOO mode, the pacing state sets a variety of values to specific output pins in order to discharge capacitor C22 and create a pulse. The output pins and their values for the pacing, or discharging state are shown below.

|  |  |
| --- | --- |
| Output Pin | Value |
| ATR\_PACE\_CTRL (D8) | LOW |
| VENT\_PACE\_CTRL (D9) | HIGH |
| PACE\_CHARGE\_CTRL (D2) | LOW |
| PACE\_GND\_CTRL (D10) | HIGH |
| Z\_ATR\_CTRL (D4) | LOW |
| Z\_VENT\_CTRL (D7) | LOW |
| ATR\_GND\_CTRL (D11) | LOW |
| VENT\_GND\_CTRL (D12) | LOW |

* + 1. *Sensing Output Pins*

There are only two output pins used in the sensing state. The first of which, FRONTEND\_CTRL (D13) which is set to high to activate the sensing circuitry. The other output is the VENT\_CMP\_REF\_PWM (D3) pin which is used to set a constant threshold for the VENT\_CMP\_DETECT pin. The threshold for this output is compared against the input to determine if a natural pulse is sensed.

From VENT\_RECT\_SIGNAL (A4) and ATR\_RECT\_SIGNAL (A3) plots below, threshold must be between 60% and 75%.

Chart, histogram

Description automatically generated

Chart

Description automatically generated

* + 1. *LEDs*

Output LEDs were used for visualization and testing purposes of the physical pacemaker shield. A blue LED is activated every time the pacemaker sends a pulse, and a red LED is activated every time the pacemaker senses a pulse.

* 1. *States and Transitions*

*Diagram

Description automatically generated*

Figure 3.3.1. State transition diagram of the four states used in the VVI system.

* + 1. *Charging*

In the charging state, capacitor C22 is charged, and the blocking cap is discharged. The charging state is the initial state of the entire system to charge the capacitor which will be used for pacing. The purpose of this state coming first is to ensure that a pace can be made as soon as needed. Directly before the charging state is the pacing state as charging will need to occur as soon as the capacitor is discharged. The time between pacing and charging is the pulse width, which can be negligible when working with the refractory period. Due to this, the transition from charging to sensing occurs after the refractory period, during this time, no sensing occurs.

* + 1. *Sensing and Waiting*

The sensing state occurs after the refractory period, and after the capacitor has been charged, since a pulse may be needed at any point. There are two output transitions linked to the sensing state. The first transition involves waiting a specific time linked to the beats per minute, if it exceeds this time without sensing a pulse, the system transitions to the pacing state. The other transition is checking to see if a pulse is sensed, if this is the case the system enters the waiting state. The waiting state immediately transitions back into the refractory period (since a natural pulse was just detected). Once the refractory period is complete the system is back in the sensing state, which senses for the desired period of time and if no beat is sensed then will enter the pacing state.

* + 1. *Pacing*

In the pacing state, capacitor C22 is discharged into the ventricle. This state occurs if the sensing state does not read any natural heart beats within a certain amount of time. This state occurs for the entire pulse width and then transitions back into the charging state.

* 1. *Testing/Validation*

## **AAI**