Watchmen Progress Report 2/3/2020

The last couple of weeks have been mainly dedicated towards quality of life changes that we believe will improve the usability and debugging of the original watch design. A second pushbutton was added as well as a newer, more efficient Bluetooth module. The battery and charging module has been tweaked to be more space and power efficient. The board layout has been optimized to leave room for future hardware features to be added.

Quality of Life Changes

The first improvement to input and debugging was changing the mounting of the pushbutton. Currently, the pushbutton is connected by wire which can make it difficult to enclose the top chassis in assembly/maintenance. We will eliminate this by instead using direct mounting to the main PCB. The same optimization is applied with the LED display. We plan to attach female connectors to the LED display that will align with corresponding male connectors on the main PCB. The location of the thoughholes for the PCB were found by using the center of the PCB as a frame of reference and measuring the distance offsets from that center point. A schematic from the datasheet of the LED display was used to determine this. Figure 1 below shows us using Inventor to find the exact location of the holes.

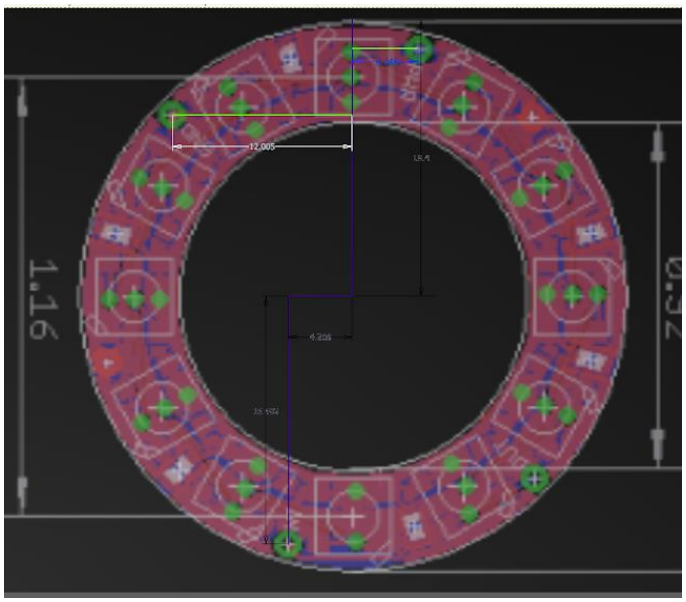

Figure 1: Inventor LED Throughhole Positions

This will completely eliminate wires on the top side of the PCB, with the only wires being the inductive charger underneath the PCB. Another quality of life change that we will fix in this board version is to move the VCC shunt from the watch PCB on the helper board. Currently the VCC shunt to switch between tool and target power for the JTAG interface is on the main watch PCB which is enclosed within a chassis. By moving the switch to an external board, debugging will be much easier, as switching power modes will no longer require removing the top chassis. We have also added a female battery connector to the PCB. This should make contact more

secure and make swapping batteries trivial. The crystal oscillator has also been changed to a surface-mount package in order to have a lower profile.

Entirely New Hardware Features

The only new hardware feature that we have added in this version was the second pushbutton. This secondary pushbutton input opens up more dynamic options for user input and software modes, such as full mouse input functionality.

Battery Efficiency Changes

Our current watch only lasts about 3.5 hours on timekeeping mode and 25 minutes on the gesture mode. We believe that the Bluetooth module was a significant factor for the battery drain. We had made some changes that made the watch only connect to Bluetooth when it was in gesture mode but the battery still proved to be very weak. Another reason why our battery was so poor was because we omitted a reset circuit for the Bluetooth module for the sake of space. This meant that there was no way for us to completely turn off the Bluetooth module. This has been fixed in our latest PCB order. We also decided to change our Bluetooth module to an RN4871, which is an updated model of the previous RN42 and should provide more efficient performance. It has a much smaller footprint that would make layout/routing easier. Another thing we previously omitted from the Bluetooth subsystem was a voltage regulator. We initially overlooked this since our battery was rated at 3.7 V, the same as the maximum operating voltage of the module. This was an erroneous assumption as the lithium-ion battery was able to overcharge up to 4.2 V. This led to the Bluetooth module being completely dysfunctional at voltages over 3.7 V and would be easily fixed by including a voltage regulator. This should be fixed in the latest order.

One thing that we noticed during testing was that our battery protection circuit successfully worked for overvoltage but it did not for undervoltage as our battery drained all the way to 0.5 V. This would be fixed by changing to a new battery with a built-in protection circuit. We will use a 3.7V 150 mAh lithium-ion battery instead of our current 85 mAh coin battery. This would mean modifying our chassis to accommodate the new battery, although we believe that it will greatly improve the battery and PCB space efficiency.

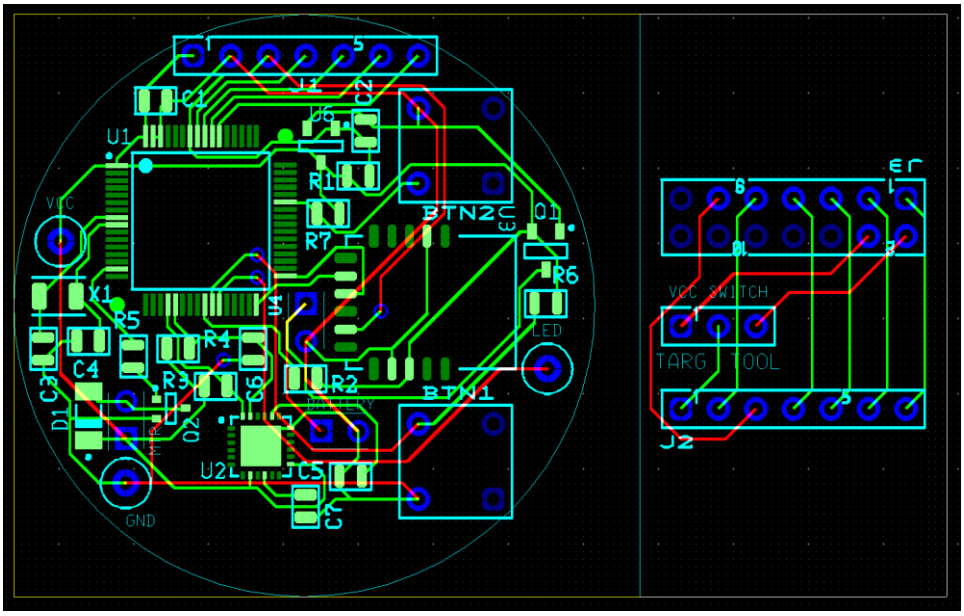

Figure 2: PCB Layout (Watch and Helper Board)

Figure 2 shows the new board layout featuring the hardware changes, including the watch PCB (left) and the JTAG connector helper board with power switch (right). Note the unused space on the bottom of the watch PCB, which is reserved for additional hardware features we will be researching in the coming weeks.

The following is a list of design changes/fixes with this next PCB board and parts order:

1.) **Quality of Life**
   a.) Pairing magnets for charging dock and watch chassis
   b.) Pushbutton side mount on PCB
   c.) Moved power shunt to helper board
   d.) Surface-mount crystal

2.) **Entirely New Hardware Features**
   a.) Second pushbutton

3.) **Power System Changes**
   a.) Smaller/newer BLE module (RN4871)
   b.) (Bluetooth) power management/reset circuit
   c.) Battery protection undervolting fix
   d.) Larger battery
   e.) Completely off state
   f.) Battery quick connector

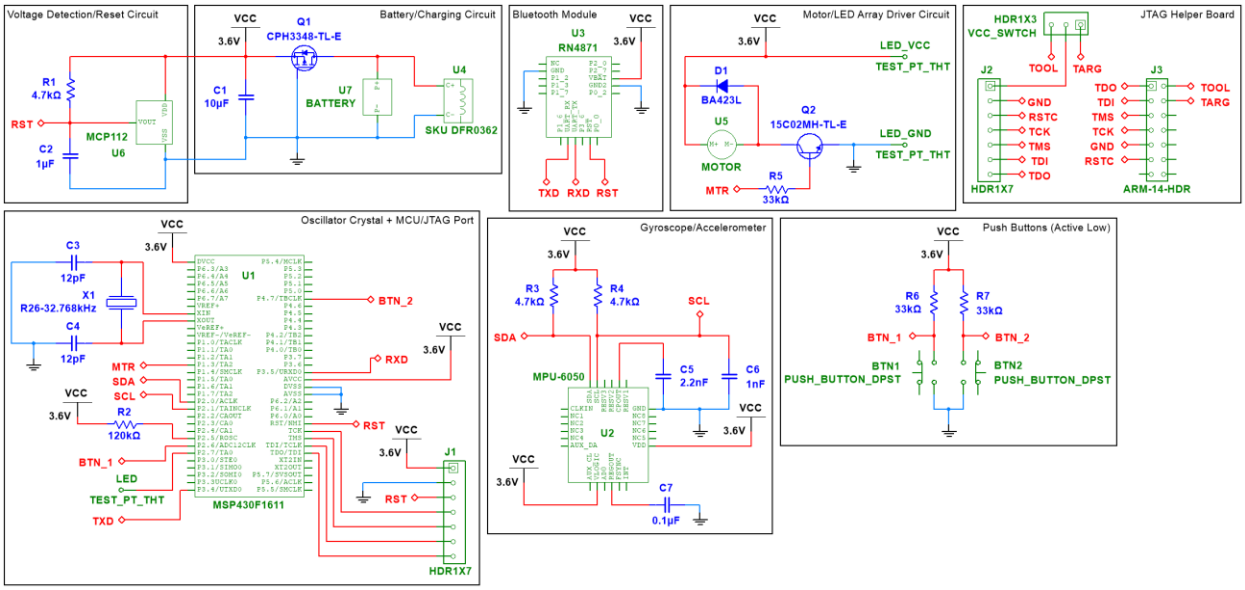

Figure 2: Multisim Circuit Schematic