Propellerhead PAPR Hood - Electronics Design Diary

2020-05-05 - Preliminary Electronic Control specifications

1. Will use an off-shelf M18 battery (Milwaukee Electric Tool or other brands compatible with MET chargers)
2. Will provide a single pushbutton which will cycle from OFF to a number of fan speeds yet to be determined.
3. Will monitor Battery voltage and Fan amperage to determine the following conditions:
    a. Low Battery (verified by using the battery indicator build into the battery pack
    b. Possible Filter sealing issues or blockage.
4. Will begin modulating the fan between the selected speed and the maximum speed to indicate any of the fault conditions listed above.
5. Will remove power to the Fan connector within 5 seconds after the Fan is disconnected.
6. Will remove power to the Fan connector when the battery voltage drops below 14.5 volts.
7. Will be sealed to allow outer-surface cleaning

2020-05-04 - Qty 5 Proto Battery Boxes have been assembled

- The only user control is a potentiometer which allows adjustment of the output voltage between two internal trim pots. The initial minimum is set at 7.85v which has been determined by filter testing with a GDStime GDB1232Q2005 Blower.
- They do provide crude battery discharge protection below 13.5 volts, where the minimum specified limit is 12.7 volts before battery damage stats to occur.
- The battery protection will cut power to the fan. However, the run time from even the smallest available MET pack is close to 10 hours.
- These prototypes provide no user feedback for low battery or filter problems.
- These prototypes are NOT sealed and should only be wiped down with alcohol to remove contaminants.
- Each box took 13 Hours to print. Each cover took 1 Hour to print.

2020-04-22 - First Proto Battery Box given to Bob for testing

2020-04-14 - First printing of MET adapter version 13

Due to the time-consuming measurements required to provide a usable interface, it took a lot longer than I thought to model the battery adapter in SCAD. This box will be used to make the first prototype control with a potentiometer.

2020-04-08 - Design Constraints

At this point there are more PCB mechanical concerns than there are electrical concerns. Since a circuit design is highly dependent on resolving these issues, I will try to list the issues to see if we can keep this project on track.

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1. **Location of the PCB** - The major issue with electronics is disinfection. Even if the PCB is conformal-coated, physical stresses during wipe down could cause component damage, ESD could cause electrical damage and chemicals could damage connectors.
    a. If the PCB is in the Hood then it will be subjected to the user-generated pathogens and will need to be cleaned occasionally.
    b. If the PCB is in the Blower Backpack, the user controls would have to the remotely located.
    c. If the PCB is in the Battery Assembly it would not require any cleaning. Even with both designs mechanical buttons through small holes in the case would be accessible. An Overlay would be inexpensive and provide a durable seal. With the proper material selection, overlay chemical cleaning would not be an issue. The number of connections is reduced because the battery wires would tie into the PCB

2. **Wiring between components**. With normal use, wires will break over time, connectors will get dirty, break or may disconnect unless secured.
    a. Connector to Battery Pack. Details are available. Durability may be an issue. One person suggested using epoxy to secure the pins and wires to the 3D printed assembly. This is time consuming in production. An injection-molded part with inserted pins exceeds the project time budget.
    b. Cable between Battery connector and Battery Assembly Output connector. This should include a 1/2 Amp replaceable fuse.
    c. Cable between Battery Assembly and Hood or Backpack Assembly. This should have connectors on both ends to allow replacement if damage occurs. There should also be a means to firmly secure it to the Battery Assembly.
        i. Molex 2451350420 (US supply 1100) 2.0m makes 2 cables $9.00 will plug into board-mounted connector. No connector at Hood.
        ii. Molex 2451350410 (US supply 1100) 1.0m makes 1 cable $8.00 will plug into board-mount connector and in-line connector at blower

        iii. TE T4070014041-001 Socket (US Stock 1600) $7.00
        TE 1-2273003-1 Cable (US Stock 883) $8.00
        Although this is a sealed connector, it adds an extra assembly step, the socket cable must be soldered to the PCB.
    d. Cable between the Fan and PCB. We should be able to get the Fan with a connector. This would plug into a socket on the PCB.
    e. Cable between the PCB and Buttons. Unless the buttons can be mounted on the PCB (preferred) a cable will be required.

i. Although Capacitive touch would eliminate a number of cleaning issues, research indicates that reliability and noise immunity may not make this approach practical. The time development and testing time would exceed the project time budget.

ii. Medical Graphic Overlay with 2 buttons requires some tooling, but would be able to be placed on the top of the hood. The hole in the hood would be covered by the label and the adhesive would provide a durable seal. Include in the assembly is an integral flex cable with connector that plugs into the PCB. The length of this cable is limited.

iii. Mechanical buttons on PCB that would protrude through holes in the top of the mask. An Overlay would be inexpensive and provide a durable seal. With the proper material selection, cleaning would not be an issue.

iv. If the PCB is located in a blower backpack, a cable and button assembly would be required. Depending on where this would be mounted, durability and disinfection will be issues.

f. **System Feedback** - Devices include LEDs, Vibrators and Beepers.

i. LEDs require a remotely-located circuit board within range of the user's vision, cable and connectors. It will be subjected to cleaning. Or have to be in a housing. Lots of design compromises.

ii. A Vibrator in the Battery Assembly might not be felt through all of the clothing that the user wears.

iii. A Beeper requires a physical opening to produce a high sound level

1. If it is located in the Battery Assembly it will be exposed to room pathogens and possibly allow disease transmission.
2. For the PropellerHead, it could be located in the exit of the Blower. A third wire would be needed in the cable to the PCB in the Battery Assembly.
3. For the Blower Backpack, it could be located behind the Filter. The sound should be able to exit through the filter.

3. **MTBF -** is directly related to how many parts are involved in a system. Keeping the number of parts to a minimum ensures better reliability over time.
4. **Time to Production** - With each component in the system there is time to research availability, engineer the component, design the tooling, produce the tooling, procure materials and setup production lines. Our time is very limited. We must concentrate on the best way to build this product with the least number of manufacturing steps.

2020-04-07 - Switch to MET 4.0Ah and 5.0Ah batteries

I spent the morning dissecting my Milwaukee Electric Tool M18 components, a Drill, a charger and two battery packs that are still in production.

I also went to Home Depot and looked at other brands. None of the others appeared to be any better. Since my packs used Samsung cells, I researched their available cells and discovered a good correlation between the different MET packs and the cells.

Analysis: PAPR_Battery_comparison.doc

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2020-04-06 - Blowers Arrived

They seem to draw 1/2 the current that was specified on Alibaba. Not sure they will have the capacity we require. If they do, we will require only 4 watts.

2020-04-03 - Placed Digikey order $209.22

2020-04-07 Update - This order is useless because we changed Batteries. Will attempt to return the 2 - ADM00865 MCP1665 Switcher Demo Kits $86.00

2020-04-02 -

2020-04-01 - Possible Conflicts

After our evening discussion,

2020-03-31 - Possible Conflicts

I wish we had a year to develop all of the features that you proposed. There are so many unknowns and conflicts in this project that some features might not be possible in the time we have..

My initial concept is to use Fan Motor Amperage for battery and filter status.

- Depending on the resolution of this monitor circuit, we might be able to get an idea of the filter status, but it may not be possible with the three fan speeds, unknown sealing and variations in filter density.
    - The difference between the absence or presence of a filter will make a big difference in the fan amperage. However, the change between a clean filter and a clogged filter may be so miniscule that it may not be detectable except at the highest fan speed and a known throat sealing situation. The throat seal will probably introduce far more variation in amperage than a clogged filter.
    - The least expensive CO2 module appears to be around $40. But, the effectiveness of such a monitor is highly dependent on where it is placed in the hood, will be subject to deterioration due to the high moisture content in the hood..
- We made the decision to go to Off-Shelf Phone Charger battery packs to allow for better availability. However, no two packs will have similar capacities. This is in direct conflict with the battery Life monitoring because we will not know the total battery capacity. We can ASSUME, but will not have control of what happens in the field. Field adjustment of battery life would not be possible unless the facility always used the exact same packs for every mask. Most hospitals have a person that verifies equipment and performs minor maintenance. Therefore, we might have to grossly under-estimate the capacity.

USB Support

- I have to talk with Darryl to see if he has ever done an integrated USB, but at this time, rolling USB support into the single Micro of this project does not appear to provide any benefit that justifies the time (which would include a PC Driver and programming user interface). This is

why many development boards have a separate Micro dedicated to the USB programming port.

- Many of the projects that I have worked on over the past 20 years are setup with the ability to initially program the Micro using a connector-less connection to the manufacturer's standard programmers as well as re-programming and monitoring of run-time parameters with an inexpensive serial interface.
- The alternative is to do what has been done on development boards. Add a USB interface chip which could be removed from the production board. The cost of these devices includes the Driver support and allows serial re-programming and monitoring of run-time parameters.

LED and buttons with the dinosaur approach

- Once the Fan moves out of the helmet onto a backpack, buttons and LEDs become very difficult.
- There are a few possible solutions
    - Use a 10 conductor cable that travels up the inside (or outside) of the airway between the circuit board by the motor/battery to the LED/button board.
    - Use a 4 conductor cable to travels up the inside (or outside) of the airway between the circuit board by the motor to a separate micro on the LED/button board.
    - Eliminate the LED/button board and use the audible alarm to indicate battery and filter status by a series of short tones with pauses that decrease as battery life decreases. Someone else would have to control the fan.
    - (Bob) If we have a necklace to hold the bottom to a shape could the buttons and indicator be added to that? What do you recommend?
- Wireless would require a separate battery on the LED/button which would require additional maintenance.

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2020-03-27 - Control Board initial refinements

Controls and indicators

Two Switches, On/Off (Left) and Fan Speed (Right)

- Pressing On/Off will toggle On-Off
- Pressing Fan Speed will loop through available speeds
- Pressing both buttons for 2 seconds will reset Battery Life Timer

LEDs

- 4 total, 2 Green, 2 Red-Green
- 2 Green and 1 Red-Green will make up a Battery Life bar
    - 3 Green - 100% Battery
    - 2 Green - 75% Battery
    - 1 Green - 50% Battery
    - 1 Yellow - (Red+Grn) 25% Battery
    - 1 Red Flashing - 10% Battery
- 1 for possible Filter Status, Green-OK, Yellow-Clog, Red-No Filter??

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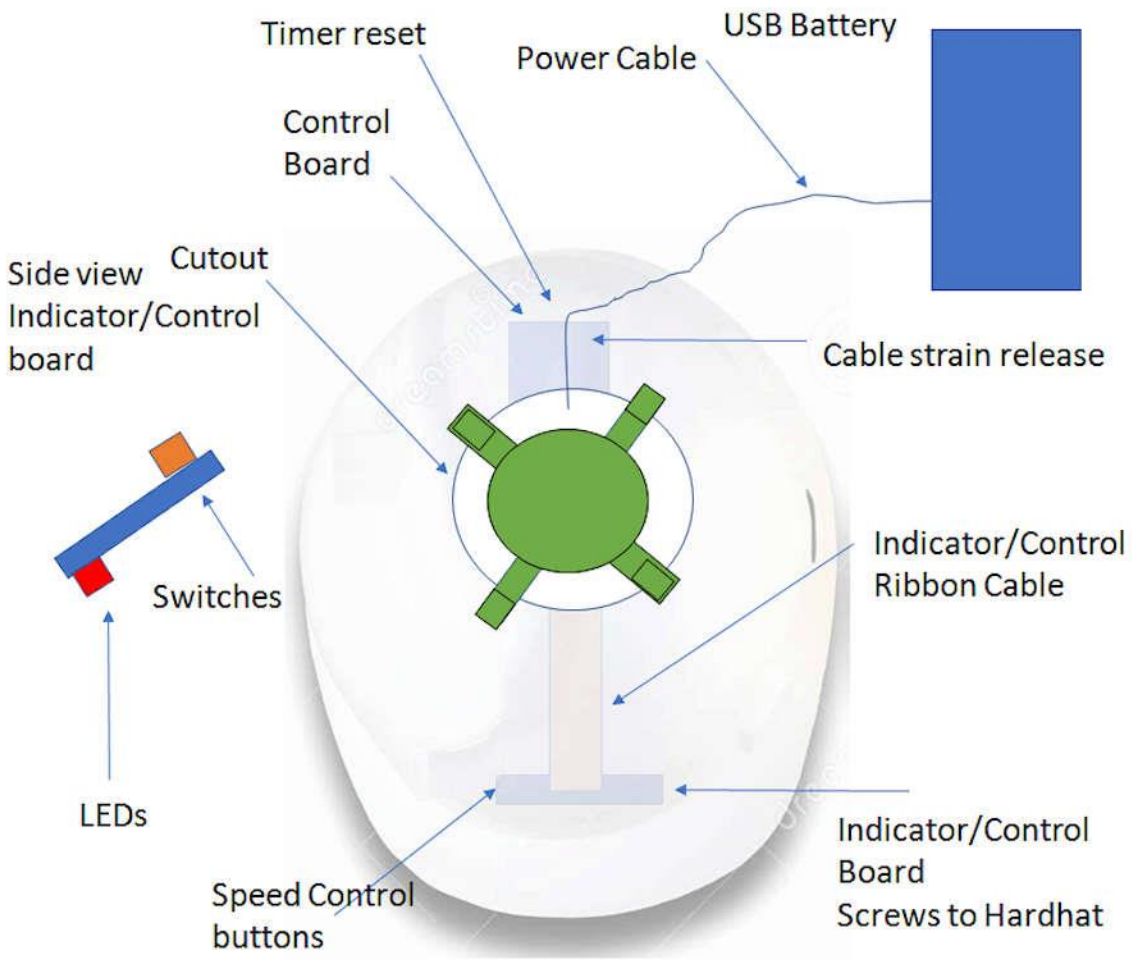
2020-03-26 - Preliminary Control Board Requirements



1. Fan Speed – External access
    - Goal: Maintain positive pressure at all speeds. User can set required speed
    - Solution :
        - 4 Speeds –
            - Minimum Speed still needs to pressurize bag,
            - Medium speed – Set for conversation level,
            - Max speed based on Max tolerated noise
            - Momentary Ludicrous speed – Fan Max for bag flushing and seal test at bag installation
        - Momentary off – For stethoscope listening, and inaudible conversation
        - Standby Off – two quick presses of momentary off will sound an audible and visual indicator that the system will shut off in 10 seconds. If the button is pressed once again the standby off is abandoned. The timer shall be suspended if the 10seconds are complete and standby Off is activated

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2. Battery life
    - Goal: Provide the wearer and support staff an indicator of battery life of standard USB batteries
    - Solution: To utilize standard USB batteries with no feedback the battery life is tracked via amperage over time
    - A means shall be proved to reset the timer when a fresh battery is installed
        - An internal button provided so that when a fresh battery is installed and the fan starts the timer starts
        - The timer reset button can be activated with a heavy magnet placed on the timer activation sensor. With this a user can reset the timer if they install a fresh battery
    - When the battery timer reaches 75% of the expected life a yellow LED is activated
    - 3 Green LED will track the progress of the Battery timer
    - When the Timer reaches 90% of the expected life a RED blinking LED is activated and an audible alarm sounds
    - Audible Alarms need to be audible inside the helmet
    - Visual alarms need to be visible to the wearer and the person servicing the battery
    - Battery status can blink slowly to conserve battery power
    - Selected Fan speed will be considered when tracking battery time on
    - Expected battery life should be 13 hours
3. Filter indicators
    - Goal: Provide feedback on properly installed filter and clogged filter
    - Solution: Use motor speed amperage as an indication of back pressure
    - If too little resistance in detected a Filter installation error alarm and indicator are activated
    - If too much resistance is detected the filter clogged error alarm and indicator are activated
    - Since these levels are unknown the design limits shall be settable via the USB cable.

2020-03-25 - Blowers Ordered - $37.05

An order was placed through Alibaba with Susan from xinyujie.com.

2020-03-22 - And so it begins