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PROGRESS REPORT
SEPTEMBER 2020

Date: 5-10-2020

Revision: 1.0

Author: Tony Little

Product: Electric Skateboard

Company: Globe Brand

1 CONTENTS

2 MAIN CONTROLLER

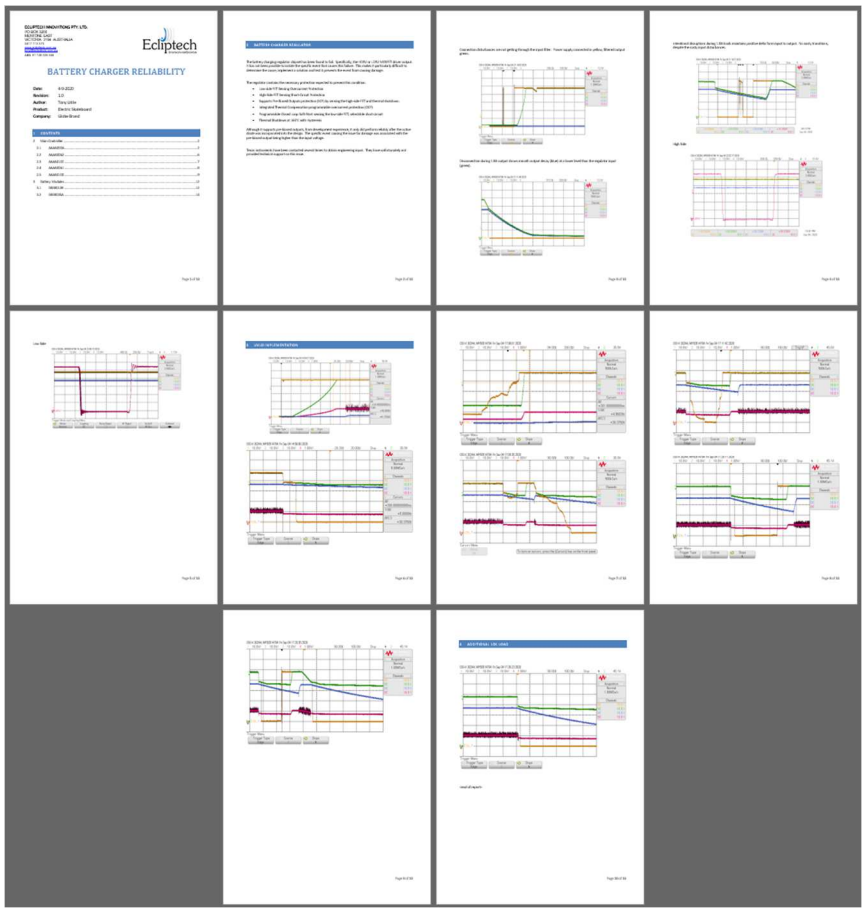
2.1 BATTERY CHARGER

Battery charger reliability was investigated.

The manufacturer of the chipset was contacted. Despite multiple communications, they did not offer assistance.

It is not possible to determine the cause of the failure without setting up for an extensive test. Both time consuming and requires a lot of units to be tested. Instead, the system was analyzed for potential issues that could cause failure. The startup/shutdown control identified as a potential cause. Although the chipset operated as expected, it is possible the state machine could cause a rare failure. Imposing an automated undervoltage cutoff can help to prevent this opportunity for failure.

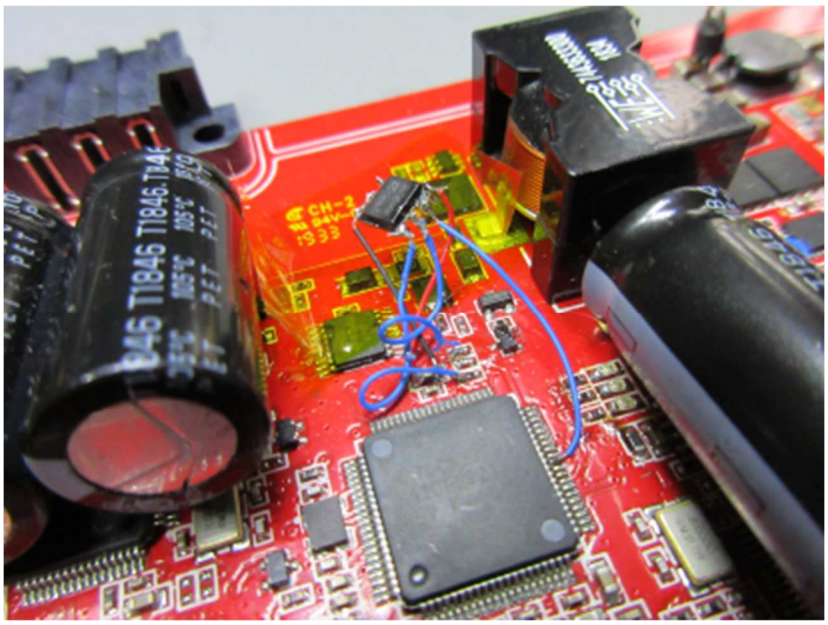
Circuit design was revised and tested to implement an undervoltage lockout.



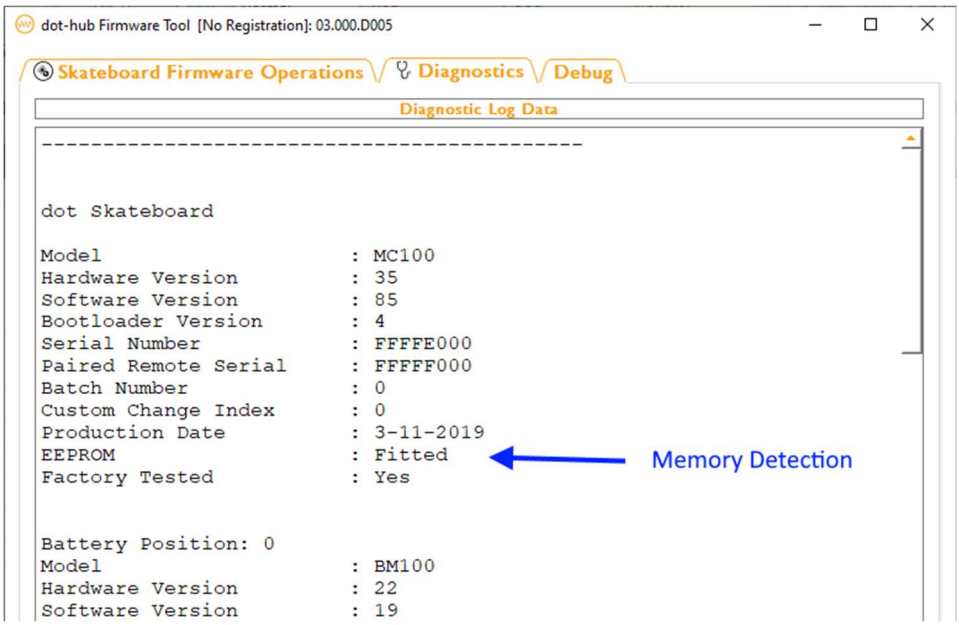
2.2 LOG MEMORY

The new production is to include an additional memory chipset for data logging. This memory can later be used to provide extended and more detailed log data. Software development is first required to utilise this memory, which can later be distributed via firmware update.

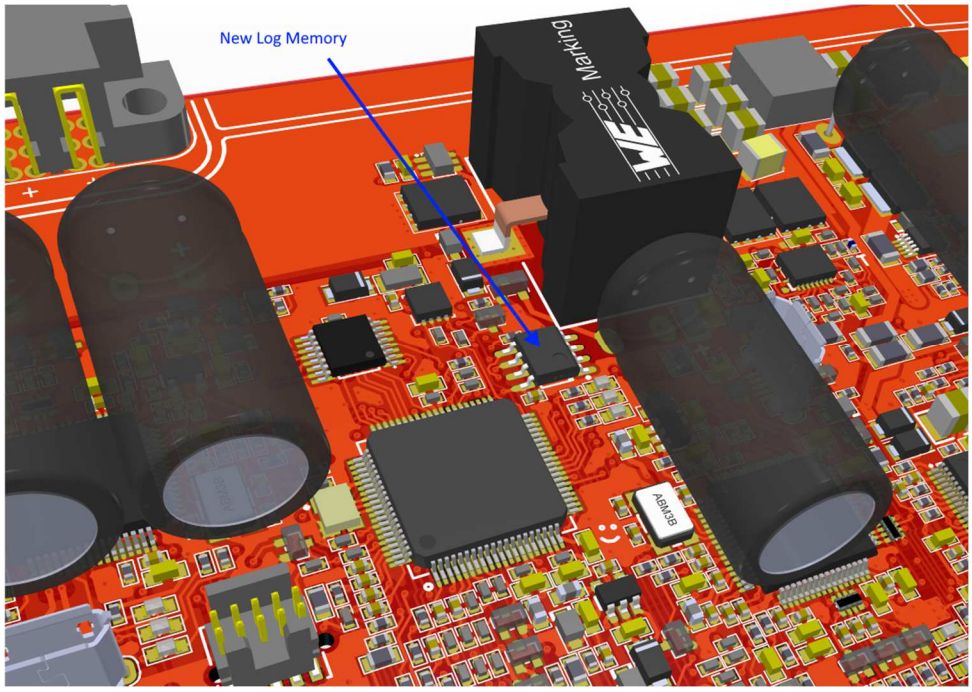
The memory device was wired into a main controller for testing. The initial driver was written to identify the memorys presence and confirm compatibility. It shares the same communications interface with the battery charger and ineria measurement unit.



The diagnostics were updated to report the detection of the memory.

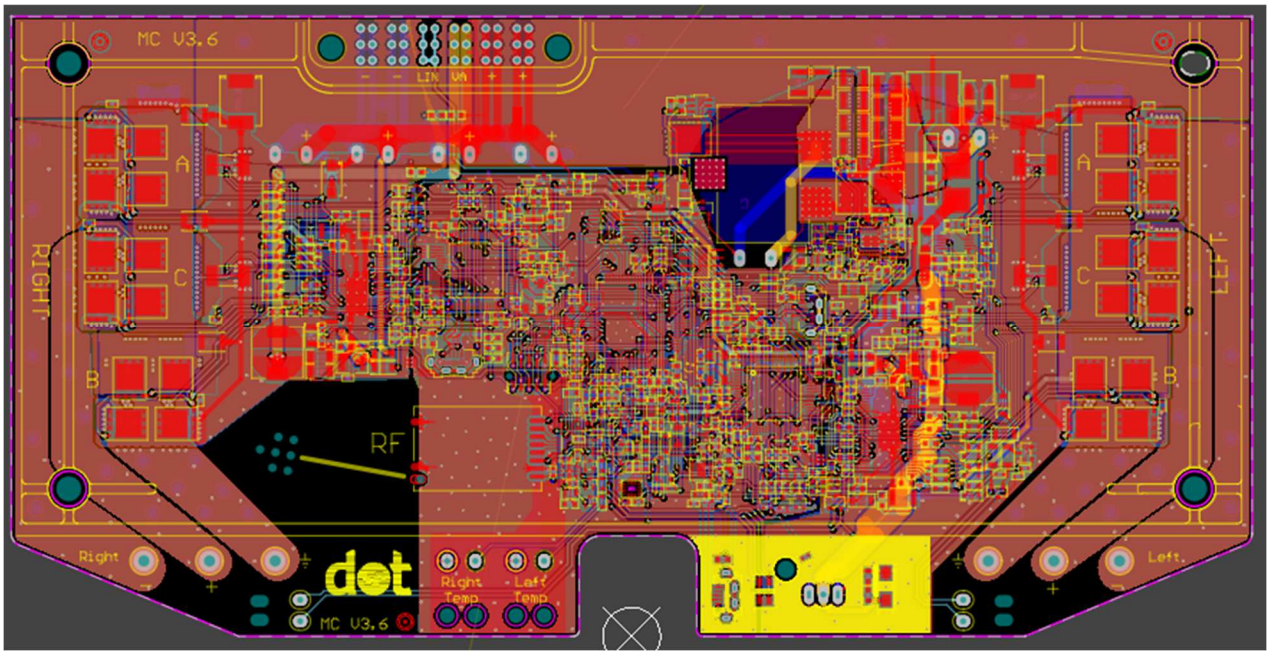


The PCB design was updated include the memory chipset.



2.3 MC PCB V3.6 DESIGN

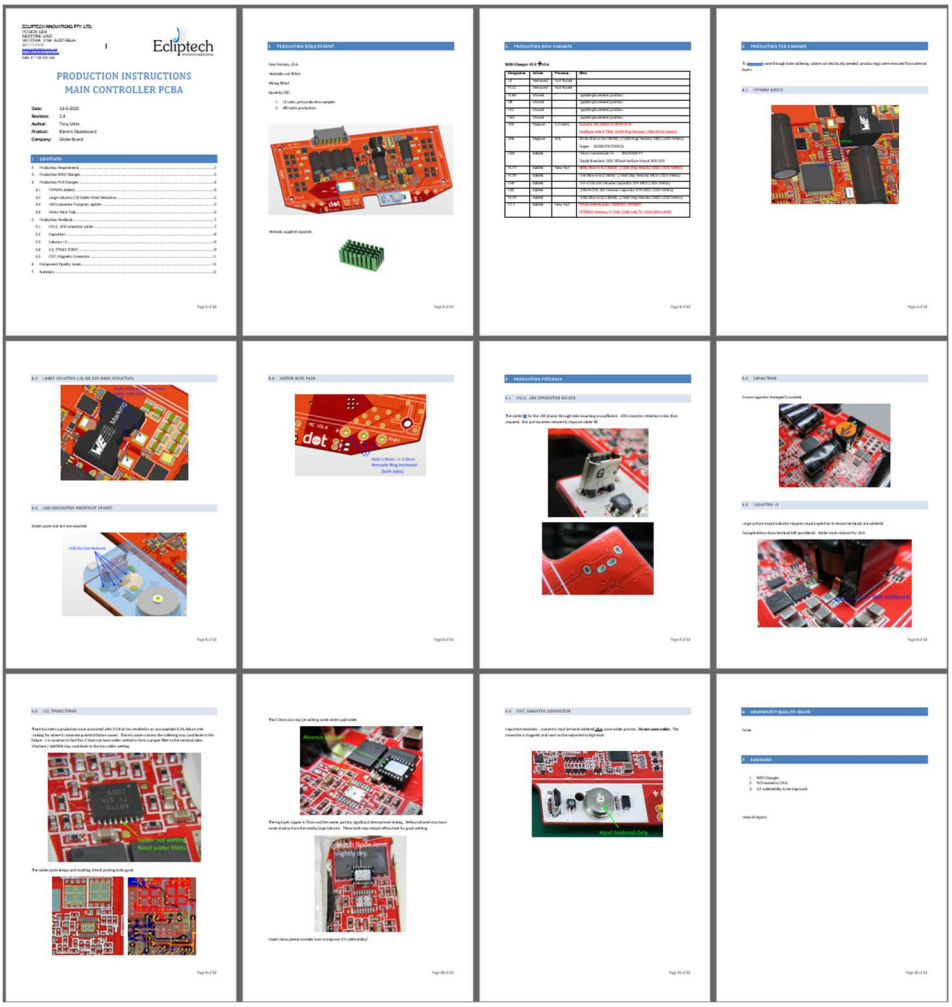
V3.6 PCB design revision completed. Includes battery charger adjustment, log memory and production tweaks.



2.4 PRODUCTION INSTRUCTIONS

Production instructions issued to Union Circuits…

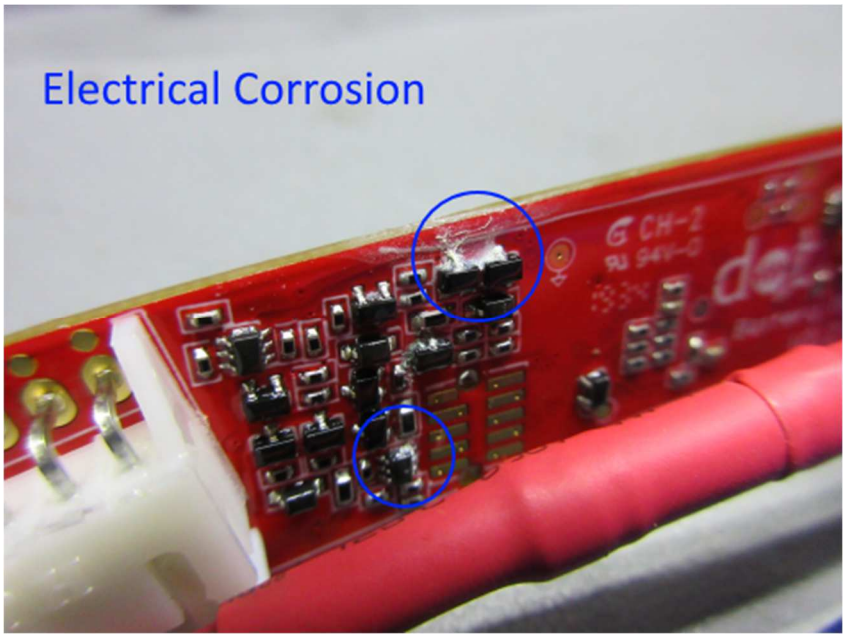
2020-09-13 - Production Instructions, Main Controller.pdf

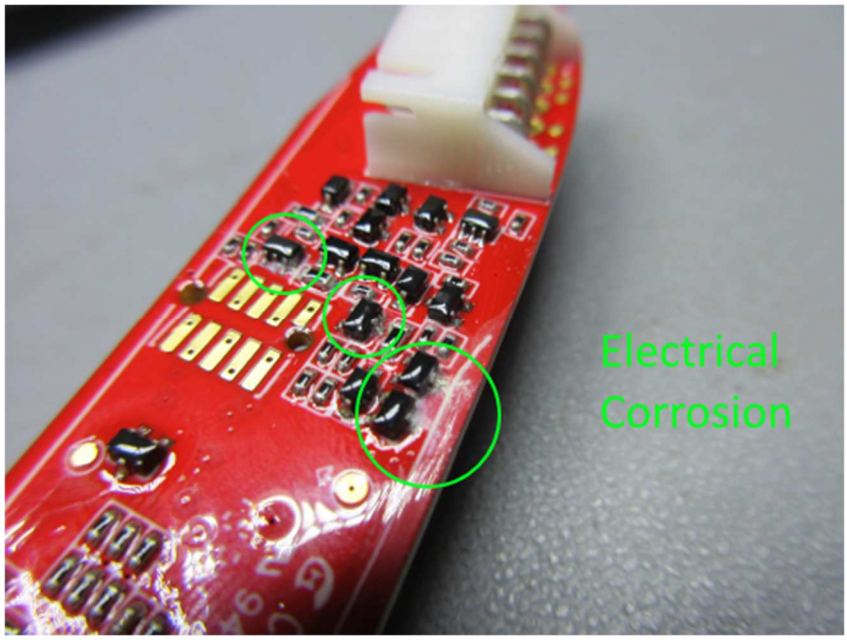


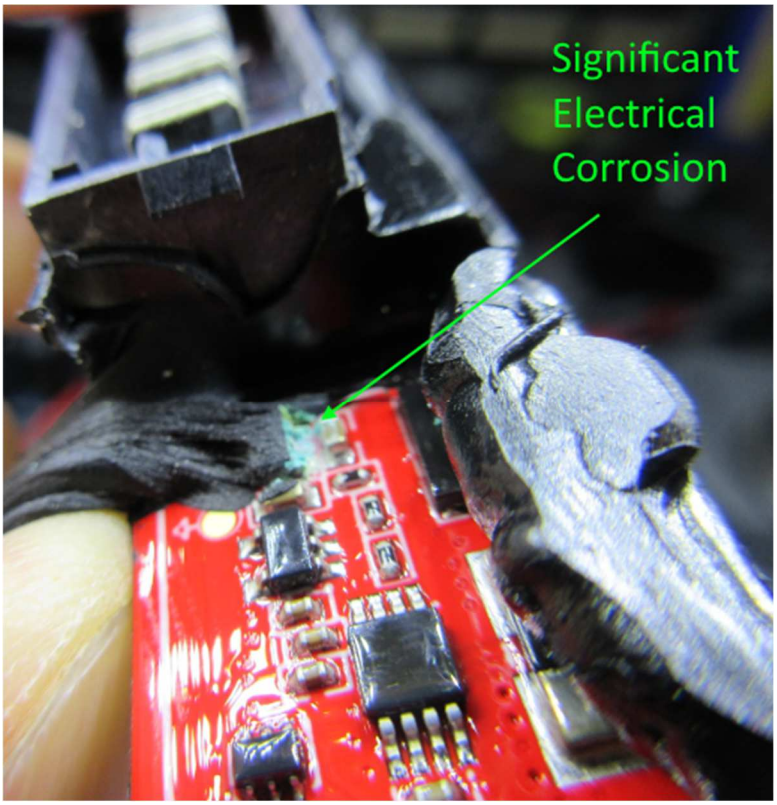
3 BATTERY MODULE RESIN COATING

3.1 GLOBE SPRAY COATING, 2-PACK

A failed battery module with 2-pack coating on the PCBA was investigated. The PCBA suffered significant water corrosion is multiple locations. The material used is not known, however it was deemed unsuitable for providing protection from water ingress.

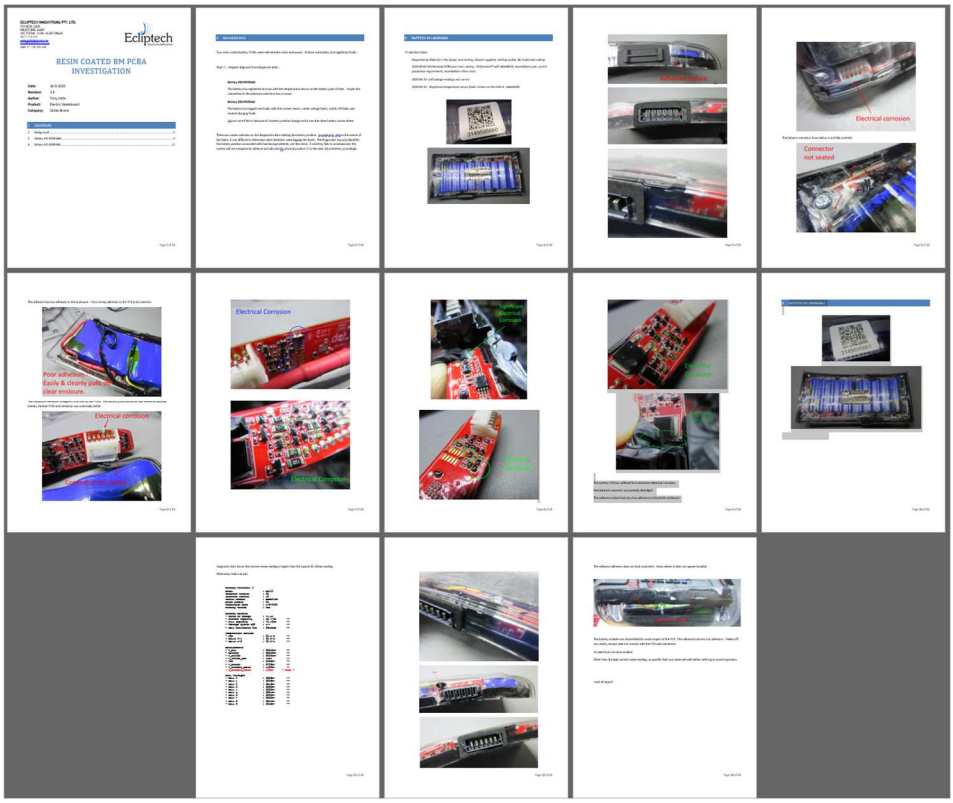






Further details provided in the report…

2020-09-16 - Resin Coated BM PCBA Investigation.pdf



3.2 NANO-COATING

Nano coating is an option that Union Circuits has investigated. It has taken an extended time to pursue. Union cannot provide this directly, however have found a 3rd party that has the equipment necessary for this coating process.

Union have recently advised the Nano-Coating of the battery module will cost ~US$1. We are still waiting on samples to be provided. This is likely to occur the week after the current holiday in China. Possibly have a sample for testing late October.

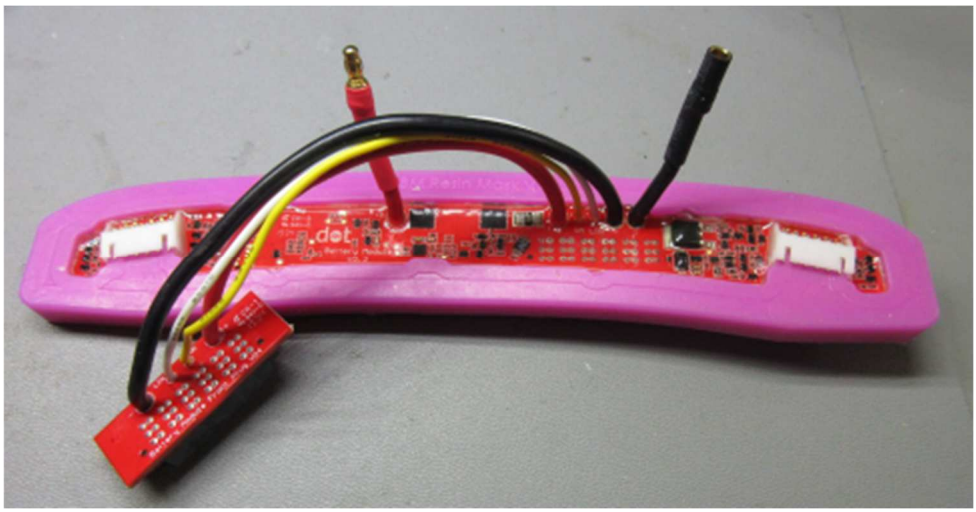
Primary concerns are the effectiveness of the coating to resist water and the coverage area. The process does not suit pre-wiring and therefore there will be masked areas not covered. This option may be difficult to support, as PCBAs will need to be programmed/tested in Melbourne without wiring.

3.3 THICK-FILM RESIN COATING

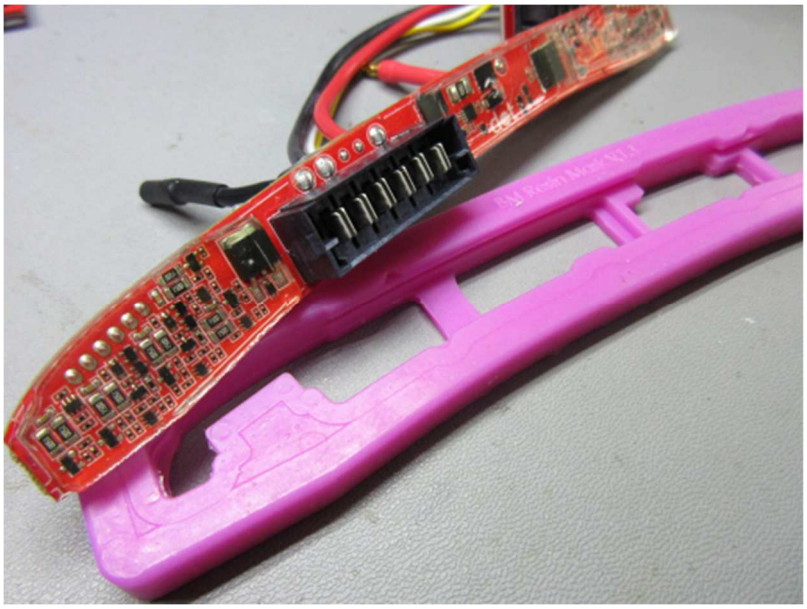
Resin coating requires the wiring to be fitted.

3.3.1 V1.1

This initial proof of concept verified the process feasibility. Both frame mask material and resin coating were on-hand substitutes.

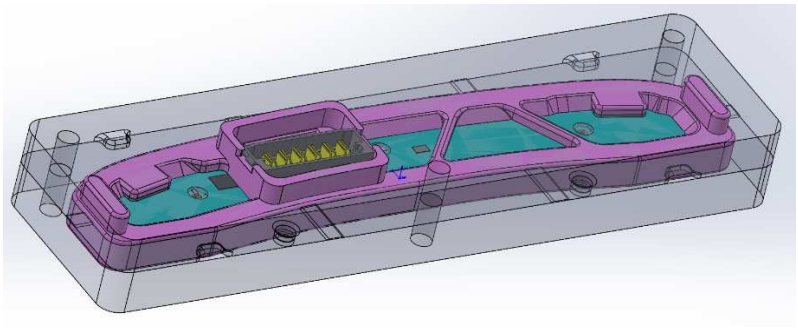


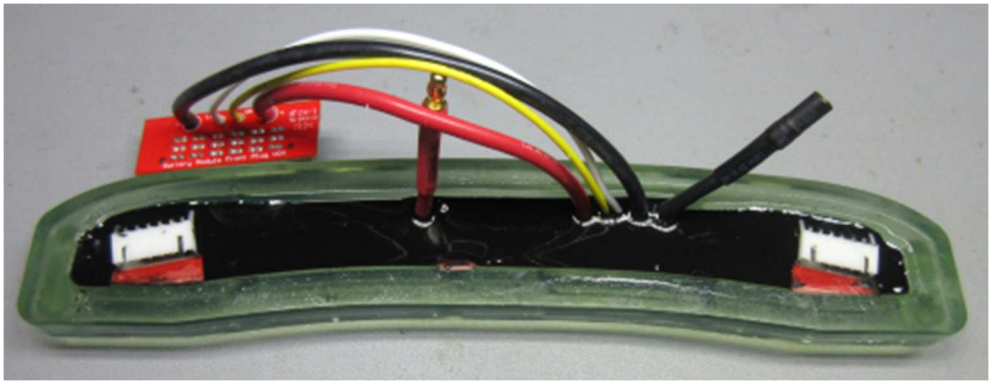
The PCBA below is resin coated with a clear material. Hard to see in the picture.



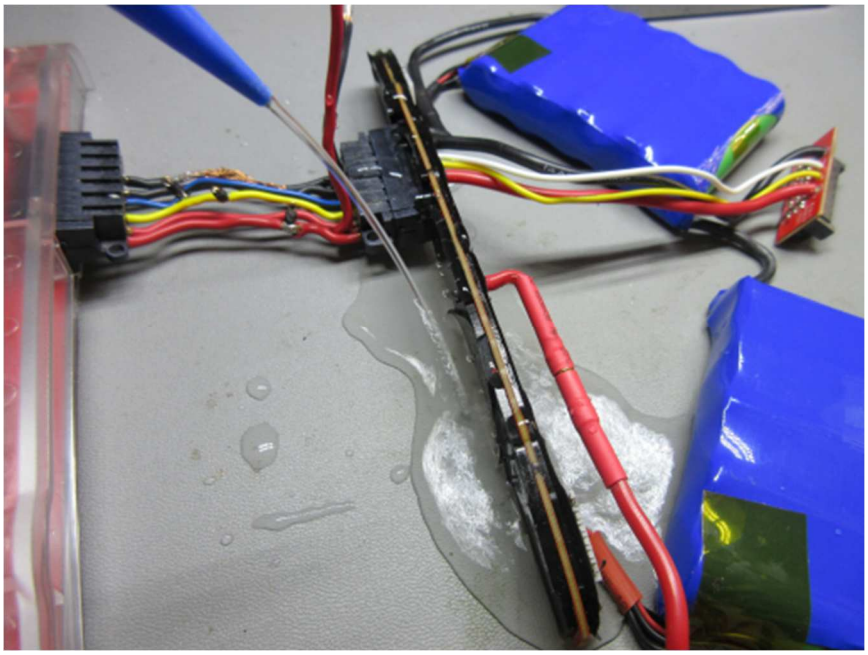
3.3.2 V1.2

This version targeted to mask the mechanical constraints. The rear side depended on using the correct fill level for fitment. Resin used for the coating is the target production resin.

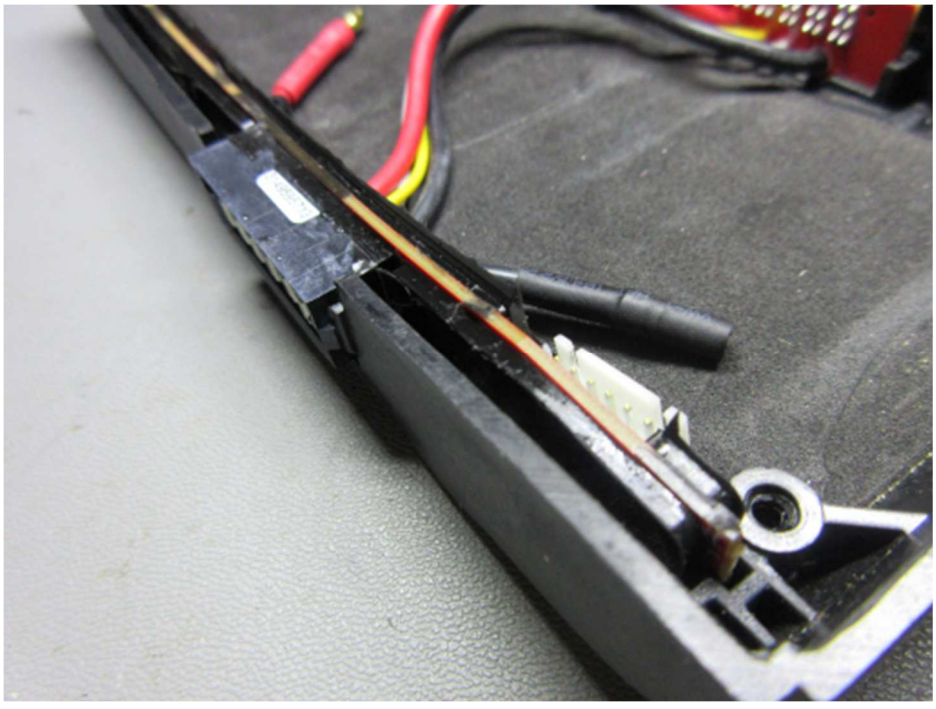




Tested with a lot of water. No failure or impact on operation.

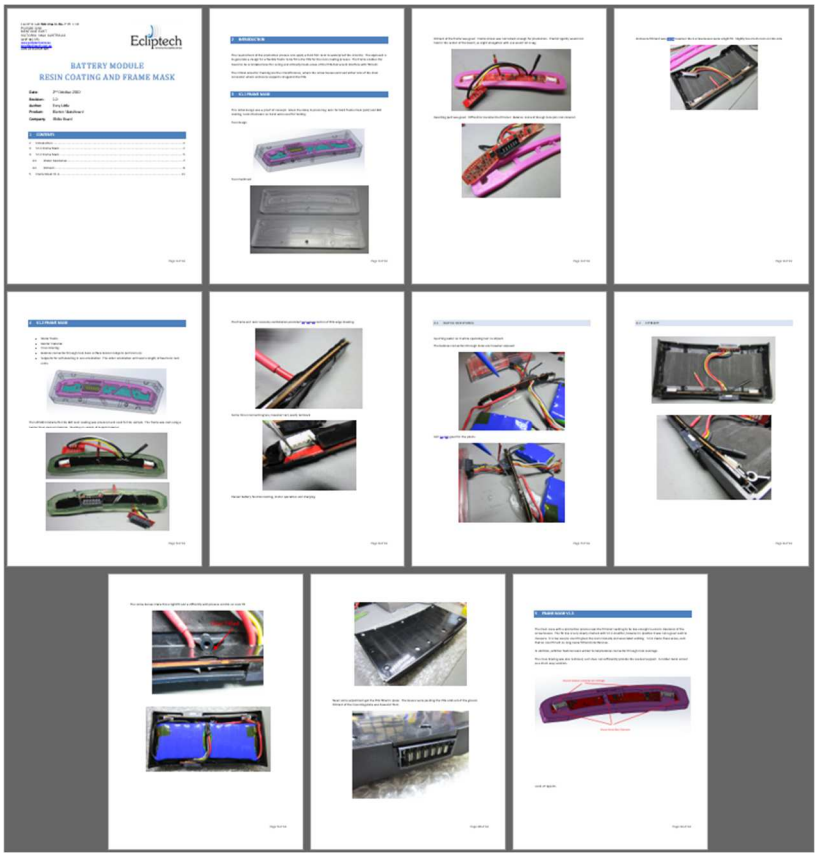


Fitment was good. A slight over-fill on the rear caused some minor interference with the 3 screw bosses. Although it fit the enclosure with some minor flex, over-fill is difficult to control to prevent fitment issues.



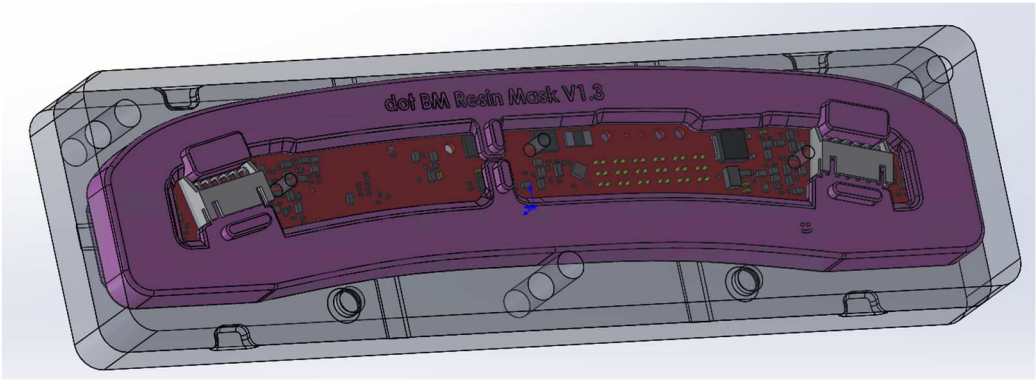
Further details provided in the report…

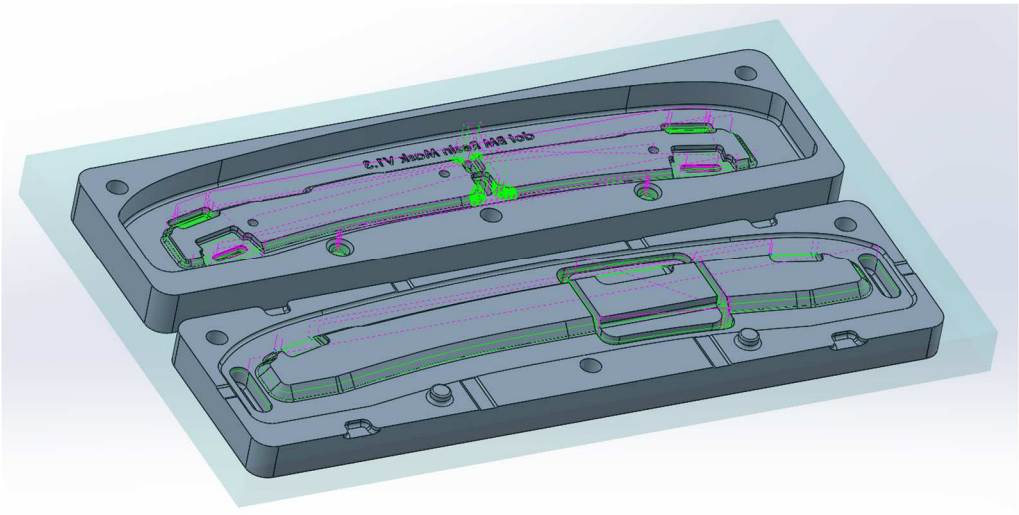
2020-10-02 - BM Resin Coating and Frame Mask.pdf



3.3.3 V1.3

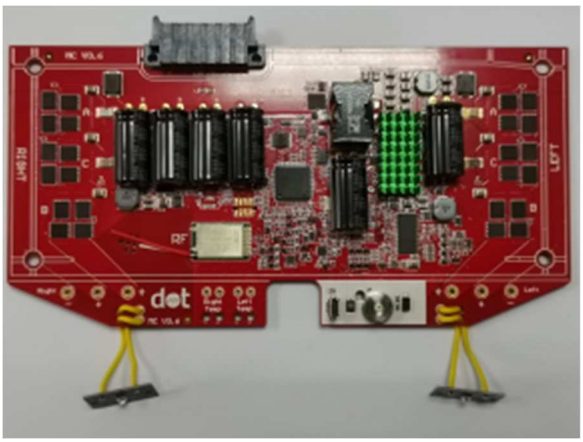
Minor adjustments made to increase frame mask durability and specifically prevent over filling on the rear from causing a fitment tolerance issue. Design was completed and the tool is ready. Waiting on resin supply intended for molding the production frame masks.

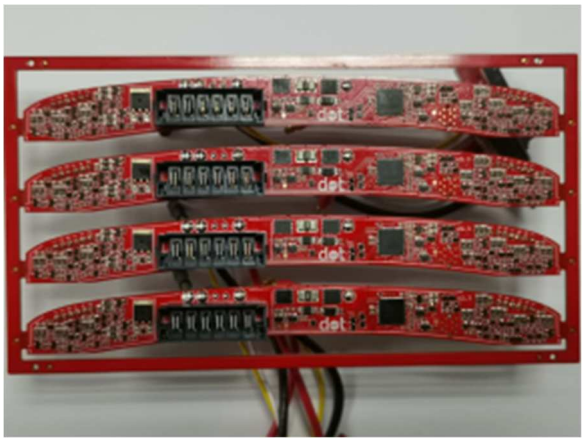


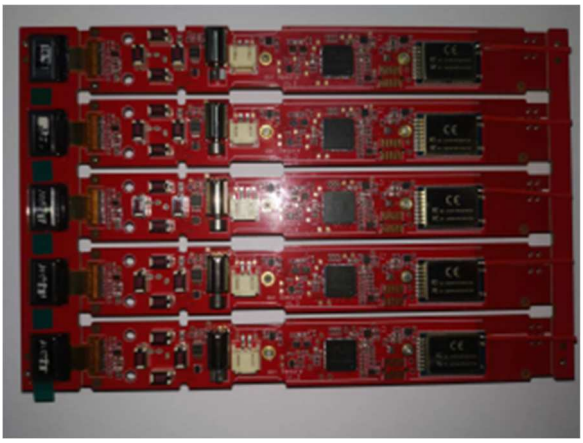


4 PRE-PRODUCTION

The designs for the new production run are proceeded without issue. Union have dispatched pre-production PCBAs for testing.





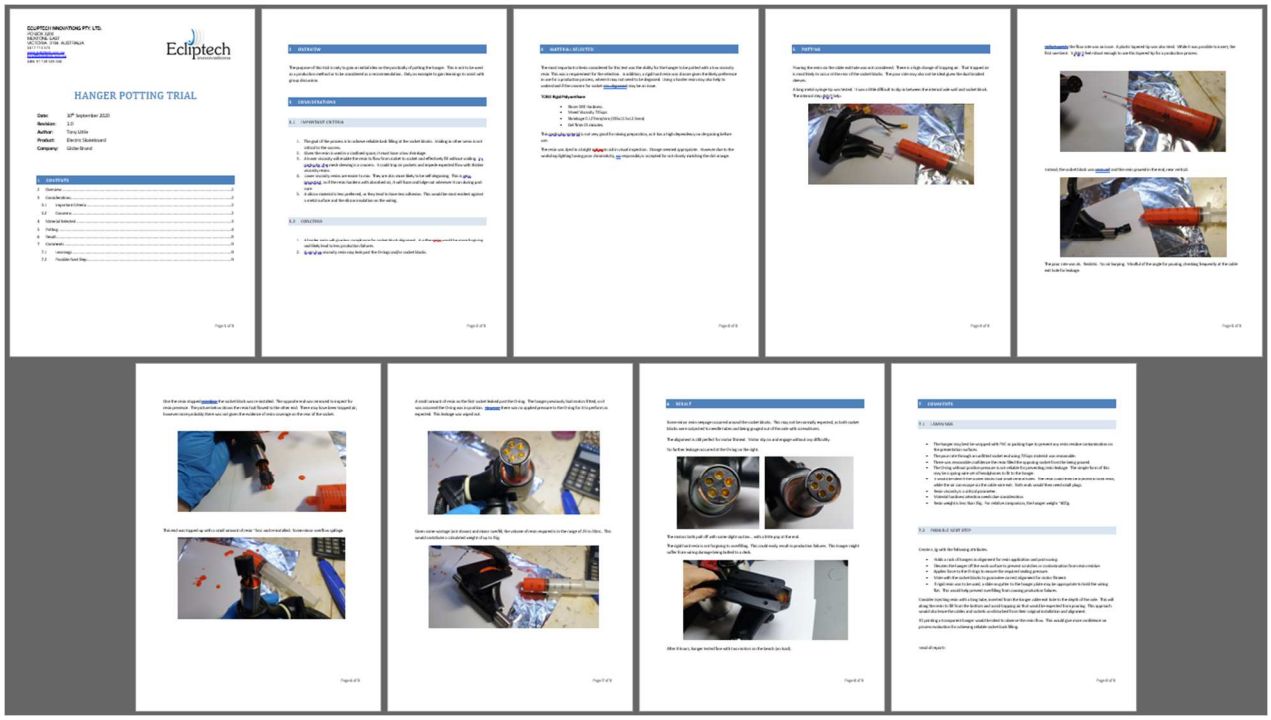


5 HANGER WATER INGRESS

Water ingress into the hanger causes persistent wet motor issues. To support possible solution considerations, a hanger was potted with a resin to test feasibility.

<35g of resin was filled into the hanger cavity. The result was successful for filling. Numerous aspects were learnt from this trial. The specific resin and viscosity is an important criteria. The difficult aspect to consider is the production process needed to support this approach. In-particularly, current hangers already have the wiring conduit sealed with adhesive, which limits options. The motor seals also did not prevent leakage of the resin, which is not surprising given there was no pressure on the seals for them to work as intended.

2020-09-10 - Hanger Potting Trial.pdf

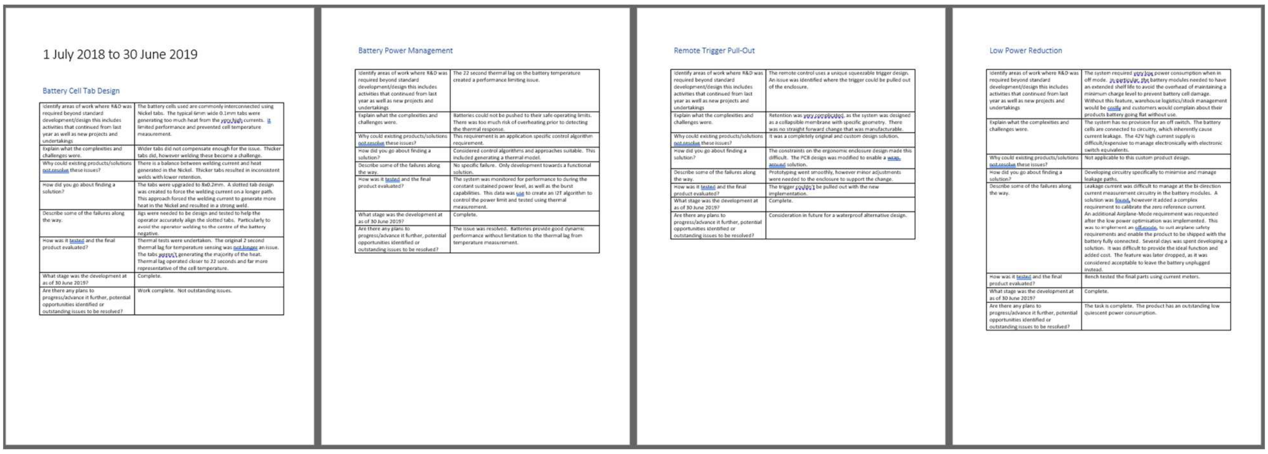


Potting the hanger may be considered in-additional the X-seals being developed. The lack of availability on suitable resin limits options. In addition, the production process will likely be different between current sealed hangers and new production.

6 R&D TAX CONCESSION DATA

Tax concession text was written for Gerhard Correa for the 2018 to 2019 period, as well as in advance for the 2019 to 2020 period.

6.1 1 JULY 2018 TO 30 JUNE 2019



1 July 2018 to 30 June 2019

Battery Cell Tab Design

Identify areas of work where R&D was required beyond standard development/design this includes activities that continued from last year as well as new projects and undertakings	The battery cells used are commonly interconnected using Nickel tabs. The typical 6mm wide 0.1mm tabs were generating too much heat from the very high currents. It limited performance and prevented cell temperature measurement.
Explain what the complexities and challenges were.	Wider tabs did not compensate enough for the issue. Thicker tabs did, however welding these become a challenge.
Why could existing products/solutions not resolve these issues?	There is a balance between welding current and heat generated in the Nickel. Thicker tabs resulted in inconsistent welds with lower retention.
How did you go about finding a solution?	The tabs were upgraded to 8x0.2mm. A slotted tab design was created to force the welding current on a longer path. This approach forced the welding current to generate more heat in the Nickel and resulted in a strong weld.
Describe some of the failures along the way.	Jigs were needed to be design and tested to help the operator accurately align the slotted tabs. Particularly to avoid the operator welding to the centre of the battery negative.
How was it tested and the final product evaluated?	Thermal tests were undertaken. The original 2 second thermal lag for temperature sensing was not longer an issue. The tabs weren't generating the majority of the heat. Thermal lag operated closer to 22 seconds and far more representative of the cell temperature.
What stage was the development at as of 30 June 2019?	Complete.
Are there any plans to progress/advance it further, potential opportunities identified or outstanding issues to be resolved?	Work complete. Not outstanding issues.

Battery Power Management

Identify areas of work where R&D was required beyond standard development/design this includes activities that continued from last year as well as new projects and undertakings	The 22 second thermal lag on the battery temperature created a performance limiting issue.
Explain what the complexities and challenges were.	Batteries could not be pushed to their safe operating limits. There was too much risk of overheating prior to detecting the thermal response.
Why could existing products/solutions not resolve these issues?	This requirement is an application specific control algorithm requirement.
How did you go about finding a solution?	Considered control algorithms and approaches suitable. This included generating a thermal model.
Describe some of the failures along the way.	No specific failure. Only development towards a functional solution.
How was it tested and the final product evaluated?	The system was monitored for performance to during the constant sustained power level, as well as the burst capabilities. This data was use to create an I2T algorithm to control the power limit and tested using thermal measurement.
What stage was the development at as of 30 June 2019?	Complete.
Are there any plans to progress/advance it further, potential opportunities identified or outstanding issues to be resolved?	The issue was resolved. Batteries provide good dynamic performance without limitation to the thermal lag from temperature measurement.

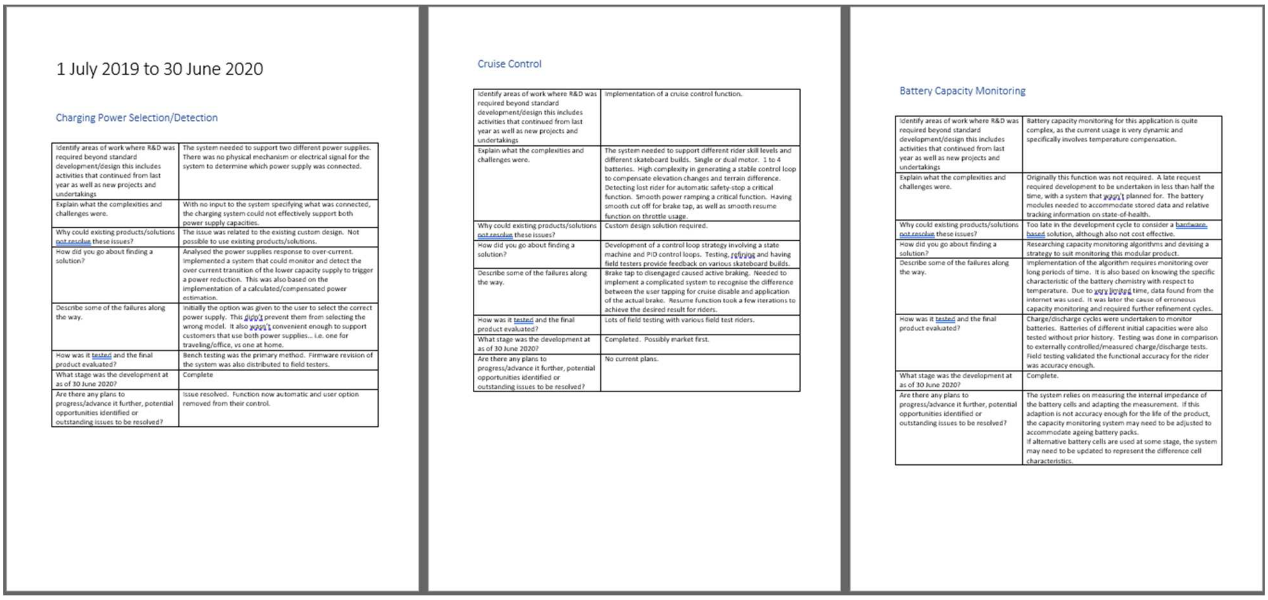
Remote Trigger Pull-Out

Identify areas of work where R&D was required beyond standard development/design this includes activities that continued from last year as well as new projects and undertakings	The remote control uses a unique squeezable trigger design. An issue was identified where the trigger could be pulled out of the enclosure.
Explain what the complexities and challenges were.	Retention was very complicated, as the system was designed as a collapsible membrane with specific geometry. There was no straight forward change that was manufacturable.
Why could existing products/solutions not resolve these issues?	It was a completely original and custom design solution.
How did you go about finding a solution?	The constraints on the ergonomic enclosure design made this difficult. The PCB design was modified to enable a wrap-around solution.
Describe some of the failures along the way.	Prototyping went smoothly, however minor adjustments were needed to the enclosure to support the change.
How was it tested and the final product evaluated?	The trigger couldn't be pulled out with the new implementation.
What stage was the development at as of 30 June 2019?	Complete.
Are there any plans to progress/advance it further, potential opportunities identified or outstanding issues to be resolved?	Consideration in future for a waterproof alternative design.

Low Power Reduction

Identify areas of work where R&D was required beyond standard development/design this includes activities that continued from last year as well as new projects and undertakings	The system required very low power consumption when in off mode. In particular, the battery modules needed to have an extended shelf life to avoid the overhead of maintaining a minimum charge level to prevent battery cell damage. Without this feature, warehouse logistics/stock management would be costly and customers would complain about their products battery going flat without use.
Explain what the complexities and challenges were.	The system has no provision for an off switch. The battery cells are connected to circuitry, which inherently cause current leakage. The 42V high current supply is difficult/expensive to manage electronically with electronic switch equivalents.
Why could existing products/solutions not resolve these issues?	Not applicable to this custom product design.
How did you go about finding a solution?	Developing circuitry specifically to minimise and manage leakage paths.
Describe some of the failures along the way.	Leakage current was difficult to manage at the bi-direction current measurement circuitry in the battery modules. A solution was found, however it added a complex requirement to calibrate the zero reference current. An additional Airplane-Mode requirement was requested after the low power optimisation was implemented. This was to implement an off-mode, to suit airplane safety requirements and enable the product to be shipped with the battery fully connected. Several days was spent developing a solution. It was difficult to provide the ideal function and added cost. The feature was later dropped, as it was considered acceptable to leave the battery unplugged instead.
How was it tested and the final product evaluated?	Bench tested the final parts using current meters.
What stage was the development at as of 30 June 2019?	Complete.
Are there any plans to progress/advance it further, potential opportunities identified or outstanding issues to be resolved?	The task is complete. The product has an outstanding low quiescent power consumption.

6.2 1 JULY 2019 TO 30 JUNE 2020



1 July 2019 to 30 June 2020

Charging Power Selection/Detection

Identify areas of work where R&D was required beyond standard development/design this includes activities that continued from last year as well as new projects and undertakings	The system needed to support two different power supplies. There was no physical mechanism or electrical signal for the system to determine which power supply was connected.
Explain what the complexities and challenges were.	With no input to the system specifying what was connected, the charging system could not effectively support both power supply capacities.
Why could existing products/solutions not resolve these issues?	The issue was related to the existing custom design. Not possible to use existing products/solutions.
How did you go about finding a solution?	Analysed the power supplies response to over-current. Implemented a system that could monitor and detect the over current transition of the lower capacity supply to trigger a power reduction. This was also based on the implementation of a calculated/compensated power estimation.
Describe some of the failures along the way.	Initially the option was given to the user to select the correct power supply. This didn't prevent them from selecting the wrong model. It also wasn't convenient enough to support customers that use both power supplies... i.e. one for traveling/office, vs one at home.
How was it tested and the final product evaluated?	Bench testing was the primary method. Firmware revision of the system was also distributed to field testers.
What stage was the development at as of 30 June 2020?	Complete
Are there any plans to progress/advance it further, potential opportunities identified or outstanding issues to be resolved?	Issue resolved. Function now automatic and user option removed from their control.

Cruise Control

Identify areas of work where R&D was required beyond standard development/design this includes activities that continued from last year as well as new projects and undertakings	Implementation of a cruise control function.
Explain what the complexities and challenges were.	The system needed to support different rider skill levels and different skateboard builds. Single or dual motor. 1 to 4 batteries. High complexity in generating a stable control loop to compensate elevation changes and terrain difference. Detecting lost rider for automatic safety-stop a critical function. Smooth power ramping a critical function. Having smooth cut off for brake tap, as well as smooth resume function on throttle usage.
Why could existing products/solutions not resolve these issues?	Custom design solution required.
How did you go about finding a solution?	Development of a control loop strategy involving a state machine and PID control loops. Testing, refining and having field testers provide feedback on various skateboard builds.
Describe some of the failures along the way.	Brake tap to disengaged caused active braking. Needed to implement a complicated system to recognise the difference between the user tapping for cruise disable and application of the actual brake. Resume function took a few iterations to achieve the desired result for riders.
How was it tested and the final product evaluated?	Lots of field testing with various field test riders.
What stage was the development at as of 30 June 2020?	Completed. Possibly market first.
Are there any plans to progress/advance it further, potential opportunities identified or outstanding issues to be resolved?	No current plans.

Battery Capacity Monitoring

Identify areas of work where R&D was required beyond standard development/design this includes activities that continued from last year as well as new projects and undertakings	Battery capacity monitoring for this application is quite complex, as the current usage is very dynamic and specifically involves temperature compensation.
Explain what the complexities and challenges were.	Originally this function was not required. A late request required development to be undertaken in less than half the time, with a system that wasn't planned for. The battery modules needed to accommodate stored data and relative tracking information on state-of-health.
Why could existing products/solutions not resolve these issues?	Too late in the development cycle to consider a hardware-based solution, although also not cost effective.
How did you go about finding a solution?	Researching capacity monitoring algorithms and devising a strategy to suit monitoring this modular product.
Describe some of the failures along the way.	Implementation of the algorithm requires monitoring over long periods of time. It is also based on knowing the specific characteristic of the battery chemistry with respect to temperature. Due to very limited time, data found from the internet was used. It was later the cause of erroneous capacity monitoring and required further refinement cycles.
How was it tested and the final product evaluated?	Charge/discharge cycles were undertaken to monitor batteries. Batteries of different initial capacities were also tested without prior history. Testing was done in comparison to externally controlled/measured charge/discharge tests. Field testing validated the functional accuracy for the rider was accuracy enough.
What stage was the development at as of 30 June 2020?	Complete.
Are there any plans to progress/advance it further, potential opportunities identified or outstanding issues to be resolved?	The system relies on measuring the internal impedance of the battery cells and adapting the measurement. If this adaption is not accuracy enough for the life of the product, the capacity monitoring system may need to be adjusted to accommodate ageing battery packs. If alternative battery cells are used at some stage, the system may need to be updated to represent the difference cell characteristics.

<end of report>