Design

Wednesday, August 13, 2025 6:55 PM

KS9 Design Changes

Tuesday, July 22, 2025 8:30 PM

Rules concerns:

LID

- MSD/HVD is in a bad location
  - Was difficult to reach at comp
  - Place further towards rear of car
  - Changes Lid interface
- Move E-meter
  - Change in lid change in HV Path
- HV Insulation for some of the LV Wires
- Change to different AIRs
  - Them welding is a rules failure
- TCU Redesign
  - Pack + and TS + shared a reference, breaking galvanic isolation
  - Isolated diode that separate TS+ and -
  - Board only uses shutdown circuit power, that why when you hit shutdown button pack still live no lights at all (Not allowed, lucky they let us run) (won't see this failure load unless we weld contactors)
  - Removing analog precharge logic, switch to code based only
- New IMD
  - Purchase 3204 that we had
  - Get the new ISO 175

LOWER CONTAINER

- Busbar glue
  - The glue used to hold the busbars down is not technically legal, but because its not a structural component
  - Doesn't pass the temp rating they want
  - Shouldn't maintain that loophole, but can try to argue again
  - Easier to change glue and plastic, than get 3m to admit higher transition temp

- ACC Mounts
  - Rear mounts weren't in spec, therefore too far from the modules
  - Update documentation along with changes

- Interconnects
  - Recommend going to single core wire, rather than second layer of corflex (not best practice to cut outer shield)
  - Don't need shielded wire inside, can use smaller single core, or just smaller gauge
  - Maintenance disconnects are good but not keyed

After Acc

- ACC to INV
  - Connection from ACC to inverter is not the best, bolted connection
  - May get scrutinized for cable being so close to firewall, not illegal as long as container is at least 1 in away

DFM and DFA Changes:

LID

- Pack + and - Connections
  - Mating lid to lower container was difficult
    - More clearance, larger hole, move airs
- Busbars in crowded location
  - difficult to manufacture
    - All HV connections are on different planes
      - Move them to same plane
      - Switch to flexible cable over busbars
  - Separation from lv side
    - Shielded connections throughout
    - More clearance
    - Complete separation
- Issues with TS Sense connections
  - Ring terminals cycled a lot caused issues (Air threads damaged, torquing connections affected
    - Combine connections (spliced harness, all connection broke out on boards
  - Some TS leads (IMD, Discharge to MSD, precharge and discharge resistors) hard to remove for service -Lead to swapping precharge and discharge resistors
    - Spliced harness
    - TCU/burger layout
      - Split or otherwise
- Lid structures
  - Mating flanges to lower container hard to line up
    - Lower flange not bent but welded
      - Process change
      - Different mounting method
  - Panels hard to navigate for service
    - Fully removable enclosure
  - Fastener types change a lot
    - Formalize standard
- Lower Container
  - Retaining Maintenance disconnects
    - Ziptie hole was an afterthought
  - Welded container was hard to hold tolerance
    - Process control (QC and)
      - Measure at stages to ensure we can rework
    - Procedure changes
    - Part changes
      - Add tab and slot to all container walls
  - Insulation sucked
    - Mica flaked
    - Nomex peeled
      - Laser insulation
      - Adhere better (prevent edge from lifting)
  - Acc Mounts
    - Removed locating feature
      - Speed up manufacture
      - Can be smaller
  - Harnessing
    - Too much extra wire
      - Main LV harness shortened
      - Module harness shortend
      - Split BMS
    - Not Poke -a -yoke BMS Harness
      - Could plug in MDB senses wrong
      - Split bms (lol)
  - Modules
    - Endline Connections
      - Bonds failed during use
        - Different Adhesive and plastic combo
          - Increase bond strength
        - Different Endline connection method
          - Lower torque on adhesive
        - New connection design
          - No adhesive
      - Very tall
        - Interaction failures
          - New/ endline design
          - New Connectors
    - Top Plate
      - Long Manufacturing time
        - Bonding Buses takes a while
          - New plastics and adhesive
          - No adhesive design
        - Assembling all parts takes a while
          - Combine parts
        - Studs and bus thickness
          - Had to edit busbars in post
            - Lower thickness
            - Longer studs
      - Inconsistent Yield
        - Inserts turning out
          - Better Plastics
        - Tabs
          - Studs turning out
            - Replacing Hex
            - Non Adhesive design
            - New plastics and adhesive
          - Busbars lifting
            - Replacing Hex
            - Non Adhesive design
            - New plastics and adhesive
      - MDB
        - Springs didn't go on
          - Failed when loaded
            - Look at pogos
        - Lots of sense harness
          - One short
          - Took long time to make
            - pogos
- Drivetrain and water loop
  - Inverter
    - LV connector sucks
      - Pigtail off purchased connector
    - Vibe dampers easy to loose
      - Glue vibe dampers
  - Motor
    - Support bearing backed out
      - Revisions to bearing retainment
    - Hard to line up parts
      - Press stop features
    - Shielding
      - Don't break shielding
  - Water loop
    - Shielding and ground connections
      - afterthought

Performance and testing:

- Weight
  - Water loop
    - Radiator
      - Smaller cross-section single
      - Split Parallel loops
    - Pump
      - Lighter pumps
    - Brackets
      - Less thick tabs
  - Drivetrain
    - Sprockets
      - Rear sprocket
    - Motor plates
      - Weight analysis
    - Diff integrations
      - Combine
      - Weight analysis
  - TS Chain
    - Smaller gauge conductors
      - Smaller/lighter wire
      - Smaller/light busbars
      - Smaller/lighter HV Connectors
  - Acc structures
    - Acc Mounts
      - Smaller
    - Frame Mounts
      - Smaller
    - Lid Structures
      - Thinner material
      - Composites
    - Container
      - Composites
      - Shrinking it
    - Modules
      - New Plastics
      - New tab method and busbars
      - Configuration change
      - New Cells
    - BMS
      - Split BMS
      - Smaller Units
- Efficiency and thermals
  - Water Loop
    - Change to Line size
      - Flow more
    - Change to pump
      - Flow more/less loss into lines
    - Series Single vs Split Parallel
  - Drivetrain and controls
    - Regenerative braking
      - Only way to gain energy
      - Reversible cell heating term
  - TS Chain
    - Minimizing parasitic loss
      - Bolted connection specs
      - Reducing joints
      - conductor CSA vs Resistance Analysis
  - Modules
    - Bolted Joints Analysis
    - Conductor CSA vs Resistance
    - Cooling strategy
      - Added Thermal mass or Couple
- Power And Controls
  - Drivetrain
    - Final drive analysis
      - Torque vs grip
      - Torque vs Speed
    - New motor or configurations
      - Different torque output
      - Hubs???
    - Inverter Tuning
      - Dynamic frequency changes
      - PID of power demand
    - Launch control
    - Traction control
  - Accumulator
    - New Cells
    - New Configuration

Goals

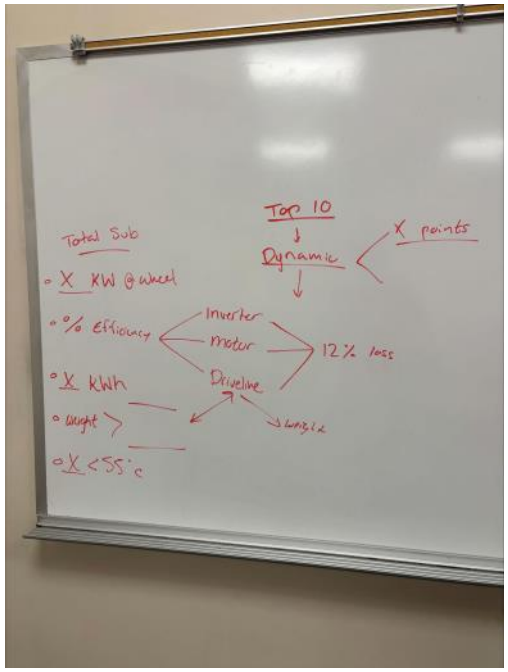
Monday, August 11, 2025 8:31 PM

Performance Goals:

- **80 kW** from Accumulator
- **6.73 kWh** total energy
- **90%** Efficiency – Motor + Inverter
- Within **+/- 2%** of Weight Projection for accumulator (148 lbs)
- Stay Below **55 deg C** cell temps

	KS9 LOW	KS9 MID	KS9 HEAVY
Powertrain	180	185	187

	KS9 LOW	KS9 MID	KS9 HEAVY
Chassis	64	65	66
Suspension	100	101	102
Cockpit	12	15	16
Safety	18	18	19
Powertrain	180	185	187
Aero	40	42	43
Driveline	25	26	28
Low Voltage	9	9	9
Misc	15	15	15
Total	463	476	485



Suggestions:

- Split up % efficiency between inverter, motor, and driveline individually
  - Inverter tuning to modify efficiency
  - Motor efficiency highly unlikely to be modified
  - Helps set targets for driveline, including ideal gear ratio
  - Logarithmic decay in increasing efficiency
- Include goal for KWH of the pack, no need to include KWH @ the wheels
  - This can be calculated using the pack KWH and % efficiency
- Create weight table of KS8E pack components for a baseline
  - Base subgroup weight goal off of overall team goal
  - Gives idea of where weight lies
- Add a goal considering maintenance and serviceability

Deadlines

Monday, August 4, 2025 8:13 PM

Design

Aug 22
- Systems requirement review
  - Goals due

Sept 5
- 2026 Rules drop

Oct 6
- Due when SES opens (OCT 6): Lower Container + Acc Mounts + Module

Oct 9 Design Freeze of Priority A Circuits LV and HV
- Goal is to be ready for Big order 2 (Oct 20)

Nov 3
- ESF Opens

Nov 17
- Send Cut Send (If needed)
  - Cooling Loop tabs
  - busbars

Nov 21
- End of design
  - Everything that isn't "A" Priority

SES Design - October 6
Accumulator Design Freeze - October 9
Critical Design Review (EV Power) - November 21
Rolling + Accumulator Container welded - January 12 (End of winter break)
KS9 Driving - 5 Weeks before - FS February 28

Build

Acc container completed before winter break
- Optimal for chassis welding

Build modules during winter break
- While torsion testing is conducted
- Complete modules during start of break/before school begins

People:

Garrett
- MSD/Lid Reorganization

Dominik
- Module

Varun + Camden
- Cooling loop

Sam F
- Lower Container
- Acc mounts

Val
- Split BMS

MSD placement

Newbie Projects:
- Charger Fix 240v
- Module Endline

Handing out projects

- Either provide requirements or work with them to create requirements
  - Project dependent
- Provide a purpose that lays the groundwork for the project
- Can ask them to do an investigation beforehand
- Provide contacts for the project, who do they need to talk to
- Provide timeline for the project
  - Either set one, or work with them to set one

Projects

Wednesday, August 13, 2025 6:59 PM

People:

Garrett
- MSD Placement
- Lid updates

Dominik
- Module Design
    - Top Plate Mechanical Stack-up
    - Endline busbars
    - Side Plastics
    - Bottom Plate Optimization

Varun
- Cooling loop investigation/testing

Sam F
- Lower Container
- Acc mounts

Val
- Split BMS

Moloney
- Cooling loop investigation
- Rad sizing and placement

Camden
- Cooling loop investigation
- Water pump selection

Mahi
- Charger 240V Fix

Projects:
- Inverter mounting
- Module busbars
- Lid busbars
- AIRS

Module Mechanical Design

Monday, August 11, 2025 9:03 PM

- Modules
  - Endline Connections
    - Bonds failed during use
      - Different Adhesive and plastic combo
        - Increase bond strength
      - Different Endline connection method
        - Lower torque on adhesive
      - New connection design
        - No adhesive
    - Very tall
      - Interaction failures
        - New/ endline design
        - New Connectors

- Bottom plate has no features
  - Can be much lighter

- Side pieces
  - Already pretty light
  - Can add skeletonized structure

- Modules
  - Bolted Joints Analysis
  - Conductor CSA vs Resistance
  - Cooling strategy
    - Added Thermal mass or Couple

- Busbar glue
  - The glue used to hold the busbars down is not technically legal, but because its not a structural component
  - Doesn't pass the temp rating they want
  - Shouldn't maintain that loophole, but can try to argue again
  - Easier to change glue and plastic, than get 3m to admit higher transition temp

EV 6.4 Connections

EV 6.4.1 All Tractive System connections must:

a. Be designed to use intentional current paths through conductors designed for electrical current

b. Not rely on steel bolts to be the primary conductor

c. Not include compressible material such as plastic in the stack up

- Rules question about requirements for material stack up
  - EV 6.4.1
  - Could allow us to use cheaper and more widely available plastics

In reference to **EV.6.4.1**, what qualifies as a compressible material within the accumulator mechanical stack-up?

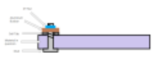
Specifically, we are seeking clarification on whether cell tab connections using studs retained in a stiff plastic component, which clamps the cell tabs against aluminum, are considered to include a compressible material.

1. Is there a defined stiffness threshold (e.g., modulus of elasticity) that determines whether a material is regarded as compressible under this rule?

2. Does the term "within the stack up" refer only to the bolted connection between conductors, or does it also include supporting structures that do not directly carry current?

Attached below is a representative image of the design in question for reference.

Thank you for your clarification.



RULE CHANGES: https://www.designjudges.com/articles/guide-to-2026-frame-rule-changes

Basically I have 2 rough ideas that I can try to test while I continue to try and come up with a more ideal solution. The first one is purchasing a sheet of PEI (Probably Ultem) from wherever I can get it the quickest, and source an adhesive that might work well for that plastic and the aluminum busbars.

The other idea is to put threaded heatset inserts into the top plate for each stud, then use studs that have some sort of feature like a hex slot to thread it into the inserts and counter hold them while a locking nut is threaded on. For this design im having trouble figuring out whether or not that stud and heatset interaction also would require positive locking. As well as the concern of heatsets generally being pretty weak to rotational force, and the studs would need to grow a significant amount in diameter to account for that hex feature. Basically wondering if you had any feedback on these ideas, wether it was something that was considered in the past already and avoided for some reason? Still working towards finding a better solution for this stack-up as I don't love either of these solutions for a couple reasons

Jonathan Peiffer

Rules Rep since 2020

If the "material in question" shown in your image is plastic, then that would be considered compressible and not compliant. There is concern in that situation around achieving sufficient clamping force as well as long term creep. These leading to the joint loosening, contact resistance increasing, and things getting hot.

Please go back into this question on the website and click "Close Inquiry" so we know you have received this response or post a follow up question.

No Attachments

MODULE ATTACHMENT TO CONTAINER F.10.3.2.A-B

We're ramping existing policy. Modules should be mechanically attached to the container. Wi
must show equivalence to the strength of a welded joint around the entire perimeter.

F.10.3.3. module positive locking, does not require critical fasteners. Just put something in she
usual if bolting in tension.

Mechanical attachments will be mandatory in 2027.

Module, Cover, and Lid attachments each require a Positive Locking Mechanism per T.8.3. An c

CONTINUING MODULE STRUCTURE RAMP - F.10.3.4

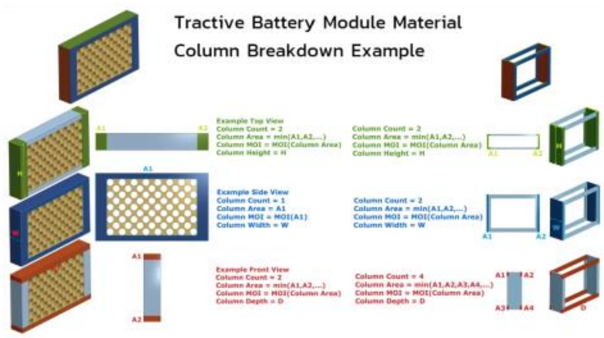
Cross sectional properties of segment structures must be included for SES calculations of F.1
area and continuous along its normal can be counted toward equivalence. The minimum prin

The SES is asking about the structure of a single segment.

- removed from the container
- aligned lat/long/vert as it is in the car

Structural cross sections are taken with all cells, wiring, cooling, etc. removed. And furthermo
statics class, a column is loaded normal to its cross section, continuous in area and continuou

If there are multiple separate cross sectional areas, select only the smallest for area and mo
thicker cross sections. It is also reasonable to ignore the smallest cross section(s), and not in
areas.



Dominik Klenik

Team Member for Kennesaw State University, Kennesaw State University - IC since 2025

Hello, we were wondering about the section, "Not include compressible material such as plastic
(e.g., modulus of elasticity) that determines whether a material is regarded as compressible und
certain material (e.g., specific polymer of plastic) in this application?

No Attachments

Approved Resolution

Steve Sayovitz

Rules Rep since 2013

No specific standard exists. Use good engineering judgement.
If in doubt, use a different material.

Please go back into this question on the website and click "Close Inquiry" so we know you have

No Attachments

Steve Perry:
Stud bond into top plate must be strong enough to retain torque of DT nuts during connection and disconnection process. I recommend to validate this connection before finalizing design and assembly of accumulator.

PP1

Module:

- Weight requirement should be derived from the upper level targets across the car
  - 2.5% is just a value that you can be at but has no foundation in what the cars upper or lower approximate should be
- Should include any photos or results from stud bonding analysis or lessons learned
- DFA goal
  - DFA is inherent to your design considerations and constraints
  - Mechanical stack up is just the goal
- Lacking certain specificity on the lessons learned especially if they can turn into some of the requirements for the project

Improve Reliability of Mechanical Stack-up reliably withstand 90 cent Nm

Description

What qualifies this criterion to be met? This can be quantitative or qualitative.

The modules design should account for the ease of module assembly to minimize possible failures that could cause large setbacks in the cars timeline. Mechanical stack up that can reliably withstand 90 cent Nm.

Execution

In what ways do you plan to meet this criterion?

According to lessons learned from the current modules, to meet this expectation the module design needs to include less reliance on adherence of the busbars and studs to the plastic top plate. A mechanical stack-up that doesn't include adhesion could be the solution to this issue that we ran into.

Bailey Graham

Exactly! Are you looking to have a cycle count and or an FOS for this torque?

Weight Reduction

Description

What qualifies this criterion to be met? This can be quantitative or qualitative.

Aim to reduce the weight of module segments by approximately 2.5% (0.5lbs)

Execution

In what ways do you plan to meet this criterion?

Bailey Graham

How did you project this number?

Design Updates – Cell Compression

Constants		
Cell Series Count	28	#
Foam Slots	29	#
Cell Area	0.0137	m^2

Compression to Evaluate		kPa	N	N	kpa	psi
Instance Name	Percentage	Related Pressure	Single Reactive Force	Total Reactive Force	Total Reacted Pressure	
Fresh Assembly	12	25	342.5	9932.5	725	105.15255
Nominal Life Max	20.9	30	411	11919	870	126.18306
End of Life, Abs Max	71.3	145	1986.5	57608.5	4205	609.88479

- The pressure reacted from the foam (25 kPa) is transferred to a point load by multiplying the pressure and area. (s*A = F).
- This calculated force is 343N.
- In my calcs each foam piece is being treated as a spring. In this design, there are 29 foam slots (all in parallel) meaning their force is additive.
- So, the total compressive force is 343N*29 = 9933N. (This is the ~2100 lbs Number)
- What I failed to consider is the compression is not a point load and needed to be transferred back to a pressure. (this force is being created but is being reacted by the entire cross section)
- The pressure required for initial compression is 9933N/0.0137m^2 = **725 kPa (~105 psi)**

hout mechanical attachment. Mechanical Cover and Lid attachments

ar for attaching the module that will take the test load. Or do the

overcentering latch does not on its own qualify as positive locking.

0.3.1 compressive loads. Only a cross section that is continuous in
cipal moment of inertia must be entered for each cross section.

re, treating hole patterns as one large opening. Just like in your
us along its normal.

ment of inertia. Take the minimum cross section, ignoring areas with
clude those when counting the number of separate cross sectional

in the stack-up" in EV.6.4.1. For this rule is there a defined stiffness threshold
er this rule? Is there any form of confidence test that would allow us to use a

10/5/2020 8:28:32 PM ET

received this response

Whats Happening – Module (Plastics)

Initial Parts:

- Busbar and Tab slots within 0.010" requirement
- Width dimension of parts 0.030" (too large to fit in container)

New Parts:

- Finished 01/09 so not here as of writing this
- Shown to be within 0.005"

Part Updates – Module Compression

Issue: Initial Compression of 14% required to assemble the segments is estimated to use 9500 Newtons of force

The Calc: The reactive pressure is used to calc an initial point load by P = F/A. Then the springs (the foam) are summed in parallel.

Why: The possible failure mode is buckling the plastic and allowing excess displacement of a press (causing cell failures lol)

What's Happening: I contacted the supplier, Saint – Gobain, and sent them all the math. We will be talking within a week to confirm the real compression.

Next: Get build doc for this process

HV Updates – Stud Issues

Adhesive:

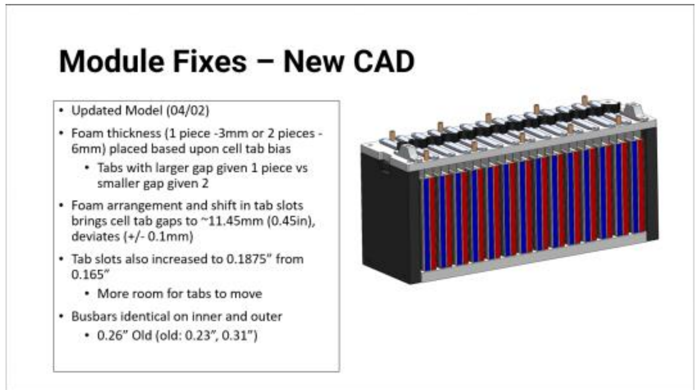
- Negotiating between 4475 and 4693
    - 4693 Is acetone carried adhesive, but has only quart size pales (unless 36 pkg)
    - 4475 is MEK carried adhesive, has 5 fl oz bottle for easy applications

Bond Method:

- Talking about adding glass beads to the bond stack to maintain bind gap
- Using lower busbar to help maintain pressure and reduce pullout

Calcs:

- Predicting adhesive performance
- Optimizing stud cavity

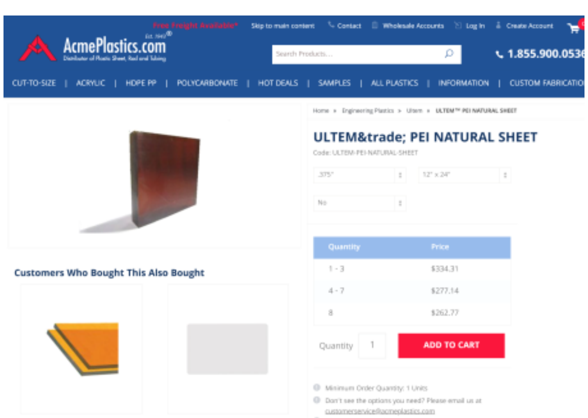


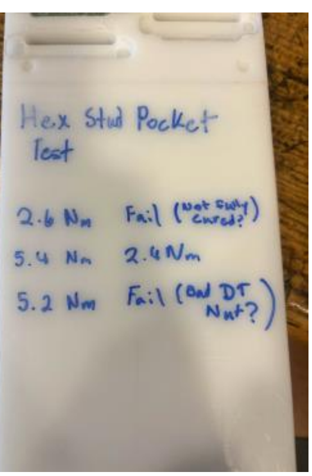
Ultem Pricing

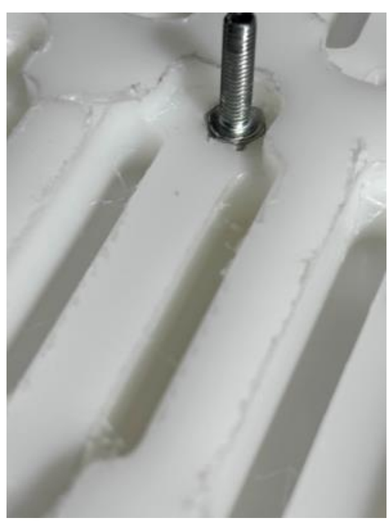
(3x) 12x24 sheet: $1002.93 ($334.41 each)

Outsourced CNC: $2023.55 ($404 each)

Outsourced 3d print: $889.85 + Shipping




Hex Stud Pocket
Test
2.6 Nm Fail (Not fully cured?)
5.4 Nm 2.4 Nm
5.2 Nm Fail (On DT Nut?)



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PLEXIGLASS POLYCARBONATE FIBERGLASS LIGHTING ALL SHEETS ALL SHAPES FILMS HOME/OFFICE ACCESSORIES FABRICATION INFORMATION SALE

HOME › SHEETS › ULTEM SHEETS › 1/2" X 24" X 48" ULTEM 1000

1/2" X 24" X 48" ULTEM 1000

SKU: ULTEMNAT0.500X24X48

Sales Unit: EA

No Reviews yet

1/2" x 24" x 48" Ultem 1000 natural sheet

$979.95

Quantity	1 – 3	4 – 7	8 +
Price	$979.95	$964.27	$948.59

CM 200 DZ

Wednesday, August 20, 2025 1:24 AM

KS8E Inverter selection history

yeah, so the inverter selection was fairly informal. We use a PMSM motor, specifically the emrax. There were originally only three (Two up until recently) companies that offered performance compatible units with documentation related to the emrax. The Unitek Bamocar (We have the 400T1 in the shop) the cascadia models (PM and CM series) and then like twoish years ago the DTI ones showed up. So it was between these options and the making our own (we never planned on doing this). We had reliability issues with the bamocar with our 300V car where it blew the Switches above 39 kW. So that left the cascadia options CM200dz (only 600V option without crazy oversize) or the DTI 550 or 850. We ran with the cm200 as we got the used model way cheaper that the normal price (3500 instead of 7100) which was also cheaper than both DTI models (I think 5500 and 6500). Plus the Cascadia didn't required much code updates to run on our car

"Performance compatible unit"
- Capable of 400arms, high voltage etc
- Can drive a PMSM

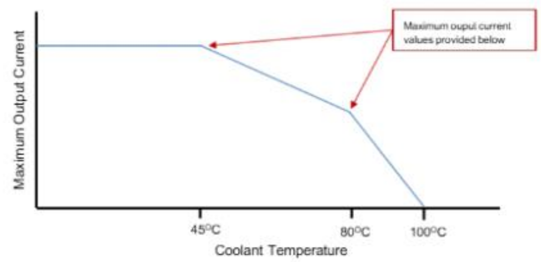
CASCADIA MOTION

7929 SW Burns Way
Suite F
Wilsonville, OR 97070

Phone: 503-344-5085
sales@cascadiamotion.com

1. Introduction

Inverter output current is automatically limited in software to match capability with operating conditions. Starting with firmware version 6505 output current is limited based on PWM switching frequency and DC bus voltage. Then in firmware version 6511 and newer, output current is also limited based on coolant temperature estimate. Where coolant temperature is estimated from module temperatures and operating output current. When coolant temperature is 45°C or below there is no reduction in output current due to coolant temperature. There are two separate linear derates when coolant is above 45°C. The first linear derate is when coolant temperature is between 45°C and 80°C. The second linear derate is when coolant is between 80°C and 100°C. Current limits at 45°C and 80°C are provided below. At 100°C the current limit is zero amps. Therefore with 62.5°C coolant the maximum output current will be 50% between the 45°C and 80°C limits. With 90°C coolant the maximum output current will be 50% between 80°C limit and zero.



The current limits provided in this manual only covers limits due to coolant temperature, switching frequency, and DC bus voltage. For low speed operation, output frequency below 10Hz, see Low Speed Operation manual.

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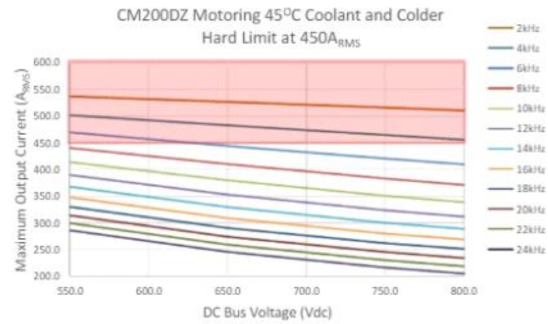
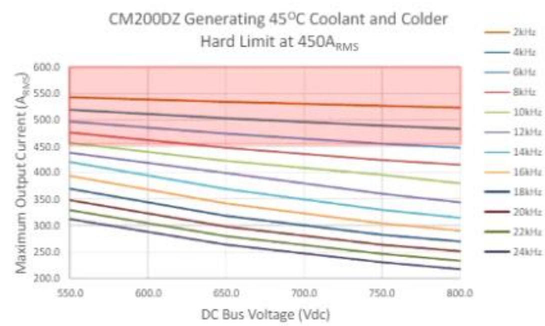
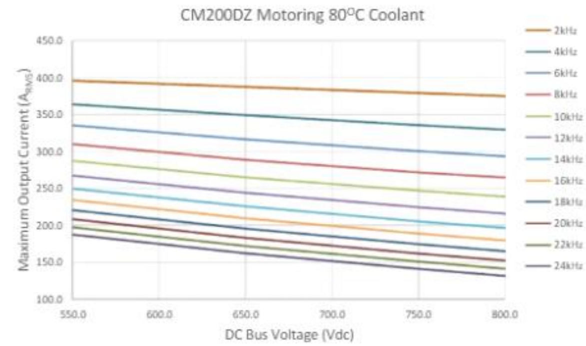
3. CM200DZ Maximum Output Current

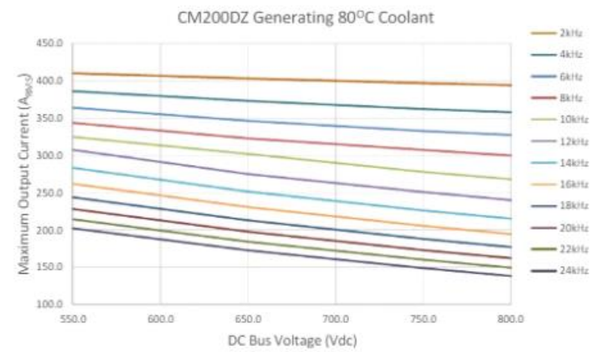
3.1 Coolant Temperature Less Than or Equal to 45°C





3.2 Coolant Temperature at 80°C



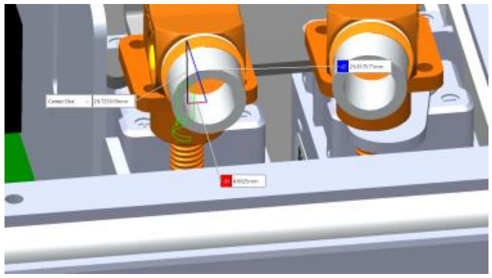


Lid Re-work

Monday, August 25, 2025   2:46 PM

CAD to do

- [x] Busbar HVD back in to HV out, need space for current meter bracket + current meter itself
- [ ] Switch Panel to other chassis tube, have space for waterproofing box
- [x] Edit lid structure to no mustard, also needs AVI cutout near TSMP's
- [x] Endline pack ASSY is goofed af, horribly different to what exists rn-- can know after Acc drop FUCK
  51.75mm length 19mm width 4.5mm from first bolt- one is offset give length
  Lil step off guy is 79.5mm from rounded edge
- [x] TSMP Connector into assy
- [ ] Add in Tab-Slot for all panels :(



T.9.3 Master Switches

Each Master Switch (IC.9.3 / EV.7.9) must meet:

T.9.3.1 Location
a. On the driver's right hand side of the vehicle
b. In proximity to the Main Hoop
c. At the driver's shoulder height
d. Able to be easily operated from outside the vehicle

T.9.3.2 Characteristics
a. Be of the rotary mechanical type
b. Be rigidly mounted to the vehicle and must not be removed during maintenance
c. Mounted where the rotary axis of the key is near horizontal and across the vehicle
d. The ON position must be in the horizontal position and must be marked accordingly
e. The OFF position must be clearly marked
f. (EV Only) Operated with a red removable key that must only be removable in the electrically open position

EV.7.9 Master Switches

EV.7.9.1 Each vehicle must have two Master Switches that must:
a. Meet T.9.3 for Configuration and Location
b. Be direct acting, not act through a relay or logic

EV.7.9.2 The Grounded Low Voltage Master Switch (GLVMS) must:
a. Completely stop all power to the GLV System EV.4.4
b. Be in the center of a completely red circular area of > 50 mm in diameter
c. Be labeled "LV"

EV.7.9.3 The Tractive System Master Switch (TSMS) must:
a. Open the Shutdown Circuit in the OFF position EV.7.2.2
b. Be the last switch before the IRs except for Precharge circuitry and Interlocks
c. Be in the center of a completely orange circular area of > 50 mm in diameter
d. Be labeled "TS" and the symbol specified in ISO 7010-W012 ⚠ (triangle with black lightning bolt on yellow background).
e. Be fitted with a "lockout/tagout" capability in the OFF position EV.11.3.1

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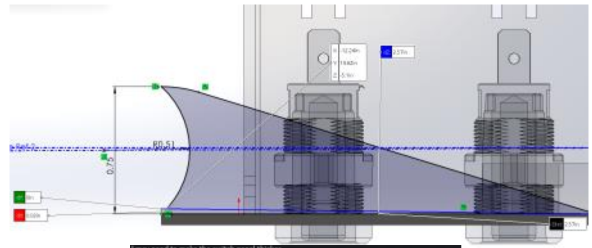
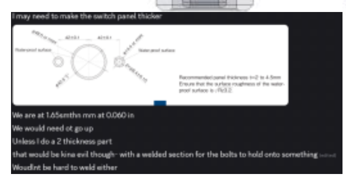
EV.5.5 Manual Service Disconnect - MSD

A Manual Service Disconnect (MSD) must be included to quickly disconnect one or the two poles of the Tractive Battery Pack EV.11.3.2

EV.5.5.1 The Manual Service Disconnect (MSD) must be:
a. A directly accessible element, fuse or connector that will visually show disconnected
b. More than 350 mm from the ground
c. Easily visible when standing behind the vehicle
d. Operable in 10 seconds or less by an untrained person
e. Operable without removing any bodywork or obstruction or using tools
f. Directly operated. Remote operation through a long handle, rope or wire is not acceptable.
g. Clearly marked with "MSD"

EV.5.5.2 The Energy Meter must not be used as the Manual Service Disconnect (MSD)
EV.5.5.3 An Interlock EV.7.8 must Open the Shutdown Circuit EV.7.2.2 when the MSD is removed
EV.5.5.4 A dummy connector or similar may be used to restore isolation to meet EV.6.1.2





Looks like it'll be 3 parts with some welded circes around the bolt area, kinda act as a washer tbh.

Update from Chance—AVI currently illegal
Will need to move somewhere, debating near Main HV out on top or near side by IR's
Funsies.

Fuse-POWrFuse_PF-F_Series_DS.pdf
150 A, in ESF

Currently current limited to 100A as I am leaning from VCU, BMS has a max of 200. So Airs need to be at 150 for main fuse but should be able to be higher, IE other things blow before IR's (As my understanding from rules)

Cannot go above 150 because that's what the surlocks are rated for

TO DO:
New current sensor-required component (in actual ordering not under project)

Explain how extrenal MSD would change and more
(Why MSD external separate, not 2 hv leads out and more etc)

DISCHARGE CIRCUIT

Could put it all the way to chainguard, lots of locations

What is scope of moving discharge outside

RULES RULES RULES

Update 9/31
Need new IR's- Data sheet shot down from 750 to 450 volt nominal (evil)
List in this onenote, somewhere.......
Keep same fuse and hopefully a similar footprint
(avoids moving LV and HV spacing)
Will probably add weight (sorry but hands are tied)
Maybe look at new gaskets before comp
Keep discharge inside and may connect to other side of E-Meter
MSD on Switch panel, using connector where E-meter is (swapping places)

#231 Kennesaw Motorsports Accumulator Tech Video for 2025

Looking at potential IR's

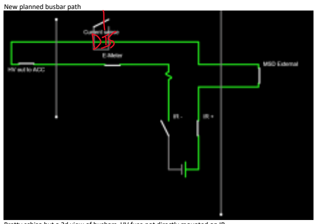
rxr20-series-datasheet.pdf -- kinda leaning toward these, closer to our current IR's
(like half a pound heavier than each (very sad))

Higher Amp-rxc15-series-datasheet.pdf

EV200AAANA : Kilovac Electromechanical Relays | TE Connectivity
Chonk and expensive

Polarized 150A High-Current High-Voltage DC Contactor Relay
Similar set up to charger IR's, isnt screaming about mounting system (from my look)

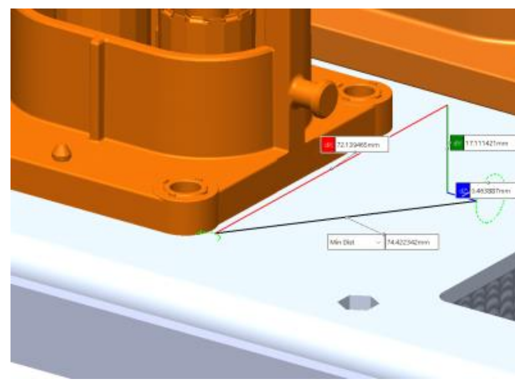
New planned busbar path



Pretty schizo but a 2d view of busbars, HV fuse not directly mounted on IR
Going external MSD, discharge can still be connected on IR- at E-meter point (should satisfy spacing req)

Busbars should stay at a similar height, also allows for current sensing not being in the sky

For planning Acc spacing, set hard measurements together along the different sketches, main worry Walls and TS taps
Mounting, will probably do 2 or 3 as sketches that are copied in the same part with global variables
That one bolt on positive IR for will farthest worry, make like 130mm or 140 for some wiggle room?



Diff AIRS?
Could go slightly smaller
Keep it simple, optimize through part
Make box extension of switch panel
Make it lower?
Maybe more resilient foam but if it works keep it the way it is-find more optimizations

Major dates,
Project proposal 1 input 9/15

First subgroup meeting--9/16 Fail
Womp womp, I was being dumb

That project proposal needs love, organization needs to be a lot better, more clearly laid out.
Talk about shortfalls from previous Lid designs, ask the ones who had to work on it!!!!!

MSD IS GOING EXTERNAL-LAY THAT OUT CLEARLY

Needed for safety and accessibility of MSD

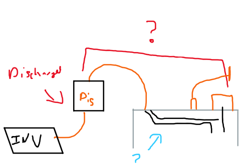
Closed rivnuts are needed for rules

ABRI'S Busbar research KS7E-- busbar material and sizing
Still worth it to look at different options in Part 2(will probs be 1100 Al)

AIR's busbar to HV leads, shorter and with aligning bracket

Discharge also will have to move external, literally just a relay that gets SDC Power into discharge board in the main cover -----(What happens if there is TS Voltage on the line with MSD from IR to MSD? (uh, im no EE))

(I would kinda like to redo Rear harness but LV manufacturing)



Snoop on how other teams do it, Panther racing

Univerisyt of Washington

Polytechnicque montreal

Input from people who have worked on ACC

Chance:
HV taps evil-more so board
MSD discharge tap- yeah uh, has to be unfused fuck-added into enclosure

Access to IR's easier

8cu wrong way, maybe spin?
(mainly along the microcontroller)

TCU ACU dist (sucky not really important)

TJ LUUUU:
ACU evil bolt holes
AVI stay put

EV.3.6 Precharge and Discharge Circuits

EV.3.6.1 The Tractive Battery Pack must contain a Precharge Circuit. The Precharge Circuit must:
a. Be able to charge the Intermediate Circuit to minimum 90% of the Tractive System voltage before closing the second IR
b. Be supplied from the Shutdown Circuit EV.7.1

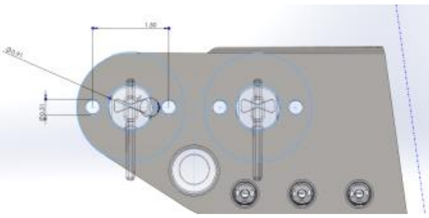
EV.3.6.2 The Intermediate Circuit must precharge before closing the second IR
a. The end of precharge must be controlled by feedback by monitoring the voltage in the Intermediate Circuit

EV.3.6.3 The Tractive System must contain a Discharge Circuit. The Discharge Circuit must be:
a. Wired in a way that it is always active when the Shutdown Circuit is open
b. Able to discharge the Intermediate Circuit capacitors if the MSD has been opened
c. Not be fused
d. Designed to handle the maximum Tractive System voltage for minimum 15 seconds

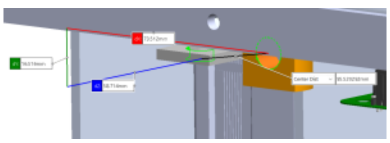
EV.3.6.4 Positive Temperature Coefficient (PTC) devices must not be used to limit current for the Precharge Circuit or Discharge Circuit

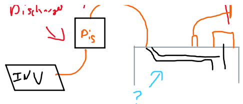
EV.3.6.5 The precharge relay must be a mechanical type relay

- Lid
  - HVD and LM will need to move
    - Changes to HV pathing in lid
    - Possible breakout and junction box?
  - Split lid for smaller panels thicknesses + check rules for tractive enclosures that are not cell bearing
  - Smaller fasteners globally



Saved for later





8cu wrong way, maybe spin?
(mainly along the microcontroller)

TCU ACU dist (sucky not really important)

TJ LUUUU:
ACU evil bolt holes
AVI stay put

Val:
ACU (cant plug in IMD then, shouldn't be different direction, component interference) Look at changing heights/TCU toward busbar (IMD higher?)

Wiring constraints
Fused connection off AIRS (hard to secure)
HV leads are fine
ACU Bolt holes(cannot interact L)
AVI (okay, just next to chassis, no notes from comp)
Hall sensor(MAJOR, broken, LV wiring has very little spacing)

Bailey:

a. Designed to handle the maximum Tractive System voltage for minimum 15 seconds

EV.5.6.4 Positive Temperature Coefficient (PTC) devices must not be used to limit current for the Precharge Circuit or Discharge Circuit

EV.5.6.5 The precharge relay must be a mechanical type relay

- Lid
  - HVD and EM will need to move
    - Changes to HV pathing in lid
    - Possible breakout and junction box?
  - Split lid for smaller panels thicknesses + check rules for tractive enclosures that are not cell bearing
  - Smaller fasteners globally
  - Busbars are Al1100 due to low resistance to weight ratio
    - Other Aluminum alloys are much higher resistance (see Alin's busbar proposals)
    - Can redo this project with lower RMS current projections (Might may not be worth it tbh)
  - Look at replacing busbars wire small single core wires
    - Bendable
    - Can be light (aluminum core)
  - HVIL's on our TS connectors need to be insulated
  - Current meter holder is iffy
  - AIRs are not reliable
    - Rated to 600 Vdc for 2000 cycles but have had 3 weld
    - Cannot predict cycle life depletion with our high fault rate while driving
    - Look at getting contactors with second coils to track state of first
      - Find welded AIRs
  - TCU needs GLV not just SDC for power
    - When SDC opened could not see RTML, SSL or AVI
  - Need new IMD
    - ISO155-3204 would be a direct replacement of the previous 3203 unit
    - ISO175 would be the newer CAN interactive IMD
      - Can use for Precharge

Schizo rules dump of all things pertaining to lid interference, MSD, Emeter [#231 Kennesaw Motorsports Accumulator Tech Video for 2025](#), HV/LV etc

F.10 TRACTIVE BATTERY CONTAINER (EV ONLY)

F.10.1 General Requirements

F.10.1.1 All Tractive Battery Containers must be:

a. Designed to withstand forces from deceleration in all directions

b. Made from a Nonflammable Material (**F.1.18**)

F.10.1.2 Design of the Tractive Battery Container must be documented in the SES

Documentation includes materials used, drawings/images, fastener locations, Cell/Module weight and Cell/Module position

F.10.1.3 The Tractive Battery Container and mounting systems are subject to approval during SES review and Technical Inspection

F.10.1.4 If the Tractive Battery Container is not constructed from steel or aluminum, the material properties should be established at a temperature of 60°C

F.10.1.5 If adhesives are used for credited bonding, the bond properties should be established for a temperature of 60°C

F.10.1.6 Open-ended pop rivets must not be used in the Tractive Battery Container

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Version 0.0 DRAFT 11 Aug 2025

SAE INTERNATIONAL [Click Here to Submit Comments](#) **DRAFT**

F.10.2 Structure

F.10.2.1 The Floor or Bottom must be made from one of the three:

a. Steel 1.25 mm minimum thickness

b. Aluminum 3.2 mm minimum thickness

c. Equivalent Alternate / Composite materials (**F.4.1, F.4.2**)

F.10.2.2 All Walls (Internal and External), Covers and Lids must be made from one of the three:

a. Steel 0.9 mm minimum thickness

b. Aluminum 2.3 mm minimum thickness

c. Equivalent Alternate / Composite materials (**F.4.1, F.4.2**)

F.10.2.3 Internal Vertical Walls:

a. Must surround and separate each Module **EV.5.1.1**

b. Must have minimum height of the full height of the Module

The Internal Walls should extend to the lid above any Module

c. Must surround no more than 12 kg on each side

The intent is to have each Module fully enclosed in its own six sided box

F.10.2.4 If Modules are arranged vertically above other Modules, each layer of Modules must have a load path to the Chassis attachments that does not pass through another layer of Modules

F.10.2.5 Floors and all Wall (Internal and External) sections must be joined on each side

The accepted methods of joining Walls to Walls and Walls to Floor are:

a. Welding
- Welds may be continuous or interrupted.
- If interrupted, the weld/space ratio must be 1:1 or higher
- All weld lengths must be more than 25 mm

b. Fasteners

Combined strength of the fasteners must be Equivalent to the strength of the welded joint (**F.10.2.5.a above**)

c. Bonding
- Bonding must meet **F.5.5**
- Strength of the bonded joint must be Equivalent to the strength of the welded joint (**F.10.2.5.a above**)
- Bonds must run the entire length of the joint

Folding or bending plate material to create flanges or to eliminate joints between walls is recommended.

F.10.2.6 Covers and Lids must be mechanically attached and include **Positive Locking Mechanisms**

T.9.3 Master Switches

Each Master Switch (**IC.9.3 / EV.7.9**) must meet:

T.9.3.1 Location

a. On the driver's right hand side of the vehicle

b. In proximity to the Main Hoop

c. At the driver's shoulder height

d. Able to be easily operated from outside the vehicle

T.9.3.2 Characteristics

a. Be of the rotary mechanical type

b. Be rigidly mounted to the vehicle and must not be removed during maintenance

c. Mounted where the rotary axis of the key is near horizontal and across the vehicle

d. The ON position must be in the horizontal position and must be marked accordingly

e. The OFF position must be clearly marked

f. (EV Only) Operated with a red removable key that must only be removable in the electrically open position

EV.3.2 Energy Meter

EV.3.2.1 All Electric Vehicles must run with the Energy Meter provided at the event

*Refer to the FSAEOnline Website **AD.2.2** for detail information on the Energy Meter*

EV.3.2.2 The Energy Meter must be installed in an easily accessible location

EV.3.2.3 All Tractive System power must flow through the Energy Meter

EV.3.2.4 Temperature sensors must be installed and connected to the Energy Meter

EV.5.5 Manual Service Disconnect - MSD

A Manual Service Disconnect (MSD) must be included to quickly disconnect one or the two poles of the Tractive Battery Pack **EV.11.3.2**

EV.5.5.1 The Manual Service Disconnect (MSD) must be:

a. A directly accessible element, fuse or connector that will visually show disconnected

b. More than 350 mm from the ground

c. Easily visible when standing behind the vehicle

d. Operable in 10 seconds or less by an untrained person

e. Operable without removing any bodywork or obstruction or using tools

f. Directly operated. Remote operation through a long handle, rope or wire is not acceptable.

g. Clearly marked with "MSD"

EV.5.5.2 The Energy Meter must not be used as the Manual Service Disconnect (MSD)

EV.5.5.3 An Interlock **EV.7.8** must Open the Shutdown Circuit **EV.7.2.2** when the MSD is removed

EV.5.5.4 A dummy connector or similar may be used to restore isolation to meet **EV.6.1.2**

EV.5.8 Tractive System Measuring Points - TSMP

EV.5.8.1 Two Tractive System Measuring Points (TSMP) must be installed in the vehicle which are:

a. Connected to the positive and negative motor controller/inverter supply lines

b. Next to the Master Switches **EV.7.9**

c. Protected by a nonconductive housing that can be opened without tools

d. Protected from being touched with bare hands / fingers once the housing is opened

Other rando schizo things,
Minimize bolted connections and simplify busbar path, WOULD LOVE the right aluminum that bailey was going for-Al 1100

Rest of structure is 6061 t-6
May look at 5052 for bending

Work with Sam for material choice?

Still need a sheet of Al-1100 and 5052 or 6061T6
Gasket thinking-could Lazer in arch, would be nice for clean gaskets

Aero bcuz its on car

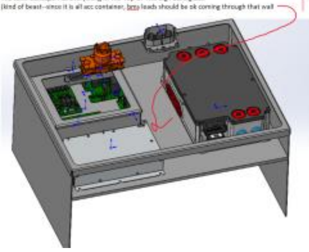
Set a max # of bolted connections,

Include box with gaskets for water proofing

May include bending a ring terminal for less wire angling

KS6E lore

The John Concept: Put Everything In The Top Of This Big Fucking Box
(kind of beast--since it is all acc container, hvs leads should be ok coming through that wall



EV.6 ELECTRICAL SYSTEM

EV.6.1 Covers

EV.6.1.1 Nonconductive material or covers must prevent inadvertent human contact with any Tractive System voltage

Covers must be secure and sufficiently rigid

Removable Bodywork is not suitable to enclose Tractive System connections

EV.6.1.2 Contact with any Tractive System connections with a 100 mm long, 6 mm diameter insulated test probe must not be possible when the Tractive System enclosures are in place

EV.6.1.3 Tractive System components and Tractive Battery(s) must be protected from moisture, rain or puddles

A rating of IP65 is recommended

EV.6.2 Insulation

EV.6.2.1 Insulation material must:

a. Be appropriate for the expected surrounding temperatures

b. Have a minimum temperature rating of 90°C

EV.6.2.2 Insulating tape or paint may be part of the insulation, but must not be the only insulation

EV.6.3 Wiring

EV.6.3.1 All wires and terminals and other conductors used in the Tractive System must be sized for the continuous current they will conduct

EV.6.3.2 All Tractive System wiring must:

a. Be marked with wire gauge, temperature rating and insulation voltage rating.

A serial number or a norm printed on the wire is sufficient if this serial number or norm is clearly bound to the wire characteristics for example by a data sheet.

b. Have temperature rating more than or equal to 90°C

EV.6.3.3 Tractive System wiring must be:

a. Done to professional standards with sufficient strain relief

b. Protected from loosening due to vibration

c. Protected against damage by rotating and / or moving parts

d. Located out of the way of possible snagging or damage

EV.6.3.4 Any Tractive System wiring that runs outside of electrical enclosures:

a. Must meet one of the two:

- Enclosed in separate orange nonconductive conduit

EV.6.3.4 Any Tractive System wiring that runs outside of electrical enclosures:

a. Must meet one of the two:

- Enclosed in separate orange nonconductive conduit
- Use an orange shielded cable

b. The conduit or shielded cable must be securely anchored at each end to let it withstand a force of 200 N without straining the cable end crimp

c. Any shielded cable must have the shield grounded

EV.6.3.5 Wiring that is not part of the Tractive System must not use orange wiring or conduit.

EV.6.4 Connections

EV.6.4.1 All Tractive System connections must:

a. Be designed to use intentional current paths through conductors designed for electrical current

b. Not rely on steel bolts to be the primary conductor

c. Not include compressible material such as plastic in the stack-up

EV.6.4.2 If external, uninsulated heat sinks are used, they must be properly grounded to the GLV System Ground, see **EV.6.7**

EV.6.4.3 Bolted electrical connections in the high current path of the Tractive System must include a positive locking feature to prevent unintentional loosening

Lock washers or thread locking compounds (Loctite®) or adhesives are not acceptable

Bolts with nylon patches are permitted for blind connections into OEM components

EV.6.4.4 Information about the electrical connections supporting the high current path must be available at Electrical Technical Inspection

EV.6.5 Voltage Separation

EV.6.5.1 Separation of Tractive System and GLV System:

a. The entire Tractive System and GLV System must be completely galvanically separated **IN.10.2.2**

b. The border between Tractive System and GLV System is the galvanic isolation between the two systems.

Some components, such as the Motor Controller, may be part of both systems.

EV.6.5.2 There must be no connection between the Chassis of the vehicle (or any other conductive surface that might be inadvertently touched by a person), and any part of any Tractive System circuits.

EV.6.5.3 Tractive System and GLV circuits must not be in the same conduit or connector except as permitted in in **EV.7.8.4**

EV.6.5.4 GLV Systems other than the IRs **EV.5.4**, parts of the Precharge and Discharge Circuits **EV.5.6**, HV DC/DC converters, the BMS **EV.7.3**, the IMD **EV.7.6**, parts of the Ready to Move Light **EV.5.10** the Energy Meter **EV.3.1** and cooling fans must not be inside the Tractive Battery Container

EV.6.5.5 Where Tractive System and GLV are included inside the same enclosure, they must meet one of the two:

a. Be separated by insulating barriers (in addition to the insulation on the wire) made of moisture resistant, UL recognized or equivalent insulating materials rated for 90° C or higher (such as Nomex based electrical insulation)

b. Maintain spacing through air, or over a surface (similar to those defined in UL1741) of:

U < 100 V DC	10 mm
100 V DC < U < 200 V DC	20 mm
U > 200 V DC	30 mm

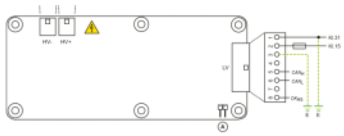
EV.6.5.6 Spacing must be clearly defined. Components and cables capable of movement must be positively restrained to maintain spacing.

IMD Wiring

Saturday, August 23, 2025 9:08 PM

KS8E imd to new IMD

ISOMETER® iso175



Connector*	Pin no.	Description
HV+	1	Mains voltage (HV+ / L1)
	2	
HV-	1	Mains voltage (HV- / L2)
	2	
LV	1	Supply voltage - (terminal 31)
	2	Supply voltage + (terminal 15)
	3	Earth connection (E)[1]
	4	n.c.
	5	CAN-High
	6	CAN-Low
	7	n.c.
	8	Status output (high side) (OK_{HS})[2]
A		Jumper CAN terminating resistor 120 Ω[3]

Illegal for competition

For the 175 remove the white wire.
From the old connector basically

ACU-IMD (C6) -> IMD (C12)

1. 12v
2. IMD-PWM white
3. IMD-OKHS white/blue
4. GND
5. Chassis GND gray/black
6. Chassis GND gray/black

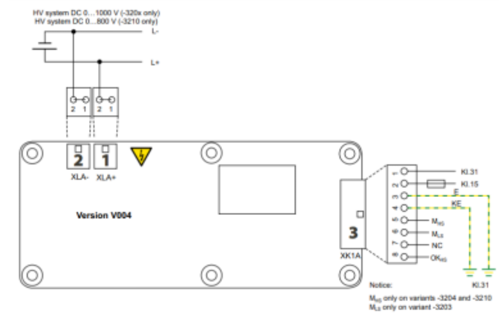
IMD (C12)

8. IMD-OKHS white/blue
7. blank
8. blank
5. blank
4. Chassis GND gray/black
3. Chassis GND gray/black
2. 12v

1.GND

ISOMETER® IR155-3203/IR155-3204

Wiring diagrams



1	Connector XLA+		
	Pin 1+2	L+	Line Voltage
2	Connector XLA-		
	Pin 1+2	L-	Line Voltage
3	Connector XK1A		
	Pin 1	Kl. 31	Chassis ground/electronic ground
	Pin 2	Kl. 15	Supply voltage
	Pin 3	Kl. 31	Chassis ground
	Pin 4	Kl. 31	Chassis ground (separate line)
	Pin 5	M_{HS}	Data Out, PWM (high side)
	Pin 6	M_{LS}	Data Out, PWM (low side)
	Pin 7	n.c.	
	Pin 8	OK_{HS}	Status Output (high side)

ACU-IMD (C6) -> IMD (C12)

1. 12v
2. IMD-PWM white
3. IMD-OKHS white/blue
4. GND
5. Chassis GND gray/black
6. Chassis GND gray/black

IMD (C12)

8. IMD-OKHS white/blue
7. blank
6. IMD-PWM white
5. blank
4. Chassis GND gray/black
3. Chassis GND gray/black
2. 12v

1.GND

BMS

Monday, August 25, 2025 3:40 PM

Need ordering deadline

Avoid MDB Rev

- Will cost ~1000
- Limits future module design
-

- Current sensor currently operates off of BMS, eithner need to make ACU compatible,

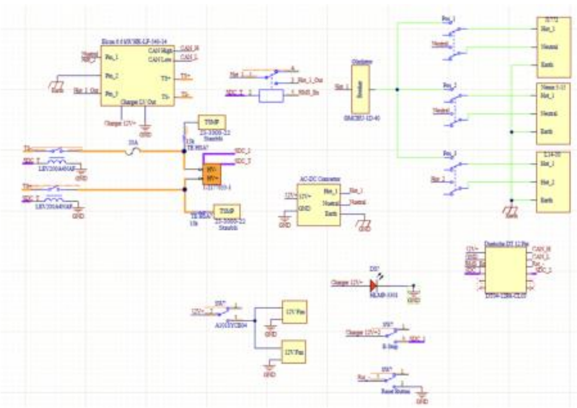
Charger 240V Fix

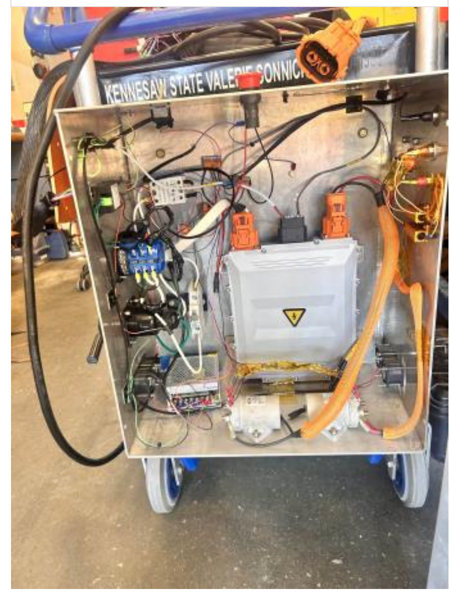
Tuesday, September 09, 2025 9:07 PM

We swapped the 240v plug to Lp 14-20P and it worked

Constraints:
- Fix the 240V Charger while maintaining similar wiring to keep the 110V working
- Clean up Wiring

Looking at possible Wago connectors that can be sponsored for the ac wiring terminal blocks





Update Documentation
- Revise charger documentation throughout.
- Update/Create "How to Charge" guide to include:
- 110 V shop charging steps
- 240 V shop charging steps
- 240 V J1772 competition setup
- Revise ESF to match final wiring and layout

Electrical Rework
- Rewire the charger input to correctly accept single-phase 240 V from a J1772 EVSE.
- Rewire the wall plug input to properly deliver 240 V line-to-line power.
- Replace the damaged TE Connectivity/Deutsch **HD36-18-20SN** I/O connector.
- Double-check that the 110 V input remains fully functional after the changes.
- Set up dedicated inputs for each use case:
- **Shop:** Verify and install the L14-30 plug and wiring.
- **Competition:** Wire the J1772 inlet and confirm correct pilot/proximity signal operation.
- Verify pilot and proximity signal handling so the EVSE enables charging when connected.
- Looking at possible **Wago connectors** that can be sponsored for the AC wiring terminal blocks.

Item	Qty	Price Per Unit	Total	URL for Item
240V Plug	1	14.99	$14.99	L14-30 Plug Amazon Link Have on Hand
Wires (Hot, Neutral, Ground)	4	3.00 per foot	$14.99	Have on Hand
TE Connectivity Deutsch Connectors HD36-18-20SN		30.28	$30.28	TE Connectivity Deutsch Connectors HD36-18-20SN

Safety
- Verify that the output-side fuse is installed per ESF requirements.
- Confirm that all HV wiring uses orange insulation and has proper labels on both ends.
- Add new labels for any modified or newly installed conductors.

Constraints
- Must remain fully compatible with standard single-phase J1772 EVSEs.
- Cannot compromise existing 110 V charging functionality.
- Must comply with **FSAE EV safety requirements** and accurately reflect the submitted ESF.

- Documentation must match the final physical build for tech inspection.

Lower Container Structure Updates

Tuesday, September 2, 2025 10:27 PM

Update SES documentation throughout
- Under teams "2024 SES" until new SES document available

Acc Mounts
- Update position in cad
- Consult Micah for related frame updates
- Keep locating feature if possible

Frame Acc Mounts
- Need acc mount design and chassis updates to finalize

Lower Container
- Use bending method for walls if possible
  - How will module fit be affected
  - Get price quote on proper stock
  - If not add tab and slot feature to all walls
- Move Acc mount locating feature holes
- Add zip-tie holes for interconnect retainment

- Insulation
  - Have plenty of nomex on hand
  - Maybe try new adhesive
    - Looked into some new adhesives, most are quite expensive. Recommendations came from when nomex had to be applied to firewall (3-4 years ago).
      - 3M Super 77 - $28.14 per 28oz aerosol can
      - Plexus MA300 - $20 per 50mL tube
      - Loctite EA9466 - Cannot find smaller than 400mL tube for $200
      - DP100FR - $23-25 per tube, can only find in packs of 12
      - MG 9200FR - $63 per 50mL tube

  - Kapton on edges to prevent corners from lifting

Stock size from old design: ~12.5 sq ft for lower container, ~6 sq ft for lid
Total: ~18.5 sq ft

Approx. quote for new stock:
All from Online Metals
5052-H32: $319.67 for 48" x 60" sheet
6061-O: $471.99 for 48" x 48" and 24" x 24" sheet
6061-T6: $346.48 for 48" x 60" sheet

Online Metals are the Ea-nāṣir of metal stock ordering

Midwest Steel quote:
5052-H32: $143.14 for 48" x 60" sheet
6061-T6: $274.41 for 48" x 60" sheet

Constraints
- Physical footprint should remain constant
  - Restricted by overall team goals, no changes in pack config.
  - Simplifies mounting solutions
  - Already at the limits of sizing rules in relation to chassis
- Module slots should remain the same size
  - May change slightly when module design is finalized
- Must keep the Orion BMS slot
  - Cannot rely on Spit BMS boards for reliability just yet

Front Chassis Mount Wider Chassis Sweep

Thursday, September 4, 2025 11:41 PM

This is to see the difference in weight when increasing the size of the front chassis mounts for the accumulator (tractive battery) due to widening the front roll hoop.

Material: 4130 Steel normalized at 870C (1600F)

Results

Original
Mass: 0.245lbs
Length: 1.055in
Total mass: 0.49lbs

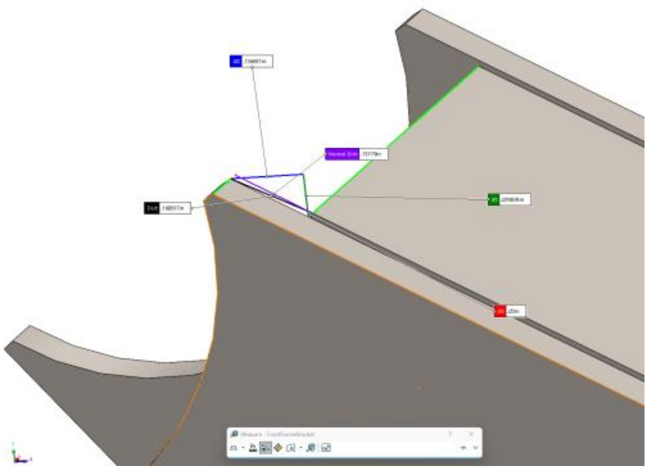
+0.25in
Mass: 0.265lbs
Change of mass: 0.02lbs
Length: 1.305in
Total mass: 0.53lbs

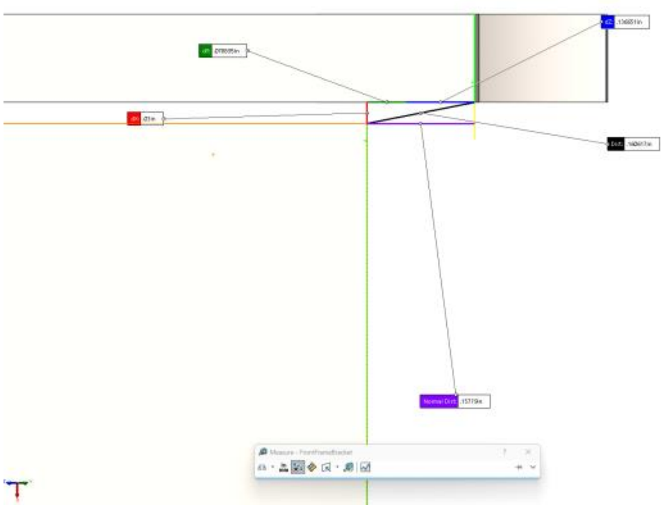
+0.5in
Mass: 0.284lbs
Change of mass: 0.019lbs
Length: 1.555in
Total mass: 0.586lbs

+0.75in
Mass: 0.300lbs
Change of mass: 0.016lbs
Length: 1.805in
Total mass: 0.600lbs

+1in
Mass: 0.314lbs
Change in mass: 0.014lbs
Length: 2.055in
Total mass: 0.628lbs

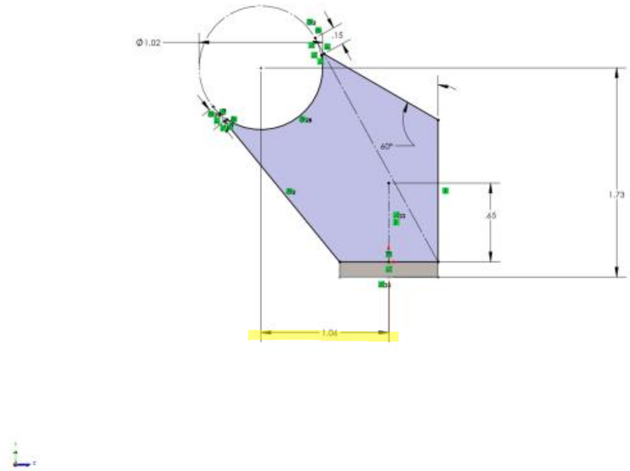
Maintained 0.16in distance from edge of bent tab to backing tab for each length increase



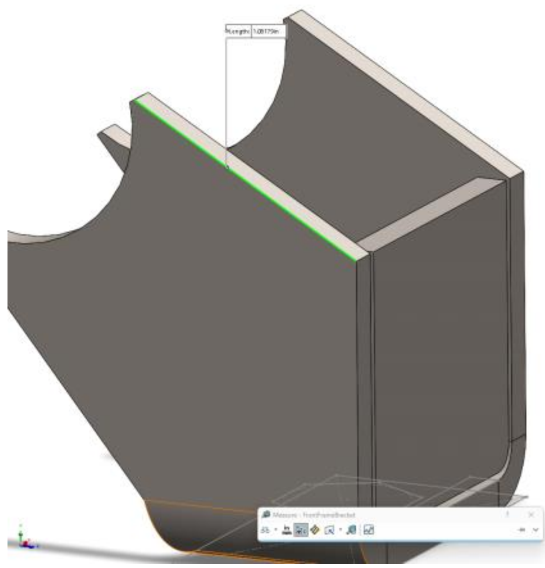


Procedure:

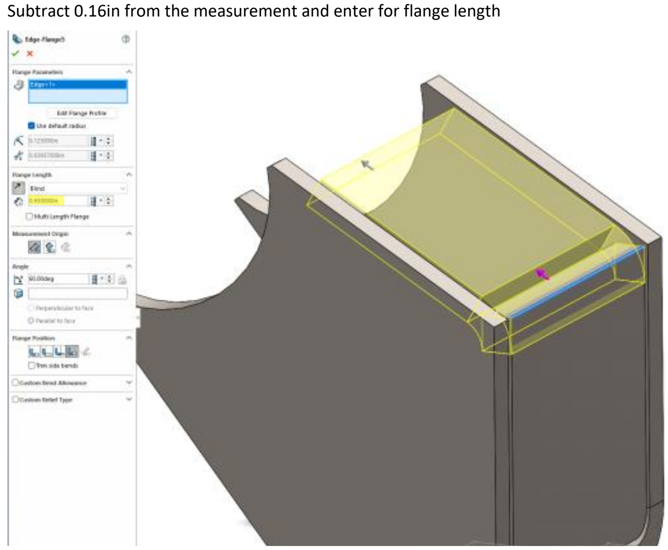
Change Dimension 3 of Sketch 26 as shown below by adding 0.25in for each length increase.



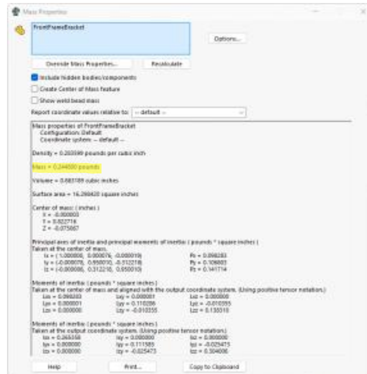
Change the length of the backing tab by measuring the new length of the edge flange



Subtract 0.16in from the measurement and enter for flange length



Find the mass of the part with the Mass Properties tool



Rinse & repeat for each length

Module Endlines

Tuesday, September 2, 2025 10:35 PM

- Modules
  - Endline Connections
    - Bonds failed during use
      - Different Adhesive and plastic combo
        - Increase bond strength
      - Different Endline connection method
        - Lower torque on adhesive
      - New connection design
        - No adhesive
    - Very tall
      - Interaction failures
        - New/ endline design
        - New Connectors

2025 Tesla Cell Sponsor

Wednesday, September 24, 2025 7:04 PM

A) 5.4.5Ah P45B 2170 cylindrical cells from Molicel (QTY 600)

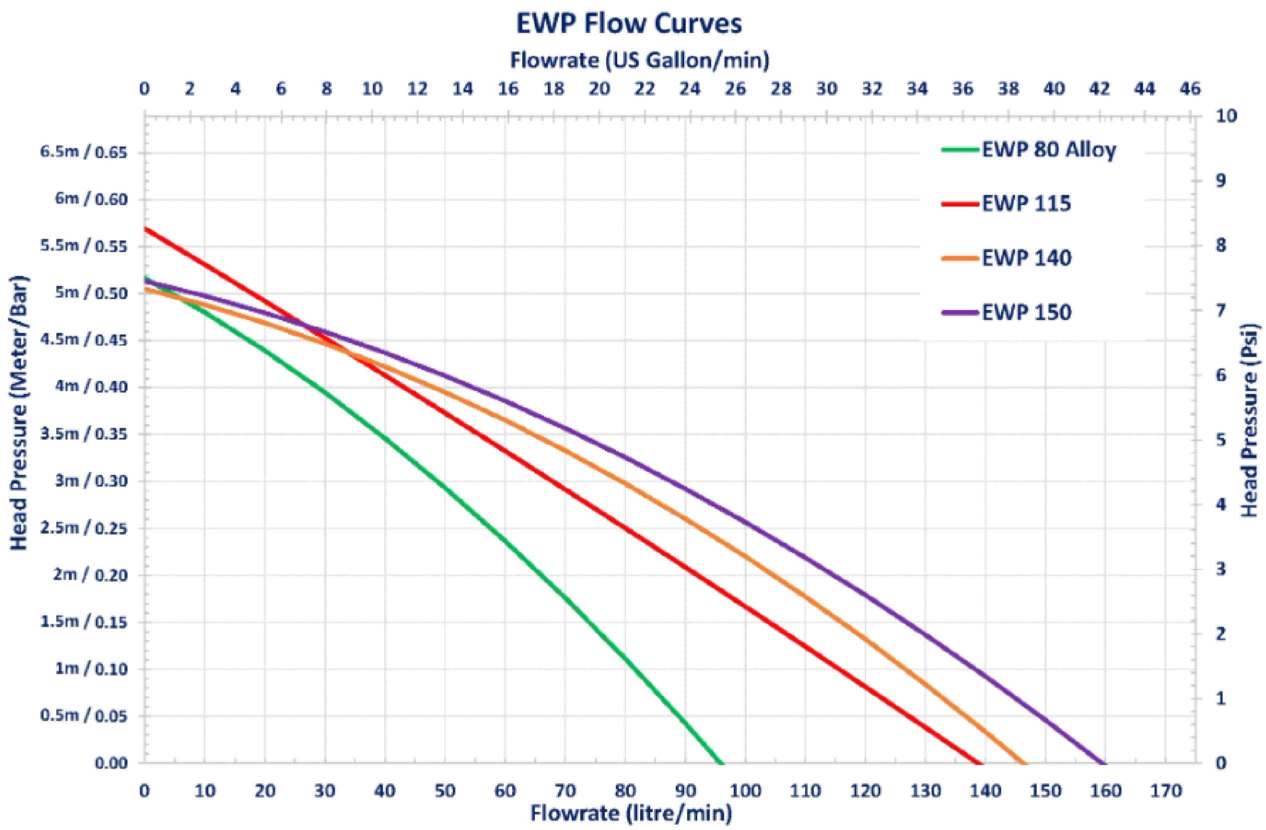
B) 3.0 Ah P30B 1865 cylindrical cells from Molicel (QTY 1000)

C) CIE Solutions Lithium Block™ or MonoLith™ commercial battery hardware – $3000 USD discount on an order of $5000 USD or more.

Cooling Loop

Sunday, September 7, 2025 8:05 PM

Goals for the project:



Water Pump Dump

Thursday, August 28, 2025 10:30 PM

Pump options

EBP 40 12v
- Runs at about 4.6-10 amps
- 3/4" in and outlet
- GPM 9.77
- Not self-priming
- 1.25 lbs
- 3 year warranty depending on the site
- Commonly used among teams
- No inner thread so would have to use hose and wire clamps and have to figure out how to step down to the motor and inverter **see image to right**
- ORRRR not step down at all??

DC50E (12V 4.5A)
- 1/2" in and outlet
- 40-100C rated
- ~5 GPM

EWP 150 12v
- ~40 GPM
- 2.5 lbs
- 130C temp rating
  35mm to 51mm (1⅜" to 2") Inlet & Outlet

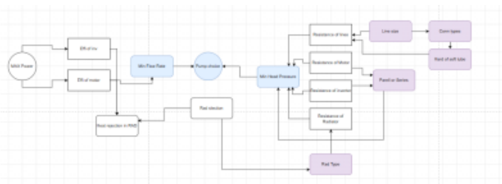
Sobek Z-P 2000 0500 centrifugal pump ifc 3000-1
- 350g
- 80 l/min
- Need for possible rewiring as it needs 8sta0 10-98 pn connector
- Also has square mounting so also need for change in mounting plate

- https://sobek-group.de/lightweight-cooling-pump-for-electric-powertrains/

Ewp 80 12v https://www.pegasusautoracing.com/productdetails.asp?RecId=25768&utm_source=google&utm_medium=cpc&utm_campaign=DC8005&gad_source=1&gad_campaignid=22731209496&gbraid=0AAAAAD-keiBmZ_TmUW4B3DyYhm3j2KX_1&gclid=CjwKCAjwq9rFBhAIEiwAGVAZP8A-c4CoCDrcWdSyjIvJhhD0vOa2-U_4WKaSb04R45y4Gvi-_S9SbxoCm6UQAvD_BwE
- Comes with attatchable fittings
- Works with pump controller to the right if that is an interest
- 2 lbs
- 80 L/min

Pump controller

https://www.pegasusautoracing.com/productdetails.asp?RecID=32129



General notes when designing cooling system

- Throughput of the pump gets lower after 7 psi for our motor
- Use a **short thermowell** only if you must—direct immersion gives faster, more accurate readings.
- Use eccentric reducers when you can, it's a lot better for pump health
- The larger the fittings/hoses/step-downs you can get the less resistance the water has and the better the flow
  - Better fort the pump but potentially worse for the rad. Exceeding the inlet and internal geometry of the radiator would likely have negative effects on heat transfer.
- 3/8" may force the pump into low-flow operation (higher electrical draw per unit heat removed).

Inverter: CM200
- Cooling hole diameter 12.7 SAEJ1926 PORT
- 9/16 female end
- 12 LPM minimum

RTD/Thermistors/Thermocouples
(Surface trackers were not considered as they are not good for this application)

RTD:
Slower (but not too slow around a 1-5 seconds depending)
Expensive as you need a conditioner (200-300$)
Reliable readings
Pretty commonly used (PT1000)

Thermistors: (NTC)
Cheaper than RTD
Faster than RTD
Less accurate readings but as long as they're installed correctly it should be fine for cooling control

Thermocouples:
Usually used in high temp systems
Inaccurate

Getting one in an inline fitting that's leak-proof and small enough for your system is harder than with RTDs/NTCs (which are already standardized in M10/M12 threads).

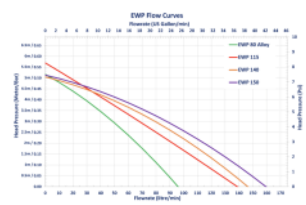
From my research if we are going to have one we should get some thermistors and place one before the motor and one after the inverter to track the high of the coolant and what the temperature of the coolant is when entering the motor. If we can have 3 one after motor and inverter would be nice and then still one after the pump behind motor.

Alternatively, the sensor placements should be beofre the rad, after the rad, and after the motor. This will tell us 3 things:
- Heat rejection by the radiator
- Heat load by the motor
- Heat Load by the motor controller

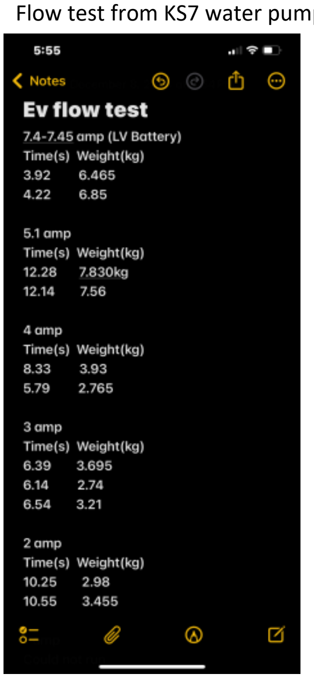
Resources:
https://www.cavs.msstate.edu/publications/docs/2016/08/1456807548642.pdf

https://www.pipeflow.co.uk/public/articles/Darcy_Weisbach_Formula.pdf

TESTING



Flow test from KS7 water pump



Rushed cooling loop design 9/19

For this design we are building around the EBP40 as we believe it has the most room to build around in the future.
For this pump we will need to change the following:
Hose sizes
Change some of the AN6 fittings
Possibly cutting radiator fittings to allow for 3/4" hose and clamps
Fixing radiator fins to allow more flow as they are bent
Figure out how to properly mount this new pump*

3/4" to 3/8" reducer fitting
3/4" hose (2 hose clamps)

*The inlet must not be pointed down, identify they outlet and direction of the loop, place low in the system for best results.

I was able to crunch some numbers using this formula I found (Darcy-Weisbach) and our pump (EWP 150) is rated for a burst pressure of 500 kPa (72.5 psi), our step down from ~1.5" to 3/8" without including the bend because that's above my paygrade was putting 850 kPa (~123 psi) for 1m of a 3/8" head.

IMPORTANT NOTE: For centrifugal pumps like the one currently on the car (EWP 150) this pressure isn't actually reality because they do not force a fixed flow

Email Response (Broken pump suspicions confirmed)

In summary, the damage is most likely do to the limiting an6 fitting and the 90 degree bend on the inlet. They even recommend using the EBP 40 with a 3/4" hose fittings for the flow rate.

Wednesday, August 13, 2025
11:36 PM

Conclusions:

Ultimately, testing was pretty inconclusive. We could not isolate a specific part or reason as to why:

a. Why the pump was dying.
b. Why the flow in the system is so low. (The flow is low because the pump is dying lol)

It is probably a combination of issues.

Morgan pointed out that output from the pump to the AN line is a large decrease in diameter, could be caused backup/clog and causing the impeller to stall. Output from water pump is also immediately put into a 90 degree bend. We can hear the pump occasionally make a loud noise. Stalling? Cavitating? I am unsure.

No tests were done to determine the effects of the AN lines on flow reduction.

Input to the pump is also a small AN fitting, perhaps we are losing pressure trying to pull water in thru such a small entrance.

More generally, it feels the pump is just over-specced for what we need it for. It is trying to flow at a much higher rate than the system can really handle.

Directly controlling the supplied power is a solution here, as it stands it is just on or off. Adding a power controller allows us to independly control the pump pressure

We are not meeting the min reqs for flow for the inverter. (3 GPM)

We are barely meeting the min reqs for the motor. (2 GPM)

Possibly introducing air into system at fittings? Rad overflow fitting is sitting on barely a thread.

How do you know this? Is it just vibes based?

Unsure if the color of the water after exiting the loop is an issue. Unsure what is causing it.

Yes this is an issue, as per the rules water must be pure, overly contaminated water is an issue.

T.5.4.2

Other:

Should test head pressure requirements of both inverters (PM100DX and CM200DZ)

We should measure temperature across multiple points across the system so we can characterize the whole loop/energy requirements.

Need an actual pressure relief cap on rad, probably loosing pressure at overflow cap.

Done by Varun Devidas, Morgan Hart, and Camden Burns.

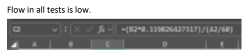
Pump failed at Michelin testing, troubleshooting why.

Pump documents rate it ~42 gals/min at 10A

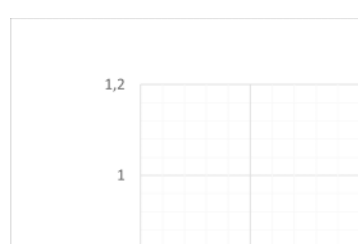
The process of testing follows the correct flow path (pump outlet->motor->inverter->rad high side->pump inlet)

Ran bucket test on the whole system, then isolated specific parts.

Flow in all tests is low.



Pressure loss calculations



KS8

MOTOR SPECS

Designation	Min. flow rate	Pressure drop (6 l/min)	Coolant volume (ml)
188	6 l/min	0.3 bar	80
208	6 l/min	0.5 bar	100
228	6 l/min	0.5 bar	100
268	6 l/min	0.5 bar	100
348	6 l/min	0.3 bar	140

Water inlet temperature should not exceed 60°C.

⚠ Maximum inlet pressure should not exceed 2 bar(g). No particles greater than 50 µm are permitted.

Goals:
- Keep power electronics below 80C
- Replace current radiator
  - Have one in shop
  - Or new CNR core
- Investigate Rear Mounting

Requirements:
- Maintain Series loop of current cooling loop
- Confirm pressure drop calculations
  - Avoid cavitation for pump

Notes:
- Current Pump: EWP 150 - https://daviescraig.com.au/product/ewp150-remote-electric-water-pump-12v-8160/ewp150-alloy-electric-water-pump-12v-8160
- Recommended Pump: Bosch PCE-XL Pump - https://www.cascadiamotion.com/images/documents/Bosch_PCE-XL_Quick_Start_Guide.pdf
- Other Cascadia Pump: Tengam 2100A - https://www.cascadiamotion.com/images/documents/Tengam_Cascadia_2100A_water_pump_user_manual_17FEB2023_Rev.6.pdf
- AN6 Coolant fittings and Lines
- Radiator
- Motor
  - Max Motor Temperature: 120C
    - Derate from 100C
  - Inlet temp max: 60C
  - Min Flow Rate: 6 L/Min
  - Pressure Drop: 0.5 bar
- Inverter
  - Max Inverter Temperature: 80C-100C
    - Derate from 80-100C
  - Min Flow Rate: 12 L/Min
  - Pressure Drop: 0.3 bar
- Water Loop Old page with papers

INVERTER SPECS

Coolant Type	50/50 mix ethylene glycol (antifreeze) / water or propylene glycol / water; with Aluminum corrosion inhibitor additive
Coolant Temperature	-30°C to +80°C full power, for PM inverters -30°C to +45°C full power, 45°C to +80°C de-rated output on CM inverters Operation -40.. -30; +80.. +100°C with de-rated output on all inverters
Coolant Flow Rate	8 – 12 LPM (2 – 3 GPM), PM100/PM150/RM100
	12 LPM minimum, CM200
	24 LPM minimum, CM350
	20 – 30 LPM (5 – 6 GPM), PM250, RM300
Pressure Drop	PM100, 0.3 bar (4.4 psi) @ 8 LPM @ 25°C
	PM150, 0.4 bar (5.8 psi) @ 8 LPM @ 25°C
	PM250, 0.9 bar (13 psi) @ 20 LPM @ 25°C
	RM100, 0.06 bar (0.8 psi) @ 8 LPM @ 25°C
	CM200, 0.3 bar (4.3 psi) @ 12 LPM @ 25°C
	CM350, 0.3 bar (4.3 psi) @ 24 LPM @ 25°C
	RM300, TBD
Port Size	PM100 and PM150, AN-6
	PM250, SAE ORB -10

	RM100, Custom O-ring port, the following options are provided to be installed in the unit, each kit includes materials for both ports. - ARaymond NT100 / 16mm Straight, CM p/n G1-0023-01 - ARaymond NT100 / 16mm 45deg, CM p/n G1-0024-01 - ARaymond NT100 / 16mm 90deg, CM p/n G1-0025-01 - 16mm / 5/8" Hose Barb, CM p/n G1-0026-01
	RM300, Custom O-ring port. The RM300 comes standard with an adapter that has a 25.4mm / 1 inch hose barb. The cooling port adapters are included in kit p/n G1-0031-01.
	PM500, SAE ORB -12
	CM200, SAE ORB -06, comes with 5/8" hose barb and -8 AN fitting
	CM350, SAE ORB -10, comes with 5/8" hose barb and -10 AN fitting

KS6

KS7

Radiator characterization
(Don't know where the matlab went or if it was effective as of 08/29/2025)

John McCrary <jmccra30@students.kennesaw.edu> Sat, Aug 22, 2020, 10:42 PM

to Joshua, me

Dr.Tolbert,

I hope you and you're family are doing well.

I have a few question on pressure and bottle necks in a coolant system.

The system is rather simple, 2 heat sources, one controllable pump, and one radiator. I have them in series for right now as the motor can handle a bit more heat before degradation.

I would like to setup a Matlab program to see my heat rejection with different sized radiators, different pump rates, and line pressure.

To be frank I do not know where to start, or If I can get any useable information with just theory. Let me know you're thoughts.

Cheers, McCrary

...

[Message clipped] View entire message

jatolbert7@gmail.com Mon, Aug 24, 2020, 8:49 PM

to John, me

Doing well, John. Hope you are doing well. A good friend of mine just started teaching at KSU, Dr. Aaron Adams. He is a big car guy. He is in my old office. Feel free to annoy him. Tell him I sent you.

So it's a first law of thermo question. Consider all of the energy into the system must equal all of the energy out of the system, in a seady-state.

So:
Eout = Ein
Qradiator = Wpump + Qinverter + Qmotor
Pump work can probably be neglected here so:
Qradiator = Qinverter + Qmotor

And:
The radiator heat rejection is evaluated as some coefficient, U, times surface area, A, times the mean temperature difference, MTD. Some manufacturers may use log mean temperature difference, LMTD instead of MTD. Just google LMTD if you need it. Let me know if you have questions. Most will probably use MTD.

Therefore:
U*A*MTD = Qinverter + Qmotor

So:
If you know what design temp you want the fluid to be in Line D and Line C, then you can calculate LMTD (or MTD), if you assume the air-side temperatures (see below point 2 to evaluate air side temperatures). Then, you can lookup (or ask manufacturer) for heat transfer coefficient values, U. From there, you can determine surface area of radiator, A.

A = (Qinverter + Qmotor)/(MTD*U)

Now, you mentioned you wanted to consider different pump rates and line pressures. Below is analysis for each of these:

1. Pump flow rate will impact LMTD in the above analysis. (Anyone who has taken thermo can help you with this)
- Qradiator = Qinverter + Qmotor = Mdot_water*Cp_water*(Td– Tc) where Mdot_water is mass flow of water, Cp_water is specific heat of water and Td is temperature of Line D and Tc is temperature of Line C.
- Therefore, you can write an equation for Td as a function of Tc and Mdot.
- You can substitute this equation into the formula for MTD and then solve radiator size for different flow rates and Heat Sources, etc.

2. This same analysis for pump flow applies for the air side.
- Qradiator = Qinverter + Qmotor = Mdot_air*Cp_air*(Tout– Tin) where Mdot_air is mass flow of air, Cp_air is specific heat of air and Tout is temperature of air leaving radiator, and Tin is temperature of air entering radiator (presumed to be ambient).
- Now you can consider analysis for different air flow rates through radiator.

3. Line pressure will have virtually no impact on this analysis, assuming you are dealing with an approximately incompressible fluid like water, and assuming you do not boil the water. The only impact will be that the pressure in the line must be higher than the saturation pressure of whatever water temperature you have so it will not boil. Anyone that has taken thermo can help you with this or ask me some questions on this.

Hope this helps. Let me know if you need more info.

From <https://mail.google.com/mail/u/0/#search/raditor/FMfcgxwJXVNpJXnqxbVpFcLwwcnJmbSM>

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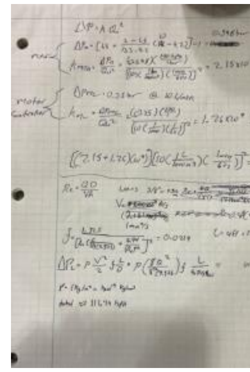

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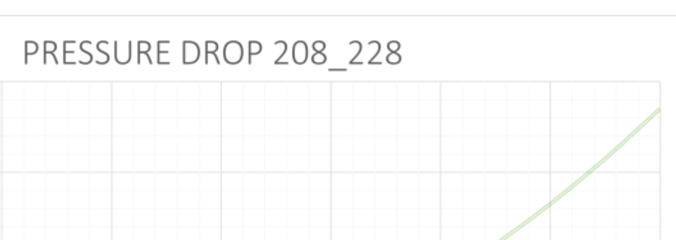

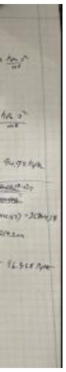

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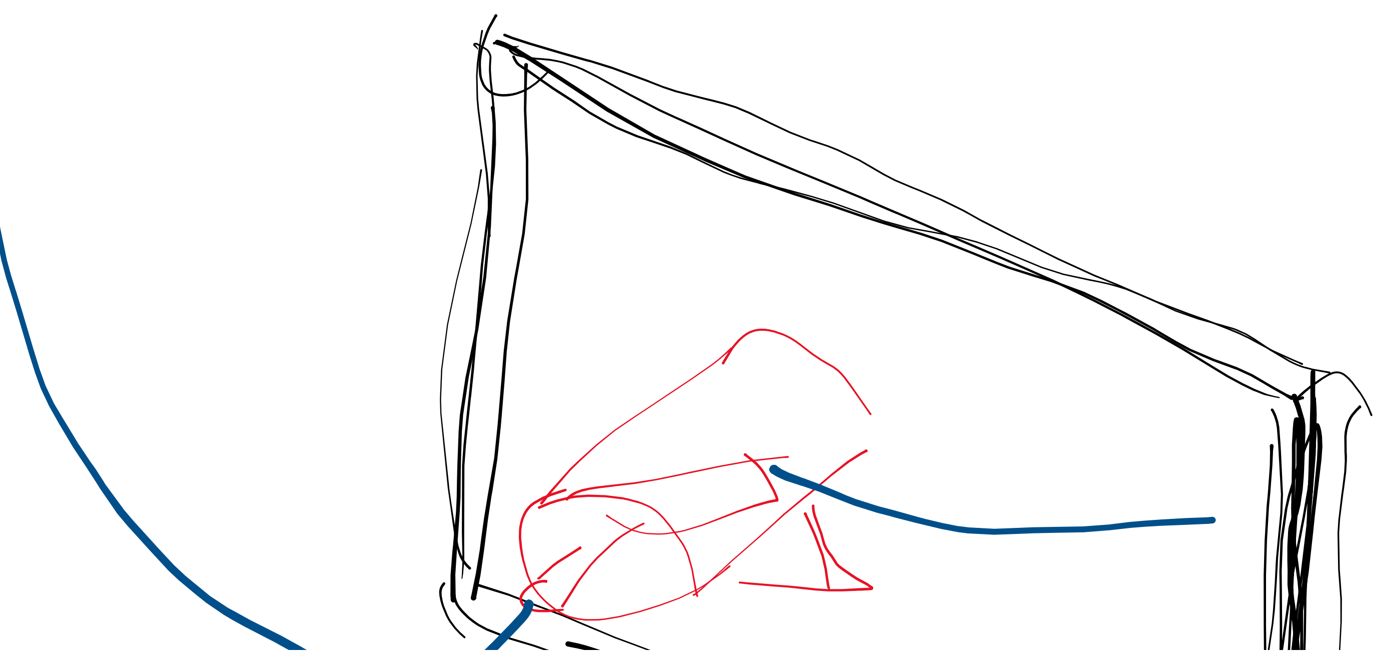


path (pump outlet->motor->inverter->rad high side->pump inlet)

Ran bucket test on the whole system, then isolated specific parts.

Flow in all tests is low.

=(B2*0.119826427317)/(A2/60)

Time (s)	Weight (lbs)	gal/min	Round
59.84	6.72	0.807387	Full System
120.78	12.02	0.715506	Full System
59.65	6.08	0.732819	Full System
120.32	16.08	0.960842	Pump + Motor/Inverter Iso
59.98	16.68	1.999371	Pump Iso
120.2	19.2	1.14842	Pump + Rad Iso

Amp clamp showed 3amps for full system, 4a for motor/inverter, and 5a for Pump iso and Pump + rad iso.

Water exiting the loop was significantly darker. We swapped the water before isolating the radiator, and got the same darker water. We believe that the thread on the fitting from the top of the radiator to the catch can broke off, and the zinc from the brass fitting corroded. Checked old water pump, no real signs to suggest this was a cause of the failure. Seal on impeller and water pump motor was secure.

MISSING PIECE FOUND AND REMOVED

CM200	DX	DZ	Units
DC Voltage – operating	50-480	200-840	VDC
DC Overvoltage Trip	500	860	VDC
Maximum DC Voltage – non-operating	500	900	VDC
Motor Current Continuous	300	200	A
Motor Current Peak *	740	400	Arms
Output Power Peak (elect) *	225	225	kW
DC Bus Capacitance	650	255	µF
Size and Volume	330 x 180 x 97 / 3.9		mm / L
Weight	6.75		kg
Active Discharge via motor winding to <50V	< 1		sec
Passive Discharge (internal resistor) to <50V	< 120		sec
Vehicle System Power	9 .. 32 (12V & 24V systems)		VDC
Inverter PWM Frequency	12 (6 .. 16 variable)		kHz
Operating Temperature Range – coolant water	- 40 .. +80, (derate to zero 80 .. 100)		°C
Coolant Flow Rate	12 (3 GPM min)		LPM
Coolant Pressure Drop (60°C coolant / 12 LPM)	0.3 (30kPa / 4.3psi)		bar
Maximum Coolant Pressure (absolute)	3 (300kPa / 45psia)		bar
Operating Shock (ISO 16750-3, Test 4.2.2.2)	500 (50g), pending		m/s²
Operating Vibration (ISO 16750-3, 4.1.2.7 Test VII)	57.9 (6grms), pending		m/s²
EMC compatibility	IEC61000 / CISPR-25 pending		
Compatible Conductor Sizes	16, 25, 35, 50		mm²

Morgan plugged old pump into LV Battery directly, impeller spun. Dom confirmed pump did not spin at Michelin. Don't what the difference between now and at Michelin is.

Running old pump off DC Battery, flowing at about 2 gals/min. Water is incredibly dirty. Took apart pump, no visible sediment on impeller or casing. Speculating that graphite from seal getting mixed into the water. Flowed around 2 gals/min.

100.05	31.20	2.066056	Old Pump Iso

Amps started at 11, then settled at 5-6 amps a few minutes later.

Took apart old pump, impeller is slightly angled/tilted so that one side is touching the motor housing. Unsure why. No visible damage to the pump. Possibly a bent shaft.

Took new pump off the car and ran with just DC Battery. Water also became very dirty.

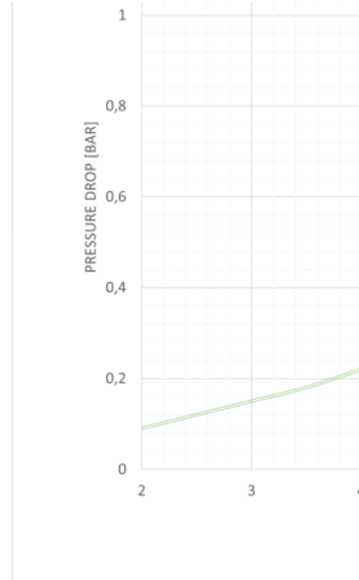
Started at 4.5amps, would occasionally spike to 5 then settle at 4.5-4.6.

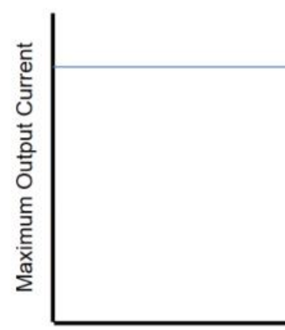
Used the FLIR on the pumps, old pump peaked at around 52C, new pump peaked around 41C. Probably not overheating, pump is rated for up to 130C.

New pump would occasionally make a loud noise, linked video. Quality got nuked.

Controller Model	PM100DX	PM100DZ	
DC Voltage – operating	50—400	100—800	V_{DC}
DC Overvoltage Trip	420	840	V_{DC}
Maximum DC Voltage – non-operating	500	900	V_{DC}
Motor Current Continuous	300	150	A
Motor Current Peak*	350	200	A_{rms}
Output Power Peak (elect)*	100	100	kW
DC Bus Capacitance	440	300	µF
Size and Volume	200 x 87 x 314 / 5.5		mm / L
Weight	7.5		kg
Active Discharge via motor winding to <50V	< 1		sec
Vehicle System Power	9 .. 16		V_{DC}
Inverter PWM Frequency	12 (6..16 adjustable pending)		kHz
Operating Temperature Range – coolant water	-40 .. +80, (derate to zero 80..100)		°C
Coolant Flow Rate	8 .. 10 (2 GPM min)		LPM
Coolant Pressure Drop (60°C coolant / 10 LPM)	0.4 (42kPa / 6psi)		bar
Maximum Coolant Pressure (absolute)	4.5 (450kPa / 65psia)		bar
Operating Shock (ISO 16750-3, Test 4.2.2.2)	500 (50g), pending		m/s²
Operating Vibration (ISO 16750-3, 4.1.2.4—IV)	27.8 ($3g_{rms}$), pending		m/s²
Cable Gland Size	M24		
Conductor Size min .. max recommended	#4/35 .. #1/50		AWG/mm²
Cable OD min .. max recommended**	9 .. 16.5		mm

<<IMG_2247.mov>>





Conversations

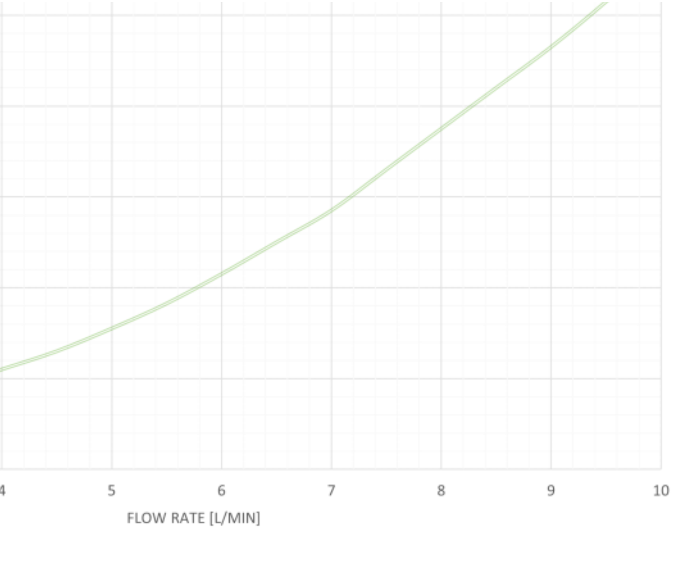
Just as a little update, I talked to chance and tj today (September 5th 25) about the current pump setup and how the driver turns on/off the pump manually. The 3 general proposals are having no switch and run it full time (there's still a lot of room for discussion on how this would be turned on) (this one seems to make the most sense to me as the current accumulator needs and states it needs constant flow unlike the one we had before that was able to manage its own heat for a period of time), have something setup with what boards are currently set up to the car where it reads temperature and then cuts the pump on when it reaches a specific temp, or having something turn on and off based on location on the lap and we model it based on testing. The current battery (12v 12ah if I remember correctly) can run the pump for about 2 hours constantly so tj proposed maybe getting a bigger battery for testing and/or more of the same battery to swap them in and out when they die. Chance did say some issues will arise when switching them in and out where they might not log the data or something along those lines?

Talked to Gtms and they run a series through 2 radiators with the hose behind the driver with an additional firewall. Also their radiators are tilted forward which I found interesting, and the ducting at least according to them really helped with the line of sight rule. The radiators are like custom and like 700 bucks a piece with discount, but they are still really small and seemed to work well enough for them, although a different system. They also showed me their amp draw for their fans and it was about 5 amps with a 6 amp peak and they have it set for whenever it gets past a temp it turns on. They also said they have a matlab script for a lot of their characterization stuff. Also they gave me some tips on if we do run parallel, the pressure valves are an absolute must because if the flows are not literally identical it's worse than a parallel, parallel is a small margin better than series for cooling and balancing with the cars weight as long as you get it right, they had a custom machined catch can but its pretty heavy, they also recommended seriously looking into a swirl pot.

Radiator company - Griffin
Fan brand - spal fans

Testing 9/22-9/23

So update on pump testing from yesterday. We tested the EWP150 with the pressure moved through the whole system and had some issues getting started but the flow rate was higher than we thought it should be (.83gpm) and it said we had 96inches of head through the whole system which really doesn't make sense as previous test showed just the inverter was 106 inches of head loss, water was very dark like previously.


4
5
6
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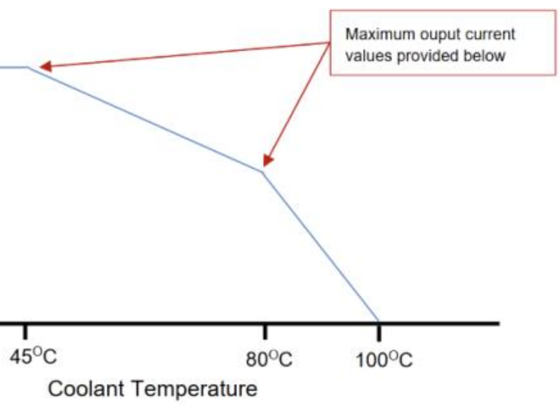
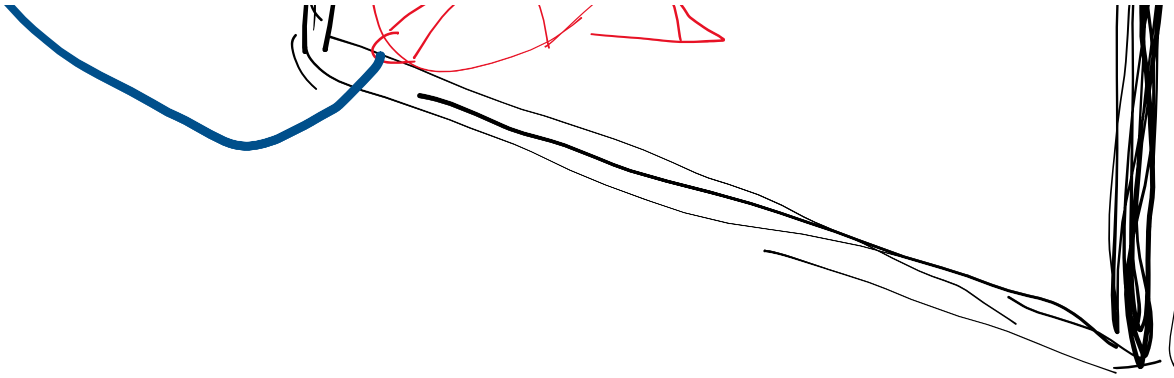
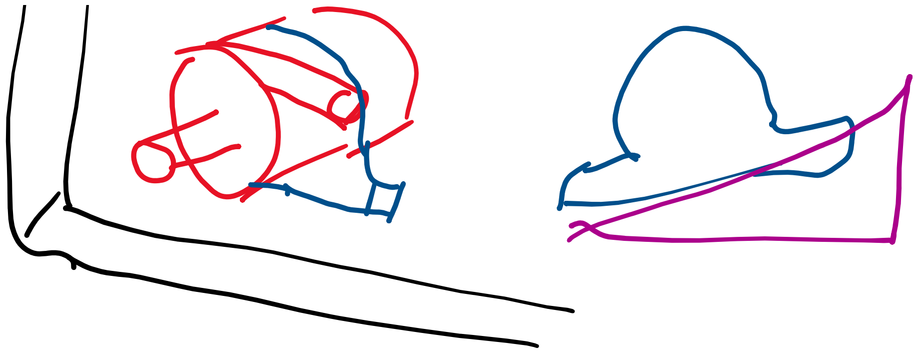
8
9
10
FLOW RATE [L/MIN]


Maximum ouput current values provided below
45ºC
80ºC
100ºC
Coolant Temperature





Testing 9/22-9/23

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John brought a positive displacement pump rated for about 12 lpm and 45psi. Using this we got a flow rate of roughly 2gpm and when matching with the chart we got a system pressure loss of 23 feet of head or 10psi. This will be the pump we most likely will use during this weekends shootout.

Things needed to be figured out:

Mounting for this pump (tilting inlet down?)

Do we need to limit the flow to get the amount of cooling needed?

We will continue testing today with some dyno testing, in which we measure mfr and temperature loss, we will need night owl to clear out dyno as well as car to be charged with the pull rod fixed. Or run it up on jacks holding down the brakes?

Coolant Flow Rate	8 .. 10 (2 GPM min)	LPM
Coolant Pressure Drop (60°C coolant / 10 LPM)	0.4 (42kPa / 6psi)	bar
Maximum Coolant Pressure (absolute)	4.5 (450kPa / 65psia)	bar
Operating Shock (ISO 16750-3, Test 4.2.2.2)	500 (50g), pending	m/s^2
Operating Vibration (ISO 16750-3, 4.1.2.4—IV)	27.8 ($3g_{rms}$), pending	m/s^2
Cable Gland Size	M24	
Conductor Size min .. max recommended	#4/35 .. #1/50	AWG/mm^2
Cable OD min .. max recommended**	9 .. 16.5	mm

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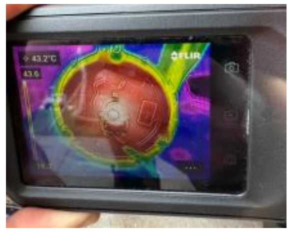
FLIR Pictures:

New Pump



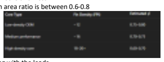
Old Pump

Radiator Dump

Monday, September 1, 2025 12:59 PM

Preliminary Meeting (Sept 1st)
- Reach out to chance for motor and inverter temps during testing
- Get James tractive system model in Teams
- Get project proposal in by next Monday, Sept 8th

Information dump
- Current radiator size is approx. 14.5" x7.5"
- Heat load can gen generalized by assuming that all drivetrain efficiency losses are expressed as heat.
- The heat rejected by the radiator must equal the heat absorbed by the liquid coolant under a wide variety of conditions. (Humid, Hot, etc.)
- Investigate the usage of a swirl pot to allow gases and steam to expel from the system.
- Pack energy is listed as 6.73kWh per Dom
  Rinehart family of controllers estimates a typical efficiency of 96% for the controller itself
- Cascadia estimates the motor to operate from 95%-97% at 80 kW
- Heat load calculation:
  - $Net\ Power\ Loss = Motor\ loss + Controller\ Loss$
  - $Power\ Loss = Poweroutput * (\frac{1}{n} - 1)$
  - $n = component\ efficiency$
    - Motor efficiency is a function of power supplied
- Estimated heat loads
  - 2.67 kW heat load from the motor
  - 4.1 kW heat load from the controller
  - 4.9 kW of total heat load a 80 kW

Testing Dump
- We talked about a test john proposed in which the radiator is fed hot water at a constant temperature, and temp delta is recorded to model a heat rejection coefficient
  - Fans can be used to induce a known CFM through the radiator to expand the model to a dynamic airstream
- We could also put the vehicle on the dyno and use buckets to supply and receive water from the loop, recording the temperature delta to model heat loads
  - Water from a supply bucket (radiator lower tank) is fed through the pump and into the motor and inverter
  - Water exits the controller and dumps into a separate bucket and temp delta is recorded
  - Could model a large number of situations such as an accel pull and the heat loads as a result
- Radiator mass flow rate test
  - Things to measure before testing:
    - Number of fins per inch
    - Thickness of 1 fin
    - Number of tubes per row
    - Thickness of one tube
    - Core thickness
  - Open area ratio is between 0.6-0.8
    - 
- 9/7 Meeting with the leads

Radiator Options Dump
- 14 x 14

- 12.8 x 5.43

  - Missing the overpressure relief
  - Pretty tall
- 8.67" x 5.36"
  - Big size reduction
  - Rouged design with strong corner bracing

.3bar PD
12 lpm
3 bar max

6lpm
.5 bar PD

Sources and good papers I read during this project
https://webthesis.biblio.polito.it/34687/1/tesi.pdf

https://core.ac.uk/download/pdf/232670541.pdf

KS8

Goals:
- Keep power electronics below 80C
- Replace current radiator
  - Have one in shop
  - Or new CNR core
- Investigate Rear Mounting

Requirements:
- Maintain Series loop of current cooling loop
- Confirm pressure drop calculations
  - Avoid cavitation for pump

Notes:
- Current Pump: EWP 150 - https://daviescraig.com.au/product/ewp150-remote-electric-water-pump-12v-8160/ewp150-alloy-electric-water-pump-12v-8160
- Recommended Pump: Bosch PCE-XL Pump - https://www.cascadiamotion.com/images/documents/Bosch_PCE-XL_Quick_Start_Guide.pdf
- Other Cascadia Pump: Tengam 2100A - https://www.cascadiamotion.com/images/documents/Tengam_Cascadia_2100A_water_pump_user_manual_17FEB2023_Rev.6.pdf
- AN6 Coolant fittings and Lines
- Radiator
- Motor
  - Max Motor Temperature: 120C
    - Derate from 100C
  - Inlet temp max: 60C
  - Min Flow Rate: 6 L/Min
  - Pressure Drop: 0.5 bar
- Inverter
  - Max Inverter Temperature: 80C-100C
    - Derate from 80-100C
  - Min Flow Rate: 12 L/Min
  - Pressure Drop: 0.3 bar
- Water Loop Old page with papers

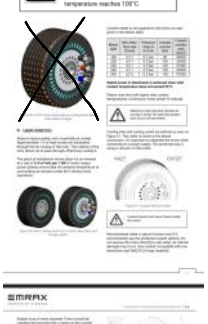
KS6

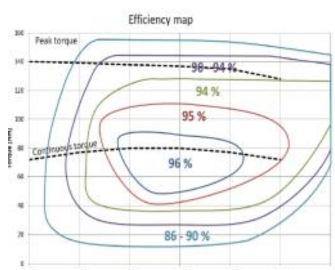
INVERTER SPECS

Coolant Type	50/50 mix ethylene glycol (antifreeze) / water or propylene glycol / water; with Aluminum corrosion inhibitor additive
Coolant Temperature	-30°C to +80°C full power, for PM inverters -30°C to +45°C full power, 45°C to +80°C de-rated output on CM inverters Operation -40...-30; +80...+100°C with de-rated output on all inverters
Coolant Flow Rate	8 – 12 LPM (2 – 3 GPM), PM100/PM150/RM100
	12 LPM minimum, CM200
	24 LPM minimum, CM350
	20 – 30 LPM (5 – 6 GPM), PM250, RM300
Pressure Drop	PM100, 0.3 bar (4.4 psi) @ 8 LPM @ 25°C
	PM150, 0.4 bar (5.8 psi) @ 8 LPM @ 25°C
	PM250, 0.9 bar (13 psi) @ 20 LPM @ 25°C
	RM100, 0.06 bar (0.8 psi) @ 8 LPM @ 25°C
	CM200, 0.3 bar (4.3 psi) @ 12 LPM @ 25°C
	CM350, 0.3 bar (4.3 psi) @ 24 LPM @ 25°C
	RM300, TBD
Port Size	PM100 and PM150, AN-8
	PM250, SAE ORB -10

	RM100, Custom O-ring port, the following options are provided to be installed in the unit, each kit includes materials for both ports. - ARaymond NT100 / 16mm Straight, CM p/n G1-0023-01 - ARaymond NT100 / 16mm 45deg, CM p/n G1-0024-01 - ARaymond NT100 / 16mm 90deg, CM p/n G1-0025-01 - 16mm / 5/8" Hose Barb, CM p/n G1-0026-01
	RM300, Custom O-ring port. The RM300 comes standard with an adapter that has a 25.4mm / 1 inch hose barb. The cooling port adapters are included in kit p/n G1-0031-01.
	PM500, SAE ORB -12
	CM200, SAE ORB -06, comes with 5/8" hose barb and -8 AN fitting
	CM350, SAE ORB -10, comes with 5/8" hose barb and -10 AN fitting

The maximum motor temperature recorded by internal temperature sensor **must never exceed 120°C**. Power derating is recommended after motor temperature reaches 100°C.





MOTOR SPECS

Designation	Min. flow rate	Pressure drop (6 l/min)	Coolant volume (ml)
188	6 l/min	0.3 bar	80
208	6 l/min	0.5 bar	100
228	6 l/min	0.5 bar	100
268	6 l/min	0.5 bar	100
348	6 l/min	0.3 bar	140

Water inlet temperature should not exceed 60°C.

Maximum inlet pressure should not exceed 2 bar(g). No particles greater than 50 µm are permitted.

KS7

John McCrary <jmcc
@students.kennesav

to Joshua, me

Dr.Tolbert,

I hope you and you're family are

I have a few question on pressur

The system is rather simple, 2 he
them in series for right now as th

I would like to setup a Matlab pro
different pump rates, and line pre

To be frank I do not know where
Let me know you're thoughts.

Cheers, McCrary

...

[Message clipped] View entire m

jatolbert7@gmail.cor

to John, me

Doing well, John. Hope you are
Dr. Aaron Adams. He is a big ca
sent you.

So it's a first law of thermo quest
the energy out of the system, in a

So:
Eout = Ein
Qradiator = Wpump + Qinverter
Pump work can probably be neg
Qradiator = Qinverter + Qmotor

And:
The radiator heat rejection is eva
mean temperature difference, MT
difference, LMTD instead of MTD
questions. Most will probably use

Therefore:
U*A*MTD = Qinverter + Qmotor

So:
If you know what design temp yo
calculate LMTD (or MTD), if you
evaluate air side temperatures).
coefficient values, U. From there

A = (Qinverter + Qmotor)/(MTD*

Now, you mentioned you wanted
analysis for each of these:
1. Pump flow rate will impact LMTD in
with this)
- Qradiator = Qinverter + Qmotor =
water, Cp_water is specific heat of
C.
- Therefore, you can write an equatio
- You can substitute this equation int
rates and Heat Sources, etc.
2. This same analysis for pump flow a
- Qradiator = Qinverter + Qmotor =
Cp_air is specific heat of air and To
entering radiator (presumed to be a
- Now you can consider analysis for c
3. Line pressure will have virtually no
approximately incompressible fluid
will be that the pressure in the line
temperature you have so it will not
some questions on this.

Hope this helps. Let me know if y

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&jsapiver=v1&newsession=1&corrid=a9f88
d1ec-568ce3704506&sftc=1&sams=1&ats=
&wdredirectionreason=Force_SingleStepBo

Radiator characterization (Don't know where the matlab went or if it was effective as of 08/29/2025)

ra30
v.edu>

Sat, Aug 22, 2020, 10:42 PM

doing well.

re and bottle necks in a coolant system.

eat sources, one controllable pump, and one radiator. I have
e motor can handle a bit more heat before degradation.

ogram to see my heat rejection with different sized radiators,
essure.

to start, or If I can get any useable information with just theory.

essage

n Mon, Aug 24, 2020, 8:49 PM

doing well. A good friend of mine just started teaching at KSU,
r guy. He is in my old office. Feel free to annoy him. Tell him I

tion. Consider all of the energy into the system must equal all of
a seady-state.

+ Qmotor
lected here so:

luated as some coefficient, U, times surface area, A, times the
TD. Some manufacturers may use log mean temperature
D. Just google LMTD if you need it. Let me know if you have
e MTD.

ou want the fluid to be in Line D and Line C, then you can
assume the air-side temperatures (see below point 2 to
Then, you can lookup (or ask manufacturer) for heat transfer
, you can determine surface area of radiator, A.

U)

l to consider different pump rates and line pressures. Below is

the above analysis. (Anyone who has taken thermo can help you

Mdot_water*Cp_water*(Td – Tc) where Mdot_water is mass flow of
water and Td is temperature of Line D and Tc is temperature of Line

on for Td as a function of Tc and Mdot.
to the formula for MTD and then solve radiator size for different flow

pplies for the air side.
Mdot_air*Cp_air*(Tout – Tin) where Mdot_air is mass flow of air,
ut is temperature of air leaving radiator, and Tin is temperature of air
ambient).
different air flow rates through radiator.
impact on this analysis, assuming you are dealing with an
like water, and assuming you do not boil the water. The only impact
must be higher than the saturation pressure of whatever water
boil. Anyone that has taken thermo can help you with this or ask me

you need more info.

#search/raditor/FMfcgxwJXVNpJXnqxbVpFcLwwcnJmbSM>

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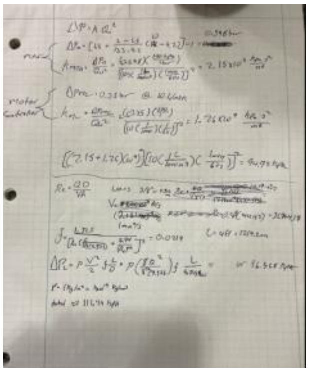

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P = k x Q^2 relates the pressure drop to flow rate using the constant of proportionality, the total system pressure drop was then calculated by adding the inverter and motor head with the frictional losses of the tubes.

9/7/25 Cooling Loop Requirements

Sunday, September 7, 2025 8:23 PM

Problems with current system

- Pump is hydraulically choked
  - Would not be solved with just optimizing the lines
- Inlet size
- 90 deg bends directly out the pump
  - Need more straight cooling lines directly out of the pump
- Water temps are high enough to cause critical components to derate

Base pump selection off:

- Line sizes
- What rad
- Rad orientation
- Load requirement

- Focus on water pump selection
- Make associated changes to the lines
- Investigate rad selection to see if its worth it
  - Cost
  - Benefit of parallel loop?

Have already reached out to:
Bosch
Davies Craig
Pegasus
Summit
Mishimoto - responded
Sobek
Texys/Texsense
Titan rig
Alloyworks

9/7/25 Meeting Conclusions:

The **main objective** of the radiator project is to find a solution to following issues with the current system:

- Pump is hydraulically choked
  - Cannot be solved with just optimizing the lines
  - Pump selection is important
- Inlet fitting size
  - Fittings are too small of a diameter
- 90 deg bends directly out the pump
  - Need more straight length of cooling lines directly out of the pump
- Water temps are high enough to cause critical components to derate
- Lack of DAQ on the cooling loop
  - Flow/pressure sensors (Flow would be more useful)
  - Coolant temp sensors (Module board temp for inverter is enough)
    - In the past looked into modified rad bungs to integrate sensors
    - Can add for testing, wouldn't need to stay on car

A parallel cooling loop with 2 radiators will be investigated, will have something to show by 9/16/25:

- @James M, present work of series vs parallel loop

  Things to evaluate for series vs parallel
    - Weight
    - Cost
    - Cooling efficiency
      - Heat rejection/Kilogram
      - Heat rejection/Dollar
      - LV draw? (Requires more detailed design work)
    - Vehicle Dynamics aspect
      - Weight distribution from center
    - Symmetrical undertray design
- Create pseudo component list for each
- Work with Camden too look for related pumps

A test proposal will be written to find mass flow rate of air through the current radiator.

- Car prepped and proposal written by 9/8/25
- Conduct testing this week to provide aero with flow rate data

Aero internal design to be finalized by end of next week
Will speak to Seth and present mass flow data for their sims

Don't have current mass flow rate to provide aero for data with current rad

Will conduct a test to find the mass flow rate of the current radiator setup

Test proposal by **9/8/25** for Pressure differentials of rad

Rad selection will be considered If:

- James can present work of series vs parallel loop
  - Compare Weight, cost, cooling
- Create pseudo component list for each
- Work with Camden too look for related pumps

Something presentable **by 9/16**

Things to evaluate for series vs parallel

- Weight
- Cost
- Cooling efficiency
  - Heat rejection/Kilogram
  - Heat rejection/Dollar
  - LV draw? (Requires more detailed design work)
- Vehicle Dynamics aspect
  - Weight distribution from center
- Daq for the cooling loop?
  - Flow/pressure sensors (Flow would be more useful)
  - Coolant temp sensors (Module board temp for inverter is enough)
    - In the past looked into modified rad bungs to integrate sensors
    - Can add for testing, wouldn't need to stay on car

Team Proposal notes

Thursday, September 11, 2025 9:03 PM

Rad MFR Test Proposal - passed

- Look into only running test at one speed, 33mph to meet aero sims and avoid poor data

Cooling Loop Proposal - rejected

- Need to narrow scope
  - Define moving radiator with qualitative data
  - Aero might not have an UT, should have an answer by Friday
- Define series v parallel and go ahead and do characterization with weight, rad reqs,
- Define rationale behind fixing water pump (effect not changing it would have at comp)
- Add rules issue with line of sight at comp into history + our possible fixes/how this will interact with series and parallel

9/16 Coolant pressure test

Tuesday, September 16, 2025 11:46 AM

Head pressure test.

Height of water 106in peak. Started dropping quickly while still running.

Still dark grey water.

Varun's Notes

Thursday, September 18, 2025 10:56 AM

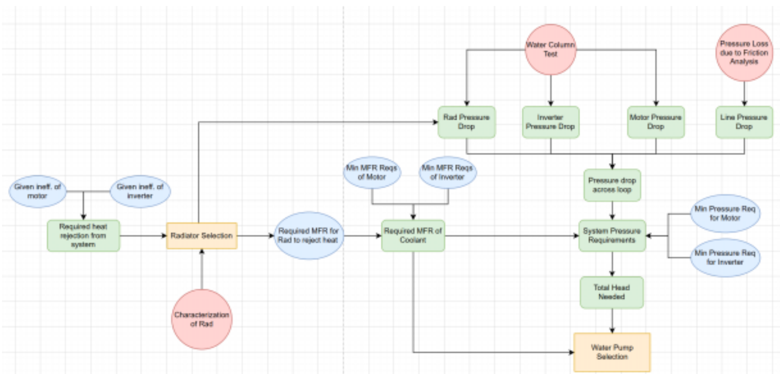
Goals:
Overall:
- Keep power electronics to ideal temps (45C for inverter, 55C for motor)

Radiator:
- Characterize radiator for loop
- Move radiator
  - For Line of sight rule
  - For potential UT

Pump:
- Characterize system requirements to select a new pump

Pump Selection:
Getting rushed due to need for loop at Michelin
What needs to get done
- Head Reqs. of current loop
  - Are the results from Johns test valid? Bends in piping may be altering results. Was proposed to measure water column both before entering component and after to get more accurate measure of head reqs for each part. Need to confirm that we need to rerun tests.
    - This, in fact did not need to be done. Measuring head after the component is completely useless.
- Pipe fittings
  - No idea what needs to be done for that
- New pump mount

Rad Selection:
Rad is changing. Prerogative is to have a characterized rad for future projects to build off of.
- Characterization of a known core
  - Not 100% sure what this entails. I know we want to run a heated bucket test at a set wind speed to get heat rejection from rad, then scale up rad from there. How we scale that up is confusing to me.
- Rad MFR Test
  - I don't know what the point of this is.
    - Cuz you are a moron



KS8 Testing Pump Notes

Saturday, September 20, 2025 8:25 PM

Problem:

- Current pump is killing itself
- Inverter temperatures are getting high during testing (reference Half Enduro (~9/20)
- Need to get a pump for Michelin and continue testing for the KS8

Knowns (per Varun):

- Current Pump is killing itself
- Inverter and Motor cooling requirements
  - Min flow rates
  - Min pressure requirements
- Given inefficiencies of the motor and inverter based on charts

Guess work:

- MFR of water required to properly reject heat from radiator to air
  - Radiator testing that Moloney presented is not helpful, only pertinent to CFD work
  - Johns heated bucket test would only be good to get data for historic purposes
  - Get approximate air speed at the radiator
  - No known core yet

- Total head pressure requirement
  - Did the water column test, gives head pressure across each component
  - Some uncertainties with Johns test due to bends in the fittings

Pump:

- EBP40

Requirements:

- Change fittings
  - Pump inlet + outlet
  - Radiator outlet
- Step downs
  - 3/4 to 3/8

Min MFR Req Testing Doc

Tuesday, September 23, 2025 9:37 PM

Goals: To obtain the minimum flow rate required to properly reject heat from the power electronics, also to validate John's positive displacement pump for Michelin.

Independent Variables:
- Wind Speed across radiator
  - Using TJ's Fan
  - Velo of air is determined by flow meter
  - We have to keep "car speed" the same as wind speed from fan
    - Car speed of dyno is probably inaccurate
- Power draw of car
  - Must keep load steady
- Loop is remaining the same (with only difference being slightly larger inner and outer diameter of pump)
  - Was proposed to run to the bottom of the rad flowing up, decided against it. Maintaining consistent loop for testing.

Dependent Variable (What we're measuring):
- Flow rate of water
  - Will validate pump for Michelin using LV battery
  - Then will move to power supply to alter air MFR to characterize water MFR

Results: (Varun Devidas)
Results from the tests were varied. We ran the pump on LV Battery for 4 tests, the first two being invalid due to improper placement of the hose in the input bucket. We should have had the amp clamp to measure current draw, but didn't. The pump more than sufficiently cooled the power electronics. We then moved to the power supply, so we could step down amperage to the pump and therefore control flow rate of water. We did two runs, one at 5amps and the other at 2.5 amps. Flow rate went from about 2.2GPM @5amps to 0.9GPM @2.5amps, yet inverter peak temp on rose by ~2degs Celsius, from 34.7 to 36, nowhere near the over-temp limit. We then upped car speed, doing a full pull hitting nearly 90mph for a minute, still at 2.5 amps. MFR was about 0.9, but inverter peak temp was 66C.

Because the loop is rejecting heat at such a low flow rate, the EBP40 may be sufficient for this loop. The loop, based on the testing, does not really need such a high flow rate like the inverter spec sheet requests. At this lower flow rate, the head requirements also decrease. Determining a system curve would be nice, especially so we don't have to be guessing whether the EBP40 will work, especially since we know that the system can cool at such a low MFR.

It is possible that we simply did not run long enough for inverter to get hot enough for us to know if the flow rate was fine. The longest test we ran was 90 seconds, at about 18mph (according to dyno), with the hose improperly placed and MFR at 0.43 GPM and it still barely hit 41C.

Test No.	Time (s)	Weight of water (oz)	Mass of water (gals)	Wind Speed (mph)	Inverter Peak Temp (Cel)	MFR of water (gal/min)	Battery Used	Amperage	Car Speed off Dyno	Air pressure from fan (Pa)	Notes
1	90.42	82	0.640625	18.5	37.4	0.43	LV Battery	? (~7.5)	~19	130	Hose may have been laying against bucket wall, choking flow rate
2	90.13	84	0.65625	18.5	41.5	0.44	Lv Battery	? (~7.5)	~19	130	Same as test 1
3	39.8	165	1.2890625	18.5	33	1.94	Lv Battery	? (~7.5)	~19	130	Set up jig to keep hose in optimal postion
4	60.11	260	2.03125	18.5	33	2.03	LV Battery	? (~7.5)	~19	130	
5	45.31	214	1.671875	18.5	34.7	2.21	Power Supply	5.1	~19	130	First test looking for min flow rate
6	60.5	97	0.7578125	18.5	36	0.75	Power Supply	2.5	~19	130	
7	61.38	119	0.9296875	18.5	66	0.91	Power Supply	2.5	End speed of 91	130	Doing a full pull, varying car speed until we hit 75C
8											

Looking back, would not recommend this test for determining min mfr.

Notes:
When testing pump on LV Battery, we should have brought the amp clamp.
Amperage was really unknown, TJ gave approx. value.

Water pump warranty claim

Monday, September 8, 2025 8:37 PM

Claim Not Approved

You can't proceed with your claim as it is not approved for the following reason:
Your issue is not yet covered by the plan. Please contact the retailer you purchased it from for assistance.

. If you have questions about this claim, Chat with us or call 1-800-317-9144 for further assistance.

Claim Information

Provide the exact date when the incident occured?	**08/16/2025**
Please tell us what happened with the product. (255 character limit)	**We experienced a failure with our water pump after only operating it a handful of times. The pump does not seem to operate at its full capacity, and we have noticed some irregular noises being generated by the pump.**
Select the reason for your claim/request	**My product is not functioning**
Has this product been used for racing?	**No**

Return To Your Dashboard

We experienced a failure with our water pump after only operating it a handful of times. Flow rate tests have been conducted that show the pump is not operating at its full capacity, and we have noticed some irregular noises being generated by the pump. Have also verified that our system is sending the correct voltage and current to the pump.

Head Tests for system curve

Thursday, October 2, 2025 11:47 PM

Running a water column test on the KS8 powertrain setup. We are using a power supply, and stepping up the amperage to increase flow rate, and therefore increasing head. We are using John's Positive Displacement Pump to conduct this test. We hope to gain multiple data points to correlate flow rate of water to head and determine a system curve.

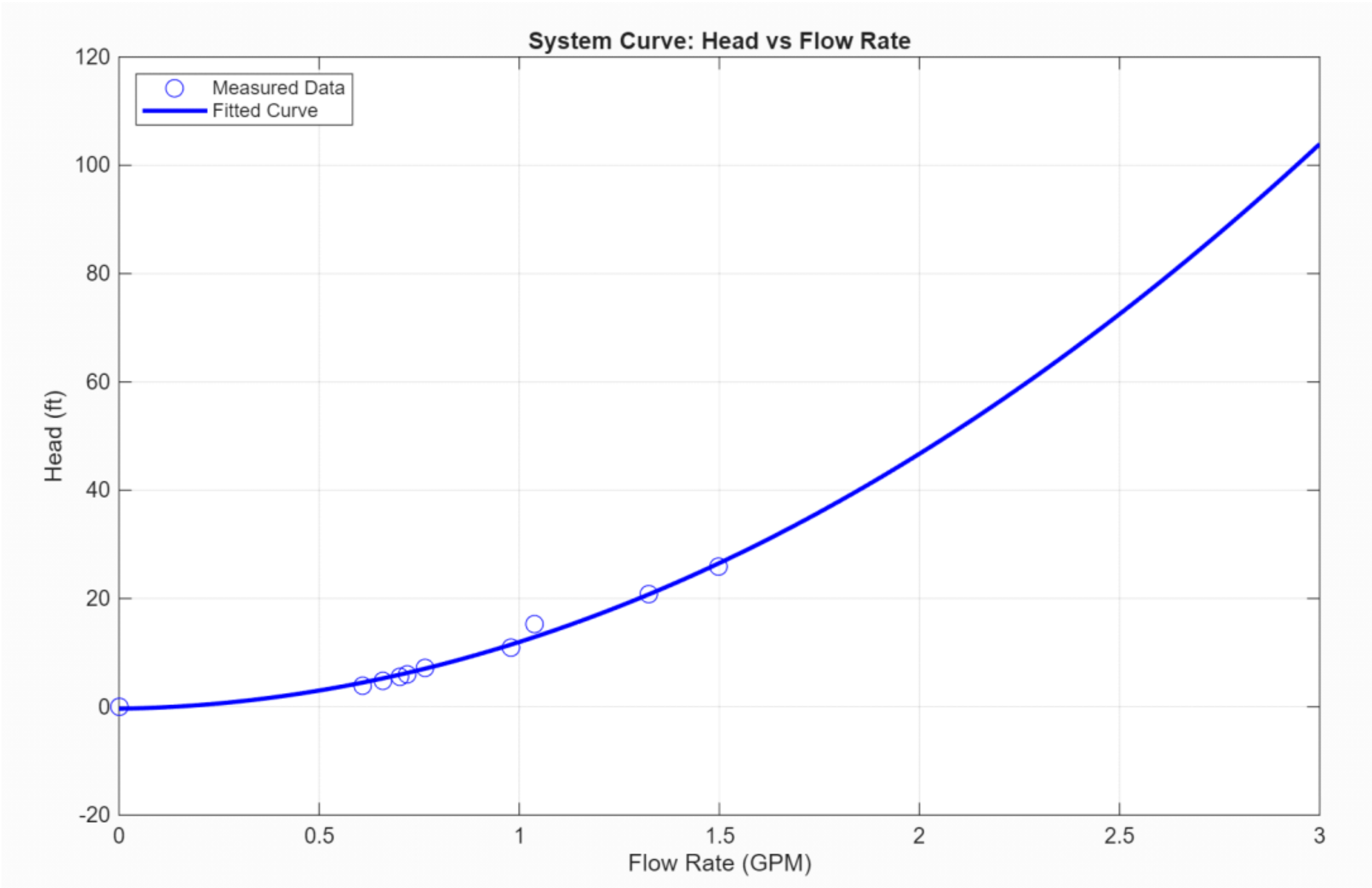
One issue we ran into on this test was that the water column was not tall enough to measure very different flow rates. The tube pretty much maxed out at 2.5amps, at about 0.76gpm. We did measure 5 different data points, but we should try to set up a water column large enough to measure at like 2gpm.

		T1	T2	T3	T4	T5
Amps		2.1	2.2	2.3	2.4	2.5
Time (s)		57.27	57.84	55.69	54.93	60
Weight (lbs)		4.85	5.3125	5.4375	5.5	6.375
Mass (gals)		0.581158	0.636578	0.651556	0.659045	0.763893
Mass Flow Rate	0	0.608861	0.660351	0.701982	0.719875	0.763893
Head Height (in)	0	46.5	58.5	66.5	72	86.5

Still need to do the analysis/fitting curve to data points. Also, still need to determine min flow rate.

Tested system in staircase to add height and measure higher flow rates. Used data to extrapolate head at even higher flow rates.

						Next Day			
	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
Amps	0	2.1	2.2	2.3	2.4	2.5	3	3.5	4	4.5
Time (s)	0	57.27	57.84	55.69	54.93	60	75.87	70.24	62.89	82.42
Weight (lbs)	0	4.85	5.3125	5.4375	5.5	6.375	10.34	10.14375	11.5875	17.18125
Mass (gals)	0	0.581158	0.636578	0.651556	0.659045	0.763893	1.239005	1.215489	1.388489	2.058768
Mass Flow Rate	0	0.608861	0.660351	0.701982	0.719875	0.763893	0.979838	1.038288	1.324683	1.498739
Head Height (in)	0	46.5	58.5	66.5	72	86.5	131.875	182.5	250.25	310.5
Head height (ft)	0	3.875	4.875	5.541667	6	7.208333	10.98958	15.20833	20.85417	25.875



System Curve: Head vs Flow Rate
Measured Data
Fitted Curve
Head (ft)
Flow Rate (GPM)
120
100
80
60
40
20
0
-20
0
0.5
1
1.5
2
2.5
3

Next Steps - 10/21/25

Tuesday, October 21, 2025 9:05 PM

Resources to reach out to regarding making script for sizing radiator

- Brendan, did rad characterization work on KS8C
- Prof. Aphale, Heat Transfer Prof
- Wasim Rad F1 contact

Reach out to Cascadia about flowing lower than specified mfr, and not running glycol/water mix

rad MFR testing tool, ask David

Bailey Questions:

Trying to determine Q-dot of inverter and motor in order to determine theoretical flow rate for keeping coolant between 25-60C

- Need Q-total first
- Using Michelin Endurance Logs
  - For Inverter
    - Looking at DC Bus Current and Voltage for Energy/Power in
    - Looking at 3Phase Current and Voltage for Energy/Power Out
      - Was told I should use matlab to determine energy lost to heat from foxglove plots
  - For Motor
    - Previously determined Power out from inverter is power in for motor
    - How can I determine motor power out? Is the torque and rpm of the motor found in foxglove?

Testing

Wednesday, August 13, 2025 6:55 PM

KS9 Powertrain Testing

Sunday, June 29, 2025 7:10 PM

Steady state test

Inverter tuning

Remove pack, measure thickness of cells, add to spreadsheet

Cell testing (CBA)
- Find dynamic R value
- SOC of cell and temp
- Open circuit voltage v capacity graph
    - Charge and discharge at same current, see how much voltage went in and out
- 4 wire vs 2 wire tester
- Don't have dynamic r value

We are missing consideration of tire grip in final drive calcs

Check on the thermistors
- Put in controlled environment and compare values

Models
- Endurance (Rint model)
    - When cells are discharged, should heat cells individually (look into might not change much)
    - Look into modeling thermal network, not just thermal mass.
        - Takes conductivity of each individual cell into account

- Thevenin model
    - Add frequency response of cells (how long it actually takes ions to move across cell) (how long does it take RC circuit to settle), parallel RC circuit
    - Done by making stepped current changes in charging and discharging
    - Better accel sims
    - Figure out how cell reacts in transients
    - Trying to measure a cell voltage source

Parasitic loss of pack
- Resistive losses everywhere
- 4 wire test on every voltage on the car
- Currently can only tell global loss
- Check on bolted connection for modules
- Cut the tabs off the cell that got dropped

Sweep torques
- Define and check torque specs for all bolted connections

- Redo water pump math
    - The output flow of pump immediately goes through a much smaller tube than pump outlet

Stud Bond Testing

Wednesday, October 22, 2025 7:45 PM

Orders placed for stud bond testing

- 3x Ultem 1000 1/2"x8"x8" sheets
- 100x M3 Hex Studs
- 100x M3 T Slot Screws
- 100x M3 DT Nuts

Testing Plan:

- Machine an ultem sheet with the pattern for the t slot and hex studs respectivley
    - Measure tolerances of the part
- Bond the studs and busbars using the DP8010 we have on hand
    - Let the adhesive set for 24 hours
- Test the torque that each stud on the sheet can handle
    - Log this number for each stud individually
- Machine the 3rd sheet of ultem to the hex pattern that performs better in the above tests
- Conduct the same testing with this sheet for more data points

0.0001 drill offset	0.0005 drill offset	0.001 drill offset
L: ____Nm R: ___Nm	L: ____Nm R: ___Nm	L: ____Nm R: ___Nm
L: ____Nm R: ___Nm	L: ____Nm R: ___Nm	L: ____Nm R: ___Nm
L: ____Nm R: ___Nm	L: ____Nm R: ___Nm	L: ____Nm R: ___Nm
L: ____Nm R: ___Nm	L: ____Nm R: ___Nm	L: ____Nm R: ___Nm
L: ____Nm R: ___Nm	L: ____Nm R: ___Nm	L: ____Nm R: ___Nm
L: ____Nm R: ___Nm	L: ____Nm R: ___Nm	L: ____Nm R: ___Nm
L: ____Nm R: ___Nm	L: ____Nm R: ___Nm	L: ____Nm R: ___Nm
L: ____Nm R: ___Nm	L: ____Nm R: ___Nm	L: ____Nm R: ___Nm

Results:

Torque spec is .85Nm

Was able to reach a consistent 4Nm on every single nut

Was also able to disassemble all nuts without issue

Studs were able to withstand at least 3 cycles

Cosmx 13AH Pouch Cell Testing

Tuesday, October 28, 2025 6:36 PM

SOC Curve

Internal resistance

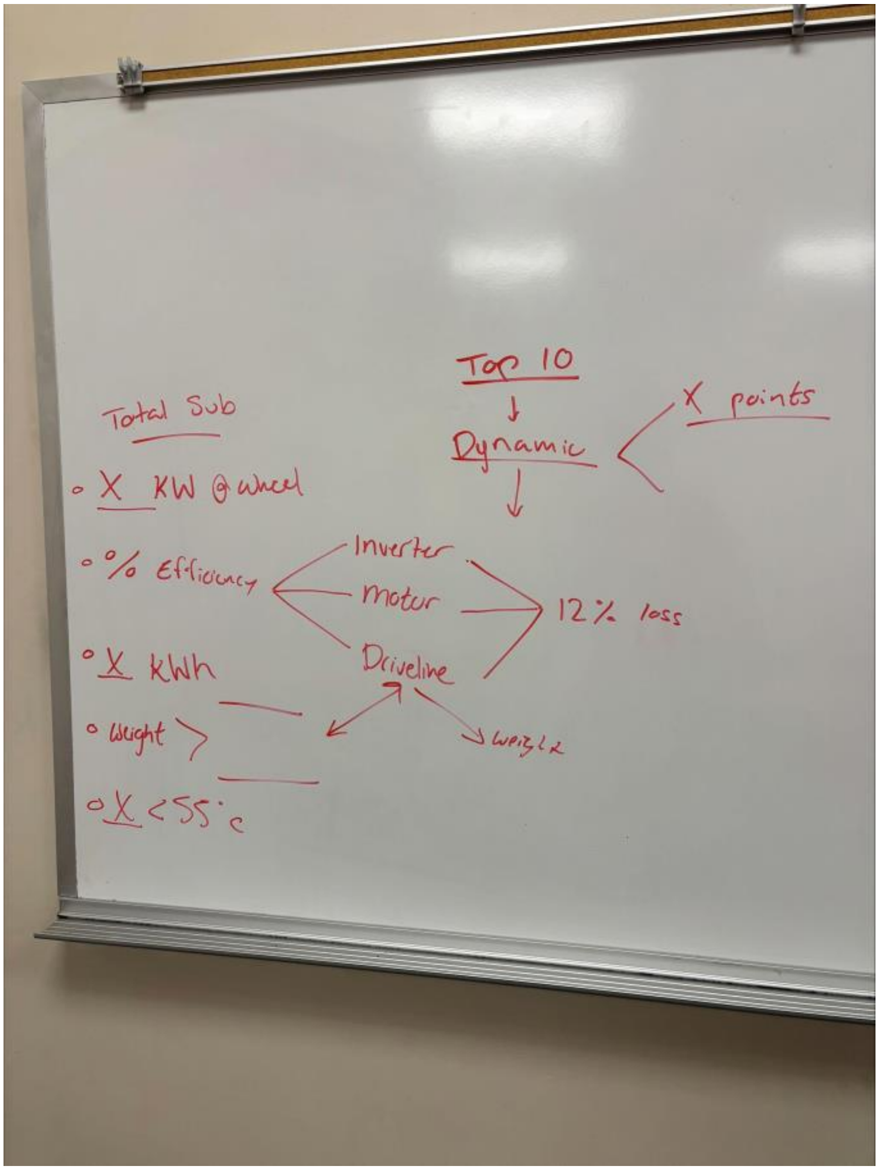
Meeting Notes

Wednesday, August 13, 2025 6:55 PM

8/12/25 - Goals, Module Plastics, Tasking, Inverter

Wednesday, August 13, 2025 8:11 PM

Goals:



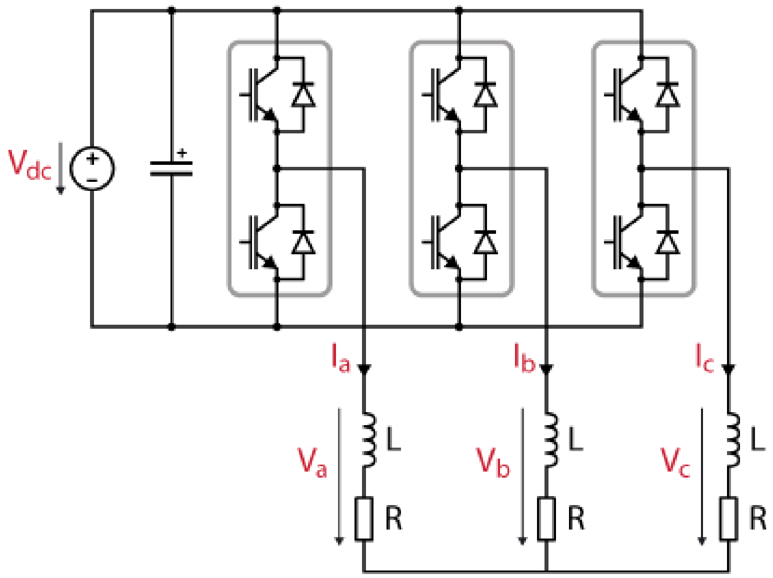
- Showed above image by Dom^
  - I like this as a breakdown of the performance targets for the subgroup
  - Missing Timeline related targets
  - Missing serviceability targets
  - Motor target should be at pack (actual design target, at wheels groups too many things)
  - Split efficiency target
    - Inverter can be affected by PID tuning
    - Motor eff is set by rpm and torque command (can be included in endurance strategy)
    - Driveline eff can be actually designed for (Sprocket sizes, chain length)
  - Energy target
    - We have a number but it is attributed to the energy "tank" method due to our poor understanding of where energy is lost when moving
    - Aero and driveline drag, parasitic losses
  - Weight
    - Create weight table (we missed a lot in our OG weight projection)

        - Can be used to pick where to put engineering effort for weight loss
        - Don't have real car target yet > can stick with projection based on reqed changes
    - Thermal limit
        - Should look to have 2 lap budget for both energy and cell body temp (just gives each driver a fuck up lap or small errors)
        - 55C was our limit based on sensor accuracy and vibe tbh
- Goal - non-negotiable items to accomplish
    - Placement at comp
    - Mileage accumulated
    - Release date
- Targets - Negotiated methods to reach out goa
    - Dynamic event target
    - Weight
    - Power
    - Energy
    - Efficiency

Module Plastics:
- EV.6.4.1 Plastic stack rules question
    - See if plastic can be within bolted connection but no preventing the electrical connections
- Two paths forward
    - New plastics and bond strategy
    - Bolt through plastic
- Showed RIT Module tops from Instagram
- Mentioned removing rib from stack
- Mentioned changing endline strat

Tasking Strategies:
- This is different per person and project (Use Water loop as example)
    - Fresher engineers may be given more upfront - their goal is to do the real mechanical design and not the fundamental system
        - Could be given whether series or parallel loop
        - Could be given pump
        - Could be given tube sizing and material
        - Could be given placement
        - Will figure out component mounting
        - Will negotiate tube length and friction
        - Will set up testing and validation of system on and off car (your requirements w/ them)
    - More experienced engineers *CAN* be given more open ended system designs - their goal is to design the system and either manage the real design or complete it
        - Allowed to explore system fundamentals
        - Select components, placement, and mechanical design
        - Calculate system requirements
    - THE ABOVE IS NOT A HARD RULING
        - Project scope is also determined by time, cash flow, and part carry over
- One note tasking
    - Contains purpose
    - Contains design constraints (think inverter and motor inlet temperature)
    - Contains restrictions (Think weight, water cable size, pump used)
    - Give needs and wants
    - Give related links (Other team papers or research papers)
- Excel workbooks similar to Accumulator one

Inverters:
- Cascadia inverter guide home page: https://www.cascadiamotion.com/documentation
    - Hardware guide: https://www.cascadiamotion.com/_files/ugd/7833d4_32270d1c28f946e1ae58ea9d92843f40.pdf
    - Software guide: https://www.cascadiamotion.com/_files/ugd/7833d4_

    4594a6cf066448b5a5ee4a386470f9fd.pdf
    - All legacy manuals are found here (A Box Link): https://app.box.com/s/8bdsg0yhbfkt6ehu0qcgmw5inxx6s19v
- Inverter Power and switching diagram:
    - 

- Read associated guides
    - Low speed operation: https://app.box.com/s/8bdsg0yhbfkt6ehu0qcgmw5inxx6s19v/file/747822601272
    - CM Series Maximum Current: https://app.box.com/s/8bdsg0yhbfkt6ehu0qcgmw5inxx6s19v/file/986105791401
- Inverter "tuning" on our team exists in two facets
    - Limits and base control - This controls the macro performance for our inverter
        - Iq max
        - Id max
        - Variable switching frequencies
        - Etc
    - Efficiency tuning
        - PID value tuning

8/20/25 SRR Notes

Wednesday, August 20, 2025 2:04 PM

~~Timeline wise the feasibility of changes made were not the issue, it was lack of mechanical validation, due to Lack of coupon testing not feasibility of design~~

~~Expected 15 lb incresae to 138 lbs~~
~~10 Lbs over design weight projection~~

~~Add more about what cells we considered~~
~~Old teams battery config investigation~~
~~Big battery spreadsheet~~
~~Looked at molicell 2170~~
~~2 puches from~~
~~Current energus pack cells~~
~~LCO pouches from hytech (Gave back)~~

~~Why we Didnt do 2170~~

~~Choose between cosmx 13 and 20 amp hr~~

~~ADD slide on cell choice~~

Neext time we should choose a cell count and performance than go for cells from there

Talk about aero drag in endurance energy consideration

Add Something about rint model something about accel model

~~Slide 5 plot is not useful, Find the more direct one about cell temp 2023-2024 statics (cooling plot)~~

Cooling capacity consideration

Accel and endurance were focused for modeling because they were most reliant on powertrain, and we did fine in those other events

SLIDE 6
~~Chasiss footprint also stayed the same in case we needed to swap energus back into the car~~
~~Cell life can be 2 or maybe 3 years~~
~~No deformation of cell tabs - reduce high cycle life failure~~s

SLIDE 7
~~Drawing is incorrect~~
~~Did not add more tab and slot to container,~~
~~Made .2in larger~~
~~Measure more jigged tighter~~
~~Measured 5 times instead of onece~~

SLIDE 8
~~Original pan was hex stud~~
~~Hysol hex stud bond failed~~
~~Then tried pem nut that also failed~~

~~New glue pem~~
~~New glue hex that work moderatley well~~

~~Want to reevaltae mechanical stackup, might want to remove adhesive~~

SLIDE 9

~~Issue with taps on connectors 3 for BMS needed to tie all together, used wrong size bolt holes~~

~~SLIDE 11~~
~~INC Bond Area~~

~~SLIDE14~~
~~TS sense crowdded not unreliable~~

Contraint goals
Are also money
Personnel

Motor is 90% of eff
Inv is 3%

~~+/- 2.5 lbs~~

If I put mainaijn and seviceabiltiy
Remove acc
Sperate lid from lower container

Goal analysis chart
80kw is best because autox and accel highest number most power
Energy, bucket per lap
Power factor chart for power
Eff number, need way more refined endurance startegy, selecting best we can

DO the 80KW and buckets for energy

8/26/25 Subgroup meeting

Wednesday, August 27, 2025 5:24 PM

8/27/25 ~7pm Meeting with Cameron
8/28/25 ~2:30pm Meeting with Garrett
8/28/25 5:30pm Meeting with Varun
9/1/25 ~7pm Meeting with Camden

Performance Goals:

- 80 kW from Accumulator
- 6.73 kWh total energy
- 90% Efficiency – Motor + Inverter
- Within +/- 2% of Weight Projection for accumulator (148 lbs)
- Stay Below 55 deg C cell temps

9/9/25 Subgroup meeting

Tuesday, September 9, 2025 5:49 PM

Tasks:
- Call summit racing about pump
- EV Active

Proposals to Review:
- Lower Container/Container Mounting
- Module Design
- Cooling Loop
- Distributed BMS

Projects to be picked up:
- Fix 240v Charging

Cooling Loop Proposal
- Needs constraints
- Needs BOM
    - One for series and parallel?
- Hygrometer for rad testing?
- Water pump under 5amps

Lower Container
- Consider 6061-T6
    - makes SES simpler
- Measure mounts from Shear plane
- Testing?

BMS
- Orion BMS is currently only thing reading current sensor
    - Orion need to be in container at comp unless ACU can be updated to read current sensor
- Would be passed on to firmware team after board is up and running
    - Would need to integrate with car, charging, etc
- May need different thermistors
    - Sim new temp curve?

9/23/25 Meeting Notes

Tuesday, September 23, 2025 8:09 PM

MSD Proposal:
Little more specificity of constraints
What does fairly set mean for aluminum
Need to provide more concrete build and ordering deadlines
Needs more detail on aux box vs internal discharge
Explain "simplify tractive system"
PASSED PP1

Lower Container PP2:

9/30/25 Meeting Notes

Tuesday, September 30, 2025 8:00 PM

Module Design:
- Just got an update from Cameron, stud tester almost done
- Completed Ultem (PEI) cost breakdown, will reorganize and post in discord to look at
  - Seems to be the only material that can meet all of our requirements for module top plate

    Material needs:
    - 90C temp minimum
    - UL94 V0 Flame Rating
    - High Dielectric strength
    - Tensile Strength @ 60C: 1000psi
    - Modulus @ 60C: 1000 psi

    Material Wants:
    - High Surface Energy Plastic (40-50 mJ/m^2)
    - Low Residual stresses: Materials have large machined features
    - Low Thermal Expansion: System can have cyclical but infrequent 30C swings with no cooling in critical part interactions
    - Low Weight: we are building a racecar

Cooling Loop:
- Need to buy a water pump, possibly conduct more testing with John pump before returning it
- EBP40? Our testing showed that we may not need as much flow rate as we thought

AIRS:
- People were curious about whether we planned to change airs
- Garrett is working on this as a part of lid rework

Lower Container:
- Working on fixing the CAD in the main assemblies
- Need to update the frame side mounts

Charger 240V fix Proposal

10/7/25 Meeting Notes

Tuesday, October 7, 2025 8:10 PM

Orders placed for stud bond testing

- 3x Ultem 1000 1/2"x8"x8" sheets
- 100x M3 Hex Studs
- 100x M3 T Slot Screws
- 100x M3 DT Nuts

Testing Plan:

- Machine an ultem sheet with the pattern for the t slot and hex studs respectivley
  - Measure tolerances of the part
- Bond the studs and busbars using the DP8010 we have on hand
  - Let the adhesive set for 24 hours
- Test the torque that each stud on the sheet can handle
  - Log this number for each stud individually
- Machine the 3rd sheet of ultem to the hex pattern that performs better in the above tests
- Conduct the same testing with this sheet for more data points

Cooling loop:

- Project requirement includes staying below 45-50 C coolant temp
- Currently don't have a system to measure coolant temp, only inv board temp

10/14/25 Meeting Notes

Tuesday, October 14, 2025 5:17 PM

10/21/25 Meeting Notes

Tuesday, October 21, 2025 4:29 PM

Stud Bond Testing:

- Waiting on the plastics to get machined

Cooling Loop Update:

- No point in searching for min flow rate because rad is changing
- Scale rad based on flow rate
- Mdot is variable in sizing of rad
- Pump selection ready to be carried out
- Confirm with supplier before we run below spec for inverter flow rate
    - May wear out the switches on the inverter sooner even though board is still cooled
    - Dimensional analysis to find new min flow
- Run Rad MFR testing
    - NTU Method
- Need thermistors asap for testing
    - Placement

LID Update:

- AVI is changing on chances end (Not rules legal)
    - Need to account for the change
    - AVI will move to the side with the smallest service panel
- Only 2 AIRS in stock, do we have any alternatives?

SES Updates:

- One section that says to check
    - Container puts tube in bending but this hasn't been an issue in the past

11/11/25 Meeting Notes

Tuesday, November 11, 2025 9:40 PM

Too many limitation to 200A Fuse