

# Evaluation of GTR No. 20 Test Procedures

Submission to IWG for GTR 20

April 2021 –IWG #21

MGA Research Corporation

Robert Schnorenberg

# Outline

---

- Scope of Evaluation
- Test Procedure Development
- Validation Testing
- Assessment

# Scope

---

- 5.1 Electrical safety in-use
  - 5.1.1 Protection against electrical shock
  - 5.1.2 Functional Safety
- 5.3 Requirements of REESS in a vehicle
- 5.4 Requirements of REESS in use
  - 5.4.5 External short circuit protection
  - 5.4.6 Overcharge protection
  - 5.4.7 Over-discharge protection
  - 5.4.8 Over-temperature protection
  - 5.4.9 Overcurrent protection

# Test Procedure Development

---

- Draft test procedure developed by NHTSA with collaboration from contract test laboratory and industry participants.
- Initial draft test procedure used for validation testing on Chevrolet Bolt EV in 2019.
- Laboratory Test Procedure for GTR 20 Electrical Vehicle Safety Section 5.1, 5.3, 5.4 drafted in 2020 based on lessons learned from initial validation testing.
- Laboratory Test Procedure used for validation testing on Nissan Leaf and Tesla Model 3.

# Validation Testing

---

## 2019 Chevrolet Bolt EV

- 60 kWh Lithium-Ion Battery Pack



## 2020 Nissan Leaf S Plus

- 62 kWh Lithium-Ion Battery Pack

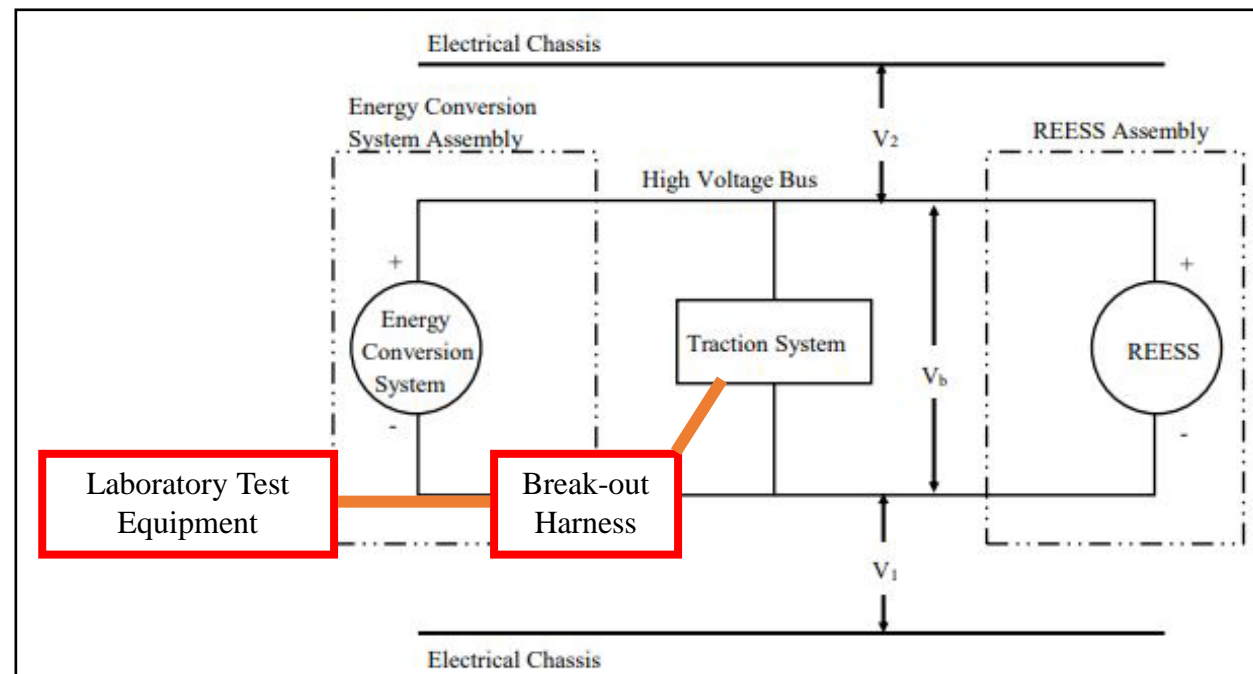
## 2020 Tesla Model 3 Standard Range

- 54 kWh Lithium-Ion Battery Pack



## 5.4 Safety of REESS in-use

- GTR breakout harness test methods chosen where applicable.
- OEM consulted for details on how to properly connect their vehicle to the laboratory test equipment.





# Chevrolet Bolt Breakout Harness

- General Motors provided harnesses and instructions for installing at each location.
  - Qty 2 breakout harness
  - Qty 3 connection locations
- Isolation measurements conducted with a separate harness.



# Nissan Leaf Breakout Harness

- Nissan breakout harness connected to high voltage bus in PDM
  - Single harness and connection location used for all testing.
- Isolation measurements conducted with a separate harness.





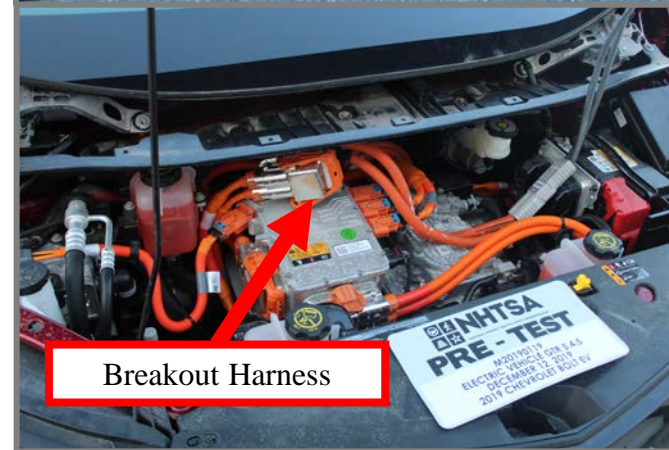
# Tesla Model 3 Breakout Harness

- Tesla breakout harness connected to DC Link Connection following instructions provided.
  - Single connection location used for all testing.
  - Harness wire gauge increased for external short circuit test.
- GTR harness connection same as isolation measurement connection

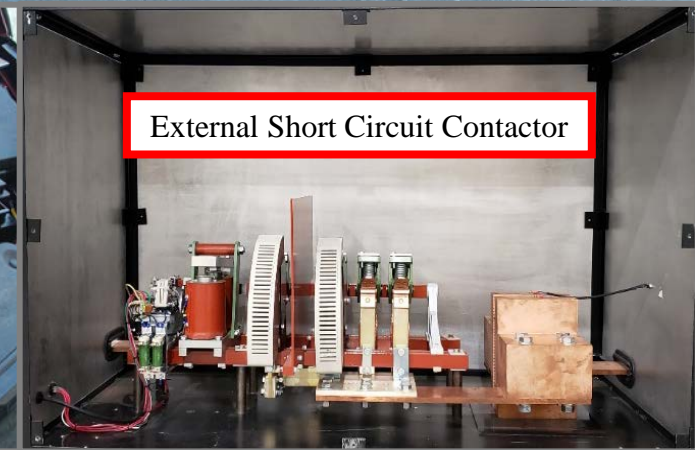


## 5.4.5 External short circuit protection

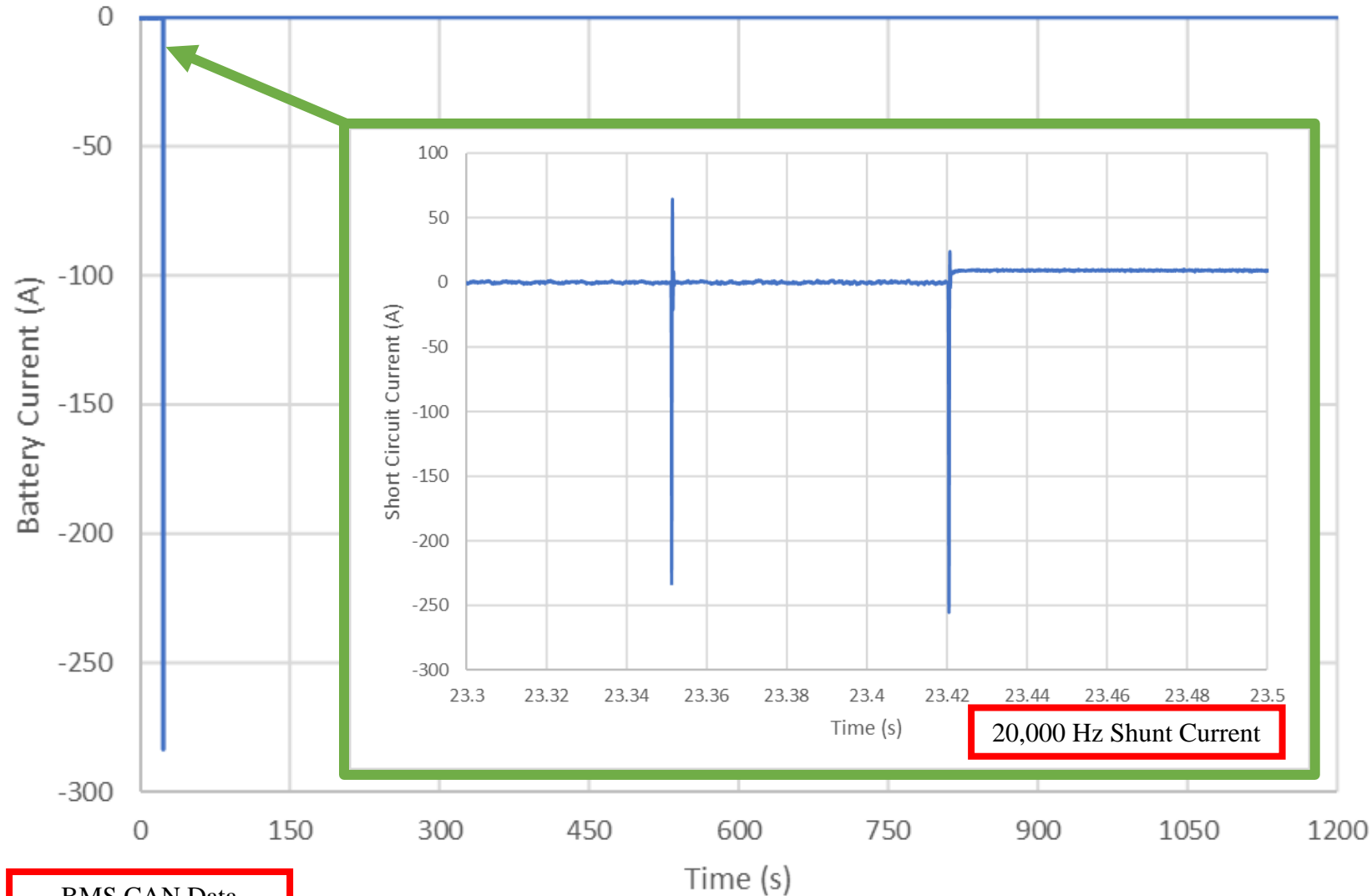
- Vehicle based test conducted with an external short test machine connected to the breakout harness.
- All three vehicles required repair after short circuit test
  - Chevrolet Bolt successfully repaired by dealership.
  - Nissan Leaf and Tesla Model 3 repairs in progress.



Breakout Harness



External Short Circuit Contactor



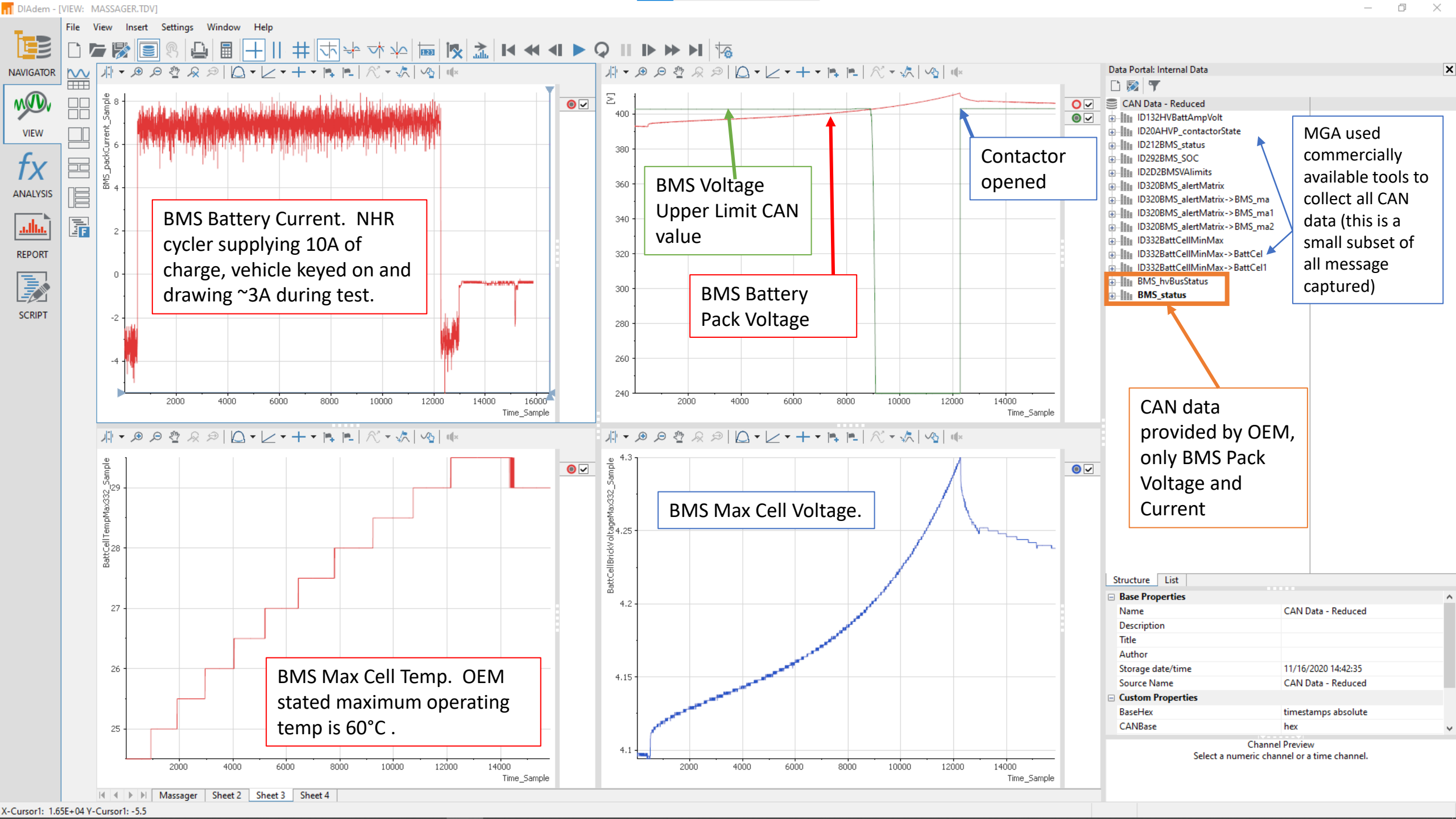
- During repair of the vehicle it was determined that the fuse on the manual disconnect level was blown and a relay contactor was shorted.



## 5.4.6 Overcharge protection

- Breakout harness and NHR 9300 Battery Test System used in conjunction with OEM Level 1 charger to perform the test in all cases.
- Vehicle REESS SOC adjusted to 95% prior to testing to reduce overall test duration.
- REESS high voltage connection to breakout harness opened for all three vehicles.

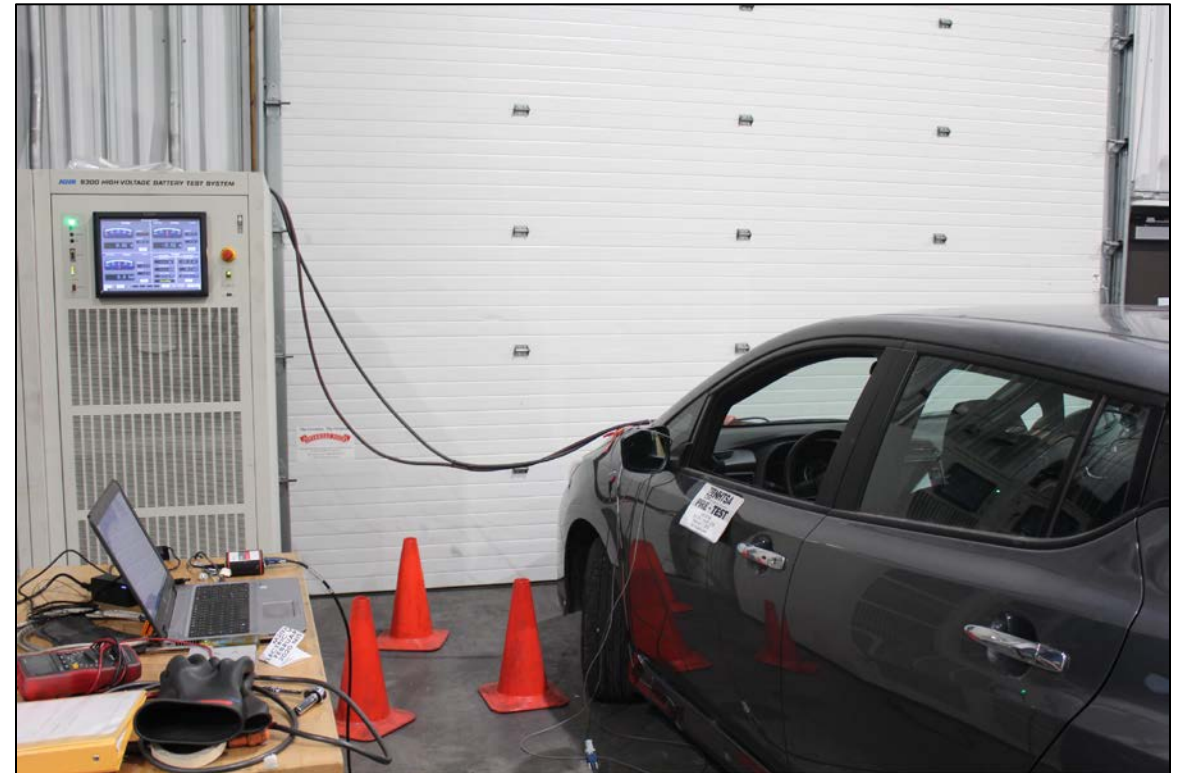


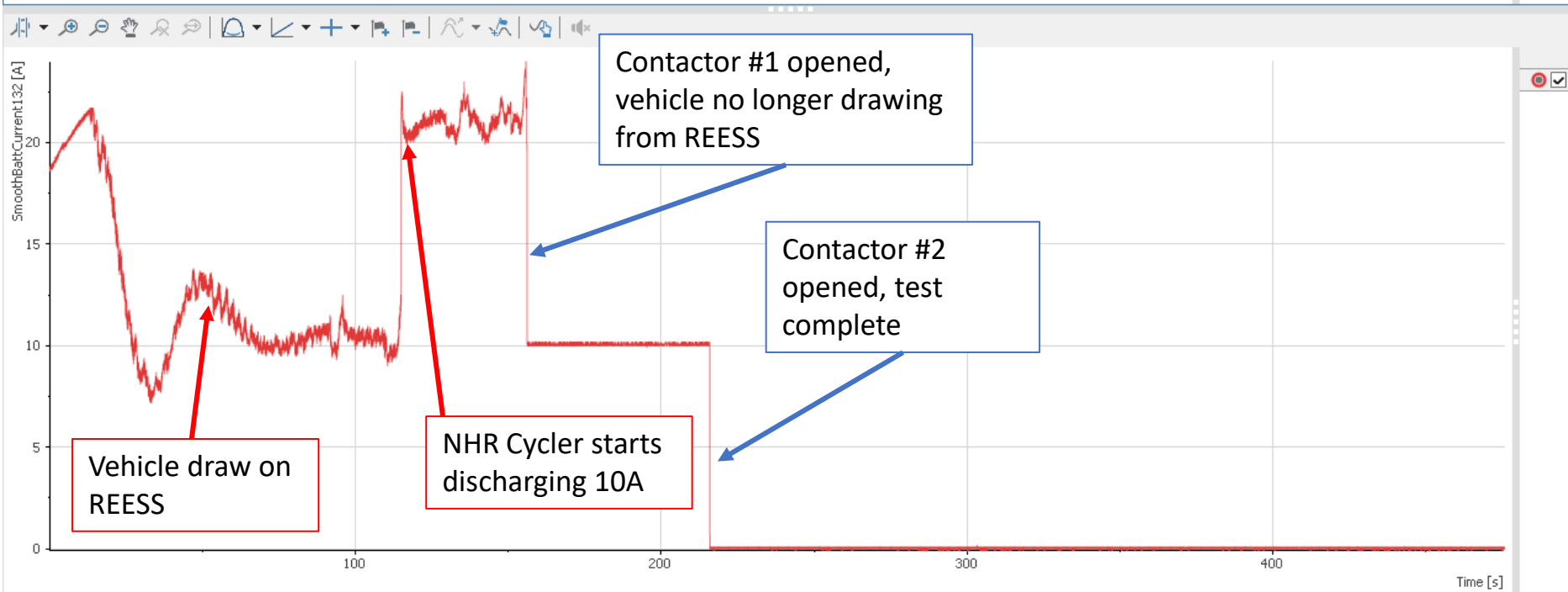
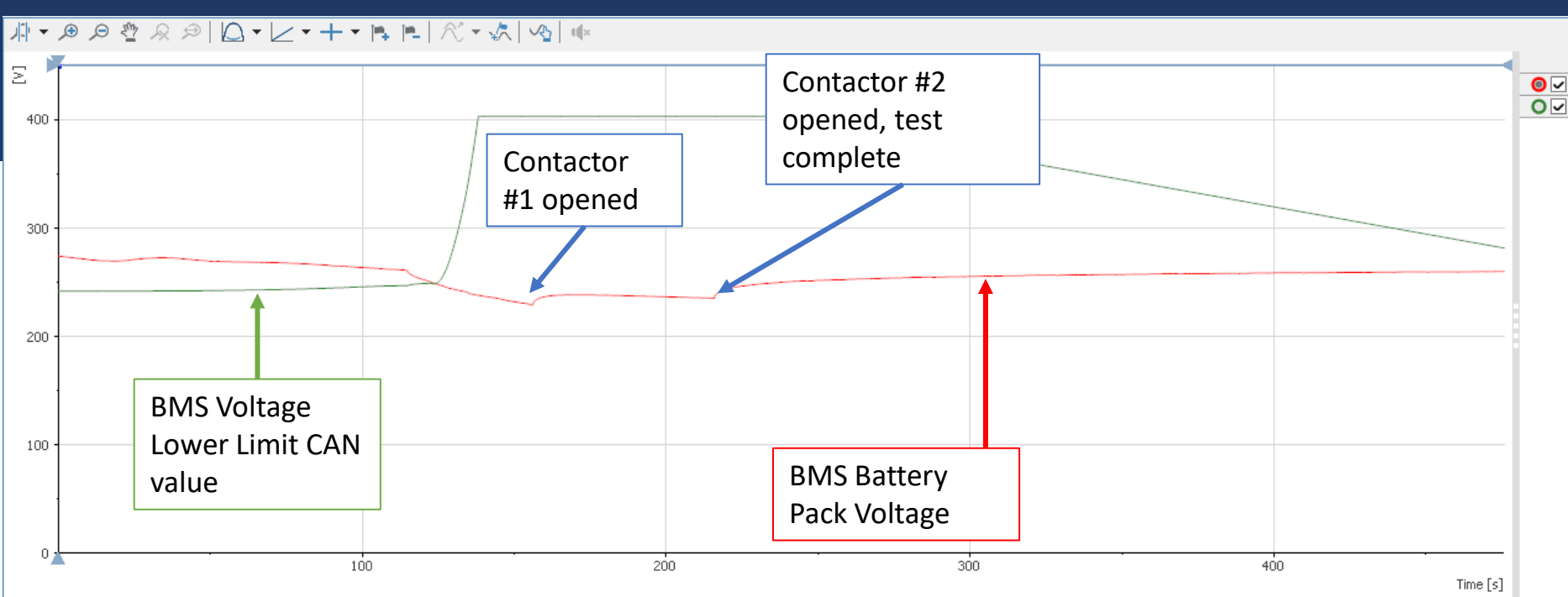




## 5.4.7 Over-discharge protection

- Breakout harness and NHR 9300 Battery Test System used to provide OEM stated discharge current.
- Vehicle REESS SOC adjusted to less than 10% prior to testing to reduce overall test duration.
- REESS high voltage connection to breakout harness opened for all three vehicles.





Data Portal: Internal Data

- Tesla Over Discharge CAN Data
  - ID132HVBattAmpVolt
  - ID20AHVP\_contactorState
  - ID212BMS\_status
  - ID292BMS\_SOC
  - ID2D2BMSValimits
  - ID320BMS\_alertMatrix
  - ID320BMS\_alertMatrix->BMS\_matrixInd...
  - ID320BMS\_alertMatrix->BMS\_matrixInd...
  - ID320BMS\_alertMatrix->BMS\_matrixInd...
  - ID332BattCellMinMax
  - ID332BattCellMinMax->BattCellMultiple...
  - ID332BattCellMinMax->BattCellMultiple...
  - BMS\_hvBusStatus
  - BMS\_status**

Structure List

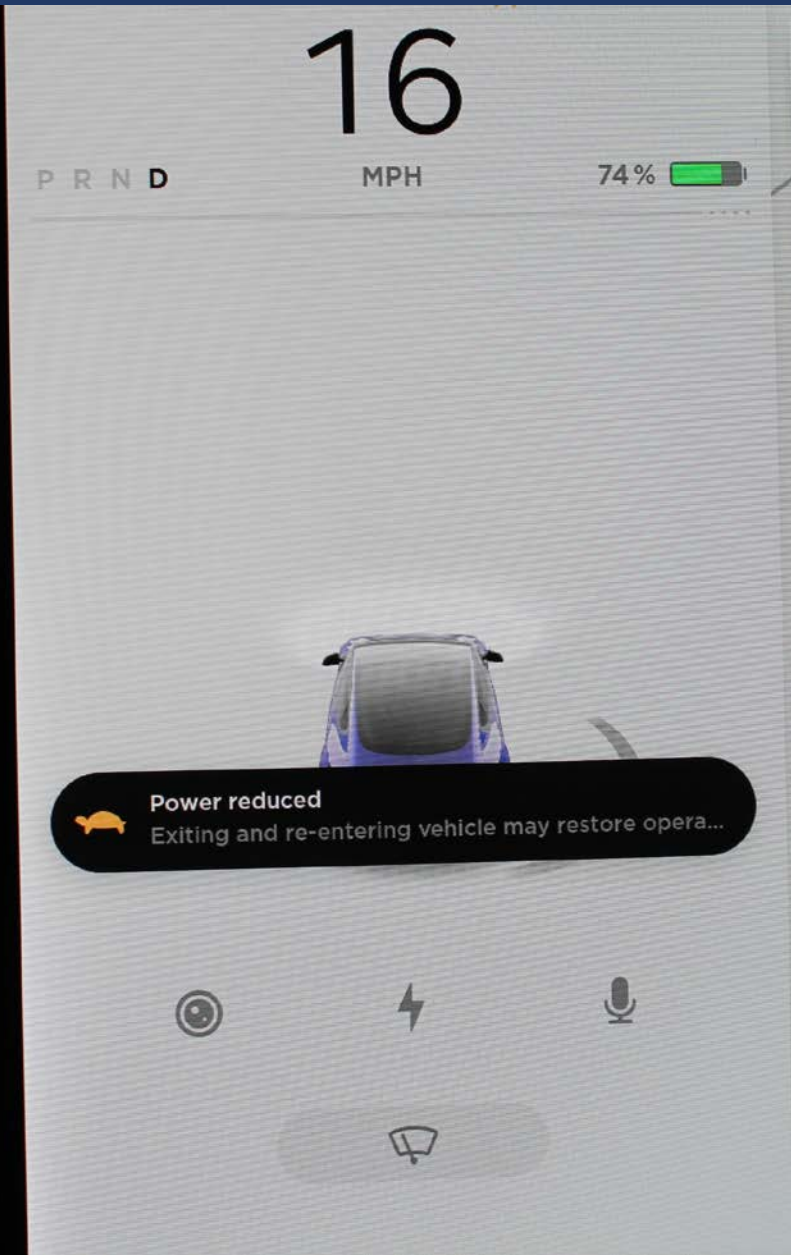
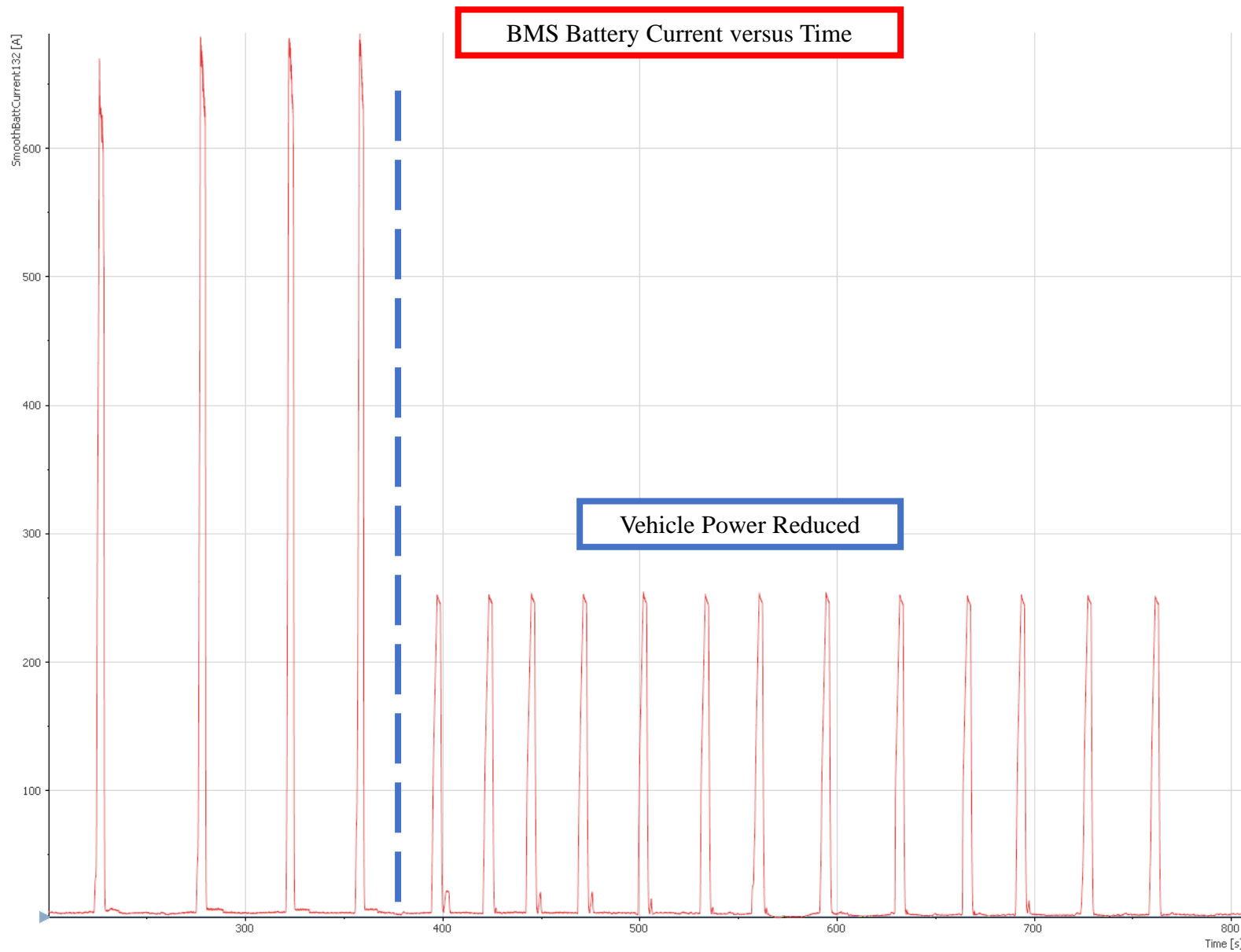
Base Properties	
Name	ID320BMS_alertMatrix->BMS_matrixlr
Description	
Index	7
Source Name	ID320BMS_alertMatrix->BMS_matrixlr
Custom Properties	
CANBusNumber	1
CANComment	Mode: 0000
CANCycletime	0
CANDBName	N:\Battery Lab\Customers\NHTSA\Te

Channel Preview  
Select a numeric channel or a time channel.

## 5.4.8 Over-temperature protection

- Vehicle was conditioned prior to installation on chassis dynamometer.
- Electric vehicle may need to be placed into a special driving mode to enable operation on the dynamometer.
  - Tesla Model 3 required disabling front anti-lock brake system.





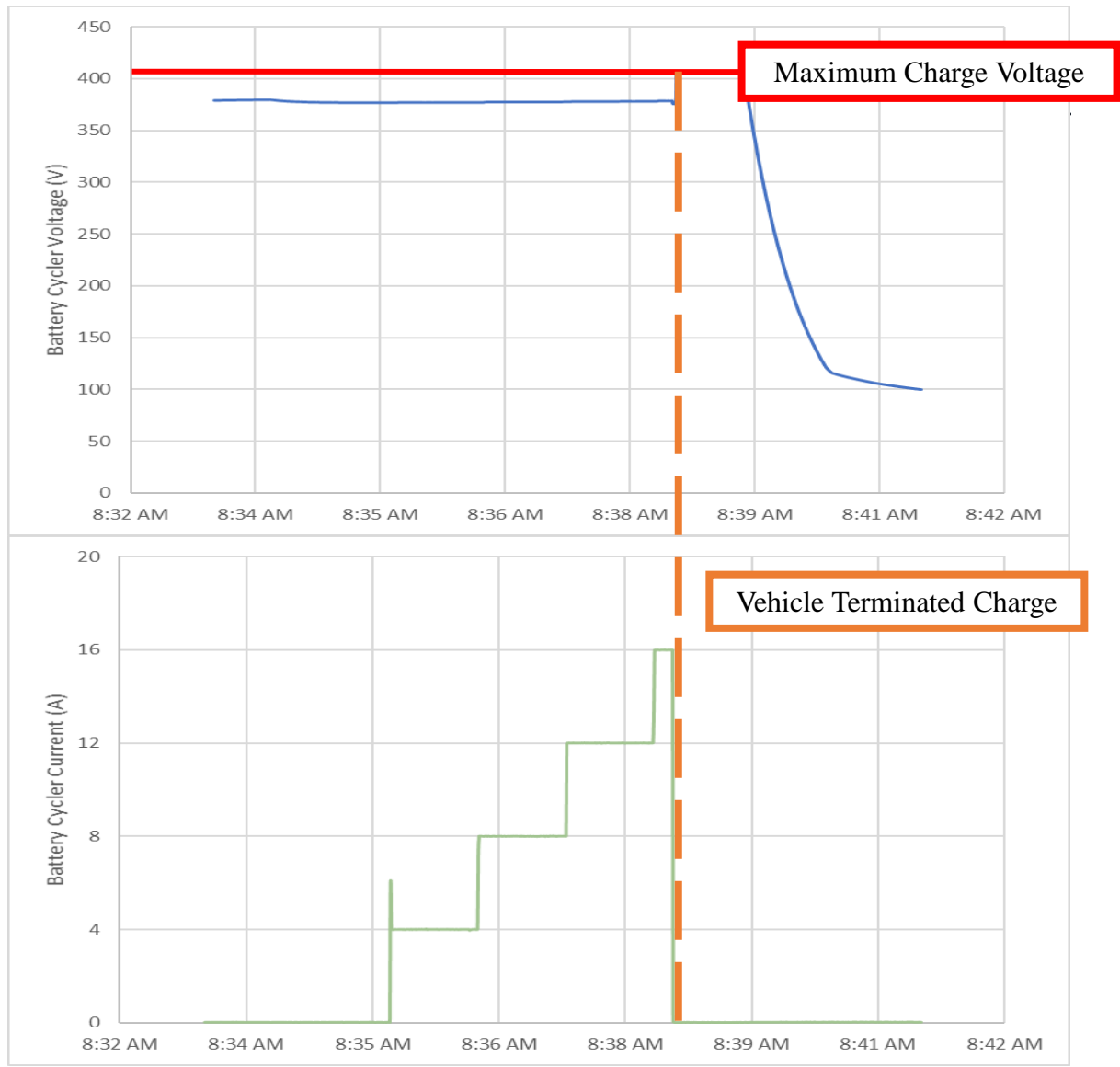


## 5.4.9 Overcurrent protection

- DC Fast Charger connected to vehicle in parallel with NHR 9300 Battery Test System.
  - Battery Test System supplied overcurrent after DC Fast Charge connection established.
  - Grounding loop can cause isolation errors with DC Fast Charge connection.







## Assessment (1 of 3)

---

- Safety of REESS in-use testing at the full vehicle/system level using the breakout harness method has been successfully demonstrated on the candidate vehicles.
- Commercially available equipment used to conduct all testing:
  - NHR 9300 Battery Test System
  - DC Fast Charger rental from EV Safe Charge, Inc.
  - External Short Circuit Contactor from Mersen Canada Toronto, Inc.
  - Full vehicle environmental chamber
  - Chassis dynamometer
  - Vehicle diagnostics tools available online
    - ODB2 Port harness for Tesla Model 3 available online

## Assessment (2 of 3)

---

- Installation and use of breakout harness was easier and more efficient than removing the REESS from the vehicle in the three candidate's chosen.
  - OEM methods for three candidate vehicles required minimal modifications.
- GTR test methods rely on OEM information and details to successfully complete evaluations, communication tools can expedite testing and reduce the risk of errors.
- TEST VEHICLE INFORMATION FOR HYBRID AND ELECTRIC VEHICLES (for GTR 20) form created to facilitate sharing of information between OEM, test laboratory, and NHTSA.
  - Form used on Nissan Leaf and Tesla Model 3 testing based on experience from Chevrolet Bolt evaluations.

## Assessment (3 of 3)

---

- Battery Management System diagnostic message available on the CAN network are very helpful in conducting these tests.
  - OEM support may be necessary to facilitate decoding and capturing this data.
- All three vehicles required repair after the External Short Circuit test, which was conducted as the final test in the series.
  - Possibility that repair is not possible through the dealership network.
  - No repairs were necessary for the other in-use test methods. Vehicles returned to operational after an ignition cycle.