Spring 2012

The Mitsubishi i electric vehicle

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The 2012 Mitsubishi “i” (innovative) Electric Vehicle

Presented by Matt Dixon, Assistant Professor

SIUC Automotive Technology

Spring 2012

2012 Mitsubishi “i”

- Rear Drive
- **all electric propulsion**
- Weighs 2579 pounds
- Been in the Euro/Japanese markets for about 2 years

ES or SE (better) trim levels, SE shown

2012 Mitsubishi “i”

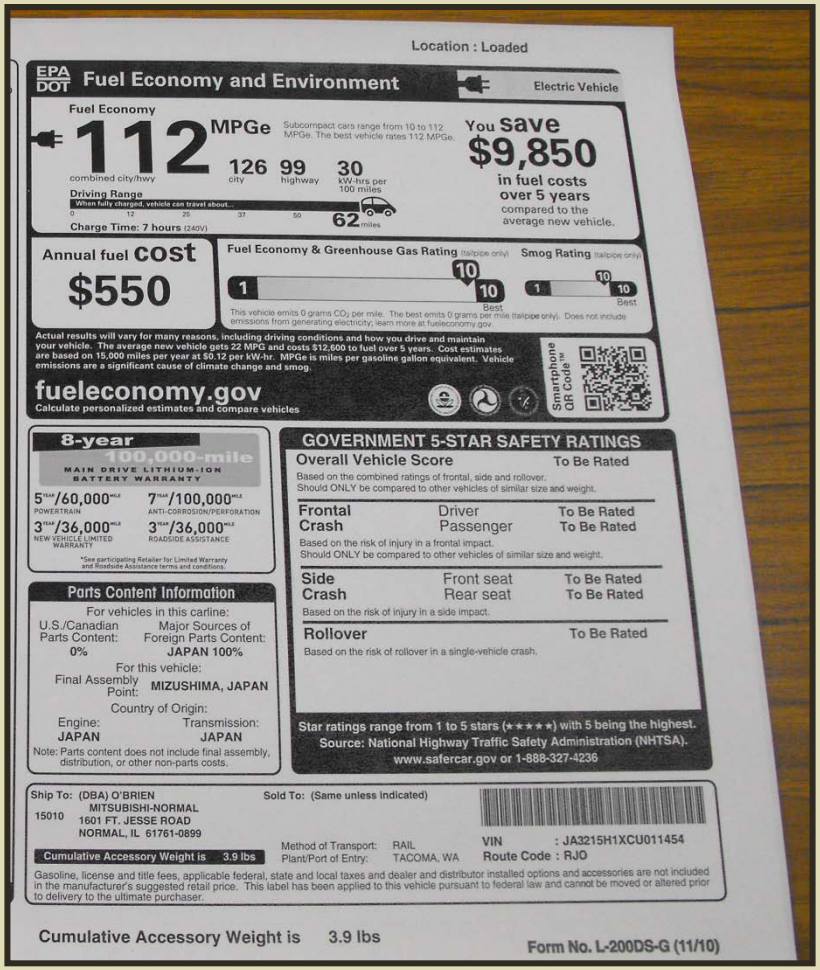
Currently qualifies to ride in the “HOV” lane*

- Seats 4 comfortably
- LED tail lamps
- 6 airbags

- Dual front wipers to meet USA regulations
- Halogen headlamps

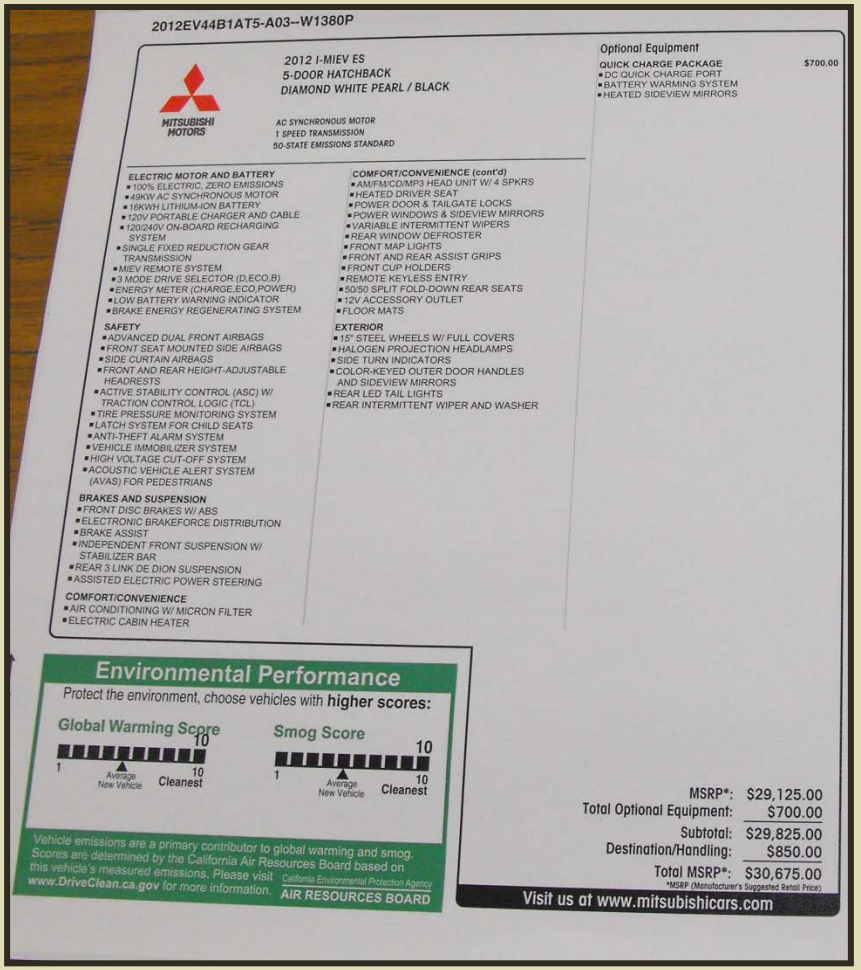
2012 Mitsubishi “i”

- 112 miles per gallon equivalent, combined range 62 miles
- **Lithium Ion** battery pack and main drive are warrantied for 8 years/80,000 miles



2012 Mitsubishi “i”

- Cost ≈ $30K
- Federal tax incentive available ($7500)
- State tax incentives available (varies $)



2012EV44B1AT5-A03--W1380P

MITSUBISHI MOTORS

2012 i-MIEV ES
5-DOOR HATCHBACK
DIAMOND WHITE PEARL / BLACK

AC SYNCHRONOUS MOTOR
1 SPEED TRANSMISSION
50-STATE EMISSIONS STANDARD

ELECTRIC MOTOR AND BATTERY
- 100% ELECTRIC, ZERO EMISSIONS
- 49KW AC SYNCHRONOUS MOTOR
- 16KWH LITHIUM-ION BATTERY
- 120V PORTABLE CHARGER AND CABLE
- 120/240V ON-BOARD RECHARGING SYSTEM
- SINGLE FIXED REDUCTION GEAR TRANSMISSION
- MiEV REMOTE SYSTEM
- 3 MODE DRIVE SELECTOR (D,ECO,B)
- ENERGY METER (CHARGE,ECO,POWER)
- LOW BATTERY WARNING INDICATOR
- BRAKE ENERGY REGENERATING SYSTEM

SAFETY
- ADVANCED DUAL FRONT AIRBAGS
- FRONT SEAT MOUNTED SIDE AIRBAGS
- SIDE CURTAIN AIRBAGS
- FRONT AND REAR HEIGHT-ADJUSTABLE HEADRESTS
- ACTIVE STABILITY CONTROL (ASC) W/ TRACTION CONTROL LOGIC (TCL)
- TIRE PRESSURE MONITORING SYSTEM
- LATCH SYSTEM FOR CHILD SEATS
- ANTI-THEFT ALARM SYSTEM
- VEHICLE IMMOBILIZER SYSTEM
- HIGH VOLTAGE CUT-OFF SYSTEM
- ACOUSTIC VEHICLE ALERT SYSTEM (AVAS) FOR PEDESTRIANS

BRAKES AND SUSPENSION
- FRONT DISC BRAKES W/ ABS
- ELECTRONIC BRAKEFORCE DISTRIBUTION
- BRAKE ASSIST
- INDEPENDENT FRONT SUSPENSION W/ STABILIZER BAR
- REAR 3 LINK DE DION SUSPENSION
- ASSISTED ELECTRIC POWER STEERING

COMFORT/CONVENIENCE
- AIR CONDITIONING W/ MICRON FILTER
- ELECTRIC CABIN HEATER

COMFORT/CONVENIENCE (cont'd)
- AM/FM/CD/MP3 HEAD UNIT W/ 4 SPKRS
- HEATED DRIVER SEAT
- POWER DOOR & TAILGATE LOCKS
- POWER WINDOWS & SIDEVIEW MIRRORS
- VARIABLE INTERMITTENT WIPERS
- REAR WINDOW DEFROSTER
- FRONT MAP LIGHTS
- FRONT AND REAR ASSIST GRIPS
- FRONT CUP HOLDERS
- REMOTE KEYLESS ENTRY
- 50/50 SPLIT FOLD-DOWN REAR SEATS
- 12V ACCESSORY OUTLET
- FLOOR MATS

EXTERIOR
- 15" STEEL WHEELS W/ FULL COVERS
- HALOGEN PROJECTION HEADLAMPS
- SIDE TURN INDICATORS
- COLOR-KEYED OUTER DOOR HANDLES AND SIDEVIEW MIRRORS
- REAR LED TAIL LIGHTS
- REAR INTERMITTENT WIPER AND WASHER

Optional Equipment

QUICK CHARGE PACKAGE $700.00
- DC QUICK CHARGE PORT
- BATTERY WARMING SYSTEM
- HEATED SIDEVIEW MIRRORS

Environmental Performance

Protect the environment, choose vehicles with **higher scores:**

Global Warming Score: 1 (Average New Vehicle) — 10 (Cleanest)

Smog Score: 1 (Average New Vehicle) — 10 (Cleanest)

Vehicle emissions are a primary contributor to global warming and smog. Scores are determined by the California Air Resources Board based on this vehicle's measured emissions. Please visit www.DriveClean.ca.gov for more information.

California Environmental Protection Agency AIR RESOURCES BOARD

MSRP*:	$29,125.00
Total Optional Equipment:	$700.00
Subtotal:	$29,825.00
Destination/Handling:	$850.00
Total MSRP*:	$30,675.00

*MSRP (Manufacturer's Suggested Retail Price)

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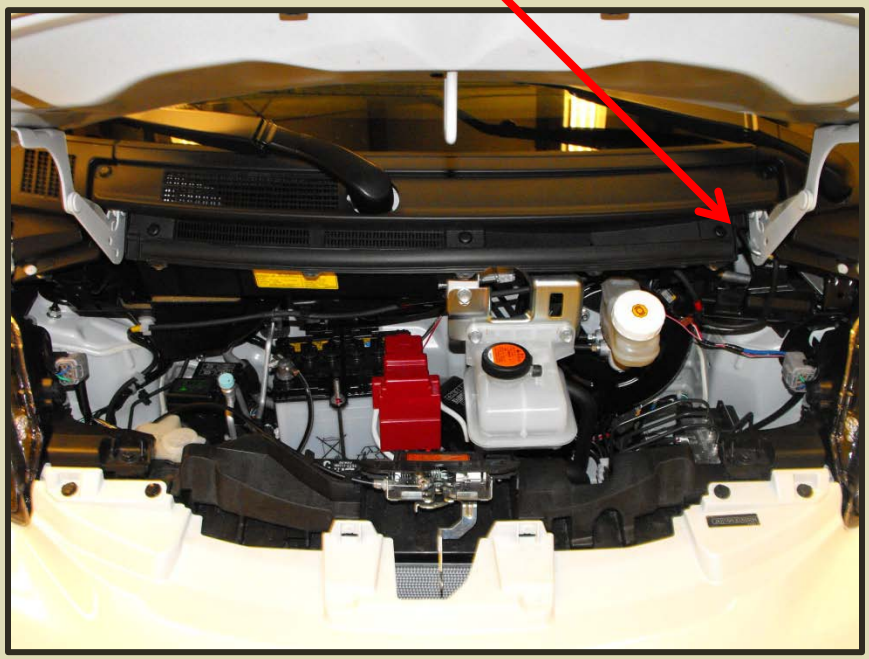
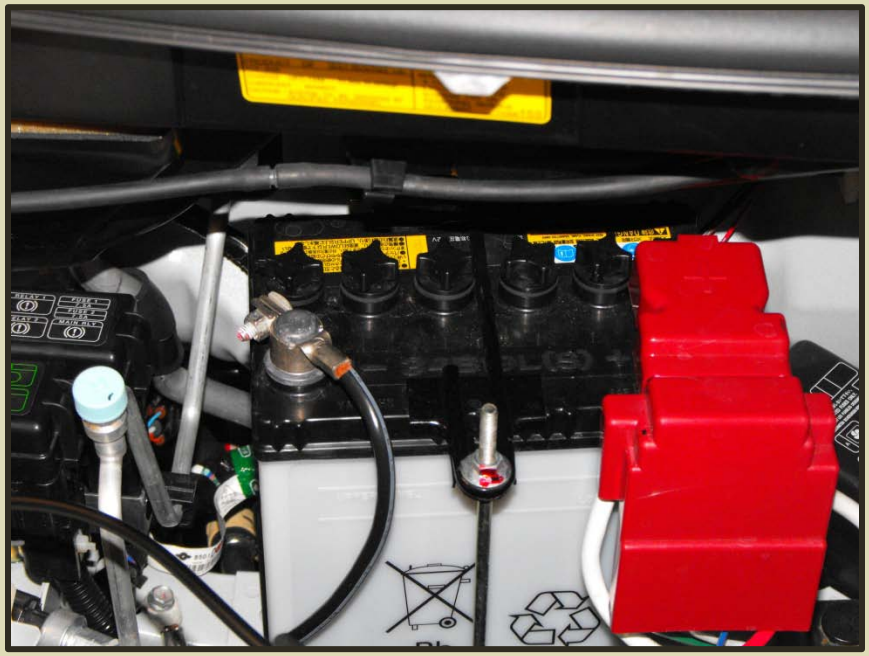
2012 Mitsubishi “i”



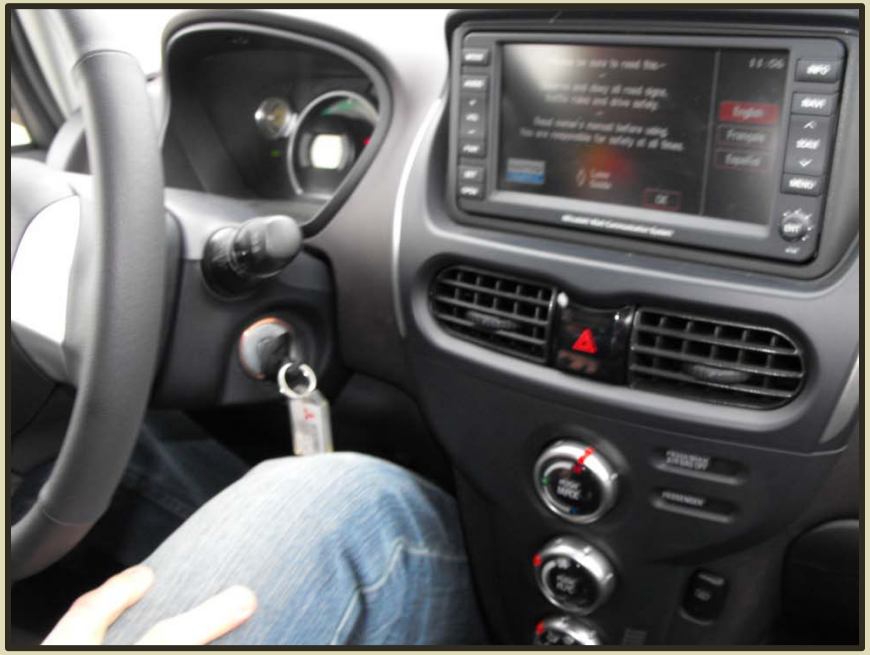
12 volt battery

- Located underhood
- Needed to “Ready” the main H.V. system
- 12 v initially powers ECU’s, communication network and ability to activate the H.V. system main contactors



- 280 CCA lead acid battery
- There is no IOD fuse

2012 Mitsubishi “i”



- Conventional Key/Lock Cylinder

2012 Mitsubishi “i”

- Features a “remote” unit.
- This can be used to precondition the vehicle
- Warm up heater, Start defrosting or turn on A/C etc.
- Can also set up charge times: off peak etc.

- Remote “stick” similar to other Mitsu products

2012 Mitsubishi “i”

Level 3 charging door (drivers side) lever

Pass side Level 1 or 2 charging port “gas door” lever

2012 Mitsubishi “i”: Charge ports

- Level 3 charge port driver side

- Level 1 and 2 charge port on Pass side **SAE J1772 SPEC**

Acoustic Vehicle Alerting System

Complies with USA Fed regulations to warn blind pedestrians etc.

"**twirling sound**" comes from an underhood speaker controlled by AVAS ECU

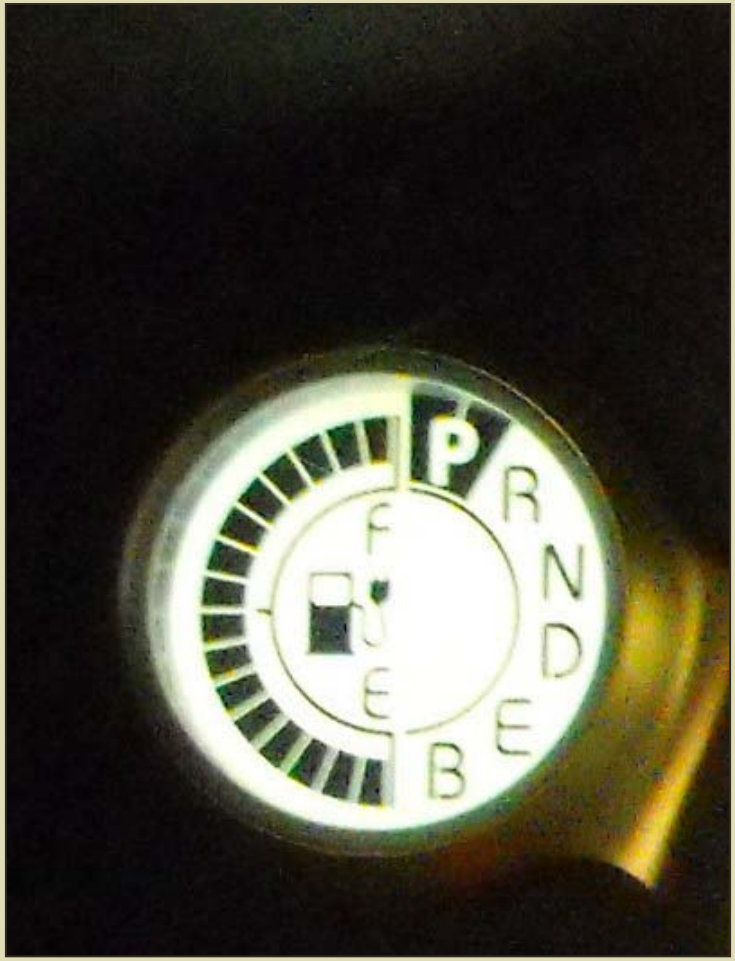
Noise loudest at low speeds about 12 MPH diminishes and fades away at 23MPH

Combination Meter (cluster)

Combination Meter (cluster)

“fuel gauge”: 16 segments

- Each segment represent 3-5 miles depending on accessories, speed, traffic, temperature and other variables
- “Turtle” icon appears on cluster with extreme depower mode last 1-2 miles



Tires/wheels

175 65 R15 tires in front

175 60R 15 tires in rear

- Front disc/rear drum
- No spare tire: Inflation kit with “goo” under rear seat

Transmission Selector

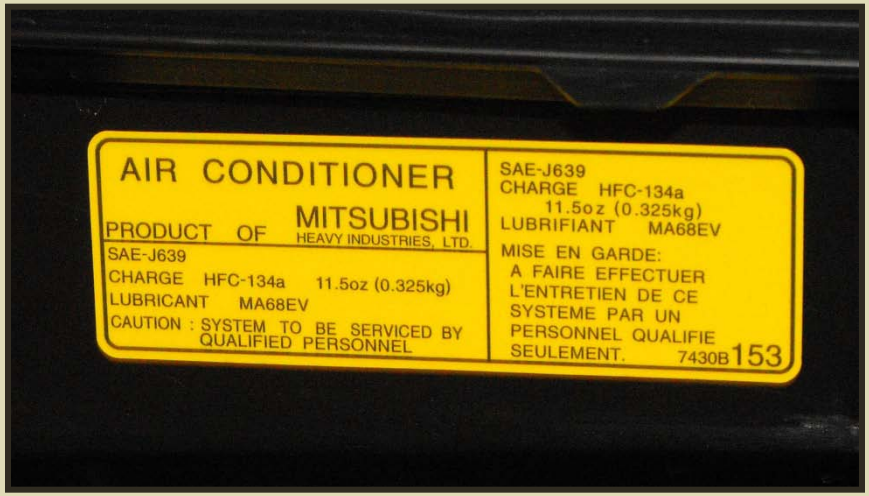
- “P”: needed for “ready”
- R: electric motor spins backwards
- D: “REGEN” only when brakes pressed
- “ECO” mode for max range
- “B” moving down hills, etc. aggressive “REGEN”

HVAC

- Very important:
  DO NOT use P.A.G. oil !

- USE dedicated A/C RRR machine (no chance of P.A.G.)

- Notice small charge of R134a

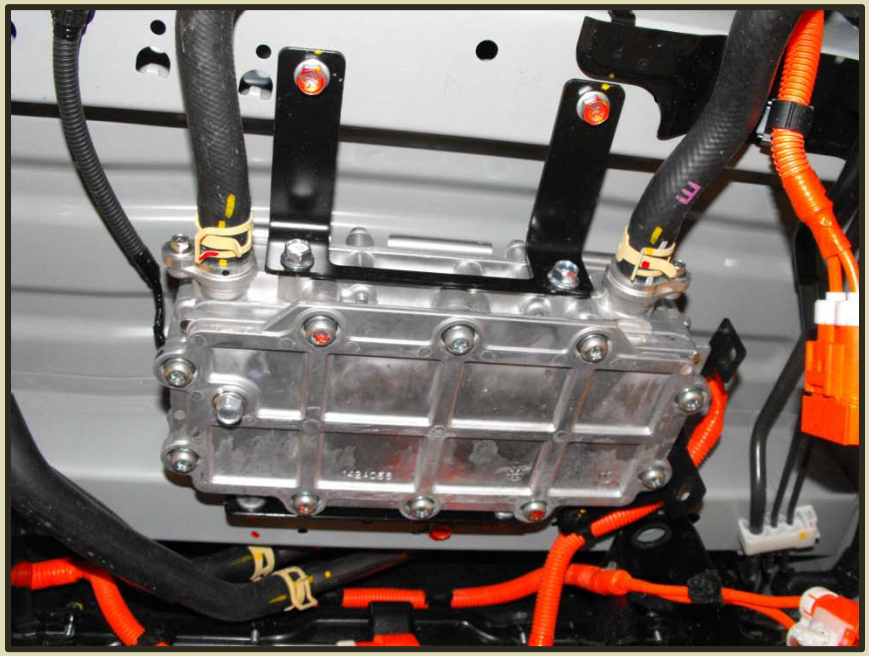


HVAC

- 330 volt scroll compressor
- 800-860 Watts
- Inverter within compressor body
- Evaporator “fin” sensor large input in controlling compressor speed

HVAC

- Electric Heater
- Uses up 5,800 watts
- Electric pump with ceramic impeller circulates coolant
- Battery S.O.C. must be 40% or more to operate



HVAC

- 2 separate coolant systems
- Front: For passenger HVAC system
- Rear: for motor electronics
- Both use Mitsu Blue colored 50/50 pre mix long life coolant

EV components coolant system

- Passenger HVAC system may be activated to heat or cool the battery pack during extreme temperatures

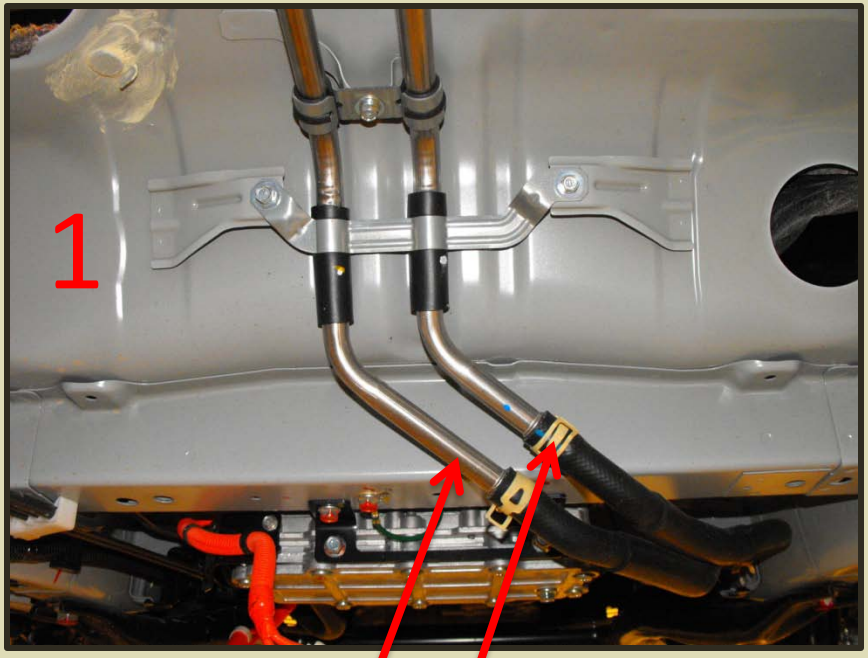
- Example: @-13F battery requires heating

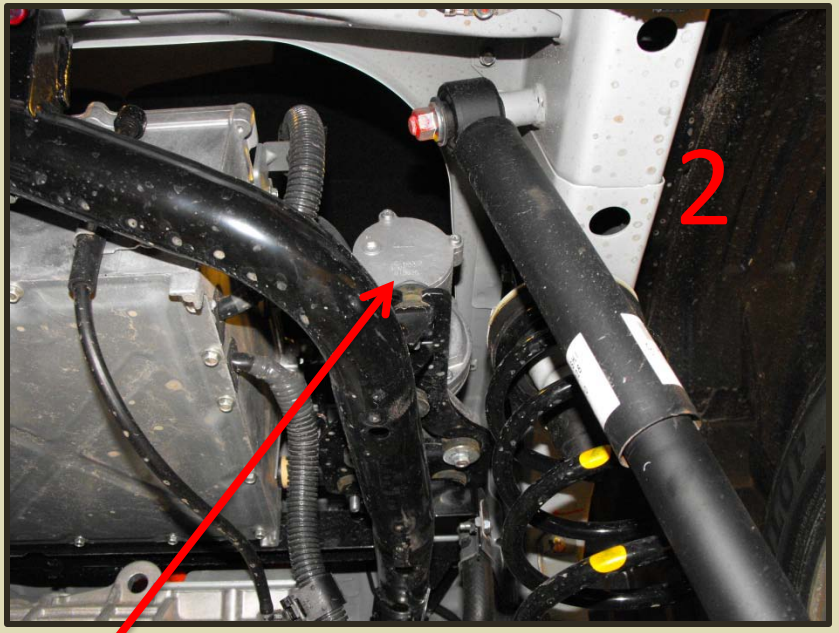
- Passenger compartment air heats/cools battery pack

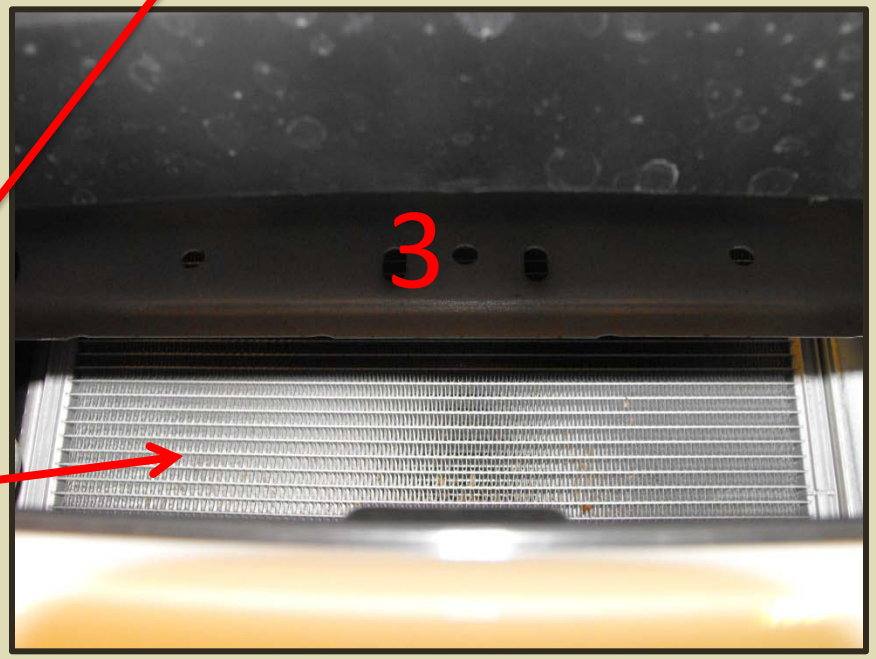
EV components coolant system

- If motor control unit reaches 176°F vehicle will enter power down mode
- If traction motor temp reaches 266°F vehicle will enter reduced torque mode

Reservoir for EV components cooling system (Trunk area) 5.4 quarts



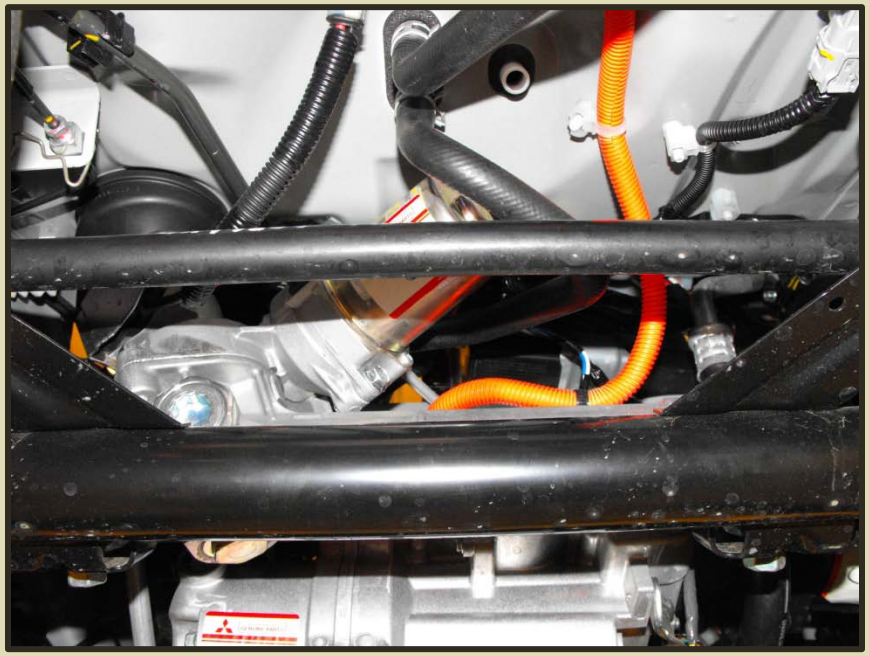




1. Coolant lines that run under length of vehicle
2. Electric coolant pump for EV components
3. Underhood radiator (radiator fan not shown)

Power Steering

- Electric Power Steering
- Low voltage motor on rack assembly
- Similar to other MITSU products

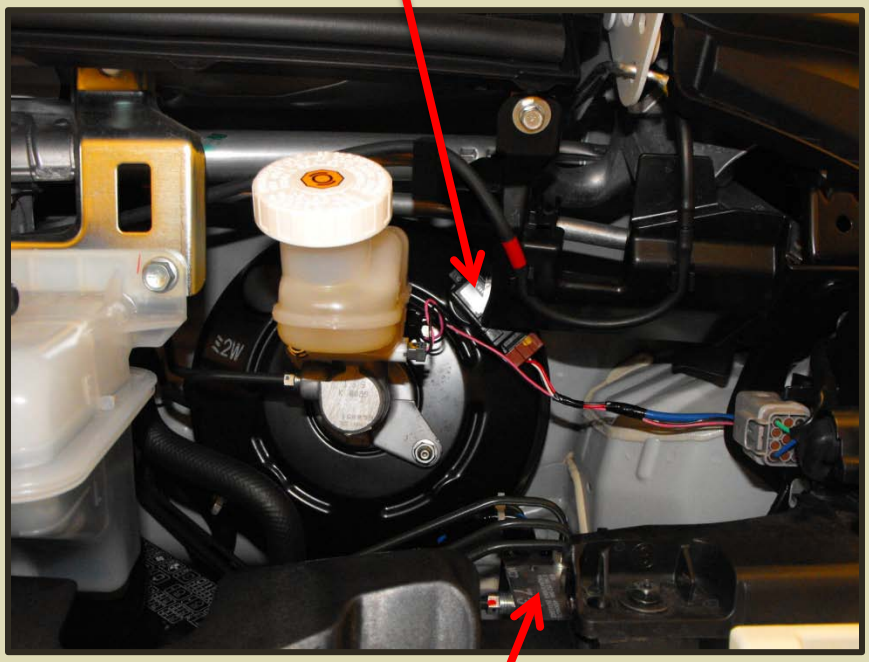


Power Steering

- Vehicle also features cruise control
- Hands free cell device
- Navigation Radio
- Back up camera

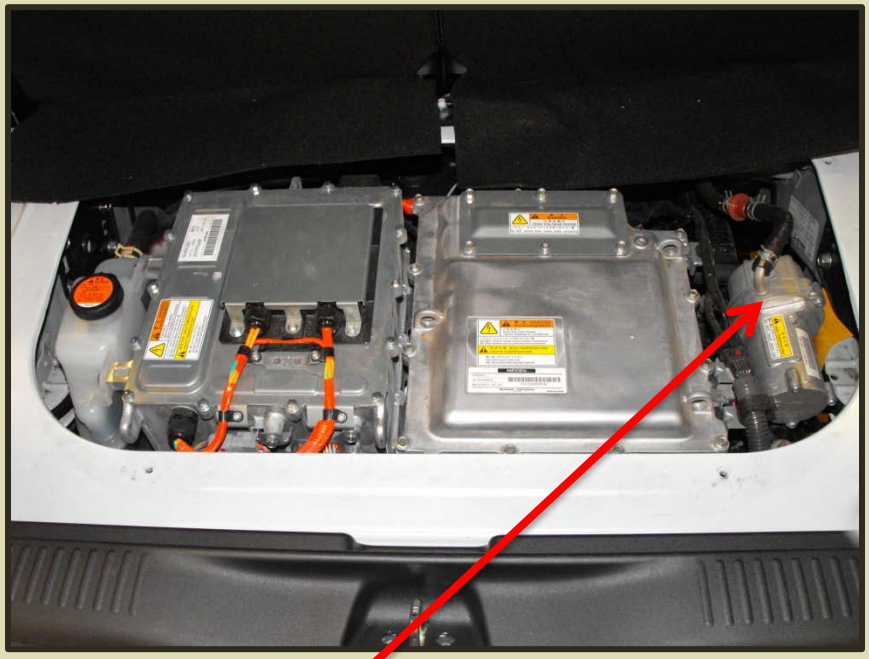
Braking

- Brake system: uses vacuum booster
- Booster has a “M.A.P.” sensor on it
- Conventional DOT 3 fluid
- M/C feeds hydraulic control unit



Braking

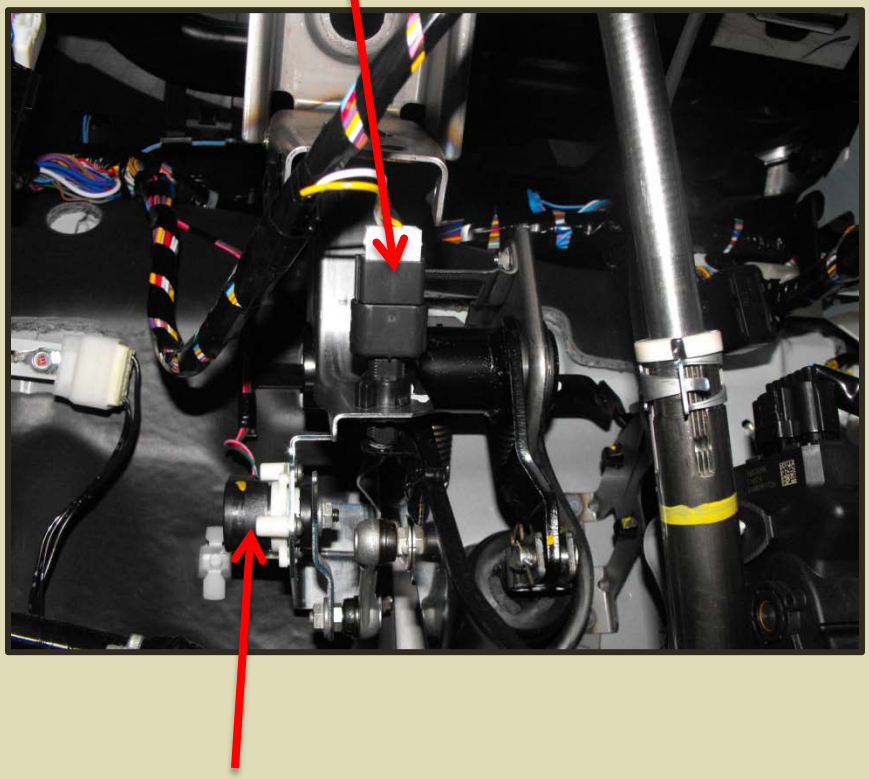
- When M.A.P. sensor senses vacuum depletion, electric vacuum pump runs to recharge the booster



Electric Vacuum Pump (Trunk area): is fairly loud

Braking

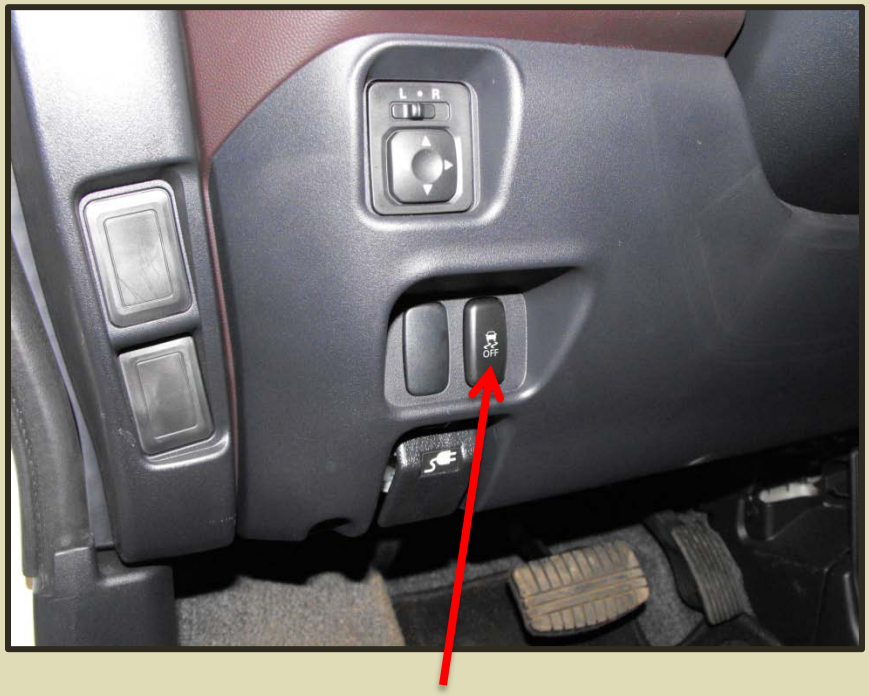
- Features brake override technology for safety
- Uses brake pedal stroke sensor as input in REGEN strategy
- Replaced as an assembly, must be initialized with MUT 3



Braking

- Vehicle has ABS, Traction control and Stability system

- Electric drive uses a “smoothing capacitor” to limit launching torque

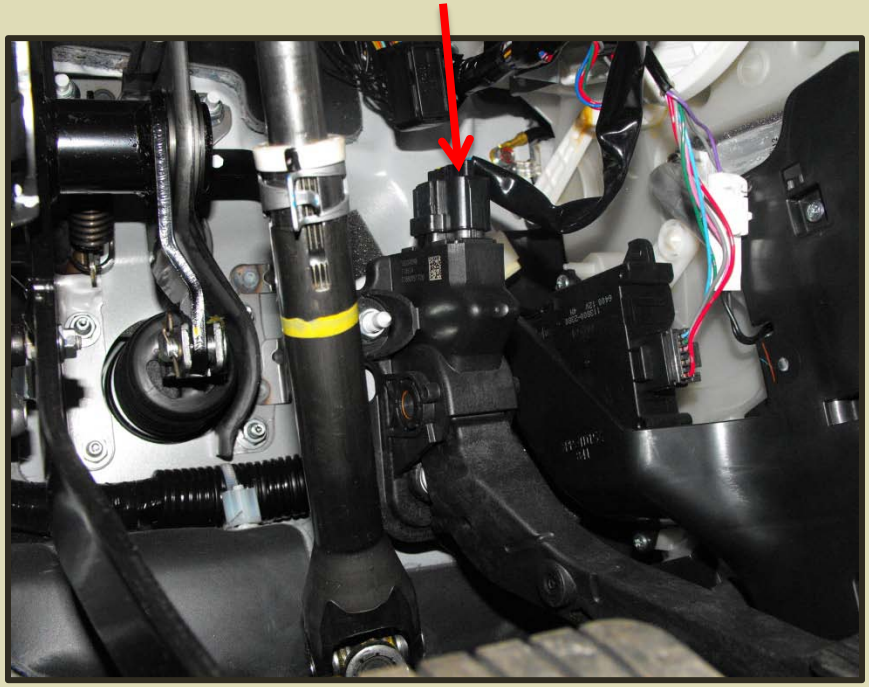


TRAC/ STAB off switch

Accelerator pedal

- A.P.P.S. assembly
- 2 signal wires
- About 1 volt at “idle”
- About 4.5v at “WOT”

APPS electrical connector



Operation: Severe temperatures

COLD: at -22°F, vehicle may not be able to “ready up”

Charge time when cold will be greater

EV ECU “wakes up” every 6 hours and monitors temperature

HOT: Does not like extreme heat, if placing in paint booth etc. @150°F or more, remove the battery

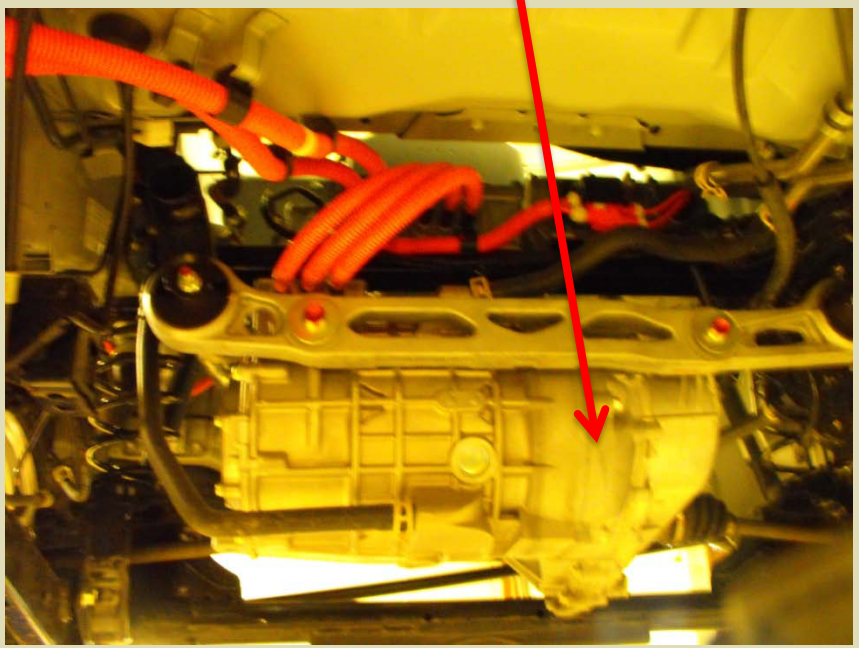
Severe temperatures may reduce range

Transaxle

- Mitsubishi **F1E1A**

- Approx. 7:1 gear reduction
- No changing of ratio

- .79 quart capacity of Diamond SP3 to be changed every 2 years for severe service

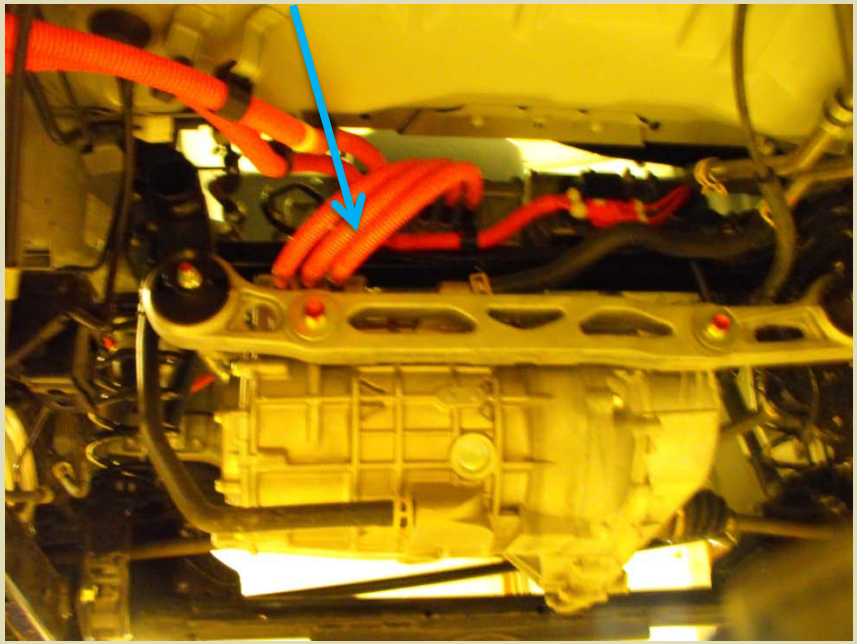


- Unequal length halfshafts

Motor

- Supplier: Miden
- Rated @ 66 horsepower
- 144 pound feet of torque
- Max speed 9900 RPM
- Resolver monitors RPM

Orange 3 phase high voltage cables



- Reduced output if temp reaches 266° F

Charging

- In addition to high voltage wires that connect car to wall outlet, there are communication lines
- Connection must be secure with proper outlet polarity and ground

- Optional level 2 charger installed

Proper Sequence

1. Plug into wall outlet first
2. Then connect to vehicle

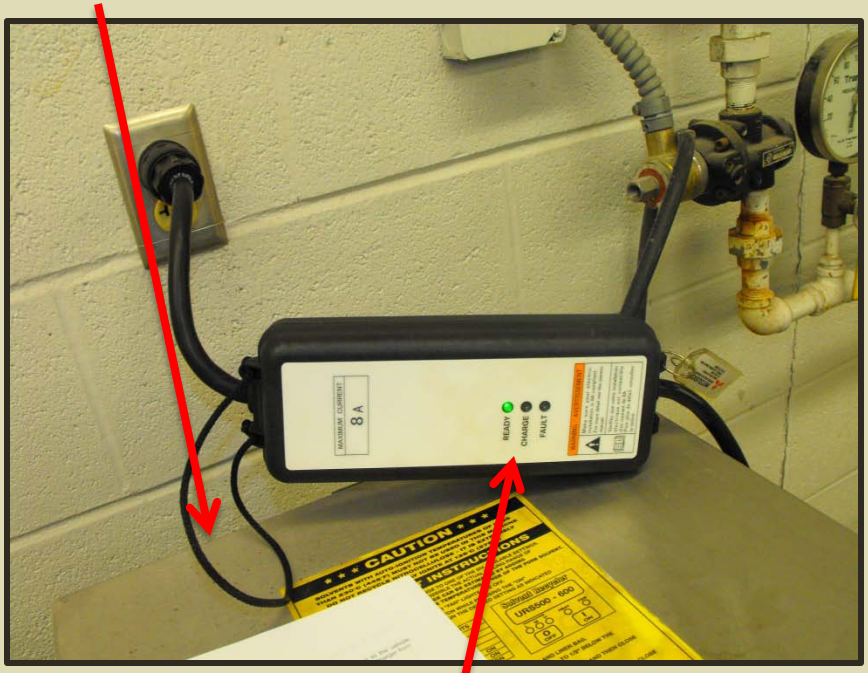
(this will save wear and tear on household outlets)

If attempt to move the vehicle with plugged in:
Vehicle will not move

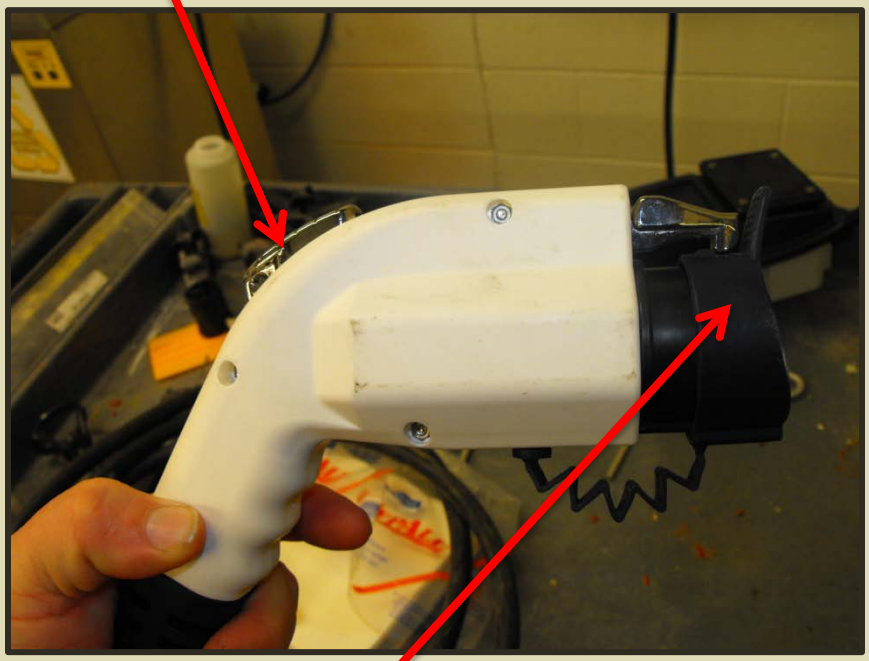
Also an (plug looking) indicator on cluster

Charging: Level 1 charger supplied with vehicle

Notice tether string provided with the level 1 charger



Release button



CCID Charging Circuit Interrupting Device; LED's :Ready, Charge, Fault

Tethered flap cover to protect against the elements

Level 1 charger

- 18 foot cord, optional 25 foot
- Level 1: maximum of 8 amperes

- Onboard charger steps up 120 volts AC to approx. 370 volts DC

- 0%-100% charge time is 22.5 hours

- When hooked up, blower fan in battery comes on for 3-5 seconds

Level 2 charger

- Level 2 charger connects to 240 volt outlet
- Optional : $995-$1172 plus installation
- Reduces 0% to 100% charge time to 6.5 hours

Note: aftermarket charger shown

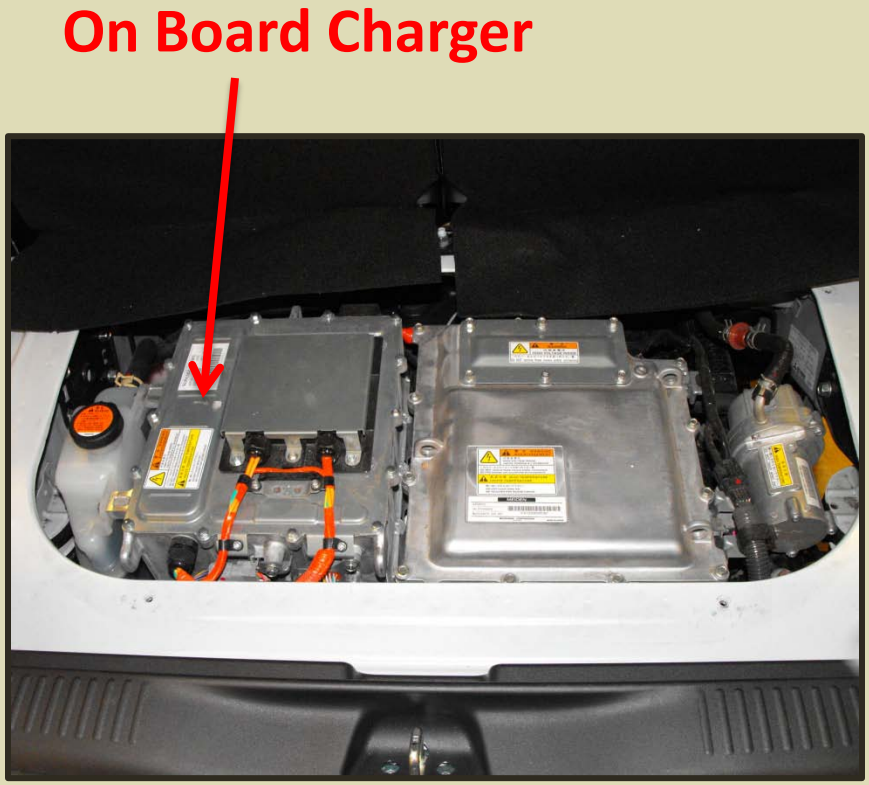
Level 3 charger

- Currently rare
- 125 amp rating
- Cost about $60K
- Charge time reduced to
  30 minutes

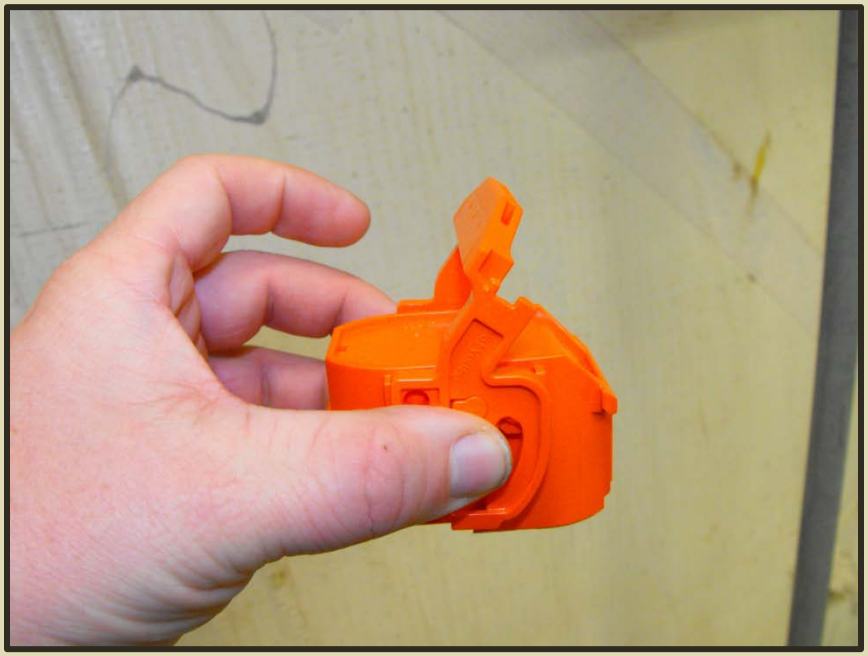
On board charger

- Onboard charger communicates with charging plug, manages battery charge

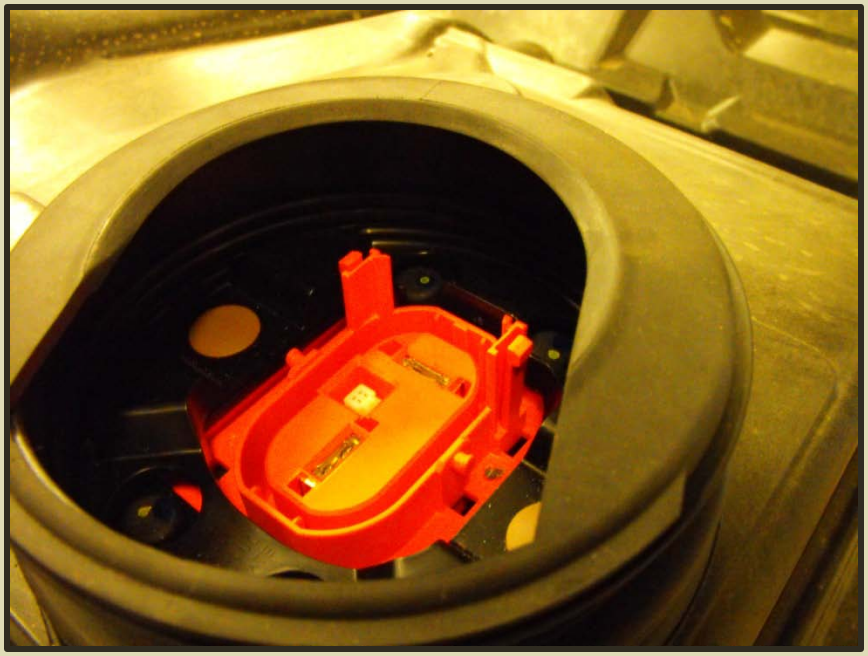
- Also acts as a DC to DC converter to step the 330V battery down to 14 volts to operate accessories and charge 12v battery

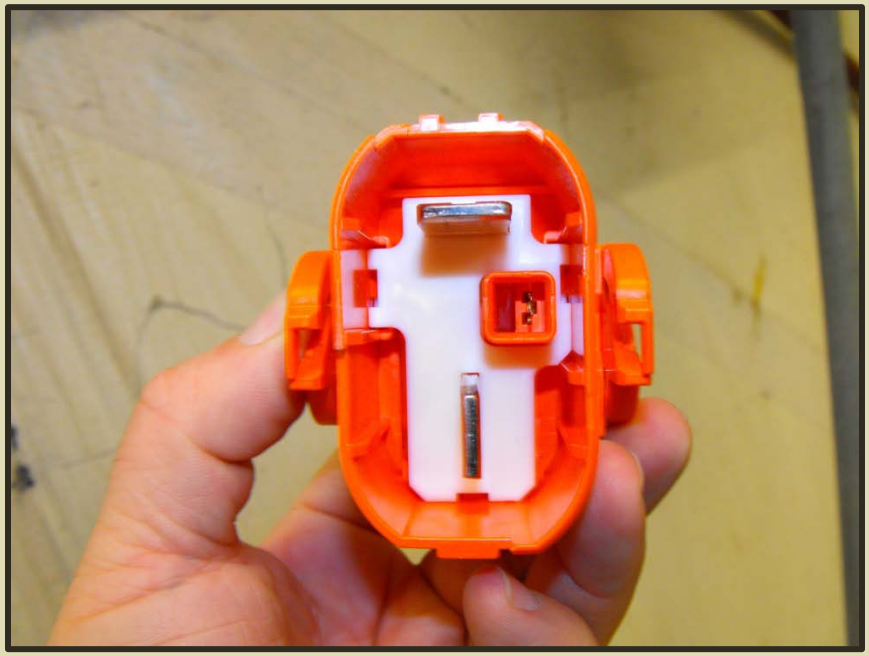


Service plug: Remove front driver seat first, **must have HV gloves on**!



Service Plug removed





Safety equipment : High voltage service

- Linesmen 1000v rubber gloves and leather protectors: Replace or recertify @6 months
- Rubber boots for working on wet floor etc.
- Also make sure DVOM and leads are CAT 3 certified

Safety equipment : High voltage service

Safety equipment : High voltage service

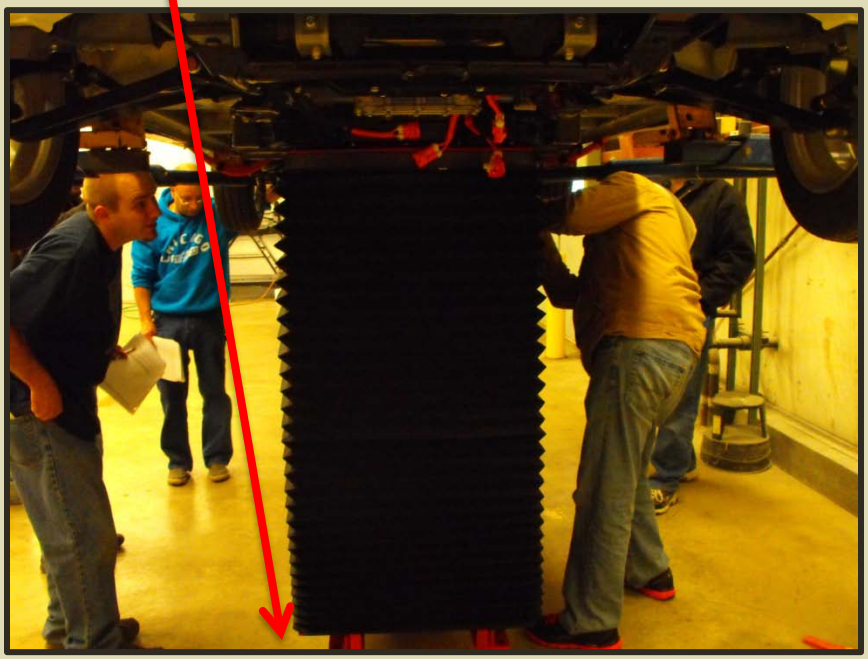
- Special insulated 10mm socket: if cracked/over torqued a black line will appear

Safety equipment : High voltage service

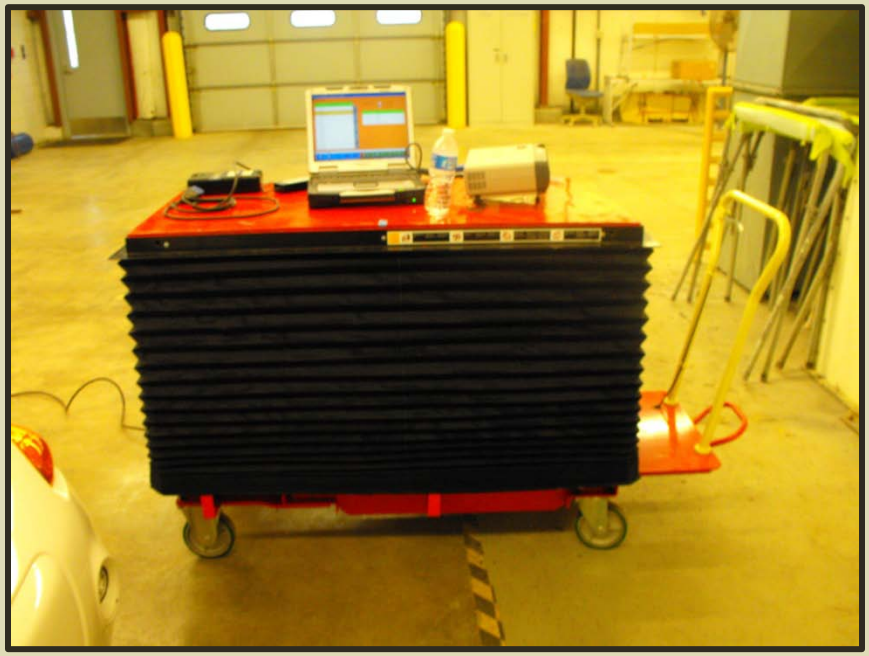
- Alignment tools for removing the battery assembly with the special fixture tool

Safety equipment : High voltage service

Mark position of fixture on floor for reference



Battery pack weighs 530 lbs: need fixture!



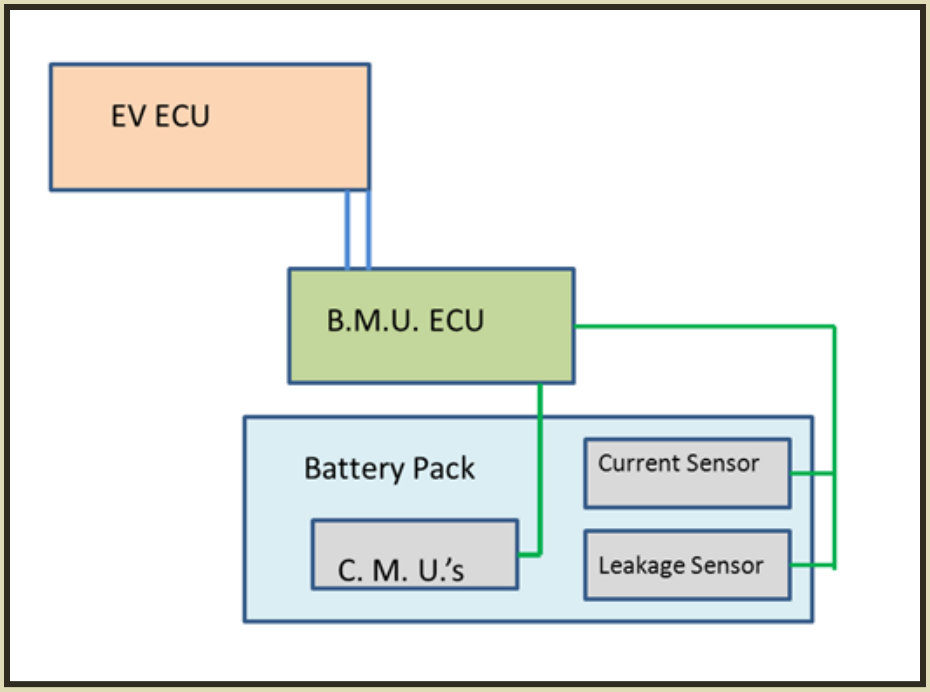
- If Battery R+R needed, zone office is contacted and special lifting fixture is delivered

Lithium Ion Battery Pack

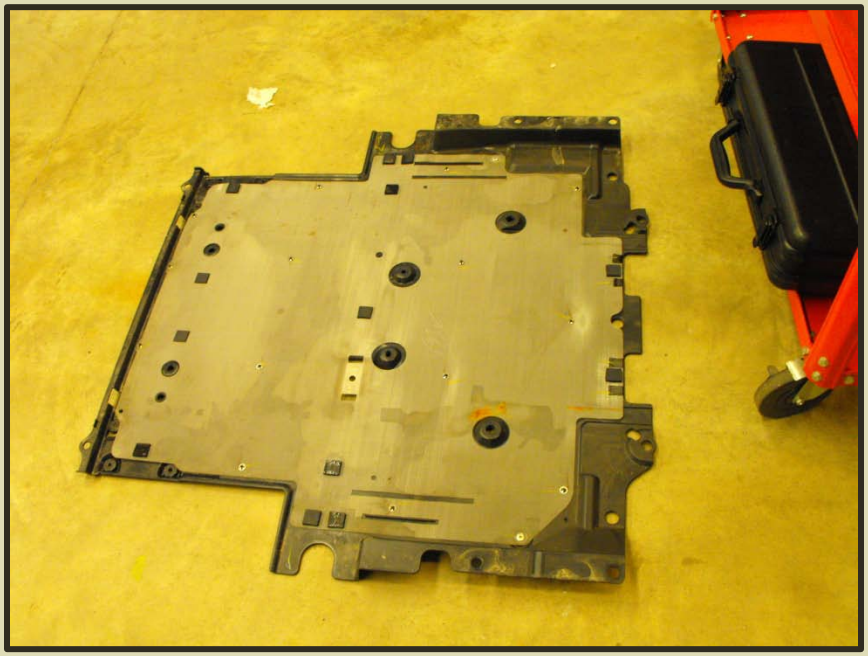
- 88 total cells @ 3.75v each wired in series
- Cells are in "**modules**"
- 10 modules of 8 cells and 2 modules of 4 cells
- 330-360 volts at full charge
- Each module monitors temperature, voltage and balance
- The BMU is an ECU on CAN high speed that monitors for "electrical leakage" and battery current
- BMU controls ventilation fan

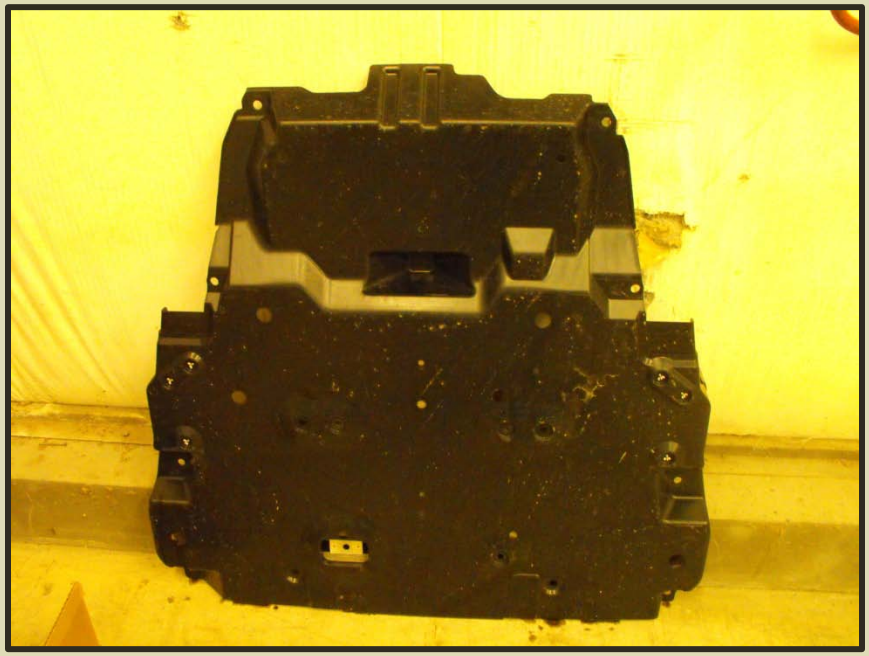
BMU ECU

12 cell monitoring units keep track of voltage and temperature of cells, report to BMU ECU



Battery pack: Covers vehicle underbody





Battery Pack

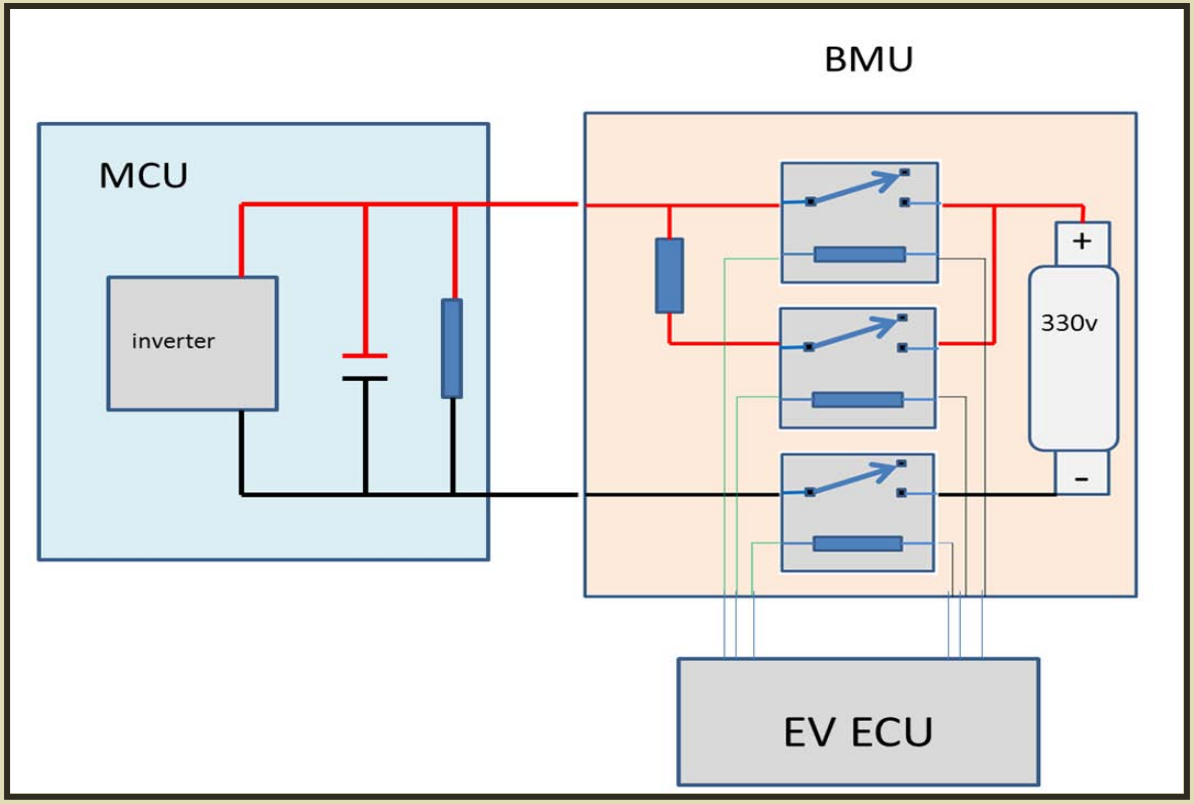
- After plastic covers are removed and HV gloves on, these covers are removed

- These cover the high voltage connections to the battery pack

Battery Pack

- Battery pack has no liquid coolant
- Air inlet is under passenger front seat
- Blower motor controlled by BMU

Battery Pack



- Main Contactors (Relays) are in the battery pack
- Controlled by EV ECU
- If Airbag ECU detects impact, Contactors are opened

Battery Pack

- Battery shipped to dealer in crate
- Eyelets with battery, lifting strap, forklift required to place pack on lifting fixture
- Battery must be recycled

- 8 year/80,000 mile warranty
- date code is on battery pack

Battery Pack: State of charge

- There is a .05 volt max allowed between cells
- A wrench symbol appears on cluster if battery conditioning is necessary
- Cell monitoring units and BMU work to keep cells equal

MCU (Motor Control Unit)

- Inverter in MCU ECU Converts DC from battery pack to AC voltage using IGBT's
- 3 phases on motor stator: U V W
- Voltage: determines torque
- Frequency: Determines speed

- MCU also contains smoothing condenser
- Current sensors on U and W phases

ECU interaction

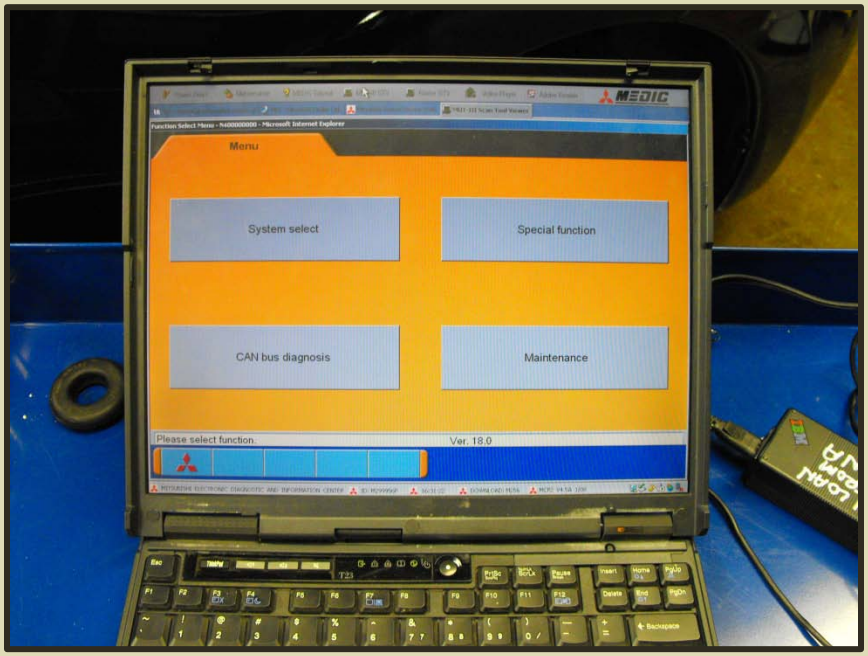
- EV-ECU is the most important however BMU, MCU, and onboard charger ECU all work as a team along with other ECU’s

Technician Diagnostics

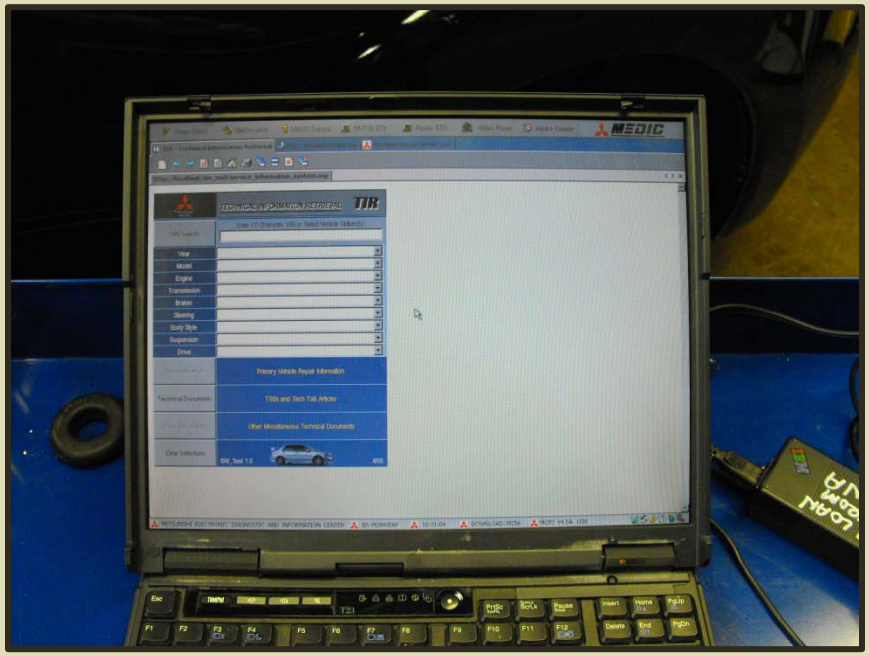
- Vehicle equipped with high speed CAN
- Laptop based MUT 3 is factory scan tool
- DTC's, Data Stream, initialization, actuators etc.

MUT 3 interface

Technician Diagnostics



Multi Use Tool (MUT) 3



MEDIC Factory Service Information

Driving the “i”

- Spirited Acceleration
- Speed limited in Reverse to 12 MPH
- Top speed is reported to be 80 MPH

Thank you to:

Mitsubishi Motors Corporation

Dan Sherman, MMC, SIUC Automotive Technology Advisory Committee

Rick LaVarta, MMC instructor

Questions?