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Prius High Voltage Battery Diagnosis and Upgrade

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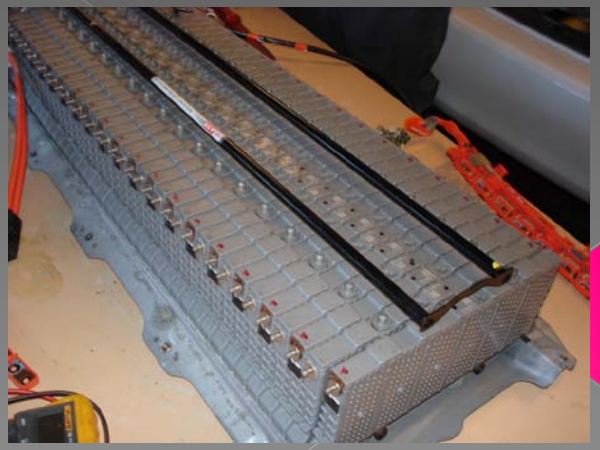
Prius!
Uncloaking High Voltage Battery Mysteries.
Corrosion Happens!

by Tim Janello



2003 Prius HV Battery Issue

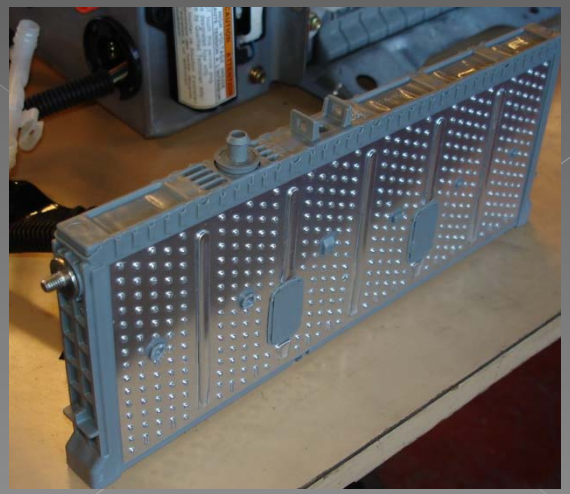
- 150K miles
- MIL On
- Tested HV Battery
- #10 Block Showed Bad
- Decided to Upgrade to Gen II Cells
- Neglected Maintenance

HV Battery Testing

- DTC P3000
- HV Battery Malfunction
- Check Freeze Frame for INF code
- Directs to Specific Problem
- P3006: HV Battery SOS Uneven
- P3011-P3029: HV Block # Malfunction
  - Internal Resistance error for Specific Block #

HV Battery Testing

- DTC 3006:
  - HV Battery State Of Charge Uneven
  - HV Battery ECU Detected Voltage Differences Between Blocks
- 38 Cells (7.2V) Make 19 Blocks (14.4V)



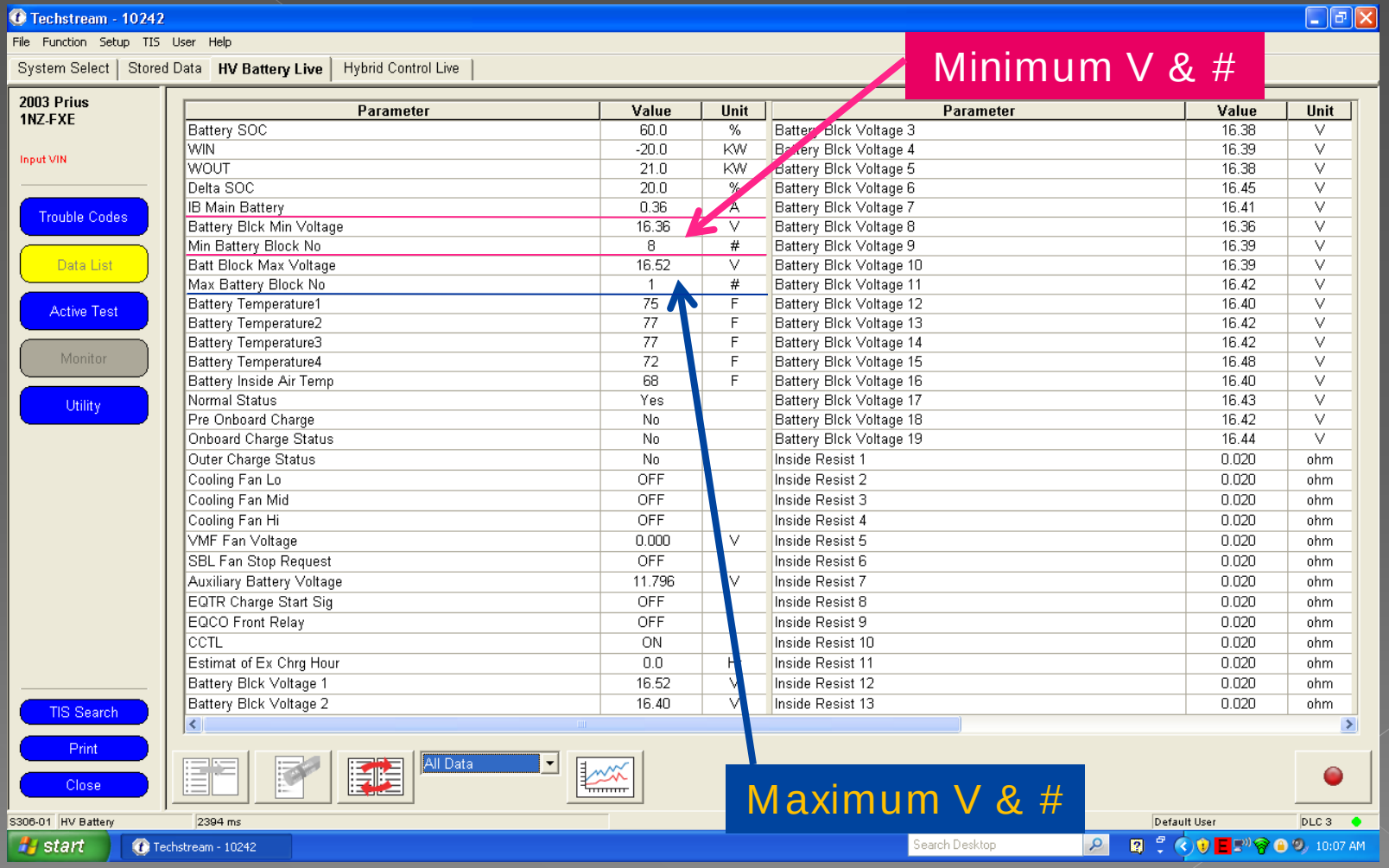
HV Battery Testing

- Testing HV Battery
- HV Battery Voltage Swing
  - Checking for Block V Difference
  - Looking for 2V Swing (Spike)
  - Looking for 1.2V Delta (min-max variance)
- Perform HV Stall Test
  - Using Electric Drive to Charge/Discharge
  - Follow Safety Procedures

Stall Testing

- Connect Scan Tool
- Tech Stream Lite (Toyota's Laptop Based)
- Check DTCs
- Check Freeze Frame for High/Low Block #
- Access HV Battery ECU
- Set Up Graphing for High & Low Block
- Observe for Swing Voltage Difference

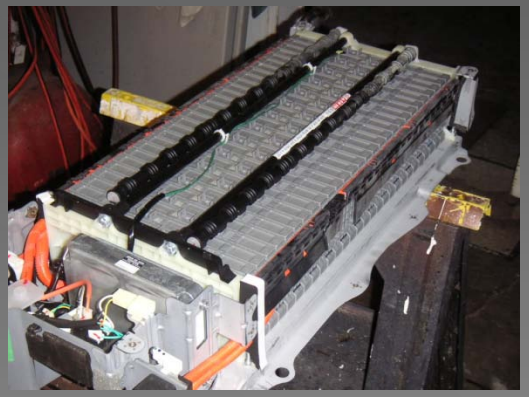
Block Voltages & Min/Max

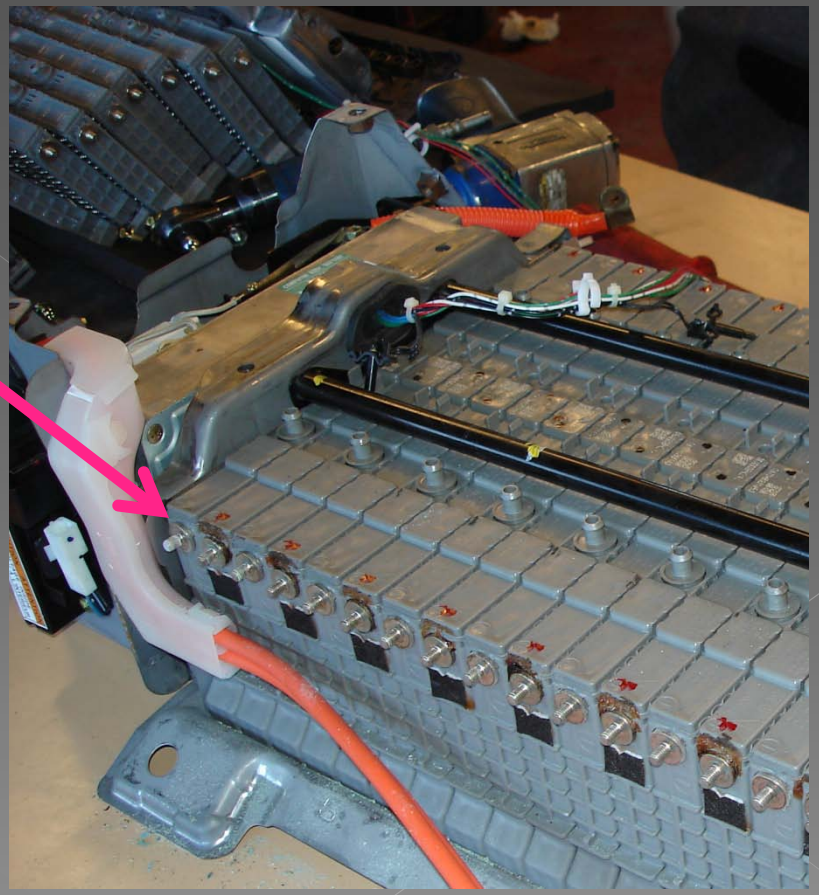


Parameter	Value	Unit	Parameter	Value	Unit
Battery SOC	60.0	%	Battery Blck Voltage 3	16.38	V
WIN	-20.0	KW	Battery Blck Voltage 4	16.39	V
WOUT	21.0	KW	Battery Blck Voltage 5	16.38	V
Delta SOC	20.0	%	Battery Blck Voltage 6	16.45	V
IB Main Battery	0.36	A	Battery Blck Voltage 7	16.41	V
Battery Blck Min Voltage	16.36	V	Battery Blck Voltage 8	16.36	V
Min Battery Block No	8	#	Battery Blck Voltage 9	16.39	V
Batt Block Max Voltage	16.52	V	Battery Blck Voltage 10	16.39	V
Max Battery Block No	1	#	Battery Blck Voltage 11	16.42	V
Battery Temperature1	75	F	Battery Blck Voltage 12	16.40	V
Battery Temperature2	77	F	Battery Blck Voltage 13	16.42	V
Battery Temperature3	77	F	Battery Blck Voltage 14	16.42	V
Battery Temperature4	72	F	Battery Blck Voltage 15	16.48	V
Battery Inside Air Temp	68	F	Battery Blck Voltage 16	16.40	V
Normal Status	Yes		Battery Blck Voltage 17	16.43	V
Pre Onboard Charge	No		Battery Blck Voltage 18	16.42	V
Onboard Charge Status	No		Battery Blck Voltage 19	16.44	V
Outer Charge Status	No		Inside Resist 1	0.020	ohm
Cooling Fan Lo	OFF		Inside Resist 2	0.020	ohm
Cooling Fan Mid	OFF		Inside Resist 3	0.020	ohm
Cooling Fan Hi	OFF		Inside Resist 4	0.020	ohm
VMF Fan Voltage	0.000	V	Inside Resist 5	0.020	ohm
SBL Fan Stop Request	OFF		Inside Resist 6	0.020	ohm
Auxiliary Battery Voltage	11.796	V	Inside Resist 7	0.020	ohm
EQTR Charge Start Sig	OFF		Inside Resist 8	0.020	ohm
EQCO Front Relay	OFF		Inside Resist 9	0.020	ohm
CCTL	ON		Inside Resist 10	0.020	ohm
Estimat of Ex Chrg Hour	0.0	H	Inside Resist 11	0.020	ohm
Battery Blck Voltage 1	16.52	V	Inside Resist 12	0.020	ohm
Battery Blck Voltage 2	16.40	V	Inside Resist 13	0.020	ohm

HV Battery Testing

- Block #1 Next to HV Battery ECU

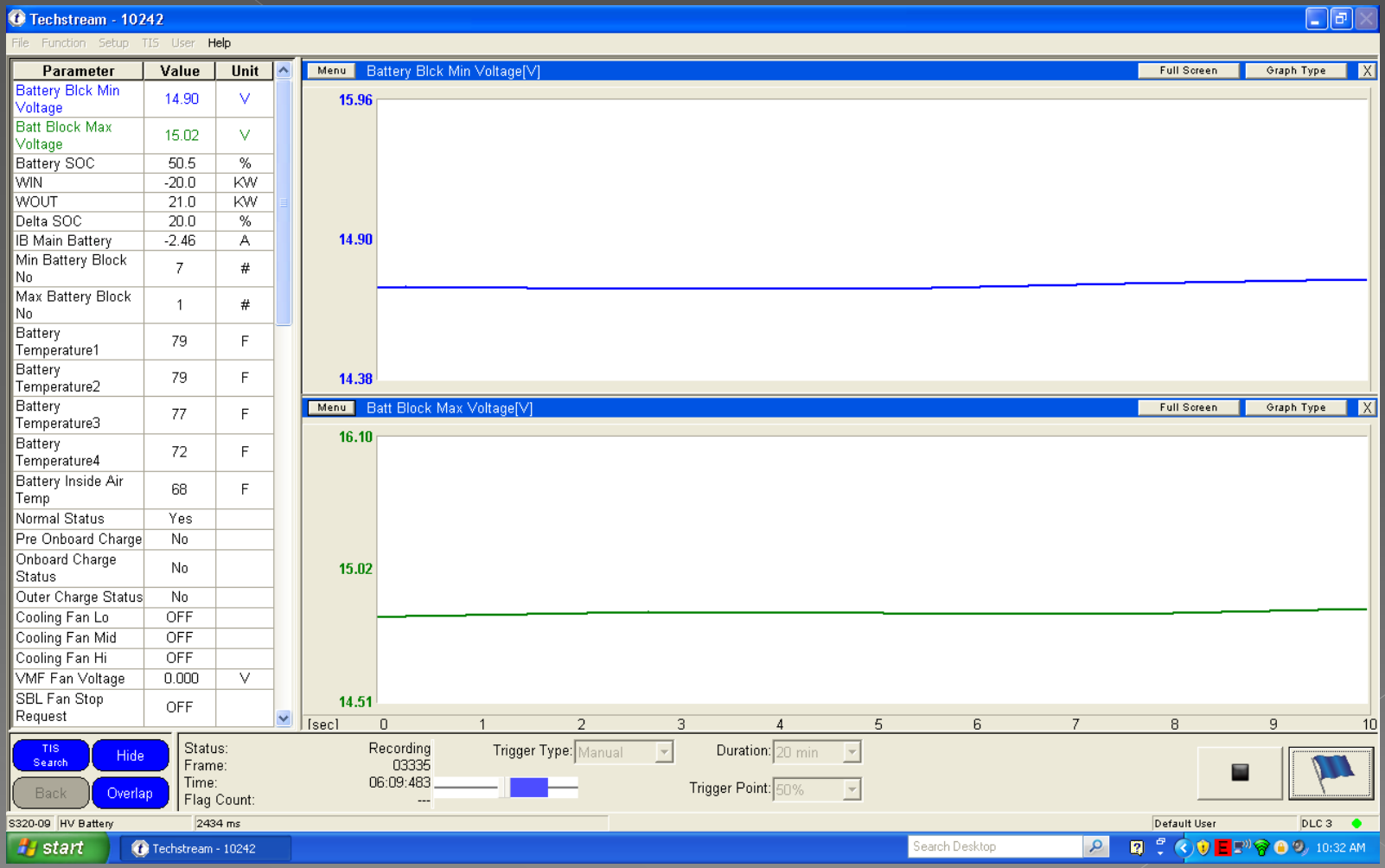




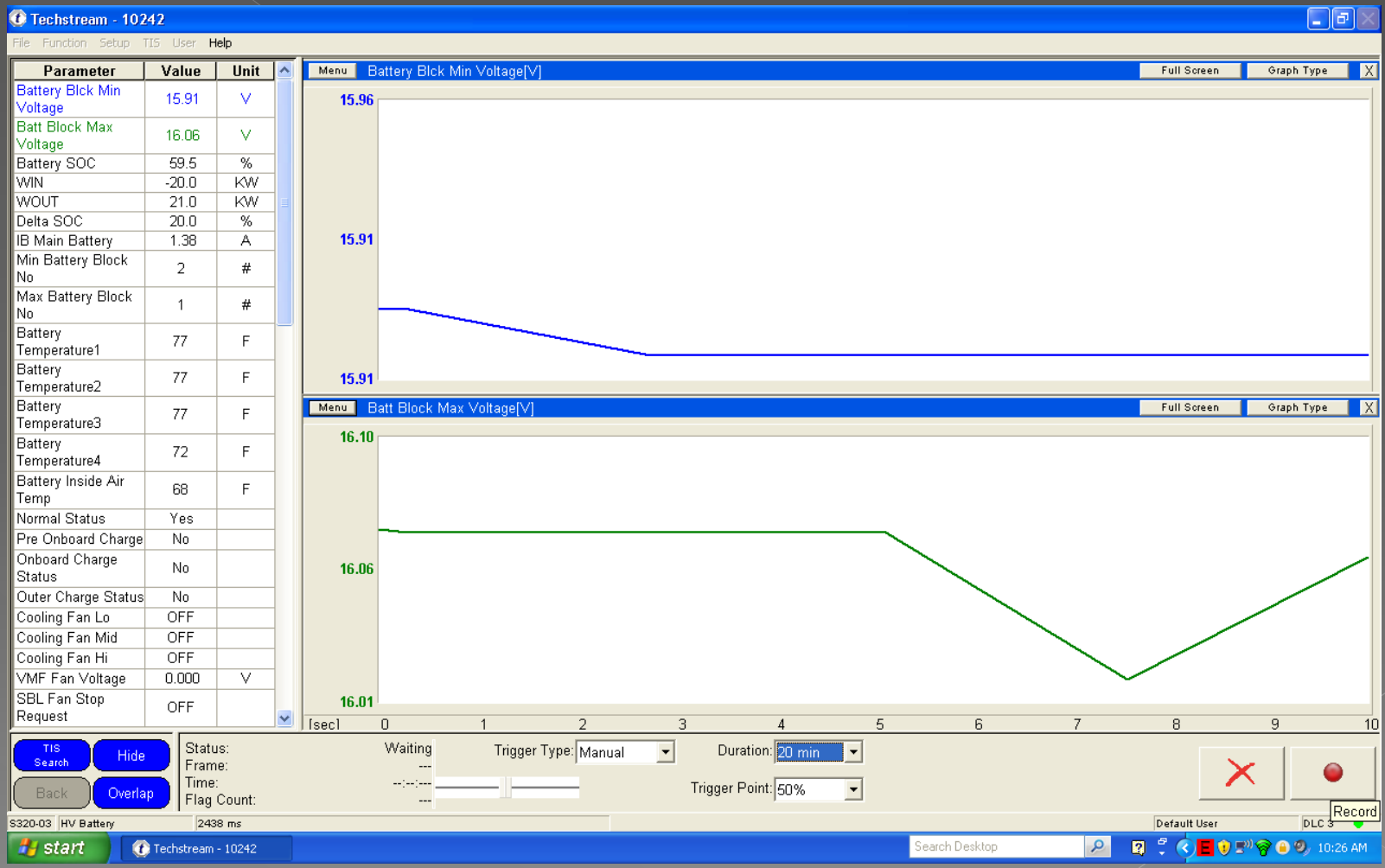
Stall Test

- Block Wheels
- Set Parking Brake
- Ready On (Start Engine)
- Let ICE Run Until Shuts Off
- Press & Hold Brake Pedal
- Select Reverse
- Press Accelerator Half Down
- Let Up When ICE Starts
- Repeat When ICE Shuts Off
- 20 Minutes

Graphing Block Voltage



ICE Starting



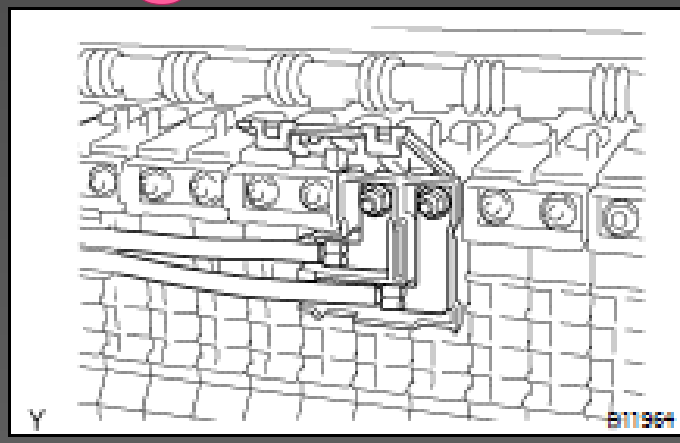
Sensing Connections

- ECU Senses Each Block
- Uses Bus Bar
- Small Wires
- Connected at Each POS Block Terminal
- 1 Connected to NEG Bus Bar

Failed Test

- 17V #1 Block
- 14.6 #10 Block
- On One Restart Voltage Fell Off Graph
- HV Battery Bad?
- Decided to Upgrade to Gen II Cells

Gen I HV Battery Design



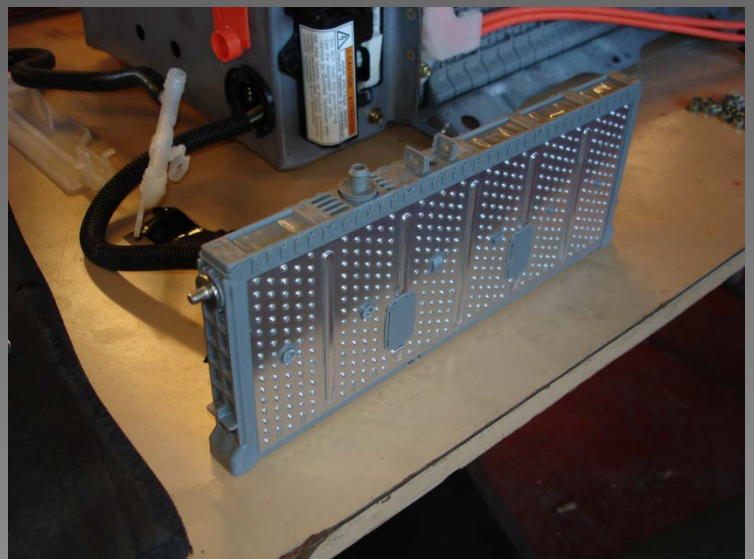
- 38 Cells = 273.6 Static Volts
- 2 Cells = 1 Block
- 19 Blocks
- Front Bus Bar Connects Positive Side
- Rear Bus Bar Connector Splits Negative Side
- Negative Side Connected by Relay
  - System Main Relay (SMR) Divides Battery

Gen II HV Battery Design

- 28 Cells
- 201 Volts Static
- About .75” Longer
- High Capacity

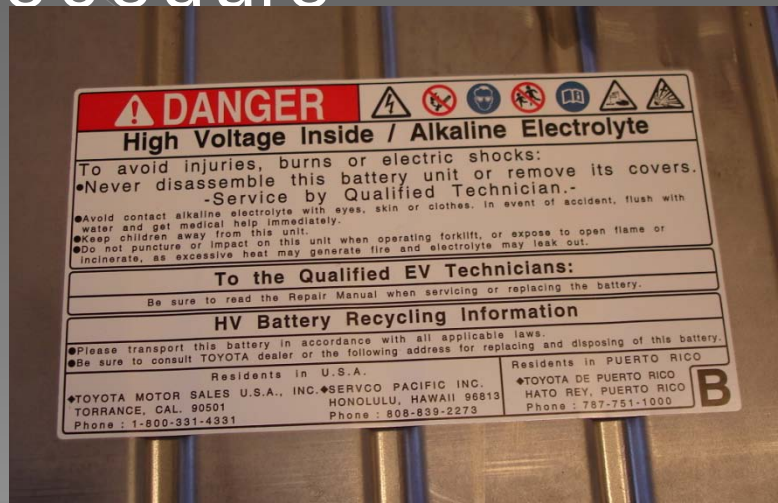
Upgrading HV Battery

- 38 Gen II Cells
- Newer in Age
- Improved Design
- Around $800



Remove HV Battery

- Follow Safety Procedures
- Safety Glasses
- Properly Insulated Gloves (1KV)
- Remember Acid Is Corrosive!
- Summarized Removal Procedure



Remove HV Battery

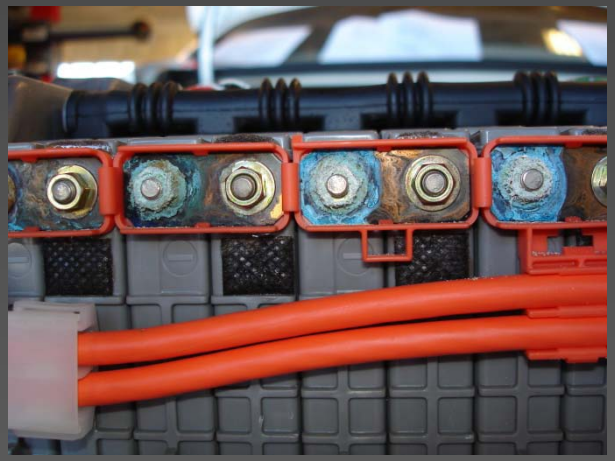
- Key Off
- Disconnect 12V Battery
- Remove HV Disconnect Plug
- Trunk/Left Side of HV Assembly
- Test For HV On Vehicle & Cover
- Remove HV Battery Cables
- Again Test For HV
- Unbolt Assembly from Vehicle

HV Battery Assembly Removed

Removing HV Battery Cover

- Turn Assembly Upside Down
- Remove 12 Cover Bolts
- If Removing Cells Remove 76 Bolts
- Turn Assembly Over
- Remove Cover
- Look For Acid Leakage & Vent Hoses
- Test Were HV Is?

HV Battery



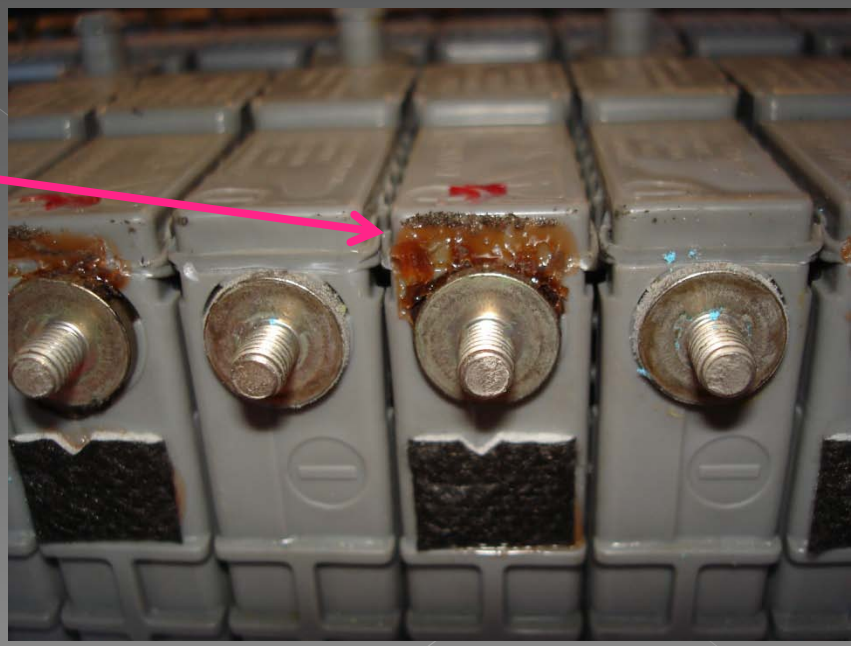
- Test Were HV Is?
- Use Insulated Tools
- Wrap Tools with Vinyl Electrical Tape
- Sockets and Handles
- Remove NEG Cables
- Remove Remaining 36 Bus Bar Nuts

Voltage Issue

- Both Bus Bars Removed
- Only Cell Voltage Left (7.2V)
- Remove POS Bus Bars
- Check Sensing Connections
- See a Problem?

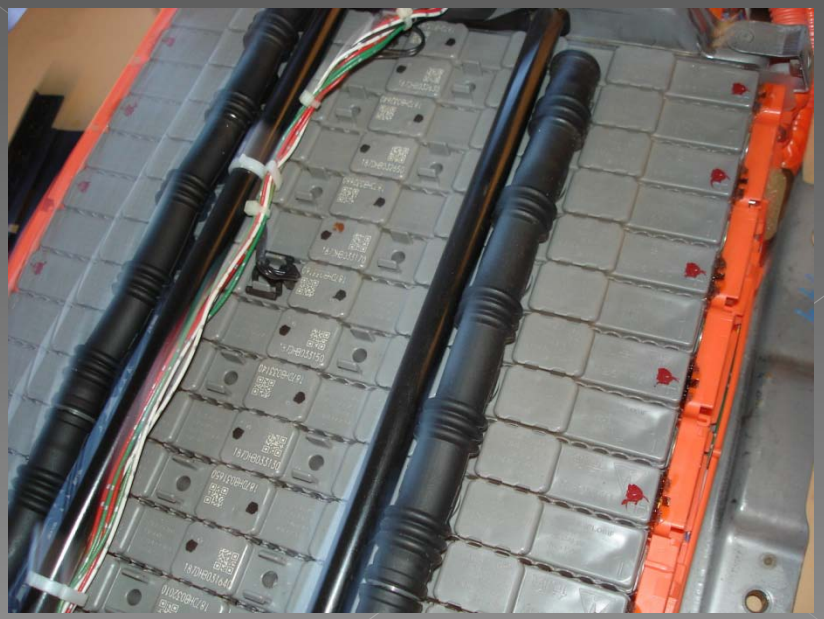
Original Cells

- First Thought “Acid Leaking?”
- After Bus Bar was Removed
- Cells Were Clean
- Epoxy Shown
- Factory Seal
- TSB Kit
- All Tested 7.2V
- Moisture & Copper?



Continued With Upgrade

- Removed Cell Hold Bolts
- Pull Off Vent Tubes
- Pull Out Temperature Sensors



Changing Cells

- Remove End Plate
- Slide Cells Out

Before Installing Cells

- Test Individual Cells
- All Cells MUST Be Equal Voltage
- Can be Slightly Drained SLOWLY
- <.3 Volt Difference
- Some Charge SLOWLY!

Installing Upgrade Cells

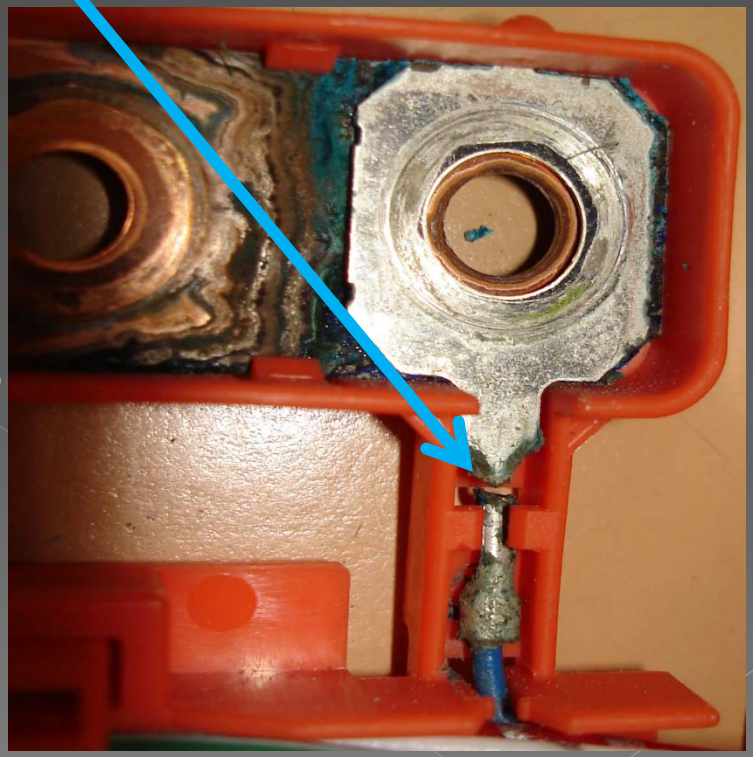
- New Cells Are Longer
- Won't Interchange
- Only 1 Bolt At POS End
- Reassembled Battery

Cleaning

- Cleaned NEG Bus Bars
- Salt & Vinegar Solution
- Coating?
- Stabilant22

Original Cells Good?

- POS Bus Bar Problems
- Found Used
- Needed Cleaning Also
- Cells ALL Tested Good?
- Reinstalled Bus Bars



Installing Error

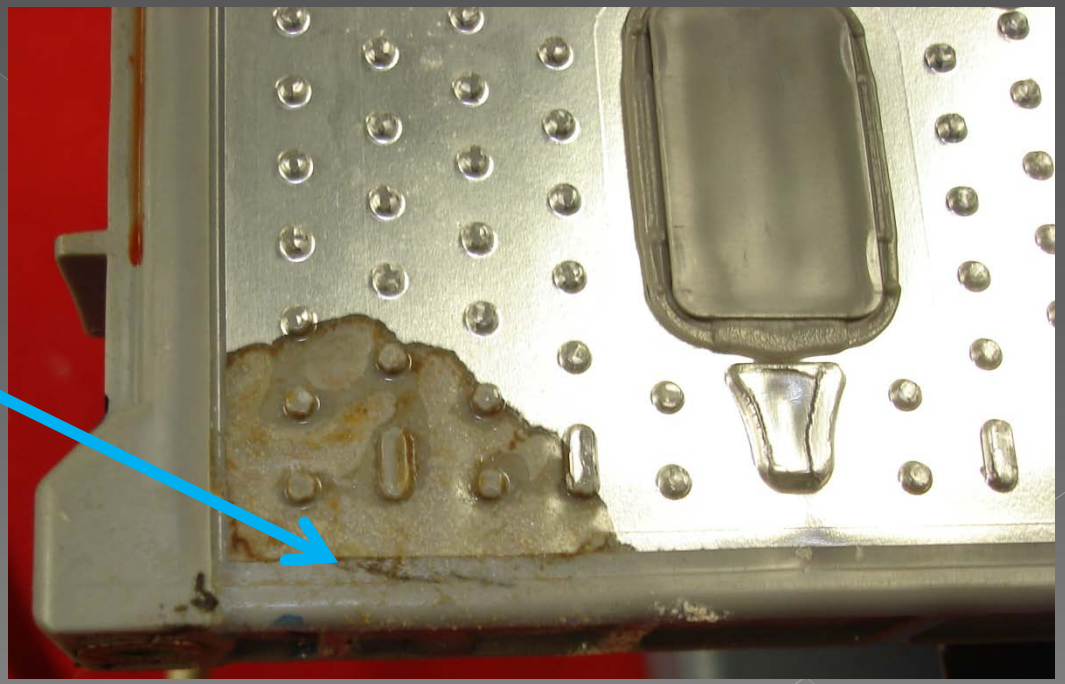
- Installed Assembly in Vehicle
- Reconnected Cables
- Installed Service Plug
- Hooked Up 12V Battery
- Started & Test Drove
- Tech Forgot a Step????

Problems

- Vehicle Drove 5 Miles
- MIL ON
- DTC 3009 (HV Leakage)
- Means HV on Vehicle Chassis
- Removed HV Battery Assembly
- Cells were Still HOT

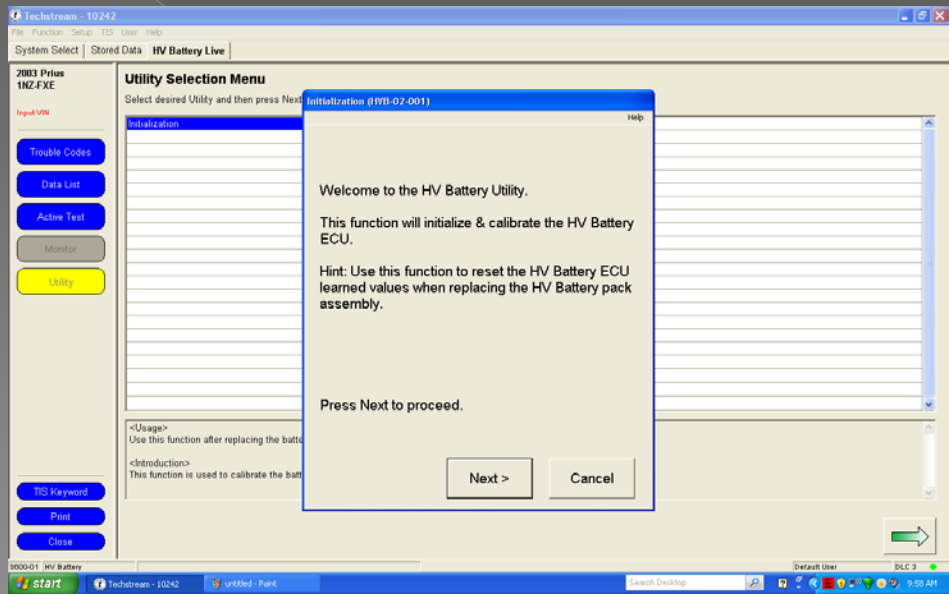
Cracked Cell

- What Was Found?
- Block in Middle
- Cracked
- Acid Leaking
- HV on Housing



Initializing

- Tech did not Initialize the HV ECU
- Overcharging
- ECU Did Not Relearn Quick Enough?
- HV Battery ECU Utilities



Back to Original

- Cannot Interchange Cells
- Reinstalled Original Cells
- Initialized System
- Preformed Stall Test
- Graphed Swing V
- All Cells Within .3V
- ICE Did Not Restart as Often
- Preformed in October, 2011
- Not Problems

Questions

- Tim Janello
- Automotive Technology
- Southern Illinois University Carbondale

- Presentation @ http://opensiuc.lib.siu.edu/auto_pres/