

EVc User Manual



NuVant Systems Inc.

Pioneering Electrochemical Technologies

An A3 Global Company



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www.nuvant.com



130 N. West Street
Crown Point, IN 46307

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Caution:

1. EVc units cannot be used safely without a battery pack cooling box and fan.
2. EVc units should not be used without training from NuVant staff.
3. EVc users must wear safety glasses.
4. EVc users should use safety barriers (e.g. Plexiglas, poly-carbonate, shatter proofglass, etc.) for protection during pack reconditioning.
5. EVd users should use an insulating electrical mat, safety glasses and high voltage gloves.
6. Always wear personal protective equipment when assembling battery packs, connecting the battery to EVd harness, operating the power tester, and installing the battery into enclosures. NuVant Systems is not responsible for any property damage and/or injury that occurs during use of equipment.

Failure to take the above precautions will result in injury or death.

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(Glossary of Terms can be found at end of document)

A	amp
Ah	amp-hour
DOD	depth of discharge
HV	high-voltage
I	current
Li-ion	lithium ion
NiCad	nickel cadmium
NiMH	nickel metal hydride
Ω	ohm
OCV	open circuit voltage
QR code	Quick Response code (found on Toyota modules)
Res	resistance
SOC	state of charge
V	voltage
Wh	watt-hour

Software:

- EVcharge - used for EVc operation and data analysis.
- TeamViewer - used for remote training by NuVant staff and diagnostics.
- WPS Office - used for module data analysis and pack building.
- Battery Pack Builder - used for module data analysis and pack building.

**Files (EVc Materials folder):****Resources:**

- Battery Webinar.pdf - Printable copy of Battery Repair Webinar
- Full EVc and EVd Manual.pdf - user manual for EVc operation
- Pack Builder Manual.pdf - user manual for Pack Builder operation
- Honda Reconditioning Instructions.pdf - Instructions on how to connect Honda modules and build cooling box
- Pack Builder (Empty).xlsx - Empty copy of Pack Builder sheet, with inventory and templates Plan

Files:

- Ford Escape Plan.xml
- Honda Cylindrical Plan.xml
- Toyota 10 Cell Plan.xml
- Toyota Prius and Camry (Steps 3-8).xml
- *Toyota Prius and Camry Plan.xml
- Ford Fusion Plan.xml
- Toyota 8 Cell (Highlander) Plan.xml
- Toyota 12 Cell Plan.xml
- Toyota Prius and Camry (Steps 5-8).xml

*this is the primary plan

Core Inspection

Tools Needed:

- Socket wrenches (to remove enclosure)
- HV plug (to remove enclosure, see images below)
- Voltmeter (to read module voltages)
- QR code scanner (to read/store QR codes)
- Spray bottle with phenolphthalein solution (1%)



HV Plug 1: Prius ('04-'10),
Camry ('07-'11)



HV Plug 2: Prius ('11-'15),
Camry ('12-'17)



QR code scanner



Phenolphthalein indicator

*Phenolphthalein Leak Test:

1. Fill a spray bottle with 1% phenolphthalein solution
2. Spray the sides of battery modules, including terminals
3. Wait a few minutes
4. The clear solution will turn pink indicating the presence of leaking electrolyte
5. Remove/reject leaking modules
6. Wipe solution off of modules with wet towel

Procedure

1. Visually inspect the outer enclosure
2. REJECT any cores that have:
 - A. Painting on part or entire enclosure
 - B. Third-party reconditioner/rebuild labels or logos
 - C. Damage/markings
3. Remove outer enclosure and inspect modules
4. REJECT any cores that have:
 - A. Leaking modules (white powder at terminals, or stains on bottom plate) - Phenolphthalein solution can also be used to detect leaks*
 - B. Modules with visible markings (for example, numbers, marker pens, tape, stickers)
 - C. Modules with voltages below 6 V
 - D. Non-sequential modules (QR codes should read in a sequential fashion)

Pre-Screening Process

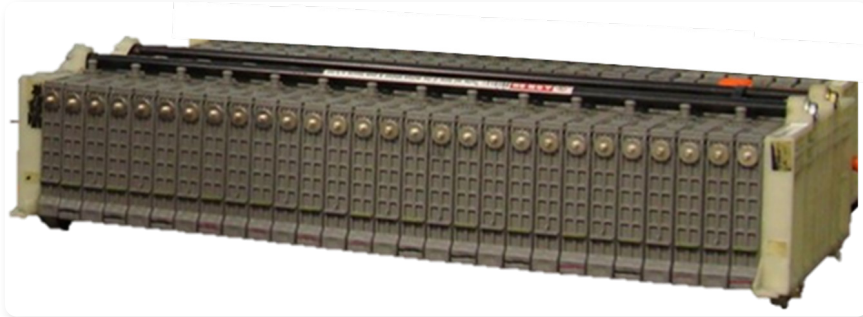
After cores arrive, their enclosures must be opened to pre-screen the modules.

1. Inventory and document cores
 - A. Vehicle type
 - B. Number of modules
 - C. Markings
2. Remove outer enclosure from cores
3. Remove modules from tie rods and note any markings on modules
4. Manually measure module voltage with voltmeter (reject if below 6V)
5. Scan module QR codes and record module mass in "Inventory A" spreadsheet
6. Place modules in "Inventory A - Pre-reconditioned Modules" shelf



Preparation

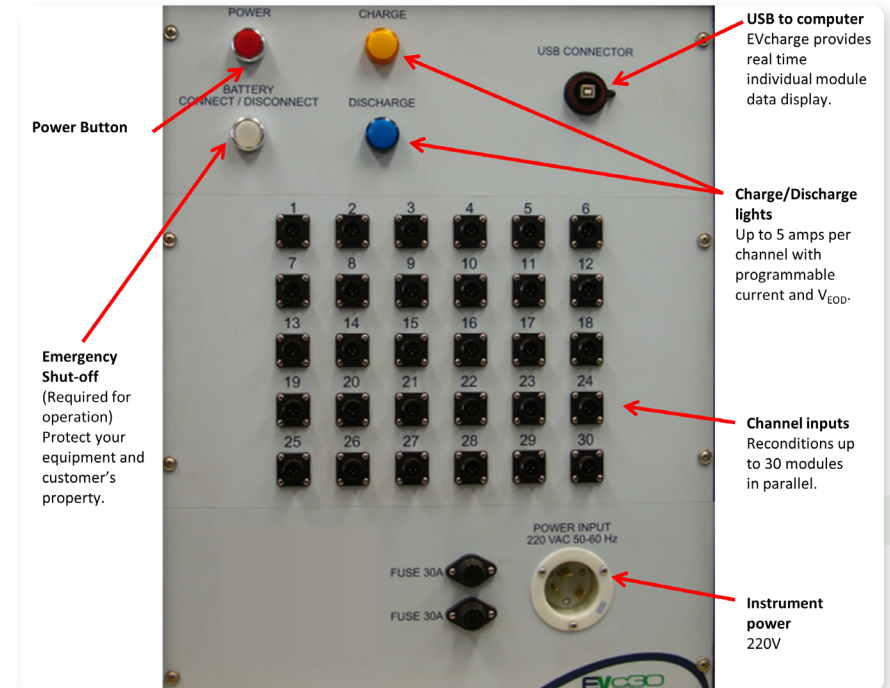
1. From the Module Inventory A shelf select 30 modules
2. Number modules (User Label) on one side. This is your own numbering system.
3. Install modules into tie rods. For the Toyota Prius tie rods, assemble 28 modules, and for Toyota Camry, connect 34 modules. These are the four metal rods (two below & two above) and end plates. Alternate the positive and negative terminals on each side.



28 modules clamped with tie rods and end plates

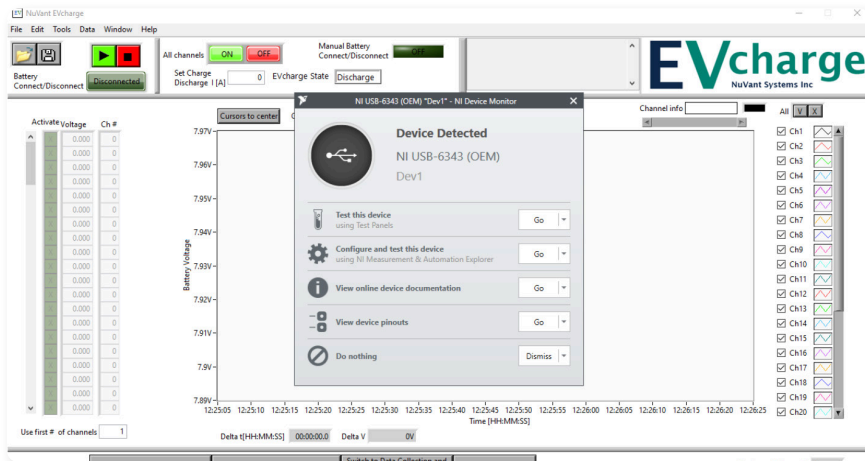
4. Make sure that your modules are clamped securely and place onto the cooling box.
5. Connect the EVc cables to the modules using the ring terminals. Do not exceed torque of 50 in-lbs (use a medium setting on drill).
 - A. EVc-30: For Prius, connect the first 28 cables and disconnect cables 29 and 30 from the front panel. For Camry, connect 30 cables and save the remaining 4 modules for later reconditioning.
 - B. EVc-12: For Prius & Camry, connect 12 cables to first 12 modules. You can only recondition 12 modules at a time.
6. THE COOLING BOX AND FAN MUST BE ON DURING RECONDITIONING.

Connecting the EVc and software

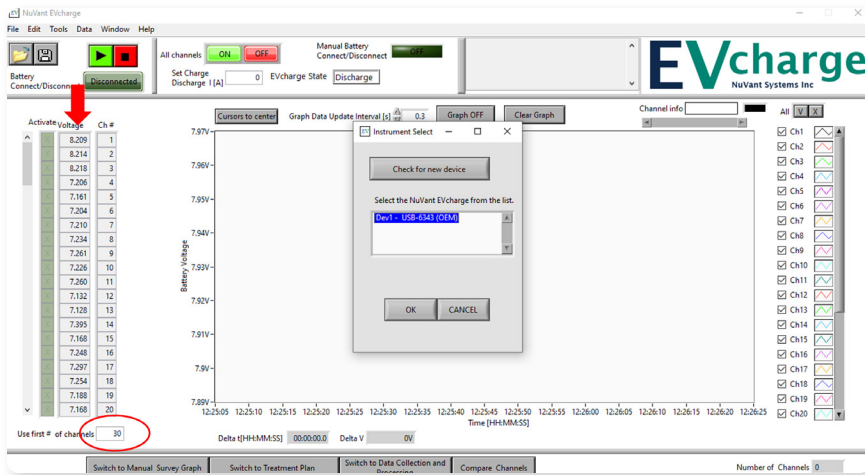


1. Push red button to turn on EVc and turn on laptop. Make sure USB cord from the EVc is connected to the laptop. Open the EVcharge software located on the desktop.
2. The laptop should automatically recognize the device. Close the National Instruments prompt (select "do nothing").





3. The "Instrument Select" window should automatically open. Select your device from the list and click "OK." If you have previously used this instrument on this laptop, it may automatically connect (the module voltages appear on the left hand side).

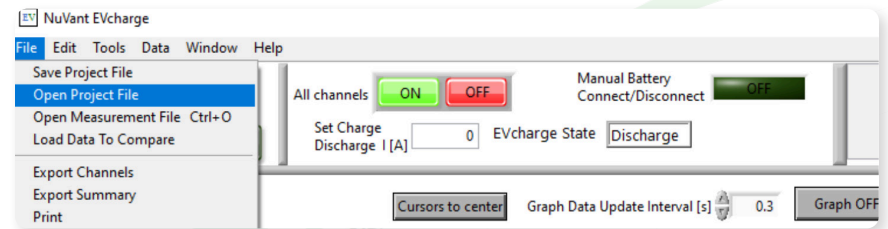


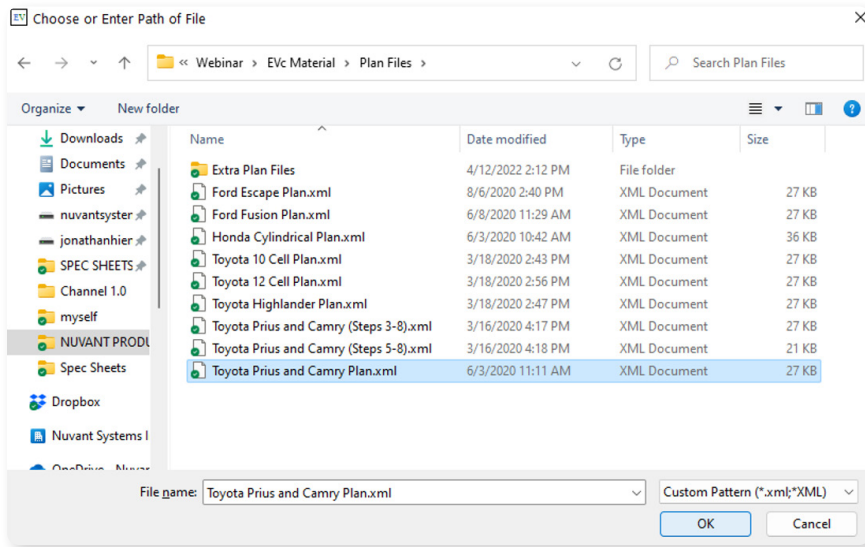
4. If the window does not appear, under "Tools," click "Configure" to re-open the "Instrument Select" window. Once EVcharge software recognizes the EVc instrument, you should see the correct voltage readings for the channels on the left side of the window (under Voltage).
5. Type in the correct number of channels to use in the "Use first # of channels" box. This is usually 28 or 30, depending on how many modules you connect. For example, when reconditioning just a Toyota Prius pack, channels 29 and 30 are inactive.

Opening and running plan (or project) file

The project plan file contains the appropriate charge/discharge steps for each type of battery. For each step, the individual modules either charge or discharge to the appropriate cut-off voltage or time limit. Once all modules reach the cut-off, the next step begins. This plan/recipe is all contained in the project file. No other input needed from the EVc user aside from the steps below.

1. Go to "File" > "Open Project File". Select the proper plan file (.xml) to open. For Toyota Prius and Camry modules, select the "Toyota Prius and Camry Plan.xml".





2. When the file opens, your treatment plan Toyota Prius and Camry Plan.xml will be displayed. **Detailed plan steps are shown in Appendix.**

Use Play Button to start the Project.

Charge/Discharge Plan Detailed info

Line	1	2	3	4	5	6	7	8
Cutoff Voltage [V]		8.6						
Log interval [s]		5						
Internal Resistance ON		No						
Internal Resistance Log Time [min]		5						
Time limit HH:MM:SS		01:30:00						
Time Limit ON		Yes						
Loop Back allowed		Yes						

Line Parameters

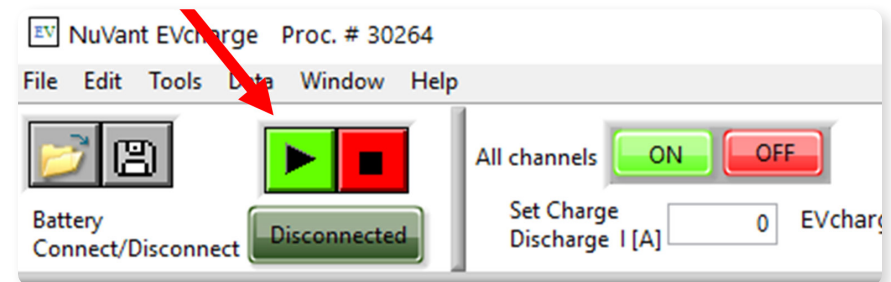
Discharging Current [A] 2
Cutoff Voltage [V] 8.6
Log Interval [s] 5.0
Get Rs
Rs Log Interval [min] 5
Apply Time Limit
Time Limit HH:MM:SS 01:30:00
Charge/Discharge to capacity
Target Capacity % 60

Cell Elimination Voltage on Discharge 0
Limit/Cutoff Capacity Ah 6.5

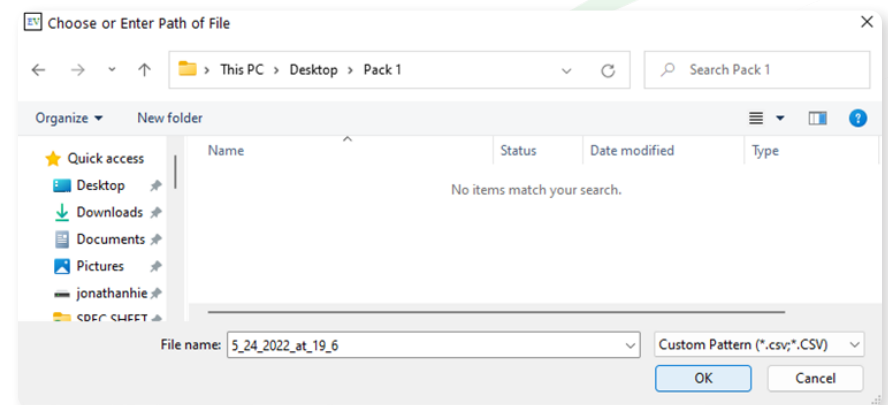
Project Charge/Discharge Steps/Plans

Step	Procedure	Total #Lines	Total Ah
Step: 1	Charge	1	03:00:00
Step: 2	Discharge	1	02:00:00
Step: 3	Discharge	4	08:54:00
Step: 4	Charge	4	04:30:00
Step: 5	Discharge	4	08:54:00
Step: 6	Charge	6	08:00:00
Step: 7	Discharge	2	06:30:00
Step: 8	Charge	1	00:00:00

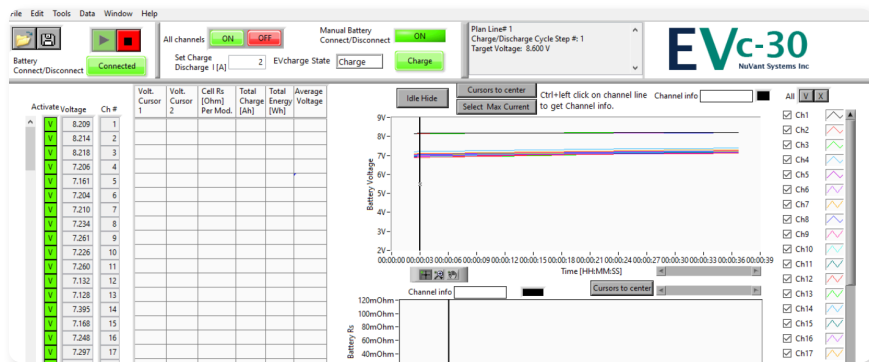
3. Click the green "PLAY" button on the upper left to start the reconditioning.
- Make sure that the "Battery Connect/Disconnect" button is pushed in on the EVc front panel.
 - If your EVc software is not activated for your instrument, please contact us.
 - If you have the activation code for your instrument, go to "Help" > "Advanced Activate" and enter the code.



4. A window will pop up asking where to save your data files.
- Click on desktop under "Quick Access" on the left.
 - Click "New Folder" and name it something such as "Pack 1"
 - Click into the newly created folder and select "OK".



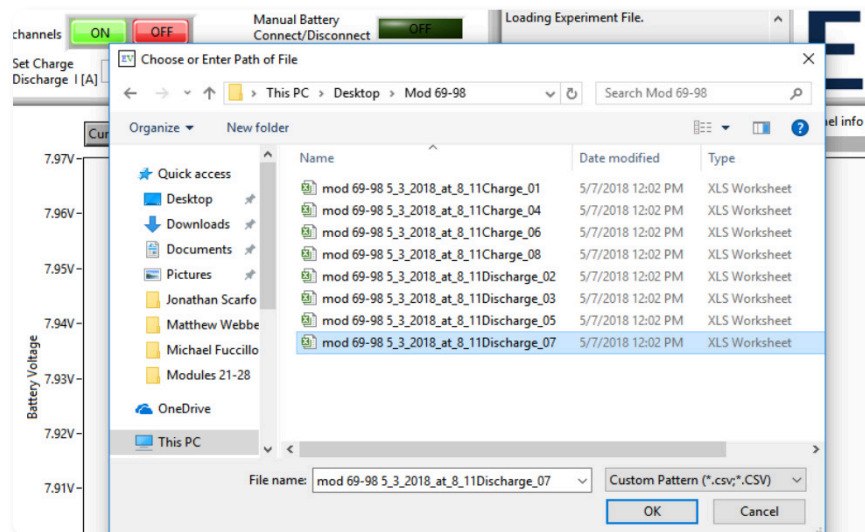
- When the reconditioning process starts, you will hear a click and the “Activate” channel lights will turn green in the software. The process will take 20-24 hours.



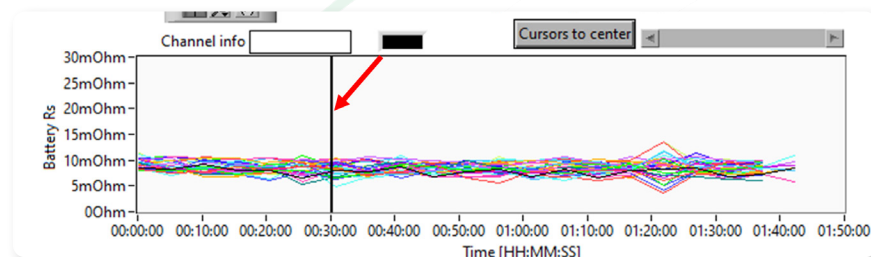
- When reconditioning ends, the software will display “Plan Completed” and all the green lights on the left will turn off. You are now ready to view the data results.

Exporting summary files from data

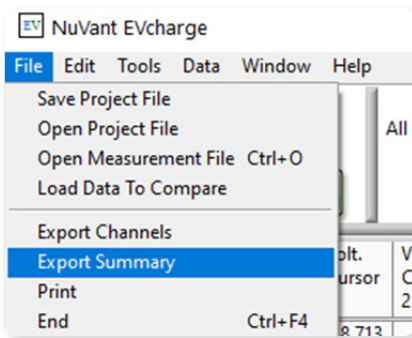
- Open EVcharge software and select “Open Measurement File” under “File” in the Toolbar.
- Select the discharge file used for diagnostic (in this case, “Discharge_07”). The data will load.



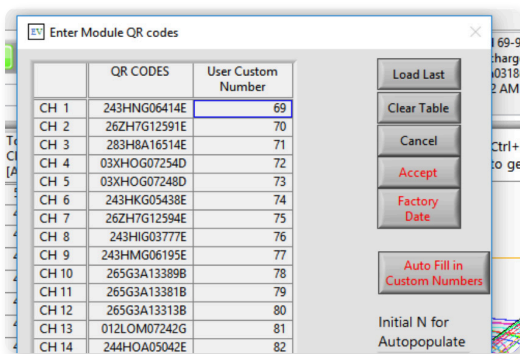
- Click on the “Battery Rs” window to fill the “Cell Rs” (Resistance) column of the data. Move the cursor to the 30 minute mark.



4. Click "File" > "Export Summary"



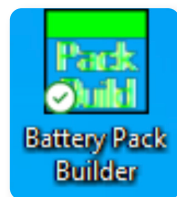
5. Enter the QR codes and User Custom Number. Use the QR code reader included with the instrument.



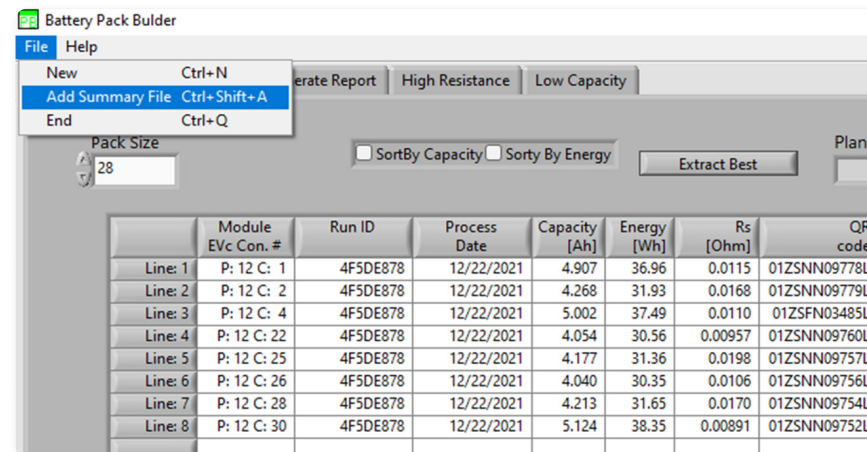
6. Click accept and save the summary file as "Summary" in the same folder as your data.

Adding Modules to Your Inventory

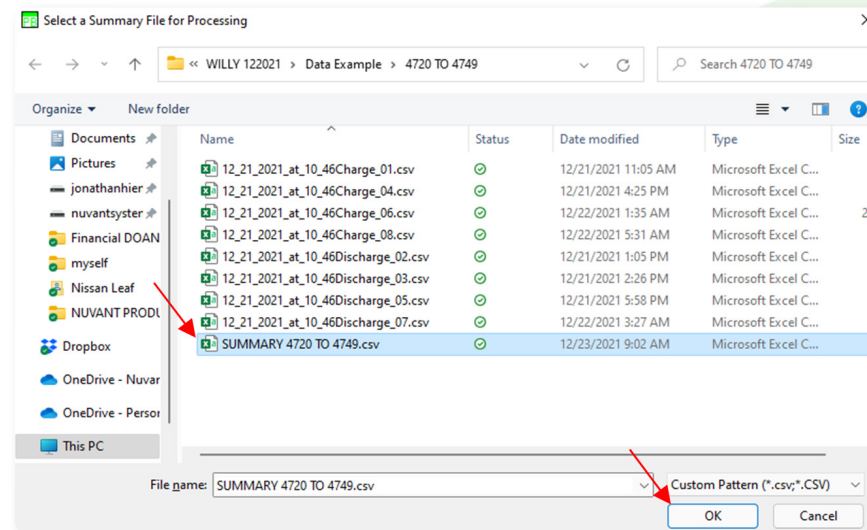
1. Open Battery Pack Builder



2. To add modules to your inventory, go to File, Add Summary



3. Choose the summary file you wish to import and click OK



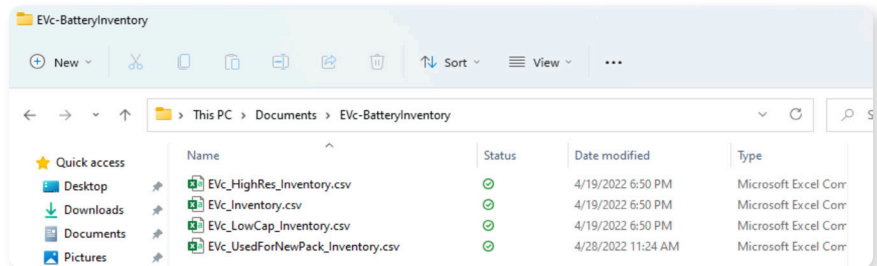
- The software will automatically separate "High Resistance" and "Low Capacity" modules into their own tabs. All satisfactory modules will be added to your "Inventory."

Line	Module Evc Con. #	Run ID	Process Date	Capacity [Ah]	Energy [Wh]	Rs [Ohm]	QR code	DAQ SN	Nominal Voltage [V]	User Label
Line 1	P: 12 C: 3	4FSDE878	12/22/2021	3.999	30.00	0.0236	01ZSNH09780L	1ESFC0B	7.502	4722
Line 2	P: 12 C: 5	4FSDE878	12/22/2021	3.143	23.00	0.0935	01ZSNH09786L	1ESFC0B	7.318	4724
Line 3	P: 12 C: 7	4FSDE878	12/22/2021	3.421	25.60	0.0221	01ZSNH09788L	1ESFC0B	7.484	4726
Line 4	P: 12 C: 9	4FSDE878	12/22/2021	2.489	18.70	0.0340	01ZSNH09790L	1ESFC0B	7.511	4728
Line 5	P: 12 C: 23	4FSDE878	12/22/2021	2.905	21.54	0.0599	01ZSNH09798L	1ESFC0B	7.413	4742
Line 6	P: 12 C: 27	4FSDE878	12/22/2021	3.088	23.15	0.0453	01ZSNH09755L	1ESFC0B	7.496	4746
Line 7	P: 12 C: 29	4FSDE878	12/22/2021	4.975	36.19	0.0514	01ZSNH09753L	1ESFC0B	7.275	4748

Line	Module Evc Con. #	Run ID	Process Date	Capacity [Ah]	Energy [Wh]	Rs [Ohm]	QR code	DAQ SN	Nominal Voltage [V]	User Label
Line 1	P: 12 C: 6	4FSDE878	12/22/2021	0.001509	0.01107	0.00	01ZSNH09787L	1ESFC0B	7.334	4725
Line 2	P: 12 C: 8	4FSDE878	12/22/2021	0.001509	0.01038	0.00	01ZSNH09789L	1ESFC0B	6.874	4727
Line 3	P: 12 C: 10	4FSDE878	12/22/2021	0.001509	0.01060	0.00	01ZSNH09791L	1ESFC0B	7.023	4729
Line 4	P: 12 C: 11	4FSDE878	12/22/2021	0.001509	0.01038	0.00	01ZSNH09792L	1ESFC0B	6.874	4730
Line 5	P: 12 C: 12	4FSDE878	12/22/2021	0.001509	0.01048	0.00	01ZSNH09793L	1ESFC0B	6.944	4731
Line 6	P: 12 C: 13	4FSDE878	12/22/2021	0.001509	0.01067	0.00	01ZSNH09794L	1ESFC0B	7.068	4732
Line 7	P: 12 C: 14	4FSDE878	12/22/2021	0.001509	0.01041	0.00	01ZSNH09795L	1ESFC0B	6.896	4733
Line 8	P: 12 C: 15	4FSDE878	12/22/2021	0.001509	0.01048	0.00	01ZSNH09796L	1ESFC0B	6.946	4734
Line 9	P: 12 C: 16	4FSDE878	12/22/2021	2.489	18.84	0.0116	01ZSNH09797L	1ESFC0B	7.569	4735
Line 10	P: 12 C: 17	4FSDE878	12/22/2021	2.621	19.93	0.0164	01ZSNH09798L	1ESFC0B	7.606	4736

Line	Module Evc Con. #	Run ID	Process Date	Capacity [Ah]	Energy [Wh]	Rs [Ohm]	QR code	DAQ SN	Nominal Voltage [V]	User Label
Line 1	P: 12 C: 1	4FSDE878	12/22/2021	4.907	36.96	0.0115	01ZSNH09778L	1ESFC0B	7.532	4720
Line 2	P: 12 C: 2	4FSDE878	12/22/2021	4.268	31.93	0.0168	01ZSNH09779L	1ESFC0B	7.479	4721
Line 3	P: 12 C: 4	4FSDE878	12/22/2021	5.002	37.49	0.0110	01ZSNH03485L	1ESFC0B	7.485	4723
Line 4	P: 12 C: 22	4FSDE878	12/22/2021	4.054	30.56	0.00957	01ZSNH09760L	1ESFC0B	7.537	4741
Line 5	P: 12 C: 25	4FSDE878	12/22/2021	4.177	31.36	0.0198	01ZSNH09757L	1ESFC0B	7.507	4744
Line 6	P: 12 C: 26	4FSDE878	12/22/2021	4.040	30.35	0.0106	01ZSNH09756L	1ESFC0B	7.512	4745
Line 7	P: 12 C: 28	4FSDE878	12/22/2021	4.213	31.65	0.0170	01ZSNH09754L	1ESFC0B	7.512	4747
Line 8	P: 12 C: 30	4FSDE878	12/22/2021	5.124	38.35	0.00891	01ZSNH09752L	1ESFC0B	7.484	4749

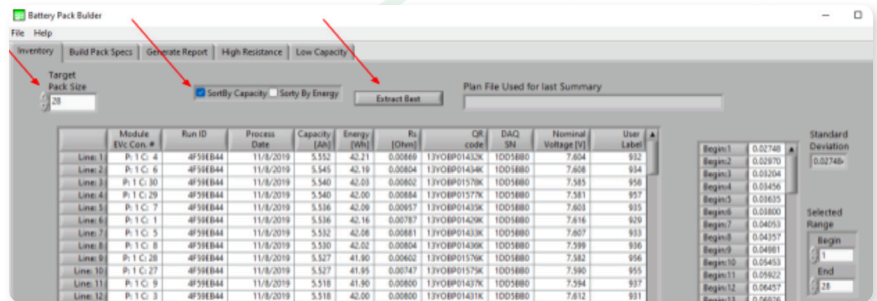
- Note that your Battery Pack Builder data is stored on your computer under "Documents" in the "Evc-BatteryInventory" folder. This includes the "High Resistance," "Low Capacity," "Inventory" and "Used for Packs" modules. Battery Pack Builder clears the High Resistance and Low Capacity tabs automatically (each time you close the software), but the module data is stored in these CSV files.



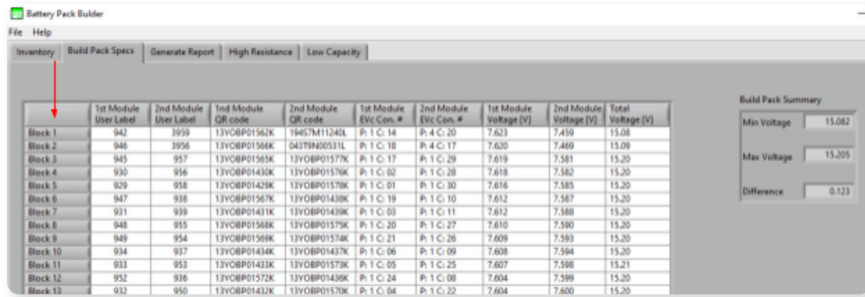
- Continue adding modules to your "Inventory" via summary files until you have enough to build a pack.

Build Toyota Prius Pack (28 modules) from Inventory

- Go to "Inventory"
- On Target Pack Size, choose 28
- Click "Sort By Capacity"
- Click "Extract Best"



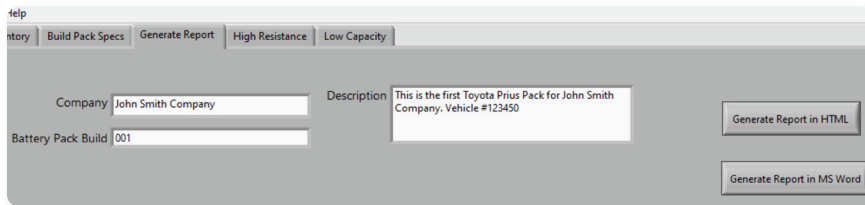
- Click "Build Pack Specs" tab. This shows you the modules chosen and how to arrange them as blocks. This also shows what the block voltages are on the right.



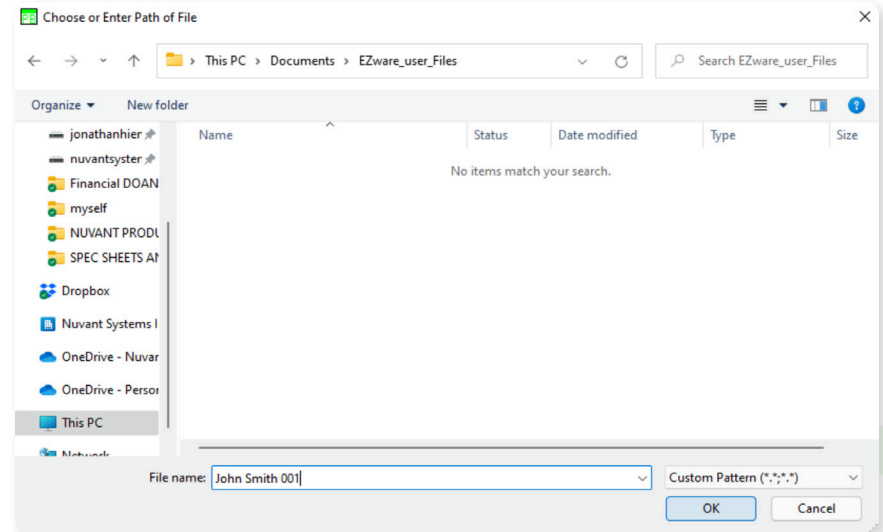
- In this example, Block 1 is Mod# 942 and 3959, Block 2 is 946 and 3956, Block 3...

Block	1st Module User Label	2nd Module User Label	1st Module QR code
Block 1	942	3959	13YOBP01562K
Block 2	946	3956	13YOBP01566K
Block 3	945	957	13YOBP01565K
Block 4	930	956	13YOBP01430K

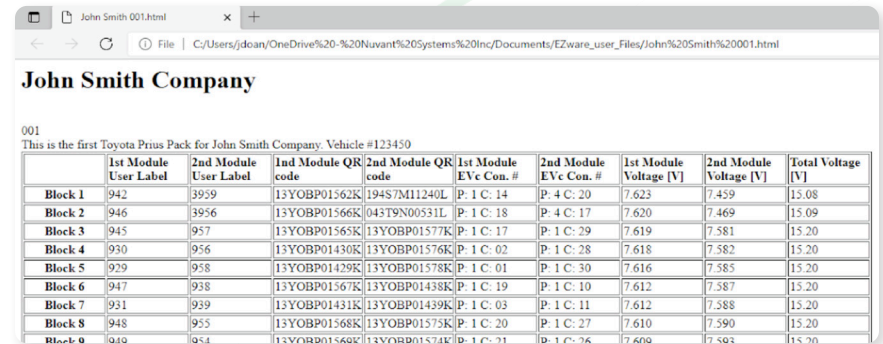
- Click "Generate Report" tab. Fill in Company, Battery Pack Build, and Description.



- Click "Generate Report in HTML"
- The default save location is under "Documents" and "EZware_user_files." Type a file name (e.g., John Smith 001) and click OK.



- Both an HTML and a CSV file will be saved. You can open the HTML file to view your pack.



Plan file: Toyota Prius and Camry (Trickle Charge) 120.xml

Step	Type	Current (A)	Cut-off (V)	Time limit (HH:MM:SS)	SOC estimate (end of step, assume 6 Ah capacity)	Note
1	Charge	2	8.6	01:30:00	75%	Assume module at 25% or 1.5 Ah
2	Discharge	1	5	02:00:00	25%	Disconnect module below 6V
3	Discharge	3	6.5	02:00:00	0%	
		0	2.5	00:00:10	0%	
		1.5	3	02:00:00	0%	
		0	2.5	00:15:00	0%	
4	Charge	2	8.4	01:30:00	50%	
		0	10	00:00:10	50%	
		1.5	8.4	01:00:00	75%	
		0	10	00:10:00	75%	
5	Discharge	3	6.5	02:00:00	25%	
		0	2.5	00:00:10	25%	
		1.5	3	02:00:00	0%	
		0	2.5	00:15:00	0%	
6	Charge	2	8.6	02:00:00	50%	
		0	10	00:10:00	50%	
		1	8.6	02:00:00	83%	
		0	10	00:10:00	83%	
		0.5	9.6	04:00:00	100%	Trickle Charge (less than C/10)
		0	10	00:10:00	100%	
7	Discharge	3.25	6	02:00:00	0%	
		0	3	00:18:00	0%	
8	Charge	1.5	8.6	n/a	60%	Charge to 60%

Glossary Of Terms

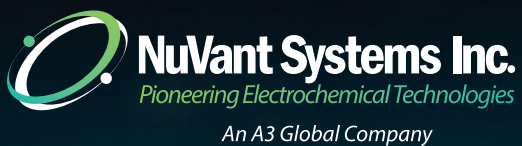
- **Amp (I)** – Unit for measurement of electric current as 1 coulomb/second.
- **Amp-hour capacity (Ah)** – Battery charge capacity. Defined as current output multiplied by time. A battery capable of outputting 2 Amp of current for 2 hours is a 4 Ah battery.
- **Anode** – The negative battery terminal during discharge. In a charged NiMH battery this is designated as MH, where M is a mixed metal and H is a hydrogen.
- **C-rate** – Discharge current is expressed as a C-rate in order to normalize against battery capacity, which varies between different batteries. A C-rate is a measure of the rate at which a battery is discharged relative to its maximum capacity. A 1C rate means that the discharge current will discharge the entire battery in 1 hour. For a 100 Ah battery, this equates to a discharge current of 100 Amps. A 5C rate for this battery is 500 Amps. C/2 is 50 Amps.
- **Cell** – The smallest form a battery can take. Comprised of a single anode/cathode pair, a separator, and an electrolyte.
- **Charge current** – The battery is charged at ~1C-rate (to roughly 70 percent SOC) before transitioning to lower C-rates (tapering eventually to $\leq C/10$)
- **Current** – Flow of electric charge measured in amps I or coulombs/second
- **Cut-off voltage** – Also called the end of discharge voltage or VEOD.
- **Cycle** – A single sequence of charge and discharge.
- **Cycle life** – An estimate of the number of cycles a battery can be subjected to before it no longer meets performance standards. Actual cycle life is dependent on factors such as temperature, DOD, cycling rate, etc.
- **Depth of discharge (% DOD)** – The percentage of battery capacity that has been discharged expressed as a percentage of maximum capacity. A discharge to at least 80 % DOD is referred to as a deep discharge.[1]
- **Electrolyte** – A chemical solution which conducts electric current by means of mobile ions. The NiMH battery electrolyte is potassium hydroxide in water (30%).
- **Energy density (Wh/L)** – Energy in the battery per unit volume. Characteristic of chemistry and packaging design. Determines battery size needed to achieve a given electric range for the vehicle.

Glossary Of Terms (Cont'd)


- **Float charge** – Constant current charging at a current low enough rate (C/10 or less) to avoid swelling due to oxygen evolution at the positive electrode.
- **Internal resistance (I)** – Resistance to flow of current within only the cell or module itself.
- **Maximum continuous discharge current** – The maximum current at which the battery can be discharged continuously. This limit is usually defined by the battery manufacturer in order to prevent excessive discharge rates that would damage the battery or reduce its capacity. Along with the maximum continuous power of the motor, this defines the top speed and acceleration of the vehicle.[1]
- **Maximum 30-sec discharge pulse current** – The maximum current at which the battery can be discharged for pulses of up to 30 seconds. This limit is usually defined by the battery manufacturer in order to prevent excessive discharge rates that would damage the battery or reduce its capacity. Along with the peak power of the electric motor, this defines the acceleration performance (0-60 mph time) of the vehicle. [1]
- **Memory effect** – An issue in NiMH and NiCd batteries observed after repetitive low DOD cycles in which the battery seems to “remember” this low DOD and behave as though it represents full discharge. This results in reversible loss of capacity due to increased resistance in the repeatedly uncycled material within the battery.
- **Module** – Several battery cells connected in series. The total voltage of the module is the sum of the individual cell voltages. The nominal module voltage for Toyota prismatic NiMH batteries is 7.2 V.
- **Nominal voltage** – The reference, or standard, voltage of the battery. The NiMH cell nominal voltage is 1.2 V.
- **Nominal energy (Wh)** – “energy capacity” or “Watt-hour capacity”. The total Watt-hours available when the battery is fully discharged at a given C-rate.[1]
- **Open-circuit voltage** – The voltage between the battery terminals with no load applied. The open-circuit voltage depends on the battery state of charge, increasing with state of charge.
- **Resistance (I)** – Material property, indicative of difficulty in passing charge through said material. Measured in ohms. Resistance is the inverse of conductance.


Glossary Of Terms (Cont'd)

- **Separator** – A material within the battery cell, between the cathode and the anode. It should allow charge to flow between the two poles of the battery, but never permit them to touch.
- **Specific Energy (Wh/kg)** – The nominal battery energy per unit mass, sometimes referred to as the gravimetric energy density. Specific energy is a characteristic of the battery chemistry and packaging. Along with the energy consumption of the vehicle, it determines the battery weight required to achieve a given electric range.[1]
- **Specific power (W/kg)** – The maximum available power per unit mass. Specific power is a characteristic of the battery chemistry and packaging. It determines the battery weight required to achieve a given performance target.
- **State of Charge (% SOC)** – An expression of the present battery capacity as a percentage of maximum capacity. SOC is generally calculated using current integration to determine the change in battery capacity over time.
- **Voltage (V)** – Electrical potential difference between two points (ex. terminals of battery). 1 volt will cause a current of 1 amp to flow through a resistance of 1 ohm



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 www.nuvant.com

 130 N. West Street
Crown Point, IN 46307