

# ALL ABOUT BATTERIES

&

Chargers and Converters

*Elliot Actor*

June 20, 2022

# Primary Technical Sources

- Interstate Batteries - Lead Acid Batteries, AGM Batteries, Chargers
- Battery Tender – Smart Battery Chargers
- Optimate (TecMate) – Desulfation Chargers
- Dakota Batteries – Lithium Batteries, Lithium Charging
- Battle Born Batteries - Lithium Batteries, Heated Lithium Batteries, and BMS  
(Battery Management System)
- Offroad Living – Charging Lithium Batteries
- Enerdrive (Dometic) – Charging Lithium Batteries
- Parallax – Battery Chargers and Airstream Converter History
- Progressive Dynamics – Converter Upgrades, Desulfation
- WFCO – Converter Upgrades
- Amazon – Lithium Battery Prices and Converter Upgrades (Cheapest Source)
- Air Forums - Battery Upgrades, Converter Problems
- Pat McDowell #10777– Airstream Electrical History

# Battery Types

- Lead Acid (Flooded Lead Acid)
- AGM (Absorbed Glass Mat)
- Lithium (Lithium Iron Phosphate)
- Future Batteries

# Battery Types

## LEAD ACID (Flooded Lead Acid)

A Lead Acid Battery consists of plates of Lead Oxide, the positive plate, and Lead, the negative plate, separated by a permeable membrane immersed in an electrolyte of water and sulfuric acid and incased in a hard plastic case.

### Starting

Higher cranking amps – Quick burst of energy

Sealed versions available – No maintenance over normal life expectancy

Inexpensive

### Deep Discharge

Greater long-term delivery – Deeper discharge

More rugged internal construction

Inexpensive

# Battery Types

## AGM (Absorbed Glass Mat)

The chemistry of an AGM batteries is the same as a Lead Acid battery except the Lead and Lead Oxide plates are separated by an absorbent glass mat that absorbs and holds the battery's acid and prevents it from flowing freely inside the battery. The plates are tightly compressed into each cell and held under pressure in the plastic case.

No outgassing

Maintenance free

Mount in any position

More useable capacity (80% vs 50% for Lead Acid)

Typically have longer life

Charge faster (less internal resistance)?

*50 % More expensive than Lead Acid*

*Overcharging an AGM battery can cause permanent damage and older 2-stage battery chargers may not be suitable to use?*

# Battery Types

## LITHIUM - LiFeP04 (Lithium Iron Phosphate or LFP)

*Comprised of 3.6 Volt 18650 cells in a series/parallel combination*

Can safely use full capacity vs 50-80% for Lead Acid or AGM

Much lighter

Can mount in any position

Last much longer

Charge much faster

*Much more expensive 4-10X*

*Cannot charge below freezing unless heated*

# What Kind of Batteries Does Tesla Use?

- Tesla currently uses mainly NCA chemistry (Lithium-Nickel-Cobalt-Aluminum), while NMC (Lithium-Nickel-Manganese-Cobalt) is more common in the rest of the EV industry. NCA has higher power density than NMC.
- In China the Model 3 and Model Y now use LFP (Lithium Iron Phosphate), which is cheaper, safer, but less power dense. Tesla is switching to LFP for those models worldwide for safety and to reduce costs.
- Tesla's new 4680 battery cell (Coming 2Q 2022 for Model Y) is more power dense, cheaper to manufacture, and **Cobalt free**. It uses Nickel in place of Cobalt for its cathode. It will eventually replace all other battery types used by Tesla.

*Most Cobalt comes from The Democratic Republic of Congo and is mined by child or forced labor.*

# Future Batteries?

## DEVELOPMENT GOALS

- Less Dangerous (Prevent Fires)
- Faster Charging
- Higher Energy Density
- Better & Cheaper Packaging
- Lower Temperature Operation
- Longer Life

## TOP TECHNOLOGIES IN DEVELOPMENT

- Sodium-Ion
- Lithium-Sulfur
- Sodium–Sulfur
- Lithium-Air
- Aluminum-Air



# Battery Measurements

COLD CRANKING AMPS (**CA**)

Not important with Deep Cycle

RESERVE CAPACITY (**RC**)

Minutes a battery can discharge 25 Amps

AMP HOUR (**AH**) = Energy storage capacity of battery

$$**AH** = 0.4167 \times **RC**$$

# Operating Temperature Range

## LEAD ACID & AGM

- Lead Acid and AGM Batteries have an operating range of -40 degrees F to 140 degrees F.
- Cold weather is not harmful to a Lead Acid or AGM battery as many of us were taught. As long as the battery(s) are kept charged you do not need to remove them when storing your trailer.
- Cold weather does affect the performance as at 32 degrees F (freezing) the capacity is reduced by 20% and at 0 degrees F it is reduced to 50%. Also, while a completely discharged battery can freeze at 20 degrees F, **a fully charged battery will not freeze until -70 degrees F.**

## LITHIUM (LiFeP04)

- LiFeP04 batteries have an operating range of -14 degrees F to 140 degrees F (Constrained by Battery Management System)
- They will operate in that range without significant performance degradation, however, **they cannot be charged below 32 degrees F.**

# Battery Life Expectancy

## LEAD ACID (Without Desulfation)

### Real Life\*

Life expectancy typically, 3-5 Years

30% Reach 48 Months

5% Reach 60 Months

### Tested Discharge Cycle Life \*\*

220 Cycles at 80% DOD (Depth of Discharge)

750 Cycles at 50% DOD

2000 Cycles at 25% DOD

*>80% DOD Can Permanently Damage Battery*

\*Based on Interstate Battery data - Due to Sulfation, too deeply discharged, or low electrolyte level

\*\* Cannot be re-charged above 70% capacity or 12.3 Volts

# Battery Life Expectancy

## AGM - Absorbed Glass Mat (Without Desulfation)

### Real Life\*

Life Expectancy typically 5-7 Years

### Tested Discharge Cycle Life \*\*

600 Cycles at 80% DOD

1000 Cycles at 50% DOD

2500 Cycles at 25% DOD

*>90% DOD Can Permanently Damage Battery*

\*Based on Interstate battery data - Due to Sulfation or too deeply discharged

\*\* Cannot be re-charged above 70% capacity or 12.3 Volts

# Sulfation

- The primary reason for the failure of Lead Acid and AGM batteries is due to sulfation, the buildup of lead sulfate crystals on the plates of the battery that make it increasingly ineffective.
- Sulfation occurs due to inappropriate charging and discharging, which is common in batteries that are routinely deeply discharged.
- There are many different proprietary methods that charger manufacturers use to dislodge the sulfate crystals from the battery's plates and mix them back into the electrolyte, rejuvenating the battery or even **reviving a dead battery**.
- Each manufacturer is convinced their methodology is the best.
- However, all the methods consist of connecting the battery periodically or on demand with a steady or oscillating on-and-off higher voltage pulse from several seconds to several minutes in duration.
- This process is called Desulfation or, less frequently, Equalization Stage.
- What they all agree on is that Desulfation can significantly **increase battery life by 2-3X**.
- Many batteries in testing are still operational (>70% efficient) after **12 or more years**.

# Battery Life Expectancy

## LITHIUM (LiFeP04)

2500 Cycles at 100% DOD

4500 Cycles at 80% DOD

10000 Cycles at 40% DOD

15000+ Cycles at 25% DOD

3000 Cycles at 100% DOD (Battle Born)

*Can Be Discharged to 100% DOD Without Permanent Damage ??*

# Lithium Battery Management Systems (BMS)

- The primary function of the BMS is to protect the battery cells from damage caused by temperature extremes or being overcharged or over-discharged.
- Additionally, the BMS also balances the charge across the cells to keep each cell functioning at maximum capacity.
- If the BMS detects any unsafe conditions, it shuts the battery down to protect the lithium-ion cells and the user.
- Most will automatically restart when unsafe condition are over. Some require an external reset.

*Battery management systems are critical in protecting the battery's health and longevity but even more important from a safety perspective. The liquid electrolyte in most lithium-ion batteries is highly flammable.*

# Heated Vs Non-Heated Lithium Batteries

*Charging a LiFePO4 battery below freezing can damage the battery so the BMS (Battery Management System) of a non-heated battery will not allow charging below that temperature.*

- The heater circuit in heated Lithium batteries, when connected, typically kick in at 35 degrees Fahrenheit and turn off at 45 degrees Fahrenheit.
- They draw 1.8 Amps (Battle Born) and at zero degrees Fahrenheit will operate 30% of the time and the battery will last approximately 185 hours before being shut down by the BMS low voltage cutoff.
- A switch is required for each group of Lithium batteries to disconnect heater circuit(s) when storing to avoid running down the battery(s).



# Battery Dimensions

<u>Size</u>	<u>Length"</u>	<u>Width"</u>	<u>Height"</u>	<u>Wgt#</u>	<u>Wgt#</u>	<u>Typ AH</u>	<u>Typ AH</u>
Group				LA & AGM	Lithium	LA & AGM	Lithium
24	10 1/4	6 7/8	8 7/8	43-57	20-24	55	75-100
27	12 1/16	6 7/8	8 7/8	54-70	25-30	67	100
31	13	6 7/8	9 3/8	60-75	25-32	87	100
GC2	10 3/8	7 3/16	9 3/8	58-68	22	220 (6V)	100

# Increasing Battery Capacity

## 1) Add Internal Battery(s) in Parallel

AGM or Lithium

## 2) Replace Existing Batteries w/ Lithium or Larger Size

Group 24 L/A or AGM to Group 24 Lithium

*300% - 400% Increase*

Group 24 to 27

*25% Increase L/A or AGM – 400% Lithium*

Group 24 to 31

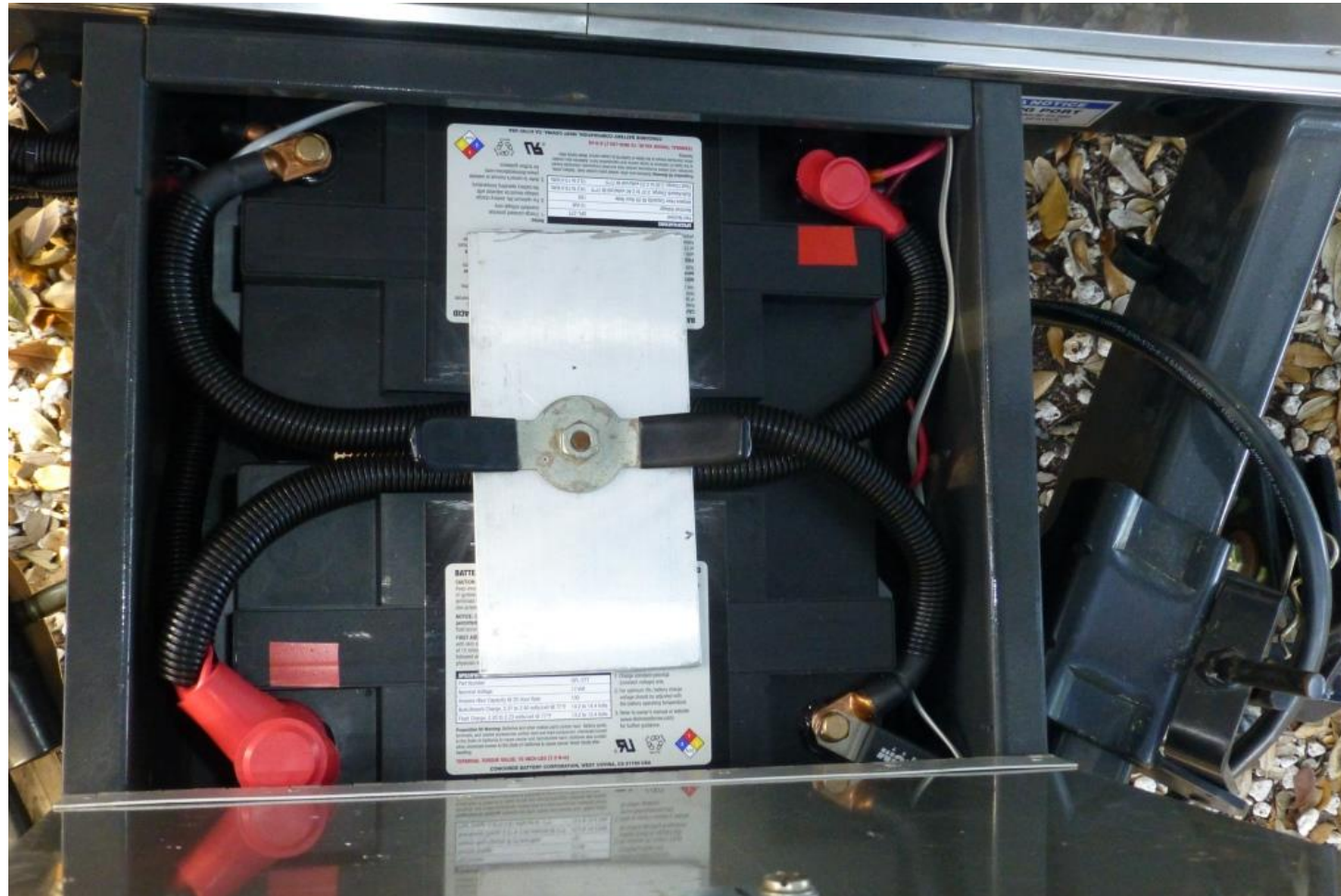
*50% Increase L/A or AGM – 400% Lithium*

Group 24 to GC2

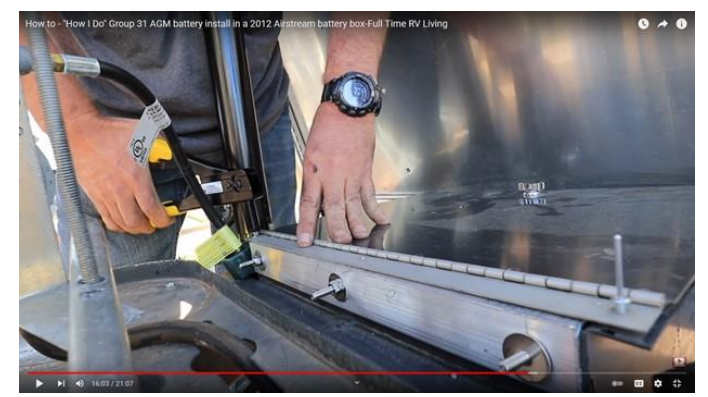
*200% Increase L/A or AGM – 400% Lithium*

## 3) Do Both 1 & 2

# Upgrade to Group 27 Batteries



# Upgrade to Group 31 Batteries





# Upgrade to 6 Volt GC2 Batteries



# Lead Acid Battery Sources 5/10/2022

<u>Source</u>	<u>Size (Group)</u>	<u>List Price</u>	<u>Reserve Amps</u>	<u>Ampere Hours</u>
Walmart	24	\$ 79.84	130	54
	27	\$ 93.76	195	81
	29	\$ 99.97	262	109
Interstate	24	\$ 165.60	140	58
	27	\$ 144.95	160	67
	31	\$ 174.95	210	87
	GC2 (6V)	\$ 168.95	N/A	225
Costco	24	\$ 79.99	140	58
	27	\$ 89.99	160	67
	GC2 (6V)	\$ 97.99	N/A	210
Sams Club	24	\$ 79.22	120	50
	31	\$ 105.88	190	79

# AGM Battery Sources 05/10/2022

<u>Source</u>	<u>Size (Group)</u>	<u>List Price</u>	<u>Reserve Amps</u>	<u>Ampere Hours</u>
Walmart	24	\$ 188.89	180	75
	27	\$ 224.99	240	100
	31	\$ 315.97	288	120
	GC2(6V)	\$ 299.99	N/A	225
Sams Club	24	\$ 124.88	132	55
Costco	24	\$ 179.99	140	58
Interstate	24	\$ 229.95	140	58
	31	\$ 399.95	200	83
	GC2 (6V)	\$ 354.95	N/A	210

# Lithium (LiFeP04) Battery Sources 05/10/2022

<u>Source</u>	<u>Size (Group)</u>	<u>List Price</u>	<u>Ampere Hours</u>
<b><u>Non Heated</u></b>			
<b>ECO-WORTHY</b>	<b>24</b>	<b>\$ 379.99</b>	<b>100</b>
Mighty Max Battery	24	\$ 399.95	75
RELiON	24	\$ 717.10	75
ChargeX	24	\$ 799.99	75
Battle Born	24	\$ 725.00	75
Power Sonic	27	\$ 795.00	100
JITA	31	\$ 419.00	100
BtrPower	31	\$ 359.99	100
Ampere Time	31	\$ 369.99	100
CHINS	31	\$ 399.99	100
<b><u>Heated</u> (to Charge Below Freezing Temps)</b>			
Renogy	27	\$ 679.99	100
Battle Born	31	\$ 874.00	100
<b>Battle Born</b>	<b>GC2 (12V)</b>	<b>\$ 899.00</b>	<b>100</b>
		<b>\$ 999.00</b>	<b>100</b>
		<b>(With Switch Kit)</b>	



# Battery Testing

## *Test Results with Battery at 80 Degrees Fahrenheit*

Charge Level	Specific Gravity L/A	Voltage L/A	Voltage AGM	Voltage Lithium
100%	1.265	>12.65	>12.75	14.34
80%	1.249	12.42	12.50	13.27
60%	1.197	12.20	12.26	13.13
40%	1.183	11.90	11.95	13.10
20%	1.148	11.58	11.66	12.87
10%	1.120	11.31	11.51	12.73
0%	1.073	10.50	10.50	10.24*

**\* BMS Disconnects Battery Below This Level**

# Digital Voltmeters



# Lead Acid and AGM Battery Testing

## HOW TO TEST

- Fully charge batteries
- Disconnect all loads
- Separate batteries (For dual batteries)
- Let sit for at least 4 hours to remove surface charge

## NOTES

- If greater than 0.05 difference in Specific Gravity, you have a bad cell (L/A Only)
- If Specific Gravity is less than 1.225 you have a bad battery (L/A Only)
- If the voltage is less than 70% or 12.3V on either a Lead Acid or AGM, you have a bad battery

# How Long Does Will It Take to Charge?

***It depends upon how deeply your batteries are discharged and your charger's capacity.***

Up to an 80% charge, you can divide the AH required by the charger's current capacity.

From 80% to 100% with a 2-stage charger, add the total AH of the batteries divided by the charger's current capacity.

For a 3 or 4-stage charger, it gets much more complicated as they are controlled by the current your batteries are accepting from the charger.

At 80% charge, determined by the decreased current draw, they lower the voltage to 13.6 Volts until the current is negligible, at which time they switch over to the 13.2 Volt Float Mode. That can take many hours additionally.

# Trickle Chargers Vs Float Chargers

Trickle chargers apply a fixed voltage of 13.2 Volts

For Lead Acid batteries disconnect from Shore Power for long storage

- or check Electrolyte level regularly

*Not recommended for AGM batteries.*

Float chargers apply on-and-off 13.2 Volts as needed to maintain full charge

Suitable for Lead Acid and AGM Batteries

*Can Remain Plugged-In to Shore Power Indefinitely*

# Charging From Tow Vehicle

- The charge voltage available to the trailer is regulated by the charge level of the battery in the tow vehicle not the charge level of the trailer battery(s).
- Although the charge connection (Pin 4) is usually a 30 Amp fused circuit, when the tow vehicle battery is fully charged the voltage drops from 14.4 volts to about 13.4 volts.
- When measured, typically **only 5 Amps are available** to charge depleted trailer battery(s).
- For a trailer with two 55 AH batteries discharged to 50% it would take about 11 hours of driving to fully recharge the batteries.

*When going to Lithium battery(s) Pin 4 must be disconnected (remove fuse) to avoid draining the battery(s) through the tow vehicle when it is not running.*

# Early Airstream Electrical History

**1940s** 120 VAC Lights and Receptacles

**1950s** Added 6 or 12 VDC Lights (Depending on tow vehicle) and optional battery  
Dual Voltage System  
120 VAC for Refrigerator, Water Heater, Vent Fans, Receptacles, Lighting  
6 VDC or 12 VDC for secondary Lighting

**1962-63** Vent Fans, Heater Fan switchable to run on installed 120/19 VAC transformer or 12 VDC

**1964** Univolt "Power Center" added, transformed 120 VAC to 19 VAC and 12 VAC  
Fan motors run at 19 VAC or 12 VDC  
Lighting runs on 12 VAC or 12 VDC

**1965** Univolt "**Converter**", converted 120 VAC to 12 VDC  
All lighting and motors changed to 12 VDC

**1968** Battery charger added to Univolt Power Center

**1980s** Began using Parallax Converters

# Converters and Battery Chargers

## **SINGLE STAGE (1965 – 2006)\***

Univolt, Parallax 6335, 6345, and Early Parallax 7355s

13.5-13.8 Volts

*\*Not suitable for AGM batteries*

## **2-STAGE (After 2006)\***

Later Parallax 7355s and All 8355s & 5055s

14.4 Volts Stage 1 (Bulk Charge – Until 80%)

13.2 Volts Stage 2 (Trickle Charge)

*\*Not recommended for AGM batteries*

## **3-STAGE (After 2018) Airstream also began using (2) 6 Volt GC2 Batteries**

**WFCO 8955, 9855 Plastic Body**

14.4 Volts Stage 1 (Bulk Charge – Until 80%)

13.6 Volts Stage 2 (Absorption Charge – Until about 95%)

13.2 Volts Stage 3 (Float – Maintain 100%)



# Converters and Battery Chargers

**4-STAGE** “Fully Automatic” Desulfation charger (*Not installed in Airstreams, upgrades available*)

Stages 1 -3 Same as 3-Stage charger

Stage 4 – Higher voltage pulse to stir electrolyte and knock loose sulfur off the plates

*Typically: A steady or oscillating short pulse about once daily*

Internal 4 Stage chargers are limited to 14.4 Volt pulse to protect installed electronics

External 4 Stage chargers typically pulse at a higher, more effective 15.8V – 22 Volts

# Repair or Upgrade Converter or Charger Section

Primary Sources Amazon or etrailer.com

## **Progressive Dynamics**

Upgrade Parallax to 4-Stage charger (\$260)

Upgrade Parallax to Lithium (\$337)

## **WFCO**

Upgrade WFCO to Lithium (\$189)

## **Power Max “Boondocker”**

Upgrade WFCO to 4-Stage (\$179)

*Note: Prices as of 5/10/2022*

# Conversion of 7455 to 4-Stage with PD4655



# 4-Stage External Battery Chargers at Amazon

*Need to disconnect battery from trailer to operate properly*

Amazon.com : desulfation battery chargers

https://smile.amazon.com/s?k=desulfation+battery+chargers&crd=34...

Amazon.com : desulfation battery chargers

https://smile.amazon.com/s?k=desulfation+battery+chargers&crd=34...

**Delivery**  
Today by 3PM  
Overnight by 8AM  
All Prime

**Delivery Day**  
Get it Today  
Get it by Tomorrow

**Department**  
Automotive Tools & Equipment  
Battery Chargers  
Automotive Replacement Parts  
Automotive Replacement  
Batteries & Accessories  
Automotive Performance Parts & Accessories  
Toys & Games  
Industrial & Scientific  
Skates, Skateboards & Scooters  
See All 9 Departments

**Customer Reviews**  
& Up  
& Up  
& Up  
& Up

**Brand**  
NOCO  
Schumacher  
CTEK

**Price**  
Under \$25  
\$25 to \$50  
\$50 to \$100  
\$100 to \$200  
\$200 & Above

Min Max Go

**Deals & Discounts**  
All Discounts


**International Shipping**  
International Shipping Eligible


**Condition**  
New  
Used


**Availability**  
Include Out of Stock

Showing results for *desulfation battery charger*  
Search instead for [desulfation battery chargers](#)


## RESULTS


 **NOCO GENIUS10, 10-Amp Fully-Automatic Smart Charger, 6V and 12V Battery Charger, Battery Maintainer,...**  
9,232  
~~\$124.95~~ **\$99.95**  
Today 10 AM - 3 PM  
FREE delivery today  
More Buying Choices  
\$91.95 (11 used & new offers)

 **TowerTop Battery Charger, 2/10/25Amp 12V Fully Automatic Smart Trickle Charger, Automotive Battery...**  
4,066  
~~\$199.99~~ **\$144.49**  
Save \$25.00 with coupon  
Overnight 4 AM - 8 AM  
FREE delivery overnight

 **NOCO GENIUS5, 5-Amp Fully-Automatic Smart Charger, 6V and 12V Battery Charger, Battery Maintainer, Trickle...**  
9,613  
~~\$89.95~~ **\$69.95**  
Today 10 AM - 3 PM  
FREE delivery today  
More Buying Choices  
\$61.56 (18 used & new offers)

## MORE RESULTS

 **Schumacher SC1281 100 Amp 30 Amp 6V/12V Fully Automatic Smart Battery Charger 100A Engine Starter...**  
7,173  
~~\$104~~ **\$95.94**  
Overnight 4 AM - 8 AM  
FREE delivery overnight  
More Buying Choices  
\$84.18 (7 used & new offers)

 **NOCO GENIUS1, 1-Amp Fully-Automatic Smart Charger, 6V and 12V Battery Charger, Battery Maintainer, Trickle...**  
25,716  
~~\$39.95~~ **\$29.95**  
Today 10 AM - 3 PM  
FREE delivery today on qualifying orders over \$35  
More Buying Choices  
\$26.36 (10 used & new offers)

 **NOCO GENIUS2X4, 4-Bank, 8-Amp (2-Amp Per Bank) Fully-Automatic Smart Charger, 6V And 12V Battery...**  
590  
Limited time deal  
~~\$249.95~~ **\$170.00**  
Today 10 AM - 3 PM  
FREE delivery today  
More Buying Choices  
\$153.85 (6 used & new offers)

 **NOCO Genius GENPRO10X2, 2-Bank, 20-Amp (10-Amp Per Bank) Fully-Automatic Smart Marine Charger, 12V...**  
551  
~~\$249.95~~ **\$193.74**  
Overnight 4 AM - 8 AM  
FREE delivery overnight  
More Buying Choices  
\$183.95 (4 used & new offers)

 **NOCO GENIUSPRO25, 25-Amp Fully-Automatic Professional Smart Charger, 6V, 12V and 24V Battery...**  
191  
~~\$499.99~~ **\$499.99**  
FREE One-Day  
Get it Tomorrow, Jan 31  
More Buying Choices  
\$499.95 (3 new offers)

 **NOCO GENIUSPRO50, 50-Amp Fully-Automatic Professional Smart Charger, 6V, 12V and 24V Battery...**  
193  
~~\$768.27~~ **\$768.27**  
FREE Delivery Tue, Feb 1

 **Clore Automotive PL2320 20-Amp Fully-Automatic Smart Charger, 6V and 12V Battery Charger, Battery Maintainer,...**  
1,030  
~~\$114.40~~ **\$79.99**  
Overnight 4 AM - 8 AM  
FREE delivery overnight  
More Buying Choices  
\$73.59 (11 used & new offers)

 **NOCO GENIUS2X2, 2-Bank, 4-Amp (2-Amp Per Bank) Fully-Automatic Smart Charger, 6V and 12V Battery...**  
1,466  
~~\$124.95~~ **\$72.14**  
Overnight 4 AM - 8 AM  
FREE delivery overnight  
More Buying Choices

# Airstream “Power Plus” Options for 2021

- No solar package - Choose your trailer batteries at the dealership.
- Select solar package from factory - Trailer ships with Victron solar controller and battery monitor, 2 AGM batteries, and respective solar panel(s).
- Optional (\$3000 - \$4000) dealer-installed upgrade to replace batteries with 2 Battle Born 100 AH heated LiFePO4 Lithium batteries and upgraded power converter.

# Can I Use My Existing Charger for Lithium Batteries?

- Yes, it worked fine for me.
- No, it will damage the battery(s)!
- Maybe, it depends on the charger and -

*Will only charge to about 80% capacity*

*Cannot use a Desulfation charger*

*Must disconnect charger after battery is fully charged*

- *Why risk it! It is not expensive to upgrade to a Lithium charger.*

**END**