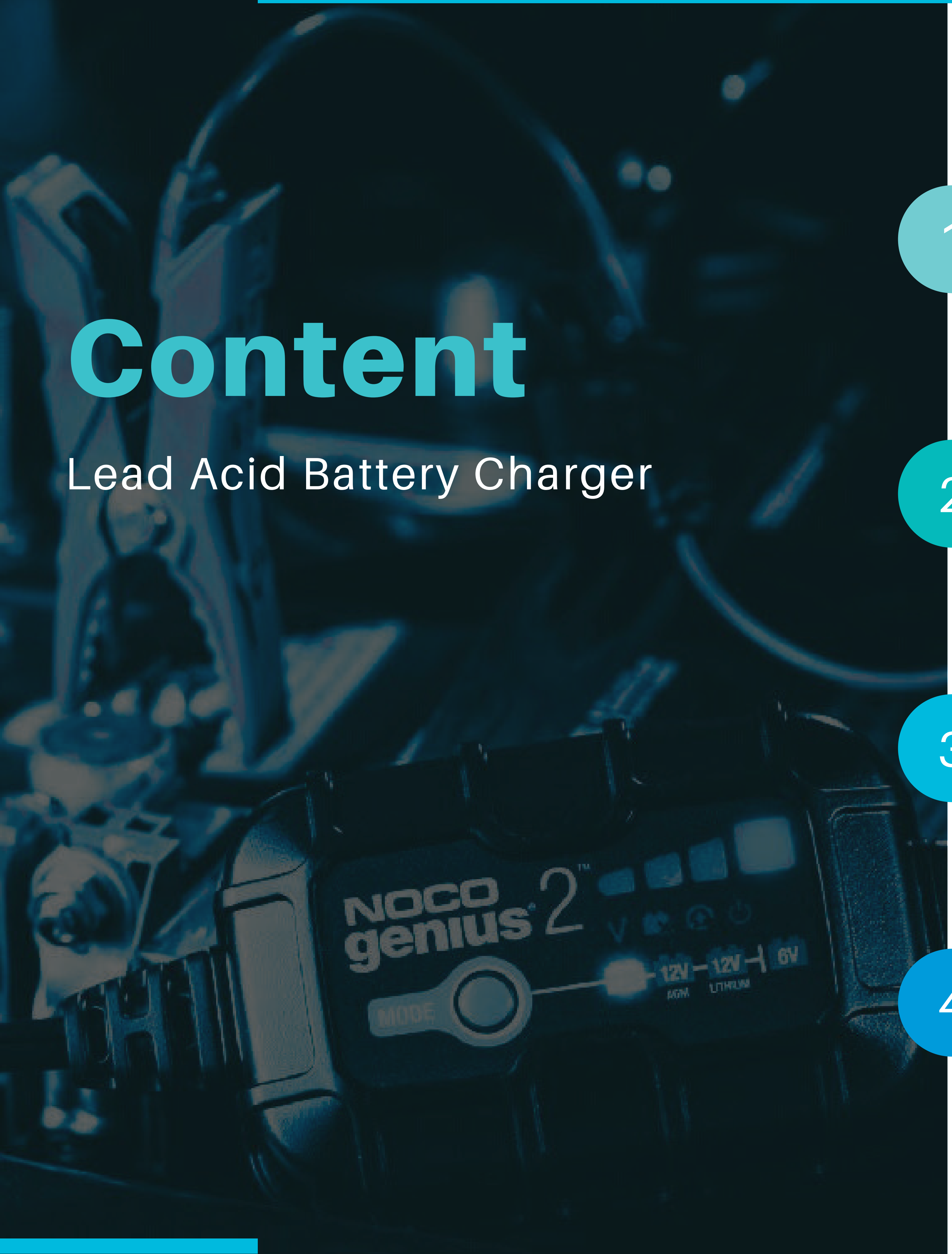
LEAD ACID BATTERY CHARGER

PROJECT PROPOSAL - ELECTRONICS III

Group - 06



Content

Lead Acid Battery Charger

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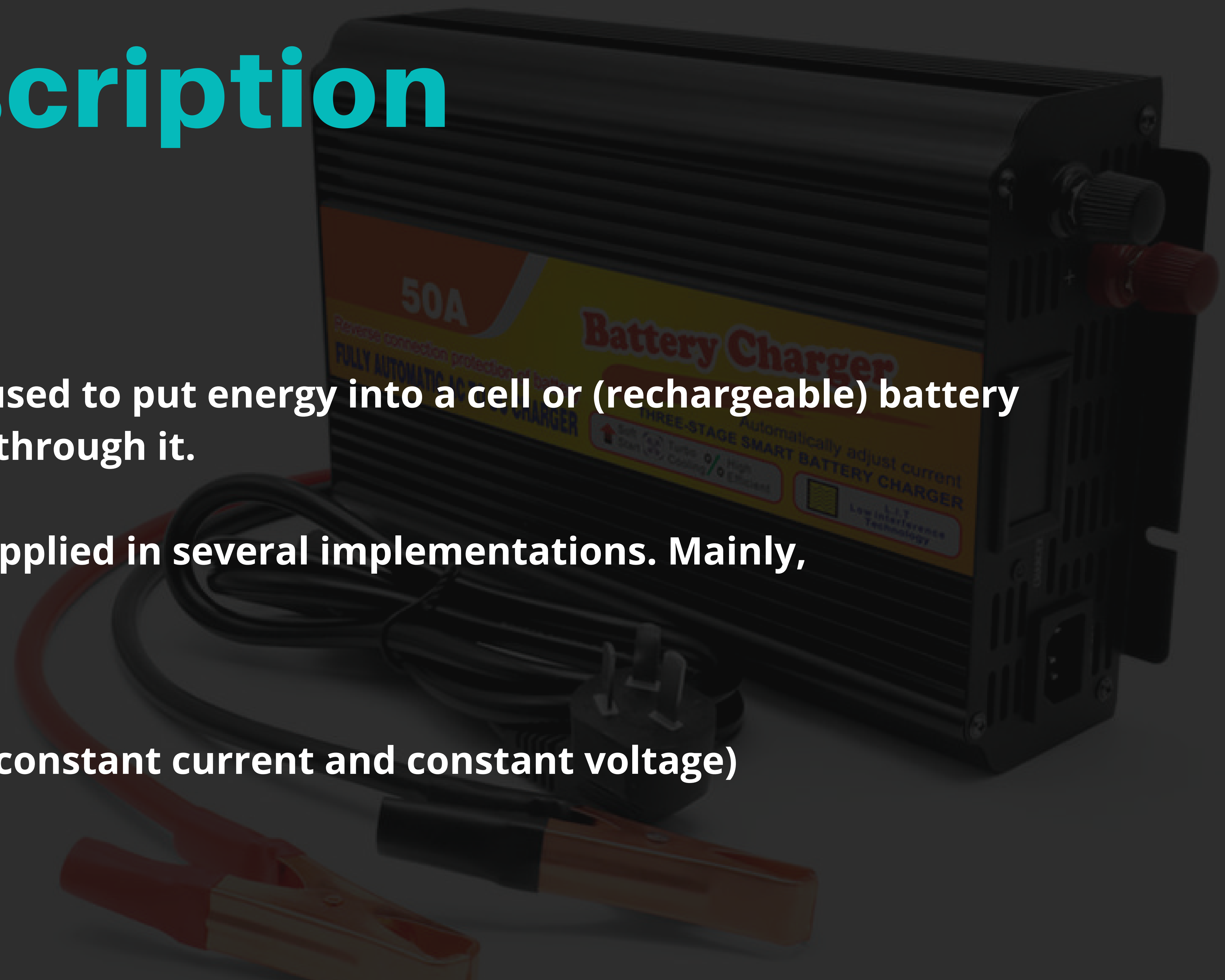
Project Description

Lead Acid Battery Charger



- A battery charger is a device used to put energy into a cell or (rechargeable) battery by forcing an electric current through it.

- The charging process can be applied in several implementations. Mainly,

1. constant current (CC) charger
2. constant voltage (CV) charger
3. Multistage charger (Use both constant current and constant voltage)

Project Specifications

Lead Acid Battery Charger

- Operating voltage - 24V
- Operating current - 8A
- Input Voltage – 230V A/C
- Technology – Lead Acid
- Power usage and efficiency will depend on the final optimized circuit design*

Market Analysis

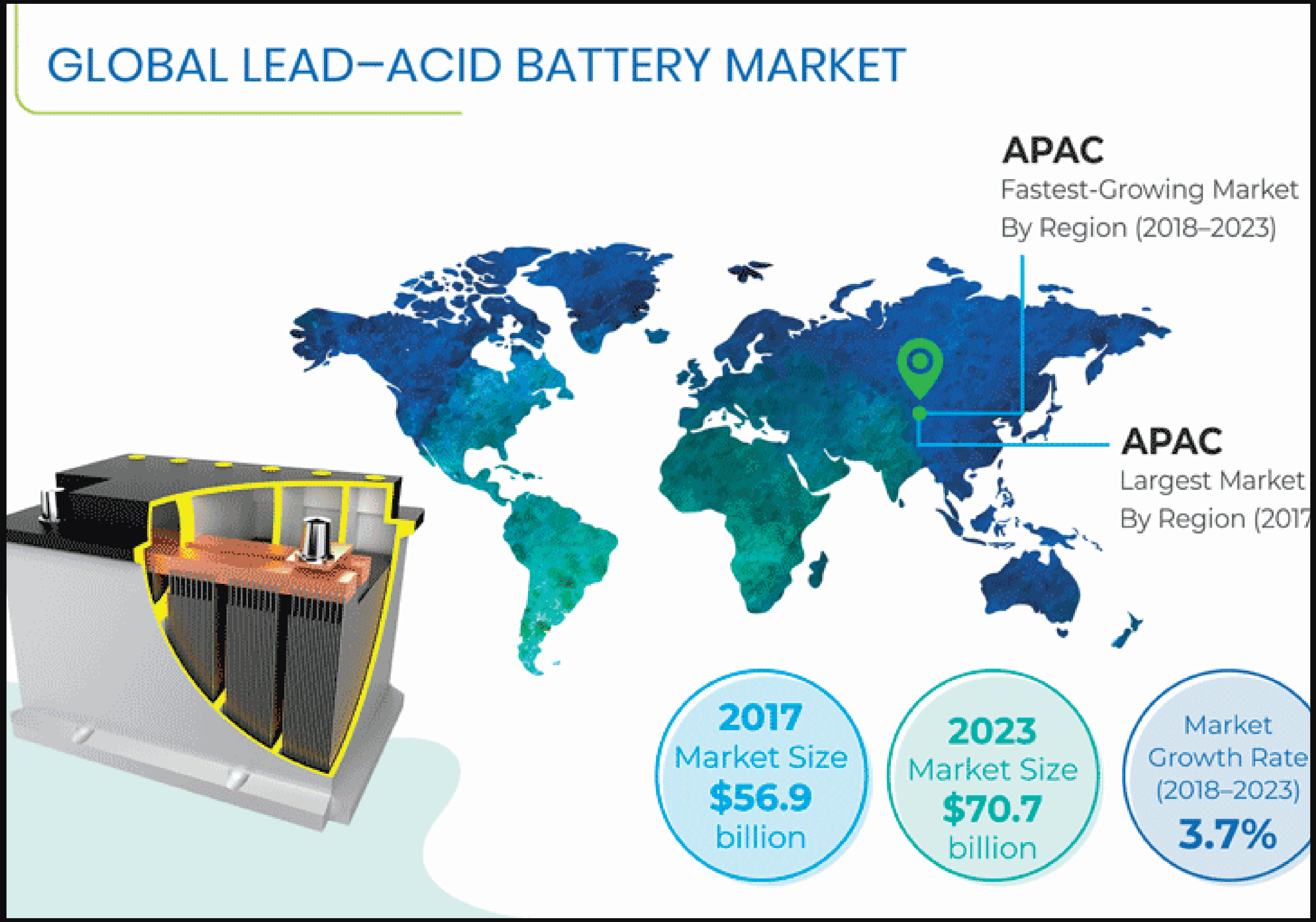
Lead Acid Battery Charger

In 2023 it is expected to have a $70.7 billion market share to lead acid battery

The lead acid battery market is sub segmented, by industrial, into data centres, telecom, oil & gas, and others.

Others in the industrial segment include construction, metals & mining, chemical & pharmaceutical, and food & beverage industries.

Compound Annual Growth Rate (CAGR) is 3.7%



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Market Analysis

Lead Acid Battery Charger

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The charger market's compound annual growth rate is about 8.5% and it create US$ 2.25 Bn in 2022.

Also, industrial chargers are expected to be more than 3.67 US billion dollars in 2027.

The growth rate of those batteries forecast shows that there is a 1.6X increment in the current period.

24V 8A Lead-acid battery chargers are used by several end users. Such as;

- Mobility Scooters
- Charge Wheelchairs
- Charge Electric Motorcycle
- Charge mobile medical applications

Charging Methods

Lead Acid Battery Charger

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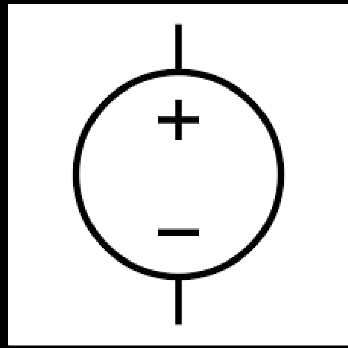
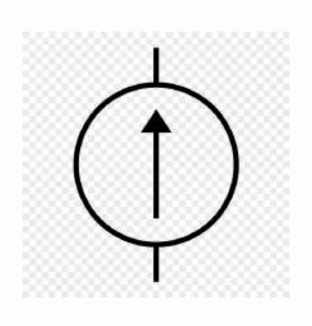
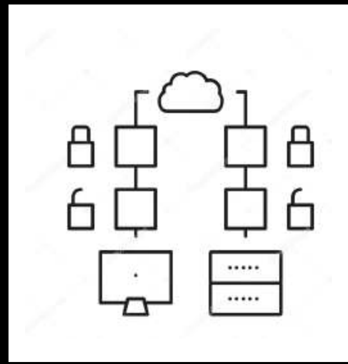


Constant Voltage Charger

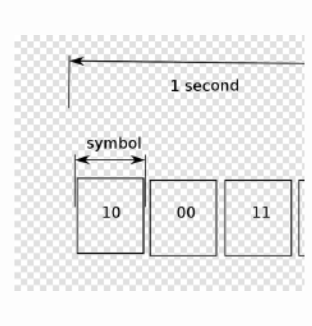
Constant Current Charger



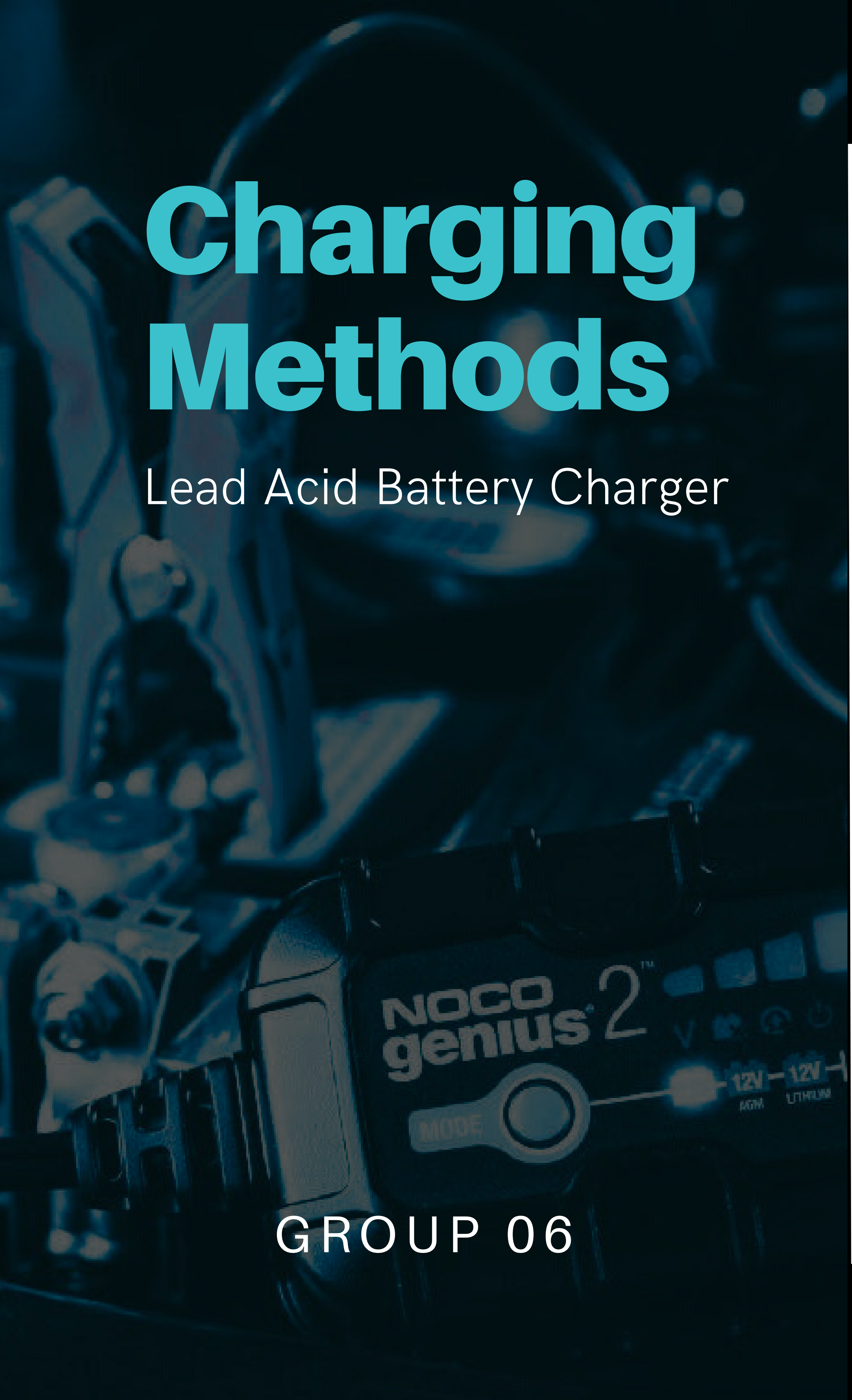


CC-CV Charger

Pulse Method Charger



SPF Charger Method



Charging Methods

Lead Acid Battery Charger

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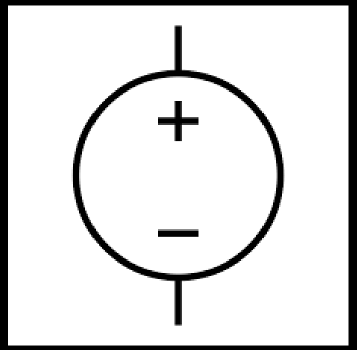


Constant Voltage Charger

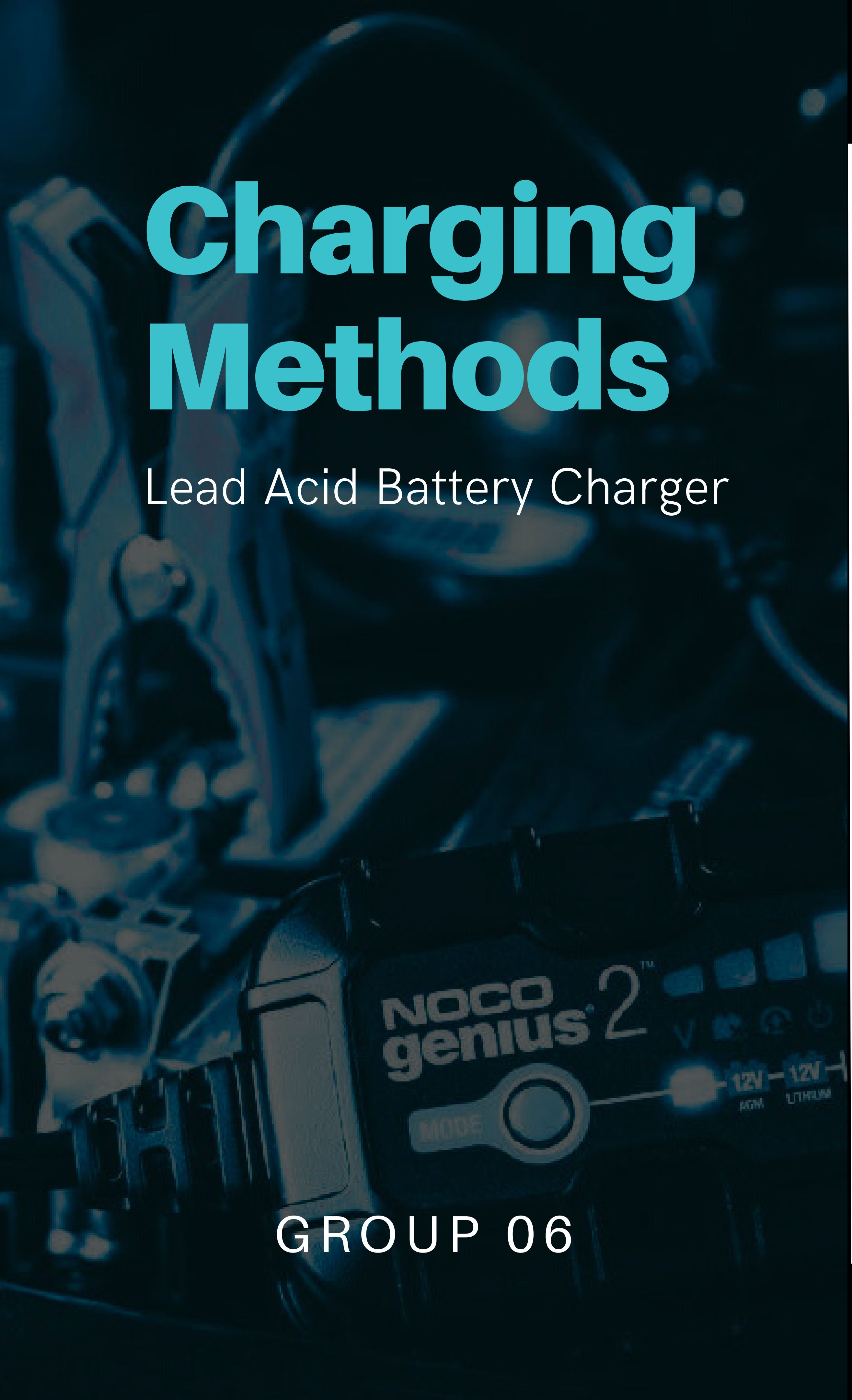
- **Always keeps Voltage in constant at terminals.**
- **Initial current is high.**

Advantages

- **Provide Large bulk current fastly to the battery.**

Disdvantages

- **Overcharging problems.**
- **Grid corrosion.**
- **Battery lifetime issues.**



Charging Methods

Lead Acid Battery Charger

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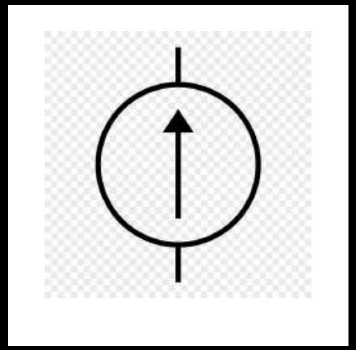


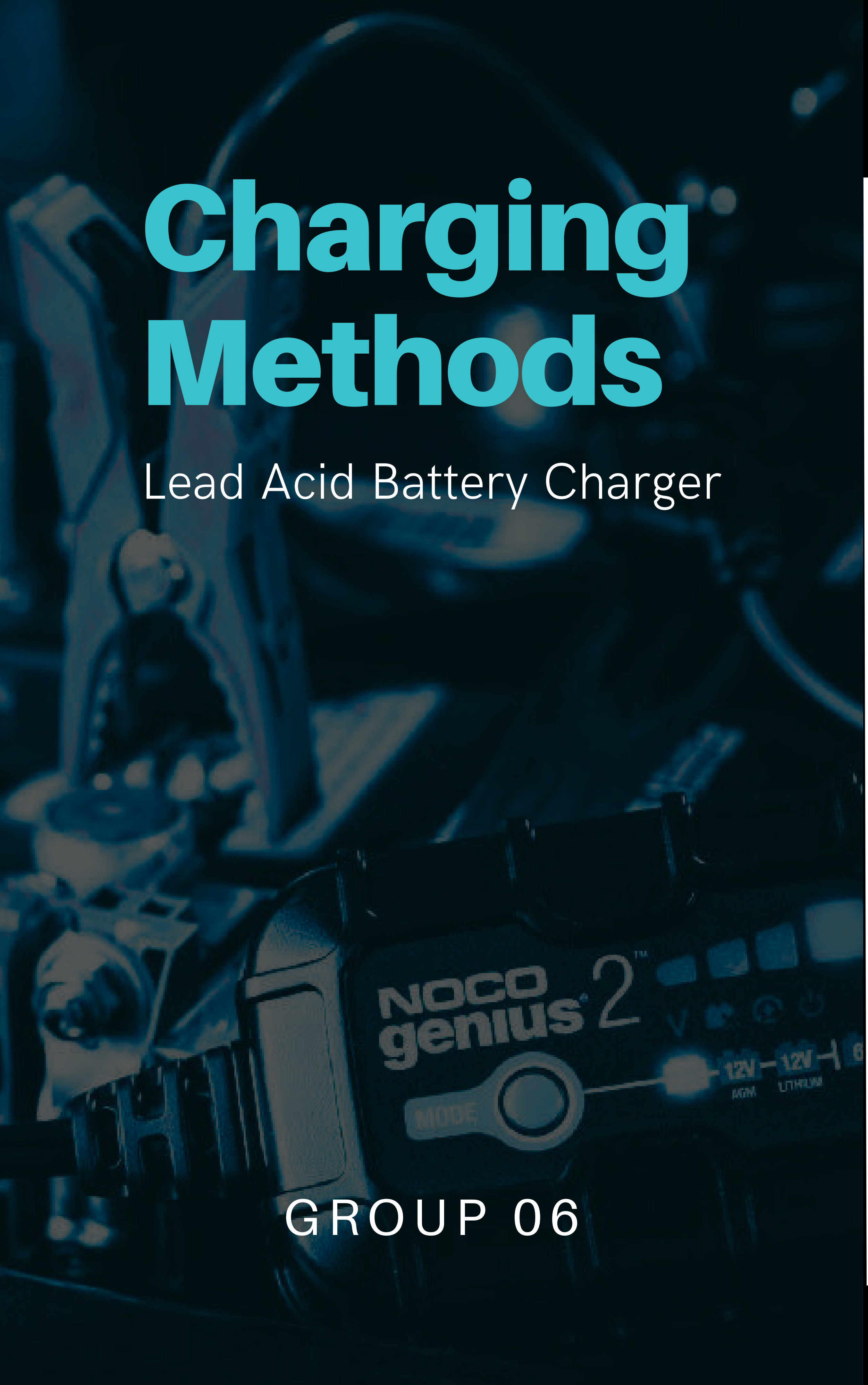
Constant Current Charger

- **A current source is used to drive uniform current through the battery in opposite direction of discharging.**

- **Ex. Water flow**

Disdvantages

- **Overcharging problems.**
- **Battery lifetime issues.**
- **Over heating problems.**



Charging Methods

Lead Acid Battery Charger

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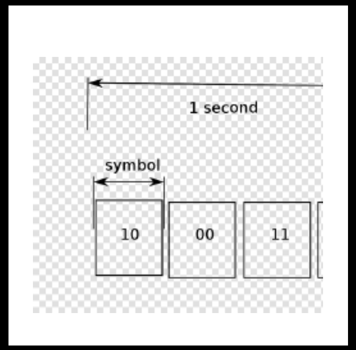
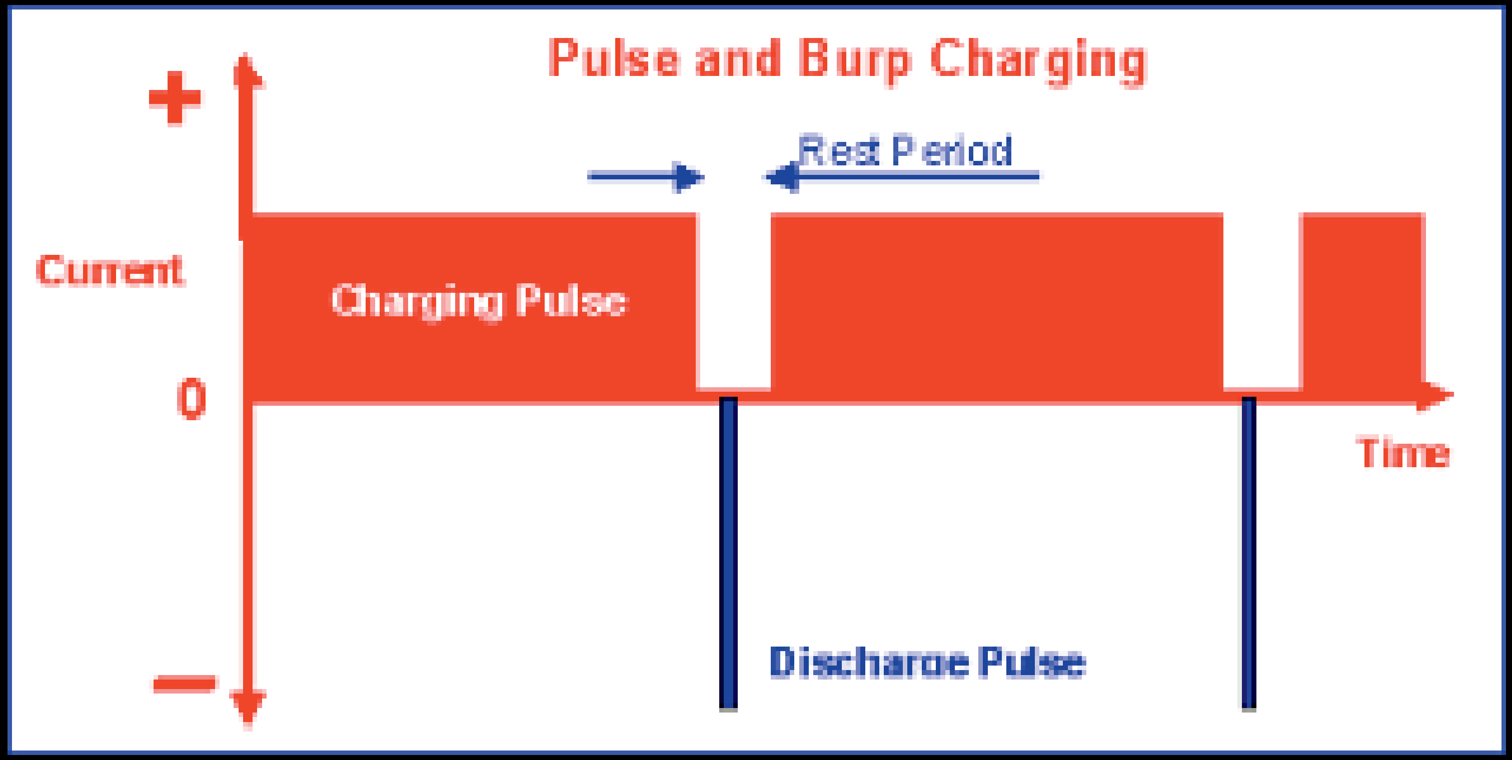


Pulse Method

- **Provide pulsed current periodically to the battery.**

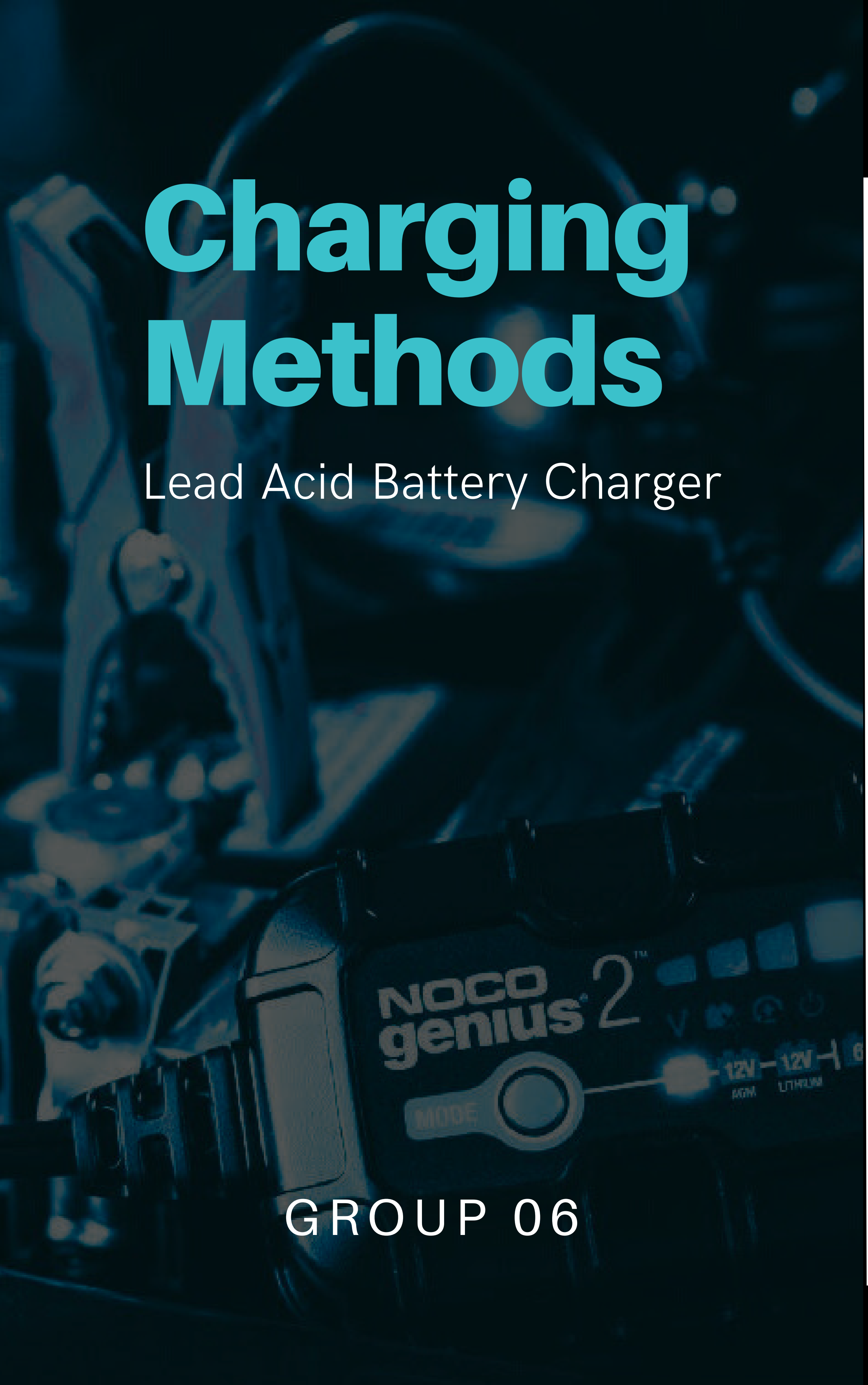
Includes;

1. **Deep charge stage**
2. **Pulse charge stage**
3. **waiting stage**



Charging Methods

Lead Acid Battery Charger



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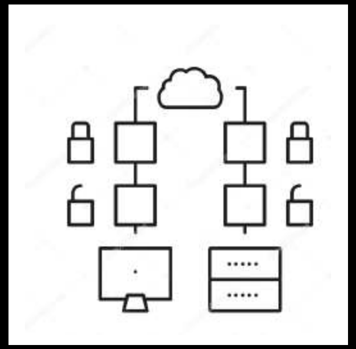
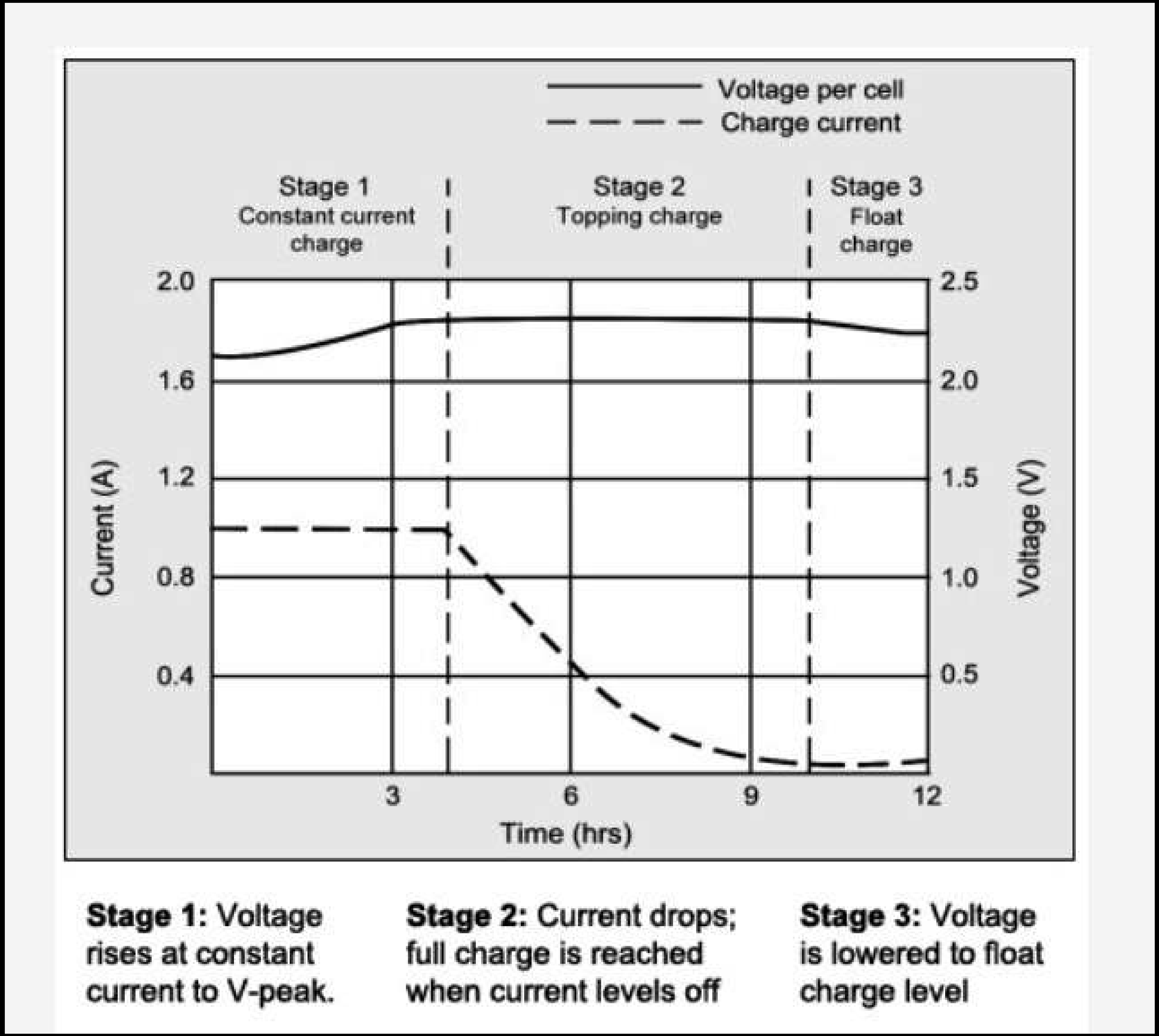


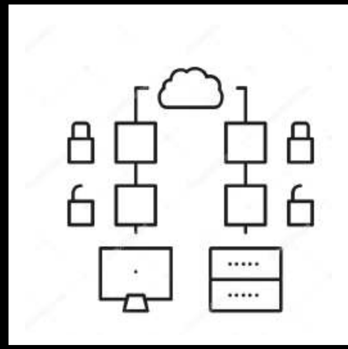
CC-CV Charger Method

- **Combination of Both Constant current (CC) & Constant voltage (CV) method.**
- **Most prefered method.**

Advantages

- **Better Approach when considering other methods.**
- **Fast charging**
- **No heat up problems.**

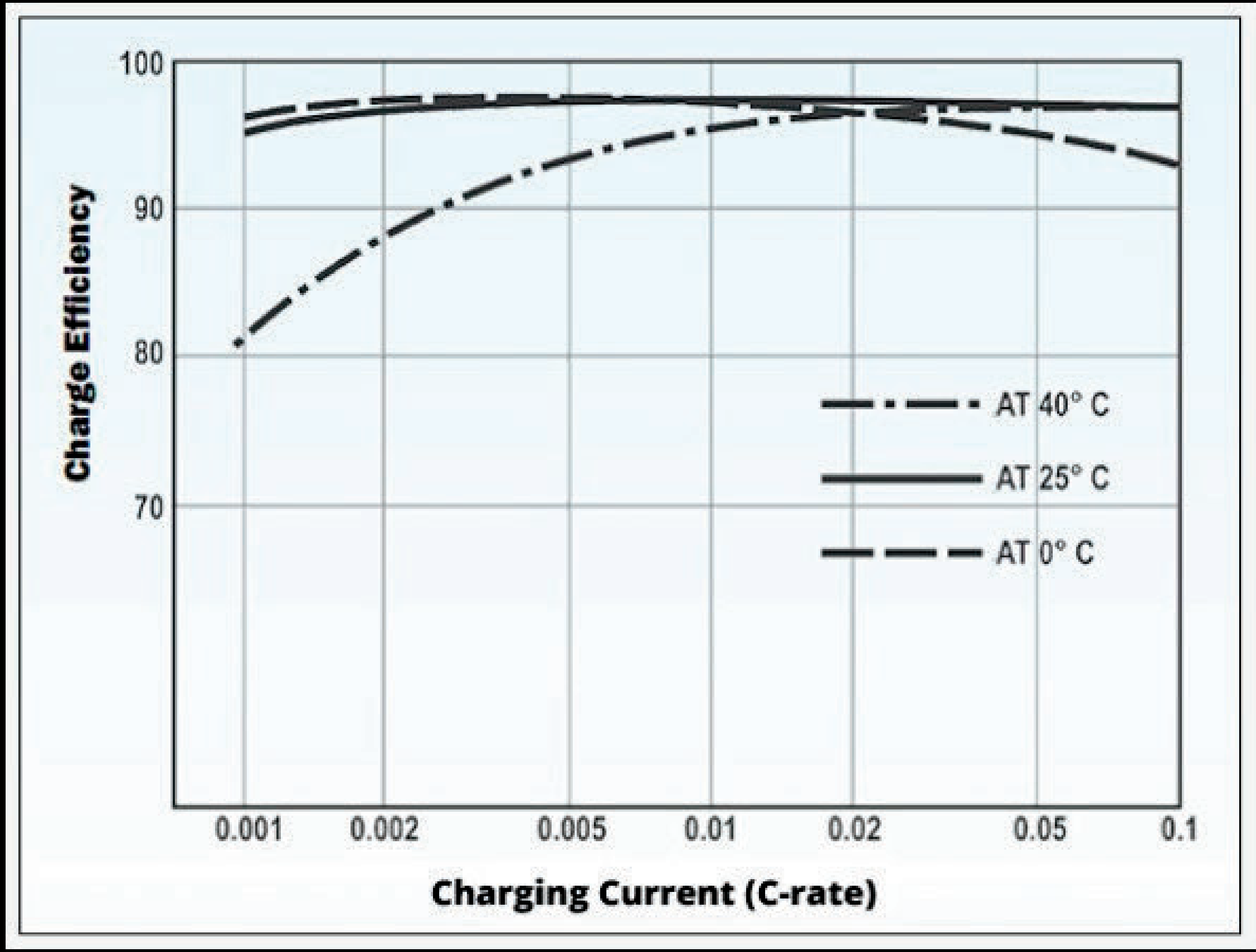


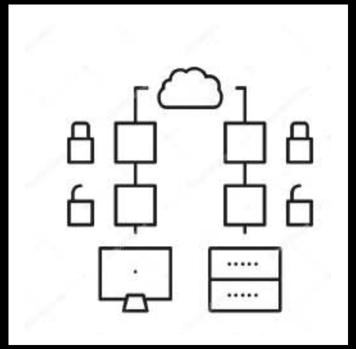


CC-CV Charger Method

Stages

- **Constant current stage**
- **Constant voltage stage**
- **Float stage**





CC-CV Charger Method

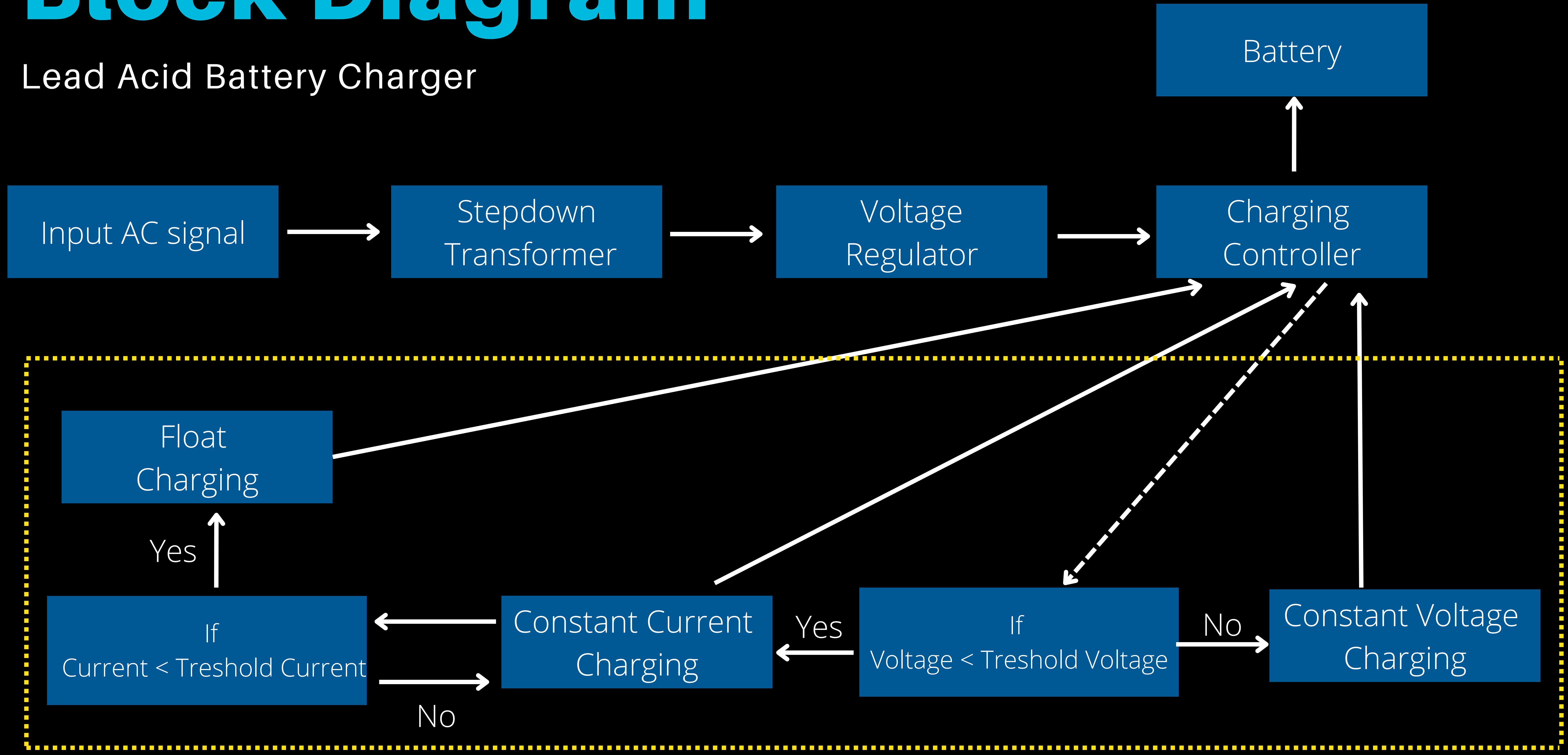
- **Effects of Nominal temperature, Charge current & efficiency variations.**

Disadvantages

- **Speed balance problems.**
- **Temperature variations.**

Block Diagram

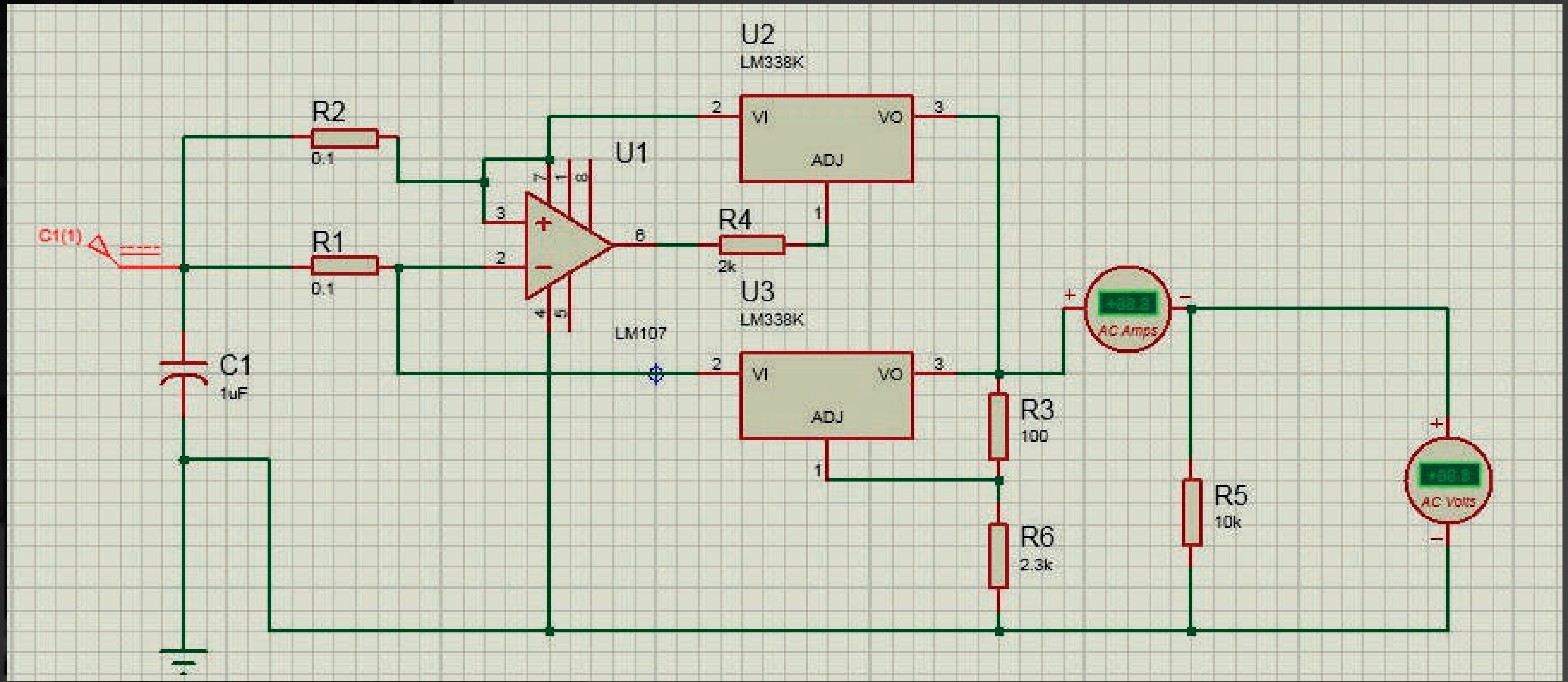
Lead Acid Battery Charger

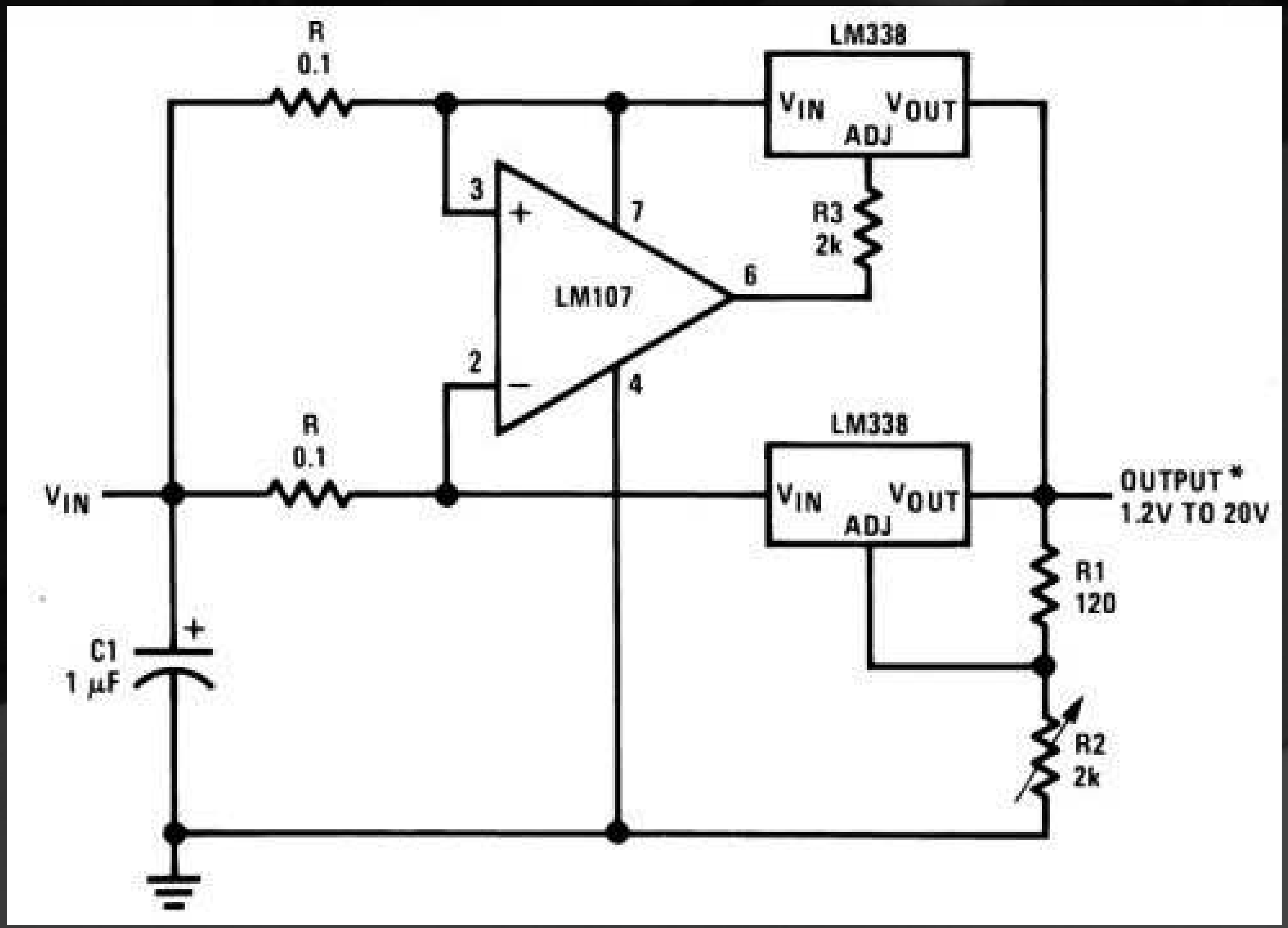


Circuit Diagram

Lead Acid Battery Charger

Power Regulator Circuit





Resistor selection

$V_{out} = 30V$;

$R_S = 2400\Omega$

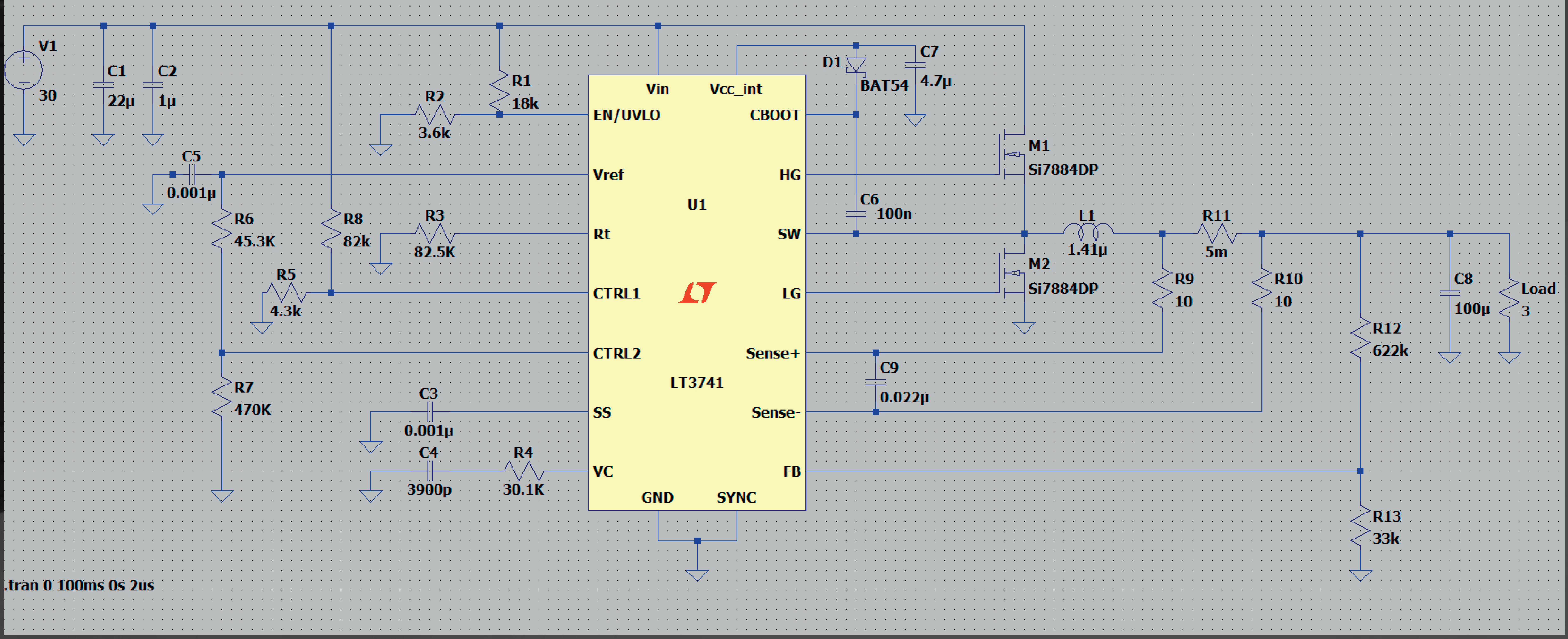
$R_1 = 100\Omega$

$$V_{out} = 1.25\left(\frac{R_S}{R_1}\right)$$

$$= 1.25 \times \left(\frac{2.4K}{100}\right) = 30\ V$$

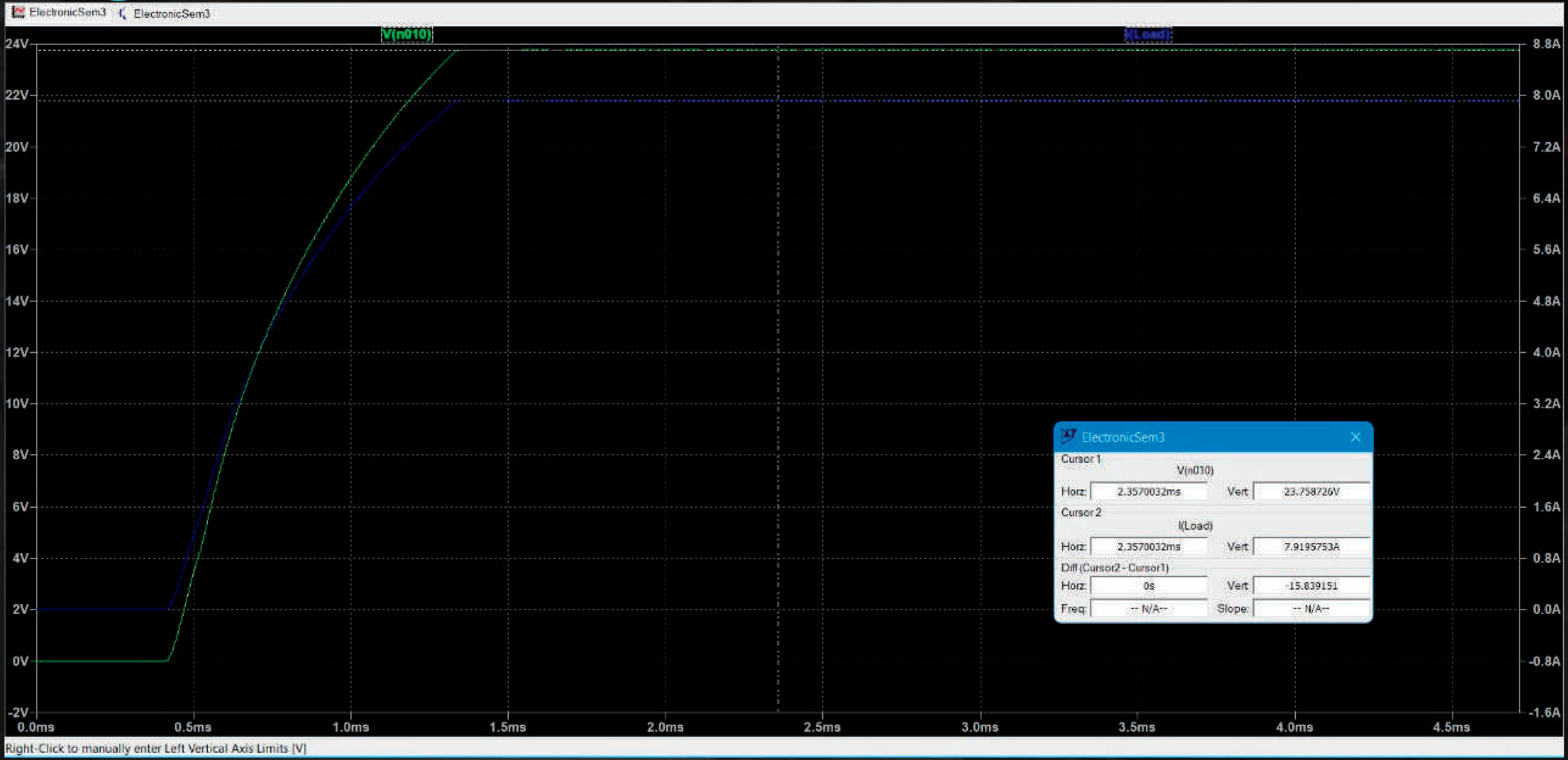
Circuit Diagram

Control Unit Circuit



Circuit Diagram

Control Unit Simulation



Component Selection

Lead Acid Battery Charger

Current and Voltage Adjustment

$V_{in} = 30V$; $V_{Ref} = 2V$

$CTRL1 = \frac{30V}{82+4.3} \times 4.3$

$= 1.494V$

$V_{out} = 24V$

$I_{out} = 8A$

∴ R_{13} ; R_{12} selection.

$R_{13} = 33K$; $V_{out} = 24V = 1.21\left(1 + \frac{R_{12}}{R_{13}}\right)$

$24 = 1.21\left(1 + \frac{R_{12}}{33}\right)$

$\therefore R_{12} = 622K$

R_{11} selection

$I_o = \frac{V_{CTRL1}}{30 \cdot R_s}$; $8 \approx \frac{1.4V}{30 \times R_s}$

$R_s \approx 5\ m\Omega$

Inductor selection

$$L = \left(\frac{V_{IN} \cdot V_o - V_o^2}{0.3 \cdot f_s \cdot I_o \cdot V_{IN}}\right)$$

$L = 1.41 \times 10^{-6}\ F$

Component Selection

Lead Acid Battery Charger

MOSFET Selection

ABSOLUTE MAXIMUM RATINGS $T_A = 25\ °C$, unless otherwise noted					
Parameter		**Symbol**	**10 s**	**Steady State**	**Unit**
Drain-Source Voltage		V_{DS}	40		V
Gate-Source Voltage		V_{GS}	± 20		V
Continuous Drain Current ($T_J = 150\ °C$)[a]	$T_A = 25\ °C$	I_D	20	12	A
	$T_A = 70\ °C$		16	10	
Pulsed Drain Current		I_{DM}	50		
Avalanche Current	L = 0.1 mH	I_{AS}	30		
Continuous Source Current (Diode Conduction)[a]		I_S	4.7	1.7	
Maximum Power Dissipation[a]	$T_A = 25\ °C$	P_D	5.2	1.9	W
	$T_A = 70\ °C$		3.3	1.2	
Operating Junction and Storage Temperature Range		T_J, T_{stg}	- 55 to 150		°C
Soldering Recommendations (Peak Temperature)[b, c]			260		

Mosfet selection

$V_{in} < V_{DS}$: $V_{DS} > 30V$ — (1)

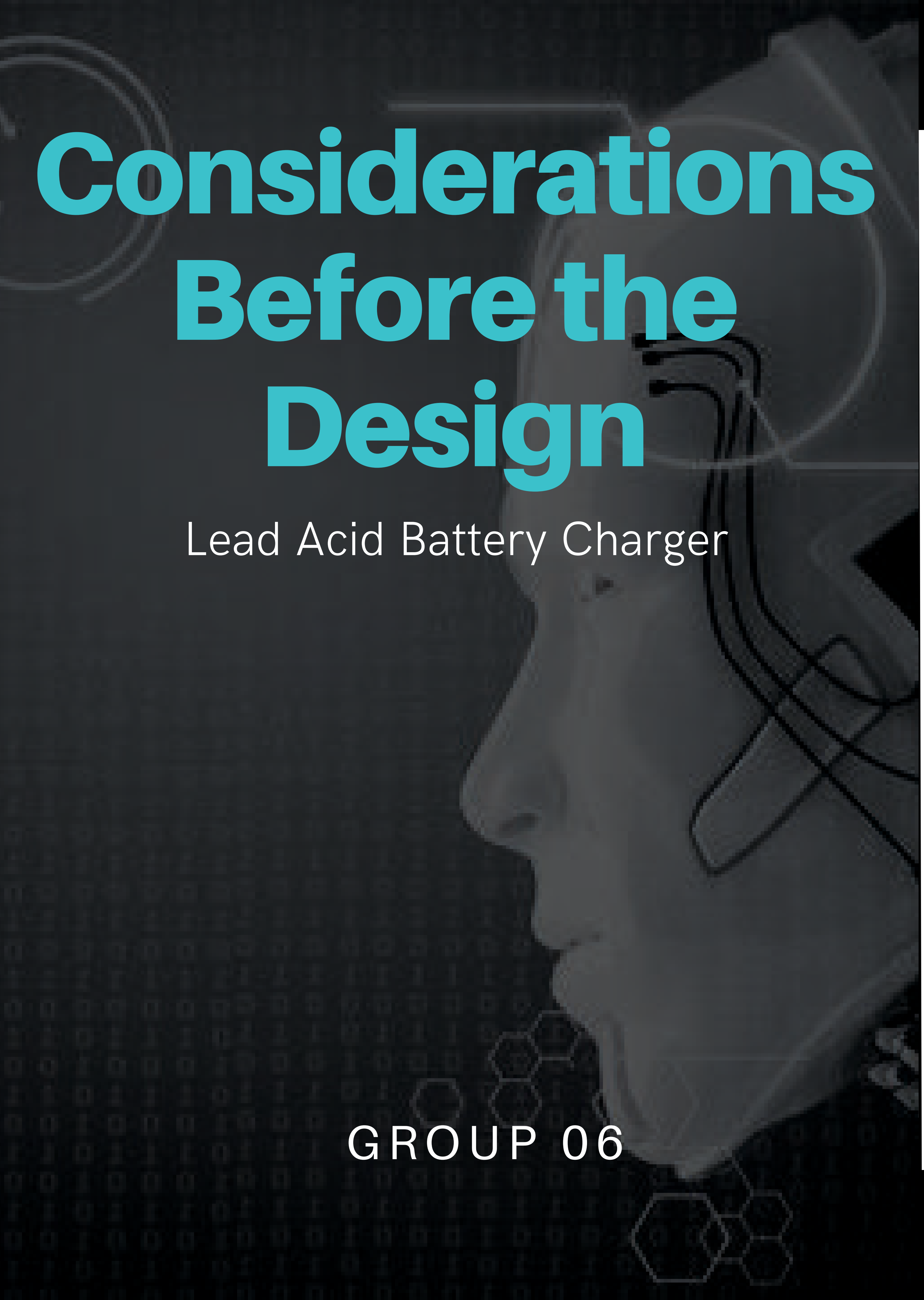
$I_{max} < I_D$:

$$I_{max} = I_{out} + \left(\frac{V_{in} \cdot V_o - V_o^2}{2 \cdot f_s \cdot L \cdot V_{IN}}\right)$$

$= 8 + 3.3$

$= 11.3\ A$ $\therefore I_D > 11.3\ A$ — (2)

Si7884DP



Considerations Before the Design

Lead Acid Battery Charger

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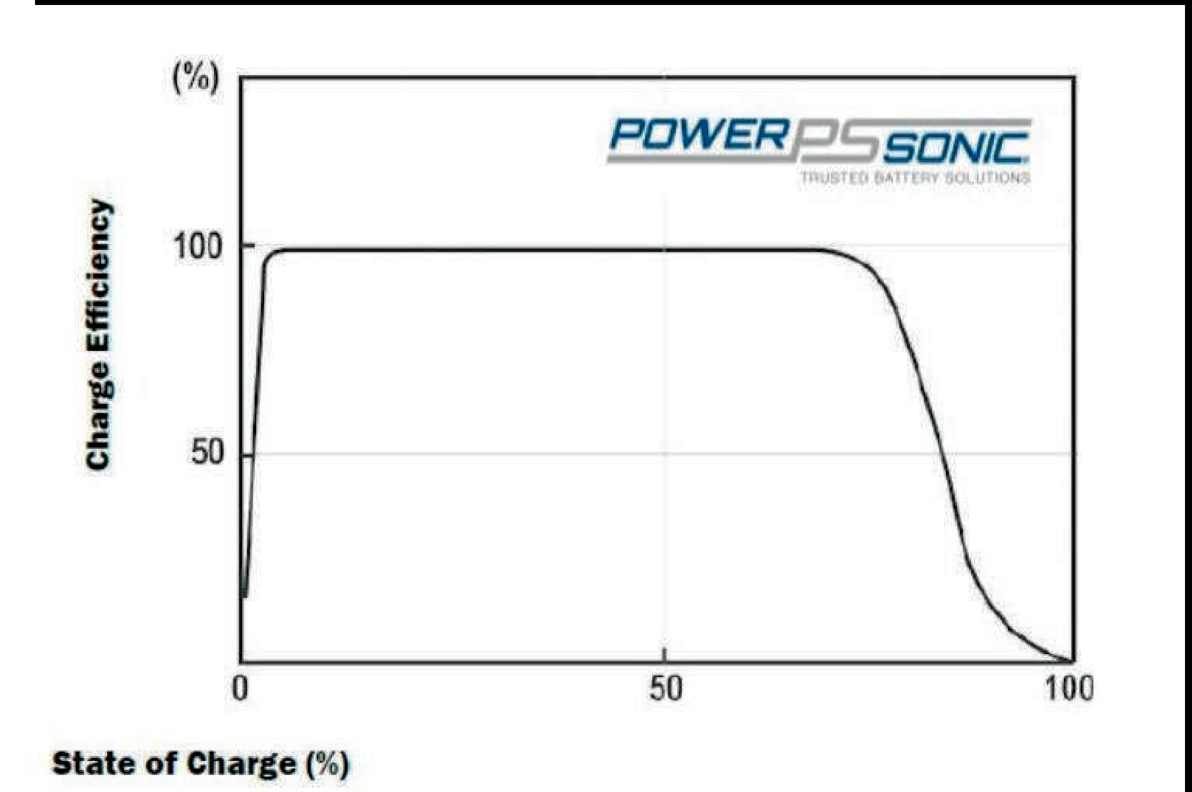
- Temparature Handling
- Batter Charging Effciency
- Circuit connections

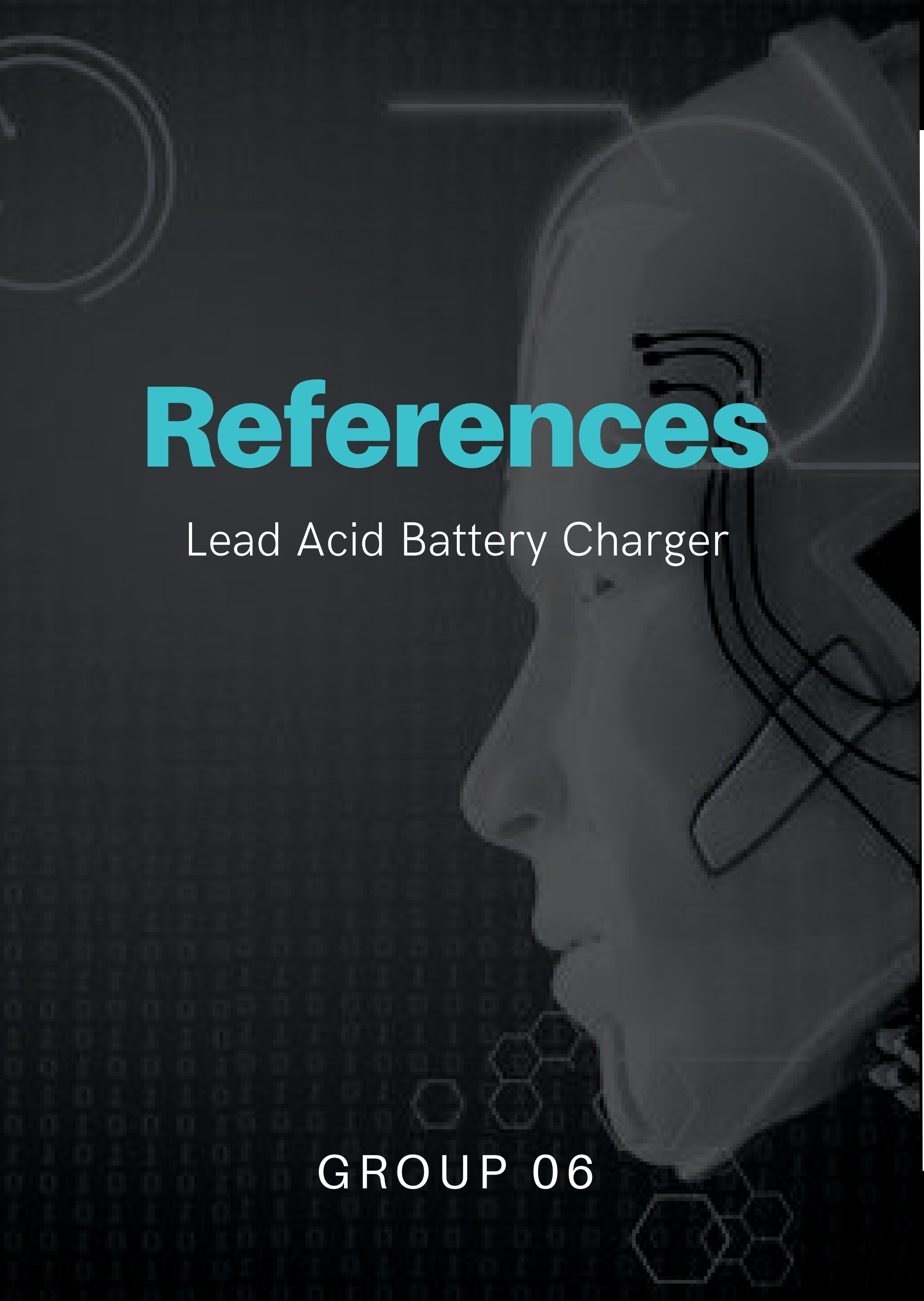
Temperature	Cyclic Use (V)	Float Use (V)
-40°C (-40°F)	2.85 – 2.95	2.38 – 2.43
-20°C (-4°F)	2.67 – 2.77	2.34 – 2.39
-10°C (14°F)	2.61 – 2.71	2.32 – 2.37
0°C (32°F)	2.55 – 2.65	2.30 – 2.35
10°C (50°F)	2.49 – 2.59	2.28 – 2.33
20°C (68°F)	2.43 – 2.53	2.26 – 2.31
25°C (77°F)	2.40 – 2.50	2.25 – 2.30
30°C (86°F)	2.37 – 2.47	2.24 – 2.29
40°C (104°F)	2.31 – 2.41	2.22 – 2.27
50°C (122°F)	2.25 – 2.35	2.20 – 2.25



Time Line of the Project

Lead Acid Battery Charger

1. design the circuit and simulations
2. Test and build the prototypes
3. Print the PCB and enclosure
4. Final product



References

Lead Acid Battery Charger

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- https://www.power-sonic.com/blog/how-to-charge-a-lead-acid-battery/
- https://www.baseapp.com/embedded/types-sealed-lead-acid-chargers/
- https://www.baseapp.com/embedded/types-sealed-lead-acid-chargers/

Thank you

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LEAD ACID BATTERY CHARGER

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