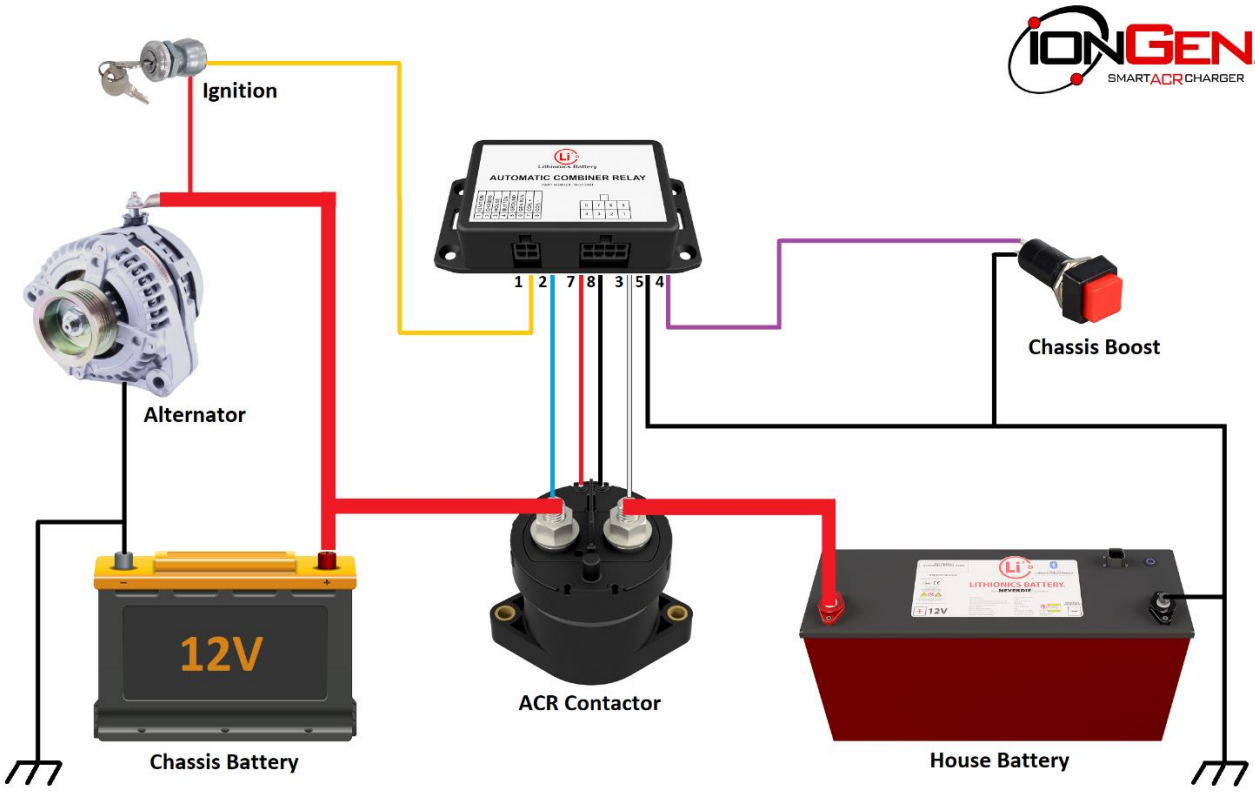
Automatic Combiner Relay Controller (ACR) Applications Overview

An Automatic Combiner Relay (ACR) is often used in vehicle applications such as RVs, Work Trucks, Marine vessels, etc. to allow charging separate Chassis and House batteries from common charge sources such as an engine alternator, inverter/charger, solar. In a typical vehicle the chassis battery is reserved for engine starting, while the house battery is used for "hotel" (or house loads) or work-related loads. Normally, when the engine is running, the chassis battery is charging, but when the vehicle is stationary and connected to the power grid, the house battery is charging. Our intelligent ACR allows customers to take advantage of all situations to keep both batteries charged, while keeping them separate when charging is not available or not desirable.

Lithium batteries have an advantage of absorbing as much charge current as possible during the bulk charge stage, which could overheat and potentially damage stock engine alternators, so our intelligent ACR reduces the duty cycle and allows cooling periods. At the same time, a lithium battery requires charge termination when fully charged, so our ACR keeps it disconnected after the charge cycle is completed.

In addition, the Lithionics Battery® ACR provides solutions for less common use cases where 2nd alternator is installed to charge the house battery, but its internal regulator is not designed for fine charge control of lithium batteries, as well as cases where a 3rd party battery disconnect (ex. Mastervolt Charge Mate Pro 40) is used to current-limit the alternator but needs an intelligent additional control to terminate the charge of a lithium battery.

Below is a functional diagram showing the typical components of a system where ACR is used to bridge Chassis and House batteries.



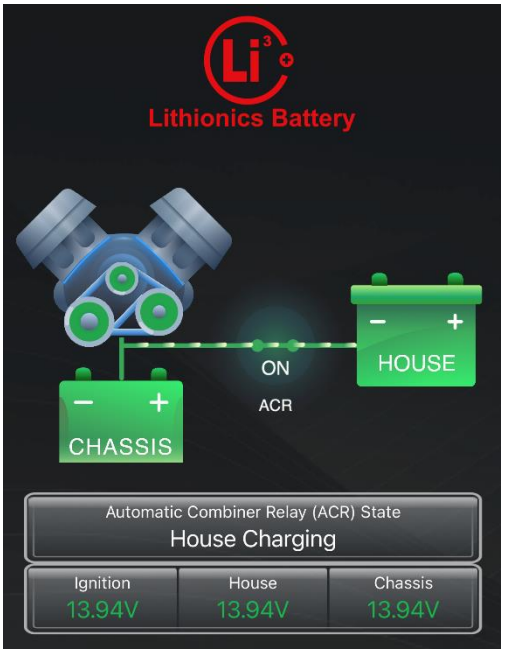
Revison: E

ACR Logic Table

ACR logic table below lists all possible functional states and entry/exit conditions for each state.

ACR STATE	State code	LED State	Enter conditions	ACR Contactor State	Exit conditions	Notes
STAND_BY	0	Short Blink	none, default "power on" state	OPEN	evaluate all inputs	both CHARGING states exit into RESTING state, all other states exit into STAND_BY state
WARMING_UP	1	Slow Blink	Ignition change OFF -> ON	OPEN	(Warm_Up Timer > 30s) OR	
					Ignition = OFF	
HOUSE_CHARGING	2	Solid On	(Ignition = ON) AND	CLOSED	(Ignition = OFF)@2min OR	
			(Chassis > 13.2) AND		(Chassis < 12.3)@2min OR	Chassis conditions are disabled when $CHASSIS=0 is set
			(House < 13.8V) *Voltage can be configured with $HACV command		(House > 14.6V)@30s OR	quick disconnect if voltage reaches maximum allowed
					(House > 14.2V)@30min OR	allowing for 30 min absorption stage if voltage stays good
					(Genrun = ON) OR	generator inhibits alternator to prevent fighting of charge sources
					Charging Timer > 60min	
CHASSIS_CHARGING	3	Solid On	(Ignition = OFF) AND	CLOSED	(Ignition = ON) OR	Chassis function can be disabled in systems with 2nd alternator charging House and ACR controls the alternator via small relay
			(6.0V < Chassis < 12.4V) AND		(Chassis < 12.3)@30s OR	Chassis conditions are disabled when $CHASSIS=0 is set
			(House > 13.4V)		Charging Timer > 60min	
RESTING	4	Slow Blink	Charging Timer > 60m	OPEN	(Resting Timer > 15min) OR	15 min resting period to cool off the alternator and settle down battery voltages, then repeat charge cycle as needed
					Ignition change	
BOOSTING	5	Solid On	Dash_Button change OFF -> ON	CLOSED	(Dash_Button Timer > 2min) OR	If button is pressed shortly, then merge for 2 minutes. If button is held down, then allow up to 15 min of merge time. Disabled when $CHASSIS=0 is set
					(Dash_Button = ON) AND (Timer > 15min)	
GEN_RUNNING	6	Slow Blink	Genrun = ON	OPEN	(Genrun = OFF) OR	
					BOOSTING state triggered	BOOSTING state disables GEN_RUNNING state
FAULT	7	Rapid Blink	(ACR_State = CLOSED) AND	OPEN	Ignition change	Possible contactor failure or loose lug when voltage across closed contactor is >0.5V
			ABS(Chassis - House) > 0.5V@5s			

ACR Support in the Lithionics Battery mobile app



Lithionics Battery Monitor app is available for free on Google Play and Apple App Store platforms. In addition to monitoring Lithionics Batteries the app is also abe to connect to the Bluetooth interface in the ACR and monitor its status as well as voltages of both Chassis and House batteries. Battery icons can be Green or Red color, where Red color indicates a low voltage, which means the battery needs charging at the earliest opportunity. When ACR contactor is closed there is an animation of the charge current flow from Chassis to House or in reverse, depending on the ACR logic table shown above.

The app can also be used to update the ACR firmware, so when new features are released the customer can update their system using their mobile device. To access Firmware Update touch Settings gear icon in the upper right corner, then touch Firmware Update and follow instructions on the screen.

ACR Customized Software Settings

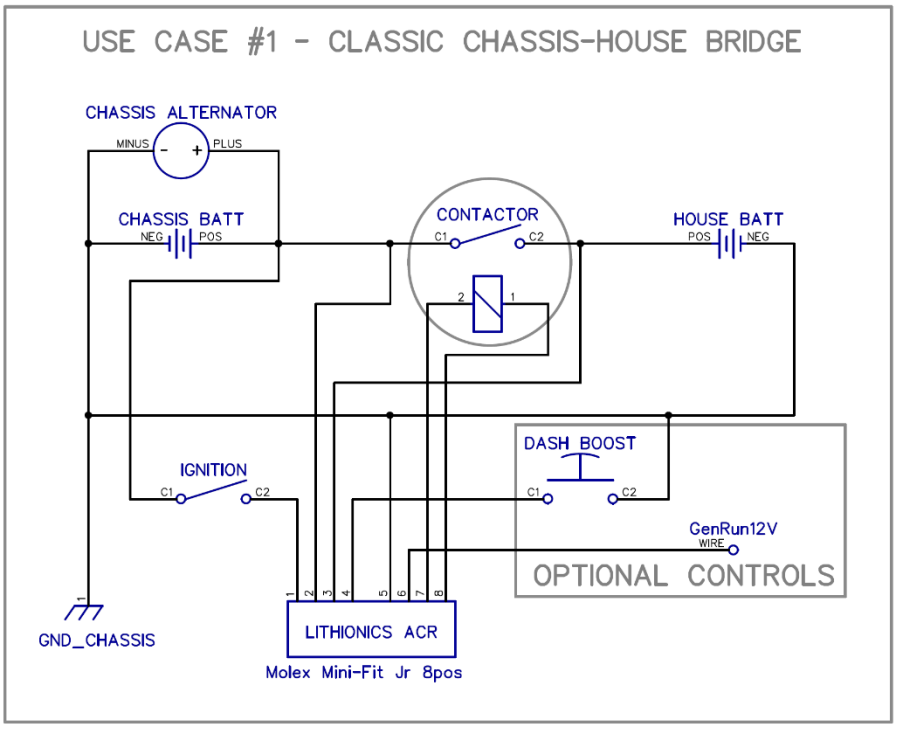
Most applications will work well using default ACR software settings, but a few special cases exist where ACR settings must be adjusted for correct function. This is done using the mobile app's feature called Terminal Console, where you can send commands to the ACR to make configuration changes.

Connect to the ACR using the Lithionics Battery Monitor app, touch the Gear icon in the upper right corner to access Settings screen, then touch the Terminal Console button to access the Terminal Console screen. You will see raw data scrolling up every second and there is a command window at the bottom with $ prefix filled in, where you type commands, then send using the return arrow icon on the right side. You can disable auto-scroll by touching 3-dot menu icon in the upper right corner, then select Disable Autoscroll menu. This allows to manually scroll the terminal window data up/down. Following commands are supported:

- **$LIST –** prints current settings values and firmware version number.
- **$CHASSIS –** when ACR is used to control the 2nd alternator independent of the Chassis battery and primary alternator, see Use Case #2 and #3 below, then ACR must be set to ignore Chassis voltage by sending command $CHASSIS=0 .
- **$DASH –** sets voltage polarity for the Dashboard or Boost button. Default value $DASH=0 means the button is wired to Ground potential as shown in the diagram on page 1. In some cases customers prefer to wire the button to 12V side. In this case you must set the ACR accordingly by sending command $DASH=1.
- **$HACV –** sets House Accept Charge Voltage level. Default value is 1380, which means 13.80V. Range of possible values is 1340 to 1400, which corresponds to 13.40V to 14.00V. This value defines maximum House battery voltage at which ACR will engage when you start the engine. If House battery voltage is above this level when engine is started, then ACR considers the House battery is already full or nearly full and will wait until the battery voltage drops below this level. This feature is designed to prevent frequent charge cycles if you drive often while the battery is already charged from shore power or solar. However, some customers prefer to charge their battery to full with every drive, in which case this value should be increased to the maximum of 14.00V by sending command $HACV=1400.

ACR Wiring Diagram – Case #1 Classic Chassis-House Bridge

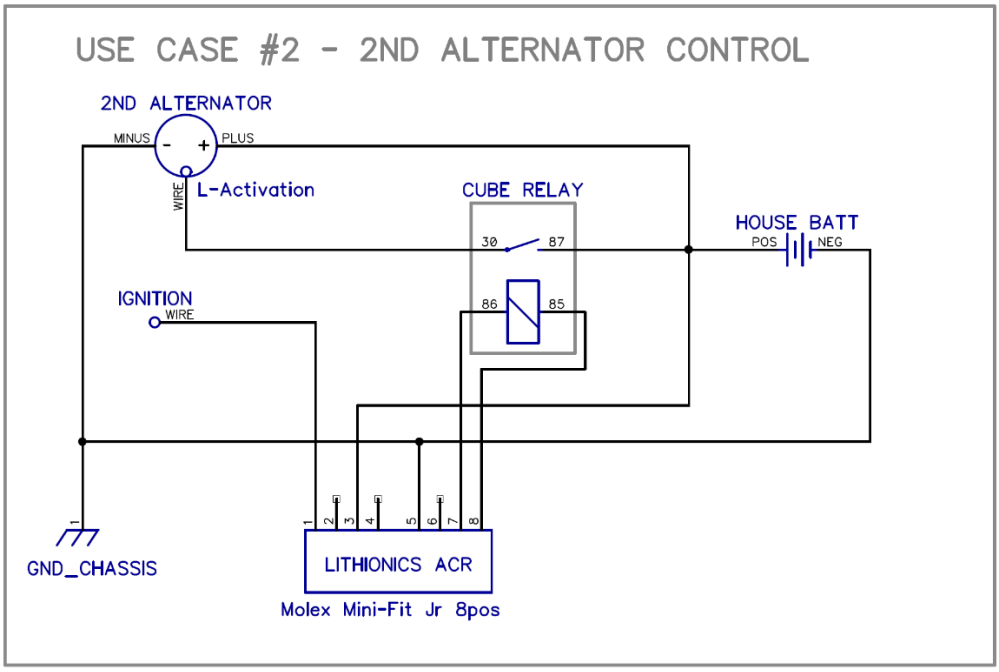
This is the most common use case of the ACR, where a heavy duty contactor closes the connection between Chassis and House batteries. It is important to select the contactor with coil economizer feature, so continuous coil consumption is less than 500mA. Tested and approved contactors are **Gigavac GV and GX series, Altran AEV250, Rincon REC35**. Contact Lithionics Battery for advise and approval of any other contactor model you'd like to use.



ACR Wiring Diagram – Case #2 Secondary Alternator Control

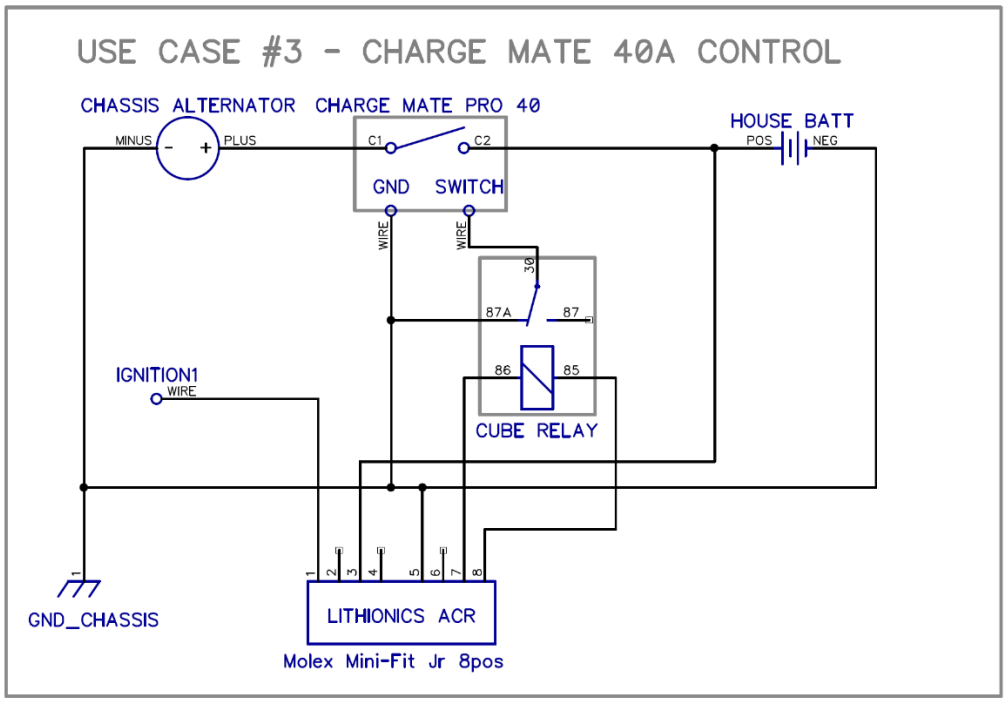
In this application a 2nd alternator is installed in the vehicle, dedicated to charging the House battery, while a stock alternator is charging the Chassis battery, so there is no need for the contactor to bridge two batteries. However, some alternators with rudimentary built-in regulators tend to overcharge the Lithionics battery due to their poor voltage regulation, so the ACR is used to disable the alternator output when House battery reaches preset full charge voltage. The alternator must have an Activation terminal, sometimes labeled "L" or it must have exposed Field winding terminals, so a relay can be added to open/close activation circuit using the ACR to drive the relay coil. In such special application please contact Lithionics Battery for support to make sure ACR can be user with your alternator.

NOTE: Alternator is enabled by connecting its "L" a.k.a. Activation terminal to battery voltage and disabled by disconnecting from battery voltage.



ACR Wiring Diagram – Case #3 Charge Mate Pro 40 Control

In this application a small chassis alternator must be current limited to maintain vehicle warranty, so instead of the contactor you can use a current limiting bridge such as Charge Mate Pro 40, which still needs to be disabled when the battery is fully charged, so an additional small relay is used to enable/disable the bridge and relay coil is controlled by the ACR. **NOTE:** Charge Mate is disabled by grounding its Switch terminal and enabled by floating the same terminal.



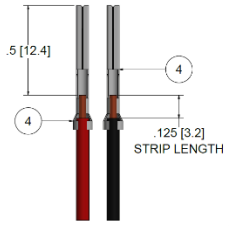
ACR Kits and wiring harnesses options with and without contactor

PARTS LIST

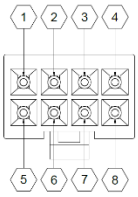
ITEM	QTY	PART NUMBER	DESCRIPTION	VENDOR	VENDOR PART NUMBER
1	1	50-273-KIT	ACR CONTROL MODULE	LITHIONICS BATTERY	50-273-KIT
2	1	53-145	GV121BAX 12V 200A NL CONTACTOR	GIGAVAC	GV121BAX
3	1	75-273-PREMIUM	ACR HARNESS PREMIUM	LITHIONICS BATTERY	75-273-PREMIUM
4	2	80-714	MINI-FIT FEMALE CRIMP TERMINAL, Sn OVER Ni, 18-24 AWG	MOLEX	39000207

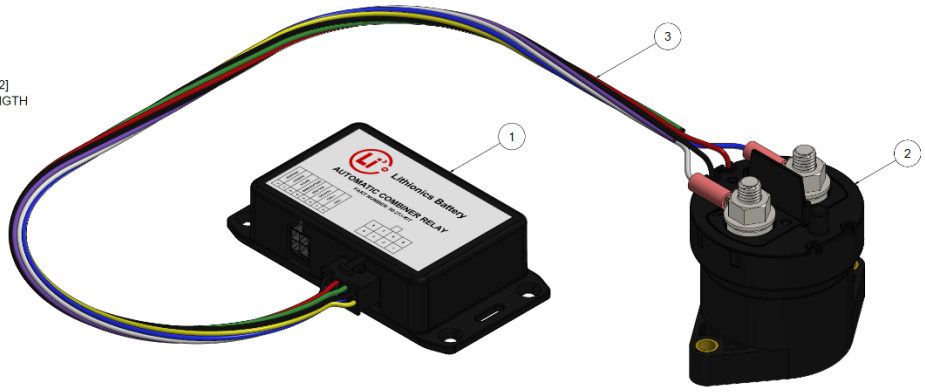
REVISION HISTORY

REV	DESCRIPTION	DATE	APPROVED
A	INITIAL RELEASE	7/14/2021	JP



CRIMP DETAIL





PINOUT DIAGRAM

POSITION	COLOR	FUNCTION
1	YELLOW	IGNITION
2	BLUE	CHASSIS
3	WHITE	HOUSE
4	PURPLE	DASH BUTTON
5	BLACK	GROUND
6	GREEN	GENRUN
7	RED	COIL+
8	BLACK	COIL -

NOTES:

1. CRIMP TERMINALS ON RED AND BLACK CONTACTOR COIL WIRES AND INSERT INTO OPEN CONNECTOR POSITIONS (7) AND (8) AS INDICATED ON PINOUT DIAGRAM

Lithionics Battery

DESCRIPTION: ACR KIT ASSEMBLY PREMIUM

PROJECT: BMS ELECTRONICS - Li3

PART NO: 50-273-KIT-PREMIUM REV: A

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± 1/64 ANGULAR +/- .25° BEND +/- TWO PLACE DECIMAL +/- .030 THREE PLACE DECIMAL +/- .005 Inspection Dimension

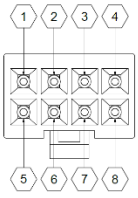
DO NOT SCALE SHEET 1 OF 1

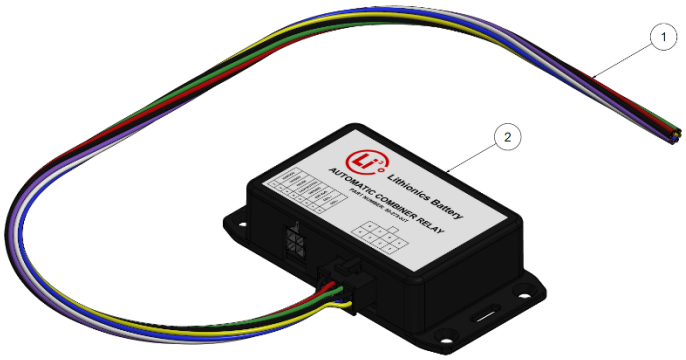
PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION	VENDOR	VENDOR PART NUMBER
1	1	75-273-STANDARD	ACR HARNESS STANDARD	LITHIONICS BATTERY	75-273-STANDARD
2	1	50-273-KIT	ACR CONTROL MODULE	LITHIONICS BATTERY	50-273-KIT

REVISION HISTORY

REV	DESCRIPTION	DATE	APPROVED
A	INITIAL RELEASE	7/14/2021	JP





PINOUT DIAGRAM

POSITION	COLOR	FUNCTION
1	YELLOW	IGNITION
2	BLUE	CHASSIS
3	WHITE	HOUSE
4	PURPLE	DASH BUTTON
5	BLACK	GROUND
6	GREEN	GENRUN
7	RED	COIL+
8	BLACK	COIL -

NOTES:

1. INSERT CONNECTOR INTO ACR CONTROL MODULE AS SHOWN

Lithionics Battery

DESCRIPTION: ACR KIT ASSEMBLY STANDARD

PROJECT: BMS ELECTRONICS - Li3

PART NO: 50-273-KIT-STANDARD REV: A

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± 1/64 ANGULAR +/- .25° BEND +/- TWO PLACE DECIMAL +/- .030 THREE PLACE DECIMAL +/- .005 Inspection Dimension

DO NOT SCALE SHEET 1 OF 1

Lithionics Battery, Clearwater, FL 33759 USA
Ph: 727.726.4204 | Fax: 727.797.8046 | Web: lithionicsbattery.com