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# ALLTRAX

PERFORMANCE MOTOR CONTROLLERS

## Operators Manual AC2 Controller



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# WARNINGS

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## GENERAL WARNINGS

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### Safety Notes:

When working on electric vehicles, sudden unexpected events can occur, it's recommended to:

- Place the drive axle on jack stands—wheels off the floor.
- When working on wiring or batteries, always remove rings, watches and secure dangling clothing/hair/jewelry.
- Use the proper safety equipment, eye protection, and insulated tools.
- Never connect a computer while the vehicle is being charged.
- Disconnect batteries before installing or working on the Alltrax controller.
- Wear safety glasses.
- Because hydrogen can build up due to gassing from the batteries, work in a well ventilated area.
- Make sure the battery pack is fused.
- Do not clean the controller with a high PSI pressure washer.
- When cleaning batteries, take precautions to keep the battery acid from splashing on the controller.

### CAUTION:

It is the installer's responsibility to ensure the correct equipment (i.e. wire, motor, solenoid, fuse etc) is installed in the vehicle. Equipment should be sized correctly for planned usage. Failure to do so could pose a significant risk of explosion, fire, property damage and serious injury or death.

## READ AND SAVE THESE INSTRUCTIONS

# WARNINGS

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## **USABILITY STATEMENT**

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Alltrax Inc's lines of AC Induction and PMAC Motor Controllers are intended for use with brushless motors only. Any application or usage that does not meet these criteria WILL NOT be covered by warranty. Also, any requests for design assistance or technical support outside the scope of the product intended use may be denied. Alltrax assumes no liability for any damage or injury as a result of use of the motor controllers in a non-traction or process motor application. See the warranty at the end of this manual.

**WARNING:** Use of this product for other than these specified uses may be highly dangerous and lead to serious injuries or death.



## **VOLTAGE SETTINGS**

The Alltrax AC1 controller works for a wide range of voltage applications. If you're running aftermarket lithium batteries, a higher voltage than standard or if this is a custom application we highly recommend you check your settings. For detailed instructions you can see our Toolkit operators manual. If the settings aren't correct it can limit torque, limit speed or even prevent operation.



## **THROTTLE SETTING**

It's important to make sure your throttle is correct for your application. The ITS throttle type should **ONLY** be used on DC EZGO applications being converted to the AC1 controller. All factory AC EZGO are 0-5v. Setting the controller for ITS when the car is equipped with a 0-5v throttle can potentially damage the factory throttle.

# AC2 SPECIFICATIONS



Model	1 Min (PhaseAmps)	Continuous (Phase Amps)
AC2-72650	650	250

<b>Type:</b>	3 phase AC, PMAC
<b>Operating Frequency:</b>	
<b>Controller Voltage, KSI &amp; Reverse:</b>	24v - 90v
<b>Operating Temperature:</b>	-20c to 90c
<b>Environmental Operating Temperature:</b>	-20c to 50c // 0F to 122F
<b>Standby Current (Power up):</b>	5mA
<b>KSI &amp; Rev Pin Input Current:</b>	200mA max
<b>Relay Drive Current:</b>	4A max
<b>Throttles Supported:</b>	0-5k, 5k-0, E-Z-GO ITS, 5k-0 3 Wire, 0-5v, USB Throttle, Absolute Mode
<b>Terminal Bolt Torque:</b>	60-80 in.lb (5-7ft.lb, 6.77-9.4nm)
<b>Mounting Bolt Torque:</b>	15-20 in.lb (1.25-1.75 ft.lb, 1.7-2.25nm)

## **Terms and Definitions**

**IPM:** *Internal Permanent Magnet*

**SMPM:** *Surface Mount Permanent Magnet*

**KI:** *Integral Gain for PI/PID controllers*

**KP:** *Proportional Gain for PI/PID controllers*

**KD:** *Derivative Gain for PI/PID controllers*

**Quadrature:** *Most common type of Speed Sensor Signal used in AC Induction motor applications*

**Sine/Cosine:** *Commonly used for speed sensors in IPM and SMPM motor applications.*

**KSI:** *Key switch input, refers to signal voltage from the KEY*

**Roll Detect:** *Is a feature that uses the speed sensor to determine whether or not the cart is moving with no active throttle.*

## **Unique Features**

### **Low Voltage Protection -**

If battery voltage falls below your set Under Voltage limit the controller will shut off the power supply completely to prevent the batteries from getting drained to the point of damaging themselves. If you plug the controller into the toolkit software you will get a large SHUTDOWN warning to notify you of what happened. You can bring power back by cycling the TOW/RUN or plugging your charger back into the cart.

#### ***Trigger Limits -***

*1v for one hour*

*5v under shutdown triggered in 5 minutes*

*10v under shutdown triggered in 1 minute*

### **Encoder Pulses/Revolution Constraint (Quadrature Encoder)**

The maximum encoder frequency the controller will accept is 10 kHz. To determine how fast this constraint will allow the motor to spin, use the equation:

$$\text{Max Speed Encoder Limit} = 600000 / \text{Encoder Size}$$

*(e.g., a motor with 128-pulse encoder can run up to 4587 rpm).*

### **Firmware Max Speed Constraint**

The maximum motor speed the controller will allow is 13,000 rpm.

$$\text{Max Speed RPM Limit} = 13,000$$



# COMPONENTS

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**Heavy Duty Contactors**



**Main Fuse**



**Heavy Gauge Wires**



## ***Contactors (Solenoids)***

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The solenoid is the primary disconnect of the battery pack in the case of the an emergency. In order to be effective, the solenoid needs to be properly rated for the current that will be drawn from the batteries. It is VERY important that the solenoid be rated correctly. It is the only way to disconnect the batteries from the motor/controller loop in case of a failure. Too small of a solenoid increases the likelihood that the contacts will weld together and not be able open.

When installing a new controller, Alltrax recommends the OEM solenoids be replaced with a heavy duty version. See below for suggested sizing of solenoid replacements.

As a regular part of a preventative maintenance plan, solenoids should be replaced every 3-5 years.



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### **Heavy Duty 400A**

*(800-1000A inrush)*

A heavy duty solenoid is required when using any of the AC1 controllers. You need a minimum of 400A continuous and 800A inrush rating.

#### **Recommended Models**

MZJ400 (Shown)

SW200 (Albright)

SOL600

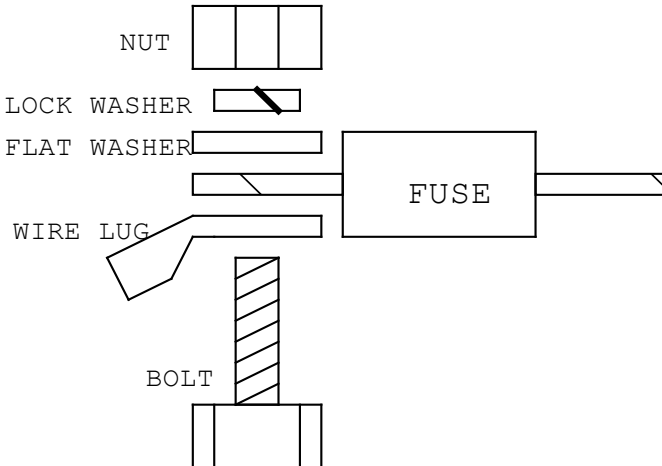
## Fuse

Any application where there is a battery pack, a fuse must be installed. A fuse will open the battery circuit and prevent any serious damage from occurring.

The fuse should be installed on or between the battery terminals. The main battery positive OR main battery negative OR in-between 2 batteries is an acceptable location for fuse installation. The fuse must be rated for pack voltage and fault current.



Controller Amperage	Fuse Style / Rating
650A	ANN / 400A



**Diagram: Fuse terminal hardware**

## **Wiring**

Wiring and battery health in an electric vehicle are very important and overlooked during performance upgrades. Wiring size is important for safety and proper operation of the vehicle. Undersized wires will affect the performance of controllers and can overheat. Wires should be crimped with proper sized terminals and tools to provide a clean low resistance connection.

Controller	Min. Wire AWG Standard Duty	Min. Wire AWG Heavy Duty
650A	2 AWG	1/0 AWG

### **Power Wiring**

When running wiring for the vehicle care must be taken for proper wire routing. Power wiring should be of proper sizing and ran as low in the framework of the vehicle as practical. Lengths of power wire runs need to be kept short and pairs of wires from common circuits should be grouped together to reduce EMC emissions. Secure all power wiring to the vehicle framework.

### **Motor Phase Wiring**

The three phase wires should be kept close to the same length and kept together as they run from the motor to the controller. For optimum reliability don't lay wire across other connections on the controller. Low current wires should not be run alongside the motor wiring or any high current wiring.

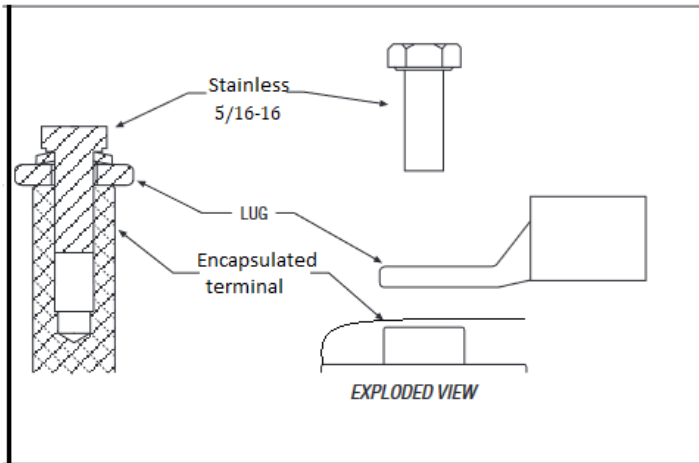
*\*\*\*Never swap motor phase wiring unless key is off and vehicle is not moving\*\*\**

# High Current Connections

TERMINAL	FUNCTION
B+	Battery positive to Controller
B-	Battery negative to Controller
R	Not Used
U	Motor phase U
V	Motor phase V
W	Motor phase W

## LUG ASSEMBLY

The AC controller comes with 5-6 stainless steel 5/16-16 bolts for holding the high current terminals to the controller.



# Low Power Wiring

## Signal Wiring

Signal wires should be kept as short as practical. Care should be taken to protect the wires from sharp edges and rubbing. Consider the use of split loom or braided wire sheathing. Fasten bundles securely to framework. Do not route the signal wires together in the same bundle with high current wires.

## Temp Sensor

Induction motors come with a two wire temp sensor which the controller uses to monitor internal temps during operation. On DC conversions the temp sensor will run through the same harness connector as your speed sensor.

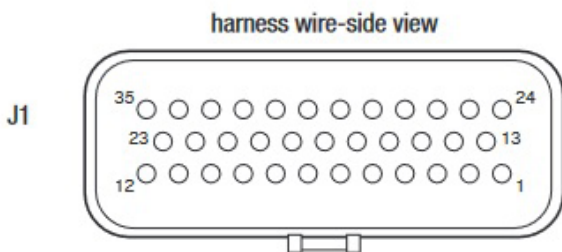
## ***Speed Sensor Information***

The speed sensor is a small group of wires attached to the side of the motor. Induction motors use a Quadrature signal that gives up to 64 readings per minute. Speed sensors are currently required. PMAC motors make use of a Sine/Cosine sensor.

# Wire Harness Pinouts

## 35 PIN AMPSEAL CONNECTOR (E-Z-GO RXV/OEM)

All low power connections are made through a single 35-pin AMPSEAL connector. The mating plug housing is AMP p/n 776164-1 and the gold-plated socket terminals are AMP p/n 770520 (Strip form) and 770854-3 (loose piece). The connector will accept 0.5 – 1.25 mm (20 – 16 AWG) wire with a 1.7 – 2.7 mm diameter (thin-wall insulation). Seal any non-used connector positions that have the silo-diaphragm pierced with seal plug 770678-1.



### Wiring Guidelines

#### ***Speed Sensor (Pins 7, 26, 31, 32)***

All four wires (+5V, Sensor A, Sensor B, and I/O ground) should be bundled together as they run between the motor and controller connections. These can often be run with the rest of the low current wiring harness.

#### ***CANbus (Pins 28, 29)***

It is recommended that the CAN wires be run as a twisted pair. The CANbus wiring should be kept away from the high current cables and cross them at right angles when necessary.

#### ***All other low power wiring***

The remaining low power wires should be run according to standard practices. Be sure to keep the input lines such as throttle, brake, temperature, and the above mentioned CAN/Speed Sensor signals separate from controller's output lines such as the coil driver outputs. Avoid routing the low-power wiring parallel to the high power battery and motor cables.

## 35 PIN TABLE 1/2

PIN	NAME	DESCRIPTION
1	KSI	Key Switch Input signal, provides power to the controller and drivers
2	Horn Ground	Driver pin used to pull the reverse horn LO.
3	Not Used	
4	Spare Ground	Can apply a digital ground
5	Brake Coil -	Control driver for brake coil negative
6	Relay Coil -	Used to control the ground side of the Relay Coil.
7	Analog Ground	Ground Reference
8	Motor Temp	Temp Sensor input from motor to controller
9	Throttle Switch	Throttle Activation interlock switch
10	Tow/Run	Battery reference voltage from Tow/Run switch
11	Charger	Interlock signal from charging system. Configurable in AC Toolkit
12	Brake Switch	Signal from brake interlock. Typically used with electronic brake systems
13	Key Switch	internally connected to pin 1
14	Not used	Not used
15	Throttle Power	+5v reference for throttles
16	Throttle Wiper	Wiper connection of throttle input used for both resistive and voltage based throttles
17	Brake Wiper	Wiper connection for braking input signal



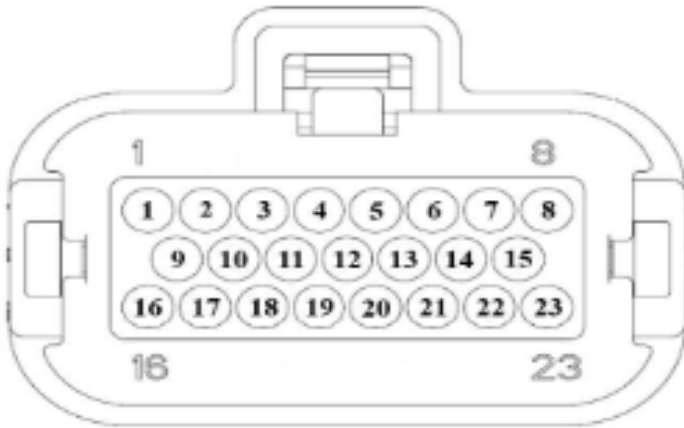
## 35 PIN TABLE 2/2

<b>PIN</b>	<b>NAME</b>	<b>DESCRIPTION</b>
<b>18</b>	Analog Ground	Analogue Ground signal used in some throttle applications
<b>19</b>	Not used	Not used
<b>20</b>	RC Pulse In	“Positive” signal from RC device
<b>21</b>	RC Ground	“Negative” signal from RC device
<b>22</b>	Forward	Forward direction input signal
<b>23</b>	CAN Hi	CAN positive signal
<b>24</b>	Logic Power	Battery reference, typically powered by or after Tow/Run
<b>25</b>	12v	12v reference
<b>26</b>	Tach Ref	5v reference for speed sensor/Tach
<b>27</b>	Not Used	
<b>28</b>	Not Used	
<b>29</b>	Tach C	Used in Absolute or BLDC Hall effect sensors
<b>30</b>	Not Used	
<b>31</b>	Tach A	Used for Quadrature and Sin/Cos speed sensors
<b>32</b>	Tach B	Used for Quadrature and Sin/Cos speed sensors
<b>33</b>	Reverse	Reverse direction input signal
<b>34</b>	Digital Ground	Ground signal
<b>35</b>	CAN Lo	CAN Lo/negative signal

# WIRE HARNESS PINOUT

## 23 PIN AMP SEAL connector - AC2

The majority of low power connections will be made through the 23 pin amp seal connector. AMP seal are water resistant connectors and have slightly less “functionality” than our 35 pin version. The big difference is requiring a separate harness for the temp and speed sensor.



*The image shows the carts wire harness when unplugged and viewed from the rear - where the wires go into the connector itself.*

On REV 1 AC2 23 pin controllers pins **14-23** all have different functions than what is listed in the pinout table on the following pages, the rev 1 are as follows:

- 14 - Tach Out
- 15 - Tach Ref
- 16 - Tach Neg
- 17 - User 1
- 18 - User 2
- 19 thru 23 - Not used

## 23 PIN TABLE 1/2

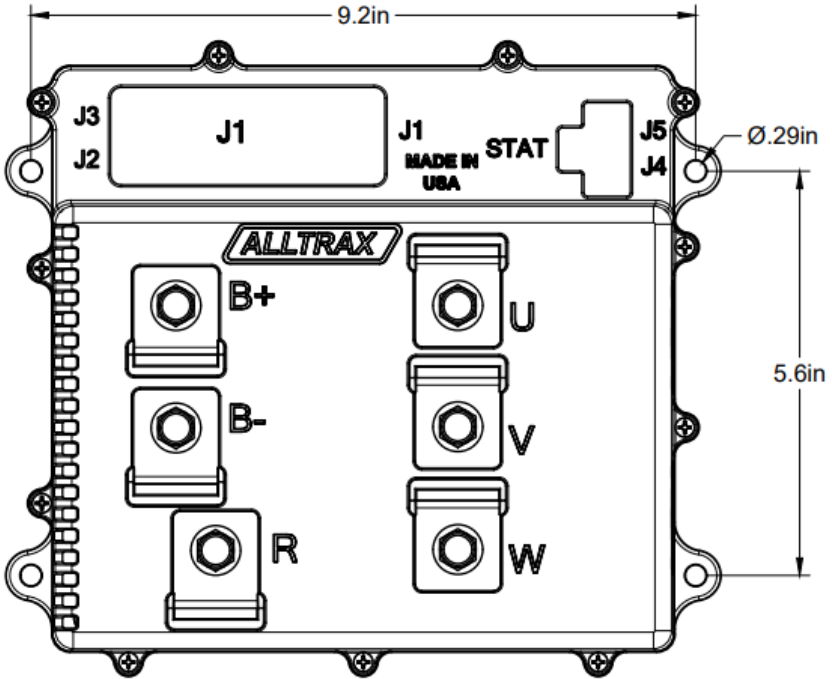
<b>PIN</b>	<b>NAME</b>	<b>DESCRIPTION</b>
1	Logic Power	Main battery positive reference
2	Not Used	Not Used
3	Throttle Switch	Throttle activation microswitch, tells the controller to ground the solenoid
4	Forward	Forward signal from direction selector
5	Reverse	Reverse signal from direction selector
6	Keyswitch	Voltage input from keyswitch
7	Throttle Wiper	Throttle output signal
8	Throttle Lo	Lo side reference of throttle potentiometer
9	Throttle Hi	Hi side reference of throttle potentiometer
10	Horn	Signal control wire for activating the reverse buzzer.
11	Relay coil -	Control signal used to engage the Solenoid/Main contactor

## 23 PIN TABLE 2/2

PIN	NAME	DESCRIPTION
12	Not Used	Not Used
13	Relay Coil -	The same as pin 11, internally tied together
14	Not Used	Not Used
15	Brake Wiper	Wiper signal from brake potentiometer, also output signal from 0-5v
16	Brake Pot Lo	Lo side of the brake potentiometer, gnd reference for 0-5v signals
17	Brake Coil -	Ground "control" for the motor brake coil
18	Brake Pot Hi	High side of the brake potentiometer, also +5v reference for 0-5v signals
19	Charge Interlock	"Charger plugged in" signal
20	Analogue Ground	Spare negative
21	Spare Ground	Works like relay coil negative pins
22	CAN Hi	Hi side of the CAN signal
23	CAN Lo	Lo side of the CAN signal

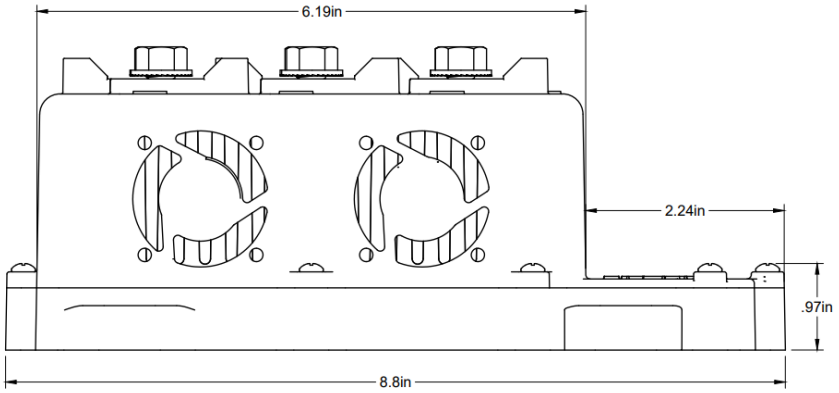
# CONTROLLER DIMENSIONS

## TOP DOWN VIEW

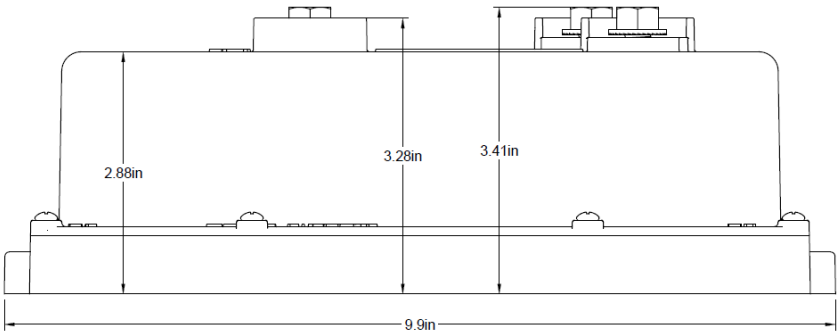


# CONTROLLER DIMENSIONS

## SIDE VIEW



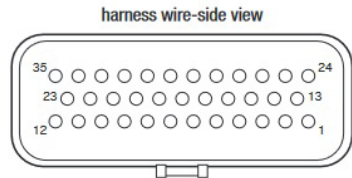
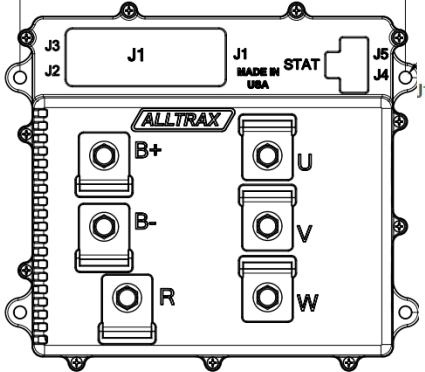
## FRONT VIEW



# **CONTROLLER DRAWINGS**

Don't see a drawing that suites your needs?  
Visit our website for full sized, updated and more drawings.  
[www.alltraxinc.com](http://www.alltraxinc.com)

# ALLTRAX AC2 GENERIC 35 PIN



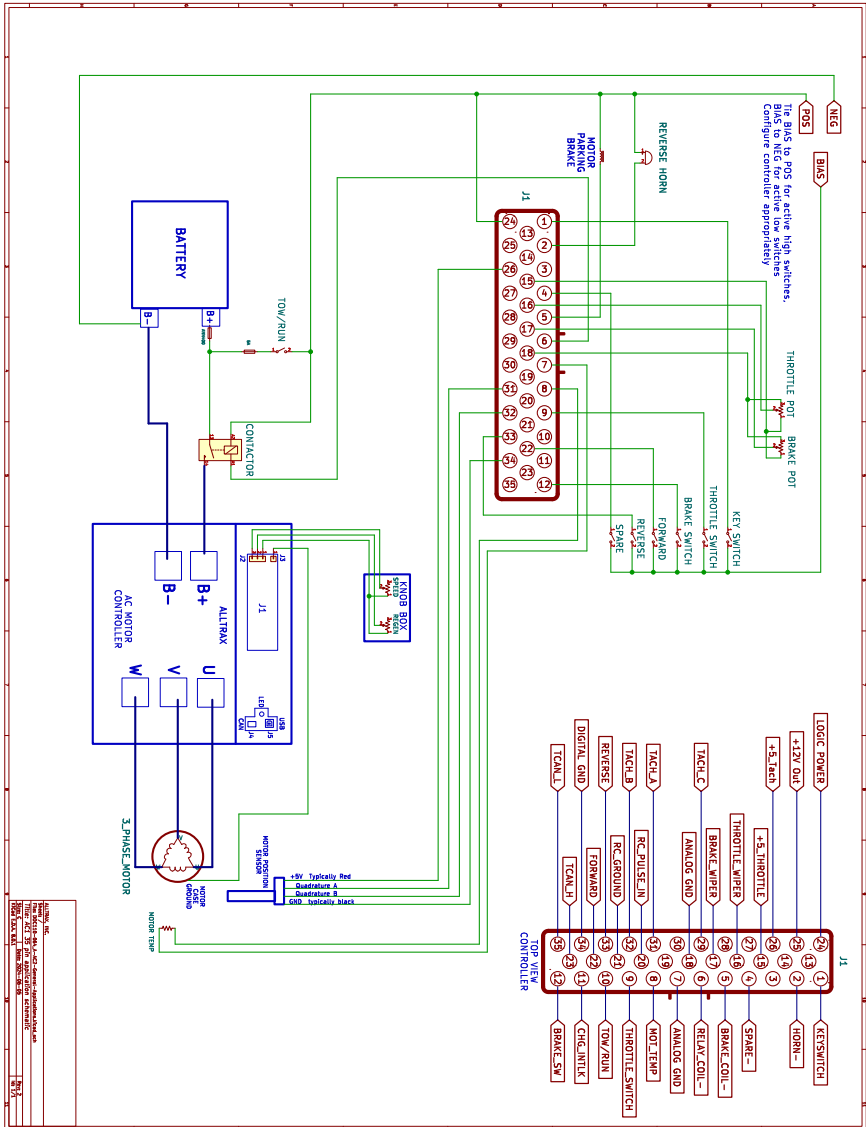
**J1** - For an indepth description of each wire on the harness see pages 15-17

- J1** - Main wire harness connector
- J2** - Personality Switch
- J3** - AC Motor case ground
- J4** - Can Bus
- J5** - Programming port (USB A)

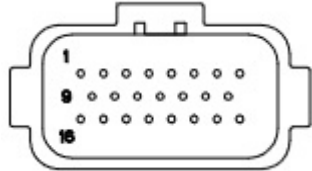
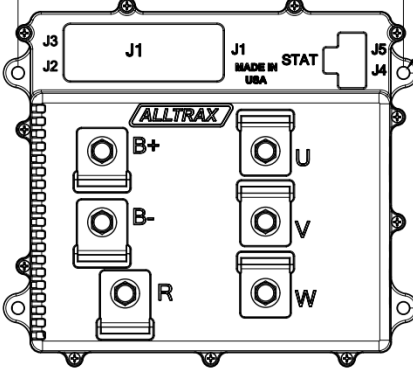
- B+** Positive from Solenoid
- B-** Battery Negative
- R** Brake Resistor
- U** U of the Motor
- V** V of the Motor
- W** W of the Motor



# AC2 GENERIC APPLICATION SCHEMATIC



# ALLTRAX AC2 GENERIC 23 PIN

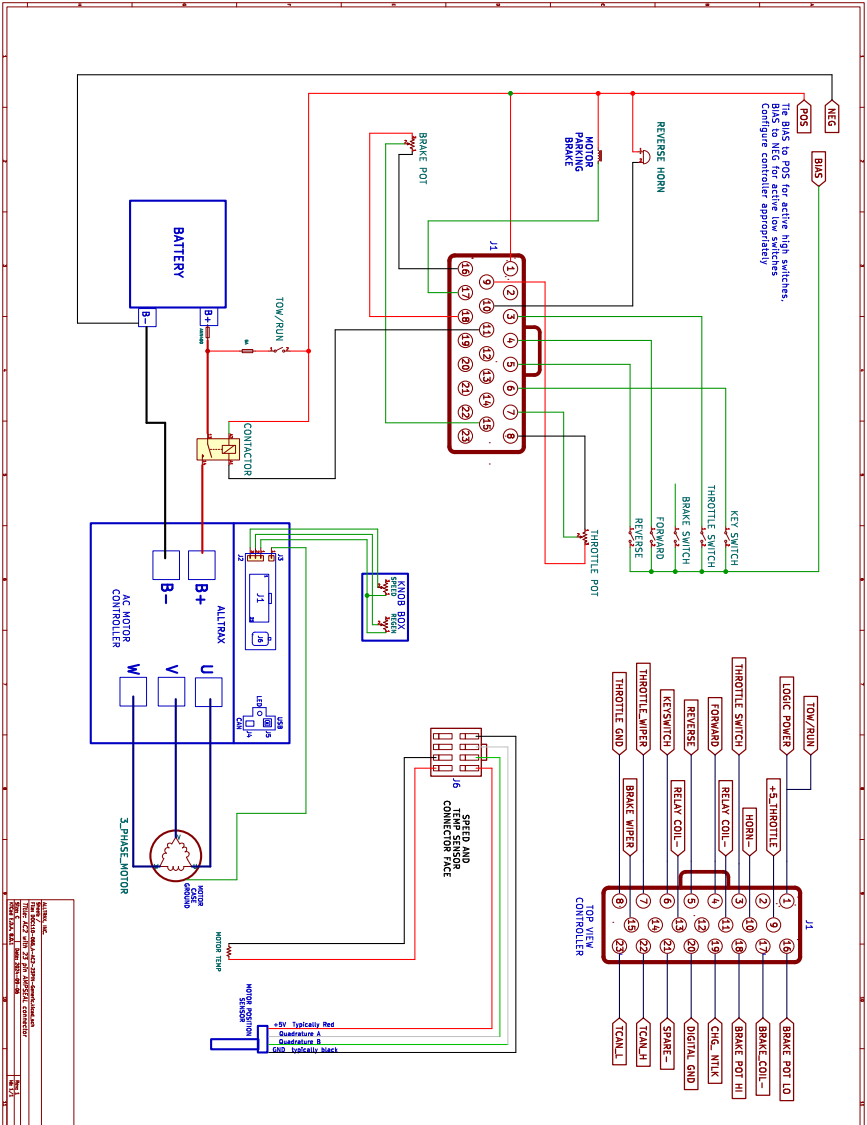


**J1-** For an indepth description of the wire harness see pages 18-20 of this manual.

- J1** - Main wire harness connector
- J2** - Personality Switch
- J3** - AC Motor case ground
- J4** - Can Bus
- J5** - Programming port (USB A)

- B+** Positive from Solenoid
- B-** Battery Negative
- R** Brake Resistor
- U** U of the Motor
- V** V of the Motor
- W** W of the Motor

# AC2 GENERIC 23 PIN



# PROGRAMMING THE CONTROLLER

Controllers ordered for stock configuration come pre-programmed and do not need to be programmed before use. If the user would like to customize their performance or has upgraded their motor and needs a matching motor map the controller can be connected to a computer with a USB A to B, commonly referred to as a “printer cable”.



The USB A to B cable is used to connect your motor controller to your personal computer. Using the free Alltrax Toolkit you can customize your performance to match your needs.

The Alltrax Toolkit software can be  
downloaded from:  
<https://alltraxinc.com/ac-toolkit-software/>  
No purchase necessary

## Software used for programming the AC Controllers.

NOTE: Toolkit software will NOT work on Windows® 8-RT (Tablet version). We are compatible with Win 10 & Win 11

[DOWNLOAD SOFTWARE](#)

### AC Toolkit Software Manual

[AC Toolkit Software Manual](#)



# BLINK CODES

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On power up, the controller will blink out a throttle code and then a Status or Error Code (see below)

## Throttle Type Codes:

1 Green LED Flash	=	2-wire 0-5k throttle
2 Green LED Flash	=	2-wire 5K-0 throttle
3 Green LED Flash	=	0-5V throttle
4 Green LED Flash	=	EZGO ITS throttle
5 Green LED Flash	=	3-wire 0-5k
6 Green LED Flash	=	6 to 10.5 Taylor Dunn throttle
7 Green LED Flash	=	MCOR
8 Green LED Flash	=	Reserved
9 Green LED Flash	=	Pump
10 Green LED Flash	=	USB Throttle
11 Green LED Flash	=	Absolute Throttle
12 Green LED Flash	=	PWM_Throttle

## Brake Type Codes:

1 Green LED Flash	=	2-wire 0-5k throttle
2 Green LED Flash	=	2-wire 5K-0 throttle
3 Green LED Flash	=	0-5V throttle
4 Green LED Flash	=	Reserved
5 Green LED Flash	=	3-wire 0-5k
6 Green LED Flash	=	6 to 10.5 Taylor Dunn throttle
7 Green LED Flash	=	MCOR
8 Green LED Flash	=	Reserved
9 Green LED Flash	=	Reserved
10 Green LED Flash	=	USB Throttle
11 Green LED Flash	=	Absolute Throttle

# BLINK CODES

## Normal Display Status:

Solid Green Light	=	Controller Ready to Run
Solid Red Light	=	Controller in programming mode
Solid Yellow Light	=	Throttle is wide open and the controller is <u>NOT</u> in Current Limit
Blinking Yellow Light	=	Throttle is wide open, but the controller is in Current Limit

## Error Codes:

AC alarm codes flash a sequence of green then red. All alarms are self clearing and will repeat until the error condition has been corrected.

1 Green and 1 Red LED Flash	=	Short Circuit/Output Fault
1 Green and 2 Red LED Flash	=	Battery Under Voltage
1 Green and 3 Red LED Flash	=	Battery Over Voltage
1 Green and 4 Red LED Flash	=	Over temperature
1 Green and 5 Red LED Flash	=	Throttle Power Fault
1 Green and 6 Red LED Flash	=	Pre-Charge Failure
2 Green and 1 Red LED Flash	=	Throttle/Brake Range
2 Green and 2 Red LED Flash	=	Bad Variables
2 Green and 3 Red LED Flash	=	High Throttle Over range
2 Green and 4 Red LED Flash	=	High Throttle Under range
2 Green and 5 Red LED Flash	=	Low Throttle Over range
2 Green and 6 Red LED Flash	=	Low Throttle Under range
3 Green and 1 Red LED Flash	=	Throttle/Brake Range
3 Green and 2 Red LED Flash	=	Bad Variable Set Loaded
3 Green and 3 Red LED Flash	=	Relay Coil Overcurrent
3 Green and 4 Red LED Flash	=	Brake Coil Overcurrent
3 Green and 5 Red LED Flash	=	Reserved Overcurrent*
3 Green and 6 Red LED Flash	=	Horn Overcurrent
4 Green and 1 Red LED Flash	=	Reserved
4 Green and 2 Red LED Flash	=	Reserved
4 Green and 3 Red LED Flash	=	Hardware Failure
4 Green and 4 Red LED Flash	=	Startup Failure
4 Green and 5 Red LED Flash	=	Reserved
4 Green and 6 Red LED Flash	=	Reserved
5 Green and 1 Red LED Flash	=	General Error

# CODE DEFINITIONS

## Error Code Definitions:

- Short Circuit/Output Fault:  
Controller detected a short circuit or other fault on the output circuit.  
Check wiring.
- Battery Under Voltage:  
B+ Voltage lower than Low Voltage Battery Setting. Check pack voltage or program settings.
- Battery Over Voltage:  
B+ Voltage Higher than Over Voltage Battery Setting. Check pack voltage or program settings
- Over temperature:  
Busbar temperature exceeds 90°C. Let controller cool and/or add fan.
- Throttle power Fault:  
This is a 5V fault, if the speed sensor gets damaged this alarm will be one of the alarms triggered. Can also be caused by a fault in voltage based throttles
- Pre-charge Failure:  
B+ voltage and KSI voltage differ by more than 5v. Stuck solenoid.
- Under Temp:  
Busbar Temperature reads less than -20°C
- High Throttle Over range & High Throttle Under range:  
High Side of throttle signal is outside of acceptable window for that throttle type. Check and/or replace throttle. Change throttle type to correct throttle installed on car.
- Low Throttle Over range & Low Throttle Under range:  
Low Side of throttle signal is outside of acceptable window for that throttle type. Check and/or replace throttle. Change throttle type to correct throttle installed on car.
- Bad Variable Set Loaded:  
Alltrax loaded variable data is missing or corrupted. Contact Alltrax
- Throttle/Brake Range:  
The RXV has a “throttle” built into the brake pedal to communicate with the motor brake. This alarm indicates an error in that signal.

# CODE DEFINITIONS

## **Error Code Definitions:**

- **Relay coil overcurrent:**  
Relay coil has shorted, the wires were attached incorrectly or the suppression control diode is backwards.
- **Brake coil overcurrent:**  
Short in the brake pedals resistor coil. Presently this can only trigger on EZGO RXV applications
- **Horn Overcurrent:**  
There is a short in the horn circuit, could be wiring or horn related



# WARRANTY STATEMENT

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Alltrax, Inc., (hereafter Alltrax) warrants that the product purchased is free from defects in materials or workmanship for a period of 2 years from the date of manufacture. This warranty does not apply to defects due directly or indirectly to misuse, abuse, negligence, accidents, repairs, improper installation, submersion, alterations or use contrary to any instructions provided by Alltrax in verbal or written form.

In the event you should need warranty repair, contact Alltrax at (541) 476-3565 to receive warranty service authorization instructions for returning the defective product to Alltrax for evaluation. Products or parts shipped by customer to Alltrax must be sent postage paid and packaged appropriately for safe shipment. Alltrax is not responsible for customer products received without warranty service authorization and may be rejected.

Alltrax reserves the right to repair or replace merchandise at its option at no cost to the customer, except for shipping costs of sending the defect item to Alltrax. Replacement shall mean furnishing the customer with a new equivalent product to the defective item. Alltrax also reserves the right to make changes to any of its products or specifications without notice.

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***“Thank you Nikola Tesla, for a better motor”***