

PowerCart User Manual

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System Overview

The Prime Heat PowerCart Production Line consists of eight key components: Track, PowerCarts, a CartCOM Laptop, a CartLord Monitor, Charge Rails, Track Switches and Cart On Demand stops.

The PowerCart is an ETL listed product for use in Class 1 Division 1 Hazardous Locations. Three explosion proof boxes house the controls for the cart: one for the battery, a second for the Microcontroller and the third for housing the blocking diodes and Intrinsically Safe circuit. Each cart is powered by a 12v Direct Current (DC) Sealed AGM battery and propelled by a Direct Drive gearbox and an explosion-proof permanent magnet 12v DC motor. The cart is controlled by a Prime Heat Microcontroller with ZigBee Communication and wireless programming capabilities.

There are two types of sensors on the cart. There are a total of 4 Magnetic Reed (MR) switches on the cart. Two switches are used to provide On/Off operation through Kick Switches on each side of the cart, one MR switch stops the cart when the Table Top is turned, and one MR switch controls track magnet stops around the production line. A 2 lbs. touch bumper stops the cart when in contact with something on the front bumper.

The maximum load on a standard cart is 550 pounds and the cart operates at 40 feet per minute (fpm). The standard table-top is 3' x 8' and is generally covered with a sheet of standard 1/2" plywood.

The track is 3/4" tall and 1" wide extruded ABS plastic. It is used everywhere but inside of Prime Heat Tunnels and Spray Booth systems. 1/2" by 1" Aluminum track is used for inside these areas.

The cart should be charged on an inline charge rail for 2 minutes per every 100 feet. The charge rails are supplied with a current maximizing Prime Heat Charger with an output voltage of 15.5 VDC. The charging stations are located predominantly inside the Prime Heat HALCON curing oven but may be located anywhere EXCEPT ten feet from a spray booth opening. The cart must stop on the rail by an in-track magnet to charge.

CartCOM laptops are mobile diagnostic and programming devices for the carts. It lists the nearest 8 carts and diagnostic information on each, including: battery voltage, charging status, Bumper and Table-Top status, and the Kick Switch statuses. Following the onscreen directions will lead to more diagnostic and programming options, as well as the ability to Reboot a cart's Microprocessor if necessary. In addition, the CartLord is a fixed position monitoring system. It displays information on every cart in range, including: battery status, charging status, Bumper and Table-Top status, and the Kick Switch statuses. It updates itself automatically every 3 minutes, or when refreshed by an operator. It can Start/Stop all carts at the end of the work-day, as well.

Track switches allow the line to diverge into multiple lines or the multiple lines can merge into one line. The carts are stopped prior to diverging and released when the controller receives a signal that a side of the track is empty. The carts are also stopped prior to merging together to allow only one cart to enter the merge line at a time. The switches are pneumatic actuators with twelve volt solenoid air valves that are controlled by a track switch controller. Limit Switches and RFID readers are set in strategic locations to provide cart presence information to the track switch controller and cart stops.

Safety

IMPORTANT

DO NOT CHARGE CARTS WITHIN A HAZARDOUS AREA

CHARGING STATIONS MUST BE LOCATED A **MINIMUM** OF 10 FEET FROM A HAZARDOUS LOCATION AND MUST BE SUPPLIED WITH FREE AIR VENTILATION

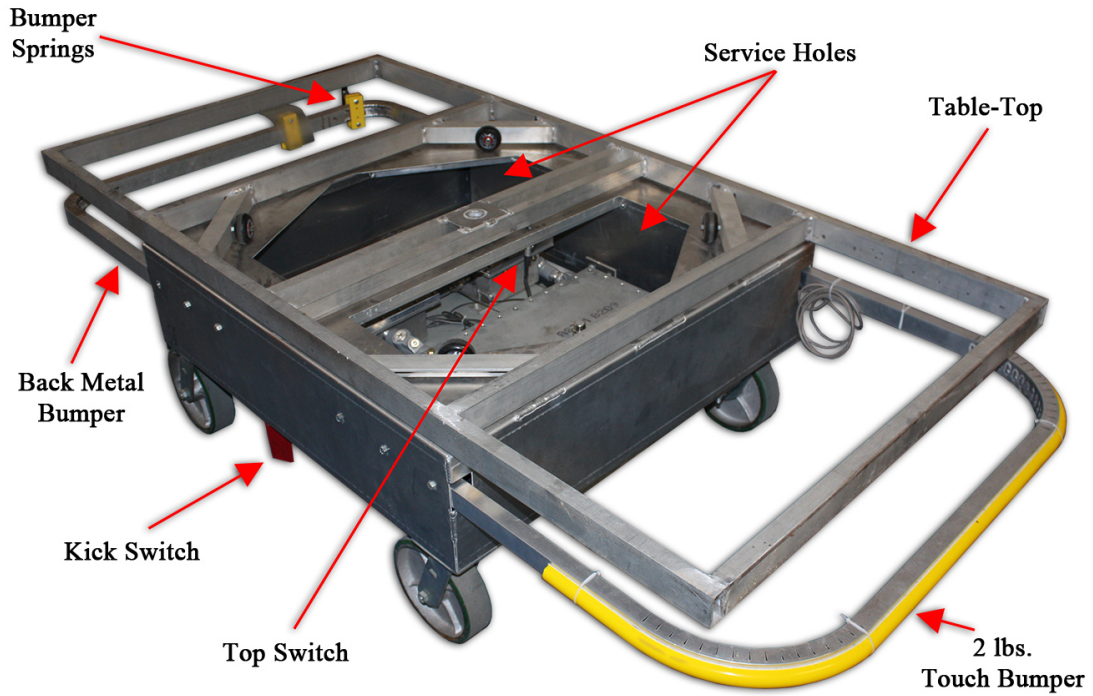
CHARGING SYSTEM UTILIZES 120 VAC NEMA 1 CONFIGURATION

THIS NOTICE COMPLIES WITH NFPA-70 & NEC-2005

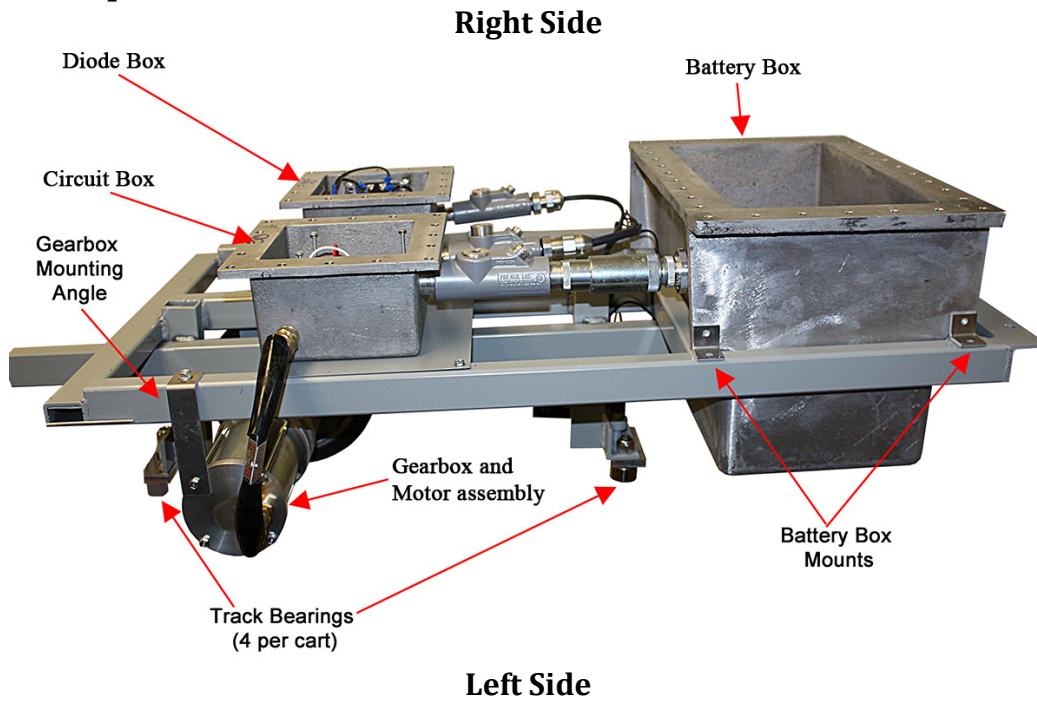
MAXIMUM LOAD 550 LB.

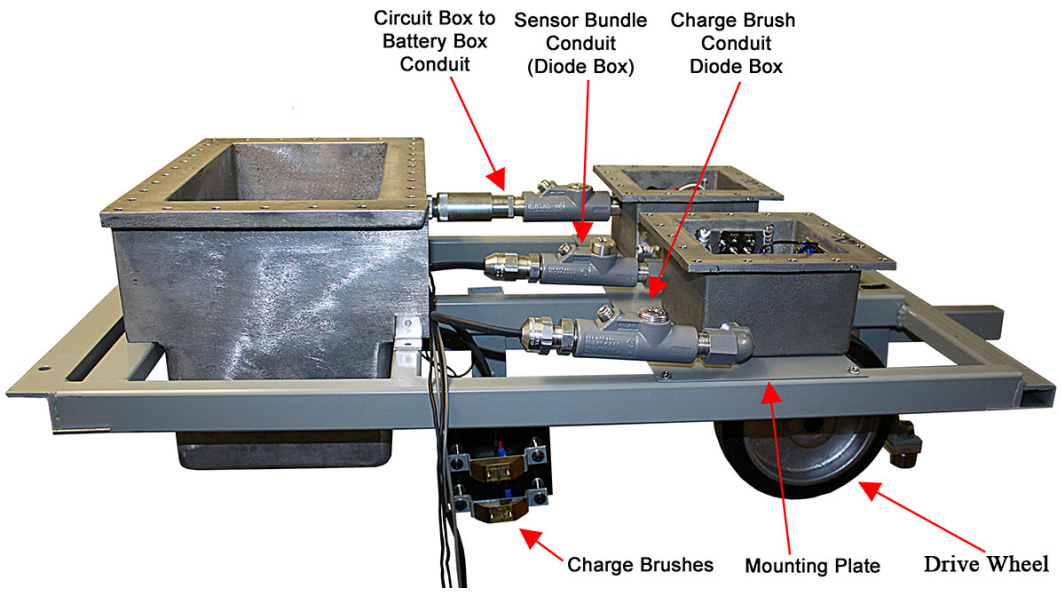
The PowerCart

Cart Components



Drive Frame Components





Maintenance

Maintenance Topics

- Over Spray
- Magnetic Sensor Check
- Charge Rail Voltage Check
- Greasing and Oiling of pneumatic system and components.
- Removal and Replacement of a Touch Bumper
- Installation of Bumper Springs

Over Spray

Over Spray is the cause of a majority of the problems the PowerCarts will encounter. If the over spray can be limited to an acceptable amount the PowerCart maintenance will be minimal. The main area of concern is the Kick Switches. If not maintained, the switches may become harder to activate and the red-painted Stop side of the switch may become hard to read. Painters should practice good painting techniques.

Magnetic Sensor Check

A frequent sensor check will keep the line and the carts running. The cart relies on magnets located in the track to stop the cart on the charge rail. The magnetic reed switches can be damaged by running over something sitting on or sticking up from the track. To check the sensor, simply watch and make sure the carts stop on the track magnets. The Kick Switches are hard to damage, however if one is damaged the cart will not run. The leading yellow bumper stops the PowerCart when in contact with an object. If the bumper does not stop the cart investigate the integrity of the bumper switch for damage. The Top Switch will stop the cart when the table-top is turned out of alignment, but should start again after 3 seconds once it's either reset to its original position or to 180 degrees. To test if the Top Switch is working, simply start the cart and turn the table-top out of alignment, and then to 180 degrees. It should stop, and then start again after 3 seconds at 180 degrees.

Charge Rail Voltage Check

The Charge Rail should be occasionally checked to ensure that the power supplies are putting out adequate voltage for charging. The Charge Rail's voltage should range from 14.5 Volts to 15.6 Volts. To check the Charge Rail voltage, use a multimeter across the two long portions of copper on the charge rail.

Greasing and Oiling of pneumatic system and components

The cart on-demands and the track switches should be lubricated on a regular basis. Simply putting a few drops of oil in the air-line will lubricate pneumatic components. The cart stop arms should be greased occasionally.

Removal and Replacement of a Touch Bumper

If a bumper is internally damaged or externally cut it will need to be replaced. To check if a bumper is operating normally, first disconnect the spade connectors inside the cart body. Then use a multimeter on the Ohm setting (one with a Ω symbol) and touch the red lead onto one lead of the bumper, and touch the black lead to the other lead on the bumper. If the bumper is good, the multimeter should beep to show continuity. **NOTE:** On some multimeters, you must enable the sound by cycling through settings. It is generally denoted with a sound-wave symbol.

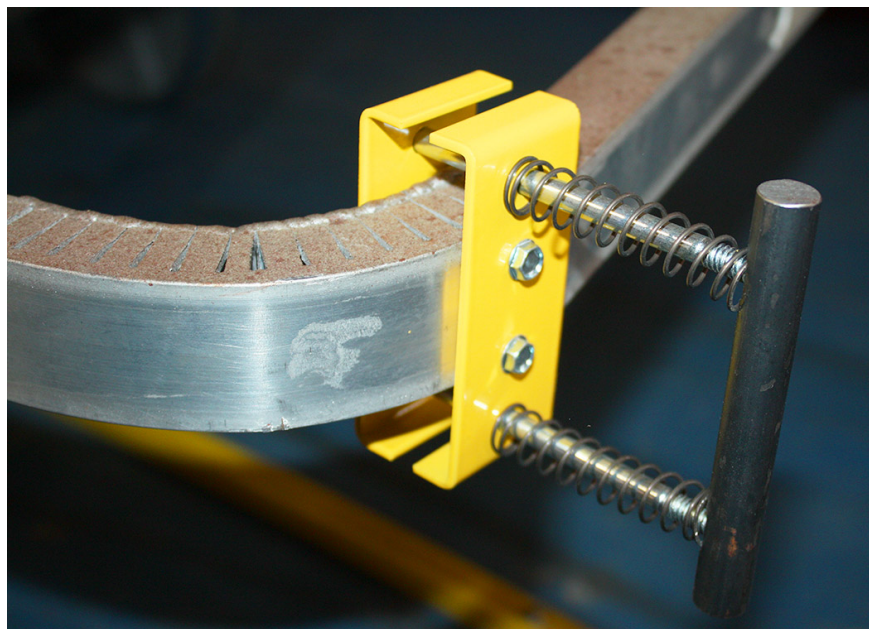
If the meter does not beep, the switch is to be considered broken and must be replaced.

First, remove the old bumper switch from the metal bumper. Clean the back of the new bumper switch and the metal bumper with Acetone to clear any dirt or oils. Use 3M double-sided tape to adhere the bumper switch to the bumper. Also use slightly loose zip-ties to secure the new bumper. This prevents the bumper from sagging or displacing during contact. Connect the leads from the cart to the leads of the bumper using 18-22 AWG Butt-Splice connectors.

A cart that is not in contact with anything but is not running (because the bumper is engaged) might be too tight around the corners of the bumper. If it is in this state, it won't beep with the multimeter. Try taking the ends off individually to see if the cart will start running.

Installation of Bumper Springs

To install Bumper Springs, screw the front plate into position using two 5/16" hex head screws. Next, put the backing plate in place (do not screw down) and put the two small posts through the provided holes in both plates. Insert springs into the posts, and washers if needed. Finally, screw the small posts into the large post and tighten using a 7/16" crescent wrench. Attach a soft plastic covering over the top to prevent accumulation of overspray on the springs, if needed. Springs can be configured in multiple ways to best suit a line.



Properly installed Bumper Spring

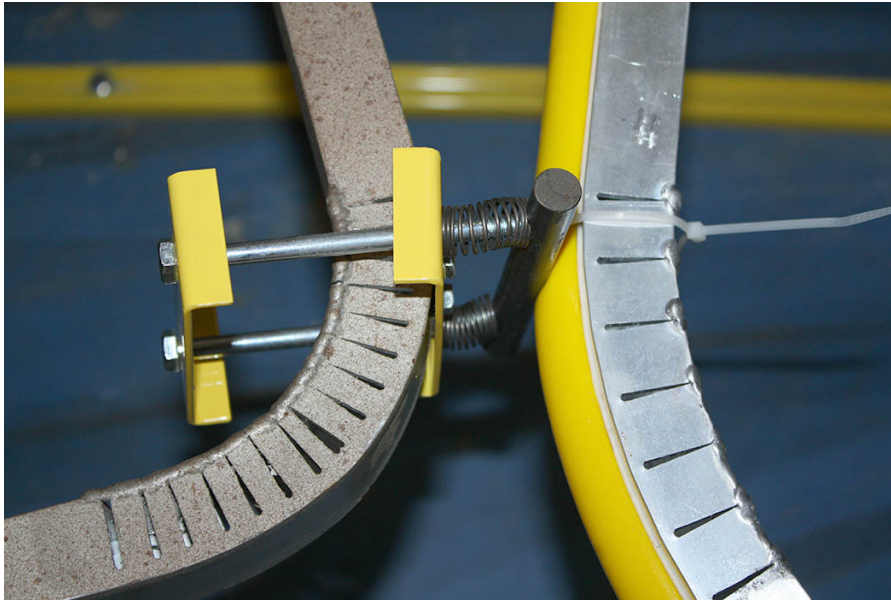
Operation of the PowerCart

The PowerCart is extremely user friendly when well maintained. In order for the cart to run all Kick Switches must be in the ON position and the table-tops must be aligned parallel with the side of the bumper. There are two Kick Switches on the PowerCart, located in the middle under both sides of the cart body. When the red side is out the switch is in the ON position.



Kick Switch in the ON Position

When running, the cart bumper should stop the cart indefinitely when in contact with an object in front of it. The cart will delay four seconds before starting back up once the bumper has been freed from an obstacle.

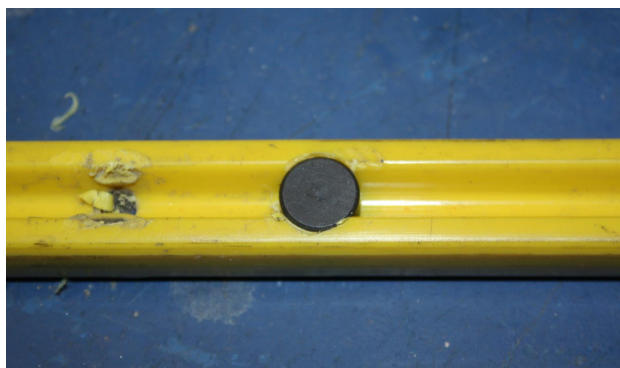


Bumper has contacted a Bumper Spring correctly and stopped

The cart can be stopped for programmable time increments anywhere on the production line by installing a magnet into the track. To install a magnet into the track use a 1/2" wood drill bit to drill into the track. Countersink the magnet enough to make it flush with the top of the track.



Glue the magnet into the track using either a hot glue gun or epoxy. Note: it's easier to pull up hot glued magnets should the magnet need to be removed (used only on plastic track outside of heated areas). Let the glue dry before operating the system.



The table-tops should be centrally loaded for easy rotation. Following photos illustrate the correct loading of a PowerCart.



(Left) - Incorrect Unbalanced Loading



(Right) - Correct Balanced Loading

To stop a cart for a production operation, the user should allow the cart to index on a track magnet then turn the kick switch to the red OFF position and complete the operation. When finished, turn the cart ON using the kick switch. The cart will move to the next station. Perform the operation procedure and keep the line moving in sync with the carts in front. Keeping the carts spaced out will help maintain a consistent production through time.

The following will explain how all Cart components are tied together to make the system work. If something has gone wrong with the cart refer to the troubleshooting guide at the end of the manual.

The Battery



Under normal operation the cart batteries will recharge during stops on the charge rails. The charge rail stop times vary due to number of rails and number of magnet stops along one rail. The battery MUST charge for at least 2 minutes per 100 feet, as a rule, and MUST be simultaneously on a magnet and the rail to charge.

DO NOT charge any batteries in a Spray Booth.

A 12 Volt Absorbed Glass Mat (AGM) Sealed Marine Battery is used to power the cart. The battery is located in the Explosion-Proof Battery Box equipped with a breather mounted onto the lid. The battery should be maintained at above 85% of charge (above 10.2 Volts).

If a battery is getting low on charge the cart should be placed either on a charge rail for an extended period of time (can be overnight if necessary). Use CartCOM or CartLord to verify that the cart is in fact charging. The charge relay should be displayed as OPEN and the battery voltage should read the charger voltage of 13.8 volts or higher.

If the battery is below 10.5 volts, it will require being charged offline from inside the Circuit Box. It is possible that the CartCOM Laptop will show charge relay open however the battery voltage will remain low. This means that the battery voltage is too low and the charge relay will not close.

To reach the Circuit Box, remove the Table-Top. When standing behind the cart (back of cart has a carrying handle), there will be two small boxes visible. The Circuit Box is on the Right. Unbolt the enclosure lid. The negative (black) lead from the charger gets connected to the negative lead going into Battery Box. The negative lead is the farthest right wire on the white terminal block (it is also the thickest), loosen it's terminal and slide it out to access it. The positive (red) lead will be attached to the open lead of the fuse holder. Remove the fuse to access the lead inside and attach the charger to the lead going into the Battery Box. Current should be going into the battery from the charger at this point.

Measure the voltage with a voltmeter on the black and red leads. If a battery does not maintain a charge then a cell might have gone bad in the battery. The battery will need to be replaced. When done, rewire the black lead and reinsert the fuse.

To replace a battery unbolt the battery box lid, then remove the wood board inside. This board is to prevent the battery from shorting out by contacting the box's lid. **It MUST be reinserted.**



Wood board to prevent battery shorting against metal lid.

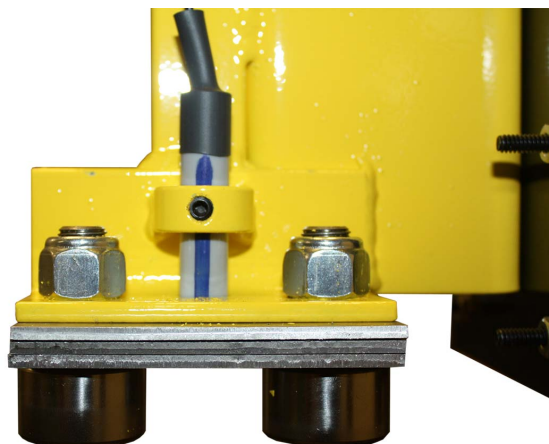
Loosen the nuts on the terminals and unhook the wire leads from the battery. Remove the old battery from the cart. Install a new battery into the Battery Box and firmly tighten the terminals, replace the wood board, and bolt the lid on.

See Appendix A for more battery information.

The Magnetic Reed Switch (MR Switch)

The magnetic reed (MR) switches are manufactured by Prime Heat and operate normally open. The circuit is closed when the MR switch is in front of a magnet. The operating gap for the MR switch to sense the magnetic field is approximately five-eighths of an inch.

The PowerCart is equipped with four MR switches. The Track Switch on the PowerCart is used for sensing track magnets. When the PowerCart runs over a magnet mounted in the track, the motor will stop for a set amount of time.



Track Sensor held in by set-screw.



Track Sensor Reverse view, notice it's flush with the spacers

The Kick Switches are located on the bottom of either side of the cart, and are kicked off to stop the cart. The Top Switch is located in the middle of the cart body, flush with the surface, and stops the cart if the table-top is turned out of alignment. The Kick Switches and Top Switch operate independent cart ON/OFF operations. With this arrangement, all the switches must be in front of a magnet to relay an ON signal. If one is damaged the cart will remain in the OFF position.

A damaged reed switch will remain either open or closed and will need to be replaced. To verify if a switch is damaged use a multimeter and a magnet to check switch continuity. To replace a magnetic reed switch simply cut off the broken switch and splice on a new one using two 18-22 AWG wire connectors. There is a set-screw in the aluminum collar that holds the sensor in place. Loosen the set-screw when replacing the reed switch. **Do not over-tighten the set-screw** when securing the replacement switch, as this may damage the switch's head. Leave a 1/2" gap between the switch end and the magnet with the Kick Switch assembly in the ON position.

The Touch Bumper



2 pound Touch Bumper

The touch bumper is activated by two pounds of pressure. The bumper is normally open and closes when experiencing two pounds of pressure on the face of the sensor. These units can be damaged by external cuts or internally shorting and a damaged bumper will prevent the cart from operating. Refer to the maintenance section for diagnosis and replacement.

The Table-Top



(Left) - Incorrect, Unbalanced Loading



(Right) – Correct central Balanced Loading

The standard table-top has dimensions 3' X 8'. The table-top can support eight hundred pounds centrally located on the table top. Keep in mind the PowerCart is only rated for 550 pounds. This includes anything added to the table-top from the aluminum frame. The table-top can rotate a full 360 degrees on four skateboard wheels and indexes on 90 degree intervals. If the cart is loaded incorrectly the cart may tip causing permanent damage to the cart body and frame.

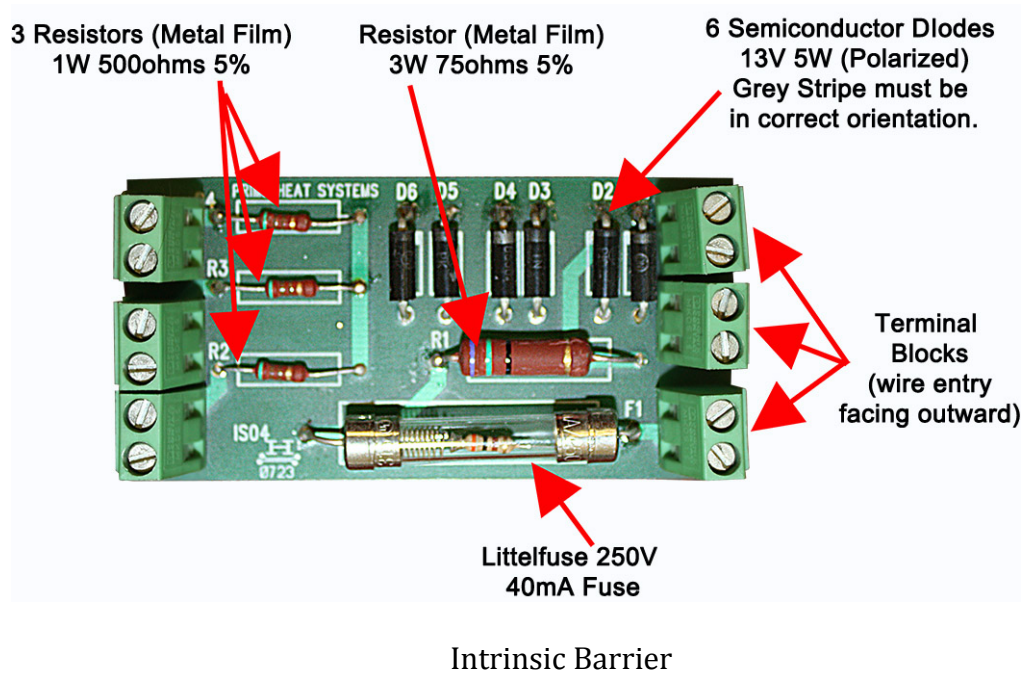
Two magnets are installed on the underside of the table-top to control ON/OFF for the Top Switch. If removed the cart will not operate and a magnet will need to be installed.

The table-top and Touch Bumper are wired together in the Diode Box. If the table-top is turned, as shown below, the Touch Bumper will read as "ON" using either CartLord or CartCOM.



90 degree index, cart is OFF in this position

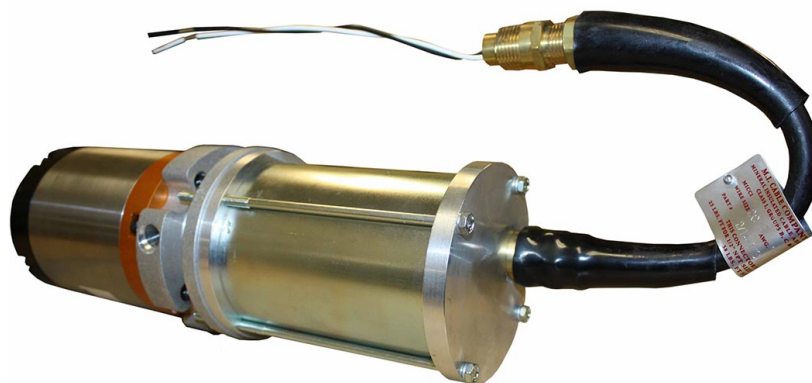
The IS Board/Barrier



The Intrinsically Safe (IS) Barrier is located inside the Explosion-Proof Diode Box. The sensor leads terminate to one side of the IS barrier. The IS barrier runs an intrinsically safe 12 volt signal to one lead of the sensor. When the sensor is closed the circuit is complete, returning the signal back to the PowerCart microcontroller.

If a switch is not responding and is not damaged, the IS barrier might be damaged. Give the circuit a visual inspection for loose wires, broken components or a blown fuse. If the switch is not damaged and a continuity check is completed inside the explosion proof diode box but the signal is not getting to the microcontroller in the explosion proof circuit box, replace the IS barrier. Unscrew all terminals and remove the old board. Install the wires into the new board's terminal blocks and tighten. *Refer to the Diode Box Wiring Diagram for wire placement.*

The Motor and Gearbox Assembly



Gearbox, Joint, and MET Motor with MI Cable

The PowerCart is propelled by an MET 12 volt Permanent Magnet Direct Current (PMDC) motor connected to a Gearbox. The motor is listed for product use in Class 1 Division 1 Hazardous Locations. It is equipped with a Mineral Insulated (MI) cable and brushes that connect the twelve volts of the commutator for motor operation. An operating motor should draw around 2 to 5 Amps depending on the load of the drive frame and the course of the track (i.e. higher amperage along curves). The white lead is positive (12 Volts) and the black lead is negative (COM).

The PMDC motor has brushes that may over time wear out causing the motor to run slow, sluggish or intermittently. This motor will need to be replaced.

The Gearbox is internally geared, and if it should fail, will need to be replaced.

To remove the Motor/Gearbox Assembly, begin by removing the cart body from the cart frame. To prevent the cart frame from tipping while separating it from the body, place two 2"x 4" runners beneath the battery box. Using a 3/8" Hex head or Socket, remove the angle joining the Motor to the cart. Next, open the Circuit Box and unwire the Motor's leads. The Black (COM) lead is in third position (left to right) of the COM terminal block, and the White lead is connected with a spade to the relay blocks. Using a 7/8" crescent wrench, remove the MI cable from its hole.

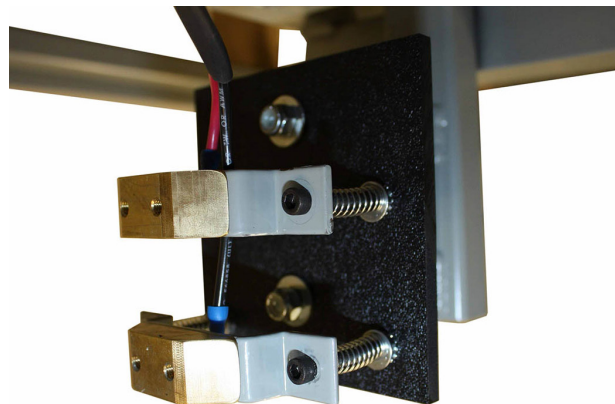
Remove the Drive Wheel using a 1/8" T-handle Allen Wrench. Next, unbolt the Motor/Gearbox Assembly using a 5/32" Allen Wrench.

To separate the Motor and Gearbox, loosen the Allen Bolt in the middle of the gray joint using a 5/32" Allen Wrench. Next, use a 3/8" crescent wrench to remove the nuts from the four long bolts going through the joint.

Replace either the Motor or Gearbox and then reinstall the assembly in reverse order of removal. Be sure to check proper operation prior to closing the circuit box.

The Charging Circuit with Blocking Diodes

The PowerCart charge brushes make contact with the charge rail. They are spring loaded so the cart can contact the charge rail without pushing the cart away. The brushes should be replaced as needed. A cart that is not charging will die after about ten hours of operation. The protection method used for the charge brushes is Intrinsic Safety (IS). The positive brush is connected to a fuse then runs through three blocking diodes and then another fuse. Two other blocking diodes prevent the battery from crossing over to the negative (COM) lead. These connections are located in the diode box. From the diode box the positive brush is connected to a relay on the PowerCart microcontroller. The charge brushes will wear over time, and should be maintained or changed as necessary to keep an efficient line running.

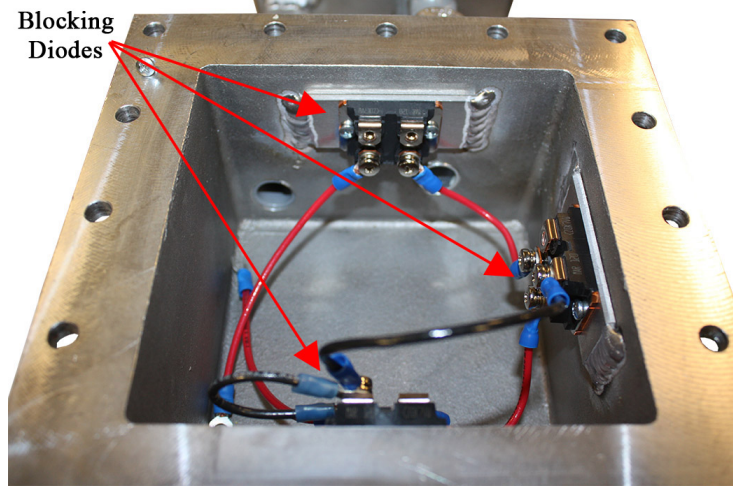


Charging Brush Assembly

To replace individual charge brush contacts, unscrew the charge brushes' two Phillip's Head screws on each brush and install the new brush. Make sure to appropriately tighten the screws over the black and red charge brush leads. An angled Phillip's Head screwdriver works best.

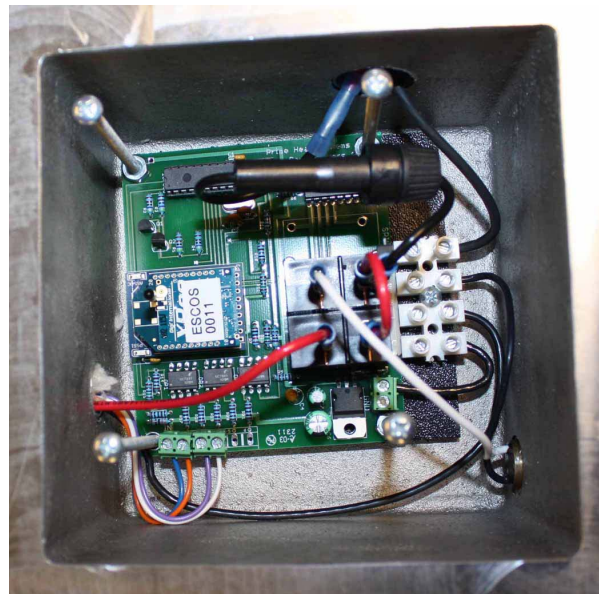
To replace an entire charge brush assembly, unscrew the 0-24 nyloc nuts on the front of the charge brush mounting plate using a 7/16" socket and wrench. Unscrew the wires from the brushes. Replace the assembly with a new one and tighten all screws and bolts.

If a cart will not accept charge, make sure the charge relay located on the Microcontroller is not damaged (see The PowerCart Microcontroller section) and that all connections thru the circuit are tight. Start checking continuity thru fuses, then thru the blocking diodes individually. Make sure when the charge relay is closed on the Microcontroller the battery has continuity all the way to the charge brush.



Microcontroller with ZigBee Communication

The controls for the PowerCart are located in the explosion-proof Circuit Box isolated from the Battery Box and the Diode Box via explosion proof seal-offs. The Prime Heat PowerCart is controlled by a microcontroller board designed and manufactured by Prime Heat Systems. The controller is equipped with a ZigBee radio for wireless communication. There are no user serviceable parts on the PCB.



Issues that can arise with the controller are limited. The microcontroller will have to be replaced if any of the following symptoms are present.

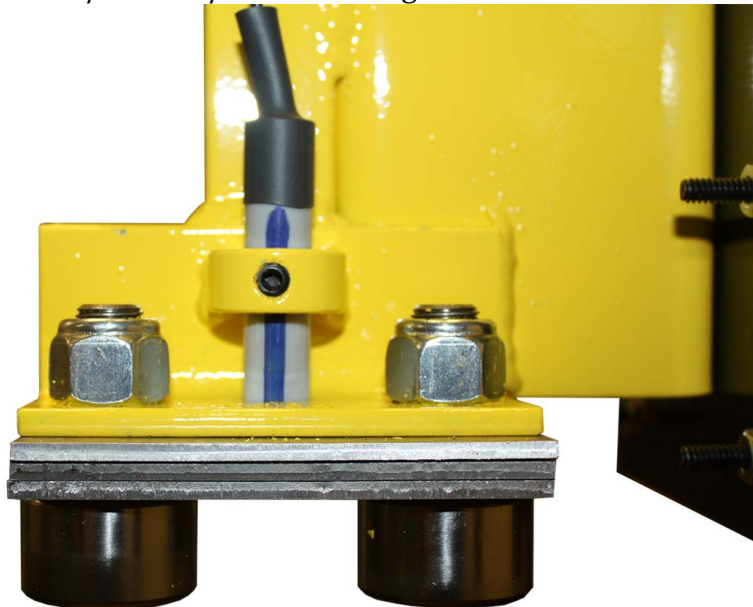
- If a charge or motor relay mechanically stops working. This would be evident if CartCOM Laptop registers the relays are closed and there is no output voltage.
- If the Pic16F886 program chip stops running and cannot be rebooted by CartCOM Laptop.
- If the ZigBee Transmitter is not communicating with the CartCOM Laptop. The red light signifies that the transmitter is getting power.
- If there is a failure of any other electrical components.

To replace a microcontroller board simply pull the power fuse out of the holder. Unhook the spade connectors from the relays. Unscrew the terminals and remove the wires. Take out the old microcontroller. Unplug the ZigBee radio and install it into the new microcontroller. *Consult the Circuit Box Diagram to hook up the wires to the board and insert the spade connectors.*

Install the fuse and the ZigBee radio transmitter should display a red light. Check the cart operations with the CartCOM Laptop for normal operation.

Track Bearings

There are four cam rollers that guide the cart around the track. They are mounted in pairs at two locations on the cart. The front track guide bearings are located below the charge brushes underneath the middle of the cart. The rear track guide bearings are mounted about five inches behind the drive wheel. The bearings should be about 3/16" to 1/4" above the ground.



Floors that are not level can provide locations where the bearings drag on the concrete or places where the carts are prone to fall off of the track. If the bearings are too low in some locations try grinding

the concrete or raising the drive wheel with a plate in that location. If the track seems too low in some location try raising the track by placing spacers underneath.

Fuses

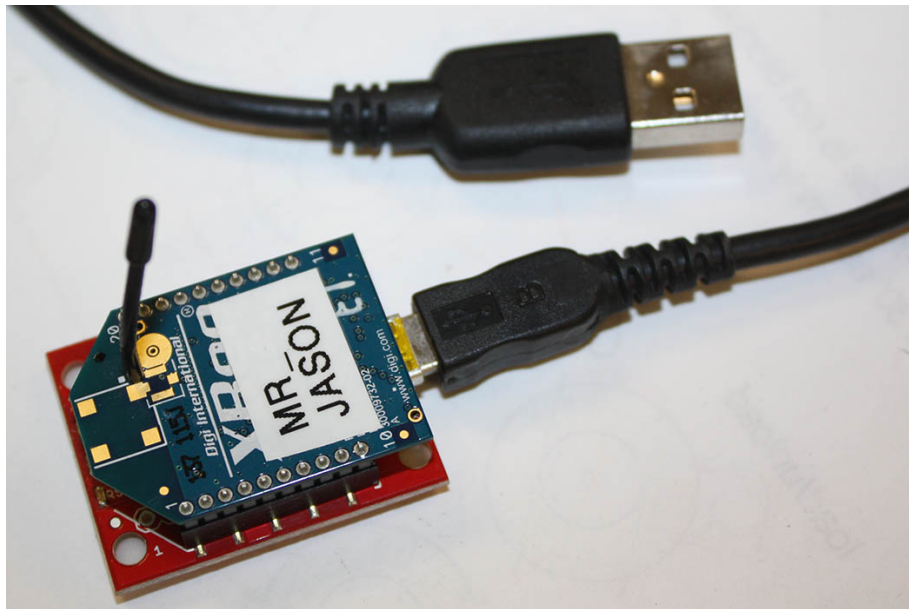
The PowerCart is equipped with three different fuses. The power fuse is one twenty amp BUSS SFE-20 Auto Fuse located in the explosion-proof Circuit Box. The charging system has two fifteen amp BUSS KTK-15 Limitron Fuses located in the explosion-proof Diode Box. A small 0.04 ampere Littelfuse is included on the intrinsic barrier PCB located in the explosion proof diode box. The Littelfuse can only be removed with a de-soldering iron. The board may need to be replaced.

The CartCOM Laptop

The Prime Heat Systems CartCOM Laptop is a stand alone system used to communicate with the PowerCarts. Using this system, cart maintenance and troubleshooting is as easy as turning on the supplied netbook computer. All aspects of the cart operation are displayed and timers used in the operation of the carts can be set or changed.

Setup

1. Prior to turning on the computer attach the Communication Module (COM) to the single left USB port on the CartCOM Netbook. The COM module MUST be attached to the USB port.

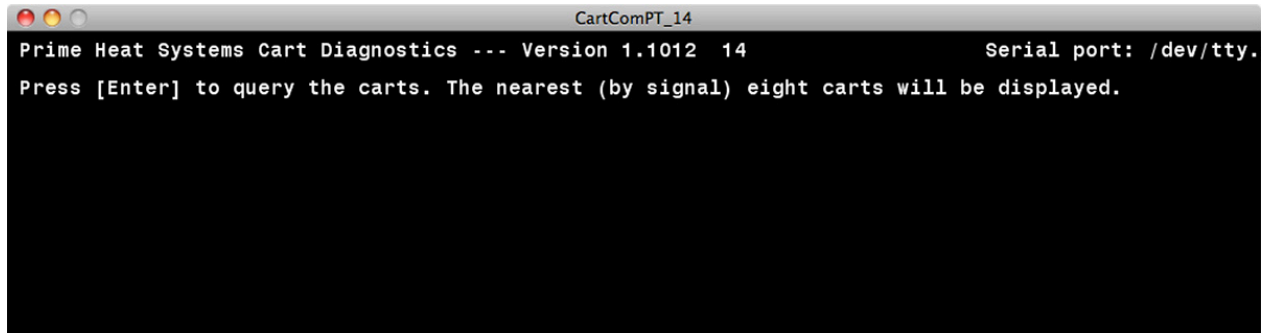


Communication Module (COM)

2. Turn the Netbook ON. Select the CartCOM icon. If the COM module is misplaced or not attached the CartCOM program will not run and a blank desktop will appear. Check your connections and restart the computer.

Using the CartCOM Program

1. The CartCOM program will load to the following start screen:

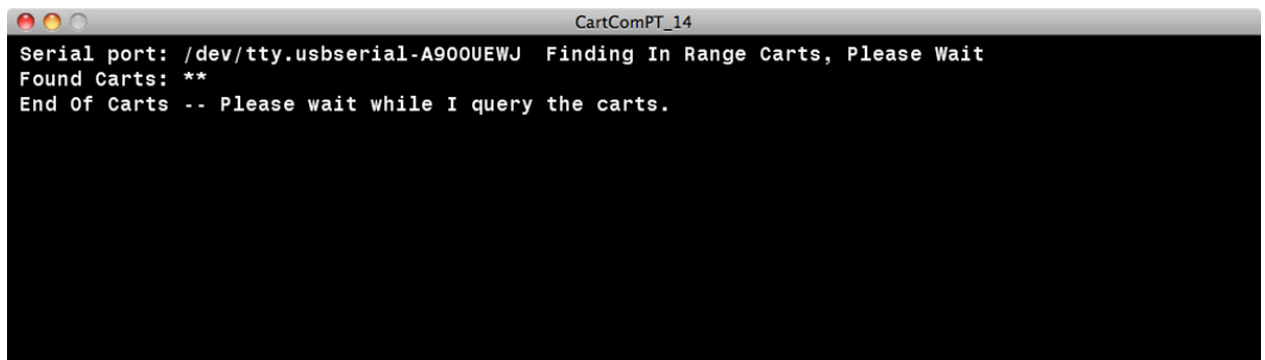


```

CartComPT_14
Prime Heat Systems Cart Diagnostics --- Version 1.1012 14      Serial port: /dev/tty.
Press [Enter] to query the carts. The nearest (by signal) eight carts will be displayed.

```

2. As the screen instructs pressing enter on the keyboard will register the carts that are within the range of the ZigBee Communication Module connected to the computer. The registered carts will appear as an asterisk (*), showing the number of carts in range. When the program has found all the carts in range it will proceed to End of Carts and start querying cart information for only the nearest eight carts.

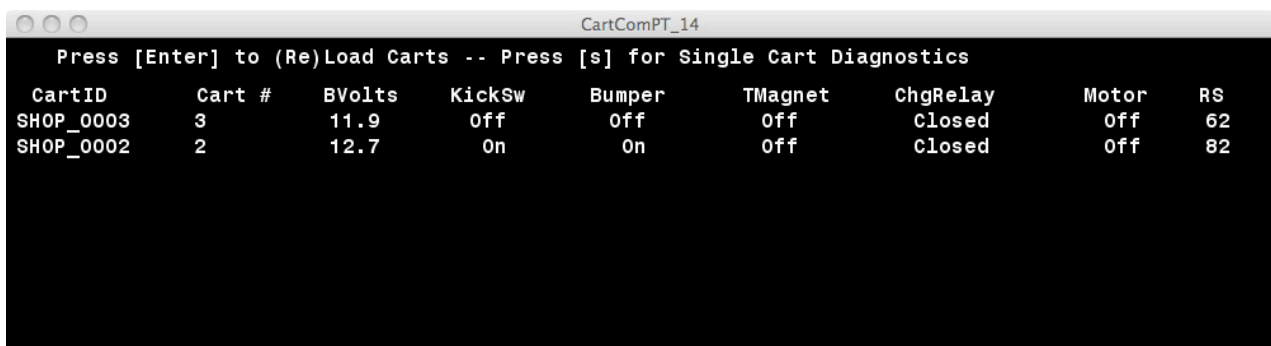


```

CartComPT_14
Serial port: /dev/tty.usbserial-A900UEWJ Finding In Range Carts, Please Wait
Found Carts: **
End Of Carts -- Please wait while I query the carts.

```

3. The nearest eight carts determined by the strength of the return signal will be loaded on the screen. Displaying the following information:



```

CartComPT_14
Press [Enter] to (Re)Load Carts -- Press [s] for Single Cart Diagnostics

```

CartID	Cart #	BVolts	KickSw	Bumper	TMagnet	ChgRelay	Motor	RS
SHOP_0003	3	11.9	Off	Off	Off	Closed	Off	62
SHOP_0002	2	12.7	On	On	Off	Closed	Off	82

Label	Description
Cart ID	The unique internal cart identification
Cart #	The Cart Number
BVolts	The current battery voltage.
KickSw	Kick Switch status, On - Magnet in front of MR Switches/Off --No Magnet.
Bumper	Bumper Status, On - Bumper is engaged, Off - Bumper is free.
TMagnet	Track Magnet, On - Track MR Switch is on a Magnet, Off - No magnet present.
ChgRelay	Open - Cart voltage is present on the charge brushes, will charge if on a charge rail. Closed -- Cart is not charging.
Motor	On - Motor should be running; Off - Cart motor is off.
RS	Signal strength. Lower is better.

NOTES:

TMagnet may indicate OFF when the cart has been stopped by a magnet. This is because the cart while stopping rolled past the magnet just enough for the MR switch to not read the magnet. The cart will resume travel after the magnet timer elapses.

- After CartCOM has displayed the eight nearest carts, pressing “s” will bring up the following screen allowing you to pick a single cart for more detailed information. Follow the instructions and left click on the cart number or ID for desired detailed cart information.

```

CartComPT_14
Press [Enter] to (Re)Load Carts -- Press [s] for Single Cart Diagnostics
  CartID      Cart #    BVolts    KickSw    Bumper    TMagnet    ChgRelay    Motor    RS
SHOP_0003    3         11.9      Off        Off        Off        Closed      Off      60
SHOP_0002    2         12.7      On         On         Off        Closed      Off      74

Click on the Cart Number you wish to further query, on any blank space to reload.
Note: Kick Switch must be in OFF position for single cart diagnostics.

```

- Cart detail screen will be displayed after the left click. The same first line information will be displayed along with more detailed information. If the details do not display try pressing “r” to reboot the cart, wait a few seconds and press ‘enter’ to reload the carts. Try displaying the cart details again. The reboot command simply restarts the program running in the cart; it is just like rebooting a computer. The individual cart detail information screen is as follows:

```

CartComPT_14
Press [Enter] to ReLoad Carts -- Press [t] to change settings, Press [r] to reboot this cart.
CartID      Cart #    BVolts    KickSw    Bumper    TMagnet    ChgRelay    Motor    RS
SHOP_0003   3        11.9     Off       Off       Off       Closed      Off     61

Emergency Charge is: Off
Motor Slip is:      Off
Bumper On Delay    4
Magnet Delay:      19
On Rail Delay:     240

Battery Volts:     11.8
Slip Minutes:      8
Magnet Off:        350
Battery Low:       718
Baterly OK:       765
Version:           14

```

CartCOM Laptop Individual Cart Information Screen	
Label	Description
Emergency Charge is:	ON – Cart battery needs to be charged, cart will not operate normal. OFF – Cart is operating normally.
Motor Slip is:	ON – Cart motor has been on for more than the setting in “Slip Minutes” and needs to be reset by cycling the Kick Switch. OFF – Cart is operating normally
** Bumper On Delay:	Time in seconds the cart will delay after the bumper has been disengaged.
** Magnet Delay:	Time in seconds the cart will stop at each magnet when NOT on a charge rail.
** On Rail Delay:	Time in seconds the cart will stop at each magnet when on the rail.
Battery Volts:	Current cart battery voltage.
Slip Minutes:	Time in minutes the motor will run continuously uninterrupted before timing out.
Magnet Off:	Time in milliseconds that the cart will ignore magnets after magnet time out.
Battery Low:	Battery Low level setting.
Battery Off:	Battery OK level setting.

** Indicates timers that can be adjusted using the ‘t’ command.

- Pressing ‘t’ will allow the user to change the adjustable timer settings. As the screen instructs left click on the timer to be adjusted. Only the bumper on delay, magnet delay, and on rail delay can be adjusted. After left clicking on the timer to adjust, the user will see a screen as follows. Make sure to delete the current time and enter the new time on the keyboard. The new timer entered must be within the limits shown for that timer. After the new time has been changed press ‘Enter’ and the screen should reflect the new timer setting.


```

CartComPT_14
Press [Enter] to ReLoad Carts -- Press [t] to change settings, Press [r] to reboot this cart.
CartID      Cart #    BVolts    KickSw    Bumper    TMagnet    ChgRelay    Motor    RS
SHOP_0003   3        11.9     Off       Off       Off       Closed     Off     61

Emergency Charge is: Off
Motor Slip is:      Off
Bumper On Delay    4
Magnet Delay:      19
On Rail Delay:     240

Battery Volts:     11.8
Slip Minutes:      8
Magnet Off:        350
Battery Low:       718
Baterly OK:       765
Version:          14

Click on the timer setting to change.

```

After clicking on a timer setting:

```

CartComPT_14
Press [Enter] to ReLoad Carts -- Press [t] to change settings, Press [r] to reboot this cart.
CartID      Cart #    BVolts    KickSw    Bumper    TMagnet    ChgRelay    Motor    RS
SHOP_0003   3        11.9     Off       Off       Off       Closed     Off     61

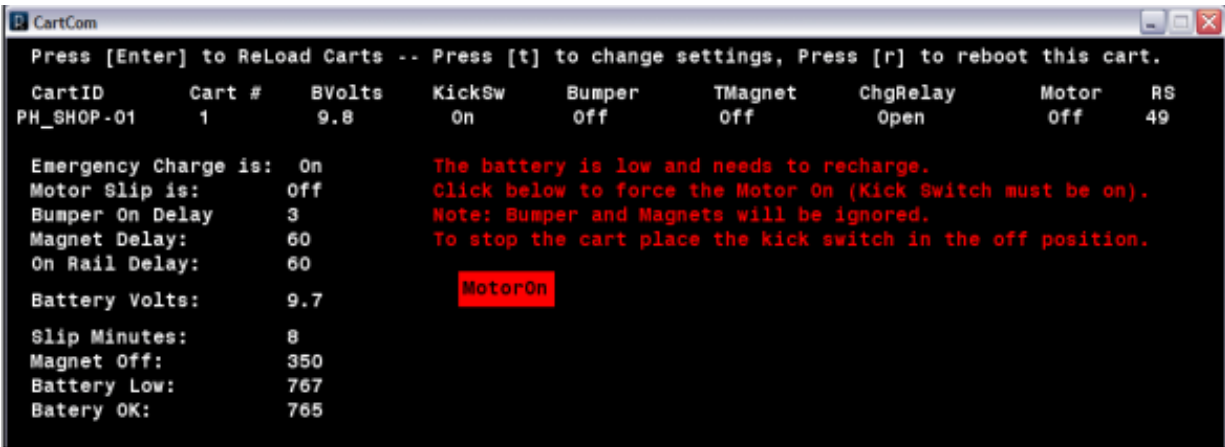
Emergency Charge is: Off
Motor Slip is:      Off
Bumper On Delay    4
Magnet Delay:      19
On Rail Delay:     240    240 Min=0, Max=900 Seconds

Battery Volts:     11.8
Slip Minutes:      8
Magnet Off:        350
Battery Low:       718
Baterly OK:       765
Version:          14

Click on the timer setting to change.

```

- Emergency Charge – If a battery is allowed to drop below 10.4 volts a very rapid voltage drop occurs. This will make charging the battery through the brushes impossible and the cart will need to be charged directly to the battery leads inside the explosion proof circuit box. To prevent having to open the circuit box the PowerCart will enter and emergency charge state if the battery voltage is registered lower than 10.7 volts. In this state cycling the kick switch will turn the motor on for four seconds and then stop again. Since the number of charge rails and placement has been designed to provide adequate charge the cart will need to be checked for physical damages. The charge brushes might be bent or disconnected. Follow the trouble shooting guide in the back of the manual for a complete list of things to check. The cart must be fully charged. CartCOM will display the following screen for single cart information when in the state of emergency charge. Forcing the motor on will allow the user to navigate the cart to the nearest charge rail for full 6 to 8 hour charging.



```

CartCom
Press [Enter] to ReLoad Carts -- Press [t] to change settings, Press [r] to reboot this cart.
CartID      Cart #   BVolts   KickSw   Bumper   TMagnet   ChgRelay   Motor   RS
PH_SHOP-01  1       9.8      On       Off      Off       Open       Off     49

Emergency Charge is:  On           The battery is low and needs to recharge.
Motor Slip is:       Off           Click below to force the Motor On (Kick Switch must be on).
Bumper On Delay     3           Note: Bumper and Magnets will be ignored.
Magnet Delay:       60          To stop the cart place the kick switch in the off position.
On Rail Delay:     60

Battery Volts:      9.7         MotorOn
Slip Minutes:       8
Magnet Off:        350
Battery Low:       767
Baterly OK:       765

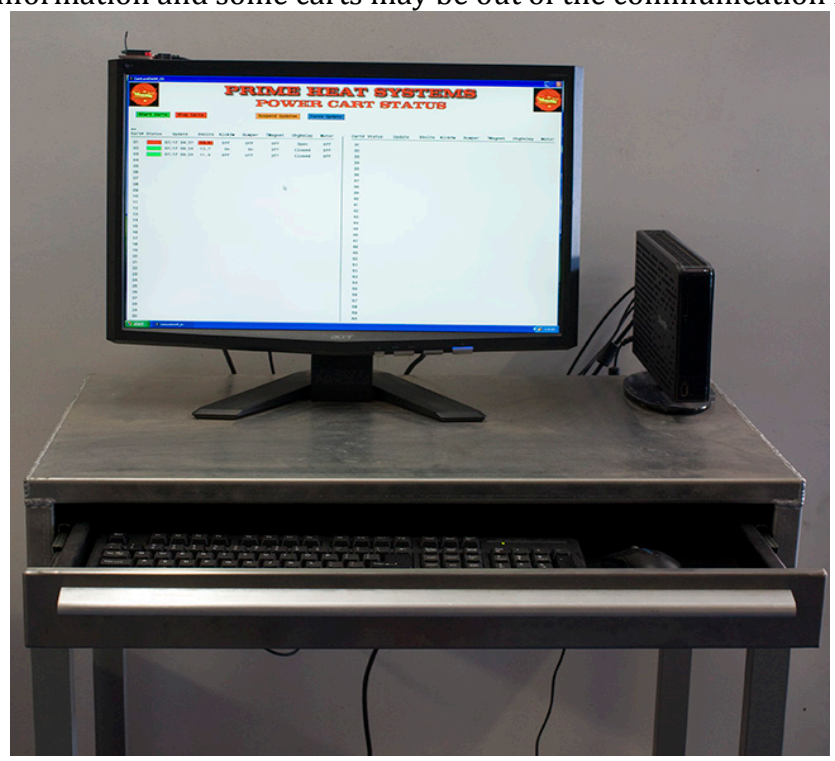
```

If the details of the screen do not appear, make sure the kick switch is ON. The kick switch must be ON for the ECharge screen to be displayed. If the voltage is too low the charge relay may not close. If CartCOM is registering Open ChgRelay check for battery voltage across the charge brushes using a multimeter. If the battery voltage is present then the relay is closed and charging the battery can be accomplished external to the explosion proof box. If battery voltage is not present open the circuit box and connect charger directly to battery leads. For more information about charging low batteries refer to the troubleshooting guide in the back of manual.

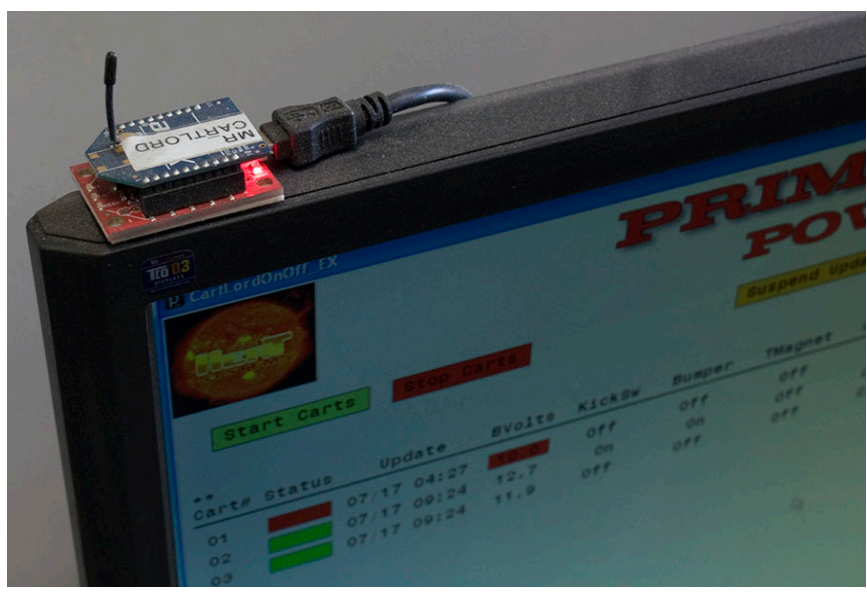
8. Shutting Down – To shut down the computer click on the power indicator in the top corner of the screen.

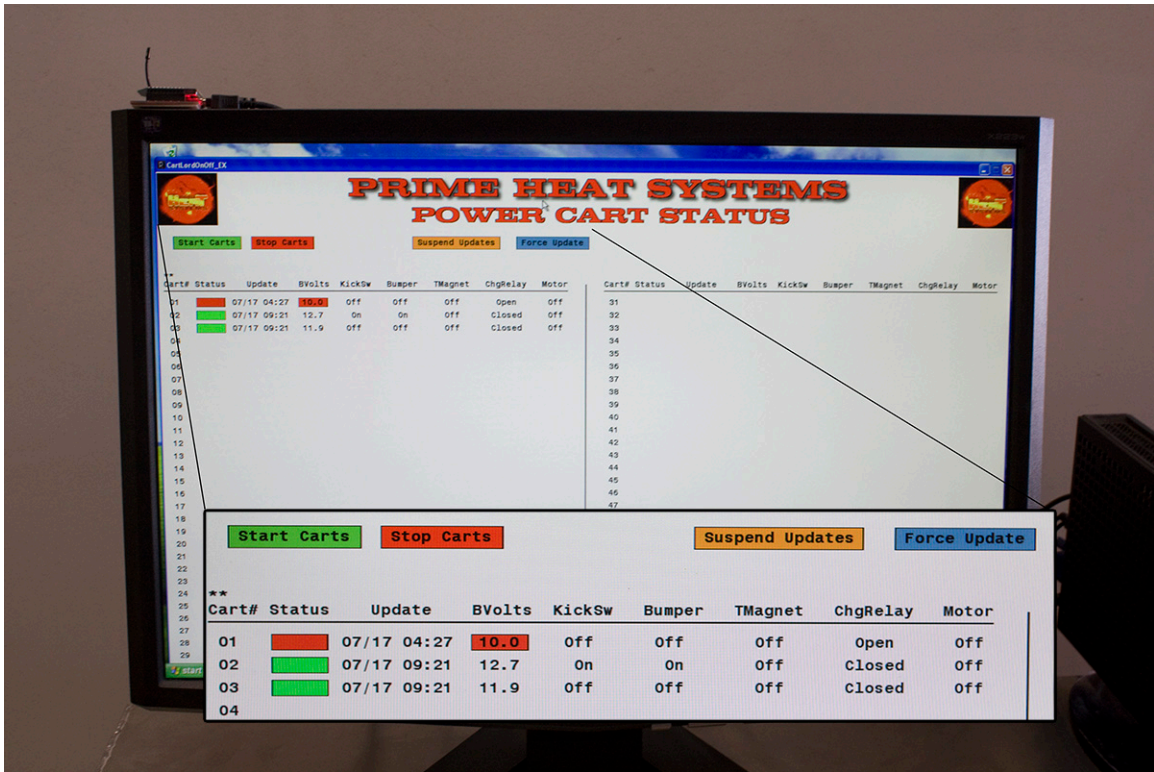
The CartLord Monitor

The CartLord Monitor is a stand-alone console using ZigBee communication to update PowerCart information every three minutes. The monitor will display the same information as the CartCOM Laptop, but without the ability to get individual cart information, as seen in the table below. Some carts will not update every three minutes due to their location in the production line. Only one ZigBee transmitter is used for the monitor information and some carts may be out of the communication range.



ZigBee Chip





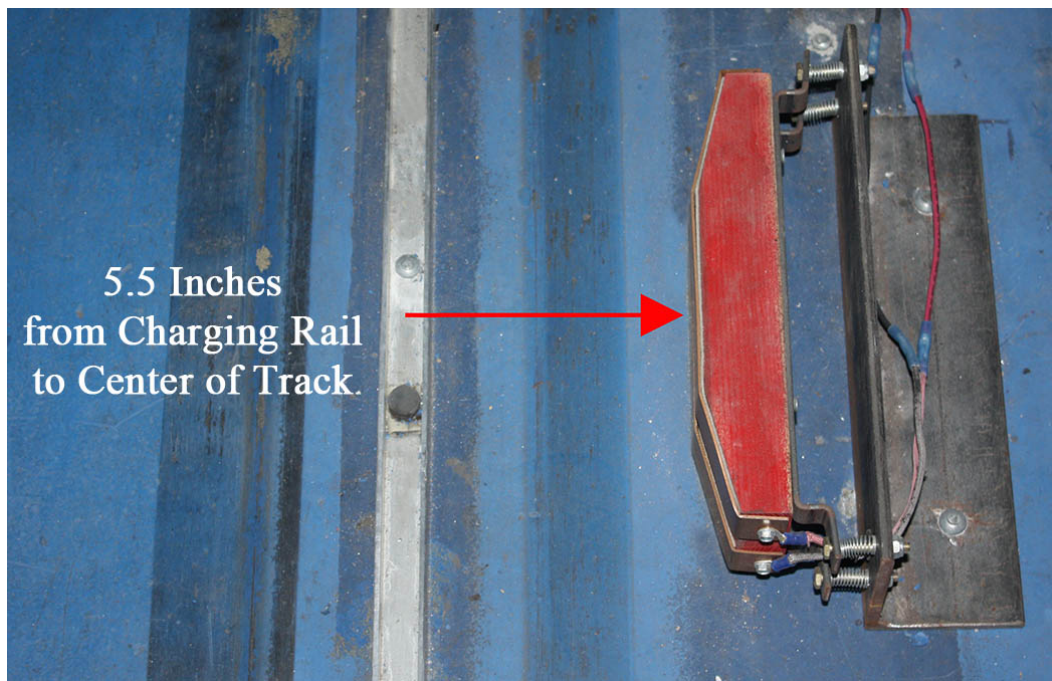
CartLord Monitor Columns	
Label	Description
Cart #	The Cart Number
Status	Green-Bvolts \geq 11.5 V; Yellow- $11.5 \geq$ BVolts \geq 10.6 V; Red- $10.6 \geq$ BVolts
Update	Time stamp from the last time the corresponding Cart# was updated.
BVolts	The current battery voltage.
KickSW	Kick Switch status, On - Magnet in front of MR Switches/Off - No Magnet
Bumper	Bumper Status, On - Bumper is engaged, Off - Bumper is free.
TMagnet	Track Magnet, On - Track MR Switch is on a Magnet, Off - No magnet present.
ChgRelay	Open - Cart voltage is present on the charge brushes, will charge if on a charge rail
Motor	On - Motor should be running; Off - Cart motor is off.

CartLord Monitor Buttons	
Label	Description
Start	Start all carts in range
Stop	Stop all carts in range
Suspend Updates	Prevents CartLord from sending update signal.
Force Update	Forces CartLord to update information on each cart in range.

NOTE: Turn the automatic updates OFF (press Suspend Updates) if trying to communicate to individual carts with the CartCOM Laptop. The laptop signal will be interrupted every three minutes while the monitor is updating.

Charging Rails

Charging Rails are predominantly located inside the Prime Heat Tunnel. A track magnet is used to stop the carts on the charge rails. The charge rails are powered by a Prime Heat designed battery charger. This charger requires 120 VAC power and has an output of 15.5 VDC, with a current maximizing circuit that varies the voltage depending on the battery that is drawing charged. The charge rails should be installed on the left side of the track, 5.5 inches from the edge of the track. The power supply should be mounted outside the path of the carts. The wires running to the Charge Rail's power supply should be protected from damage by being installed in a channel cut in the concrete. The channel can then be capped with silicone, concrete, etc, provided it doesn't interfere with the PowerCart wheels. There are no serviceable parts inside the power supply boxes.



The cart should be charged **two minutes per hundred feet of track**. The charge rails should be checked periodically to ensure that there is ~15.5 volts across the contactors and that the springs are working. Conductive Grease applied to the Charging Rails will also help maintain both the Rail and the Charge Brushes by alleviating metal on metal grinding.

The Track Switch

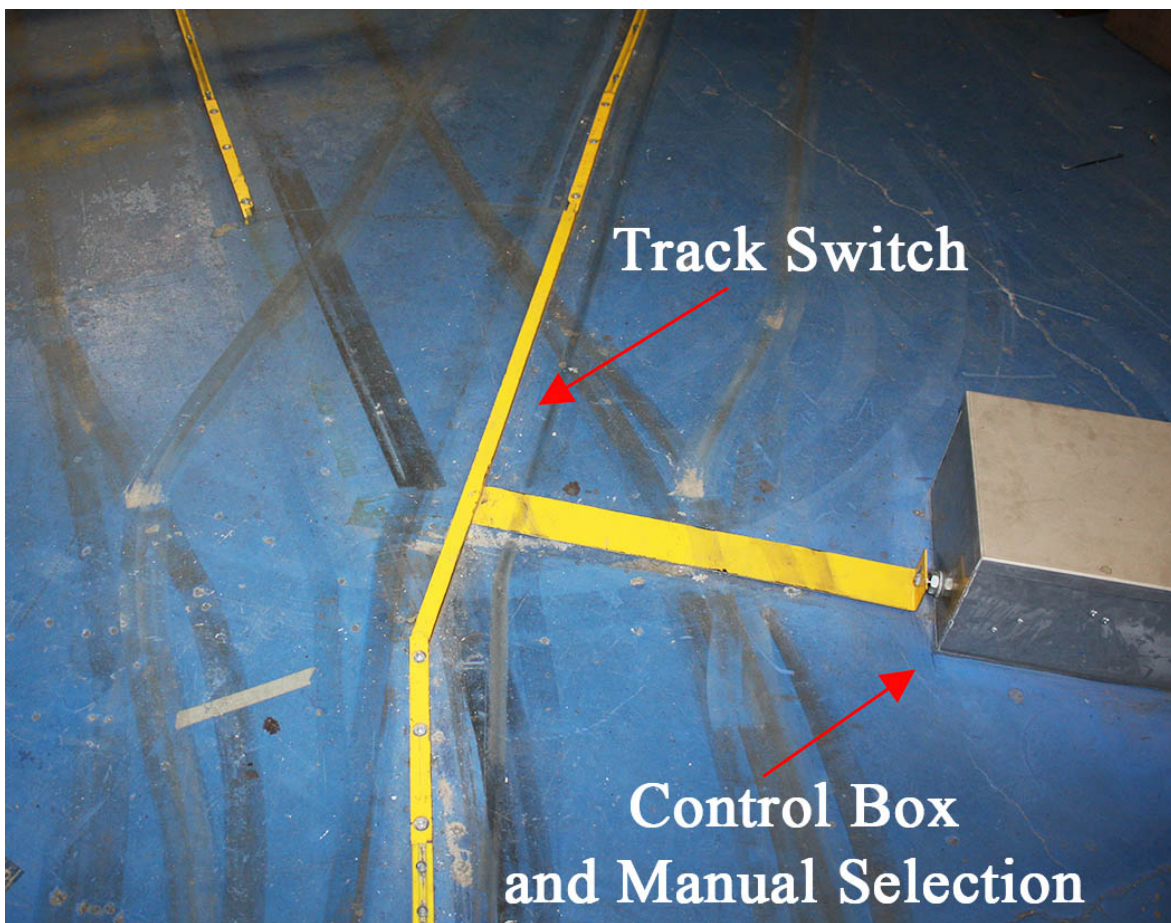
The track switch has two different operations. One is to split the track from one line into two lines- this is called the Diverge side. The Merge side is just the opposite; two tracks merge into one track. The Track Switch system uses RFID readers, Limit Switches, regulated pneumatic Cart Stops, a regulated 12-volt actuator switch and steel track components. The controls for both sides have the ability to run in Manual or Automatic functions. Manual mode allows the user to pick a side to set the track switch to. Automatic operations are explained in the following.

On the diverge side, every PowerCart will be stopped prior to diverging. The Cart Stops are pneumatic actuators that move an arm into position to make contact with the cart bumper to stop the PowerCart. When the control has set a track direction the cart will be released from the automatic cart stopper. The stopper will pop back out when the cart is clear of the stopper to stop the next cart in line.

Limit Switches monitor the right and left track directions to relay empty or full information to the controller. If both sides of track are empty the controller will send a cart to the track direction opposite of the previous cart. If one side is empty then the controller will send a cart to that side. If both sides are full the controller will not release a cart to either side. Once a cart has been released the controller will wait until the Limit Switch is broken then reset, informing that the cart reached a point clear of the switch and that it is safe to release a cart to the other side. The track will move to the other side and the system will continue in auto mode.

The merge side works a little bit different. This side stops carts on both track directions prior to the track switch. Limit Switches are located at each stop to inform controls that a cart or carts are ready to merge. Another switch is set up to relay full or empty line information.

When a released cart clears this point the controls will continue by setting track switch direction and then releasing the next cart in sequence. The control will alternate sides unless a cart is not present on the opposing side.



If any of the Limit Switches are not operating in a stable mode, the control systems will fail. If the user is having a hard time with the operation of either track switch, check each Limit Switch to see that

the switch's indicator arm is working properly and that all wires are secure. The arm should be able to drag along the cart and then spring back into position.

If a track switch malfunctions, follow the procedure listed below to get things running again.

1. Turn any carts involved OFF.
2. Maneuver the carts off of the track switch steel track portion.
3. If you need to move the cart stopper turn off the air pressure and do it manually. Unhook the air hose from the supply and maneuver the stop arm. Reconnect when finished and ready for normal operation.
4. Turn the controls off. The track may switch directions when the power is turned OFF.
IMPORTANT: DO NOT change track directions with a cart on the track switch, as this will damage the track switch.
5. After all carts have been placed back on the track and the air turned back on, turn on the controls.
6. Turn on the carts then observe normal operation.

There are no user serviceable parts in the control box. It is good to oil the pneumatic actuators, solenoids and regulators on a regular maintenance schedule. The cart stops will need to be greased periodically to maintain reliable function.

Cart on Demand

The cart on demand is a simple system that will stop carts at a given location prior to a finishing operation. The user is in full control of this manual switch. The stop operation is activated with a toggle switch on top of a stand. The stop arm is either out or in depending on which way the toggle switch is turned. When the user is ready for the next cart to enter he or she will flip of a switch. Keep in mind that once that cart has passed the stop the switch will have to be flipped again to stop the next cart inline.



Cart on Demand Tower. (Switch can also be mounted on wall by user)

Troubleshooting

Sensor (Switch) Related Issues

Problem	Possible Solution(s)
Track Sensor stops correctly on most magnets, but bypasses a few.	The Sensor may be too high above the track. Lower the sensor using a 1/8" Allen wrench. The sensor has a 5/8" operating gap. Do not tighten past 'snug'.
Track Sensor doesn't stop on any magnet.	The Sensor may be broken. If set too low, the sensor head may have been sheared off. If over tightened with the set-screw, it might have been damaged as well. Replace the sensor. Cut the sensor wire close to the tube. Using 18-22 AWG butt-connectors, wire a new sensor head onto the existing wire.
One or both of the Kick Switches doesn't work.	<ol style="list-style-type: none"> 1. Check that the Kick Switch's magnet is not broken or out of place. 2. Check that the Sensor is not broken. 3. Check the Diode Box, a wire may have become loose in the terminal. Refer to the Diode Box Wiring Diagram.
Top Switch not working correctly.	<ol style="list-style-type: none"> 1. Check that the magnet is correctly above the sensor when the Table-Top is spun both ways. If correct, take the Table-Top off and start the cart. 2. Next, place a magnet directly over the sensor. The cart should start in 4 seconds if the switch is working. If not, check the Diode Box for loose wires.
Touch Bumper Switch is not working correctly.	The Bumper may be broken. Visually inspect for cuts. Using a multimeter on Ohm Setting (Ω), check that the Bumper is good. Unplug the Bumper leads from the leads to the Diode Box. Either lead of the meter can go to either lead of the Bumper. The meter should Beep (showing continuity) if the Bumper is good.
Touch Bumper checks as good, but Bumper still isn't working correctly.	Check the leads going into the Diode Box for possible loose wire.
Touch Bumper is shown "ON" on CartLord and CartCOM, but is not in contact with anything.	The Table-Top magnet may be out of position or turned. The Bumper and Table-Top are wired together inside the Diode Box. So when the Table-Top is turned, the Bumper will be shown as "ON".

Cart will not start, but all Switches appear to be wired correctly.	It might be too tight around the corners of the bumper. Try taking the ends off individually to see if the cart will start running.
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Motor/Gearbox/Drive-Wheel Issues

Problems	Possible Solution(s)
The Drive-Wheel is slipping in certain areas.	<ol style="list-style-type: none"> 1. Check the floor along the track for slick surfaces, inclines, or fluids. Floors are rarely level, and sudden inclines coupled with slick concrete or wood can lead to slippage. Grip tape strips may be needed to provide better traction. 2. The wheel may be bald to the point it needs to be replaced.
The cart is moving slowly, and it sounds like it's dragging or grinding.	Turn the cart OFF. Check the front and back Track Bearings. A loose item along the track may have lodged itself between the bearing and the track.
The motor is running slow, sluggish or intermittently.	The motor brushes may be worn out. This motor will need to be replaced. Refer to the maintenance section.
The Drive-Wheel won't turn, but the motor is trying to run.	Turn the cart OFF. The Gearbox is internally geared, and if it should fail, will need to be replaced. Refer to the maintenance section.

Cart Issues

Problems	Possible Solution(s)
The cart is not working.	<ol style="list-style-type: none"> 1. Most likely cause is a depleted Battery. If the Battery Voltage falls too low (under ~10.5v), the Charging Rails won't be able to charge it. It must be charged through the Diode Box. Refer to the maintenance section. 2. The cart might simply need to be Rebooted using CartCOM. Select the cart in CartCOM by pressing <u>S</u> and then clicking on the cart. Next (in the single cart diagnostic screen) press <u>R</u> to reboot the cart. Wait 10 sec. and then try to run the cart.
The cart stops on the Charge Rail as specified, but the Battery Voltage has fallen below acceptable levels.	<p>Three Likely Causes:</p> <ol style="list-style-type: none"> 1. The Battery isn't holding a charge anymore and must be replaced.

	2. The Charge Brushes aren't in contact with the Charge Rail. The magnet may be set too far back. Visual inspection should suffice to diagnose. Reset the magnet and glue down. Use CartLord to verify that the ChgRelay is listed OPEN next time the cart stops on the Rail.
CartLord lists the ChgRelay OPEN, but the cart doesn't seem to actually charge.	One of the Blocking Diodes may have shorted. Check the voltage of each diode. It should be between ~ .125.
The Track Bearings have rusted.	Bearings rust when being subjected to harsh floor cleaning solvents. Clean any spills or puddles of solvents along the track. The Bearings will need to be replaced.
The Track Bearings are too low or high for certain areas of the factory.	Bearings can be raised or lowered using shims.
The Bumper Springs have rusted.	Practice good spray techniques and avoid overspray. The springs will have to be replaced.
The Front and Back metal Bumpers have become loose.	Tighten with a 1/2" wrench. Never lift the cart from the Bumpers. This will loosen them. Lift from the bottom corners of the Cart Body.

Microcontroller/CartCOM/CartLord Issues

Problem	Possible Solution(s)
The microcontroller board isn't working and reboot.	The board will need to be replaced.
The microcontroller board's charge or motor relay mechanically stops working. This would be evident if CartCOM Laptop registers the relays are closed and there is no output voltage.	The board will need to be replaced.
If the ZigBee Transmitter on the microcontroller board is not communicating with the CartCOM Laptop. The red light signifies that the transmitter is getting power.	The board will need to be replaced.
The microcontroller board's electrical components fail.	The board will need to be replaced.
CartCOM suddenly becomes cluttered with overlapping text.	While using CartCOM, make sure to restrict updates on CartLord. The overlapping text results from CartLord querying the carts every 3 minutes.
CartCOM won't return any results.	Make sure the ZigBee Chip on the CartCOM laptop is correctly plugged in. Also, if removed and reinserted it may be necessary to Restart the laptop.

CartCOM Laptop went to sleep and when woken will not display new information.	Close the CartCOM program and restart the program.
Pressing T to change settings in the Single Cart Diagnostic page in CartCOM does nothing.	One of the cart's Kick Switches must be OFF to change settings with CartCOM.
CartLord updated, but didn't update statuses of a few carts.	The carts may be out of range. It will update in 3 minutes, which should bring the carts closer.
CartLord program is Frozen or Unresponsive.	Restart the program, if necessary, the computer.

Track Switches/Cart Stops Issues

Problems	Possible Solution(s)
The Track Switch is hitting the other side too hard.	The Switching system uses Solenoid Valves with restrictors/diffusers. The restrictors/diffusers are small, metal pieces attached to the solenoids. To slow down the switch, simply adjust the restrictors/diffusers using a small screwdriver.
The cart is not stopping and continually bumping the Cart Stop.	The Cart Stop will need to be repositioned. Grind out the heads concrete anchors holding it down. Position it so that it will hit around the curve to flat of the side of the bumper. This effectively puts the cart in a bind on the track and stops it.
The cart hits a Limit Switch but the Cart Stop arm does not extend.	The Limit Switch may be broken and require replacement.