Technical Note 008: What is Plug/Dynamic Braking for series motors?

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Overview

Plug braking, also refered to as dynamic braking, is a safe way to slow down a vehicle with a series motor when the motor direction is reversed. Without plug braking, if the operator reverses direction while the vehicle is in motion the armature will lock up. When the vehicle comes to a halt, then the motor will reverse direction. Reversing the current to the armature while moving causes the armature to lock up with violent and potenially dangerous consquences for the motor, controller and operator.

Alltrax AXE controllers that have a “P” designation at the end of the model number are plug brake controllers. They can be identified by an additional bus bar in the lower right corner marked as A2.

Plug Brake, Dynamic Brake and Regen Braking

Plug and dynamic braking is completely different than regenerative braking. Regen braking is found on shunt wound (separately excited) motors and will put the energy used back into the batteries. Plug and dynamic braking loose that energy as heat in the controller and motor and none is returned back to the batteries, which is typical for series motors.

Plug braking commonly found on electric forklifts, walk behind pallet stackers and other applications where the operator is constantly changing direction. Plug braking not used during normal braking operations. It only comes into play when the motor direction is reversed.

Reversing direction without plug brake

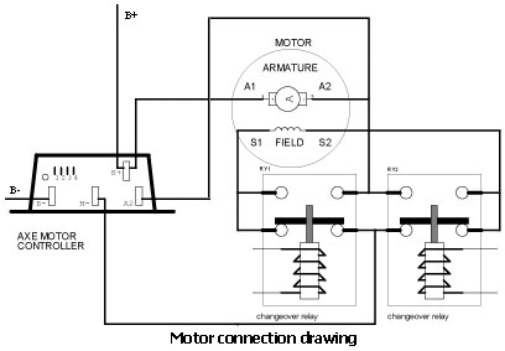
When the direction o the motor is changed, the field polarity reverses. This is what causes the motor to spin the opposite direction. When under power, the field reverses, but the momentum of the vehicle is keeps the armature from reversing. The motor then turns into a generator. As the voltage generated by the motor flows back to through the controller and field winding, the current increases. As the current increases the field intensity increases causing more voltage to be generated. This feedback loop builds quickly to the point where the field intensity is so strong it will stop the armature from spinning. If the vehicle is still moving, this will cause the drive wheels to lock up. This energy buildup happens very quickly inside the motor and controller.

Reversing direction with plug brake

The A2 bus bar on the plug brake AXE controllers prevents the drive wheels from locking up. As the motor turns into a generator the voltage at the A2 bus bar increases. The controller senses this condition and shorts out the armature through the plugging diode. Shorting the armature prevents the feedback loop from creating a strong field. The controller can then modulate the field current to control braking force.

How it works

The controller detects plugging by comparing the voltage across a diode connected to the A2 bus bar. If there is voltage across the diode, the controller switches the PWM of the controller to a low duty and frequency mode. A “whine” may be heard during plug braking, this is normal a normal condition of the reduced frequency of the PWM. Using the slower and lower powered, allows the controller to safely control the speed of the armature.



Motor connection drawing

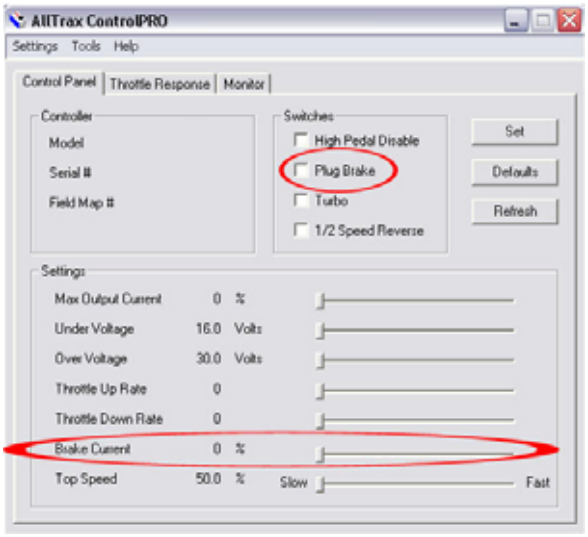
(See drawing: Doc100-048-A_DWG-AXE-PlugBrk-Rev-wire-dia.pdf)

How it works (cont.)

As the motor slows, the armature voltage drops. This results in a loss of braking torque as speed approaches zero and no braking at a stop. When the voltage across the diode drops to zero, the controller resumes normal PMW operation. The armature now spins in the reverse direction. The energy dissipated by plug braking is converted into heat in the motor and controller.

Plug Braking in ControllerPro

In controllers equipped with plug braking, two additional features become available in ControllerPro. One is the Plug Brake switch and the other is the Brake Current. In order for Plug Braking to work on a P model controller, the Plug Brake switch needs to be checked. Otherwise, the controller will behave just like a non plug brake controller.



Brake current adjusts the available current for plug braking. It works on a scale of 0-100%. The higher the percentage the more braking torque is applied to the motor and the faster the armature spins down to zero RPM.

When Plug Braking is needed

Plug brake is a fairly common feature on golf cars. Not all series golf cars have the option, check with the manufacturer for requirements.

Plug braking is required for vehicles that reverse the motor to change vehicle direction. For applications where the motor only spins one direction, no plug braking is needed.

Conclusion

Plug braking is an essential feature for some applications. When the direction reverses on a series wound motor, plug braking turns a dangerous situation into a safe one. The controlled braking and smooth stop protects not only the operator but the motor and the controller.

WARNING: Switching between forward and reverse without an interlock or plug brake on a series motor can permanently damage the controller, motor or operator and cause a catastrophic failure in the controller

ALLTRAX Inc., Company History:

The company founder developed our core technology at the race track for high power electric vehicles. Throughout the 90's, the market demanded robust and high performance electronic controllers. In 2001 ALLTRAX was formed based on the E-race car developed technology.

Today, Power Conversion Engineering (PCE) is the research and development arm and ALLTRAX provides the industry a powerful and robust controller to meet all your recreational, industrial, and commercial electrical vehicle needs.

For more information please go to http://www.alltraxinc.com

"The company was founded at the track"