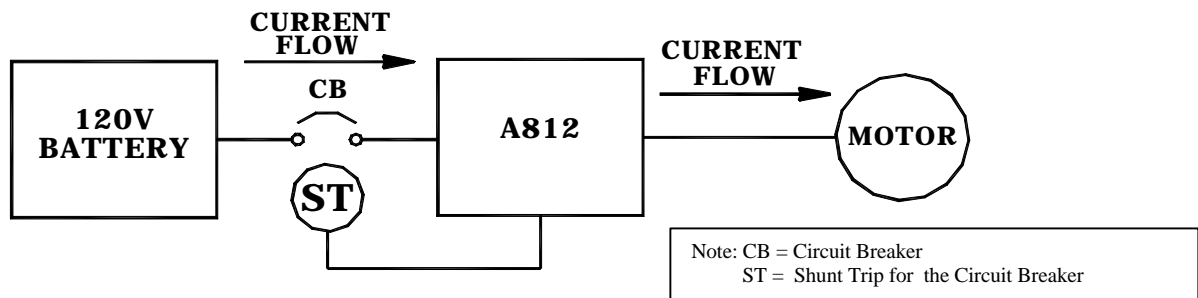


## Improving Electrical Braking for A812 and A820 drive systems

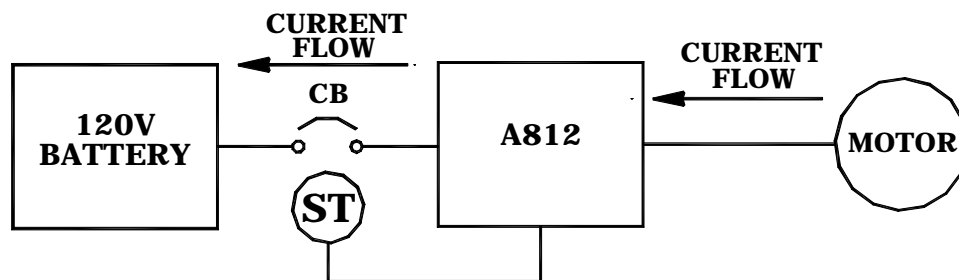
### 1. How Electrical Braking (Regenerative Braking) Works.

#### 1.1 Trimming.



During normal trimming and acceleration, current flows from the battery to the A812 controller and then to the motor.

#### 1.2 Regenerative Braking



When an electric vehicle is slowing down, the motor becomes a generator and provides energy to the batteries. An additional benefit of this process is the braking effect of the motor on the vehicle, thereby reducing mechanical brake wear. During "regen" braking, current flows from the motor to the A812 and then to the battery. This current is controlled to provide smooth electrical braking.

## 2. Over-Voltage Protection

Due to the energy returning to the batteries during regen braking, the battery voltage will rise. For example, under normal conditions a “healthy” 120V battery absorbing 300A of regen current might go to 150V. There are some instances that may cause the voltage level to rise to higher levels. To protect the A812 controller and motor in the event of these higher voltages, two levels of over-voltage protection are provided:

- 2.1 **165V** – the A812 will be inhibited momentarily until the voltage drops below 160V after which braking can be resumed.
- 2.2 **200V** – the A812 shuts down and trips the circuit breaker.

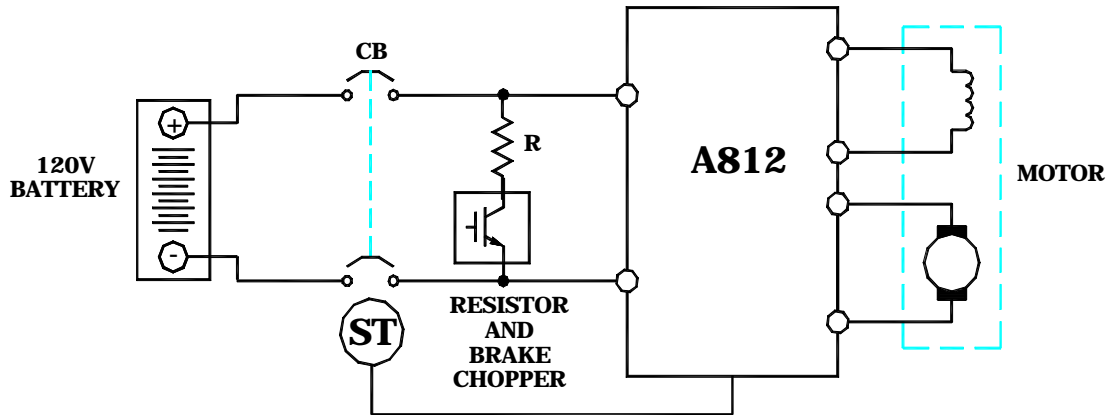
## 3. Battery problems

If the internal impedance of the battery happens to increase, the resulting battery voltage may rise above the 165V protection level during hard electrical braking. Some of the reasons for this increased internal impedance may be:

- Low water level
- Bad cell
- Shorted cell

When the battery is healthy, its voltage at 300A braking current is less than 160V, but if the water level is low (or other battery related problem) it might go above 165V and momentarily inhibit the A812, in which case the operator will lose electrical braking control until the voltage returns below the trip level.

#### 4. Braking Chopper



The OV trip problem with a faulty battery can be eliminated by the addition of a brake chopper (Saminco model BM-302) as shown above. The chopper is set to turn ON at 155V. If the battery impedance has increased, the resistor will be switched ON to absorb the excess energy during regen braking to maintain the battery voltage level less than 160 V.

#### 5. Battery Condition Monitoring

The BM-302 also provides a contact closure, which can send a signal to the vehicle operator indicating repeated operation of the braking module. This would be an indication of battery degradation alerting the operator to have maintenance of the battery performed. This contact can be programmed to activate after a preset number of cycles in a set period of time to avoid nuisance indications and allow for self resetting of the indicator.

#### 6. Battery Maintenance

It is very important to maintain a healthy battery by ensuring that the water level in all cells is always at the appropriate level. A regular battery maintenance schedule is important to ensure:

- Safety during vehicle operation
- Longer battery life
- Longer vehicle operating time before battery is recharged
- Better regen braking
- Increased mechanical brake pad life

## 7. Safety Checks

Each time the portal bus or locomotive is taken into operation, please perform the following safety check:

- **Check function of the E-Stop circuit before operating the vehicle. The circuit breaker must trip when the E-Stop button is depressed.**