A capacitor precharger for electric vehicles

The most important aspects of electric vehicles are their reliability and readiness to use. In order to ensure this reliability the high voltage systems must have plenty of protective electronics that ensure safe operation. The system that we developed enables these protections.

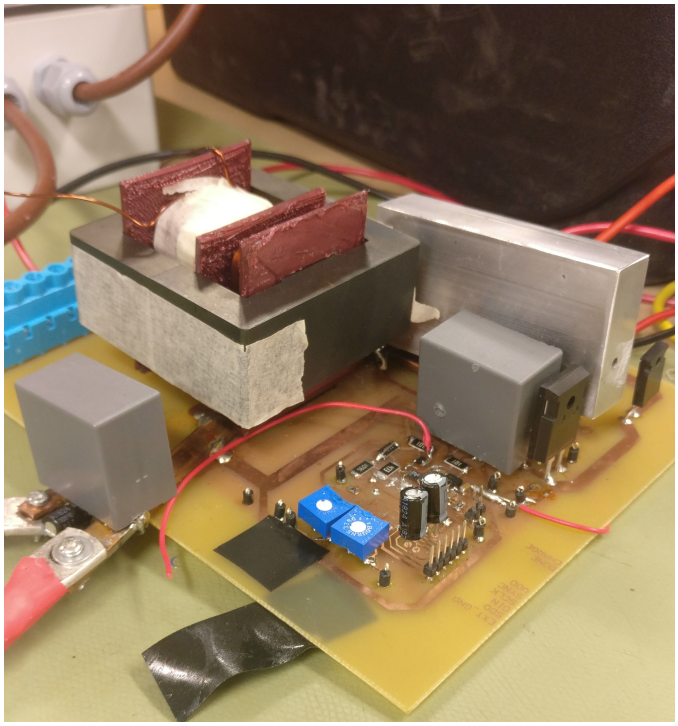
The drive line in an electric vehicle has three major parts. Most of us are aware of the battery and the electric motor, but in order to get the energy stored in the high voltage battery to run the motor, there must be an electrical converter which connects the two. This converter reacts quickly to the input from the driver and the road and ensures that the ride is smooth and that the vehicle is pleasant to drive. However, because the converter has to handle high energy currents, additional electrical protection is needed.

The most common form of high current protection is the capacitor which acts as an energy buffer and smooths out spikes and sudden shifts in the power throughput. The high voltage battery and the capacitor buffer can be thought of as two chambers in a water lock with a gate between them. The battery is a much larger chamber and the level is constantly high. The capacitor buffer is much smaller and it is empty when it has not been used for some time. Just as in the water lock, the gate can not be opened wide while the water has different levels. Instead, there is a smaller opening which allows the water to flow slowly from the higher to the lower side until the levels are the same and the gates are opened. In the electric vehicle the buffer must also be charged to the same level as the battery before they are connected. Charging this buffer is what our system does.

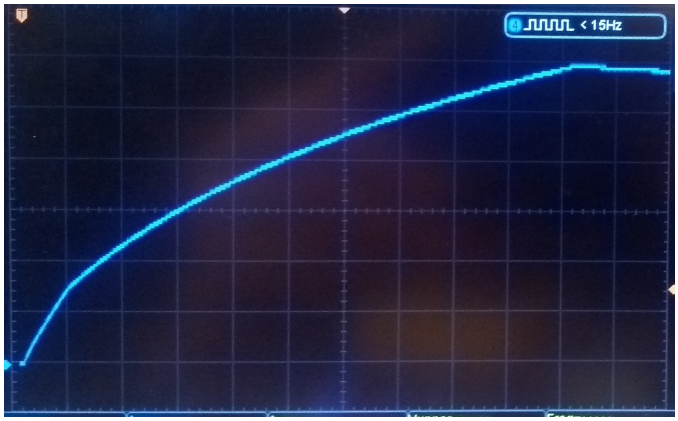
The conventional method to charge the buffer is to put a relay and a resistor between the buffer and the high voltage battery. This slows down the flow of energy and limits the current. The problem with this method is that the buffer becomes unusable if the high voltage battery is depleted.

Our approach is to instead use a converter connected to the low voltage battery to charge the buffer. The converter is used alone to activate the high voltage systems in the electric vehicle. This activation allows technicians to run tests without using the high voltage battery which can be potentially dangerous if connected.

We designed and built a flyback converter prototype to charge the buffer. This type of converter can be found in many common household appliances such as laptops and phone chargers. Flyback converters work similarly to pneumatic jacks. A low voltage on one end of the flyback (equivalent to the pressure in the jack) is transformed to a higher voltage on the other end. A diode works as a check valve, preventing the electricity from going back the same way it came. By temporarily converting the electricity to magnetic energy, the flyback converter also provides a layer of electrical isolation which protects the driver and passengers from electric shock. The flyback converter allows us to take a mere 12 or 24 V and ”jack” it up to 850 V using a conventional lead battery - the same type that you find in combustion trucks.



The flyback converter prototype



From the lab: the voltage in the buffer rises to 600 volts in one second

The flyback converter prototype contains some low power components that are typically used in camera flashes but the converter could still provide 100 W of power. Unfortunately, 1500 W was eventually needed but can not be delivered by this prototype. The camera flash components were not powerful enough but the underlying mathematics combined with more powerful components can give vehicle manufacturers a new way to charge their high voltage buffers.

Alexander Lundström & Hannes Bydén