



INNOVATIVE ENGINEERING SOLUTIONS



# POWER MODULES



Chelyabinsk 2016

- The modules are optimal for vehicle START-STOP systems
- Help to start the engine reliably in winter
- Benefit the environment



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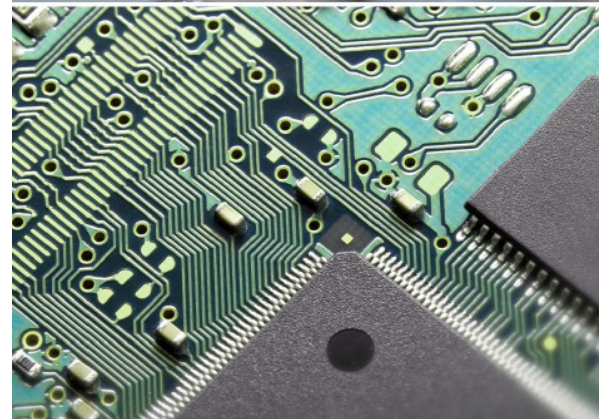


## HISTORY

Smarter LLC was established in 2014 by a group of engineers with a military and industrial background. The company has a creative approach to new market applications and it is becoming a strong player in the use of Energy Efficient Technology.

Today Smarter LLC is a promising engineering company with a team of solid professionals and a portfolio of truly innovative solutions.

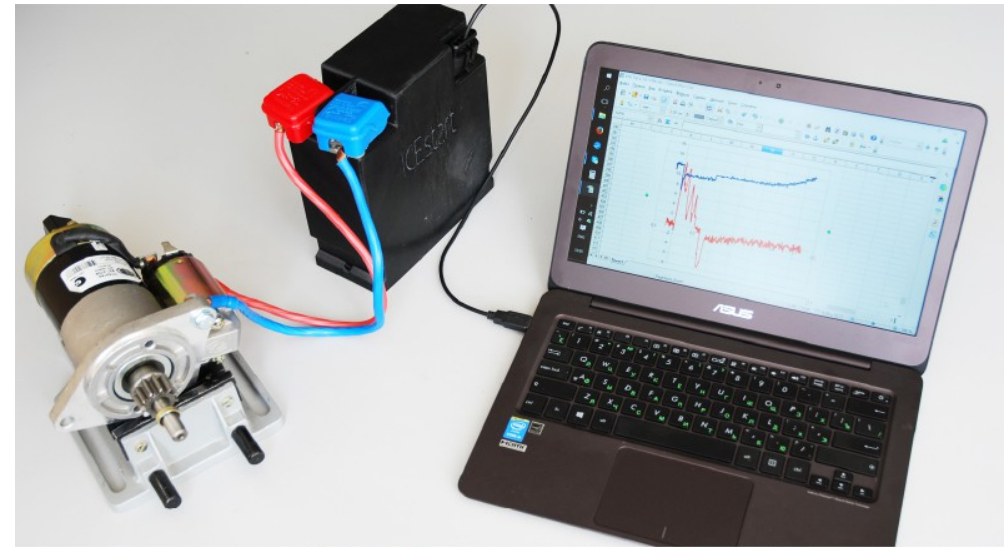
One of these solutions is the ICEstart® product line of power modules.



## PURPOSE

Lead Acid batteries that are normally used for starting internal combustion engines (ICEs) in automobiles are rather power-inefficient. On the one hand, the energy stored in a battery is hundreds of times greater than what is necessary for a single engine start. On the other hand, only a fraction of this energy can be used because of the battery's high internal resistance, especially at temperatures below  $-20^{\circ}\text{C}$ .

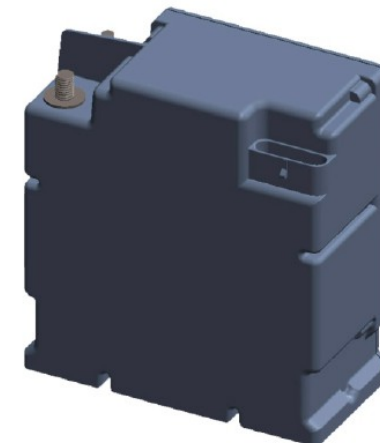
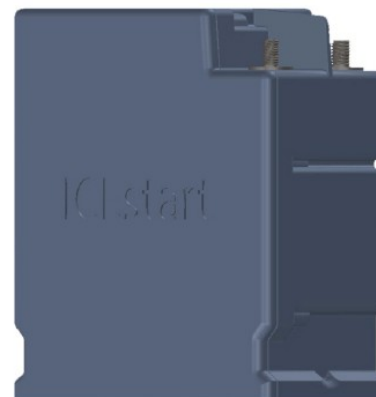
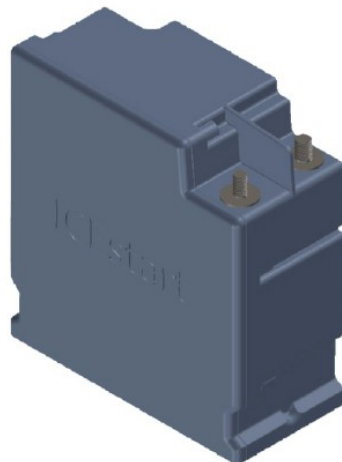
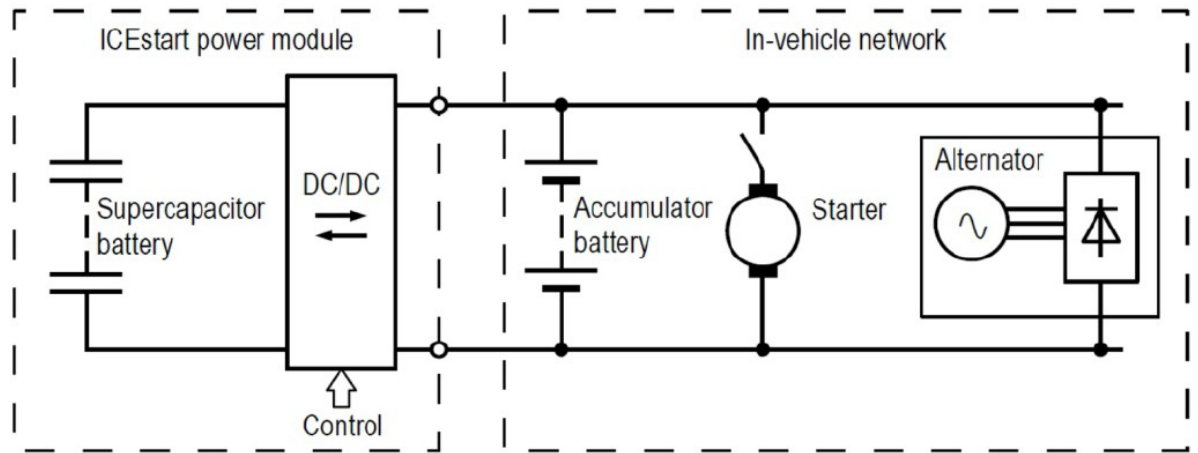
The ICE start systems developed by Smarter LLC use supercapacitor-based energy storage units, which are more efficient compared to lead acid batteries. These systems guarantee engine start in any weather conditions, and they are optimal for use with vehicle START-STOP systems.



## DESCRIPTION

ICEstart® is a product line of supercapacitor-based energy storage modules offering unprecedented characteristics and advantages.

Their distinctive feature is a high power DC/DC converter, which connects the supercapacitors to the vehicle's electrical network as shown on the diagram.





## ADVANTAGES

### 1 Efficient utilisation of supercapacitor energy

The converter used in ICEstart® modules is a bidirectional buck-boost DC/DC converter, i.e. it permits to both charge and discharge the supercapacitor battery on the entire range of battery voltages (from zero to its maximal value). This allows the system to use the stored energy more fully. Compared to the competing products, efficient utilisation of the stored energy means that the supercapacitor battery size is optimized, thus reducing the cost, weight, and dimensions of the modules.

### 2 Controlling the output voltage

In the competing products the starter is connected directly to the supercapacitor battery. As a result, at engine start the supercapacitor battery discharges uncontrollably, leading to a decline in the ICE cranking speed. In contrast to this, the DC/DC converter of an ICEstart® module is able to stabilize starter voltage (and, by consequence, the cranking speed) depending on the conditions in which the ICE is being started:

- In winter, after a long downtime and at a temperature below -20°C, ICE cranking is done at 9V starter voltage, which makes it possible to sustain the cranking process for an extended period of time by discharging the accumulator and super-capacitor batteries simultaneously.
- When starting a warm engine frequently, i.e. in START-STOP mode, cranking is carried out at 12V starter voltage, which starts the ICE quickly (0.5 ÷ 0.6 seconds) with virtually no usage of the accumulator battery.



### 3 Controlling the charge current

During a long downtime of the vehicle the ICEstart® module shuts down and doesn't consume any current. Before starting the ICE after a lengthy downtime, the ICEstart® module is charged from the accumulator battery. Charging time is approximately 10 seconds. In START-STOP mode the ICEstart® module is charged by the current from the alternator. In this mode a pause of at most 2 seconds is sufficient to recharge the ICEstart® module between consecutive engine starts.

### 4 Controlling the discharge current

In the competing products, when connecting the starter directly to the supercapacitor battery, there occurs an excessive pulse of current through the starter, which leads to mechanical stress and makes the commutator function in a sub-optimal regime. In contrast to this, the DC/DC converter in an ICEstart® module limits the initial pulse of the current, thus extending the starter's lifetime and allowing it be used in START-STOP mode (when the engine needs to be started frequently).

### 5 Improved power quality

The ICEstart® module improves power quality in the vehicle network by reducing the voltage dips due to the current surges that occur during the operation of the car's electrical equipment.

### 6 Benefits for the environment

More than half of the lead production worldwide is due to automobile accumulator batteries. ICEstart® modules allow to make the accumulator battery 2 + 3 times smaller, and to extend its lifetime by the same factor. This opens up the possibility to drastically reduce the need for one of the most ecologically hazardous metals.

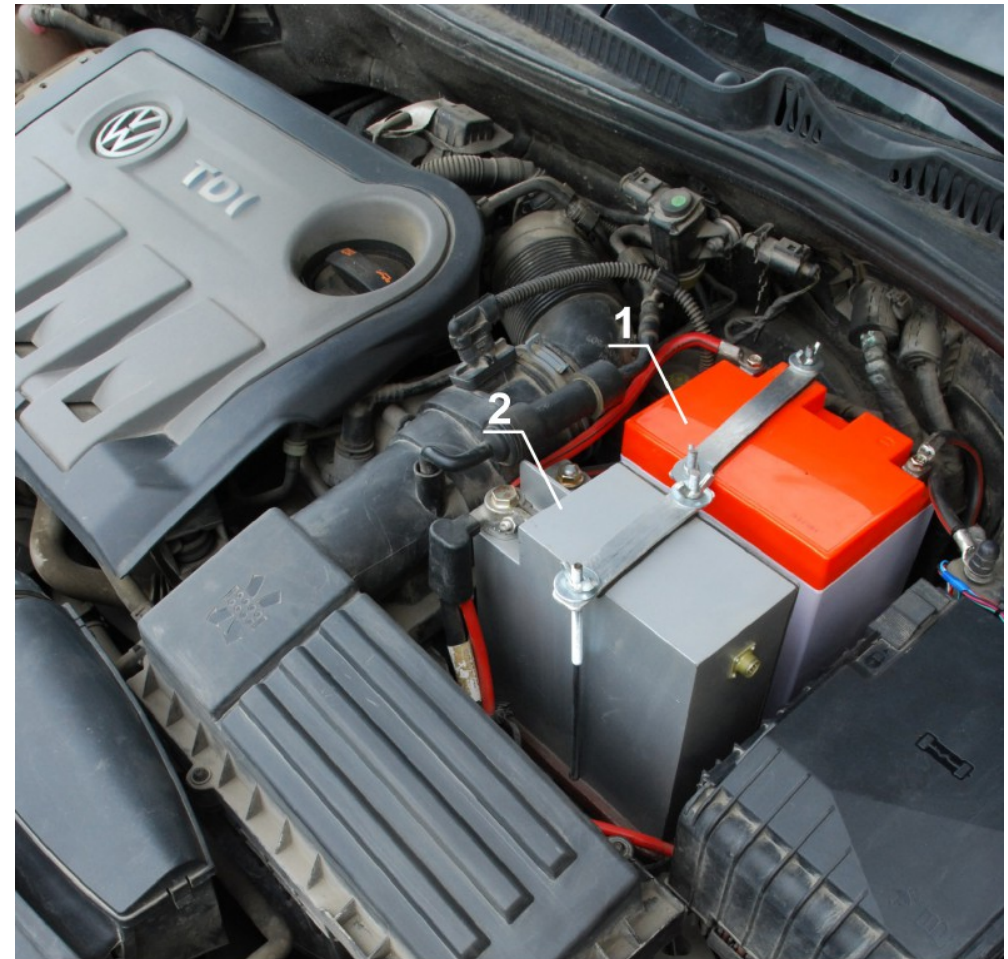
## TRIAL RESULTS

The photo on the right shows the engine compartment of a Volkswagen Golf with a 2L diesel engine. Instead of the stock 72Ah lead acid battery, installed in this vehicle are:

1. A 30Ah lead acid battery.
2. An ICEstart® 12S2300 module (prototype).

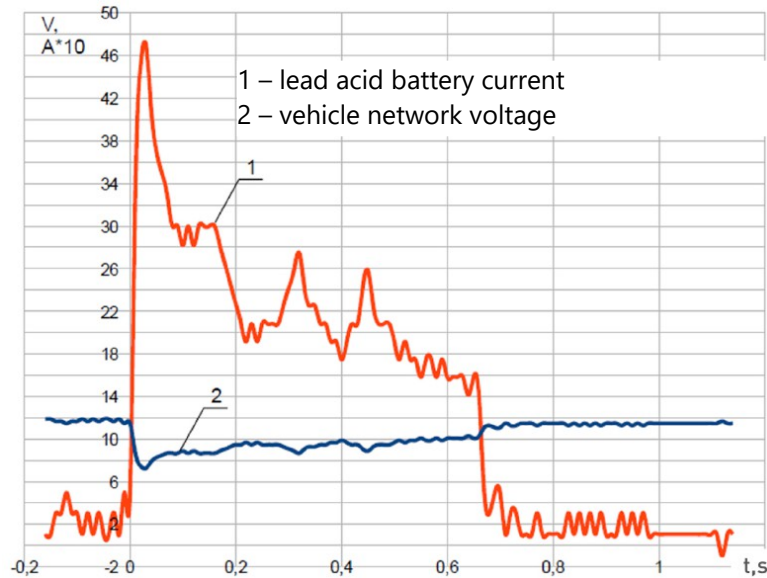
Trial starts of the car's ICE have been executed both with the stock 72Ah battery (no ICEstart® module) and with the reduced 30Ah battery (with an ICEstart® 12S2300 module connected to it in parallel).

In the diagrams on the next page you can see the waveforms of the vehicle network voltage, the lead acid battery current, and the ICEstart® module current that were observed in the trials.

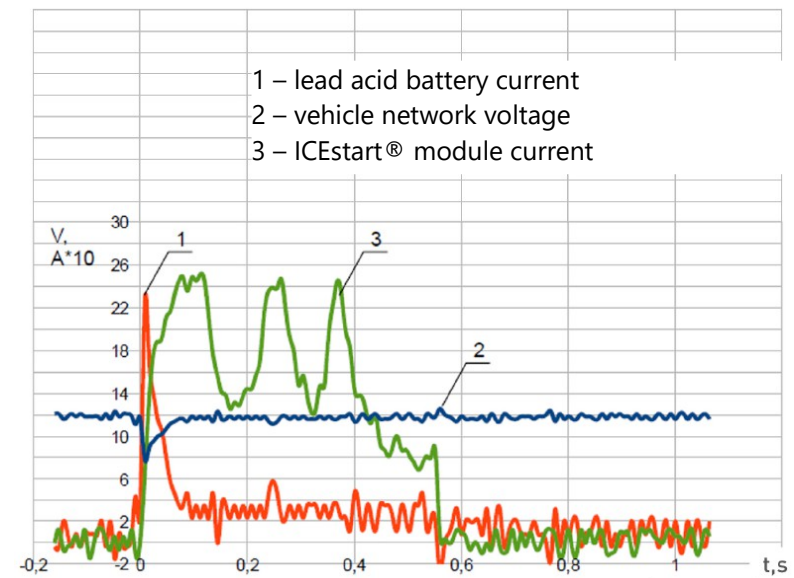




### Waveforms of the ICE start using the 72Ah battery



### Waveforms of the ICE start using the 30Ah battery with the ICEstart® module



1. When starting the engine with the stock lead acid battery, the average discharge current of the battery is 230A, the average voltage in the vehicle network is 9V, start time is 0.68s.
2. When starting the engine with the reduced lead acid battery and the ICEstart® module connected to it in parallel, the average discharge current of the lead acid battery is 40A, whereas the average discharge current of the ICEstart® module is 190A; vehicle network voltage remains virtually stable (except for a transient dip at the moment of starter power up), start time is 0.55s.

**Conclusions:** when an ICEstart® module is used, it provides the major part of power supply for the starter, while the lead acid battery discharges only a little; stable voltage in the vehicle network permits to crank the starter at constant speed and reduces engine start time.



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## Product range

Model	12S1800	12S2300	12M4500 <sup>1)</sup>	24M8000
Dimensions L*W*H, mm	82*175*190		242*175*190	
Nominal voltage, V	12	12	12	12/24
Starter inrush current, A	240	360	840	720
Output power <sup>2)</sup> , W	1800	2300	4500	8000
Applications	Passenger cars		Light commercial vehicles, SUVs	Trucks, buses

1) Module 12M4500 is equipped with an additional 14 Ah accumulator with automatic heating.

2) The power is ensured at ambient air temperatures between -40°C and +60°C.

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