Test drive

Record-breaking electric car to go the distance with ABB

Frank Griffith, Steve Malpass, John Schofield

Land speed records have always provided an ideal opportunity for testing technology to its limits. For ABB's drives and motors, the forthcoming challenge by a British team on the world electric land speed record will be no exception.

An inverter from ABB's ACS 800 range and two 40-W IP23 through ventilated AC motors will be put to the ultimate test in mid-2004 when they will be used to drive the ABB e=motion electric car to speeds of over 300 mph, well in excess of the top speed of a Formula One racing car.

Producing a combined output of more than 500 bhp, the two motors have already helped propel the electric car to 146 mph during testing. This unofficially broke the 139 mph UK record for the fastest speed traveled by an electric vehicle and equaled the first ever land speed record set by Sir Malcolm Campbell in 1924. The car is due to be transported to Chott-el-Jerid in Tunisia in May 2004, where it will be used by the vehicle's designers, Mark Newby and Colin Fallows, to attempt to set the new world electric land speed record and beat the current world record of 247 mph held by a team from the USA.

Off-the-shelf equipment was preferred

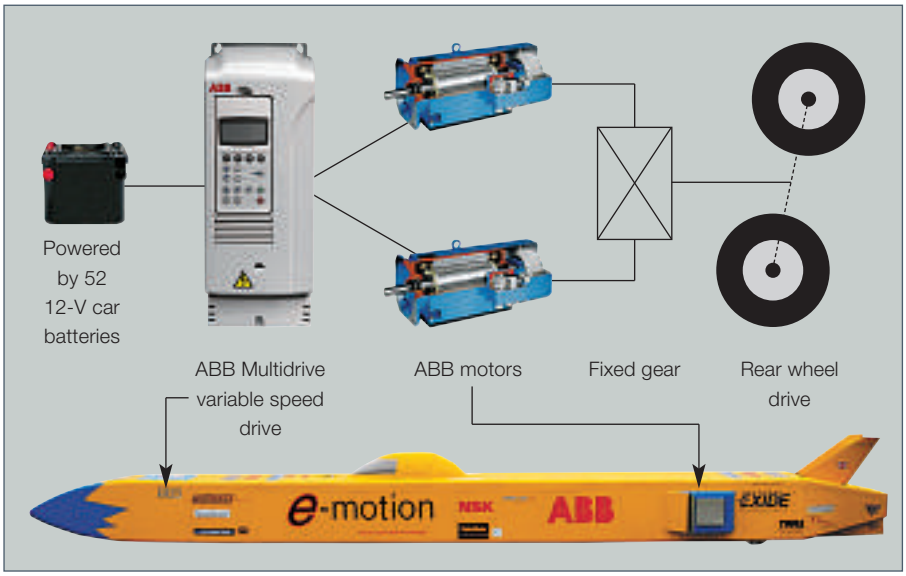
ABB's system uses the drive to convert the 600 V DC output from the car's four packs of lead acid batteries into AC power for the two motors.

When building the car, Newby and Fallows were keen to use only equipment that could be easily sourced off-the-shelf from any supplier, both to help reduce the cost of the project and to add to the prestige of the challenge. Despite this, finding a company that could supply the drives and motors needed to power the car proved a frustrating struggle that would last 18 months.

Before contacting ABB, Newby and Fallows initially approached two of ABB's key competitors, neither of which were able to provide the technology needed to power the car. "Finding a company

that could supply the necessary drive and motor technology to drive the car was the biggest single technical hurdle we faced in building the car," says Mark Newby, the car's driver. "Of the companies we originally approached, none could provide either the technology or expertise that justified a world record attempt of this magnitude."

"In fact, one suggested a water-cooled drive solution which resulted in us extending the nose of the vehicle by some 1.5 meters, at great expense. ABB's solution is extremely compact and means our car does not even need to be the 10 meters that it is!"



Drive system developed for the attempt on the world land speed record for electric cars

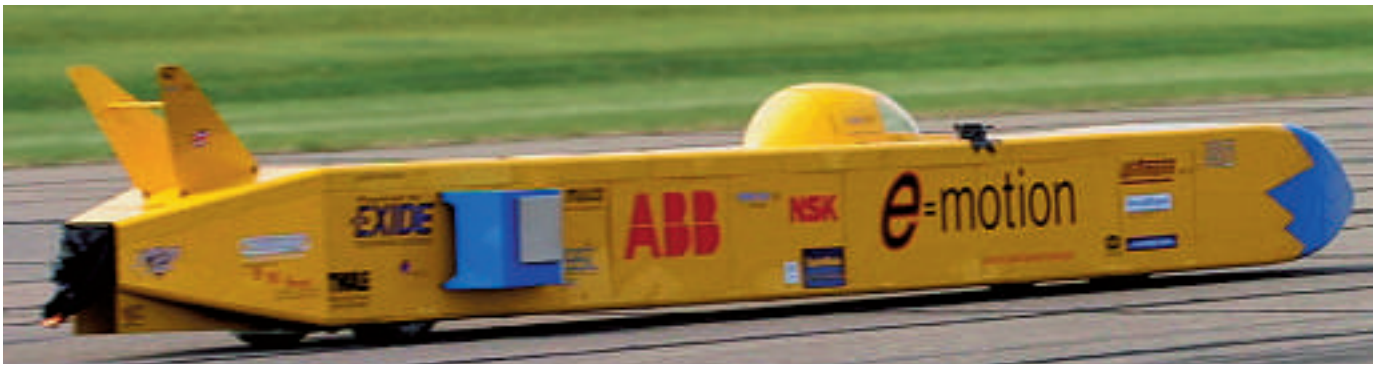
Acceleration is everything

To become the official world record holder, the car must perform two runs at better than 252 mph over a distance of one kilometer, requiring the motors to reach speeds in excess of 6000 rpm. To achieve this, ABB has supplied induction motors capable of operating at speeds of between 5000 and 9000 rpm. Overheating is prevented by adapting each motor to include a force ventilation system with a 24 V DC fan. This will cool the motors and ensure they do not exceed their maximum operating temperature of 180°C. PT100 sensors fitted to each motor winding provide real-time information about the motor operating temperature.

A major consideration in designing the car's drive system was the necessity to be able to accelerate quickly to enable the car to achieve its maximum speed within the permitted distance. Due to the modification of the nose cone and the use of slightly heavier motors, the car was some 150 lb over the original target weight of 3500 lb, a fact that initially caused concern for Newby. "Acceleration is the single most important factor in a land speed record attempt. For this reason, we were concerned about the impact that extra weight could have on the car's performance."

Motors have a high power-to-weight ratio

ABB's drive system combines motors featuring a high power-to-weight ratio with ABB's Direct Torque Control (DTC) drive technology, which provides excellent control of motor torque, with full torque available even at zero speed. The ability of this system to provide the acceleration required was proven during the car's first test run at Bruntingthorpe airfield in Leicestershire, UK. During this test, the car unofficially surpassed the existing British electric land speed



record within one-third of the distance traveled by the official title-holder.

"The car used by the Bluebird team, which holds the current British electric land speed record, reached a top speed of 139 mph over a distance of two miles. In its first-ever test run, ABB e=motion easily reached 147 mph within just 1,000 yards. In fact, the only reason we had to stop the car was because we ran out of road!" says Newby. "With this sort of performance, we're convinced that our car will easily beat the existing world electric land speed record."

Development challenges were overcome

The drive system developed for the car is the work of members of ABB's UK drives application engineering team. The team has worked closely with the ABB e=motion engineers since November 2002. Developing the system involved a number of challenges, including simulation of the vehicle dynamics and performance likely to be experienced during the land speed record attempt.

The drive system had to be developed without the ABB team initially being able to physically test the car on a track. This meant having to model and calculate likely performance based on a set of estimated conditions involving factors such as rolling resistance, drag and battery discharge rate. Much of this information was extrapolated from data found on the Internet. Not only that, but there was only a limited amount of space available for installing the system in the car, so whatever the team came up with also had to be compact.

Fine-tuning for maximum performance

To help fine-tune the performance of the system, ABB is using data from the two independent four-channel data loggers incorporated within the drive. Data from the recorders was statistically processed using multi-variable regression (least squares) to obtain estimated values of inertia and rolling resistance. The figures obtained helped to refine the vehicle model. During tests performed at the Bruntingthorpe airstrip, the data loggers have been extensively used to collect a range of data on drive and motor status, which is uploaded to a PC using ABB's Drives Window tool. As the name suggests, this tool provides a window to the parameters and signals of the drive and allows motor signals to be easily recorded and analyzed. Once in the PC, the car's performance data can be displayed graphically or exported if preferred.

The data loggers allow the performance of the drive system to be improved in much the same way as in Formula One racing. One of the data loggers is set to a rapid sampling rate of 1 sample per millisecond, which records all the actual events as they happen. The other logger, which is set to a slower rate, is used to record information on trends that occur throughout the duration of the tests being carried out, which gives the team an overall picture of how the car is faring.

"We initially approached ABB, via a mutual colleague, because we were aware of its profile in the world of electrical engineering," says Colin Fallows, the designer of the ABB e=motion car. "Throughout the development of the car, we have constantly been able to call upon ABB's vast expertise and have been unbelievably impressed by what its drives application engineering team has come up with. Based on what we've seen so far, we are 100% confident that ABB will be joining us in the record books when we break the world speed record."

Frank Griffith
Steve Malpass
John Schofield
ABB Automation Technologies
Manchester, UK
frank.griffith@gb.abb.com