Popular Scientific Summary
PMSM Diagnostics and Prognostics

Evaluation of an on-line method based on high frequency current response

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Electrical vehicles are becoming more and more popular. But with new technology comes new challenges. One of those challenges is to guarantee that the electrical machine running the electrical or hybrid vehicle runs satisfactory without breaking. In the spirit of this a method to monitor the status of the quality of the electrical machine has been investigated.

Electrical vehicles are becoming more and more popular. The reduced emissions of green house gases that are associated with electrical vehicles are appealing. The fact that an electrical machine has a lot higher efficiency compared to a traditional combustion engine makes the electric vehicle even more likable. An electrical machine typically has an efficiency of over 90 percent while a gasoline engine typically has an efficiency between 25 and 30 percent. These two reasons alone makes the electric vehicle sound like an obvious participant of the sustainable transport solutions of the future. Lots of different companies have now started to develop, for instance,electrical buses. But with new technology, or rather old technology used in a new way, there are of course challenges. A traditional electrical machine used in an industry is generally highly reliable. But when an electric machine is placed inside a vehicle instead of in an industry the electrical machine is faced with new challenges. In an electric vehicle the load conditions are more varied as a result of acceleration and breaking of the vehicle. The temperature and environment that the machine is placed in may also differ much more than the environment surrounding a typical electrical machine in the industry. This puts more stress on the electrical machine in an electric vehicle and increase the wear on it. As this was not enough even more stress is put on the electrical machine in a vehicle compared to in the industry as a consequence of how it is controlled. A traditional machine in the industry is typically connected to the power grid and is thereby run by the smooth, sinusoidal voltage that the grid provides. An electrical machine in a vehicle is instead connected to a power converter that transforms direct current from a battery into alternating current. This is done through fast switching transistors that produce a less smooth voltage that contains voltage spikes and other unwanted disturbances that causes additional stress on the electrical machine. The space and weight that the electrical machine takes up in the vehicle is also wanted to be kept to a minimum and over-sizing the electrical machine "just to be safe" is unacceptable. At the same time an unscheduled breakdown of the vehicle is unacceptable and would result in high economic losses and could possibly be dangerous.

With this in mind it would be nice to be able to monitor the quality or the so called State of Health of the electrical machine. It would be even nicer if this could be done without needing to take the vehicle to a workshop or using any external equipment, so called on-line. In fact, it would be best if the driver did not notice that the electrical machine was being diagnosed at all.

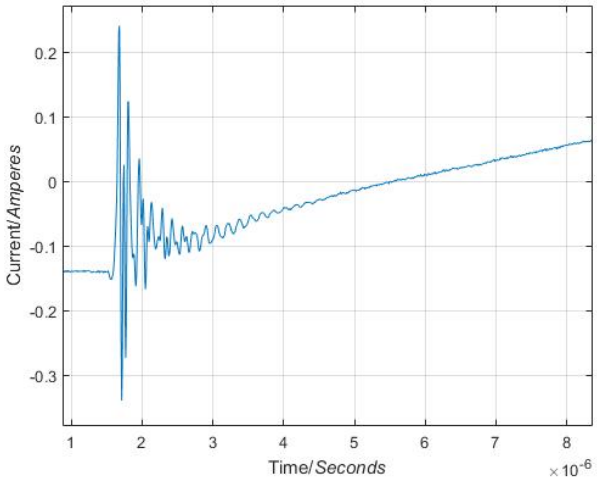

Figure 1: Picture of what the current response can look like. By comparing different measurements such as this one it is possible to draw conclusions of the quality of the electrical machine.

A method to do such a thing is investigated in the project relating to this article. One type of electrical machine that is suitable to use in an electric bus is a so called Permanent Magnetised Synchronous Machine (PMSM). It is electrical machines of this type that has been used during this project.

The method investigated is quite brilliant really. It uses equipment that are already present in an electric vehicle today to diagnose the electrical machine in the the vehicle. The power converter, the device that is used to control the motor so that it rotates and can drive the vehicle forward, is in this method instead used to diagnose the

electrical machine. This is done by, instead of generating a sinusoidal voltage, generate a very short voltage pulse. This voltage pulse will create something called a current response that can be measured. See figure 1.

By measuring this current response and storing it, it can be compared to other earlier measurements and from the difference of these current responses the quality of the electrical machine can be determined. The experiments that have been conducted in this project shows that it it possible to detect small early developing faults this way. However there are some things with the method that should be mentioned. The method requires to be able to measure current at a very high frequency. We are talking megahertz, which is on million times per second. This makes the current sensors already present in electrical vehicles today to slow and thus additional, faster and there by more expensive current sensors needs to be added to the vehicle. It will be interesting to see if the talked about method will be applied in vehicles in the future and if the value of the information about the electrical machines' State of Health is valued higher than the cost of implementing the method in a vehicle.

The report from this master thesis project is found at the publications tab at IEA:s homepage and has the name: CODEN:LUTEDX/(TEIE-5373)/1-65/(2016) - PMSM diagnostics and prognostics - Evaluation of an on-line method based on high frequency current response