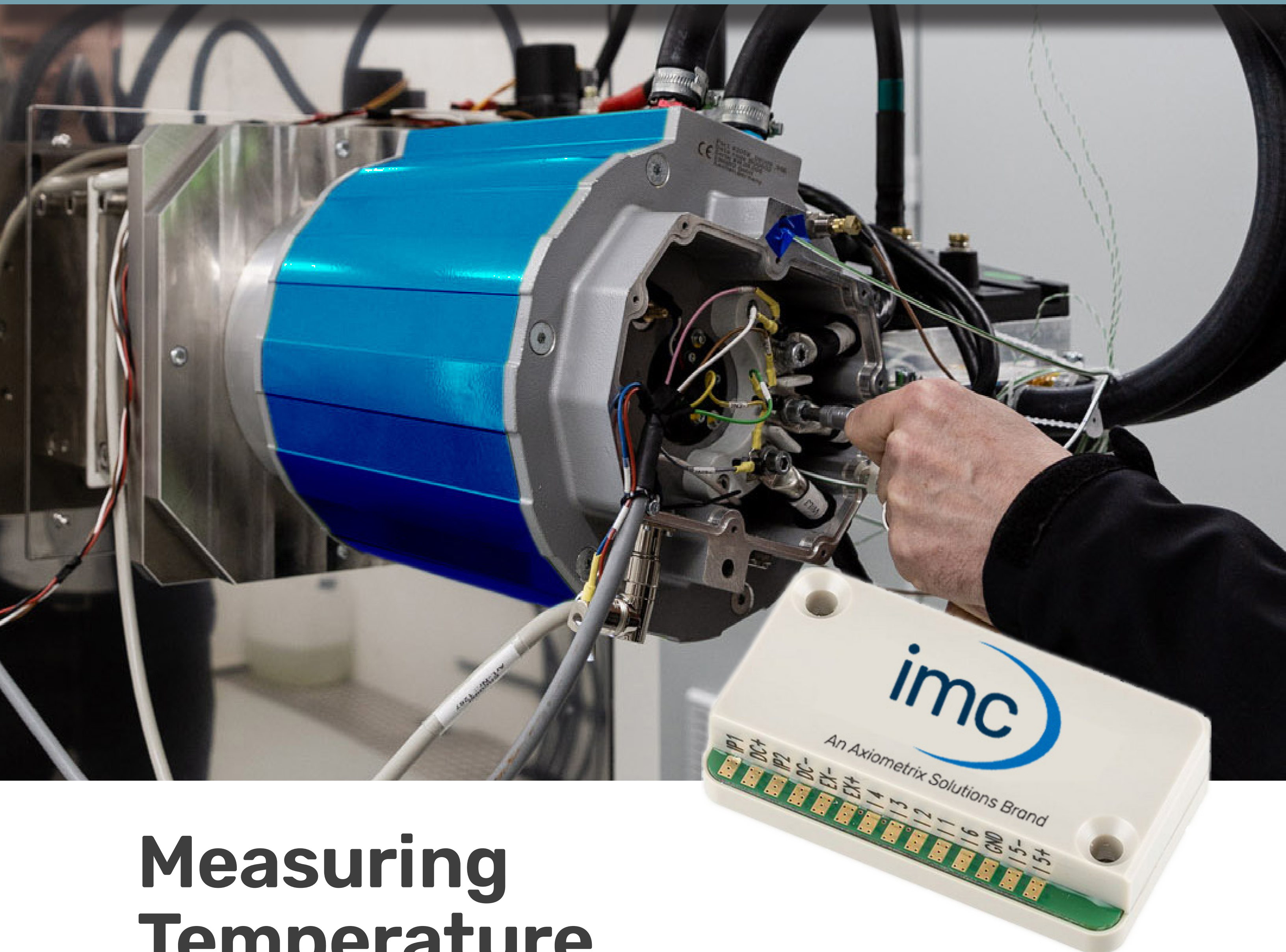

Measuring Temperature in Electric Motor Rotors

Compact and Wireless DAQ for Investigation, Monitoring, and Optimization

imc Test & Measurement
Application Note // By Diego Llopis, Strategic Product Manager Telemetry

APPLICATION NOTE

Introduction

In the domain of contemporary electric vehicles, automotive manufacturers have an array of electric motor types at their disposal. These options encompass both asynchronous and synchronous motors. Interestingly, some manufacturers even adopt a hybrid approach, seamlessly integrating both motor types within a single vehicle. Notably, synchronous motors stand out for their superior efficiency, surpassing their asynchronous counterparts.

Among synchronous electric motors, two types of motors exist: one requires external excitation of the rotor and the second contains a permanent magnet. For a permanent magnet synchronous motor (PMSM) there is no need to power the rotor externally, making it more energy-efficient. In operation, however, currents caused by the motor's operation limit its load capacity or can damage the permanent magnet installed in its rotor. The electrical polarization of the magnets is weakened if the rotor temperature is too high. As soon as a certain threshold value, also known as the Curie temperature, is exceeded, the polarization is completely lost, resulting in motor failure.

Controlling and managing the temperature development in a permanent magnet synchronous motor is therefore a critical factor in ensuring the performance of the motor and improving its efficiency when using it in an electric vehicle.

Measurement challenges on the test bench

To establish a basis for the thermal management of the synchronous motor and to study, monitor, and optimize it, engineers in the electric motor development department of a global automotive supplier needed to record the rotor temperature while running the motor on the test stand. The data acquisition technology used had to be as compact as possible, and had to withstand high temperatures and rotation. Despite the high ambient temperatures and high rotor speeds, precise measurement data was required. To monitor and control the rotor's temperature, the energy flow and the temperature development of the motor was acquired.

A compact, wireless, rugged, versatile and time-tested data acquisition

Rotor temperature recording for electric vehicle motor validation was used on several test benches within the company. Since the measurements are taken on the running rotor, the data acquisition, a wireless telemetry system with an inductive power supply, was mounted directly on the rotor shaft. A universal telemetry data acquisition system such as the imc D^X, which is particularly compact and lightweight, allows measurement data to be acquired on rotating components. In addition to engines, common test objects include rail vehicle wheelsets, vehicle axles, and heavy-duty winches.

FIGURE 1.
imc D^X SCT-Transmitter with 1-6 sensor inputs

In confined measurement environments, such as a test bench, the transmitter unit's small, lightweight housing facilitates adaptation to the test specimen. It measures at speeds up to 20,000 rpm in a temperature range from -40°C to 125°C (-40°F to 257°F) . Digitization of the data and transmission via the CAN field bus ensures constant signal quality, which contributes to the accuracy of the measurement data. The imc D^X telemetry is configured externally via Ethernet so that no settings need to be made on the measurement hardware itself.

Transmission frequencies are available so that multiple telemetry transmitters can be used in parallel in the same environment. Depending on the test environment and the task at hand, the imc D^X telemetry system can record other sensors on the rotating components in addition to the temperatures.

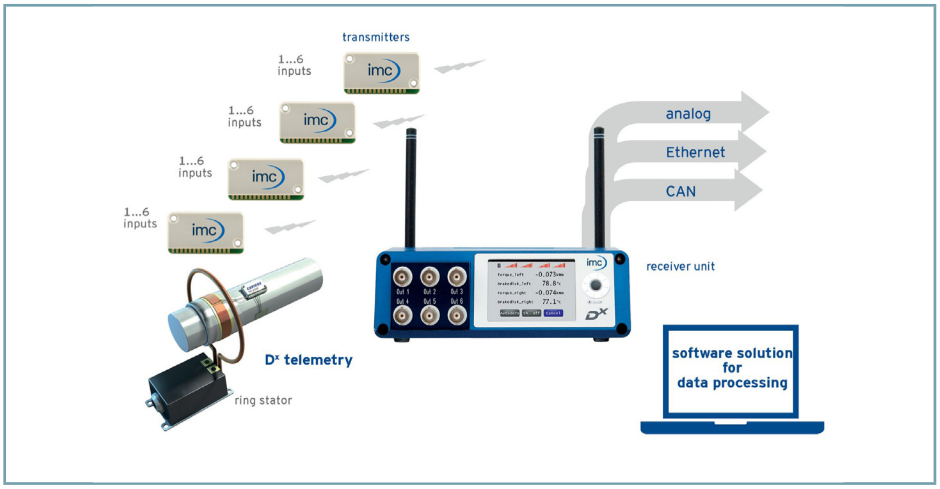

FIGURE 2.
imc D^X DAQ telemetry system with up to four transmitters that can be connected with the receiver.

Advancing electric motor development through innovative data acquisition

On the electric motor test stand, thermocouples were mounted in the rotor and the data acquisition leads routed through the hollow shaft to the transmitter. The transmitter, located on the rotor shaft, was powered by an inductive ring stator. This allowed continuous operation of the data acquisition solution, even in the climatic chamber. Data was transmitted by radio to an external receiver. This provided a data acquisition solution that helped developers to accurately visualize and overcome current challenges in developing electric motors.

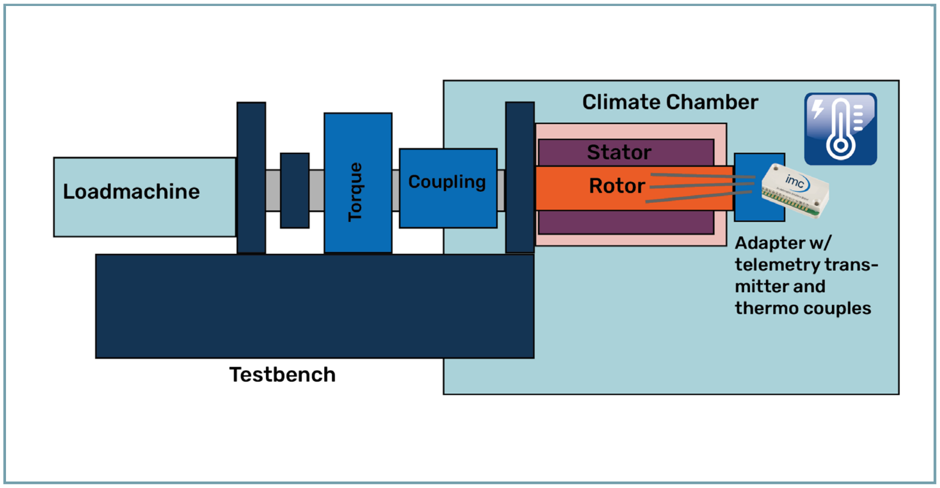

FIGURE 3.
Schematic structure of the test bench

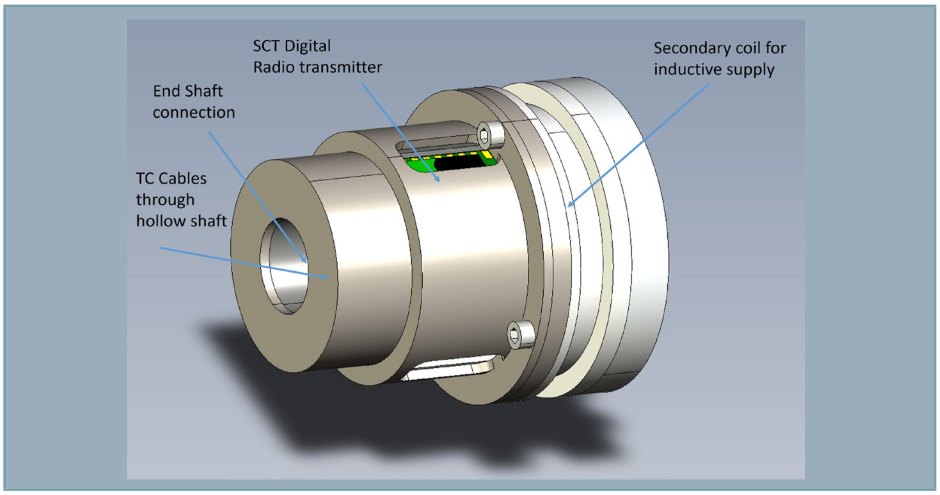

FIGURE 4.
Rotor with imc D^X telemetry transmitter applied

Conclusion and Outlook

Data acquisition is becoming increasingly important as the demand for ever more compact and powerful electric motors raises physical and engineering issues. In the context of thermal management simulation models or test bench testing, high accuracy of measurement data is required. In terms of dat acquisition technology, this can be achieved through compact, adaptable, flexible measurement systems, the use of wireless data transmission technologies, and the use of materials that can withstand harsh environments. The measurement solution discussed can be applied in durability tests, with or without a climatic chamber, and for developing simulation models for engine thermal management. It enables the creation of an engine temperature model that can be integrated into a vehicle's thermal management system. This model helps accurately estimate rotor temperature, ensuring safe vehicle operation across various driving conditions and environments.