Motor Monitor

VEDLIoT
Very Efficient Deep Learning in IoT

An external sensor box for DL-based motor state detection

OVERVIEW

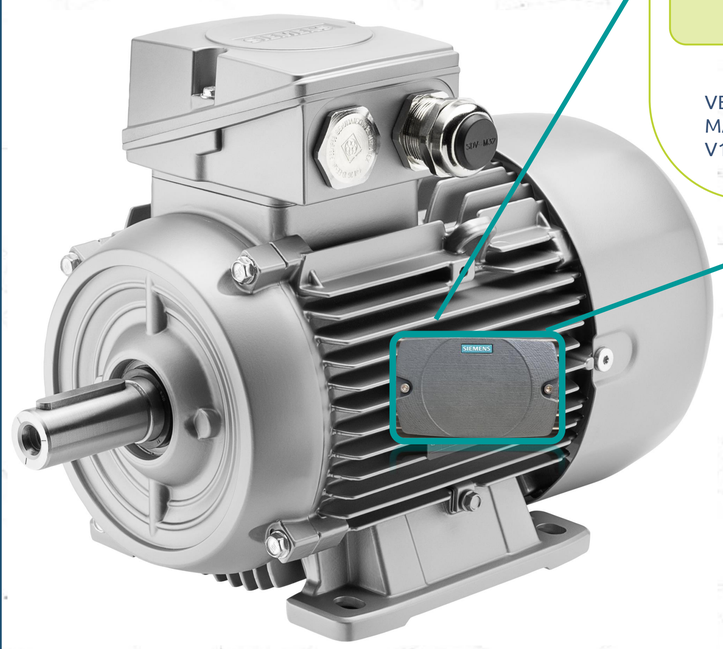
For motors that are directly connected or driven by a soft starter, there is typically no information about the state of the motor available. In this case, an SFD (Smart Field Device, the smallest category of an edge device) can be used to log the hours of operation, the condition of the cooling system, and the mechanical condition of components like the bearings and mountings.

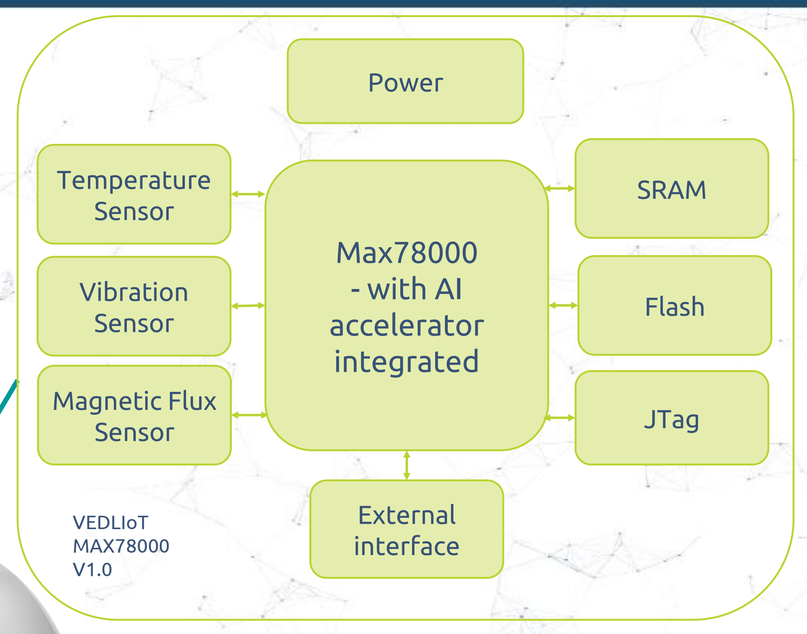
SFDs that collect data and forward them to a cloud system are state of the art. The today's challenge is to get the algorithm and even DL methods ported to the SFDs to reduce the number of wirelessly transmitted data. The distributed computing- and DL-power provides improved adaptability and thus also improved flexibility for the whole system. For the motor condition classification, the raw data can be reduced to three state variables that will give a sufficient overview of the drive systems condition:

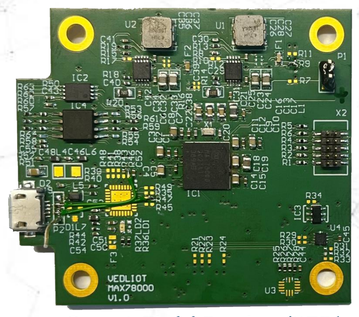
- **Operational state** (e.g. State on, state off, state unknown)
- **Cooling system state** (e.g. State cooling good, state cooling warning, state cooling error, state cooling unknown)
- **Mechanical state** (e.g. State mechanical good, state mechanical warning, state

The useful usage of SFDs for motor condition classification depends highly on the power class of equipped motors. For large drives, the implementation of special monitoring systems is more efficient than SFD. For small drives, even the costs of an SFD are too high compared to the costs of the motor. So, the expected range of targe drives is within an axis height of 150 to 400 mm or a power range of 5kW to 500 kW.

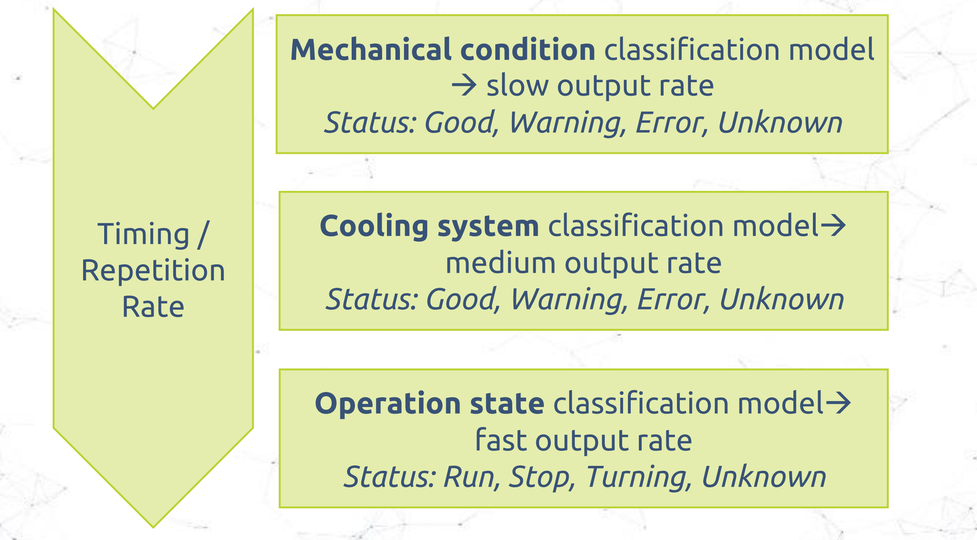
Condition monitoring for direct driven motors. The usual power range of such motors is between 5kW to 500kW



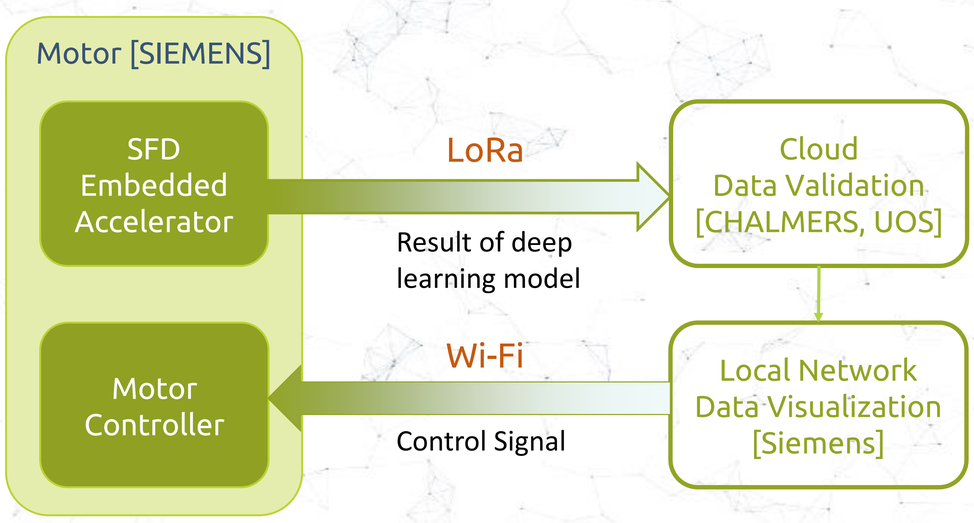




Smart Field Device (SFD) for Vibration, Temperature and Speed Deep Learning Accelerator integrated



Basic DL model concept for motor condition classification



Test setup for DL based motor condition classification

Challenges

State of the art motor condition monitoring is using non-ML algorithm, in combination with sophisticated measurement equipment. The cost efficient ML-based motor condition monitoring system which uses SFD's mounted to the surface of the motor is facing several main challenges in the field of training and validation data generation and labelling and also in the field of energy efficiency.

Huge variety of states for training

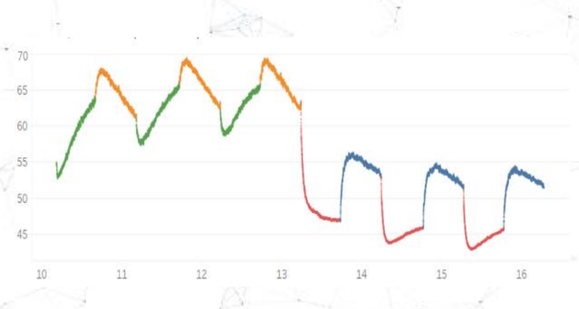
Training data for the cooling condition classification must be recorded with respect to error types like loose or broken fan blades and blocked or jammed air inlet.

For the mechanical condition classification error types like lose machine basement, lose or broken bolts, misalignment, broken or cracked housing, unlubricated, strained or damaged bearing must be considered, to name just a few.

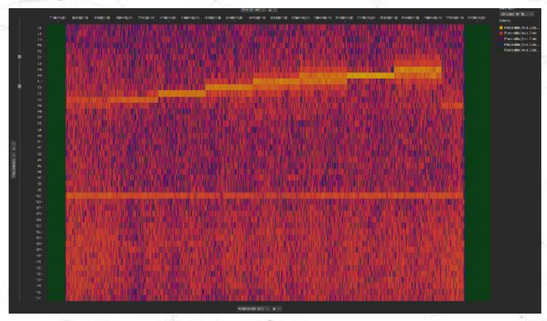
Energy efficiency

A battery powered SFD with a battery lifetime of about two years is challenging anyhow. When adding additional DL capabilities, like software-based solutions on the microcontroller or also hardware based with attached DL accelerator modules, makes the topic energy efficiency even more challenging.

These long battery lifetimes can only be reached when implementing low power operation state (sleep-mode), that is active for most of the time, in combination with short and rare scheduled algorithm slots that will be managed by a sophisticated power manager



Example of data for the motor use case



Spectrogram of the running motor, amplitudes of the frequencies of acceleration data over time

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