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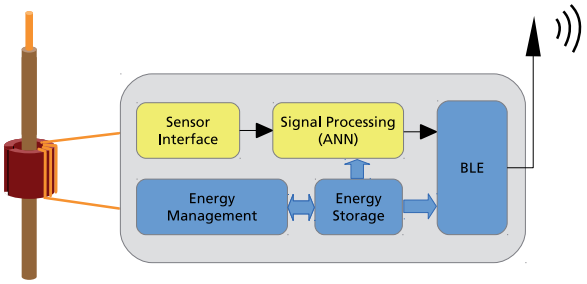

1 *Industry 4.0 retrofitting application*
2 *Schematic sketch of the wireless current sensor*

WIRELESS CURRENT SENSOR FOR CONDITION MONITORING

An efficient production and avoidance of production losses are two of the goals of a "Smart Factory". This can be achieved by a minimization of energy costs and an optimization of production processes, for example. In order to avoid unexpected production losses predictive maintenance is of interest. These goals are addressed in well known "Industry 4.0" concepts in where networking of all manufacturing components across hierarchical levels is the key technology, also called „Industrial Internet of Things". Thereby numerous sensing data are required in order to get detailed information about every component. But the installation of hundreds of sensors and their related cables is a considerable effort. Especially in existing machineries this presents an insurmountable challenge. Often older machines do not have open interfaces or sensors cannot be installed. For example, cutting machines have a typical life expectancy of 30 years. It can be estimated that the machinery park in today's manufacturing industry in Germany is typically 15 years old. An exchange by new networkable machines would be absolutely uneconomic. For this reasons an easy retrofit solution to monitor existing machinery and equipment is of great interest.

In many applications the current power consumption of a machine gives detailed information about its operation mode, energy efficiency and maintenance demand based on wearing or damages. Therefore the measurement and evaluation of the supply current is a valuable approach and can replace many other sensors.
For these applications Fraunhofer IMS has developed a smart sensor solution that meets the requirements discussed above:

- wireless and energy self-sufficient operation for easy retrofitting
- measurement of the supply current of a facility
- smart signal processing for condition monitoring

Energy self-sufficiency by means of energy harvesting prevents maintenance effort.

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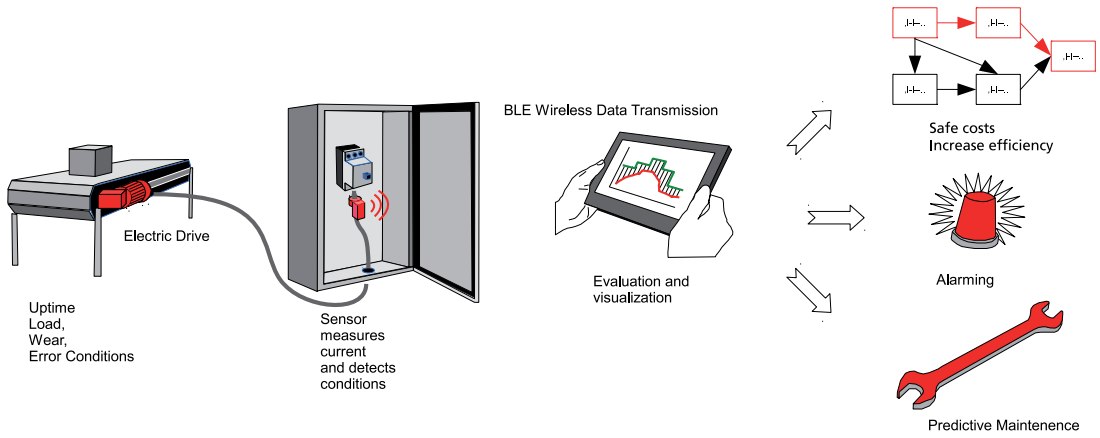

And smart data processing enables deduction of high number of single sensors. The determination of mechanical and electrical conditions can be done by the analysis of the supply current. Switching states of control elements, torque on electric motors leads to characteristic supply currents. By measuring the supply current and doing suitable signal processing the mechanical state can be determined.

Wireless Operation

Wireless operation of sensors avoids cabling and enables easy retrofitting. Several wireless standards are appropriate to be used. A low power implementation is most important due to the energy self-sufficient operation. The best choice depends on individual requirements.

Energy Harvesting

In order to realize an energy self-sufficient operation an inductive harvester gains energy from the magnetic stray field around the enclosed conductor. An extremely low power design of the sensor electronics (microcontroller, sensor interface and wireless frontend) is crucial.

Signal Processing

The detailed course of the supply current is evaluated by means of artificial intelligence in order to make a classification of the sensor signals in order to determine machine states. An artificial neural network (ANN) including the related learning algorithm is implemented as an integral part of the microcontroller software.

Features

- Non-invasive installation - no power interruption
- Easy installation - clip around the conductor
- Wireless - no cabling needed
- Maintenance-free - thanks to energy harvesting
- Smart - near-sensor signal processing

System Properties of the demonstrator

- Energy harvesting range (conductor current): 1 A … 32 A
- Wireless communication: Bluetooth Low Energy (BLE)
- Current measurement: inductive, by current transformer (same as for harvesting)
- Current measurement range: 1 A … 32 A
- Signal processing based on artificial neural network (ANN) technology integrated in the microcontroller software

Smart Factory Applications

- Process optimization
- Utilization determination
- Quality monitoring
- Energy monitoring
- Peak load management
- Costs per single quantity determination
- Condition monitoring

Smart Home Applications

- Digitization of existing machinery
- Integration into Industrial Internet of Things
- Energy monitoring
- Appliance monitoring