Monitoring of selected environment parameters in collaborative manufacturing workplace

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Abstract The goal of the paper is to design an industrial monitoring system focused on sensing production environment parameters based on network of IO-Link components. The networked devices fulfill a real-time data acquisition and alerting task. The system consists of the main central monitoring system with different remote communication options. The core of the system is a central data collecting and processing unit. This unit gathers data from various sensors. Then the collected data is processed and in case of critical states or fulfilled requirements alarms are triggered. The central unit also acts as a smart gateway with multiple channel available to transfer data. The sensors are configured and organized through IO-Link interface. Visualization of the actual data and graphical trend of the monitored parameters is created in Grafana environment.

Keywords industrial automation, environment monitoring, iiot

1. INTRODUCTION

The modern advancements in the field of industrial automation and communication technologies create possibilities for small manufacturing enterprises to keep up with bigger and new producers abroad. By applying additional sensor technologies is possible to increase the insight of their ongoing production and processes. In many cases the enterprises use older technologies without communication capabilities or self-diagnostic functions.

Maintenance operations are established on waiting for hazardous, sometimes destructive situations where the devices stop to produce or break-down for short- or long downtime. These situations lead to excessive costs and low competitiveness for small enterprises.

A significant improvement overall, not only in maintenance questions is the implementation of reliable modern IIOT systems which are able to work independently of the actual production. With monitoring the most vital parts of the manufacturing process a higher productivity and seamless maintenance becomes possible. [1]

This paper focuses on industrial environmental data possibilities based on IO-Link system. The paper aims to propose the configuration and testing of sensor and the visualization of the acquired data with a goal to improve the insight of manufacturing environment. [1-3]

The example manufacturing environment is a material handling workplace based on collaborative robot application. This workplace consists of multiple mechanical and electrical subsystems, with combination of human workforce. In such environments several factors can influence the desired quality of the product or process. (Fig.1)

In the current configuration the system consists of a conveyor line and a robot with pneumatic end effector. While the robot has properties of collaborative work, its incapable to collect real time data about its environment without additional equipment. [1-4, 10]

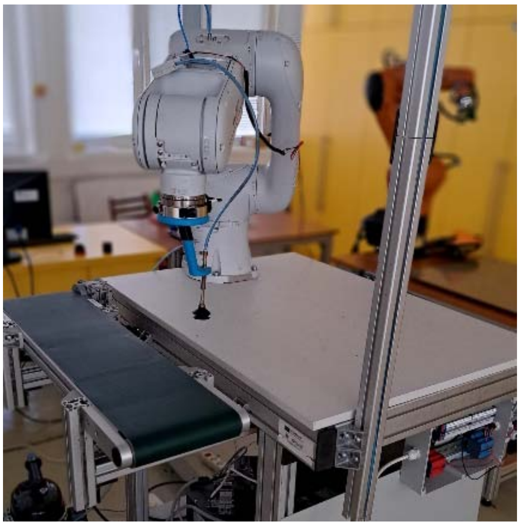

Fig. 1 Collaborative manufacturing system at Laboratory of Automation

The goal of the proposed system is to setup and test a environment monitoring system which can indicate a malfunction or extraordinary situation on the workplace.

2. MONITORING METHODOLOGY

The measurement of manufacturing environment parameters and alerting system combines both hardware and software tools. The hardware part usually consists of one or more control units that are connected to sensors. The control unit works with the configuration data within the systems limitations. The sensor signal is acquired via IO-Link network and interfaces. (Fig.2)

The software part ensures that the sensors are correctly configured, and that the central unit process their data in the desired way. Also, the visualization of the processed signals is conducted by this subsystem. The network architecture includes the main unit and the sensors while the connection to other control devices such PLCs, or robot controllers is possible, but their malfunction or failure does not affect the whole monitoring system.

The sensor data describes the lowest level in the information channel. With the current advances of smart sensor technologies, the sensors represent an additional layer of intelligence because of the self-check functionalities.

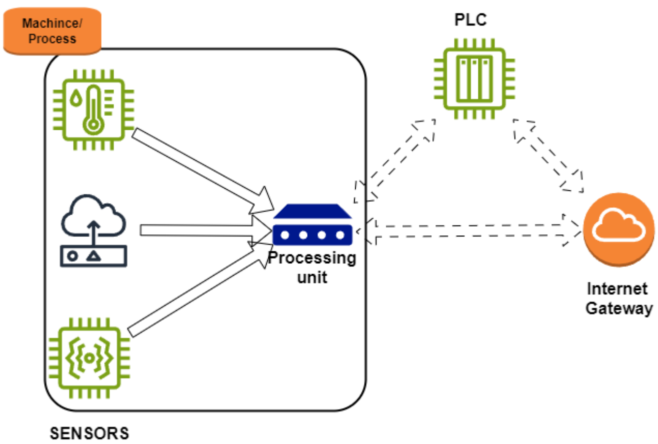

Fig. 2 IO-Link network principle

3. HARDWARE

The testing setup consists of central unit and two IO-Link based sensors capable of monitoring environmental parameters. This setup is powered by a standard industrial power supply with 24 VDC. The following subchapters include brief introduction on the hardware parts.

3.1 Central unit

The central unit for the data acquisition, processing and visualization is the BAV002N Balluff central unit. This central unit consists of processing and communication capabilities. The main technical parameters include:

- 2 x separately programmable – Ethernet based network interfaces
- 4 x IO- Link Interfaces
- MQTT
- OPC UA
- Node Red
- Memory Card – for data storing

3.2 Sensors

The first sensor is the Balluff condition monitoring sensor BCM R15E-002. With its technical solution it combines in one body multiple subsystems internally. The complex build allows programmable configuration and reduced energy consumption. The main measurable parameters include (Tab.1):

- Vibration Velocity
- Vibration Acceleration
- Vibration Severity Zone
- Contact Temperature
- Relative Humidity
- Ambient Pressure
- Sensor Self-Awareness

Parameter	Value
Vibration acceleration, measuring range RMS	0…16 g
Relative humidity, measuring range	5...95 %rF
Vibration, frequency range	2...3200 Hz
Vibration velocity, measuring range RMS	0…220 mm/s @79.4 Hz
Contact temperature, measuring range	0…70 °C
Ambient pressure, measuring range	300…1100 hPa

Tab. 1 Technical parameters BCM R15E 002

Based on the measured values statistical parameters are generated i.e. speed, acceleration, RMS, Peak-to-Peak. [7,8]

The sensor has a standardized M12 (3-Pin) industrial sensor interface, which allows connection to other IO-Link interfaces or devices.

The configuration of the sensor is possible via multiple methods:

- USB: IO-Link configurator programming
- IO-Link master and PLC configuration
- Webserver configuration via IO-Link Master devices.

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The second sensor for data acquisition is SMC IZD10-510 a sensor designed for electrostatic potential measurements.

The main technical parameters are listed below(Tab.2):

Parameter	Value
Potential measurement	±20 kV (Detected at a 50 mm distance)
Output voltage	1 to 5 V (Output impedance: Approx. 100 Ω)
Effective detection distance	25 to 75 mm
Linearity	±5% F.S. (0 to 50°C, at detection distance: 50 mm)

Tab. 2 Technical parameters IZD10-510

Additionally, a sensor monitor was connected to the sensor. This device is suitable to monitor the current value from the sensor and also transfers the measurement forward. Because of the continuous signal an external ADC IO-Link converter was integrated to this channel of data. This converter transforms the analog input (0…20 mA) to IO-Link message at 14 bits of resolution. The described sensor is shown on the following figure. [6] (Fig. 3)

Fig. 3 SMC IZD10-510 with signal monitor and signal converter

4. CONFIGURATION OF SENSORS BASED ON IO-LINK

The configuration process is divided into 2 base steps. The first is focused on the configuration of the central unit, while the second aims to set up the sensors for correct parameters.

In the following subchapter the first step will be described.

4.1 Central unit configuration

To connect to the central unit configuration window the integrated webserver is available. For the beginning an accessible network address is needed. This has to be set up for the device and/ or for the network adapter of the programming PC. [7,8]

If the sensor is physically connected and we use the IP address of the device, we enter the configuration interface. This is show on figure bellow (Fig.4)

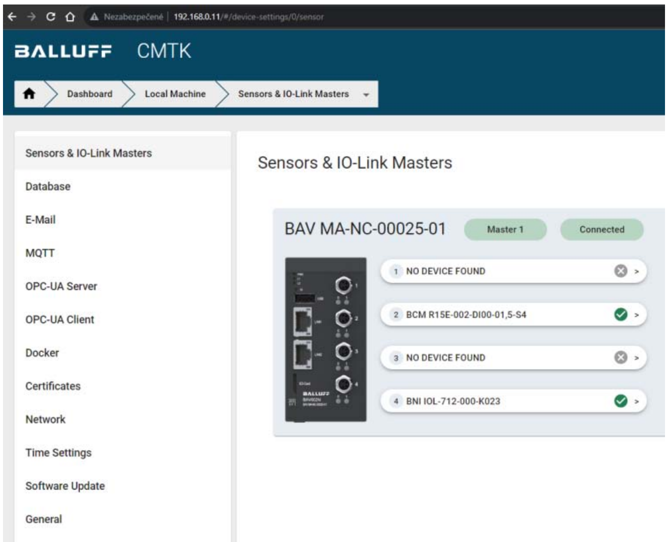

Fig. 4 Online view of correct network configuration

The configuration options include tasks with the sensors, communication channels, network configuration, firmware operation, database manipulation. For basic use, the initialization data satisfies the needs for startup.

While most of the connected sensors are automatically identified some special or foreign (non-Balluff) sensors need additional configuration data. This is called IODD or IO Device Description file. The purpose is to describe sensors and actuators with IO-Link communication interface. This data structure contains information about the device itself, vendor, process data and diagnosis data. This structure is standardized and commonly used for all the IO-Link devices. Some of the IO-Link master devices and configuration tools process IODD file to understand the new unknown devices.

4.2 Sensors configuration

The sensor configuration is possible if the central unit or master recognizes the connected periphery. In some cases, the IODD file has to be uploaded to the supervisor device or replaced for additional options of sensors. The basic view on the configuration option of the sensor is shown on the following figure. (Fig.5)

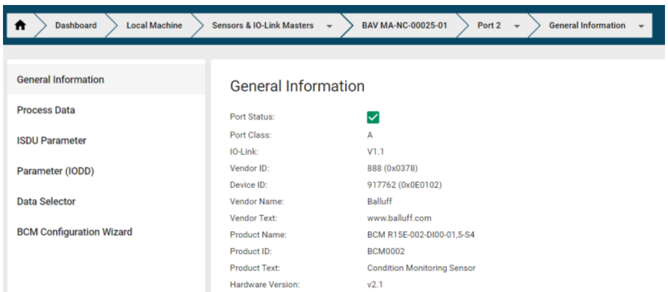

Fig. 5 Configuration window of a sensor

The data structure is based on reading and writing to indexes and subindexes inside the device.

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These are parametrizable also by USB configuration tools and software or also by a connected industrial programmable logic controller (PLC).

Example view on part of the observable and editable IODD data for the BCM sensor is shown below (Fig. 6)

In this example the actual temperature parameters and the statistical data of the historical temperature measurement is figured.

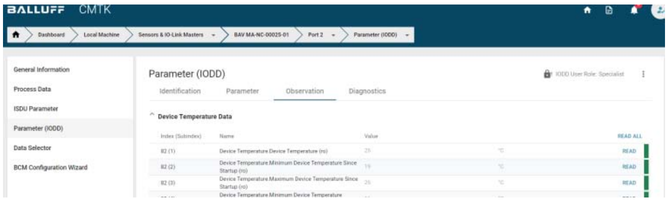

Fig. 6 View on parameters of IO-Link interface

Based on the captured values, the calculated values, the historical and threshold limitations its possible to implement or generate various cautions, warning and alarm variables that informs the technicians, maintenance workers about the ongoing extraordinary situation.

4.3 Monitoring

For data monitoring purposes the following monitoring window was developed (Fig. 7)

Fig. 3 View on the Visualization window

The monitoring window is based on Grafana software tool, that is connected to the Influx DB database system. The starting version of the visualization is automatically generated based on the connected sensors. After the startup, the graphical objects are configurable and programmable for not only direct data visualization, but also for calculating different logical evaluations and generating alerts for critical values. There are additional options for user management and data sharing via these tools. Additionally, the gathered data is available for further transfer via multiple communication interfaces i.e. MQTT, OPC UA and Node Red.

5. CONCLUSION

The aim of the article was to present the IO-Link smart sensor-based method of production environment monitoring. The presented sensor tools are designed for a collaborative workplace with industrial collaborative robot. While the robot is uncapable in current configuration to sense and react on its environmental parameters or their change, with the presented system it's possible to acquire information on the desired part of the manipulation process. The described sensor provides measurements in the field of contact vibration analysis, surface temperature, ambient pressure, electrostatic charge. The basics of central control unit and options of sensor configuration is also included. For further data processing and visualization, a monitoring tool is designed. In this view its possible to graphically visualize historical data, calculate logical and mathematical equations and functionalities. Lastly the presented work offers an example solution and base scenario for similar tasks for various fields of industrial production systems.

The future options for the presented approach will be oriented on the area of moving object in similar scenario with focus on integration multiple similar sensors to the full ongoing collaborative process.

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