EN

# WHITEPAPER

## ENERGY MONITORING AND PRODUCTION /PROCESS DATA ACQUISITION

Authors: Dipl.-Ing. Christian Fiebach
Chief Executive Manager ipf electronic gmbh

Giuseppe Vinci
Product Management Process Data Acquisition

IPF ELECTRONIC

# TABLE OF CONTENT

## *1 INTRODUCTION*

Thanks to the rapid advances in the field of digitalization, data-based decisions can now be increasingly made for the organization and execution of production in many different industrial sectors. Data-supported information ensures greater transparency at all levels of the company and, with targeted decisions, noticeably increases productivity while simultaneously improving production quality. Added to this is greater efficiency thanks to sustainable cost savings through the more effective use of energy and operating resources.

Against this backdrop, it is all the more surprising that many companies still only record their production and process data incompletely or not at all and therefore do not have an overview of their actual capacity utilization, among other things. This can repeatedly lead, for example, to production bottlenecks due to inaccurately calculated production resources or even production stoppages due to raw materials not being available in time or unforeseen machine breakdowns- with significant negative effects on order processing and delivery times.

***What are the most important production/process data that an industrial company should record?***

- Energy consumption data from machines, systems, processes and compressed airsystems
- Machine data such as capacity utilization, running times, availability, etc.
  (Most important key figures for overall equipment effectiveness- OEE)
- Production figures such as production quantities, unit numbers, throughput, etc.
- Quality data such as the number of IO and NOK parts, other scrap data, etc.
- Materials used, e.g. data on raw materials, semi-finished and finished parts, etc.
  as well as the consumption of operating materials such as coolants and lubricants, etc.
- Scheduling and delivery times

***Various technologies are available for recording production data in this context, e.g:***

- Manual recording with digital end devices such as tablets, terminals, etc.
- Production data acquisition (PDA data, material flow) and machine data acquisition
  (MDE- cycle times, machine statuses)
- Manufacturing Execution Systems (MES)- bundling of production data e.g.
  from machines, but also from other sources
- IIoT platforms for collecting, visualizing and evaluating data
- Sensors and machine interfaces

## *2 VALUABLE DATA EVEN FROM OLD SYSTEMS WITHOUT COSTLY CONVERSIONS*

Many companies shy away from the immense effort required to set up a system for production/process data acquisition by combining the above-mentioned technologies. In addition, some are under the misconception that such a system can only be implemented with comparatively new production facilities that have the appropriate „intelligence“ for production/process data acquisition via control (unit) systems and network interfaces, for example. In this context, the issue of retrofitting old systems plays a decisive role.
Whatever the initial situation may be, it is certainly usually completely illusory, straight away, to implement an end-to-end solution that takes into account all the aspects mentioned and is also practicable.



**ipf electronic gmbh** | Tel +49 2351 9365-0 | info@ipf-electronic.com • **www.ipf-electronic.com**

Instead, as a first decisive step, the objective should be to use the recorded production/process data to calculate the actual capacity utilization in order to identify the main reasons for wasting energy, time and materials. Valid decisions can then be made to sustainably change the situation and eliminate the potential weak points.

Another argument for this approach that should not be underestimated is that the majority of the technologies presented below can also be used to modernize old systems as part of a retrofit in order to make them „fit“ for digitalization. In this respect, it is not just reserved for modern systems with existing control (unit) and network architecture to provide valuable data, e.g. on production volumes, machine utilization, processing times, energy consumption and specific process parameters, which ultimately significantly increase the transparency of production and therefore offer tangible benefits on many levels.

This whitepaper uses a system solution from ipf electronic to show how a scalable solution for production/process data acquisition can be set up at any time using the three technologies already mentioned above (IIoT platforms as well as sensor technology and machine interfaces, if available) without costly conversions and high initial investments. To emphasize this once again: For legacy systems, a system controller is not necessarily required to realize this objective in order to be able to record and evaluate data.

For the first decisive measures, the direct machine environment is recommended because, as already described above, a great deal of valuable data is collected there, including on energy consumption, the consumption of operating and auxiliary materials, machine utilization and, in particular, the part counting produced, including possible reject rates.

### *2.1 STRAIGHT DATA COLLECTION WITH IIOT PLATFORM*

A basic requirement for straightforward data acquisition of production/process data is first of all a solution with which the desired information and data can be brought together, visualized and easily analysed.
With the **BY000002**, ipf electronic offers a powerful IIoT gateway as a manufacturer-independent platform that is not only highly compatible with all hardware and IT systems currently available on the market, but is also free of costly software licenses or possible update costs in the basic version, as the solution is based on long-established open source applications and freeware.
The **BY000002** has up to 4 inputs for analog sensors and 6 programmable I/Os for the direct connection of digital sensors, provides interfaces such as 100MbE/GbE, CAN, RS485, USB2.0 Host and USB2.0 Device and supports numerous protocols such as Modbus, CAN, MQTT, HTTP, Cloud of Things, OPC U/A and DB/SQL.

The straightforward components of the IIoT gateway with a fast ARM processor and large ring memory for continuous data acquisition include a Linux-based operating system „onboard“ and proven web clients that can be accessed via any standard browser to process the data, which can be visualized using individually configurable dashboards, among other things.

As the introduction of new technologies is often associated with many questions,
ipf electronic offers various service packages for the initial installation of the IIoT gateway and customized configuration of the web clients as initial support. In this context, it is also possible to check, for example, which retrofit measures are possible and sensible for old systems.

### *2.2 MEASUREMENT OF ENERGY CONSUMPTION AND $CO_2$ FOOTPRINT*

Extremely volatile energy prices are increasingly increasing the cost pressure on companies. Anyone who not only wants to hope for more favorable long-term supply contracts in this area, but also wants to reduce energy costs independently and sustainably, needs to be


**ipf electronic gmbh** | Tel +49 2351 9365-0 | info@ipf-electronic.com • **www.ipf-electronic.com**

aware of which machines, systems and processes are responsible for particularly high consumption. This is where the use of the IIoT gateway **BY000002** in combination with the energy measurement module **AB000008** and suitable current transformers for mounting on a round conductor or busbar (e.g. the NZ series with measuring ranges between 30A and 600A) from ipf electronic comes in handy right from the start.


The IIoT gateway (center) **BY000002** as well as the energy measurement module AB000008 (top right) and the I/O module **AB000009** (bottom right) make it easy to get started with energy monitoring and production/process data acquisition * (all images: ipf electronic gmbh).

The **AB000008** energy measurement module is used in conjunction with the current transformers for the continuous measurement and evaluation of energy consumption in 1-phase and 3-phase networks. The primary task of the **AB000008** is to determine e.g. the active, reactive and apparent power or data such as the effective values for current and voltage from the individual measurements. As many industrial machines have a three-phase three-phase supply and the phases can be switched due to the consumers connected to them. (e.g. control unit, drive, transformer, etc.) are usually loaded asymmetrically, a separate current transformer is required for each phase to record the exact total current consumption of a machine. All current transformers are ultimately connected to the **AB000008** energy measurement module, which in turn is coupled to the **BY000002** IIoT gateway via Ethernet or backplane bus.
If required, the system can also be integrated into a network via LAN, WLAN or LTE or connected to higher-level systems via numerous software interfaces.

Incidentally, the gateway is not necessarily required to use the **AB000008** energy measurement module together with the current transformers, as the module has its own operating system and works with the dashboard visualization solution that is already part of the gateway's basic equipment as freeware, among other things.

### *2.3 ENERGY MONITORING FOR COMPRESSED AIR GENERATION*

Another highly interesting area of application for the gateway, energy measurement module and current transformers from ipf electronic is the measurement of current consumption in compressors used to generate compressed air. After all, an average of 14 percent of industrial electricity consumption in Germany is required for the generation of compressed air, with leakages in compressed air networks alone being responsible for energy losses of up to 40 percent.
Installing the devices on a compressed air system is as simple as installing a machine. The current transformer is installed on the compressor supply line and is connected to the energy measurement module connected to the gateway for processing and evaluating the measured values.

NZ series current transformers are used in combination with the **BY000002** gateway and the **AB000008** energy measurement module.

In addition to the measured values of the current transformers on the compressor, the gateway can process a wide range of sensor signals for compressed air monitoring and consumption measurement. In addition to the solutions described above, ipf electronic therefore offers a very broad portfolio of sensor solutions for these tasks, from pressure and temperature sensors, via parameterizable flow sensors and differential pressure sensors, to devices for locating leaks, etc. in compressed air networks. All solutions have the primary task of consistently ensuring the faultless operation of a compressed air system and identifying potential for saving compressed air and the energy required for this by recording and evaluating measured values (**see chapter 3.1**).
Measurements of the electricity consumption of machines, systems and compressors can ultimately also be used to determine the carbon footprint of a production facility more precisely, which is becoming increasingly important in view of the Corporate Sustainability Reporting Directive (CSRD), which will be mandatory under the EU directive from 2028.


**ipf electronic gmbh** | Tel +49 2351 9365-0 | info@ipf-electronic.com • **www.ipf-electronic.com**

### *2.4 FLEXIBLE SYSTEM SCALING WITH I/O MODULE*

In addition to the hardware-based system solution, ipf electronic provides the **AB000009** I/O module for flexible scaling. The compact module is connected to the IIoT gateway **BY000002** via a backplane bus connection. This further increases the number of device interfaces (inputs: 12 x digital, 6 x analog, outputs: 6 x digital, 2 x analog) if the I/Os of the gateway are not sufficient. As up to 10 I/O modules can be connected to one gateway, nothing stands in the way of scaling your own production/process data acquisition as required.

In addition, the **AB000009** is able to work as a stand-alone device and „data collector“ if a system for signal processing and visualization is already in place.


The I/O module **AB000009** increases the number of inputs and outputs if the I/Os of the gateway are not sufficient.

### *2.5 VISUALIZATION AND EVALUATION WITH PROVEN APPS*

The solutions described so far are rounded off by versatile and powerful apps.
A pre-installed solution on the IIoT gateway is based on freeware and is used to visualize all measured values on a clear, dynamic dashboard. The dashboard can be individually configured in a variety of ways and offers numerous display options (e.g. speedometer, bar charts, curve charts, heat maps, histograms, etc.). In addition, there is a simple selection of individual detailed views with higher resolution of individual displays and, if required, fast automatic alerts, e.g. based on rules, conditions or threshold values. Simple data transfer, for example via email or messenger services, and efficient teamwork without media disruptions via a platform-independent VNC connection have also been considered.

The dashboard for the freeware offers a variety of display options.

A further, optionally available app is an extremely powerful tool for continuously monitoring the productivity and downtimes of systems.
It is well known that high availability of machines and systems is essential e.g. for high productivity, for the optimal use of all production capacities and for simple planning and implementation of the entire production organization, to name just a few arguments. It is also undisputed that the recording of runtimes, capacity utilization and plant availability, for example, not only provides the most important key figures for overall equipment effectiveness (OEE), but also makes a decisive contribution to greater transparency in production.
Via the additional app for the IIoT gateway, all systems and processes can be monitored and the most important information visualized and processed. This makes it possible, among other things, to react to production bottlenecks or even production downtimes at an early stage and to inform all those responsible via the most important machine statuses without unnecessary time delays.
In addition to displaying the productivity of a system, the app can also show the number of units produced if required. Another extremely useful feature is, for example, the selection of predefined reasons for certain system statuses, e.g. maintenance, break, repair, etc. The app also offers a wide range of analysis functions for various system statuses. The display of the app can also be individually configured with flexibly selectable system parameters and viewing periods.

Another optional app for the IIoT gateway is an extremely powerful tool for continuously monitoring the productivity and downtimes of systems.

### *3 SUSTAINABLE COST REDUCTION THROUGH TARGETED USE OF SENSORS*

As previously mentioned, ipf electronic has a very large selection of high-performance sensors to complement the IIoT gateway and the energy measurement module and I/O module (**AB000008**, **AB000009**). These are not only intended for compressed air monitoring and consumption measurement, but can be used in all conceivable areas of production. An overview of the main functions and features is provided below.

### *3.1 COMPRESSED AIR NETWORK: MEASUREMENT OF FLOW, QUALITY AND PRESSURE PROFILE*

Chapter 2.3 has already described how the current consumption of a compressor for compressed air generation can be recorded using the IIoT gateway **BY000002**, the energy measurement module **AB000008** and the current transformers (NZ series) from ipf electronic. In addition, ipf electronic provides a wide range of sensor solutions for flow and consumption measurements in compressed air networks, some of which are presented here.

#### *3.1.1 FLOW AND CONSUMPTION MEASUREMENTS*

Using parameterizable flow sensors (which can be found in the Internet product selector on the ipf electronic homepage under „Compressed air and gas consumption measurement"), the IIoT gateway makes it possible to measure consumption at several relevant points in a compressed air network and use the measurement results to determine whether there are leaks in the network, among other things. As with the other solutions presented, all the sensor data collected converges in the gateway for visualization and analysis.

Technologies from ipf electronic offer a wide range of options for use in compressed air networks: IIoT gateway and current measurement module (1), current transformer on the compressor supply line (2), dew point sensor downstream of an absorption dryer (3), differential pressure sensor on the filtration (4), pressure transmitter downstream of the pressure accumulator (5), puncture sensor in the main line upstream of the compressed air distribution (6) and flow sensors with integrated measuring section in the individual supply lines to the compressed air distribution (7).

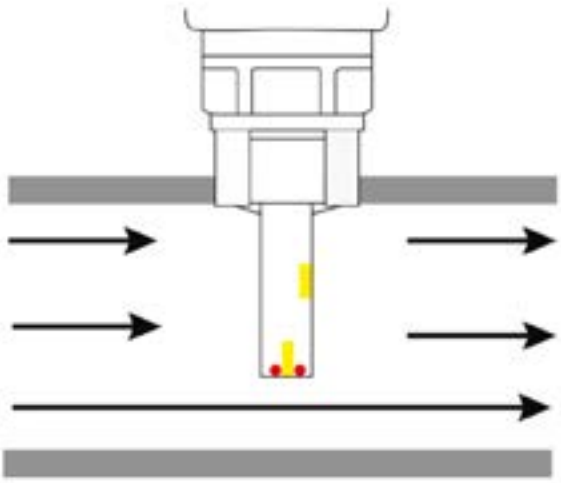
In this context, it should be emphasized that experience has shown that there are leaks of some kind in almost every compressed air network, which often go unrecognized. Such leaks usually prove to be real cost drivers in compressed air generation, treatment and distribution and are in no ratio to the investment in, for example, parameterizable flow sensors. It is therefore less a question of „if?" and more a question of „when?".

| Costs per year | | | | | | |
|---|---|---|---|---|---|---|
| | Leakage size - diameter (mm) | | | | | |
| Print | 0,5mm | 1,0mm | 1,5mm | 2,0mm | 2,5mm | 3,0mm |
| 3bar | 90€ | 361€ | 812€ | 1.444€ | 2.256€ | 3.248€ |
| 4bar | 113€ | 451€ | 1.015€ | 1.805€ | 2.820€ | 4.061€ |
| 5bar | 135€ | 541€ | 1.218€ | 2.166€ | 3.384€ | 4.873€ |
| 6bar | 158€ | 632€ | 1.421€ | 2.527€ | 3.948€ | 5.685€ |
| 7bar | 180€ | 722€ | 1.624€ | 2.888€ | 4.512€ | 6.497€ |
| 8bar | 203€ | 812€ | 1.827€ | 3.248€ | 5.076€ | 7.309€ |

Leaks in compressed air networks can be real cost drivers, as the table assigns. The figures illustrate the annual costs caused by leaks based on compressed air costs of 1.9 ct/Nm3 for continuous compressor operation (24 h/365 days).

The flow sensors from ipf electronic, which are very easy to operate and simple to install, all work on the calorimetric principle without exception.

For this purpose, the sensors are equipped via a measuring probe that integrates two temperature sensors and is installed in the mass flow of the medium. One sensor measures the temperature of the passing medium and thus forms a reference. The second temperature sensor in the sensor tip is heated from the inside to a constant excess temperature with the aid of heating elements and cooled by the passing medium. The greater the heating power required to keep the temperature sensor in the tip at the constant excess temperature, the greater the flow velocity of the medium. Flow sensors from ipf electronic are characterized by very high precision, not least because of this measuring principle.



Functionality of flow sensors using a compact device. The sensor integrates two temperature sensors (yellow elements). The temperature sensor in the probe tip is heated from the inside via heating elements (red). The second sensor in the probe measures the temperature of the medium flowing past.

The flow sensors from ipf electronic are divided into parameterizable insertion sensors, parameterizable devices with integrated measuring section and compact inline flow sensors with rectifier. Insertion sensors such as the **SL870027** can be easily integrated into the compressed air line under pressure, i.e. with the compressor running, via a ball valve. Along with volume flow measurements to determine the amount of compressed air produced, these sensors can also very easily measure the compressed air temperature due to their measuring principle.
The flow sensors from ipf electronic are divided into parameterizable insertion sensors,

parameterizable devices with integrated measuring section and compact inline flow sensors with rectifier. Insertion sensors such as the **SL870027** can be easily integrated into the compressed air line under pressure, i.e. with the compressor running, via a ball valve. Along with volume flow measurements to determine the amount of compressed air produced, these sensors can also very easily measure the compressed air temperature due to their measuring principle.

Compact devices with rectifiers (inline flow sensors) from the **SL90** and **SL95** series, on the other hand, do not require an inlet section during installation, as their flow rectifiers always enable an optimum flow to the integrated sensor elements, regardless of the installation situation. Such solutions are therefore particularly suitable for use in the immediate vicinity of a compressed air consumer (e.g. machine or system) and are also ideal for air flow measurements within hose lines.

Flow sensors from the SL series are available as solutions with an integrated measuring section (above) or as so-called insertion sensors.

The very compact flow sensors from the **SL5507x** series with integrated pressure sensor are among the comparatively latest products from ipf electronic. Due to their small dimensions, these sensors are particularly suitable for installation in the machine environment and enable high-resolution process and status monitoring, e.g. for condition monitoring with a cost-efficient predictive maintenance strategy. The entire device series offers a wide range of process connections for both pipe and hose lines.
The flow sensors in the **SL5507x** series can also be integrated into existing system controls via an analog output and two adjustable switching outputs. Another outstanding feature is the device‘s internal display for showing the current flow rate and operating pressure. If a previously set threshold value is reached, the display also visualizes this with a colour change.

**SL5507x** series flow sensors with connections for pipes and hoses.

### *3.1.2 MEASUREMENT OF COMPRESSED AIR QUALITY*

Compliance with a certain moisture content or dew point of the compressed air is a basic prerequisite for the long-term trouble-free operation of compressed air systems, which, among other things, ensures higher energy efficiency with sustainable cost savings.

The **YT900001** for absorption dryers and the **YT900002** for refrigeration dryers were developed specifically for humidity and dew point measurement in compressed air and gases. The relative humidity is measured via a capacitive polymer sensor. The sensor element is particularly impressive due to its high long-term stability (>5 years) and high accuracy (±1 °C at 50...-20 °C, ±2 °C at -20...-50 °C, ±3 °C at -50...-80 °C). The sensors are designed for two measuring temperature ranges: -80 °C...+20 °C (**YT900001**) and -20 °C...+50 °C (**YT900002**). The measured values can be output either via an analog output (4...20mA) or a Modbus RTU interface and transmitted to the IIoT gateway **BY000002**.
The **YTTS0002** system solution is also available, which consists of a set with a dew point sensor for refrigeration dryers, a measuring chamber for the dew point sensor and a separate evaluation unit.

Dew point sensors for absorption dryers (**YT900001**, left) and refrigeration dryers (**YT900002**, right).

The **YTTS0002** system solution consists of a set with a dew point sensor for refrigeration dryers (top left), a measuring chamber for the dew point sensor (bottom left) and a separate evaluation unit.

### *3.1.3 CONTINUOUS FILTER MONITORING IN COMPRESSED AIR SYSTEMS*

The **DW46310L** differential pressure sensor from ipf electronic enables the continuous monitoring of compressed air systems and fluids in fluid group 2 (all liquid media that are neither explosive, flammable, oxidizing or toxic or very toxic). For this purpose, one measuring line is installed upstream and one immediately downstream of the filter system via two integrated push-in fluid quick connectors for hose lines (6 mm). The resulting pressure difference of 0 to 1.6 bar is converted directly into an analog signal (4...20 mA) and output.
The all-in-one solution, which is already pre-assembled on a mounting bracket, is very easy to install and commission. Thanks to continuous monitoring with the **DW46310L**, the filter elements can always be replaced in good time, thus preventing pressure drops and associated energy losses, among other things.


All-in-one: The **DW46310L** differential pressure sensor is already pre-mounted on a mounting bracket.

### *3.1.4 DETERMINING THE PRESSURE PROFILE IN DOWNSTREAM SYSTEMS*

In many compressed air systems, there are pressure accumulators that absorb consumption peaks due to a temporarily higher air pressure requirement in production if the compressor output itself is not sufficient to supply the required volumes. To determine the pressure profile of the downstream compressed air system, for example, the **DT24310D** pressure transmitter with stainless steel measuring cell was developed, which integrates an analog output (4...20mA) proportional to the air pressure. With this solution for pressures from 0 to 10 bar, the measured values can be used to reduce the nominal pressure or pressure setpoint of a compressor by means of appropriate switch-on and switch-off cycles, thus reducing energy consumption with less compressed air consumption in production.

### *3.1.5 TEMPERATURE AND CONSUMPTION MEASUREMENT OF OTHER MEDIA*

The magnetic-inductive sensors of the **SM** series are designed for flow, volume and temperature measurement of electrically conductive liquids and are suitable for highly flexible use even under demanding environmental conditions.

The devices in stainless steel housing form a compact unit consisting of sensor and evaluation electronics, cover measuring ranges up to a maximum of 650 l/min and are available via various process connections (G1/4“, G1/2“, G3/4“, G1“, G2“).

All settings can be made via the buttons on the color digital display, including functions for dosing or temperature measurement with a **PT1000** temperature sensor on quick selection buttons. The display also offers numerous options for on-site configuration and calibration to prepare the devices for almost any measuring situation. The sensors in the **SM** series integrate two analog outputs (0...10V, 0...20mA, 4...20mA, 2...10V) as well as switching, pulse and frequency outputs.


Magnetic-inductive sensors from the **SM** series for electrically conductive media enable high-precision measurements.

For the measurement of flow, consumption and temperature of technical gases such as compressed air, natural gas, nitrogen, carbon dioxide, etc., ipf electronic offers the **SL** series. The various designs (insertion sensors, sensors with integrated measuring section and compact devices) and areas of application of the **SL** series - e.g. for monitoring the consumption of compressed air have already been described in more detail in chapter 3.1.1, so there is no need to describe the solutions „en détail“ again here. In summary, however, it can be said that the **SM** and **SL** series presented here can already be used for a wide range of consumption measurements of electrically conductive liquids and technical gases, whereby the devices can be easily integrated into a wide variety of internal supply networks.

The temperature sensors of the **YT45** series with a measuring range of -40 °C to +120 °C are among the parameterizable compact devices in the ipf electronic portfolio and have an adjustable switching point as well as a scalable analog output 4...20mA. The sensors with a 330° rotatable display are often used for temperature monitoring of liquids in pipes. They can be installed in any commercially available T-piece or in a weld-in socket.
The technical features of the **YT45**, which can be connected via an M12-connector, include a switching output that can be variably adjusted as normally open or normally closed, a hysteresis and window function (e.g. for monitoring a temperature range) and a turn-on and turn-off delay for bridging short-term temperature changes, to name just a few functions.

### *3.1.6 PRESSURE MEASUREMENT OF GASEOUS AND LIQUID MEDIA*

ipf electronic relies on four proven measuring cell designs. Three of these are based on a membrane construction that deforms under pressure, resulting in a change in resistance of strain gauges or resistors printed on the back of the membrane using the thick-film or thin-film method. This results in an electrical voltage change proportional to the pressure of the strain gauges or resistors connected to form a measuring bridge.

A distinction is made between the following measuring cell structure:

- Silicon diaphragm with diffused strain gauges

- Ceramic diaphragm with thick-film resistors printed on the back
- Stainless steel diaphragm with printed thin-film resistors and integrated signal * pre-processing with digital measured value output

The fourth method uses a capacitive ceramic measuring cell in which a ceramic diaphragm deforms under pressure, resulting in a change in distance between the ceramic diaphragm and a counter electrode. This results in a change in capacitance proportional to the pressure, which is evaluated by the pressure sensor electronics.

### *3.1.6.1 PRESSURE MEASUREMENT OF AIR AND NEUTRAL GASES*

For pressure measurement of gaseous and liquid media, ipf electronic offers the **DT24**, **DW25** and **DW5x** sensor series.

The particularly economical and virtually indestructible **DT24-series** pressure transmitters in stainless steel housing (protection class IP67) have been designed for use with all gaseous and liquid media (non-hazardous, non-flammable or non-toxic) in an extremely wide pressure range of 0...400bar. The measured values can be easily output via the integrated analog output (4...20mA) on a PLC (programmable logic controller) or an external display device. The pressure transmitters impress with their very low long-term drift, among other things

Sensors from the

The IO-Link pressure sensors of the **DW25-series** with G1/4“ process connection have two outputs, a pure switching output and a second output that can be parameterized via IO-Link as a switching, analogue (0...20mA, 4...20mA) or alarm output. The sensors are available with two measuring ranges of -0.1...0.1bar (DW25310N) and 0...0.25bar (**DW25310P**).

An exceptional feature of the sensors is certainly the particularly wide operating temperature range of -40 °C to +100 °C, which makes the devices ideal for static level measurements in containers with liquids such as hydraulic oils or cooling lubricant emulsions.

Thanks to the IO-Link interface, the sensors also enable further flexible parameterization, e.g. simple switchover from normally closed to normally open, setting of switching and release position, hysteresis settings, window function, definition of a turn-off delay, storage of minimum and maximum value or setting of damping, e.g. to smooth measured values of very dynamic pressure fluctuations.

Ipf electronics high-end technologies in the field of intelligent pressure measurement of liquid and gaseous media undoubtedly include the IO-Link pressure sensors with color TFT display from the **DW5x-series**. These sensors fulfill a variety of very different requirements in all conceivable applications for gaseous and liquid media, not least due

to their extremely broad functionality. The devices with variably selectable units (e.g. bar, psi and MPa) cover a very wide pressure range from -1bar to +600bar and are equipped via a digital full stainless steel measuring cell and an integrated processor. The sensors not only provide the pressure, but also a relative temperature value of the medium to be monitored, for example, if required.

The **DW5x** is characterized by a whole range of outstanding features. For example, the setting and parameterization of the pressure sensors is particularly easy and convenient via three diffuse reflection sensors integrated into the housing (protection class IP67) and the plain text menu navigation on the display. The DW5x can also be flexibly parameterized via IO-Link, with the interface providing additional diagnostic information on the devices during operation if required.
All settings can also be checked before practical use in an application without having to apply pressure to the sensor. The integrated test function therefore enables a complete „offline test".

Along with a fixed switching output, the pressure sensors have a second variable output that can be defined as a switching, analogue or alarm output as required. The analog output can also be parameterized both as a current output (0...20mA, 4...20mA) and as a voltage output (0...10V, 0...5V).

At first glance, the integrated and very easy-to-read TFT color display on all devices is particularly striking, enabling very intuitive operation of the sensors and also offering a wide range of different display modes. For example, the pressure can be shown via the display in plain text with trend display and accurate identification of the switching points. Colored display options for reaching previously defined switching points are also available. Another decisive plus point for practical use is that the display can be rotated in 90 degree increments and the sensor housing can also be continuously rotated by 305 degrees after installation so that the display can be read perfectly in any installation position.


Illustration with display


Example of the current status of a switching output: switching output active (left), switching output inactive (right)


Example of the current status of two switching outputs: Both switching outputs active (left), switching output 1 active - switching output 2 inactive (right)

The sensors are available in three different measuring cell versions: **DW50** with ¼-inch outside thread for 7 pressure ranges, **DW51** with ¼-inch inside thread for 8 pressure ranges and DW52 with ½-inch outside thread and front-flush diaphragm for 7 pressure ranges.

### *3.2 PRODUCTION AND PROCESSES: DETERMINING CAPACITY UTILIZATION*

The **BY000002** IIoT gateway for production/process data acquisition can be connected directly to the PLC (programmable logic controller) of a machine or system via the integrated OPC U/A interface, among other things, in order to obtain a wide range of valuable information from the control (unit).
In addition to this, the productivity and downtimes of systems can also be monitored using a further, optionally available app (**see section 2.5**).

If, in addition to the information provided by a PLC (programmable logic controller), further data is to be used for analysis and evaluation, a whole range of sensor solutions from ipf electronic can be used in a wide variety of areas to provide information about the utilization and consumption of operating or auxiliary materials in production, for example. The use of sensor technology is also necessary if, for a variety of different reasons, the control (unit) of a machine or system is generally not to be used for production/process data acquisition.

### *3.2.1 DETERMINING THE PRODUCTION QUANTITY AS WELL AS IO AND NOK PART COUNTING*

As an option for recording part counting via a PLC (programmable logic controller), including the specification of manufactured IO and NOK parts, ipf electronic offers a wide range of digital sensors in conjunction with the IIoT gateway, with a choice of frame, ring and hose sensors, impact sensors or light barriers as one-way systems, reflex light barriers or diffuse reflection sensors, among others. Only a few selected technologies are therefore described here as examples.

#### *3.2.1.1 LIGHT BARRIERS, FRAME, RING AND HOSE SENSORS*

Optical sensors are ideal for the contactless and therefore wear-free determination of part counting or for detecting IO and NOK parts. The solutions from ipf electronic are available both as through-beam systems with separate transmitter and receiver, as diffuse reflection sensors with transmitter and receiver in one device, as retro-reflective sensors with a reflector or as so-called smart retro-reflective systems, which can use any surface with sufficient reflectivity as a counter element instead of a reflector (e.g. a machine part).
Such systems can be used in many areas and detect objects very precisely, almost regardless of their nature (e.g. shape, color, surface structure, material).
In addition, some solutions such as the fiber optic sensors from ipf electronic can be used in Ex zones. For areas with high levels of contamination (e.g. in punching operations), where oils, coolants or release agents are used, we recommend high-performance photoelectric sensors, which have very high contamination compensation.
The inductive ring sensors in the IY series, for example, are ideal for detecting small parts and reliably detect all metallic objects. The ring sensors are available with static and dynamic operational modes. Static ring sensors detect both stationary and moving metallic parts and thus enable, for example, the reliable recognition and at the same time jam control of objects in feed hoses.
Dynamic ring sensors, on the other hand, were developed exclusively for the recognition of moving metallic parts. These devices generally have a higher response sensitivity than static ring sensors and are therefore able to recognize even extremely fast moving objects and also extremely small parts with a low mass in feed hoses.

The inductive hose sensors of the **IY19** series from ipf electronic can be easily attached to a non-metallic hose or duct from the outside, e.g. with a cable strap, and achieve switching distances of up to 16 mm.

Optical frame sensors from the OH series, on the other hand, are used to detect a wide variety of objects, including non-metallic objects. Compared to inductive ring sensors, they are able to monitor much larger areas. They also have a higher resolution for detecting very small parts and a higher response sensitivity, especially in dynamic operational mode, so that even extremely fast-moving objects are reliably detected.

Optical frame sensors from the OH series (left), inductive ring sensors from the IY series (right) and very easy-to-install hose sensors from the **IY19** series (above).

### *3.2.1.2 SIMPLE, ROBUST SOLUTION FOR EJECTION CHUTES*

Ipf electronic has a so-called impact sensor (**YM500170**) in its portfolio for the particularly simple determination of part counting or IO and NOK parts, e.g. in machine ejection chutes. The sensor in an aluminum housing (protection class **IP67**) impresses with its high endurance and is particularly suitable for applications in which, for example, screws, rivets, punched parts, springs, but also non-metallic parts must be detected and counted. The compact impact sensor (55mm x 50mm x 10mm) is simply mounted on a machine ejector and only reacts to the physical impact of objects on the replaceable steel impact plate. The **YM500170** can detect up to 100 parts per second.

Interesting niche product: The **YM500170** impact sensor impresses with its very high endurance in applications where metallic and non-metallic objects need to be detected and counted.

### *3.2.1.3 DETERMINING THE PRODUCTION QUANTITY OF BELT MATERIALS*

For the continuous determination of the production quantity of strip materials (e.g. steel coils) in combination with the IIoT gateway, for example, parameterizable encoders and very flexible optical position measuring systems have proven their worth.
For length measurement or recording the production quantity via a previously defined

period, the encoder shaft of the **VD58982x** incremental encoder series from ipf electronic is either connected directly to a material deflection roller, for example, or a measuring wheel is mounted on the encoder shaft. One of the encoders' features is that they can be parameterized directly on site and can therefore always be set to the required number of pulses (between 1 and 65,536 pulses). The solutions therefore differ in every respect from conventional devices, whose line spacing on the impulse disc must be specified before delivery. This is certainly a decisive advantage for companies with a high demand for encoders for different length measurements. Due to their high approval rotation speed of up to 6,000 rpm, the encoders can also be used for length measurement in very high-speed processes.

Can be parameterized on site: examples of the incremental encoders from ipf electronic. From the left: **VD589820** with 6mm solid shaft, **VD589821** with 10mm solid shaft and **VD589822** with 12mm hollow shaft.

The **VO330570** parameterizable optical position measuring system from ipf electronic with a sensing range of up to 60 mm detects all moving objects without contact and therefore without slippage, regardless of material or color. This means that the system can also be used to detect transparent materials, for example. The sensor is parameterized via free PC software from ipf electronic, with the units pulse/mm, m/min and mm available. If the **VO330570** is connected to a PC during use, the software also determines the traverse speed of the belt material to be detected. In addition, the solution integrates an output that provides two 90-degree phase-shifted square wave signals A/B, so that a travel distance can also be displayed by connecting a counter. A further switching output also makes it possible to parameterize a zero point for a predefined distance in order to reset a counter or process the signal in a PLC (programmable logic controller), for example. The second output can also be used as an alarm output, which further significantly increases process reliability during displacement and angular measurement.

The **VO330570** optical position measuring system offers a wide range of functions and can therefore be used very flexibly, even for detecting transparent strip materials.

### *3.3 MORE DETAILS ON THE CONSUMPTION OF OPERATING AND AUXILIARY MATERIALS*

In operational practice, less attention is often paid to the actual consumption e.g. of lubricants, release agents or coolants, although there is usually a lot of potential for savings here. In particular, fill level sensors from ipf electronic with analog output can help to leverage this potential, as they reveal specific details about the actual consumption quantities and thus also track down possible waste of resources. The range of solutions from ipf electronic products range from ultrasonic sensors via radar sensors to rope probes and pressure sensors, to name just a few.

#### *3.3.1 ULTRASONIC SENSORS: LEVEL MEASUREMENTS FROM ANY DISTANCE*

Ultrasonic scanners work according to the echo transit time method (Time of Flight measurement) and integrate a sound transducer that acts cyclically as a transmitter and receiver. The transformer emits a certain number of sound waves that are reflected by the material to be detected, regardless of its shape or transparency. The time that elapses between the transmitter and receiver of the signals is evaluated and is proportional to the distance between the sensor and the material surface.
The first evaluable signal that hits the sound transducer when it acts as a receiver is always decisive for the distance and thus level measurement.

Ultrasonic probes such as the **UT309023** with analog output (0...10V, 4...20mA) and IO-Link interface are particularly suitable for level measurements from large distances of up to 6,000mm and are therefore recommended for use in large or deep containers such as silos.

In this application, the ultrasonic probe was mounted in the lid area of a silo container (right). The measuring transducer (left) is located in a switching cabinet near the silo (center).

In contrast, particularly compact ultrasonic sensors such as the **UT129021** diffuse reflection sensor with analog output can be used for level monitoring of media in containers with very small openings. Depending on the size, standard ultrasonic sensors have sound transducers with a comparatively large surface area and therefore a sound cone with a large angle of beam spread. As described above, the first evaluable signal that hits the sound transducer in receive mode is always used for the level measurement. With particularly small containers, it is therefore possible that, for example, the sound cone hits the edge of the container first and not the medium to be detected. The **UT129021**, on the other hand, has a very small angle of beam spread of the sound transducer of only 6°. A beam columnator is also used to additionally focus the sound pulse, enabling level detection in proportion to the distance, even in containers such as test tubes.

The UT129021 with analog output for detecting the filling level in glasses with very small openings (left). Another sensor (UT129520) with digital switching output is used for presence monitoring (right).

### *3.3.2 RADAR SENSORS: INTERESTING FOR PARTICULARLY DEMANDING ENVIRONMENTS*

Radar sensors such as the **FR900020** from ipf electronic achieve ranges of up to 5m ex works and are switchable up to 10m. The sensors impress with a short response time of 0.3ms and very high measuring accuracy. The devices are usually a very good alternative when other sensors reach their limits due to various environmental conditions such as temperature, gas or steam, via, negative pressure or vacuum as well as dust and interfering ambient light. The radar sensor offers clear advantages compared to ultrasonic sensors, for example, when monitoring the level of media on which foam or gas layers can form. Due to the operating principle, the devices work independently of heat or cold and are maintenance-free and insensitive to moisture and dirt. In addition, detection is also possible through a plastic lid, which serves as a coverage or protective window, for example.

Radar sensors such as the **FR900020** are usually a very good alternative when other sensors reach their limits in level measurement due to a wide variety of environmental conditions such as temperature, gas or vapor layers on a medium, via positive or negative pressure or vacuum, as well as dust and interfering ambient light.

### *3.3.3 PRESSURE SENSORS AND ROPE PROBES: FROM PRESSURE TO FILLING LEVEL*

The rope probes and hydrostatic pressure sensors from the **FY98** series have proven to be a simple and maintenance-free solution for a wide range of level measurements.
Ipf electronic, which can be installed in a container without any further setting by means of „suspended mounting“. The sensors are equipped via a pressure measuring cell with downstream electronics, which converts the static pressure of a liquid column into an analog measuring signal. Since the static pressure is determined purely by measurement, gel-like or pasty media can also be inquired.

Hydrostatic pressure sensors of the **FY98** series can be installed in a tank without further settings by means of „suspended mounting“.

As an alternative to rope probes, filling levels can also be measured using pressure sensors such as the **DW363111** from ipf electronic. The sensor is installed with a corresponding connection from the lateral side in the lower area of a container filled with a liquid medium. An interesting feature of the **DW363111** is the scalable display, which can also show the correlating fill level in a container in millimetres as an alternative to the pressure in millibars. This can sometimes be relevant if, for example, a container is filled with lighter oil instead of water. The complicated conversion of pressure into the corresponding fill level is no longer necessary in such a case.

### *4 CASE STUDIES FROM PRACTICE*

Following the introduction of ipf electronic's technologies for simple, economical process data acquisition and energy monitoring, many companies have recognized the potential of the IIoT gateway, as some case studies from practice show, which at the same time underline the high flexibility of the solutions.

### *4.1 AUTOMATED METER READING*

A manufacturer of metal and plastic rails and special profiles, among other things, manually records the measured values of a total of 40 energy meters distributed throughout the company at regular intervals. To do this, employees go to the individual meter locations, read various measured values and record them in a list, which is later transferred to a table.

A total of five gateways (**BY000002**) were installed to record the measured values of the 40 counters in an automated manner. Another gateway serves as a master that combines all measured values and visualizes the data on a dashboard (web client).

The topology of the concrete solution for automated meter reading.


Current measured values from a counter for a specific operating range for voltage, current, active power as well as total active energy and total active power of a system are clearly displayed on the dashboard.

**The results:**

- Automated, decentralized recording of various measured values from 40 energy meters (active power, reactive power, apparent power, current, voltage, energy, etc.)
- Data can be accessed at any time in the company network
- Enormous time saving, as no manual recording and processing
- Potential source of error eliminated by handwritten notes
- Straight processing and visualization on a clear dashboard
- Simple export of consumption values for any time period to Excel
- Automatic notification by e-mail if consumption values are overrun
- Fulfillment of the requirements for energy management according to ISO-50001

### *4.2 ENERGY MONITORING OF MACHINES*

A company specializing in sheet metal processing, plastics processing and surface finishing uses systems with high energy requirements for production, e.g. laser cutting machines. The company would like to continuously monitor, analyze and evaluate the energy consumption of a total of five systems, including state-of-the-art sheet metal processing systems, a grinding machine and its extraction system.

An IIoT gateway, 5 energy measurement modules (**AB000008**) and 15 **NZ** series current transformers were installed to meet the company's specific requirements. In combination with the current transformers, the energy measurement modules continuously measure the energy consumption of the systems. Due to the three-phase three-phase supply with mostly asymmetrical loading of the individual phases, each machine requires three current transformers. All transformers are connected to the energy measurement modules connected to the gateway. The gateway in turn brings together all measured values and visualizes the consumption data on the dashboard.

The topology for energy monitoring of several machines.


Display of active, apparent and reactive power of a system with distribution terminal of the respective phases (L1, L2 and L3).

**The results:**

- Continuous recording of the energy consumption of a total of 5 systems
- Straight data processing and clear visualization on a dashboard
- Data can be retrieved from the company network at any time
- Potential for energy savings based on actual consumption data
- Simple export of consumption values for any time period to Excel
- Automatic notification by e-mail if consumption values are overrun
- Fulfillment of the requirements for energy management according to ISO-50001

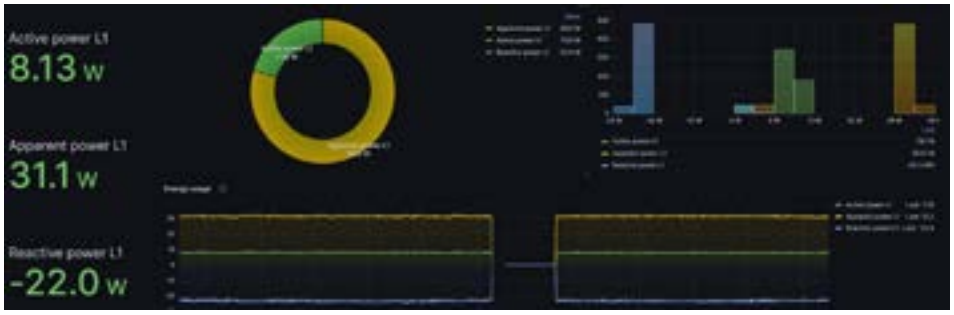
### *4.3 ENERGY MONITORING OF AN INJECTION MOLDING MACHINE INCLUDING GAS CONSUMPTION MEASUREMENT*

A manufacturer of systems and components for professional electrical installations wants to monitor the energy consumption of an injection molding machine in its production facility. In addition, the gas consumption of the machine and the gas temperature are to be recorded continuously.

In this case, the system solution consists of an IIoT gateway (**BY000002**), an energy measurement module (**AB000008**), three NZ series current transformers and an SL series flow sensor. As the machine is via a three-phase three-phase supply, a current transformer for round conductors is installed on each phase. The current transformers are connected to the energy measurement module, which in turn is connected to the gateway.

The flow sensor with analog output (4...20mA) was also coupled with the gateway to monitor gas consumption (volume flow measurement) and gas temperature. The gateway again combines all measured values and visualizes them on an individually configurable dashboard.


The energy measurement module, the machine's control (unit) and the flow sensor are connected to the gateway for processing and visualization.




Active, apparent and reactive power of an injection molding machine (here for phase 1 / L1) are precisely recorded.


The volume flow and temperature of the gas are measured and visualized at the same time as the energy consumption is recorded.

## The results:

- Continuous monitoring of a machine's energy consumption
- Additional recording of gas consumption and temperature
- Potential for energy savings based on valid consumption data
- Greater process reliability thanks to real-time data acquisition
- Straight processing and visualization of all measured values on a dashboard
- Simple export of consumption values for any period of time to Excel for Further processing and documentation
- Automatic e-mail notification when predefined overruns occur Consumption values
- Fulfillment of the requirements for energy management according to ISO-50001

## *5 SUMMARY AND CONCLUSION*

Sustainably reducing energy consumption and at the same time increasing the efficiency of production by optimizing processes so that the transparency of production is increased at all levels- these are the key requirements that will determine the competitiveness of almost all companies now and in the future.

All beginnings are difficult, aren‘t they? But with the IIoT gateway from ipf electronic, that doesn‘t have to be the case! In a first step, the gateway creates all the prerequisites for end-to-end energy monitoring and seamless production/process data acquisition, whereby the associated solutions can be flexibly scaled at any time.
In addition, ipf electronic‘s technologies are suitable for modernizing old systems as part of retrofits as part of the urgently needed digitalization of production.
And in all the cases mentioned, neither high initial investments nor expensive conversions of machines or systems are necessary.

With the energy monitoring of machines and systems such as compressors for compressed air generation, the actual costs of energy generation become clearly visible within a very short time. Greater transparency regarding actual energy consumption, down to the individual consumer (individual machine, system, etc.) if required, means that the reasons for any deviatingly high energy requirements can be analyzed more precisely and concrete measures for sustainable energy savings combined with noticeable cost reductions can be taken.

And what is needed to get started? Just the IIoT gateway **BY000002** with integrated data memory and the energy measurement module **AB000008** in combination with the current transformers from ipf electronic.

By recording and visualizing machine and process data (capacity utilization, running times, processing times, downtimes, part counting, reject rates, etc.), the actual capacity utilization of a production facility can be determined in order to obtain important key figures on overall plant effectiveness and thus an overview of the current operating and production situation. This enables bottlenecks, inefficiencies and weak points to be identified and eliminated in a targeted manner. In addition, the collection and visualization of data in real time enables faster intervention in the event of problems or deviations in the ongoing process. Taken together, the collected data ultimately forms a valid and well-founded basis for both operational and strategic decision-making.
The continuous analysis of machine and process data also identifies patterns for impending failures, which can be used to better plan maintenance and repairs as well as spare parts stocks. Instead of reactive or preventive maintenance strategies, predictive and thus condition-based measures can now be implemented to optimize maintenance cycles and reduce spare parts costs.

Further potential for cost savings can be identified by recording the consumption of operating and auxiliary materials, among other things. Anyone who has accurate knowledge of the use of lubricants, release agents or coolants, for example, can consciously counteract waste and thus conserve resources in the long term.

In addition to the IIoT gateway for data acquisition of energy flows and/or production/ process data acquisition, ipf electronic offers a wide range of high-performance sensors as required, e.g. for monitoring compressed air networks in compressed air generation and distribution, for flow and consumption measurements of technical gases, for pressure measurement of gaseous and liquid media, for consumption measurements of operating and auxiliary materials, for determining part counting including IO and NOK parts and for determining the production quantity of strip materials, to name but a few.

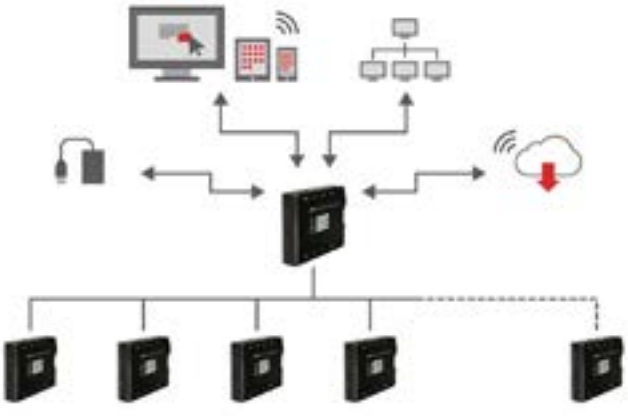
***In this context, the ipf electronic system offers the following options:***

/ Monitoring and supervision of a single system or machine

**or**

/ Implementation as a networked, factory-wide solution


Use of the gateway at machine level



Use of the gateways at operating level

The IIoT gateway, which already contains the operating system and a web client solution for processing and visualizing the measurement data, offers a high level of connectivity and supports numerous common communication protocols. As an option, the gateway can also be expanded to include a very comprehensive web client solution for targeted productivity monitoring and system downtime monitoring.
The gateway itself already offers a range of interfaces for the connection of digital, analog and, for example, any number of sensors via Modbus. In addition, the gateway can be scaled via a backplane bus connection with the **AB000009** I/O module to significantly expand the number of interfaces if the gateway's I/Os are not sufficient. The module can also be used as a stand-alone device and „data collector" if a system for signal processing and visualization is already in place.

In summary, the IIoT gateway **BY000002**, the additional modules, the equally versatile and powerful apps and, last but not least, the wide range of different sensor technologies form the decisive basis for data-based decisions that go hand in hand with a noticeable increase in efficiency, quality and cost-effectiveness in production.





**ipf electronic gmbh** | Tel +49 2351 9365-0 | info@ipf-electronic.com • **www.ipf-electronic.com**

**ipf electronic gmbh**
info@ipf.de • **www.ipf.de**

Änderungen vorbehalten! Stand: März 2025