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WHITE PAPER

LOGIC MODULES

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IPF ELECTRONIC

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1. INTRODUCTION

The demand for manufacturing and thus product quality is becoming visibly higher in a wide variety of industrial sectors. One reason for this is usually the increasing complexity of the products and solutions to be manufactured. This in turn requires a high level of process reliability with a consistently high level of reproducibility of specific production processes. Against this background, sensors for monitoring tools, handling systems or clamping devices, for example, are becoming increasingly important, for example to ensure the correct positioning of workpieces. However, querying a large number of sensors via a plant control system (PLC) extends cycle times and also increases the need for inputs and signal lines. If, in addition, there are not enough inputs available on the control side, logic modules or logic distributors are recommended, which logically AND or OR digital sensor signals with each other on site.

It is not always the number of inputs available on the control side that determines whether the use of logic modules makes sense. The objection that all functions taken over by such modules can also be programmed directly on a PLC is therefore quite justified. However, such controllers are not freely accessible everywhere and in every plant, so that the possibilities for external intervention in the program code of a PLC are sometimes limited or even non-existent.

Another aspect is the question of warranty when accessing plant controllers and adapting or changing their program code. Many users shy away from this step because of the possible risk of losing the warranty if any errors or problems occur afterwards. Logic modules, however, perform their tasks without direct access to a PLC program code and are therefore always reversible solutions. This means that in the event of system problems, which may be related to the installed modules, the previous status can be restored at any time.

Last, but not least, especially in smaller companies there is often a lack of skilled personnel who would be able to program a PLC. Also in this case, logic modules as pure hardware, which do not require any programming skills, can be a solution to link sensor signals.

This white paper provides an overview of the development of logic modules at ipf electronic and shows how, among other things, proven technologies are also changing due to technical progress, opening up a range of completely new potentials.

2. FROM CONCRETE NEED TO THE FIRST SOLUTION

ipf electronic has been offering logic distributors for more than 20 years, making it one of the very first suppliers of such solutions. In 1998, for example, the company developed one of the first logic modules, the **VL25**, which consisted of a small housing for DIN rail mounting with screw terminal connection. The trigger for this product development was, as so often, the concrete need of a customer for a solution for the logical linking of several sensor signals.

The first developments are still part of ipf electronic's portfolio and consist of the **VL250100** for AND-connections and the **VL250120** for OR-connections. Both modules have four inputs (terminals) each, via which the logically linked switching signals of up to four sensors can be transmitted to a controller with a single linked end signal.

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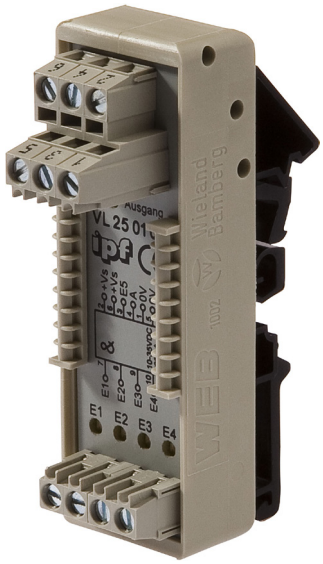
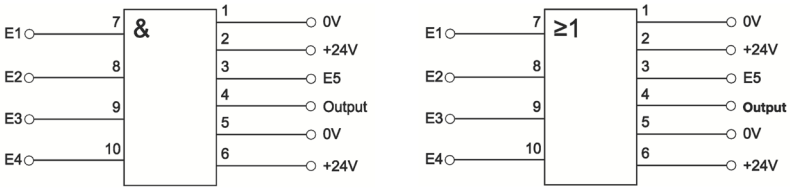
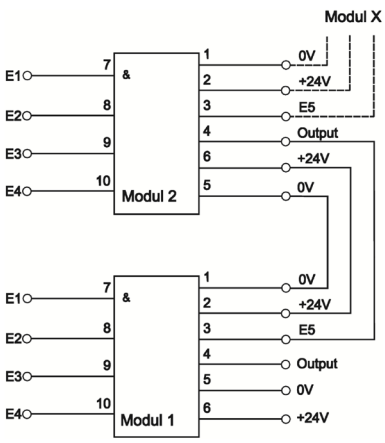


The **VL25** (here the **VL250100**) were among the first logic modules from ipf electronic. (all pictures: ipf electronic gmbh)



Connection diagrams of the **VL25**. Left: **VL250100** (AND), right: VL250120 (OR)

ipf electronic also thought about cascading the logic modules and thus the possibility of linking more than four sensor signals on site. Therefore, both logic distributors of the VL25 series integrate an additional input (E5), with which the devices can be expanded or connected in series.



The modules can be cascaded via input E5.

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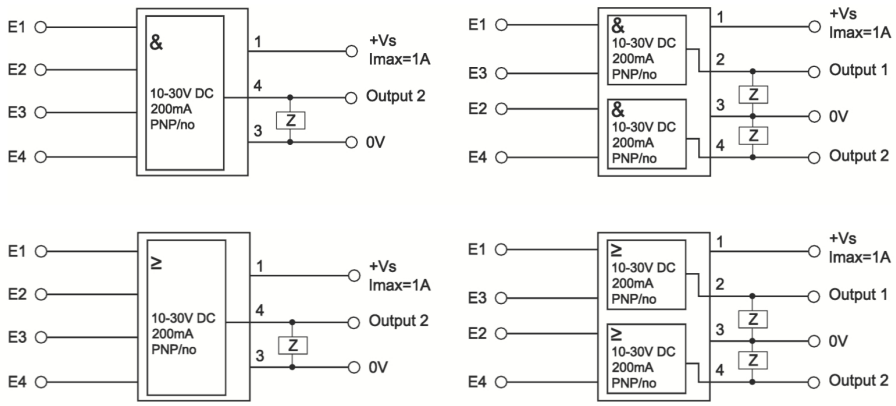
3. CONSISTENT FURTHER DEVELOPMENTS

Nothing motivates as much as success. And since the first logic distributors from ipf electronic met with an extremely positive response in the market, the company's engineers developed the technology further. Instead of creating their own design for the successor series **VL60**, they reverted to the housings of passive distributors as already established solutions for connecting multiple sensors.

Unlike the **VL25**, the **VL60** therefore has several M12 ports instead of the terminals for connecting the sensors and a connection hood with a cable gland where a 4-pin M12-connector for the cable to the PLC could be integrated. In addition, the hood provides sufficient space for the entire electronics. Due to the 4-pin M12-connection, a free connection pin was available for a second output, so that solutions could be realized for the first time in which the sensor signals can be applied to two separate logic gates. Therefore, it is possible to select a separate AND or OR operation for each sensor input row (e.g. E1 and E3 as well as E2 and E4 for the 2x2-fold modules), which is routed to one of the two outputs as separate logics.
The field distributors of the **VL60** series are available as 4- and 8-fold modules as well as 2x2-fold and 2x4-fold modules in IP67.



Connection diagrams of the 4-fold logic modules of the **VL60** series for AND links (top) as well as OR links (bottom) with 4-pin connectors. On the right the pin assignment of the connections for the 2x2-fold modules (AND/OR).

The housing design of passive distributors was the inspiration for the logic modules of the **VL60** series. Here an 8-fold logic module (AND operation).

After the market launch of the **VL60** with M12 sensor ports, ipf electronic received customer requests for logic modules with M8 inputs for sensor technology relatively quickly. As a result, the logic modules of the **VL30** series were developed. These field distributors had either a fixed connection cable to a PLC or a 12-pin M12-connector for the control cable.

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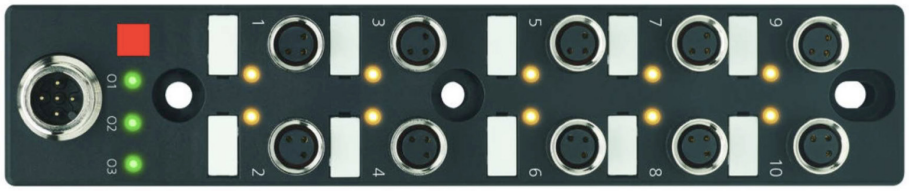
The changed housing design is also noticeable, with the **VL30** logic modules having a much more compact and flat design compared to the **VL60**. One of the challenges was thus to integrate the entire electronics in the space available on the underside of the device.

With the **VL30010A**, ipf electronic also developed a logic module with a total of 10 sensor ports that combines both AND and OR links as freely selectable logics in one solution. Since the 12-pin M12-connector also provides sufficient connection pins, the 10-fold module can output not only the linked sensor signals, but also the signals of each individual sensor output separately.

As further developments to the **VL30** logic modules, ipf electronic then introduced the **VL31** series with 4-pin connector plugs to the market. These solutions will successively replace the **VL30** series. Apart from the number of poles of the connection plugs to the PLC, the **VL31** differ from their predecessors mainly in the housing geometry, as they are comparatively more compact and the slots for the sensor technology are arranged slightly differently. With the **VL310104**, **VL310108** and **VL31010A**, the **VL31** series has, among other things, 4-, 8- and 10-fold modules for AND as well as OR links with M8-connections on the sensor side.



10-fold logic module **VL31010A** (AND/OR).

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4. "CLEAN SIGNALS": FIRST FULLY ELECTRONIC DUAL LOGIC MODULES

In 2020, ipf electronic proved that there can still be real progress even in the already proven dual logic modules, because with the **VL150102**, the first fully electronic dual logic module with 3-pin M8-connection was introduced. The outputs of the sensors connected to this logic module are AND-linked via integrated electronics and not by means of hard wiring. Thus, the switching output of the distributor only becomes active when the switching outputs of both sensors are switched on at the same time.

In the case of a wired series connection, however, the switching output of the first sensor supplies the operating voltage internally for the second sensor, whose output is then the switching output of the distributor. Depending on the voltage drop or start-up current of a sensor, this can lead to unsafe switching behavior. The electronics of the **VL150102**, on the other hand, ensure that ''clean'' signals are always present at the controller, just as if only one sensor were connected.

The first fully electronic dual logic module **VL150102**.

The **VL150102** for AND connections was supplemented a little later by a solution (**VL150122**) with M8-connection for OR connections. In 2021, the **VL170102** and **VL170122** with M12-connections as well as the **VL160102** and **VL160122** were added. The latter two logic modules provide two 3-pin M8 inputs for the sensor connection and an M12-connection on the control side. With these fully electronic dual logic modules, ipf electronic was finally able to cover all connection variants.

In principle, the same applies to the fully electronic dual logic modules **VL150122**, **VL160122** and **VL170122** as to the solutions for AND connections. However, in the case of the devices mentioned, the electronics ensure that the outputs of the sensors connected to the modules are OR-linked. The switching output of the modules is therefore always active when at least one of the two connected sensors is switched on, regardless of which device is currently switching.

Fully electronic dual logicw modules of the VL15, VL16 and VL17 series (from left).

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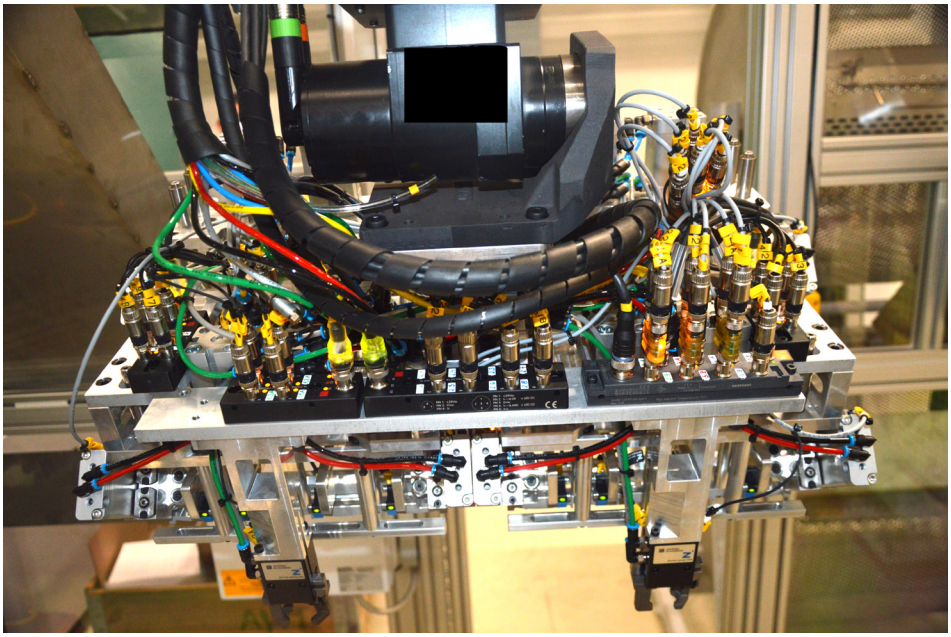
4.1 FULLY ELECTRONIC DUAL LOGIC MODULES IN PRACTICE

The possibilities offered by the fully electronic dual logic modules in practice are demonstrated by an application at RICO Elastomere Projecting, a company from Upper Austria which, as part of the RICOGROUP, specializes in the development and construction of injection molds, the automation of injection molding machines, and the production of elastomer parts.

For the automation of injection molding machines, RICO develops, among other things, robot-assisted handling heads for the removal of injection molded parts from a machine. The number of gripper stations integrated in the handling heads and interrogated with sensors for damage-free handling of such parts varies depending on their complexity and size. Therefore, RICO's solutions also include very complex handling devices with a very large number of sensors for a wide variety of interrogations.

In one specific case, a total of eight logic modules of type **VL310108** were integrated in a handling head with more than 50 sensors. These were partially combined with the fully electronic **VL150102** dual logic modules in order to be able to increase the number of slots for the AND link of the sensors despite the limited installation space for the logic distributors.



Complex handlink head from RICO with logic distributors from ipf electronic, which were additionally supplemented with fully electronic dual logic modules **VL15** (right in the picture).

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5. REAL PROGRESS THROUGH IO-LINK LOGIC MODULES

Technologies may well be mature to a certain extent. Nevertheless, there are always advances, especially in the field of sensor technology, which also offer new possibilities for already proven solutions and thus open up completely new types of potential. One example of this is IO-Link, whereby the digital interface in particular offers a variety of approaches for extremely flexible parameterization of logic modules, as ipf electronic has recognized. In this respect, the development of the first logic modules with IO-Link interface was a consistent step towards greater flexibility. These solutions therefore provide an answer to the question of how the functionality of logic modules can be designed even more flexibly with a view to diverse fields of application, without having to offer a separate device for each application, which, moreover, is also very difficult or impossible to adapt to changed requirements in retrospect. Instead, the new IO-Link logic modules from ipf electronic are highly flexible because they can be freely parameterized via the IO-Link interface.

IO-Link logic modules of the **VL61** series: the 4-fold logic module **VL610304** (above) and the 8-fold logic module VL610308.

What applies to IO-Link sensors also applies in this context to IO-Link logic modules, because this flexibility decisively reduces the number of variants of the solutions otherwise required for a wide variety of linking tasks, which, among other things, enables sustainable use of the modules because they conserve resources. The immense potential that the new IO-Link logic modules open up for practical applications is illustrated by a few selected examples.

5.1 SIMPLE DEACTIVATION OF FREE INPUTS

If, for example, only four sensors are AND-linked with a conventional 8-fold logic distributor (eight inputs), the remaining four free slots or ports require a so-called simulation plug for wiring so that the distributor works properly or the selected logic functions. With the new logic distributors from ipf electronic, the free slots can now be deactivated independently of each other via the IO-Link interface, so that the use of simulation plugs is no longer necessary. This again leads to a reduction in the wiring effort in practice as well as to further material and cost savings.

Simulation plugs for vacant slots in AND operations, as in a logic distributor without IO-Link interface (right), are no longer required with the IO-Link logic modules (left). Among other things, this leads to further material and cost savings.

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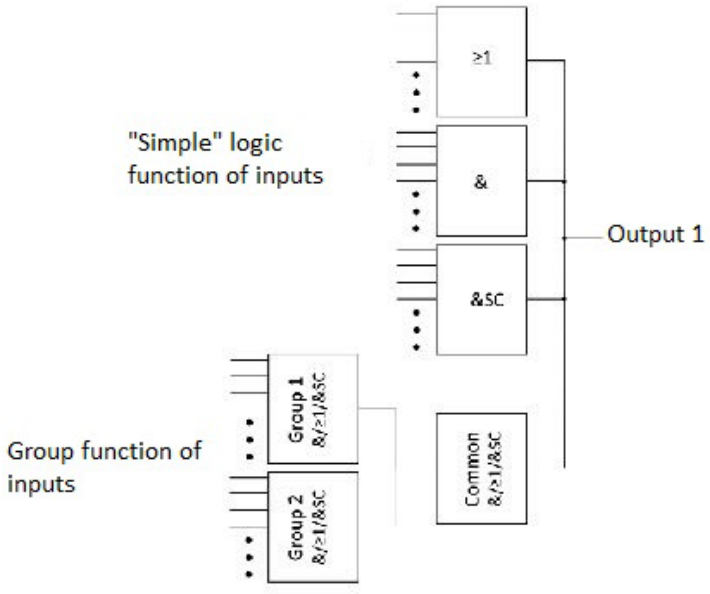
5.2 FREE CHOICE OF INPUTS AND LOGICS

The inputs of the new IO-Link logic distributors can be linked completely independently of each other, whereby the user is also free to select the required logic. In the case of an eight-fold logic distributor, for example, an AND operation could be implemented at output 1, e.g. for ports 1 to 4, or an AND operation could be implemented at output 2 for ports 5 to 8, while the inputs that remain free in each case would then receive an OR operation. This significantly increases the application flexibility of a logic module with IO-Link, because a single solution can be used for many different tasks.

5.3 SETTING UP VIRTUAL GROUPS

Another extremely interesting function of the IO-Link logic modules is the creation of virtual groups, which can also be used to replace several conventional logic distributors with a single IO-Link logic module. For example, certain slots (e.g., ports 1 to 4) can be combined in a virtual group with an AND operation, while the remaining slots (e.g., ports 5 to 8) are assigned an OR operation in a second virtual group. The respective outputs of the groups ultimately lead to a further common and also freely selectable logic. Since an IO-Link logic module generally always allows the setup of two virtual groups and one common logic per output, the user also always remains flexible here in the choice of inputs and the desired logics. All combinations are conceivable in this context, regardless of the number of linked sensors.

To implement such combinations with conventional logic distributors, three devices would be required instead of a single solution (one logic module for the AND linking of the sensors, one logic module for the OR linking and an additional logic module for the implementation of the common logic). In practice, however, the use of the new solutions means: less space required for the IO-Link modules at the installation site (one device replaces up to three distributors) and, moreover, a significantly reduced wiring effort.



By forming virtual groups, a single, flexibly parameterizable IO-Link logic module takes over the tasks of previously several devices.

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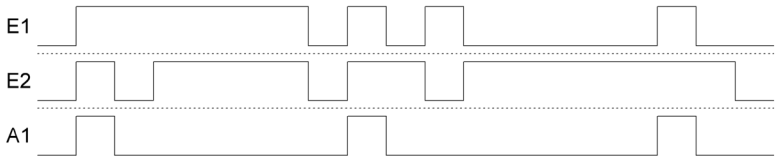
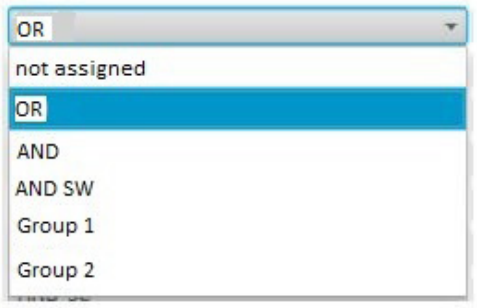
5.4 NEW OPTION FOR LINKING

Another new feature of the IO-Link logic modules is the adjustable ''AND_SW'' option, a special AND link that additionally queries a signal change on each sensor input. Each of the linked inputs must therefore have switched off once, i.e. go ''low'', before the corresponding output of the logic module becomes active again. With such linking options, it is possible, among other things, to reliably avoid false signals from the sensors, e.g. caused by jammed components. In the past, this required a logic module with two logic gates (AND as well as OR linkage) to enable the additional OR query of the sensors.

In addition, each sensor output had to be simultaneously connected to two separate inputs of a logic module for such a separate query, which meant a not inconsiderable wiring effort due to the double connection and, moreover, the assignment of two inputs for one sensor connection. The new logic modules from ipf electronic are probably the first solutions to provide this special AND link with an adjustable parameter ''UND_SW'' in order to additionally query a signal change (SW) on each input.



Fictitious example: The ''AND_SW'' function checks the edge change and therefore ensures that the output only switches when all linked inputs have completed a negative edge change. Indirectly the function of the sensor is monitored by this. The example shows how the switching output (A1) behaves when the first inputs (E1, E2) monitor the negative edge change.



A section of the interface of the **VY000005** IO-Link master shows the options for setting the sensors connected to the IO-Link logic modules.

5.5 ALTERNATIVE FUNCTIONS IN IO-LINK TOPOLOGIES

Alternatively, the logic distributors of the **VL61** series can also be used as an IO-Link hub. In an IO-Link topology, only one IO-Link device per input can be connected to an IO-Link master. An IO-Link hub, on the other hand, combines the signals of several devices with or without an IO-Link interface and thus functions as a distribution island that occupies only one input of the IO-Link master.

If a logic distributor of the **VL61** series is used as an IO-Link hub, the signals of the sensors connected to it can also be combined, whereby their linking can then take place directly on a controller (PLC), since all signals of the sensors are available here.

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5.6 EASY IDENTIFICATION AND EXCHANGE

In addition to the properties described so far, the new logic modules offer further advantages, such as those known from IO-Link sensors. If, for example, an installed logic distributor has to be replaced due to a defect, this is now very simple thanks to IO-Link. For example, two LEDs can be activated at the outputs via IO-Link to identify a device in more complex applications, so that the installation location of the relevant field distributor can be identified immediately. IO-Link masters that operate according to the V1.1x software standard determine the identity of an IO-Link logic module directly, whereby the already stored parameters of the defective module are automatically transferred after installation of the replacement device. This rules out the possibility of installing a module with incorrect logic input links. In addition, this saves maintenance valuable time when replacing a device, thus avoiding longer system downtimes.

6. SUMMARY AND CONCLUSION

ipf electronic looks back on decades of experience in the development and realization of logic modules. Without a doubt, the company is therefore one of the pioneers in this field and is also one of the few suppliers that can offer a very wide range of devices for the logical linking of sensor signals in the field. Above all, customer demand for solutions with specific properties and functions is always considered a decisive impetus in this context to rethink the technologies in parts and also fundamentally in order to launch practical new and further developments.

Examples of this in the early years include logic modules that combine both AND and OR links as freely selectable logics in a single device, but also solutions that offer further selection options, for example with regard to sensor and control-side connection variants. The development of the first fully electronic dual logic modules can be regarded as a real innovation, which replaces hard wiring of the devices for AND as well as OR links with much more reliable electronics in terms of safe or ''clean'' signal transmission.

ipf electronic also recognized the potential of comparatively new technologies such as IO-Link for its logic modules at a very early stage. With the development of the first completely freely parameterizable IO-Link logic distributors, it is now possible to cover an immensely wide range of tasks with just a few modules and also to open up new fields of application. For ipf electronic's customers, this means a higher degree of flexibility in use and, moreover, enormous time and cost savings.

Progress is a continuous process. And it will be interesting to see which technological possibilities will be offered, for example, by new developments in other areas of sensor technology for the future logic modules from ipf electronic.

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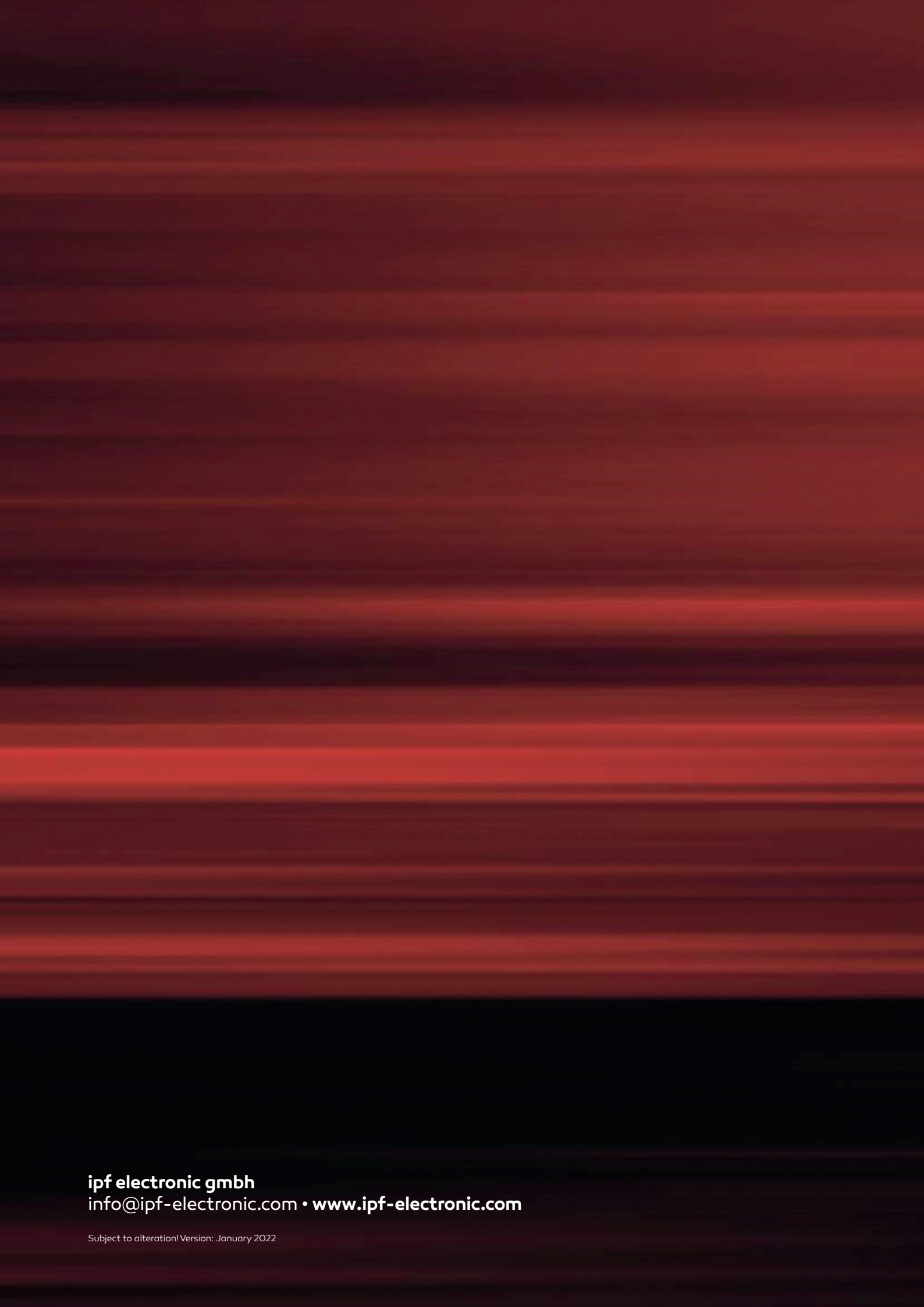

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