ISOFACE™ provides Intelligent Protection

Galvanically Isolated 8-Channel High-Side Switches and Digital Input ICs

The ISOFACE™ product family intelligently solves a challenge common to most industrial automation systems, e.g. Programmable Logic Controllers (PLCs), Drives, Industrial PCs, Robotic Systems, Distributed Control Systems, Building Control Systems, General Control Equipment and Sensor Input Modules. The common challenge is the need for robust galvanic isolation between the 3.3V or 5V side, which is also called the “control-side” of the system, that’s where microcontroller or control-ASIC resides and the 24V factory-floor environment, also called the “process-side”.

Galvanic isolation is needed for two reasons:

a) Differential electric currents generated on both the control-side and the process-side can lead to substantial shifts of the ground potential. In particular the low voltage control-side must be protected from such ground shifts. This protection can only be attained by electrically decoupling the control-side from the process-side. The means to attain that is by galvanic isolation. Such decoupling is possible since in the industrial control system only information is transported from the one side to the other side of the system, i.e. across the galvanic isolation barrier.

b) Inverters, for example used to control the speed of a motor, are a frequent source for energy-rich disturbances on the process-side that can create surges and rapid transients as well as high-frequency noise. Without galvanic isolation, such disturbances would directly affect the microcontroller or control-ASIC. On the process-side, in terms of its electrical characteristics, the galvanic isolation represents a circuit element which is of very high impedance. The resultant net effect is that the galvanic isolation protects the control-side from the energy loaded disturbances created by the inverter on the process-side.

Galvanic isolation intelligently integrated

Robust galvanic isolation can be attained between the process-side of an industrial control system and its control-side using the ISOFACE™ product families. Both the 8-channel high-side switches and the 8-channel digital input ICs feature integrated galvanic isolation rated with $500V_{AC}$ (EN60664-1, UL508). This galvanic isolation is attained through inductive coupling and based on proven silicon technology which is in use in a range of industrial products from Infineon. The electro-magnetic robustness of the ISOFACE™ products has been certified in multiple tests, e.g. ISO11452-7 and IEC61131-2.

Unlike solutions based on opto-couplers, the silicon-based isolation technology is not subject to degradation of the current transfer ratio (“CTR”) due to operation at elevated temperatures or aging. [Note: In an opto-coupler based solution CTR is the ratio of the current through the LED versus the current on the output transistor.] ISOFACE™ products can durably be operated in the temperature range from -25°C up to +135°C, whereas, affordable opto-couplers are typically rated to operate at temperatures of up to +105°C. To off-set the detrimental implications to CTR from operating an opto-coupler at such high temperatures as well as to preemptively cancel out aging effects, frequently designers decide to increase the biasing current of the LED. [Note: As a side-effect, the more the biasing current is being increased the more the aging effect of the opto-coupler is accelerated.] The galvanic isolation of ISOFACE™ products is not subject to this type of aging effect. Moreover, its tolerance range over temperature is orders of magnitudes lower. The performance of the galvanic isolation barrier of ISOFACE™ products is significantly more linear over temperature as well as over product life-time. In consequence, their power dissipation is inherently lower.

Protecting Outputs

Robust Galvanically Isolated 8-Channel Switches

The ISO1H81xG family of 8-channel high-side switches can drive any kind of resistive, inductive or capacitive loads. The maximum nominal load current per channel is up to 1.2 A. Combining two output channels in parallel allows switching of 2 A loads. It is even possible to combine four output channels in parallel, this leads to a maximum permissible load current of 4 A. The integrated inductive clamping diodes can repeatedly absorb 1 Joule per output channel. This allows switching of inductive loads without a need for additional clamping diodes to absorb the commutation power.

Safety and Diagnostics built in

The output current of each of the high-side switches is monitored on-chip. In case of short-circuit at an output the maximum current is limited to a level continuously sustainable by the IC. In consequence, the outputs can withstand prolonged short-circuits and still be safely switched off. Additionally, over-temperature protection for each of the output channels is built in. When the over-temperature threshold of 135°C ($t_{junction}$) is exceeded, the respective output channel is automatically turned off. After cooling down, the respective channel is automatically turned on again, provided the microcontroller or control-ASIC has not issued a turn-off command in the meanwhile.

Moreover, to ensure proper switching of the MOSFET output stages, the supply voltage on the process-side (V_{bb}) is monitored. If V_{bb} decreases to a level of 10.5V or less, the outputs are automatically switched off.

For solutions built with switches which do not have an integrated galvanic isolation “loss of ground” on the process-side can become a serious challenge. In such designs both sides of the switching IC share a common ground connection. When loss of ground occurs, the control signals of this switching IC loose their ground reference as well. This can lead to a

situation whereby the switching IC can no longer be turned off. Such situation can not occur with ISOFACE™ switches, since they have the galvanic isolation integrated. When “loss of ground” happens on the process-side the control-side of ISOFACE™ switches remains fully functional. Therefore, even under loss of ground ISOFACE™ switches can reliably be turned off.

To complete the safety concept an extra disable pin is provided. This “emergency off” feature allows the microcontroller or control-ASIC to concurrently turn-off all of the outputs. This is a particularly useful feature if multiple switch ICs are connected to one microcontroller or to one control-ASIC.

In their combination, these features underscore the extreme ruggedness built into the ISOFACE™ switches.

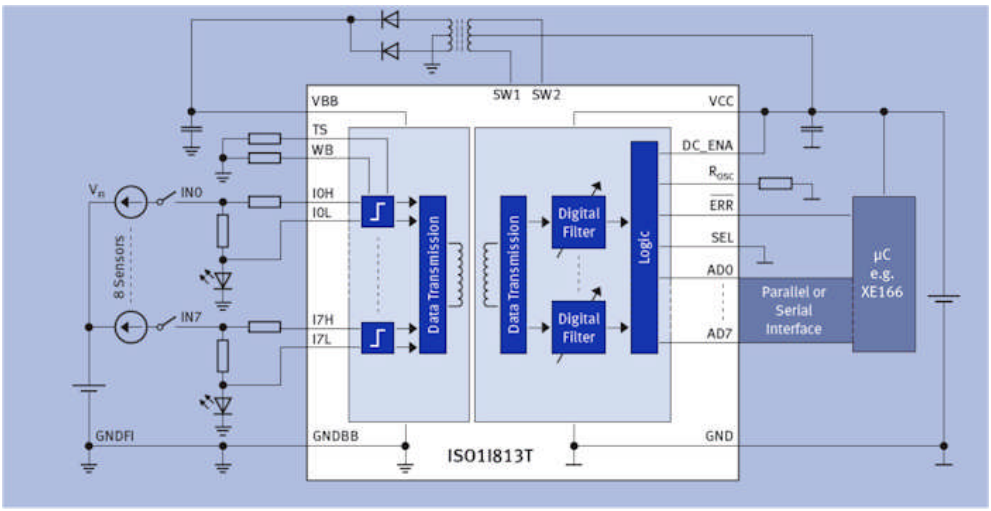
Whilst the safety features work autonomously, the user has visibility to any events. In cases of over-load or over-temperature or insufficient V_{bb} a diagnostic feedback is provided to the microcontroller or control-ASIC. This is a valuable contribution to improve the maintenance support at system level.

Protecting Inputs

Galvanically Isolated Digital Input ICs

With the ISOFACE™ ISO1I81xT product family, up to 8 digital inputs according to IEC61131-2 (Type 1/2/3) can be connected per IC. The IC’s inputs serve as current sinks. A result of their precise current sink characteristics is that the power dissipation per channel is up to 2.5-times lower when compared with legacy solutions using a combination of opto-couplers and passive components. Input status LEDs can be deployed optionally. As a consequence of the lower power dissipation and high level of functional integration system designers can either create very compact input module designs, or alternatively, substantially increase the number of input channels within a given form-factor.

To improve the EMI robustness of the system solution, the 8 input channels are equipped with deglitching filters. In case of the ISO1I811T, jumpers can be used to select one of the four possible settings common to all inputs. The ISO1I813T allows programming of the filter setting individually for each of the channels. Even reprogramming during operation is possible. Common to both products is the bypass mode which sets the deglitching filtering time to zero. The bypass mode offers back-ward compatibility for system solutions that employ a control-ASIC which already has an integrated deglitching filter.



Block diagram 1: Typical application circuit of an ISO1I813T

ISOFACE™ Digital Input ICs flexibly support sampling frequencies in the range from 50 kHz up to 500 kHz, per input channel. This is multiple times higher than the approximately 25 kHz offered with affordable opto-couplers. Within the range supported by ISOFACE™ the system designer can adapt the sampling frequency to the actual system requirements. The high sampling speed is of particular relevance for high-precision or high-speed motor drive applications, like bottling machines, as well as equipment used in the paper and printing industries.

A feature only available with the ISO1I813T is the capability to synchronously capture the input signals from multiple input ICs. This is of significant practical value when an isochronous time-stamp of the status of a complex machine with numerous sensors needs to be gathered.

Comprehensive diagnostics

The diagnostic capabilities of the ISO1I813T include the detection of a wire-break between the IC`s input pins and the sensors or switches connected to it. Since system requirements can vary substantially, the system designer can determine the sensitivity level of the wire-break detection. Interestingly, the wire-break detection can be masked on a channel-specific level. This is an important provision for applications where a hybrid set of inputs is concurrently attached to the same ISO1I813T IC, i.e. sensors which support wire-break detection and those which do not. When wire-break is detected, the microcontroller or control-ASIC receives a respective feedback from the ISOFACE™ Digital Input IC. In a subsequent step it is possible to identify the individual channel where the wire-break occurred.

The ISO1I813T also can monitor the supply voltage on the process-side (V_{bb}) and differentiate between three states. The IC provides an indication for V_{bb} being higher than 16V, this is the normal mode of operation. When V_{bb} drops below 16V, but remains above the 13V level, a so called pre-warning information „V_{bb} under-voltage“ is issued to the microcontroller or control-ASIC. As long as V_{bb} remains above this 13V level the IC is still

operating properly. System designers may decide to use this pre-warning information to change the system's mode of operation or alternatively to safely and in a controlled manner shut down the system. If V_{bb} falls in the range between 13V and 9V the IC is still working, however, the input data collected on the process-side is invalid. This is called the warning range and a "V_{bb} missing voltage" feedback is provided.

Both, the ISO1I811T and the ISO1I813T are equipped with an error pin which indicates "V_{bb} missing voltage", however the trigger levels differ. At the ISO1I811T the error pin becomes active when V_{bb} is below the 13V threshold. At the ISO1I813T the error pin indicates „V_{bb} under-voltage", i.e. V_{bb} is below the 16V threshold, in other words entering the pre-warning range is being flagged.

Both, wire-break monitoring and V_{bb} monitoring greatly improve factory level maintenance support; providing a very valuable contribution to minimize costly machine down-times.

Flexible microcontroller and control-ASIC interfaces

Common to both the switch IC and the digital input IC families is that they support both serial and parallel interfaces to the microcontroller or the control-ASIC. The 8-bit parallel interfacing capability enables system designers to up-grade from opto-coupler solutions to ISOFACE™ without the need to change the control-ASIC. The 4-wire serial interface can be used if smallest possible PCB area is a design criterion. Naturally, the serial interface will also be used when multiple switch ICs or digital input ICs are concatenated in daisy chain mode.

The switch ICs are available either with serial or parallel interface. The digital input products can flexibly be configured by the system designer to either operate in serial or in parallel mode. The ISO1I813T offers an extra level of safety in serial mode, optionally supporting CRC-checking of the serial communication. In case of a CRC error this is being flagged to the microcontroller or control-ASIC by activating the CRCERR pin.

Conclusions

Only the Infineon ISOFACE™ products offer a complete system solution integrating a) an intelligent microcontroller/control-ASIC interface, b) robust galvanic isolation and c) rugged high-side switches or very versatile digital input functionality.

Since the galvanic isolation is based on silicon technology, ISOFACE™ products can durably operate at higher temperatures (+135°C) than opto-coupler solutions. Moreover, the ICs offer a substantial reduction of the quantity of components required to attain a complete system solution. This high level of functional integration leads to significantly improved system stability and reliability. Additionally, the robustness as well as the diagnostic feedback built into ISOFACE™ products greatly improve system safety and provide strong support for system maintenance.

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