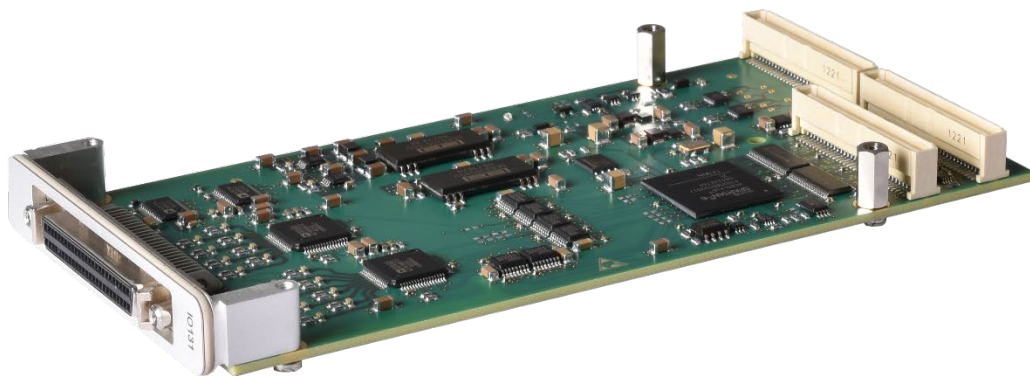


IO131

Analog I/O Module

Hardware Reference Manual



v1.1

speedgoat
real-time simulation and testing

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Document Version History

Version Number	Document Action	Author	Date
1.0	Initial release	MoGr	20 September 2022
1.1	5.1 Pin Mapping: Corrected entry for pin 26	BeSc	01 February 2023

1 Technical Information

Description

The IO131 I/O module is a fast, simultaneous-sampling, 16-bit isolated analog input and output module with Simulink® driver blocks.

The analog input channels can be sampled simultaneously with a constant conversion time, and the analog output channels are updated simultaneously.

The 16 analog inputs offer software selectable ± 5 V and ± 10 V bipolar input voltage ranges with a sampling rate of up to 200 kSPS.

The 8 analog outputs offer software selectable 0-5 V, 0-10 V, ± 5 V and ± 10 V output voltage ranges. The conversion time is typically 10 μ s, resulting in a maximum update rate of 100 kSPS.

This I/O module is ideal for closed-loop controls and hardware-in-the-loop simulations using MATLAB® and Simulink.

Features

Analog Inputs

- Up to 16 channels of simultaneous-sampling, true bipolar differential voltage inputs
- 16-bit resolution
- Up to 200 kSPS
- Software selectable ± 5 V, ± 10 V input range (one setting for all channels)
- Simulink Real-Time™ analog input driver blocks

Analog Outputs

- Up to 8 single-ended, isolated, simultaneous update, unipolar/bipolar outputs
- 16-bit resolution
- 10 μ s settling time
- Software selectable 0-5 V, 0-10 V, ± 5 V, ± 10 V output range (one setting per channel)
- 20 mA current limit
- Simulink Real-Time™ analog output driver blocks

2 Technical Specifications

Physical	
Form factor	PMC
Power requirements	330 mA typical @ +5 V DC
Connectors	50-pin SCSI-2
Analog Input	
Number of inputs	16 voltage inputs
A/D resolution	16 bit
Maximum ADC sample time	Up to 200 kSPS with DMA
Voltage ranges	Software selectable ± 5 V, ± 10 V (one setting for all channels)
Input over voltage protection	16.5 kV, 7 kV ESD rating
Anti-aliasing filter	-3dB cutoff frequency of 32 kHz
Input impedance	1 M Ω
ADC chip	AD7609
Analog Output	
Number of outputs	8 single-ended voltage outputs
D/A resolution	16 bit
Voltage ranges	Software selectable 0-5 V, 0-10 V, ± 5 V, ± 10 V (one setting for all channels)
Output load	Max 2 k Ω 4000 pF per channel
Protection	20 mA current limit, thermal shutdown option, 3.5 kV ESD rating
Settling time	Typ. 10 μ s
DAC chip	AD5754R
Environmental	
Operating temperature	-40 °C to +85 °C
Relative humidity	5 to 95 %, non-condensing
Reliability	
Mean time between failures (MTBF) ^a	544,000 hours

^a MTBF values shown are based on calculation according to MIL-HDBK-217F and MIL-HDBK-217F Notice 2. Environment GB 20 °C. The MTBF calculation is based on component FIT rates provided by the component suppliers. If FIT rates are not available, MIL-HDBK-217F and MIL-HDBK-217F Notice 2 formulas are used for the FIT rate calculation

3 Handling and Operating Instructions

3.1. ESD Protection



The module is sensitive to static electricity. Appropriate care must be taken when packing, unpacking and handling the module.

3.2. I/O Interface Installation



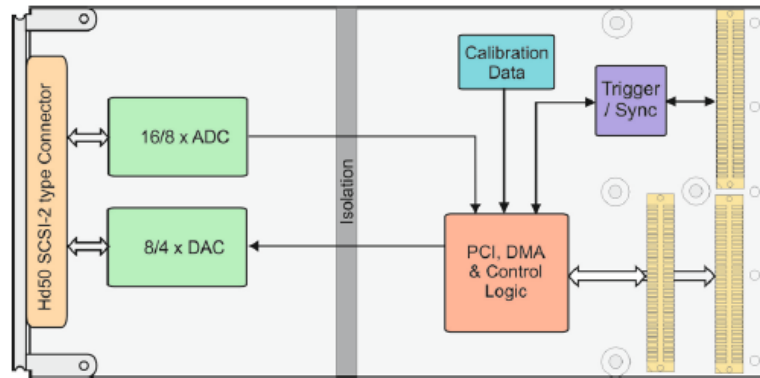
Signals are available on both the front and rear connectors. Only one connector can be used/installed at a time.

3.3. Assembly Recommendations



When removing the module from the carrier board, ensure mechanical stress is kept as low as possible.

4 Functional Description



IO131 I/O module block diagram

4.1. Analog Input

4.1.1. Overview

The 16 analog inputs of the IO131 are implemented with two AD7609 ADC devices. The AD7609 is an 18-bit, 8-channel, true differential, simultaneous sampling analog-to-digital data acquisition system (DAS). The eight analog input channels for each ADC can be configured as either eight single-ended or four differential inputs.

The AD7609 operates from a single 5 V supply and can accommodate ± 20 V and ± 10 V true bipolar differential input signals while sampling at throughput rates of up to 200 kSPS for all channels. Its anti-aliasing filter has a -3 dB cutoff frequency of 32 kHz and provides 40 dB anti-alias rejection when sampling at 200 kSPS.

4.1.2. Input Range

Owing to the ADC's true differential inputs, the ADC data coding differs significantly from a single-ended ADC's data coding.

For analog-to-single-ended inputs, the input voltage range setting directly describes the input voltage range of the ground-related voltages that can be tied to the ADC differential inputs.

With true differential inputs, this results in an extended input voltage range, as the ADC measures the voltage between the Analog Input X (+) and the Analog Input X (-) differential inputs.

Example

If the input voltage range is ± 10 V, then the (single-ended/ground-related) voltage permitted on each ADC input pin is ± 10 V. If we examine the two largest differential voltages, we obtain the following results:

Analog Input X (+) (ground-related input voltage)	Analog Input X (-) (ground-related input voltage)	ADC Input Value (differential input voltage)
+10 V	-10 V	+20 V
-10 V	+10 V	-20 V

The example shows that the range of differential ADC input values is -20 V to +20 V, which results in a full-scale range of 40 V for the ± 10 V input voltage range setting. Similarly, the full-scale range for the ± 5 V input voltage range setting is 20 V.

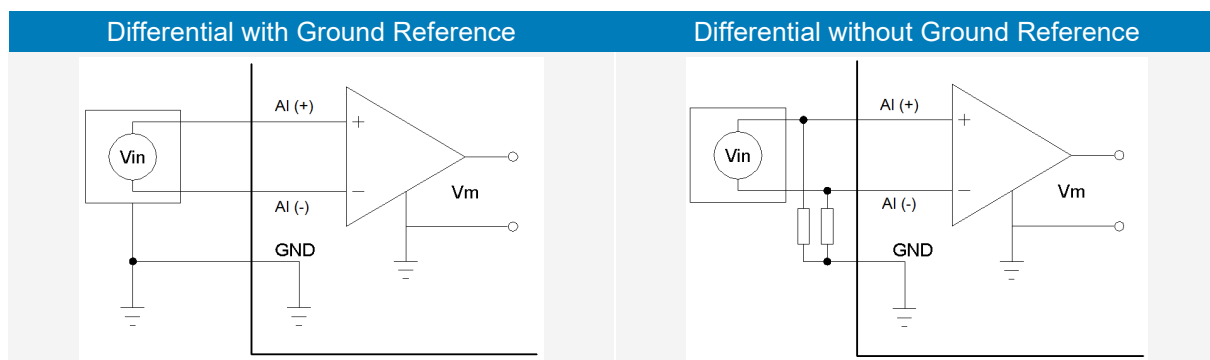
Description	± 5 V	± 10 V
Full-scale range	20 V	40 V
Least significant bit	305.18 μ V	610.35 μ V
Full scale (pos.)	9.999695 V	19.99939 V
FSR - 1LSB	9.99939 V	19.99878 V
Midscale + 1LSB	305.18 μ V	610.35 μ V
Midscale	0 V	0 V
Midscale - 1LSB	-305.18 μ V	-610.35 μ V
-FSR + 1LSB	-9.999695 V	-19.99939 V
Full scale (neg.)	-10 V	-20 V

4.1.3. Voltage Input Interface

The electrical interface of the IO131 Analog Input channels is defined by the following characteristics:

Protection	7 kV ESD rating on analog input channels ± 16.5 V overvoltage protection
Maximum ground-related input voltage	± 5 V and ± 10 V
Input impedance	1 M Ω
Input capacitance	5 pF
Maximum ground-related input voltage	± 5 V and ± 10 V
Full-scale range	± 10 V and ± 20 V
Common-mode input range	± 5 V
Sample rate	200 kSPS

ADC Electrical Interface



ADC Input Schemes

If signals without a ground reference are connected to the I/O module, connect Analog Input (+) and Analog Input (-) to GND with a resistor to prevent the signal source from floating out of the ADC common-mode range. In most cases the Analog Input (-) connection suffices.

Important: Unused input channels should be connected to GND.

4.2. Analog Output

4.2.1. Overview

The eight analog output channels of the IO131 are implemented with two AD5754R DAC devices. This DAC is a quad 16-bit serial input, voltage output device that provides software selectable, nominal full-scale output ranges from +5 V, +10 V, ± 5 V or ± 10 V.

4.2.2. Voltage Range

Description	+5 V	+10 V	+10.8 V
Full-scale range	+5 V	+10 V	+10.8 V
Least significant bit	76.295 μ V	152.59 μ V	164.79 μ V
Full scale (pos.)	4.999924 V	9.999847 V	10.799835 V
FSR - 1LSB	4.999847 V	9.999695 V	10.79967 V
Midscale + 1LSB	2.500076 V	5.000153 V	5.400165 V
Midscale	2.5 V	5 V	5.4 V
Midscale – 1LSB	2.499924 V	4.999847 V	5.399835 V
-FSR + 1LSB	76.295 μ V	152.59 μ V	164.79 μ V
Full scale (neg.)	0 V	0 V	0 V

Unipolar output range data coding

Description	± 5 V	± 10 V	± 10.8 V
Full-scale range	± 5 V	± 10 V	± 10.8 V
Least significant bit	152.59 μ V	305.18 μ V	329.59 μ V
Full scale (pos.)	4.999847 V	9.999695 V	10.79967 V
FSR - 1LSB	4.999695 V	9.99939 V	10.79934 V
Midscale + 1LSB	152.59 μ V	305.18 μ V	329.59 μ V
Midscale	0 V	0 V	0 V
Midscale – 1LSB	-152.59 μ V	-305.18 μ V	-329.59 μ V
-FSR + 1LSB	-4.999847 V	-9.999695 V	-10.79967 V
Full scale (neg.)	-5 V	-10 V	-10.8 V

Bipolar output range data coding

4.2.3. Analog Output Interface

Protection	3.5 kV ESD rating 20 mA current limit
Output type	Unipolar/bipolar single-ended
Output voltage ranges	± 5 V, ± 10 V, +5 and, +10 V
DC output impedance	0.5 Ω
Maximum load	2k Ω
Capacitive load	4000 pF
Settling time	10 μ s

DAC Electrical Interface

The I/O module provides an "Automatic Channel Power-Down" feature for the DACs. If a DAC channel overcurrent occurs, the DAC channel is powered down and its output is clamped to ground with a resistance of ~4 kΩ.

After power-on, a 0 V is present at the output of each channel. During download of the model, signals in the defined output range may be present at the output.

4.3. Data Correction

There is an individual offset correction value and an individual gain correction value for each input channel and each output channel for each voltage range.

The following formula is applied by the IO131 I/O module when data correction for input and output channels is enabled:

$$Data_Corrected = Data \cdot \left(1 - \frac{Gain_{CORR}}{262144} \right) - \frac{Offset_{CORR}}{4}$$

- *Data* = the digital value that would be used if the ADC channels and DAC channels were ideal
- *Data_Corrected* = the corrected digital value that must be used with the real ADC channels and DAC channels
- *Gain_{CORR}* and *Offset_{CORR}* = the correction values for each channel

Data correction can be enabled by software for all channels.

4.4. Inter-Module Synchronization

Both ADC and DAC offer programmable sample clocks. With this, external synchronization of the modules is possible, using rear I/O pins. For more information about the rear I/O connection for inter-module synchronization, please contact Speedgoat.

To activate inter-module synchronization, one IO131 must be set as the initiator, the other modules are configured to be the targets.

A trigger impulse must be at least 25 ns long to be detected. The Sync output pulse duration is 100 ns.

4.5. Continuous Sampling Mode

When the sample timing is not crucial but recent data must always be available, a "continuous sampling mode" can be selected in the Analog Input tab of the Setup block mask in Simulink. Note that the Sample Clock is null (or smaller than 5 μs). In this mode, the ADCs/DACs are continuously converting. The ADCs will write the conversion data into the ADC Data Registers, the DACs will use the values from the DAC Data Registers, using the old values if they are not updated.

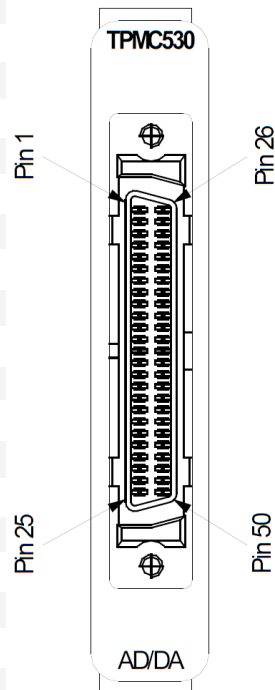
This mode means that recent data is always available without having to start and control the conversions.

5 I/O Connector

Pin count	50 pins
Connector type	HD50 SCSI-2 type female connector (e.g. AMP# 787395-5)
Mating Cable Connector	Tyco Electronics part no. 5749069-5

5.1. Pin Mapping

Signal	Dir	Pin
GND		1
Analog Input 1 (+)	IN	2
Analog Input 2 (+)	IN	3
Analog Input 3 (+)	IN	4
Analog Input 4 (+)	IN	5
Analog Input 5 (+)	IN	6
Analog Input 6 (+)	IN	7
Analog Input 7 (+)	IN	8
Analog Input 8 (+)	IN	9
Analog Input 9 (+)	IN	10
Analog Input 10 (+)	IN	11
Analog Input 11 (+)	IN	12
Analog Input 12 (+)	IN	13
Analog Input 13 (+)	IN	14
Analog Input 14 (+)	IN	15
Analog Input 15 (+)	IN	16
Analog Input 16 (+)	IN	17
GND		18
Analog Output 1	OUT	19
Analog Output 3	OUT	20
Analog Output 5	OUT	21
Analog Output 5	OUT	22
GND		23
GND		24
GND		25



Signal	Dir	Pin
GND		26
Analog Input 1 (-)	IN	27
Analog Input 2 (-)	IN	28
Analog Input 3 (-)	IN	29
Analog Input 4 (-)	IN	30
Analog Input 5 (-)	IN	31
Analog Input 6 (-)	IN	32
Analog Input 7 (-)	IN	33
Analog Input 8 (-)	IN	34
Analog Input 9 (-)	IN	35
Analog Input 10 (-)	IN	36
Analog Input 11 (-)	IN	37
Analog Input 12 (-)	IN	38
Analog Input 13 (-)	IN	39
Analog Input 14 (-)	IN	40
Analog Input 15 (-)	IN	41
Analog Input 16 (-)	IN	42
GND		43
Analog Output 2	OUT	44
Analog Output 4	OUT	45
Analog Output 6	OUT	46
Analog Output 8	OUT	47
GND		48
GND		49
GND		50

6 Legal

As used herein, the term "Seller" shall mean Speedgoat GmbH, and term "Buyer" shall mean the person, firm or corporation executing a purchase order for "goods", sold by Seller (hereinafter "Products").

6.1. Limited Warranty

Seller warrants that the Products delivered hereunder shall be free from defects in workmanship and material under normal use and wear in accordance with Seller's instructions and specifications for a period of twenty-four (24) months from date of delivery to the Buyer, including component parts of Products sold as spare, replacement, maintenance or storage parts, which are also warranted for twenty-four (24) months from date of delivery, provided, however, in either case, that notice of any such defect is provided to Seller within thirty (30) days of its discovery by the Buyer. THE WARRANTY SET FORTH IN THIS SECTION SHALL BE IN LIEU OF ALL OTHER WARRANTIES, AND ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO WARRANTY OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE, AND FITNESS FOR ORDINARY PURPOSE USED OR PURPOSE INTENDED, ARE EXCLUDED. IN NO EVENT SHALL SELLER, ITS EMPLOYEES OR SUPPLIERS BE LIABLE, EITHER DIRECTLY OR BY WAY OF INDEMNIFICATION, TO BUYER OR ANY THIRD PARTY FOR (A) AN AMOUNT EXCEEDING THE PURCHASE PRICE OF THE PRODUCT IN QUESTION AND (B) ANY PUNITIVE, EXEMPLARY, SPECIAL, INDIRECT OR CONSEQUENTIAL LOSSES, DAMAGES OR INJURIES regardless of whether such claim is based upon delays in delivery or payment, breach of warranty, breach of contract, strict liability, negligence, or any theory now known or hereinafter adopted by legislation or by any court. Neither Seller nor its affiliates shall be liable for any damage or loss to exposure of Products and/or their packaging to the elements (including but not limited to rain, snow, sleet, sun, wind, floods, etc.); chemicals, corrosive solvents or soils; unauthorized or improper use, maintenance, storage or repair; due to any failure to follow Seller's manuals, warnings, notices or instructions; or due to any malfeasance, recklessness or negligence by Buyer, any employee or customer of Buyer or any other third party.

EXCLUSIVE REMEDY: In any event, the Buyer's exclusive remedy hereunder is limited to the furnishing of replacement parts on an exchange basis, or, at the option of Seller, to the repair or replacement of defective Products or replacement parts at one of Seller's locations, but in either case only if the defective Product or part has been submitted to Seller during the period of warranty. The Buyer accepts and acknowledges that the foregoing allocation of risk is reflected in the purchase price.

The parties further agree that if any portion of the foregoing exclusion of damages is held to be voidable or void by reason of public policy or unenforceable for any other reason whatsoever, all remaining portions of the foregoing exclusion shall continue in effect.

THE WARRANTY SET FORTH ABOVE DOES NOT EXTEND TO: Any systems which have been damaged or rendered defective as a result of accident, misuse, or abuse; by the use of parts not manufactured, authorized or sold by Seller; by modification or as a result of service by anyone other than Seller; systems not containing original components or original replacement of components; damage during shipment, unless due to incorrect packaging by Seller; systems which fail or are damaged after delivery due to shipment, handling, storage, operation, use or maintenance in manner or environment not conforming to any published instructions or specifications issued by Seller.

In-warranty repaired or replacement parts or Products are covered by warranty only for the remaining unexpired portion of the original warranty period applicable to the repaired or replaced parts or Products. In other words, repair or replacement of Products or parts under warranty does not extend the original warranty period.

Products that are no longer part of the regular sales offering are considered EOL (end-of-life) and are repaired on a best-effort basis.

EXTENDED HARDWARE WARRANTY SERVICE

Extended Hardware Warranty Service is available as an option and must be purchased at the time the Products are purchased for which the warranty shall be extended.

The **Level One Hardware Warranty Service** extends the standard 24-month warranty period by 12 months resulting in a 36-month warranty period.

The **Level Two Hardware Warranty Service** extends the standard 24-month warranty period by 36 months resulting in a 60-month warranty period.

Hardware warranty terms exceeding the 60-month range are available on request.

6.2. Return

Buyer shall not return any Product without Seller's prior written consent. An R.M.A. (Return Material Authorization) number issued by Seller must accompany all returned material. An RMA number can be obtained by contacting the Seller's support department (support@speedgoat.com).

Within Warranty, Products returned and needing corrective repair are serviced at no-charge in accordance with the terms of Seller's Warranty policy.

Repairs on out of Warranty Products are performed at Buyer's expense.

Please pack the returned Products in their original shipping cartons, or in equivalent strong protective shipping cartons. Shipping costs from Buyer to Seller associated with warranty repairs or replacements shall be borne by the Buyer. Shipping costs for the return of repaired goods from Seller to Buyer shall be borne by Seller.

6.3. Systems Software Maintenance and Support Services

Delivery of Seller systems and hardware/software components by default include 12 months (1 year) of Systems Software Maintenance and Support Services.

Subscription to Systems Software Maintenance and Support Services includes access to Seller tools and driver software compatible with future releases of MathWorks software and professional technical support by phone and e-mail.

Subscription to Systems Software Maintenance and Support Services does not include free updates of existing custom implementations (FPGA bitstreams).

Software Maintenance and Support Renewal

For uninterrupted Systems Software Maintenance and Support Services in subsequent years Buyer may opt to renew its subscription annually to maintain its investment. Reinstatement if elapsed is possible on request, but incurs back maintenance charges of up to 6 months. Staying subscribed is the most cost-effective way to access latest advances and technical support.

6.4. Use of Speedgoat Software Including Tools and Drivers

LEGAL INFORMATION ABOUT THE USE OF SPEEDGOAT TOOLS AND DRIVERS: Speedgoat tools and drivers are optimized for hardware purchased from Seller and may be used only in conjunction with the hardware (serial no.) for which the tools and drivers were purchased for. Access to the Speedgoat tools and drivers is only available if the target machine component has active subscription to Systems Software Maintenance and Support Services.

Terms and Conditions for software components are defined in the Speedgoat End-User License Agreement (EULA).

7 Contact Information

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