
USER'S MANUAL

I/O Module

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1 Introduction

The I/O Module is an optional add-on to the iC5000 emulator.

It provides the capability to measure digital and analog signals as well as drive them.

Input signals can be read out asynchronously from winIDEA IDE or by external applications and scripts using the ***isystem.connect*** interface. A real-time capture, alongside the on-chip trace or standalone, is also possible.

Output signals can likewise be driven from the IDE or via ***isystem.connect***. Beside simple assertion of an output, one or more outputs can be driven by a state machine based waveform generator, which can be triggered by input signals.

testIDEA uses ***isystem.connect*** interface to assert outputs prior to the test and verify inputs after the test.



1.1 Ordering codes

iSYSTEM offers two I/O Modules featuring different sets of ports. Refer to the chart below for more information about the differences between the modules.

- **IC50011** (Standard I/O Module – IOM2),
- **IC50014** (24-port digital I/O Module – IOM2-D)

1.2 Hardware Features

Feature	IOM2	IOM2-D
System Port: Trace trigger output, 100ohm series termination	Yes	Yes
Digital inputs: 10kOhm input impedance, 5V tolerant, ESD protected	8	24
Digital outputs: 100ohm output series termination, ESD protected	8	8
Analog inputs: 8-bit ADCs, 1MSPS, 1MOhm input impedance, range is $\pm 5.0V$ with 1:1 probe, $\pm 50V$ with a 10:1 probe, 3ns acquisition time. Power measurement probe uses these two inputs for power measurement.	2	
Analog outputs: 8-bit DACs, $\pm 4.5V$ bipolar output, $\pm 7mA$ drive, 100ohm output resistance	2	2
Current Sense Port: For power measurement via Power Probe	Yes	
10MHz temperature compensated precision oscillator TCXO for a high accuracy long duration trace/analyzer session measurements	Option	Option

All digital signals are 3.3V LVTTTL compatible and are ESD protected.

All analog signals have a Schottky diode over- / undervoltage protection, except the Current Sense signals.

The maximum voltage on the Current Sense probe is 60V.

Nominal sampling rate of all inputs and outputs is 1MSPS.

1.2.1 Connectors

1.2.1.1 IOM2

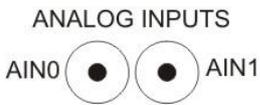


CURRENT SENSE			
RS1+	AIN	GND	CTL
RS1-		GND	

ANALOG OUTPUTS		
AOUT0		AOUT1
GND		

DIGITAL OUTPUTS							
O0	O1	O2	O3	O4	O5	O6	O7
GND							

IOM2



DIGITAL INPUTS							
I0	I1	I2	I3	I4	I5	I6	I7
GND							

SYNCHRONIZATION		
RESET	STOP	TO
GND		

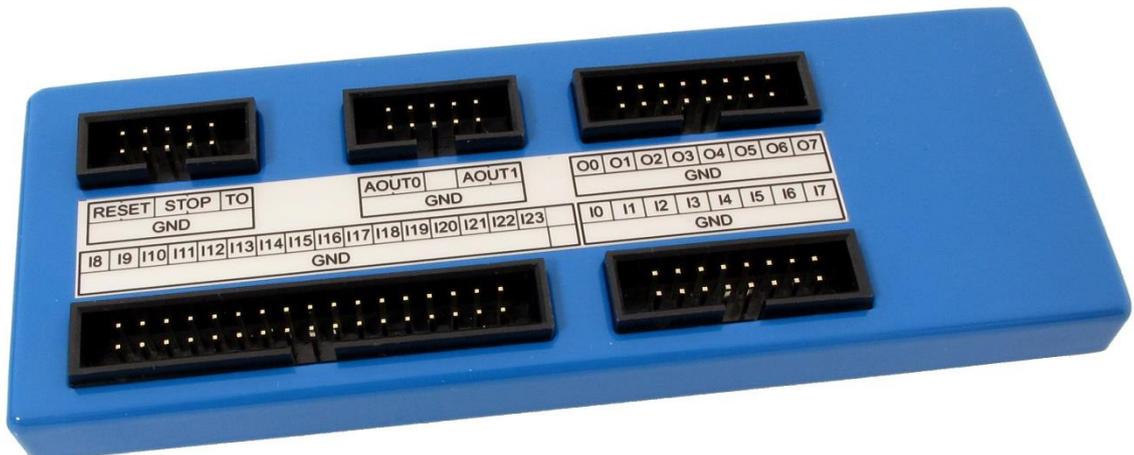
Connector Pinout

- 10-pin header for the System Port.
- 16-pin header for 8 digital inputs.
- 16-pin header for 8 digital outputs.
- 10-pin header for 2 analog outputs.
- 2 BNC connectors for 2 analog inputs.
- 10-pin header for Power Measurement Port (rev. C and later).

All connectors, except the BNCs, are standard Berg 2.54mm / 100mils raster.

For analog inputs, standard scope probes can be used.

1.2.1.2 IOM2-D



SYNCHRONIZATION

RESET	STOP	TO
GND		

ANALOG OUTPUTS

AOUT0	AOUT1
GND	

DIGITAL OUTPUTS

O0	O1	O2	O3	O4	O5	O6	O7
GND							

IOM-D

DIGITAL INPUTS

I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18	I19	I20	I21	I22	I23
GND															

DIGITAL INPUTS

I0	I1	I2	I3	I4	I5	I6	I7
GND							

- 10-pin header for the System Port.
- 16-pin header for 8 digital inputs.
- 32-pin header for 16 digital inputs.
- 16-pin header for 8 digital outputs.
- 10-pin header for 2 analog outputs.

All connectors are standard Berg 2.54mm / 100mils raster.

2 Usage

2.1 Connecting External Signals

2.1.1 Input Signal Adaptation

When connecting to external signals please make sure not to exceed the specified input and output range of the IOM signal interface. If the digital input source voltage is higher than 5V, please condition the signal source with a suitable resistor divider, or a resistor-zener diode limiter.

In case, for example, a 24V source is connected directly to a module digital input, an excess input current of about 18mA will flow through an input 1K resistor and a diode in the ESD protection device to the module internal 5V power supply.

Although this may not sound catastrophic, it must be avoided. Any long-term exposure will lead to a degradation of the module electronics due to electromigration.

On the other hand, if an analog input signal amplitude is smaller than the module input analog range, it is recommended to add a suitable amplifier to make use of the full A/D converter resolution.

2.1.2 Power Measurement

When the IOM is switched to Power Measurement mode (*Hardware/Options/ IO* dialog, *Use AIN0/AIN1 for Power Measurement*), the **AIN0** is used for voltage measurement and **AIN1** for current measurement.

For voltage measurement

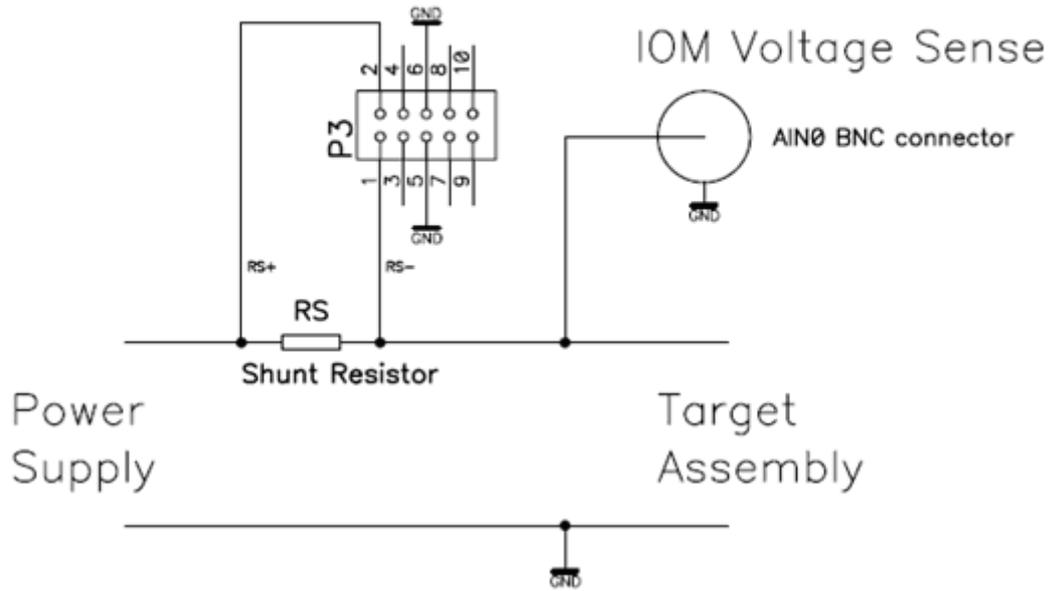
- Connect **AIN0** input to the target voltage at the **RS-**. That's the low side of the target shunt resistor.
- If the voltage is higher than 5V, use a suitable resistor divider. Enter the divider ratio as a *Voltage/Multiply* factor in the configuration dialog.

For current measurement

- Disconnect the **AIN1** from other sources
- Use the **Current Sense** connector to connect the **RS+** and **RS-** pins to a high side and a low side of the target shunt resistor, respectively.
- Specify the resistance of the **RS** shunt resistor in the configuration dialog.

This schematic depicts correct power measurement setup.

IOM Current Sense

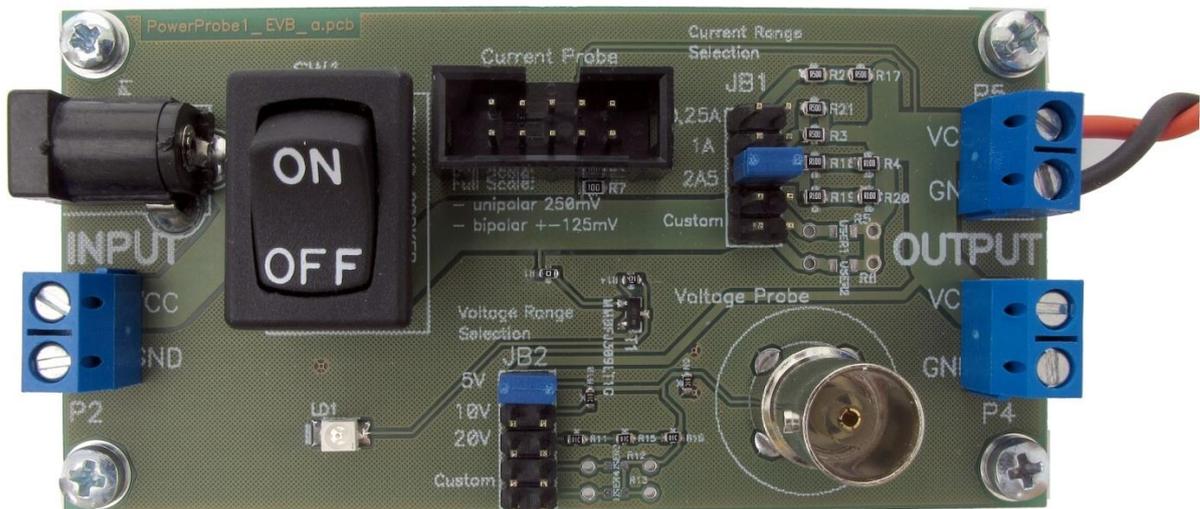


Note: The full-scale shunt voltage range is 250mV. So, for example, a 1Ω shunt resistor gives a current range of 250mA.

Full-scale Shunt Voltage	Shunt Resistance	Full-scale Current Range	Shunt Power Dissipation
250mV	1.00 Ω	0.25A	0.063W
250mV	0.25 Ω	1.00A	0.250W
250mV	0.10 Ω	2.50A	0.625W

2.1.3 Power Probe

The **PowerProbe** is an optional power interface board. It is to be connected between a target power supply and a target board itself. Additional connections are to be made for the IOM current and voltage probes.



2.1.3.1 Connectors, Jumpers and a Switch

P1 and P2

Target power supply inputs. Use one or the other. Maximum voltage is 20V.

P3

10-pin Berg connector to connect the IOM **Current Probe**.

P4 and P5

Power supply output towards the target.

ST1

BNC connector for the IOM Voltage Probe. To be connected to the **AIN0** analog input.

JB1

Jumper block for selecting different shunt resistors.

Note:

- 1) Excessive current will burn the resistors.
 - 2) Never set more than one jumper position at a time.
 - 3) Selected shunt resistors must handle the heat generated by the power dissipated on them.
-

Three of the five available positions are populated with resistors:

Position	Shunt Resistance	Shunt Resistance including JB1
0.25A	1.00 Ω	1.00 Ω
1A	0.25 Ω	0.26 Ω
2A5	0.10 Ω	0.11 Ω

The remaining two positions are available for a custom user setup with unpopulated resistors R5 and R6.

Note that with lower shunt resistor values also the JB1 jumper resistance starts to play a role and may influence the measurement. This can be easily compensated by slightly increasing the shunt resistance value in the winIDEA setup dialog, by 0.01 Ω , for example.

JB2

Jumper block for selecting different voltage ranges.

Note: 1) Never set more than one jumper position at a time.

Three of the five available positions are populated with resistor dividers:

Position	Resistors	Voltage Multiply (configuration)
5V	0/10k Ω	1
10V	10/10k Ω	2
20V	30/10k Ω	4

The remaining two positions are available for a custom user setup with unpopulated resistors **R12** and **R13**. The lower part of the voltage divider is set by the **R9** of 10k Ω .

SW1

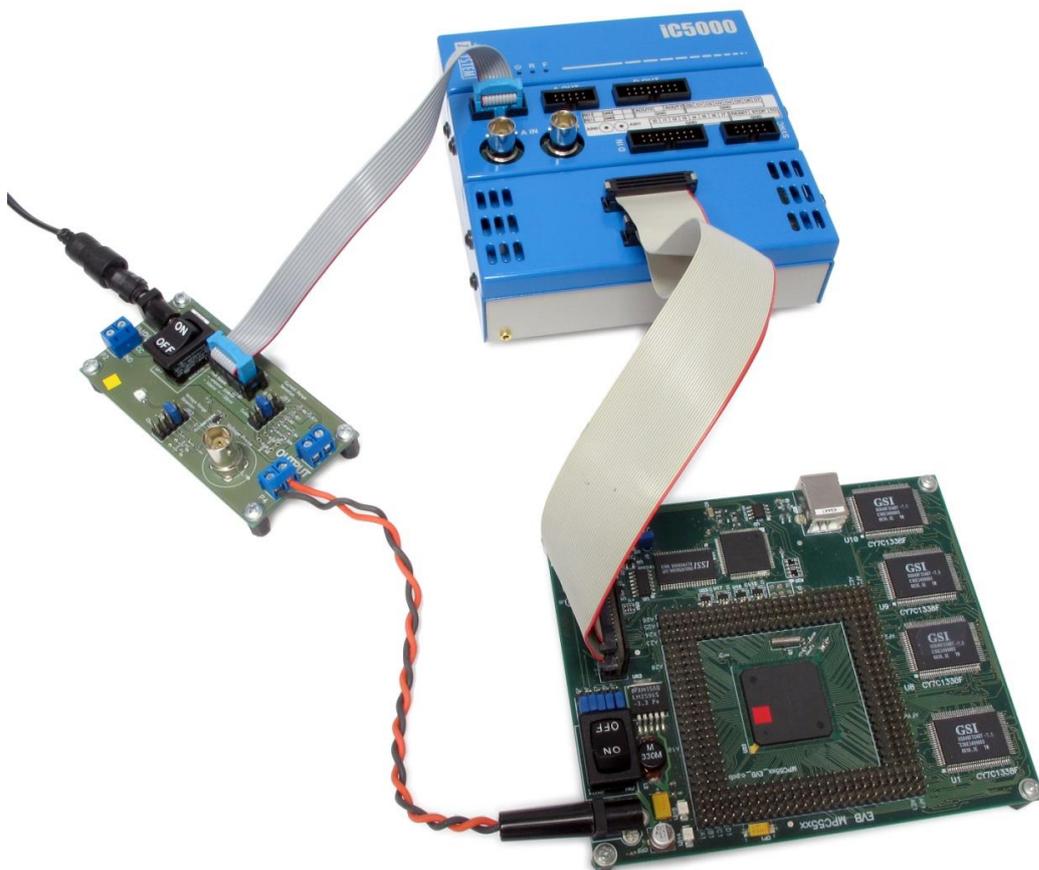
Switches target power on or off.

LD1

Power LED. Note that the LED needs a very small current to light and may glow because of a parasitic current flowing, for example, when the emulator switched on and the target is off.

2.1.3.2 Connection Procedure

- Switch off target and emulator
- Power down the target supply
- Select 2.5A or higher target current range to be on the safe side
- Select 20V voltage range
- Set SW1 to OFF position
- Connect target supply to P1 or P2
- Connect target to P4 or P5
- Connect the ST1 voltage probe to the IOM AIN0 input
- Connect P3 to the IOM Current Sense connector
- Switch emulator on
- Switch target supply on
- Switch SW1 to ON position
- Now, you are set to go.



In case the target current and/or voltage are below the other given ranges, repeat the procedure above and select appropriate ranges to improve resolution of the measurement.

2.1.3.3 Verification

To verify that the displayed voltage and current values are correct, use an independent voltage and current measurement instrument.

2.2 Configuration

I/O module configuration is performed in **Hardware/Options** dialog.

Hardware Options

I/O

Digital IN: 0 - 7

Show	Name
<input checked="" type="checkbox"/>	0 DIN0
<input checked="" type="checkbox"/>	1 DIN1
<input checked="" type="checkbox"/>	2 DIN2
<input checked="" type="checkbox"/>	3 DIN3
<input checked="" type="checkbox"/>	4 DIN4
<input checked="" type="checkbox"/>	5 DIN5
<input checked="" type="checkbox"/>	6 DIN6
<input checked="" type="checkbox"/>	7 DIN7

Digital OUT

Driver	Name	Initial state
Manual	extHold	HIGH
Manual	DOUT1	LOW
Manual	DOUT2	LOW
Manual	DOUT3	LOW
Manual	DOUT4	LOW
Manual	DOUT5	LOW
Manual	DOUT6	LOW
Manual	DOUT7	LOW

Analog IN

Show	Name	Multiply
<input checked="" type="checkbox"/>	AIN0	1
<input checked="" type="checkbox"/>	TempLvl	1

Multiplier specifies by how much the detected input is multiplied.
If signal is externally divided by 10, set multiplier to 10.

Average 4 samples

Analog OUT

Driver	Name	Initial state
Manual	AOUT0	0 V
Manual	AOUT1	0 V

Trace Sampling

Qualifier: Every clock

Mode: All IN and OUT

Show Outputs in Analyzer

Power Measurement

Use AIN0/AIN1 for power measurement

Current Shunt Resistor: 1 Ohm

Power Probe table	
0.25A	1.00 Ohm
1A	0.26 Ohm
2.5A	0.11 Ohm

Control

CTRL0: LOW HIGH

Note: these are the startup setting which take effect at download time.
For live manipulation open: Hardware/Tools/IO Module

OK Cancel Help

All signals are accessible (HIL interface) by a **configurable symbolic name**. I/Os are mapped as follows:

I/O	HIL Mapping	Example
Digital IN	DIN.<name>	DIN.DIN0
Digital OUT	DOUT.<name>	DOUT.extHold
Analog IN	AIN.<name>	AIN.TempLvl
Analog OUT	AOUT.<name>	AOUT.AOUT1

2.2.1 Inputs

Show

If set, the Input will be shown in the Measurement plugin and via HIL interface.

2.2.1.1 Analog IN

Multiply

Multiplier specifies by how much the detected input is multiplied.

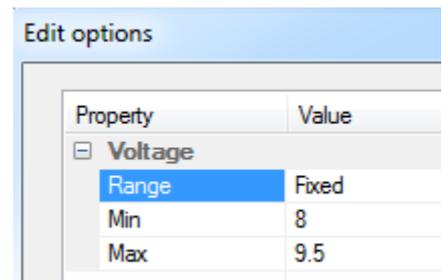
If a signal is externally divided by 10, set the multiplier to 10.

Advanced configuration

The  button next to signal name allows further configuration of an analog signal.

Range setting provides means to display an analog signal scaled to the range of interest.

- **Full** the signal is scaled between minimum and maximum measurable range
- **Fixed** the signal is scaled between the configured **Min** and **Max** values
- **Auto** the signal is scaled between minimum and maximum recorded values



2.2.2 Outputs

Driver

An output can be driven manually (e.g. via script or Manipulation Dialog), via Pattern engine or both.

Driver	Effect
Disabled	The output cannot be driven
Manual	The output can be driven manually only
Pattern	The output can be driven by the pattern engine only
Both	The output can be driven manually and by the pattern engine

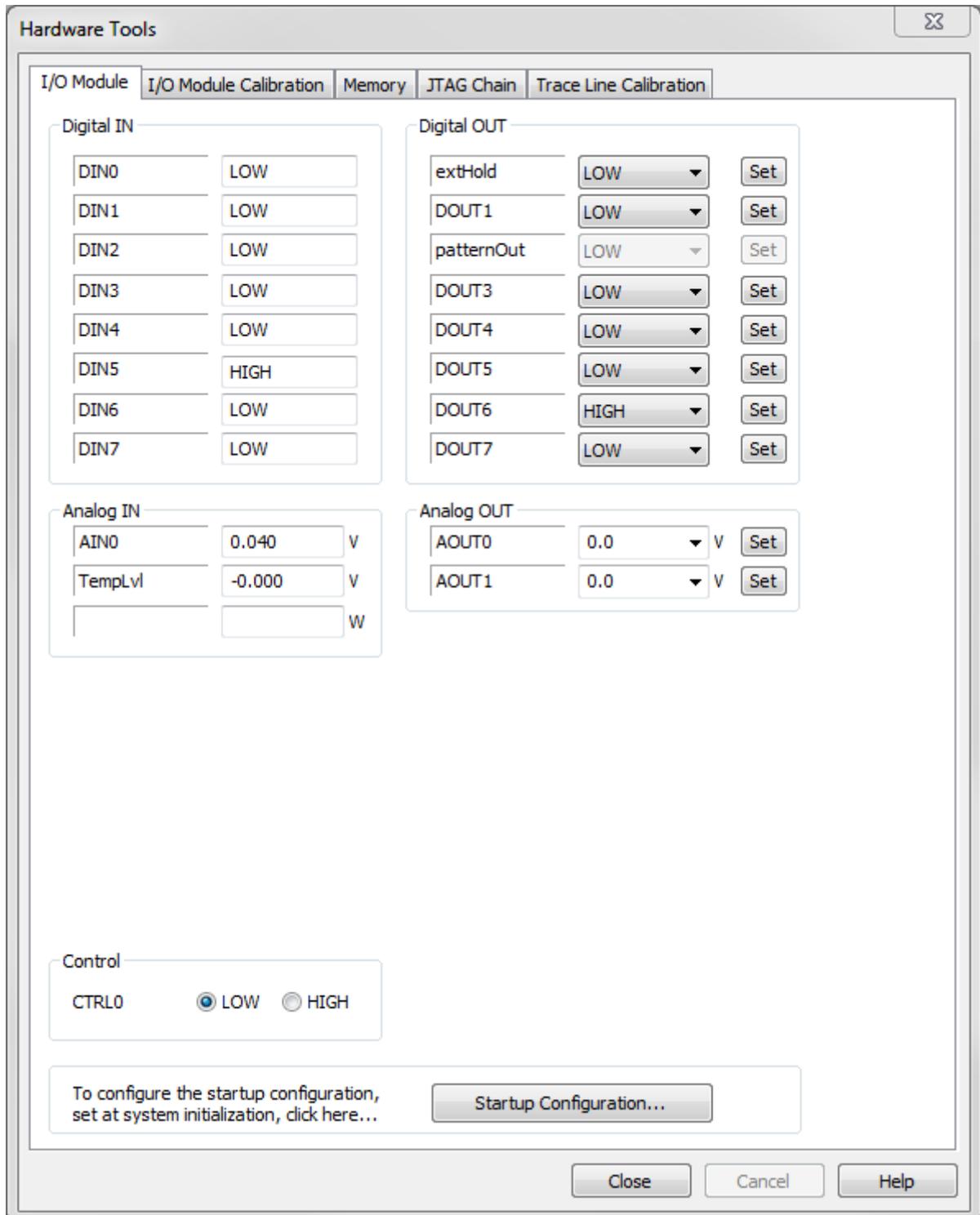
Initial state

When the I/O module is initialized, the outputs will assume the specified initial state.

2.3 Monitoring Inputs and Manipulating Outputs

2.3.1 Manipulation Dialog

The **Hardware/Tools/I/O Module** dialog provides the monitoring and manipulation capability of the I/O Module.



2.3.1.1 Inputs

For all inputs (Digital IN, Analog IN) the currently detected state is displayed and periodically refreshed.

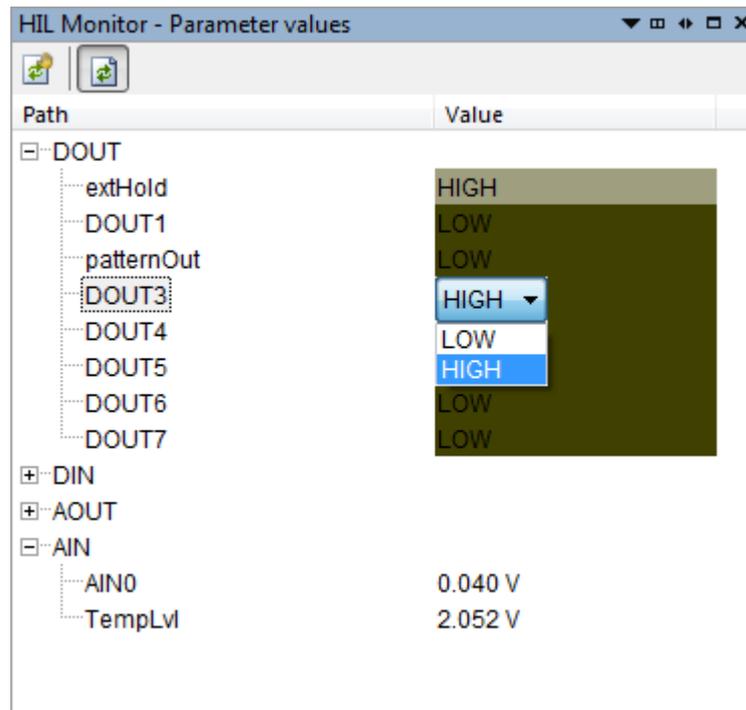
2.3.1.2 Outputs

Digital and Analog outputs which can be **manually** driven, can be asserted to the specified value.

Note: the value is asserted when the **Set** button is clicked.

2.3.2 HIL Monitor Plugin

Plugin/HIL Monitor provides the monitoring and manipulation capability of the I/O Module.



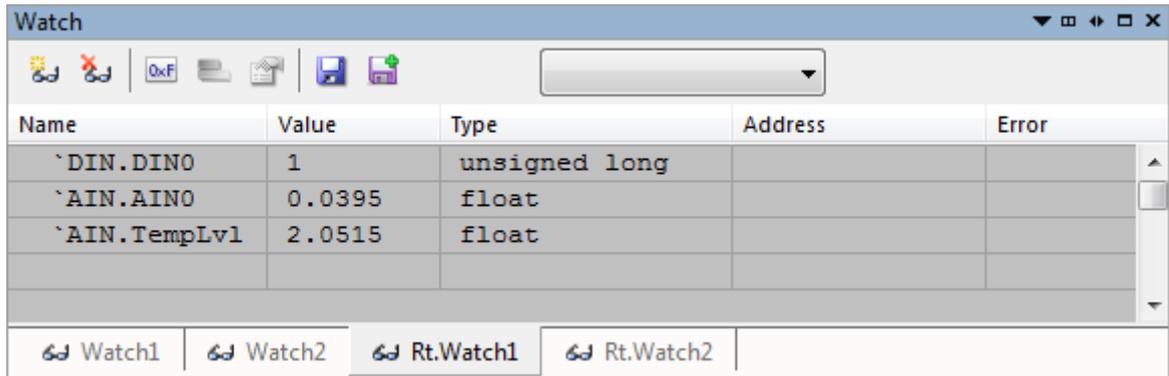
To modify an output, double click its value in the **Value** column.

To refresh the inputs manually, click the  icon.

To refresh the inputs automatically, enable the  icon.

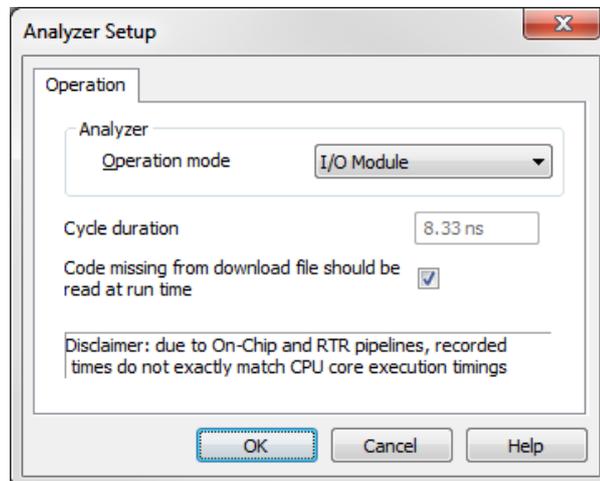
2.3.3 Watch Window and Evaluation Expressions

HIL variables can be added to the watch window (including standard expressions), by using the **grave accent `** prefix.



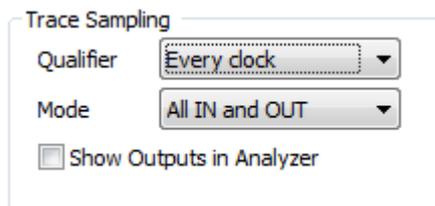
2.3.4 Trace

I/O module trace is supported either in combination with the trace port or stand alone. Open **Hardware / Analyzer Setup** dialog and choose either one of the trace ports or the I/O module:



Note: It is not possible to use I/O module trace in combination with the on-chip trace buffer, because the I/O module trace messages can not be synchronized to the MCU's trace messages in such case.

All Input signals are sampled simultaneously. The sampling is configured in the **Hardware / Options** dialog.



Qualifier

Qualifier defines an additional filter for sampling.

- Every clock – a sample is taken at every 1MHz internal clock
- Every 4 / 16 / 64 clocks – a sample is taken at a divided rate

- On change – a sample is taken only when the states on the input lines change. This reduces the amount of recorded data.

Note: only input lines which are not *disabled* in the **Hardware/Options** dialog are monitored for change.

Mode

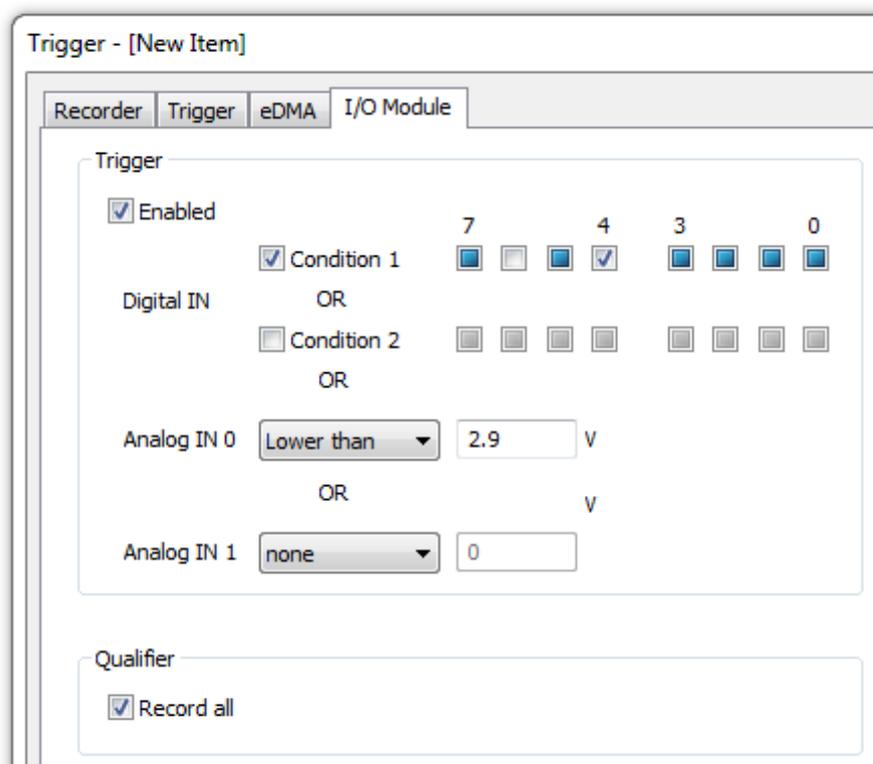
- **All IN and OUT** – all input and output lines are sampled
- **Direct DIN0-3** – digital inputs 0-3 are sampled at 10MHz rate. **On change** qualifier is used in this case. Note that other inputs and outputs are not operational in this mode.

Show Outputs in Analyzer

If this option is checked, the **output channels** will be **available in the Analyzer**. If not, only input channels are available.

2.3.4.1 Trigger configuration

Beside recording the I/O module signals, the I/O module can generate a trigger for the iC5000 trace engine. Configuration is available in the **manual trigger configuration** dialog of the Analyzer window.



2.3.4.1.1 Trigger

Trigger determines the condition upon which the I/O module will signal the iC5000 to start recording.

Enabled

Enables the I/O module trigger output to the emulator trace engine.

Digital IN

Digital inputs 0 – 7 can be a trigger source. Two combinations of digital inputs (Condition 1 and Condition 2) can be defined.

- trigger if this input is in low state
- trigger if this input is in high state
- do not consider this input in the trigger condition

A condition is fulfilled if the enabled inputs match the configured value.

The trigger will be generated if either of enabled Conditions matches.

In the above example, trigger is generated if DIN4 is high and DIN6 is low, or AIN0 is below 2.9V.

Analog IN 0 and 1

Both analog inputs can be a trigger source. The trigger is generated if the measured voltage is **Lower** or **Higher** than the specified threshold.

2.3.4.1.2 Qualifier

Qualifier determines the type of I/O module acquired information which is recorded in the trace buffer and streamed to the host.

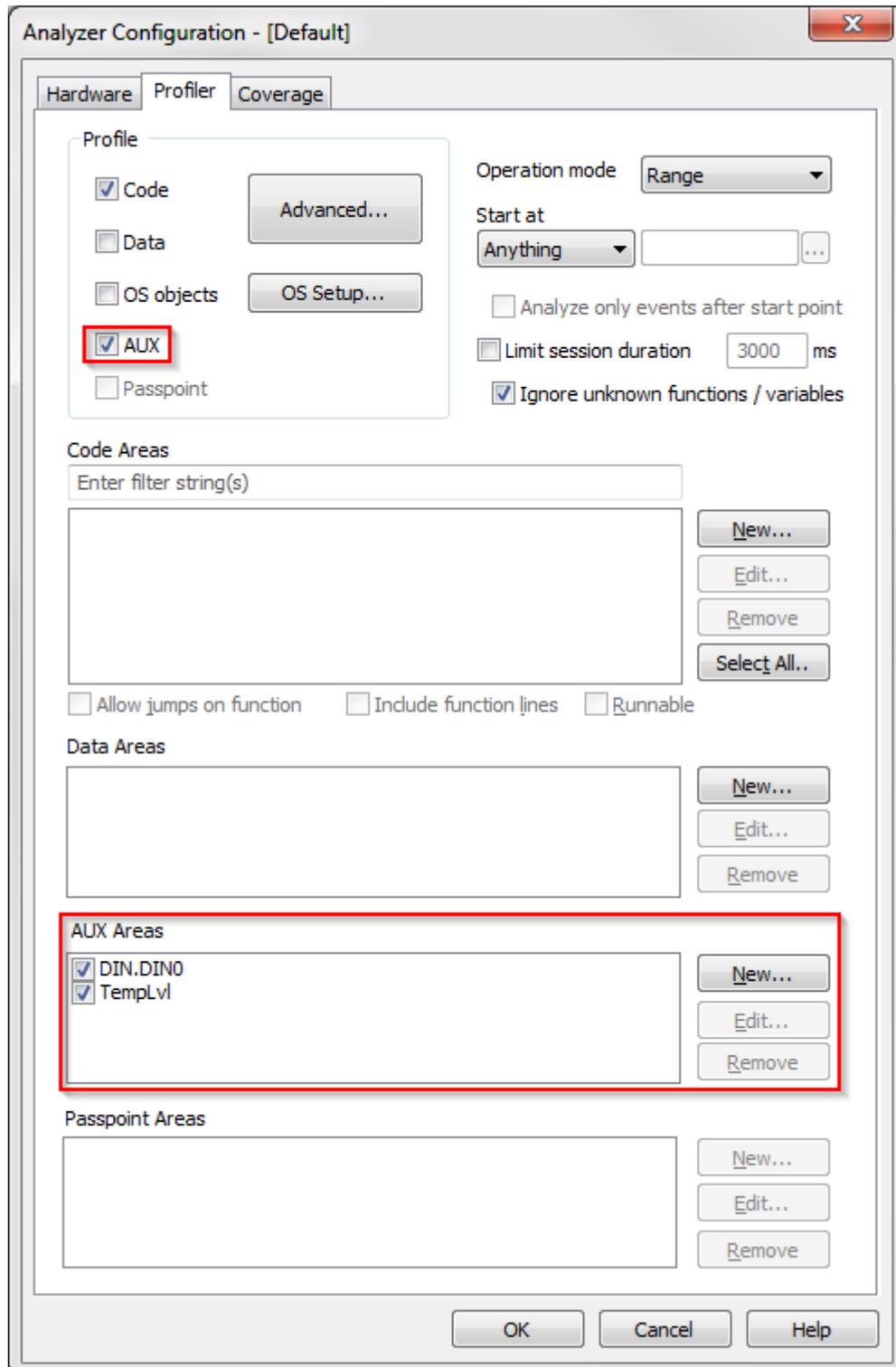
Record all

If this option is checked then all I/O module inputs are recorded. Otherwise no I/O samples are recorded.

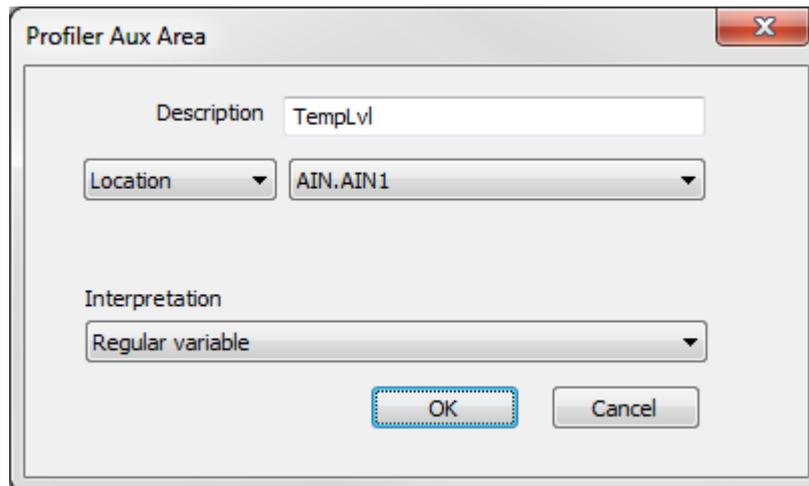
2.3.5 Profiler

Real-time profiling of I/O module's signals is available in Analyzer's Profiler mode.

To enable profiling, enable the **AUX** option in the **Profiler configuration** dialog and list the channels you want to trace:

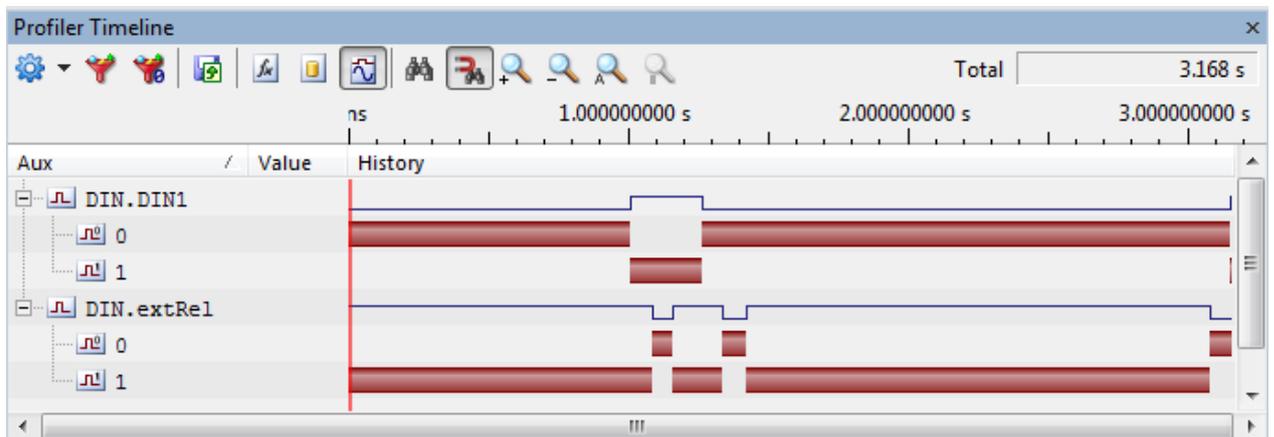


For each channel specify the description, channel and the value interpretation:



Note that in order to select output channels (DOUT / AOUT), the option **Show Output in Analyzer** must be enabled. The option can be found in the **Hardware / Options** dialog.

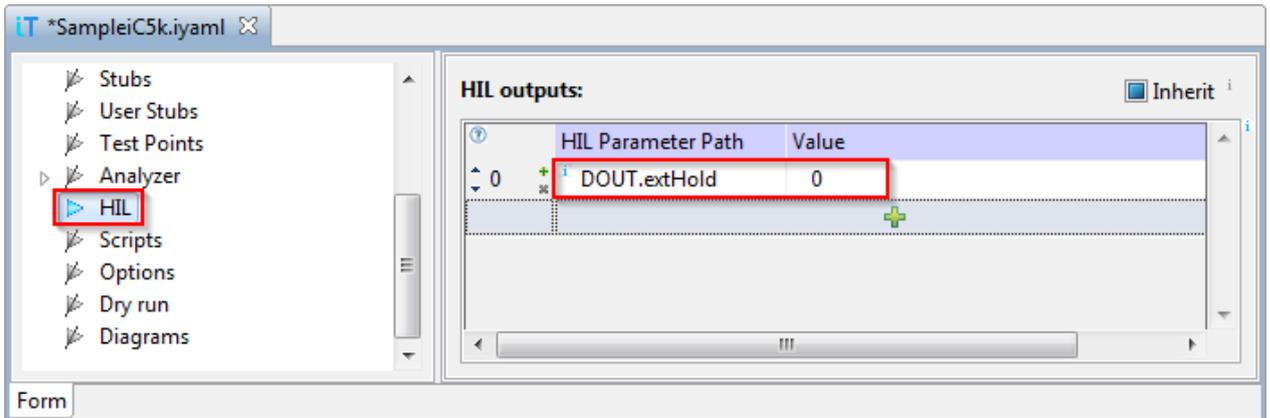
State variable interpretation will produce more detailed profiling analysis, but is limited to a number of samples that it can analyze. For analog values it is recommended to select a **Regular variable**.



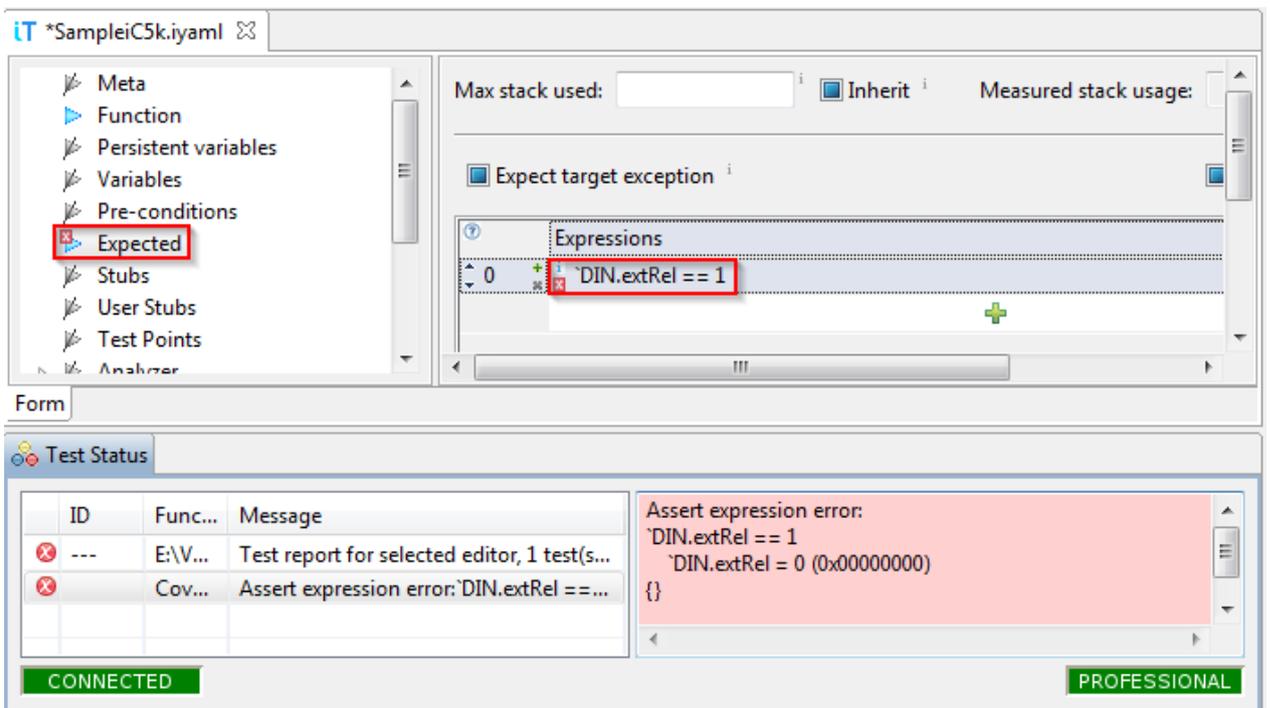
For more information refer to the [Analyzer Window](#) chapter.

2.3.6 testIDEA

testIDEA is using the HIL interface to gain access to the I/O Module. This allows setting of inputs prior to performing a unit test:



...and evaluation of outputs after the test. Please note the **syntax** for specifying the IO channels:



For more information please refer to testIDEA manual.

2.3.7 isystem.connect access

External applications can use `isystem.connect` to monitor and manipulate the I/O module via the HIL interface class **CHILController**.

This Python example demonstrates reading and writing analog and digital I/Os. Make sure you use **channel names** as specified in the **Hardware / Options** dialog.

```
import isystem.connect as ic

#create connection and hil controller object
cMgr = ic.ConnectionMgr()
cMgr.connectMRU('')

hilCtrl = ic.CHILController(cMgr)

#set analog output to specified voltage level
def AnalogOutputWrite(channelName, voltageLevel):
    hilCtrl.write('AOUT.' + channelName + ': ' + voltageLevel)

#get analog input voltage level
def AnalogInputRead(channelName):
    return hilCtrl.read('AIN.' + channelName)

#set digital output to specified level
def DigitalOutputWrite(channelName, state):
    hilCtrl.write('DOUT.' + channelName + ': ' + state)

#get digital input state
def DigitalInputRead(channelName):
    return hilCtrl.read('DIN.' + channelName)

AnalogOutputWrite('AOUT0', '1.8')
print "Analog input AIN0 voltage level: ", AnalogInputRead('AIN0')

DigitalOutputWrite('DOUT0', 'HIGH')
print "Digital input DIN0 state: ", DigitalInputRead('DIN0')
```

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