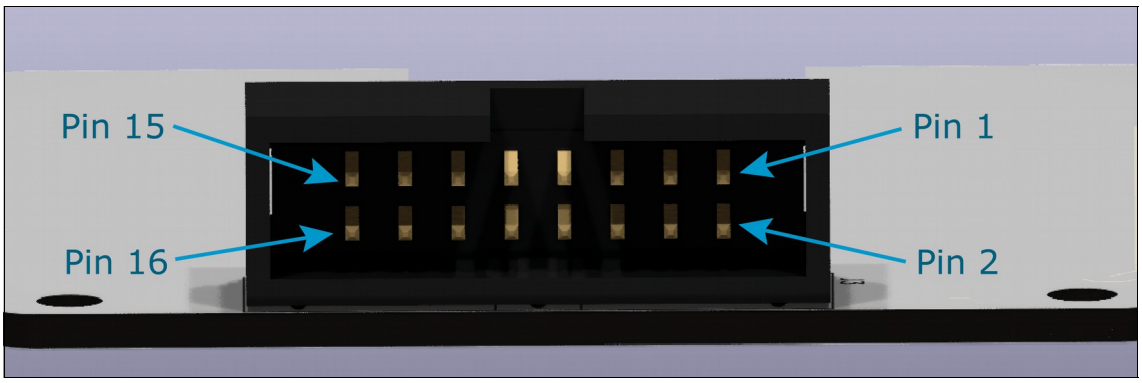
THE ANALOG THING (THAT)
Hybrid Port Description

The analog computer THAT has a hybrid port, which can be used to feed analog signals in and out and to take full control over it including digital control of the timing, iniitial mode (IC), operating mode (OP), HALT and repetition (REP/REPF).

The access of the hybrid port is on the back side via a 16-pin IDC connector jack which can adapted with flat cables or a female 16 pin header socket mounted directly on a small pcb. If you want to create a pcb, you should keep in mind the positions and space needed for other jacks for not covering them with the pcb.



The picture above shows the connector on top view and the official pin numbering for IDC jacks. Please keep in mind that the pin numbering for the female socket is mirrored (!).

The table below shows the pin numbering.

Name, Function	Pin	Pin	Name, Function
IN-X, input/output X RCA jack	1	2	HYB-X, output X signal shifted
IN-Y, input/output Y RCA jack	3	4	HYB-Y, output Y signal shifted
IN-Z, input/output Z RCA jack	5	6	HYB-Z, output Z signal shifted
IN-U, input/output U RCA jack	7	8	HYB-U, output U signal shifted
GND, 0V	9	10	GND, 0V
VUSB, +5V from USB port	11	12	VUSB, +5V from USB port
DIR, direction of control signals	13	14	/ModeOP, operation signal
Voffset, offset voltage shifted signals	15	16	/ModeIC, initial condition signal

The hybrid port offers +5V voltage directly from the USB port to use as power supply instead of a separate power supply. This output is protected with a 750 mA PTC fuse for possibly shorts and is able to deliver up to 750 mA current continously depending on the USB power supply used for the operation of THAT. If THAT is used with an USB port or small USB power supplies the output current on the hybrid port might be limited to just 300 mA or less.

Attention: The logic signals of the control ports are operating on 3.3V TTL level to match with most modern general purpose microcontroller boards. The control signals are protected with output resistors and so are tolerant to 5V to match even with older microcontroller boards like Arduino. If you want to supply the microcontroller board via the USB voltage on the hybrid port a suitable DC/DC converter might be necessary.

Functions of the hybrid port

1. Read analog signals

The port has two different voltage levels depending on your needs. The IN-X, IN-Y, IN-Z and IN-U signals are downscaled from +/- 10V by factor 10 to +/- 1V. Due to it's negative level this signals are not directly suitable for single supply microcontrollers.

The output level is downscaled with resistors 4k22 and 470R with a precision of 0.2% but the circuit has an output impedance of about 470R and require an high impedance input of about 100k or may need to be buffered for keeping it's precision. When using a 10k input impedance the output signal has a loss of about 4%.

Alternatively and suitable for most single supply microcontrollers are the HYB-X, HYB-Y, HYB-Z and HYB-U signals. The output level is the same as the IN- ports with +/- 1V with precision of 0.1% and they are buffered and can be used even with low impedance inputs with down to 150R without loss of precision.

Additionally these signals are shifted via level shifters with 1.64V DC to the range of +0.64V to +2.64V. These voltages are positive only due to the shift voltage and suitable directly for most single supply microcontrollers.

The shift voltage of 1.64V is feeded to an extra pin for use in further signal processing or conversion and might be read from an ADC to have an exact zero point of the signals.

Note: Be sure to connect signals to the X/Y/Z/U 2mm jacks on the THAT patch field to read them through the hybrid port.

2. Write analog signals

It is also possible to feed analog signals into the IN-X, IN-Y, IN-Z and IN-U port instead of reading them. This is available for these signal pins only and not for the corresponding HYB pins, which are output only. Due to simple construction of THAT these signals are taken as they are and not upscaled.

If signals with +/- 1V are feeded into these signal pins the x10 inputs of Summers or Inverters can be used to upscale them for use with multipliers for example or feed them directly into x10 inputs of summers or integrators. The inputs of the IN pins have a low impedance of 470R. A voltage level of about +/- 1V is recommended while +/- 10V would draw currents of about 20mA per input.

When using DAC outputs of single supply microcontrollers directly these outputs are usually level shifted, too. To remove this shift voltage additional output stages with operational amplifiers may be used as summers with an opposite shift voltage. Alternatively it is possible to use an extra port to feed the shift voltage and to use a summer on THAT to remove the DC offset.

Note: The feeded signals are available at he X/Y/Z/U 2mm jacks on the THAT patch field to patch them to summers or integrators for example. Additionally the feeded signals are available directly at the RCA ports of the THAT for easy use with an oscilloscope for example.

3. Read and write analog signals simultaneously

It is possible to read and write signals at the same time according to the needs of the application. It is possible to read 1 signal and write 3 signals or to read 3 signals and write 1 signal or any other combination of the 4 available ports.

4. Detecting operation condition IC/OP/HALT

The default mode/direction is to signal the operation mode of THAT to the hybrid port with the digital /ModeOP and /ModeIC signals. These signals have 3.3V TTL voltage levels and might be connected directly to microcontroler input ports. To avoid damage and protect THAT against shorts they have a 5k1 series resistors.

The signals are low level active and the operation mode is signaled as shown in the table below.

ModeIC	ModeOP	Mode
high	high	HALT, operation halted
low	high	IC, initial condition
high	low	OP, operating condition
low	low	not allowed, undefined results

In the repeat mode (REP/REPF) of THAT the IC (initial condition) and OP (operation condition) are alternated. The duration of the operation condition can be adjusted with the OP-TIME potentiometer on THAT while the initial condition duration is fixed to approx. 10ms duration.

This covers the maximum time necessary to unload the 100nF capacitors in SLOW mode of THAT but due to simple construction the same timer is used for the smaller default capacitors of 1nF which could be unloaded in approx. 100us. The timing is optimized in general to get a steady image on oscilloscopes in repeat mode depending on the choosen operation time.

There are two repetitions speeds which can be choosen on THAT with the mode switch. REP supports an adjustable operation time of 0 to 10s and the potentiometer is working with logarithmic scale to allow finer adjustments for lower values. To choose precise shorter operation times the REPF position allows to choose an operation time of 0 to 100ms. The resulting time can be read on the panelmeter display of THAT.

5. Take control over THAT and choose IC/OP/HALT externally

It is possible to select operation mode and timing from an external microcontroller over the hybrid port. The external control is activated with a logic low (0V) on the DIR pin. The default signal level is high with an internal pull-up resistor (100k). The control switch is disabled in the external control mode and can stay in any position. Manual switching has no effect as long as external control is active.

The signal levels are optimized to 3.3V but are 5V tolerant and valid for all 3 signals, DIR, ModeIC and ModeOP. The ModeIC and ModeOP signals control the operation mode in the same way as it does in the operation read mode.

ModeIC	ModeOP	Mode
high	high	HALT, operation halted
low	high	IC, initial condition
high	low	OP, operating condition
low	low	not allowed, undefined results

The advantage of the external control is the use of more exact timings as they can be choosen with the OP-TIME potentiometer and even choose longer periods than 10s or smaller periods than 1ms which is approx. the shortes manual operation time. Also the IC time can be customized.

The required IC time is minimum of 100us for the default integrator values and 10ms for the SLOW mode of THAT when using integrators the internal 100nF capacitors for lower time-scaling-values. Repetition is possible when alternating these modes with a microcontroller and it is even possible to change the operation time for every new cycle depending on the application.