# PIDmareike

## Functionality

vastly enhanced PID-Thijs

## Control Overview

- It has two input SMA connectors and one Sub D9 input connector. The first SMA connector CONN1 is the setpoint signal input. The second SMA connector CONN2 is the input of the signal that has to be controlled. In case of a current stabilization, the second SMA input can be exchanged with a Sub D9 connector CONN7 by a jumper J9. The Sub D9 connector can be connected to a hall sensor. It gives a voltage supply and receives a current signal from the sensor that is transduced into a voltage on board. The pin configuration is suited for a LEM IT 200-S Ultrastab current transducer.
- The three input connectors are followed by a jumper pair which can be used to optionally invert the signals at the following instrumentation amplifiers. In order to obtain an error signal, the input signals have to be of opposing sign. At the operational amplifier U4, the input signals are summed. Here, a dipswitch S1 should be used to adjust the voltage level of the error signal. The resistors R11 to R15 are connected in parallel (Remember: 1/Rges=1/R1+…1/Rn). In order to choose an order of magnitude for the amplification, only enable one resistor at a time. The amplification factors for the following dipswitch configurations are: (0000)=1M/10k=100, (x000)=50, (0x00)=10, (00×0)=1, (000x)=0.1.
- The next part is the actual PID controller with P-, I- and D-parts connected in parallel.
- The P-part has a fixed amplification factor of 1.
- The I-part has an adjustable amplification factor. It is adjusted by two dipswitches S2 and S3. The amplification at an integrating operational amplifier is given by -1/(R*C). Dipswitch S3 switches capacitors that are connected in parallel. This dipswitch gives the order of magnitude with (0000)=1/1n=10^9
- Additionally, there are up to three TTL input connectors. The first TTL signal is for discharging the capacitor in the integrator part, the second one quickly turns off the controller and the third one, if enabled, gives the setpoint signal to the output.
- As well as the Thijs-PID, there is a optional voltage offset that has to be enabled with a jumper. It can be adjusted with a potentiometer.
- Instead of using potis for the adjustment of the amplification, this controller uses dipswitches for the resistors and capacitors such that the amplification can easily be read out.
- The controller has four monitor outputs for the input signal, the internal error signal, the internal control signal and the output control signal.
- The are two optional filters that can be enabled behind the PID part.
- In the end there is an optional ideal diode that gives only positive control signals as they are needed for AOM drivers.

Choice of operational amplifiers: * the integrator has a OP27 which has a very low input voltage offset.

# Detailed Control Options

## Connectors

| Connector | Purpose | Description |
|---|---|---|
| CONN1 | SMA signal input | |
| CONN2 | SUB D9 signal input | It is supposed to be connected to a current transducer. The pin configuration fits a LEM IT 200-S Ultrastab. |
| CONN3 | SMA setpoint signal | |
| CONN4 | SMA monitor signal | gives the input signal |
| CONN5 | - | |
| CONN6 | SMA monitor internal error signal | It gives the error signal that is given to the PID controller. The input signal is substracted from the setpoint signal. |
| CONN7 | JAE 5V voltage supply | has to be connected to the front panel's coaxial power connector |
| CONN8 | SMA monitor internal control signal | gives the output of the PID part before any other operation (e.g. filtering) is performed |
| CONN9 | SMA TTL input fast shut down | if signal is high, controller is shut down fast |
| CONN10 | SMA TTL input discharge integral part | if signal is high, short cuts the integral part in order to discharge the integral capacity |
| CONN11 | SMA output signal | output of the controller signal |
| CONN12 | SMA monitor output signal | |
| CONN13 | SMA TTL input pick off setpoint signal | if signal is high, picks off the setpoint signal and gives it to the output signal |
| CONN14 | JAE 5 Pin | |
| CONN15 | XLR power plug | voltage supply |

## Jumper

| Jumper | Purpose | Description |
|---|---|---|
| J1 | ground connection for CONN2 housing | |
| J2 | ground connection for housing | |
| 1J1 | sign of the setpoint input at the instrumentation amplifier at 1U1 | |
| 1J2 | sign of the input signal at the instrumentation amplifier at 1U3 | |
| 1J3 | sign of the current transducer signal at the instrumentation amplifier at 1U4 | |
| 1J4 | chooses input signal either from CONN1 or CONN2 | |
| 1J5 | enables/disables an input offset | |
| 3J1 | enables/disables optional low-pass filters | |
| 3J2 | enables/disables optional high-pass filter | |
| 3J3 | enables/disables an output offset | |
| 3J4 | enables/disables optional ideal diode | |
| 3J5 | choose which TTL signal to use to shut down the controller | |

| | | |
|---|---|---|
| 4J1 | if enabled, sets supply voltage to +12V instead of +15V | 4J1 and 4J2 should always be both enabled or disabled |
| 4J2 | if enabled, sets supply voltage to -12V instead of -15V | |

## Dipswitches

### First amplification

- Dipswitch 1S1
- compared to 10k resistor

| setting | amplification | resistor |
|---|---|---|
| 0000 | 100 | 1M |
| x000 | 50 | 1M |
| 0x00 | 10 | 100k |
| 00×0 | 1 | 10k |
| 000x | 0.1 | 1k |

### Integral amplification

- amplification is calculated by -1/(R*C)
- use Dipswitch 2S2 to adjust the order of magnitude and 2S1 for a fine adjustment of the amplification
- Dipswitch 2S1 resistors

| setting | amplification (*10 | **5)** | resistor |
|---|---|---|---|
| 0000 | 1 | 100k | |
| x000 | 8.7 | 13k | |
| 0x00 | 6 | 20k | |
| 00×0 | 4 | 33k | |
| 000x | 2 | 100k | |

- Dipswitch 2S2 capacities

| setting | amplification (*10 | **6)** | capacity |
|---|---|---|---|
| 0000 | 10000 | 100p | |
| x000 | 1000 | 1n | |
| 0x00 | 100 | 10n | |
| 00×0 | 10 | 100n | |
| 000x | 1 | 1u | |

### Differential amplification

- amplification is calculated by -(R*C)
- use Dipswitch 2S3 to adjust the order of magnitude and 2S4 for a fine adjustment of the amplification
- Dipswitch 2S3 capacities

| setting | amplification (*10 | **9)** | capacity |
|---|---|---|---|
| 0000 | 1 | 1n | |
| x000 | 1000 | 1u | |
| 0x00 | 100 | 100n | |
| 00×0 | 10 | 10n | |
| 000x | 2 | 1n | |

* Dipswitch 2S4 resistors

| setting | amplification (*10 | **9)** | resistor |
|---|---|---|---|
| 0000 | 1 | 10k | |
| x000 | 8 | 40k | |
| 0x00 | 6 | 15k | |
| 00×0 | 4 | 6.8k | |
| 000x | 2 | 2.4k | |

### Final amplification

- the output stage has a fixed amplification of 21 but in front of the output stage is a voltage divider, that can be used to amplify or attenuate the signal
- amplification is calculated by R2/(R1+R2)
- use Dipswitch 3S6 to adjust the order of magnitude and 3S11 for a fine adjustment of the amplification
- Dipswitch 3S6 resistors

| setting | amplification | resistor |
|---|---|---|
| 0000 | 0.0001 | 1M |
| x000 | 0.1 | 1k |
| 0x00 | 0.01 | 10k |
| 00×0 | 0.001 | 100k |
| 000x | 0.0002 | 1M |

- Dipswitch 3S11 resistors
- the exact amplification varies with the chosen resistor at dipswitch 3S6
- the total maximum amplification at the output stage is 12.6 (given by 21*0.6 when all resistors are activated and 1k is chosen at 3S6)

| setting | amplification (with 1k @3S6) | resistor |
|---|---|---|
| 0000 | 0.1 | 100 |
| x000 | 0.44 | 680 |
| 0x00 | 0.33 | 390 |
| 00×0 | 0.23 | 200 |
| 000x | 0.17 | 100 |

* in this case, the amplification can be chosen more precisely by combining several resistors

### Switches

## Date

V2.1: July 2021

## Status

In Use

Reproduction Effort: Fix Me!

## Developer

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## Users

Various Experiments in Group Klempt

## Files

- All files can be found in the git project here: https://git.iqo.uni-hannover.de/elektroniq/PIDmareike
- The schematic as PDF
- Fix Me! The layout as pdf

## Layout

- Abmessungen der Leiterplatte: Fix Me!
- Versorgung: Fix Me!
- Eingang: Fix Me!
- Ausgang: Fix Me!

- Anzeigen: Fix Me!
- Der Bestückungsdruck: start_layout.pdf
- Die Bestückungsliste: start_bom.pdf, start_bom.xls
- Die gezippten Gerberdaten für die Bestellung der Platine
- Die Source des Layouts im pcb-Format liegt auf der Download-Seite des Wiki.

Fix Me!

## Casing

Fix Me!

## Test Protocol

### Voltage supply

- supply voltage: give a supply voltage of +/-18V. Check if the voltage regulators 4U1 and 4U4 receive +/-18V and give +/-15V at pin 2.
- reference voltage: check that 4U2 pin 6 gives +10V and 4U3 pin 6 gives -10V (which it will not do until you fix the following mistakes):
- first possible mistake: 4U2 is probably not connected to an input voltage of +18V. It can be solved by adding a cable
- second possible mistake: 4U2, 4U3 do not have a ground connection, 4U3 is not properly connected to the voltage supply
- check if jumpers 4J1 and 4J2 are set, the supply voltage is set to +/-12V. Do not use these jumpers in the following.

### Input signals

- give an triangle input signal at CONN1.
- set 1J4 and check if the Monitor signal input at CONN4 gives the (inverted) input signal with the same amplitude (the sign depends on the jumper setting at 1J2)
- test input offset: set jumper 1J5 and turn the poti 1R14. The signal should go up and down.
- check if 1U5 pin 6 gives the inverted input signal.
- check the internal error signal monitor output. It should give the inverted signal with an amplification defined at dipswitch 1S1.
- test first amplification stage: check if 1S1 setting 00×0 gives an amplification of 1. (0000, x000, 0x00, 000x) should correspond to amplification factors (100, 50, 10, 0.1).
- the red, green and red LEDs 1D1, 1D3 and 1D2 should alternatingly glow.

### PID controller

- disable I- and D-part with 2S6 and 2S7.
- the internal control monitor signal at CONN8 should give the non-inverted signal with the same amplitude
- disable 2S5 and enable the I-part with switch 2S6. Signal either saturates or a sinusoidal signal is arising. Use dipswitch configuration 2S1 (0000), 2S2 (000x) (smallest amplification).
- press 2S8 to check if the discharging of the integrator works. The signal should vanish for the time the button is pressed.
- disable 2S6 and enable the D-part with switch 2S7. It should give a square-wave signal. Use dipswitch configuration 2S3 (0000), 2S4 (0000) (smallest amplification).

### Low-pass filter

- set jumper 3J1 such that the low-pass filter is enabled.
- give a triangle signal of about 1kHz. Look at signal of 3U1 and 3U2 at pin 6. The triangle should have rounded edges and a significant phase shift compared to the input signal.

### High-pass filter

### Ideal diode

- set jumper 3J4 such that the ideal diode is enabled.
- measure at 3J4. Only the positive part of the triangle signal should be left.

### Output offset

- enable jumper 3J3. Measure at pin 6 of 3U3.
- by turning 3R10, the signal should go up and down.

### Final amplification

- choose at dipswitch 3S6 configuration (0000) and at 3S11 (0000) for smallest amplification (0.00001) to start with.
- the output stage has an additional amplification factor of 21.
- check the monitor signal at CONN12. It should give the inverted signal (maybe) compared to 3U7 pin 6.

### TTL signals

- connect 5V supply
- I-part: enable the integrator at switch 2S6 and connect a TTL signal (+3.3-5V pulse) to CONN10
- when the TTL is enabled, the integrator signal should vanish (similar to the discharging butten 2S8)
- Fast shut down: generate a control output signal with P- I- and/or D-part. Connect a TTL signal to CONN9. When the TTL signal is enabled, the controller output should vanish.
- pickoff setpoint signal: give a setpoint signal that looks different to the control signal (this is usually the case when the integrator is enabled, as it smoothes out edges). Connect a TTL signal to CONN13. When the ttl signal is enabled, the controller output should give the setpoint signal. Make sure it is not the control signal that you still see (e.g. it does not change when you

change control parameters in P, I and D.).

- or: turn off P-, I- and D-part. When TTL is disabled, there should not be an output signal, when enabled, it should give the setpoint signal.
- discharge I part feature+

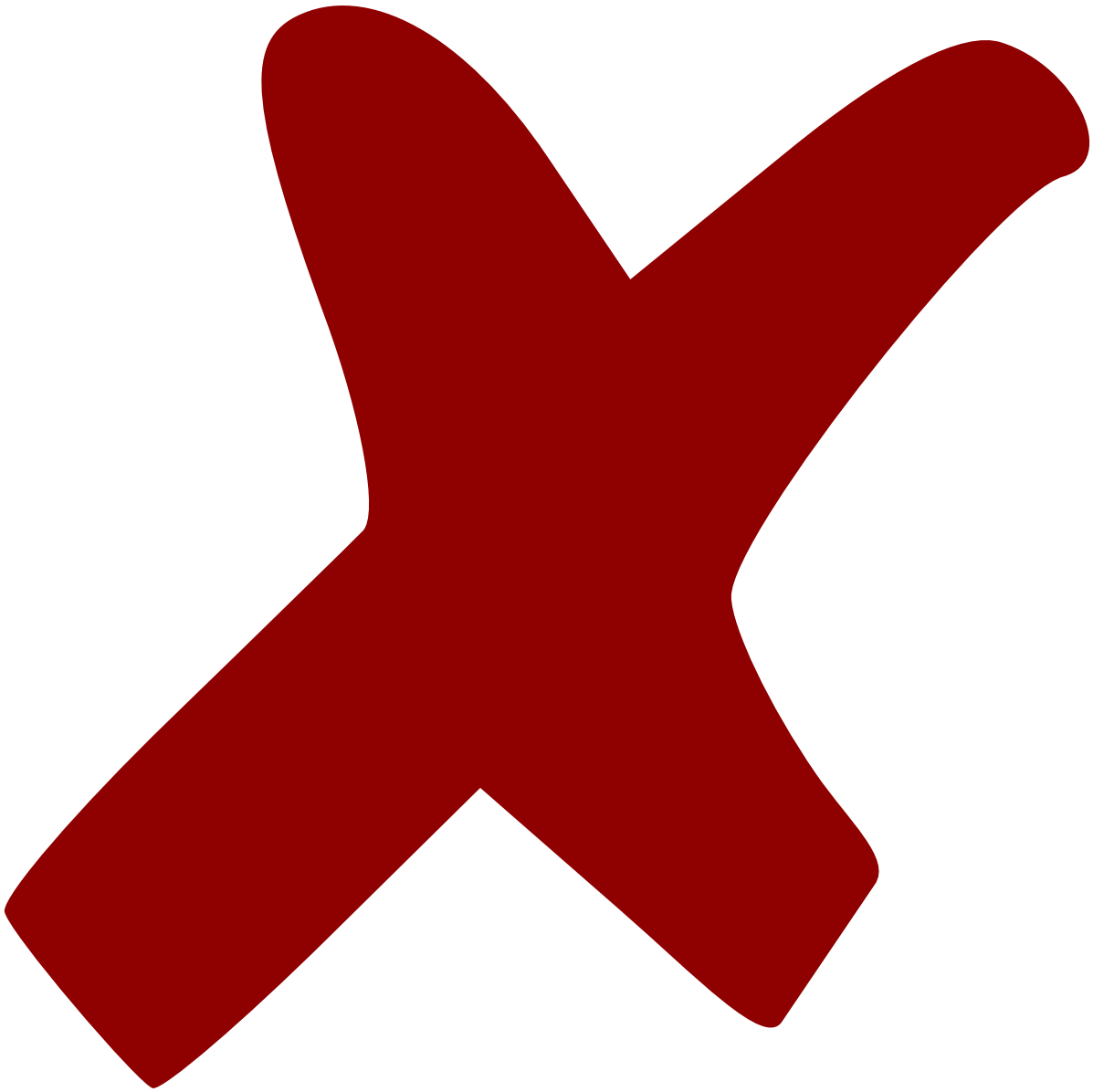
## Pictures


## Calculation


| was | wieviel | E-Preis | Preis | Anmerkung |
|---|---|---|---|---|
| Leiterplatte | 1x | ??.?? € | € | 1/n von XXX EUR |
| Gehäuse | 1x | ??.?? € | € | |
| * | ?x | ??.?? € | € | ... |
| R,C | ??x | 0.02 € | € | Bauform 0805 |
| Bestückung | | ??.00 € | | bei SRM |
| Verschnitt | | ?.?? € | | |
| | | **Summe** | **€** | |

## Improvements

What the next version should do better: (



:

abandoned,

: WIP,

: in the Schematic, but not the Layout,

: done)

### Version 2.1

- Footprints for 3C1 and 3C2 are larger than the size of the required components
- The access holes for the trimmers 1R14 and 3R10 are located too low in the front plate, necessitating the trimmer cover to be installed upside down to get it low enough to fit.
- Switches 2S5, 2S6 and 2S7 are recessed more than is optimal, shortening the accessible length of their arms.
- The chosen two-part plug design for CONN15 has a screw and nut for attaching the front plate section roughly at the height of the board. Currently, the board bends down at this point if it is not modified to fit properly.