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PID Controller with Operational Amplifier

The paper presents a PID controller made with LM741 operational amplifier that implement the PID controllers laws and allow for a wide range of applications of in the field of automatic control of technical processes and systems.

Keywords: *PID controller, operational amplifier*

1. Introduction

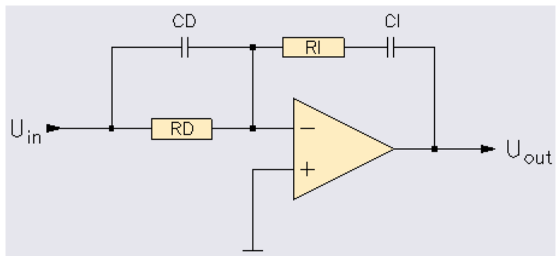
The PID controller algorithm involves three separate parameters: the proportional, the integral and derivative values [6]. The proportional value determines the reaction to the current error, the integral value determines the reaction based on the sum of recent errors, and the derivative value determines the reaction based on the rate at which the error has been changing. The weighted sum of these three actions is used to adjust the process via a control element [7].

Today proportional-integral (PI) and proportional-integral-derivative (PID) type controller are certainly the most used control strategy. It is estimated that over 90% of control loops employ PID control [1].

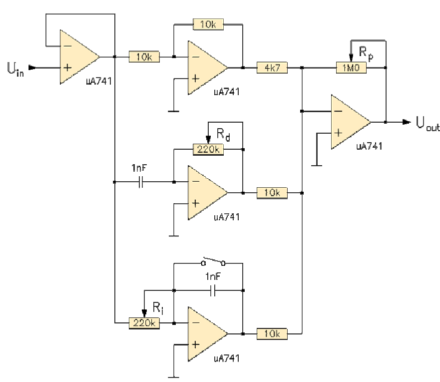
To dimension a PID controller is quit difficult because the time constants of the controller way are not exactly know [3]. That why it is important to have in such cases an PID controller with the possibility to change the parameters of the P, I or D component in a large domain [4]. The control parameters are tuned so that the closed loop system meet the following objectives: stability and robustness, steady state accuracy, disturbance attenuation and robustness against environmental uncertainty [2].

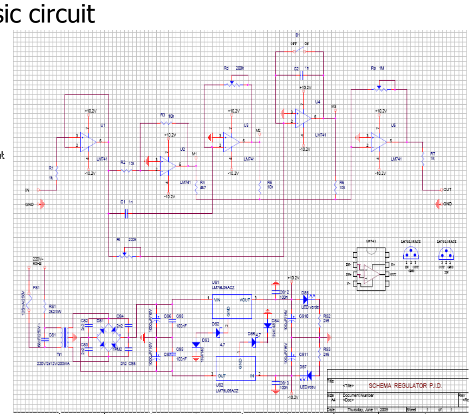
2. Controllers scheme and realization

Figure 1a presents the basic circuit of the PID scheme; the electric bloc scheme of the PID controller are shown in figure 1b and figure 1c presents the electrical scheme of the PID controller, for a frequency domain of aproximatively 10kHz and the electric scheme of the dc power source.



a. basic circuit





b. electric bloc scheme **c.** electrical scheme with power source

Figure 1. Electric scheme of the PID controller and the dc voltage source

The components used to implement the electric circuit of the PID controller are presented in table 1 and those of the dc power source in table 2.

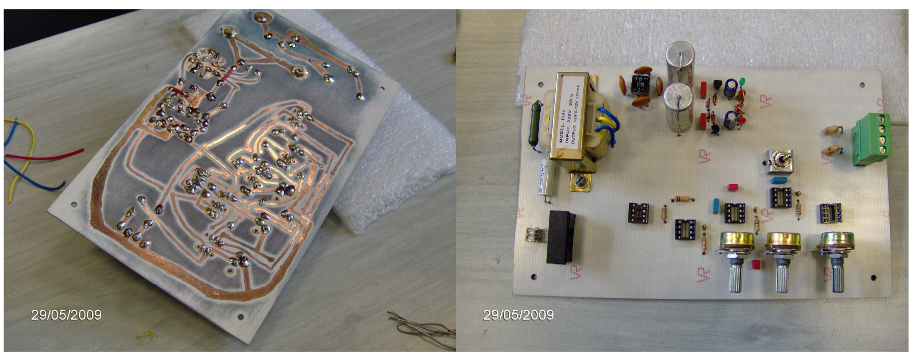
Table 1 Components used for the PID controller

Noted	Component / value	Noted	Component / value
R1	1k	R5	10k
R2	10k	R6	10k
R3	10k	R7	1k
R4	4k7	Rd	200k
Ri	200k	Rp	1M
B1	Switch	U1	LM741
U2	LM741	U3	LM741
U4	LM741	U5	LM741
M1	oscilloscope measurement	M2	oscilloscope measurement
M3	oscilloscope measurement	C1	1nF

Table 2 Components used for the dc power source

Noted	Component	Noted	Component	Noted	Component
DS1	1PM2	DS7	Red LED	FS1	fuse 125mA/250V
DS2	4,7	RS1	2k2/3W	Tr1	220V/12V+12V/200mA
DS3	1N4148	RS2	2k5	CS1	68nF/250
DS4	1N4148	RS3	2k5	CS2	2n2
DS5	4,7	US1	LM78L05	CS3	2n2
DS6	Green LED	US2	LM79L05	CS4	2n2
CS5	2n2	CS6	1μF/16V	CS7	1μF/16V
CS8	100nF	CS9	100nF	CS10	100μF/16V
CS11	100μF/16V	CS12	100nF	CS13	100nF

The PCB of the entire electric scheme, PID controller and dc voltage source figure 2 a and a general overview of the controller is shown in figure 2 b. The first operational amplifier (OA) has to ensure a high input impedance. The second OA will change the signal phase with 180 degree for the proportional OA, so that the output of the controller shoud be in phase with the input. The other two OA implements the derivative and the integral controll law [5].



a. **b.**

Figure 2 PCB board of the PID controller

The controller adjustment goes through the following steps [8]: first, the switch on the integral controller is closed and the potentiometer Rd turned to zero. Through this the I and D component doesn't contribute to the controller response, he behaves like a pure P – controller. Now, a square wave signal will be put on the controller's input, the strengthening of the P-controller will be increased until the output of the controller shows only a weak subdued. The next step will be the degraded the frequency of the D-controller by turning the potentiometer Rd so far that the oscillating process will be no longer visible. The third step implies to optimized the control law by adjusting the I-controller, opening the switch and acting on the potentiometer Ri.

4. Conclusion

The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the setpoint and the degree of system oscillation.

Some applications may require using only one or two modes to provide the appropriate system control. PI controllers are particularly common, since derivative action is very sensitive to measurement noise, and the absence of an integral value may prevent the system from reaching its target value due to the control action.

The build PID controller offers the posibility to act with different controll laws in a wide frequency range, adjusting the constants through modifying the corresponding potentiometer as well it can be provided with manual control.

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