Lab-Report
Control Engineering

Real Water tank

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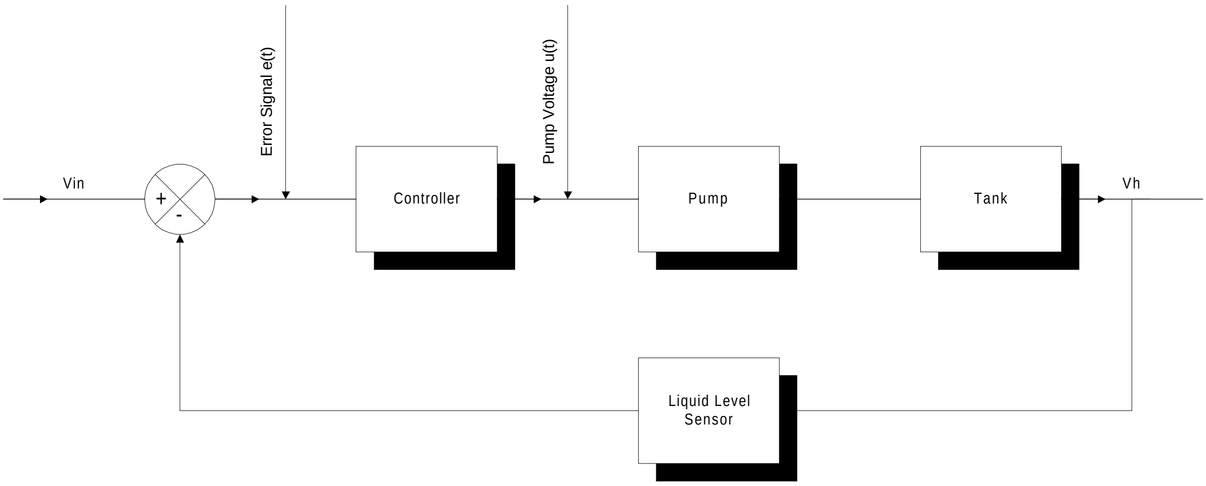
1. Contents

2. Introduction

The first control engineering lab was the simulation of a proportional liquid level system with the aid of matlab.
According to this lab the 2nd lab was to perform a control of a real liquid level system. Different controller types could be applied to it and via a digital storage oscilloscope the behaviour of the system was to obtain.

3. The liquid level system

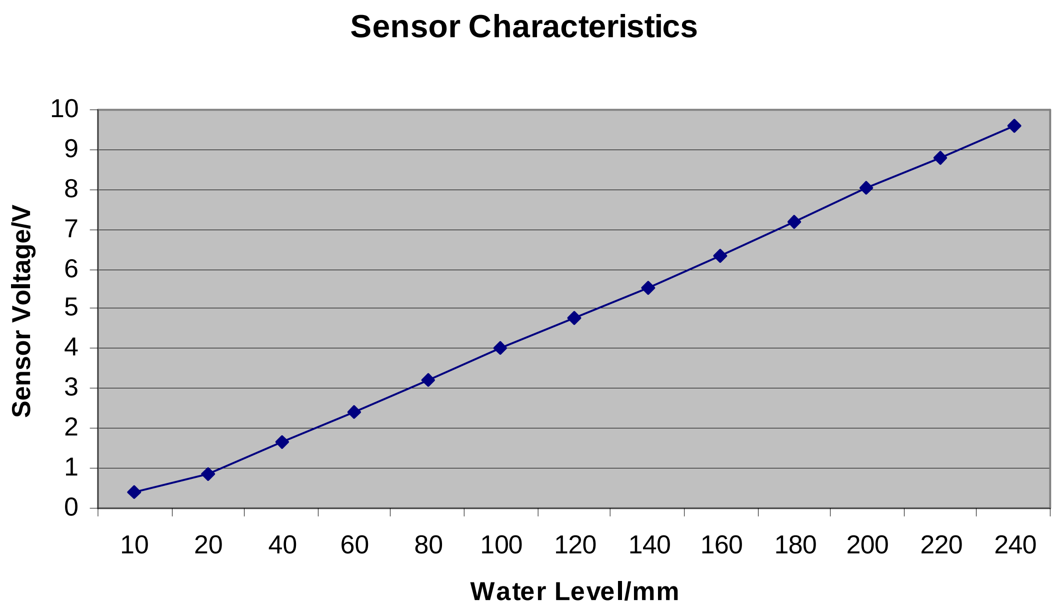


The schematic above shows the block diagram of the used liquid level control system. The controller drives the pump which fills the tank with water. The backward signal transfers the water level back to the input. The controller could be changed in its characteristics between proportional. integral. derivative. some of them and all together to change the properties of the control-process.

4. The sensor characteristics

First part of the Lab was to determine the characteristics of the liquid sensor built in the watertank. It provides a voltage depending on the actual water-level.

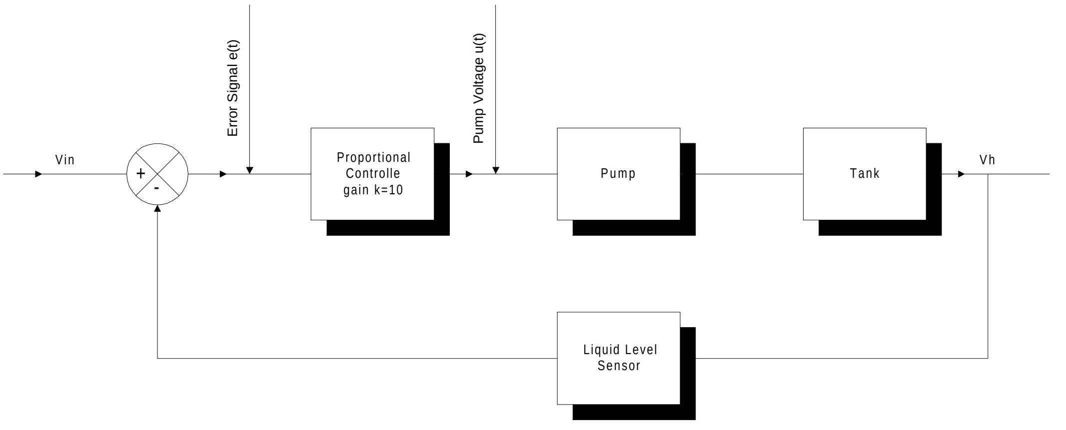
Water level /cm	Sensor voltage / V
10	0.4
20	0.85
40	1.65
60	2.42
80	3.22
100	4
120	4.77
140	5.55
150	6
160	6.35
180	7.19
200	8.03
220	8.81
240	9.59



The liquid level sensors works linear – A higher liquid level provides a proportional higher output voltage.

5. Different controllers

a) Proportional controller



With the proportional control only the difference of the actual liquid-level and the input voltage (error signal) is amplified and directly fed to the pump. Therefore the proportional control doesn't reach the desired setting point of 150mm, because the end value depends very much on the value of k. The following plot from the oscilloscope shows this.

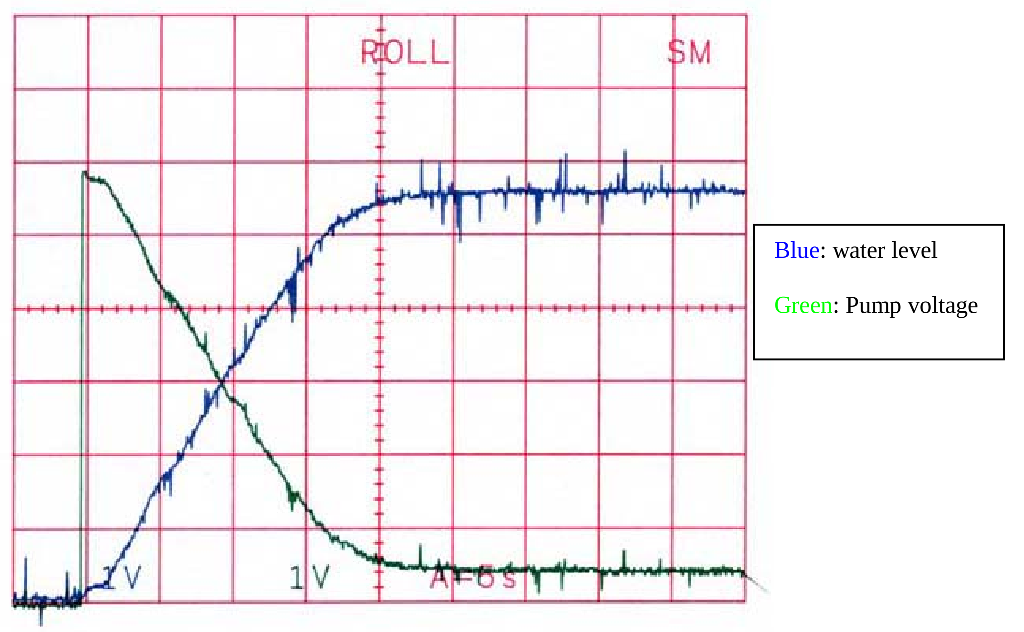
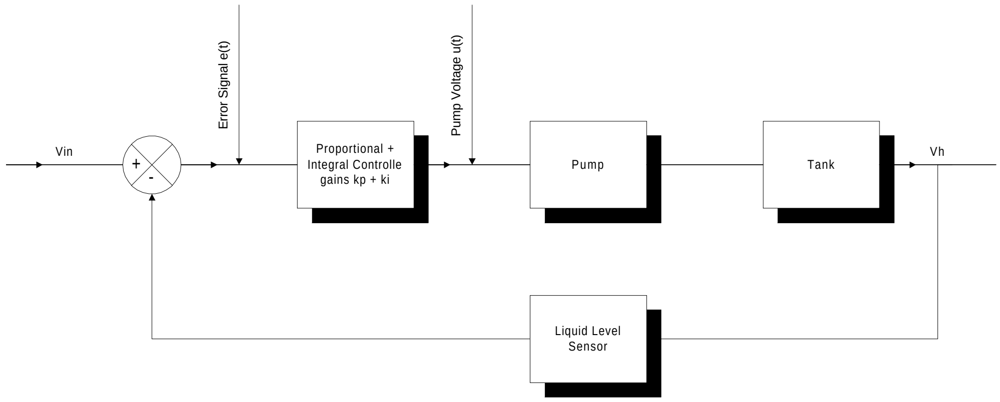


Figure 1 – Transient response plot of the proportional controller with gain k=10

Time constant τ=10s, settling time t_s=25s, e=7 per cent

b) Proportional + integral controller k_i=10 and k_p=10



The combination of the integral and the proportional controller brings an improvement to the system by reducing the final error e. Now the output reaches the desired input (6V==150mm). The integral part brings a short oscillation with over and- under-shots to the system before it settles.

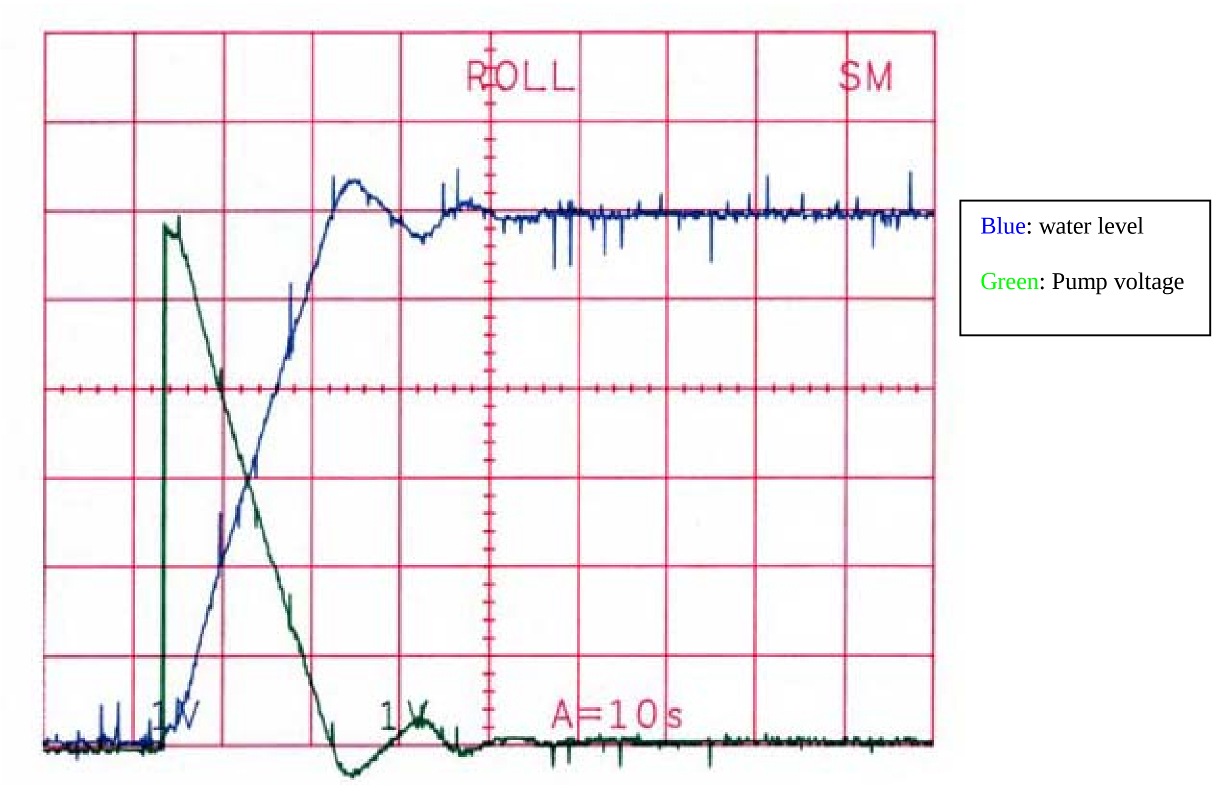
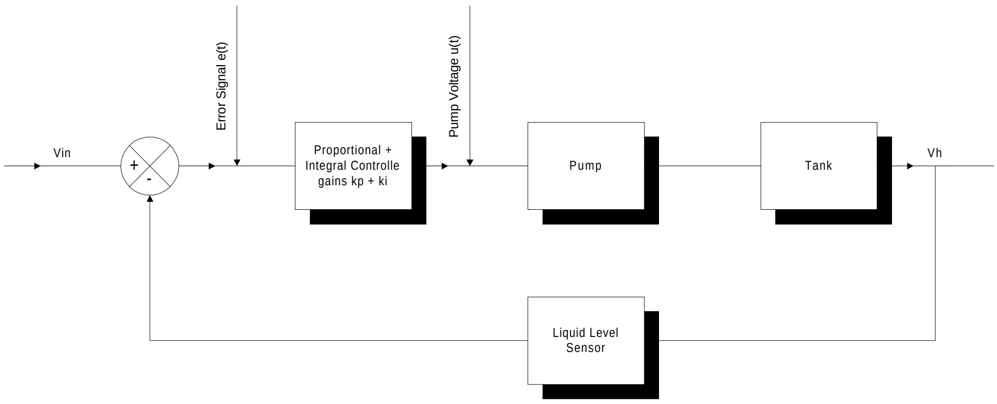


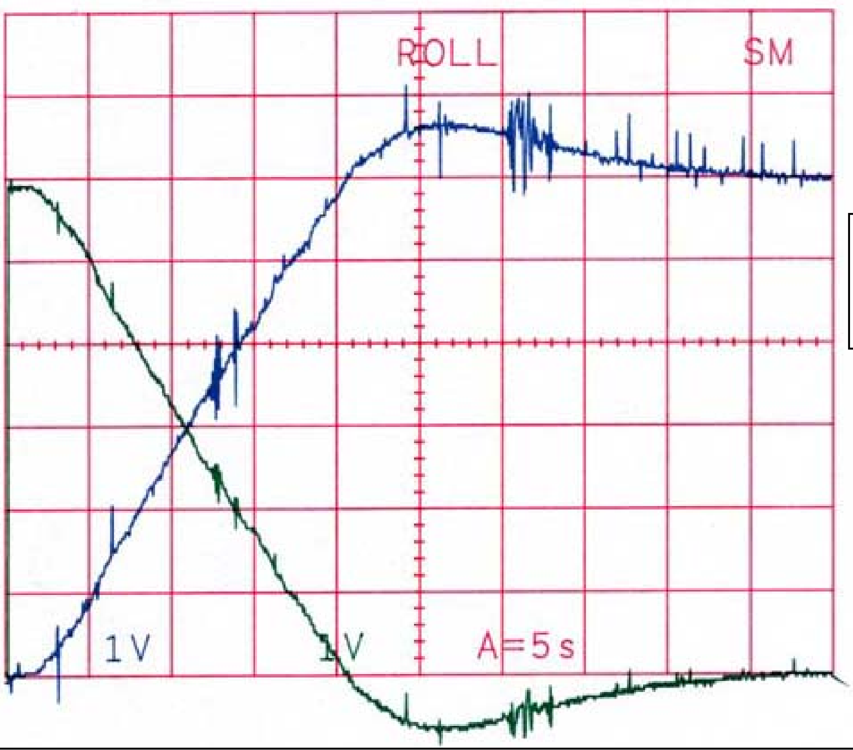
Figure 2 – Transient response plot with k_i=10 and k_p=10

τ=16s; e=2per cent, t_s=48s

c) Proportional + integral controller k_i=10 and k_p=10



The overall performance of the system increases, when the integral part is reduced and the proportional factor is left constant. This reduces the oscillating and results only in one overshot, after which the outputs settles to its desired value.



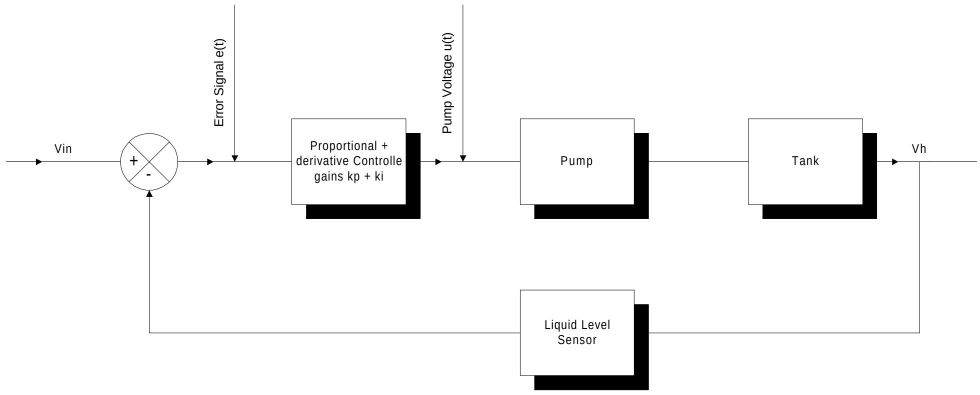
Blue: water level

Green: Error signal

Figure 3 – Transient response with k_i=1 and k_p=10

τ=13s, t_s=45s, e=0per cent

d) Proportional wit derivative controller



Adding a derivative controller to the proportional one brings no big difference. The output never reaches the desired input value and the derivative controller brings no improvement to the time constant or the settling time.

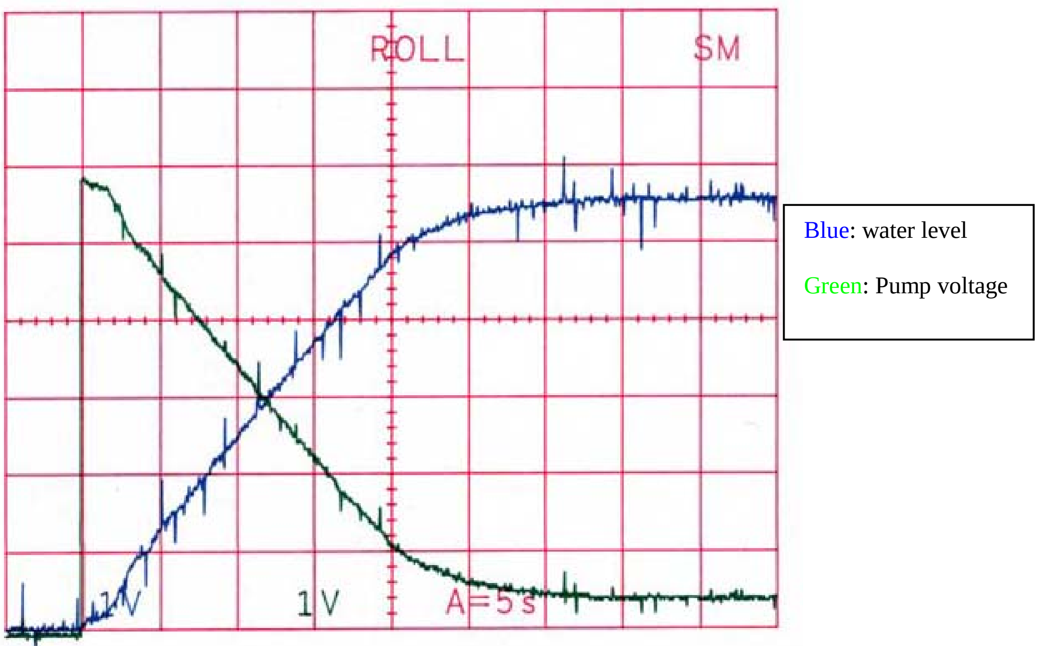
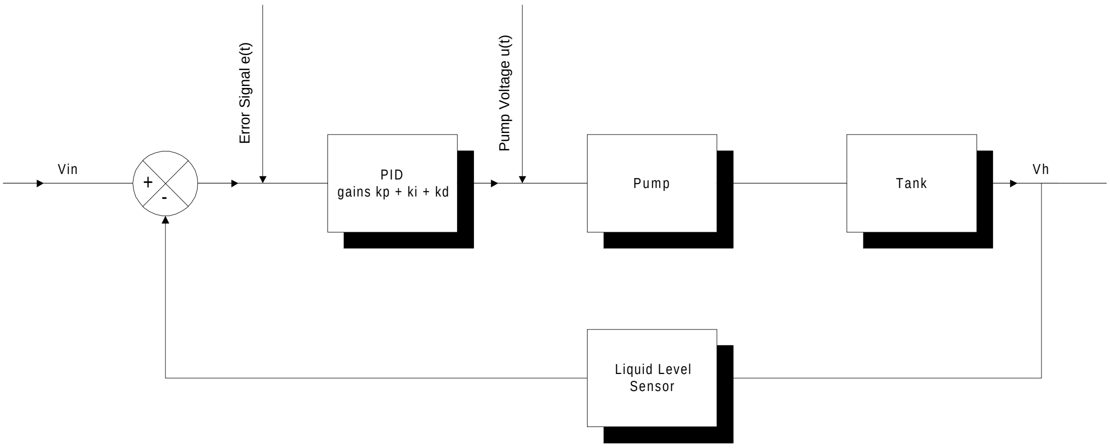


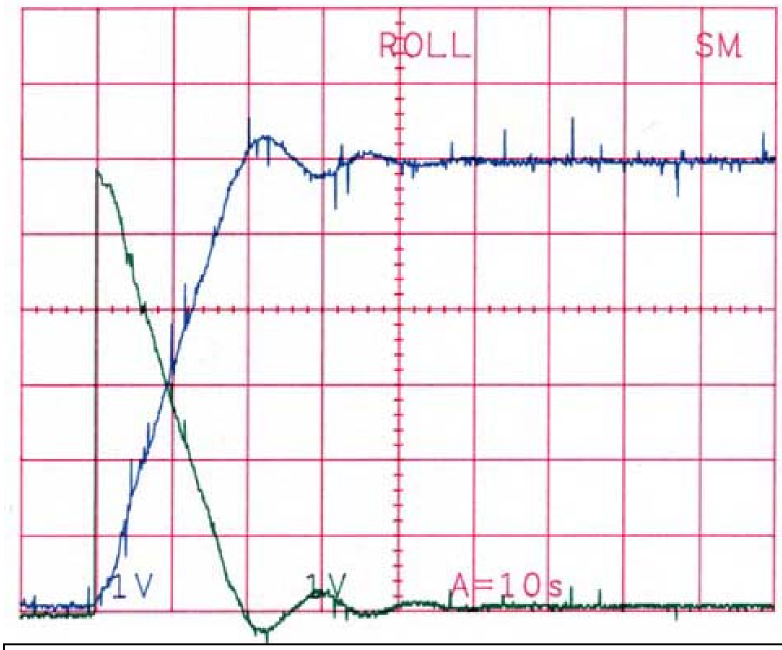
Figure 4 – Proportional and derivative controller with k_p=10 and k_d=10

τ=17s, t_s=40s, e=7per cent (6V/0.4V)

e) PID controller (Proportional + Integral + Differential)



From the other parts it should be expected, that a combination of all three controllers brings the best result, but the transient response shows, that the settling time t increases and the systems tends to oscillate.



Blue: water level

Green: Pump voltage

Figure 5 – Transient respone with k_p=10, k_i=10 and k_p=10

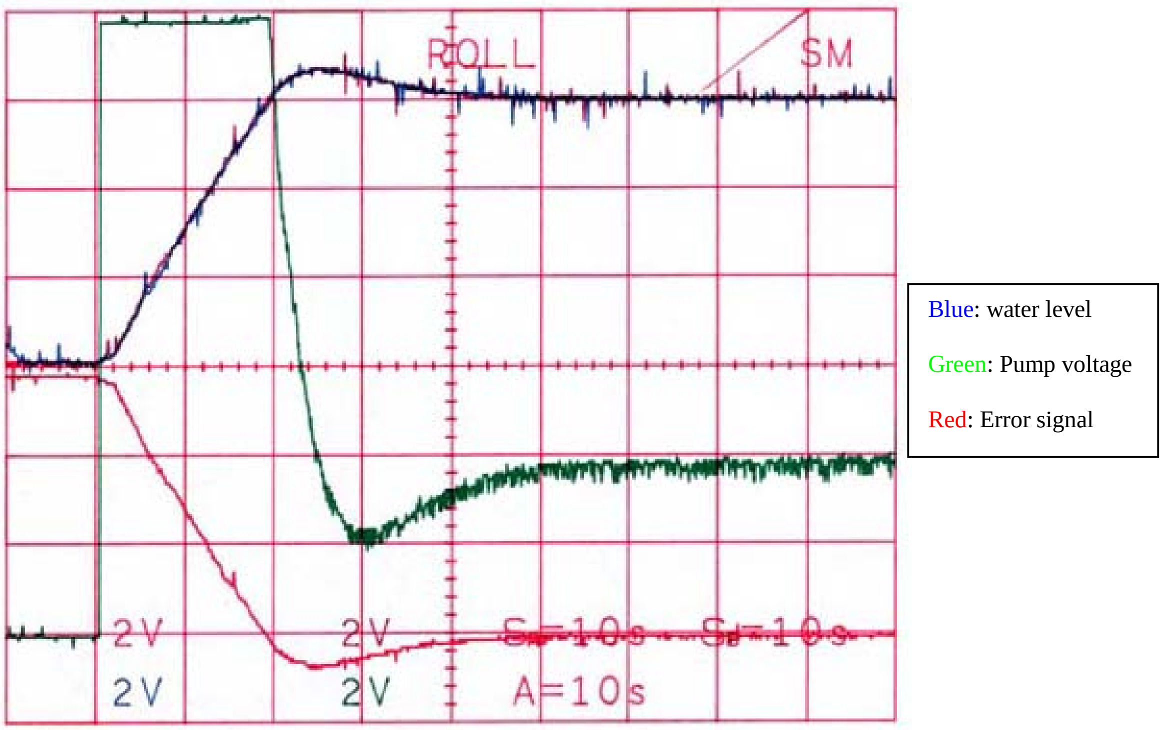
τ=12s, t_s=55s, e=0

6. Comparision

Part	P	I	D	τ	t_s	E
a)	**10**	**0**	**0**	**10**	**25**	**7**
b)	**10**	**10**	**0**	**16**	**48**	**2**
c)	**10**	**1**	**0**	**13**	**45**	**0**
d)	**10**	**0**	**10**	**17**	**40**	**7**
e)	**10**	**10**	**10**	**12**	**45**	**0**

From the above table it can be said, that part c) and e) produce the best result. From the transient response part c) has the best overall performance:-No oscillation
- Output value = desired
- Reasonable settling-time

The following graph shows part c) with the occurring error signal.



At the beginning the pump voltage increases to its maximum. Then, when the output reaches its desired value the pump-voltage drops, the output overshoots and due to the negative error signal the output decreases until it has settled down to the end-value of 150mm or 6V.
So the PI controller is the best solution for this system.

7. Conclusion

In difference to the first lab, where only a simulation with a simple proportional controller was to do, in this Lab the difference between a range of controllers could be seen.
Also it could be obtained, that not a mixing of all three used controller types results in the best solution.
Hence it's very important to choose the right type and structure of arrangement the when a control system is to be designed.

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