Digital Control Project

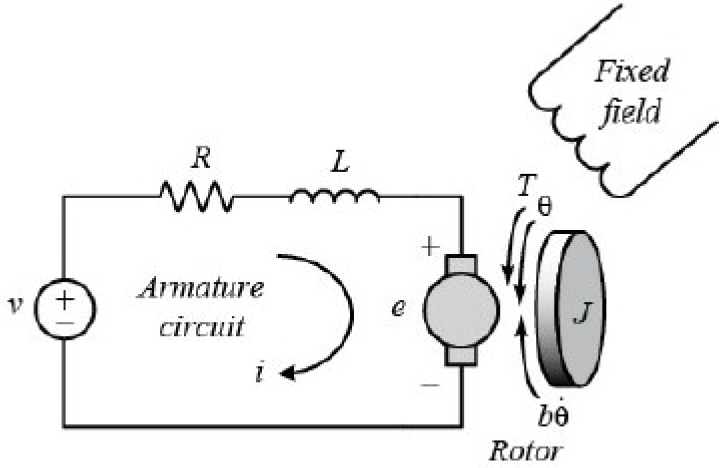
Sygkounas Alkis

University of Patras

Dc-Motor Simulation and Control

Purpose of this project is to simulate a dc-motor and compare it in real time using the Labview software.

Circuit Diagram



Equations of the model

$$T = K_t . I \quad (1)$$

$$E_\varphi = K_e . \Omega \quad (2)$$

$$J \frac{d\Omega}{dt} + b\Omega = KI \quad (3)$$

$$L \frac{dI}{dt} + RI = V_{in} - K\Omega \quad (4)$$

Vin: Voltage Input of the system

E_φ= Voltage of motor

Ω= Angular Velocity of motor

I= Current of the motor

T= Torque of the motor

Parameters of the model

We need to calculate all the parameters of our motor in order to proceed. The total parameters of the system are 6 and specifically are:

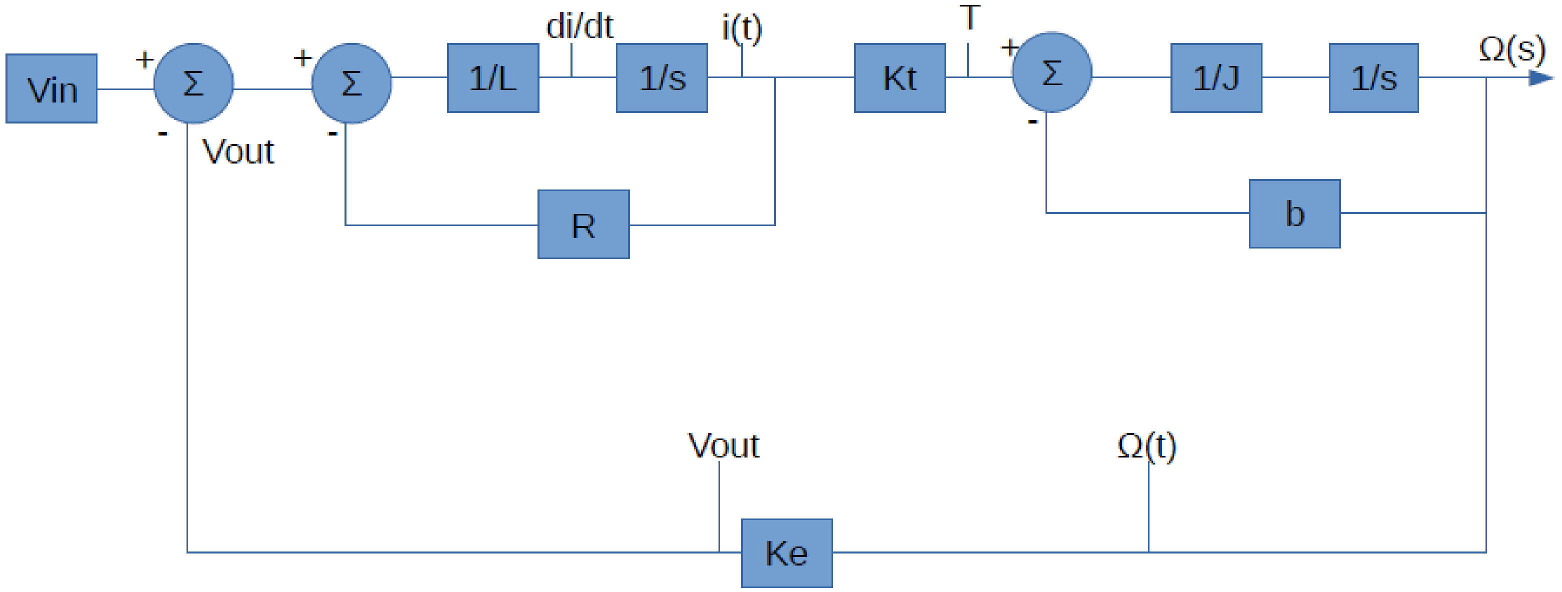
- **J**= Moment of inertia
- **b**= Coefficient of rubbing
- **K_e**= Electrostatic coefficient
- **K_t**= Torque coefficient
- **R**= Resistance
- **L**= Induction

Transfer function

- For $K_t=K_e$, then the transfer function of our system is given:
- $$\frac{\Omega(s)}{V_{in}(s)}=\frac{K}{JLs^2+(bL+JR)s+bR+K^2}\left(\frac{rad/sec}{V}\right)$$

Building Chart

- Through the building chart we can obtain every theoretical value of motor.



Calculating the R, L parameters

- We calculated the resistance R with multimeter.
- Specifically, we measured the voltage output, while our motor was on from: $R=(V_o-V_i)/i$
- We observed, that the resistance was changing value as the time was passing due to the temperature rise.
- Same procedure we did for the calculation of the induction L but with AC input Voltage.

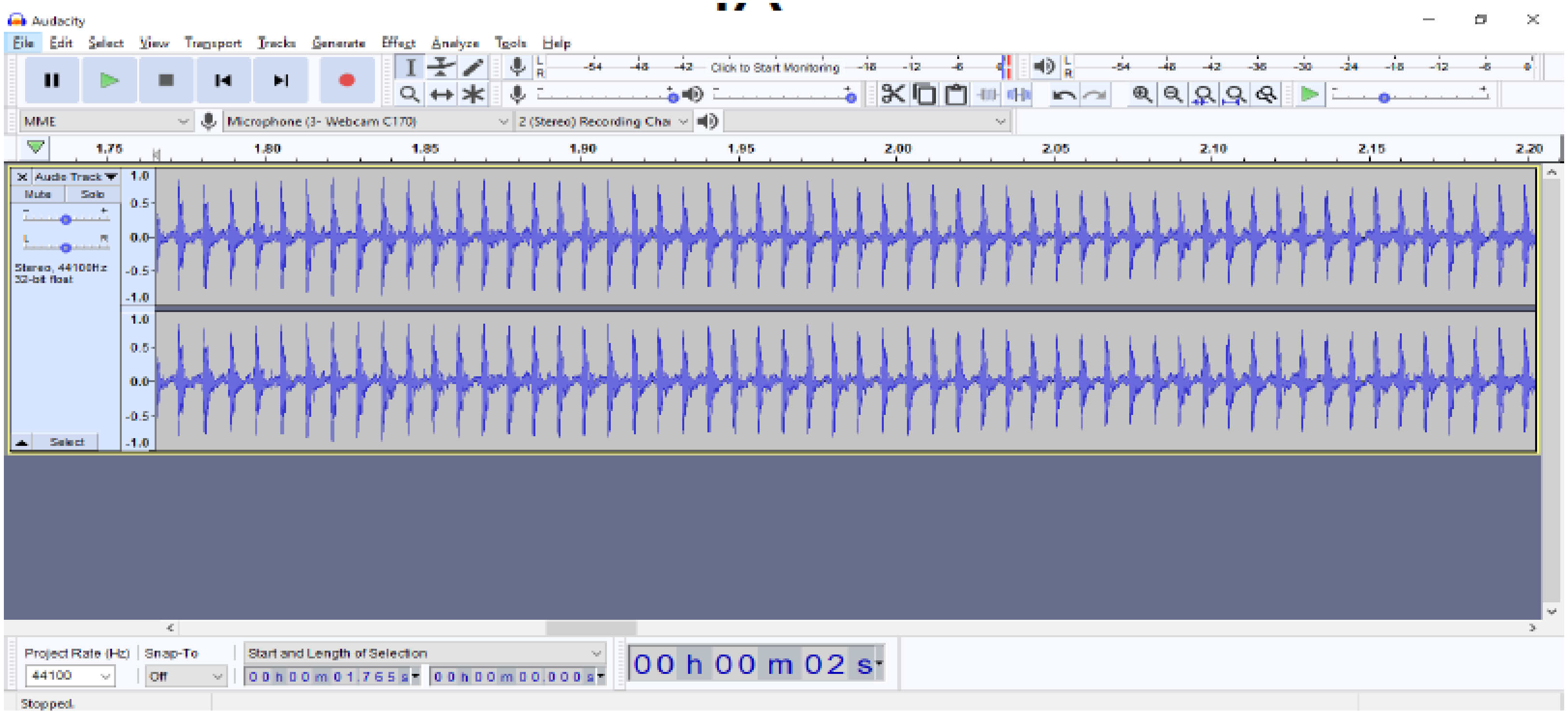
Calculating Ke

- In order to calculate the coefficient Ke, we used the software called audacity.
- Specifically, we measured the sound of the rotating motor, while we were changing the input voltage.
- One period measurement T, so Ω(rpm)= 60/T
- 1rpm=π/30 r/s, so Ke= $\pi/30 * V_o/\Omega$ [V/rad/sec]

Calculating J,b

- The same process was done for the calculation of inertia J and the coefficient of rubbing b.
- We calculated the orders of magnitude for both of them based of the t_r, which is the rise time.

Image-1 Audacity processing sound



Temperature dependency of restistance R

- On our motor the temperature rises quicly, tho changing the value of the resistance.
- As the temperature was going up the resistance was going down
- The temperature change can be calculated from the given type:
- $\mathbf{R=R_0(1+\alpha\theta)}$, where R_0 is the resistance on room temperature, θ the temperature and α the temperature coefficient.
- Measuring the resistance R across multiple temperatures we can get the value α from the above equation.
- But we kept a steady value of the R, as it was difficult to calculate correctly the temperature of the motor.
- Note, that the α has negative value.

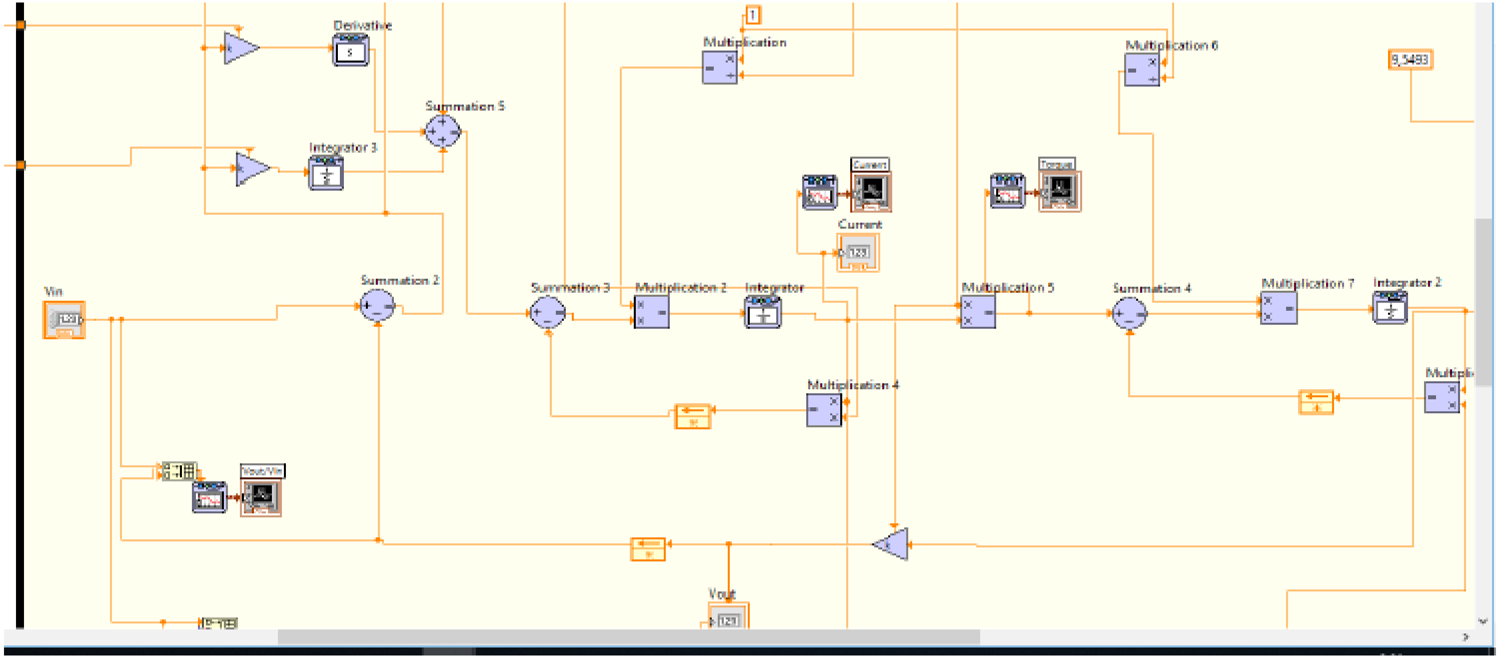
Coefficients of our dc-motor

- For our small motor we calculated:
- K=0.001455 [V/rad/sec] (N*m/Amp for the $K_{t)}$
- b=4E-7 [Nms]
- R~0.63Ω(max value 0.68 and min value 0.58)
- L=0.001 H
- J=1E-6 m^2
- R=0.63Ω (R=(R_{max}-R_{min})/2), where R_{max} was 0.68Ω and R_{min} was 0.58Ω.

Measuring the Ω(rpm)

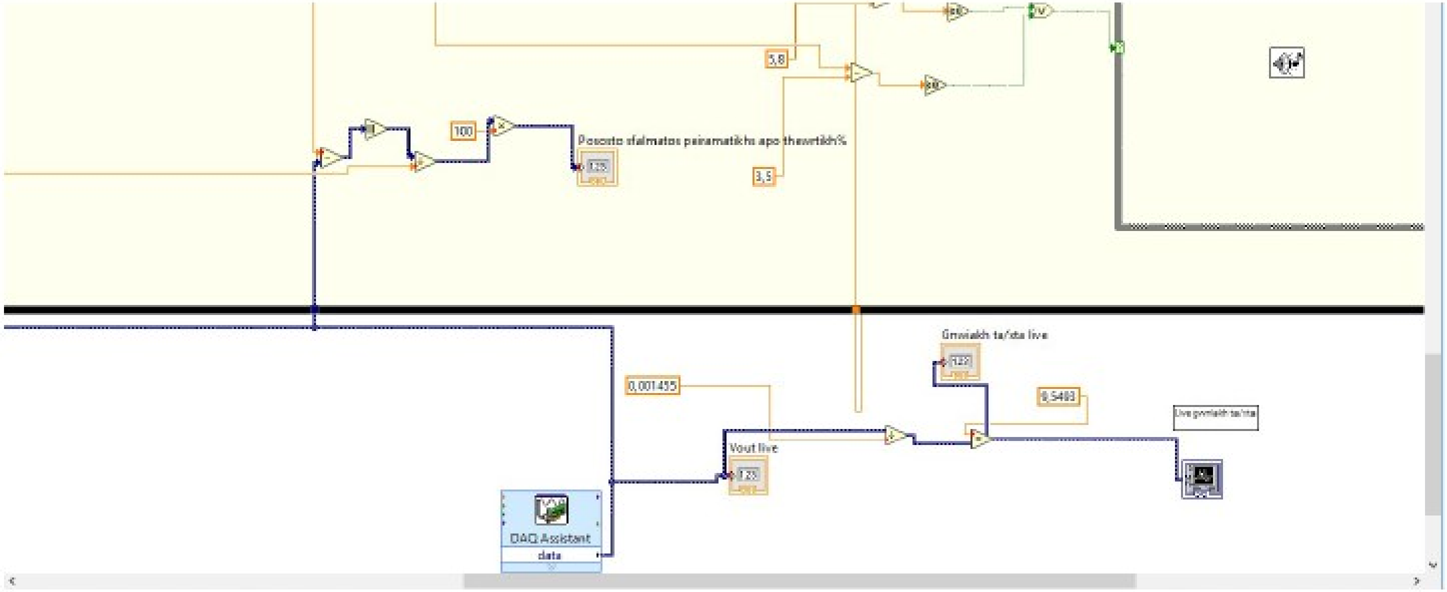
- The classical way of measuring the angular velocity is through accelerometer.
- That, wasnt available so the Ω was calculated throught the equation: $E_{\varphi}=K_e\Omega$,where K_e has steady value.
- We measured the output voltage each tIme on the rotor using the mydaq assistant.

Snapshot 1/3

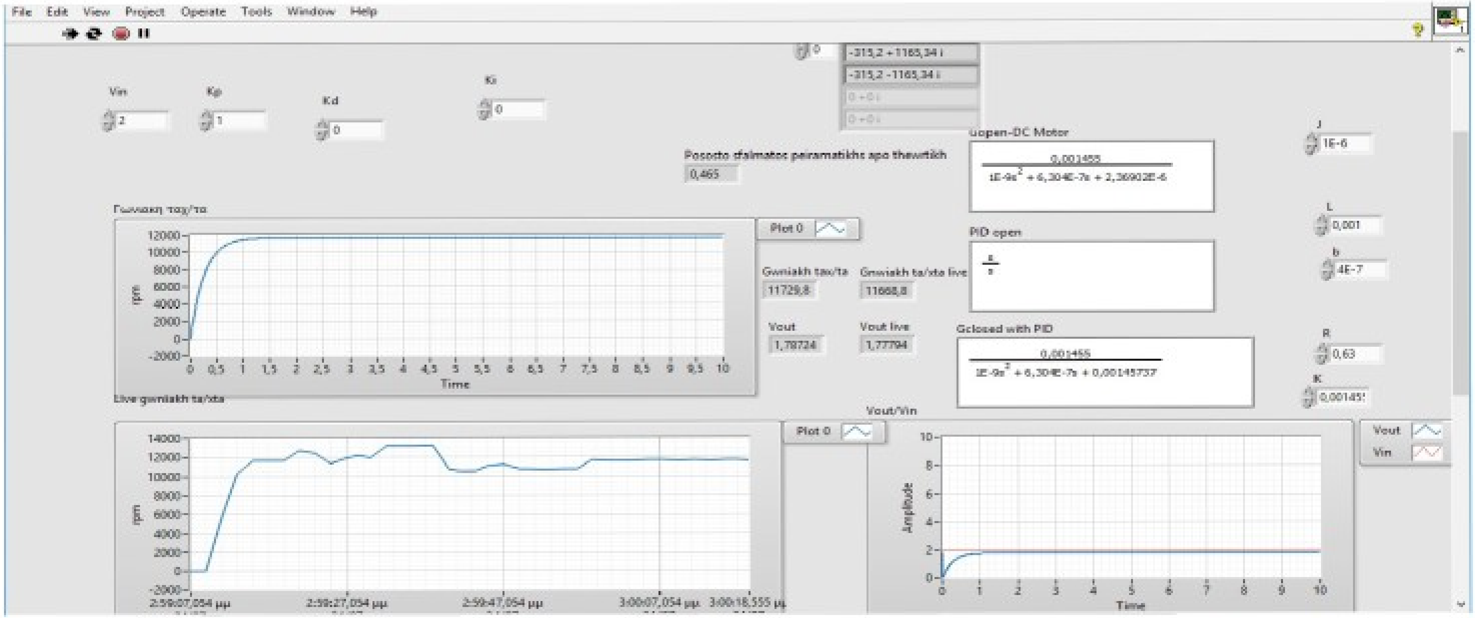


Derivative
Summation 5
Integrator 3
Multiplication
Multiplication 6
9,5493
Current
Torque
Current
Vin
Summation 2
Summation 3
Multiplication 2
Integrator
Multiplication 5
Summation 4
Multiplication 7
Integrator 2
Multiplication 4
Vout/Vin
Vout

Snapshot 2/3


5,8
100
Pososto sfalmatos peiramatikhs apo thewrtikh%
3,5
Gnwiakh ta/sta live
0,001455
0,5403
Vout live
DAQ Assistant
data

Snapshot 3/3



File Edit View Project Operate Tools Window Help
Vin
Kp
Kd
Ki
Gopen-DC Motor
Posocto sfalmatos peiramatikhs apo thewrtikh
0,465
PID open
Gclosed with PID
Gwniakh tax/ta
Gnwiakh ta/xta live
11729,8
11668,8
Vout
Vout live
1,78724
1,77794
Γωνιακη ταχ/τα
Live gwniakh ta/xta
Vout/Vin
Plot 0
rpm
Time
Amplitude
Vout
Vin
J
L
b
R
K
1E-6
0,001
4E-7
0,63

Validity of the comparison

- For the (0-6)V of the operating area of the dc-motor we measured a ~5% divergence of the theoretical values to the experimental values.
- This happened due to the changing value of the R as we coudnt measure correctly the temperature of the motor as it was a small one.
- The coefficients J, b was hard to calculate the specific value(only the order of magnitude) through the time rise t_r.

Extras

- On the software development we introduced a PID controller, illustrations of the transfer functions open/closed loop and also the poles of the transfer function.
- Furthermore, we put a safety measure with a beeping of danger, when the input voltage is closing to the limit/

Future work

- The software part can be used in any dc-motor.
- Through the building chart we can obtain every useful value of the motor(voltage, current…)
- The PID controller can be used to correct or change the behaviour of the motor.