FINAL PROJECT OF DYNAMIC SYSTEMS

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Abstract - The Final Project of the subject of Dynamical Systems seeks that students apply the concepts and theories presented in the subject where transfer function values, block diagrams, dynamic equations are found, comparison of input and output signals, frequency analysis and circuit design with operational amplifier

Keywords - transfer function, block diagrams, dynamic equation, frequency analysis.

I. INTRODUCTION

In the following project carried out by the work team has as main functions to determine both the theoretical and experimental transfer functions according to all the knowledge acquired during the course of Dynamical Systems all these mathematical calculations are based on data taken experimentally and in a real way, which will allow us to see the difference between experimental behaviors and theoreticians as will be revealed in the next process.

II. PROCEDURE FOR SUBMITTING THE WORK

A. *Point 1*

Determine the experimental transfer function (F.D.T) using the data acquired during the home experiment (time vs height). The required data are: input flow data [m3/s], height in the vertical tank [m] and time of each sample using a timer indicating the time of data collection (sampling period (Tm)). This data can be entered into the Matlab or Octave tool. (attach in the delivery the experiment data)

TIEMPO (segundos)	NIVEL (metros)		k tao
0	0,00	0	0,0000000
3	0,01	0,0072278	0,0000031
6	0,02	0,01406124	0,0000009
9	0,02	0,02052184	0,0000002
12	0,03	0,02662994	0,0000027
15	0,03	0,03240478	0,0000058
18	0,04	0,03786454	0,0000082
21	0,04	0,0430264	0,0000092
24	0,04	0,04790663	0,0000153
27	0,05	0,05252059	0,0000204
30	0,05	0,0568828	0,0000238
33	0,06	0,06100701	0,0000251
36	0,06	0,06490619	0,0000153
39	0,07	0,06859263	0,0000129
42	0,07	0,07207794	0,0000095
45	0,07	0,07537308	0,0000056
48	0,08	0,07848844	0,0000002
51	0,08	0,08143381	0,0000002
54	0,08	0,08421849	0,0000000
57	0,09	0,08685123	0,0000000
60	0,09	0,08934032	0,0000004

Stabilization point: 0.123m

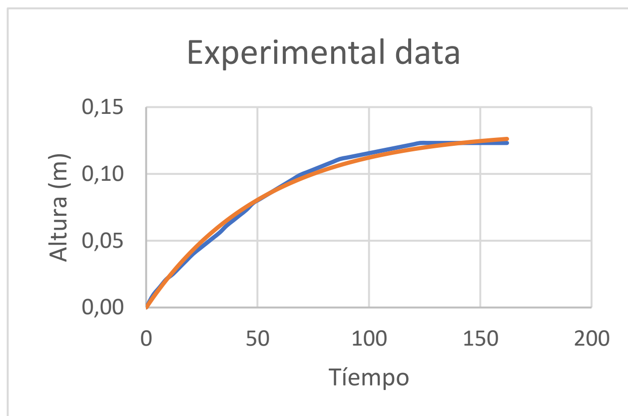
Tank diameter = 16.5 cm

$$A = \pi r^2$$
$$A = 3.14 * 8.25^2$$
$$A = 213.71\ cm^2$$
$$q = \frac{h.A}{T}$$

Inflow

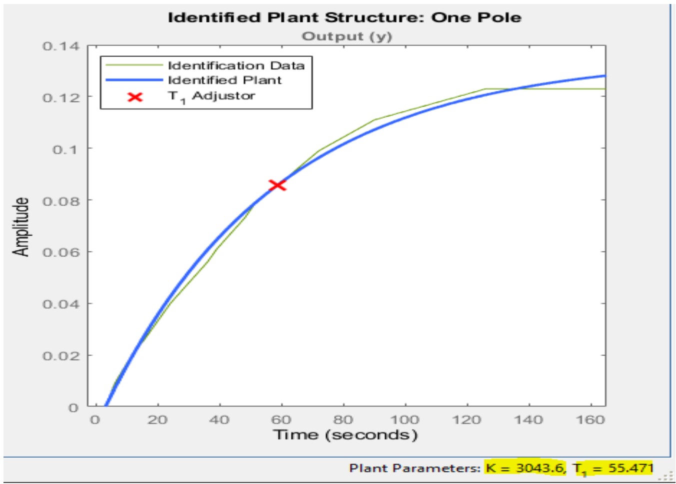
qin= $\frac{3cm.*213.71\ cm^2}{14.41}$ =44.49 cm^3/seg

qin= $4.449x10\ x^{-5}\ m^3$/seg



To determine the experimental transfer function, the Excel program was used in order to determine the parameters (K, Tao) of the system as similar as possible. The blue line is the data extracted from the experiment and the orange line is the correction or adjustment of the experimental data. Excel's Solver function was used to reduce the error.

Thanks to the IDENT function of Matlab, it was also possible to determine the same parameters of the system by importing the data of the experiment obtaining data similar to the information obtained from Excel allowing to obtain the following Experimental F.D.T



In this way, the Experimental F.D.T of our system is achieved. the data used were those of Excel since they presented a better similarity with the experimental data.

$$\frac{H(s)}{Qi(s)} = \frac{2.977 * 10^3}{53.47S + 1}$$

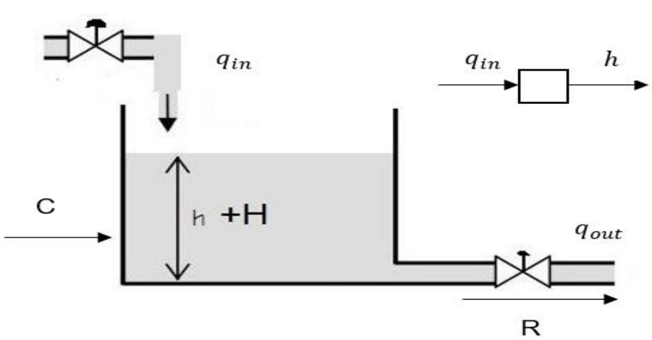
B. *Point 2*

Make a video no longer than one minute in which the experiment performed at home is observed and
detail the set-up of the experiment performed to take the modeling of the system.

https://youtu.be/QszYwl1kPKQ?t=6

C. *Point 3*

Determine the theoretical F.D.T. using the block diagram technique presented in the classes of the subject. To extract the physical parameters of the system, use what you learned in the response chapter in the time of this subject.



$$Sea\ q_{in} = 4.449x10^{-5}\frac{m^3}{seg}$$
$$Sea\ C = 0.021371m^2$$
Sea h= 0.123m
$$q_o = \frac{h}{R}$$

$$\frac{Cdh}{dt} = q_{in} - \frac{h}{R} \rightarrow q_{in} = \frac{Cdh}{dt} + \frac{h}{R}$$

Applying Laplace transform

$$Q_{in(s)} = CSH(s) + \frac{H(s)}{R}$$

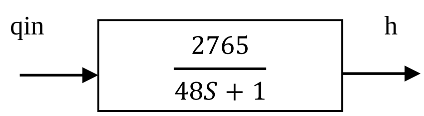
Applying common factor

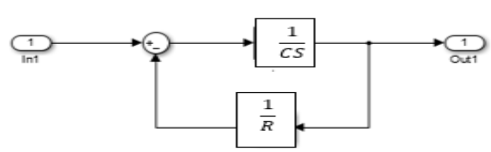
$$Q_{in(s)} = H(s)\left(CS + \frac{1}{R}\right)$$

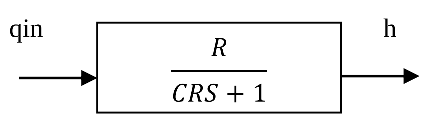
$$\frac{H(s)}{Q_{in(s)}} = \frac{R}{CRS + 1}$$

$$H(s) = \frac{R * Q_{in(s)}}{CRS + 1} \rightarrow F.D.T$$

$$\tau = 0.123 * 63\%$$
$$\tau = 48seg\ determined\ from\ a\ height\ of\ 0.077$$
$$R = \frac{\tau}{C} = \frac{48seg}{0.021371m^2}$$
$$R = 2246\frac{seg}{m^2}$$
$$K = \frac{h}{q_{in}} \rightarrow \frac{0.123\ m}{4.449 * 10^{-5}\frac{m^3}{seg}}$$
$$K = 2765\frac{seg}{m^2}$$
$$Sea\ \ H(s) = \frac{k}{\tau s + 1}$$







D. *Point 4*

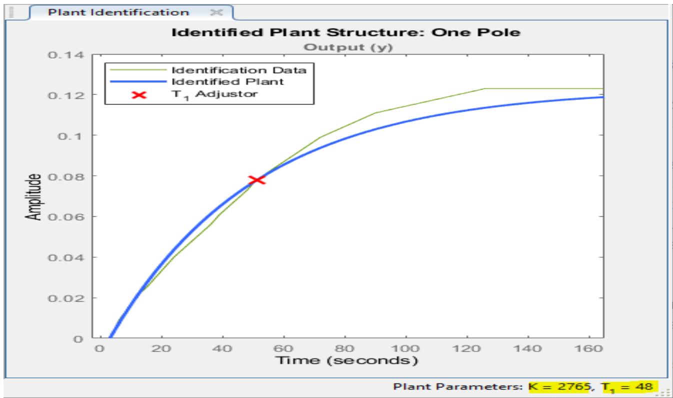
Find the dynamic equation of the hydraulic system from the elements that are part of the system.

$$\frac{Cdh}{dt} = q_{in} - \frac{h}{R} \rightarrow q_{in} = \frac{Cdh}{dt} + \frac{h}{R}$$

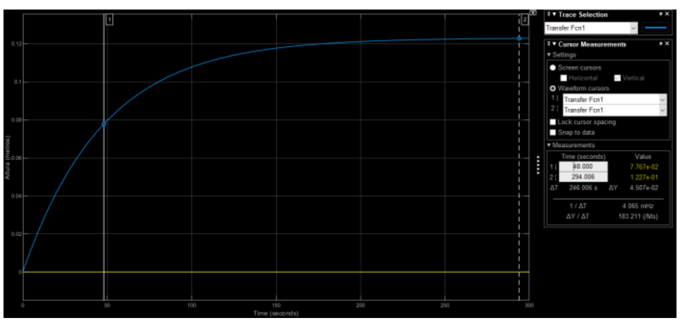
E. Point 5

Compare the two output signals (theoretical and experimental model) from the signal used in the experiments.

R// the output of the transfer function of the theoretical system presents a longer time for its stabilization compared to the output of the experimental system. how it can be seen in the following graph



Using simulink, it is observed that when the point of stabilization is about to be reached, the variation in the height data is in decimals, so it can be concluded that possibly in the experimental data it was determined that it was already stabilized.



F. Point 6

Express the mathematical model of the plant found using the representation in state variables and its output matrix, the latter will depend on the output signal of the plant.

State variable {h}, Interest variable {h}

$$q_o = \frac{h}{R}$$

$$\frac{Cdh}{dt} = q_{in} - \frac{h}{R}$$

$$Matriz\ de\ entrada\ \{\dot{x} = Ax + Bu\}$$

$$\left[\frac{dh}{dt}\right] = \left[-\frac{1}{CR}\right]_{1x1}[h] + \left[\frac{1}{C}\right]q_{in}$$

$$Matriz\ de\ salida\ \{y = Cx + Du\}$$

$$[h] = [1]_{1x1}[h] + [0]q_{in}$$

G. Point 7

Analyze the frequency response of the plant from the Fourier Transform, perform the respective simulation and analysis. Present the conclusions regarding the behavior of the system.

the frequency analysis of the system is determined and plotted using MATLAB

$$\frac{H(s)}{Qi(s)} = \frac{2.765 * 10^3}{48S + 1} * \frac{\frac{1}{48}}{\frac{1}{48}} = \frac{57.60}{S + 0.02083}$$

$$s = 0\ ; \quad \frac{57.60}{0.02083} = 2765.242$$

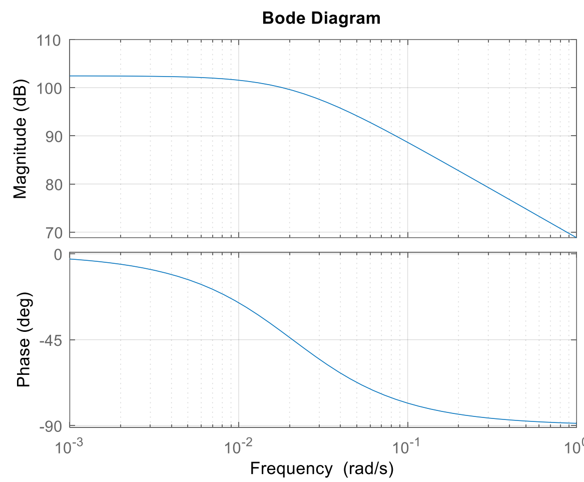
Cutoff frequency

$$s + \propto = 0\ ; S = -\propto\ ;\ s = 0.02083$$

Behaviour

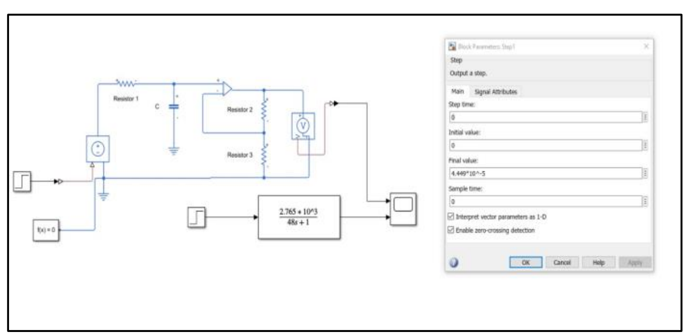
$$H(s)dB = 20\log\left[\frac{57.60}{S + 0.02083}\right]$$

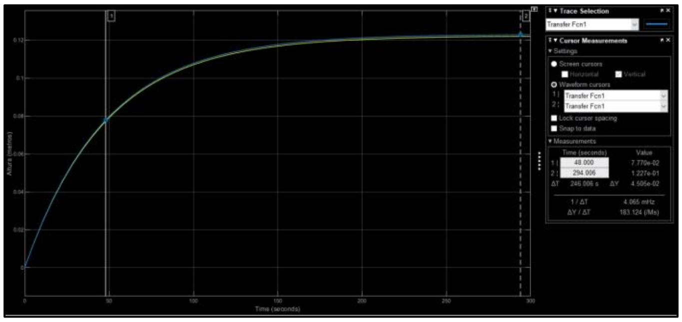
$$H(s)dB = 20\log(57.60) - 20log(s + 0.02083)$$



H. Point 8

Design an electrical circuit (with Operational Amplifier), so that the FDT of the electrical circuit responds equally to the experimental FDT. Simulate the response and compare the two output signals: designed electrical circuit and theoretical FDT response.





The values given in each component of the electrical circuit were the same data as obtained in the model of the experimental plant since the condensator value is determined from the transverse area of the tank, the value of R_1 is obtained with the division of τ/c where τ is determined with 63% of the stabilization height of our tank, the R_2 and R_3 represent the gain of the system, R_3 with a value of 1Ω is assumed to ensure that the FDT of the electrical system is the same as the theoretical one and the input voltage is the same as the input flow.

$$\frac{VS}{VE} = \frac{R_2 + R_3}{R_3(CSR_1 + 1)} \rightarrow FDT.$$

CONCLUSIONS

This project finally concludes where the team believes they have obtained the necessary knowledge and learning through this experimental practice, since it is possible to acquire a new knowledge by relating the theoretical stage seen in the whole semester and the practical stage from the hydraulic system. Finally, the work team thanks the teacher of the subject of Dynamic Systems for sharing their knowledge in detail, for their learning methodology and being very flexible in all activities