MXET 375
Term Project Spring 2019:
Dynamics of a VCR Player

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Abstract -

In this report, we will discuss the inner workings of a VCR, how we went about testing the components, and modeling the system. The approaches we took to modeling the system will also be discussed and how the results compare to those of a non simplified system. This project had to be simplified and broken down more and more at each step in order to make this a workable size. A large error that skewed our data was the deletion of some components. Each major section of the VCR was broken down into it's appropriate subsystem where the equations could be created.

I. Introduction

VCR players, videocassette recorder, was a popular movie playback device used throughout the late 20th century and into the early part of the 21st century. After taking around 20 years to be finalized, the resultant assembly is a compilation of a myriad of complex mechanical and electrical subsystems that when working together properly are able to read data from an electromagnetic strip into a rotating drumhead that produces an image when connected with a monitor. This act is called helical scanning. Other than solenoids that read the electromagnetic force of the tape as an input the drumhead also utilizes a complex circuit board containing resistors and capacitors. Inside of this component is a stepper motor that ensures the one rotation is equivalent to the number of steps. In between the stepper motor and the circuit board is a rotary transformer that places two electrical signals together.

Another key component in our VCR system are the roller guides and capstan which act as rotating polls within the system that the tape passes through in order to keep the same angular velocity throughout the system. This component comes from the tape gears that are connected to the VCR tape. Only one of these components rotates at any given time. If the right gear is rotating then the tape is going in the forward position while if the left gear is rotating then the tape is rewinding. The idler gear is what determines which of the tape gears is moving at any given time. It slides parallel to a spring which hits a clasp that triggers the gear to move. In our design we attached a motor to the idler gear to act as a power source to the system.

All in all, we have only accounted for around 10% of the original VCR components since the complete system would have been too complicated to finish. This is due to the sheer complexity of the dynamics system. The system should be between 30 Watts and 50 Watts for total energy consumption.

II. Design Process

The design process of this lab can be broken up into four major sections, the disassembly, the testing, the Solidworks CAD portion, and the Simulink Model. For our purposes, disassembly and testing will be combined into one overarching topic of hardware.To accomplish this project, we purchased two working VCRs for testing and disassembly purposes. We used numerous online resources to research our topic and we also checked out 5 books from the library on the inner workings of VCRs as well as the testing conditions and repair methods associated with them to get a better understanding.

A. Hardware

To start off, the first task we delved into was the disassembly of a working VCR. To do this, we took apart one of our purchased VCRs and broke it down to its most basic sub-assemblies, which can be seen below in figures 2-5. This allowed for a modular analysis of each sub-system and simplified it enough to gain a more basic understanding. This stage also allowed us to see the inner workings and see how each system interacts with the other components. We then broke it down to the bare minimum in order to dimension and model each component present. We used the other VCR we purchased for testing. We tested this by running it under a load (5 movies worth). After deeming it to work, we proceeded to remove the cover of this one and brought it to a location where we could run our tests. From here, we started running our tests and measured the voltages and resistances across all the exposed electrical components. We left the drumhead intact for this, as it would be too complicated and mainly focused on components on top of the drumhead. The bottom of the drumhead, which allows a view inside can be seen below in figure 4. We decided upon only focusing on the tape system which can be seen in figure 3, in order to drastically reduce the complexity of the system, however even this was still going to be very extensive.

B. Solidworks

Next, using the completely disassembled VCR, each component was modeled. Both group members had very little experience when it came to solidworks which made this task especially cumbersome. Over 65 components were modeled for this task. This task took up the majority of the time spent working on this project. Many components were simplified and combined. For example, some complex assemblies that only moved as a whole were modeled as one component to reduce modeling time and simplify the system. In order to reduce the complexity, the assembly was fixed in the forward position and some parts were synthesized. This was necessary for many reasons, one of which being that because based on our limited understanding, we had no way of finding the I value of such complicated components. In order to model this system, one at a time each component was modeled by taking the dimensions we could with a dial caliper and then calculating and estimating the rest. Assembly files were made for many of the subsystems and those inserted into a larger assembly file. Each component was appropriately constrained within the system as much as we were able. The full assembly model can be seen below in figure 1. The biggest problem we had with this was that Solidworks has no concept of flexibility in singular components. This prevent us from properly modeling the tape, which took a significant source of time. We first attempted this by using a sketch and sweeping method using Solidworks' own 'belt/chain' function. However, we soon realized that the lack of flexibility broke the other constraints present in the system and that they were not quite compatible.

C. Simulink

Starting the simulink portion of this process involved converting the solidworks file into a usable matlab file. This converted file can be seen in the appendix in figure 8. Once inside of matlab each joint could be given a specific angular velocity in order to move the different components. Although while viewing the animation it is hard to see this rotation, it can be seen if the axis of the object itself is selected. The rotational values that were used for the model were taken based on the rpm of the tape gears and related to other components by using gear ratios.

To begin the next part of the simulink process we gathered all the known and unknown values of our total system. These values can be seen in figure 6 in the appendix. Each individual component was given its own subsystem to view the energy of utilizing a scope. Energy for the left rotator was calculated first, by using the equation for the inertia of a circle which was then placed into the rotational kinetic energy equation. This same equation set up would be used for finding the energy of the right rotator head and the same components that were on the left side of the animation. The other equations used involved a spring system or an electrical system.

For the electrical components since some of the values were unreadable, such as the capacitor values, we had to use a best fit value for what the output data should be. We used the resistor values that were found on the drumhead circuit. The equations are all in the appendix. The original units that were used in the system were standard units.

III. Results

The graphical results for all the subsystems and total system can be seen in the appendix below. Because of the components that we had to disregard for this project the output results of each section do not accurately fit real world applications. An easy to spot discrepancy can be seen in both the left and right rotator as they appear to be at a constant state of energy. This is because of the removal of many components that act on this specific system whenever the system should model a kinetic energy parabolic waveform. An example of what the correct waveform would look like in real world applications would be the tape gears. Although it should be noted that no proper cap value is reached on this portion of the project.

The drumhead is the only component that has a linear energy output. This is likely because many of the values on the drumhead were unknown and not factored in properly since there was no way to reach that component. The solenoidal electromagnetic forces could not be factored into the equations since there was no way to account for all 12, coupled into three sets of two, accurately. This leads to a more linear instead of parabolic result. The total energy for the system was 42 Watts which should be around 2.5 KJ which works within the constraints of an actual VCR system.

IV. Conclusion

In order to accomplish this project, we had to strip a VCR down to the bare minimum, test it, and build it up again virtually. From there we had to come up with equations to mathematically model the relationships between components to find the resultant energies. The energy can be modeled by a quadratic function and will be continuously increasing. For this scenario it acts very idealistic but that would be different when sampling a product off of the shelf. This is due to our simplification of the system and removal of components. Based on data found in books and other resources, we have come to expect the energy range to be between 30 watts and 45 watts. By removing a multitude of components, the energy loss per subsystem will be a lot less, making the graph behave more ideally, this should reveal a lower energy value. At a time of around 10 seconds, the estimated power in an actual system should be around 50 watts or a little above, however we turned up the value of 42 watts. Based on our removal of components this makes sense and fits well within our expected standard, but still behaves very idealistically.

To set a VCR going forward or backward, an idler gear attached to a motor is used. When the motor is rotating clockwise, the VCR will be set to forward. For our system however, we fixed the assembly in forward position to simplify it further. This changes many things in the overall assembly, one such would be the graphs of the rotators. The graphs of the rotators in our system are at a constant energy of around .014 kJ. In a realistic system though, a kinetic energy model would be followed and would resemble a quadratic function based on the angle of the idler gear.

Overall this project provided us an interesting way to reinforce the knowledge gained in class and help boost our own confidence when taking on massive projects which we lack confidence in. We were able to go about a project this size by working in subsystems and simplifying the project down to manageable sizes. By doing this, we could now explain the inner workings of a VCR, a task most people of today and yesterday's era could not do.

V. Appendix

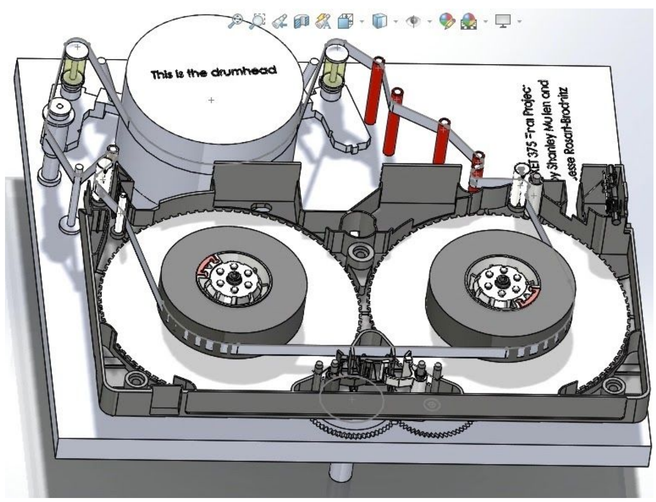

Figure_1_Completed_Solidworks_model

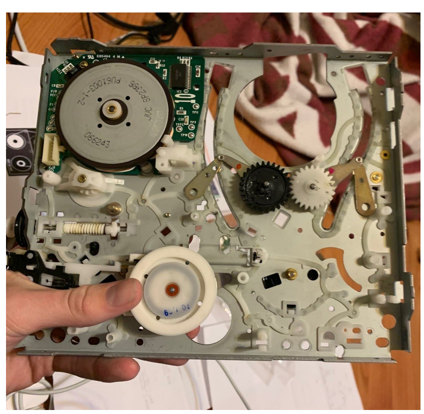

Figure_2_Base_VCR

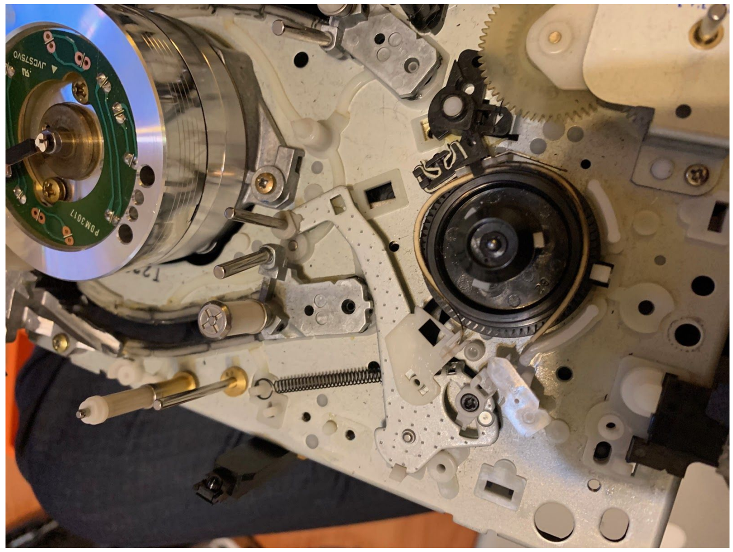

Figure_3_Tape_Gear

Figure_4_Drumhead

Figure_5_Bottom_Base

ae	1.3700
ans	748.2000
be	1.1700
C	1.0000e-03
ec	4.6370
er	6.9040
g	3787
k	50
k1	50
ke	42
m1	1
m2	1
mab	1
md	2
me	0.2500
mw	2.5600
myz	1
P	28
r	0.6300
R	82
r1	0.6300
r4	0.0200
ra	0.0750
rb	0.0500
rd	1.2210
rm	0.6200
rtape	0.3580
rw	0.0750
ry	0.1400
rz	0.0400
t	6
tout	57x1 double
w	1.1520
w1	1.1520
wab	1.1520
wd	0.8723
wm	11.7000
wtape	1.1520
ww	1.1520
wyz	1.1520
x1	2
x2	2
xe	0.6900

Figure_6_Labeled_Values

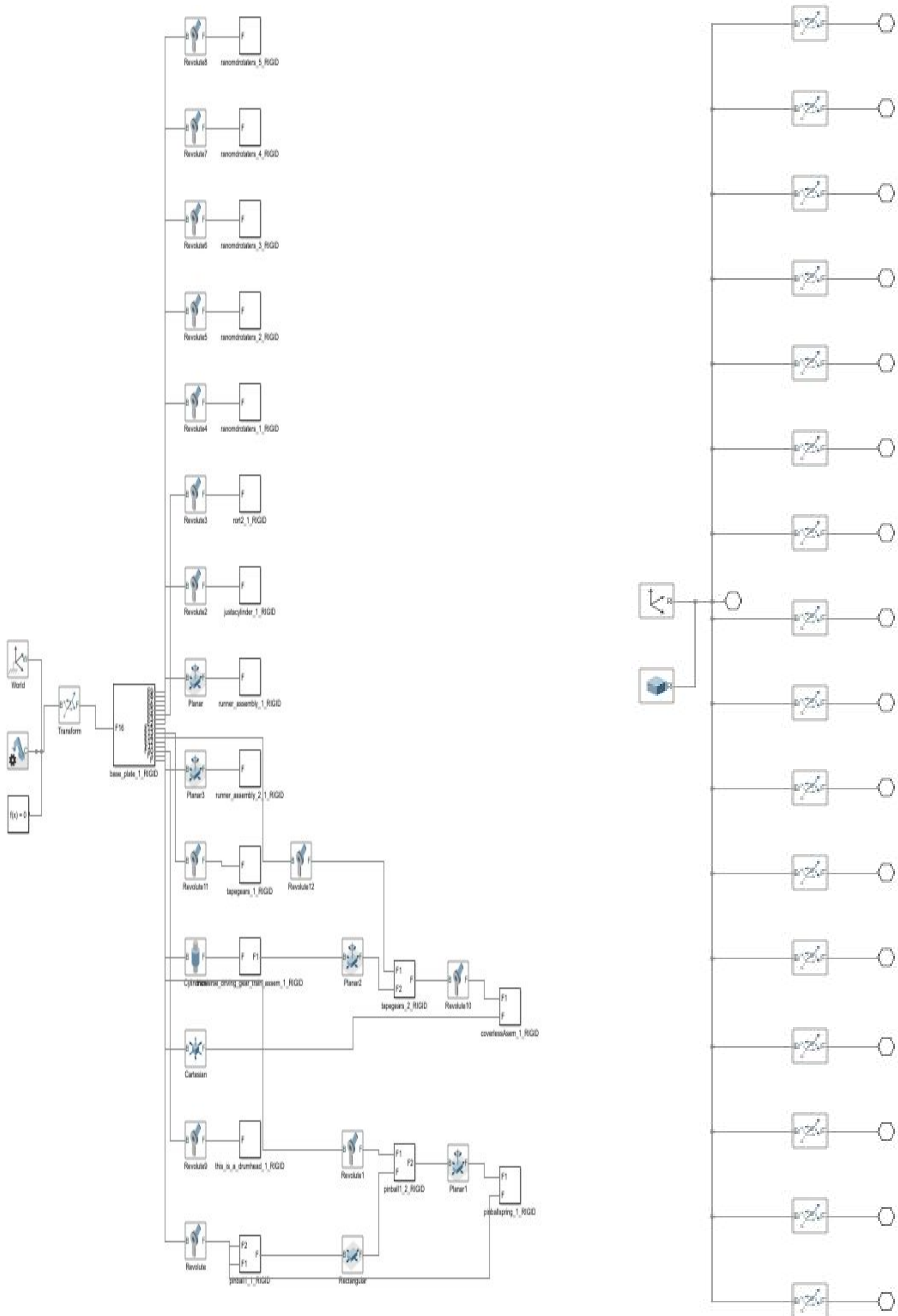

Figure_8_Solidworks_In_Matlab1

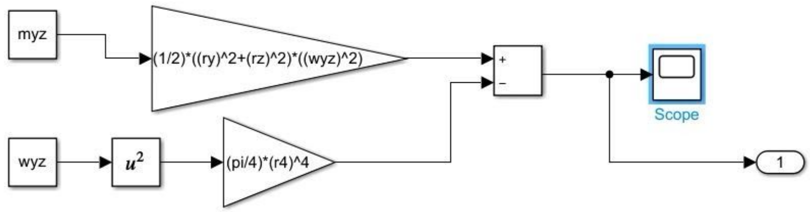

Figure_9_Equation_Left_Rotator_Head

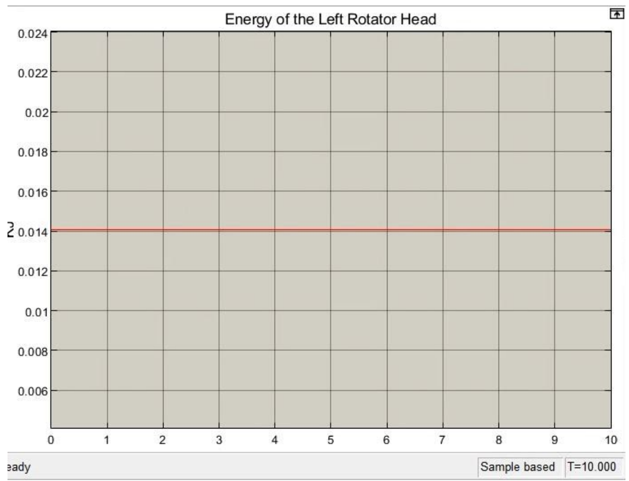

Figure_10_Graph_Left_Rotator_Head

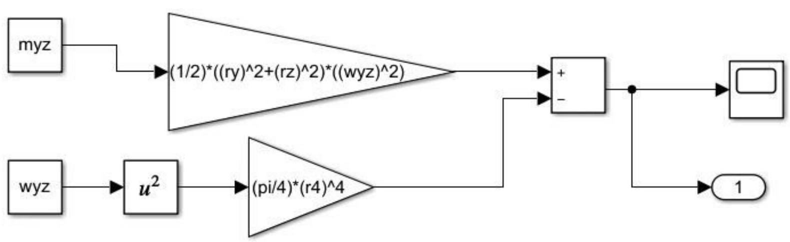

Figure_11_Equation_Right_Rotator_Head

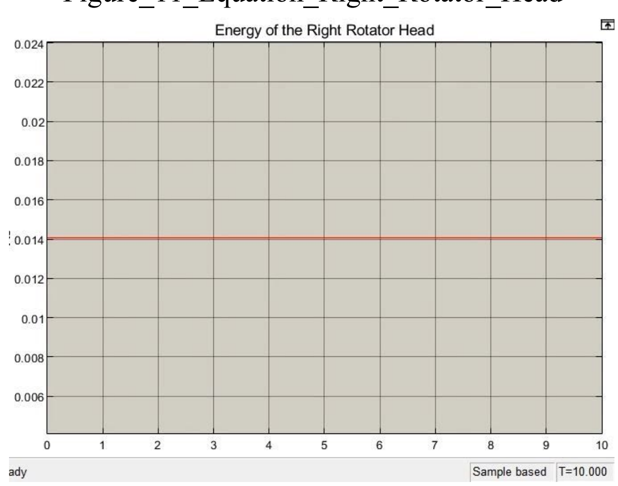

Figure_12_Graph_Right_Rotator_Head

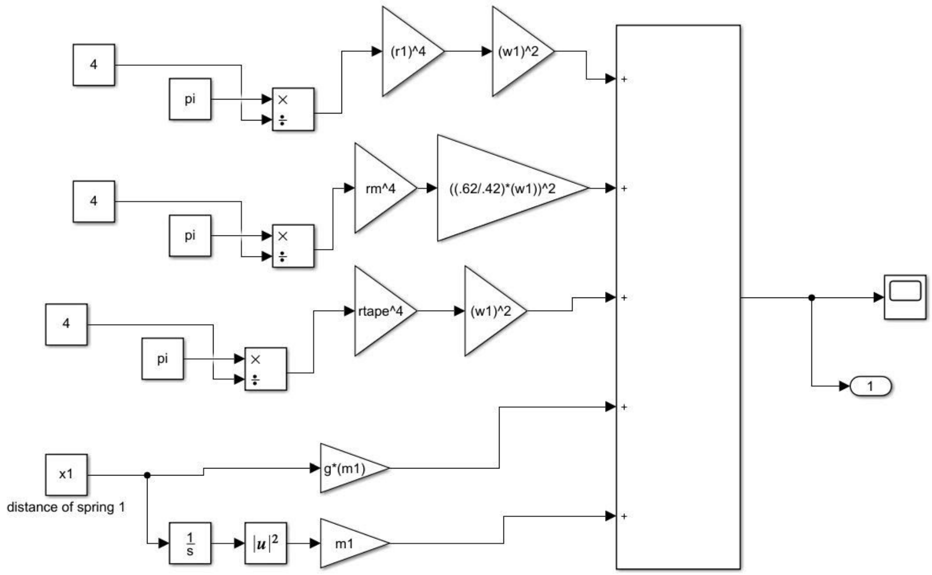

Figure_13_Equation_Tape_Gears_One_And_Two

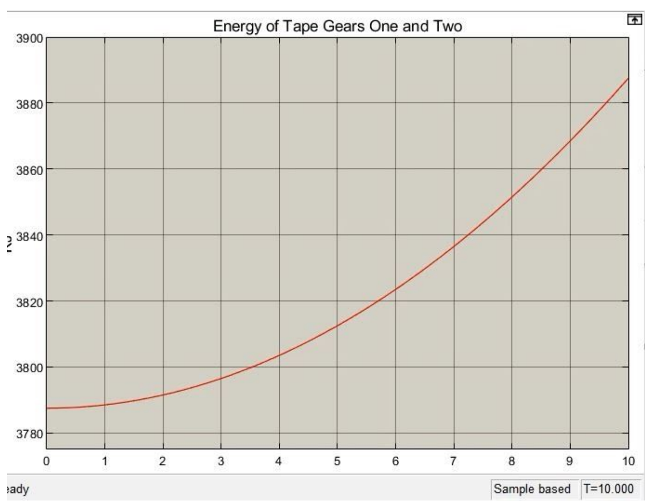

Figure_14_Graph_Tape_Gears_One_And_Two

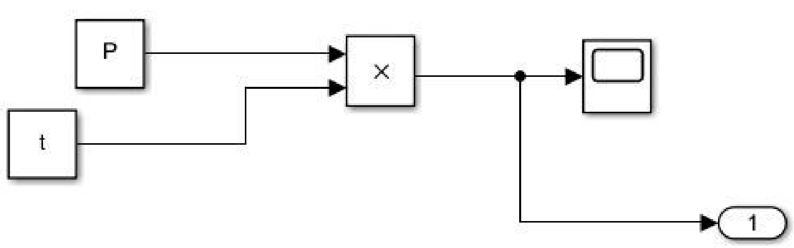

Figure_15_Equation_Motor

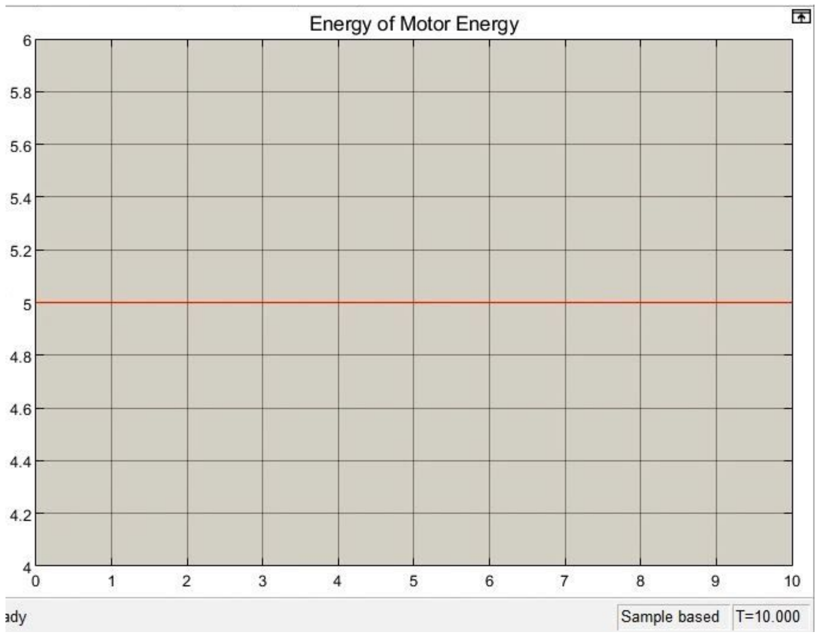

Figure_16_Graph_Motor

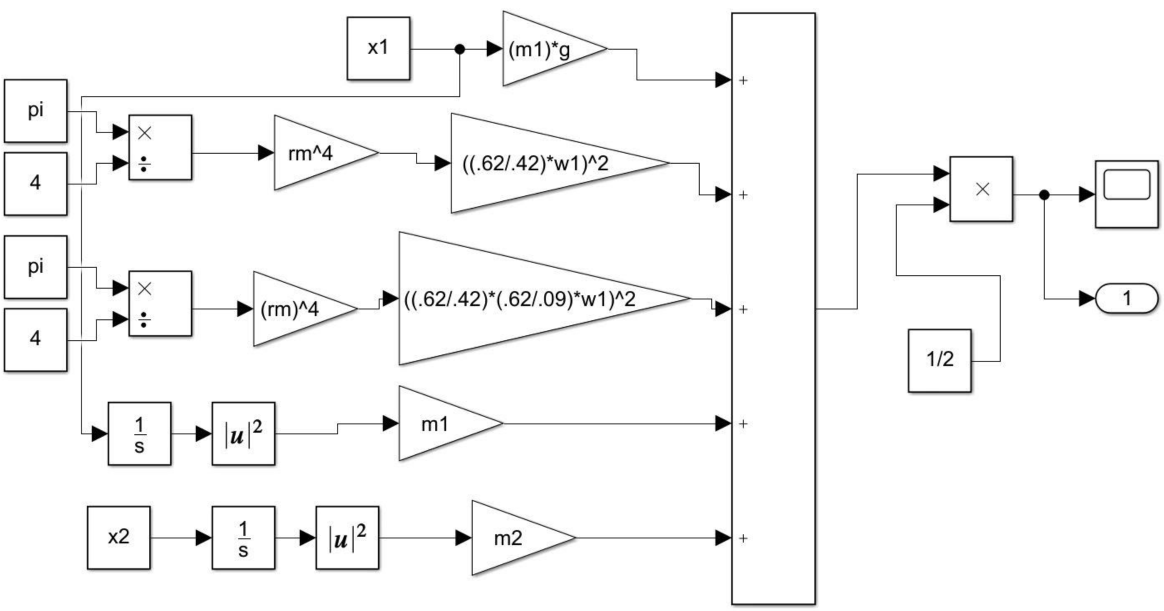

Figure_17_Equation_Middle_Gear

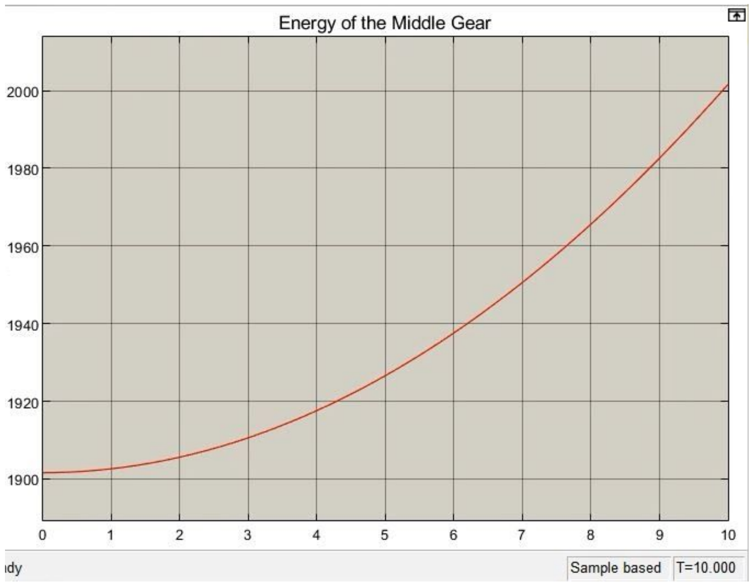

Figure_18_Graph_Middle_Gear

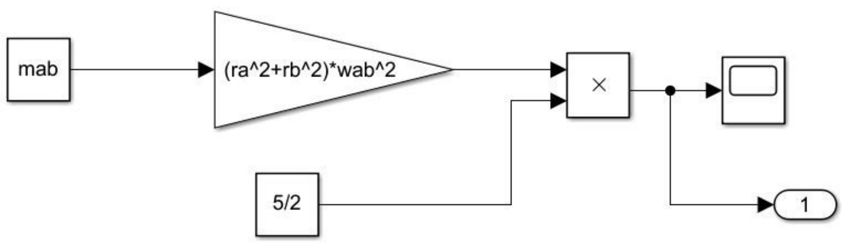

Figure_19_Equation_Five_Rollers

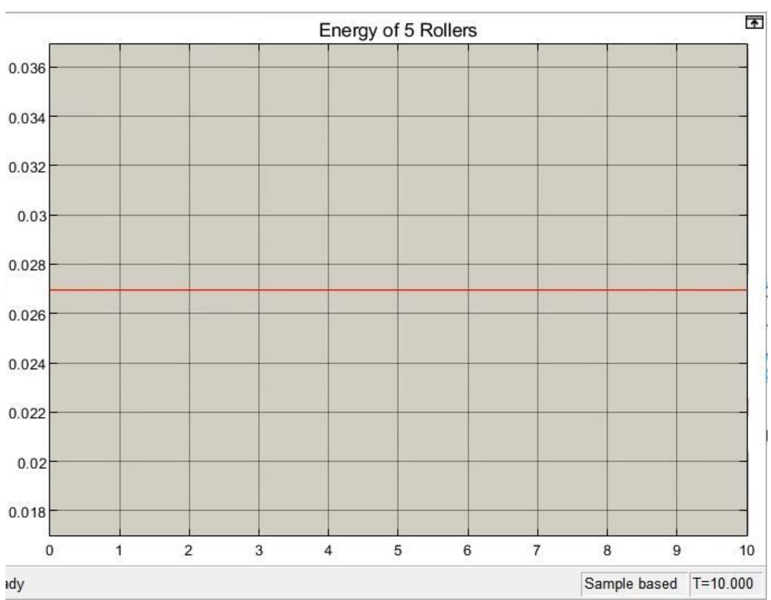

Figure_20_Graph_Five_Rollers

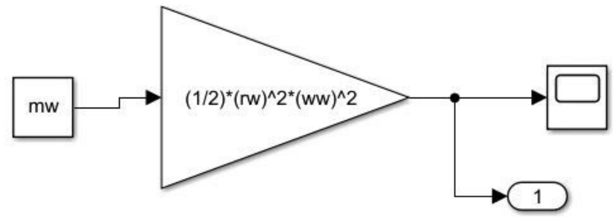

Figure_21_Equation_Left_Side_Roller

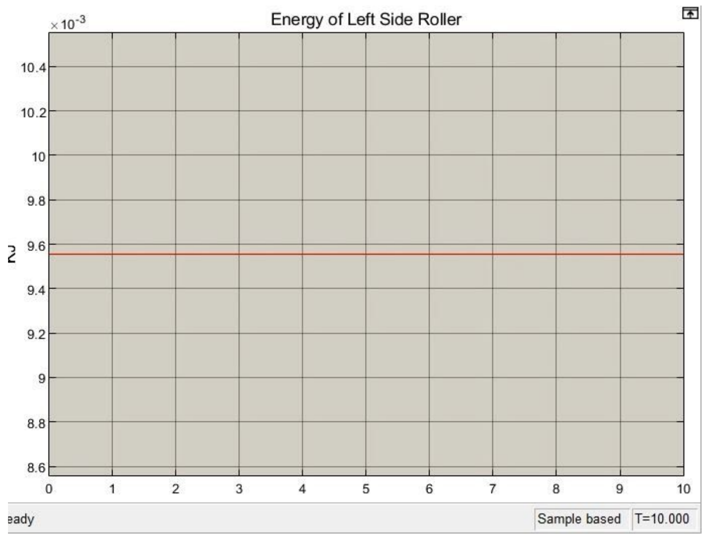

Figure_22_Graph_Left_Side_Roller

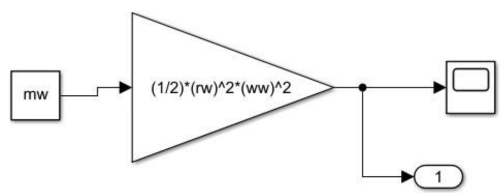

Figure_23_Right_Slide_Roller

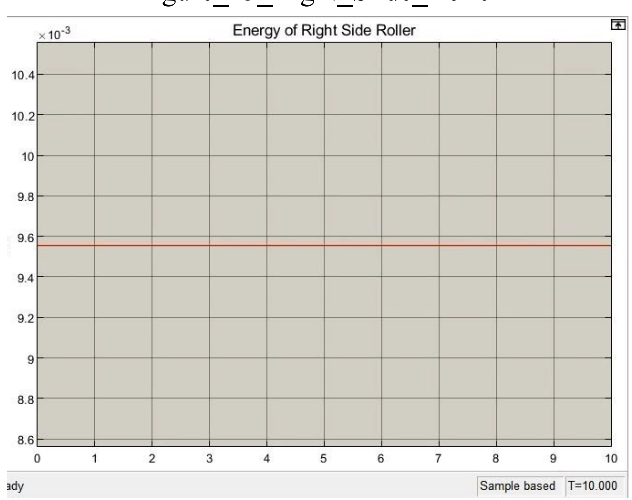

Figure_24_Right_Side_Roller

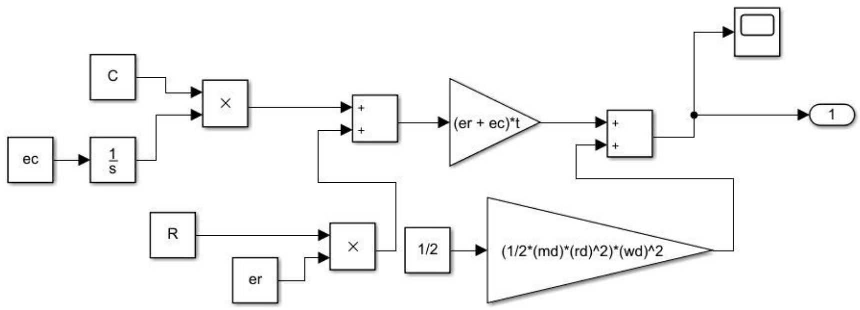

Figure_25_Equation_Drumhead

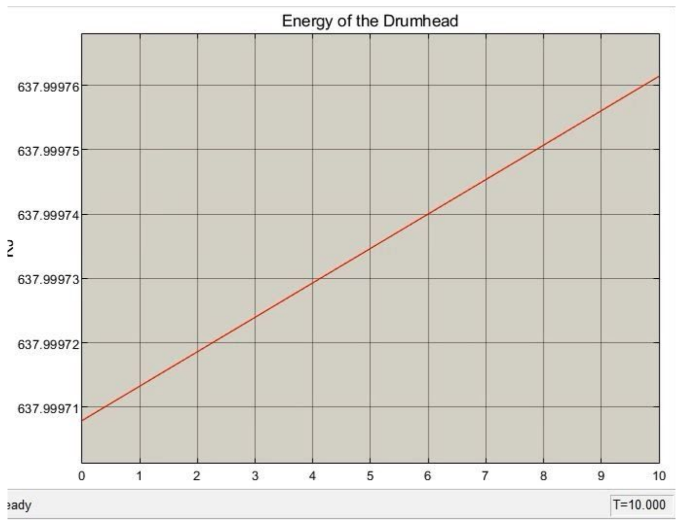

Figure_26_Graph_Drumhead

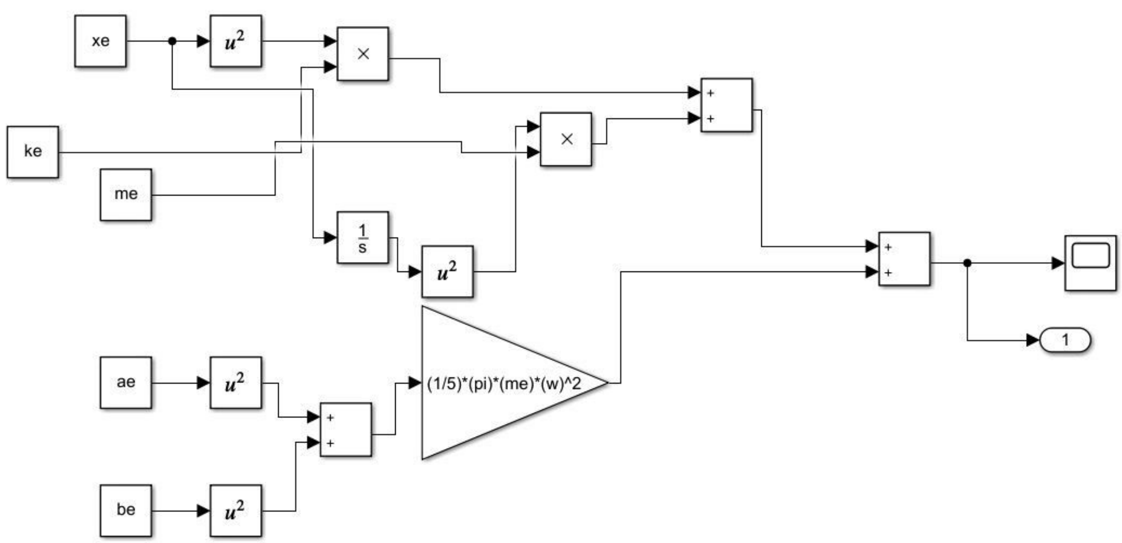

Figure_27_Equation_Closing Mechanism

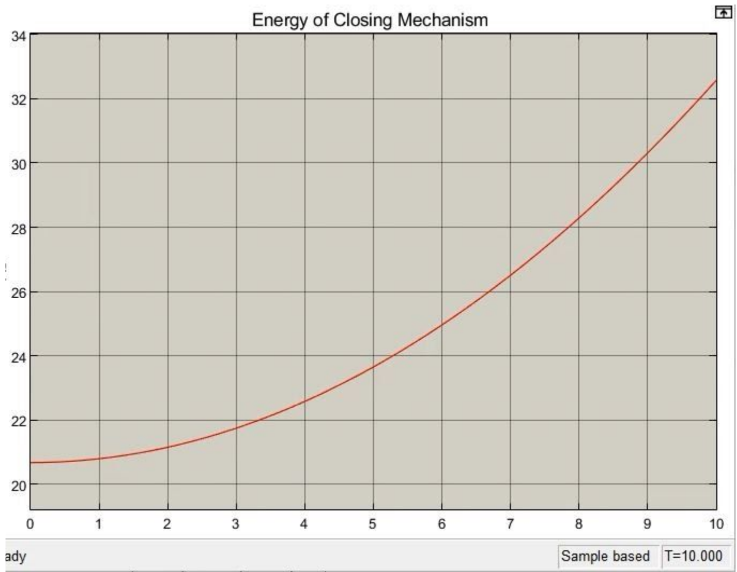

Figure_28_Graph_Closing_Mechanism

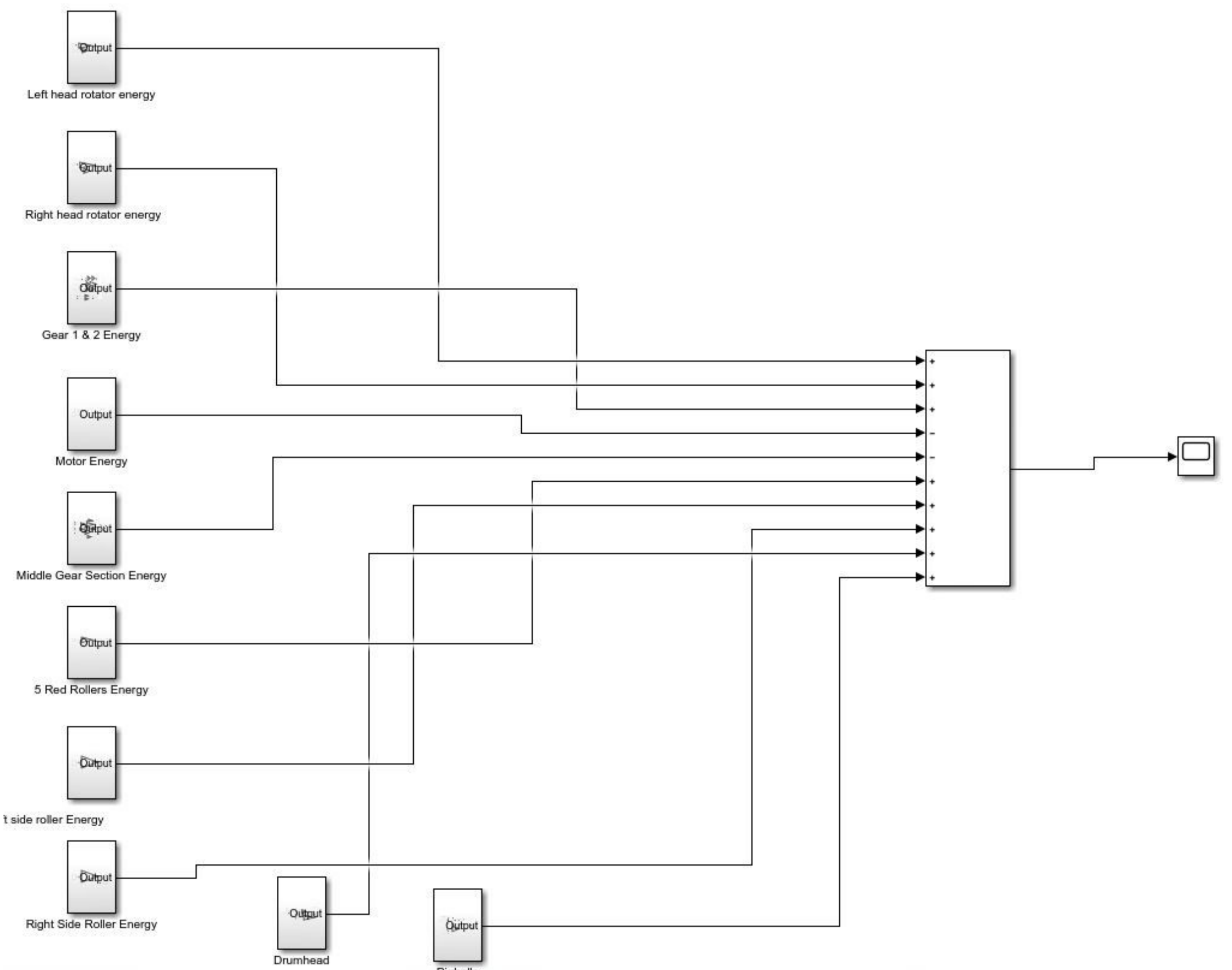

Figure_29_Equation_Total_System

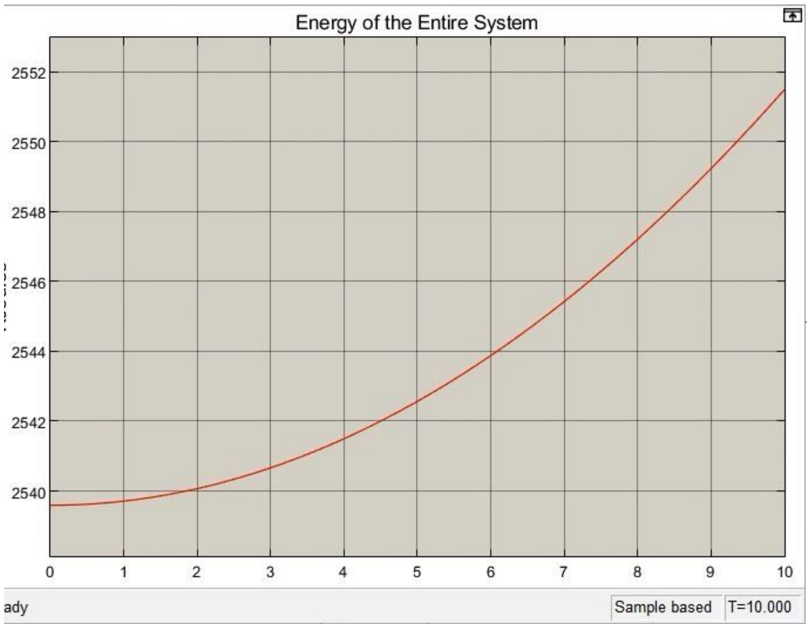

Figure_30_Graph_Total_System