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Mechanical Logic Gates

Contributor: Charles P. Callis
Affiliation: School of Engineering
University of Tennessee At Martin
Martin Tennessee 38238
Telephone: (901) 587-7381(office) 587-5679 (home)
FAX: (901) 587-7375
e-mail: e ccallis@UTM.EDU

Type: Design Problem
Student Time: 2 weeks
Location: Take home

Summary

This open ended design problem may be an appropriate assignment for a first year course during the first or second semester. It is suggested that it be assigned to individual students and that students have approximately two weeks to work on it and respond with a report and an oral presentation to explain and defend the work. Since the gathering of the appropriate materials may be difficult the students are not required to produce a working model. Since students are likely enrolled in a lower division graphics course, hopefully the requirements will dovetail with the material they are simultaneously learning regarding sketching and drawing of small mechanical parts in their fundamentals course in graphics.

After having the concept of gating and using bi-stable devices of any type, explained to him/her the student will be assigned the responsibility of designing the intermediate means to accomplish a particular logic request associated with a simple 2-input machine. The main purpose of the project, besides providing an introduction to design vocabulary, is to begin the students' education in logic applications for students in all engineering majors, and avoid keeping logic education confined to the digital electronics courses.

ABET Descriptors

Engr Sci Content: First Year Engineering
Type: Component
Functions: Define objectives, develop performance specifications, evaluate concepts, communication
Features: Design methodology, creativity, open ended
Constraints: Time, performance within specified criteria
Effort: Individual

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Mechanical Logic Gate Design

You are to produce a neat, mechanical drawing showing a metal container equipped with two mechanical rod inputs and one output. (sketch of this portion of your final drawing is given below). The interior of the box is to show your design of an intermediate means of accomplishing the simple logic of A (and) B equals C. While it is true this can be done magnetically, hydraulically, etc., you are to use only mechanical means. (springs, links, rods, hinges, etc.)

You are to provide your instructor a written progress report at the end of the first week, at which time you may confer with him, ask questions, etc.

At the end of two weeks you are to submit a written report of the project, including a description of the application of all design procedures and efforts which you applied during the project. You must also present your drawing to the class using a viewgraph, and explain and defend the design used to accomplish the requirements. (Fifteen minutes - instructor will help you produce a viewgraph and handouts for the class showing your design drawing.)

Remember to attempt to use good mechanical procedures that will work smoothly, will not produce binding, will restore properly, etc. You should read and study the basic information you have received about using bi-stable devices to perform simple gating. e.g. each input is independent of the output and other inputs; meaning your design must not inhibit motion of some inputs or cause them to move simply to help you achieve the required logic.

Mechanical Logic Gates

Engineering Notes:

Occasionally the beginning engineering students may feel that those instructors attempting to inject design assignments are giving them too "rinky dink" projects. Even when the instructor explains how the project is allowing the students to learn to apply and understand design principles along with design vocabulary and fundamentals, the students still may feel the assignments are kindergarten level since the projects may be requiring kindergarten materials. This project will permit the student to receive a very simple body of important knowledge (introduction of deductive logic seems to be reserved for beginning philosophy courses or our fundamental course in elementary digital concepts appearing in our sophomore or junior electrical engineering courses) and permit him/her to apply some design fundamentals, along with his/her own creativity, to produce a seemingly more sophisticated "engineering project". (One that won't appear trivial to his friends and instructors outside this class).

The instructor should attempt to explain the very simplest applications of gating or logic by using simple devices. It appears the students learn quickly that any device with only two distinct states (high-low, off-on, up-down, energized-non energized, in-out, etc.) can be referred to as a 'bi-stable device'. It also appears the student learns quickly that, by clearly defining the high-low states of the device, that simple, well known, logic gating arrangements can be obtained. Remember, the student will more easily follow and understand the logic request if you spend adequate time explaining the recognized high-low states of the device you are calling the 'input' or 'output'. In Figure 1. below, the device choice for the inputs is a simple spst switch (open is called state '0' or 'not A), closed is called state '1',or simply (A). The output is the appearance or disappearance of the battery voltage. (voltage present is '1', or 'C', no voltage present is '0', or (not C). With the switches arranged as shown, the arrangement accomplishes A (and) B equals C. ('A' simply means switch 'A' is in the high state (on), while 'not A' or A means that switch 'A' is open. Using this procedure, implies that 'C output' is in state '1', simply means that the battery voltage appears at the output terminals; and 'not C or C' means the voltage does not appear at the terminal marked C.

Obviously, with more inputs, the combinations of states of the inputs increases. The beginning students in digital electronics quickly learn all this type of information and seem to immediately appreciate the 'quantum jump' it gives their technical education, while the material is actually very simple and easy to learn. The simple table used to demonstrate the different number of combinations of inputs and the corresponding state of the outputs is called the 'truth table'. It may help to call it the 'test table' or 'test matrix' (I just made that up), since the student often must use the table during testing, so he/she will know what state the output must be for a specific set of inputs. All this is very simple when the number of inputs is small, and its use remains simple when the number of inputs increases, once the student learns the simple procedure for defining input and output states and preparing the truth table.

Mechanical Logic Gates

Coaching the student:

The instructor can shorten his/her efforts in giving appropriate backdrop information to the students in logic principles by using a few handouts from texts used for introductory digital courses. Your effectiveness in introducing the project will be greatly improved by discussing the design solution to accomplish 'A' or 'B' equals 'C'. (figure 2). (A simple 'or gate' configuration).

Expected Results:

Graphical documentation of the final design will be included in the written and verbal reports. These reports will also include a discussion of the various design activities, or methodology, that lead to the final mechanical design. Students should be encouraged to use good graphical procedures and even use their graphics instructors as resource persons. Graphics requirements can be determined by the instructor; but should attempt to utilize the graphics course information the students may have acquired.

Discussion/Follow-on:

Students should be encouraged to watch for opportunities in future courses to apply the logic principles associated with this problem. Few students in hydraulics, pneumatics, magnetics, etc. know (or are encouraged to learn) about simple logic gates that are available in devices that are not electronic in nature. e.g. logic valves with multiple inputs are available commercially for use in pneumatic, fluidic, and hydraulic configurations. Good mechanical, industrial, civil, chemical, etc. engineering students will be better practicing engineers, and their creativity in their specific practicing fields enhanced, if they are not denied early exposure to fundamental logic applications.

(***See hard copy for graphics and additional notes***)