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Activator Token KWh Meter Using Servo Motor SG90 Based on Arduino Uno Microcontroller

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Abstract

The design of the kWh meter token activator using the SG90 Servo Motor based on the Arduino Uno microcontroller has been studied. The tools and materials used are the SG90 Servo Motor, PCA9685 Servo Motor Driver, Arduino Uno, 5V 1 A Adapter, pressure wire, and additional supporting tools. When pushing the kWh meter keypad, a servo motor at a 90° angle causes the wire to travel ideally perpendicularly. When the token value is entered into the interface, Arduino Uno executes the token value and tells the PCA9685 Servo Motor Driver to operate eleven SG90 Servo Motors to drive the push wire for the kWh meter keypad. The precision of the token number on the kWh meter and the display of the word "true" on the LCD kWh meter demonstrate the tool's effectiveness. The kWh meter Token Activator Tool successfully activated five new kWh meter Tokens with 100% correctness in terms of numbers, and each token took 44 seconds to activate. They are making an error and wasting time activating the kWh meter token.

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Abstrak

Telah dilakukan penelitian mengenai rancang bangun aktivator token kWh meter menggunakan Motor servo SG90 berbasis mikrokontroler arduino uno. Alat dan bahan yang digunakan adalah Motor servo SG90, Driver Motor servo PCA9685, Arduino Uno, Adaptor 5V 1 A, kawat penekan dan peralatan penunjang lainnya. Sudut Motor servo sebesar 90° untuk membuat kawat bergerak tegak lurus dan tepat dalam menekan keypad kWh meter. Prinsip kerja dari aktivator Token kWh meter yaitu saat nilai token dimasukkan ke interface, lalu dieksekusi oleh Arduino Uno yang memerintahkan Driver Motor servo PCA9685 untuk mengendalikan sebelas Motor servo SG90 yang menggerakkan kawat penekan keypad kWh meter. Nilai keberhasilan alat dapat dilihat dari ketepatan angka token pada kWh meter dan tampilan kalimat 'benar' pada LCD kWh meter. Alat Aktivator Token kWh meter berhasil mengaktivasi lima Token kWh meter baru dengan ketepatan angka mencapai 100% dan waktu aktivasi setiap tokennya 44 detik. Dengan adanya alat tersebut diharapkan dapat menambah keakuratan data, mengurangi data akibat human error dan menghabiskan waktu yang efektif dalam mengaktivasi token kWh meter.

1. Introduction

An essential prerequisite for many tasks is electrical energy. In Indonesia, the State Electricity Company provides electrical energy for industrial, residential, and governmental purposes (PLN). A State-Owned Enterprise (BUMN) in Indonesia, PLN Persero provides power to the community using kWh meters, a common abbreviation for the kilowatt-hour (kWh) unit of measurement. Can account for the kWh meter customer's electricity use (Mukhlis et al., 2017). People currently prefer using prepaid kWh meters because they can determine how much electricity is required, and it is not easy to receive fines. If it first completes the kWh meter activation procedure by entering five tokens with 20 different number combinations, the prepaid kWh meter can be utilized. The PLN performs token activation. Token, which consists of five different sorts and has 20 numbers, including Key Change Token 1, Key Change Token 2, Clear Tamper 1, Set Max Power Load, and Clear Credit, is used to activate the kWh meter. (PLN, 2017) . Every token atop every other. There are a total of 100 numbers needed to activate a new kWh meter, and it

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comprises 20 numbers. Although there are many activation tokens, PLN officers must complete the process manually. Given the effectiveness of human resources and the possibility of human error, this could be more effective.

Research by Vistarika (Vistarika, 2021) made a kWh meter typing tool using raspberries and an SG90 Servo Motor. The process of pressing the kWh meter button uses 12 pieces of the solenoid, each of which will be placed right in front of the kWh meter button. Even though the accuracy of the tool is high, the tool needs to be quite expensive and can only be used on one kWh meter that has been installed in the housing.

Based on this justification, a mechanical movement to push the keypad utilizing the motion of the SG90 servo motor was engineered to create a prototype of the kWh meter activator tool. This research is developed by the servo motor's motion design. (Salim et al., 2020) . Due to its tiny circuit, the SG90 servo motor provides high accuracy and occupies less space. A PCA9685 servo motor driver is necessary for the number of 11 servo motors to facilitate assembly. Eleven servo motors can be connected to the Arduino Uno via the PCA9685 interface. (Ashari & Faruuq, 2019) . The Arduino Uno microcontroller, which has a very simple programming language and can operate the tool automatically, is used to control the entire tool. (Wadhwani et al., 2018) . The SG90 servo motor drives a simple wire radius that will automatically press the kWh meter keypad. It makes software using Arduino IDE *software* as an interface for the whole system to run as it should. Data input is done through the PLN database and copied into the interface connected to the Arduino IDE. The purpose of this research is to make a mechanical system and control program on the kWh meter token activator automatically. System testing is done by entering several kWh meter tokens using an activator tool to ensure the successful activation of these tokens.

2. Research methods

The SG90 servo motor, PCA9685 servo motor driver, Arduino Uno, and 5V 1A adapter were the equipment employed in this study. Pressure wires, support boards, jumper cables, and other auxiliary tools are among the materials employed.

2.1 Hardware Design

The Arduino Uno is connected to the servo Motor Driver 9685 through the GND, 5V, and two analog pins, which are attached to the SDA and SCL pins of the Motor Driver in the prototype of the tool's electronic circuit. Eleven SG90 servo motors are connected to the 5V, PWM, and GND pins on the servo motor driver, which then controls them. A 5V Adapter is also attached to the Motor Driver to deliver power. In **Figure 1**, the hardware layout is displayed.

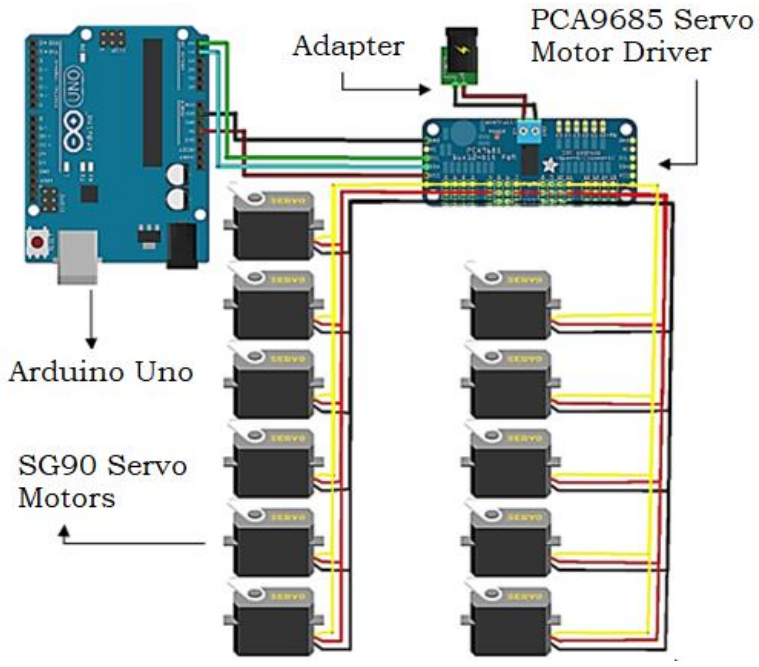

Figure 1. Electronic Circuit Prototype

Eleven SG90 servo motors are connected to a wire at the end of each arm, forming a mechanical circuit separate from the electronic one. The servo motor's wire-connected end of the arm becomes hinged against the upright wire, directly pressing the keypad's eleven buttons. **Figure 2** depicts the mechanical circuit's prototype.

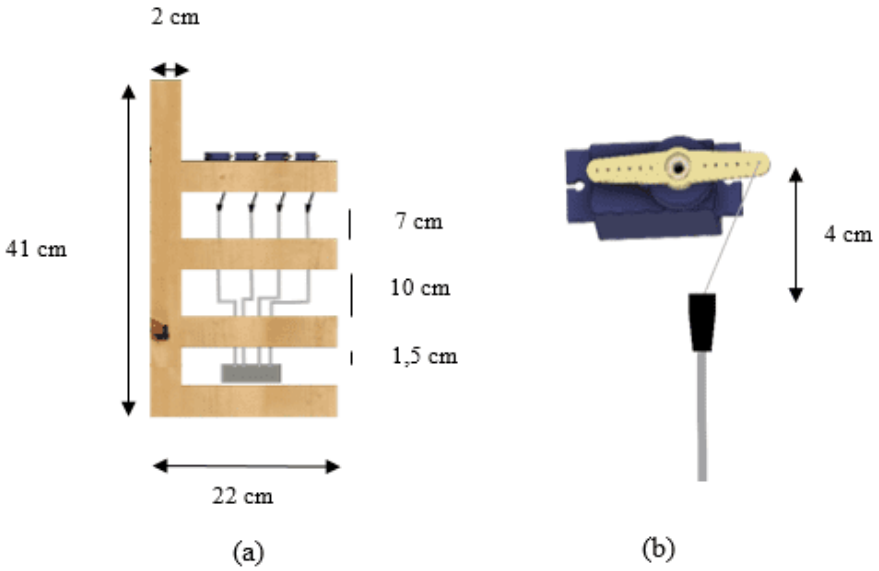

Figure 2. Prototype Mechanical Circuit

The mechanical circuit design is shown in **Figure 2(a)** and the servo motor arm and the hook on the wire are shown in **Figure 2(b)**. The planned wires are trimmed on the wood, serving as the kWh meter's support and mounting location to align perfectly with the keypad. Each wire is constructed to move precisely when pressing the keypad's eleven buttons. The rotational angle that was utilized to 90° modifies wire movement.

2.2 Software Design

The Arduino IDE application is used in the study's software design. This application supports the system's functionality to operate correctly and produce the intended results.

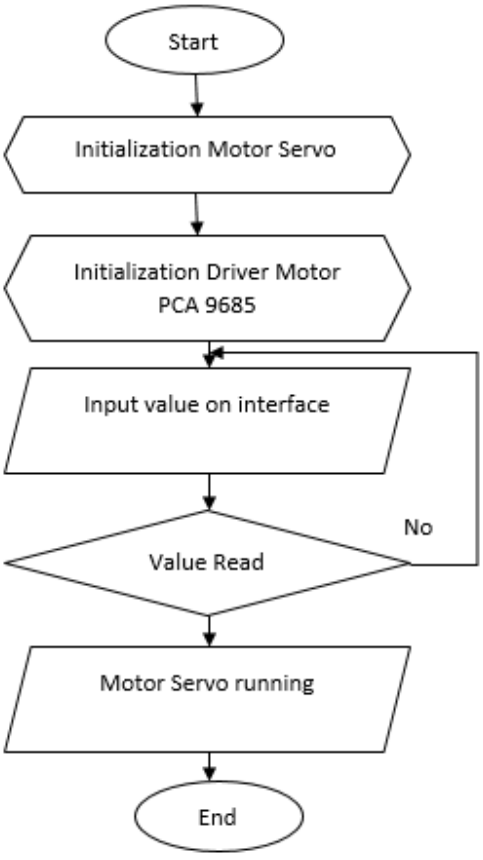

Figure 3. Flow chart software design

The Arduino IDE is utilized, and the program begins by initializing the servo motor and servo motor driver. To read the data from the kWh meter tokens, the Arduino IDE software is attached to the interface. Arduino Uno receives the database value until the servo motor is operational.

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2.3 General Layout of The Tool

The hardware and software suites are combined to create the tool's overall design. **Figure 3** illustrates the tool's general layout.

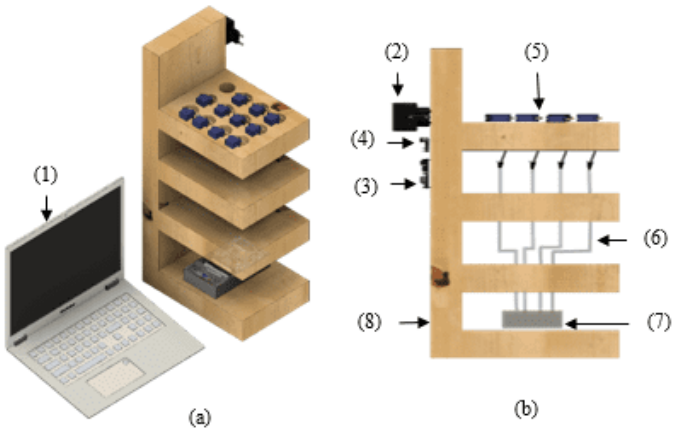

Figure 4. General Layout of The Tool

Just below the typewriter, which is organized using a wooden board, is where the kWh meter is located. When the tool is to be used, the laptop is linked to the Arduino, and the adapter is connected to a power source. **Table 1** lists the tool names and their functions.

Table 1. Names of tools and functions

No	Tool's name	Function
1	Laptops	as a token number input
2	Adapter 5V 1A	the appliance's connection to a power source
3	Arduino Uno	Motor Control for Servos
4	Motor Driver PCA9685	11 Servo Motors are Connected to an Arduino by Motor Driver
5	Servo Motor SG90	shifting wire
6	Wire	Keypad kWh meter
7	kWh meter	Activated tools
8	Buffer Board	as a divider between wires and electrical equipment

3. Results and Discussion

Previous research conducted by Vistarika (Vistarika, 2021), made a kWh meter typing tool using raspberries and an SG90 Servo Motor. Pressing the kWh meter button uses 12 pieces of the solenoid. Each is placed right in front of the kWh meter button. However, this tool must be expensive and will not be accessible if used interchangeably on the kWh meter. This research makes a tool that can activate the kWh meter alternately.

3.1 Tool Realization

The kWh meter token activation gadget is in a two-chambered hardwood stand. Due to its great temperature resistance and ease of shaping, wood can be used as a support. **Figure 4** depicts the shape of the kWh meter Token Activator.

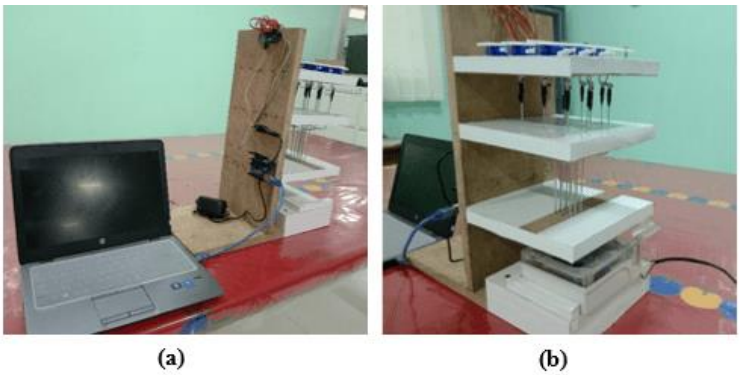

Figure 5. (a) Left view of the token kWh meter activator (b) Right View of the kWh meter Token Activator

The electronic circuit comprises eleven SG90 servo motors, an Arduino Uno, and a PCA9685 servo motor driver. The device linked to the PCA9685 servo Motor Driver uses the 5V 1A adapter as its current source. The current supplied is adjusted to the 5-volt current from the power supply. **Figure 6** displays the result of assembling the electronic circuit.

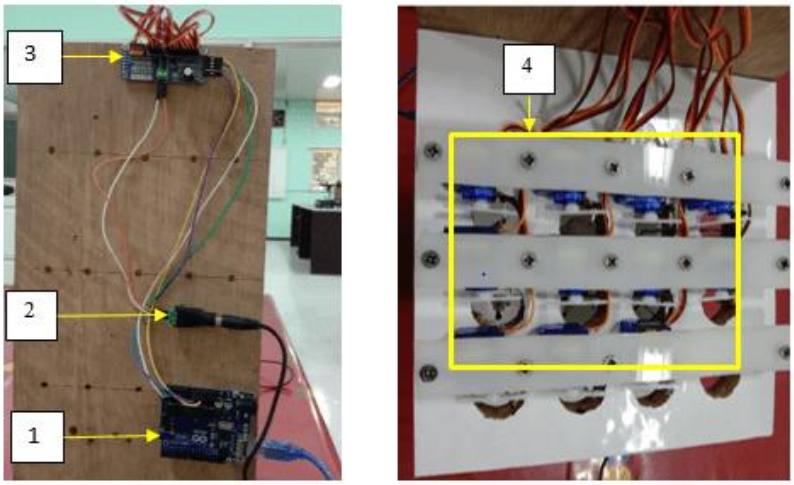

Figure 6. Electronic Circuit on the Activator Token kWh meter

Figure 6. Shows (1) Arduino Uno as the coordination center of software and hardware, (2) 5V 1A Adapter Distributes power from the socket that the hardware will use, (3) Servo Motor Driver 9685 Connecting 11 Servo motors with Arduino Uno (4) SG90 Servo Motor Drives the wire pressing the keypad. A mechanical system comprises the arm of an SG90 servo motor and a wire positioned to press the keypad. In **Figure 7**, the mechanical circuit is depicted.

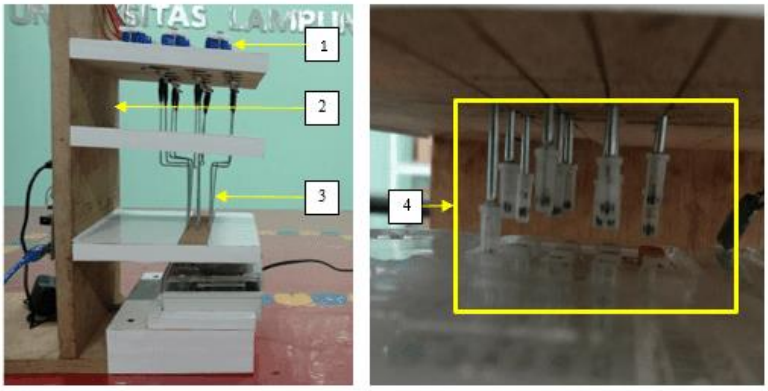

Figure 7. Mechanical Circuit (1) Servo Motor Arm (2) Support Board (3) Wire (4) Wire Position on Keypad kWh meter

Eleven SG90 servo motor arms are connected each other by with a wire. The servo motor's wire-connected end of the arm becomes hinged against the upright wire, directly pressing the keypad's eleven buttons. The wire is rotated at a 90° angle to control its movement. Each wire is constructed to move precisely when pressing the keypad's eleven buttons. Wooden boards are employed as wire supports to keep the wires adequately placed. Each wire may exactly push each keypad. The exact wire pressing of each keypad will improve the instrument's accuracy. The kWh meter Token Activator tool integrates hardware and software into a single system. The user enters a token in the form of numbers into the interface to begin the tool's work system, after which the Arduino Uno instructs the PCA9685 servo motor driver to move the SG90 servo motor following the numbers entered. The PCA9685 servo motor driver is instructed to regulate the associated servo motor so that it moves as far as 90°, pushing the wires below it, pressing the number 1 on the kWh meter keypad when the user enters the number 1 on the interface.

3.2 Tool Work System

One servo motor controls each keypad on the kWh meter. The Arduino IDE software specifies a 90° angle for the SG90 servo motor. The appropriateness of the running time on the servo motor with the time that the program has made allows one to determine the level of stability of the SG90 servo motor's working time. The application takes two seconds to process one keystroke. Two seconds pass between when the servo motor arm descends 90 degrees to press the keypad and when it returns to its starting position. **Table 2** displays the servo motor's time stability in the manner stated below.

Table 2. *Keypad* Pressing Time According to SG90. Servo Motor Movement

No. Perc	Servo motor	Movement Time(s)
1	1	2.09
2	2	2.09
3	3	2.09
4	4	2.09
5	5	2.18
6	6	2.24
7	7	2.09
8	8	2.24
9	9	2.09
10	0	2.09
11	Enter	2.09
Average		2.12

When a key is pressed on a kWh meter keypad, the servo motor moves for an average of 2.12 seconds. The servo motor's precision in pushing each keypad demonstrates the efficiency of each motor. The value entered using the keypad's 0.1,2,3,4,5,6,7,8,9, Enter sequence is the input value. The value that appears on the LCD kWh meter is the output value. The written information describes the compatibility of the servo motor pushing the keypad on the kWh meter. **Table 3** illustrates how well the input and output values work with the tool.

Table 3. Conformity of Input and Output Values on the Tool

No.	Keypad Number	1st Test		2nd Test		3rd Test	
		Output value	Desc	Output value	Desc	Output value	Desc
1.	0	0	True	0	True	0	True
2.	1	1	True	1	True	1	True
3.	2	2	True	2	True	2	True
4.	3	3	True	3	True	3	True
5.	4	4	True	4	True	4	True
6.	5	5	True	5	True	5	True
7.	6	6	True	6	True	6	True
8.	7	7	True	7	True	7	True
9.	8	8	True	8	True	8	True
10.	9	9	True	9	True	9	True
11.	Enter	Enter	True	Enter	True	Enter	True

The tool's precision in entering the value on the completed kWh meter has a zero percent mistake rate. That demonstrates that the Arduino application operates as intended to drive the servo motor when pressing the keypad.

A number can be entered into the application in two seconds. One set of five kWh meter tokens, each with 20 numbers to enter, takes 42 seconds to activate. Add to that the device's 2-second loading delay, and the total activation time is 44 seconds. **Table 4** displays the measurement of the kWh meter token's activation time.

Table 4. Activation time of kWh meter token

No.	Token to-	Activation time(s)
1	Token 1	44
2	Token 2	44
3	Token 3	44
4	Token 4	44
5	Token 5	44

In order to activate the kWh meter token, for instance, five token values might be supplied. These values would then be entered into the kWh meter and compared to the input and output values. The token input value is the amount submitted into the kWh meter Activator Token interface. The value displayed on the LCD kWh meter is the token output value. The test outcome is whether the token value entered was successful or not. The LCD kWh meter in **Figure 8** will offer a success or failure display.

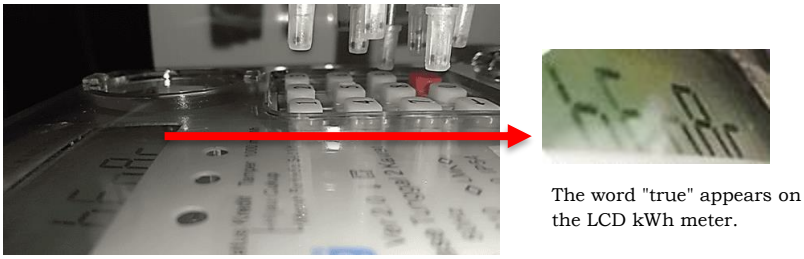

Figure 8. The word "true" appears in the LCD kWh meter's activation success display

After verifying that the kWh meter Token has been activated, the LCDs the word "true." **Table 5** displays the following information regarding the effectiveness of the kWh meter token activator tool.

Table 5. Information about the kWh meter token activator's performance

No. Perc	Token	Input Token Value(s)	Output Token Value(s)	Test Results (True/Fail)
1	1st	2575 8211 5098 7709 2369	2575 8211 5098 7709 2369	True
2	2nd	3068 0455 7047 2870 1800	3068 0455 7047 2870 1800	True
3	3rd	4431 3024 8478 1865 5953	4431 3024 8478 1865 5953	True
4	4th	2134 2718 9617 9008 0519	2134 2718 9617 9008 0519	True
5	5th	5867 8135 0675 7922 7513	5867 8135 0675 7922 7513	True

The output value produced by the tool's testing on tokens 1 through 5 matches the prepaid token database. For each token inserted, the kWHMeter LCDs the word "true," indicating that the kWh meter has been successfully engaged.

4. Conclusions

The creation of the Activator Token kWh meter using an SG90 servo motor based on the Arduino Uno microcontroller has been successful, as evidenced by the tool's suitability in pressing eleven numbers on the kWh meter keypad during three tests, according to the findings of the research and discussion that have been conducted. The kWh meter Token Activator has been successful as a performance tool in activating five new kWh meter Tokens with a numerical accuracy of 100% and an activation duration of 44 seconds for each token.

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