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A New Protection Design Prepaid Meter Based On Smart Relay Safety Equipment

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Abstract - A relay safety device on prepaid Kwh meters as a power limiting protection system to avoid damage to relays on prepaid Kwh meters caused by power consumption that is greater than the registered power. In the device that will be designed, the code safety method cuts the electric current automatically if the power used is greater than the registered power so that this method can reduce damage to the kwh relay for customers. Test results for tools designed with calculation results have different calculation percentages. For irons, the error percentage of the calculation results is 1.99%, while for testing water heaters, the error percentage is 0.53% due to the lack of sensitivity of the PZEM-004T sensor in reading the used load. The measured voltage at the output of the designed tool reaches 205 V. Measuring test of the designed tool Based on SNSU PK.P-02:2020 - National Standardization Agency The error tolerance in measuring digital measuring tools is - 5%, if it exceeds the predetermined regulations then the results cannot be used or are referred to inappropriately.

Keywords: Protection Relay, Prepaid Kwh Meter, Overload, Microcontroller

1. INTRODUCTION

KWh meter has a function to calculate electrical power usage by a load in a certain time. This value will be calculated in kWh units (kilo Watt hours) every month and will be multiplied by the unit price of the power tariff electricity (TDL) and added to the subscription value plus the tax that will be generate monthly electricity bills or in the form of credit.

In the application of prepaid electricity, disturbances or damage are often found on the kWh meter Prepaid Meter (MPB) causing interference or failure in the operation of the Prepaid kWh Meter used by PLN customers. Of course, this will have an impact on PT PLN (Persero)'s losses. because the Prepaid Meter used by the customer is experiencing interference oR The MPB was damaged so PT PLN (Persero) had to replace it Kwh with the new Kwh meter. This could be detrimental to PT. PLN (Persero)Mdue to the large number of new Kwh replacements due to Kwh damage. ExampleM the type of damage that customers often experience so that Kwh meters are required to Replaced with a new indicator*Relay*because the power consumption is greater than Kwh meter used by customers so Indicator*Relay*disconnected and Kwh meter can no longer be used. (*SPLN D3.009-1:2010)*

Based on this, it is necessary to carry out follow-up research, collect data to design a relay safety device for the Kwh meter Prepaid as a power limiting protection system to avoid this happening Damage to the relay on the prepaid Kwh meter due to excessive power usage greater than the registered power or as well as the occurrence of undervoltage or excessive. This tool will be designed with a system safety method protection cuts off the electricity supply automatically if the power used is greater than the listed power, if there is under voltage or over voltage so This method can reduce KWh relay damage to customers.

2. LITERATURE REVIEW

2.1 Kwh Prepaid Meter

Prepaid KWH Meter is a tool designed by PLN using the new electric KWH, the charging system uses credit. For starting an electricity subscription to PLN, customers must know first system implemented by PLN for electricity customers.*(SPLN D3.009-1:2010 No. 719.K/DIR/201)*. The general way digital kWh meters work is by calculating digital amount of customer electricity usage. To detect or measure Voltage and electric current are used by current sensors. The output from the sensor will be converted into digital data which will then be processed in the section microcontroller to produce the price or amount of customer electricity usage which will then be displayed on the LCD. Apart from being displayed on the LCD, data is also displayed stored in memory. The data stored in memory is not only data from kWh only meters, but also the value of the pulse size. The pulse size is defined by certain numbers as voucher codes. If the voucher code is entered that's right, then the amount of kWh pulse will increase and will decrease along with PLN power consumption. Voucher code is entered via keypad and code has been entered and cannot be used again. These data must not be lost at any time there is no supply, therefore a

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microcontroller is needed that has Internal EEPROM. Relays are used to disconnect PLN power when there is a pulse prepayment expired.*(SPLN D3.009-1:2010 No.719.K/DIR/201)*

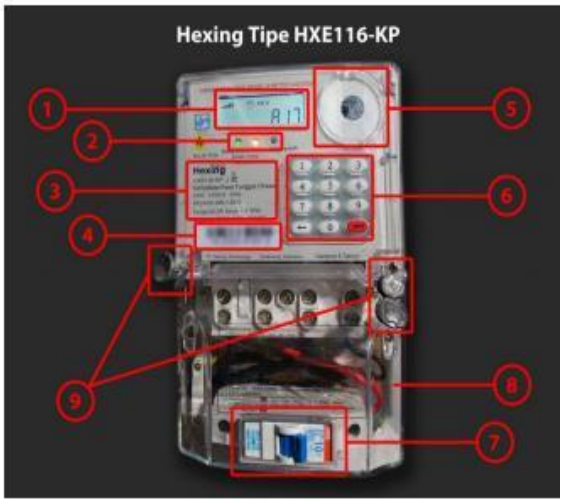

Figure 1. Prepaid KWH meter section.

Image captions consist of:

1. **LCD screen**
   Functions to display various information on the meter
2. **LED Indicator Light**
   Functions as an indicator that indicates certain conditions meter Meter Specifications
   Contains technical specifications of the meter, meter type and manufacturer produce it.
3. **Meter Number**
   Number used to purchase electricity credit.
4. **Optical Port Terminal**
   meter communication that will be used by PLN officers for Download data stored in the KWH meter memory.
5. **Keyboard / Keypad**
   Buttons to carry out commands with input specific code on the meter.

2.2 Electric Power

Electric power is defined as the rate of delivery of electrical energy in a circuit electricity. Electrical power is divided into three, namely active power, reactive power and apparent power. *(Ibnu Hajar, et al. 2020)* Power in units of Joules/second or watts is referred to as active power. The symbol is P. Active power is the actual power dissipated or worn by the load. Active power is calculated by equality

$$P = V \cdot I \cdot \cos \varphi \quad \text{.....}$$

Active power is valid if φ is 0 (zero), so cos φ = 1

The unit of reactive power is VAR (Voltampere – reactive). Reactive power(Q) This is the amount of power required for formation magnetic field, reactive power is also understood as power that is not dissipated by the load or in other words is the power absorbed but returned to the source. Reactive power can be calculated with the equation:

$$Q = V \cdot I \cdot \sin \varphi \quad \text{.....}$$

Visible power is the result of the trigonometric addition of active power and reactive which is symbolized by S. The unit is VA (Voltampere). Visible power can be calculated using the equation:

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$$S=V \cdot I \quad \text{.....}$$

2.2.Power factor

The power factor consists of two properties, namely the "leading" power factor and the power factor" lagging". This power factor has the following characteristics: If the current is ahead of the voltage, then this power factor is said to be "*leading*". This leading power factor occurs when the load is capacitive, like capacitors,*synchronocus generators*,*synchronocus motors*And *synchronocus condenser*.

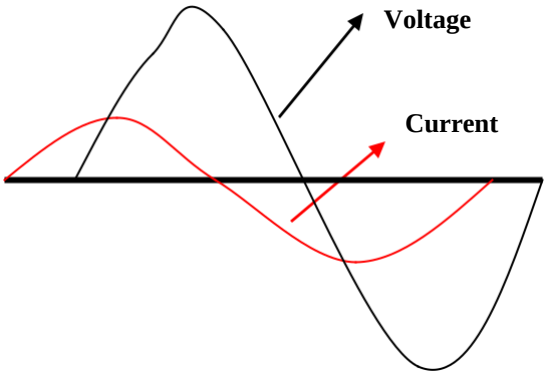

Figure 2. Power factor "*leading*"

2.3. Power Factor "*lagging*"

If the voltage is ahead of the current, then this power factor is said to be "*lagging*". This lagging power factor occurs when the load is inductive, such as induction motors, ACs and transformers

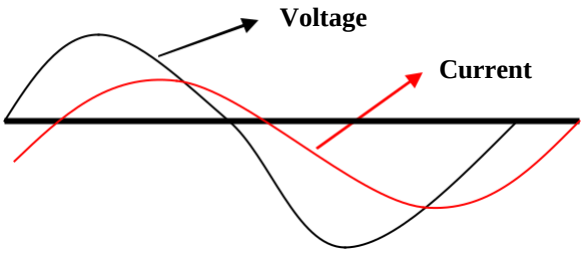

Figure 3. Power Factor "*lagging*"

2.3 Properties of Electrical Loads

In an alternating current source, when a load is applied it is pure resistive, then the voltage and current waves are in phase like shown in the image below

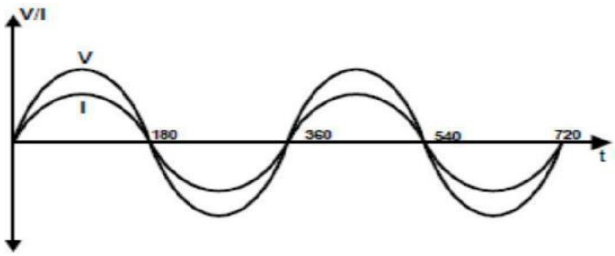

Figure 4. Resistive Load

Loads that are inductive or capacitive can shift the crossing point zero between voltage and current. If the load is a crossed inductive load zero current wave appears some time after the zero wave crossing voltage appears. This is usually said to be a lagging current shown in the image below:

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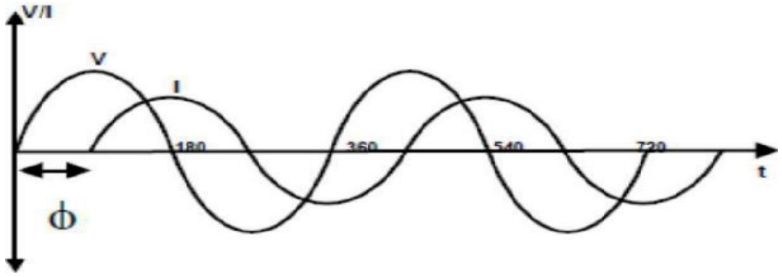

Figure 4. Inductive Load

On the other hand, for capacitive load currents, the crossover is zero The current wave will appear a few moments before the zero wave crossing voltage. This is usually said to be a leading current as shown in the image below:

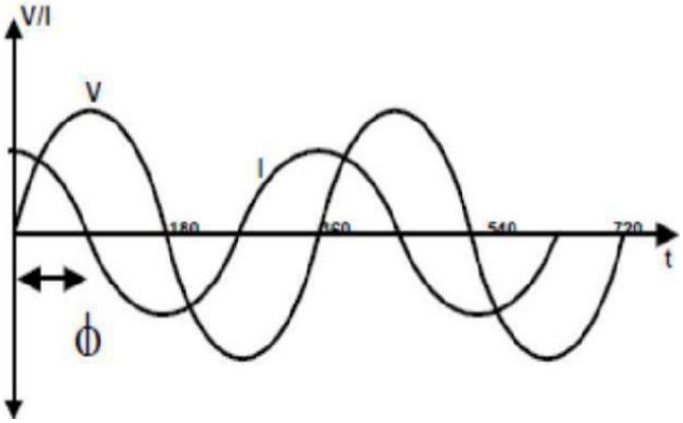

Figure 5. Capacitive Load

2.4 Microcontroller

Currently, technological developments are increasingly rapid thanks to technology microcontroller, so that there are more and more control circuits or control circuits needed to control various equipment used by humans in everyday life. From this series of controls a tool will be created can control something. The control circuit or control circuit is a circuit designed in such a way that it can perform functions certain controls according to needs.

Starting from making it*Integrated Circuits*(IC). Apart from ICs, tools that can functions as a control*chips*Same goes for IC.*Chips*is development of IC, where*chips*contains electronic circuits made from articles*silicon*capable of carrying out logical processes.*Chips*functions as a medium storage of programs and data, because in a*chips*available RAM where data and this program is used by logic*chips*in carrying out the process.

*Chips*more synonymous with the word microprocessor. Microprocessor,is part of*Central Processing Unit*(CPU) found on computers without the memory, I/O required by a complete system. Besides microprocessor there is a*chips*also known as a microcomputer. In contrast to microprocessors, this microcomputer has I/O and memory. With advances in technology and with development*chips*which is fast so it's currently in a piece*chips*there is CPU memory and I/O control.*Chips* this type is often called*microcontroller*. *Microcontroller*is a system computers in which all or most of the elements are packaged in a single IC chip (*Integrated Circuits*), so it is often mentioned*single chip microcomputer*. This microcontroller is also a computer system that has one or several specific tasks, in contrast to a PC which has a variety of functions. Another difference is the very large ratio of RAM and ROM between microcontroller with computer. In microcontrollers the ROM is much larger compared to RAM, whereas in a computer or PC RAM is much larger compared to ROM.

Microcontrollers have the ability to process and process data at the same time it can also be used as a control unit, so with one piece*chips* namely our microcontroller can control a device. Microcontroller

There are differences between microprocessors and microcomputers. Something The microprocessor is part of the CPU without memory and supporting I/O a computer, while a microcontroller generally consists of a CPU, memory, certain I/O and other supporting units.*(Saputro, T.T, 2017)*

Basically there are very striking differences between microcontrollers and microprocessors and microcomputers, namely in their applications, because Microcontrollers can only be used in certain applications. Another advantage that is, it lies in comparison*Random Access Memory*(RAM) and*Read Only Memory*(ROM). So

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the size*boards*microcontrollers become very compact orsmall, from the existing advantages there are advantages to using a microcontroller with a microprocessor, namely the microcontroller already has RAM and equipment,Supporting I/O so there is no need to add more. Basically the structure of Microprocessors are similar to microcontrollers. Microcontroller usually grouped in one family, each microcontroller has separate specifications but suitable in programming, for example the MCS-family 51 produced by ATMEL such as AT89C51, AT89S52 and others, meanwhile AVR family such as Atmega 8535 and so on.

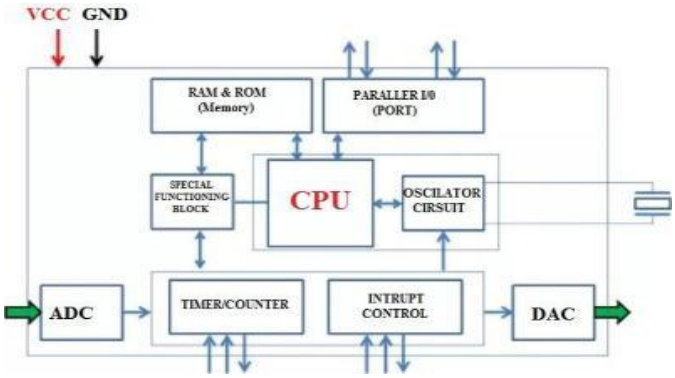

Figure 6. General Microcontroller Block Diagram

3. METHOD

This Method description a research time and place, tools and materials, tool design, research methods, and research procedures. The research procedures will be carried out. In designing the tools in this research, the author use several tools and materials for design:

Table 1. Tools and Materials

TOOL	MATERIAL
Laptops	Arduino Uno microcontroller
Cutting pliers	16 x 2 LCDs
Negative and Positive Screwdrivers	PZEM-004T sensor
Soldering	5 volt relay
Cellphone	12 volt power supply
	LM9526 Voltage Regulator
	450 Watt Prepaid Kwh Meter
	220V Dimmers

What is meant by a system is a collection of interconnected elements associated with processing input*(input)*one with another input so that it can produce output*(output)*in the form of information that can be obtained used in making a decision. kWh meter supplies the electrical load and is connected to the power supply for reduces the 220 VAC voltage to 12VDC, output from the power supply connected to a voltage regulator to reduce the voltage from 12V to 5 V to supply Arduino Uno, and other components. Meanwhile module

The dimmer works to regulate the voltage rise and fall. Pzem004t sensor works detects the voltage from the dimmer output and at the same time detects the poweron load. If the voltage detected by the pzem004t sensor is greater than 231V or smaller than 198V and the detected power is greater than 450 watts then pzem004t sends data

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to Arduino so that Arduino orders it protection relay to cut off electricity to the load. Meanwhile, if the sensor Pzem004t detects voltages smaller than 231V or greater than 198V as well

The detected power is smaller than 450 watts then the pzem004t sends data on the Arduino so that the Arduino orders the protection relay to connect flow of electricity to the load. The minimum system circuit is the minimum circuit where the chip the microcontroller can work (running). The Atmega AVR chip is equipped with internal oscillator so, to save costs, there is no need to use external crystal/resonator for CPU clock source:

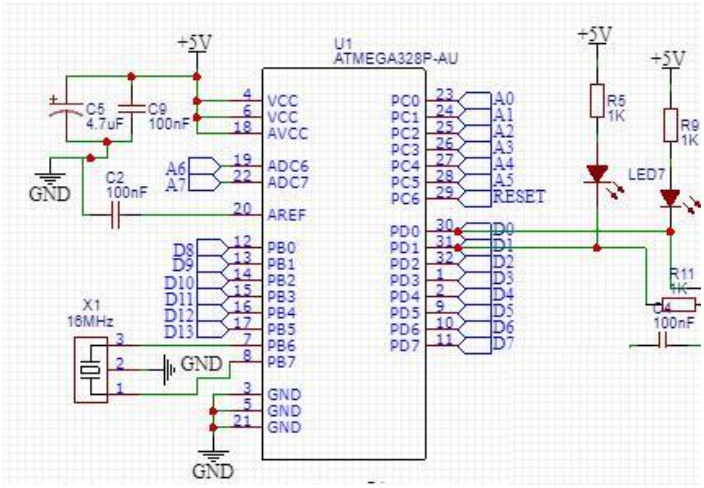

Figure 7. Arduino Uno schematic

The Arduino schematic circuit has several components, namely:

1. ATMega 328 microcontroller IC
2. 2 capacitors, namely 22 pF (C1 and C2) and 10 uF (C3)
3. 1 resistor whose value is 4k7 ohm
4. 1 reset pushbutton (PB1)

`Program memory is Flash PEROM memory which is responsible for storing programs (*software*) which we create in the form of program codes (containing addresses along with the program code in the memory address space) which we compile in the form of hexa or binary numbers.

4. RESULT

4.1. Power supply testing is carried out twice to obtain

In accordance with the outline of the aim of this research is to create tools Prepaid Kwh Meter Protection Relay Safety Based on Overload Microcontrolle Based r. There are several steps used in making the tool before carrying out testing. The voltage source used as the working voltage in the circuit Prepaid Kwh Meter Security Tool Based on Overload For Avoiding Microcontroller Based Relay Damage has its origin from DC12 V. In this research, testing will be carried out on the supply circuit power, namely by measuring the output voltage produced by each each voltage source applied to the circuit

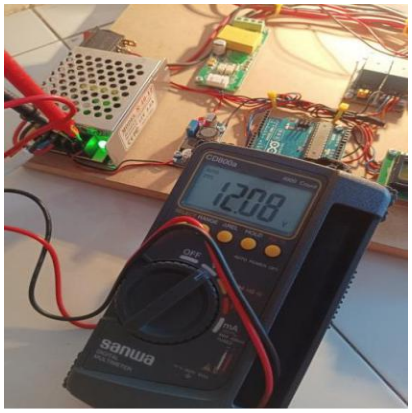

Figure 8. Testing*Output*Power supply

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Good results based on the data sheet of the power supply, but measurements which was carried out directly using a multitester can be seen in the table below This:

Table 2. Power supply stability test measurements

Test	Expected based on data sheets	Measurement results
	Vcc	Vcc
Number 1	12 V	12.08 V
2nd	12 V	12.08 V
The 3rd	12 V	12.08 V
To 4	12 V	12.08 V
5th	12 V	12.08 V
Average value	12 V	12.08 V

4.2 Testing *Outputs* Voltage Regulator

Use of regulators on Prepaid Kwh Meter Security Devices Based on Excessive Load To Avoid Damage The relay is used to provide constant voltage in the minimum system circuit of the tool. Based on*datasheet* There are several types of regulator ICs that indicate the output voltage produced. This series of tools uses the LM2596 regulator IC, according to *data sheet*The LM2596 regulator IC produces a voltage of 5 volts DC which is listed in the two digit numbers from the back of the page*body*regulators

The testing system on the LM2596 regulator IC was carried out to find out output voltage produced by the regulator IC. Reasons for choosing to use The regulator IC is LM2596 because each component in the device works on average based on 5V DC voltage.

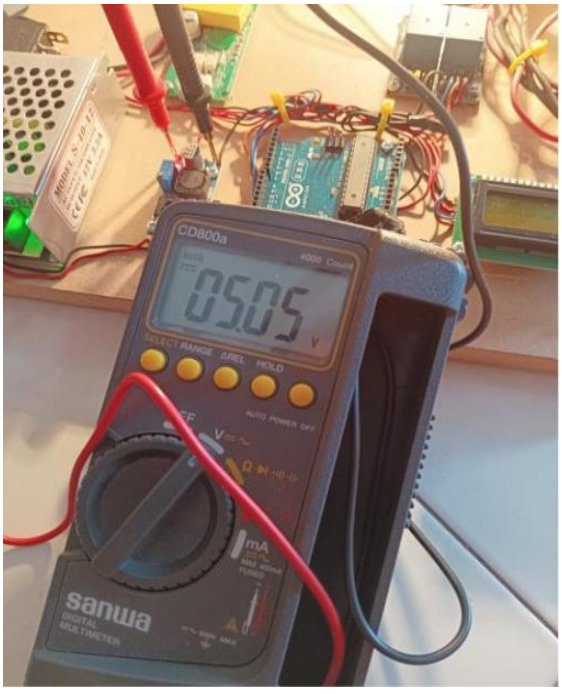

Figure 9**.** Voltage Regulator Output Testing

To achieve more accurate test results, testing output This voltage regulator was tested 3 times. The following is the test table

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Table 3. IC Regulator Test Results

Test	Expected	Measurement results
Number 1	5 V	5.05 V
2nd	5 V	5.05 V
The 3rd	5 V	5.05 V
Average value	5 V	5.05 V

4.3 Relay Testing Based on Power

The figure and table below shows relay testing with the system power usage is registered on the program system so that the contacts will move from*normaly close*(NC) to*normaly Open*(NO). This test is carried out as proof that the electricity circuit breaker system is based on size power that exceeds the load capacity as a safety relay on this Kwh meter can function well.

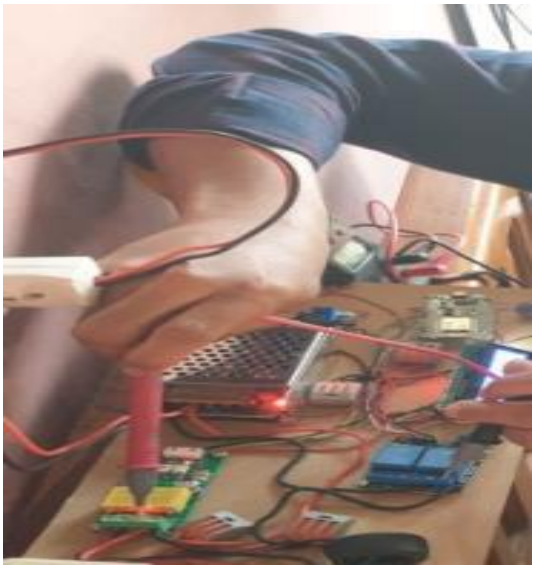

Figure 10 . NO and NC Relay Voltage Testing

Table 4. NO and NC Relay Voltage Testing

Relays	Voltage Coil	Condition Relays	Big Power on Burden (Watt)	Information
5 Pins	5 V	NC (Normaly Closed)	< 420 Watts	Connecting Electricity to the Load
	0 V	NO (Normaly Open)	> 455 Watts	Cutting Off Electricity to the Load

5. CONCLUSION

From the results of the discussion in the previous chapter, the writer will create a conclusions in writing this paper are as follows:

1. To help people save electricity usage at home, use electricity properly and appropriately to turn it on and to turn it off
2. Test results of tools designed with calculation results percentage calculation is different, for iron it has a percentage error 1.99% of the calculation results for heating testing Water has an error percentage of 0.53% due to lack sensitivity of the PZEM-004T sensor in reading the used load
3. The protection relay will work to cut off the flow of electricity if there is voltage <198V or >231V, and if the power is >450 Watts.
4. The measured voltage at the output of the designed tool reaches 205 V and still in the SPLN standard.

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