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Design and Build of an Electrical Installation Control System for Residential Houses based on the Internet of Things

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***Abstract*— Technological advancements have become indispensable in the modern digital era. With growing environmental concerns, energy efficiency has become a critical priority, particularly at the household level, as it plays a significant role in supporting global energy conservation. This study explores the implementation of an Internet of Things (IoT)-based system for controlling electrical installations remotely via an Internet connection. The system is designed to optimize electricity usage, save time, and enhance daily convenience. The research employs NodeMCU ESP8266 and the Blynk application to enable users to manage the flow of electricity to connected devices. Two modes of operation are available: manual control using a selector switch and automatic control through the Blynk application. Testing results indicate that the system operates effectively, providing remote control capabilities without geographical limitations, provided an internet connection is available. However, the system's performance heavily depends on the stability and speed of the internet connection. A slow or unstable connection can result in delays or failures in executing commands. Overall, this IoT-based control system presents a practical solution for improving energy efficiency and offers a modern approach to managing electrical devices in households. It aligns with the needs of contemporary living by integrating smart technology into daily activities and addressing the demand for efficient energy management.**

***Keywords*—IoT; Control; Electrical Installation; NodeMCU ESP8266; Blynk**

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I. INTRODUCTION

In the current era of globalization 4.0, technology is very rapidly developing and increasingly advanced, so it becomes an encouragement for humans to continue to innovate, think creatively, and not only create new inventions but also optimize the performance of systems and technologies that have been created before fulfilling the maximum human work system. Thus, this technology is also known as the Internet of Things (IoT)[1].

The Internet of Things (IoT) is a combination of a network connected by machines, or other device devices that send and receive data through a network connection. The Internet Of Things is a technology that requires the operation, and cooperation of various hardware, and files via the Internet network. The Internet of Things (IoT) can be used in large homes by controlling electronic devices such as lights in a room that are remotely controlled using Internet communication, there is no need to worry anymore for the rapid progress of technology is very fast, understood and implemented in everyday life, for example in the development of technology that can be used with the internet network connected, it is easy to control or operate home electrical devices such as lights in every room of the house online by utilizing a mobile phone, namely a smartphone. So that users can easily turn on and off lights remotely under good internet connection conditions[2].

The use of Internet of Things can be utilized into various needs in everyday life to facilitate human work so that various design ideas arise that can be used in various ways. In addition, attention to environmental issues is increasing, and consumer negligence in the use of home electricity is generally found when leaving home, such as forgetting to turn off electrical devices such as electronic devices that consume electricity and can cause house fires, so users often feel uncomfortable when traveling far or so. Therefore, this research aims to implement an electrical installation control system in IoT-based residential homes. Thus, this research can be an important step towards smarter, more energy-efficient households, and contribute positively to environmental sustainability

II. THE MATERIALS AND METHOD

A. Internet of Things (IoT)

Internet of Things (IoT) is a collection of objects in the form of physical devices (hardware/embedded systems) that can exchange information between service operators or other devices connected to the system to provide greater utilization[3]. In its use, the Internet of Things is widely found in various activities, such as online transportation, e-commerce, online ticket booking, live streaming, e-learning, and other even to tools to help in certain fields such as remote temperature sensors, GPS tracking, and so on that use the internet or network as a medium. With the many benefits of the Internet of Things, it makes things easier. In the field of education, IoT is needed to carry out all activities using a well-organized and precise filing system[4].

The hardware used in the control system for electrical installations in residential homes based on the Internet of Things is in the form of NodeMCU ESP8266 as shown in Figure 1A. NodeMCU is an electronic board based on the ESP8266 chip with the ability to carry out microcontroller functions and also an internet connection. A microcontroller is a small controller and a computer system where most of the components are packaged in one Integrated Circuit (IC). Microcontrollers are also part of an embedded system, which is a system designed to perform one or more specialized functions in real-time.

B. Control System

A control system is a tool or relationship between components that are interconnected so that they are in the same range, producing the expected system response or in other words have the ability to monitor, control and regulate system conditions. The control system is divided into two parts, namely the manual control system and automatic control[5].

The control system design used is a feedback control system (closed control system). The hardware used for the control system is a relay as shown in Figure 1B. A relay is an electronic component that serves to disconnect or connect an electronic ring again with another electronic circuit. A relay is a switch that works based on electromagnetic principles that will work when current flows through the coil, the iron core will become a magnet and will attract the contacts inside the relay[6].

In addition to controlling using relays, the tool also uses selector switches. The selector switch is a circuit connector according to what is designated by the selector stalk. Selector Switch is a tool that is used to select. The work of the selector switches to connect the circuit according to what is designated by the selectorstalk[7]. This circuit uses a 2-position type selector switch (1NO, 1NC), the use of the selector switch in this tool is as a manual control in the circuit. The working system of the tool that researchers make is a control tool that can be controlled physically using a selector switch and online through network media using the Blynk application.

Figure 1. A. NodeMCU ESP8266 B. Relay C. Selector Switch

C. System Planning

1. **Research Flowchart**
2. **Tool Work System Planning**
   Planning the working system of this tool is the initial stage in designing an IoT-based home electrical installation control system tool that can be used to control electrical installations manually or remotely.
3. **Tool Working Circuit Picture**
   The working system of this control device can be done manually and using the Blynk application that has been programmed on the NodeMCU to turn on or turn off the use of electric current on the load using a relay module. Manual control of electricity can be done by shifting the selector on the selector switch installed on the NodeMCU.

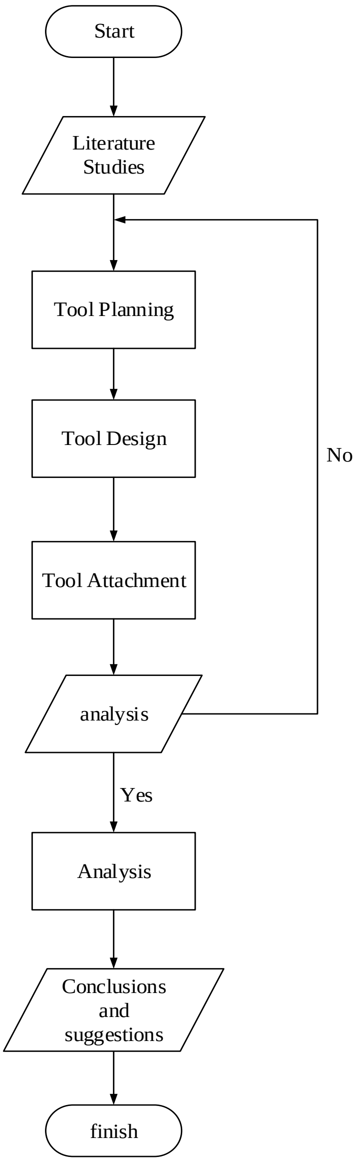


FIGURE 2. Flowchart System

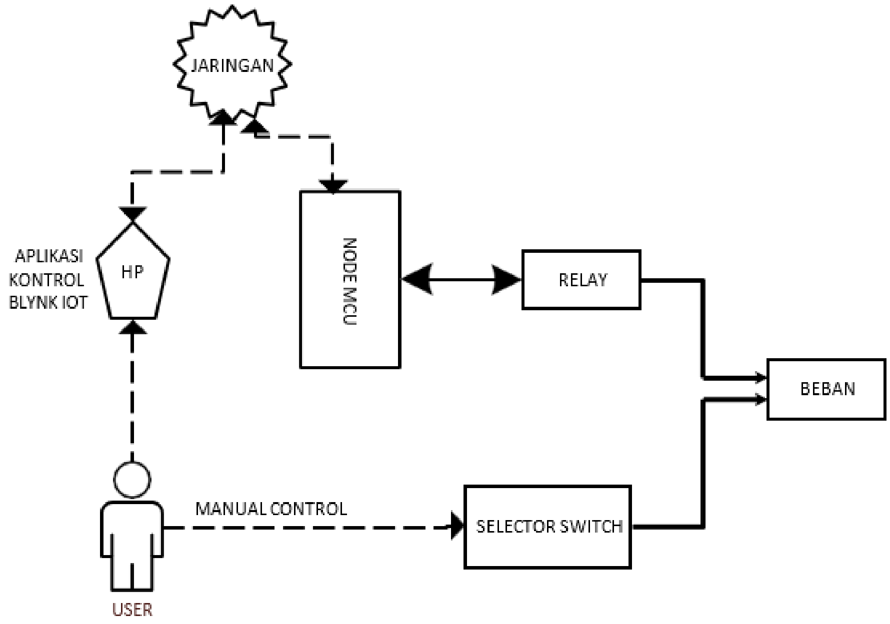


FIGURE 3. Tool Working System

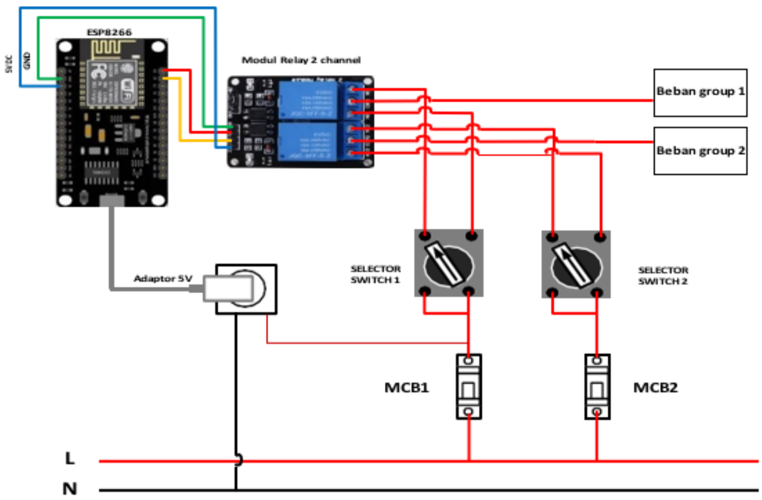


FIGURE 4 Tool Working Circuit

4. Component Selection

TABLE I
Component

No	Nama Material	Quantity
1.	Box panel 20X30X12 cm	1 unit
2.	MCB 1 Fasa	2 unit
3.	*Node MCU ESP8266*	1 unit
4.	*Relay*	2 unit
5.	Cable NYA 1.5	As needed
6.	Cable NYM 3×2.5	As needed
7.	Cable Jamper	As needed
8.	Cable USB	1 unit
9.	Adaptor Power	1 unit
10.	*Selector Switch*	2 unit
11.	Electric socket	1 unit
12.	Terminal 10A	1 unit
13.	*Pilot Lamp*	2 unit
14.	*Breadboard*	1 unit

D. Tool Design

1. Component Layout Determination Design Stage

   In this tool, a panel box is needed as a place for tools and safety components so that this tool can be installed and adjusted to the previously available home installation, so it is necessary to determine the layout of the components used by this tool. The following is a picture of the component layout design of the panel box:

2. Tool Installation Setup

   Installing the circuit according to the circuit drawing in Figure 6 that has been designed and adjusting the installation to the position of the tool components on the panel box as determined in Figure 5A.

3. Programming Phase

   After completing the installation of the device that has been made, a C-based programming or machine language/program command is required in the Arduino application as a command to run the IoT-based electrical installation control system as shown in Figure 5B.

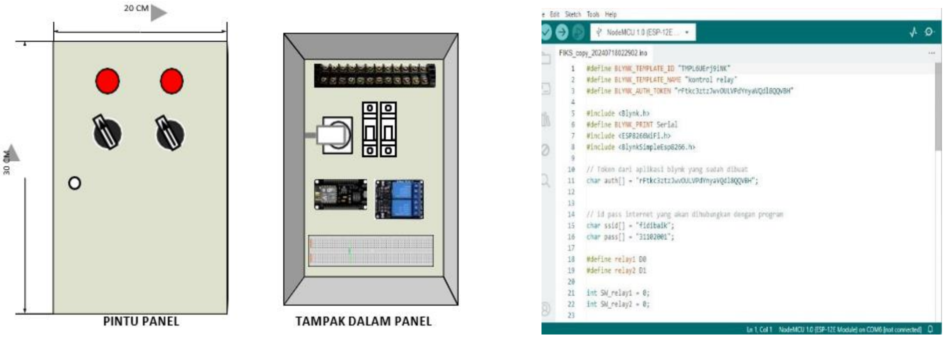


FIGURE 5 A. Tata Letak Komponen pada Box Panel B. Programming Image Form

E. Testing

This test is carried out to ensure whether or not it is feasible the use this control tool, as well as testing the extent of the response speed received in running the control system. The advantages of this IoT-based control system can be used to connect or disconnect the use of electricity whether it is being used or not used before and can be controlled via a smartphone in use either inside or outside the home so that electricity users do not need to worry about traveling or leaving the house where all electricity users can be controlled through a programmed application.

The following are supporting applications used to create programming and control applications for the Internet of Things-based electrical installations using microcontrollers including:

1. Arduino IDE 2.3.2: This software application is used to create a coding program.
2. Blynk IoT: It is an Android application that is used to control the on/off of electrical installations that have been designed. In the Blynk application, we must first create a project device to get an ID token so that it can connect to the internet network that has been programmed in the Arduino application, then make 2 ON / OFF buttons so that it can control the installation that we will controller.

III. RESULTS AND DISCUSSION

A. IoT-based Electrical Installation Control System Design Results

This Iot-based electrical installation control system is designed as an electrical installation controller whose installation can be adjusted to the conditions of the electrical installation circuit at home, so that in this tool the researcher designs the placement of components in this tool on a panel box measuring 20X30X12 cm, to make it easier to install. The form of installing the tool components on the panel box is as follows:

a. The front view of the panel box in Figure 6A can be seen there are 2 pilot lights as an indicator of the disconnection or connection of electric current from the source to the load, under the pilot lamp there is a selector switch as a switch for direct control.
b. The inside view of the panel box assembled according to Figure 6 and the installation of the components on the inner panel box can be seen in Figure 6B. The form of the programming stages of the electrical installation control system tool in an IoT-based residentialhouse is as follows:
   1. Prepare the tools and materials to be used
   2. Assemble the module as shown in Figure 6C

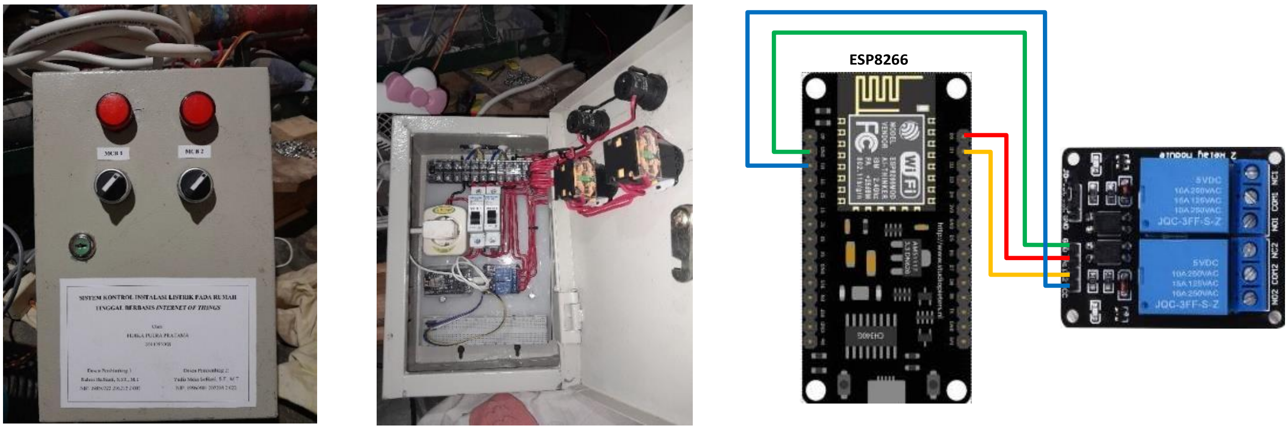
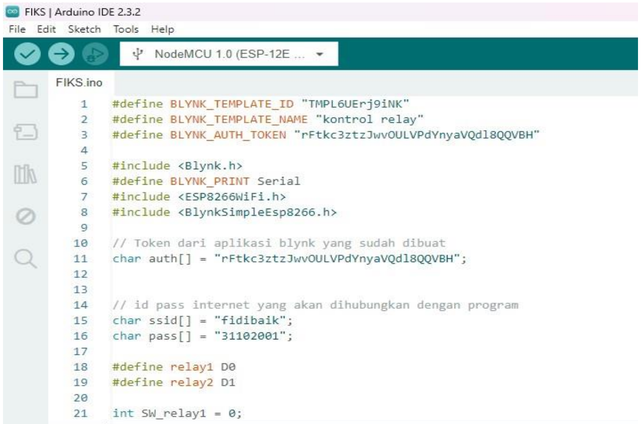


FIGURE 6 A. The Front View of The Panel Box B. The Inside View of The Panel Box C. ESP8266 Module Circuit with Relay Module

3. Configuration and input programming that has been made using Arduino IDE software to run the tool as shown in Figure 7.




```
#define BLYNK_TEMPLATE_ID "TMPL6UErj9iNK"
#define BLYNK_TEMPLATE_NAME "kontrol relay"
#define BLYNK_AUTH_TOKEN "rFtkc3ztzJwvOULVPdYnyaVQd18QQVBH"

#include <Blynk.h>
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

// Token dari aplikasi blynk yang sudah dibuat
char auth[] = "rFtkc3ztzJwvOULVPdYnyaVQd18QQVBH";


// id pass internet yang akan dihubungkan dengan program
char ssid[] = "fidibaik";
char pass[] = "31102001";

#define relay1 D0
#define relay2 D1

int SW_relay1 = 0;
```

FIGURE 7. Programming using Arduino IDE Application

4. Configuration and design of applications used for control tools, media in the form of applications on smartphones, and the official website of the Blynk application used.
5. After all the design and configuration of the programming that has been done, the tool can be tested for use so that in testing this tool can be categorized as feasible or not used in controlling home installations.

B. Test Result

Testing the control system using the Blynk application carried out on the network aims to see the response time to the working system of the device in connecting and disconnecting the flow of electricity from the source to the load and in this test the control is carried out with different distances to observe the working response of the device when controlled remotely. The test results are as follows:

TABLE II
Response Testing of Blynk Application Control System on MCB 1

NO	Testing with Blynk on MCB 1		
	Testing ON / OFF	**Distance**	**Response Time**
1.	Testing 1 ON	5 meter	0.5 second
2.	Testing 2 OFF	5 meter	0.5 second
3.	Testing 3 ON	10 meter	0.5 second
4.	Testing 4 OFF	10 meter	0.5 second
5.	Testing 5 ON	100 meter	0.5 second
6.	Testing 6 OFF	100 meter	0.5 second
7.	Testing 7 ON	1 kilometer	0.5 second
8.	Testing 8 OFF	1 kilometer	0.5 second

The results of testing the response of the control system using the Blynk application carried out on the internet network to the working system of turning on and off MCB 1 response time has an average value of 0.5 seconds due to a good internet network at the time of testing.

TABLE III
Response Testing of Blynk Application Control System on MCB 2

NO	Testing with Blynk on MCB 2		
	Testing ON / OFF	**Distance**	**Response Time**
1.	Testing 1 ON	5 meter	0.5 second
2.	Testing 2 OFF	5 meter	0.5 second
3.	Testing 3 ON	10 meter	0.5 second
4.	Testing 4 OFF	10 meter	0.5 second
5.	Testing 5 ON	100 meter	0.5 second
6.	Testing 6 OFF	100 meter	0.5 second
7.	Testing 7 ON	1 kilometer	0.5 second
8.	Testing 8 OFF	1 kilometer	0.5 second

The results of testing the response of the control system using the Blynk application carried out on the internet network to the working system of turning on and off the MCB 2 response time has an average value of 0.5 seconds due to a good internet network at the time of testing. Testing the response of the manual control system on the selector switch is carried out to see the response to the working system of the tool in connecting and disconnecting the flow of electricity from the source to the load is as follows:

TABLE IV
Manual Control System Response Test on MCB 1

NO	Testing with Selector Switch on MCB 1	
	Testing ON / OFF	**Response Time**
1.	Testing 1 ON	0.5 second
2.	Testing 2 OFF	0.5 second
3.	Testing 3 ON	0.5 second
4.	Testing 4 OFF	0.5 second

The results of testing the response of the manual control system with selector switches carried out on MCB 1 response time has an average value of 0.5 seconds.

TABLE V
Manual Control System Response Test on MCB 2

NO	Testing with Selector Switch on MCB 2	
	Testing ON / OFF	**Response Time**
1.	Testing 1 ON	0.5 second
2.	Testing 2 OFF	0.5 second
3.	Testing 3 ON	0.5 second
4.	Testing 4 OFF	0.5 second

When testing the response of the control system using the Blynk application, it can be observed that the response of the device works well because, at the time of testing, the internet network used is in good condition. At the time of control using the Blynk application can be done without any distance limit in its use so that users can control anywhere that the main requirement must be in the internet network.

After completing the control response testing process on the next tool, measurements of current, voltage, and power consumption are carried out when the tool is installed in the home installation, the control system tool works properly in disconnecting and connecting current and voltage at home, this measurement is done manually using a multimeter measuring instrument on each control system on this tool, both control with IoT using the Blynk application and manual control using a selector switch. The following are the current and voltage measurements when the device is attached to the home installation.:

TABLE VI
Measurement of current and voltage on IoT control system using Blynk application on MCB 1

NO	MCB 1	V (volt)	I (ampere)	$\cos \varphi$	P (watt)
1	ON	221	0,895	0,85	168,126
2	OFF	0	0		0

Based on Table 6, the value of current and voltage measurements on the IoT control system using the Blynk application on MCB 1, namely when the control system is activated, it can be seen that in the ON condition, a voltage of 221 volts and a current of 0.895 are obtained, while in the OFFcondition the load gets a voltage of 0 volts. So the value of P (real power) is obtained in the ON condition using formula (1) of 168.126 watts.

TABLE VII
Measurement of current and voltage on IoT control system using Blynk application on MCB 2

NO	MCB 2	V (volt)	I (ampere)	cos φ	P (watt)
1	ON	221	0,894	0,85	167,938
2	OFF	0	0		0

Based on Table 7, the value of current and voltage measurements on the IoT control system using the Blynk application on MCB 2, namely when the control system is activated, it can be seen that in the ON condition, a voltage of 221volts and a current of 0.894 are obtained, while in the OFF condition, the load gets a voltage of 0 volts. So the value of P (real power) is obtained using formula(1) of 167.938 watts.

TABLE VIII
Measurement of Current and Voltage on Manual Control System using Selector Switch on MCB 1

NO	**MCB 1**	**V (volt)**	**I (ampere)**	**cos φ**	**P (watt)**
1	ON	221	0,906	0,85	170,192
2	OFF	0	0		0

Based on Table 8, the value of current and voltage measurements on the manual control system with a selector switch on MCB 1, namely when the control system is activated, it can be seen that in the ON condition, a voltage of 221 volts and a current of 0.906 are obtained, while in the OFFcondition the load gets a voltage of 0 volts. So the value of P (real power) is obtained using formula (1) of 170.192 watts.

TABLE IX
Measurement of Current and Voltage on Manual Control System using Selector Switch on MCB 2

NO	**MCB 2**	**V (volt)**	**I (ampere)**	**cos φ**	**P (watt)**
1	ON	221	0,938	0,85	176,203
2	OFF	0	0		0

Based Based on Table 9, the value of current and voltage measurements on the manual control system with a selector switch on MCB 2, namely when the control system is activated, it can be seen that in the ON condition, a voltage of 221 volts and a current of 0.938 are obtained, while in the OFFcondition the load gets a voltage of 0 volts. So the value of P (real power) is obtained using formula (1) of 176.203 watts.

C. Analysis of Result

In the use of this control tool in addition to remotely controlling electricity using a smartphone through the Blynk application this tool can also turn off and turn on home installations using manual control using a selector switch and the use a manual control system there are no obstacles or any time duration that occurs because the function of this exchange switch only disconnects or connects the flow of electric power manually.

IV. CONCLUSION

The designed tool can work well. The tool can be controlled using 2 ways, namely through a selector switch and through an application that is accessed using a smartphone. The working system of this control tool can be done manually and using the Blynk application that has been programmed on the NodeMCUESP8288 to turn on or off the use of electric current on the load. Manual control of electricity can be done with the selector switch installed. The use of Blynk application serves as a medium that can be used to turn on or off the use of electric current remotely.

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