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Abstract. The PLC is widely used as a controller with input in the form of switches and sensors and output in the form of coils. PLC can be connected with HMI to facilitate the operation of the PLC. The usual HMI is installed on a PLC in the form of a stand-alone PC HMI and HMI that is connected via serial cable or Ethernet cable. The HMI in the form of wireless is rarely found. In this paper, will show the use of HMI connected with Bluetooth (BT) on the Outseal PLC (locally made PLC). The PLC is programmed with standard ladder diagram. Selector 4 channels with input in the form of switches and output in the form of coils (lights). Lights can be selected via the switch. Difficulties in the PLC with input using the switch are not easily changed from afar. HMI designed has facilities available for ALL OFF, ALL ON and TOGGLE mode. The HMI uses a smart phone with HMI modbus apk for android. The Smart phone screen can be used as a monitor and is a touch screen for input. Screen size of 5.5 inch, pixel size of 720 1280 is capable of displaying 7 switches and 4 indicators

INTRODUCTION

The PLC is widely used for controllers in industry. The simplest PLC unit is a CPU with an input in the form of a switch and an output in the form of a coil. To display and control the PLC used HMI (Human Machine Interface) which is in the form of a touch screen. On the HMI screen can be filled with input and display devices. The widely available HMIs are PC monitor screens as HMIs and dedicated HMIs. HMI communication can be done using serial communication via an attached cable

Problem to solve in this paper: Selector 4 channels of relays starting all the OFF condition. The channel can be controlled ON or OFF directly using the switch. There is an option to change the Indi dually channel into ON of OFF condition. The other option is to change all condition into ON condition. The next option is all OFF and the reverse choice from the original state using remote access.

THE THEORETICAL BACKGROUND

The Outseal PLC is an Arduino-based PLC that has been loaded with a special boat loader [1]. The PLC input part that is connected to the outside world is S1 to S8, while the output part is connected via the relay coil R1 to R8. There is a memory bit with names B1 through B128. Input ports and output ports can be expanded up to 128 ports

Modbus protocol is a protocol for communication on PLC with other equipment such as HMI [2]. Modbus communication between master and slave can be via serial cable (modbus RTU) or TCP / IP (modbus TCP / IP).

Modbus protocol, the master gives the command (function) and the address to the slave. The data format on the RTU modbus is shown in the Figure 1.

Kuang [3] conducted a communication experiment between Arduino and PLC using the Modbus protocol. PLC as modbus master and Arduino as slave modbus
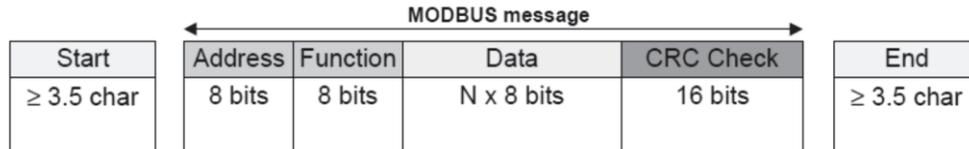

Start	Address	Function	Data	CRC Check	End
≥ 3.5 char	8 bits	8 bits	N x 8 bits	16 bits	≥ 3.5 char

FIGURE 1.The data format for modbus RTU

Modbus function and addresses are presented in the **TABLE 1** and **TABLE 2**

TABLE 1 Modbus functions code

Modbus function code	Description
0x01	Read Coil / Bit Status
0x02	Read Switch Status
0x03	Read Holding Register
0x04	Read Internal Register
0x05	Write Single Coil
0x06	Write Single Register
0x0F	Write multiple Register

TABLE 2 Modbus address

Table Name PLC	object	permission	Address	Address offset
R1... R128	Coil Relay	Read only	0 … 9999	0 - 127
B1... B128	Bit	Read / Write	0 … 9999	128 - 255
S1... S128	Switch	Read only	10000 - 19999	0 - 127
I.1.. I.40	Internal Register	Read / write	40000 - 49999	1.. 100
H1... H500	Holding Register	Read// Write	40000 - 49999	500 - 1000

Ladder diagram shows the logic used. The logic used is IDENTITY logic, NOT logic, AND logic, OR and EXOR logic. Logical operations according to Boole are shown in the **TABLE 3.**

TABLE 3. The Boolean algebra for logic operation [4]

Logic AND operation	Logic OR operation	Logic XOR operation
$A \, 0 \, = \, 0$	$A + 0 \, = \, A$	$A \otimes 0 \, = \, A$
$A.1 \, = \, A$	$A + 1 \, = 1$	$A \otimes 1 \, = \, \bar{A}$
$A.A \, = \, A$	$A + A \, = \, A$	$A \otimes A \, = \, 1$
$A.\bar{A} = 0$	$A + \bar{A} = 1$	$A \otimes \bar{A} = 0$

In the logic operation table according to Boole, the logic operation AND produces two conditions namely A, 0. The output is 0 (FALSE) if one of the inputs is 0 (FALSE). In OR logic operations, outputs are valued at A, 1. Output is 1 (TRUE) when one input is 1 (TRUE). In XOR operations output can be A, NOT A, 1, 0. Output is A when input is 0 while output is NOT A when input is 1.

METHODOLOGY

The equipment used in this research are the Outseal Studio Release 10 rev 1 from www.outseal.com , an Outseal PLC board V3, a Bluetooth module and a Smartphone with HMI modbus apk (available on play store) as shown in Figure 2 2. The PLC outseal board is programmed in ladder diagram using the Outseal studio. Interaction between PLC and humans using HMI which is designed on a smartphone. The next problem is designing and implementing HMI on smart phones
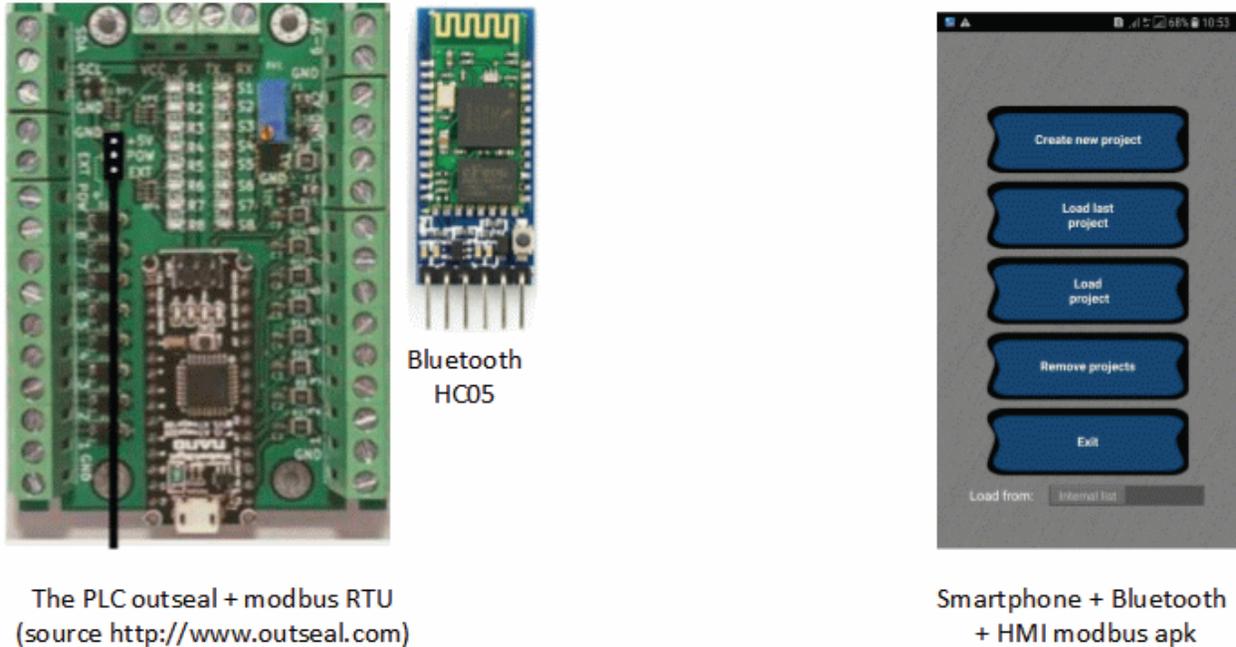

The PLC outseal + modbus RTU
(source http://www.outseal.com)

Bluetooth
HC05

Smartphone + Bluetooth
+ HMI modbus apk

FIGURE 2. Setup experiment the PLC outseal + HMI Bluettoh

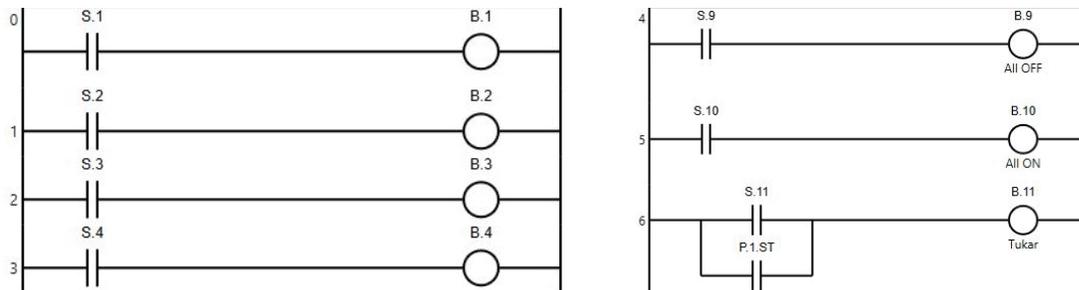Diagram ladder for Selector 4 channels controlled by HMI android Bluetooth shown in Figure 3 and Figure 4

FIGURE 3. Ladder diagram for input from switch (rung 0 – 3), rung 4 – 6 select mode ALL ON, ALL OFF, TOGGLE
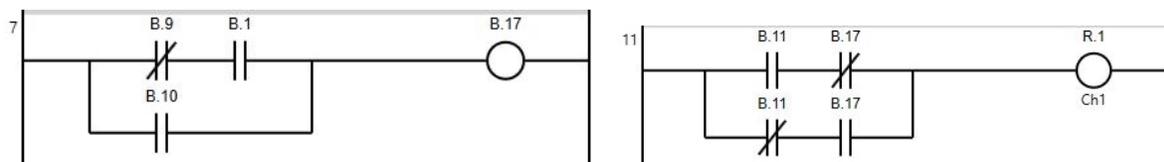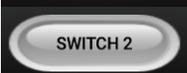

FIGURE 4..(a) Ladder diagram of ALL ON mode and ALL OFF mode. (b) ladder diagram for TOGGLE mode

In rung 0 to rung 3, S1 to S4 are connected with an external switch to activate channels 1 to 4. S1 cannot be connected directly to R1 but is connected to B1 (memory bit). In rung 7 and rung 11 shows the logic implementation for ALL OFF, ALL ON and TOGGLE modes.

Address table and Request type on the HMI created are presented in the **TABLE 4.**

TABLE 4. Setting object in HMI modbus

Object	Label	Ladder PLC	Modbus Address	Request Type	Function Code
SWITCH 2	CH1	I.1	0	Int16, 0=OFF, 1=ON	Read Holding Reg 0x03
SWITCH 2	CH2	I.2	1	Int16, 0=OFF, 1=ON	0x03
SWITCH 2	CH3	I.3	2	Int16, 0=OFF, 1=ON	0x03
SWITCH 2	CH4	I.4	3	Int16, 0=OFF, 1=ON	0x03
SWITCH 2	ALL OFF	I.9	8	Int16, 0=OFF, 1=ON	0x03
SWITCH 2	ALL ON	I.10	9	Int16, 0=OFF, 1=ON	0x03
SWITCH 2	TOGGLE	I.11	10	Int16, 0=OFF, 1=ON	0x03
(green light)	R1		0	Read Bit State (switch)	Read coil status 0x01
(green light)	R2		1	Read Bit State (switch)	0x01
(green light)	R3		2	Read Bit State (switch)	0x01
(green light)	R4		3	Read Bit State (switch)	0x01
(red light)	R8		7	Read Bit State (switch)	0x01

RESULTS AND DISCUSSION

HMI results made are presented in the following figure. The HMI consists of only one screen and contains 4 Ch1, Ch2 Ch3 and Ch4 buttons to select channels, 3 buttons to select modes: ALL OFF, ALL ON and TOGGLE. There are 4 outputs in the form of lights and 1 indicator to show the HMI is connected to the PLC.There are 4 views to test each mode. In direct mode the output state matches the switch state. In ALL OFF mode all lights go out even though the input value is correct. In ALL ON mode all output states are TRUE even though the input is FALSE. In TOGGLE mode the output state is the opposite of the input state. When the input is true, the output is false, when the input is false, the output is true. The complete logic operation for Selector 4 channel show in **TABLE 5**.

TABLE 5 Logic Operation used in Selector 4 channels

Operation	Description
S1 → B1, S2 → B2, S3 → B3, S4 → B4	Input from the Switch
I.1 → B9	I.1 is activated from the HMI as the ALL OFF button
I.2 → B10	I.2 is activated from the HMI as the ALL ON button
L3 → B11	I.3 is activated from the HMI as the TOGGLE button
((B1 AND B9) OR B10) XOR B11→ R1	Output to Coil Relay R1
((B2 AND B9) OR B10) XOR B11→ R2	Output to Coil Relay R2
((B3 AND B9) OR B10) XOR B11→ R3	Output to Coil Relay R3
((B4 AND B9) OR B10) XOR B11→ R4	Output to Coil Relay R4

(a)	(b)	(c)	(d)
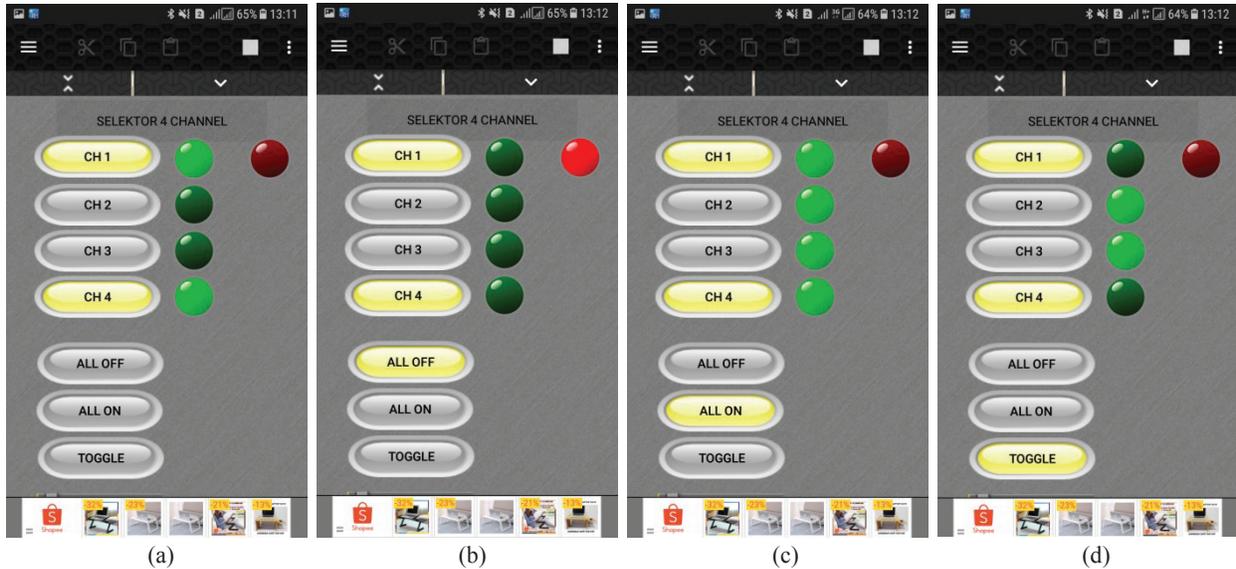
FIGURE 5 (a) Selector for 4 channels with Direct Mode. Push button with CH1 label will activate Green Lamp #1. (b), in ALL OFF mode, all output become OFF condition whatever input conditions. (c) in ALL ON mode, all output become ON condition whatever input conditions. (d) in TOGGLE mode, the outputs will negation from input

Button ALL ON, ALL OFF and button TOGGLE operate individually, not allow activating together. The comparison between HMI created with HMI design Tips shown in table 6

TABLE 6. Comparison HMI created with McDaniel [5] HMI design tips

HMI design Tips	HMI created	Comments
Create a storyboard	Not apply	Just one page
Talk to operators	Yes	Operated by other user
Use colour and animation judiciously	Yes	Colour default from apk
Add graphics	No	Don't need graphics
Display appropriate images	Yes	Image of switches and lamps
Keep important items available	Yes	All item has a function
Offer situational awareness	No	
Limit required screen access clicks	Yes	User need to open main HMI page and select HMI project
Give feedback and lead the way	Not yet	
Beware of pop-ups	ok	There are promotion pop up plug in (free android apk)
Use date and time stamp logging	Not yet	No logging function
Use appropriate password protection	no	Single user, password from smartphone
Create a style guide	yes	Using template from apk

HMI design using HMI modbus for android is free apk, but its apk with pop up advertising. To remove pop up advertising user must pay for registration to apk creator.

In making HMI, it is necessary to pay attention to the esthetics and functionality of the object used. It should also be noted that the parameters used for each object are the slave PLC address used, modbus address, request type.

Benefit using android smartphone as HMI is cheap and easy to use. Now Bluetooth communication is standard in smartphone and easy to access. Bluetooth baud rate used in this project is 57600bps.

CONCLUSIONS

1. Communication between the Outseal PLC and HMI android using Bluetooth with baud rate 57600 bps
2. Communication Protocol used in this project is Modbus RTU
3. HMI created success with all function button work done, and fit from HMI design tips.
4. Using smartphone android as HMI is cheap and easy to build.

ACKNOWLEDGEMENT

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