Design and Build Tools of Tele Monitoring and Controlling Water Chiller System in the Tire Industry with IoT-based

Andri Widiarto
Electrical Engineering Master Program,
Gunadarma University,
Jl. Margonda Raya 100, Depok, West Java 16424,
Indonesia

Wahyu Kusuma Raharja
Electrical Engineering Master Program,
Gunadarma University,
Jl. Margonda Raya 100, Depok, West Java 16424,
Indonesia

ABSTRACT
This research is motivated by phenomenon technology develops in industrial, water chiller system automation in the tire production process should be developed in accordance with industry 4.0, where the system is integrated with internet (IoT) so that can be accessed anywhere and anytime making easier monitoring and control process. The design and control water chiller system has process that must be carried out, namely the manufacture of the water chiller unit, the manufacture control panel, the assembly of hardware and computers and their equipment. The conclusion this study is the tools designed are composed of RTD PT100 sensors, pressure transmitter sensors as input blocks, controllers and chiller units as process blocks, temperature and pressure as output blocks, testing SCADA system, for displaying HMI Client on the Mobile Access menu via smart phone. With the operating system Mobile Access Log On, Main Menu Mobile Access, Main Screen View, Menu Alarm, Process Values, Trend runs smoothly. Based on resistance measurements RTD sensors on the evaporator and condenser, average accuracy of 99.9% is obtained. Based on the PT100 Temperature Sensor Reading Accuracy Test in the monitoring menu, the evaporator has average accuracy of 99.65%, while condenser has an average accuracy of 99.2%.

Keywords
Tele Monitoring, Water Chiller System, PT100 Temperature Sensor, SCADA, IoT

1. INTRODUCTION
Tires are one of the most important factors in driving which have various functions to anticipate accidents while driving. In general, the function of tires is to withstand the load and then absorb shocks on uneven roads and transmit power from the engine and no less important is to continue the steering system.

Based on data from the Ministry of Industry, as of 2019, there were 16 tire manufacturers with an installed production capacity of 211.49 million units for outer tires and 225.13 million units for inner tubes. The absorption capacity reaches 87.9 percent and 70 percent of its production is exported.

In 2020, tire production companies in Bekasi City will produce 1,078,632 tires or an average of 89,886 units per month. The output of this production is 60 percent absorbed by the domestic market and 40 percent is exported.

At a tire production company in Bekasi, there is a water chiller system that is used to cool rubber in the tire production process. The location of the water chiller is spread over each sub-production which is relatively far from each other. The control system using PLC and operating panel is still a sequencer (Manual), and there is no data acquisition system yet. Cold water from the water chiller process is flowed on a conveyor with the condition that on the conveyor there is hot rubber that comes from the extruder process in the tire manufacturing sub process. The cooling process aims to avoid Scot (hardened rubber).

Considering that the sub-productions are not close to each other, this makes it difficult to monitor the water chiller system [1]. There is the possibility of not knowing if a problem occurs, and errors during data collection because it has not been equipped with an automatic data acquisition system. In addition, it also experienced difficulties for the operating panel because they had to visit each machine [2].

With the development of technology in the industrial world, an automation system should be able to be controlled and monitored remotely, this is due to the high mobility of industry players who have limited personnel and time, so a system should be able to be controlled remotely [3]. Therefore, to meet the demands of the performance of the system, the engineer must cooperate with IT, it is necessary to create a system according to industry 4.0, the system is connected to the internet network (IoT) so that it can be controlled from anywhere and anytime [4].

To meet the needs of the industry players above, the authors try to design and apply the wishes of industry players through this research. This research describes the application of an automation system to an intelligent water chiller system.

Based on the problems above and the research that has been done by previous researchers, the author will combine ideas with problems that occur in the form of research "Design of IoT-Based Tele monitoring and Water Chiller System Control" which is expected to overcome the problems that exist in the tire industry.

The tele monitoring and control system in Figure 1 made can be controlled using electronic devices (Note book/Personal Computer, Smart Phone, Tab) which has Google Chrome browser, Internet Explorer, Opera and other browsers connected to the Local Area Network (LAN). or Wide Area Network (WAN) by using the Mobile Access Runtime menu on the Indusoft Web Studio 8.1 SCADA system.

PC Server that is used as an HMI connected to the Water Chiller System which functions as direct monitoring, control and data acquisition.

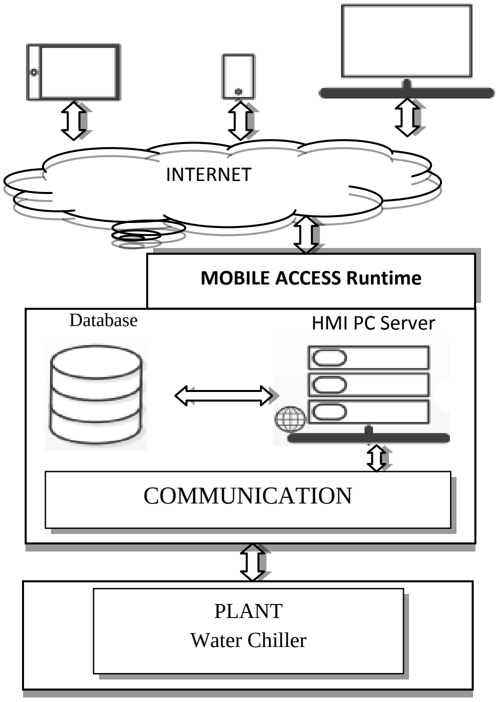

Figure 1. System Design Block

2. HARDWARE AND SOFTWARE DESIGN

2.1 Hardware Design

Hardware design is the initial design that must be prepared in this research. In designing a tool or hardware as shown in Figure 2, it is required to understand all the working principles of the tool to be made, and understand the components of the tool so that errors do not occur. In addition, it is also required to be able to measure and calibrate the existing instrumentation in the system.

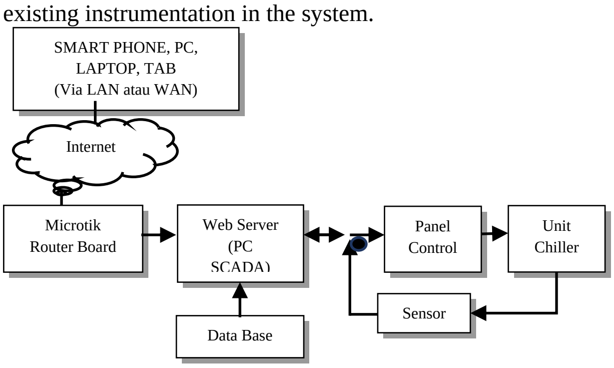

Figure 2. Hardware Design Block Diagram

Based on the block diagram above, the processes that must be carried out are Making the Chiller Unit as shown in Figure 3, Making Control Panels, Assembling Hardware and Computers and their equipment as shown in Figure 4.

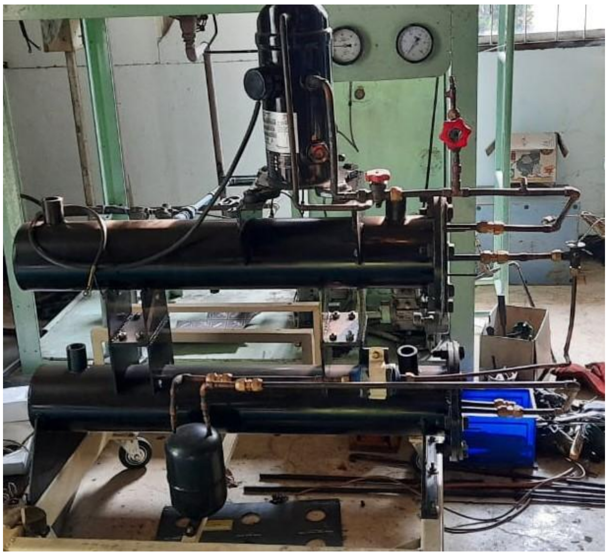

Figure 3. Chiller Unit

The chiller unit consists of several components, namely Compressor, Condenser, Filter Dryer, Expansion Valve.

Figure 4. Control Panel

Making Control Panel consists of several components such as NFB, CB, PLC, Power Supply Unit, Inverter, Relay, Push Button, Pilot Lamp, Terminal Block.

2.2 Software Design

GX Works2 is a software developed by GX Developer which is a software that is compatible with the Mitsubishi Q-Series PLC to create Ladder Programming [5]-[6]. Before making a ladder program, what is done is to make a flowchart according to the program that will be made in Figure 5.

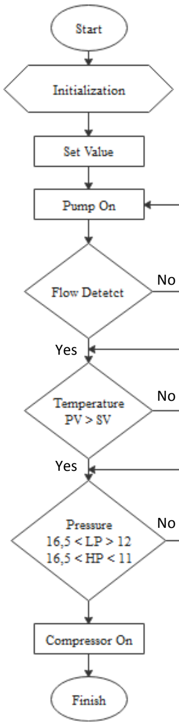

Figure 5. Ladder PLC Program Flowchart

InduSoft Web Studio® (IWS) is an automation software that provides various facilities in developing SCADA systems, HMI and embedded instrumentation, as well as connecting to the web via internet or intranet connections [3]-[7]. Before making a design over view, the first step that must be done is to create a flowchart as shown in Figure 6.

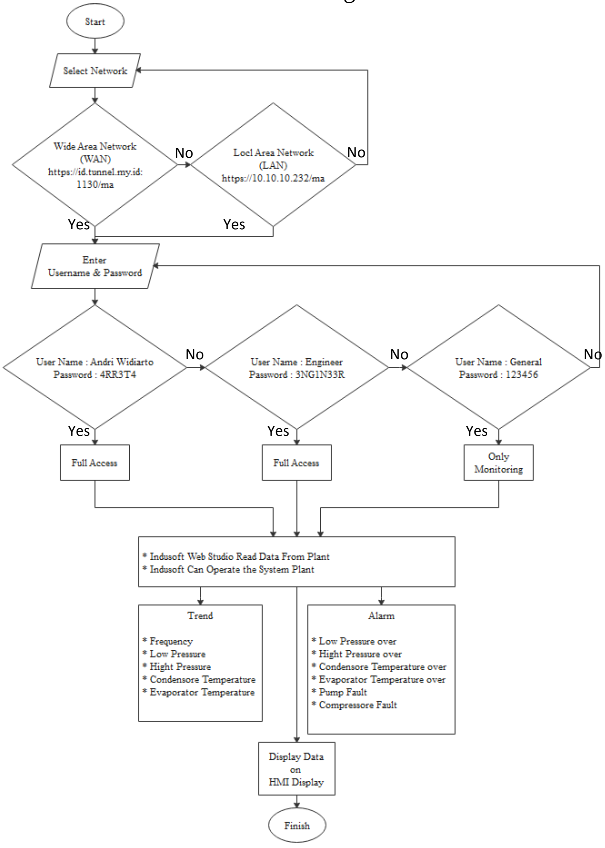

Figure 6. Flowchart of Scada Program

The Data Base tag is an identity that is owned by an object on the screen view, the tag also serves to bridge each address on a device field or a PLC with SCADA software so that it can be displayed in the project that created. The amount and type of data on the tag must match the data taken from the address in the PLC. New tags can be added by accessing the project explorer and selecting "Project Tags" then selecting insert tags, filling in the name and tag type. The tags that have been created will be displayed in the form of a data sheet as shown in Figure 7.

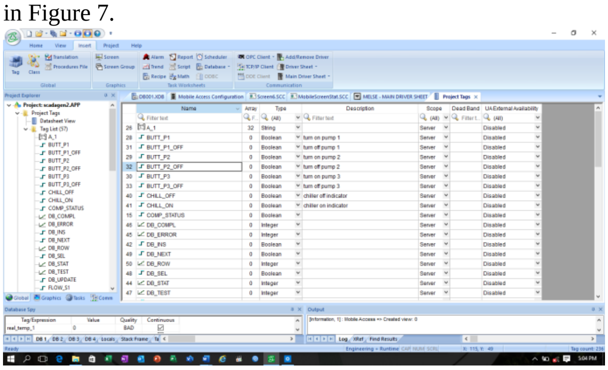

Figure 7. Tag Database

The tag still hasn't saved any data or it's still empty because it hasn't been connected to the I/O address of a PLC. To connect the tag to the PLC I/O, you can add it via the main driver sheet as shown in Figure 8 in the Comm menu, enter the name of the tag along with the appropriate I/O in the column, in the "Action" column, select read if the tag only functions to display data, write if the type of tag can be changed to the contents of the data at the I/O address or Read+Write for both functions.

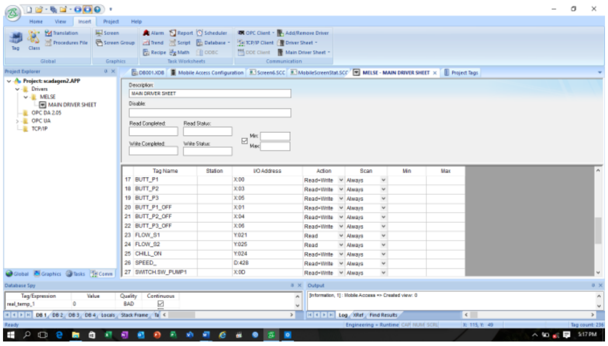

Figure 8. Main Driver Sheet

After configuring the driver and tags, the next step is to design a screen over view of a plant or machine that will be monitored, operating, and data acquisition is shown in Figure 9. A view of a plant is created in the screen editor, to add a new screen, enter on the graphics menu in the project explorer, make the size and style of the screen. The screen is made in such a way as to resemble the actual situation.

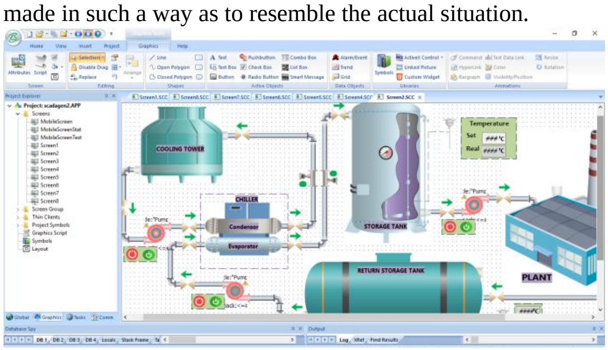

Figure 9. Main Screen Over View

After all object and text components are added to a screen, the next step is to insert a tag into the object, this can be done by double-clicking on the object, then a dialog box appears as shown in figure 10, then add the tag name in the tag/ column. expressions. A simple script command can also be added to an object, such as a command to move to another screen, close the screen, provide logic or data content in tags.

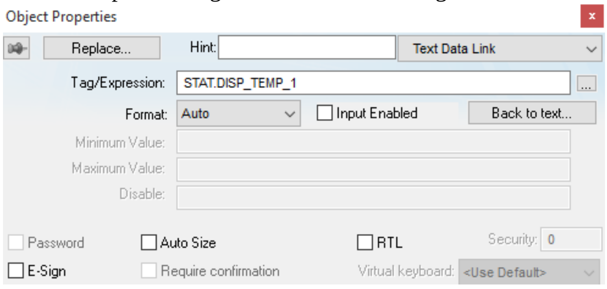

Figure 10. Object Properties

In a process, abnormal conditions can occur which of course cannot be predicted when they will occur. In general, notification of such conditions is required. Therefore needs a system that can ensure and coordinate this as a whole through an alarm worksheet [3].

HiHi : alarm is active when the value is greater than or equal to the limit

Hi : alarm is active when the value is greater than or equal to the limit (Boolean data type)

LoLo: alarm is active when the value is less than or equal to the limit

Lo : alarm is active when the value is less than or equal to the limit (Boolean data type)

Limit is a set value limit, then the message column is filled with an alarm message for what happened or it could be a solution, priority is filled with numbers 0-255 to set which alarm is displayed first. The alarm that has been set in the worksheet will appear in the Alarm/event object in figure 11.

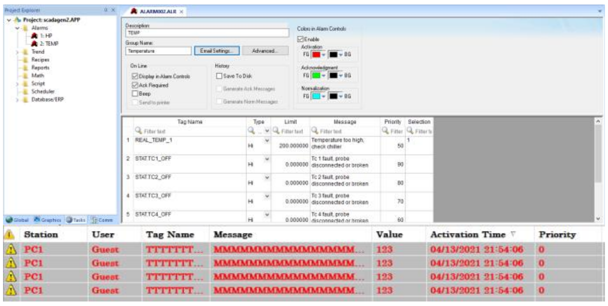

Figure 11. Alarm

Trend is a graph that displays the data value of a tag, the data displayed comes from a process or measurement carried out by devices in the plant, such as the temperature and pressure graph shown in Figure 13. The trend worksheet page can be added by entering the ribbon graphic menu and then select the trend on the Data Object tab. Tags declared in a trend can also be stored on disk. To add a tag that will be monitored, click on the object and then object properties will appear, then select points, enter the tag in the column provided as shown in figure 12.

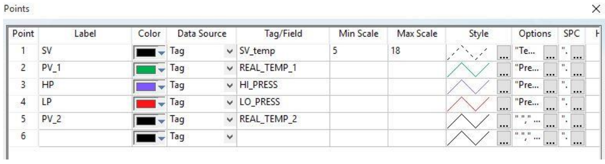

Figure 12. Data Object

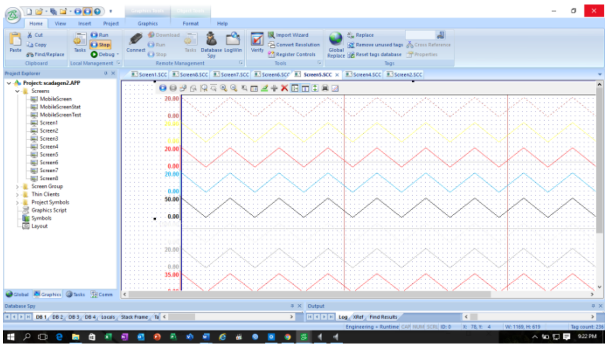

Figure 13. Trend Graph

The database is the most important part of a modern SCADA system, because the process of acquiring data that is not stored on the computer will only be in vain. In addition, SCADA's ability to store data in databases is a distinct advantage compared to other HMIs. In the data acquisition process, there are several database software that can store data resulting from the acquisition process, one of which is Ms Access.

The database configuration shown in Figure 14 is basically connecting the tasks from IWS (alarms, events, trends) to the external database provider table that has been selected, in this case the author uses Ms Access. Each task history (alarms, events, trends) can be saved via a proprietary format as default from IWS, or an external database.

The first step in creating a database is setting up a connection, the author uses Ms Office 12.0 Access Database Engine OLE DB Provider. Additional connections can be set in the database/erp folder in the project explorer, right-click the Connection folder, select insert, then the Database Connection dialog box appears, fill in the name and connection string fields, enter the Ms access path that was created previously in the data source column, click test connection, if there are no errors, the message "test connection successful" appears.

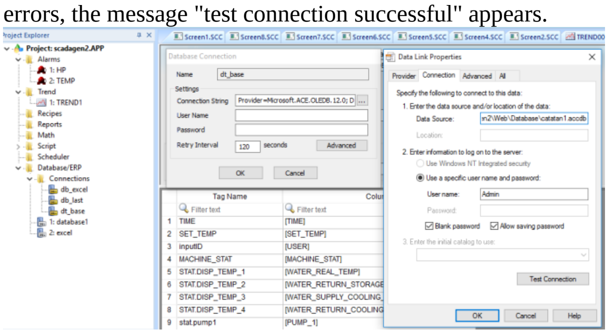

Figure 14. Database/ERP

After the connection configuration is complete, the thing that needs to be done is to connect the tag with the column figure 14 that has been created in Ms Access figure 15 so that the data on the tag can be written into Ms Access.

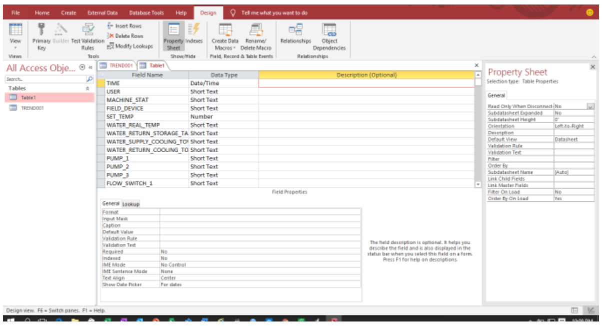

Figure 15. Configuring Ms Access

The communication driver is a built-in module from IWS which functions as a liaison and translator of communication between the SCADA software and the PLC. In the process of making this paper used Direct Communication Driver MELSEC Protocol CE 10.9, because the PLC used is a Mitsubishi Q-series PLC. After adding the driver, the next step is to configure several parameters that need to be filled as shown in Figure 16.

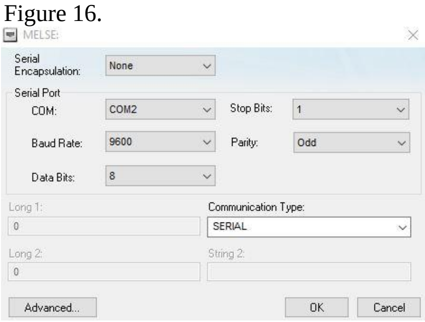

Figure 16.Communication

Mobile access is a web interface based on HTML5 [8] so it can run almost all web browsers, computers and more diverse devices such as smart phones and tablets. Mobile access can be set in the thin client folder in the project explorer. The appearance of mobile access is simpler and the initial window viewer is the default from IWS so we can't change it, it can only be added. There are four main menus that can be set alarm, trend, process value and screen. In the process value there are several widgets that can be selected, namely text box, gauge, semi circular gauge, and circular gauge, these widgets are used to display or as input from a tag. The screen that has been created can also be displayed in mobile access as shown in Figure 17.

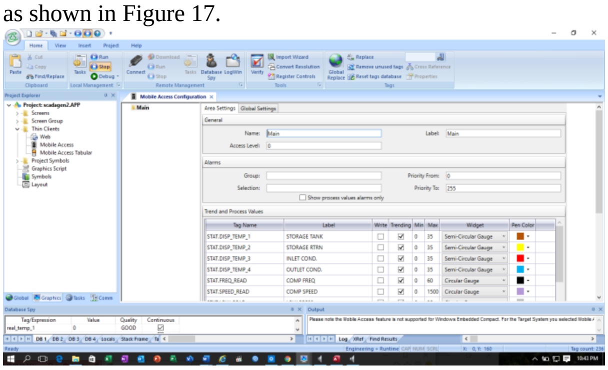

Figure 17. Mobile Access

After the configuration is complete, the project that has been created can be controlled via a web browser with the address https://10.10.10.232/iws81 along with a view that is controlled via the Chrome web browser as shown in Figure 18.

Figure 18. Mobile Access Logon

One of the important components so that projects created on IWS can be controlled via a web browser is by distributing the web that created to clients, this is where IIS functions as a supporting service for the TCP/IP protocol at the application layer as shown in Figure 19. Screen What has been created is not simply deployed to IIS due to differences in document formats, the thing that needs to be done is to publish the screen into HTML format by clicking the application menu in the IWS window then selecting "Publish" then "Save All as HTML".

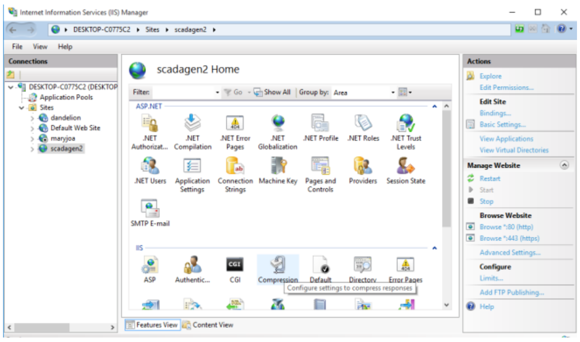

Figure 19. Internet Information Server (IIS)

In IIS, the thing that needs to be done is to add a new website address and point the physical path to the folder where the screen is saved, in the binding option the default setting is on port 80, then run the IIS service by clicking "Start". The connection test can be done in internet explorer by typing https://127.0.0.1/. If the web page has appeared, then the settings in IIS are correct, the web can be controlled via another computer if the server PC is connected to a network that has the same gateway.

One of the goals of the project that has been created is that it can be controlled by anyone and anywhere, so the thing that must be done is to host the project to the internet. In the discussion of the IIS configuration above, it has been explained that the web can be controlled by the client via a web browser, but is still in a local network or intranet, so the next step is to control it via the internet or the public by means of Nat forwarding. This forwarding will divert traffic that goes to the public IP installed on the router to the local IP of the SCADA server that has been created.

In this study, using an IP (Virtual Private Network) VPN because the rent of Public IP is relatively expensive [9]. VPN is a communication technology that allows you to connect to a public network and use it to join a local network [10]. VPN has several tunneling that can be used, including Point to Point Tunneling Protocol (PPTP) and Layer Two Tunneling Protocol [11]. The hosting used is id.tunnel.my.id with the

VPN IP address of 192.168.195.130 which is shown in Figure 20. In this study, the Local IP setting is 10.10.10.242.

```
Tipe VPN        : VPN Remote

Username        : Andri
Password        : Andri123
Status          : active
Last Login      : 03 May 2020
Last IP         : 116.206.29.123 / Three Indonesia

Server          : id.tunnel.my.id
Port            : 21 / 1000
Config          : http://id.tunnel.my.id/id-1000.conf
IP VPN          : 192.168.195.130
CNAME           : Andri.id.tunnel.my.id
Port 22         : id.tunnel.my.id:1130 <--> 192.168.195.130:22
Port 80         : id.tunnel.my.id:1430 <--> 192.168.195.130:80
Port 8291       : id.tunnel.my.id:1730 <--> 192.168.195.130:8291
```

Figure 20. Order IP VPN

3. RESULTS AND DISCUSSION

The intelligent tele monitoring system that is created must of course go through a testing stage in order to meet the monitoring system standards that can facilitate the performance that occurs at the tire factory. The testing stages are as follows.

3.1 HMI Client Display on Mobile Access Menu

Before displaying the HMI screen over view, first enter the username and password shown in Figure 21. Username and Password function as authority limits. The authority, but only certain users who can operate the control system on the water chiller. If you don't have authority, you can only see the system.

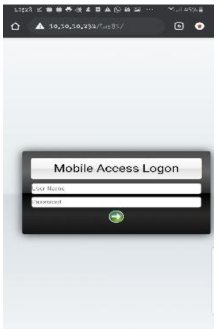

Figure 21. Mobile Access Logon on a Smart Phone

After successfully entering the username and password as shown in Figure 21, the next step is to enter the main menu which contains the alarm, screen, process values, and trend shown in Figure 22.

Figure 22. Main Menu Mobile Access

The menu screen is usually designed to display the main screen on a system that is designed to resemble the field designed using IWS in Figure 23. If the username and password do not have full access authority, they can only monitor it, in other words, they cannot operate the system.

Figure 23. Main Screen View

The alarm menu is used to notify the operator to anticipate before a problem occurs as shown in Figure 24.

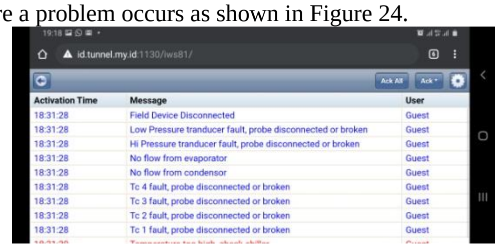

Figure 24. Alarm Menu

The process values menu functions for monitoring and operating the system, but the difference is that it only contains buttons and data views that have been created in Figure 25.

Figure 25. Process Values

The trend menu functions to monitor the status of temperature and pressure that occurs in graph form so that fluctuating conditions can be seen as shown in Figure 26.

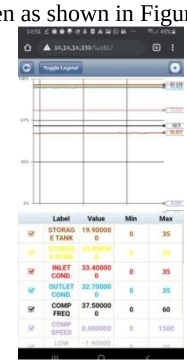

Figure 26. Trend

3.2 Measurement of Resistance Temperature Sensor RTD (Resistance Temperature Detector)

Before installing the sensor, it should be checked first in order to determine the condition of the sensor in a normal or up-normal state. In table 1 are the results of measuring the resistance of the PT100 sensor which will be installed on the input evaporator. Of the 7 test results obtained an average value of 99.94% accuracy. Table 2 is the result of measuring the resistance of the PT100 sensor which will be installed on the evaporator output. From 7 test results obtained an average value of 99.92% accuracy. In table 3 is the result of measuring the resistance of the PT100 sensor which will be installed on the input condenser. From 7 test results obtained an average value of 99.92% accuracy. In table 4 is the result of measuring the resistance of the PT100 sensor which will be installed on the output condenser. Of the 7 test results obtained an average value of 99.91% accuracy. From the results of these measurements all sensors are in good condition.

Table 1 Measurement of PT100 sensor resistance at the Evaporator Input.

No	Temperature (˚C)	Actual Resistance(Ω)	Standard Resistance(Ω)	Accuracy
1	5	101,92	102	99,92%
2	15	105,77	105,92	99,86%
3	25	109,62	109,62	100,00%
4	37	114,24	114,32	99,93%
5	59	122,71	122,75	99,97%
6	81	131,18	131,30	99,91%
7	98	137,73	137,73	100,00%
Average accuracy				99,94%

Table 2 Measurement of PT100 sensor resistance at the Evaporator Output.

No	Temperature (˚C)	Actual Resistance(Ω)	Standard Resistance(Ω)	Accuracy
1	5	101,96	102	99,96%
2	15	105,81	105,92	99,90%
3	25	109,52	109,62	99,91%
4	37	114,32	114,32	100,00%
5	59	122,53	122,75	99,82%
6	81	131,21	131,30	99,93%
7	98	137,61	137,73	99,91%
Average accuracy				99,92%

Table 3 Measurement of PT100 sensor resistance at the Condenser Input.

No	Temperature (˚C)	Actual Resistance(Ω)	Standard Resistance(Ω)	Accuracy
1	5	101,83	102	99,83%
2	15	105,86	105,92	99,94%
3	25	109,55	109,62	99,94%
4	37	114,28	114,32	99,97%
5	59	122,64	122,75	99,91%
6	81	131,22	131,30	99,94%
7	98	137,62	137,73	99,92%
Average accuracy				99,92%

Table 4 Measurement of PT100 sensor resistance at the CondenserOutput.

No	Temperature (˚C)	Actual Resistance(Ω)	Standard Resistance(Ω)	Accuracy
1	5	101,81	102	99,81%
2	15	105,87	105,92	99,95%
3	25	109,50	109,62	99,89%
4	37	114,32	114,32	100,00%
5	59	122,45	122,75	99,76%
6	81	131,28	131,30	99,98%
7	98	137,70	137,73	99,98%
Average accuracy				99,91%

3.3 Testing the Accuracy of PT100 Temperature Sensor Readings On the temperature monitoring menu.

After all sensors are confirmed to be in good condition, then further testing is carried out on the accuracy of temperature readings on the monitoring menu that has been made. In table 5, the temperature reading accuracy test at the evaporator output is tested with an accuracy result of 99.77% from 9 times of testing. In table 6, the accuracy of temperature readings on the input evaporator is tested with an accuracy of 99.60 % from 9 times of testing. In table 7, the accuracy of temperature readings at the output condenser was tested with an accuracy of 99.02% from 9 times of testing. In table 8, the accuracy of temperature readings on the input condenser was tested with an accuracy of 99.35% from 9 times of testing.

Table 5 Testing the Accuracy of Temperature Readings at the Evaporator Output

No	Calibration Temperature (˚C)	Temperature Readout Evap. Out(˚C)	Accuracy
1	10,1	10,1	100,00%
2	15,3	15,2	99,35%
3	20,6	20,6	100,00%
4	24,7	24,6	99,60%
5	30,2	30,1	99,67%
6	35,8	35,8	100,00%
7	40,6	40,5	99,75%
8	45,1	45,2	99,78%
9	49,4	49,3	99,80%
Average accuracy			99,77%

Table 6 Testing the Accuracy of Temperature Readings at the Evaporator Input

No	Calibration Temperature (˚C)	Temperature Readout Evap. Input (˚C)	Accuracy
1	10,1	10,3	98,06%
2	15,3	15,3	100,00%
3	20,6	20,6	100,00%
4	24,7	24,6	99,60%
5	30,2	30,1	99,67%
6	35,8	35,8	100,00%
7	40,6	40,3	99,26%
8	45,1	45,1	100,00%
9	49,4	49,3	99,80%
Average accuracy			99,60%

Table 7 Testing the Accuracy of Temperature Readings at the Condenser Output

No	Calibration Temperature (˚C)	Temperature Reading Condenser Out (˚C)	Accuracy
1	10,1	10,2	99,02%
2	15,3	15,6	98,08%
3	20,6	20,8	99,04%
4	24,7	25,1	98,41%
5	30,2	30,6	99,69%
6	35,8	35,8	100,00%
7	40,6	41,0	99,02%
8	45,1	45,3	99,56%
9	49,4	49,7	99,40%
Average accuracy			99,02%

Table 8 Testing the Accuracy of Temperature Readings at the Condenser Input

No	Calibration Temperature (˚C)	Condenser Reading Temperature. Input (˚C)	Accuracy
1	10,1	10,0	99,01%
2	15,3	15,2	99,35%
3	20,6	20,5	99,51%
4	24,7	24,5	99,19%

5	30,2	30,0	99,34%
6	35,8	35,5	99,16%
7	40,6	40,2	99,01%
8	45,1	45,1	100,00%
9	49,4	49,2	99,60%
Average accuracy			99,35%

3.4 Database Testing

The data base functions to record all events that occur at the plant through the Microsoft Access connection as shown in Figure 27. In the data base, you can see the status and users who have logged in to the system for operating with the aim of knowing the user if something goes wrong.

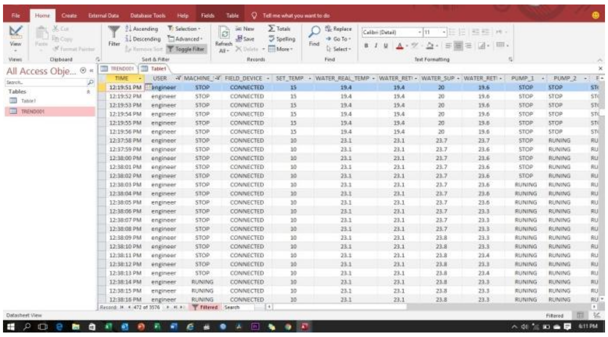

Figure 27. Database

4. CONCLUSION

This research has succeeded in building a tele monitoring and water chiller control system based on the internet of things. Based on testing on the SCADA system, the HMI Client display on the Mobile Access Menu via Smart Phone with the Mobile Access operating system log on, Main Menu Mobile Access, Main Screen View, Alarm Menu, Process Value, Trend runs smoothly in other words the system can be monitored remotely. Based on the resistance measurement on the RTD sensor on the evaporator and condenser, an average accuracy of 99.9% is obtained. Based on the PT100 Temperature Sensor Reading Accuracy Test, the temperature monitoring menu on the evaporator obtained an average accuracy of 99.65%, while in the condenser the average accuracy was 99.2%. With high accuracy, the data that appears during monitoring have been tested for validity. In addition to the tire industry, in the future it is hoped that a monitoring system will also be developed in the fisheries and agricultural sectors.

5. ACKNOWLEDGMENTS

Thank you to the research supervisor and the Electrical Engineering Masters Program at Gunadarma University for all the support provided.

6. REFERENCES

[1] R.Keerthika dan Jagadeeswari, Coal Conveyor Belt Fault Detection and Control in Thermal power plant using PLC and SCADA, dalam*International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 4 Issue 4, April 2015.*

[2] Chen, Chin-Tsung, dkk, A Case Study of Underground Bus Chiller SCADA System and The Development of Custom Design Systems, dalam*11th Conference on Industrial Electronics and Applications (ICIEA),* 2016 IEEE.

[3] Kapadia, Harsh, dkk, Data Acquisition in Wind Power Plant using SCADA, dalam*International Conference on Intelligent Computing,Instrumentation and Control Technologies (ICICICT),* 2017 IEEE.

[4] Nguyen, Ba Thanh and Anh Vu Nguyen, IoT Application for Gas Leakages Monitoring, dalam*International Research Journal of Advanced Engineering and Science,* Volume 5, Issue 4.

[5] Hidayat, Nur Step by Step MenguasaiPemrograman PLC Mitsubishi Q Series (Mosfet Interlock Indonesia Publisher, 2019).

[6] Mitsubishi Electric. Programmable Logic Controllers User’s Manual (HadwareDesciption).

[7] AVEVA, Indusoft Web Studio, Technical References, 2019.

[8] Maccarana, Yamuna, dkk, Design of a HTML5 SCADA System, dalam*International Forum on Research and Technologies for Society and Industry Leveraging a better tomorrow (RTSI),* 2016 IEEE 2nd

[9] Supendar, Hendra Implementasi Remote Site Pada Virtual Private Network BerbasisMicrotik, dalam*Bina Insani ICT Journal,* Vol. 3, No.1, Juni 2016.

[10] Syariful Ikhwan dan Ahya Amalina. AnalisisJaringan VPN Menggunakan PPTP dan L2TP (Studi Kasus :DinhubkominfoKabupatenBanyumas). *JurnalInfotel*, Vol.9, No.3, Agustus 2017.

[11] Hari Antoni Musril. Desain Virtual Private Network (VPN) Berbasis Open Shortest Path First (OSPF). *Jurnal Nasional Informatika dan TeonologiJaringan*, Vol. 3, No.2, Maret 2019.