Digital Pressure Recorder

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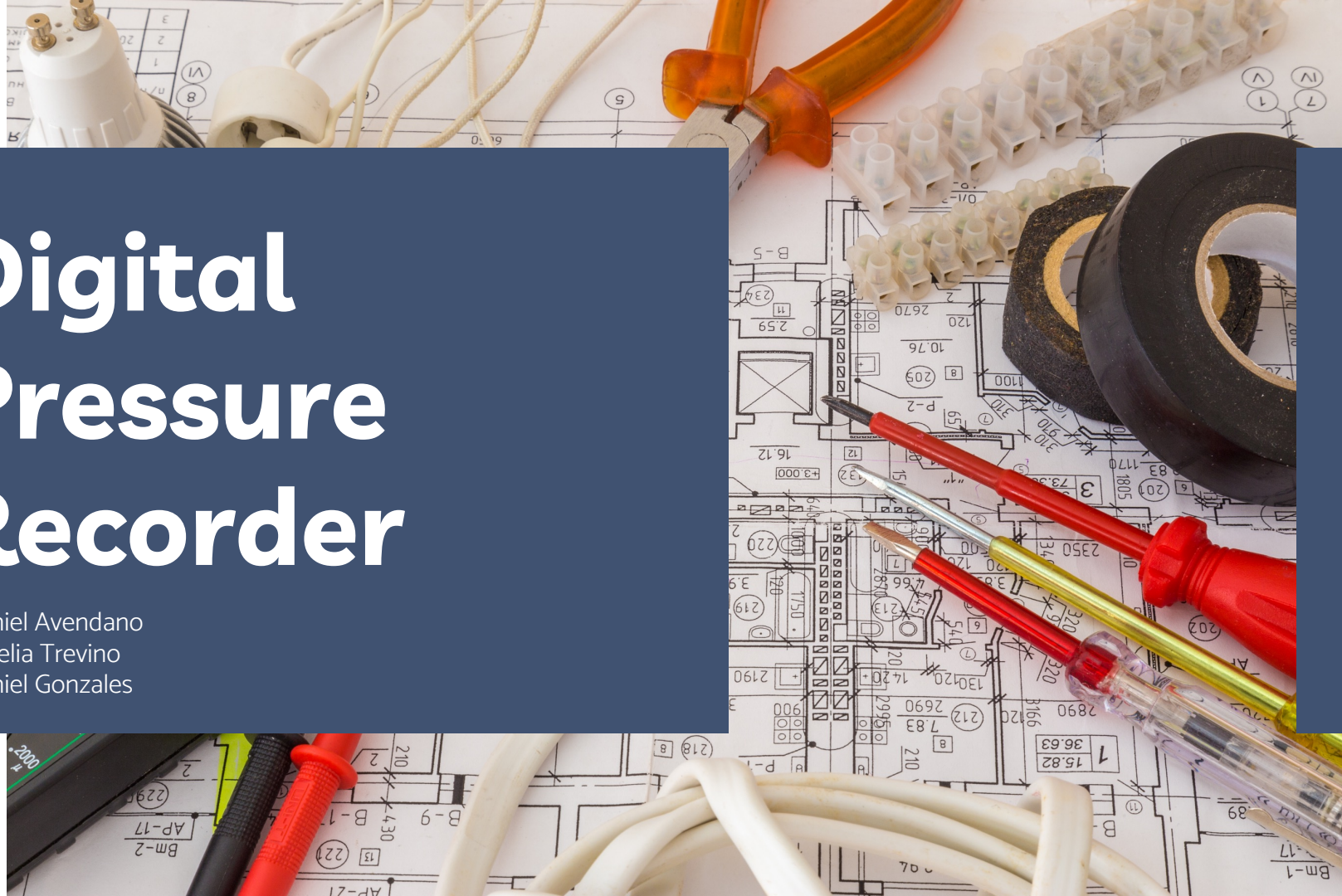


INTRODUCTION

Our team has developed a Digital Pressure Recorder that takes pressure readings from industrial hydraulic systems using a PLC and a transducer sensor. This device has internet capability, allowing it to upload data to an online database, where all information is stored. The primary objective of this project is to replace the outdated system of chart recorders, eliminate the possibility of data tampering, and enhance data storage of pressure data.

BACKGROUND: Paper Chart Recorders

Paper chart recorders are used by various machines to record data on paper with pen.
Example: Meyer is currently using paper chart recorders to read the pressure value of their accumulators.

Problems:

- Charts are susceptible to damage and loss
- Prone to errors
- Analyzing data from multiple paper
- Potential for data to be accessed and tampered with by unauthorized individuals
- Time consuming
- Difficult to analyze
- Lack of real-time monitoring

Digital Pressure Recorder Advantages

Advantages:

- **Accurate and precise** measurements 0.1-0.25% at LHR
- **Backup of data** in a form of a database or external storage
- Ease of Use (**simple interface**)
- **Real-time monitoring & data visualization** with the real time graph on the HMI screen
- **No data manipulation** as only authorized users have access to the data.
- **Portable**
- **Weatherproof**
- **Remote monitoring**

DESIGN

Considering all the requirements and constraints, this project follows a safe and well-organized logical system in order to follow proper safety principles. These principles are used in the overall design to make sure that the digital pressure recorder is designed with needed components. In addition, these diagrams show how the device will function with these principles in place. As an illustration, the next few slides will show how these principles are applied.

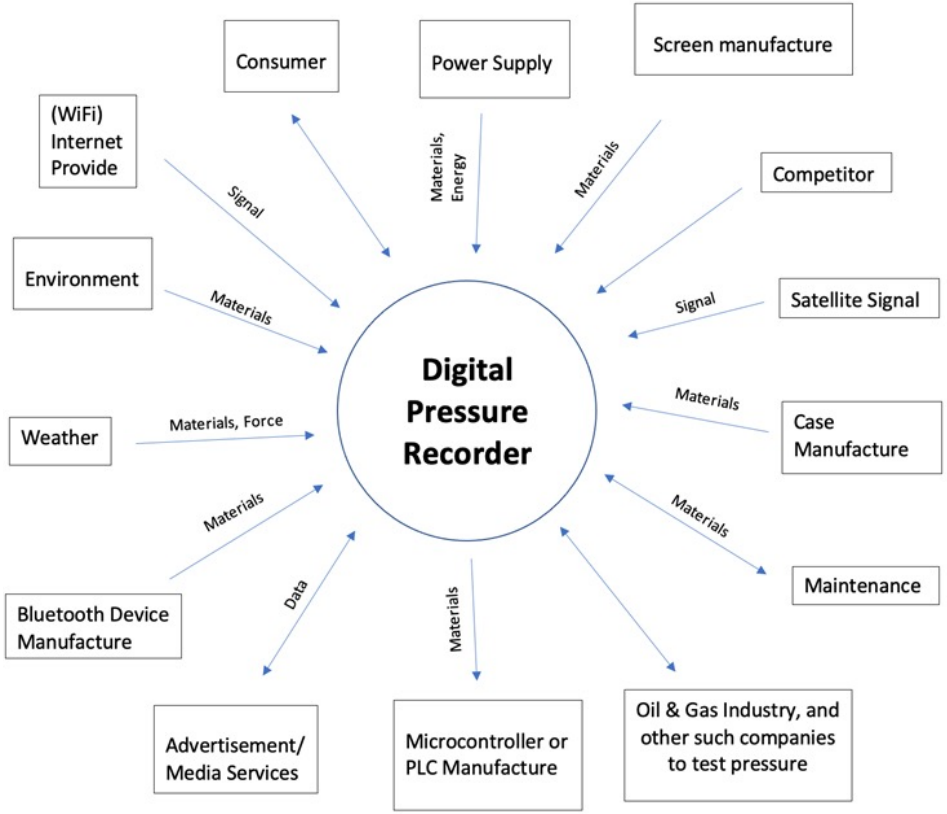
System Context Diagram	Functional Diagram	Block Diagram	System Design Requirements ,Constraints, and Specifications

SYSTEM CONTEXT DIAGRAM

This diagram presents different types of factors, benefiters, and contributors which affect the device in some way.

From the weather to the consumer each category has its effect on the digital pressure recorder.

For example, the oil/gas industry would benefit form our device by getting more accurate pressure readings.



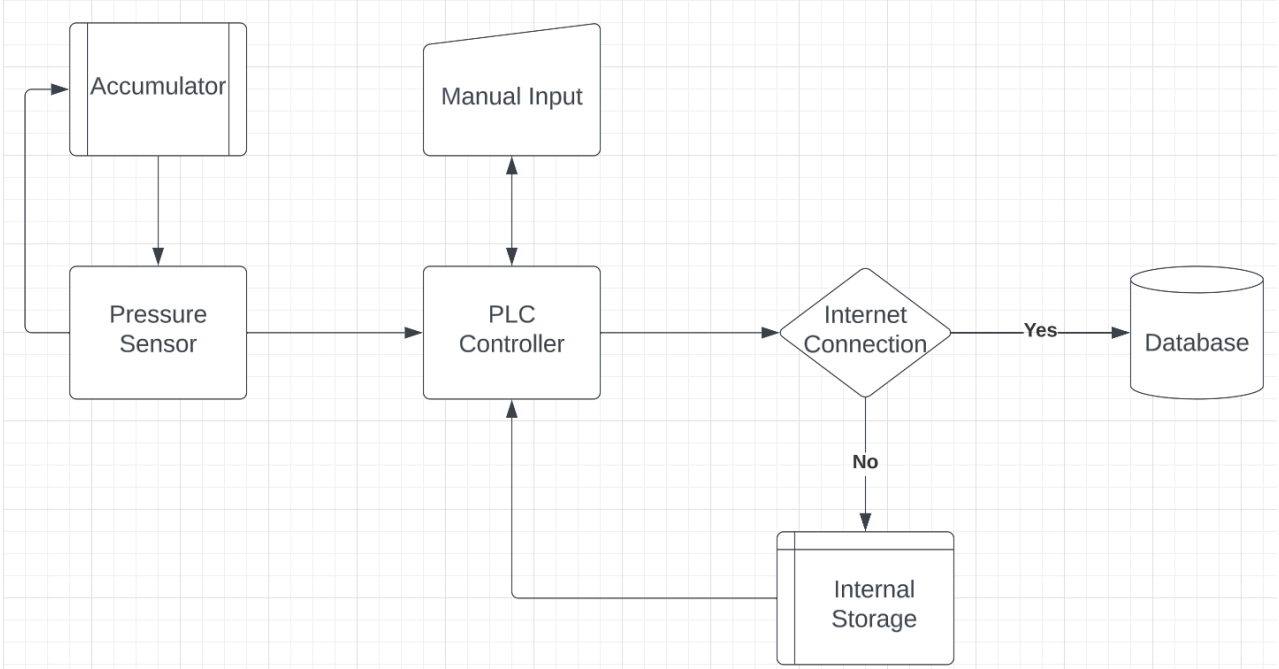
FUNCTIONAL DIAGRAM

This table shows the inputs that the device will take, the functions of those inputs, how those inputs transform into the output function, and finally the outputs that will be left with.

Functional Diagram: Digital Pressure Recorder				
Inputs	**Input Functions**	**Transform Functions**	**Output Functions**	**Outputs**
Sensor Readings	Takes pressure readings from machine	Transducer sensor to computer	Collects pressure data from machine	Collected pressure data
Test Pressure	Pressure test with inputted number	Test the inputted number on computer	Pass or failing test score	Completed tested pressure data
Internet Connection	If Internet, then Connects to cloud Database	Collects data and Uploads data to computer	Collected data is added in cloud database	Updated / Completed Database
No Internet Connection	If no internet, then there is no connection	Collects data and uploads data to computer	Collected Data Stored on Local Storage	Stored pressure data on device

BLOCK DIAGRAM

As a result, from the previous slides that state the principles and functions. This block diagram is focused on the **flow of information and how our system works as a whole**.



Constraints & Standards

These tables outline the constraints and industry standards, that were considered when designing the device.

Practical and Realistic Quantitative and Qualitative Constraints	
Quantitative Constraints	**Qualitative Constrains**
+/-1.5% accuracy on the systems data	Durability of case and components
Operates for minimum of 1 hours	Rugged design
No bigger than 22 in x 16 in x 8 in	Portable design
Operates over a range of 0 C to 60 C	Visually appealing / user friendly design

Applicable Standards	
Standard Code	**Standard**
Article 725 of the NEC	Methods for wiring, cables, grounding, protection, connected devices.
RTA IEC 61131-3	Syntax, semantics, and defines PLC programming language environment
OSHA 1910.305	Wiring methods, components, and equipment for general use.
OSHA 1910.269	Electric power generation, transmission, and distribution

NEC: National Electrical Code

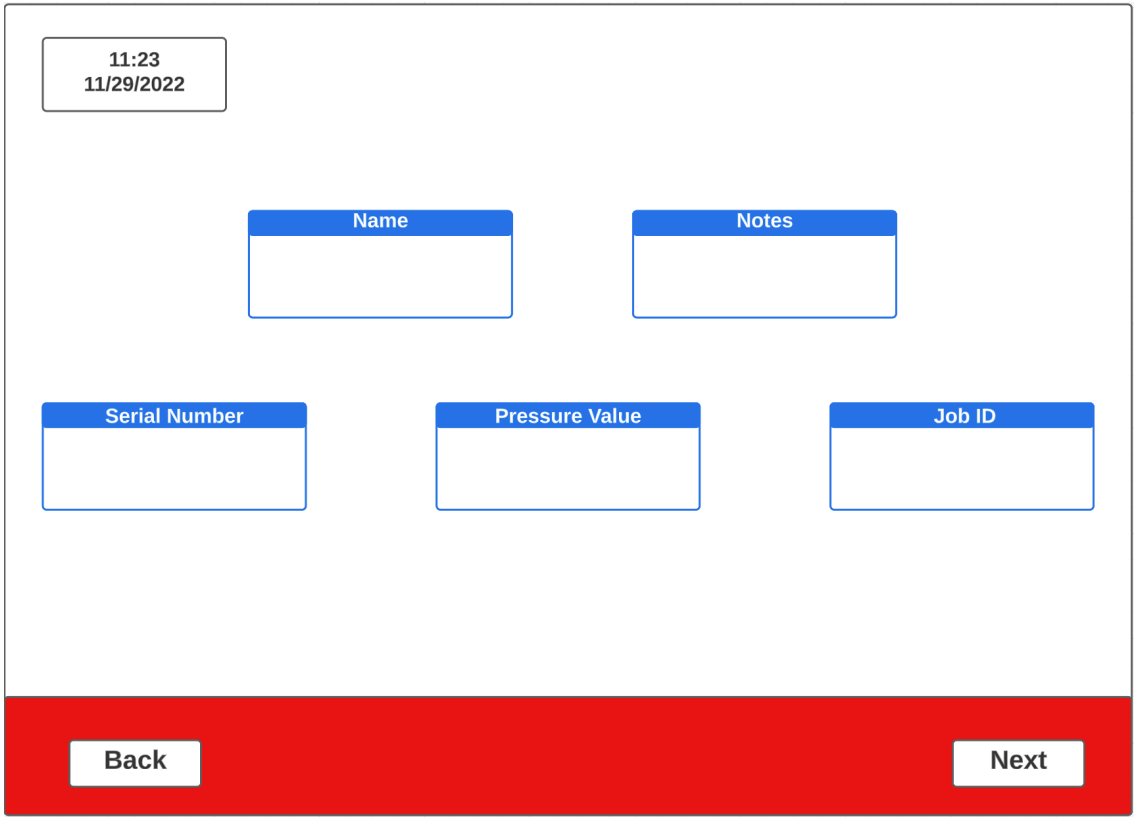
RTA: Real Time Automation

Interface Design

Final design concept of the HMI screen interface.

Built in Features:

- Time and Date
- Input Boxes
- Display Boxes
- Next/Back Buttons



IMPLEMENTATION

HARDWARE

The digital chart recorder consist of hardware that is specifically designed to work in a shop/outdoor environment.

Weather-Proof Case

Seahorse Weather-Proof Case

Programmable Logic Controller (PLC)

Click Plus PLC

I/O Modules

Click I/O Modules

POWER SOURCE HARDWARE

The digital chart recorder consist of hardware that is specifically designed to work in a shop/outdoor environment.

120V Power Inlet

Marinco 120V Power Inlet

20A Circuit Breaker

Siemens 20A Circuit Breaker

24V Power Supply

Click AC-DC Power Supply

COMMUNICATION HARDWARE

The digital chart recorder consist of hardware that is specifically designed to work in a shop/outdoor environment.

CAT5 Ethernet Port

CAT5 Ethernet Port

Stride Ethernet Hub

Stride Ethernet Hub

HMI Touch Panel

HMI C-More Touch Panel

TESTING & SIMULATING HARDWARE

The digital chart recorder consist of hardware that is specifically designed to work in a shop/outdoor environment.

Pressure Transducer

Barksdale Pressure Transducer

Voltage & Current Signal Generator

Voltage & Current Signal Generator

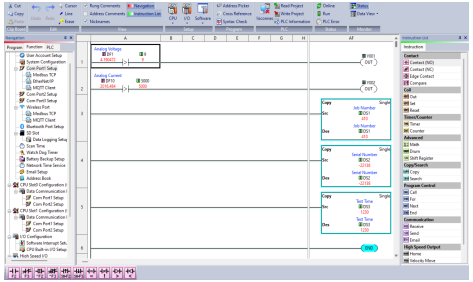
FINAL PRODUCT

The final design of the digital pressure recorder consists of a case that houses all the components. The inside of the case includes the PLC and wiring, while the top of the case houses the HMI screen and simulator.

TESTING SOFTWARES

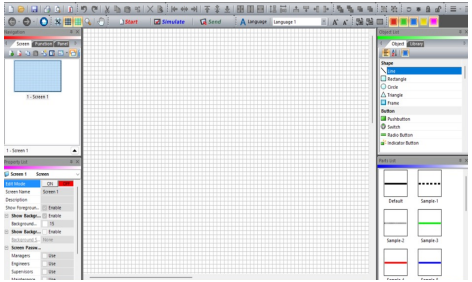
The digital chart recorder comprises software that enables the device to have data logging capabilities to a database.

Click Programming



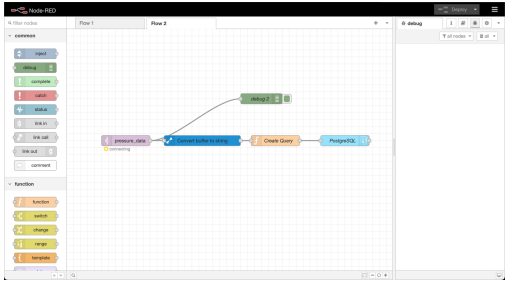
Click Plus PLC programming software

C-more Programming



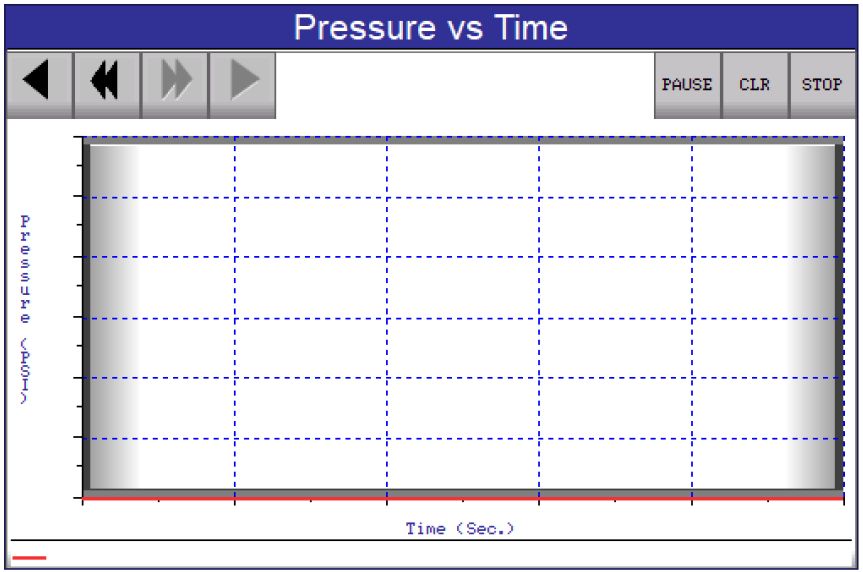
HMI screen programming & designing software

Node-RED



A programming tool used as a data bridge for hardware devices

C-More Programming Software



DPR

07:43 PM
04/27/23

Current Generator
(6k Transducer)

Test Pressure

0.00

Previous

Next

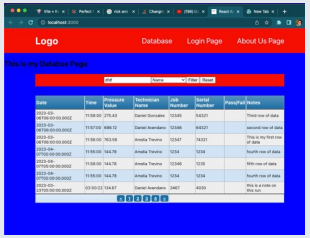
IMPLEMENTING DATA LOGGING PROCESS

Click Plus PLC with MQTT to send and receive data

A MQTT Message Broker

A programming tool used as a data bridge for hardware devices, APIs, and online services

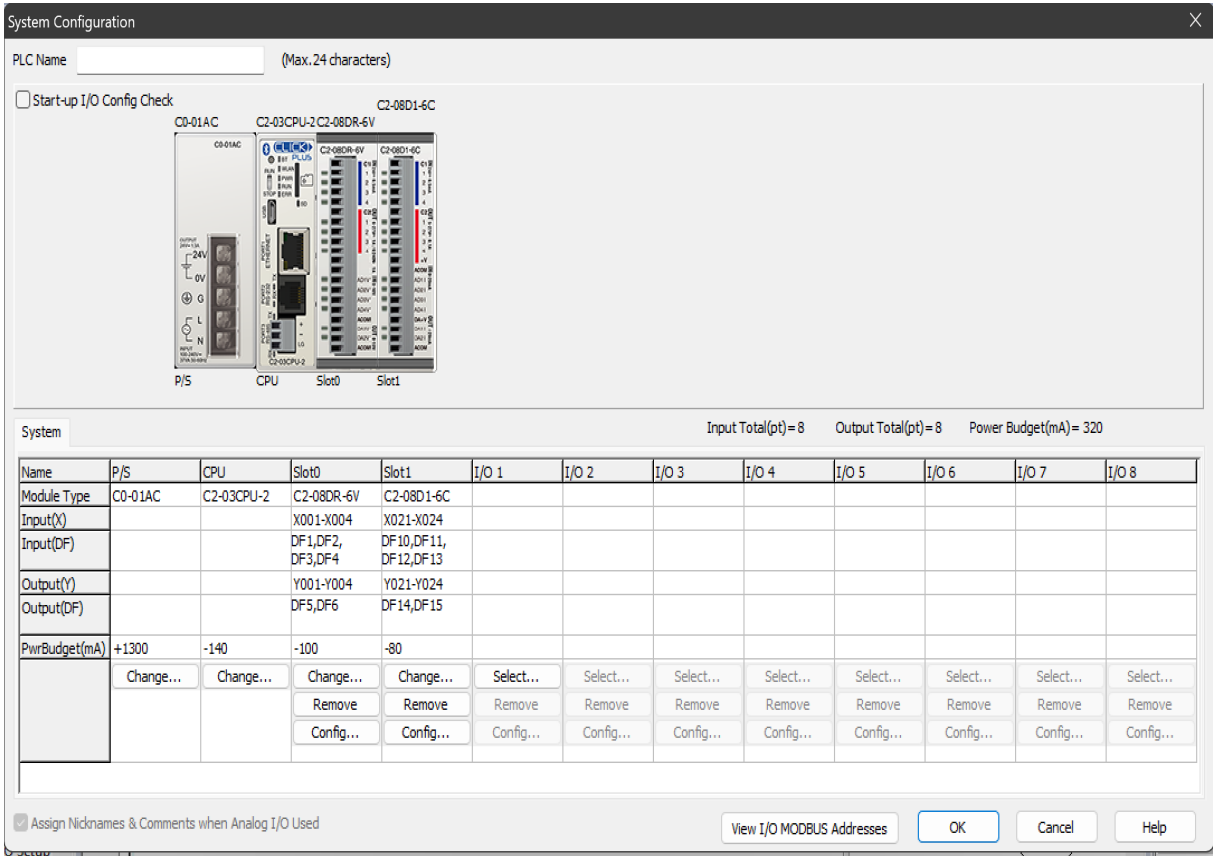
Amazon Cloud Database with PostgreSQL



Website to display all collected data

Click Programming Software

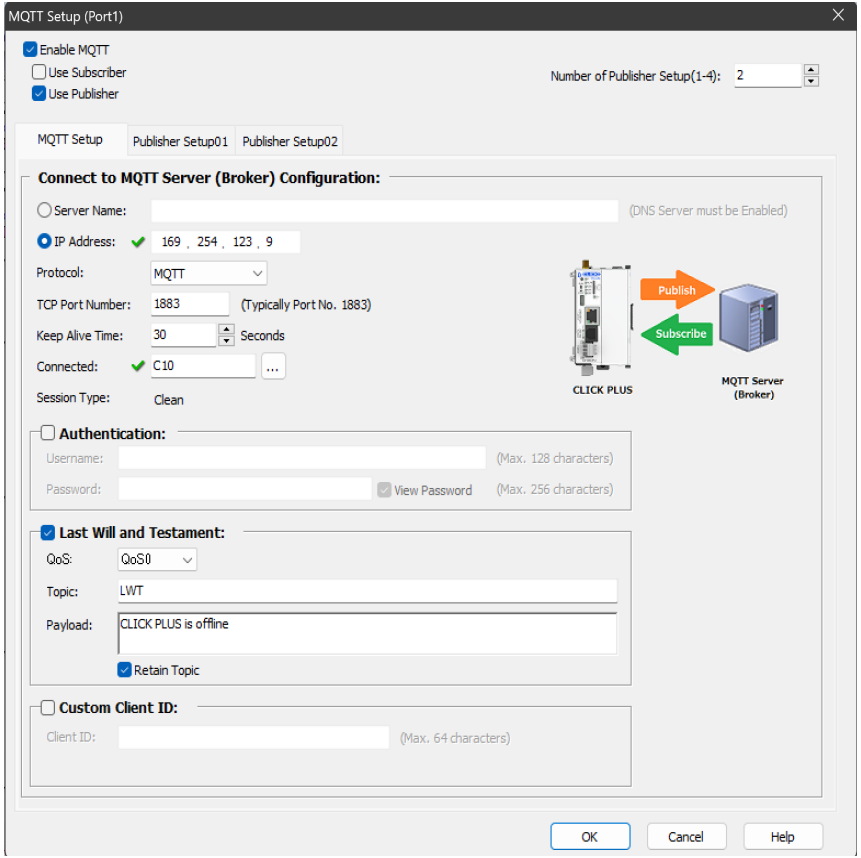
System Configuration



Setting up and configuring the Click Plus PLC

Click Programming Software

MQTT Configuration

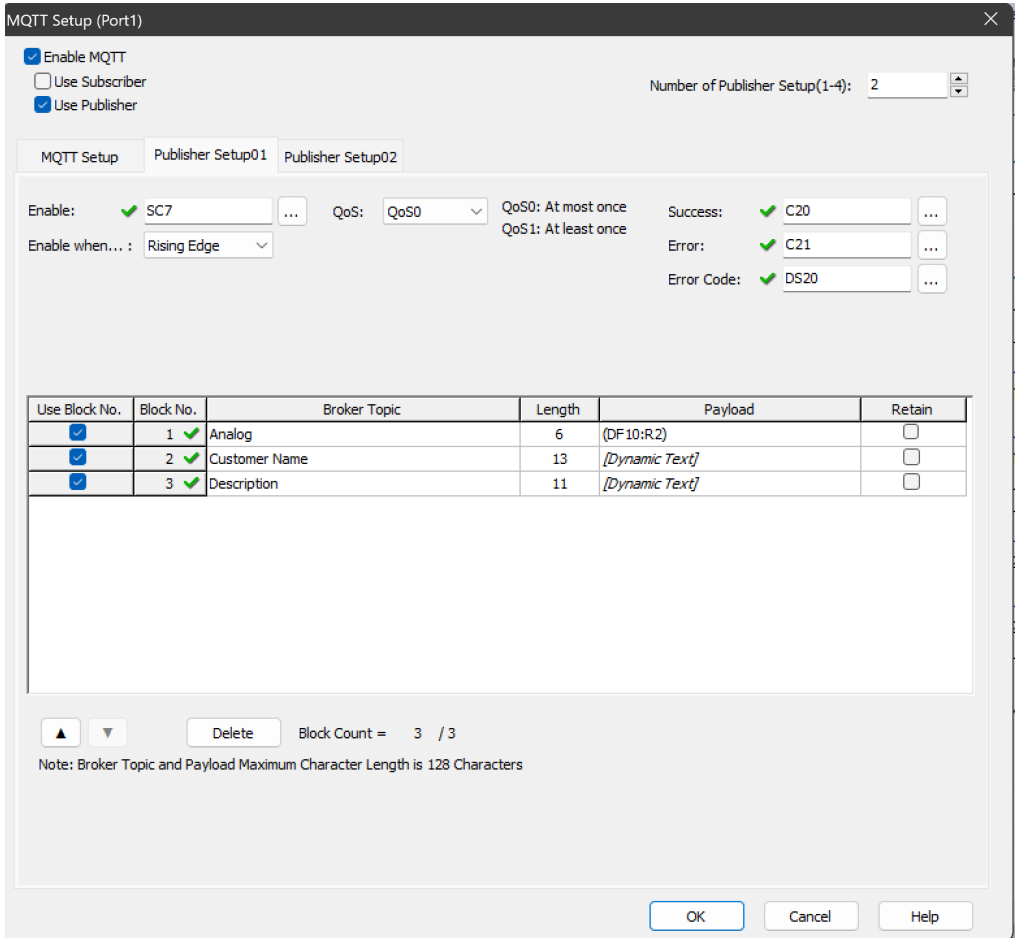


Setting up MQTT on PLC to allow communication

Click Programming Software

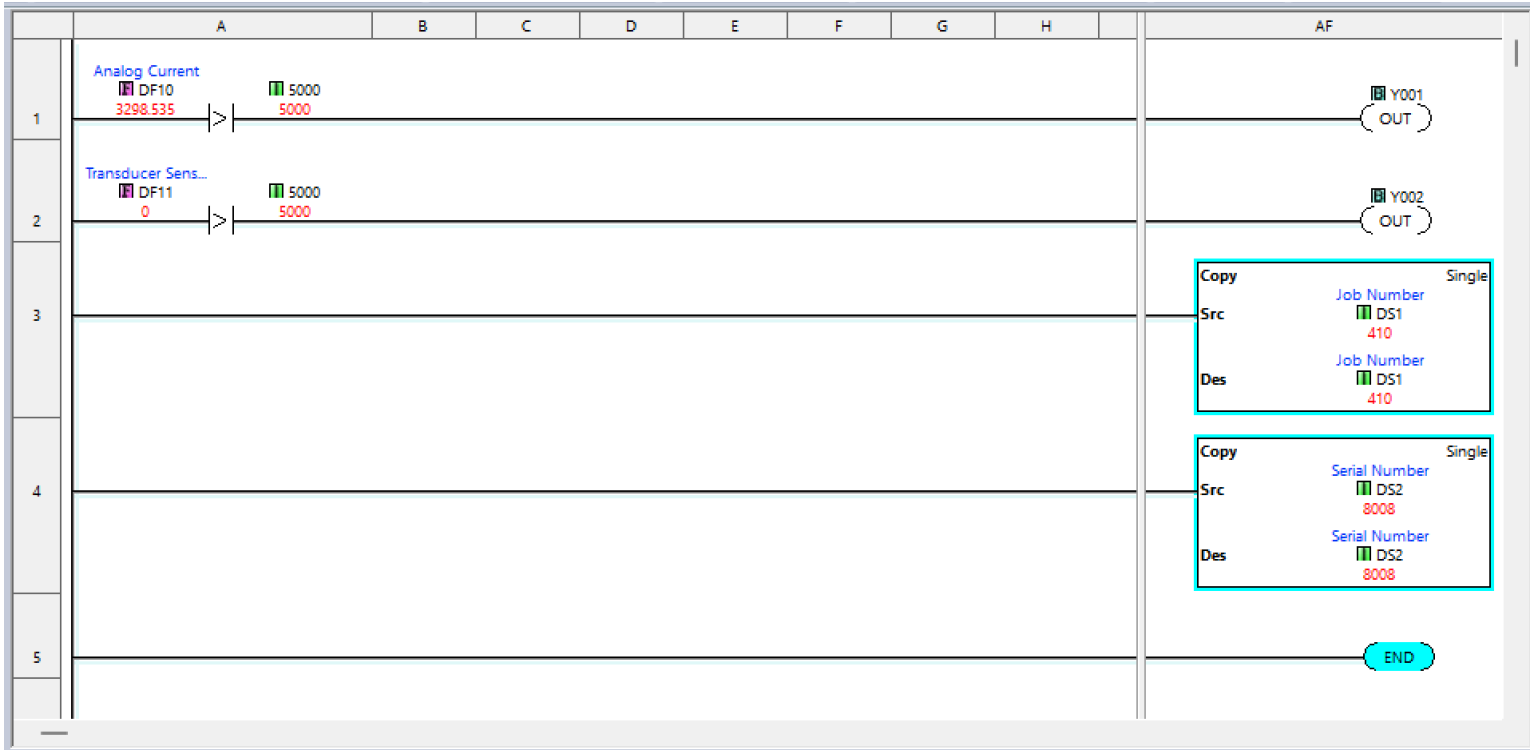
MQTT - Publisher Configuration

SC7 = 1 sec clock



Setting up publisher to allow PLC to send data

Click Programming Software

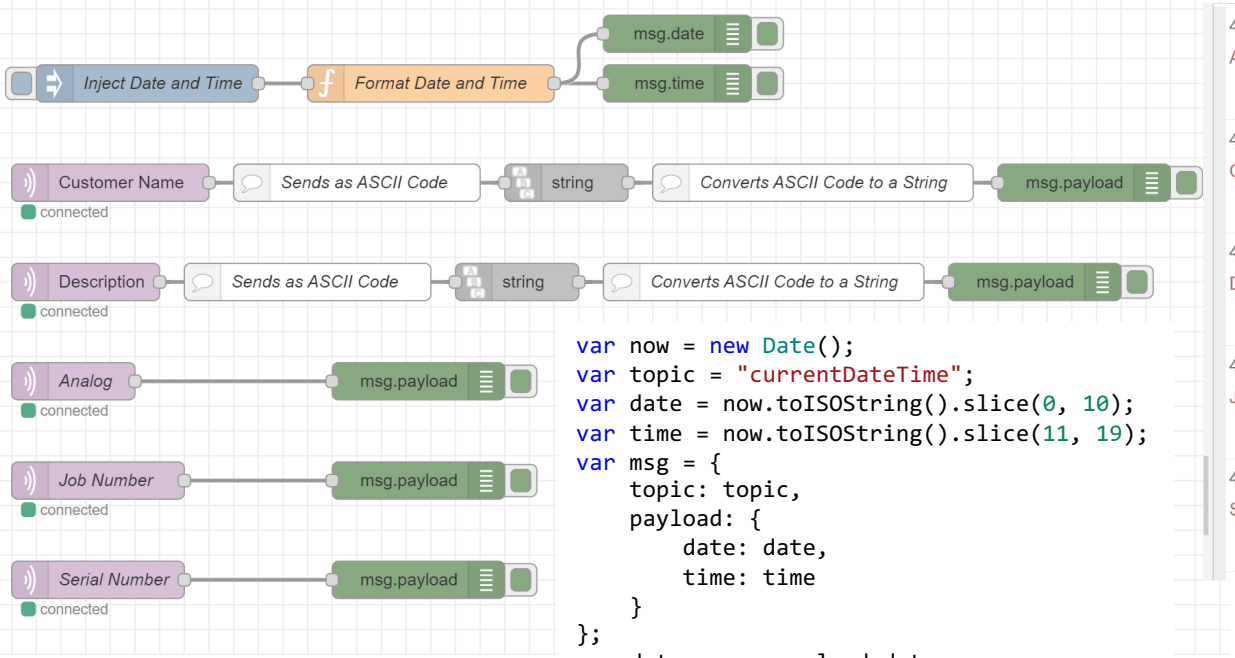


Ladder Logic

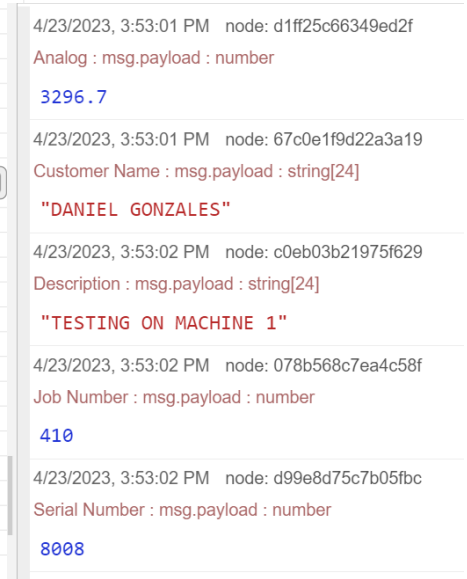
Ladder logic is used to receive analog current/voltage signals and other variables from an HMI screen, and to transmit them to Node-RED for further processing.

RESULTS

Node-RED Results



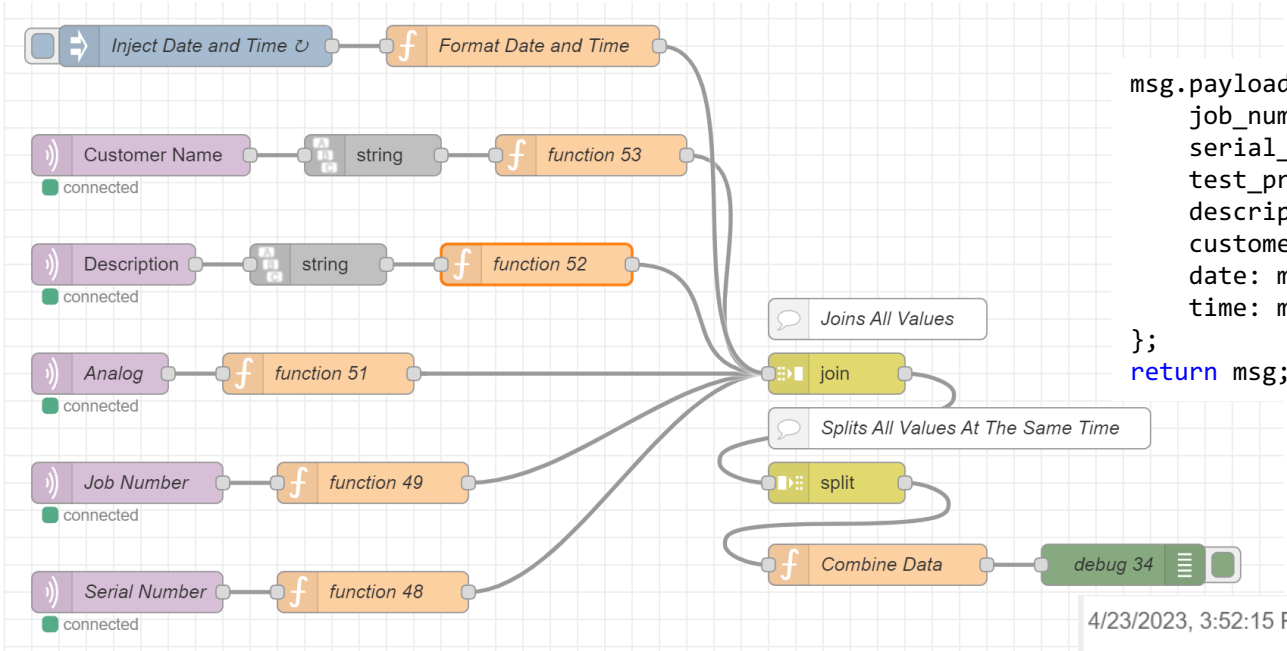

```
var now = new Date();
var topic = "currentDateTime";
var date = now.toISOString().slice(0, 10);
var time = now.toISOString().slice(11, 19);
var msg = {
    topic: topic,
    payload: {
        date: date,
        time: time
    }
};
msg.date = msg.payload.date;
msg.time = msg.payload.time;
msg.topic = topic;
return msg;
```



Node-RED flow to receive MQTT values from the PLC. In order to receive values, we had to set up, configure, and turn on the mosquitto broker.

Debug nodes allow us to see the output of each node. We can see that with each output we are receiving the data from PLC.

Values are Received




```
msg.payload = {
    job_number: msg.jobnumber,
    serial_number: msg.serialnumber,
    test_pressure: msg.analog,
    description: msg.description,
    customer_name: msg.customername,
    date: msg.date,
    time: msg.time
};
return msg;
```

This Node-RED flow stores all values as an object called msg.payload. This is necessary so the database receives all data in a single row.

4/23/2023, 3:52:15 PM node: debug 34

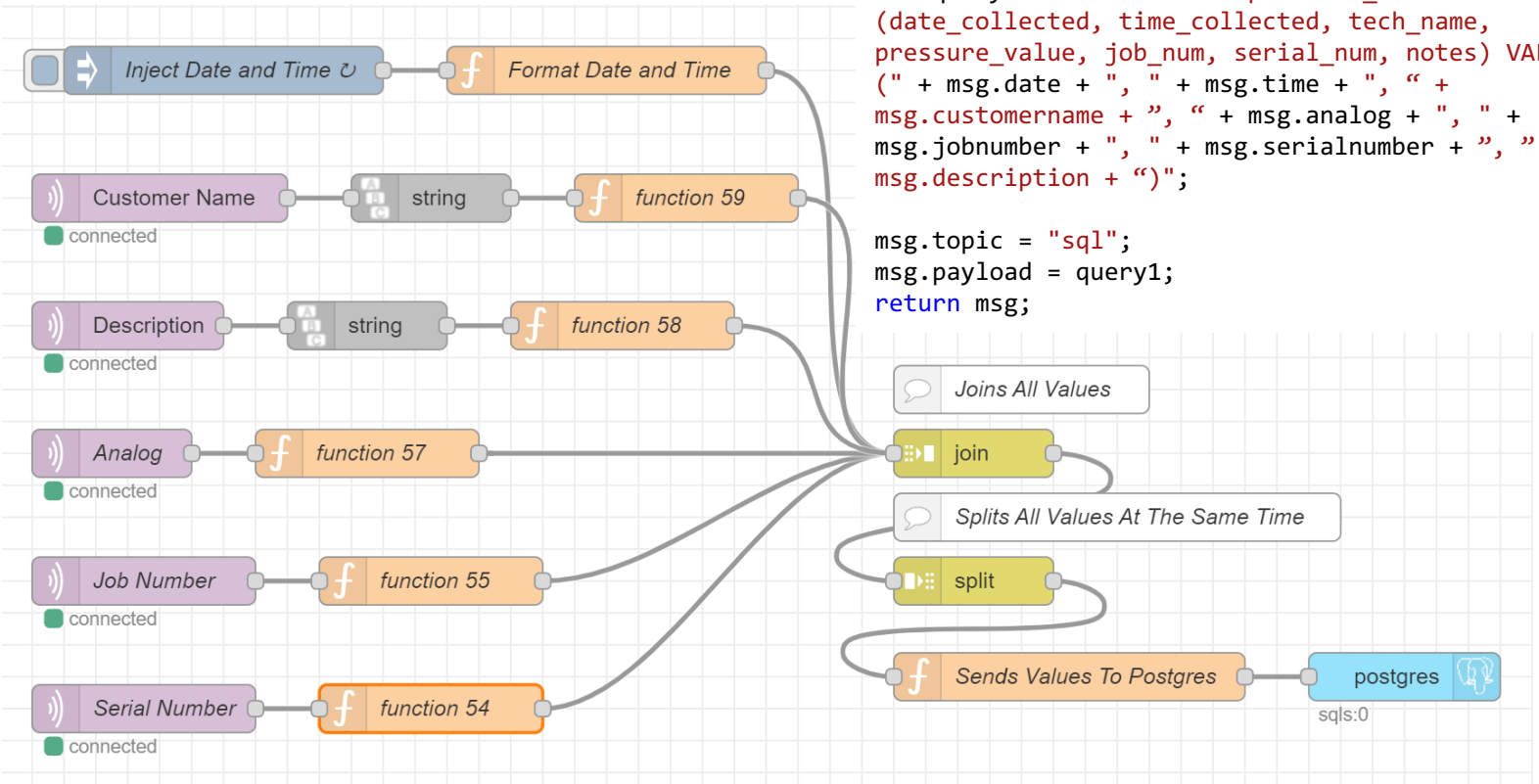
currentDateTime : msg.payload : Object

```
▾ object
   job_number: 410
   serial_number: 8008
   test_pressure: 3293.04
   description: "TESTING ON MACHINE 1"
   customer_name: "DANIEL GONZALES"
   date: "2023-04-23"
   time: "20:52:14"
```

Node-RED Results

Values Are Sorted

Node-RED Results

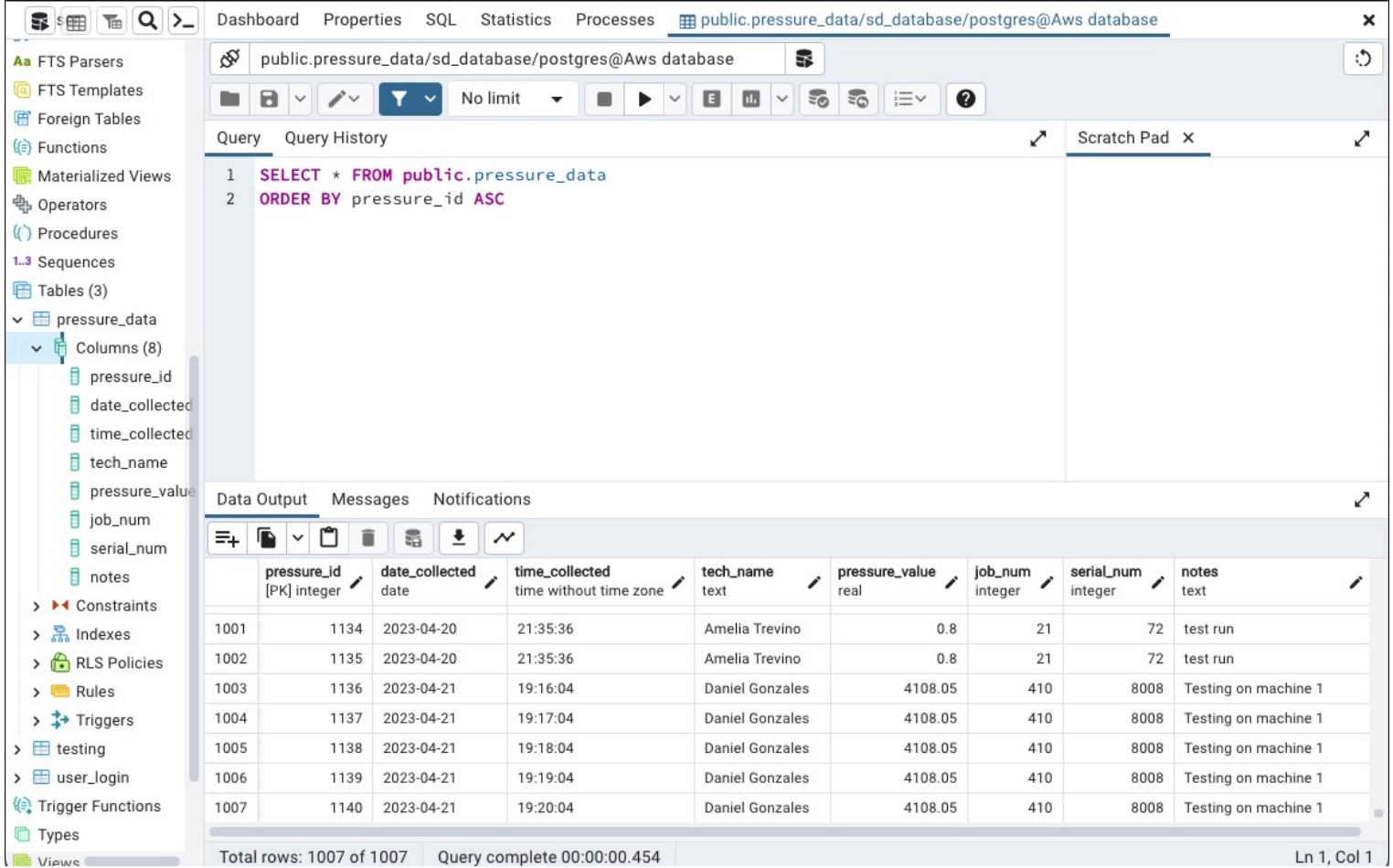



```
var query1 = "INSERT INTO pressure_data
(date_collected, time_collected, tech_name,
pressure_value, job_num, serial_num, notes) VALUES
(" + msg.date + ", " + msg.time + ", “ +
msg.customername + ”, “ + msg.analog + ", " +
msg.jobnumber + ", " + msg.serialnumber + ”, ” +
msg.description + “)";

msg.topic = "sql";
msg.payload = query1;
return msg;
```

Final Flow

This Node-RED flow sends all data to the PostgreSQL database. Join and split node are used to create an array of data. The code sends all data to our linked database.



Postgres & PgAdmin

Updated table

The database is updated with new data. The data was correctly sent into a single row.

DPR

Database About Us Log Out

Technician Name | Pressure Value | Date Collected | Job Number | Serial Number

Filter Reset

Date	Time	Pressure Value	Technician Name	Job Number	Serial Number	Notes
03-06-2023	11:58:00 AM	275.43 PSI	Daniel Gonzales	12345	54321	Third row of data
03-06-2023	11:57:00 AM	698.12 PSI	Daniel Avendano	12346	64321	second row of data
03-06-2023	11:56:00 AM	763.56 PSI	Amelia Trevino	12347	74321	This is my first row of data
04-07-2023	11:55:00 AM	144.78 PSI	Amelia Trevino	1234	1234	fourth row of data
04-07-2023	11:58:00 AM	144.78 PSI	Amelia Trevino	12346	1235	fifth row of data
04-07-2023	11:55:00 AM	144.78 PSI	Amelia Trevino	1234	1234	fourth row of data
03-23-2023	3:50:22 AM	134.67 PSI	Daniel Avendano	3467	4030	this is a note on this run
04-26-2023	10:11:38 PM	4842.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:38 PM	4842.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:38 PM	4842.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:38 PM	4842.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:38 PM	4842.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:38 PM	4842.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:48 PM	5611.72 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:48 PM	5611.72 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:48 PM	5611.72 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:48 PM	5611.72 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:48 PM	5611.72 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:11:48 PM	5611.72 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:15:19 PM	5342.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:15:19 PM	5342.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:15:19 PM	5342.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:15:19 PM	5342.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:15:19 PM	5342.49 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1
04-26-2023	10:18:45 PM	5983.51 PSI	DANIEL GONZALES	14	1738	TESTING ON MACHINE 1

The DPR Website is fully updated will all new and incoming data.

DPR Website

Updated table on website

Conclusion

Our team has successfully developed a Digital Pressure Recorder that provides an efficient and reliable solution for monitoring pressure readings in industrial hydraulic systems. By incorporating a PLC and transducer sensor technology, our device is able to accurately measure and transmit data to an online database, providing secure and tamper-proof data storage. With the ability to replace the outdated system of chart recorders, our project delivers an innovative solution to enhance data storage and improve efficiency in industrial settings.

ACKNOWLEDGMENT

We would like to extend our sincere gratitude and appreciation to Meyer for funding and supporting this project. Their contribution has enabled us to achieve our goals and develop a valuable product. We would also like to give a special acknowledgment to Noel McKim, lead engineering manager at Meyer, for providing us with valuable insights and guidance throughout the project. His expertise and support have been invaluable in bringing this project to fruition.

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THANK YOU!

Does anyone have any questions?