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WATER TANK CONTROL AND MONITORING SYSTEM BASED ON NODEMCU AND NODERED[8]

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Abstract: *Liquid level measurement in today's industrial environment encompasses a wide variety of needs and applications. To meet this wide array of needs the process controls industry has developed a planty of sensors and devices to handle this demand. Water measurement is a very critical and widely measured variable for most automation engineers due to guarantee safty of people in the industry and safe as much as possible electrical power. Many processes in the industries must have either a monitored or a controlled liquid level. In this paper a water level control and monitoring solution is used, based on the microcontroller 'Nodemcu ESP8266' (it has its own wifi module) and the NodeRed platform.*

Keywords: *water level control, Nodemcu ESP8266, PID Control, NodeRed*

INTRODUCTION

We are living in a modern world where we want to know, see and control every process within our environment. This is made possible by the large technological progress and the integration of complex systems for automated control and the application of Internet technoloies.

Nowadays, a large number of automatic systems are based on monitoring over the Internet. (Barber, R., De La Horra, M., & Crespo, J., (2013)). The new technoloies like IoT are arising on the horizon. The next step in this process is mass deployment of IoT (Internet of Things) in the industry systems. In the last years all major industrial companies (https://new.siemens.com/global/en.html) are implementing IoT techologies in there products and this led to the appearance of IIoT (Industrial Internet of thinks). The main difference between the two is that, the IIoT (Industrial internet of things) refers to the use of IoT concepts in industrial productio. IoT come from the world of SN (sensor networks) where all hardware components are connected through some communication medium. When the SoC (system on chip) was enriched with a wireless functionality, these modules now have the ability to communicate wirelessly - WSN (wireless sensor networks). The main drives of IoT are wireless sensors connected together.

In the industrial environment there are a huge nimber of process variables that can be controled. The level control is one of the main process controled in the modern factories. When there is a need

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of a material balance the "level" comes on stage. In level-control systems, fluid flow rates are controlled by varying the degree of opening of a gate-type valve or controlling the speed of a pump. The brain of the automation system is as usual an industrial controller [Siemens – SIMANTIC Controllers] who implements a control algorithm. There are many control algorithms out there, but the most famous in the industry ground is PID algorithm. 98% of implemented algorithms in the industry are PID. In the conteporary industry there are specialised monitoring programs implemented by the controller manufacturers that are called "Operator Stations", which are the "eyes" of the modern system. Operator statitions and industrial controllers are an expensive investment in some small projects. This brings us to the idea of using some cheaper components and platforms to implement the same goal.

Thanks to some platforms like NodeMcu [8] and NodeRed [7] we can dive in the control problems. The new microcontrollers have the ability to give enough processing power for solving the control problem. This gives the possibility of simplifying complex systems in order to make them more accessible, in terms of price, and to be widespread in companies whose automation is an indispensable part of production. (Mohammed, Kadhim, Fuad and Jaber, 2014)

NodeMcu is used from some researchers for tank level control [4,5,6] as a base controller module or as a part of a communication pattern. NodeRed on the other hand is used for integration of the control system as well as for supervisory control and visualisation (SCADA) [7,9]

EXPOSITION

This article will be focused on automating water tank systems. The concept of supervisory control and data acquisition(SCADA) is used to create a real-time system that gathers data from edge level sensors and display it on remote dashboard in forms of graphs and other dashboard nodes. Supervisory control will be from the dashboard itself with the switch between automatic and manual controls. This article focuses on the design of a water level control system, gradually controlling a pump in order to reach a setpoint value. In the article the PID algorithm will be used to precisely control the level in the tank. The work involves the development of a control system schematic diagram, implementation and tuning of a PID control and monitoring of a wate tank level by supervisory dashboard.

Hardware components like a microcontroller NodeMCU ESP8266 fig.1 is used as a heart of the system. It is an open source based firmware for the ESP8266 and uses an on-module flash-based file system. NodeMCU uses C language for programming and is perfect tool for wireless based projects. The controller can be programmed with a standard Arduino IDE and can use all the libraries used by the platform. As a successor of Arduino platforms it has all there advantaes including the possibility of wireless connection. It makes it perfect tool in the world of IoT. Microcontroller also can be powered by a main supply or by battery. It has a good quality/price ratio compared to other wireless sensor network modules.

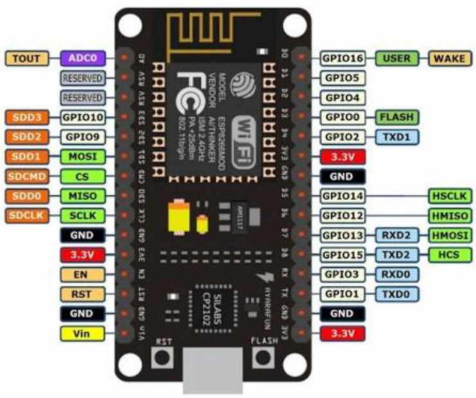


Fig.1 NodeMCU Wifi development module

The next part of the system is a monitoring module. A software component used for the purpose of integrating and monitoring the system is NodeRed fig2. platform. It is a programming tool for wiring together hardware devices, APIs and online services in an IoT world. It provides a browser-based editor that makes it easy to wire together flows using the wide range of nodes in the palette that can be deployed to its runtime. In our project NodeRed is an integrated unit connecting different modules of the system and implementing the supervisory control. NodeRed platform gives an ability of the engineer to structure the system communication and to visualize the control processes. When binder functions are programmed with Node-RED they are presented in the form of bricks. Thus the data stream passes from one treatment to the other (from one function to the other). It is easy to use flow-based programming environment that helps IoT developers interact with APIs and different services. As Node-RED includes node.js, it can be run at the edge of the network or in the cloud. Over a thousand flows and nodes exist in the Node-RED library today, which enable connections to all kinds of devices and services. A Node-RED flow works by passing messages between the nodes.

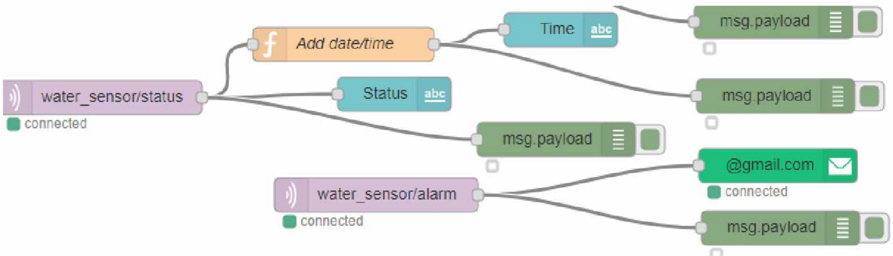


Fig.2 NodeRED platform

The easyest way NodeMcu to communicate with the NodeRed platform is through MQTT. The communication between NodeMcu and NodeRed platform is made through “mosquitto” MQTT server. The two platforms NodeRed and “mosquitto” are installed on the computer. In our study RasperryPi 3 computer is used and all software is hosted there. For wireless comunication a standard WiFi router is used.

The control of a tank level is implemented in the nodemcu code with a PID control alorithm. A standard arduino library “AutoPID” is used for the algorithm. The communication between NodeMcu and NodeRed is implemented with the help of MQTT. In the Arduino platform there is a MQTT client library called “PubSubClient” that is used for this kind of communication.

The shcematic diagram of the system is shown on fig.3

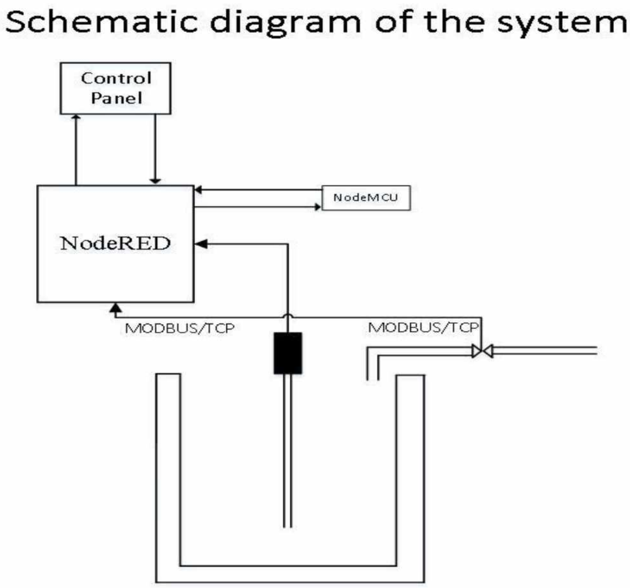


Fig.3 Schematic diagram of the system

The implemented control panel fig.4 gives the operator possibility to enter a parameter for the desired amount of liquid in a tank, to tune the parameters for the PID algorithm and to visualize the level by chart graph, as well as to enforce the system in Manual or Automatic mode. The software developed in the NodeRed platform is given on the fig.5

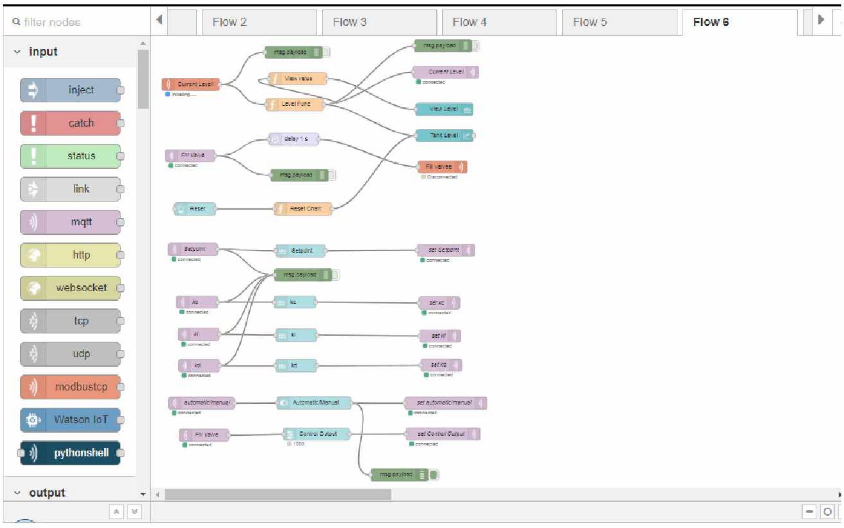


Fig.5. Node-RED deployment

The tank is a virtual object in a 3D platform FactoryIO [https://factoryio.com/]. The connection between the virtual object and the real controller (NodeMcu) is made through ModbudTCP and MQTT.

To control the tank, ‘virtual’ valve for input flow is actuated. There is another valve for the discharge flow. The measurement of the level is performed by ‘virtual’ inductive sensor. In the current project thank level is implemented as a self-regulated object fig.6

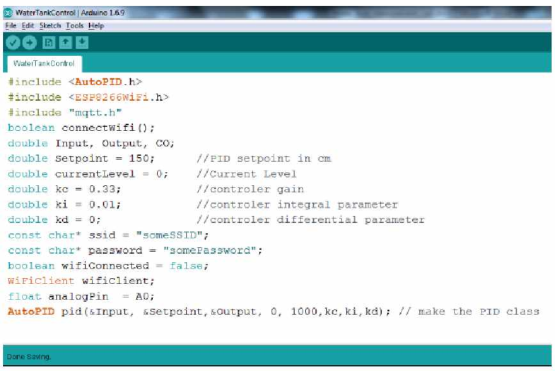
Fig.6 Virtual tank by FactoryIO

NodeRed platform is full of possible “palletes” which are like a libraryies in a softwre language and give the posibility to add many usefull functionalities. A module like this is “node-red-dashboard” a usefull tool for making graphical vizualizations and implementing HMI web-based pannels. For the project a web-based panel is implemented to control the functionality of the tank. The pannel is given on fig.7

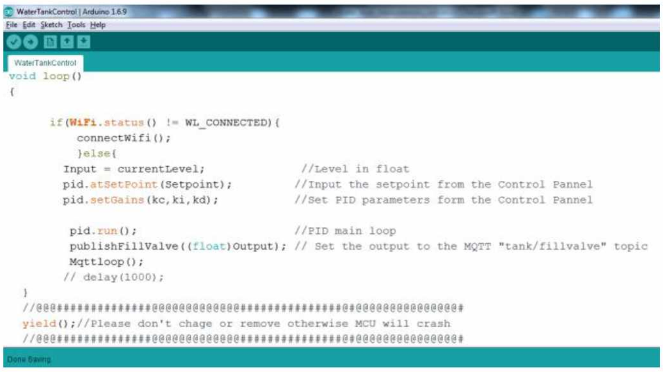
fig.7 Tank Level control Panel

The control panel gives the user to freely operate and adjust the tank to desired level of water. In order to do so it is necessary to enter an IP adress of the NodeRed platform into the web browser from either computer or smartphone. In this situation, we browse the following address: 127.0.0.1:1880 (standart Node-Red port). Precise control is realised via change of Proportionla, Integral or Diferential componets of PID algorithm given with kc, ki, kd and change of the level setpoint by the option „Setpoint“. There is an automatic and manual mode. Automatic mode works by using controler parameters. But in manual mode the process is controlled by the operator using the option “Controler output”, which initiate commands to the valve. To visualize the tank level there is a chart which displaiys the dynamic characteristic of water level. There is as well an option to clear the chart using “Clear chart” button.

The software to control the system is implementated with a standard Arduino IDE including the NodeMcu library. Short code snippets are given bellow on fig. 8 which include the library for PID control implementation and the MQTT library to communicate with the virtual object:



a)



b)

Fig.8 NodeMcu snippet for PID control

In order to implement the PID algorithm we add <AutoPID.h> library and to enable the wifi communication <ESP8266WiFi.h> is needed as shown on fig.8a. On fig.8b the algorithm to control the virtual obbject is shown. It includes the loops to implement the PID control and the MQTT comunication. The file <mqtt.h> enables MQTT connection and includes all the topics to connect to the virtual object and to the “Control Panel” fig.9.

a) b)

Fig.9 NodeMcu snippet for MQTT connection

On fig. 9a are shown MQTT topics and the parameters to connect to the MQTT server. On fig.9b is shown the MQTT callback function that gets topics from the "Control Panel" and takes them as variables to the NodeMcu PID algorithm.

CONCLUSION

The built-in system has the excellent ability to be integrated in a real environment. Stability and simplified construction make it usable for the industry and strong competitive among other systems of this kind. The opportunity for easy hardware and software support puts the project on one of the first options for successful level handling, both on site and remotely. The paper presents a type of system with a stability and easy realization. As an advantage it would be a preferable tool for tank level control and monitoring. The two platforms NodeMcu and NodeRed in a colaboration with each other are good applicants for a new generation of industrial control systems.

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