DEVELOPMENT OF SCADA SYSTEM FOR TEMPERATURE AND HUMIDITY CONTROL USING PLC AND ECLIPSE SOFTWARE FOR GUI IN VERTICAL FARMING

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Abstract- **This paper aims to develop and design a SCADA (Supervisory Control & Data Acquisition) System for Temperature and Humidity control using PLC (Programmable Logic Controller) and Eclipse SCADA Software for GUI (Graphical User Interface) in vertical farming. SCADA system integrates information coming from the analog humidity and temperature sensors present in vertical farm. Temperature and humidity are accurately controlled by using PLC. The valves in the intelligent air conditioner are controlled to allow it to operate in one of these four modes: Dehumidifier, Heater, Cooler, and Fan Blower. This developed control system implements a hierarchical cascade controller in which inner loops are performed by the local PLC and outer loop is managed by centralized SCADA System. Eclipse SCADA Software is used for GUI and is connected to personal computer using 485-modbus.**

Keywords:SCADA, PLC, Vertical Farming

1. INTRODUCTION

Since its inception in one of the classroom activities by Dr. Dickson Despommier in 1999, vertical farming has come a long way. Fruits and vegetables which are in demand can be grown all year around, with minimal use of chemicals. This organic approach to farming not only addresses the food security issue of the world but also the deforestation of the remaining untouched parts on this planet.

For production of any crop, relative humidity and temperature are two main factors. Relative humidity directly influences the water relations of plant and indirectly effects leaf growth, photosynthesis, pollination, occurrence of diseases and finally the plant growth.Air temperature is important to agriculture as it influences plant growth through photosynthesis and respiration, affects soil temperature and controls available water in the soil. In fact farmers use soil temperature and soil moisture to decide when to plant, what varieties of crops to choose. According to a study by Climate and Development Knowledge Network in 2012 on ‘Agriculture and Climate Change in India’, one degree Celsius increase in temperature may reduce yields of major food crops by 3-7%.When theindoor temperature is too high, natural or forced ventilation may beapplied if the outdoor temperature is lower than the indoor temperature of the vertical farm.The water vapor sprayer or the air cooler may be applied if theoutdoor temperature is higher than the indoor temperature.Heat conservation or heater may be appliedwhen the temperature inside is too low. Whenthe indoor humidity is too high, dehumidifier or natural moistureabsorbing mechanism may be utilized to remove moisture in the air. When the indoor humidity is too low, humidifier or water vapor sprayer may be used to regulate the indoor air humidity. In the original state, the vertical farms already have water sprayer and other facilities to roughly regulate temperatureand humidity according to the exterior factor.

This studyproposes the use of an intelligent air conditioner with heating, coolingand dehumidifying functions that is capable of regulating theindoor temperature and humidity based on the original condition.In a conventional air conditioning system, only one single sensoris often installed at the air inlet to detect the temperatureand humidity of the environment. However, due to the locationof the sensor, the effective sensor range is limited to the vicinityaround the air conditioning system.In order to obtain more accuratedata of the environment conditions of the vertical farm, thisstudy adopts a multi-points measuring structure to collect temperatureand humidity data around the farm. The data fromthe sensors are delivered by a communicationsystem toprovide more accurate data input to a more flexible intelligent control.

This study also uses humidity and temperature sensors to collect temperature and humidity data in the vertical farm uses EclipseSCADA software to design graphical user interface (GUI) for control, supervision and historic data browsing. In a conventional air conditioning system, only one single sensor is often installed at the air inlet to detect the temperature and humidity of the environment.

2. THE SCADA & PLC SYSTEM

The advantage of having a SCADA system to monitor the farm is that the human errors could be reduced. The system proposed in this paper is somewhat similar to the one used in an oil refinery in Egypt. [1] While the SCADA monitors thesystem, PLC is used for the internal storage of instructionsforimplementing functions such as logic, sequencing,timing, counting and arithmetic to control various types of machine processes through digital and analog input/ output modules.The system will collect information via RTU (Remote Terminal Unit) PLCs and IED (Intelligent Electronic Devices) and transfer it back to Master Station for analysis and control. The information will also be displayed on the operator's screen. In this paper, Eclipse SCADA software is used for GUI. FXIN-40MR PLC is used to communicate between input and output instruments. The interface between Eclipse SCADA Software and the PLC station is using 485 modbus.The HMI device baud rate is 9600 and the network profile is Point to Point Interface (PPI) [2].

The speed of MPI/DP connection in main control loop is 185kbps due to which it is preferred over Ethernet where connection speed is 10/100 kbps. This helps to increase the transfer data speed between the system components and the SCADA System.

3. SUPERVISORY CONTROL STRATEGY

There are two levels of control in the proposed system – Interactive level and Operational level as shown in figure 1.The operational-level controller which is commonly known as a hierarchical cascade controller integratesa first control loop (inner loop) managed by local PLCs anda second control loop (outer loop) controlled by a SCADA system [3].The interactive level communicateswith the SCADA system and shows the result and analysis in GUI. The main feature of the SCADA system is the ability to communicate with various sensors

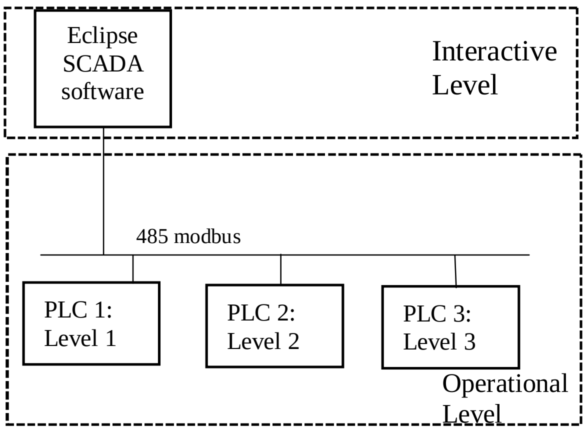


Fig. 1: Supervisory Control Architecture

and IEDs through the implemented network. As the PLCs are monitored anddata are recorded, the SCADA application responds according tosystem logic requirements or operator requests [3].

4. HARDWARE DESIGN & INSTALLATION SCHEME

4.1 Air Conditioner

The air conditioner consists of one indoor unit and one outdoorunit. There are four major components in the indoor unit: compressor, condenser, expansion device, and evaporator [4]. The tubesact either as condenser or evaporator and are included in the outdoorunit. The air conditioner operates in one of the four operation modes: dehumidifier mode, heater mode, air cooler mode and fan blower mode. These operationsare controlled by the switching of the valves [5].

Dehumidifier Mode: In this mode thepressurized gas refrigerantflows out of the compressor, passes through the 4-way valve, andflows through the coil of the indoor condenser coil where it gives offheat, cools down, and turns into liquid form. Then the refrigerantflows through the expansion device B, the indoor evaporator coil,and back into the compressor. The high pressure liquid refrigerantabsorbs heat as it expands into gas form and its pressure dropsalong this path. The blower fan of the indoor unit forces the air to flow into the indoor unit and pass through the evaporator unitto cool down the air so that its temperature drops below the dewpoint. Thus the water vapor in the air condenses on the surface ofthe evaporator coil, and the function of dehumidification is accomplished.Then the air flows through the condenser coil and is heatedup back to its original temperature as it leaves the air conditioner.

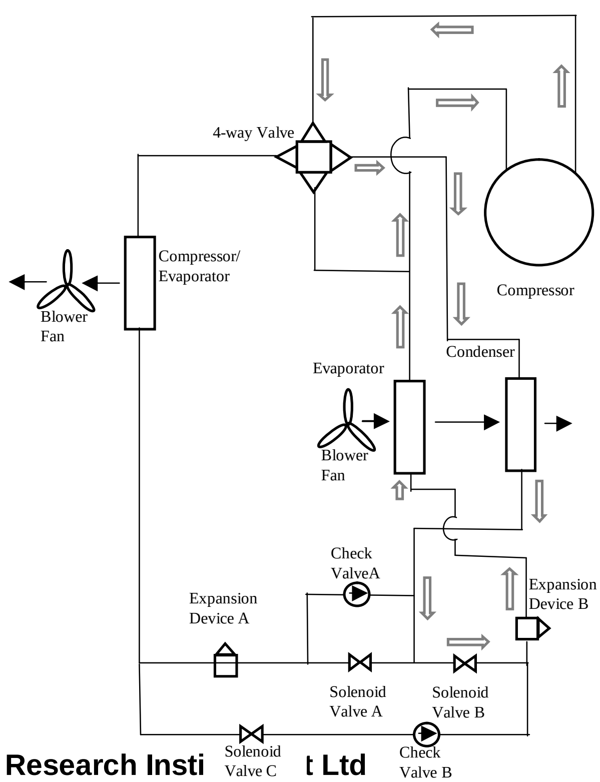


Fig. 2: Dehumidifier Mode

Heater Mode:High temperature and high pressure gas refrigerantflows out of the compressor, passes through the 4-way valve,and flows through the coil of the indoor condenser coil where itgives off heat to the supply air that passes by and turns into normaltemperature and high pressure liquid form. Then the refrigerantflows through solenoid valve A and expansion device A, where itreleases its pressure and becomes normal temperature and lowpressure liquid refrigerant. Finally the refrigerant flows throughthe fin tubes of the outdoor unit, absorbs heat as it expands intolow pressure gas refrigerant, and flows back to the compressor. The fin tubes play the role of an evaporator. The blower fan of theindoor unit forces the supply air to pass through the condenser coilof the indoor unit. The air is heated up, and its relative humidity i

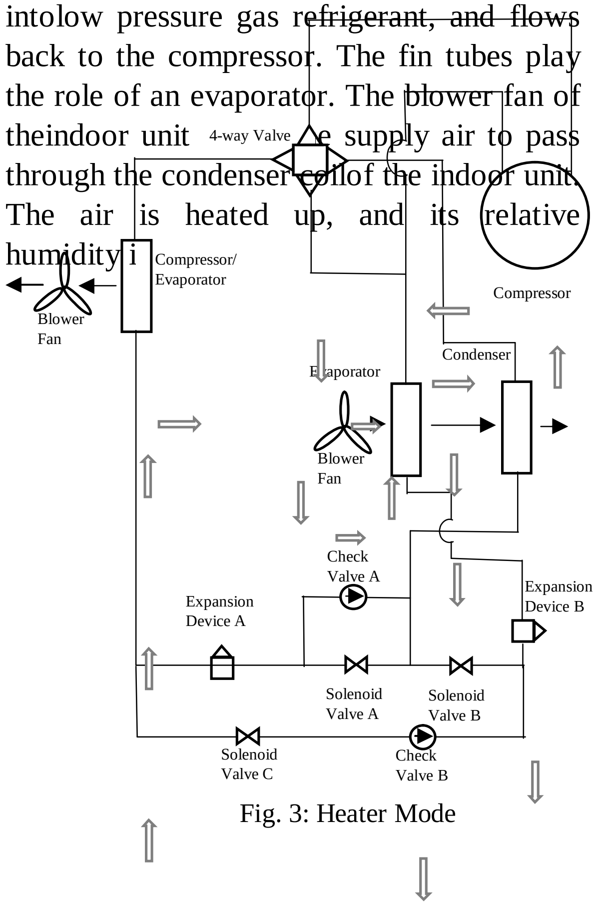


Fig. 3: Heater Mode

Air Cooler Mode: High temperature and high pressure gas refrigerant flowsout of the compressor, passes through the 4-way valve, and flowsthrough the fin tubes of the outdoor unit where it gives off heat andturns into normal temperature and high pressure liquid form. Thefin tubes play the role of a condenser. Then the refrigerant flowsthrough the solenoid valve C and expansion device B, releases itspressure, and turns into normal temperature and low pressure liquid form. The refrigerant then flows into the evaporator coil of theindoor unit, absorbs heat, expands into gas form, and finally flows back into the compressor. The supply air is forced by the blower fanof the indoor unit to flow the evaporator coil and cools down, andits temperature drops below the dew point, thus both functions ofcooling and dehumidification are accomplished.

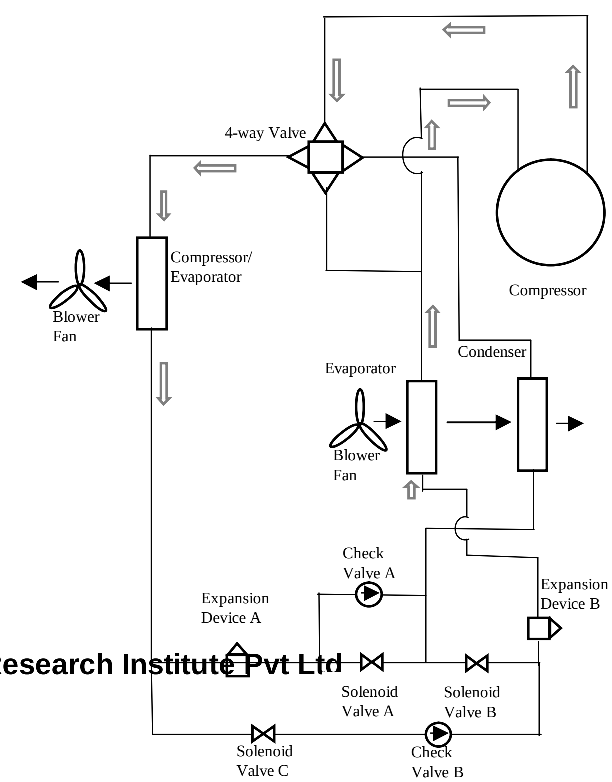
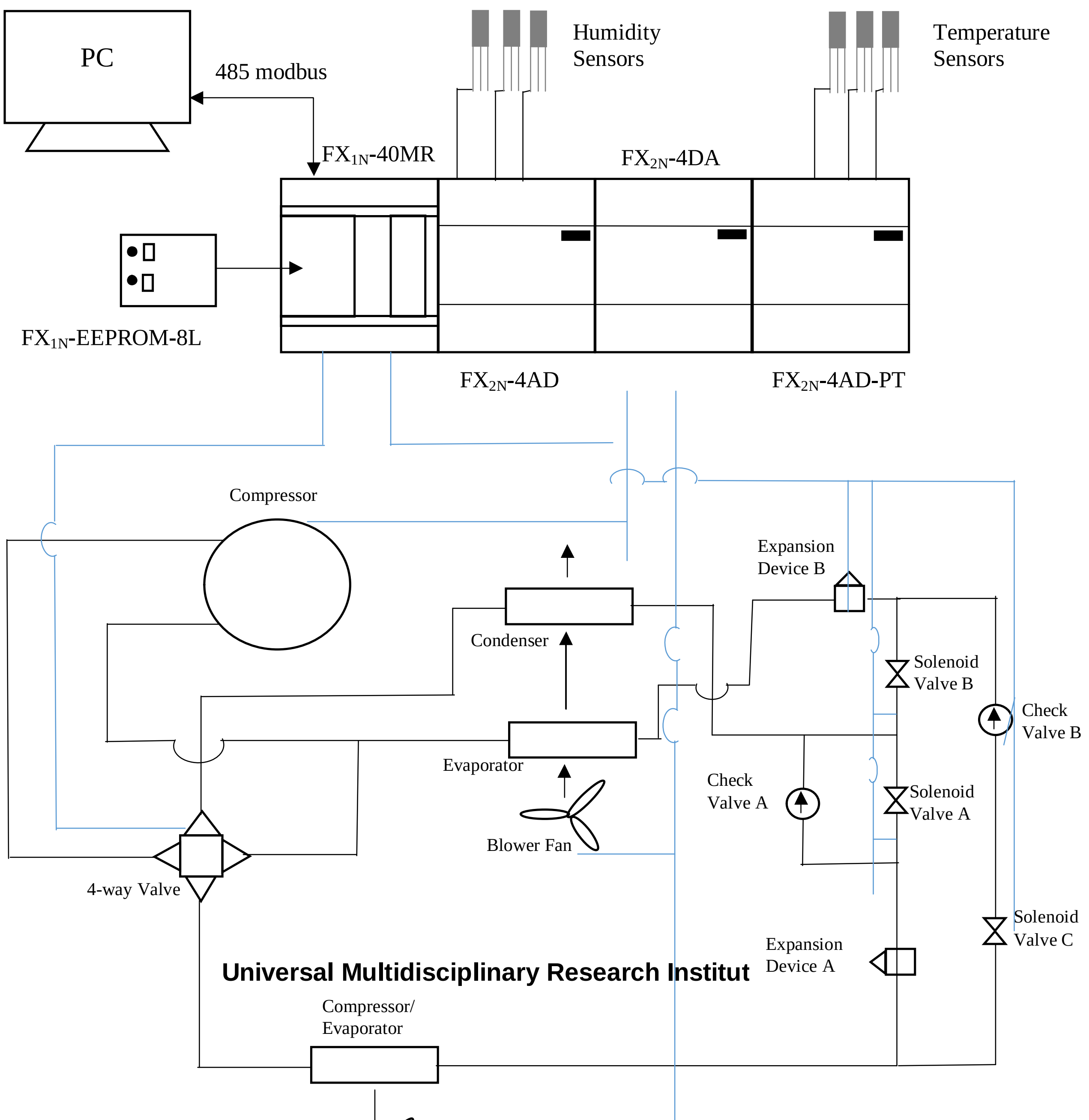


Fig. 4: Air Cooler Mode

Fan Blower Mode: When the temperature and the humidity of the controlledenvironment is within the desired range set in the intelligent airconditioner, only the blower fan of the indoor unit operates to circulateair in the vertic...

Fig. 5: Control Setup [6]

4.2 Control Setup



5. CONCLUSION

This study integrates PLC and Eclipse SCADA software to design and build an intelligent air conditioner, and successfully applies them to the temperature and humidity control of a vertical farm of different levels. Humidity and temperature sensors are usedto measure the respective values closer to the real environment and enables the intelligent air conditioner to achieve desired settings more efficiently. The GUI can record the entire sensor data received from the sensor nodes and the air inlet of the air-conditioner, monitor the temperature and humidity at each environment node, to provide a more suitable plantation environment in vertical farming operations.

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