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Automatic Smartcity Power Consumption Control Unit

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Abstract
The probability of a transformer to get overloaded in the night times is very high due to high residential uses. In such case, one phase of transmission line is pulled off to protect the transformer due to which single phase users are affected more than who consume more electricity(3 phase users). In this project to avoid this conflict in smart cities and to maintain 24*7 power supply to high emergency areas the tripping of transformer load is prioritized into five. Initially when heating of transformer is detected alternate Street lights is switched off. If the overloading continues 3 phase supply of industrial lines are pulled off and 1 phase supply is given. If the sensor still indicates the transformer heat, 1 phase supply of 3 phase users who consume more power exceeding the tolerance limit is pulled off. If overloading still continues every 1 phase line from the transformer is tripped except the high emergency areas (hospitals, fire station and control rooms). The high emergency areas are to be supplied with 24*7 power supply and in worst case if the transformer fails to provide power supply, generator backup is provided for the high emergency areas and to alternate street lights. The switching of loads after the transformer reaching normal state is also automated based on priority from highest to lowest. The whole arrangement is automated, monitored and controlled by PLC and SCADA unit.

Keywords: *Priority based load switching, PLC, SCADA, 24/7 power supply for high emergency areas.*

I. INTRODUCTION

The transformers used in distribution system have the tendency to get heated due to overload conditions in the night time. The TNEB (Tamil Nadu Electricity Board) in order to protect the transformer trips the single phase connection from the transformer or trips the entire transformer through circuit breaker. Due to this, single phase users are affected more than the person who consumes more power [1].

In smart cities generation of power is from renewable resources and the net power generated will not be more efficient the whole day. The smart city may be comprised of hospitals, educational institutions, industries, shopping malls etc and residential houses. During night times if the transformer is overloaded, we can't directly shut down the transformer directly or trip single phase from transformer considering that the fact that he/she is also paying for what he/she is consuming. To prevent this scenario in the night times and to provide 24/7 power supply for high emergency areas [2], the distribution station of a smart city is

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automated by PLC and SCADA with five reasonable priorities for switching and tripping.

Initially when the transformer is overloaded, the heat is sensed using a heat sensing device and automatically alternate street lights are switched off. If the transformer heat is still sensed the 3 phase of industrial lines are tripped and single phase supply is given for security purpose. From the above two ways the overload can be almost matched. If the transformer is still in overload condition 3 phase supply of the consumers who consumes more power than tolerance rating is pulled off and 1 phase supply is provided. If the overload still continues, 3 phase supply of all consumers is pulled off and 1 phase supply is given for them. In worst case if the heat sensor shows overload condition all the 3 phase and 1 phase supply is pulled off except for the high emergency areas. In case if there is any problem with the transmission line and the transformer fails to provide power supply, Diesel generator backup is provided for the high emergency areas and alternate street lights [2]-[5]. The ultimate aim of the project is to provide power supply for the residential consumers and high emergency areas during night times and in worst case for the high emergency areas throughout the day.

II. SYSTEM OVERVIEW

The overall control and automation process is done using PLC and SCADA. The temperature sensor senses the heat and gives the input to the control room where the priorities are checked and respective actions are taken. The tripping sequence is explained in Fig(i) and the switching sequence is explained in Fig(ii)

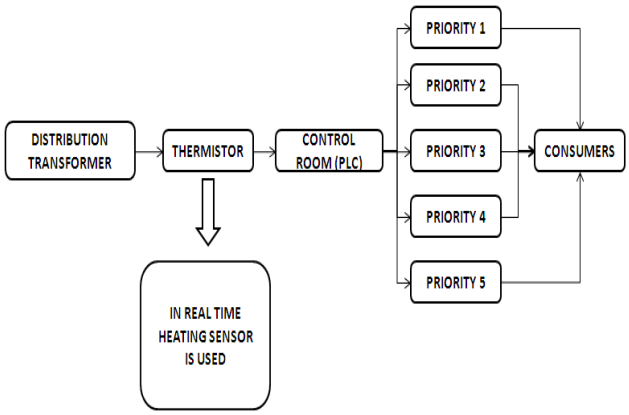

Figure (i)

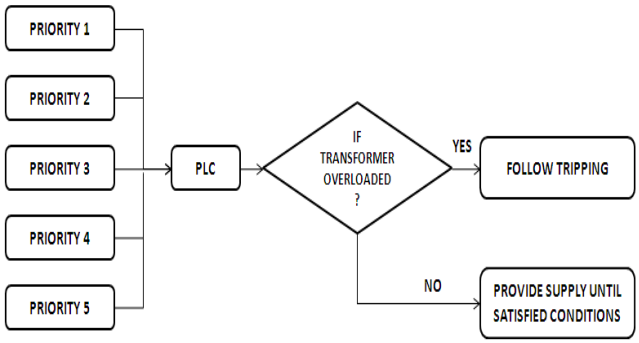

Figure (ii)

A. Temperature sensor

The heat sensor is used to sense the heat of the transformer if overloaded. In real time applications heat sensing equipments are used while in our project thermistor is used to sense the heat of the transformer. The input of the heat sensing device is given to the control room for controlling action. Depending upon the load the heat sensor operation takes place.

Figure (iii)

The fig (iii) shows the different types of thermistors used for sensing the heat.

B. Control room

The control room is a place where all the inputs and outputs of the distribution system are controlled. The control room consists of the following

- Relays
- Circuit breakers
- Programmable Logic Controller (PLC)
- Computer with SCADA software
- Infra Red sensors

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Every action against distribution system is taken in the control room and not in the field. PLC is the hardware and it will be

the controlling device and SCADA is the software to monitor and control the complete process. Any fault in system will be indicated by use of sensors and circuit breakers are used to immediately trip the network.

C. Tripping sequence

Priority 1

The street lights are given the least priority. When the transformer is overloaded, the heat sensor gives input to control room and automatically alternate street lights are tripped. Street lights have an individual line from the transformer secondary and so light overload can be resolved by tripping the alternate street lights.

Priority 2

Industrial 3 phase loads are given 2nd least priority. When the alternate street lights are OFF, after 10 seconds delay, 1 phase of the three phase supply is pulled off and 1 phase supply is provided. All the 3 phase industrial loads are tripped which will balance the load demand and supply will be provided when the transformer heat is completely dissipated.

Priority 3

Third priority is given to the 3 phase users who consume more power than the tolerance limit. Every house is monitored in the control room and the power ratings are monitored by the industrial energy meter in real time purpose. The smart city is subjected to a particular limit and if the user is consuming more than the tolerance percentage, 1 phase of the 3 phase user is pulled off by activating the IR sensor and 1 phase supply is provided.

Priority 4

Three phase users are given 4th priority. All the 3 phase loads in the smart city are tripped by the IR sensor if the transformer still indicates the overload. Thus by pulling off the 3 phase loads maximum demand of the transformer is met and the chance for the transformer to get cooled is increased. 1 phase supply will be provided to all the consumers in this condition.

Priority 5

If the transformer indicates overload even after 4th condition, all the 1 phase supply are pulled off. In this condition, except the high emergency areas the power supply is restricted for the protection of the transformer. The alternate street lights and the hospitals are provided supply for emergency purpose. Incase if there is any fault in the transmission line, circuit breaker trips the whole transformer, where the high emergency areas will be provided supply with generator backup available.

D. Switching sequence

Once the transformer is cooled and if the demand is met, the supply is to be provided to the consumers. The following steps are followed while switching on loads.

1. Check whether the transformer is cooled after tripping the alternate street lights, if yes, provide supply back to the system or else follow the tripping sequence.
2. Check whether the transformer is cooled after tripping the 3 phase industrial loads, if yes provide supply back to system or else follow tripping sequence.
3. Check whether the transformer is cooled after tripping the 1 phase of the user who consumes more power than the tolerance limit, if yes provide supply back to system or else follow tripping sequence.
4. Check whether the transformer is cooled after tripping 1 phase of every 3 phase user in the smart city, if yes provide supply back to system or else follow tripping sequence.
5. Check whether the transformer is cooled after tripping the single phase loads, if yes provide supply back to system or else follow tripping sequence.

The priorities if satisfied, inputs are given to the PLC which will automatically provide supply to the system. Thus priority wise load switching is done to ensure every user is provided supply with equal importance.

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III. ALGORITHM FOR PROPOSED SYSTEM

The flowchart in the fig (iv) explains the tripping and switching process.

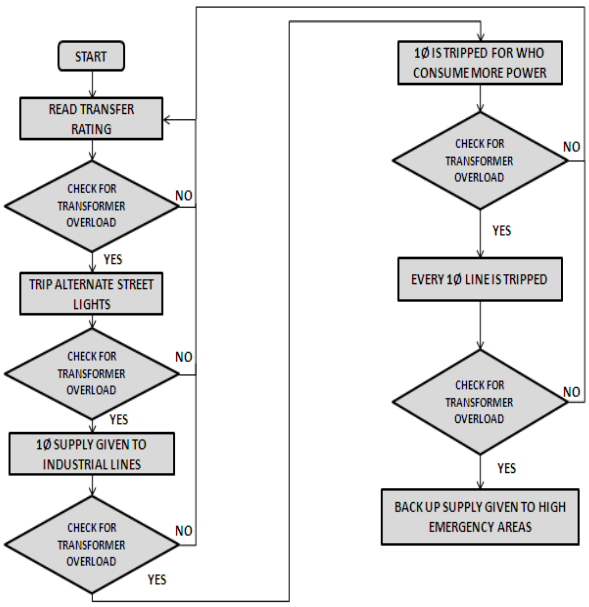

Figure (iv)

IV. COMPONENTS USED IN HARDWARE

A. Relay

Relays are used for switching and tripping, which provide contact between two mechanical elements. Relays have a coil which works on 12v dc and provides double pole double throw action as an output. In general relays provide potential free contacts which can be used for functions like DC, AC voltage switching and for controlling bigger electrical switch gears. They are based on the comparison between operating torque/force and restraining torque/force. The VA burden of such relays is high.

Figure (v)

The above fig (v) shows the typical relay used for tripping action.

B. IR sensor

Infrared sensor is a device that detects infrared radiation passing through it. IR sensors in our project are used for tripping the single phase and three phase supplies from the system. When a disturbance is placed between the transmitter and receiver the supply is tripped for the corresponding relay. The relay connected to respective load will be tripped till the disturbance is present.

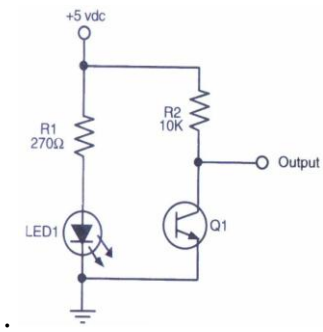

Figure (vi)

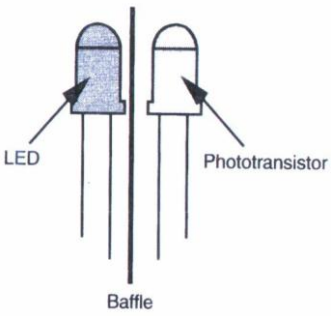

Figure (vii)

The fig (vi) and fig (vii) shows the circuit diagram and typical design of IR sensor pair respectively.

C. Programmable Logic Controller (PLC):

It is a solid state device, which can control the output on the basis of input and user developed program. Universal operating voltage of PLC is 24 Volt DC.

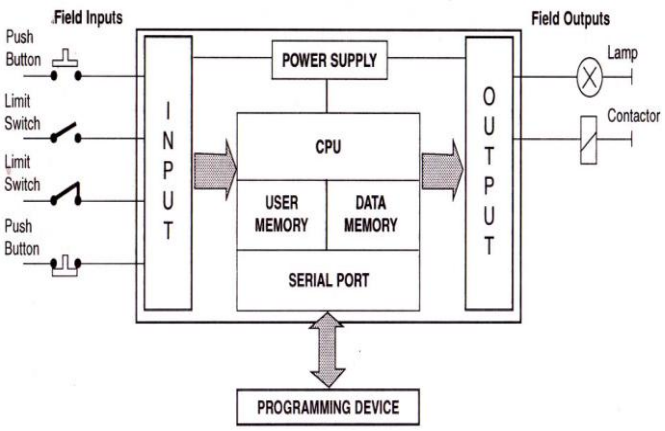

Figure (viii)

The fig (viii) shows the internal units of PLC. PLC is the hardware used in control room for controlling the whole process in a automated way. All the inputs are read through the available sensing

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devices and the output is processed through the connected output devices.

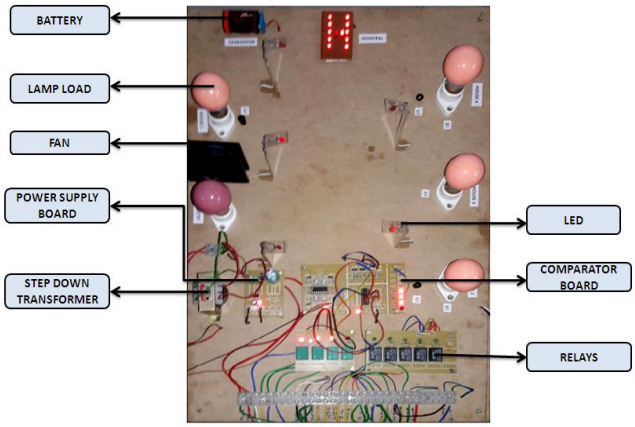

Figure (ix)

The hardware setup of the system is shown above in the Fig (ix)

V. SOFTWARE DESIGN

A. CX programmer

CX-Programmer is used for programming OMRON PLC in our project. OMRON is a brand of PLC whose input connections varies from 18 to 24 and output connections varies from 12 to 16.

B. SCADA

Supervisory Control And Data Acquisition (SCADA) is used for monitoring and controlling action. Wonderware InTouch is one of the type of SCADA software. Wonderware InTouch is the quickest and easiest way to create human-machine interface (HMI) applications. The designing of project is made using this software which will be monitored and controlled when interfaced with PLC.

The SCADA design for the process is shown in the fig (x) below

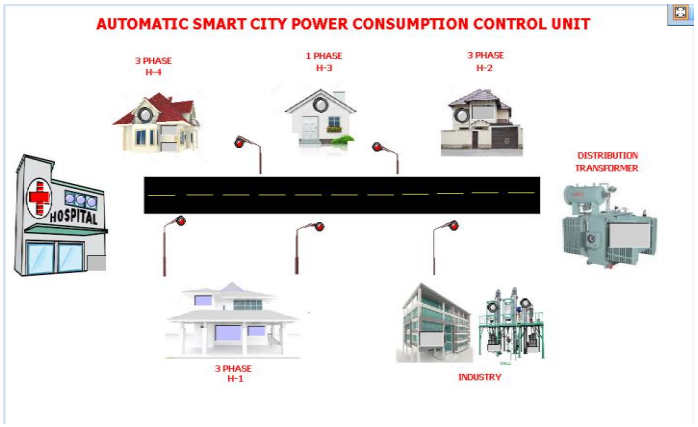

Figure (x)

VI. CONCLUSION

This paper provides a solution for a load management system for controlling the distribution transformer of smart city by supplying the consumers based on their priority during overload conditions.

The main advantages of the system are

1. Shifting different types of appliances according to an optimized algorithm.

2. Switching OFF appliances that consume vampire or phantom power.

3. Producing flatter demand load profiles of consumers. An equal share of power supply can be provided among all the consumers. Due to prioritized switching of loads during overload conditions the life time of transformers gets increased.

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