INTELLIGENT CONTROL AND PROTECTION SYSTEM FOR INDUSTRY

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Abstract

Maximum power demand means the maximum load demand required to an industrial consumer. The load demand at every instant is calculated and is compared with the permissible maximum load demand value, and when the instantaneous maximum demand value is inferior than the permissible limit then the operation is considered to be in equilibrium state, but when the value of instantaneous maximum demand crosses the limits of permissible maximum load demand then the controller comes into picture. The main objective of this paper is to maintain the relationship between power requirement, control and protection. Controlling the power requirement by maximum demand control scheme and monitor the over voltage and under voltage. The protection is provided is underground cable fault (Short circuit fault), fire detection, leakage current detection, earth fault detection, breakdown of overhead transmission line detection (Single line to ground fault) using microcontroller AT89c51. The graphical representation of temperature of a specific area where the fire protection is provided is in LabVIEW (Laboratory Virtual Instrument Engineering Workbench). The LabVIEW records as well as monitor the temperature at every instant (User defined in seconds) and it stored in the computer which is interfaced to LabVIEW with the help of serial communication.

Index terms: Maximum demand control, over and under voltage control, microcontroller AT89c51, LabVIEW.

I. INTRODUCTION

The name maximum demand means power limitation given to the user by the electricity board. In our country power generation is always lesser than the requirement. Ultimately distribution of the generated power to the users constantly is a big work. In these circumstances limits the power to the industrial user. Another control feature is over and under voltage control. The over voltage and under voltage controller is monitor the voltage level. The monitored voltage is coming from the supply. To determine the distance of underground cable fault from base station in kilometres. While a fault occurs for some reason, at that time the repairing process related that particular cable is difficult due to not knowing the exact location of the cable fault. To detect the fire in the industry so as to increase protection of industry, in this we are sense the temperature. Water is good conductor of electricity so this protection is use to detects the water leakage on the walls where the operating panels are fixed or the person is working nearby.

The proposed system is to find the exact location of the fault in the underground cables by the use of different taps on it called as junctions. The system shows the fault in between the junctions We can use the fire and smoke detectors to protect but smoke detector can sense the unnecessary smoke and trigger the alarm hence we are using the temperature sensor. Earthing is also an effective measure of the power system. Earthing should be maintained in system and protection is given into this to protect against the earth faults. This control and protection system is worked out by microcontroller family 8051 by using the electronic and power electronic components. The graphical representation is shown by Laboratory Virtual Instrument Engineering Workbench (LabVIEW).

II. BLOCK DIAGRAM AND ITS EXPLANATION

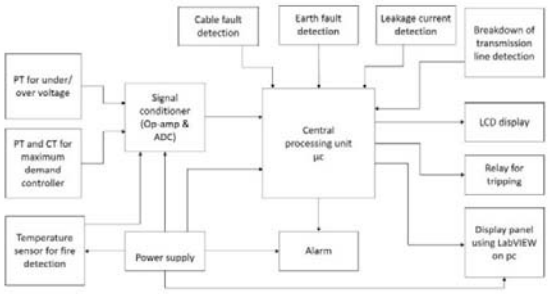

Fig. 1 Basic block diagram

The block diagram of the proposed system is shown above which has two control schemes and five protection schemes. The control and protection schemes are maximum demand control, under and over voltage control, fire detection, leakage current detection, earth fault detection, underground cable fault detection and breakdown of overhead transmission line detection respectively. The maximum demand control is for controlling the maximum power demand of an industry, in this demo model a PT is used for control of maximum demand to vary the voltage, in order to achieve the maximum demand more than the desired value the voltage is varied by keeping load constant and this block is connected to signal conditioning unit which converts analog signal into digital signal for which the microcontroller understands only the digital signal. When power exceeds the desired value the relay connected to load is gets tripped. The under and over voltage control is done by the on load tap changer (OLTC). For this model a pair of CT and PT is used for voltage variations, the primary input voltage is varying from 210V to 240V by keeping secondary voltage at 230V. This over and under voltage block connected to signal conditioner unit for analog to digital signal conversion. Fire detection is carried out by using the temperature sensor LM35, the reason of using LM35 is it having operating range of -55^0C to 150^0C and operate on 5V input supply. This sensor generates the voltage according to the temperature value. The maximum limit temperature is set inside the controller programme memory. When the underground cables are used for power transmission then it becomes very tedious to find out the exact fault location, the easiest way is to find fault location the cable is divided into number of junctions which has different voltage drops at each junction. This is simple calculation based on ohm's law. The earth fault protection is provided in such a way that it should not get open from the system. For leakage current detection the water leakage sensing device is prepared for detection of water leakage. Breakdown of overhead transmission line is detected in this system. The two electrode of this system is kept at same potential when this potential is disrupted then it detects the open conductor fault. The power supply block is used to supply the power for microcontroller, different sensors, and signal conditioning unit. Each control and protection circuit has alarm circuit to alarm on occurrence of fault. LCD display used to display the fault notifications of control or protection schemes. LabVIEW is interfaced with PC by using serial communication this screen shows the temperature data which is real time data and also it stores the temperature log that means it serves two purposes it give real time data and as well give historical data on temperature sensing.

III. CONTROL AND PROTECTION TECHNIQUES

A. Maximum Demand Control

All large facilities that are charged for peak demand usage will benefit from the industrial grade Maximum Demand Controller. The load demand at every instant is calculated and is compared with the permissible maximum load demand value, and when the instantaneous maximum demand value is inferior than the permissible limit then the operation is considered to be in equilibrium state, but when the value of instantaneous maximum demand crosses the limits of permissible maximum load demand then the industries under load conditions and if it exceeds the allotted demand then the Electricity Board will insist penalty for that consumer. The permissible value is adjusted is 200kW beyond this limit the microcontroller sets an exceeding power consumption alarm. To achieve this much power there is provision is made that vary the voltage using a POT by keeping load constant. The CT and PT used in this technique is must be calibrated. They are as follows,

Calibration of PT

CH0 FOR PT

Set resistance of variable pot w. r. t. GND i.e. R1

We are using variable pot of 10 k□

R1 = 3.28 k□

We got voltage across of variable pot w. r. t. GND of PT

VR1 = 3.32V

Calibration of CT

CH1 FOR CT

Set resistance of variable pot w. r. t. GND i.e. R1

We are using variable pot of 10 k□

R1 = 6.76 k□

We got voltage across of variable pot w. r. t. GND of PT

VR1 = 1.50V

B. Over Voltage and Under Voltage Control

Transformer has tapping of 0-210-220-230-240-250. The MT1 of all TRIAC is connected to the supply. The tapings are connected to the MT2 of their respective tapings. The gate of TRIAC is connected to the 4th pin of MOC 3041(opt coupler). Since, MOC3041 has an inbuilt zero cross detector circuit it gives firing pulse when the voltage crosses zero. Opt coupler fires the TRIAC when the internal LED is on. The 1st pin of opt coupler is the anode of internal LED and pin 2 is the cathode. The circuit is divided into two parts 1st is the Control Circuit and 2nd is Switching Circuit.

C. Cable Fault Detection Method (Short Circuit Fault)

To determine the distance of underground cable fault from base station in kilometres. The underground cable system is a common practice followed in many urban areas. While a fault occurs for some reason, at that time the repairing process related that particular cable is difficult due to not knowing the exact location of the cable fault. The proposed system is to find the exact location of the fault. The standard concept of Ohms law i.e., when a low DC voltage is applied at the feeder end through a series resistor (Cable lines), then current would vary depending upon the location of fault in the cable. In case there is a short circuit (Line to Ground), the voltage across series resistors changes accordingly, which is then fed to an ADC to develop precise digital data which the programmed microcontroller of 8051 family would display in kilometres. It is to be allotted to the user efficiently as per the priority of the loads. For the purpose of security temperature and water sensors are used. Tapping detector detects tapping of energy using lab view technique graphical representation is done.

D. Fire Detection Method

For the fire detection LM35 sensor is used. LM35 is a precision IC temperature sensor with its output voltage is proportional to the temperature (in ^oC). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self-heating and does not cause more than 0.1 ^oC temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every ^oC rise/fall in ambient temperature, *i.e.,* its scale factor is 0.01V/ ^oC. Ultimately when the sensor gets value up to specific temperature (i.e. sufficient caught fire 50*c approximate) further then ADC send this value in the form of digital signal to microcontroller to get quick action.

Its temperature is in between 1^0C to 150^0C and supply to LM35 is range from 4V to 20V.

On 1^0C it gives the output voltage of 10mV.

i.e. $1^0C = 10mV$

Like that on maximum 150^0C the output voltage will be 1500mV ~ 1.5V.

i.e. $150^0C = 1500mV = 1.5V$

Example:

For the normal room temperature i.e. 27^0C the output voltage will be 270mV

$27^0C = 270mV$

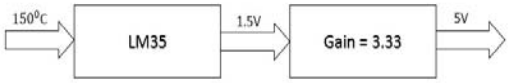

Fig input and output gain settings of LM35

Gain setting of LM35

As shown in fig. 150^0C is the maximum temperature and it gives an output voltage of 1.5V which is an input to the Op-Amps.

So gain can be defined as follow,

$$Gain = \frac{\text{Output voltage}}{\text{Input voltage}} \quad (1)$$

$$Gain = \frac{Vo}{\text{Vi}} = \frac{5}{1.5}$$

Therefore Gain = 3.33

Now, to get these gain we have to adjust the value of feedback resister (R_f)

Gain can be given as,

$$Gain = 1 + \frac{\text{Rf}}{\text{R1}} \quad (2)$$

E. Leakage Current Detection method

It is used to detect the leakage current caused due to water leakage inn industry, a simple circuit is made on PCB board consisting of two electrodes. It these two electrodes are gets shorted circuited by water content present on its surface. Let us call this circuit is a water leakage sensor.

The sensor is made by electrodes are of different polarities a small voltage is provided at the positive electrode and the negative electrode is connected at input port of microcontroller via A/D converter, Normally the bit 0 is at that controller port. When it gets short circuited the bit 1 is set at that pin i.e. the water leakage is detected, this is indicated by controller using LCD and an alarm.

F. Earth Fault Detection Method

This detection detects the earth fault of the system. The protection circuit is connected to the system which has to be provided. The circuit is of two electrodes which one connected to the ground and another is to the circuit (from circuit to earth) both are at same potential that means the circuit is to be protected is lie inside the protective circuit protective region. If this earthing circuit or circuit to earth link is gets open then it will give an alarm and the fault message is displayed on LCD screen.

G. Breakdown Of Overhead Transmission Line Detection Method (Single Line to Ground Fault)

This fault detection circuit is connected to the overhead transmission line to detect the breakdown of a conductor. The both terminals of the circuit is connected at the end terminals of the overhead conductor. Hence the no potential difference is present between that terminals but at the fault (single line to ground fault) then the potential difference at the both terminals is present or we can say that two terminals at different potential. Microcontroller senses that difference and take a protective action that this system gives an alarm on breakdown of a conductor and display fault message on LCD screen.

IV. RESULTS AND CONCLUSION

A. Experimental Results Of Maximum Demand Control

The load demand at every instant is calculated and is compared with the permissible maximum load demand value, and when the instantaneous maximum demand value is inferior than the permissible limit then the operation is considered to be in equilibrium state, but when the value of instantaneous maximum demand crosses the limits of permissible maximum load demand then the controller comes into picture. In this project we keep the load constant and simply vary the input voltage. For this the maximum demand is set at 200kW after this limit the system load have to be maintained under 200kW

Fig 2. Photograph of maximum demand control on exceeding the desired maximum demand

B. Experimental Results Of Under And Over Voltage Control (On Load Tap Changing)

The input voltage is varied from 210-220-230-240 Volts. As the tap changes the LED specifies for desired range is gets on.

TABLE I
PRIMARY AND SECONDARY VOLTAGES DURING TAP CHANGING

Taps	Primary voltage (V_p) in volt	Secondary voltage (V_s) in volt
T1	210	230
T2	220	230
T3	230	230
T4	240	230

C. Experimental Results Of Underground Cable Fault Detection (Short Circuit Fault)

Cable fault detection method the voltages across each junction is measured, if fault occurs

at a junction the voltage drop across it is lower than its precise value then it gives an alarm with the display indication on LCD. The voltage measures at each junction is as in below table:

TABLE II
VOLTAGE DROP ACROSS EACH JUNCTION WHEN FAULT OCCURE AT EACH JUNCTION.

Junction	Prefault voltage	Postfault voltage
JN 1	5.09V	2.54V
JN 2	5.09V	3.38V
JN 3	5.09V	3.80V
JN 4	5.09V	4.05V

Fig 3. Photograph of underground cable fault detection at junction JN2

D. Experimental Results Of Fire Detection

This control and protective system is interfaced with a computer by using serial communication. LabVIEW is a graphical control on computer for logging of the temperature. The interfaced computer screen as shown below:

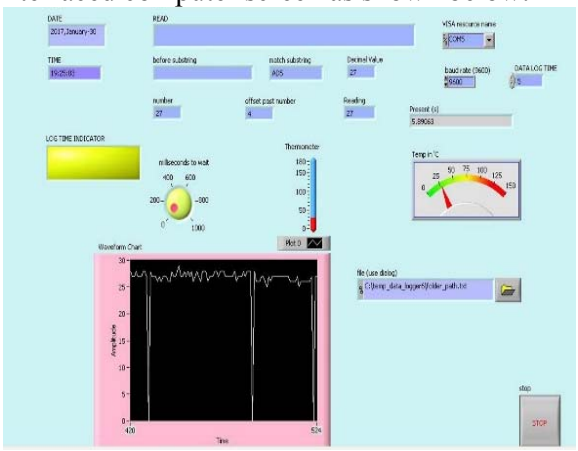

Fig 4. Photograph of temperature data logging interfaced on computer through serial communication using LabVIEW

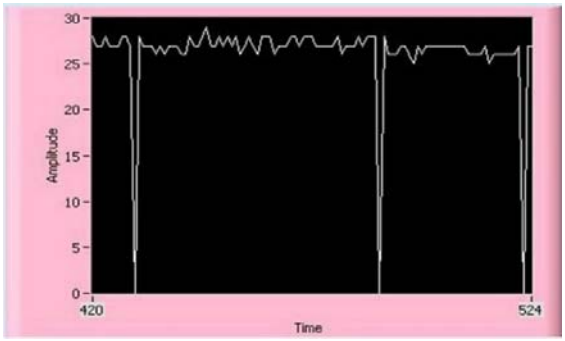

Fig 5. Photograph of real time waveform of temperature variations.

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