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Research Article

Load Trimming scheme for Overload Protection of Power Transformer

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Abstract

The paper presents a microcontroller based automatic scheduling system for the operation and control of distributed energy resources connected to electrical power system. We have proposed a new structure of power system network which has a connection between Transmission and Distribution control circuit through RF transmitter and receiver which provides us the opportunity to control the load. Load side devices can work on the basis of information provided by the transmission side devices as a result we can implement different type of control strategies. Proposed transmission side devices can also be used for transformer protection as it monitors status of transformer. After implementation of our project available energy sources can be used efficiently and maximum load can be supplied. This gives the utility the ability to provide preferential service to customer and avoid unnecessary full-load transformer trips. The case study is also being provided to overlook the practical implementation of the system.

Keywords: *Control, Priority based power Transmission system, Load trimming, Alarm and trip etc.*

1. Introduction

Electrical power crisis can be minimized by making proper utilization of existing resources. Our objective was to design an automated power system network which can control the load centrally. Control over distribution network implements the proper resources utilization. Automation in distribution field allows utility to implement flexible control of distributing system which can be used to enhance efficiency, reliability and quality of electrical services but controlling of loads needs an interconnection between users load and central control unit. Many have tried to create wireless network using SMS. Dividing the loads into different categories enables us to differentiate in between necessary load and luxury load or more precisely less necessary loads. Turning off the unnecessary loads may lead us to supply more users at a time for their daily necessity. In conventional system to provide service to other users, we have to switch off others when we are in power shortage but in our system we will switch off the less necessary loads to provide the service to all users. (Kazi Ahmed Asif Fuad, Md. Maruf Ibne Hasan, Laila Nawsheen Manzoor, 2015) Here a priority based trimming scheme is designed to sense power failures and automatically act on low priority loads. The system basically uses the load trimming scheme. Load trimming scheme is a new technique utilized for the protection of power transformers. Generally protection is provided to the power transformer under overload condition. But this protection leads to unnecessary trip of whole transformer. Due to which load affected area increases. The whole area which feeds from transformer goes in vain. To prevent this condition, Load Trimming Scheme is designed. It helps in preferential cut off of load which will help to reduce the load on the transformer and hence prevents overload condition of the power transformer. By using this scheme load affected area reduces due to which transformer can be shifted from overload condition to the under load condition.

Transformer load standard with a smart relay is the ability to monitor transformer's current and set multiple prioritized overload level for Alarm or Trip. This gives the utility the ability to provide preferential service to customer and avoid unnecessary full-load transformer trips. In addition, the tap changer can be blocked if current is above a user-defined setting and prevent load restoration if hot-spot temperature is greater than a user-defined level. (Dave Fedirchuk, Curtis Rebizant, 2000)

There are two functions included in the scheme

1) Transformer overload alarm function
2) Transformer overload Trip function

In the above mentioned functions protective relay continuously monitors the load conditions in the form of current. If this monitoring indicates that the load current exceeds its Trip setting then it provides an alarm function and after given delay of time it directly

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sends the tripping signals to the remote end feeders for the opening of circuit breaker to reduce the load and hence prevent the transformer from unnecessary trips. The loads are chosen on the priority basis and tripping signal is provided to the load which has lesser priority. Rest of the paper is organized as follows:

Section 2 explains the requirements of the scheme.

Section 3 Proposed methodologies, Section 4 gives the working principle of scheme followed by section 5 which gives the idea of the Implementation. Section 6 shows the experimental results. Case study has been thoroughly discussed in section 7. Finally the conclusion is given followed by acknowledgment and references.

2. Requirements of the Scheme

The Basic requirements for the scheme are as follows

1) Over-current Relay
2) RF Transmitter and Receiver
3) Master Trip Relay

2.1 Over-Current Relay

A digital over current relay is a type of protective relay which operates when the load current exceeds a pickup value In a typical application the over current relay is connected to a current transformer and calibrated to operate at or above a specific current level. When the relay operates, one or more contacts will operate and energize to trip (open) a circuit breaker. The name 'over current relay' implies that this is a special type of protection which is used to protect the costly apparatus from the effect of huge current flow. Over current relays are those relays which operate during the excess current flow through the network and trips the circuit of circuit breaker, which isolates the faulty part of the network from the healthy part**.**

2.2 RF Transmitter and Receiver

General Description

The ST-TX01-ASK is an ASK Hybrid transmitter module. ST-TX01-ASK is designed by the Saw Resonator, with an effective low cost, small size, and simple-to-use for designing.
Frequency Range: 315 / 433.92 MHZ.
Supply Voltage: 3~12V.
Output Power: 4~16dBm
Circuit Shape: Saw

2.3 Master Trip Relay

Master trip relay is the main trip relay. The breaker will trip through this relay only. In transmission & distribution line there are so many protection relays like....distance relay over current earth fault, differential. The entire relay's contact will connect parallel to master trip relay. If any of the protection rely sense the fault, it will energize the master trip relay and the master trip relay will trip the breaker. It got one more name like lock out relay.

3. Proposed Methodology

Our proposed system consists of three units connected wirelessly to create communication with each other.

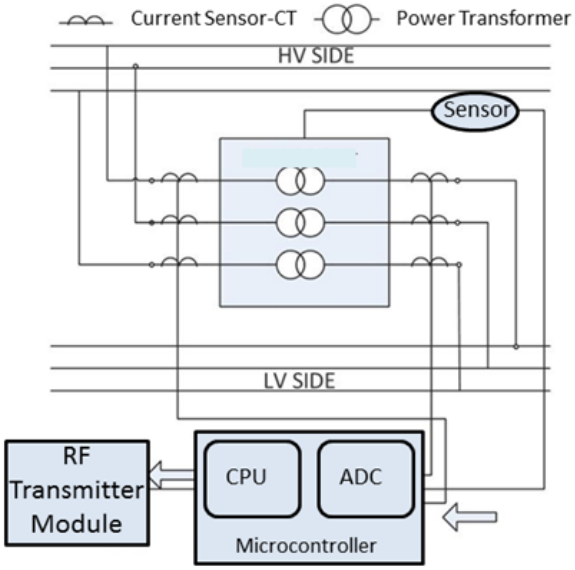


Fig.1. Block Diagram of DSD

The measure units are

1) Central Processing Unit (CPU)
2) Transmission side devices (TSD)
3) Distribution Side devices (DSD)

Central processing unit is the brain of this system. CPU receives the data, analyzes and makes the decision to stable the system. It's a big database of information which is received from TSD continuously as it has all the load data of transformer at different times, it will have the ability to predict future. Any kind of algorithm can be implemented as it is a computerized system.

The decision making condition can be many types,

1) Demand factor
2) User type
3) Hourly load curve
4) User load type
5) Used daily Loads
6) Load curves at different season in different area
7) Request services
8) Special occasion
9) Natural climatic and many other

Dividing users in different category can be in many ways. In every country, there is VIP lines in which

electricity is provided 24/7. User can be categorized depending on their consumption.

For an example: A feeder having more industrial load and other feeder has less industrial load.

So different devices with different configuration can be installed at different feeders depending on their consumption. The demand factor depends upon nature and the activities of the consumer and to some extend upon the location of power system. Group diversity factor gives the ratio of some of individual max demand and actual maximum demand of the group. Where peak diversity factor shows the ratio of maximum demand of feeder and demand of feeder at time of system peak. The chronological variation in demand for the energy on the source of supply is plotted graphically for study and easy comprehension. Such graphs for electrical energy demand are termed as load curves. Load factor and capacity factor helps to drive the power station efficiently. As we will have all the data of loads we will be able to utilize the energy properly. Load factor shows the degree of variation of a load over a period of time whereas as extent of use of the generating plant is measured by the capacity factor. The power system will be efficient if both load factor and capacity factor is unity.

Transmission side devices consist of sensor which is capable of sensing the tap position and send it to CPU. TSD generally measures HT and LT side current. Magnitude and phase angle varies depending on the nature and type of fault. Analog to digital converter-ADC is used to measure the current. RF transmitter module is used to send the data to distribution side devices DSD.

Distribution side device-DSD is more or less smarter with load controlling feature. Its main operation is to switch the connected load. It is directly connected to CPU through wireless communication. In our case we are using RF transmitter and RF receiver network. Fig-2 shows the block diagram of DSD. Relay is used to switch the load. Keys, buzzer and LCD display is used as the user interface which allows the user to acknowledge the alarm and reset the system.

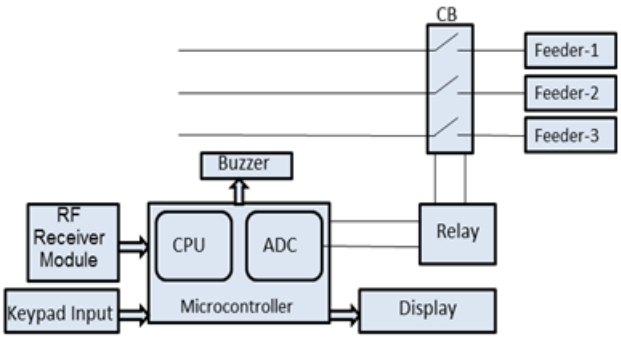


Fig.2. Block Diagram of DSD

Implementation Tools

To implement DSD we have used

1) Microcontroller
2) RF transmitter and receiver module
3) Power supply
4) Current Sensor(CT)
5) Transformer
6) 20x4 LCD Display
7) Keypad

4. Working Principle of Scheme

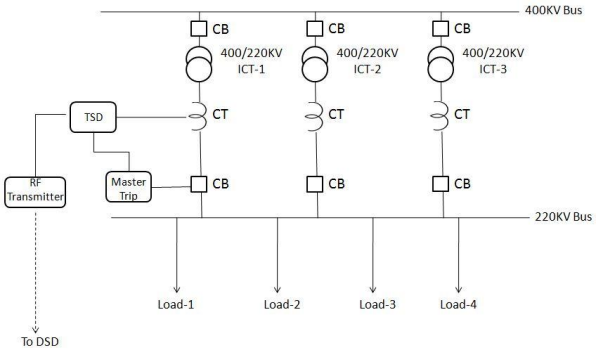


Fig.3 Basic Circuit of Load Trimming Scheme

Above diagram shows basic arrangement of load trimming scheme. There are three numbers of ICT connected in parallel and having same MVA rating. For the sake of understanding other protection circuits are eliminated. Transmission side equipments are connected as shown. In normal operating condition all the three ICTs will share the equal amount of load as all are having same percentage impedance. Now let us consider that ICT-3 trips due to any contingency on it. The total load supplied by ICT-3 will now being supplied by the ICT-1 & ICT-2. If the load is equal to or less than the available capacity of ICT-1 & ICT-2 then shifted load of tripped ICT-3 can be supplied by ICT-1 & ICT-2 without any fail. But if load is greater than the available full load capacity of ICT-1 & ICT-2 then both the ICTs will get overloaded and as a result overcurrent protection may operate and will trip both the ICTs. To prevent this condition load trimming scheme can be implemented to cut the load immediately and save ICT-1 & ICT-2 from tripping on overload protection.

In load trimming scheme TSD is utilized for trimming the load. For overcurrent protection IDMT (Inverse definite minimum time) characteristic is used. And for the trimming purpose definite minimum time characteristic is used. The TSD continuously monitors the loading condition of ICT. If load on ICT is more than the predetermined value then definite minimum time function of TSD come in picture and transmit command through RF transmitter. After that the generated tipping signal is sent to the remote end where it is receiver by RF receiver at the Distribution end and relay generates tripping command for local breaker operation.

While implementing the scheme time coordination of overcurrent and earth fault relay with the trimming scheme is most important. Load trimming scheme should operate before the operation of overload protection and this can be achieved by keeping the operating time of trimming scheme less than that of overload protection. Different stages can also be designed for different overload conditions to trim the load as per requirement and to disconnect the minimum possible load depend on the load on ICT. For the Successful operation of this scheme, RF transmitter and receiver module should always in service. On failure of this communication the scheme will not work and in such a condition the ICT will trip on overcurrent protection.''

5. Implementation

In order to verify the behavior of the proposed automatic load trimming system, a prototype has been implemented by using a modern Microcontroller PIC16F877A.

Following fig shows the schematic diagram of the scheme.

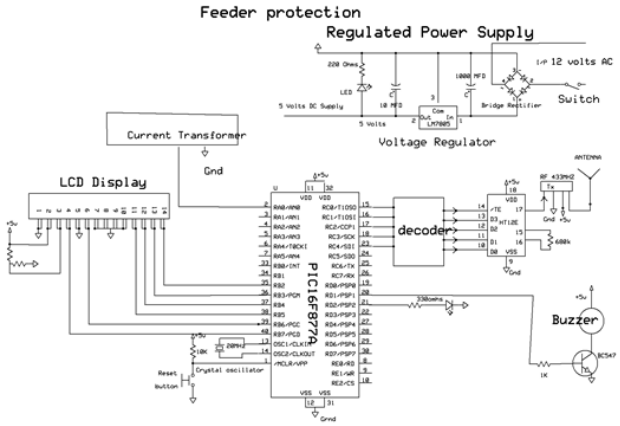


Fig.4. Schematic arrangement of Scheme

The microcontroller-based system has been installed in an experimental set-up, whose structure is shown in fig.4.

It consists of a Transformer having full load current of 60 mA, supplying 3 loads each of 100W, through a current transformer and Also has regulated power supply of 5V for microcontroller. Current transformer senses the load on power transformer and provides this data as input to microcontroller which controls the end relay through wireless link. Load in mA is shown on display. The load can be increased or decreased by manually switching the lamp.

Fig.4 & 5 illustrate the wireless link between microcontroller based automated trimming scheme. The output of microcontroller is tripping signal and it is transmitted through this wireless link.

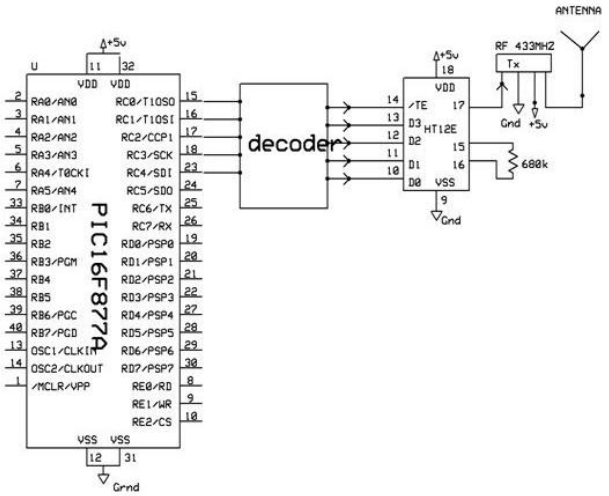


Fig.5 Wireless link at Transformer End

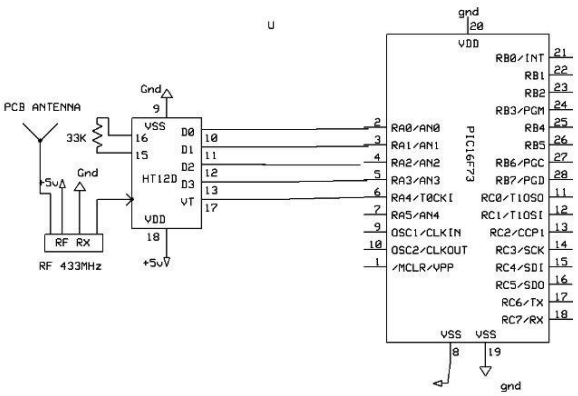


Fig.6. Wireless link at Load End

6. Experimental output

This section shows the behavior of the system and the action of the automatic trimming prototype during overload condition. Test characteristic of load current is shown in Fig.7.

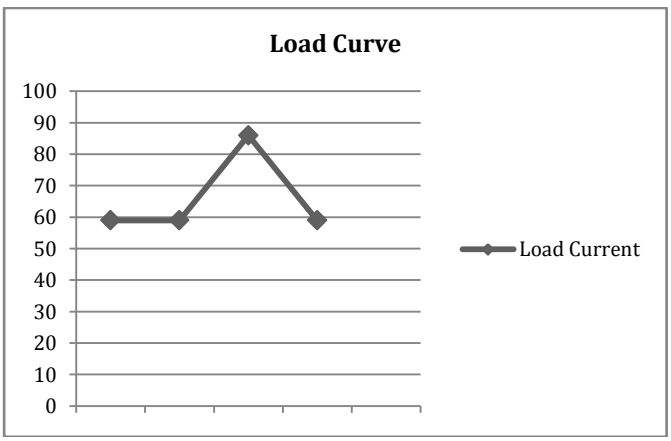


Fig.7. Load profile adopted during the experimental tests

During the test the load is estimated by using the measurement of lamp load current. The full load value is 60mA. And overload current value is 86mA. This value of overload is chosen to verify the possible trimming operation of the scheme. When the test starts two lamps glow which gives the load current of 38mA. This healthy condition is shown below.

Fig.8. Full load condition of Transformer

After manual switching of third lamp, load is increased and transformer gets overloaded as shown

Fig.9. Over load condition of Transformer

As soon as transformer gets overloaded a tripping signal is initiated and transmitted to the load end to trip the breaker and stables the system by reducing load current to 55mA. Snap of tripping of non-priority load is shown below

Fig.10.Stable system after non-priority load Trimming

7. **Case study**

The major example regarding this project implementation is thoroughly been discussed in this case study. It deals with the load trimming scheme for ICTs at 400KV substations Girwali-Parli.

7.1. The Preamble is as follows

4oo KV substation at Girwali transmits 1300 to 400MW power through 400KV and 220KV network. Six Districts of Marathwada have witnessed power failure on 9-11-2007 at crucial hours of laxmipujan on the eve of Diwali festival on the account of loss of 50% generation at parli and subsequent tripping of 400/220KV ICTs at Girwali. This incidence have led to consider the possibility of providing load trimming scheme at 400 KV Girwali and Parli Substations.

7.2. The Main features of Scheme

1. The proposed scheme envisages tripping of radial loads at Girwali 220 KV and 132KV bus at full capacity of ICTs in stage I with 1 second delay and radial loads at 220KV Parli bus in stage II with 2 second delay through coded carrier signals.
2. Isolations of 220 KV and 132KV connections between Parli and Girwali in stage I and islanding the two stations can also be feasible.
3. This scheme is also workable in case of tripping of one ICT on protection.
4. The proposed scheme is not workable in case of overloading of ICTs for power direction from 220KV to 400KV side. Under such circumstances, alarms can be generated at Parli stations.
5. A condition of excessive overloading may arise in case of disturbance in 220KV corridors ahead of pusad.

This can be taken care by a high set overload stage 3 with 1 second delay with interlocked contacts of directional relay to be provided on 22o KV nanded and parbhani feeders at Girwali Sub stations to trip 220KV pusad line breakers at 220KV Nanded and 220KV parbhani substations through PLCC. For this coded signal is required to be transmitted for reliability and security.

6. To implement load trimming scheme DCD type ER make numerical relays or MICOM P127 type AREVA make relays are to be utilized.

7.3 Design of Load Trimming Schemes For Girwali-Parli network

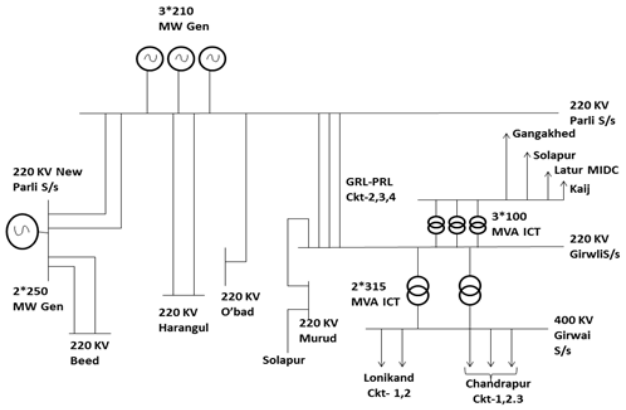


Fig.11. Single line Diagram of Girwali-Parli Network

7.3.1. Steps for designing the scheme are given as below

1. This scheme will protect the source against tripping on O/C by cutting off some load before to operation of O/C protection.
2. This scheme will cut off the loads by switching off the radial feeders.
3. This scheme will be in two stages.
4. Each stage will be implemented either by local control wiring or using PLCC link.

7.3.2. Highlights for the load trimming scheme for ICTs at Girwali are

1. The full load capacity on 400 KV side of ICT is 455 Amperes. The CT ration connected on 400KV side is 500/1 amperes.
2. Load trimming scheme should operate before to O/C protection.
3. O/C setting of IDMT characteristics is 100% i.e. 500 Amperes on 400KV side.
4. The Load trimming scheme should operate at full load capacity of ICT i.e. at 455 Amperes.
5. It should operate only when power flow through ICT is from 400KV side to 220KV side.
6. It shall be ineffective for loads on the ICTs above 130%
7. The scheme shall operate in 2 stages
   a) Stage I with time delay of 1 second
   b) Stage II with time delay of 2 seconds
8. After operation of stage I on load trimming scheme, following 132 KV feeders at 400/220KV Girwali substation shall be cutoff.

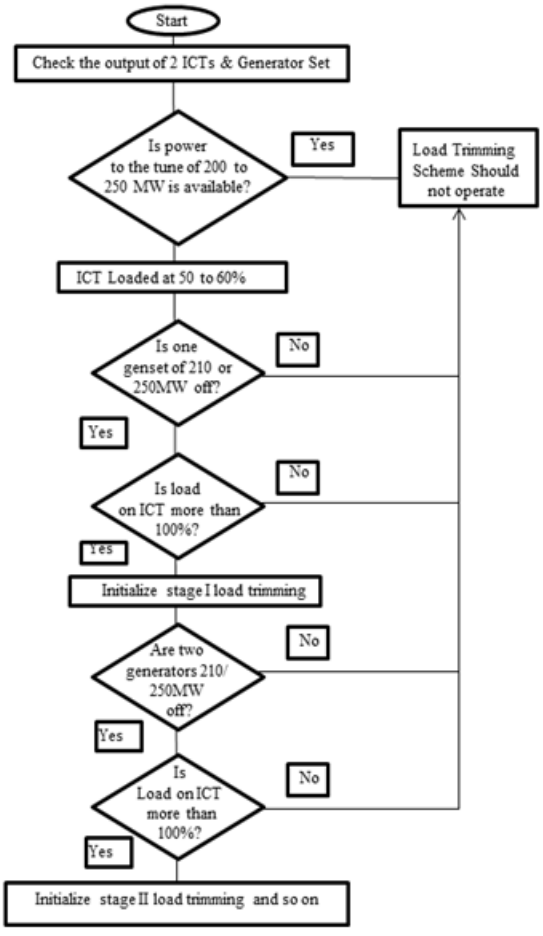
a) 132 KV Kaij of 75MW at 400KV Girwali S/S
b) 132KV Gangakhed of 25MW at 400KV Girwali S/S
c) 132KV Ahmadpur of 40MW at 400KV Girwali S/S

9. After operation of stage-II, following feeders at 220KV Parli S/S shall be cut off through PLCC

a) 220KV Harangool I&II of 250MW at 220KV Parli S/S through PLCC
b) 220KV Osmanabad of 80MW at220KV Parali S/stn through PLCC

It is necessary to utilize the coded carrier signal in parallel for reliable tripping operation at remote bus. For this contact, multiplication trip relays are to be provided for achieving tripping. [4]

7.4 Working Algorithm for Load Trimming Scheme of ICTs at 400 KV S/S Girwali



Conclusions

The Ability to protect, monitor, and control utility transformer assets in one integrated platform is now possible with improved processing power and simplified windows-driven interfaces. Integrating features of all the hardware components used have

been developed in it. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. Secondly, using highly advanced IC's with the help of growing technology, the project has been successfully implemented. Thus the project has been successfully designed and tested. This project can be extended by long distance wireless mechanism by interfacing a Zigbee module, which helps in monitoring multiple sources and loads and display them on PC. GSM module can also be interfaced to monitor as well as to control the loads from anywhere in the world.

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