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Transformer Protection by Using Micro Controller

[1]Khavale Shankar N., [2]Mandke Radheya N., [3]Rananavare Chandrashekhar M., [4]Prof. Nehete Amit L.

[1,2,3,4] KJ College of Engineering and Management Research, Pune, India

Abstract: **Presently in distribution system, various protection schemes are used for transformers which are carried out manually. When any fault occurs within a distribution line, the power transformer feeding the distribution transformers is tripped, ultimately leading collapse of the power system. This results in poor power quality and reduces reliability of the system. This paper helps to overcome the above mentioned limitation. Overloading is the main reason to trip the power transformer which requires human intervention. Automatic protection helps to reduce human intervention and also needs less attention to the system. Today, the feeder groups are categorized as A, B, C, D, E, F, and AG. A has the highest priority, followed by B, C, and so on. Feeder AG has the lowest priority. When the transformer is overloaded, the feeder of lower priority is tripped. When the load decreases, the feeder is brought back in the operation. The temperature is also, one of the important issues with transformers. In the proposed scheme transformer temperature is controlled and monitored by temperature sensing elements and controller.**

Keywords: **power system, transformer protection, automatic load handling, temperature control.**

I. INTRODUCTION

The transformer protection, currently, is done manually. The schemes employed for protecting the transformers are circuit breakers, gang operated isolators, over current relays, tap changers, Buchholz relay, etc. Out of these the relays and circuit breakers trip the circuit when they sense a fault in the system. However, the system has to be brought into operation manually. Subsequently, a record has to be kept of the faults and interruptions in the systems and reported to the concerned officials.

The paper, Automatic Transformer Protection, serves these purposes, as well. In addition to these, the load handling system has been introduced. The load handling, in present system, is done manually. The project offers a full control over load by using microcontroller. It also keeps a record of all the operation going in the system.

The oil temperature is, often, ignored, mainly in the remote areas. The transformer oil, many a times, heats up and the transformer bursts into pieces, spilling thousands of litres of oil over the substation yard. Sometimes, over the road, if the transformer is located near the road. Hence, oil temperature cannot be ignored. The project also has kept in view of continuity of the system and only the cooling system is ascended in order to maintain the oil temperature.

II. AUTOMATIC LOAD HANDLING

The distribution company in Maharashtra, India has classified the feeders according to the tariff collection from the consumers. The feeder groups are named as A, B, C, D, E, F and AG. The company has also prioritized the feeders for the purpose of shedding the load. Accordingly, feeder AG (meaning Agricultural) has the lowest priority in the system. F has greater priority than AG but lower than E and so on. Feeder A has the highest priority and it is recommended that the conditions whatever, feeder A mustn't be brought out of operation. The feeder largely consists of industrial loads, and if the operation is ceased, it would affect the economy of the country, largely.

So when the officials instruct the substation in-charge to shed load due to over current, the operators manually switch off the AG feeder, being the lowest priority for the system. On the contrary, as the name suggests, this operation can be done automatically.

If the substation in-charge does not receive any such instruction in spite of over current in the system, the L.V. side circuit breaker trips, in case of over current in the line. With this the whole system is shut down and as mentioned earlier, the industry has to face a huge loss as the raw product cannot be further finished. This doesn't make the system reliable and even not affordable to the distribution company, as well.

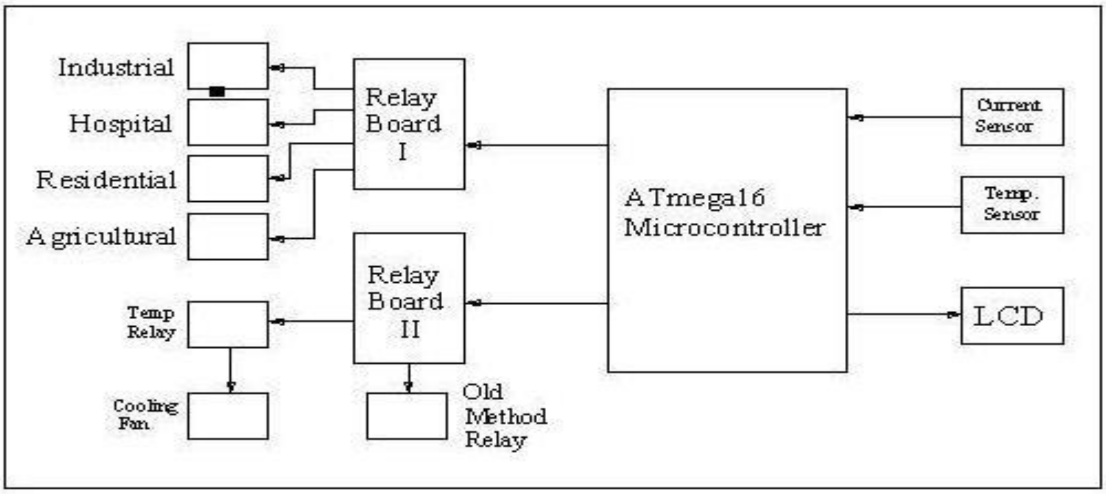

Fig.1 Block Diagram

The project therefore, handles the load current automatically. When the system demands more current than it is capable of delivering, the feeder with lowest priority is tripped. The industry being at the highest priority does not suffer any loss and the power is delivered to other feeders. With this the current is reduced less than the rated value of the transformer.

If the over current still persists, in spite of cutting down one of the feeders, the then with the lowest priority, i.e. feeder F is cut down. This further reduces the current. Now if the total load current is reduced, the transformer being capable of serving the latter feeder which was tripped, then it is brought back in service and this goes on.

The switch is a section of control in the circuit. A single pole double throw type of switch is used to switch over modes. The project runs in two modes viz. Conventional mode and Advanced mode. The LCD, displays "OLD METHOD" and "NEW METHOD" respectively for the two modes. In the conventional mode, the project runs in the way the power system operates currently. On the other hand in advanced mode, the project serves its main purpose of protection of transformer.

The current sensor is connected in series with line. Hence the line runs to the common terminal of the four relays. The Normally Closed terminal is connected to the respective loads. There are four different lamps and four sockets connected to their respective relays. Each relay feed one lamp and one socket. The socket is connected in parallel to the lamps. One lamp and one socket connected to one relay all combine to form one feeder. A variable load can be connected to the system through the socket provided. The four feeders are named as Agricultural, Residential, Hospital, and Industrial respectively. According to the system, the Industrial feeder has the highest priority and must not in any case be tripped. The Agricultural commonly known as AG has the lowest priority.

When the load current exceeds 3A, already prescribed, the current sensor senses the current and sends data to the micro controller about the current value. After exceeding the rating, the micro controller gives active high signal to the relay driver ULN2003. According to the priorities set, the coil of the relay preferred is energized. The contact which was Normally Closed switches to open the contact. In the project, the Agricultural feeder has the lowest priority and when such over current condition occurs, the AG feeder is the first one to shut down. Consequently, the line current reduces. But it may occur, that the over current condition may pertain in spite of cutting down a feeder. Else, the current with three feeders may decrease. In this case, the then lowest priority feeder, Residential, which has a higher priority than AG and lower than Hospital, is compelled to shut down. For this operation, the coil of the relay serving the Residential feeder is energized to trip it. Now, the prototype only runs the Hospital and Industrial feeders. It may occur that the total load current is reduced and the transformer may be capable to serve a larger current. In that case, the feeder which was shut down recently, is brought back into service. Or it may have a possibility of exceeding the current beyond limit; in that case, the Hospital feeder will be tripped.

In the former case, if the current reduces below 3A, the feeder which was tripped recently, i.e. the Residential feeder is turned on again by the micro controller sending active low signal to the ULN2003 relay driver. As a result, the relay coil is de energized. The process is again the same for turning on the relays. The current sensor senses the ac current below 3A, and communicates with the micro controller ATmega16. The micro controller commands the relay driver to bring back the Residential feeder back in service, by supplying 0VDC i.e active low to de energize the relay coil. Further, as stated, the current is monitored continuously. Yet the transformer being capable of serving the load, then the lowest priority feeder Agricultural or simply AG is turned on through the ULN2003.

The latter case is very rare that the two higher priority feeders demand a current greater than the rated current of the Low Voltage side of the distribution transformer. But in case it occurs, the feeder, the relay in case of the project, may be tripped. It is possible that due a fault condition, in spite of cutting down all the feeders save the Industrial one, that the current still has a larger value, that the transformer is incapable of serving it, then the Industrial feeder is also compelled to shut down and the officials have to work on it. The prototype, can demonstrate the over current condition only in the Industrial load simulating a fault, and relay will trip the load consequently.

This procedure continues in the system, load being handled efficiently. Thus, we can have a reliable system to serve the consumer with so less an interruption possible. In addition to this, the current system compels the officials to cut down the system more than once in a day. The transformer pulls in a great amount of magnetizing current during starting. It is about 7-8 times the full load current. The frequent over current during starting may damage not only the transformer but also the accessories like the CT, PT, Circuit Breakers, Lightning Arrestors, Current measuring devices, etc. This leads to reduced life of the transformer. The project ensures the continuity in the system and prevents the transformer to be tripped in a day. By this project, the transformer may not serve its purpose for more than its life, but it certainly serves not less than its life.

Keeping in view all these advantages, the consumer side also benefits with continuity of power supply. Especially the industrial sector benefits with this continuity, as the production line does not halt at all. Hence, the material and economic loss is very low, increasing their profits and quality of the product.

The hospitals are also benefited by this management of power, as they lie in higher priority feeders. The hospitals possess large amount of refrigeration products such medicines, and other drugs. The refrigeration is only attained by the availability of power supply. It is again not a good sign to cut down its power supply. Hence, the project proves beneficial to hospitals as well.

Most of the residential consumers have fuses as to protection schemes. These fuse elements melt in case over currents. Switching frequently increases the danger of surge currents damaging the fuse elements. With reduced switching operation, the surge current may be reduced and also protect the system.

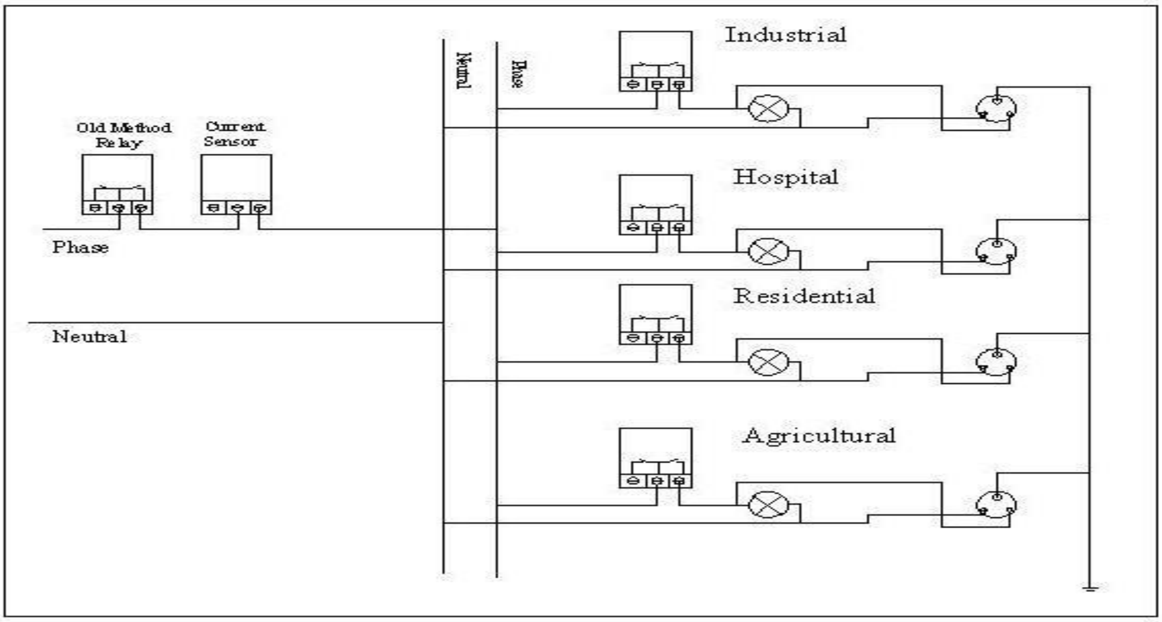

Fig.2 Relay connections

III. TEMPERATURE CONTROL

The transformer oil is a major component of the power system responsible for maintaining the temperature within safe limits. Currently, the Buchholz relay is deployed to prevent the transformer from overheating. The Buchholz relay uses a mercury switch which is light in weight. When the oil temperature exceeds, as it happens with all physical materials, it is converted into gaseous vapour. The vapour of the oil has lesser weight than the liquid oil. As a result, it is lifted due to gravitational force and it hits the mercury switch. The mercury switch closes a circuit and sounds an alarm to be noticed by the concerned officials. The officials take relative action. But in some cases, action is not taken or ignored. If the oil temperature still shoots up, then the vapour droplets become lighter than the previous condition. The vapour, further, is lifted due to lesser weight. It hits another mercury switch, to close the trip circuit this time. The system is shut down awakening another alarm of disoperation.

However, the conventional method, too, causes frequent interruptions in power delivery. In another cases, the remotely located distribution transformers are ignored till the time that oil temperature is heated to a value enough to burst up the transformer.

It is evident due to any disoperation that the oil temperature may exceed beyond its permissible limit. At the Lonikand substation, one such singular incidence took place, where the oil temperature overheated only to burst the power transformer and about 78000 litres of oil spilled over the yard premises.

To prevent this type of accidents, cooling fans are used to maintain the temperature. The oil is circulated in and out of the radiator and the heat is expelled in the atmosphere, keeping the transformer temperature in limits. But, the number of cooling fans used is fixed, and they are continuously in operation to bring down the temperature. Sometimes, the temperature falls down below the safe limit and there is no need of using all the cooling fans.

As it is a prototype, the temperature limit is kept as low as possible. It is prescribed to be below 60 degrees. When the temperature exceeds the prescribed limit, the cooling fan is signalled by the micro controller to operate. The microcontroller supplies +5V signal to ULN2003. With this, the coil of the temperature relay is energized to close the contact of the relay. The closed contact switches on the fan. The cooling fan is operated through a similar relay that in conventional method and is mounted on the Relay Board II. When the temperature further increases, the number of cooling fans in operation is increased step-by-step. (Only one fan is shown in the prototype but the system may have more than one).

With decrease in the oil temperature, the required number of cooling fans in operation is brought down. The prototype displays only one fan and with decrease in the temperature it is switched off.

The conventional Buchholz relay trips the whole circuit, as mentioned earlier, cutting down the whole system. This causes interruption. But the temperature control in the project, offers continuous operation of the system without any interruption. It also leads to enhance the operation of transformer. This increases its life. Again, as mentioned in the earlier articles, the reliability increases remarkably.

IV. ADVANTAGES

1. With this, the stability and reliability of the power system increases.
2. The project offers protection to the power transformer as the load and oil temperature is monitored continuously, controlling simultaneously.
3. The voltage regulation of the system is efficiently maintained.
4. The life of power transformer increases, leading to lower maintenance cost of the machine.
5. The efficiency of the power system increases.
6. By application of the project, it becomes economical both to the distribution company and the consumer.
7. The power consumed by the cooling fans is less as the fan is switched when not required.

V. CONCLUSION

This project has proposed one step ahead towards Smart Grid system. The reliability on the power system increases allowing optimum use of power. Also the faults occurring in the system would reduce considerably. The life of transformer increases. With this it offers lesser chances to damage of transformer. The system regulation is maintained.

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