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Original Article

132 KV Grid Station Larkana Site Pakistan-A Comprehensive Study

Abdul Hameed Soomro[1], Saeed Ahmed Shaikh[1], Zahoor Ahmed Baloch[2], Hina Solangi[3], Aneesa Naz[3] & Dur e Shah Warana[3]

[1]Department of Electrical Engineering, The University of Larkano, Sindh - Pakistan
[2]Department of Electrical Engineering, BUET Khuzdar, Balochistan – Pakistan
[3]Undergraduate Students, Department of Electrical Engineering, The University of Larkano, Sindh – Pakistan

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Abstract

Electrical power system consists of generation, transmission, and distribution system. The grid station is a link between power generation and area where power is distributed. Numerous equipments are available in grid station i.e. isolators, circuit breakers, earth switches, lightning arresters, relays, capacitor banks, and power transformers. Grid Station of 132 KV is located at Larkana site Pakistan at a distance of 3 Kilometers from QUEST campus to supply electricity to the industrial, commercial, and residential consumers for utilization. Faults are mainly occurring on the power system which badly affects the performance of equipment and give revenue loss. Grid station housed very expensive equipments so, protection is necessary due to otherwise equipment may damage or fail due to flow of massive currents during fault condition. Protection in grid station increases the reliability and revenue of the utility company. In Larkana site grid station, different protective devices are used to protect the equipment against faults. Power transformer is the essential component of grid station which provides power to the consumers for utilization. In this study the essential components of 132 KV Larkana grid station are discussed and performance of Instantaneous over current relay is analyzed through MATLAB Simulink Software for the protection of 11KV feeder..

Keywords: Grid station, Power Transformer, Instantaneous Over-current Relay

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INTRODUCTION

Electrical power system consists of Power generation, transmission, and distribution system (Lai, et al., 2021). The grid station is a link between power generation and area where power is distributed (Bagdadee & Zhang, 2022). Several equipments are available in grid station i.e. isolators, circuit breakers, earth switches, lightning arresters, relays, capacitor banks, and power transformers (Colak, et al., 2020). Grid station of a 132 KV is located at Larkana site in Pakistan at the distance of 3 Kilometers from The University of Larkano to supply electricity to the industrial, commercial, and residential consumers for utilization (Alzakkar, et al., 2022). A 132KV is supplied to the grid station Larkana through the main city grid station and Nasserabad grid station. The lines are connected to the line bay which consists of isolators, current transformers, and circuit breakers (Raza, et al., 2022). Bus-bar also contains potential transformers, current transformers, circuit breakers, isolators, and power transformers (Aman, et al., 2022). The 132KV is stepped down to 11kv through a power transformer and 6 feeders of 11KV are taken out and distributed in the areas of Larkana city. The switch yard, control room, and batteries room are the interior sections of grid station (El-Hawary, 2014).

Switch yard consists of transformers, bus-bar, and line-bay. The 11 KV feeders are taken from a power transformer through power cables (line-bay) and connected to the busbar. The control room provides assistance to control each section of the grid station, and 11 KV feeders are housed in control room with separate panels which consist of circuit breaker, bus-bar, relay, CTs, power meter, etc. In this grid station the relays are electromechanical and circuit breakers of vacuum type are installed on 11KV feeders. In

*Corresponding Author: Abdul Hameed Soomro , Department of Electrical Engineering, The University of Larkano, Sindh - Pakistan
abdul.hameed@uolrk.edu.pk

control room, two incoming 11 KV busbars are connected through bus-coupler (Kovačev, et al., 2023). Batteries room provides power to the protective system in case of failure of rectifier. It consists of 55 cells of 2V dc are connected in series to get 110V with a specific gravity of 1.22. The rectifier is a device which converts AC-DC power and essential in grid stations because it will supply DC to the load, charge the batteries, and share the load with batteries in case of over loading (Blume, 2016).

The 132KV protection section consists of over-current relay, distance relay, and earth fault relay. Distance relay will operate when impedance of protected zone falls. In this protection, the relays are divided into zones and only a particular relay of zone will operate under fault conditions. Over-current and earth fault relays will operate under phase-phase and phase-ground fault conditions. The auxiliary room is also available which consists of two meters, one meter shows the tape-changing position and other meter shows the transformer temperature (Fazaeli, et al., 2022).

In the 132 KV control room, the AC-DC panel is essential for controlling the grid supply. It consists of two panels, one for AC power and other for DC power control. In AC panel, three meters are installed for three phases and voltmeter and KWH meter. The AC panel control the power of switch yard, tap-changer, battery charger, transformer cooling fans, and control panels. The DC panel consists of DC voltmeter and ammeter which provide the control to the control room light and relay panels (Adefarati, et al., 2014).

In Larkana 132 KV grid station, the different protection schemes are installed to protect the equipment from possible faults. The differential relay is supported with CTs to protect the power transformer when vector difference between two same electrical quantities exceeds from predetermine values. The Buckholz relay is installed for the protection of power transformer against the slow-developing faults inside the transformer tank. Distance relay is installed at 132 KV to provide protection when the impedance of protected zones falls from pre-determined values and over-current and earth fault relay provide protection against phase-phase and phase-ground fault. On the 11KV side, electromechanical relays are installed on each feeder separately and on 132 KV side SF6 circuit breaker is installed to break the circuit manually or automatically because such breaker is more suitable for higher voltages due to superior arc quenching medium. On the 11KV side vacuum circuit breaker is installed on each feeder due to several advantages on low voltage side. The valve type lightning arrestor is installed to conduct the high voltage surges and provide path to ground and capacitor banks are installed to improve the power factor (Brunello, et al., 2003).

In this research study, an instantaneous over current relay is proposed and performance is analyzed with 11 KV feeders under three-phase fault condition through MATLAB Simulink software. The one line diagram of 132 KV Larkana is shown in figure 1. The units sent and received from January 2022 to July 2022 and the maximum load on different feeders are tabulated in Tables 1and I and II.

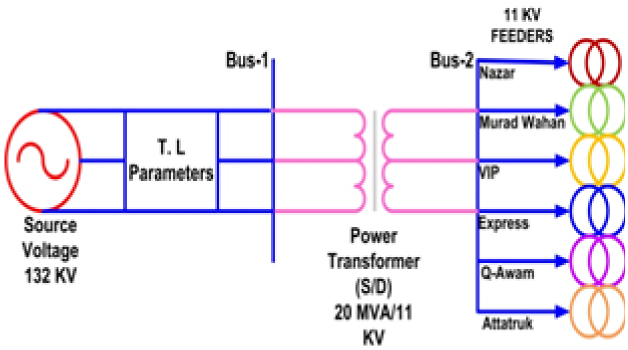

Fig. 1. Single line diagram of grid station Larkana

Table I

Units received and sent out of incoming feeders

Month	Received	Sent out	Difference	Losses
Jan-22	3006320	3019332	-13012	-0.43%
Feb-22	2486040	2480114	5926	0.23%
Mar-22	4336600	4362672	-26072	-0.60%
Apr-22	6548150	6591526	-43376	-0.66%
May-22	8732900	8798010	-65110	-0.75%
Jun-22	8064450	8121700	-57350	-0.71%
Jul-22	8460030	8463155	-3125	-0.04%

Table II

Max load in ampere of outgoing feeders

Month	VIP	Express	M-Wahan	Nazar	Ataturk	Q-Awam
Jan-22	70	70	190	230	160	45
Feb-22	60	80	190	230	100	60
March-22	100	130	360	370	200	70
April-22	180	160	390	400	310	40
May-22	200	200	400	400	370	40
June-22	190	220	390	390	380	100
July-22	190	210	390	400	380	160

POWER TRANSFORMER

The power transformer is the key component of grid station which steps down the higher voltages to lower voltages and uses the magnetic induction process to step down the voltages because of number of turns on both sides (Pihler, et al., 1997). A power transformer with a 20 MVA rating is installed at the Larkana site grid station. The main parts of a power transformer are conservator, main tank, bushings, fan, tape changer, fins, breather, core, and windings. A conservator is a sort of drum mounted on the top of the transformer tank that provides expansion and contraction of oil. A breather is utilized to absorb the moistures entering in transformer tank and contains silica gel. The radiator tubes are used to reduce the temperature of heated oil. The cooling fans are also fitted near the radiator tubes to cool down the temperature of oil (Paulhiac & Desquiens, 2022).

When the transformer operates continuously, transformer heats up and life and efficiency of the transformer will be reduced, so in the Larkana grid station power transformer is cooled through process of Oil Natural and Air Forced system. The power transformer is shown in figure 2 (Mharakurwa, 2022).

Fig. 2. Power Transformer

The 132 KV Larkana grid station housed a very expensive power transformer and reliability of power depends on this, so protection is very essential for power transformer, following protective devices are installed in Larkana site grid station for the protection of power transformer.

Grounding

Grounding provides protection to humans and also equipment. Mesh of conductors of grounding is installed and also for individual equipment such as circuit breaker, potential transformer, current transformer, etc. The transformer is also grounded having quite impedance. In normal condition only iron loss will occur but in abnormal conditions current will increase which can be reduced by connecting the resistors in series with the neutral circuit (Tenbohlen, et al., 2016).

Protective Relays

The ground over current relay offers protection against line-to-ground faults or double line-to-ground faults, triggering the circuit breaker to isolate the transformer. Meanwhile, the Buckholz relay serves to safeguard the transformer from incipient faults arising internally. Differential relay is deployed to shield the transformer against faults by scrutinizing incoming and outgoing current or voltage levels, and activating both primary and secondary circuit breakers as necessary to prevent damage. Back-up protection is also installed whenever primary protection such as, circuit breakers, and relays fail to trip the circuit or fail to isolate healthy section (Jegarluei, et al., 2023).

Circuit Breaker

A circuit breaker functions as an interrupting mechanism, capable of manually or automatically disconnecting the circuit during both normal operation and fault occurrences. Sulpher Hexa Fluoride gas circuit breaker is installed at the incoming side and Vacuum circuit breakers are installed at outgoing feeders in Larkana site grid station.

Lightning Arrestor

The valve type arrestor is used for a power transformer in Larkana grid station. The surge arresters are installed on each phase with greater height. Two types of lightning arresters are installed on transformers, 132KV lightning arrester and 11KV lightning arrester which arrest the value of currents due to fall of lighting on the power transformer and protect the transformer from any damage. The dielectric strength of a lightning arrester is 132Kv, if voltages increase then it acts as a conductor and provides the path to high voltages to the ground.

Instrument Transformer

The current and potential transformers are instrument transformers and used for system parameters measurement (Kaczmarek & Nowicz, 2010). These instrument transformers step down the high values of current and voltages to make the measurement easy. A current transformer is utilized with relay operation and selected in Larkana grid station is 600/5 rating (Crotti, et al., 2021).

INSTANTANEOUS RELAY

A protective relay is an apparatus designed to identify faults and initiate the activation of a circuit breaker, thereby isolating the affected portion from the system (Abdelmoumene & Bentarzi, 2014). In instantaneous relay, the delay is not provided and when fault occurs it will operate immediately. In this research study, we have proposed the instantaneous operation of relay, so we have selected the over-current instantaneous relay for the protection of 11 KV feeders. The simulation model of instantaneous over-current relay is shown in figure 3.

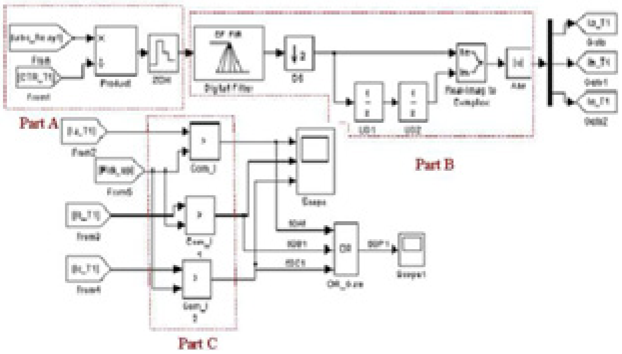

Fig. 3. Simulation model of Instantaneous over-current relay

METHODOLOGY

In this research investigation, MATLAB Simulink software is employed to assess the effectiveness of an Instantaneous over current relay in safeguarding power transformer during fault scenarios. The parameters in table 3 are utilized to get the simulation results of over current protection and simulation model is shown in figure 4.

Table III

Simulation Parameters

S.No	Parameters	Value
1	Voltage Source	132 kV
2	Power Transformer (S/D)	20 MVA/11 kV
3	Line Parameters	R=0.01 Ohm, L= 16.89 e-6 Henry
4	Relay setting	100%
5	Fault time	0.04 Seconds
6	CT ratio	600/5

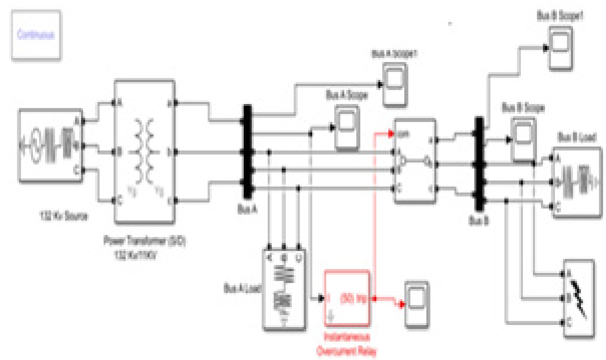

Fig. 4. Simulation model of Proposed System

V. RESULTS & DISCUSSIONS

11 KV Feeder under Normal operating condition

Under normal operating conditions, the relay remains in the OFF state and does not send any signals to the circuit breaker to interrupt the circuit. This ensures the continuous and smooth operation of the power system without unnecessary disruptions. The performance of the system under these normal conditions, specifically the output load voltages and currents, is illustrated in figures 5(a) and 5(b). These figures provide a visual representation of the electrical parameters, demonstrating the stable operation of the grid when there are no faults or abnormal conditions.

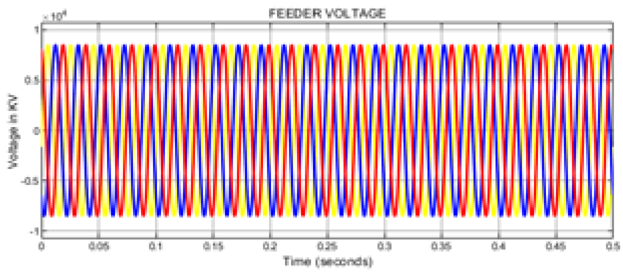

Fig. 5(a) Feeder voltage without fault

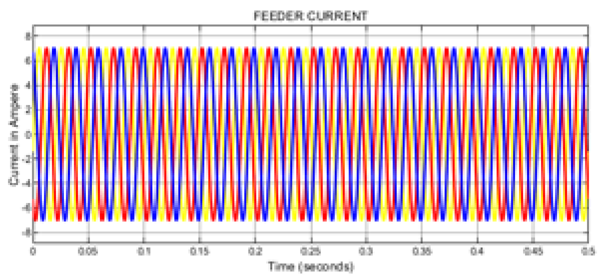

Fig. 5(b) Feeder current without fault

11KV Feeder under three phase fault condition

During the fault condition, a fault occurred in all three phases, causing the relay to initiate switching at 0.04 seconds with a sampling interval of 0.5 seconds. Detailed observations during this event revealed a significant decline in feeder voltage and a substantial surge in feeder current, which increased from the typical value of 7 Amperes to 60 Amperes. This dramatic change is depicted in figure 6(b). The relay responded instantaneously, promptly activating and entering its operational state. Consequently, the relay signaled the circuit breaker to isolate the 11KV feeder from the system, effectively preventing further damage. This critical action is illustrated in figure 6(a), showcasing the relay's effectiveness in protecting the grid equipment during fault conditions.

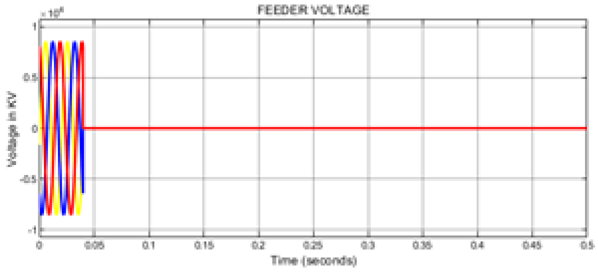

Fig. 6(a) Feeder voltage under three phase fault

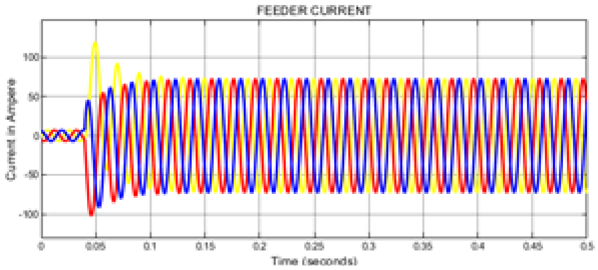

Fig. 6(b) Feeder current under three phase fault

Discussion

The objective of this investigation is to evaluate the effectiveness of protective devices for grid equipment. Ensuring that these devices operate instantaneously during fault conditions is imperative to prevent potential damage. Without protective devices, costly equipment in grid stations could suffer significant harm, leading to substantial financial losses and jeopardizing the reliability of the power supply. The simulation outcomes, which provide detailed insights into the performance and reliability of these protective devices under various fault conditions, are summarized in Table 4.

Table IV

Simulation results

Parameters	Normal condition	Fault condition
Feeder voltage	11 kV	10 Volts
Feeder Current	7 Ampere	60 Ampere

CONCLUSIONS

This research study is carried out through an official visit to 132 kV grid station Larkana site which is located at 3 kM from The University of Larkano. Through this study we have concluded that the grid station is housed with very expensive equipment, so protection is essential for that equipment. When protective devices are not installed then huge financial losses will be faced by utility companies and also reliability of the system will be affected. The power transformer is the key component of grid station so we have analyzed the performance of instantaneous over current relay on outgoing 11 kV feeder then we have seen that the voltage dropped and current increased from normal value, so this will be more harmful for the transformer so protection under fault condition is necessary. The instantaneous over-current relay performs satisfactorily and isolates the 11kV feeder from the power transformer.

Competing Interests

The authors did not declare any competing interest.

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