GPS (Global Positioning System) and its application in protection scheme

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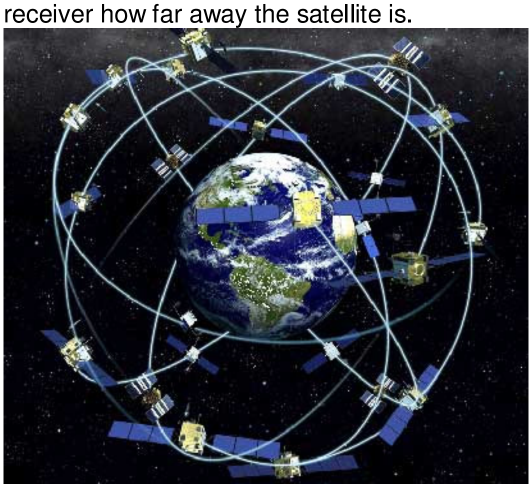
Abstract- This is a new technique for the protection of transmission systems by using Global Positioning Systems(GPS) and fault generated transients .In this scheme the relay contains a full transient detection system together with a communication unit which is connected to the power line through the high voltage coupling capacitor of the CVT(Capaitive Voltage Transformer). Relays are installed at each busbar in transmission network. These detect the fault generated high frequency voltage transient signal and record the time instant corresponding to when the initial travelling wave generated by the fault arises at the busbar. The decision to trip is based on the components as they propagate through the system.
Keywords- GPS, Fault detection, Transient analysis, Transient wave based protection scheme, fault current, signal processing

INTRODUCTION

What is GPS:-The GPS is satellite based navigation system made up of a network of 24 satellites placed into orbit. Current GPS enables users to determine their 3-D(Three Dimensional) differential position, velocity and time. By combining GPS with current and future computer mapping techniques we will be better able to identify and manage our natural resources. GPS satellite circles the earth twice a day and transmits signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is.



Dia. 1

Travelling Wave Fault location

Faults on the power transmission system cause transients that propagate along the transmission line as waves. Each wave consists of several frequency components ranging from a few kilohertz to several megahertz, having a fast rising front and a slower decaying tail. Composite waves have a propagation velocity and characteristic impedance and travel near the speed of light away from the fault location towards line end. They continue to travel throughout the power system until they diminish due to impedance and reflection waves and new power system equilibrium is reached. The faults can be located by precisely time-tagging the wave fronts as they cross a known point typically in substations at line ends. Accuracy of 300 m can be obtained with time tagging the waves with a resolution of 30m. Fault location can then be obtained by multiplying the wave velocity by the time difference in line ends. The master station performs the task of time data collection and calculation.

DETECTION UNIT

Detection of fault current and current transients:-During a fault on the transmission line wide band voltage and current waves travel throughout the transmission line away from the fault point. When these signals reach discontinuities on the transmission line some of the signals are reflected back towards the fault point. The characteristics of these waves are determined by several factors such as position of fault on the line, fault path resistance and the characteristic impedance of the transmission line. Relays located at each substation in the power system independently monitor the power system. The frequency range for monitoring these fault generated high frequency signals is between 40-80 KHz and the signal processing unit is designed accordingly to detect the arrival of a high frequency transient characteristic of those generated by a fault. At these frequencies , bus bars are dominated by their capacitive elements , and as a result, the incoming high frequency current signal is both inverted and reflected .A resistive fault in this frequency range will also reflect a current wave of the opposite polarity.

Fault current transient detector

A specially designed transient current detector fed from the primary CTs(Current Transformers) is employed which extracts high frequency signals associated with the fault generated current transients. A simplified block diagram of the detector arrangement is shown in the figure (1).The circuit comprises of an analogue input circuit for signal conditioning and a digital circuit for determining the transients. Particular emphasis has been placed on the development of digital circuit. The detector is designed to interrogate signals in the range of frequencies from 40-80KHz. Analog circuit extracts the band of fault generated transient current signal from the line by acting as a band pass filter. As a result, the response of the scheme is not affected by the power frequency short circuit band at the busbar or the precise configuration of the source side networks.

Signal Processing unit

The signal is decoupled into its respective aerial modes by using model transformation. The signal mixing circuit is fed from the 3 phase CTs continue to form mode2 and mode3 signals. There are filters to remove any spurious noise. The outputs of the analog circuit are then passed to the digital circuit. The sampling frequency of the analog to digital A/D converter is 1 MHz and the speed of propagation of the high frequency transient is similar to the speed of light. The digital processing unit includes filters sequence recording, ampldoitude comparison, counters and decision logic.

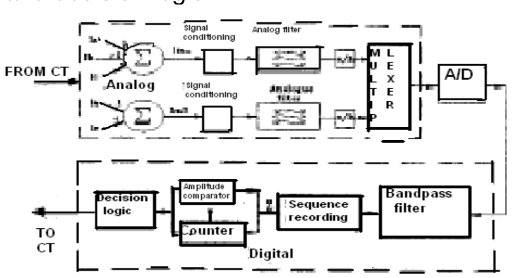


fig-1

BLOCK DIAGRAM OF HIGH FREQUENCY FAULT DETECTOR UNIT

PRINCIPLE AND DESIGNING

Basic principle and relay design:- A short circuit fault on a power transmission line generates voltages and current signals of several frequency range which propagate away from the fault point in both directions along the transmission system with velocity close to the speed of light. It has been long recognized that the actual faulted position can be determined on line if the transient signals are time tagged at key points on the power system network. The global positioning system, with its ability to provide synchronization with an accuracy of microsecond over the wide area, provides an ideal tool for performing time tagging of the fault generated transients.

Basic Principle:-The basic principle of the technique can be demonstrated by referring to the 400KV, EHV(Electrical High Voltage) transmission network, shown in figure(2). Relays are installed at the bus bars P,Q,R and S and are responsible for the protection of the network . The protection of the network PQR and tripping of the breakers associated with that network is studied. High frequency signals are generated at the fault point and travel outward from that point along the network conductors. In time they reach the monitored bus bar are detected by the relays connected to them. Each relay record the arrival instant of the signal generated by the fault. The recorded arrival instant is then code with details of their identification by the relays and transmits this to their neighboring relays. All relays are continuously ready to receive the coded messages send by other devices. Data protocols are used to avoid conflict between information sent by different devices along the same line. The relays compare the fault transient arrival time recorded at its sight with those send by other relays and determine whether the fault is within the protected zone. Appropriate tripping instructions are then send to the relevant local circuit breakers. The actual location where the fault occurs can be clearly identified at each relay location by this method.

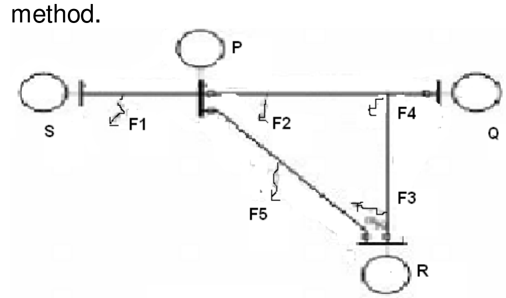


fig-2

transmission network

Relay design:- A simplified block diagram of the relay unit is shown in fig(3). Three CVTs connect the transient detector unit to the line and detect the voltage signal level. The communication unit also uses CVTs and a hybrid unit to connect the two circuits i.e., Transmitter and Receiver circuits.

The transient detector is used to detect the fault generated signals and to record the time tag obtained from the GPS receiver. All the relays connected to the system receive this time tag information from the transmitter circuit. Previous research has investigated the use of digital filters to detect the high frequency signals generated by the fault and had shown that the accuracy of fault location was a function of the sampling rate used to digitalize the measured signal. The accuracy was directly related to the sampling rate and higher the sampling rate, the more accurate the measureme. Hence continuous sampling has an upperhand i.e., an analog system and a pass band filter tuned to operate between 40 and 80 KHz. The protection technique is therefore divorced from the power system frequency. The decision to trip the local breaker depends on the comparison between the times measured by the GPS system at that location and those measured by other relays. Unlike the conventional protection scheme, where each relay associates with one circuit breaker on that line section, this relaying scheme protects several lines connected to the bus bar where it is installed. For e.g., as shown in fig. the relay at bus bar "R" responsible for the protection of both line section , connected to the busbar, by controlling both circuit breakers CB-RP and CB-RQ. Therefore the technique offers a network protection scheme rather than than one which concentrates on specific units of plant. This provides several technical advantages over conventional relaying [1].

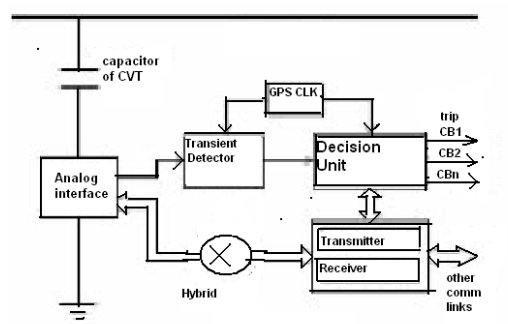


fig-3

Block diagram of relay unit

CONCLUSION

The positional protection using GPS is a high speed protection system and offers a high accuracy in fault location. The protection system monitors the network to which it is connected and is not limited to individual unit plant as in traditional protection scheme.

ABBREVIATIONS

GPS- Global Positioning System
CVT-Capacitive Voltage Transformer
3-D- Three Dimensional
KHz-Kilo Hertz
CT- Current Transformer
A/D Convertor- Analog to Digital Convertor
MHz- Mega Hertz
KV- Kilo Volt
EHV- Extra High Voltage
CB- Circuit Breaker
GPS CLK – Global Positioning System Clock

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