Signal conditioning analog to digital conversion computer science essay

Technology, Information Technology

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Abstract: Numerical protection relays (IED) are used in electrical protection for detection of fault condition. The IED analyzes Current & Voltage signal in the electrical system, and derives fault condition based on the output obtained by analysing the signals. For analysing the signal we perform FFT on the signal. The output of FFT is used and using various algorithms fault condition will be detected. This paper describes a method to use numerical protection as power factor controller. A power factor controller provides control output to maintain the power factor in an electrical system to unity. To provide this control output PF controller analyses the current and voltage waveforms of electrical system. Since this is the same voltage and current waveform which are being analysed by numerical protection relay, and since these IED’s have higher processing capacity we can built the power factor control algorithm within the IED. This method will help us reduce parallel

processing of same data and thereby reducing the cost of the system by simply adding some software features. Key Words: Numerical Protection Relay, Power Factor Controller, FFT

INTRODUCTION

This discussion in this paper is based upon how a data processed by numerical protection relay can be effectively used as power factor controller. This paper here discusses power factor control mechanism only for distribution. So we will restrict ourselves only for distribution segment. A numerical protection relay which is used in control system for electrical transmission and distribution has voltage and current as signal inputs. Both these signal are obtained from the transmission or distribution line. These signals are first signal conditioned by an analog circuitry for removal of noise and other unwanted interferences. Now using a DSP (digital signal processor) we have to perform FFT on all the signals. We will get real and imaginary terms as output of FFT. From these terms we can find the magnitude and phase of each of these current and voltage signal. This data can now be used for calculation of power such as KW, KVA, KVAR, KWH and PF. One of these parameters is power factor (PF) which is crucial for our analysis. This power factor is then used for controlling the capacitor bank switching to maintain the PF of the system to unity. Thus we are using the data processed by a numerical protection relay for power factor control. The complete system is divided into three steps: Signal conditioning & analog to digital conversion. Performing FFT on all the signals. Using the output of FFT for power factor control algorithm. SIGNAL CONDITIONINGSignal conditioning is hardware module which is built inside the numerical protection relay. This hardware

part is responsible for converting incoming current/voltage signal to appropriate voltage levels so that it can be digitized. Also the signal conditioning circuit takes the responsibility of reducing the noise and other interferences which can distort the incoming signal. The signal conditioning circuit should be designed in such a way that it will pass the required harmonic content involved in signal processing and bypass the rest. Usually up to 15th harmonic is passed and above these are attenuated.

PERFORMING FFT

Usually a digital signal processor is used for performing FFT on the incoming signals. Depending upon the requirement of how much harmonic content is to be extracted from the signal the samples are taken. Again here we will consider a distribution electrical system, harmonic content up to 15th is considered. To achieve this we will have to take a 32 point DFT of the signal. The DFT can be calculated using the following formulaDFT Equations(1)(2)Using the above mentioned equation we will real and imaginary terms in frequency domain. It can be graphically represented as followsFigure 1. Conversion from time domain to frequency domainSo we will have N/2 real & imaginary terms. The magnitude and phase of the corresponding signal can be calculated by the following equation(3)(4)Here frequency domain terms represent the fundamental quantity and the harmonics. The 0th term will represent the DC shift of the signal. The 1st term will represent the magnitude of the signal and remaining terms will represent the harmonic content.

POWER FACTOR

Power factor in an electrical system is defined as ratio of real power flowing to load to apparent power. Power factor has no unit. In any system it is desirable to have power factor of unity. But it is not case practically. For an inductive current lags and for capacitive load current leads. Usually in electrical system such as distribution the load is inductive. So depending on how much inductive load is present, capacitive banks are added in parallel to the load so that power factor can be maintained to unity. By doing so we reduce the losses in the system and hence increasing the efficiency. As discussed earlier we have real & imaginary terms of all current and voltage signals. The power calculation can be done as follows$\bar{S}$ = $\bar{V}$r . $\bar{I}$r* + $\bar{V}$y . $\bar{I}$y* + $\bar{V}$b . $\bar{I}$b* (5)Here$\bar{S}$ = Three phase power$\bar{V}$ = Respective line voltage. $\bar{I}$* = Complex conjugate of respective Line currentFrom the above mentioned formula we will have three phase power of the system. But in order to calculate the power factor we need to calculate real and apparent power. It can be done using the following formula. P = real ($\bar{S}$) - Real power(6)Q = Imag ($\bar{S}$) – Apparent power(7)Now power factor can be calculated asPF = P/S – three phase power factor.

NUMERICAL PROTECTION RELAY

All the above mentioned formulas and procedure is already being calculated by numerical protection relay in electrical system. As can be seen these are the exact calculation required by the power factor controller. So instead of recalculating the same output in another device we can use calculation for control output. A numerical protection relay has a lot of processing capacity.

This processing capacity can be utilized for building control algorithm within itself. Thus we can have the capacitor bank switching output directly from numerical protection relay. Also there is enough communication capability in the IED (numerical protection relay) such as Ethernet, Fiber optic. These are very high speed communications, which can be utilized to take the real time power data from the device. This data in turn is utilized by control algorithm build in another device directly. In both the case we can save hardware cost. If the first solution is exploited, we can have use the Ethernet communication of the protection to some other purpose, such as web communication. By doing so we can have all the real time power data and power factor control and switching history available on internet. This capability opens a lot of topics for discussion as how the available data can be used, which is beyond the limit of this paper.

PROCEDURE

The processing capacity of numerical protection relay has to be utilized at the most by using the following procedureThe whole system is has two devices which perform the same calculation on the same signal. Select a device with communication and processing capacity to perform the calculation in our case numerical protection relay. Calculate the required data and use the same for other device’s operation. In our case for power factor control algorithm. Build the power factor control algorithm within the numerical protection relay. If not possible transfer the processed data by communication and just build the control algorithm elsewhere.

CONCLUSION

From this we have analyzed that a numerical protection relay with higher processing capability can be used as power factor controller. By constructing a power factor controller algorithm within the numerical protection relay we have utilized the processing capability for maintaining the overall system power factor. Also we have reduced the system complexity and cost. As complexity has reduced we can some more features from the same system such as providing a web server application within the IED and get all the information on the internet.