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A Practical approach for fault component network for Current and Voltage Phasor Diagram in Power Electronic Environment

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Abstract

In many large-scale power plants, the structure of its auxiliary power system is complex, and the coordination of its relay protections is difficult. To enhance power supply reliability for the user terminals in the case of the distribution system to avoid interference by the fault again, rapidly complete the automatic identification, positioning, automatic fault isolation, network reconfiguration until the resumption of supply of non-fault section, a microprocessor-based relay protection device has developed. As the fault component theory is widely used in microcomputer protection, and fault component exists in the network of fault component, it is necessary to build up the fault component network when short circuit fault emerging and to draw the current and voltage component phasor diagram at fault point. We proposed a special phase sequence component based on the boundary condition. We analysis the velocity according to the relationship between analysis formula and phasor diagram and current in fault component boundary conditions and sequence voltage and current in boundary conditions. The negative and zero sequence component current and voltage at fault point are the same as fault component. The positive sequence component current and voltage at fault point are different from the fault component. So we consider the positive sequences according to that sequences we analyze the fault point.

Keywords

Data Mining, Concept Lattice, Attribute Reduction, Close-degree

1. Introduction

In some medium voltage distribution lines and almost all high voltage transmission lines, a fault can be in two different directions from a relay, and it can be highly desirable for a relay to respond differently for faults in the forward or reverse direction. The IEEE device number used to signify a directional element is either a 21 (impedance element, based on Z=V/I, and having a distance to fault capability) or a 67 (directional over current, generally based on the phase relationship of V and I, with no distance to fault capability). With the development of power electronic technology and the relatively high switching frequency of Pulse Width Modulation (PWM), HVDC transmission system based on Voltage Source Converters (VSCs) has taken on some excellent advantages. The new VSC-HVDC system known as “HVDC Light” or “HVDC Plus” [1,2] by leading vendors, has been applied in several special occasions such as the connection of off-shore wind farms or oil drilling platforms into the mainland electrical network and for underground transmission or distribution systems within congested cities. The differences in structure between the two types of converters (Conventional HVDC and VSC-HVDC) contribute to the differences in their performance. Generally, the new transmission technology has the following advantages compared with conventional, thyristor based HVDC [3-5]:

- Possibility to control the reactive power (consumed or generated by the converter) independently of the active power (to or from the converter).
- No risk of commutation failures in the converter.
- Ability to connect to weak AC networks, or even dead networks.
- Faster response due to increased switching frequency (PWM).
- Minimal environmental impact.

However, VSC transmission does have some disadvantages, which include potentially high power losses and high capital costs when compared with conventional HVDC, but the technology continues to evolve.

Reliable electrical energy transmission and supply is the purpose of the Power System operation. Faults occur inevitably especially when the system is large scale. And transmission lines are the common parts of power system where the faults are mostly likely to happen [6]. When faults occur, they must be removed immediately. Because long distance high-voltage transmission lines may produce many problems for the protection relays ensuring a proper function, and the performance of these protections are influenced by many factors. The notion of overcoming the mentioned problems together with the desire to reduce fault-clearance time for more stability and safety of power system has brought about the development of traveling wave protection [7].With the electric power system automation technology development and a large number of microprocessor-based protection devices put into use, the power system have higher requirements of microprocessor based protection, and because of the particularity of the power system itself, it needs to microprocessor-based protection device has strong real-time, high reliability and scalability, enhanced network communication capability and a more friendly interface, powerful man-machine interaction.

We provide here an overview of electric automation system services. The rest of this paper is arranged as follows: Section 2 introduces AC Inductance; Section 3 describes Phasor Diagram; Section 4 shows the evolution and recent scenario; Section 5 describes the proposed method. Section 6 describes Conclusion and outlook.

2. AC Inductance

Inductors store their energy in the form of a magnetic field that is created when a DC voltage is applied across the terminals of an inductor. The growth of the current flowing through the inductor is not instant but is determined by the inductors own self-induced or back emf value. Then for an inductor coil, this back emf voltage V_L is proportional to the rate of change of the current flowing through it. This current will continue to rise until it reaches its maximum steady state condition which is around five time constants when this self-induced back emf has decayed to zero. At this point a steady state DC current is flowing through the coil, no more back emf is induced to oppose the current flow and therefore, the coil acts more like a short circuit allowing maximum current to flow through it.

However, in an alternating current circuit which contains an AC Inductance, the flow of current through an inductor behaves very differently to that of a steady state DC voltage. Now in an AC circuit, the opposition to the current flowing through the coils windings not only depends upon the inductance of the coil but also the frequency of the applied voltage waveform as it varies from its positive to negative values.

The actual opposition to the current flowing through a coil in an AC circuit is determined by the AC Resistance of the coil with this AC resistance being represented by a complex number. But to distinguish a DC resistance value from an AC resistance value, which is also known as Impedance, the term Reactance is used. Like resistance, reactance is measured in Ohm's but is given the symbol X to distinguish it from a purely resistive R value and as the component in question is an inductor, the reactance of an inductor is called Inductive Reactance, (X_L) and is measured in Ohms. Its value can be found from the formula.

Inductive Reactance

$$X_L = \omega L = 2\pi f L$$

Where: X_L is the Inductive Reactance in Ohms, f is the frequency in Hertz and L is the inductance of the coil in Henries. We can also define inductive reactance in radians, where Omega, ω equals $2\pi f$. So whenever a sinusoidal voltage is applied to an inductive coil, the back emf opposes the rise and fall of the current flowing through the coil and in a purely inductive coil which has zero resistance or losses, this impedance (which can be a complex number) is equal to its inductive reactance. Also reactance is represented by a vector as it has both a magnitude and a direction (angle). Consider the circuit below.

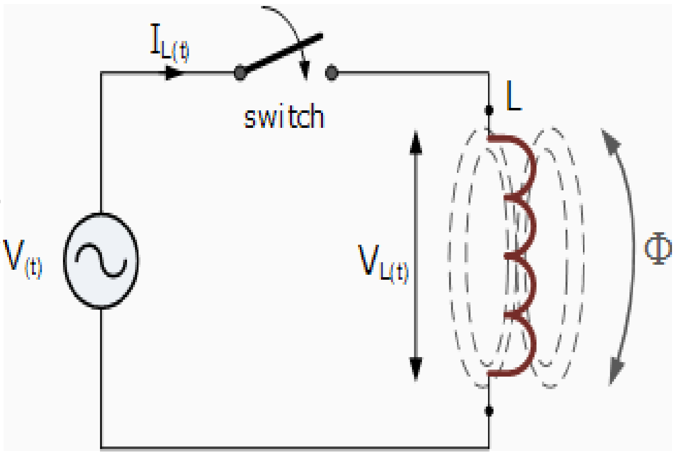

Fig 1: AC Inductance with a Sinusoidal Supply

This simple circuit above consists of a pure inductance of L Henries (H), connected across a sinusoidal voltage given by the expression: V (t) = V_{max} sin ωt. When the switch is closed this sinusoidal voltage will cause a current to flow and rise from zero to its maximum value. This rise or change in the current will induce a magnetic field within the coil which in turn will oppose or restrict this change in the current. Before the current has had time to reach its maximum value as it would in a DC circuit, the voltage changes polarity causing the current to change direction. This change in the other direction once again being delayed by the self-induced back emf in the coil, and in a circuit containing a pure inductance only, the current is delayed by 90^o.

The applied voltage reaches its maximum positive value a quarter ($1/4f$) of a cycle earlier than the current reaches its maximum positive value, in other words, a voltage applied to a purely inductive circuit "LEADS" the current by a quarter of a cycle or 90^o as shown below.

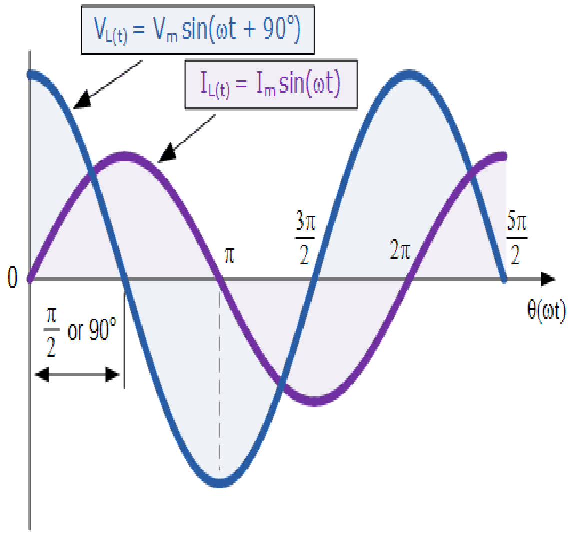

Fig 2: Sinusoidal waveform

3. Phasor Diagram

The phase of the voltage across a purely reactive device (a device with a resistance of zero) *lags* the current by $\pi/2$ radians for a capacitive reactance and *leads* the current by $\pi/2$ radians for an inductive reactance. Note that without knowledge of both the resistance and reactance the relationship between voltage and current cannot be determined.

The origin of the different signs for capacitive and inductive reactance is the phase factor in the impedance.

$$\tilde{Z}_C = \frac{1}{\omega C} e^{j(-\frac{\pi}{2})} = j\left(\frac{-1}{\omega C}\right) = -jX_C$$

$$\tilde{Z}_L = \omega L e^{j\frac{\pi}{2}} = j\omega L = jX_L$$

For a reactive component the sinusoidal voltage across the component is in quadrature (a $\pi/2$ phase difference) with the sinusoidal current through the component. The component alternately absorbs energy from the circuit and then returns energy to the circuit, thus a pure reactance does not dissipate power.

This effect can also be represented by a phasor diagram were in a purely inductive circuit the voltage "LEADS" the current by 90°. But by using the voltage as our reference, we can also say that the current "LAGS" the voltage by one quarter of a cycle or 90° as shown in the vector diagram below.

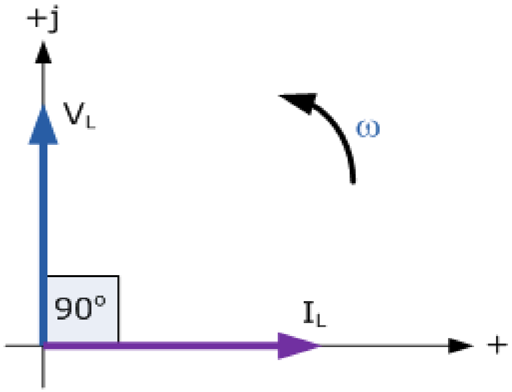

Fig 3: Phasor Diagram for AC Inductance

When a 50Hz supply is connected across a suitable AC Inductance, the current will be delayed by 90° as described previously and will obtain a peak value of I amps before the voltage reverses polarity at the end of each half cycle, i.e. the current rises up to its maximum value in "T secs". If we now apply a 100Hz supply of the same peak voltage to the coil, The current will still be delayed by 90° but its maximum value will be lower than the 50Hz value because the time it requires to reach its maximum value has been reduced due to the increase in frequency because now it only has "1/2 T secs" to reach its peak value. Also, the rate of change of the flux within the coil has also increased due to the increase in frequency.

Then from the above equation for inductive reactance, it can be seen that if either the Frequency OR the Inductance is increased the overall inductive reactance value of the coil would also increase. As the frequency increases and approaches infinity, the inductors reactance and therefore its impedance would also increase towards infinity acting like an open circuit. Likewise, as the frequency approaches zero or DC, the inductors reactance would also decrease to zero, acting like a short circuit. This means then that inductive reactance is "directly proportional to frequency" and has a small value at low frequencies and a high value at higher frequencies as shown.

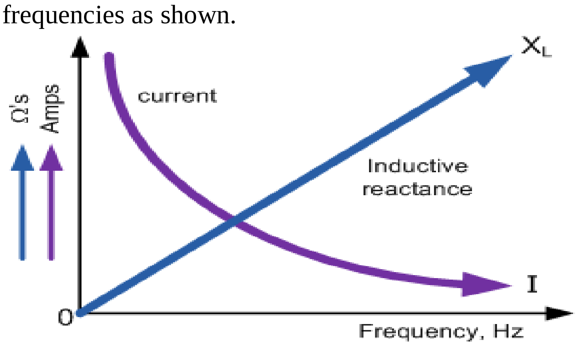

Fig 4: Inductive Reactance

The inductive reactance of an inductor increases as the frequency across it increases therefore inductive reactance is proportional to frequency ($X_L \alpha f$) as the back emf generated in the inductor is equal to its inductance multiplied by the rate of change of current in the inductor. Also as the frequency increases the current flowing through the inductor also reduces in value.

4. Evolution and Recent Scenario

In 2010, Yawen Yi et al. [8] introduce the operation mode of auxiliary system in the Three Gorges Hydropower Plant, and some representative problems about the coordination of relay protection are raised and solved successfully.

In 2010, Gaohua Liao et al. [9] observe to enhance power supply reliability for the user terminals in the case of the distribution system to avoid interference by the fault again, rapidly complete the automatic identification, positioning, automatic fault isolation, network reconfiguration until the resumption of supply of non-fault section,a microprocessor-based relay protection device has developed. By use of DSP, device operating realize the real-time measurement, calculation and display for parameters, a combination of difference method with Fourier transform algorithm realize the relay protect for distribution power lines. Sensitive and reliable reflection of the various lines of work and under normal circumstances in non-rapid start to issue warning signal or protection actions in export tripping circuit so that line to security, economic to run.

In 2010, Enrique Reyes-Archundia et al. [10] presents the applications of the Wavelet Transform (WT) for analyzing fast transient signals originated from fault events in power grids with presence of power electronics-based controllers and its protective devices. The study cases included emphasizes the wavelets ability to discriminate signals originated by the fault events from those injected by power controllers, like the TCSC and its associated protection, the MOV, and determine location and electrical distance of the fault to a reference point.

In 2011, Wang Jihong et al. [11] observe that the fault component theory is widely used in microcomputer protection, and fault component exists in the network of fault component, it is necessary to build up the fault component network when short circuit fault emerging and to draw the current and voltage component phasor diagram at fault point. In order to understand microcomputer protection based on the symmetrical component principle, they obtained the sequence current and sequence voltage according to the concept of symmetrical component.

5. Proposed Model

As the fault component theory is widely used in microcomputer protection, and fault component exists in the network of fault component, it is necessary to build up the fault component network when short circuit fault emerging and to draw the current and voltage component phasor diagram at fault point. We proposed a special phase sequence component based on the boundary condition. We analysis the velocity according to the relationship between analysis formula and phasor diagram and current in fault component boundary conditions and sequence voltage and current in boundary conditions. The negative and zero sequence component current and voltage at fault point are the same as fault component. The positive sequence component current and voltage at fault point are different from the fault component. So we consider the positive sequences according to that sequences we analyze the fault point.

Steps:

1) Obtain Boundary Conditions for Fault.
2) To obtain the special phase sequence component according to boundary conditions, then to draw fault component compound sequence network
3) To obtain the relationship between current and voltage fault component phasor diagram.
4) To check the veracity of the analysis according to the relationship between analysis formula and phasor diagram of full voltage and current in fault component boundary conditions and sequence voltage and current in boundary conditions.

Consider the positive values with the boundary conditions because they generate different fault point. Then apply the formula:

The effect of an inductor in a circuit is to oppose changes in current through it by developing a voltage across it proportional to the rate of change of the current. An ideal inductor would offer no resistance to a constant direct current;

However, only superconducting inductors have truly zero electrical resistance. The relationship between the time-varying voltage v(t) across an inductor with inductance L and the time-varying current i(t) passing through it is described by the differential equation:

$$v(t) = L\frac{di(t)}{dt}$$

When there is a sinusoidal alternating current (AC) through an inductor, a sinusoidal voltage is induced. The amplitude of the voltage is proportional to the product of the amplitude (I_P) of the current and the frequency (f) of the current.

$$i(t) = I_P \sin(2\pi f t)$$

$$\frac{di(t)}{dt} = 2\pi f I_P \cos(2\pi f t)$$

$$v(t) = 2\pi f L I_P \cos(2\pi f t)$$

In this situation, the phase of the current lags that of the voltage by π/2.If an inductor is connected to a direct current source with value I via a resistance R, and then the current source is short-circuited, the differential relationship above shows that the current through the inductor will discharge with an exponential decay:

$$i(t) = Ie^{-(R/L)t}$$

Laplace circuit analysis (s-domain)

When using the Laplace transform in circuit analysis, the impedance of an ideal inductor with no initial current is represented in the s domain by:

$$Z(s) = Ls$$

Where L is the inductance, and s is the complex frequency.

If the inductor does have initial current, it can be represented by:adding a voltage source in series with the inductor, having the value:

$$LI_0$$

or by adding a current source in parallel with the inductor, having the value:

$$\frac{I_0}{s}$$

Where L is the inductance, and

I_0 is the initial current in the inductor.

6. Conclusion

We proposed a special phase sequence component based on the boundary condition. We analysis the velocity according to the relationship between analysis formula and phasor diagram and current in fault component boundary conditions and sequence voltage and current in boundary conditions. The negative and zero sequence component current and voltage at fault point are the same as fault component. The positive sequence component current and voltage at fault point are different from the fault component. So we consider the positive sequences according to that sequences we analyze the fault point. In future we can analyse the aspects with their practical implementations and also the simulation result which shows the advantage graph of our method.

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