DISTRIBUTION SYSTEM ANALYSIS USING METER DATA

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BACKGROUND

Technical Field

[0001] This application relates to electrical system analysis and, in particular, to electrical distribution system analysis.

Related Art

[0002] Phasor data may be used to analyze power systems such as transmission systems. The phasor data may be synchronized allowing various analyses to be completed for conductor lines in the power system using synchronized system data. However, sensors used for obtaining the phasor data may be spaced far apart along conductor lines, which may reduce accuracy in locating a problem with a conductor line based on the phasor data.

SUMMARY

[0003] According to an embodiment, a monitoring system configured to determine at least one phase conductor condition in a distribution system may include a first sensor positioned at a location along a phase conductor line. The first sensor may be configured to generate a first set of synchrophasor data. The monitoring system may include a second sensor positioned at a second location along the phase conductor line. The second sensor may be configured to generate a second set of synchrophasor data. The monitoring system may include a processor configured to receive the first set of synchrophasor data and the second set of synchrophasor data. The processor may be further configured to determine a primary side voltage of at least one distribution transformer electrically connected to the phase conductor based on a secondary side voltage of the at least one distribution transformer. The processor may be

further configured to determine at least one phase conductor condition based on the first set of synchrophasor data, the second set of synchrophasor data, and the primary side voltage of the at least one distribution transformer.

[0004] According to an embodiment, a method of determining at least one condition of a phase conductor line may include receiving a first set of synchrophasor data associated with the phase conductor line. The method may further include receiving a second set of synchrophasor data associated with the phase conductor line. The method may further include determining a primary side voltage of at least one distribution transformer based on a secondary side voltage of the at least one distribution transformer. The method may further include determining the at least one phase conductor line condition based on the first set of synchrophasor data, the second set of synchrophasor data, and the primary side voltage of the at least one distribution transformer.

[0005] According to an embodiment, a computer-readable medium may be encoded with computer executable instructions executable with a processor. The computer-readable medium may include instructions executable to receive a first set of synchrophasor data associated with a phase conductor line and instructions executable to receive a second set of synchrophasor data associated with the phase conductor line. The computer-readable medium may further include instructions executable to determine a primary side voltage of at least one distribution transformer based on a secondary side voltage of the at least one distribution transformer. The computer-readable medium may further include instructions executable to determine at least one phase conductor line condition based on the first set of synchrophasor data, the second set of synchrophasor data, and the primary side voltage of the at least one distribution transformer.

[0006] According to an embodiment, a method of determining a plurality of sensor points in a distribution system to obtain synchronized data may include loading a map representative of a distribution system. The method may further include determining a first set of sensor points on the map at a first level of the distribution system based on first predetermined criteria. The method may further include determining a second set of sensor points on the map at the first level of the distribution system based on a user input criteria.

[0007] According to an embodiment, a method of determining a primary side voltage of a distribution transformer may include determining a first current flowing through a secondary winding of the distribution transformer at a plurality of time instants. The determination of the first current may be based on current meter data generated by a plurality of metered loads connected to a secondary side of the distribution transformer. The method may include determining a second current flowing through the secondary winding of the distribution transformer at the plurality of time instants. The determination of the second current is based on current meter data generated by the plurality of metered loads connected to the secondary side of the distribution transformer.

[0008] The method may include determining a total current flowing to the plurality of metered loads for each of the plurality of time instants based on the first current at the plurality of time instants and the second current at the plurality of time instants. The method may include receiving a respective meter voltage from each of the plurality of metered loads at each of the plurality of time instants. The method may include determining a secondary side voltage of the distribution transformer at each of the plurality of time instants based on the first current, the second current, the total current, and the respective meter voltages at the plurality of time instants. The method may include determining the primary side voltage based on the secondary side voltage determined at one of the plurality of time instants.

[0009] In one example, the plurality of time instants may be a first time instant, a second time instant, and a third time instant. In another example, the respective meter voltage from each of the plurality of metered loads at each of the plurality of time instants may be a respective meter voltage from a first meter and a second meter at each of the plurality of time instants. In another example, the method may include determining the secondary side voltage of the distribution transformer at each of the plurality of time instants based on respective service line drop losses. In another example, the method may include determining the secondary side voltage of the distribution transformer at each of the plurality of time instants based on common line losses.

[0010] According to an embodiment, a system to determine a primary side voltage of a distribution transformer may include a processor configured to determine a first current flowing

through a secondary winding of a distribution transformer at a plurality of time instants based on current meter data generated by a plurality of metered loads connected to the secondary side of the distribution transformer. The processor may be configured to determine a second current flowing through the secondary winding of a distribution transformer at the plurality of time instants based on current meter data generated by the plurality of metered loads connected to the secondary side of the distribution transformer.

[0011] The processor may be configured to determine a total current flowing to the plurality of metered loads for each of the plurality of time instants based on the first current at the plurality of time instants and the second current at the plurality of time instants. The processor may be configured to receive a respective meter voltage from each of the plurality of metered loads at each of the plurality of time instants. The processor may be configured to determine a secondary side voltage of the distribution transformer at each of the plurality of time instants based on the first current, the second current, the total current, and the respective meter voltages at the plurality of time instants. The processor may be configured to determine the primary side voltage based on the secondary side voltage determined at one of the plurality of time instants.

[0012] In one example, the plurality of time instants may be a first time instant, a second time instant, and a third time instant. In another example, the respective meter voltage from each of the plurality of metered loads at each of the plurality of time instants may be a respective meter voltage from a first meter and a second meter at each of the plurality of time instants. In another example, the processor may be further configured to determine the secondary side voltage of the distribution transformer at each of the plurality of time instants based on respective service line drop losses. In another example, the processor may be further configured to determine the secondary side voltage of the distribution transformer at each of the plurality of time instants based on common line losses.

[0013] According to an embodiment, a computer-readable medium encoded with computer executable instructions that are executable with a processor may include instructions executable to determine a first current flowing through a secondary winding of a distribution transformer at a plurality of time instants based on current meter data generated by a

plurality of metered loads connected to a secondary side of the distribution transformer. The computer-readable medium may include instructions executable to determine a second current flowing through the secondary winding of the distribution transformer at the plurality of time instants based on current meter data generated by the plurality of metered loads connected to the secondary side of the distribution transformer.

[0014] The computer-readable medium may include instructions executable to determine a total current flowing to the plurality of metered loads for each of the plurality of time instants based on the first current at the plurality of time instants and the second current at the plurality of time instants. The computer-readable medium may include instructions executable to receive a respective meter voltage from each of the plurality of metered loads at each of the plurality of time instants. The computer-readable medium may include instructions executable to determine a secondary side voltage of the distribution transformer at each of the plurality of time instants based on the first current, the second current, the total current, and the respective meter voltages at the plurality of time instants. The computer-readable medium may include instructions executable to determine a primary side voltage of the distribution transformer based on the secondary side voltage determined at one of the plurality of time instants.

[0015] In one example, the plurality of time instants may be a first time instant, a second time instant, and a third time instant. In another example, the respective meter voltage from each of the plurality of metered loads at each of the plurality of time instants may be a respective meter voltage from a first meter and a second meter at each of the plurality of time instants. In another example, the computer-readable medium may include instructions executable to determine the secondary side voltage of the distribution transformer at each of the plurality of time instants based on respective service line drop losses. In another example, the computer-readable medium may include instructions executable to determine the secondary side voltage of the distribution transformer at each of the plurality of time instants based on common line losses.

[0015a] According to a first aspect, there is provided a monitoring system configured to determine at least one phase conductor line condition in each of a plurality of segments of a phase conductor line of a distribution system, the monitoring system comprising: a first sensor positioned at a first location along the phase conductor line, wherein the first sensor is configured to generate a first set of synchrophasor data; a second sensor positioned at a second location along the phase conductor line, wherein the second sensor is configured to generate a second set of synchrophasor data; and a processor configured to receive the first set of synchrophasor data and the second set of synchrophasor data and to determine a primary side voltage of at least one distribution transformer electrically connected to the phase conductor based on a secondary side voltage of the at least one distribution transformer, wherein the processor is further configured to determine at least one phase conductor line condition comprising at least power dissipation in each of the plurality of segments based on the first set of synchrophasor data, the second set of synchrophasor data, and the primary side voltage of the at least one distribution transformer.

[0015b] According to a second aspect, there is provided a method of determining at least one condition in each of a plurality of segments of a phase conductor line, the method executable by a computer device having a processor and memory, the computer device coupled with at least one data capture device or system, the method comprising: receiving, by the computer device, a first set of synchrophasor data associated with the phase conductor line; receiving, by the computer device, a second set of synchrophasor data associated with the phase conductor line; determining, by the processor, a primary side voltage of at least one distribution transformer based on a secondary side voltage of the at least one distribution transformer; and determining, by the processor, the at least one phase conductor line condition comprising at least power dissipation in each of the plurality of segments based on the first set of synchrophasor data, the second set of synchrophasor data, and the primary side voltage of the at least one distribution transformer.

[0015c] According to a third aspect, there is provided a computer-readable medium encoded with computer executable instructions for determining at least one phase conductor line condition in each of a plurality of segments of a phase conductor line, the computer executable instructions executable with a processor, the computer-readable medium comprising: instructions executable to receive a first set of synchrophasor data associated with the phase conductor line; instructions executable to receive a second set of set of synchrophasor data associated with the phase conductor line; instructions executable to determine a primary side voltage of at least one distribution transformer based on a secondary side voltage of the at least one distribution transformer; and instructions executable to determine at least one phase conductor line condition comprising at least power dissipation in each of the plurality of segments based on the first set of synchrophasor data, the second set of synchrophasor data, and the primary side voltage of the at least one distribution transformer.

[0016] Further objects and advantages of the present invention will be apparent from the following description, reference being made to the accompanying