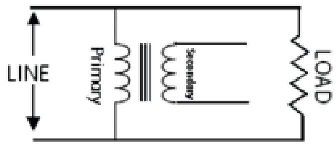
Connections - Potential Transformers

Potential transformers are normally connected across two lines of the circuit in which the voltage is to be measured. Normally they will be connected L-L (line-to-line) or L-G (line-to-ground). A typical connection is as follows:



When a phase relationship of "direction of flow" is of no consequence, such as in a voltmeter which operates only according to the magnitude of the voltage, there is no need to observe the polarity of the transformer. However, in watthour meter applications, polarity must always be observed.

Most potential transformers have a single winding secondary as previously shown, however, they may have tapped secondary windings, or dual secondary windings.

Construction Features

Potential transformers consist of two separate windings on a common magnetic steel core. One winding consists of fewer turns of heavier wire on the steel core and is called the secondary winding. The other winding consists of a relatively large number of turns of fine wire, wound on top of the secondary, and is called the primary winding.

Rating and Ratio

The rating of an instrument transfer is expressed by two groups of numbers representing the nominal current or voltage which may be applied to its primary winding and the current or voltage which would then be induced in its secondary winding. For example, the designation 480:120 volt expresses the rating of the potential transformer. This means that when 480 volts is applied to the primary winding, 120 volts will be induced on the secondary. Likewise a designation of 400:5 amperes expresses the rating of a current transformer and means that when 400 amperes flow through the primary, 5 amperes will flow through the secondary.

Industry standards have established 120 volts as the secondary rating of potential transformers having primary ratings up to 24,000 volts and 115 volts as the secondary rating of PT's having ratings above 24,000 volts. Similarly, industry standards have established 5 amperes as the secondary rating of current transformers.

The ratio of an instrument transformer is the relationship of its primary rating to its secondary rating. For example, the potential transformer mentioned above having a rating of 480:120 volts will have a ratio of 4:1 and the current transformer having a rating of 400:5 amperes will have a ratio of 80:1.

Potential Transformer Thermal Rating

Potential transformers have a thermal rating rather than a rating factor as with the CT and it designates the maximum volt-ampere burden, which may be connected to its secondary at specified ambient temperatures of either 30 or 55°C.

Potential Transformer Overvoltage Requirements

The IEEE standards allow two levels of operation. One is a continuous operation level and one is for emergency conditions. A potential transformer must be capable of operating at 110% above rating voltage continuously provided the secondary burden in volt amperes at this voltage does not exceed the thermal rating. The emergency rating of potential transformers is defined at one minute of operation, thus enough time for protective equipment to operate.

Voltage Transformer Ratings and Characteristics

GROUP	BUSHINGS	RATING	RVF
1	2	L-G	1.25/8hr
2	2	L-L	-
3	1	L-G	(25-161kV, 1.74/1min) (230-750kV, 1.40/1min)
4A	1	L-G	1.25/8hr
4B	1	L-L	-
5	1	L-G	1.40/1min

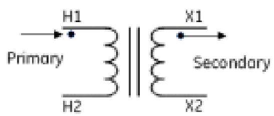
IEEE C57.13-2008 defines five distinct groups of voltage transformers and provides ratings and characteristics of each grouping. This table summarizes each grouping.

Insulation/Voltage Class

The insulation class indicates the magnitude of voltage, which an instrument transformer can safely withstand between its primary and secondary winding and between its primary or secondary winding and ground (core, case or tank) without a breakdown in the insulation. Industry standards have established insulation classes ranging from 600 volts up through 545 KV. System voltages presently extend up to 765 KV with 1100 and 1500 KV being investigated for future transmission expansions. Industry recommendations are that the insulation class of an instrument transformer should be at least equal to the maximum line-to-line voltage existing on the system at the point of connection. For example, the insulation class of a potential transformer used on a 7200/12470 volt system should be 15 KV even though the PT has a primary rating of 7200 volts and is connected phase-to-ground. Similarly, any current transformer used on a 7200/12470Y volt system should be of the 15 KV insulation class. Under fault conditions these units could be subjected to line-to-line voltage.

Polarity

In the application of instrument transformers it is necessary to understand the meaning of polarity and to observe certain rules when connecting watthour meters, relays, etc. If you will accept the fact, without proof, that the flow of current in the secondary winding is in a direction opposite to in the primary winding, that is, 180° out of phase with it, it will be relatively simple to understand the meaning of polarity. At any instant, when the current is flowing into one of the primary terminals it will be flowing out of one of the secondary terminals.



The polarity of a transformer therefore is simply an identification of the primary terminal and the secondary terminal, which satisfies the previously stated conditions. All instrument transformers, whether current or potential will have polarity marks associated with at least one primary terminal and one secondary terminal. These markings usually appear as white dots or letter and number combinations. When number and letter combinations are used IEEE refers to H1 as the primary terminal marking and to X1 for the secondary polarity mark.

In applications which depend on the interaction of two currents, such as a watthour meter or protective relay, it is essential that the polarity of both current and potential transformers be known and that definite relationships are maintained.

While all instrument transformers should be clearly marked as to their polarity, it is sometimes necessary to verify existing markings or to determine the polarity of an old or unmarked transformer. One simple method of determining polarity on a potential transformer is to connect a suitable DC permanent magnet voltmeter, preferably one with a 150 volt range, across the high voltage terminals, with the marked primary terminal of the transformer connected to the plus (+) terminal of the voltmeter. Then connect a battery and connect the plus (+) terminal of the battery to the marked secondary terminal. Make an instantaneous contact between the negative (-) terminal of the battery and the unmarked or (X2) secondary terminal of the transformer. A deflection or "kick" will be indicated on the voltmeter. If the initial "kick" (the one resulting from making, not breaking the circuit) is in an upscale direction, the potential terminals are marked correctly.

Similarly, a polarity check may be made on a current transformer. Connect a DC permanent magnet ammeter of 5 ampere capacity or less (depending on the transformer ratio) across the current transformer secondary. Connect the plus connect a battery in series and connect the negative (-) terminal of the battery to the unmarked of (H2) marked terminal of the transformer, make an instantaneous contact between the marked or (H1) primary terminal of the transformer and the plus (+) terminal of the battery. If the initial kick (the one resulting from making not breaking the circuit) is upscale, the current transformer terminals are marked correctly.

Precautions should be taken when making this test on current transformers to prevent core magnetization from occurring due to the direct current. Window or bar type units with low current ratings (400 ampere and down) are particularly susceptible to this residual magnetism. It is a best practice to demagnetize the CT after using DC. This can be accomplished by connecting at least 50 ohms variable across the secondary terminals and bring the primary current up to full load. Reduce the series resistance until it reaches zero without opening the secondary circuit. For best results, gradually reduce the primary circuit to zero before disconnecting the resistance circuit.

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