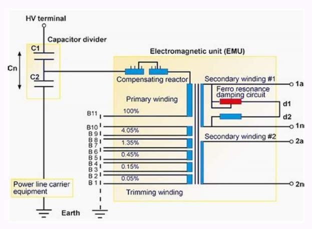
Potential transformer accuracy class definition



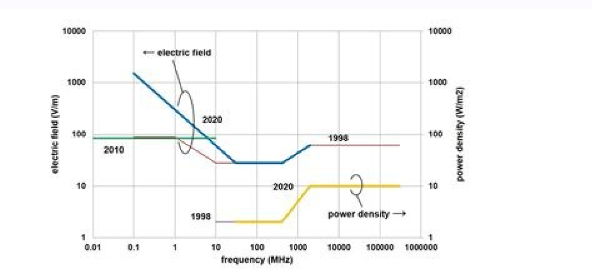


Figure 1. Whole body average reference levels for the general public for the ICNIRP (1998), ICNIRP (2010) and ICNIRP (2020) guidelines, for the 100 kHz to 300 GHz frequency range. Note that the units of the two y-axes (i.e. electric field and power density) are independent of each other.

What is rating of transformer. What does class 2 transformer mean. Current transformer accuracy class definition. Transformer rating definition.

Potential transformers (PT) or voltage transformers are instrument transformers used for voltage measurements. They are connected in parallel to the line and operates under the same principle of power transformers. They cannot be used used to supply raw power to the loads. They have an accurate voltage ratio and phase relationship between primary and secondary windings. To understand the principle of operation of electric transformers better, kindly read: Transformer – Operation, construction and types. Definition of potential transformers or voltage transformer A potential transformer (PT) is a static device used to step down high voltages to measurable levels in order to facilitate measurement and controllability. Low voltages are easy to measure and can be used to operate protection relays. Image credit: Wordtwist The electric power is transmitted and distributed at various high voltages. These voltages need to be stepped down to the rated voltage of measurement devices for voltage measurements. Also, measurement devices cannot be directly connected to high voltage circuits for measurement. In addition to that, it improves the compatibility of standard measuring devices. The principle of operation of potential transformers The principle of operation of a potential transformer is the same as a normal transformer. It works on the principle of mutual inductance and Faraday's law of electromagnetic induction. The flow of alternating current through a conductor produces a varying magnetic field. When another conductor is brought in contact with this magnetic field, voltage is induced in it. According to Faraday's law, the magnitude of the induced voltage depends on the rate of change of magnetic flux linking the second coil and the number of turns. $\varepsilon = -N\, d\Phi/dt$ In the case of transformers, Since the rate of change of magnetic flux between the coils is almost the same, the induced voltage depends on the number of turns of the coils. Construction of a PT Image credit: Alstom Grid Waynesboro The above image shows the construction of a voltage transformer. It can be noted that the construction of a voltage transformer is slightly different from that of a power transformer. It has a core or shell type magnetic circuit(core). The coils are wound over one leg of the core. The primary and secondary windings are insulated from each other. In some medium and high voltage transformers, tertiary windings are also present. The primary winding consists of a large number of turns, whereas the secondary winding consists of only a fewer number of turns. There are three types of potential transformer: Electromagnetic induction type, capacitive-coupled type and optical type. The construction features of the electromagnetic induction type potential transformers are discussed above. Capacitive-coupled Voltage Transformer (CCVT) A capacitive-coupled voltage transformer is a combination of capacitance voltage divider and electromagnetic type PT. It is a cost effective alternative to electromagnetic PT. It has three parts: A capacitance potential divider, a tuning reactor and an isolation transformer as shown in the below figure. The capacitor potential divider circuit consists of two capacitors C1 and C2 connected across the high voltage line and the ground. C1 is a series connection of several small capacitors. The majority of voltage is dropped across C1. The tuning reactor is used to tune the circuit for the line frequency. In addition to that, a tuning reactor enhances the energy transfer. The isolation transformer isolates the measuring instrument from the resonant circuit. Image credit: GE Grid solutions An optical voltage transformer works on the principle of Kerr effect, by which the light which is reflected from a magnetized surface may change both polarization and reflected intensity. This reflected light is measured optically and converted to an analog signal proportional to the applied voltage. This analog signal can be measured by using suitable instrument. Since there is no magnetic core and windings, these transformers are significantly smaller the CCVT and conventional PT. Optical voltage transformers are rarely used because of their complexity and high initial cost. Potential transformer connection Potential transformers come with either two-bushings or a single bushing. Single bushing types are strictly for line to ground connections and two-bushing types can either be connected line-to-line or line-to-ground. Polarity of the winding must be taken in consideration during the connection. The measurement devices can be connected to the secondary of the voltage transformer. A typical connection diagram of voltage transformer is shown below: Source: Technical Specification Burden The external impedance in the secondary circuit in ohms at the specified power factor. It is usually mentioned in VA. It is the maximum amount of load that can be connected to the secondary of the VT without causing a higher error. Accuracy class Accuracy class defines how accurate the voltage transformer can be when the burden is below its rated value. The accuracy class, according to IEC, is given as 0.2, 0.5 or 1.0 depending on the application when a rated burden of around 1.3-1.5 times the connected burden will give maximum accuracy. Voltage Transformer and current Transformer are known as Instrument Transformer. They are used in the substation to transform high magnitude voltage and current to low magnitude voltage and current suitable for metering and protection purposes. While the main purpose of the instrument transformer is metering and protection it also isolate the high voltage side from the low voltage side comprised of measurement and protection devices and circuits. Before proceeding further one should have some basic knowledge about working of the transformer. Here in this article we discuss about the voltage transformer (also called as potential transformer) and in the next article we will discuss about current transformer. The voltage transformers are broadly of two types. These are inductive VT and Capacitive VT (CVT). Let us first consider the inductive (electromagnetic) Voltave Transformer. We Know the two fundamental laws of the inductive transformer. For an ideal transformer, $V_p / N_p = V_s / N_s$ $I_p N_p = I_s N_s$ Subscripts 'p' and 's' are used for primary and secondary sides of the transformer. N is the number of turns of the respective side of the transformer. The voltage and current transformers are used for measuring or protection purpose. Hence in the ideal case we desire to get the value of secondary voltage which is proportionate to the primary voltage. The voltage transformer (potential transformer) is designed to closely follow the formula $V_p / N_p = V_s / N_s$ for a specified range of operation. The equivalent circuit of an actual voltage transformer is shown in Fig-B. R_p and L_p are primary side resistance and leakage reactance of transformer. R_s and L_s are for the secondary of transformer. R_c and L_m are the core loss component and magnetising reactance component respectively. Error is mainly introduced in the measurement of voltage and phase angle due to these parameters of transformer. In comparison to current transformer the voltage transformers operate at a relatively higher point of the operating curve. In the design process care is taken to limit the exitation current otherwise the increased exciting current will result in excessive voltage drop in the series impedances, so the error is increased. The inductive voltage transformer is constructed similar to power transformer. The secondary(low voltage) side winding has few turns wound over the magnetic core and the primary (high voltage) side winding is comprised of several turns wound over the primary winding. The cross sectional area of the secondary side conductor is considerably more than the primary side conductor. The secondary side voltage adopted is usually 100 volt or 110 volt. A sketch of voltage transformer is shown in Fig-C. The porcelain insulator provide required creepage distance for HV terminal from ground. The tank made from galvanized steel filled with oil contains the magnetic core wound with primary and secondary windings of VT. In a voltage transformer the core size is comparatively more so that a low flux is maintained at operating point. The instrument transformers are classified according to the allowed percentage error and burden. The load on the secondary side of the voltage transformer is called as burden(For instrument transformers burden terminology is used instead of load on the secondary side).The rated burden is specified in voltampere or VA. The Total burden of all the instruments connected to the secondary of the voltage transformer (VT) should be less than the rated burden. For example the VT secondary may be connected to a voltmeter, a watt meter, Integrating meter, a synchroscope and some relays. The sum of the burdens of all these equipments should be less than the rated burden of the VT. More over if the conductor lead used for connecting to these instruments is very long, then the burden due to this long lead should also be added to the burdens of all the equipmets connected to the secondary of the Voltage Transformer. The burden of the VT can also be specified by impedance value in Ohm. The voltage transformers has a specified rated transformation ratio. If kn is the rated transformation ratio then voltage error in percentage is given as, Voltage Error = (kn * Vs - Vp) *100 / Vp Vp and Vp are the actual primary and secondary voltage. And Kn is the ratio of rated primary voltage to rated secondary voltage. The Accuracy class of voltage transformer (VT & CVT) is defined by the IEC. The table below display the limits specified for the accuracy classes. Voltage Transformer Accuracy Classes (As IEC 60044-2) Accuracy Class Voltage Error (%) Phase Error (Minutes) Application 0.1 +0.1 +5 Precise Measurement 0.2 +0.2 +10 Measurement 0.5 +0.5 +20 Measurement 1.0 +1.0 +40 Measurement 3.0 +3.0 --- Measurement 3P +3.0 +120 Protection 6P +6.0 +240 Protection (Phase angle Error expressed in Minutes. One degree = 60 minutes) The protection VTs are less accurate than the metering VTs. For revenue metering purposes the VT with accuracy class 0.2 may be preferred. For indicating meters less accuracy class like 1.0 may be chosen. For the metering VTs the above accuracy of VT should be valid for voltage range between 80% to 120% of the rated voltage. For the protection VTs the above accuracy of VT should be valid for voltage range from 5% to Vf times the rated voltage. Vf is the voltage factor. Vf has been defined by IEC. Vf is equal to 1.5 for solidly earthed system and 1.9 for the system which is not solidly earthed(See IEC standard). For both metering and protection VTs, the above accuracy of VT should be valid for the burden between 25% to 100%. of rated burden. The above described inductive voltage transformer is usually economical for system voltage rating upto 132 kV. For higher system voltage at Extra High Voltage (EHV) and Ultra High Voltage(UHV), Capacitor Voltage Transformers (CVT) are used. At system voltage above 38 kV the inductive VT is not cost effective. The CVT is basically comprised of a capacitor voltage divider (see figure below) and an inductive Voltage transformer (as described above). The tapped voltage from the last unit of capacitor voltage divider is fed as input to the inductive VT. By using the capacitor voltage divider the system voltage is reduced to a voltage level suitable as input to the transformer. As the circuit is capacitive a reactor L is connected in the primary so that the sum of the reactance L and the leakage reactance of the transformer compensate the capacitive effect at power frequency. The phenomon of ferroresonance considerably influences the design of CVT. Under the conditions of various network disturbances or fault conditions the divider capacitor and inductor in the CVT form a series tuned resonating circuit. In resonance the magnetic circuit may saturate and overheat the transformer. It is necessary to damp out ferroresonance in CVT. So the CVTs are equipped with ferroresonance damping circuit as shown in the figure above.

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