Current Balancing Transformer

Description & Installation

P31111
P31121

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Description & Installation

P31111 Current Balancing Transformer (CBT) for Stray Voltage

1.0 Introduction

The majority of North Amercian power distribution design practices involve multi-grounded neutral-conductor serving arrangements. Power customers with moderately sized power needs are served by one phase taken from three phase distribution service. Step down distribution transformers change the single phase primary distribution voltage to a common user voltage of 240/120 volt service. The 120 volt supply is derived from a grounded, center tapped connection of the secondary 240 volt winding.

Secondary service is ordinarily grounded to the primary neutral at the distribution transformer and at the customer load center. In rural areas multiple services (such as at a farm) are connected to the distribution transformer secondary winding terminals. These services all have neutral conductor

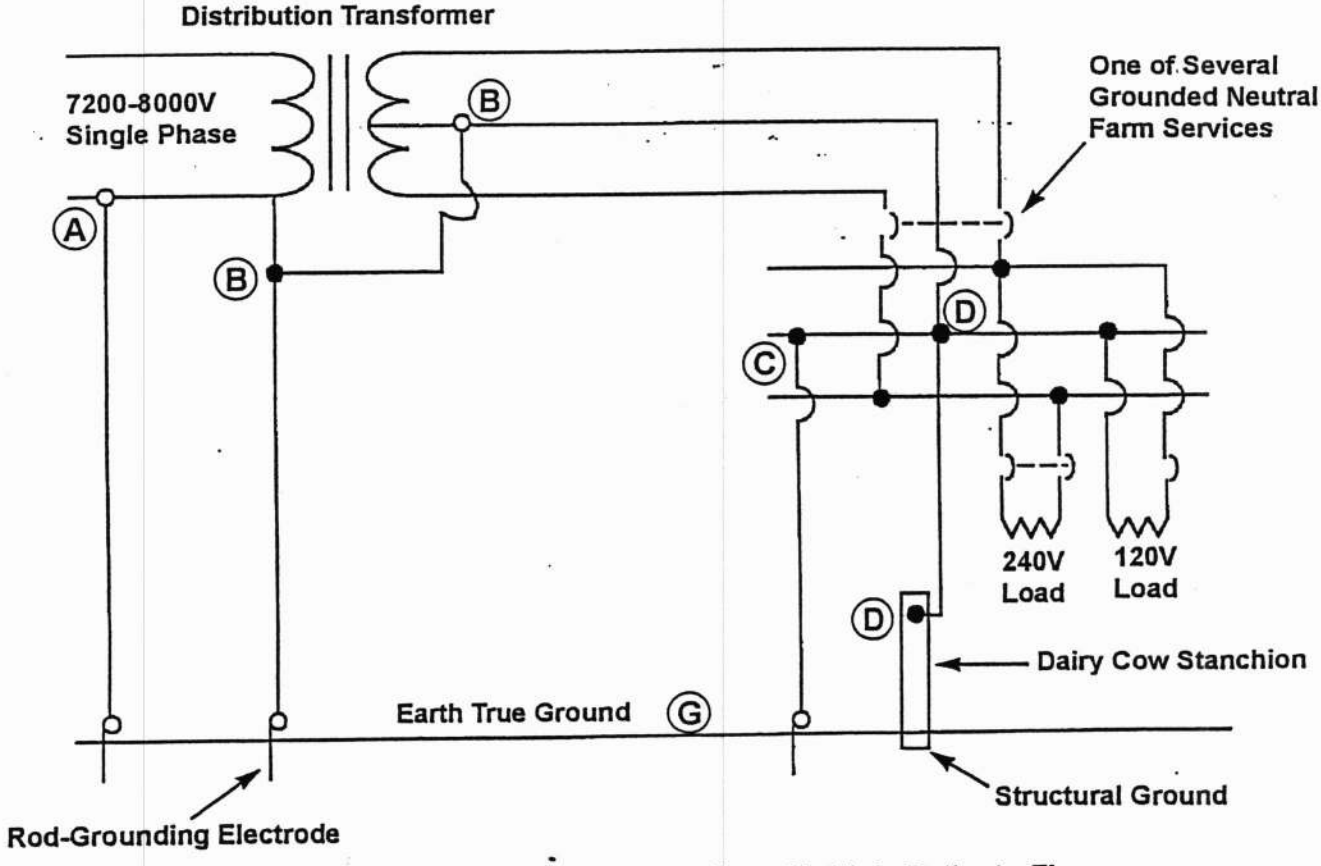


Figure 1: The Problem: Neutral Currents Have Multiple Paths to Flow Into and Through Earth and Primary and Secondary Neutrals.

grounds at the load center, such as at the house, dairy parlor, machine shed, etc. Wells with metallic casings may distribute water via metallic pipes to dairy parlors, houses, etc. These pipes are normally connected to load center neutral service grounds. The net effect is that the customer grounding

resistance is at a lower value in relation to true or remote ground because of the deep well casing and water pipe bonding of electrical service.

Urban or suburban single phase power feeds may be similar to rural facilities. Several neighboring residences may be connected to a single phase distribution transformer secondary winding. The customer grounding at the service entrance/load center is usually enhanced to a low value to true or remote ground by a metallic water supply connection to the electrical service neutral conductor, which is similar to the rural customer's well casing. The grounding serves human safety concerns and facilitates detection and isolating insulation failures that cause abnormal fault current flow on either primary or secondary distribution circuits.

Figure 1 illustrates the potential for stray voltage in multi-grounded power distribution systems. The primary phase and neutral conductors connect to a farmstead via the distribution transformer providing the farm with 240/120 volt service. Grounding is shown by means of ground rod connections on the primary neutral conductor (A), at the distribution transformer where the primary and secondary neutrals are linked to a common ground rod (B), and at the load center service point (C) with a ground rod also deployed. A dairy parlor cow stanchion or equivalent cow contact-point metallic structure (D) would contact the electrical service neutral directly or indirectly through the dairy parlor structure. This cow contact point will typically have a different voltage value to remote or true ground (G) than the voltage value at the dairy parlor floor where the cow stands during milking.The resulting voltage difference at cow contact points can force small currents to flow through the cow, agitating the cow and affecting milk production.

This stray voltage may be excessive, in part because the farmstead grounding may be of less resistance to current flow than the primary neutral conductor grounding system (A). Thus, primary neutral current may flow to the customer grounds, increasing the level of stray voltage at cow contact points. Stray voltage values, at worst, are a few volts or less, but this may be sufficient for the body current to affect cow behavior.

Similar situations may exist in urban environments where electrical customer grounding may be non-uniform between solidly grounded water pipe-to-neutral connections and other premises structures that may be less adequately grounded.

2.0 Application

Except for the addition of the CBT in the primary distribution line, Figure 2 illustrates a primary distribution voltage transformation to secondary voltage such as 240/120 volts. The 240/120V supply is distributed via two service drops to load centers for several branch loads. Figure 2 also shows multiple grounds, indicating current loops may result due to stray voltage between grounding contact points and remote or true ground.

Grounding on electrical circuits provides a general reference level to which electrical potential can be measured. It also provides a means to detect and clear faults (short circuits to ground) as well as reference circuit insulation requirements. Unfortunately, stray voltage can be an undesirable result of grounding because zero impedance to earth cannot be realized at the points of grounding. A grounding system reference level can be enhanced by bonding grounding points in a confined area together. By means of the bonding conductor, the impedance difference is lowered so that stray

voltage differences to remote or true earth is minimized for different points of contact. Grounding connections to a water pipe system is an example of bonding ground contact or reference points.

Previous solutions to minimize stray voltage have included the use of isolator devices such as arresters to create the effect of opening the primary to secondary ground bonding connection at the distribution transformer (Figure 1 "B"). Thus, primary and secondary neutrals are separated at the distribution transformer. This, in effect, creates two electrical system ground entities which are not metallically connected. The result is additonal possible insulation stress between the windings of the distribution transformer plus safety concerns because of lightning surges that may create dangerous voltage gradients across isolated grounding systems.

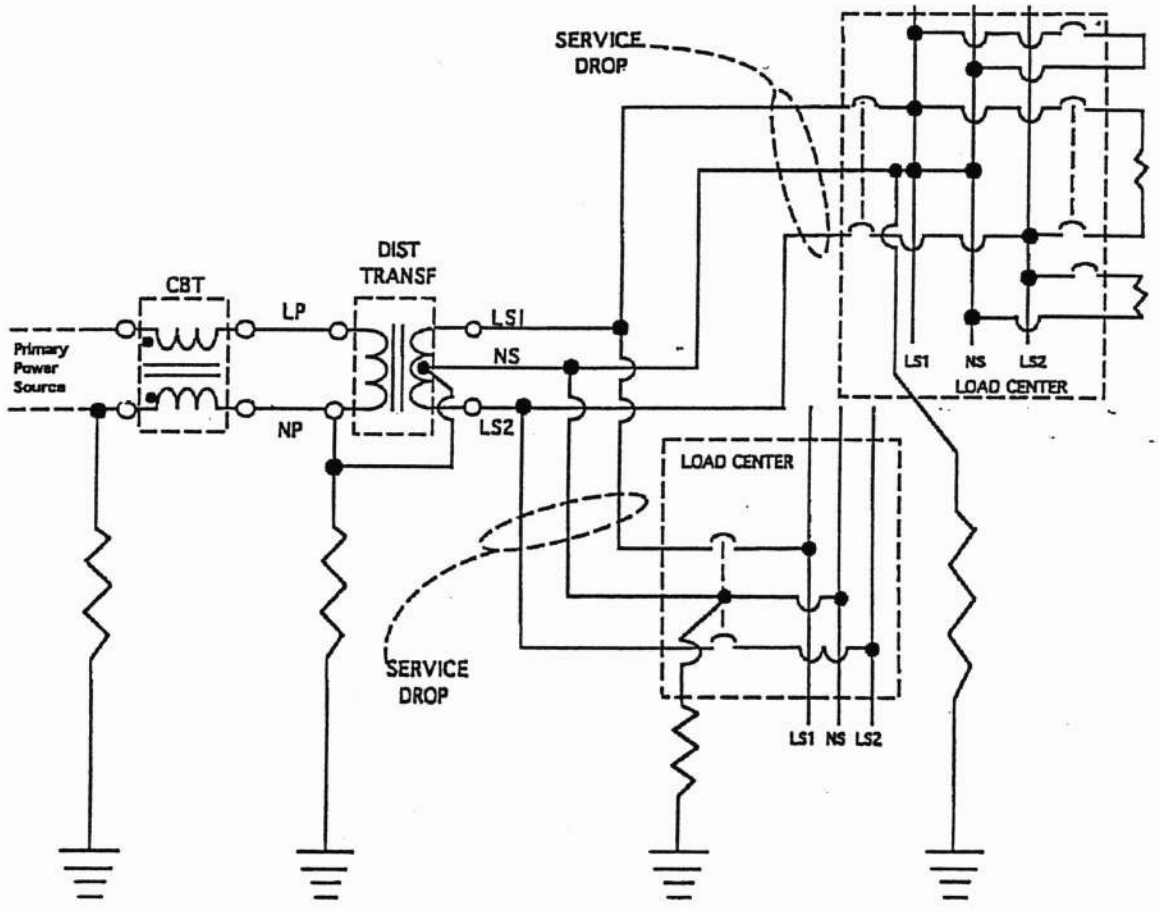


Figure 2: The Solution

Another stray voltage reduction technique is to balance LS1 and LS2 currents against NS currents so there is no net current to flow in reference ground points at the distribution transformer and at the load centers. However, without isolation of primary to secondary ground bonding at the distribution transformer net current will not be compensated by this technique, and very low impedance water lines connected to several ground points can make the net current technique difficult to achieve.

Figure 2 shows a CBT connected into the primary power source to minimize stray voltage. The CBT does not have the drawbacks of previously listed approaches. It is located at a point in the power

supply circuit where it has the greatest effectiveness to prevent the flow of power system source current from flowing into the farm grounding system without disturbing standard grounding arrangements, such as the distribution transformer ground and its primary to secondary connection.

The CBT is a closely magnetically coupled device polarized so that the flux in conductor path LP produces a magnetic field that urges the current in conductor path NP to flow back toward the source by way of conductor NP and not through any shunting grounding, such as the distribution transformer or farm load center grounds. The result is that stray voltage is reduced or greatly minimized because of less grounding path current flowing between these grounding points.

3.0 Technical Data

- Single Phase, 15 kV Two Wire Service
- Rated to 7 Ampere, 60Hz, 55°C Rise
- Series Impedance: 0.044 Ohms at 75°C Under Balanced Loading
- Certified to withstand 1,000 Amperes rms of fault current for 2.5 cycles, 60 Hz (40ms) to exceed clearing time of a 15 Amp T-link fuse. It also carries a 95kV impulse rating.
- Weight: 180 lbs. (82 kg)
- Testing per ANSI/IEEE C57.12.90
  (Impulse:clause 10.3; Voltage:clause 10.6; Short Circuit:clause 12)

4.0 Installation

The CBT has two "H1" 15kV class bushings on the tank cover. These must be connected in series with the phase wire of the 7.8kV single phase tap which serves the customer. The CBT also has two "H0" bushings on the tank side which must connect into the single phase tap neutral lead to the customer.

The CBT should be located as close to the customer distribution transformer as possible, preferably within one span. The source side "H0" neutral bushing should be connected to a pole down-ground.

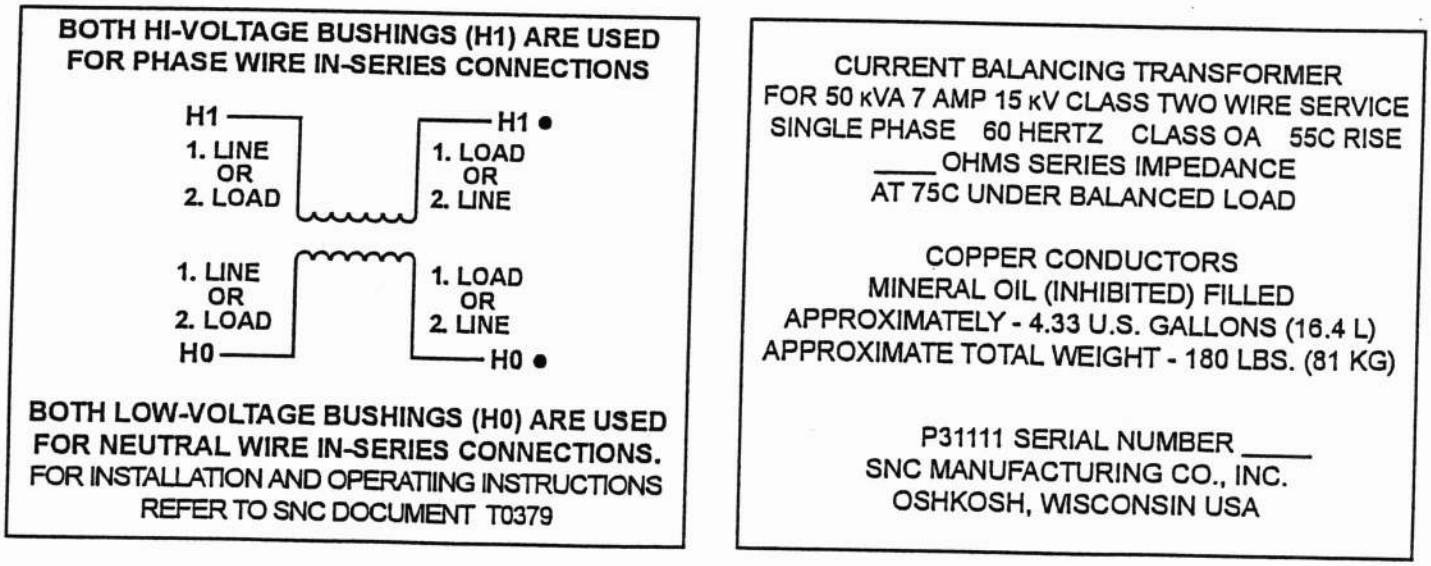


Figure 3: CBT Nameplates

The load side CBT "H0" bushing and the neutral conductor to the distribution transformer should not be down-grounded between the CBT and the distribution transformer pole ground.

A 9-10kV distribution class arrester for a 15kV class MGN feeder system should be connected from the source side "H1" bushing of the CBT to the pole down-ground grounding electrode lead.

A 10 ampere fused open cutout should be placed on the 7-8kV phase wire tap between the feeder and the CBT.

5.0 Safety

WARNING: The CBT must be installed by trained electric power utility personnel only!

As with any piece of electrical apparatus, the CBT, when energized, is dangerous and must be handled by trained electric power supplier personnel. The "H1" - "H1" bushing terminals have 7-8kV of voltage-to-neutral or ground on the terminals. The "HO" - HO" bushings are at metallic neutral conductor voltage with respect to earth, essentially zero volts.

In operation "H1" to "H1" and "HO" to "HO" of the CBT are close to zero volts due to the winding (additive) polarity. However if there is for any reason an open primary neutral condition between the feeder source and the farm distribution transformer, the CBT "H1" to H1" voltage will be the voltage of a saturated magnetic circuit of less than 200 volts maximum. This level is below any level that would affect telephone protection.

Should the neutral conductor open between the CBT location and the distribution transformer, the phase conductor is still energized through the CBT to the distribution transformer, the saturated voltage of the phase "H1" to "H1" CBT winding will be induced on the opened load-side "HO" - "HO" winding. This will be less than 200 volts and a warning label advises of this on the CBT. For this reason safety is always enhanced by locating the CBT close to the farm distribution transformer so there will be minimal exposure for a neutral being opened.

WARNING: The CBT must be installed close to the farm distribution transformer, perferably within one span, to minimize the exposure for a neutral being opened.

6.0 Features/Benefits

- Cow Contact voltage reduction of seven to one or higher is common, often to less than one tenth of a volt.
- Neutrals remain safely connected in accordance with the National Electrical Safety Code (NESC Rule 97B).
- Completely passive device - no electronic components to fail.

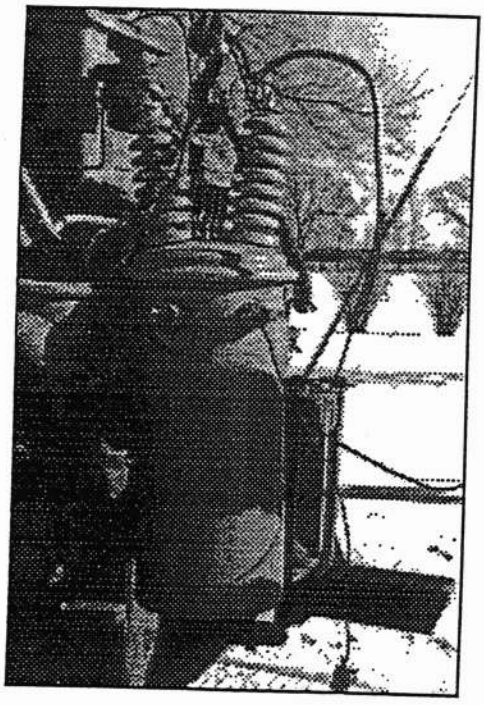
7.0 Typical Dairy Farm Measurements

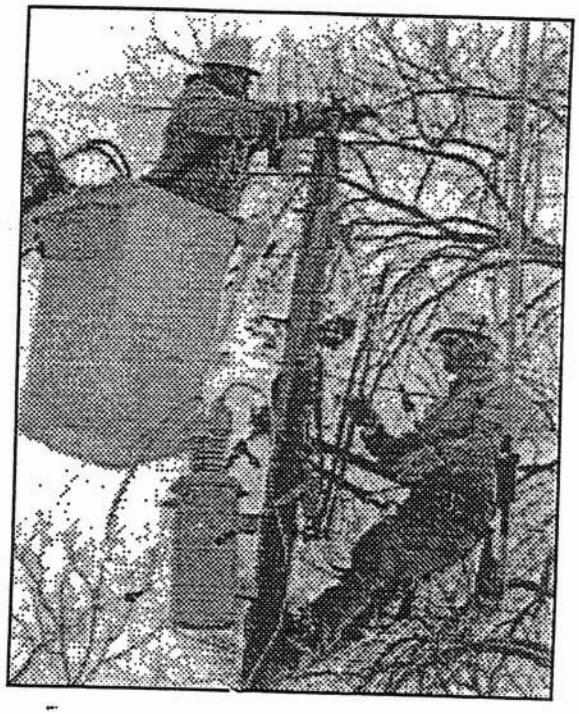
NOTE: Compare items 1 and 3 (voltage) and items 2 and 4 (voltage and current).

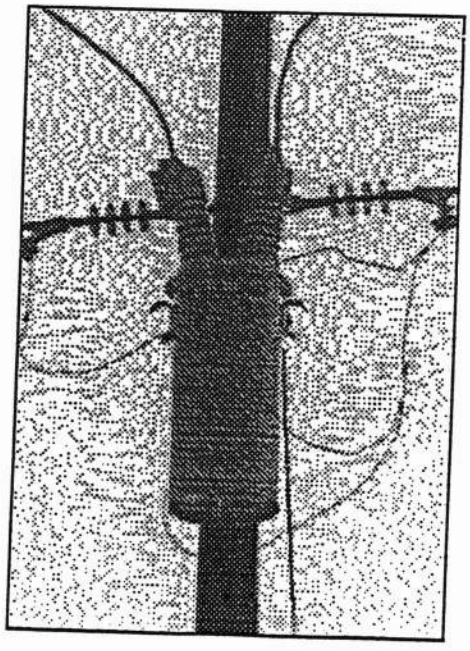
CONDITION WITHOUT CBT	Dairy Parlor Cow Contact (Voltage)	Primary Current (Amps) Phase	Neutral
1. Primary Open (is disconnected from farm distribution transformer)	(Farm A) 0.405 (Farm B) 0.136	0 NA	0.9 NA
2. Primary Closed (connected to farm distribution transformer with 30kW farm load on secondary)	(Farm A) 0.287 (Farm B) 0.502	4.1 4.2	3.9 2.5
CONDITION WITH CBT INSTALLED			
3. Primary Closed (connected to farm distribution transformer-normal load)	(Farm A) 0.094 (Farm B) 0.050	NA .04	NA .04
4. Primary Closed (connected to farm distribution transformer with 30kW farm load on secondary)	(Farm A) 0.025 (Farm B) 0.078	4.1 4.2	4.1 4.2

IF YOU HAVE ANY QUESTIONS OR CONCERNS REGARDING YOUR CBT INSTALLATION, OR IF YOU WOULD LIKE MORE INFORMATION ON THE SNC LINE OF PROTECTION PRODUCTS, CALL THE SNC HOTLINE (800-558-3325) OR CALL OUR REGULAR NUMBER (920-231-7370).

Easy, Quick Installation.







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