Power Factor Control Input Signals

Before automatic power factor correction equipment is purchased, the input signals required for the power factor controller should be considered. These input signals can be derived from several locations in an existing facility without the need for the purchase of new equipment (i.e. purchase of a capacitor bank or filter bank with a potential transformer and the installation of a current transformer). This bulletin discusses the external signal requirements for the power factor controller (PFC) that NEPSI offers and some of the possible locations from which the signals can be derived.

Figure 1 - Typical Medium Voltage Potential Transformers and Current Transformers

PFC Signals

The required control signals for the PFC are system voltage and line or load current. These signals in general are derived from potential transformers and current transformers which steps (scale) the system voltage and current from system levels down to standard control voltage and current levels of 120VAC and 5AMPs maximum. The signals must be derived from the electrical system such that the PFC will sense a 90° lead in current when the power factor of the load is at unity. For a 90° lead in current, the PT must be connected from phase-C to Phase-B and the CT in line with Phase-A. Figure 1A illustrates the required connection for a 90° lead in current measurement. Note that the load has been placed downstream from the CT with the capacitor bank between the CT and the load. This arrangement is required for most PFC's to operate properly. Some new controllers have the capability to perform internal phase rotation changes, but it is still advisable to connect those controllers up with the connections as shown in Table 1.

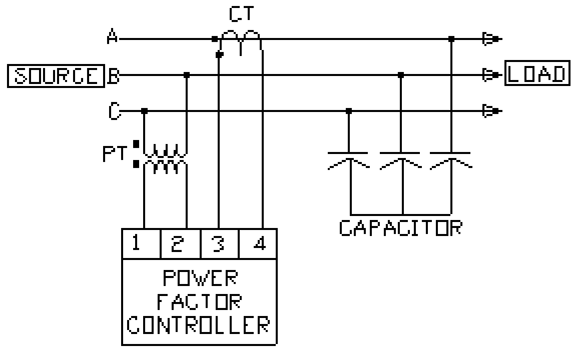

Figure 1A - PFC Connection Requirements

Table 1 – Possible Phase Relationships for Voltage and Current for Proper PFC Operation		
PT		**CT**
H1	H2	Phase Current
C	B	A
A	C	B
B	A	C
B	C	-A
C	A	-B
A	B	-C

Other CT and PT connections are possible. Some of these connections are shown in the in the table to the left.. The table shows five other connections that are possible. In fact there are many other connections which are possible if the secondary leads of the PT and CT are swapped. This is a very common problem associated with the start-up of an Automatic Power Factor Correction capacitor bank. In general the PT connection must be made across any two phases with the CT in line with the third phase. If this condition is met, it is possible to get a proper phase shift in current to voltage by changing the polarity on the secondary leads that are located at the PFC terminal block.

Existing Signals

For many situations, it is possible to utilize existing Relay Signals and/or Metering CT and PT circuits for the input signals to the PFC if they are located near the proposed capacitor bank installation and sense the corresponding load current. These signals are advantages to use because they require no additional cost for installation and in many cases no shut down time for PT and CT connections. A new CT on a main incoming cable for example, requires that the plant process be shut down momentarily so that the CT may be installed by breaking the main cable connection and inserting the CT over the cable jacket. In many cases a low voltage split core type CT may be used if the cable is fully insulated and exposed. In this case a plant shut down may not be necessary.

Existing CT and PT circuits may be readily available to cut cost and prevent plant shutdown since one of the following circuits may exist.

1. Over current relay protection circuits (CT only) is widely used as primary protection or back-up protection for transformers, utility tie circuits, and cable mains.

2. Differential relay protection circuits such as transformer differential (CT only) and bus differential (PT only).

3. Demand meter and watt-hour meter circuits (PT and CT).

Figure 2 illustrates a typical industrial tie from the utility source. It shows both differential (87 device) and over current protection (50/51 device) and metering of voltage, current and KW. Rather than use a separate CT for the PFC for example, the CT secondary circuit of the 50/51 device could be broken and brought through the PFC. This would prevent the need for the tie to be isolated or plant to be shut down for the installation of the CT and the need for a new CT. The PT circuit could also be utilized for the voltage signal that the PFC requires.

Care should always be taken whenever using these circuits to ensure that the protection system or metering circuit is not adversely affected by an improper connection. When in doubt, NEPSI can provide guidance for a proper installation.

These relay and metering circuits may be used for power factor sensing because the PFC has a very low input burden for both current and voltage signals. Most metering class CT and PT circuits have ratings of 1500VA, while the PFC has a burden of 5VA for power factor sensing. The PFC also requires control voltage for switching the capacitor bank. The required VA necessary for switching ranges from a few VA to 1000VA. Care should be taken if the switching control power is to be taken from and exiting PT circuit.

The CT and PT circuits which are most commonly employed for relay protection and metering are shown in Figure-3 and Figure-4. The PFC terminals have been included in each circuit to show how it would be incorporated. Figure 2 shows the PFC integrated with a time overcurrent protection system which has metering for voltage. The connections to the PFC terminals for the current signal are shown in the figure as boxes at the top of the figure. Connections to the CT circuit are shown to be taken from the A-Phase current.

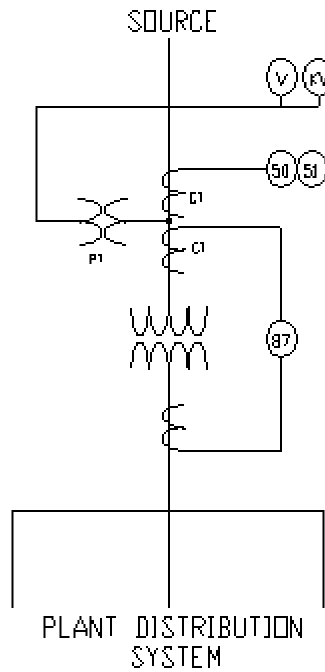

Figure 2 - Typical Industrial Tie

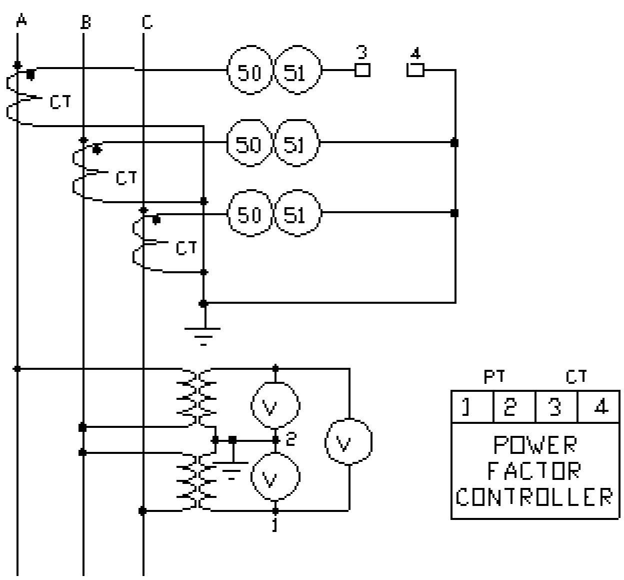

Figure 3 - Typical Relay Protection Circuit

The PT circuit is connected in Delta and the connections necessary to the PFC are shown with the labeling of the points 1 and point 2 in the figure. Care should always be taken when using these circuits. Note that the PT circuit is shown with no fuse for short circuit protection. NEPSI recommends that the secondary of the PT circuit to be connected to the PFC be fused .

Figure-4 shows one of many metering circuits which are commonly employed in industry. The connection to the circuit is shown using both the PT and CT which the metering circuit requires. Note that the any demand meter, PF meter, kW meter, kVA meter, or KVAr meter will require both a PT and CT to derive its input signals. If the metering looks at all three phases or two phases then it is possible to use them for the input signals to the PFC.

NEPSI Recommendations

NEPSI recommends that the voltage sensing device be derived from the NEPSI capacitor bank since the control power is also required for controlling contactors or switches for capacitor switching. The control power demands that are required for the switches are beyond what should be taken from any metering or protection circuit.
If the customer has auxiliary control power for the switching needs of the capacitor bank, then the voltage signal for the PFC to derive PF may be obtained from an existing PT circuit and the control power from the customer's auxiliary power.

The CT circuits which are used for overcurrent protection are less complex than those of differential protection system. If plant policies allow the protection circuit to be broken and used in conjunction with the PFC, additional cost and down time can be avoided with an existing metering or protection system.

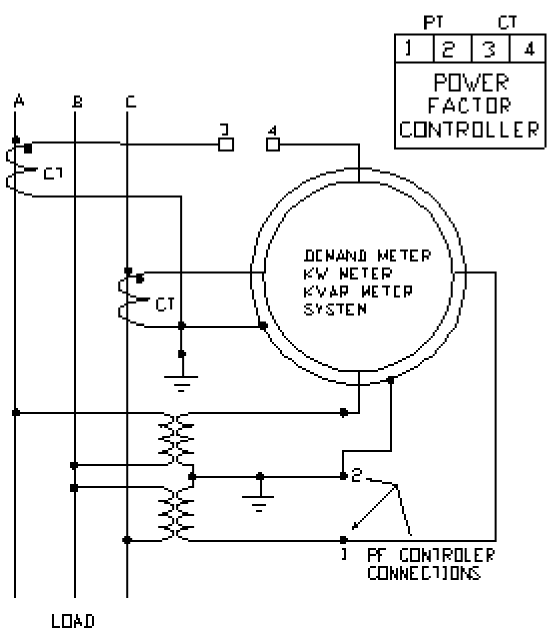

Figure 4 - Typical Metering Circuit

If the installation is new, the additional cost for a CT is minimal, and should be added as a standalone CT for the PFC only. In many cases, an inexpensive 600 volt class current transformer can be placed around the plants main incoming cables (around shield portion of cable only).

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