

Installation Instructions

APO Series of AutoPhase™ Digital Power Transducers Models with LCD Display

APO Series AutoPhase* Digital Power Transducers measure the power demand (kW) and energy consumption (kWH) of any single phase or three phase, 50 or 60 Hz electrical system. The transducers provide analog and digital (discrete) outputs that represent kW and kWH. The units show Volts, Amps, kW and kWH on the LCD display and provide a System Alarm contact.

Model	Description
APO-KWKH-"X"-MX-LM	Module Level (Shown at right)
APO-KWKH-"X"MN-LM	Module in NEMA-1 Enclosure, Display on Module
APO-KWKH-"X"-MN-LC	Module in NEMA-1 Enclosure, Display on Enclosure Door

Note: Replace "X" in model number above with "PC" for current inputs via ProteCT current transformers, or with "5A" for current inputs via traditional 5A output current transformers.

If the Transducer you are installing is not listed here, call Neilsen-Kuljian at 1-800-959-4014 for the correct Instruction Sheet.



Model APO-KWKH-PC-MX-LM

Installation Overview

Neilsen-Kuljian's APO Series Power Transducers are easy to install, wire and program. N-K's exclusive AutoPhase Technology automatically does the hard work for you. That's the AutoPhase Advantage.

You need to perform the following functions:

1. Mount the APO transducer.
2. Install the Current Transformers (CT's) and wire them into the APO.
3. Connect the voltage inputs.
4. Connect the transducer outputs to your control system or data acquisition system inputs.
5. Program the CT amp rating, kWH pulse rate and alarm set points.

When you choose to activate the AutoPhase feature, the APO takes over and performs the following steps automatically:

- A. Identifies all CT inputs by phase.
- B. Corrects any polarity reversals (wiring errors) in the CT inputs.
- C. Identifies all voltage inputs by phase.
- D. Matches current and voltage inputs by phase.
- E. Senses, selects and programs the correct input voltage level (120, 208, 480 or 600 VAC) and number of phases (1 or 3 phase).
- F. Calculates the Maximum kW from the voltage level and CT amp rating.
- G. Provides outputs and displays the instantaneous kW and total kWH.

The AutoPhase Advantage eliminates the tedious and sometimes dangerous task of rewiring or reconnecting miswired CTs and voltage inputs.



Neilsen-Kuljian, Inc.
500 Division Street
Campbell, CA 95008
800-959-4014



APO TRANSDUCCERS SHOULD BE INSTALLED BY QUALIFIED ELECTRICIANS IN COMPLIANCE WITH ALL LOCAL CODES AND STANDARDS. MAKE SURE POWER IS OFF BEFORE MAKING CONNECTIONS. EXERCISE EXTREME CAUTION WHEN EVER WORKING ON OR NEAR ENERGIZED CIRCUITS.

HAZARDOUS VOLTAGES EXIST INSIDE THE UNIT. THERE ARE NO USER SERVICEABLE PARTS INSIDE THE UNIT. FOR SERVICE AND REPAIR CONTACT THE NEILSEN-KULJIAN FACTORY.

Step 1: Mount the Transducer

Module Level products (APO-KWKH-MX-LM) are designed to be mounted in a code approved enclosure furnished by others. Models APO-KWKH-MN-LM and APO-KWKH-MN-LC are already mounted in a NEMA-1 enclosure. Mount the enclosure in a clean, dry location with

suitable clearance for wiring and operation of the keypad and display. Units may be mounted in any orientation that is convenient and are not sensitive to magnetic fields. Be sure the temperature and humidity is within specifications. See page 5

Step 2: Install and Wire the Current Transformers

IMPORTANT:

Verify the transducer model before proceeding. Models with "PC" in the model number are designed for use with ProteCT Current Transformers with 0-0.333V output. Models with "5A" are designed for use with traditional 5A CT's.

MODELS WITH "PC"

ProteCT™ Current Transformers can be installed on a live conductor if absolutely necessary. We highly recommend that you turn off power before installing the ProteCT to reduce the chance of accidental shock.

Verify that the ProteCT amp rating is equal to or slightly greater than the maximum amperage the conductor will carry. Proper ProteCT selection is important for instrument accuracy. Contact Neilsen-Kuljian if you have any questions.

The ProteCT split core design makes installation easy. The side opposite the wire leads is marked with the amperage rating and is removable. Pull off this side, place the sensor over the conductor and snap the sensor back together. Do not force since the connection is keyed. Keep the mating surfaces clean as dirt or grit can cause accuracy problems.

ProteCT™ current transformers have low voltage outputs (0 - 0.333V) that reduces the likelihood of electric shocks. Unlike traditional Current Output CTs (100:5, 200:5, etc.) ProteCTs do not produce dangerous voltages when their leads are opened.

NEVER CONNECT AN APO TRANSDUCER DESIGNED FOR ProteCTs TO CURRENT OUTPUT CTs (100:5, 200:5, etc.) DOING SO WILL DAMAGE THE TRANSDUCER.

Use shielded, twisted wire, 16-22 AWG. Wire lengths up to 50 feet will not affect accuracy. Using unshielded wire may cause accuracy problems.

Three Phase Loads

Connect each ProteCT's pair of wires to a pair of terminals labeled C.T.1, C.T.2, and C.T.3. The default polarity is white on top and black on bottom. The default phase match up is as follows:

CT1 to Voltage 1 (BROWN lead)
CT2 to Voltage 2 (ORANGE lead)
CT3 to Voltage 3 (YELLOW lead)

See Figure 1.

If the unit is wired correctly to the phase relationships and CT polarity noted above, it will not be necessary to activate the AutoPhase feature.

If the polarity of any phase is reversed or if any phase mismatch is present, activating the AutoPhase feature will correct for all errors without the need for rewiring.

Single Phase Loads

Connect the ProteCT's leads to the pair of terminals labeled "C.T. 1". The default polarity is white on top and black on bottom. See Figure 2.

Activating the AutoPhase feature will correct for any polarity reversal.

MODELS WITH "A" IN THE MODEL NUMBER

Current Output CTs (also called Ratio:5) should not be installed on a live conductor. Turn off power before installing the CT to reduce the chance of accidental shock. Verify that the CT amp rating (first number in the ratio) is equal to or slightly greater than the maximum amperage the conductor will carry. Proper CT selection is important for instrument accuracy. Contact Neilsen-Kuljian if you have any questions.

**DANGER !!**

- 1. Do not turn on the monitored power (CT Primary) until the CT output (CT Secondary) has been wired and connected to the APO.**
- 2. Do not connect the CT Secondary to the APO while the Primary is under load.**
- 3. Never open the secondary of any Current Output type CT while the primary is under load. DOING ANY OF THESE CAN CAUSE PERSONAL INJURY AND/OR INSTRUMENT DAMAGE.**
- 4. The use of shorting blocks for the CT's is highly recommended.**

To install a CT, turn off and lock out power to all phases. For solid core CTs, thread the power wires through the center aperture. For split core CTs, take apart the removable leg of the CT, place the sensor over the conductor and gently snap the sensor back together. Be careful to keep the mating surfaces clean. Dirt or grit on the mating surfaces can affect accuracy.

Three Phase Loads

Connect CT's pair of wires to a pair of terminals labeled C.T.1, C.T.2, and C.T.3. The default polarity is white on top and black on bottom. The default phase match up is as follows:

CT1 to Voltage 1 (BROWN lead)
CT2 to Voltage 2 (ORANGE lead)
CT3 to Voltage 3 (YELLOW lead)

See Figure 1.

If the unit is wired correctly to the phase relationships and CT polarity noted above, it will not be necessary to activate the AutoPhase feature.

If the polarity of any phase is reversed or if any phase mismatch is present, activating the AutoPhase feature will correct for all errors without the need for rewiring.

Single Phase Loads

Connect the CT's leads to the pair of terminals labeled "C.T. 1". The default polarity is white on top and black on bottom. See Figure 2.

Activating the AutoPhase feature will correct for any polarity reversal.

Wire Size

Use stranded wire rated for the expected voltages. Minimum wire size is #18 AWG. For best accuracy, we recommend using #14 AWG. Maximum recommended wire length for #18 AWG is 50 feet and for #14 AWG is 150 feet.

Step 3: Connect the Voltage Inputs

Connect the APO Transducer to the same power source that the CT's are sensing. Please note that the APO is powered from the same source that it is monitoring.

Follow all local codes for high voltage connections. The APO has internal fuses so external fusing may not be required. Check with local code authorities to be sure.

We recommend providing some means of disconnecting power to allow for future service. This can be a circuit breaker or disconnect switch. Make all connections with code approved connectors or on a terminal strip rated for the appropriate voltage.

Three Phase, Three Wire Loads

Connect the three phases to the BROWN, ORANGE and YELLOW wires. Connect the GREEN wire to true earth ground. Safe off the white wire. See Figure 1.

Three Phase, Four Wire Loads

Connect the three phases to the BROWN, ORANGE, and YELLOW wires. Connect neutral to the WHITE wire and GREEN to true earth ground. See Figure 1.

Single Phase Loads

Connect the BROWN wire to HOT, the ORANGE and WHITE wire to NEUTRAL and the GREEN wire to earth ground. Safe off the YELLOW wire. See Figure 2.

All output connections are made to terminals in the lower left corner of the transducer. See *Figure 1*. Skip this step if your transducer will stand alone with no connections to an automation system.

kW Demand Output Overview

The APO Series provides two analog outputs proportional to the instantaneous kW demand. One output is a user selectable 0-5 VDC or 0-10 VDC signal. The second is a 4-20 mA signal. Both are self powered and both are available at all times. See "Useful Formulas" on Page 5 for formulas to help calibrating your analog inputs. Check with your automation system manufacturer for recommended wire size and type. The APO wire terminals will accept 16-22 AWG wire.

0-5 or 0-10 VDC Self Powered Output

Connections are made to the terminals marked "0-5 VDC or 0-10 VDC". This connection is polarity sensitive, be sure to connect your systems' (+) to the APO (+) and your systems' (-) to the APO (-). The output is factory configured for 0-5 VDC. If you want a 0-10 VDC output, remove the jumper that is located directly below the output terminals. The output is self powered and no external DC power is required. Minimum input impedance is 10,000 ohms.

4-20 mA Self Powered Output

Connections are made to the terminals "4-20 mA Self Power". This connection is polarity sensitive, be sure to connect your systems' (+) to the APO (+) and your systems' (-) to the APO (-). Maximum loop burden is 500 ohms. The output is self powered and no external DC power is required. The red LED lights when the loop is electrically complete (loop current flowing).

kWH Pulse Output

The APO Series provides a pulse output for kWH. See Step 5 for pulse values. The output is a Normally Open, Opto-Isolated solid state contact. Each time the output opens, one unit of power has been measured. Maximum pulse rate is one per second. Pulses are symmetrical, with the OPEN and CLOSED periods of the same length. Connections are labeled "kWH Pulses" and are not polarity sensitive. The red LED lights when the output is CLOSED.

System Alarm

The APO provides a System Alarm if the voltage drops below the Low Voltage Alarm Setpoint. The System Alarm is a Normally Open, Opto-Isolated solid state output that closes on alarm. The connections are labeled "System Alarm" and are not polarity sensitive. The red LED lights when the output is CLOSED.

Step 5: Programming

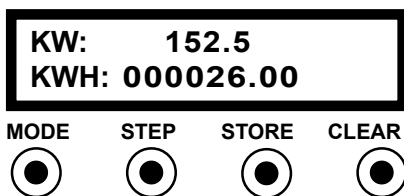
All your wiring should be installed and tested. Check that all connections are tight and that all local codes have been followed.

Using The Programing Buttons

Press one button at a time. Hold the button down until the LCD display changes. This may take up to one second.

Apply power to the APO.

Once power is applied, the LCD will display the instantaneous kW and the accumulated kWH. The numbers you see may be different than in this illustration but the LCD format will be the same.



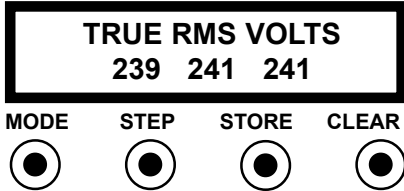
Programming Menu

The MODE button will scroll through the menu list in the following order:

1. Voltage display
2. Amperage display
3. CT Value setting
4. Maximum Watts display
5. Voltage Alarm setting
6. KWH Per Pulse setting
7. AutoPhase setting

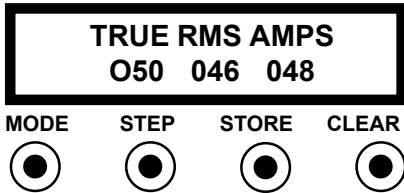
1. Voltage Display

Press **MODE** to show monitored voltage. For single phase connection, voltage will appear in the left position.



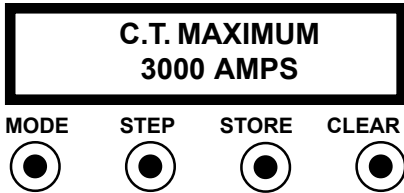
2. Current Display

Press **MODE** again to show measured current. For single phase connection, current will appear in the left position.



3. Program the CT Amp Rating

Press the **MODE** button until the LCD displays "C.T. MAXIMUM" like this:



Now press and hold the **STEP** button until the LCD displays the amp rating of the CT you are using. Release the button. Check that the correct amp rating is being displayed. Press the **STORE** button until the screen looks like this:



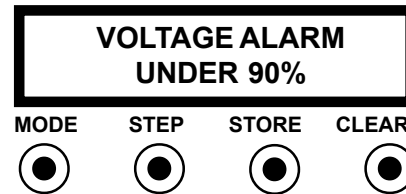
The CT Amp rating is now stored in nonvolatile memory.

4. Check the Maximum Watts

Press the **MODE** button until "MAXIMUM WATTS" is displayed. The APO calculates MAXIMUM WATTS from the CT amperage and the nominal applied voltage. The MAXIMUM WATTS value is not affected by fluctuating input voltage. The MAXIMUM WATTS value determines the span of the kW outputs. Use this value to calibrate your analog input.

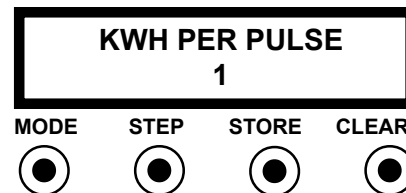
5. Program the Under Voltage Alarm

Press the **MODE** button until "VOLTAGE ALARM" is displayed. Press the **STEP** button until the desired value is displayed. "OFF" means that the Under Voltage Alarm is disabled. Press the **STORE** button until the word "STORED" is displayed. The Under Voltage Set point is now stored in nonvolatile memory.



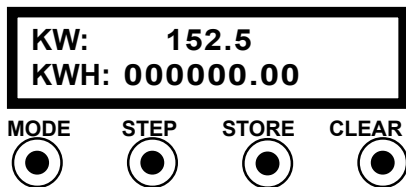
6. Program the kWh Per Pulse Value

Press the **MODE** button until "KWH PER PULSE" is displayed. Available pulse values are 0.01, 0.1, 1.0 and 10 kWh per pulse. Press the **STEP** button until the desired pulse rate is displayed. Press the **STORE** button until the word "STORED" is displayed. The kWh Per Pulse Value is now stored in nonvolatile memory.



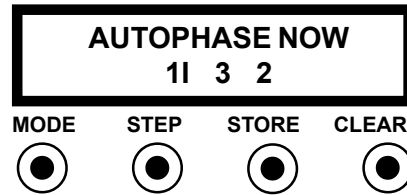
Please note that NOT all kWh / Pulse values will be available. The maximum pulse rate the APO will produce is 1 pulse per second. The APO looks at the Maximum Watts (see above) and calculates how fast a pulse rate it would have to produce for each of the four kWh/Pulse values (0.01, 0.1, 1.0 and 10 kWh/Pulse). If the pulse rate exceeds one per second, the APO automatically eliminates that pulse rate from the menu. Select from the available kWh/Pulse values. If you want to clear the kWh total, press the **MODE**

button until the LCD displays kW and kWh. Press the **CLEAR** button until the kWh value becomes 000000.00. You have reset the kWh to zero. The APO now begins a new accumulation of kWh. Note: If power to the APO is lost, the kWh total on the LCD will reset to zero when power is restored.



the information is stored in nonvolatile memory. The display will then show how the unit was actually wired. Because the information is stored in nonvolatile memory, the APO will retain this information even on loss of power to the transducer.

How to Determine Phase Arrangements:



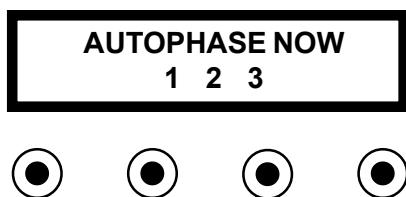
7. AutoPhase Programming

In the event of incorrect wiring -- CT polarity reversal and/or phase mismatch -- the patented AutoPhase feature will sort the voltage and current signals internally, so no rewiring is necessary.

IMPORTANT: In order for the AutoPhase feature to work properly, the internal microprocessor will require adequate signal amplitude to sort the signals. A minimum of 7% of the full scale CT value is needed. For example, if 100A CT's are used, a load of at least 7A on each phase is needed to perform the AutoPhase function.

Press the **MODE** button until "AUTOPHASE NOW" is displayed.

To perform the AutoPhase function, simply press the



STEP button. The display will briefly show "WORKING..." while the signals are being sorted. When the microprocessor has completed the sorting,



The numbers displayed provide information on how the APO was wired.

The position indicates the voltage phase:

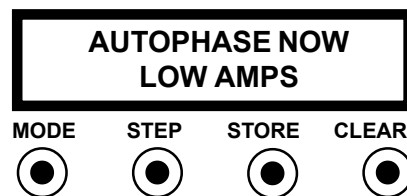
- Left - Corresponds to the BROWN lead
- Middle - Corresponds to the ORANGE lead
- Right - Corresponds to the YELLOW lead

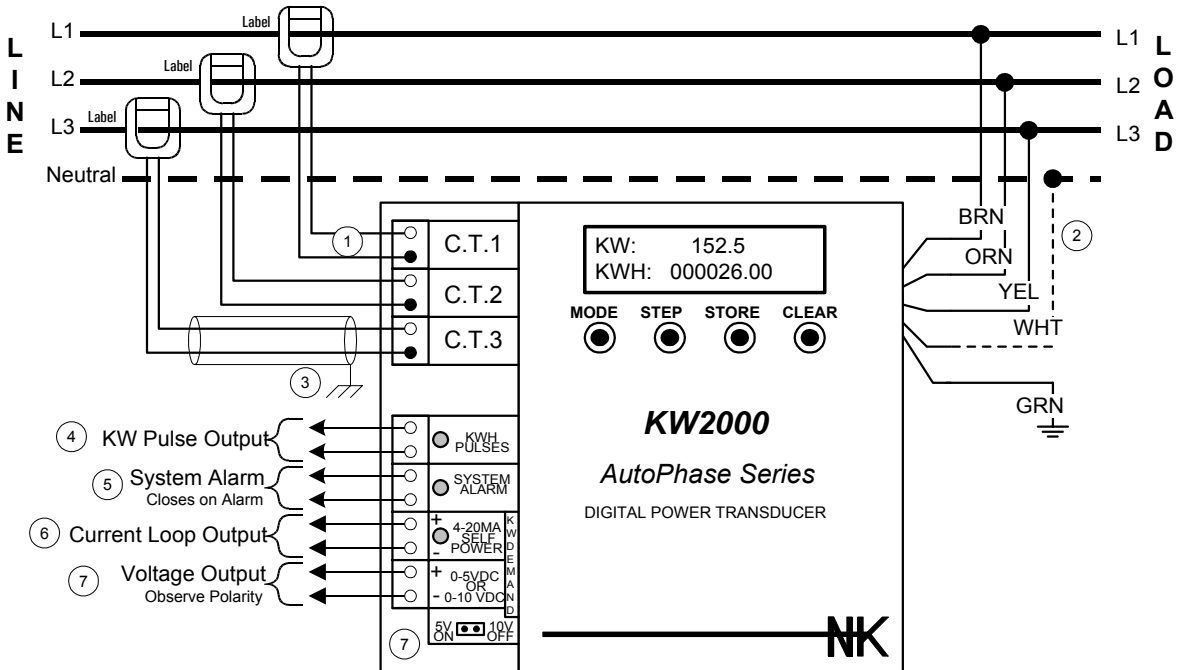
The number itself represents the actual CT number. If an "I" appears next to a number, the APO has determined that a polarity reversal exists on that particular CT.

The display example above shows "1I 3 2." This indicates that the BROWN lead is matched with CT1 with CT1 reversed; the ORANGE lead is matched with CT3; the YELLOW lead is matched with CT2.

When the APO is shipped from the factory, the default phase relationship is set to "1 2 3." This means that BROWN, ORANGE, AND YELLOW are matched with CTs 1, 2, and 3, respectively. **PRESSING THE CLEAR BUTTON WILL CHANGE THE SETTING BACK TO THE DEFAULT PHASE RELATIONSHIP. ANY PREVIOUS PHASE MATCH-UPS WILL BE LOST.**

If the load is such that the current is below the 7% threshold, the unit will display "LOW AMPS" when attempting to activate the AutoPhase function. The unit will revert back to the previous phase relationship last stored in memory.

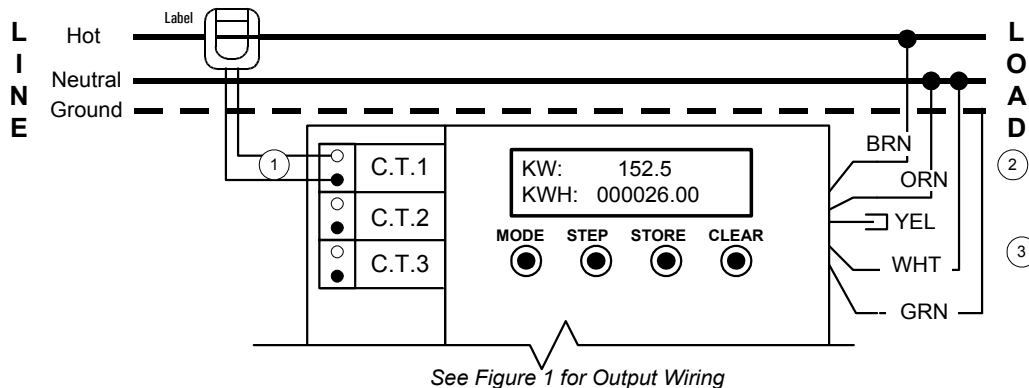




NOTES

- ① Connect Current Transformers as shown with label to source (line)
- ② Connect BROWN, ORANGE, and YELLOW to power as shown. Connect WHITE to NEUTRAL and GREEN to GROUND. Disconnect recommended. Unit is internally fused. Safe off unused wire.
- ③ Shielded twisted wire recommended for current inputs. Only one shield shown for clarity.
- ④ Opto Isolated solid state output, polarity insensitive. Each change of state from "ON" to "OFF" is one unit of kWh.
- ⑤ Opto Isolated solid state output, polarity insensitive.
- ⑥ Self powered 4-20mA output, observe polarity.
- ⑦ Self powered 0-5 VDC or 0-10 VDC output (user selectable), observe polarity. Jumper ON = 0-5VDC, Jumper OFF = 0-10VDC

Figure 2: Single Phase Wiring



NOTES

- ① Connect Current Transformer as shown with label toward source (Line). Install CT on HOT Leg.
- ② Connect BROWN to HOT, ORANGE and WHITE to NEUTRAL and GREEN to GROUND.
- ③ Safe off unused wire.

Inputs

Voltage Inputs 120, 208, 480 & 600 VAC, 50 or 60 HZ, Automatic selection
Consult Factory for 240 VAC/ 1 ϕ

Connection Five # 18 AWG leads, pre-stripped and tinned, 12 " long

Isolation Voltage 3,750 VAC

Current Inputs 0-0.333 VAC (V Suffix)
0-5 A (A Suffix)

Connections Captive screw terminal blocks, accept # 16-22 AWG wire (Current inputs and all outputs)

Analog Outputs

0-5 / 0-10 VDC Self powered, User selectable, Minimum load impedance 10,000 Ohms

4-20 mA Self powered, Maximum loop burden 750 Ohms

Digital Outputs

kWH Opto isolated solid state contact, 0.1 A, 30 VAC/VDC, no off state leakage. ON resistance 30 Ohms

System Alarm Normally Open (N.O.) Opto isolated solid state contact, 0.1 A, 30 VAC/VDC, no off state leakage. ON resistance 30 Ohms

Dimensions

Module 9.0"H x 6.5"W x 2.3" D (22.9 x 16.5 x 5.3 CM)

NEMA1 Enclosure 10"H x 10.0"W x 4" D (26 x 26 x 10 CM)

Environmental Conditions

Temperature -18 to 50 C, 0 to 122 F

Humidity 0-95% RH, Non condensing

Altitude 0-2000 Meters, 0-6,500 feet

Installation Overvoltage Category II

Pollution Pollution Degree 2

Useful Formulas

A. To find AMPS if KW or KVA are known:

$$1\phi: I = \frac{kW \times 1000}{E \times pf} \quad 3\phi: I = \frac{kW \times 1000}{E \times pf \times 1.73}$$

B. To find KW if AMPERAGE is known:

$$1\phi: kW = \frac{E \times I \times pf}{1000} \quad 3\phi: kW = \frac{E \times I \times 1.73 \times pf}{1000}$$

C. To find kW from the 4-20 mA output

$$kW = \left(\frac{mA \text{ Output} - 4 \text{ mA}}{16 \text{ mA Span}} \right) \times \text{Max kW}$$

Max kW is calculated by the KW2000 and displayed on the LCD.

Where:

E= Volts (phase-phase)
I = Amperes
kW = Kilo Watts
pf = Power Factor (use 1.0 for sizing purposes)
kW = kVA x pf

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