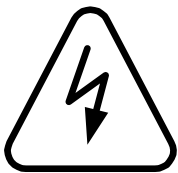


Low Voltage Transformer Installation, Operation & Maintenance

Safety Notice

Retain these instructions for future reference. Failure to follow these instructions could result in serious injury or death. Powersmiths International accepts no liability from damages arising from handling, miss-installation or miss-application of this product.

DANGER



HAZARD OF ELECTRIC SHOCK OR ARC FLASH

This equipment to be installed and maintained only by qualified personnel

Use appropriate personal protective equipment (PPE) and follow safe electrical work practices (see NFPA 70E, CSA Z462)

Before working on this equipment ensure that all power is off and locked out

Ensure all covers and doors are in a closed condition prior to applying power

NOTICE: FOR YOUR SAFETY: IT IS IMPERATIVE THAT POWER BE PROVEN DISCONNECTED BEFORE ANY WORK ON OR PHYSICAL CONTACT TO ELECTRICAL CIRCUITS IS ATTEMPTED.

DO NOT ASSUME BUT CHECK ACROSS THE LINES AND TO GROUND WITH A SUITABLE METER AND ENSURE THAT THE SOURCE DISCONNECTION DEVICES ARE SECURELY LOCKED OUT.

For your additional protection ground all transformer terminals using heavy clip jumpers

Receiving and Handling

Inspection

Upon receipt of the equipment, immediately inspect for damage that may have occurred during transit. Any damage claims are to be filed with the carrier and reported to Powersmiths expeditiously with serial number information and carrier details.

Storage

Store Transformers in a dry and clean location protected from the elements and also ensure that the ventilation openings remain covered to prevent the entry of moisture or dust. No special precautions are required for temperature extremes in the range of -40°C to $+70^{\circ}\text{C}$ but it should be protected from rapid temperature changes to avoid moisture condensation.

Handling

CAUTION



Transformers can be very heavy with a relatively high center of gravity, handle with care and move slowly to avoid tipping

Lift only by a forklift or pallet truck on the bottom of the transformer case (see moving & handling) or by overhead crane using the internal lifting eyes attached on the top frame of the core & coil assembly while ensuring even distribution of the load

Do not allow the transformer to tip on its side which may permanently damage it

Powersmiths Transformers are normally shipped using Powersmiths "Easy Skid" which is designed to minimize the use of shipping materials, maximize shipping efficiency and facilitate easy moving and safer installation even with just one installer. The transformers are also equipped with internal lifting eyes to facilitate overhead crane lifting; to access remove case covers and top; when utilizing lifting eyes, ensure even weight distribution and observe safety precautions. Padmount models have external lifting eyes.

Installation

Transformer Installation Guidelines

These guidelines are provided as a guide to assist in the installation of the transformer but for more indebt installation refer to ANSI/IEEE C57.94-2002 (Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers) and for Electrical Codes: National Electric Code (NEC) for USA; Canadian Electric Code (C22.1) for Canada:

- Ratings: Nameplate ratings (Voltage/Power) of the Transformer matches the site requirements
- Ventilation Clearance: Two (2") inches minimum between ventilation openings and adjacent surfaces
- Access: 42" front access space requirement for installation, inspection and service (re NEC, CEC etc.)
- Mounting Surface: Mounting over a non-combustible floor only (combustible floor mounting option)
- Wiring: Conduit entry through sides or bottom (see "Outline Dimensions and Wiring Access")
- Heat Load: Ventilation must be adequate to remove heat (see unit data sheet for BTU load)
- Location & Environmental conditions: Ensure that the enclosure specified and supplied is suitable for the location and environment with regard the following:
 - Sprinkler proof (UL Type 2 or 3R)
 - Outdoor (UL Type 3R)
 - Public accessibility (standard units must not be installed in publically accessible areas)

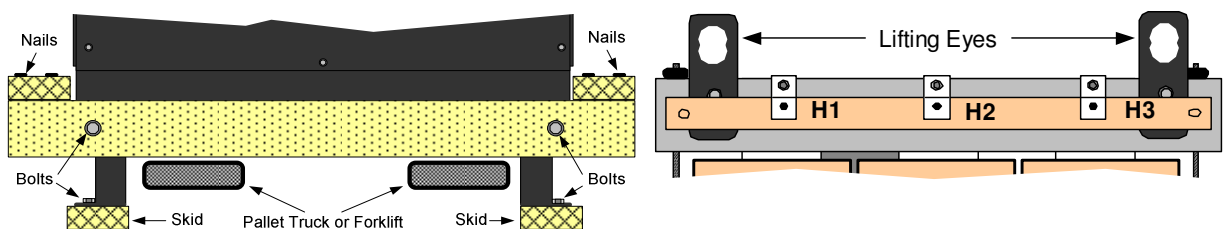
Note: Padmount models suitable for publically accessible areas are an available option

- Audible Noise: Transformers generate Audible Noise which can propagate through walls so location relative to occupant should be considered.

Note: Where sound levels may be of concern (in close proximity to people), a low noise model (-SE) is recommended and/or utilize the services of a recognized acoustical consultant to provide the proper installation environment to minimize noise and vibration transmission

Moving and Mounting

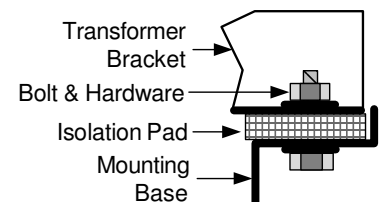
- Remove protective wrap and then the wooden skids after transformer is located in desired area as follows: Unbolt the bottom skids from the base, lift and then remove. With unit on floor, carefully remove the wooden skirts at the sides using a claw hammer and unbolt and remove the front and back protective wooden skirts (Note: Certain cabinets require inside access)



- Mark out and drill the mounting holes on the mounting pad by which the Transformer will be secured referring to the outline drawing for the unit
- Locate the transformer in the desired location using a Pallet or Forklift truck or utilizing the lifting eyes located directly on the transformer frame by removing the case cover (see diagrams above)

Note: If accessibility to the sides and rear may be an issue after installation, it may be advisable to attach the rear "Rain-shields before installation.

- Unbolt and remove the front covers (or open hinged doors)
- To minimize noise transmission re-adjust torque on internal transformer retaining bolts as follows (illustrated opposite): Slacken the four Transformer mounting bolts, retighten to finger tight and then apply two full turns.



Connections

- Identify the applicable Phasor and Terminal diagram from the Nameplate and figures provided in this bulletin; Inputs are labelled H1, H2, H3, (H0 with Wye Primaries) and Outputs X1, X2, X3, X0 etc.
Note that dual output models (T2000 and K-Star-D) have two outputs labelled X1, X2, X3 and X4, X5, X6 respectively for each set of outputs with a common dual neutral (internally connected) and T1000 Config3 and K-Star Config3 have three outputs labelled X1, X2, X3 and X4, X5, X6 and X7, X8, X9 respectively for each set of outputs with a common dual neutral (internally connected)
- Terminations: Terminations will be Copper (for copper wound units) or tin plated Aluminum (for Aluminum wound units) and do not require any special terminal preparations apart from ensuring that no foreign material contamination; mechanical lugs when supplied will be tin plated aluminum
- Wire unit to the prevailing local electric codes (eg. NEC NFPA 70, CEC C22.1) with the following additional notes:
 - **Size wire on the basis of 75°C Ampacity with insulation rated for at least 90°C**
 - Separation of primary and secondary circuit wiring with regard to required spacings for the voltage class
 - Neutral wiring normally requires over-sizing for non-linear loading
Note: K-Rated units are equipped with 200% rated neutral and some models have two neutral terminals; in such cases neutral wires should be split between them to share the current
 - Terminals are designed to support the weight of wires specific to its own connection
Note: Do not allow wires from the other terminals to load adjacent ones (weight can be significant)
 - Safety Grounding of the enclosure is mandatory (core is internally bonded to case at the factory)
 - A Neutral to Ground bond is generally required either at the transformer or at distribution panel
 - Multi-output Secondaries must be protected to a maximum of 125% of nominal nameplate rating
 - For outdoor installations seal connections with an approved electrical joint compound
 - Conduit hardware should be rated for the environment conditions (eg. water-tight where applicable)
- N1000 Models are for local Harmonic treatment and are connected to the circuit by the X terminals
 - Unit is to be protected by fuse or breaker to the listed Nameplate current rating
 - Neutral must be oversized to 200% of nominal current rating
- Lugs are not normally supplied for Transformers 112kVA and larger unless ordered as a Lug Kit
- Electrostatic shield(s) are standard on the T1000 family of transformers and customer specified/ ordered on the other models; refer to the Powersmiths bulletin on “Electrostatic Shields and Grounding” for additional information re multiple shields
- Torque all connections and check all internal bolted bus-bar connections for tightness per torque table

Torques

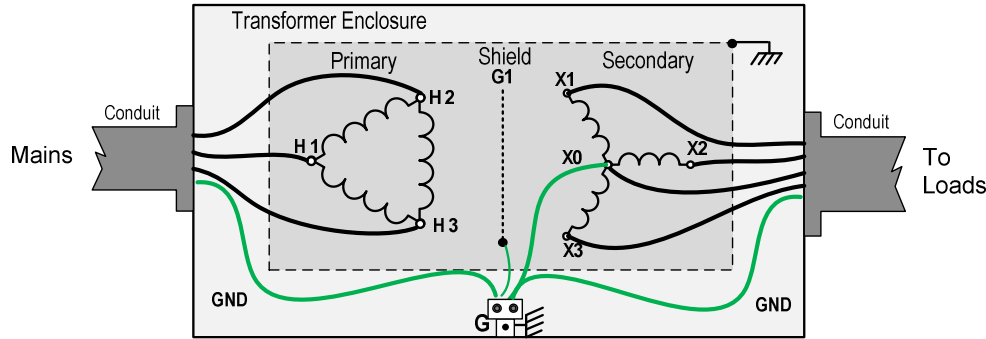
The following tables list recommended torques for the electrical connections for both bolted and compression connections.

Table of Recommended Torques (Dry) for Bolted Connections					
Bolt (Size/thread ins.)	Torque (ft-lbs)	Bolt (Size/thread ins.)	Torque (ft-lbs)	Bolt (Size/thread ins.)	Torque (ft-lbs)
1/4 - 20	6	3/8 - 16	20	1/2 - 13	47
5/16 - 18	12	7/16 - 14	32	9/16 - 12	69

Table of Recommended Torques for Compression Electrical Lugs					
Wire Size	Torque Inch/lbs	Wire Size	Torque Inch/lbs	Wire Size	Torque Inch/lbs
14	75	6	110	2/0	180
12	75	4	110	3/0	250
10	75	2	150	4/0	250
12	75	1	150	250/350 mcm	325
8	75	1/0	180	500 mcm	375

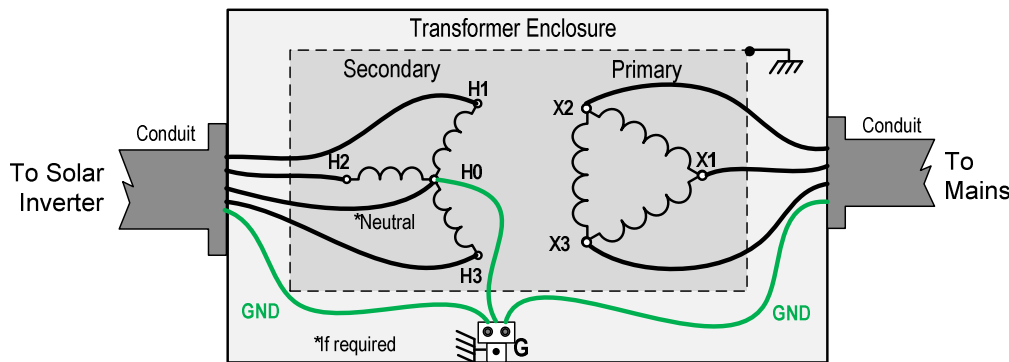
Typical Electrical Hook-ups

Power Distribution application with electrostatic shields



Note on Shield(s):
Transformers with 1 Shield, G1 is factory connected to Ground. When 2 shields are provided and there is only a single system ground, connect both G1 & G2 to the common ground as shown. Refer to the Powersmiths application guide for multi-shield connections for more guidance

Typical Solar application



Pre-service tests (optional)

The following pre-service checks may be optionally preformed prior to putting the transformer in service:

- Torque checks on all terminal connections (see torque tables)
- Insulation resistance > 100 meg ohms (using a 1,000 Volt Megger Insulation Tester)
- High Potential Voltage (HI-POT) test at 75% ($\frac{3}{4}$) of (1,000 volts AC + 2 x line voltage)
- Ratio check within 0.5% (IEEE Std C57.12.01-1998 Section 9.1) but note the following:
 - Checks should be done at the nominal tap position
 - Ratio checks on harmonic correction transformers (zig-zag secondary) require full 3-phase excitation and may not be practical to test in the field (request factory test report if required)
 - Larger Transformers (500kVA and larger) may exhibit up to a 1% ratio error or even higher due to ratio restrictions of large low voltage transformers
 - Tap adjustments are normally shown as a nominal (eg. 2 $\frac{1}{2}$ %) but may not be exact due to technical limitations of achieving exact ratios on larger low voltage distribution transformers
- Polarity and phase relation (rotation)

Start-up and Operation

- Check connections are properly torqued, required clearances and for the presence of loose strands
- Close/install all covers/doors and install external optional hardware (eg. rain shields, etc.)
- Energize and check output voltages and phase rotation at the downstream distribution point
- Should Voltage adjustment be required follow Tap adjustment procedure
- Ensure equipment is properly secured prior to leaving the site including installation of padlocks on cabinets with hinged door options and outdoor cabinets accessible to the public

Maintenance

CAUTION



HAZARD OF ELECTRIC SHOCK OR ARC FLASH

Refer to and follow the "Safety Instructions" listed at the beginning of this manual before attempting any work on this Transformer

Transformers, like any other piece of equipment, require periodic attention and maintenance in order to ensure trouble-free service and the following is provided as an overview; for more in depth guidance please refer to ANSI/IEEE C57.94-2002 (Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers).

Schedule	Procedure
<p>Periodic Visual and Thermographic* Inspections</p> <p>*Requires fitted IR Port</p>	<ul style="list-style-type: none"> - Check that the ventilation grills are not obstructed by foreign objects or for dust accumulation on grills which may indicate a major annual maintenance - Clean off excess dirt from the surface of the Enclosure using a damp rag <i>Note: Non-ventilated units must be kept substantially free of dust/dirt accumulation</i> - Using the IR Port, perform an Infrared Scan of Transformer & Terminals to check for overheating or connection hot spots indicating loose connections
<p>Major Annual Maintenance</p> <p>DANGER</p> <p>See "Safety Instructions"</p>	<p>Power checks (at the down-stream distribution panel):</p> <ul style="list-style-type: none"> - Check that loading is in correct range for the transformer - Check load balance per phase and redistribute loading if possible <p>Visual Checks: De-energize transformer and remove covers, then:</p> <ul style="list-style-type: none"> - Blow off (dry compressed air) and/or vacuum any excessive dust build-up from windings, terminals, core and the interior of the cabinet - Check for signs of discoloration on the coils and terminals (overheating) - Check for signs of insulation deterioration (blackening) on coils (ionization) - Check that connections are tight and re-torque as required

Note: The inspection frequency depends on the operating conditions with annual or longer periods acceptable for clean dry locations but more frequent for adverse environmental conditions (eg. Dust, airborne contaminants, chemical fumes, etc.).

Tap Adjustment Procedure

Taps are used to adjust to input voltages or to 'tweak' the output voltage (e.g. adjust for cable voltage drops). Transformers are normally supplied with two 2½ % Taps above nominal (2 x 2½ % FCAN) and two to four 2½ % Taps below (2/4 x 2½ % FCBN) and shipped at nominal setting. Examples shown below:

<p>DANGER</p> <p>See safety Instructions</p>	Single Phase		Three Phase					
	Tap	Link	Tap	Link	Tap	Link		
	+5%	1 - 1		+5%	1		+5%	1 - 2
	+2.5%	2 - 2		+2.5%	2		+2.5%	2 - 3
	0%	3 - 3		0%	3		0%	3 - 4
	-2.5%	4 - 4		-2.5%	4		-2.5%	4 - 5
	-5%	5 - 5		-5%	5		-5%	5 - 6

To adjust for:

- Higher Input voltage Unbolt Tap and reconnect to a higher voltage output setting
- Lower Input voltage Unbolt Tap and reconnect to a lower voltage output setting
- Reduce output voltage Unbolt Tap and reconnect to the next higher voltage setting
- Increase output voltage Unbolt Tap and reconnect to the next lower voltage setting

Note: Refer to Transformer Nameplate for specific Voltage and Tap configurations as some models are equipped with two 5% taps and others six 2 ½% taps or more

Options (Partial list)

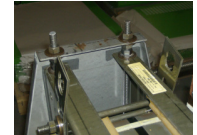
Terminal Options

Powersmiths offers a variety of termination options to ease installation from mechanical to compression lugs with up to 12 landing points per terminal.



Seismic Qualification (OSHPD & IBC)

Transformers are available with Seismic certification to IBC or OSHPD (California) prequalification for any zone in North America



Electrostatic Shields

An Electrostatic shield is standard on the T1000 family of transformers and optional on the other models. Single shield units are supplied factory grounded to the case ground and multiple shields are brought out and labelled G1, G2, G3. Note that G1 is closest to the secondary and G2/3 to the primary respectively.

Hinged Doors

Hinged doors are available as an option on all cabinets to facilitate easier and safer maintenance. Note that a padlock is necessary for personnel safety using the padlocking provision provided.



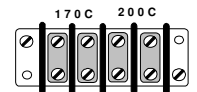
Accessory Breakers

Transformers are available with accessory Input and/or Output Breakers; refer to separate instruction provided for installation.



Thermal Sensors

Thermal sensors (when supplied) are terminated at the upper Transformer bracket. Electrical Rating is 1 Amp @ 250VAC or 24VDC max. Wiring must be rated for the Transformer voltages (generally 600 or 480V) and separated from the power wires.



SMART Integrated Meters & Ports

SMART™ Integrated Meters and Measurement Ports are optionally installed into any of Powersmiths transformers to allow fast and easy access to transformer performance, energy consumption and power quality data.



SMART-1 is a measurement Port for transformer primary and secondary electrical parameters including coil temperatures and internal surge protection status (when supplied).

SMART-2 incorporates a Power Meter for direct measurement of Load parameters and supports both local and remote access over RS485 using the popular Modbus RTU protocol or over Ethernet (option). SMART-1 capability is additionally available as an option.

SMART3 is similar to SMART-2 but includes a WEB server for dynamic WEB pages.

Cyberhawk-Tx Metering

The *Cyberhawk-Tx* is an energy and power quality monitor, available on any of Powersmiths Transformers (mounted on the top right corner of the cabinet). It measures the operating efficiency of the Transformer and other electrical parameters (V, I, THD, kW, kWh, kVA, VAR, PF, Harmonics, Waveforms, etc.) and provides date stamped event recording of deviations from user set points, including Sags and Swells. It also includes a WEB server that delivers dynamic WEB pages to a common Internet Browser (IE, Firefox, Safari, Opera, etc) without requiring any special user software.



Rotatable IR Inspection Port (Patented)

A Rotatable Infrared Inspection (IR) Port is available from Powersmiths that facilitates safe preventative maintenance IR inspections of the transformer under actual live operating conditions. It allows the operator to “see” with a 360° view, the transformer and connections inside the closed cabinet using Infrared Imaging Equipment (e.g. IR Cameras), virtually eliminating any Arc Flash triggers.

Note: Refer www.powersmiths.com for further information on any product/options



Transformer Enclosures

<p>CAUTION</p> 	<p>Potential Hazard or Equipment Failure</p> <p><i>Ensure that the enclosure ordered and supplied is suitable for the operational environment</i></p> <p>Do not install units intended for restricted access in areas accessible to the public</p>
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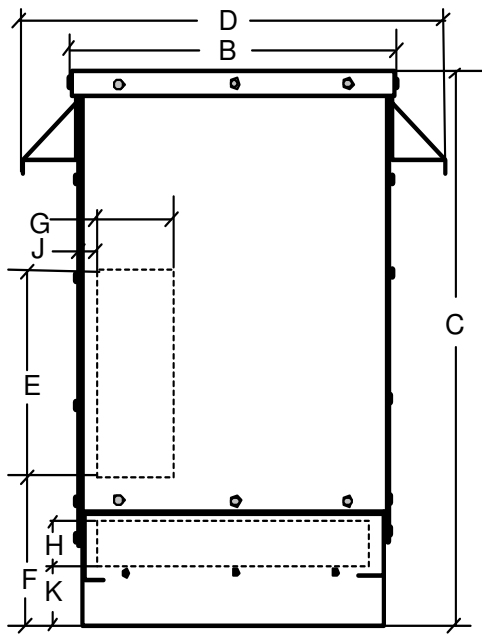
Transformers are available from Powersmiths in a variety of enclosures to suite most environments as follows:

- Type 1: Standard Enclosure for installation indoors in areas **inaccessible** to the public
- Type 2: Standard Enclosure fitted with “Rain-shields” (at site) for protection against dripping moisture and water from sprinklers for installation indoors in areas **inaccessible** to the public
- Type 3R: Outdoor Enclosure for installation outdoors in areas **inaccessible** to the public
- Type 3R Padmount: Robust Outdoor Enclosure for installation in pad mounted outdoor areas accessible to the public (requires a user added padlock)
- Type-4X: A sealed stainless-steel enclosure (no openings) available for up to 75kVA Transformers for installation in corrosive environments (eg. Swimming pool areas) in areas accessible to the public (requires a user added padlock). Outdoor installation is also possible with an optional solar shield
- Type-12: A Sealed enclosure available for up to 75kVA Transformers for installation in dusty environments in areas inaccessible to the public (requires a user added padlock)

Note: Hinged doors are an option at time of order and facilitate easier and safer service. **Units fitted with hinged doors have provision for padlocking and a padlock must be installed which is a code requirement for personnel safety.**

Outline Dimensions and Wiring Access (standard indoor enclosures)

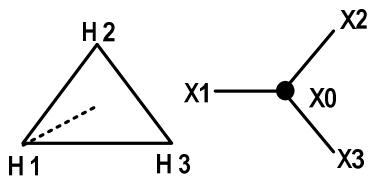
The following dimensions are provided for the standard indoor enclosures as a guide only; for specific outline details, please refer to the specific data sheet on the transformer.

	A-Case	B-Case	C-Case	C-Plus	D-Case	D-Plus	E-Case	E-Plus	F-Case	F-Plus	
Typ. kVA	≤15	30 - 45	75 - 112.5	112.5 Dual	125 - 150	225 - 300	400	500	750	1000	 <p>Note: Dotted lines for side wiring access area; Bottom wiring access permissible (not shown)</p>
A*	17.4	25.4	31.4	31.4	37.4	37.4	51.4	51.4	63.4	63.4	
B	16.8	17.8	21.5	22.5	26.5	31.5	31.5	37.5	44.5	52.5	
C	27.1	29.9	39.9	39.9	47.6	51.6	60.6	60.6	66.6	66.6	
D	24.3	25.3	29.3	33.3	34.3	39.3	39.3	45.3	52.3	60.3	
E+	9	9	16	16	21	24	28	30	36	36	
F	11	11	11	11	11	13	14	14	14	14	
G+	4	6	6	6	7	8	9	10	11	11	
H	3	3	3	3	3	5	5	5	6	6	
J**	1	1	1	1	1	1	1	1	1	1	
K	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	
Notes:	<ul style="list-style-type: none"> - All dimensions in inches - *A' dimension is width (not illustrated) - ** is Minimum & + is maximum recommended - 'D' dimension only with rain-shields installed <p>Wiring permissible through bottom grille which is at height K-1.0 inches from footing</p>										

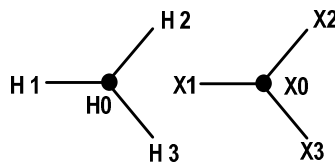
Connections and Phasor Diagrams

The following Phasor diagrams are typical for the Powersmiths line of Transformers; however please refer to the Transformer Nameplate to identify the Phasor diagram specific to the transformer

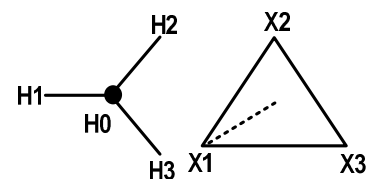
E-Saver, TPNL & HC-ISO (Delta-Wye)



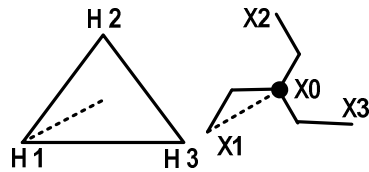
E-Saver & HC-ISO (Wye-Wye)



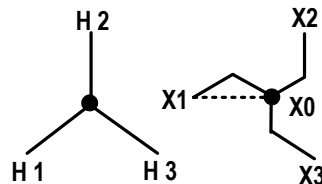
E-Saver & HC-ISO (Wye-Delta)



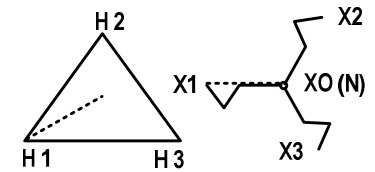
K-Star & T1000-0/15/45 (0 & 15/45 Deg.)



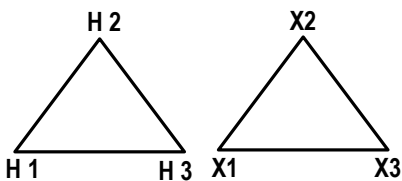
T1000-30 (30 deg.)



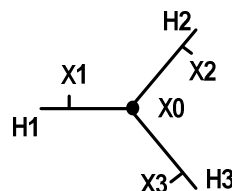
T1000-30 Config3 (30 deg.)



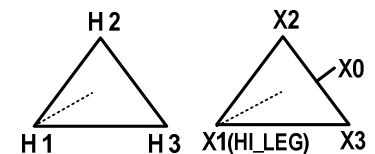
HC-ISO (Delta-Delta)



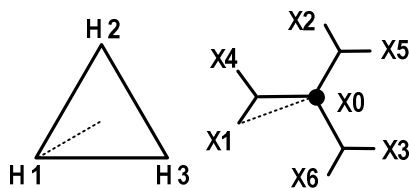
HC-AUTO



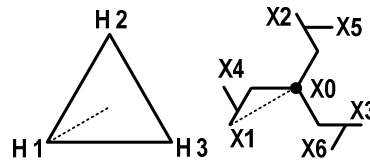
HI-LEG (all models)



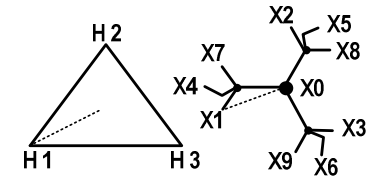
K-Star-D & T2000 (15/45 deg)



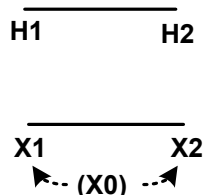
K-Star-D & T2000 (0/30 deg)



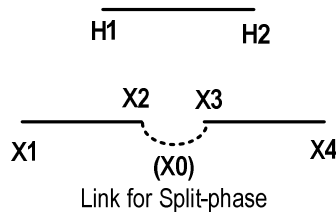
K-Star-D-Conf3 & T2000-Conf3



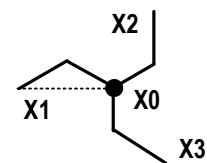
Single Phase (all models)



Single/Split Phase (all models)



N1000



Notes:

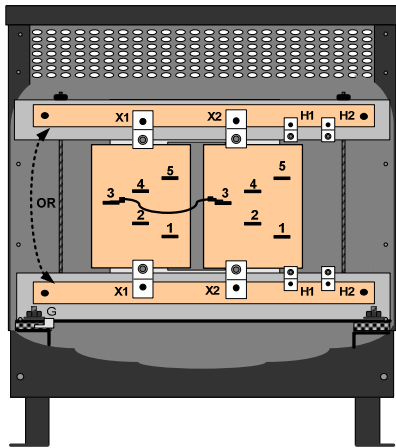
Electrical codes (NEC, CEC) require that the Transformer output be grounded (safety and fault clearing) either at the transformer **Case Ground** or at the **Electrical Panel** or other approved location. This **Neutral/Ground bond is not factory connected; this bond is to be made by the electrical contractor at installation.**

Multiple Outputs: The secondary output from each multiple output transformer must be protected by external over-current protection at a maximum of 125% of its rated nameplate output current. (Primary protection only is insufficient where each output is rated less than the total transformer kVA).

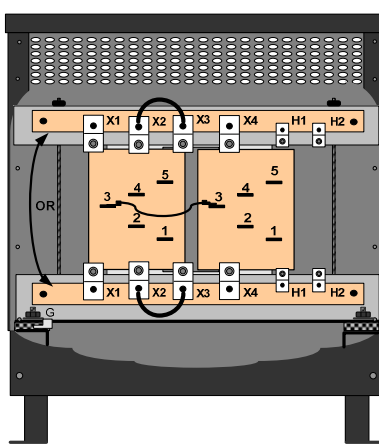
Solar installations generally require a balanced ground on the Inverter/Solar Panel side and the Neutral of a Wye (4-wire) primary provides a convenient grounding point (secondary connection to the mains can be Delta or Wye as grounding will be made at the power source).

Terminal Layouts

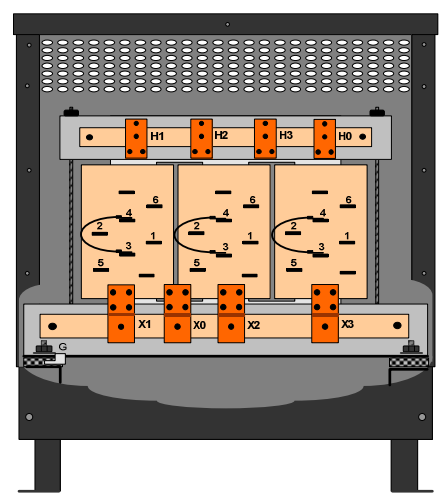
Single Phase < 100kVA



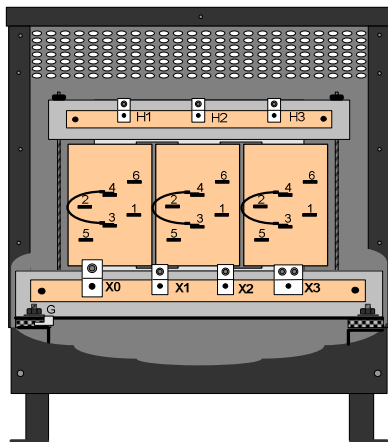
Split-Phase < 100kVA



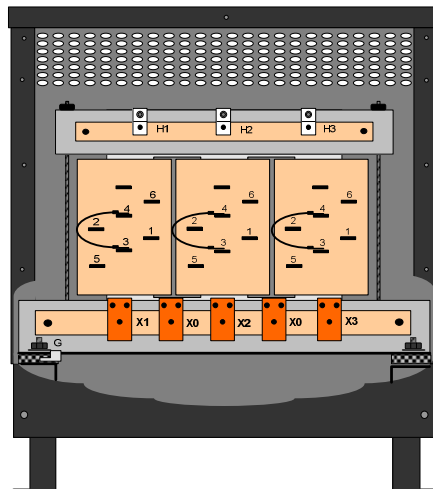
Three Phase Wye – Wye (Solar)



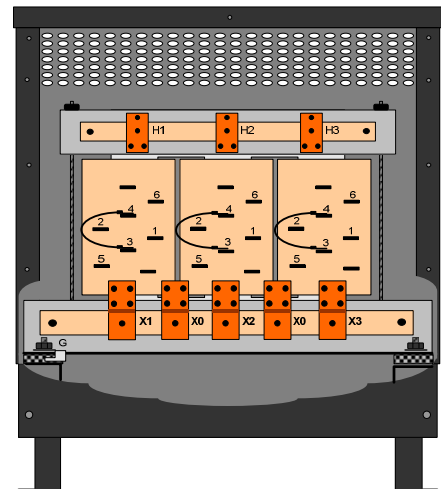
Three Phase < 75kVA



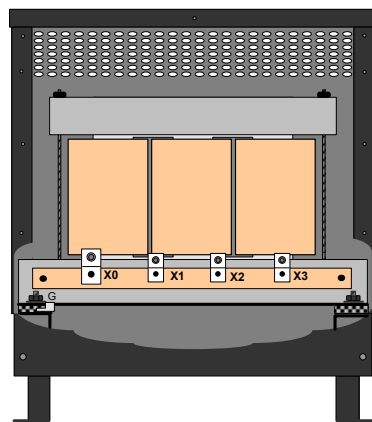
Three Phase 112 – 150kVA



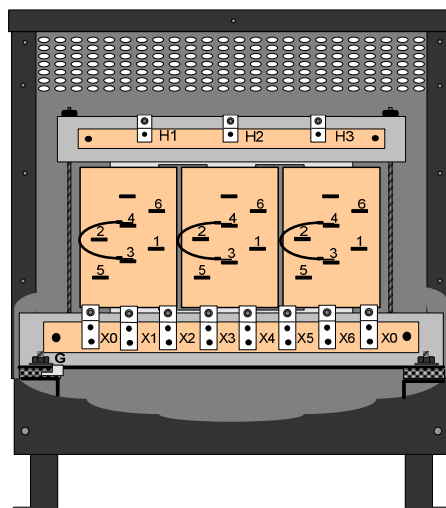
Three Phase > 225kVA



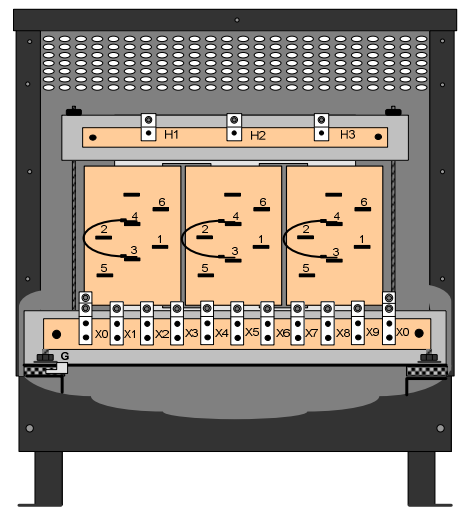
N1000



Three Phase Dual Output



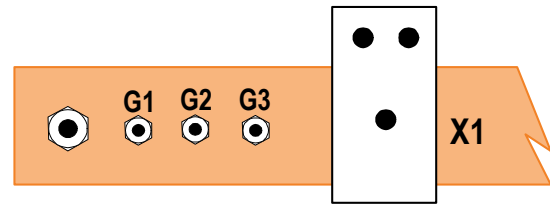
Three Phase Triple Output



Note: Neutral connections can be split between the two Neutral Terminals when so equipped (these are internally connected for the 200% required rating for K-Rated Transformers)

Shield Terminals

Typical Multi Shield Terminal Layout:



Notes:

1 x Shield: Factory connected to the Case Ground

2 x Shields: Shields to be connected to independent grounds or both to common ground for single ground systems

3 x Shields: Shields are connected to independent grounds and case ground or all to common ground for single ground systems

Note: Refer to Powersmiths paper on multi-shield connections for more details

Transformer Case Disassembly and Reassembly

Due to access width restrictions, it may be necessary to disassemble the Transformer assembly to facilitate transportation through narrow entrances. The following procedure documents the procedure:

Note: The case top and sides are retained by 1/4" sheet-metal screws removed with a standard 3/8" socket. When retightening do not over tighten or use a power driver as the screws will strip out of the sheet metal.

1. Case Disassembly:

- a. Remove the sheet metal cladding as follows: 1) Front cover 2) Top and 3) Sides (*Note: Easy skid may be left in place until the end of the operation*)

2. Detach Core/Coil from base:

- a. Detach the Transformer from the base as follows:
- b. Disconnect the core/coil ground strap(s) from the bottom transformer brackets
- c. Unscrew the four bolts retaining the bottom transformer bracket to the base

3. Moving to location

- a. Lift the transformer using a Hoist or Fork-lift with rigging distributing load on all four lifting eyes
- b. Transport Core/Coil Assembly to the required location

4. Reassembly

- a. Lower Core/Coil onto base and reattach 4 mounting bolts, tightening 2 complete turns after contact
- b. Re-attach Grounding straps
- c. Attach cladding starting with 1) Sides, 2) Rear, 3) top

5. Installation

- a. Complete installation following normal procedures

