Constant Voltage Sinusoidal Transformers
Operating and Service Manual

Introduction
This operating and service manual has been prepared to ensure that your Sola/Hevi-Duty Constant Voltage Transformer can be operated and serviced with minimal effort and involvement. This manual covers Sola/Hevi-Duty Constant Voltage Sinusoidal (CVS) Transformers.

Installation - Mechanical Position
All stock sizes with and without mechanisms are intended to be mounted with the shielding-screened this side up, as shown in Figure 1. This will place the vented capacitor compartment downward, thus providing cooler operation of the capacitors. Shielding-screened units will give satisfactory performance if mounted in a horizontal position, in either case. No provision is made in any case where it is unlikely that anyone will come into contact with the core surface of the unit. Mounting Considerations
If an unit is to be wall mounted, the mounting hardware should be sized as in Table 1 below. All mounting holes provided must be used.

Table 1: Mounting Screw/Bolt Sizing

<table>
<thead>
<tr>
<th>VA</th>
<th>Catalog Number</th>
<th>Outline Drawing</th>
<th>Min. Diameter of Mounting Screw</th>
<th>#10 Machine Screws</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>23-12-030-2</td>
<td>A</td>
<td>1/16”</td>
<td>0.0625”</td>
</tr>
<tr>
<td>60</td>
<td>23-12-030-2</td>
<td>A</td>
<td>5/32”</td>
<td>0.156”</td>
</tr>
<tr>
<td>120</td>
<td>23-12-030-2</td>
<td>A</td>
<td>9/32”</td>
<td>0.285”</td>
</tr>
<tr>
<td>250</td>
<td>23-12-030-3</td>
<td>A</td>
<td>15/32”</td>
<td>0.472”</td>
</tr>
<tr>
<td>500</td>
<td>23-12-030-3</td>
<td>A</td>
<td>19/32”</td>
<td>0.601”</td>
</tr>
<tr>
<td>1000</td>
<td>23-12-030-4</td>
<td>A</td>
<td>1”</td>
<td>0.938”</td>
</tr>
</tbody>
</table>

All ratings depend on natural draft air circulation for cooling. They should not be mounted in confined or enclosed spaces unless special provisions have been made for ventilation. Technical Services is available for assistance in doubtful situations (see note on Operating Temperature). Table 2 and Figure 1 show model number with their weight and physical dimensions.

Table 2: CVS Weights and Physical Dimensions, 60 Hz Single Phase

<table>
<thead>
<tr>
<th>VA</th>
<th>Dimensions</th>
<th>Approx. Shipping Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>380 x 190 x 1050</td>
<td>2.2</td>
</tr>
<tr>
<td>60</td>
<td>760 x 190 x 1050</td>
<td>4.2</td>
</tr>
<tr>
<td>120</td>
<td>1180 x 190 x 1050</td>
<td>9.0</td>
</tr>
<tr>
<td>250</td>
<td>1780 x 190 x 1050</td>
<td>17.2</td>
</tr>
<tr>
<td>500</td>
<td>2370 x 190 x 1050</td>
<td>30.6</td>
</tr>
<tr>
<td>1000</td>
<td>2960 x 190 x 1050</td>
<td>52.8</td>
</tr>
</tbody>
</table>

Installation - Electrical
On 50/60 Hz or smaller units, screw-type lugs in the outlet box are marked “input” and “output”, and no connection diagram is necessary. Units rated 120 to 150kVA are provided with multiple inputs for any one, two, three, or four different line voltages, and some have provision for three-wire output. As shown in Figure 3, Figure 4 shows the output connections for all models. Figure 4 shows the output connections for all models. Figure 4 shows the output connections for all models.

Figure 2: Electrical Connections for 4 models

Figure 3: Electrical Connections for Non-8 models

Three-Phase Power Wiring
If operation from a three-phase source is required, three hardwired regulators must be used as shown in Figure 4. Considerations
It is desirable to have a switch in the input circuit for turning off the power to the unit. When the units are configured for continuous duty, they draw appreciable current regardless of output loading.

The outputs of all Sola/Hevi-Duty standard CVS Transformers are isolated from input lines. Voltages and leakage currents will occur with respect to ground. This can have undesirable effects in many pieces of electronic equipment. Therefore, if Figure 4 circuit “B” is used, it is suggested that the installer remove X2 grounding on -8 units, then connect all X2 from each phase to one location and ground at that location only. This is not necessary for circuits “A”. This will not affect regulation or the ability to reject power line noise or transients.

Any three units having a tap for 190-260 volt input connections may be connected in delta to a 240-volt, three-phase power supply. Those units equipped with primary taps for 175-205 volts may also be connected in delta to a 208-volt supply. (Terminals to be used are identified on the connection diagram located on the inside face of the outlet box cover.) All stock production, harmonic-free units now have uniform terminal polarity. This eliminates the need for “phasing out” either input or output connections.

Output must be three, independent, single-phase loads of the same total volt-amperes rating. Connections should be made in one of two ways shown in Figure 4.

Use With Switchmode Power Supplies
If a CVS transformer is used as a source for a switchmode power supply, a slight amount of ringing may be noticed on the sinewave output of the CVS at half cycle intervals for a short duration. This ringing occurs at the point when the switchmode power supply current demand drops to zero. This ringing should not be a cause for concern since it is relatively low magnitude and frequency. The CVS has been tested with a variety of switchmode power supplies; and it has been determined that the ringing never affects the output, nor has it found to degrade the components of any switchmode power supply.

Multiple Operation
Two CVS transformers with the same rating may be connected with their inputs and outputs in parallel. The combined units will exhibit the characteristics of a single unit; however, the standard ±1% cannot be guaranteed. Series connection of either input or output is not recommended.

Use With Rectifier Loads
The ratio of crest to rms values is approximately 1.3 at rated load, and slightly lower at fractional loads. This factor must be considered when all or a portion of the voltage is rectified. The rectified voltage will now be 10 – 15% lower than if connected directly to a sine-wave source.

Operation With Motor Loads
Because of the current limiting effect described later, special attention should be given to motor applications. In general, the CVS must have a load rating nearly equal to the maximum power drawn during the starting cycle. This may run two to eight times the normal running rating of the motor. In doubtful cases, it is advisable to measure the actual starting current.

Cascade Operation
For applications requiring close regulation, two CVS transformers may be operated in “cascade”. The output of the combination will show little or no detectable change arising from supply (q), as discussed under Effect of Frequency, page 15. Since even good power systems may vary in frequency by 0.1% or more, the output of a Sola/Hevi-Duty cascade combination may vary up to 0.2% from this range. In actual practice, then, a cascade combination is highly recommended for special applications requiring regulation in the general region of ±0.25%. If the tendon setup is to be operated at near full rating, then the Type CVS “driver” unit should be one standard size larger than the driven unit, in order to overcome the losses in the latter.
Field Replacement of Capacitors

Capacitors used in all CTV transformers are of the highest commercial grade available. Nonetheless, there is a certain small percentage of failures. Sola/Hevi-Duty’s guarantee includes free replacement at the factory of any capacitor unit that fails within one year from date of purchase. Older units can be returned to the factory for inspection at once. A Return Authorization Number will be issued.

Factory Test and Inspection

If the field test suggested earlier indicated that the CTV transformer itself may be faulty, a full report of the characteristics should be communicated to the place of purchase, with a request for permission for return. The Authorized Sola/Hevi-Duty Distributor may then perform a helpful field test, or authorize return for inspection at once. A Return Authorization Number will be issued. This number must appear on the outside of the shipping container. Otherwise the shipment will not be accepted.

Warranties

Sola/Hevi-Duty warrants its standard catalog products to be free from defects in materials and workmanship and agrees to correct by repair or replacement, at the factory, any Sola/Hevi-Duty product that may fail to perform the service provided the product has been installed, operated and maintained in accordance with accepted industry practice.

Warranty begins at the date of manufacture and is according to the following schedule:

1. Standard catalog transformer and single phase power conditioning products – 10 years plus an additional 2 years if online registration (www.solahd.com) is completed within 12 months after installation.
2. Products manufactured to a purchaser’s specifications – 1 year.

Effects of Frequency

Changes in the frequency of the supply voltage will be directly reflected in the output voltage. A change of approximately 1% in the output voltage will occur for every 1% change in input frequency in the same direction as the frequency change.

Effect of Temperature

The output voltage will show a small change as the unit warms up to stable operating temperatures at a constant ambient temperature. This change may be as much as 1 or 2% depending on the unit’s design. As a stable operating temperature, the output voltage will change slightly with varying ambient temperature. This shift is approximately 1% for each 4°C of temperature change.

Current Limitation

When the load is increased beyond the transformer's rated value, a point is reached where the output voltage suddenly collapses and will not return its normal value until the load is at least partially released. Under a direct short circuit, the current is limited to approximately 150-200% of the full-load current and the output voltage to less than 10% of normal. A CTV will protect itself and its load against damage from excessive fault currents. Fusing of load circuits is not necessary.

Manufacturing Tolerance

The nominal output voltage of each stock Constant Voltage Transformer is adjusted with respect to the factored load plus 2%, minus 5% of rated (nominal) value with rated, nominal voltage at rated frequency applied to the input, and with full rated load at 100% power factor applied to the output. This adjustment is made with the unit at substantially the same temperature as room ambient temperature (20°C).

Servicing

Routine Maintenance

As the Sola/Hevi-Duty CTV Transformer is a simple rugged device without any moving parts or manual adjustments, no servicing or maintenance is needed with the ordinary service. The percentage of possible poor performance or failure is exceedingly low. In any case of apparent poor performance, the user is urged to check the following points immediately:

Checklist on Factors Affecting Performance

1. The load may be considerably less than full rating. (See “Load Regulation”)
2. The load may be having a leading power factor. (See “Load Regulation”)
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5. The load may be considerably less than full rating. (See “Load Regulation”)
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14. The load may be having a leading power factor. (See “Load Regulation”)
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16. The load may be having a leading power factor. (See “Load Regulation”)
17. The load may be considerably less than full rating. (See “Load Regulation”)
18. The load may be having a leading power factor. (See “Load Regulation”)
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24. The load may be having a leading power factor. (See “Load Regulation”)
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58. The load may be having a leading power factor. (See “Load Regulation”)
59. The load may be considerably less than full rating. (See “Load Regulation”)
60. The load may be having a leading power factor. (See “Load Regulation”)

Checklist on Factors Affecting Performance continued...

1. Check power source stabilizers or line filters.
2. Check continuity between input terminals, and also between output terminals.
3. Transformer Operating Temperature

1. These transformers are designed to operate at high flux density, and hence, relatively high temperatures (see Operating Temperature). After return to line for a half hour or so, the exposed core structure may be too hot to touch with bare hand, but this is normal and need give no concern. However, if there is any indication of oil or compound leakage, unit should be returned to factory (see below).

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Effect of Load Power Factor

The median value of output voltage will vary from the nameplate rating of the load if a power factor other than that for which the unit was designed is used. Load regulation will also be relatively greater as the inductive load power factor is decreased (see Figure 5). However, the resulting median values of the output voltage will be regulated against supply line changes at any reasonable load or power factor.

Figure 6: Median Output Voltage vs. Load Power Factor

Factors Affecting Operation

Input Characteristics

As the Sola/Hevi-Duty CTV transformer includes a resonant circuit that is fully exposed when either no load or a light load is present, the input current at no load or light loads may run 50% or more of the full-load primary current. As a result, the temperature of the unit may rise to near full-load levels, even at light or non-Iosaceous loads. Input power factor will average 90%-100% at full load, but may drop to approximately 75% at half load and 25% at no load. In any case, it is always leading.

Table 4: Output Voltage Changes – 25% Load to Full Load (100% Power Factor – Nominal Input Voltage)

<table>
<thead>
<tr>
<th>Transformer VA</th>
<th>%Change from Nominal</th>
<th>Approximate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>125-150</td>
<td>120-140</td>
<td>3%</td>
</tr>
<tr>
<td>125-150</td>
<td>110-130</td>
<td>2%</td>
</tr>
<tr>
<td>125-150</td>
<td>90-110</td>
<td>1%</td>
</tr>
</tbody>
</table>

Phase Shift

The phase difference exists between input voltage and output voltage of the transformer is in the range of 120° to 140° at full load. This phase difference varies with the magnitude of the load and, to a lesser extent, with changes in line voltage.

Output Wave Shape

The CTV transformers all include harmonics-neutralizing circuitry. These units typically have less than 3% total harmonic distortion at full load and less than 4.5% at no load.

Response Time

An important advantage of the Sola/Hevi-Duty principle of static magnetic regulation is that a rapid transient response time compared with other types of AC regulators. Transient changes in supply voltage are usually corrected with a Sola/Hevi-Duty CTV with 1.1 cycles or less, the output voltage will not fluctuate more than a few percent during this interval.

Isolation

Since the input and output are separated not only electrically, but also physically, the magnetic field, the Sola/Hevi-Duty CTV has a space-isolating effect than a conventional transformer. This may often eliminate the need for static shields.

Change in “Medium” Output Voltage vs. Load Power Factor

Checking With Voltmeters

All checks on output voltages should be made with a true RMS voltmeter such as a Fluke model 8020. Ratiometer-types voltmeters will not give accurate readings due to the small amount of harmonics present in CTV output.

Load Regulation

Changes in output voltage resulting from changes in resistive loads are usually small – running one percent or less in the larger units. Table 4 shows average values for output voltages.

Industrial Automation

Sola/Hevi-Duty (800) 377-4384 www.solahd.com