High Frequency
Sinewave Guardian™ Filter
380V – 480V
TECHNICAL REFERENCE MANUAL

FORM: SHF-TRM-E
REL. April 2015
REV. 001

Caution	Prior to start up; confirm the drive operation mode is properly set (Volts per Hertz or suitably set for sensor less vector mode). Please consult drive manual/manufacturer to configure proper parameters. Failure to do so may result in failure of drive or filter components.
WARNING	**High Voltage! Only a qualified electrician can carry out the electrical installation of this filter.**

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1. WARNINGS

Warnings and Cautions

There are two types of warnings in this manual:

- WARNING describes situations that can lead to serious faults, physical injuries, or even death.
- Caution describes situations that can lead to malfunction or possible equipment damage.

 **WARNING**	WARNING describes situations that can lead to serious faults, physical injuries, or even death.
 **Caution**	Caution describes situations that can lead to malfunction or possible equipment damage.

The following symbols are used in this manual.

- High Voltage Warning: warns of situations that dangerously high voltage is involved. Failure to use proper precautions may lead to serious injury or even death.
- General Warning: warns of situations that can result in serious injury or death if proper precautions are not used.
- General Caution: identifies situations that could lead to malfunction or possible equipment damage.

 **WARNING**	High Voltage Warning: warns of situations that dangerously high voltage is involved. Failure to use proper precautions may lead to serious injury or even death.
 **WARNING**	General Warning: warns of situations that can result in serious injury or death if proper precautions are not used.
 **Caution**	General Caution: identifies situations that could lead to malfunction or possible equipment damage.

General Safety Instructions

 **WARNING**	**High Voltage! Only a qualified electrician can carry out the electrical installation of this filter.**
 **WARNING**	High voltage is used in the operation of this filter. Use Extreme caution to avoid contact with high voltage when operating, installing or repairing this filter. **Injury or death may result if safety precautions are not observed.**
 **WARNING**	The opening of the branch circuit protective device may be an indication that a fault current has been interrupted. To reduce the risk of fire or electrical shock, current-carrying parts and other components of the filter should be examined and replaced if damaged.
 **WARNING**	An upstream disconnect/protection device must be used as required by the National Electrical Code (NEC) or governing authority.
 **WARNING**	Even if the upstream disconnect/protection device is open, the drive down stream of the filter may feed back high voltage to the filter. The drive safety instructions must be followed. **Injury or death may result if safety precautions are not observed.**
 **WARNING**	The filter must be grounded with a grounding conductor connected to all grounding terminals. Modular filters must have reactor grounded through a 2”x2” area cleaned of paint and varnish on lower mounting bracket.
 **WARNING**	Only spare parts obtained from MTE Corporation or an authorized MTE distributor can be used.
 **WARNING**	After removing power, allow at least five minutes to elapse and verify that the capacitors have discharged to a safe level before contacting internal components. Connect a DC voltmeter across the capacitor terminals and ensure that the voltage is at a safe level.
 **Caution**	Loose or improperly secured connections may damage or degrade filter performance. Visually inspect and secure all electrical connections before power is applied to the filter.
 **Caution**	Prior to start up; confirm the drive operation mode is property set (Volts per Hertz). Please consult drive manual/manufacturer to configure proper parameters. Failure to do so may result in failure of drive or filter components.
 **Caution**	Damage to the filter may occur if the output frequency is not set between 4.8 kHz and 8 kHz. Optimum output frequency is 5kHz.
 **Caution**	Over speeding a motor can cause it to break. Motor must be rated to run above 60Hz

2. INTRODUCTION

The purpose of the manual is to properly specify, size, and install the High Frequency Sinewave Filter.

High Frequency Sinewave Filters transform the output of Variable Frequency Drives (VFDs) to a near perfect sinusoidal waveform for the best level of motor protection. MTE's unique, patent-pending design offers high performance with smaller size and better efficiency than traditional LC Filters.

For most current information, please refer to website
http://www.mtecorp.com/products/dvsentry/

Receipt & Repair Statement

Upon Receipt of this Filter:

The high frequency sinewave motor protection filter has been subjected to demanding factory tests before shipment. Carefully inspect the shipping container for damage that may have occurred in transit. Then unpack the filter and carefully inspect for any signs of damage. Save the shipping container for future transport of the filter.

In the event of damage, please contact and file a claim with the freight carrier involved immediately.

If the equipment is not going to be put into service upon receipt, cover and store the filter in a clean, dry location. After storage, ensure that the equipment is dry and that no condensation or dirt has accumulated on the internal components of the filter before applying power.

Repair/Exchange Procedure

MTE Corporation requires a Return Material Authorization Number and form before we can accept any filters that qualify for return or repair. If problems or questions arise during installation, setup, or operation of the filter, please contact MTE for assistance at:

Toll Free: 1-800-455-4MTE (1-800-455-4683)

International Tel: 262-253-8200

Fax: 262-253-8222

3. HOW TO SELECT

Selection Guide

MTE High frequency SineWave Guardian™ filters are designed to provide a sine wave output voltage when driven from PWM inverters with switching frequencies from 4.8 kHz to 8 kHz. For drive applications, these filters eliminate the problem of motor insulation failures and they also reduce electromagnetic interference by eliminating the high line-load dV/dt associated with inverter output wave forms.

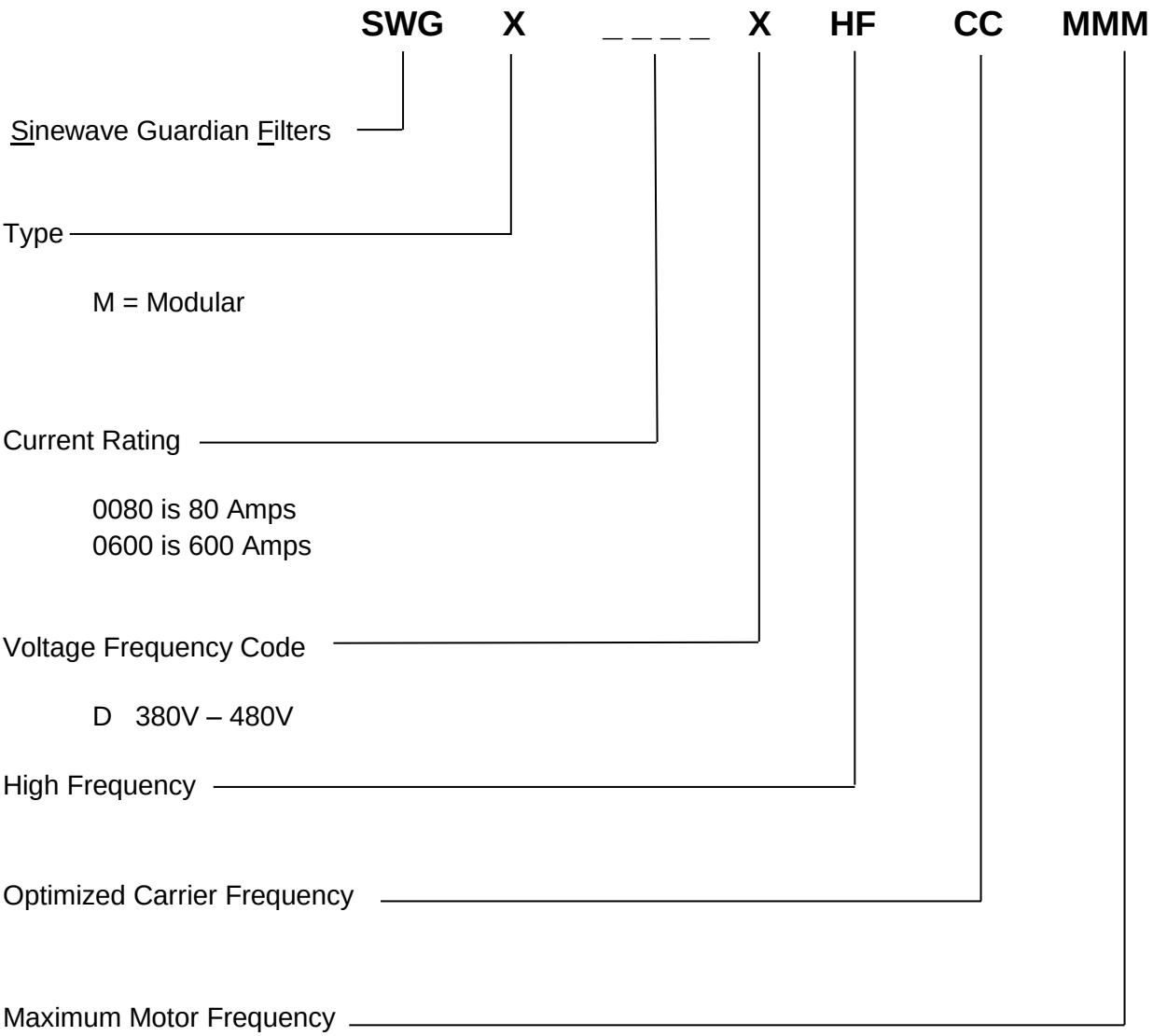
High Frequency Sinewave Filters are available in Modular configuration. For other configurations call MTE.

For inverters feeding isolation transformers select a filter with a current rating equal to or greater than that of the transformer primary current.

Please verify information below for proper selection:

- ☐ **Voltage**: Input voltage from 380V – 480V. See Table 4-1 (p9) for specification.
- ☐ **Current Rating**: Support for 80 Amps – 600 Amps. See Table 4-1 (p9) for Amp breaks.
- ☐ **Switching Frequency**: Support for carrier frequency of 4.8kHz – 8kHz, see Table 4-1 (p9).
- ☐ **Drive Output Frequency**: Support for 6Hz to 300Hz without derating
- ☐ **Temperature**: Maximum ambient temperature, 60C (modular). See Table 4-1 (p9) for specification.
- ☐ **Altitude**: 3,300 feet above sea level without derating. See Figure 3 (p13) for derating curve.
- ☐ Verify the drive output can be configured to Volts per Hz mode or that the drive is designed for use with filter in sensor less vector mode.

Part Number Configuration



Part Number Selection Tables

Table 3-1: Modular Selection Table

380V Motor KW	480V Motor HP	HF-SWG Part Number	Amps	Type	Weight (lbs.)	Size (in.) HxWxD	Ref. Fig.	Capacitor Panel (in.) HxWxD	Ref. Fig.
37	60	**SWGM0080D-HF05300**	80	Open	62	10.5x12.0x9.1	A-1	5.8x16.3x7.6	A-13
55	75	**SWGM0110D-HF05300**	110	Open	77	10.4x12.0x10.1	A-2	5.8x16.3x7.6	A-14
-	100	**SWGM0130D-HF05300**	130	Open	91	10.3x12.0x11.5	A-3	5.8x16.3x7.6	A-15
75	125	**SWGM0160D-HF05300**	160	Open	98	10.4x12.0x11.6	A-4	5.8x16.3x7.6	A-16
110	150	**SWGM0200D-HF05300**	200	Open	130	11.9x15.3x11.2	A-5	6.7x16.3x7.6	A-12
132	200	**SWGM0250D-HF05300**	250	Open	139	12.0x15.3x11.3	A-6	6.7x16.3x7.6	A-11
160	250	**SWGM0305D-HF05300**	305	Open	170	12.2x15.3x12.6	A-7	6.7x16.3x7.6	A-11
220	350	**SWGM0415D-HF05300**	415	Open	236	12.1x15.3x14.3	A-8	6.7x16.3x7.6 6.7x16.3x7.6	A-11
280	450	**SWGM0515D-HF05300**	515	Open	248	14.4x15.3x13.1	A-9	6.7x16.3x7.6 6.7x16.3x7.6	A-11
335	500	**SWGM0600D-HF05300**	600	Open	296	14.5x15.3x14.3	A-10	6.7x16.3x7.6 6.7x16.3x7.6	A-11

*Based on 300Hz output frequency, 5kHz carrier frequency at full load.

4. PRODUCT SPECIFICATIONS

Performance Specifications

Table 4-1: Performance Specifications

Service Load Condition	Conventional 3 phase motors operating in volts per Hertz mode Standard step-up transformer or design for use of filter in sensor less vector mode.
Voltage	380V - 480V +/- 10%
Input Voltage Wave Form	PWM
Harmonic Voltage Distortion	5% maximum @ 5kHz 8% maximum @ 6-8 kHz
Inverter Switching Frequency	4.8kHz – 8kHz
Inverter Operating Frequency	6Hz to 300Hz
Maximum Ambient Temperature	-40C to +60C Modular Filter -40C to +90C Storage Temperature
Insertion Loss (480V system voltage)	6% maximum @ 150Hz 12% maximum @ 300Hz
Efficiency	>99%
Current range	80A – 600A
Available form factors	Modular
Altitude without derating	3,300 feet above sea level
Maximum Motor Lead Length	15,000 feet
Relative Humidity	0% to 95% non-condensing
Current Rating	100% RMS Continuous 150% for 1 minute Intermittent
Audible Noise	75dB A at 1 meter

Filter does not mitigate any DC bus ripple that may be present.

Agency Approvals

UL and cUL listed to UL508 Type MX and CSA-C22.2 No 14-95, File E180243, CE

Warranty

Three years from the date of shipment. See www.mtecorp.com for details.

Over Temperature Switch

Table 4-2: Over Temperature Switch

NC Switch opens at 180 Deg. +/- 5 Deg. C		
Current Amps	**Voltage**	**Contact Load**
6	120 AC	Resistive Loads
3	120 AC	Inductive Loads
3	240 AC	Resistive Loads
2.5	240 AC	Inductive Loads
8	10 VDC	Resistive Loads
4	24 VDC	Resistive Loads

MTE highly recommends the use of the over temperature switch to prevent damage to the filter in rare instances of overheating from abnormal operating conditions.

5. TYPICAL PERFORMANCE DATA

Voltage Waveforms

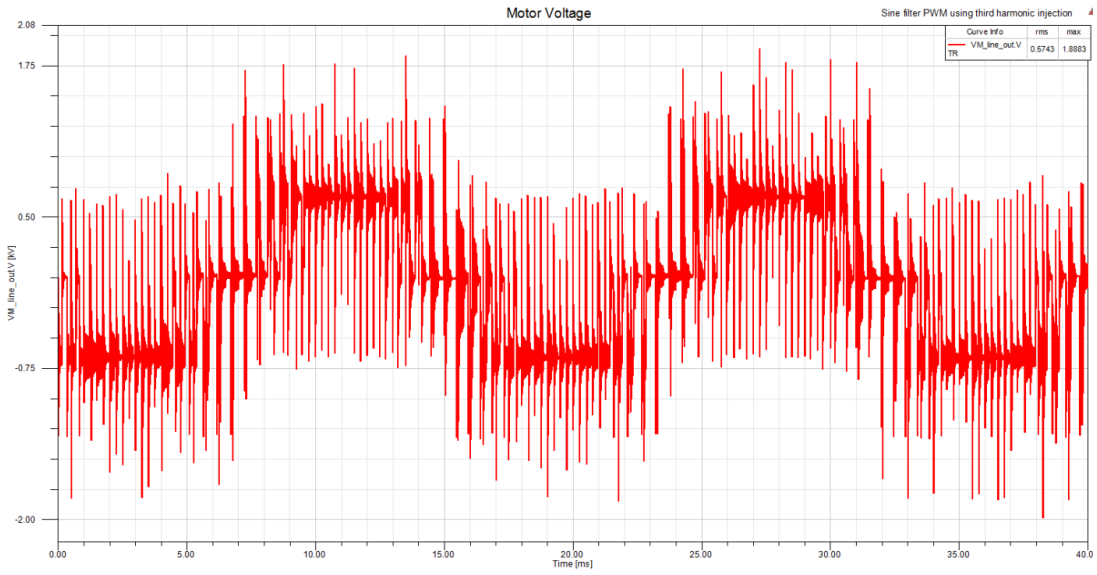


Figure 1: Output Voltage before High Frequency Sinewave Filters

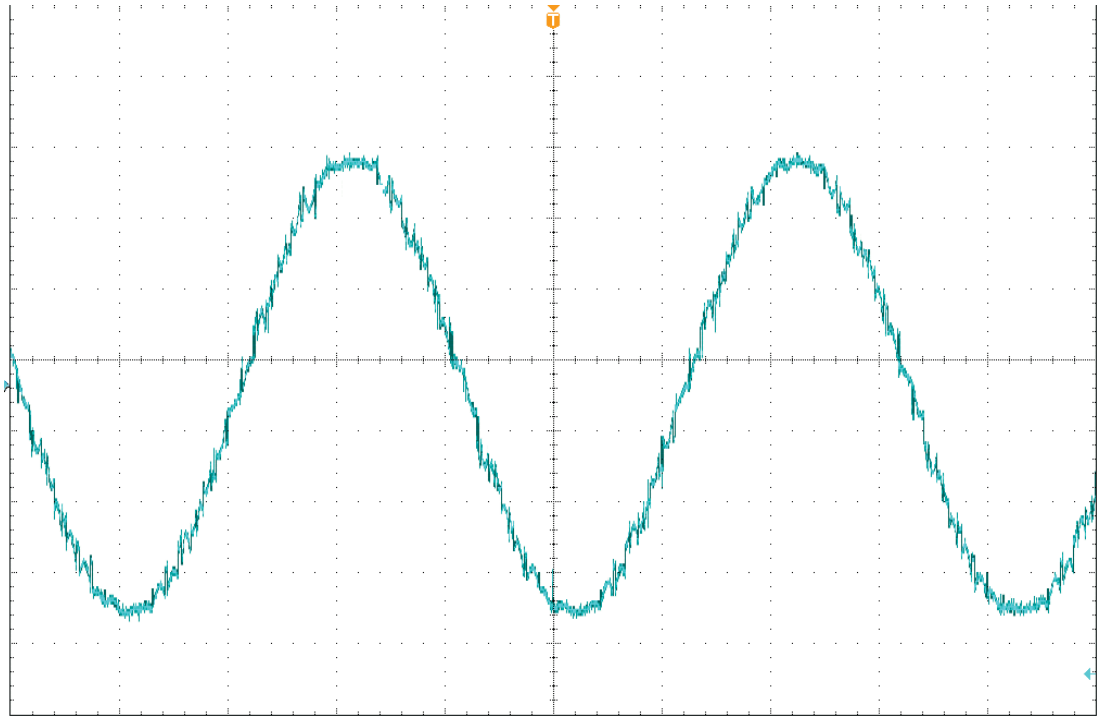


Figure 2: Output Voltage after High Frequency Sinewave Filters

Filter Efficiency + Watt loss

Table 5-1: Filter Efficiency & Watt Loss

Maximum Output Amps RMS/Filter Current Rating Amps RMS	Efficiency %	Power Dissipation (Typical) (Watts*)
80	99.5%	360
110	99.5%	451
130	99.5%	504
160	99.6%	563
200	99.6%	718
250	99.6%	911
305	99.6%	958
415	99.7%	1144
515	99.7%	1250
600	99.7%	1321

*Based on 300Hz output frequency, 5kHz carrier frequency at full load.

Altitude Derating

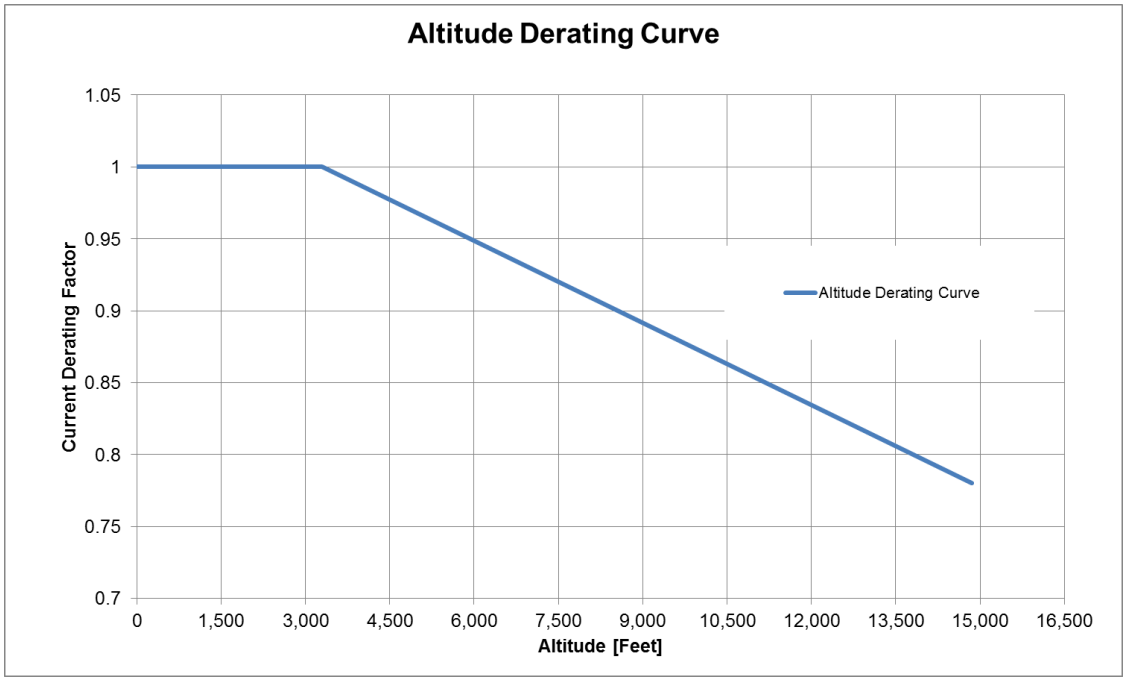


Figure 3: Attitude Derating Curve

6. HOW TO INSTALL

Installation Checklist

 **WARNING**	**Prior to installation, please refer to all general warnings on page 4. Failure to practice this can result in body injury!**
 **WARNING**	**Input and output wiring to the filter should be performed by authorized personnel in accordance with NEC and all local electrical codes and regulations.**
 **WARNING**	The filter is designed for use with copper conductors with a minimum temperature rating of 75 degrees C.

Verify that the rating of the filter is compatible with the drive to which it is to be connected. Follow all detailed drive manufacturer installation and safety instructions. Drive and load cable selection / placement should be in accordance with the requirements of the NEC and all local electrical codes and regulations.

The typical interconnection diagrams that follow are shown for a motor load but the load can be either a motor or a transformer.

- For modular filters interconnection between the filter, motor and the drive is shown in
- Figure 4 (p16).
- For isolation transformer connections between the filter, motor and the drive is shown in Figure 6-3 (p18).

Refer to the drive user manual for instructions on interconnecting the drive and motor and the correct start-up procedures for the drive.

Table 6-4 (p19) lists the wire range and terminal torque requirements for the power input and output connections and capacitor/capacitor panel connections (modular only).

Use the cable recommended by the drive manufacturer to connect the drive to the filter and the filter to the motor. Make certain that the selected cable size conforms to the requirements of the National Electric Code and all local codes.

Grounding

 **WARNING**	The filter must always be grounded with a grounding conductor connected to ground terminals.
 **WARNING**	For modular units, ensure a 2” X 2” area is cleaned of paint and varnish on lower mounting bracket for ground connection.

For cable shield grounding follow the drive manufactures recommendations.

Over Temperature Interlock

An over temperature interlock circuit should be used in conjunction with thermal switch to turn off the drive to prevent filter damage due to abnormal operating conditions. The temperature switch is normally closed and will open when an internal reactor temperature of 180°C is reached. See Table 4-2 (p10) for contact rating information and the drive user manual for interconnection information.

Location & Spacing

Modular filters are designed for mounting in the customer’s enclosure. Include the power dissipation of the filter along with all the other components located in the panel to determine the internal temperature rise and cooling requirements of the enclosure. A general guideline is to allow a side clearance of four (4) inches and a vertical clearance of six (6) inches for proper heat dissipation and access within the enclosure. Clearances may be less if proper ventilation exists. Filter components must operate within temperatures specified in this manual or filter operating life will be compromised. Also be aware of minimum electrical clearances as defined by the appropriate system safety standard(s). Modular Sinewave filters generate heat and should be positioned away from heat sensitive components. Ensure that proper panel orientation is maintained. Keep the capacitors away from reactor and resistor heat flow. Avoid locations where the filter would be subjected to excessive vibrations. Locate the filter as close to the inverter as possible.

Modular Unit Interconnection Diagram

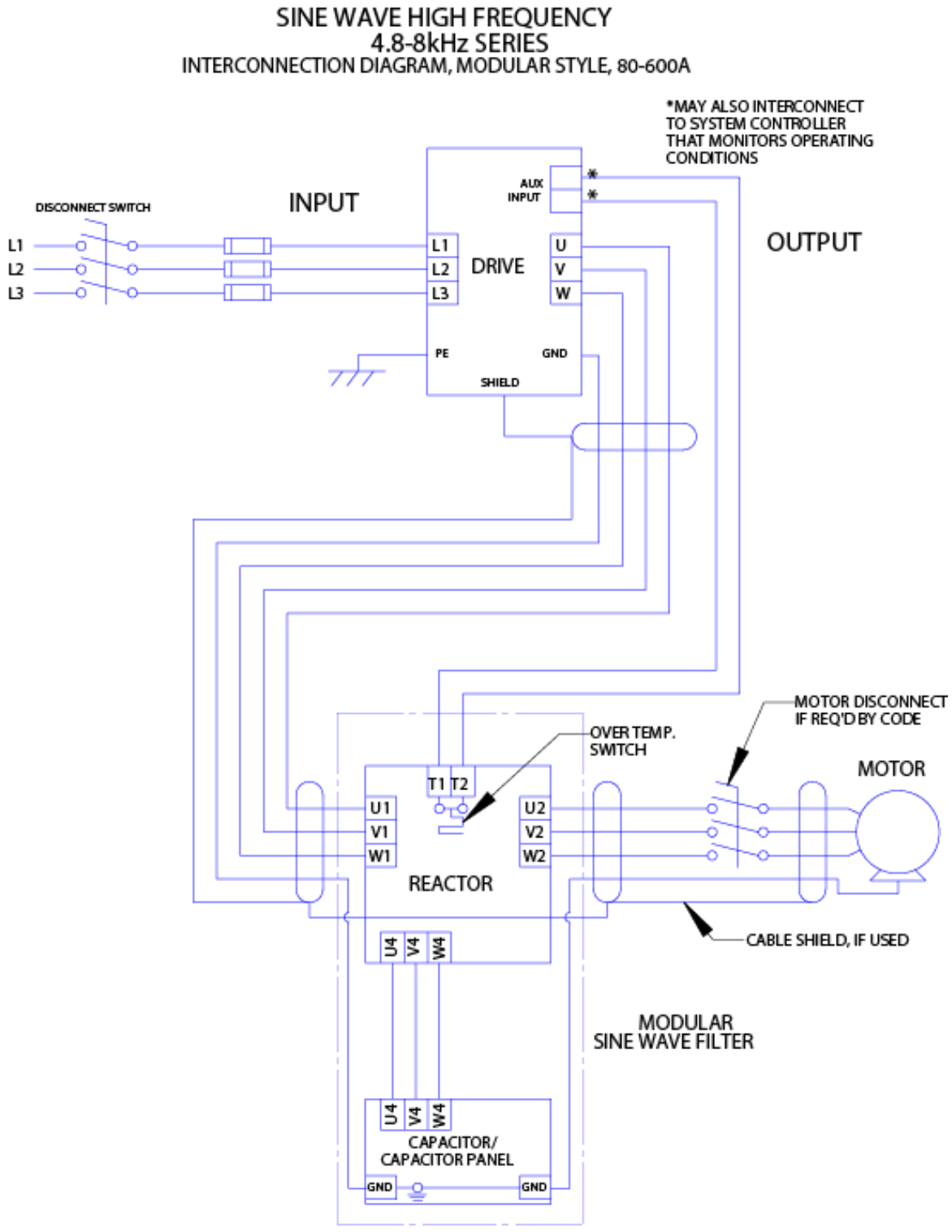


Figure 4: Modular Interconnection

Basic Schematic Diagram

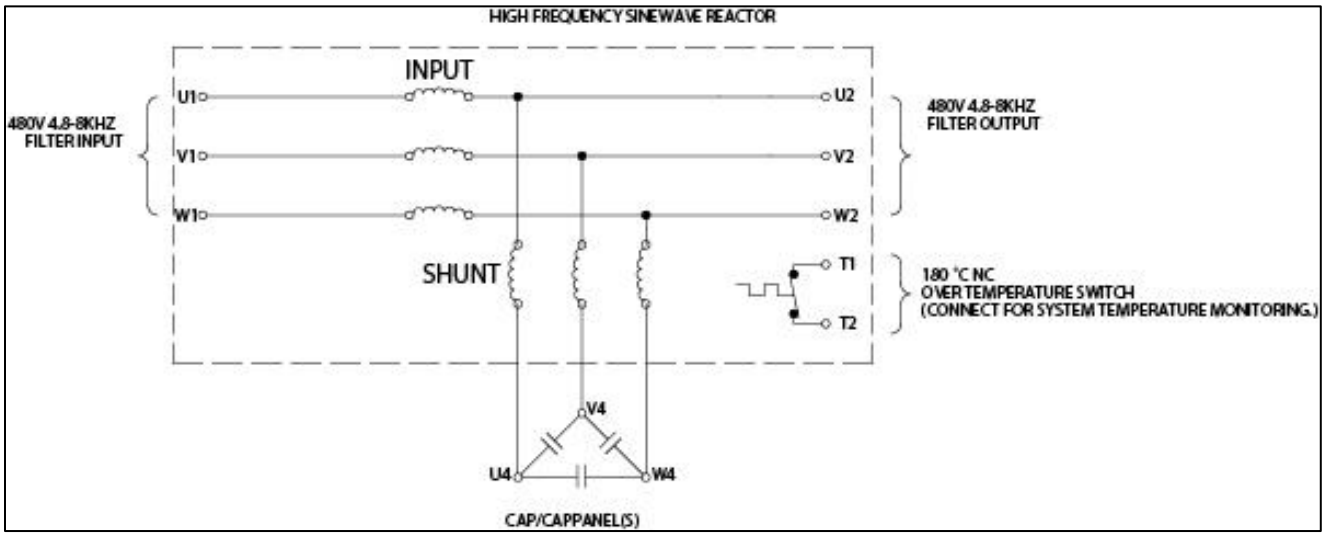


Figure 6-2: Basic Schematic Diagram

Isolation Transformer Diagram

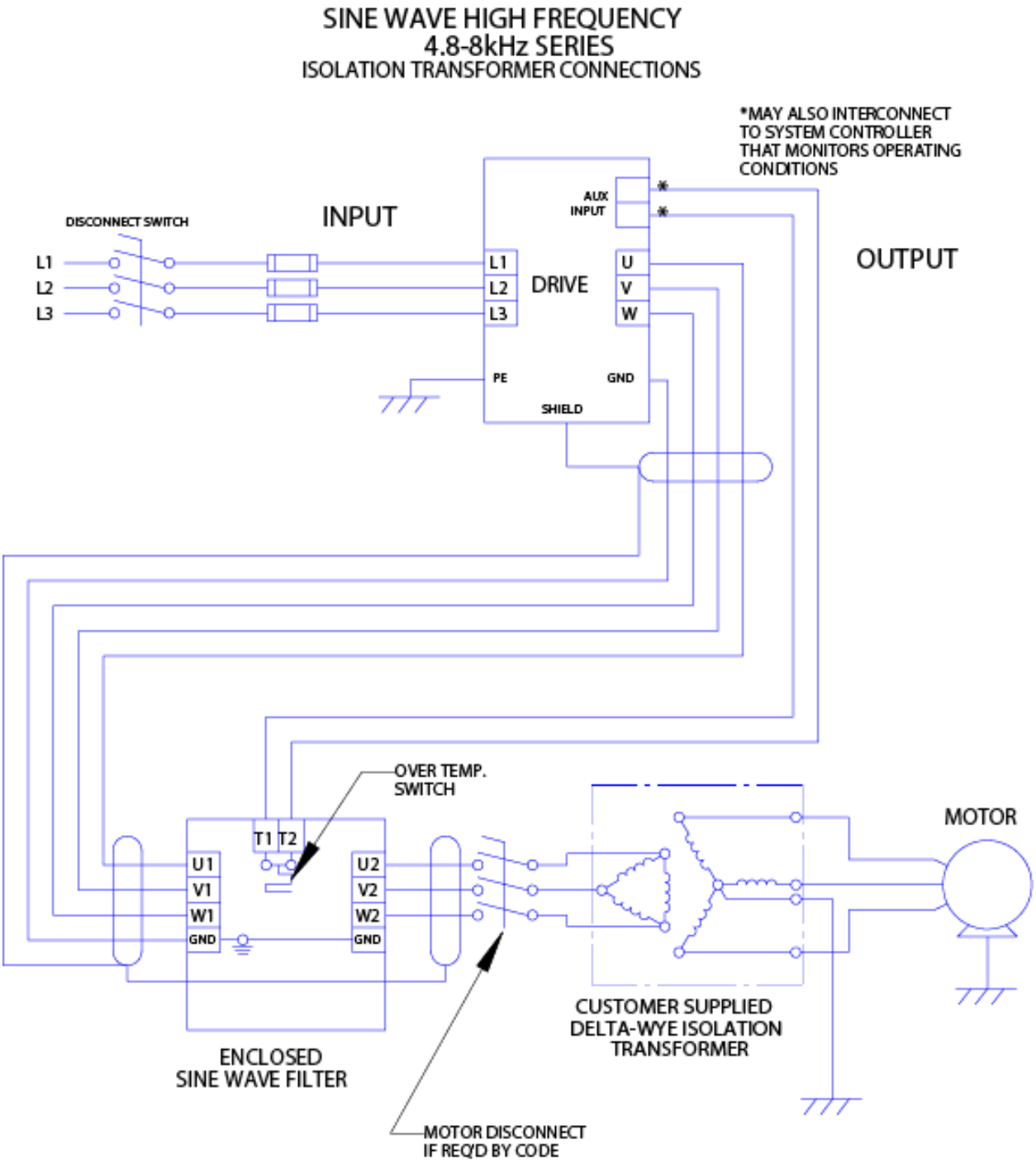


Figure 6-3: Isolation Transformer

Torque Ratings

Table 6-4: Torque Ratings

Filter Rating (Amps)	HF-SWG Terminals			Cap-panel Terminals U4-V4-W4		
	Input /Output Power U1-V1-W1 / U2-V2-W2		U4-V4-W4 interconnect Cap-panel	Capacitor/ Cap-panel Part Number	Minimum Interconnect Wire Gauge (AWG)	Terminal Torque (in-lbs.)
	Recommended Minimum Wire Size (AWG)	Terminal Torque (in-lbs.)	Terminal Torque (in-lbs.)			
80	4	N/A	N/A	CAPPANEL-006	10	60
110	2	N/A	N/A	CAPPANEL-007	8	60
130	1	N/A	N/A	CAPPANEL-008	8	60
160	4 (2x) or 2/0	N/A	N/A	CAPPANEL-009	6	60
200	3 (2x) or 1/0	N/A	N/A	CAPPANEL-003	4	60
250	1 (2x) or 250K CMIL	N/A	N/A	CAPPANEL-002	4	60
305	2/0 (2x)	N/A	N/A	CAPPANEL-002	3	60
415	4/0 (2x)	N/A	N/A	CAPPANEL-002 (2X)	4 each	60
515	300 MCM (2x)	N/A	N/A	CAPPANEL-002, 003 (2X)	4 each	60
600	400K CMIL (2x)	N/A	N/A	CAPPANEL-002, 003 (2X)	4 each	60

Note: Cap-panel interconnect wiring specification according to UL508 75° C Table.
Note: To prevent flexing or bending of the coil windings attached to SWG reactor use appropriate strain relief to prevent stress on terminals. For flat copper terminal tabs, use two wrenches to tighten customer provided cable mounting hardware.
Notes: Refer to reference drawings for termination wire ranges.

7. START UP

Startup Checklist

Safety Precautions

Before startup, observe the following warnings and instructions:

 **WARNING**	Internal components of the filter are at line potential when the filter is connected to the drive. This voltage is extremely dangerous and may cause death or severe injury if you come in contact with it.
 **WARNING**	Remove all power to the Sinewave filter in compliance to standardized 26 CFR 1920.147 lockout/tagout policies. After disconnecting the utility power, wait at least 5 minutes before doing any work on the filter connections. After removing power, allow at least five minutes to elapse and verify that the capacitors have discharged to a safe level before contacting internal components. Connect a DC voltmeter across the capacitor terminals and ensure that the voltage is at a safe level.
 **WARNING**	Use extreme caution to avoid contact with line voltage when checking for power. INJURY OR DEATH MAY RESULT IF SAFETY PRECAUTIONS ARE NOT OBSERVED.
 **Caution**	Prior to start up; confirm the drive operation mode is property set or properly designed to operate in sensor less vector mode with a filter. (Volts per Hertz). Please consult drive manual/manufacturer to configure proper parameters. Failure to do so may result in failure of drive or filter components.
 **Caution**	MTE recommends 10 seconds as an initial starting point for motor ramp time and that customers examine the actual inrush and ratings of their drive system. Inrush current seen at the drive from the filter that can easily be overcome by changing the motor ramp time.

Sequence of Operation

1. Read and follow safety precautions including those of drive manufactures.
2. Verify the proper wiring of the filter:
    a. U1-V1-W1 Input wiring and U2-V2-W2 Output wiring
    b. U4-V4-W4 Capacitor/Capacitor Panel wiring (Modular units only)
3. Prior to start-up, conform the drive operation mode is properly set or properly designed for use with a filter operating in sensor less vector mode (Volts per Hertz). Please consult drive manual/manufacturer to configure proper parameters. Failure to do so may result in failure of drive or filter components.
4. MTE recommends 10 seconds as an initial starting point for motor ramp time and that customers examine the actual inrush and ratings of their drive system. Inrush current seen at the drive from the filter that can easily be overcome by changing the motor ramp time.
5. Ensure that all filter components are properly connected to ground.
    a. For modular units, ensure a 2” X 2” area is cleaned of paint and varnish on lower mounting bracket for ground connection.
6. Check that moisture has not condensed on the filter components. If moisture is present, do not proceed with startup until the moisture has been removed.
7. Refer to the drive user manual for the drive startup procedure. Observe all safety instructions in the drive user manual.
8. Disconnect filter output terminals from the motor.
9. Set the drive switching frequency between 4.8 kHz and 8 kHz. Refer to the drive user manual.

8. TROUBLESHOOTING

WARNING	**INJURY OR DEATH MAY RESULT IF THE DRIVE SAFETY PRECAUTIONS ARE NOT OBSERVED.**
WARNING	**When properly installed, this equipment has been designed to provide maximum safety for operating personnel. However, hazardous voltages and elevated temperatures exist within the confines of the enclosure. Servicing should therefore be performed by qualified personnel only and in accordance with OSHA Regulations.**
WARNING	**High voltage is used in the operation of this filter. Use Extreme caution to avoid contact with high voltage when operating, installing or repairing this filter. INJURY OR DEATH MAY RESULT IF SAFETY PRECAUTIONS ARE NOT OBSERVED.**
Caution	After removing power, allow at least five minutes to elapse and verify that the capacitors have discharged to a safe level before contacting internal components. Connect a DC voltmeter across the capacitor terminals or terminals U1, V1 or V1, W1 and ensure that the voltage is at a safe level.
Caution	Component may be hot +100°C/212°F

Table 8-1: Troubleshooting Guide

PROBLEM:	**Drive Overcurrent Fault**
Possible cause: **Solution:**	Motor ramp –up time too short MTE suggests a ramp time of >5-10 seconds. Consult drive manufacturers manual to configure proper parameters
Possible cause: **Solution:**	Failed or Incorrect Wiring Verify all field and product wiring is correct
Possible cause: **Solution:**	Parameter Compatibility Consult drive manufacturers manual for operating drive with a motor protection filter
Possible cause: **Solution:**	Filter, Drive, Motor Current Ratings Compatible Verify the filter/motor are properly sized for the application
Possible cause: **Solution:**	Motor Winding Fault Verify motor windings and hi pot is necessary
Possible cause: **Solution:**	Cable Failure Verify cable continuity and insulation

PROBLEM:	Excessive Filter Noise
Possible cause: **Solution:**	Mismatched Motor Rating Verify the filter is properly sized for the application
Possible cause: **Solution:**	Capacitors Disconnected or Improperly Wired Verify the proper connection of the capacitors
Possible cause: **Solution:**	Carrier frequency less than 4.8 kHz Verify the carrier frequency is at least 4.8 kHz
PROBLEM:	**Temperature Switch Open**
Possible cause: **Solution:**	Mismatched Motor Rating Verify the filter/motor are properly sized for the application
Possible cause: **Solution:**	Capacitors Disconnected or Improperly wired Verify the proper connection of the capacitors
Possible cause: **Solution:**	Carrier Frequency Less Than 4.8 kHz Verify the carrier frequency is at least 4.8 kHz
Possible cause: **Solution:**	Excessive Ambient Temperature Ensure the filter is operating within specified ambient temperature below 60°C
PROBLEM:	**Motor Will Not Turn**
Possible cause: **Solution:**	No Power Check fuses or breakers for proper input power
Possible cause: **Solution:**	Motor Incorrectly Wired Check for wiring faults
Possible cause: **Solution:**	Locked Rotor Motor Load Check motor load
Possible cause: **Solution:**	Drive Fault Consult drive manufacturers manual
Possible cause: **Solution:**	Drive Not Configured for Volts / Hertz or not properly configured for sensor less vector mode. Consult drive manufacturers manual to configure proper parameters
Possible cause: **Solution:**	Cable Damage Motor bearing or locked load
PROBLEM:	**Motor Running Hot**
Possible cause: **Solution:**	Capacitors Disconnected or Improperly Wired Verify the proper connection of the capacitors
Possible cause: **Solution:**	Overloaded Motor Verify the motor is properly sized for the application