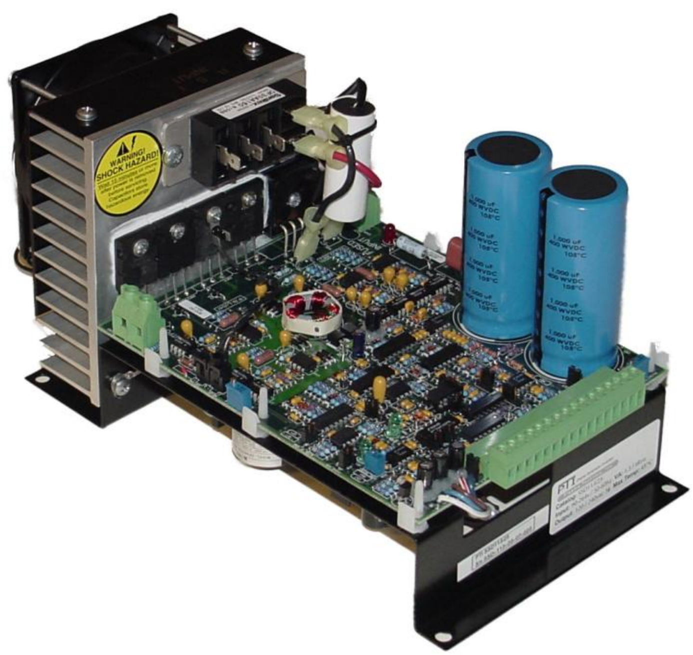
INSTALLATION & OPERATION MANUAL
SSD110/113 SERIES

Version: Rev 2.2



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NOTE:
THIS MANUAL COVERS SECOND GENERATION INVERTERS DESIGNATED AS: SSD110 (rev2) & SSD113 (rev2).

The information contained in this manual is considered accurate to the best knowledge of the supplier at the time of publication. The manufacturer, however, assumes no liability for errors that may exist. The supplier reserves the right to change data and specifications without notice.

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PCB I.D. Label: 50127.002

What's new or different about the Rev2 product:

1. More power capacity (Scotty).
2. Maximum frequency limit and fault response have been increased.
3. Pulse width start-up ramp to enable soft start at the selected frequency.
4. Bus compensation is available when internal voltage pot is used.
5. Internal voltage pot can be used as a trimmer for the external voltage pot.
6. Balanced amplifier input resistance (10k) for user amplifier (J4, 11-13)

Rev2.1 product:

7. PDM blanking methods enhanced.
8. Turrets for lesser-used functions replaced with standard mounting holes.
9. Fine tune PDM and Freq. maximums to 10.0v.

Rev2.2 product:

10. Inverter 'ON' terminal 7 output resistance was 1k, now= 220Ω (R99).

Table of Contents:

1. Unpacking

1.1 Verify delivery.

Check that you received the inverter and optional equipment that was ordered.
Verify that the part numbers match your purchase order and that the correct options have been installed.
Report any discrepancies to your supplier.

1.2 Inspect for damage.

Inspect the inverter for damage that may have occurred during shipment. Visually examine the contents for obvious problems.
If damage is found, do not operate the inverter. Report the problem immediately to your supplier.

1.3 After the initial inspection.

Your inverter can be repacked and stored for future use. Choose a storage location that is clean and dry.
Do not store in ambient temperatures below 5° F or above 158° F (-15°C to 70° C)
Do not store in wet areas or areas of high condensation.
Do not store in corrosive environments.

2. Mechanical Mounting.

Proper mechanical installation of the SSD110 is necessary to ensure both reliable and efficient operation and ease of maintenance.

2.1 Mounting Environment

The inverter should be mounted in an environment that is free from the following:

!*Corrosive or volatile vapors. Dust and particles, Excessive moisture.*

!*Shock, Excessive vibration, Temperature extremes*!

The following environmental specifications apply:

Surrounding air ambient operating temperature: 32° to 104° F (0° to 40° C)

Relative humidity: 5 to 90%, non-condensing.

Altitude (maximum): 3,310 ft (1,000 m), de-rating for altitude is 1% for every 300 ft (100m) above 1000m.

2.2 Mounting Considerations

The following should be considered when planning the physical installation of your SSD110.

Leave enough clearance for access to all electrical connections.

Allow room for troubleshooting.

Allow at least 3 inches of clearance above and below the unit to permit adequate cooling airflow.

The SSD110 **must be fan cooled** in order for the inverter to be run at full output power. Consult the factory for heat sink only de-ratings or fan placement. It is recommended that applications requiring input currents above 10 amps RMS be fan cooled. In the final installation the convection cooled SSD110 should be mounted with the cooling fins vertical so as to maximize the affects of normal convection cooling. Fan cooled can be mounted in any orientation

Allow a minimum clearance of 1.0" between units when mounted side by side.

Separate conduit is required for line voltage and control wiring.

2.3 How to Mount the Inverter

Figures 2.1 and 2.2 shows the mechanical layout of the SSD110 inverter without and with optional fan mounting bracket. Refer to this drawing when planning your layout. The SSD110 is an open type of equipment and should be mounted to a secure sub-panel or frame.

CAUTION:

Make sure the mounting rack is secure before mounting the inverter onto it. Equipment damage could result from an improperly mounted rack or inverter.

Figure 2.1

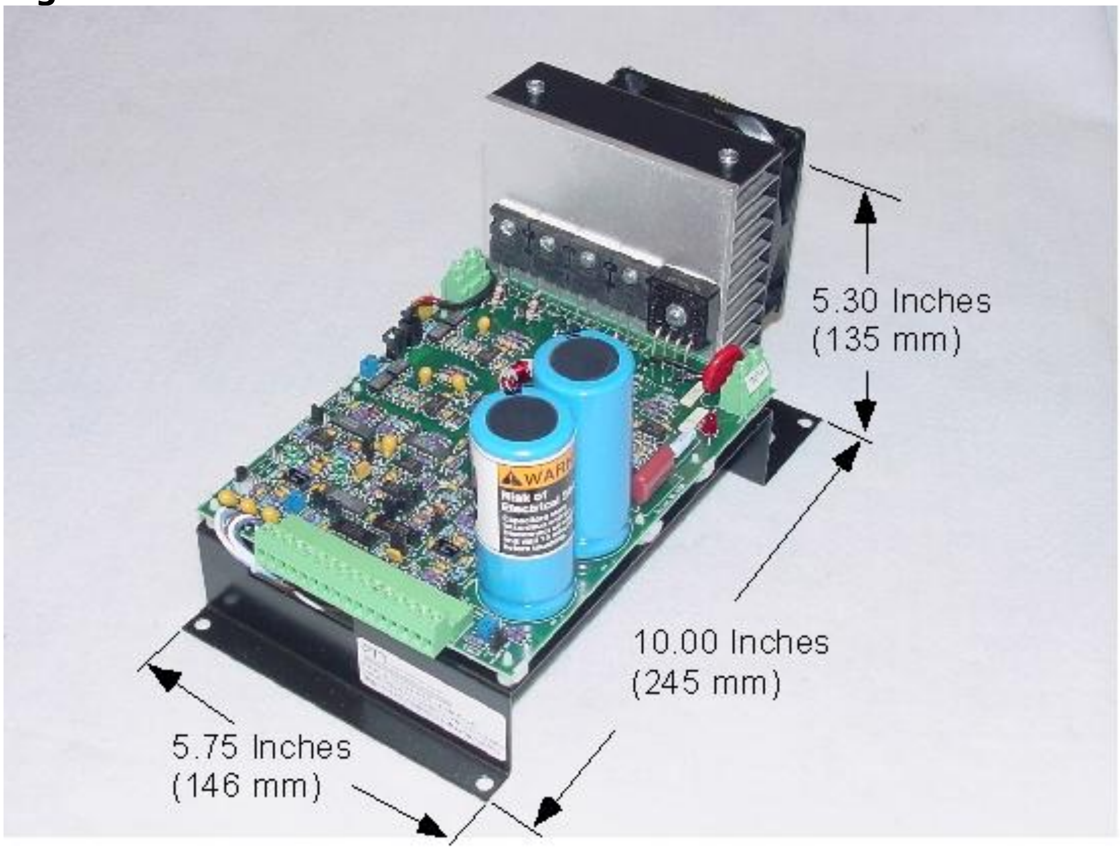
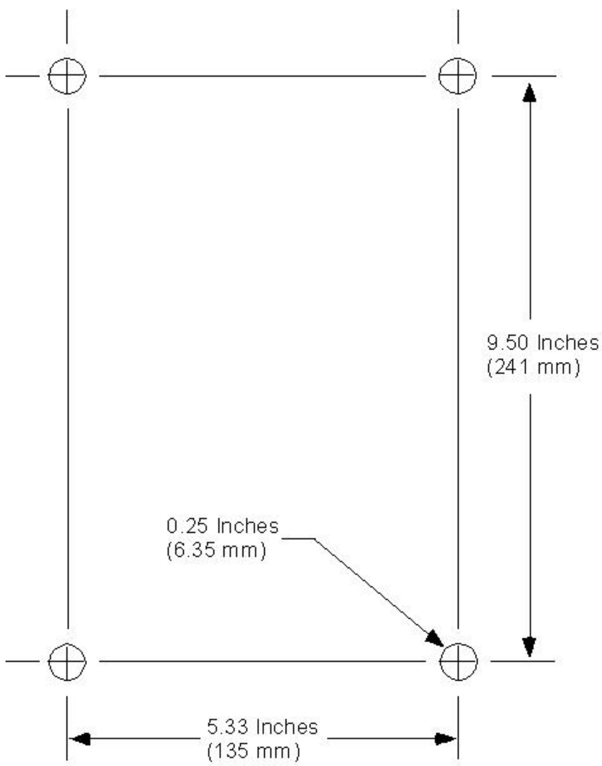


Figure 2.2



SSD110 Mounting Dimensions

3. Electrical Installation

3.1 Wiring Standards and Codes

The installation person is responsible for following the wiring plan produced by the design engineer for the specific application.

All wiring must conform to the following standards:

National Electrical Code, Publication NFPA No. 70.

All local and national codes which apply. For motor usage; use appropriate NEMA relay for protection.

The supplier cannot assume responsibility for the compliance or noncompliance to any code governing the proper installation of this equipment.

3.2 Inverter Electrical Connection Wire Sizing and Fusing

The SSD110/15 input current rating is 25amps RMS. Use branch circuit fuses suitable for use on a circuit capable of delivering not more than 25rms symmetrical amperes, 250 volts maximum. Output current rating is 15amps RMS. Refer to the National Electrical Code[NEC], Publication NFPA No. 70, Article 310, and any local codes that may apply for wire sizing and selection. Use 60/75°c wire min. and 25 amp input fuses of class K5 or RK5.

Terminal connection max torque .5 newton meters[4.4inch lbs].

3.3 Case Ground

Each of the inverters must be connected to ground at their case ground terminal. A grounding electrode conductor or bonding jumper must be connected from the ground terminal to either a grounding electrode buried in the earth or a suitable plant ground with solid connections to earth ground. Refer to NFPA No. 70, Article 250, for details on grounding and grounding electrodes.

3.4 Safety Grounding

The case ground connections should be made at the ground terminals. The case ground of the various system components should be connected to the star grounding bus of the cabinet. A grounding electrode conductor or bonding jumper must be connected from the star grounding bus to either a grounding electrode buried in the earth or a suitable plant ground with solid connections to earth ground. Refer to NFPA No. 70, Article 250, for details on grounding and grounding electrodes.

3.5 Soft Charge

While direct line starts are permissible, a soft charge circuit will extend the life of the filter capacitors, see figure 3.3. High input surge currents can be reduced by using one 50-ohm resistor for a single-phase input. The resistor should be bypassed by a time delay relay contact(s) approximately one second after the power is supplied to the resistor. This soft charge procedure will increase the bus capacitor life.

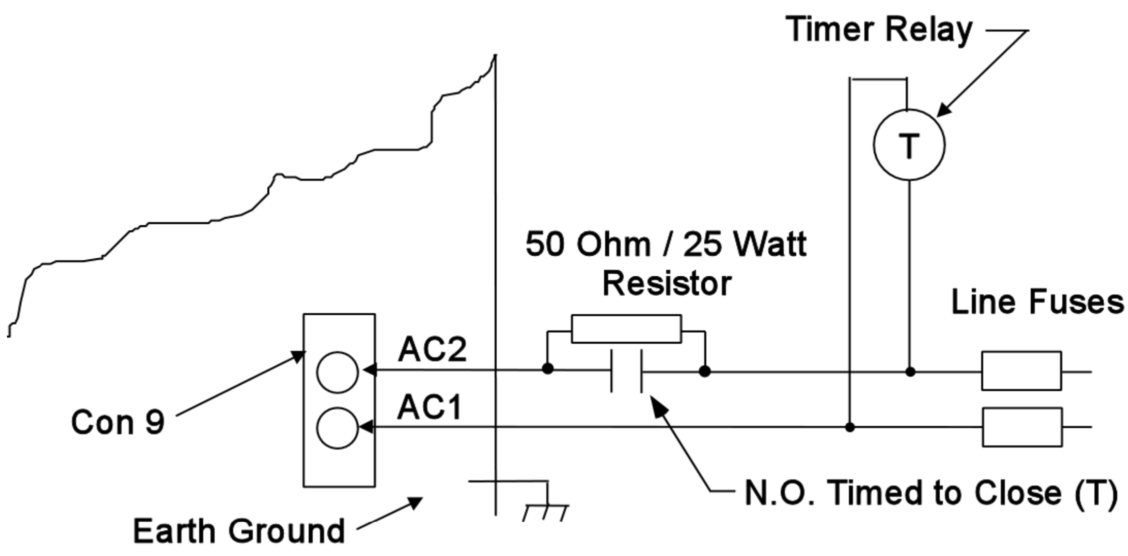
3.6 Surge and Current Protection

While the SSD110 has an on board surge suppressor (MOV), the customer can add surge protection to protect the inverter devices from line spikes. See Figure 3.3 for connection diagram. Contact your surge suppression supplier for sizing details. The SSD110 utilizes an on board current limiting circuit. The circuit performs current limiting when a potentially destructive current value is detected. When this event occurs the SSD110's output section will automatically shutoff.

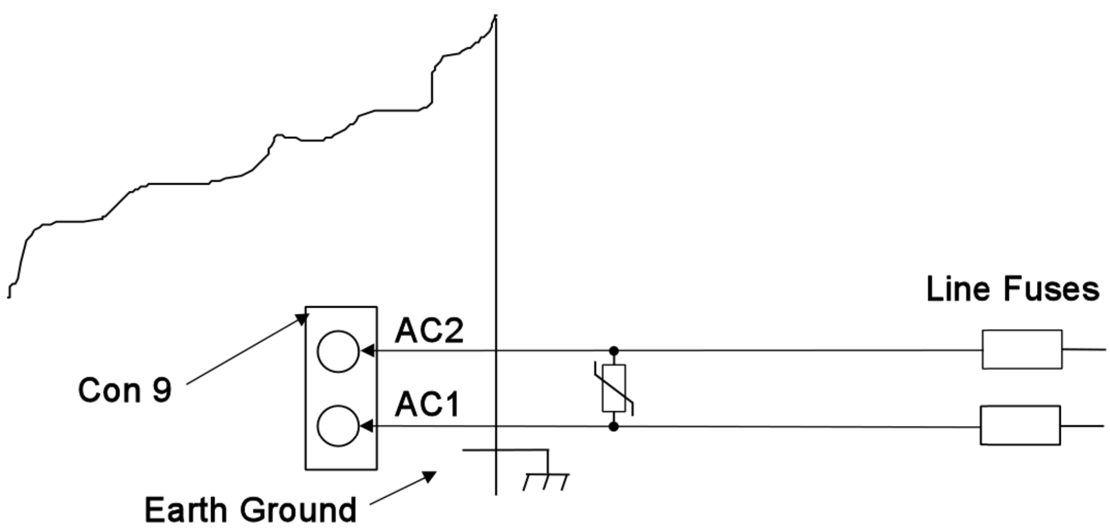
3.7 Motor Application Precautions

The SSD110 does not provide Solid State Motor Overload, over-current, over-speed Protection. Installer (end-user) must provide Motor Overload, over-current, and over-speed Protection in accordance with the NEC.

Figure 3.3



Customer Supplied Soft Charge Circuit.



Additional Customer Supplied Surge Protection.

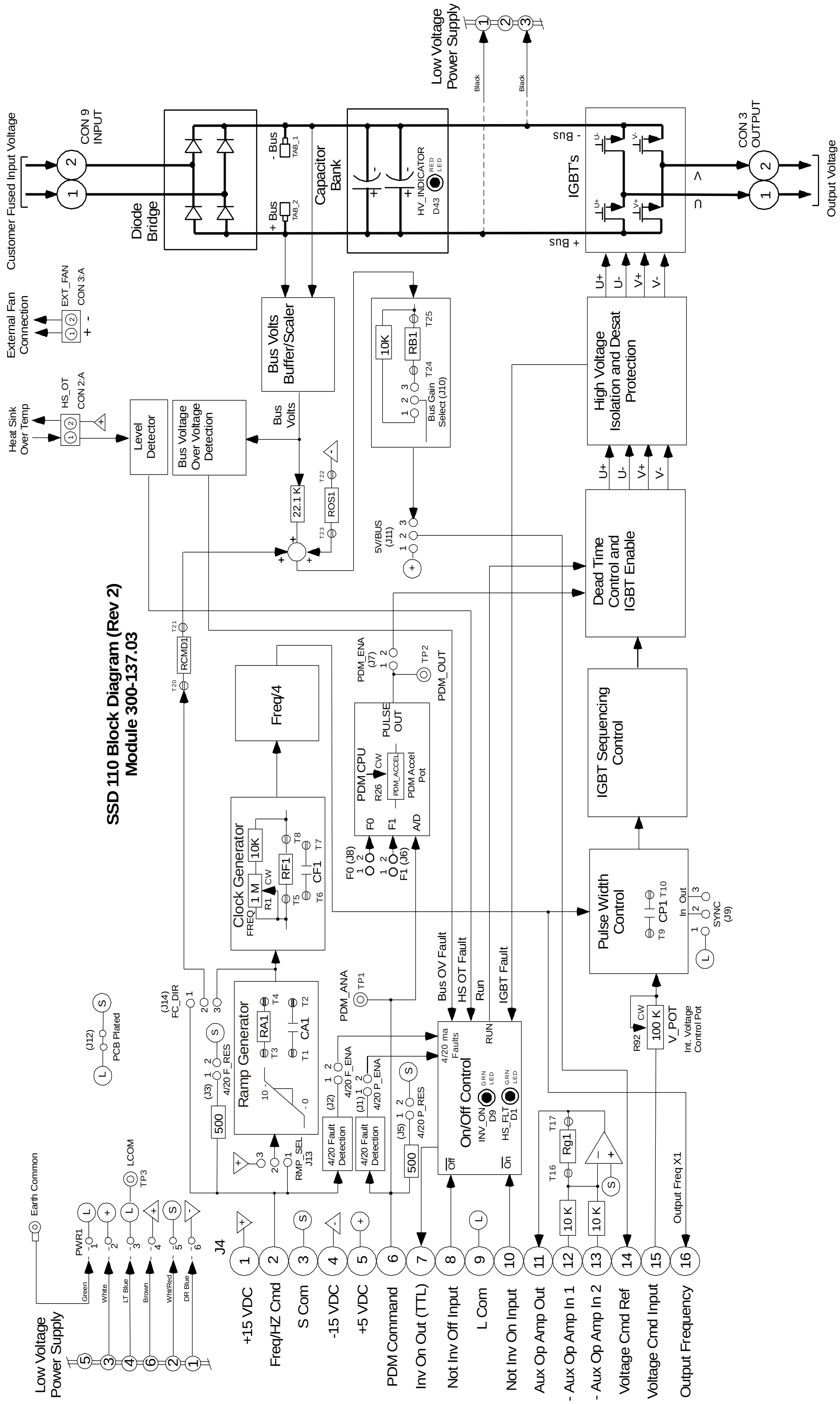


Figure 3.1. General Inverter Block Diagram

SSD110 Control Board (Rev 2) Component and Potentiometer Setups

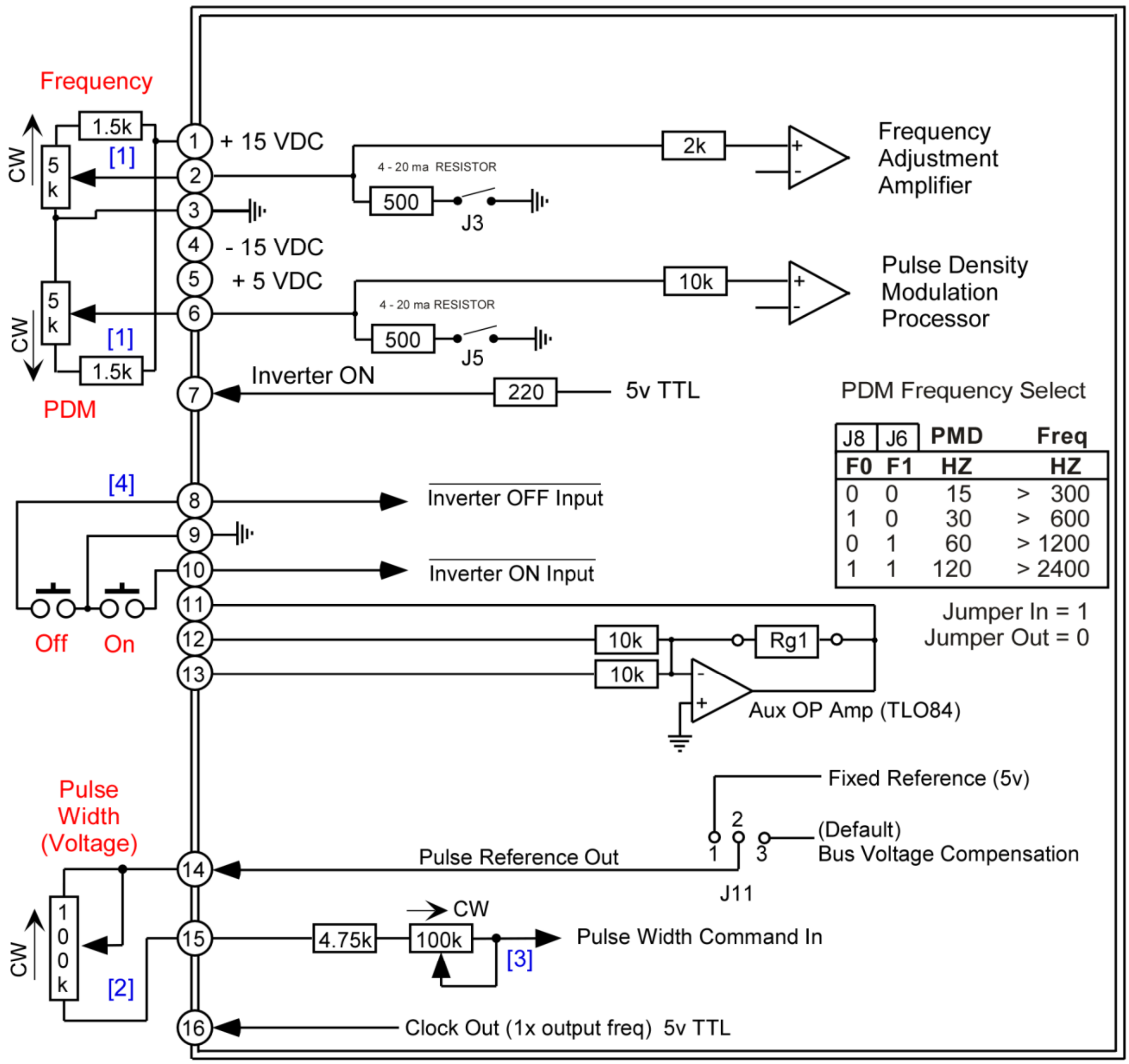
Designator	Connection		Default	Component Used	Description	Setup Procedure
CA1	T1	T2		Cap Cer 50V 10%	Frequency command acceleration rate	Larger capacitance will increase the frequency command acceleration time.
RA1	T3	T4		Res 1/4 Watt 1%	Frequency command acceleration rate	Smaller resistance will decrease the frequency command acceleration time.
RF1	T5	T8		Res 1/4 Watt 1%	Frequency command maximum frequency	Smaller resistance will increase the maximum frequency.
CF1	T6	T7		Cap Cer 50V 10%	Frequency command maximum frequency	Larger capacitance will decrease the maximum frequency.
CP1	T9	T10	User Defined	Cap Cer 50V 10%	Pulse width (break point) frequency	Larger capacitance will decrease the maximum break point frequency.
RG1	T16	T17		Res 1/4 Watt 1%	Auxiliary op-amp gain	RG is the feedback resistor for the customer available auxiliary operational amplifier. Amplifier connections are on, connector J1, Pin 11 (output) Pin 12 (10K ohm negative input) Pin 13 (zero ohm negative input).
RCMD1	T20	T21		Res 1/4 Watt 1%	V/H Slope adjustment resistor	V/H Slope adjustment resistor consult factory.
ROS1	T22	T23		Res 1/4 Watt 1%	V/H Slope adjustment resistor	V/H Slope adjustment resistor consult factory.
RB1	T24	T25	10k on PCB	Res 1/4 Watt 1%	Bus Voltage scaling	Default: 10k for 120/240 VAC operation.
PDM ANA CMD	TP1			Test point	PDM Analog command input signal	Analog command signal to microprocessor.
PDM OUTPUT	TP2			Test point	PDM digital pulse output signal	Digital PDM signal from microprocessor.
L_COM	TP3			Test point	Logic common	Used as an instrument, low voltage, ground point.
CON3	CON3			Connector	Inverter Output Connector	Customer power output connector.
CON9	CON9			Connector	Line Voltage Input Connector	Customer power input connector.
PDM FAULT ENABLE	J1		Open	Jumper	Push-on setup jumper	Enables inverter shut off if PMD signal < 4ma.
Freq FAULT ENABLE	J2		Open	Jumper	Push-on setup jumper	Enables inverter shut off if Freq signal < 4ma.
Freq 4/20 ENABLE	J3		Open	Jumper	Push-on setup jumper	Converts Freq input from voltage to current type (4/20).
J4	J4			Terminals	Low Voltage Terminals	Customer signal level in/out connector.
PDM 4/20 ENABLE	J5		Open	Jumper	Push-on setup jumper	Converts PDM input from voltage to current type (4/20).
F1	J6		In	Jumper	Push-on setup jumper	** Jumper used to select PDM frequency.
PDM ENABLE	J7		In	Jumper	Push-on setup jumper	Enable the Pulse Density Mode (PDM).
F0	J8		In	Jumper	Push-on setup jumper	** Jumper used to select PDM frequency.
SYNC	J9		In 2-3	Jumper	Push-on setup jumper	Master/Slave select to operate multiple units from 1 master. Default: 2-3, cable if Sync.
BUS GAIN SELECT	J10		In 1-2	Jumper	Push-on setup jumper	Default: 1-2 for 120/240vac operation.
5v / BUS SELECT	J11		In 2-3	Jumper	Push-on setup jumper	Selects a Fixed vs Compensating source for Voltage (pulse width) command potentiometer(Internal and External). 1-2 Internal fixed 5v reference. 2-3 Compensates pulse width if bus voltage (line voltage) changes and also soft starts output Voltage gradualy when output is engauged. Default: 2-3 Bus Compensation. (also see J13 & J14)
Factory Fixed	J12		Fixed	PCB Jumper	PCB Jumper	Connects Logic and Signal common PCB jumper
RAMP SELECT	J13		In 2-3	Jumper	Push-on setup jumper FACTORY CONFIGURED	Selects a fixed ramp (2-3) which is unaffected by control settings. 1-2 causes frequency to sweep from 0 to the selected value when output is engauged. If the latter is used, RCMD resistor should be removed and other components may require altering.
FC_DIR	J14		In 2-3	Jumper	Push-on setup jumper FACTORY CONFIGURED	Selects Frequency Ramp 1-2 which integrates frequency output from command potentiometer. Select 2-3 for direct un-integrated command of frequency. Consult factory.
FREQ	R1		User Requested	Potentiometer 5k	Maximum frequency Potentiometer	This potentiometer is used to adjust the maximum settable output frequency. Turn CW for higher maximum frequencies.
PDM_ACCEL	R26		1 - 2 Seconds	Potentiometer 5k	PDM Acceleration Potentiometer	This potentiometer is used to adjust the PDM frequency acceleration time from 0.1 to 20 Sec. Turn CW for shorter acceleration time.
V_POT	R92		Full Counter Clock Wise (CCW)	Potentiometer 100k	On board voltage control potentiometer	This potentiometer is used to adjust the pulse width, which changes the voltage, when the frequency is above the break point. This pot is <u>always</u> in series with the external control pot, if the external pot is used.

****PDM Frequency selection chart**

PWM Frequency	F0 (J8)	F1 (J6)
15 Hz	0pen	0pen
30 Hz	Jumper	0pen
60 Hz	0pen	Jumper
120 Hz	Jumper	Jumper

Figure 3.2

SSD110 Connections



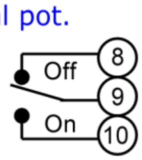
Grounding either #3 or #9 usually reduces signal noise and is recommended.

[1] Optional to obtain full use of potentiometer range.

[2] External voltage pot is optional, Circuit Board has an on-board pot.

[3] If External pot is used, set to full CCW for full external control or adjust as needed to trim low limit of external pot.

[4] Optional SPDT Toggle Switch.



4. Inverter Component Selection and Calculations

4.1 Ratings and Measurements

It is very important to measure, evaluate and understand the electrical performance of the system.
Wattage can be either measured or estimated using the generally accepted premise for DC supply devices. In this example the single-phase power line input to the Inverter is supplying 15a:

Watts ≈ (Volts * current) * .65

∴ (240v * 15a) * .65 = 2340 watts

The general rule for any type of transformer that determines the maximum primary amps ***regardless*** of applied primary volts is: **Nameplate VA / Configured Volts (not applied volts)**
Example: 1000va / 240v = 4.17a max or 3000va / 240v = 12.5a max.
Note that maximum primary amps is not related to applied volts. If the applied primary voltage is 50% of the rated value then the va rating of the transformer has effectively been cut in half.

To continue with this example, if the expected ozone performance is being achieved with 50% of rated primary voltage then it is likely that the output voltage rating of the transformer is twice as high as it should be. Under these conditions the inverter input current could be well within its rating but the transformer could be at twice its rated primary current. This is why it is essential to also measure the transformer primary current. If a voltmeter is available rather than an amp meter then the primary current can be reasonably estimated by taking the inverter input watts and dividing it by the measured primary volts. For the purpose of this example 200vac is measured. Using the above numbers: 2340w / 200v = 11.7a.
You can see this 11.7a is nearly the rating of the transformer, which in this configuration is 12.5a.

Note: the output voltage (pulse width) will increase as the frequency is increased if the frequency is below the SSD break frequency (usually 800hz). If the frequency control is going to be substantially increased it is recommended that the pulse width (voltage) control be reduced first.

4.2 Output Voltage Calculations

The RMS output line-to-line voltage (VLL) and its maximum value are partially determined by the input voltage. The Approximate maximum output voltage is calculated by using Equation 4.2.

Equation 4.2

$$Vo\ (RMS)\ Max = 1.1547 * Vi\ (VRMS) \text{ or}$$
$$Vo\ (RMS)\ Max = 1.1547 * Vi\ (VDC) / \sqrt{(2)}$$

The output voltage (VLL) is determined by the pulse width (Tp), at a selected Frequency (f). The pulse width (Tp) is set by the combination of Cp1 and an external resistor or potentiometer Rp, connected across pins 1 and 2 of terminal J3. The appropriate pulse width calculation is shown in Equation 4.3. If Cp1 or Rp1 is increased, the pulse width will increase if the frequency is not changed the RMS output voltage will also increase and vice versa.

Equation 4.3

$$Tp \cong 0.77 * (Rp1 + 4750) * (0.001 * 10^{-6} + Cp1) \text{ in seconds.}$$

4.3 IGBT State Machine Control

The SSD110 creates a frequency six times that of the output frequency. This allows the SSD110 to set up a state machine, for each output cycle, with six unique states. To describe the states for one cycle, we will start with the first output off state. In this state the output will be disabled for $1/6^{th}$ of the output cycle, independent of the output frequency. The pulse of the next clock will increment the inverter to the next state. In the next state (2) the clock triggers a monostable, which creates a pulse of a width (Tp) as shown in the Equation 4.3. In this state one of two things can happen, either the monostable will time out driving the output to the off, or the clock will arrive, changing to the next state (3), once again triggering the monostable keeping the output in the on. Once the second pulse is complete or the next clock pulse arrives (4), the output will be returned to an off condition. If Tp is greater than $1/6^{th}$ of the output cycle, the output is disabled for $1/6^{th}$ of the complete cycle. At this time the negative side of the output will run through the same sequence as the positive portion of the cycle creating a modified sign wave output. See example 4.1.

In terms of typical unit operation, the minimum pulse width can be adjusted to zero but the controls have better feel in an actual application if the minimum output voltage is 10 to 30% of the maximum attainable voltage. In so far as maximum pulse ON time are concerned, at 1khz and full control pot adjustment, 99.7% of theoretical is attainable. At a frequency of 25khz, 92.5% is the limit.

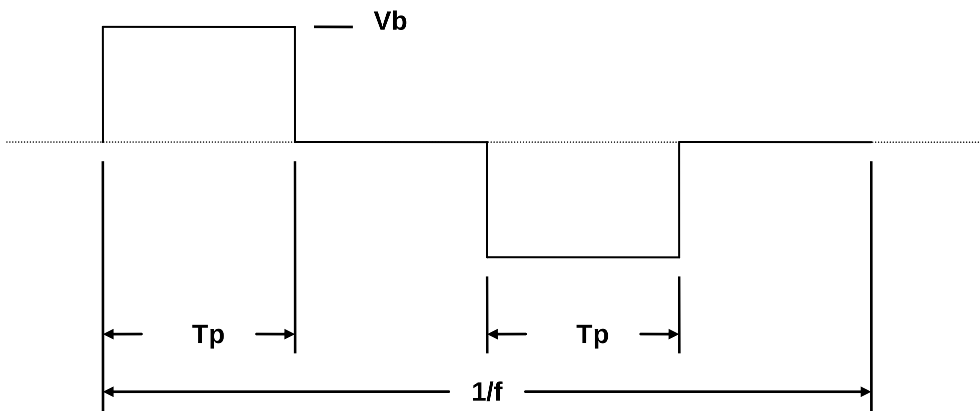
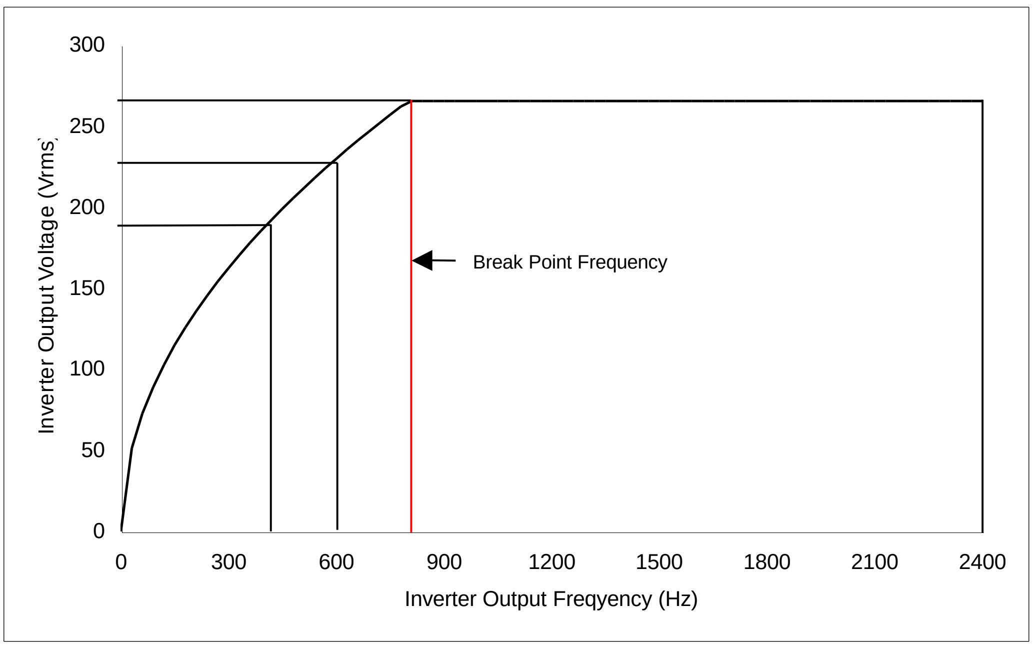


Figure 1



Graph 4.1 Inverter Output Vrms Vs Commanded Frequency

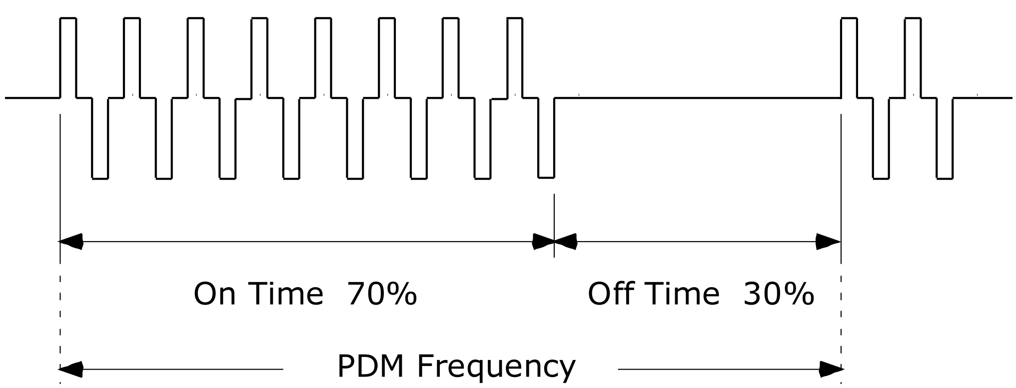


FIGURE 2

4.4 Output Frequency Calculations

The external voltage applied to the frequency amplifier controls the output frequency, see Figure 1 for connection details. Setting the frequency range and limits are determined by Rf1 and Cf1 as shown in Equation 4.4. Both are components added to circuit board turrets.

Equation 4.4

$$F\ (Hz) \cong \frac{2.7 * 10^{-6} * (1 * 10^{6} + Rf1)}{Rf1 * (1032 * 10^{-12} + Cf1)}$$

4.5 Output Rate of Change Calculations

The output frequency, as controlled by the frequency potentiometer, can ramp up at a desired rate by selecting the proper Ca1 and Ra1. The output will change zero to full in a time of no less then Ta seconds as calculated in Equation 4.5. Note: normally this frequency sweep ramp is factory set to a very short time (a few milliseconds) and the integration control pot R28, which sweep PDM) is used to adjust start-up.

Equation 4.5

$$Ta\ (sec) \cong Ra1 * Ca1$$

Table 4.1 (see next page)

Table 4.1

Tuning Component	Location
Ca1	Tp1 to Tp2
Ra1	Tp3 to Tp4
Cf1	Tp6 to Tp7
Rf1	Tp5 to Tp8
Cp1	Tp9 to Tp10
Rp1	J4 Terminals 14 to 15

5. Start-up

5.1 Transformer Configuration Jumpers

It is necessary however to be certain the load i.e.: transformer and optional lamp are properly jumpered for the expected primary voltage.

PTI has 2 transformer types that are routinely used with the SSD110: 100-HLHxx302/D230 and 55-HLHxx102/D115. The 55-HLHxx102/D115 is rated for 120v or 240v operation, 1kva at 1.2khz. While this transformer can be operated at 600hz one must be very careful to reduce the input voltage in half so as to prevent over heating and burn out. This reduction will also reduce the power available for said transformer to 600va. Increasing the frequency above 1.2khz is no problem either as long as the case temp limits are observed. Frequencies at or above 2khz generally yields excessive transformer heat however, if full rated power is applied. The HSH series transformers will operate from 5 to 10khz however. This transformer can easily be driven to power levels beyond its means by the SSD110. The HSH series is used with a matching choke to form a tuned circuit, which are intrinsically self-protecting.

The same general rules also apply to the 100-HLHxx302/D230, which is rated at 3kva at 1.2khz. It has a primary of either 230 or 460v. This transformer obviously a better match for the capacity of the SSD110.

PTI has several voltage output levels available in the 3kva Case100 series. If you are uncertain as to the proper high voltage level needed in your application it is recommended that the transformer be strapped for 460v operation while the inverter has 230 applied. This will reduce the output high voltage by 50%. I.E. A 10kv transformer would produce 5kv and is also de-rated in power from 3kva to 1.5kva. The need for this test configuration is mandated by the measurement of rated or nearly rated inverter input current while having a relatively low transformer primary voltage measurement, say 100-140v (240ac inverter input). Contact PTI if this condition occurs so as to select a more suitable transformer.

5.2 Safety Considerations

DANGER

To avoid injury to personnel and/or damage to equipment only qualified personnel should perform the procedures outlined in this chapter. This person must understand both the electrical and mechanical components associated with the application.

Thoroughly read and understand the following procedures before beginning the start-up process.

The following specific safety procedures must be observed when performing any maintenance or adjustments on the amplifier.

Always turn off and lock out AC power at the main machine disconnects switch. Do this before touching any electrical or mechanical components.
High voltage may be present even with all electrical power supplies disconnected.
Use an appropriate meter to verify that all DC bus capacitor banks have been discharged before working on any equipment. Do not rely exclusively on high voltage RED LED indicator for bus voltage, as dangerous voltage levels may remain even when the indicator is off.
Follow industry recognized safety procedures. Use only one hand to hold test equipment probes, wear approved eye protection, etc. Before energizing the inverter, make sure that device(s) connected to the output of the inverter will not result in injury or damage to equipment. Keep unnecessary personnel out of the immediate work area. Never leave an inverter cabinet open and unattended.

5.3 Start-up Procedure

To ensure a complete checkout and test, check off each step as it is completed. If the proper event does not occur while performing this start-up procedure, do not continue. Take the appropriate action to correct the malfunction before proceeding.

- Ensure the main disconnect switch is locked off. High voltage may be present even with all electrical power supplies are disconnected. Use an appropriate meter to verify that all DC bus capacitor banks have been discharged before working on any equipment. Do not rely exclusively on RED LED indicator of bus voltage, as dangerous voltage levels may remain even when indicator is off.
- Verify that the inverter mounting has been performed in accordance with the guidelines listed in Chapter 2.
- Inspect the inverter to verify that all optional modules have been selected and installed according to the system drawings and documentation.
- Verify that all wiring has been installed according to the wiring plan produced by the design engineer and according to the guidelines listed in Chapter 3 for proper connection, grounding, wire size, labeling, routing and applicable codes. The SSD110 does not have internal fusing. Install input and output (optional) fusing.
- Verify that all electrical terminals, screws, nuts, and bolts are securely fastened.
- Apply high voltage DC, single-phase AC power to the inverter.
- Check to make sure that the RED Bus voltage LED is on, indicating bus voltage.
- Measure the bus voltage with an appropriate DC meter. The bus voltages must be between 120 and 373 VDC. For other voltages disconnect the inverter input and consult the factory.

- Adjust the pulse width signal, on pin 15 of connector J4, to get the minimum pulse width. Set pin 14 to a highest voltage or turn the Voltage potentiometer (Rp), between pins 14 and 15 to its minimum resistance (full CW).
- Set the frequency inputs pins 2 and 3 on connector J4 to approximately mid rotation.
- Connect an oscilloscope or a true RMS meter with a frequency counter, such as a Fluke 87 true RMS multimeter, across the two-inverter outputs (Con 3).
- Turn on the inverter. The GREEN LED will indicate the inverter is in the on condition and supplying power to the output terminals.
- With the oscilloscope or meter monitoring the output. Adjust the voltage and frequency inputs to verify that the inverter has been set up properly.
- Turn off the inverter and disconnect input power. Once the RED LED has switched off connect the intended load.
- Return all inputs to minimum output settings. With a true RMS amp meter monitor the output current as you bring up the output to its intended operating level.
- While the inverter is operating at this level, check for overheating which may be a sign of an overloaded the inverter.

6 First Time Users

Read this manual cover to cover.
These procedures are to be performed only by a technician with experience in high voltage electronics.

6.1 Test Procedures

The SSD110 provides a wide range of independent voltage and frequency control with the ability to customize the performance as desired. Input power can be 120 or 240vac single phase. Output can have multiple transformers if within the SSD rating.

6.1.1 The recommended test setup requires

Appropriate single phase Variac fused at 20 - 30 amps, using fast acting fuses.

SSD Power input monitored with true RMS volt, amps and watts if available. Fluke 41B or 43B, watt.

SSD output monitored with TRMS voltmeter, frequency counter and/or oscilloscope.

Transformer high voltage output measured by TRMS voltmeter and high voltage probe. For high voltage measurement, use oscilloscope, Tektronics probe P6015 or equivalent (1-800-426-2200). The Fluke, high-voltage multimeter probe commonly used for 60hz measurements (80k-40) **will not yield correct readings above 60hz.**

Transformer primary is best monitored using Tek differential probe P5200 and current using Fluke high-speed current clip 80i-110s.

6.1.2 Power Input Connections (Single and 3 Phase)

Single phase is connected to the screw terminals of Con9 (next to large red disk).

For the SDD113 model, which is identical to the SSD110 single phase unit except for AC input, 3 phase Delta 240v is connected to the optional bridge located on the upper area of the heat sink. Terminals are .25" (.032") spades. Connection order is not important. The single phase terminals are not live if the 3 phase bridge is used but are functional and can be used if desired.

While direct line starting is permissible, **it is recommended to use a soft charge circuit**, see figure 3.3. High input surge currents can be reduced using one 50-ohm resistor for a single-phase system. The resistor(s) should be bypassed by a time delay relay contact(s) approximately one second after the power is supplied to the resistor(s). This soft charge procedure will increase the bus capacitor life. For bench testing purposes, a Variac can be used to prevent these inrush currents.

6.1.3 Power Output Connections

For initial lab experiments, all power output lines should be fused. This is a precaution to ensure the unit is protected against an unforeseen accident during lab testing. Start with fusing levels of 50% of product rating until such time as the technician understands the SSD110 and how the complete system responds. This will prevent damage to the components of the ozone system, (inverter, transformer, generator) while its performance familiarity is learned.

It is recommended to do the initial start-up **tests using a light bulb as the load and not the transformer.** This will allow the technician to become familiar with the controls before connecting the actual load. This will enable validation of proper hook up and also provide visual feedback as the controls are adjusted. It is also recommended that the light bulb load remain connected for the initial tests on the transformer. This will continue to provide visual feedback during the adjustment process.

If 120 volt source is applied then use a single 40 - 60 watt bulb; if 240v is applied then two bulbs of equal rating can be wired in series and placed across any two of the output terminals.

6.2 Control Connections and Jumpers

The SSD110 is considerable more complex than its predecessor. Take time to understand the on board controls and jumpers.

6.2.1 Potentiometer Connections

PULSE WIDTH CONTROL CONNECTIONS: The potentiometer (Rp) is used to adjust output voltage. This potentiometer controls pulse width, which is manifested as output voltage to the load. Connect the 100k potentiometer to connector J4 pins 14 and 15 as shown in figure 3.2. Remote mounting of this control is not recommended. The longer the wire used for remote mounting increases the probability of external signals being intercepted. Signals of this nature will disrupt output waveforms causing a drop in SSD performance.

FREQUENCY CONTROL CONNECTION: The 5k pot with 3-connection pigtails controls ***output frequency.*** The SSD is configured for a range specified by the customer, which can be from 5hz to 30khz. See figure 3.2. Connect the frequency potentiometer (typically 5k) to connector J4 pins 1, 2 and 3, as shown in figure 3.2. Typically for ozone use it is configured for a full power range of 800hz to 2.5khz. The pot can be remote mounted if desired. Note that while the SSD can be adjusted for frequencies below the lower break frequency, in this case 800hz, the SSD will automatically reduce the output pulse width for frequencies below said break frequency thus reducing the maximum power output. This automatic compensation protects the transformer and inverter against the excessive currents that would result from this frequency mismatch.

The on board frequency pot(R1) sets the highest inverter frequency, without changing component values, with the external pot set to max.

PULSE DENSITY MODULATION CONNECTION:
The 5k pot connects to J4 pin 6 and share a power connection on pins 1 and 3. If J7 is installed, PDM can be controlled via external pot or command signal. The PDM frequency is adjusted via the binary selection jumpers J6 and J8. Both jumpers in yields roughly 120hz modulation frequency, which would be appropriate to use with operational frequencies at or above 1200hz As a general rule, the jumpers should be selected to yield a PDM frequency 1/10 or less than the fundamental frequency controlled by the frequency pot. Removing J7 disables PDM and causes the unit to look electrically like an SSD100.

The SSD does not contain any power line input voltage jumpers and will operate from 90 to 260vac automatically. It does however come configured for either 120vac or 240vac. Most units are sold to operate on 240vac. While the **SSD will operate down to 90vac**, there are 2 things that must be considered: Bus voltage compensation, which is discussed in detail below and the lack of proper cooling if the fan is not operating. If the start-up conditions are expected to be completely unknown, it is a good idea to reduce the line voltage input for a 240vac Inverter to 90 to 120vac so as to soften the affects of determining the load behavior. This can safely be done for several minutes due to the thermal inertia of the heat sink. It is imperative however that bus voltage compensation be disabled if the line voltage is going to be drastically reduced.

The **bus voltage compensation (BVC)** resistor is located between turrets **RB1**. The factory installed value is: 10k on the PCB this is for both 120 / 240vac line operation. If improved regulation is required values can be placed on TP24-TP25, consult factory for values. When BVC is active, the incoming line voltage is monitored and if it increases above nominal then the pulse width is automatically reduced. This results in a nearly constant transformer primary voltage or more importantly a nearly constant plasma production. This is especially useful in simple open loop systems that don't measure ozone and automatically adjust the inverter. Conversely, if the line voltage sags, the pulse width increases automatically if BVC is enabled.

The alternate +5vdc strapping is ONLY for special factory provided custom configurations. To disable the affects of BVC and thereby eliminate the units ability to compensate for line voltage changes. A resistor (Rg1) of approximately 6.7k is added to the Aux Amp turrets TP15-TP16. This value is used to scale the Aux Amp to provide an output at J3-3 of approximately 10vdc which then provides a fixed reference voltage for the Pulse Width Pot. Add Jumper from J1-5 to J3-5. Move pot Rp connection from J3-1 to J3-3.

Auxiliary Amplifier Use:

If the Aux Amp is not used per above bus voltage compensation removal, it is available for any utility purpose needed by the customer. For example, it can be used to scale, invert, level shift and add if desired. Gain is adjusted by soldering a resistor to the Rg1 turrets. It is supplied by the same internal power supply that operates the SSD circuits, ±15v. Load impedance should not be less than 1k. See Fig 3.2.

After all the fine tuning is done:

It is highly recommended that the 3 adjustment pots located on the circuit board and the frequency adjustment pot on the connection header be locked in place using a small drop of adhesive like silicon rubber, glyptol or the like. Most small adjustment type pots will have their position setting altered if vibration is present i.e.: from compressors or shipping. This procedure will insure that the fine-tuning set points will not change. If the final tune occurs in the field, then encourage the installation technician to lock the pots in position.

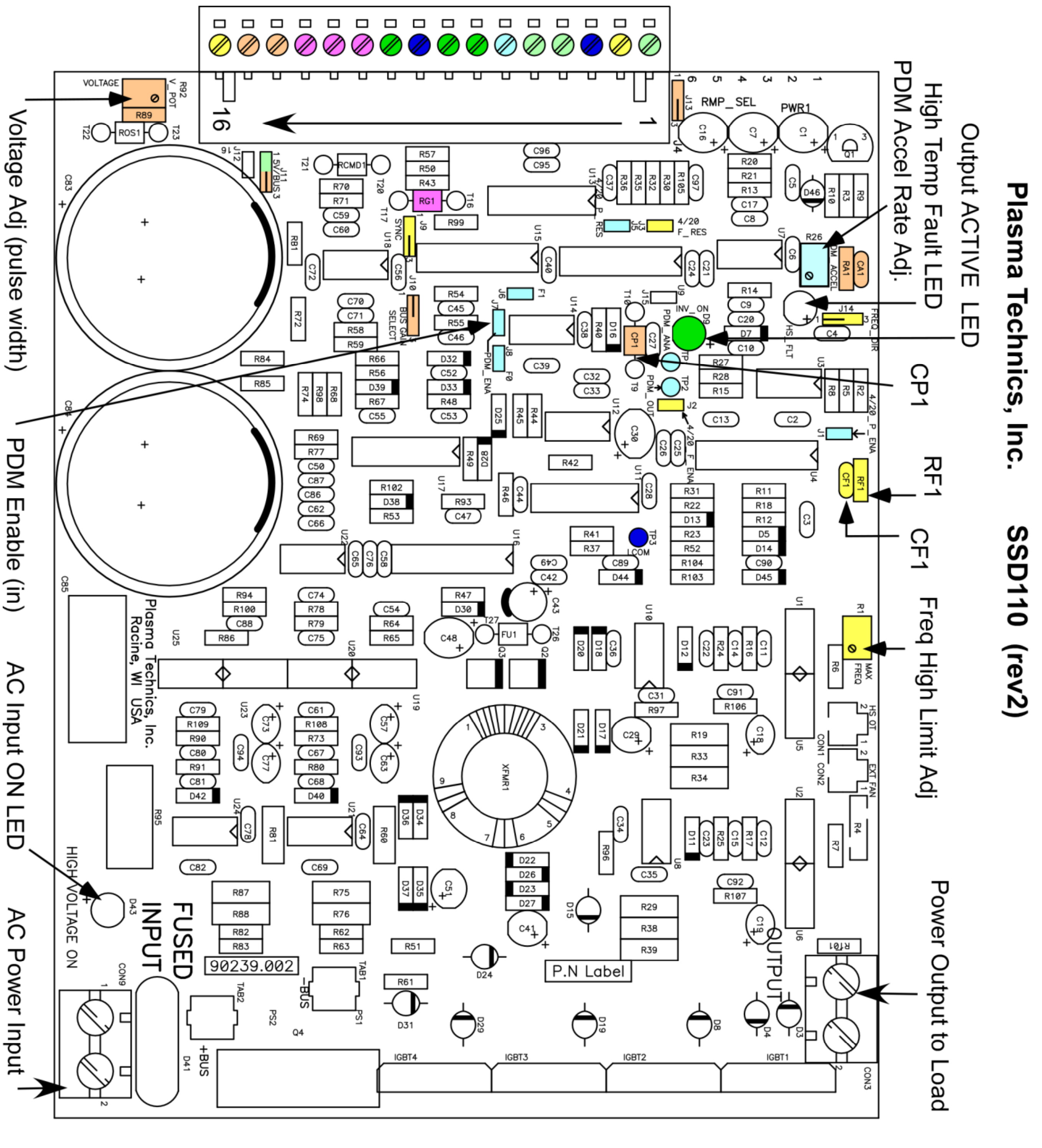
-Reconfiguring Operating Frequency-

Use the chart below to determine desired operating frequency. Change the resistor and capacitor as the chart specifies. The location of Rf1 and Cp1 are shown in Figure 6.2.

BreakPoint (Hz)	**Max** (Hz)	**Rf1** (ohms)	**Cf1** (µf)	**Cp1** (µf)
60	2k	Open	.1	.1
200	2k	Open	.01	.039
450	35k	Open	Open	.016
700	35k	Open	Open	.01
1.3k	35k	Open	Open	.0047
5.6k	35k	Open	Open	Open
5.6k	35k	10k	Open	Open

Notes:
1. Values given are nominal.
2. Values taken with on-board voltage and freq pots set to max CW.
3. Using Bus Ref or fixed 5 volts yields similar results.
4. BreakPoint Freq, lowest freq that produces full output voltage (also full pulse width).
5. Default for normal use in the 800hz to 2500hz band utilizes CP1= .01uf.

Figure 6.2. Part Locations



6.2.2 On/Off Switch Connection

Connect the inverter ON/OFF switch. A SPDT switch is wired to connector J4 with the NC connected to pin 8 the common to pin 9 and NO to pin 10. For bench testing the switch can be connected directly to the terminal block. It can also be remote wired. Momentary push buttons can be used for normal 'push ON / push OFF' machine control type interface.

6.2.3 On Board Controls and Jumper

Frequency pot:

Use pin 16 for frequency measurement (Gnd is #3). The output is a digital signal, which is **1x** base frequency. No load needs to be applied, just switch output 'ON'. To set small frequency trimmer pot R1: turn external freq pot to full C.W., PWM to mid range, PDM to max. This yields best scope signal. Set the frequency trimmer R1 to the desired maximum frequency. If external frequency control is not needed, the pot, which is normally connected to J4 1,2,3 can be replaced by a jumper between J4 1-2. The on-board frequency pot (R1) then becomes the sole control.

Voltage pot:

The on-board pot (R92) can be used to replace the off-board pot by inserting a jumper in place of the two pot connections if desired. The off-board and on-board pots are connected in series (see block or connections diagrams). If an off-board control is used, the on-board (R92) must be set to the full CCW position to obtain full use of the off-board pot range. It is also possible to limit the minimum voltage that the off-board pot can achieve by the use of the on-board pot. For example, if the completed system requires a minimum voltage of 20% to operate properly, follow this adjustment procedure. Set the off-board pot to full CCW. Adjust the on-board pot CW until the desired minimum output voltage level is achieved.

PDM-Acceleration ramp pot (power on ramp):

CCW provides the longest startup ramp after turn ON by digital ON/OFF switch. Generally a 1 or 3 second ramp is fine. This adjustment affects only the PDM integration time and affectively ramps the power delivered to the cells. *Thermal shock to the cell can be minimized by using the full CW setting (yields approximately 1 minute power ramp)*.

On Board Jumpers:

See the 'SSD110 Circuit Board (Rev2) Component and Pot Setups' for specific details.

PDM Enable Jumper:

If J7 is installed, PDM can be controlled via external pot or command signal. The PDM modulation frequency is adjusted via the binary selection jumpers J6 and J8. Removing J7 disables PDM and causes the unit to look electrically like an SSD100. See 'Component and Potentiometer' table on page 10

Fault Enable Jumper:

J1 enables PDM and J2 enables Frequency shutdown in the event that the command signal is less than 4 ma. If the inverter is faulted by either one of these then the On/Off must be cycled to reset the fault and reactivate the unit.

4/20 Enable Jumper:

Jumpers J3 and J5, when installed, apply a 500 ohm resistor across the input terminals J4-2 and J4-6 respectively. As with the fault jumpers above, they can be used individually if desired. An increasing voltage or current, depending on the configuration mode selected, results in increasing frequency for frequency input J4-2 and increasing Pulse Density (more power) for PMD input J4-6.

Bus Compensation/Voltage Ramp Select Jumper:

J11 selects the signal source for BOTH the EXTERNAL and INTERNAL voltage pots.

(Default) 2-3 selects bus-compensation/voltage-ramp start-up, which is about 5 volts when 240vac line voltage is present. This position enables the output compensation circuits that attempt in an open loop fashion to stabilize the plasma load if the line voltage fluctuates. Also provided in this position is a start-up voltage ramp, which automatically increases voltage (pulse width) from minimum to the selected set point. This action eliminates high inrush current, which might cause an automatic shut down during the turn on period. It is important to also configure the bus gain jumper if 2-3 has been selected.

1-2 selects a fixed 5 volt reference, hence no bus voltage compensation to improve output stability. This position also eliminates the start-up ramp for pulse width, which causes the pulse width (voltage) to instantly snap to the set value when the ON command is received. In this position it would be recommended to select a frequency ramp as an alternative so as to reduce inrush currents, which might cause the SSD to shut down due to excessive current. This configuration would be used if the SSD were being used as a motor control.

Bus Gain Select Jumper:

This jumper should remain in position 1-2. The input line voltage will determine which set of resistors should be installed. For 208-240 volts the standard factory position; components Ros1= 18.2k, Rcmd1= 13.0k will be placed.

For 120 volts place the following resistors: Ros1= 30.0k, Rcmd1= 24.0k.

Ramp Select (RMP_SEL) and Frequency Control (FC_DIR):

Jumpers J13 and J14 are factory configured. These jumpers determine the modes of operation for the linear ramp generator which, controls initial start-up. Changing these jumpers also requires that other component values be changed. These values are factory selected to suit a particular application need and hence cannot be field adjusted.

Synchronization Jumper:

For normal operation J9 MUST be installed in the 2-3 location. It must NEVER be installed in the 1-2 location. This connector is also used to synchronize two SSD110 via a special jumper cable. Consult factory.

6.2.4 Power Connections

The SSD does not contain any fuses. It is recommended for bench experimenting that all input legs be fused at the beginning levels with 50% of the expected load value. Both output legs should also be fused with values not exceeding the peak rating of the supplied SSD (FAST fuses). This redundant fusing is not required once the bench-testing phase is complete.

While the low voltage control wiring is not connected to either power line, caution should be used to prevent the potentiometers and switch connections from shorting to any other conductive material. A nonconductive test surface is recommended.

- Connect the load to the inverter output on connector CON3 terminals.
- Connect the input power, through a separately fused Variac if possible, to terminals marked CON9.

The SSD110 includes 3 LED's. The RED LED near CON9 will indicate that there is bus voltage present on the SSD110. **CAUTION** must be taken when the RED LED is on. The GREEN LED D9 will indicate that the SSD110 is enabled and able to provide voltage to the output terminals. The SSD110 contains a safety start up protection circuit, which prevents the output from turning on when the main power is applied to the inverter even if the ON/OFF switch is in the ON position. The SSD110 is only enabled on the transition of this switch from OFF to ON.

The SSD110 does not require any primary input voltage configuration and will operate from 90 VAC to 264 VAC or 120 VDC to 373 VDC automatically. See Section 7.1 for the specifications to determine maximum input and loading conditions.

6.2.5 Test Equipment Connections

If an oscilloscope is used to observe the output waveforms be certain to use an oscilloscope equipped with differential inputs.

IMPORTANT-neither output leg can be grounded.

NOTE: Unless the scope power connection is isolated, the normal scope ground clip is grounded and could destroy the SSD unless the above external fusing is added by the user.

CAUTION: Connecting any of the inverter outputs to earth ground may cause injury to personnel and/or damage to equipment!

CAUTION: Never float the oscilloscope by isolating the ground connection to the oscilloscope and allowing the scope chassis to be insulated from a ground. This may also cause injury to personnel and/or damage to equipment!

6.2.6 Cooling Requirements

It is recommended that applications requiring input currents above 10 amps RMS must be fan cooled i.e. have factory installed heat sink mounted fan. In the final installation the SSD110 should be mounted with the cooling fins vertical so as to maximize the affects of normal convection cooling. If the full 25 amp input current is utilized, the SSD110 should also be in the path of addition air circulation, which bathes the entire unit.

6.3 PLC or Computer Interface

It is recommended that cable connection to PLC's and computers are done using shielded cable and run separately from the power leads. The SSD110 power supplies are isolated and therefore connecting the signal common to a PLC is not a problem.

PLC or Computer control: **PDM** is the best method to control power. It was developed specifically to enable fine and wide ranging control that no other method could accomplish. 0-10vdc can be supplied to J4 pin 6, with 10v producing maximum output. Installing J5 enables the use of a 4-20ma input signal rather than the above voltage control. 20ma produces maximum output.

Frequency control: Follows the same rules as the above PDM input command. Connect to J4 #2 signal line, #3 signal ground.

Voltage Control (Pulse Width): The voltage input can also be PLC (programmable logic controller) or computer driven if desired. This input requires a voltage source, which can be accomplished by connecting the PLC voltage source output

directly to J4 pin 15. The source is usually 0-5vdc or 0-10vdc. If a voltage greater then 10v is used, a resistor (>10k) should be between the supply output and pin 15. This input is unique in that REDUCING the input command voltage will INCREASE the output voltage. Care must be taken to assure that the command input is broken, as this will cause the SSD110 to produce maximum output. As above the PLC ground is connected to J4 pin 3.
Remote control of pulse width (voltage) is rarely needed. Usually remote interfaces to PDM and Frequency provide sufficient control of the load. The resistor designated SEL-connecting to J4 #1 is not supplied and is used only for very special control application. Consult factory for details.

ON/OFF CONNECTION: The SPDT switch is wired to terminals **J4 #8 - 10.** For bench testing the switch can be connected directly to the terminal block, but remote wired if desired. Note that push buttons can also be used if desired – see schematic. The SSD replicates the control logic found in Push – ON, Push – OFF contactor control systems. These control inputs can also be PLC controlled. See block diagram.

While the low voltage control wiring is not committed to either power line, caution should be used to prevent the pot and switch connections from shorting to any other conductive material. A wooden test surface is recommended.

6.4 Test Procedure Steps

- Switch SSD110 ON/OFF to OFF position.
- Set (Freq. Pot.) potentiometer to minimum command frequency.
- Set (Voltage) potentiometer to minimum (CCW) rotation.
- Turn on the external power source using a Variac or soft charge circuit.
- Enable the SSD110 by setting the ON/OFF to the ON position.
- Adjust the frequency and voltage potentiometer; observe the changes in the brightness of the lights connected to the output. Also monitor the true RMS meter and/or the oscilloscope until you become familiar with the operation of the SSD110 inverter. Check frequencies and voltage levels in order to make sure that the inverter has been setup correctly.

CAUTION: The output voltage will increase as the frequency is increased. If the frequency control is going to substantially increase it is recommended that the pulse width (Voltage) control be reduced first.

6.5 System Tuning Goals

- A tuned system using either standalone transformers or a separate transformer and choke combination can only be effectively tuned to optimum by using a P6015 high voltage probe connected to the high voltage output of the transformer.
- Adjust the freq to max, PDM to max, begin increasing pulse width (voltage) to about 100v (for 240v line) while observing that the AC input current is not excessive.
- Sweep the freq down until an output voltage peak is found. A resonant point can also be found at ½ the frequency of the fundamental resonant freq. The fundamental will have the purest sine wave however. Adjust power using the pulse width control to about 90% of the max needed for the application and measure the voltage being applied to the transformer primary using TRMS meter. The voltage should be above 190v. If it is not then the transformer output voltage is too high and a lower voltage model should be substituted. Conversely, if the primary voltage is above 260v a higher voltage model is needed.
- Slowly lower the freq below the resonant point until the ozone output peaks. The drop in freq should be within 10% of the peak freq.
- Adjust pulse width again so as to obtain 110% of desired ozone output while being sure that power and current limits are not exceeded.
- Reduce the PDM control to obtain the desired system output performance. PDM provides a linear control of output versus command signal. Turn down to 10% using PDM is possible.

6.6 Troubleshooting

- If a system has been functional but now it will not start when the ON/OFF is turned ON:
- Is RED led on? If not check input fusing. If it will not hold a slow-blow which is 25% above the inverter rating than make arrangements for RMA.

- If the Green led (Inverter-On) winks on and off when ON/OFF is engaged:
  Disconnect any loads connected to the output terminal. This includes measurement instruments temporarily to be certain they are not causing a short by grounding one of the outputs.
  Turn ON/OFF and back to the On position. If it still winks out, check the line voltage. The SSD110 disables itself if the line voltage exceeds 264rms. If the problem still persists when turned on then obtained return RMA from PTI.

- If it stays on, then either the load has been damaged or the SSD has its pulse width control turned up too much resulting in very high current to the load. Consult factory to discuss this issue.

7. Specifications

The SSD110 must include the heat sink mounted fan in order to run the units above 10 amps RMS.

Displacement power factor: 0.5 to 0.6 at all loads.
Overload current: 120% of rated for 1 min.
Electronic over-current fault protection (all output devices).
Over temperature sensing and shut-off.
Maximum AC input current: 25 RMS *****
Inverter unit: Full Bridge, Four-IGBT's.
Regeneration: Capacitor bank energy storage.
Surrounding Air temperature: 32° to 104° F (0° to 40° C).
Storage temperature: -40° to 158° F (-40° to 70° C).
Relative humidity: 95% maximum, non-condensing.
Altitude: To 3,310 ft. (1,000 m) at rating.

***** At current levels above 15 amps added cooling may be needed. It is important that air be directed at the circuit board and large cylindrical filter capacitors. Consult the factory for fan placement and sizing.

7.1 Inverter Selection / Information Guide

Model Number	Max Input (VRMS)	Input (VDC)	Output Voltage (VRMS)	Output Current (ARMS)	Output Frequency (Hz)
SSD110/15	90 to 264	120 to 373	104 to 304	15	5 to 30000

8. Warranty

PTI warrants that its Products will be free from defects in workmanship and materials under normal use and service for a period of 90 days from the date of delivery pursuant to section 2 of these Terms and Conditions of Sale. This warranty is void in cases of damage in transit, negligence, abuse, abnormal usage, misuse, and/or accidents, or improper installation and maintenance.

PTI’s sole obligation under this warranty shall be, upon prompt written notice by Buyer of any defect, to repair or replace without charge, F. C. A. Racine, Wisconsin, any defective part or parts expressly warranted herein against defects by PTI. This warranty covers only replacement or repair of defective parts at PTI’s main office and does not include field service travel and living expenses. In no event shall PTI be liable for incidental, consequential, or other damage. PTI’s aggregate liability with respect to defective products shall be limited to the moneys paid by Buyer to PTI for the defective products manufactured by PTI.

On equipment furnished by PTI, but manufactured by others, the written warranty of the manufacturer, if any, will be assigned to Buyer if assignment is reasonably practicable. However, PTI does not adopt or guarantee or represent that the manufacturer will comply with any of the terms of the warranty of such manufacturer.

PTI will not reimburse Buyer for any expenses incurred by Buyer in repairing or replacing any defective Products, except for those incurred with the prior written permission of PTI.

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PTI and buyer agree that the warranties in the preceding section are exclusive and in lieu of all other express or implied warranties, including, but not limited to, implied warranties of merchantability and fitness for a particular purpose. PTI hereby disclaims and excludes all other express or implied warranties. Any oral or written description of the Products is for the sole purpose of identifying the Products and shall not be construed as an express warranty.