USER'S GUIDE AND
TECHNICAL REFERENCE

BEHLMAN MODEL BL1350 SERIES
1.35 KVA AC POWER SUPPLY

FOR SERVICE ASSISTANCE

CONTACT BEHLMAN
CUSTOMER SERVICE DEPARTMENT
PHONE TOLL FREE 1-800-874-6727

OR WRITE

BEHLMAN ELECTRONICS CORPORATION
CUSTOMER SERVICE DEPARTMENT
80 CABOT COURT
HAUPPAUGE, NY 11788-3729

PHONE: (631) 435-0410
FAX : (631) 951-4341

FOR SALES INFORMATION:

PHONE: (631) 435-0410(NY) OR (805) 375-7046 (CA)
USA : 1-800-874-6727(NY) OR (800) 456-2006(CA)
FAX : (631) 951-4341(NY) OR (805) 498-2147(CA)

DATE: 11/11/13 REV. G

SAFETY SUMMARY

The following safety precautions must be observed during all phases of operation, service, and maintenance of this equipment. Failure to comply with these precautions or with specific warnings elsewhere in the manual violates safety standards associated with the design and intended use of this equipment. This manual forms an integral part of the equipment and must be available to operating personnel.

GROUND THE EQUIPMENT

This equipment may have high leakage current to chassis due to EMI filtering requirements. To minimize shock hazard, the equipment chassis(s) must be connected to an electrical safety ground. This equipment is supplied with a three conductor line connection for single phase applications. It includes an earth terminal intended for protective earth connections. In addition, isolated installation sites may require neutral to earth connections as per NEC section 250 (National Electrical Code). Refer installation to licensed electrician or other qualified personnel.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERE

Do not operate the equipment in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove equipment covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power applied. Under certain conditions, dangerous voltage may exist even with the power removed. To avoid injuries, always disconnect power and discharge circuits before touching them. During normal operation the operator does not have access to internal hazardous voltages. However, depending on the user's application configuration, **HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY** may be normally generated at the output terminals. The customer/user must insure that the output power lines are labeled properly as to the safety hazard and that any inadvertent contact is eliminated.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to this equipment. Contact Behlman Electronics for proper replacement parts and specific service information.

DANGEROUS PROCEDURE WARNINGS

Warnings will precede potentially dangerous procedures in this manual. Instructions contained in the warning must be followed. Warnings will be proceeded by the caution symbol (above).

RISK OF ELECTRIC SHOCK

This symbol warns personnel of hazardous conditions due to the exposure of hazardous voltage that can be lethal if contacted.

Neither Behlman Electronics , Hauppauge , NY, USA, nor any of the subsidiary sales organizations can accept any responsibility for personnel, material or inconsequential injury, loss or damage that may result from improper use of the equipment and/or accessories provided.

For additional safety related technical information, contact the Behlman Electronics sales department or local sales representative.

sales@behlman.com

or call in N.Y.

631-435-0410

CLAIM FOR DAMAGE IN SHIPMENT

Under the FOB factory terms of sale, ownership and responsibility are transferred to the customer when the equipment leaves the factory. Each Behlman equipment is shipped from the factory in proper operating condition.

Immediately upon receiving equipment, unpack and inspect it for evidence of damage incurred in shipment. File a claim with the freight carrier if the equipment has been damaged in any way or it fails to operate properly. Forward a copy of the damage claim report to Behlman. Include the model number, serial number and date the shipment was received. Behlman will advise the disposition of the equipment and will arrange for necessary repair or replacement.

RETURNING EQUIPMENT TO FACTORY

Do not return equipment to the factory without prior authorization from Behlman.
A RETURN MATERIAL AUTHORIZATION NUMBER (RMA) is required to return equipment.

This equipment, like all precision electronic equipment, is susceptible to shipping damage. It contains heavy magnetic components as well as delicate electronic components.

If equipment is returned without prior authorization, the shipment will be refused, the customer being liable for all shipping, handling and repair costs.

When packing for reshipment, use the original shock absorbent material and shipping container to preclude damage to the equipment.

Insure that the return authorization numbers (RMA) is available on the container for identification.

SHIPPING INSTRUCTIONS

RACK MOUNTED UNITS

1) Box (es) must be double wall with minimum 350 lbs. bursting test.
2) Box (es) must provide for a minimum of 3to 4 inches of clearance around sides, top and bottom of unit.
3) When packing unit, utilize either a foam-in-place system or high density foam. Clearance provided for above must be completely filled with foam.

FAILURE TO COMPLETELY SECURE UNIT IN BOX WILL ALLOW MOVEMENT DURING SHIPPING, RESULTING IN DAMAGE.

4) Secure box (es) to pallet (s). This is necessary to insure proper handling and protection during shipping.
5) Place the following warning label on box (es)

DO NOT STACK

6) Ship unit (s) using a freight cargo carrier; air or ground.

CABINET MOUNTED UNITS

Cabinet mounted units require that a special crate be used. The crate should be manufactured of plywood (3/8" or thicker) and reinforced (using 1 x 3 or larger pine) on all edges. The unit must be firmly secured to the crate's base. The crate must be shock mounted to avoid damage during shipping. Detail drawings for Behlman's crates are available upon request.

WARRANTY CERTIFICATE

Behlman Electronics, Inc. warrants to the original purchaser, for a period of one (1) year from the shipment from Behlman, each item to be free from defects in material and workmanship. Behlman's obligation and the Purchaser's sole remedy for any breach or violation of this agreement is limited to adjustments, repair or replacements for parts which have been promptly reported by the Purchaser as having been in its opinion, defective and so found by Behlman upon inspection. All replacement parts will become the property of Behlman on an exchange basis. This warranty will not apply if such adjustment repair or parts replacement is required because accident, neglect, misuse, failure of environmental controls, transportation damage or causes other than normal use.

If during the warranty period a defect should impair the performance of the unit, Behlman agrees, at its option, to repair or replace the unit or its defective components F.O.B. Behlman at 80 Cabot Court, Hauppauge NY 11788 or at another Behlman service facility at Behlman's option. To obtain service under this warranty, the original Purchase shall notify Behlman at the above address or by telephone at 631-435-0410 and provide information about the defect or impairment of performance. Behlman with then supply the Purchaser a Return Material Authorization (RMA) number. This number must be attached to the equipment sent back for warranty repair. Equipment must be shipped back to Behlman prepaid. No collect shipments will be accepted.

Behlman shall be excused from supplying warranty service if the unit's case has been open or if the unit has been subject to unauthorized repair. All service outside the scope of this warranty shall be paid for by the Purchaser at Behlman's rates in effect at the time of this repair. Behlman will not perform any repairs outside of the warranty without written authorization by the Purchaser. If the repair is a warranty repair, Behlman will ship the unit back to the Purchaser, by a method determined solely by Behlman, prepaid. If the Purchaser requests, any other means of transportation it shall be at the Purchaser's expense.

The use of the equipment shall be under the Purchaser's exclusive management and control. The Purchaser will be responsible for assuring the proper installation, use, management and supervision of the equipment. Behlman will not be liable for personal injury or property damage.

The forgoing warranties are in lieu of all other warranties, expressed or implied including without limitation warranties of merchantability and fitness for purpose.

In no event shall Behlman be liable for loss of profits, loss of use, or any indirect, consequential or incidental damages. Purchaser agrees that Behlman will not be liable for any damages caused by the Purchaser's failure to fulfill any of the Purchaser's responsibilities set forth herein.

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TABLE OF CONTENTS
BEHLMAN AC POWER SOURCE, MODEL BL1350

SECTION

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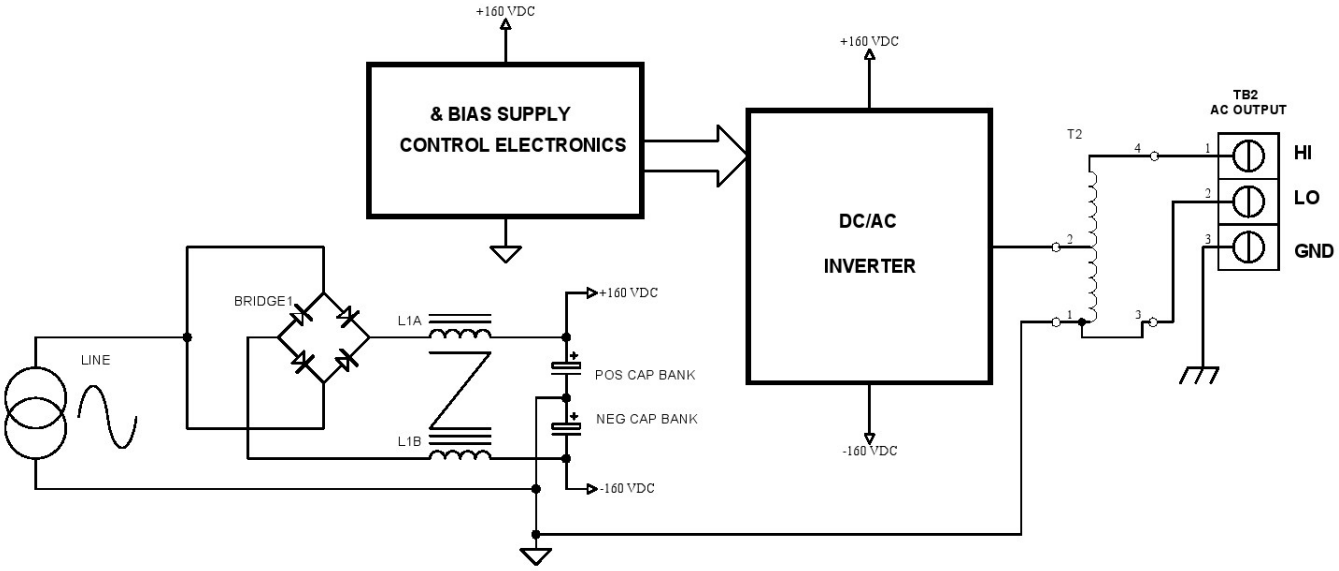
BEHLMAN AC POWER SOURCE, MODEL BL1350

SECTION 1
BL1350 AC POWER SUPPLY INTRODUCTION

The Behlman model series BL1350 AC Power Source are solid state frequency converters. They provide regulated AC power at frequencies that are not available from local utility power. The output of these models is transformer coupled providing a voltage source similar to utility power. These models incorporate the latest in hard switched, PWM technology. A high frequency “Class D” type output stage provides a savings in weight and waste heat. This accounts for the compact size and high power capability of this AC power source. The following is a brief description of the conversion process performed by the BL1350.

Line power is applied to the input of the unit. After passing through a noise filter, the input AC is converted to a bulk DC link voltage. This DC voltage is applied to the output inverter (refer to the block diagram). The output inverter is a switch mode power amplifier. A sine wave signal of the desired frequency is developed by the control circuitry and applied to the input of the power amplifier. This sine wave is amplified and “stepped - up” by the output transformer to provide the proper voltage. The output voltage of the unit is sensed electronically and used as feedback to regulate the output. This action rejects fluctuations in the input line voltage and provides an output that may be adjusted above or below the input line. The output current of the power source is monitored and used to provide overload protection for the output inverter. Model variations include isolated or non -isolated output, dual range output, dual range input and extended output frequency.



SIMPIFIED BLOCK DIAGRAM BL1350 SERIES

SECTION 1
BL1350 AC POWER SUPPLY INTRODUCTION

BL1350 AC POWER SUPPLY SPECIFICATIONS (general)

INPUT REQUIREMENTS:	120 VAC +/- 10% 47-63 Hz (A & B versions) 120VAC or 240 VAC +/- 10% (C1 & C2 versions) * see table 1
OUTPUT POWER:	1350 VAC MAX. (with input @ 120 VAC)
LOAD POWER FACTOR:	Zero to Unity with no derating.
OUTPUT VOLTAGE:	0 -135VAC @ 10 AMPS AND 0-270VAC @ 5 AMPS * see table 1
OUTPUT FREQUENCY:	Continuously adjustable from 45 to 500 Hz.
OUTPUT REGULATION:	Less than 1% of full scale from no load to full load
SETTLING TIME:	Approximately 200mSec to 1%. 10-90% (linear load)
LINE REGULATION:	+/- 0.1% for +/- 10% line change @ 115V 10A / 230V 5A
OUTPUT DISTORTION:	1% Typical @ 115 V 50Hz into pure resistive load.
.	
OUTPUT NOISE :	2.5 V peak to peak typ.(on low range into 10 ohms.)

FRONT PANEL METERS:

VOLTMETER RESOLUTION:	1 Volt
ACCURACY:	2% of reading + (+/- 1digit) RMS responding
AMMETER RESOLUTION:	0.1 Amp
ACCURACY:	2% of reading + (+/-0 .5 % of range) RMS responding.
FREQUENCY RESOLUTION	1 Hertz
ACCURACY	2% SETTING + (+/- 1 Hertz)

PROTECTIVE CIRCUITS:

SHORT CIRCUIT	Inverter latches off in response to output short. Response time less than 20usec.
CONSTANT CURRENT	Responds to long term overloads by reducing output voltage. Set @ approximately 110% of rated current for range in use. 250mSec approximate response time.

MISCELLANEOUS:

PHYSICAL	Aluminum chassis, 17" W x 22" D x 3.5" H. 45 lbs.
TEMPERATURE RANGE	0 - 50 Degrees Celsius (operating) -10C to +65C (storage)

SECTION1
BL1350 AC POWER SUPPLY INTRODUCTION

BL 1350 SERIES MODEL VARIATIONS

Table 1-1 below lists the various models in this series. Any of the six models may include any combination of the available option listed below the table.

MODEL	INPUT VOLTAGE	OUTPUT VOLTAGE	DUAL RANGE	ISOLATED OUTPUT
BL 1350A-1	115V +/- 10%	0 -135V @ 10A	NO	NO
BL1350B-1	115V +/- 10%	0- 135V @ 10A 0 - 270V @ 5A	YES	NO
BL1350B-2	115V +/- 10%	0- 34V @ 30A 0- 135V @ 10A	YES	NO
BL1350C-1	115V/230V +/-10%	0 -135V @ 10A	NO	YES
BL1350C-2	115V/230V +/-10%	0 -135V @ 10A 0 - 270V @ 5A	YES	YES
BL 1350C-3	115V/230V +/-10%	0 -34V @ 30A 0 - 135V @ 10A	YES	YES

OPTIONS: Add "A" suffix for recessed safety sockets on front panel.
Add "B" suffix for rubber feet used for bench top operation.
Add "E" suffix for extended frequency range of 45 -1000Hz.
Add "G" suffix for front panel circuit breaker guard.
Add " I" suffix for IEEE 488 control interface.
Add "IR" suffix for RS-232 control interface.
Add "J" suffix 100/200Vac (Japan) for C1 - C3 units only.
Add "L" suffix for locking type controls for (VOLTS & FREQ)
Add "S" suffix for rack mount chassis slides.
Add "T" suffix for 0-150V/ 0-300V dual range output (B1, C2).

MODEL # EXAMPLE: B1350C-1- L-S = 115/230V input , single range 0-135 output with slides and locks.

Behlman has produced many "engineering special" units. These will be identified by a four digit suffix at the end of the model number. For info on special units contact Behlman Electronics or send Email to: sales@behlman.

SECTION 2
BL1350 AC POWER SUPPLY UNPACKING AND INSTALLATION

2.1 UNPACKING

After unpacking the equipment, carefully conduct a thorough inspection of all controls, indicators, and chassis. If the unit shows signs of shipping damage, do not attempt to operate. File a damage claim with the responsible carrier. Notify Behlman immediately.

2.2 INSTALLATION

WARNING

This equipment exposes the installer and user to voltage and current levels that can be hazardous if handled improperly. All covers, panels and guards must be in place during operation. Refer all operation, installation and service to qualified personnel only. A copy of the manual must be kept with the equipment and made available to personnel responsible for it's maintenance.

WARNING

This equipment produces AC leakage current that may exceed dangerous levels. **This equipment is supplied with a three-wire AC input that provides for a protective earth connection to the equipment chassis. For operator safety the chassis of the equipment must be connected to the installation site safety earth. The safety earth connection also provides a return path for leakage currents associated with the equipment's internal line filter. Leaving this connection floating is dangerous and my cause electromagnetic interference**.

IMPORTANT USA NEC NOTE:

The output circuit of this series varies depending on the model type. For A and B versions, the input neutral is "carried" through to the output and will meet the NEC section 250 requirement. For C units, the input and output neutrals are isolated. It is permissible to tie the low side output (neutral) of the C type unit to the safety earth. This will allow the power supply to conform to section 250 of the National Electrical Code (NEC). Consultation with a qualified electrician is recommended for permanent installations in buildings or vehicles.

CAUTION

This device is designed to operate in an EIA standard equipment rack. **DO NOT! ATTEMPT TO MOUNT BY RACK "EARS" ONLY.** Rear support must be provided. Support angles are available from most rack manufactures or may be purchase from Behlman. Contact sales@behlman.com.

This equipment is designed to operate in a dry, indoor location which will maintain an air temperature between zero to 50 degrees Celsius around the ventilation ports. If the unit is to be rack mounted, it is recommended that the enclosure be ventilated. The installation should insure that the side and rear vents are unobstructed. Do not operate in the presence of moisture.

SECTION 2
BL1350 AC POWER SUPPLY UNPACKING AND INSTALLATION

2.3 INPUT POWER REQUIREMENTS

This model is supplied with a rear panel mounted terminal block for input and output connections. The Model BL1350 can operate from a wide input voltage range but continuous full power operation requires a “stiff” 120V capable of supplying at least 20A (or 240 @ 10A for C1 & C2 units). These terminal blocks are rated at 30A and require ring lugs for # 6 hardware. Consult with qualified electrician or Behlman if in doubt.

2.4 INPUT WIRING

The figures below illustrate the input wiring connections for the various version of this unit.

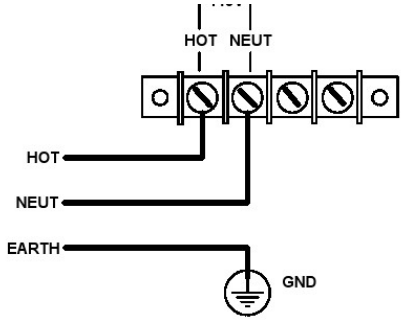


FIGURE 1 INPUT CONECTION FORBL1350A-1, BL1350B-1, & BL1350B-2

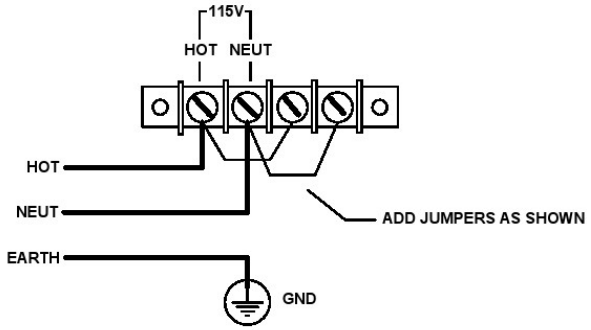


FIGURE 2 INPUT CONECTION FOR BL1350C-1,-2,-3 CONFIGURED FOR 115V

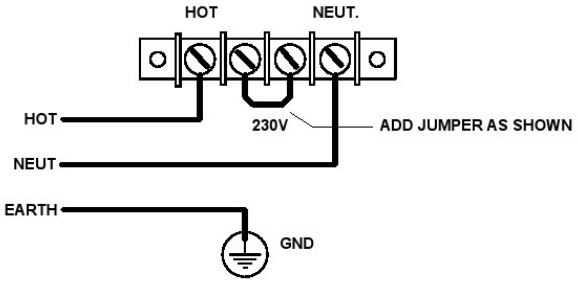


FIGURE 3 INPUT CONECTION FOR BL1350C-1,- 2, -3, CONFIGURED FOR 230V IN

2.4 INPUT WIRING (continued)

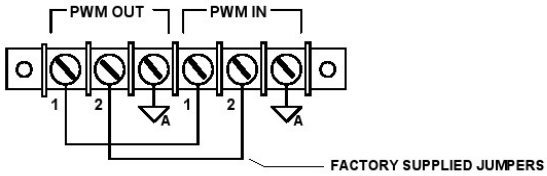
Once the available input voltage has been determined, wire the input to the unit using the appropriate figure from the previous page. The protective earth connection is made to the stud terminal labeled “GND”. This terminal is located on the rear panel just below the AC input terminal block. Size 10 hardware is used. The front panel circuit breaker has a trip rating of 30A. All input wiring should be sized to carry at least 30A. Wiring covers are provided and should be secured to the terminal blocks once wiring has been completed.

2.5 PWM IN/OUT TERMINAL BLOCK

This terminal block is used to export or import drive signals in multiple unit configurations. It is factory pre-wired for standalone operation.

CAUTION

The power supply will not operate if the jumpers are removed from the PWM terminal block. Likewise, improper connection can cause damage to the power supply. Always confirm proper hook-up prior to applying power. The figure below illustrates a stand-alone configuration. See operating instructions for information on connecting multiple units for higher output power. This terminal block uses #6 hardware. Always replace the supplied cover over the PWM terminals to prevent a potential shock hazard or damage to the power supply should a grounded or other point touch one of the PWM terminals.



SINGLE UNIT CONFIGURATION OF PWM SIGNALS

2.6 OUTPUT WIRING.

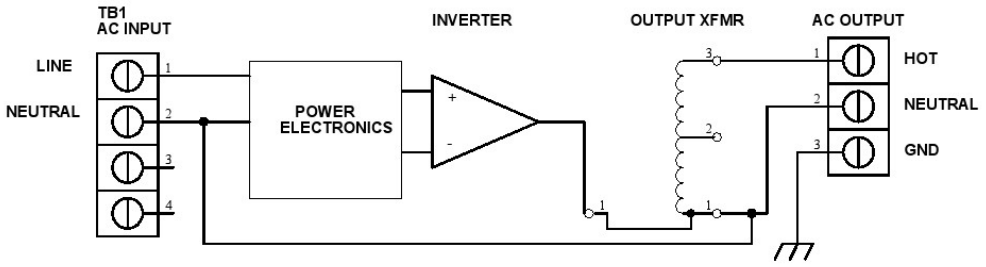
Connect the load to the rear panel mounted AC OUTPUT terminal block. All units have three output terminals. They are labeled “HOT”, NEUT, and GND. For all units except the C1, C2, & C3 versions, the output neutral is tied to the input neutral and is referred to as “carried through”. This must be treated like the neutral in typical US domestic wiring. The GND terminal is tied to the equipment chassis and can be bonded to the load if required.

All “C” versions incorporate an input isolation transformer. This allows the output NEUT terminal to be tied to a reference point other than the input neutral without violating NEC* rules. If desired, the output and input neutral of “C” type units may be tied together. This may be required by some applications. For permanent installations, consultation with an experienced electrician is recommended. It is also permitted to tie the output neutral of any “C” unit to the GND terminal. This will satisfy the requirements of U.S. NEC section 250.

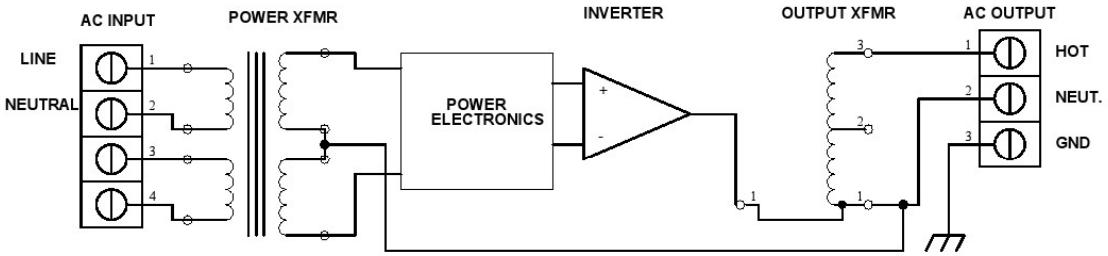
* NEC= National Electrical Code (USA)

2.7 OVERALL WIRING

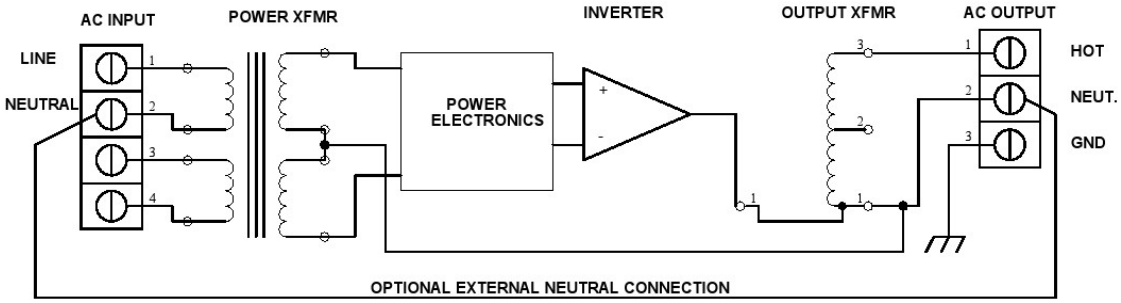
The diagrams below illustrate the wiring difference between the isolated and non-isolated versions of the BL1350 model series.



SIMPLIED BLOCK DIAGRAM FOR BL1350A & B UNITS



SIMPLIED BLOCK DIAGRAM FOR BL1350C-1, -2, -3 UNITS



SIMPLIED BLOCK DIAGRAM FOR BL1350C-1, -2, -3 UNITS
WITH USER PROVIDED CONNECTION TO INPUT NEUTRAL

SECTION 2
BL1350 AC POWER SUPPLY UNPACKING AND INSTALLATION

2.8  WIRING SAFETY CONSDIERATIONS

The models in the BL1350 series produce voltages and currents that are “hazardous live” under normal operating conditions. These hazardous voltages are made available for connection to external devices as determined by the end user. The user is responsible for preventing inadvertent contact with these hazards. If the load requires a protective earth connection, it may be connected back to the chassis of the BL1350 or the GND terminal of the AC output terminal blocks. Note also that the front panel mounted binding posts on most models are not considered “touch proof” and may also pose a shock hazard if access is not limited.

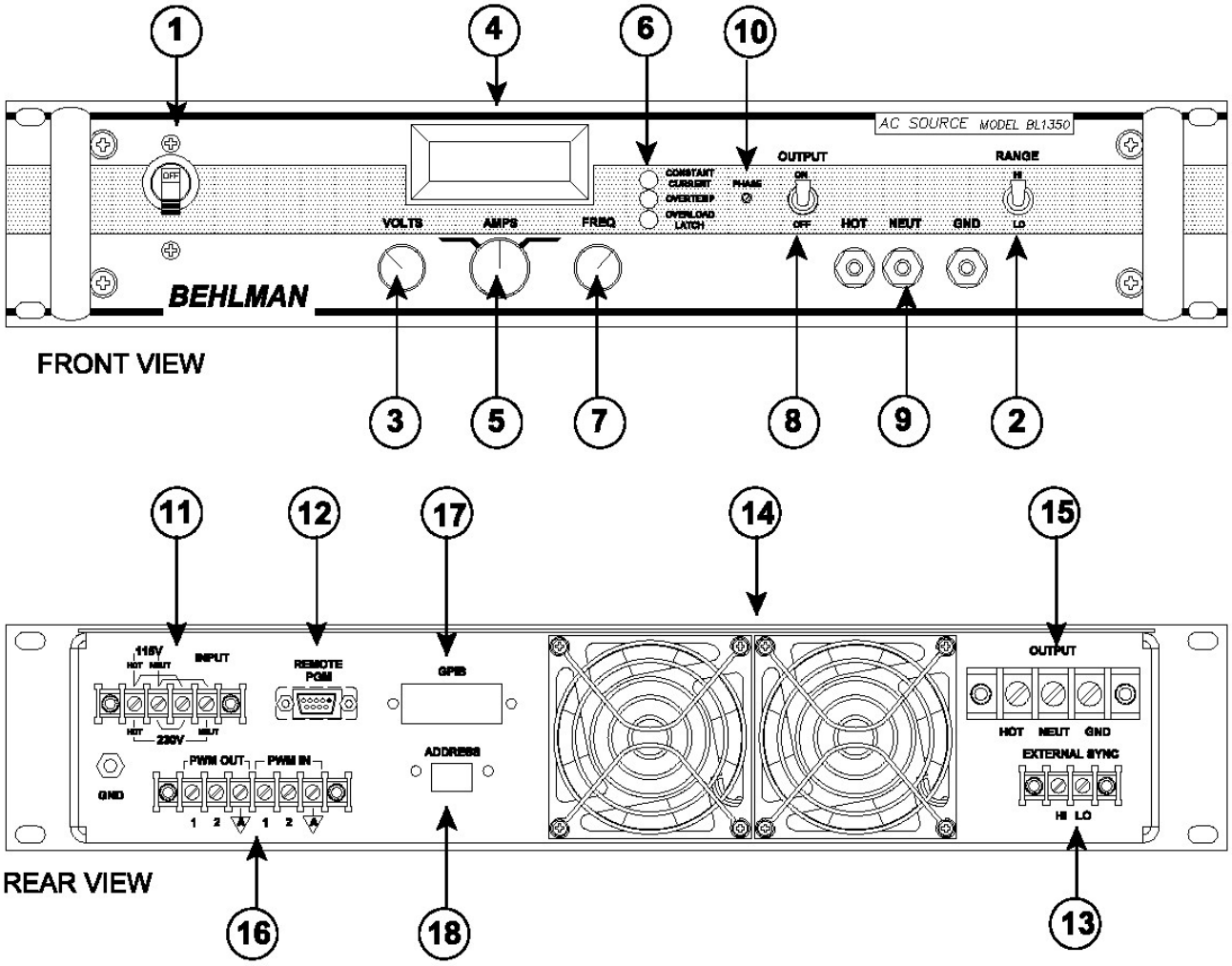
This model series provides remote control functions via the rear panel remote PRGM connector, sync input, or optional RS-232 or IEEE-48 interface. The control circuits are tied to the internal power circuit common. In some instances, this is the same point as the AC Neutral or L2 line connections. These points may also become hazardous live under internal fault conditions. For operator safety, isolation must be provided between these circuits and the external equipment intended for connection and control. Consult with qualified personnel.

SECTION 3
BL1350 AC POWER SUPPLY OPERATING INSTRUCTIONS

WARNING

THIS DEVICE PRODUCES VOLTAGE AND CURRENT LEVELS WHICH ARE HAZARDOUS.
MIS APPLICATION OF THIS DEVICE MAY INTRODUCE ADDITIONAL HAZARDS.
THIS DEVICE IS INTENDED FOR USE BY QUALIFIED PERSONNEL ONLY!

The following section provides descriptions of the various features of the MODEL BL1350 AC power supply front and rear panels. Figure 3-1 below illustrates the various controls and indicators associated with this model.



BL1350 SERIES CONTROLS & INDICATORS

FIGURE 3-1

SECTION 3
BL1350 AC POWER SUPPLY OPERATING INSTRUCTIONS

3.1 CONTROLS AND INDICATORS

Before operating this equipment the user should become familiar with the controls and indicators provided. These are summarized in the table 3-1. Refer to figure 3-1 (previous page) for locations.

TABLE 3-1

ITEM#	DESIGNATION	FUNCTION / DESCRIPTION
1	**POWER** switch	Controls input line power.
2	**RANGE SELECT** switch	Selects output voltage range: HI = 0 -270 Vac Lo = 0-135 Vac
3	**VOLTS** adjust control	Multi-turn control provides continuous adjustment of the unit's output voltage. See item 4.
4	**VOLTS** display	LED readout of the units output voltage ,current , & frequency
5	display **SELEC**T switch	3 position rotary switch used to select which quantity is displayed (volts, amps, or frequency)
6	**OVERLOAD** LED **OVERTEMP** **CONSTANT CURRENT** LED	Indicates unit disabled due to overload (short circuit). Indicates unit is disable due to hi internal temperature. Indicates the unit is in current limit due to overload.
7	**FREQ** adjust control	Multi-turn control provides continuous adjustment of the power supply's output frequency.
8	output **ON/OFF** switch	Switch toggles the power supply output on and off via an internal relay.
9	front panel **OUTPUT**	Recessed "Banana" safety type receptacles provide front panel load connections.
10	**PHASE** adjust	Trim adjust for multi phase unit connections (see section 3)
11	AC input terminals	Connect to input line per section 2 of this manual.
12	Remote control connector	DB type used for analog control (see section 3)
13	Ext Sync input	Provides for connection to external synchronization.
14	Fan exhaust	Heated air is exhausted at the rear of the unit. A minimum clearance of 4 inches is required for proper cooling.
15	**AC OUTPUT** terminals	Used to connect load
16	**PWM IN/OUT**	Used for multiple unit connections. See section 3.
17	GPIB connector	Optional for units with "I" suffix.
18	GPIB ADDRESS SWITCH	Optional for units with "I" suffix. Used to set power supply address for GPIB systems. (OPTIONAL)

SECTION 3
BL1350 AC POWER SUPPLY OPERATING INSTRUCTIONS

3.2 TYPICAL OPERATION.

(NOTE: the items in boldface refer to the actual marking of controls on front and rear panels)

1.) Connect the AC power supply to a suitable source of line power. See operational considerations for further information on input power requirements.

2.) Connect the load or device to be tested to the rear panel output terminals. The load must be connected between the **HOT** and **NEUT** terminals.

3.) Set the **VOLTS** adjust control to minimum (fully CCW) and ensure that the output switch is in the off position.

4.) Turn on the power switch. At this point the sound of the cooling fans should be evident and the front panel **VOLTS** display should indicate zero volts. (000 to 002 is normal)

5.) Set meter **SELECT** switch to read frequency. Use the **FREQ** adjust control to set the desired output frequency.

6.) Set the output range as desired using the output **RANGE** switch. This applies to dual range units only.

7.) Set the **VOLTS** control to provide the desired output voltage and energize the load by pressing the **OUTPUT** switch. It is also permissible to set the **OUTPUT** switch on and then slowly increase the output voltage with the **VOLTS** control. The best procedure to use is load dependent. See section 4 of this manual for additional information.

8.) To monitor the load current, set the meter select switch to **AMPS**. The meter now displays the load current.

The frequency and voltage may now be varied as required by individual testing needs. The load may also be turned on and off using the **OUTPUT** switch, however, certain limitations exist. Certain load types may cause surge currents that may eventually wear out the power supply's output relay or trip output protective circuits. See section 4 for more information.

IMPORTANT !

To prevent damage to the load or power supply the RANGE switch should only be used when the output is off and the VOLTS control is set to zero. This will prevent potentially damaging output transients.

SHUTDOWN PROCEDURE

1.) Set the OUTPUT switch to off (down) to turn off the load.

2.) Set the VOLTS adjust to maximum counter-clockwise.

3.) Set the POWER switch to OFF.

3.3 ANALOG CONTROL VIA REMOTE PRGM CONNECTOR

A nine pin connector, located on the rear panel, enables the user to control the power supply remotely. A mating 9 pin, female "D" connector is required for the user to fabricate interface wiring for this purpose. Once connected, the user may control voltage, frequency, range (optional) and the output on/off functions from a PLC or other circuitry. Table 3-2 lists the pins and functions of this connector. All control lines should be shielded.

TABLE 3-2 **REMOTE PRGM** CONNECTOR PIN ASSIGNMENT

PIN #	PIN NAME	FUNCTION
1	VOLTS CONTROL	0 TO 10 VDC INPUT TO CONTROL "VOLTS"
2	COMMON	0 TO 10 VDC RETURN FOR PIN 1
3	FREQUENCY CONTROL	0 TO 10 VDC INPUT TO CONTROL "FREQ"
4	COMMON	RETURN FOR RANGE & OUTPUT RELAYS
5	RANGE SWTICH	SHORT TO PIN 6 TO SET RANGE HI
6	N/C	
7	N/C	
8	N/C	
9	OUTPUT SWTICH	SHORT TO PIN 4 TO SET OUTPUT ON

WARNING

The common pins of the REMOTE PRGM connector are internally tied to the power circuit common. On some units this point is also tied to the input line neutral reference. See warnings in section 2. All control circuitry must be isolated from the protective earth to avoid potential issues with connecting a grounded point to the neutral. This will prevent a potential shock hazard and possible EMI issues.

Since there is a direct connection to the power circuits, an internal fault could cause these control points to become hazardous live. Safety isolation must be provided externally to conform with various safety standards. Consult Behlman electronics or It's representative for additional information regarding isolation of control circuits.

3.3 ANALOG CONTROL VIA REMOTE PRGM CONNECTOR (continued)

In order for the analog control to function properly, the front panel controls must be set as follows:

VOLTS adjust	=	Fully counter-clockwise
FREQ adjust	=	Fully counter-clockwise
OUTPUT switch	=	off (down)
RANGE switch *	=	low (down)

Note that the setting of the VOLTS and FREQ controls will sum with the remote control inputs. This can be useful for some applications as the remote inputs can modulate the values set by the front panel controls. In addition, the remote controls will not be able to turn the output off (or range to low) if the front panel switches are in the “on” position.

The stability of the power supply output will be affected by the quality of the control signals. If the controls signals are unstable then output voltage and frequency specifications will be degraded. The slew rates of the voltage and frequency control inputs are about 300mSec and are limited by an internal filter.

3.4 MULTIPLE UNIT OPERATION

The BL1350 series of AC power supplies may be connected together to provide either higher single phase output power or mutli-phase outputs. The following section describes these arrangements along with information on limitations and precautions.

PARALLEL OPERATION

Up to 3 BL1350 units can be configured to higher single phase output power. In this arrangement, one unit will operate as a master and additional units become slaves. The master will export it’s drive signals and control signals to the slave units. With this arrangement, each unit can supply about 1100VA for a total of 2.2KVA for two units and 3.3KVA for three units. For this arrangement to work certain conditions must be satisfied.

⚠ CAUTION

The input line to each unit must be from the same source and phase. The line should be able to handle the total input current which will approach 40 amps for two units and 60amps for three units. Operating the units from line sources with dissimilar phase or impedance will greatly affect current sharing and may cause damage to the units if pushed to full power.

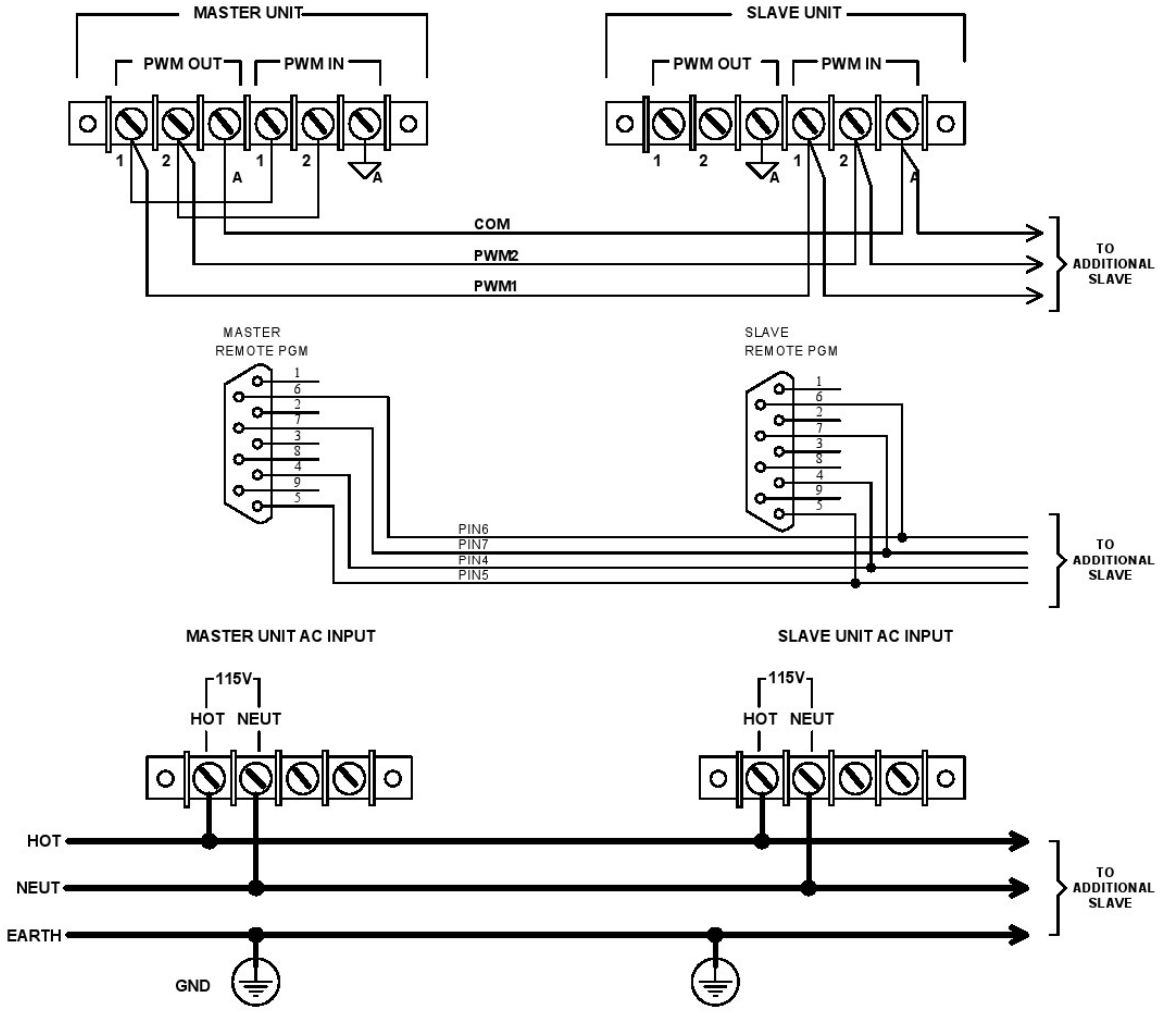
In the parallel arrangement, the power up and shut down sequence must be considered in order to prevent damage to any of the units connected. The master unit must be turned on before the slave units. Also, as shown in figure 3-3, the output of the three units will be wired in parallel. It is important to connect the load through an external relay or switch so that the load may be applied to units at the same time. The load power up sequence should proceed as follows:

1. Turn on the output switch of the master, **slave(s) output switch(es) must be <u>off</u>.**

2. Turn on the load using an external switch or relay.

PARALLEL OPERATION

The figure below illustrates a multiple unit parallel connection**. IMPORTANT,** the PWM in and out wires must be made as short as possible and should never exceed 24" inches. For best performance the units should be stacked one above the other.



PARALLEL CONNECTION OF MODEL BL1350 AC SUPPLY FOR HIGHER POWER

FIGURE 3-3

3.4 MULTIPLE UNIT OPERATION (continued)

Note that when configured for parallel operation, the frequency meters of the slave units will not indicate the output frequency as set by the master. The slave(s) will always be at the same frequency as the master. The frequency display(s) of the slave(s) should be ignored.

POLYPHASE OPERATION

Two or more BL1350 power supply may be interconnected and configured to provide a two or more phase output. In this configuration, one unit becomes the reference or zero phase and the other(s) will be adjusted to lag the master in phase. The frequency of all units will be the same, however, each unit's output voltage can be adjusted independently. Operation in this mode also requires some special considerations**.**

Figure 3-4 on the following page illustrates a typical 3 phase configuration using 3 model BL1350s**.** Note that external resistors are required to limit the voltage and current into the sync inputs. With this configuration, all phases will have the same frequency but may be loaded and adjusted independently. The front panel PHASE adjustment must be used to set the phase angles for phase B and C. To adjust angles follow the procedure below **BEFORE CONNECTING LOADS.**

PHASE ADJUST PROCEDURE (120 degrees typical)

1.) Set all front panel VOLTS adjust controls fully counter clockwise and turn on power to all three units.

2.) Set the OUTPUT switch of all three units to on. Set all three units for 100Vac as displayed on front panel meters. Set the A unit FREQ adjust for the desired frequency.

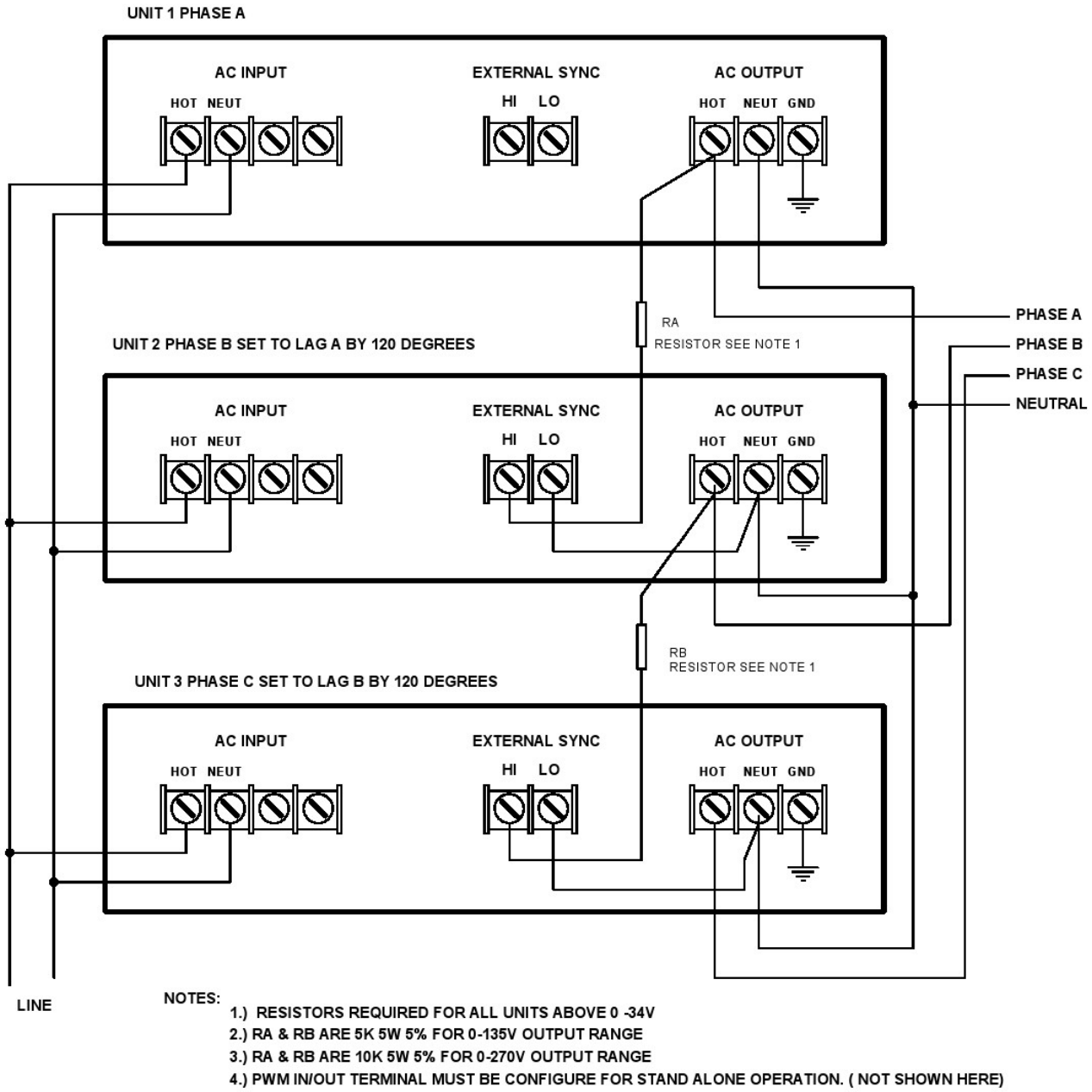
3.) Connect an external DVM set to read AC volts between phases A and B. Note reading and adjust the B unit PHASE control to produce a reading of 173 volts +/- 2 V.

3.) Connect the DVM between phases B and C. Note reading and adjust the C unit PHASE control to produce a reading of 173 volts +/- 2 V.

The information above will set up the units to simulate typical balanced three phase power systems. The phase angles are adjusted by measuring the resulting line to line voltages. Other phase angles between any two units may be set by using the following table or formula.

DVM	**Phase**	$\mathbf{V = [(1-\cos \varphi)\ 20{,}000]^{1/2}}$
(Vrms)	**Angle(°)**	$\mathbf{\varphi = \cos^{-1}\ [1-V^2/20{,}000]}$
81.3	48	where V = Vrms setting on DVM
100.0	60	and φ = phase angle desired
141.4	90	
173.2	120	
190.2	144	

Also note that the outputs must be on for the units to maintain the adjusted angles. For this reason, the loads must be switched on/off by external means. When adjusting the output voltages, keep in mind the phase angles will become un-controlled below the threshold of the external sync input (about 20% of the total).



TYPICAL 3 PHASE CONFIGURATION FOR MODEL BL1350

Figure 3-4 3 Phase configuration

3.5 EXTERNAL SYNC

The unit provides for external synchronization via its rear panel **EXTERNAL SYNC** connector. When an external sync signal is applied to the unit, it reacts to produce an output frequency that is equal to the sync signal regardless of the FREQ control setting. The external sync can be either TTL compatible or an AC signal from 5 to 30 VRMS. Note that a square-wave produces the least amount of phase shift between the sync signal and output of the power source.

⚠ CAUTION

The external sync signal applied to the unit must not be lower than 45 Hz to avoid possible damage to the unit. It is also recommended that load be de-energized and the output voltage of the power supply be set to zero before connecting a sync signal. This will prevent potentially damaging transients from reaching the load.

3.6 OPERATION UNDER FAULT CONDITIONS

The BL1350 series AC source incorporates three levels of over current protection. Long term overload protection is provided by a fold back circuit that reacts to the output RMS current. In the event that the load is outside the range of the power source, the output voltage will decrease or "fold-back" to limit the maximum current. During fold back, the output waveform remains sinusoidal. This can be a useful feature for starting AC induction motors and other types of motion related loads.

In the event that the load becomes short circuited, the amount of fault current could rise to levels high enough to damage the output semiconductors of the power source. The current of the output stage is monitored on a cycle by cycle basis at the 20KHz switching frequency. If the peak current exceeds an unsafe value, a logic signal is sent to the drive circuits and initiates a controlled shutdown of the output stage. This circuit can respond in 20usec. The action of this overload circuit is "latching." The input power must be cycled to reset the power source. Allow at least 20 -30 seconds for the internal soft start circuit to reset. Further information is provided in this manual under operating considerations.

Final protection is provided by a 30 amp magnetic circuit breaker. The breaker is employed primarily to provide line protection in the event of an internal failure of the power source. Repeated tripping of this breaker usually indicates that an internal problem exists.

The amount of in-rush or surge current available from this power supply, (or any electronic type power supply) is limited by the need to protect it's power semiconductors**.** Non-electronic sources such as generators and distribution transformers can usually provide high very short term overloads with little or no danger of failure. Behlman supplies can also provide relatively high inrush currents for as long as 250 mSec. The point at where the protection circuit "kicks in" is dependent on the size of the power semiconductors used. This model uses an IGBT output stage that is capable or about 50A amps for very short durations. This value is not adjustable and will vary from unit to unit and also with ambient temperature and age. If the user experiences frequent tripping of the overload protection circuit it is most likely load related. Section 4 of this manual discusses typical load related problems that may be encountered. This section also suggests various countermeasures that can be used to handle difficult loads.

For help with load related faults, see section 4 of this manual or contact a Behlman representative. Application engineers are available for consultation with our customers.

3.6 OPERATIONAL TROUBLE SHOOTING

This device contains no user serviceable parts. Do not remove covers. Refer all servicing to qualified personnel only.

In the event a problem is encountered with the operation of the AC power supply, refer to the chart below:

Table 3-3

PROBLEM	POSSIBLE CAUSE
No output, meter indicates 000	Adjust **VOLTS** control, check if overload latch LED is on. See section 4.
Load does not operate, unit indicates desired output.	Check that the load is switched on. Check that the load is connected between **HOT** and **NEUT** output terminals vs. **HOT** and **GND**. terminals. See section 2, output wiring info. Check setting of **OUTPUT** switch .See section 3.1, figure 3-1
Output voltage drops when load is connected.	Check load current to insure that the rating of the power supply is not exceeded. This may be indicated by a “blinking” or steady constant current LED.
Output drops to zero when load is connected, Overload LED is on.	Load in-rush or surge current has exceeded the short circuit limit for the power supply. See section 4 for techniques to limit in-rush current.
Output current not indicated.	Check setting of display select switch. Refer to section 3, figure 3-1.
Output frequency not indicated.	Check setting of display select switch. Refer to section 3, figure 3-1.
Output frequency does not change with FREQ control	External sync applied. Control is defective.
Output current changes with frequency setting.	Reactive load impedance, check load characteristics.
Unit is Dead, no display or fan sound. Front panel breaker trips.	Internal defect. Remove unit from use and refer to qualified service personnel or Behlman service dept.

SECTION 4
BL1350 AC POWER SUPPLY OPERATING CONSIDERATIONS

4.0 OPERATIONAL CONSIDERATIONS

4.1 OPERATION INTO LINEAR LOADS

The model BL1350 will provide the best overall performance into a linear load. A linear load is characterized by that fact that its current wave shape is sinusoidal. The phase relationship between the voltage and current may be anything between zero and 90 degrees (leading or lagging). Some examples of linear loads are as follows:

Most AC Motors, Power Transformers, Heating Elements, Resistors, Capacitors, Most Inductors Incandescent Lighting (without dimmers), and most Solenoids

Operation into these types of loads usually causes little interaction with the AC power supply. The main concern with a linear load is the inrush current associated with it. Most heating elements and resistors have little or no inrush concerns and usually do not present any problem for the power source. Inductive and capacitive loads may present a special problem based on their construction and the way in which they are energized. Motors and tungsten filament lamps also present some special “start-up” concerns. The following is intended to give the end user some insight into applying the AC source to these types of loads.

4.2 DRIVING REACTIVE LOADS

Capacitors and inductors are reactive in nature. If the load is applied during the peak of the AC cycle there may be a considerable inrush of current several magnitudes larger than the steady state current. This current is only limited by any series resistance that may be present in the load circuit. Under the right conditions, this could trip the overload protection circuits in the power source. Certain transformers and solenoids (inductance) present the same problem.

Several methods can be used to prevent tripping the protection circuits in the power source. One common method is to insert a limiting impedance in series with the load. This could be a fixed resistor or NTC (negative temperature coefficient) thermistor. Also, zero crossing switching can be employed. The most obvious way to prevent a high in rush current is to apply the load with the voltage set to zero (or some low value) and energize the load slowly by turning up the voltage.

4.3 DRIVING LAMPS

Tungsten filament lamps, when cold, present a very low resistance. Once they are energized, their resistance quickly climbs to a steady state value. This characteristic must be accounted for when driving tungsten filament lamps. The same methods for driving reactive loads can be applied to tungsten.

4.4 DRIVING MOTORS

Driving an AC motor presents a special problem. Most motors require a starting current that is several times higher than the running current. This current may last for a few cycles to several seconds depending on the construction and mechanical load on the motor. This current is sometimes referred to as the motor’s “locked rotor” current. This current is not to be confused with the inrush current that usually occurs over the course of one or two cycles of the AC waveform.

The model BL1350's fold back current limiting can be an advantage when starting motors. During the starting period, the motor will attempt to draw excessive power from the power source. The fold-back circuit will reduce the output voltage in order to maintain the maximum current for the range in use.

4.4 DRIVING MOTORS (continued)

During this time the current supplied to the motor will remain sinusoidal. This action allows the motor to start rotating. Once the motor reaches its normal operating speed, it generates the required "back EMF" and the supply current drops off to the nominal "run" current for the motor. Ramping up the voltage to the motor can reduce the locked rotor current demand. This will allow the AC power supply to start many types of motors with run currents up to 10 Amps.

4.5 DRIVING NON-LINEAR LOADS

Loads utilizing rectifiers and SCRs interact with the AC power source and have a significant affect on the distortion of the output waveform. Consider the use of a bridge rectifier followed by a capacitive filter. The current waveform associated with this circuit is illustrated in figure 4-1. The input current to this type of circuit is drawn in large "gulps" whenever the voltage across the capacitor falls below the peak of the input waveform. This current is limited only by the series impedance present in the wiring and capacitor. The impedance of large electrolytic capacitors is very small.

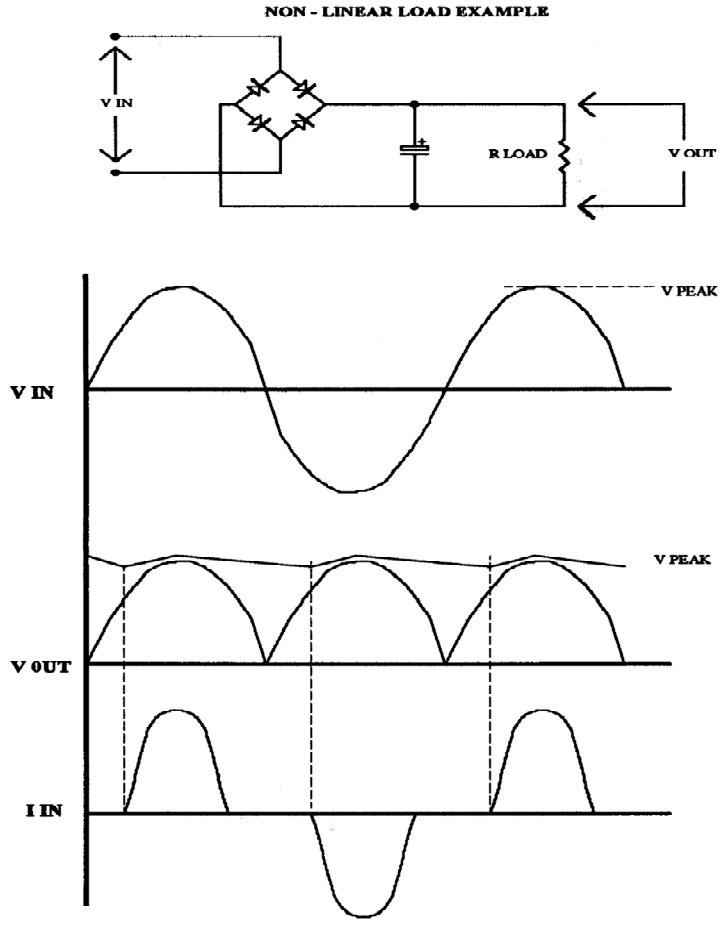


FIGURE 4-1

4.5 DRIVING NON-LINEAR LOADS (continued)

This action causes a current waveform with a peak value that may be several times the RMS value. This ratio of peak current to RMS current is known as “Crest Factor.” High values of crest factor cause distortion of the AC voltage waveform.

The amount of distortion incurred is dependent on many factors and is beyond the scope of this manual. It should be noted that this type of load may cause the output waveform to exhibit “flat-topping”. This effect should not be associated with a defect of the power source. Most “real world” electric distribution systems exhibit this distortion for this reason.

4.6 INPUT POWER REQUIREMENTS

The model BL1350 utilizes a rectifier followed by a bank of filter capacitors. This arrangement presents a nonlinear load to the utility power. Because it’s input current waveform has a high crest factor, it contains a large amount of harmonic current. These harmonic currents do not contribute to the output power but must still be supplied by the input line. This adds up to a poor input power factor.

⚠ CAUTION

When selecting a suitable line input, it must be understood that the input current required for full output power (1350 watts) may exceed 20Amps RMS @ 110V input. This is only true for purely resistive loads (real Watts vs. Volt Amperes). If continuous full power operation is desired, the unit must be supplied from the 20A NEMA type line and receptacle. **Failure to do so may cause overheating of the input line connection**. This may cause a fire hazard. Units supplied from a 220-240V nominal input only require 10A.

Full power operation into a full resistive load may cause loading (sagging) of the supplied line voltage if a large series impedance is present. This is due to the high peak current required by this model. If problems are encountered while trying to achieve full output power, monitor the input line. If the line drops below 110VAC, move the unit to a known “stiff” line.

4.7 OUTPUT NOISE

Because the model BL1350 uses a high frequency PWM conversion technique, a certain amount of output noise or ripple is to be expected. The amount of noise on the output voltage waveform from this unit varies somewhat with the load. Maximum noise levels are present when there is no load applied. In any event, the amount of noise present should not constitute a problem for properly designed equipment. If the devices being tested are disabled by the noise present on the output waveform, then serious consideration should be given to the design of the device being powered as it may not pass typical commercial EMC requirements.

In special cases where the output noise is objectionable, an external line filter can be added to the output of the unit. Please note that most line filters are not intended to be used beyond 63 Hz. If the noise level is interfering with low level measurements, a linear type AC source should be considered. For more information on linear sources, contact Behlman Sales.

SECTION 4
BL1350 AC POWER SUPPLY OPERATING CONSIDERATIONS

BL1350 AC POWER SUPPLY REMOTE CONTROL OPTIONS

The BL1350 series of AC power supplies is available with several remote control options. Behlman also produces modified versions of this unit that may be application specific. These units will be assigned a 4 digit "engineering" number. Any information required for operation will be added to this manual as an addendum. Versions that have extensive physical and operational differences will have dedicated manuals.

REMOTE CONTROL OPTIONS

The model BL1350 series is available with one of three choices of remote control options. Table 4-1 below summaries these options. Only one of these options can be installed in any given model.

TABLE 4-1

OPTION TYPE	INTERFACE	FEATURES
GPIB	REAR PANEL IEEE 488	Computer control of output voltage, frequency, and range read back of voltage, frequency, and current. Status reporting.
RS 232	REAR PANEL 9 PIN "D"	Same as GPIB option
ANALOG REMOTE (included with all standard units)	REAR PANEL 9 PIN "D"	0 to 10 VDC control of frequency and voltage. External control of output relay and range switching via contact closure

Additional information will be included as an appendix to this manual if the unit supplied incorporates either the GPIB or RS-232 options. For more information, contact the Behlman Sales office or local representative or Email questions to sales@behlman.com.

WARNING

This equipment involves the use of voltage and current levels that are hazardous. Only qualified personnel should be allowed to operate or service it. The top cover and terminal block covers must always be in place during operation.

Before performing any adjustment or maintenance where access to the inside of the equipment is required, disconnect the power source and allow at least 5 minutes for internal DC power supply capacitors to discharge before removing covers.

5.1 MAINTENANCE

Failure to maintain or operate the unit properly will void the equipment warranty. Not maintaining the cleanliness of air intakes, operating outside the recommended environment, and physically damaging the unit will be considered abuse. The decision as to whether a units' warranty has been voided will be exclusively reserved for Behlman Electronics.

These units require very little in the way of routine maintenance. A visual inspection should be performed periodically to insure that dust and debris have not accumulated around intake vents and on circuit boards. The inspection interval is dependent on the operating environment. Units operated in areas where dust and particulate matter are present must be inspected more frequently**.**

Units that are found to be contaminated may be cleaned using a vacuum and light brushing. Forced air cleaning is not recommended as the static electricity generated by the high pressure air may damage internal circuit board components. It is recommended to remove the top cover so that all areas may be properly cleaned.

Contamination of outer surfaces should be cleaned with a soft cloth and mild detergent. Most glass cleaners work well for this purpose. **Do not** use liquid cleaners on internal components.

5.2 PERFORMANCE VERIFICATION

When operated within it's limits, this equipment will provide many years of service. Routine adjustment is not required nor recommended. The operating condition of the supply may easily be verified by using the specifications in this manual as guide. The user must then decide which parameters are important for their application and check these accordingly. These units are essentially power sources and not measuring instruments and as such there is limited need for routine calibration. Any recommended calibration cycle is highly dependent on the application and users needs.

An adjustment procedure is provided in this section to allow service personnel to return a defective or repaired unit back to factory specifications. It can also be used to optimize a unit for a specific purpose. This procedure need only be performed when a unit is found to be out of specifications. Do not attempt to adjust any unit if the required test equipment is not available. The accuracy of the external measuring equipment should be a least 4 times better than the specification being verified.

5.3 REQUIRED TEST EQUIPMENT

Table 5-1 lists the test equipment required for the procedure that follows. Although a specific make and model may be listed, substitutions may be made based on the listed minimum specifications.

TABLE 5-1 REQUIRED TEST EQUIPMENT

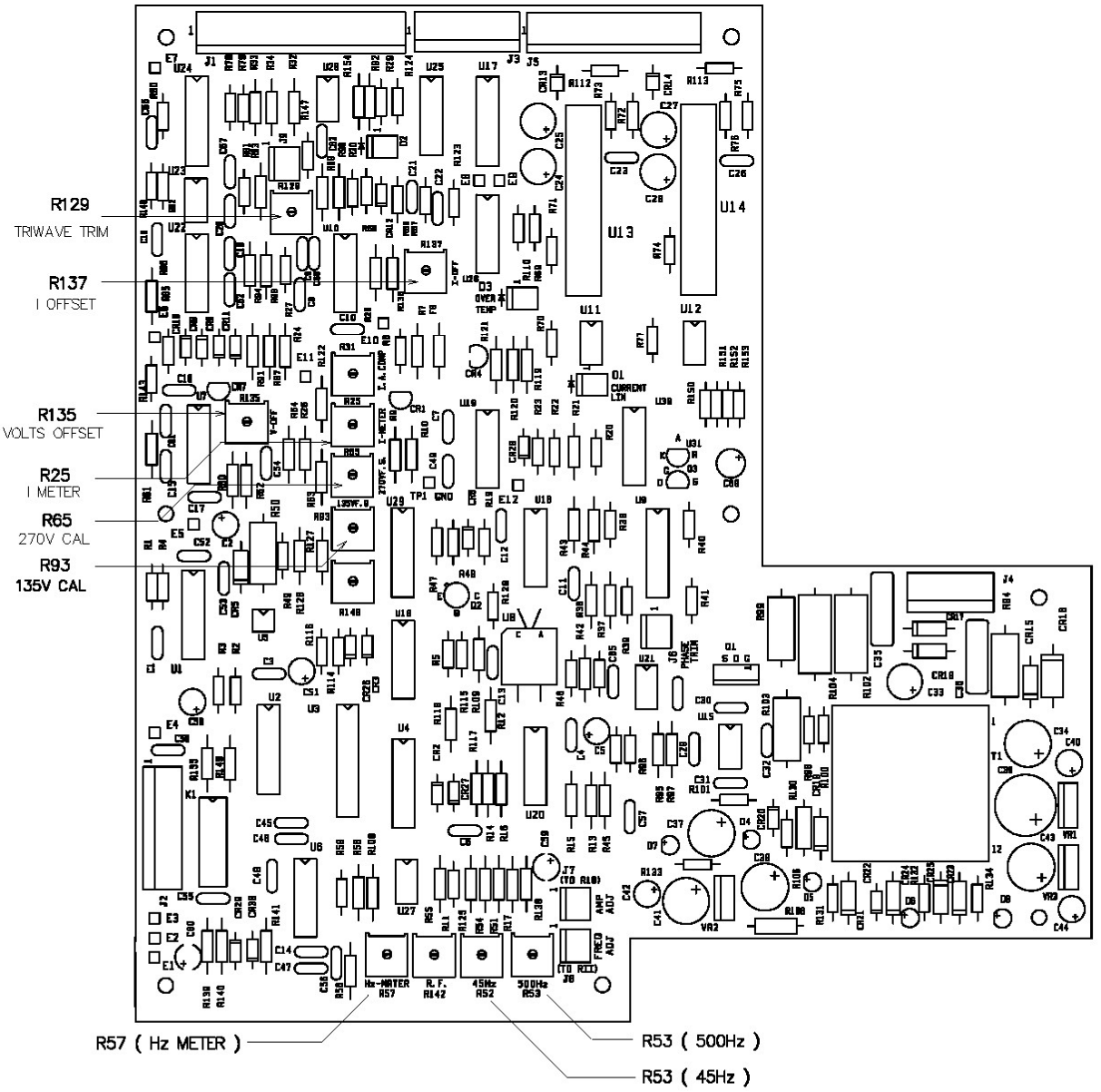
TYPE	SUGGESTED	MINIMUM SPECIFICATIONS
Oscilloscope	Tektronix Model TDS1002 or equivalent	2 channel 20 MHz minimum bandwidth
Digital multi-meter	Fluke model 87	0.5% basic AC accuracy frequency measure function.
Current Meter	Fluke model 87	0.5% @ 10A , 100Hz
Test loads	fabricated	10 ohms 5% @ 1kW min.
Isolation Transformer * optional for A, B, units	any	1:1 ratio at the required line voltage 1kVA
Miscellaneous	any	scope probe and test leads for equipment inter-connections

GENERAL INFORMATION

All potentiometers used in the procedures that follow are located on the A1 controller printed circuit board (P/N 106-685-000). See figure 5-1 on next page for adjustment locations. For the purposes of this procedure the unit being tested will be referred to as the **DUT**.

⚠ CAUTION

Always use a non-metallic screwdriver when adjusting potentiometers. Dangerous voltage levels are present on the control board. All testing and adjustment should be performed at an ambient temperature of 25 degrees Celsius (+/-3). The equipment should be powered up and allowed to stabilize for at least 10 minutes prior to any adjustments or measurements. It the DUT is turned off for any reason during testing, the user must wait about 30 seconds before switching power back on. Failure to wait may cause the input breaker to trip as the soft start circuit will not be reset.



ADJUSTMENT LOCATION BL1350 CONTROL PWA 106-685-00X

FIGURE 5-1 CONTROL BOARD ADJUSTMENT LOCATIONS

5.4 ADJUSTMENT PROCEDURE

Since certain potentiometer adjustments affect other associated potentiometer settings, a sequence of adjustment must be followed. The adjustment for this unit can be broken down into three groups: frequency, voltage, and current. A quick summary of the adjustments are listed in the table below.

ADJUSTMENT SEQUENCES						
SEQ.	FREQUENCY	STEP	VOLTAGE	STEP	CURRENT	STEP
1	R52	5.4.1	R135	5.4.4	R137	5.4.7
2	R53	5.4.2	R93	5.4.5	R25	5.4.8
3	R57	5.4.3	R65	5.4.6		

5.4.1 LOW END FREQUENCY (R52)

1.) With the DUT powered and stabilized, attach the DVM to the output terminals and set it to read frequency.

2.) Set the DUT **FREQ** control fully counter clockwise.

3.) Set the DUT **OUTPUT** switch to on and the DUT meter selector switch to volts.

4.) Adjusts the **VOLTS** control for some value compatible with the DVM.

5.) Note the output frequency and if required, adjust trimmer pot R52 for 45.0 Hz.

5.4.2 HIGH END FREQUENCY ADJUST (R53)

1.) Set the DUT **FREQ** adjust fully clockwise.

2.) Note the output frequency and if required, adjust R53 for 500.0 Hz

5.4.3 FREQUENCY METER ADJUST (R57)

1.) Set the DUT meter select switch to **FREQ**.

2.) With the DUT set for 500.0Hz, note the frequency displayed on the DUT meter. If required, adjust R57 so that the DUT meter displays 500 +/- 1.

5.4.4 VOLTMETER ZERO (R135)

1.) Set the DUT **VOLTS** adjust completely counter clockwise and set **OUTPUT** switch to on.

2.) Set the DVM connected to the output to read AC volts.

3.) Adjust R135 so that the DVM indicates zero volts.

4.) Set the DUT meter select switch to **VOLTS**, and confirm a DUT display of 000 +/- 2.

5.4.5 LOW RANGE VOLTMETER ADJUST (R93)

1.) Ensure the DUT **RANGE** switch is set to low (dual range units only).

2.) Set the DUT **VOLTS & FREQ** controls to produce a full scale output (135V typical) @100Hz. Note the DVM reading.

3.) If required, Adjust R93 so that DUT display agrees with the DVM reading.

5.4.6 HIGH RANGE VOLTMETER ADJUST (R65)

1.) Set the DUT **RANGE** switch to high (dual range units only)

2.) Set the DUT **VOLTS** control to produce a full scale output (270V typical). Note the DVM reading.

3.) If required, Adjust R65 so that DUT display agrees with the DVM reading.

5.4.7 CURRENT METER ZERO ADJUST (R137)

1.) Ensure that no load is connected and the output switch is on.

2.) Set the DUT **VOLTS** control to zero and the meter select switch to **AMPS**.

3.) If required, adjust R137 so that the DUT current display is 00.0 +/- 0.2

5.4.8 CURRENT METER FULL SCALE ADJUST (R25)

1.) With to DUT power off, connect the 10 ohm test load and DVM set to read current to the front or rear output terminals.

2.) Set the **OUTPUT** switch off and the **VOLTS** control fully counter-clockwise.

3.) Turn on the DUT.

4.) Set the **OUTPUT** switch on and adjust the **VOLTS** control to provide 10.0 amps as measured on the external DVM.

5.) If required, adjust R25 so that the DUT display agrees with the DVM +/- 0.1A.

6.) Remove DVM from output circuit for the remainder of the procedure.

5.4.9 OUTPUT RIPPLE CANCELLATION (R129)

1.) With the 10 ohm load connected, connect one channel of the oscilloscope to the output terminals of the DUT. Note, for A and B type units, an isolation transformer must be used on the DUT input. Failure to so will cause the oscilloscope ground to be connected to the input neutral. This may cause an unsafe condition. If isolation is not possible a differential probe or battery powered oscilloscope must be used. C type units are internal isolated from neutral.

2.) Set the DUT **VOLTS** controls for zero output and set the **OUTPUT** switch on.

3.) Note the peak to peak value of the output noise. Adjust R129 for the smallest amplitude. This will occur at some “null” point. This R129 sets the switching frequency of the PWM modulator.

5.4.10 EXTERNAL SYNC AND PHASE ADJUST CHECK (optional function test)

1.) Disconnect test equipment from previous steps.

2.) Connect and external square wave source between 5 and 30V peak to the **EXTERNAL SYNC** input on the rear panel of the DUT. Set the square wave frequency to 100Hz.

3.) Use a Tee connector to send the square wave to the oscilloscope trigger input. Set the scope for external trigger.

4.) Connect one channel of the scope to the output of the DUT See step 5.4.9 for notes on connecting the scope.

5.) Turn on the DUT and adjust the output so that one or more cycles of the output wave form are visible on the scope display.

6.) Confirm the following:

A.) The scope display is locked indicating the DUT is in sync with the square wave applied to the sync terminals.

B.) Adjusting the DUT **PHASE** trimmer causes the output phase relationship to vary.

C.) The output frequency matches the sync input (square wave). Note that in this mode the frequency display is inactive and will not change with the applied sync signal.

7.) The above check verifies that the units will work with others in a poly phase arrangement as described in section 3 of this manual.

5.4.11 ADDITIONAL TESTS

Once the adjustment procedure has been performed, additional testing at the end users operating conditions can be verified using the published specifications as a guide. It is also possible to optimize these specifications at a given voltage, current, or frequency using this procedure as a reference. This decision is dependent on individual needs.

SECTION 6
BL1350 AC POWER SUPPLY THEORY OF OPERATION

6.1 GENERAL

The BL1350 series (unit) represent a family of AC to AC power sources that provide performance advantages not realized with older linear type designs. These units use state of the art IGBT technology to provide efficient power conversion in a small package. These models convert the incoming AC input to DC operating voltages. These voltages in turn supply a Class “D” type output amplifier to “reconstruct” an AC output with variable voltage and frequency. The addition of a sine wave oscillator, matching transformer and metering circuitry provide a complete AC power system. Figure 6-1 provides a block diagram of this system.

6.2 OVERALL THEORY

The applied input voltage is rectified and filtered by a full wave doubler circuit consisting of CR1 and the A4 capacitor board (106-711-000). Units with a “C” suffix also incorporate a dual primary isolation transformer ahead of the rectifier. The later allows operation at either 115 or 230 volts inputs. The rectifier circuit provides unregulated, dual polarity outputs of +/- 160Vdc. A differential inductor provides additional filtering and improves the input power factor. A line filter is provided on non-isolated units to limit the conduction of electro-magnetic interference onto the AC power lines.

A soft start circuit is employed to limit the amount of surge or in-rush current at power on. This is required due the nature of capacitive filter rectification. At turn on, these capacitors represent a very low impedance to the input voltage and could trip the front panel breaker. To prevent this a power resistor is placed in series with the cap bank. The resistor is than bypassed with a relay once the cap bank is charged. This circuitry is part of the A4 cap board (106-711-000).

The +/-160Vdc supplies are applied to a class “D” type switching power amplifier. This amplifier is supplied with a sine wave reference signal at the desired output frequency. The pulse width modulation (PWM) scheme used by the amplifier creates rectangular pulses with a peak to peak to amplitude of about 320 V and repetition rate of 20 KHz. The duty cycle of the pulse ranges from 2% to 92 % in response to the applied sine wave. This pulse train is applied to a two stage low pass filter that strips the 20KHz “carrier” and leaves an amplified version of the original modulating signal (sine wave). The amplifier develops about 90Vrms which is applied to a step up transformer to provide either a 135 or 270 volt AC output.

6.3 REFERENCE OSCILLATOR

The reference oscillator produces a digitally derived sine wave of which the amplitude and frequency are controlled by DC levels set by the front panel VOLTS and FREQ controls. The FREQ control voltage is applied to U6, an integrated circuit voltage controlled oscillator (VCO). This IC produces a square wave clock signal at the desired output frequency.

The clock developed by the VCO is applied to a phase lock loop (PLL) circuit formed by an 8 bit counter, a sine PROM, and a multiplying D to A converter (U1, U2, U3 , & U4). The PLL multiplies the clock by 256 . The output of the counter is applied to the PROM address lines. The data outputs from the PROM are applied to the digital to analog convertor (DAC) U4. This action will produce a DAC output that contains 256 voltage levels that approximate a sine function. Additional filtering provides a clean sine wave output to drive the power amplifier.

The PLL circuit allows the oscillator to be locked to an external synchronization signal. When applied, the external signal will override the internal clock and become the reference input to the PLL. The output frequency of the oscillator will now track the external input. The external signal can be either TTL compatible or a sine wave from 5 to 30Vrms.

6.3 REFERENCE OSCILLATOR (continued)

The reference oscillator also contains a unique phase control circuit. This circuit is used to adjust the relative phase of the output with respect to the external sync input. This allows multiple units to be configured in a poly phase arrangement with adjustable phase angles (see section 3). The phase shift is accomplished by the phase control circuits formed by U8, U9, U16, U21 and associated components. The sine wave from the MDAC is applied to an all pass network the produces a phase shift that is constant with frequency. U9 is configured as a phase detector. The output of the detector is proportionate to the phase shift in the circuit and provides feedback to keep the phase constant by varying the resistance of U8.

6.4 VOLTAGE CONTROL LOOP

There are essentially two feedback loops used to provide a low distortion regulated AC output voltage. The inner loop is part of the power amplifier and provides feedback before the amplifiers' output filter. This loop corrects for non-linear switching effects inherent in this type of amplifier. The second or "outer" loop is closed at the output of the step-up transformer and is use to regulate the RMS value of the output voltage.

A scaled down sample of the output voltage is applied to an integrated circuit RMS to DC converter U7. The DC output of U7 is summed with the reference voltage to produce an error signal. The error is integrated by U20 and applied to the MDAC reference input. The output of the MDAC will change to maintain the value set by the reference voltage (VOLTS pot). This secondary loop is slower than the inner loop due to the nature of the RMS to DC converter. To maintain stability, this circuit must have a longer time constant than the lowest output frequency period. Response time is about 250mSec.

An additional feedback loop is used to provide long term over current protection for the unit. A sample of the output current is sent to the control board RMS to DC converter U10. The output of U10 is sent to the front panel meter for display. This same signal is also applied to a comparator through reference diode CR4. Once the DC voltage at CR4 exceeds 2.5V, the output of U19 will rise and subtract from the voltage regulation reference. This action will reduce the output voltage thereby maintaining the current at the limit point. The voltage will remain sinusoidal. Increasing the load at this point will cause the output voltage to reduce further to maintain a constant current. This will continue until the overload is removed.

6.5 METERING

A three digit panel meter is provided to measure output current, voltage, and frequency. The signals for the metering circuit are supplied by the A1 control board. RMS to DC converter U7 & U10 provide scaled down DC levels proportionate to the RMS values of the output voltage and current. The Frequency display is provided by reading the voltage set by the frequency pot. The display is scaled so that 1mV is equal to 1 Hz. These three signals are applied to the meter via the front panel selector switch.

6.6 HOUSEKEEPING SUPPLY

All operating voltages for the control board are supplied by an on board, flyback based, dc to dc converter. This supply operates from the raw +160VDC supply rail and provides multiple regulated outputs. This circuit consists of U15, Q1, T1, and associated components. U15 provides all control and current limit functions. T1 provides multiple rectified outputs.

6.7 POWER AMPLIFIER

The power amplifier is based on hard switched IGBT technology and is typically referred to as class "D". In this arrangement, a high frequency pulse train is developed and modulated by the sine wave. The resulting wave form is filtered to produce the low frequency AC output from 45Hz to 500Hz.

All control and logic signals for the power amplifier are developed on the A1 board (106-685-000). The PWM modulator is comprised of U22, U23, U24, and hybrid drivers U13 and U14. U22 is a quad operational amplifier and is split into two functions. Sections B & C form the 20KHz triangle wave generator. This circuit sets the PWM frequency and is applied to one input of both comparators. The comparator outputs will transition whenever the modulation signal exceeds the peak value of the triwave. This action creates a pulse train that's duty cycle is proportionate to the modulating signal. This PWM method is sometimes referred to as "Sine / Triangle Intercept" . The output of this circuit is referred to as "sine weighted"

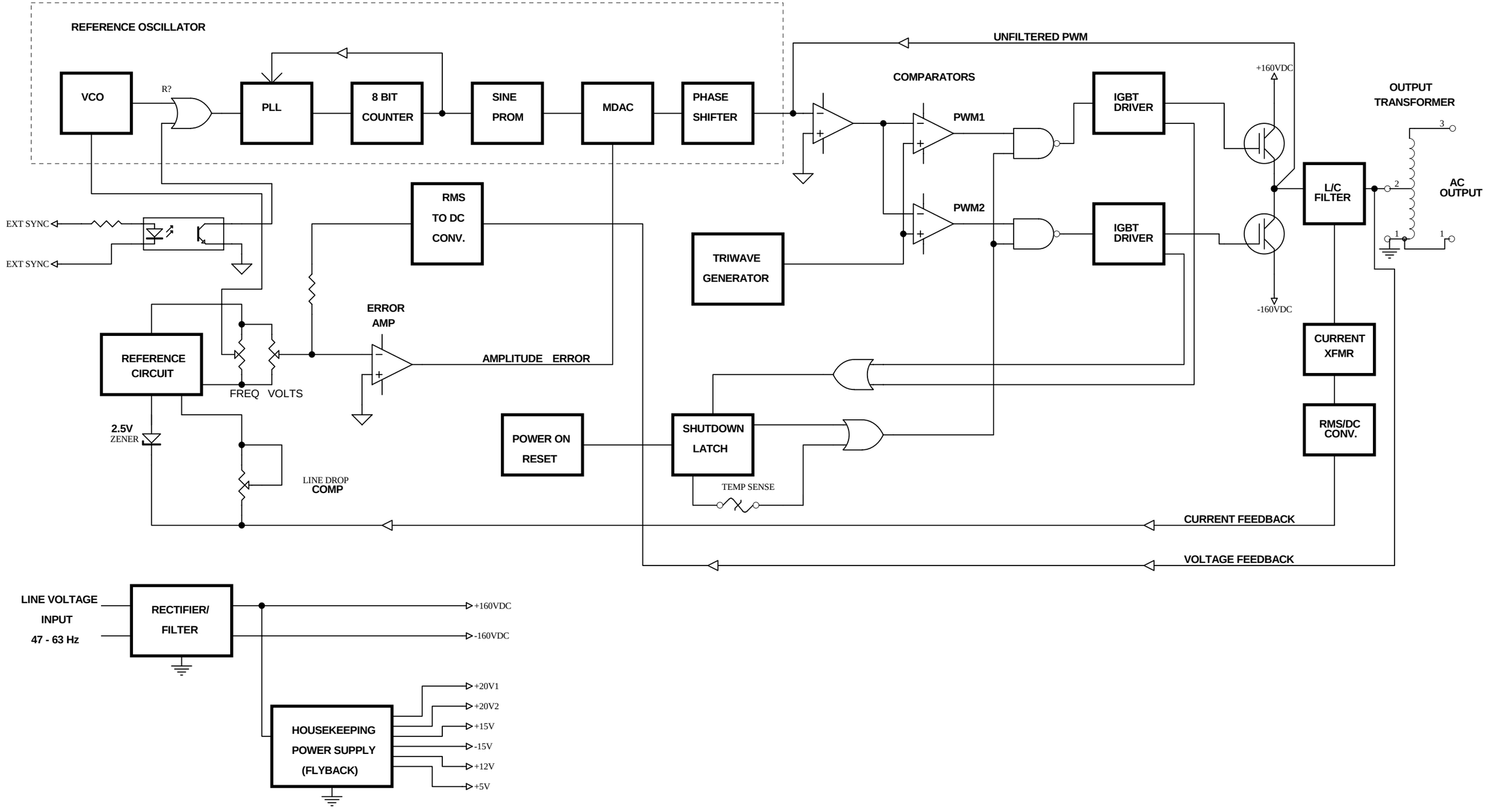
The sine weighted pulse train passes through inverting buffers U24 sections A - D and is brought out to PWM in-out connector for use in multiple unit parallel configurations (see section 3). For standalone operation the signals are routed via gates U25 C & D and buffers U17 to the hybrid driver inputs. The drivers provide the isolation and level translation required to the drive the IGBT power module.

The IGBT module used here is a half bridge type consisting of two large 50A, 600V IGBTs packaged with two anti-parallel diodes. The diodes are rated to be operated as commutation switches for this application. The IGBTs are connected between the +/-160Vdc rails and are alternately switched to provide a 320V peak to peak pulse train. When the output voltage of the power supply is set to zero, the pulses will be 50% negative and 50% positive. The result is a cancellation that provides a net output of zero volts when filtered. On the positive going portion of the input sine wave, the IGBT connected to +rail will be turned on with an increasing duty cycle. At the same time the lower IGBT is conducting with a decreasing duty cycle. This action creates an output with a net positive value. The reverse action happens when the modulating sine wave goes negative. At this time the IGBT connected to lower rail receives an increasing duty cycle while the upper IGBT duty cycle is reduced. This switching action, once filtered, produces an amplified version of the modulating signal (sine wave).

Short circuit protection for the power amplifier is provided by the hybrid IGBT drivers U13 & U14. These devices monitor the collector to emitter voltage (VCE) of each transistor. When an output short circuit occurs, the VCE voltage will rise rapidly. This rise in voltage or de-saturation of the IGBT is sensed and triggers a one-shot circuit in the driver IC. The circuit will produce a "fault" pulse of about 2mSec. The fault signal is sent via opto-couplers U11 or U12 to the drive logic on the control board. A latch circuit formed by U25 and U26 will respond to this signal and turn off the IGBT drives. The input power must be cycled to reset the latch. During an overload event, the front panel overload LED will be illuminated.

6.8 OUTPUT FILTER ASSEMBLY 106-714-00X

Output filtering as well as the output on/off function and optional range selection are handled by the power filter assembly p/n 106-714-00x. A two stage L/C filter and a 20KHz series resonant "trap" remove the 20KHz carrier from the output waveform. The filtered signal is applied to the output transformer and routed back to the filter board for application to the output and range relays. A current transformer and voltage divider located on this assembly provide feedback signals to the control board.



SYSTEM BLOCK DIAGRAM BL1350 SEIRES AC POWER SUPPLY

SECTION 7
DRAWINGS

TABLE 1 BL1350 CROSS REFERENCE LIST

MODEL	INPUT VOLTAGE (AC)	OUTPUT VOLTAGE (AC)	DUAL RANGE	ISOLATED OUTOUT	TOP ASSY	NOTE	BASEPLATE ASSY	NOTE	POWER PWB ASSY	NOTE	FRONT PANE'. ASSY	NOTE
BL1350A–1	115V	0–135V			106–676–101		106–692–101	T2 SMALL AUTO XFMR 106–733–000	106–714–000		106–691–001	NO RANGE SW2
BL1350B–1	115V	0–135V 0–270V	√		106–676–201		106–692–201	T2 LARGE AUTO XFMR 106–689–000	106–714–000		106–691–000	
BL1350B–2	115V	0–34V 0–135V	√		106–676–202	ADD RELAYS TO LEFT SIDE PNL	106–692–202	T2 LARGE AUTO XFMR 106–686–000	106–714–001	NO RELAYS	106–691–000	
BL1350C–1	115V/230V	0–135V		√	106–676–301		106–692–301	T2 SMALL AUTO XFMR T1 INPUT (NO FL1)	106–714–000		106–691–003	NO RANGE SW2
BL1350C–2	115V/230V	0–135V 0–270V	√	√	106–676–302		106–692–302	T2 LARGE AUTO XFMR T1 INPUT (NO FL1)	106–714–000		106–691–002	
BL1350C–3	115V/230V	0–34V 0–135V	√	√	106–676–303	ADD RELAYS TO LEFT SIDE PNL	106–692–303	T2 LARGE AUTO XFMR T1 INPUT (NO FL1)	106–714–001	NO RELAYS	106–691–002	

OPTIONS: ADD E FOR EXTENDED FREQUENCY RANGE.
ADD L FOR FRONT PANEL LOCKING CONTROLS (VOLTS, FREQ) ON VOLTAGE AND FREQUENCY. (106–425–000)
ADD S FOR CHASSIS SLIDES (106–690–000).
ADD R FOR RUBBER FEET (106–723–000).
ADD A FOR FRONT PANEL SAFETY SOCKETS (106–725–00X).
ADD I FOR IEEE KIT (107–005–000).
ADD P FOR 4:1 CURRENT CREST FACTOR.
ADD J FOR 100V/200VAC INPUT (C–1,C–2,C–3),(107–074–000 INPUT XFMR).
ADD T FOR 150V/300V OUTPUT (107–073–000 AUTO XFMR).
ADD G FOR CIRCUIT BREAKER GUARD (107–073–000 OUTPUT XFMR).
ADD MT FOR MOTOR TESTER.

TABLE 2 CUSTOMER INPUT DIAGRAM

INPUT VOLTAGE	CUSTOMER HOOKUP (ISOLATED OUTPUT 106–676–301, 302, 303)	CUSTOMER HOOKUP (106–676–101,201,202)
115V	TB1 115V INPUT HOT NEUT GND 1 2 3 4	TB1 115V INPUT HOT NEUT GND 1 2 3 4
230V	TB1 INPUT 1 2 3 4 GND HOT 230V NEUT	

REV STATUS OF SHT	
SHT	REV

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	–	RELEASED FOR PROTOTYPE		
	A	REVISED PER ECO 92–094	92–10–09	DKM
	B	REVISED PER ECO 93–034	3/1/93	G.Z.
	C	REVISED PER ECO 93–053	4/23/93	G Z
	D	REVISED PER ECO 93–063	93-6-11	DKM
	E	REVISED PER ECO 96 064	96	

43	A3E21	K1–B (LEFT SIDE PNL)	–202,–303 (34V)	
42	A3E20	K1–7 (LEFT SIDE PNL)	–202,–303 (34V)	
41	A3E19	K1–6 (LEFT SIDE PNL)	–202,–303 (34V)	
40	A3E18	K1–4 (LEFT SIDE PNL)	–202,–303 (34V)	
39	A3E17	K2–9 (LEFT SIDE PNL)	–202,–303 (34V)	
38	A3E16	K2–B (LEFT SIDE PNL)	–202,–303 (34V)	
37	R11P2 (FNT PNL)	A1J8 (CNT BD)	FREQ ADJ	
36	R18P1 (FNT PNL)	A1J7 (CNT BD)	AMPTD ADJ	
35	CHAS GND (REAR PNL)	CHAS GND STUD (BASEPLATE)	⏚	
34	W2P1 (FNT PNL)	A1J2 (CTRL BD)	METER	W2 106–802–000
33	W6P1	A1J1–9–12	REMOTE PRGM	W6 106–858–000
32	W7P1	A5J1 (FNT PNL PWA)		
31	W7P3	A1J9 (CTRL BD)	I SENSE	
30	W7P2	A1J6	PHASE	W7 107–098–000
29	W7P5	A1D3 (CTRL BD)	OVERTEMP	
28	W7P4	A1D2 (CTRL BD)	OVLD LATCH	
27	W7P6	A1D1 (CTRL BD)	CONST CURR	
26	---	A3J3–1,2	N, +12V	
25	B2P1 (REAR PNL)	A3J3–3,4	N, +12V	
24	B1P1 (REAR PNL)	A3J3–5,6	N, +12V	
23	W5E8 BLU	A3E1	–	
22	W5E7 RED	A3E3	–	
21	W5E6 GRN	A4Q1–B2 (IGBT TAB)	GATE–2	
20	W5E5 VIO	A4Q1–E2 (IGBT TAB)	SOURCE–2	
19	W5E4 BLU	A4Q1–C2E1 (IGBT STUD)	DRAIN–2	W5 106–805–000
18	W5E3 YEL	A4Q1–B1 (IGBT TAB)	GATE–1	
17	W5E2 ORG	A4Q1–E1 (IGBT TAB)	SOURCE–1	
16	W5E1 RED	A4Q1–C1 (IGBT STUD)	DRAIN–1	
15	W5P1	A1J5–3–10 (CTRL BD)	–	
14	W4P3	A2J1 (CAP BD)	N, +150V	
13	W4P2	A3J2 (PWR BD)	N, +12V	W4 106–804–000
12	W4P1	A1J4–2–5 (CTRL BD)	–	
11	W3P2	A3J1 (PWR BD)	FEEDBACK, SCALEDOWN	W3 106–803–000
10	W3P1	A1J3 (CTRL BD)	FEEDBACK, SCALEDOWN	
9	W1E8 GRN	TB2–4 (REAR PNL)	PWM IN 1	
8	W1E7 VIO	TB2–5 (REAR PNL)	PWM IN 2	
7	W1E6 BLU	TB2–3 (REAR PNL)	⏚	
6	W1E5 GRN	TB4–1 (REAR PNL)	EXTL SYNC HI	
5	W1E4 YEL	TB4–2 (REAR PNL)	EXTL SYNC LO	
4	W1E3 ORG	TB2–2 (REAR PNL)	PWM OUT 2	
3	W1E2 RED	TB2–6 (REAR PNL)	⏚	
2	W1E1 BRN	TB2–1 (REAR PNL)	PWM OUT 1	
1	W1P1	A1J1–1–8 (CTRL BD)	–	W1 106–801–000
REF	A4P1	A1J5–1,2	S1	
REF	A3P1	A1J3–5,6	I SENSE	
CONN NO.	FROM	TO	FUNCTION	

INTERCONNECTION SCHEDULE

60	CR1–	33	C6–B	–	–	–	•	
59	CR1+	33	C6–A	–	–	–	•	
58	CR1–AC–1	29	CR1–AC–2	29	14	–	–101,–201,–202	BLK
57	CB1–4	29	T1–4	33	14	–	–301,–302,–303	BLK
56	TB1–4	28	CB1–3	29	14	–	–301,–302,–303	WHT
55	CB1–2	29	T1–1	29	14	–	–301,–302,–303	BLK
54	TB1–1	28	CB1–1	29	14	–	–301,–302,–303	BLK
53	K2–7 (LEFT SIDE PNL)	29	K1–9 (LEFT SIDE PNL)	29	10	–	–202,–303 (34V)	BLK
52	K2–6 (LEFT SIDE PNL)	29	TB3–2 (REAR PNL)	32	10	N OUT	–202,–303 (34V)	
51	K2–4 (LEFT SIDE PNL)	29	TB3–1 (REAR PNL)	32	10	HOT OUT	–202,–303 (34V)	
50	K2–A (LEFT SIDE PNL)	30	SW1A (FNT PNL)	30	22	OUTPUT	–202,–303 (34V)	BLK
49	K1–1 (LEFT SIDE)	29	T2–4	29	10	135V	–202,–303 (34V)	YEL
48	K1–3 (LEFT SIDE PNL)	29	K1–1	29	18	135V	–202,–303 (34V)	BLK
47	K1–A (LEFT SIDE PNL)	30	SW2A (FNT PNL)	30	22	RANGE	–202,–303 (34V)	YEL
46	T1–7	29	CR1–AC–1	29	14	–	–301,–302,–303	BLK
45	A2E5	29	A3E11	29	14	N	–301,–302,–303	WHT
44	T1–6	33	A2E6	29	14	N	–301,–302,–303	WHT
43	T1–5	29	CR1–AC–2	29	14	–	–301,–302,–303	BLK
42	TB3–3	28	CHAS GND STUD	31	14	⏚	•	GRN
41	T1–3	29	TB1–3 (REAR PNL)	28	14	–	–301,–302,–303	W/G
40	T1–2	29	TB1–2 (REAR PNL)	28	14	–	–301,–302,–303	W/B
39	A2E4	29	A2E7	29	14	–	–301,–302,–303	BLU
38	CR1 –	29	L1–3	29	14	–	•	VIO
37	CR1 +	33	L1–1	29	14	–	•	RED
36	CR1–AC–1	33	FL1–3	34	14	+V OUT	–101,–201,–202	BLK
35	1P3 (FNT PNL GND)	31	CHAS GND STUD	31	14	⏚	•	GRN
34	FL1–⏚	34	CHAS GND STUD	31	14	⏚	–101,–201,–202	GRN
33	TB1–2 (REAR PNL)	28	FL1–2	34	14	NEUT IN	–101 –201,202	WHT
32	TB1–1 (REAR PNL)	28	CB1–LOAD	29	14	HOT IN	–101,–201,–202	BLK
31	W2E1 YEL	–	SW2A (FNT PNL)	30	–	RANGE HI	–201,–202, –302,–303	
30	W6E1 YEL	–	SW2A (FNT PNL)	30	–	RANGE HI	–201,–202, –302,–303	
29	W6E2 WHT	–	SW2B (FNT PNL)	30	–	N	–201,–202, –302,–303	
28	A3E6	29	SW2A (FNT PNL)	30	22	RANGE HI	–201,–302	YEL
27	SW2B (FRNT PNL)	30	SW1B (FNT PNL)	30	22	N	–201,–202,–302,–303	WHT
26	T2–3	33	SW1B (FNT PNL)	30	22	N	•	WHT
25	A3E7	29	SW1A (FNT PNL)	30	22	OUTPUT ON	–101,–201,–301,–302	YEL
24	C3–B (REAR PNL)	–	TB3–2 (REAR PNL)	–	–	–	•	REF
23	C3–A (REAR PNL)	–	TB3–1 (REAR PNL)	–	–	–	•	
22	A5E1 (FNT PNL PWA)	–	SW2A (FNT PNL)	–	20	–	•	YEL
21	A5E2 (FNT PNL PWA)	–	SW1B (FNT PNL)	–	20	–	•	WHT
20	TB3–1 (REAR PNL)	35	TP1 (FNT PNL RED)	35	14	HOTOUT	•	BLK
19	TB3–2 (REAR PNL)	35	TP2 (FNT PNL WHT)	35	14	NOUT	•	WHT
18	T2–3	33	T2–1	33	14	N	•	WHT
17	A2E5	29	FL1–4	34	14	N	–101,–201,–202	WHT
16	A3E11	29	FL1–4	34	14	N	–101,–201,–202	WHT
15	A3E11	29	T2–1	33	14	N	•	WHT
14	A3E10	29	T2–2	29	14	+	•	BLK
13	A3E9	29	TB3–1 (REAR PNL)	35	14	HOT OUT	–101,–201,–302,–301	BLK
12	A3E8	29	TB3–2 (REAR PNL)	35	14	N OUT	–101,–201,–302,–301	WHT
11	A3E5	29	T2–4	29	14	135V	–101,–201,–301,–302	BLK
10	A3E4	29	T2–5	29	14	270V	–201,–202,–302,–303	BLK
9	A3E2	29	A4Q1–E2 (IGBT STUD)	31	14	–	•	VIO
8	A2E10	29	A4Q1–E2 (IGBT STUD)	31	14	–150V	•	VIO
7	A2E9	29	SPARE	–	–	–150V	•	
6	A2E8	29	L1–4	29	14	–150V	•	VIO
5	A2E7	29	FL1–1	34	14	+V IN	–101,–201,–202	BLK
4	A2E6	29	CB1–LINE	29	14	HOT IN	–101,–201,–202	BLK
3	A2E3	29	A4Q1–C1 (IGBT STUD)	31	14	+150V	•	RED
2	A2E2	29	SPARE	–	–	+150V	•	
1	A2E1	29	L1–2	29	14	+150V	•	RED
CONN NO.	FROM	LUG ITEM NO.	TO	LUG ITEM NO.	AWG	FUNCTION	USED ON • = ALL FINAL ASSYS	

WIRE RUN SCHEDULE

NOTE: UNLESS OTHERWISE SPECIFIED.
1. APPLY ITEM 23 TO THREADS OF ITEMS 18, 19 AND 21 BEFORE ASSY.
2. ITEMS 9–12, 36, AND 37 ARE SUPPLIED TO CUSTOMER UNASSEMBLED.
3. REFERENCE DOCUMENTS.
   3.1 SYSTEMS SCHEMATIC 106–677–000.
   3.2 POWER PWB SCHEMATIC 106–712–000, & 001.
   3.3 CONTROLLER PWB SCHEMATIC 106–683–000.
   3.4 CAPACITOR PWB SCHEMATIC 106–709–000.
   3.5 OUTLINE DWG 106–677–500.
4. ITEMS 13 –16 (K1 & K2 RELAYS AND HARDWARE) ARE USED ON –202 AND –303 (34V) AND ARE MOUNTED TO ITEM 4.
5. USE GROMMET # 100–973–002 AS REQD TO PREVENT WIRE FROM RUBBING ON SHARP EDGES.
6. ADD CABLE CLAMPS AS REQD WHEN DRESSING WIRING.

SEE SEPARATE PARTS LIST

106-676-XXX

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
ANGLES ±
DO NOT SCALE THIS DRAWING
MATERIAL:

CONTRACT
DRAWN EWG 92–03–06 DATE
CHECKED G.ZEITLER 92–3–6
ENGR

BEHLMAN
An Astrosystems Company

AC SOURCE TOP ASSY
BL1350X–X

SIZE	CODE IDENT NO.		REV
D	53636	106–676–XXX	E
SCALE 1:1		SHEET 1 OF 3	

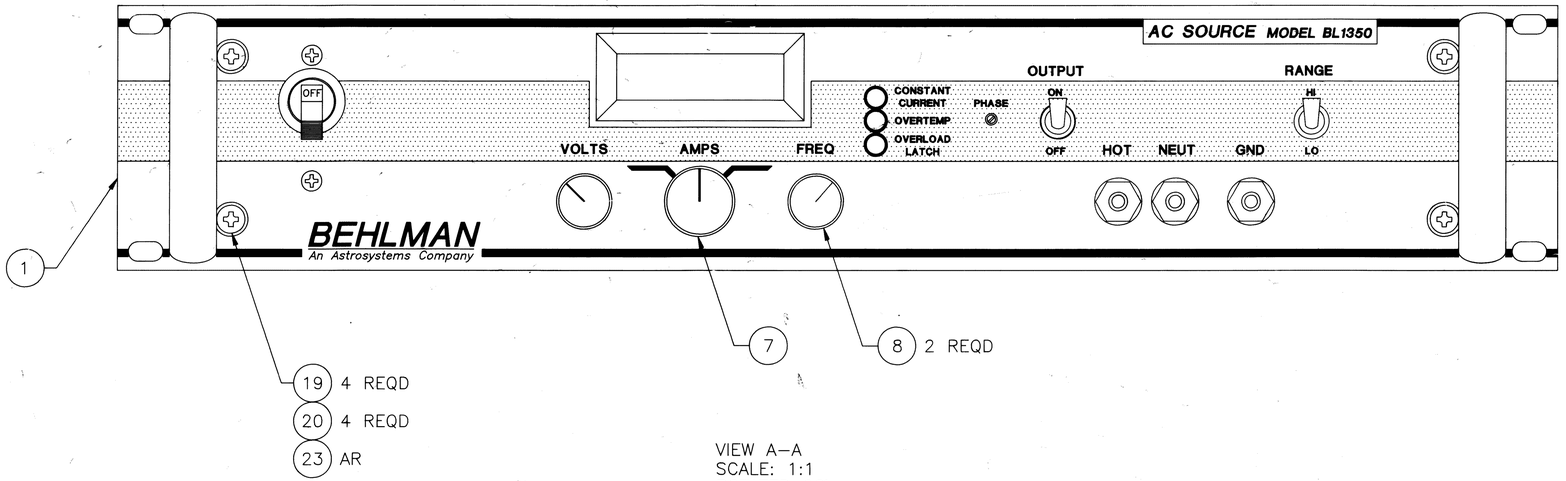
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
		SEE SHEET 1 FOR REVISION HISTORY		

COVER (ITEM 6) NOT SHOWN FOR CLARITY.

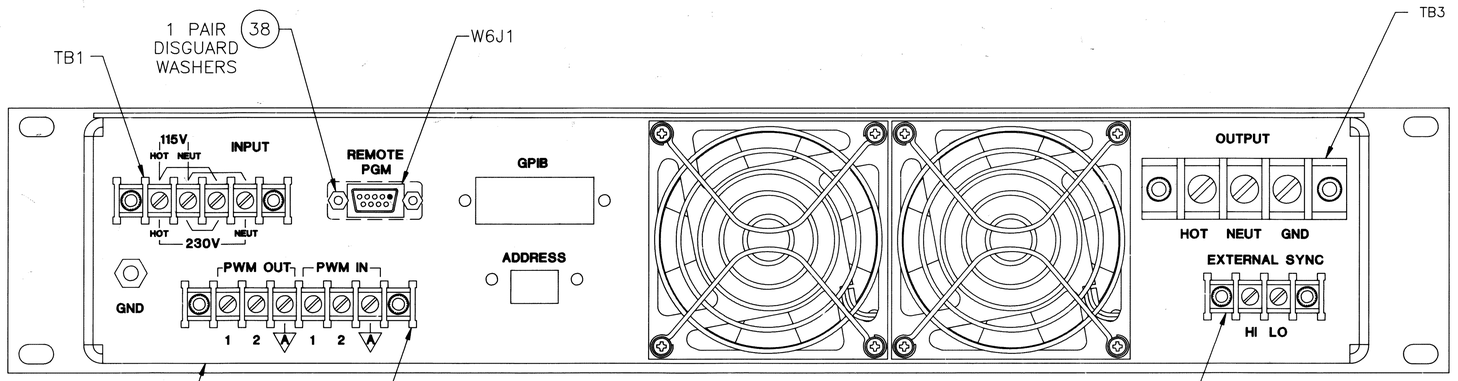
SIZE	CODE IDENT NO.		REV
D	53636	106-676-XXX	E
SCALE 1:1		SHEET 2 OF 3	

106-676-XXX

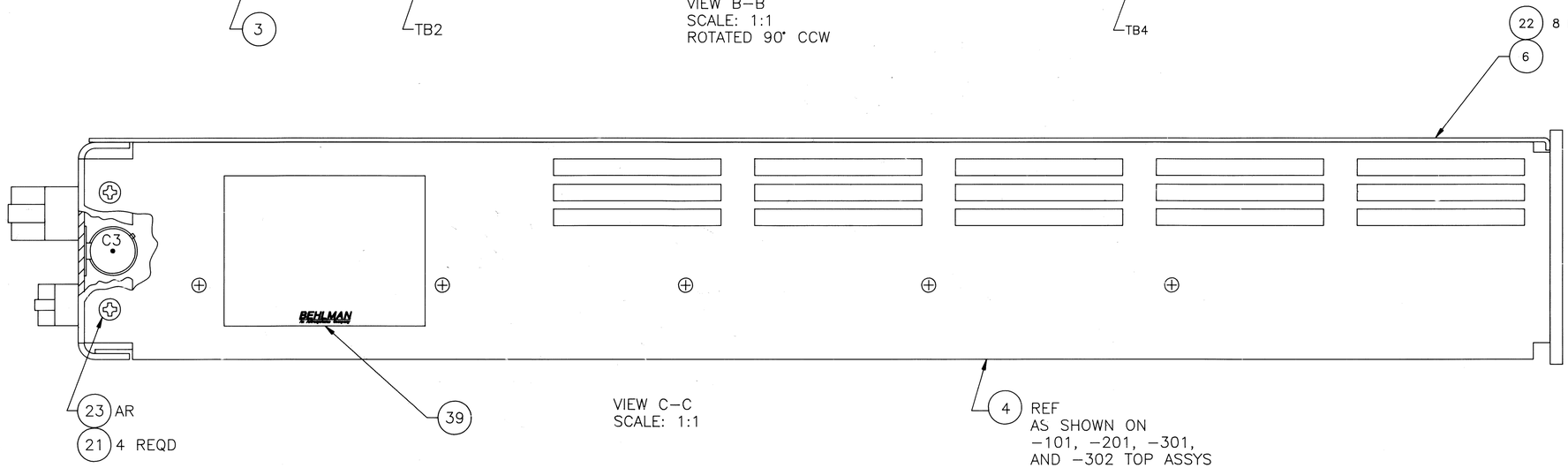
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
		SEE SHEET 1 FOR REVISION HISTORY		



VIEW A–A
SCALE: 1:1
ROTATED 90°



VIEW B–B
SCALE: 1:1
ROTATED 90° CCW



VIEW C–C
SCALE: 1:1

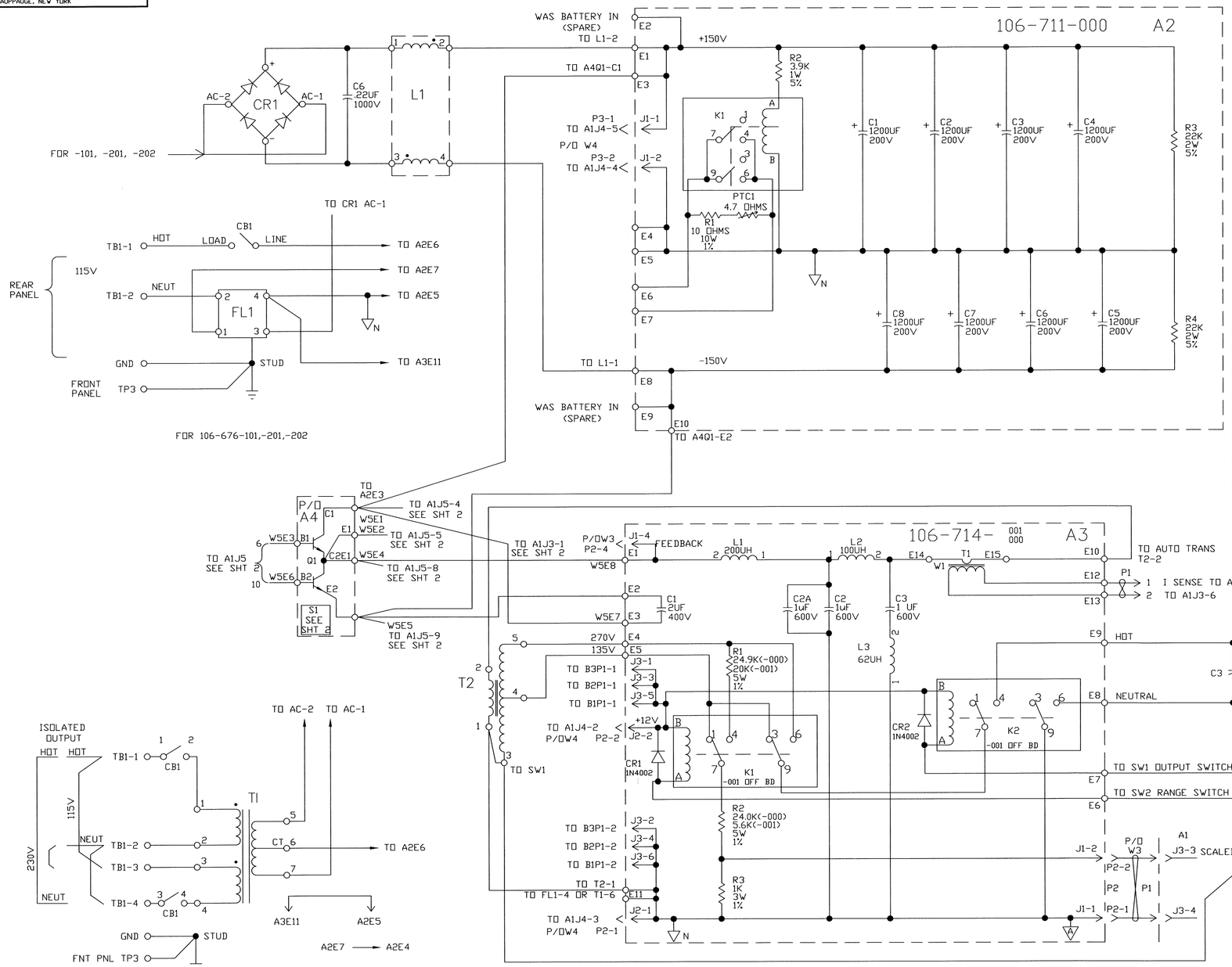
SIZE	CODE IDENT NO.		REV
D	53636	106–676–XXX	E
SCALE 1:1		SHEET 3 OF 3	

106-676-XXX

REV STATUS OF	SHT
REV	SHT
H	1
F	2

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED	DRL #	INIT
	-	RELEASED FOR PRODUCTION	920226			
	A	DEBUG PROTOTYPE	920516			
	B	REVISED PER ECO 92-090	921009			
	C	REVISED PER ECO 92-134	921124			
	D	REVISED PER ECO 96-004	960313			
	E	REVISED PER ECO 96-062	961220			
	F	REVISED PER ECO 97-013	970813			
	G	REVISED PER ECO 97-113R1	971229			
	H	REVISED PER ECO 98-102R1	980813			



NOTES: UNLESS OTHERWISE SPECIFIED:
1. FOR 34V MODELS A3K1 & A3K2 ARE LOCATED ON THE LEFT SIDE PANEL.
2. REFERENCE DOCUMENTS:
   2.1 TOP ASSY 106-676-XXX.
   2.2 OUTLINE DWG 106-677-500

CONTROLLED DOCUMENT

106-676-XXX	106-676-XXX
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: FRAC
3 PLACE DEC ±.005
2 PLACE DEC ±.01
ANGLES ± 1°
DO NOT SCALE THIS DWG
MATERIAL:

THIS DRAWING SHALL ONLY BE CHANGED BY USE OF CAD

DRAWN B. ZAKREWSKI	DATE 001213
CHECKED	12/14/00
ENGR S. Bagli	12/15/00
QUALITY CONTROL	
MANUFACTURING	

BEHLMAN

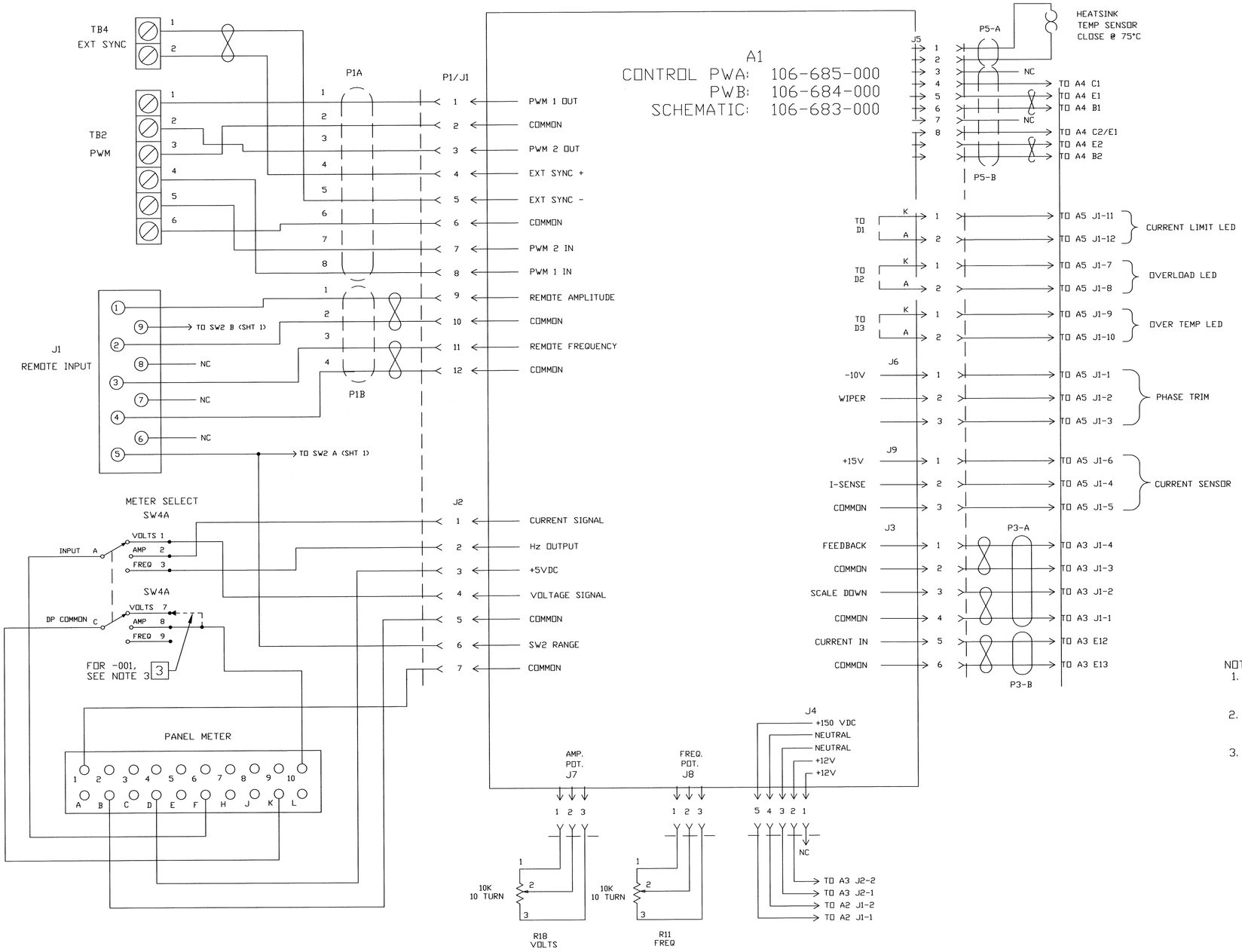
SYSTEM SCHEMATIC, AC SOURCE BL1350

SIZE	CODE IDENT NO.		REV
D	53636	106-677-000	H
SCALE NONE	CAD FILE:677-000H.DWG	SHEET 1 OF 2	

106-677-000

AutoCAD Generated Document

REV STATUS OF SHT		REVISIONS				
REV	SHT	ZONE	LTR	DESCRIPTION	DATE	APPROVED
				SEE SHEET 1 FOR REVISION HISTORY		



NOTES: UNLESS OTHERWISE SPECIFIED:
1. FOR 34V MODELS, A3K1 & A3K2 ARE LOCATED ON THE LEFT SIDE PANEL.
2. REFERENCE DOCUMENTS:
   2.1 TOP ASSY 106-676-XXX.
   2.2 OUTLINE DWG 106-677-500
3. FOR 34V MODELS, ADD A JUMPER BETWEEN SW4A PIN 7 AND SW4A PIN 8.

CONTROLLED DOCUMENT

SIZE	CODE IDENT NO.		REV
D	53636	106-677-000	F
SCALE NONE	CAD FILE: 677-000H.DWG	SHEET 2 OF 2	

106-677-000

AutoCAD Generated Document

LTR	DESCRIPTION	DATE	APPVD
U	ECO 04-072	070411	
V	REVISED PER ECO 05-048	050506	
W	REVISED PER ECO 06-072 (DM)	06/27/06	
Y	REVISED PER ECO 09061 (FM)	06/17/09	

REV STATUS OF SHT: SHT 1 | REV W

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	N	ECO 96-076	961220	S.B.
	P	ECO 97-014	970912	S.B
	R	ECO 97-134	980108	S.B.
	T	ECO 01-115	010807	

REVISIONS

P/O J1 PROG-V 9 10 E10

P/O J2 PROG-HZ 11 12 E3 J8

P/O J2 HZ-METER 2 3 5 7 TP1

P/O J3 SW2 V-METER 6 4

P/O J3 SCLD-DWN 3 FEEDBACK 1 2 4

P/O J1 HI 5 EXT SYNC LO 4

J4 +150U 5 1 2 3 4 NEU

E7 E11 E4 E2 E10 E3 E1 E5 E6 E8 E9 E12

J7 2 1 3

J6 1 -10U 2 -10U 3 PHSE-TRM

P/O J2 1 I-METER

J9 1 2 3

P/O J3 5 I-SENSE1

P/O J1 1 PWM1OUT 3 PWM2OUT 7 PWM2IN 8 PWM1IN 2 6

J5 2 1 THERM-SW 3 4 DRAIN-1 6 GATE-1 5 SOURCE-1 7 8 DRAIN-2 10 GATE-2 9 SOURCE-2

R1 33K; C1 220p 200V; C2 100uF; R2 10K; R3 10K; R4 1K; C3 330p 200V; C52 1u; C53 680p 200V; R5 10K; U1 SIG1MPCOMP1 COMP PCOMP2 PPULSE VCO1NVCOOUT INH DMOD CI-1 RX-1 RX1 RX2 ZENER CD4046B (8=A,16=+5V)

U2 (8=A,16=+5V) RESET 74S472; U3 (10=A,20=+5V); U4 (3=A,14=+5V) DB0 DB1 DB2 DB3 DB4 DB5 DB6 DB7 UREF FDBK CS DR OUT1 OUT2 AD7524; CD4018B U18/D

R6 10K; R7 10K 1%; R8 10K 1%; U15/A TL084N; CR1 LM336Z-5; R9 10K 1%; R10 10K 1%; U19/B; C49 .1u; C7 .1u

R114 51K; CR26 1N4148; Q2 2N2907; R116 51K; C51 22u; C6 2.2u; R115 1K; C70 .01u; R117 10K 1%; R157 10K 1%; CR27 1N4148; R118 49.9K 1%; R138 49.9K 1%; C59 22u 25V; R16 100K 1%; R17 100K 1%; R14 100K 1%; C57 .01u; R15 10K 1%; R13 25.5K 1%; R156 46.4K; R109 45.3K 1%; R148 10K; R146 3K; U8 UTL5C1; R128 22M; C12 .01u NPO; R45 100K 1%; R42 100K 1%; R145 1K; R144 1K; R41 15K; R40 10K; R39 15K; R37 100K 1%; R36 100K 1%; C11 1u; R43 20K 1%; R44 10K 1%; U16/B; U16/C; U21/A LM393FN; U21/B; U20/A; U20/B; U20/C; U20/D; CR2 1N4148; CR3 1N6263; R11 10K; R12 1K; C4 1000p 200V; R19 1K; R38 10K; C64 1000p; C65 1000p; U9 SIG1MPCOMP1 COMP PCOMP2 PPULSE VCO1NVCOOUT INH DMOD CI-1 RX-1 RX1 RX2 ZENER CD4046B (8=A,16=+10V); LOCATED FRONT-PANEL (R1) (500K); R122 511K 1%; R31 10K; I.R.COMP; R24 15K 1%; R25 1K; I-METER; R26 200 1%; R121 499 1%; R119 4.99K 1%; R120 1K 1%; U19/C; CR4 1N4148; R155 1K 1%; K1-14; U16/A; R149 1K 1%; R32 33.2K 1%; R27 24K; C8 1u; C71 1.0u; R154 243 1%; U28/A LT1013; 1.15V (FULL LOAD X 1.5); C58 1u; C68 .01u; R136 49.9K 1%; R137 50K I-OFF; R33 1K 1%; R34 1K 1%; U10 VIN +U CRU COM DB IOUT BUFIN RL -U BUFOUT ADS36A; C9 1u; C72 1uF; C10 1u; R28 1K 1%; R29 2.2K; R30 2.2K; U25/A U25/B U25/C U25/D CD4093B; U26/A (7=A,14=+15V) CD4001B; C75 .01u; SW1 OFF BD; R110 5.1K; R69 10K; D2 HP3001 OFF BD; D3 HP3001 OFF BD; R68 5.1K; R67 1K; U26/B CD4001B; U11 HCPL2211; U12 HCPL2211; R123 51K; R124 51K; U17/A U17/B U17/C U17/D U17/E U17/F CD4049UB (8=A,1=+15V); R70 4.7K; R77 4.7K; R71 1.5K; R72 100; R73 100; R112 10K; R74 1.5K; R75 100; R76 100; R113 10K; DRIVER1 DRIVER2 +20B +20C; CR13 ERA38-06; CR14 ERA38-06; U13 U14 VSENSE OUT FAULTOUT IN+ +SUBIAS IN- GND EXB840; C24 100u; R151 1K; C25 100u; C28 100u; C27 100u; R152 4.02K; R153 1K; C69 47u; U31 TL431

R50 1K 1W; CR5 1N4002; U5 PS2501-1; R49 15K; R139 49.9K 1%; R140 49.9K 1%; C60 22u 25V; R51 226K 1%; R52 100K 45Hz; R53 10K 500 Hz FREQ ADJ; R54 22.1K 1%; C73; (R11) (10K) LOCATED FRONT-PANEL; R56 1K 1%; C56 1u; .500U F.S.; R57 10K Hz-METER; R158 47 .5W; 1.35U F.S.; K1 U172DIP-23; 135UF.S.; C55 1u; R65 500 270UF.S.; R64 1K 1%; R127 1K 1%; R63 22.6K 1%; R126 46.4K 1%; R93 500; R91 10K 1%; C18 470pF; C54 2.2u; R92 118K 1%; R92A 118K 1%; C62 1000p; R87 24.9K 1%; R88 1K 1%; R89 1K 1%; R90 24.9K 1%; C63 1000p; R147 1K; R82 10K; R83 10K 1%; R86 10K 1%; R85 3.3K; R84 7.5K 1%; DIST.TRM; R129 5K; C19 1000p 200V NPO; C20 .1u; R146 1K; R80 2.2K; R78 2.2K; R79 2.2K; R81 2.2K; U23/A U23/B LM393FN; U22/A U22/B U22/C U22/D TL084N; U24/A U24/B U24/C U24/D U24/E U24/F CD4050B; CR7 LM336Z-2.5; CR8 CR9 CR10 CR11 1N4148 4PL; U28/B LT1013; U29/A U29/B U29/C U29/D U29/E U29/F CD4049UB; U26/C U26/D CD4001B; C50 22u; C45 .1u; C47 1u; C46 .1u

R61 24.3K 1%; C16 1u; U7 VIN +U CRU COM DB IOUT BUFIN RL -U BUFOUT RDS36R; R143 510; C61 .01u; C15 1u; R62 49.9K 1%; R135 50K V-OFF; R60 1K 1%; C17 1u; C48 .15u WIMA; U6 VOUT IN+ IN- OFFSET FOUT NULL NULL CMP CIN DGND RDS58; C14 .15u WIMA; R59 1K; R58 20K 1%; R108 16.5K 1%; U27/B; R55 24.9K 1%; C74 .1uF; R158 47 .5W; 1.35U F.S.; K1 U172DIP-23; 135UF.S.; C55 1u; R65 500 270UF.S.; R64 1K 1%; R127 1K 1%; R63 22.6K 1%; R126 46.4K 1%; R93 500; R91 10K 1%; C18 470pF; C54 2.2u; R92 118K 1%; R92A 118K 1%; C62 1000p; R87 24.9K 1%; R88 1K 1%; R89 1K 1%; R90 24.9K 1%; C63 1000p; R147 1K; R82 10K; R83 10K 1%; R86 10K 1%; R85 3.3K; R84 7.5K 1%; DIST.TRM; R129 5K; C19 1000p 200V NPO; C20 .1u; R146 1K; R80 2.2K; R78 2.2K; R79 2.2K; R81 2.2K; U23/A U23/B LM393FN; U22/A U22/B U22/C U22/D TL084N; U24/A U24/B U24/C U24/D U24/E U24/F CD4050B; CR7 LM336Z-2.5; CR8 CR9 CR10 CR11 1N4148 4PL; U28/B LT1013; U29/A U29/B U29/C U29/D U29/E U29/F CD4049UB; U26/C U26/D CD4001B; C50 22u; C45 .1u; C47 1u; C46 .1u

R97 4.99K 1%; R96 150K; C29 100p 200V; R94 56K 1W; R95 21.5K 1%; U15 CMP VCC VFB VREF IS OUT GNDRT/CT UC3844; R98 10K; C30 470p 200V; C31 1000p 200V; R100 220; Q1; R101 1K; C32 .1u; R102 5.1K 2W; C33 100u; C34 470u; CR15 CR16 MBR360; R99 680 1W; C35 330p 500V; CR17 IN4937; C36 680p 500V; R104 2.2K 2W; CR18 IN4937; R103 .5 1W; T1; R105 330 1/2W; CR19 MUR130; C37 470u; CR20 1N4747; R130 2.7K; D4 LN28RP; R106 330 1/2W; C38 470u; CR22 1N4747; R131 2.7K; D5 LN28RP; CR21 MUR130; CR23 MUR130; CR24 MUR130; CR25 MUR130; 7805CTV UR1; 7815CTV UR2; 7915CTV UR3; C39 1000u; C40 1000u; C41 470u; C42 22u; C43 470u; C44 22u; R132 430; R133 1.5K; D7 LN28RP; R134 1.5K; D8 LN28RP; R110 5.1K; R69 10K; D2 HP3001 OFF BD; D3 HP3001 OFF BD; R68 5.1K; R67 1K; U26/B CD4001B; U11 HCPL2211; U12 HCPL2211; R123 51K; R124 51K; U17/A U17/B U17/C U17/D U17/E U17/F CD4049UB (8=A,1=+15V); R70 4.7K; R77 4.7K; R71 1.5K; R72 100; R73 100; R112 10K; R74 1.5K; R75 100; R76 100; R113 10K; DRIVER1 DRIVER2 +20B +20C; CR13 ERA38-06; CR14 ERA38-06; U13 U14 VSENSE OUT FAULTOUT IN+ +SUBIAS IN- GND EXB840; C24 100u; R151 1K; C25 100u; C28 100u; C27 100u; R152 4.02K; R153 1K; C69 47u; U31 TL431

HIGH REF DES		NOT USED	
T1	J5	C64	C23
R158	SW1	C65	C26
CR30	C74	U30	C5
Q2	VR3	R150	
D8	U31		

106-685-000	BL1350
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
ANGLES ±
DO NOT SCALE THIS DRAWING
MATERIAL:

CONTRACT

DRAWN G. LESKOWITZ DATE 010807
CHECKED 8/14/92
ENGR F. PIGNATELLI 12/22/92

BEHLMAN

SCHEM. DIAG
CONTROLLER BOARD
AC SOURCE, BL1350

SIZE	CODE IDENT NO.		REV
D	53636	106-683-000	X
SCALE		SHEET 1 OF 1	

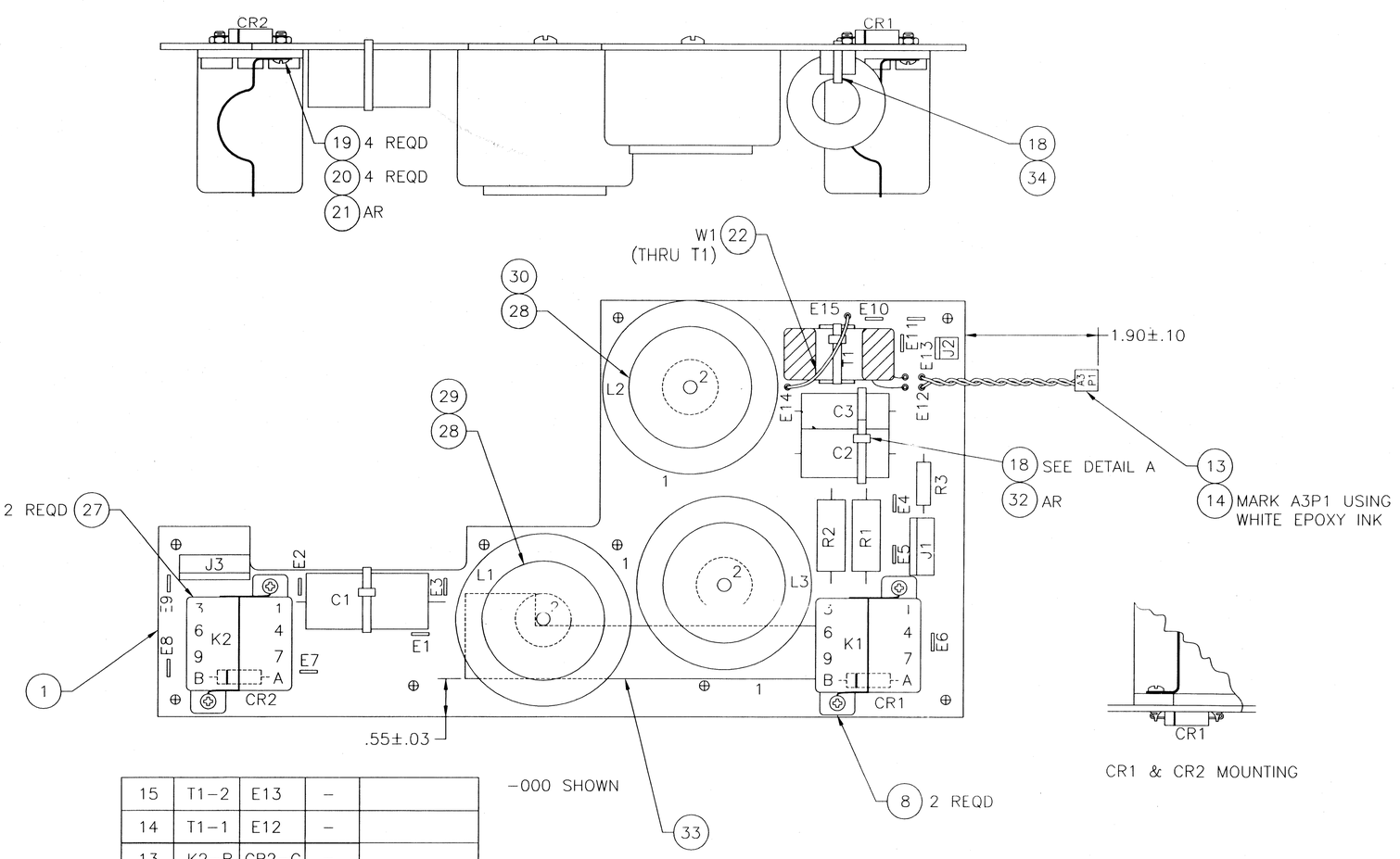
106-683-000

CONTROLLED DOCUMENT

REV STATUS OF SHT	
REV	SHT
G	1

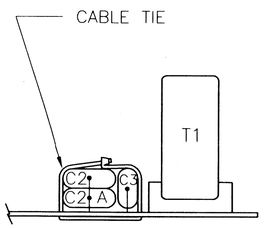
REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED	DRL #	INIT
	A	REVISED PER ECO 92-026	92-01-30	JP		
	B	REVISED PER ECO 92-065	92-05-05	DM		
	C	REVISED PER ECO 92-084	92-07-17	TM		
	D	REVISED PER ECO 92-136	92-09-30	CS		
	E	REVISED PER ECO 96-039	97-08-27	CS		
	F	REVISED PER ECO 97-113R17	97-08-27	CS		
	G	REVISED PER ECO 00-157	00-07-28	S.B.	12690 CR	



-000 SHOWN

CR1 & CR2 MOUNTING



DETAIL A

WIRE NO.	FROM	TO	WIRE ITEM	NOTES
9	T1-2	E13	--	
8	T1-1	E12	--	
7	K2-B	CR2-C	--	MOUNT CR1 & 2 TO SOLDER SIDE OF BD SLEEVE LEADS
6	K2-A	CR2-A	--	
5	K1-B	CR1-C	--	
4	K1-A	CR1-A	--	
3	E14	E15	22	THRU T1
2	E13	P1-2	23	TWISTED
1	E12	P1-1	23	

WIRE RUN LIST -000

WIRE NO.	FROM	TO	WIRE ITEM	NOTES	
15	T1-2	E13	-		
14	T1-1	E12	-		
13	K2-B	CR2-C	-	INSTALL BUSS BAR FOR K1-A & K2-A MOUNT CR1 & CR2 TO SOLDER SIDE OF BD SLEEVE LEADS	
12	K2-A	CR2-A	-		
11	K1-B	CR1-C	-		
10	K1-A	CR1-A	-		
9	K1-B	E21	22	E16-E21 ITEM 25	4" LG
8	K1-7	E20	22		4" LG
7	K1-6	E19	22		4" LG
6	K1-4	E18	22		4" LG
5	K2-9	E17	22		3" LG
4	K2-B	E16	22		3" LG
3	E14	E15	22	THRU T1	
2	E13	P1-2	23	TWISTED	
1	E12	P1-1	23		

WIRE RUN LIST -001 (34V)

NOTES: UNLESS OTHERWISE SPECIFIED:

1. LEAD PROTRUSION TO BE .06 MAX EXCEPT K1, K2, A & B .08 MAX.
2. MARK APPROPRIATE DASH NO USING WHITE EPOXY INK.
3. MARK SERIAL NO. NEAR ASSY NO. USING WHT EPOXY INK.
4. REFERENCE DOCUMENTS:
   3.1 SCHEMATIC DIAGRAM 106-712-XXX (C SIZE).
   3.2 SYSTEM SCHEMATIC 106-677-000.
5. FOR -001 OMIT K1 & K2 SOCKETS. K1 & K2 ARE CALLED OUT ON TOP ASSY PL'S 101-676-202 OR 101-676-303 (34V MODELS).
6. FOR -001 MARK LEADS E16-E21 USING MASKING TAPE AND INK.
7. FOR DASHES 003, 111, 404, 405 & 406 SEE SEPARATE DRAWINGS.

CONTROLLED DOCUMENT

SEE SEPARATE PARTS LIST

106-692-303	106-676-303
106-692-302	106-676-302
106-692-301	106-676-301
106-692-202	106-676-202
106-692-201	106-676-201
106-692-101	106-676-101
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: FRAC
3 PLACE DEC ±.005
2 PLACE DEC ±.01
ANGLES ± 1°
DO NOT SCALE THIS DWG
MATERIAL:

THIS DRAWING SHALL ONLY BE CHANGED BY USE OF CAD

	DRAWN	DATE
	J.MORRELL	00-07-26
CHECKED		00-08-21
ENGR		00-08-18

BEHLMAN

POWER BOARD ASSY

SIZE	CODE IDENT NO.		REV
D	53636	106-714-XXX	G

SCALE NA | CAD FILE: 714-XXXG.DWG | SHEET 1 OF 1

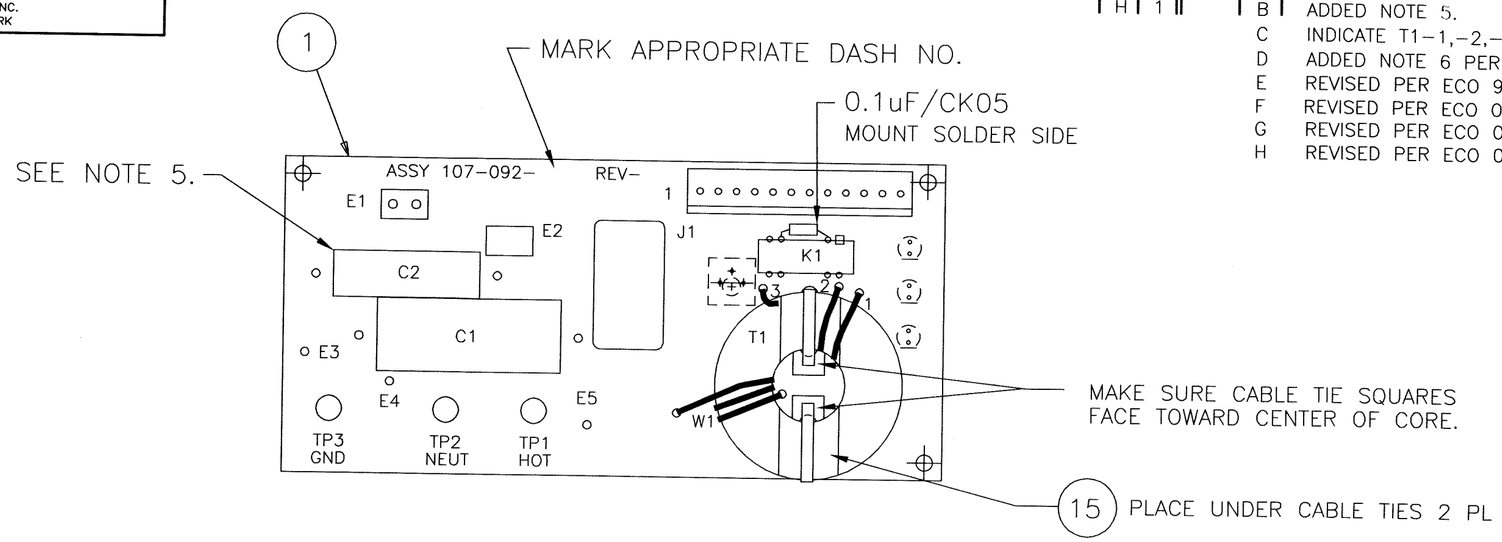
107-714-XXX

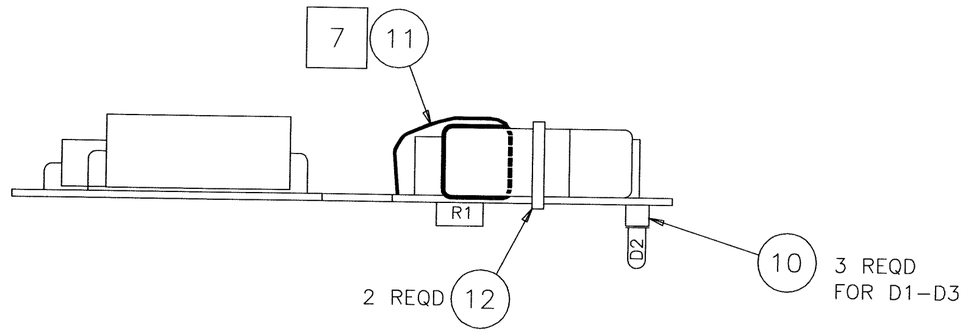
AutoCAD Generated Document

REV STATUS OF SHT	
REV	SHT
H	1

REVISIONS

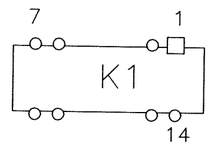
ZONE	LTR	DESCRIPTION	DATE	APPROVED	DRL #	INIT
XX	A	ADDED NOTE, "MARK APPROPRIATE DASH NO."				
	B	ADDED NOTE 5.				
	C	INDICATE T1–1,–2,–3 LOCATION.				
	D	ADDED NOTE 6 PER ECO 96–037.	961014			
	E	REVISED PER ECO 97–013.	970813			
	F	REVISED PER ECO 00–097	000517			
	G	REVISED PER ECO 00–286	001215			
	H	REVISED PER ECO 01–100	7/2/-1		12716 PM	





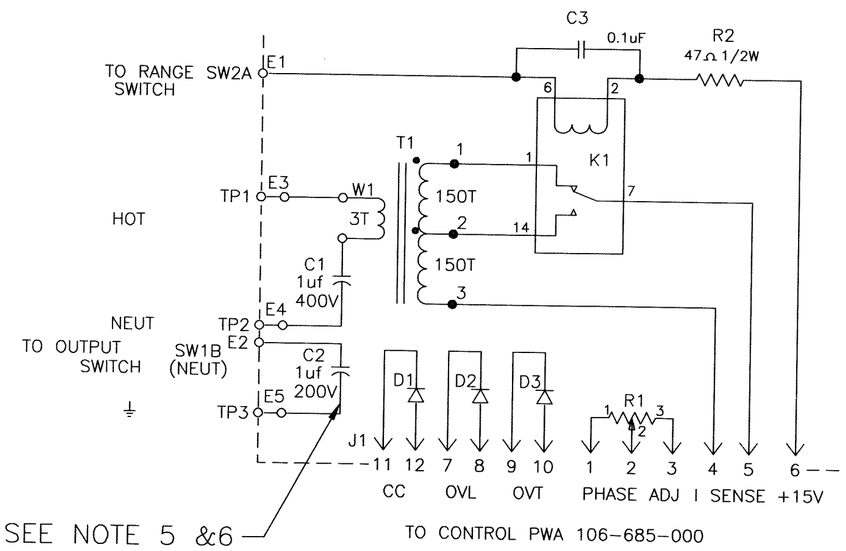
NOTES: UNLESS OTHERWISE SPECIFIED:

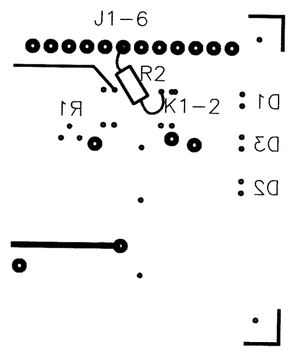
1. MAX LEAD PROTRUSION TO BE .10.
2. R1 D1–D3 ARE MOUNTED SOLDER SIDE.
3. MARK SERIAL NO. NEAR ASSY NO. USING WHITE EPOXY INK.
4. REFERENCE DOCUMENTS:
   4.1 SYSTEM SCHEMATIC BL1350 106–677–000.
5. C2 NOT REQD FOR –404 PWR FACTOR UNIT.
6. FOR –405 OMIT K–1, R2, C2 &C3. JUMP K1–7 TO K1–1 COMPONENT SIDE.



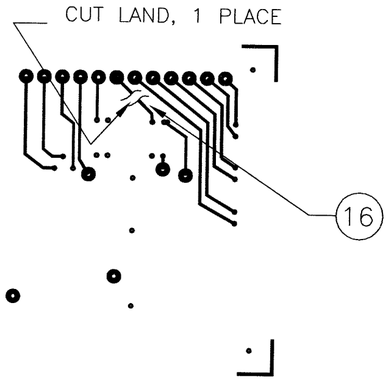
7. WIND 3 TURNS OF ITEM 11 THROUGH CENTER OF TOROID.

SCHEMATIC DIAGRAM





SOLDER SIDE



COMPONENT SIDE

CONTROLLED DOCUMENT

SEE SEPARATE PARTS LIST

106–691–XXX	106–676–XXX
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: FRAC
3 PLACE DEC ±.005
2 PLACE DEC ±.01
ANGLES ± 1°
DO NOT SCALE THIS DWG
MATERIAL:

THIS DRAWING SHALL ONLY BE CHANGED BY USE OF CAD

DRAWN G.LESKOWITZ DATE 010620
CHECKED 2001/07/03
ENGR 7/2/-1
QUALITY CONTROL
MANUFACTURING

BEHLMAN

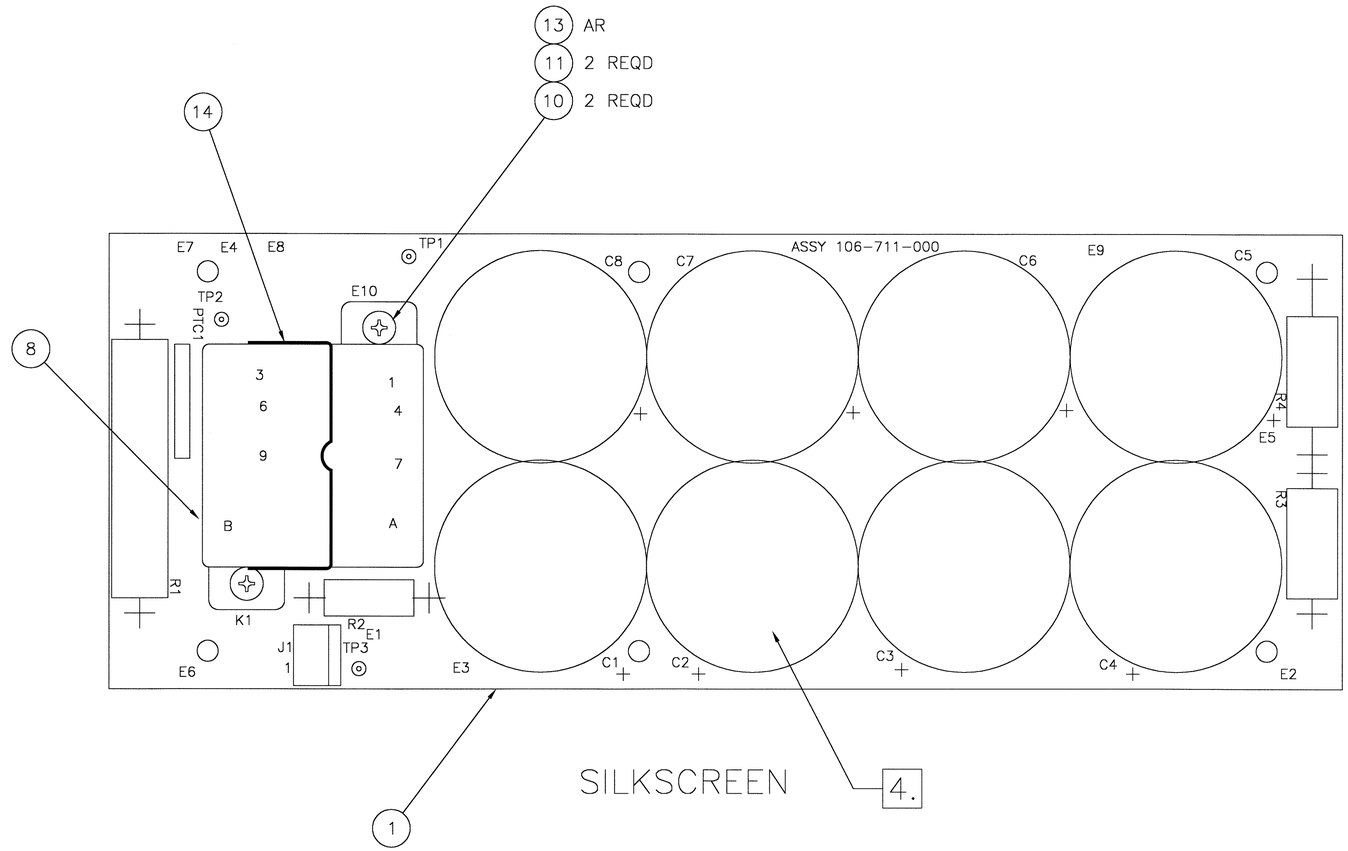
PWA, FRONT PANEL
BL1350

SIZE	CODE IDENT NO.		REV
C	53636	107–092–XXX	H
SCALE 1:1	CAD FILE: 092–XXXH.DWG	SHEET 1 OF 1	

107–092–XXX

AutoCAD Generated Document

REVISIONS						
ZONE	LTR	DESCRIPTION	DATE	APPROVED	DRL #	INIT
	–	RELEASED FOR PROTOTYPE				
	A	REVISED PER ECO 92-044	920211			
	B	REVISED PER ECO 06-062 (AGB)	060403		13119	PM



NOTES: UNLESS OTHERWISE SPECIFIED:
1. MAX LEAD PROTRUSION TO BE .06.
2. MARK SERIAL NO. NEAR ASSY NO. USING BLACK EPOXY INK.
3. REFERENCE DOCUMENTS:
   3.1 SCHEMATIC DIAGRAM 106-709-000 (C SIZE).
4. DO NOT CLINCH LEADS ON CAPACITORS C1-C8.

CONTROLLED DOCUMENT

SEE SEPARATE PARTS LIST

106-692-	106-676-
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: FRAC
3 PLACE DEC ±.005
2 PLACE DEC ±.02
ANGLES ± 1°
DO NOT SCALE THIS DWG
MATERIAL:

THIS DRAWING SHALL ONLY BE CHANGED BY USE OF CAD

DRAWN: J. ALGERIO DATE 920211
CHECKED: 4/20/06
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CAPACITOR PWB ASSY

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D	53636	106-711-000	B
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APPENDIX A

BL1350 AC POWER SUPPLY
IEEE-488 INTERFACE OPTION SPECIFICATIONS

1.0 INTRODUCTION

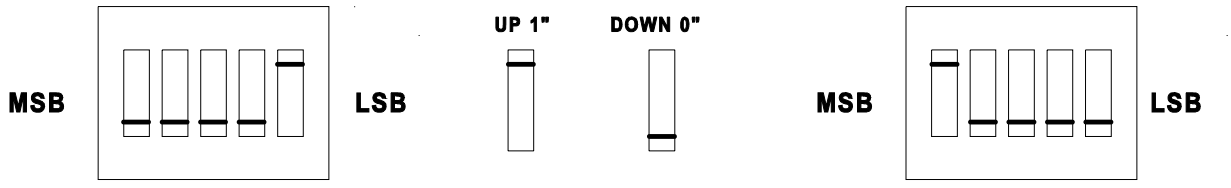
The IEEE488 remote control option enables computer control of the Model BL1350. The output voltage and frequency may be set and read back over the 488 bus. Status reporting of overloads or load faults is also provided. All of the command syntax and programming information is provided in this section. In addition drivers for use with the popular “LAB VIEW” and “ LAB WINDOWS” (registered trademarks of National Instruments Corp. are available from Behlman.

SPECIFICATIONS

Programming Range (voltage)	0 to 135 V or 0 to 270 V with 0.1 volt resolution.
Accuracy	2% of programmed value +/- 1 digit from 10% to 100% of range.
Programming Range (frequency)	45 to 500 Hertz with 0.1 Hertz resolution.
Accuracy	2% of programmed value +/- 1 digit
Voltage Read Back	0.1 volt resolution, 2% +/- 1 digit accuracy.
Frequency Read Back	0.1 amp resolution, 2% +/- 1 digit accuracy.
Frequency Read back	1 Hertz resolution, +/- 1 Hertz accuracy.

ADDRESS SETTING

The IEEE 488 bus allows connected devices to be “addressed” individually by the host controller. This unit may be set to address numbers 0 to 31 (excluding the host controllers address). The address is set via a dip switch on the rear of the unit located beside the IEEE 488 connector. The address must be set prior to applying power to the unit. Setting of the address is illustrated below.



EXAMPLE ADDRESS # 1

EXAMPLE ADDRESS # 16

1.1 IEEE-488 BUS UTILIZATION

The BL1350 Series Power Supplies incorporates an embedded TMA that is compatible with the electrical and mechanical standards outlined in IEEE-STD-488. The IEEE-488 interface uses a TI LSI device to implement all necessary talker/listener functions. This device is configured under software control to support the following subsets:

SH1 - Source Handshake
AH1 - Acceptor Handshake
T8 - Basic Talker
L4 - Basic Listener
RL1 - Remote/Local
DC1 - Device Clear
SRO - No Service Request
PPO - No Parallel poll response
DTO - No Device Trigger
CO - Not a controller

1.2 IEEE-488 BUS COMMANDS

1. Single-Line Commands

IFC - Clears GBIB interface

2. Multi-Line Command

DCL - Resets AC Power Supply to the quiescent state if a catastrophic failure is not present. The only way to clear a catastrophic failure is to read the Power Supply's response by using the Status command.

1.3 GPIB COMMUNICATION

The embedded TMA receives ASCII encoded command strings via a GPIB IEEE-488 according to MATE System Control Interface Standard No. 2806763 (IEEE-716 CIIL). Programmed I/O is utilized to transmit and receive command strings after a talker/listener relationship is established. The AC Power Supply supports all OPCODES, NOUNS, and MODIFIERS required by the stimulus module. They are as follows:

OPCODES
FNC, FTH, INX, :CHO, SET, SRX, SRN, CLS, OPN, RST, CNF, IST,STA

MODIFIERS
FREQ, VOLT, CURR

NOUN
ACS

1.4 **AC POWER SUPPLY SYNTAX**

Setup Command:

FNC ACS :CHO SET VOLT <value>

[SET FREQ <value>]
[SRX VOLT <value>]
[SRN VOLT <value>]
[SRX FREQ <value>]
[SRN FREQ <value>]
[SET VLT(0,1)] <cr><lf>

Table 1-1

CIIL SOFTWARE COMMANDS

CIIL COMMANDS	EXPLANATION
SET VOLT <value>	Sets output voltage to given value, in volts rms. The following values are permitted: 0 ≤ value ≤ 135, or 270, dependent on range selected and type of unit. If set volt (value) not received, then use SRN VOLT (value), or SRX VOLT (value). If none of these 3 are sent then generate error message.
SET FREQ <value>	Optional. Sets frequency of output voltage to given value, in Hz. The following values are permitted: 45 ≤ value ≤ 500. Default is 45 Hz only if SET FREQ, SRN FREQ, or SRX FREQ are not received. Otherwise the values shall be used in the order stated.
SRX VOLT <value>	Optional. Sets maximum limit for SET VOLT command. If SET VOLT value is greater than SRX VOLT value in a command string, an error message is generated and the setup command ignored. The following values are permitted: 0 < value ≤ 135, or 270, dependent on range selected and type of unit. If a value for SRX VOLT is not specified, the required maximum value for SET VOLT default to 135, or 270, dependant on range selected and type of unit.

Table 1-1
CIIL SOFTWARE COMMANDS (continued)

CIIL COMMANDS	EXPLANATION
SRN VOLT <value>	Optional. Sets minimum value limit for SET VOLT command. If SET VOLT value is less than SRN VOLT value in a command string, an error message is generated and a setup command ignored. The following values are permitted: 0 ≤ value < 135, or 270, dependent on range selected and type of unit. The SET VOLT default is 0 for the minimum value if a value is not specified for SRN VOLT.
SRX FREQ <value>	Optional. Sets maximum limit for SET FREQ command. If the SET FREQ value in a command string is grater than the maximum limit, an error message is generated and the setup command ignored. Legal values are: 45 < value ≤ 500. If a value for SRX FREQ is not specified, SRX FREQ defaults to 500.
SRN FREQ <value>	Optional. Assigns minimum value to SET FREQ command. If the SET FREQ value in a command string is less than the minimum limit, an error message is generated and the setup command ignored. Legal values are: 45 ≤ value < 500. If a value for SRN FREQ is not specified, SRN FREQ defaults to 45.
SET VLT0	Set LO voltage range.
SET VLT1	Set HI voltage range.

On dual range Power Supplies, this command selects the LO or HI voltage range. Dual Ranges are 0-135 volts and 0-135/0-270 volt. If this command is omitted from the setup string the unit will default to the lowest range.

NOTES:

1. The setup command specifies the voltage and frequency of the AC power Supply output. The AC Power Supply responds only to the last setup command entry. Its memory does not retain previously entered setup commands.

2. During IEEE operation, the unit's front panel VOLTS and FREQ must be fully CCW. If the controls are not set fully CCW, then the output voltage and frequency will be a sum of the programmed value and the value set with the front controls.

Table 1-1
CILL SOFTWARE COMMANDS (continued)

CILL COMMANDS	EXPLANATION
FETCH DATA COMMAND:	
FTH VOLT <cr><lf>	The AC supply responds to this command by transmitting the RMS voltage (in volts) measured at its output, in decimal format as follows: <sp><digit><digit><digit><dp><digit><digit><cr><lf>
FTH CURR <cr><lf>	The AC Supply responds by transmitting the current (in amps) measured at its output, in decimal format, as follows: <sp><digit><digit><dp><digit><cr><lf>
FTH FREQ <cr><lf>	The AC Supply response by transmitting the frequency (in hertz) measured at its output, in decimal format, as follows: <sp><digit><digit><digit><cr><lf>
CLS :CH0 <cr><lf>	Closes output relay contacts. Connects the AC power supply outputs to output terminal block. The setup command specifies the voltage and frequency. The setup command must be entered before the CLS: CH0 command.
OPN :CH0 <cr><lf>	Opens output relay contacts. Disconnects the output of AC power supply from output connector. AC power supply retains voltage and frequency assigned by setup command.
RST ACS:CH0	Resets AC power supply to quiescent. The output relay opens and error messages are erased. Catastrophic error messages are cleared by reading the power supply's response, by use of the Status command.
CNF <cr><lf>	Instructs AC power supply to perform internal confidence test. STA command transmits the message. The AC power supply responds with one of the following: Pass <sp><cr><lf> Fail F07ACS0(DEV): CONFIDENCE TEST FAILURE <cr><lf>

Table 1-1
CIIL SOFTWARE COMMANDS (continued)

CILL COMMANDS	EXPLANATION
IST <cr><lf>	Instructs AC power supply to perform internal self test. The STA command transmits the message. The AC power supply responds with one of the following: Pass <sp><cr><lf> Fail F07ACSO(DEV): BIT TEST FAILURE (-PROM CHECKSUM FAULT| -RAM FAULT -AC SUPPLY HARD FAULT| <cr><lf>
STA <cr><lf>	Status. Prepares AC power supply for a response transmission. Clears error condition if one exists. The following response messages and conditions exclude confidence and internal self test.
RESPONSE:	Status OK <sp><cr><lf> Device error messages F07ACSO(DEV):BIT TEST FAILURE <description consisting of up to 60 characters><cr><lf> TMA error messages All begin with: F07ACSO (MOD): This message is followed by one explanatory message from the following text: ILLEGAL NOUN : AC power supply does not recognize illegal noun. ILLEGAL NOUN MODIFIER : AC power supply does not recognize illegal noun modifier. ILLEGAL OPCODE : AC power supply does not recognize illegal opcode. ILLEGAL VALUE: Entered value lies outside upper and lower limits. NO SETUP: Close command received but setup not programmed. Example: F07ACS00(MOD): NO SETUP <cr><lf>

1.5 CATASTROPHIC ERRORS

A catastrophic failure is generated each time the AC power supply experiences a hardware failure. Errors are cleared whenever the AC power supply transmits a response, except in the case of a short circuit fault which may only be cleared by cycling power to the AC Supply.

Catastrophic Error Messages

All begin with:

F00ACS0 (DEV):

This message is followed by one explanatory message from the following text:

OVER TEMP FAULT <cr><lf>

The heat sink temperature has exceeded its upper limit. The OVER TEMP LED on the front panel will light.

CURRENT LIMIT FAULT <cr><lf>

SHORT CIRCUIT FAULT: AC SUPPLY<cr><lf>

An output loading fault has occurred causing the supply to exceed 500% rated current output. The supply automatically shuts down and the OVERLOAD LATCH LED on the front panel will light.

GPIB PROGRAMMING EXAMPLES

Examples of actual command strings transmissions and typical responses are outlined below.

All commands must be in upper case ASCII, lower case characters are ignored. All commands transmitted to the BL1350 must terminate with a carriage return <cr> and a line feed <lf>, as will all responses received from the BL1350.

IMPORTANT NOTE: The EOI line of the GPIB controls MUST be asserted when transmitting the line feed character, otherwise the Source will not recognize command reception and command processing will not occur.

EXAMPLE 1: Setup a single range BL1350 Source to output 120 V @60 Hz, and close the output relay.

Transmit setup command:
FNC ACS :CHO SET VOLT 120 SET FREQ 60<cr><lf>

Transmit status command to request status response:
STA <cr><lf>

Talk address the BL1350 Source to enable response:
<space><cr><lf> : Positive response indicating status is OK.
F07ACS00 (MOD) ILLEGAL VALUE <cr><lf> : Negative response indicating error condition.

(Typically a negative response would only occur if an error existed in the entry or reception of the command string, or the values entered were out of range of the Source).

Transmit output relay close command:
CLS :CHO <cr><lf>

Transmit status command to request status response:
STA <cr><lf>

Talk address the BL1350 Source to enable response:
<space><cr><lf> : Positive response indicating status is OK.
F07ACS00 (MOD) NO SETUP <cr><lf> : Negative response indicating error condition.
(Negative response would only occur if invalid or no setup string had been transmitted prior to close command).

EXAMPLE 2 : Setup a dual range BL1350 Source to output 30 V on low range @400 Hz.

Transmit setup command:
FNC ACS :CHO SET VOLT 30 SET FREQ 400 SET VLTO <cr><lf>

Transmit status command to request status response:
STA <cr><lf>

Talk adrress the Source to enable response:
<space><cr><lf> : Positive response indicating status is OK.

GPIB PROGRAMMING EXAMPLES (continued)

3. EXAMPLE: Setup a dual range BL1350 Source to output 115 V on high range @50 Hz, and read back what the actual voltage, current, and frequency being output is set at.

Transmit setup command:
FNC ACS :CHO SET VOLT 115 SET FREQ 50 SET VLT1 <cr><lf>

Transmit status command to request status response:
STA <cr><lf>

Talk address the Source to enable response:
<space><cr><lf> : Positive response indicating status is OK.

Transmit output relay close command:
CLS :CHO <cr><lf>

Transmit status command to request status response:
STA <cr><lf>

Talk address the Source to enable response:
<space><cr><lf> : Positive response indicating status is OK.

Transmit fetch volt command:
FTH VOLT <cr><lf>

Talk address the Source to enable response:
115.0 <cr><lf>

Transmit fetch current command:
FTH CURR <cr><lf>

Talk address the Source to enable response:
5.2 <cr><lf>

Transmit fetch frequency command:
FTH FREQ <cr><lf>

Talk address the Source to enable response:
50 <cr><lf>

APPENDIX B

BL1350 AC POWER SUPPLY
EIA-232 SERIAL INTERFACE SPECIFICATIONS

1.0 INTRODUCTION

The RS232 interface option for the BL1350 series AC Power Supplies allows two way communication with most computer systems. All programmable setup parameters may be queried or modified via the RS232 interface using command syntax described below.

1.1 EIA-232 INTERFACE UTILIZATION

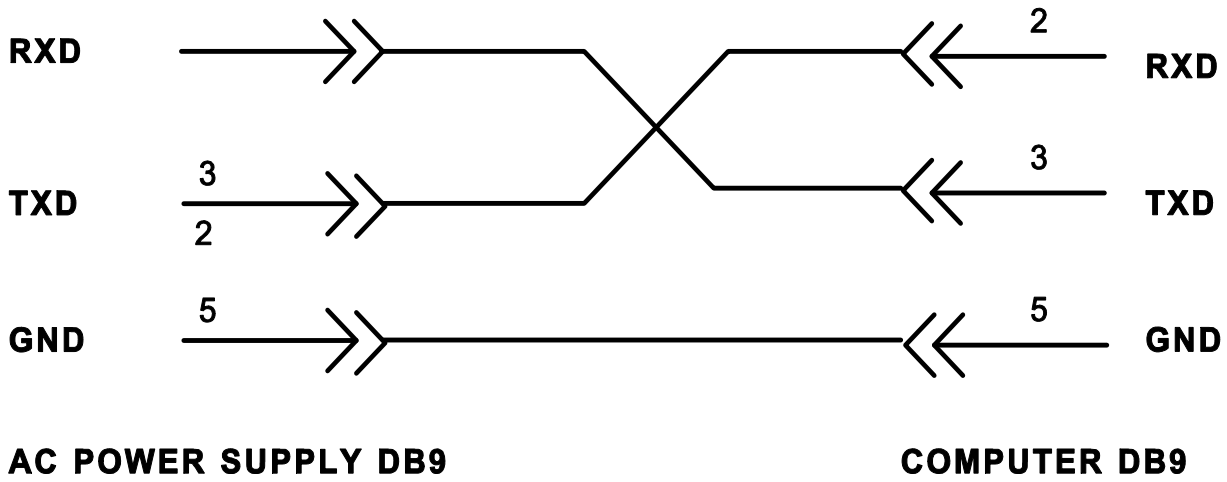
The RS232 interface may be connected to modems, controllers, computers, or any other equipment capable of communicating with the RS232 protocol. It is assumed in the remainder of this document that the RS232 interface is connected to a “host” computer.

The interface is configured to communicate with the following format:

Duplex:	Full
Baud Rate:	9600
Bits:	8
Parity:	None
# Stop Bits	1

Other BAUD rates, however, are available by special order

1.2 EIA-232 CONNECTIONS



The RS232 interface does not currently support hardware handshaking.

1.3 EIA-232 SERIAL COMMUNICATION

The Power Supply receives ASCII encoded command strings via a EIA-232 interface according to MATE System Control Interface Standard No. 2806763 (IEEE-716 CIIL). The AC Power Supply supports all OPCODES, NOUNS, and MODIFIERS required by the stimulus module. They are as follows:

OPCODES
FNC, FTH, :CHO, SET, SRX, SRN, CLS, OPN, RST, CNF, IST,STA INX,

MODIFIERS
FREQ, VOLT, CURR, VLT0, VLT1

NOUN
ACS

The BL1350 Series Power Supply can be used in point-to-point mode where a host Computer is connected directly to One Power Supply.

NOTES:

1. Leading zeroes must be entered for commands.
2. Leading zeroes are blanked in response transmit.

Table 1
CILL SOFTWARE COMMANDS

CIIL COMMANDS	EXPLANATION
SET VOLT <value>	Sets output voltage to given value,in volts rms. The following values are permitted: 0 ≤ value ≤ 135, or 270, dependent on range selected and type of unit.
SET FREQ <value>	Optional. The following values are permitted: 45 ≤ value ≤ 500. Default is 45 Hz only if SET FREQ, SRN FREQ, or SRX FREQ are not received. Otherwise the values shall be used in the order stated.
SRX VOLT <value>	Optional. Sets maximum limit for SET VOLT command. If SET VOLT value is greater than SRX VOLT value in a command string, an error message is generated and the setup command ignored. The following values are permitted: 0 < value ≤ 135, or 270, dependent on range selected and type of unit. If a value for SRX VOLT is not specified, the required maximum value for SET VOLT default to 135, or 270, dependant on range selected and type of unit.

CIIL SOFTWARE COMMANDS (continued)

CIIL COMMANDS	EXPLANATION
SRN VOLT <value>	Optional. Sets minimum value limit for SET VOLT command. If the SET VOLT value is less than SRN VOLT value in a command string, an error message is generated and a setup command ignored. The following values are permitted: ≤ value < 135, or 270, dependent on range selected and type of unit. The SET VOLT default is 0 for the minimum value if a value is not specified for SRN VOLT.
SRX FREQ <value>	Optional. Sets maximum limit for SET FREQ command. If the SET FREQ value in a command string is grater than the maximum limit, an error message is generated and the setup command ignored. Legal values are: 45 < value ≤ 500. If a value for SRX FREQ is not specified, SRX FREQ defaults to 500.
SRN FREQ <value>	Optional. Assigns minimum value to SET FREQ command. If the SET FREQ value in a command string is less than the minimum limit, an error message is generated and the setup command ignored. Legal values are: 45 ≤ value < 500. If a value for SRN FREQ is not specified, SRN FREQ defaults to 45.
SET VLT0	Set LO voltage range.
SET VLT1	Set HI voltage range.

This command selects the LO or HI voltage range. Ranges are 0-135 volts and 0-135/0-270 volt. If this command is omitted from the setup string the unit will default to the low range.

Delay is necessary after issuing a setup command, due to the output voltage slew rate of about 100v per 500ms.

IMPORTANT NOTES:

1. The setup command specifies the voltage and frequency of the AC power Supply output. The AC Power Supply responds only to the last setup command entry. Its memory does not retain previously entered setup commands.

2. During EIA-232 remote operation, the unit's front panel VOLTS and FREQ must be fully CCW. If the controls are not set fully CCW, then the output voltage and frequency will be a sum of the programmed value and the value set with the front controls. Front Panel OUTPUT switch must be set to OFF position. Thhe front panel RANGE switch must be set to LO.

Table 1
CILL SOFTWARE COMMANDS (cont)

CILL COMMANDS	EXPLANATION
FETCH DATA COMMAND:	
FTH VOLT <cr><lf><eos>	The AC supply responds to this command by transmitting the RMS voltage (in volts) measured at its output, in decimal format as follows: <sp><digit><digit><digit><dp><digit><digit><cr><lf><eos>
FTH CURR <cr><lf><eos>	The AC Supply responds by transmitting the current (in amps) measured at its output, in decimal format, as follows: <sp><digit><digit><dp><digit><cr><lf><eos>
FTH FREQ <cr><lf><eos>	The AC Supply response by transmitting the frequency (in hertz) measured at its output, in decimal format, as follows: <sp><digit><digit><digit><cr><lf><eos>
CLS :CH0 <cr><lf><eos>	Closes output relay contacts. Connects AC Power Supply outputs to output terminal. The setup command specifiesthe voltage and frequency. The setupcommand must be entered before the CLS :CH0 command.
OPN :CH0 <cr><lf><eos>	Opens output relay contacts. Disconnects output of AC Power Supply from output connector. Ac Power Supply retains voltage and frequency assigned by setup command.
RST ACS:CH0	Resets AC Power Supply to quiescent. The output relay opens and error messages are erased.

Catastrophic error messages are cleared by reading the Power Supply's response, by use of the Status command.

CNF <cr><lf><eos>	Instructs AC Power Supply to perform internal confidence test. STA command transmits the message. The AC Power Supply responds with one of the following: Pass <sp><cr><lf><eos> Fail F07ACS0(DEV): CONFIDENCE TEST FAILURE <cr><lf><eos>

Table 1
CIIL SOFTWARE COMMANDS (continued)

CILL COMMANDS	EXPLANATION
IST <cr><lf><eos>	Instructs AC Power Supply to perform internal self test. The STA command transmits the message. The AC Power Supply responds with one of the following: Pass <sp><cr><lf><eos> Fail F07ACSO(DEV): BIT TEST FAILURE (-PROM CHECKSUM FAULT| -RAM FAULT -AC SUPPLY HARD FAULT| <cr><lf><eos>
STA <cr><lf><eos>	Status. Prepares AC Power Supply for a response transmission. Clears error condition if one exists. The following response messages and conditions exclude confidence and internal self test.
RESPONSE:	Status OK <sp><cr><lf><eos> Device error messages F07ACSO(DEV):BIT TEST FAILURE <description consisting of up to 60 characters><cr><lf><eos> TMA error messages All begin with: F07ACSO (MOD): This message is followed by one explanatory message from the following text: ILLEGAL NOUN AC Power Supply does not recognize illegal noun. ILLEGAL NOUN MODIFIER AC Power Supply does not recognize illegal noun modifier. ILLEGAL OPCODE AC Power Supply does not recognize illegal opcode. ILLEGAL VALUE Entered value lies outside upper and lower limits. NO SETUP Close command received but setup not programmed. Example: F07ACS00(MOD): NO SETUP <cr><lf><eos>

1.4 AC POWER SUPPLY SYNTAX

Example of Setup Command:

FNC ACS :CHO SET VOLT <value>

[SET FREQ <value>]
[SRX VOLT <value>]
[SRN VOLT <value>]
[SRX FREQ <value>]
[SRN FREQ <value>]
[SET VLT(0,1)] <cr><lf><eos>

NOTES:

(cr) =ASCII ‘ carriage return’ code 0D Hex, ISO keyboard ^M
(lf) =ASCII ‘ line feed ’ code 0A Hex, ISO keyboard ^J
(eos) =ASCII ‘carriage return’ code 1A Hex, ISO keyboard ^Z (ASCII file transfer end-of string command)

1.5 CATASTROPHIC ERRORS

A catastrophic failure is generated each time the AC Power Supply experiences a hardware failure. Errors are cleared whenever the AC Power Supply transmits a response, except in the case of a short circuit fault which may only be cleared by cycling power to the AC Supply.

Catastrophic Error Messages

All begin with:

F00ACS0(DEV):

This message is followed by one explanatory message from the following text:

OVER TEMP FAULT <cr><lf><eos>

The heat sink temperature has exceeded its upper limit. The OVER TEMP LED on the front panel will light.

CURRENT LIMIT FAULT <cr><lf><eos>

SHORT CIRCUIT FAULT: AC SUPPLY<cr><lf><eos>

An output loading fault has occurred causing the supply to exceed 500% rated current output. The supply automatically shuts down and the OVERLOAD LATCH LED on the front panel will light.

EIA-232 SERIAL PROGRAMMING EXAMPLES

Examples of actual command strings transmissions and typical responses are outlined below.

All commands must be in upper case ASCII, lower case characters are ignored. All commands transmitted to the power supply must terminate with a carriage return <cr> and a line feed <lf>, and <eos> as will all responses received from the power supply.

EXAMPLE 1: Setup a single range BL1350 Source to output 120 V @60 Hz, and close the output relay.

Transmit setup command:
FNC ACS :CHO SET VOLT 120 SET FREQ 60<cr><lf><eos>

Transmit status command to request status response:
STA <cr><lf><eos>

Talk address the Source to enable response:
<space><cr><lf><eos> : Positive response indicating status is OK.
F07ACS00 (MOD) ILLEGAL VALUE <cr><lf>: Negative response indicating error condition.
(Typically a negative response would only occur if an error existed in the entry or reception of the command string, or the values entered were out of range of the P1351 Source).

Transmit output relay close command:
CLS :CHO <cr><lf><eos>

Transmit status command to request status response:
STA <cr><lf><eos>

Talk address the Source to enable response:
<space><cr><lf><eos> : Positive response indicating status is OK.
F07ACS00 (MOD) NO SETUP <cr><lf>: Negative response indicating error condition.
(Negative response would only occur if invalid or no setup string had been transmitted prior to close command).

EXAMPLE 2: Setup a dual range Source to output 30 V on low range @400 Hz.

Transmit setup command:
FNC ACS :CHO SET VOLT 30 SET FREQ 400 SET VLTO <cr><lf><eos>

Transmit status command to request status response:
STA <cr><lf><eos>

Talk adrress the Source to enable response:
<space><cr><lf><eos> : Positive response indicating status is OK.

EXAMPLE 3: Setup a dual range Source to output 115 V on high range @50 Hz, and read back what the actual voltage, current, and frequency being output is set at.

Transmit setup command:
FNC ACS :CHO SET VOLT 115 SET FREQ 50 SET VLT1 <cr><lf><eos>

Transmit status command to request status response:
STA <cr><lf><eos>

Talk address the Source to enable response:
<space><cr><lf><eos> : Positive response indicating status is OK.

Transmit output relay close command:
CLS :CHO <cr><lf><eos>

Transmit status command to request status response:
STA <cr><lf><eos>
Talk address the Source to enable response:

<space><cr><lf><eos> : Positive response indicating status is OK.

Transmit fetch volt command:
FTH VOLT <cr><lf><eos>

Talk address the Source to enable response:
115.0 <cr><lf><eos>

Transmit fetch current command:
FTH CURR <cr><lf><eos>

Talk address the Source to enable response:
5.2 <cr><lf><eos>

Transmit fetch frequency command:
FTH FREQ <cr><lf><eos>

Talk address the Source to enable response:
50 <cr><lf><eos>