USER'S GUIDE AND
TECHNICAL REFERENCE

AC SOURCE

BEHLMAN MODEL BL20000 SERIES

FOR SERVICE ASSISTANCE

CONTACT BEHLMAN
CUSTOMER SERVICE DEPARTMENT

PHONE TOLL FREE 1-800-874-6727

OR WRITE

BEHLMAN
CUSTOMER SERVICE DEPARTMENT
80 CABOT COURT
HAUPPAUGE, NY 11788

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

FOR SALES INFORMATION:

PHONE: (631) 435-0410
USA : (800) 874-6727
FAX : (631) 951-4341

DATE: 2/13   REV. E

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. Batteries are warranted for 30 days from date of purchase.

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.

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.

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.

PACKING INSTRUCTIONS

<u>RACK MOUNTED UNITS</u>

1) Box (es) must be double wall with minimum 350 lbs. bursting test.

2) Box (es) must provide for a minimum of 2 to 3 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.**

DO NOT USE PEANUTS OR BUBBLE

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.

DO NOT USE UPS

<u>CABINET MOUNTED UNITS</u>

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 crates base. The crate must be shock mounted to avoid damage during shipping.

Detail drawings for Behlman's crates are available upon request.

SAFETY SUMMARY

The following safety precautions must be observed during all phases of operation, service, and operation 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.

GROUND THE EQUIPMENT

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 and a five wire connection for three phase applications. Both types include an earth terminal intended for safety ground connections. In addition, installation sites may require neutral to earth connections as per NEC section 250 (National Electrical Code). Refer installation to licenced 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.

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.

TABLE OF CONTENTS

BEHLMAN AC SOURCE, MODEL BL20000 SERIES

TABLE OF CONTENTS (cont)

BEHLMAN AC SOURCE, MODEL BL20000 SERIES

SECTION 1

INTRODUCTION

1.1   GENERAL DESCRIPTION

The Behlman AC Source models (table 1) are sophisticated ac power supplies. Each of the models provide independent verification of operating voltage, current, and frequency values thereby lessening the need for external measuring devices. All models provide a single voltage range output.

Any of the models can include all or any combination of the available options if desired (see OPTIONS listed below table 1).

TABLE 1. BEHLMAN BL20000 MODELS

MODEL	INPUT VOLTAGE (ac)	OUTPUT VOLTAGE (ac)
BL20000C1	120V/208V	0 - 135V, 3φ
BL20000C2	220V/380V	0 - 135V, 3φ
BL20000C3	277V/480V	0 - 135V, 3φ
BL20000C4	200V Δ	0 - 135V, 3φ
BL20000C5	346V/600V	0 - 135V, 3φ
BL20000C6	230V/400V	0 - 135V, 3φ

OPTIONS: Add E to the dash number for extended frequency range.
Add I to the dash number for Remote GPIB IEEE-488 Interface.
Add IR to dash number for Remote RS-232 interface.
Add L to the dash number for front panel locking controls (VOLTS, FREQ)
Add S10 to the dash number for chassis slides.
Add T15 to the dash number for custom voltage ranges may add additional chassis.
Add T15D to the dash number for dual voltage ranges 0-150/300 add 7.0" chassis.
Add value for V option (fixed output voltage) example :BL15000C-1-115 = fixed 115V
Add value for F option (fixed frequency) example : BL20000C-1-115/400 = fixed 115 @ 400Hz

Engineering specials will have a four digit suffix added to the model #

1.2 SPECIFICATIONS

INPUT POWER

Voltage:	**See Table 1**
Frequency:	**47-63 Hz.**

OUTPUT POWER

Voltage:	**See Table 1**
Frequency:	**45-500 Hz (setting resolution 1Hz) or F option fixed @ +/- 1%** **Option E: 45 - 1000Hz**
Maximum Power:	**18000 VA (3 phase total)continuous, 20,000 VA for 20 minutes**
Maximum Current:	**50 amperes per phase for 0-135 V output** **22 amperes per phase for Option T20, 300 V output.**
Current Crest Factor:	**3:1**
Power Factor:	**100% of rated output into any power factor load.**
Distortion:	**1.5% maximum THD (measured at full load, 100 Vac, 50 Hz).**
Load Regulation:	**±0.7% from no load to full load.**
Line Regulation:	**±0.1% for ±10% of line change.**
Efficiency:	**85-90%**
Metering:	**Voltmeter Accuracy: +/-2% of range +/-1 digit (1 volt resolution)** **Ammeter accuracy: +/2% of range +/1 digit (0.1 amp resolution)** **Frequency Meter: +/-2 % of range +/- 1 digit (1 Hz resolution)**

MECHANICAL

Dimensions:	**22.1 in. wide, 28.3 in. high, 31.6 in. deep.**
Weight:	**425 lbs. (without options)**
Operating Temperature:	**0°C to 55°C (32°F to 131°F).**
Safety:	**Designed to meet the general safety requirements of** **IEC-61010-1 . Equipment class 1 , Light Industrial.**

1.3   SPECIAL UNITS

BEHMAN has produced many special versions of the BL series supplies over the years and will continue to offer specials to our customers. These specials are usually in the form of customer specified output voltages, special control functions, or special waveforms (square wave is one example). With this in mind it should be noted some of the information (including specifications) contained in this manual may not be applicable to the unit shipped.

All special units will be designated by a four digit "engineering" number following the model number indicated on the power supply rating tag (identification label). This number refers to an engineering file that contains modification instructions and (or) drawings related to the special unit. This information may or may not be included in this manual. Unless specified by purchase contract, the decision to include this information in this manual is reserved solely by Behlman .

All special unit manuals will include an addendum that explains the modification and refers to any special operating considerations required by the modification. Any exceptions to standard unit specifications will also be addressed by the addendum. When ordering replacement or additional manuals , make sure to check the ID label on the power supply so that any addendums may be included.

CE marked units are available and may include additional filtering (on input line) as well as EMI (Electro Magnetic Interference) suppressing cable assemblies added to various parts of the units. Units certified with "CE" mark for electro-magnetic compatibility will have the following additions:

1.   Input line filter   Behlman P/N 108-115-060

2.   Various Ferrite   Behlman P/N 110-012-001
       Inductors   Behlman P/N 110-013-005 & 110-013-019

The Ferrite inductors are added to input and output wiring of the control chassis. The line filter is added to the input chassis. All other parts and specifications are un-changed.

ALL MANUAL ADDENDUMS WILL FOLLOW THIS PAGE

2.1 UNPACKING

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

2.2 INSTALLATION

⚠ **IMPORTANT**

1) **This device must be installed and operated by qualified persons only. The content of this manual must be reviewed prior to use.**

2) This unit is assembled in an EIA standard rack cabinet. It consists of a removable control chassis and integral DC power supply. Connections to the DC supply are factory provided. External connection are made through an access hole located at the bottom rear of the cabinet. The installation site must provide proper cooling air circulation. Cool air is drawn in through the rear of the control chassis and heated air is exhausted out of the lower exhaust fan mounted to the rear door. The cabinet rear door must be installed and closed during normal operation. Door Locks and keys are provided for safety.

3) Ensure that the line circuit breaker and all other unit controls are in the OFF position before connecting input power. Use **only** the lower screws when connecting wires to the control chassis terminal blocks. Turning or removing the upper screws will loosen internal hardware and will cause damage to the unit.

4) All wiring should enter through the access hole in the bottom rear of the cabinet. Strain relief and mechanical protection for wiring must be supplied by the end user. Connect 3 phase units as follows: (refer to inter-connect diagrams provided on following pages.)

   a) INPUT POWER- Connect 47-63 Hz, power lines to the rear panel terminals designated , φA, φB, φC, and neutral (required for all inputs above 240V L-N) on the AC INPUT terminal block at the bottom of the power chassis. Re-install all provided safety covers.

   b) OUTPUT POWER- Output power lines are connected to designated terminals, φA, φB, φC, and neutral provided on the control chassis (or on the output chassis supplied with "T" option). Refer to figure 2-1. Re-install all provided safety covers.

   c) Interconnection between chassis:

   Standard units have hardwired DC connections and are factory connected to the control chassis.

   d) On all units, a chassis mounted stud is provided to connect a protective earth to each metal chassis. **This connection is required to provide operator safety** and reduce EMI emissions.

IMPORTANT NOTE:

If this unit is to be installed as part of a permanent power source with wiring distributed in a building the user is responsible for conformance to local electrical codes. The National Electrical Code (NEC),section 250 , requires that all separately derived AC power sources (generators, inverters, etc.) must have one conductor tied to earth. This is similar to the concept of the neutral conductor in domestic power distribution systems. This connection may be provided by connecting the input neutral to the output neutral or connecting the output neutral to the chassis ground (assuming the chassis is tied to earth). See figure 2-x . Consult local codes and a licenced electrician.

2.3   3 PHASE INPUT POWER REQUIREMENTS

The total input Volt/Ampere requirement for this equipment is approximately 22500 V/A.. This number is based on a balanced, purely resistive load applied to the output at 135Vac. The actual input V/A product is somewhat dependent on the quality and impedance of the input line provided to it. The BL20000 series power supplies within the model number range C2 to C6 are designed to be used with a four wire " Wye" input configurations. Delta configurations above 277 volts require the addition of back-up fuses for proper safety. The chart below indicates the proper fuse based on the model number of the power supply.

The following lists should be used to select the proper line fuse size for the model numbers shown. The selections are based on nominal line voltages and maximum output power. All fuses carry a 600 Vac rating. DO NOT substitute any other fuse voltage . See warning on following page.

MODEL #	L-L VOLTAGE	FUSE SIZE	PART NUMBER
BL 20000 - C2	380V	30 AMP / 600V	108-201-025
BL 20000- C3	480V	30 AMP/ 600V	108-201-025
BL 20000- C5	600 V	25 AMP/ 600V	108-201-024
BL 20000- C6	400V	30 AMP/ 600V	108-201-025
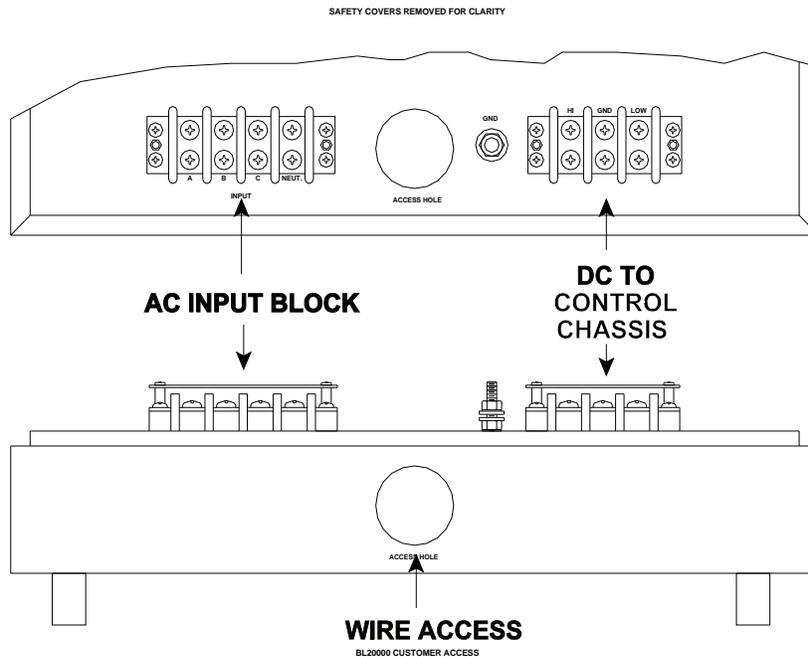
FIGURE 2-1 WIRE ACCESS TOP/BOTTOM VIEW

2.3   3 PHASE INPUT POWER REQUIREMENTS   (continued)

<div align="center">

⚠️ **WARNING**

</div>

SUPPLEMENTAL PROTECTION FOR ALL 277 - 600V DELTA INPUTS.

Units supplied with a Wye or Delta connection higher than 277 (line to neutral) require back-up fuses for proper protection. These fuses should be rated at least 600V at a current rating of no more than 30 amps. The fuse interrupt rating is dependant on the installation site capacity. Consultation with an experienced electrician is recommended. The interrupt rating of the power supply's front panel breaker is 10KA @ a maximum of 277Vac.

2.4   UNITS WITH T20 OR T20D OPTIONS

The diagram below illustrates chassis inter-connection for units provided with the T15 or T15D options. The T15D units are dual range versions of the standard T15 type. As shown below this option includes an additional internal step-up transformer assembly mounted to the side panel of the lower half of the equipment cabinet. Output lines connect to the AC OUTPUT terminal block mounted to this panel.

Units supplied with T20 options may vary slightly depending on actual customers requirements. Units with a or 0 to 300 Vac output are considered standard. Units supplied with other voltages will be assigned a 4 digit engineering number. T20 units require some special operating considerations. Refer to section 3 of this manual for operating instructions. T20 unit are pre-wired at the factory.

2.5   Installation Considerations

This device relies on the proper flow of air to provide internal cooling. Failure to provide this will cause intermittent shut down of the unit due to overheating and will affect the long term reliability. Air is taken into to the unit through "grills" in the front and side of the unit. A distance of at least 6 inches must be maintained between the front intake and any obstruction. Likewise, the heated air is exhausted through grills in the rear panel. A distance of four inches is required between the rear panel and any obstruction to prevent "back pressure" from severely reducing air flow.

This device is intended for use in a relatively clean environment . For this reason, air filters are not provided on the intakes. If air filtering is desired, it may be added at the expense of reduced air flow. This may result in some required de-rating of the output power available from this unit.

An additional "stud" has been included on the rear panel of this device. This point may be used for a protective earth connection to the chassis. This is also a convenient tie point for a "bonding" conductor or other chassis grounding arrangement. Refer to figure 2-4 below.


Figure 2-4

 WARNING
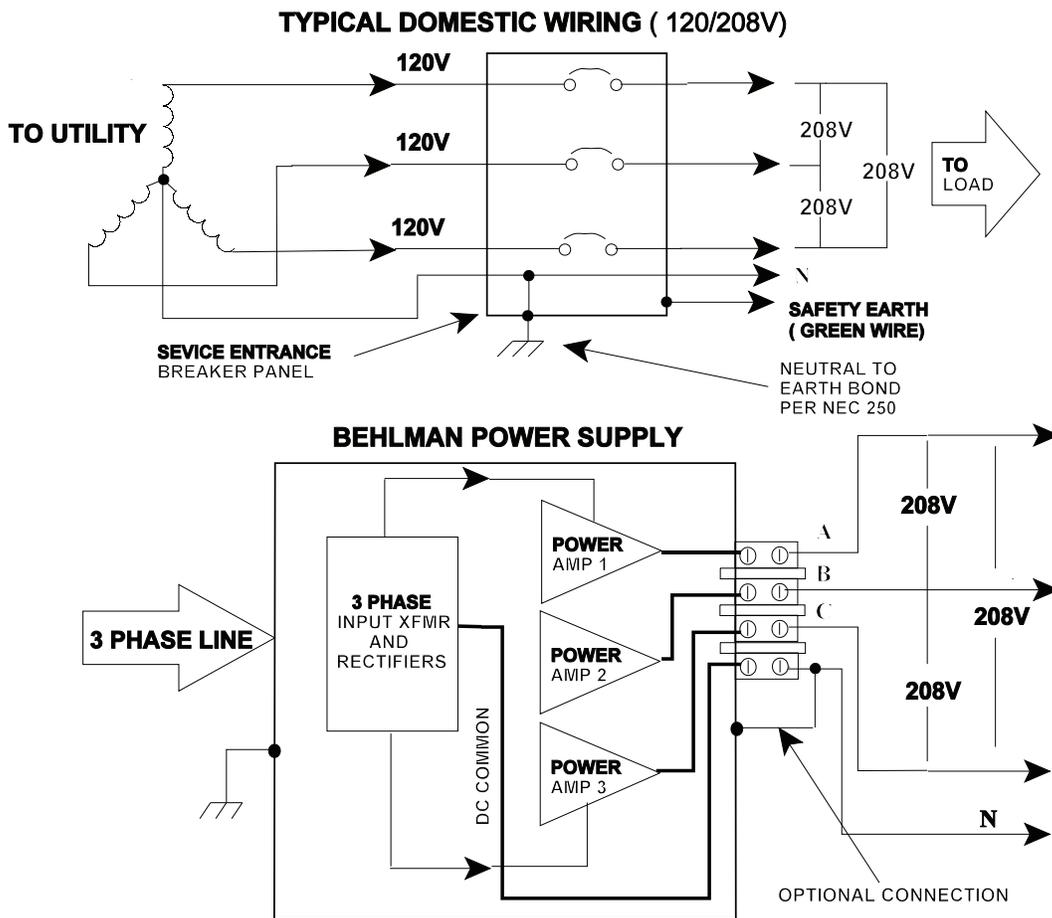
This equipment involves the use of voltages and currents that can be hazardous. Only qualified personnel should be allowed to operate or service it. All covers and doors must always be in place during operation.

3.1   CONTROLS AND INDICATORS

Table 1 lists the controls and indicators used on the Model BL20000 AC Source. The table also includes their function. Figure 3-1and 3-2 locate these front panel controls and interconnection terminals.

3.2   TO OPERATE THE EQUIPMENT

1)   Ensure that line circuit breaker and OUTPUT switch are set to OFF. Set the VOLTS control fully counter- clockwise.

2)   Connect suitable load across output terminals. (Do not exceed rating of unit.)

3)   Set line circuit breaker of power chassis to ON (cooling fan noise should become evident).

4)   Set the Meter Select switch to Phase A..

4)   Rotate VOLTS control to desired voltage as indicated on the VOLTS display.

5)   Rotate the FREQ control to desired frequency as indicated on the FREQ display.

6)   Set OUTPUT switch to ON to energize load. The load current is indicated on the AMPS display. The meter switch may now be set to monitor the other phases.

NOTE

It is also permissible (and sometimes desirable) to energize a load gradually by setting the OUTPUT switch ON and rotating the VOLTS control from zero to low voltage position up to the voltage desired.

3.3   SHUTDOWN PROCEDURE

1)   Set OUTPUT switch to OFF.

2)   Rotate VOLTS control completely counter-clockwise.

2)   Set line circuit breaker to OFF.

The output switch may be used to switch the load on or off. It controls a relay located in the control chassis. The useful life of this relay will be affected by high in-rush load currents. To extend relay life, it is better to switch the output off /on with the voltage set to zero. Extremely high in-rush currents may activate the unit's short circuit detection. See section 3 for further details.

The table below lists the various controls and indicator associated with this equipment.
Figure 3.1 on the following page illustrates the location of the items listed in the table.

TABLE 3- 1. CONTROLS AND INDICATORS		
1	CIRCUIT BREAKER	Controls application of line power to equipment**.** (on main cabinet)
2	**VOLTS** control	Multi-turn control used to set the output voltage.
3	**FREQ** control	Multi-turn control used to set the output frequency.
4	**OUTPUT** switch	Controls internal power relay to allow on/ off switching of the load connected to the output terminals**.**
5	**RANGE** switch	Provided on TD option units only. Used to select output voltage range.
6	**PHASE** adjust trim	Allows adjustment of electrical phase difference between outputs. Factory set to 120 electrical degrees. Approximate range +/- 45 degrees**.** See operating instructions.
7	**LINE DROP COMP** adjust	Provides compensation for resistive losses (I/R) in output wiring . One trimmer for each phase. See operating instructions.
8	DIGITAL READOUTS	A 3 digit LED readout is provided for : Voltage, Current, & Frequency. The voltage and current displays indicate the True RMS value.
9	METER SELECTOR	A 3 position rotary switch selects which phase is currently displayed on the front panel digital displays.
10a	**C. CURRENT** indicator	Illuminates to indicate the power supply is operating in the constant current protection mode. The output voltage is reduced to limit the current and maintain a sine wave current into an overload.
10b	**OVER-TEMP** indicator	Illuminates to indicate the power source is disabled due to excessive internal temperature. The power source will recover once the temperature falls below a safe limit.
10c	**OVERLOAD LATCH** indicator	Illuminates to indicate the power supply is disabled due to excessive output current or short circuit. The power supply must be turned off for at least 30 Seconds to clear this type of fault.
11	**AC OUTPUT**	Provides load connections. 1/4" inside diameter ring lugs recommended. **USE LOWER SCREWS ONLY!**
12	**REMOTE PRGM**	9 pin "D" connector provided for remote analog control inputs . See operating instruction in section 3.4
13	**GND** stud	Heavy stud for earth connection**.**
14	**DC INPUT**	Used to connect +/- 250VDC from lower input chassis to control chassis. Standard units are factory wired.
15	**Control Terminals or Optional temp sense**	Optional Terminal connection. Used for thermal switch on CE type units. Used for fan and output relay control on T15 units. The temp switch monitors the input power supply temperature and will shut down the output relay if overheating should occur.

The figure below locates the items listed in table 3-1
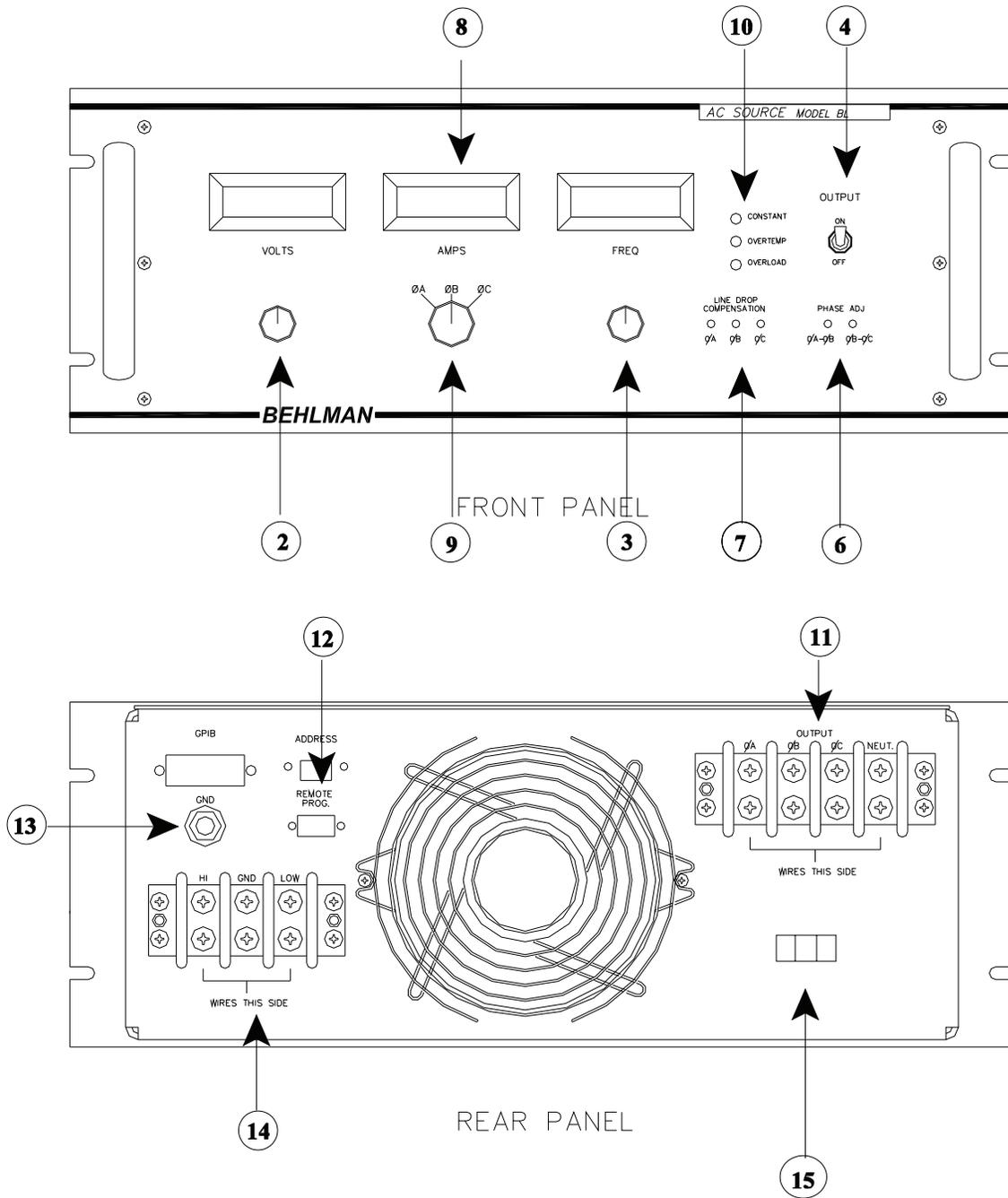

Figure 3-1 BL20000 CONTROL CHASSIS

CONTROL CHASSIS →

CIRCUIT BREAKER →

FRONT VIEW

**CONTROL CHASSIS
REAR VIEW** →

REAR VIEW WIRING ENTRY
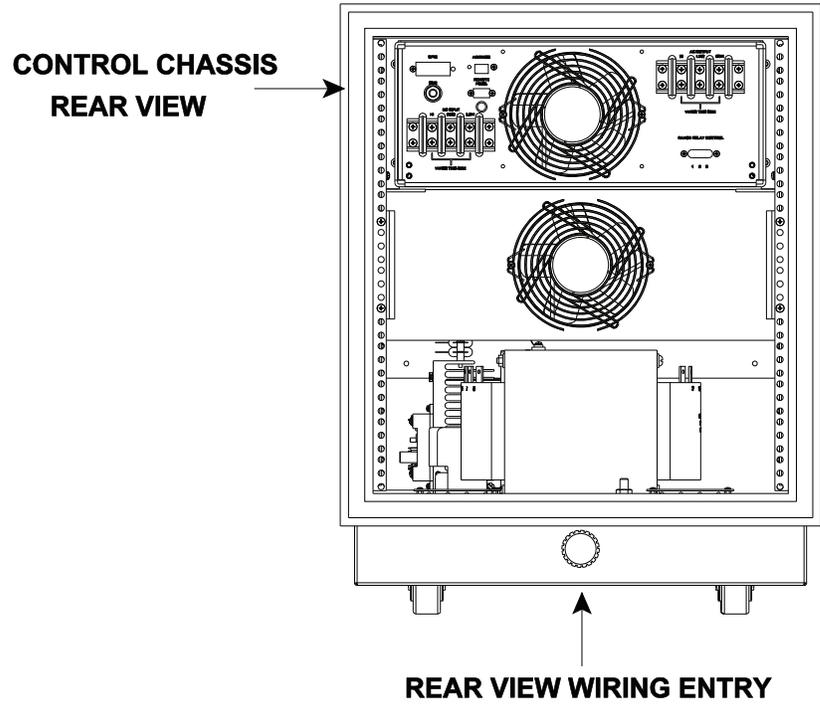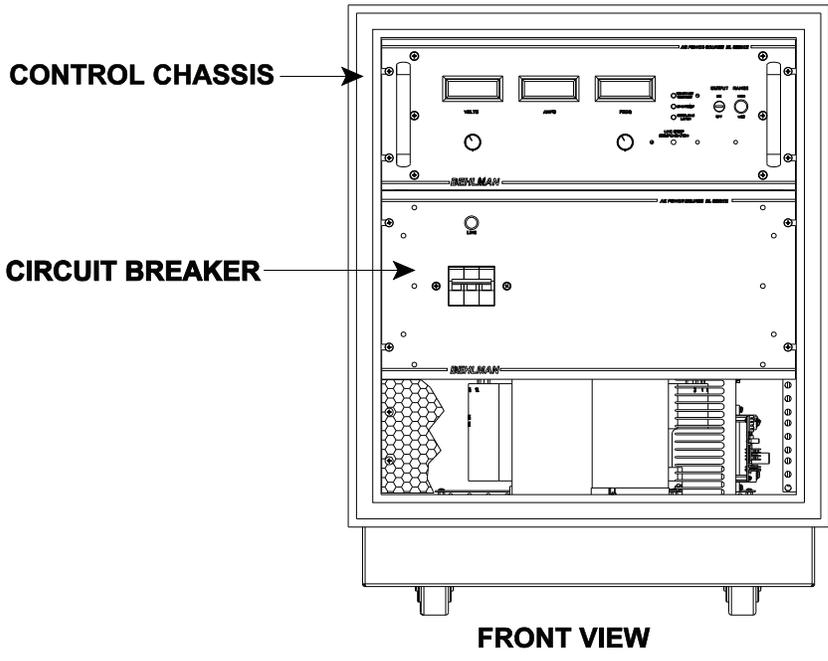
Figure 3-2 Typical BL 20000 Front and Rear Panel Views

3.4. REMOTE PRGM CONNECTOR

⚠ WARNING

The remote control connector ties to points which may become hazardous live under certain fault conditions. The common of this circuit is directly connected to the power supply common point (DC common). Any connection between this device and external equipment should provide isolation to prevent a potential shock hazard. Connection to ITE equipment (computer terminals, printers, faxes, etc.) requires isolation per IEC or UL/ 60950. This interface is not rated for direct connection to ITE equipment.

The REMOTE PRGM connector is a nine-pin female "D" connector located on the rear panel. It provides remote analog control of the power source's amplitude, frequency, output relay, and voltage range (TD option only). A mating nine pin male connector is required for connection. It is recommended the user use multi-conductor shielded wire to fabricate the control cable. Table 3-2 lists the connector pin descriptions and functions. During remote operation, the unit's front panel VOLTS and FREQ controls must be set fully counter-clockwise

3.4.1 REMOTE AMPLITUDE AND FREQUENCY CONTROL

Two 0-10 Vdc control voltages from externally isolated voltage sources are used to control the unit's amplitude and frequency via the fabricated remote cable. Note the control inputs are tied to the power circuit common. This point is not the same as chassis potential unless externally connected (see wiring info)

TABLE 3- 2. REMOTE PRGM CONNECTOR PIN DESCRIPTIONS

PIN	FUNCTION	DESCRIPTION
1	External synch HI	The power source will lock to the frequency of the signal applied to this pin. See external sync below.
2	External synch LO	Isolated return for sync signal.
3	DC control common*	Common return of power source . CAUTION see note 1
4	Amplitude control (hi)	0-10V applied controls output voltage from 1 - 100%. Input impedance greater than 50K ohms. 300msec response.
5	Frequency control (hi)	0-10V applied controls output frequency from 45 -500 Hz. Input impedance greater than 20K ohms.
6	Output relay control	Application of short to pins 6-7 will activate the output relay.
7	Output relay control	Application of short to pins 6-7 will activate the output relay.
8	Range relay control	Application of short to pins 8-9 will activate the output relay. This function is provided with TD option only .
9	Range relay control	Application of short to pins 8-9 will activate the output relay. This function is provided with TD option only .

3.5 EXTERNAL SYNC

The unit provides for external synchronization via its rear panel REMOTE PRGM 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.

3.5 **EXTERNAL SYNC** (continued)

⚠ **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 **ADJUSTMENT OF LINE DROP COMPENSATION**

The line drop compensation trim pots on the power source front panel allows the user to compensate for resistive loses in the load wiring. One trimmer is provided for each of the three output phases. And external voltmeter with 0.1V resolution is required to properly set this trimmer. **Always use a non-metallic screwdriver for this adjustment.**

1.) With the Unit on and stabilized, note the voltage indication on the front panel meter for phase A . Apply the desired load and use an external voltmeter (as close to the load as practical) to measure the voltage supplied to the load terminals A and Neutral.

2.) Using an insulated screwdriver, adjust the front panel "LINE DROP COMP" to bring the load terminal voltage to the same value as that indicated by the front panel voltmeter. This will compensate for I/R drops due to the load wiring. Note, Line drop comp will not work without a load applied.

3.) Repeat steps 1 and 2 for the remaining phases.

3.7 **PHASE ADJUSTMENT**

⚠ **CAUTION**

MIS-ADJUSTING PHASE ANGLES CAN CAUSE A LARGE IMBALANCE IN DELTA CONNECTED LOADS AS THE LINE TO LINE VOLTAGE ARE AFFECTED. DO NOT ATTEMPT TO ADJUST PHASE UNLESS THE IMPACT ON THE LOAD IS UNDERSTOOD.

Two front panel trim controls are provided for phase angle adjustment. To adjust the phase shift between two phases, proceed as follows: **USE NON METALLIC SCREWDRIVER**.

1) Connect an external DVM between φA and φB on the output terminal strip.

2) Turn on circuit breaker and output switch and adjust output to 100 VRMS.

3) To produce a phase shift between phase A and phase B, adjust phase difference between φA - φB until external DVM indicates the Vrms value required to produce the desired phase angle. Use the table below as a guide. It shows five predetermined values. For in-between phase angles, use the formulas shown.

DVM (Vrms)	Phase Angle(°)	$V = [(1-\cos \phi)\,20,000]^{1/2}$ $\phi = \cos^{-1}[1-V^2/20,000]$
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	

4) Connect DVM across φB and φC and repeat and adjust φB - φC trimmer for the desired phase shift between phases B & C .

3.8   OPERATIONAL CONSIDERATIONS

GENERAL

All BL series incorporate an input rectifier system followed by a capacitive filter. To limit the in rush current to the unit, a soft start circuit is employed. This circuits prevents nuisance tripping of protective circuits in the line circuits as well as reducing stress on internal components . When the unit is switched off for any reason a period of about 30 to 60 seconds is required to allow the soft start circuit to "reset" . Failure to do so may cause the front panel breaker of the power supply to trip repeatedly as power is reapplied. This may lead to eventual failure of the breaker. In automated systems, a time delay relay should be considered to handle power interruptions.

OPERATION INTO LINEAR LOADS

The BL series 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 0 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)		Most Solenoids

Operation into these types of loads usually cause little interaction with the output stage of the model BL6000. The main concern with a linear load is the "in-rush" current associated with it. Most heating elements and resistors have no in-rush 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.

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 in-rush 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 in the form of 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.

DRIVING LAMPS

 Tungsten filaments lamps, when cold, present a very low resistance. Once they are energized, their resistance quickly climbs to it's 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**.**

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 in rush current that usually occurs over the course of one or two cycles of the AC waveform.

3.8   OPERATIONAL CONSIDERATIONS

DRIVING MOTORS (continued)

 The BL series 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 output current for the range in use. During this time the current supplied to the motor will remain sinusoidal, this allows the motor to start rotating. Once the motor reaches it's normal operating speed, it generates the required "back EMF" and the supply current drops off to the nominal "run" current for the motor.

DRIVING NON-LINEAR LOADS

 Loads utilizing rectifiers and SCRs interact with the AC power source and have a profound effect on the distortion of the output waveform. Consider the use of a bridge rectifier followed by a capacitive filter, 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. 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 dependant 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 should not be associated with a defect of the power source. Most "real world" electric distribution systems exhibit this distortion for this reason.

OUTPUT NOISE

 Because the BL series uses a high frequency PWM conversion technique, a certain amount of output noise or ripple is to be expected. The amount of noise present 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 unit being tested as it may not pass the European EMI tests.

 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 at 400Hz. 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.

T20 & T20D UNITS

Adding the external transformer chassis will affect the regulation specifications of the power supply when measured at the transformer secondary. This is due to the winding resistance of the transformer and will vary depending on which transformer is used. Higher voltage transformers tend to exaggerate this effect. An internal "boost" circuit as been added to the control chassis to minimize this drop in voltage versus load current. The boost circuit works very similar to the "Line Drop Compensation" provided on the control chassis (see operating instructions).

INPUT SOFT START CIRCUIT

These power supplies use a simple circuit to limit in-rush current at turn on. This prevents tripping of the unit's front panel breaker and any other protection devices in-line. This circuit uses a simple relay and current limiting resistors which are "shorted out" once the internal operating voltages rise to a certain level. It the unit is powered down, a period of about 30 seconds is required to allow the circuit to "reset". Failure to do so put unnecessary stress on all components involved.

⚠ **WARNING**

This procedure involves the use of voltages and currents that can be hazardous. Only qualified personnel should be allowed to operate or service it. This procedure requires the removal of guards and covers and will expose personnel to hazardous voltages.

Before performing any adjustments where access to the inside of the equipment is required, be sure to turn off the unit and allow five minutes for the DC power supply capacitors to discharge.

4.1   MAINTENANCE

IMPORTANT :

FAILURE TO MAINTAIN OR OPERATE THE UNIT PROPERLY WILL VOID THE WARRANTY. AMONG THE ABUSES THAT ARE INCLUDED (BUT NOT LIMITED TO) ARE:

NOT MAINTAINING THE CLEANLINESS OF THE FILTERS (VACUUMING), OPERATING OUTSIDE THE ALLOWABLE ENVIRONMENT, AND PHYSICALLY DAMAGING THE UNIT.

The decision on whether a units warranty is voided will be exclusively reserved for Behlman.

4.2   ADJUSTMENTS

NOTE

All the potentiometers used in the procedures that follow are located on the controller card A1. See the printed wiring assembly in Section 6 for parts location. Always use a non-metallic screwdriver when adjusting potentiometers.

4.2.1   TEST EQUIPMENT REQUIRED

TEST EQUIPMENT	MANUFACTURER/MODEL
Current Clamp	0 -150 A (Fluke 80I-600 or equivalent current transformer)
Digital Voltmeter	(DVM) Fluke 80 series True RMS type (or equivalent)
Frequency Counter	HP 5314A (or equivalent, Fluke 80 measures frequency)
Oscilloscope	2 channel, min 20KHz Bandwidth with 10:1 probes.
Test Loads	3 X 3.6 ohms @ 5 KW each +/- 5% or equal Alternate values will be needed for T15 option units**.**

4.2.2 CONTROLLER CARD POTENTIOMETER ADJUSTMENTS

Since certain potentiometer adjustments affect other associated potentiometer settings, a sequence of adjustments must be followed to ensure the proper setting of each potentiometer within the three groups comprising the unit. The three groups: frequency, voltage, and current, are listed below in the sequence to be performed within each group. Note that each phase control card (106-944-00X) contains three adjustments. One for overall Gain (R29) , one to calibrate the voltage display (R61) and one to calibrate the current display (R58). The frequency is determined by the motherboard adjustments. There are no individual frequency adjustment as all phases control boards receive the same clock signal.

FREQUENCY		VOLTAGE		CURRENT	
POT.	PARA	POT.	PARA	POT.	PARA
R15	4.2.3	R29	4.2.6	R58	4.2.9
R16	4.2.4	R61	4.2.7		
R19	4.2.5				

4.2.3 LOW FREQUENCY TRIM (45 Hz R15)

1)   Connect frequency counter to rear panel **φA** and **NEUT** terminal strip.

2)   Turn the **FREQ** control fully ccw.

3)   Set the power circuit breaker to ON.

4)   Set the **OUTPUT** switch to ON

5)   Set the selector switch to **φA.**

6)   Adjust **the VOLTS** control clockwise until volts meter indicates 10 Vrms minimum.

7)   Adjust the 45 Hz potentiometer R15 until the frequency counter indicates 45 Hz.

4.2.4 HIGH END FREQUENCY TRIM (500 Hz R16)

1)   Turn the **FREQ** control fully cw.

2)   Adjust the 500 Hz potentiometer R16 until the frequency counter indicates 500 Hz.

4.2.5 FREQUENCY METER ADJUST Hz-METER (R19)

1)   Turn the **FREQ** control fully ccw.

2)   Adjust Hz-METER potentiometer R19 until the DUT frequency meter indicates 500 Hz.

4.2.6 FULL SCALE OUTPUT VOLTAGE ADJUST (R29)

1)   Using a DVM set to ac volts, connect it across rear panel **φA** and **NEUT** on output terminal strip.

2)   Turn the **VOLTS** control fully clockwise.

3)   Set the circuit breaker of power chassis to **ON**.

4)   Set the **OUTPUT** switch of the control chassis to **ON**.

5)   Adjust R29 until the external DVM indicates 135 VMS..

4.2.7 VOLTAGE METER ADJUST (R61)

1)   Set the meter selector switch to φA.

2)   Adjust F.S. potentiometer R61 until the DUT front panel voltage meter indicates the same as theDVM.

3)   Repeat 4.2.6 and 4.2.7 for φB and φC.

4.2.8 CURRENT METER ADJUST (I-METER R58)

1)   Set the circuit breaker to **OFF**.

2)   Set the **OUTPUT** switch to **OFF**.

3)   Turn the **VOLTS** control fully ccw.

4)   Connect a test load to **OUTPU**T terminals **φA** and **NEUT**.

5)   Connect an AC current clamp or other current measuring device to measure phase A load current.

6)   Set the circuit breaker to **ON**.

7)   Set the **OUTPUT** switch to **ON**.

8)   Set the meter selector switch to **φA**

9)   Adjust the **VOLTS** control, making certain it does exceed 50 amps, to 100 VRMS. Increase load until current reading on the measuring device is about 50 amps.

10)   Adjust I-METER potentiometer R58 on **φA** board until the front panel current meter indication is same as load current noted in step 9.

11)   Repeat 4.2.8 for **φB** and **φC**.

4.2.9 20 KHz TRIANGLE WAVE TRIM (DIST. TRM R34)

1)   Turn the **VOLTS** control fully ccw.

2)   Connect an oscilloscope across output terminals **φA** and **NEUT**

3)   Set the oscilloscope gain to 500 mV/div.

4)   Adjust DIST. TRIM potentiometer R34 for the smallest "ripple" waveform peak-to-peak value.

4.2.10 LINE DROP COMPENSATION TRIM

1)   Connect selected load to **OUTPUT** terminals **φA** and **NEUT**.

2)   Connect a DVM at the load terminals so as to measure the I/R voltage drop from the connecting lines.

3)   Set circuit breaker to **ON**. Set the **OUTPUT** switch to off. Set the meter to phase A.

4)   Adjust the **VOLTS** control to desired setting as displayed on the DUT front panel.

5)   Set **OUTPUT** switch to ON and note the voltage displayed on the DVM at the load.

6)   Adjust front panel **φA I.R. COMP** potentiometer so that voltage at the load matches the value set in step 4.

8)   Repeat 4.2.10 for φB and φC.

4.3   PHASE ADJUSTMENT

To adjust the phase shift between two phases, proceed as follows:

1)   Connect a DVM between φA and φB on the output terminal strip.

2)   Turn on the circuit breaker and output switch and adjust the **VOLTS** control for an output of 100 VRMS.

3)   To produce a phase shift between phase A and phase B, adjust phase difference between φA - φB until DVM indicates the Vrms value required to produce the desired phase angle. Use the table below as a guide. It shows five predetermined values. For in-between phase angles, use the formulas shown.

DVM (Vrms)	Phase Angle(°)	
		$V = [(1-\cos \phi) \, 20{,}000]^{1/2}$
		$\phi = \cos^{-1} [1-V^2/20{,}000]$
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	

4)   Connect the DVM across φB and φC outputs and repeat 4.3.1.

SECTION 5
THEORY OF OPERATION

5.1 GENERAL

5.1.1   The BL High Power series represents low cost, high performance, AC to AC power invertors. These units provide variable output voltage and frequency from 0 to 135 Vac and 45 to 500 Hz respectively. This series may be operated from a 120/208 Vac, 220/380 Vac 277/480 Vac, 200 Vac (Delta), or 346/600 Vac three phase input line at 50 or 60 Hertz. Other versions include higher single phase outputs and external step-up/down output transformer options.

5.2 INPUT POWER

5.2.1   The BL series models consist of two basic sections, and input power chassis (DC power supply) and an inverter/control chassis. The incoming line voltage is connected to the input chassis where it is applied to a multi-pulse transformer/rectifier system. The output of the rectifier circuit is applied to a large bank of electrolytic capacitors to provide the required filtering. The output of the power chassis is a bipolar DC voltage of +/-250 Vdc centered around the circuit common. Additional circuitry is incorporated to provide in rush current limiting and overload protection.

5.2.2   In rush surge limiting is provided by placing large power resistors in series with each of the input phases and the power chassis transformer primary. During power up, these resistors limit the current surge to the filter capacitor bank. Once full voltage is reached, a relay is used to bypass the limiting resistors allowing normal operation.

5.2.3   Over current protection of the DC supply is provided by the multi-pole input circuit breaker. Additional protection is provided by fast acting semiconductor fuses located in the control chassis.

5.2.4   The output of the power chassis is available at a rear mounted terminal block. Connection to the control chassis is afforded by supplied jumper cables. Note that the length of these cables is somewhat critical. Do not substitute with longer cables.
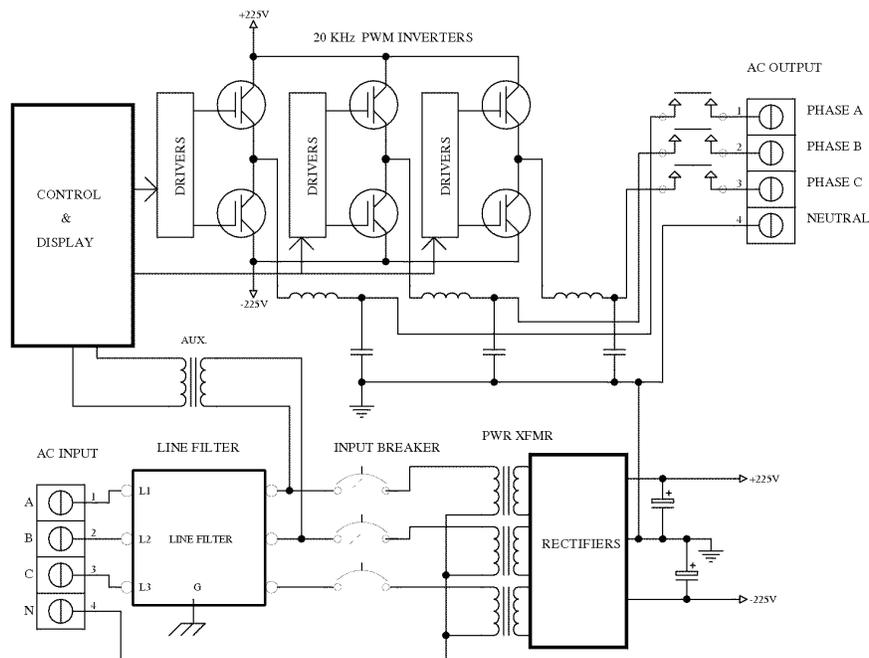
5.3   CONTROL CHASSIS

5.3.1   The control chassis contains the main power inverters, bias, and control circuitry. The diagram of Figure 1 depicts the basic functional blocks. Note that in the case of the three phase units, only one phase is illustrated as the others are identical. The circuitry is configured so that each of the three "Phase Control Cards" plug into a "Motherboard". The output devices and output filter components are mounted on separate assemblies.

5.3.2   Bias power for the control chassis is derived from the +250 Vdc rail. This voltage is applied to the Motherboard. All other operating voltages are provided by the Motherboard.
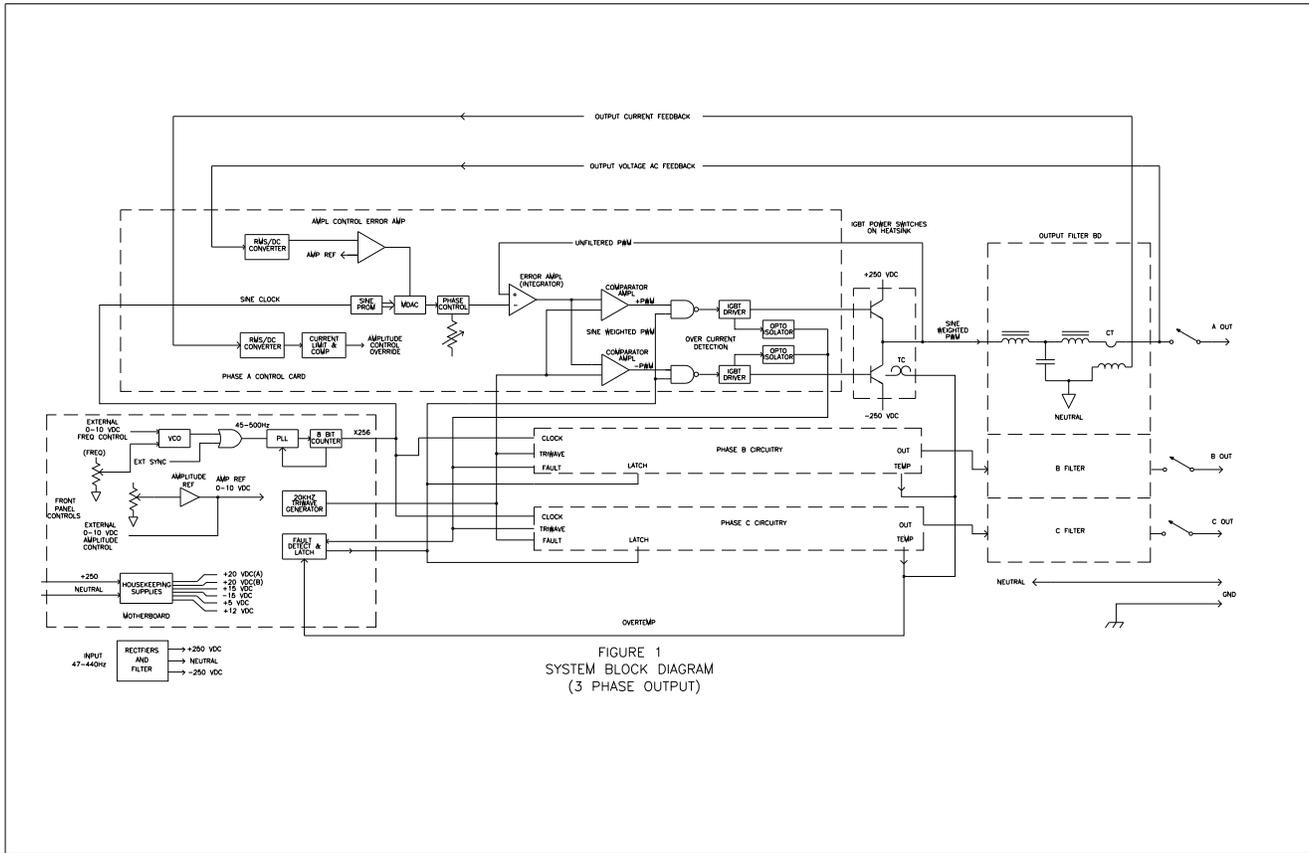

Figure 5-1. System Block Diagram

5.4   MOTHERBOARD

5.4.1   The Motherboard uses a flyback type inverter to provide the following low voltage supplies.

    a.   +/-15 Vdc for analog circuits
    b.   +5 Vdc for metering circuits
    c.   +12 Vdc for fans and relays
    d.   isolated supplies for IGBT drivers

A quick indication of the supply status is provided by LEDS connected to each supply output.

5.4   MOTHERBOARD (continued)

5.4.2   The variable frequency 45 to 500 Hertz square-wave is generated on the Motherboard. A CMOS phase locked loop (U5), and 8 bit counter (U6) and Voltage Controlled Oscillator (U7) are the basis for the square-wave generator. The front panel frequency control sets a DC voltage which determines the frequency of the VCO. The VCO generates a square-wave at a frequency between 45 and 500 Hertz. This square-wave is used as a reference signal for the PLL. The frequency of the VCO is multiplied by a factor of 256 by the PLL. The resultant is used as a clock signal for the 8 bit counter.

5.4.3   In order to produce data in the form of a sinewave, a "Look-up" table is stored in a PROM on each phase control card. The outputs of the 8 bit counter are tied to the address lines of each PROM. As the clock runs, the data in the PROMS are clocked into the D/A convertors. This action produces a series of steps at the output of the D/A convertor that approximate a sinewave. Further filtering produces a clean sinewave at the frequency of the VCO. Phase displacement is determined by the PROM data.

5.4.4   The mother board also produces a triangle-wave signal that is common to the PWM modulators contained on the phase control cards discussed later.

5.4.5   All inter-connection between circuits and controls are provided via the Motherboard. Four 22 pin card edge connectors are present for the installation of 3 phase control cards and a GPIB interface card. Distribution of all low voltage supplies is via the Motherboard.

5.5   OUTPUT INVERTER

5.5.1   The 3 output inverters (3 phase units) are based on a half bridge topology. A 600 volt, 100 amp, IGBT module (1200V for 20K) is connected between the +/-250 Vdc rails. The drive signal to the inverter is a "sine weighted" Pulse Width Modulated (PWM), isolated rectangular pulse train. The output of the half bridge is a 20 KHz pulse train that swings 500 volts peak-to-peak and has a varying duty cycle based on the modulating signal (sinewave generator). This output is filtered by a low pass network. The result is a sinewave voltage that is an amplified version of the sinewave signal.

5.5.2   Pulse Width Modulation is performed by the individual phase control cards. The tri-wave signal generated by the Motherboard is distributed to each phase control card. Components U7, U12, U13, and U14 form a modulator circuit that provides a dual polarity PWM signal that is applied to opto-coupled driver IC's U17 and U18. These driver IC's provide boosted, isolated, drive for the upper and lower IGBT of the output invertor. The two inputs to the modulator are the 20 KHz tri-wave and the locally generated sine-wave.

5.5.3   The driver IC's provide short circuit protection via an isolated fault output. This circuit detects the VCE voltage of the upper and lower IGBT. If the output of the inverter is shorted the IGBT's collector to the emitter voltage will increase and trigger the short circuit detection. The fault detect signal is used to set a latching lock out that turns off the PWM drive signals. The latch logic is comprised of U9, U10, U12 on the Motherboard. The latch must be reset by cycling power.

5.5.4   The output amplitude of each phase is also regulated by the phase control card. A sample of the output voltages fed to an RMS to DC convertor (U4). The resultant DC voltage is compared to a reference DC voltage set by the front panel voltage control or remote interface. This comparison is performed by U3a and is integrated to provide an error signal to control the amplitude of the sinewave signal fed to the PWM modulator. Compensation for load line (wire) drops performed by summing in a signal form the current monitor. The more current drawn, the more correction is provided. This compensation is adjustable via the front panel.

5.6   METERING

5.6.1   Metering is provided by DC signals taken from the phase control cards. These signals are derived from the voltage and current monitoring circuits. These signals are attenuated and applied to the front panel DVM's. The frequency display derives it's data from the VCO signal.

5.7   MISCELLANEOUS

5.7.1   Internal heat sink temperature is monitored via an sensor mounted to the extrusion. The sensor is normally open but will close when a safe temperature is exceeded. When this sensor closes the PWM signal is eliminated by setting the same latch used by the short circuit protection.

5.7.2   The optional GPIB board provides an isolated computer interface for remote control of frequency, voltage, and the output relay. The GPIB card will also provide read back of current and voltage to the GPIB.

5.7   IGBT DRIVER

The insulated gate bipolar transistor (IGBT) driver is a hybrid IC that is used in the over current detector circuit of each BL20000 unit. Two of these drivers are used in each unit to provide signal isolation, over current detection, and low-speed over current cutoff features. Figure 1 shows the internal parts of an IGBT driver and its pin descriptions.

SIGNAL ISOLATION - A photo-coupler with a high isolation voltage is used for signal isolation.

OVER CURRENT DETECTION - The IGBT driver can withstand an over current of 10 μsec duration when short circuited. An extremely fast protection circuit is used here for this reason.

LOW-SPEED OVER CURRENT CUTOFF - A low-speed cutoff circuit slowly turns off the IGBT driver in response to an over current sensing. This feature protects the driver against damage from high voltage spikes generated during normal drive speed cutoffs.

PIN	DESCRIPTION
1	**Connected to smoothing capacitor for reverse bias power supply.**
2	**Power supply (+20 Vdc).**
3	**Drive output.**
4	**Not connected.**
5	**Over current detection output.**
6	**Collector voltage monitoring.**
7,8	**Not connected.**
9	**Power supply (0 Vdc).**
10-13	**Not connected.**
14	**Drive signal input (-).**
15	**Drive signal input (+).**
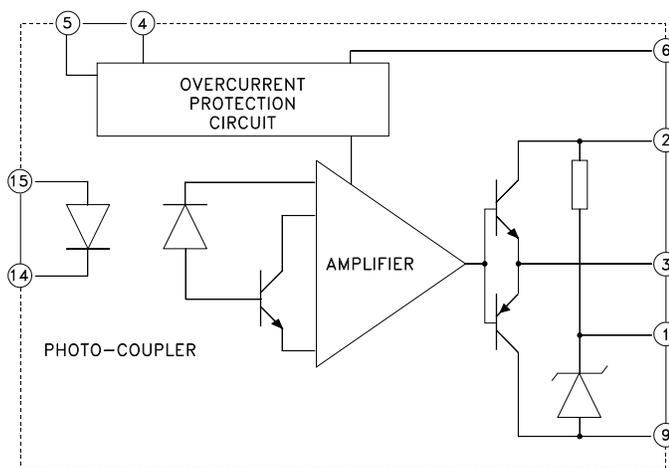
 Figure 5-3 IGBT Driver, Pin Description and Schematic

FIGURE 1
SYSTEM BLOCK DIAGRAM
(3 PHASE OUTPUT)
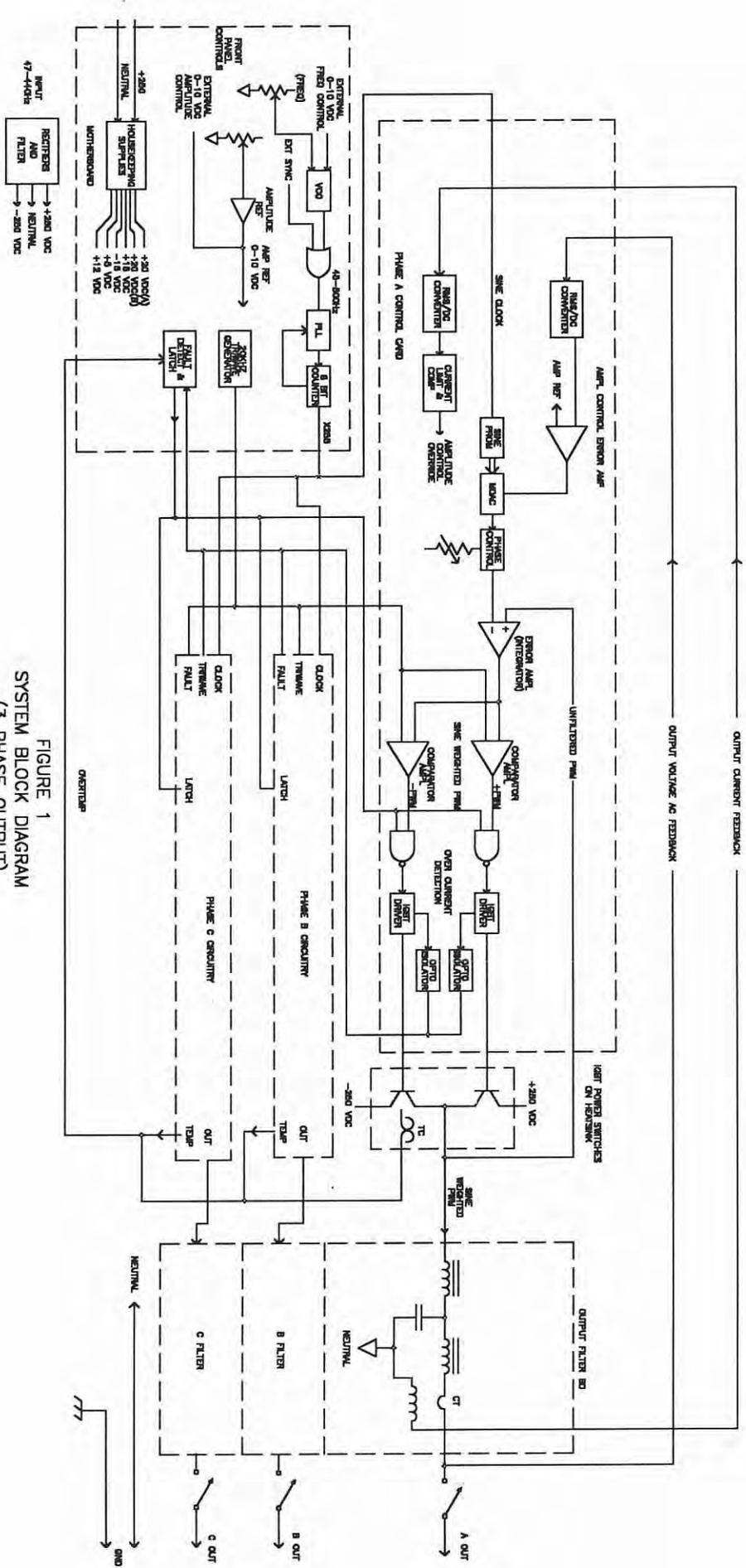
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APPENDIX B

BL SERIES AC POWER SUPPLY
IEEE-488 INTERFACE SPECIFICATIONS

1.1   IEEE-488 BUS UTILIZATION

The BL 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
DC1	- Device Clear
RL0	- No Remote / Local Function
SR0	- No Service Request
PP0	- No Parallel poll response
DT0	- No Device Trigger
C0	- Not a controller

1.2   IEEE-488 BUS COMMANDS

1. <u>Single-Line Commands</u>

   IFC - Clears GPIB interface

2. <u>Multi-Line Command</u>

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:

<u>OPCODES</u>
FNC, FTH, INX, :CH0, SET, SRX, SRN, CLS, OPN, RST, CNF, IST,
STA
<u>MODIFIERS</u>
FREQ, VOLT, CURR, VLT0, VLT1

<u>NOUN</u>
ACS

1.4   AC POWER SUPPLY SYNTAX

Setup Command:

FNC ACS :CH0 SET VOLT <value>

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

- All SET, SRX, SRN commands are part of the setup command above.

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 60 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 ≤ 34, or 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 34, or 135, or 270, dependant on range selected and type of unit.

Table 1-1
CIIL SOFTWARE COMMANDS (cont)

<u>CIIL COMMANDS</u>	<u>EXPLANATION</u>
SRN VOLT <value>	Optional. Sets minimum value limit for SET VOLT command. If SETVOLT 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: $0 \leq$ 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: $45 \leq$ 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.

Delay is necessary after issuing setup command, due to output voltage slew rate of 100v per 250 ms.

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 available range. On single range units this command will be ignored.

NOTE
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 controls 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. The front panel OUTPUT switch must be set to OFF position. The front panel RANGE switch (on dual range units) must be set to LO.

Table 1-1
CILL SOFTWARE COMMANDS (cont)

<u>CILL COMMANDS</u>	<u>EXPLANATION</u>
FTH VOLT <cr><lf>	The AC supply responds to this command by transmitting the RMS voltage (in volts resolute to 0.1V) measured at its output, in decimal format as follows: **<sp><digit><digit><digit><dp><digit><cr><lf>**
FTH CURR <cr><lf>	The AC Supply responds by transmitting the current (in amps resolute to 0.1A) 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 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 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: <u>Pass</u> **<sp><cr><lf>** <u>Fail</u> **F07ACS0(DEV): CONFIDENCE TEST FAILURE** **<cr><lf>**

Table 1-1
CILL SOFTWARE COMMANDS (cont)

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
F07ACS0(DEV): BIT TEST FAILURE
                          -PROM CHECKSUM FAULT
                          -RAM FAULT
                          -AC SUPPLY HARD FAULT
                           <cr><lf>

CILL COMMANDS   **EXPLANATION**

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**
<sp><cr><lf>

Device error messages

F07ACS0(DEV):BIT TEST FAILURE
<description consisting of up to 60 characters>< cr><lf>

TMA error messages   All begin with:
F07ACS0 (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:

OVERTEMP FAULT <cr><lf>

The heat-sink temperature has exceeded its upper limit. The OVERTEMP 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 200% rated current output. The supply automatically shuts down and opens its output relay. The OVERLOAD LATCH LED on the front panel will light.

1.6   ADDRESS SELECTION

The GPIB Address for the BL Series Power Supplies is configured via the dip-switch located on the rear panel. The dip-switch represents the address in binary format. Valid GPIB Address settings are from 0 to 30. Switch 1 is the LSB, switch 5 is the MSB. Each individual switch bit is set ('1') when in the 'OFF' position and reset ('0') when in the 'ON' position.

LSB   MSB   UP "0"   DOWN "1"   LSB   MSB

EXAMPLE ADDRESS # 1   EXAMPLE ADDRESS # **16**
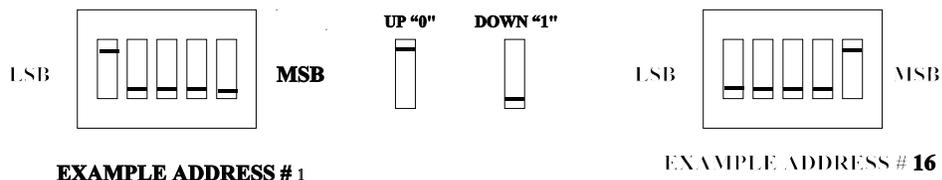
1.7 THREE PHASE COMMUNICATION

The GPIB Interface of the BL has additional Fetch commands which allows the user to Fetch voltage and current from each phase. If no phase is specified during a Fetch for current or voltage, then the response is an average of the three phases.

<u>FETCH DATA COMMANDS FOR THREE PHASE UNITS</u>

FTH VOLT <1, 2, or 3><cr><lf>   The AC Supply response to this command by transmitting the RMS voltage (in volts) for the individual phase specified, measured at its output.

FTH VOLT <cr><lf>   The AC Supply responds by transmitting the average RMS voltage for the 3 phases.

FTH CURR <1, 2 or 3><cr><lf>   The AC Supply responds by transmitting the average current (in amps) for the individual phase specified, measured at its output.

FTH CURR <cr><lf>   The AC Supply responds by transmitting the average current for the 3 phases.

All other commands for Fetch remain the same as BL, described on page B-4 of this appendix.

The setup commands for the three phase units remain the same. The operation of the BL prohibit adjusting voltages for phases individually, therefore phase cannot be specified during the "SET VOLT" command.

GPIB PROGRAMMING EXAMPLE FOR THREE PHASE UNIT

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 BL must terminate with a carriage return <cr> and a line feed <lf>, as will all responses received from the BL.

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

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

<u>Transmit setup command:</u>
FNC ACS :CH0 SET VOLT 120 SET FREQ 60 <cr><lf>

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

<u>Talk address the BL Source to enable response:</u>
<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 BL Source),

<u>Transmit output relay close command:</u>
CLS :CH0 <cr><lf>

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

Talk address the BL 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).

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

Transmit setup command to request status response:
FNC ACS :CH0 SET VOLT 30 SET FREQ 400 Hz.

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

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

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

Transmit setup command
FNC ACS :CH0 SET VOLT 115 SET FREQ 50 SET BLT1 <cr><lf>

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

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

Transmit output relay close command:
CLS :CH0 <cr><lf>

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

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

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

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

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

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

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

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

GPIB PROGRAMMING EXAMPLE FOR THREE PHASE UNIT

1. EXAMPLE: Setup single range BL to output 120 V @ 60 Hz and read back actual voltage and current from phase 2 and the average voltage. Assume for this example a load is connected drawing 1.5 amps RMS from phases 1 and 2, 0 amps from phase 3.

Transmit setup command:
FNC ACS: CH0 SET VOLT 120 SET FREQ 60 <cr><lf>

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

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

Transmit output relay close command:
CLS :CH0 <cr><lf>

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

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

Transmit fetch volt command for phase 2:
FTH VOLT2 <cr><lf>

Talk address the bl source to enable response:
120.0 <cr><lf>

Transmit fetch volt command for average of 3 phases:
FTH VOLT <cr><lf>

Talk address the BL source to enable response:
120.0 <cr><lf>

Transmit fetch current command for phase 2:
FTH CURR2 <cr><lf>

Talk address the BL source to enable response:
1.5 <cr><lf>

Transmit FTH current command for average of 3 phases:
FTH CURR <cr><lf>

Talk address the BL source to enable response:
1.0 <cr><lf>:Average of 3 phases.

APPENDIX C

BL SERIES AC POWER SUPPLY
EIA-232 SERIAL INTERFACE SPECIFICATIONS

1.0   INTRODUCTION

The RS232 interface option for the BL 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

SIGNAL

	AC SOURCE **(DB-9)**		**HOST** **(ANY)**
GND	5	--	**GND**
RXD	2	--	**TXD**
TXD	3	--	**RXD**

The RS232 interface does not currently support hardware handshaking.

Use of a good quality shielded cable is recommended. All cables should be secured with proper retaining hardware .

Important !

When using remote control, all control chassis front panel controls must be set fully counter-clock wise. The output switch and range switch (optional) must be set to the "off" position (low for range switch). Failure to do so will prevent proper control.

1.3   EIA-232 SERIAL COMMUNICATION

The BL Series Power Supply incorporates an EIA-232 serial communications interface, which allows all function to be programmed and monitored remotely via a host computer.

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 BL Series Power Supply can be used in point-to-point mode where a host Computer is connected irectly to One Power Supply.

NOTES:

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

EXAMPLES:
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><eos>

Table 1-1

CIIL SOFTWARE COMMANDS

(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

CIIL COMMANDS   **EXPLANATION**

-ALL SET, SRX, SRN	commands are part of the setup command above.
SET VOLT <value>	Sets output voltage to given value, in volts rms. The following values are permitted: $0 \leq$ 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: $45 \leq$ 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.
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: $45 \leq$ 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.
	Notes

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

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 available range. On single range units this command will be ignored.

<div align="center">NOTES:</div>

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. Front Panel RANGE switch must be set to LO.

<div align="center">CILL SOFTWARE COMMANDS</div>

CILL COMMANDS   **EXPLANATION**

FETCH DATA COMMAND:

CILL COMMANDS	EXPLANATION
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 block. The setup command specifies the voltage and frequency. The setup-command 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>

<div align="center">CILL SOFTWARE COMMANDS (cont)</div>

CILL COMMANDS   **EXPLANATION**

                                     Fail

	F07ACS0(DEV): CONFIDENCE TEST FAILURE
	<cr><lf><eos>

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>

1.5   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:

OVERTEMP FAULT <cr><lf><eos>

The heatsink temperature has exceeded its upper limit. The OVERTEMP 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 occured causing the supply to exceed 200% rated current output. The supply automatically shuts down and opens its output relay. 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 AC SUPPLY must terminate with a carriage return <cr> and a line feed <lf>, and <eos> as will all responses received from the AC SUPPLY.

1. EXAMPLE: Setup a single range AC 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 AC 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 AC 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 AC 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).

2. EXAMPLE: Setup a dual range AC 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 AC Source to enable response:
<space><cr><lf><eos>   **: Positive response indicating status is OK.**

EIA-232 SERIAL PROGRAMMING EXAMPLES

3. EXAMPLE: Setup a dual range AC 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 AC 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 AC 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 AC Source to enable response:
115.0 <cr><lf><eos>

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

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

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

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

SECTION 6

DRAWINGS

NOTE:
HDW SUPPLIED
WITH ITEM 2.
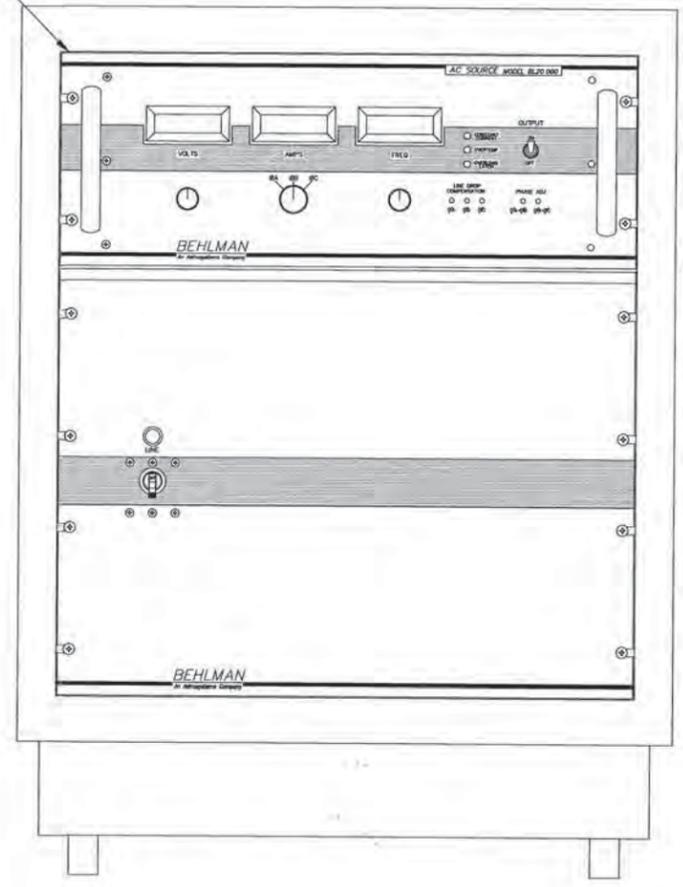
SIDE OF CHASSIS REMOVED FOR CLARITY

CONTROLLED
DOCUMENT

SEE SEPARATE PARTS LIST

WIRE RUN SCHEDULE

CONN NO.	FROM	TO	ITEM NO.	COLOR	COMMENTS
4	BASE PLATE GND STUD	CONTROL CHASSIS GND STUD	4	–	101-631-000
3	BASE PLATE LOW	CONTROL CHASSIS LOW	3	BLU	106-976-000
2	BASE PLATE GND	CONTROL CHASSIS GND	3	BRN	106-976-000
1	BASE PLATE HI	CONTROL CHASSIS HI	3	WHT	106-976-000

		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CONTRACT	BEHLMAN		
		TOLERANCES: FRAC ± 3 PLACE DEC ± 2 PLACE DEC ±				
	106-676-906	ANGLES ±	DRAWN J.ALGERIO DATE 93-4-20			
	106-676-905	DO NOT SCALE THIS DWG	CHECKED R.Young 7/2/15	TOP ASSY 20K SERIES		
	106-676-904	MATERIAL:	ENGR S.Park 4/2/15			
	106-676-903			SIZE	CODE IDENT NO.		REV
	106-676-902			D	53636	106-676-9XX	A
	106-676-901						
NEXT ASSY	USED ON					
APPLICATION				SCALE 1/3		SHEET

106-676-9XX

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED NOTE 1	93/12/20	D.M.
	B	ADDED CONN NO'S.	94/12/16	T.M.
	C	WIRE RUN SCHEDULE, ADDED CONN NO'S 16 AND 17		T.M.
	D	WIRE RUN SCHEDULE, CONN. NO.2 WAS F3-A	96/03/15	T.M.
	E	ADDED CAP BOARD ASSY PER ECO 96-019	96-06-05	T.M.
	F	REVISED WIRERUN PER ECO 98-018	98-02-20	T.M.
	G	REVISED PER ECO 98-108	99-03-04	T.M.
	H	REVISED PER ECO 01-007	01-01-26	T.M.
	J	REVISED PER ECO 09-045 (FM)	04-15-09	R.LOWERY
	K	REVISED PER ECO 09-097 (BZ)	07-15-15	R.LOWERY
	L	REVISED PER ECO 15-173 (BZ)	09-21-15	R.LOWERY
	M	REVISED PER ECO 16-018 (KG)	06-06-16	

WIRE RUN SCHEDULE
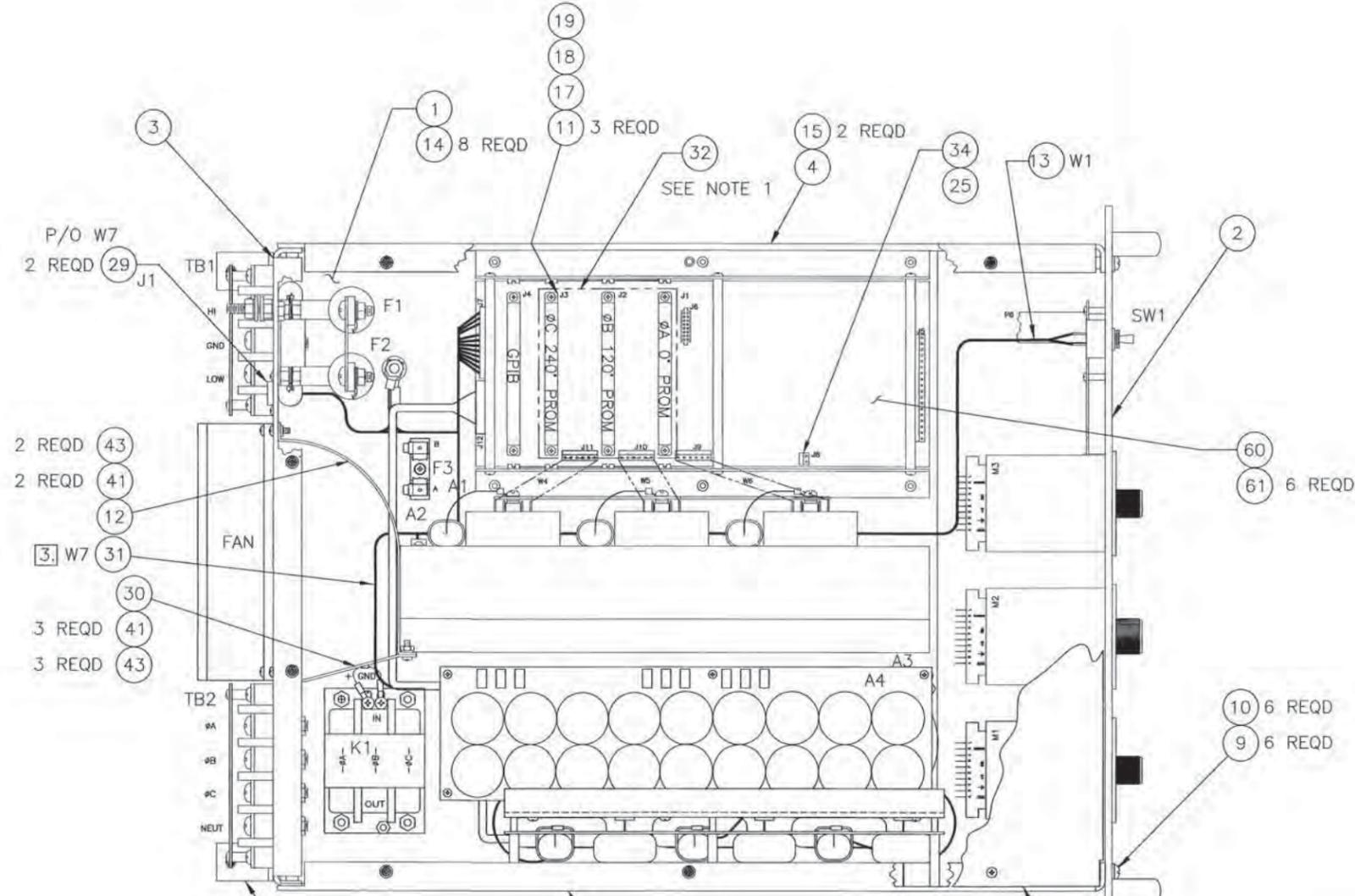
CONN NO.	FROM	LUG ITEM NO.	TO	LUG ITEM NO.	AWG	COLOR	COMMENTS
17	A3A1-E14	24	NEUT STUD	21	10	WHT	NEUT
16	A3A1-E15	24	NEUT STUD	21	10	WHT	NEUT
15	A3A1-E16	24	NEUT STUD	21	10	WHT	NEUT
14	F3-B	23	F1-A*	-	22	RED	
13							
12	A3L6-OUT	-	K1-IN øA	-	10	WHT	(REF.)
11	A3L5-OUT	-	K1-IN øB	-	10	WHT	(REF.)
10	A3L4-OUT	-	K1-IN øC	-	10	WHT	(REF.)
9	K1-øC OUT	22	TB2-øC	21	10	BLUE	øC
8	K1-øB OUT	22	TB2-øB	21	10	RED	øB
7	K1-øA OUT	22	TB2-øA	21	10	BLK	øA
6	NEUT STD	40	TB2-NEUT	40	8	WHT	
5	NEUT STD	20	A1J8-2	25,34	22	WHT	NEUT
4	F2-A	40	A2Q6-E2	40	8	ORN	-250V
3	TB1-GND	21	NEUT STUD	21	10	WHT	NEUT
2	F1-A*	40	A2Q5-C1	40	8	RED	+250V
1	F3-A	23	A1J8-1	25,34	22	RED	+250V

NOTES:

1. ADHERE ITEM 32 (1/8" THICK GRAY FOAM 4.50 X 3.60) TO UNDERSIDE OF TOP COVER, LINING UP WITH PHASE CARDS.

2. INSTALL ITEMS 26, 27 & 28 AFTER PLACING CONTROL CHASSIS INTO CABINET. APPLY BLUE LOCTITE. THIS IS TO BE DONE AT THE FINAL ASSEMBLY LEVEL. REFERENCE PL106-676-101.

3. WHEN INSTALLING W7 HARNESS, ALSO PLACE 2.2uf CAPACITOR (100-155-000) ACROSS FAN TERMINALS.

CONTROLLED DOCUMENT

SEE SEPARATE PARTS LIST

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	J.MORRELL	DATE 01-01-26
CHECKED		DATE
ENGR	S.Buel	DATE 6/20/16
QUALITY CONTROL		DATE
MANUFACTURING		DATE

NEXT ASSY: 106-676-9XX
USED ON
APPLICATION

BEHLMAN

ASSY, CONTROL CHASSIS
(BL20,000)

SIZE D | CODE IDENT NO. 53636 | 106-909-002 | REV M

SCALE 1:2 | CADFILE: 909-002M.DWG | SHEET 1 OF 1

106-909-002

SCHEMATIC
BL20,000 CONTROL CHASSIS

BEHLMAN

SIZE	CODE IDENT NO.		REV
D	53636	106-951-001	B

SCALE 1:1 CAD FILE: 951-001B.DWG SHEET 1 OF 1

REV STATUS OF SHT		ZONE	LTR	DESCRIPTION	DATE	APPROVED
SHT	REV		A	REVISED AND REDRAWN	1-29-93	
1	K		B	ADDED TABLE 1 AND SH 2.	95-8-10	
2	K		C	REVISED PER ECO 96-055	96-10-24	
			D	REVISED PER ECO 97-038	97-03-12	SB
			E	REVISED PER ECO 98-075	98-06-27	
			F	REVISED PER ECO'S 98-069 & 98-056	99-05-18	
			G	REVISED PER ECO 99-127	99-06-15	
			H	REVISED PER ECO 00-034	000316	
			J	REVISED PER ECO 01-034	010517	
			K	REVISED PER ECO 01-166 (GN)	020124	
			L	REVISED PER ECO 13-109 (FPM)	08 07 13	RKL

5 AR
4
3   3 REQD
2   VR1-VR3
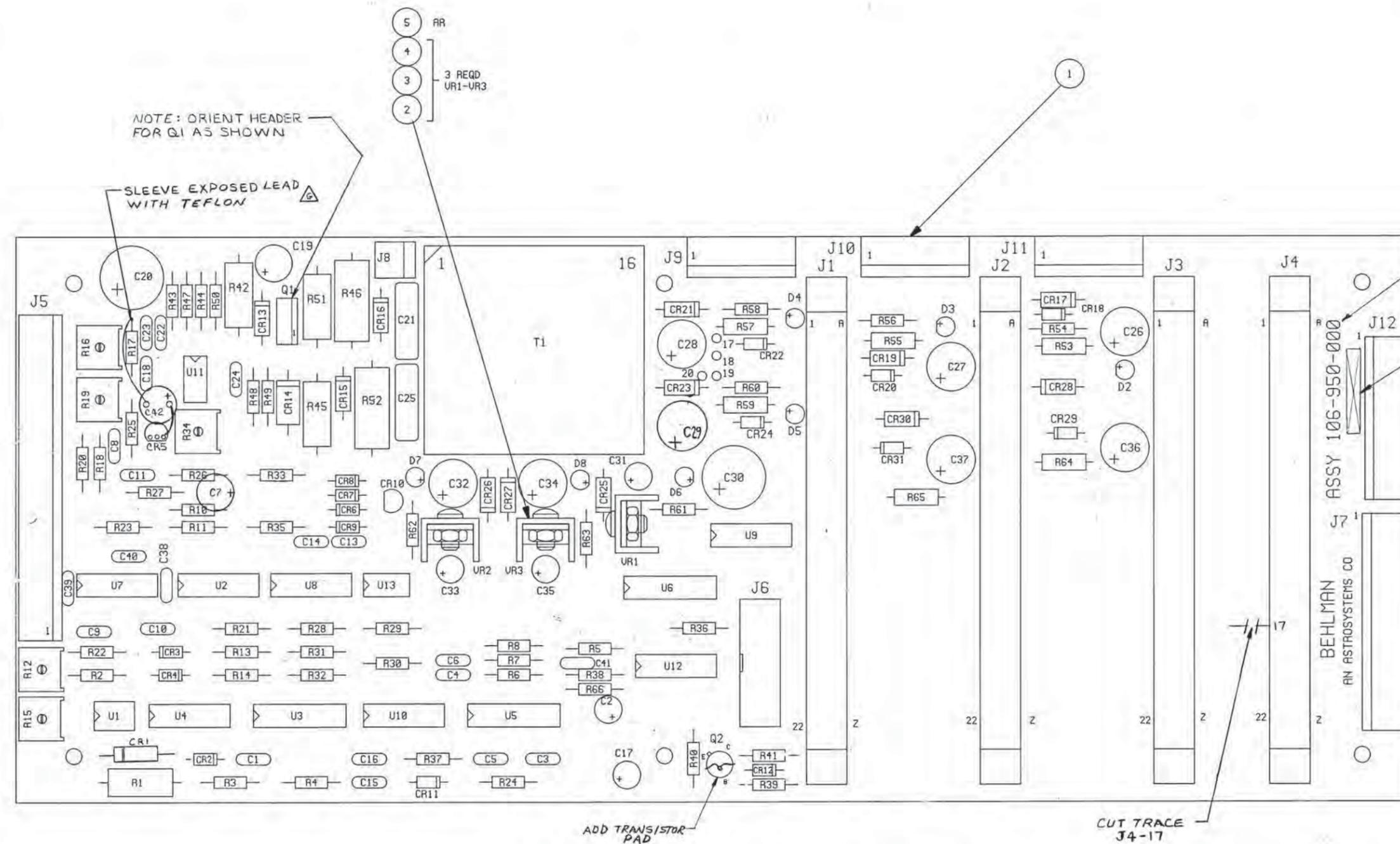
NOTE: ORIENT HEADER
FOR Q1 AS SHOWN

SLEEVE EXPOSED LEAD
WITH TEFLON

SEE TABLE 1.

SEE SEPARATE PARTS LIST

ASSY 106-950-000

BEHLMAN
AN ASTROSYSTEMS CO

106-950-XXX-

NOTE:
1. DESIGNATIONS 17, 18, 19 AND 20 ARE FOR TRANSFORMER LEADS.
2. INSTALL ITEMS 2, 3, AND 4 ON VR1, VR2, AND VR3. SECURE NUT WITH ITEM 5.
3. APPLY SERIAL NUMBER WHERE SHOWN USING SERIALIZED LABEL OR .09 HIGH CHARACTER USING BLACK EPOXY BASED INK.
4. WORKMANSHIP TO BE IN ACCORDANCE WITH IPC-A-610, CLASS 2.
5. SOLDER IN ACCORDANCE WITH ANSI/J-STD-001 , CLASS 2.

ADD TRANSISTOR PAD

CUT TRACE
J4-17

ATTENTION!
OBSERVE PRECAUTIONS FOR HANDLING
ELECTROSTATIC SENSITIVE DEVICES

TABLE 1	
106-950-000	INSTALL COMPONENTS AS SHOWN ON SH 1 AND SH 2. MARKED ✱
106-950-100	INSTALL COMPONENTS AS SHOWN ON SH 1 AND SH 2. MARK APPROP DASH NO.

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

CONTRACT

DRAWN J. BOTTIGLIERE DATE 1-29-93
CHECKED 2/10/95
ENGR 13/2/1

106-934-100
106-934-000
NEXT ASSY   USED ON
APPLICATION

BEHLMAN

PRINTED WIRING ASSY
MOTHER BOARD
3 PHASE

SIZE D   CODE IDENT NO. 53636   106-950-XXX   REV L

SCALE 2:1   SHEET 1 OF 2