USER'S GUIDE AND
TECHNICAL REFERENCE

AC SOURCE

BEHLMAN MODEL BL-PLUS SERIES
30KVA AC POWER SUPPLY

MODEL NUMBER BL+30-3-C-___- _____

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) 642-0660 (CA)
USA : 1-800-874-6727(NY) OR (800) 456-2006(CA)
FAX : (631) 951-4341(NY) OR (805) 642-0790(CA)

DATE: 12/10 REV. H

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 (protective earth). 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. Failure to use the protective earth connection may expose operating personnel to hazardous voltages. In addition this earth connection provides a return path for the equipment EMI filter(s).

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 EQUIPMENT

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.

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.

BEHLMAN MODEL BL+30 SERIES
TECHNICAL REFERENCE

TABLE OF CONTENTS

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Behlman BL +30 series models (table 1-1) are sophisticated, solid state, ac power supplies. Specific models provide independent verification of operating voltage, current, power, and frequency values thereby lessening the need for external measuring devices. The frequency of the output is available fixed at user specified values or variable from 45 Hz to 500 Hz. The output voltage is adjustable from 0 to 132Vrms (L-N). Higher output voltages are available as well as dual ranges. See options below table 1. All standard models provide a single voltage range output.

All Behlman BL series units are based on hard switched, IGBT technology. The high speed PWM control scheme and advanced magnetic design provide a highly efficient and rugged power output stage. Full output current is available at any voltage from 10% to 100% of full scale. These features combine to create a versatile power source for laboratory or industrial applications:

These units may be shipped with one of the input options listed in table 1 below.

TABLE 1. BL+30 INPUT VOLTAGE OPTIONS

MODEL	INPUT VOLTAGE (ac)	MAX INPUT CURRENT (ac)
BL+30-3-C1-X-XXXX	120V/208V, 3ϕ, 57-63 Hz	115A
BL+30-3-C2-X-XXXX	220V/380V, 3ϕ, 47-53 Hz	63A
BL+30-3-C3-X-XXXX	277V/480V, 3ϕ, 57-63 Hz	50A
BL+30-3-C4-X-XXXX	200 Vdelta, 3ϕ, 57-63 Hz	120A
BL+30-3-C5-X-XXXX	346V/600V, 3ϕ, 57-63 Hz	40A
BL+30-3-C6-X-XXXX	230V/400V, 3ϕ, 47-53 Hz	60A
BL+30-3-C7-X-XXXX	240V/415V, 3ϕ, 47-53 Hz	58A

In addition to input voltage , the output voltage and frequency may be supplied as fixed or variable. The model number on the unit's rating label will indicate which version is supplied. The following page gives examples of typical part numbers as well as available options.

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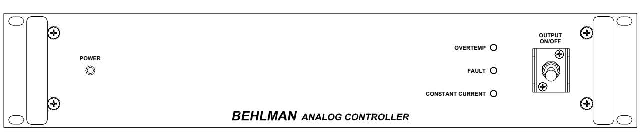
BL+30 SERIES CONTROL OPTIONS SUMMARY

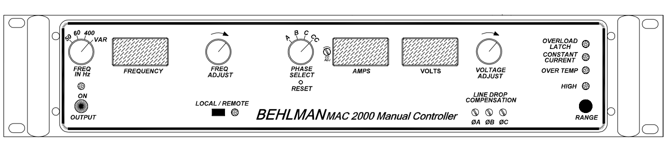
CONTROL OPTION	FEATURES	BASIC SPECIFICATIONS
ANALOG (NONE)	Fixed Frequency and Voltage with on/off control. No metering or external control.	Available Frequencies: any between 45 - 500Hz Accuracy: +/- 0.1 Hz Voltage : fixed +/- 1% of specified.
M (MAC2000)	Manual controller provides three fixed frequencies , variable frequency , and variable voltage. External analog control and metering. Output on /off control.	Frequencies: Fixed @ 50,60, & 400Hz Variable 45 - 500 Hz Voltage: 0 - 135V standard. Others available.
P (PAC2000)	Programmable control provides local or remote control via RS-232 interface. Provides for control of Frequency, Voltage, Phase, and Current limit. In addition metering functions include output power and power factor.	Frequency : Variable from 45 - 500Hz std. Custom ranges available. Voltage: Programmable in 0.1V steps. 0.0 - 135.0V standard. Phase : Programmable in 1 degree steps from 0 -120 degrees.
PI	Same as PAC2000 but includes additional IEEE-488 / RS-232 interface to allow control from IEEE-488 Bus.	See section 1.2 for more information on PAC 2000 options.

STANDARD FIXED ANALOG CONTROL

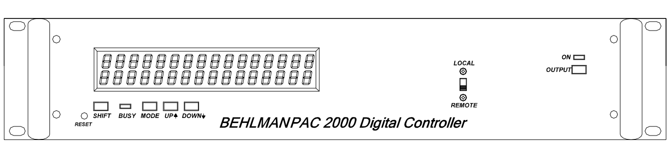
The simplest control method available for this series is the fixed analog controller option. This control unit provides a fixed frequency and preset output voltage. In addition the output of the power source my be enabled or disabled using the front panel OUTPUT switch. The fixed analog controller is supplied unless the "V" or "P" option is ordered. To complete the model number the output voltage and frequency desired must be specified at time of ordering. The part numbering scheme for this series is outlined on the page that follow. If in doubt, consult the factory or Email <sales@behlman.com>.



FIXED ANALOG CONTROL



(-M) MAC 2000
VARIABLE MANUAL CONTROL



(-P) PAC 2000
PROGRAMMABLE CONTROL

1.2 MODEL NUMBER EXPLANATION

The model numbers for BL30-plus series are coded to indicate the options included with each unit. The format of these model numbers are as follows:

BL+30- 3- (X X) - (X) - (XXXX)

BL30+ 3- (input voltage)- (output voltage #)- (options)

Item 1. Input voltage: (all voltages 3 phase line-neutral/ line to line)

C1 = 120V/208 **C2** = 220/380 **C3** = 277/480 **C4** = 115/ 200 **C5** = 346/ 600

C6 = 230/400 **C7** = 240/415 **X** = Custom Input

Item 2. Output voltage (*) (voltages RMS line to neutral)**:**

1 = 0 to 132 2 = 0 to 264 3 = 0 - 305 Volts/Freq = any standard value fixed , specified.
Example. 115/400 = 115V @ 400Hz

***** Other output voltage may be supplied as an option

Item 3. Control Options

M = MAC 2000 manual controller P = PAC 2000 programmable controller

Item 4. Options:

Other options may include engineering specials with modified Input, output, functions, or mechanical features as determined by our sales department. These options will be assigned four digit “engineering” numbers . These numbers refer to engineering data that may or may not be included in this manual. Consult the factory for further information regarding engineering specials.

MA: Manual controller with external 0-10Vdc Analog remote control or frequency & voltage.
E: Extended frequency from 45 to 1000 Hz
P: Model PAC2000 programmable controller
P3: Model PAC2000 programmable controller with independent control of each phase voltage.
PI: PAC2000 with IEEE-488 interface
P3I: PAC2000 with independent voltage control and IEEE-488 interface.
WF: “Wild” Frequency. Output frequency range of 350 - 800 Hz.

MODEL NUMBER EXAMPLES:

1.) **BL+30-3-C1-115/400** = 3 phase output, 120/208V input, fixed 115 VAC output, fixed @ 400Hz

2.) **BL+30-3-C2-1-P-WF** = 3 phase output, 220/380V input, 0 to 132 Vac output, with PAC2000 controller and “Wild Frequency” output frequency range.

Engineering specials will be followed by a four digit ENG #. In the case of engineering specials, an addendum is included with the technical manual that will describe the modifications.

1.3 SPECIFICATIONS (STANDARD UNITS)

INPUT POWER

Voltage:	See Table 1, ±10%, 3ϕ
Frequency:	See Table 1 (400Hz. Available by special order only)

OUTPUT POWER

Voltage:	-1: 0-132 VAC, L-N, 3-phase -2: 0-264 VAC, L-N, 3-phase -3: 0-305 VAC, L-N, 3-phase -XXX Fixed at any L-N, 3-phase
Frequency:	45-500 Hz (see individual controller info in this manual)
Maximum Power:	30000 VA
Maximum Current	-1: 76 Amps/phase @ 0-132 V -2: 38 Amps/phase @ 0-264 V -3: 33 Amps/phase @ 0-305 V
Current Crest Factor:	3:1 (150 ampere Peak maximum)
Power Factor:	100% of rated output into any power factor load.
Distortion:	3% maximum THD (measured at full load, 115 Vac, 60 Hz Resistive).
Load Regulation:	±0.7% from no load to full load.
Line Regulation:	±0.5% for ±10% of line change.
Efficiency:	80%

MECHANICAL

Dimensions:	49 in. High x 31.6 in. Deep x 22 in. Wide . (125 cm H x 80.3 cm D x 56 cm W)
Weight:	900 lbs. (408kg)
Operating Temperature:	0°C to 40°C (32°F to 104°F).

1.2 SPECIFICATIONS (OPTION -2 or -3 UNITS)

INPUT POWER

Voltage:	See Table 1, ±10%, 3ϕ
Frequency:	See Table 1 (400 Hz. Available by special order only)

OUTPUT POWER

Voltage:	0-264 Vac, 3ϕ (for -2) or 305 Vac, 3ϕ (for -3)
Frequency:	45-500 Hz (see individual controller information in this manual)
Maximum Power:	30000 VA
Maximum Current:	38 (-2) 33 (-3) amperes per phase.
Current Crest Factor:	3:1 (75/67 ampere Peak maximum)
Power Factor:	100% of rated output into any power factor load.
Distortion:	3% maximum THD (measured at full load, 220 Vac, 50 Hz Resistive).
Load Regulation:	±0.7% from no load to full load.
Line Regulation:	±0.1% for ±10% of line change.
Efficiency:	85-90%

MECHANICAL

Dimensions:	59 in. High, 31.6 in. Deep .22 in. Wide (160 cm H, 80.3 cm D, 56.1 cm W)
Weight:	1200 lbs. (544 kg)
Operating Temperature:	0°C to 40°C (32°F to 105°F).

2.1 UNPACKING

This equipment is shipped upright with a wooden carton assembled over its shipping skid. To unpack, carefully remove hardware securing wooden panels. A forklift base is provided for ease of handling. 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

1) This unit is shipped as a standard EIA rack assembly. These units require proper cooling air circulation. Cool air is taken in through the front and exhausted to the rear . When selecting an installation site, care must be taken to ensure exhausted hot air does not build up behind the unit. A minimum clearance of 24 inches should be maintained between the rear door of the rack assembly and nearest obstruction (IE wall or bulkhead). Consult with qualified personnel.

2) The location site most protect the unit from coming in contact with any fluids or other moisture.

⚠ *WARNING*

INSTALLATION AND OPERATION OF THIS EQUIPMENT EXPOSES PERSONNEL TO HAZARDOUS VOLTAGES. ALL INSTALLATION AND OPERATION MUST BE PERFORMED BY QUALIFIED PERSONNEL ONLY. FAILURE TO FOLLOW INSTALLATION INSTRUCTION MAY CREATE A SAFETY HAZARD.

2.3 WIRING

All input and output wiring may be accessed by opening the rear door of the equipment enclosure. Figure 2-1 illustrates the location of the input and output terminal blocks. All wiring must enter/leave the enclosure through holes in the bottom of the cabinet. Special consideration must be given to units that will be operating with output frequencies above a few hundred Hertz. The routing of the output wiring and the type of conduit used can adversely affect performance. Refer to section 3.5 for further information.

A) INPUT POWER- Connect 47-63 Hz, power lines to the ϕA, ϕB, ϕC and neutral terminals of the input power block TB1. The terminal marked “GND” is to used to attach a safety earth connection (protective earth). This terminal is tied to the chassis. The required wire gauge is dependent on the connection length and input current (from table 1-1).Check local code requirements. See additional cautions in this section.

B) To make the “earth” connection, tie the installation protective earth conductor to the power supply enclosure “GND” stud with a minimum of AWG 4 wire or equivalent ground strap . The output neutral terminal can be tied to this point for additional safety. See figure 2-2. If output isolation is not required , the input and output neutrals may be connected together to provide a “carried through” neutral as illustrated in figure 2-3. Note that certain electrical safety code require a grounded conductor as part of the output wiring. Consult with a licenced electrician for more information.

C) OUTPUT POWER- Output power lines are connected to the ϕA, ϕB, ϕC, and NEUT (if desired) terminals of TB2 on the inverter output assembly. Wire must be routed to the bottom rear of the cabinet for exit. See figure 2-1

2.3 WIRING (continued)

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, UPs, etc.) must have one output conductor tied to the system earth conductor .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). Consult local codes and a qualified electrician.

Figure 2-1 above illustrates wiring locations. The rear door must be opened to access wiring points.

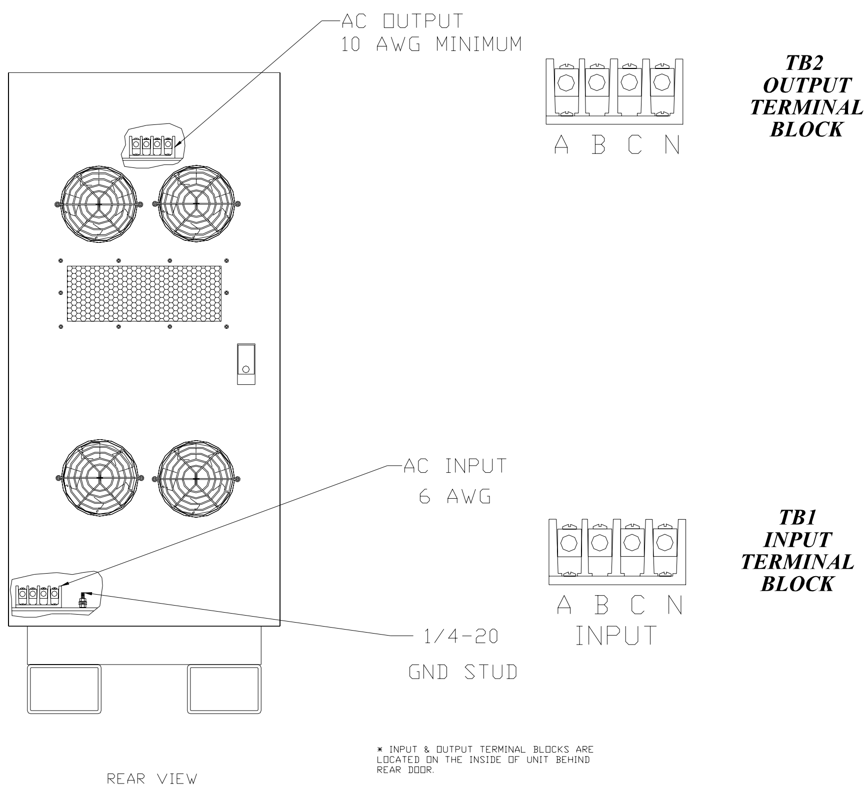


FIGURE 2-1

A lock is provided to keep un-authorized persons from accessing internal wiring.

WARNING !

The rear door must be in place during operation. Besides exposing hazardous voltages, proper cooling is not possible with the door open or removed.

2.3 WIRING (continued)

The input current requirement (per phase) is listed for each model in Table 1-1 at the beginning of this manual. All units incorporate electronic overload detection that will protect the unit from various load related problems. In addition, supplemental ac line protection should be added to the lines feeding this unit. This should be in the form of fuses or magnetic circuit breakers rated for this purpose. The interrupting rating of the supplemental protective device is dependent on the rating of the branch feeding the equipment. Consult a qualified electrician for proper selection of protection devices and their installation.

RECOMMENDED HOOK-UP

Figure 2-2 below illustrates a typical wiring scheme for the B+L30 series units. This will provide the best overall performance and safety.

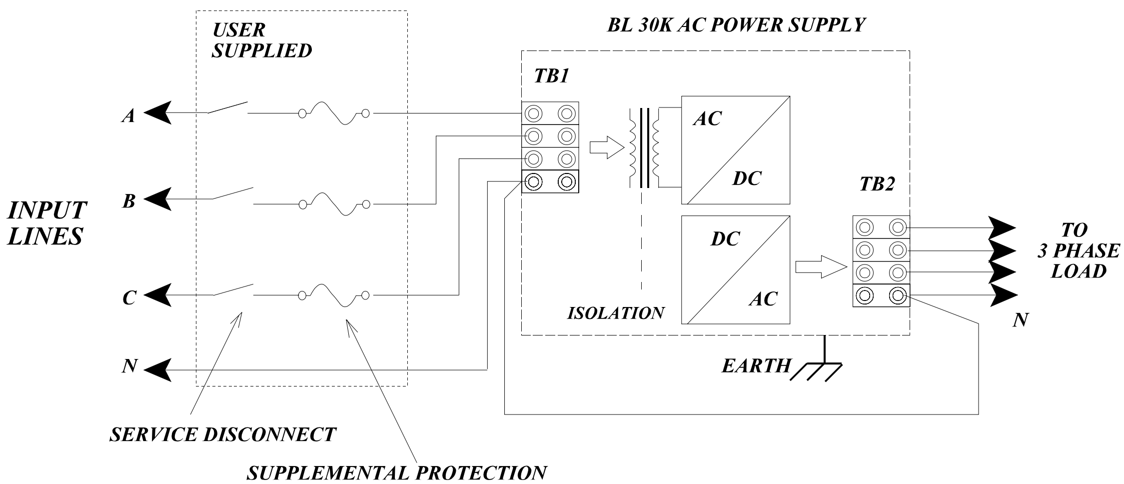


Figure 2-2 recommended hook -up (Neutral “carried through”)

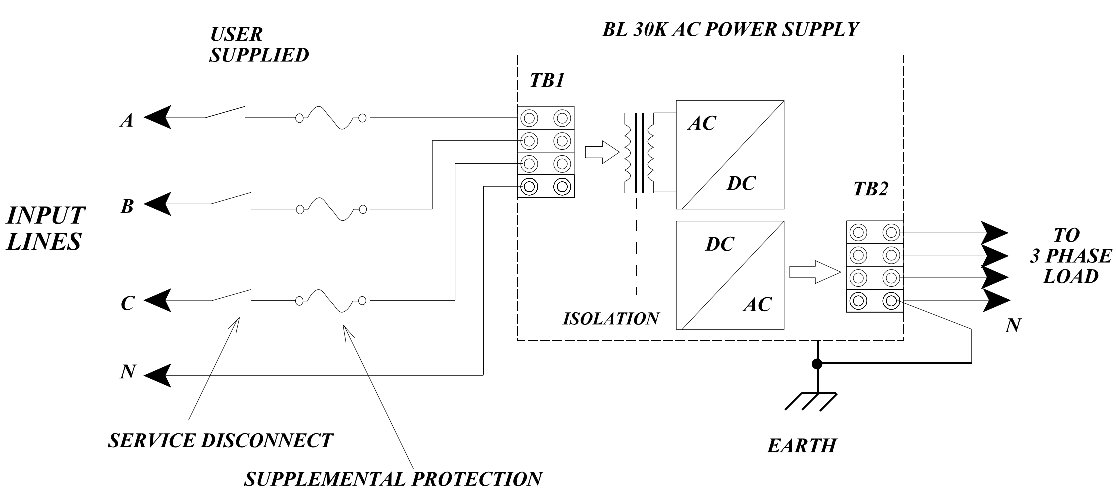


Figure 2-2b recommended hook-up (isolated output)

2.3 WIRING (cont.)

REMOTE LOAD SENSING

The unit is shipped from the factory with option for sensing the output voltage at the point of the load. This provides a “Kelvin” type connection at the load terminals that will allow the regulation control loop to correct for resistive voltage drops in the load wiring. The unit is shipped with the remote sense terminals tied directly to the output terminal block TB2. TB2 is located behind the rear door on the output filter assembly. Refer to figure 2-1 in this section.

If remote load sensing is desired, these leads that originate from the remote sense board must be brought out to the load terminals. Access to the remote sense board is made possible by removing the front panel located directly in front of the filter assembly. Trace the sense wire from TB2 to the sense board and locate the sense terminal block attached to the board. This block is labeled A, B, C, & N to indicate which line is which. To use remote sense, attach user supplied sense line to this board. Disconnect and discard factory wires connected to TB2 (AC output).

Using the remote sense lines for very long distances can present a limitation on the amount of correction that can be obtained by this system. Refer to section 3 (operational considerations) for further details on remote sense operation.

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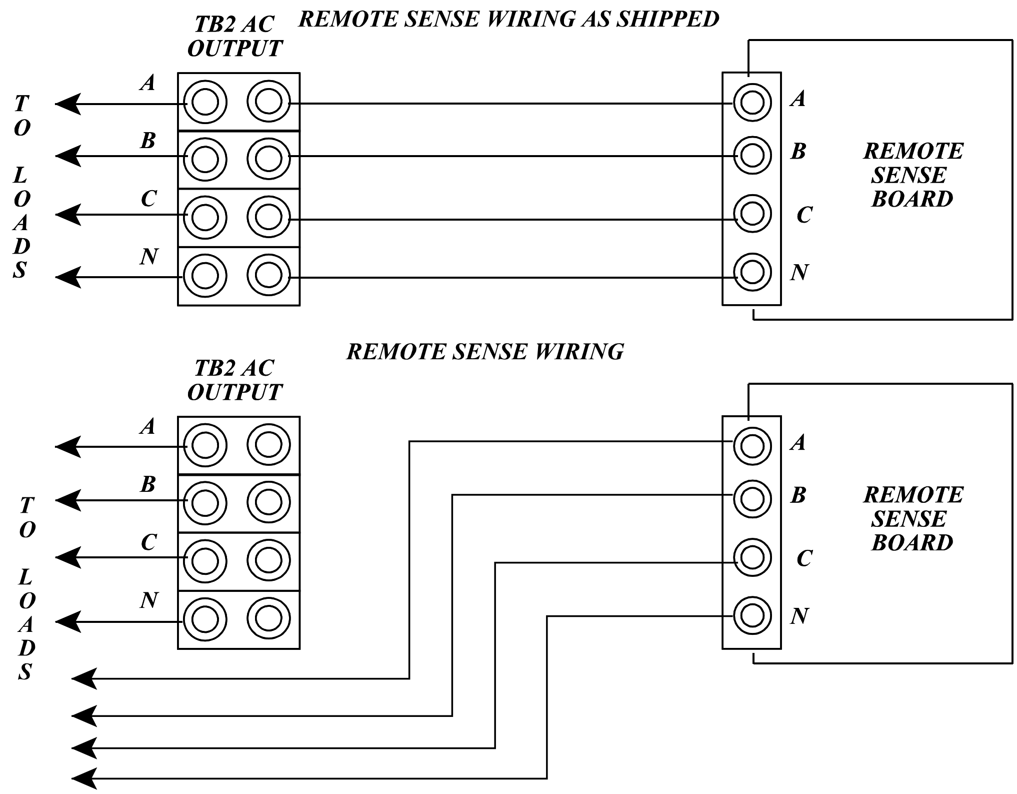


Figure 2-3 remote sense wiring.

2.4 MECHANICAL OUTLINE

Refer to figure 2-4 below for the mechanical configuration of the unit.

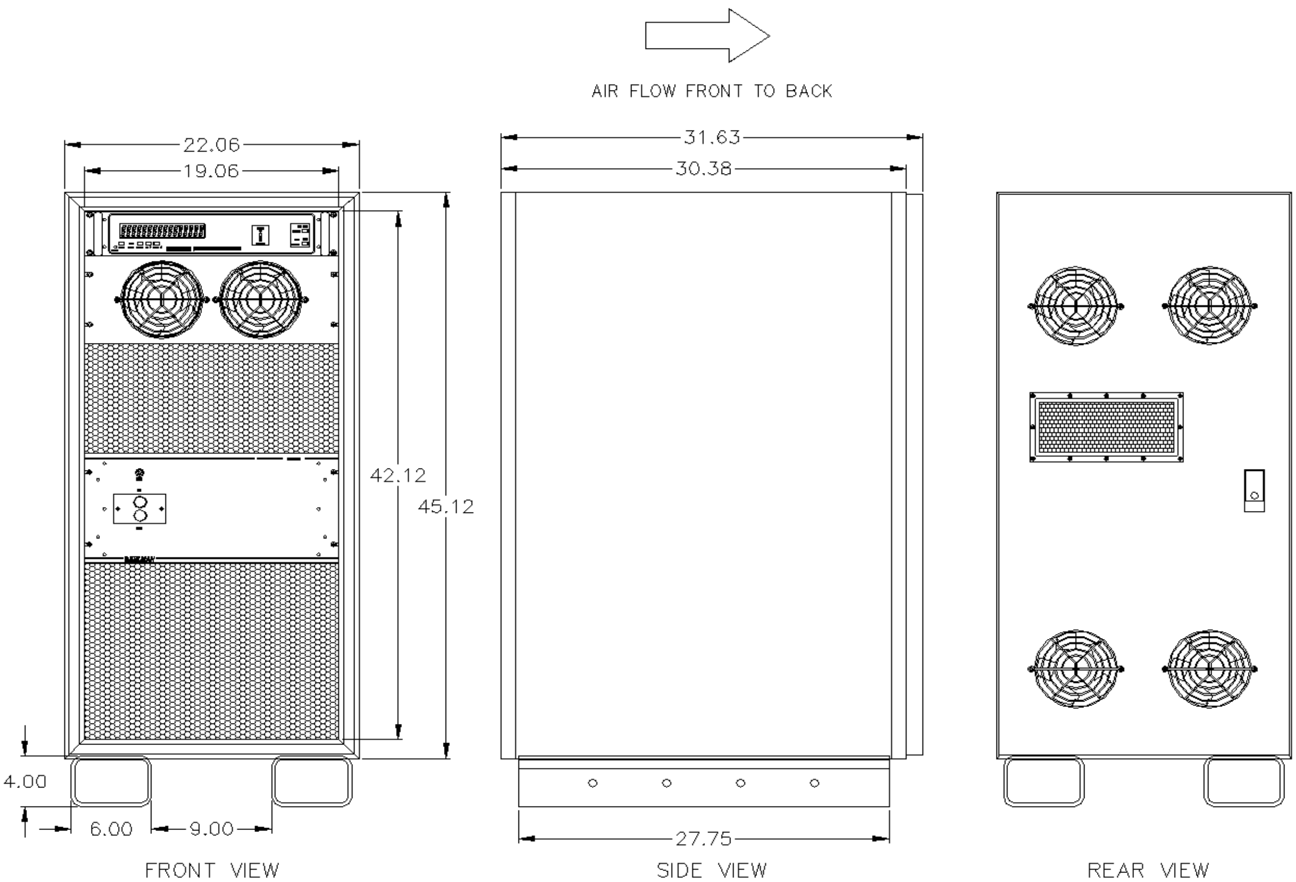


Figure 2-4

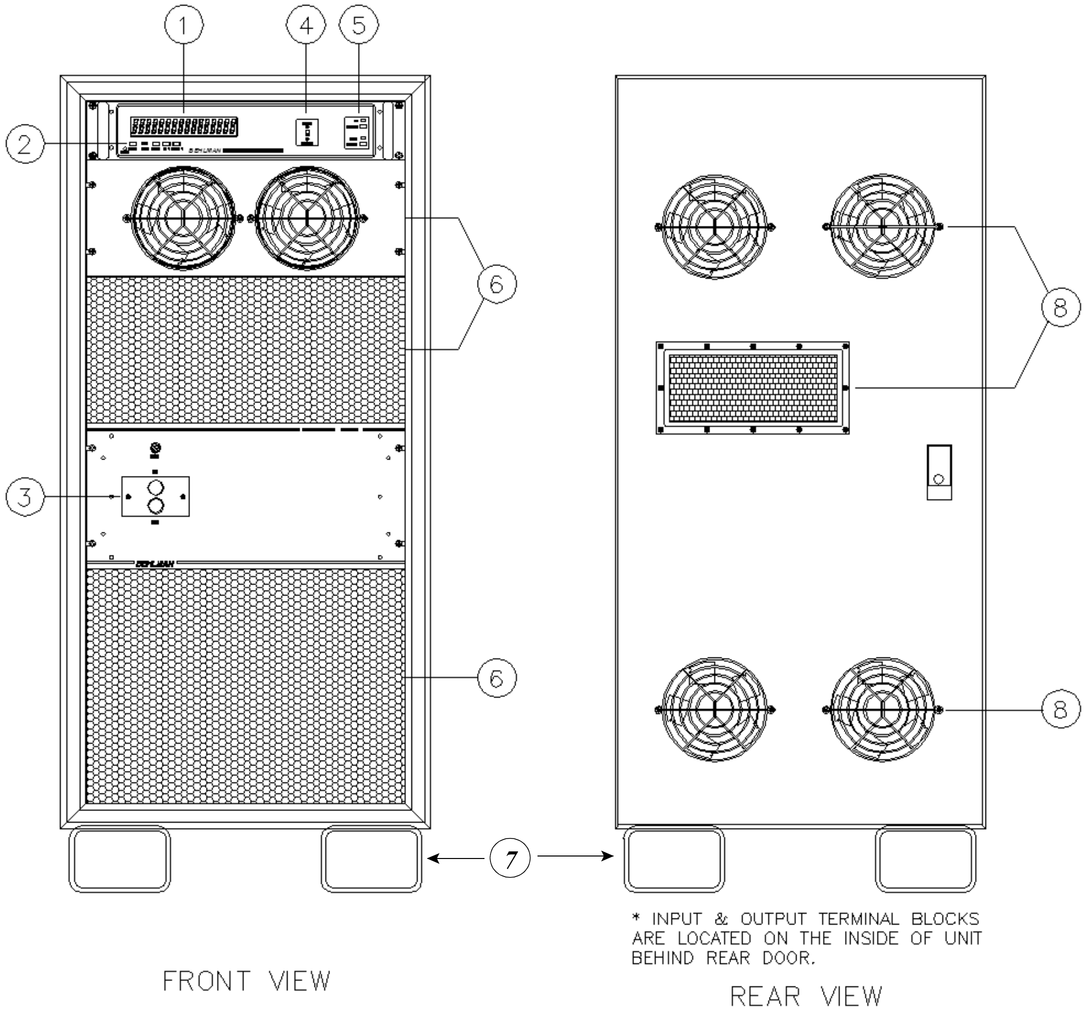


FIGURE 2 -5 POWER SUPPLY FEATURES

Figure 2-5 illustrates the various external features of a typical BL+30 series power supply . A brief description is given below.

1. Output Display (optional PAC2000 shown)
2. Controller assembly (PAC 2000 shown)
3. Main power ON/OFF
4. Status LEDS
5. Output ON/ OFF control
6. Air intakes
7. Fork lift base
8. Heated air exhaust

In addition to those shown here, the input and output terminal blocks are accessed via the back door of the enclosure (refer to figure 2-1). The RS 232 interface or GPIB connector is located on the rear of the controller assembly (upper most chassis).

⚠ 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. The top cover(s) and doors must always be in place during operation.

3.1 CONTROLS AND INDICATORS

The controls and indicators associated with this equipment vary dependent on the control option ordered. This section is broken into three subsections to deal with each type of option. Specific operating consideration and specifications for each controller are listed in these sections.

3.2 ANALOG CONTROLLER

The is the simplest form of controller available. It provides a fixed output voltage and frequency that is specified at the time of ordering. The only control provided is an output on/off switch. In addition three front panel LEDs are included to indicate the following:

OVERLOAD LATCH	Illuminates to indicate the unit is disabled due to an output short or other gross overload. Input power must be cycled to reset this fault.
OVER-TEMP	Illuminates to indicate the unit is disabled due to high internal temperature. This fault will reset once the temperature returns to normal.
CONSTANT CURRENT	Illuminates to indicate the unit is in current limit due to overload.

OPERATING PROCEDURE

1. With the desired load connected , Set the OUTPUT switch to off.
2. Press the green "START" button on the unit and confirm the sound of cooling fans.
3. Turn on the output switch to energize the load. If desired, confirm the output voltage and frequency using an external digital multi-meter.

SHUTDOWN PROCEDURE

1. Set the OUTPUT switch to "OFF", press red "STOP" button.

CAUTION !

On some versions of this equipment the output switch disables the output electronically. As such it DOES NOT make a physical disconnect between the unit and the load. If it is desired to change loads or output wiring. Turn off power or provide an external disconnect switch at the load. Refer to qualified personnel.

3.2 CONTROLS AND INDICATORS ANALOG CONTROLLER

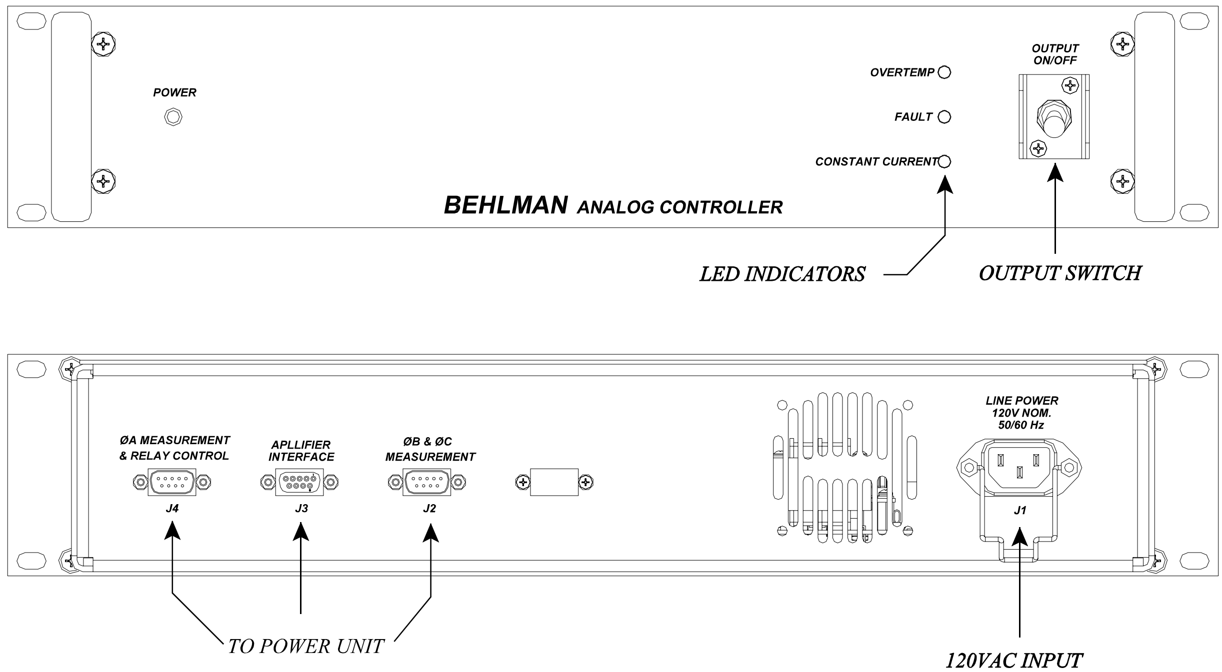


FIGURE 3.1 ANALOG CONTROL FRONT & REAR VIEWS

ANALOG CONTROLLER SPECIFICATIONS:

Frequency: Customer Specified +/- 0.1% (Crystal Clock)

Voltage: Customer Specified factory set +/- 1.0%

Current Limit: Approximately 110% of rated. Voltage sags tp limit current.

Output Switch: Ramps voltage up to preset value when switched on . Response time is approximately 500mSec. Turns off output relay.

OPERATIONAL CONSIDERATIONS:

Overload: The power unit is protected from short circuit currents by an independent overload scheme. When activated the controller will indicate with the OVERLOAD LED. Input power must be cycled to reset the overload.

Current Limit: The constant current mode is provided to protect the power source from excessive output current that is below the overload trip point. The power supply must not be left in this mode for extended periods. This will prevent overheating and possible damage.

3.3 CONTROLS AND INDICATORS FOR MAC2000

Figure 3-3 below illustrates the controls associated with the MAC2000 manual controller. Table 3-3 lists and explains these control functions.

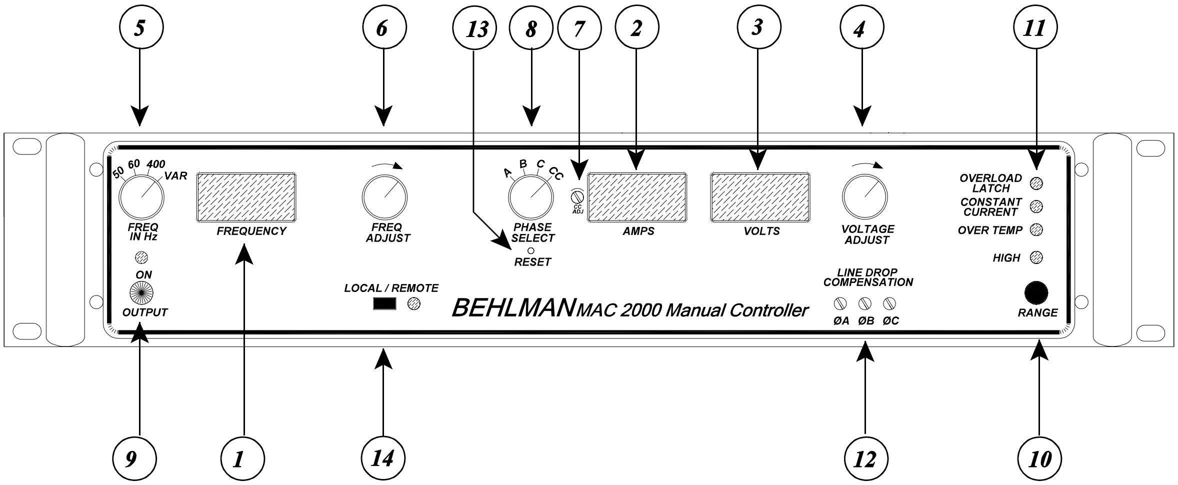


FIGURE 3-3 MAC2000 CONTROLS & INDICATORS

TABLE 3-3 MAC CONTROLS AND INDICATORS		
ITEM	**DESIGNATION**	**DESCRIPTION**
1	FREQUENCY DISPLAY	3 digit LED readout of output frequency. +/- 1% reading +/- 1Hz
2	CURRENT DISPLAY	3 digit LED readout of output current . +/- 1% reading +/- Amp
3	VOLTAGE DISPLAY	3 digit LED readout of output voltage . +/- 1% reading +/- Volt
4	VOLTAGE ADJUST	Multi-turn control provides adjustment of output voltage. Note that the voltage is adjusted on all phases simultaneously.
5	FREQ SELECT SWITCH	4 position rotary switch. Selects between the three fixed output frequencies of 50, 60, or 400Hz. When placed in the VAR position the unit is in the variable frequency mode . In this mode the output can be adjusted between 45 -500Hz using item 6.
6	FREQUENCY ADJUST	Multi-turn control provide adjustment of the output frequency when the VAR mode is selected by the frequency switch (Item 5)
7	CONSTANT CURRENT TRIM (C/C)	Single turn trimmer allows for adjustment of the current limit trip point when the meter select is set to C/C. See item 8
8	METER SELECT SWITCH	4 position rotary switch that selects which phase is being displayed on the voltage and current meter. When set to the C/C position it allows the current limit trip point to be adjusted. Note that C/C is adjusted for all phases simultaneously .
9	OUTPUT SWITCH & LED	Used to enable the output voltage of the power supply. The LED is illuminated to indicate the output is on.

TABLE 3-3 MAC CONTROLS AND INDICATORS		
10	RANGE SWITCH & LED	Provided on dual range T option units only. Sets output range**.** **This feature is optional for future use.**
11	STATUS INDICATORS	3 LEDs provide visual indication of output overloads: OVER-TEMP : Indicates the unit is disabled due to high internal temperature. To reset , allow to cool and cycle power OVERLOAD LATCH: Indicates the unit is shut down due to short circuit or gross output overload. Input power must be cycled to clear this fault. CONSTANT CURRENT: Indicates the unit is operating in current limit mode. The output voltage will be reduced to limit current. Current limit trip point is adjusted with Item 7.
12	LINE DROP COMPENSATION	3 recessed trim adjustments allow output voltage compensation for resistive losses in output wiring. One adjustment is provided for each phase. Access requires a small non-metallic flat blade screwdriver. This adjustment allows for a about 5 -10% of correction to be added to the output when loaded. The actual amount depends on the output voltage and current. With no load applied this control has little or no effect on the output**.**
13	RESET button	Recessed momentary push-button used to recover from any potential "lock-up" of internal controls. Set output to OFF before pressing. Used mainly for factory testing purposes.
14	LOCAL / REMOTE SWITCH	This switch is active only on units supplied with the external analog control options. When in REMOTE mode the front panel controls are disabled and the output of the power supply is controlled via the external analog signals applied to the rear of the controller. Setting this switch to LOCAL returns control to the front panel.

3.3.1 TO OPERATE THE EQUIPMENT

1) Ensure that line power and OUTPUT switch are set to OFF. Set the LOCAL/ REMOTE switch to “LOCAL” .

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

3) Depress the GREEN push button of power chassis (cooling fan noise should become evident). Set the frequency to the desired value.

4) Set OUTPUT switch to ON and adjust the voltage to the desired value.

NOTE

It is permissible to energize a load gradually by setting the OUTPUT switch ON and adjust the VOLTAGE from zero or low voltage position up to the voltage desired. The load must be less than the current limit of the unit to reach the full voltage of the unit

3.3.2 SHUTDOWN PROCEDURE

1) Set the OUTPUT switch to OFF.

2) Depress RED push button to turn the unit OFF.

3.3.3 ADJUSTMENT OF CURRENT LIMIT.

This device has the ability to provide a semi-regulated current into an overload. This is accomplished by causing the output voltage to "fold-back" when the current limit set point is exceeded. The current limit threshold is adjustable via the front panel **C/C** trimmer.

To set the current limit threshold:

1.) Set the meter select switch (item 8 / table 3-3) to the C/C position.

2.) Using a non-metallic flat blade screwdriver adjust the C/C trimmer for the desired trip point as indicated by the current display.

Due to the nature of the current limit circuit there is always the possibility of interaction with certain types of loads. When using current limit to protect sensitive loads the user must experiment to achieve the best results. Contact the factory for additional information.

If the current limit setting is un-important, it is best to leave this trimmer at maximum. This will avoid possible dynamic interaction with certain load types.

3.3.4 LINE DROP COMPENSATION ADJUSTMENT

These trim adjustment allow the user to compensate for resistive losses associated with the output wiring of the power supply. Under heavy load, a correction factor is added to boost the output voltage and improve regulation at the load terminals.

To set the Line Drop Compensation:

1.) With the load disconnected, set the output voltage and frequency to the desired value.

2.) Connect and external meter to the output of phase A and NEUTRAL of the power supply. Note the reading .

3.) Connect the desired load to the unit and move the external meter to the load terminals. If required , adjust the Line drop trimmer for phase A to provide the same voltage as noted in step 2. Use a non-metallic flat blade screwdriver.

4.) Repeat adjustment for phase B and phase C.

Note: this adjustment should not be used to provide positive or "over-regulation" This could lead to instability of the output voltage. Also , this adjustment will have little or not effect when no load is present.

⚠ **CAUTION**

The output switch disables the output electronically. As such it DOES NOT make a physical disconnect between the unit and the load. If it is desired to change loads or output wiring, turn off power or provide an external disconnect switch at the load. Refer to qualified personnel.

3.3.5 ANALOG REMOTE CONTROL OPTION FOR MAC2000

INTRODUCTION

This option provides a means of controlling the MAC2000 with analog signals. The output voltage and frequency may be set using 0 to 10 Vdc signals applied to a rear panel mounted connector. The output on/off and optional range control may also be controlled via this connector. Control of the later may be accomplished by or contact closure. This interface provides complete isolation from ground and the power stage of the power supply.

SPECIFICATIONS

0 To 10VDC Control Input Impedance .... 10K ohms minimum

Maximum Input Voltage .... +/- 15 Vdc

Control Input to Output Linearity .... 1% typical

Control Response Time ....250mS typical

Output and Range Relay Control Current
(Contact closure) ....5mA to 15mA

Isolation Voltage .... 500 Vdc (500 Vac 60Hz 10 sec) all inputs.

CONNECTOR PIN ASSIGNMENT

PIN #	PIN NAME	FUNCTION
1	FREQUENCY CONTROL	0 TO 10 VDC INPUT TO CONTROL “FREQ”
2	COMMON	0 TO 10 VDC RETURN FOR PIN 1
3	AMPLITUDE CONTROL	0 TO 10 VDC INPUT TO CONTROL “VOLTS”
4	COMMON	0 TO 10 VDC RETURN FOR PIN 3
5	NOT USED	NOT USED
6	RANGE	TIE TO COMMON TO SET HI RANGE (OPTIONAL)
7	NOT USED	NOT USED
8	OUTPUT-	TIE TO COMMON TO ENABLE OUTPUT
9	NOT USED	NOT USED

Cables used to connect the control circuit should be shielded to prevent noise and electro-magnetic interference from entering the controller chassis. The maximum length of these cables is dependent on the control circuits drive capability. Typical IC output stages and op-amps tend to oscillate when driving long capacitive cables or wiring. Low impedance output buffers and low capacitance cable should be used .

The stability and regulation of the power supply will be affected by the stability of the remote control circuit. This must be considered when designing the control circuit

3.4 CONTROLS AND INDICATORS FOR PAC2000

Figure 3-4 below illustrates the controls associated with the PAC2000 manual controller. Table 3-3 lists and explains these control functions.

EXPLANATION OF FRONT PANEL LOCAL CONTROLS:

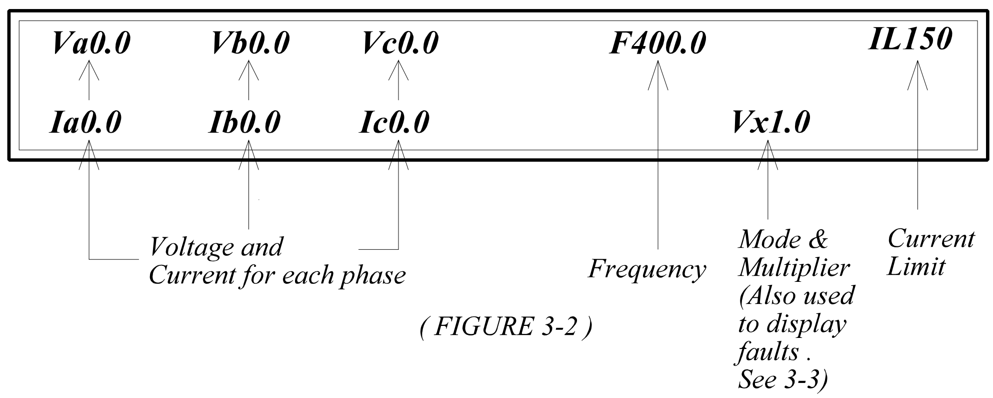
The output parameters of the AC power supply are controlled in LOCAL mode by four “Keys” on the front panel. The momentary type push buttons are located directly below the front panel display. In addition to these “KEYS” there are 2 latching type push buttons located on the upper right hand side of the front panel. These control the output range and on/off functions as stated previously in this manual. The table below summarizes the local control functions: (optional range switch not shown)

	CONTROL	DESCRIPTION
1	**MODE KEY**	Selects parameter to be Adjusted or displayed. (Volts, Freq, Current Limit , Power Monitor)
2	**SHIFT KEY**	Used in conjunction with the “**MODE**” button to set the adjustment resolution, (ie x100, x10, x1.0, x 0.1)
3	**“UP/ DOWN” KEYS**	Used to adjust selected parameter up or down . Step size is set with the “ **MODE**” and “**SHIFT**” buttons.
4	**BUSY INDICATOR**	Led illuminates while input commands are processed. This is true whether the unit is in local or remote mode.
5	**REMOTE/ LOCAL SWITCH**	Used to select **LOCAL** (front panel) or **REMOTE** switch control mode.
6	**RESET SWITCH**	Momentary push button used to reset unit to power -up default state. Access thru hole in front panel requires non metallic tool or pen tip
7	**OUTPUT SWITCH**	Push button switch controls output voltage to rear panel connector The green LED next to switch illuminates when the output is enabled.
8	**DISPLAY**	Fluorescent alpha-numeric display. Displays output parameters.

3.4.1 PAC2000 OPERATING INSTRUCTIONS

OPERATION IN 3 PHASE LOCAL MODE

After a few seconds of initialization the display will show default settings. The appearance of the display will be as illustrated in figure 3-2 below.



(FIGURE 3-2)

Note: words shown in boldface capitals refer to front panel control or indicators.

The individual phase voltage and currents are indicated by an uppercase “V” or “I” followed by a lowercase letter which indicates which phase is displayed. The frequency (F) is displayed in Hertz, and current limit (IL) in amps. The “mode & multiplier” indicates which parameter is set to be controlled by the **UP/DOWN** keys. The “V” means that voltage is to be controlled in 1.0 Volt steps. Note that all three phases are controlled simultaneously.

The programming mode is set by using the **MODE** key to scroll through available parameters. The default mode is “V” or voltage. This will be followed by “F” for frequency, then “I” for current limit. The last mode is the “power display mode” . This last mode is optional and is described further on in this manual. After reaching the last mode, pressing the **MODE** key again will return the unit to the “V” or voltage mode.

Once the parameter to be adjusted is selected the programming resolution or “step size “ can be selected. The is done by holding the **MODE** key in and using the **SHIFT** key to scroll through the available resolutions for the selected parameter.

Local programming example: Setting the voltage to 100.0 Vac in 10V volt steps.

1.) While observing the display, press and hold the **SHIFT** key.

2.) While holding the **SHIFT** key, press the **MODE** key one time and confirm that the multiplier now displays “Vx10.0.” Release the **SHIFT** key.

3.) While observing the display, press the **UP** key one time and confirm that the voltage of each phase is now 10.0V. Press the **UP** key again and confirm that the output voltage increments to 20.0V. Repeat eight times to produce a 100.0V output. It should be noted that each time a key is pressed the front panel **BUSY LED** will flash. It requires about a second for the command to be processed.

3.4.1 OPERATING INSTRUCTIONS (continued)

To set the frequency to another value:

1.) Press the **MODE** key to select frequency as the “multiplied” value. Pressing the **UP/DOWN** key will now increment frequency by 10 Hertz.

To set the frequency in 1.0 Hertz Steps:

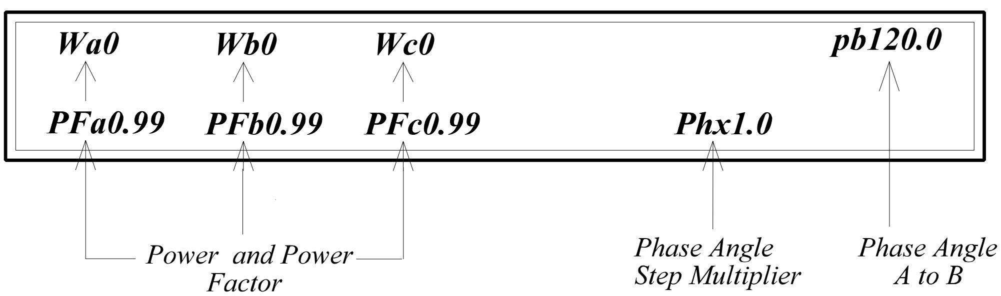
1.) Press and hold the **SHIF**T key.

2.) While holding the **SHIFT** key, repeatedly press the **MODE** key until the multiplier indicates “Fx1.0". The UP/DOWN keys may now be used to increment frequency by 1.0 Hertz.

With the above combinations of the 4 keys (**SHIFT, MODE, UP, DOWN**) all parameters can be adjusted at all available resolutions.

3.4.2 OPERATION IN POWER MEASUREMENT MODE

In this mode of operation the output power (in real watts) and power factor of all three phases are monitored. An optional feature allows adjustment of phase angle. When this mode is selected the display will appear as in figure 3-3 below (assuming the unit is not loaded).



(FIGURE 3-3)

Note that the power monitor mode may only be selected via the front panel **MODE** control and can not be invoked from the remote control port.

3.4.3 ADJUSTING THE PHASE ANGLES

An optional feature allows the phase angle displacement between phases A (zero reference) and either phase B and/or phase C to be varied. This feature provides a range of zero -360 degrees with a resolution of 0.3 degrees. The default values for these angles are B lags A by 120 degrees and C lags A by 240 degrees. Any changes to the phase angle settings are not retained when power is shut off and must be reprogrammed at each use.

Caution should be used when manipulating phase angles when the unit is loaded. Certain polyphase loads may be damaged by the application of the incorrect phase displacement. Keep in mind that increasing the phase angle from the default values will cause a corresponding increase in the line to line voltages of the affected phases.

3.4.3 ADJUSTING THE PHASE ANGLES (continued)

To adjust the phase angles:

1) Place the unit into the power measurement mode as described in the previous sections.

2) Hold in the **SHIFT** key and use the **UP** key to select which phase will be varied. The **UP** will "toggle" between phase B and phase C as indicated on the display. Once the phase is selected, the **SHIFT** key may be released.

3) Use the **UP/DOWN** keys to set the phase angle to the desired value.

4) Use the **MODE** key to return the unit to the voltage programming mode. At this time, the new phase angles are executed by the controller.

NOTE: The Unit must be changed from power display mode to voltage programming mode in order for the programmed phase angles to change.

3.4.4 TO OPERATE THE EQUIPMENT

1) Ensure that line power and OUTPUT switch are set to OFF. Set the LOCAL/ REMOTE switch to "LOCAL"

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

3) Depress the GREEN push button of power chassis to ON (cooling fan noise should become evident).

4) Set OUTPUT switch to ON to energize load.

NOTE

It is permissible to energize a load gradually by setting the OUTPUT switch ON and program the unit from zero or low voltage position up to the voltage desired. The load must be less than the current limit of the unit to reach the full voltage of the unit

3.4.5 SHUTDOWN PROCEDURE

1) Set the OUTPUT switch to OFF.

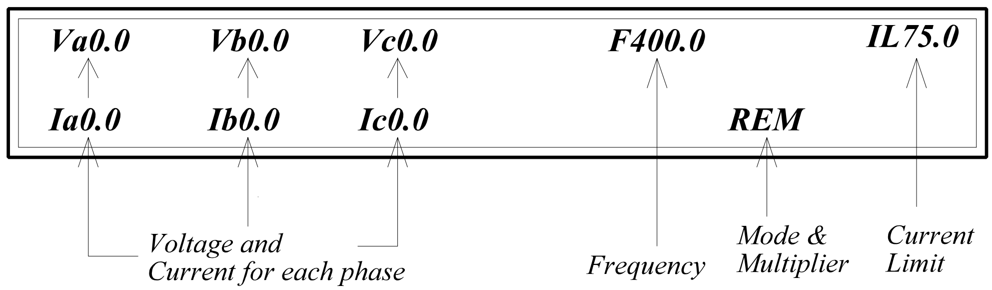
2) Depress RED push button to turn the unit OFF.

CAUTION !

The output switch disables the output electronically. As such it DOES NOT make a physical disconnect between the unit and the load. If it is desired to change loads or output wiring. Turn off power or provide an external disconnect switch at the load. Refer to qualified personnel.

3.4.4 OPERATION IN REMOTE MODE

This device may be controlled via an RS-232 serial interface. The unit is connected to the control computer through a rear panel mounted 9 pin "D" connector. Under remote control, all output parameters may be set and "read back". For further information, refer to the section on "Remote Programming". The unit is set to the remote mode by placing the front panel LOCAL/REMOTE switch in the "REMOTE" position. In remote mode the display will indicate as shown below in figure 3-4



(FIGURE 3-4)

3.5 OPERATION UNDER FAULT CONDITIONS

The BL series of AC power supplies incorporate several output protection features. Electronic circuitry monitors output stage current, voltage, and temperature and will shutdown the unit in the event of a problem. The following section describes the operation of these protective features.

3.3.1 CURRENT LIMIT

This device provides a pre-setable current limit that allows the user to protect the load from over current. Default values for current limits are 75 amps per phase in low range 3 phase mode, (33amps for T-option units). This value may be set between 0.5 and maximum with a resolution of 0.1 amp. When the output current reaches the limit setting, the power supply output is disabled and the output voltage will revert to zero. After a current limit event, the display will flash “O/I” in the multiplier field.

3.3.2 CONSTANT CURRENT MODE

When the current limit value is left at the default value, the operation of the current limit circuit is such that the unit will enter a “constant current” mode when maximum output current is reached. In this mode the power supply output voltage will be reduced to maintain a fixed current. In other words, as the load resistance across the output terminals is lowered, the output voltage will be reduced to keep current constant. When the output current drops below the default limit value, the unit will revert back to a regulated voltage source. During a constant current event the display will flash “C/C” in the multiplier field.

3.3.3 OVERLOAD

Catastrophic load faults will cause the power supply output to be completely disabled. This is usually caused by a short circuit or external voltage applied to the output. When this occurs, the power output stage becomes disabled through latching hardware. To recover from this type of fault, the cause of the overload must be removed and the input power must be cycled off for 3 seconds. When an overload event occurs the display will flash “O/L” in the multiplier field.

3.3.4 OVER VOLTAGE

If the output voltage measured is more than 135V, the power supply will sense an OVER VOLTAGE fault and disable the power output. This is a very rare occurrence and will only be caused by some internal failure or by operating into very large capacitive loads at the powers supply’s upper frequency limits. The later is caused by resonant “peaking” of the units output filter and may be mitigated by adding a resistive load in parallel (shunt) with the capacitive load. After an OVER VOLTAGE event the display will flash “O/V” in the multiplier field.

3.3.5 OVER TEMPERATURE

In the event the internal temperature of the power output assemblies exceeds a safe value. A signal is sent to the micro controller to shut down the output. The front panel display will indicate “O/T” in the multiplier field. The unit must be allowed to cool and the input power cycled off for three seconds to recover from this fault.

3.4 SHUTDOWN PROCEDURE

1) Set the OUTPUT switch to OFF.

2) Depress RED push button to turn the unit OFF.

3.5 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 circuit 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 three to five 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 components.

3.5.1 **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 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)		Most Solenoids

Operations into these types of loads usually cause little interaction with the output stage of the model BL30000. The main concern with a linear load is the “inrush” current associated with it. Most heating elements and resistors have 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.

3.5.2 **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 inrush 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.

3.5.3 **DRIVING LAMPS**

Tungsten filament lamps present a very low resistance when cold. Once they are energized, their resistance quickly climbs to its 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.

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

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 its normal operating speed, it generates the required "back EMF" and the supply current drops off to the nominal "run" current for the motor.

3.5.5 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 and can cause de-saturation of the power devices and overload latch shutdown.

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.

3.5.6 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 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.

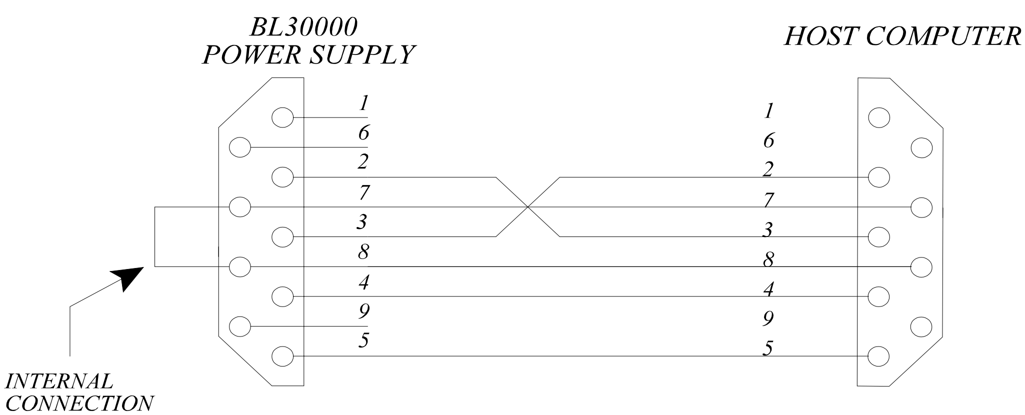
3.6 REMOTE PROGRAMMING

3.5.1 REMOTE PRGM CONNECTOR (**J5**)

The REMOTE PRGM connector, a nine-pin D connector located on the rear panel of the controller, is provided to enable the user to program the unit remotely. A mating nine pin male connector is supplied to the user for fabricating the cable required for remotely setting the unit's amplitude, frequency, and on dual range models, the voltage range. It is recommended that 20 AWG shielded wire be used to fabricate the cable. Table 3 lists the connector pin descriptions. During remote operation, the unit's front panel programming controls will not be functional. For programming instructions, see programming manual in appendix A.

TABLE 3. REMOTE PRGM CONNECTOR PIN DESCRIPTIONS

PIN	DESCRIPTION
1	Data Carrier Detect (NOT USED)
2	Received Data (RXD)
3	Transmitted Data (TXD).
4	Data Terminal Ready (DTR).
5	Signal Ground (GND)
6	Data Set Ready (NOT USED)
7	Request to Send (NOT USED)
8	Clear to Send (NOT USED)
9	Ring Indicator (NOT USED)



RS 232 CABLE CONNECTIONS

3.7 REMOTE VOLTAGE SENSE OPTION

3.7.1 On units equipped with the remote sense option, some careful considerations need to be made. The remote sense lines must always be connected to prevent damage to the unit. When remote sensing is not used or desired, the sense lines must be connected to the output terminal block as a reference. Failure to connect these lines will cause the unit to go out of control and output maximum voltage. This is an extremely serious problem for units that are equipped with the T-option transformers. The extreme output voltage will cause damage to the output inverter or damage the capacitor banks.

3.7.2 Special consideration must be made with regard to remote sense and long lines. The amount of available voltage that can be used is largely dependent on two factors. The first is the maximum voltage that the unit can attain without saturating, and the other is the maximum percent of regulation compensation available from the remote sense circuit. These work in conjunction to provide the regulation at the load which can be some distance from the converter . It is recommended that larger wires be used for this type of application. When using a distribution system, it is recommended to sense the voltage at the distribution panel .

3.7.3 Long lines present an additional problem for the unit due to added inductance and capacitance. Generally the capacitance poses no problem as it may tend to smooth out the switching noise further. Wiring inductance can be a problem. Keeping the conductors short and direct becomes critical as the operating frequency is increased. The use of steel in close proximity to the output wires should be avoided for units operating at the upper frequencies (400Hz). Current flow in the wiring will cause localized heating due to eddy currents in the steel. The steel will also increase the inductance of the output lines which will reduce performance. It is recommended that the conduit should be aluminum or non metallic.

3.7.4 The unit is capable of driving both delta and wye loads from the output. The remote sense system is 4 wire wye sensing system. It compensates for the line drops of the three phases as well as the neutral line losses due to unbalanced loads. The remote sense lines must be connected at all times so that there is always a path to the output terminal block. If the NEUTRAL line is not used, the sense wire must be connected directly to the output terminal block. If an unbalanced load is intended, (such as three single phase loads) it is recommended that the neutral conductor size be increased since the neutral current can be nearly double (1.73 times higher than) the individual phase currents.

SECTION 4

MAINTENANCE AND PERFORMANCE VERIFICATION

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 doors and cover must always be in place during operation.

Before performing any work where access to the inside of the equipment is required, be sure to turn off the unit and allow 10 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 GRILLES (VACUUMING), OPERATING OUTSIDE THE ALLOWABLE ENVIRONMENT, AND PHYSICALLY DAMAGING THE UNIT AND OPERATION BEYOND ELECTRICAL RATINGS.

The decision on whether a unit’s warranty has been voided will be exclusively reserved by Behlman.

Periodic calibration of the BL30000 series of power supplies is generally not required. Periodic verification of performance is left to discretion of users requirements. Preventative maintenance is required to maintain performance. The maintenance interval required is determined by environment that the unit operates in. A monthly maintenance schedule is recommended for all new units in dirty environments.

Maintaining Air Intake / exhaust

While the unit has no filters, the grilles have small holes which can become clogged. This reduces the volume of cooling air available. In addition to cleaning the grilles it may be necessary to remove the dust and debris from inside of the unit. Care must be taken to prevent static buildup and discharge. In dry climates this can damage the sensitive CMOS circuits. High pressure air hoses should never be used around printed circuit boards for this reason. Vacuuming the grilles with light brushing is the preferred method. Before attempting to clean inside the unit, disconnect (**LOCK OUT**) the main feed to the converter and allow at least 10 minutes before touching any parts inside the unit. This will allow for any electrical charge to dissipate.

4.2 PERFORMANCE VERIFICATION

The following procedure is intended to allow the end user to verify that the AC power source is operating within specifications. In all instances that follow, the power supply will be referred to as the DUT (device under test). In addition, controls located on the power supply will be denoted by boldface capital letters.

This procedure is intended for use by qualified personnel only.

4.2.1 TEST EQUIPMENT REQUIRED

Below is a list of suggested test equipment :

TEST EQUIPMENT	MINIMUM SPECIFICATIONS
Current Transducer	0-150Arms(FlukeY810IA-150 or equivalent)
Digital Multi- meter (DMM)	Fluke Model 45 (or equivalent) 0.1 % AC
Frequency Counter	0.1 Hz resolution (Fluke 87 DMM)
Oscilloscope	20MHz 2 ch. (or equivalent)
Distortion meter	Leader LDM-171(or equivalent)
Digital Power Analyzer **	Voltech PM3000A (or equivalent)
Test loads (3-1phase 10KW min./phase)	Avtron 10KW resistive.(or equivalent)
Discharge resistor 18 ohm 660W with insulated extension wires	Eagle Electric (or equivalent)
PC with a serial port and DB9 cable and windows Terminal emulator	Any

**Note: the Voltech power meter allows verification of all output parameters with one instrument and is listed only as a suggestion, verification can be performed with standard test equipment

The procedure that follows is intended as a guide for quick performance verification of the AC power supply. The end user must determine if this sufficient for their individual needs. Any procedure that will check the specifications of the unit may be used. If further information is required, contact the Behlman factory for customer service.

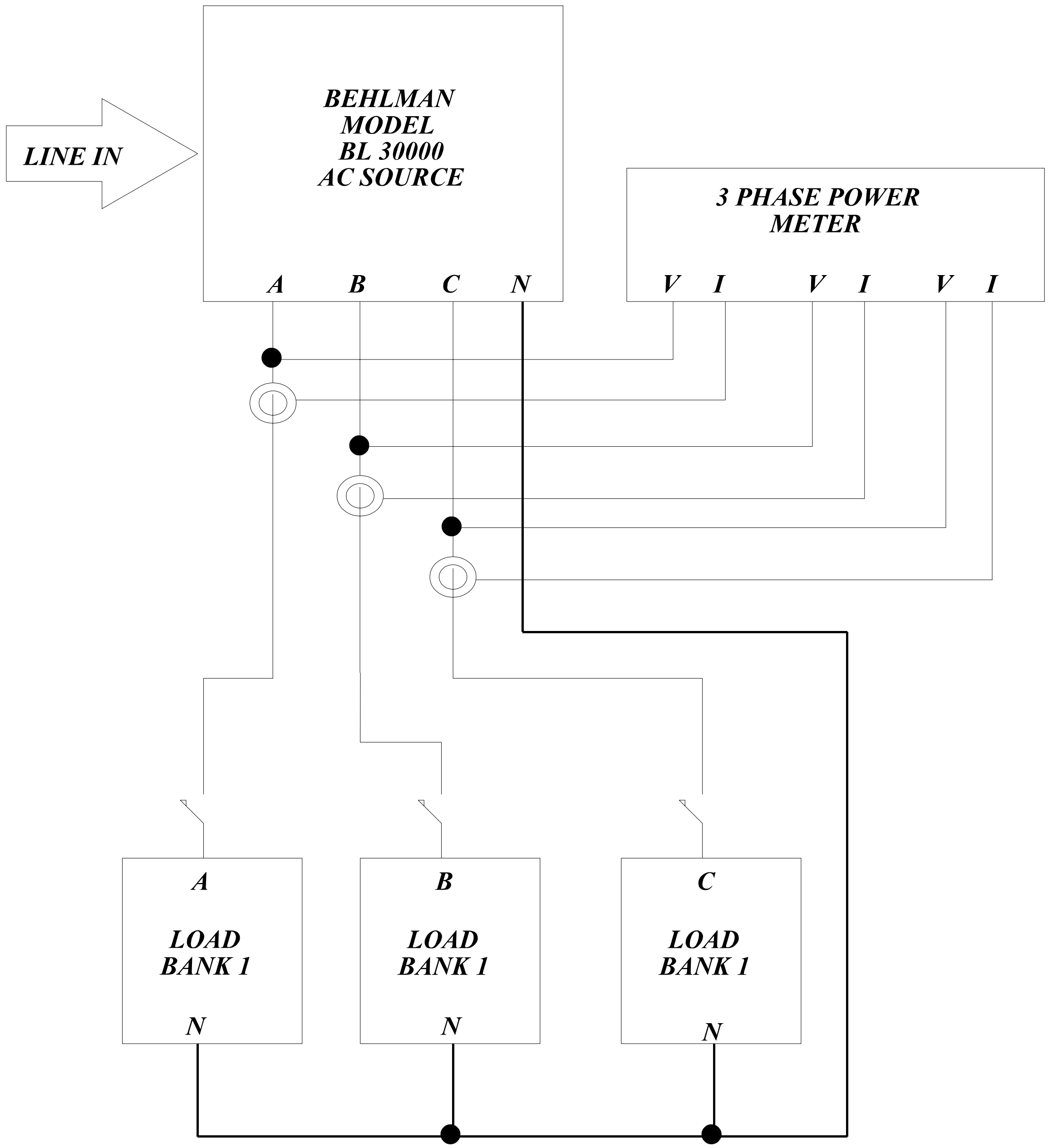


FIGURE 4-1 PERFORMANCE TEST HOOK UP

4.2.3 OUTPUT VOLTAGE AND DISPLAY (MANUAL MODE / NO LOAD)

1) Hook up test equipment as illustrated in figure 4-1. Set all load switches to off.

2) Press the **GREEN** power button to turn the DUT on. Allow 5 minutes for stabilization.

3) Insure that all cooling fans are running an that air is not blocked to and from the DUT.

4) Connect the DMM to Phase A of the output terminal block of the unit and set the meter to read AC voltages above 100V. Set the **OUTPUT** switch to on.

5.) For units with adjustable controllers, Set the frequency to 100Hz (or other value of interest).

6) For units with adjustable controllers set the voltage to 100Vrms. Confirm the output voltage measured on the DMM matches the set value within +/- 0.25% of full scale range . Accuracy may be checked at other settings if required. For fixed controllers the output should be within 1% of the specified value.

7) Repeat step 5 for B phase and C phase outputs.

8) For DUTs supplied with dual ranges (TD option) . Set the unit into the high range and measure the ser output. Again, the output voltage should match the set value within +/- 0.25% of full scale for the range in use.

9) Set the DUT output to 100.0 volts . (confirm output for fixed units)

10) Connect the DMM set to measure ac volts across outputs A & B . Confirm a reading of 173.0 volts. +/-3V.Repeat this measurement between phases B & C and phases A & C. This step checks the outputs for a 120 degree phase angle displacement . (If the Voltech power meter is available, the phase angles will be displayed on the print out.) For a fixed output unit the phase to phase voltages will be 1.73 X the output voltage. For 115V line to neutral we except 198.9V (1.73 x 115).

4.2.3 OUTPUT CURRENT DISPLAY

1) Connect the current measuring device to phase A. . Apply a fixed 10 KW resistive load to phase A and note the current displayed on DUT front panel. The measured current should agree with the external meter within +/- 1.5%.

2) Repeat step 1 for phase B and phase C.

3) If desired, the load should be varied to produce current “steps” of other values to check the overall accuracy of the current display. In each case, the measured output current is compared to the displayed value.

4.2.4 POWER MEASUREMENTS (with optional PAC 2000 controller only)

1) Set the DUT output to zero. Set the DUT **OUTPUT** to “off”.

2) Connect a 10KW resistive load to each phase.

3) Set the DUT frequency to 60 Hz and set the DUT output to a value that will produce exactly 10KW in the load connected to phase A..

4) Multiply the DUT current and voltage (as determined by the front panel display) to determine the output power in watts for each phase (100% resistive load is assumed).

5) Use the **MODE** switch to place the display in the power measurement mode.

PERFORMANCE VERIFICATION (continued)

4.2.4 POWER MEASUREMENTS (cont.)

6) Confirm that power displayed by the DUT corresponds to the value calculated in step 4. Note: if the Voltech power meter is available, compare the DUT to the measured power . All power readings should be within +/- 3.5 %. The power factor displayed should also indicate 1.0 (unity) on a truly resistive load.

4.2.5 FREQUENCY SETTING / ACCURACY

1) Connect a frequency counter across the any one of the output phases. If a Voltech power meter is connected, the frequency can be read from it. For fixed units, verify the output frequency is +/- 1% of specified value.

2) Set the DUT frequency to 45 Hertz and note the frequency measured on the counter (using period of the counter will increase the measurement resolution at low frequencies).

3) Confirm that the counter indicates 45.0 Hz (22.222mS) .

4) Set the DUT frequency to 50 Hertz and confirm a reading of 50.0 Hz (20.00mS) on the counter.

5) Set the DUT frequency to its maximum value using 10 Hertz steps. Check the measured frequency at each set and confirm an accuracy of +/- 0.1%.

4.2.6 OUTPUT NOISE AND DISTORTION

1) Connect the output of phase A to the distortion meter and a 10KW load bank.

2) Set the DUT frequency to 50 Hz (or other frequency of interest).

3) Confirm the distortion at 50 - 60 Hz is less than 3 % (less than 5% @ 400Hz)

4) Use the oscilloscope to view the output voltage waveform of the unit. Confirm the output noise switching frequency ripple) is less than 10 V p/p.

5) Repeat the steps above for phase B , and phase C.

This procedure is intended to verify operation only. If the unit is found to be malfunctioning contact Behlman for additional information and specific trouble shooting procedures. **The device contains no user serviceable parts. Refer all service to qualified personnel only.**

SECTION 5
THEORY OF OPERATION

5.1 GENERAL

5.1.1 The BL30000 series represent a high performance AC to AC converter. These provide variable output voltage and frequency from 0-135V and 45-500Hz respectively. This series may be operated from one of eight three-phase input voltage options from 47 to 63Hz. (See Table 1 of section 1 for details). The output voltage and frequency can be adjusted from 0-132 Vac and from 45-500 Hz. There are output transformer options to suit specific power requirements as well as a Dual Range and Remote Sense options. Other versions include higher voltage single phase inputs by special order where practical. Contact the factory for more details.

5.2 DETAILED THEORY

5.2.1 The BL30000 series models consist of four basic sections, An input power section (DC power supply), an inverter section, a filter section, and a controller section. The incoming line voltage is connected to the input power section 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 supply section is a bipolar DC voltage of +/-250VDC centered around circuit common. Additional circuitry is incorporated to provide inrush current limiting and overload protection.

5.2.2 When the power button is depressed a contactor closes to allow power to be applied to the unit, the low impedance seen by the AC input line due to the unit's large input capacitors would cause most line circuit breakers to trip. To prevent this, during initial power up, large power resistors are placed in series with the three input phase voltages and the transformer primary. During power up these resistors limit the current surge into the filter capacitor bank. Once full voltage is reached, a contactor closes to bypass the in-rush resistors. After the “soft start” interval the unit has uninterrupted power application and can start converting power.

5.2.3 The pulse width modulation (PWM) design of this switching unit generates a high frequency square wave of variable duty cycle. By varying the duty cycle from 8% to 92% and allowing for dead time, a net AC component is created that ranges between the positive and negative DC buses. A two stage LC low-pass filters the PWM pulse train to produce the AC component.

5.2.4 Over current protection of the DC supply is provided by a multi-pole electronic circuit breaker. An over current/startup controller board is employed to control the startup and shutdown events. The front panel push buttons are connected to the board. A control transformer provides an isolated voltage which is power for the primary startup contactor. An auxiliary switch on the input contactor resets the time constant so that the unit can be restarted immediately without waiting for the capacitors to discharge to reset the soft-start circuit. The board also measures the current going into the input power transformer. If an Over current condition exists, the board will open the input power contactor and shut the unit down. This will protect the power supply should a severe overload condition exist, or a power component should fail.

5.3 DIGITAL CONTROLLER CHASSIS

5.3.1 The Digital Controller chassis contains the main oscillator for the power invertors, bias, and control circuitry. The diagram of Figure 1 depicts the basic functional blocks. Note only one phase is illustrated as the others are identical. The circuitry is configured so that the additional two of the three phases plug into a "Motherboard". The output isolation devices output are mounted on a separate board assembly. The chassis also has provisions for the optional GPIB interface card and an optional remote control board for analog control and event memory.

5.3.2 Bias power for the Digital Controller chassis is derived from one of the 115 Vac 47-63hz auxiliary windings of the main power transformer. This voltage is applied to the Motherboard. All other operating voltages are provided by the internal power supplies inside the controller unit.

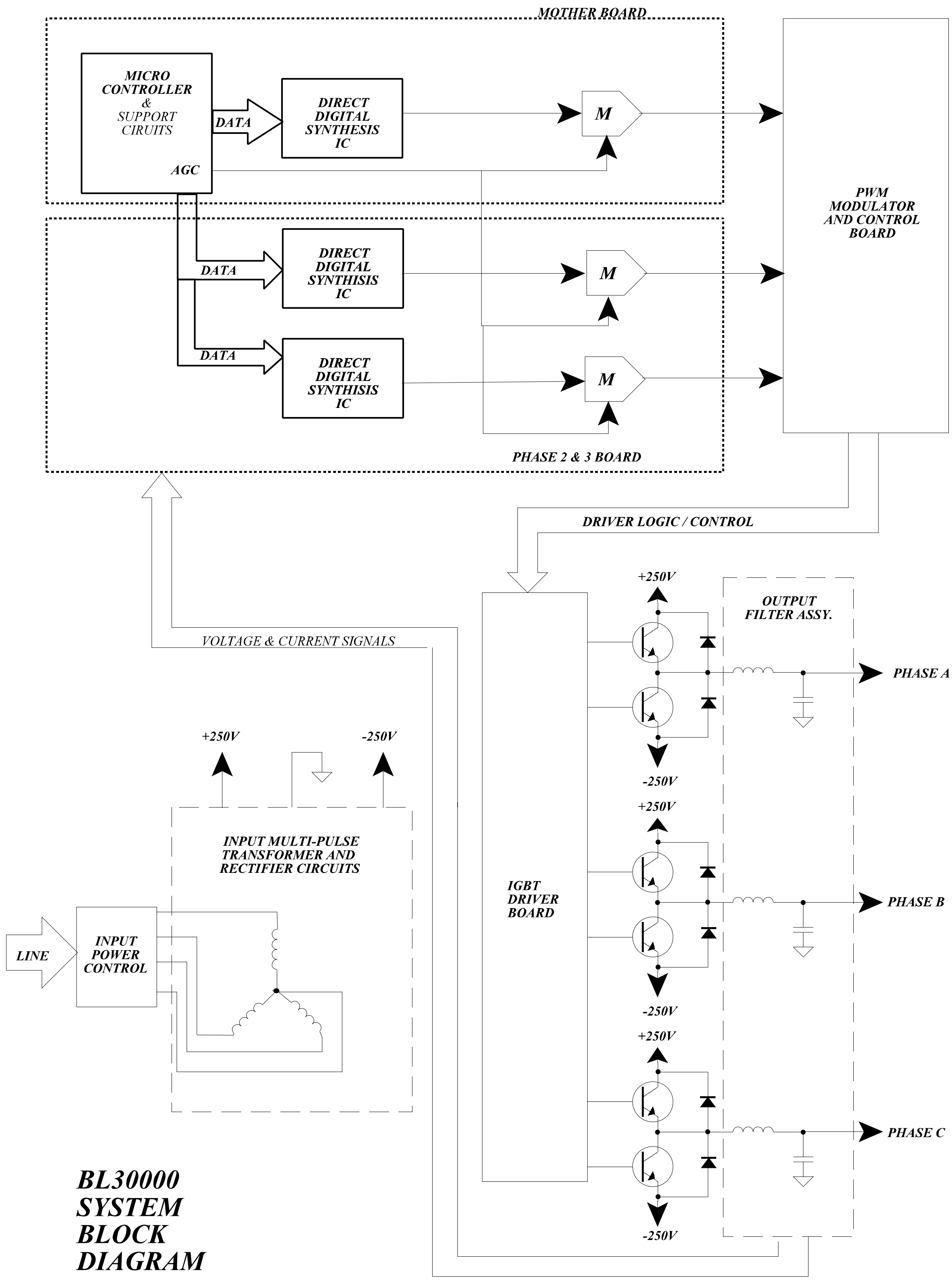

MOTHER BOARD
MICRO CONTROLLER & SUPPORT CIRUITS
AGC
DATA
DIRECT DIGITAL SYNTHESIS IC
M
PWM MODULATOR AND CONTROL BOARD
DATA
DIRECT DIGITAL SYNTHISIS IC
M
DATA
DIRECT DIGITAL SYNTHISIS IC
M
PHASE 2 & 3 BOARD
DRIVER LOGIC / CONTROL
+250V
OUTPUT FILTER ASSY.
VOLTAGE & CURRENT SIGNALS
PHASE A
-250V
+250V
+250V
-250V
INPUT MULTI-PULSE TRANSFORMER AND RECTIFIER CIRCUITS
IGBT DRIVER BOARD
+250V
PHASE B
LINE
INPUT POWER CONTROL
-250V
+250V
PHASE C
-250V
BL30000 SYSTEM BLOCK DIAGRAM

FIGURE 5-1

5.4 MODULATOR BOARD

5.4.1 The modulator board provides the following low voltage supplies.

a. +/-15 Vdc for analog circuits
b. +5 Vdc for control and logic circuits
c. +24Vdc isolated supply for amplifier assembly drivers

All output stage logic signals and control originate from the modulator board. Sine wave signals from the micro controller board are applied to the modulator inputs. This circuitry converts the sine waves into a “carrier-based PWM” pulse train. These pulses are sent to the amplifier assemblies to produce the output waveforms. Fault detection and power up sequences are also handled by the modulator board.

5.5 DIGITAL CONTROLLER MOTHERBOARD

5.5.1 The Controller board uses an analog type power supply to provide the following low voltage supplies.

a. +/-15 Vdc for analog circuits
b. +5 Vdc for digital circuits
c. +5Vdc for Isolation board and/or GPIB interface or analog remote board

5.5.2 The control assembly supervises the operation of the power supply. It generates the sinewave signals, controls and regulates the output voltage and current, and measure and displays output parameters .The sine wave generation is accomplished by Direct Digital Synthesis IC U2. The operation of the control circuitry is managed by the Micro controller U1. All firmware is stored in U1. The front panel frequency control sets an interrupt to the microprocessor which is processed and determines the frequency of the DDS. The DDS generates a sine wave at a frequency between 45 and 500 Hertz. Phase displacement is also determined by the controller.

5.5.3 The controller board also regulates the output voltage of the power source. The measured voltages from 6 RMS to DC converters are fed to the control circuitry. The voltages are measured through a multiplexed line to the microprocessor. Each signal is measured and compared to the programmed value. The difference is used as an error signal to control the gain of an analog multiplier. This arrangement provides an AGC (automatic gain control) function. This action regulates the output voltage of the power supply.

5.5.4 All inter-connection between circuits and controls are provided via the main board. A 20 pin ribbon cable connector is present for the installation of 2nd and 3rd phase control card. Distribution of all low voltage supplies is via the Main board.

5.6 OUTPUT INVERTER AMPLIFIERS

5.6.1 The three output invertors are based on a half bridge topology. A 1200 volt, 150 amp, IGBT module 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 (sine wave generator). This output is filtered by a low pass network. The result is a sine wave voltage that is an amplified version of the original sine wave signal.

5.6.2 Pulse Width Modulation is performed by the individual pulse width modulator IC’s on the modulator control board. The tri-wave signal generated by the Phase A Modulator is distributed to each of the other modulators on the board. Components U1, U2, U3,U4,U11 and U12 form a modulator circuit that provides a dual polarity PWM signal . These signals are applied to opto-coupled driver IC's on the amplifier driver board. These driver IC's provide boosted, isolated, drive for the upper and lower IGBT of the output inverter unit. The three inputs to the modulator chips are the locally generated 20 KHZ tri-wave the 500V p-p square wave from the inverter and the sine wave from the digital controller.

5.6.3 The driver IC's of the inverter assembly 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 signals are used to set a latching lock out that turns off the PWM drive signals from the modulator board. The latch logic comprises U7 and U8 on the Modulator board. The latch must be reset by cycling power.

5.6.4 The modulator board has several other features that are important to the operation of the unit. These features include monitoring of the input capacitor voltages. It provides a shutdown mechanism if the split DC rails become unbalanced due to load unbalancing. If one of the rails becomes “pumped up” or if both rails are too high to safely switch, the unit will stop the modulation until the rails return to a safe operating level. A separate input monitors the condition of the soft-start contactor to prevent driving power until the soft-start function is complete. The over temperature signals will also shut down the modulation if the unit exposed to an excessive operating temperature There are three inputs that process the overload latch pulse to shut down the inverter. If any of the IGBT drivers reports a de-saturation due to excessive output current, or a device fault occurs in one of the amplifier modules, it will permanently shut down the switching pulses. Operation can only be restored by recycling power. These signals are processed and sent to the digital controller for display.

5.7 METERING

5.7.1 Metering is provided by AC signals taken from transformers on the output filter board. These signals are attenuated and applied to the controller where they are converted to DC voltages. The voltages are measured by the micro-controller and sent to front panel display. The frequency display derives it's data from the DDS circuitry.

5.8 CLOSING THE LOOP

In order to provide a clean output with very good regulation, two feedback loops are used. One feedback loop is a fast loop that takes the IGBT output and closes the loop to the PWM error amplifier. This loop, on a pulse-by-pulse basis, corrects for switching effects. The second feedback loop corrects for regulation. It is a slow loop that measures the output voltage of the ac power supply and converts it from RMS to DC as described earlier in this section. Feedback from the current sense transformer is also used in another loop to effectively limit the output current. The output of this transformer is converted from RMS to DC and is used to modify the AGC error signal.

5.9 CURRENT LIMIT

There are two distinct current limits:

Slow Limit- The slow current limit uses the RMS/DC converter output derived from the current sense transformers in each phase. When the DC exceeds a pre-set trip point (approximately 120% of nominal), the output goes into constant current mode. The output voltage decreases to force the unit to hold the current at 100% of nominal. When this happens, the CONSTANT CURRENT front panel display indicator lights. The RMS/DC converter has a filter with an equivalent 200 millisecond delay. This means that as long as the RMS output current does not exceed 100% of nominal for more than 200 milliseconds, the output will not be affected. This allows the unit to drive loads with continuous peak currents (high crest factors) exceeding 200% of nominal, indefinitely as long as this peak current does not exceed the limit of the actual RMS current.

Fast Limit- The fast current limit circuitry protects the unit from overloads of greater than 200% of nominal current. The IGBT drivers have internal circuitry to sense the collector to emitter voltage of the device. If the IGBT is exposed to excessive output current, the collector emitter voltage will rise and the device becomes “de-saturated” . This condition is detected by the driver which will generate a fault pulse. gets reset This pulse will set a “latch” used to inhibit the PWM to the IGBT drivers which immediately shuts off the output and lights the OVERLOAD LATCH on the front panel display.

5.10 OVER TEMPERATURE

The unit contains an over temperature sensor that is located on the IGBT heat sink. If an excessive temperature is sensed, the sensor turns off the output until the temperature has decreased to an acceptable limit . This action also lights the OVER-TEMP front panel LED. This condition will also set the controller back to a default value of 0 Volts. When the over temperature condition clears the unit's output voltage must be programmed to the desired value again (see programming instructions in the appendices for details).

5.11 HOUSEKEEPING SUPPLIES & MISCELLANEOUS

5.11.1 A small power transformer and rectifier arrangement are used to provide operating voltages for the drive circuitry and modulator boards. Power for the controller is derived from linear power supplies mounted in the controller chassis assembly. Both the bias supply and controller assembly receive 115 VAC nominal from an auxiliary winding on the main power transformer.

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APPENDIX A

BEHLMAN PAC 2000 Controller RS232 Interface Details FOR 1/3 PHASE UNITS

Revised 9/05/03

The following performance characteristics of the power supply may be controlled via the RS232 I/O:

1. Set or Change the frequency from 45Hz to 500Hz with a resolution of 0.1Hz.
2. Set or Change the Voltage for all 3 phases with a resolution of 0.1V.
3. Set or Change the Current Limit for all 3 phases with a resolution of 0.1A
4. Set or Change the Phase Angle in B and C Phases with Resolution 0.3 degrees (only in 3 Phase Units).
5. Switch the unit to LOW or HIGH range (for 2 Range Unit)
6. Switch the output ON/OFF

The following information may be read from the power supply:

1. Frequency at a resolution of 0.1 Hz;
2. Voltage at a resolution of 0.1 Volt;
3. Current Limit at a resolution of 0.1A (the same for all 3 Phases);
4. Status - Output ON or OFF, Three-Phase or One-Phase, Over Temperature- Over Current - Over Voltage conditions , Constant Current and Power Stage Failure.
5. Current with resolution 0.1A;
6. Phase Angle of B and C Phases with resolution 0.3 degrees;
7. Power in Watts with resolution 1Watt;
8. Power Factor with resolution 0.01;

The host computer may initiate a communication session only if the controller is in the 'remote' Mode. (local-remote switch on the controller is in the 'remote' position). In the remote mode the controls on the front panel are disabled.

COMMUNICATIONS PROTOCOL

The serial communication format is ; 9600 baud, 8 bits, No Parity, 1 stop bit, full duplex. A DB9 connector is provided for connecting to the host computer. The host computer will receive data from the controller without handshaking. Refer to figure 1 at the end of this document.

The controller will receive data from the host only when it's ready to receive. Due to this feature the controller uses handshaking. The host must check to see if the controller is ready to receive a character. In a Windows interface using Visual Basic or Visual C++, the MICROSOFT Communication Control (MSCOMM) will support handshaking automatically if the properties of the MSCOMM are installed correctly.

When Pin4 (DB9) is high, the power supply is ready to receive a character from the host.

COMMUNICATIONS SYNTAX

Communication utilizes the following commands. Every command is an ASCII code string. There are two types of commands; 'SET' and 'READ'.

'SET' Commands:

'SET' commands are used to program the output parameters of the power supply. These parameters include frequency, voltage, current limit, phase angle, output voltage range, and output on/off switching. In one phase mode the commands for phase A will control the power supply.

SET Commands (continued) :

There are two types of 'Set' commands; short 'Set' and Long 'Set'. Short 'Set' commands are single characters (ASCII codes of characters). In addition to acting on the command, the controller will send back a response to acknowledge the command. The short 'Set' commands are :

Command / Function	**Response**
"**O**"- switches the output ON;	M01000.0
"**o**"- switches the output OFF;	M02000.0
"**R**"- switches to the HIGH range; *	M03000.0
"**r**"- switches to the LOW range; *	M04000.0
"**E**"- resets errors	M05000.0

* **Note:** Whenever a range command is received the output voltage defaults to zero.

"**E**"- Resets the over- (voltage, current .temperature ,output stage failure) conditions and clears the RS232 input buffer.

The Long 'Set' commands consists of eight (8) Characters. The seventh character is a decimal point (.). Command name and 7 characters. (VXXXXX.X)

Long Set Commands:

"**V**"- Sets Voltage -in Volts- all three phases simultaneously.
"**F**"- Sets Frequency - in Hertz- all three phases simultaneously.
"**I**" - Sets Current Limit - in Amperes - all three phases simultaneously.
"**g**"- Sets Phase angle of B phase (relative to phase A) in Degrees.*
"**h**"- Sets Phase angle of C phase (relative to phase A) in Degrees.*

* Note: In order to set either phase angle , the "**h**" phase command must be sent . This is done to provide the option to change both phase angles at the same time. If only the B phase angle is to change, send the new phase B angle command and the command for phase C with no change from it's previous value.

SET COMMAND EXAMPLES:

The following are examples of the long 'Set' commands sent to the controller. Note that each character will be converted to its corresponding ASCII Code and placed into the transmit buffer .For security reasons every long 'SET' command must be sent twice in one string without blanks. The controller will check both commands, and only if they are the same, act upon the command and send back a response.

Desired Action	**Command Format**
Set Voltage to 125.6 Volt	"V00125.6V00125.6"
Set Frequency to 390 Hz	"F00390.0F00390.0"
Set Current Limit to 12.3 A	"I00012.3I00012.3"
Set Phase Angle in B Phase to 100.3 degrees	"g00100.3g00100.3"

If the data received by the controller is correct, the controller will send back the following messages to the host computer.

"M00000.1"	-for correct Voltage;
"M00000.2"	-for correct Current Limit;
"M00000.3"	-for correct Frequency;
"M00000.4"	-for correct Phase Angle B;
"M00000.3"	-for correct Phase Angle C;

SET COMMAND EXAMPLES (continued):

If the received data is corrupted the controller will send the following message:

"M00000.8" or "M00000.9" = data is corrupted

It's recommended to check the response messages and if the host receives an error response (M00009.0) or does not receive a response message at all, repeat the command. After the 'Set' command is sent, check the result of this command -the voltage, the frequency, the current limit or the phase angles .If the result is OK send a new command.

'READ' COMMANDS:

A 'Read' command is sent by the host computer to get information from the power supply controller. These commands are case sensitive characters.

'Read' commands sent by the host computer:

"**A**" - retrieve Phase A Voltage;
"**a**" - retrieve Phase A Current;
"**B**" - retrieve Phase B Voltage;
"**b**" - retrieve Phase B Current;
"**C**" - retrieve Phase C Voltage;
"**c**" - retrieve Phase C Current;
"**W**" - retrieve Phase A Power; (optional)
"**P**" - retrieve Phase A Power Factor; (optional)
"**X**" - retrieve Phase B Power; (optional)
"**Q**" - retrieve Phase B Power Factor; (optional)
"**G**" - retrieve Phase B Phase Angle; (optional)
"**Y**" - retrieve Phase C Power; (optional)
"**q**" - retrieve Phase C Power Factor;(optional)
"**H**" - retrieve Phase C Phase Angle; (optional)
"**f**" - retrieve Frequency;
"**I**" - retrieve Current Limit (same for all three phases).
"**s**" - retrieve Status information:
Output is ON/OFF
Low or High range
Over Current -Over Voltage- Over Temperature
Constant Current
Output Stage Failure

After the 'Read' command is transmitted by the host computer, the response will be sent back by the controller .The response format is a string of eight (8) characters. The first character is the command itself. The seventh character is a decimal point (.).

Following are examples of 'READ' command responses received by the host computer:

Response Read	**Explanation**
"A00125.6"	Phase "A" Voltage = 125.6V
"f00360.0"	Frequency = 360.0Hz
"i00012.3"	Current Limit = 12.3A;
"b00002.3"	Phase "B" Current=2.3A;
"W12125.0"	Power in Phase A is 12125 Watt

READ COMMANDS (continued):

Explanation of status (“S”) ‘READ’ command:

The status "s" command consists of eight (8) characters. The seventh character is a period (.). The format is = (sXXXXX.X = sabcde.x) where the characters “a” thru “e” represent the following:

Second character “a” indicates output on/off status:	a="0"- HEX Code 0x30- Output OFF a ="1"- HEX Code 0x31- Output ON.
Third character "b"; indicates operating range/mode	b="0"- Three-Phase Output. b="1"- One-Phase Output.
Fourth character "c"; indicates “Over” conditions Over Voltage, Current , or Temperature	c="0"- everything OK; c="1"- OT, OV or OC fault.
Fifth character "d" Constant Current Mode	d ="0"- everything OK; d="1"- Constant Current
Sixth character "e" Output Stage Failure	e="0" - everything OK; e="1"- Output Stage Failure

Seventh character "x" is reserved for future development

Status Considerations:

The unit will only enter the constant current mode current limit value = the default current . The default current limit is always set to the maximum capacity for the size of the power supply being controlled. The output voltage will be decreased to set the output current close to default current limit for this mode to protect the power supply from over current.

Note: During any "Over" conditions the output voltage will be set to zero and the current limit will revert to the default value. To recover from any detected "Over" conditions, the "E" command- must be sent through RS232. Reset may also achieved by pressing the front panel RESET button , or by cycling the input power to the unit off and on.

After the eight (8) characters are received the Host computer will check the information. Character 7 must be a decimal point (.) and all other characters must be numeric . If not, the received data is corrupted and the host computer must clear the input buffer and repeat its request for data.

Response data is a floating-point number [NNNNNN.N]; [(6 Digits), decimal point (.), (1 Digit)]. Digit corresponds to the ASCII code for a number from 0 to 9. Every character in this number, including the decimal point, will be replaced by its ASCII code.

For example: If the string , 102 48 48 51 52 53 46 54 - is received by the host computer, it must be converted as follows :

ASCII Code	**Alphanumeric**
102	“f”
48	“0"
51	“3"
52	“4"
53	“5"
46	“.” (decimal point)
54	“6"

The converted string "f00345.6" means that the Frequency is 345.6 Hz.

ADDITIONAL 'READ' COMMANDS:

The following 'READ' commands are provided to allow the user to query the controller for it's default values and/or predefined limits which are stored in firmware. The function of these command are described
below:

Command	Function
"J"	Read predefined maximum voltage when in high range.
"L"	Read predefined maximum voltage when in the low range.
"M"	Read Default current limit when in high range.
"N"	Read Default current limit when in low range.
"T"	Read predefined maximum frequency.
"U"	Read predefined minimum frequency.
"Z"	Read predefined hardware/software status.

Examples of additional READ commands:

Response	Explanation
J00270.0	Predefined high range of 270.0 Vac.
L00135.0	Predefined low range of 135.0 Vac.
M00005.0	Predefined default high range current limit of 5.0A
N00010.0	Predefined low range current limit of 10.0 A
T00500.0	Predefined maximum frequency of 500 Hertz.
U00045.0	Predefined minimum frequency of 45 Hertz.

The "Z" query defines some software and hardware options that may be included with the AC power supply systems. The end user may' READ' read these values by sending the "Z" command.

The format of the "Z" response is the "s" or status command explained earlier in this document.

The Z response format = Zabcde.f , where characters "a" thru "e" indicate hardware status as defined below:

Character	Indication	Status
"a"	Power Measurement options	"a" = 1 = installed "a" = 0 = not installed
"c"	Dual or Single range output	"c" = 1 = dual "c" = 0 = single
"b"	Variable Phase Angle options	"b" = 1 = installed "b" = 0 = not installed
"d"	Single or Three phase output	"d" = 1 = 3 phase "d" = 0 = 1 phase

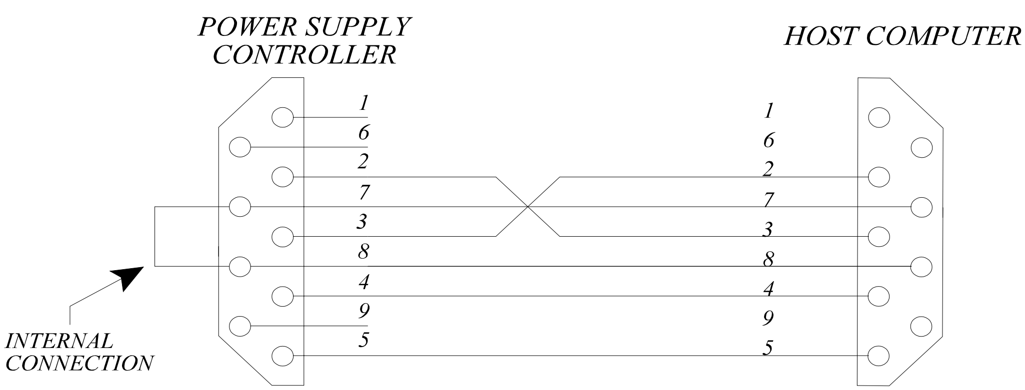
Characters "e" and "f" are reserved for future development.

REMOTE PRGM CONNECTOR (**J5**)

The REMOTE PRGM connector, a nine-pin D connector located on the rear panel of the controller, is provided to enable the user to program the unit via a computer. A mating nine pin male connector is supplied to the user for fabricating the cable required for connecting to the host computer. It is recommended that 20 AWG shielded wire be used to fabricate the cable. Table 3 lists the connector pin descriptions for a standard RS 232 serial port.

TABLE 3. REMOTE PRGM CONNECTOR PIN DESCRIPTIONS

PIN	DESCRIPTION
1	Data Carrier Detect (NOT USED)
2	Received Data (RXD)
3	Transmitted Data (TXD).
4	Data Terminal Ready (DTR).
5	Signal Ground (GND)
6	Data Set Ready (NOT USED)
7	Request to Send (NOT USED)
8	Clear to Send (NOT USED)
9	Ring Indicator (NOT USED)



RS 232 CABLE CONNECTIONS

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IEEE-488 USER'S GUIDE

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TABLE OF CONTENTS

SECTION 1
INTRODUCTION TO PAC-2000 IEEE-488 INTERFACE

About This Guide
This User's Guide contains programming information for controlling Behlman Electronics AC Power Supplies using the PAC-2000 AC Source Controller with its optional IEEE-488 (GPIB) communication interface. These units shall be called the Controller throughout this manual.

Most of this guide explains the specifics of Controller command syntax and assumes that the user understands how to send these commands over the bus. No attempt has been made to specify how any specific brand of GPIB interface controlling device would be programmed. It is left up to the user to learn these details from the device's manufacturer. Some knowledge of common GPIB terminology is assumed, but the user need not be an expert on the GPIB to understand this manual.

Relevant Additional Documentation
The following documents contain additional useful information as references about the IEEE-488.1 bus or the programming conventions contained herein.

ANSI/IEEE Std. 488.1-1987 IEEE Standard Interface for Programmable Instrumentation.

> Defines the technical details and hardware implementation of the GPIB interface. References to this specification will be abbreviated as IEEE-488.1

ANSI/IEEE Std. 488.2-1987 IEEE Standard Codes, Formats, Protocols and Common Commands.

> Defines the programming formats, Common Commands, and Fault Response Protocols. It is helpful to get a precise definition of Common Commands, message and data formatting, and error handling. References to this specification will be abbreviated as IEEE-488.2

Both of these documents are available from the IEEE, 345 East 47th Street, New York, NY 10017, USA.

SECTION 2
INTRODUCTION TO PROGRAMMING

GPIB CAPABILITIES OF THE AC SOURCE
All Functions of the PAC-2000 AC Source Controller, except for setting the GPIB address, are programmable over the GPIB.

The operation of the Controller's GPIB interface is IEEE-488.2 compliant.

IEEE-488.1 Available Subsets.
The following subsets are implemented on the Controller:
SH1:AH1:T6:L4:SR1:RL1:PP0:DC1:DT0:C0

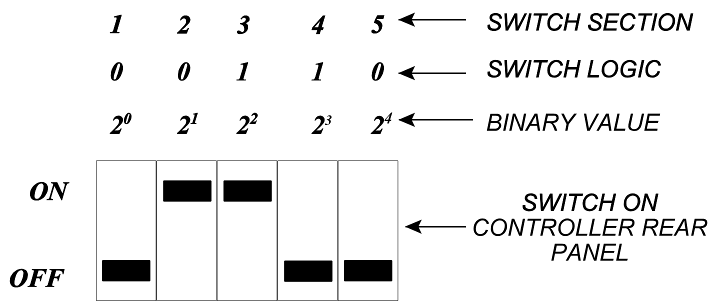
IEEE-488.2 Optional Features.
None of the IEEE-488.2 optional features are implemented in the Controller.

GPIB Address
The GPIB address of the Controller is set using a five position switch on the rear of the AC source's control chassis. (Many Behlman AC Sources have more than one rack mount chassis. The Control Chassis is the chassis that has the PAC-2000 display and control keys on the front panel.) Access to the address switch and GPIB interface connector requires opening of equipment cabinet. **CAUTION ! Removing covers exposes hazardous voltages. Refer to power unit technical manual and qualified personnel** .

GPIB Address Setting

Any address from 0 through 30 (decimal) may be selected using the five switch segments. Address 31 is an invalid address and, if selected, may cause erratic operation of the GPIB interface.

A switch in the ON (up) position is logic 0 and when it is in the OFF (down) position it is logic 1. Address 6 would be:



Conventions Used in this Guide

Angle Brackets:	**< >**	Items enclosed in angle brackets are parameter abbreviations. I.E. <NL> indicates a New Line character.
Vertical bar	**|**	Vertical bars separate alternate parameters. I.E. MAX|MIN indicates that either “MAX’ or “MIN” can be used as a parameter.
Square Brackets	**[ ]**	Items enclosed in square brackets are optional.
Braces	**{ }**	Parameters enclosed in braces may be repeated zero or more times.
`Computer` font		This font is used in literal examples.

It is assumed that all data accepted or returned by the Controller conforms to the ASCII standard.

Abbreviations

<bool>	Data format that specifies a binary state. Includes 0|1, OFF|ON, or where appropriate, HI|HIGH|LO|LOW (0 = OFF|LO|LOW, 1 = ON|HI|HIGH) In fact, any non-zero numeric data value is considered a 1. When used as a talker parameter only 0|1 are returned.
<CRD>	Character Response Data. ASCII response string defined in IEEE-488.2.
<CPM>	Command Program Message. A <PMU> that changes some condition in the instrument.
d	Decimal value when it follows a number.
<END>	GPIB EOI, End or Identify uni-line message.
h	Hexadecimal value when it follows a number.

Abbreviations (continued)

MAX	Maximum value implicit in the range specification for the parameter. Can be: MAX|MAXIMUM.
MIN	Minimum value implicit in the range specification for the parameter. Can be: MIN|MINIMUM
<NL>	New Line character, which is ASCII 10d or 0Ah.
<NR1>	Numerical data with an implied decimal point assumed to be at the right of the least-significant digit. Examples: 12, 1357.
<NR2>	Numerical data with an explicit decimal point. Examples: 12.3, 0.05.
<NR3>	Numerical data with an explicit decimal point and an exponent. Examples: 4.5E+2, 0.9e-5, 5E4.
<NRf>	Numeric Data that includes any of <NR1>, <NR2>, or <NR3>.
<NRf+>	Numeric Data the includes <NRf> and MIN|MAX.
<PM>	Program Message, basically a complete command message sent to the instrument over the GPIB interface.
<PMT>	Program Message Terminator, a sequence to inform the Controller that the incoming Program Message is complete.
<PMU>	Program Message Unit, an individual instrument command for the instrument. One or more <PMU> constitute a <PM>, along with the appropriate separator and termination sequences.
<QPM>	Query Program Message. A <PMU> that requests data from the instrument.

General Programming Syntax

Each command sent to the Controller follows the same general programming syntax and is called a Program Message, <PM>.

Each <PM> contains at least one Program Message Unit, <PMU>, followed by a Program Message Terminator, <PMT>. The details of the different <PMU> are given in Section 3,

In a graphical form: <PM> = <PMU>[;<PMU>]<PMT>

When multiple <PMU> are sent in the same <PM> they must be separated by a Program Message Unit Separator, which is the ASCII semi-colon ‘;’.

All <PM> and <PMU> conform to the IEEE-488.2 standard with regards to formatting.

Each <PMU> can be considered an individual instrument command that will either cause the instrument to change some function or condition, Command Program Messages, <CPM> , or cause the instrument to prepare and return some item of data for the host computer, Query Program Messages, <QPM>.

General Programming Syntax (continued)

<CPM> consist of a header, which usually takes the form of a mnemonic or abbreviated form of a function, and, optionally, some program data. Program data are required when there is more that one acceptable state for a particular header. If there is only one state for the header it is sent by itself.

The graphical form: <PMU> = <CPM>[<data>] Note: space required before <data>
or
<PMU> = <QPM>

As an example: it is logical for the <CPM> that controls the state of the output relay to have an ON and an OFF state. The <PMU> for these commands are `L ON` or `L OFF`, respectively. Notice that a space is required to separate the header from the program data to prevent the instrument from assuming that `RON` is a different Command Program header.

An example of a <CPM> that requires no data is *RST, which resets the instrument to its power-on conditions.

<QPM> contain only a header which **must** end with the character '?'. Although query headers that require data are allowed by the IEEE 488.2 specification, the Controller does not implement any. An example of a <QPM> would be the one that requests the state of the output relay, `L?`. The response prepared by the Controller would be either '0' or '1', depending on if the relay is open or closed, respectively.

Program Message Terminator, <PMT>
The <PMT> indicates to the Controller that the host computer has sent the last character in a message and that the Controller may proceed with implementing the commands contained in the message. There are three termination sequences allowed by IEEE-488.2. They are:

<NL>	An ASCII New Line sent by itself, or
<END>	An IEEE-488.1 End-or-Identify, EOI, message, or
<NL><END>	Both of the above.

In the examples in this guide the <PMT> will be assumed as being present and will not be shown explicitly, except if expressly needed. In that case, it will be shown as <NL>, regardless of the form of the actual termination.

Case
The Controller is case insensitive.

Numerical Data Formats
Numerical data sent to, or returned by the Controller, conform to the IEEE-488.2 standard. All <NRF1> data can be sent as Non-Decimal Numeric Program Data.

Suffixes and Multipliers
The Controller does not recognize any Suffixes or multipliers. All numeric data, sent or received, is assumed to be in the default units given for the particular parameter or <PM>.

Character Data
All character strings returned by query <PM> take the form of <CRD>.

SOURCE SUBSYSTEM

F Source Output Frequency

This command sets the output frequency of the Controller.

Command Syntax:	F <NRf+>
Units:	Hz (Hertz)
Range:	
Standard:	45.0 - 500.0
Extended frequency:	45.0 - 1000.0
Resolution:	0.1
Reset Value:	400
Examples:	`F 100.1, F MIN`
Query Syntax:	F?
Example:	`F?`
Returned Parameters:	<NR2>

I Source Output Current Limit

This command sets the current limit value. Affects all phases simultaneously.

Command Syntax:	I <NRf+>
Units:	A (RMS Amperes AC)
Range:	Varies with amplifier configuration and capabilities.
Resolution:	0.1
Reset Value:	MAX
Examples:	`I 12.2, I MIN`
Query Syntax:	IL?
Returned Parameters:	<NR2>

PB Source Phase Angle A - B (Three Phase units only)

This command sets the lagging phase angle of Phase B relative to the reference Phase A. The PB command must be followed by the PC command. The PB phase angle will not be set until completion of the PC command. If it is required to set PB without affecting the PC value then PC must be sent with its present value.

Command Syntax:	PB <NRf>
Units:	Degree
Range:	0.0 - 360.0
Resolution:	1.0
Reset Value:	120
Examples:	`PB 121`
Query Syntax:	PB?
Returned Parameters:	<NR2>

SOURCE SUBSYSTEM (continued)

PC Source Phase Angle A - C (Three Phase units only)

This command sets the lagging phase angle of Phase C relative to the reference Phase A. The PC command must be preceded by the PB command. The PB phase angle will not be set until completion of the PC command. If it is required to set PC without affecting the PB value then PB must be sent with its present value.

Command Syntax: PC <NRf>
Units: Degree
Range: 0.0 - 360.0
Resolution: 1.0
Reset Value: 240
Examples: `PC 245`
Query Syntax: PC?
Returned Parameters: <NR2>

V Source Output Amplitude

This command sets the output voltage amplitude of the Controller. On multiphase units that have the independent phase amplitude programming option, including the phase identifier, A|B|C, will program the amplitude on the specified phase only.

Command Syntax: V[A|B|C] <NRf+>
A|B|C specifies the phase to be programmed on units with the independent phase amplitude programming option.
Units: V (RMS Volts AC)
Range:
P1352
Low Range 0.0 - 135.0
High Range 0.0 - 270.0
BL+
Option 1 0.0 - 132.0
Option 2 0.0 - 264.0
Option 3 0.0 - 305.0
NOTE: The MAXIMUM value is dependent on the range(s) available and the active range selected with the R command. The BL+ units do not have dual output range capability.
Resolution: 0.1
Reset Value: 0.0
Examples: `V 100.1, V MAXIMUM, VA 25, VC 34.7`

OUTPUT SUBSYSTEM

The output subsystem controls the state of the main outputs.

L Set Output Relay

This command sets the state of the output relay.

Command Syntax: L <bool>
Reset Value: 0|OFF
Examples: `L 1, L OFF`
Query Syntax: L?
Returned Parameter: <bool>

OUTPUT SUBSYSTEM (continued)

R Set Range Relay (Multi-range units only)

This command sets the state of the output voltage range relay on those units that have multiple output ranges.

Command Syntax:	R <bool>
Reset Value:	0|OFF|LOW
Examples:	`R 0, R HI, R HIGH`
Query Syntax:	R?
Returned Parameter:	<bool>

MEASUREMENT SUBSYSTEM

I? Measure Output Current

This query returns the value of the output Current, by Phase, on multi-phase units, in RMS Amperes AC.

Query Syntax:	I[A|B|C]? A|B|C specifies the phase of the measurement on multi-phase units.
Examples:	`I?, IC?`
Returned Parameters:	<NR2>

PF? Measure Output Power Factor

This query returns the absolute value of the output Power Factor, by Phase, on multi-phase units. Power Factor is a unitless measurement in the range of 0 - 0.999.

Query Syntax:	PF[A|B|C]? A|B|C specifies the phase of the measurement on multi-phase units.
Examples:	`PF?, PFB?`
Returned Parameters:	<NR2>

T? Measure Output Power

This query returns the value of the output Power, by Phase, on multi-phase units, in Watts.

Query Syntax:	T[A|B|C]? A|B|C specifies the phase of the measurement on multi-phase units.
Examples:	`T?, TC?`
Returned Parameters:	<NR2>

V? Measure Output Voltage Amplitude

This query returns the value of the output Voltage amplitude, by Phase, on multi-phase units, in RMS Volts AC.

Query Syntax:	V[A|B|C]? A|B|C specifies the phase of the measurement on multi-phase units.
Examples:	`V?, VA?`
Returned Parameters:	<NR2>

PAC EVENT STATUS REGISTER COMMANDS

PSE

This command programs the PAC Event Status Enable register bits. The programming determines which events of the PAC Event Status register are allowed to set the PACR (PAC Event Summary Bit) of the Status Byte register. A "1" in the bit position enables the corresponding event of the PAC Event Status Register, PSR. All of the enabled events of the PSR are logically ORed to cause the PACR of the Status Byte Register to be set.

The associated query reads the Standard Event Status Enable register.

Bit definition of the PAC Event Status Enable register:

Bit Position	Bit Name		Bit Weight
7	RSE	RS232 Link Timing error	128
6	Not Used		
5	Not Used		
4	AOC	Amp Over Current	16
3	AOV	Amp Over Voltage	8
2	AOT	Amp Over Temp	4
1	ACC	Amp Constant Current	2
0	OPF	Output Fail	1

Command Syntax:	PSE <NRf>
Parameters:	0 to 255
Power-On Value:	0
Examples:	`PSE 129`
Query Syntax:	PSE?
Returned Parameters:	<NR1>
Related Commands:	*ESR? PSR? *STB?

PSR?

This query reads the PAC Event Status register. Reading the register clears it and resets any AOC, AOV, or AOT status that may have been the cause of the PAC Event. Note that clearing the Amp error status may not clear the physical condition that caused the error. It is recommended to remove any load from the unit when any of these errors occur, either by an external means or sending the L OFF command.

The bit configuration of this register is the same as the PAC Event Status Enable register (see PSE).

Query Syntax:	PSR?
Parameters:	None
Returned Parameters:	<NR1> (register value)
Related Commands:	*CLS *ESE *ESE? PSE PSE?

NOTICE

The output voltage of the source will be set to zero and any amplitude programming will be disabled whenever AOC, AOV, or AOT in the PAC Event Status Register are set. Any attempts to program the output voltage with any of these bits set will produce a DDE Error in the Standard Event Status Register (see *ESE and *ESR). Periodic reading of the PSR or enabling the AOV, AOC, and AOT in the PSE is recommended.

CONFIGURATION QUERY SUBSYSTEM

FMN? Program Frequency Minimum
This query command obtains the Minimum frequency that the unit is configured to accept.

Query Syntax:	FMN?
Examples:	FMN?
Returned Parameters:	<NR2>

FMX? Program Frequency Maximum
This query command obtains the Maximum frequency that the unit is configured to accept.

Query Syntax:	FMX?
Examples:	FMX?
Returned Parameters:	<NR2>

IMXH? High Range Current Limit Maximum
This query command obtains the Maximum Current limit value that the unit is configured to accept, in the high range, for multiple range units.

Query Syntax:	IMXH?
Examples:	IMXH?
Returned Parameters:	<NR2>

IMXL? Low/Single Range Current Limit Maximum
This query command obtains the Maximum Current limit value that the unit is configured to accept, in the low range, for multiple range units and for single range units.

Query Syntax:	IMXL?
Examples:	IMXL?
Returned Parameters:	<NR2>

VMXH?High Range Voltage Maximum
This query command obtains the Maximum program Voltage that the unit is configured to accept, in the high range, for multiple range units.

Query Syntax:	VMXH?
Examples:	VMXH?
Returned Parameters:	<NR2>

VMXL?Low/Single Range Voltage Maximum
This query command obtains the Maximum program Voltage that the unit is configured to accept, in the low range, for multiple range units and for single range units.

Query Syntax:	VMXL?
Examples:	VMXL?
Returned Parameters:	<NR2>

IEEE-488.2 Common Commands

*CLS

This command clears the following registers:
Standard Event Status
Status Byte
PAC Status

Command Syntax:	*CLS
Parameters:	None

*ESE

This command programs the Standard Event Status Enable register bits. The programming determines which events of the Standard Event Status register are allowed to set the ESB (Event Summary Bit) of the Status Byte register. A "1" in the bit position enables the corresponding event of the Standard Event Status Register, ESR. All of the enabled events of the ESR are logically ORed to cause the Event Summary Bit (ESB) of the Status Byte Register to be set.

The associated query reads the Standard Event Status Enable register.

Bit definition of the Standard Event Status Enable Register

Bit Position	Bit Name	Bit Weight
7	PON Power-On	128
6	Not Used	
5	CME Command Error	32
4	EXE Execution Error	16
3	DDE Device_dependent	8
2	QYE Query Error	2
1	Not Used	
0	OPC Operation Complete	1

Command Syntax:	ESE <NRf>
Parameters:	0 to 255
Power-On Value:	0
Examples:	`ESE 129`
Query Syntax:	ESE?
Returned Parameters:	<NR1>
Related Commands:	*ESR? PSR? *STB?

*ESR?

This query reads the Standard Event Status Event register. Reading the register clears it. The bit configuration of this register is the same as the Standard Event Status Enable register (see ESE).

Query Syntax:	*ESR?
Parameters:	None
Returned Parameters:	<NR1> (register value)
Related Commands:	*CLS *ESE *OPC PSE

IEEE-488.2 Common Commands (continued)

***IDN?**

This query requests the Controller identification string. It returns the data in four fields separated by commas.

Query Syntax:	*IDN?
Parameters:	None
Returned Parameters:	<AARD>

Field Information

Manufacturer: Behlman Electronics Inc

Model Number: PAC-2000-ddddd.d

where: ddddd.d gives the unit configuration of the Controller. The meaning of the configuration digits are:

(MSD) D5	1:	Independent phase voltage programming enabled
	2:	Power readings enabled
	3:	Power readings and independent phase voltage programming both enabled
D4	1:	Dual output range; 0: Single output Range
D3	0:	Fixed output phase angles
	1:	Output phase angle programmable
D2	0:	Single phase output unit
	1:	Three phase output unit
	2:	Two phase output unit
D1	0:	Variable output voltage unit
	1:	Fixed output voltage unit
(LSD) D0	0	Variable output frequency Unit
	1:	Fixed output frequency unit

Serial Number: 0xxxx or 0

Firmware Revision: nn.nn/nn.nn is the typical format. The fist group is the revision of the main board firmware, the second group is the revision of the GPIB interface firmware.

Example `Behlman Electronics Inc.,PAC-2000-21010.1,0,02.27/02.00`

***OPC**

This command will set the OPC bit (bit 0) of the Standard Event Status register when the Controller completes all prior pending operations. (see *ESE for the bit definitions of the Standard Event Status registers.) Pending operations are complete when:

all commands sent before *OPC have been executed. The Controller has no overlapped commands. The *OPC command provides notification that all commands have been completed by providing a means to send generate an IEEE-488.1 Service Request when the commands are finished.

Command Syntax:	*OPC
Parameters:	None
Query Syntax:	*OPC?
Returned Parameters:	<NR1>
Related Commands:	*WAI

IEEE-488.2 Common Commands (continued)

***RST**

This command resets the unit to the following factory-defined states:

L OFF
R LOW
F 400.0
I MAX
V MIN
PB 120.0
PC 240.0
PSE 0
*ESE 0
*SRE 0

NOTE: *RST does not clear any of the status registers or the error queue, and does not affect any interface error conditions.

Command Syntax:	*RST
Parameters:	None

***SRE**

This command programs the value of the Service Request Enable Register. The set bits in this register determines which bits of the Status Byte Register (see *STB for the bit definitions) are allowed to set the Master Status Summary (MSS) bit and the Request for Service (RQS) summary bit. A “1" in any Service Request Enable Register bit enables the associated bit in the Status Byte Register and all such enabled bits then are logically ORed to determine the state of Bit 6 of the Status Byte Register.

When the Host computer conducts a serial poll in response to SRQ, the RQS bit is cleared, but the MSS bit is not. When *SRE is cleared (by programming it with 0), the interface cannot generate an SRQ to the controller.

Command Syntax:	*SRE <NRf>
Parameters:	0 to 255
Default Value:	0
Example:	*SRE 128
Query Syntax:	*SRE?
Returned Parameters:	<NR1> (register binary value)
Related Commands:	*ESE *ESR PSE PSR

***STB?**

This query returns the value of the Status Byte register. This register contains the Controller's status summary bits and the Output Queue Message Available (MAV) bit. The Status Byte register is not cleared when read. The status summary bits are cleared or set by actions that affect the associated event registers.

A serial poll also returns the value of the Status Byte register, except that bit 6 returns the IEEE-488.1 Request for Service message, RQS, instead of Master Status Summary (MSS). A serial poll clears RQS, but not MSS. When MSS is set, it indicates that the Controller has one or more reasons for requesting service.

IEEE-488.2 Common Commands (continued)

***STB?** (continued)

Bit definition of the Status Byte Register:

Bit Position	Bit Name	Bit Weight
7	Not Used	
6	MSS/RQS	64
5	ESB	32
4	MAV	16
3	Not Used	
2	Not Used	
1	Not Used	
0	PACR	1

Query Syntax:	*STB?
Parameters:	None
Returned Parameters:	<NR1> (register value)
Related Commands:	*SRE *ESR *ESE PSR PSE

***TST?**

This query causes the Controller to do a self-test and report any errors. All communication with the PAC amplifier digital oscillator is through an RS-232 communication link. The TST command will attempt to verify that this link is operating properly and that the PAC amplifier is able to respond properly and return correct data.

The self test sends a command to reset the RS232 Communication link, attempts to open the output relay, set the output voltage amplitude to zero, and then to read the output voltage. If there are any problems in completing this command sequence the Controller will return an error as listed below.

Query Syntax:	*TST?
Parameters:	None
Returned Parameters:	<NR1> 0 indicates the ac source has passed selftest. Non-zero indicates an error code.

Error Codes:

0 No error,	
100H+xxH	Could not send PAC reset command,
200H+yyH	Internal PAC reset failed,
300H+xxH	Could not send Open Relay command,
400H+yyH	Improper PAC response to Open Relay command,
500H+xxH	Relay failed to open,
600H+xxH	Could not send Reset Voltage command,
700H+xxH	Could not send Read Output Voltage command,
800H+yyH	Output voltage did not reset,

xx is a code that tells where in the RS-232 communication process the command failed. The Controller always requests the amplifier status prior to executing any command. The error code is the sum of Transmit Error Code and the Command Error Code which specifies whether the err happened while getting the status or sending actual command.

Command Error Codes:

010H	Error while requesting the status,
020H	Error while attempting the command.

IEEE-488.2 Common Commands (continued)

Transmit Error Codes:

081H	RS-232 never went ready for data transmit,
083H	RS-232 didn't acknowledge data,
084H	RS-232 took too long to acknowledge command termination,
085H	RS-232 didn't release data acknowledge,
0C1H	Received response but it was corrupted,
0C3H	Status response incorrect format,
0CFH	No response from PAC after multiple attempts.

yy is a code that tells where the expected response differed from the actual PAC response.

***WAI**

This command causes the Controller to suspend processing of any further commands until any previous commands are complete. Pending operations are complete when:

all commands sent before *WAI have been executed. This includes overlapped commands. Most commands are sequential and are completed before the next command is executed. Overlapped commands are executed in parallel with other commands. Commands that affect output voltage or state, relays, and trigger actions are overlapped with subsequent commands sent to the PAC. The *WAI command prevents subsequent commands from being executed before any overlapped commands have been completed.

*WAI can be aborted only by sending the a IEEE-488.1 DCL (Device Clear) command.

Command Syntax:	*WAI?
Parameters:	None
Related Commands:	*OPC

APPENDIX C

ADDENDUM TO PAC2000 USER'S MANUAL
SPECIAL DIGITAL CONTROLLER WITH THE ABILITY TO SET
VOLTAGE INDEPENDENTLY IN EVERY PHASE

This document explains the operation of a special version of the PAC2000 controller. This version allows for independent control of the voltage on each of the three output phases. Except for as described below, all other operating instructions and considerations remain un-changed. Refer to section 3.4 for full information on the PAC2000 controller.

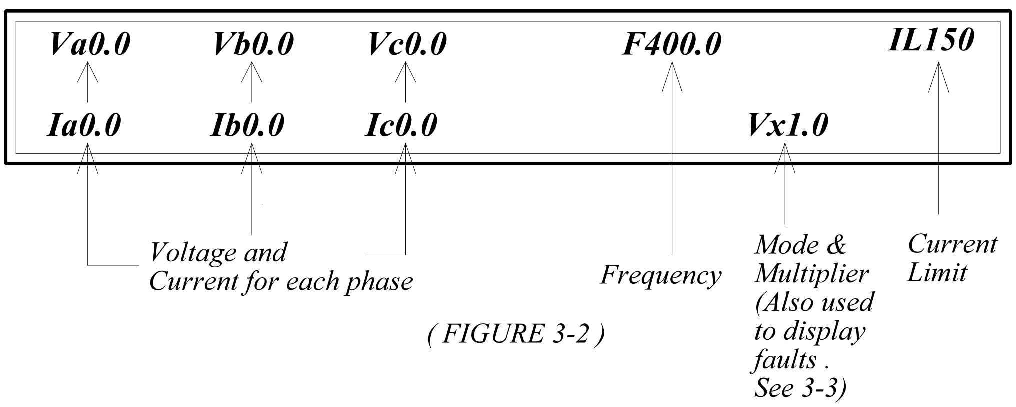
To adjust the output voltages:

MANUAL MODE

1.) Set the LOCAL/REMOTE switch on the front panel to the "LOCAL" position.

2.) Turn on the power supply , after initial self test, the display will look as below.

3.) Press the OUTPUT switch to enable the output. The display should look as follows:



(FIGURE 3-2)

4.) Press the MODE key once and the Vx1.0 on the display will change to Vax1.0 . The Voltage of Phase A may now be adjusted in 1.0V increments. If a larger step is desired hold the MODE key in and press the SHIFT key This will advance the step size to X10.0V.

5.) To adjust the B phase, Press the mode switch again, the display should now indicate Vbx1.0V. Now the B phase may be adjusted. Every time the MODE key is pressed the controller with sequence through adjustable parameters.This version limits adjustment to the Phase angles between the Phases are limited to +/- 10deg.

RS232 REMOTE MODE

Four additional remote commands are added. Commands are case sensitive.

“D” (Capital letter)-read the Version of the Software;
“w” (low case)-set Voltage in A Phase only;
“x” (low case)-set Voltage in B Phase only;
“y” (low case)-set Voltage in C Phase only;