USER'S GUIDE AND
TECHNICAL REFERENCE

AC SOURCE

BEHLMAN MODEL BL4500

FOR SERVICE ASSISTANCE

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PACKING 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 2 to 3 inches of clearance around sides, top and bottom of unit.

3) When packing unit, utilize either a foam-in-place system or high density foam. Clearance provided for above must be completely filled with foam.

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

DO NOT USE PEANUTS OR BUBBLE

4) Secure box (es) to pallet (s). This is necessary to insure proper handling and protection during shipping.

5) Place the following warning label on box (es)

DO NOT STACK

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

DO NOT USE UPS

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 crates base. The crate must be shock mounted to avoid damage during shipping.
Detail drawings for Behlman's crates are available upon request.

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. Foward a copy of the damage claim report to Behlman. Include the model number, serial number and date the shipment was received. Behlman will advise the disposition of the equipment and will arrange for necessary repair or replacement.

RETURNING EQUIPMENT TO FACTORY

Do not return equipment to the factory without prior authorization from Behlman.

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

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

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

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

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

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

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

TABLE 1. BEHLMAN MODELS

MODEL	INPUT VOLTAGE (ac)	OUTPUT VOLTAGE (ac)
BL4500C-1	120V/208VAC 3 PHASE	0-270 V
C-2	220/380VAC 3 PHASE	0-270 V
C-3	277/480VAC 3 PHASE	0-270 V
C-4	200 VAC, DELTA, 3PHASE	0-270 V
C-5	346/600VAC 3 PHASE	0-270 V
C-6	230/400VAC 3 PHASE	0-270 V
C-7	240/415VAC 3 PHASE	0-270 V

OPTIONS: Add E to the dash number for extended frequency range.
Add I to the dash number for Remote GPIB IEEE-488/RS232 Interface
Add L to the dash number for front panel locking controls (VOLTS, FREQ) on voltage and frequency.
Add P to the dash number for 6:1 current crest factor.
Add S to the dash number for chassis slides.
Add MT to the dash number for Motor Test Option.

1.2 SPECIFICATIONS

INPUT POWER

Voltage:	SEE TABLE 1
Frequency:	47-440 Hz.

OUTPUT POWER

Voltage:	0-270 Vac
Frequency:	45-500 Hz
Maximum Power:	4500 VA
Maximum Current:	17A
Current Crest Factor:	3:1
Power Factor:	100% of rated output into any power factor load.
Distortion:	1.5% maximum THD (measured at full load, 100 Vac, 50 Hz).
Load Regulation:	±0.7% from no load to full load.
Line Regulation:	±0.1% for ±10% of line change.
Efficiency:	85-90%

MECHANICAL

Operating Temperature:	0°C to 55°C (32°F to 131°F).

SECTION 2

UNPACKING AND INSTALLATION

2.1 UNPACKING

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

2.2 INSTALLATION

1) This unit is rack mounted.

NOTE

The unit must have bottom support when mounting in a rack or a cabinet. Do not attempt to mount by front panels only. These units, when stacked, require proper cooling air circulation therefore, a six inch clearance is required at the rear of the units.

2) Ensure that the line circuit breaker and all other unit controls are in the OFF position before connecting input.

3) Connect the unit as follows.

CAUTION

Be careful to connect input neutral, if desired to GND stud.

a) INPUT POWER - Connect 47-440 HZ, power lines to the designated terminal strip on the rear panel of the input chassis.

b) OUTPUT POWER - Output power lines are connected to the output terminal strip on the rear panel of the control chassis.

c) Interconnection between chassis:

Connect HI, GND, and Low with cable provided.

Connect chassis GND studs with cable provided.

See Figure 2-1 for interconnect information.

NOTE: Chassis ground may be connected to users chassis ground or to service neutral if desired.

SECTION 3

OPERATION

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) must always be in place during operation.

3.1 CONTROLS AND INDICATORS

Table 1 lists the controls and indicators used on the different models of the AC Source. The table also includes their function. Figure 1 locates these front panel controls and indicators. Also shown are the rear panel REMOTE PRGM connector, two terminal strips, cooling fan, and a GND stud.

3.2 TO OPERATE THE EQUIPMENT

1) Ensure that line circuit breaker and OUTPUT switch are set to OFF.

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

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

4) Rotate VOLTS control to desired voltage (selector switch set to VOLTS).

5) Rotate FREQ control to desired frequency (selector switch set to FREQ).

6) Set OUTPUT switch to ON to energize load.

NOTE

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

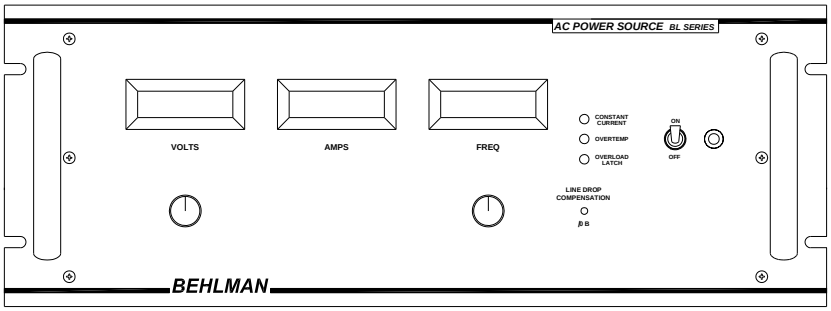
3.3 SHUTDOWN PROCEDURE

1) Set OUTPUT switch to OFF.

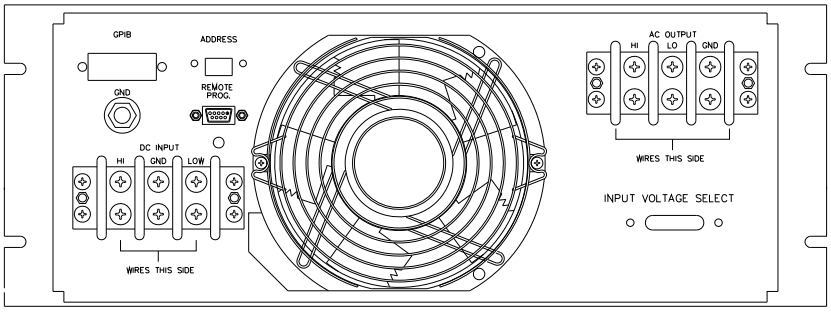
2) Set line circuit breaker to OFF.

TABLE 1. CONTROLS AND INDICATORS

CONTROL/INDICATOR	FUNCTION
Circuit breaker	ON: Connects input power to unit. OFF: Disconnects input power from unit.
CONSTANT CURRENT indicator	Lights to indicate protective circuits are automatically operating to provide rated current and distortionless output during an overload condition.
FREQ control	Used to establish output frequency.
OUTPUT switch	ON: Connects output power to base plate terminal strip. OFF: Disconnects output power from base plate.
OVERLOAD LATCH indicator	Lights to indicate short circuit protection for over load conditions that disables the output. Overload latch is reset by removing load and recycling power. Overload latch is reset by removing load and recycling
OVERTEMP indicator	Lights to indicate over temperature condition and removal of output power. Output power is automatically restored on termination of overtemperature condition.
Digital readout meters	VOLTS: Provides output voltage (RMS) display. AMPS: Provides output current (RMS) display. FREQ: Provides output frequency display.
VOLTS control	Used with selector switch (set to VOLTS) to establish desired output voltage.
Line drop compensation	Allows for output adjustment due to IR drops in the load line.



FRONT PANEL



REAR PANEL

3.4 REMOTE PROGRAMMING

3.4.1 REMOTE PRGM CONNECTOR

The REMOTE PRGM connector, a nine-pin connector located on the rear panel, is provided to enable the user to program the unit remotely. It is recommended the user use AWG 20 wire to fabricate the cable. Table 1 lists the connector pin descriptions. During remote operation, the unit's front panel VOLTS and FREQ controls must be set fully ccw. An isolated 0 to 10 Vdc remote voltage is used to control the unit's output voltage from 0 to full-scale and its output frequency from 45 to 500 Hz.

3.4.2 REMOTE AMPLITUDE AND FREQUENCY CONTROL

Two 0-10 Vdc control voltages from externally isolated voltage sources are used to control the unit's amplitude and frequency via the fabricated remote cable.

TABLE 2. REMOTE PRGM CONNECTOR PIN DESCRIPTIONS

PIN	DESCRIPTION
1	External synch HI
2	External synch LO
3	Amplitude & frequency control (rtn).
4	Amplitude control (hi).
5	Frequency control (hi).
6	Output relay control
7	Output relay control
8	Not used.
9	Not used.

3.5 EXTERNAL SYNC

The unit provides for external syncing via its rear panel EXTERNAL SYNC connector. When an external sync signal is applied to the unit, it reacts to produce an output frequency that is equal to the sync signal regardless of the FREQ control setting. The external sync signal can be either TTL compatible or an AC signal from 5 to 30 VRMS.

CAUTION

The external sync signal applied to the unit must not be lower than 45 Hz to avoid possible damage to the unit.

SECTION 4

MAINTENANCE AND ADJUSTMENTS

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) must always be in place during operation.

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

4.1 MAINTENANCE

WARNING:

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

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

The decision on whether a units warranty has been voided will exclusively reserved for Behlman.

4.2 ADJUSTMENTS

NOTE

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

4.2.1 TEST EQUIPMENT REQUIRED

TEST EQUIPMENT	MANUFACTURER/MODEL
Current Clamp	Fluke 801-600 (or equivalent current transformer)
Digital Voltmeter (DVM)	Fluke 8062A (or equivalent)
Frequency Counter	HP 5314A (or equivalent)
Oscilloscope	Iwatsu SS-5571 (or equivalent)

4.2.2 CONTROLLER CARD POTENTIOMETER ADJUSTMENTS

Since certain potentiometer adjustments affect other associated potentiometer settings, a sequence of adjustments must be followed to ensure the proper setting of each potentiometer within the three groups compromising the unit. The three groups: frequency, voltage and current, are listed below in the sequence to be performed within each group.

FREQUENCY		**VOLTAGE**		**CURRENT**	
POT.	**PARA**	**POT.**	**PARA**	**POT.**	**PARA**
R15	4.2.3	R29	4.2.6	R129	4.2.9
R16	4.2.4	R61	4.2.6	F.P.	4.2.10
R19	4.2.5	R58	4.2.8		

4.2.3 LOW FREQUENCY TRIM (45 Hz R15)

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

2) Turn FREQ control fully ccw.

3) Set circuit breaker to ON

4) Set OUTPUT switch to ON.

5) Adjust VOLTS control until volts meter indicates 10 Vrms minimum.

6) Adjust 45 Hz potentiometer R15 until frequency counter indicates 45 Hz.

4.2.4 HIGH END FREQUENCY TRIM (500 Hz R16)

1) Turn FREQ control fully ccw.

2) Adjust 500 Hz potentiometer R15 until frequency counter indicates 500 Hz.

4.2.5 FREQUENCY METER ADJUST (Hz-METER R19)

1) Turn FREQ control fully cw.

2) Adjust Hz.-METER potentiometer R19 until front panel meter indicates 500 Hz.

4.2.6 FULL SCALE OUTPUT VOLTAGE ADJUST (R29)

1) Using DVM set to ac volts, connect it across output terminal strip, located on the baseplate.

2) Turn VOLTS control fully ccw.

3) Set circuit breaker of power chassis to ON.

4) Set range switch to LO.

5) Set OUTPUT switch of power chassis to ON.

6) Turn VOLTS control fully cw.

7) Adjust R29 until DVM indicates 265 VMS.

4.2.7 VOLTAGE METER ADJUST (F.S R61)

1) Turn VOLTS control fully cw.

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

4.2.8 CURRENT METER ADJUST (I-METER R58)

1) Set circuit breaker to OFF.

2) Set OUTPUT switch to OFF.

3) Turn VOLTS control fully ccw.

4) Connect load to rear panel OUTPUT terminals ϕA and NEUT.

5) Connect current clamp or other current measuring device across load.

6) Set circuit breaker to ON.

7) Set OUTPUT switch to ON.

8) Adjust VOLTS control, making certain not to exceed 17 amps, to 100 VRMS. Increase load until current read on the measuring device is about 17 amps.

9) Adjust I-METER potentiometer R58 on ϕA board until front panel current meter indication is same as load current noted in step 8.

4.2.9 20 KHz TRIANGLE WAVE TRIM (DIST. TRM R129)

1) Turn VOLTS control fully ccw.

2) Connect oscilloscope across output terminal strip.

3) Set oscilloscope gain to 500 mV/div.

4) adjust DIST.TRM potentiometer R34 for smallest waveform peak-to-peak value.

4.2.10 LINE DROP COMPENSATION TRIM

1) Connect selected load to output terminal strip.

2) Connect DVM at load input so as to compensate for IR losses in the conncting lines.

3) Set circuit breaker to ON.

4) Set OUTPUT switch to OFF.

5) Adjust VOLTS control to desired setting on DVM. Note voltage setting. (Should be the same as the panel meter indication).

6) Set OUTPUT switch to ON.

7) Adjust front panel I.R. COMP potentiometer to pre-load voltage setting noted in step 5.

SECTION 5

THEORY OF OPERATION

5.1 GENERAL

5.1.1 The BL4500 series represents low cost, high performance, AC to AC power invertors. These units provide variable output voltage and frequency from 0 to 135 Vac and 45 to 500 Hz respectively. This series may be operated from a 120/208 Vac, 220/380 Vac 277/480 Vac, 200 Vac (Delta), or 346/600 Vac three phase input line at 50 or 60 Hertz. Other versions include higher single phase outputs and external step-up/down output transformer options.

5.2 INPUT POWER

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

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

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

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

5.3 CONTROL CHASSIS

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

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

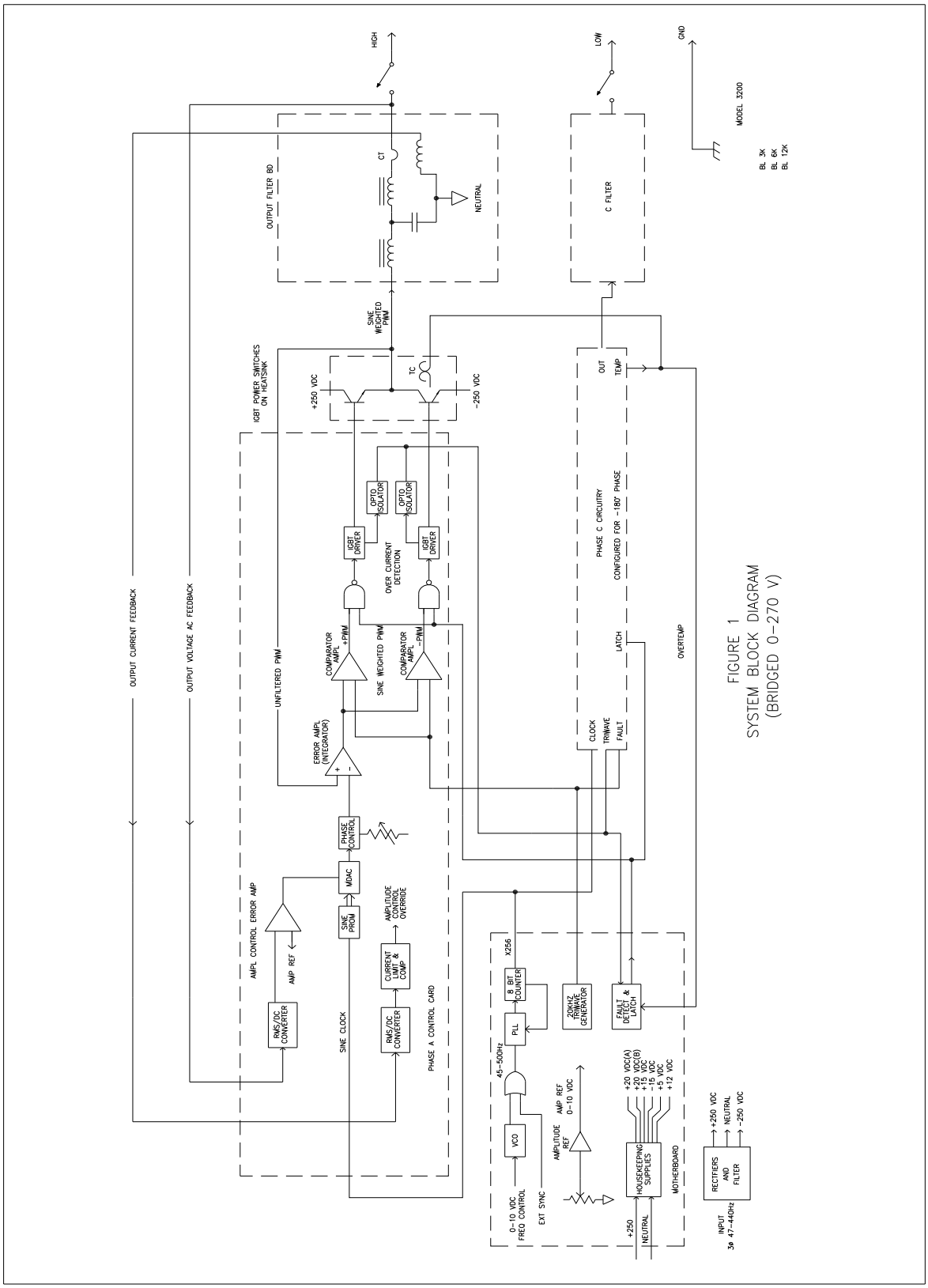


FIGURE 1
SYSTEM BLOCK DIAGRAM
(BRIDGED 0-270 V)

5.4 MOTHERBOARD

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

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

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

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

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

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

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

5.5 OUTPUT INVERTER

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

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

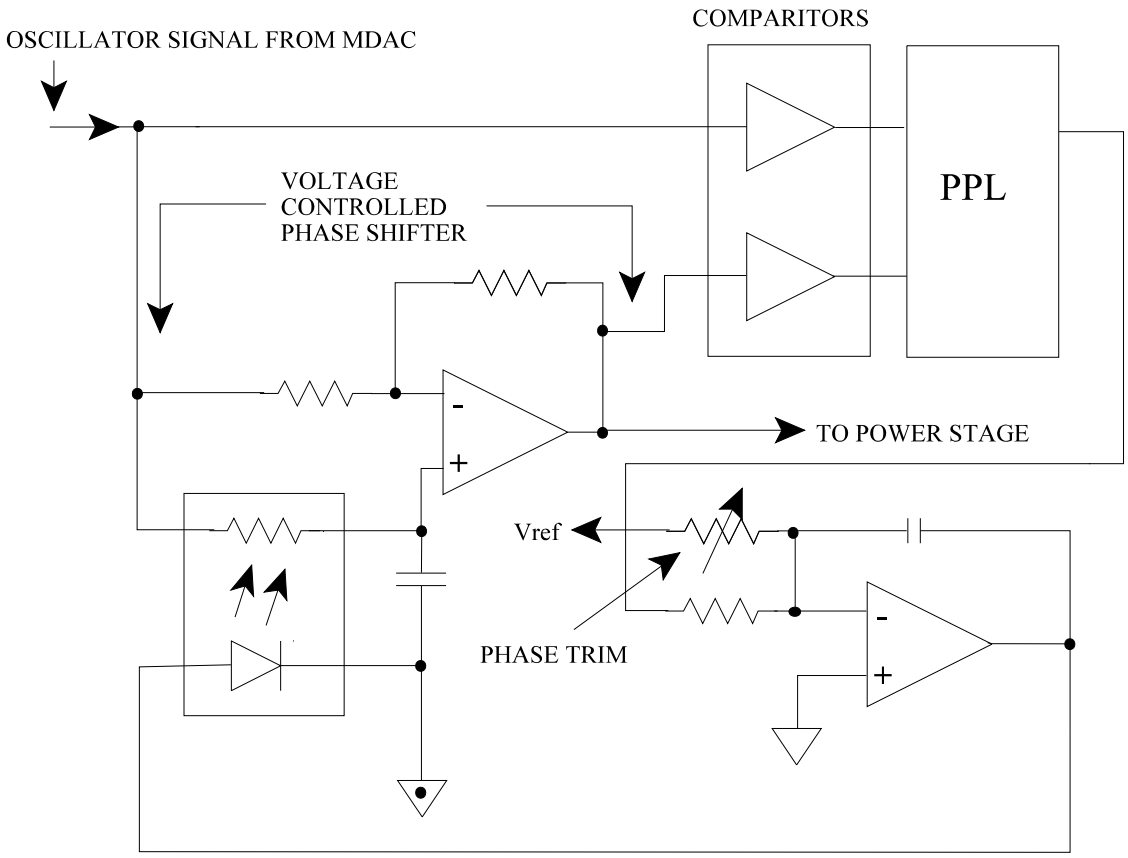


FIGURE 2 PHASE CONTROL CIRCUIT

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

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

5.6 METERING

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

5.7 MISCELLANEOUS

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

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

SECTION 6

DRAWINGS

APPENDIX A

IGBT DRIVER

The insulated gate bipolar transistor (IGBT) driver is a hybrid IC that is used in the overcurrent detector circuit of each BL4500 unit. Two of these drivers are used in each unit to provide signal isolation, overcurrent detection, and low- speed overcurrent cutoff features. Figure 1 shows the internal parts of an IGBT driver and its pin descriptions.

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

OVERCURRENT DETECTION - The IGBT driver can withstand an overcurrent of 10 *u* sec duration when short circuited. An extremely fast protection circuit is used here for this reason.

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

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

Figure 1. IGBT Driver, Pin Description and Schematic

APPENDIX B

BL SERIES AC POWER SUPPLY
IEEE-488 INTERFACE SPECIFICATIONS

1.1 IEEE-488 BUS UTILIZATION

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

SH1 - Source Handshake
AH1 - Acceptor Handshake
T8 - Basic Talker
L4 - Basic Listener
DC1 - Device Clear
RL0 - No Remote / Local Function
SR0 - No Service Request
PP0 - No Parallel poll response
DT0 - No Device Trigger
C0 - Not a controller

1.2 IEEE-488 BUS COMMANDS

1. Single-Line Commands

IFC - Clears GPIB interface

2. Multi-Line Command

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

1.3 GPIB COMMUNICATION

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

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

NOUN
ACS

1.4 AC POWER SUPPLY SYNTAX

Setup Command:

FNC ACS :CH0 SET VOLT <value>

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

Table 1-1

CIIL SOFTWARE COMMANDS

CIIL COMMANDS	EXPLANATION
- All SET, SRX, SRN commands are part of the setup command above.	
SET VOLT <value>	Sets output voltage to given value,in volts rms. The following values are permitted: 0 ≤ value ≤ 34, or 135, or 270, dependent on range selected and type of unit. If set volt (value) not received, then use SRN VOLT (value), or SRX VOLT (value). If none of these 3 are sent then generate error message.
SET FREQ <value>	Optional. Sets frequency of output voltage to given value, in Hz. The following values are permitted: 45 ≤ value ≤ 500. Default is 60 Hz only if SET FREQ, SRN FREQ, or SRX FREQ are not received. Otherwise the values shall be used in the order stated.
SRX VOLT <value>	Optional. Sets maximum limit for SET VOLT command. If SET VOLT value is greater than SRX VOLT value in a command string, an error message is generated and the setup command ignored. The following values are permitted: 0 < value ≤ 34, or 135, or 270, dependent on range selected and type of unit. If a value for SRX VOLT is not specified, the required maximum value for SET VOLT default to 34, or 135, or 270, dependant on range selected and type of unit.

Table 1-1
CIIL SOFTWARE COMMANDS (cont)

CIIL COMMANDS	EXPLANATION
SRN VOLT <value>	Optional. Sets minimum value limit for SET VOLT command. If VOLT value is less than SRN VOLT value in a command string, an error message is generated and a setup command ignored. The following values are permitted: 0 ≤ value < 34, or 135, or 270, dependent on range selected and type of unit. The SET VOLT default is 0 for the minimum value if a value is not specified for SRN VOLT.
SRX FREQ <value	Optional. Sets maximum limit for SET FREQ command. If the SET FREQ value in a command string is grater than the maximum limit, an error message is generated and the setup command ignored. Legal values are: 45 < value ≤ 500. If a value for SRX FREQ is not specified, SRX FREQ defaults to 500.
SRN FREQ <value>	Optional. Assigns minimum value to SET FREQ command. If the SET FREQ value in a command string is less than the minimum limit, an error message is generated and the setup command ignored. Legal values are: 45 ≤ value < 500. If a value for SRN FREQ is not specified, SRN FREQ defaults to 45.
SET VLT0	Set LO voltage range.
SET VLT1	Set HI voltage range.

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

On dual range Power Supplies, this command selects the LO or HI voltage range. Dual Ranges are 0-34 volts 0-135 volts and 0-135/0-270 volt. If this command is omitted from the setup string the unit will default to the lowest available range. On single range units this command will be ignored.

NOTE

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

2. During IEEE operation, the unit's front panel VOLTS and FREQ controls must be fully CCW. If the controls are not set fully CCW, then the output voltage and frequency will be a sum of the programmed value and the value set with the front controls. Front Panel OUTPUT switch must be set to OFF position. Front Panel RANGE switch (on dual range units) must be set to LO.

Table 1-1
CILL SOFTWARE COMMANDS (cont)

CILL COMMANDS	EXPLANATION
FTH VOLT <cr><lf>	The AC supply responds to this command by transmitting the RMS voltage (in volts resolute to 0.1V) measured at its output, in decimal format as follows: <sp><digit><digit><digit><dp><digit><cr><lf>
FTH CURR <cr><lf>	The AC Supply responds by transmitting the current (in amps resolute to 0.1A) measured at its output, in decimal format, as follows: <sp><digit><digit><dp><digit><cr><lf>
FTH FREQ <cr><lf>	The AC Supply response by transmitting the frequency (in hertz) measured at its output, in decimal format, as follows: <sp><digit><digit><digit><cr><lf>
CLS :CH0 <cr><lf>	Closes output relay contacts. Connects AC Power Supply outputs to output terminal block. The setup command specifies the voltage and frequency. The setup command must be entered before the CLS :CH0 command.
OPN :CH0 <cr><lf>	Opens output relay contacts. Disconnects output of AC Power Supply from output connector. AC Power Supply retains voltage and frequency assigned by setup command.
RST ACS :CH0	Resets AC Power Supply to quiescent. The output relay opens and error messages are erased. Catastrophic error messages are cleared by reading the Power Supply's response, by use of the Status command.
CNF <cr><lf>	Instructs AC Power Supply to perform internal confidence test. STA command transmits the message. The AC Power Supply responds with one of the following: Pass <sp><cr><lf> Fail F07ACS0(DEV): CONFIDENCE TEST FAILURE <cr><lf>

Table 1-1
CILL SOFTWARE COMMANDS (cont)

CILL COMMANDS	EXPLANATION
IST <cr><lf>	Instructs AC Power Supply to perform internal self test. The STA command transmits the message. The AC Power Supply responds with one of the following: Pass <sp><cr><lf> Fail F07ACS0(DEV): BIT TEST FAILURE -PROM CHECKSUM FAULT -RAM FAULT -AC SUPPLY HARD FAULT <cr><lf>
STA <cr><lf>	Status. Prepares AC Power Supply for a response transmission. Clears error condition if one exists. The following response messages and conditions exclude confidence and internal self <sp><cr><lf> Device error messages F07ACS0(DEV):BIT TEST FAILURE <description consisting of up to 60 characters>< cr><lf> TMA error messages All begin with: F07ACS0 (MOD): This message is followed by one explanatory message from the following text: ILLEGAL NOUN AC Power Supply does not recognize illegal noun. ILLEGAL NOUN MODIFIER AC Power Supply does not recognize illegal noun modifier. ILLEGAL OPCODE AC Power Supply does not recognize illegal opcode. ILLEGAL VALUE Entered value lies outside upper and lower limits. NO SETUP Close command received but setup not programmed.

Example: F07ACS00(MOD): NO SETUP <cr><lf>

1.5 CATASTROPHIC ERRORS

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

Catastrophic Error Messages
All begin with:

F00ACS0(DEV):

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

OVERTEMP FAULT <cr><lf>

The heatsink temperature has exceeded its upper limit. The OVERTEMP LED on the front panel will light.

CURRENT LIMIT FAULT <cr><lf>

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

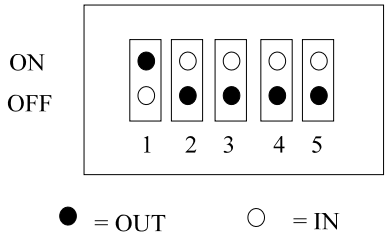
An output loading fault has occured causing the supply to exceed 500% rated current output. The supply automatically shuts down and opens its output relay. The OVERLOAD LATCH LED on the front panel will light.

1.6 ADDRESS SELECTION

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

EXAMPLE:

ADDRESS #1



Dipswitch Element	Equivalent Binary Value
1	1
2	2
3	4
4	8
5	16

1.7 **THREE PHASE COMMUNICATION**

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

FETCH DATA COMMANDS FOR THREE PHASE UNITS

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

All other commands for Fetch remain the same as the BL135Ø, described on page B-4 of this appendix.

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

GPIB PROGRAMMING EXAMPLES FOR BL1350

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

All commands must be in upper case ASCII, lower case characters are ignored. All commands transmitted to the AC Supply (2 phase) must terminate with a carriage return <cr> and a line feed <lf>, as will all responses reeived from the AC Supply (2 phase) .

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

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

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

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

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

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

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

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

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

Transmit setup command:
FNC ACS :CH0 SET VOLT 30 SET FREQ 400 SET VLT0 <cr><lf>

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

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

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

Transmit setup command:
FNC ACS :CH0 SET VOLT 115 SET FREQ 50 SET VLT1 <cr><lf>

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

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

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

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

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

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

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

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

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

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

Talk address the AC Supply to enable response:
50.0 <cr><lf>

GPIB PROGRAMMING EXAMPLE FOR THREE PHASE UNIT

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

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

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

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

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

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

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

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

Talk address the AC Supply to enable response:
120.0 <cr><lf>

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

Talk address the AC Supply to enable response:
120.0 <cr><lf>

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

Talk address the AC Supply to enable response:
1.5 <cr><lf>

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

Talk address the Ac Supplyto enable response:
1.0 <cr><lf> Average of 3 phases.

APPENDIX C

BLSERIES AC POWER SUPPLY
EIA-232 SERIAL INTERFACE SPECIFICATIONS

1.0 INTRODUCTION

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

1.1 EIA-232 INTERFACE UTILIZATION

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

The interface is configured to communicate with the following format:

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

Other BAUD rates, however, are available by special order

1.2 EIA-232 CONNECTIONS

SIGNAL

	AC SOURCE (DB-9)		HOST (DB-25)
GND	5	----------	7
RXD	2	----------	2
TXD	3	----------	3

The RS232 interface does not currently support hardware handshaking.

1.3 EIA-232 SERIAL COMMUNICATION

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

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

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

MODIFIERS
FREQ, VOLT, CURR, VLT0, VLT1

NOUN
ACS

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

NOTES:

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

EXAMPLES:

1.4 AC POWER SUPPLY SYNTAX

Setup Command:

FNC ACS :CHO SET VOLT <value>

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

Table 1-1

CIIL SOFTWARE COMMANDS

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

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

0 < value < 135, or 270, dependent on range selected and type of unit.

The SET VOLT default is 0 for the minimum value if a value is not specified for SRN VOLT.

SRX FREQ <value> — Optional. Sets maximum limit for SET FREQ command. If the SET FREQ value in a command string is grater than the maximum limit, an error message is generated and the setup command ignored. Legal values are:

45 < value < 500.

If a value for SRX FREQ is not specified, SRX FREQ defaults to 500.

CIIL SOFTWARE COMMANDS (cont)

CIIL COMMANDS	EXPLANATION
SRN FREQ <value>	Optional. Assigns minimum value to SET FREQ command. If the SET FREQ value in a command string is less than the minimum limit, an error message is generated and the setup command ignored. Legal values are: 45 ≤ value < 500. If a value for SRN FREQ is not specified, SRN FREQ defaults to 45.
SET VLT0	Set LO voltage range.
SET VLT1	Set HI voltage range.

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

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

NOTES:

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

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

CILL SOFTWARE COMMANDS (cont)

CILL COMMANDS	EXPLANATION
FETCH DATA COMMAND:	
FTH VOLT <cr><lf><eos>	The AC supply responds to this command by transmitting the RMS voltage (in volts) measured at its output, in decimal format as follows: <sp><digit><digit><digit><dp><digit><digit><cr><lf><eos>
FTH CURR <cr><lf><eos>	The AC Supply responds by transmitting the current (in amps) measured at its output, in decimal format, as follows: <sp><digit><digit><dp><digit><cr><lf><eos>

CIIL COMMANDS	EXPLANATION
FTH FREQ <cr><lf><eos>	The AC Supply response by transmitting the frequency (in hertz) measured at its output, in decimal format, as follows: <sp><digit><digit><digit><cr><lf><eos>
CLS :CH0 <cr><lf><eos>	Closes output relay contacts. Connects AC Power Supply outputs to output terminal BLock. The setup command specifiesthe voltage and frequency. The setupcommand must be entered before the CLS :CH0 command.
OPN :CH0 <cr><lf><eos>	Opens output relay contacts. Disconnects output of AC Power Supply from output connector. Ac Power Supply retains voltage and frequency assigned by setup command.
RST ACS:CH0	Resets AC Power Supply to quiescent. The output relay opens and error messages are erased. Catastrophic error messages are cleared by reading the Power Supply's response, by use of the Status command.
CNF <cr><lf><eos>	Instructs AC Power Supply to perform internal confidence test. STA command transmits the message. The AC Power Supply responds with one of the following: Pass <sp><cr><lf><eos> Fail F07ACS0(DEV): CONFIDENCE TEST FAILURE <cr><lf><eos>
IST <cr><lf><eos>	Instructs AC Power Supply to perform internal self test. The STA command transmits the message. The AC Power Supply responds with one of the following: Pass <sp><cr><lf><eos>

Fail
F07ACSO(DEV): BIT TEST FAILURE
(-PROM CHECKSUM FAULT|
-RAM FAULT
-AC SUPPLY HARD FAULT|
<cr><lf><eos>

STA <cr><lf><eos>

Status. Prepares AC Power Supply for a response transmission. Clears error condition if one exists. The following response messages and conditions exclude confidence and internal self test.

RESPONSE:

Status OK
<sp><cr><lf><eos>

Device error messages

F07ACSO(DEV):BIT TEST FAILURE
<description consisting of up to 60 characters><cr><lf><eos>

TMA error messages All begin with:

F07ACSO (MOD):

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

ILLEGAL NOUN

AC Power Supply does not recognize illegal noun.

ILLEGAL NOUN MODIFIER

AC Power Supply does not recognize illegal noun modifier.

ILLEGAL OPCODE

AC Power Supply does not recognize illegal opcode.

ILLEGAL VALUE

Entered value lies outside upper and lower limits.

NO SETUP

Close command received but setup not programmed.

Example: F07ACS00(MOD): NO SETUP <cr><lf><eos>

1.5 **CATASTROPHIC ERRORS**

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

Catastrophic Error Messages

All begin with:

F00ACS0(DEV):

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

OVERTEMP FAULT <cr><lf><eos>

The heatsink temperature has exceeded its upper limit. The OVERTEMP LED on the front panel will light.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Talk address the AC Source to enable response:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SECTION 6

DRAWINGS

PROPRIETARY

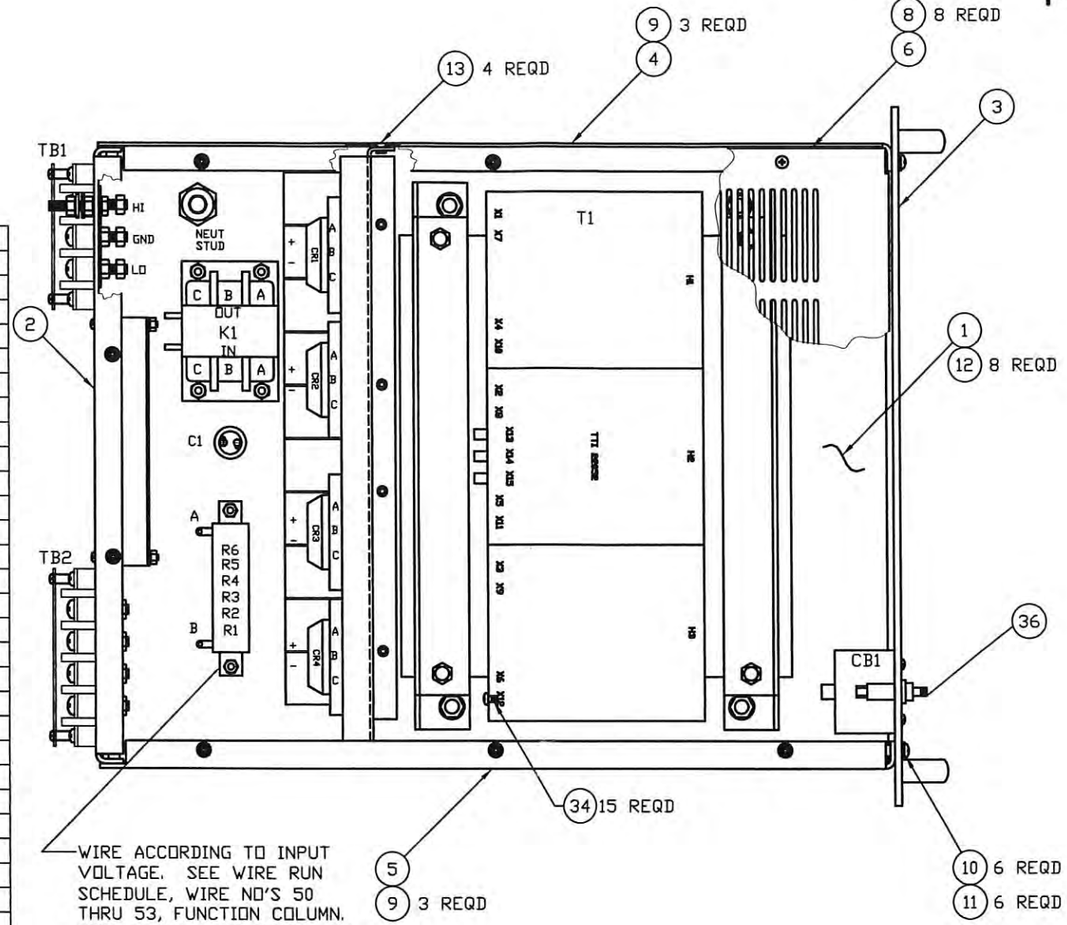
THE PROPRIETARY INFORMATION CONTAINED IN THIS DOCUMENT MUST NOT BE DISCLOSED TO OTHERS FOR ANY PURPOSE, NOR USED FOR MANUFACTURING PURPOSES WITHOUT PERMISSION OF BEHLMAN ELECTRONICS INC. THE ACCEPTANCE OF THIS DOCUMENT WILL BE CONSTRUED AS AN ACCEPTANCE OF THE FOREGOING CONDITION.

BEHLMAN ELECTRONICS INC.
HAUPPAUGE, NEW YORK

REV STATUS OF SHT	
REV	SHT
H	1

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED	DRL #	INIT
	-	RELEASED FOR PRODUCTION	920729			
	A	REVISED WIRE RUN SCHEDULE	931122			
	B	REVISED PER ECO 93-080				
	C	REVISED WIRE RUN SCHEDULE	950727			
	D	REVISED WIRE RUN SCHEDULE				
	E	REVISED PER ECO 96-049 & 96-063	961022			
	F	REVISED PER ECO 98-084	980706			
	G	REVISED PER ECO 03-036	030519			
	H	REVISED PER ECO 03-117	030912			



WIRE RUN SCHEDULE

CONN NO.	FROM	LUG ITEM NO.	TO	LUG ITEM NO.	AWG	COLOR	FUNCTION
48	C1–	–	K1 COIL–	19	20	WHT	
47	K1 OUT–B	–	T1–H2	15	10	BLK	
46	K1 OUT+A	–	T1–H1	15	10	RED	
45	R4B	–	K1 OUT–B	–	10	BLK	
44	R2B	–	K1 OUT +A	–	10	RED	
43	R3A	–	K1 IN–B	–	10	BLK	
42	R1A	–	K1 IN+A	–	10	RED	
41	TB2–NEUT	–	NC	14	12	BLK	
40	TB1–GND	14	NEUT STUD	14	10	BLK	
39	CR2 –	16	NEUT STUD	21	10	WHT	
38	A1E4	23	NEUT STUD	14	12	BLK	
37	A1E3	23	NEUT STUD	14	12	BLK	
36	T1 X3	22	INDICATOR LIGHT	21	20	WHT	
35	T1–X1	22	INDICATOR LIGHT	21	20	BLK	
34	A1E6	23	TB1 – (LO)	14	12	BLK	
33	A1E5	23	TB1 – (LO)	14	12	BLK	
32	A1E2	23	TB1 + (HI)	14	12	RED	
31	A1E1	23	TB1 + (HI)	14	12	RED	
30	K1 COIL +	19	A1E8	19	20	WHT	
29	K1 COIL –	19	A1E7	19	20	WHT	
28	CR4–	16	TB1 – (LO)	14	10	BLK	
27	CR1+	16	TB1 + (HI)	14	10	RED	
26	CR3 –	16	CR4 +	16	10	BLK	
25	CR2 –	16	CR3 +	16	10	BLK	
24	CR1 –	16	CR2 +	16	10	BLK	
23	J1–2	–	FAN –	20	20	BLK	
22	J1–1	–	FAN +	20	20	RED	
21	T1–X14	19	A1 J1–3	–	20	RED	
20	T1–X15	19	A1 J1–4	–	20	BLK	
19	T1–X13	19	A1 J1–5	–	20	RED	
18	T1–X12	16	CR4–øC	15	12	BRN	
17	T1–X11	16	CR4–øB	15	12	BRN	
16	T1–X10	16	CR4–øA	15	12	BRN	
15	T1–X9	16	CR3–øC	15	12	BRN	
14	T1–X8	16	CR3–øB	15	12	BRN	
13	T1–X7	16	CR3–øA	15	12	BRN	
12	T1–X6	16	CR2–øC	15	12	BRN	
11	T1–X5	16	CR2–øB	15	12	BRN	
10	T1–X4	16	CR2–øA	15	12	BRN	
9	T1–X3	16	CR1–øC	15	12	BRN	
8	T1–X2	16	CR1–øB	15	12	BRN	
7	T1–X1	16	CR1–øA	15	12	BRN	
6	CB1–øC (D)	15	K1 IN C	15	10	WHT	
5	CB1–øB (D)	15	K1 IN B	15	10	WHT	
4	CB1–øA (D)	15	K1 IN A	15	10	WHT	
3	TB2–øC	14	CB1–øC (A)	15	10	WHT	
2	TB2–øB	14	CB1–øB (A)	15	10	WHT	
1	TB2–øA	14	CB1–øA (A)	15	10	WHT	

WIRE RUN SCHEDULE, CON'T

CONN NO.	FROM	LUG ITEM NO.	TO	LUG ITEM NO.	AWG	COLOR	FUNCTION
62	R5–B	–	R6–A	–	14	BUSS WIRE	FOR C2,3,5,6,7
61	R5–B	–	R6–B	–	14	BUSS WIRE	FOR C1,C4
60	R5–A	–	R6–A	–	14	BUSS WIRE	FOR C1,C4
59	K1 OUT–C	–	T1H–3	–	10	WHT	
58	R6–B	–	K1 OUT C	–	10	ORG	
57	R5–A	–	KI IN C	–	10	BLU	
56	TB2N	–	T1N	–	10	WHT	
55	R3–B	–	R4–A	–	14	BUSS WIRE	C–2,C–3,C–5, C–6,C–7
54	R1–B	–	R2–A	–	14	BUSS WIRE	
53	R3–B	–	R4–B	–	14	BUSS WIRE	C–1,C–4
52	R3–A	–	R4–A	–	14	BUSS WIRE	C–1,C–4
51	R1–B	–	R2–B	–	14	BUSS WIRE	C–1,C–4
50	R1–A	–	R2–A	–	14	BUSS WIRE	C–1,C–4
49	C1+	–	K1 COIL+	19	20	WHT	

SEE SEPARATE PARTS LIST

	106-676-80X
NEXT ASSY	USED ON
APPLICATION	

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

THIS DRAWING SHALL ONLY BE CHANGED BY USE OF CAD

DRAWN J.ALGERIO	DATE 920727
CHECKED	DATE
ENGR	DATE
QUALITY CONTROL	DATE
MANUFACTURING	DATE

BEHLMAN

POWER CHASSIS ASSY

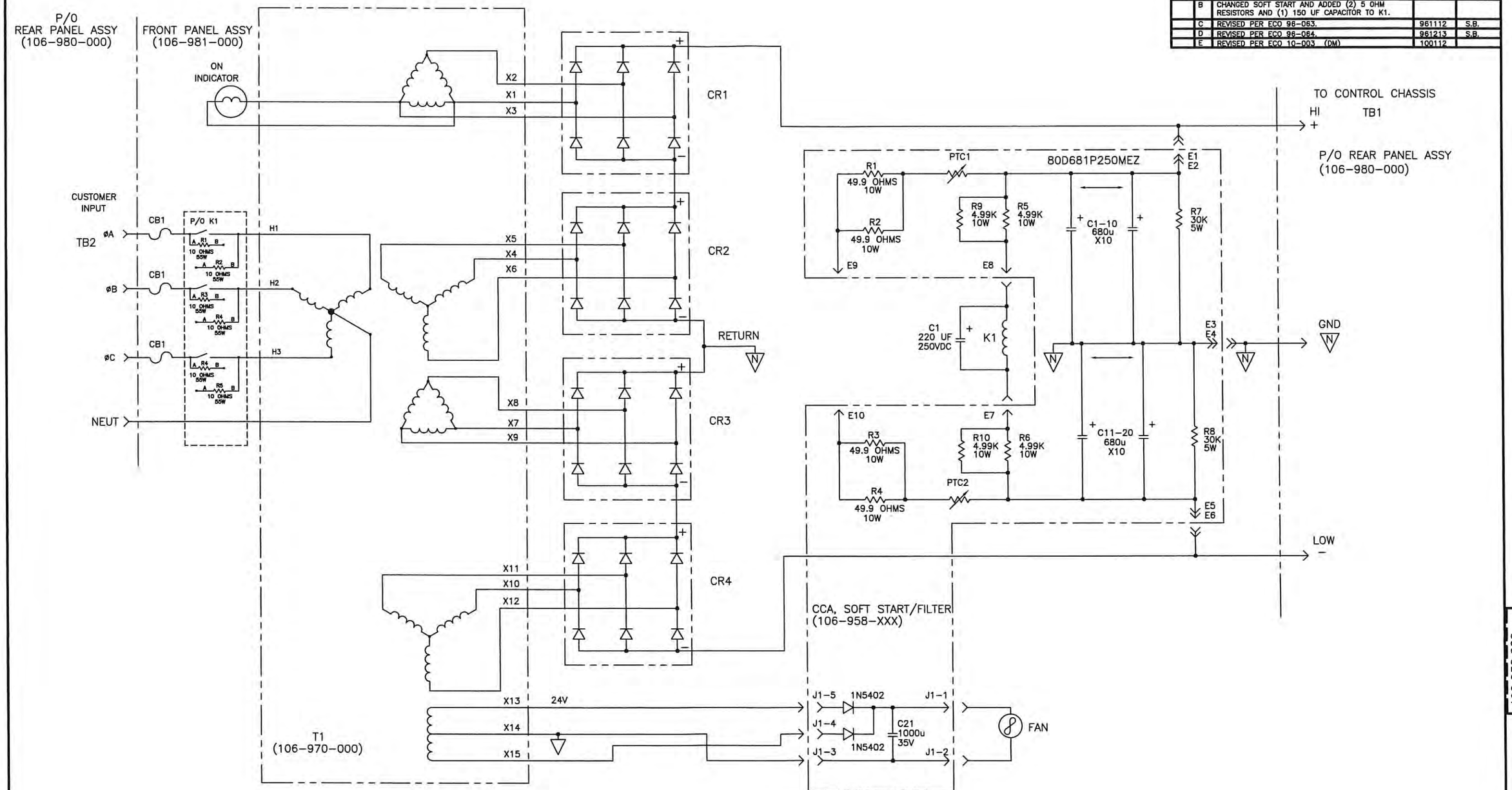
SIZE	CODE IDENT NO.		REV
D	53636	106-977-1XX	H

SCALE 1/2 | CAD FILE: 106-977-1XXH.DWG | SHEET 1 OF 1

106-977-1XX

AutoCAD Generated Document

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED R9 & R10 TO SOFT START FILTER BOARD		
	B	CHANGED SOFT START AND ADDED (2) 5 OHM RESISTORS AND (1) 150 UF CAPACITOR TO K1.		
	C	REVISED PER ECO 96-063.	961112	S.B.
	D	REVISED PER ECO 96-064.	961213	S.B.
	E	REVISED PER ECO 10-003 (DM)	100112	



106-956-000

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

CONTRACT

		DATE
DRAWN	J.ALGERIO	92-07-07
CHECKED	D.MORTENSEN	93-02-03
ENGR	T.MURRAY	1/21/93

BEHLMAN

TITLE: SCHEMATIC, POWER CHASSIS BL5K, BL6K, BL7K AND BL10K

SIZE	CODE IDENT NO.	DWG. NO.	REV
D	53636	106-956-000	E

SCALE | SHEET 1 OF 1

106-977-XXX	106-676-XXX
NEXT ASSY	USED ON
APPLICATION	

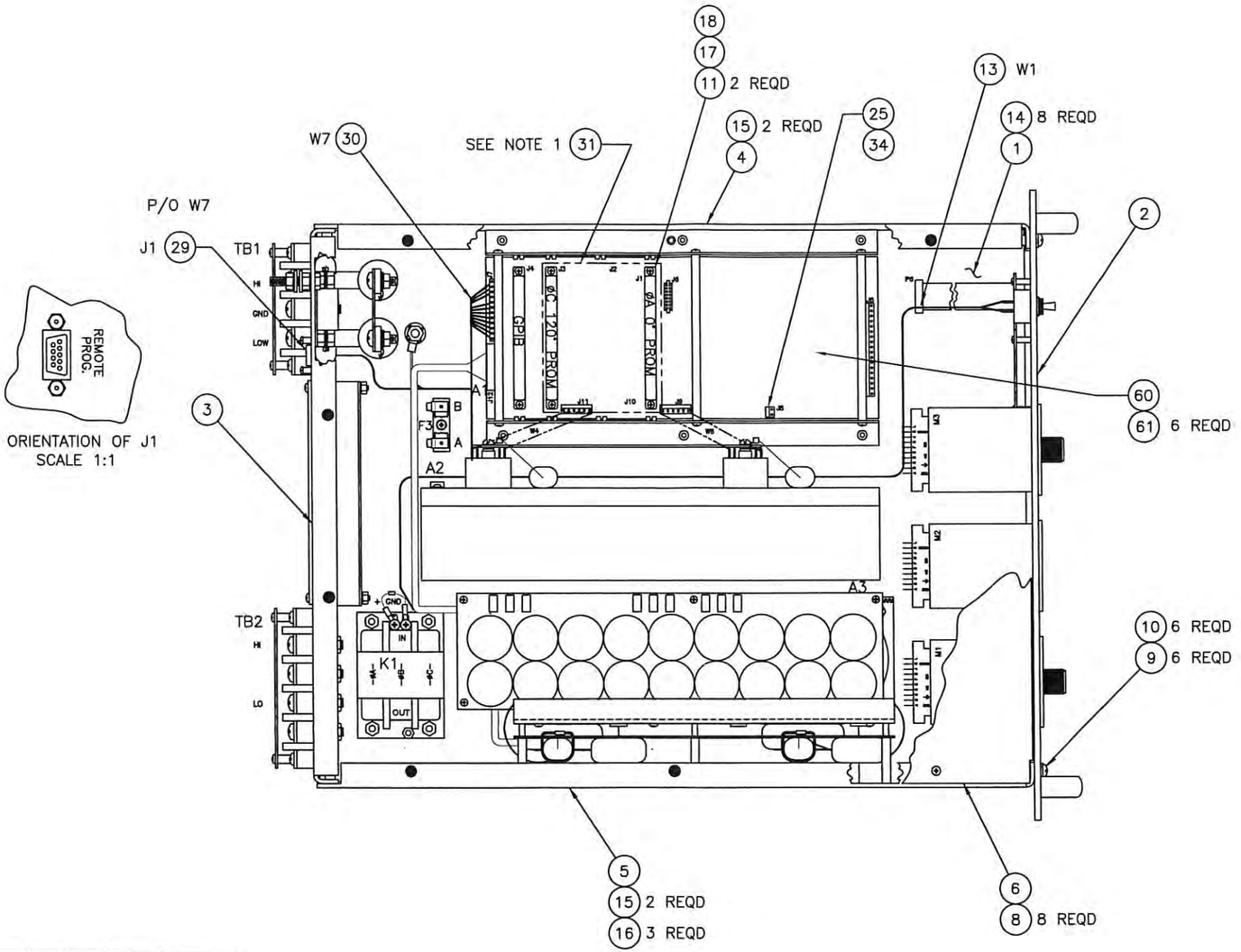
PROPRIETARY

THE PROPRIETARY INFORMATION CONTAINED IN THIS DOCUMENT MUST NOT BE DISCLOSED TO OTHERS FOR ANY PURPOSE, NOR USED FOR MANUFACTURING PURPOSES WITHOUT PERMISSION OF BEHLMAN ELECTRONICS INC. THE ACCEPTANCE OF THIS DOCUMENT WILL BE CONSTRUED AS AN ACCEPTANCE OF THE FOREGOING CONDITION.

BEHLMAN ELECTRONICS INC.
HAUPPAUGE, NEW YORK

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED CAP BOARD ASSY PER ECO 98-019	98-06-07	
	B	ROTATED K1	98-02-20	
	C	REVISED PER ECO 98-018	99-03-08	
	D	REVISED PER ECO 98-108	99-03-09	
	E	REVISED PER ECO 01-007	01-01-26	
	F	REVISED PER ECO 09-047 (FM)	04-15-09	



CONN NO.	FROM	LUG ITEM NO.	TO	LUG ITEM NO.	AWG	COLOR	COMMENTS
13	A3A1E3	–	NEUT STUD	–	10	WHT	
12	F3-B	20	F1-A	25	22	RED	
11	A3L6-OUT	–	K1-HI IN	–	10	WHT	
10	A3L4-OUT	–	K1-LO IN	–	10	WHT	
9	K1 COIL GND	23	NEUT STUD	21	22	BLK	
8	A3A1-E7	23	NEUT STUD	21	10	WHT	
7	K1-LO OUT	21	TB2-LO	21	10	BLK	LO
6	K1-HI OUT	21	TB2-HI	21	10	BLK	HI
5	GND STD	21	A1J8-2	25	22	WHT	NEUT
4	F2-A	21	A2Q6-E2	21	10	ORN	-250V
3	TB1-GND	21	NEUT STUD	21	8	WHT	NEUT
2	F1-A	21	A2Q5-C1	21	10	RED	+250V
1	F3-A	20	A1J8-1	25	22	RED	+250V

WIRE RUN SCHEDULE

NOTE:
1. ADHERE ITEM 31 (1/8" THICK GRAY FOAM 4.50 X 3.60) TO UNDERSIDE OF TOP COVER, LINING UP WITH PHASE CARDS.

SEE SEPARATE PARTS LIST

NEXT ASSY	106-676-6XX
USED ON	
APPLICATION	

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

THIS DRAWING SHALL ONLY BE CHANGED BY USE OF CAD

DRAWN J.MORRELL	DATE 01-01-26
CHECKED	DATE
ENGR	DATE
QUALITY CONTROL	DATE
MANUFACTURING	DATE

BEHLMAN

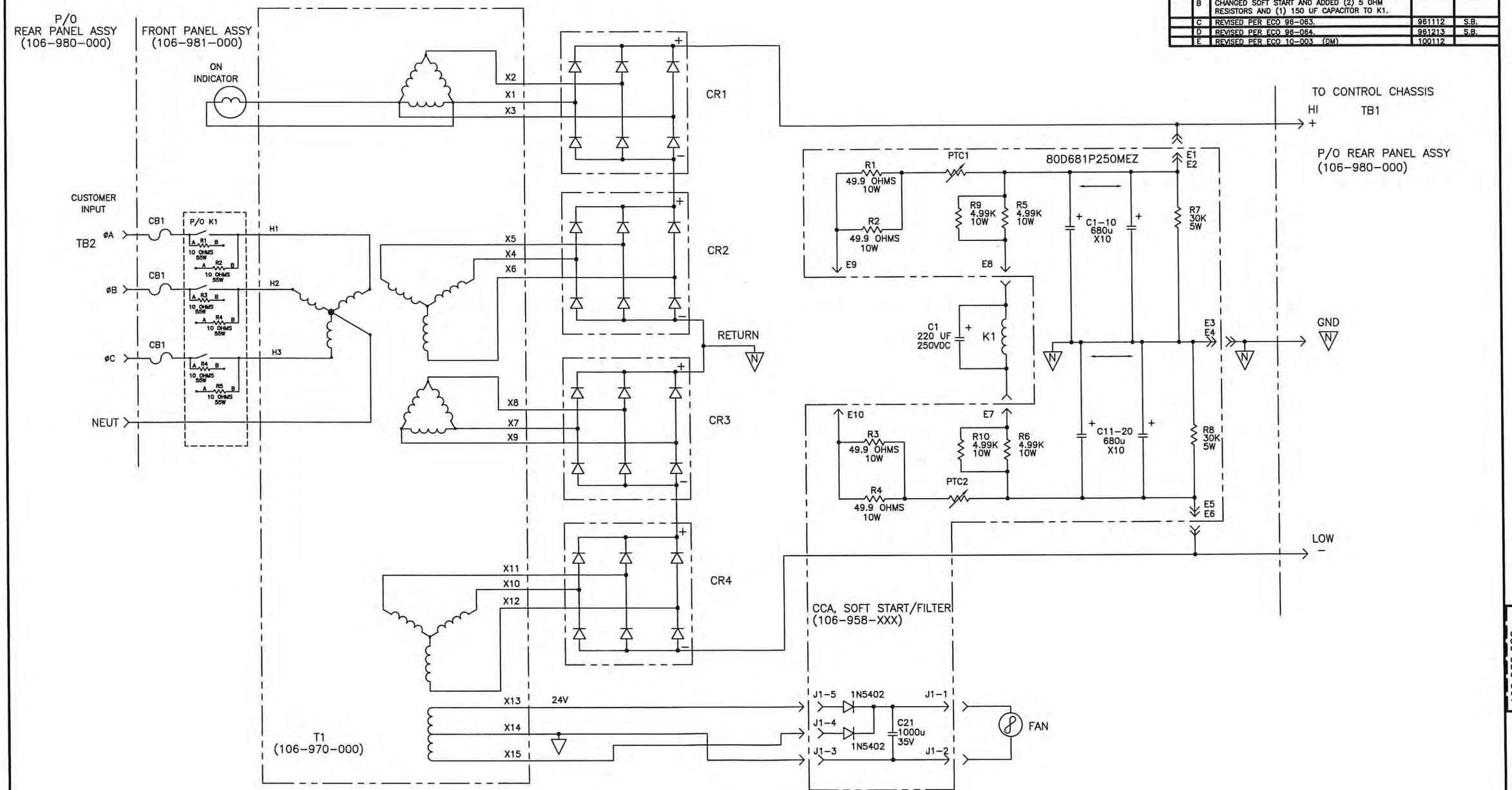
ASSY, CONTROL CHASSIS
BL6,000

SIZE	CODE IDENT NO.		REV
D	53636	106-909-006	F
SCALE 1:2	CADFILE: 106-909-006F.DWG		SHEET 1 OF 1

106-909-006

AutoCAD Generated Document

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED R9 & R10 TO SOFT START FILTER BOARD		
	B	CHANGED SOFT START AND ADDED (2) 5 OHM RESISTORS AND (1) 150 UF CAPACITOR TO K1.		
	C	REVISED PER ECO 96-063.	961112	S.B.
	D	REVISED PER ECO 96-064.	961213	S.B.
	E	REVISED PER ECO 10-003 (DM)	100112	



106-956-000

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRAC ± 3 PLACE DEC ± 2 PLACE DEC ± ANGLES ± DO NOT SCALE THIS DWG MATERIAL:	CONTRACT DRAWN J.ALGERIO DATE 92-07-07 CHECKED D.MORTENSEN 93-02-03 ENGR T.MURRAY 1/21/93

106-977-XXX	106-676-XXX
NEXT ASSY	USED ON
APPLICATION	

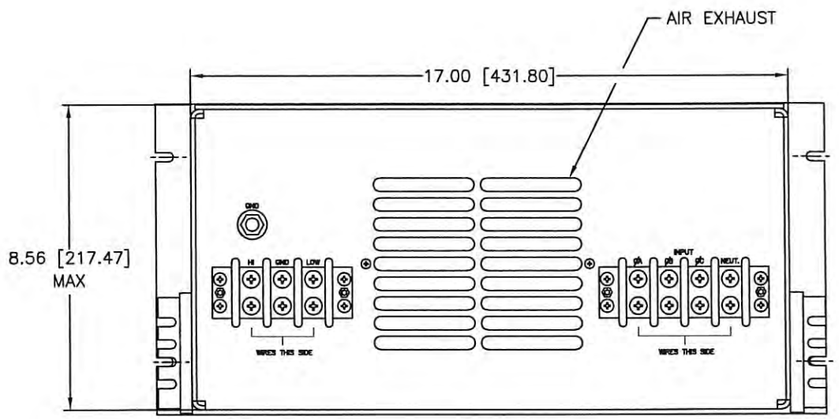
BEHLMAN

TITLE:
SCHEMATIC, POWER CHASSIS
BL5K, BL6K, BL7K AND BL10K

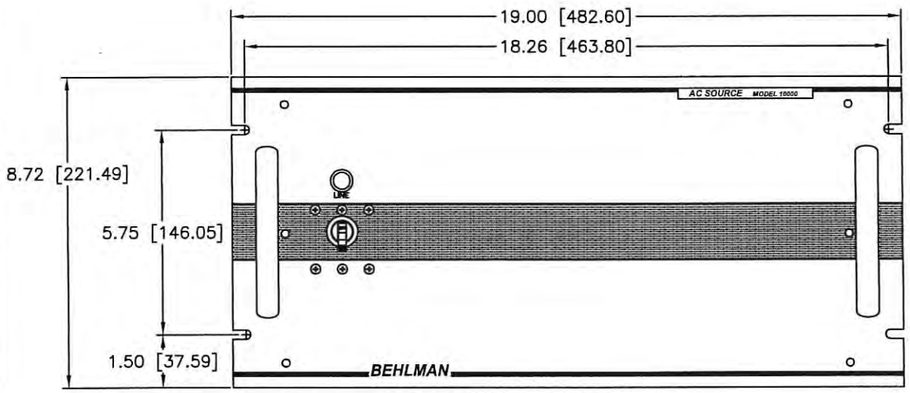
SIZE	CODE IDENT NO.	DWG. NO.	REV
D	53636	106-956-000	E

SCALE | SHEET 1 OF 1

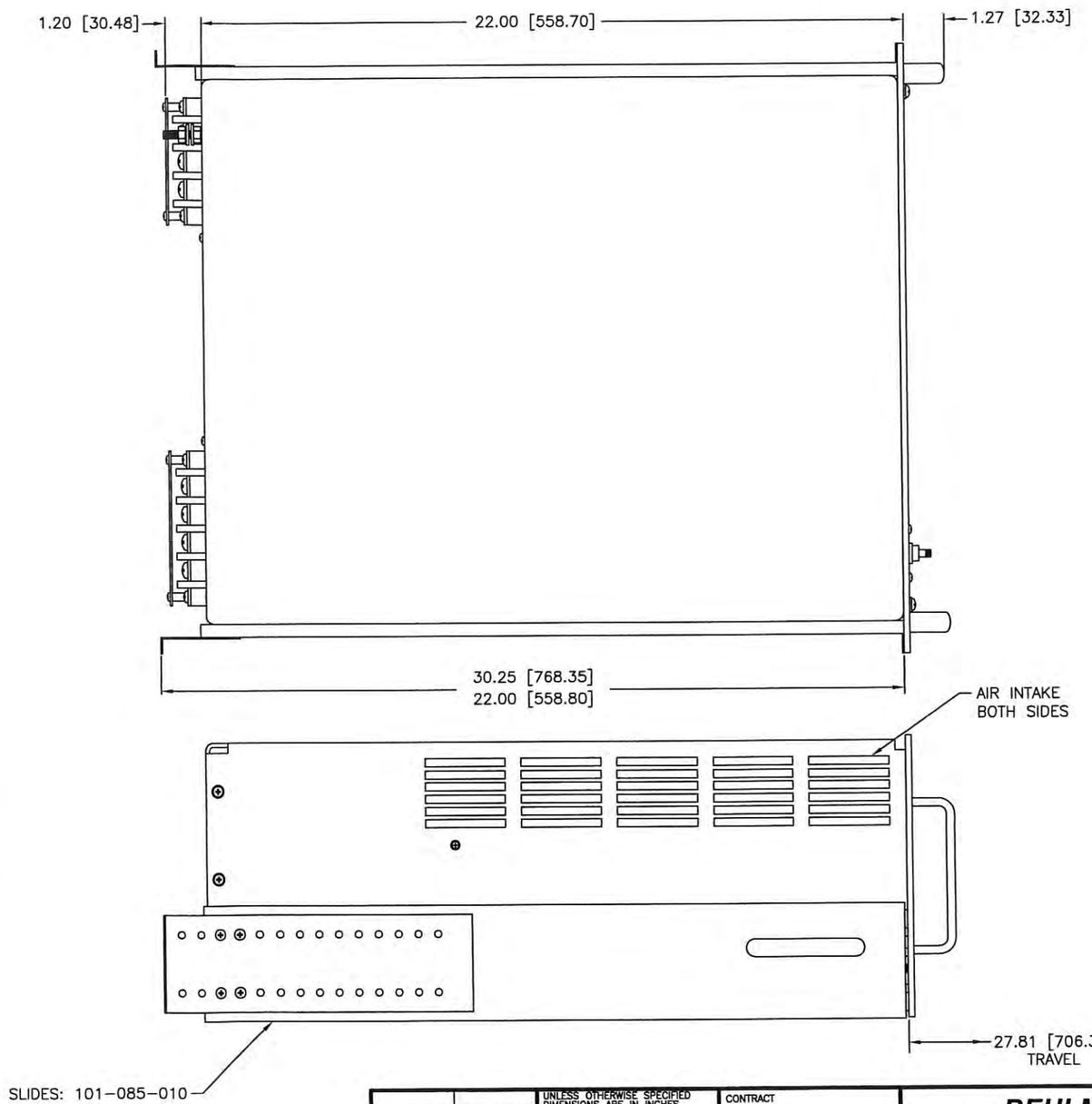
REV STATUS OF SHT		REVISIONS				
REV	SHT	ZONE	LTR	DESCRIPTION	DATE	APPROVED



REAR VIEW
TERMINAL BLOCK SAFETY COVERS REMOVED FROM VIEW FOR CLARITY



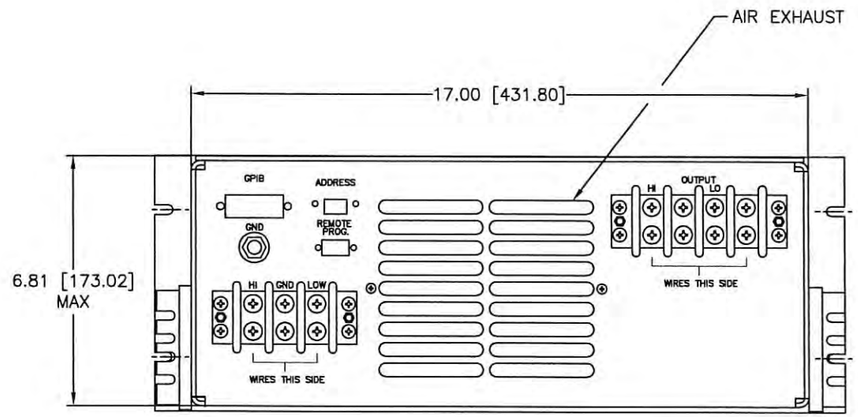
FRONT VIEW



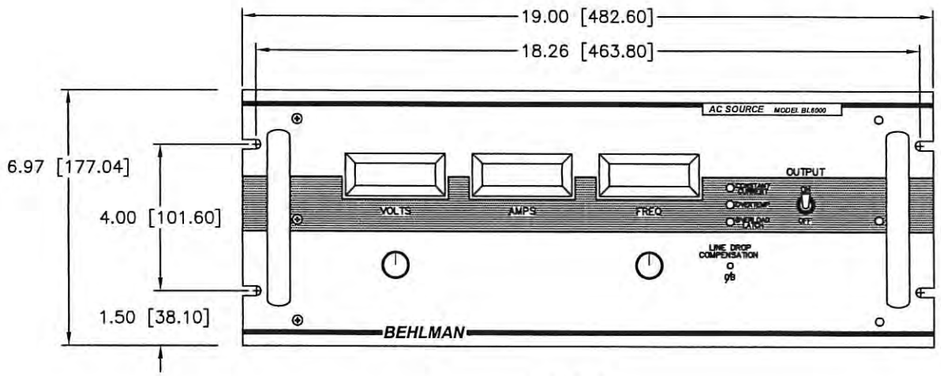
106-977-500

NEXT ASSY	USED ON	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRAC ± 3 PLACE DEC ± 2 PLACE DEC ± ANGLES ± DO NOT SCALE THIS DWG MATERIAL:	CONTRACT	**BEHLMAN**
APPLICATION			DRAWN J.ALGERIO 92-07-24 CHECKED D.MORTENSEN 93-1-26 ENGR A.ROMAY 93-1-20	OUTLINE DRAWING BL10K POWER CHASSIS
				SIZE D · CODE IDENT NO. 53636 · 106-977-500 · REV —
				SCALE 1/2 · CADFILE: 977-500-.DWG · SHEET 1 OF 1

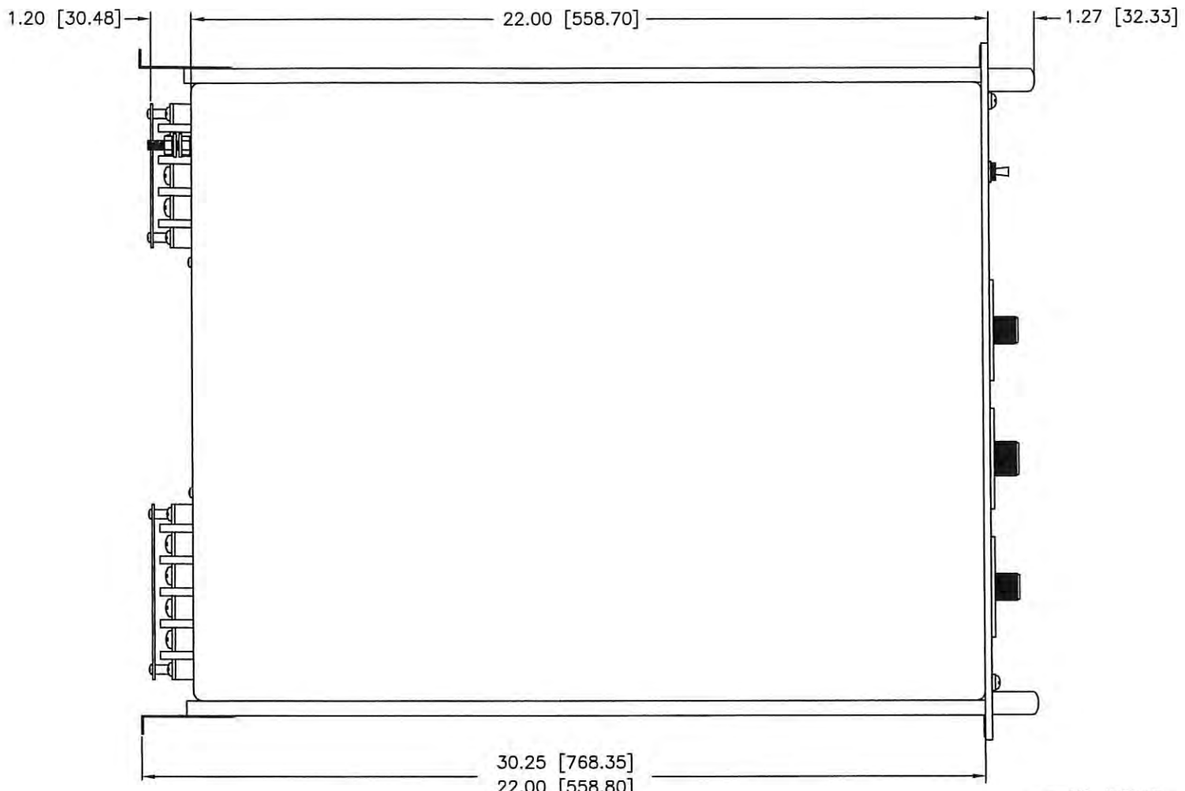
REV STATUS OF SHT		REVISIONS				
REV	SHT	ZONE	LTR	DESCRIPTION	DATE	APPROVED

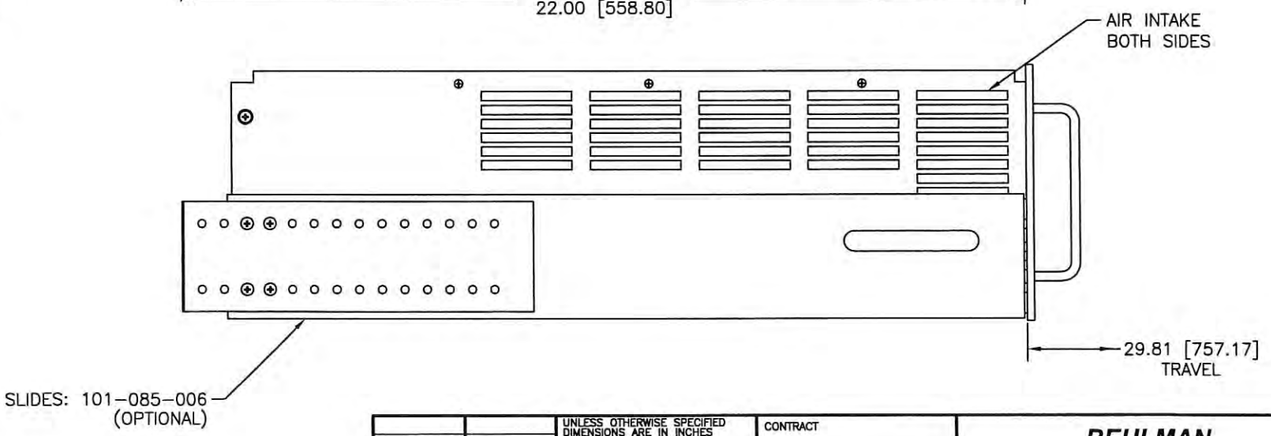


REAR VIEW
TERMINAL BLOCK SAFETY COVERS REMOVED FROM VIEW FOR CLARITY



FRONT VIEW





106-909-508

		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRAC ± 3 PLACE DEC ± 2 PLACE DEC ± ANGLES ±	CONTRACT	**BEHLMAN**
		DO NOT SCALE THIS DWG	DRAWN L.WALLACE DATE 95-03-31	OUTLINE DRAWING CONTROL CHASSIS BL6000
		MATERIAL:	CHECKED	
			ENGR	
	106-676-6XX			SIZE D · CODE IDENT NO. 53636 · 106-909-508 · REV —
NEXT ASSY	USED ON			SCALE 3/4 · CADFILE: 909-508-.DWG · SHEET 1 OF 1
APPLICATION				