INSTRUCTION MANUAL FOR

POWER SUPPLY

83-494-001 Revision D

TDK-Lambda Americas Inc.

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ONE YEAR WARRANTY

TDK-Lambda Americas, Inc. (405 Essex Road, Neptune, N.J. 07753), warrants that the unit is free from defects in material or workmanship for a period of ONE YEAR from the date of initial shipment. TDK-Lambda Americas Inc. will service and, at its option, repair or replace parts which prove to be defective. This will be done free of charge during the stated warranty period. This warranty excludes defects resulting from misuse, unauthorized modification, operation outside the environmental or safety specifications of the power supply, or improper site preparation or maintenance. The customer shall contact TDK-Lambda Americas Inc., for warranty service or repair as described in the RETURNING EQUIPMENT section. The customer shall prepay shipping charges. If the unit is covered under the foregoing warranty, then TDK-Lambda Americas Inc. shall pay the return shipping charges.

The "WARRANTY", "CLAIM FOR DAMAGE IN SHIPMENT", and "RETURNING EQUIPMENT" information applies to equipment purchased directly from TDK-Lambda Americas Inc. End users receiving equipment from a third party should consult the appropriate service organization for assistance with these issues.

THIS LIMITED WARRANTY IS IN LIEU OF, AND TDK-LAMBDA AMERICAS INC. DISCLAIMS AND EXCLUDES, ALL OTHER WARRANTIES, STATUTORY, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OR OF CONFORMITY TO MODELS OR SAMPLES.

CERTIFICATION

All test and measuring equipment used by TDK-Lambda Americas Inc. for Final Acceptance Testing are traceable to primary standards certified by the National Institute of Standards and Technology.





All power supplies contain hazardous voltage and energy. The power supply must only be operated by qualified personnel who have read this operator's manual and are familiar with the operation, hazards and application of the power supply. Proper care and judgment must always be observed.

- 1. Before connecting input AC power, ensure all covers are in place and securely fastened. Ensure the required safety ground to chassis is installed and sufficient cooling is supplied.
- 2. Proper grounding from the input AC power is required to reduce the risk of electric shock, and to comply with safety agency and code requirements.
- 3. Use extreme caution when connecting input AC power. Only apply the input voltage specified on the rating label.
- 4. Use extreme caution when connecting any high voltage cables. Never handle any output cables when the power supply is operating.
- 5. After a power supply is switched OFF, its output section will retain a charge which may be lethal. Allow sufficient time for self-discharge before handling anything connected to the output. The discharge time specified in the Safety Notes does *NOT* include extra time required to discharge the energy stored in the user's load.
- 6. When user serviceable fuses are present, always replace fuses with the same type and Volt/Amp rating.
- 7. Never attempt to operate the power supply in any manner not described in this manual.
- 8. Never remove DANGER or WARNING labels from the power supply. Replace lost or damaged labels immediately. Contact TDK-Lambda Americas Customer Service for replacement labels.
- 9. The power supply may be serviced only by TDK-Lambda Americas Inc. factory qualified service personnel. Breaking the warranty seal will void the warranty. Prior to opening the power supply, contact TDK-Lambda Americas Inc. Customer Service for a written Service Waiver and a replacement warranty seal.

TDK-Lambda

MANUFACTURER'S PRODUCT DECLARATION

INTENDED PURPOSE (USE)

The Power Supplies described by this manual are defined by TDK-Lambda Americas Inc. as a <u>component</u> for use in the composition of an apparatus as defined in Article 1 (1) of the EMC Directive (89/336/EEC). These products, as individual components, do not perform in themselves a direct function for the user of the end product. They are <u>not intended</u> to be placed on the market with a direct function to a final user! As such, the products described by this manual are <u>not</u> subject to the provisions of the EMC Directive (89/336/EEC, with amendment 92/31/EEC).

The products described by this manual are intended for incorporation into a final product by a professional assembler. It is the responsibility of the assembler to ensure that the final apparatus or system incorporating our products complies with all relevant EMC standards for that final product.

OPERATING ENVIRONMENT

The operating environment as defined by TDK-Lambda Americas Inc., for the products described by this manual is stated as follows:

The Power Supplies described by this manual are intended for use in a protected industrial environment or in proximity to industrial power installations. These locations are often referred to as industrial locations containing establishments that are <u>not connected</u> to the low voltage public mains network.

Industrial locations are characterized by the existence of one or more of the following conditions:

- 1) industrial, scientific and medical (ISM) apparatus are present;
- 2) heavy inductive or capacitive loads are frequently switched;
- 3) currents and associated magnetic fields are high;
- 4) location supplied by their own transformer.

These components are <u>not</u> intended for connection to a public mains network, but are intended to be connected to a power network supplied from a high or medium-voltage transformer dedicated for the supply of an installation feeding manufacturing or similar operations. They are suitable for use in all establishments other than domestic and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

TDK-Lambda

Description of symbols used in product labeling

SYMBOL	PUBLICATION	DESCRIPTION
Œ	EC Council Directive 93/68/EEC	European Community Conformity Assessment Product Mark
\triangle	IEC 348	Attention, consult Accompanying documents
	IEC 60417-1-5036	Dangerous voltage
	IEC 60417-1-5019	Protective earth (e.g. power line earth ground)
<u> </u>	IEC 60417-1-5017	Functional earth (e.g. chassis ground)
	IEC 60417-1-5134	Electrostatic Discharge (ESD) Sensitive Device

ELECTRICAL STANDARDS

All company primary standards are either certified or are traceable to certification by the National Institute of Standards and Technology.

CLAIM FOR DAMAGE IN SHIPMENT

This instrument received comprehensive mechanical and electrical inspection before shipment. Immediately upon receipt from the carrier, and before operation, this instrument should be inspected visually for damage caused in shipment. If such inspection reveals damage in any way, a claim should be filed with the carrier. A full report of damage should be obtained by the claim agent and this report should be forwarded to us. We will then provide a disposition of the equipment and arrange for repair or replacement.

When referring to this equipment, always include the model and serial numbers.

The "WARRANTY", "CLAIM FOR DAMAGE IN SHIPMENT", and "RETURNING EQUIPMENT" information applies to equipment purchased directly from TDK-Lambda Americas Inc. End users receiving equipment from a third party should consult the appropriate service organization for assistance with these issues.

RETURNING EQUIPMENT

Before returning any equipment to the factory, the following steps shall be taken.

- 1. Notify TDK-Lambda Americas Inc. at 732-918-6888 or follow the instructions at <u>www.US.TDK-Lambda.com/HP/service.htm</u>. Give a full description of the difficulty including the model and serial number of the unit in question. Upon receipt of this information, we will assign a Return Material Authorization (RMA) number and provide shipping instructions.
- 2. The customer shall prepay shipping charges. Equipment returned to us must be packed in a manner to reach us without damage. The shipping container must be marked with the RMA number in an area approximate to the shipping label with numbers that are easy to read. All returned units that do not show the RMA number on the outside of the container will be refused.

If the equipment is repaired within the warranty agreement, than TDK-Lambda Americas Inc. shall pay for the return shipping to the customer.

3. For non-warranty repairs, we will submit a cost estimate for your approval prior to proceeding. The customer shall pay return shipping charges.

MECHANICAL INSTALLATION

Most power supplies are heavy and, when rack mounted, they should be supported by rails along the sides of the supply from front to rear. The rails must adequately support the unit and not block airflow. Do not support the power supply from the front panel only.

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1 GENERAL

1.1 INTRODUCTION

The LC1202 is a liquid cooled high voltage switching power supplies designed for charging capacitors in laser systems and modulated applications. They are specifically designed for operation in any position or orientation with very high pulse to pulse repeatability at high rep rates. The LC1202 provides 15kW. average power and peak power at the rated output voltage.

The LC1202 incorporates high frequency IGBT based resonant inverter topology for generation of the output power. The control scheme provides excellent regulation of the output voltage and automatically compensates for line, load and temp variations. The latest development resonant invertor topology which improves pulse to pulse repeatability by reducing the ripple or "bucket effect" even at very high pulse repetition frequencies. The high voltage tank has been specially designed with liquid cooling and forced convection cooling. This allows the power supply to be operated in any orientation. The output voltages of the LC1202 supply are fully adjustable over each range.



Figure 1 LC1202 Block Diagram

2.1 AVERAGE CHARGING RATE

12,000J/sec at rated output voltage

2.2 PEAK CHARGING RATE

13,500J/sec at rated output voltage

2.3 STANDARD OUTPUT VOLTAGES/CURRENTS

Voltage	Current at 100%
	of rated V
1KV	27A
2KV	13.5A
4KV	6.75A
5KV	5.4A
10KV	2.7A
20KV	1.35A
30KV	0.9A

- 2.3.1 LINEARITY: To within ±1% of full scale
- 2.3.2 ACCURACY: To within ±1% of rated output

2.4 POLARITY

Available as fixed positive or negative.

2.5 HV INSULATING MEDIUM

DOW 561 silicone oil

2.6 INPUT CONNECTIONS

Via 4 position VDE/IEC approved terminal block. Connections are Ø1, Ø2, Ø3, and ground.

2.7 INPUT REQUIREMENTS:

180 - 250V, 50/60Hz, 50A max. 340 - 460V, 50/60Hz, 25A max.

2.8 POWER FACTOR

>0.90

2.9 EFFICIENCY

>90%

2.10 STORED ENERGY

<0.5J in output stage

2.11 STABILITY

<0.2%/hr after 1 hr warmup

2.12 PULSE REPEATABILITY

 $\pm 0.1\%$ to 300Hz - Standard $\pm 0.3\%$ to 1000Hz - Standard $\pm 0.1\%$ to 1000Hz - Available

2.13 PHYSICAL DIMENSIONS

 $8.75^{\prime\prime}/222mm$ H (4U) x 19 $^{\prime\prime}/483mm$ W x 17 $^{\prime\prime}/432mm$ D. Depth of handles over panel 7/8 $^{\prime\prime}/20mm.$

2.14 WEIGHT

Approximately 90 pounds/41 kg

2.15 MOUNTING

Chassis support rails or brackets required.

2.16 WATER FITTINGS

Swagelok 12mm

2.17 COOLING WATER

A 2GPM/7.6 liters/min, max supply temp 35°C. All water paths are at ground potential and are copper or brass. An analog temp signal, 0-10VDC, will be supplied for a heat sink temp of 10°-60°±3°C at the DB-25 back panel connector.

2.18 AIR COOLING

Internal, 100CFM. Supply makeup air not required.

2.19 AMBIENT TEMPERATURE

2.19.1 STORAGE: -40°C to +85°C

2.19.2 OPERATING: +5°C to +45°C

2.20 HUMIDITY

<90%, non-condensing

2.21 FAULT PROTECTION

Three line fuses, accessible through rear panel of power supply.

2.22 PROTECTION

The power supply is protected against open and short circuit operation, current overloads, and arcs.

2.23 SAFETY STANDARDS

EN61010/IEC1010 (Pending)

2.24 EMC STANDARDS (Pending)

2.24.1 IMMUNITY

- a) ESD: EN61000-4-2 (IEC 801-2)
 - ENV 50140 (IEC 801-3)
 - EN61000-4-4 (IEC 801-4)
- b) Radiated:c) EFT/Burst:d) Conducted: ENV 50141 (IEC 801-6)
- e) Power Freq Mag Field: EN 61000-4-8
- f) Surge Immunity: EN61000-4-5 (IEC 801-5)

2.24.2 EMISSION: MEETS WITH EXTERNAL FILTER:

a)	Conducted	EN 55011	Group	1,	Class	А
			-		<u>.</u> .	

b) Radiated EN 55011 Group 1, Class A

2.25 VIBRATION

Meets MIL-STD-810E, Method 514.4. Basic Transportation Common Carrier 10-500Hz, 0.015g²/Hz. Duration = 1 hour

2.26 SHOCK

25Gpk, half sinewave 11ms.

2.27 FRONT PANEL DISPLAY

Voltage and current 31/2 character indicators, 10 segment voltage and current trend graphs, HV ON push button, HV ON indicator, power supply status signals. 3 Position Key SW. Local/Remote/OFF. Key will come off in all positions.



Figure 2 Mechanical Details

3 INSTALLATION

3.1 INITIAL INSPECTION

The shipping container should contain the following items: power supply, HV output cable, test data sheets and operator's manual. Examine the items immediately for damage. Locate the serial number labels on the power supply and verify the model number, the input voltage rating and the output voltage rating and polarity. In the event of any damage promptly notify the transportation company and the TDK-Lambda Americas Inc. customer service manager.

3.2 MOUNTING AND COOLING REQUIREMENTS

The power supply can be mounted in a standard 19" EIA enclosure or equivalent. Chassis support brackets or rails must be added to the bottom of the power supply for proper weight distribution. The power supply can also operate on a bench or table top. In all cases adequate clearances must be provided for cable bends. Generally, at least 4" (161.6mm) of clearance should be allowed at the rear of the power supply.

When operating in an enclosed system, care must be taken to ensure the ambient air to the power supply does not exceed the maximum ambient operating temperature of 45°C, this may require addition of a system heat exchanger.

The power supply requires a cooling water supply with a minimum 2GPM (7.6 l/m) flow and a maximum inlet temp of 35°C. The water connection is at the rear of the supply. The connection in SWAGELOK 12mm. The water flow direction must be as marked on the rear panel. All water connections are at ground potential. The power supply can be operated in any orientation/position.

3.3 GROUNDING AND INPUT AC POWER

Proper grounding from the input AC power is required to reduce the risk of electric shock. The metal chassis of the power supply is grounded through the green earthing wire at the input AC power terminal block. Use extreme caution when connecting input AC power and never apply the incorrect input power. Connect the three lines of the input power to the L1, L2, L3 terminals and the earth ground to the terminal marked with the protective earth symbol. No neutral connection is required for the 200V and 400V configurations. Verify the input voltage configuration (208 or 400VAC) is on the nameplate on the rear panel before applying the correct voltage. Applying incorrect voltage will immediately cause major damage and void the warranty. The input voltage change should only be performed by qualified technical personnel equipped with proper parts and detailed instructions from the factory. Refer to Section 5 "Applications", to calculate line currents for various operating conditions such as reduced power or charging very large capacitor banks.



Figure 3: Input AC Power Connections





3.4 POWER CORD SPECIFICATION

Use wire with a minimum of 8 AWG. (diameter = 0.147" (3.73mm)) and 600V insulation.

3.5 CONNECTING HIGH VOLTAGE OUTPUT

Ensure that the power supply is off and disconnected from the input power and that all load capacitors are discharged and shorted to ground before making any connections. Never handle the HV cable during operation.

Always use the HV connector and cable provided with the power supply or an equivalent substitute provided by TDK-Lambda Americas Inc. Fully insert the connector end of the HV cable and tighten the locking nut only "hand tight".

When operating above 20kV or 200 Hz rep rate it is recommended that a silicone grease (such as Dow Corning DC-4) be used on the HV cable before insertion into the HV connector. This displaces the air in the connector and reduces long term corona effects.

The HV cable shield is connected to the power supply chassis and should be used as the HV return. An additional grounding stud is provided adjacent to the HV connector and should also be connected to the HV return. The standard shielded HV cable can contact earth ground without consequence. The optional unshielded silicone HV cable can also contact ground, but isolating it will minimize the effects of corona in the system.

Keep the minimum HV cable bend radius greater than 4" (101.6mm) to minimize stress on the insulation. Keep the HV cable as distant as possible from the input power and the input control signals.

Page 7 of 25 83-494-001 Rev. D Some peak current will flow out of the power supply during discharge and return through the HV return and system chassis. This current comes from voltage reversal in underdamped systems and from normal discharge of filter and cable capacitance. The path for this current should not parallel control signal returns since the resulting voltages could interfere with normal system operation. When due to voltage reversal at high rep rates, this current could damage the power supply. Generally a resistor in series with the HV output can be added to limit this current to an acceptable level. Refer to Section 5.2 "Applications" for more information.

The oil-filled HV assembly should not be opened. The oil and components have been specially cleaned and vacuum impregnated at the factory and the assembly hermetically sealed. Opening the assembly will compromise performance.

3.6 GROUNDING THE PRODUCT

3.6.1 GROUNDING OF INPUT LINE:

The supply is grounded through the ground terminal of the input connector. A protective ground connection by the way of the grounding conductor in the input terminal is essential for safe operation.

3.6.2 OUTPUT GROUND CONNECTION:

It is important that there be a ground connecting the supply to the load as shown in Figure 4.



Figure 4 Output Ground Connection

4 OPERATION

4.1 L, S, OEM MODELS

<u>Model LC1202L</u>: This model has full front panel instrumentation for use in laboratory, prototype or OEM systems. The LC1202L can be operated either from the front panel or from the rear panel remote control connector. The front panel includes power on/off, remote/local and HV on/off switches, output voltage adjust, view set switch, digital voltage and current meters, quick reference bar graphs and status indicators. An internal AC contactor is included which is controlled by the front panel power switch. The model LC1202L can be operated as a "master" unit in parallel with several model LC1202S "slave" units for increased output power. Refer to Section 5.3 "Paralleling Units".



Figure 5 Model LC1202L

<u>Model LC1202S</u>: This model has only a power switch and status indicators on the front panel. It must be operated through its remote control connector and can function as a standalone unit or in parallel with other units. Several model LC1202S units can be paralleled as "slaves" controlled by either a "master" LC1202L or a single remote control circuit. An internal AC contactor is included which is controlled by the front panel power switch.



Figure 6 Model LC1202S

Page 9 of 25 83-494-001 Rev. D <u>Model LC1202 OEM</u>: This model has a blank front panel and is operated the same as an LC1202S, from the remote control connector only. It can function as a stand alone unit or in parallel for increased output power. The basic model LC1202 OEM is supplied by externally controlled AC power. It can also be configured with either an internal AC contactor or front panel circuit breaker option.



Figure 7 Model LC1202 OEM

4.2 REAR PANEL

Figure 8 shows the rear panel of the model LC1202L. The REMOTE connector is used to control the power supply when the CONTROL KEY SWITCH on the front panel is in the REMOTE position. The INTERLOCK terminal block (at 28 VAC) can be connected to system interlocks to disable the power supply when opened. Jumpering the two terminals together allows the power supply to operate. The INHIBIT connector allows for easily connecting a pulsed INHIBIT signal when operating from the front panel. The INHIBIT signal in the REMOTE connector can be used when operating in remote control mode. The SLAVE connector is used to control model LC1202S power supplies operating in parallel with an LC1202L "master" unit. The model LC1202S and model LC1202 OEM do not have the INHIBIT and SLAVE connectors.



Figure 8 Rear Panel

4.3 FRONT PANEL CONTROL (L model only)

4.3.1 POWER SWITCH:

Connects AC input power to the control circuitry and closes the internal AC contactor if the interlock is closed.

4.3.2 CONTROL SWITCH:

Directs the power supply to take on/off and voltage program commands from either the front panel (LOCAL position) or the remote control connector (REMOTE position). The OFF position disables the power supply regardless of other commands.

4.3.3 HV ON SWITCH:

Turns on the high voltage output to the level set by the HV adjust knob. Also used with HV OFF to reset latched fault conditions: overvoltage, open circuit, over-temp, AC undervoltage, interlock open, overload and inverter current.

4.3.4 HV OFF SWITCH:

Turns off the high voltage output.

4.3.5 VOLTAGE ADJUST:

Clockwise increases the output from zero to maximum, 10 turns full scale.

4.3.6 VIEW SET:

Previews the voltage adjust set point before HV ON. Also displays set point during operation to indicate whether a load condition is affecting the desired HV output level.

4.4 REMOTE CONTROL (L, S, OEM models)

All three models are easily controlled through their remote connector on the rear of the unit. Only the ON/OFF, V PROGRAM and GND signals are required for operation. The remaining signals are provided for status monitoring and fault diagnosis. A schematic diagram showing the suggested interface circuit appears after the following description of control signals.

Pin #

1	ANALOG OUT	0-10V THRU 1K 1%
2	INTERNAL CONNECTION	(DO NOT USE)
3	INHIBIT INDICATOR	OPEN COLLECTOR THRU 100 OHMS
4	INTERNAL CONNECTION	(DO NOT USE)
5	END OF CHARGE INDICATO	OR OPEN COLLECTOR THRU 100 OHMS
6	INTERNAL CONNECTION	(DO NOT USE)
7	INHIBIT INPUT	2-24V 5K INPUT Z
8	ENABLE RESET	0-15V 100K INPUT Z
9	VOLTAGE PEAK OUTPUT	0-10V THRU 1K 1%
10	ON INDICATOR	OPEN COLLECTOR THRU 100 OHMS
11	INTERNAL CONNECTION	(DO NOT USE)
12	GROUND	
13	OUTPUT CURRENT MONIT	OR 0-10V THRU 1K 1%
14	+15VDC	FUSED AT 250mA
15	PLATE TEMP SENSE	0-10V THRU 1K 1%
16	TEMP FAULT INDICATOR	OPEN COLLECTOR THRU 100 OHMS
17	INTERLOCK OPEN INDICAT	TOR OPEN COLLECTOR THRU 100 OHMS
18	LOAD FAULT INDICATOR	OPEN COLLECTOR THRU 100 OHMS
19	SUMMARY FAULT INDICAT	OR OPEN COLLECTOR THRU 100 OHMS
20	NOT INHIBIT	0-3V 10K INPUT Z
21	PHASE LOSS INDICATOR	OPEN COLLECTOR THRU 100 OHMS
22	VREF INPUT	0-10V 1 MEG INPUT Z
23	OFF INDICATOR	OPEN COLLECTOR THRU 100 OHMS
24	INTERNAL CONNECTION	(DO NOT USE)
25	GND	



Figure 10 Suggested Interface

4.5 INITIAL CHECK-OUT PROCEDURE

The power supply should have no visible damage or defects and the cover should be securely fastened. Properly connect the input power, control connector and HV output. If there is no load connected, the power supply will sense an open circuit and immediately shut down indicating a LOAD FAULT. If there is a short circuit or overload condition on the output, the power supply will operate in a 50% duty cycle protection mode and indicate a LOAD FAULT. An overload condition can occur if the INHIBIT signal is missing and the discharge rep rate is too high to allow the capacitor to fully charge to V PROGRAM. Double check all connections and ensure that all personnel are protected from the HV output. With the HV adjust at zero volts, turn the power supply on in the following sequence:

LC1202L Front Panel Control:

- 1. Turn HV ADJUST knob fully counterclockwise.
- 2. Turn POWER switch to ON.
- 3. Turn CONTROL key switch to LOCAL.
- 4. Push HV ON switch.
- 5. Verify the HV output is at approx. zero volts.
- 6. Increase HV output slowly and verify adjustability.

LC1202L Remote Control:

- 1. V PROGRAM signal (pin 22) at zero volts.
- 2. ON/OFF signal (pin 8) at zero volts.
- 3. Turn POWER switch to ON.
- 4. Turn CONTROL key switch to REMOTE position.
- 5. Assert ON/OFF signal to 15V.
- 6. Verify HV output is at approx. zero volts.
- 7. Increase HV output slowly and verify adjustability.

LC1202S Remote Control:

- 1. V PROGRAM signal (pin 22) at zero volts.
- 2. ON/OFF signal (pin 8) at zero volts.
- 3. Turn POWER switch to ON.
- 4. Assert ON/OFF signal to 15V.
- 5. Verify HV output is at approx. zero volts.
- 6. Increase HV output slowly and verify adjustability.

LC1202 OEM Remote Control:

- 1. V PROGRAM signal (pin 22) at zero volts.
- 2. ON/OFF signal (pin 8) at zero volts.
- 3. Assert ON/OFF signal to 15V.
- 4. Verify HV output is at approx. zero volts.
- 5. Increase HV output slowly and verify adjustability.

5.1 DETERMINING CAPACITOR CHARGE TIME

The LC1202 Series is rated at 13500 J/sec peak and 12000 J/sec average charge rate. Although the measure of Joules/sec equates to Watts, it is more convenient when working with energy storage capacitors. The peak charge rate determines the capacitor charge time. The average charge rate determines the total power delivered from the power supply. It is possible to charge a capacitor at a rate of 13500 J/sec, but to discharge it at a low rep rate amounting to only 100 J/sec.



5.2 VOLTAGE REVERSAL

When the capacitor or PFN is discharged, a high peak current may flow out of the power supply as a result of voltage reversal. This occurs in a system which is underdamped in order to clear the high voltage switch after each pulse. The average value of this peak current added to the normal output current may exceed the rating of the HV diodes in the power supply. This current can be measured with a current transformer as shown.



A series terminating resistor (or series inductor or clamp diode) must be added as shown if the average value of the peak current exceeds 10% of the normal output current.

When choosing Rs, ensure it can withstand the full output voltage across it as well as the power dissipation caused by discharging Co (460pF) and Cc (20pF/ft) each cycle as well as conducting the normal output current. It's power dissipation can be calculated as,

 $P_D = Io^2 R_S + \frac{1}{2}(C_0 + C_C)V^2(F_{REP RATE})$

5.3 PARALLELING UNITS

The LC1202 power supply is designed for simple parallel operation. Any model (L, S, OEM) can be paralleled with any other model. The input power and HV output should be connected directly together. The REMOTE connectors on the rear panel can also be connected directly together using a "daisy chain" ribbon cable from the system controller. Each of the power supplies operate at the same time with the total charge rate equal to the sum of each.

When operating an LC1202L as a master with either one or more LC1202S's as slaves, connect the SLAVE connector on the LC1202L to the REMOTE connector on each of the LC1202S's. This allows control of the entire system from the LC1202L front panel when in local mode, or the LC1202L REMOTE connector when in remote mode. The status of each individual LC1202L and LC1202S is displayed on its front panel.

Sometimes when operating several units in parallel, the high total power generates noise which interferes with the power supply control. This is usually due to the many interconnecting control cables acting as an antenna picking up noise. The problem usually appears as one or more of the power supplies shuts down when the output voltage increases beyond a certain level. Dressing the control cables as short as possible and close to ground or using shielded cables should help. In severe cases, it is necessary to wrap the cables several times through large ferrite cores at the rear panel of each unit.

5.4 MEASURING HIGH VOLTAGES

A sample of the output voltage is available in the REMOTE connector. If it desired to measure the HV output externally, care must be taken to understand the accuracy of the measurement.

When making a DC measurement, such as when the power supply is holding voltage on a capacitor, any HV probe and DMM combination can be used. The Fluke 80k - 40 probe with any 10MW input resistance DMM is adequate up to 40kV. Building a simple resistor divider using appropriate HV resistors is also very straightforward. Keep in mind that all HV resistors, including the one in the Fluke probe, exhibit a negative voltage coefficient, changing by up to 4% from zero to max voltage. Derating the resistors and calibrating at the operating point solves this problem.

Making a pulsed measurement with an oscilloscope requires a compensated HV probe having a wide bandwidth. Simply connecting a DC probe, through the proper resistance, into a scope yields a slow response adequate for only low rep rate systems. As with DC probes, the pulsed probe resistor voltage coefficient is a problem. In addition, damage to the resistors can occur during pulsing due to high electric field gradients. Also, stray capacitance to nearby objects can significantly alter the pulse response. The Tektronix P6015 is a high-performance, shielded probe and a good choice up to 40kV.

Measurements accurate to better than 0.1% can be achieved using a bias technique. For example, if a 40V signal (40kV divided by 1000) is to be measured accurately, the minus input of the DMM would be biased up 40V. The original signal, with respect to

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ground, is fed to the plus input of the DMM. The bias can be measured accurately for absolute measurements, or relative measurements read directly as the line or load is varied. In the same manner, an oscilloscope return can be biased for accurate peak measurements during pulsing.



5.5 DETERMINING AC LINE CURRENT

- $I_{L} = \frac{P}{\sqrt{3} V_{L} P_{F^{\pi}}}$ $I_{L} = \text{Line current}$ P = Average output power $V_{L} = \text{Line voltage}$ $P_{F} = \text{Power factor (0.9 min)}$ $\pi = \text{Efficiency (0.9min)}$
- EX: An LC1202 operating from 208V 10% and delivering 12000W average.

$$I_L = \frac{12000}{\sqrt{3} (.9 \times 208)(0.9)(0.9)} = 45.7A$$

When charging very large capacitor banks requiring many seconds or minutes to reach end-of-charge, the power supply will display a load fault and go into a 50% duty cycle protection mode. If this feature is defeated and the power supply is allowed to charge for an extended period, then the peak output power rather than the average must be used to determine line current.

5.6 OPERATION AS A DC POWER SUPPLY

The LC1202 can provide a regulated voltage to a DC load such as an electron beam. The output current will be preset at the factory in order to limit the average output power to 12000W, while making full rated HV steady state. The voltage ripple can be easily filtered to any desired level with an external capacitor across the load.

6 MAINTENANCE AND TROUBLESHOOTING

6.1 SAFETY PRECAUTIONS

The calibration and troubleshooting steps described in this section require operation of the power supply with the top cover removed. Proceed with extreme caution as hazardous voltages are exposed throughout the unit. Safety glasses must be worn to prevent serious injury in the event of a component failure (e.g., power transistors readily explode during fault conditions).

6.2 CALIBRATION

Calibration of the output is accomplished with trimpots located on the Control Board. This pc board is horizontally mounted on top of the high voltage output assembly on the right side of the unit as you face the front panel.

6.2.1 OUTPUT VOLTAGE LEVEL:

RP14. Slowly adjust clockwise to increase output voltage for a given V PROGRAM level. Factory set for 10V = rated voltage.

6.2.2 OVERVOLTAGE TRIP POINT:

PP17 (12 turns). Slowly adjust clockwise to increase trip point. Factory set at 10% above rated voltage.

6.3 MAINTENANCE

No maintenance is required under normal operating conditions. Occasional vacuum or blowout of the chassis may be required when operated in extremely dirty environments. The oil-filled HV assembly must not be opened. The oil and components have been specially cleaned and vacuum impregnated at the factory and the assembly hermetically sealed. Opening the assembly may compromise performance.

6.4 TROUBLESHOOTING

First check for obvious trouble such as input power, output connections, control connections and signal levels. In particular, the interlock, the INHIBIT and the ON/OFF signals. If there is no load connected, the power supply will sense an open circuit and immediately shut down indicating a LOAD FAULT. If there is a short circuit or overload condition on the output, the power supply will operate in a 50% duty cycle protection mode and indicate a LOAD FAULT. An overload condition can occur if the INHIBIT signal is missing and the discharge rep rate is too high to allow the capacitor to fully charge to V PROGRAM.

- If the power supply is making high voltage but does not appear to be functioning properly in a specific application, the problem may be application related. Consult the TDK-Lambda Americas Inc. customer service department.
- If the power supply is not making high voltage, the problem is usually either failed HV output diodes or a problem on a pc board. Refer to the schematics provided in this manual.
 - Check the DC bus voltage on the SWG C1 C2 and SWG C3 C4 on Inverter Board. Should be 250-350 V.
 - Check for failed power transistors or diodes on the Inverter Board.
 - Check the +15V and -5V on the Control Board.

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- Check the output and inputs of the main OR-gate U2-2, 3, 4, 5 and u11 pins 3 and 4. A high level will disable the power supply. Check the output of the latches U28-1, U31-1, U37-1, U12-1 and U41-1.
- Check the V PROGRAM input at U1-12.
- Check the clock at "Drain" Q4.
- Check the transistor gate drives at Q4, Q5, Q8, Q10

7 INPUT VOLTAGE CONVERSION PROCEDURE

7.1 OVERVIEW

The 1202 power supply was designed so that the input line voltage can be easily changed from 208VAC to a 400VAC (and vice versa) in the field by <u>technically</u> <u>qualified person</u>. Each supply will be shipped configured to the voltage shown on the input label on the rear panel of the supply.

- A conversion kit will be included in the shipping package of each supply. Kit will be labeled clearly.
 - Kit part number 12494001 Conversion kit for converting 208VAC to 400VAC
 - Kit part number 12494002 Conversion kit for converting 400VAC to 208VAC
 - Kit part number 12494005 Conversion kit new for converting 208 to 400VAC
 - Kit part number 12494004 Conversion kit new for converting 400VAC to 208VAC

	12494001	12494002	12494005	12494004
Fuses Qty 3	24A	50A	30A	60A
Fuses Qty 3	0.125A	0.25A	-	—
Selector Board Qty 1	20008100	20007900	20008100	20007900

7.2 CONVERSION PROCEDURE

7.2.1 CHANGE SELECTOR BOARD

Make sure the power supply is disconnected from the line and load and all caps must be discharged.

Take the cover off.

On the inverter board (Figure 11) discharge the bus capacitor by shorting SWGC1 - SWGC2 and SWGC3 - SWGC4 with a 10Ω 10W resistor.

Remove the Selector Board (Figure 11) by unscrewing the 7 #10 x 3/8 screws. Be careful not to drop any screws in the supply as it is not easy to retrieve them.

Replace the Selector Board in the supply with the one provided in the kit. The #10 screws must be tightened and torqued to 25 in-lbs. Loose screws will damage the board and will cause the supply to fail.

7.2.2 CHANGE FUSE

To access the fuses, unscrew the four screws in the rear panel (Figure 8) and two screws on the bottom of the supply (Figure 12). Pull the fuse assembly out.

Note the revision level of the fuse PCB assembly. (Figure 14). Depending on the PCB revision level go to a) or b).

a) For fuse PCB assembly Rev. D or lower use kits 12494001 or 12494002. Six fuses need to be replaced for the conversion. These fuses are all located on the fuse assembly (Figure 14). Replace the fuses. F4, F5 and F6 are 50A for 208 VAC and 24A for 400VAC supply. F1, F2 and F3 are 0.25A for 208VAC and 0.125A for the 400VAC power supply.

b) For fuse PCB assembly Rev. E or higher, use kits 12494004 or 12494005. Three fuses need to be replaced for the conversion. These fuses are all located on the fuse assembly (Fig 14). Replace the fuses F4, F5, and F6 are 60A for

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the 208VAC and 30A for the 400VAC supply. Fuse F1, F2, F3 do not need replacement.

After replacing the fuses slide the fuse assembly back into the supply.

First use a 6 x 1¹/₄ (74-011-011) screw (supplied in the kit to locate fuse assembly in place by screwing the long screw in the bottom of the supply. Screw in the 4 screws on the rear panel of the power supply. Then go back and replace the 6 x 1¹/₄ long screws in the bottom of the screw with the correct 6 x ³/₄" (74-039-008) screws.

7.2.3 SELECTOR SWITCHES ON AUX POWER BOARD

There are 3 selector slide switches on the Aux Board which have to be correctly selected. For 208VAC line operation the position of the slide switches should be so that 110VAC is visible. For 400V line 220VAC should be visible.

The Aux Board is located on the front right hand corner (standing in front of the supply). Figure 13 shows the location of the slide switches on the Aux Board. The slide switches can be selected with a flat head screw driver.

7.2.4 CORRECTING THE INPUT LABEL

The input label is located on the rear panel and is screwed to the chassis with 4 $6 \times .312$ screws. The input label plate is silk screened on both sides. One side is for the 208VAC line and the other side is for the 400VAC line.

Unscrew the silk screened input label plate and reverse it for the changed input voltage.

The supply is tested for both input voltages prior to being shipped. On completion of the above steps, the supply is ready for operation with the changed input voltage.



Figure 11 Power Supply Top View



Figure 12 Power Supply Bottom View



Figure 13 Aux Board

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Figure 14 Fuse Assembly

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DOW CORNING DOW CORNING CORPORATION **Material Safety Data Sheet** Page: 1 of 7 DOW CORNING(R) 561 SILICONE TRANSFORMER LIQUID 1. IDENTIFICATION OF THE SUBSTANCE AND OF THE COMPANY 24 Hour Emergency Telephone: (989) 496-5900 **Dow Corning Corporation** South Saginaw Road Customer Service: (989) 496-6000 Midland, Michigan 48686 Product Disposal Information: (989) 496-6315 CHEMTREC: (800) 424-9300 MSDS No.: 01496204 Revision Date: 2002/12/06 Generic Description: Silicone Physical Form: Liquid Color: Colorless Odor: Characteristic odor NFPA Profile: Health 0 Flammability 1 Instability/Reactivity 0 Note: NFPA = National Fire Protection Association 2. OSHA HAZARDOUS COMPONENTS None present. This is not a hazardous material as defined in the OSHA Hazard Communication Standard. 3. EFFECTS OF OVEREXPOSURE Acute Effects Eye: Direct contact may cause temporary redness and discomfort. Skin: No significant irritation expected from a single short-term exposure. Inhalation: No significant effects expected from a single short-term exposure. Oral: Low ingestion hazard in normal use. Prolonged/Repeated Exposure Effects Skin: No known applicable information. Inhalation: No known applicable information. Oral: No known applicable information. Signs and Symptoms of Overexposure No known applicable information. Medical Conditions Aggravated by Exposure No known applicable information. The above listed potential effects of overexposure are based on actual data, results of studies performed upon similar compositions, component data and/or expert review of the product. Please refer to Section 11 for the detailed toxicology information.

DOW CORNING CORPORATION Material Safety Data Sheet

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DOW CORNING(R) 561 SILICONE TRANSFORMER LIQUID

4. FIRST AID MEASURES

Eye:	Immediately flush with water.
Skin:	No first aid should be needed.
Inhalation:	No first aid should be needed.
Oral:	No first aid should be needed.
Comments:	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flash Point:	> 213.8 °F / > 101 °C (Closed Cup)
Autoignition Temperature:	Not determined.
Flammability Limits in Air:	Not determined.
Extinguishing Media:	On large fires use dry chemical, foam or water spray. On small fires use carbon dioxide (CO2), dry chemical or water spray. Water can be used to cool fire exposed containers.
Fire Fighting Measures:	Self-contained breathing apparatus and protective clothing should be worn in fighting large fires involving chemicals. Determine the need to evacuate or isolate the area according to your local emergency plan. Use water spray to keep fire exposed containers cool.
Unusual Fire Hazards:	None.

Hazardous Decomposition Products

Thermal breakdown of this product during fire or very high heat conditions may evolve the following hazardous decomposition products: Carbon oxides and traces of incompletely burned carbon compounds. Silicon dioxide. Formaldehyde.

6. ACCIDENTAL RELEASE MEASURES

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DOW CORNING(R) 561 SILICONE TRANSFORMER LIQUID

Containment/Clean up: Determine whether to evacuate or isolate the area according to your local emergency plan. Observe all personal protection equipment recommendations described in Sections 5 and 8. For large spills, provide diking or other appropriate containment to keep material from spreading. If diked material can be pumped, store recovered material in appropriate container. Clean up remaining materials from spill with suitable absorbant. Clean area as appropriate since some silicone materials, even in small quantities, may present a slip hazard. Final cleaning may require use of steam, solvents or detergents. Dispose of saturated absorbant or cleaning materials appropriately, since spontaneous heating may occur. Local, state and federal laws and regulations may apply to releases and disposal of this material, as well as those materials and items employed in the cleanup of releases. You will need to determine which federal, state and local laws and regulations are applicable. Sections 13 and 15 of this MSDS provide information regarding certain federal and state requirements.

Note: See section 8 for Personal Protective Equipment for Spills. Call Dow Corning Corporation, (989) 496-5900, if additional information is required.

7. HANDLING AND STORAGE

Use with adequate ventilation. Avoid eye contact.

Use reasonable care and store away from oxidizing materials.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Component Exposure Limits

There are no components with workplace exposure limits.

Engineering Controls

Local Ventilation:	None should be needed.
General Ventilation:	Recommended.

Personal Protective Equipment for Routine Handling

Skin: Washing at mealtime and end of shift is adequate.

Suitable Gloves: No special protection needed.

Inhalation: No respiratory protection should be needed.

Suitable Respirator: None should be needed.

Personal Protective Equipment for Spills

Eyes: Use proper protection - safety glasses as a minimum.

Skin: Washing at mealtime and end of shift is adequate.

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DOW CORNING(R) 561 SILICONE TRANSFORMER LIQUID

Inhalation/Suitable No respiratory protection should be needed. Respirator:

Precautionary Measures: Avoid eye contact. Use reasonable care.

Note: These precautions are for room temperature handling. Use at elevated temperature or aerosol/spray applications may require added precautions. For further information regarding aerosol inhalation toxicity, please refer to the guidance document regarding the use of silicone-based materials in aerosol applications that has been developed by the silicone industry (www.SEHSC.com) or contact the Dow Corning customer service group.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical Form: Liquid Color: Colorless Odor: Characteristic odor Specific Gravity @ 25°C: 0.96 Viscosity: 50 cSt Freezing/Melting Point: > 65 °C Vapor Pressure @ 25°C: Not determined. Vapor Density: Not determined. Solubility in Water: Not determined. pH: Not determined. Volatile Content: Not determined.

Note: The above information is not intended for use in preparing product specifications. Contact Dow Corning before writing specifications.

10. STABILITY AND REACTIVITY

Chemical Stability: Stable.

Polymerization:

Hazardous Hazardous polymerization will not occur.

Conditions to Avoid: None.

Materials to Avoid: Oxidizing material can cause a reaction.

11. TOXICOLOGICAL INFORMATION

Special Hazard Information on Components

No known applicable information.

12. ECOLOGICAL INFORMATION

Environmental Fate and Distribution

Complete information is not yet available.

Environmental Effects

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DOW CORNING(R) 561 SILICONE TRANSFORMER LIQUID

Complete information is not yet available.

Fate and Effects in Waste Water Treatment Plants

Complete information is not yet available.

Ecotoxicity Classification Criteria Hazard Parameters (LC50 or EC50) High Medium Low Acute Aquatic Toxicity (mg/L) >1 and <=100 >100 <=1 >100 and <= 2000 >2000 Acute Terrestrial Toxicity <=100 This table is adapted from "Environmental Toxicology and Risk Assessment", ASTM STP 1179, p.34, 1993. This table can be used to classify the ecotoxicity of this product when ecotoxicity data is listed above. Please read the other information presented in the section concerning the overall ecological safety of this material. **13. DISPOSAL CONSIDERATIONS** RCRA Hazard Class (40 CFR 261) When a decision is made to discard this material, as received, is it classified as a hazardous waste? No State or local laws may impose additional regulatory requirements regarding disposal. Call Dow Corning Corporate Environmental Management, (989) 496-6315, if additional information is required. **14. TRANSPORT INFORMATION** DOT Road Shipment Information (49 CFR 172.101) Not subject to DOT. Ocean Shipment (IMDG) Not subject to IMDG code. Air Shipment (IATA) Not subject to IATA regulations. Call Dow Corning Transportation, (989) 496-8577, if additional information is required. **15. REGULATORY INFORMATION** Contents of this MSDS comply with the OSHA Hazard Communication Standard 29 CFR 1910.1200. **TSCA Status:** All chemical substances in this material are included on or exempted from listing on the TSCA Inventory of Chemical Substances. **EPA SARA Title III Chemical Listings** Section 302 Extremely Hazardous Substances:

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DOW CORNING(R) 561 SILICONE TRANSFORMER LIQUID

None.

Section 304 CERCLA Hazardous Substances:

None.

Section 312 Hazard Class:

Acute: No Chronic: No Fire: No Pressure: No Reactive: No

Section 313 Toxic Chemicals:

None present or none present in regulated quantities.

Supplemental State Compliance Information

California

Warning: This product contains the following chemical(s) listed by the State of California under the Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) as being known to cause cancer, birth defects or other reproductive harm.

None known.

Massachusetts

No ingredient regulated by MA Right-to-Know Law present.

New Jersey

CAS Number	<u>Wt %</u>	Component Name
63148-62-9	> 60.0	Polydimethylsiloxane
Pennsylvania		
CAS Number	<u>Wt %</u>	Component Name
63148-62-9	> 60.0	Polydimethylsiloxane

16. OTHER INFORMATION

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DOW CORNING(R) 561 SILICONE TRANSFORMER LIQUID

Prepared by: Dow Corning Corporation

These data are offered in good faith as typical values and not as product specifications. No warranty, either expressed or implied, is hereby made. The recommended industrial hygiene and safe handling procedures are believed to be generally applicable. However, each user should review these recommendations in the specific context of the intended use and determine whether they are appropriate.

(R) indicates Registered Trademark











REVI	SIONS	
ECO NO	BY/DATE	APP/DATE
RELEASE	GB 9/26/96	GFS
EASE	LPN 9/11/97	GFS
20284	SA 4-10-02	



N			REVISION	RECORD	
T ASSY	QTY	LTR	DESCRIPTION	APPROVED	DATE
		1	PROTO RELEASE	GB 8/29/96	GFS
		2	INITIAL RELEASE	GB 3/11/97	GFS
		3	GENERAL CLEANUP	JB 6/13/97	GFS
		A	TG RELEASE	LPN 7/31/97	GFS
		8	ECO # 16636	LPN 9/4/97	GFS
		С	ECO # 17449	LPN 11/16/98	GFS
		D	ECO # 18660	LPN 9/10/99	

	APPLICATION	
USED ON	NEXT ASSY	
402, 802, 1202		

RELEASE TO MFG		ENG	ENG CONTROL		ELECTRONIC MEASUREMENTS INC.			
PROJ ENG: JAB	DATE: 9/5/97	DRAWN: DSF	DATE: 8/29/96					
MFG: R.S.	DATE: 9/5/97	CHK: DRB	DATE: 8/29/96		1202 DISPLAY I	≥СВ		
DOC REL: GFS	DATE: 9/5/97	ENG: GB	DATE: 8/29/96	P/L: 493	PCB NO: PCB # 21-003-900	SHEE	T 1 OF 2	
		APPVD: GFS	DATE: 9/5/97	DRAWING NO:	01-000-728		REV: D	



APPLICATIONS				REVISIONS				
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				1	PROT RELEASE	GB 9/24	/96 GE	9/24/96
				3	ENG CHNG	GB 8/5/	98 GB	8/5/98
				4	ENG 4CHNG	GB 9/4/	98 GE	9/4/98
				A	TOL REL	WJW 10/	19/98 WJ	W 10/19/98
				В	ECO 19134	WJW 3/2	24/00	
 LV CKT ACING 8MM 12")		M [M [M [M [M [M [M M 12 CER M 38-032 M M	AMIC S -003	H1 P PACERS	H2 O		S018R4
	TOL: .X = ±.02	RELEASE TO MFG	ENG CON	ITROL	a.l.e systems a division of	ELECTRONIC	MEASUREMENTS,	INC.
	$.XX = \pm .01$ $.XXX = \pm .005$	PRJ.MGR: DATE: GB 9/24/96	DWN: DSF 9/24/96	DATE:	TITLE:	ATIC DIA	GRAM	
	$FRAC = \pm 1/64$ ANGLES = $\pm 1/2$	MFG: DATE:	снк: WJW 10/19/1	DATE: 98	SCR BOARD	LC120	2/SX502	,1002
	P/L: 494	DOC.REL: DATE: WJW 10/19/98	ENG: GB 9/24/96	DATE:	рсв: 21-007-30	0	SHEET 1	OF 1
	SCALE:		APP: WJW 10/19/1	DATE: 98	DRAWING NO:	01-00	7-300	rev. B
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APPLICATIONS			REVISIONS				
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			1	PROT RELEASE	GB 9/24	/96 GB	9/24/96
			3	ENG CHNG	GB 8/5/	′98 GB	8/5/98
			4	ENG 4CHNG	GB 9/4/	<u>'98 GB</u>	9/4/98
			A	TOL REL	WJW 10/	19/98 WJ	W 10/19/98
		l	В	ECO 19134	WJW 3/2	24/00	
	M M M M M M	M M 12 CER/ M 38-032 M M	AMIC S -003	H1 PACERS	H2 O		S018R4
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P/L: 494	DOC.REL: DATE: WJW 10/19/98	ENG: GB 9/24/96	DATE:	рсв: 21-007-30	00	SHEET 1	of 1
SCALE:		APP: WJW 10/19/9	DATE: 98	DRAWING NO:	01-00	7-300	REV. B



REVISIONS							
ECO NO	BY/	DATE	AP	P/DATE			
O RELEASE	GB 9/	22/96	GB 9	/22/96			
PDATES	GB (3/7/97	S	.A.			
ELEASE	LPN 9/	/11/97	G	FS			
# 21254	GB 2/2	4/04					
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				P024R2 S017R2			
ELECTRONIC a.i.e.	S MEASU	REMENTS division	5, INC	•			
.E:							
1202	SCHE GATE	MATIC DRIVE	PCI	3			
3 NO: 21-007-40	00	SHE	ET 1 (OF 1			
WING NO:	01-00	7-400		rev. B			