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VALHALLA SCIENTIFIC, INC.

MODEL 4650A

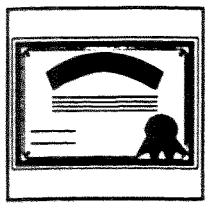
PROGRAMMABLE
DIGITAL IGNITER TESTER

OPERATION MANUAL



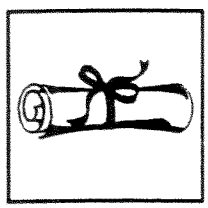
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CERTIFICATION



Valhalla Scientific, Inc. certifies that this instrument was thoroughly tested and inspected and found to meet published specifications when shipped from the factory. Valhalla Scientific, Inc. further certifies that its calibration measurements are traceable to the National Institute of Standards and Technology to the extent allowed by NIST's calibration facility.

WARRANTY



The warranty period for this instrument is stated on your invoice and packing list. Please refer to these to determine appropriate warranty dates. We will repair or replace the instrument during the warranty period provided it is returned to Valhalla Scientific, Inc. freight prepaid. No other warranty is expressed or implied. We are not liable for consequential damages. Permission and a return authorization number must be obtained directly from the factory for warranty repairs. No liability will be accepted if returned without such permission. Due to continuing product refinement and due to possible parts manufacturer changes, Valhalla Scientific reserves the right to change any or all specifications without notice.

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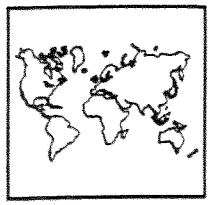
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SECTION I UNPACKING & INSTALLATION



1-1. Introduction

The Model 4650A is a programmable, battery powered, portable ohmmeter designed specifically for ultra-safe resistance testing of explosive devices.

There are a variety of critical military, aerospace, and industrial applications that utilize squibs and other blasting devices. In each case, it is extremely important that these devices detonate when required. It is equally important that these devices do *not* detonate while being tested for coil integrity. To this end, the Valhalla Model 4650A is equipped with dual redundant fail-safe current limiting networks to ensure that the test currents cannot exceed the specified amount. Even in the unlikely event of a worst case component failure, the output current limiting network is still in effect.

1-2. Inspection

If the shipping carton is damaged, request that the carrier's agent be present when the unit is unpacked. If the instrument appears damaged, the carrier's agent should authorize repairs before the unit is returned to the factory. Even if the instrument appears undamaged, it may have suffered internal damage in transit that may not be evident until the unit is operated or tested to verify conformance with its specifications. If the unit fails to operate or fails to meet the performance specifications of Section 2, notify the carrier's agent and the nearest Valhalla Sales Office. Retain the shipping carton for the carrier's inspection. DO NOT return equipment to Valhalla Scientific or any of its sales offices prior to obtaining authorization to do so.

1-3. Initial Adjustments

The only adjustments required before placing the unit in operation are to verify that the instrument has been set for the proper local AC line voltage and to verify that the proper fuse has been installed as follows:

105 to 125 VAC = ½ Amp Slo-blo
210 to 250 VAC = ¼ Amp Slo-blo

The AC line receptacle, located on the 4650A rear panel, is used to provide power to the battery charging circuitry and does not power the instrument directly. The AC line voltage is selected by the installation of the fuse block of the receptacle. The block may be pulled out using a hook or screwdriver. The points should be aligned for the desired line voltage as follows:

110-120V▾ 220-240V▾
▲ ▲

1-4. Instructions for Bench Use

The unit is supplied with all the hardware required for bench use and special instructions for use in this manner are not necessary. However, before connecting the unit to the local power source, verify that the power cord is equipped with a three-terminal connector. Note that the instrument is battery powered and does not need to be plugged into the AC line in order to operate.

1-5. Instructions for Rack Mounting

Optional brackets are available for mounting the Model 4650A in a standard 19" equipment rack. These are listed in Section 3. The size of the unit and the location of its center of gravity dictate that it must be supported on both sides along its entire length through the use of trays or slides. If it is to be transported while mounted in a rack, it should be supported so as to prevent upward or downward movement.

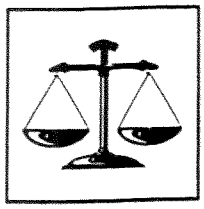
It is recommended that blank panels at least 1.75 inches high be installed between this and any other units in the rack to ensure freedom of air flow. Under no circumstances should the ambient air temperature around the unit exceed 50°C while the unit is in operation or 60°C when power is removed.

1-6. Safety Precautions

The power plug must be a three-contact device and should be inserted only into a three-contact mating socket where the third contact provides a ground connection. If power is provided through an extension cable, the ground connection must be continuous. **Any discontinuity in the ground lead may render the unit unsafe for use!**

The 4650A need not be plugged into the AC line under normal use as it is powered by an internal battery. If it is more convenient to leave the instrument plugged in at all times, the user should note that the input terminals are double-isolated from the line and it is therefore safe to leave the instrument plugged into the line when making measurements.

SECTION II SPECIFICATIONS



2-1. General

This section contains the Model 4650A specifications. The accuracy specifications are valid following a minimum 15 minute warm-up period. Accuracy may be degraded if environmental conditions are not within the specified limits. Accuracies apply to *settled* readings. Settling is indicated by a brightening of the display. Initial readings (prior to settling) or "one-shot" readings have a specified accuracy of ±1% of the range (±10% of the range for the 2.5MΩ and 25MΩ ranges). One-shot measurements may be taken at the rate of 1 per second. See Section 6 for details on the various reading modes.

2-2. Accuracy

The accuracy specifications are valid ±5° perature for 1 year from the date of calibration. The specifications apply to fu measurements using a high-quality shielded low-thermal lead set such as Valhalla Option "SL-48". 2-wire measurements are subject to test lead resistances, contact resistances, and ambient noise levels and are therefore not specified.

MODEL 4650A ACCURACY SPECIFICATIONS

Rng #	Maximum Input	Maximum[1] Resolution	Accuracy [2]	Accuracy [3]	Test [4] Current
1	2.49999Ω	10μΩ	±0.015% of rng	±0.1% of range	5mA
2	24.9999Ω	100μΩ	±0.015% of rng	±0.1% of range	500μA
3	249.999Ω	1mΩ	±0.015% of rng	±0.1% of range	50μA
4	2.49999kΩ	10mΩ	±0.015% of rng	±0.1% of range	5μA
5	24.9999kΩ	100mΩ	±0.015% of rng	±0.1% of range	500nA
6	249.999kΩ	1Ω	±0.015% of rng	±0.1% of range	500nA
7	2.49999MΩ	10Ω	±0.5% of rng	±0.2% of range	50nA
8	24.99MΩ	10kΩ	±2% of rng	±0.2% of range	5nA

Notes:
[1] Resolution is user-selectable. The maximum available resolution for each range is shown.
[2] Valid for inputs above 10% of the maximum input.
[3] Valid for inputs from 1% to 10% of the maximum input. Inputs less than 1% are not specified.
[4] Fail-safe current is 7.5mA on all ranges if range 1 is installed, otherwise 750μA all ranges.

2-3. Operating Specifications

Compliance Voltage ..... Clamped at 50mV±5%(rngs 1-5) or 200mV±5%(rngs 6-8)

True Ohms Mode ..... Pulsed test current available in ranges 1-4 only

CMRR ..... > 70dB @ 50-60Hz

NMRR ..... > 35dB @ 50-60Hz

Overload Protection ..... $100V_{peak}$ all terminals

Sample Rate ..... 2 rdg/sec standard mode (1 rdg/sec in TrueΩ mode or 25MΩ rng)

Settling Time ..... approximately 15 seconds (45 seconds in TrueΩ mode or 25MΩ rng)

Settling Indications ..... display dims during settling, brightens after settling

4-Wire Lead Rejection: ..... 3ppm per %
(% = lead+contact resistance ÷ unknown resistance x 100)

Interface: IEEE-488 with subsets SH1 AH1 T6 TE0 L4 LE0 SR1 RL1 PP0 DC1 DT1 C0

Display Type ..... 20 character vacuum fluorescent

Indicator Lamps ..... rectangular red and green light emitting diodes (LED)

Overrange Indication ..... display shows "OVERRANGE" or "OPEN CIRCUIT"

Data Entry ..... 27 key silicon rubber keyboard, or via the interface

Calibration Enable Switch ..... front-mounted, screwdriver accessible

Input Connectors ..... front and rear low-thermal binding posts

2-4. Power Requirements

Power ..... powered from internal sealed lead-acid battery

Battery Endurance ..... up to 4 hours continuous following full charge

Charging Time ..... min 10 hours to restore fully discharged battery

Charging Voltage ..... provided by AC line, 105-130VAC or 210-260VAC, 50-60Hz

Charging Mode ..... enabled by front switch or by a logic 0 (short) on rear terminals

2-5. Environmental and Physical Specifications

Dimensions ..... 4"H X 17"W X 17"D (10cm X 43cm X 43cm)

Weights ..... 25lbs(11.4kg) net; 32lbs(14.5kg) shipping

Operating Temperature Range ..... 32°F to 122°F (0°C to 50°C)

Storage Temperature Range ..... -4°F to +140°F (-20°C to +60°C)

Temperature Coefficient ..... ±0.002%/°C (from 0°C to 19°C and 30°C to 40°C)

Humidity ..... 70% RH @ 40°C non-condensing

Altitude ..... -1000 ft. to 10,000 ft.

Vibration ..... Per MIL-T-28800C, Type III, Class 5, Style E

Safety ..... Designed to comply with UL1244 and IEC 348



SECTION III OPTIONAL EQUIPMENT



3-1. Available Options

Listed below are the options available for use with the Model 4650A Programmable Igniter Tester. Standard accessories include an operating manual and detachable power cord.

Option RX-3: Rack Ears

Option "RX-3" is a set of rack ears that permit mounting of the Model 4650A in a standard 19" equipment rack.

Options GP-1, GP-2: GPIB Cable

These options are 1 or 2 meter IEEE-488 GPIB interface cables for connection to the GPIB port.

Replacement Battery

Replacement batteries are available under the Valhalla stock number 05-10613. Refer to Section 8-3 for replacement instructions.

3-2. Test Leads

Option K: General Purpose Lead Set

Option "K" is a general purpose shielded 4-wire Kelvin cable set, 48" in length terminated in "KCS" gold-plated clips.

Option KCS: Gold-Plated Clips

Option "KCS" are the light-weight gold-plated Kelvin clips used to terminate Option "K" above. Clips open to ½" and accommodate test currents of up to 10 amperes.

Option MP-1: Kelvin Micro-Probes

Option "MP-1" is a 48-inch shielded Kelvin 4-wire cable set with a 1-ampere test current capacity employing a set of Kelvin Micro-Probes. The probes are equipped with stainless steel tips separated by 0.05 inches.

Option MP-2: Kelvin Mini-Probes

Option "MP-2" is a 48-inch shielded 4-wire cable set equipped with Kelvin Mini-Probes having spring loaded stainless steel tips. The tips are separated by 0.18 inches.

Option MP-4/MP-5: Surface Probes

These probes permit rapid, repeatable bonding testing on a variety of screened or flat surfaces. Test current is evenly distributed through the probe base while sensing is accomplished via a spring loaded center contact. The MP-4 target area is 1" in diameter. The MP-5 target area is .4" in diameter.

Options KK and KL: JAWS Cables

These options are heavy duty cable sets terminated in large "JAWS" for connecting to larger bushings, bolts, etc. Option KK connects to the 4650A via dual banana plugs. Option KL connects via spade lugs.

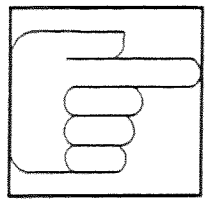
Option SL-48: Low Thermal Leads

Option "SL-48" is a 48" shielded lead set terminated in gold-plated spade lugs. This lead set is designed to eliminate problems caused by thermal EMF's and is the recommended lead set for calibration, or whenever the best performance is required.

Option C: Banana-to-Clip Cable

Option "C" is a 48" general-purpose shielded lead set terminated on one end in a dual banana plug and on the other end in red and black copper alligator clips.

SECTION IV FRONT PANEL CONTROLS



4-1. General

This section outlines the use of each of the front panel controls and connectors. This section should be used in conjunction with Sections 5 and 6 for complete operating instructions. The paragraph numbering in this section refers to the numbering of Figure 4-1.

4-1-1. Display Window

This alpha-numeric display is used to indicate the resistance of the device under test and to provide a means of interactive communication between the user and the instrument.

4-1-2. Keypad

This block contains 25 keys which are used to select the operating mode and for data entry.

4-1-3. Calibration Enable Switch

This switch is accessible using a standard flat screwdriver and is used to enable the calibration cycle of the 4650A. Refer to Section 8-4 for details.

4-1-4. Voltage Terminals (V)

These binding posts are the voltage sensing terminals when using a 4-wire configuration.

4-1-5. Current Terminals (I)

These binding posts are the current sourcing terminals. In 2-wire mode, these terminals double as the voltage sensing terminals.

4-1-6. Fail-safe Status Indicator

This indicator glows green if the fail-safe circuitry has been verified as operational. **The 4650A should not be used for testing purposes unless this indicator is illuminated!**

4-1-7. Interface Controls

This block contains the keys and indicators used by the IEEE-488 interface. A LOCAL key and an ADDRESS key are used to control the interface while indicators are provided for talk/listen, SRQ assertion and remote mode. Refer to Section 7.

4-1-8. Battery Status Indicators

This section contains indicators that monitor the condition of the internal battery pack and charging circuitry. The AC ON indicator is illuminated if AC line power is available. The CHARGING indicator is illuminated if the battery is receiving a charging current. The LOW BAT indicator illuminates when the battery output drops below 10.7 volts, indicating that it requires a charge. This indicator will not illuminate if the battery is completely discharged.

4-1-9. Power Switch

This push-on, push-off switch is used to apply power to the igniter tester and to control the battery charging circuitry. In the ON position, the tester circuitry is completely isolated from the AC line and power is applied to the circuits by the internal battery pack. In the OFF position, the tester circuitry is disconnected from the battery and the battery is connected to the charging circuitry (AC line).

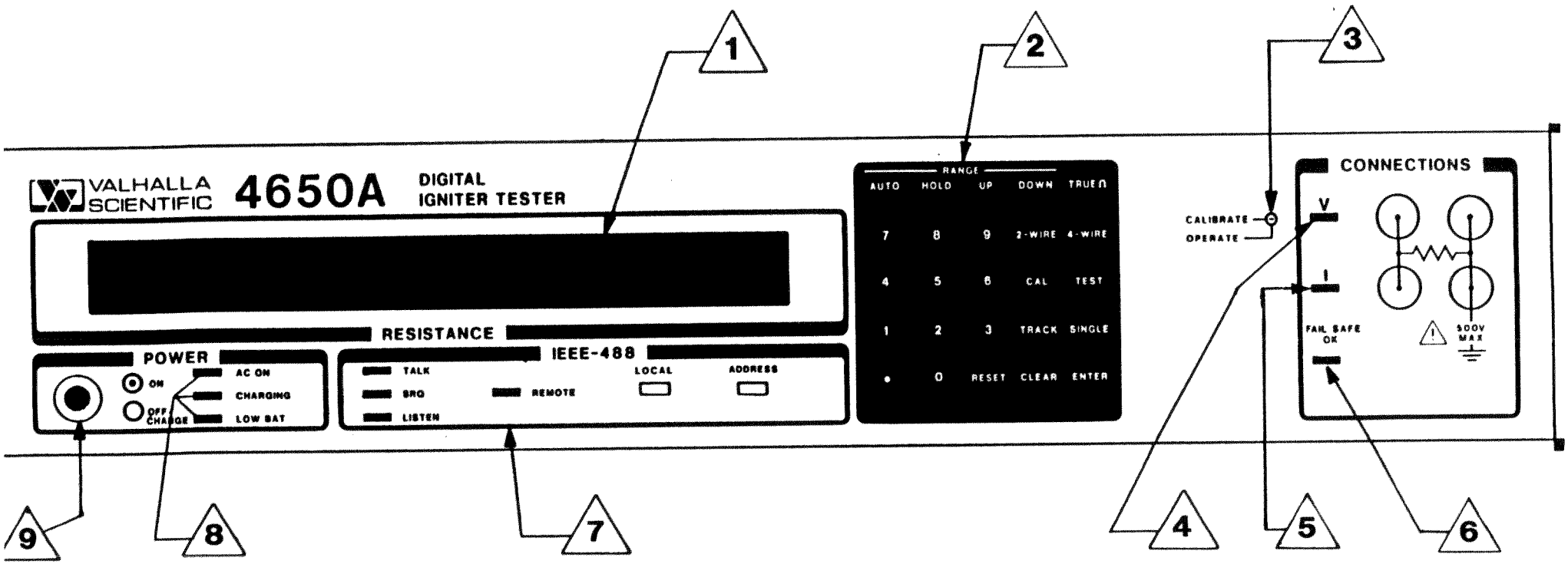
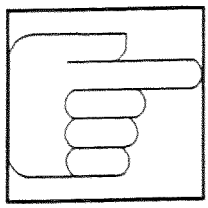


Figure 4-1. Model 4650A Front Panel

SECTION V REAR PANEL CONTROLS



5-1. General

This section outlines the use of each of the rear panel controls and connectors. This section should be used in conjunction with Sections 4 and 6 for complete operating instructions. The paragraph numbering in this section refers to the numbering of Figure 5-1.

5-1-1. Input Terminals

These binding posts are used to connect the device under test to the 4650A. The function of these terminals is identical to that of the front panel terminals and **no isolation is provided between these and the corresponding front terminals.**

5-1-2. Interface Connector

This connector is used to interface with the GPIB (aka HP-IB) in accordance with IEEE Standard 488 of 1978. Refer to Section 7.

5-1-3. Remote Charging Control

These terminals may be connected to an external device to remotely cause the 4650A to shut down the internal circuitry and enter the battery charging mode. A logic 0 (or short circuit) on these terminals has the same effect as placing the front panel POWER switch in the OFF position. Note: These terminals have no effect unless the instrument is connected to the AC line and the rear power switch is in the 1 (on) position.

5-1-4. AC Switch / Receptacle / Fuseholder

This multi-function block controls the application of AC power to the instrument. Contained in this block are the receptacle, the power switch, and the fuseholder. AC power is used only to charge the battery and therefore this switch need not be in the 1 (on) position during normal operation. This block also contains the mating receptacle for the power cord supplied with this instrument. The AC line fuses are also contained within this block. Fuse inspection is described in Section 1-3.

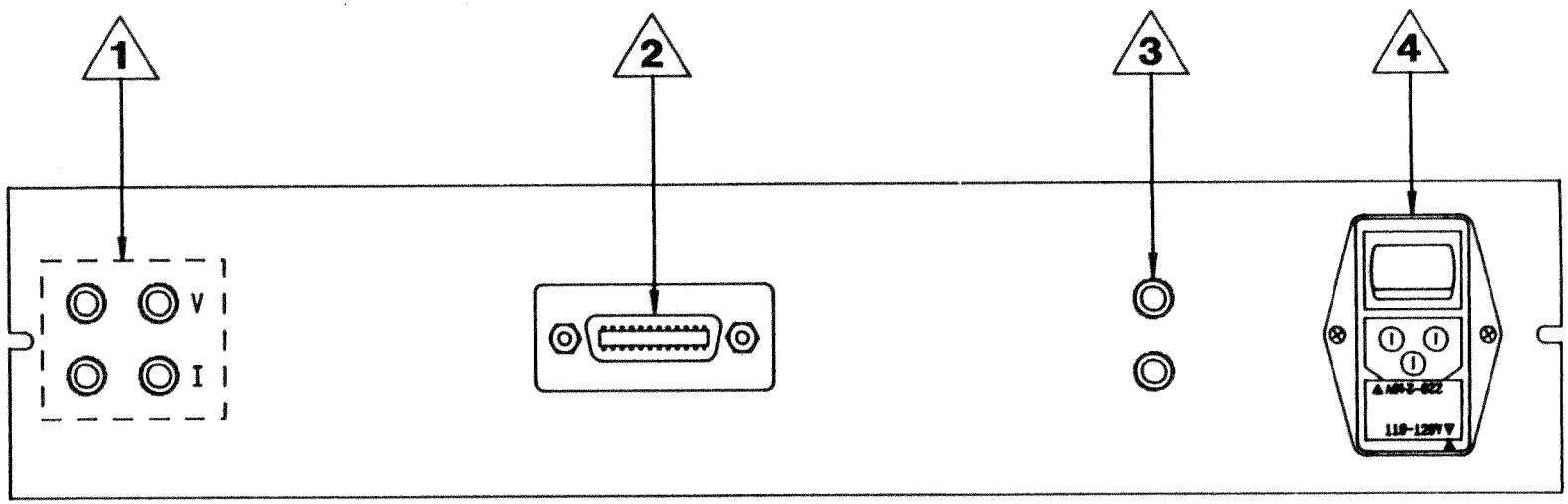
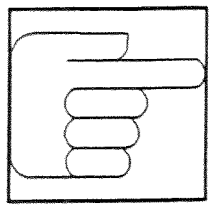


Figure 5-1. Model 4650A Rear Panel

SECTION VI MANUAL OPERATION



6-1. General

The Model 4650A is a portable, ultra-safe tester designed for non-destructive testing of explosive devices, squibs, and igniters. The 4650A also functions quite well as a programmable precision 4-wire ohmmeter, and may be utilized for either purpose using the procedures described below. The additional information required to operate the Model 4650A via the IEEE-488 interface is provided in Section 7.

6-2. Applying Power

The 4650A is a battery operated instrument and does not need to have the AC power cord connected in order to operate. However, isolation is provided therefore AC power may remain connected during testing without danger. Power is applied by depressing the switch located in the lower left corner of the front panel. The switch must be returned to the OFF position (or short the Remote Charging terminals on the rear) in order to enable charging of the battery.

The user is greeted by a power-up routine including such items as identification, software version, IEEE address, and any pertinent messages concerning operation. The 4650A then moves to the ready mode where it may or may not indicate OPEN CIRCUIT. If no connections are made to the input terminals, the 4650A may search for an input. Random data may be displayed during searching. Searching is indicated by an audible clicking of relays and does not indicate a fault in the instrument.

6-3. Self-Test

The Model 4650A features a self-diagnostic function which automatically tests the integrity of all fail-safe circuitry and calibration data. **It is recommended that this self-test be performed prior to critical testing.**

To initiate a self-test, remove all connections to the front or rear terminals and press the TEST key on the front panel keypad. The user will be prompted through the procedure and messages will appear in the display window indicating *pass* or *fail*. The sequence of tests is:

1) Fitted ranges. The 4650A checks to see which ranges have been installed.
2) Fail-Safe test. The 4650A tests the current limiting circuitry of each range.
3) Calibration test. The 4650A tests the calibration of the instrument using the internal precision reference resistors.
4) Fail-Safe current. The maximum possible test current is displayed.
5) Display test. The 4650A tests the operation of all display segments and indicators by illuminating them all simultaneously. NOTE: The indicators in the POWER section are not included in this test.
6) NOVRAM test. The 4650A checks its non-volatile memory for valid calibration data.
7) Fail-Safe Passed. This final message indicates the end of the procedure.

NOTE: If power is removed or a reset initiated during a self-test, the calibration data may become corrupted. Corrupted data is indicated by any of three messages: "Calibration Needed", "Internal Cal Needed" or "NOVRAM Error 6". If any of these messages are observed, perform an internal calibration to restore the data.

6-4. Internal Calibration

The Model 4650A features an automatic self-adjustment procedure that compensates for small variations in temperature and/or environment. It is recommended that the internal calibration procedure be performed following transport of the instrument, if a self-test indicates that it is necessary, or at a minimum interval of 30 days. The procedure is described below:

1) Remove all connections to the front or rear terminals. Allow the 4650A to warm-up for a minimum of 15 minutes before proceeding.
2) Press the CAL key on the front panel keypad. The user is prompted AUTO CAL?. Press ENTER for yes.
3) The user is reminded to remove all connections. Press ENTER to proceed.
4) The remainder of the procedure is performed automatically by the 4650A and takes approximately 12 minutes.

NOTE: If power is removed or a reset initiated during a self-test, the calibration data may become corrupted. Corrupted data is indicated by any of three messages: "Calibration Needed", "Internal Cal Needed" or "NOVRAM Error 6". If any of these messages are observed, perform an internal calibration to restore the data.

6-5. Connections

The Model 4650A accommodates 2-wire or 4-wire connection techniques. The maximum accuracy is obtained using the 4-wire connection method. 2-wire mode may be used reliably for inputs greater than 10 ohms.

6-5-1. 4-Wire Connections

Connections to the tester are made via 4 binding posts on the front or rear panel of the instrument. When using Valhalla test leads, the tabbed side of each banana jack is connected to the CURRENT terminals (see below). This ensures that current is carried in the largest conductor of the cable, and that the voltage input is shielded.

VOLTAGE	HI *	* LO
CURRENT	HI *	* LO
	tab↑	↑tab

The 4-Wire configuration eliminates errors normally caused by test lead and contact resistances. In many applications the contact resistance can exceed the value of the load by several orders of magnitude. The 4650A bypasses this potential error source by providing two terminals of constant current and an additional two terminals for high impedance voltage measurement. The result is a fast, accurate resistance measurement of the load, independent of the resistance of the current carrying leads.

Figure 6-1 illustrates how the 4-wire principle is used to eliminate lead, wire and contact resistances as potential error sources. The internal current source inherently overcomes all series resistance (within compliance voltage limits) and delivers a precise constant current. The internal high-impedance DVM senses the voltage drop across the load. There is negligible contact and lead resistance error created by the voltage measurement because the high input impedance of the DVM limits current flow in the voltage leads.

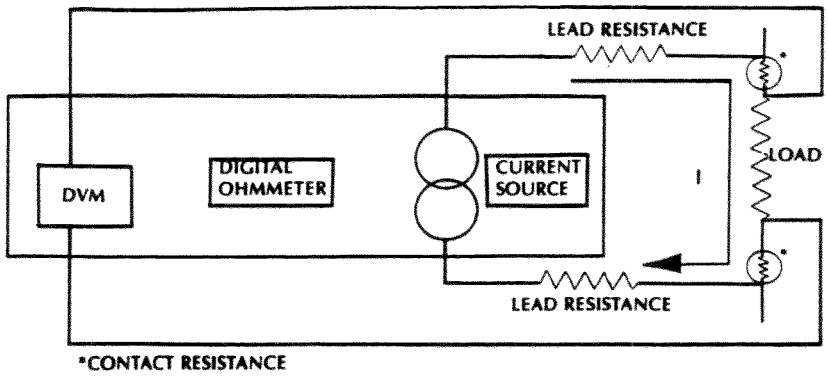


Figure 6-1. Error Sources in Resistance Measurements

6-5-2. 2-Wire Connections

2-wire connections are not recommended for resistances less than 10 ohms. 2-wire connections are made to the current (I) terminals. This mode of operation is indicated by illumination of the LED under the "I" only.

6-6. Taking Measurements

The following paragraphs describe the procedures normally used to measure the device under test.

1) **Select the terminal configuration.** Press either the 2-WIRE or 4-WIRE key for the desired connection method.

2) **Select the resistance range.** The autorange feature is the default mode however the 4650A may be preset to a specific range using the UP and DOWN keys. The HOLD key causes the instrument to remain in the present range until the UP, DOWN, or AUTO key is pressed.

3) **Select the display resolution.** The default resolution is 2499 counts. Greater resolution may be selected by pressing the **5** or **6** keys. The **4** key selects the standard display resolution. The maximum resolution is 249999 counts.

4) **Select the type of measurement.** The 4650A features a True Ohms mode to compensate for any offset caused by thermal EMF's. The True Ohms mode uses a pulsed test current and is selected by pressing the TRUEΩ key. The settling time in this mode is significantly increased over the normal mode, however the safety factor is improved by the fact that the test current is presented to the load for brief periods only.

   The True Ohms mode is deselected by pressing the TRUEΩ key a second time.

5) **Select the sampling mode.** The 4650A may be used to provide continuous measurements or may take "one-shot" measurements of the device. The default mode is the continuous reading mode.

   The TRACK key may be pressed to select continuous readings, or to clear the measurement buffer. A brightening of the display in either mode indicates that settling has occurred. A dim display indicates that the instrument is in the process of taking data.

The one-shot mode is selected by pressing the SINGLE key. The display dims momentarily, and then brightens with the resultant measurement in the display window. The 4650A is returned to the continuous mode by pressing the TRACK key. Specified accuracy is decreased using the one-shot mode. Please refer to Section 2-1.

6) **Interpreting the display.** The display includes the resistance measurement and range information. The resistance measurement may be indicated in ohms (Ω), kilo-ohms (KΩ), or megohms (MΩ). The range number is preceded by an "A" if the 4650A is set to autorange or an "R" if it is in either the HOLD or manual ranging mode. The number next to this letter is the present range number, 1-8.

6-6-1. Noisy Readings

The 4650A is a precision instrument that detects very small changes in voltage. It is important that certain precautions are taken to avoid undesirable results such as noisy resistance measurements.

When testing dangerous devices such as explosives, the meter is often placed far away from the test device for safety reasons. From a measurement standpoint this is not an ideal situation and should be avoided if at all possible. Long lead lengths act as antennas and may funnel ambient noise into the 4650A.

If a long lead run is unavoidable, the following suggestions will help reduce noise pick-up:

1) Use coaxial or triaxial cabling with the shield conductor carrying the current.
2) Use gold plated terminals for the best connection and lowest series resistance.
3) Be aware of the limitations of the 4650A's current source. When making measurements in the 2.5Ω range, the total series resistance including the test device and current-carrying leads must be < 10Ω.

6-7. Other Keys

The functions of most of the keys on the 4650A front panel were discussed in the previous paragraphs. Several keys, however, were not discussed and are explained here.

6-7-1. RESET Key

Pressing this key causes the 4650A to perform a soft reset of the microprocessor and hardware. This key is provided as a means of escape out of undesired operating modes or to reset the instrument to its default operating parameters. **Avoid use of this key to exit the Self-Test or Internal Calibration cycles as it may corrupt the calibration data.**

6-7-2. CLEAR Key

The CLEAR key is used to respond with a negative answer (NO) to prompts by the 4650A. This key is also used in the External Calibration cycle as discussed in Section 8.

6-7-3. ENTER Key

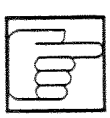
The ENTER key is used to respond with a positive answer (YES) to prompts by the 4650A. This key is also used to enter data in the External Calibration cycle as discussed in Section 8.

6-7-4. Numeric Keypad

The numeric keypad is used to select the display resolution as described in Section 6-6. This keypad is also used in the External Calibration cycle as described in Section 8.

6-7-5. LOCAL and ADDRESS Keys

These keys are discussed in Sections 7-7 and 7-8-1, respectively.



SECTION VII REMOTE OPERATION



7-1. General

This section of the manual contains instructions for operating the Model 4650A Programmable Igniter Tester via the standard GPIB IEEE-488 interface. These paragraphs should be used in conjunction with the principles discussed in Sections 4 through 6 for complete operating instructions.

7-2. IEEE-488: An Explanation of the Bus

The reader who is not familiar with the requirements of the 1978 IEEE Standard 488 (IEEE-488) should review the following paragraphs which provide some basic explanations of terms and examples of commands. For a complete explanation of the requirements, refer to the 1978 IEEE-488 Standard.

The purpose of the standard is to allow for interconnection of programmable instruments with a minimum of engineering. The intent is to remove the need for adapters and numerous types of patching cables often encountered with other forms of interfaces. The IEEE-488 standard defines a system configuration for programmable instruments such as calculators, voltmeters and other types of peripheral devices produced by various manufacturers that provides a set of rules for establishing a defined communications link. This system provides a high degree of compatibility yet maintains flexibility between independently manufactured products. The IEEE-488 standard defines the following:

Electrical characteristics - interface circuit parameters, electrical signal levels, loading requirements and grounding requirements.

Mechanical characteristics - connector type, contact assignments and cable assembly.

Functional characteristics - the complete repertoire and precise definition of each of the signal lines, the protocol and timing relationships and the mandatory responses for universal (device independent) messages.

The IEEE-488 (1978) standard does *not* define the following:

The way in which device dependent messages will be interpreted by the receiving device, leaving these up to the manufacturer to define. These are defined for the 4650A in Section 7-8.

Maximum amount of time for a full handshake of data to occur ensuring compatibility with the slowest device on the bus (it does define the minimums, however).

7-3. Definitions

Listed below are definitions of the terms used to describe the IEEE-488 interface:

Bus: A data link which is usually a set of several parallel wires within a multi-wire cable.

Bi-Directional Bus: A "highway" used for two-way communication, with input and output data being carried on the same lines.

Bit-Parallel: A data transmission method in which all of the bits composing an item of data are present simultaneously on a group of wires in a bus.

Byte: A group of eight data bits which is treated as a single item of data.

Byte-Serial: A data transmission method in which information, in bit-parallel bytes, is transferred sequentially between devices.

Device Dependent Message: A message containing commands or data intended for a specific device.

Handshake: An exchange of signals between two devices which is used to control the transfer of data between them.

Interface: The part of an instrument or system which enables it to be connected to another via a bus.

Interface Message: A message intended for interface management.

Local Operation: Operation of a device by its front panel controls (also referred to as Manual Control).

Remote Operation: Operation of a device under the control of another via the bus.

7-4. Bus Restrictions

The IEEE-488 Interfacing Standard (also known as IEC DTC66 (WG3), ANSI MC1-1, GPIB, HP-IB, etc.), defines a bidirectional bus for interconnecting programmable instrumentation in a bit-parallel, byte-serial fashion. It defines limitations as follows:

1. A maximum of 15 devices may be interconnected by a single bus.

2. The total bus length may not exceed 20 meters, with a maximum interconnection length of 4 meters.

3. Maximum transmission rate is 1 megabyte per second.

4. All bus data is digital.

Of the devices on the bus, only *one* may be the controller which exercises control over all other devices, and is also capable of operating as a talker or listener. The other devices may be listeners (only able to receive data) or talkers (only able to send data), or both. The Model 4650A is capable of talking and listening, and indicators are provided on the 4650A front panel to monitor this activity. The controller may address other devices and command them to listen or talk. Only one device may talk at any one time.

The interconnecting cable consists of sixteen signal wires and eight ground returns linking devices into a complete system:

1. Eight data wires (DIO-0 through DIO-7)

2. Five management wires (ATN, EOI, SRQ, IFC, and REN)

3. Three "handshake" wires (DAV, NRFD and NDAC)

Each cable connector is a plug/socket combination to permit "daisy-chaining" of units.

It should be noted that these wires use "inverse logic". That is to say that a low level indicates the true (asserted) state and a high level indicates a false (non-asserted) state.

7-5. Detailed Bus Descriptions

The five bus management wires are described as follows:

ATN: Asserted by the controller whenever an address or a command is present on the bus.

EOI: May be asserted by the controller or any talker. With ATN true, EOI indicates that the controller is polling devices. With ATN false, EOI is asserted by the talker to indicate the end of data.



SRQ: May be asserted by any device. This indicates that the device requires attention (e.g., a fault has occurred). Normally, the controller will respond by polling to determine which device requires service.

IFC: May be asserted only by the controller. This line initializes the bus to a reset state.

REN: May be asserted only by the controller. This signal places the addressed device into the remote mode.

The three handshake wires are described as follows:

DAV: May be asserted by any talker; indicates that a valid data byte is present on the data wires.

NRFD: May be asserted by any listener. Indicates that the listener is not ready to receive data.

NDAC: May be asserted by any listener. Indicates that the listener has not yet finished reading the data byte.

The transfer of data on the bus is controlled by these three handshake wires. It is important to note that the drivers for the handshake wires are all connected for parallel operation. That is, as long as any of the devices on the bus asserts a handshake line, it will remain true. There must be a complete consensus among the devices for any handshake wire to be high (false).

The talker first waits for all devices to be ready to accept data (checks that NRFD is false) then puts one byte of data on the bus and asserts DAV. It waits for all devices to indicate that the data has been accepted (that is, NDAC to become false) before starting to transfer the next byte of data. This handshake protocol assures that data on the bus is transferred at the speed of the slowest device on the bus.

Data is sent in 8-bit bytes on the DIO wires, usually (as in the 4650A) using the ISO-7 standard ASCII characters. Table 7-1 lists each ASCII character and the bus messages applicable to each.

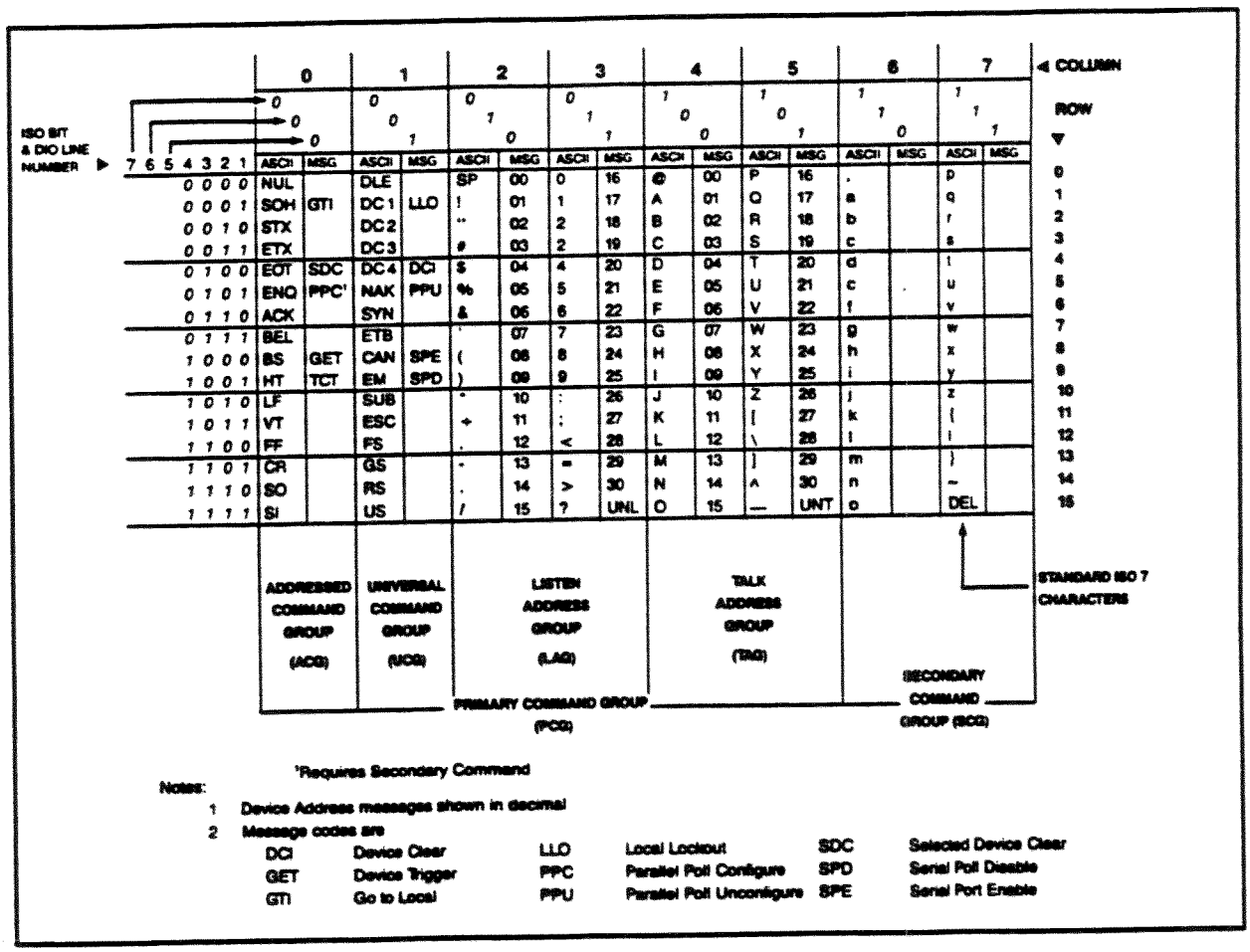
Note that the table is divided into two main groups; the primary command group and the secondary command group. The secondary command group is not utilized in the 4650A.

The primary command group is further divided into four subgroups as follows:

1. **Addressed Command Group** - applied only to addressed devices.
2. **Universal Command Group** - applied to all devices.
3. **Listen Address Group** - set of device listen addresses.
4. **Talk Address Group** - set of device talk addresses.

Data in the above command groups is sent with ATN "true". These type of commands are understood by all devices using the IEEE-488 standard. When data is sent with ATN "false", it is referred to as a *device dependent* command. A device dependent command is specific to a particular device, and may or may not be understood by other devices.





ISO BIT & DIO LINE NUMBER 7 6 5 4 3 2 1	0 ASCII	0 MSG	1 ASCII	1 MSG	2 ASCII	2 MSG	3 ASCII	3 MSG	4 ASCII	4 MSG	5 ASCII	5 MSG	6 ASCII	6 MSG	7 ASCII	7 MSG	ROW
0 0 0 0	NUL		DLE		SP	00	0	16	@	00	P	16	`		p		0
0 0 0 1	SOH	GTI	DC1	LLO	!	01	1	17	A	01	Q	17	a		q		1
0 0 1 0	STX		DC2		"	02	2	18	B	02	R	18	b		r		2
0 0 1 1	ETX		DC3		#	03	2	19	C	03	S	19	c		s		3
0 1 0 0	EOT	SDC	DC4	DCI	$	04	4	20	D	04	T	20	d		t		4
0 1 0 1	ENQ	PPC'	NAK	PPU	%	05	5	21	E	05	U	21	c		u		5
0 1 1 0	ACK		SYN		&	06	6	22	F	06	V	22	f		v		6
0 1 1 1	BEL		ETB		'	07	7	23	G	07	W	23	g		w		7
1 0 0 0	BS	GET	CAN	SPE	(	08	8	24	H	08	X	24	h		x		8
1 0 0 1	HT	TCT	EM	SPD	)	09	9	25	I	09	Y	25	i		y		9
1 0 1 0	LF		SUB		*	10	:	26	J	10	Z	26	j		z		10
1 0 1 1	VT		ESC		+	11	;	27	K	11	[	27	k		{		11
1 1 0 0	FF		FS		,	12	<	28	L	12	\	28	l		|		12
1 1 0 1	CR		GS		-	13	=	29	M	13	]	29	m		}		13
1 1 1 0	SO		RS		.	14	>	30	N	14	^	30	n		~		14
1 1 1 1	SI		US		/	15	?	UNL	O	15	_	UNT	o		DEL		15

COLUMN

ADDRESSED COMMAND GROUP (ACG)

UNIVERSAL COMMAND GROUP (UCG)

LISTEN ADDRESS GROUP (LAG)

TALK ADDRESS GROUP (TAG)

SECONDARY COMMAND GROUP (SCG)

PRIMARY COMMAND GROUP (PCG)

STANDARD ISO 7 CHARACTERS

'Requires Secondary Command

Notes:

1 Device Address messages shown in decimal

2 Message codes are

DCI	Device Clear	LLO	Local Lockout	SDC	Selected Device Clear
GET	Device Trigger	PPC	Parallel Poll Configure	SPD	Serial Poll Disable
GTI	Go to Local	PPU	Parallel Poll Unconfigure	SPE	Serial Port Enable

Table 7-1. ASCII Characters

7-6. Universal Commands

This section describes all of the IEEE-488 defined universal commands and their effect upon the operation of the 4650A. The following examples are given in HP Basic and it is assumed that the 4650A has its address set to 15.

NOTE: The example commands that follow are given in HP Basic. If you are using a language other than HP Basic, consult your user's manual for the proper command syntax. The 4650A is assumed to be at address 15.

7-6-1. Device Clear (DCL)

This command will cause all of the devices on the bus to enter their reset states (both interface and instrumental functions). The 4650A will perform a soft reset cycle when this is received.

This command can sometimes cause the interface to reset and then re-read the device clear command if the responding instrument is slow to release the handshake. This will be visible as a complete bus lockout with all of the devices continuously performing a device clear. Although every precaution has been taken to eliminate this problem with the IEEE-488 Standard, lockout may sometimes occur. It is recommended the Selective Device Clear Command be used if possible (see 7-6-2).

An example of a Device Clear command in HP Basic is **CLEAR 7**.

7-6-2. Selective Device Clear (SDC)

This command will cause only the device at the specified address to perform a reset. This command

will perform the same function as the DCL command in 7-6-1 but on individual devices only, thus overcoming the problem inherent with the DCL command.

An example of this command in HP Basic is **CLEAR 715** which causes only the device at address 15 to reset.

NOTE: To ensure that all wires are settled following a device clear or selective device clear command, it is recommended that a 5 second minimum delay is allowed prior to performing any bus operation with the 4650A. Note that the 4650A will not operate the IEEE-488 bus until the complete set of status messages have been displayed following a power-up or reset. Any bus activity with the 4650A during either of the above periods of time may cause undefined results.

7-6-3. Group Execute Trigger (GET)

The execution of this command is dependent on the particular device receiving it, the exact result not being defined by the IEEE-488 (1978) standard. Upon receiving this command the 4650A will handshake the command, but will not respond with any action.

The user should note that only the addressed form of this command is defined by the IEEE-488 (1978) standard however certain manufacturers also include an unaddressed form of this command. The result of receiving this "unofficial" command by the 4650A is not defined and may cause bus errors if used.

Examples of these commands in HP Basic are the statements **TRIGGER 715** for the addressed form, and **TRIGGER 7** for the unaddressed, "unofficial" form.

7-6-4. Go to Local (GTL)

This addressed command will cause the individual addressed device to enter the LOCAL state (i.e. enables manual operation of the device). This command is fully implemented in the 4650A and is executed in HP Basic by the statement **LOCAL 715.**

The user should note that many computers also have a similar unaddressed version of this command (**LOCAL 7** for HP Basic). This command is actually quite different from the addressed command (it disasserts the REN line) but will cause all of the devices including the 4650A to enter the LOCAL state.

7-6-5. Interface Clear (IFC)

This command will cause all of the interfaces of the devices on the bus to enter an idle state. This is fully implemented in the 4650A and may be executed in HP Basic by the statement **RESET 7.**

7-6-6. Identify (IDY)

This command is also called "parallel poll". This will cause all devices on the bus to respond by simultaneously placing their parallel poll response byte onto the DIO bus wires. This command is implemented in HP Basic by the statement **PPOLL (7).**

7-6-7. Local Lock Out (LLO)

This command will cause all of the devices on the bus to enter a Lock Out state. The function of this command is to disable the manually operated LOCAL key and manual controls of the devices on the bus. This command is implemented in HP Basic by the statement **LOCAL LOCKOUT 7.** Note: The RESET key of the 4650A is still active in the Local Lock Out mode.

7-6-8. Parallel Poll Configure (PPC)

This command is used to select which DIO line will be asserted by the device in response to a



parallel poll. This command is not implemented in the 4650A and will be ignored if received.

7-6-9. Remote Enable (REN)

Many computers also have a command that includes the sending of the listen address which will place only the addressed device into the REMOTE state. This is accomplished in HP Basic by the statement **REMOTE 715**, which would place only the device at address 15 into the REMOTE state.

7-6-10. Serial Poll Enable (SPE) and Disable (SPD)

These commands control the process of performing a serial poll. The serial poll sequence is as follows:

A) The controller commands SPE.

B) The controller addresses a single device as a talker.

C) The addressed device returns its Serial Poll response byte.

D) The controller reads the response byte.

E) The controller may now repeat the sequence from step B or send SPD to end the serial poll.

The 4650A implements this function (see Section 7-8-2) and may be commanded to send its serial poll response byte using the HP Basic statement **A=SPOLL(715)**, in which the the result will be contained in "A". This statement will implement the entire sequence once.

7-6-11. Take Control (TCT)

This command from the system controller to another potential controller will request that the other take over bus responsibilities. The 4650A does not have the capability of becoming a controller, thus this command is not implemented and will be ignored.

7-7. REMOTE and LOCAL States

A full explanation of the implementation of the LOCAL and REMOTE states is given here. The 4650A is assumed to have its address set to 15 in all examples.

7-7-1. LOCAL State

When the 4650A is in the LOCAL state the REMOTE indicator on the front panel is extinguished and full manual control of the 4650A as described in Section 6 may be exercised. Note that it is not possible to enter the REMOTE state from the 4650A front panel. The 4650A will accept commands from the IEEE-488 bus while in the LOCAL state but they will be discarded. The unit may however be read at any time without entering the REMOTE state.

The 4650A is placed in the LOCAL state using the HP Basic statement **LOCAL 715**. Some controllers do not have the capability of placing a single device into the local mode. To ensure compatibility with these controllers, the 4650A may be placed in the local mode upon receipt of the command **LO**. An example of this is the HP Basic statement:

OUTPUT 715;"LO"

7-7-2. REMOTE State

If the 4650A receives its listen address while the REN line is asserted it will enter the REMOTE state. In this state the REMOTE indicator on the front panel is illuminated and all keys on the front panel are ignored except the RESET and LOCAL keys. Pressing the LOCAL key will return the 4650A to the LOCAL state and reactivate the keys (unless a Local Lock Out



has been commanded). The 4650A may only be returned to the REMOTE state by the controller.

The 4650A is placed into the REMOTE state using the HP Basic statement **REMOTE 715.**

7-7-3. REMOTE with Lock Out

While in this state the 4650A will operate as in the REMOTE state, however all keys on the 4650A front panel are ignored except the RESET key. The effect is to prevent anyone from changing settings from the front panel short of turning off the power or pressing the RESET key. This state is entered *from the REMOTE state* upon execution of the HP Basic command **LOCAL LOCKOUT 7**. This command affects all devices on the bus. An alternate method of placing only the 4650A into the REMOTE with Lock Out mode is to send the code **LK**.

7-8. IEEE Commands for the 4650A (Device Dependent)

The Device Dependent command set for the 4650A is described in the following paragraphs. Command examples are given for each in which it is assumed that the 4650A has an address of 15 and that the programmer is using HP Basic.

NOTE: The example commands that follow are given in HP Basic. If you are using a language other than HP Basic, consult your user's manual for the proper command syntax.

If an undecipherable command is received it will be ignored by the 4650A. In this case the 4650A may be instructed to generate an error message in the form of an SRQ. See Section 7-8-2 for details.

7-8-1. Setting the IEEE Address

The IEEE "address" of an instrument on the bus is the method by which the system controller distinguishes one device from another. The address may be any number from 1 to 30. No two devices on the bus should have the same address as they may interfere with each other.

The address of the 4650A is set via the controls on the front panel. The default address is 10. To change the address, press the ADDRESS key in the IEEE-488 box (The 4650A must be in LOCAL mode). Key in the desired address using the numeric keypad and press ENTER to store the new address in non-volatile memory. The CLEAR key may be used to reset the address to its default number.

7-8-2. SRQ and Serial Polls

The 4650A may be configured to assert SRQ (service request) if it requires attention. The default setting is "no SRQ". An indicator is provided on the front panel that illuminates if the 4650A is asserting SRQ.

Examples:

OUTPUT 715;"Q0" Prevents the 4650A from asserting SRQ (default state)

OUTPUT 715;"Q1" Asserts SRQ for an Open Circuit condition

OUTPUT 715;"Q2" Asserts SRQ for input data errors

OUTPUT 715;"Q3" Asserts SRQ for "Open Circuit" and/or input data errors.

SRQ remains asserted until a serial poll is conducted or an interface clear command is received.

SERIAL POLL RESPONSE

When the controller conducts a serial poll, the 4650A responds with a byte of data that informs the controller of the reason(s) for the SRQ. The SRQ bit patterns are as follows (the 4650A must be in REMOTE):



Reason	Bit Pattern Response
No SRQ	0 0 0 0 0 0 0 0 (0)
Open Circuit	1 1 0 0 0 0 0 1 (193)
Input Error	0 1 1 0 0 1 0 0 (194)
Open Circuit & Input Error	1 1 0 0 0 0 1 1 (195)

The following events generate the results indicated for a serial poll, but are not affected by the **Q** commands and do not assert SRQ (the 4650A does not need to be in REMOTE):

Internal Cal Completed	0 1 1 0 0 0 0 1 (97)
Self-Test Completed	0 1 1 0 0 0 1 0 (98)
Buffer Full (Settling has occurred, display brightens)	0 1 1 0 0 1 0 0 (100)

7-9. 4650A Device Dependent Command Summary

GPIB commands for the 4650A are defined as two ASCII characters that are a meaningful subset of the entire command name. Using HP Basic, each command below would be sent in the format **OUTPUT 715;"??"** in which the ?? represents the possible two-letter GPIB commands listed below, and the 4650A address has been set to 15. If the command duplicates the function(s) of one of the front panel keys, the corresponding key is indicated in brackets [] following the description.

RS - perform a software reset [RESET key]

LK - 4650 enters REMOTE with Lockout

EN - enter or yes [ENTER key]

TK - continuous tracking of readings [TRACK key] (default)

FS - fast trigger mode = 8 rdgs/sec

SL - slow trigger mode = 2½ rdgs/sec (default)

SG - takes a one-shot reading [SINGLE key]

D4 - 4 digit resolution (2499 counts) [4 key] (default)

D5 - 5 digit resolution (24999 counts) [5 key]

D6 - 6 digit resolution (249999 counts) [6 key]

TW - two-wire configuration [2-WIRE key]

FW - four-wire configuration [4-WIRE key] (default)

SO - standard ohms mode [TRUEΩ key] (default)

TO - True Ohms mode [TRUEΩ key]

AT - auto ranging [AUTO key] (default)

HL - manual ranging [HOLD key]

UP - uprange one range [UP key]

DW - downrange one range [DOWN key]

R1 - sets the unit to Range 1 (2.5Ω)

R2 - sets the unit to Range 2 (25Ω)

R3 - sets the unit to Range 3 (250Ω)

R4 - sets the unit to Range 4 (2.5kΩ)

R5 - sets the unit to Range 5 (25kΩ)

R6 - sets the unit to Range 6 (250kΩ)

R7 - sets the unit to Range 7 (2.5MΩ)

R8 - sets the unit to Range 8 (25MΩ)

CI - invokes internal calibration [CAL key]

CR - loads the read buffer with the results of the internal calibration cycle (see Section 7-11)

TS - invokes self-test [TEST key]



TR - loads the read buffer with the results of the self-test cycle (see Section 7-12)

ST - loads the read buffer with a status word detailing present configuration of the 4650A (see Section 7-13)

T0 - sets output terminator to EOI only
T1 - sets output terminator to CR/LF and EOI
T2 - sets output terminator to LF and EOI
T3 - sets output terminator to CR/LF (default)
T4 - sets output terminator to LF

Q0 - disables 4650A from asserting SRQ
Q1 - asserts SRQ for an Open Circuit
Q2 - asserts SRQ for input data errors
Q3 - asserts SRQ for Open Circuit and/or input data errors

7-10. Reading the Display

If requested by the controller, the 4650A looks at the top of its output "read buffer" for the information to place on the bus. This buffer normally contains the measurement indicated on the display, however may contain other pertinent information as described in Sections 7-11, 7-12, and 7-13.

The 4650A does not need to be in REMOTE in order to read this buffer. The TALK indicator will be illuminated whenever the 4650A is making the data in its read buffer available to the controller. A sample program for obtaining the contents of the read buffer is shown below in HP Basic. The 4650A is assumed to be at address 10.

```
10    ENTER 710;A$
20    PRINT A$
30    END
```

The resistance measurement is returned as a 22 byte string in the format:

xxxxxx vΩ rn

where:

x = The numeric value of the measurement. The resolution is affected by the **D** commands.
v = is "K" or "M" for kilo-ohms or megohms, respectively. A "T" indicates true ohms mode.
r = A for autoranging or R for manual
n = the present range number

7-11. Performing a Self-Test via the Bus

The 4650A may be instructed to perform its self-diagnostic procedure (self-test) via either the front panel or the IEEE-488 bus. When initiated via the bus, the 4650A responds upon completion with a 65 byte word containing the results of the test. A sample program detailing this process is shown below in HP Basic. The 4650A is assumed to be at address 10.

```
10    DIM A$[100]
20    OUTPUT 710;"TS"
25    WAIT 2
30    OUTPUT 710;"EN"
40    IF SPOLL(710)=98 THEN 70
50    WAIT 1
60    GOTO 40
70    OUTPUT 710;"TR"
80    ENTER 710;A$
90    PRINT A$
100   END
```

The 4650A returns the results of the self-test in the format shown below:

FIT[R..R..]CAL[x]FSC[i]NVR[x]CALD[z]FS[x]

where:
FIT = the ranges installed
CAL = internal calibration status
x = "p" for pass or "f" for fail
FSC = fail-safe current
i = amount of fail-safe current
NVR = non-volatile memory status
CALD = source and type of the calibration data
z = "d" for default or "n" for normal
FS = fail-safe circuitry status



7-12. Performing an Internal Calibration via the Bus

The 4650A may be instructed to perform its self-adjustment procedure (internal cal) via either the front panel or the IEEE-488 bus. When initiated via the bus, the 4650A responds with a 10 byte word containing the results of the procedure. A sample program detailing this process is shown below in HP Basic. The 4650A is assumed to be at address 10.

```
10      OUTPUT 710;"CI"
20      IF SPOLL(710)=97 THEN 50
30      WAIT 1
40      GOTO 20
50      OUTPUT 710;"CR"
60      ENTER 710;A$
70      PRINT A$
80      END
```

The 4650A returns the results of the internal cal in the format shown below:

ICx

where:

x = "p" for pass or "f" for fail

7-13. Configuration Status Word

The 4650A may be instructed to place information regarding the present status of certain variables into its read buffer where it may be obtained by the controller. A sample program for reading this "configuration status word" is shown below in HP Basic. The 4650A is assumed to be at address 10.

```
10      OUTPUT 710;"ST"
20      ENTER 710;A$
30      PRINT A$
40      END
```

The status word is returned in the format:

TTFFHHSSRnTnQnFn

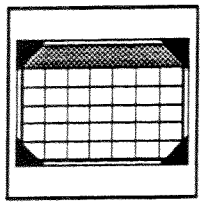
where:

TT	=	"TK" for tracking or "SG" for one-shot readings
FF	=	"FW" for 4-wire or "TW" for 2-wire terminal configuration
HH	=	"AT" for autorange or "HL" for manual range
SS	=	"SL" for slow trigger mode or "FS" for fast trigger
Rn	=	the present range number (1-8)
Tn	=	the present output terminator as set using the **T** command
Qn	=	the present SRQ status as set by the **Q** command

Note: The status word will not be updated if the 4650A is not actively tracking a measurement (i.e. if it displays Open Circuit or Overrange).



SECTION VIII ROUTINE MAINTENANCE



8-1. General

This section contains routine maintenance procedures designed to provide maximum utility from the Model 4650A. Included are cleaning instructions, battery replacement instructions, and a calibration procedure.

8-2. Periodic Maintenance

As a recommendation, the Model 4650A should be operated in a dust-free, clean environment. However if the unit is exposed to contaminants, periodic cleaning will be required.

Loose dirt or dust on the exterior surfaces may be removed with a dry soft cloth or brush. Any remaining residue may be removed with a soft cloth dampened in a mild soap and water solution. **Do not use abrasive cleaners!**

The front panel may be cleaned with a soft cloth and a glass cleaner such as Windex or its equivalent. **Do not use petroleum based cleaners on the front panel!**

If required, the interior may be cleaned by blowing with dry compressed air.

If the unit becomes heavily contaminated with dirt or other residue, a complete overhaul is recommended. Contact your local Valhalla Scientific representative or the factory for details.

8-3. Battery Replacement

The battery used in the 4650A is a sealed lead-acid type and should provide many hours of trouble-free operation. However, even rechargeable batteries become depleted and replacement will eventually be necessary.

The following procedure describes replacement of the battery in the 4650A:

A) Ensure that the unit is OFF and has been disconnected from the AC line.

B) Remove the top rear bezel and top cover. **Warning: The internal components are static sensitive and appropriate precautions must be taken to protect the 4650A from static discharge!**

C) Disconnect the wires from the battery terminals. Note the polarity of the connectors for future reference.

D) Remove the six nuts, lockwashers and flat washers that secure the battery strap to the bottom plate.

E) Lift the battery strap from the battery, then remove the battery.

CAUTION!

Even nearly depleted batteries possess sufficient energy to be dangerous. Care must be taken to avoid shorting the terminals of the battery together or to the chassis!

F) Place the new battery on the bottom plate (ensure battery terminals do not short).

G) Place the battery strap over the battery, and install (in order) the six flat washers, lock washers and nuts on the bottom plate studs but do not tighten. Squeeze the battery strap against the battery and tighten all nuts.

H) Reconnect the battery wires to the battery terminals observing polarity.

I) Reinstall the top cover and rear bezel.

J) It is recommended that the battery be charged for 24 hours prior to initial use.

8-4. Calibration Procedure

The calibration procedure should be performed on a regular basis (annually is recommended) to ensure that the Model 4650A remains within the specifications set forth in Section 2. The 4650A should be allowed to warm-up for a minimum of 30 minutes with the covers in place in a stable environment prior to beginning the procedure.

8-4-1. Required Test Equipment

The Model 4650A is available with a variety of resistance range combinations. The calibration procedure will require a precision resistor (with a known value to within ±0.005%) equal to 40% of the full scale input for each range. For example, the 2.5Ω range requires a 1Ω resistor. Also required is a 4" length of high quality 18AWG bus wire, and a high-quality, low-thermal lead set such as Valhalla Option "SL-48".

8-4-2. External Calibration Procedure

The 4650A is calibrated with the covers in place using data entered from the front panel. **Before continuing, it is recommended that a self-test and internal calibration be completed as described in Sections 6-3 and 6-4.**

Remove all connections to the front or rear terminals and turn the calibration enable switch on the 4650A front panel to the CALIBRATE position. This may be accomplished using a small flat blade screwdriver or similar. The user is prompted through the procedure by the 4650A and may skip any step by pressing the CLEAR key. The ENTER key is used to respond with a "yes" to inquiries and also to enter data.

1) **ENTER TO CONTINUE.** The user is instructed to press the ENTER key to confirm external calibration. The CLEAR key aborts calibration.

2) **DO 2 WIRE ZEROS?** Press ENTER to confirm that this step will be calibrated.

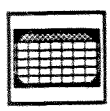
3) **APPLY 2 WIRE SHORT -** Using the bus wire, short the front I_{HI} and I_{LO} terminals together. Press ENTER when completed. The 4650A will perform a calibration of each range.

4) **DO 4 WIRE ZEROS?** Press ENTER to confirm that this step will be calibrated.

5) **APPLY 4 WIRE SHORT -** Using the bus wire, short all four terminals together. Press ENTER when completed. The 4650A will perform a calibration of each range.

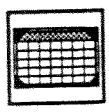
6) **CALIBRATE xxΩ ?** This step depends upon the ranges with which your particular instrument is fitted. As an example, calibration of the 2.5Ω range is described. Press ENTER to confirm that this range is to be calibrated.

7) **CONNECT 1Ω STANDARD**
ENTER STANDARD VALUE
1.000000 Ω
Connect the standard resistor to the 4650A using the full 4-wire configuration as described in Section 6-5. Enter the value of the standard resistor being used. If enough significant digits are keyed-in for the resistor, the 4650A automatically accepts the entry. Otherwise the operator is required to press ENTER. The 4650A calibrates the range and moves on to the next installed range.

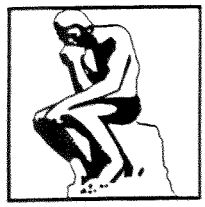


The procedure for each range is identical to the one described previously. Substitute the appropriate resistor for each range.

8) **STORING CAL DATA**
CAL COMPLETE
TURN OFF CAL SWITCH
The procedure has been completed. Return the calibration enable switch to the OPERATE position.



SECTION IX THEORY OF OPERATION



9-1. Troubleshooting

Apparent malfunctions are often the result of misinterpretation of specifications or due to an incomplete understanding of the instrument. **A thorough review of the operating instructions for this instrument is recommended prior to any component replacement, etc.** Check to be sure that cables and other test equipment are in good working order before attempting to troubleshoot the 4650A.

If the Model 4650A exhibits problems that cannot be eliminated by reviewing Sections 4, 5 and 6, the following guidelines have been established to help solve the problem.

9-1-1. Localizing the Problem

The key to successful troubleshooting is to localize the problem as much as possible before trying to pin the problem down to a specific component. Certain questions should be asked such as "Does the problem occur on all ranges or on a specific range only?". The power supplies are also one of the first things that should be checked.

As it is not possible to anticipate all failure modes of the 4650A, servicing personnel should become familiar with this section of the manual to gain a complete understanding of the internal workings of this instrument.

9-1-2. Component Replacement

If the problem has been identified as a faulty component, the accuracy of the 4650A can be maintained only if the following precautions are taken:

- Use only the specified component or its exact equivalent. Spare parts can be ordered from your nearest Valhalla Scientific Service Center or directly from the factory by referring to the Valhalla Stock Number listed in the Parts Lists section at the back of this manual.

- Use only 63/37 grade rosin core electronic grade solder with a 50W or lower maximum power soldering iron. **The 4650A uses a multi-layer PCB which requires extra care when soldering.**

- When soldering, heat the terminal of the component, *not* the solder. Apply solder smoothly and evenly. Do not move the component until the solder has cooled. **Bad solder joints can cause additional problems!**

- Static sensitive parts require special handling procedures. Always treat an unknown part as if it were static sensitive.

9-2. Functional Descriptions

The general operation of the 4650A is described in this section. The following paragraph titles refer to the Model 4650A block diagram, Figure 9-1.

9-2-1. Microprocessor

The microprocessor controls 4650A operation. It accepts commands and data from the keyboard and IEEE-488 interface and controls the analog circuitry. The microprocessor reads the A to D logic, applies calibration constants and provides the signals for the front panel display.

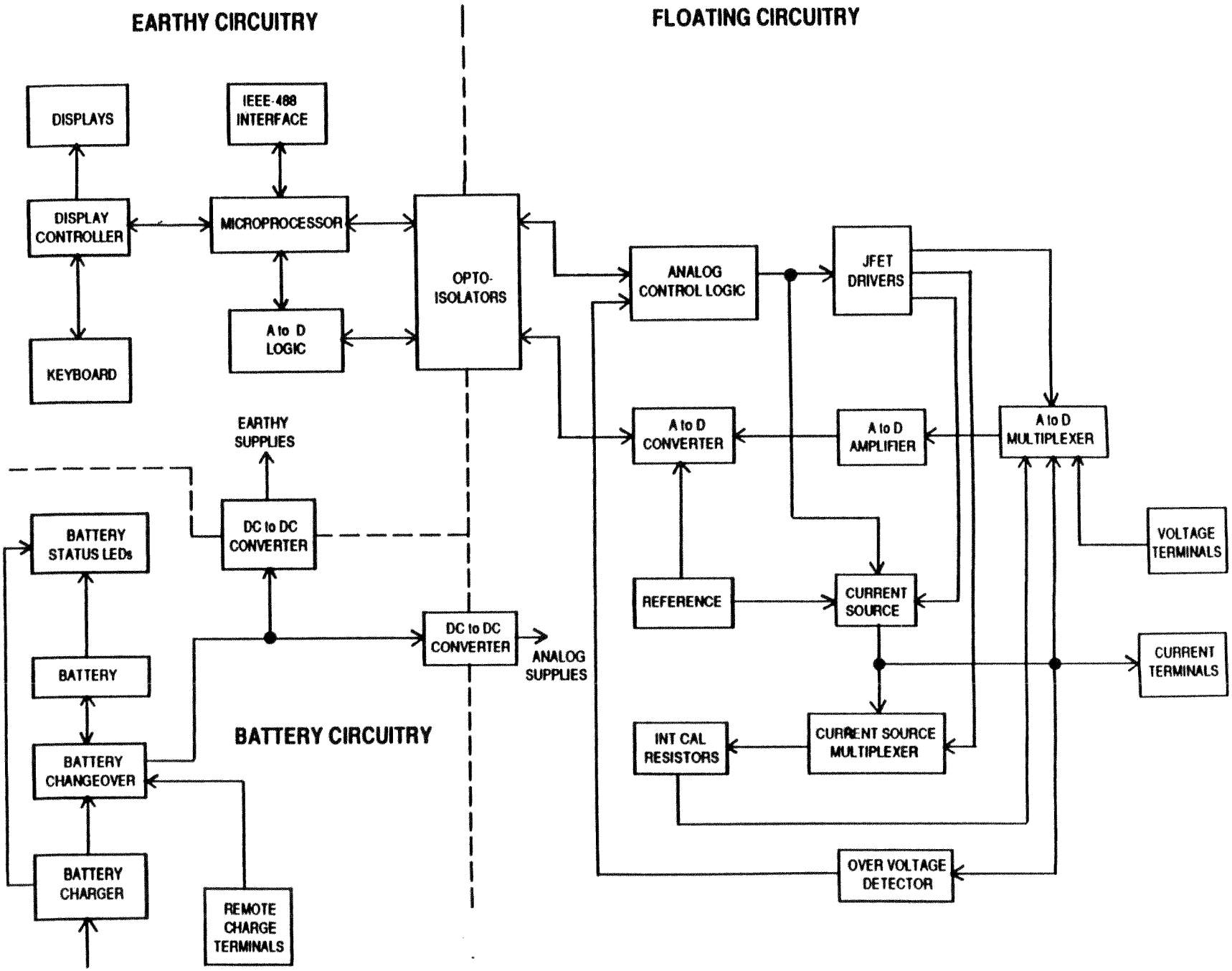


Figure 9-1. Model 4650A Block Diagram

9-2-2. IEEE-488 Interface

The IEEE-488 interface adapts the microprocessor data bus to the IEEE-488 interface bus. The interface accepts commands and data from the IEEE-488 bus and provides resistance data and status from the 4650A to the IEEE-488 bus.

9-2-3. Display Controller

The display controller interfaces the microprocessor data bus to the front panel LED's and vacuum fluorescent display (VFD). Circuitry is provided that scans the multiplexed VFD and the keyboard.

9-2-4. Displays

The display section contains circuitry to both drive the LED's and shift the 5 volt logic level signals to the 45 volt levels required by the VFD.

9-2-5. Keyboard

The keyboard is an electronic matrix design. The display controller sequentially scans the keyboard matrix for a pressed key (closed contact).

9-2-6. A to D Logic

The analog to digital converter (A to D) is a voltage-to-time period converter, and contains circuitry to measure the resulting time period. When a measurement is completed, the A to D logic informs the microprocessor to read the measured time period.

9-2-7. Opto-Isolators

The circuits described in preceding paragraphs are referenced to chassis ground. For safety, the analog circuitry is floating with respect to chassis ground. The opto-isolators provide a means to transmit data between the earthy (chassis ground) and floating sections.

9-2-8. Current Source

The 4650A measures resistance by forcing a constant current through the unknown resistance, then measuring the resultant voltage drop. The values of current are dependent on the resistance ranges installed in the 4650A. The output of the current source is applied directly to the "I" terminals.

9-2-9. A to D Multiplexer

The A to D multiplexer receives signals from a number of inputs and sends these signals to the A to D converter. When in the 4-wire mode, the A to D multiplexer alternately measures the signal at the "V" terminals. When in the 2-wire mode, the "I" terminals are measured. During internal calibration or self-test modes the A to D multiplexer measures the voltage drop across the internal calibration resistors.

9-2-10. A to D Amplifier

The 4650A uses very small test currents for safety reasons, and the resulting voltage drops are also very small. The A to D amplifier contains a very low noise amplifier with two selectable gains under microprocessor control which increase the signal amplitude to useable levels.

9-2-11. A to D Converter

The A to D converter operates on the voltage-to-time period conversion principle. This circuit converts the input voltage into a corresponding time period which is measured by the A to D logic through the opto-isolators.

9-2-12. Reference

The reference circuit provides stable reference voltages to the A to D converter and current source.



9-2-13. Over Voltage Detector

The over voltage detector monitors the current source output. If the voltage or current rises beyond a preset limit, the current source is clamped via the analog control logic and JFET drivers.

9-2-14. Current Source Multiplexer

During internal calibration or self-test, the current source multiplexer receives the signals from the current source and sends these signals to the internal calibration resistors.

9-2-15. Internal Calibration Resistors

The internal calibration resistors are measured during an Internal Calibration cycle to verify and make adjustments to instrument calibration. Up to four internal calibration resistors, corresponding to the 4650A resistance ranges, are installed. The resistors are a low drift wire-wound type with stabilities of only a few PPM per °C. The exact values of the internal calibration resistor values are measured and then stored in non-volatile memory during the External Calibration procedure.

9-2-16. Analog Control Logic

The analog control logic decodes the range and mode information received from the opto-isolators to control the analog circuitry.

9-2-17. JFET Drivers

The JFET drivers shift the 0 to 5 volt logic levels to levels sufficient to operate the JFET switches in the current source, the A to D converter and current source multiplexers.

9-2-18. DC to DC Converters

The DC to DC converters supply isolated DC voltages to the earthy and floating sections of the 4650A. The converters are self-regulating, isolated, and provide constant 5 volt outputs over a wide range of battery voltages. Power is routed across the isolation barriers at the 5 volt level and converted to ± 15 volts in the floating section through the use of secondary DC to DC converters. Similarly, a secondary converter supplies 6.3VAC and 45VDC for the Vacuum Fluorescent Display in the earthy section.

9-2-19. Battery

A sealed 12 volt lead-acid battery provides power to the DC to DC converters. The battery capacity is sufficient to power the 4650A for approximately 3 to 4 hours. Circuitry is also provided to detect if the battery voltage is low.

9-2-20. Battery Changeover

The battery changeover circuit connects the battery to either the DC to DC converters or to the battery charging circuitry. The battery is disconnected from the charging circuitry when the 4650A is operating and connected to the charging circuitry when the 4650A is not operating. Additional circuitry is provided to remotely select the charging mode via the rear panel remote charge terminals.

9-2-21. Battery Status LEDs

Three front panel mounted LED's driven by the battery and battery charging circuitry indicate the 4650A power supply status. The LOW BAT indicator is illuminated when the battery voltage falls below approximately 10.5 volts. The AC ON indicator is illuminated when AC line power is applied to the rear panel power cord receptacle. The CHARGING indicator is illuminated when the charging mode is selected, AC power is applied and the battery is accepting a charging current.

9-2-22. Battery Charger

The battery charger provides a constant voltage to float-charge the battery. An additional circuit



is provided to monitor the charging current and illuminate the CHARGING indicator on the front panel.

9-3. Detailed Circuit Descriptions

The following detailed circuit descriptions are referenced to the paragraph titles and general descriptions contained in Section 9-2 above. It is assumed that personnel have a general knowledge of electronics and are familiar with all Model 4650A operating procedures. In addition, refer to the schematics and parts lists located at the back of this manual.

9-3-1. Microprocessor

Refer to drawing number 4650-071, sheet 4. IC407, a 16-bit microprocessor, executes the program stored in EPROMS IC401 and IC402. Static rams IC403 and IC404 are used as scratch memory. IC410, a programmable logic array, contains the logic necessary to decode the upper microprocessor address bus and support the microprocessor timing requirements. IC410 divides the microprocessor address map into several blocks, each corresponding to a support chip (e.g., ROM, RAM, A to D Logic, etc.).

The microprocessor reads IC406 when power is applied to determine the installed resistance ranges, and writes data into latch IC405 to control the analog circuits. The microprocessor address and data buses are buffered by IC413-IC416, and drive the display board through ribbon cable SK401. Calibration constants are stored in serial NOVRAM IC411.

IC412 holds the microprocessor in reset during power-up until the supply rises above +4.6 volts. IC412 also monitors the +5V digital supply, resetting the microprocessor and providing an orderly instrument power down when the voltage drops below approximately +4.6 volts from battery depletion or turning off the power switch. In addition, IC412 contains a watchdog circuit. The microprocessor periodically sends a pulse to pin 7 of IC412. If the pulses stop, IC412 resets the microprocessor.

9-3-2. IEEE-488 Interface

Refer to schematic 4650-071, sheet 5. IC501 interfaces the microprocessor bus to the IEEE-488 bus. IC502 and IC503 are bi-directional bus drivers and buffer IC501 from the IEEE-488 bus. A complete operating description is beyond the scope of this manual. Consult the manufacturer data sheet for further information on IC501-IC503.

9-3-3. Display Controller

Refer to schematic 4650-073, sheet 1. IC103, an application specific integrated circuit, decodes the address bus lines CA1-CA3, CA9-CA12 and CA16. Outputs from IC103 allow the microprocessor to write and read data to and from the front panel. The microprocessor writes data into IC104 to control the operation of IC103. IC105, a programmable oscillator, provides a local 100 KHz timing signal to IC103. IC103 also contains circuits to scan the multiplexed vacuum fluorescent display, detect the closure of the calibration switch, and inform the microprocessor when external calibration has been selected.

9-3-4. Displays

Refer to schematic 4650-073, sheet 2. The front panel LED's are static driven (non-multiplexed) by IC206 and IC207. The microprocessor writes a sixteen-bit word into the address location identified as OPLEDS (decoded by IC103) to control the LED's. A logic 0 turns the LED's on while a logic 1 turns them off. LED current is limited by resistor networks RN201 and RN202.

The vacuum fluorescent display (VFD) is multiplexed to reduce the number of drivers required



for a 20-character display to 36 (a non-multiplexed display would require 320 drivers). The 20 display windows are sequentially activated at a frequency high enough to appear continuous. Display segment illumination is determined when the microprocessor writes a sixteen bit word into IC201 and IC202. At the same time IC205, under control of IC103, selects the display window for illumination.

The Vacuum Fluorescent Display is similar to a triode vacuum tube. The illuminating segments are similar to the triode tube plates, and are activated when approximately 45 volts is applied. IC203 and IC204 shift the logic level signals to the 45 volt levels required by the VFD. A display window is selected when approximately 45 volts is applied to the grid from IC205. The VFD filament is biased at approximately +7.5 volts to ensure that illumination does not occur when either the plates or the grid are at zero volts.

9-3-5. Keyboard

Refer to schematic 4650-073, sheet 1. The keyboard circuit is arranged in a matrix of rows and columns. IC101, under microprocessor control, sequentially drives the columns (C1-C8) to a logic low. The microprocessor examines the rows by reading IC102, which returns all logic highs when no keys are depressed. If a key is depressed, a zero will appear in one of the rows. The microprocessor, knowing the column addressed, can determine the key depressed.

The RESET key is not part of the matrix. A logic low is routed to IC103, pin 11 when the RESET key is depressed, directly resetting the microprocessor.

9-3-6. A to D Logic

Refer to schematic 4650-071, sheet 4. IC408, a programmable logic array, contains the A to D converter logic. The converter logic utilizes two 13-bit counter chains that are driven by the 9.8304 MHz microprocessor clock. The first counter chain, operating at 4.9152 MHz is used for timing by the IEEE-488 interface and identified as CLK5. The second counter chain operating at 1.2 KHz (identified as GLUGD) is the forcing waveform for the A to D converter analog circuit. The A to D analog circuit produces a 1.2 KHz variable duty-cycle signal (identified as COMPOUT). IC408 synchronizes the COMPOUT signal to the 9.8304 MHz clock and returns the signal (identified as REFD) to the A to D analog circuit.

The second counter chain counts the number of 9.8304 MHz clock periods that occur during the time that REFD is in a high state. When REFD goes to a low state, the second counter chain contents are latched, the counter chain is cleared, and the microprocessor is informed via the ATDINT signal that the measurement is complete. The microprocessor then adds enough 13-bit GLUGD periods to provide the required display resolution.

9-3-7. Opto-Isolators

Refer to schematic 4650-071, sheet 3. Opto-Isolators are used to bridge the barrier between the earthy and floating sections of the 4650A. Range and mode data are transferred to the analog section through IC301, IC302 and IC303. The A to D GLUGD and REFD signals are transferred through high speed opto-isolator IC304. IC305 transfers the clamp clear and ATDSEL signals. IC306 transfers data from the analog section to the digital section. IC307 transfers the COMPOUT signal from the A to D analog circuitry.

9-3-8. Current Source

Refer to schematic 4650-071, sheet 1, and the simplified current source diagram in Figure 9-2. IC2 buffers the reference voltage providing a low impedance source for the range



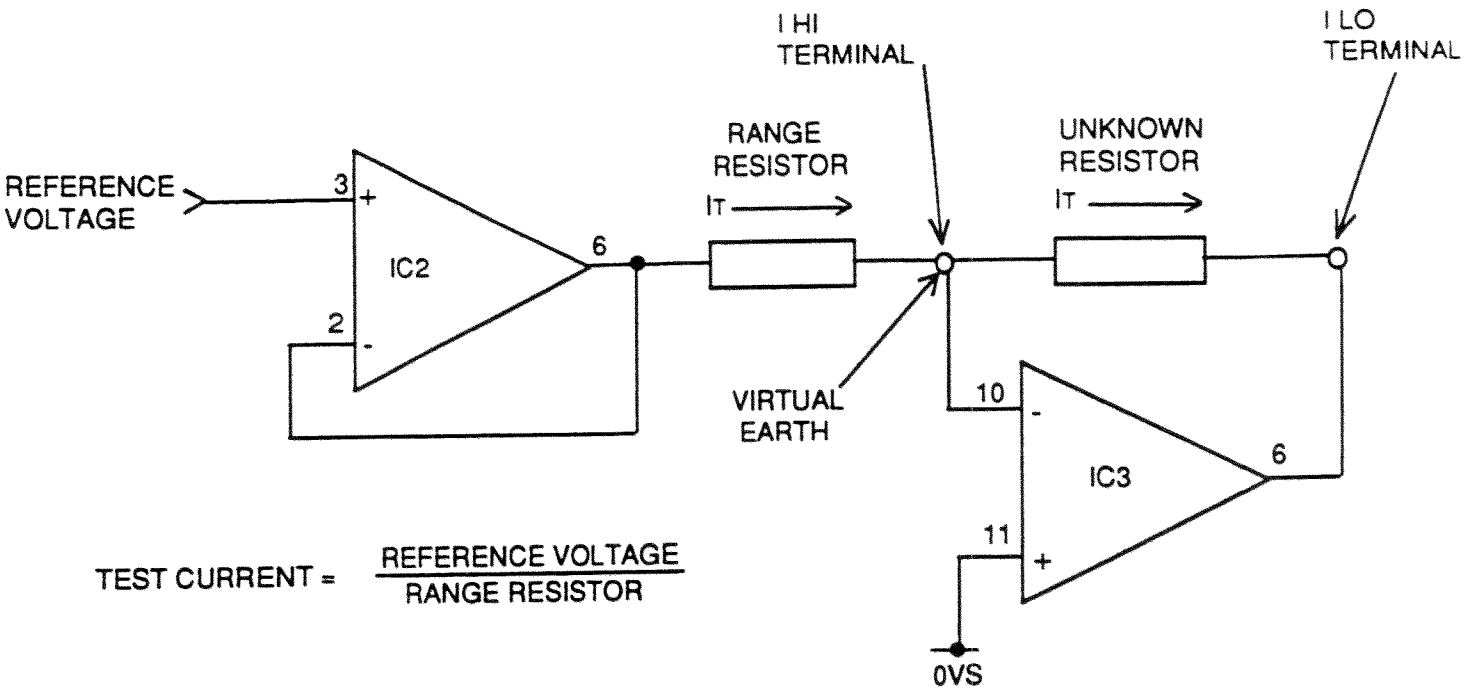


Figure 9-2. Simplified Current Source

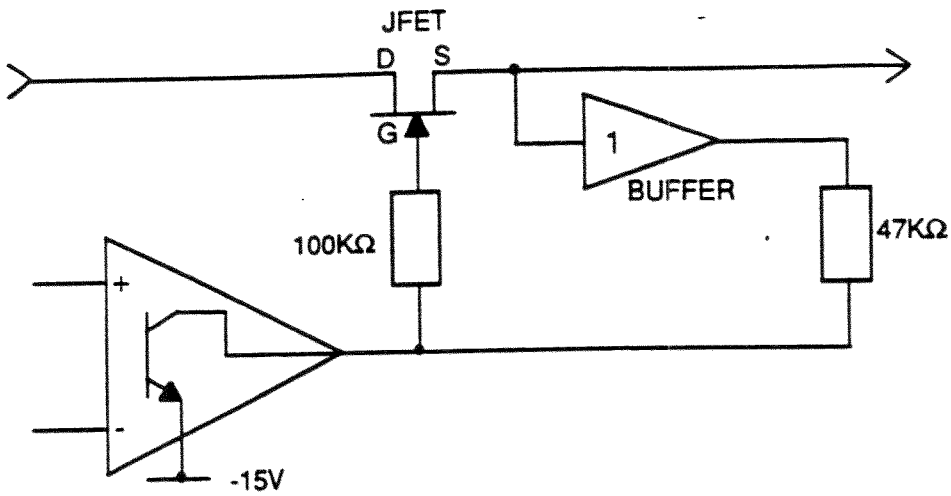


Figure 9-3. Simplified JFET Driver



resistor. The unknown test resistor provides a negative feedback path around IC3. With the loop closed around IC3, the voltage on pin 10 will be the same as on pin 11, zero volts. Because IC3 has essentially zero input bias current, the current through the unknown resistor is equal to the current through the range resistor. IC1 selects one of five reference voltages applied to IC2. Relays RLA-RLD select one of four range resistors connected in series with R6. Resistance ranges, their corresponding range resistors and reference voltages are indicated below in Table 9-1.

R33 and C1 provide filtering around IC3 to maintain stability and provide 50 Hz rejection. Low leakage diode pair D1 protects the input of IC3 by limiting the I_{HI} terminal to ± 0.6 volts. The output voltage swing of IC3 is limited to between -5.1 volts and 0.6 volts by R34 and D4.

The current source fail-safe current is defined by D4 and R25 on the 25Ω through the 25MΩ ranges. R26 is placed in parallel with R25 by RLE to set the fail safe current on the 2.5Ω range. JFETs TR2 and TR17 clamp the current source when an overload is detected.

9-3-9. A to D Multiplexer

Refer to schematic 4650-071, sheets 1 and 2. The A to D converter measures the voltage drop across the unknown resistor by alternately measuring the voltage on each end of the unknown resistor. The microprocessor subtracts the two measurements to determine the voltage drop. JFET transistors TR202 and TR204 alternately connect the input of the A to D amplifier to the ATDIP2 and ATDIP1 lines.

Transistors TR201 and TR202 connect the ATDIP2 and ATDIP1 lines to the V_{LO} and V_{HI} terminals respectively when the 4-wire mode is selected. TR15 and TR1 connect the ATDIP2 and ATDIP1 lines to the I_{LO} and I_{HI} terminals respectively when the 2-wire mode is selected. Transistors TR4, TR5, TR7, TR8, TR10, TR11, TR13 and TR14 connect the ATDIP1 and ATDIP2 lines to the internal calibration resistors R16-R19 when the internal calibration or self-test cycle is selected.

Table 9-1. Resistance Range Variables

Resistance Ranges	Reference Resistors	Reference Voltages	Test Currents Nominal	Test Currents Actual	Full-Scale Voltage Drops Nominal	A to D Amplifier Gains	A to D Input Voltages
2.5Ω	909Ω	5V	5mA	4.95mA	10mV	201	2.01V
25Ω	10KΩ	5V	500μA	495μA	10mV	201	2.01V
250Ω	111.1KΩ	5V	50μA	44.9μA	10mV	201	2.01V
2.5KΩ	1MΩ	5V	5μA	4.99μA	10mV	201	2.01V
25KΩ	1MΩ	0.5V	500nA	499nA	10mV	201	2.01V
250KΩ	1MΩ	0.5V	500nA	499nA	100mV	21	2.1V
2.5MΩ	9.9MΩ	0.5V	50nA	50.5nA	100mV	21	2.1V
25MΩ	9.9MΩ	0.05V	5nA	5.05nA	100mV	21	2.1V



9-3-10. A to D Amplifier

Refer to schematic 4650-071, sheet 2. IC3 and resistors R207-R209 compose a high input impedance, non-inverting amplifier with two selectable voltage gains. When RLF is open the amplifier gain is set to 21 by R207 and R209. With RLF closed, the gain is increased to 201 by placing R208 in parallel with R209. Table 9-1 lists the amplifier gain for each resistance range.

Capacitors C201 and C219 provide 60 Hz rejection. R206 and R222 in conjunction with D201-D203 provide fail-safe current limiting in the event that IC3 fails. IC201 and R223 bootstrap D201 to reduce diode leakage current.

9-3-11. A to D Converter

Refer to schematic 4650-071, sheet 2. IC202, IC204, IC205 and associated components form a voltage-to-time-period A to D converter. The GLUG signal, a 1.2 KHz square wave from the A to D logic drives one-half of high speed analog switch IC205. The output of IC205 switches between 0 volts and the +5 volt reference. C203 AC couples the GLUG signal into integrator IC202. A small offset current is injected into the integrator by R211. The output of the integrator, a triangular waveform, is applied to zero crossing detector IC204. The output of IC204 is applied to the A to D logic where it is synchronized with the 9.8304 MHz clock and returned as the REF signal.

The REF signal drives the other half of IC205. The output of IC205, switching between the +5 volt reference and 0 volts, is returned to the integrator via R213, closing the loop. Feedback forces the duty cycle of the REF signal so that the average current through R213 balances the current through R211.

When an input voltage is applied to the A to D converter via E202, the current through R210 is balanced by the average current through R213. The A to D logic measures the duty cycle of the REF signal, producing a digital representation of the A to D input voltage.

9-3-12. Reference

Refer to schematic 4650-071, sheet 2. IC206 is the main voltage reference of the 4650A. IC206 provides a constant 10 volt output that is divided by resistor set R217-R220, providing outputs of 5, 0.5 and 0.05 volts. IC205 and associated components provide a low impedance 5 volt reference for the A to D converter.

9-3-13. Over Voltage Detector

Refer to schematic 4650-071, sheet 1. One section of IC4 is used as a comparator that monitors the I_{LO} terminal. IC4 pin 7 provides either -50mV or -200mV to the comparator, as selected by the LORNG line via TR16. D2, D3, R28 and R29 limit the ±15 volt swing of IC4 to a 0 to 5 volt swing compatible with the analog control logic. Pin 1 of IC4 will swing to -15 volts when the voltage on the I_{LO} terminal exceeds -50mV or -200mV. R27 provides fail-safe current limiting for IC4.

Another section of IC4 monitors the output swing of IC3. IC4 pin 14 provides approximately -4 volts to the comparator. D5, D6, R38 and R39 limit the ±15 volt swing of IC4 to a 0 to 5 volt swing compatible with the analog control logic. Pin 8 of IC4 will swing to -15 volts when the output of IC3 exceeds -4 volts, indicating that the current source cannot maintain constant current.

9-3-14. Current Source Multiplexer

Refer to schematic 4650-071, sheet 1. JFET transistors TR3, TR6, TR9 and TR12 connect the internal calibration resistors to the current



source during the internal calibration or self-test cycles.

9-3-15. Internal Calibration Resistors

Refer to schematic 4650-071, sheet 1. Internal Calibration Resistors R16-R19 are used to verify 4650A operation during the self-test cycle. During the internal calibration cycle, the microprocessor uses these resistors to verify the A to D converter measurement with the calibration constants stored in NOVRAM.

The internal calibration resistors are precision low drift types having low temperature coefficients. By measuring the internal calibration resistors, the effects of time and temperature on the analog circuits is compensated for. Up to four internal calibration resistors may be installed in the 4650A. Their values correspond to approximately 40% of the full scale ranges installed.

9-3-15. Analog Control Logic

Refer to schematic 4650-071, sheet 3. The analog control logic is contained in IC308, a programmable logic array. IC308 decodes the range selection lines RNG0 and RNG1 to drive relays RLA-RLD in the current source. IC308 also uses the decoded range lines for outputs ICAL1-ICAL4 to drive the JFETs in the A to D multiplexer and current source multiplexer when the internal calibration or self-test cycle is selected.

IC308 also contains logic to clamp the current source when the over-voltage detectors indicate excessive voltage at the current terminals. Once the clamp is triggered, the microprocessor reads the VOLTSOK and AMPSOK signals to determine which triggered the clamp. The microprocessor can then clear the clamp through the CLMPCLR line.

9-3-16. JFET Drivers

Refer to schematic 4650-071, sheets 2 and 3. IC309-IC312 shift the 0 to 5 volt logic level signals to levels sufficient to operate the JFET switches. Figure 9-3 illustrates a simplified JFET driver. The JFET is turned off when the gate is held below the source. IC309-IC312 have open collector outputs that go to the -15 volt rail when the negative input is greater than the positive input, turning the JFET off. If the positive input is greater than the negative input, the output transistor is turned off and the 47KΩ resistor brings the gate up to a voltage (provided by the buffer) equal to the source voltage, turning the JFET on. the 100KΩ gate resistor provides fail-safe current limiting in the event of JFET failure.

The JFETs associated with the ATDIP2 line are pulled up to the BUFFALO signal provided by IC201 via RN306. R203 provides fail-safe current limiting in the event IC201 fails. The voltage level of the ATDIP1 line is close to 0 volts (virtual earth). The JFET's associated with this line are pulled up to 0V, and no buffer is required.

R304 and R305 provide a 1.16 volt nominal reference for the IC309-IC312 inputs that are centered in the IC308 TTL swing.

9-3-17. DC to DC Converters

Refer to schematic 4650-074, sheet 2. M201 is an isolated 12V to 5V, DC to DC converter module that powers the earthy section of the 4650A. M202 provides 40 volts DC and 6.3 VAC for the Vacuum Fluorescent Display tube. D201 and R201 bias the filament supply at ±7.5 volts. M203 is an isolated 12V to 5V, DC to DC converter module that powers the floating section of the 4650A. M204 produces ±15 VDC outputs from



the analog 5 volt supply to power the op-amps in the analog section.

9-3-18. Battery

Refer to schematic 4650-074, sheet 1. The battery voltage is monitored by IC102 and associated components. IC103 provides a 2.5 volt reference for IC102. R106, RV102, and R108 divide the battery voltage to 2.5 volts. When the battery voltage drops below approximately 10.5 volts the output of IC102 goes to a low state, illuminating the LOW BAT indicator on the front panel. RV102 is used to adjust the voltage at which the indicator illuminates.

9-3-19. Battery Changeover

Refer to schematic 4650-074, sheet 1. Relay RLA and the front panel ON OFF/CHARGING switch connect the battery to either the DC to DC converters via F101 or to the battery charger circuit. If the ON OFF/CHARGING switch is in the ON position and RLA is energized, the battery will be disconnected from the DC to DC converters and connected to the charger circuit. RLA is energized by the EXTERNAL POWER CONTROL terminals via TR102, TR103 and associated components.

9-3-20. Battery Status Indicators

Refer to schematic 4650-073, sheet 2. The AC ON, CHARGING, and LOW BAT indicators (DS211-DS213) are directly driven by circuitry on the power supply board. These are the only indicators on the display board that operate independently of the microprocessor and control logic. For safety, a separate connector and cable is used to connect these indicators.

9-3-21. Battery Charging Circuitry

Refer to schematic 4650-070 and 4650-074, sheet 1. 115 or 230 VAC is applied to the instrument power connector which contains a power switch, fuses, line filter and line voltage selector. The toroidal power transformer T1 contains two primary windings. The windings are connected in parallel for 115 VAC operation, in series for 230 VAC operation.

The two secondary windings are connected in parallel and are full-wave rectified by the chassis mounted bridge rectifier BR1. C101 smoothes the raw DC voltage and R101 and R102 provide a current bleed to discharge C101 when AC power is removed. R111 provides current limiting for the front panel AC ON LED.

IC101 provides a regulated 13.7 VDC to charge the battery. The output voltage of IC101 is determined by R103, R104 and RV101. RV101 provides an output voltage adjustment to compensate for IC101, R103, and R104 tolerances. D102 ensures that the battery cannot discharge into IC101 when AC power is removed and charging mode is selected.

TR101 monitors the voltage across R109 to determine whether or not the battery is receiving a charge. When the battery charging current rises above approximately 60mA, TR101 turns on and illuminates the front panel CHARGING indicator. R112 provides LED current limiting. D103 provides a high current bypass to quickly charge a fully discharged battery.

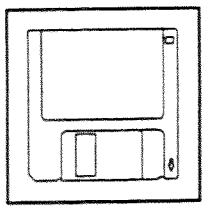


SECTION X MANUAL CHANGES AND ADDENDUMS



If no addendums follow this page, your manual is complete as printed.

SECTION XI PARTS LISTS



The following parts lists have been included in this manual:

4650-400	2 pages	4650A Chassis Assembly
4650-402	1 page	4650A Front Panel Assembly
4650-401	1 page	4650A Rear Panel Assembly
4650-604	2 pages	4650A Power Supply Board Assembly
4650-603	2 pages	4650A Display Board Assembly
4650-606	1 page	4650A Keyboard Assembly
4650-601	5 pages	4650A Main Board Assembly
4650-404 thru 4650-411	2 pages	Range 1 through Range 8 Factory Installed Resistors

REF.DES.	STOCK #	QUANTITY A	QUANTITY T	QUANTITY N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	4650-402		1		4650A Front Panel Assy	Assembly 4650-402	
2	4650-401	1			4650A Rear Panel Assy	Assembly 4650-401	
3	30-00120		1		PCB Assy - 4650 Main Board	ASSY 4650-601	
4	30-00076		1		4650A Power Supply Board Assy.	ASSY 4650-604	
5	91-06003	2			#6-32 x 3/16" Phil Flat 82 Deg. S.S.		
6	04-10458	2			2724A Side Rail	DWG 2724-215	
7	04-10333	4			Standard Bezel	DWG 2724-205	
8	04-10795	1			4650 Bottom Plate	DWG 4650-206	
9	04-10332	3			Standard Corner Block	DWG 2724-204	
10	04-10796	1			4650 Binding Post Support Bracket	DWG 4650-207	
11	04-10788	1			4650 Battery Strap	DWG 4650-201	
12	04-10797		1		4650 Top Cover	DWG 4650-208	
13	04-20052	1			Toroidal Power XFMR. 15V + 15V	Cotswold, D1003 W/Hardware	
14	05-10613	1			Battery 12V 6.5AH Lead Acid	Panasonic LCR12V6.5P	
15	03-20054	1			Diode,Bridge,100V,25A	Motorola MDA2501	
16	05-10086	1			Solder lug, #6, internal star	Smith 1412-6	
17	05-10369	3			Standoff hinged, 1/4 dia, 1 lg, 6-32	Keystone 354	
18	04-10791		1		4650 Power Supply Support Bracket	DWG 4650-205	
19	90-06004	17			#6-32 x 1/4" Phil Pan S.S.		
20	90-06009	2			#6-32 x 9/16" Phil Pan S.S.		
21	97-06001	11			#6-32 Hex Nut, Small Pattern, Stainless-Steel		
22	98-06001	12			#6 Split Lock Washer,STD,S.S.		
23	98-06000	13			#6 Flat Washer STD S.S.		
24	91-06006	14			#6-32 x 3/8" Phil Flat 82 Deg. S.S.		
25	05-10808	2			Dual Tilting Feet (Plastic,Gray)	Elma Electronics 63-018S	
26	91-06010	2			#6-32 x 5/8" Phil Flat 82 Deg. S.S.		
27	90-06006	2			#6-32 x 3/8" Phil Pan S.S.		
28	98-06002	17			#6 Internal Star Washer, S.S.		
29	05-10694		1		Display Power Cable Assy	DWG 4650-052	
30	05-10695		1		Battery Cable Assy	DWG 4650-053	
31	05-10696		1		Display LED Cable Assy	DWG 4650-054	
32	05-10096	6			Standoff, 1/4 dia, 1 lg, 6-32	Smith 2124 1"	
37	05-10266	20			Strip,rubber,adhesive,neoprene,3/16T,1/2W	ACC. Rubber 1/2x3/16-NEOPRENE	
38	90-06008	2			#6-32 x 1/2 Phil Pan S.S.		
39	05-10232		1		Washer, insulator, TO3	Berquist K4-06	
40	91-06009	6			#6-32 x 9/16" Phil Flat 82 Deg. S.S.		
42	04-10790	1			4650 Battery Spacer	DWG 4650-204	
43	05-10436	1			Standoff, 1/4 hex, 7/16 lg, 6-32, M-F	RAF 4533-632-SS-0	
44	91-06005	2			#6-32 x 5/16" Phil Flat 82 Deg. S.S.		
45	04-10838	4			Single Binding Post Spacer	DWG 2730-287	
46	05-10531	2			Binding post, very low thermal, red	Pomona 3770-2	
47	05-10532	2			Binding post, very low thermal, black	Pomona 3770-0	
48	05-10698	1			Digital Power Cable Assy	DWG 4650-056	
49	05-10710	1			Power Switch Cable Assy.	DWG 4650-058	
50	05-10711	1			Remote Power Cable Assy	DWG 4650-059	
51	05-10712	1			Charging Power Cable Assy	DWG 4650-060	
52	98-06003	8			#6 Ext.Star Washer S.S.		
53	05-10026	1			Standoff, 1/4" dia, 3/4 lg,#8 FULL THD	Smith 2128 BRASS/ZINC	
54	90-08008	1			#8-32 x 1/2" Phil Pan S.S.		
55	98-08001	1			#8 Split Lock Washer STD S.S.		
56	05-10015	2			Foot, rubber, white	Acc. Rubber 2089W-017	

REF.DES.	STOCK #	QUANTITY A	QUANTITY T	QUANTITY N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
57	92-06004			9	6-32 x 1/4" Phil Truss Head S.S.		
58	91-06004	2			#6-32 x 1/4" Phil Flat 82 Deg. S.S.		
59	91-06005	2			#6-32 x 5/16" Phil Flat 82 Deg. S.S.		
62	80-02522	33			22AWG Wire, Green TFE	M16878/4-BFE-5	
63	80-02022	29			22AWG Wire, Black TFE	M16878/4-BFE-0	
64	80-02516	3			16 AWG Wire, Green TFE	M16878/4-BJP5	
66	70-00004	10			1/4" Black Shrink Tubing FP301	3M 3000250BK	
67	05-10441	9			Tie-wrap block, small	Panduit ABMM-AT	
68	05-10019	13			Cable tie, 4"x 1/8"	Panduit WRN-4	
69	80-02022	3			22AWG Wire, Black TFE	M16878/4-BFE-0	
73	04-10812	1			Adhesive Insulating Material	Jesco .020" Polycarb & 3M465-12 Adhesive	
74	05-10437	3			Ribbon Cable Clamp, Adhesive	Icorally FRC-1	
75	05-10867	1			SIL-PAD Sq 1.0 w/ .187 Hole	Berquist 1007-48	
77	05-10866	1			4650 Rear Binding Post Cable Assy	ASSY 4650-063	
78	05-10865	1			4650 Front Binding Post Cable Assy	ASSY 4650-062	
IC101	03-30356		1		Positive Adjustable Regulator,1.5A,TO3	LM317KC	

PARTS LIST : 4650-402 REV F 4650A Front Panel Assy 7/15/1996 Page : 1

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	4650-603	1			4650A Display Board Assy	Assembly 4650-603	
2	30-00075	1			4650 Keyboard Assy	ASSY 4650-606	
3	04-10810	1			Finished Front Panel Assy	ASSY 4650-403	
4	04-10800	1			4650 Cal Switch Plate	DWG 4650-211	
5	04-10686	1			5 X 8 Silicone Keypad	DWG 2700-240	
7	05-10686	4			Standoff 1/4 Hex,3/8 Lg,4-40	Smith 8402	
8	05-10685	5			Standoff 1/4 Hex,1/4 Lg,4-40	Smith 8401	
9	98-04002	14			#4 Internal Star Washer S.S.		
10	97-04001	11			#4-40 Radio Hex Nut S.S.		
11	98-04000	13			#4 Flat Washer S.S.		
12	05-03104	1			Switch,Rotary,1 Pole,2 Pos.	Grayhill 50YY29026-01-1-02-N-F	
13	05-10312	2			Spacer, 3/16 hex, 1/8 lg, #4	Smith 9115 or 9015	
14	98-04001	2			#4 Split Lock Washer S.S.		
15	98-40000	1			1/4" Flat Washer		
16	80-02022	2			22AWG Wire, Black TFE	M16878/4-BFE-0	
17	04-10812	1			Adhesive Insulating Material	Jesco .020" Polycarb & 3M465-12 Adhesive	
19	80-02922	2			22AWG Wire, White TFE	M16878/4-BFE-9	

PARTS LIST : 4650-401 REV D 4650A Rear Panel Assy 7/15/1996 Page : 1

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	04-10789	1			4650 Rear Panel	DWG 4650-203	
3	05-10590	1			Pwr.Conn.,Fs.Hldr.,Sw.	Schaffner,FN 393-6-05-11	
4	05-10001	1			Binding post, red	Superior BP21RC	
5	05-10003	1			Binding post, black	Superior BP21BC	
6	05-10531	2			Binding post, very low thermal, red	Pomona 3770-2	
7	05-10532	2			Binding post, very low thermal, black	Pomona 3770-0	
8	97-06001	2			#6-32 Hex Nut, Small Pattern, Stainless-Steel		
9	98-06001	1			#6 Split Lock Washer,STD,S.S.		
10	91-04006	2			#4-40 x 3/8" Phil Flat 82 Deg. S.S.		
11	05-04010	1			0.25A,Slo Blo Fuse	Littlefuse,313-.250	
12	05-04007	1			0.5A Slo Blo Fuse	Littlefuse,313-.500	
13	04-10798	1			4650 IEEE Plate	DWG 4650-209	
14	05-10681	1			IEEE Cable Assy	DWG 4650-051	
15	05-10244	1			IEEE connector hardware kit	AMP 552633-3	
16	99-99009			1	THREADLOCK MEDIUM	Loctite 222	

REP.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	04-30211	1			Display Board	DWG 4650-703	
2	05-10454	10			Spacer, nylon, led, .1" lg	Bivar 908-100	
3	99-99010			1	SOLDER SN63WRAP3	QQ-S-571	
C201	02-40029	1			100uF 25V Aluminum Radial	Illinois 107RMR025M	
C202	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
C203	02-40029	1			100uF 25V Aluminum Radial	Illinois 107RMR025M	
C204	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C205	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C206	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C207	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C208	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C209	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
DS201	05-01031	1			LED, Rectangular, Red	Hewlett Packard HLMP0300	
DS202	05-01031	1			LED, Rectangular, Red	Hewlett Packard HLMP0300	
DS203	05-01033	1			LED, Rectangular, Green	Hewlett Packard, HLMP0503	
DS206	05-01031	1			LED, Rectangular, Red	Hewlett Packard HLMP0300	
DS208	05-01031	1			LED, Rectangular, Red	Hewlett Packard HLMP0300	
DS209	05-01031	1			LED, Rectangular, Red	Hewlett Packard HLMP0300	
DS210	05-01031	1			LED, Rectangular, Red	Hewlett Packard HLMP0300	
DS211	05-01033	1			LED, Rectangular, Green	Hewlett Packard, HLMP0503	
DS212	05-01032	1			LED, Rectangular, Yellow	Hewlett Packard, HLMP0400	
DS213	05-01031	1			LED, Rectangular, Red	Hewlett Packard HLMP0300	
DS214	05-01030	1			Display, V-F, 14 Seg., 20 Digit	Itron FG209M2	
IC101	03-30101	1			BCD to Decimal Decoder/Driver	74LS145N	
IC102	03-30401	1			Octal 3 State Buffer (HCMOS)	74HC541	
IC103	03-50063		1		Display Controller	DWG 2730-913 using 03-30443	
IC104	03-30403	1			Octal latch (HCMOS)	74HC574	
IC105	05-02007	1			Programmable Osc.,8.3Hz-1MHz	Statek,PX01000KHzA	
IC201	03-30403	1			Octal latch (HCMOS)	74HC574	
IC202	03-30403	1			Octal latch (HCMOS)	74HC574	
IC203	03-30440	1			Octal VFD Driver	Sprague UDN6118A	
IC204	03-30440	1			Octal VFD Driver	Sprague UDN6118A	
IC205	03-30503	1			20 Digit VFD Driver, Serial Input	TL5812N	
IC206	03-30403	1			Octal latch (HCMOS)	74HC574	
IC207	03-30403	1			Octal latch (HCMOS)	74HC574	
PL101	05-10527	1			Connector,34 pin,0.1x0.1,with lock	Robinson Nugent IDH-34K-S3-TG-EL-1K	
PL102	05-10526	1			Connector, 20 pin, 0.1 x 0.1, with lock	Robinson Nugent IDH-20K-S3-TG-EL-1K	
PL201	05-10585	1			Connector,10 pin,0.1x0.1,with lock	Robinson Nugent IDH-10K-S3-TG-EL-1K	
PL202	05-10585	1			Connector,10 pin,0.1x0.1,with lock	Robinson Nugent IDH-10K-S3-TG-EL-1K	
R201	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
RN101	01-40014	1			9 x 100K Network (SIP)	A-B 110A-104	
RN102	01-40014	1			9 x 100K Network (SIP)	A-B 110A-104	
RN103	01-40014	1			9 x 100K Network (SIP)	A-B 110A-104	
RN104	01-40014	1			9 x 100K Network (SIP)	A-B 110A-104	
RN105	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103	
RN201	01-40017	1			9 x 470 Network (SIP)	A-B 110A-471	
RN202	01-40017	1			9 x 470 Network (SIP)	A-B 110A-471	
XIC101	05-10008	1			Socket, dil, 16 pin	Burndy C8516-01	
XIC102	05-10294	1			Socket, dil, 20 pin	Burndy DILB20P-108	
XIC103	05-10596	1			68-pin PLCC Socket	Burndy QILE-68P-410T	
XIC104	05-10294	1			Socket, dil, 20 pin	Burndy DILB20P-108	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
XIC105	05-10008	1			Socket, dil, 16 pin	Burndy C8516-01	
XIC201	05-10294	1			Socket, dil, 20 pin	Burndy DILB20P-108	
XIC202	05-10294	1			Socket, dil, 20 pin	Burndy DILB20P-108	
XIC203	05-10293	1			Socket, dil, 18 pin	Burndy DILB18P-108	
XIC204	05-10293	1			Socket, dil, 18 pin	Burndy DILB18P-108	
XIC205	05-10295	1			Socket, dil, 28 pin	Burndy DILB28P-108	
XIC206	05-10294	1			Socket, dil, 20 pin	Burndy DILB20P-108	
XIC207	05-10294	1			Socket, dil, 20 pin	Burndy DILB20P-108	

PARTS LIST : 4650-606 REV B 4650 Keyboard Assy 7/15/1996 Page : 1

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	04-30181	1			4650 Keyboard	DWG 4650-706	
2	05-10612	1			2730/4650 Keyboard Cable Assy	DWG 2730-051	
3	99-99010			1	SOLDER SN63WRAP3	QQ-S-571	

REF.DES.	STOCK #	QUANTITY A T N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	80-00022	1	22AWG Buss Wire	1BB-2201 ANIXTER	
A1	04-30215	1	4650 Main Board	DWG 4650-701	
C1	02-90000	1	0.005u 5% 50V Polycarbonate	IMB RA78502J	
C2	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C3	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C4	02-60002	1	0.1uF 250V Mylar	Illinois 104MSR250K	
C5	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C6	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C201	02-90001	1	0.05u 5% 50V Polycarbonate	IMB RA7A503J	
C202	02-90008	1	0.02u 5% 50V Polycarbonate	IMB RATA203J	
C203	02-90006	1	1uF 5% 50V Polycarbonate	IMB RA20105J	
C204	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C205	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C206	02-30001	1	10uF 25V Tantalum Bead	AVX TAP106K025SP	
C207	02-30001	1	10uF 25V Tantalum Bead	AVX TAP106K025SP	
C208	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C209	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C210	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C211	02-20013	1	100pF 500V Mica	CM05FD101J03	
C212	02-60017	1	0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C213	02-40029	1	100uF 25V Aluminum Radial	Illinois 107RMR025M	
C214	02-40029	1	100uF 25V Aluminum Radial	Illinois 107RMR025M	
C215	02-40029	1	100uF 25V Aluminum Radial	Illinois 107RMR025M	
C216	02-40029	1	100uF 25V Aluminum Radial	Illinois 107RMR025M	
C217	02-40029	1	100uF 25V Aluminum Radial	Illinois 107RMR025M	
C218	02-60017	1	0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C219	02-90005	1	0.1uF 5% 50V Polycarbonate	IMB RA7A104J	
C220	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C221	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C301	02-60017	1	0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C302	02-60002	1	0.1uF 250V Mylar	Illinois 104MSR250K	
C303	02-60002	1	0.1uF 250V Mylar	Illinois 104MSR250K	
C304	02-60002	1	0.1uF 250V Mylar	Illinois 104MSR250K	
C305	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C307	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C308	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C309	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C310	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C311	02-20011	1	1000p 500V Mica	CM06FD102J03	
C401	02-40029	1	100uF 25V Aluminum Radial	Illinois 107RMR025M	
C402	02-60004	1	0.01u 630V Mylar	ILL. 103MSR630K	
C403	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C404	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C405	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C406	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C408	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C409	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C410	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C411	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C412	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C413	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	

REF.DES.	STOCK #	QUANTITY A	QUANTITY T	QUANTITY N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
C414	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C501	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C502	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
D1	03-20024	1			Pair, low leakage diodes, 10pA	DPAD10	
D2	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D3	03-20028	1			Diode, signal, schottky	1N5711	
D4	03-20025	1			Diode, zener, 4.7V, 10%, 1 watt	1N4732	
D5	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D6	03-20028	1			Diode, signal, schottky	1N5711	
D7	03-20006	1			Diode, low leakage	1N3595	
D8	03-20006	1			Diode, low leakage	1N3595	
D9	03-20048	1			Rectifier, Schottkey	Motorola 1N5818	
D201	03-20024	1			Pair, low leakage diodes, 10pA	DPAD10	
D202	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D203	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D302	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D303	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D304	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D305	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D306	03-20000	1			Diode, general purpose	1N4148 or 1N914	
IC1	03-30330	1			8 to 1 CMOS Analog Switch	DG508ACJ	
IC2	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC3	03-30482	1			Dual Precision Op-Amp	LT1024ACN	
IC4	03-30501	1			Lower Power Quad Op-Amp	OP421HY	
IC201	03-30165	1			Dual general purpose Op-amp	LF412CN	
IC202	03-30166	1			General Purpose JFET Op-amp	LF411CN	
IC203	03-30166	1			General Purpose JFET Op-amp	LF411CN	
IC204	03-30073	1			Comparator,JFET	LF311H or TL311	
IC205	03-30499	1			Dual, Very High Speed, SPDT Switch	DG5143C	
IC206	03-30449	1			10v Pretrimmed Volt. Ref.	Anal Dev AD581JH	
IC207	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC301	03-30185	1			Quad general purpose Opto-isolator	Litronix ILQ-74A	
IC302	03-30185	1			Quad general purpose Opto-isolator	Litronix ILQ-74A	
IC303	03-30084	1			General Purpose Opto-Isolator	IL1 or TIL111	
IC304	03-30186	1			Dual high speed opto-isolator	Hewlett Packard HCPL-2630	
IC305	03-30186	1			Dual high speed opto-isolator	Hewlett Packard HCPL-2630	
IC306	03-30201	1			Dual general purpose opto-isolator	ILCT6 or MCT6	
IC307	03-30093	1			Very High Speed Opto-Isolator	Hewlett Packard HCPL-2601	
IC308	03-50093		1		4650 Analog Control	DWG 4650-900 using 03-30405	
IC309	03-30133	1			Quad general purpose comparator	LM339N	
IC310	03-30133	1			Quad general purpose comparator	LM339N	
IC311	03-30133	1			Quad general purpose comparator	LM339N	
IC312	03-30133	1			Quad general purpose comparator	LM339N	
IC401	03-50096		1		4650A ROM (UPPER)	DWG 4650-903 using 03-30399	
IC402	03-50097		1		4650A ROM (LOWER)	DWG 4650-904 using 03-30399	
IC403	03-30373		1		8Kx8 Static RAM (350ns,CMOS)	Hitachi or RCA 6264LP-15	03-30428
IC404	03-30373		1		8Kx8 Static RAM (350ns,CMOS)	Hitachi or RCA 6264LP-15	03-30428
IC405	03-30403	1			Octal latch (HCMOS)	74HC574	
IC406	03-30401	1			Octal 3 State Buffer (HCMOS)	74HC541	
IC407	03-30407		1		16/32 Bit Microprocessor (12MHz, PLCC)	Motorola MC68HC000FN12	
IC408	03-50094		1		4650 A to D Control	DWG 4650-901 using 03-30443	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
IC409	05-02016	1			Oscillator 9.8304 MHz		
IC410	03-50095		1		4650 Main Processor Decode	DWG 4650-902 using 03-30539	
IC411	03-30546	1			NOVRAM,Serial,512x8	XICOR X2404P	
IC412	03-30427	1			Power Fail Detector	Dallas DS1232	
IC413	03-30404	1			Octal bus tranciever	74HC245	
IC414	03-30404	1			Octal bus tranciever	74HC245	
IC415	03-30403	1			Octal latch (HCMOS)	74HC574	
IC416	03-30403	1			Octal latch (HCMOS)	74HC574	
IC501	03-30471		1		GPIB Controller to MPU Interface	TMS9914ANL	
IC502	03-30469	1			IEEE Data Bus Driver	SN75160BN	
IC503	03-30470	1			IEEE Controller Driver	SN75162AN	
PL201	05-10372	1			Wafer,6 pin,gold,0.10 Sp,0.56 Lg	Molex 22-10-2061	
PL301	05-10529	1			Header, 3 pin, .56 lg, gold, .10 sp.	Molex 22-10-2031	
PL401	05-10509	1			Wafer, 0.1sp 0.56lg, 2 X 8	Molex 10-89-1161	
PL402	05-10529	1			Header, 3 pin, .56 lg, gold, .10 sp.	Molex 22-10-2031	
PL403	05-10529	1			Header, 3 pin, .56 lg, gold, .10 sp.	Molex 22-10-2031	
PL501	05-10683	1			CONNECTOR, 24 PIN, .10 x.10, WITH LOCK	MOLEX 10-86-1243	
R1	01-10000			1	Factory Select Resistor	RN60C???	
R2	01-10000			1	Factory Select Resistor	RN60C???	
R3	01-10000			1	Factory Select Resistor	RN60C???	
R4	01-10000			1	Factory Select Resistor	RN60C???	
R5	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R6	01-20013	1			100 0.05% 5ppm/C Wire Wound	Goldstar GS711-100R-.05%-5PPM	
R7	01-01119	1			10M 5% 1/4W Carbon Film	RC07GF106J	
R8	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R16	01-10000			1	Factory Select Resistor	RN60C???	
R17	01-10000			1	Factory Select Resistor	RN60C???	
R18	01-10000			1	Factory Select Resistor	RN60C???	
R19	01-10000			1	Factory Select Resistor	RN60C???	
R20	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R21	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R22	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R23	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R24	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R25	01-10113	1			8.06K 1% 50ppm/C 1/4W Metal Film	RN60C8061F	
R27	01-01070	1			33K 5% 1/4W Carbon Film	RC07GF333J	
R28	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R29	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R30	01-10227	1			665 1% 50ppm/C 1/4W Metal Film	RN60C6650F	
R31	01-10078	1			2K 1% 50ppm/C 1/4W Metal Film	RN60C2001F	
R32	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R33	01-10047	1			49.9K 1% 50ppm/C 1/4W Metal Film	RN60C4992F	
R34	01-01040	1			910 5% 1/4W Carbon Film	RC07GF911J	
R35	01-01119	1			10M 5% 1/4W Carbon Film	RC07GF106J	
R36	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R37	01-10109	1			43.2K 1% 50ppm/C 1/4W Metal Film	RN60C4322F	
R38	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R39	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R40	01-10047	1			49.9K 1% 50ppm/C 1/4W Metal Film	RN60C4992F	
R41	01-10047	1			49.9K 1% 50ppm/C 1/4W Metal Film	RN60C4992F	
R42	01-01120	1			12M 5% 1/4W Carbon Film	RC07GF126J	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
RN1	01-40006	1			8 x 100K Network	A-B 316B-104	
R201	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R202	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R203	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R204	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R205	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R206	01-10004	1			15K 1% 50ppm/C 1/4W Metal Film	RN60C1502F	
R207	01-20006	1			90K 0.05% 5ppm/C Wire wound	Goldstar GS711-90K-.05%-5PPM	
R208	01-20222	1			700 0.05% 5ppm/C 700 0.05% 5ppm/C	Goldstar GS602-700R-0.05%-5ppm	
R209	01-20176	1			4.5K 0.1% 5ppm/C Wirewound	GS602-4.5K-0.1%-5ppm	
R210	01-20172	1			100K 0.1% 1ppm/C Wirewound	GS602-100K-0.1%-1PPM	
R211	01-10076	1			1.5M 1% 50ppm/C 1/2W Metal Film	RN65C1504F	
R212	01-10255	1			35.7K 1% 50ppm/C 1/4W Metal Film	RN60C3572F	
R213	01-20172	1			100K 0.1% 1ppm/C Wirewound	GS602-100K-0.1%-1PPM	
R214	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R215	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R216	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R217	01-20150	1			50K .05% 5ppm/C Wire Wound	Goldstar GS602-50K-.05%-5ppm	
R218	01-20175	1			45K 0.1% 5ppm/C Wirewound	GS602-45K-0.1%-5ppm	
R219	01-20176	1			4.5K 0.1% 5ppm/C Wirewound	GS602-4.5K-0.1%-5ppm	
R220	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R221	01-01021	1			100 5% 1/4W Carbon Film	RC07GF101J	
R222	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R223	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R224	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R225	01-10008	1			10K 1% 50ppm/C 1/4W Metal Film	RN60C1002F	
R301	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R302	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R303	01-01033	1			470 5% 1/4W Carbon Film	RC07GF471J	
R304	01-01050	1			3.3K 5% 1/4W Carbon Film	RC07GF332J	
R305	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R306	01-01033	1			470 5% 1/4W Carbon Film	RC07GF471J	
R307	01-01033	1			470 5% 1/4W Carbon Film	RC07GF471J	
R308	01-01073	1			47K 5% 1/4W Carbon Film	RC07GF473J	
R309	01-01073	1			47K 5% 1/4W Carbon Film	RC07GF473J	
R501	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
RN301	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103	
RN302	01-40017	1			9 x 470 Network (SIP)	A-B 110A-471	
RN303	01-40001	1			8 x 470 Network	A-B 316B-471	
RN304	01-40001	1			8 x 470 Network	A-B 316B-471	
RN305	01-40024	1			9 x 47K Network (SIP)	A-B 110A-473	
RN306	01-40024	1			9 x 47K Network (SIP)	A-B 110A-473	
RN401	01-40014	1			9 x 100K Network (SIP)	A-B 110A-104	
RN402	01-40016	1			9 x 2.2K Network (SIP)	A-B 110A-222	
RN403	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103	
RN405	01-40016	1			9 x 2.2K Network (SIP)	A-B 110A-222	
RN406	01-40016	1			9 x 2.2K Network (SIP)	A-B 110A-222	
RN407	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103	
RN408	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103	
RN501	01-40014	1			9 x 100K Network (SIP)	A-B 110A-104	
RN502	01-40014	1			9 x 100K Network (SIP)	A-B 110A-104	

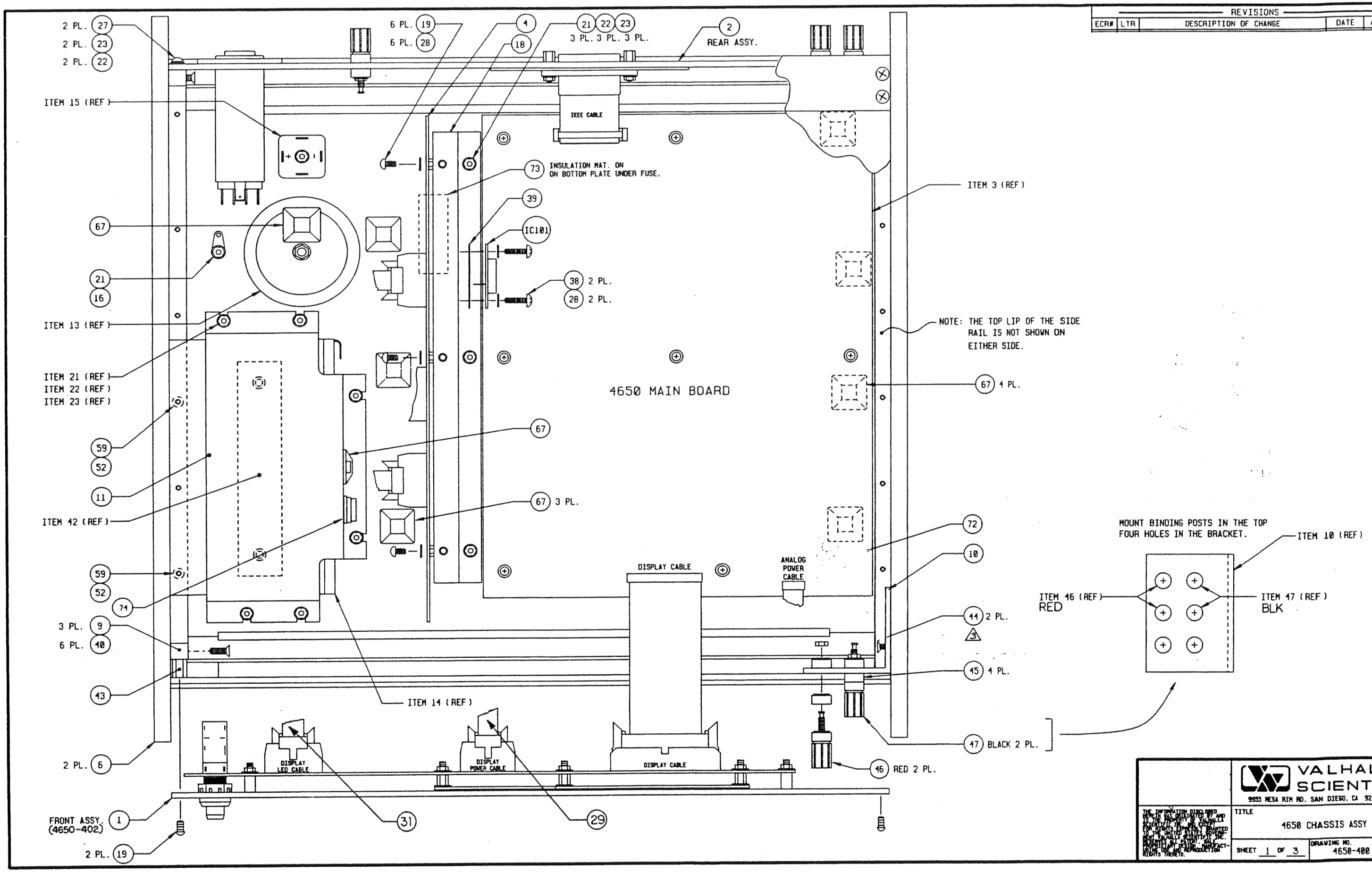
REF.DES.	STOCK #	QUANTITY A	QUANTITY T	QUANTITY N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
RLA	05-03089	1			Relay, 4 form A, 5V	Aromat S4EB-5V	
RLB	05-03089	1			Relay, 4 form A, 5V	Aromat S4EB-5V	
RLC	05-03089	1			Relay, 4 form A, 5V	Aromat S4EB-5V	
RLD	05-03089	1			Relay, 4 form A, 5V	Aromat S4EB-5V	
RLF	05-03089	1			Relay, 4 form A, 5V	Aromat S4EB-5V	
SK201	05-10697	1			Analog Power Cable Assy	DWG 4650-055	
SK401	05-10729	1			2734 Regulator/Power Supply Cable	DWG 2734-056	
TB1	05-10666	1			Terminal Block, Screw Conn., 4 pin PCB Mtg	WECO 20-874-004	
TB2	05-10666	1			Terminal Block, Screw Conn., 4 pin PCB Mtg	WECO 20-874-004	
TR1	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR2	03-10066	1			N-Channel JFET LoRdson (TO92)	SILICONIX J105	
TR3	03-10066	1			N-Channel JFET LoRdson (TO92)	SILICONIX J105	
TR4	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR5	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR6	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR7	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR8	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR9	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR10	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR11	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR12	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR13	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR14	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR15	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR16	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR17	03-10066	1			N-Channel JFET LoRdson (TO92)	SILICONIX J105	
TP201	05-10290	1			Test Hook, PCB	Vector K32-2	
TP202	05-10290	1			Test Hook, PCB	Vector K32-2	
TP401	05-10290	1			Test Hook, PCB	Vector K32-2	
TR201	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR202	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR203	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR204	03-10000	1			N-Channel JFET	U1899E or PN4392	
TR301	03-10026	1			N-Channel VMOS (TO92)	VN10KM	
TR302	03-10026	1			N-Channel VMOS (TO92)	VN10KM	
XIC308	05-10406	1			Socket, DIL, 24 pin, 0.3", Gold Contacts	Amp 583640-3	
XIC401	05-10295	1			Socket, dil, 28 pin	Burndy DILB28P-108	
XIC402	05-10295	1			Socket, dil, 28 pin	Burndy DILB28P-108	
XIC403	05-10295	1			Socket, dil, 28 pin	Burndy DILB28P-108	
XIC404	05-10295	1			Socket, dil, 28 pin	Burndy DILB28P-108	
XIC407	05-10596	1			68-pin PLCC Socket	Burndy QILE-68P-410T	
XIC408	05-10596	1			68-pin PLCC Socket	Burndy QILE-68P-410T	
XIC410	05-10596	1			68-pin PLCC Socket	Burndy QILE-68P-410T	
XIC411	05-10070	1			Socket, DIL, 8 pin, Gold Machine Pin Sockets	Robinson Nugent ICA083STG	
XIC501	05-10246	1			Socket, dil, 40 pin	Burndy DILB40P-11	
XPL301	05-10488		1		Shorting plug, .1 spacing, gold	Molex 15-29-1024	
XPL401	05-10488		3		Shorting plug, .1 spacing, gold	Molex 15-29-1024	
XPL402	05-10488		1		Shorting plug, .1 spacing, gold	Molex 15-29-1024	

PARTS LIST : 4650-604 REV E 4650A Power Supply Board Assy. 7/15/1996 Page : 1

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	04-30222	1			4650 PSU Board	DWG 4650-704	
2	05-10582	1			Cable Tie 8.0"lg x .10"wide	Panduit PLT2M	
3	99-99010			1	SOLDER SN63WRAP3	QQ-S-571	
4	05-10266	2			Strip,rubber,adhesive,neoprene,3/16T,1/2W	ACC. Rubber 1/2x3/16-NEOPRENE	
C101	02-40017	1			2200u 35V Aluminum	Illinois 228TTA035	
C102	02-40026	1			10u 50V Alum. Radial	ILL. 106RMR050M 20%	
C103	02-40026	1			10u 50V Alum. Radial	ILL. 106RMR050M 20%	
C104	02-40026	1			10u 50V Alum. Radial	ILL. 106RMR050M 20%	
C201	02-40010	1			1000u 25V Aluminum	Illinois 108TTA025	
C202	02-60017	1			0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C203	02-40031	1			470u 10V Alum. Radial	ILL. 477RMR010M	
C204	02-60017	1			0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C205	02-40052	1			470uF 63V Aluminum Radial	Illinois 477RSM063M	
C206	02-40010	1			1000u 25V Aluminum	Illinois 108TTA025	
C207	02-60017	1			0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C208	02-40031	1			470u 10V Alum. Radial	ILL. 477RMR010M	
C209	02-60017	1			0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C210	02-40029	1			100uF 25V Aluminum Radial	Illinois 107RMR025M	
C211	02-60017	1			0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C212	02-40029	1			100uF 25V Aluminum Radial	Illinois 107RMR025M	
D101	03-20002	1			Diode, rectifier, 1A, 50V	1N4001-1N4007	
D102	03-20049	1			Diode, Rectifier, 3A, 50v	Motorola MR500	
D103	03-20049	1			Diode, Rectifier, 3A, 50v	Motorola MR500	
D104	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D105	03-20025	1			Diode, zener, 4.7V, 10%, 1 watt	1N4732	
D201	03-20067	1			Diode, Zener, 7.5V, 10%	Motorola 1N4737	
F101	05-04001	1			2A,Fuse	Littlefuse,312-002	
IC102	03-30133	1			Quad general purpose comparator	LM339N	
IC103	03-30385	1			2.5V low power reference	LM385-2.5	
M201	03-30524	1			12V to 5V Isolated DC to DC Converter	IPD FRS1205	
M202	03-30525	1			5 Volt VFD Power Supply 45V, 6.3V	TDK CD1783P	
M203	03-30524	1			12V to 5V Isolated DC to DC Converter	IPD FRS1205	
M204	03-30523	1			5V to 15V DC to DC Converter 33mA	IPD CRD-A-515	
PL101	05-10691	1			2 PIN WAFER 0.156 SP. LOCKING	MOLEX 09-74-1021	
PL102	05-10691	1			2 PIN WAFER 0.156 SP. LOCKING	MOLEX 09-74-1021	
PL103	05-10692	1			6 Pin Wafer 0.156 Sp. Locking	Molex 09-74-1061	
PL104	05-10585	1			Connector,10 pin,0.1x0.1,with lock	Robinson Nugent IDH-10K-S3-TG-EL-1K	
PL105	05-10881	1			Wafer, 3 pin Locking, 0.1" Spacing, Gold	Molex 22-11-2032	
PL201	05-10881	1			Wafer, 3 pin Locking, 0.1" Spacing, Gold	Molex 22-11-2032	
PL202	05-10585	1			Connector,10 pin,0.1x0.1,with lock	Robinson Nugent IDH-10K-S3-TG-EL-1K	
PL203	05-10585	1			Connector,10 pin,0.1x0.1,with lock	Robinson Nugent IDH-10K-S3-TG-EL-1K	
R101	01-30071	1			270 5% 2W Carbon Comp	RC42GF271J	
R102	01-30071	1			270 5% 2W Carbon Comp	RC42GF271J	
R103	01-10247	1			261 1% 50ppm/C 1/4W Metal Film	RN60C2610F	
R104	01-10083	1			2.49K 1% 50ppm/C 1/4W Metal Film	RN60C2491F	
R105	01-01086	1			220K 5% 1/4W Carbon Film	RC07GF224J	
R106	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R107	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R108	01-10079	1			30.1K 1% 50ppm/C 1/4W Metal Film	RN60C3012F	
R109	01-01007	1			10 5% 1/4W Carbon Film	RC07GF100J	
R110	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	

REF.DES.	STOCK #	QUANTITY A	QUANTITY T	QUANTITY N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
R111	01-01049	1			3K 5% 1/4W Carbon Film	RC07GF302J	
R112	01-01047	1			2.4K 5% 1/4W Carbon Film	RC07GF242J	
R113	01-10160	1			10K 5% 50ppm/C 1W Metal Film	RC32GF103K	
R114	01-01100	1			1M 5% 1/4W Carbon Film	RC07GF105J	
R115	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R201	01-01070	1			33K 5% 1/4W Carbon Film	RC07GF333J	
R202	01-01005	1			6.2 5% 1/4W Carbon Film	RC07GF6R2J	
R203	01-01005	1			6.2 5% 1/4W Carbon Film	RC07GF6R2J	
RV101	01-50017	1			500 End Adjust	Beckman 89PR500ohm	
RV102	01-50023	1			10K End Adjust	Beckman 89PR10K	
RLA	05-03019	1			Relay,4 pole,form C,12VDC	Potter-Brum,R10-E2Z4-V185	
TR101	03-10013	1			NPN Transistor (TO92)	2N4401	
TR102	03-10026	1			N-Channel VMOS (TO92)	VN10KM	
TR103	03-10026	1			N-Channel VMOS (TO92)	VN10KM	
XF101	05-10269	2			Clip, fuse, pcb mount	Zierick 926, 927 or 798	
XIC101	05-10315	1			Socket, TO3	Smith 6243	

REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED



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VALHALLA SCIENTIFIC
9955 MESA RIM RD. SAN DIEGO, CA 92121

TITLE: 4650 CHASSIS ASSY

SHEET 1 OF 3 | DRAWING NO. 4650-400 | REV: G

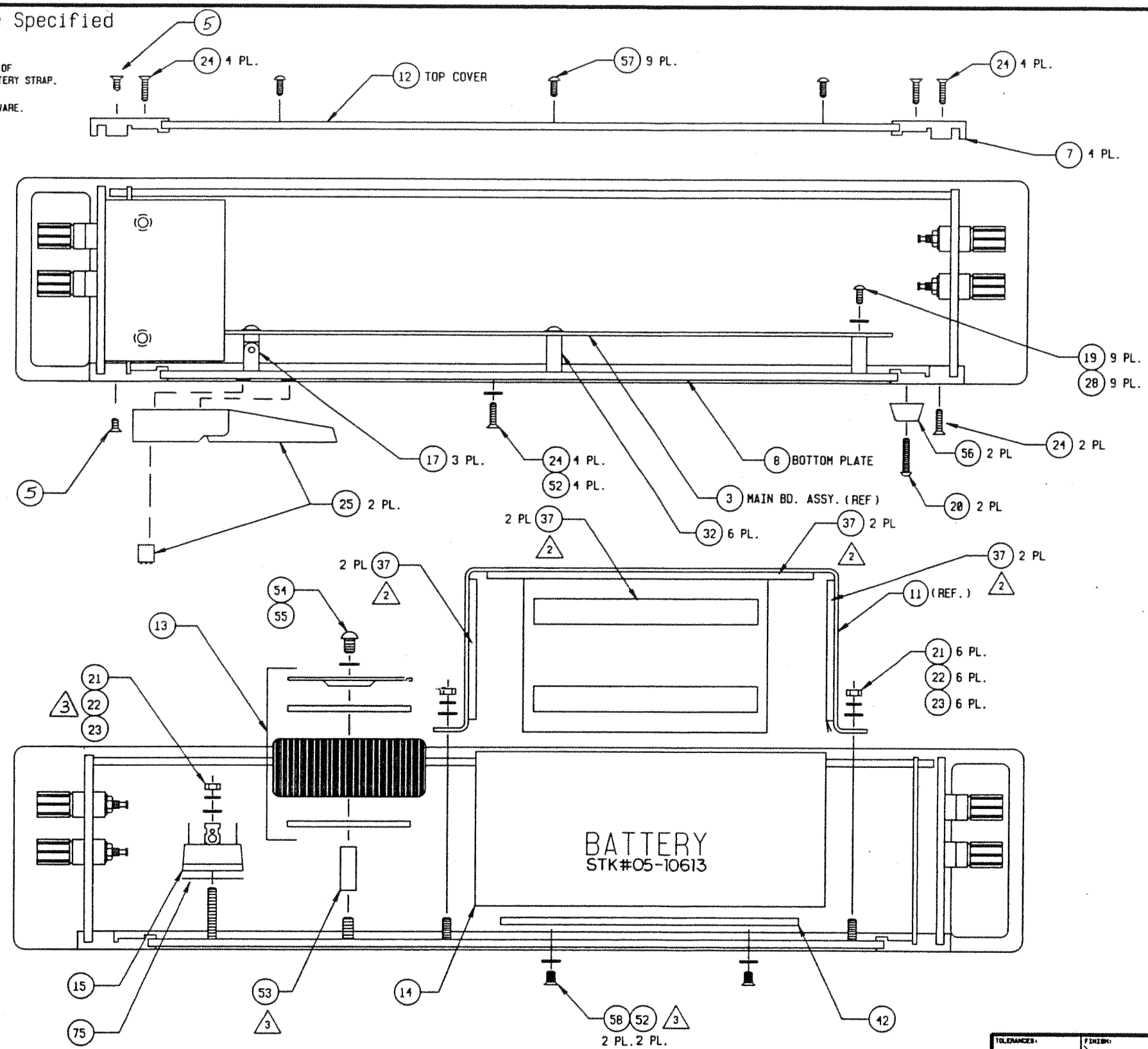
NOTES: Unless Otherwise Specified

1. SEE SEPERATE PARTS LIST
2. PLACE FOAM ON THE TOP AND SIDES OF BATTERY BETWEEN BATTERY AND BATTERY STRAP.
3. USE ITEM NO. 79 LOCTITE ON HARDWARE.

REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED

SEE SHEET 1 FOR REVISIONS

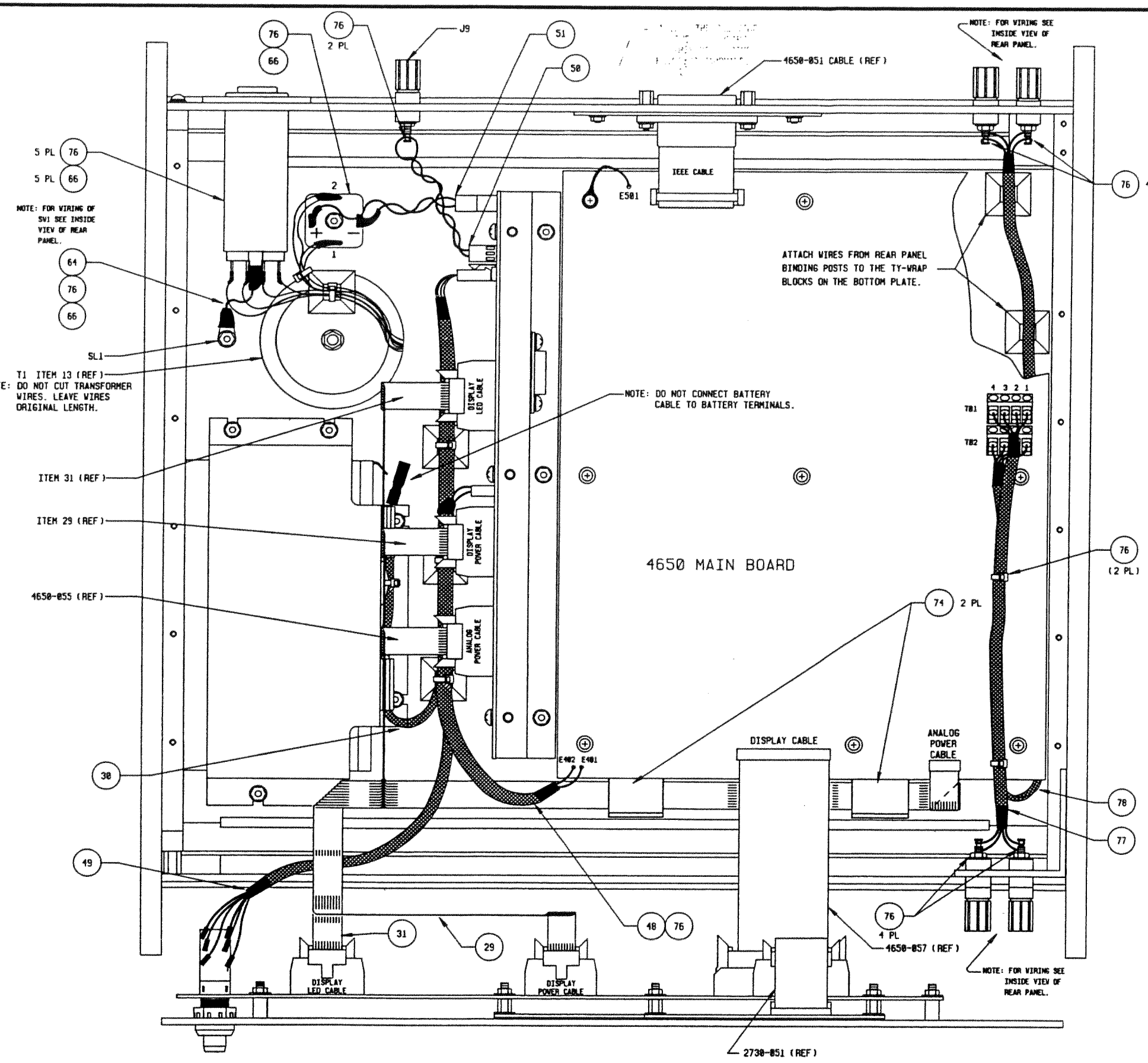
RIGHT SIDE VIEW
(WITH SIDE RAIL REMOVED)

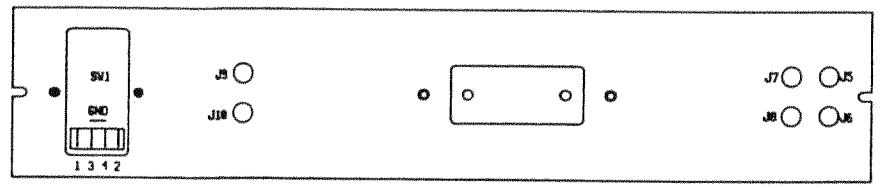


LEFT SIDE VIEW
(WITH SIDE RAIL REMOVED)

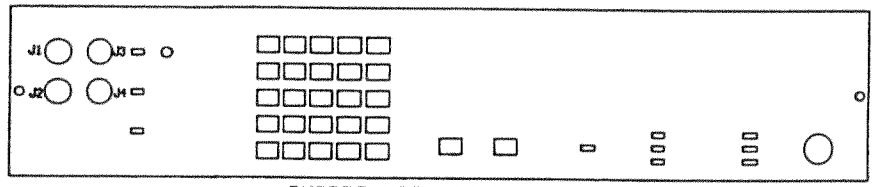
TOLERANCES: X = ±30' .XX = ±.02 .XXX = ±.005	FINISH:	MATERIAL:	VALHALLA SCIENTIFIC 9955 MESA RIM RD. SAN DIEGO, CA 92121
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS			THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC, INC. AND SHALL NOT BE DISCLOSED IN WHOLE OR IN PART TO OTHERS OUTSIDE RECIPIENT'S ORGANIZATION WITHOUT THE PRIOR WRITTEN PERMISSION OF VALHALLA SCIENTIFIC, INC. RECIPIENT AGREES TO NOTIFY VALHALLA SCIENTIFIC, INC. OF ANY UNAUTHORIZED USE OF THIS INFORMATION. ©1997 VALHALLA SCIENTIFIC, INC. ALL RIGHTS RESERVED. UNPUBLISHED RIGHTS UNDER THE COPYRIGHT LAWS OF THE UNITED STATES.
MACHINED SURFACES ARE TO HAVE A FINISH OF	SCALE: 1:1	STOCK NO.	TITLE: 4650 CHASSIS ASSY.
			SHEET 2 OF 3 — DRAWING NO. 4650-400 — REV: G

REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED
		SEE SHEET 1		





INSIDE VIEW OF REAR PANEL



INSIDE VIEW OF FRONT PANEL

WIRE TABLE

FROM		TERMINATION	TO	TERMINATION	AWG	COLOR	LEN	
ITEM 13 T1		INTERNAL	SW1 PIN #1	SOLDER & SLEEVE		VLT		
		INTERNAL	SW1 PIN #2	SOLDER & SLEEVE		GRY		
		INTERNAL	SW1 PIN #3	SOLDER & SLEEVE		BRN		
		INTERNAL	SW1 PIN #4	SOLDER & SLEEVE		BLU		
		INTERNAL	BRI PIN #1	SOLDER & SLEEVE		YEL		TWISTED PAIR APPROX TWO TWISTS PER INCH
		INTERNAL	BRI PIN #1	SOLDER & SLEEVE		RED		
		INTERNAL	BRI PIN #2	SOLDER & SLEEVE		BLK		TWISTED PAIR APPROX TWO TWISTS PER INCH
		INTERNAL	BRI PIN #2	SOLDER & SLEEVE		ORN		
MAIN BD. E501		GND WIRE	REAR PANEL	EXISTING HDW		BRN		
SL1		SOLDER & SLEEVE	SW1 GND	SOLDER & SLEEVE	16	BRN	2"	
ITEM 77 PIN #1		WIRE CLAMP	J4	SOLDER		ORG		
		WIRE CLAMP	J2	SOLDER		BRN		
		WIRE CLAMP	J1	SOLDER		BLK		
		WIRE CLAMP	J3	SOLDER		RED		
ITEM 78 PIN #1		WIRE CLAMP	J8	SOLDER		ORG		
		WIRE CLAMP	J6	SOLDER		BRN		
		WIRE CLAMP	J5	SOLDER		BLK		
		WIRE CLAMP	J7	SOLDER		RED		

NOTE: USE LOW THERMAL SOLDER FOR J1-8. FOLLOW VALHALLA SCIENTIFIC LOW THERMAL SOLDERING PROCEDURE.

CABLE HOOK-UP

CABLE #	FROM	TERMINATION	TO	TERMINATION	AWG	COLOR	LEN	
4650-051	MAIN BD. PL501	CONNECTOR	REAR PANEL ASSY	CONNECTOR				
ITEM 29	DISPLAY PL201	CONNECTOR	PSU BD. PL202	CONNECTOR				
ITEM 30	PSU BD. PL102	CONNECTOR	BATTERY +	CONNECTOR		RED		NOTE: DO NOT CONNECT WIRES TO BATTERY TERMINALS.
	PSU BD. PL102	CONNECTOR	BATTERY -	CONNECTOR		BLK		
ITEM 31	DISPLAY PL202	CONNECTOR	PSU BD. PL104	CONNECTOR				
4650-055 (REF)	MAIN BD. SK201	CONNECTOR	PSU BD. PL203	CONNECTOR				
ITEM 48	PSU BD. PL201	CONNECTOR	MAIN BD. E401	SOLDER		BLK		
	PSU BD. PL201	CONNECTOR	MAIN BD. E402	SOLDER		RED		
4650-057 (REF)	DISPLAY PL101	CONNECTOR	MAIN BD. SK401	CONNECTOR				
ITEM 49	FRONT PANEL	POWER SWITCH	PSU BD. PL103	CONNECTOR				
ITEM 50	PSU BD. PL105	CONNECTOR	REAR PANEL J9	SOLDER		RED		
	PSU BD. PL105	CONNECTOR	REAR PANEL J10	SOLDER		RED		
ITEM 51	PSU BD. PL101	CONNECTOR	BRI "+"	SOLDER & SLEEVE		RED		
	PSU BD. PL101	CONNECTOR	BRI "-"	SOLDER & SLEEVE		BLK		

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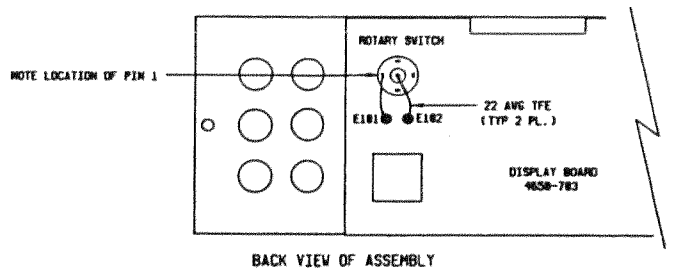
TITLE
4650 CHASSIS ASSEMBLY

SHEET 3 OF 3 | DRAWING NO. 4650-400 | REV: G

NOTES: Unless Otherwise Specified

1. CLEAN BACK OF KEYPADS WITH DENATURED ALCOHOL BEFORE INSTALLING.

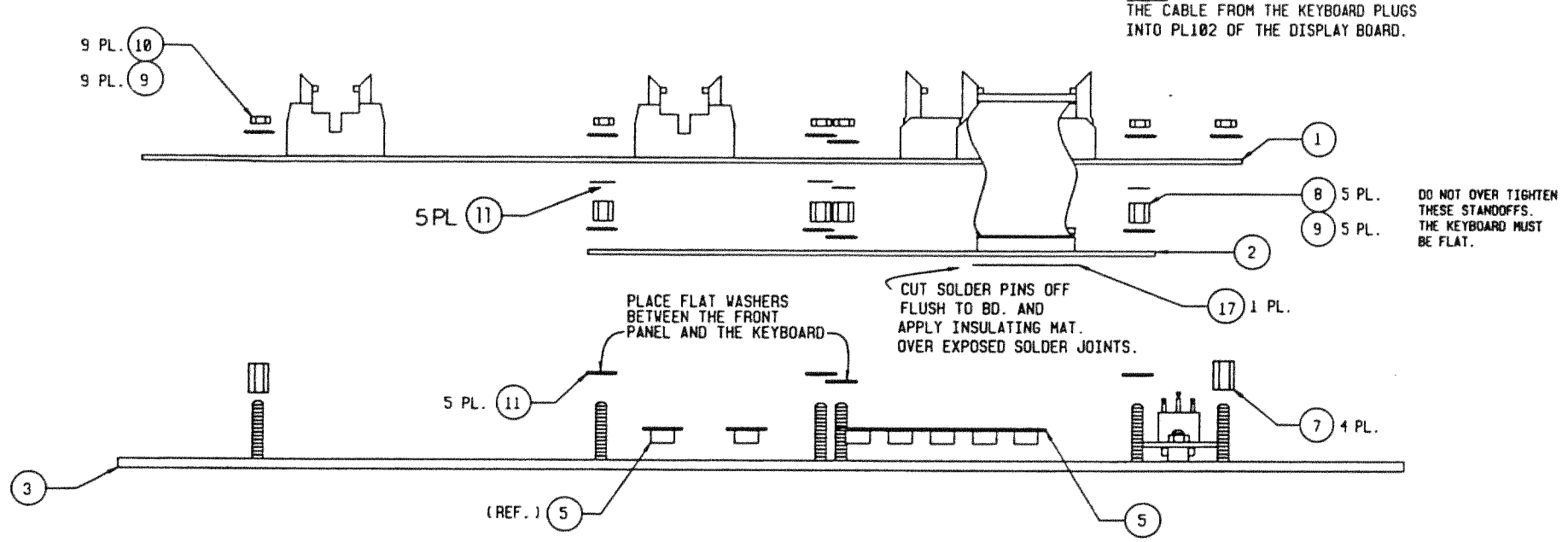
REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED



BACK VIEW OF ASSEMBLY

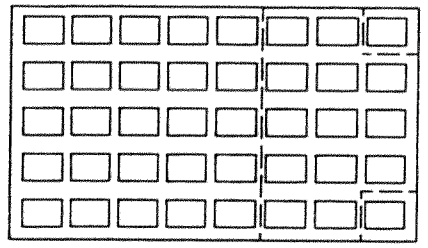
TOP VIEW

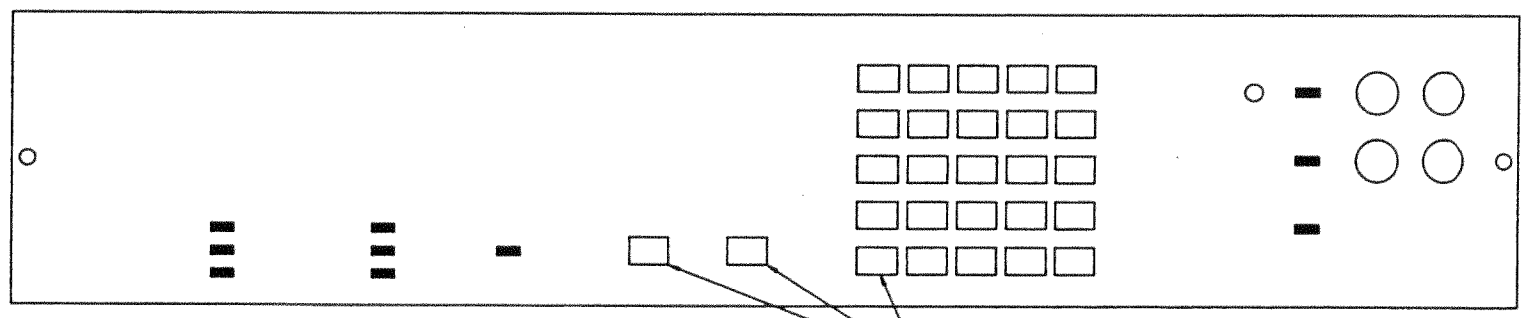
NOTE:
THE CABLE FROM THE KEYBOARD PLUGS INTO PL102 OF THE DISPLAY BOARD.



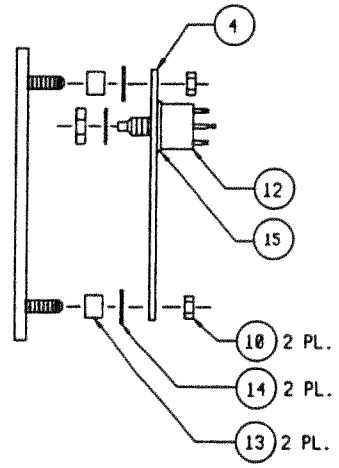
DO NOT OVER TIGHTEN THESE STANDOFFS. THE KEYBOARD MUST BE FLAT.

NOTE: CUT 5 x 8 SILICONE KEYPAD ALONG DOTTED LINES AS SHOWN, AND PLACE IN PROPER LOCATION BE SURE NOT TO CUT TOO CLOSELY TO KEYS OF KEYPAD.





FRONT VIEW



SIDE VIEW

TOLERANCES:
X = ±.01'
.XX = ±.02
.XXX = ±.005

DEBURR AND BREAK ALL SHARP EDGES AND CORNERS

MACHINED SURFACES ARE TO HAVE A FINISH OF

FINISH:

MATERIAL:

SCALE: 1:1

STOCK NO.

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TITLE
1650A FRONT ASSY.

SHEET 1 OF 1

DRAWING NO. 1650-102

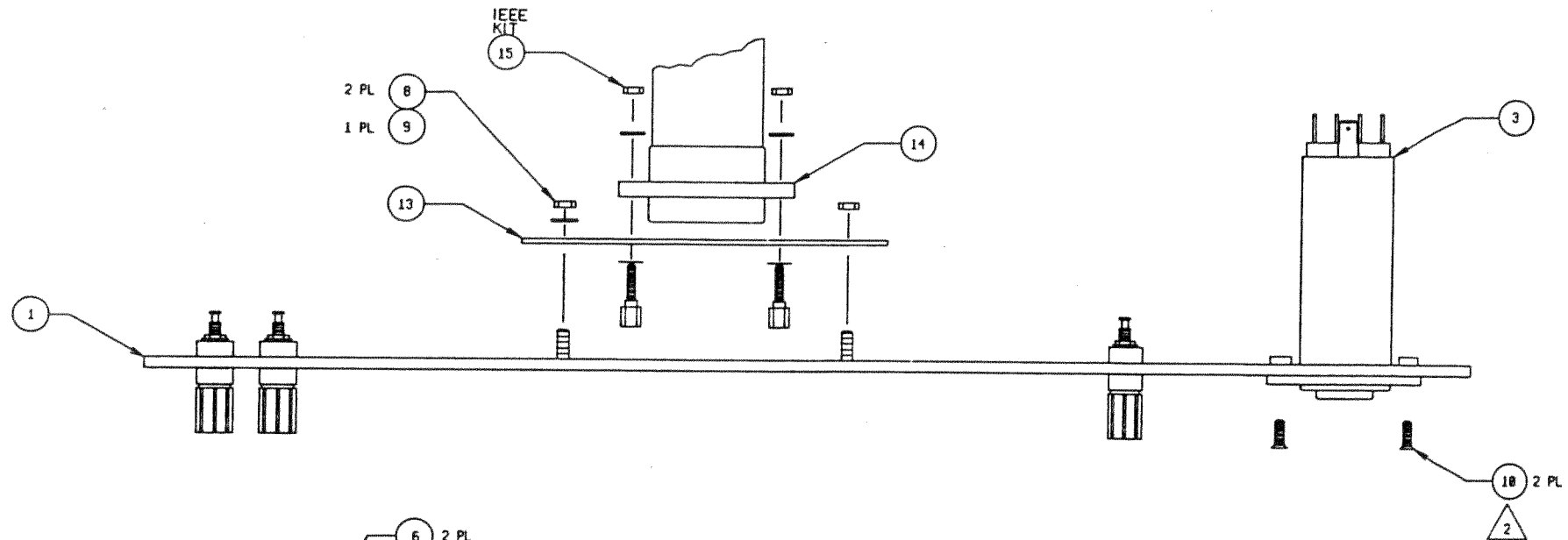
REV: D

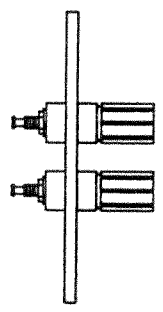
NOTES: Unless Otherwise Specified

1. SEE SEPERATE PARTS LIST
2. USE ITEM 16 (LOCKTITE) ON HARDWARE.

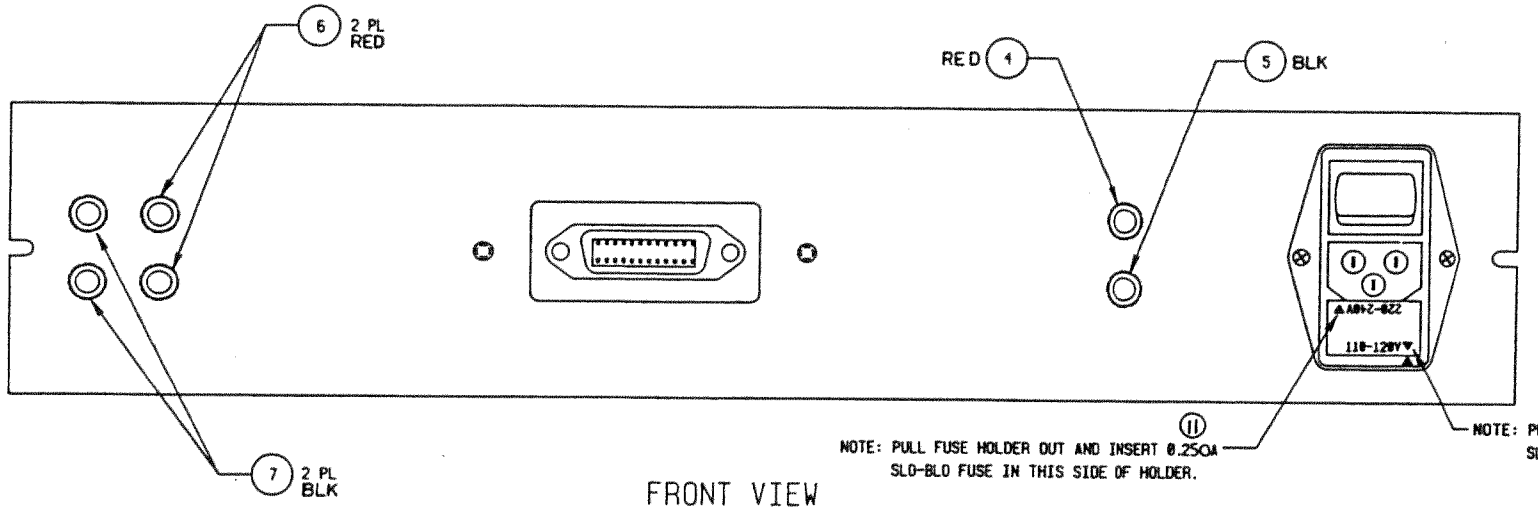
REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED

TOP VIEW





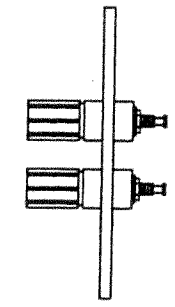
LEFT SIDE VIEW



NOTE: PULL FUSE HOLDER OUT AND INSERT 0.25OA SLO-BLO FUSE IN THIS SIDE OF HOLDER.

FRONT VIEW

NOTE: PULL FUSE HOLDER OUT AND INSERT 0.50A SLO-BLO FUSE IN THIS SIDE OF HOLDER.

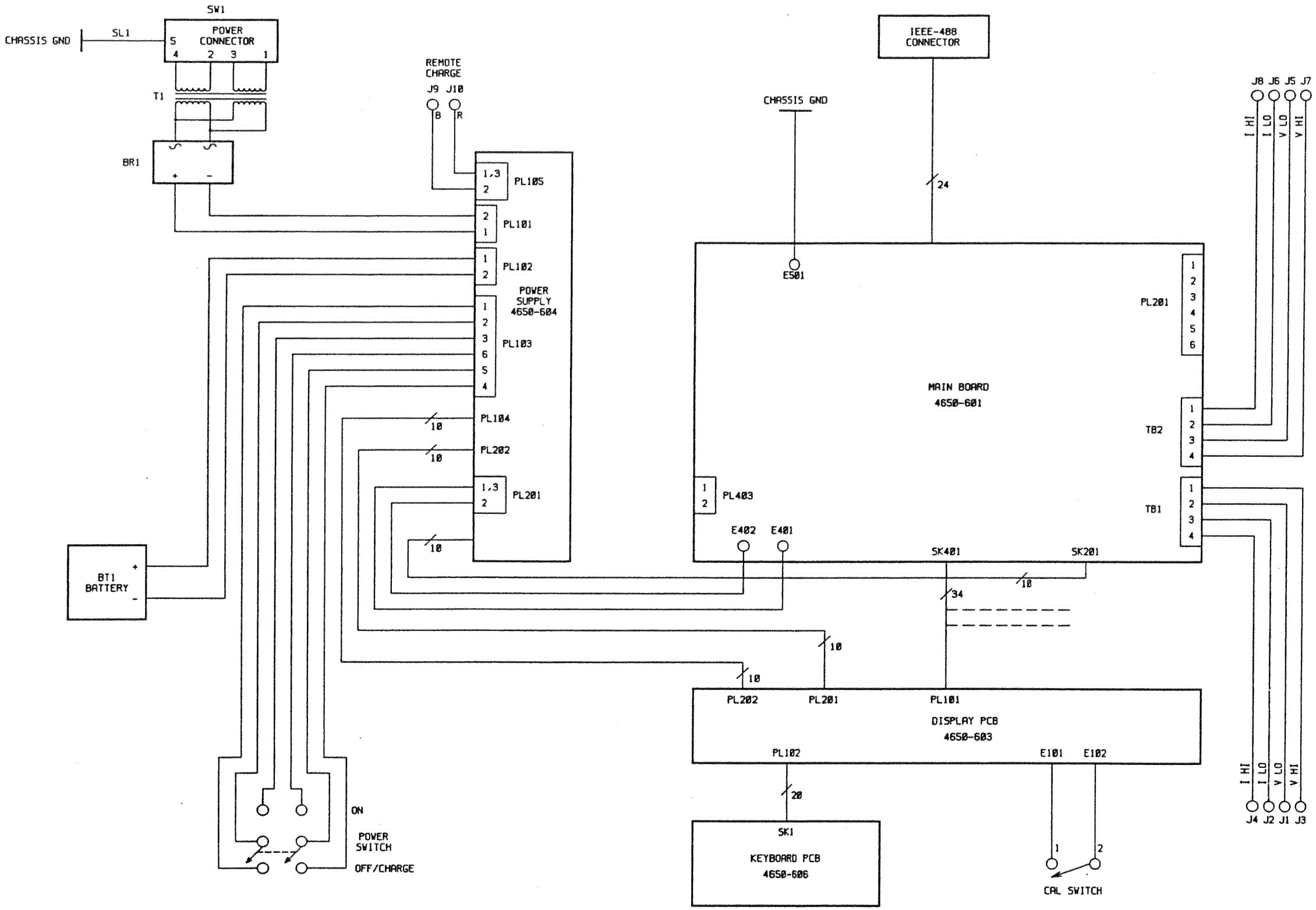


RIGHT SIDE VIEW

TOLERANCES: X = ±30' .XX = ±.02 .XXX = ±.005	FINISH:	MATERIAL:	VALHALLA SCIENTIFIC 9955 MESA RIM RD. SAN DIEGO, CA 92121
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS			TITLE: 4650A REAR PANEL ASSY
MACHINED SURFACES ARE TO HAVE A FINISH OF	SCALE: 1:1	STOCK NO.	SHEET 1 OF 1 / DRAWING NO. 4650-401 / REV: D

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ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED



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TITLE
4650 INTERCONNECT DIAGRAM

SHEET 1 OF 1

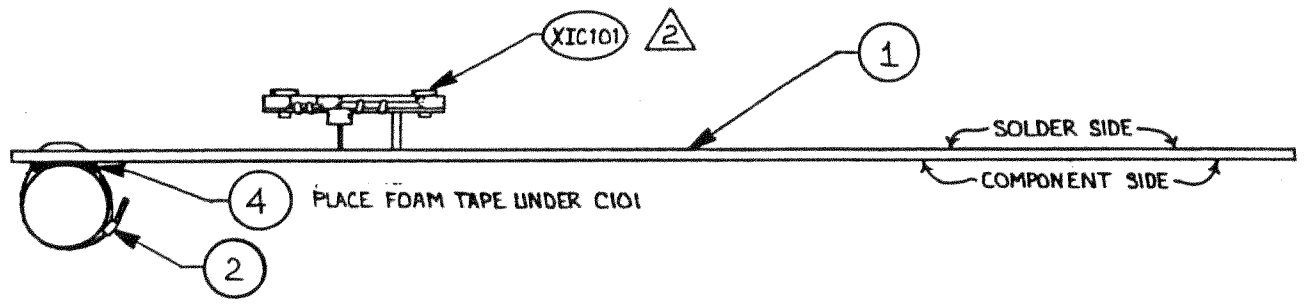
DRAWING NO.
4650-070

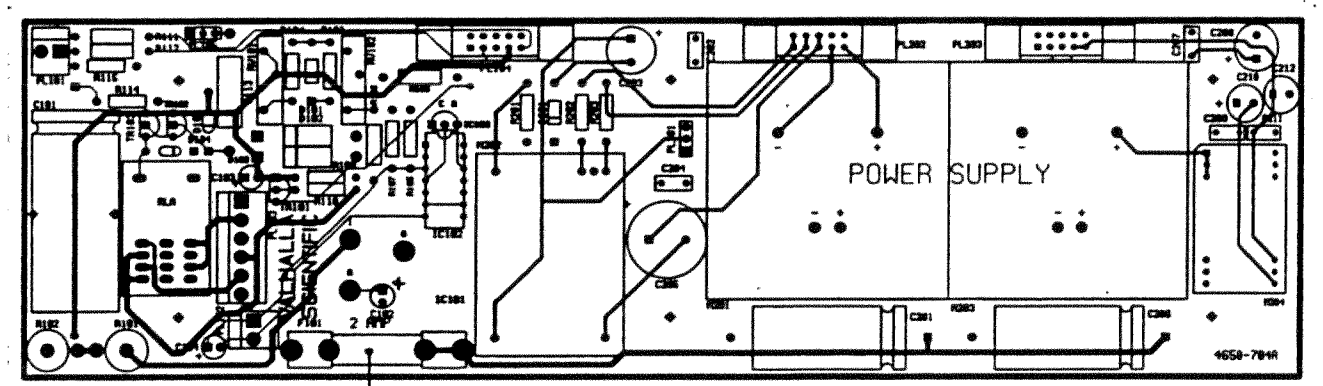
REV:
B

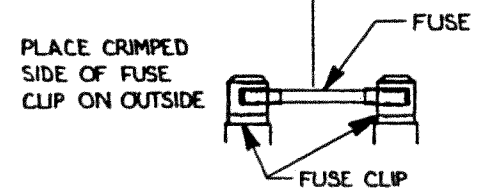
NOTES: Unless otherwise specified

1. SEE SEPERATE PARTS LIST
2. TO3 TRANSISTOR & HARDWARE IS INSTALLED AT NEXT ASSY.

REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED







FUSE SHOULD BE PUT INTO FUSE CLIPS BEFORE CLIPS ARE SOLDERED TO THE BOARD.

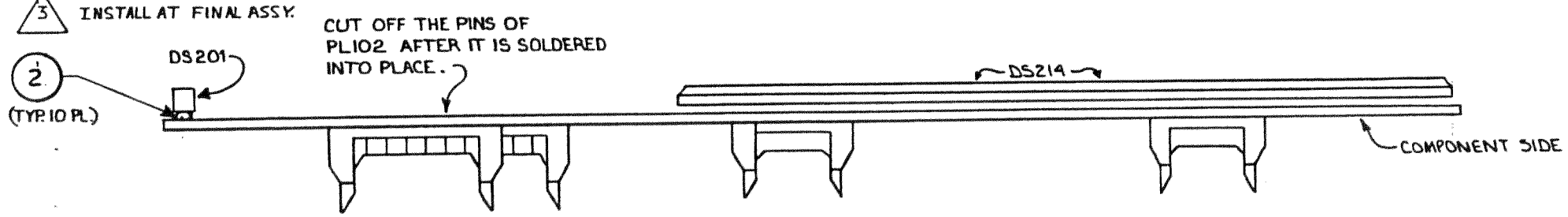
TOLERANCES: X° = ± 30′ .XX = ±.02 .XXX = ±.005	MATERIAL:	VALHALLA SCIENTIFIC 9955 MESA RIM ROAD, SAN DIEGO, CA 92121	
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS	FINISH:	TITLE: 4650 POWER SUPPLY ASSY	
MACHINED SURFACES ARE TO HAVE A FINISH OF 63	SCALE: NONE	STOCK NO. 30-00076	DRAWING NO. 4650-604
	SHEET 1 OF 1		REV: D

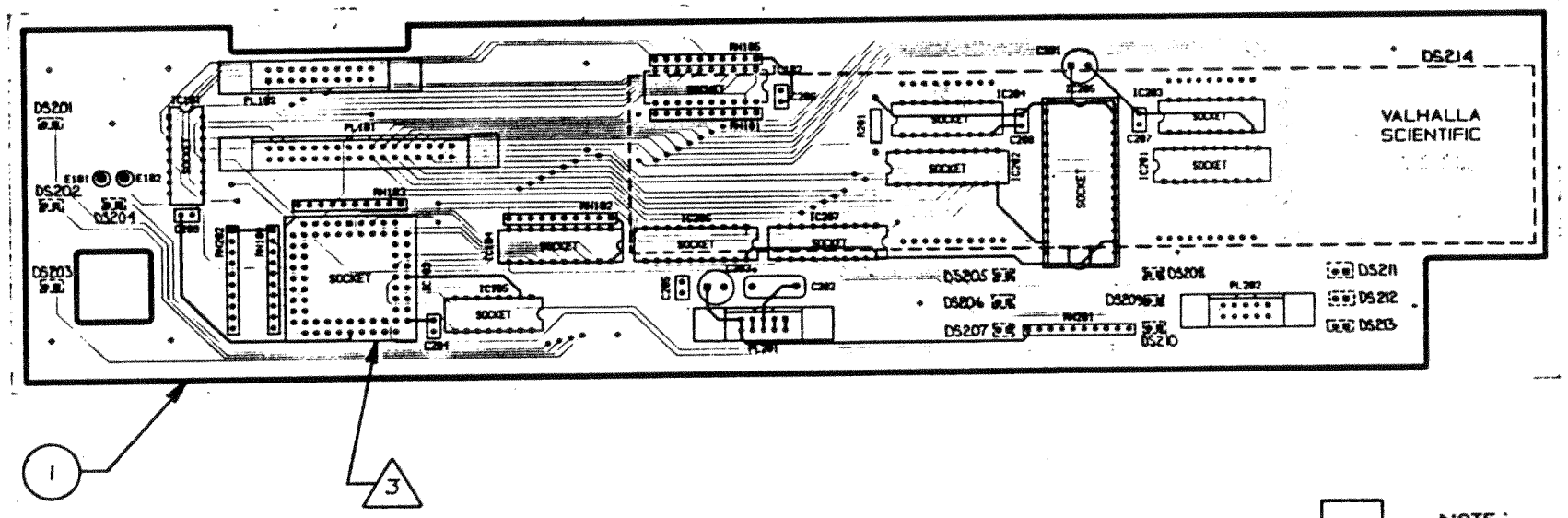
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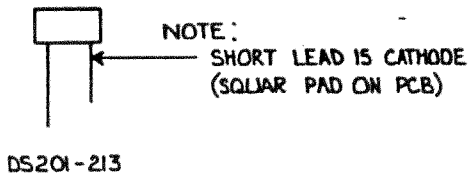
REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED

NOTES: Unless otherwise specified

1. THE FOLLOWING PARTS ARE TO BE PUT ON THE SOLDER SIDE OF THE BOARD: DS201 – DS219
2. INSURE LEDs ARE MOUNTED PERPENDICULAR TO PCB.
3. INSTALL AT FINAL ASSY.





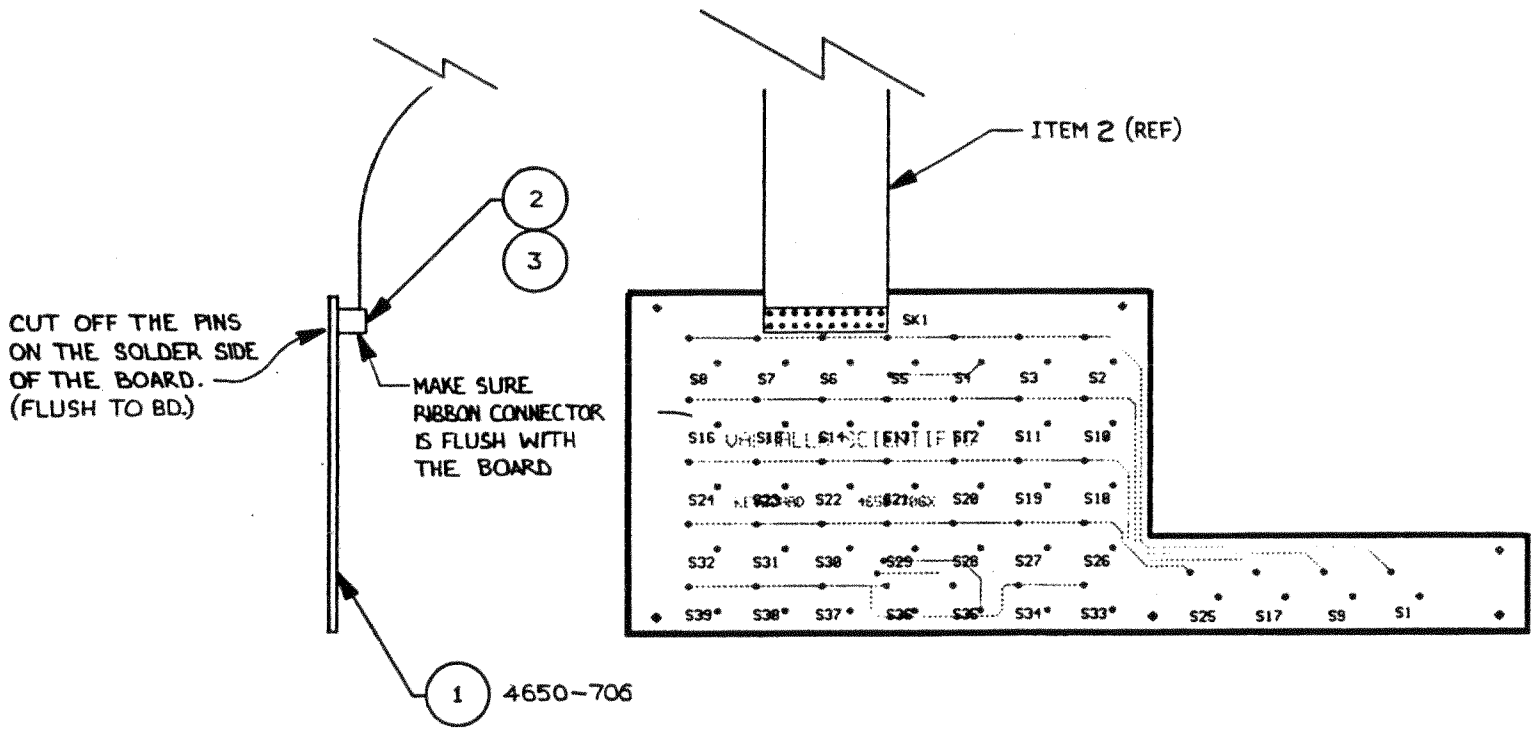


TOLERANCES: X° = ± 30′ .XX = ±.02 .XXX = ±.005	MATERIAL:		VALHALLA SCIENTIFIC 9955 MESA RIM ROAD, SAN DIEGO, CA 92121
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS	FINISH:	THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC INC. AND EXCEPT FOR RIGHTS EXPRESSLY GRANTED TO THE UNITED STATES GOVERNMENT, VALHALLA SCIENTIFIC INC. RESERVES ALL PATENT, DUAL, PROPRIETARY, DESIGN, MANUFACTURING, USE AND REPRODUCTION RIGHTS THEREIN.	TITLE: DISPLAY BOARD ASSY.
MACHINED SURFACES ARE TO HAVE A FINISH OF 63		SCALE: — SHEET 1 OF 1	STOCK NO. — DRAWING NO. 4650-603 REV: C

NOTES: Unless otherwise specified

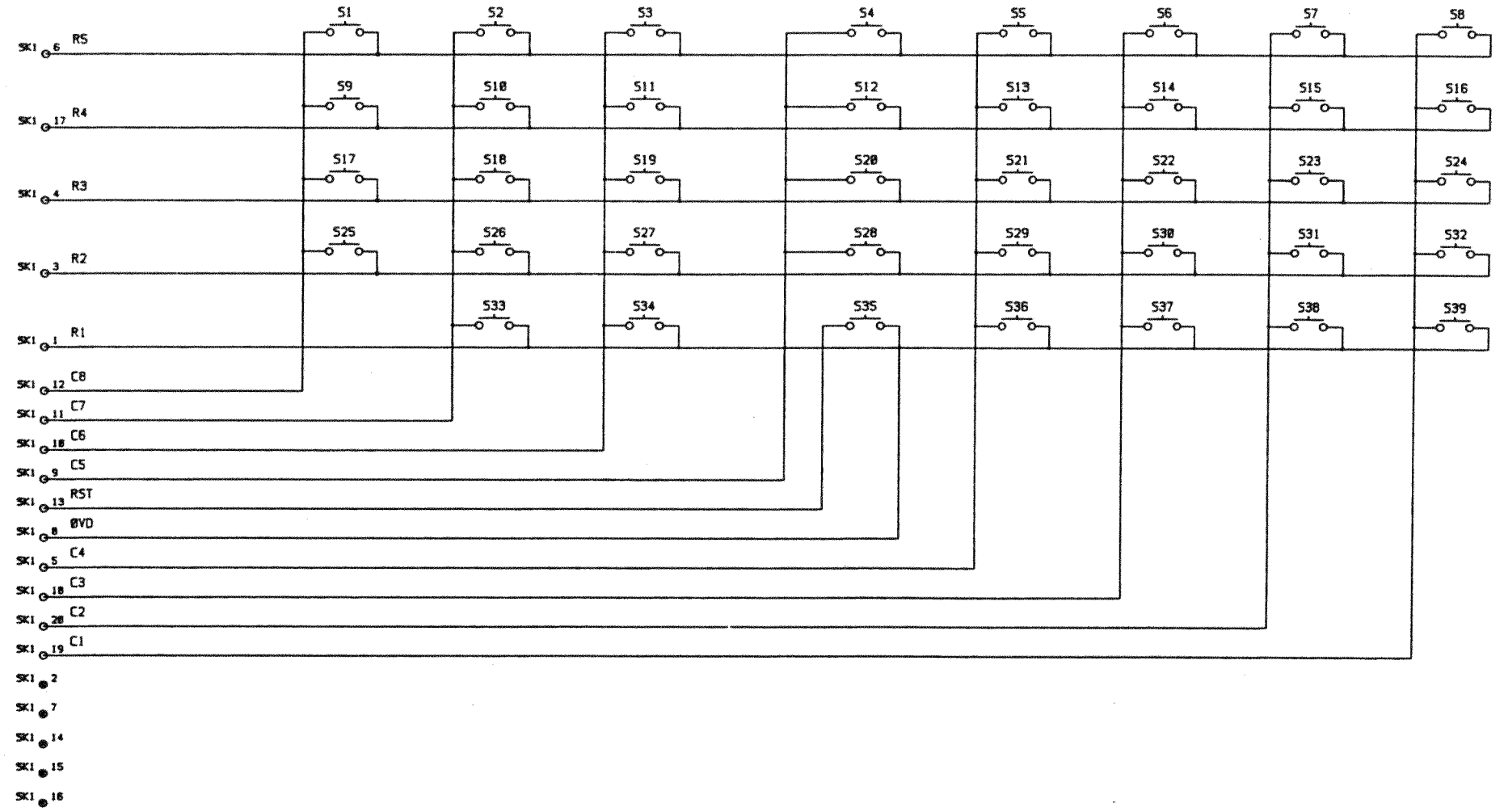
1. SEE SEPARATE PARTS LIST
2. BAG AND TAG WITH DRAWING NO., LATEST REV. LETTER AND STOCK NO.

REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED

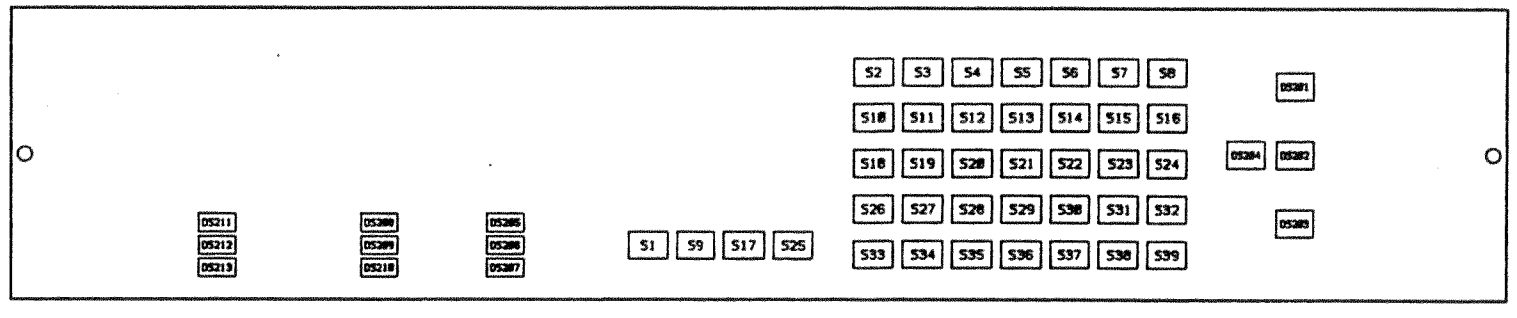


TOLERANCES: X° = ± 30' .XX = ±.02 .XXX = ±.005	MATERIAL: NONE	VALHALLA SCIENTIFIC 9955 MESA RIM ROAD, SAN DIEGO, CA 92121	
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MACHINED SURFACES ARE TO HAVE A FINISH OF 63	FINISH: NONE	SCALE: 1:1 SHEET 1 OF 1	STOCK NO. 30-00075 / DRAWING NO. 4650-606 / REV: B

REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED



4650 FRONT PANEL



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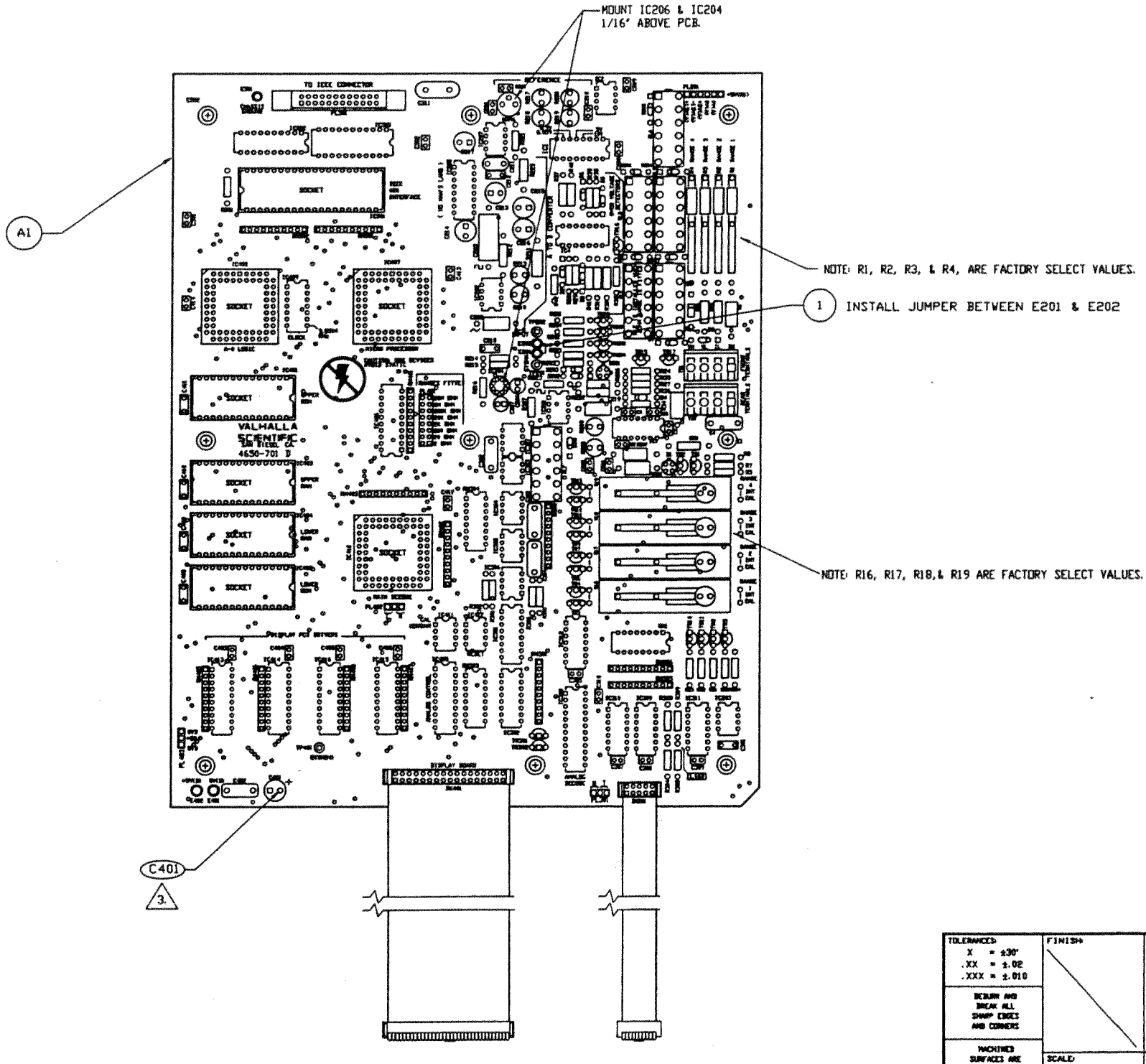
TITLE
4650 KEYBOARD

SHEET 1 OF 1 | DRAWING NO. 4650-076 | REV: A

NOTES UNLESS OTHERWISE SPECIFIED:

1. SEE SEPARATE PARTS LIST.
2. INSTALL C213, 214, 215, 216, 217, 206, AND 207 WITH POSITIVE LEAD IN SQUARE PAD.
3. INSTALL C401 WITH POSITIVE LEAD IN ROUND PAD.

REVISIONS			
ECO# LTR	DESCRIPTION OF CHANGE	DATE	APPROVED



TOLERANCES: X = ±.01, .XX = ±.02, .XXX = ±.010	FINISH:	MATERIAL:		VALHALLA SCIENTIFIC, 9955 MESA RIM RD. SAN DIEGO, CA 92121
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS				TITLE: PCB ASSY- 4650 MAIN BOARD
MACHINED SURFACES ARE TO HAVE A FINISH OF ▽	SCALE: 1 : 1	STOCK NO. 04-30305	THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC, INC. AND PROVIDED FOR SUCH PURPOSE GRANTED TO THE UNITED STATES GOVERNMENT. VALHALLA SCIENTIFIC, INC. RESERVES ALL PATENT, PROPRIETARY, DESIGN, MANUFACTURING, REPRODUCTION, USE AND SALE RIGHTS THEREIN.	SHEET 1 OF 1	DRAWING NO. 4650-601 M

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