

Model 4020

Digital Ohmmeter

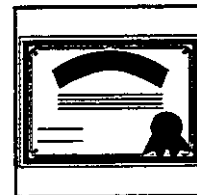
Operation Manual



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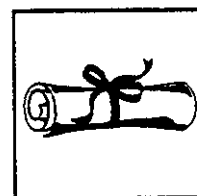
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CERTIFICATION



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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SECTION I UNPACKING & INSTALLATION



1-1. Introduction

Inspired by the need for a low-cost solution to the problems inherent in low resistance measurements, Valhalla Scientific developed the Model 4020 Digital Ohmmeter. The 4020 uses a true "four-wire kelvin" configuration in order to provide an accurate resistance measurement down to 1 milliohm resolution. The wide range of the 4020 allows measurement up to 1.9999 megohms. Four-wire resistance measurement is explained in more detail in Section 3.

The 4020 is available with a variety of test probes, accessories, and a BCD data output. The 4020 is also capable of being operated from an internal heavy-duty battery pack (optional). These items are explained in more detail in Section 2.

1-2. Initial Inspection

If the external shipping container shows evidence of damage, it should be immediately brought to the attention of the carrier and such damage noted on the bill of lading.

Unpack the instrument and retain the shipping container until the instrument has been inspected for possible damage in shipment. If shipment damage is apparent, notify the carrier and obtain authorization for repairs before returning the instrument to the factory. If the external shipping container shows evidence of damage, but the instrument shows no external damage, it may be advisable to check the performance of the unit using the adjustment procedure of Section 5 as a guide to determine that the instrument has not sustained hidden damage.

1-3. Power Requirements

The standard Model 4020 is fitted for operation from an AC power source such as municipal AC line power. It may also be modified for operation from an internal rechargeable battery pack. Battery operation is indicated by the lack of an AC power cord receptacle on the rear of the instrument.

For AC operation, the 4020 is shipped from the factory for operation at either 115VAC or 230VAC, 50 to 400 Hz. This voltage range is preset at the factory and should be specified when placing the order. All units are wired for 115VAC unless otherwise noted. When 115VAC is selected, the unit will operate at line voltages of 105 to 125 volts. If 230VAC is indicated, the unit will operate at line voltages of 210 to 250 volts. The rear panel line fuse value is 0.1 amp Slo-blo.

Battery operation is indicated by the presence of a battery charging jack on the rear panel of the instrument. In this case, the 4020 uses four (4) rechargeable nickel-cadmium batteries as its source of power. A battery charger is supplied with the 4020. The 4020 may be operated from the batteries for 12 hours (minimum) before requiring a recharge. The 4020 may also be operated directly from the charger if desired, or if batteries have become depleted. Use only the charging adapter provided or its equivalent to avoid internal damage. The line fuse installed for battery operation is a 2 amp fast-blo fuse.

1-4. Installation

If the Model 4020 is to be used in the bench-top configuration, installation requires only that the line cord be connected to the rear panel connector and the other end inserted into the appropriate wall receptacle. A rear-panel mounted fuse provides protection for the internal circuits.

If the unit is to be installed in a rack, assemble the ohmmeter into the rack mount adapter (Option R4) using the instructions included with the option. Then it is only necessary to locate the unit in the rack and make the power source and test lead connections.

The unit should be operated only in areas where the ambient temperature does not exceed 50°C. If the internal temperature of the rack system in which the unit is installed will exceed this temperature limit, forced air cooling should be employed to maintain the ambient air at or below the 50°C limit.

1-5. Safety Precautions

The Model 4020 is a very safe and easy to use device. Several items, however, are worth mentioning in order to obtain maximum utility and safety from your instrument.

- 1) For AC instruments, always use the three-terminal power cord provided or its exact equivalent. The 4020 requires a continuous ground connection for proper operation. If using an extension cord, ensure the ground connection is continuous throughout the extension.
- 2) For battery-operated instruments, use only the adapter provided or its exact equivalent. The batteries may be damaged by excessive charging currents.
- 3) The fuses for both AC and battery operated instruments are for the safety of the user as well as the instrument. Always replace blown fuses with their exact equivalent *only*!

- 4) If testing large inductive devices such as transformers, avoid drawing an arc when connecting or disconnecting the leads. This is best accomplished by selecting the highest resistance range (2M Ω) before making or removing connections.

1-6. Battery Pack (Operational Notes)

The Valhalla Model 4020 may be equipped for operation using an internal rechargeable nickel-cadmium battery pack. On battery operated units the fuse value is increased to 2A and the rear panel is modified to accept the charging adapter. This battery pack can power the ohmmeter for up to 12 hours before requiring a recharge. Should the batteries become fully discharged, it is recommended that the instrument be connected to the charging adapter for at least 24 hours prior to use. A more desirable method may be to use the instrument as much as necessary during the day, and connect it to the charger overnight.

Note: As a rule of thumb, the instrument requires twice as much time to recharge as the time it was in operation. (i.e. 4 hrs. charge for 2 hrs. use)



SECTION II SPECIFICATIONS & OPTIONS



2-1. General

This section contains descriptions of optional equipment, and operating and accuracy specifications for the Model 4020.

2-2. Optional Accessories

The standard 4020 is fitted for operation using standard AC line power at 115VAC. Included as standard accessories with the 4020 are a power cord and an Operation Manual. Several items that may be of interest for specific applications are described below.

2-2-1. Test Leads

This section details the different test lead sets available for use with the Model 4020 ohmmeter.

Option K: Kelvin Lead Set

Option "K" is a shielded, 4-wire Kelvin cable set, 48 inches in length terminated in "KCS" gold-plated clips. Option "K" is the recommended general purpose lead set for most applications.

Option KCS: Gold-Plated Clips

Option "KCS" are the gold-plated Kelvin clips used on the Option "K" lead set for 4-wire measurements of smaller components and leads. Clips open to 1/2".

Option MP-1: Kelvin Micro-Probes

Option "MP-1" is a 48-inch shielded Kelvin 4-wire cable set employing a set of Kelvin Micro-Probes. The probes are equipped with spring-loaded stainless steel tips with 0.05" spacing.

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 with 0.18" spacing.

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.

Option BBL: Banana-to-Banana Cable

Option "BBL" is a 48" shielded cable terminated on both ends in dual banana plugs. This cable may be used for voltage and current connections to the ohmmeter.

Option C: Banana-to-Clip Cable

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

Option KK: Heavy-Duty Lead Set

Option "KK" is a 48" four-wire kelvin lead set terminated in large "JAWS" for connection to larger bolts, bushings, and connectors. The JAWS have an open span of 2".

2-2-2. Other Accessories

This section details the variety of accessories available for use with the Model 4020.

Option CC4: Carrying Case

This item is a meter and accessory carrying-case designed to hold the 4020, probes and power cord while being transported from place to place. Option CC4 is made of black vinyl and includes a shoulder strap.

Option HDB: Battery Operation

The 4020 may be modified at the factory for operation from an internal rechargeable battery pack. This option was described in Section 1. Replacement batteries for Option HDB are available as Valhalla Stock #05-10117, quantity: 4.

Option A: AC Adapter

Option "A" is an AC to DC converter that is used to convert 115VAC line voltage into 6VDC @300mA which is required to recharge the batteries of a 4020 fitted with Option HDB. One Option "A" is provided if the 4020 has been fitted with Option "HDB". Additional adapters may be ordered as needed.

Option R4: Rack-Mount Adapter

This option is used to adapt the 4020 for installation in a standard 19" equipment rack.

Option BCD: Data Outputs

This optional output provides measurement data in a standard binary-coded-decimal format that may be used by the Valhalla Model 1248, or other types of data acquisition equipment. See section 3-6.

Model 1248: Dual-Limit Comparator

The Valhalla Model 1248 may be used in conjunction with a Model 4020 and Option BCD above. The Model 1248 is a dual-limit comparator that interprets the display indications of the 4020 as either "HI", "LO" or "GO", based on a tolerance that is set by the user. Relay contact closure is provided to trigger an alarm, batch sorter, counter or other device. The mating cable from the 4020 to the 1248 is 2½ feet in length and designated as "IDC-2".



2-3. Specifications

This section lists the operating and accuracy specifications for the Valhalla Scientific Model 4020 Digital Ohmmeter. Accuracies are valid at 25°C ±5°C for a period of one year from the date of calibration.

Table 2-1. Ranges, Resolutions and Accuracies

Range	Resolution	Maximum Input	Nominal Test Current	Accuracy
20Ω	1mΩ	19.999Ω	10mA	±0.05% of rdg, ±0.025% of rng
200Ω	10mΩ	199.99Ω	1mA	±0.05% of rdg, ±0.025% of rng
2KΩ	100mΩ	1.9999KΩ	100μA	±0.05% of rdg, ±0.025% of rng
20KΩ	1Ω	19.999KΩ	10μA	±0.05% of rdg, ±0.025% of rng
200KΩ	10Ω	199.99KΩ	1μA	±0.05% of rdg, ±0.025% of rng
2MΩ	100Ω	1.9999MΩ	100nA	±0.1% of rdg, ±0.1% of rng

Full Scale Test Voltage	200 millivolts
Current Source Compliance Voltage	5 volts
Terminal Configuration	4 - wire
Display Type	4½ digit LED's
Overrange Indication	Display flashes
Conversion Rate	4 per second
Temperature Coefficient	10 ppm/°C
Operating Temperature Range	0°C to 50°C
Power Source (Standard AC)	115 or 230 VAC, ±10%, 50Hz - 400Hz
Power Source (Optional DC)	(4) Rechargeable Nickel-Cadmium Batteries
Chassis Dimensions	10" W x 3" H x 9" D (25cm W x 7.5cm H x 23cm D)
Weight (AC power)	3 lbs (1.5kg) net; 5 lbs (2.5kg) shipping
Weight (Batteries)	4 lbs (2kg) net; 8 lbs (4kg) shipping



SECTION III OPERATION

3-1. General

This section of the manual contains complete operating instructions for the Model 4020 Digital Ohmmeter. A description of the front panel controls, connection instructions, and the theory behind 4-wire resistance measurement is discussed in this section.

3-2. Front Panel

» Power Switch

Power is applied to or removed from the internal circuits of the 4020 by this switch. On battery operated units, this switch does *not* need to be turned OFF in order to charge the batteries.

» Range Switch

The Model 4020 input range is selected by depressing the desired button on a multi-station interlocking push-button array located on the right-hand side of the front panel. The push-button for the lowest resistance range is nearest to the POWER switch.

3-3. Rear Panel

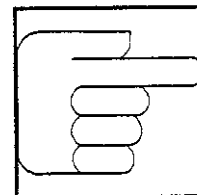
» Fuseholder

The fuseholder is mounted on the rear panel and is designed to protect the internal circuitry. For AC units, this fuse is a 0.1 Amp slo-blo fuse. In battery operated units, this fuse is used to protect the battery pack from excessive charging currents and is a 2 Amp fast-blo fuse. Replace blown fuses with the same type and rating only!

» AC Receptacle

The standard AC receptacle is a three-contact type where the third contact provides a

protective ground. Use the mating power cord provided or its exact equivalent.



» Charging Jack

For battery operated units, the battery charging jack is a barrel type and is located on the rear panel. The center pin of the connector is positive (+). The charging requirements of the internal battery pack are 6VDC @300mA. The correct charging voltage is supplied by the adapter included with the instrument. Additional adapters are available as Option "A".

3-4. 4-Wire Resistance Measurement

The four-terminal configuration of the 4020 eliminates errors normally caused by test lead and contact resistances. In many applications the contact and lead resistance can exceed the value of the load by several orders of magnitude. The 4020 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 3-1 illustrates how the 4-wire principle is used to eliminate test lead 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.

3-5. Connections

Connections are made to the front panel terminals using a 4-wire configuration as described in section 3-4. When using Valhalla test leads, the tabbed side of the banana jack is plugged into the **current** terminals. This ensures that the current is carried in the largest conductor and that the voltage input is shielded.

V_{HI}^* $*I_{HI}$ ←Tab

V_{LO}^* $*I_{LO}$ ←Tab

All Valhalla ohmmeters use a high impedance voltmeter as part of the resistance measurement process. This voltmeter is a highly accurate and stable 4½ digit analog-to-digital converter (A to D). Unless it is receiving a definite input signal, the output reading of this A to D is ambiguous. The display may indicate a randomly wandering number or it may indicate an overrange condition. This unpredictable display may make it seem to appear that the instrument is experiencing some sort of malfunction. It is, in fact, just a characteristic of the voltmeter circuit and should not be mistaken for a fault in the instrument.

The display indications should be ignored unless there is a definite measurement being taken. If this wandering display is not acceptable, the ohmmeter can be made to indicate an overrange condition whenever the terminals are open by using a 4-wire Kelvin type lead set, or by shorting the V_{HI} and I_{HI} terminals together.

The display should indicate a stable reading when the test leads are securely attached to the device under test. If the display appears to be erroneous when connected to a load, recheck the test leads for integrity and cleanliness. If all external items appear to be functioning properly, the problem may be the ohmmeter. In this case, please contact your local Valhalla Scientific Sales Office.

3-6. BCD Operation (Optional)

The Model 4020 may be equipped with a Binary Coded Decimal data output. This output is designed for use with the Valhalla Model 1248 Comparator, but may be used for other applications as well. See the Model 1248 Operation Manual for details on interfacing with this device.

For custom applications, refer to the schematic 4500-077 at the end of this manual. The outputs are TTL compatible and may drive 1 LS TTL load.

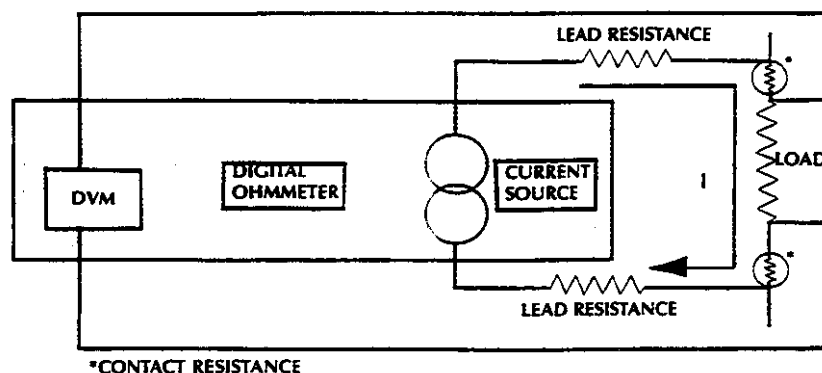


Figure 3-1. Error Sources in Resistance Measurements



SECTION IV THEORY OF OPERATION



4-1. General

The Valhalla Model 4020 Digital Ohmmeter is shown in block diagram form in Figure 4-1. It consists of an ohms-to-DC converter (constant current source) and an analog-to-digital converter (voltmeter). The unknown resistance is measured by the ohms-to-DC converter. Its output is a DC voltage precisely proportional to the unknown resistance. This precise DC voltage is converted from analog to digital form by the A/D converter which then displays it as the resistance value.

The Model 4020 uses solid state semiconductors exclusively and CMOS circuits extensively, thereby minimizing power consumption and making battery operation practical.

4-2. Functional Description

Refer to Figure 4-1, the 4020 block diagram; and Figure 4-2, the timing diagram for the A/D converter. The ohms converter accurately produces a DC voltage proportional to the unknown resistance being measured. The ohms converter output is conditioned by the range switches prior to being sent to the preamplifier.

During the RESTORE period of Figure 4-2 the offsets and/or drift of the integrator are nulled so that its output is at true zero at the beginning of the INTEGRATE period. During the 100 msec INTEGRATE period, the multiplexer connects the input of the preamplifier to the output of the ohms converter. The level of integrator output is proportional to the value of the resistor under test.

At the end of the first part of the INTEGRATE period, the multiplexer

switches the input of the preamplifier to the reference, which is of opposite polarity. The time (T_x) required for the output of the integrator to return to zero during the second integration is also proportional to the value of the resistor under test.

Integration ends when the output of the integrator crosses zero (as determined by the zero detector) which triggers the logic circuits. This second integration period (T_x) is measured by the counter which is crystal controlled for accuracy. The count is latched into the display circuits from the end of the counting period (T_x) until the end of the next cycle when it is updated.

4-3. Detailed Circuit Descriptions

The detailed descriptions in this section are referenced to the 4020 schematic diagram at the back of this manual, drawing number 4020-070. References to integrated circuits are made in the format IC# - pin# (i.e. IC15-4 would indicate "Integrated Circuit 15, pin 4").

A/D Converter

The Model 4020 incorporates a three-step integrator that manipulates the output of the ohms-to-DC converter for presentation on the display. The initial step, RESTORE mode, lasts 200 msec. During this period, the input to preamplifier IC12 is grounded through one section of quad-bilateral switch IC2. The "sample and hold" switch (Q15) is turned on and closes the feedback loop around integrator IC13 and zero detector IC14. This forces the zero detector output to zero, and capacitor C21 charges to the level of any offset voltage present in the preamplifier, integrator, or zero detector.

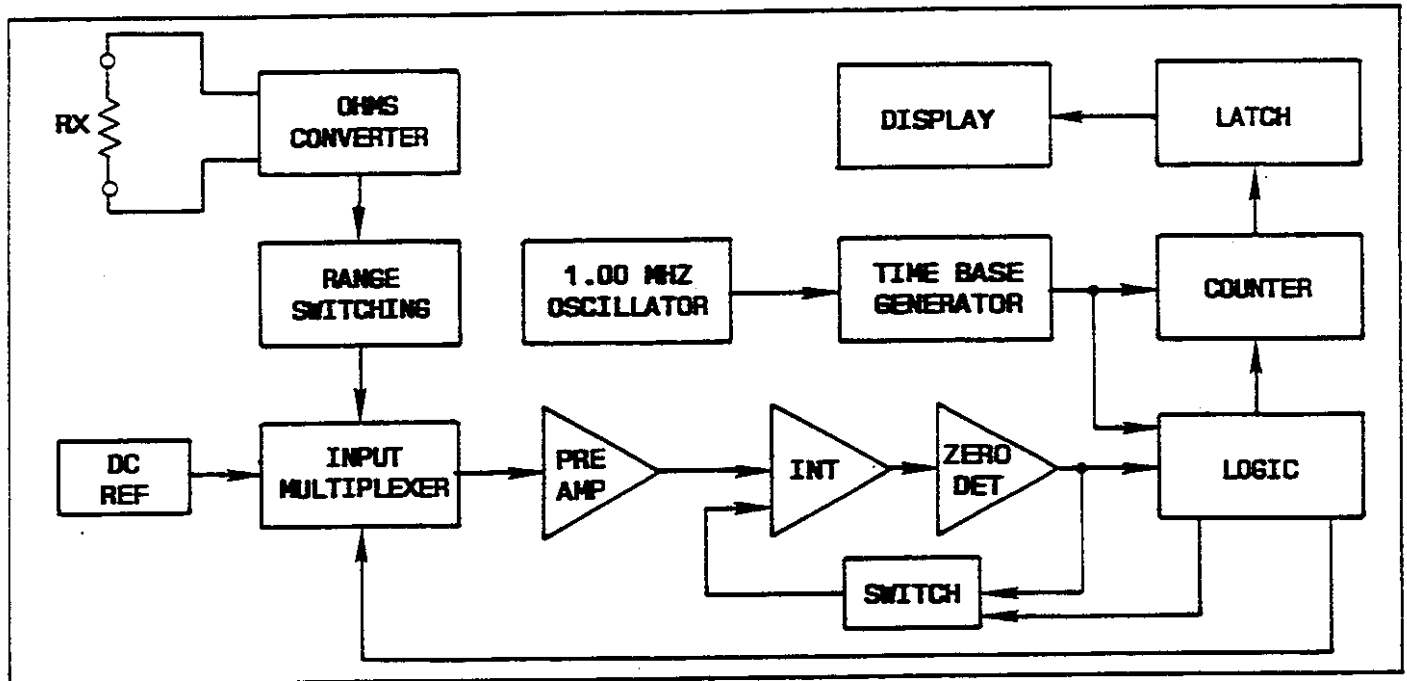


Figure 4-1. Model 4020 Block Diagram

With capacitor C21 charged to offset any zero error present, the second step of the digitizing process begins. Q15 is switched off opening the feedback loop. The ohms-to-DC converter output is applied to the input of unity gain amplifier IC12. The output of this preamplifier is applied to the integrator input.

During the 100 msec INTEGRATE period, the integrator output rises to a level proportional to the input voltage (resistor under test). The output of the zero detector which senses the integrator output delivers a control voltage to the *D* input of IC6-5.

At the end of the INTEGRATE period the input of IC12 is disconnected from the ohms-to-DC converter output, and the control signal at IC6-5 is clocked through the flip-flop to IC6-1 which is its *Q* output. This connects the reference voltage (E_{ref}) to the input of IC12. The polarity of E_{ref} is opposite to that of the ohms-to-DC converter output.

With E_{ref} applied to the input of the preamplifier, IC13 (the integrator previously charged to the ohms-to-DC converter output) begins to charge in the opposite direction towards the value of E_{ref} .



Time T_x (step 3 of Figure 4-2) is the time required for the integrator voltage to decrease to zero volts, and is directly proportional to E_x (the unknown voltage drop across the resistor under test):

$$E_x \div E_{ref} = T_x \div 100\text{msec}$$

The formula shows that the value of E_x can be determined by measuring T_x .

The actual digitizing process is performed when IC7 counts the cycles of the crystal controlled clock during the T_x time period. When the zero detector output passes through zero due to E_{ref} integration, the count process is halted, totaled and displayed on the digital readout. Simultaneously the zero detector sets the monostable (composed of IC4-10 and IC4-11) which returns the A/D converter to the RESTORE mode.

Reference Amplifier

The precision reference (E_{ref}) required to perform Step 3 of the A/D conversion is produced by IC15 in conjunction with CR17. Current for the reference zener CR17 is provided by the constant current source, Q9.

The zener voltage is sensed at the noninverting input of IC15-2. Feedback from IC15-1 to IC15-2 sets the output of IC15-1 to approximately -1.05 volts. This voltage is applied to quad bilateral switch IC2-1. During Step 3 of the A/D converter timing, this voltage is also applied to the resistor divider composed of R20, R22, R23 and R24.

Quad bilateral switch IC3 connects the -1V to the input of preamplifier IC12 through the arm of R23.

Ohms-to-DC Converter

The purpose of the ohms-to-DC converter is to generate a stable, constant source of current that is passed through the resistor

under test in order to develop a voltage across it. The A/D converter measures this voltage and interprets it as the resistance value which is then placed on the display.

Constant Current Source

The constant current source (CCS) is part of the ohms-to-DC converter and is the core of the instrument. The CCS is composed of a section of IC15, IC17, Q8 and precision resistors R115 - R119.

The input to the CCS is approximately +1.05 volts. This +1.05 volts is produced by inverting the reference voltage E_{ref} mentioned in the "A/D converter" section.

The amplifier of IC15-14 is used as an inverter with variable gain. The output current level is adjusted by varying R69. The amplifier of IC15-8 has unity gain due to the feedback through R74. Its output is applied to the inverting input of IC17-3. The circuit operates through several feedback loops to maintain the inverting and noninverting inputs of IC17 at the same level. A simplified version of this circuit is shown in Figure 4-3 and described below.

The heart of the CCS is the voltage-to-current converter (Transconductance Amplifier U.S. Patent No. 4,091,333) which is discussed in detail in the next section.

Transconductance Amplifier

Refer to Figure 4-3. Assume that the terminals I_{HI} and I_{LO} are shorted, and +1 volt is applied to the input terminals so that I_{HI} is positive. To equalize the inputs of IC17, IC15 must be driven to zero. This occurs only when the voltage drops across R73 and R77 are equal to the drops across R74 and R76.



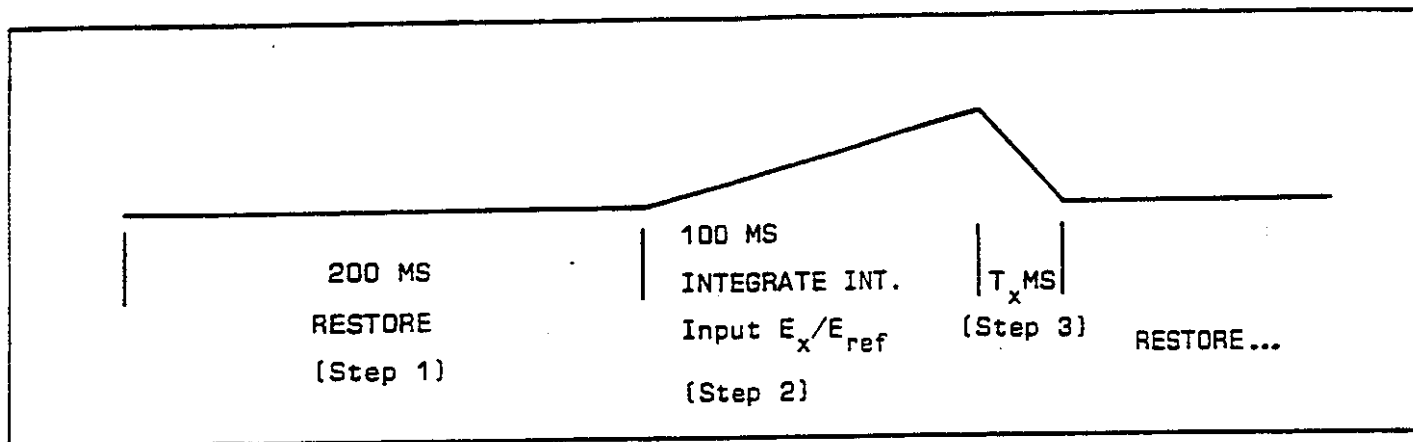


Figure 4-2. Analog-to-Digital Converter Timing

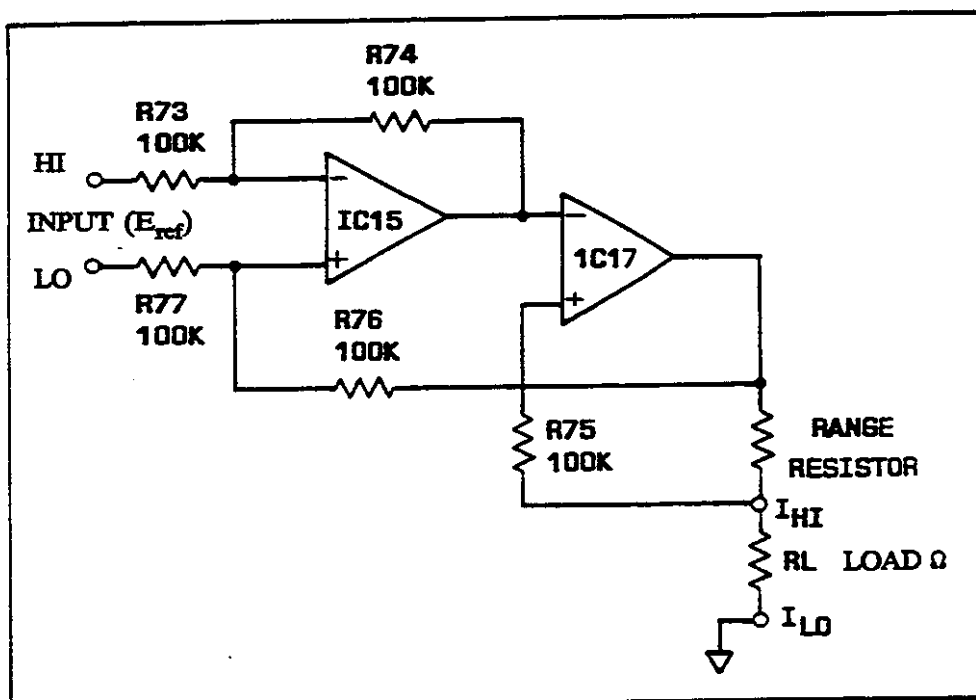


Figure 4-3. Transconductance Amplifier (Simplified)

Protected by U.S. Patent No. 4,091,333



For these voltage drops to be equal, the output of IC17 must be +1 volt. Since the output of IC15 must be zero, the drop across R74 is 0.5V making the inverting input level 0.5V. The drops across R73, R76 and R77 will also be 0.5V.

Since the inputs to IC15 are essentially equal its output is zero, offset by the few microvolts necessary to drive IC17 to +1 volt. Under these conditions the sum of the voltages across R73, R74, R76 and R77 equals the sum of the input voltage (1V) and the output of IC17 (1V). The inverting input of IC17 is zero.

If the short is removed and R_L replaced with a 100 Ω resistor, the current through R_L will cause the input voltage of IC15 to be higher.

A balanced condition will be reached when the output of IC15 is equal to the noninverting input of IC17. This condition occurs when the drops across R73 and R77 are equal to the drops across R74 and R76. At this time the output of IC17 is 2 volts. The range resistor is usually equal to $\frac{1}{2}$ the full scale range resistance (i.e. 100 Ω for the 200 Ω range). Therefore the voltage drop across the range resistor is 1 volt and the current through the load resistor R_L is 10 mA. The amount of current flow is constant regardless of the value of the load due to the feedback to IC17.

Digital Display

At the completion of the A/D conversion process, the count is stored in four registers of IC7. IC7 also contains an internal oscillator which is set by C4 to 10 KHz.

IC7 output DATA terminals 1, 2, 23 and 24 are connected to decoder/driver IC10. These outputs contain the BCD code used to illuminate the appropriate segments of the 7-segment LED's. These outputs are linked to the outputs at IC7 pins 6-9. Pins 6-9 are enabled in sequence to turn on the

appropriate display device when its data appears on pins 1, 2, 23 and 24.

For example, when the MSB data is present on the DATA terminals, Q5 is turned on to enable DS2 to receive and display the data. The repetition rate is sufficiently high so that the display appears to be continuous.

4.4. Power Supplies

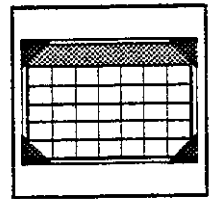
The 4020 operates from three supplies: +5V, -5V and -10V. The +5V supply is rectified by CR26 and CR27 and regulated by IC24 in AC units. The +5V supply is provided directly by the batteries in DC units. The other power supplies are identical in either AC or DC units.

The -10V supply is the result of a DC-to-DC converter composed of Q11, Q12, T1, CR19, CR20 and associated components.

The -5V supply is regulated by IC22 from the -10V supply mentioned above.



SECTION V ROUTINE MAINTENANCE



5-1. General

This section of the manual contains routine maintenance information regarding the Valhalla Scientific Model 4020 Digital Ohmmeter. Calibration should be performed on a regular basis to ensure continued instrument accuracy. The recommended calibration interval is 1 year.

5-2. Required Test Equipment

Below is a list of the standard resistors required to calibrate the Model 4020.

Precision Resistors:

- 10 ohms \pm 0.005% Accuracy
- 100 ohms \pm 0.005% Accuracy *
- 1000 ohms \pm 0.005% Accuracy *
- 10000 ohms \pm 0.005% Accuracy *
- 100K ohms \pm 0.005% Accuracy *
- 1.0M ohm \pm 0.01% Accuracy *

*The Valhalla Model 2724A may be used for 100 Ω and above.

Test Leads:

- 4-wire lead set
(Valhalla Option "K" or "C")

5-3. Calibration Procedure

The 4020 should be allowed to warm-up for a minimum of 5 minutes before beginning the procedure. The adjustments are accessed by removing the four feet screws, then lifting off the top cover only. The locations of the adjustments are shown on drawing number 4020-600 at the back of this manual.

5-3-1. Linearity Adjustments

1. Select the 20K Ω range. Connect the Kelvin clips to the 10 ohm standard resistor.
2. Adjust potentiometer R60 for a display indication of 0.010.
3. Short all four leads of the 4020 together and adjust R3 for a display of 0.000.

5-3-2. Full Scale Adjustment

1. Select the 20K Ω range. Connect the Kelvin clips to the 10000 ohm standard resistor.
2. Adjust R69 for a display indication of 10.000.
3. Select the 2M Ω range. Connect the 4020 to the 1.0M Ω standard resistor.
4. In necessary, adjust varicap C43 for a display of 1.0000 \pm 30 counts. If adjustment was needed, go to step 1.

■ The 2M Ω range uses just 100 *nano*-amps of test current to make the resistance measurement. This amount of current can easily be disturbed by movement of people or objects in the test area. When adjusting this range, keep movement to a minimum.

5. Check all remaining ranges with the appropriate standard resistors. The maximum allowed deviation for the lower ranges is \pm 10 counts. The maximum allowed deviation for the 2M Ω range is \pm 30 counts. See Section 2 for complete specifications.

End of procedure. ■

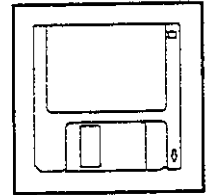
5-4. Battery Replacement Instructions

The rechargeable ni-cad batteries used in the 4020 (if installed) are very durable and should provide years of trouble-free operation. As with all batteries, replacement will eventually be necessary. Batteries may be ordered from Valhalla Scientific as stock #05-10117, quantity: (4). The process of battery replacement is described below:

- 1) Remove the four feet screws and the bottom cover.
- 2) Undo the reusable tie-wraps by pushing down on the locking pin.
- 3) Remove the old batteries and replace. **Observe polarity!**
- 4) Secure the new batteries in place by re-tightening the tie-wraps.
- 5) Replace the cover and feet screws, taking care not to pinch any wires.



SECTION VI PARTS LISTS



The following parts lists are included in this manual:

4020-400	4 pages	4020 AC Final Assembly
4314-614	1 page	HCTR4010 (IC7) Replacement PCB Assembly
4020-401	1 page	4020 AC to DC Conversion
4500-607	1 page	4020 Option BCD Assembly

REF.DES.	STOCK #	QUANTITY			DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
		A	T	N			
1	04-30009	1			4440 Main Board	DWG 4440-700	
2	04-30010	1			4440 Display Board	DWG 4440-701	
3	04-10534	1			4020 Front Panel (screened)	DWG 4020-100 using 04-10253	
4	05-10198	4			Spacer, 1/4 dia, 1/8 lg, #4, nylon	Smith 8880	
5	05-10199	4			Washer, fib, 1/4 od, 7/64 id, 1/16 tall	Smith 2161	
6	90-04608	4			#4 x 1/2" Self-Tap Phil Pan S.S. Type AB		
7	04-10130	1			Chassis	PAKTEK CH250-BETGE ETC.	
8	05-10278	1			Nut, Panel, blind	CKR 7099	
9	05-10277	6			Knob, silver	Centralab B-426	
10	80-00014	5			14AWG Buss Wire	ANIXTER 1BB-1401	
11	80-01622	10			22AWG Wire, Blue PVC	M16878/1-BFE-6	
12	80-01022	10			22AWG Wire, Black PVC	M16878/1-BFE-0	
13	80-01922	7			22AWG Wire, White PVC	M16878/1-BFE-9	
14	80-01222	7			22AWG Wire, Red PVC	M16878/1-BFE-2	
16	04-10236	1			4440 Rear Panel (AC unit)	DWG 4440-215	
19	90-06008	4			#6-32 x 1/2 Phil Pan S.S.		
20	98-06001	3			#6 Split Lock Washer, STD, S.S.		
21	05-10086	1			Solder lug, #6, internal star	Smith 1412-6	
22	97-06001	4			#6-32 Hex Nut, Small Pattern, Stainless-Steel		
23	05-10019	10			Cable tie, 4"x 1/8"	Panduit WRN-4	
24	80-10174	24			RG174/U Coax Cable, 50 ohm	Belden 8216	
104	80-00022	11			22AWG Buss Wire	1BB-2201 ANIXTER	
114	70-11020	7			20awg TFE Sleeving	Atlantic TPT 20	
C1	02-60019	1			2200pF 100V Mylar	WIMA FK52-2200P	
C2	02-10009	1			0.001uF 50V Ceramic Disc	NIC MCD102KIVX5P	
C3	02-10000	1			0.005uF 100V Ceramic Disc	SPRAGUE 56AD50	
C4	02-10002	1			500pF 100V Ceramic Disc	SPRAGUE 56AT50	
C7	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C8	02-10009	1			0.001uF 50V Ceramic Disc	NIC MCD102KIVX5P	
C10	02-10000	1			0.005uF 100V Ceramic Disc	SPRAGUE 56AD50	
C12	02-10000	1			0.005uF 100V Ceramic Disc	SPRAGUE 56AD50	
C13	02-10000	1			0.005uF 100V Ceramic Disc	SPRAGUE 56AD50	
C20	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C21	02-50000	1			0.22uF 10% 50V Polystyrene	IMB PA2A224K	
C22	02-10005	1			50pF 500V Ceramic disc	Illinois 500BCR050K	02-20002
C23	02-10004	1			0.02uF 500V Ceramic disc	SPRAGUE 140CD50029-203Z	
C26	02-10007	1			330pF 1000V Ceramic disc	SPRAGUE 56AT33	
C27	02-10007	1			330pF 1000V Ceramic disc	SPRAGUE 56AT33	
C32	02-30003	1			47uF 10V Tantalum Bead	AVX TAP476M020SP	
C33	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C34	02-10009	1			0.001uF 50V Ceramic Disc	NIC MCD102KIVX5P	
C35	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C36	02-10000	1			0.005uF 100V Ceramic Disc	SPRAGUE 56AD50	
C41	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C43	02-70001	1			2-12p Top Adjust	Mouser 24AA061	
C44	02-40004	1			2200uF 16V Aluminum	Illinois 228TTA016	
C45	02-10004	1			0.02uF 500V Ceramic disc	SPRAGUE 140CD50029-203Z	
C46	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C50	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
CR2	03-20000	1			Diode, general purpose	1N4148 or 1N914	
CR9	01-01021	1			100 5% 1/4W Carbon Film	RC07GF101J	

REF.DES.	STOCK #	QUANTITY	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
		A T N			
C101	02-10007	1	330pF 1000V Ceramic disc	SPRAGUE 56AT33	
C102	02-10007	1	330pF 1000V Ceramic disc	SPRAGUE 56AT33	
C201	02-60017	1	0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C202	02-60017	1	0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C203	02-60017	1	0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C204	02-60017	1	0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C205	02-30004	1	1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C206	02-60017	1	0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
C207	02-60017	1	0.1uF,63V,Mylar,5%	WIMA MKC2-0.1uF	
CR17	03-20041	1	Zener, reference, 6.3V, 20ppm/C, 5%	1N825	
CR18	03-20002	1	Diode, rectifier, 1A, 50V	1N4001-1N4007	
CR19	03-20000	1	Diode, general purpose	1N4148 or 1N914	
CR20	03-20000	1	Diode, general purpose	1N4148 or 1N914	
CR26	03-20002	1	Diode, rectifier, 1A, 50V	1N4001-1N4007	
CR27	03-20002	1	Diode, rectifier, 1A, 50V	1N4001-1N4007	
CR28	03-20000	1	Diode, general purpose	1N4148 or 1N914	
CR29	03-20000	1	Diode, general purpose	1N4148 or 1N914	
CR30	03-20000	1	Diode, general purpose	1N4148 or 1N914	
CR31	03-20000	1	Diode, general purpose	1N4148 or 1N914	
DS1	05-01020	1	LED Display, +/-1, Red	HP 5082-7656, Bin C or D only	
DS2	05-01010	1	LED Display, 7-Segment (0-9), Red	HP 5082-7650 Bin C or D only	
DS3	05-01010	1	LED Display, 7-Segment (0-9), Red	HP 5082-7650 Bin C or D only	
DS4	05-01010	1	LED Display, 7-Segment (0-9), Red	HP 5082-7650 Bin C or D only	
DS5	05-01010	1	LED Display, 7-Segment (0-9), Red	HP 5082-7650 Bin C or D only	
D201	03-20006	1	Diode, low leakage	1N3595	
D202	03-20006	1	Diode, low leakage	1N3595	
D203	05-01011	1	LED,Red,Panel Mount	Micro Elec. MRB51D	
D204	03-20006	1	Diode, low leakage	1N3595	
D205	03-20006	1	Diode, low leakage	1N3595	
F1	05-04000	1	0.1 Amp slo-blo fuse	Littlefuse 313-.10A	
FX1	05-10521	1	Fuse holder, panel mount	Littlefuse 342004	
IC1	03-30022	1	LCD Display Driver (CMOS)	4054BE	
IC2	03-30023	1	Quad Analog Switch (CMOS)	4066BF (Ceramic)	
IC4	03-30024	1	Quad 2 Input NOR (CMOS)	4001BE	
IC5	03-30025	1	Quad 2 Input Exclusive OR (CMOS)	4030BE	
IC6	03-30026	1	Dual D-Type Flip Flop (CMOS)	4013BE	
IC7	30-00156	1	HCTR4010 Replacement Board Assembly	ASSY 4314-614	
IC8	03-30026	1	Dual D-Type Flip Flop (CMOS)	4013BE	
IC9	03-30027	1	Quad 2 Input NAND (CMOS)	4011BE	
IC10	03-30106	1	BCD to 7-Segment decoder/driver	74LS47N	
IC11	03-30012	1	A to D Converter Logic	Mostek MK5009	
IC12	03-30315	1	Precision JFET Op Amp	Burr Brown OPA103CM	
IC13	03-30017	1	Op-Amp,Uncompensated	LM308H	
IC14	03-30013	1	Op-Amp,General Purpose,Uncompensated	LM301AH or LM301AN	
IC15	03-30031	1	Quad Op-Amp,General Purpose	LM324N	
IC17	03-30074	1	General Purpose JFET Op-Amp,Metal Can	LF356H	
IC22	03-30035	1	Regulator,-5V,0.5A,T0202 or T0220	79M05CP or LM320T-5.0	
IC24	03-30034	1	Regulator,+5V,0.5A,T0202 or T0220	78M05CP or LM340T-5.0	
IC25	05-02007	1	Programmable Osc.,8.3Hz-1MHz	Statek,PX01000KH2A	
IC201	03-30170	1	Low Noise, low drift Op-amp	OP07DP	
IC202	03-30487	1	Low Noise Chopper Amplifier(8 pin)	LTC1052CN8	

REF.DES.	STOCK #	QUANTITY	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
		A T N			
IC203	03-30487	1	Low Noise Chopper Amplifier(8 pin)	LTC1052CN8	
J1	05-10030	1	Banana jack, red	Pomona 1581-2	
J2	05-10030	1	Banana jack, red	Pomona 1581-2	
J3	05-10031	1	Banana jack, white	Pomona 1581-9	
J4	05-10063	1	Connector, AC, receptacle	Switchcraft EAC-301	
J5	05-10031	1	Banana jack, white	Pomona 1581-9	
Q1	03-10003	1	NPN Darlington Transistor (TO92)	2N5172	
Q2	03-10003	1	NPN Darlington Transistor (TO92)	2N5172	
Q3	03-10003	1	NPN Darlington Transistor (TO92)	2N5172	
Q4	03-10003	1	NPN Darlington Transistor (TO92)	2N5172	
Q5	03-10003	1	NPN Darlington Transistor (TO92)	2N5172	
Q8	03-10015	1	NPN Transistor (TO220)	MJE3439	
Q9	03-10000	1	N-Channel JFET	U1899E or 2N4392	
Q11	03-10013	1	NPN Transistor (TO92)	2N4401	
Q12	03-10013	1	NPN Transistor (TO92)	2N4401	
Q15	03-10004	1	P-Channel JFET	P1087E (selected)	
Q17	03-10010	1	PNP Transistor (TO92)	2N4402	
R1	01-01073	1	47K 5% 1/4W Carbon Film	RC07GF473J	
R2	01-01073	1	47K 5% 1/4W Carbon Film	RC07GF473J	
R3	01-50005	1	50K Single Turn	CTS X201R505	
R4	01-01073	1	47K 5% 1/4W Carbon Film	RC07GF473J	
R5	01-01081	1	100K 5% 1/4W Carbon Film	RC07GF104J	
R6	01-01073	1	47K 5% 1/4W Carbon Film	RC07GF473J	
R7	01-01073	1	47K 5% 1/4W Carbon Film	RC07GF473J	
R10	01-01028	1	270 5% 1/4W Carbon Film	RC07GF271J	
R11	01-01028	1	270 5% 1/4W Carbon Film	RC07GF271J	
R12	01-01028	1	270 5% 1/4W Carbon Film	RC07GF271J	
R13	01-01028	1	270 5% 1/4W Carbon Film	RC07GF271J	
R14	01-01028	1	270 5% 1/4W Carbon Film	RC07GF271J	
R15	01-01028	1	270 5% 1/4W Carbon Film	RC07GF271J	
R16	01-01028	1	270 5% 1/4W Carbon Film	RC07GF271J	
R17	01-01028	1	270 5% 1/4W Carbon Film	RC07GF271J	
R19	01-01021	1	100 5% 1/4W Carbon Film	RC07GF101J	
R21	01-10000		1 Factory Select Resistor	RN60C???	
R22	01-10038	1	90.9K 0.1% 50ppm/C 1/4W Metal Film	RN60C9092B	
R23	01-50000	1	100 Single Turn	CTS X201R101	
R24	01-10037	1	10K 0.1% 50ppm/C 1/4W Metal Film	RN60C1002B	
R28	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R29	01-10039	1	274K 1% 50ppm/C 1/4W Metal Film	RN60C2743P	
R30	01-01080	1	91K 5% 1/4W Carbon Film	RC07GF913J	
R48	01-01073	1	47K 5% 1/4W Carbon Film	RC07GF473J	
R49	01-01018	1	75 5% 1/4W Carbon Film	RC07GF750J	
R50	01-01045	1	2K 5% 1/4W Carbon Film	RC07GF202J	
R51	01-01041	1	1K 5% 1/4W Carbon Film	RC07GF102J	
R52	01-01065	1	20K 5% 1/4W Carbon Film	RC07GF203J	
R53	01-01051	1	3.9K 5% 1/4W Carbon Film	RC07GF392J	
R54	01-01128	1	1000M 5% 1/4W Carbon Film	RC07GF108J	
R55	01-01045	1	2K 5% 1/4W Carbon Film	RC07GF202J	
R56	01-01007	1	10 5% 1/4W Carbon Film	RC07GF100J	
R57	01-01086	1	220K 5% 1/4W Carbon Film	RC07GF224J	
R58	01-10000		1 Factory Select Resistor	RN60C???	

REF.DES.	STOCK #	QUANTITY			DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
		A	T	N			
R59	01-10037	1			10K 0.1% 50ppm/C 1/4W Metal Film	RN60C1002B	
R60	01-50005	1			50K Single Turn	CTS X201R503	
R62	01-10037	1			10K 0.1% 50ppm/C 1/4W Metal Film	RN60C1002B	
R64	01-01053	1			4.7K 5% 1/4W Carbon Film	RC07GF472J	
R65	01-01028	1			270 5% 1/4W Carbon Film	RC07GF271J	
R66	01-10037	1			10K 0.1% 50ppm/C 1/4W Metal Film	RN60C1002B	
R67	01-10215	1			1.65K 1% 50ppm/C 1/4W Metal Film	RN60C1651F	
R68	01-10037	1			10K 0.1% 50ppm/C 1/4W Metal Film	RN60C1002B	
R69	01-50000	1			100 Single Turn	CTS X201R101	
R70	01-10073	1			9.76K 1% 50ppm/C 1/4W Metal Film	RN60C9761F	
R71	01-10073	1			9.76K 1% 50ppm/C 1/4W Metal Film	RN60C9761F	
R72	01-01053	1			4.7K 5% 1/4W Carbon Film	RC07GF472J	
R73	01-10049	1			100K 0.1% 50ppm/C 1/4W Metal Film	RN60C1003B	
R74	01-10049	1			100K 0.1% 50ppm/C 1/4W Metal Film	RN60C1003B	
R75	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R76	01-10049	1			100K 0.1% 50ppm/C 1/4W Metal Film	RN60C1003B	
R77	01-10049	1			100K 0.1% 50ppm/C 1/4W Metal Film	RN60C1003B	
R78	01-10215	1			1.65K 1% 50ppm/C 1/4W Metal Film	RN60C1651F	
R80	01-01004	1			4.7 5% 1/4W Carbon Film	RC07GF4R7J	
R81	01-01048	1			2.7K 5% 1/4W Carbon Film	RC07GF272J	
R82	01-01048	1			2.7K 5% 1/4W Carbon Film	RC07GF272J	
R93	01-01028	1			270 5% 1/4W Carbon Film	RC07GF271J	
R94	01-01028	1			270 5% 1/4W Carbon Film	RC07GF271J	
R96	01-01028	1			270 5% 1/4W Carbon Film	RC07GF271J	
R105	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R106	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R107	01-01033	1			470 5% 1/4W Carbon Film	RC07GF471J	
R112	01-01032	1			430 5% 1/4W Carbon Film	RC07GF431J	
R114	01-20013	1			100 0.05% 5ppm/C Wire Wound	Goldstar GS711-100R-.05%-5PPM	
R115	01-20004	1			900 0.05% 5ppm/C Wire Wound	Goldstar GS711-900R-.05%-5PPM	
R116	01-20005	1			9K 0.05% 5ppm/C Wire Wound	Goldstar GS711-9K-.05%-5PPM	
R117	01-20006	1			90K 0.05% 5ppm/C Wire wound	Goldstar GS711-90K-.05%-5PPM	
R118	01-20007	1			900K 0.05% 2ppm/C Wire Wound	Goldstar GS805-900K-.05%-2PPM	
R119	01-10018	1			9W 1% 15ppm/C Film	Caddock TF050W-9W-1%-15PPM	
R120	01-10000			1	Factory Select Resistor	RN60C???	
R201	01-10178	1			10K 0.1% 25ppm/C 1/8W Metal Film	PRP 1/8W - 10K - 0.1% - 25PPM	
R202	01-10178	1			10K 0.1% 25ppm/C 1/8W Metal Film	PRP 1/8W - 10K - 0.1% - 25PPM	
R203	01-10178	1			10K 0.1% 25ppm/C 1/8W Metal Film	PRP 1/8W - 10K - 0.1% - 25PPM	
R204	01-10178	1			10K 0.1% 25ppm/C 1/8W Metal Film	PRP 1/8W - 10K - 0.1% - 25PPM	
R205	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R206	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
S2	05-03005	1			Switch, 6 Station, Int-Lock, 6 Pole, Chrome	Centralab, ZKBC000600864+B426	
S3	05-03015	1			Toggle Switch, 2PDT	C&K, 7201-7760-7062-3	
T1	04-20006	1			4440 Transformer (DC to DC Converter)	DWG 4440-010	
T2	04-20007	1			Main Power Transformer	DWG 4440-011	
XIC2	05-10041	1			Socket, dil, 14 pin	Burndy 8514-01	
XIC7	05-10406	1			Socket, DIL, 24 pin, 0.3", Gold Contacts	Amp 583640-3	
XIC11	05-10008	1			Socket, dil, 16 pin	Burndy C8516-01	
XIC15	05-10041	1			Socket, dil, 14 pin	Burndy 8514-01	

REF.DES.	STOCK #	QUANTITY			DESCRIPTION	MANUFACTURING/PURCHASING DATA
		A	T	N		
A1	04-30293	1			HCTR4010 Replacement Board	DWG 4314-714
C1	02-60021	1			1500pF, 100V, Mylar	WIMA MKC4-1500p
C2	02-10005	1			50pF 500V Ceramic disc	Illinois 500BCR050K
C3	02-10014	1			0.1uF 50V Ceramic disc	AVX SR205E104MAA00
IC1	03-30633	1			Hex Schmitt-Trigger Inverter	74HC14N
IC2	03-30383	1			Dual D-Type flip flop (HCMOS)	74HC74N
IC3	03-30619	1			Octal Buffer and Line Driver	74HC244
IC4	03-30637	1			CMOS 4 1/2 Decade Counter	Hughes HCTR6010AP
P1	05-10990	1			24 pin Adaptor Plug, 0.585 sp.	Samtec APA-624-T-P
R2	01-01068	1			27K 5% 1/4W Carbon Film	RC07GF273J
R3	01-01068	1			27K 5% 1/4W Carbon Film	RC07GF273J
R4	01-01068	1			27K 5% 1/4W Carbon Film	RC07GF273J
R5	01-01068	1			27K 5% 1/4W Carbon Film	RC07GF273J
R6	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J
R7	01-01068	1			27K 5% 1/4W Carbon Film	RC07GF273J

REF.DES.	STOCK #	QUANTITY			DESCRIPTION	MANUFACTURING/PURCHASING DATA
		A	T	N		
1	4020-400	1			Model 4020 (STD) Final Assembly	Assembly 4020-400
2	05-10049	1			Box, battery, four D cells	Sogyo BH13
3	05-10325	4			Cable tie, 14"x.25" reusable	Panduit PRT-4S
4	05-10325	4			Cable tie, 14"x.25" reusable	Panduit PRT-4S
5	04-10235	1			4440 Rear Panel (battery unit)	DWG 4440-214
6	90-04004	4			#4-40 x 1/4" Phil Pan S.S.	
7	98-04001	4			#4 Split Lock Washer S.S.	
8	97-04001	4			#4-40 Radio Hex Nut S.S.	
9	80-00022	2			22awg Bus Wire	1BB-2201 ANIXTER
10	80-02622	24			22awg Wire, Blue TFE	M16878/4-BFE-6
11	80-02022	20			22Awg Wire, Black TFE	M16878/4-BFE-0
12	80-02222	8			22awg Wire,Red TFE	M16878/4-BFE-2
13	80-02322	7			22awg Wire, Orange TFE	M16878/4-BFE-3
B1	05-10117		1		Battery, ni-cad, heavy duty, D cell	Panasonic P-400D-E15
B2	05-10117		1		Battery, ni-cad, heavy duty, D cell	Panasonic P-400D-E15
B3	05-10117		1		Battery, ni-cad, heavy duty, D cell	Panasonic P-400D-E15
B4	05-10117		1		Battery, ni-cad, heavy duty, D cell	Panasonic P-400D-E15
F1	05-04001	1			2A,Fuse	Littlefuse,312-002
J4	05-10033	1			Battery Charging Jack	Switchcraft 712A
R120	01-01004	1			4.7 5% 1/4W Carbon Film	RC07GF4R7J
R121	01-01007	1			10 5% 1/4W Carbon Film	RC07GF100J

DELETE THE FOLLOWING FROM PARTS LIST: 4020-400

16	04-10236	1			4440 Rear Panel (AC unit)	DWG 4440-215
17	05-10063	1			Connector, AC, receptacle	Switchcraft EAC-301
F1	05-04000	1			0.1 Amp slo-blo fuse	Littlefuse 313-.10A
T2	04-20007	1			Transformer	DWG 4440-011
IC24	03-30034	1			Regulator,+5V,0.5A,T0202 or T0220	78M05CP or LM340T-5.0
C45	02-10004	1			0.02uF 500V Ceramic Disc	Sprague 140CD500Z9-203Z
C46	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP
CR26	03-20002	1			Diode, rectifier, 1A, 50V	1N4001-1N4007
CR27	03-20002	1			Diode, rectifier, 1A, 50V	1N4001-1N4007
CR28	03-20000	1			Diode, general purpose	1N4148 or 1N914

REF.DES.	STOCK #	QUANTITY			DESCRIPTION	MANUFACTURING/PURCHASING DATA
		A	T	N		
2	05-10012	1			Connector, female, 50 pin, with bail	Amphenol 57-40500
3	80-01022	10			22awg Wire, Black PVC	M16878/1-BFE-0
4	80-01122	20			22awg Wire, Brown PVC	M16878/1-BFE-1
5	80-01222	20			22awg Wire, Red PVC	M16878/1-BFE-2
6	80-01322	10			22awg Wire, Orange PVC	M16878/1-BFE-3
7	80-01422	20			22awg Wire, Yellow PVC	M16878/1-BFE-4
8	80-01522	20			22awg Wire, Green PVC	M16878/1-BFE-5
9	80-01622	10			22awg Wire, Blue PVC	M16878/1-BFE-6
10	80-01722	10			22AWG Wire, Violet PVC	M16878/1-BFE-7
11	80-01822	10			22awg Wire, Gray PVC	M16878/1-BFE-8
12	80-01922	10			22awg Wire, White PVC	M16878/1-BFE-9
A1	04-30186	1			B.C.D. Board	DWG 4500-707
C1	02-40029	1			100u 25V Alum. Radial	Illinois 107RMR025M
C2	02-60002	1			0.1u 250V Mylar	Illinois 104MSR250K
C3	02-20009	1			470p 500V Mica	CM05FD471J03
C4	02-20009	1			470p 500V Mica	CM05FD471J03
C5	02-20009	1			470p 500V Mica	CM05FD471J03
C6	02-20009	1			470p 500V Mica	CM05FD471J03
C7	02-60002	1			0.1u 250V Mylar	Illinois 104MSR250K
IC1	03-30080	1			7-Segment to BCD Decoder (CMOS)	74C915N
IC2	03-30382	1			Dual Monostable (HCMOS)	74HC4538
IC3	03-30382	1			Dual Monostable (HCMOS)	74HC4538
IC4	03-30460	1			Quad D Flip-Flop With Clear	74HC175N
IC5	03-30460	1			Quad D Flip-Flop With Clear	74HC175N
IC6	03-30460	1			Quad D Flip-Flop With Clear	74HC175N
IC7	03-30460	1			Quad D Flip-Flop With Clear	74HC175N
IC8	03-30383	1			Dual D-Type flip flop (HCMOS)	74HC74N
R1	01-01065	1			20K 5% 1/4W Carbon Film	RC07GF203J
R2	01-01065	1			20K 5% 1/4W Carbon Film	RC07GF203J
R3	01-01065	1			20K 5% 1/4W Carbon Film	RC07GF203J
R4	01-01065	1			20K 5% 1/4W Carbon Film	RC07GF203J
RN1	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103
RN2	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103
RN3	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103
TR1	03-10026	1			N-Channel VMOS (TO92)	VN10KM

SECTION VII DRAWINGS AND SCHEMATICS

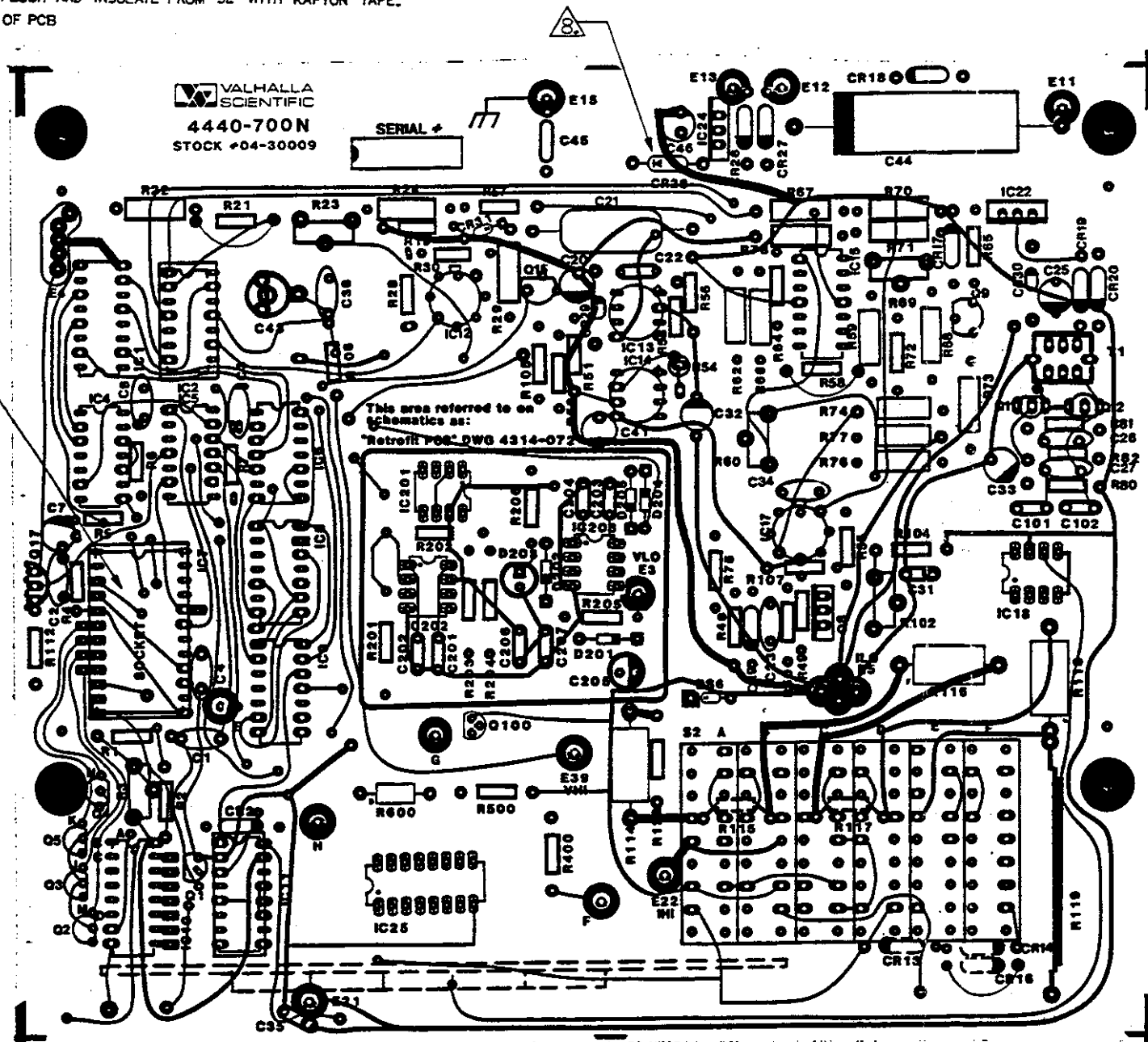


The following schematic diagrams have been included in this manual:

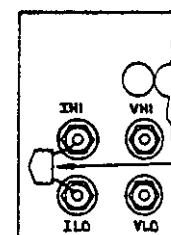
4020-600	1 page	4020 Main Board Assembly
4440-601	1 page	4020 Display Board Assembly
4020-070	1 page	4020 Schematic
4314-072	1 page	Retrofit Board Schematic
4314-614	1 page	HCTR4010 (IC7) Replacement PCB Assembly
4314-084	1 page	HCTR4010 (IC7) Replacement PCB Schematic
4500-077	1 page	4020 Option BCD Schematic

NOTES: (CONTINUED FROM BELOW)

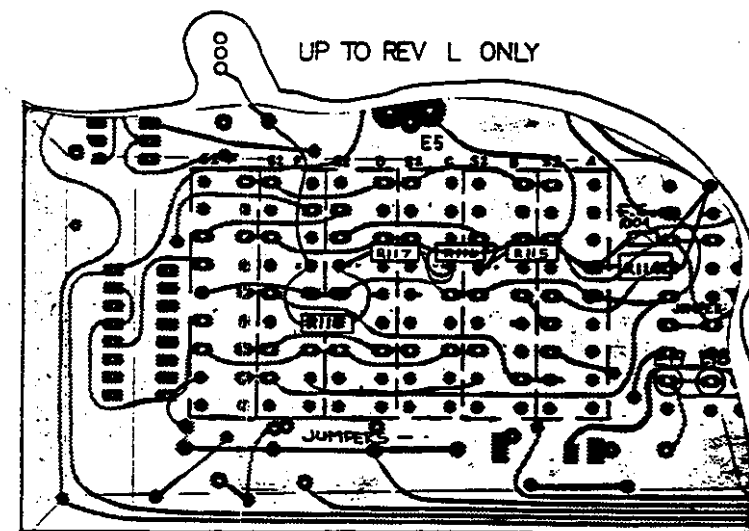
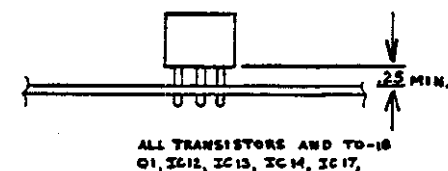
- △ CUT SOCKET FOR IC7 IN HALF AND INSTALL FLUSH WITH PCB.
INSTALL ASSEMBLY 4314-614 SECURELY IN SOCKET.
7. JUMPER R21, R58 AND CR16 USING ITEM #104 BUSS WIRE.
TRIM LEADS OF CR16 FLUSH AND INSULATE FROM S2 WITH KAPTON TAPE.
- △ JUMPER ON BOTTOM OF PCB
AS INDICATED.



PARTIAL FRONT PANEL ASSY
VIEWED FROM INSIDE THE UNIT



ADD C50 BETWEEN
CURRENT HI AND
CURRENT LO.
SOLDER DIRECTLY
TO BINDING POSTS



VIEW FROM BOTTOM OF PCB.
(CLAD SHOW IS REAR SIDE)

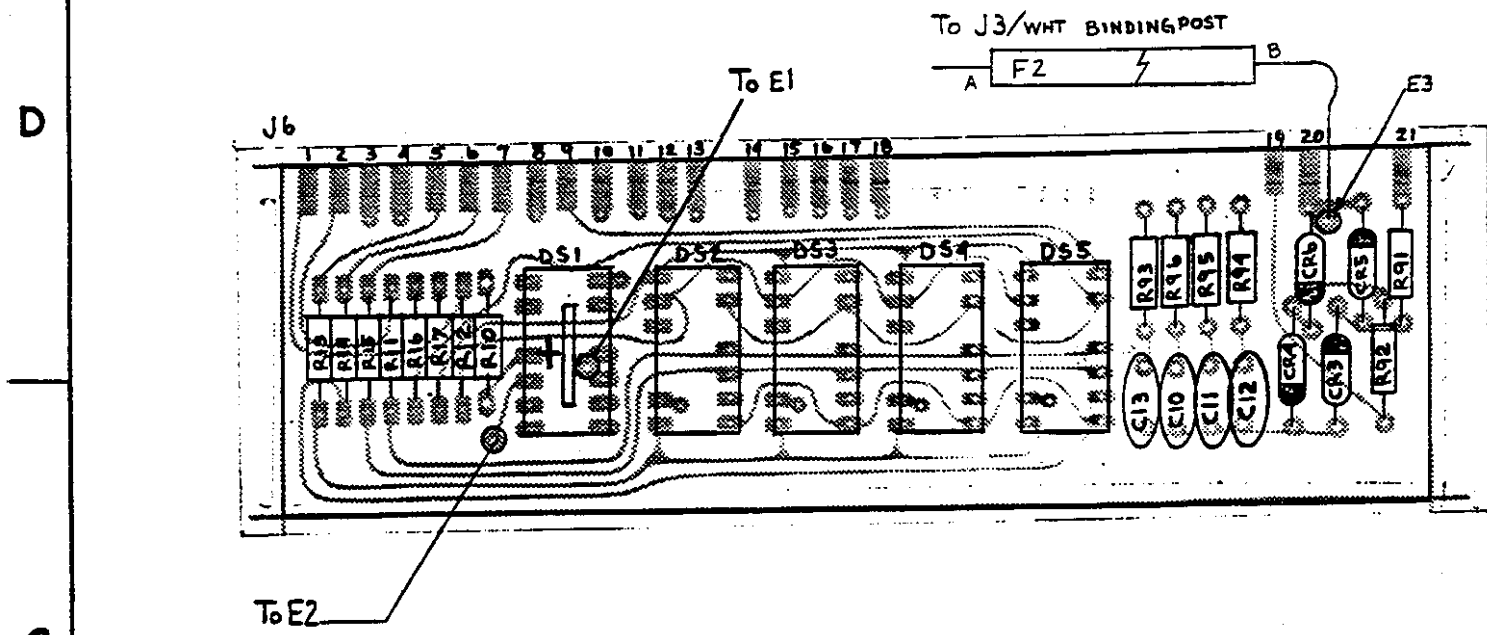
(CONT. ABOVE)

5. USE PARTS LIST 4020-400.
4. USE PCB BOARD 4440-700.
3. FOR ASSEMBLY DIAGRAM SEE 4440-400.
2. FOR WIRE TAB TABLE SEE 4020-050.
1. FOR SCHEMATIC SEE 4020-070.

NOTES:

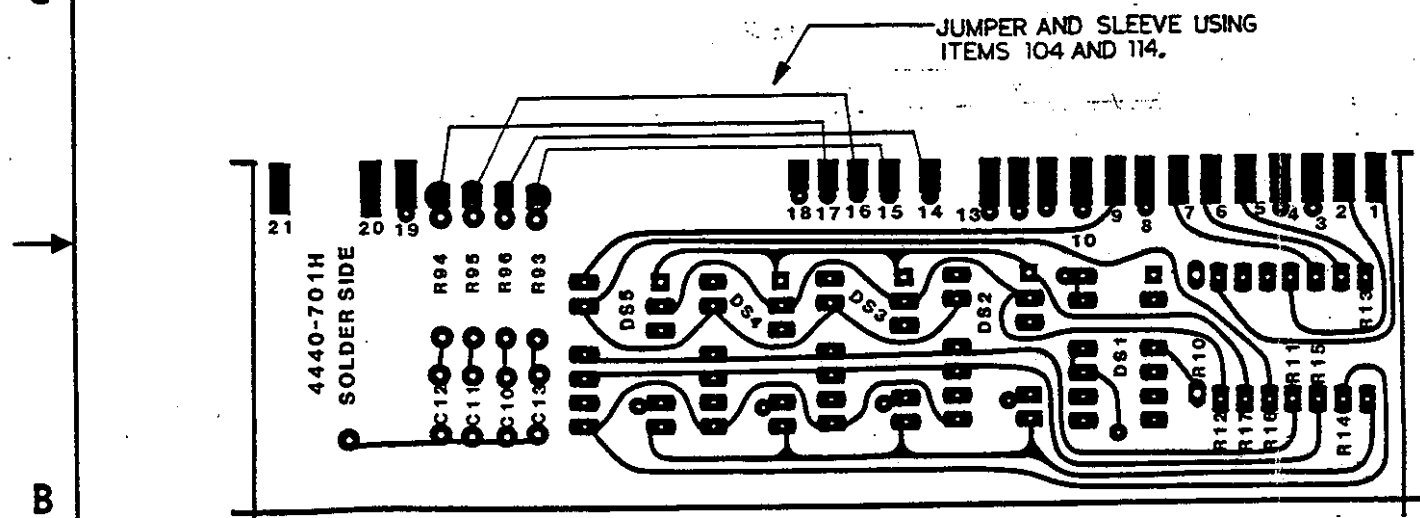
MATERIAL	Valhalla Scientific Inc. SAN DIEGO, CALIFORNIA			
FINISH	ASSEMBLY PCB. DIGITAL OHMMETER 4020			
SCALE	NONE	CODE IDENT NO.	SIZE	DRAWING NO.
		53504	D	4020-600

CLAD SHOWN IS COMPONENT SIDE



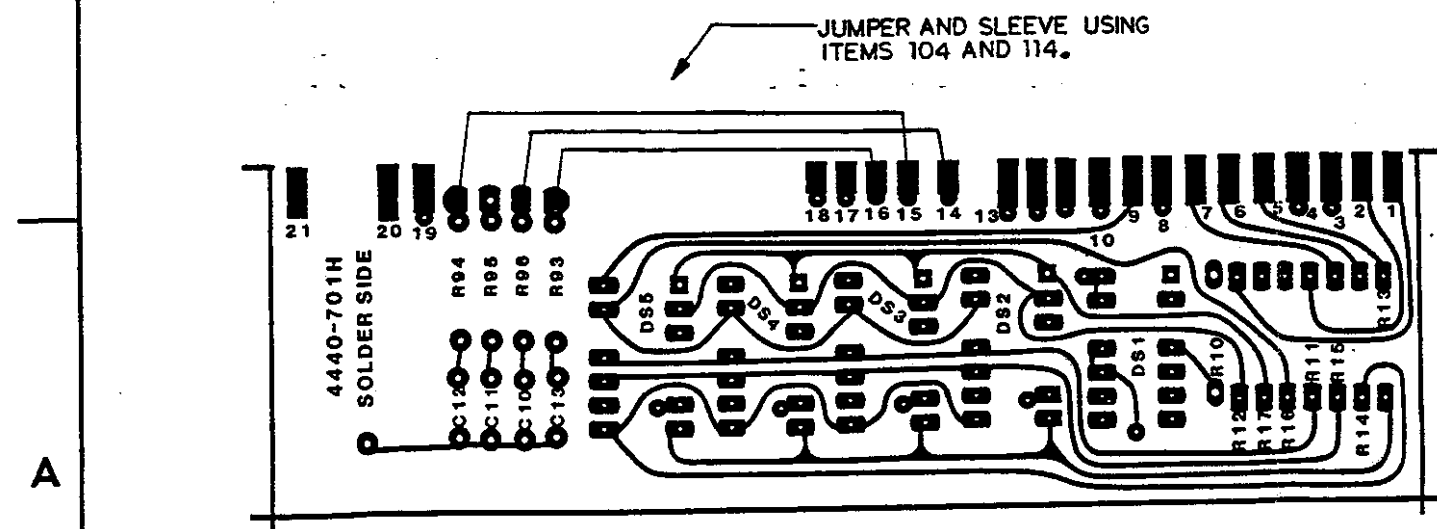
SHOWN IS P.C.B. ASSY. 4440-601-1
CLAD SHOWN IS FAR SIDE

4. USE UP TO REV F PCB ONLY.
3. FOR ASSY. SEE 4440-600
2. FOR WTT. SEE 4440-050
1. FOR SCHEMATIC SEE 4440-070
NOTES: MODEL 4440 ONLY.



(CLAD SHOWN IS SOLDER-SIDE)
SHOWN IS P.C.B. ASSY. 4440-601-2

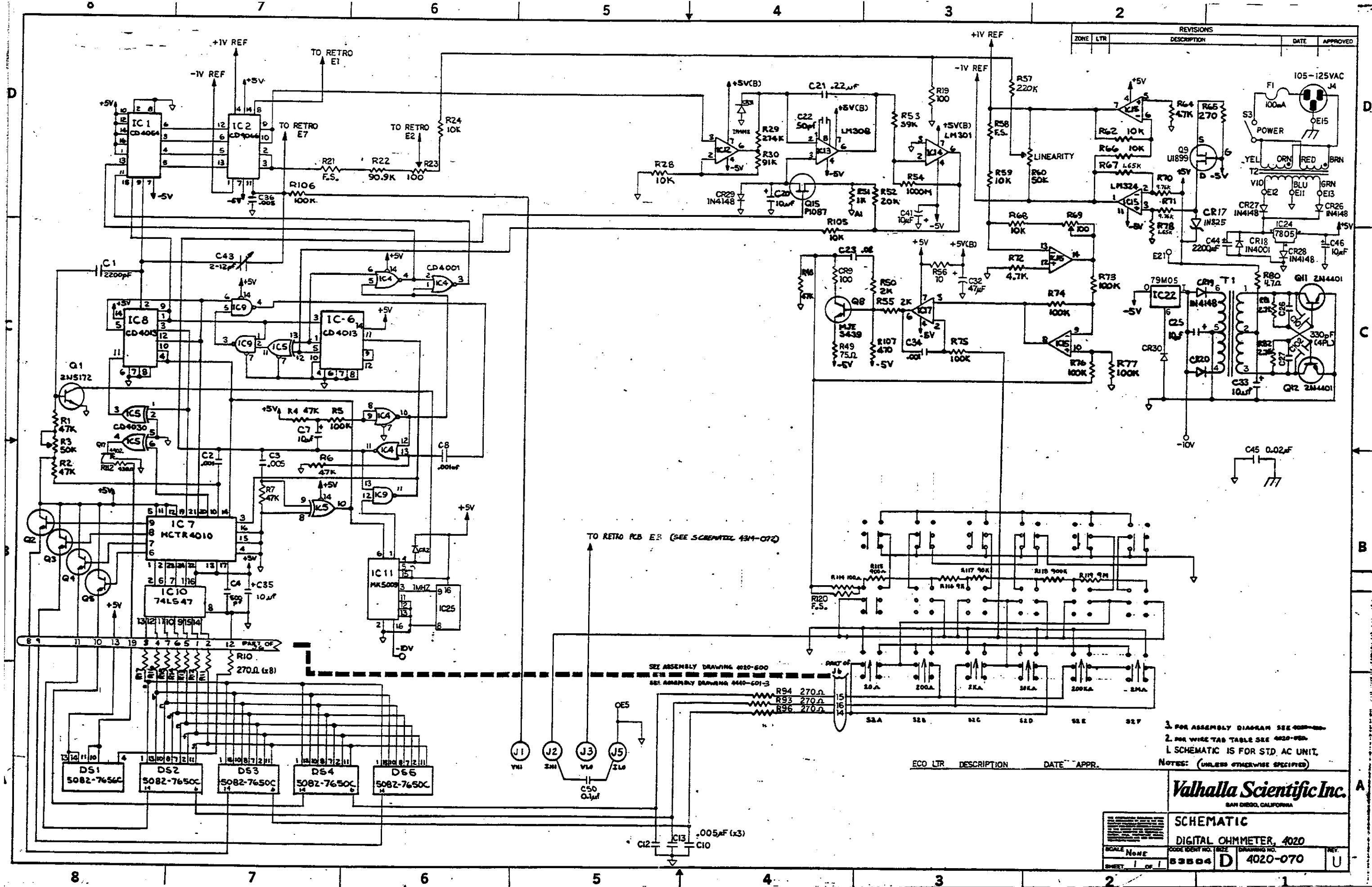
3. FOR ASSY. SEE 4314-600
2. FOR WTT. SEE 4314-050
1. FOR SCHEMATIC SEE 4314-070
NOTES: MODEL 4314A ONLY. FOR PARTS LIST SEE 4314-400.



(CLAD SHOWN IS SOLDER-SIDE)
SHOWN IS P.C.B. ASSY. 4440-601-3

3. FOR ASSY. SEE 4020-600
2. FOR WTT. SEE 4020-050
1. FOR SCHEMATIC SEE 4020-070
NOTES: MODEL 4020 ONLY. FOR PARTS LIST SEE 4020-400.

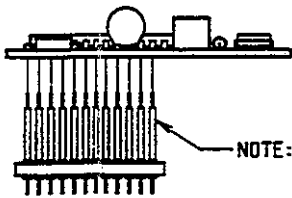
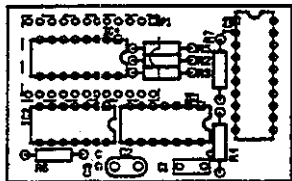
MATERIAL		Valhalla Scientific Inc. SAN DIEGO, CALIFORNIA			
FINISH		ASSEMBLY: DISPLAY P.C.B.			
SCALE	NONE	CODE IDENT NO.	SIZE	DRAWING NO.	REV.
SHEET 1 OF 1		53504	C	4440-601	K



NOTES: Unless Otherwise Specified

- 1. SEE SEPARATE PARTS LIST.
- 2. BAG AND TAG WITH DRAWING NUMBER, STOCK NUMBER, AND CURRENT REVISION LETTER.

REVISIONS			
ECR#	LTR	DESCRIPTION OF CHANGE	DATE
APPROVED			

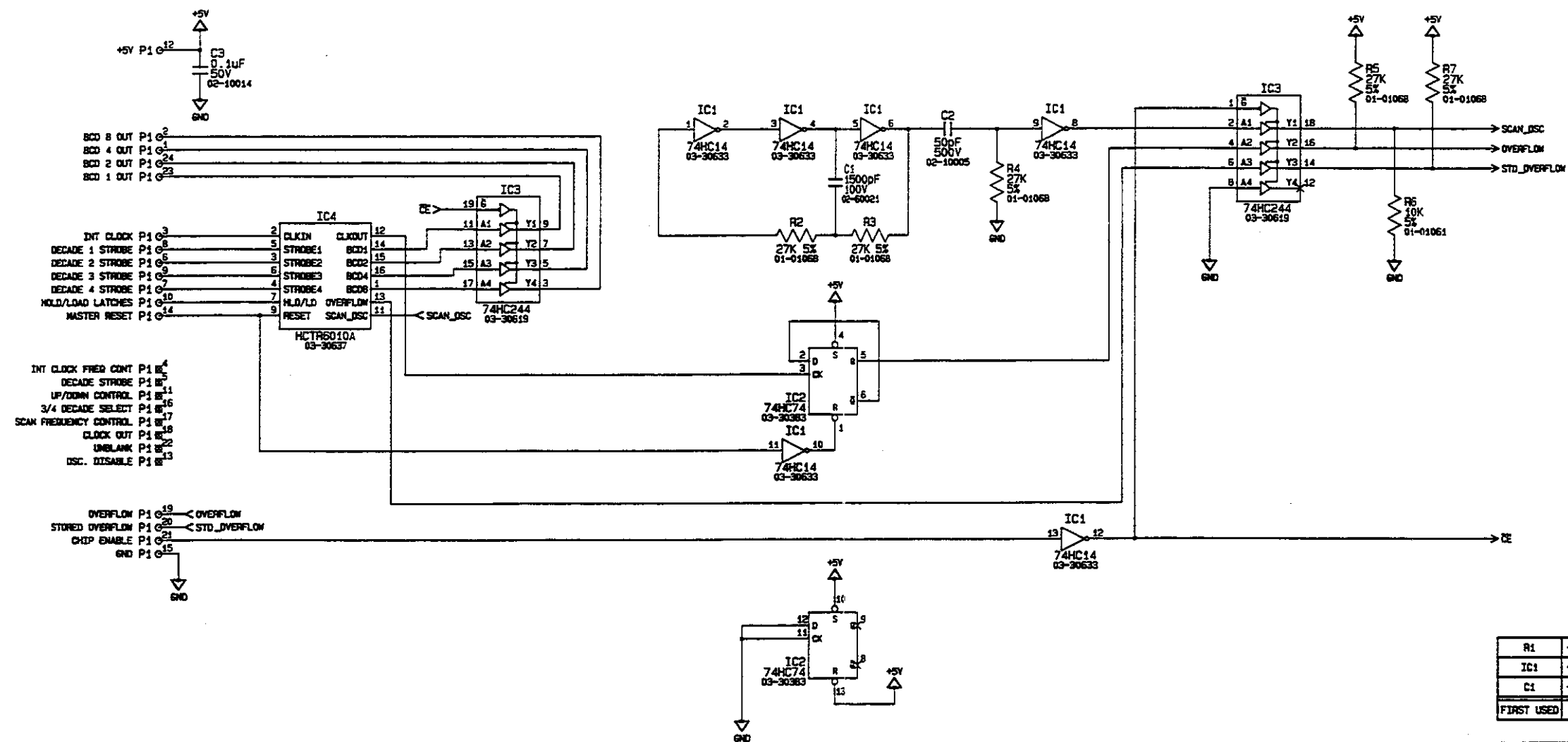


NOTE: INSTALL P1 ON
SOLDER SIDE AS
SHOWN.

TOLERANCES: X = ±.001 .XX = ±.02 .XXX = ±.005	FINISH: 	MATERIAL: 	 VALHALLA SCIENTIFIC 9955 MESA RIM RD. SAN DIEGO, CA 92121	
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS	SCALE: 1 : 1	STOCK NO.: 38-00156	THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC, INC. AND IS NOT TO BE DISCLOSED OR REPRODUCED IN ANY MANNER WITHOUT THE WRITTEN PERMISSION OF VALHALLA SCIENTIFIC, INC. PROPRIETARY DESIGN. NO USE AND REPRODUCTION RIGHTS THEREOF.	
MACHINED SURFACES ARE TO HAVE A FINISH OF .001			TITLE P.C.B. ASSEMBLY- HCTR4010 REPLACEMENT BD.	
			SHEET 1 OF 1	
			DRAWING NO. 4314-614	
			REV: A	

NOTES: Unless Otherwise Specified

REVISIONS			
ECR#	LTR	DESCRIPTION OF CHANGE	DATE



R1	---	R7
IC1	---	IC4
C1	---	C3
FIRST USED	NOT USED	LAST USED

IC4	8	10	DIP16
IC3	20	10	DIP20
IC2	14	7	DIP14
IC1	14	7	DIP14
DEVICE	+5V	GND	PACKAGE

	VALHALLA SCIENTIFIC	
	9955 MESA RIM RD. SAN DIEGO, CA 92121	
	TITLE SCHEMATIC- HCTR4010 REPLACEMENT	
SHEET 1 OF 1	DRAWING NO. 4314-084	REV. A

