

# Model 4021

## Digital Ohmmeter

# Operation Manual

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## **VALHALLA SCIENTIFIC INC. 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 Nation Institute of Standards and Technology to the extent allowed by NIST's calibration facility.

Due to continuing product refinement and due to possible parts manufacturer changes, Valhalla Scientific, Inc. reserves the rights to change any or all specifications without notice.

## **VALHALLA SCIENTIFIC INC. WARRANTY STATEMENT**

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 the instrument during the warranty period provided it is returned to Valhalla Scientific, Inc. freight prepaid. No other warranty is expressed or implied.

Valhalla Scientific, Inc. is not liable for consequential damages.

Permission and a Return Material Authorization number (RMA) 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 change, Valhalla Scientific reserves the right to change any or all specifications without notice.



4021 Digital Ohmmeter User Manual  
Edition 1

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## Documentation History

All Editions and Updates of this manual and their creation date are listed below. The first Edition of the manual is 1. The Edition Number increments by 1 whenever the manual is revised. Updates, which are issued between Editions, contain replacement pages to correct or add additional information to the current Edition of the manual. Whenever a new Edition is created, it will contain all of the Update information for the previous Edition. Each new Edition or Update also includes a revised copy of this documentation history page.

Edition 1 .....April, 2003  
 Update 1 .....September, 2004 (Board Rev. B)

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## Safety Symbols

	Instruction manual symbol affixed to product. Indicates that the user must refer to the user manual for specific WARNING or CAUTION information to avoid personal injury or damage to the product		Alternating current (AC)
	WARNING, RISK OF ELECTRICAL SHOCK.		Direct current (DC)
	Indicates the field wiring terminal that must be connected to ground before operation the equipment --- protects against electrical shock in case of fault.	<b>WARNING</b>	Calls attention to a procedure, practice, or condition that could cause bodily injury or death.
	Frame or chassis ground terminal --- typically connects to the equipment's metal frame.	<b>CAUTION</b>	Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent lost of data.

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## WARNINGS

The following general safety precautions must be observed during all phases of operation, service, and repair of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. Valhalla Scientific assumes no liability for the customer's failure to comply with these requirements.

**Ground the equipment:** For Safety class 1 equipment (equipment having a protective earth terminal), an interrupted safety earth ground must be provided from the main power source to the product input wiring terminals or supplied power cable.

**DO NOT** operate the product in an explosive atmosphere or in presence of flammable gases or fumes.

**For continued protection,** replace the line fuse(s) only with fuse(s) of the same voltage and current rating and type. **DO NOT** use repaired fuses or short-circuited fuse holders.

**Keep away from live circuits:** Operating personnel must not remove equipment covers or shields. Procedures involving the removal of covers or shields are for use service trained personnel only. Under certain conditions, dangerous voltage may exist even with the equipment switched off. To avoid dangerous electrical shock, **DO NOT** perform procedures involving cover or shield removal unless you are qualified to do so.

**DO NOT operate damaged equipment:** Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any reason, **REMOVE POWER** and do not use the product until safe operation can be verified by service-trained personnel. If necessary, return the product to Valhalla Scientific for service and repair to ensure that safety features are maintained.

**DO NOT service or adjust alone:** Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

**DO NOT substitute parts or modify equipment:** Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to Valhalla Scientific for service and repair to ensure that safety features are maintained.

**Measuring high voltage is always hazardous:** ALL multimeters input terminals (both front and rear) must be considered hazardous whenever inputs greater than 42V (dc or peak) are connected to ANY input terminal.

**Permanent wiring of hazardous voltage** or sources capable of delivering greater than 150VA should be labeled, fused, or in some other way protected against accidental bridging or equipment failure.

**DO NOT** leave measurement terminals energized when not in use.

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**Introduction**

This manual has information to perform Inspection, Installation, Measurement Operations, and Troubleshooting for Valhalla Scientific Model 4021. Also included in this manual are: Specifications, Parts Lists and all Schematics.

**Manual Description**

This manual is separated into the 11 following Chapters.

**Chapter 1 – General Information**

Chapter 1 contains a brief description of the instrument and other general information.

**Chapter 2 – Unpacking and Installing**

Chapter 2 contains information for unpacking and inspection the equipment. Also contains power requirements and installation procedure.

**Chapter 3 - Specifications**

Chapter 3 contains all specifications, including Range, Resolution, Test Current, Accuracy, General and Physical Specifications for Valhalla Model 4021.

**Chapter 4 – Optional Equipment**

Chapter 4 contains information on all available options and test leads for the Valhalla Model 4021.

**Chapter 5 – Operations**

Chapter 5 describes all operations including a description of the front and rear panel, Measurements and Connections.

**Chapter 6 – Theory of Operation**

Chapter 6 describes the theory of operation of all circuits and sub circuits used on Valhalla Model 4021.

**Chapter 7 – Routine Maintenance**

Chapter 7 contains maintenance information, such as calibration procedure.

**Chapter 8 – Interface Operation**

Chapter 8 contains information on the optional BCD Output.

**Chapter 9 – Addendums**

Chapter 9 lists updates and addendums for this manual.

**Chapter 10 – Parts List**

Chapter 10 contains all parts used in the Main Board, Display Board, and Chassis of the Valhalla Model 4021. The parts are listed with a Reference Designator, Valhalla Part Number, Description, and Manufacturers Part Number.

**Chapter 11 – Schematics**

Chapter 11 contains all schematics and drawings for Valhalla Model 4021.

## Instrument Description

Inspired by the need for a low-cost solution to the problems inherent in low resistance measurements in the millennium, Valhalla Scientific developed the Model 4021 Digital Ohmmeter. The 4021 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 4021 allows measurement up to 1.9999 M $\Omega$ . Four-wire resistance measurement is explained in more detail in Chapter 5.

The 4021 is available with a variety of test probes, accessories, and a BCD data output (see Chapter 8). The 4021 is also capable of being operated from an internal heavy-duty battery pack (optional). These items are explained in more detail in Chapter 4.

## Safety Considerations

The Model 4021 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 4021 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 $\Omega$ ) before making or removing connections.

## Instrument Identification

Valhalla Scientific instruments are identified by a two part serial number. The Serial Tag is located on the rear or bottom of the instrument. The number is in a form of 00-0000. The first two digits, called the serial number prefix, indicate the model. It changes only when a change is made to the instrument. The last 3 or 4 digits, called the serial number suffix, are unique for each individual unit.

Be sure to include the entire serial number, both prefix and suffix, in any correspondence about your instrument.

The serial number can also be found on the Main Board, Calibration Tag and Certificate of Calibration.

## 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 Chapter 3, 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.

## Power Requirements

The standard Model 4021 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 4021 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 0.1A 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 4021 uses four (4) rechargeable nickel-cadmium batteries as its source of power. A battery charger is supplied with the 4021. The 4021 may be operated from the batteries for approximately 12 hours before requiring a recharge. The 4021 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.

**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)

## Installation

If the Model 4021 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.

This section lists the operating and accuracy specifications for Valhalla Scientific Model 4021 Digital Ohmmeter. Accuracy is valid at  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  for a period of one year from the date of calibration.

### Range/Resolution/Test Current/Accuracy

Table 1

Range	Resolution	Maximum Input	Nominal Test Current	Accuracy
20 $\Omega$	1m $\Omega$	19.999 $\Omega$	10mA	$\pm 0.05\%$ of rdg, $\pm 0.025\%$ of rng
200 $\Omega$	10m $\Omega$	199.99 $\Omega$	1mA	$\pm 0.05\%$ of rdg, $\pm 0.025\%$ of rng
2k $\Omega$	100m $\Omega$	1.9999k $\Omega$	100 $\mu\text{A}$	$\pm 0.05\%$ of rdg, $\pm 0.025\%$ of rng
20k $\Omega$	1 $\Omega$	19.999k $\Omega$	10 $\mu\text{A}$	$\pm 0.05\%$ of rdg, $\pm 0.025\%$ of rng
200k $\Omega$	10 $\Omega$	199.99k $\Omega$	1 $\mu\text{A}$	$\pm 0.07\%$ of rdg, $\pm 0.03\%$ of rng
2M $\Omega$	100 $\Omega$	1.9999M $\Omega$	100nA	$\pm 0.1\%$ of rdg, $\pm 0.15\%$ of rng

### Temperature

Temperature Coefficient:  $\pm 0.002\%$  per  $^{\circ}\text{C}$  (from  $0^{\circ}\text{C}$ - $15^{\circ}\text{C}$  and  $35^{\circ}\text{C}$ - $50^{\circ}\text{C}$ )  
not applicable for 200k $\Omega$  range and above.

Operating Temperature Range:  $0^{\circ}\text{C}$  to  $50^{\circ}\text{C}$

Storage Temperature Range:  $-10^{\circ}\text{C}$  to  $70^{\circ}\text{C}$

### General Specifications

Full Scale Test Voltage: 200mV

Current Source Compliance Voltage: 5V

Terminal Configuration: 4-Wire

Display Type: 4 ½ Digit LED's

Overrange/Overload Indication: Display Flashes

Conversion Rate: 3 readings/seconds

## Power Specifications

Power Source (Standard AC):	115 or 230 VAC, $\pm 10\%$ , 50Hz – 400Hz
Power Source (Optional DC):	4 rechargeable Ni-Cad Batteries 1.2V 4000mA/H
Battery Charger (Standard with DC)	Provides 6VDC at 300mA nominal

## Physical Specifications

Width:	9.5" / 24cm
Depth:	11" / 27cm
Height:	3" / 8cm
Weight (AC Power):	3 lbs / 1.5kg net; 5 lbs / 2.5kg shipping <sup>[1]</sup>
Weight (DC Power):	4 lbs / 2kg net; 8 lbs / 4 kg shipping <sup>[1]</sup>

[1] Shipping weight may vary.

**Available Options**

Listed below are the options available for use with the Model 4021 Digital Ohmmeter.

**Option CC4: Carrying Case**

Option "CC4" is a meter and accessory carrying case with extra room for test leads, power cord, etc.

**Option HDB: Battery Operation**

The 4021 may be modified at the factory for operation from an internal rechargeable battery pack. This option was described in Chapter 2.

Replacement batteries for Option HDB are available as Valhalla Stock № 05-10117 quantity: 4.

**Option A: Battery Charger**

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 4021 fitted with Option HDB. One Option "A" is provided if the 4021 has been fitted with Option "HDB". Additional adapters may be ordered as needed.

**Option R4: Rack Mount Adapter**

Option "R4" is an adapter tray that allows the Model 4021 to be installed in a standard 19" equipment rack.

**Test Leads****Option K: 4-Wire Kelvin Lead Set**

Option "K" is the recommended general purpose lead set for all Valhalla Ohmmeters. Option K is a shielded 48" lead set terminating in ½ inch gold plated clips.

**Option MP-S: Single Probe Lead Set**

Option "MP-S" is a 4-wire lead set terminated in single points. The 4-wire configuration is maintained up to the point of the probe, eliminating most cable resistance effects.

Option MP-S may be used where a single probe tip is a must.

**Option MP-1: Kelvin Micro-Probes**

Option "MP-1" is a 48" shielded lead set (dual banana), handheld pencil type, terminated in spring loaded steel tips with .05" separation (1 amp max.). Special orders or modified versions available upon request.

**Option MP-2: Kelvin Mini-Probes**

Option "MP-2" is a 48" shielded lead set, handheld pencil type, terminated in spring loaded steel tips with 0.18" separation. (1 Amp max.)

**Option MP-3: Kelvin Micro-Probes**

Option "MP-1" is a 48" shielded lead set (dual banana), handheld pencil type, terminated in spring loaded steel tips with .08" separation (1 amp max.). Special orders or modified versions available upon request.

**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 KK: 4-Wire Kelvin Lead Set**

Option "KK" is a 48" heavy duty cable set terminated in large "jaws" that have an open span of 2".

**Option C: Banana-to-Clip Cable**

Option "C" is a 48" shielded cable terminated in dual alligator clips

**Option BBL: Banana-to-Banana Cable**

Option "BBL" is a 48" shielded cable terminated in dual banana plugs at both ends.

**Option KCS: Kelvin Clips**

Option "KCS" is the gold plated Kelvin clips used on the Option "K" cable. These clips may be used when making custom cables or when repairing Option "K".

**Option JAWS: Heavy-Duty Clips**

2" opening for use on large bushings, transformers and motors. The upper/lower jaw teeth (gold plated) provide true 4-wire measurement. Can accommodate up to 150 amps.

**Interface****Option BCD: Data Output**

This option provides parallel BCD data on p rear-panel 50-pin connector. All outputs are TTL comparable levels with a drive capability of 1 LS load. The Option BCD may be used to drive the Valhalla Model 1248. (*See Chapter 8*)

**Model 1248: Dual-Limit Comparator**

The Valhalla Model 1248 may be used in conjunction with a 4021 and Option BCD above. The Model 1248 is a dual-limit BCD comparator that interprets the display indications of the ohmmeter 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, counter, batch sorter or other device. The 1248 also reduces operator workload by allowing him to make an instant determination of the test results. The mating cable from the ohmmeter to the 1248 is 3' in length and designated as "IDC-2".

## General

This section of the manual contains complete operating instructions for the Valhalla Model 4021 Digital Ohmmeter. A description of the front panel controls, connection instructions, and the theory behind 4-wire resistance measurement is discussed in this section.

## Front Panel

### Power Switch

Power is applied to or removed from the internal circuits of the 4021 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 4021 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. The value of the range is indicated above the respective button.

## Rear Panel

### Fuse holder

The fuse-holder 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".

## 4-Wire Resistance Measurement

The four-terminal configuration of the 4021 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 4021 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.

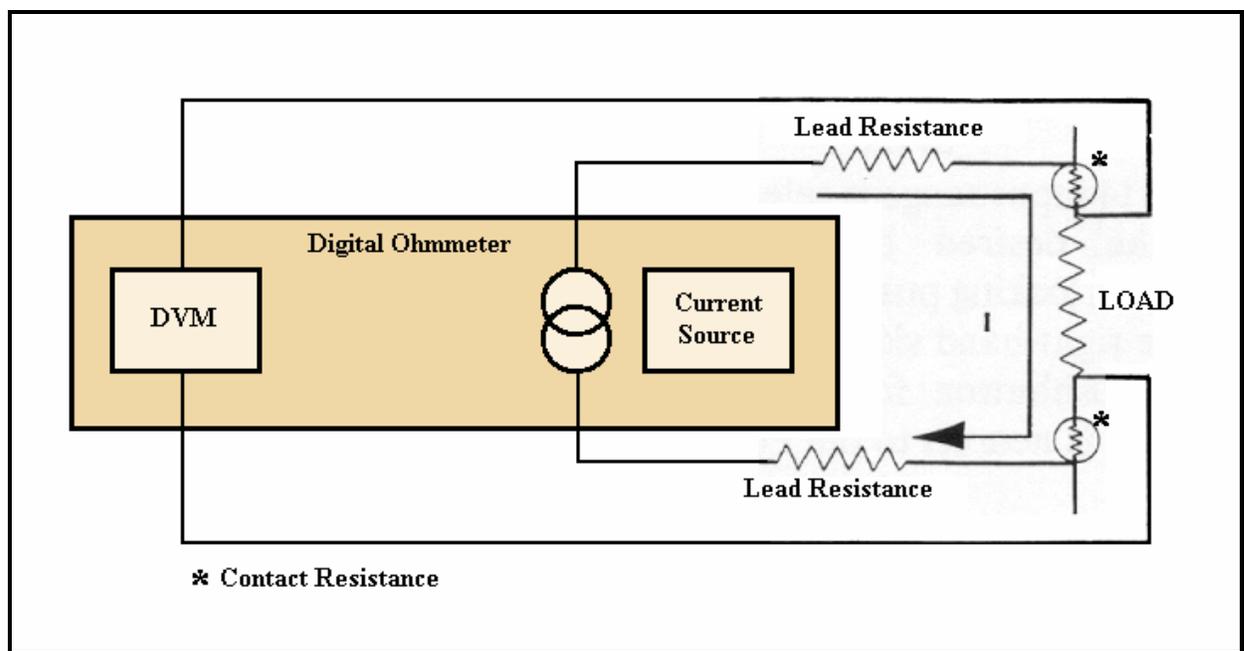


Figure 1 Error Sources in Resistance Measurements

Figure 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.

## Connections

Connections are made to the front panel terminals using a 4-wire configuration as described in **4-Wire Resistance Measurement**. 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

## Interpreting the Display

All Valhalla ohmmeters use a high impedance voltmeter as part of the resistance measurement process. This voltmeter is a highly accurate and stable 4 ½ 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 VHI and IHI 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.

## General

The Valhalla Scientific Model 4021 Digital Ohmmeter is shown in block diagram form in Figure 2. All information disclosed in this section is proprietary and is included in order to make troubleshooting to component level possible.

The Model 4021 uses solid-state semiconductors exclusively and CMOS circuits extensively to minimize power requirements and make battery operation practical.

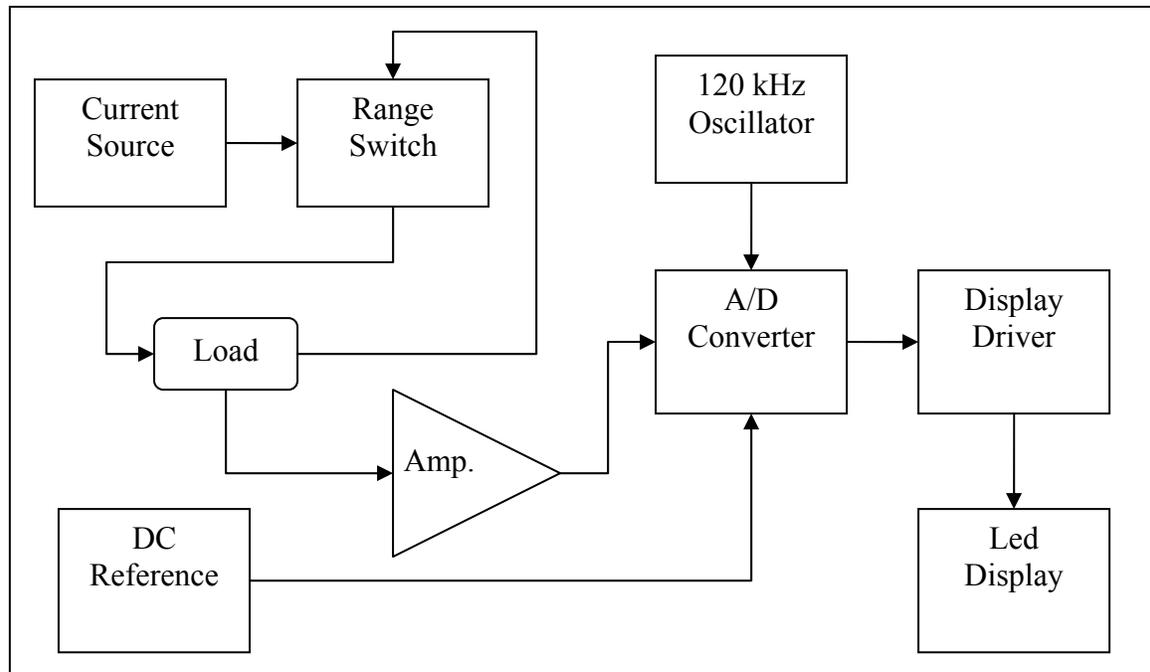


Figure 2 Model 4021 Block Diagram

## Troubleshooting

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.** Check to be sure that cables and other test equipment are in good working order before attempting to troubleshoot the 4021.

If the Model 4021 exhibits problems that cannot be eliminated by reviewing Chapter 3 and 5, the following guidelines have been established to help solve the problem.

**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 4021, servicing personnel should become familiar with this section to gain a complete understanding of the internal workings of the Model 4021.

**Component Replacement**

If the problem has been identified as a faulty component, the accuracy of the 4021 can be maintained only if the following precautions are taken:

- a) 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.
- b) Use only 63/37 grade rosin core electronic grade solder with a 50W or lower maximum power soldering iron.
- c) 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!
- d) Static sensitive parts require special handling procedures. Always treat an unknown part as if it were static sensitive.

**Circuit Description**

The circuit descriptions which follow are referenced to Figures 2, 3, 4 and the schematic diagrams in Chapter 11. In the following descriptions, references to integrated circuits are given in the form "IC2-1", which refers to Integrated Circuit 2, pin 1.

**Power Supply**

The 4021 operates from 4 supplies: +5V, +5Vb, -5V and -10V. The +5V supply is rectified by D1 and D2 and regulated by IC1 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 Q1, Q2, T1, D5, D6 and associated components.

The -5V supply is regulated by IC2 from the -10V supply mentioned above.

The +5Vb supply is regulated by IC3 from a +10V resultant from the DC-to-DC converter composed of Q1, Q2, T1, D8, D9 and associated components.

## Constant Current Source

The constant current source is composed of IC4, IC5, Q4 and the precision resistor R26 and R28 – R32. The input to the constant current source is approximately +1.05 volts, developed at IC4-7 and connected to IC4-13 through R12 and R13.

The heart of the constant current source is the voltage-to-current converter, which incorporates a Transconductance Amplifier. A simplified schematic of this unique circuit is shown in Figure 3 and described in the next section. The amplifier of IC4-12 is an inverter, and its output is applied to IC4-9. The amplifier of IC4-8 has unity gain due to the feedback through R18. Its output is applied to the inverting input of IC5-3. The output of IC5-6 provides feedback to the non-inverting input of IC4-10. This circuit operates to maintain the inverting input at IC5-3 and the non-inverting input at IC5-2 at the same potential.

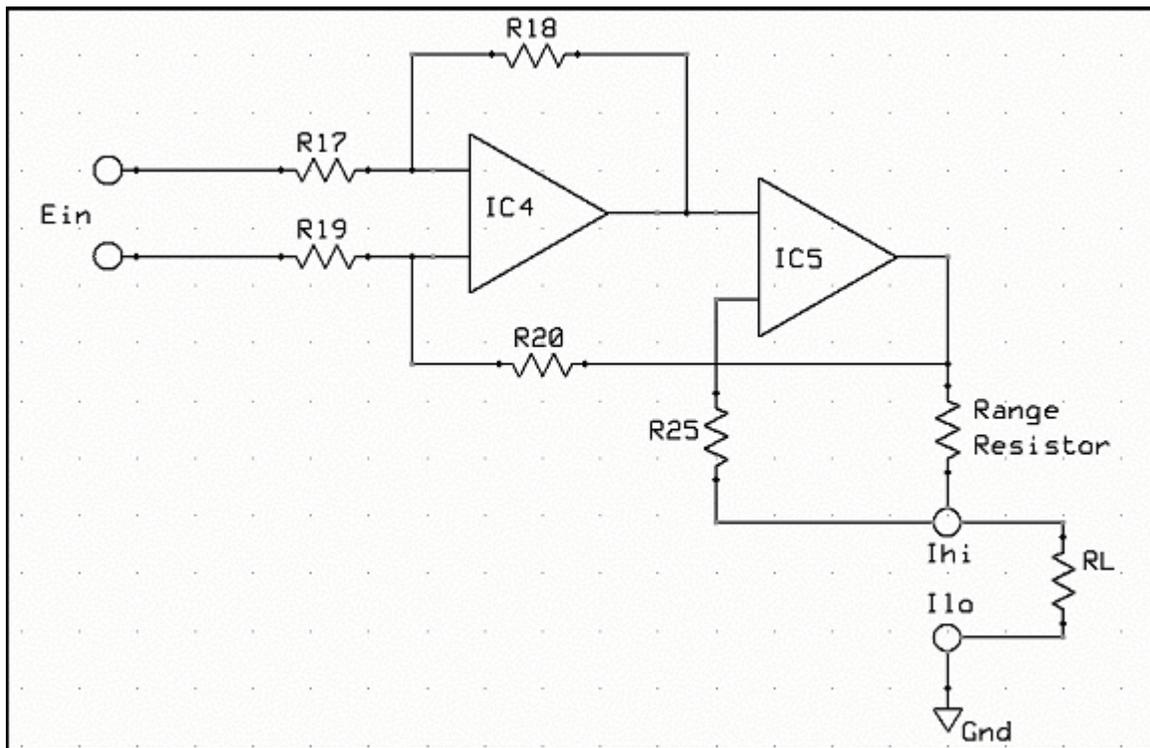


Figure 3 Transconductance Amplifier

## Transconductance Amplifier

(U.S. Patent No. 4,091,333)

Assume that terminals  $I_{hi}$  and  $I_{lo}$  of Figure 3 are shorted, and 1 volt is applied to  $E_{in}$  so that  $I_{hi}$  is positive. To equalize the inputs of IC5, IC4 must be driven to zero. This condition occurs only when the voltage drops across R17 and R19 are equal to the drops across R18 and R20. For these voltage drops to be equal, the output of IC5 must be at +1 volt. Since the output of IC4-8 must be zero, the drop across R18 is 0.5 volts, making the inverting input 0.5 volts. The drops across R17, R20 and R19 will also be 0.5 volts. Since the inputs to IC4 are essentially equal, its output is zero (offset by the few  $\mu V$  required to drive IC5 to +1 volt). Under these conditions the sum of the voltages across R17, R18, R19 and R20 equals the sum of  $E_{in}$  plus the output of IC5.

Consider now that the short is removed from the  $I_{hi}$  and  $I_{lo}$  terminals and a 100-ohm resistor ( $R_L$ ) is connected in its place. The current through  $R_L$  increases the voltage at the input to IC4. A balanced condition will be reached when the output of IC4 is equal to the non-inverting input of IC5. Again, this condition occurs when the voltage drops across R17 and R19 are equal to the voltage drops across R18 and R20. At this time the output of IC5 is 1.1 volts. The voltage drop across the Range Resistor is 1 volt, just as it was when the output terminals were shorted. The current through  $R_L$  is 10mA, just as it was through the jumper when the output terminals were shorted.

## Analog to Digital Converter

The Analog to Digital conversion in the Model 4021 is aloud by IC 7 and its associated components. The reference voltage applied to IC7-2 is 1Volts. 1.2Volts are generated buy D16 and adjusted by R40 before being applied to IC7-1. Due to this reference, the voltage across the load is amplified X10 by IC6 and its associated components. IC8 generates a 120 kHz clock signal for IC7-22; the frequency of the oscillator allows the 4021 a conversion rate of 3 readings per second.

The digital portion of IC7 is applied to IC9 a BCD to 7 Segment Converter/Driver and to the driver transistors Q5-Q9.

### LED Display

The signal converted by IC9 is applied to four 7 Segment LEDs (DS2-DS5) and a  $\pm 1$  LED (DS1). Concurrently, driver transistors Q5 through Q9 are turned on in sequence. This sequence is repeated at the 120 kHz rate, and the data display consequently appears to be continuous.

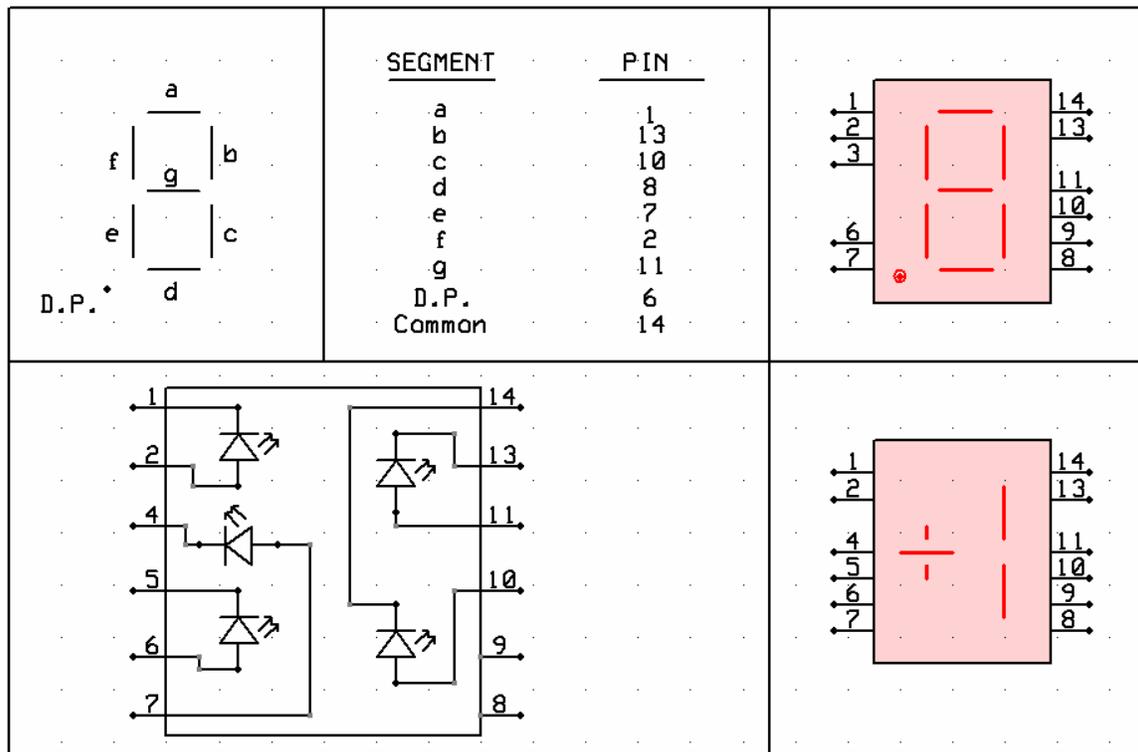


Figure 4 LED Display Pin Function

**General**

This section of the manual contains routine maintenance information regarding the Valhalla Scientific Model 4021 Digital Ohmmeter. Calibration should be performed on a regular basis to ensure continued instrument accuracy. The recommended calibration interval is 1 year.

**Required Test Equipment**

Following is a list of the standard resistors and other equipment required to calibrate the Model 4021.

Precision Resistors:

10 $\Omega$   $\pm$  0.005% Accuracy  
100 $\Omega$   $\pm$  0.005% Accuracy  
1K $\Omega$   $\pm$  0.005% Accuracy  
10K $\Omega$   $\pm$  0.005% Accuracy  
100K $\Omega$   $\pm$  0.005% Accuracy  
1M $\Omega$   $\pm$  0.005% Accuracy

Test Leads:

4-Wire Lead Set  
(Valhalla Option "K" or "C")

Voltage Standard:

Voltage Calibrator capable of outputting negative 100mV, 0.03% Accuracy or better.  
(Valhalla Model 2701C)

## Calibration Procedure

The 4021 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 4021-700 in Chapter 11.

### Voltmeter Adjustment

1. Select the 20 $\Omega$  Range on the 4021.
2. Connect the Voltage Calibrator to the Sense terminal observing polarity.
3. Apply -100mV and adjust R40 for a display reading of "10.000"  $\pm$  1 digit.
4. Apply -100 $\mu$ V and adjust R37 for a display reading of "0.010".
5. Repeat steps 3 and 4 until both are in specification.
6. Disconnect the Voltage Calibrator.

### Full Scale Adjustment

1. Select the 20k $\Omega$  Range.
2. Connect the Kelvin clips to a 10 $\Omega$  standard resistor.
3. Adjust R37 for a display reading of "0.010".
4. Connect the Kelvin clips to a 10k $\Omega$  standard resistor.
5. Adjust R15 for a display reading equal to the resistor value.
6. Check all remaining ranges with the appropriate standard resistors. All ranges must be within the specifications outlined in Chapter 3.

Note: The 2M $\Omega$  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 checking this range, keep movement to a minimum.

Note: When using the 2M $\Omega$  Range, allowe approximetly 30 seconds for the readings to stabilize.

End of procedure. #

### **Battery Replacement Instructions (*For DC powered instruments only*)**

The rechargeable NiCad batteries used in the 4021 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.

## BCD Interface

Option BCD has a rear mounted 50 pin Amphenol connector providing data in a parallel binary-coded-decimal (BCD) format. The outputs are TTL compatible and may drive 1 LS load. The summary of pin functions is provided below and on the schematic number 2053-076 at the back of this manual.

<u>Pin Number</u>	<u>Data</u>
1	1
2	2
3	4
4	8
6	10
7	20
8	40
9	80
11	100
12	200
13	400
14	800
16	1000
17	2000
18	4000
19	8000
21	10000
22, 40	20000 (overrange)
26	+5 VDC supply
50	0 VDC common
35	End of Conversion on negative transition (A high signifies "Busy")
45	Display Hold Line (+5V or open = Run; 0V = Hold)

The BCD outputs are fully compatible with the Valhalla Model 1248 BCD Comparator. When connecting to the comparator using the standard IDC-2 interface cable, the end of the cable possessing the wire break-outs is connected to the Model 1248.