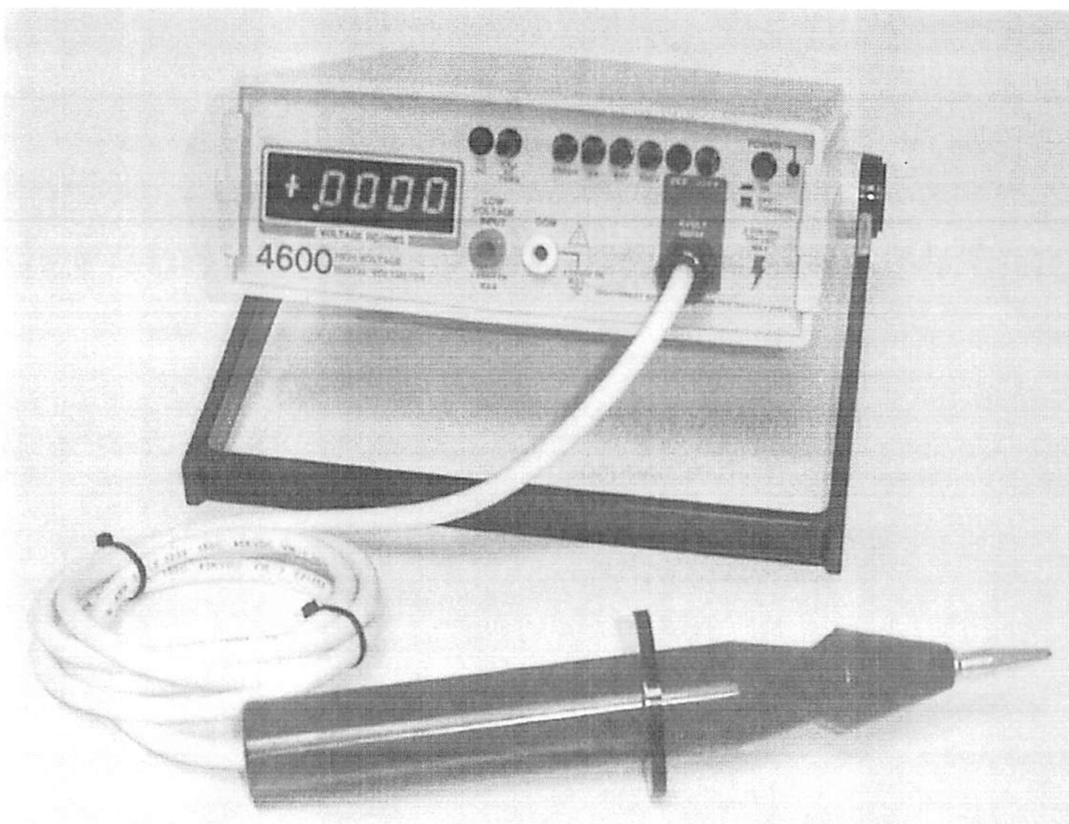
Model 4600 High-Voltage Digital Voltmeter



Operating Manual

9880A Via Pasar, San Diego CA 92126 USA
V: (858)689-2755 F: (858)689-2760
Web: www.vitrek.com E-mail: info@vitrek.com

CERTIFICATION

Vitrek Corporation certifies that this instrument was thoroughly tested and inspected and found to meet published specifications when shipped from the factory. Vitrek Corporation 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 Vitrek Corporation 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, Vitrek Corporation reserves the right to change any or all specifications without notice.

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SECTION I UNPACKING & INSTALLATION

1-1. Introduction

The Vitrek Corporation Model 4600 is a 4½-digit voltmeter capable of measuring AC or DC voltages from 10µV resolution to 19,999 volts full scale. It is especially useful for servicing computer terminals and other types of CRT display equipment as it permits voltage measurements to ±20KV DC (15KV AC) with an option that allows it to be used to 30KV DC. The 4600 incorporates overload protection on all input ranges when operated within specified limits. The lower voltage ranges have excellent linearity and high-frequency bandwidth to 20kHz.

The 4600 operates from an internal battery supply which is rechargeable. To prevent the possibility of shorts to ground when working with high voltages, the charging circuit is disabled when the meter is in the operate mode. It is for this reason that the 4600 must be turned off in order to charge the batteries. For additional safety, it is recommended that the charger be physically disconnected from the meter while making high voltage measurements. Typical battery life of 5-6 hours may be expected between charges.

The 4600 has been designed with safety in mind but may be **hazardous or fatal** if misused! Please read this manual thoroughly, including the safety precautions in section 1-7, before attempting to operate the Model 4600.

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 Vitrek Sales Office. Retain the shipping carton for the carrier's inspection. DO NOT return equipment to Vitrek Corporation or any of its sales offices prior to obtaining authorization to do so.

1-3. Fuse Protection

The Model 4600 uses two fuses, one each for battery and internal circuitry protection. The fuse located on the rear of the instrument protects the batteries from receiving an excessive charging current. This fuse is a 2A fast-blo fuse. If this fuse is blown, it may indicate a problem with the internal battery pack or with the external battery charger. **Replace blown fuses with their exact equivalent *only*!**

The internal fuse is a 1A fast-blo fuse. This fuse is used to protect the internal power supply from an overcurrent condition. If this fuse is blown, it may indicate a problem with the internal power supply circuits. **Replace blown fuses with their exact equivalent *only*!**

1-4. 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. The user should become familiar with the operating instructions in Section 4 before attempting to operate the voltmeter.

1-5. Rack Mounting

An optional kit is available for mounting the 4600 in a standard 19" equipment rack. This is listed in Section 3. Follow the installation instructions included with the option. If the 4600 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 airflow. Under no circumstances should the ambient air temperature around the unit exceed 50°C while the unit is in operation or 70°C when power is removed.

1-6. Tips for Longer Battery Life

The 4600 uses rechargeable lead-acid batteries to power the internal circuits. These batteries are quite reliable and should provide years of service. Observing the following notes can maximize this life span:

1. Fully charged batteries have a useable duration of 5-6 hours in the Model 4600 voltmeter.

2. High ambient temperatures while in storage or operation will reduce battery life span. Whenever possible, keep the batteries cool.

3. Keep the 4600 connected to the charger whenever not in use.

4. Do not allow batteries to fully discharge (i.e. do not leave it on overnight).

5. If the batteries do become depleted to the point that they will no longer store a charge, please refer to section 5-4 for battery replacement instructions.

1-7. Safety Precautions

<u>Warning:</u> Although the Vitrek Model 4600 has been designed to provide a safe high voltage measurement (i.e. battery isolation, flush mounted input terminals, plastic instrument case, etc.) extreme caution must always be used when working with high voltages. Always heed the following precautions to ensure maximum safety:

1. **Follow all warnings on the instrument.**

2. **Never attempt to change ranges with high voltages applied.**

3. **Always remove power from the high voltage source when not in use.**

4. **The maximum isolation of the COM terminal from the instrument chassis is ±2500 volts. This means that a shock hazard may occur if the COM input is raised more than 2500 volts from earth ground potential.**

SECTION II SPECIFICATIONS

2-1. General

The accuracy specifications for the Model 4600 are valid for a period of 1 year from the date of calibration at 25˚C (±5°C). Outside of this range, the temperature coefficient specification of ±0.002% of the reading per ˚C applies.

2-2. DC Voltage Measurements

Ranges:	**200mV, 2V, 20V, 200V, 2KV, 20KV, and 30KV (if installed)**
Accuracy:	±0.05% of reading ±0.025% of range (±0.5ppm/V on KV ranges)
Maximum Inputs: (without damage)	±20,000 volts DC max at the KVolt Input jack (optional 30,000 volt DC available)
	±300 volts DC max at the Low Voltage Input jack

2-3. AC Voltage Measurements (True RMS)

Minimum Input:	5% of range
Crest Factor:	3:1, not to exceed 150% of range
Ranges:	**200mV, 2V, 20V, 200V**
Accuracy:	20Hz to 5kHz = ±0.1% of reading ±0.1% of range 5kHz to 20kHz = ±0.5% of reading ±0.5% of range
Range:	**2KV**
Accuracy:	20Hz to 100Hz = ±0.1% of reading ±0.1% of range ±0.5ppm/V 100Hz to 400Hz = ±0.5% of reading ±0.25% of range ±0.5ppm/V
Range:	**20KV and 30KV (if installed)**
Accuracy:	20Hz to 60Hz = ±0.5% of reading ±0.25% of range ±0.5ppm/V
Maximum Inputs: (without damage)	20,000V peak (15,000V RMS) at the KVolt Input jack 300V peak (200V RMS) at the Low Voltage Input jack

▶ CAUTION! The maximum AC input allowed in any range is 15,000 volts RMS.

2-4. Miscellaneous Specifications

Display Resolution:	0.005% of the range, except the optional 30KV range which is 0.033% of the range.
Input Impedances:	1000MΩ on the 200mV and 2V ranges 10MΩ on the 20V and 200V ranges 100MΩ on the 2KV, 20KV, and 30KV (if installed) ranges
NMR:	50db at 50 or 60 Hz
CMR:	Near infinity (battery powered)
Battery Pack Voltage:	6VDC nominal (3x 2-volt cells)
Charging Requirements:	+12VDC (center=+) @60mA nominal at the rear charging jack
Charging Time:	12 hours to fully recharge depleted batteries (As a rule of thumb, the 4600 requires twice as much recharge time as actual time in use.)
Dimensions:	10"W x 10"D x 3"H (254mmW x 267mmD x 83mmH)
Weights:	3.5lbs (1.6kg) Net 7lbs (3.2kg) Shipping

2-5. Option "Peak Hold" Specifications

Decay Rate:	The stored reading will decay at a rate of not more than -25 counts of the display per minute.
Accuracy:	The AC uncertainties in section 2-3 are increased by an additional ±0.1% of range with the Peak Hold switch in the ON position.

SECTION III OPTIONAL EQUIPMENT

3-1. General

The Model 4600 is shipped with a detachable battery charging adapter, a high-voltage lead set (Option HVL), and an operation manual as standard equipment. This section lists several items that may be desirable for special applications.

Option HVL: High Voltage Lead Set

This item is a lead set specially designed for making high voltage measurements using the 4600. The COM wire is 6 feet long and terminated in an insulated alligator clip. The KVOLT "hot" wire is 6 feet long, double insulated, and terminated in a probe tip ideal for making high voltage connections. One of these lead sets is included as standard equipment with the Model 4600.

Option C: Low Voltage Lead Set

This optional item is designed to facilitate voltage measurements up to 200 volts. One end of the lead set is terminated in a double banana jack for connecting to the 4600. The other end is terminated with insulated red and black alligator clips. A variation of this low voltage lead set available is Option "BBL" which is terminated on both ends with double banana jacks.

Option R4: Rack Mount Kit

This tray and mounting plate kit allow the Model 4600 to be installed in a standard 19" equipment rack. Caution must be exercised when using the 4600 in a rack to ensure that the ±2500 volt isolation from COM specification is not exceeded.

Option "Peak Hold"

This option offers additional safety by allowing the user to capture the peak RMS value of the input voltage and hold it on the display of the 4600 even after the voltage is removed. This feature may only be used in the AC measurement mode. Please refer to section 4-6 for more details.

Option "30KV"

This option allows higher DC voltage measurements to be made (up to 30,000 volts). The 2KV and 20KV ranges are replaced by the 20KV and 30KV ranges, with the 2KV range being deleted. Note that this increased capability is for DC voltages only. The maximum AC voltage allowed is still 15,000 volts. Refer to the specifications in Section 2.

Option CC4: Meter Carrying Case

This option consists of a black vinyl case with a shoulder strap. The case has room for the meter and its accessories, and may be useful if the 4600 is often moved from one location to another.

Spare Battery Chargers

The 4600 is supplied with one battery charger as standard equipment. If the 4600 is moved to various locations, it may be desirable to have several charging stations. If additional chargers are desired, please specify Vitrek Stock #05-10626.

Replacement Batteries

Replacement batteries are available as Vitrek Stock #05-10146. Three (3) are required. Please refer to section 5-4 for replacement instructions.

SECTION IV OPERATION

4-1. General

This section provides complete operating instructions for the Model 4600. The 4600 is a safe and reliable instrument when used in accordance with the operating instructions. However, **this instrument may be hazardous or fatal if misused!** Please read all instructions thoroughly before attempting to operate the Model 4600.

4-2. Front Panel Controls

The POWER switch is a push ON, push OFF switch located in the upper right corner of the front panel. NOTE: This switch must be in the "OFF/CHARGING" position in order to recharge the batteries.

The "function" switches determine whether AC or DC voltages will be measured. Make the desired selection by depressing the corresponding push-button.

Voltage range selection is accomplished using the remaining six push-buttons. The range switches are interlocked so that only one switch may be depressed at any one time.

4-3. Making Connections

The 4600 offers three input terminals. The COM terminal should be connected to the "common", "negative", "low", "neutral", or "ground" of the voltage source. The other two terminals are selected according to the amount of input voltage to be measured and should be connected to the "output", "line", "positive", or "high" of the voltage source.

If the input voltage is not expected to exceed 200 volts DC or RMS, connections may be made to the "LOW VOLTAGE INPUT" jack. Follow the instructions of section 4-4.

If the input voltage is unknown or expected to exceed 200 volts DC or RMS, make connections to the "KVOLT INPUT" terminal. Follow the instructions of section 4-5.

4-4. Low Voltage Measurements

Low voltage measurements (<200V DC or RMS) are made by connecting the input to the "LOW VOLTAGE INPUT" terminal. Before applying the input voltage, select the voltage range, 200mV, 2V, 20V, or 200V, which best approximates the voltage level of the test. If the voltage level is unknown, select the 200V range.

If the input voltage is unknown but there is a possibility that it may exceed 200 volts, make connections to the KVOLT input terminal and determine the voltage level. If it then becomes apparent that the voltage can be safely measured on the lower ranges, move the connections to the LOW VOLTAGE INPUT.

▶ It should be noted that if the 4600 receives an input that is significantly higher than the selected range, it will attempt to protect itself by disabling the voltage measurement circuitry. This may be seen as a condition in which the 4600 will not respond to any input in any range, and the display may wander around aimlessly. This condition is temporary and will correct itself within 30 seconds after removal of the input voltage. **This automatic protection is limited and should not be used as a substitute for selection of the proper range!** Damage may occur to the 4600 due to excessive inputs.

4-5. High Voltage Measurements

<u>Warning</u>

Always use a high-voltage probe with proper insulation (Vitrek Option HVL, provided). Do not touch any part of the 4600 with high voltages (greater than 2500 volts) applied. Contact with high voltages may cause injury or death.

Voltages expected to exceed 200 volts DC or RMS may be measured at the KVOLT INPUT terminal. Maximum safety is achieved by following the guidelines given below for making high voltage measurements:

1. Disconnect the battery charger from the rear of the Model 4600.

2. Disable the high voltage source by removing its power source or by other suitable means.

3. Set the 4600 range to 20KV, and AC or DC as required.

4. Connect the HVL test probe set to the KVOLT and COM jacks of the 4600.

5. Connect the ground clip to the common of the high voltage source.

6. Enable the high voltage source.

▶ **If the ground clip should pull loose after power is applied to the high voltage source, *do not touch it!* Disable the high voltage source first and then reconnect the clip.**

7. Allow time for the high voltage source to reach full output, and then touch the HVL probe tip to the high voltage source terminal. If the reading is less than 2KV, remove the probe and repeat steps 1-7 selecting the 2KV range instead.

▶ **Never attempt to change ranges on the 4600 without first disabling the high voltage input!**

▶ It should be noted that if the 4600 receives an input that is significantly higher than the selected range, it will attempt to protect itself by disabling the voltage measurement circuitry. This may be seen as a condition in which the 4600 will not respond to any input in any range, and the display may wander around aimlessly. This condition is temporary and will correct itself within 30 seconds after removal of the input voltage. **This automatic protection is limited and should not be used as a substitute for selection of the proper range!** Damage may occur to the 4600 due to excessive inputs.

4-6. Option "Peak Hold" Operation

The Vitrek Model 4600 High Voltage Meter is available with an optional Peak Hold circuit. This feature allows the user to capture the peak RMS value of the input signal. This makes for safer measurements as the high voltage need be applied only momentarily. This function is available only in the AC measurement mode, but may be used in any range. The steps below should be followed when using the Peak Hold function.

1) Place the meter in the AC mode and the desired range for the expected voltage level.

2) Ensure that the voltage source is disabled and make connections to the 4600.

3) Place the rear panel "HOLD" switch in the ON position (down). Press the "RESET" button for 5 seconds and then release to clear any arbitrary data.

4) Apply the test voltage. The highest RMS value will be held on the display. To clear the display, press and hold the RESET button for 5 seconds.

▶ **Do not touch any part of the 4600 case *including the range or peak controls* if voltages in excess of ±2500 volts are applied to the input terminals.**

5) The voltage source may now be removed and the maximum RMS value will be held on the display until either the RESET button is pressed or the HOLD switch is returned to the OFF (up) position.

Alternate Method:

The Peak Hold feature may also be used to store for future reference the maximum RMS value in a series of measurements. This process is described below.

1) Make the desired series of measurements using the standard operating procedure described in the operating instructions. The HOLD switch should be left in the OFF (up) position.

2) Disconnect or disable the voltage source from the input terminals. Move the HOLD switch to the ON (down) position. The reading on the display will be the maximum RMS value measured since the last RESET.

▶ This procedure will only work for measurements taken within the same voltage range. If a range change is required, RESET the reading and repeat the procedure.

▶ The peak reading will decay over time at the rate specified in section 2-5. Therefore if a significant period of time has elapsed, the stored reading may be invalid.

SECTION V ROUTINE MAINTENANCE

5-1. General

This section provides general maintenance information and a procedure for calibrating the voltmeter. The Model 4600 should be calibrated on a routine basis (every 12 months is recommended) to ensure continued accuracy.

5-2. Required Test Equipment

The test equipment listed below or its equivalent is required for performance of the calibration procedure. The recommended Vitrek product is indicated in parentheses ().

EQUIPMENT	MINIMUM ACCURACY
DC Voltage Standard (Vitrek 2701C)	± 0.003%, 0.1V to 200V ± 0.01%, 200V to 1000V
AC Voltage Calibrator (Vitrek 2703)	± 0.02%, 0.1V to 100V at 20Hz to 20kHz; with 1000V up to 400Hz.

5-3. Calibration Procedure

The 4600 should have its batteries fully charged (over-night is recommended) prior to beginning the procedure. Turn on the instrument at least 5 minutes before beginning calibration. The locations of the adjustments are indicated on drawing number 4600-600 at the back of this manual.

The adjustments are accessed by removing the four screws that hold the feet in place. The PCB is mounted to the top cover so that adjustments may be made by tilting the 4600 up on its bail. **Avoid contact with the input terminals when making adjustments!**

5-3-1. DC Calibration

This section describes the DC calibration adjustments. These adjustments should be performed or at least verified as within tolerance prior to making any AC adjustments. Revisions for instruments fitted with Option "30KV" are shown in brackets [].

1. Select the DC measurement mode and the 200mV range. Connect the DC voltage source between the COM and LOW VOLTAGE inputs.
2. Apply .0001 volts and Adjust R75 for an indication of 00.10 in the 4600 display. Reverse polarity and balance R75 so that the reading is the same at both polarities.
3. Apply +.10000 volts. Adjust R21 for 100.00 in the display. Reverse polarity and balance any offset.
4. Select the 2V range. Apply +1.0000 volts and adjust R19 for 1.0000 in the display. Reverse polarity and balance any offset.
5. Check that the 20V and 200V ranges are in specifications by applying 10V and 100V respectively (no adjustment).
6. Move the high of the DC voltage source to the KVOLT INPUT terminal.
7. Select the 2KV [20KV] range. Apply +1000.0 volts and adjust R51 for 1.0000 [1.000] in the display. Reverse polarity and balance any offset.
8. Select the 20KV [30KV] range. Apply 1000 volts and verify that the reading is within specifications (no adjustment). This completes DC calibration.

5-3-2. AC Calibrations

▶ All steps of the DC calibration procedure must be performed first to ensure specified AC accuracy.

1. Select the AC measurement mode and the 2V range. Connect the AC voltage source between the COM and LOW VOLTAGE terminals.

2. Apply .1000V AC @ 100Hz. Adjust R69 for .1000 in the 4600 display.

3. Increase the input voltage to 1.0000 volts. Adjust R7 for 1.0000 in the display. Repeat steps 2 and 3 if necessary.

4. Reduce the input voltage to .10000 volts and select the 200mV range. Adjust R23 for 100.00 in the display.

▶ Adjustment of the variable capacitors C16 and C38 is not recommended unless specific problems with the frequency response of the instrument are suspected. These capacitors have been preset at the factory for optimum linearity throughout the bandwidth of the instrument.

5. Select the 20V range. Apply 10.000 volts @ 20kHz. Adjust C16 for 10.000 on the 4600 display. C16 may be balanced to bring other frequencies within specifications.

6. Select the 200V range. Apply 100.00 volts @ 20kHz. Adjust C38 for 100.00 on the display. C38 may be balanced to bring other frequencies within specifications.

7. Move the high of the AC voltage source to the KVOLT INPUT terminal.

8. Select the 2KV [20KV] range. Apply 1000.0 volts @ 100Hz. Check that the reading is within specifications (no adjustment).

9. Select the 20KV [30KV] range. Apply 1000V at 100Hz. Verify that the reading is within specifications. This completes the AC calibration.

5-4. Battery Replacement Instructions

The rechargeable battery pack used in the 4600 consists of three (3) 2-volt cells. The cells are of the sealed lead-acid type, and should provide years of trouble-free service. Eventually, however, these batteries will need to be replaced. Replacement batteries are available as Vitrek Stock #05-10146. The batteries should always be replaced as a set (three at a time).

Follow the instructions below for battery replacement. The tools required are a screwdriver and a soldering iron.

1) Remove the bottom cover by unscrewing the four feet screws.

2) Turn the unit off and **remove the fuse from the battery PCB** (drawing number 4600-601 at the back of this manual).

3) Remove the two screws that hold the battery PCB in place.

4) Turn the board over and de-solder the six battery posts. Remove the batteries.

5) Install the new batteries **observing polarity** as indicated on the top of the battery and on the PCB.

6) Trim off the excess length of the battery posts and re-install the PCB.

7) Replace the fuse on the battery PCB. A 24-hour charge is recommended before use.

SECTION VI THEORY OF OPERATION

6-1. 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!** Check to be sure that cables and other test equipment are in good working order before attempting to troubleshoot the 4600.

6-1-1. Localizing the Problem

Frequently the malfunction will be evident only on a single range or function. At other times, it will be apparent on every range and function. When an instrument is totally inoperative, examine the power supply. If the error is observed on all functions, check for problems in the common sections of the instrument; i.e. the power supplies or the A/D converter. For single range errors, check the range switches or input attenuators.

Cycling the instrument through each of its functions and ranges while observing the display will often indicate exactly which section of the instrument is malfunctioning. Refer to the drawings at the back of this manual and the accompanying circuit descriptions if unfamiliar with the operating principles of any part of the instrument. The clues obtained, combined with a working knowledge of the circuits, should allow correction of any malfunction.

6-1-2. Component Replacements

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

- Use only the specified replacement part or its exact equivalent. Spare parts can be ordered from your nearest Vitrek Corporation Service Center or from the factory directly by referring to the Vitrek 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.
- 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.

6-2. Functional Descriptions

The following functional descriptions are based on the Figures 6-1, 6-2, 6-3 and the Model 4600 schematic, drawing number 4600-070 at the back of this manual. For convenience, references to integrated circuits are made in the format "IC11-3" which refers to integrated circuit 11, pin 3.

6-3. Power Supplies

The power supplies consist of a sealed, rechargeable battery supply and a DC-to-DC converter. The DC/DC converter is composed of IC1, IC2, Q1, Q2, C1 and a transformer, and is located on the separate power supply PCB.

When the Power Switch is ON, the battery voltage is connected across the center tap of the transformer and the emitters of Q1 and Q2. IC1 and IC2, dual flip-flops, divide the 200kHz output of IC11-3. The resulting 12.5kHz pulses alternately switch Q1 and Q2 on and off. The resulting conduction of Q1 and Q2 produce AC pulses in the transformer primary. These pulses induce an AC voltage across the transformer secondary.

This AC voltage is rectified by the bridge composed of CR1-CR4 and is filtered by C2 and C3. The ∀12 volt output is regulated by IC5 and IC6 to produce the ∀8 volt supplies. The batteries are arranged in series to produce the +6 volt supply.

6-4. A/D Converter

The Model 4600 analog-to-digital converter (A/D converter) incorporates a three-step integrator, which provides automatic zero correction, high-impedance differential inputs, and automatic polarity.

The major components of the A/D converter are a precision timer IC11, an analog processor IC12, a digital processor IC13, and a precision voltage reference IC14.

The analog processor contains the zero-correction circuitry, an integrator, a zero-crossing detector and the switches required to implement the integration process.

The digital processor contains an oscillator, a counter, a buffer register, an output decoder and circuitry to control the analog processor.
The three-step integration process consists of (1) sensing and storing in C14 any error voltage present in the analog circuits due to offset, noise or drift: (2) charging integrator capacitor C17 from the unknown input voltage for a fixed time; and (3) applying the reference voltage to C17 in the opposite polarity to the unknown input voltage for whatever time it takes to discharge C17 back to zero. Refer to Figure 6-2.

The greater the charge on C17, the longer it will take to discharge it to zero. This time is measured by counting the output of the oscillator in the digital processor. The oscillator frequency and the maximum integration time are chosen to produce a count exactly equal to full-range input. If the unknown voltage is less than full-range, the integration time will be shorter and the count will be proportionately less.

The count is stored in the buffer register of the digital processor and after the reference has been integrated it is shifted into the display, where it remains until the next reference integration has been completed. At that time, the display is updated to again indicate the unknown input voltage.

6-4-1. Integrator Operations and Control

Time periods A and B of Figure 6-2 show two complete integration cycles; the former is for a positive input, the latter for a negative input. During the first step of Period A, both IC12-8 and -9 are set LOW by the digital processor, IC13. Analog inputs IC12-1 and -2 are internally disconnected from the integrator, and its input is grounded. Zero Sense capacitor C14 is charged to the value of any error voltage present in the analog circuits, and Reference Capacitor C20 is charged from precision reference supply IC14 via IC12-4.

After a fixed time IC13 forces both IC12-8 and -9 HIGH and the second integration step begins. C14 and IC12-1 and -2 are connected to the integrator. The C14 charge corrects for offset while C17 charges toward the value of the unknown input voltage at a rate proportional to its amplitude. During this time the zero-crossing detector output at IC12-10 goes HIGH and sets the polarity bit in the digital processor.

At the end of the fixed integration period, IC13 forces IC12-8 LOW and the reference integration begins. C20 is connected to the integrator with its charge opposing the polarity of the charge on C17. The counter in IC13 is simultaneously gated ON and as C17 discharges back toward zero, it counts the oscillator output in BCD format and stores it in the Buffer Register.

When the charge on C17 is reduced to zero, IC12-10 drops out of its high state, telling IC13 to gate the counter OFF. IC13 then forces IC12-9 LOW, returning the analog processor to the Zero Sense state. The accumulated count and the polarity are then displayed on the LED display until the next measurement is completed, when the display is updated.

Period B of Figure 6-2 shows timing for a negative voltage measurement. With IC12-8 and -9 LOW, C14 and C20 are charged. When IC13 forces IC12-8 and -9 HIGH, the negative input is applied to the integrator input, charging C17 negative until IC13 forces IC12-9 LOW. During this time, IC12-10 sets the polarity bit LOW, C20 discharges C17 back toward zero, and the oscillator output is counted. When C17 is discharged, IC12-10 leaves the LOW state, the counter is gated OFF and IC12-8 is set LOW, returning IC12 to the Zero Sense state. The new count and polarity are now displayed.

6-4-2. LED Display

The display is produced by a scanning process, with each LED indicator being switched on and off at a 1kHz rate. While no two indicators are turned on simultaneously, the 1kHz switching rate makes them all appear to be on continuously.

Dividing the 200kHz oscillator output, set by the precision timer input applied to IC13-17, derives the 1kHz pulse train used to switch the indicators. The switching outputs are applied to LED drivers Q2-Q6 via IC13-2 to -6, as shown in Figure 6-3.

The BCD count corresponding to the least significant digit is shifted out of the buffer register, decoded into seven-segment format, and appears at IC13-7 to -14 at the time IC13-2 enables Q-4, causing the LED indicator to display the count. This shifting and decoding process is repeated for the 10^1, 10^2, 10^3, and finally the most significant digit as Q2 through Q6 are sequentially enabled. The result is a display that appears continuous to the human eye.

6-5. Input Attenuators

Refer to the schematic diagram, 4600-070.

When either the 200mV or 2V range is selected, the unknown input voltage is not attenuated. Instead, it is applied via the Function and Range switches directly to the A/D Converter input IC12-1 and -2. If the 200mV range is selected, however, +8 volts is applied to electric switches IC7-12 and -13. This sets the A/D Converter gain to maximum and reduces the reference voltage by a factor of 10. Since IC7-1 and -2 are effectively open and IC7-3 and -4 are effectively closed, the reference voltage is applied to IC12-4 from the arm of R19.

When the 2V range is selected, the +8 volts is removed from IC7-12 and -13 and applied to IC7-5 instead. Consequently, the A/D Converter gain is reduced by a factor of 10 and the reference voltage is increased by the same factor, since it is sent to IC12-4 from the arm of R21 instead of R19.

When either the 20V or 200V range is selected, the input voltage is applied to a divider consisting of R47, 48 and 49. The output of the divider is the junction of R47 and R49, and the unknown input is attenuated by a factor of 100:1. On the 20V range, IC7 sets the gain of the A/D Converter high; on the 200V range, the gain is reduced as it was on the 2V range with the attenuator composed of R47-52, providing 10,000:1 attenuation. The A/D Converter gain is again selected by IC7, as it was on the lower range pairs.

6-6. True RMS Converter

The TRMS converter is made up of IC4 and its associated components. Its input at IC4-1 is coupled from IC8-6 via C9, R7 (gain trimmer) and C6. The internal circuitry of IC4 consists of a voltage-to-current converter, a squarer/divider, a current averager and a source follower that produces the proportional DC output voltage at IC4-6. C4 and C5 set the current averaging period and also determine the ripple level and settling time of the converter. C3 filters the current output at IC4-8 before it is applied to the output buffer at input terminal IC4-7. R69 is the zero offset adjustment.

The AC voltage input at IC4-1 is converted to a proportional AC current, which is squared, averaged, and divided to provide an RMS current output at IC4-8. This output drives the buffer input at IC4-7 to produce a DC voltage equivalent to the true RMS AC input. The DC output voltage is connected to the A/D Converter input IC12-1 and -2 for measurement.

6-7. AC Input Attenuation

In the AC measurement mode the range attenuation is identical to that described in section 6-5 with one exception: When measuring AC Volts, the DC reference voltage and A/D Converter gain are held constant for all ranges by IC7-12 and IC7-5 via the AC Function switch. The TRMS converter gain, however, is alternately set high and low via the Range Selector switches.

SECTION VII PARTS LISTS

The following parts lists have been included in this manual:

4600-600	3 pages	4600 Main Board Assembly
4600-601	1 page	4600 Battery Board Assembly

SECTION VIII DRAWINGS AND SCHEMATICS

The following drawings have been included in this manual:

4600-600	1 page	4600 Main Board Assembly
4600-601	1 page	4600 Battery Board Assembly
4600-602	1 page	4600 Display Board Assembly
4600-070	1 page	4600 Schematic Diagram