



Advanced Test Equipment Corp.

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# 2105

Wide-Range Power Analyzer

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## Operation Manual



VALHALLA  
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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. reserve the rights to change any or all specifications without notice.

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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.

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For repair and calibration services, call 800-548-9806 or visit [valhallascientific.com](http://valhallascientific.com).

Email support available at [support@valhallascientific.com](mailto:support@valhallascientific.com)

2105 Wide Range Power Analyzer  
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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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# Chapter 1 General Information

## Introduction

This manual has information to perform Inspection, Installation, Measurement Operations, and Troubleshooting for Valhalla Scientific Model 2105. Also included in this manual are: Specifications, Parts Lists and Schematics.

## Manual Description

This Manual is separated into the 9 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 Ranges, Resolutions, Accuracy, General and Physical Specifications for Valhalla Model 2105.

### **Chapter 4 – Options and Accessories**

Chapter 4 contains information on all available options and test leads for the Valhalla Model 2105.

### **Chapter 5 – Operations**

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

### **Chapter 6 – Routine Maintenance**

Chapter 6 contains maintenance information, such as calibration procedure.

### **Chapter 7 – Theory of Operation**

Chapter 7 describes the theory of operation of all circuits and sub circuits used on Valhalla Model 2105.

### **Chapter 8 – Addendums**

Chapter 8 lists updates and addendums for this manual.

## 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.



## Chapter 2 Unpacking and Installing

### Introduction

Valhalla Scientific Model 2105 is accurate, reliable low-cost power measurement devices designed to aid engineering, production test, and quality assurance departments in determination of product power consumption from DC and AC power sources. The instruments feature dual independent digital displays. The left display provides a continuous indication of true power in watts. The right display is switch-selectable between amperes (true RMS) or volts (true RMS).

Model 2105 provides a fast and convenient method of determining product efficiency, power factor, and true RMS current draw. Phase angle relationships may be calculated through manipulation of the displayed quantities.

### 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, 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.

### Line Voltage/Fuse Selection

The switch on the rear of the 2105 is used to configure the power analyzer for operation at different AC line voltages. The supply voltages and their corresponding fuses are listed below:

105 to 125 VAC, 50-400Hz = .250 Amp Slo-Blo

210 to 250 VAC, 50-400Hz = .125 Amp Slo-Blo

Note that this switch is for the internal operating voltages required by the power analyzer and should not be confused with the input voltage selectors on the front of the instrument.

### Bench Use

The 2105 is delivered for operation in bench use and special instructions for use in this manner other than the procedures of optional accessories are not required.

### Rack Mounting

An optional kit is available for mounting the 2105 in a standard 19" equipment rack. This is listed in Optional Accessories section of this manual. Follow the installation diagram included with the kit. If the 2105 is to be transported while mounted in a rack, then it must be supported to prevent upward and downward movement.

The user should note that the specifications for the 2105 become degraded at high temperatures thus it is required that sufficient room be allowed for airflow around the 2105. This may be achieved by placing a minimum 1.75" blank panel above and below the 2105 in the rack.

If a unit placed beneath the 2105 has an unusually hot exterior top surface and it is not possible to alter its location, it is recommended that an aluminum "reflector" plate be used between this unit and the 2105.

Under no circumstances should the ambient air temperature surrounding the 2105 be allowed to exceed 50°C while in operation or 70°C while in storage.

### Safety Precautions

The power connector is a three-contact device and should be mated only with a three-contact connector where the third contact provides a continuous ground connection. A mating power cord has been provided. If the power is provided through an extension cable, then the ground connection must be continuous throughout this cable. Failure to provide a continuous ground connection to the 2105 may render it unsafe for use!

**Lethal voltages are routinely present on the rear terminals of the 2105! Always disable the power source before changing load or source connections.**

## Chapter 3 Specifications

This section contains accuracy, operating and environmental specifications for the Model 2105.

### Range and Resolution Table

Table 1

		Current Ranges		
		.2000A	2.000A	20.00A
Voltage Ranges	30.00V	6.000W	60.00W	600.0W
	150.00V	30.00W	300.0W	3000W
	300.0V	60.00W	600.0W	6000W
	600.0V	120.00W	1200.0W	12000W
		<b>Watts</b>		

### Accuracies

Specified accuracies are valid for a period of 1 year from the date of calibration at 25° C ±5°C, following a 30-minute warm-up.

#### **Voltage - AC+DC, DC Coupled**

DC and 40Hz - 5 kHz: ..... ±0.1% of reading ±6 digits  
 5 kHz - 10 kHz: ..... ±0.5% of reading ±0.5% of range  
 10 kHz - 20 kHz: ..... ±1% of reading ±1% of range  
 (Useable above 20 kHz to 50 kHz with typically an additional 1% error per 10 kHz)

#### **Current - AC+DC, DC Coupled**

DC and 40Hz - 5 kHz: ..... ± 0.1% of reading ±6 digits  
 5 kHz - 10 kHz: ..... ±0.5% of reading ±0.5% of range (12 Amps maximum)  
 10 kHz - 20 kHz: ..... ±1% of reading ±1% of range (2 Amps maximum)  
 (Useable above 20 kHz to 50 kHz with typically an additional 1% error per 10 kHz)

#### **Watts - True Power (EI A cos φ)**

DC and 40Hz - 5 kHz: ..... ±0.25% of reading ±6 digits  
 5 kHz - 10 kHz: ..... ±0.75% of reading ±0.75% of range (12 Amps maximum)  
 10 kHz - 20 kHz: ..... ±1% of reading ±1% of range (2 Amps maximum)  
 (Useable above 20 kHz to 50 kHz with typically an additional 1% error per 10 kHz)

## Operating Specifications

Crest Factor Response:	50:1 for minimum RMS input, linearly decreasing to 2.5:1 for full scale RMS input
Minimum Inputs:	5% of voltage and current ranges for specified accuracies
Maximum Voltage Input: (Without damage)	600VDC or RMS, $\pm 1500V_{PEAK}$
Maximum Current Input:	$\pm 35A_{PEAK}$ , 20ADC or RMS continuous; 100ADC or RMS for 16 milliseconds without damage
Voltage Input Impedance:	600k $\Omega$
Current Shunt Impedance:	0.01 $\Omega$
Max Common Mode:	$\pm 1500V$ peak, neutral to earth
Peak Indicators:	Illuminate at 2.5 x full scale for voltage and current
Over-range:	150% of full scale for DC, up to "maximum input" specification

## Environmental and Physical Specifications

Temperature Range:	0°C to 50°C operating; -20°C to 70°C storage
Temperature Coefficient:	$\pm 0.025\%$ of range per °C from 0°C-20°C and 30°C-50°C
Power Consumption:	105-125VAC or 210-250VAC, 50-400Hz; 25VA maximum
Dimensions:	25cm W x 27cm D x 8cm H (10" W x 10.5" D x 3" H)
Weights:	1.7kg (3.5 lbs) net; 3kg (6 lbs) shipping
Source/Load Connections:	4-terminal heavy-duty input jacks

## Chapter 4 Optional Accessories

This section lists the accessories available for the 2105 Digital Power Analyzer. Standard accessories include a detachable power cord and an operation manual.

### Optional Accessories

#### **I-100: Current Transformer**

This "clamp-on" type current transformer extends the AC current measurement capability on the 2105 to 100 amps RMS. The 100:1 output ratio is 2% accurate from 45Hz to 1000Hz. The device accommodates up to 2" diameter conductors.

#### **I-150: Current Transformer**

This "clamp-on" type current transformer extends the AC current measurement capability on the 2105 to 150 amps RMS. The 1000:1 output ratio is 2% accurate from 50Hz to 60Hz, and 3% accurate at 60Hz to 10 kHz. The device accommodates up to 2" diameter conductors.

#### **I-1000: Current Transformer**

This "clamp-on" type current transformer extends the AC current measurement capability on the 2105 to 1000 amps RMS. The 1000:1 output ratio is 2% accurate from 50Hz to 1000Hz. The device accommodates up to 2" diameter conductors.

#### **X21: Load Power Adaptor Cord**

This cable is specifically designed for use with the 2105 Power Analyzer. It allows for quick and easy connection and testing of loads that use a standard AC plug (i.e. televisions, toasters, microwaves, radios, hair dryers, etc.). The entire cable is 6 feet in length and accommodates supply currents up to 20 amperes.

#### **CC4: Carrying Case**

This item is a meter and accessory carrying case designed to protect the Power Analyzer when moved from one location to another. The case is made of black vinyl and includes a shoulder strap.

#### **R4: Rack Mount Adaptor Kit**

This item adapts the Power Analyzer for installation in a standard 19" equipment rack.

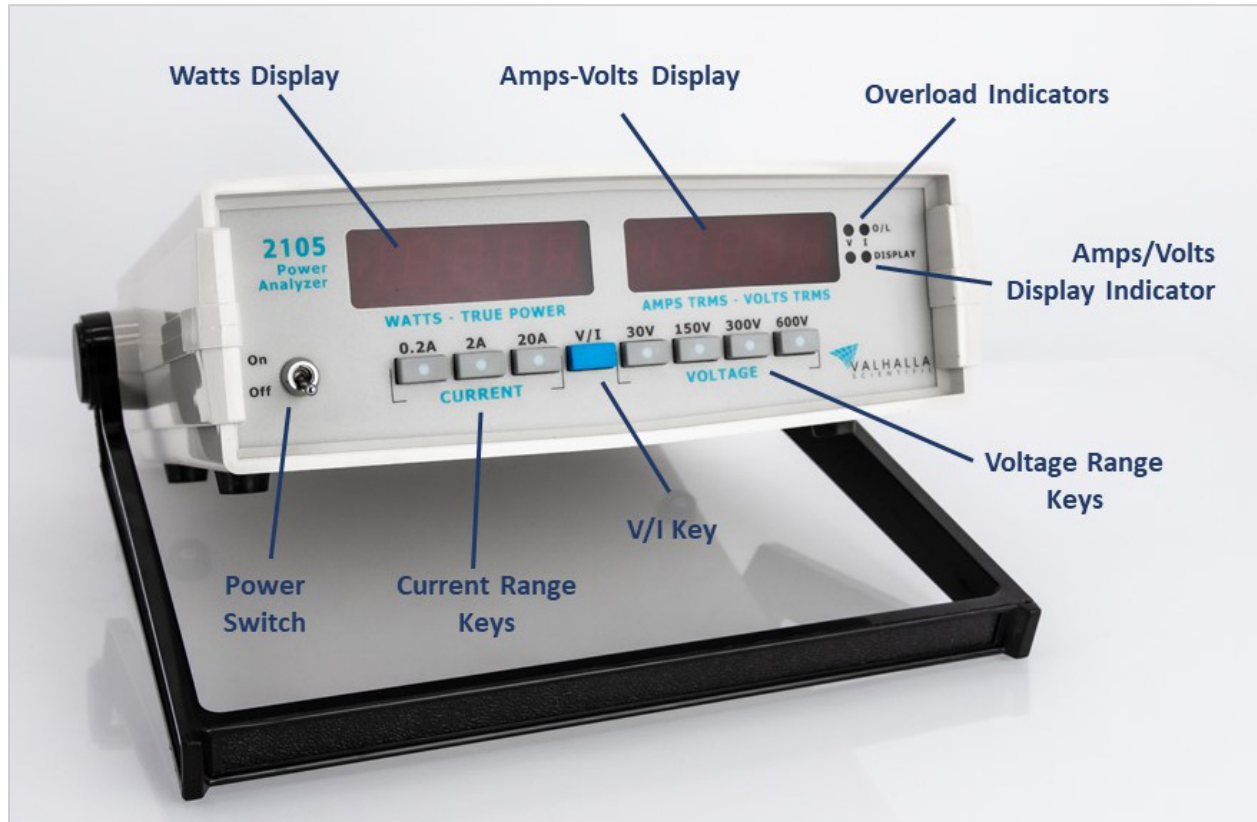
## Chapter 5 Operations

### General

This section of the manual contains complete operating instructions for the Model 2105 Digital Power Analyzers. Included are control functions, connection methods, and operational precautions.

### Front Panel Controls

The functions of all front panel controls and indicators are described in the following paragraphs.



### Power Switch

Power is applied to the 2105 by placing the ON/OFF switch in the ON position. Application of power is indicated by lighting of the digital displays.

### V/I Key and Amps/Volts Display Indicator

The Amps/Volts Display Indicator specifies which value is being displayed on the Amps/Volts display. The user can switch between volts and amps by pressing the V/I key on the front panel keypad.

### Current Range Keys

These keys select the range of current that will be measured. For the greatest accuracy, select the range that provides the highest resolution without exceeding the value of the range.

If the amount of current is unknown, select the highest current range before applying power to the load. If the amount of current can be approximated, select the appropriate range.

### Voltage Range Keys

These keys select the range of voltage that will be measured. For the greatest accuracy, select the range that provides the highest resolution without exceeding the value of the range.

If the level of voltage is unknown, select the highest voltage range before applying power to the load. If the level of voltage can be approximated, select the appropriate range.

### Peak Amp Overload Indicator

This indicator may be used to alert the user to the presence of spikes on the input signal. If the peak or steady-state current to the measured load is greater than 250% of the range selected with the Current Range Key, the "Amps O/L" indicator illuminates. Select a higher current range or reduce the current to the load to extinguish the indicator. Current and power displays may or may not be correct and should not be trusted if this indicator is lit.

### Peak Volt Overload Indicator

This indicator may be used to alert the user to the presence of spikes on the input signal. If the peak or steady-state voltage applied to the load is greater than 250% of the range selected with the Voltage Range Key, the "Volts O/L" indicator will be illuminated. Select a higher voltage range or reduce the supply voltage to extinguish the LED. Volts and power displays may or may not be correct and should not be trusted if this indicator is lit.

### Amps-Volts Display

When the Volts Display Indicator is ON, the right-hand digital display will show the True RMS

(AC+DC) voltage applied to the rear panel connectors.

When the Amps Display Indicator is ON, the True RMS (AC+DC) current passing through the internal shunt will be displayed in the right-hand display.

A flashing display in either mode indicates an overload condition. Reduce inputs or increase the ranges until a stable reading is observed.

### Watts – True Power Display

The power dissipated in the load (in watts) is indicated on the left-hand display. This reading is invalid if either the amps or volts overload indicator is illuminated. These peak indicators occur independently of whether "Amps" or "Volts" has been selected for the right-hand display. In either case, select a higher range or reduce the input signals. If the highest range has been selected and a peak O/L indicator is still on, the measurement may require the use of external dividers and/or current shunts.

This display includes a polarity (-) sign which indicates the general phase relationship between the voltage and current. A negative sign indicates that the voltage and current are out of phase. The lack of a negative sign means that the voltage and current are in phase. Note that a negative sign may also indicate that the voltage or current leads are reversed. The polarity sign may also be used to determine source or load power. Load power is that power which is consumed by a load. Source power (-) is that power which is supplied by a source.

If external dividers or shunts are used, the power display will be a fraction of the actual load power. Simple ratio calculations will then reveal the power delivered to the load. See *Using CTs and PTs* on page 16.

Under certain conditions where complex waveforms are being applied to the load, it may be necessary to select a current and/or voltage range that is well above the true RMS value indicated on the display to extinguish the "O/L" indicator. This will reduce the resolution of the wattmeter reading but is necessary for instrument accuracy. The display will blink if the load power is greater than that required for a display of 19999 (decimal omitted).

## Rear Panel Controls

The locations of the rear panel controls are shown in Figure 5-1. The function of the 115V/230V switch and power cord receptacle were covered on page 8 (Line Voltage/Fuse Selection). It is important to connect the load in accordance with the L (line) and N (neutral) indications on the rear panel for maximum safety and accuracy.

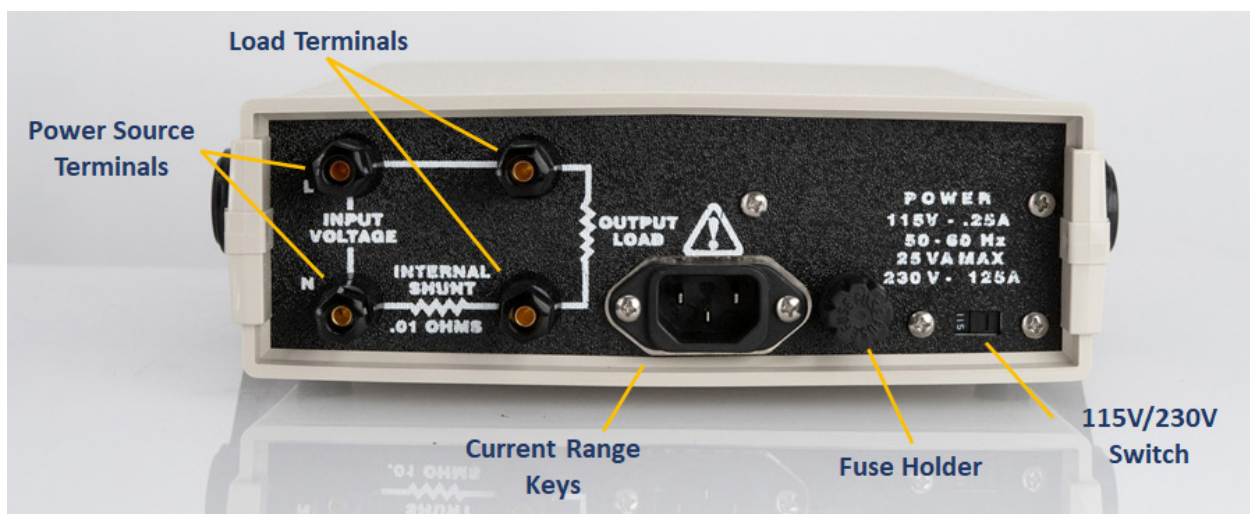


Figure 5-1 | Rear Panel

## Making Connections

The 2105 is designed to accommodate a multitude of connection methods allowing the user or test engineer to design custom harnesses according to the application. The basic guidelines for making connections are:

1. The supply voltage is connected between the "L" and "N" terminals (line and neutral).
2. The current to the load passes through the internal shunt. The load is connected to the right-hand

In effect, the Power Analyzer is placed in series with the load to monitor the power drawn by it.

Some connection methods are more complex and require some explaining. These are described in the following paragraphs.

### **CAUTION!**

Lethal voltages are routinely connected to the terminals of the 2105. Make sure that power sources are disabled before making or removing connections.



## Using the X-21

Perhaps the easiest and most common method of making connections to the Power Analyzer is using the Option X21 Load Power Cable. Option X21 allows for quick and easy connection of any device that uses a standard AC plug. Connections using Option X21 are shown in Figure 5-2.

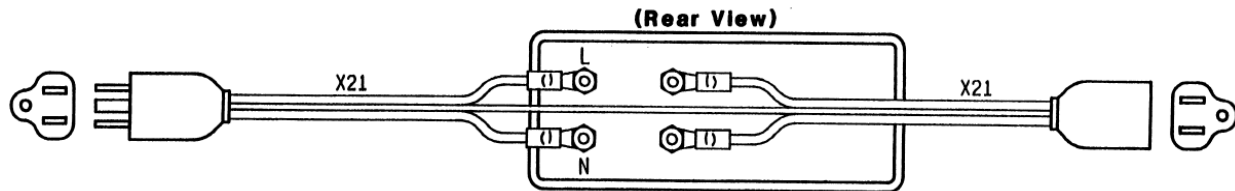


Figure 5-2 | 2105 Connections using the X-21

## Using CTs and PTs

Current and potential transformers (CTs and PTs) may be used with any Valhalla Digital Power Analyzer to increase its measurement range. Clamp-on CTs may also be used to simplify power analyzer connections.

### Current Transformers

Current transformers (CTs) are used to extend the current measurement capabilities of Valhalla digital power analyzers. CTs are available in many ratios, maximum current ratings, and isolation voltages.

There are two styles of CTs available, fixed and clamp-on. Fixed CTs are generally used for permanent test set-ups. The conductor being measured must be disconnected, passed through the center of the CT, and reconnected. Clamp-on CTs are easier to use because they are just clamped around the conductor. The conductor need not be disconnected when using a clamp-on CT.

CTs are also used for isolating the power analyzer from high voltage systems. Many high voltage systems operate at current levels directly measurable by the power analyzer, but with voltages beyond the power analyzer limits. The isolation voltage rating should be at least  $1\frac{1}{2}$  times the peak input voltage.

When selecting a CT, try to use decade ratios e.g., 10:1, 100:1, etc. Decade ratios make for easier power analyzer measurements. The user just mentally moves the current and power display decimal points to the right the appropriate number of places. Valhalla offers three types of CTs which are listed Optional Accessories on page 12. Of course, non-decade ratios may also be used. The maximum current rating of the CT should be selected  $1\frac{1}{2}$  times the expected current to allow for high crest-factor waveforms.

The ratio accuracy of CTs is usually about 2%. This is quite a bit wider than the accuracy of a digital power analyzer. The easiest way to improve this accuracy is to measure the actual ratio and use this value when correcting measurements.

CTs are low frequency devices, typically 50-400Hz. At high frequencies, their phase shift will cause the power measurement to be in error.

## CAUTION!

When using CTs, never open circuit their secondary while power is applied. The CT will act like a step-up transformer and may produce lethal voltages which can damage the operator and/or the power analyzer.

Figure 5-3 illustrates the basic method of connecting a CT to a digital power analyzer.

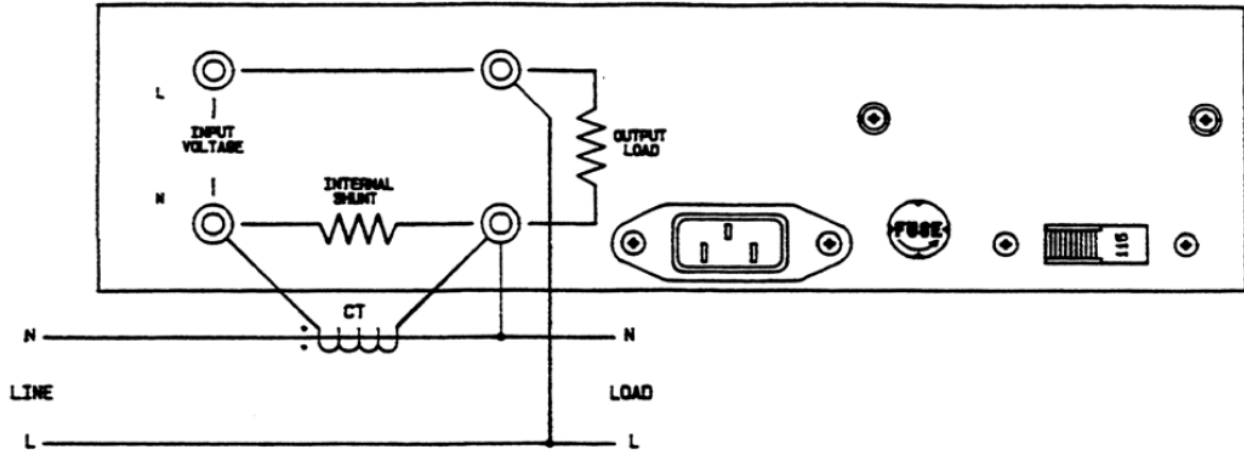


Figure 5-3 | 2105 Connections using a CT

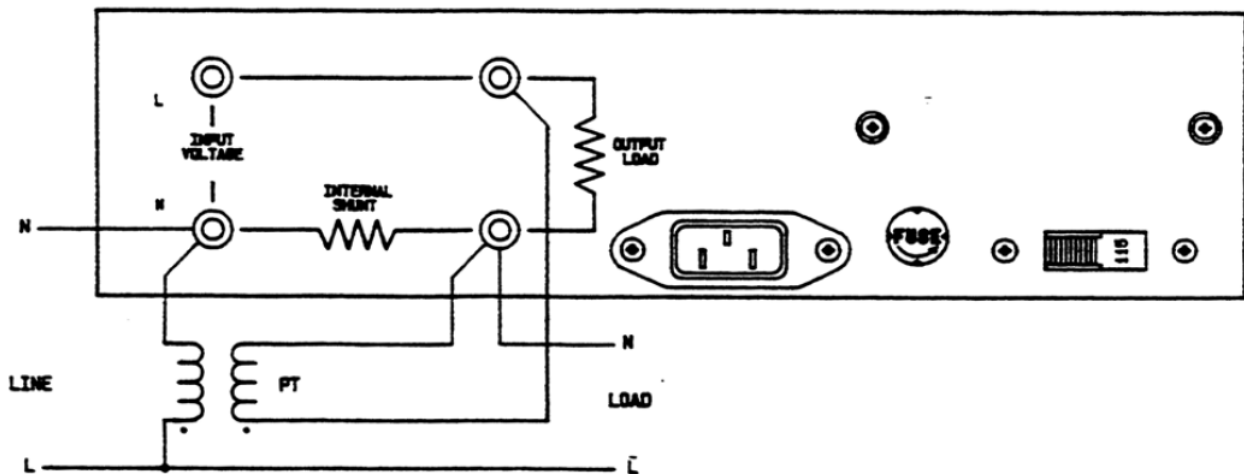


Figure 5-4 | 215 Connections using a PT

### Potential Transformers

Potential transformers (PTs) are used to extend the voltage measurement capabilities of Valhalla digital power analyzers. PTs are available in many ratios, maximum voltage ratings and isolation voltages.

PTs can be used to isolate the digital power analyzer from high voltage systems. Some high voltage systems operate at voltage levels directly measurable by the power analyzer but at common-mode

voltages beyond the power analyzer's limits. The isolation voltage rating should be at least 1 ½ times the common-mode voltage or peak input voltage.

When selecting a PT, try to use decade ratios, e.g., 10:1, 100:1, etc. Decade ratios make for easier power analyzer measurements. The user just mentally moves the voltage and power display decimal points to the right the appropriate number of places. Of course, non-decade ratios may also be used. The maximum voltage rating of the PT should be selected 1 ½ times the expected voltage level to allow for high crest factor waveforms.

The ratio accuracy of PTs is usually about 2%. This is quite a bit wider than the accuracy of a digital power analyzer. The easiest way to improve the accuracy is to measure the actual ratio and use this value when correcting measurements. PTs are low frequency devices, typically 50-400Hz.

At high frequencies, their phase shift will cause the power measurement to be in error. Figure 5-4 illustrates the method of connecting a PT to a digital power analyzer.

#### Using Both CTs and PTs

Many applications using PTs will use CTs as well. In this case, the power measurement must be multiplied by both the CT and PT ratios. Figure 5-5 illustrates the method of connecting a CT and PT to a digital power analyzer.

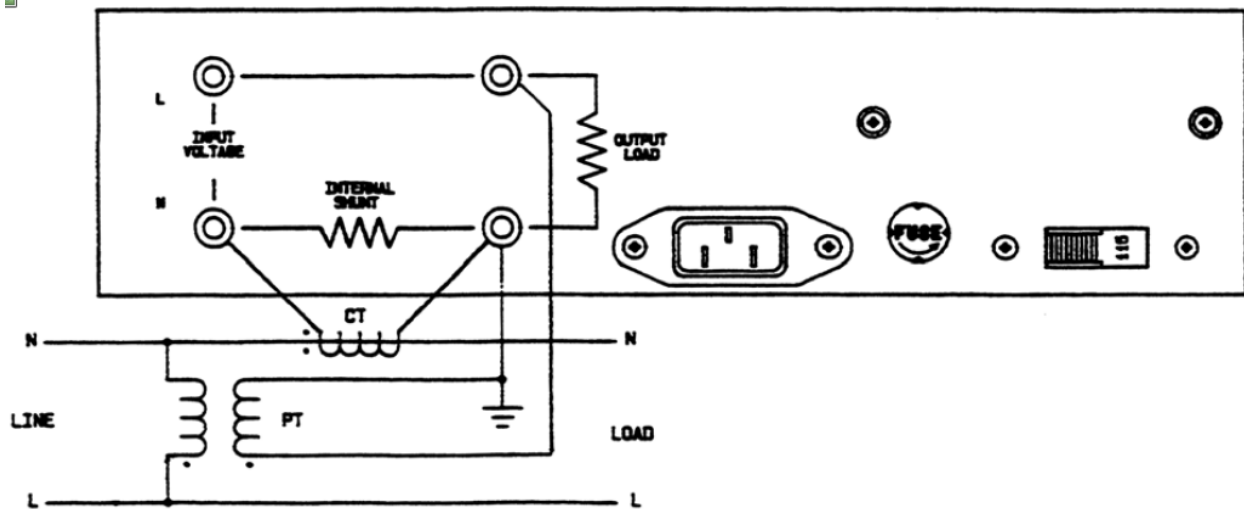


Figure 5-5 | 2105 Connections using a PT and a CT

## Manipulating the Data

The 2105 directly measures the voltage, current and power used by a single-phase system. Volt-Amperes (VA), Reactive Volt-Amperes (VAR), power factor (PF), and phase angle ( $\phi$ ) are not displayed but can easily be calculated from the voltage, current and power measurements. The following paragraphs describe the methods for calculating VA, VAR, PF, and  $\phi$ .

### VA, VAR, PF and $\phi$

The relationships between VA, Watts, VAR, PF and  $\phi$  can best be described in a graphical manner. Figure 5-6 illustrates these relationships. VA is calculated by multiplying the true RMS voltage and true RMS current measurements of the digital power analyzer. PF is the cosine of the angle between VA and Watts and can be calculated using basic trigonometry. VAR is calculated from VA and Watts using Pythagorean's theorem. Phase angle ( $\phi$ ) may be calculated after the power factor has been determined. The relative phase (in degrees) between the voltage and current waveforms is the anti-cosine ( $\cos^{-1}$ ) of the power factor.

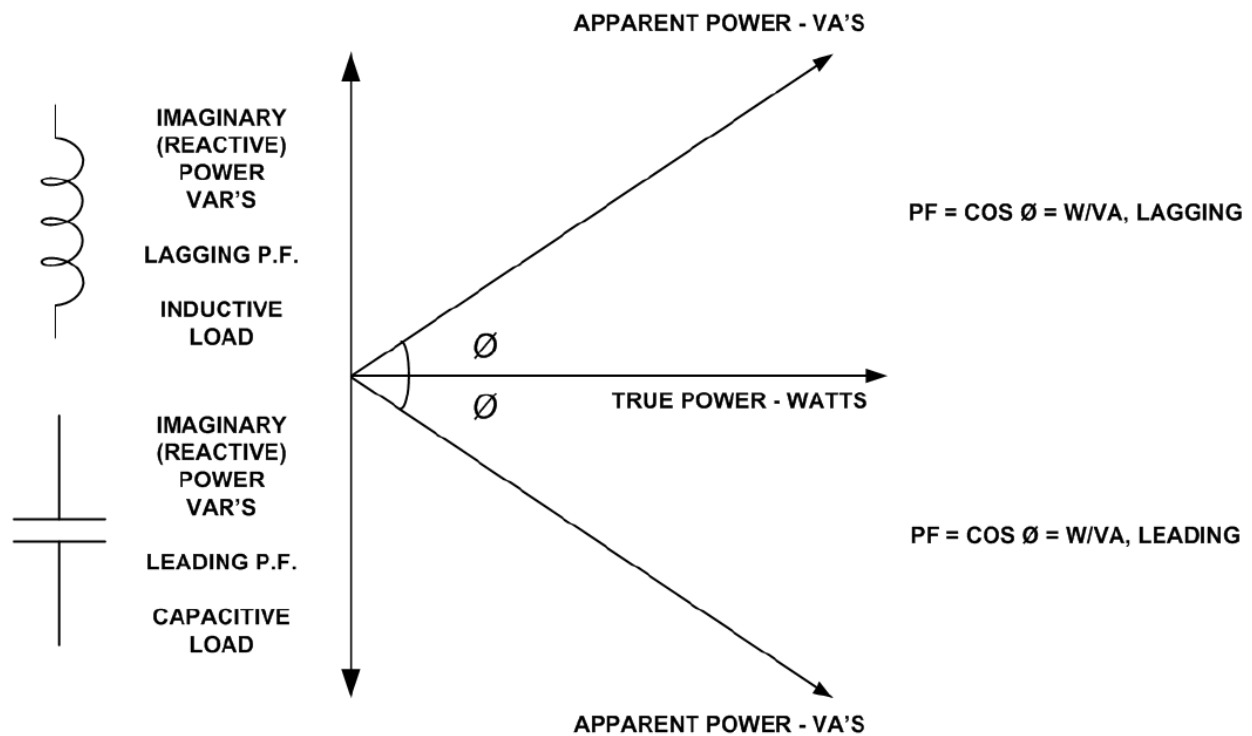


Figure 5-6

$$VA = TRMS\ VOLTS \cdot TRMS\ AMPS$$

$$VAR = \sqrt{VA^2 - W^2}$$

$$VA = \sqrt{VAR^2 + W^2}$$

$$W = \sqrt{VA^2 - VAR^2}$$

### PF, Leading or Lagging?

The terms leading and lagging power factor refer to the relative phase shift between the current and voltage waveforms. The current leads the voltage in a capacitive load while the current lags the voltage in an inductive load. When calculating power factor using a 2105, there is no way of determining whether the voltage waveform is leading or lagging the current. An oscilloscope must be used to determine leading or lagging. Fortunately, most every load has a lagging power factor.

If the load has a transformer, fan, or motor, it is safe to assume lagging power factors and an oscilloscope is not required.

### Accuracies

The accuracies of these calculations are the sums of the accuracies of the voltage, current and power measurements. For the 2105, the specified accuracies of Chapter 3 should be summed to find the total uncertainty.

## Chapter 6 Routine Maintenance

### General

The following paragraphs provide the information required to perform the required periodic maintenance and basic guidelines for troubleshooting the 2105.

### Periodic Maintenance

The 2105 requires little periodic maintenance other than regular performance of the calibration procedure of Chapter 6. Maintenance which may be required is discussed in the following paragraphs.

### Cleaning

It is recommended that the 2105 be operated in a clean environment. However, if the environment is dusty periodic cleaning of the unit will be necessary.

Loose dirt or dust which has collected on the exterior surfaces of the 2105 may be removed with a soft cloth or brush. Any remaining dirt may be removed with a soft cloth dampened in a mild soap and water solution. **Do not use abrasive cleaners.**

The front panel may be cleaned with a soft cloth and a "Windex" type cleaner. **Do not use petroleum-based cleaners on the front panel.**

If required, the 2105 interior may be cleaned by blowing with dry compressed air.

If the 2105 has become heavily soiled with dirt or by other contaminants it is recommended that the unit be completely overhauled. Contact your local Valhalla Scientific Service Center for details.

### Tightening

Tightness of connections to the input terminals is important for safety and reliability of measurements. Loose connections, especially when working with high current levels, may cause excessive temperatures to build up on the shunt input terminals. This contact resistance also requires the source to supply additional power to overcome it.

It is recommended that power be periodically removed, and the integrity of connections checked as they may have become relaxed.

### Calibration

The following procedures should be performed at routine intervals to ensure that the Power Analyzer remains within specified limits. In addition, calibration should be performed following repairs involving accuracy determining components.

Remove the top cover from the unit to gain access to the internal adjustments. The locations of the adjustments are listed on the circuit board and on drawing number 2105-600 at the back of this manual. Apply power to the 2100 and test equipment and allow approximately 30 minutes for stabilization.

Note that the instrument may also be returned to the factory for full calibration traceable to NIST.

#### Equipment Required

Qty 1 – Multi Calibrator (Fluke 5500A or equivalent)

Qty 1 – Precision Multimeter DMM (Agilent 3458A or equivalent)

#### ADC Reference Adjustments

1. Leave the DVM COMMON on the GND POST and connect the DVM POSITIVE lead to TP5.
2. Adjust RV22 for a 1.0000V on the DVM.
3. Connect the positive lead to TP6.
4. Adjust RV23 for a 1.0000V on the DVM.
5. DVM Negative lead to TP7, DVM Positive lead TP8. Apply +10A  
Adjust RV1 for -100.00mV. (see figure 6-1 for connections to calibrator)
6. DVM POSITIVE lead to TP1.
7. Close calibrator lid.

## Calibration Connections

Refer to Figure 6-1 if using the Fluke 5500.

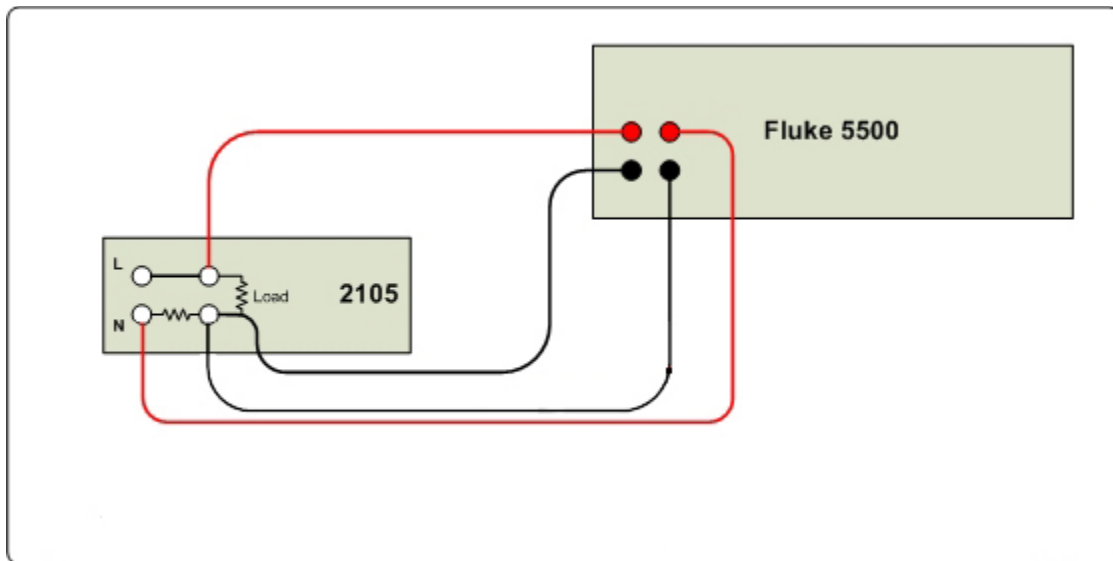


Figure 6-1 | DC Connections

## Offset Adjustment

1. Set the 2105 to Volts and the 150V range. Set the Fluke to 10V operate.
2. Alternating polarity of the input voltage, adjust RV8 for an equal reading at both polarities.
3. Adjust RV13 for 10.00

## -5 Volt Reference Adjustments

1. Place the 2105 in the 30V range.  
Apply +30V and adjust RV9 for -5VDC on the DVM.
2. Select the 150V range.  
Apply +150V and adjust RV10 for -5.0000 VDC on the DVM.
3. Select the 300V range.  
Apply +300V and adjust RV11 for -5.0000 VDC on the DVM.
4. Select the 600V range.  
Apply +600V and adjust RV12 for -5.0000 VDC on the DVM.

## Display Adjustments

1. Fluke to 150V operate, 2105 in the 150V range. Adjust RV15 for a 150.00 display.
2. 2105 in the 600V range, Fluke to 600V operate. Adjust RV16 for a 600.0 display.
3. Fluke to 300V operate, 2105 in the 300V range. Adjust RV17 for a display reading of 300.0.
4. Fluke to standby.



### Linearity Adjustments

1. Fluke to 10V operate, 2105 to 150V range. Adjust RV13 for a display reading of 10.00.
2. Reverse input polarity and adjust RV8 for balanced display.
3. Repeat until  $\pm 10V$  readings are balanced and reading exactly 10.00.
4. Fluke to standby.

### 20A Range Adjustments

1. 2105 to Amps, 20A range.
2. Fluke to 10A Operate.
3. Adjust RV2 for -2.5V DC on the DVM.
4. Adjust RV14 for a 10A display.

### 2A Range Adjustments

1. 2105 to 2A range.
2. Reversing input polarity repeatedly, adjust RV5 for an equal reading at both polarities.
3. Adjust RV6 for a display of 1.000 at both polarities.

### 0.2A Range Adjustments

1. Fluke to 100mA Operate, 2105 to .2A range.
2. Reversing input polarity repeatedly, adjust RV4 for an equal reading at both input polarities.
3. Adjust RV7 for a display of .1000 at both polarities.
4. Fluke to STBY.

### Watts Zero and Offset Adjustments

1. 2105 to Amps, 2A, 600V ranges.
2. Adjust RV18 for 000.0 on the watts display.

### Full Scale Watts Adjustments

1. Set the 2105 to the 2A, 600V ranges.  
Apply 1A and 600V, positive polarity.  
Make sure "LO's" are set to OPEN on the Fluke.  
Adjust RV19 for 600.0 in the watts display.
2. Fluke to 300V 1A operate, 2105 to the 300V range.  
Adjust RV20 for a watt display of 300.0.
3. Fluke to 150V 1A operate, 2105 to the 150V range.  
Adjust RV21 for a 150.0 watts display.
4. Fluke to standby.

## AC Adjustments and Checks

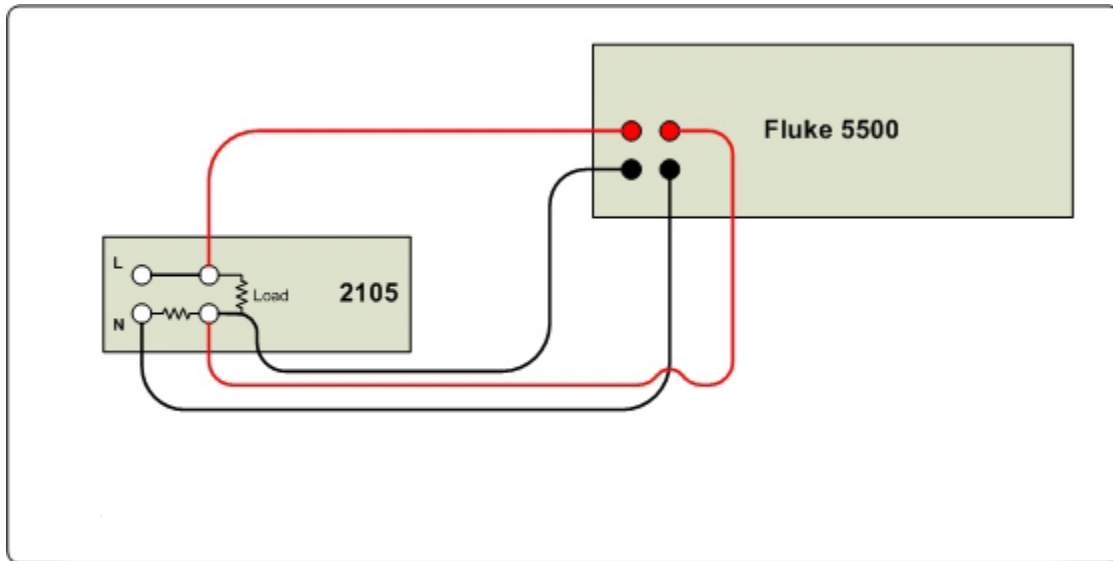


Figure 6-2 | AC Connections

1. Select AMPS and the 20A, 600V ranges on the 2105.
2. Set the AC Calibrator for 600V, 10A, 100Hz, 180°, operate.
3. Adjust RV3 for 10.00 in the current display.  
Check Watts display for 6000  $\pm$ 6 digits.
4. Current source to 1A operate.  
Check linearity of AMPS display  $\pm$ 2 digits.  
2105 to the 2A range. Check for 1.000 display  $\pm$ 3 digits.
5. Reduce current source to 0.1A.  
Check display for .100  $\pm$ 3 digits.  
2105 to .2A range. Check for .1000  $\pm$ 8 digits.  
Increase range to 2A and input to 1 amp.
6. Switch to VOLTS display. Check each voltage range with the corresponding inputs  $\pm$ 6 digits ( $\pm$ 20 digits for the 150V display).
7. 1A, 120V inputs on the 2A, 150V ranges.  
Check frequency response at 60Hz, 1000Hz and 10 kHz.  
Voltage accuracy  $\pm$ 100 digits at 10 kHz. Current accuracy  $\pm$ 6 digits. Watt accuracy  $\pm$ 6 digits.

## Chapter 7 Theory of Operations

Knowledge of circuit operation is a prerequisite for efficient fault finding in the 2105. This section is divided into two parts. The functional description gives basic descriptions as to the functions of various circuits in the Power Analyzer. The detailed descriptions explain circuit operation down to component level.

### Functional Descriptions

A block diagram of the Model 2105 is shown in Figure 7-1. Power for the load under test is connected to one set of rear panel terminals and passes through the instrument to a second set of terminals where the external load under test is connected. A  $0.01\Omega$  current shunt is installed between one input terminal and one output terminal. The inputs to the voltage amplifier are connected to both power line terminals. The inputs to the three-stage current amplifier are connected across the current shunt.

The voltage amplifier gain is controlled by the voltage range relays so that it has a full-scale 5-volt output at the selected range. The gains of the three stages of the current amplifier are 25, 10 and 10, respectively. The outputs of each current amplifier stage are individually selected by the current range relays for the 0.2, 2 and 20 ampere ranges.

The signal applied to the true RMS converter is determined by the position of the amps/volts selector relay. The 5-volt full-scale output of the voltage amplifier is the same for the four ranges and the output of the RMS-DC converter will pass through the scaler when the voltage amplifier output is selected. The scale factor is controlled by the voltage range relays, which selects the correct voltage to be applied to the RMS-DC converter. If a current amplifier output is selected, scaling is not required.

The DVM is a true dual slope, integrating digital voltmeter. The full-scale voltage applied to its input is 0.2 volts in the current ranges and 0.3, 1.5, 0.3 and 0.6 volts in the four voltage ranges of the Model 2105. The voltage measured by the DVM is latched to its internal registers at the end of the measurement cycle. During the time of the next input measurement, each digit of the previously measured voltage is sequentially applied to the inputs of the decoder/driver. While the decoded data is present at the output of the decoder/driver, the display digit selector energizes the appropriate display digit. Thus, the display is multiplexed from a single BCD output of the DVM and at such a rate that it appears to be continuously illuminated.

The output of the voltage amplifier and the output of the current amplifier stage are applied to individual inputs of the power converter. The output of the power converter is passed through a scaler controlled by the voltage range relays. Again, scaling is necessary since the full-scale output of the voltage amplifier is the same on all ranges. The DVM which follows the scaler is identical to that used for the amps/volts display.

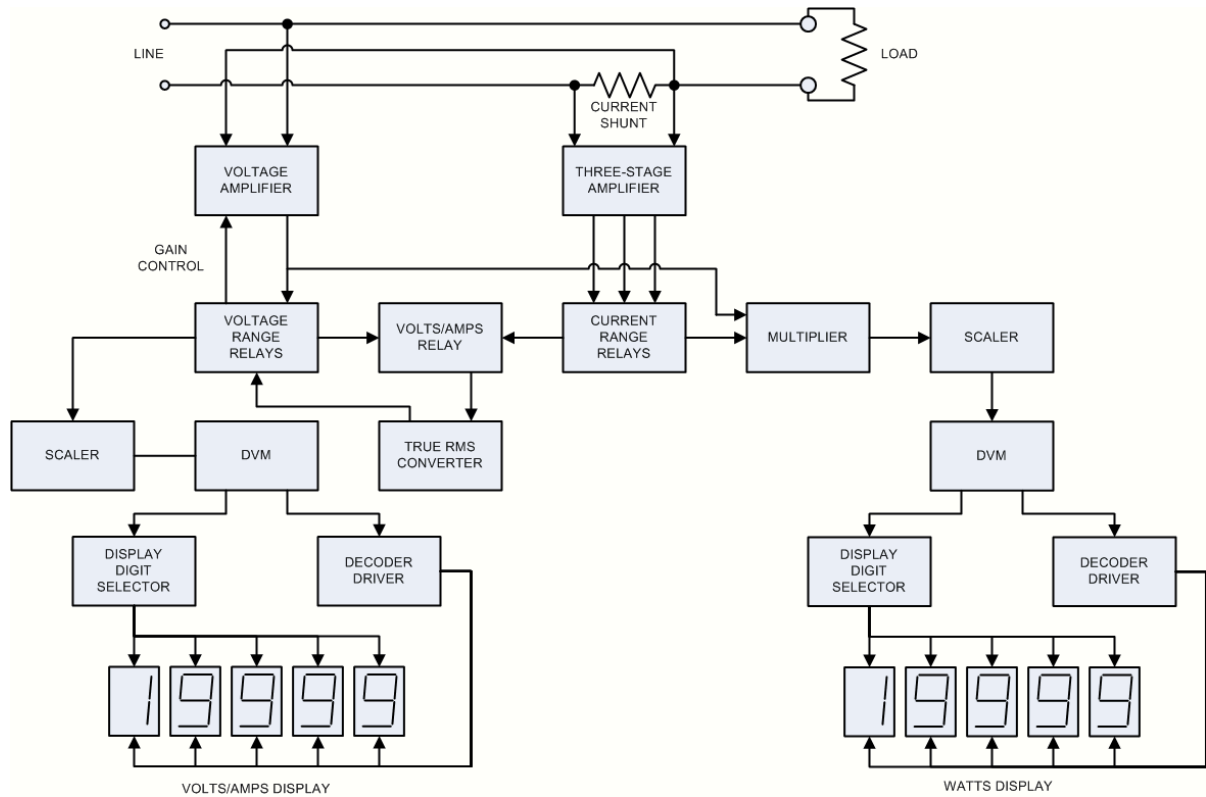


Figure 7-1 | 2105 Block Diagram

**WARNING**  
**HAZARDOUS VOLTAGES MAY BE PRESENT INSIDE THE 2105**

Experience has shown that apparent malfunctions are often the result of misinterpretation of the specifications or operating procedures of the unit. Check to be sure that the cables and other test equipment are in good order before attempting to repair the 2105.

## Chapter 8 Addendums

Immediately following this page may be found any notices regarding manual changes, or operating considerations for special 2105.

Please refer to any applicable material before attempting to operate your Model 2105.

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