

Model 2105

Wide-Range Digital Power Analyzer

Operation Manual

Updated March 2015



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2105 Wide Range Power Analyzer
Operation & Maintenance Manual
Edition 2

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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 October, 2007

Edition 2 March, 2015

SAFETY SYMBOLS



This icon accompanies text and/or other international symbols dealing with hazards to personnel. When present, it indicates that a potential hazard to your personal safety exists if information stated within the "**WARNING**" paragraph is not adhered to or procedures are executed incorrectly.



This icon accompanies text and/or other international symbols dealing with potential damage to equipment. When present, it indicates that there is a potential danger of equipment damage, software program failure or that a loss of data may occur if information stated within the "**CAUTION**" paragraph is not adhered to or procedures are executed incorrectly.



Paragraphs marked by this symbol indicate that a potential hazard to your personal safety exists from a high voltage source. In this document, the "**WARNING**" icon will accompany this symbol. To reduce risk of electrical shock, all devices employ a three-wire electrical cable and plug to connect the equipment to earth ground. Ensure that the wall outlet receptacle is properly wired and earth grounded.

DO NOT use a three-to-two wire plug adapter.

DO NOT use a two wire extension cord or a two wire multiple-outlet power strip.

Disconnect power to the system before performing maintenance.

DO NOT remove any panels; panels should be removed only by qualified service personnel.



Indicates the field wiring terminal that must be connected to ground before operation the equipment --- protects against electrical shock in case of fault.

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

1.1 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.

1.2 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.

Chapter 9 – Parts List

Chapter 9 contains all parts used in the Main Board, Display Board, and Chassis of the Valhalla Model 2105. The parts are listed with a Reference Designator, Valhalla Part Number, Description, and Manufacturers Part Number.

Chapter 10 – Schematics

Chapter 10 contains all schematics and drawings for Valhalla Model 2105.

1.3 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

2.1 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.

2.2 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, 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.

2.3 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.

2.4 Bench Use

The 2105 is delivered for operation in bench use and special instructions for use in this manner other than the procedures of Section 4 are not required.

2.5 Rack Mounting

An optional kit is available for mounting the 2105 in a standard 19" equipment rack. This is listed in Section 4 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 so as 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.

2.6 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.

3.1 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
Watts				

3.2 Accuracies

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

Voltage - AC+DC, DC Coupled

DC and 40Hz - 5 kHz: \pm 0.1% of reading \pm 6 digits
 5 kHz - 10 kHz: \pm 0.5% of reading \pm 0.5% of range
 10 kHz - 20 kHz: \pm 1% of reading \pm 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: \pm 0.1% of reading \pm 6 digits
 5 kHz - 10 kHz: \pm 0.5% of reading \pm 0.5% of range (12 Amps maximum)
 10 kHz - 20 kHz: \pm 1% of reading \pm 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: \pm 0.25% of reading \pm 6 digits
 5 kHz - 10 kHz: \pm 0.5% of reading \pm 0.5% of range (12 Amps maximum)
 10 kHz - 20 kHz: \pm 1% of reading \pm 1% of range (2 Amps maximum)
 (Useable above 20 kHz to 50 kHz with typically an additional 1% error per 10 kHz)

3.3 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 Ω
Current Shunt Impedance:	0.01 Ω
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

3.4 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 Equipment

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

4.1 Optional Accessories

Option 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.

Option 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.

Option 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.

Option 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.

Option 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.

Option R4: Rack Mount Adaptor Kit

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

5.1 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.

5.2 Front Panel Controls

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

5.2.1 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.

5.2.2 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.

5.2.3 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.

5.2.4 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.

5.2.5 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.

5.2.6 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.

5.2.7 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.

5.2.8 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 actually delivered to the load. See Section 5.4.2.

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 in order 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).

5.3 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 in section 2-3. 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. Refer to section 5-4.

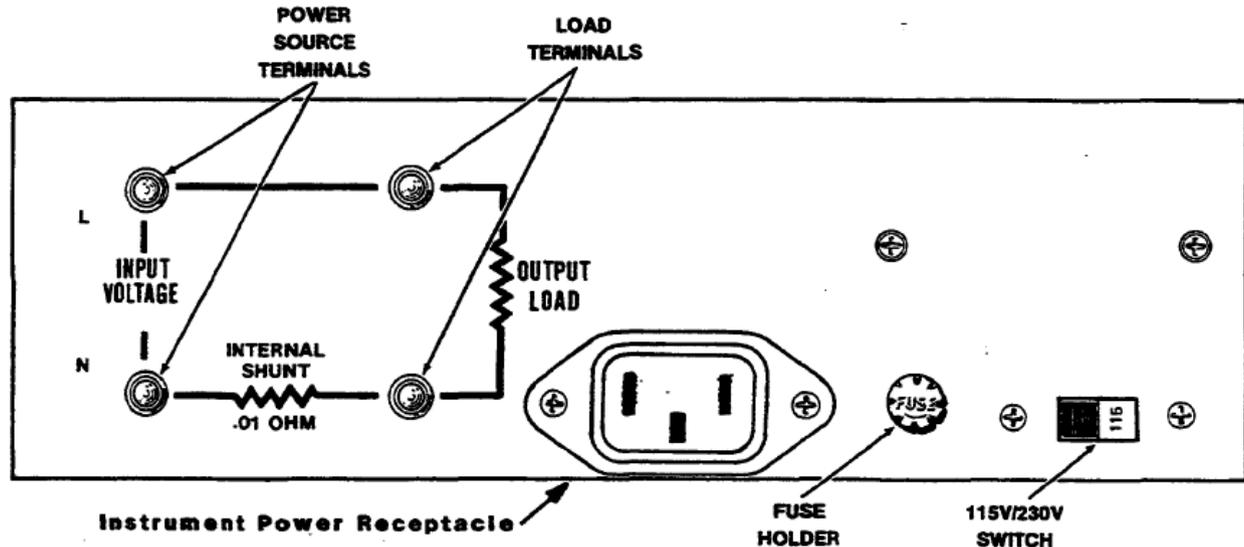


Figure 5-1 | Rear Panel

5.4 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.

5.4.1 Using Option X-21

Perhaps the easiest and most common method of making connections to the Power Analyzer is through the use of 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.

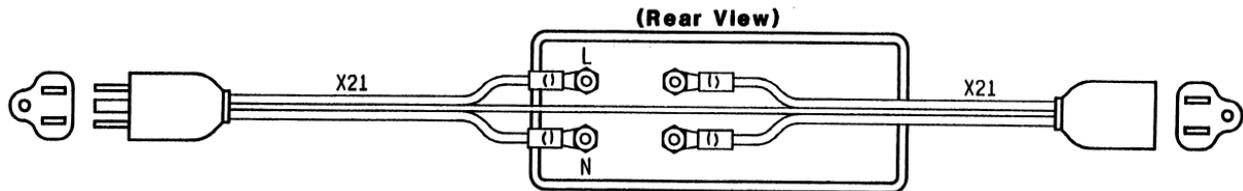


Figure 5-2 | 2105 Connections using the X-21

5.4.2 Using CT's and PT's

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

5.4.2.1 Current Transformers

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

There are two styles of CT's available, fixed and clamp-on. Fixed CT's 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 CT's are easier to use because they are just clamped around the conductor. The conductor need not be disconnected when using a clamp-on CT.

CT's 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 ½ 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 CT's which are listed in Section 4 of this manual. Of course, non-decade ratios may also be used. The maximum current rating of the CT should be selected 1 ½ times the expected current to allow for high crest-factor waveforms.

The ratio accuracy of CT's 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.

CT's 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 CT's, 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.

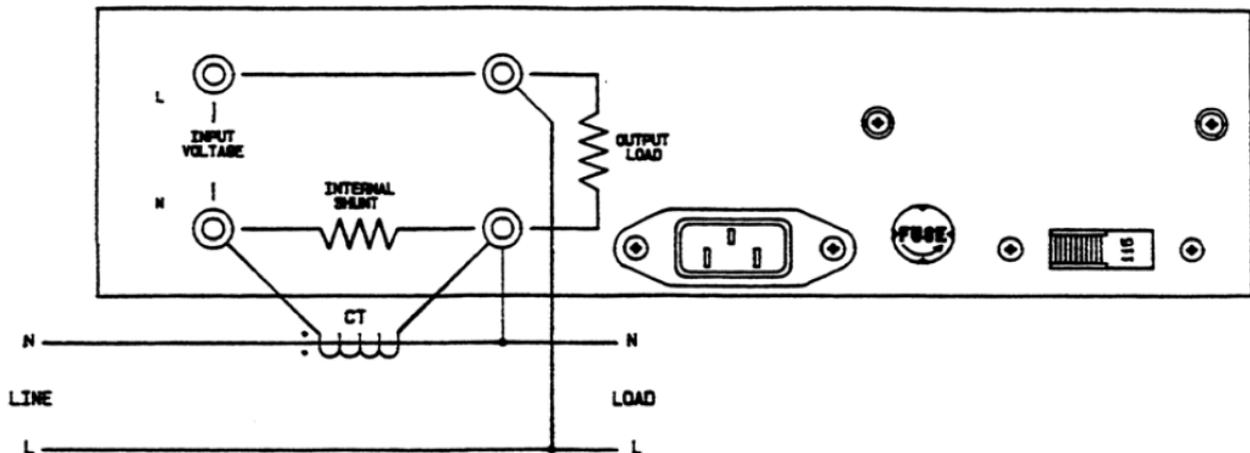


Figure 5-3 | 2105 Connections using a CT

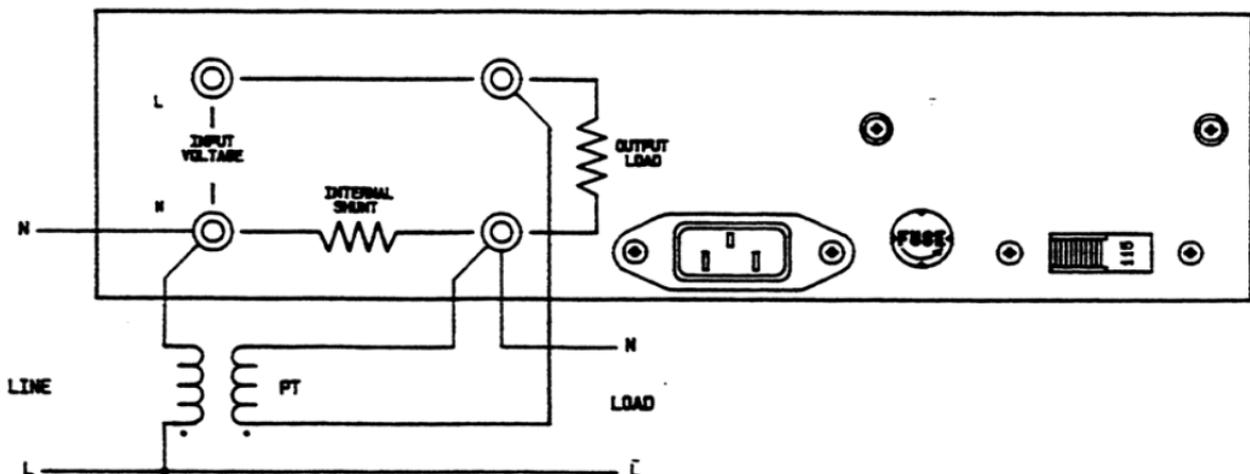


Figure 5-4 | 2115 Connections using a PT

5.4.2.2 Potential Transformers

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

PT's 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 $1\frac{1}{2}$ 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 $1\frac{1}{2}$ times the expected voltage level to allow for high crest factor waveforms.

The ratio accuracy of PT's 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. PT's 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.

5.4.2.3 Using Both CT's and PT's

Many applications using PT's will use CT's 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.

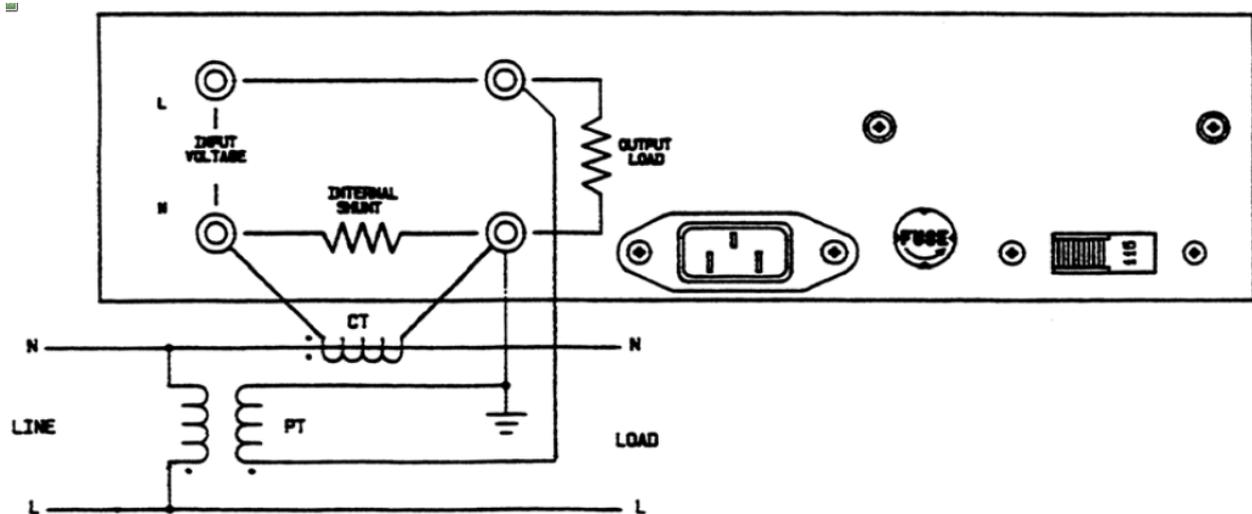


Figure 5-5 | 2105 Connections using a PT and a CT

5.5 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 (ϕ) 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 ϕ .

5.5.1 VA, VAR, PF and ϕ

The relationships between VA, Watts, VAR, PF and ϕ 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 (ϕ) 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.

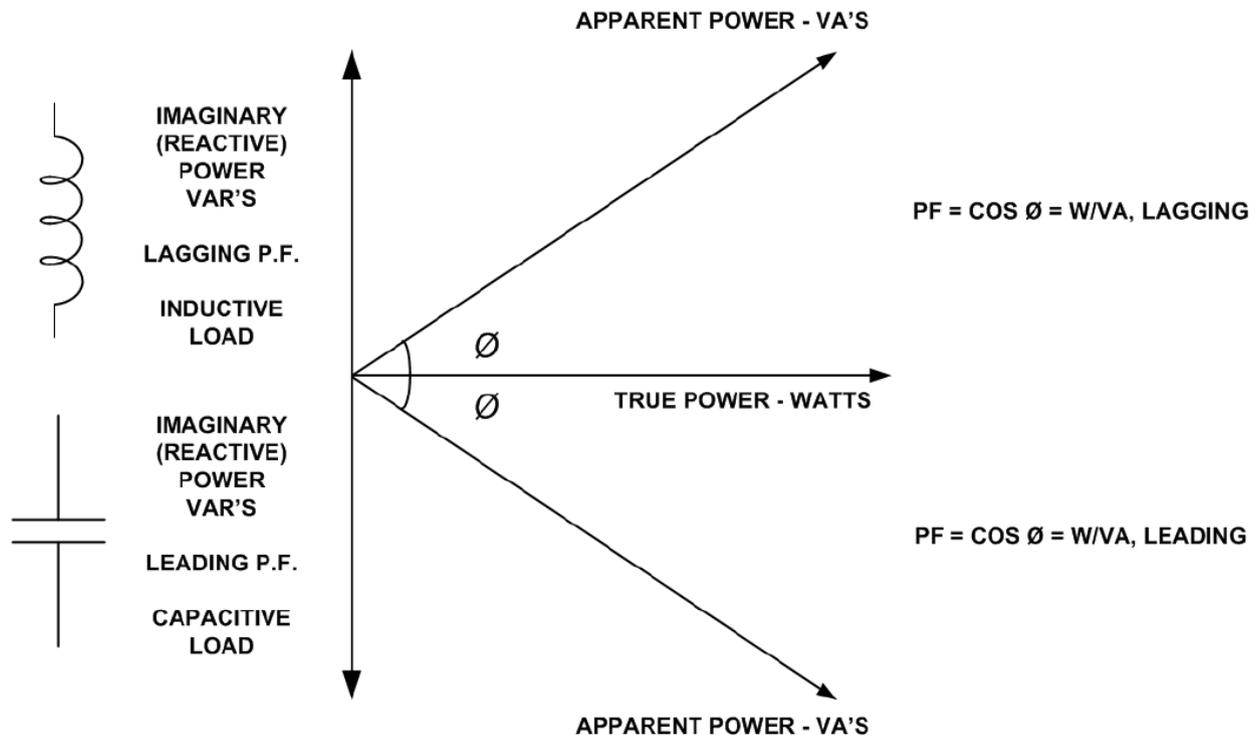


Figure 5-6

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

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

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

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

5.5.2 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.

5.5.3 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 section 3-3 should be summed to find the total uncertainty.

Chapter 6

Routine Maintenance

6.1 General

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

6.2 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.

6.2.1 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.

6.2.2 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 in order to overcome it.

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

6.3 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.

6.3.1 Equipment Required

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

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

6.3.2 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.

6.3.3 Calibration Connections

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

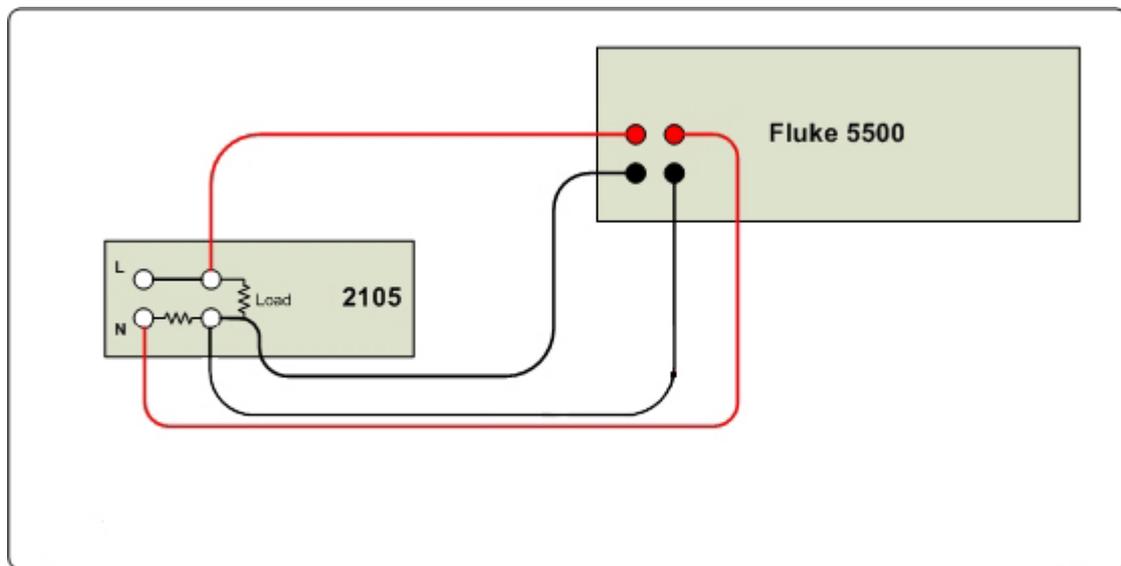


Figure 6-1 | DC Connections

6.3.4 Offset Adjustment

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

6.3.5 -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.

6.3.6 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.

6.3.7 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.

6.3.8 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.

6.3.9 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.

6.3.10 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.

6.3.11 Watts Zero and Offset Adjustments

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

6.3.12 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 watts 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.

6.3.13 AC Adjustments and Checks

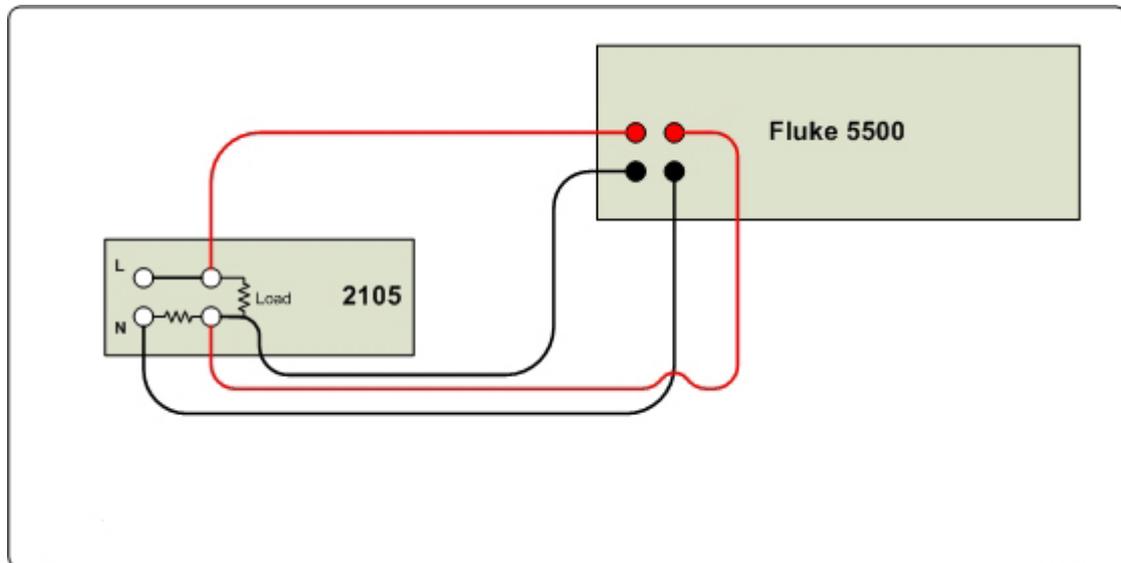


Figure 6-2 | AC Connections

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.

7.1 Troubleshooting

The following paragraphs give basic procedures for troubleshooting and component replacement in the 2105.

7.1.1 Component Replacement

The 2105 accuracy and reliability can only be maintained if the following precautions are taken when changing a component:

- Remove all power from the instrument and input terminals before attempting component replacement.
- Use only the specified component or its exact equivalent. Spare parts may be ordered from your nearest Valhalla Scientific Service Center by referring to the Valhalla part number listed in the Parts List section at the back of this manual. Please provide the type and serial number of the instrument with your order.
- Use only 63/37 rosin core electronic grade solder with a 50W (or lower) maximum power soldering iron.
- Many of the semiconductor devices used in the 2105 can be damaged by static discharges. Thus, the user should follow strict static-free procedures to ensure that damage does not occur.
- When re-soldering components the user must ensure that the highest possible quality soldering is used. A dry joint may cause the 2105 to drift outside of its specification limits.
- Minimize handling of components and assemblies. Transport and store components in their original containers.
- Discharge static build-up on the user and instrument prior to handling components or assemblies.
- Handle the components such that all (or as many as possible) of the leads are in contact with the user.
- Never slide a component over a surface.
- Use a grounded tip soldering iron and ensure that the assembly being (de)soldered is also grounded.

7.1.2 Finding the Faulty Component

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.

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.

7.2 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 0.01Ω 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.

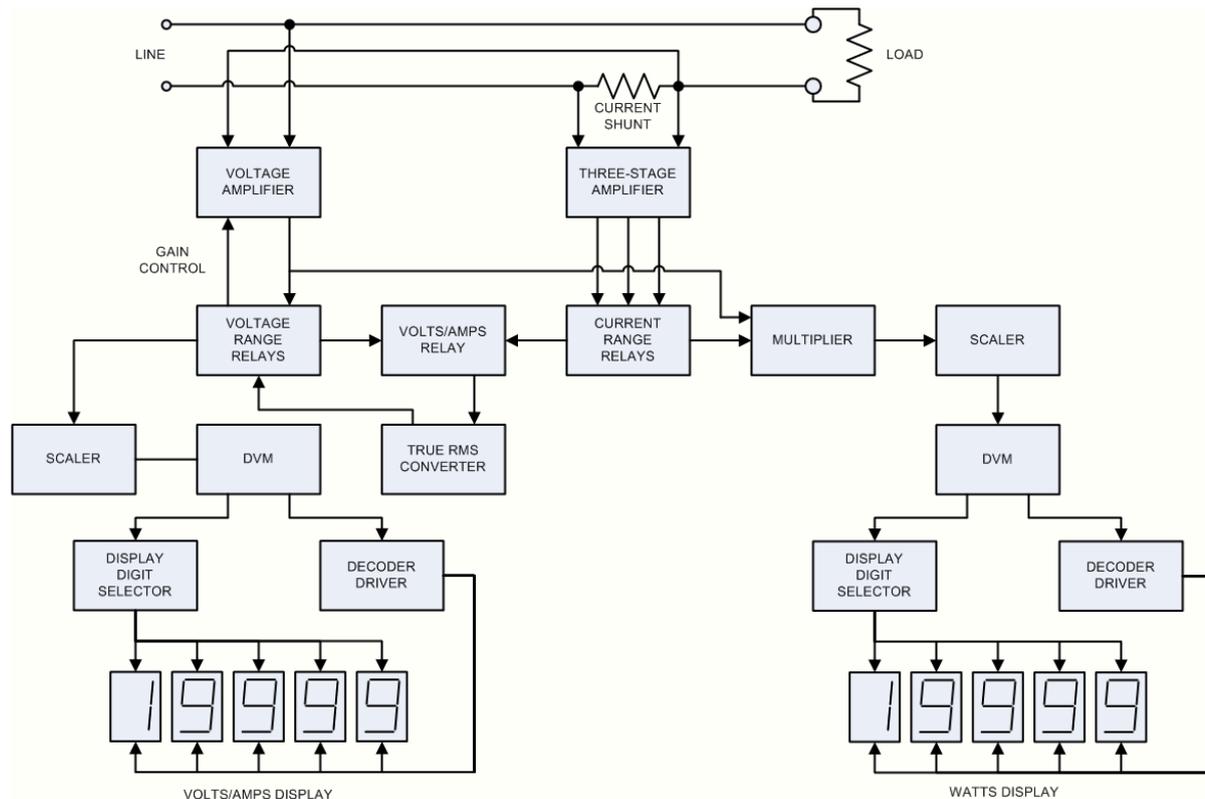


Figure 7-1 | 2105 Block Diagram

7.3 Detailed Circuit Descriptions

To supplement the overview provided by the preceding functional description, this section describes the operation of each circuit. The reference designators used in this section are those of the schematic diagram of the Model 2105, 2105-070.

For convenience, the individual circuits of a multiple-circuit device are identified by the device designator followed by a suffix number corresponding to the output pin number. For example, the amplifier of U7 that has its output connected to pin 1 is identified as U7-1.

7.3.1 Power Supply

Schematic 2105-070 sheet 1.

S1 is the front panel toggle switch that connects one side of the power line to one end of the primary windings of transformer T1. The other end of the primary windings is permanently connected to the other side of the line. T1 has two primary windings that are connected in parallel by S10 for operation at 115 volts and in series for operation at 230 volts.

The voltage across one secondary winding of T1 is rectified by D3 and D4 to provide a positive DC input to voltage regulator U1 which develops +5 volts at its output. The same secondary is also rectified by D1 and D2 to provide the negative DC input to voltage regulator U2 which develops -5 volts at its output. The other secondary is rectified by D7 and D8 to provide a positive DC input to voltage regulator U3 which develops +15 volts at its output. The same secondary is also rectified by D5 and D6 to provide the negative DC input to voltage regulator U4 which develops -15 volts at its output.

The neutral input terminal is connected to the internal common bus (ground). T1 provides isolation between the common bus and the power line. The plastic case and other insulators isolate the operator from the input terminals. However, when taken apart for service, personnel should verify that the neutral terminal is at the same potential as the power line ground or serious injury could occur.

7.3.2 Voltage Amplifier and Scaling

Schematic 2105-070 sheets 3 & 4

The neutral line of the input (measured) voltage source is connected to the common internal bus (ground). The other line is connected to the input of the voltage amplifier circuit through a 600K Ω resistor, R100, on the rear panel assembly.

Figure 7-2 is a simplified diagram of the operational amplifier circuit U9 and RMS-DC voltage converter U11. The four switches connected to the input of U9 are sections of the voltage range relays. The number adjacent to each switch indicates the selected range for which it is closed.

The gain of U9 is determined by the closed section of the relay, which selects the resistance value for the feedback loop of U9. RV9, RV10, RV11 and RV12 provide fine adjustments of gain in each range. The output of U9 for full-scale input (30, 150, 300 or 600 volts) is 5 volts. RV8 provides the offset adjustment for U9.

The output of U9 passes through switch RL8, which selects the output of the voltage or current amplifiers as an input to U11. When the "Volts" mode is selected, the output of U11 is a DC voltage directly proportional to the RMS value of the input voltage and will be 5 volts full-scale. It appears across the voltage divider composed of R38 through R41.

The switches connected to the arms of the potentiometers in this voltage divider are other sections of the range relays that close simultaneously with those in the feedback circuit of U9. The output of U11 is scaled down through the divider to 0.6 volts for the 600 volt range, 0.3 volts for the 30 and 300 volt range and 1.5 volts for the 150 volt range, with the potentiometers RV15 through RV17 providing the line calibration adjustments.

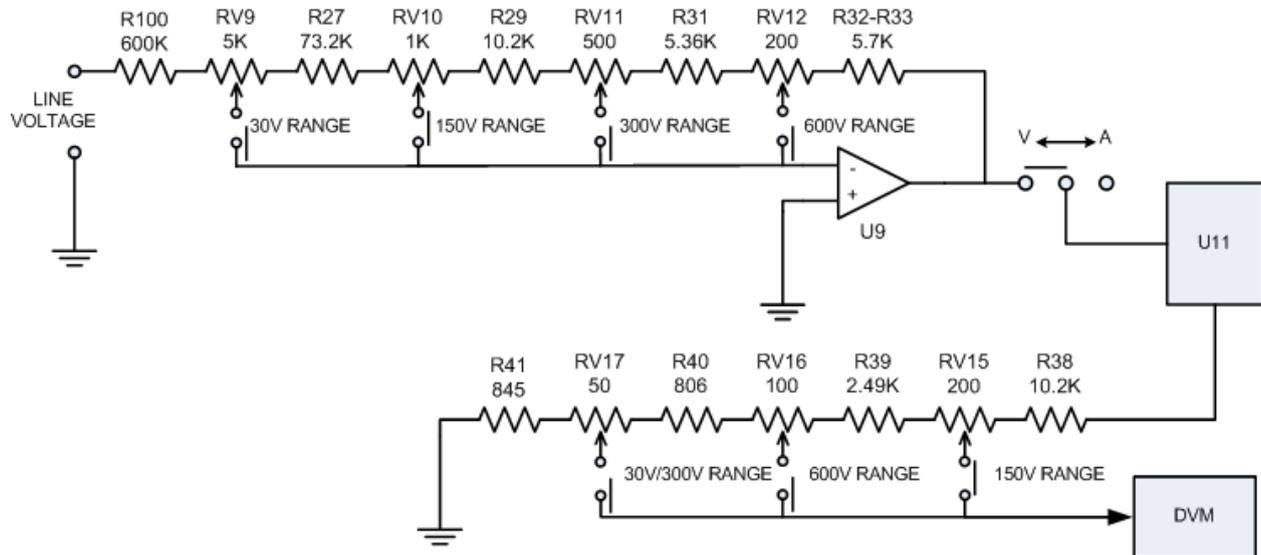


Figure 7-2 | Simplified Voltage Scaler/Amplifier

7.3.3 Current Amplifiers and Scaling

Schematic 2105-070 sheet 2 & 4

The source of the signal for the current meter is a 0.01 ohm shunt resistor, R200, through which the load current flows. The resistance of R200 is very low so there is minimal effect on the voltage applied to the load.

The signal developed across R200 must be amplified, especially in the lowest current range. The current signal amplifiers are shown in the schematic 2105-070 sheet 2. A simplified diagram of the input current amplifier is shown in Figure 7-3.

The minimal full-scale voltage developed across R200 is only 2mV. Therefore, the input amplifier must remain stable at DC and from 40 Hz through the bandwidth of the instrument. Operational amplifier U7-1 and chopper-stabilized amplifier U6 operate in concert to achieve the required stability. Any offset appearing at the output of U7-1 is reduced by a factor of 25 at the arm of RV2 where it is applied to the non-inverting input of U6. A differential exists between the two inputs of U6. An offset is produced at the output of U6 that places a charge on C13 with a polarity that drives the output of U7-1 toward zero. The gain of U6 is 200 and its output is integrated by R11 and C13 which eliminates any tendency toward oscillation. The system finds a point of equilibrium where the offset at U7-1 has been reduced to a negligible level.

U7-1 has a gain of 25 and the amplifiers that follow, U7-7 and U8-6, have a constant gain of 10 when properly adjusted with RV6 and RV7. The output of U7-1, U7-7 and U8-6 are each connected to one contact of the "Current" switch. The other contact is connected to its counterparts so that the selected output is applied to the true RMS-DC converter, U11, when "Amps" is selected with the "V/I" keypad.

A 200mV input from U7-1 produces 5 volts at the output of U7-7 and 2mV produces 5 volts at the output of U8-6. The full-scale voltage applied to the true RMS converter in any range is 5 volts.

The output of the true RMS converter appears across the divider composed of R36, RV14 and R37. The potential at the arm of RV14 is 200mV and is applied to the amps/volts DVM, U13, through a section of RL8 relay when "Amps" is selected.

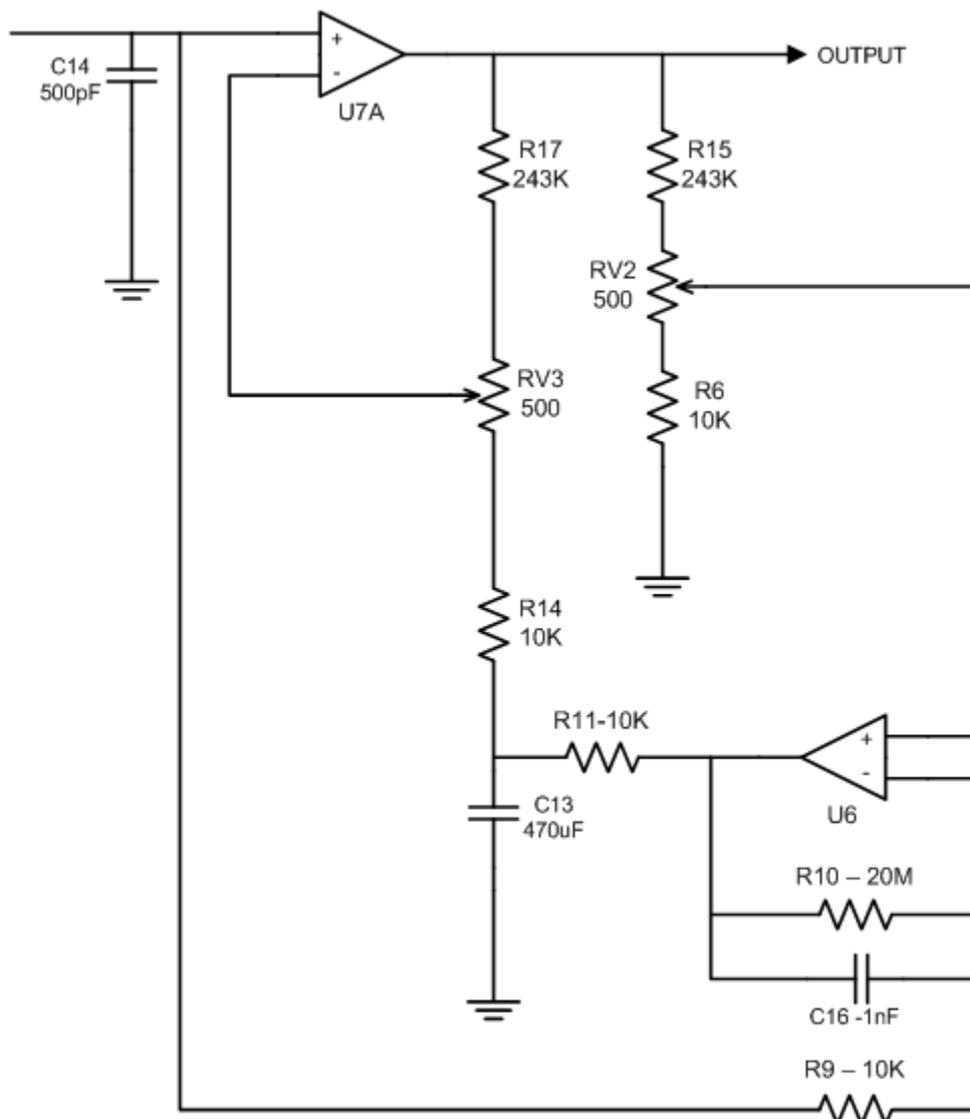


Figure 7-3 | Simplified Current Amplifier

7.3.4 Peak Detector/Indicators

Schematic 2105-070 sheet 2 & 3.

When the voltage applied to the rear panel terminals exceeds 250% of the selected voltage range, the peak voltage indicator illuminates. This signals that the displayed voltage and power value may not be accurate and that spikes may be present on the input signal. An identical circuit provides a visual signal when the current to the load exceeds 250% of the selected current range. The peak detectors provide their visual signals irrespective of whether "Amps" or "Volts" has been selected for display.

The voltage peak detector is composed of comparators U10-1, U10-2 and U10-13. Their circuit is shown in the upper area of drawing 2105-070 sheet 3. The reference voltage at the inverting input of U10-6 is at -12 volts, which is derived from the divider composed of R28 and R30. The non-inverting input is connected to the output of the voltage amplifier, IC1-6. The non-inverting input U10-5 is at +12 volts which is derived from the divider composed of R24 and R26. Its inverting input is also connected to the output of U9-6.

When zero volts are applied to the input, the outputs of both comparators are high (+15 volts). Since the inverting input U10-11 is at ground potential, its output will be high, back-biasing voltage peak indicator D2 and holding it out of conduction.

When the input voltage (either peak or steady-state) exceeds +12 volts, the output of U10-1 will transition to -15 volts, causing the output of U10-13 to transition to -15 volts, turning on D2. When the input voltage exceeds -12 volts, the output of U10-2 and U10-13 will transition to -15 volts to turn on D2. An integrating capacitor C18 holds the output of U10-13 at a low state between peaks so that D2 is continuously illuminated until the input to U10-13 is increased above its transition level.

An identical circuit for the current peak detector/indicator is composed of U5-1, U5-2, U5-13 and associated components. The input to this detector is from the output of the selected current signal amplifier.

7.3.5 Analog to Digital Converters

Schematic 2105-070 sheet 6

There are two nearly identical digital voltmeter (DVM) circuits. These are shown on the schematic 2100-070 sheet 6.

7.3.5.1 Volts/Amps Display

The Analog to Digital conversion in the Model 2105 is allowed by U13 and its associated components. The reference voltage applied to U13-2 is 1Volts. 1.2Volts are generated by D9 and adjusted by RV22. X1 generates a 100 kHz clock signal for U13-22; the frequency of the oscillator allows the 2105 a conversion rate of 3 readings per second. The digital portion of U13

is applied to U14 a BCD to 7 Segment Converter/Driver and to the display driver transistors Q1-Q5.

7.3.5.2 Watts Display

The Analog to Digital conversion in the Model 2105 is allowed by U15 and its associated components. The reference voltage applied to U15-2 is 1Volts. 1.2Volts are generated by D11 and adjusted by RV23. X1 generates a 100 kHz clock signal for U15-22; the frequency of the oscillator allows the 2105 a conversion rate of 3 readings per second. The digital portion of U15 is applied to U16 a BCD to 7 Segment Converter/Driver and to the display driver transistors Q6-Q10.

7.3.6 Decimal Point Positioning

Schematic 2105-070 sheet 8

The decimal points for both displays are selected by U17

7.3.7 Analog Multiplier

Schematic 2105-070 sheet 5

Analog multiplier U12 receives the output of voltage amplifier U9-6 and the output of either U7-1, U7-7 or U8-6, depending on the selected current range.

The output from U12, which is proportional to the product of the signals at its two inputs, is then scaled according to the selected voltage range by R44, R45, R46, R47, RV19, RV20 and RV21.

RV18 adjusts the offset of the analog multiplier.

7.3.8 Range Selection

Schematic 2105-070 sheet 2-5 & 2105-072

The Ranges for both current and voltage are selected by U1 of the switch board, by configuring relays RL1-RL8.

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.

Chapter 9

Parts List

Main Board Assembly.....	2105-600F
Display Board Assembly.....	2105-601F
Switch Board Assembly.....	2105-602G
Chassis Assembly.....	2105-499

Model 2105 Parts List				
Assembly No.:		Schematic DWG No.:		PCB DWG No.:
2105-600F		2105-070F		2105-700F
Description:				
2105 Main Board Assembly				
Ref Des	QTY	VPN	Description	MPN

A1	1	04-30333	2105 MAIN PCB REV F	DWG 2105-700 Rev F
C01	1	02-40052	470uF/63VALUMINUM CAPACITOR RADIAL	ILL 477RSM063M
C02	1	02-30001	10uF/25V TANTALUM CAPACITOR	AVX TAP106K025SP
C03	1	02-40052	470uF/63V ALUMINUM CAPACITOR RADIAL	ILL 477RSM063M
C04	1	02-30001	10uF/25V TANTALUM CAPACITOR	AVX TAP106K025SP
C05	1	02-40052	470uF/63V ALUMINUM CAPACITOR RADIAL	ILL 477RSM063M
C06	1	02-30001	10uF/25V TANTALUM CAPACITOR	AVX TAP106K025SP
C07	1	02-40052	470uF/63V ALUMINUM CAPACITOR RADIAL	ILL 477RSM063M
C08	1	02-30001	10uF/25V TANTALUM CAPACITOR	AVX TAP106K025SP
C09	1	02-30001	10uF/25V TANTALUM CAPACITOR	AVX TAP106K025SP
C10	1	02-10006	0.01uF/50V CERAMIC CAPACITOR	103GCR050-Z ILL
C11	1	02-10014	0.1uF/50V CERAMIC CAPACITOR	SR205E104MAA
C12	1	02-10014	0.1uF/50V CERAMIC CAPACITOR	SR205E104MAA
C13	1	02-40031	470uF/10V ALUMINUM CAPACITOR RADIAL	477RMR010M
C14	1	02-10002	500pF/100V CERAMIC CAPACITOR	DD501 (CENTRLAB)
C15	1	02-10004	0.02uF/500V CERAMIC CAPACITOR	21FA020
C16	1	02-10009	0.001uF/50V CERAMIC CAPACITOR	C331C105M5R5CA
C17	1	02-10006	0.01uF/50V CERAMIC CAPACITOR	103GCR050-Z ILL
C18	1	02-30001	10uF/25V TANTALUM CAPACITOR	AVX TAP106K025SP
C19	1	02-20012	10pF MICA CAPACITOR	CM05CD100J03
C20	1	02-10004	0.02uF/500V CERAMIC CAPACITOR	21FA020
C21	1	02-60002	0.1uF/250V MYLAR CAPACITOR	104MSR250K
C22	1	02-60002	0.1uF/250V MYLAR CAPACITOR	104MSR250K
C23	1	02-10014	0.1uF/50V CERAMIC CAPACITOR	SR205E104MAA
C24	1	02-10014	0.1uF/50V CERAMIC CAPACITOR	SR205E104MAA
C25	1	02-30000	4.7uF/16V TANTALUM CAPACITOR	TAP475K0165P
C26	1	02-10014	0.1uF/50V CERAMIC CAPACITOR	SR205E104MAA
C27	1	02-90019	0.47uF 5% 250WVDC POLYPROPYLENE CAP.	Xicon 1431-2474J
C28	1	02-90020	1uF POLYPROPYLENE CAPACITOR . MET.	Xicon 1429-2105
C29	1	02-90020	1uF POLYPROPYLENE CAPACITOR . MET.	Xicon 1429-2105
C30	1	02-60002	0.1uF/250V MYLAR CAPACITOR	104MSR250K
C31	1	02-30000	4.7uF/16V TANTALUM CAPACITOR	TAP475K0165P
C32	1	02-10014	0.1uF/50V CERAMIC CAPACITOR	SR205E104MAA
C33	1	02-90019	0.47uF 5% 250WVDC POLYPROPYLENE CAP.	Xicon 1431-2474J
C34	1	02-90020	1uF POLYPROPYLENE CAPACITOR . MET.	Xicon 1429-2105
C35	1	02-90020	1uF POLYPROPYLENE CAPACITOR . MET.	Xicon 1429-2105
C36	1	02-90007	10uF/50V 5% POLYCARBONATE CAPACITOR	RA7A106J
C37	1	02-30001	10uF/25V TANTALUM CAPACITOR	AVX TAP106K025SP
C38	1	02-30000	4.7uF/16V TANTALUM CAPACITOR	TAP475K0165P
C39	1	02-60011	1000pF/100V MYLAR CAPACITOR	FKS2-1000P
D01	1	03-20002	RECTIFIER DIODE	2N4001
D02	1	03-20002	RECTIFIER DIODE	2N4001
D03	1	03-20002	RECTIFIER DIODE	2N4001
D04	1	03-20002	RECTIFIER DIODE	2N4001
D05	1	03-20002	RECTIFIER DIODE	2N4001
D06	1	03-20002	RECTIFIER DIODE	2N4001

Model 2105 Parts List				
Assembly No.:		Schematic DWG No.:		PCB DWG No.:
2105-600F		2105-070F		2105-700F
Description:				
2105 Main Board Assembly				
Ref Des	QTY	VPN	Description	MPN
D07	1	03-20002	RECTIFIER DIODE	2N4001
D08	1	03-20002	RECTIFIER DIODE	2N4001
D09	1	03-20033	LOW VOLTAGE REFERENCE 1.2V	LM285LP-1.2
D10	1	03-20000	GENERAL PURPOSE DIODE	2N4148
D11	1	03-20033	LOW VOLTAGE REFERENCE 1.2V	LM285LP-1.2
D12	1	03-20000	GENERAL PURPOSE DIODE	2N4148
D13	1	03-20000	GENERAL PURPOSE DIODE	2N4148
D14	1	03-20000	GENERAL PURPOSE DIODE	2N4148
D15	1	03-20000	GENERAL PURPOSE DIODE	2N4148
D16	1	03-20000	GENERAL PURPOSE DIODE	2N4148
D17	1	03-20000	GENERAL PURPOSE DIODE	2N4148
D18	1	03-20000	GENERAL PURPOSE DIODE	2N4148
D19	1	03-20000	GENERAL PURPOSE DIODE	2N4148
D20	1	03-20000	GENERAL PURPOSE DIODE	2N4148
NA	1	05-10495	STANDOFF #6 HEX 7/16L	
NA	1	90-06012	#6-32 X 3/4" PHIL PAN SS	
NA	1	98-06002	#6 INTERNAL STAR WASHER	
Q01	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q02	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q03	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q04	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q05	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q06	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q07	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q08	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q09	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q10	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q11	1	03-10026	MOSFETS - N CHANNEL 60V 50 OHM	VN10KN3-G
Q12	1	03-10026	MOSFETS - N CHANNEL 60V 50 OHM	VN10KN3-G
Q13	1	03-10026	MOSFETS - N CHANNEL 60V 50 OHM	VN10KN3-G
Q14	1	03-10026	MOSFETS - N CHANNEL 60V 50 OHM	VN10KN3-G
Q15	1	03-10026	MOSFETS - N CHANNEL 60V 50 OHM	VN10KN3-G
Q16	1	03-10026	MOSFETS - N CHANNEL 60V 50 OHM	VN10KN3-G
Q17	1	03-10026	MOSFETS - N CHANNEL 60V 50 OHM	VN10KN3-G
Q18	1	03-10026	MOSFETS - N CHANNEL 60V 50 OHM	VN10KN3-G
Q19	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q20	1	03-10013	SMALL SIGNAL NPN TRANSISTOR	2N4401
Q21	1	03-10010	SMALL SIGNAL PNP TRANSISTOR	2N4402
R01	1	01-01047	2.4K 5% 1/4W CARBON FILM	
R02	1	01-01085	200K 5% 1/4W CARBON COMP	
R03	1	01-01061	10K 5% 1/4W CARBON FILM	
R04	1	01-01041	1K 5% 1/4W CARBON FILM	
R05	1	01-01041	1K 5% 1/4W CARBON FILM	
R06	1	01-10008	10K 1% 50PPM/C 1/4W M.F.	
R07	1	01-01061	10K 5% 1/4W CARBON FILM	
R08	1	01-01047	2.4K 5% 1/4W CARBON FILM	
R09	1	01-01061	10K 5% 1/4W CARBON FILM	
R10	1	01-01123	20M 5% 1/4W CARBON FILM	

Model 2105 Parts List				
Assembly No.:		Schematic DWG No.:		PCB DWG No.:
2105-600F		2105-070F		2105-700F
Description:				
2105 Main Board Assembly				
Ref Des	QTY	VPN	Description	MPN

R11	1	01-01061	10K 5% 1/4W CARBON FILM	
R12	1	01-01041	1K 5% 1/4W CARBON FILM	
R13	1	01-01041	1K 5% 1/4W CARBON FILM	
R14	1	01-10008	10K 1% 50PPM/C 1/4W M.F.	
R15	1	01-10015	243K 1% 50PPM/C 1/4W M.F.	
R16	1	01-01040	910 5% 1/4W CARBON FILM	
R17	1	01-10015	243K 1% 50PPM/C 1/4W M.F.	
R18	1	01-01102	1.5M 5% 1/4W CARBON FILM	
R19	1	01-01040	910 5% 1/4W CARBON FILM	
R20	1	01-10017	9.09K 1% 50PPM/C 1/4W M.F.	
R21	1	01-10001	1.0K 1% 50PPM/C 1/4W M.F.	
R22	1	01-10001	1.0K 1% 50PPM/C 1/4W M.F.	
R23	1	01-10017	9.09K 1% 50PPM/C 1/4W M.F.	
R24	1	01-01047	2.4K 5% 1/4W CARBON FILM	
R25	1	01-01085	200K 5% 1/4W CARBON COMP	
R26	1	01-01061	10K 5% 1/4W CARBON FILM	
R27	1	01-10154	73.2K 1% 50PPM/C 1/4W M.F.	
R28	1	01-01061	10K 5% 1/4W CARBON FILM	
R29	1	01-10099	10.2K 1% 50PPM/C 1/4W M.F.	
R30	1	01-01047	2.4K 5% 1/4W CARBON FILM	
R31	1	01-10149	5.36K 1% 50PPM/C 1/4W M.F.	
R32	1	01-10042	5.62K 1% 50PPM/C 1/4W M.F.	
R33	1	01-10091	80.6 1% 50PPM/C 1/4W M.F.	
R34	1	01-01093	470K 5% 1/4W CARBON FILM	
R35	1	01-10085	249 1% 50PPM/C W M.F.	
R36	1	01-10028	24.9K 1% 50PPM/C 1/4W M.F.	
R37	1	01-10001	1.0K 1% 50PPM/C 1/4W M.F.	
R38	1	01-10099	10.2K 1% 50PPM/C 1/4W M.F.	
R39	1	01-10083	2.49K 1% 50PPM/C 1/4W M.F.	
R40	1	01-10127	806 1% 50PPM/C 1/4W M.F.	
R41	1	01-10133	845 1% 50PPM/C 1/4W M.F.	
R42	1	01-10296	78.7K 1% 50PPM/C 1/4W M.F.	
R44	1	01-10019	1.27K 1% 50PPM/C 1/4W M.F.	
R45	1	01-10157	475 1% 50PPM/C 1/4W M.F.	
R46	1	01-10119	237 1% 50PPM/C 1/4W M.F.	
R47	1	01-10085	249 1% 50PPM/C W M.F.	
R48	1	01-10012	20K 1% 50PPM/C 1/4W M.F.	
R49	1	01-10216	2.10K 1% 50PPM/C 1/4W M.F.	
R50	1	01-10017	9.09K 1% 50PPM/C 1/4W M.F.	
R51	1	01-01081	100K 5% 1/4W CARBON FILM	
R52	1	01-01012	27 5% 1/4W CARBON FILM	
R53	1	01-01081	100K 5% 1/4W CARBON FILM	
R54	1	01-01061	10K 5% 1/4W CARBON FILM	
R55	1	01-10012	20K 1% 50PPM/C 1/4W M.F.	
R56	1	01-10216	2.10K 1% 50PPM/C 1/4W M.F.	
R57	1	01-10017	9.09K 1% 50PPM/C 1/4W M.F.	
R58	1	01-01081	100K 5% 1/4W CARBON FILM	
R59	1	01-01012	27 5% 1/4W CARBON FILM	

Model 2105 Parts List				
Assembly No.:		Schematic DWG No.:		PCB DWG No.:
2105-600F		2105-070F		2105-700F
Description:				
2105 Main Board Assembly				
Ref Des	QTY	VPN	Description	MPN
R60	1	01-01081	100K 5% 1/4W CARBON FILM	
R61	1	01-01061	10K 5% 1/4W CARBON FILM	
R74	1	01-01073	47K 5% 1/4W CARBON FILM	
R75	1	01-01073	47K 5% 1/4W CARBON FILM	
R76	1	01-01053	4.7K 5% 1/4W CARBON FILM	
RL1	1	05-03012	RELAY REED, 5V COIL, 1AMP, 1-FORM-A	PRMA1A05
RL2	1	05-03012	RELAY REED, 5V COIL, 1AMP, 1-FORM-A	PRMA1A05
RL3	1	05-03012	RELAY REED, 5V COIL, 1AMP, 1-FORM-A	PRMA1A05
RL4	1	05-03089	Relay 4 Form A 5V	S4EB-5V
RL5	1	05-03089	Relay 4 Form A 5V	S4EB-5V
RL6	1	05-03089	Relay 4 Form A 5V	S4EB-5V
RL7	1	05-03089	Relay 4 Form A 5V	S4EB-5V
RL8	1	05-03083	Relay 2A+2B	S2EB-5V
RN1	1	01-40009	8 X 220 NETWORK RESISTOR	898-3-R220
RN2	1	01-40009	8 X 220 NETWORK RESISTOR	898-3-R220
RN3	1	01-40015	9 X 10K NET. SIP	L10-1C-103
RV01	1	01-50033	50 TOP ADJUST	68WR50
RV02	1	01-50029	500 TOP ADJUST	68WR500
RV03	1	01-50029	500 TOP ADJUST	68WR500
RV04	1	01-50028	50K TOP ADJUST	68WR50K
RV05	1	01-50028	50K TOP ADJUST	68WR50K
RV06	1	01-50033	50 TOP ADJUST	68WR50
RV07	1	01-50033	50 TOP ADJUST	68WR50
RV08	1	01-50028	50K TOP ADJUST	68WR50K
RV10	1	01-50013	1K TOP ADJUST POTENTIOMETER	68WR1K
RV11	1	01-50029	500 TOP ADJUST	68WR500
RV12	1	01-50037	200 TOP ADJUST	68WR200
RV13	1	01-50028	50K TOP ADJUST	68WR50K
RV14	1	01-50033	50 TOP ADJUST	68WR50
RV15	1	01-50037	200 TOP ADJUST	68WR200
RV16	1	01-50014	100 TOP ADJUST POTENTIOMETER	68WR100
RV17	1	01-50033	50 TOP ADJUST	68WR50
RV18	1	01-50014	100 TOP ADJUST POTENTIOMETER	68WR100
RV19	1	01-50033	50 TOP ADJUST	68WR50
RV20	1	01-50014	100 TOP ADJUST POTENTIOMETER	68WR100
RV21	1	01-50014	100 TOP ADJUST POTENTIOMETER	68WR100
RV22	1	01-50037	200 TOP ADJUST	68WR200
RV23	1	01-50037	200 TOP ADJUST	68WR200
RV9	1	01-50040	5K TOP ADJUST	68WR5K
SK1	1	05-10313	10 PIN WAFER, GOLD	
TP-G	1	05-10007	GROUND POST TERMINAL (1300B-1)	
TP1	1	05-10290	J-PIN TERMINAL "TEST HOOKS"	
TP5	1	05-10290	J-PIN TERMINAL "TEST HOOKS"	
TP6	1	05-10290	J-PIN TERMINAL "TEST HOOKS"	
TP7	1	05-10290	J-PIN TERMINAL "TEST HOOKS"	
TP8	1	05-10290	J-PIN TERMINAL "TEST HOOKS"	
U01	1	03-30034	+5 VOLT REGULATOR	7805CT
U02	1	03-30035	-5VOLT REGULATOR .5 AMP	LM320T-5.0

Model 2105 Parts List				
Assembly No.:		Schematic DWG No.:		PCB DWG No.:
2105-600F		2105-070F		2105-700F
Description:				
2105 Main Board Assembly				
Ref Des	QTY	VPN	Description	MPN
U03	1	03-30036	+15 VOLT REGULATOR POSITIVE	L78M15CV
U04	1	03-30037	-15 VOLT REGULATOR NEGITIVE	79M15C
U05	1	03-30133	QUAD DIFFERENTIAL COMPARATOR	LM339N
U06	1	03-30111	STABILIZED OPAMP	ICL7650SCPD
U07	1	03-30134	DUAL LOW-NOISE HIGH SPEED OPAMP	NE5532N
U08	1	03-30090	JFET INPUT OPAMP	LF356N
U09	1	03-30090	JFET INPUT OPAMP	LF356N
U10	1	03-30133	QUAD DIFFERENTIAL COMPARATOR	LM339N
U11	1	03-30045	TRUE RMS-TO-DC- CONVERTER	AD536AJH
U12	1	03-30046	Analog Multiplier	AD734ANZ
U13	1	03-30656	4.5 Digit A to D Converter	ICL7135
U14	1	03-30016	BCD-TO-SEVEN-SEGMENT DECODER	SN7447AN
U15	1	03-30656	4.5 Digit A to D Converter	ICL7135
U16	1	03-30016	BCD-TO-SEVEN-SEGMENT DECODER	SN7447AN
U17	1	03-30682	8-bit Microcontroller	ATTINY88-PU
X1	1	05-02010	DUAL OUTPUT CLK OSC 12.800MHZ	EXO35D12.800M

Model 2105 Parts List				
Assembly No.:		Schematic DWG No.:		PCB DWG No.:
2105-601F		2105-071F		2105-701F
Description:				
2105 Display Board Assembly				
Ref Des	QTY	VPN	Description	MPN

A2	1	04-30334	2105 Display PCB Rev F	DWG 2105-701 Rev F
D1	1	05-01005	Small Red LED	MV5074C
D2	1	05-01005	Small Red LED	MV5074C
D3	1	05-01005	Small Red LED	MV5074C
D4	1	05-01005	Small Red LED	MV5074C
DSP1	1	05-01010	HIGH DENSITY SUPER DIGIT 8	SR43-13SRWA
DSP2	1	05-01010	HIGH DENSITY SUPER DIGIT 8	SR43-13SRWA
DSP3	1	05-01010	HIGH DENSITY SUPER DIGIT 8	SR43-13SRWA
DSP4	1	05-01010	HIGH DENSITY SUPER DIGIT 8	SR43-13SRWA
DSP5	1	05-01020	+/- 1 HIGH INTENCITY LED	5082-7656
DSP6	1	05-01010	HIGH DENSITY SUPER DIGIT 8	SR43-13SRWA
DSP7	1	05-01010	HIGH DENSITY SUPER DIGIT 8	SR43-13SRWA
DSP8	1	05-01010	HIGH DENSITY SUPER DIGIT 8	SR43-13SRWA
DSP9	1	05-01010	HIGH DENSITY SUPER DIGIT 8	SR43-13SRWA
DSP10	1	05-01020	+/- 1 HIGH INTENCITY LED	5082-7656
R1	1	01-01033	470 5% 1/4W CARBON FILM	
R2	1	01-01033	470 5% 1/4W CARBON FILM	
R3	1	01-01033	470 5% 1/4W CARBON FILM	
R4	1	01-01033	470 5% 1/4W CARBON FILM	

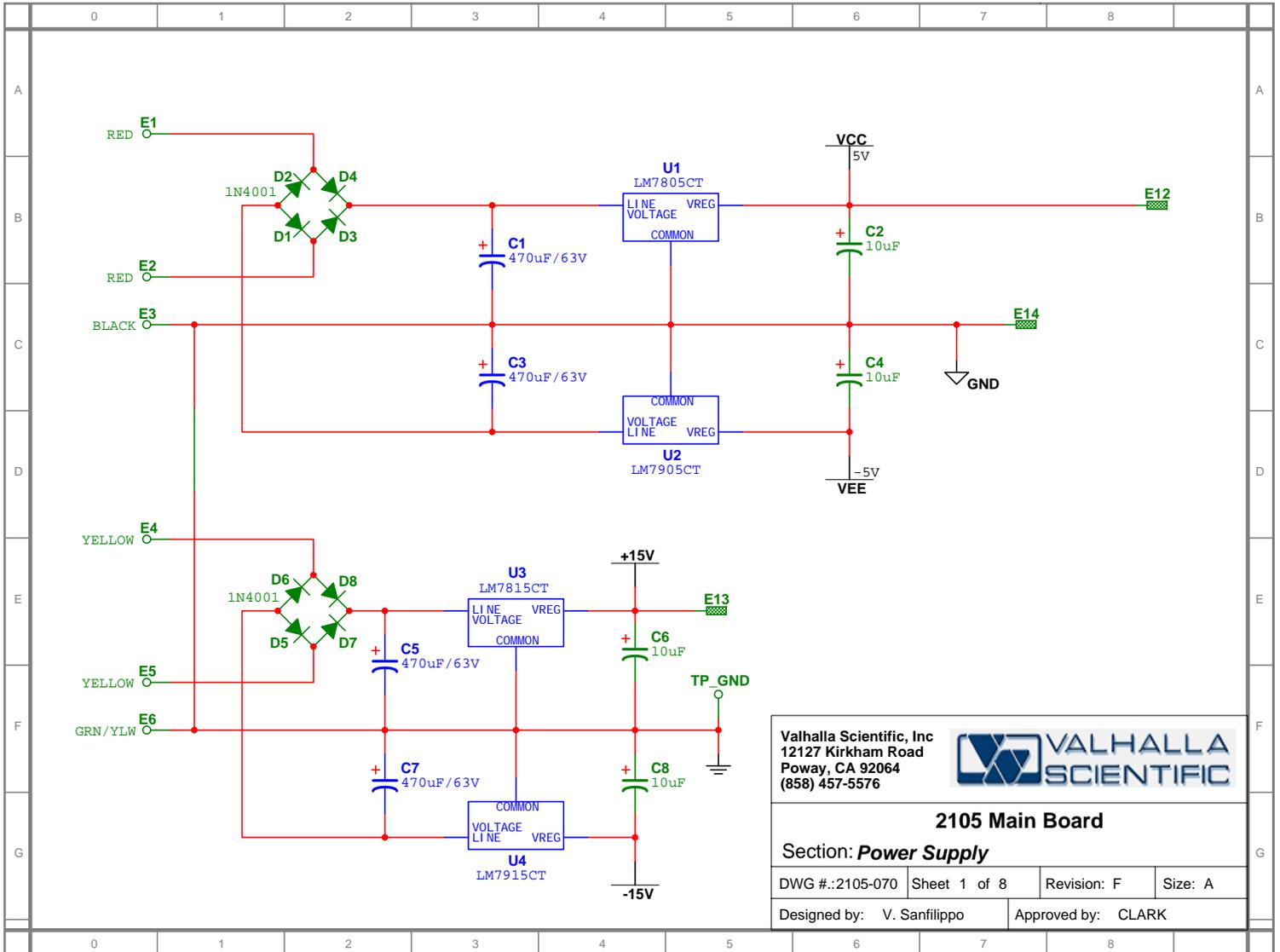
Model 2105 Parts List				
Assembly No.:		Schematic DWG No.:		PCB DWG No.:
2105-602G		2105-072H		2105-702G
Description:				
2105 Switch Board Assembly				
Ref Des	QTY	VPN	Description	MPN

A3	1	04-30335	2105 Switch PCB Rev G	DWG 2105-702 Rev G
C1	1	02-10006	0.01 μ F/50V Ceramic Cap	
RN1	1	01-40015	9 X 10K Network Resistor	L10-1C-103
RN2	1	01-40009	8 X 220 Network Resistor	
SW1	1	05-03134	TACTSWITCH TH SP MOEN RED LED	3FTL80
SW2	1	05-03134	TACTSWITCH TH SP MOEN RED LED	3FTL80
SW3	1	05-03134	TACTSWITCH TH SP MOEN RED LED	3FTL80
SW4	1	05-03132	TACTSWITCH TH SP MOEN	3FTL
SW5	1	05-03134	TACTSWITCH TH SP MOEN RED LED	3FTL80
SW6	1	05-03134	TACTSWITCH TH SP MOEN RED LED	3FTL80
SW7	1	05-03134	TACTSWITCH TH SP MOEN RED LED	3FTL80
SW8	1	05-03134	TACTSWITCH TH SP MOEN RED LED	3FTL80
U1	1	03-30682	8-bit Microcontroller	ATTINY88-PU

Model 2105 Parts List				
Assembly No.:		Schematic DWG No.:		PCB DWG No.:
2105-400		n/a		n/a
Description:				
2105 Chassis Assembly				
Ref Des	QTY	VPN	Description	MPN
n/a	1	01-10089	600K 1% 80PPM/C 1W M.F.	MG714-600K-1%
n/a	1	01-20256	0.015 OR 0.012 CURNT SENSE R	PBV-R012-1.0
n/a	1	04-10130	CHASSIS PAC-TEC	
n/a	1	04-10283	HEATSINK SHUNT	DWG 2105-203 Rev.A
n/a	1	04-10285	SHORTING STRAP	DWG 2105-207
n/a	1	04-10309	INPUT SHIELD	DWG 2100-210
n/a	1	04-11101	2105 FRONT PANEL	DWG 2105-200
n/a	1	04-11102	2105 Overlay	DWG 2105-100
n/a	1	04-11103A	2105 REAR PANEL	DWG 2105-202
n/a	1	04-20083	2110 POWER TRANSFORMER	DWG 2110-010
n/a	1	05-03007	TOGGLE SWITCH	C&K 7101SYZQE
n/a	1	05-03017	SLIDE SWITCH	SW 46256LFR
n/a	1	05-10018	FUSEHOLDER, PANEL MOUNT	H345601
n/a	20	05-10019	4" CABLE TIE	08-432
n/a	2	05-10020	30A BLACK BINDING POST	BP30B
n/a	1	05-10085	11/32OD, 1/8ID, 1/4DIA, GROMMET	SMITH 91114
n/a	1	05-10086	#6 SOLDER LUG	SMITH 1412-6
n/a	1	05-10166	RECEPTICAL LINE FILTER	DELTA DEEG3E
n/a	8	05-10198A	1/4D, 1/8L, #4, NYLON SPACER	
n/a	3	05-10198B	1/4D, 3/8L, #4, NYLON SPACER	
n/a	2	05-10252	CUT BNDG POST	FROM 05-10020
n/a	1	05-10450	#10 SOLDER LUGS	
n/a	2	05-10490	BINDING POST WASHER	5710-292-40
n/a	1	05-10495	STANDOFF #6 HEX 7/16"L	

Chapter 10**Schematics**

Power Supply (Main Board).....	2105-070 Rev. F pg.1/8
Current Amplifier (Main Board).....	2105-070 Rev. F pg.2/8
Voltage Scaler (Main Board).....	2105-070 Rev. F pg.3/8
RMS-to-DC Converter (Main Board).....	2105-070 Rev. F pg.4/8
Analog Multiplier (Main Board).....	2105-070 Rev. F pg.5/8
A/D Converters and Display Drivers (Main Board).	2105-070 Rev. F pg.6/8
Keypad Interface and Relay Drivers (Main Board).	2105-070 Rev. F pg.7/8
Decimal Point Driver (Main Board).....	2105-070 Rev. F pg.8/8
Display Board.....	2105-071 Rev. F pg.1/1
Switch Board.....	2105-072 Rev. H pg.1/1



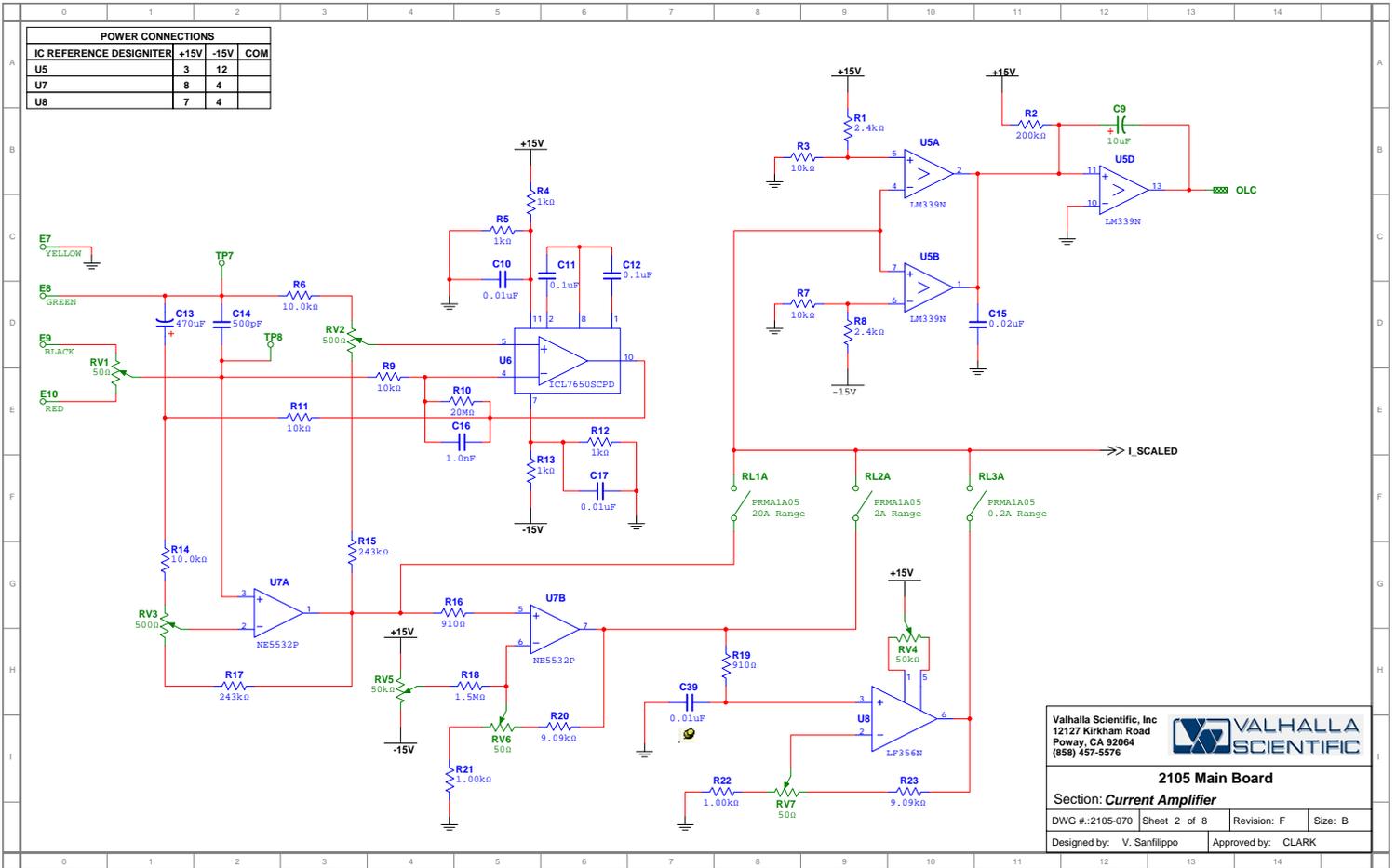
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 Poway, CA 92064
 (858) 457-5576



2105 Main Board

Section: **Power Supply**

DWG #: 2105-070	Sheet 1 of 8	Revision: F	Size: A
Designed by: V. Sanfilippo		Approved by: CLARK	

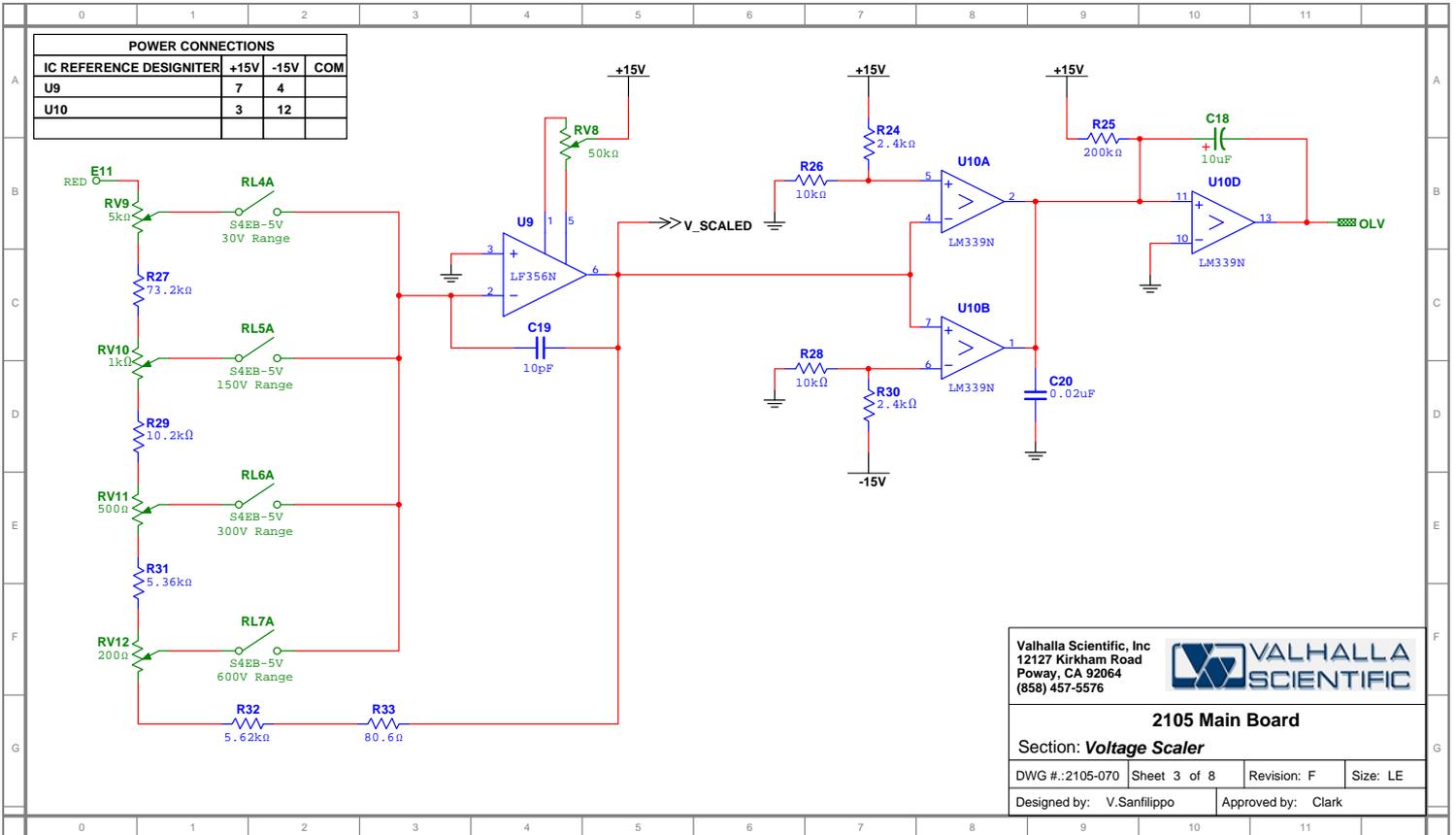


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2105 Main Board

Section: **Current Amplifier**

DWG #: 2105-070	Sheet 2 of 8	Revision: F	Size: B
Designed by: V. Santillipo	Approved by: CLARK		



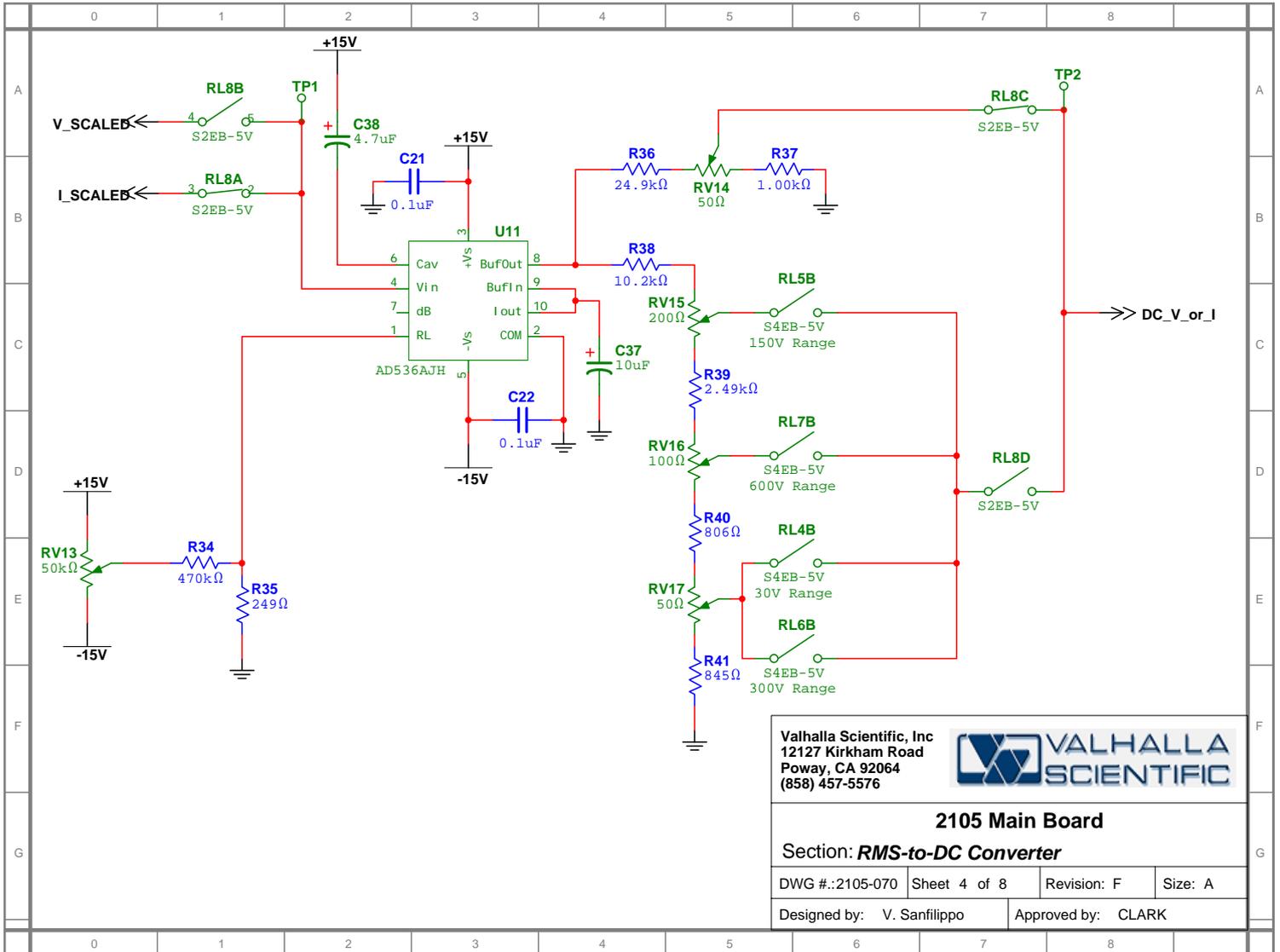
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2105 Main Board

Section: **Voltage Scaler**

DWG #: 2105-070	Sheet 3 of 8	Revision: F	Size: LE
Designed by: V.Sanfilippo	Approved by: Clark		



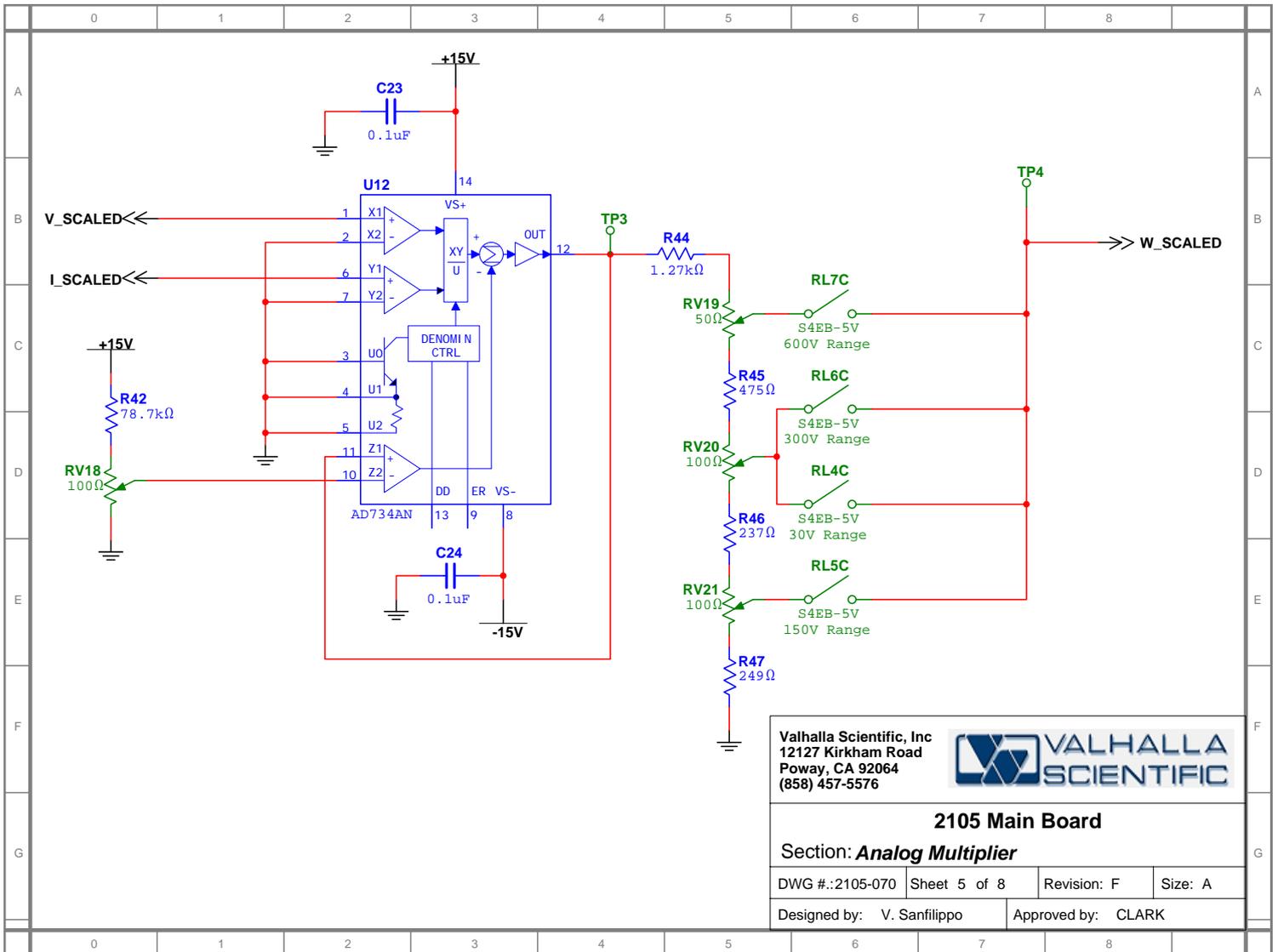
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2105 Main Board

Section: **RMS-to-DC Converter**

DWG #: 2105-070	Sheet 4 of 8	Revision: F	Size: A
Designed by: V. Sanfilippo		Approved by: CLARK	



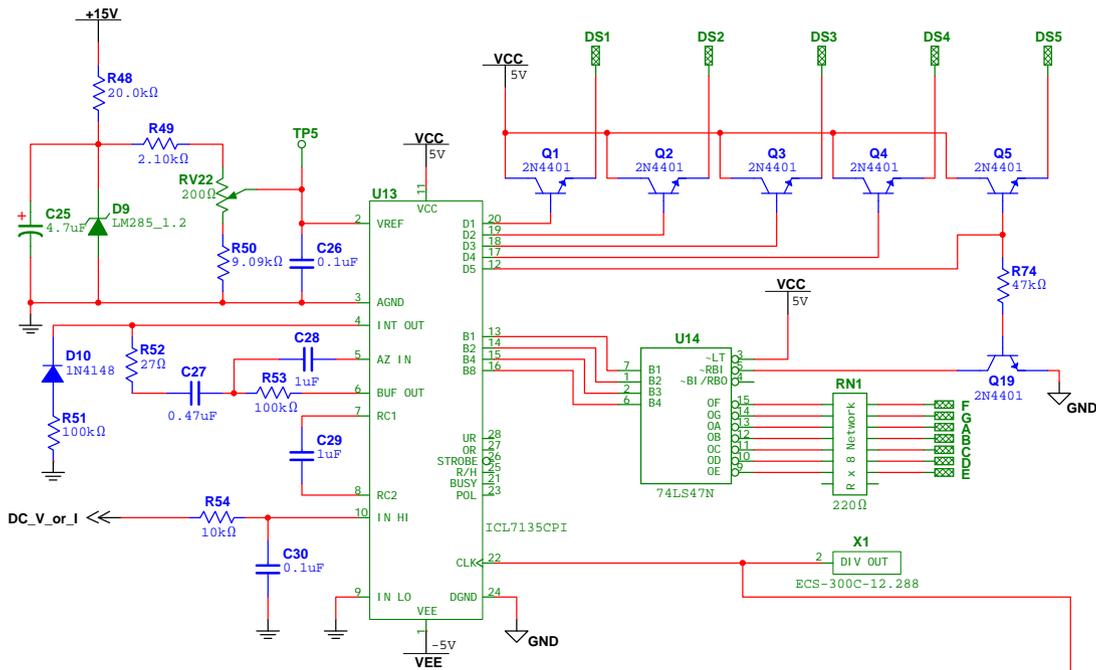
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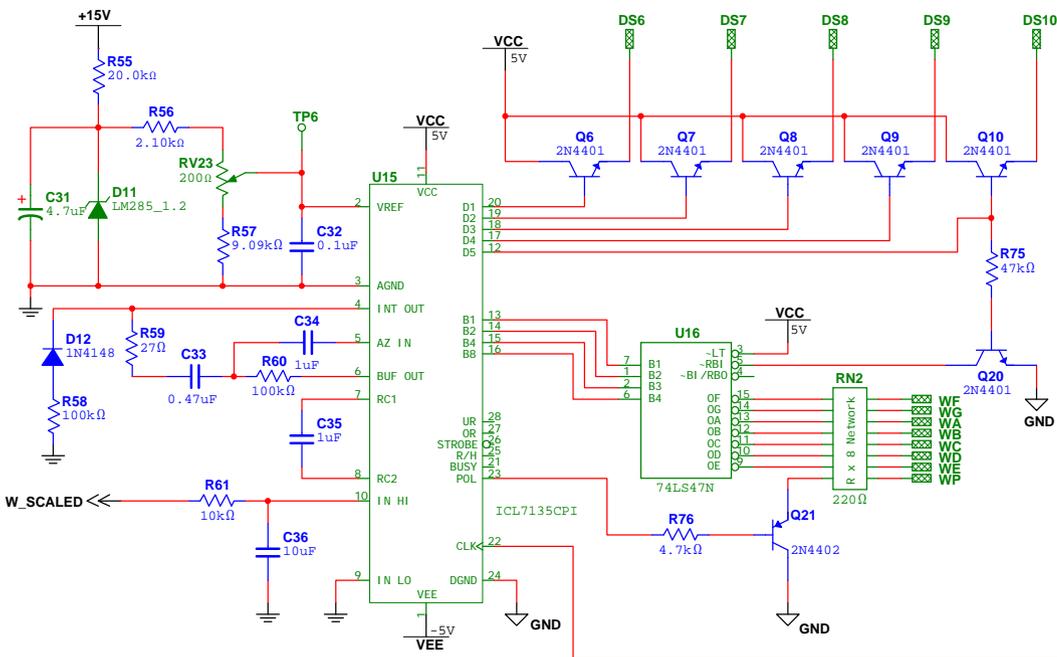
2105 Main Board
 Section: **Analog Multiplier**

DWG #: 2105-070	Sheet 5 of 8	Revision: F	Size: A
Designed by: V. Sanfilippo		Approved by: CLARK	

Voltage and Current A-to-D Converter



Watts A-to-D Converter



POWER CONNECTIONS

IC REFERENCE DESIGNITER	VCC	VEE	GND
U14 - U16	16	-	8

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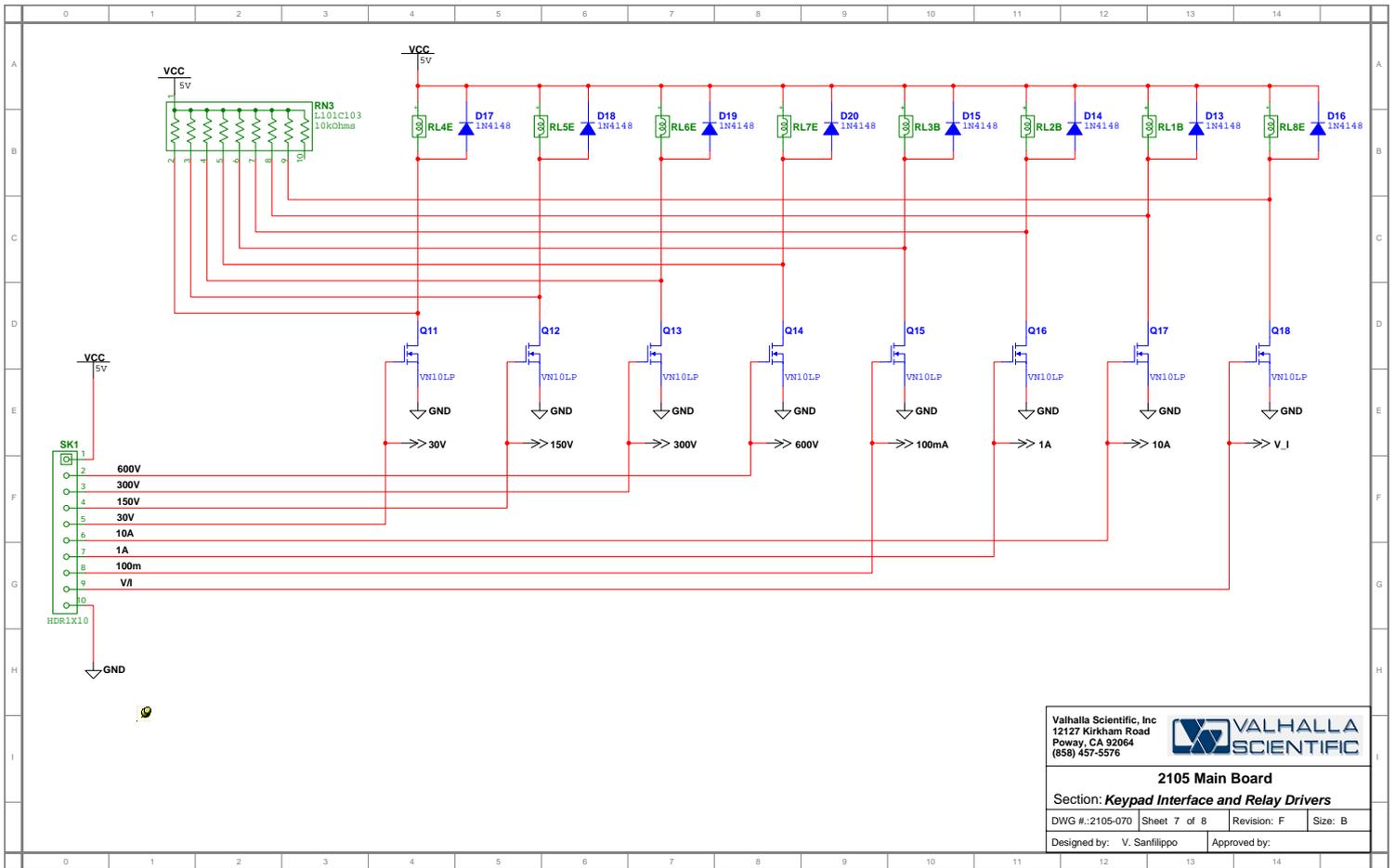


2105 Main Board

Section: A/D Converters Display Drivers

DWG #: 2105-070 Sheet 6 of 8 Revision: F Size: B

Designed by: V. Sanfilippo Approved by: CLARK

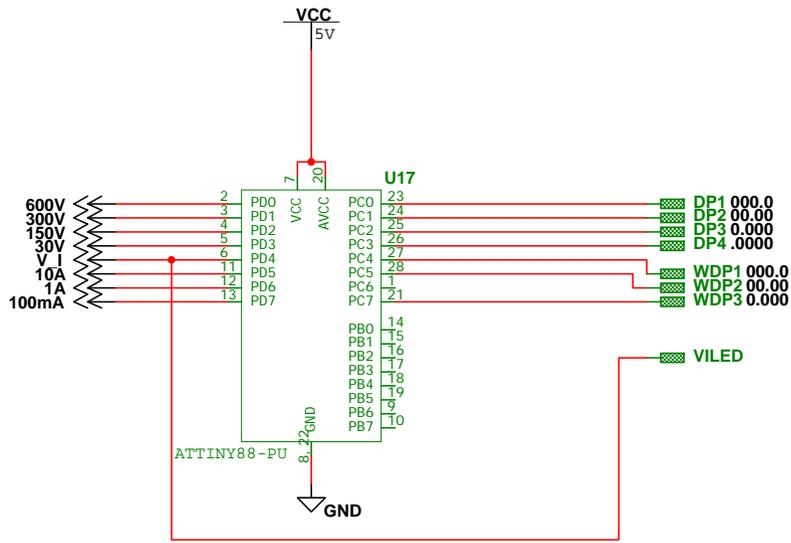


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2105 Main Board
 Section: *Keypad Interface and Relay Drivers*

DWG #: 2105-070	Sheet 7 of 8	Revision: F	Size: B
Designed by: V. Sanfilippo		Approved by:	



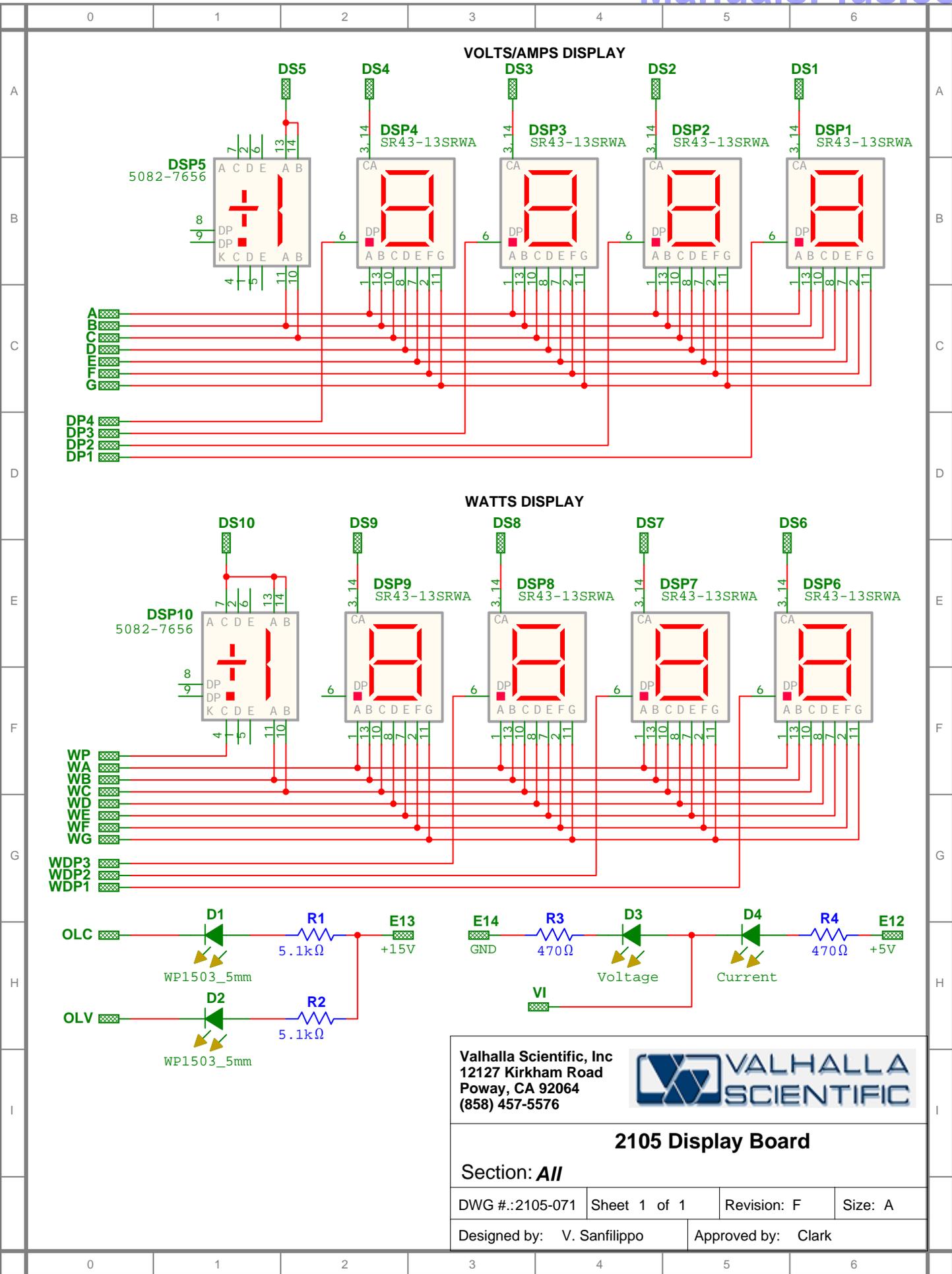
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2105 Main Board

Section: **DP Driver**

DWG #: 2105-070	Sheet 8 of 8	Revision: F	Size: A
Designed by: V. Sanfilippo		Approved by: CLARK	

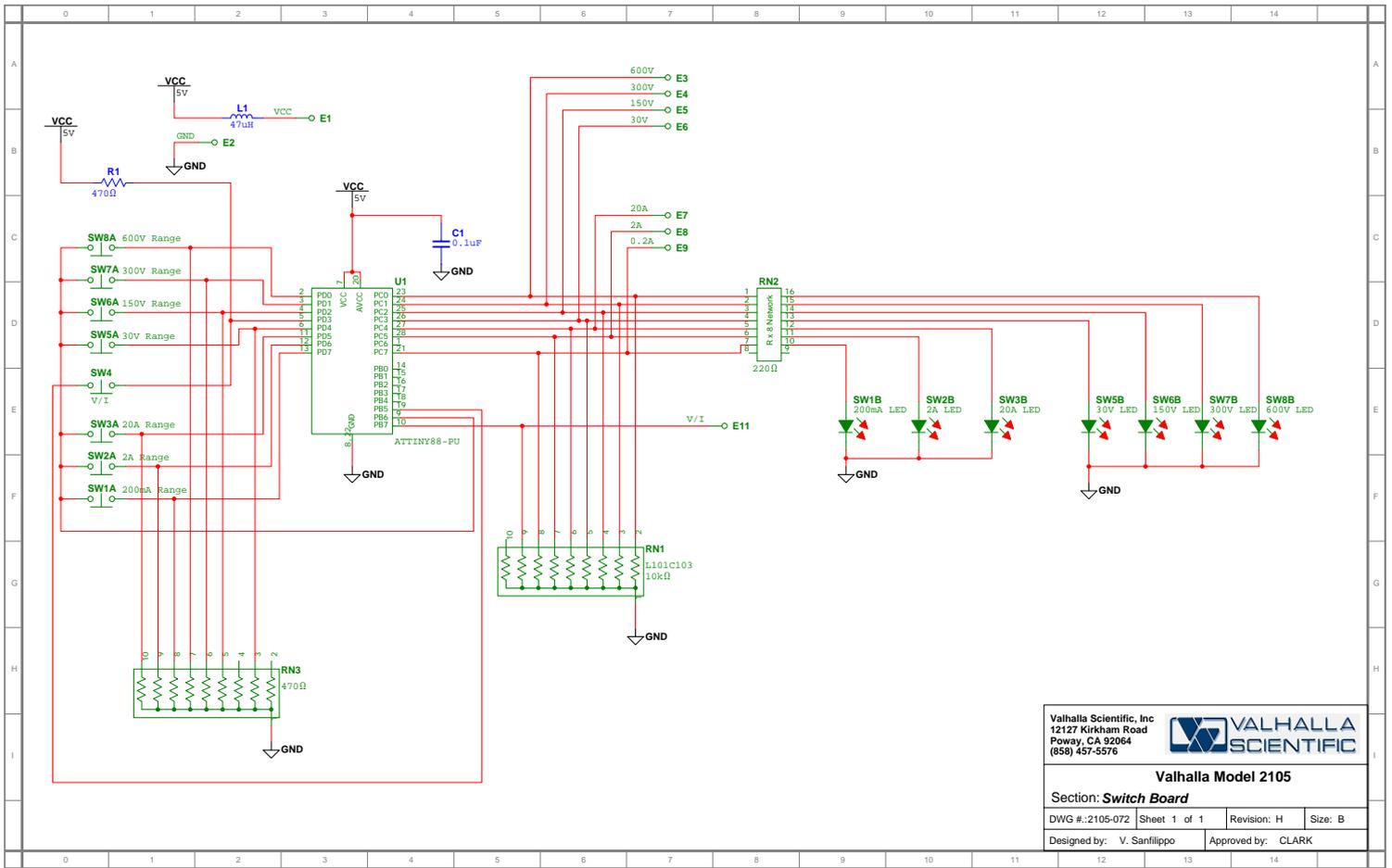


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2105 Display Board

Section: *All*

DWG #: 2105-071	Sheet 1 of 1	Revision: F	Size: A
Designed by: V. Sanfilippo		Approved by: Clark	



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Valhalla Model 2105

Section: **Switch Board**

DWG #: 2105-072	Sheet 1 of 1	Revision: H	Size: B
Designed by: V. Santillipo	Approved by: CLARK		