MAGTROL

THREE PHASE POWER ANALYZER MODEL 4614 B

INSTRUCTION AND REFERENCE MANUAL

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MODEL 4614B

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AND
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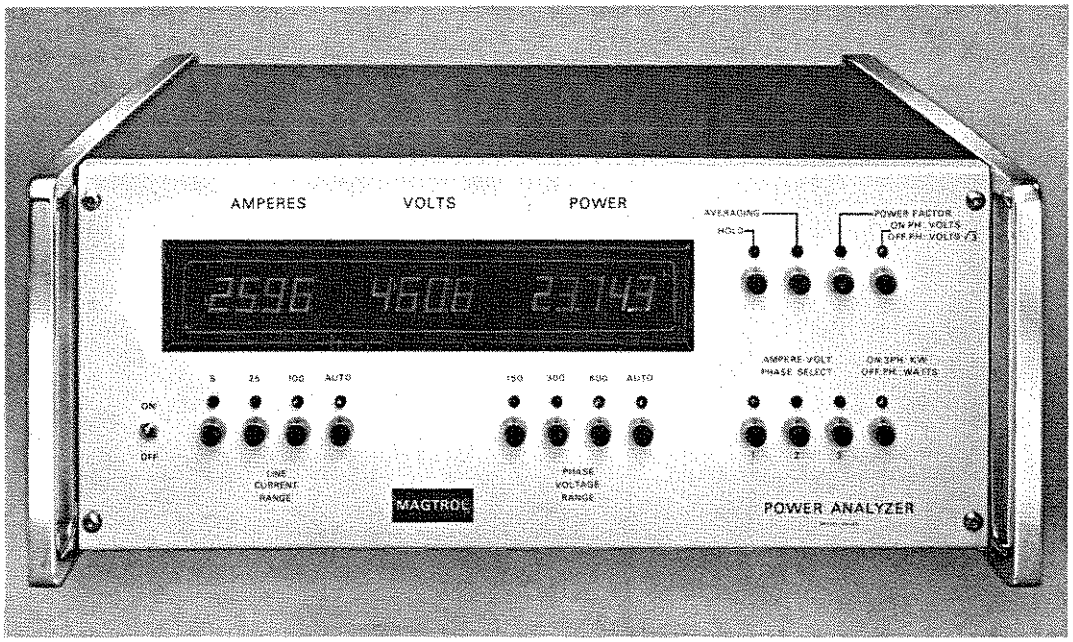
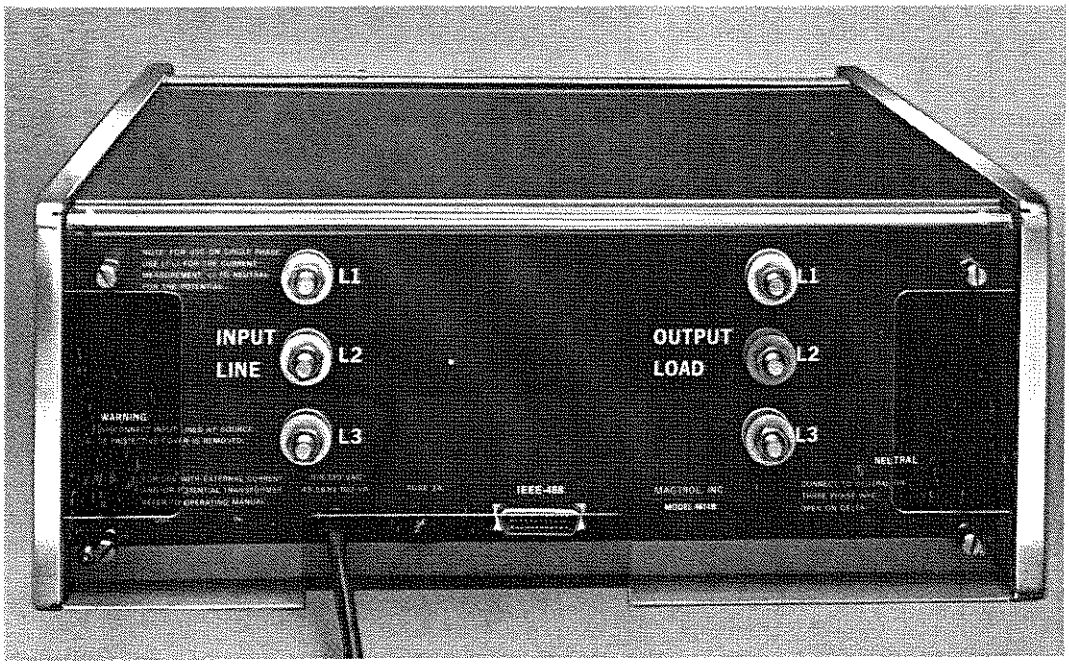
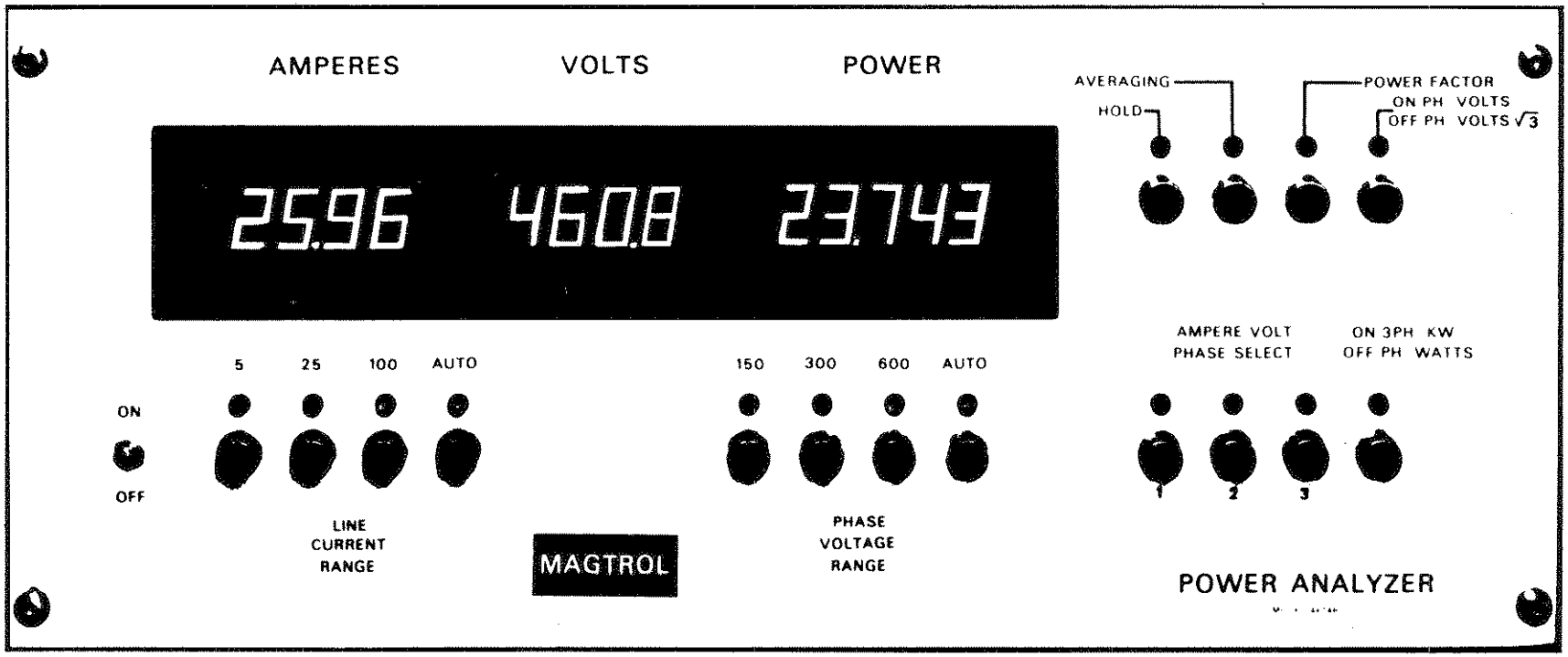


FRONT

UNIT IS 17" WIDE BY 20" DEEP BY 7" HIGH, WEIGHT 46 POUNDS NET — ADAPTER AVAILABLE FOR 19" PANEL MOUNTING. BACK IS FITTED WITH A FORMED-ACRYLIC TRANSPARENT PROTECTIVE COVER.

BACK




AMPERES
VOLTS
POWER
25.96
460.8
23.743
AVERAGING
HOLD
POWER FACTOR
ON PH VOLTS
OFF PH VOLTS √3
5
25
100
AUTO
150
300
600
AUTO
ON
OFF
LINE
CURRENT
RANGE
PHASE
VOLTAGE
RANGE
AMPERE VOLT
PHASE SELECT
ON 3PH KW
OFF PH WATTS
1
2
3
MAGTROL
POWER ANALYZER

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SECTION 1

1.1 INTRODUCTION

1.1.1 UNPACKING

The Model 4614B is adequately packaged for shipping. We recommend that upon unpacking the unit, all cartons and internal cushioning material be saved until the unit is checked out and normal operation is established. In the event there should be shipping damage, notify the carrier within 24 hours and have all the shipping material available for his inspection. Please call the MAGTROL Customer Service Dept.

1.1.2 INSTRUMENT CHECK-OUT

Remove the plastic rear panel cover. Plug the line cord into a standard power source. The rear panel is marked with the appropriate power source for the instrument, 117/230, whichever was specified at the time of purchase. If unspecified, 117V 60 Hz is assumed for all domestic shipments.

PLEASE NOTE: In all of the following, the term LED refers to the Light Emitting Diode red indicator on the front panel above it's respective push button.

Turn the unit on.

The AMPERES, VOLTS and POWER should read zero, or a very small value. The LINE CURRENT RANGE LED's should indicate 5 and AUTO, the PHASE VOLTAGE at 150 and AUTO. One of the three PHASE SELECT LED's must be indicating and the cooling fan should be audible along with a slight "hum" caused by the shunt control power relays.

Select the 100 Ampere range.

The "hum" should diminish, the AUTO LED should extinguish, and the 100 LED should go on.

Select the AUTO on the current range.

The 5 amp range, and AUTO LED should go ON.

If all of the above checks out, and appearance is normal, you may assume satisfactory operation.

1.1.3 MODEL 4614B RATINGS AND PRECAUTIONS.

Before connecting a power souce to the 4614B rear panel studs, please observe the following maximum instrument ratings and precautions.

VOLTAGE: Line to line, or line to ground - 1000 VRMS.

CURRENT: Any phase, 100 Amperes maximum continuous, 200 amps not to exceed 5 seconds duration.

WARNING: Please consider inductive surges. If the voltage to either the line or load side exceeds 2000 VRMS, line to line or line to ground, damage to the 4614B can result. Inductive surges may easily attain potentials of many kilovolts at substantial current levels.

If a circuit breaker is to be used, whatever the type of device, it must be installed on the load side of the 4614B (downstream). This method will leave the low impedance line always connected to the 4614B, therefore suppressing inductive surges when the power to the load is opened. If the line side must also contain a circuit breaker, it is good practice to devise a circuit such that the input circuit breaker could not be opened until after the load side is opened. Additionally, arc suppression devices such as Metal Oxide Varistors (MOV's) are a wise choice, installed line to line and/or line to ground, AT THE DEVICE UNDER TEST.

1.2 CONNECTING THE 4614B

Connect the input/output lines to the 3/8" bronze connector studs. Do not overtighten the nuts, (ten pound-feet of torque maximum.) Wiring should be neat and of adequate capacity to carry the expected load. Inadequate capacity wiring is not only dangerous, but line drops create inaccurate readings. Replace the plastic rear cover for safety. Tighten the four retaining screws of the safety cover finger-tight only.

Please refer to the following connection diagrams, and select whichever power form is appropriate. Paragraph 1.2.1 for single phase, 1.2.2 for three phase delta (three wire systems) or 1.2.3 three phase WYE (4 wire, typical 208 volt systems).

1.2.1 SINGLE PHASE CONNECTION METHOD:

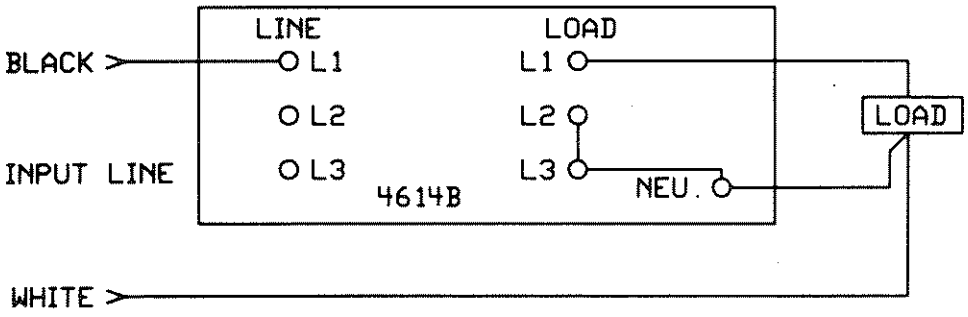


FIGURE 1

Select AMPERE VOLT PHASE SELECT for Phase 1 and proceed to paragraph 1.3.

1.2.2 THREE PHASE WYE:

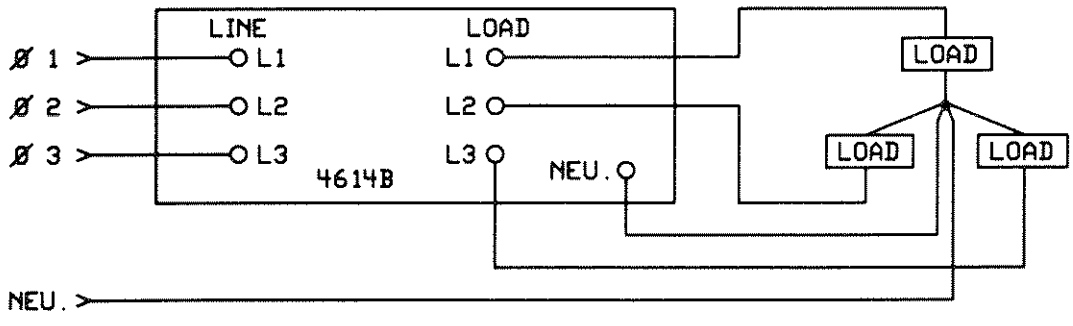


FIGURE 2

1.2.3 THREE PHASE DELTA:

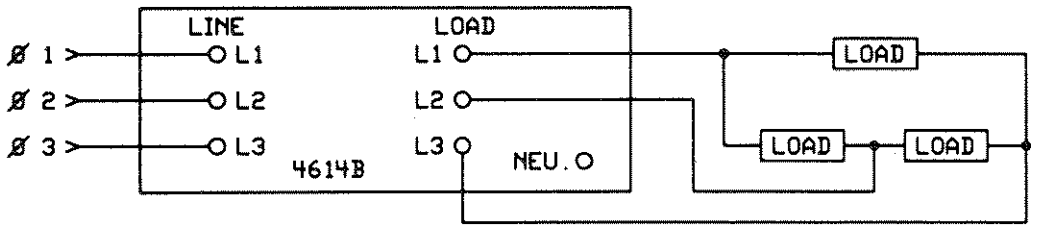


FIGURE 3

1.3 OPERATIONAL DESCRIPTION

With the 4614B turned on, the power source connected and a load applied, readings of amperes, volts and watts will be observed. If not, be sure that the HOLD function is not on, indicated by the HOLD LED off. All pushbuttons toggle, with the exception of the RANGE control and PHASE SELECT push-buttons.

1.3.1 "AMPERES" READOUT:

The AMPERES reading displays the line current of the phase selected, either 1, 2 or 3 as indicated by the AMPERE-VOLT PHASE SELECT LED's. Any phase reading may be selected by pressing the appropriate push button.

Line amperes is equal to phase amperes in either a single phase or WYE system.

1.3.2 "VOLTS" READOUT:

Single phase system:
The VOLTS indication is correct only if the (upper right push button) ON: PH. VOLTS LED is ON, or else the read-out will be equal to voltage × 1.7321 (Square root of 3).

Three phase WYE system:
On a three phase WYE system the VOLTS measurement is line to neutral, equivalent to phase voltage. If the ON: PH. VOLTS (Upper right push button) LED is ON, phase voltage is the indicated, typically 120.1 volts on a 208 volt 4 wire 3 phase system. If the LED is off, the indication is line voltage, or 208 in this example. (Line voltage = phase volts × 1.7321 in a WYE system.)

Three phase DELTA system:
The 4614B utilizes an artificial neutral in order to obtain an equivalent for the product of phase voltage and phase current. Paragraph 3.1 THEORY OF OPERATION covers this more thoroughly. Two voltage indications are available. The line to artificial neutral (phase) voltage, or × 1.7321 which is equal to line voltage in a 3 phase 3 wire balanced system. For the line voltage reading, select the OFF: PH. VOLTS $\sqrt{3}$" upper right push button.

1.3.3 "POWER" READOUT.

Three formats are available

Individual phase watts:
Select OFF: PH. WATTS. This is the appropriate setting for single phase use, or where power per phase is of interest. The indication is always in watts, and is equivalent to the instantaneous value of: EI cos θ.

Three phase power:
Select ON: 3PH. KW. The reading is equal to Phases (1+2+3)/1000. The indication is always in kilowatts, and is true regardless of line imbalance.

Power factor:
Select by pressing the POWER FACTOR push-button such that the LED is ON. Two values of PF are available. The true three phase PF, obtained by ON: 3 PH. KW selection, calculated by the 4614B according to the formula:

$$\text{3PH. KW POWER FACTOR} = \frac{W1 + W2 + W3}{VA1 + VA2 + VA3}$$

Individual PF per-phase selected by OFF: PH. WATTS. This would be the correct selection for single phase operation.

$$\text{PH. WATTS (1,2 or 3) POWER FACTOR} = \frac{W1\ (2 \text{ or } 3)}{VA1\ (2 \text{ or } 3)}$$

Where: W = EI cos θ. (1,2,3 denote phases)
VA = Volt-Amp

1.3.4 "HOLD" FUNCTION.

The HOLD push button may be depressed at any time. All internal machine functions are halted except the auto-ranging.

PLEASE NOTE: The 4614B retains all mode settings when the unit is turned off. If the unit is turned off, with the HOLD on, when it is turned back on again the HOLD will still enable leaving the displays without information and therefore blanked. To restore, set the HOLD off.

1.3.5 "AVERAGING" FUNCTION.

In this mode, all data consisting of amps, volts, watts, kilowatts, and all phases are continuously averaged. The exception is POWER FACTOR: no averaging is performed on this parameter.
In the POWER FACTOR mode, if AVERAGING is selected, AVERAGING takes precedence, and the POWER FACTOR mode automatically cancels. The POWER readout will switch to PH.WATTS, or 3 PH. KW, whichever was previously selected.

In AVERAGING mode, if POWER FACTOR is selected, the function will not be accepted. The averaging process will be delayed while the POWER FACTOR push button is depressed.

The averaging continues accurately, in the event range changes or other operating modes are selected during the process.

Averaging is an integration function. The displays continuously update, reporting the integrated value. If a slow varying value of either the line, load or

frequency make the readout variation difficult to follow, the averaging function will accurately stabilize the reading. It may require anywhere from several seconds to several minutes, depending upon the rate and magnitude of change. There is no maximum integration time period. The 4614B will function as an amp-hour, volt-hour and KW-hour meter in the averaging mode, except that the time factor must be externally determined.

It may be useful to understand that the data stored in the averaging registers (the summation of amps, volts, watts and the summation count) is maintained when the AVERAGING is disabled. It is non-volatile, meaning that, after the unit is turned off, the data is still retained indefinitely. To maximize the usefulness of this feature, please consider the following:

The AVERAGING and HOLD functions work together. Normal operation occurs when entering the AVERAGING mode with the HOLD OFF. The Internal data registers are first cleared and the averaging starts fresh.

If the AVERAGING is enabled when the HOLD is ON, the memory is not cleared. New data will be averaged into existing data, as soon as the HOLD is subsequently released.

This important feature permits the measurement of the true integrated power consumption on complex types of loads, such as those where power is applied intermittently.

1.3.6 "RANGE" CONTROL

The 4614B is an autoranging instrument, permitting limited fixed range operation. At power up, the AUTO (ranging) mode enables. If a specific current or voltage range is selected, the AUTO mode goes off and the selected range remains fixed. However, if the value of input current or voltage exceeds the selected range, plus approximately 20%, the 4614B automatically switches to a higher range, and will remain there.

In the manual range select mode always select the lowest range possible for the load to be measured.

PLEASE NOTE: The LINE CURRENT RANGE is for all three phases. An overrange condition ON ANY PHASE will result in an automatic uprange.

1.3.7 AMPS RANGE INSTABILITY.

Upranging is determined if a peak value exceeds the range times 1.414, plus approximately 20%. However, downranging is determined by the RMS value being within full scale of the next lower range.

Under some conditions of high crestfactor (typically, severe amps form-factor distortion), the 4614B may detect an out of range peak value; but at the same time the true RMS value is within range. The 4614B would respond to this situation by rapidly switching between two ranges. In this event it will be necessary to manually select a midrange value. (AUTO off).

1.3.8 PHASE VOLTAGE RANGE:

Voltage is expressed in phase voltage on the 4614B. Line voltage, more commonly expressed, will be 1.7321 times greater. This means that a 230 volt three phase line normally operates on the 150 volt range. Example, 230/1.7321 = 132.8. This is discussed in greater detail in SECTION 3: "Theory of Operation".

1.4 MAINTENANCE

The 4614B contains a cabinet blower to withdraw heat from the current shunts and relay control circuitry. On the side plate opposite to the blower, there is a filter to trap dust. Depending upon the degree of contaminants in the air, periodic cleaning of this filter should be done. The easiest method is to place a vacuum cleaner nozzle against the side plate fins and pull the dust out the way it went in.

Never use solvents to clean any portion of the cabinet or front panel. Warm water with a bit of soap, if required, is adequate.

1.5 ACCURACY

Conditions:
Between 1% and 120% of full scale range.
Frequency DC to 2.5 KHZ
Crest factor <10:1. Power factor .1 to 1.0, lead or lag.
Ambient temperature 72° F ± 10° F.

VOLTS = reading ± (.2% of reading + .20% range)
AMPS = reading ± (.22% of reading + .25% range)
POWER = reading ± (.2% of reading + .3% VA range)
PF = reading ± (VA error ± KW error)
Temperature coefficient: <.01%/° C (.003 typical).

NOTE: The VOLTS accuracy shown is for phase voltage. The line voltage indication is the phase voltage × square root of 3. This calculated value is subject to deviation from a line to line measurement proportional to any 3 phase line imbalance. Line imbalance has no effect upon the power measurement accuracy.

All instruments are shipped with an Accuracy Certification from Magtrol Inc., traceable to the NBS, and so stated.

Magtrol is a member of the American National Standards Institute. Calibration practice and accuracy statements are based upon ANSI certification C39.6 and other standards.

1.6 CURRENT-POTENTIAL TRANSFORMER INSTALLATION

Figure 4 schematic shows a typical connection method for both a current transformer (CT) and a potential transformer (PT). Figure 5, is for 3 wire CT installation only.

POTENTIAL AND CURRENT TRANSFORMER CONNECTIONS FOR 3 PHASE DELTA

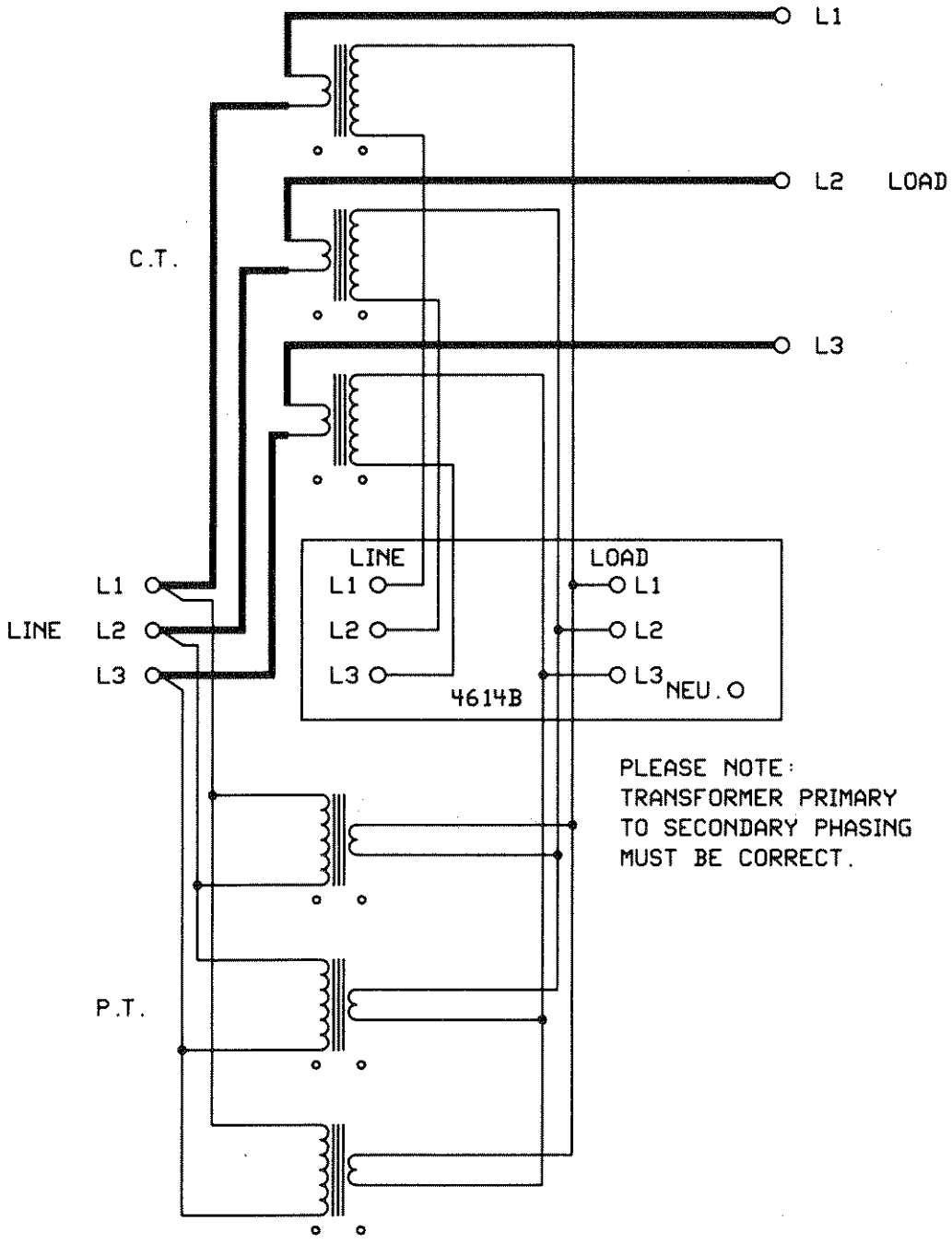


FIGURE 4

CURRENT TRANSFORMER CONNECTIONS

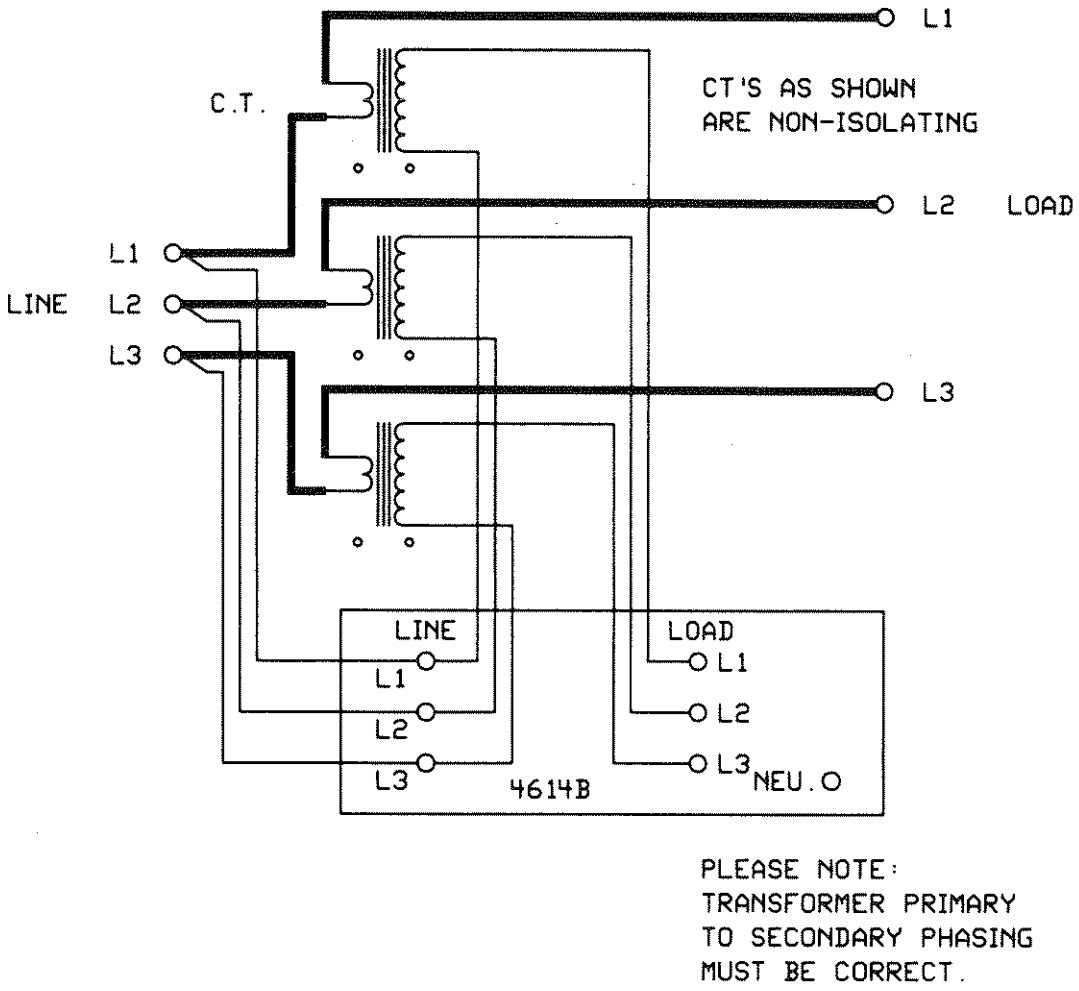


FIGURE 5

Reading correction to compensate for PT-CT transformer ratios is available. A switch on the rear panel of the 4614B at the lower left corner must be set to IN. If ratio information was supplied to Magtrol before delivery of the instrument, this value will already be coded into the 4614B. Otherwise a default value of 1.0 will be installed.

Field installation must be done through the GPIB. This is covered in section 2, specifically Paragraph 2.4.3.

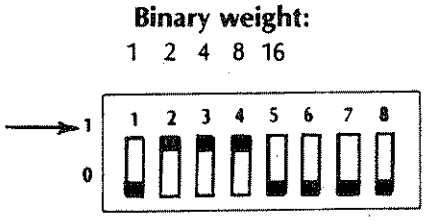
SECTION 2

2.1 USING THE IEEE-488 (GPIB)

The IEEE-488 or GPIB (General Purpose Interface Bus) permits direct connection of the 4614B to any computer, so equipped, for the purpose of data aquisition and instrument control.

On the rear panel on the 4614B there is a small rectangular opening on the upper right side. The primary address of the 4614B is controlled here by a miniature eight position slide switch. The default (factory) setting of this switch is fourteen (14). If this address is suitable, no alteration of the setting is necessary. If a different setting is required please refer to the following chart for the set-up.

Switch Segment					Address
1 LSB	2	3	4	5 MSB	
0	0	0	0	0	0
1	0	0	0	0	1
0	1	0	0	0	2
1	1	0	0	0	3
0	0	1	0	0	4
1	0	1	0	0	5
0	1	1	0	0	6
1	1	1	0	0	7
0	0	0	1	0	8
1	0	0	1	0	9
0	1	0	1	0	10
1	1	0	1	0	11
0	0	1	1	0	12
1	0	1	1	0	13
0	1	1	1	0	14
1	1	1	1	0	15
0	0	0	0	1	16
1	0	0	0	1	17
0	1	0	0	1	18
1	1	0	0	1	19
0	0	1	0	1	20
1	0	1	0	1	21
0	1	1	0	1	22
1	1	1	0	1	23
0	0	0	1	1	24
1	0	0	1	1	25
0	1	0	1	1	26
1	1	0	1	1	27
0	0	1	1	1	28
1	0	1	1	1	29
0	1	1	1	1	30
1	1	1	1	1	31



NOTE: The binary levels read from left to right; that is, the most significant bit is to the right, least significant to the left. Only the first five switches from left to right are used. Additionally, a change in the primary address will also change that factor in the software examples in section 2.3.2 and 2.3.3

2.2 COMPUTER TYPES

2.2.1 HEWLETT-PACKARD

Most lab oriented Hewlett-Packard computers, equipped with the GPIB interface, contain the GPIB driver routines in the operating systems. All that is necessary is to write the commands using the correct port and primary address identification. If this is the case, proceed to Paragraph 2.3.

2.2.2 IBM PC, COMPATIBLES, OR OTHER.

If any of the numerous PC's with IEEE-488 interface capability are to be used, an interface card with suitable software is required. For recommendations and assistance in setting up an interface for an IBM PC, or compatibles, please request Magtrol software assistance.

Communication termination characters are a common problem with PC interfaces to any GPIB controlled instrument. The 4614B is configured for the Hewlett-Packard standard termination characters of carriage return (CR hex OD) and line feed (LF hex OA). On a read cycle (4614B to computer), the 4614B expects the standard IEEE-488 read protocols and primary address. It responds with a data string followed by the ASCII CR and LF to signal to the computer the end of transmission. The computer must be configured to accept these characters as instructions to terminate GPIB communication and proceed with program execution. On a write cycle (computer to 4614B), the 4614B expects to receive: the standard read protocols, the primary address, instructional data string; then the termination characters of CR and LF. The software identification for these is CHR$(13) and CHR$(10) respectively. If these terminators are not forthcoming, the 4614B has no way of knowing when to terminate hand-shaking, reset the GPIB and continue with program execution. If omitted, the only way to restore operation is to turn the unit off, then on again, or force a GPIB interface reset, if available.

2.3 MODEL 4614B DATA OUTPUT

2.3.1 READ CYCLE

In a read (4614B to Computer) command mode, the 4614B will output a data string containing the information on the AMPERES-VOLTS-POWER readout. This will appear, in ASCII format, as follows:

A=aa.aaV=vvv.vWA=ww.www( )

Where: aa.aa is the amperes value exactly as displayed on the AMPERES four digit readout, vvv.v for VOLTS and ww.www is the five digit POWER readout. The ( ) in the example, is to indicate a blank space at the end of the character string. The notation is a floating point. The string length is always 24 characters, including the space. Most PC's will require that the input string length be precisely dimensioned. Most HP computers will ignore any characters beyond the default (usually 18) unless dimensioned.

In the above example the WA indicates that PHASE WATTS is the operating mode.

Additional display configurations are:

FOR KW mode: A=aa.aaV=vvv.vKW=ww.www( )

For PF mode: A=aa.aaV=vvv.vPF=p.pppp( )

Where: p=power factor reading, always fractional.

The purpose of the blank space is to allow a character "E" to be substituted for it. For programming convenience this leaves the string length constant. If any parameter exceeds the display capacity, then the "E" is substituted, flagging a possible error.

Example: A=1000 V=vvv.vKW=wwwww.E

Please note the missing decimal point in the amps value. This could be caused by a large ratio CT installed, in conjuction with a high value range selection. The result could be an excessively large number (Eg; 10,000 Amps). The displayed value is still accurate, except that the magnitude would be known only intuitively - perhaps.

2.3.2 Programming example in HP BASIC.

The following example is for the purpose of demonstrating how data is transmitted from the 4614B to the host computer.

```
10 DIM A$[24]          !Length of string
20 CLEAR               !Clear the screen
30 ENTER 714; A$       !7=PORT, 14=4614B GPIB addr.
40 DISP A$             !Place on CRT.
50 GOTO 30             !Keep running.
```

NOTE: Check individual computer manual for GPIB port number. The above example would directly operate into an HP Model 85.

Programing example in HP BASIC to command the 4614B and return data, for each of the 3 phases of measurement.

```
10 DIM A$[24], B$[24] ,C$ [24]    !Three variables
20 OUTPUT 714; "SP1"              !Set up phase 1.
25 WAIT 100                       !Give it .1 sec to update
30 ENTER 714;A$                   !Fetch phase 1 data.
40 OUTPUT 714;"SP2"               !Set up phase 2.
45 WAIT 100                       !Another .1 sec
50 ENTER 714;B$                   !Fetch phase 2 data.
60 OUTPUT 714;"SP3"               !Set up phase 3.
65 WAIT 100                       !Third .1 sec delay
70 ENTER 714;C$                   !Fetch phase 3 data.
75 REM Display all three readings on one line.
80 DISP "PHASE 1 = ";A$;" PHASE 2 = ";B$;" PHASE 3 = ";C$
90 GOTO 20
```

For explanations of SP1, SP2, and SP3, refer to paragraph 2.4.1.

2.3.3 Programming example for MS DOS, BASICA.

Various GPIB interfaces are available for IBM PC's and compatibles. The following program is applicable for National Instruments Inc., Part number GPIB-PC2A, hardware interface and software installation.

This example assumes that the National software has been loaded and configured with the correct termination operators of CR and LF. (Explanation in paragraph 2.2.2)

Information transfer, 4614B to computer...

In the following program, lines 1 thru 6 are assembly language sub-routines.

```
1 CLEAR, 60304!          'BASIC Declarations
2 IBINIT1 = 60304!
3 IBINIT2 = IBINIT1 + 3
4 BLOAD "BIB.M",IBINIT1
5 CALL IBINIT1   (IBFIND, IBTRG, IBCLR, IBPCT, IBSIC, IBLOC, IBPPC, IBBNA,
IBONL, IBRSC, IBSRE, IBRSV, IBPAD, IBSAD, IBIST, IBDMA, IBEOS, IBTMO,
IBEOT, IBRDF, IBWRTF)
6 CALL IBINIT2   (IBGTS, IBCAC, IBWAIT, IBPOKE, IBWRT, IBWRTA, IBCMD,
IBCMDA, IBRD, IBRDA, IBSTOP, IBRPP, IBRSP, IBDIAG, IBXTRC, IBRDI,
IBWRTI, IBRDIA, IBWRTIA, IBSTA%, IBERR%, IBCNT%)
10 CLS
20 RD$=SPACE$(26) 'Dimension the input string +CR+LF.
30 BDNAME$="DEV14" 'Default GPIB address of the Model 4614B
40 CALL IBFIND (BDNAME$,BD%)
50        CALL IBRD (BD%, RD$) 'Actual data entry here.
60        PRINT RD$ 'CRT display the 4614B digital readout.
70        GOTO 50
80 END
```

Instruction transfer, Computer to 4614B:
The following example will transmit an instruction to configure the instrument to read Phase 2, then input the data on that phase.

NOTE: Lines 1 thru 6 of the above program are required.

```
10    CLS
20    BDNAME$="DEV14"
30    WRT$="SP2"+CHR$(13)+CHR$(10) 'Set phase 2+CR+LF.
40    RD$=SPACE$(26)' Dim the input statement +CR+LF.
50    CALL IBFIND (BDNAME$,BD%)
60    CALL IBWRT (BD%,WRT$)'Set phase 2
70    CALL IBRD (BD%,RD$)' Fetch the data.
80    PRINT RD$ 'Display the data.
90    GOTO 70 'Continue reading.
100   END
```

2.4 MODEL 4614B INPUT INSTRUCTION SET

2.4.1 MODEL 4614B CONTROL CHARACTERS.

The 4614B recognizes the following characters as the instruction set for machine control, resulting in the actions described.

DATA STRING	ACTION
AVG1	Sets the AVERAGING function ON.
AVG0	Sets the AVERAGING function OFF.
AR	Sets Amps Auto ranging ON.
AR5	Sets Amps range to 5.0
AR25	Sets Amps range to 25.
AR100	Sets Amps range to 100.
AZ	Turns off Auto zeroing of displays. Unit must be turned OFF then ON to restore auto zeroing function.
HOLD1	Sets the HOLD function ON.
HOLD 0	Sets the HOLD function OFF.
KW1	Sets the Power display = 3 phase KW.
KW0	Sets the Power display = per phase W.
LV1	Sets volts display to line volts.
LV0	Sets volts display to phase volts.
LO1	Locks out all front panel controls.
LO0	Restores normal front panel control.
PF	Sets the power display to read power factor. Exit PF with KW1 or KW0.
SP1	Sets AMPERE-VOLT PHASE SELECT to 1.
SP2	Sets Phase 2.
SP3	Sets Phase 3.
VR	Sets volts range to Autorange.
VR150	Sets volts range to 150.
VR300	Sets volts range to 300.
VR600	Sets volts range to 600.
PT	(Refer to paragraph 2.3.3)
CT	(Refer to paragraph 2.3.3)

2.4.2 "HELP" OUTPUT INSTRUCTION.

The 4614B recognizes "HELP" character string as a special event function where the data output on the next read cycle will be modified from measurement data to information.

After "HELP" is output, upon the next GPIB read instruction (4614B to computer), the instruction set outlined in paragraph 2.4.1., above, is transmitted instead of Amps-Volts-Watts data.

The output is organized for a full 80 column by 25 line screen format. The computer input must be dimensioned for 2000 character length string.

Upon completion, 4614B resets to normal operation and subsequent read instructions will then be normal data.

2.4.3 PT-CT MULTIPLIER READING CORRECTION.

The following characters when transmitted from a host computer to the 4614B will set up, in non-volatile memory, fixed multipliers to compensate the 4614B readout data.

The maximum ratio for either current or potential is 1000 and 100,000 for the product. For example, if the CT were 1000:1, the maximum allowable PT would be 100:1.

DATA	ACTION
CTxxx.x	Multiply the AMPERES and POWER reading by the value of xxx.x, which may be any number from .0001 to 1000. The value must be four digits maximum and must contain a decimal point to be accepted. 1.0 is the default value.
PTxx.xx	Multiply the VOLTS and POWER reading by the value of xx.xx, which may be any number from .0001 to 1000, four digits maximum, and must contain a decimal point. 1.0 is the default.

Data entries always overwrite previous CT or PT entries. One output statement each is required.

In the event both a PT and CT are used, the power reading is muliplied by the product of the (PT) (CT) ratios.

The default 1.0 is the value that is factory installed, if no other ratios were specified. This keeps the rear panel switch (if set IN) from generating unknown effects.

SECTION 3

3.1 THEORY OF OPERATION

3.1.1 CURRENT AND VOLTAGE DETECTION.

The Model 4614B does not utilize any current of potential transformers in the input circuits. Figure 6 schematic shows the actual circuit configuration that the 4614B presents to the line and load for the purpose of measuring power. It is basically the classic three wattmeter method.

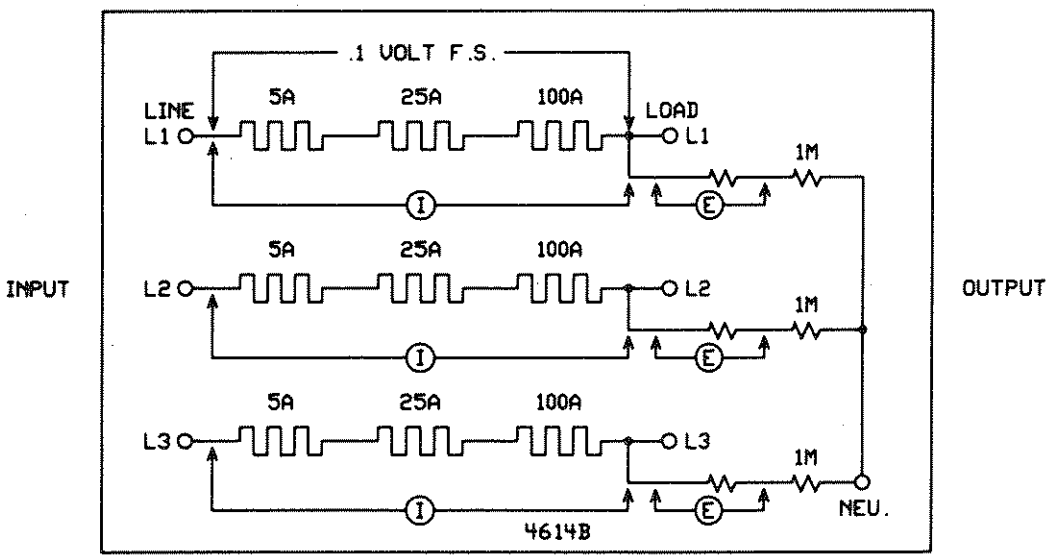
The measurement requirement is: Power is equal to phase volts times phase amps times the cosine of the phase angle.

The potential measuring circuit is essentially a "Y" box creating an artificial neutral. In a WYE configured 3 phase system, the artificial neutral should be connected to the real neutral, and is non-current carrying. In the WYE system, phase amps is equal to line amps and line to neutral is equal to phase volts. The voltage measurement of the 4614B is line to neutral under all conditions, therefore the above measurement requirement is satisfied.

In a DELTA system, line voltage and phase voltage are the same. However, only line current is available; therefore we have a square root of 3 error factor in the current circuit. This is satisfied by producing the "Y" configuration in the potential measuring circuit.

No connection to the neutral terminal is required or desirable. Voltage and current are detected by use of non-inductive resistor dividing networks and manganin current shunts. To facilitate a broad range of measurement, multiple shunts protected by low contact resistance relays are used.

VOLT-AMP DETECTION MEANS



Ⓘ CURRENT MEASURING CIRCUIT

Ⓔ POTENTIAL MEASURING CIRCUIT

FIGURE 6

3.1.2 Signal conversion.

The signal voltages, at "E" and "I" on schematic Figure 6, are applied to operational amplifiers for signal processing. This provides a true-value input capability without modifying the wave shape. It is the only accurate method for measuring true power and RMS equivalent of non-sinusoidal wave shapes, especially with any DC insertions.

Referring to Figure 7, the amplifier outputs of I and E are applied to two inputs each. These are: a true RMS converter, and the X and Y inputs to a four quadrant multiplication element. The output of the multiplication element, which is now the instantaneous product of EI cos θ, passes to a 2 pole Butterworth filter. The filter algebraically sums the − and + portions of the power wave-form to DC. Any ripple content at very low frequencies will be further removed by digital processes to acquire a steady state reading. The outputs of the RMS converters and the (Watts) filter connect to precision voltage-to-frequency converters. The E, I and P values now pass through 2500 Volt optical isolators to earth ground potential reference. The information is processed digitally from here on by an 8 bit microprocessor.

There are three identical circuits of that shown in Figure 7—one for each phase. These are physically located on the 4614B chassis under insulated protective covers, and isolated from one another.

ANALOG INPUT CIRCUIT

One phase only shown. Simplified schematic.

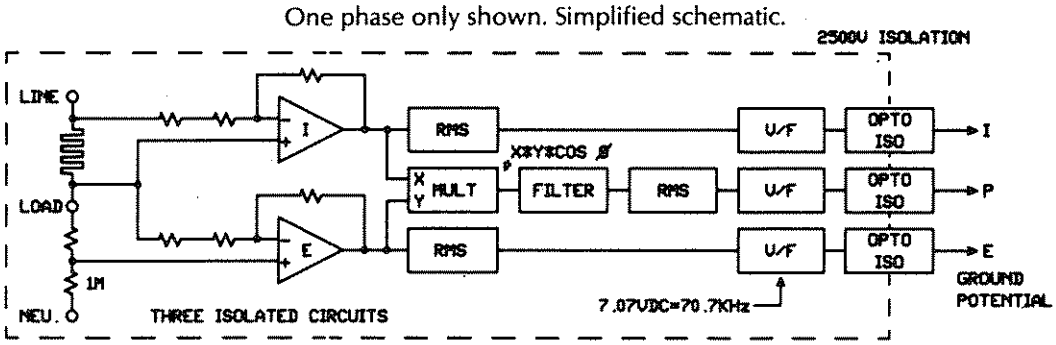


FIGURE 7

WARNING: No attempt should be made to remove the protective cover. Do not attach test instruments to the circuits, or adjust any of the offset or balance potentiometers with any LINE POWER CONNECTED to the unit. Failure to observe this warning could result in serious personal injury, destruction of equipment and possible fire.

Complete schematic diagrams of the digital system are available from Magtrol Inc., and will be supplied upon request. As a general rule, field trouble-shooting of microprocessor systems is rarely effective. Please contact customer service at Magtrol for assistance.

3.2 CALIBRATION

The calibration procedure for the Model 4614B is complex. A source of precision single phase power is required. If the power source is of known sinusoidal high (undistorted) quality, most any precision AC voltmeter and ammeter of at least

.05% accuracy and resolution is satisfactory. Otherwise only thermal transfer standards for true RMS should be used. The following diagrams show the simplest means for calibrating Volts and Amperes.

In the following examples, these set-ups are suitable for determining the readout accuracy of VOLTS-AMPERES-POWER only. Due to common mode line considerations, mentioned in the warning above, plus offset and balancing requirements, calibration adjustments should not be attempted without consulting the Instrument Calibration Dept. at Magtrol Inc. for assistance.

3.2.1 VOLTAGE CALIBRATION CHECK

Connect the unit as shown in FIGURE 8., and compare readings of volts for phases 1,2 and 3. This should be done at or near full scale on the range(s) of interest. Be sure the ON: PH. VOLTS LED is ON. There will be no AMPERES reading in this configuration.

VOLTS CALIBRATION CHECK

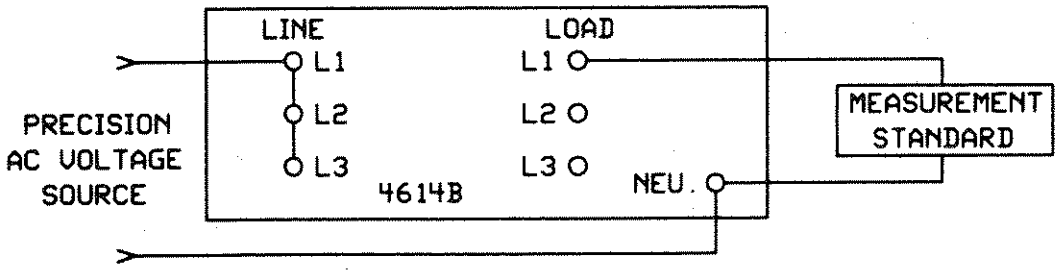


FIGURE 8

3.2.2 AMPERE CALIBRATION CHECK.

Connect the unit as shown in FIGURE 9 and compare the readings at or near full scale values. There will be no VOLTS reading in this configuration.

AMPERES CALIBRATION CHECK

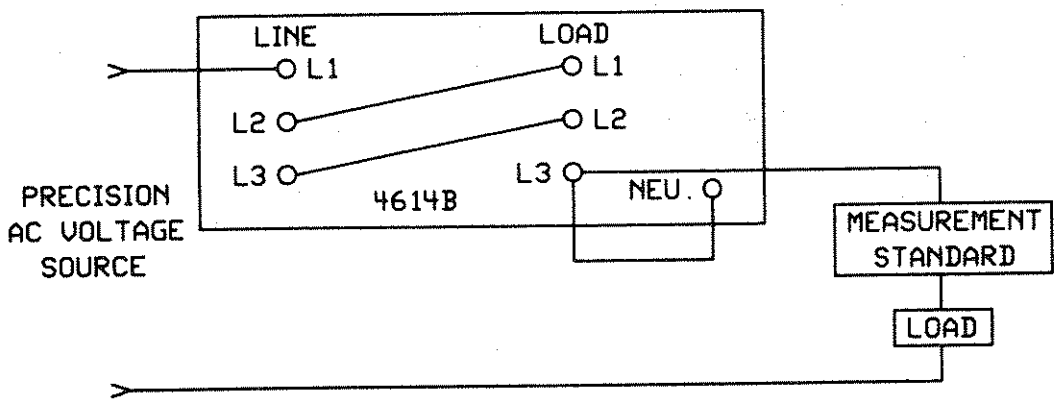


FIGURE 9

If a precision Amp-Volt meter calibrator of at least the accuracies stated above is available, the above tests can be performed without the use of the measurement standards or load. Simply apply the voltage and current, but using the above connection methods.

3.2.3 POWER CALIBRATION

The easiest method for determining the accuracy of the power readout is to first establish the volts and amps calibration accuracy at, or near full scale on any volt and amp range. With a unity power factor load, check that the watts reading is equal to the product of volt-amps. A high power factor load of non-inductively wound resistance, or incandescent lamps, is useful for this. Referring to Figure 7, the same calibration controls which adjust the volts and the amps, also calibrate watts. This means that a single point on only one range is required to establish watts accuracy, in relation to the volt-amp readings.

3.2.4 PRECISION CALIBRATORS FOR POWER.

IMPORTANT: Precision instrument calibrators which supply a source of both voltage and current will not calibrate the 4614B POWER measurement accurately unless they operate with a high current source impedance. Since this implies high power dissipation within the calibrator, it is not normally available. The reason then, despite any claims to the contrary, is that the applied current is really an applied voltage adjusted to a level to maintain a value of selected current. It is an inherently low impedance source with separate potential and current circuits. Whereas this will produce a known current and voltage, the phase relationship between the two—in the 4614B shunt portion of the (closed) circuit—IS UNKNOWN. If the calibrator contains a phase adjustment control, this will be useful if it is infinitely adjustable (potentiometer means), and is used to peak the power reading of the 4614B only. An alternative would be to measure the phase angle with another precision instrument. This must be done inside the 4614B rear panel with the probes connected across the active shunt, and at the potential measurement points, just as the 4614B sees the true load power in it's normal operation. Again, if adjustments are to be made, refer to the WARNING above. Calibrator isolation from the live power line must exist.

3.2.5 4614B EI PHASE ANGLE COMPLIANCE.

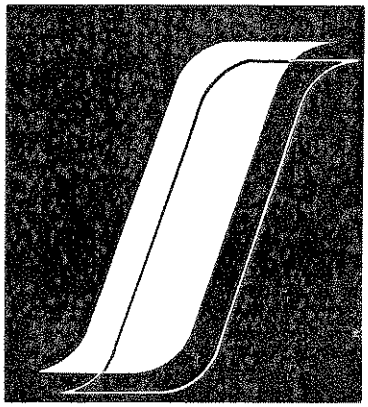
If a check for phasing accuracy is required, the easiest method is to apply power to a very low power factor type load, connected as shown in Figure 1. A large value (several Microfarad) "high Q", oil type capacitor as the load, is an excellent method to establish the 4614B phase angle (power factor) accuracy. This type of load will draw current typically 89.5 degrees to nearly 90 degrees phase angle relationship to voltage. This should produce a very small wattage reading at a substantial Volt-Amp reading. It is easy to establish the phase accuracy of the 4614B, to within a few minutes of phase angle up to approximately 1 KHz., by this method. Actual values of all parameters are easily calculated. EI phase accuracy is intrinsic, and not subject to long or short term drift in the 4614B.

MAGTROL LIMITED WARRANTY

This Magtrol product is warranted against defects in materials and workmanship for ninety (90) days from the date of delivery. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Magtrol. Additionally, any repairs which may become necessary beyond the ninety (90) day warranty period will be made subject to review by our quality control department. No other warranty is expressed or implied. We are not liable for consequential damages.

Customer assistance agreements are available for Magtrol products that require maintenance and repair on site.

MAGTROL, INC. **BUFFALO, NEW YORK 14224**



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