Magtrol 4614B User's Manual

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PLEASE READ

This document includes text recovered from the final edition of a (now) obsolete manual, of a discontinued Magtrol product. Magtrol, Inc. assumes no responsibility for errors or omissions. Additionally, no liability is assumed for any damages that may result from the use of the information contained within this publication.

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MAGTROL

1. Introduction

ABBREVIATIONS

PA Model 4614B Power Analyzer.

GPIB IEEE 488 Instrument Bus Standard.

LED front panel indicators.

A,V and P Amperes, Volts, Power display.

MPU Microprocessor unit.

UNPACKING

The 4614B was adequately packaged for shipping. We recommend that all cartons and internal packing material be saved until the instrument is checked for proper operation. In the event of damage, please notify the carrier and Magtrol Customer Service.

INSTRUMENT POWER

Instrumentation service power is 120V 50/60Hz., or 230V 50/60Hz, 75 watts. If none was specified, all domestic shipments will be supplied as 120V 60Hz. The Line Cord is a detachable NEMA standard 3 wire. For personnel safety, please make sure – with certainty – that your ground line is intact and connects the cabinet to an earth ground.

OPERATIONAL CHECK

Plug in the unit – turn it on and in quick succession you should see the readouts flash, then blank, then read zero or a small value. The RANGE indicators will start on the highest amps volts range, then drop down to the lowest ranges leaving the AUTO LED's on. This should all happen in 1 or 2 seconds. If so, assume the unit has survived shipping and is ready for service.

MAXIMUM RATINGS

Rear panel, input/output lines:

Voltage – line to line or line to ground – 1000 VRMS maximum.

Current – Per phase – 100 Amps continuous, 200 Amps for 6 seconds, 500 Amps maximum, for 2 seconds.

INSTALLATION

Because of the use of special, low contact resistance relays, the PA must be mounted in a nearly horizontal position.

There are six 100 Amp connectors supplied. Do not try to secure too small of a wire – the locking screw may run out of threads and jam in the connector body.

SAFETY

Once the line and load is wired, install the connectors before power is applied. All operating personnel should make a habit of the following:

Power input: Never disconnect only one or two of the line input connectors. When you disconnect any – *always pull all three!*

Load output: Always keep the output connectors in place when power is applied. Again, when you disconnect any – *always pull all three!*

Transient Overloads

Warning: Unsuppressed inductive loads, upon interruption, may generate kilovolts at high energy! This type of surge may be line to line and line(s) to ground. Your Magtrol Power Analyzer is a rugged instrument designed to tolerate overloads, however – as with all electrical equipment – it has limits. Do not allow the PA to function as an "arc suppressor," where you repeatedly exceed the maximum voltage ratings! Please follow the load control, arc quenching and wiring suggestions outlined in chapter 2.

Short Circuits

There are no fuses within the PA. Short circuits at the load, with the PA connected to an unlimited power source, can be destructive. If such a failure should occur; immediately disconnect all power and refer to LINE ISOLATION in Chapter 8, before proceeding.

2. Line/Load Connections

Always install a properly rated circuit breaker between the PA and the load. Your best setup is to use two: one on the input, the second at the load side with a foolproof setup insuring that the load breaker always opens first!

SURGE PROTECTION

Metal Oxide Varistors (MOVs), under various trade names, are a good choice to connect between lines at the load for transient protection from inductive loads.

3 PHASE 3 WIRE DELTA SYSTEM

Since a connection to measure phase I is generally not available in a Delta system, a "Y box" within the PA converts E line to E phase. This satisfies the power conversion formula, by converting line E to phase E, and so incorporating the 3 factor.

The common point of the internal "Y" (false neutral) is accessible at the NEUTRAL terminal – so identified on the rear panel. This has no connection in a Delta system. A detailed description of the PA method voltage transducing is covered in Chapter 4.

3 PHASE, 4 WIRE WYE SYSTEM

Types of systems, ie; 3 wire or 4 wire are transparent to the PA. The power conversion formula is identical to the Delta system, except that in a WYE system:

Connect the (non-current carrying) neutral terminal to the neutral at the load. Any system voltage imbalance will be accurately indicated.

SINGLE PHASE

$P=EI \cos \theta$

A number of connection configurations are possible. The connection method shown opposite, places the line current measurement on the PA phase 1, with unused legs tied off. With this connection method, set the PA mode pushbutton selections as follows:

AMPERE VOLT PHASE SELECT –

1. ON: PH VOLTS

ON OFF: PH WATTS

OFF

The readout is line current, line voltage and true power in watts.

CIRCUIT BREAKERS

If circuit breakers are electrically controlled (relays), if possible use D.C. control. Place a quenching diode across the coils – at the relay. If you must use A.C. controlled breakers, install a metal oxide varister, or at least a 2 watt common resistor across the coil(s). Determine the resistor value such that the power dissipation is 1 to 1 1/2 watts. The correct resistance is easily determined by:

INSTABILITY CAUSES & SOLUTIONS

Instability of the PA can be caused by excessive voltage spikes, or electromagnetic power pulses that manage to reach the high speed digital circuitry within the unit.

High frequency noise generating a potential between the instrumentation power line and the line cord ground is troublesome. Try to determine the source by temporarily attaching an isolated earth ground line to the cabinet of the PA. If this helps, then the noise is in the grounding system. If there is little change, or the problem becomes worse, then very likely, the noise is coming through the 117/230 50/60Hz line cord power. Suppress it with noise filters, bring in a separate line or install a small isolation (not auto) transformer (1A@120V). This should eliminate the problem or reduce it to a tolerable level.

If the instability is directly traceable to some specific device; like other instrumentation control relays or magnetic circuit breakers – try to isolate the cause. If it is intrinsic to the breaker, refer to the above paragraph, CIRCUIT BREAKERS. If it is an electromagnetic current surge from the load, when a switch is closed, isolate that line or "soften" the start.

In any event, in electromagnetically severe environments – sometimes a combination of remedial efforts are required. With severe EMI, most test and computing instruments are susceptible to these problems to some extent. Despite internal shielding, the circumstance unique to the Magtrol PA is that the current carrying power lines pass inside the instrument cabinet where all the action is.

You may obtain additional assistance by contacting Magtrol Power Analyzer Customer Service.

3. Operation and Display

DIGITAL DISPLAYS

Each digit is a Light Emitting Diode seven segment, high brightness 14cm., display. Each A,V and P display is directly controlled by the system MPU.

For readability, the display is refreshed at a rate of two per second (20% of the MPU data acquisition and conversion rate).

Chapter 5. SPECIFICATIONS describes resolution and accuracies. There is a digit segment and decimal point check procedure. See DIGIT TEST in Chapter 8.

Mode pushbuttons toggle, ON/OFF.

HOLD

This button stops the display updating and data accumulation in all modes of operation. The HOLD button serves an additional function when used in conjunction with AVERAGING.

AVERAGING

Full data is accumulated at a rate of 10 readings per second – summed over any desired time period. The running average is continuously calculated and displayed by dividing the summed value of each parameter, by the total number of summations.

When the AVERAGING is stopped, the data, summations and sample count for each A,V and P, are retained in NV* memory.

Normally, as the AVERAGING push button is depressed, with HOLD OFF, A,V and P data previously stored in memory is erased and immediate data starts accumulating. However, if the AVERAGING is initiated while the HOLD is ON, data previously retained in memory is recalled – and new data is then integrated into it. – The HOLD automatically goes OFF.

This function will allow you to exit the AVERAGING mode – perform some other task – then return and continue where you left off, or simply retain and recall data.

POWER FACTOR

Good line voltage balance is required for power factor measurements of induction motors. Chapter 4 contains additional information.

PF data cannot be averaged. PF calculations are invalid when VOLTS AMPS and WATTS are separately integrated.

PHASE VOLTS @ 3

This pushbutton provides an indication of line voltage by applying the above formula. It is not identified as "line voltage," because it is not a true line to line measurement. If there is excessive line to line imbalance, a difference may exist between the displayed value and an actual line to line measurement. This is unavoidable since phase voltage is required for accurate power determination in balanced or unbalanced systems.

AMPERES RANGE

When you select a specific range, the AUTO LED turns OFF indicating the MANUAL range selection mode. If the line amperes exceeds full scale, (>105%) on any phase, (either AUTO or manual) the unit will advance uprange to avoid reading inaccuracies or overload.

Current over 105 AMPS – on any phase – results in the readout begging "HELP," and remaining that way, until the overload is removed.

To return the unit to AUTO ranging mode – press the AUTO pushbutton.

VOLTAGE RANGE

Operation is identical to CURRENT RANGE described above and upranging also occurs at 105% of phase voltage range in effect. If you have selected OFF: PH. VOLTS @ 3, then uprange will occur at: 105% of range × 1.73.

PHASE SELECTION

Pushbuttons 1,2 or 3 select that specific phase for display. Pushbutton ON: 3PH KW – OFF: PH WATTS provides a choice on the POWER display of that individual phase watts, or KW where:

If all three, pushbuttons (1 2 3) are simultaneously depressed, all four LEDS will go ON. Each display then converts to:

The only remaining operator control, is a recessed slide switch for CT/PT provision on the lower left corner of the PA rear panel. Programming and operating details are covered in the Chapter 7 – CT/PT INSTALLATION.

4. Technical Description

Magtrol Power Analyzers use the "Three Wattmeter Method" to determine true RMS and EIcos θ. Transducing is accomplished by analog means, followed by conversion to digital at 16 bit binary precision. Binary data is then calibrated and converted to BCD for display and GPIB output.

AMPERES TRANSDUCING

Manganin meter shunts comprise the current measuring circuits. – The schematic shows the essential elements for obtaining signals E and I, either AC or DC.

The voltage drop across each meter shunt is analogous to line current. CR1 and CR2 are *normally closed* shunt bypass relays. They have no function in load control and act only as shunt current bypass devices. This method permits automatic current control, resulting in a wide measurement range, transparent to the operator. To establish range; each applicable shunt signal is electronically selected – synchronized with CR1 and CR2.

VOLTAGE TRANSDUCING

Resistor networks, on the load side, form a classic "Y Box" where the individual resistors shown are actually divider networks. The resulting phase voltage signal is selected and amplified for conversion and processing.

ANALOG PROCESSING

A simplified schematic shows the essential elements of the analog section and applicable conversion formulas.

Conversion from voltage to frequency permit the use of optical isolators to transfer signals to an earth ground related potential. Balancing and calibration controls, referred to in chapter 8., are identified on their respective elements.

DATA PROCESSING

Three variable frequency signals AFo, VFo, and WFo represent one of three phases for a total of nine. Each are integrated, for a precise period of 0.1 second, for digital conversion. The system MPU controls functions of auto zero, range control, calibration, conversion to BCD, digital display and preparation for GPIB transmission.

DISPLAY RATE

To avoid a "nervous" display; the readouts update at a reduced rate of 500 milliseconds, from the MPU acquisition and conversion rate of 100 milliseconds. A minor software change can revise the display rate – faster or slower. Contact Magtrol Customer Service.

PUSHBUTTONS

The MPU looks at the condition of all pushbuttons approximately 25 times per second. If the MPU detects a pushbutton; the appropriate LED is immediately turned ON – OFF. The MPU then locks in a program loop until the button is released. On the next program cycle the action programmed, for the respective push button, is then executed. No damage will result to the unit from the inadvertent selection of any push button – at any time.

LOW FREQUENCY MEASUREMENTS

Some invertor power supplies have variable (low) frequency control – also some complex loads have slowly changing power consumption. Normally, as any digital readout begins to follow the line or load change, the display quickly becomes useless. In the AVERAGING mode the PA snapshots and integrates A,V and P data at a rate of 10 readings per second. As readings accumulate, the display will steady down to provide an accurate measurement of the true power, equal to the average A,V and P from the time the function was started.

In the conversion of sinusoidal information to steady state; RMS conversion and Watts transducing have inherent time constants. Refer to ACQUISITION RATE. A power pulse of short duration, like a few cycles, will be integrated into the data, but the PA cannot analyze short term phenomenon. A Digital oscilloscope is probably more appropriate.

POLYPHASE IMBALANCE

In polyphase systems, lines should be maintained balanced. In most applications three phase power is very inefficient if excessively unbalanced. To quantify "excessively," for example: on an inductive load – like a motor or transformer – for every percent of line voltage imbalance the resulting (percent) current imbalance will be seven to ten times greater! Excessive current in one phase results in temperature rise and reduced efficiency. Also, in unbalanced polyphase systems, for the above reasons, *true* power factor is indeterminate.

DISPLAY = "HELP"

If the A or V displays show "HELP," this indicates that the maximum range of the PA is exceeded, or wave form distortion (high crest factor) is such that a portion of the signal is exceeding the PA range. If the condition lasts for only a few seconds, such as a start up overload, it is of no consequence. However, do not allow an overload to persist. For example; if one of three phases should open – most loads will draw excessive current on the remaining lines. Any phase – regardless of the *phase selected* – when overloaded causes the display to protest.

If you install an overload detection circuit breaker (a good idea!) please refer to Chapter 2 for circuit location and type considerations.

5. Specifications

VOLTAGE

Three phase line to line: 920 VRMS maximum.

Phase voltage: 630 VRMS maximum.

AMPERES

Maximum continuous line current per phase:

- 100 amperes continuous
- 200 amps for 6 seconds
- 500 amps for 2 seconds

Maximum reading capability is 105 amperes.

METER LOAD COMPENSATION

Each current range extracts 100 millivolts from the load potential at full scale. Voltage is measured on the load side, therefore no compensation is required.

The potential measuring circuit (burden) is a fixed resistance drawing approximately 1/2 milliampere at a line potential of 920 volts. Therefore potential load (burden) is insignificant.

RESOLUTION

Basic resolution of all parameters is 1:65535 = 16 bit (binary) precision.

AMPERES DISPLAY: 5.0 Amp Range: ±.001 amps 25.0 Amp Range >>9.999 amps: ±.01 amps. 100.0 Amp Range >>99.99 amps: ±1 amps.

VOLTS DISPLAY: All Volts Ranges <<10V: ±.001 volts. – – – – – – >>10V<<100V: ±.01 volts.

>>100V: ±.1 volts.

POWER DISPLAY W/KW: Range dependant – .01%.

GPIB A,V & P:

Identical to display resolution.

AUTOZERO

If the A, V, P Reading is << .1% FS of Rng., the value is set to zero. To disable, refer to DIGIT TEST in Chapter 8.

DATA ACQUISITION RATE

ANALOG: V A signals require AC conversion to analog according to the formula: Since Watts = Instantaneous $EI\cos\theta$, active filtering is required, resulting in a Time Constant.

For a stepped input 0 to F.S. any range:

Volts and Amps signal TC=60 milliseconds.

Watts signal TC=120 milliseconds.

Where: TC=.63 of final value.

DIGITAL:

Integration period		= 0.10 seconds
Display		= 2.0 reading/sec.
GPIB:	Synchronized	= 0.1 sec/reading.
	Not synchronized	= .04 to .07 sec/reading.

ACCURACY

The following accuracy specifications are valid under the conditions of:

Ambient Temperature (room) 72°F ±10°F.

Waveform distortion <<8:1 crest factor.

Power factor 0.1 to 1.0 lead or lag.

Frequency << 4KHz.*

REF: ANSI specification – C39.6

Phase Voltage:

E = ±(0.2% of reading + 0.2% of range)<%0>

Line Amperes:

I = ±(0.22% of reading + 0.25% of range)

Power (W or KW):

P = ±(0.2% of reading + 0.3% of VA range)

PF = ±(VA error±W error)

Temperature Coefficient = ±(.008%/°C max. of range)

Note: .004% is typical.

*Cos θ error 4Min/KHz, 4KHz to 15KHz.

6. GPIB Data Acquisition

GPIB (IEEE 488)

When installing the GPIB cable, the PA should be OFF. This cable is normally supplied with the computer interface card. It is also available from Magtrol Inc., most electronic distributors or Hewlett Packard Inc.

GPIB COMPUTER INSTALLATION

A GPIB interface, requires an interface card installed in the host computer with the driver software made resident on disk. There are several manufacturers for these products – Magtrol has good experience with National Instruments™ Corp. GPIB PC2A®, for IBM® or compatible PCs.

SOFTWARE INSTALLATION

There are a number of formatting and initialization questions to be answered the first time that the GPIB interface control software is installed in the computer. You may obtain assistance in the installation and formatting procedure from Magtrol – ask for GPIB software assistance.

All GPIB data acquisition systems require the use of termination characters to signal conclusion of a data exchange. The PA uses the Hewlett Packard HPIB™ standard ASCII termination characters "Carriage Return (CR) Line Feed (LF)," in that order. On a read cycle, the PA looks for the CR LF to signal completion of an instruction, and transmits these characters upon conclusion of a data write cycle.

PRIMARY ADDRESS

All instruments serviced on the bus have a separate primary address code. The factory setting for the 4614B, is fourteen (14). If you wish to change the code; on the rear panel above the GPIB connector, there is an opening providing access to the code selection switch. The chart may help in selecting the switch combination for the address that you want. Switch segment identification resulted in the binary code notation reversed from the normal convention. The MSB is to the right.

Some PC interfaces (National GPIB PC2A) will access 0 to 15 (4 Bit) primary address numbers only. Others, may access up to 31 (5 Bit) codes; even though the GPIB capability is limited to 16 instruments. The 4614B code range uses the 5 bit format. Before selecting a value greater than 15, check that your particular interface has 5 bit capability.

COMPUTER –> PA

A5, A25, A100	Amperes range selection.
V150, V300, V600	Volts range selection.
AA	Amps AUTO range ON.
VA	Volts AUTO range ON.
FULL	Sets data format to A,V and W for 3 phases.
SGL	Sets data output format = to the front panel display.

SYNC	GPIB data output rate is synchronized to 0.10 second bus output rate.
OPEN	Data output is transmitted (nearly) upon request.
SP1, SP2, SP3	Select phase 1,2 or 3 same as pushbuttons 1, 2 or 3.
SPA	Select phase all; same as pushbuttons 1,2 and 3 simultaneously depressed.
LV	Select to read line voltage.
PV	Select to read phase voltage.
KW	Select to read kilowatts.
W	Select to read (per phase) watts.
P	Select to read powerfactor.
I, IC	Averaging ON, Averaging OFF.
H, HC	Hold ON, Hold OFF.
L, LC	All front panel pushbuttons Lock out, Lock out clear.
AZ	Cancel auto zeroing function.
CT, PT	Cancel or enter data for current and/or potential transformer calibration.
RES	Reset instrument to "power up" state.

In addition to the standard instructions listed, there are special instructions for reading and writing directly to the PA memory elements. A specific program in the host computer is required. If you have a special situation where you want direct memory access, or wish to directly alter machine functions – or calibration, this can be made available. Contact Magtrol Software Assistance for more information.

PA –> COMPUTER

There are two choices for A, V and P data format. Therefore before you execute a read statement, it is necessary to instruct the PA for the data format you wish to receive. The selection is retained by the PA, becoming the default mode for subsequent data transmissions.

"SGL" Instruction

Sets the data format to a string length of 24 ASCII characters, including CR LF, duplicating the digital display. The data string is exactly:

A=nn.nnV=nnn.nW=nnnn.ncl

Where: n = any number 0 thru 9 – and "W," as shown, is for Watts. This letter changes for the mode selected, and may be "P" for Powerfactor or "K" for Kilowatts. Carriage return and line feed are shown "cl," and will not print. Leading zeros maintain the string length fixed.

"FULL" Instruction

Data for all three phases is supplied. The string is a contiguous 68 ASCII characters:

A=xx.xxV=xxx.xW=xxxx.xA=yy.yyV=yyy.yW=yyyy.yA=zz.zzV=zzz.zW=zzzz.zcl

Where, "x" is 0 thru 9 for phase 1, "y" is phase 2, "z" phase 3. This configuration transmits only amps, volts and watts. If you require LINE voltage, PF or KW these may be easily calculated from the data by the host computer using:

Data Rate

The OPEN or SYNC commands affect bus timing. – Selection is dependant upon what other instruments are on the bus, their acquisition rate, and how you wish to process data.

"OPEN" Instruction

If your data acquisition is random, or for some reason you must not wait the .1 second period, use the OPEN instruction. Data will be output nearly on command, depending upon the MPU status at the time of the request. If multiple data requests are made within the MPU integration period, (.1sec.) you will simply receive multiple transmissions of the same data. If your program is accumulating data in an array – you might want to include a routine to ignore the second of any two identical words received.

"SYNC" Instruction

The computer will be held by the PA until the integration period is up. In this mode, data will always be the result of the most recent integration period. However, if you are using another Magtrol controller that is also operating at a 0.1 second acquisition rate – like the Model 4629B – the two instruments should be synchronized to avoid a timing conflict where one instrument may temporarily blank the other. This is easily accomplished by the following technique:

Output any instruction, except "RES" – to each of the instruments – only suppress the CR and LF termination characters. You now have both instruments "hung up" at fixed program locations, waiting for the CR LF. Then, output only the CR LF characters to both instruments in quick successive statements.

The instruments will slowly drift apart and not remain synchronized indefinitely. If you are accessing data in batches, consider executing this procedure just prior to each data input routine.

PROGRAMMING EXAMPLE

The sample program, sets PA in the "SYNC" mode with "FULL" data format. The CRT displays:

Amperes – summed for total three phase line.

Voltage – average three phase line.

Power – three phase kilowatts.

This example assumes National GPIB PC2A® Interface Hardware – programmed in Microsoft Quick Basic,® suitable for most any PC system operating under MS DOS®.

7. CT/PT Installation

Calibration of the 4614B has special provisions for readout compensation, that permit the installation of Current Transformers(CT) and Potential Transformers (PT). Reading compensation consists of multipliers installed into non volatile memory via the GPIB.

Standard CT's are usually rated for 5.0 Amps, however current is current; and any range on the PA should read correctly. You may install a CT alone or a CT and PT. There is no instance where you would want a PT only.

The schematics suggest connection methods for a three wire three phase system.

CT/PT DETECTION

During power up initialization the MPU interrogates that portion of memory where CT or PT compensation values reside. If a value is found, then the MPU checks to see if the recessed slide switch on the rear panel is set "IN." If both of these are true, then normal calibration values are revised to include the CT/PT multiplier. Otherwise, default calibration (standard reading) values are loaded. Neither the switch nor the compensation values are interrogated again as long as the PA remains ON. Therefore, to remove the compensation and return to standard calibration, set the switch to OUT then toggle the power switch – OFF, wait for a few seconds, then back ON.

CT/PT RATIO RANGE

The PA compensates all display parameters for any ratio of amps (CT) or volts (PT) for any value from 0.01 to a maximum of 255.

DIGITAL RANGE

After CT/PT installation, if the resulting compensated reading is in excess of the display capability – there will be no Decimal Point. The reading will be correct for four (A V) or five (W KW) most significant digits. You have a clue that the compensated value is above the display capability when the DP is missing.

If the integer is in excess of the maximum resolution of the GPIB data, the DP cannot simply be omitted since that would alter the length of the data string. – Therefore, an exclamation mark (! = ASCII 033) is substituted to the right of the least significant digit to signal unknown magnitude.

GPIB – CT/PT PROGRAMMING

The PA accepts either upper or lower case, whole numbers or decimal numbers in any numerical format.

For CT installation: CTnnncl

For PT installation: PTnnncl

Where: nnn = 0.01 to 255. "cl" denotes the carriage return – line feed termination characters.

For example:

A CT, with 250:1 ratio: CT250.cl

A PT, with 10:1 ratio: PT10.0cl

The PA will ignore any value that is out of range, ie; >>255 or<<.01. In addition, it will briefly flash "HELP" on the respective display to signal displeasure with the entry.

CHANGING/REMOVING CT/PT VALUES

To change a value, simply overwrite the existing value(s). To remove a CT or PT value – output a CT(cl) or PT(cl) only.

To eliminate both, but save the data, switch the rear panel slide switch to "OUT," toggle the power switch OFF ON. If you eliminate both CT and PT reading correction data by GPIB instruction; the unit will automatically reset, saving the necessity to switch the power OFF ON.

If both CT's and PT's have been software erased, to avoid the possibility for any future confusion, don't forget to set the rear panel switch to "OUT."

8. Calibration

GENERAL

If you wish to perform a full scale accuracy verification check, skip the section OFFSET ADJUSTMENTS.

With the PA outputs shorted, all A,V and W displays should show zero, or a very small value. If the zero input readings are greater than 0.2% of full scale range, and the unit is stable and operates normally, proceed with the OFFSET ADJUSTMENTS.

If there appears to be excessive drift, or you suspicion a component failure call Magtrol, ask for Power Analyzer servicing for instructions.

If there are line transient induced problems, resulting in display instability, refer to the section INSTABILITY – CAUSES AND SOLUTIONS in Chapter 2 – p5.

Three categories of measurement and adjustment are necessary to calibrate the PA. These are ISOLATION TEST, OFFSET balancing and SPAN adjustment. In the following, all descriptions assume proper operation when stating the result of an action.

DIGIT TEST

With the PA OFF – simultaneously depress both the HOLD and SELECT PHASE 1 push buttons. Turn the PA ON with the buttons depressed. – While maintaining the buttons IN, observe all 13 digits – all digit segments and decimal points should be ON. When released the PA operates normally, except that the AUTO ZERO function is disabled. To re enable, toggle the PA OFF – ON normally.

EQUIPMENT REQUIRED

For offset balancing the PA front panel indicators are sufficient.

For the isolation test; a "HI POT" tester or a source of 1200 Volts AC with leakage current measurement will be required.

For span calibration you must have the capability for known accurate true RMS reading of AC volts and amperes within the range of the PA. Meter calibrators are very useful for A and V, providing they have at least .05% accuracy of reading.

If you do not have a calibrator, you will need a source of precision isolated and known AC voltage and current. Please do not even think about using the common power line for this. The shock hazard is too great, and stability inadequate.

LINE INPUT ISOLATION

With the PA OFF, interconnect the output terminals according to the diagram. – Any terminal to the metal cabinet should read infinity resistance (open circuit) with an Ohmmeter.

With caution – apply a potential of 1200 VRMS 50 60 Hz between the interconnected terminals and the uninsulated aluminum side plate of the PA – for at least 10 seconds. Some leakage current will be indicated. It should be steady and not exceed 400 microamperes. This is due to approximately 850 picofarads of distributed capacity between the input circuitry and the surrounding metal cabinet – plus some capacitive coupling in the optical isolaters and PC Bd foils.

OFFSET ADJUSTMENTS

Be sure you have performed the DIGIT TEST, and have not turned the PA – OFF since that procedure. Allow the unit to stabilize for at least 1/2 hour, then remove the top cover plate.

Interconnect the rear panel terminals according to the diagram, and set up the front panel:

1. 5 Amps
2. 150 Volts
3. ON: PH. VOLTS
4. PHASE SELECT 1.
5. OFF: PH. WATTS

VOLTAGE BALANCE

On an internal cover plate, there are six, 3/8 by 5 inch, ventilation and trimpot access slots, 2 for each phase. Phase 1 are the two on the right as you face the front.

In the PHASE 1 access slot, find and rotate the trimpot identified **Vvf** slowly CCW until the VOLTS display shows a reading about 0.100.

Move (left) to the next slot and find the trimpot marked **Vbal**, and slowly adjust this to obtain a minimum (null) reading. Allow several seconds after each 1/8 turn of the pot for the reading to settle. Try to locate the mechanical center of the CW CCW positions that result in the lowest reading. When you are satisfied you have attained the lowest reading, re adjust the trimpot **Vvf** – CW until you obtain between 0.000 and a minimum value – probably around 0.020. – Leave the minimum value reading.

1. Select PHASE SELECT 2 Push Button, move to the set of access slots marked PHASE 2 and repeat the above.
2. Select PHASE SELECT 3 and repeat.

AMPS BALANCE

This is similar to volts above, except the reading will be smaller and somewhat more sensitive.

Select PHASE 1, and adjust the trimpot identified **Avf** in the PHASE 1 access slot – ccw until you read about 0.005 – on the AMPS display. Move to the next slot to your left and find the trimpot marked **Abal** – Slowly – null the value for the lowest amps reading. Try to locate the mechanical center of the cw ccw positions that result in the best null (lowest reading).

Return to the **Avf** trimpot and set an amps reading for 0.000 to 0.001 – but favor one digit. Repeat the procedure for PHASE 2 and 3.

WATTS BALANCE

Always perform the VOLTS and AMPS balancing before adjusting WATTS null.

Select PHASE 1, and adjust the trimpot identified **Wvf** – CCW until you read +0.0005 on the WATTS display. Then adjust **Wbal** for a minimum reading.

Return **Wvf** to a minimum reading or 0.0001. If you find that the reading will not go any lower than a few digits, then change the direction of rotation and readjust for a slight increase above the minimum attainable.

Repeat the procedure for PHASE 2 and 3.

Adjustment of the Adc, Vdc and Wdc trimpots will not be required. If you have questions, consult Magtrol Power Analyzer Customer Assistance.

CALIBRATION

If the calibration power source is frequency adjustable; 100 Hz is a good calibration frequency otherwise use 50 – 60Hz.

Wire the PA according to the diagram, and apply between 125 to 150 VRMS.

Set up the PA:

1. Select PHASE 1.
2. Select ON: PH. VOLTS
3. Select 150 PHASE VOLTAGE RANGE

The applied voltage will be identical for all three phases, since they are wired in parallel.

On the 2nd slot from the right (PHASE 1), find the **150v** trimpot and match the PA reading to the standard. Reduce the voltage to 10% of full scale – about 15.0 VRMS. The reading should be within ±0.15 V. If so, further compensation is unnecessary.

If the difference is >>0.15V, and if you are sure the difference is the PA and not your standard, compensate the difference by slight adjustment of **Vvf** to bring it closer – then reset the applied voltage to FS and touch up the calibration. Do not adjust Vvf too far – this is a compromise situation – Chapter 5. SPECIFICATIONS, states the basic accuracies attainable.

Repeat the above calibration for phases 2 and 3 by selecting that phase, and adjust the appropriate trimpots.

Calibration for the 300 and 600V ranges is accomplished by applying full scale voltage on each respective range, for all three phases, as above. The exception is to omit the 10% of full scale check. This is required only on the 150V range.

A good final check is to verify minimal voltage reading change – on all ranges – as you switch from one phase to another.

AMPERES CALIBRATION

1. Select PHASE 1.
2. Select AMPERES RANGE 5.0

Wire the PA according to the diagram.

Apply a known current, with a precision of at least ±.05%. Since "current is identical in each leg of a series circuit," the current will be the same in all three phases.

On the 2nd slot from the right, find the trimpot marked **5a** and match the PA reading to the standard. Reduce the value to 10% of full scale or about 0.500 Amps, and check agreement.

If the difference is >>0.005A, and you are certain the difference is the PA and not your standard, compensate the error by slight adjustment of **Avf** to trim it closer – then return to the full scale value and touch up the calibration.

Proceed, as above for PHASES 2 and 3. Then apply 25 and 100 amps – selecting the appropriate range and calibrate all three phases. On the higher current ranges omit the 10% FS check, required only on the 5.0 amp range.

When your calibration is complete, verify all ranges on all phases by applying a value and switch through phases 1,2 and 3. The readings should agree within ±2 LS digits.

WATTS CALIBRATION

Meter calibrators – perfectly satisfactory for Volts Amps above – are generally unsuitable for watts calibration. The reasons are described in the paragraph METER CALIBRATORS.

Do not proceed with the following until you are certain of the individual VOLTS AMPS calibration accuracy. Volts and amperes calibration establishes the power reading calibration on all ranges for W/KW and PF, however; there is a single adjustment, one for each phase, to set the multiplier span.

The easiest method is to use a unity power factor single phase VOLT AMP to establish a known wattage. If a non inductive lamp or ribbon heater load is used, phase shift error from minor affects from small XL or XC will be negligible. This is provided the frequency = 100Hz, and the ampere value is minimal. Therefore use a power source and load that is stable, producing 700 to 750 Watts on the 150V – 5A ranges.

Three wiring examples are shown, one for each phase. Set up the PA as follows:

1. SELECT 5A – 150 V range.
2. SELECT Phase 1.
3. SET OFF: PH. WATTS
4. SET ON: PH. VOLTS

Multiply Volts × Amps (VA) and adjust PHASE 1 – **Wcal** for a watts reading equal to that product.

Re wire the rear panel to the Phase 2 diagram,

1. SELECT Phase 2 on the front panel and repeat the above procedure, likewise for Phase 3.

If a Standard Wattmeter is used instead of the VOLT AMP method described above, calculated reading compensation will be required. – External potential or current fields, installed anywhere in the circuit, apply some load that will not be equally measured by both meters.

METER CALIBRATORS

Unless a current potential calibration source is phase controlled, specifically intended to calibrate Watts, there will be no control over the phase angle between the applied voltage and applied current. This difference is not dependant upon the calibrator only, it is dependant upon what the calibrator sees as a load form. Since the nature of the load is a factor unknown and not under control of the instrument or its manufacturer, to have predictable phase compliance, the instrument must phase align the potential to the current. Most do not.

The reason for current/potential phase shift is basic. If you wish to generate current in terms of amperes, unless there is substantial power dissipation, a low voltage source for obtaining that current is the only efficient alternative.

Consider:

Low impedance AC voltage, from a transformer and passed through the metal back panel of the 4614B – albeit non ferrous – nevertheless will have some inductive component. If you apply Ohms law formula above – using a few microhenrys, for L, R = total circuit resistance with the PA contributing only about .001 ohms, and a value for F = 60Hz; the result will be a phase shift of a few degrees. This is enough to create a measurable error in watts calibration.

Some V A calibrators have an adjustable means for controlling the phase relationship of volts to amps. This will be useful for watts calibration if the control is infinitely variable and if the operator remembers to adjust the phase control to peak the watts reading each time any electrical parameters are changed. Instruments with stepped or switched phase controls, to be useful, must be calibrated for adjustment in minutes of arc.

Of course, Ohms law applies equally to the volt amp – load – calibration method outlined above. However, with a power absorbing load, the total circuit "R" is much higher. This results in insignificant phase shift at low frequencies, providing the load reactance is minimized.

CALIBRATION PROBLEMS

If the calibration fails to achieve the results expected or you suspicion a defective part, call Magtrol and ask for Power Analyzer service. Very often either a procedural change or component replacement will satisfy the problem.

If there has been a short circuit disaster, and the unit fails the "Hi Pot" test, do not attempt to use the instrument. The only alternative is to return it to Magtrol for service.

Please do not hesitate to request assistance for any of the above.

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