SECTION I
GENERAL INFORMATION

1.1 INTRODUCTION AND DESCRIPTION

This manual describes the performance and operating features of Models 220 and 225 Digital Phase Angle Voltmeters (DPAV) together with information on calibration, maintenance, general troubleshooting and parts listing.

The primary function of the Phase Angle Voltmeter is to make the following measurements on an AC voltage:

1. TOTAL: Average of the rectified signal, including noise and harmonics (scaled in RMS).

2. FUNDamental: Fundamental voltage

3. IN-PHASE: Rectangular (vector) component of input voltage in phase with a reference input voltage of the same frequency. Polarity and magnitude of voltage is displayed.

4. QUADrature: Rectangular component of input voltage 90° out of phase with an input reference voltage. Polarity and magnitude of voltage is displayed.

5. PHASE ANGLE: The amount of phase shift in degrees by which the signal voltage leads the reference. The range is +0.0° to +359.9°.

In all measurement modes, except TOTAL, effects of noise and harmonics are rejected by an amount defined in the specifications.

A detailed breakdown of the features and options of Models 220 and 225 is provided in paragraph 1.3. The basic 220 is configured as a single frequency phase-sensitive voltmeter capable of measuring the FUNDamental, IN-PHASE and QUADrature voltages of the preselected frequency, plus broadband TOTAL mode measurements. The full complement of options can then be added as desired to satisfy individual requirements.

The Model 225 is a multi-frequency instrument with the PHASE ANGLE, REF PHASE and AUTORANGING options as standard, making it more suitable for broad general purpose applications.

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In both models of the Digital Phase Angle Voltmeter, phase angle is measured by a unique (patent pending) type of signal processing designated the TAN^{-1}GO™ angle computation. Key features and options of the instruments are:

1. 10mV to 500V scaling (see specifications for maximum input)
2. Signal autoranging
3. 4-1/2 digit display
4. Reference Level automatic gain control
5. OVERLOAD and NO SYNC warning lights
6. 20% over-ranging
7. ±45° REFERENCE OFFSET adjustment
8. REMOTE CONTROL and DATA OUTPUT
9. REFerence and SIGnal isolation
10. 30Hz to 32kHz phase-sensitive frequency range
11. DC Recorder Output

The seven segment, 1/2" high, planar Beckman Display provides an easy to read, wide viewing angle readout. Range, function and warning lights are also displayed.

The general packaging approach is planar with most circuitry on large horizontal boards. This allows for ease of maintenance and troubleshooting.

1.2 SPECIFICATIONS

The following specifications apply to North Atlantic Industries' Models 220 and 225. Where a special modification or variation is involved, the governing specifications will be either a separate specification control document, the purchase order or a supplement contained in this manual. The options contained in an instrument are identified on the rear panel nameplate. The option numbers are in paragraph 1.3.

1.2.1 SIGNAL VOLTAGE RANGE: 10mV to 1000V rms in 6 ranges. 120% over-range.

1.2.2 MAXIMUM SIGNAL INPUT: 500V rms (±400VDC max.) for non-isolated, Broadband Isolation (Option 05) and DIRECT mode in Transformer Isolation (Option 04).

Determined by "F" rating in Transformer Isolation (Option 04). 0.75F at 400Hz where F = frequency in Hz. 0VDC without external coupling capacitor.

1.2.3 REFERENCE VOLTAGE RANGE: 0.2V to 200V rms, AGC (no adjust necessary) (±50VDC max.)

1.2.4 SIGNAL AUTORANGING: Up-ranges at 120% of range. Down-ranges at 10% of range. 330 milliseconds per range change.

1.2.5 DISPLAY: Beckman Information Display, 0.55" high indicates polarity and digital reading. Illuminated window indicates unit of measurement, mode overload and no sync condition.

Voltage: 4-1/2 digits, 0.01% full range resolution

Phase: +0.0° to +359.9° phase lead. 0.1° resolution.

1.2.6 FREQUENCY RANGE: TOTAL MODE: 30Hz to 100kHz

FUNDamental, IN PHASE, QUAD and ANGLE Modes: 1, 2, 3 or 4 frequencies from 30Hz to 32kHz, ±5% bandwidth.

1.2.7 WARM-UP TIME: 2 hours for rated accuracy.

1.2.8 VOLTAGE ACCURACY:**

1.2.8.1 TOTAL Mode (Non-Isolated Mode)

	Accuracy(23°C±5°C)	Temp. Coef.(0-18°C,28-50°C)
60Hz to 30kHz	0.25% FS	0.01%/°C
30Hz to 100kHz	0.5% FS	0.02%/°C

TOTAL MODE Accuracy (Isolated Mode Only)

	Accuracy(23°C±5°C)	Temp. Coef.(0-18°C,28-50°C)
60Hz to 10kHz	±.25% FS	0.01%/°C
30Hz to 30kHz	±.5% FS	0.02%/°C
30kHz to 100kHz	±1% FS	0.04%/°C

1.2.8.2 FUND & PHASE SENSITIVE Modes

	Accuracy(23°C±5°C)	Temp. Coef.(0-18°C,28-50°C)
30Hz to 60Hz	0.05% FS +0.1% rdg.	(.003% FS +0.01% rdg)/°C
60Hz to 1.5KHz	0.05% FS +0.07% rdg.	(.003% FS +0.005% rdg)/°C
1.5kHz to 20kHz	0.1% FS +0.15% rdg.	(.004% FS +0.012% rdg)/°C
20kHz to 32kHz	0.15% FS +0.2% rdg.	(.005% FS +0.016% rdg)/°C

1.2.9 PHASE ACCURACY (PHASE ANGLE & REF PHASE MODES)

	(Accuracy-23°C±5°C) Display	Arc Tangent*	Temp. Coef. (0-18°C,28-50°C)
30Hz to 60Hz	0.25° ±1/2LSB	0.2°	.015°/°C
60Hz to 5kHz	0.2° ±1/2LSB	0.13°	.01°/°C
5kHz to 20kHz	0.25° ±1/2LSB	0.2°	.015°/°C
20kHz to 32kHz	0.35° ±1/2LSB	0.3°	.02°/°C

* For SIGnal level above 30% FS

NOTE: For an instrument with the Angle Mode Option (01), without the Autorange Option (02), the accuracy specification increases 50% when the SIGnal level is between 10% and 30% full scale.

1.2.10 ORTHOGONALITY

	(23°C ±5°C)	Temp. Coef. (0-18°C,28-50°C)
30Hz to 60Hz	0.15°	0.01°/°C
60Hz to 5kHz	0.09°	0.007°/°C
5kHz to 20kHz	0.15°	0.01°/°C
20kHz to 32kHz	0.2°	0.015°/°C

1.2.11 HARMONIC REJECTION

Fundamental & Phase-Sensitive Modes: 2nd and 3rd harmonic is 40db to 70db dependant on frequency. All other harmonics will vary with frequency and harmonic order.

**Noise & Offset

Accuracy at zero input, in the voltage measuremnet modes, is defined as the ___% FS statement in the various specifications. Total Mode, 10mV range, noise specification is 35uV.

1.2.12 **COMMON MODE REJECTION - Broadband Isolation (10mV Range)

Source Impedance	In-Phase 0Ω	In-Phase 100Ω	Quad 0Ω	Quad 100Ω
30Hz to 5KHz (min.)	126db	110db	126db	87db
5KHz to 32KHz (min.)	100db	92db	106db	71db
400Hz (typ.)	132db	126db	132db	114db

300V rms maximum common-mode voltage. Source impedance in signal high lead.

1.2.13 COMMON MODE REJECTION - Transformer Isolation

400Hz 97db min. (zero source impedance)
88db min. (1KΩ source impedance)

1.2.14 SIGNAL INPUT IMPEDANCE:

Transformer Isolation: 400KΩ at 400Hz (0.75F max. input volt.)

Broadband Isolation: 10MΩ shunted typically by 75pf (140pf with Option 07 or 08)

Non Isolated Input: 10MΩ shunted by typically 60pf (125pf with Option 07 or 08)

1.2.15 REFERENCE INPUT IMPEDANCE:

500KΩ shunted by typically 25pf (71pf with Option 07 or 08)

1.2.16 RESPONSE TIME TO RATED ACCURACY:

Phase-Sensitive and Angle Modes: Typical, 1.5 seconds
Maximum, 6 seconds

TOTAL Mode: Typical, 1.5 seconds
Maximum, 10 seconds

The maximum response time occurs under worst case conditions of mode selection, input overload and autoranging.

1.2.17 REMOTE CONTROL/DIGITAL OUTPUT (Option 03)

Remote control input and digital outputs are interfaced at rear panel connectors J1 and J2 respectively.

Positive logic is DTL, TTL compatible and in static parallel form.

1.2.17.1 Signal Description

Remote Control Inputs: Low ("0") = 0V to +0.4V
(-1.5mA maximum)
High ("1") = +2.4V to +5.5V

**Rejection is minimal at upper end of frequency band and is generally higher at lower frequencies.

1.2.17.2 Digital Outputs

Low ("0") = 0V to 0.5V, 12mA maximum sink current
High ("1") = +2.4V to +5V, 6kΩ source resistance

1.2.17.3 MODE TRUTH TABLE

	Remote Control (J1) Pin			Digital Output (J2) Pin		
	5	6	7	37	36	25
TOTAL	0	0	1	0	0	1
FUND	0	1	0	0	1	0
IN-PHASE	0	1	1	0	1	1
QUAD	1	0	0	1	0	0
PHASE ANGLE	1	0	1	1	0	1
	J1 Pin 1			J2 Pin 17		
REF OFFSET	1			1		

1.2.17.4 RANGE TRUTH TABLE

	Remote Control (J1) Pin			Digital Output (J2) Pin		
	2	3	4	19	18	16
10mV	0	0	0	0	0	0
100mV	0	0	1	0	0	1
1000mV	0	1	1	0	1	1
10V	1	0	0	1	0	0
100V	1	0	1	1	0	1
1000V	1	1	1	1	1	1
Auto	1	1	0			

1.2.17.5 FREQUENCY TRUTH TABLE

	Remote Control (J1) Pin		Digital Output (J2) Pin	
	8	15	35	34
F1	0	0	0	0
F2	0	1	0	1
F3	1	0	1	0
F4	1	1	1	1

1.2.17.6 DATA OUTPUT (BCD) J2

	Pin 33		Pin 13	
Polarity +:	1	Over-range 1:	1	
-:	0			

	Most Sig. Digit				Next M.S.D.				Next L.S.D.				Least S.D.			
	8	4	2	1	8	4	2	1	8	4	2	1	8	4	2	1
J2 Pin:	12	10	9	8	7	6	5	4	1	2	3	24	23	22	21	20

1.2.16.7 OVERLOAD FLAG — J2-15

Signal Overloaded: 1 (pulsing)

NO SYNC FLAG — J2-14

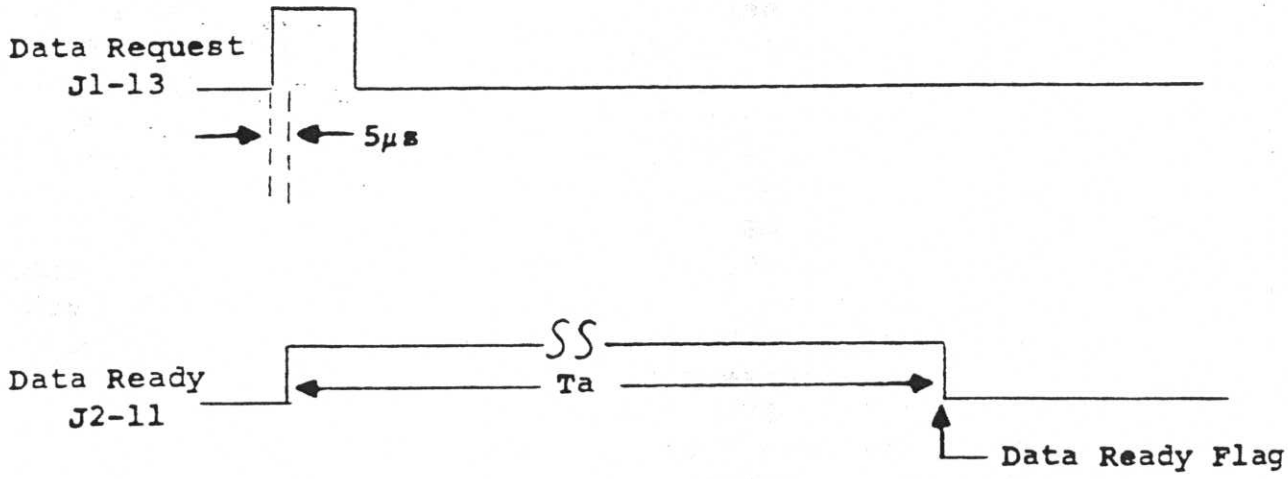
Out of Sync: 1

1.2.16.8 DATA REQUEST/READY

Data Request Pulse: Logic "1" for from 25μs to 1 sec. duration.

Data Ready: Logic "1" pulse whose leading edge trails Data Request leading edge by approximately 5μs; trailing edge to logic "0" is the Data Ready flag. The duration is a function of state of system, i.e., whether it is ranging, overloaded, out of sync.

TIMING DIAGRAM



Where the unit is not ranging, or overloaded or out of sync, Ta is approximately 2.5 seconds.

If, after a Data Request pulse, the unit is ranging, out of sync or overloaded, the Data Ready flag will occur 2.5 seconds after the unit reaches a stable operating condition.

Where the unit is in TOTAL mode and is overloaded after Data Request, the Data Ready flag will occur approximately 6 seconds after unit comes out of overload.

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1.2.17.9 CONNECTOR WIRING

Remote Control (J1)

Pin 1	REF OFFSET	Pin 9	Ground
2	Range Remote Control	10	Spares
3		11	
4		12	
5	Mode Remote Control	13	Data Request
6		14	+5V
7		15	FREQ SELECT
8	FREQ SELECT		

Digital Outputs (J2)

Pin 1	"8" of next LSD	Pin 20	"1" of LSD
2	"4" of next LSD	21	"2" of LSD
3	"2" of next LSD	22	"4" of LSD
4	"1" of next MSD	23	"8" of LSD
5	"2" of next MSD	24	"1" of next LSD
6	"4" of next MSD	25	Mode Output
7	"8" of next MSD	26-32	Spares
8	"1" of MSD	33	Polarity
9	"2" of MSD	34	FREQ SELECT Output
10	"4" of MSD	35	FREQ SELECT Output
11	DATA READY	36	Mode Output
12	"8" of MSD	37	Mode Output
13	Over-range Digit		
14	OUT OF SYNC Flag		
15	Overload Flag		
16	Range Output		
17	REF OFFSET		
18	Range Output		
19	Range Output		

1.2.18 DC RECORDER OUTPUTS (OPTION 06)

IN-PHASE and QUADrature DC outputs are available at rear panel. TOTAL and FUNDamental DC voltages appear at IN-PHASE terminals when unit is in appropriate mode. Low terminal is instrument circuit ground.

Full Scale Output: ±8.75V ±5%
Output Impedance: 2kΩ
Linearity and Stability: Same as specification for TOTAL, FUND, IN-PHASE and QUAD modes.

1.2.19 MECHANICAL SPECIFICATIONS

Size:	Panel is 5-7/32" x 19"
	Depth behind panel: 15"
	Width behind panel: 16-3/4"
Weight:	30 lbs. net, 35 lbs. shipping
Mounting:	Rack or bench mounted
Front Panel Paint:	Semi-Gloss Gray #26280 (Dress Panel) #26132 (Sub-Panel)
Line Cord:	6' long with ground pin
Front Panel Input:	Inputs are standard, 5-way binding posts, spaced on 3/4" centers

Specifications subject to change without notice

1.3 OPTIONS AND FEATURES

1.3.1 Tabulation

STANDARD & OPTIONAL FEATURES	MODEL 220	MODEL 225
TOTAL, FUNDamental, IN-PHASE & QUADRATURE Voltage Modes and Reference Isolation	Included	Included
Phase-Sensitive Frequencies Included	1	2
Optional Frequencies	N/A	3rd or 4th
ANGLE MODE & ±45° PHASE OFFSET	Option 01	Included
Auto Ranging	Option 02	Included
Remote Control & Digital Output	Option 03	Option 03
Transformer Isolation (Signal)	Option 04	N/A
Broadband Isolation (Signal)	Option 05	Option 05
DC Recorder Output (VOLTAGE Modes Only)	Option 06	Option 06
Rear Input Connectors (Signal & Reference) MS Type: / Terminal Strips:	Option 07 / Option 08	Option 07 / Option 08
Special Custom Variation (Contact Factory)	Option 09	Option 09
Rack Mount Adapter & Ribbon Cable Removal Tool	Included	Included
Ratio Option	See Section IX	
Null Meter	Option 10	Option 10