INFRATEK

305A VECTOR WATTMETER

OPERATING MANUAL

CONTENTS

1. INTRODUCING THE INFRATEK 305A VECTOR WATTMETER

The Infratek 305A Vector Wattmeter is designed for bench-top, field service, and system applications. The 2x40 character vacuum fluorescent display allows 8 measured quantities, range indications, and status indications to be displayed at the same time (e.g. 3-phase currents and average current, and 3-phase voltages and average voltage).
The 305A Vector Wattmeter is available in single phase-, 2-phase-, and 3-phase versions. The 3-phase instrument measures simultaneously 144 electrical quantities. In spite of the many measurement data, the 305A is simple to operate.
A Centronics printer interface is provided to print desired measurement data.
With the (optional) IEEE-488 computer interface the instrument is fully programmable for use on the IEEE standard 488.1 interface bus (1987).

1.1. OPTIONS

Fifteen options are available. These options can be installed in the wattmeter at the factory or by the customer on site. Options 10, 11, 13, and 14 require factory installation.

- Option 01: The IEEE-488 Interface provides full programmability.

- Option 02: The RS-232 interface provides full programmability, and uses where ever possible the same command set as the IEEE-488 interface.

- Option 03: These low current plug-ins provide the 305A with current ranges 0-25mA, 0-50mA, 0-100mA, 0-200mA, 0-400mA, and 0-800mA for the 0-800mA plug-in. The ranges for the 0-8A are from 250mA to 8A and for the 16A plug-in from 1A to 32A.

- Option 04: This current plug-in provides the current ranges 0-5A, 0-10A, 0-20A, 0-40A. For larger currents of short duration two additional ranges 0-80A, and 0-160A are provided.

CAUTION: The 5 Milliohm measuring resistore is not protected and may be damaged by extreme thermal stress.

- Option 05: The current plug-in provides additional isolation for measurements on frequency inverters. The slew rate of the common mode signals may be as large as 20kV per micro-second. The ranges are 0-1A, 0-2A, 0-4A, 0-8A, 0-16A and 0-32A. The frequency range is DC to 10kHz. Additional dc offset ±30mA.

- Option 06: The current plug-in is similar to Option 05. The ranges are 0-2.5A, 0-5A, 0-10A, 0-20A, 0-40A, and 0-80A. The frequency range is DC-20kHz.

- Option 07: The high current plug-in provides current ranges 0-25A, 0-50A, 0-100A, 0-200A, 0-400A, and 0-800A. The broad band transformer (DC-10kHz) is mounted in a plastic case 200 x 120 x 76mm and connected to the 305A by a 2m cable. The current conductor is pulled through a 35mm hole.

- Option 08: The plug-in for external shunt voltages adapts the shunt voltage to the 305A. The ranges are 25mV, 50mV, 100mV, 200mV, 400mV, and 800mV.

- Option 10: The high voltage plug-in provides voltage measurements up to 16000V. The ranges are: 0-2000V, 0-4000V, 0-8000V, and 0-16000V. Factory installation is required.

- Option 11: The analog output provides 17 signals for viewing or monitoring. The inrush current and inrush power of a transient state can be recorded. The following signals are available: current and voltage wave form of each phase, rms current and rms voltage of each phase, power of each phase, and instantaneous power of each phase (rms current of phase 3 is not available).

- Option 12: The programmable analog output provides 4 signals for xy-recording. The desired output can be programmed. The outputs are synchroneously updated with the display.

- Option 13: This option provides line-to-line rms voltage and rectified mean voltage measurement as well as neutral current- and neutral voltage measurement. The ranges for the line-to-line voltage is 1.732 times the selected wattmeter voltage ranges.

- Option 14: This option provides up to 6 DC input signals and up to 2 frequency input signals. These signals can be displayed or read via IEEE-488 interface.

- Option 15: Current clamps for AC and AC+DC.

1.3. WATTMETER SAFETY

Before using the Vector Wattmeter, read the following safety information carefully. In this manual **"WARNING"** is reserved for conditions that pose hazards to the user; **"CAUTION"** is reserved for conditions that may damage your wattmeter.

- Avoid working alone.
- Follow all safety procedures for equipment being tested.
- Inspect the test leads for damaged insulation.
- Be sure the wattmeter is in good operating condition.
- To avoid electrical shock, use caution when working above 30V dc or rms.
- Disconnect the live test leads before disconnecting the common test leads.
- When making a current- or power measurement, turn the circuit power off before connecting the wattmeter in the circuit.
- Switching on inductive loads means large inrush currents. Take precautions to avoid overloading the current channels by shorting the start-up currents accross the current inputs.
- Switching off inductive loads or switching on rotating loads means large voltages or extremely fast changing voltages on the wattmeter input terminals. Such conditions may damage the wattmeter and are potentially hazardous.
- Check plug-in fuse before measuring transformer secondary or motor winding current. An open fuse may allow high voltage build-up, which is potentially hazardous.

1.4. FEATURES OF THE 305A VECTOR WATTMETER

The 305A Vector Wattmeter is an easy to use precision instrument to simultaneously measure 144 electrical quantities. It is wide band, DC-800kHz, and is available as single-phase, two-phase, and three-phase model.
The touch of a button gives direct readout of currrent, voltage, power, apparent power, reactive power, impedance, and energy. The 305A determines harmonic current and voltage. Power is available in vectorial form for harmonics 1 through 59.
Furthermore, the 305A Vector Wattmeter complies with the IEC555-2 / EN60555-2 recommendations for harmonic current measurements in electrical equipment.

- Wide band width: DC-800kHz
- 0.1 % basic accuracy
- Simultaneous harmonic analysis of current, voltage, power, apparent power, reactive power, power factor, and impedance up to the 59th harmonic.
- Performs harmonic current measurements according to IEC555-2.
- The 305A Vector Wattmeter is available as single-phase, 2-phase, and 3-phase model.
- Galvanic isolation between all inputs.
- Wide input range on voltage, 7.5V-960V; up to 16'000V with option.
- Exeptionally wide input range on current (25mA-800A), including DC.
- Performs automatic analysis of a system under load. For a selected range of harmonics the 305A determines current, voltage, power, apparent power, reactive power, and impedance.
- Background energy computation of Wh, VAh, Varh, Ah on each phase and total. Positive and negative energy is accumulated separately.
- Full system capabilities: Centronics printer output is standard, IEEE-488, RS232, 17 hard wired recorder output signals and 4 programmable outputs are options.
- Line-to-line rms- and rectified mean voltage and neutral current measurement capabilities (option).
- Yields total phase information in a three phase system.
- Transformer test versions and motor test versions available.
- Up to 8 inputs from external transducers (AC, DC, frequency, etc.).
- Menu-controlled programming functions.
- Versatile VF-display to simultaneously display 8 measured values, the selected ranges, and the harmonic number.

1.5. COMPREHENSIVE BASIC MEASUREMENTS

POWER, APPARENT POWER
Displays total power (including harmonics) and total apparent power of phase 1, 2, 3, and sum values.
Toggles to display % of fundamental power to total power and % of fundamental apparent power to total apparent power.

RMS CURRENT, RMS VOLTAGE
Displays rms current and rms voltage of phase 1, 2, 3, and average values.
Toggles to display % of fundamental current to total current and % of fundamental voltage to total voltage. (In Analyze mode total harmonic distortion THD in % is displayed)

REACTIVE POWER, POWER FACTOR
Displays reactive power (positive or negative) and power factor of phase 1, 2, 3, and sum and average value, respectively.
Toggles to display % of fundamental reactive power to total reactive power and % of fundamental power factor to power factor of total.

MEAN VALUE
Displays DC component of current and voltage of phase 1, 2, 3, and average value.

CURRENT PEAK, VOLTAGE PEAK
Displays repetetive peak current and peak voltage of phase 1, 2, 3, and average values. When programmed for peak hold the maximum peak value of inrush current is displayed.
Toggles to display current crest factor and voltage crest factor (peak value /rms value).

RECTIFIED MEAN
Displays rectified mean current and rectified mean voltage of phase 1, 2, 3, and average value.
Toggles to display current crest factor and voltage crest factor (rms value/rectified mean value).

IMPEDANCE, PHASE, FREQUENCY
Displays magnitude of impedance and associated phase angle for phase 1, 2, and 3. The last value of second display line is the frequency of the fundamental.
Toggles to display the phase angle between the 3 voltages. Total phase information in a three phase system is therefore available.

ENERGY Wh, APPARENT ENERGY VAh
Displays positive or negative energy and apparent energy of phase 1, 2, 3, and sum value. Unless deactivated, the integration is always in progress.
Toggles to display positive or negative energy. When total power is positive, positive energy is accumulated. When total power is negative, negative energy is accumulated.

REACTIVE ENERGY VARh, CHARGE Ah
Displays reactive energy or charge (summation of rectified mean current) of phase 1, 2, 3, and sum value. Unless deactivated, the integration is always in progress.
Toggles to display accumulated values when total power is negative (same decision criteria as used for Wh computation.

1.6. COMPREHENSIVE HARMONIC ANALYSIS

HARMONICS
Harmonic analysis is active when "HARM 1" is selected. Toggles between "HARM 1" and "HARM OFF".

HARMONIC UP
Selects higher harmonic number
1 through 59

HARMONIC DOWN
Selects lower harmonic number
59 through 1

HARMONIC POWER
Displays harmonic power and harmonic apparent power of phase 1, 2, 3, and sum value of the selected harmonic number.
Toggles to display % of harmonic power to total power and % of harmonic apparent power to total apparent power.

NOTE

Total power or total apparent power in this context means broad band values, including all harmonics.

HARMONIC CURRENT, HARMONIC VOLTAGE
Displays harmonic rms current and harmonic rms voltage of phase 1, 2, 3, and average values of the selected harmonic number.
Toggles to display % of harmonic content to total rms value (current and voltage). The phase angle between harmonic voltage and harmonic current can be viewed by pressing Z/Phi.

HARMONIC REACTIVE POWER, HARMONIC POWER FACTOR
Displays harmonic reactive power and power factor of phase 1, 2, 3, sum value and average power factor of selected harmonic number.
Toggles to display % of harmonic reactive power to total reactive power and % of harmonic power factor to power factor of total.

IMPEDANCE AT HARMONIC, FUNDAMENTAL FREQUENCY
Displays system impedance Vn/An (magnitude and phase) of phase 1, 2, 3 at the selected harmonic number. The fourth value on the second display line is the frequency of the harmonic.

NOTE

All other display controls maintain their original function and are not affected by the "HARM ON/OFF" selection.

HARMONIC CURRENT ANALYSIS ACCORDING TO IEC555-2/EN60-555-2

PROGRAMMING
Enter menu "AVERAGE" and select IEC *.

HARMONIC CURRENT (IEC555-2)
Select harmonic number. 305A Vector Wattmeter displays harmonic current according to IEC555-2 and harmonic voltage of phase 1, 2, 3, and average values.
Toggles to display % of harmonic content.

SYSTEM ANALYSIS

PROGRAMMING
Enter menu "ANALYZE". Select ON *, BEG X , END Y , X= start harmonic number, Y = end harmonic number.
In the standard "RUN"-mode the 305A operates as is. When the system is ready to be analyzed, select the start harmonic number and bring the 305A into the "TRIG"-mode, then press "TRIG" again. The 305A Vector Wattmeter will now scan through the programmed range of harmonics and determines harmonic current, voltage, power, apparent power, reactive power in % of total and system impedance in Ohms including phase angle.
While the 305A is performing computations its display remains active and is updated when new data is available. When finished the "HOLD" mode is entered and all data can be viewed on the display printed on the printer, or transfered to a controller via IEEE or RS232.

1.7. 305A CONTROL FUNCTIONS

COUPLING
AC coupling is normally selected. The 305A performs computation on all signals in the frequency range 0.7Hz to 800kHz. For mixed signals containing dc components use AC+DC.

RANGING
The 305A performs automatic ranging for both voltage and current over the whole range of plug-ins available.
Manual ranging is used to avoid recurring range overload when signals are varying. Manual ranging is also used for recording transient events.
In both ranging modes the selected ranges are shown to the right of the top display line.

A-OVERLOAD, UP-RANGE
LED lights up when current peak overload or current range overload occurs (any phase). In manual ranging this key selects the next higher current range.

A-DOWN-RANGE
LED lights up when current underrange occurs.
In manual ranging this key selects the next lower current range.

V-OVERLOAD, UP-RANGE
LED lights up when voltage peak overload or voltage range overload occurs (any phase).
In manual ranging this key selects the next higher voltage range.

V-DOWN-RANGE
LED lights up when voltage underange occurs.
In manual ranging this key selects the next lower voltage range.

3-WATTMETER, 2-WATTMETER
Select "3W" for the 305A in a three-wattmeter hook-up. Inputs are 3 line voltages and 3 line currents (system with neutral or artifical neutral). Select "2W" for the 305A in a two-wattmeter hook-up. Inputs are 2 line-to-line voltages and 2 line-to-line currents. Computations are adapted accordingly.

LINE-TO-LINE MEASUREMENTS (OPTION)
Selects line-to-line rms and rectified mean voltages. Also displays neutral current and neutral voltage. The line-to-line values are derived from the input voltages on the 305A.

TRIGGER, LOW PASS FILTER

This key selects triggered measurement, LED "TRIG" is on. ON pressing the TRIG-key a single measurement cycle or a system analysis is initiated to compute all properties except energies. To leave the triggered modus select **HOLD** and press **TRIG.**

LED "LP" indicates that the input low pass filters are on (fg = 1.6kHz, voltage and current).

HOLD

This key terminates continuous measurements. LED indicates the HOLD status. All 144 measured values can be viewed on the display or can be printed when the printer interface is set accordingly.

Voltage rms Vr rect. mean Vt mean V= peak Vp	Ranges, 9 ranges 1-2-4-sequence 7.5V, 15V, ..., 240V, 480V, 960V High Voltage Option: 2000V, 4000V, 8000V, 16000V Option for enhanced common mode rejection: 60V, 120V, 240V, 480V		1000Vrms max. 1400Vpk Scaling required Scaling required
	Frequency range Low pass filter on		DC, 1Hz-800kHz DC, 1Hz-1kHz
	Crest Factor		5:1 at 50 % full scale
	Input Impedance		1 Megohm
	Common Mode Rejection Ratio Enhanced Input	50Hz 100kHz 100kHz	120dB 82dB 90dB
	Accuracy 23° ±3°K; Vr, V=, Vt 0Hz, 1Hz-15Hz ±(0.2 % rdg + 0.2 % range) 16Hz -10kHz ±(0.08 % rdg + 0.09 % range) 10kHz -80kHz ±(0.2 % rdg + 0.2 % range) 80kHz -200kHz ±(0.8 % rdg + 0.15 %/10kHz rdg) 200kHz-800kHz ±(3 % rdg + 2 %/100kHz rdg), typical		Vt: 0-200kHz above 200kHz use signal level of less than 50 % full scale. 15V to 960V ranges
Current rms Ar rect. mean At mean A= peak Ap	Ranges, 6 ranges each plug-in, 1-2-4-sequence Plug-in 0.025A-0.8A / 10hm Plug-in 0.25A-8A / 0.10hm Plug-in 1A-16A / 0.02500hm Plug-in 5A-80A / 0.0050hm Plug-ins for enhanced Common Mode Rejection: Plug-in 0.5A-16A / 0.002 Ohm Plug-in 2.5A-80A / 0.002 Ohm Plug-in 25A-800A external		 Protected by fuse Protected by fuse Protected by fuse 40A max. continuous 20A max. continuous 80A max. continuous 1000A max. continuous
	Frequency range, 0.8A/8A plug-in Low pass filter on		DC, 1Hz-800kHz DC, 1Hz-1kHz
	Crest Factor		5:1 at 50 % full scale
	Common Mode Rejection Ratio Enhanced Input	50Hz 100kHz 100kHz	140dB 110dB 120dB
	Accuracy 23° ±3°K, *Ar, A=, At (plug-in 0.8A/8A/coax) 0Hz, 1Hz-15Hz ±(0.2 % rdg + 0.2 % range) 16Hz -10kHz ±(0.08 % rdg + 0.09 % range) 10kHz -50kHz ±(0.2 % rdg + 0.2 % range) 50kHz -200kHz ±(0.8 % rdg + 0.15 %/10kHz rdg) 200kHz-800kHz ±(3 % rdg + 2 %/100kHz rdg), typical		At: 0-200kHz above 200kHz use signal level of less than 50 % full scale.

Power	312 ranges corresponding to the products VxA	187.5mW to 12.8MW per phase
	Frequency range Low pass filter on	DC, 1Hz-800kHz DC, 1Hz-1kHz
	Accuracy 23° ±3°K, power factor 0 to ±1 0Hz, 1Hz-15Hz ±(0.2 % rdg + 0.3 % range) 16Hz -10kHz ±(0.1 % rdg + 0.1 % range) 10kHz -50kHz ±(0.2 % rdg + 0.4 % range) 50kHz -200kHz ±(1 % rdg + 0.4 %/10kHz range) 200kHz-800kHz add % error of current and voltage,PF=1	Plug-in 0.8A/8A/coaxial
Frequency	Ranges, triggered from I1, U1, Ext.	0-100Hz, 0-1000Hz, 0-100kHz
	Accuracy	±(0.15 % rdg + 0.15 % range)
Computed Values	Accuracy 23° ±3°K Apparent Power VA=ArVr Reactive Power Var= $\pm(VA^2 - W^2)^{1/2}$ Power Factor PF=W/VA Crest Factor CF=Ap/Ar = Vp/Vr Form Factor FF=At/Ar = Vt/Vr % Values = 100 % (Harmonic/Total Value)	Add accuracy percentage figures of values involved in computation
Energy	Accuracy 23° ±3°K; Range Energy Wh Apparent Energy VAh Reactive Energy Varh Charge Ah (rect. mean)	1mWh-99999GWh Basic accuracy percentage figures +0.1 %
Harmonic Analysis	Frequency range	DC, 8Hz-100kHz
	Range of harmonic	1-59
	Accuracy 23° ±3°K Harmonic current; 10Hz - 40Hz ±0.5 % rdg Harmonic voltage; 40Hz -400Hz ±0.3 % rdg 400Hz - 10kHz ±0.9 % rdg 10kHz-100kHz ±1.5 % rdg Harmonic phase 0-360° 10Hz - 10kHz ±0.2 % rdg + 0.2° 10kHz- 30kHz ±1 % rdg + 1° 30kHz-100kHz ±1° + 1°/10kHz Harmonic power Harmonic apparent power Add percentage figures Harmonic reactive power given for current, Harmonic power factor voltage, and phase. Harmonic impedance	
Display	VFD, 8 values + range- and harmonic indication	two line
Digital Outputs	Centronics standard	programmable
	IEEE-488, RS232	Option

Analog Output	Functions Number of Outputs Range Accuracy	A,V, Ar, Vr, W, Wm 17 0 to ±5V ±0.3 %, 0.5 % for W, typical
Inrush Current	Range (3 simultaneous currents) Accuracy	0-1000Apk ±1 %
Recorder Output	Functions Number of Outputs Range Accuracy	programmable 4 0 to ±5V ±0.2 %
External Trigger	Frequency input Integrator Start/Stop Trigger measurement	1Vp-10Vp, 0-100kHz TTL, 5V/0V TTL, 5V/0V
Power	AC, 50-400Hz Fuse	110V/220V; +20 % / -10 % 400mA/45VA
Isol. Voltage	Input-Power, Input-Case, Input-Input	3kV/50Hz/1 minute
Dimen-sions	H x W x D Weight	132 x 450 x 300mm 7.5kg

Models 305A-3S, 305A-2S, and 305A-1s measure no harmonics, no phase, and no frequency.
Reactive power is computed from $Q = (S^2 - P^2)^{1/2}$ and is always positive (as a consequence, in the two wattmeter measurement, the computation of apparent power and reactive power may yield ambiguous results).
For all measured and computed quantities the accuracy percentage figures of the standard 305A are applicable.

2. INTRODUCTION

Section 2 explains how to prepare the Vector Wattmeter for operation, discusses general operating features, and explains some common measurements.

2.1. UNPACKING AND INSPECTING THE WATTMETER

Carefully remove the instrument from its shipping container and inspect it for possible damage or missing items. If the instrument is damaged or something is missing, contact the place of purchase immediately. Save the container and packing material in case you have to return the instrument.

2.2. FRONT PANEL AND REAR PANEL

The front panel (shown in Figure 2.1) has two main elements: the two line 80 character display, and the function keys. The keys are used to select major functions, ranging operations, and function modifiers. These elements are described in detail in Section 3.
The rear panel (shown in Figure 2.2) contains the power line cord connector, the line voltage selector switch, the parallel printer port connector, the RS-232 and external input connector, the recorder output connector (option), and the IEEE-488 interface connector (option). The 3-phase wattmeter contains three plug-ins each equipped with 2 current input terminals and 2 voltage input terminals. Plug-ins for currents up to 16A also contain a slo-blo input protection fuse (1A, 8A, 16A). The 2-phase wattmeter uses only 2 plug-ins, and the single-phase wattmeter only one plug-in.

2.3. ADJUSTING THE TILT STAND

At the bottom plate of the wattmeter are four tilt stands to adjust the viewing angle for bench-top use. To adjust their position, press in one end and rotate them to a stop position.

2.4. LINE POWER

WARNING

TO AVOID SHOCK HAZARD, CONNECT THE INSTRUMENT POWER CORD TO A POWER RECEPTACLE WITH EARTH GROUND.

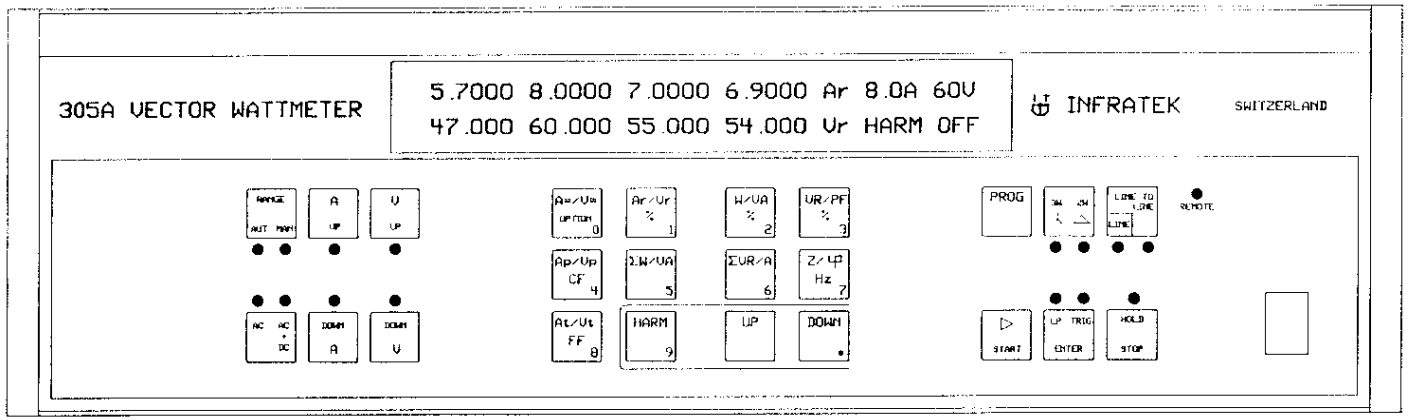

305A VECTOR WATTMETER
5.7000 8.0000 7.0000 6.9000 Ar 8.0A 60V
47.000 60.000 55.000 54.000 Vr HARM OFF
INFRATEK
SWITZERLAND
RANGE
AUT MAN
A
UP
V
UP
A=/V=
OPTION
0
Ar/Vr
%
1
W/VA
%
2
VR/PF
%
3
Ap/Vp
CF
4
ΣW/VA
5
ΣVR/A
6
Z/Φ
Hz
7
At/Vt
FF
8
HARM
9
UP
DOWN
.
PROG
REMOTE
AC
AC + DC
DOWN
A
DOWN
V
START
UP TRIG
ENTER
HOLD
STOP

Figure 2.1

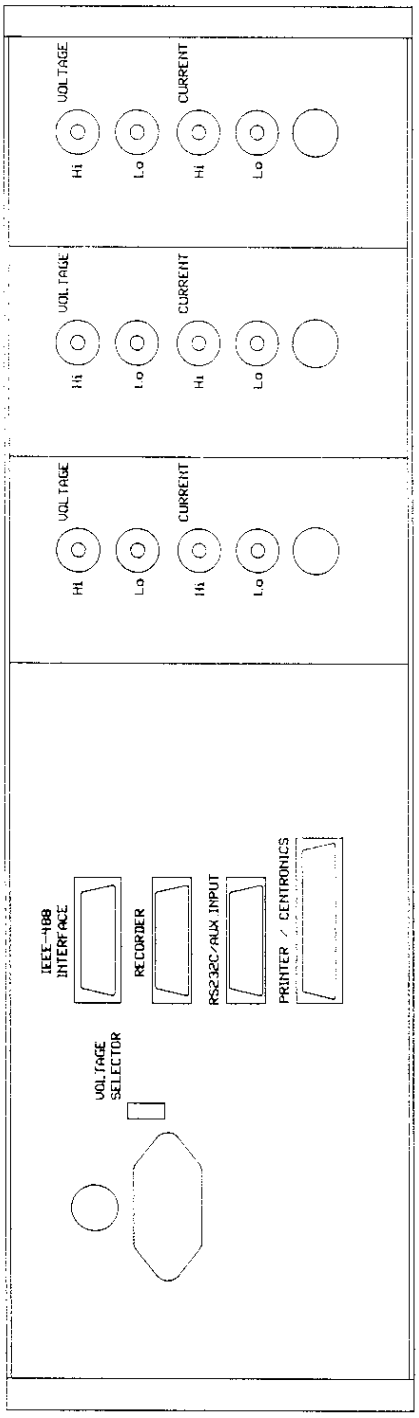

VOLTAGE
Hi
Lo
CURRENT
Hi
Lo
VOLTAGE
Hi
Lo
CURRENT
Hi
Lo
VOLTAGE
Hi
Lo
CURRENT
Hi
Lo
IEEE-488
INTERFACE
RECORDER
RS232C/AUX INPUT
PRINTER / CENTRONICS
VOLTAGE
SELECTOR

Figure 2.2

Select the rear panel line voltage selector switch for the correct line voltage. A 300mA slo-blo fuse is installed in the factory for 195V-250V operation. For 98V to 125V line voltage a 500mA slo-blo fuse is required.

2.5. TURNING THE WATTMETER ON

To turn the wattmeter on, activate the black **POWER** switch located on the lower-right of the front panel.
When the wattmeter is turned on, the display will show for about 2 seconds the current scaling factors and the voltage scaling factors stored in non-volatile memory.
After the instrument completes the power-up sequence, it assumes its power-up measurement configuration: AC-coupling, automatic ranging, harmonic measurement off (HARM OFF), display of rms current and rms voltage.

2.6. USING THE FUNCTION KEYS

The keys on the front panel select display functions and wattmeter operations. A summary of basic key operations is shown in Figure 2.1.

Keys can be used in two ways. You can:

- Press a single key to select a display function or wattmeter operation.

  Example: Press **W/VA** to select Watt and VA display.

- Press a combination of keys, one after the other.

  Example: Press **Ar/Vr** to select rms current and rms voltage display, then press **HARM** to select fundamental (HARM 1) of current and voltage, then press **UP** to select the next higher harmonic of current and voltage.

For more details on the uses of each key, refer to Section 3, "Operating the Vector Wattmeter from the front panel".

2.7. SELECTING A MEASUREMENT RANGE

Measurement ranges can be selected automatically by the wattmeter in "autorange" or manually by the user. In the autorange mode (LED AUT is on), the instrument selects the appropriate range automatically.
Pressing the RANGE-key toggels the 305A to manual ranging (LED MAN is on). To select the next higher current range press **I UP**. To select a lower current range press **I DOWN**. Similarly, the voltage ranges are selected pressing **U UP** and **U DOWN**. The selected ranges are displayed on the right of the top display line.

2.8. TAKING BASIC POWER MEASUREMENT

WARNING

READ WATTMETER SAFETY BEFORE OPERATING THIS WATTMETER.

The following procedures describe the basics of taking common power measurement operating the Vector Wattmeter from the front panel.
These procedures are provided for the user who needs to get started quickly. However, to take full advantage of your 305A, you should read the remainder of this manual carefully and completely.

WARNING

TO AVOID ELECTRICAL SHOCK OR DAMAGE TO THE VECTOR WATTMETER, DO NOT APPLY MORE THAN 1400 (PEAK) BETWEEN ANY TERMINAL AND EARTH GROUND. EXCEEDING THIS LIMIT POSES A HAZARD TO THE WATTMETER AND THE OPERATOR.
THE USER SHOULD BE WELL AWARE OF THE FACT, THAT SWITCHING OFF AN INDUCTIVE LOAD MAY GENERATE EXTREMLY FAST (UP TO 10KV/MICROSECOND) AND EXTREMLY HIGH (4-5kV) COMMON MODE VOLTAGES ON THE WATTMETER INPUT TERMINALS.

To measure current, voltage, and power in your three-phase four-wire circuit, connect the test leads as shown in Figure 2.3 and described in the following procedure:

- Turn off power in the circuit to be measured.
- Break the circuit in each phase and place a wattmeter current path (I1, I2, I3) in series with each breaking point. Connect the 3 voltage inputs between phase and neutral. V1 goes with I1, V2 with I2, and V3 with I3.
- Turn on power to the circuit. The wattmeter will select the appropriate range in the autorange mode and displays the ranges on the right of the top display line.
- Press the desired display function key and take the reading.

The top line displays, from left to right, rms current phase 1, phase 2, phase 3, and average current of the three phase currents, and the appropriate unit.
Similarly, the second line displays the three line voltages, and average line voltage. HARM OFF indicates that the values displayed are total values (fundamental + all harmonics including DC if DC-coupling is selected).

MEASURING CURRENT, VOLTAGE AND POWER IN A THREE - PHASE,

FOUR WIRE CIRCUIT USING THE 305A VECTOR WATTMETER

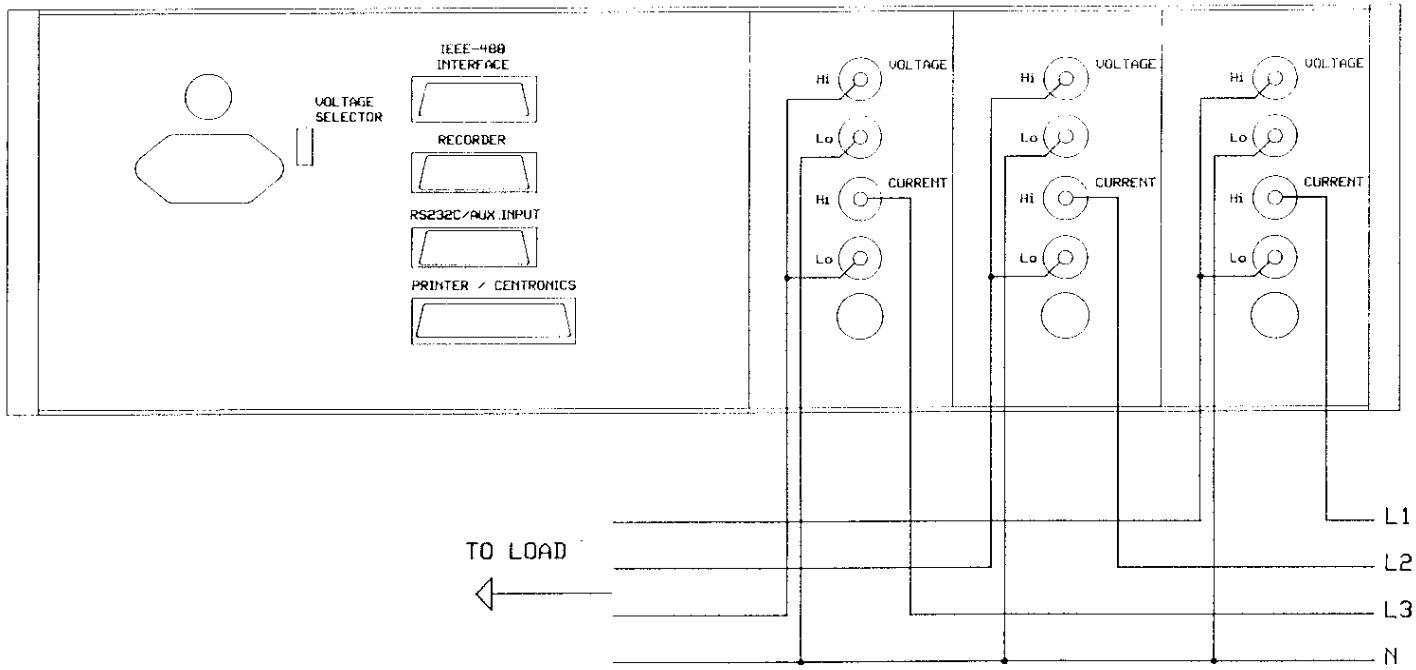


Figure 2.3

Toggles to HARM 1. Fundamental current of each phase and fundamental voltage of each phase is displayed.
Press **HARM** a second time to toggle to HARM OFF.

The top line displays, from left to right, power phase 1, phase 2, phase 3, and total power of all three phases including units (the range display is not affected by display function keys).
The second line displays apparent power (the product of rms current times rms voltage including all harmonics) of each phase and the sum value.

Toggles to HARM 1. Now the display shows fundamental power and fundamental apparent power of each phase, and total values.
Press **HARM** again to toggle to HARM OFF.

The top line displays, from left to right, reactive power of phase 1, phase 2, phase 3, and total reactive power.
A positive value means inductive reactive power, and a negative sign means capacitive reactive power.
The second display line shows power factors of each phase, and total power factor = Wtot / VAtot.

Toggles to HARM 1. Fundamental reactive power and power factor of fundamental as well as total values are displayed.

Turn off power to the circuit and disconnect the Vector Wattmeter from the tested circuit.

3. INTRODUCTION

Section 3 explains how to operate the wattmeter from the front panel. The Vector Wattmeter measures simultaneously 144 electrical quantities every measurement cycle. When the line-to-line voltage measurement option is installed 8 more values are added.
Those values not so common to every days use, will be defined in this section.

3.1. FRONT PANEL OPERATIONS

The following operations can be performed from the front panel:

- Select a display function.
- Select the manual or autorange mode.
- Select AC or DC-coupling.
- Select a voltage or current range.
- Select 3 Wattmeter or 2 Wattmeter configuration.
- Select line voltage or line-to-line voltage.
- Select triggered or hold mode.
- Select the menu controlled programming mode.
- Send a set of measurements to a printer.

These and other front panel operations are described in the remainder of Section 3.

3.2. DISPLAY

The 2 x 40 character vacuum fluorescent display (shown in Figure 3.1) indicates 8 measurement readings, measurement units, current and voltage range, and harmonic number selection.

From left to right, the first reading is from phase 1, the second from phase 2, the third from phase 3, and the fourth is either an average value or a sum value from phase 1, 2, and 3. This two-line display allows you to see 8 properties (e.g. 4 power values (W) and 4 apparent power values (VA)).
The 305A Vector Wattmeter takes all 144 readings within every reading cycle of 0.6 seconds. Only the eight selected properties are sent to the display. Selecting the HOLD mode allows you to see all 144 measured values.
When a range overload occures the range annunciator changes to **"over"**.

3.3. DISPLAY FUNCTION SELECTION

The twelve keys to select the display function are located in the centre of the front panel below the display. Section 3.4. explains and defines the display properties when the harmonic annunciator displays **"HARM OFF"**. Section 3.5. explains and defines the display properties when the harmonic annunciator displays a harmonic number 1 through 59. Press the function key shown (on the left side of the page) to display the property. Most keys toggle to a second (related) property.

3.4. DISPLAY FUNCTION SELECTION WHEN HARMONIC ANNUNCIATOR DISPLAY "HARM OFF"

When you select **"HARM OFF"** the properties described below are broad band values from 1Hz to 800kHz. If you select DC-coupling the properties also include possible DC-components.

POWER W, APPARENT POWER VA, % FUNDAMENTAL
This Function key displays power (top line mW, W, kW, GW) of phase 1, 2, 3, and total power.
The second display line shows apparent power in mVA, VA, kVA, or GVA of phase 1, 2, 3, and total apparent power.

(Def.: VA = rms current x rms voltage; incl. harmonics.)
(Def.: Total VA = (total W^2 - total Var^2)$^{1/2}$)

Pressing **W/VA** a second time toggles the display to show on the top line percentage of fundamental power to broad band power of each phase (% W). The second display line shows percentage of fundamental VA to broad band VA (% VA).

(Def: Fundamental power = UIcosx, fundamental apparent power = UI).

RMS CURRENT Ar, RMS VOLTAGE Vr, DISTORTION FACTOR
This key displays true rms current of phase 1, 2, 3, and average current computed from the three phase currents. The second display line shows true rms voltage of phase 1, 2, 3, and average voltage.
Pressing Ar/Vr a second time toggles the display to show on the top line percentage of fundamental current to broad band current of each phase (% Ar). The second display line shows percentage of fundamental voltage to broad band voltage (% Vr).
After going through a system analysis using the **ANALYZE** mode this display function will show total harmonic distortion (THD in %) for current and voltage of each phase. (See also section 3.7, Analyze).

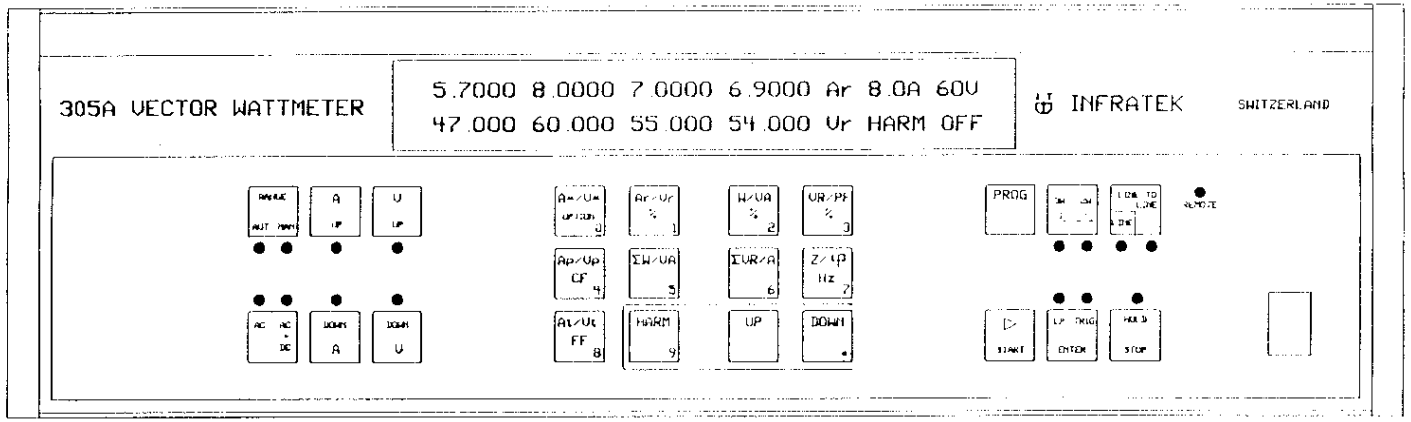

305A VECTOR WATTMETER
5.7000 8.0000 7.0000 6.9000 Ar 8.0A 60V
47.000 60.000 55.000 54.000 Vr HARM OFF
INFRATEK
SWITZERLAND
PROG
HARM
UP
DOWN

Figure 3.1

REACTIVE POWER VAR, POWER FACTOR, % FUNDAMENTAL
If the reactive power display function is selected the top line shows reactive power (including sign) of each phase and total reactive power. A positive sign indicates inductive reactive power, a negative sign indicates capacitive reactive power. The sign is derived from the phase of the fundamental component of current and voltage.

(Def.: Reactive Power = $(VA^2 - W^2)^{1/2}$; VA and W are properties including all harmonics).

The second display line shows power factor of each phase and power factor of the 3-phase system.

(Def.: PF = W/VA; Total PF = total W/total VA;
Note: Total VA = (total W^2 + total $Var^2)^{1/2}$)

The **VR/PF** key toggles to display percentage of fundamental reactive power to reactive power including harmonics. The second display line displays percentage of fundamental reactive power factor to power factor due to broad band signals.

MEAN VALUE, OPTION
When DC-coupling is active, the **A=V=** key displays mean value (DC) of the three currents, and average; and three voltages, and their average.

Pressing the key a second time the following will happen:

- The standard 305A displays the values of the rear panel dc inputs. If option is not installed meaningless values will be shown.

  The 305A motor version displays properties such as torque, speed, mechanical power, and efficiency.

- The 305A transformer version displays corrected power according to IEC.

CURRENT PEAK, VOLTAGE PEAK, CREST FACTOR
This display function shows repetetive current and voltage peaks of each phase and their average values.
The display function toggles to show current and voltage crest factors of each phase and their average values.

(Def.: Crest Factor = Peak Value /rms value)

The function can be modified to hold and display the maximum current and voltage peaks during a transient state.

RECTIFIED MEAN , FORM FACTOR
When the rectified mean display function is selected the top line shows rectified mean current of each phase and average value.
The second display line shows rectified mean voltage of each phase and their average value.
The **At/Vt** key toggles to display current and voltage form factors.

Note: For sinusoidal signal is the ratio of rms value / rectified mean value = 1.11.

MAGNITUDE OF IMPEDANCE AND PHASE, FREQUENCY
This function key displays on the top line the magnitude of impedance in Ohm (and average value) and on the second line phase angle of impedance. This phase angle is equal the phase difference between voltage and current, indicating leading or laging current. The range of phase is ±180°.
The fourth property on the second display line is the frequency of the current or the voltage. The frequency measurement is autoranging: the ranges are 0-100Hz, 0-1000Hz, and 0-100'000Hz.

POSITIVE AND NEGATIVE ENERGY, Wh AND VAh
This function key displays on the top line the accumulated energy of each phase and total value.
The second line displays accumulated apparent energy in VAh.
The key toggles to display negative accumulated energy in the same time interval. This property is usefull to measure recuperation processes. Negative energy is summed when total power becomes negative.

REACTIVE ENERGY VARh, CHARGE Ah
The top line displays the accumulated reactive energy of each phase and total value of the three phases.
The second line displays charge. The rectified mean current is summed over time. The function toggles to display the accumulated values over the time periods during which total power was negative.

3.5. DISPLAY FUNCTION SELECTION WHEN HARMONIC ANNUNCIATOR DISPLAYS "HARM 1 THROUGH 59"

When you select "HARM X" (x = 1 through 59 equals harmonic number) the properties described below are values at multiples of the fundamental frequency. The fundamental values are seen when "HARM 1" is selected (e.g. 50Hz). The second harmonic values are displayed by selecting "HARM 2" (e.g. 100Hz), etc.
Not affected by "HARM X" selection are the following display functions: rectified mean values, peak values, crest factors, form factors, energies, and charges.

HARMONICS ON / OFF
This function key activates the display of harmonic properties. The 305A Vector Wattmeter provides harmonic analysis capabilities from fundamental (HARM 1) up to the 59th harmonic for current, voltage, power, apparent power, reactive power (positive and negative), impedance, phase angle, and harmonic power factor. These values are simultaneously determined for the selected harmonic number.

HARMONIC UP
This key selects the next higher harmonic number up to the 59th.

HARMONIC DOWN
This key selects the next lower harmonic number.

HARMONIC POWER, HARMONIC APPARENT POWER
This function key displays harmonic power (top line) of phase 1, 2, 3, and total harmonic power at the selected harmonic frequency (1 through 59 times fundamental frequency). The second line displays apparent power of each phase and total apparent power at the selected harmonic frequency.
Pressing **W/VA** a second time toggles the display to show on the top line percentage of harmonic power to broad band power and on the second line percentage of harmonic apparent power to broad band apparent power.

HARMONIC CURRENT, HARMONIC VOLTAGE, IEC555-2
If the harmonic current function key is selected, the top line displays harmonic current of each phase and average harmonic current.
The second display line shows harmonic voltages. The measurement response can be modified to comply with the IEC555-2 norm for harmonic current measurement. The key toggles to display percentage of harmonic values to total values. In the Analyze mode THD (total harmonic distortion) is displayed.

HARMONIC REACTIVE POWER, HARMONIC POWER FACTOR
Selecting this function key will display reactive power at the selected harmonic frequency of each phase and total reactive power. Positive reactive power indicates an inductive load and negative reactive power indicates a capacitive load at that harmonic.
This property can be used for power factor compensation and is also valid for frequency inverter driven systems.
The second display line displays power factor of the selected harmonic.

(Def.: Power Factor = harmonic power / harmonic apparent power)

The key toggles the display to show percentage of harmonic reactive power to broad band reactive power and percentage of harmonic power factor to broad band power.

IMPEDANCE AT HARMONIC, HARMONIC FREQUENCY, PHASE BETWEEN VOLTAGES
The impedance display function shows on the first line the magnitude of impedance at the harmonic frequency of each phase. On the second line the corresponding phase angle in degrees is displayed. The fourth display value is the harmonic frequency in Hz.
When this key is pressed a second time the phase angles between the three phase voltages are displayed. First value = 1-2, second value = 2-3, and third value = 3-1.

NOTE 1

At any time the harmonic measurements can be terminated using the **HARM** key (annunciator shows "HARM OFF"). Instant display of broad band properties is obtained.

NOTE 2

When performing harmonic measurements the measurement data can be held by pressing the "HOLD"-key and be viewed on the display. The user must be aware that the following data are stored: All harmonic values of the harmonic frequency selected prior to entering "HOLD", and all broad band values (HARM OFF).

3.6. CONTROL FUNCTIONS

The control fields to the left and right of the display are control function keys to change the operating mode.

COUPLING
This key selects ac- or dc-coupling of both voltage and current signals of all channels. The 305A Vector Wattmeter performs computation on all signals in the frequency range dc to 800kHz if dc-coupling is selected. We recommend to always check dc components by selecting dc-coupling and the display function **A=/V=**.
When no dc components are present it is sufficient to select ac-coupling. The 305A performs computation on all signals in the frequency range 0.7Hz to 800kHz.
If you are measuring power on square wave signals at 50Hz or less you should use dc-coupling. DC-coupling avoids signal droop and consequently avoids erreneous measurements.

RANGING
In automatic ranging the 305A selects the current and voltage ranges for all three phases automatically based on display and peak values. This includes all types of plug-ins available.
Manual ranging may be required for signals from frequency inverters with dc components. Manual ranging is also used to avoid recurring range overloads when signals are varying or for recording transient events.
Finally, in peak-hold-mode manual ranging should also be applied. In both ranging modes the current and voltage ranges are shown to the right of the top display line. The indicated ranges are valid for all three channels.
It is possible to use three different current plug-in for the three channels. The correction factors for current are read at start-up. The units displayed (mA/A; mW, W, ect.) are derived from the current range of phase I.

RANGE UP, A-OVERLOAD (MANUAL RANGING SELECTED)
When a current overload (peak or range) occurs the LED lights up and the range annunciator shows "over". This overload may exist in any channel. There is no indication which channel is suffering an overload unless the display value gives the pertinent information. Pressing the **A UP** key will select the next higher current range for all three channels.

RANGE DOWN CURRENT
When the signal level falls below approximately 40 % of the range the underrange LED lights up.
In manual ranging mode this key selects the next lower current range of the three channels.

RANGE UP, VOLTAGE OVERLOAD
When a voltage overload occurs the LED lights up and the range annunciator shows "over". An overload condition may occure in any channel. This key selects the next higher voltage range.

RANGE DOWN VOLTAGE
When the signal level falls below 40 % of the selected voltage range the LED lights up.
This key selects the next lower voltage range.

NOTE

The 305A Vector Wattmeter exhibits excellent range overlapping. To select the optimal ranges for power measurements is not all that critical to achieve high precision.

3-WATTMETER-, 2-WATTMETER CONFIGURATION

This function key toggles between the 3-wattmeter configuration and the 2-wattmeter configuration (Aron).

The 3-wattmeter configuration requires 3 line voltages and 3 line currents. The line voltages are measured against neutral or an artifical neutral formed by the three 1 Megohm input resistors of the voltage inputs. The 3-wattmeter configuration is by far the best to get most information from your measurements. Averages and sum values are computed from all three phase values.

The 2-wattmeter configuration requires 2 line-to-line voltage and 2 line currents. Averages and sum values are computed from channel 1 and 2. The third channel can be used for other measurements. For measurements on frequency inverter driven systems the 2-wattmeter configuration should not be used. Common mode signals up to 10kV per micro seconds at the voltage and the current inputs occur.

LINE AND LINE-TO-LINE RMS AND RECTIFIED MEAN VOLTAGE, NEUTRAL CURRENT NEUTRAL VOLTAGE; HARMONIC OFF

When the line-to-line option is installed this control key will display three line-to-line rms voltages and the neutral voltage on the top display line. The line-to-line voltages are as follows: first value = voltage L1- voltage L2, second value = voltage L2 - voltage L3, and third value = voltage L3 - voltage L1.

The line-to-line display function is active only when the 3-wattmeter configuration is selected, that is, the wattmeter input voltages must be line values. The fourth display value on the top line is the neutral voltage V = V1 + V2 + V3.

The second display line shows the rectified mean values of the line-to-line voltages. The fourth property on the second display line is the neutral current = sum of all three phase currents. The displayed figure is in Ampere and the units are not shown.

TRIGGER MODE, LOW PASS FILTER ANNUNCIATOR

This key activates the trigger mode (LED lighted). Every time this control key is pressed a new measurement of all basic properties (except energies) is taken. After measurement all measured values can be viewed or printed. Harmonic off or on (Harm 1 through 59) can be used.

A triggered measurement with "HARM OFF" or "HARM 1" will measure all basis properties including the complete set of fundamental values (HARM 1: Ar, Vr, W, VA, Var, Z, and phase). After measurement "HARM OFF" or "HARM 1" can be selected to display basic (Harm 1 = fundamental) properties.

A triggered measurement with "HARM Y", Y = 2 through 59, will measure all basic properties and the complete set of harmonic values at the selected harmonic (HARM Y: Ar, Vr, W, VA, Var, Z, and phase).

NOTE

After measurement, the harmonic values should be viewed first (note the harmonic number). Afterwards select "HARM OFF" to view the basic properties. When you now go back to select "harmonic on" the first harmonic number is 1. Step up to the harmonic number you had your measurement performed before. If you don't do that you may easely relate the wrong harmonic number to your stored and displayed harmonic values.

Exit the triggered mode (LED trigg = on) as follows: Select HOLD ⟶ Press TRIG (LED off) ⟶ Press HOLD to enter the normal RUN mode again. A lighted LED "LP" indicates that the input low pass filters in the voltage and the current channels are on. The 3dB corner frequency of each filter is 1.6kHz. These filters are switched on or off via the 305A programming function described in Section 3.7.

HOLD
This function key toggles between measurement HOLD (LED lighted) and the normal RUN mode. In the HOLD mode the 144 measured values are stored and can be viewed including the energy values. For the harmonic values the same rules as for the triggered mode are valid.

START PRINTING
When you have programmed the 305A to output data via printer you simply press "START" to have the whole set of data being printed. The user can program the set of printer output data.

PROGRAMMING, FUNCTION MODIFIER
This function key enters the 305A programming and function modifier mode. The available menus are displayed. To select a menu bring the cursor to the desired menu using the key ⇨. Press the **ENTER** key to display the available programming functions (see section 3.7 for available programming functions).
To leave the programming simply press **STOP**.

3.7. PROGRAMMING AND FUNCTION MODIFIERS

Section 3.7 describes the programming functions and the function modifiers available for the 305A Vector Wattmeter. It also explains how the 305A is set to work with the modified function.

If you press this key the following menus are displayed:

```
ANALYZ /SC:AUD /AVERAG /FILTER /OUTPUT
TIMER  /TRIG   /MODE   /        /
```

Brief menu description:

ANALYZE
Set up the 305A for an automatic system analysis. For the range of selected harmonics the following properties for all three phases are determined: rms current, rms voltage, power, apparent power, (+-) reactive power, magnitude of system impedance, phase angle between current and voltage (phase), and harmonic frequency, and total harmonic distortion THD for current and voltage.

SCALE
The scaling menu allows to select three current scaling factors and three voltage scaling factors. The factors must be in the range 0.001 to 99999.

AVERAGE / FILTER
The averaging time can be selected: STD / IEC / 2s / 8s, and the input low pass filter be switched on or off.

OUTPUT
The data output can be selected: OFF, Printer, IEEE, or RS232. The printer can be activated by using the timer function.

TIMER
This menu allows to set the time of summation, and the number of time bands 1 through 59. The timer can be activated, or set for external summation start and stop.

TRIGGER / MODE
This function allows for selection of synchronization to current, voltage, or external signal for harmonic measurement. It also allows for deactivating the standard initialisation. A peak hold mode can be activated, and the current- and voltage range display can be modified.
The general procedure to access and leave any of these menus is as follows:
Move the cursor using the ▶ key to the desired menu. Press **ENTER** to display the available functions. Make the changes and when finished and you want to modify other menu functions you press **PROG**. If you want to leave the programming mode you simply press **STOP**. The 305A resumes normal operation.

ANALYZE

```
AUTO HARM ANALYZIS OF %Ar,Ur,W,VA,VAR,Z
OFF     /ON     /BEG     /END     /
```

NOTE: **Always use standard averaging in the automatic systems analysis mode.**

If you want to disactivate the automatic harmonic analysis move the cursor to "OFF" and press **ENTER.** A "x" will indicate 'off selected'.
To switch on the analyze mode move the cursor to "ON" and press **ENTER.**
Move the cursor to "BEG" and enter a one or two digit number from the number field below the display and press **ENTER.** This is the harmonic number from which the automatic harmonic analysis starts.
Finally, move the cursor to "END" and enter from the number field below the display a one or two digit number and press **ENTER.** This sets the highest harmonic frequency in the automatic analaysis.
Leave the programming mode by pressing **STOP.** The 305A goes into the regular measuring mode and remains in this mode until you initiate the automatic harmonic analysis.
This way you start it:

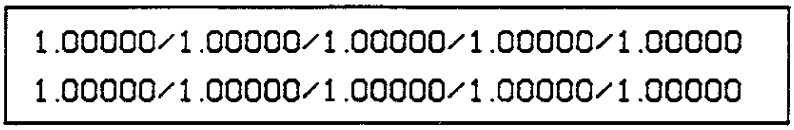
Select the starting harmonic number while the 305A is in the RUN mode (not HOLD). Press the "TRIG" key, the LED lights up. When your system is ready to be analyzed press the "TRIG" key again to start the measurement. The 305A scanes now all the harmonics. It requires approximately 1.8 sec. averaging time for each harmonic. The measurement technique applied copes with the most severly distorted wave forms from any frequency inverter type. High frequency components do not cause aliasing.
Power, even at high frequencies, is accurately computed. The fundamental frequency can be anywere in the range from 10Hz to 100kHz.
When the 305A has finished the analysis, it enters the HOLD mode and all harmonic values can either be viewed or printed.
To get a printout of the measured values simply press **START.** (We assume you have set-up the 305A for data output via printer). The available output data will be the following:
All basic properties including dc-, rectified mean-, and peak values, and all harmonic values of the starting harmonic frequency. These values are available in actual units V, mA, A, W, VA, and Var. All other (higher harmonic) values are given in percent of the basis properties. This is done so, to get precise measurements even when currents and voltages are changing during the time the analysis is performed.
The measurement data can also be viewed on the display. Except for the basic values and the harmonic values of the starting harmonic, you must make sure to select percent-values, such as % A, % V, % W, etc. Moving the harmonic number up and down, and selecting the appropriate display function allows you to see all measured values. Selecting "HARM off" will display the basic properties in V, A, W, etc. Total harmonic distortion for the programmed range of harmonics is available when %Ar and %Vr-values are displayed.

NOTE

The impedances, the phase angles, and frequency of the harmonic are always displayed in actual units (Ohm, Degree, Hz).

Once you leave the HOLD mode, the data from the previous system analysis are discarded. The 305A runs now in the standard measuring mode. To perform an other system analysis select the starting harmonic number and press the **TRIG** key twice.

SCALE



This menu allows you to change three scaling factors for currents and three scaling factors for voltages, and four scaling factors for the rear panel inputs DC1, DC2, DC3, and DC4. The first factor pertains to the current of phase 1. To change it move the cursor to this figure and enter the new factor from the number field below the display. The decimal point is set by the **DOWN** key. To store the new scaling factor press **ENTER**. Proceed by moving the cursor to the next scaling factor to be changed.
To move to the next menu press **PROG**. To leave the programming mode press **STOP**.
The scaling factors are stored in nonvolatile memory. This is why at start-up the 305A scaling factos are displayed to remind the user and to avoid measurement errors.

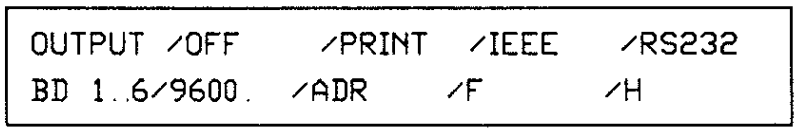
AVERAGE / FILTER

This menu allows you to increase averaging to take measurements down to 1Hz. The 305A always starts up with standard averaging. The measurement rate is approximately one display per 0.62 seconds. To select it move the cursor to "STD" and press **ENTER**. A "x" indicates that "STD" is selected. The averaging "IEC" conforms to the IEC555-2 / EN60555-2 recommendations for harmonic current measurements in electrical equipment. This averaging is only needed when currents are varying. The measurement rate is approximately 1 display per second. To select "IEC" averaging move the cursor to "IEC" and press **ENTER**.

For signal frequencies below 15Hz use averaging "2s". The measurement rate is 1 display per 2 seconds. To select this averaging move the cursor to "2s" and press **ENTER.**

For signal frequencies below 7Hz use averaging "8s". The measurement rate is 1 display per 8 seconds. Move the cursor to "8s" and press **ENTER.**
At this slow measurement rate the user must be patient to access the 305A. If you want to change the setting enter the HOLD mode, change the setting, and leave HOLD.
On the second display line you can switch on or switch off the input low pass filters. There are 6 identical filters, 3 for the current channels and 3 for the voltage channels. The 3-dB corner frequency is 1.6kHz and the roll-off is 20dB/decade. When the filters are switched on the "LP" LED lights up.

OUTPUT



The menu "OUTPUT" allows for selection of digital data output. It does not affect the analog outputs. If no data output is needed move the cursor to "OFF" and press **ENTER.**

PRINTER OUTPUT
Move the cursor to "PRINT" and press **ENTER.** To select the properties to be printed move the cursor to "F" or "H". The selection basically follows the same rules as the IEEE-488 data output commands. Below is the list of possible data output selection. Any combination of setting is possible. The F-commands practically duplicate the display function keys. They are the broad band values.

F0:	outputs	A= /V=	phase 1, 2, 3, and average
F1:	outputs	Ar/Vr	phase 1, 2, 3, and average
F2:	outputs	W/VA	phase 1, 2, 3, and sum
F3:	outputs	Var/PF	phase 1, 2, 3, and sum
F4:	outputs	Ap/Vp	phase 1, 2, 3, and average
F5:	outputs	Wh/VAh	phase 1, 2, 3, and sum
F6:	outputs	Varh/Ah	phase 1, 2, 3, and sum
F7:	outputs	Z/Phi/Hz	phase 1, 2, 3, and frequency
F8:	outputs	At/Vt	phase 1, 2, 3, and average
F9:	outputs	%DA/%DV	distortion factors. Total harmonic distortion after system analysis has been performed, otherwise % of harmonic to total value.

H0*:	outputs	An/Vn	current and voltage of selected harmonic
H1*:	outputs	Wn/VAn	W and VA of selected harmonic
H2*:	outputs	Varn/PFn	Var and PF of selected harmonic
H3:	outputs	Zn/Phin/Hzn	Z, Phi, Hz of selected harmonic
H4:	outputs	Line-to-line voltages, neutral current/voltage	
H5:	outputs	Option values	

*In the automatic analyze mode the printer will output % values (% harmonic/total) from the second harmonic upwards.

Option values are:
For standard 305A: one to eight values of the rear panel transmitter inputs DC1 to DC8. The first four inputs DC1 through DC4 are scaled by the front panel selectable dc-scaling factors.

For 305A Motor Version: 8 values, torque in NM, speed 1/min., frequency, value of fourth DC input, mecanical power, efficiency, and slip (8th value is not used).

For 305A Transformer Test Version: four values corrected power, and 4 values not used.
To select the output data "F1238" move the cursor to F and enter the numbers "1238" from the number field below the display and press **ENTER.**
To select outputs from the H-commands you move the cursor to "H" and enter the desired numbers from the number field and press **ENTER.**

If you want to output H-command properties only you can delete the F-commands as follows:
Move the cursor to "F", press **DOWN V** (on the left hand side of the front panel), and press **ENTER.** This will delete all F-commands. Similarly, you can delete all H-commands.

You can construct your custom made printer output commands using the IEEE-488, or the RS232 interface. You simply send a command which includes the desired output functions to the 305A and then switch to printer output. The output command OUTPUT "F12F24" would print current phase 1 and 2 and power phase 1, 2, 3, and sum.

When the 305A is turned off, the output programming remains stored until changed from the front panel or via interface.
The print command can also be initiated using the **TIMER.** Example: set time = 120s, timer = ON, T-B = 10, and P-TIME* (on). This setting prints 10 outputs in 2 minute time intervals.

TIMER

```
TIME S  60.0000 /OFF    /ON     /T-B
VIEW    /RESET  /P-TIME /EX ON  /
```

The timer menu allows setting up the energy integrator. The integrator (timer) can be switched on or off, the integration time can be set between 1 and 9999999 seconds (115.7 days), the number of time bands can be selected (1-59), the stored energy values (positive and negative) can be viewed for each time band. The integration can also be started and stopped by an external trigger signal (EX ON).

SETTING THE INTEGRATION TIME
Move the cursor to the selected time. Enter the desired time in seconds from the number field below the display. Press **ENTER** to store the setting.

NOTE

Short integration times less than 30 seconds should be avoided. Since the 305A computes 144 properties in every measurement cycle and also has to do a lot of checking and controlling, the start and stop event may be delayed up to 0.6 seconds.
Furthermore, energies are computed from time increments times average power. If power is rapidely changing a crude approximation may result.
We recommend to start energy measurements from the "HOLD" state.

TIMER ON/OFF
To switch the energy integrator off or on move the cursor to "OFF" or "ON" and press **ENTER.**

NUMBER OF TIME BANDS (T-B)
Move the cursor to "T-B" and enter a number 1 through 59 to set the number of time bands.
When you select T-B = 1 the integration is performed from start until the set integration time is reached. With the display control key you can display all energy values. When you select T-B greater than 1 for example, T-B = 3, the summation progresses until it reaches the set integration time. The 305A then stores the accumulated energy values under the heading T-B 1, and starts to sum the energy values for T-B 2. When the set time is reached the energy values of time band 2 are stored under the heading T-B 2. The 305A proceeds and then stores the energy values of time band 3 under the heading T-B 3. Up to 59 time bands can be stored each containing positive and negative values of each phase for Wh, VAh, Varh, and Ah and can be displayed selecting view on.

VIEW
When energy values are stored for a number of time bands the results can be displayed as long as the view function is switched on. Move the cursor to "VIEW" and press **ENTER.**
To display the results leave the programming mode and select the HOLD mode. Now press **HARM.** The annunciator on the second display line shows "T-B 1". Select the desired energy display function to see the results for time band 1. The energy display function key toggles between positive and negative values. Remember, when total power in the system is positive, the summation is performed on positive energy (Var can be positive or negative). When total power in the system is negative, the summation is performed on negative energy (VA, and Ah are positive, Var can be positive or negative).

When the view function is selected, the timer and the analyze function are turned off. This is implemented in this way to avoid conflicts.

RESET

Before starting energy measurements old data should be descarded with the reset function. Move the cursor to "RESET" and press **ENTER.**
There is a second way to reset and initialize. In the normal RUN mode select "HOLD", display Wh/VAh and press **TRIG.** This will reset the energy values. Selecting "RUN" starts a new energy measurement.

EXTERNAL Wh-TRIGGER

To activate the external start/stop energy trigger move the cursor to "EX ON" and press **ENTER.** When the external signal is low, energy summation starts, and stops again when the external signal is high or the elapsed time is larger than the set integration time. To perform a measurement proceed as follows: Bring the 305A into the HOLD state and reset the energy values.
Set the integration time to a large value such as 9999999s. This way the internal timer will not interfere with your external Wh-start/stop signal.

Set the Wh-trigger signal LOW (at the rear panel) to start the measurement. The summation will stop when either the Wh-trigger goes Hi or the selected integration time is exceeded. The Wh-start/stop signal is checked every measurement cycle (0.62s). A start/stop delay of up to 0.6 seconds is possible.

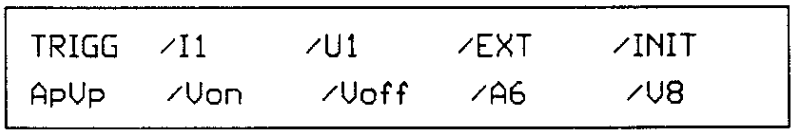
PRINTING OF TIME BAND VALUES

The measured time band energies can be printed in the following way. Select printer output, select "VIEW", bring the 305A into the "HOLD" mode, and select the desired T-B x. Finally press **START** to print the data.

SETTING TIME INTERVALS FOR PRINTER OUTPUTS

When selecting 'P-TIME*', data will be printed in the selected timer intervals (T-B must be greater than 1 and Printer OUTPUT must be selected). The number of output printings is determined by the number of time bands T-B. To deactivated the printer time intervals move the cursor to 'P-TIME*' and press ENTER.

TRIGGER / MODE



This menu allows for the selection of the synchronization signal for the harmonic measurement. A special monitoring mode can be selected to store current and voltage peaks occuring during a transient process. Furthermore, the 305A start-up and range display can be modified.

The first line of this menu concerns the synchronization or trigger signal for the harmonic measurements. At 305A start-up the current of phase 1 (I1) is selected. If you have a clean periodic voltage signal you can select voltage U1 as trigger signal as follows:
Move the cursor to U1 and press **ENTER.** An external trigger signal (max. 20 V) can be selected by moving the cursor to "EXT" and the press **ENTER.**

For harmonic measurements a synchronization signal is mandatory. In almost all applications the standard synchronization to current I1 will suffice and the user does not have to reprogram the 305A synchronization. The signal I1 is digitally averaged (filtered) to obtain a well determined zero crossing for synchronization. The synchronization to I1 may fail for two reasons:
first, the filtering in the 305A at frequencies below 30Hz fundamental may not be sufficient such that several zero crossings occur (frequency inverters that generate a chopped current wave form); and second, a current signal > 20kHz is switched on. In this case the filter will dampen too much so that no trigger signal will be available. Moving the frequency to 8-10kHz for 3-4 seconds and then moving it back up to the desired value will insure proper triggering up to 100kHz.
Triggering to voltage U1 or an external signal only makes sense, when a clean periodic wave form at the fundamental frequency is available.

PEAK-HOLD MODE SELECTION
Move the cursor to "ApVp * " and press **ENTER.** A "*" selects the peak-hold mode. Leave the menu by pressing **STOP.**
To perform a transient current (inrush current) and voltage measurement proceed as follows: Select **TRIG** (Led lights up, the 305A is ready), press **TRIG.** The 305A is now monitoring the 3 current and 3 voltage channels and will store the maximum peaks (magnitude) of more than 5ms duration. Shorter pulses will be averaged. To stop the monitoring and to display the peaks press HOLD and then TRIG.
To reset the stored measurements, display CFA and CFV, press HOLD and select Ap/Vp again; Apeak and Vpeak will be set to zero. The 305A is now ready for an other peak measurement.

INIT (Initialisation on/off)
This function allows modification of the 305A start-up procedure.
When "INIT*" is selected, the 305A will initialize on start-up to the standard setting (AC-coupling / autoranging / display Ar, Vr / 3W-measurement / reset of the following programming functions: Timer off, peak-hold mode off, trigger I1).
When "INIT" is deselected, the 305A will start-up in the configuration it was in before turning the 305A off. This feature is very usefull when the 305A is installed in a fixed test set-up.

RANGE DISPLAY MODIFIER (A6/V8)
When **"A6 *"** is selected the 305A current range display is A1, A2, A3, A4, A5, and A6 (A1 is the lowest current range).

When **"V8*"** is selected the voltage range display is V1, V2, V3, V4, V5, V6, V7, and V8. This programming feature can be used for nonstandard ranges and plug-ins that require scaling.
The 305A starts up in the selected range display when **"INI"** is deselected.

LINE-TO-LINE MEASUREMENT ACTIVATION

"Von*/Voff" is factory set when the hardware for the line-to-line voltage measurement (Option 13) is installed.

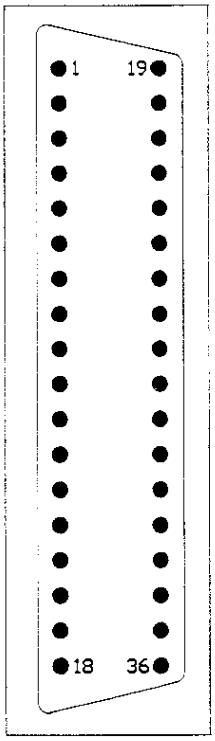
"Voff*" must be set when the line-to-line hardware is not installed.

This section describes the connectors and their signals. The 36 pol printer output connector directs the controlling and data signals to the printer. The 25 pol RS232 / Aux Input connector is for the RS232 data transfer and also for external trigger signals. The recorder output connector contains all available recorder output signals. The IEEE-488 interface connector allows for parallel data transfer to a host.

PRINTER OUTPUT CONNECTOR (STANDARD)

A printer can be hooked up to the 36 pol connector. Data are transfered to the printer when the 305A OUTPUT menu is set accordingly and the **START** key is pressed.

pin	name	
1	$\overline{\text{STROBE}}$	⊓⊔
2	Data	D0
3		D1
4		D2
5		D3
6		D4
7		D5
8		D6
9/33	Ground	
11	Busy	
12	Paper End	
13	Select	
31	$\overline{\text{PRIME}}$ = 5V	
32	$\overline{\text{Error}}$	



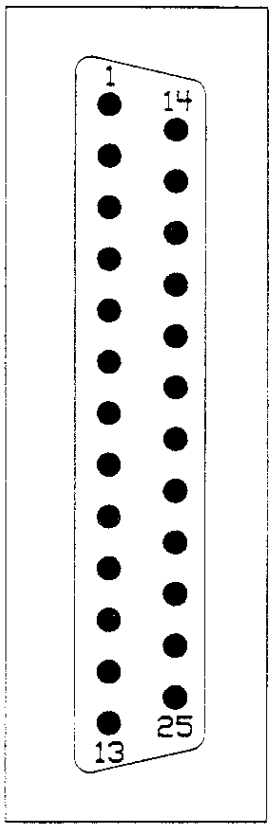
RS232 (OPTION) / AUXILIARY INPUT CONNECTOR (STANDARD)

This 25 pol connector serves the purpose to transfer RS232 signals from the host to the 305A and visa versa. The connector also carries the external trigger signals.

RS232- / EXTERNAL INPUT CONNECTOR

pin		name
1	PG	Protective ground
2	TxD	Transmitted data
3	RxD	Received data
4	RTS	Request to send
5	CTS	Clear to send
6		
7	SG	Signal ground
8		
9	DTR	Data terminal ready
10		
11		
12		
13		
14	DC8	frequency input, specify range
15	DC7	frequency input, specify range
16	DC6	DC input 6; 0 to ±5V
17	DC5	DC input 5; 0 to ±5V
18	DC4	DC input 4; 0 to ±5V
19	DC3	DC input 3; 0 to ±5V
20	DC2	DC input 2; 0 to ±5V
21	DC1	DC input 1; 0 to ±5V
22	Ext. synchronization (EXT)	
23	Trigger for energy start/stop	
24	Trigger measurement	
25	Ground	

these inputs can be scaled by scaling factors



EXTERNAL INPUTS DC1 TO DC8

Inputs DC1 to DC4 are for external dc signals. The standard input range is 0 to ±5V (other ranges are available). These inputs can be scaled with the last four scaling factors displayed in the scaling menu.
Pressing the control A=/V= display twice will display these inputs on the top display line. Full scale (5V) corresponds to a display of 5.0000 (scaling factor 1.0).
The inputs DC5 and DC6 are for 0 to ±5V dc signals (no scaling).
The inputs DC7 and DC8 are for external frequency inputs (max. 20Vp+p). Full scale frequency (e.g. 0-1kHz, 0-10kHz) is displayed as 5.0000. Inputs DC5 to DC8 are displayed on the second display line.
If frequency inputs need scaling, it is possible by a minor hardware change to have inputs DC7 and DC8 displayed at the display position of DC3 and DC4.

Motor Test Version: The inputs DC1 through DC3 are dedicated inputs as follows:

DC1: Signal proportional to torque
DC2: Signal proportional to speed
DC3: Signal proportional to frequency

DESCRIPTION OF SIGNALS

External synchronization, pin 22/25

Ext. Synchronization (EXT) can be used to synchronize the harmonic measurements to any frequency between 10Hz and 100kHz. It must be a clean periodic wave form between pin 22 and pin 25 in the amplitude range 500mVrms to max. 10Vrms. Use the menu TRIGGER to select EXT. In a frequency inverter driven system you can perform harmonic measurements synchronizing to 11 to get the main information from your system (the fundamental frequency is normally between 10Hz and 1000Hz).
At the external synchronization input you apply now the chopper frequency of your inverter (2kHz to 50kHz) and you switch (via the TRIGGER menu) to external synchronization. Now you can analyze your system at harmonics of your chopper frequency.

TRIGGER FOR ENERGY START/STOP, PIN 23/25

This TTL signal pin 23/25, when pulled LOW, will start the energy measurement and stop the energy measurement when set Hi (switch between pin 23/25 opened). See section 3.7 Timer menu for information how to set-up the 305A.

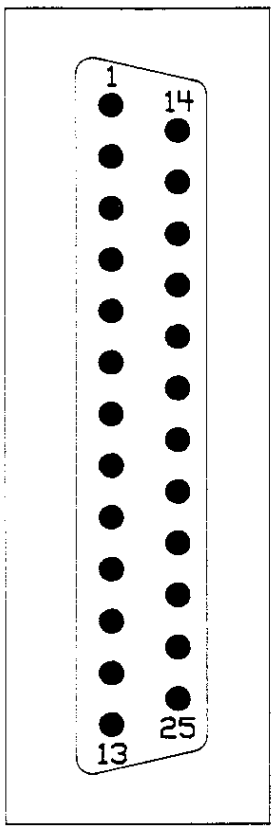
TRIGGER MEASUREMENT, PIN 24/25

When the 305A is in the triggered mode (Trig/LED selected via front panel or selected via interface) the TTL signal betwen pin 24 and 25, when set LOW for 0.5 seconds will initiate a measurement of all properties except energies.

RECORDER OUTPUT CONNECTOR (2 OPTIONS)

The recorder output connector contains two types of signals; on-line signals which are presented to the connector output in real time as they occur and 4 programmable outputs which are updated every measurement cycle.

pin	name, on-line signals, output impedance 2kOhm
1	signal ground
14	RMS current phase 1
2	Current signal phase 1
15	Instantaneous power phase 1
3	Average power phase 1
16	RMS voltage phase 1
4	Voltage signal phase 1
17	RMS current phase 2
5	Current signal phase 2
18	Instantaneous power phase 2
6	Average power phase 2
19	RMS voltage phase 2
7	Voltage signal phase 2
20	Current signal phase 3
8	Instantaneous power phase 3
21	Average power phase 3
9	RMS voltage phase 3
22	Voltage signal phase 3
10	RMS current phase 3 (on request only)



pin	name, programmable outputs
23	Programmable output 1
11	Programmable output 2
24	Programmable output 3
12	Programmable output 4
25	Signal ground

The on-line signals (pin 1-10, and 14-22) all have a 2kOhm output impedance, and 5V output level for range full scale. Exceptions are the 3 instantaneous power output signals. Their level is 2.5V (average) for full scale power.
The sum of power or the sum of instantaneous power can be obtained by simply connecting each a 10kOhm / (0.1 %) resistor in series with the power outputs. At the node of the 3 resistors the voltage is 5V, respectively 2.5V, for full scale. The output impedance at the node is 4kOhm and a dc-offset of up to 1 % of full scale may occure. This dc-offset can be trimmed out by connecting a 2MOhm resistor to the summing node. An external dc voltage is required to achieve the nulling.

Operating the Vector Wattmeter Using the Computer Interface

The Vector Wattmeter can be operated from a host (e.g. a terminal, controller, PC, or computer) by sending commands to it through a computer interface on the rear panel.
Section 5 describes how to set up, configure, and operate the instrument via the IEEE-488 or RS232 interface. With the IEEE-488 interface the 305A is fully programmable.

5.1. PREPARING THE 305A TO BE OPERATED VIA IEEE-488 INTERFACE

The following limitations govern the IEEE-488 interface:

- Maximum 15 devices can be connected in a single bus system.

- The length of the IEEE-488 cable must be the lesser of 20 meters or 2 meters times the number of devices in the system.

5.2. ENABLING THE IEEE-488 INTERFACE

The IEEE-488 interface can only be enabled from the front panel using the programming function. Enter the menu "OUTPUT", select IEEE-488 on and enter the desired address "ADR" 1 through 31.

5.3. HOW THE 305A PROCESSES INPUT

This section describes how commands and data received by 305A are processed.

INPUT STRINGS

The 305A processes and executes valied input strings sent by the host. A valid input string is one or more syntactically correct commands followed by an "input terminator".
The 305A accepts alphabetic characters in upper case and numbers 0 to 9. If a command cannot be understood it will be ignored. In general the processing will continue with the next command in the same string.

There are 3 types of input strings which cannot be mixed.

- Strings containing one upper case letter and one number (string type a).

- Strings containing one upper case letter and two numbers (string type b).

- Strings containing one upper case letter and one number followed by a number with or without decimal point (string type c).

Example of valid input strings:

type a: "I2U5D5C2C6KØK6" type b: "F13F17F14F73"
type c: "SØ 10.058"

VALID INPUT TERMINATORS
Every input string must be terminated by:

- CR LF (Carriage Return - Line Feed pair)

LIST OF DEVICE DEPENDENT COMMANDS

Output Functions Commands (type b)

Output	Function	Commands Fnx, Hnx (type b)
FØx	A=/V=	mean current or voltage
F1x	Ar/VR	RMS current or voltage
F2x	W/VA	power or apparent power
F3x	Var/PF	reactive power or power factor
F4x	Ap/Vp	peak value of current or voltage
F5x	Wh/VAh	energy or apparent energy
F6x	Varh/Ah	reactive energy or charge
F7x	Z/Phi/Hz	impedance or phase and frequency
F8x	At/Vt	true rectified mean current or voltage
F9x	%DA/%DV	distortion factor in % of current or voltage (valied only after automatic system analysis)
HOx *	Arn/Vrn	harmonic current or voltage, n = 1 to 59
H1x *	Wn/VAn	harmonic power or apparent power, n = 1 to 59
H2x *	Varn/PFn	harmonic reactive power or PF, n = 1 to 59
H3x	Z/Phi/f	harmonic impedance or phase and frequency
H4x	V	line-to-line rms and rectified mean voltage; see 5.10
H5x		special values motor and transformer version, and up to 8 dc-inputs for standard version; see 5.10

NOTE 1

x is an index 1 to 8; x = 1 to 4 references the first property (e.g. Ar), x = 5 to 8 references the second property (e.g. Vr).

* In the automatic analyze mode these commands will output % values (% harmonic/total) starting from the second harmonic.

Range commands (type a)

Plug-in	0.8A	8A	16A	40A/80A	800A
I0	25mA	0.25A	1A	5A	25A
I1	50mA	0.5A	2A	10A	50A
I2	100mA	1A	4A	20A	100A
I3	200mA	2A	8A	40A	200A
I4	400mA	4A	16A	80A	400A
I5	800mA	8A	32A	160A	800A

	standard input	high voltage input
U0	7.5V	2000V
U1	15V	4000V
U2	30V	8000V
U3	60V	16000V
U4	120V	
U5	240V	
U6	480V	
U7	960V	

SEND Data Command (RS232 only)

X	305A starts measurement data transmission

Display Commands (type a)

D0	display A=/V=	E0	display %Var/%PF
D1	display Ap/Vp	E1	display Wh/VAh
D2	display CFA/CFV	E2	display Varh/Ah
D3	display At/Vt	E3	display Z/Phi/Hz
D4	display FFA/FFV	E4	display Vrsr/Vrst
D5	display Ar/Vr	E5	display motor/transformer version
D6	display %Ar/%Vr	E6	display Arn/Vrn harmonic
D7	display W/VA	E7	display Wn/VAn harmonic
D8	display %W/%VA	E8	display Varn/PFn harmonic
D9	display Var/PF	E9	display Zn/Phin/Hzn harmonic

Mode Command 1 (type a)

C0	Auto range
C1	Manual range
C2	AC-coupling
C3	DC-coupling
C4	Run
C5	Hold
C6	Trigger measurement
C7	Trigger mode off
C8	Low-pass filter off
C9	Low-pass filter on

Mode Command 2 (type a)

K0	3W (3-Wattmeter)
K1	2W (Aron)
K2	Line voltage
K3	Line-to-line voltage
K4	Harmonic analysis on
K5	Harmonic analysis off
K6	Averaging standard
K7	Averaging IEC-555/2
K8	Averaging 2s
K9	Averaging 8s

Mode Command 3 (type a)

```
L0      Timer on
L1      Timer off
L2      Trigger I1 for harmonic measurement
L3      Trigger U1 for harmonic measurement
L4      Trigger external for harmonic measurement
L5      Wh Reset
L6      Local lockout on
L7      Local lockout off
L8      Header off/on (toggles off/on)
```

SRQ Mask (tpye a)

```
P0      SRQ disabled
P1      SRQ on data ready
P2      SRQ on data ready or current or voltage over
```

Set Commands (tpye c), send single commands only

```
S0      Scaling current phase 1; format "S0 10.2"
S1      Scaling current phase 2;
S2      Scaling current phase 3;
S3      Scaling voltage phase 1; format "S3 1.5273"
S4      Scaling voltage phase 2;
S5      Scaling voltage phase 3;
S6      Set time for timer;      format "S6 7200"
S7      Set harmonic number;     format "S7 59"
S8      Start harmonic number for analyze
S9      End harmonic number for analyze
```

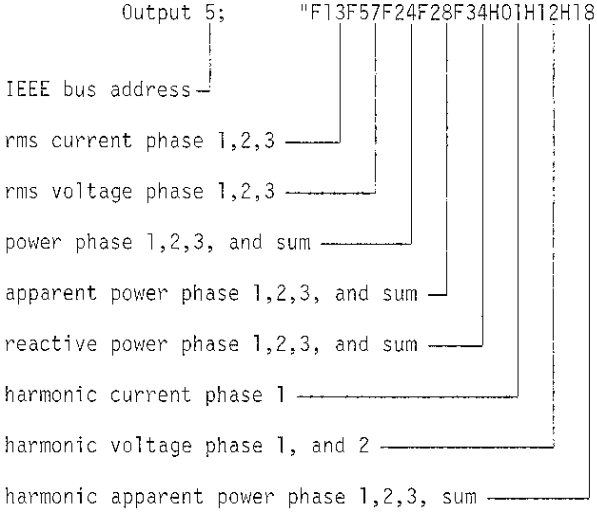
5.4. SENDING COMMAND STRINGS TO THE 305A

When you construct strings to be sent to the Vector Wattmeter over the computer interface, the following rules must be observed:

- Command type a, b, and c can not be mixed.
- Commands must follow a logical sequence as if you would operate the 305A from the front panel.
- Send output commands only once. The data from this output command can be read over and over again.
- The length of a string must not exceed 51 characters.

Example 1: Format of command string type b

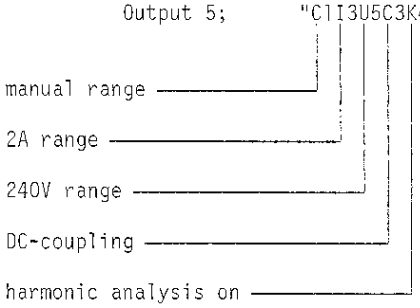
Output 5; "F13F57F24F28F34H01H12H18" (max. 51 character)



This string remains stored in nonvolatile memory even when the instrument is turned off and on again. Every time data are read from the 305A it will send all data contained in above output command string.

Example 2: format of command string type a

Output 5; "C1I3U5C3K4" (max. 51 characters)



To run the automatic harmonic analysis you must set the start- and end harmonic numbers using the S8 and S9 command, also set the harmonic number S7 (=S8), and finally enter the triggered mode C6. To run the harmonic analysis send C6 a second time.

Example 3:	format of command string type c	
Output 5;	"S7 1"	sets the harmonic number to 1
Output 5;	"S8 1"	start- harmonic number = 1 for the automatic system analysis
Output 5;	"S9 21"	end- harmonic number = 21 for the automatic system analysis.
Output 5;	"S1 100.0507"	sets current scaling factor phase 2 to 100.0507.

5.5. HOW THE VECTOR WATTMETER PROCESSES OUTPUT

The Vector Wattmeter outputs a large amount of data. A data line is terminated with CR LF. Depending of the type of measurement and programming the 305A sends several hundred lines of data. When the whole data transfer is finished the EOI (End or Identify) is sent.
The command string "F14F18" will result in the following data flow: 1. line with comment, 2. line 4 current values, and 3. line 4 voltage values. The output strings look like this:

```
*DC-COUPLED/2A240V**TOTAL VALUES & n.Harmonic (n=1=FUND)*
Ar 2.001070E+00  2.000180E+00  1.980850E+00  1.998250E+00
Vr 2.200000E+02  2.210000E+02  2.180000E+02  2.196700E+02
```

When data are read after an automatic system analysis the basic properties and the harmonic properties from start-harmonic to end-harmonic are output. If you have programmed the 305A to output "H04" and you have performed a system analysis from 1. to 11. harmonic output will be the current from fundamental in mA, A, or kA followed by all harmonic values from 2. to the 11. harmonic all in % of the total current.

Example: Output 5; "F14F18F24F28F34H04H08H14"
will output the following data:

- 4x rms current, 4x rms voltage, 4x power, 4x apparent power, 4x reactive power; 4x current of start-harmonic, 4x voltage of start-harmonic, 4x power of start-harmonic. All above values are actual units in A, V, W, VA, Var, An, Vn, Wn.

- Above data follows the harmonic values for (start-harmonic +1) up to end-harmonic. For each harmonic: 4x current, 4x voltage, and 4x power all in % of the basic properties.

5.6. SERVICE REQUESTS (IEEE-488 only)

Service requests let an instrument on the IEEE-488 bus get the attention of the host. The 305A initiates a service request by dropping the SRQ line (low = true). The controller can read the SRQ register to determine the cause of the service request. When the 305A initiated the SRQ and the controller reads the SRQ register the SRQ-line will be set high again (high = false).
The SRQ register bits 1 through 8 are set as follows:

Bit 1: Bit is set to 1 when the measurement is finished in RUN-, TRIGGERED, and ANALYZE Mode.

Bit 2: Bit is set to 1 when current peak- or current rms is overload.

Bit 3: Bit is set to 1 when voltage peak or voltage rms is overload.

Bit 7: Is the SRQ-bit which, when set from 0 to 1, will activate the SRQ-line. Bit 7 is set only, when the SRQ-mask P1 or P2 is selected.

Bit 4, 5, 6, and 8 are not used.

In the RUN-mode the SRQ-line is set low for 100ms. At the end of the 100ms the controller can read the data from the 305A.

NOTE

Reading the SRQ register will not alter its contents but it will reset the SRQ-line.

5.7. PREPARING THE 305A TO BE OPERATED VIA THE RS-232 SERIAL INTERFACE

The RS-232 interface allows ASCII, asynchronous, serial communication between the Vector Wattmeter and a host.
The number of data bits, stop bits, and parity bits are fixed as follows:

Number of Data Bits: 8

No parity

Number of Stop Bits: 1

The baud rate can be programmed from the front panel selecting the menu **OUTPUT**. Move the cursor to the baud rate displayed and select a number 1 through 6 and press **ENTER**. The selected baud rate is as follows:

1 = 600 Baud, 2 = 1200 Baud, 3 = 2400 Baud
4 = 4800 Baud, 5 = 9600 Baud, 6 = 19200 Baud

5.8. HOW THE 305A PROCESSES INPUT FROM RS-232

To enable the RS-232 communication select the menu **OUTPUT** and **RS-232.**
The input strings sent to the 305A via the RS-232 must follow exactly the same rules as when using the IEEE-488 interface. Please refer to sections 5.3. and 5.4. of this manual.

Valid Input Terminator
Every input string to the 305A must be terminated by a CR LF (Carriage Return - Line Feed pair).

Hand Shake Procedure for Data Transmission from Host to 305A
sets its RTS-line high using an "Open Port #1" command (or similar). The 305A will respond within 400ms by setting its RTS-line high. Now the host can send the data terminated by CR/LF. The host must now set the RTS-line low using a command such as "Close Port #1". As soon as RTS is low, the 305A is freed to continue its measurements.

5.9. HOW THE 305A SENDS DATA VIA THE RS-232 SERIAL INTERFACE

The data format is the same as described in the section 5.5. for the IEEE-488 interface. The 305A is first programmed with the output function commands (F and H: List of Device Dependent Commands). This programming has to be done only once.
In order to tell the 305A to send data, the "Send Data Command" ("XCRLF") must be sent from the host to the 305A.
The 305A then starts to transmit the programmed output data.
Everytime data are required, send "XCRLF" to the 305A. To simplify the host programming the 305A terminates its output data string with a capital "X". The host can check the data for a received "X" to use it as a termination criteria.

Hand Shake Procedure for Data Transmission from 305A to Host
The host must first send "XCRLF" following the hand shake rules described in section 5.8. As soon as the host has lowered its RTS-line the 305A goes into the data transmission mode by setting its RTS-line high. The host must set its RTS-line high using an "Open Port #1" command. The 305A starts now with data transmission terminated with "X" and lowers its RTS-line. The host either checks for "X" or monitors the CTS-line. When conditions are met it lowers its RTS-line using a command such as "Close Port #1". Now the 305A is released to continue measurements.

Following is a program example written in Q-Basic.

```
Declare Sub Inst (Code$)
Cls
Inst ("CØ")
Inst ("F3")
Inst ("X")
Sub Inst (CodeS)
Open "Com2:9600.N.8.1.CD0,CS0.DS0 OP0.TB2048.RB2048. LF" For Random as#1
```

```
Sleep 1
Print #1. Code$
Close  1
Sleep 1
If Code$ = "X" Then
OPEN"COM2:9600.N.8.1.DC0.CS0.DS0.OP0.TB2048.RB2048.LF" For Random as #1
Loop: If Loc(1) Then Goto Loop
Input #1, Read$
Print Read$
Input #1, Read$
Print Read$
Close #1
End If
End Sub
```

5.10 OUTPUT DATA FROM OPTION 13 AND SPECIAL VERSIONS 305A, COMMANDS H4x and H5x

This section describes the 305A output commands H4x and H5x. H4x is valid only when Option 13, line-to-line measurement, is installed. H5x is valied when Option 14, external dc-inputs, is installed, or when a motor test- or transformer test instrument is used.

H4x: LINE-TO-LINE MEASUREMENT (OPTION 13)

The output function command H44 outputs 3 line-to-line rms voltages and the neutral voltage. H58 outputs 3 line-to-line rectified mean voltages and the neutral current in ampere.

H5x: 8 EXTERNAL DC-INPUTS (OPTION 14)

The values of the external dc-inputs can be read with the H54 and H58 commands. The command H54 outputs the first four dc-inputs DC1, DC2, DC3, and DC4. If these inputs are scaled the output values are multiplied by the scaling factors.
The command H58 outputs DC5, DC6, DC7, and DC8.

H5x: 305AM MOTOR TEST VERSION

The motor test version is equipped with 4 dc-inputs DC1, DC2, DC3, and DC4. DC1, DC2, and DC3 are scaled by the scaling factors C1, C2, and C3. DC4 is not scaled. Mechanical power, efficiency, and slip are computed and displayed as shown below.

H54	TORQUE (Nm) DC1 · C1	SPEED (1/min) DC2 · C2	FREQUENCY (Hz) DC3 · C3	DC4
H58	MECH.POWER (Wm) DC1·C1 · DC2·C2·2phi/60	EFFICIENCY eta =Pm/Pe	SLIP 1 - C4 · DC2/DC3 · 60	0

C4 sets the number of poles and is used in the computation of the slip.
The output command H54 outputs the top line of the display and H58 outputs the second line. No units are displayed.

H5x: 305AT TRANSFORMER TEST VERSION

The transformer test version is equipped with 4 dc-inputs, DC1 through DC4, which can be scaled by C1 through C4.
The 305AT computes the corrected power Pc of each phase and their sum. The display and the interface output are in the format shown below.

DC1 · C1	DC2 · C2	DC3 · C3	DC4 · C4
Corrected power PC1, PC2, PC3, and their sum			
$P1/(0.5+0.5(Vr1/Vt1)^2)$	$P2/(0.5+0.5(Vr2/Vt2)^2)$	$P3/(0.5+0.5(Vr3/Vt3)^2)$	Sum Pc

Vt1, Vt2, Vt3 are rms-corrected rectified mean values.
Vtx = 1.1107 rectified mean voltage.
The command H54 outputs the top line of the display and H58 outputs the second line. No units are displayed.

305A SINGLE-PHASE AND TWO-PHASE VECTOR WATTMETER AND 305A OPTIONS

Section 6 describes the deviations of the single- and two phase models from the standard three phase 305A. The deviations pertain mainly to the display and the data output not so much to the operation. A description of the options to the 305A follows.

6.1. 305A-2 TWO PHASE VECTOR WATTMETER

The two phase instrument measures properties of two currents and two voltages. The operation and the programming is basically the same as the operation of the three phase instrument with few alterations (display and data output).

DISPLAY

The display always shows properties of two front panel keys, e.g. **Ar/Vr** and **W/VA**. In this example the display shows on the left hand side two currents with units and two voltages with units, and the right hand side shows two power values with units and two apparent power values with units. To the very right of the display the selected current ranges A1 through A6 and the voltage ranges V1 through V8 as well as the harmonic number selection are shown.
If you want to display rectified mean values press **At/Vt**. This action displays four rectified mean values on the left hand side and shifts **Ar/Vr** to the right hand side and discards the **W/VA**-display.
The range display is as follows:
A1 is the lowest current range of the plug-in in use and A6 is the highest current range.
V1 is the lowest voltage range (7.5V standard) and V8 is the highest voltage range.
V1 = 7.5V; V2 = 15V; V3 = 30V; V4 = 60V; V5 = 120V; V6= 240V; V7 = 480V; V8 = 960V;
High voltage option: V1 = 2000V; V2 = 4000V; V3 = 8000V; V4 = 16000V.

DATA OUTPUT

If you use for example the printer output command F1 (rms current, rms voltage) the data output will be two rms currents from phase 1 and phase 2 on the top line and two rms voltages on the second line.
When data are read via the interface the output function commands FØx through F9x and HØx through H5x must be modified accordingly.
For example F11 will output rms current phase 1, F12 outputs currents phase 1 and phase 2. If you use by mistake the command F13 three currents are output but the third is garbage. F14 would yield four current values. The last two values will be meaningless. To read for example two rms voltages the command F16 had to be used.
There is one exeption to above rule. The 305A-2 can be equipped with up to 8 external dc-inputs. Although you can only display DC1, DC2, and DC5 and DC6 you still can read all values from interface using the commands H54 and H58.

RECORDER OUTPUT

On the recorder output of the 305A-2 only the signals from phase 1 and phase 2 are present.

6.2. 305A-1 SINGLE PHASE VECTOR WATTMETER

The single phase instrument measures properties of a single current and voltage input. This section describes the operations that are different from the three phase instrument.

DISPLAY

The display shows six quantities including units resulting from 3 front panel key operations. After start up the display shows from left to right **Ar/Vr**, **W/VA**, and **VR/PF**. When you press the control **At/Vt** the display from left to right will be **At/Vt**, **Ar/Vr**, and **W/VA**. **VR/PF**-values are shifted out of the display. To the right of the display the range and harmonic numbers are shown. To display % values proceed as described in the following example. Assuming the left most quantities are **Ar/Vr**. If you press the key **Ar/Vr** a second time the display shows **%Ar/Vr**, **Ar/Vr**, ...
Although up to 8 external dc-inputs can be installed only DC1 and DC5 can be displayed. All dc-inputs can be obtained via the IEEE- or RS232-interface.
To output data over the interface the output function must be adapted to only read values from phase 1, e.g. rms current use F11. If you used F14 the values 2 to 4 would be garbage.
The read command to output up to 8 external dc-signals is the only exception. If you want to read the first four inputs use H54 and the second four values are read using H58.

RECORDER OUTPUT

Only signals from phase 1 are present.

SCALING

The first factor is for current scaling and the second for voltage scaling.

6.3. DESCRIPTION OF 305A OPTIONS

This section describes those 305A options that need further explanations and additional specifications not already given in the main specifications.

OPTION 03, 0-16A PLUG-IN

Specifications:

Current ranges:	1A, 2A, 4A, 8A, 16A, (32A)
Max. current:	16A continuous
Accuracy 23° ±3°K (Current and power)	
DC-5kHz:	Same as 8A plug-in
5kHz-20kHz:	Multiply accuracy percentage figures of 8A-plug-in by 2.
20kHz-100kHz:	Multiply accuracy percentage figures of 8A-plug-in by 3.

OPTION 04, 0-40A PLUG-IN

Specifications:

Current ranges:	5A, 10A, 20A, 40A, (80A, 160A)
Max. current:	36A continuous, 40A 30sec.
Range indication:	requires A1, A2, ... A6 programming
Scaling factor:	Use 2.0
Accuracy 23° ±3°K (current and power)	
DC-2kHz:	Same as 8A plug-in
2kHz-5kHz:	Multiply accuracy percentage figures of 8A Plug-in by 3.
5kHz-10kHz:	Multiply accuracy percentage figures of 8A plug-in by 5.

OPTION 05, 32A PLUG-IN ENHANCED COMMON MODE

The current path often is exposed to very large commmon mode transients in frequency inverter applications and when loads are switched on and off by fast semiconductor switches. Option 05 gives additional isolation from amplifier input, it exhibits a wide current range 0-32A, and a frequency range DC-10kHz.

Specifications:

Ranges:	1A, 2A, 4A, 8A, 16A, 32A, 32A continuous
Isolation voltage:	3000V/50Hz/1min.
DC-offset:	±0.03A at zero external magnetic field
Accuracy 23° ±3°K; current > 0.5A (current and power)	
DC-400Hz:	±0.1 % range ±0.3 % input
400Hz-1.2kHz:	±0.2 % range ±0.5 % input
1.2kHz-2kHz:	±0.2 % range ±1 % input
2kHz-5kHz:	±0.2 % range ±2 % input
5kHz-10kHz:	±0.2 % range ±3 % input
Input resistance:	0.002Ohm

OPTION 06, 80A PLUG-IN, ENHANCED COMMON MODE

Option 06 also provides additional protection of the 305A inputs against large current- and voltage transients at the electrical load.

Specifications:

Ranges:	2.5A, 5A, 10A, 20A, 40A, 80A
Max. current:	70A continuous, 80A 30 seconds
Isolation voltage:	3000V/50Hz/1min.
DC-offset:	±0.1A
Accuracy 23° ±3°K; current > 2A (current and power)	
DC-400Hz:	±0.1 % range ±0.3 % input
400Hz-1.2kHz:	±0.2 % range ±0.5 % input
1.2kHz-2kHz:	±0.2 % range ±1 % input
2kHz-5kHz:	±0.2 % range ±2 % input
5kHz-10kHz:	±0.2 % range ±4 % input
Input resistance:	0.002Ohm

OPTION 07, 800A PLUG-IN, ENHANCED COMMON MODE

Option 07 is available in the standard 0-800A range as well as in the nonstandard ranges 0-400A and 0-1600A.
This option consists of the following parts (3-phase instrument): 3 plug-ins to the 305A rear, 3 remote broad band transformers (2m cable), and a common supply for the transformers. The hook-up of this option is shown in the drawing of the following page.
The current carrying cable is looped through a whole in the broad band transformer. Program the 305A with the required scaling factors given below and use the relative range display A1, A2, A3, A4, A5, and A6, where A1 indicates the lowest current range.
The single phase 305A-1 uses 1 plug-in, 1 broad band transformer, and 1 supply.
The two phase 305A-2 uses 2 plug-ins, 2 broad band transformers and 1 supply.

Specifications:

Ranges; 0-800A input:	25A, 50A, 100A, 200A, 400A, 800A
Ranges; 0-400A input:	12.5A, 25A, 50A, 100A, 200A, 400A
Ranges; 0-1600A input:	50A, 100A, 200A, 400A, 800A, 1600A
DC-offset:	±0.2 % of transformer range
Accuracy 23° ±3K°; current > 22A	(current and power)
DC-400Hz:	±0.1 % range ±0.4 % input
400Hz-1kHz:	±0.2 % range ±1 % input
1kHz-2kHz:	±0.5 % range ±4 % input, typical
2kHz-10kHz:	±0.5 % range ±10 % input, typical
Scaling 400A, 800A, 1600A:	5.0, 10.0, and 20.0
Max. cable diameter:	400A: 22mm; 800A/1600A: 35mm
Transformer case:	400A: 56 x 120 x 122mm
	800A, 1600A: 78 x 120 x 200mm
Supply case:	78 x 120 x 200mm
Cable length:	2m, 305A to transformer

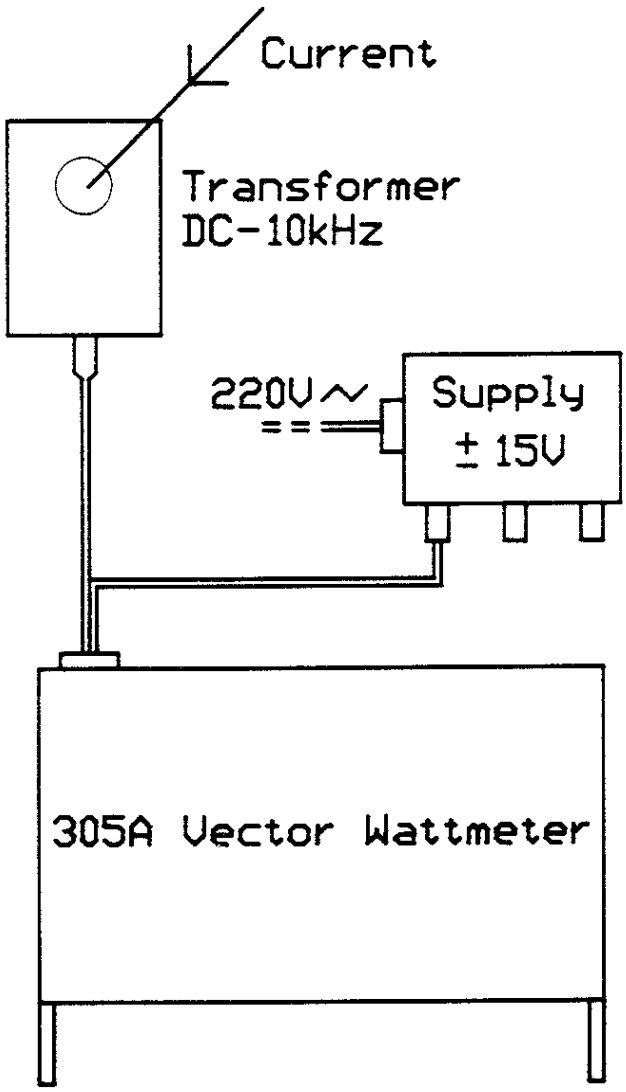
OPTION 08, PLUG-IN FOR EXTERNAL SHUNTS

If you are using your own current shunts you can feed the shunt voltage into option 08, which accepts a 0-800mV shunt voltage. Using the current scaling the actual currents can be displayed. In addition, all other quantities are corrected accordingly and are displayed in actual units.

Specifications:

Input impedance:	30kOhm
Sensitivity:	10mV = 1A; 800mV = 80A
Voltage ranges:	25, 50, 100, 200, 400, 800mVrms
Max. input voltage:	100Vrms

Connection of External High Current Transformers DC - 10kHz



Caution:

Do not operate High Current Transformers **without** DC-Supply, otherwise damage may occur.

Vorsicht:

Stromdurchflutete Hochstromwandler dürfen **nie** ohne Gleichstrom-speisung betrieben werden.

OPTION 10, HIGH VOLTAGE PLUG-IN UP TO 16kV

The high voltage option allows for direct voltage measurements up to 16kV in the frequency range dc to 5kHz. There is no phase shift error at 50Hz.
The high voltage sensor is 2m away from the 305A Vector Wattmeter for safety reasons and is housed in a solid plastic case. The isolation voltage of the low input terminal to the 305A input is 10kV/50Hz. The input impedance is 8MOhm when no jumper on the voltage devider is used.

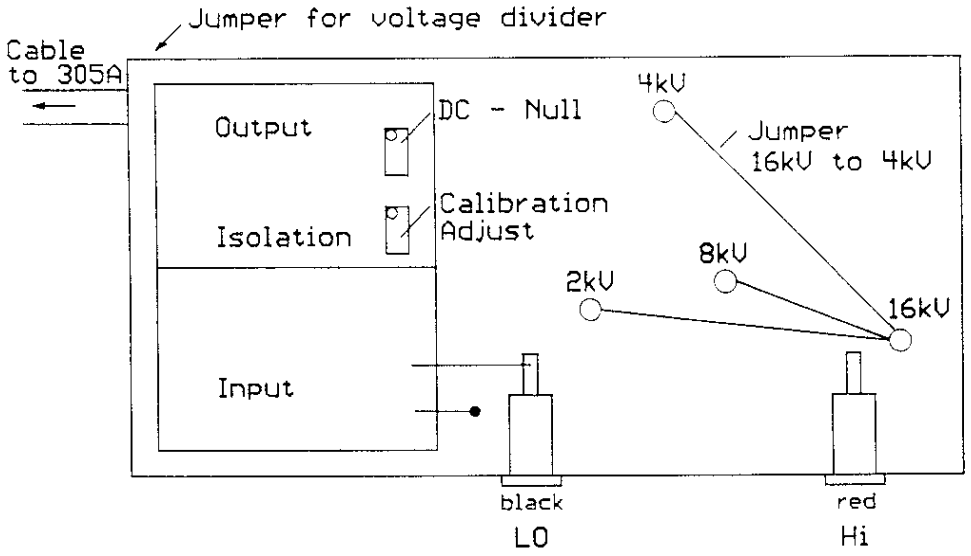
Specifications:

Voltage ranges:	0-2kV/4kV/8kV/16kV; max. 16kV
Scaling factor:	266.7
305A range display:	7.5V/15V/30V/60V/ ....; V1/V2/V3/V4 ...
Frequency range:	DC-5kHz
Accuracy: (voltage and power)	10Hz-1kHz: 0.5 %; > 960V
	1kHz-5kHz: 2 %; > 960V
Isolation Voltage	
Input/Output low:	10kV/50Hz high voltage input "low terminal" to 305A.
Operating conditions:	The high voltage sensor box must be kept away from magnetic fields and current carrying leads.

SELECTING INCREASED VOLTAGE SENSITIVITY

At the lowest voltage range 0-2000V, external magnetic fields could affect the voltage measurement. The high voltage devider in the voltage sensor box can be jumpered to better adapt to the optimum operating condition.

No jumper:	Input range 0-16kV; scaling 266.7
Connect jumper 16kV to 8kV:	Input range 0-8kV; scaling 133.4
Connect jumper 16V to 4kV:	Input range 0-4kV; scaling 66.67
Connect jumper 16kV to 2kV:	Input range 0-2kV; scaling 33.34



OPTION 11, ANALOG OUTPUTS, 17 SIGNALS

The analog output presents 17 on-line signals at its output connector (section 4-4). The signals are:

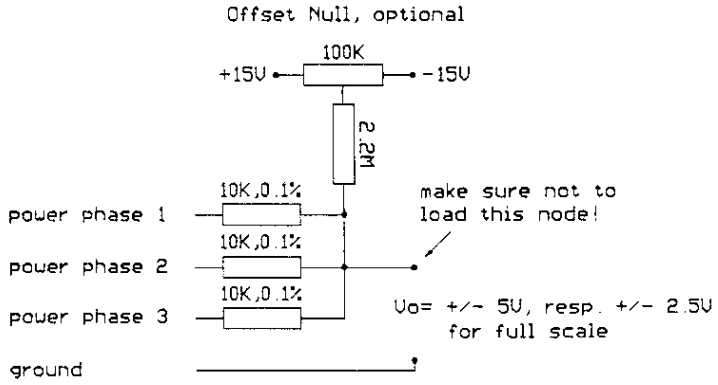
- 3x instantaneous current signals
- 3x instantaneous voltage signals
- 3x rms voltages (approx. 1 sec. time constant)
- 2x rms currents (I1 and I2)
- 3x average power (approx. 1 sec. time constant)
- 3x instantaneous power

The rms current of phase 3 is not connected to the rear panel connector.

Specifications:

Voltage output range:	±5V for full scale, max. ±10V
Output for instantaneous power:	±2.5V average, max. ±5V
Output impedance:	2kOhm, 1 %
Output offset:	±15mV; average power ±50mV; instantaneous power ±25mV
Accuracy:	0.3 % typical, power 0.6 % typical
Frequency range:	DC-800kHz

The sum of average or instantaneous power of all three phases can be obtained as follows:



OPTION 13, 3-PHASE LINE-TO-LINE VOLTAGE MEASUREMENT

Option 13 allows for line-to-line rms- and rectified mean voltage measurement as well as neutral current and neutral voltage measurement. For all quantities a true vectorial computation is performed.

Specifications:

Voltage ranges:	1.732 times the standard voltage ranges (7.5V, 15V, 30V, ... 960V).
Frequency range:	Same as line voltages

Accuracy:	DC-10kHz: ±0.5 %, typical 0.2 %; 10kHz-80kHz ±1.5 %
Display:	**Top line**, Line-to-line rms voltages First quantity: V12 = V1 - V2 (Phase 1 - Phase 2) Second quantity: V23 = V2 - V3 Third quantity: V31 = V3 - V1 Fourth quantity: V = V1 + V2 + V3 (vectorially) **Second display line**, Line-to-line rectified mean voltages and neutral current First quantity: V12t = V1 - V2 (rectified mean) Second quantity: V23t = V2 - V3 (rectified mean) Third quantity: V31t = V3 - V1 (rectified mean) Fourth quantity: Iorms = I1 + I2 + I3 neutral rms current in Ampere (units are not displayed)

PROGRAMMING

When the hardware for the line-to-line measurements is installed the following factory settings are performed: Select **PROG**, select menu **MODE**, and select **Von ***. (**Voff *** deactivates the line-to-line measurement).

OPERATION

To display the line-to-line voltages select **HARMONIC OFF**, select the **3W**-configuration, and select **LINE-TO-LINE** on.

OPTION 14, 4+4 EXTERNAL DC-INPUTS

Option 14 can be used to monitor external signals such as temperature, current, voltage, or power using one of the many Infratek Transmitters. Once every measurement cycle (0.62 seconds, standard averaging) these external inputs are scanned and can be displayed, printed or read via interface.

Specifications:

Inputs:	DC1, DC2, DC3, DC4; and DC5, DC6, DC7, DC8
Voltage range:	0 to ±5V, display ±5.0000
Accuracy:	0.1 %
Input impedance:	200kOhm
Update:	Once per measurement cycle
Galvanic isolation:	None
Scaling:	DC1 through DC4 can be scaled by C1 through C4

Optionally DC7 and DC8 can be a 0-10kHz frequency input.
The dc-inputs can be displayed pressing the control key **A=/V=** twice. The top line are DC1, DC2, DC3, and DC4 inputs, denoted by Ex1. The second line displays the DC5, DC6, DC7, and DC8 inputs, denoted by Ex2. Full scale is ±5.0000 when scaling factors 1 are used.

EXEPTIONS 305A-1 AND 305A-2

305A-2 allows also up to 8 dc-inputs but only DC1, DC2, and DC5, DC6 can be displayed (readable over interface).
305A-1 allows also up to 8 dc-inputs but only DC1 and DC5 can be displayed (8 inputs readable over interface).

There are three special versions available, a 3-phase motor test version, a 3-phase transformer test version, and a 1-, 2-, or 3-phase burden test version. The special features are described in the following pages. Additional specifications are given.

7.1. MOTOR TEST VERSION 305AM (3-PHASE ONLY)

The motor test version 305AM is a three-phase wattmeter with all the features of the standard 305A-3. In addition, it is equipped with 4 rear panel dc-inputs to measure torque, speed, frequency, and temperature. Four scaling factors, C1 for torque, C2 for speed, C3 for frequency, and C4 = number of poles can be entered from the front panel. Mechanical power, efficiency, and slip are computed. Because each quantity has different units no units are displayed and also no units are output when the mechanical data are read over the interface.
The computed values are shown in the following table:

TORQUE (Nm) DC1 * C1	SPEED (1/min) DC2 * C2	FREQUENCY (Hz) DC3 * C3	DC4
MECH.POWER (Wm) DC1*C1 * DC2-C2-2phi/60	EFFICIENCY eta =Pm/Pe	SLIP 1 - C4 * DC2/DC3 * 60	Not used 0

C1 through C4 are the scaling factors (last 4 factors in the scaling menu). C4 is the number of poles of the motor under test.
To display the values shown in above table press the control **A=/V=/Option** twice. The top line of the display corresponds to the top line of above table. "**Mec 1**" is added to this line to distinguish between line 1 and line 2. The second line of the display corresponds to the second line of above table. "**Mec 2**" is added.
These values can be printed or read from the interface with the output function commands H54 and H58.
The motor test version can be equipped with all available options except the second set of dc-inputs (DC5, DC6, DC7, and DC8), which can not be used because the memory locations are used by the values shown on the second line of above table.
When using external dc-inputs, the user is cautioned not to degrade signals due to external ground loops. Check signal inputs for hum or excessive noise.
The accuracy of the dc-inputs is specified in section 6, option 14.

7.2. TRANSFORMER TEST VERSION 305AT (3-PHASE ONLY)

The transformer test version 305AT is a three-phase wattmeter with all the features of the standard 305A-3. In addition, it is equipped with 4 dc-inputs for external sensors to monitor room temperature, transformer temperatures, and other physical quantities. Corrected power PC according IEC is computed for each phase and their sum is determined.
The computed values are shown in the following table.

DC1 • C1	DC2 • C2	DC3 • C3	DC4 • C4
PC1	PC2	PC3	PC1+PC2+PC3

Corrected Power PCx = $Px/(0.5 + 0.5\ (Vrx/1.1107 \cdot Vtx)^2)$
x = Phase 1, 2, 3
Vrx = rms voltage phase x
1.1107 • Vtx = corrected rectified mean voltage
Px = Power phase x

Specifications:

Power:	30Hz-1kHz: ±(0.05 % of input +0.05 % of range) for power factor 0 to 0.1
Corrected power (worst case):	Add accuracy percentage figures involved in the computation.

To display the values shown in above table press the **A=/V=/Option**-key twice. No units are displayed for the 4 dc-inputs. Corrected power is displayed in mW, W, kW, or W.
To print all 8 values use the print function command H4 (see also section 3.7). To read the top line of the display from the interface use the output function command H54. To read the second line use the H58 output function command.

7.3. BURDEN TEST VERSION 305AB-1/2/3

The burden test version is capable of obtaining accurate measurements at low currents and low voltages without influencing the circuit under test. Precise impedance measurements (magnitude and phase) can be performed. Even at the lowest current range of 25mA the measuring resistor in the current path is less than 0.005Ohm. Two plug-ins cover the current range 0-0.8A, and 0-32A.
In addition to the standard voltage input a low voltage input with ranges 0.75V, 1.5V, 3V, 6V, 12V, 24V, 48V, and 96V is supplied.
Other than the special features described above the instrument operates just like a standard 305A. The burden test instrument is available in single-, two-, and 3-phase versions.

Specifications:

Current ranges:	0.8A plug-in; 25, 50, 100, 200, 400, 800mA
	16A plug-in; 1, 2, 4, 8, 16, 32A (max. 32A)
Accuracy:	OHz-10kHz, same as Option 05
Impedance:	Less than 0.005Ohm
Voltage ranges:	Standard input; standard ranges
	Aux. input: 0.75, 1,5, 3, 6, 12, 24, 48, 96V
Accuracy:	Same as standard ranges
Impedance:	Standard input 1MOhm
	Aux. input: 100kOhm

SECTION 8

FUNCTIONAL DESCRIPTION, USAGE, AND PROTECTION OF THE 305A

Section 8 presents a functional description of the 305A Vector Wattmeter. The remainder of this section deals with measurement configuration and wattmeter protection.

8.1. FUNCTIONAL DESCRIPTION

The 3-phase Vector Wattmeter computes 144 different electrical quantities within each measurement cycle, the motor- and transformer test version compute even 152 quantities. Dedicated signal processors work in parallel and have new data ready each measurement cycle. The signal processors compute the average over a time of approximately 1 second. This window is shifting on the time axis. Every measurement cycle the main processor reads the signal processors. The values represent an average of the past 1 second time interval. This kind of averaging is also used for the values obtained by Fourier Transformation.
The input amplifiers for current and voltage have the purpose of amplifying signals to their proper level. This is achieved by gain switching and signal conditioning. The input amplifiers also serve the purpose of signal isolation. The amplified signals are converted and transmitted to the main electronics.
The 305A is controlled by the main controller. It collects data from the signal processors, displays data, and serves the data outputs. At the beginning of a measurement cycle data from all signal processors including the Fourier transforms are received. Where required, the controller performs further data processing. In the same time interval the rear panel dc-inputs are multiplexed to an A/D-converter and also transferred to the controller.
In the remainder of a measurement cycle the controller serves the front panel, the display, the printer, and the interface.

When performing an automatic system analysis the 305A scans in approximately 1.8 second intervals the whole set of broad band values and all values from one harmonic (3 currents, 3 voltages, 3 power, 3 apparent power, 3 reactive power, and impedances including phase). For the higher harmonics (second and up) %-values of harmonic divided by broad band values are determined. This assures correct measurements even when the supply or the loading is varrying.
In this type of measurement an average over the past 1 second time interval is determined. This is the reason why in the analyze mode always standard averaging must be used.

Most practical systems (electrical loads) are time independent systems, that is, the system parameters (resistance, inductance, and capicitance) are constant or if they are varrying the variation is slow (1 % change over 15 minutes). As a consequence above described measurement process can be used to monitor system parameter changes over a long periode of time.

8.2. HOW TO USE AND PROTECT YOUR 305A

There are many measurement considerations for measuring power in three phase systems.

2-WATTMETER-CONFIGURATION

If you have an application to measure power in a 50/60Hz system or in a thyristor controlled system you could use the 2-Wattmeter connection and use the third channel for other measurements. In that case select **"2W"** configuration on the 305A front panel.

You must be aware of the fact that in addition to the current inputs also the voltage low terminals are exposed to the full common mode signal of the line voltages. In standard 50/60Hz applications and thyristor controlled circuits there is nothing to worry about.

When you switch off inductive loads you must be aware of the stored energy in the inductance. This energy is either discharged in the load itself, or discharged through the wattmeter inputs, or radiated. The discharging is always accompanied with a extremely fast voltage rise up zo ±4000V within microseconds. The faster the circuit breakers open the faster is the voltage rise. Because all Infratek Wattmeters have isolated inputs and exhibit only 20pF to 40pF capacitance from input to earth the wattmeter input will rise to any voltage level above or below ground potential. If excessive transients occure to 4 wattmeter inputs simultaneously damage may result or its operation may be disturbed.

In system applications where frequent load switching is required the following precautions help to reduce or eliminate transients.

1. Use switches that open when current goes through zero.

2. Connect wattmeter to a good power ground.

3. Place switches that turn off the load supply 2m away from the wattmeter terminals between wattmeter and load. If necessary place a chocke between switch and wattmeter. The situation can be improved when a 10nF capacitor is placed between the current- and voltage low terminals to wattmeter power ground.

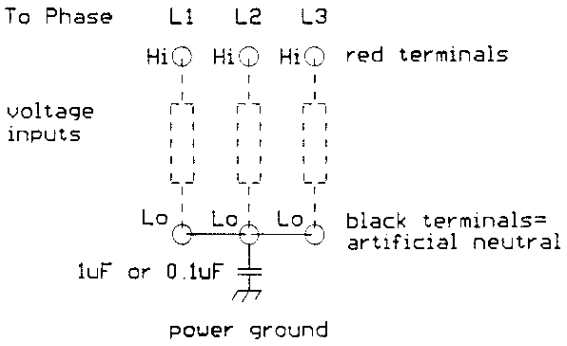
4. If both, the wattmeter and the load, must be disconnected from power use two switches. One as described in 3 and the second switch between supply and wattmeter. First turn off the switch between wattmeter and load and 1 second later the switch between supply and wattmeter.

5. The worst situation results, when the load is supplied from an isolation transformer with ground disconnected from the wattmeter power ground. Precautions 1 through 4 do not work unless the reference potential of the isolation transformer is set to wattmeter power ground before the load is turned off. This ground switching could be achieved with an additional switch between wattmeter power ground and isolation transformer reference potential.

3-WATTMETER CONFIGURATION

The 3-wattmeter configuration is by far the best configuration for all types of applications. It is mandatory to use the 3-wattmeter hook-up in frequency inverter driven systems. Due to the switching transients of up to 10kV/microsecond, which unfortunately act as common mode signals at the wattmeter current inputs and at the low terminals of the voltage inputs, common mode errors result. Not surprising. The slew rate of 10kV/microsecond corresponds to a common mode signal of 100Vrms at 10MHz.

Instead of fighting the system use a plug-in with enhanced common mode (16A, 80A/800A) and connect the voltage input low terminals together to form an artifical neutral. Put a 1 microfarad capacitor to ground if there is no neutral available in your system.



If a neutral is accessible connect the low voltage terminals to the system neutral. The red Hi-terminals of the voltage inputs can be exposed to the switching transients. The plug-ins with enhanced common mode feature additional isolation of the current paths.

In system applications where frequent load switching is required follow the same recommendations given in this section for the 2W-configuration.

305AH VECTOR WATTMETER WITHOUT HARMONIC MEASUREMENT

The 305AH-versions (without harmonic measurement) differs from the standard 305A Vector Wattmeter as follows:

- Harmonics are not measured. As a consequence all %-values relating harmonics to broad band values are zero.
- Frequencies of fundamental and harmonics are not measured.
- Power factor PF = W/VA; from broad band values.
- Reactive power Var = $\sqrt{VA^2 - W^2}$; is always positive and can not distinguish between inductive reactive power (+Var) and capactive reactive power (-Var).
- Phase angle φ = arctg Var/W ; 0 to 90°.
- Sum VA = VA1 + VA2 + VA3
- Sum Var = Var1 + Var2 + Var3
- Power factor of total = SumW / SumVA

Harmonic quantities can still be printed when they are selected in the output menu. All values are zero. Furthermore, harmonic quantities can also be read via interface. The 305AH can be programmed to perform the analyze function, all values will be zero.