# USERS MANUAL 108A

## SINGLE- TO SIX PHASE

## INFRATEK POWER ANALYZER

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## 1. Power Analyzer Features, Quick Overview, Safety

The Infratek 108A High Precision Power Analyzer is available in 1-, 2-, 3-, 4-, 5-, or 6- phase versions. All voltage inputs (ranges 0.3V up to 1500Vpeak) and all current inputs (1.5mA up to 1A; 15mA up to 5A; 1A up to 40A; and current shunt inputs 60mV up to 6V) are potential free and exhibit

- Excellent low noise
- Common mode suppression
- DC-stability
- Wide frequency range (2MHz)
- Very low self-heating on current inputs.

There is no need to fiddle with dc-compensation, or changing current plug-ins. All is built into the input sections of the Power Analyzer, ready to be used.

Your intuition will guide you to operate the Power Analyzer touch screen correctly. With basic knowledge of power measurement, you will be able to change the settings to your needs. Almost all setting changes are accomplished with two touches on the display screen or two clicks with the mouse.

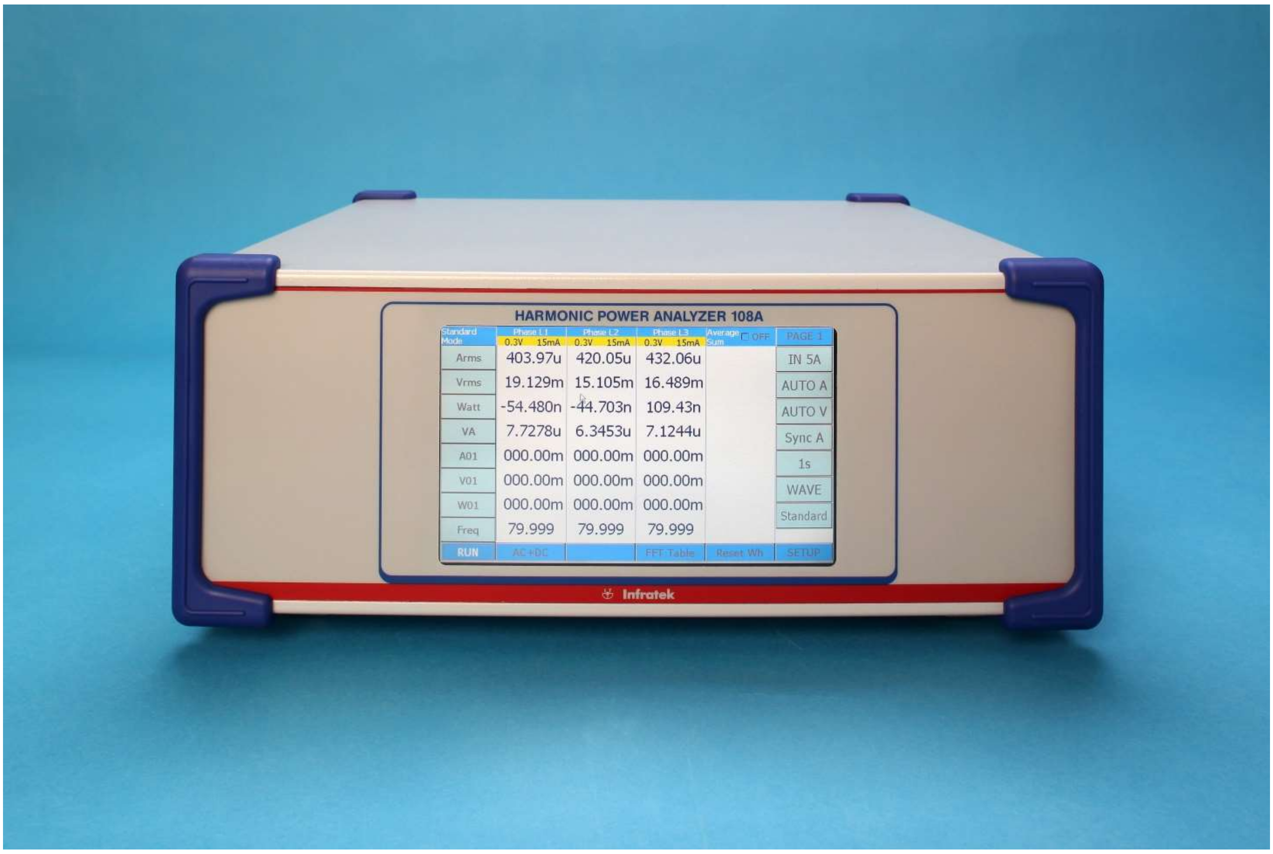



Figure 1.1 Shows the display of a 3-phase instrument in “Standard Mode”.

Figure 1.1 shows the display of a 3-phase instrument in “Standard Mode”. To change the current range from 15mA to 500mA touch the button “AUTOA”. A pop-up window is presented from which you select “500mA”. Now the Power Analyzer is in 500mA current range (manual ranging).


Figure 1.2     108A Value Selection Table

Just as simple is to change the quantity at the bottom line “Freq” to Arectified mean (Arect). Touch “Freq” at the left side of the display. This will present you a value selection table as shown in Figure 1.2. Now touch “Arect” which brings you back to Figure 1.1 with the bottom line quantity changed to “Arect”.

Four different measure modes enhance the 108A Power Analyzer capabilities. These are: standard measure mode, logging measure mode, transient measure mode, and power-speed measure mode.

## 1.1 Standard Measure Mode

In the Standard Measure Mode 280 quantities per phase are continuously measured (no gaps) and are updated. Values can be displayed on four display pages, can be saved in internal memory, or on a memory stick, or can be transferred via Interface to a computer.

Touching “WAVE” will display a sub-menu which lets you select the current-, voltage-, and power wave forms of any phase.

Select “OFF” (Wave OFF). Now you have access to the buttons “FFT Table”. Touching “FFT Table” selects “FFT L1”. On five pages you can now view the harmonics of current, voltage, power, and phase angle (harmonics 1 to 40 for current and voltage, harmonic 1-21 for power and phase angle).
Similarly, selecting “FFT Bar” the bar graph of the harmonics will be displayed in percent of the fundamental (1. harmonic).
Touching “FFT L1” will toggle to “FFT L2”, “FFT L3”, and so on.

## 1.2 LOGGING MEASURE MODE

The basic operation is as follows: Select the number of cycles for which you desire a periodic data output to the RS232- / USB-IEEE interface. If you perform measurements on the 50Hz power line and you select cycles = 1 you obtain new data every 20ms; if you select cycles = 30000 you obtain new data every 10 minutes.

Before starting the measurement, a valid synchronization signal 5Hz to 2kHz must be applied to all installed phases of your Power Analyzer. Select SyncA, SyncV, or S_Ext V. Touch the START-button to start the measurement, touch the STOP-button to stop it. DC signals can also be measured (e.g. DC-motors). For DC you must apply an external synchronization signal in the frequency range 5Hz – 2kHz (select EXT synchronization).
Furthermore, the frequency of the synchronization can be varied up and down as much as 10% per second.

From every phase you obtain 8 values: frequency, RMS current, RMS voltage, power, power factor, apparent power, energy Wh, and apparent energy VAh.
If you select the baud rate of 463.2 kBaud (in SETUP) a 6-phase Power Analyzer transmits 8 x 6 = 48 values in less than 20ms. This can be used to analyze the start-up behaviour of power systems.

## 1.3 TRANSIENT MEASURE MODE

The transient measure mode can be used in two ways: You can catch current-, voltage-, and power wave forms in a start-up on all phases simultaneously or you can view all wave forms at a critical operating point in Standard Measure Mode (up to maximum 6 phases).

The duration of the measurement is set by changing in the SETUP menu the Transient-id from 0 to 7. Sections of the wave forms can be expanded by simply touching one of the 4 “Zoom Sectors” (maximum zoom factor is 256).
For proper operation you must apply signal synchronization to all installed phases of your Power Analyzer.

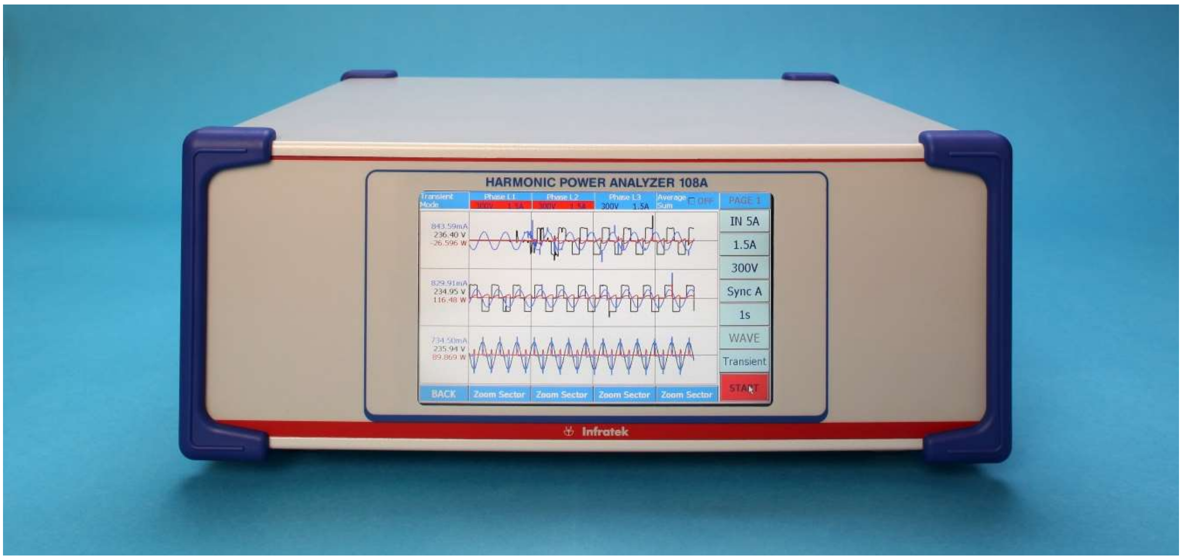



Figure 1.3 108A 3-Phase Power Analyzer Display in Transient Measure Mode

## 1.4 POWER-SPEED MEASURE MODE (OPTION)

This measure mode analyzes the performance of electric devices such as electric cars.

In 20ms intervals the following data are stored in internal memory: RMS current, RMS voltage, power, apparent power, energy, apparent energy, and speed of an axis or a wheel. Rms current and –voltage are average values of the number of phases used, power and energy are the sums of phases used.

Power speed measurements can be performed on DC- as well as AC-drives using either phase 1, or phase 1 and phase 2, or using phase 1, 2, and phase 3 of the Power Analyzer.

At the end of a measurement cycle (maximum 11 seconds) data versus time are plotted, can be expanded to view details, or can be stored.

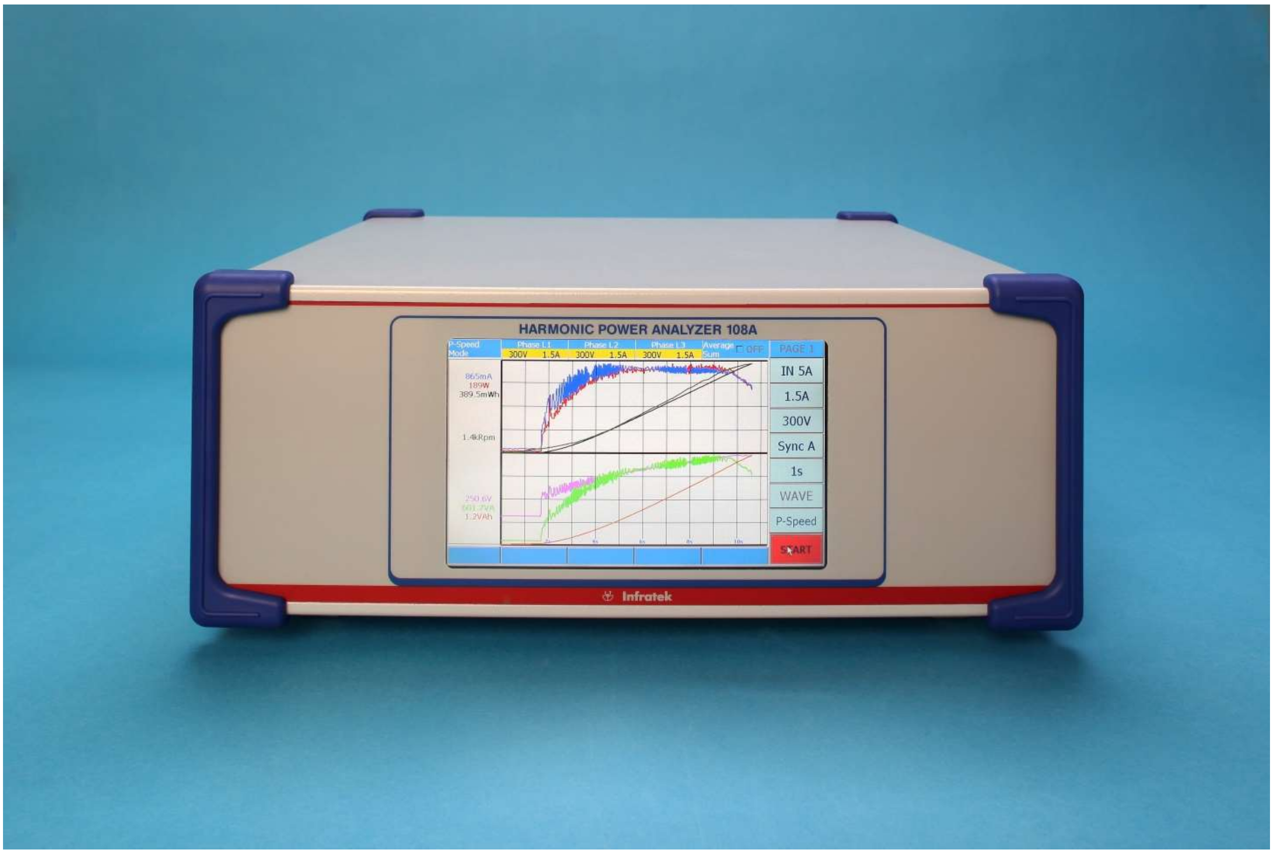



Figure 1.4 108A 3-Phase Power Analyzer in Power-Speed Measure Mode

## 1.5 POWER ANALYZER REAR PANEL

Figure 1.5 shows the 108A rear panel with three phases installed. Every phase consists of a potential free voltage input along the top side.
Below the voltage inputs are the 40A input, and the 5A input (7A max.) with common Lo socket. Above the 40A socket is the 3 pole Amphenol socket for the 1A input and shunt input. It is normally covered with the shunt short circuit cap.


Figure 1.5 Rear panel of a 3 Phase Power Analyzer

All four current inputs are referenced to the black Lo socket and are potential free.

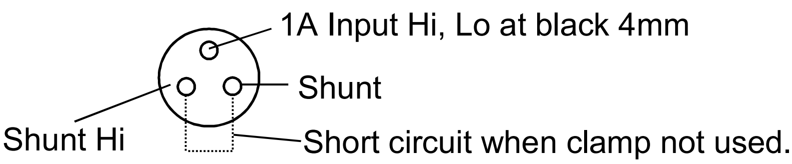



Figure 1.6 3 pole Amphenol Socket for 1A current input and shunt input

For use of 1A input remove the shunt short circuit cap and insert the 1A adapter. The 1A adapter is the Hi input, and the black current socket is the 1A Lo.

**Caution:** When 1A adapter is removed the shunt short circuit cap must be inserted.

## 1.6 SUMMARY OF 108A POWER ANALYZER FEATURES

- Available as 1-, 2-, 3-, 4-, 5-, or 6-phase instrument.
- Highest precision available: 0.02 % reading + 0.02 % range.
- 18bit measurement resolution. High accuracy at 10 % full scale.
- Wide angle, touch-screen TFT color display (800 x 480 pixels).
- Simple to operate, most settings in 2 steps (2 touches).
- Settings per phase for V- A-ranges, current inputs, and synchronization.
- Standard-, Logging-, Transient-, Power-Speed measurement functions.
- Standard: calculates all quantities of power electronics, including motor- and transformer values, harmonics, energies, analog inputs, and speed.
- Very fast data transfer; up to 3400 values per second.
- High DC precision for solar applications.
- Includes 4 current inputs: 1mA - 1A, 15mA - 5A, 1A - 40A, shunt.
- Voltage Ranges: 0.3V to 1000V.
- USB memory stick >4GByte
- USB interface for downloading measurement data
- Optional interfaces: RS232, USB, Ethernet, IEEE-488
- Optional: 2 frequency inputs max 150kHz, 6 analog inputs, and 12 analog outputs.
- Interface commands for fast data transmission.
- Optional operating software under Windows, LabView Driver
- Reasonably priced by virtue of smart design.
- Simple servicing, modular concept, pre-calibrated input amplifiers.
- Optional high precision, broadband, current sensors.
- Upgrading the number of installed phases is possible at any time

## 1.7 SAFETY INSTRUCTIONS

The manufacture of this equipment conforms to the safety standards defined in IEC 61010-1.

**Protection:** The device assigns to protection class II and is equipped with a protective earth stud.

This equipment may be operated only by qualified personnel. A qualified person has completed training to operate a Power Analyzer.

### PROPER USE

Do not exceed maximum currents of the 1A-input, 5A-input, 30A-input, and the shunt input.
Do not exceed maximum voltages on voltage inputs. Do not exceed 1000V on any input terminal with respect to case.
Improper use or modifying any part of the equipment shall void all warranty.

Warranty
The warranty period is 2 years from the date of purchase.

### CONNECTING A POWER ANALYZER

- Use a power line cable with earth connection
- Inspect the connecting cable for faulty connection
- Connect the rear panel earth stud to power ground
- Make cable connections with the help of a second qualified person
- Ensure that connected devices work properly
- In case of direct connection to current circuits we recommend to use an external protection circuit to not exceed the maximum current input in use (1A, 5A, 30A)
- Refer Power Analyzer servicing and repair to authorized organizations
- Use of this instrument in life support systems and in systems for people transportation must be expressly authorized by the manufacturer
- Use shielded cables for interface connections and keep interface cables away from parts which can carry large currents and transients.

## 2. Connection to Circuits

Please read section “Safety” of this manual before performing the measurements described below.

## 2.1 Measurement in 3-Phase mains Circuit

### 2.1.1 Three Wattmeter Connection

Power and energy consumed by a load are positive values. This means that current Hi and Lo, and voltage Hi and Lo must be connected in correct directions (polarity).

Rule 1: All currents flow from supply to load that is into the red current socket and from current Lo (black socket) to input of load.

Rule 2: Connect current Lo to voltage Hi.
Connect all voltage Lo to power line neutral (3 wattmeter circuit)

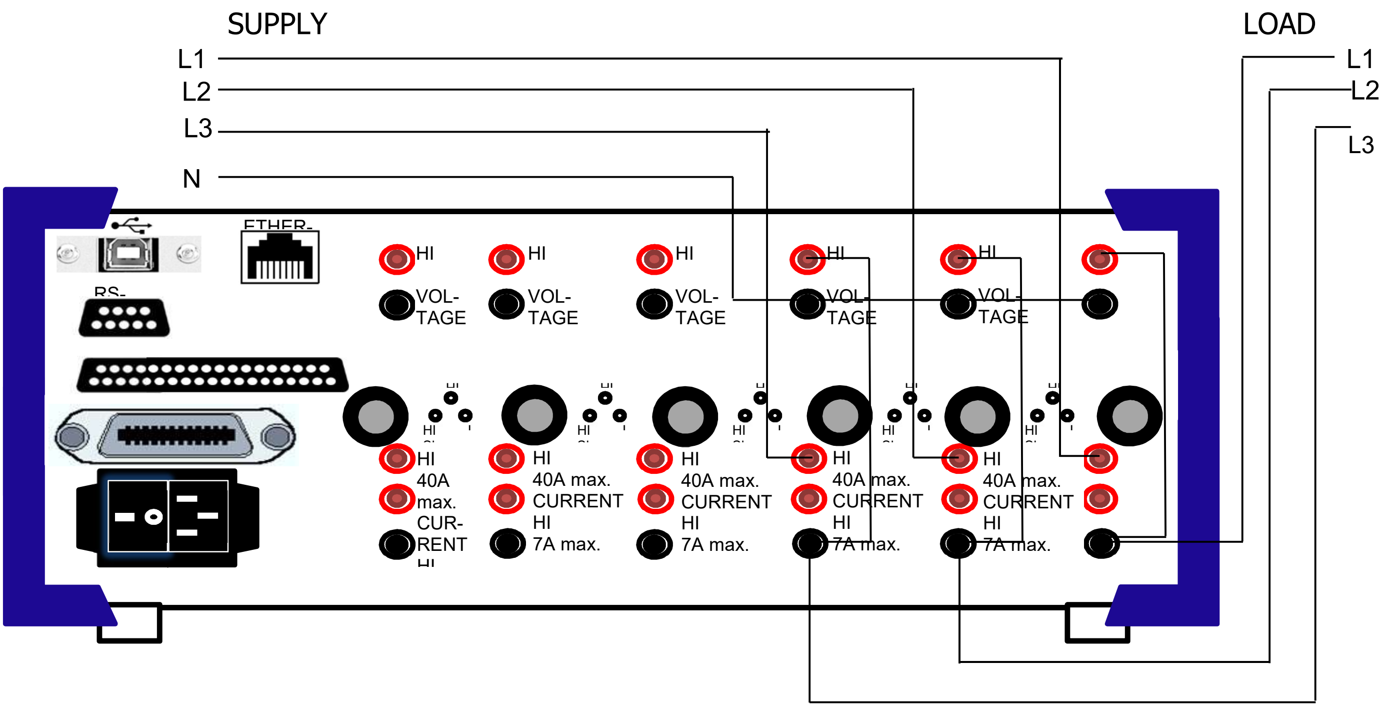



Figure 2.1 Power Measurement in 3-phase mains circuit using three Wattmeter configuration. Rule 1 and Rule 2 apply.

Power values of the 3 phases are all positive. You can verify that power of phase 1 becomes negative by reversing current phase 1.

### 2.1.2 Aron Connection

Important! Do not use Aron Connection for unsymmetrical loads.

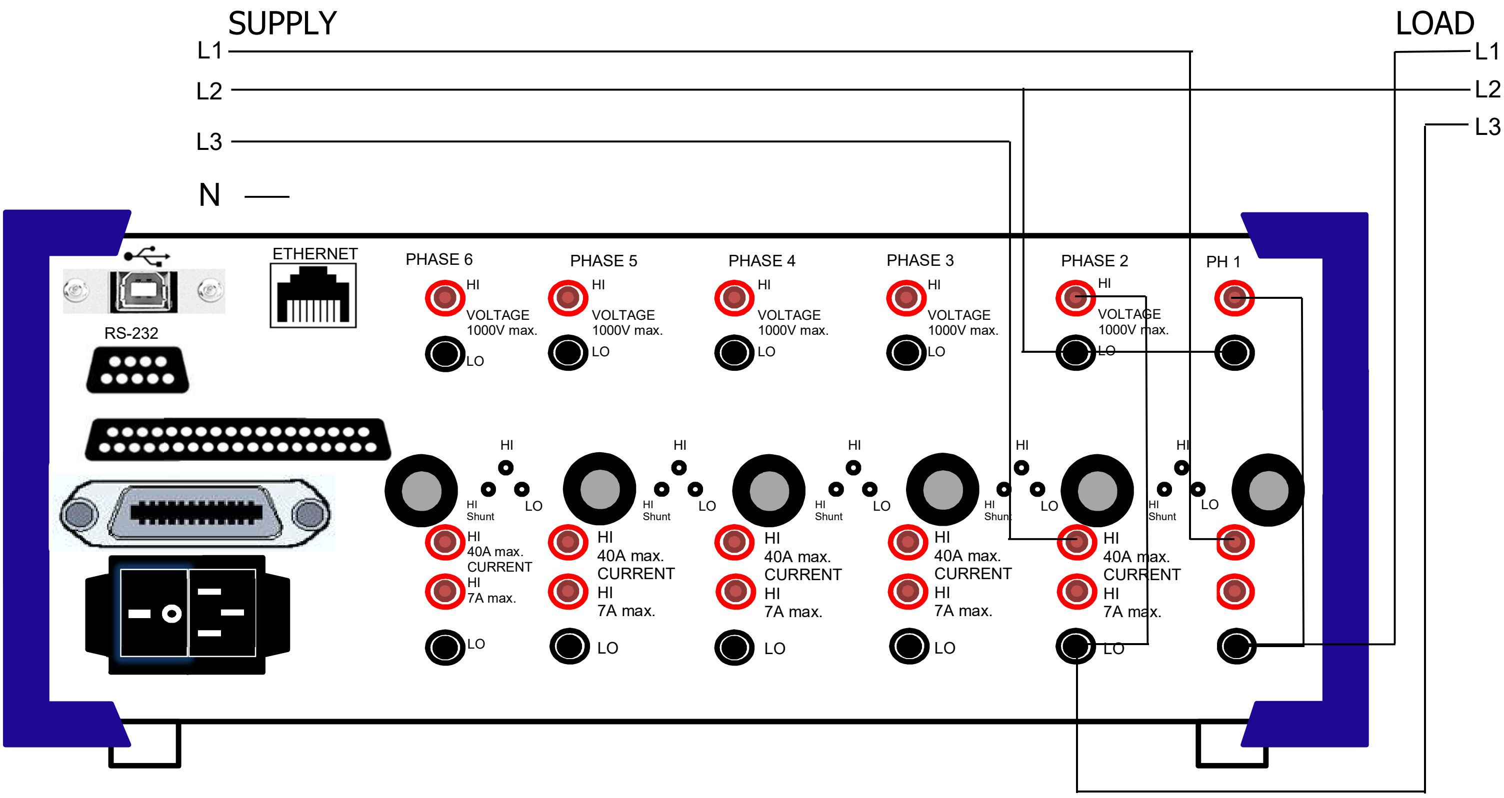



Figure 2.2 Measurement in 3-phase mains circuit using 2 Wattmeter configuration. Rule 1 and Rule 3 apply.

Rule 3: Voltage Lo connects to third wire not used for current measurement (Figure 2.2). Phase to phase voltages are measured.

The 2 Wattmeter circuit measures 2 currents, and 2 line-to-line voltages and determines total power of the 3 phase load. One of the displayed power values can become negative due to phase shifts of inductive loads. This may lead to confusion. Therefore, strictly follow rule 1 and rule 3.

### 2.1.3 Connecting a 6 Phase Power Analyzer to 2 Mains Circuits

Figure 2.3 shows the connections to a 6-phase Power Analyzer using three 30A current inputs and three 1A current inputs from a three phase 0-100A current sensor module. Such current sensors have at 100A primary current a nominal of 50mA output current and therefore require a current scaling factor of 2000 to display actual current and power.

This is how you proceed.

- Make connections as shown in Figure 2.3. Observe Rules 1 and 2 to obtain positive power on all phases. **Note:** Rms current is positive independent of direction
- Touch Phase 1 button, select 30A (green), touch Phase 1 to exit. Touch Phase 2 button, select 30A, touch Phase 2 to exit. Do the same for phase 3.
- Finally, select the 1A input for Phase 4, 5, and 6.
- Select the appropriate ranges for current and voltage, or select auto-ranging.
- Select SETUP and enter the current scaling factors required for the current sensors

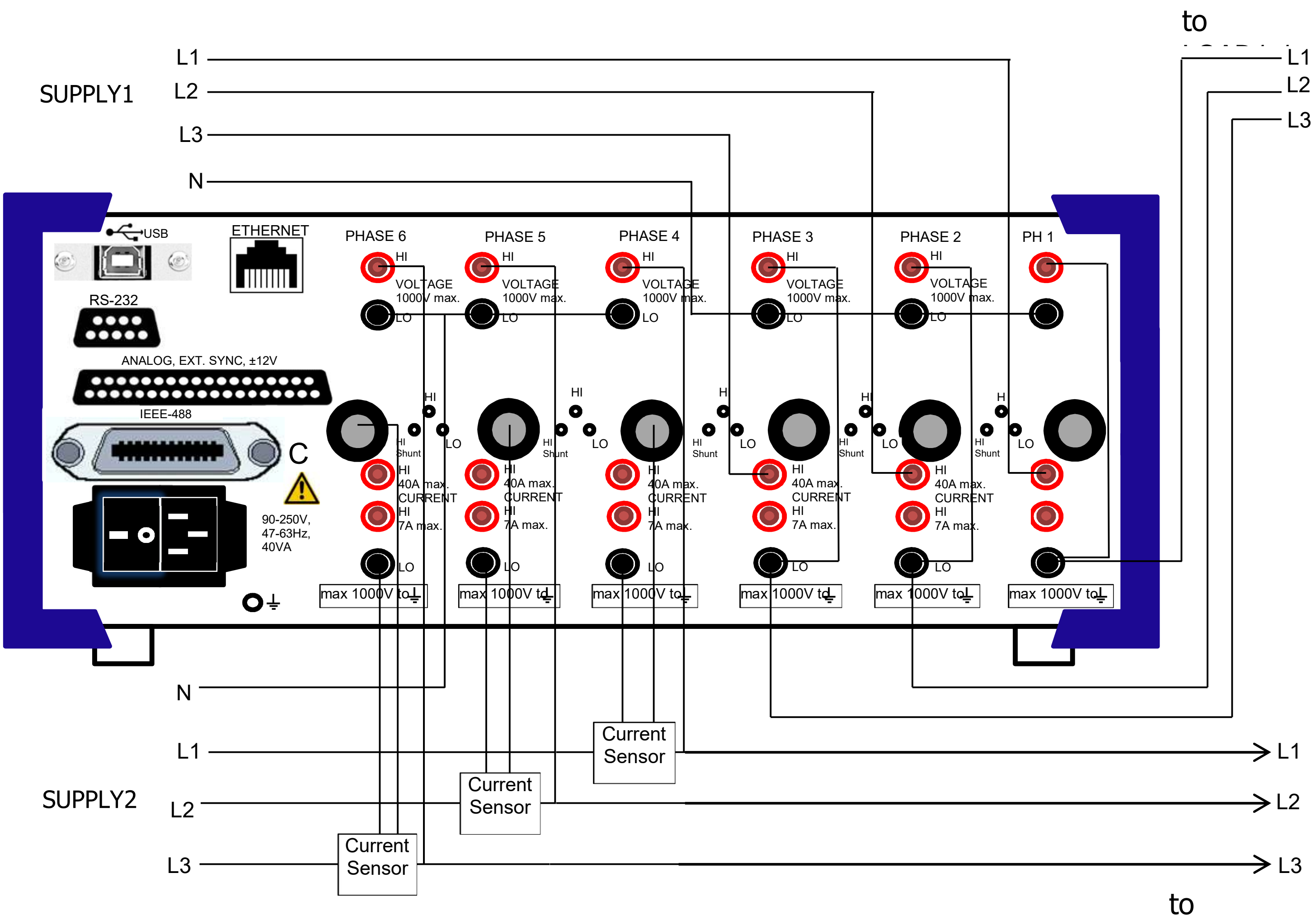



Figure 2.3 Power measurement using three 30A current inputs and three 1A current inputs

# 3. 108A Mathematical Definitions and Specifications

## 3.1 Mathematical Definitions

Tables 3.1 and 3.2 define all quantities measured and computed. The “batch” column shows the symbol that must be used in the interface batch command of section 6 (setting the quantities viewed on the display).

Table 3.1. List of standard values that can be displayed

| Description | Symbol = Formula, Description | Batch |
|---|---|---|
| rms current | Arms = $(1/T \int_0^T A^2 dt)^{1/2}$, includes all harmonics | A00 |
| mean current | Amean = $1/T \int_0^T A dt$, dc-component of current | A01 |
| rectified mean current | Arect = $1/T \int_0^T \lvert A \rvert dt$, rectified mean current | A02 |
| peak current | Amax = maximum current in time interval | A10 |
| current distortion | Athd1 = $(Arms^2 – A01^2)^{1/2}$ / Arms, use for frequency inverter | A23 |
| harmonic current distortion | Athd2 = $(\Sigma An^2)^{1/2}$ / Arms, n = 2,3, … 40 | A25 |
| current crest factor | Acf = Amax / Arms | A20 |
| current form factor | Aff = Arms / Arect, is 1.1107 for sine wave | A22 |
| current fundamental | A01 = fundamental current of FFT | A35 |
| current 2. to 7. harm | A02,A03,A04,A05,A06,A07 | A37,A39,A41,A43,A45,A47 |
| current 8. to 13. harm | A08,A09,A10,A11,A12,A13 | A49,A51,A53,A55,A57,A59 |
| rms voltage | Vrms = $(1/T \int_0^T V^2 dt)^{1/2}$, includes all harmonics | A03 |
| mean voltage | Vmean = $1/T \int_0^T V dt$, dc component of voltage | A04 |
| rectified mean voltage | Vrect = $1/T \int_0^T \lvert V \rvert dt$, rectified mean voltage | A05 |
| peak voltage | Vmax = maximum voltage in time interval | A13 |
| lowest voltage | Vmin = lowest voltage in time interval | A12 |
| peak to peak voltage | Vptp = $V_{max} – V_{min}$ | A11 |
| voltage distortion | Vthd1 = $(Vrms^2 – V01^2)^{1/2}$ / Vrms, use for frequency inverter | A24 |
| harmonic voltage distortion | Vthd2 = $(\Sigma Vn^2)^{1/2}$ / Vrms, n = 2,3, …, 40 | A26 |

| Table 3.1: continued. List of standard value that can be displayed | | |
|---|---|---|
| Description | Symbol = Formula, Description | Batch |
| voltage crest factor | Vcf = Vmax / Vrms | A19 |
| voltage form factor | Vff = Vrms / Vrect, is 1.1107 for sine wave | A21 |
| voltage fundamental | V01 = fundamental voltage of FFT | A36 |
| voltage 2. to 7. harm | V02,V03,V04,V05,V06,V07 | A38, A40, A42, A44, A46, A48 |
| voltage 8. to 13. harm | V08,V09,V10,V11,V12,V13 | A50, A52, A54, A56, A58, A60 |

| | | |
|---|---|---|
| active power | W = 1/T $^T\int_0$ u·i dt, total power in W | A06 |
| apparent power | VA = Arms · Vrms, total apparent power VA | A17 |
| reactive power | Var = ±($Papp^2$ – $Pact^2$)$^{1/2}$, reactive power Var | A18 |
| power factor | PF = Pact / Papp, includes all harmonics | A27 |
| fundamental power | W01 = A01 · V01 · cos φ01, φ01 = phase | A61 |
| fund apparent power | VA01 = A01 · V01 | A29 |
| fund reactive power | Var01 = ($VA01^2$ – $W01^2$)$^{1/2}$, magnitude only | A30 |
| fund power factor | PF01 = W01 / VA01 | A28 |
| power 2. to 6. harm | W02, W03, W04, W05, W06 | A63, A65, A67, A69, A71 |
| power 7. to 10. harm | W07, W08, W09, W10 | A73, A75, A77, A79 |
| power of distortion | D = V01(Σ$An^2$)$^{1/2}$, n = 2,3, …, 40; D in Watt | A31 |

| | | |
|---|---|---|
| energy | Wh = $^t\int_0$ Pact · dt, active energy in Wh | A14 |
| apparent energy | VAh = $^t\int_0$ Papp · dt, use it for long term PF | A15 |
| reactive energy | VAR = $^t\int_0$ Prea · dt, can be positive / negative | A16 |
| battery charge | Ah = $^t\int_0$ Arect · dt, is positive only | A09 |
| elapsed time | time = $^t\int_0$ dt, time in hours since RESET | A32 |

| | | |
|---|---|---|
| magnitude impedance | Mag Z = V01 / A01 fundamental | A33 |
| phase of fundamental | Phi01 = phase V01, A01 | A34 |
| phase 2. to 6. harm | phase 2., 3., 4., 5., 6. harmonic | A64, A66, A68, A70, A72 |
| phase 7. to 10. harm | phase 7., 8., 9., 10. harmonic | A74, A76, A78, A80, |
| frequency | Freq =zero crossing of A, V, Ext; SYNCI, U, Ext | A07 |

**Note:** Harmonic values not contained in table 3.1 can be read via interface:
These are: current A14 to A88 and voltage V14 to V88.

| Table 3.2: List of special values that can be displayed | | |
|---|---|---|
| Description | Symbol = Formula, Description | batch |
| sum1 of power | sum1 = Pact1 + Pact2 + Pact3; Power phase 1+2+3 | A81 |
| sum2 of power | sum2 = Pact1 + Pact2 | |
| sum3 of power | sum3 = Pact4 + Pact5 + Pact6; Power phase 4+5+6 | |
| sum4 of power | sum4 = Pact4 + Pact5 | A82 |
| sum5 of power | sum5 = not used | |
| sum6 of power | sum6 = not used | |
| ratio1 of power | ratio1 = Pact4 / Pact1 + Pact2 + Pact3 | A83 |
| ratio2 of power | ratio2 = Pact3 / Pact1 + Pact2 | |
| ratio3 of power | ratio3 = Pact2 / Pact1 | |
| ratio4 of power | ratio4 = Pact4 + Pact5 + Pact6 / Pact1 +Pact2 +Pact3 | A84 |
| ratio5 of power | ratio5 = Pact6 / Pact4 + Pact5 | |
| ratio6 of power | ratio6 = Pact5 / Pact4 | |
| Motor1 Values from phase 1, phase 2, and phase 3 | | |
| Mec input power | Pin = electric power applied to motor | A85 |
| Mec output power | Pout = Pin – Pin at no load in Watt (Loss) | |
| Torque | Torque = Pout · poles1 / 4 · 3.1416 · frequency1 | |
| Slip | Slip = 1 – fout / fin | A86 |
| rotation per minute | rpm = 120 · frequency1 / poles1 | |
| efficiency | efficiency = 1 – Pin at no load / Pin | |
| Transformer values from phase 1 and phase 2 | | |
| Vrect, rms corrected | Vcorrected = 1.1107 · Vrect | A87 |
| correted power | Corr power = Pact 1 / (0.5 + 0.5 · Vrms / Vcorrected) | |
| Loss factor Q | Q = tan X/R, where Z=R + jX | |

| Table 3.2: List of special values that can be displayed | | |
|---|---|---|
| Description | Symbol = Formula, Description | batch |
| Loss resistance | Equivalent loss resistance = Pact1 / $Arms^2$ | A88 |
| Loss inductance | Equivalent loss reactance = Prea 1 / $Arms^2$ | |
| turn ratio | turn ratio = N2 / N1 = Vrms2 / Vrms1, no load | |

| | | |
|---|---|---|
| analog input1 | ±5V analog input1 | A89 |
| analog input2 | ±5V analog input2 | |
| analog input3 | ±5V analog input3 | |
| analog input4 | ±5V analog input4 | A90 |
| analog input5 | ±10V analog input5 | |
| analog input6 | ±10V analog input6 | |
| V1 line to line | V1 ltl = $(V_{1rms} + V_{2rms}) \cdot 0.86603$ | A93 |
| V2 line to line | V2 ltl = $(V_{2rms} + V_{3rms}) \cdot 0.86603$ | |
| V3 line to line | V3 ltl = $(V_{3rms} + V_{1rms}) \cdot 0.86603$ | |
| V4 line to line | V4 ltl = $(V_{4rms} + V_{5rms}) \cdot 0.86603$ | A94 |
| V5 line to line | V5 ltl = $(V_{5rms} + V_{6rms}) \cdot 0.86603$ | |
| V6 line to line | V6 ltl = $(V_{6rms} + V_{4rms}) \cdot 0.86603$ | |
| Motor2 Values from phase 4, phase 5, phase 6 | | |
| Mec input power | Pin = electric power applied to motor | A95 |
| Mec output power | Pout = Pin – Pin at no load in Watt | |
| Torque | Torque = Pout · poles / 4 · 3.1416 · frequency2 | |
| Slip | Slip = 1 – fout / fin | A96 |
| rotation per minute | rpm = 120 · frequency / poles | |
| efficiency | efficiency = 1 – Pin at no load / Pin | |

*Example:*

Assuming you are using a 2-phase Power Analyzer and want to display ratio 3 = Pact2 / Pact1 at the bottom of the display (Figure 1.1). Touch icon, “Ah” (Fig. 1.1). In the value selection table touch “R1|R2|R3” (Fig. 1.2).
In Figure 1.1 at the bottom line you have now 3 quantities displayed: ratio1, ratio2, ratio3, where ratio1 = 0, ratio2 = 0, and ratio3 = Pact2 / Pact1.

## 3.2 SPECIFICATIONS

| Voltage Measurement | | | |
|---|---|---|---|
| % reading + % range | 8 measuring ranges: 0.3V – 1V – 3V – 10V – 30V – 100V – 300V – 1000V | | Bandwidth DC-2MHz |
| | Coupling: AC or AC + DC | Common mode rejection: | 100dB at 100kHz |
| | Input impedance: 1MΩ / 15pF. Floating input | | max. 1000Vrms |
| | Crest Factor 15:1 at 10% fs. Typical accuracy at 10% is 0.1% | | fs = full scale |
| | Temperature coefficient: 0.004% / °C | | |
| | Standard accuracy 23°C ±1°C. 3V to 600V | | **High precision** 10V to 600V |
| | 45 to 65Hz | 0.08 + 0.08 | 0.02 + 0.02 |
| | 3 to 1000Hz | 0.1 + 0.1 | 0.03 + 0.03 |
| | 1 to 10kHz | 0.2 + 0.2 | 0.1 + 0.1 |
| | 10 to 100kHz | (0.2 + 0.2) +(0.2 + 0.2)*log(f/10kHz) | (0.2 + 0.2) +(0.2 + 0.2)*log(f/10kHz) |
| | DC[1]//100-500kHz[1] | 0.1 + 0.1// 0.012*f(kHz) | |
| | Linearity 100V range: | 130 % 100 % 50 % 10 % 5 %<br>130.01V 100.00V 49.988V 10.000V 5.0014V | Typical linearity at 50/60Hz |
| Voltage Scaling U1-U6 | Individual voltage scaling factors of every phase. Use pop-up number pad. Format 2000.8. | | |

| Measured & Computed Voltage Values | | | |
|---|---|---|---|
| RMS voltage | $Vrms = (1/T \int_0^T V^2 dt)^{1/2}$, includes all harmonics | Voltage crest factor | Vcf = Vmax / Vrms |
| Mean voltage | $Vmean = 1/T \int_0^T Vdt$, dc component of voltage | Voltage form factor | Vff = Vrms / Vrect, is 1.1107 for sine wave |
| Rectified mean voltage | $Vrect = 1/T \int_0^T \lvert V \rvert dt$, rectified mean voltage | Voltage fundamental | V01 = fundamental voltage of FFT |
| Peak voltage | Vmax = maximum voltage in time interval | V1 line to line | $V1\ ltl = (V_{1rms} + V_{2rms}) \cdot 0.86603$ |
| Lowest voltage | Vmin = lowest voltage in time interval | V2 line to line | $V2\ ltl = (V_{2rms} + V_{3rms}) \cdot 0.86603$ |
| Peak to peak voltage | $Vptp = V_{max} - V_{min}$ | V3 line to line | $V3\ ltl = (V_{3rms} + V_{1rms}) \cdot 0.86603$ |
| Voltage distortion | $Vthd1 = (Vrms^2 - V01^2)^{1/2} / Vrms$, [2] | V4 line to line | $V4\ ltl = (V_{4rms} + V_{5rms}) \cdot 0.86603$ |
| Harmonic voltage distortion | $Vthd2 = (\Sigma Vn^2)^{1/2} / Vrms$, n = 2,3, …, 40 | V5 line to line | $V5\ ltl = (V_{5rms} + V_{6rms}) \cdot 0.86603$ |
| | | V6 line to line | $V6\ ltl = (V_{6rms} + V_{4rms}) \cdot 0.86603$ |

| Current Measurement | | | | | |
|---|---|---|---|---|---|
| % reading + % range | 4 inputs: In30A, In5A, In1A, shunt. Floating inputs. 1 sec averaging. | | | | max. 1000Vrms to earth |
| | In1A: 6 ranges | 1.5mA[1] - 5mA - 15mA - 50mA - 150mA - 500mA - 1500mA. DC-100kHz | | | max. 2A continuous |
| | In5A: 6 ranges: | 15mA[1] - 50mA - 150mA - 500mA - 1.5A - 5A - 15A. DC-100kHz | | | max. 7A continuous |
| | In30A: 4 ranges: | 1A[1] - 3A - 10A - 30A - 100A. DC-100kHz | | | max. 40A/30A cont., 1-3phase /4-6phase |
| | Shunt: | 60mV - 200mV - 600mV - 2V - 6V. DC-100kHz | | | max. 30V continuous |
| | Coupling: AC or AC + DC | Common mode rejection: | | | 115dB at 100kHz |
| | Crest factor 15:1 at 10% fs. Typical accuracy at 10% fs is 0.1% | | | | fs = full scale |
| | Temperature coefficient: 0.004% / °C | | | | |
| | Standard accuracy 23°C ± 1°C | | | | **High precision In1A/In5A** |
| | **Input** | **In1A,In5A,Shunt** | **In30A** | | 15,50,150,500mA,1A/150,500mA,1.5,5A |
| | 45 to 65Hz | 0.08 + 0.08 | 0.08 + 0.08 | | 0.02 + 0.02 |
| | 3 to 1000Hz | 0.1 + 0.1 | 0.2 + 0.2 | | 0.03 + 0.03 |
| | 1 to 10kHz | 0.15 + 0.15 | | | 0.15 + 0.15 |
| | 10 to 100kHz | (0.15+0.15)+ (0.5+0.5)*log(f/10kHz) | | | (0.15+0.15)+ (0.5+0.5)*log(f/10kHz) |
| | DC[1]//100-500kHz[1] | 0.1 + 0.1// 0.023*f(kHz) | | | |
| | **Current Sensors** | **0-150Apeak** | **0-400Apeak** | **0-600Apeak** / **0-700Apeak** | Exposure of current inputs to their max. value will result in additional errors[1] |
| | 45 to 65Hz | 0.004 + 0.004 | 0.004 + 0.004 | 0.002 + 0.002 / 0.01 + 0.01 | In1A: 0.03% * $I^2$ |
| | 3 to 1000Hz | 0.01 + 0.01 | 0.01 + 0.01 | 0.01 + 0.01 / 0.02 + 0.02 | In5A: 0.003% * $I^2$ |
| | **Input** | **0-100A** precision current sensor (Option 04) connected to In1A input | | | In30A: 0.0001% * $I^2$ |
| | 3 to 100Hz | 0.05 + 0.05 | | | |
| | 100 to 1000Hz | 0.1 + 0.1 | | | |
| | Linearity 500mA range: | 130 % 100 % 50 % 10 % 5 %<br>650.02mA 500.02mA 250.02mA 49.979mA 24.997mA | | | Typical linearity at 50/60Hz |
| | Shunt Sensitivity: | 60mV/A. For an external shunt with 1mV/A scale by 60.0 | | | |
| Current Scaling I1-I6 | Individual current scaling factors of every phase. Use pop-up number pad. Format 2000.8. | | | | |

| Measured & Computed Current Values | | | |
|---|---|---|---|
| RMS current | $Arms = (1/T \int_0^T A^2 dt)^{1/2}$, includes all harmonics | Current distortion | $Athd1 = (Arms^2 - A01^2)^{1/2} / Arms$, [2] |
| Mean current | $Amean = 1/T \int_0^T Adt$, dc-component of current | Harmonic current distortion | $Athd2 = (\Sigma An^2)^{1/2} / Arms$, n = 2,3, … 40 |
| Rectified mean current | $Arect = 1/T \int_0^T \lvert A \rvert dt$, rectified mean current | Current crest factor | Acf = Amax / Arms |
| Peak current | Amax = maximum current in time interval | Current form factor | Aff = Arms / Arect, is 1.1107 for sine wave |
| | | Current fundamental | A01 = fundamental current of FFT |

1) Typical max. Error 2) Used for frequency inverter

# Power Measurement

| | | | | |
|---|---|---|---|---|
| | W range = voltage range times current range | | | 112 power ranges |
| | Standard accuracy 23°C ± 1°C | | | **High precision** |
| | **Input** | **PF** | **In1A, In5A, Shunt** | **In1A, In5A, Shunt** |
| | 45 to 65Hz | 0-1 | 0.16 + 0.16 | 0.04 + 0.04 |
| | 45 to 65Hz | 0-0.05 | | 0.01 + 0.01 |
| | 3 to 1000Hz | 0-1 | 0.2 + 0.2 | 0.1 + 0.1 |
| **% reading +% range** | 1 to 20kHz | 0-1 | 0.2+(0.2 + 0.2*log (f/100Hz) + 0.08*k1*log (f/100Hz)) | |
| | 20 to 100kHz | 1 | %error (A+V) | %error (A+V) |
| | DC[1]//100-500kHz[1] | 1 | 0.2 + 0.2// add %error (V+A) | |
| | **Input** | **PF** | **In30A** | **Current Sensor 0-100A** |
| | 45 to 65Hz | 0-1 | 0.16 + 0.16 | 0.1 + 0.1 |
| | 3 to 1000Hz | 0-1 | 0.2+(0.2+0.2 * log(f/3Hz) + 0.1 *k1 * log(f/3Hz) | |
| | DC[1] | | 0.2 + 0.2 | 0.1 + 0.1 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PF | 1 | 0.9 | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 | 0.1 | 0 | $k1 = (2 - PF^4) / (1+PF^2)$ |
| k1 | 0.5 | 0.74 | 0.97 | 1.18 | 1.38 | 1.55 | 1.70 | 1.83 | 1.92 | 1.98 | 2.00 | [1] Typical max. error |

| | | | | | | |
|---|---|---|---|---|---|---|
| W Linearity | 130% | 100% | 50% | 10% | 5% | Typical linearity of voltage, current and power |
| Volt | 130.00 | 100.00 | 49.985 | 9.9992 | 4.9990 | |
| Ampere | 6.5004 | 5.0014 | 2.5020 | 500.82m | 250.40m | |
| Watt PF=1 | 844.74 | 500.07 | 125.05 | 5.0056 | 1.2522 | |

## Measured & Computed Power Values

| | | | |
|---|---|---|---|
| Active power | $W = 1/T \int_0^T u \cdot i \, dt$, total power in W | Fundamental power | $W01 = A01 \cdot V01 \cdot \cos \varphi 01$, $\varphi 01$ = phase |
| Apparent power | $VA = Arms \cdot Vrms$, total apparent power VA | Fundamental apparent power | $VA01 = A01 \cdot V01$ |
| Reactive power | $Var = \pm(Papp^2 - Pact^2)^{1/2}$, reactive power Var | Fundamental reactive power | $Var01 = (VA01^2 - W01^2)^{1/2}$, magnitude only |
| Power Factor | PF = Pact / Papp, includes all harmonics | Power of distortion | $D = V01(\Sigma An^2)^{1/2}$, n = 2,3, …, 40; D in Watt |
| | | Power Factor of Fundamental | PF01 = W01 / VA01 |

# Frequency Measurement

| | |
|---|---|
| SyncA: 2Hz-5kHz | Accuracy: 0.05 % |
| SyncV: 2Hz-150kHz | Accuracy: 0.05 % |
| S_ExtV: 2Hz-150kHz | Accuracy: 0.05 % |
| S_ExtV is a TTL output for SyncA/V or a TTL input for S_ExtV | Sync for each phase |

## Measured & Computed Values

| | |
|---|---|
| Frequency | Freq =zero crossing of A, V, Ext; SYNC I, SYNC U, Ext; Accuracy 0.05% |

# Energy Measurement

Wh, VAh, Varh, Ah, integration time. Add accuracy % of values involved.
Reset sets all values to zero. Integration runs uninterrupted, also in the background.

## Measured & Computed Values

| | | | |
|---|---|---|---|
| Energy | $Wh = \int_0^t Pact \cdot dt$, active energy in Wh | Battery charge | $Ah = \int_0^t Arect \cdot dt$, is positive only |
| Apparent energy | $VAh = \int_0^t Papp \cdot dt$, use it for long term PF | Elapsed time | $time = \int_0^t dt$, time in hours since RESET |
| Reactive energy | $VAR = \int_0^t Prea \cdot dt$, can be positive / negative | Time | Accuracy: 0.05 % |

# Harmonic Measurement

| | |
|---|---|
| Frequency range of fundamental 3Hz – 15kHz<br>Harmonics: V and A: 1-88; W and phase angle 1-21<br>Accuracy: Fundamental[1], use % figures of V, A, W | FFT averaging:<br>Set FFT ID = 0, 1, 2, 3, 4 which corresponds to averaging over 4, 16, 64, 256, or 1024 periods. |

Harmonic Display: Select button '**FFT Table**' to view current-, voltage-, power-, impedance-, and phase harmonics 1-40. A single harmonic can be displayed by selecting **A FFT**, **V FFT** or **W FFT**. The whole range of harmonics can be read via interface.

## Measured & Computed Values

| | | | |
|---|---|---|---|
| Magnitude impedance | Mag Z = V01 / A01 fundamental | Phase of fundamental | Phi01 = phase V01, A01 |

## Additional Computed Values

| | |
|---|---|
| Accuracy: Add % figures of values involved | 65 values per phase |
| Rectified mean, VA, Var, impedance, distortion factor, power factors, motor- and transformer values, sums, ratios, analog inputs and -outputs, speed inputs, and more are continuously updated and ready for display or interface output. | |

1) Typical max. Error

## Measured & Computed Values

| | | | |
|---|---|---|---|
| Sum1 of power | Sum1 = Pact1 + Pact2 + Pact3; Power phase 1+2+3 | Ratio1 of power | Ratio1 = Pact4 / Pact1 + Pact2 + Pact3 |
| Sum2 of power | Sum2 = Pact1 + Pact2 | Ratio2 of power | Ratio2 = Pact3 / Pact1 + Pact2 |
| Sum3 of power | Sum3 = Pact4 + Pact5 + Pact6; Power phase 4+5+6 | Ratio3 of power | Ratio3 = Pact2 / Pact1 |
| Sum4 of power | Sum4 = Pact4 + Pact5 | Ratio4 of power | Ratio4 = Pact4 + Pact5 + Pact6 / Pact1 +Pact2 +Pact3 |
| Sum5 of power | Sum5 = not used | Ratio5 of power | Ratio5 = Pact6 / Pact4 + Pact5 |
| Sum6 of power | Sum6 = not used | Ratio6 of power | Ratio6 = Pact5 / Pact4 |

## Motor Measurement

| Measured & Computed Values from phase 1, phase 2, phase 3 | | Measured & Computed Values from phase 4, phase 5, phase 6 | |
|---|---|---|---|
| Mechanical input power | Pin = electric power applied to motor | Mechanical input power | Pin = electric power applied to motor |
| Mechanical output power | Pout = Pin – Pin at no load in Watt (Loss) | Mechanical output power | Pout = Pin – Pin at no load in Watt |
| Torque | Torque = Pout · poles1 / 4 · π· frequency1 | Torque | Torque = Pout · poles / 4 · π· frequency2 |
| Slip | Slip = 1 – fout / fin | Slip | Slip = 1 – fout / fin |
| Rotation per minute | rpm = 120 · frequency1 / poles1 | Rotation per minute | rpm = 120 · frequency / poles |
| Efficiency | efficiency = 1 – Pin at no load / Pin | Efficiency | efficiency = 1 – Pin at no load / Pin |

## Transformer Measurement

### Measured & Computed Values from phase 1 and phase 2

| | | | |
|---|---|---|---|
| Vrect, rms corrected | Vcorrected = 1.1107 · Vrect | Loss resistance | Equivalent loss resistance = Pact1 / $Arms^2$ |
| Corrected power | Corr power = Pact 1 / (0.5 + 0.5 · Vrms / Vcorrected) | Loss inductance | Equivalent loss reactance = Prea 1 / $Arms^2$ |
| Loss factor Q | Q = tan X/R, where Z=R + jX | Turn ratio | Turn ratio = N2 / N1 = Vrms2 / Vrms1, no load |

## Analog Input / Output

| Analog Input | | Analog Output | |
|---|---|---|---|
| 4 Analog inputs (I1-I4)<br>2 analog inputs (I5-I6)<br>2 TTL auto ranging speed inputs 20Hz-150kHz | ±5V, 100kΩ input impedance, accuracy 0.2%[1)]<br>±10V, 100kΩ input impedance, accuracy 0.2%[1)]<br>Accuracy 0.1%[1)]. Reading rate in Standard-Mode 0.5sec, reading rate in Power Speed-Mode 20ms<br>Each input can be scaled 0.0001 up to 99999 | 12 analog outputs (O1-O12) | ±5V, 1kΩ output impedance, accuracy 0.2%[1)]<br>Update rate 0.5sec. Arms, Vrms, W, VA, Var, PF, Frequency, and Wh can be sent to the analog outputs. In Logging- and Power Speed-Mode output1 is an actuator to Start/Stop ext. devices. |
| Scaling An1-An6 | Individual analog scaling. Use pop-up number pad. Format 10.0. | | |
| Scaling rpm1-rpm2 | TTL freq1/rpm1 and freq2/rpm2 scaling. Use pop-up number pad. Format 2.0. For 180 pulses per turn, scaling = 1.0000 | | |

## Four Measuring Functions

| | |
|---|---|
| Standard | 1 to 6 phase, measures all electrical values at 0.8s updates or 100ms updates. |
| Logging | Up to 48 values in 20ms, or long time averaging up to 10 minutes. |
| Transient | Simultaneous V-, A-, W-waves on 6 phases, time 0.25 to 16 seconds. |
| Power-Speed | Measures in 20ms intervals V, A, W, VA, Wh, VAh, speed of rotating devices. |

1) Typical max. Error

## Interface

USB connection to Host Computer for downloading measurement data (Windows Mobile Device Center)

10/100 Mbps Ethernet interface (Up to 230.4kBaud)

RS232 Interface (Up to 115.2kBaud)
or
USB Interface (Up to 921.6kBaud)


Analog Input / Output connector (37-pole)

GPIB, IEEE 488.2 (Set address 1 to 30, store in setting)


## Saving and Recalling 108A Setting Configurations

Save your personal setting in **S01**, or **S02**,...., or **S20**. The 108A starts up in setting **S01**. With Load Setup you can change to your personal setting.

If start up in your setting is required store it in **S01**.

## Continuous Storing of Measurement Data

Select the storing interval (1s, 2s, 3s,…). Select storing location **D01**, or **D02**,…, or **D20**. All values displayed on page 1 are stored at set time interval in EXCEL compatible format.

## Servicing and Calibration

Servicing: Replacement amplifier boards from the factory are calibrated (no re-calibration is required). All other boards can simply be exchanged.
Calibration: Enter calibration code, follow calibration instructions. Apply 60Hz, 1.5mA - 20A, and 0.3V - 1000V. Calibration cycle 2 years.

## General Technical Data

| | |
|---|---|
| Dimensions | Metal housing H x W x D; 148 x 355 x 335mm |
| Weight | Maximum 7kg, 6-phase |
| Display | TFT color display, 155 x 94, 800 x 480 pixels, 262k Colors, Wide viewing angle (X-Y) 170° |
| Operation | By touch screen, wireless mouse or interface |
| Mains | 90 - 256V, 47 - 63Hz, 40VA |
| Warm up time | 25 minutes |
| Calibration cycle | 2 years |
| Inputs | 4mm safety sockets, 3-pol Amphenol socket |
| Temperature range | Operation 2 to 32°C, storage -10 to 50°C |
| Standards | Electrical safety EN61010-1, 1000V CAT II<br>Emission IEC 61326-1, class B<br>Immunity IEC 61326-1 |
| Dielectric Strength | Line input to case: 1500V ac<br>Measuring inputs to case: 2500V ac<br>Measuring inputs to measuring inputs: 2500V ac |

# 4. Operating The Power Analyzer from the Front Panel

Apply line voltage 90Vac to 264Vac, 47 – 63Hz, and turn on rear panel power switch. The Power Analyzer requires 30 seconds for start-up.
Common to all four measurement functions (Standard, Logging, Transient, and Power-Speed) the following actions are needed:

- Select current inputs (IN1A, IN5A, IN30A, SHUNT: 2 touches)
- Select current range, or AUTO ranging (2 touches)
- Select voltage range, or AUTO ranging (2 touches)
- Select measurement synchronization (SyncI, SyncU, Ext, 2 touches)
- Select measurement duration (2 touches)
- Select wave form on or off (2 touches)
- Select HOLD or RUN or coupling AC or DC+AC (1 touch)
- Select FFT-TABLE (harmonics of current, voltage, power and phase angle) of one phase (1 touch)
- Select FFT-BAR of one phase (1 touch)
- RESET charge, Wh, VAh, Varh, and time (1 touch)
- Select new display page 1, 2, 3, 4, (5) (1 touch), page (5) for harmonics
- Select different value on display line (2 touches)
- Select new measurement mode (2 touches)
- Select scaling A/V, Baud, GPIB address, Cycles, Transient ID, FFT-ID,
- Select suppress, time, save setup, load setup and scaling of analog inputs and frequency inputs. (Example Scaling I3: 2000.5 needs 9 touches).

- Select display of phase L1-L4 or L3-L6 (1 touch)

**Important:** It is possible to use individual current inputs, individual ranges, and individual synchronization on different phases for all measurement modes.

## 4.1 Operations in Standard Measure Mode

The Power Analyzer starts up in Standard Measure Mode as shown in Figure 4.1. The touch control buttons to the right and at the bottom set operating conditions, and the control buttons to the left set display quantities. The buttons along the top are used to select individual settings for every phase (current input, ranges, and synchronization). The buttons are controllable by a click of the mouse, or by a touch using the supplied pointer, or just using a finger.

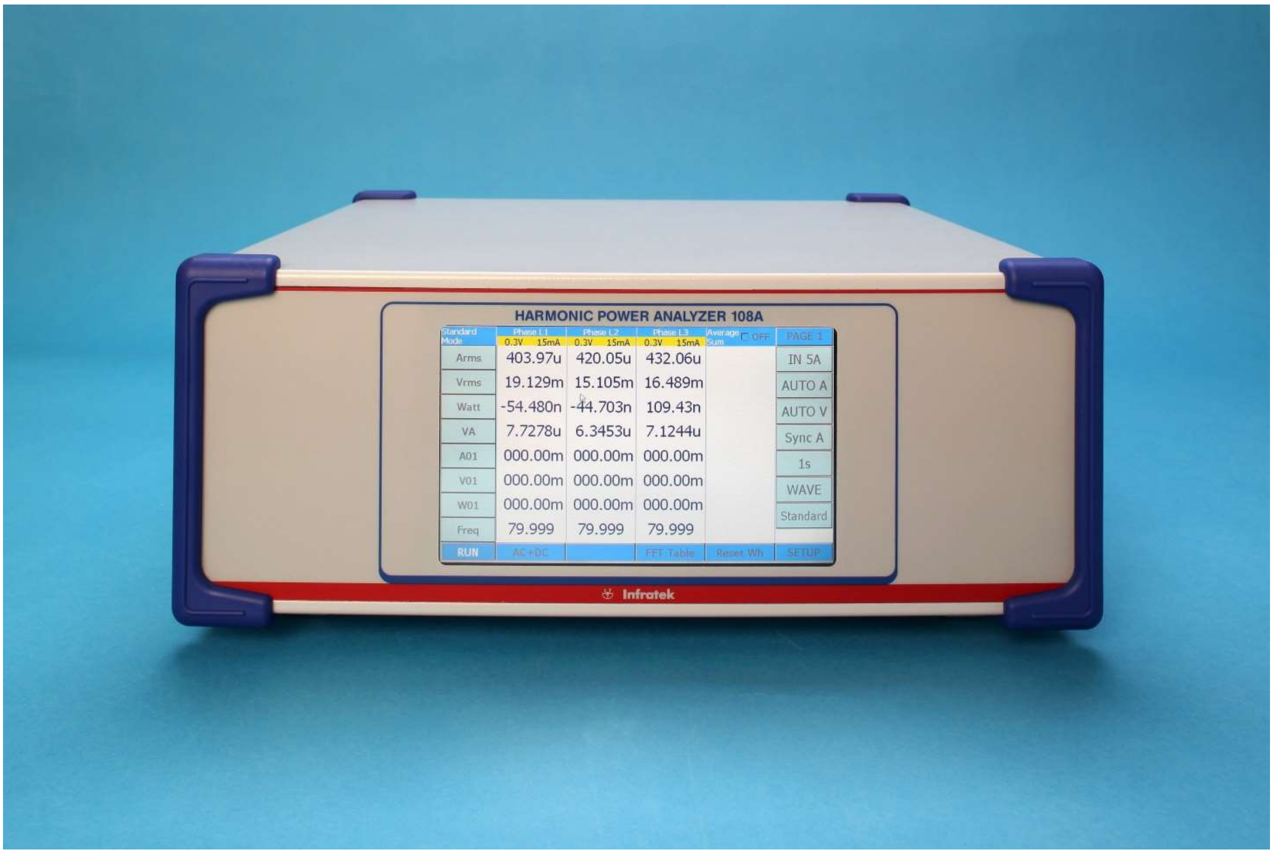



Figure 4.1 Start-up configuration of Power Analyzer

Along the top of the display you find phase, current input, synchronization, voltage- and current range, and over (red) - and under (yellow) range indication.

**For touch screen operation we highly recommend to use the mouse. An unintentional double click for critical operations, such as loading a new setting, may lead to stalling. Should this happen, you must restart the Power Analyzer (off / on).**

### 4.1.1 Selecting Measure Mode

Touch [Standard] → pop-up window

| | |
|---|---|
| Standard | Default |
| Logging | |
| Transient | |
| P-Speed | Option |

Touch desired Measurement Function

### 4.1.2 SELECTING CURRENT INPUTS USING SAME INPUTS FOR ALL PHASES

Touch IN 5A → pop-up window

| | |
|---|---|
| IN 1A | |
| IN 5A | Default |
| IN 30A | |
| SHUNT | |

Touch desired current input

### 4.1.3 SELECTING INDIVIDUAL CURRENT INPUTS PER PHASE

Touch the phase button L1 along the top of the display. The button turns to green, indicating to be ready for phase L1 current input- and range selection

Touch IN 5A choose the input from pop-up Window

| |
|---|
| IN 1A |
| IN 5A |
| IN 30A |
| SHUNT |

We recommend, as a next step, to also select the current range for phase L1.

Touch AUTO A Select from the pop-up window the desired range or auto ranging

| 1A Input | 5A Input | 30A Input | Shunt Input |
|---|---|---|---|
| 1.5mA | 15mA | 1A | 60mV |
| 5mA | 50mA | 3A | 180mV |
| 15mA | 150mA | 10A | 600mV |
| 50mA | 500mA | 30A | 1.8V |
| 150mA | 1.5A | 100A | 6V |
| 500mA | 5A | AUTO A | AUTO A |
| 1.5A | 15A | | |
| AUTO A | AUTO A | | |

Continue above process to set the current inputs of other phases.

### 4.1.4 SELECTING CURRENT RANGE USING SAME RANGE FOR ALL PHASES

The available ranges depend on the current input selected.

| | |
|---|---|
| IN 1A: | 1.5mA, 5mA, 15mA, 50mA, 150mA, 500mA, 1.5A. |
| IN 5A: | 15mA, 50mA, 150mA, 500mA, 1.5A, 5A, 15A. |
| IN 30A: | 1A, 3A, 10A, 30A, 100A. |
| SHUNT: | 60mV, 180mV, 600mV, 2V, 6V. **Shunt sensitivity: 1A/60mV.**<br>Using a current clamp with output 1mV/A enter scaling factor 60. |

Touch AUTO A → pop-up window

| | |
|---|---|
| 15mA | |
| 50mA | |
| 150mA | |
| 500mA | |
| 1.5A | |
| 5A | |
| 15A | |
| AUTO A | Default |

Touch desired current range. Power Analyzer is now in manual current ranging.
"AUTO A" selects automatic current ranging.

**NOTE:** If none of the phase buttons is green (phase selected), the range selection is valid for all phases. If one phase button is green the range selection is valid for the selected phase.

### 4.1.5 SELECTING VOLTAGE RANGE USING SAME RANGE FOR ALL PHASES

Touch AUTO V → pop-up window

| | |
|---|---|
| 0.3V | |
| 1V | |
| 3V | |
| 10V | |
| 30V | |
| 100V | |
| 300V | |
| 1000V | |
| AUTO V | Default |

Touch desired voltage range. Power Analyzer is now in manual voltage ranging.
"AUTO V" selects automatic voltage ranging.

**NOTE:** Individual voltage range selection for every phase is possible. Touch the phase button along the top of the display, touch AUTO V and select from pop-up window desired voltage range.

### 4.1.6 SELECTING MEASUREMENT SYNCHRONIZATION USING SAME SYNCHRONIZATION FOR ALL PHASES

Touch [Sync A] → pop-up window

| | | |
|---|---|---|
| Sync A | 2Hz-5kHz | Default |
| Sync V | 2Hz-150kHz | |
| S_Ext V | 2Hz-150kHz | |

Touch desired measurement synchronization. For precise AC-measurements at low frequencies a periodic wave form is required. If you are measuring voltages only, you must select Sync V. If you are measuring current only, you must select Sync A.

**NOTE:** Individual synchronization for every phase is possible. Touch the phase button along the top of the display, touch SYNC A and select from pop-up window desired synchronization.

### 4.1.7 SELECTING AVERAGING TIME

Touch [1s] → pop-up window

| | |
|---|---|
| 100ms | |
| 500ms | |
| 1s | Default |
| 2s | |
| 8s | |
| 32s | |

Touch desired averaging time. Arms, Arect, Amean, Vrms, Vrect, Vmean, W, VA, Var, and frequency are averaged over selected time.

Display update occurs at 0.8 sec intervals also in the "Fast" mode.

**Fast:** New data are available at 100ms intervals. "Fast" mode can be used to read new data via interface at the rate of 10 datasets per second.

### 4.1.8 SELECTING DISPLAY PAGES

Touch [PAGE 1] → increments to [PAGE 2] Default: Page 1

→ Touch [PAGE 2] → increments to [PAGE 3]

→ Touch [PAGE 3] → increments to [PAGE 4]

→ Touch [PAGE 4] → resets to [PAGE 1]

Every PAGE displays 8 user programmable measurement quantities. Programmed quantities on a display line are valid for all phases L1 … L6.

### 4.1.9 SELECTING WAVE FORMS (GRAPH)

Touch WAVE → pop-up window for 3-phase instrument.

| |
|---|
| Wave 1 |
| Wave 2 |
| Wave 3 |
| - |
| - |
| - |
| OFF |

Touch desired phase L1, L2, or L3. Touch OFF to exit wave display.

The lower 3/8 of the display shows current- (blue), voltage- (black), and power waveforms (red) of selected phase. For a consistent display a periodic zero crossing is required.

**NOTE:** When displaying waveform, the button “FFT Table” is greyed (disabled).

### 4.1.10 SELECTING DISPLAY L1 TO L4 AND L3 TO L6

Power Analyzers for 5-, or 6 phases have the choice to select display of L1 to L4 or L3 to L6. Touch L1 - L4. The button toggles to L3 - L6.

### 4.1.11 SELECTING FFT TABLE AND FFT BAR GRAPH

Touch FFT Table. The button will toggle to FFT L1. At the same time the button FFT Bar is activated which lets you select the bar graph of phase L1.

This action will display harmonics of current, voltage, power, and phase on 5 pages (PAGE H1, H2, H3, H4, H5). Harmonics 1-40 of current and voltage, and harmonics 1-20 for power, and phase angle. Phase angle is displayed in a range ±180°.
**Limitation**: The maximum fundamental frequency for harmonic computation is 15kHz.
The minimum fundamental frequency is 5Hz

Touch FFT Bar. This displays harmonic bar graphs in percent of fundamental of current, voltage, and power. Touching FFT Bar a second time turns off the bar graph.

Touching FFT L1 will increment it to FFT L2, to FFT L3 and so on up to the number of phases installed and will return to FFT Table

### 4.1.12 SELECTING AC OR DC+AC-COUPLING

Touch AC+DC, the button toggles to AC.

AC: Arms, Vrms, W, and VA are measured excluding DC.
Amean and Vmean are independent of AC, or AC+DC.

DC+AC: Arms, Vrms, W, and VA are measured including DC.

**Reminder:** The rms value of a 50Hz component and a DC component is equal to the square root of (50Hz component squared + DC component squared).

### 4.1.13 SELECTING DISPLAY RUN AND DISPLAY HOLD

Touch RUN, the button toggles to HOLD.

The display update is halted. In the background the continuous measurement process goes on. This guarantees correct energy- and charge measurements (Wh, VAh, Varh, Ah).
If USB memory stick is inserted, measurement data on hold are also stored on memory stick with filename **108A_data_HOLD**.

### 4.1.14 RESETTING ENERGY

Touch Reset Wh. This will reset all energies, charge, and time (Wh, VAh, Varh, Ah, time).

### 4.1.15 SELECTING DISPLAY QUANTITIES

Touch one of the 8 buttons to the left of the display. This pops-up the value selection table (Figure 4.2). Touch the button of the desired quantity. This will replace the previously displayed quantity with the new one.

<table>
<tr><td rowspan="2">CURRENT</td><td>Arms</td><td>Amean</td><td>Arect</td><td>A01</td><td>Ah</td><td>HELP</td></tr>
<tr><td>Amax</td><td>A CF</td><td>A FF</td><td>A THD1</td><td>A THD2</td><td>A FFT</td></tr>
<tr><td rowspan="2">VOLTAGE</td><td>Vrms</td><td>Vmean</td><td>Vrect</td><td>V01</td><td>Vptp</td><td>Vmin</td></tr>
<tr><td>Vmax</td><td>V CF</td><td>V FF</td><td>V THD1</td><td>V THD2</td><td>V FFT</td></tr>
<tr><td rowspan="2">POWER</td><td>Watt</td><td>VA</td><td>VAR</td><td>W01</td><td>VA01</td><td>Q1</td></tr>
<tr><td>D</td><td>PF</td><td>PF01</td><td>Wh</td><td>VAh</td><td>W FFT</td></tr>
<tr><td>OTHER</td><td>Freq</td><td>|Z01|</td><td>Phi01</td><td>Time</td><td>VARh</td><td>LTL 1- 3<br>LTL 4- 6</td></tr>
<tr><td>SpecVal 1</td><td>S1|S2|S3</td><td>S4|S5|S6</td><td>R1|R2|R3</td><td>R4|R5|R6</td><td>M1| 1 - 3</td><td>M1| 4 - 6</td></tr>
<tr><td>SpecVal 2</td><td>T1|T2|T3</td><td>T4|T5|T6</td><td>A1|A2|A3</td><td>A4|A5|A6</td><td>m2| 1 - 3</td><td>m2| 4 - 6</td></tr>
</table>

Figure 4.2 Value Selection Table of all available quantities which can be displayed. Touching “A FFT”, “V FFT”, or “W FFT” lets you select Harmonics 2 to 13. Touching “HELP” pops up the help window explaining the special values.

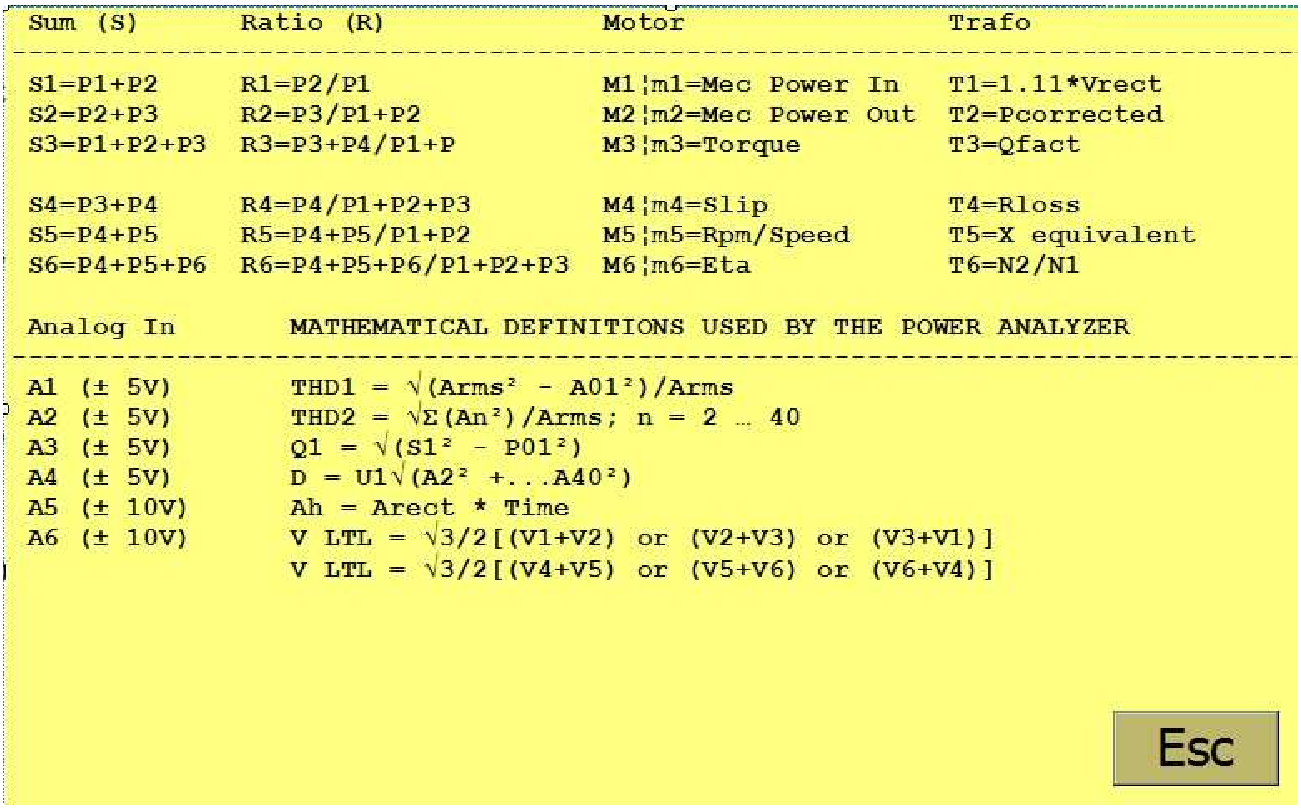
**Exception 1:** Touching A FFT, V FFT, or W FFT will activate a pop-up window from which you can select one out of the first 13 harmonics.

**Exception 2:** Touching one of the special values at the bottom of the value selection table, such as S1|S2|S3, will always display 3 values, some of them may be zero.

Special values are:

| | | |
|---|---|---|
| SUMS: | S1\|S2\|S3, S4\|S5\|S6; | Definition Table 3.2 |
| RATIOS: | R1\|R2\|R3, R4\|R5\|R6; | Definition Table 3.2 |
| MOTOR1: | M1\|1-3, M1\|4-6; | Definition Table 3.2 |
| TRANSFORMER: | T1\|T2\|T3, T4\|T5\|T6; | Definition Table 3.2 |
| ANALOG: | A1\|A2\|A3, A4\|A5\|A6; | Definition Table 3.2 |
| MOTOR2: | m2\|1-3, m2\|4-6; | Definition Table 3.2 |

The HELP button defines the display quantities in a pop-up window. Figure 4.3 Definition of Special Values.



```
Sum (S)        Ratio (R)               Motor                 Trafo
-----------------------------------------------------------------------------
S1=P1+P2       R1=P2/P1                M1¦m1=Mec Power In    T1=1.11*Vrect
S2=P2+P3       R2=P3/P1+P2             M2¦m2=Mec Power Out   T2=Pcorrected
S3=P1+P2+P3    R3=P3+P4/P1+P           M3¦m3=Torque          T3=Qfact

S4=P3+P4       R4=P4/P1+P2+P3          M4¦m4=Slip            T4=Rloss
S5=P4+P5       R5=P4+P5/P1+P2          M5¦m5=Rpm/Speed       T5=X equivalent
S6=P4+P5+P6    R6=P4+P5+P6/P1+P2+P3    M6¦m6=Eta             T6=N2/N1

Analog In         MATHEMATICAL DEFINITIONS USED BY THE POWER ANALYZER
-----------------------------------------------------------------------------
A1 (± 5V)         THD1 = √(Arms² - A01²)/Arms
A2 (± 5V)         THD2 = √Σ(An²)/Arms; n = 2 … 40
A3 (± 5V)         Q1 = √(S1² - P01²)
A4 (± 5V)         D = U1√(A2² +...A40²)
A5 (± 10V)        Ah = Arect * Time
A6 (± 10V)        V LTL = √3/2[(V1+V2) or (V2+V3) or (V3+V1)]
                  V LTL = √3/2[(V4+V5) or (V5+V6) or (V6+V4)]

                                                                   Esc
```

Figure 4.3 Help Table defining sums, ratios, motor1- and motor2 values, transformer values, analog inputs, and harmonic distortion.

### 4.1.16 MOTOR TESTING: Motor 1 values from phase 1, 2, and 3.
Motor 2 values form phase 4, 5, and 6.

A three phase Power Analyzer calculates 6 motor values (motor 1). To display these values select M1|1-3 on one display line and M1|4-6 on the next display line. Speed in rpm must be entered via analog input-output option at speed 1/ freq 1 input terminal (Section 7). A rotating disc with 180 divisions yields rpm (rotation per minute).
A disc with 90 divisions requires multiplication by 2 to obtain true rpm. An external torque transducer can be applied to one of the 6 analog inputs and can be displayed by selecting either A1|A2|A3 or A4|A5|A6 from the value selections table. Scaling for analog inputs and rpm, setting the number of motor poles, and storing idle motor power can be done via SETUP or via Interface.

Using the Computer Operating Software the motor settings are basically using the following Interface commands:

| | |
|---|---|
| Write number poles=6: | Command (Commands Section 5)<br>acq:nr_pole1 6→CR LF |
| Write scaling rpm1 (2.0) | Dis:rpm_sc1 2.0→CR LF |
| Write scaling torque 1 10.1<br>(using analog input 1) | Dis:an_sc1 10.1→CR LF |
| Motor 1 is running at no load. Send the command. Power loss of motor 1 is stored and from now on the motor 1 output power is reduced by this loss. | Comp:mot1_Loss?<br>6 values are sent from the Power Analyzer to the PC. From now on the motor 1 output power is reduced by motor 1 loss. |

A six phase Power Analyzer calculates motor values of two motors simultaneously. Motor 1 values from phase 1, 2, and 3. Motor 2 values from phase 4, 5, and 6. Display motor 2 values by selecting m1|1-3 and m1|4-6 in the value selection table. Use the speed 2/ freq 2 input for motor 2 rpm determination; a disc with 180 divisions yields rpm, needs no rpm scaling.
An external torque transducer for motor 2 could be applied to analog input 2, or any other of the 6 analog inputs.
Just like setting the parameters of motor 1 you must enter parameters for motor 2.

Write number poles = 4 : acq:nr_pole2 4 → CR LF

Write scaling rpm 2 (4.0) : dis:rpm_sc2 4.0 → CR LF

Write scaling torque 2 (8.5) : dis:an_sc2 8.5 → CR LF

| | |
|---|---|
| Motor2 is running at no load.<br>Send the command. Power<br>Loss of motor2 is stored<br>And from this time on<br>motor2 output power is<br>Reduced by motor2 loss | Comp:mot2_loss?<br>6 Motor Values are returned<br>to the PC. From this time on<br>motor2 output power is<br>reduced by motor2 loss. |

For more information on motor testing please read Section 10.

### 4.1.17 SELECTING SETUP

Touch SETUP. The pop-up window, shown in Figure 4.4 lets you select the following instrument parameters:

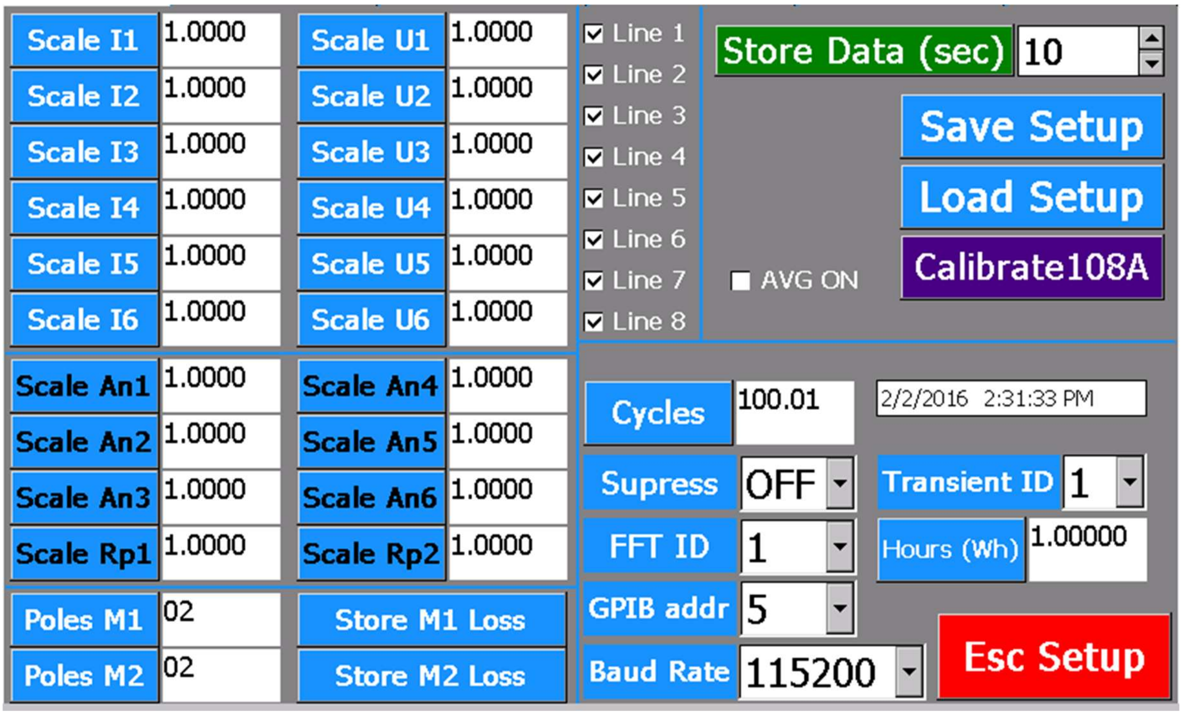



Figure 4.4 Setup Window for selecting instrument parameters

**Scaling I1-I6**: Individual current scaling factors of every phase. Use pop-up number pad. Format 2000.8.

**Scaling U1-U6**: Individual voltage scaling factors of every phase. Use pop-up number pad. Format 9.9427.

**Scaling An1-An6:** Individual analog scaling. Use pop-up number pad. Format 10.0.

**Note: An6 also scales the analog outputs of power at low power factor.**

**Scaling rpm1-rpm2:** Individual TTL freq1/rpm1 and freq2/rpm2 scaling. Use pop-up number pad. Format 2.0.

**Cycles:** For Logging Measure Mode set 1 to 32000. Defines the measurement duration per measurement set. Use pop-up number pad. Format 160.

**Suppress:** Toggles on and off. If on, small values of Arms, Vrms, and Watt are set to 0.

**FFT ID:** Set to 0, 1, 2, 3, 4. Corresponds to FFT averaging over 4, 16, 64, 256 or 1024 cycles. FFT_ID=3 corresponds to 1.5sec averaging.

**□Line1…□Line8:** Serves two functions: If deselected, display line is off. If selected display line is on and in case data storing is also on, the values are stored in internal memory D01, D02, …, D20. If USB memory stick is inserted, measurement data are also stored on memory stick 108A_data_01, 108A_data_02, …, 108A_data_20.

**Store Data:** Select the desired storing interval in seconds. Press green “Store Data” button and select D01…D20. The measurement data displayed on page 1 of all phases are stored in the selected data file Dxy (D01… D20) and on the memory stick. Average of Arms and Vrms are not stored if selected.

**Stop Storage:** Press “Stop Storage” press “Standard”, select “Standard” in submenu.

**AVG ON:** The average of 3 rms currents (phase 1 to 3 or phase 4 to 6) and 3 rms voltages are displayed in red digits when AVG ON is checked.
This is valid only for values displayed on page 1 on line 1 and line 2

**Transient ID:** Set to 1, 2, … 7. The transient ID determines the measurement duration after start.

| Transient ID | Measurement duration |
|---|---|
| 1 | 0.25 seconds |
| 2 | 0.5 seconds default |
| 3 | 1 second |
| 4 | 2 seconds |
| 5 | 4 seconds |
| 6 | 8 seconds |
| 7 | 16 seconds |

**Hours (Wh):** If selected “OFF” energy computation runs continuously. Select “ON” and set time in hours for Wh, VAh, Varh, and Ah summation. Touch Reset Wh button to start the energy summation. When time is reached the energy display values are held at the final values.

**Poles M1/M2:** Set number of motor 1 poles and motor 2 poles, minimum 2, maximum 98.

**Store Idle W:** Store idle power motor 1 or motor 2. When idle power has been stored, motor output power (and torque) is computed from motor input power - idle power (**Store M1 Loss** / **Store M2 Loss**).

**Baud rate:** Set Baud ID to 0, 1, 2, 3, 4, 5, 6, 7.
The Baud ID corresponds to:

| Baud ID | Baud Rate | |
|---|---|---|
| 0 | 9600 | |
| 1 | 19200 | |
| 2 | 38400 | |
| 3 | 57600 | |
| 4 | 115200 | default |
| 5 | 230400 | can be |
| 6 | 460800 | used for |
| 7 | 921600 | USB interface |

**GPIB addr:** Set 1 to 30. Use pop-up number pad.

**Save Setup:** Give the setting your personal number. If you want that the Power Analyzer starts up in your preferred configuration you must store the setting in S01.

**Load Setup:** Recall your setting number

**Calibration**: Enter your personal code if okay → Current Cal on
→ Voltage Cal on

## 4.2 Operations in Logging Measure Mode

- Touch Standard → pop-up window

| |
|---|
| Standard |
| Logging |
| Transient |
| P-Speed |

Touch Logging to switch to Logging function Measure Mode. The logging mode configures the display, line 1 to line 8, as follows: Frequency, Arms, Vrms, W, PF, VA, Wh, and VAh. These values are fixed; there is no access to the value selection table.

**Caution:** **Before touching START a valid synchronization signal must be applied to all inputs of the Power Analyzer. Not doing so the Power Analyzer may stall. Turn power off and restart again.**

Example: Logging function is used on a 6-Phase Power Analyzer to measure a 3-phase motor. Current synchronization is used.

Connect current I1 in series with I4, I2 in series with I5, and I3 in series with I6 to synchronize all 6 phases at the same speed. For data analysis use data from phase 1, 2, and 3 only.

### 4.2.1 Valid Synchronization

A valid synchronization for Logging is current or voltage, or both applied to every phase of the Power Analyzer. The synchronization frequency must be in the range 5Hz to 2kHz for current (Sync A), 5Hz to 10kHz for voltage (Sync V).

DC-current and DC-voltage can be measured too (DC-motors). For DC use an external TTL synchronization (5Hz to 10kHz), apply it to the rear panel Sync1, Sync2, … Sync6 inputs and select "S_Ext V".

Example: 2-phase Power Analyzer: Connect Sync1 and Sync2 to TTL-signal.
3-phase Power Analyzer: Connect Sync1, Sync2, and Sync3 to TTL-signal.

### 4.2.2 Selecting CYCLES

Please note that CYCLES is set in the SETUP menu accessible in the STANDARD mode.

Touch SETUP. In the pop-up window Figure 4.4

Touch CYCLES. Use the pop-up number pad. Enter the number of Cycles, minimum 1, maximum 32000.

**Hint:** Number of cycles divided by applied frequency must be greater than 10ms
Also, use a high RS232 baud rate for fast data transmission.

- In Logging Measure Mode 8 values per phase are measured. These are: frequency, Arms, Vrms, W, PF, VA, Wh, and VA. The buttons to the left of the display are deactivated (greyed). There is no access to the value selection table.
- Logging can be started from the display or from the computer interface.

### 4.2.3 What has to be observed when using Logging?

- A valid synchronization signal must be applied before pressing START or before sending the interface command acq:go.

- Cycles divided by frequency of synchronization determines the time for one measurement.

  Example: “Cycles” set to 1, frequency of synchronization is 50Hz (1/50Hz = 0.02sec).
  Time interval for one measurement = 0.02 sec.
  If “cycles” is set to 30000 the time for one measurement is
  30000 · 0.02 sec. = 10 minutes.

- To read Logging data from the 108A via Interface use commands COMP:LOG1? or COMP:LOG2? (Table 5.4).

- For fast data acquisition use manual ranging. Select ranges such that no severe overloads occur.

- To transmit data from a 6-phase Power Analyzer via RS232 to a PC within 20ms (time interval for measurement) the Baud Rate of 460800 Baud must be selected or use the IEEE-Interface.

- To catch data from a short term transient process we recommend: Start Logging and slightly delayed start the process.

- Measurements on frequency inverters must be synchronized to current or to an external frequency. Do not use synchronization to voltage.

- In Logging Measure Mode the display updates in 0.8 second intervals.


Figure 4.5: 108A display in Logging Mode.

## 4.3 Operations in Transient Measure Mode

- Touch Standard → pop-up window

| |
|---|
| Standard |
| Logging |
| Transient |
| P-Speed |

Touch Transient to switch to the Transient Measure Mode

Please note that TRANSIENT ID is set in the SETUP menu accessible in the STANDARD mode.
**Before pressing START synchronization to all phases of the Power Analyzer is required.**

- Touch SETUP → touch Transient ID. Select 1, 2, 3, 4, 5, 6 or 7

| Transient ID | Transient Measurement Duration | |
|---|---|---|
| 1 | 0.25 seconds | |
| 2 | 0.5 seconds | Default |
| 3 | 1 second | |
| 4 | 2 seconds | |
| 5 | 4 seconds | |
| 6 | 8 seconds | |
| 7 | 16 seconds | |

### 4.3.1 What is measured in Transient Measure Mode?

Upon touching the START button all phases start measurement at the same time. The start delay between different phases is less than 1 microsecond.
The duration of measurement is determined by the SETUP variable “Transient ID”. Default Transient ID = 2 corresponds to 0.5 seconds measurement time. If required, you can scale currents and voltages.

Every phase samples current, voltage, and power. The time relation between phases is precisely maintained. When measurement is done, all wave forms are displayed. Touching a zoom sector allows for enlargement of up to 256 times. Select L4 to L6 to display wave forms of phases L4, L5, L6.
Touch BACK to return to the original wave forms.

### 4.3.2 Two Ways To Use Transient Measure Mode

- **Quick viewing of wave forms in Standard Measure Mode**.

Touch Standard, touch Transient, touch START.

Assuming you are measuring in a 50Hz/60Hz 3-phase system you obtain on one pitch all wave forms. Zoom once to obtain 5 to 6 periods of all wave forms in precise phase relation to each other. This is assuming you have selected Transient ID = 2.
If you wish zoom more to view details.

Touch Transient, touch Standard to return to previous measure mode.

- **View Wave Forms of System in Transient State**

  The system can be 1 to 6 phase:

  - 3 phase or multi-phase rotating device being started or being loaded.
  - DC motors starting or being loaded.
  - Accelerating or recuperating electric cars.
  - Start-up behavior of large electromechanical system.

- For this kind of measurements you must use broad band current sensors and must select AC+DC coupling of the Power Analyzer.

- Select Transient ID that fits best to your measurement.

- You must select proper current- and voltage ranges, to avoid serious overloads.

- Start the transient measurement then start your system.

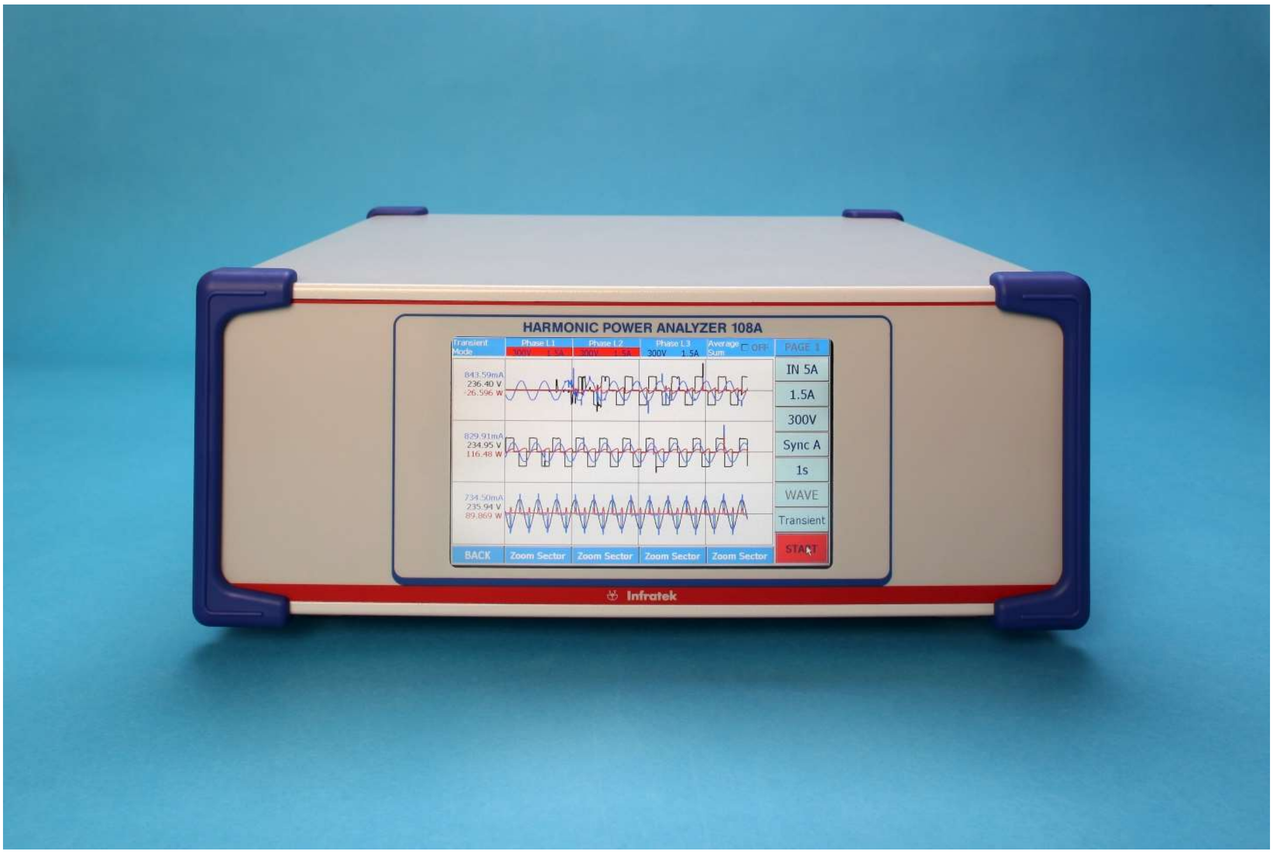



Figure 4.6 Shows the transient display of a 3-phase Power Analyzer.

The three values to the left are rms current, rms voltage, and average power of the displayed wave forms.

## 4.4 BASICS OF POWER-SPEED MEASURE MODE (OPTION)

Power-Speed measurements are performed on single- and three-phase AC- or DC systems. The external speed input is applied to TTL-Speed1 of the analog input - output option. If not installed the speed will be zero.
Use an optical speed sensor with a rotating disc of 180 divisions. Apply its TTL-output to the speed1 input to obtain speed values in rpm (rotations per minute). The range of frequency of the TTL speed1 input is 20Hz to 150kHz. Maximum rpm with a disc of 180 divisions is (150000 / 180) 60 = 50000 rpm.

### 4.4.1 WHAT IS MEASURED IN POWER-SPEED MEASURE MODE

The Power Analyzer input can be DC from a battery, or AC from power line, or AC from frequency inverter. Upon START the Power Analyzer measures in 20ms time intervals Arms, Vrms, Wtotal, VAtotal, Whtotal, VAhtotal, and rotating speed in rpm (rotation per minute). Where Arms and Vrms are averages of 3 phases, of the 20ms measurement interval.

When the START button is touched analog output1 is set 20ms later from 0V to 5V. It can be used to activate the system under test. Datasets are stored in internal memory.

Upon pressing STOP measured values versus time are displayed. Maximum duration of power – speed measurement is 10.7 seconds, amounting to 535 datasets in 20ms time increments. This time is sufficient to monitor the start of an electric car. Values such as current peaks, voltage dips, consumed energy, maximum speed, and maximum acceleration are parameters of interest to the manufacturer.

If you insert a memory stick on the rear panel the complete data set is displayed on the 108A display and also stored on the memory stick for off-line analysis in Excel.

### 4.4.2 OPERATIONS IN POWER-SPEED MEASURE MODE

- Touch Standard → pop-up window

| |
|---|
| Standard |
| Logging |
| Transient |
| P-Speed |

  Touch P-Speed to switch to the Power-Speed Measure Mode.

- **Correction factors** for single phase systems. Multiply Vrms and Arms by 3.

- Set Voltage range according to supply voltage applied to load under test

  Touch AUTO V → pop-up window

| |
|---|
| 0.3V |
| 1V |
| 3V |
| 10V |
| 30V |
| 100V |
| 300V |
| 1000V |
| AUTO V |

  Touch appropriate voltage range (Do not use AUTO V).

- Set current input. You must set the current range based on the estimated maximum rms current. Many applications experience currents larger than 40A. If so, use external current sensors capable of transmitting DC currents.

***Example:*** *Estimated current is 100A. A 3-phase current sensor module 0-100A, DC to 100kHz, with output 50mA at 100A primary current is used. Select Current Input In1A and range 50mA.*

  Touch IN 5A → pop-up window

| |
|---|
| IN 1A |
| IN 5A |
| IN 30A |
| SHUNT |

  Touch IN 1A. Use the 1A-adapter. Connect it to the rear panel 3 pole socket.

- Set current range

  Touch AUTO A → pop-up window

| |
|---|
| 1.5mA |
| 5mA |
| 15mA |
| 50mA |
| 150mA |
| 500mA |
| 1.5A |
| AUTO A |

  Touch 50mA to select desired current range. (Do not use AUTO A)

- Enter the SETUP window in standard measure mode. Set phase 1, 2, and 3 scaling factors by entering the scaling factor written on the 3-phase current sensor module

- Touch START and turn on the system under test.
  Alternatively start your system by using the 0 to +5V signal of analog output1.

- After system reached steady state
  Touch RUN → returns to STOP and Power Analyzer will plot seven functions versus time. Four functions at the top (voltage, current, power, speed), and three functions at the bottom of the display (energy, apparent power, apparent energy).
  If you have inserted a memory stick on the rear panel, all measurement data are also stored on the memory stick for off-line analysis.

- The left side of the display shows maximum values of Arms, power, energy, rpm, Vrms, Wh, and Vah during the run.

- All data sets are written to the USB memory stick for off-line analysis.

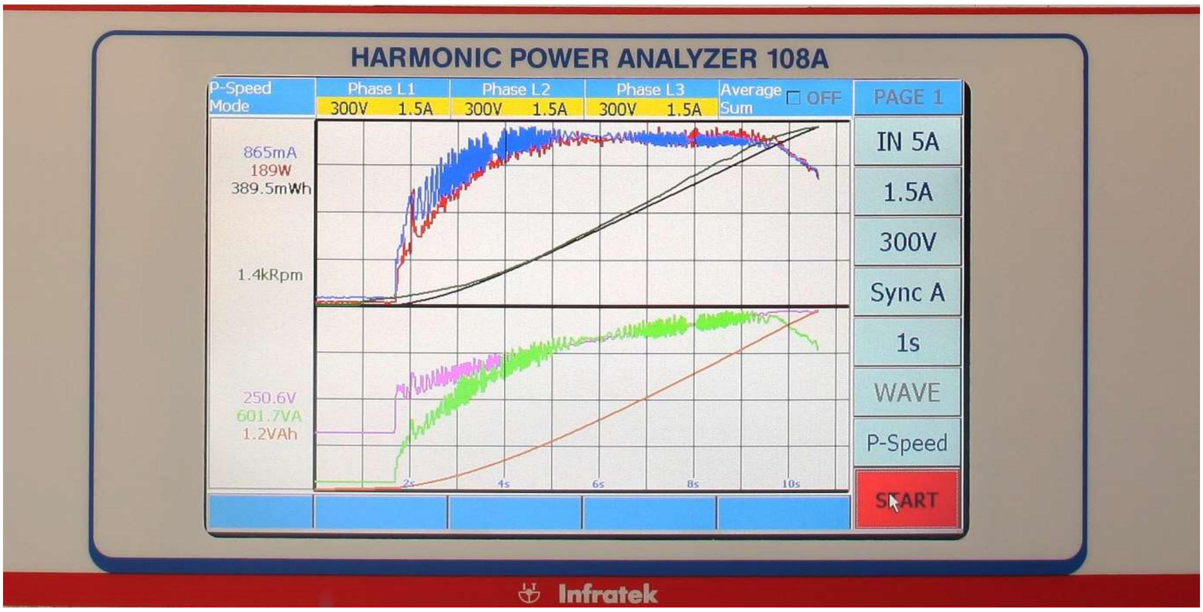



Figure 4.7 Graphs of Current, Voltage, Power, Apparent Power, Energy, Apparent Energy and rotating speed versus time.

# 5. OPERATING THE POWER ANALYZER USING A COMPUTER INTERFACE

The following interfaces are available:

- USB for wireless mouse
- IEEE-488 on rear panel using the Computer Interface Command set.
- RS232 on rear panel using Computer Interface Command set.
- USB on rear panel using Computer Interface Command set.
- USB memory stick for measurement data storage, or downloading 108A software update.
- Ethernet interface on rear panel using Interface Command set.
- 6 analog inputs and two TTL inputs 0-150kHz for external transducers.

## 5.1 WHAT HAS TO BE OBSERVED WHEN USING AN INTERFACE

The RS232 cable must be one-to-one connected. Use shielded cables.

Keep interface cables at least 10cm from Power Analyzer current- and voltage input cables. Current- and voltage transients may couple into interface cables and can cause communication errors or even failure.

Every command must be terminated with CRLF (carriage return, line feed) or with EOI (end or identify) using IEEE-488.

## 5.2 WHAT HAS TO BE OBSERVED WHEN USING THE INTERFACE COMMAND SET

- All commands listed in the table are assuming that a 6 phase Power Analyzer is used and thus PH_START = 1 and PH_END=6. If you are using a 3-Phase Power Analyzer Ph_START=1 and PH_END=3.

- In response to the command VOLT:MEAN?CRLF the 6 phase instrument sends Vmean of six phases, and the 3 phase instrument sends Vmean of three phases. Every value consists of 8 ASCII characters, e.g. -999.58m. The string for a 3 phase instrument could look like this:

  VOLT:MEAN?CRLF → 999.58m 200.01m–1.0008 CRLF (26 ASCII characters).

  The string length is 24 characters followed by the terminators CR (carriage return) LF (line feed).

❋ One or several Control Commands marked with ❋ must be terminated with the control command DISplay:UPDATE. This assures that changes are transferred to the display processor to also update the display panel.

**Suggestion**: Send first all required control commands, such as CURRent:SC1 <R>, ACQuire:AUTO_V, ACQuire:INput, etc. one after the other; when done, send DISplay:UPDATE to transfer all changes to the display processor.

- The capital letters in the command list are mandatory. They can be sent upper case or lower case. The lower case letters in the command set can be added if desired.
- <R> = decimal number, e.g. 2000.5. It follows the command with one space.
- <N> = integer number, e.g. 32000. It follows the command with one space.
- Every command must be terminated with CR/LF (carriage return / line feed).
- Query commands are terminated by a question mark and CR/LF. The Power Analyzer returns measurement values.

  Example: volt:rms?CRLF returns rms voltages of all phases.
  curr:sc1?CRLF returns scaling factor phase 1.

  The question mark follows the command without space

- Set commands. Examples of set commands:

| | |
|---|---|
| CURR:SC3 <R>; | CURR:SC3 2000.5CRLF, sets current scaling factor phase 3 to 2000.5. There is one space between SC3 and 2000.5. |
| FORM:PH_END <N> | FORM:PH_END 3CRLF, sets phase end to 3. If you are using a 6-phase Power Analyzer the query volt:rms? returns 3 voltages phase 1, 2, and 3. |

- DISP:BATCH command is used to configure up to 4 pages (32 lines) of the display in a single batch. The following example shows how to reconfigure the first 6 lines on page 1.

  DISP:BATCH A02A03A04A36A06A83CRLF. This command reconfigures the first 6 lines of the display page 1. The batch values of all displayable quantities you find in tables 3.1 and A83 you find in table 3.2

| | | |
|---|---|---|
| A02 | rectified mean current | on display line 1 |
| A03 | rms voltage, | on display line 2 |
| A04 | DC-voltage, | on display line 3 |
| A36 | fundamental voltage V01, | on display line 4 |
| A06 | active power, | on display line 5 |
| A83 | ratio 1 = Pact2 / Pact1 in display column 1, line 6<br>ratio 2 = (Pact1 + Pact2) / Pact3 in display column 2, line 6<br>ratio 3 = (Pact3 + Pact4) / (Pact1 + Pact2) in display column 3, line 6 | |

Maximum 32 batch values Axy can be sent. Using Table 3.2 sums, ratios, motor values, transformer values, analog inputs, and frequency inputs can be displayed.

- Composite commands Table 5.1 using a 3 Phase Power Analyzer.

| | |
|---|---|
| COMP:CMP1? | returns:3 Vrms, 3 Arms, and 3xW, terminated with CRLF. The data string is: Vrms1, Vrms2, Vrms3, Arms1, Arms2, Arms3, W1, W2, W3, CRLF. Where Vrms1 = voltage phase 1, etc. The string length is 9 x 8 + 2 = 74 ascii characters. |
| COMP:CMP2? | returns: 3 Vrms, 3 Arms, 3 W, 3 VA, 3 PF, 3 Wh, 3 elapsed time. Data string length = 21 · 8 + 2 = 170 ascii characters. |
| COMP:CMP3? | 3 V1, 3 A1, 3 W1, 3VA1, 3 PF1, 3 Z1, 3 Phi1. V1, … Phi1 are FFT-values of the fundamental frequency. |
| COMP:DSP1? | returns the displayed values of display line 1, 2, 3, and 4 of page 1. For a 3-phase instrument there will be 12 quantities. For a 6-phase instrument there will be 24 quantities. |
| COMP:SUMS? | returns SUM1, SUM2, SUM3, SUM4, SUM5, and SUM6 defined in table 3.2. Note: SUM4, SUM5, and SUM6 are zero when a 3-phase power Analyzer is used. |
| COMP:RATIO? | returns 6 ratios, these ratios define efficiencies. Use the defined ratios in table 3.2 and hook up the Power Analyzer accordingly.<br><br>*Example: ratio 1 = Pact2 / Pact1. It requires connecting the system input to phase 1 and the system output to phase 2.* |
| COMP:MOTOR1? | Returns 6 motor1 values from connection to phase 1, 2, 3. |
| COMP:MOTOR2? | Returns 6 motor2 values from connection to phase 4, 5, 6. |
| COMP:MOT1_Loss? | returns 6 motor values when motor1 is idling. It stores motor loss and is then used in command COMP:MOTOR1? To calculate motor output power on the drive shaft. |
| COMP:MOT2_Loss? | returns 6 motor values when motor2 is idling. It stores motor loss and is then used in command COMP:MOTOR2? To calculate motor output power on the drive shaft |
| COMP:TRAFO? | returns 6 transformer values from phase 1 and phase 2 at idle and short circuit. |
| COMP:ANIN? | returns the values of 6 analog inputs. 4x ±5V and 2x ±10V inputs. |
| COMP:VLTL? | returns 6 line to line voltages according to definition at end of table 3.2. |

## 5.3 COMPUTER INTERFACE COMMAND SET

Throughout the command set tables it is assumed a 6 phase Power Analyzer is used. If you are using a 3 phase instrument “6x” must be replaced by “3x”.
The default for ph_start=1 (Table 5.7). The default of ph_end is equal the number of phases installed in your instrument.

***Example:*** You are using a 6 phase Power Analyzer. After start-up you send the command: comp:cmp1?

In return you receive 6x Vrms, 6x Arms, and 6x W; measurement values from phase 1, 2, … , 6. If you send the command “form: ph_start 4” the Power Analyzer will return to the command “comp:cmp1?” 3x Vrms, 3x Arms, and 3x W; measurement values from phase 4, 5, and 6.

## 5.4 COMPOSITE COMMANDS, read several quantities with one command.

Table 5.1 composite commands

| Command | Output for a 6 phase instrument with PH_START=1, PH_END=6 |
|---|---|
| COMPose:CMP1? | 6x Vrms, 6x Arms, 6x Watt, phase 1 value first |
| COMPose:CMP2? | 6x Vrms, 6x Arms, 6x W, 6x VA, 6x PF, 6x Wh, 6x time |
| COMPose:CMP3? | 6x Fundamental V1, A1, W1, VA1, PF1, Z1, Phi1 |
| COMPose:CMP4? | 6x Wh, VAh, Varh, Ah, time since RESET |
| COMPose:DSP1? | 6x Display value line 1, 6x line 2, 6x line 3, 6x line 4 of page 1 |
| COMPose:DSP2? | 6x Display value line 5, 6x line 6, 6x line 7, 6x line 8 of page 1 |
| COMPose:SUMS? | 1x SUM1, 1x SUM2, 1x SUM3, 1x SUM4, 1x SUM5, 1x SUM6 (table 3.2) |
| COMPose:RATIO? | 1x Ratio1, 1x Ratio2, 1x Ratio3, 1x Ratio4, 1x Ratio5, 1x Ratio 6 |
| COMPose:MOTOR1? | 1x Winput, 1x Woutput, 1x Torque, 1x Slip, 1x Speed, 1x Efficiency |
| COMPose:MOTOR2? | 1x Winput, 1x Woutput, 1x Torque, 1x Slip, 1x Speed, 1x Efficiency |
| COMPose:MOT1_Loss? | Stores motor1 power consumed without load. Output 6 motor values. |
| COMPose:MOT2_Loss? | Stores motor2 power consumed without load. Output 6 motor values. |
| COMPose:TRAFO? | 1x Vrect x1.11, Wcorrected, Qfactor, Reqiv, Xeqivalent, n2/n1 |
| COMPose:ANIN? | 4x Analog input ±5V, 2x Analog input ±10V |
| COMPose:VLTL? | 6x voltage line to line (Table 3.2) |
| COMPose:LOG1? | 6x Arms, 6x Vrms, 6xW, 6xPF; reads data in Logging mode |
| COMPose:LOG2? | 6x frequ, 6xArm, 6xVrms, 6xW, 6xPF,6xWh, 6x VAh |

## 5.5 READING VOLTAGES, READING AND WRITING VOLTAGE SCALE FACTORS

Table 5.2 Voltages Reading Commands

| | |
|---|---|
| VOLTage:RMS? | 6x Vrms (root mean square), phase 1 value first. |
| VOLTage:FUND? | 6x fundamental of voltage (V1) |
| VOLTage:RECT? | 6x Vrect (rectified mean of voltage) |
| VOLTage:MEAN? | 6x Vmean (is valid also when AC coupling is used) |
| VOLTage:MIN? | 6x minimum voltage |
| VOLTage:MAX? | 6x maximum voltage |
| VOLTage:PEAK? | 6x peak to peak voltage |
| VOLTage:FFTL1? | Harmonics L1: V1, V2, …, V40.<br>Can be changed by altering FFT_START, FFT_END (max. 88) |
| VOLTage:FFTL2? | Harmonics L2: V1, V2, …, V40.<br>Can be changed by altering FFT_START, FFT_END (max. 88) |
| VOLTage:FFTL3? | Harmonics L3: V1, V2, …, V40.<br>Can be changed by altering FFT_START, FFT_END (max. 88) |
| VOLTage:FFTL4? | Harmonics L4: V1, V2, …, V40.<br>Can be changed by altering FFT_START, FFT_END (max. 88) |
| VOLTage:FFTL5? | Harmonics L5: V1, V2, …, V40.<br>Can be changed by altering FFT_START, FFT_END (max. 88) |
| VOLTage:FFTL6? | Harmonics L6: V1, V2, …, V40.<br>Can be changed by altering FFT_START, FFT_END (max. 88) |
| VOLTage:THD1? | 6x THD1 = $(Vrms^2 – V1^2)^{1/2}$/Vrms. Use it for frequency inverter. |
| VOLTage:THD2? | 6x THD2 = $\Sigma(Vn^2)^{1/2}$/Vrms, n = 2 -40. |
| VOLTage:CREST? | 6x Voltage Crest Factor |
| VOLTage:FORM? | 6x Voltage Form Factor |
| VOLTage:CURVEL1? | 512 samples of wave L1.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| VOLTage:CURVEL2? | 512 samples of wave L2.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| VOLTage:CURVEL3? | 512 samples of wave L3.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| VOLTage:CURVEL4? | 512 samples of wave L4.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| VOLTage:CURVEL5? | 512 samples of wave L5.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| VOLTage:CURVEL6? | 512 samples of wave L6.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| VOLTage:SC1 <R><br>❋ | Read Voltage Scaling Factor L1: VOLT:SC1?<br>Write voltage scaling factor L1: VOLT:SC1 20.15 or 2.015e1 |
| VOLTage:SC2 <R><br>❋ | Read Voltage Scaling Factor L2: VOLT:SC2?<br>Write voltage scaling factor L2: VOLT:SC2 20.15 or 2.015e1 |
| VOLTage:SC3 <R><br>❋ | Read Voltage Scaling Factor L3: VOLT:SC3?<br>Write voltage scaling factor L3: VOLT:SC3 20.15 or 2.015e1 |
| VOLTage:SC4 <R><br>❋ | Read Voltage Scaling Factor L4: VOLT:SC4?<br>Write voltage scaling factor L4: VOLT:SC4 20.15 or 2.015e1 |
| VOLTage:SC5 <R><br>❋ | Read Voltage Scaling Factor L5: VOLT:SC5?<br>Write voltage scaling factor L5: VOLT:SC5 20.15 or 2.015e1 |
| VOLTage:SC6 <R><br>❋ | Read Voltage Scaling Factor L6: VOLT:SC6?<br>Write voltage scaling factor L6: VOLT:SC6 20.15 or 2.015e1 |

## 5.6 READING CURRENTS, READING AND WRITING CURRENT SCALE FACTOR

Table 5.3 Current Reading Commands

| | |
|---|---|
| CURRent:RMS? | 6x Arms (root mean square), phase 1 value first. |
| CURRent:FUND? | 6x fundamental of current (A1) |
| CURRent:RECT? | 6x Arect (rectified mean of current) |
| CURRent:MEAN? | 6x Amean (is valid also when AC coupling is used). |
| CURRent:MAX? | 6x maximum current |
| CURRent:FFTL1? | Harmonics L1: A1, A2, …, A40.<br>Can be changed by altering FFT_START, FFT_END (max. 88). |
| CURRent:FFTL2? | Harmonics L2: A1, A2, …, A40.<br>Can be changed by altering FFT_START, FFT_END (max. 88). |
| CURRent:FFTL3? | Harmonics L3: A1, A2, …, A40.<br>Can be changed by altering FFT_START, FFT_END (max. 88). |
| CURRent:FFTL4? | Harmonics L4: A1, A2, …, A40.<br>Can be changed by altering FFT_START, FFT_END (max. 88). |
| CURRent:FFTL5? | Harmonics L5: A1, A2, …, A40.<br>Can be changed by altering FFT_START, FFT_END (max. 88). |
| CURRent:FFTL6? | Harmonics L6: A1, A2, …, A40.<br>Can be changed by altering FFT_START, FFT_END (max. 88). |
| CURRent:THD1? | 6x THD1 = $(Arms^2 – A1^2)^{1/2}$/Arms. Use if for frequency inverter. |
| CURRent:THD2? | 6x THD2 = $\Sigma(An^2)^{1/2}$/Arms, n = 2, 3, …, 40. |
| CURRent:CREST? | 6x current crest factor |
| CURRent:FORM? | 6x current form factor |
| CURRent:CURVEL1? | 512 samples of wave L1.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| CURRent:CURVEL2? | 512 samples of wave L2.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| CURRent:CURVEL3? | 512 samples of wave L3.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| CURRent:CURVEL4? | 512 samples of wave L4.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| CURRent:CURVEL5? | 512 samples of wave L5.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| CURRent:CURVEL6? | 512 samples of wave L6.<br>Each sample 3 ascii numbers centered around 500 ±255. |
| CURRent:SC1 <R><br>❋ | Read current scaling factor L1: CURR:SC1?<br>Write current scaling factor L1: CURR:SC1 2000.0 or 2.0e3 |
| CURRent:SC2 <R><br>❋ | Read current scaling factor L2: CURR:SC2?<br>Write current scaling factor L2: CURR:SC2 2000.0 or 2.0e3 |
| CURRent:SC3 <R><br>❋ | Read current scaling factor L3: CURR:SC3?<br>Write current scaling factor L3: CURR:SC3 2000.0 or 2.0e3 |
| CURRent:SC4 <R><br>❋ | Read current scaling factor L4: CURR:SC4?<br>Write current scaling factor L4: CURR:SC4 2000.0 or 2.0e3 |
| CURRent:SC5 <R><br>❋ | Read current scaling factor L5: CURR:SC5?<br>Write current scaling factor L5: CURR:SC5 2000.0 or 2.0e3 |
| CURRent:SC6 <R><br>❋ | Read current scaling factor L6: CURR:SC6?<br>Write current scaling factor L6: CURR:SC6 2000.0 or 2.0e3 |

## 5.7 READING POWER, APPARENT POWER, AND REACTIVE POWER

Table 5.4 Power Reading Commands

| | |
|---|---|
| POWer:ACTive? | 6x W (active power) |
| POWer:APParent? | 6x VA (apparent power) |
| POWer:REActive? | 6x Var (reactive power) |
| POWer:FFTL1? | Power Harmonics L1: W1, W2, …, W21.<br>Can be changed by altering FFT_START, FFT_END (max. 21) |
| POWer:FFTL2? | Power Harmonics L2: W1, W2, …, W21.<br>Can be changed by altering FFT_START, FFT_END (max. 21) |
| POWer:FFTL3? | Power Harmonics L3: W1, W2, …, W21.<br>Can be changed by altering FFT_START, FFT_END (max. 21) |
| POWer:FFTL4? | Power Harmonics L4: W1, W2, …, W21.<br>Can be changed by altering FFT_START, FFT_END (max. 21) |
| POWer:FFTL5? | Power Harmonics L5: W1, W2, …, W21.<br>Can be changed by altering FFT_START, FFT_END (max. 21) |
| POWer:FFTL6? | Power Harmonics L6: W1, W2, …, W21.<br>Can be changed by altering FFT_START, FFT_END (max. 21) |
| POWer:FACTor? | 6x Power factor W/VA |
| POWer:ACT1? | 6x fundamental Power W1 (Harmonic 1) |
| POWer:APP1? | 6x fundamental apparent power VA1 (Harmonic 1) |
| POWer:REA1? | 6x fundamental reactive power Var1 (Harmonic 1) |
| POWer:FAC1? | 6x power factor of fundamental (Harmonic 1) |
| POWer:DIST? | 6x Apparent power of distortion = $V1(A2^2 + \ldots + A40^2)^{1/2}$ |

## 5.8 READING ENERGY, CHARGE, AND TIME

Table 5.5 Energy Reading Commands

| | |
|---|---|
| ENergy:ACTive? | 6x active energy Wh |
| ENergy:APParent? | 6x apparent energy VAh |
| ENergy:REActive? | 6x reactive energy Varh |
| ENergy:CHArge? | 6x charge in Ah = ∫Arect x dt |
| ENergy:TIME? | 6x elapsed time since RESET in hours |
| ENergy:RESET | Resets all energy values including Ah and Time |

## 5.9 READING FREQUENCY, IMPEDANCE, AND PHASE ANGLE.

Table 5.6 Frequency, Impedance, Phase Angle Reading Commands

| | |
|---|---|
| FREQency? | 6x frequency of current or voltage (fundamental) |
| IMPedance:MAG? | 6x magnitude of impedance = V1/A1 (fundamental) |
| IMPedance:ANGle? | 6x phase angle of fundamental impedance |
| IMPedance:FFT_ANGL1? | Phase angle L1: phi1, phi2, …, phi21 |
| IMPedance:FFT_ANGL2? | Phase angle L2: phi1, phi2, …, phi21 |
| IMPedance:FFT_ANGL3? | Phase angle L3: phi1, phi2, …, phi21 |
| IMPedance:FFT_ANGL4? | Phase angle L4: phi1, phi2, …, phi21 |
| IMPedance:FFT_ANGL5? | Phase angle L5: phi1, phi2, …, phi21 |
| IMPedance:FFT_ANGL6? | Phase angle L6: phi1, phi2, …, phi21 |

## 5.10 READING AND WRITING RANGE OF HARMONICS, NUMBER PHASES FOR OUTPUT, AND CYCLE FOR LOGGING

Table 5.7 Format Reading Commands

| | | |
|---|---|---|
| FORMat:FFT_START <N> | Read FFT_START 1-88.<br>Write FFT_START 1-88. | FORM:FFT_START?<br>FORM:FFT_START 18. Set harmonic to 18. |
| FORMat:FFT_END <N> | Read FFT_END 1-88.<br>Write FFT_END 1-88. | FORM:FFT_END?<br>FORM:FFT_END 50. Set harmonic to 50. |
| FORMat:PH_START <N> | Read PH_START 1-6.<br>Write PH_START 1-6. | FORM:PH_START?<br>FORM:PH_START 5. Set phase start to 5. |
| FORMat:PH_END <N> | Read PH_END 1-6.<br>Write PH_END 1-6. | FORM:PH_END?<br>FORM:PH_END 3. Set phase end to 3. |
| FORMat:CYCLE <N><br>❋ | Read CYCLE (for logging).<br>Write CYCLE (for logging). | FORM:CYCLE?, integer max. 32000.<br>FORM:CYCLE 32000. Set cycle to max. |

## 5.11 READ AND WRITE DISPLAY, RS232 BAUD RATE, IEEE-488 ADDRESS

Table 5.8 Display, Interface, Analog Scaling Commands

| | |
|---|---|
| DISplay:PAGE <N><br>❋ | Read active display page 1-4. DISP:PAGE?<br>Write display page 1-4. DISP:PAGE 4. Display shows values of page 4 |
| DISplay:BATCH<br>❋ | Example to change the display values of page 1, line 1, 2, 3, 4<br>DISP:BATCH A00A03A06A14. Arms, Vrms, Pact, Wh. (Table 3.1 and 3.2) |
| DISplay:AN_SC1 | Read analog1 scaling factor: DIS:AN_SC1?<br>Write analog1 scaling factor: DIS:AN_SC1 2.0 |
| DISplay:AN_SC2 | Read analog2 scaling factor: DIS:AN_SC2?<br>Write analog2 scaling factor: DIS:AN_SC2 10.0 |
| DISplay:AN_SC3 | Read analog3 scaling factor: DIS:AN_SC3?<br>Write analog3 scaling factor: DIS:AN_SC3 5.1 |
| DISplay:AN_SC4 | Read analog4 scaling factor: DIS:AN_SC4?<br>Write analog4 scaling factor: DIS:AN_SC4 201.0 |
| DISplay:AN_SC5 | Read analog5 scaling factor: DIS:AN_SC5?<br>Write analog5 scaling factor: DIS:AN_SC5 0.85 |
| DISplay:AN_SC6 | Read analog6 scaling factor: DIS:AN_SC6?<br>Write analog6 scaling factor: DIS:AN_SC6 1.0 |
| DISplay:RPM_SC1 | Read rpm1 scaling factor: DIS:RPM_SC1?<br>Write rpm1 scaling factor: DIS:RPM_SC1 2.0 |
| DISplay:RPM_SC2 | Read rpm2 scaling factor: DIS:RPM_SC2?<br>Write rpm2 scaling factor: DIS:RPM_SC2 8.0 |
| RS232 <N><br>❋ | Read BAUD-ID. RS232? → Output: 4, 0, 0. First Integer = Baud-ID<br>Write BAUD-ID. RS232 5.<br>Baud-ID = 0,1, … 7=9.6/19.2/38.4/56.6/115.2/230.4/460.8/921.6k Baud |
| GPIB <N><br>❋ | Read GPIB ADDRESS: GPIB? address 1- 30.<br>Write GPIB ADDRESS: GPIB 20, writes address 20. |
| DISplay:UPDATE<br>❋ | Write update command to send all changes to the display |

## 5.12 READ AND WRITE COMMON CONTROL COMMANDS.

Table 5.9 Control Commands

| | |
|---|---|
| VERsion? | Read type of instrument, Software, number phase |
| ACQuire:INPUT<br>❋ | Read current input id: ACQ:INPUT? 1A=3, 5A=0, 30A=1, Shunt=2.<br>Set current input 30A: ACQ:INPUT 1x, x=1, 2, .., 6=phase. x=9=all phase |
| ACQuire:AUTO_V<br>❋ | Read V-auto: ACQ:AUTO_V? 1/0=auto on/off<br>Set auto on/off: ACQ:AUTO_V 1x, x=1, 2, .., 6=phase, x=9=all phase |
| ACQuire:AUTO_A<br>❋ | Read A-auto: ACQ:AUTO_A? 1/0=auto on/off<br>Set A-auto on/off: ACQ:AUTO_V 1x, x=1, 2, .., 6=phase, x=9=all phase |
| ACQuire:RANGE_V<br>❋ | Read V-range: ACQ:RANGE_V? 0,1,..,7=0.3,1,3,10,30,100,300,1000V<br>Set 300V range: ACQ:RANGE_V 6x, 6=300V, x=1, ..,6=phase, x=9=all phase |
| ACQuire:RANGE_A<br>❋ | Read A-range: ACQ:RANGE_A? 1A/5A=0, 1, ..,6. 30A/Sh=0,1,2,3,4<br>IN5A/50mA range ACQ:RANGE_A 1x; x=1, 2, ..,6=phase, x=9=all phase |
| ACQuire:SYNChro<br>❋ | Read Sync: ACQ:SYNC? 0/1/2=current/voltage/external<br>Set Sync: ACQ:SYNC 0x, x=1, 2, ..,6=phase, x=9=all phase |
| ACQuire:APERture<br>❋ | Read averaging time: ACQ:APER?. 0, 1, 2, 3, 4=0.5s, 1s, 2s, 8s, 32s<br>Set averaging time: ACQ:APER 1. 5 = Fast (100ms) |

| | |
|---|---|
| ACQuire:QU_V | Read V-under, -ok, -over: ACQ:QU_V? 0, 1, 2=ok, over-, underange. |
| ACQuire:QU_A | Read A-under, -ok, -over: ACQ:QU_A? = 0, 1, 2=ok, over-, underrange. |
| ACQuire:DC_AC<br>❋ | Read coupling of input amplifiers: ACQ:DC_AC? 0=DC, 1=AC<br>Set coupling of input amplifiers: ACQ:DC_AC 1. Set AC coupling. |
| ACQuire:MODE | Read measure mode: ACQ:MODE?<br>0,1,2,3=stand,1=Log,2=Trans,3=psp<br>Set measure mode: ACQ:MODE 0. Set standard measure mode |
| ACQuire:TRANS_ID<br>❋ | Read duration transient: ACQ:TRANS_ID? 0, 1, 2, 3, 4, 5, 6=duration in sec. 0.25, 0.5, 1, 2, 4, 8, 16<br>Set duration: ACQ:TRANS_ID 2. 2=1 sec. |
| ACQuire:AVG_FFT<br>❋ | Read fft-averaging: ACQ:AVG_FFT? 0,1,2,3,4 = Every fft-point is an average of 4, 16, 64, 256, 1024 samples.<br>Set fft-averaging: ACQ:AVG_FFT 1. |
| ACQuire:SUPRESS<br>❋ | Read suppress: ACQ:SUPRESS? 0=suppress off, 1=on<br>Set suppress: ACQ:SUPRESS 1. Suppress on. |
| ACQuire:HOLD<br>❋ | Set display run: ACQ:HOLD 0.<br>Set display hold: ACQ:HOLD 1.<br>Set display locked: ACQ:HOLD 2; (2:**must** be used for PC operation)<br>(ACQ:HOLD 2 grays 108A display buttons, avoids conflicts)<br>Turn display off: ACQ:HOLD 4; ACS10<br>Turn display on: ACQ:HOLD 5; ACS10 |
| ACQuire:GO | ACQ:GO starts measurement if in Logging, transient or power-speed. Has no effect in standard measure mode. |
| ACQuire:HALT | ACQ:HALT stops measurement if in Logging, transient or power speed. Has no effect in standard measure mode. |
| ACQuire:SETTING<br>❋ | ACQ:SETTING? Output is previously loaded setting number 0,1,2, ..<br>ACQ:SETTING 12 Loads setting number 12 if present in memory. |
| ACQuire:NR_POLE1 | Read number motor poles, motor1 ACQ:NR_POLE1? 2, 4, 6, 8, 10, 12 …<br>Set number of motor1 poles to 12: ACQ:NR_POLE1 12. |
| ACQuire:NR_POLE2 | Read number motor2 poles, motor2 ACQ:NR_POLE2? 2, 4, 6, 8, 10, 12 …<br>Set number of motor2 poles to 12: ACQ:NR_POLE2 6. |
| ACQuire:ZOOM | Set expand sector/back ACQ:ZOOM 0, 1, 2, 3 / 4<br>TRANSIENT MEASURE MODE ONLY |

**Important:** Rules for using ACQuire:MODE x, x = 0, 1, 2, 3.
x = 0 = standard measure mode
x = 1 = logging measure mode
x = 2 = transient measure mode
x = 3 = power-speed measure mode

- From standard measure mode you can switch to any other measure mode. After sending the command wait 1 second.

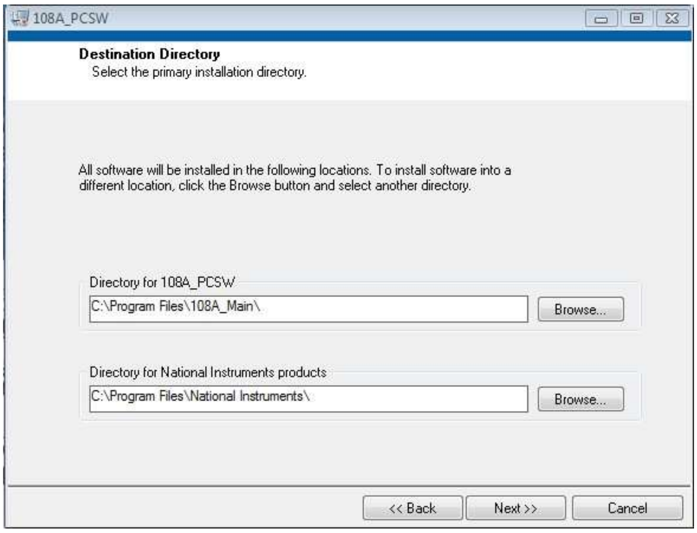
- If you are operating in any other measure mode (1, 2, 3) you must first send ACQ:MODE 0 to return first to standard measure mode, wait 1 second, and send the next command to enter the desired measure mode, and wait 1 second to continue.

## 6. Computer Operating Software

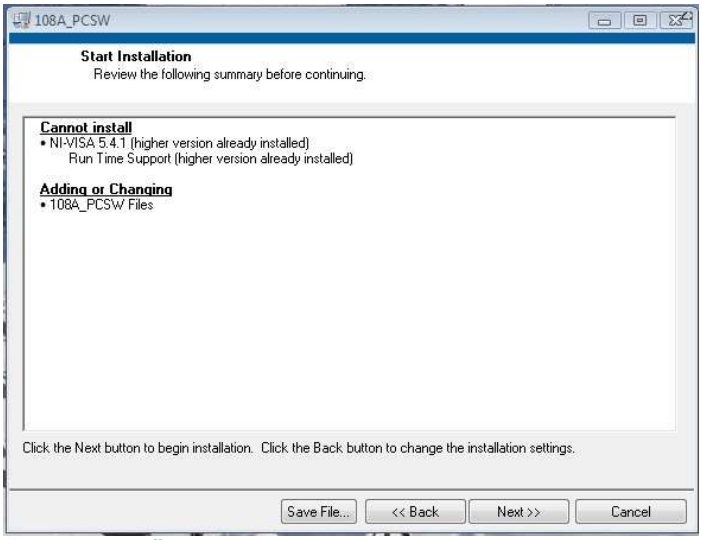
### 6.1 Installing Computer Operating Software

Insert the CD-ROM in to the drive for installation.


Click setup.exe for installation.




Click "NEXT" if directory location is correct.




Click "NEXT >>" to start the installation

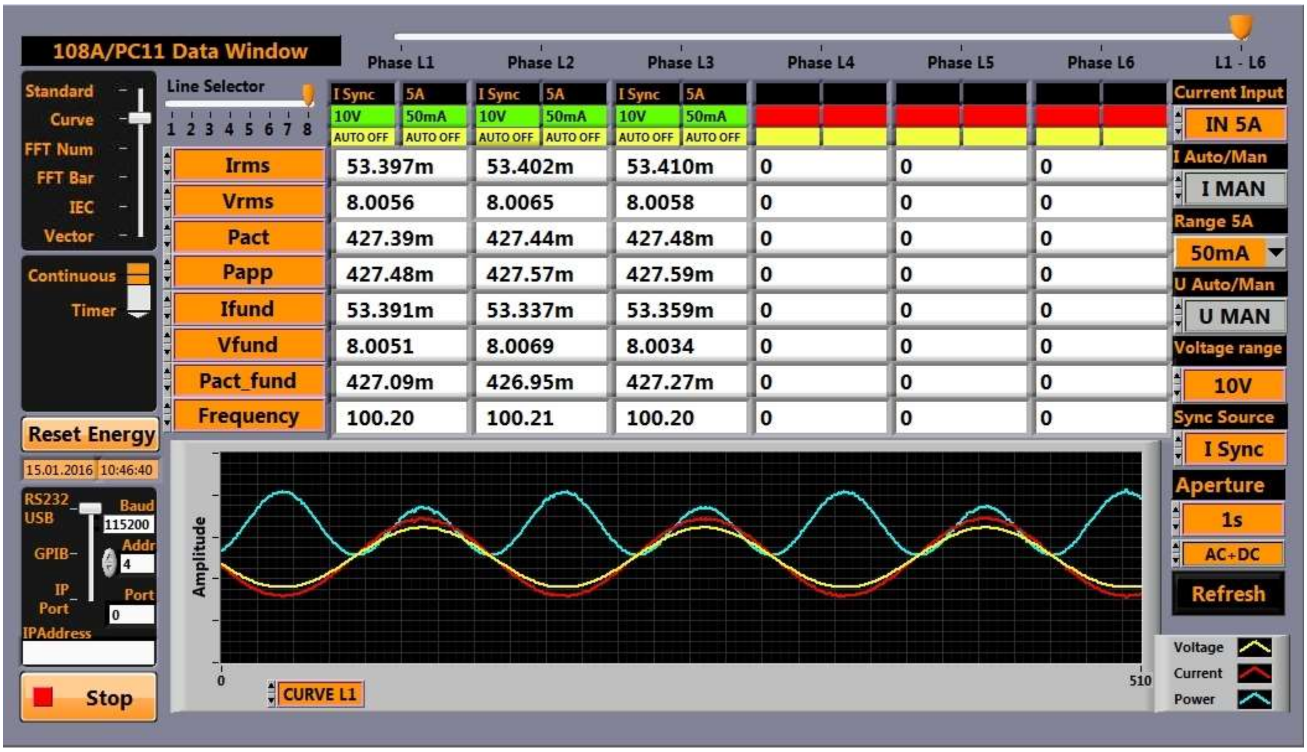
## 6.2 108A Data Window (Computer Software)

The Power Analyzer Computer Operating Software consists basically of 3 Windows: The Data Window, the IEC Data Window and the Control/Setting Window.

The **Data Window** displays the measured values, and the actual ranges of current and voltage. A reserved field is for displaying voltage- and current wave forms (Curve), FFT numeric values and FFT Bar chart. The Data Window lets you select the current inputs, the synchronization, the ranges for current and voltages, the averaging time, the measure mode and the values to be displayed.

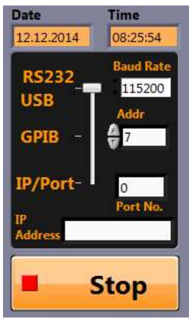
The **IEC Data Window** displays numeric values and charts in context with IEC 555-2 (EN 61000-3-2) standards.

The **Control/Setting Window** let you select the scaling factors for current, voltage, and analog inputs, Harmonic range, Cycles, FFT- and Transient ID, Suppress and instrument setting numbers.



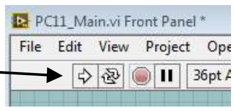

**108A Front Panel**

### 6.2.1 Select Interface



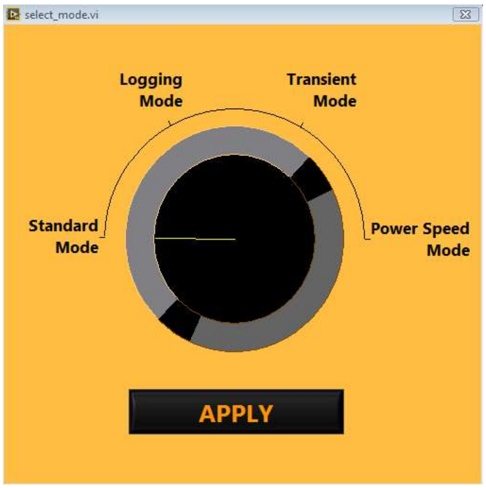

Move interface slider to **RS232/USB** or **GPIB** or **IP/Port**.

1. RS232/USB >> select Baud Rate and set Addr (COM)
2. GPIB >> set Addr
3. IP/Port >> set IP Address and Port No.
4. press button




**Stop Button** press **Stop** to terminate the communication.

### 6.2.2 SELECT INSTRUMENT MODE




Turn knob to **Standard Mode**, **Logging Mode**, **Transient Mode** or **Power Speed Mode**.

Press **APPLY**

**STANDARD MODE**
In the Standard Measure Mode 280 quantities per phase are continuously measured (no gaps) and are updated. Values can be displayed on four display pages, can be saved in internal memory, or can be transferred via Interface to a computer.

**LOGGING MODE**
The basic operation is as follows: Select the number of cycles for which you desire a periodic data output to the RS232 / USB-interface. If you perform measurements on the 50Hz power line and you select cycles = 1 you obtain new data every 20ms; if you select cycles = 30000 you obtain new data every 10 minutes.

**TRANSIENT MODE**
The transient measure mode can be used in two ways: You can catch current-, voltage-, and power wave forms in a start-up on all phases simultaneously or you can view all wave forms at a critical operating point in Standard Measure Mode. (up to maximum 6 phases).

**POWER-SPEED MODE**
This measure mode analyzes the performance of electric devices such as electric cars.

### 6.2.3 SELECT SOFTWARE MODE


Move function slider to **Standard, Curve, FFT Num, FFT Bar, IEC** or **Vector.**

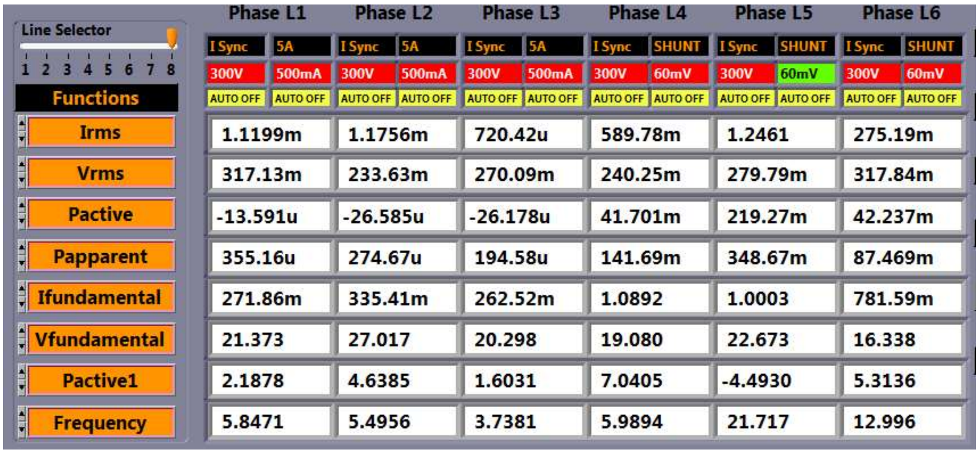
| | | |
|---|---|---|
| 1. | Standard | >> measurement values |
| 2. | Standard + Curve | >> measurement values and curves |
| 3. | Standard + FFT Num | >> measurement values and harmonics |
| 4. | Standard + FFT Bar | >> measurement values and bar graphs |
| 5. | IEC | >> move to 108A/PC11 IEC Data Tab |
| 6. | Standard +Vector | >> measurement values and vector graphs |

**Continuous mode** Continuous measurement (and data storage)

**Timer mode** Measurement after 1s, 2s, ...., 60s (and data storage)

**Abort** Abort the timer at the next time interval elapsed.

### 6.2.4 OPERATE THE COMPUTER SOFTWARE



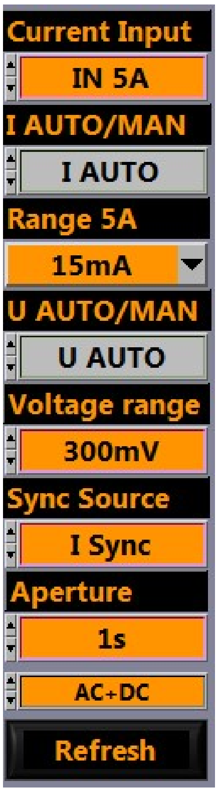
| Line Selector 1 2 3 4 5 6 7 8 | Phase L1 | | Phase L2 | | Phase L3 | | Phase L4 | | Phase L5 | | Phase L6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I Sync | 5A | I Sync | 5A | I Sync | 5A | I Sync | SHUNT | I Sync | SHUNT | I Sync | SHUNT |
| | 300V | 500mA | 300V | 500mA | 300V | 500mA | 300V | 60mV | 300V | 60mV | 300V | 60mV |
| Functions | AUTO OFF | AUTO OFF | AUTO OFF | AUTO OFF | AUTO OFF | AUTO OFF | AUTO OFF | AUTO OFF | AUTO OFF | AUTO OFF | AUTO OFF | AUTO OFF |
| Irms | 1.1199m | | 1.1756m | | 720.42u | | 589.78m | | 1.2461 | | 275.19m | |
| Vrms | 317.13m | | 233.63m | | 270.09m | | 240.25m | | 279.79m | | 317.84m | |
| Pactive | -13.591u | | -26.585u | | -26.178u | | 41.701m | | 219.27m | | 42.237m | |
| Papparent | 355.16u | | 274.67u | | 194.58u | | 141.69m | | 348.67m | | 87.469m | |
| Ifundamental | 271.86m | | 335.41m | | 262.52m | | 1.0892 | | 1.0003 | | 781.59m | |
| Vfundamental | 21.373 | | 27.017 | | 20.298 | | 19.080 | | 22.673 | | 16.338 | |
| Pactive1 | 2.1878 | | 4.6385 | | 1.6031 | | 7.0405 | | -4.4930 | | 5.3136 | |
| Frequency | 5.8471 | | 5.4956 | | 3.7381 | | 5.9894 | | 21.717 | | 12.996 | |

< Current input indicators
< Isync / Usync indicators
< Voltage range indicators
< Current range indicators
< Auto ON/OFF indicators

**Functions** Select a measurement value.

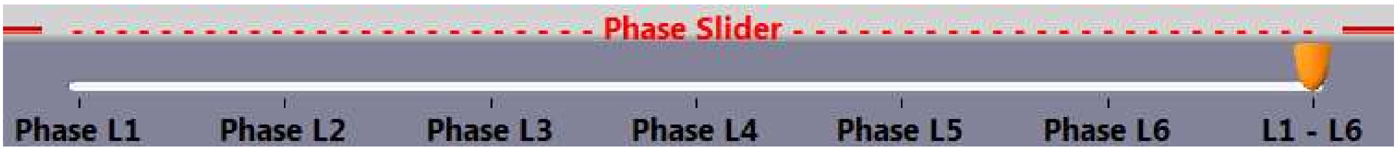
Irms/Ifundamental/Irectified/Imean/Imaximum/Ithd1/Ithd2/Icrest factor/Iform factor
Vrms/Vfundamental/Vrectified/Vmean/Vminimum/Vmaximum/V peak-to-peak/Vthd1/Vthd2
Vcrest factor/Vform factor
Pactive/Pappearent/Preactive/Pfactor/Pactive1/Pappearent1/Preactive1/Pfactor1/Pdistortion
Eactive/Eappearent/Ereactive/Echarge/Etime/Frequency/Zmagnitude/Zphase
Power Sum/Power Ratio/Motor1/Motor2/Motor1_loss/Motor2_loss/Trafo/Analog in/Line-to-line

### 6.2.5 Input, Ranges, Synchronization, Aperture selection



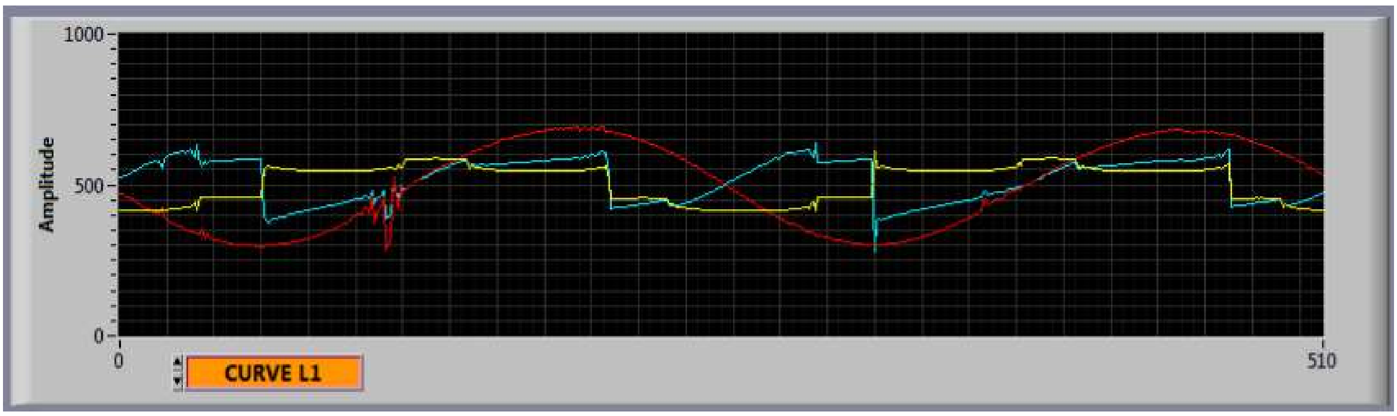

| | |
|---|---|
| **Current Input**: | Select IN 1A / IN 5A / IN 30A or SHUNT |
| **I AUTO/MAN**: | Select mode: I AUTO/MAN = current auto/manual ranging |
| **IN 5A**: | 15mA, 50mA, 150mA, 500mA, 1.5A, 5A, 15A |
| **IN 30A**: | 1A, 3A, 10A, 30A, 100A |
| **IN 1A**: | 1.5mA, 5mA, 15mA, 50mA, 150mA, 500mA, 1.5A |
| **SHUNT**: | 60mV, 200mV, 600mV, 2V, 6V |
| **U AUTO/MAN**: | Select mode: U AUTO/MAN = voltage auto/manual ranging |
| **Voltage range**: | 300mV/1V/3V/10V/30V/100V/300V/1000V |
| **Sync Source**: | I Sync = current synchronisation (Default); 2Hz-5kHz<br>U Sync = voltage synchronisation, 2Hz-150kHz<br>Ext Sync = external synchronisation, 2Hz-150kHz |
| **Aperture**: | 100ms/500ms (default)/1s/2s/8s/32s |
| **AC+DC**: | Set coupling of input amplifiers: AC or AC+DC coupling |
| **Refresh**: | Press Refresh button to execute settings. |

### 6.2.6 Phase Slider for selecting individual settings per phase




Individual selection for voltage ranges, current inputs, current ranges and synchronization for every phase is possible. Move the Phase Slider along the top of the software to L1, L2, …, L6 or L1-L6, and press the  button to send the settings to the instrument.

### 6.2.7 Curve



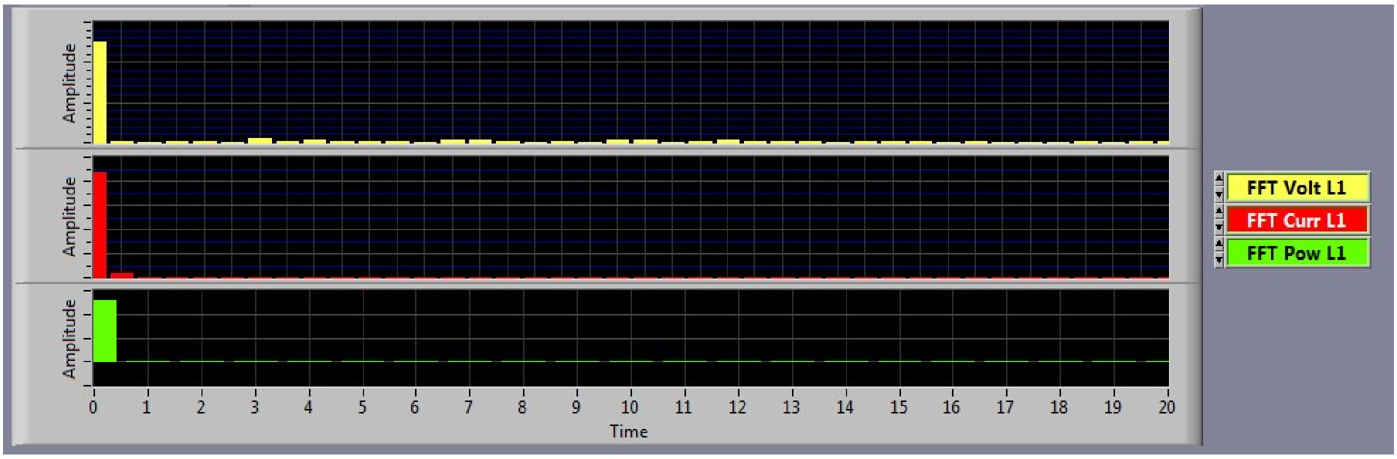

| | |
|---|---|
| **Curve**: | Select desired waveform chart. Curve L1, L2, ...., L6 of current, voltage and power. |

## 6.2.8 FFT NUMERICS (HARMONICS)


**Harmonics**: Select a FFT measurement value. FFT Volt L1-L6 / FFT Current L1-L6 FFT Power L1-L6 / FFT Angle L1-L6.

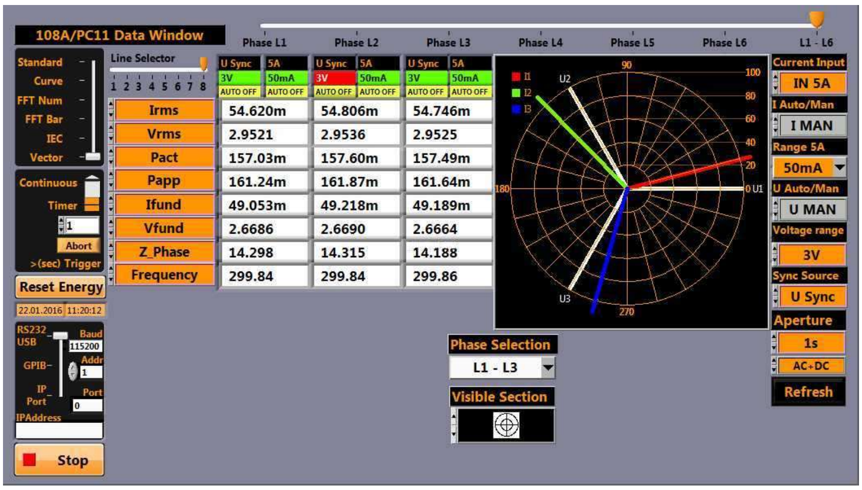
Save **Harmonics:** Press button to store harmonics in a file.

## 6.2.9 FFT BAR GRAPH (HARMONICS)




**Waveform Graph:** Select a FFT Bar Graph. FFT Volt L1-L6 / FFT Current L1-L6 FFT Power L1-L6 / FFT Angle L1-L6

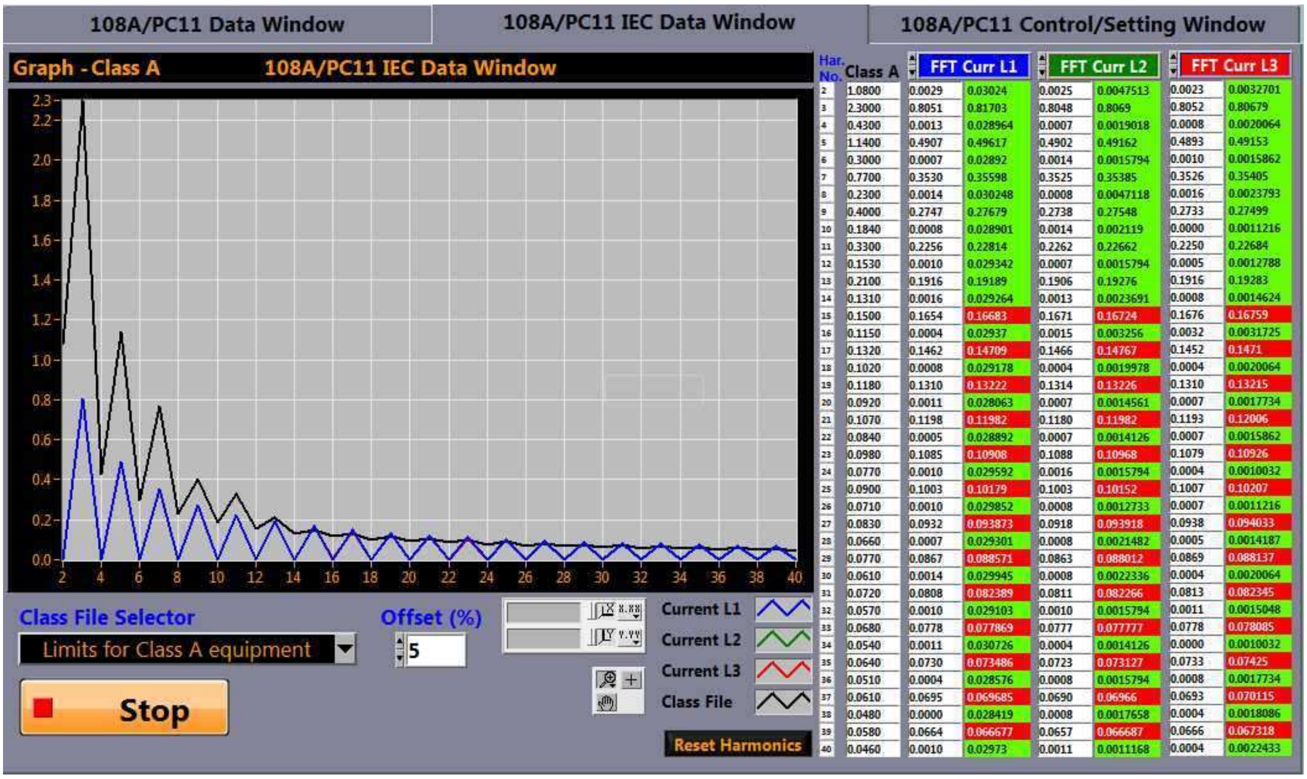
## 6.2.10 VECTOR GRAPH (PHASE ANGLE)




Display vector graphs from phase L1-L3 or L4-L6 using Phase Selection function.

Visible Section function allows sectional- or full graphs.

## 6.2.11 IEC DATA WINDOW




The **IEC Window** displays numeric values and charts in context with IEC 555-2 (EN 61000-3-2) standards.

| | |
|---|---|
| **Class File Selector** | Classification of Equipment into Classes A, B, C, D for Harmonic Measurement. |
| **Class A**: | Balanced three-phase equipment and all other equipment except that stated in one of the following classes. |
| **Class B**: | Portable tools. |
| **Class C**: | Lighting equipment including dimming devices. |
| **Class D**: | Equipment having an input current with a "special waveshape" and an active power P up to 600W. |

Limits for **Class A**: (max. permissible harmonic current [A])
1.08 / 2.30 / 0.43 / 1.14 / 0.30 / 0.77 / 0.23 / 0.40 / 0.184 / 0.33 / 0.153 / 0.21 / 0.131 / 0.15 / 0.115 / 0.132 / 0.102 / 0.118 / 0.092 / 0.107 / 0.084 / 0.098 / 0.077 / 0.09 / 0.071 / 0.083 / 0.066 / 0.077 / 0.061 / 0.072 0.057 / 0.068 / 0.054 / 0.064 / 0.051 / 0.061 / 0.048 / 0.058 / 0.046

Limits for **Class B**: (max. permissible harmonic current [A])
1.62 / 3.45 / 0.645 / 1.71 / 0.45 / 1.155 / 0.345 / 0.600 /0.276 / 0.495 / 0.230 / 0.315 / 0.197 / 0.225 / 0.173 0.199 / 0.153 / 0.178 / 0.138 / 0.161 / 0.125 / 0.148 / 0.115 / 0.135 / 0.106 / 0.125 / 0.099 / 0.116 / 0.092 0.109 / 0.086 / 0.102 / 0.081 / 0.096 / 0.077 / 0.091 / 0.073 / 0.087 / 0.069

Limits for **Class C**: (max. value expressed as a % of the fundamental input current of luminaires)
1.62 / 3.45 / 0.645 / 1.71 / 0.45 / 1.155 / 0.345 / 0.600 /0.276 / 0.495 / 0.230 / 0.315 / 0.197 / 0.225 / 0.173 0.199 / 0.153 / 0.178 / 0.138 / 0.161 / 0.125 / 0.148 / 0.115 / 0.135 / 0.106 / 0.125 / 0.099 / 0.116 / 0.092 0.109 / 0.086 / 0.102 / 0.081 / 0.096 / 0.077 / 0.091 / 0.073 / 0.087 / 0.069 / 0.118 / 0.092 / 0.107 / 0.084 0.098 / 0.077 / 0.09 / 0.071 / 0.083 / 0.066 / 0.077 / 0.061 / 0.072 / 0.057 / 0.068 / 0.054 / 0.064 / 0.051 0.061 / 0.048 / 0.058 / 0.046

Limits for **Class D**: (max. permissible harmonic current [A])
1.08 / 2.30 / 0.43 / 1.14 / 0.30 / 0.77 / 0.23 / 0.40 / 0.184 / 0.33 / 0.153 / 0.21 / 0.131 / 0.15 / 0.115/ 0.132 / 0.102 / 0.118 / 0.092 / 0.107 / 0.084 / 0.098 / 0.077 / 0.09 / 0.071 / 0.083 / 0.066 / 0.077/ 0.061 / 0.072 / 0.057 / 0.068 / 0.054 / 0.064 / 0.051 / 0.061 / 0.048 / 0.058 / 0.046

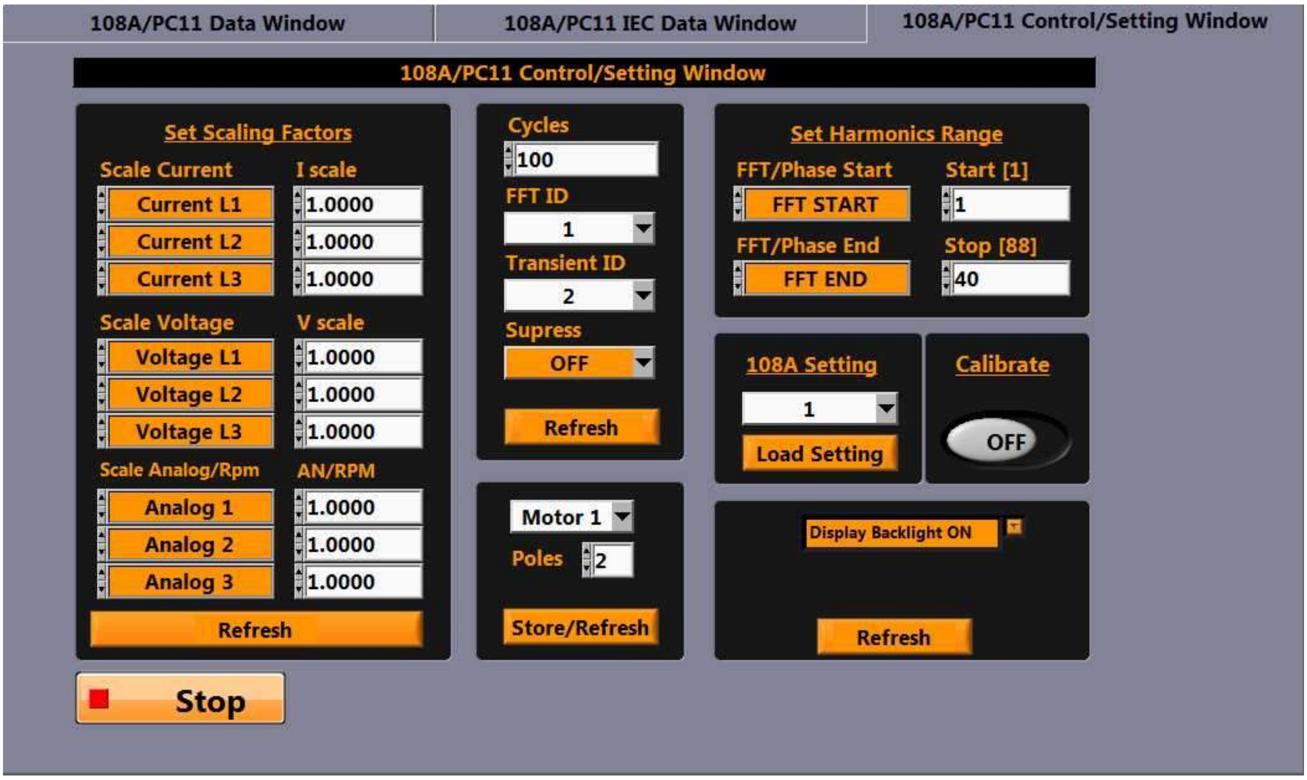
**Offset (%)** Modify offset for limits in %.


Select FFT Current L1 ... L6.

**Reset Harmonics** Press button to reset the measurements.

**Stop** Press STOP to terminate the communication.

### 6.2.12 Control / Setting Window




**Scale Current (I)**

Select desired phase for scaling: Current L1 - L6

Multiplication factor for current. This is especially useful when using external voltage sensors.
Valid Range: **-3.38e-38/+3.37e38** (default Value: 1.0)
**NOTE:** Be careful when changing scaling factors as it could look like an instrument malfunction in case of improper choice.

**Scale Voltage (V)**

Select desired phase for scaling: Voltage L 1- L6

Multiplication factor for voltage. This is especially useful when using external voltage sensors.
Valid Range: **-3.38e-38/+3.37e38** (default Value: 1.0)
Note: Be careful when changing scaling factors as it could look like an instrument malfunction in case of improper choice.

**Scale Analog/Rpm**

Select desired analog input, rpm for scaling: Analog 1 - 6 / Rpm 1 - 2

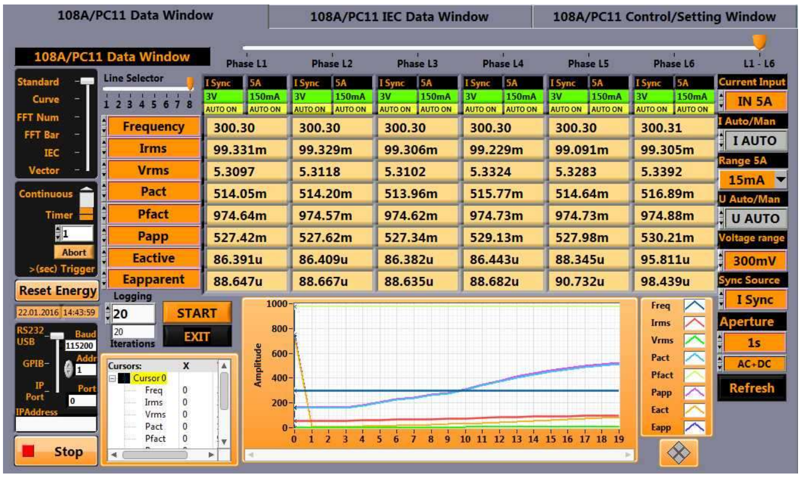
Multiplication factor for analog/rpm. This is especially useful when using external voltage sensors.
Valid Range: **-3.38e-38/+3.37e38** (default: 1.0).
Note: Be careful when changing scaling factors as it could look like an instrument malfunction in case of improper choice.

**Cycles [32000]**

For Logging Measure Mode set 1 to 32000. Defines the measurement duration per measurement set.
If you perform measurements on the 50Hz power line and you select cycles = 1 you obtain new data every 20ms;
if you select cycles = 30000 you obtain new data every 10 minutes.

| | |
|---|---|
| **FFT ID** | Set to 0, 1, 2, 3, 4. Corresponds to FFT averaging over 4, 16, 64, 256, or 1024 cycles. |
| **Transient ID** | Set it to 1, 2, 3, 4, 5, 6 or 7. The transient ID determines the measurement duration after start.<br>Transient ID Measurement duration: 1 = 0.25 seconds<br>2 = 0.5 seconds (default)<br>3 = 1 second<br>4 = 2 seconds<br>5 = 4 seconds<br>6 = 8 seconds<br>7 = 16 seconds |
| **Suppress ON/OFF** | If on, small values of Arms, Vrms, and Watt are set to zero. |
| **FFT/Phase Start/End** | Select FFT START/END or Phase START/END.<br>Start/Stop index of the data to be queried.<br>Valid Range: 1 ... 88 (default: 1) |
| **Refresh** | Press Refresh button to execute settings. |
| **Display Backlight** | The display backlight can be switched **ON** or **OFF** for energy savings. (Option must be installed) |
| **Load Setting** | Loads selected setting number in memory. Press 'Load Setting' button to execute settings. |
| **Calibrate** | Move slider '**Calibrate**' to start the calibration procedure. |

## 6.2.13 Logging-, Transient-, Power Speed Measure Mode



Logging Mode Window

Select the number of cycles and set the frequency; then press APPLY.

Now set the number of Logging iterations and press the START button.

After the last iteration is completed, the amplitudes of the signals are displayed in the graph window. Press EXIT to leave Logging Mode.

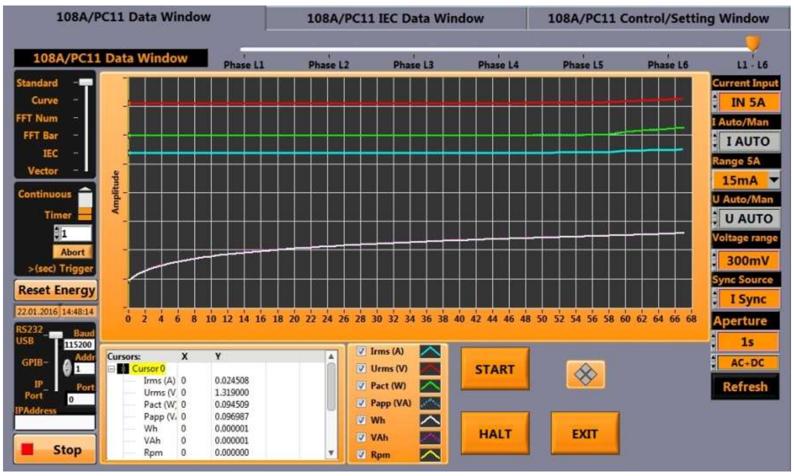
Transient Mode Window

Select Transient ID then press APPLY.

Press the START button to scan signals.

Use Zoom A … Zoom D selector and press button next to selector.

Press EXIT to leave Transient Mode.



Power Speed Mode Window

Press the START button.

Press HALT to stop data acquisition.

Amplitudes of the signals are displayed in the graph window.

Press EXIT to leave Power Speed Mode.

# 7. Analog Input and -Output

The rear panel DB37 connector Figure 7.1 provides all signals for processing inputs to- and processing outputs from the Power Analyzer.

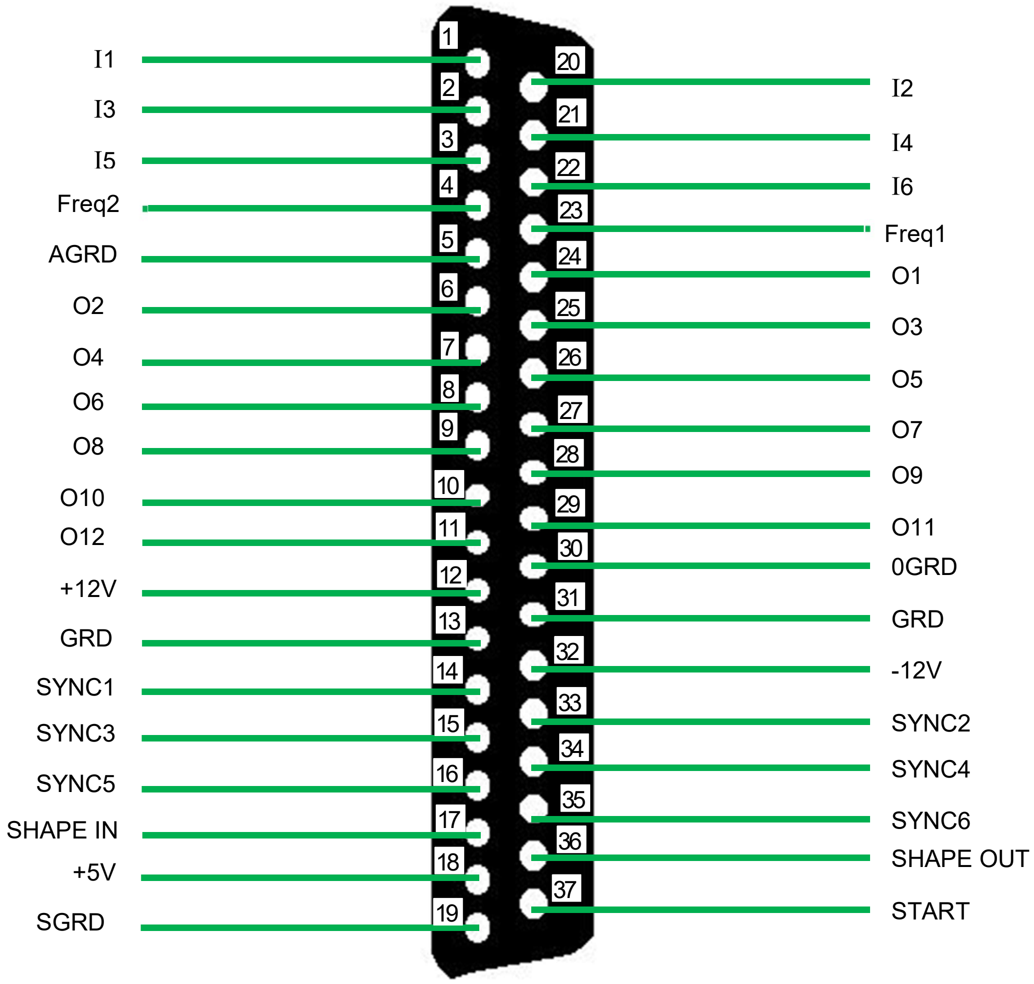



Figure 7.1: Process Input-Output Connector DB37

| Symbol | Description |
|---|---|
| I1-I4 | Analog inputs -5V to +5V, if not used short to AGRD |
| I5-I6 | Analog inputs -10V to +10V, if not used short to AGRD |
| Freq1 | TTL frequency range 5Hz to 150kHz |
| Freq2 | TTL frequency range 20Hz to 150kHz |
| AGRD | Ground for input signals (analog and TTL) |
| 01-012 | Output of displayed values, ±5V max |
| +12V/GRD/-12V | Supply for external current sensor unit (300mA) |
| SYNC1-SYNC6 | Synchronization inputs or outputs for external synchronization |
| SHAPE IN | 0-80Vac input to form a TTL signal |
| SHAPE OUT | Sharper TTL output, can be applied to Sync1-Sync6 |
| SGRD | Ground for Sync1-Sync6 inputs. |
| START | Provides hardware start by connecting to 5V/pin18. (Logging/Transient/Power-Speed) |

## 7.1 Analog Input And Output Specification

| | |
|---|---|
| Analog input 1-4, span: | -5V to +5V, Ri = 100kΩ, Typical max error 0.2 % |
| | If not used short inputs to AGRD |
| Analog input 5,6, span: | -10V to +10V, Ri = 100kΩ, Typical max error 0.2 % |
| | If not used short inputs to AGRD |
| Frequency input 1,2: | 20Hz – 150kHz, Typical max error 0.2 % |
| Analog output 1-12: | -5V to +5V, Rout = 1kΩ, Typical max error 0.2 % |
| Update interval: | 0.5 sec |
| Output quantities: | Arms, Vrms, W, VA, Var, PF1, -5V to +5V.<br>Frequency, Wh as relative output: 0.3125V – 5V.<br>When output reaches 5V it drops to 5V/16 and so forth (increasing values). When output falls below 0.3125V it increases to 0.3125 x 16 (decreasing values). |

## 7.2 Programming The Analog Outputs

In standard measure mode all analog inputs, Freq1, and Freq2 are measured in 500ms time intervals. All analog outputs are set according to the criteria described below.
In power-speed measure mode freq1 is measured in 20ms time intervals. At Start analog output1 is set to +5V and can be used to start the system under test (power-speed only).
In logging- and transient measure mode the analog option is not used.

In standard measure mode the displayed quantities on display page 1 are applied to the analog outputs. The output configuration depends on the number of phases installed in the Power Analyzer.

The analog outputs for power and reactive power can be scaled using An6 scaling factor (in SETUP).

***Example:*** At 100W power range (10V/1A/PF = 1) the full scale analog output is 5V with An6 scale factor = 1.

At low power factor, e.g. PF = 0.02 the analog output voltages are 5V x 0.02 = 100mV.
Setting An6 to 20.0 the analog outputs for power become 2V resulting in increased resolution at small power factor variations.

Below examples of output configurations are given:

**Single phase:** Display lines 1 to 8 = Arms, Vrms, W, VA, Var, PF1, frequency, Wh.
Analog output 1, 2, 3, 4, 5, 6, 7, 8 are proportional to Arms, Vrms, W, VA, Var, PF1, freq, Wh.
Analog outputs 9, 10, 11, 12 are zero.

**Two phase:** Display lines 1 to 6 are Arms, Vrms, W, PF1, VA, Wh.

| | |
|---|---|
| Analog output 1, 2 = | Arms of phase 1 and phase 2 |
| Analog output 3, 4 = | Vrms of phase 1 and phase 2 |
| Analog output 5, 6 = | W of phase 1 and phase 2 |
| Analog output 7, 8 = | PF1 of phase 1 and phase 2 |
| Analog output 9, 10 = | VA of phase 1 and phase 2 |
| Analog output 11, 12 = | Wh of phase 1 and phase 2 |

**Three phase:** Display lines 1 to 4 = W, VA, Arms, PF1

| | |
|---|---|
| Analog output 1, 2, 3 = | W phase 1, 2, 3 |
| Analog output 4, 5, 6 = | VA phase 1, 2, 3 |
| Analog output 7, 8, 9 = | Arms phase 1, 2, 3 |
| Analog output 10, 11, 12 = | PF1 phase 1, 2, 3 |

**Four phase:** Display lines 1 to 3 = Arms, W, VA

| | |
|---|---|
| Analog output 1, 2, 3, 4 = | Arms phase 1, 2, 3, 4 |
| Analog output 5, 6, 7, 8 = | W phase 1, 2, 3, 4 |
| Analog Output 9, 10, 11, 12 = | VA phase 1, 2, 3, 4 |

**Five phase:** Display lines 1 to 3 = Arms, W, VA

| | |
|---|---|
| Analog output 1, 2, 3, 4, 5 = | Arms phase 1, 2, 3, 4, 5 |
| Analog output 6, 7, 8, 9, 10 = | W phase 1, 2, 3, 4, 5 |
| Analog output 11, 12 | VA phase 1 and phase 2 |

**Six phase:** Display lines 1 and 2 = Arms, W

| | |
|---|---|
| Analog output 1, 2, 3, 4, 5, 6 = | Arms phase 1, 2, 3, 4, 5, 6 |
| Analog output 7, 8, 9, 10, 11, 12 = | W phase 1, 2, 3, 4, 5, 6 |

## 7.3 USING INPUTS FOR MOTOR TESTING (SEE ALSO 4.1 MOTOR TESTING)

Using a 6 phase Power Analyzer two motors can be tested simultaneously. Motor1 is connected to phase 1, 2, and 3. Motor2 is connected to phase 4, 5, and 6. Speed of motor1 is measured via TTL FREQ1 input, and Speed of motor2 is measured via TTL FREQ2 input. Both inputs exhibit excellent accuracy over a wide frequency range 20Hz to 150kHz. A rotating disc with 180 divisions at 150kHz will display 50000 rpm (rotations per minute). FREQ1 and FREQ2 can be scaled via interface commands to accommodate different speed sensor. External torque transducers can be connected to one of the six analog inputs. All inputs can be scaled in the SETUP window or using the interface to display actual torque.

Power-Speed measurements are limited to phase 1, 2, and 3 and Freq1 speed input.

## 7.4 USING LOW CURRENT SHUNT FOR STANDBY POWER MEASUREMENT

- Insert Shunt in the 3-pin connector on rear panel

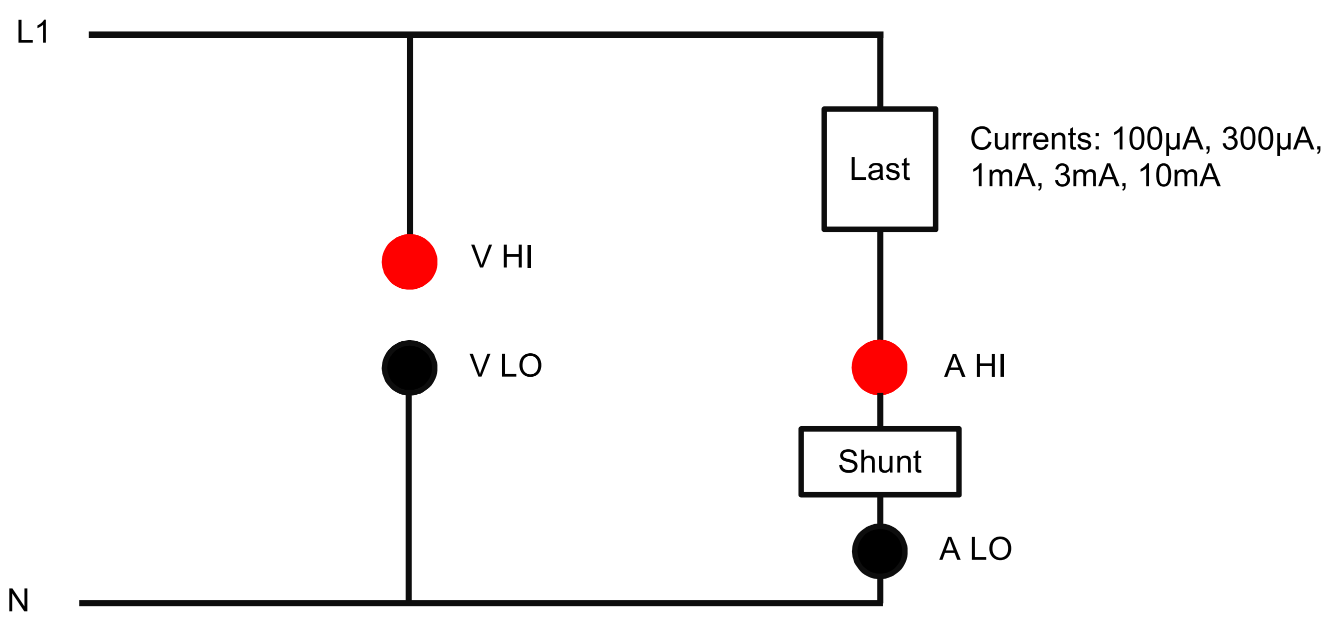
- Select SHUNT input

| | |
|---|---|
| Shunt voltage 60mV corresponds to | current range 0 - 100µA |
| Shunt voltage 180mV corresponds to | current range 0 - 300µA |
| Shunt voltage 600mV corresponds to | current range 0 - 1mA |
| Shunt voltage 1.8V corresponds to | current range 0 - 3mA |
| Shunt voltage 6V corresponds to | current range 0 - 10mA |

- Scale current by 0.0001

- Red socket = Current High, Black socket = Current Low

- Observe the correct wiring. The Current of the voltage path must not flow via shunt

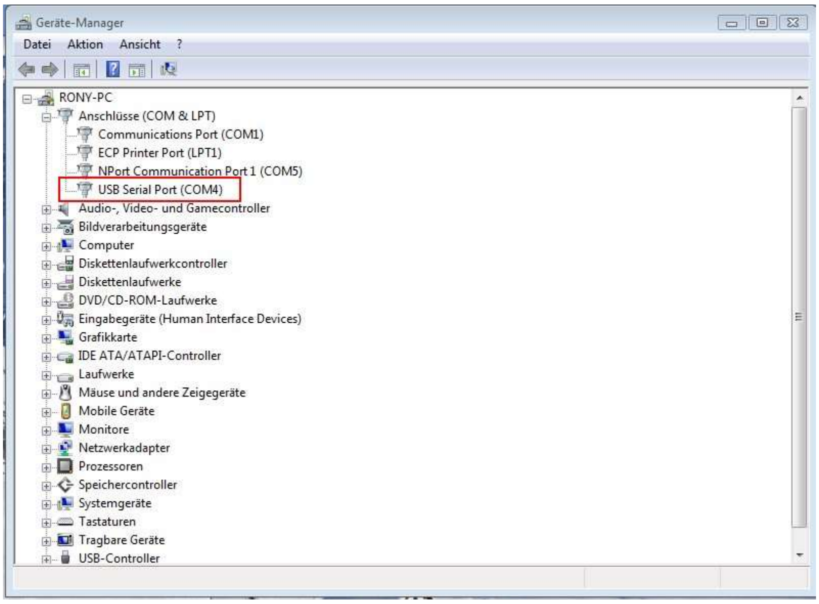


# 8. DATA MANAGEMENT

## 8.1 OPERATING THE POWER ANALYZER USING THE USB INTERFACE

To operate the USB interface you must install the USB driver. Use the following driver (on the CD-ROM) for your Windows operating system:

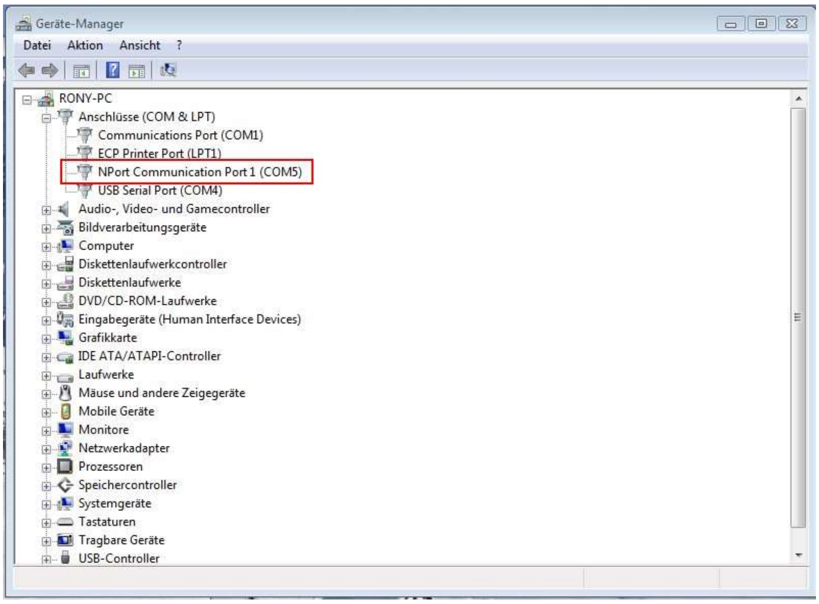
**CDM v2.12.14 WHQL Certified for Windows** (Windows XP to Windows 10 (32/64)).




Open the hardware manager and check for proper USB Driver installation. Use COM4 to run 108A Computer Software.

## 8.2 OPERATING THE POWER ANALYZER USING THE ETHERNET INTERFACE

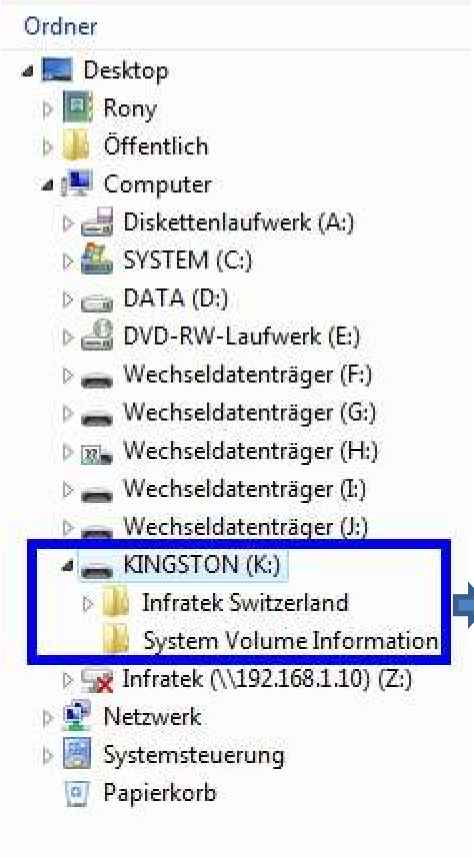
To operate the Ethernet interface you must consult the attached documentation “COMMUNICATION SETUP 108A ETHERNET” (also stored on a CD).

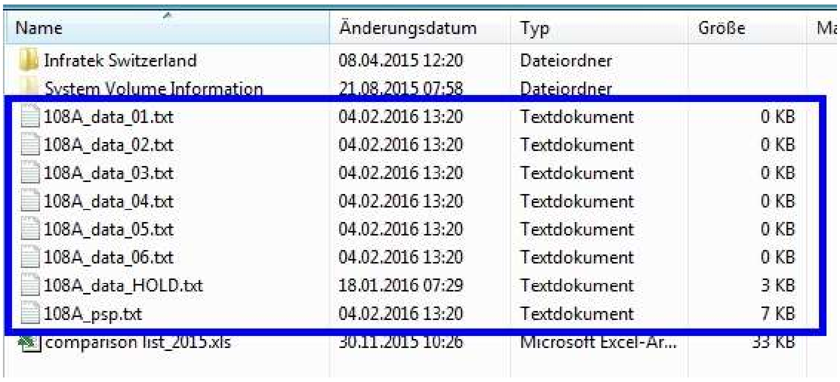



Open the hardware manager and check for proper Ethernet installation. Use COM5 to run 108A Computer Software.

## 8.3 MEASUREMENT DATA FROM THE POWER ANALYZER (USB) TO COMPUTER

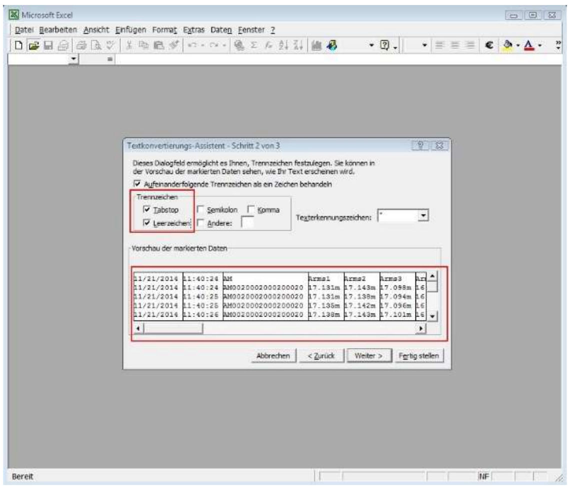
If USB memory stick is inserted, measurement data are also stored on memory stick 108A_data_01, 108A_data_02, …, 108A_data_20.

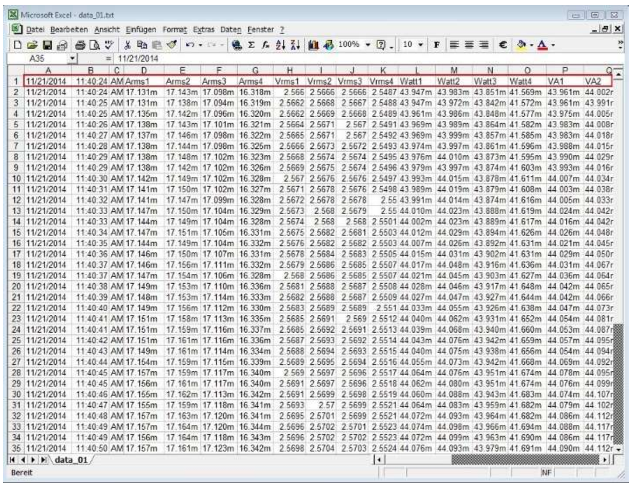



The 108A stores measurement data in Standard Mode, on HOLD and in Power Speed Mode.

- Standard Mode data files are named: **108A_data_01, 108A_data_02, ……, 108A_data_20**.
- Standard Mode on HOLD data file is named: **108A_data_HOLD**.
- Power Speed Mode data file is named: **108A_psp**.





Launch MS Excel and select file from USB stick for conversion to MS Excel format.

# 9. Calibration via 108A Front Panel

A calibration cycle of two years is appropriate. If occasional overloads occur (greater two times maximum value) we recommend one year calibration cycle.

## 9.1 Equipment Needed

Voltage: 0.3V, 1V, 3V, 10V, 30V, 100V, 300V, 1000V; 60Hz

Current: 1.5mA, 5mA, 15mA, 50mA, 150mA, 500mA, 1.5A;
1A, 3A, 10A, 20A; 60Hz

## 9.2. Calibration Procedure

- **Set all voltage- and current scaling factors to 1.0000.**
- Select Standard Measure Mode, select 1 second averaging
- Touch SETUP. In the pop-up window touch Calibrate 108A. Enter your calibration code 7123.
- Touch one of the buttons Voltage Calibration or Current Calibration.
  You will exit to the Standard Measure Mode. The bottom line of the display, will display the button TAKE VOLTAGE READING or TAKE CURRENT READING depending on what you selected in the setup menu.
  Now proceed with section 9.2.1 Voltage Calibration at 60Hz or section 9.2.2 Current calibration at 60Hz.

### 9.2.1 Voltage Calibration At 60Hz

You must select Sync V. Touch button TAKE VOLTAGE READING when values have stabilized. Apply voltage to all phases simultaneously.

| | | | |
|---|---|---|---|
| Select 0.3V | range, apply 0.3V, | wait | → touch TAKE VOLTAGE READING |
| Select 1V | range, apply 1V, | wait | → touch TAKE VOLTAGE READING |
| Select 3V | range, apply 3V, | wait | → touch TAKE VOLTAGE READING |
| Select 10V | range, apply 10V, | wait | → touch TAKE VOLTAGE READING |
| Select 30V | range, apply 30V, | wait | → touch TAKE VOLTAGE READING |
| Select 100V | range, apply 100V, | wait | → touch TAKE VOLTAGE READING |
| Select 300V | range, apply 300V, | wait | → touch TAKE VOLTAGE READING |
| Select 1000V | range, apply 1000V, | wait | → touch TAKE VOLTAGE READING |

If only voltage calibration was needed continue with Section 9.2.3 “Storing the Calibration Constants”.

### 9.2.2 CURRENT CALIBRATION AT 60HZ, SHUNT INPUT CALIBRATION

You must select Sync A.

a.) Select Current Input **IN 5A**.

Apply current to all current inputs in series.

| | | | | |
|---|---|---|---|---|
| Select 15mA | range, apply 15mA, | wait | → touch | TAKE CURRENT READING |
| Select 50mA | range, apply 50mA, | wait | → touch | TAKE CURRENT READING |
| Select 150mA | range, apply 150mA, | wait | → touch | TAKE CURRENT READING |
| Select 500mA | range, apply 500mA, | wait | → touch | TAKE CURRENT READING |
| Select 1.5A | range, apply 1.5A, | wait | → touch | TAKE CURRENT READING |

b.) Select current input **IN 1A**, use 1A input 3 pole connector.

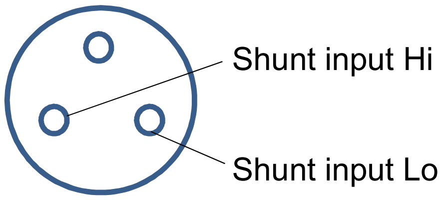
| | | | | |
|---|---|---|---|---|
| Select 150mA | range, apply 150mA | wait | → touch | TAKE CURRENT READING |
| Select 500mA | range, apply 500mA | wait | → touch | TAKE CURRENT READING |
| Select 1.5A | range, apply 1.0A, | wait | → touch | TAKE CURRENT READING |

c.) Select current input **IN 30A**, remove 1A input 3 pole connector and insert short circuit cover.

| | | | | |
|---|---|---|---|---|
| Select 1A | range, apply 1A, | wait | → touch | TAKE CURRENT READING |
| Select 3A | range, apply 3A, | wait | → touch | TAKE CURRENT READING |
| Select 10A | range, apply 10A | wait | → touch | TAKE CURRENT READING |
| Select 30A | range, apply 20A, | wait | → touch | TAKE CURRENT READING |
| Select 100A | range, apply 20A, | wait | → touch | TAKE CURRENT READING |

d.) Shunt input calibration at 60Hz

Remove the short circuit cover on the shunt input.




Select shunt input **SHUNT**.

Apply voltage to all shunt inputs in parallel.

Select 60mV range, apply 60mV, wait → touch TAKE CURRENT READING

Select 200mV range, apply 180mV, wait → touch TAKE CURRENT READING

Select 600mV range, apply 600mV, wait → touch TAKE CURRENT READING

Select 2V range, apply 1.8V, wait → touch TAKE CURRENT READING

Select 6V range, apply 6V, wait → touch TAKE CURRENT READING

### 9.2.3 Storing the Calibration Constants

At end of calibration the calibration constants are saved in nonvolatile memory.

- Enter the SETUP menu, touch Store Constants / Exit Calibration.
  This stores all calibration constants in nonvolatile memory.
  In case you do not want to store the calibration constants press the button Esc.
  The instrument returns to the Standard Measure Mode.

- **Wait at least 2 seconds. After calibration the Power Analyzer must be turned off and restarted for normal use.**

## 9.3. A Few Practical Hints

- It is acceptable to calibrate a single voltage range.

- It is acceptable to calibrate a single current range on the 30A input.

- It is acceptable to calibrate a single shunt input range.

- In case one of the ranges of the 5A input, or one of the ranges of the 1A input is out of tolerance all calibration steps of 9.2.2 a. and b. must be performed.

**After calibration of a single range the Power Analyzer must be switched off and on again.**

## 9.4. 108A CALIBRATION USING WINDOWS OPERATING SOFTWARE (LABVIEW)

### 9.4.1 EQUIPMENT NEEDED

Voltage: 0.3V, 1V, 3V, 10V, 30V, 100V, 300V, 1000V; 60Hz

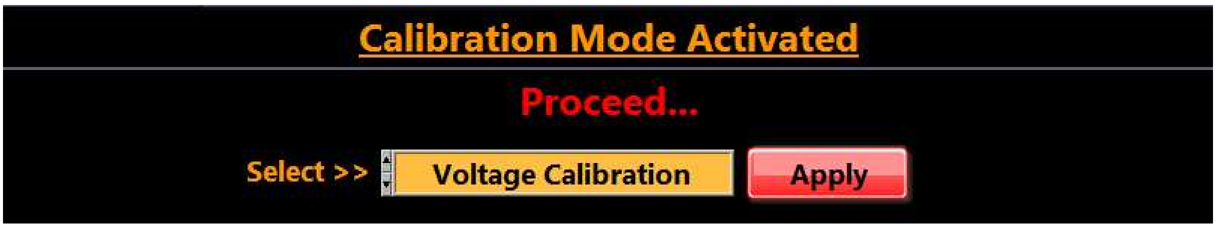
Current: 1.5mA, 5mA, 15mA, 50mA, 150mA, 500mA, 1.5A;
1A, 3A, 10A, 20A; 60Hz

### 9.4.2 CALIBRATION PROCEDURE

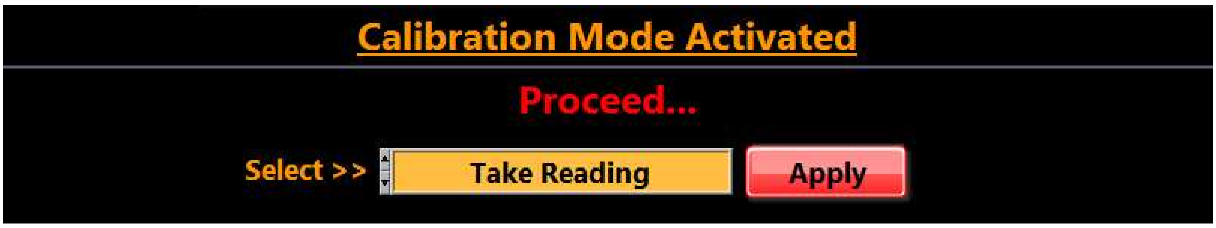
- **Set all voltage- and current scaling factors to 1.0000.**
- Select Standard Measure Mode, select 1 second averaging
- Launch 108A Windows Operating Software (NI LabVIEW)
- Select Tab 108A/PC11 Control Setting Window
- Switch slider Calibrate to ON
- Select Tab 108A/PC11 Data Window

### 9.4.3 VOLTAGE CALIBRATION AT 60HZ

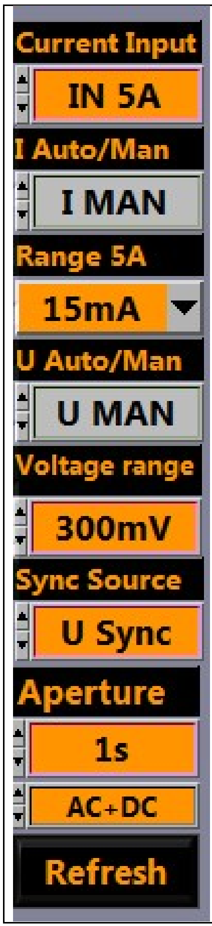
Select **Voltage Calibration** and press **Apply**




Select **Take Reading**, DO NOT PRESS APPLY now**!**




Apply voltage to all phases simultaneously.




Select **U MAN**, **U Sync**, **300mV** and press **Refresh**
Apply 300mV from calibrator – wait – press **Apply**

Select **1V** and press **Refresh**
Apply 1V from calibrator – wait – press **Apply**

Select **3V** and press **Refresh**
Apply 3V from calibrator – wait – press **Apply**

Select **10V** and press **Refresh**
Apply 10V from calibrator – wait – press **Apply**

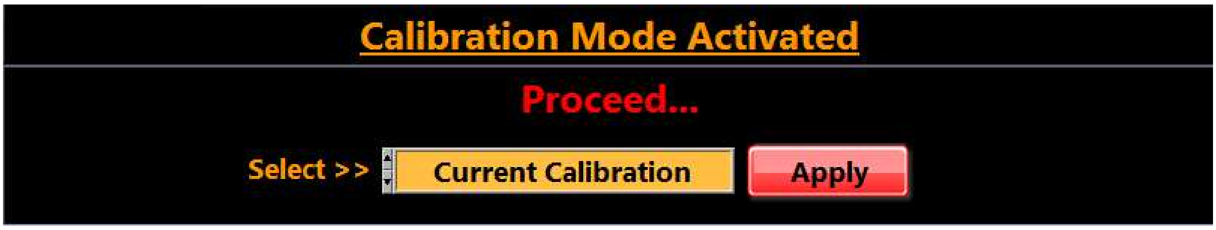
Select **30V** and press **Refresh**
Apply 30V from calibrator – wait – press **Apply**

.
.
.

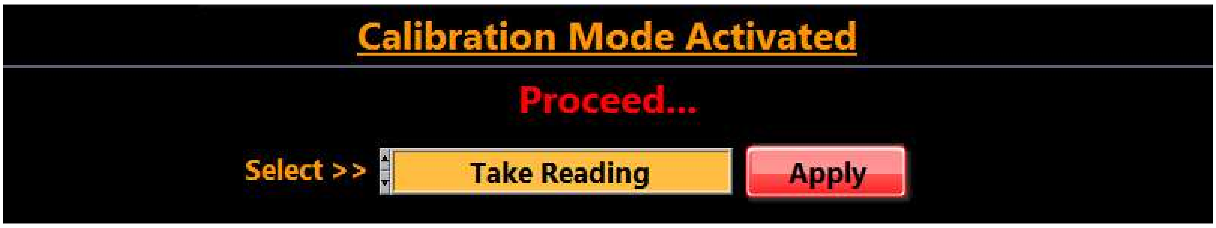
Select **1000V** and press **Refresh**
Apply 1000V from calibrator – wait – press **Apply**

### 9.4.4 CURRENT CALIBRATION AT 60HZ (IN 5A)

Select **Current Calibration** and press **Apply**




Select **Take Reading**, DO NOT PRESS APPLY now**!**




Apply current to all current inputs in series (IN 5A).


Select **IN 5A, I MAN, 15mA, I SYNC** and press **Refresh**
Apply 15mA from calibrator – wait – press **Apply**

Select **50mA** and press **Refresh**
Apply 50mA from calibrator – wait – press **Apply**

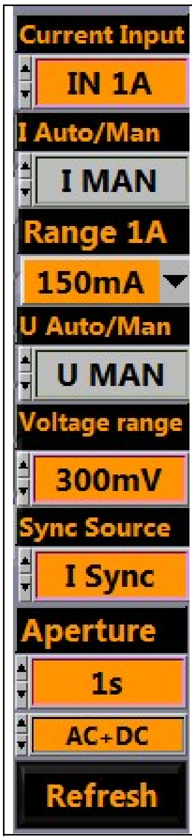
Select 1**50mA** and press **Refresh**
Apply 150mA from calibrator – wait – press **Apply**

Select **500mA** and press **Refresh**
Apply 500mA from calibrator – wait – press **Apply**

Select **1.5A** and press **Refresh**
Apply 1.5A from calibrator – wait – press **Apply**

### 9.4.5 CURRENT CALIBRATION AT 60HZ (IN 1A)

Apply current to all current inputs in series using the 3 pole connector.



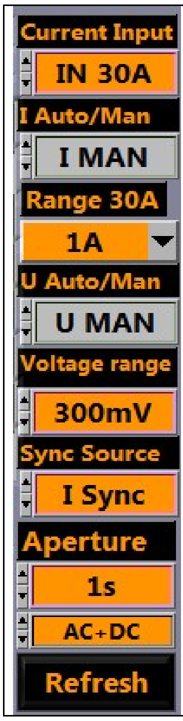

Select **IN 1A, 150mA** and press **Refresh**
Apply 150mA from calibrator – wait – press **Apply**

Select **500mA** and press **Refresh**
Apply 500mA from calibrator – wait – press **Apply**

Select **1.5A** and press **Refresh**
Apply 1.0A from calibrator – wait – press **Apply**

### 9.4.6 CURRENT CALIBRATION AT 60HZ (IN 30A)

Remove 1A input 3 pole connector and insert short circuit cover. Apply current to all current inputs in series




Select **IN 30A, 1A** and press **Refresh**
Apply 1A from calibrator – wait – press **Apply**

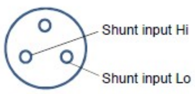
Select **3A** and press **Refresh**
Apply 3A from calibrator – wait – press **Apply**

Select **10A** and press **Refresh**
Apply 10A from calibrator – wait – press **Apply**

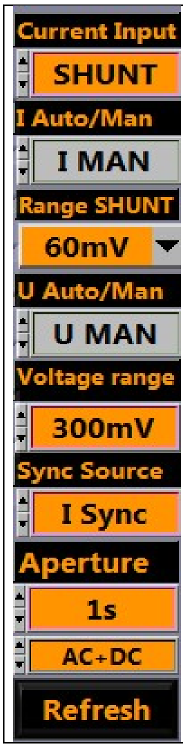
Select **30A** and press **Refresh**
Apply 20A from calibrator – wait – press **Apply**

Select **100A** and press **Refresh**
Apply 20A from calibrator – wait – press **Apply**

### 9.4.7 CURRENT CALIBRATION AT 60HZ (SHUNT)




Remove the short circuit cover on the shunt input. Apply voltage to all shunt inputs in parallel.




Select **SHUNT, 60mV** and press **Refresh**
Apply 60mV from calibrator – wait – press **Apply**

Select **200mV** and press **Refresh**
Apply 180mV from calibrator – wait – press **Apply**

Select **600mV** and press **Refresh**
Apply 600mV from calibrator – wait – press **Apply**

Select **2V** and press **Refresh**
Apply 1.8V from calibrator – wait – press **Apply**

Select **6V** and press **Refresh**
Apply 6V from calibrator – wait – press **Apply**

### 9.4.8 Storing the Calibration Constants

Select **Store/Exit Calibration** and press **Apply**


This stores all calibration constants in nonvolatile memory. In case you do not want to store the calibration constants (abort calibration process), the instrument uses the previous stored calibration constants.

**Wait at least 2 seconds. After calibration the Power Analyzer must be turned off and restarted for normal use.**

### 9.4.9 A Few Practical Hints

- It is acceptable to calibrate a single voltage range.
- It is acceptable to calibrate a single current range on the 30A input.
- It is acceptable to calibrate a single shunt input range.
- In case one of the ranges of the 5A input, or one of the ranges of the 1A input is out of tolerance all calibration steps of 9.2.2 a. and b. must be performed.

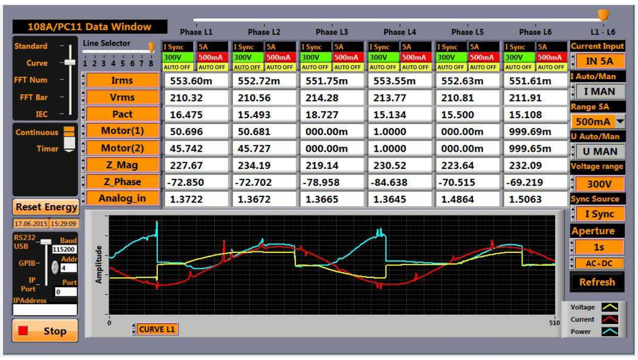
**After calibration of a single range the Power Analyzer must be switched off and on again.**

# 10. Amendment

## 10.1 Electric Motor Testing Using Infratek 108A-6 High Precision Power Analyzer

The 108A-6 equipped with Option 03, (6 analog inputs, 2 digital inputs, and 12 outputs) performs all required measurements for motor testing.

Use the Infratek operating Software to perform motor tests in ***STANDARD*** measure mode. Values at different motor operating points can be stored and viewed when done.



**108A Computer Software**

The 108A scalable analog inputs can be used for torque-, temperature- and vibration measurements. Two scalable TTL-inputs are for speed- or torque measurement. An external synchronization input per phase from an encoder can be used to synchronize measurements to the pole position.

The 108A-6 measures two motors simultaneously: input power, output power, torque, slip, speed, and efficiency of every motor, as well as harmonics of current, voltage, power, impedance, and phase angle. For none sinusoidal signals (trapezoidal wave-forms or frequency inverters), we recommend to use the fundamental of impedance and fundamental of phase. From these values the motor inductances L, $L_d$, $L_q$ and the motor resistances $R = R_m + R_{dc}$ can be determined.

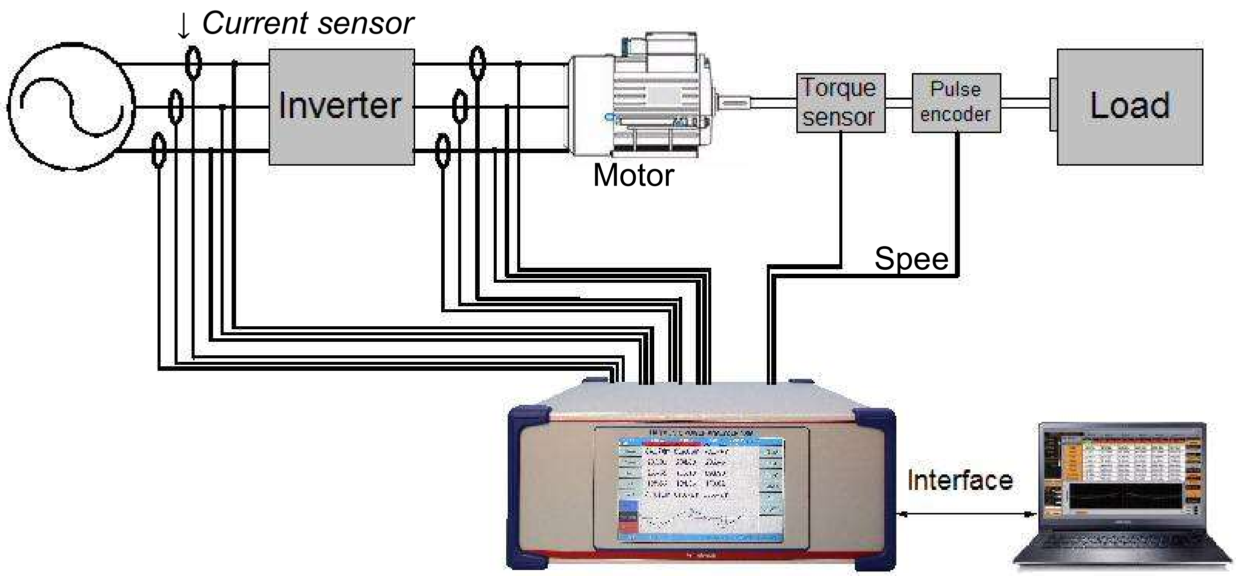
The motor DC-resistance is obtained by applying a DC-current: $R_{dc} = P_{dc} / I^2_{dc}$. $R_m$ is a magnetization dependent loss.


The 108A display and the computer software screen can be configured to the user's needs.

| | |
|---|---|
| M1\| M2\| M3\| | = Input power, output power, torque |
| M4\| M5\| M6\| | = Slip, rpm, efficiency |
| Phi01 | = Phase angle of fundamental |
| A1\| A2\| A3\| | = Analog inputs 1, 2, 3 |

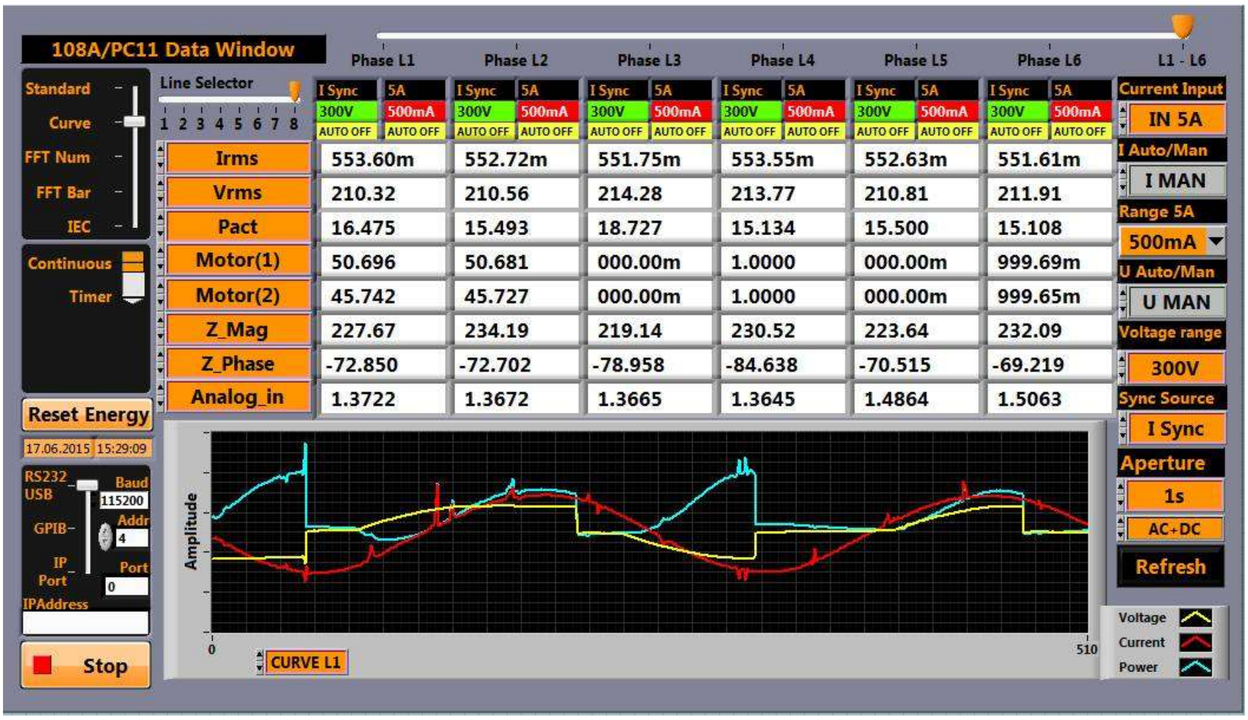
**108A Display Screen**

## 10.2 Efficiency Measurement of an Inverter driven Induction Motor in Steady State



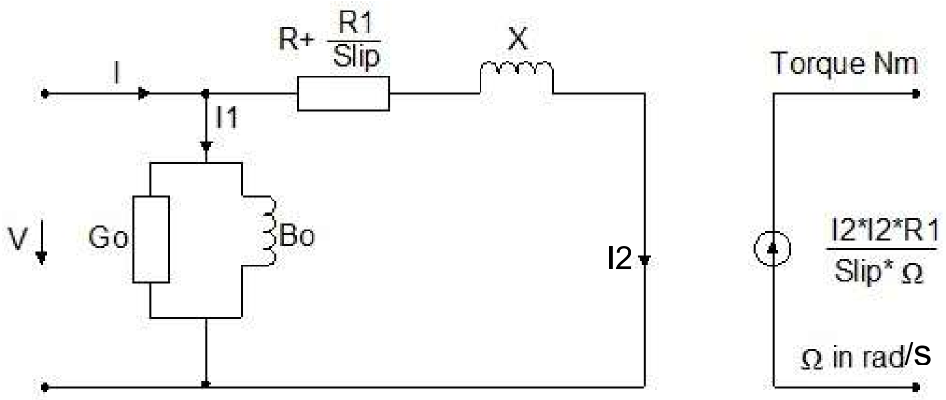

Overall Efficiency = 4π* rotation per second*torque/(nr_poles)*(P1+P2+P3)

First, run a no load motor test. The interface command “**COMP:MOT1_Loss?**” stores the motor loss. For tests on loaded motor this loss is subtracted to compute motor output power. With the command “**COMP:MOTOR1?**” all motor values: input power, output power, torque, slip, speed (rpm), and efficiency are sent to the PC.



The external torque- and temperature inputs are transferred to the PC by the command “COMP:ANIN?”. Run tests at different loads to obtain graphs of slip versus torque, input power versus torque, and efficiency versus torque. Remember, the speed- and torque inputs can be scaled to read actual rpm and Nm.

## 10.3 Circuit Model of an Asynchronous Induction Motor




Circuit model of one phase

Perform a no-load test and a blocked-rotor test.
The circuit elements can be determined.

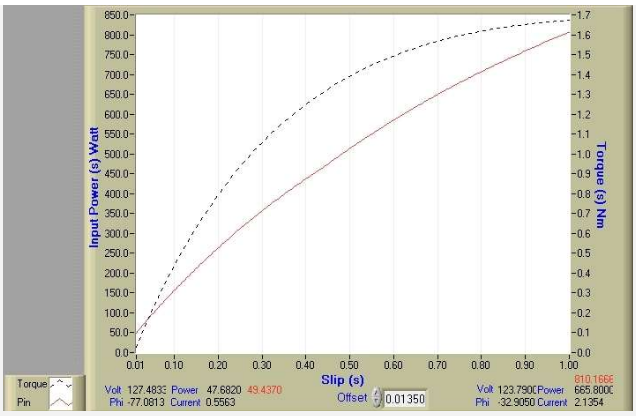
***No-load test***
Measure the fundamental of voltage, current, impedance and phase angle. Calculate Go and Bo.

***Blocked-rotor test:***
Measure the fundamental of voltage, current, impedance, and phase angle. From a DC measurement obtain the ohmic resistance Rdc. Approximate R = 0.5Rdc. Calculate R1 and X from fundamental of impedance and phase.

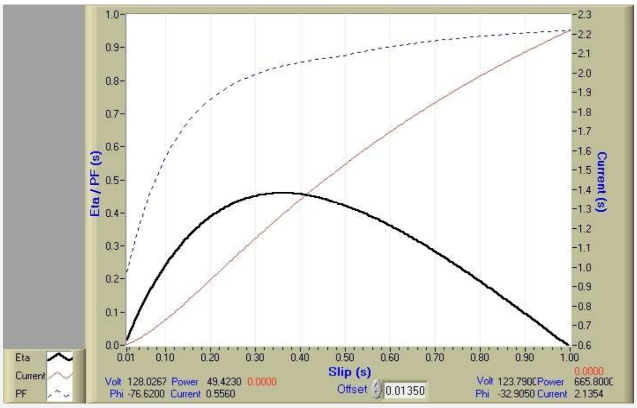
Once the elements of the equivalent circuit are determined various motor characteristics can be plotted, such as: torque / power / power-factor versus slip.

## 10.4 Measurements on loaded Motor

Operate the motor at various load points. Store the measurements using the PC Operating Software, alternatively store the measurements on the Power Analyzer in Excel. Plots like torque versus slip, input power versus slip, and many more graphs can be obtained.

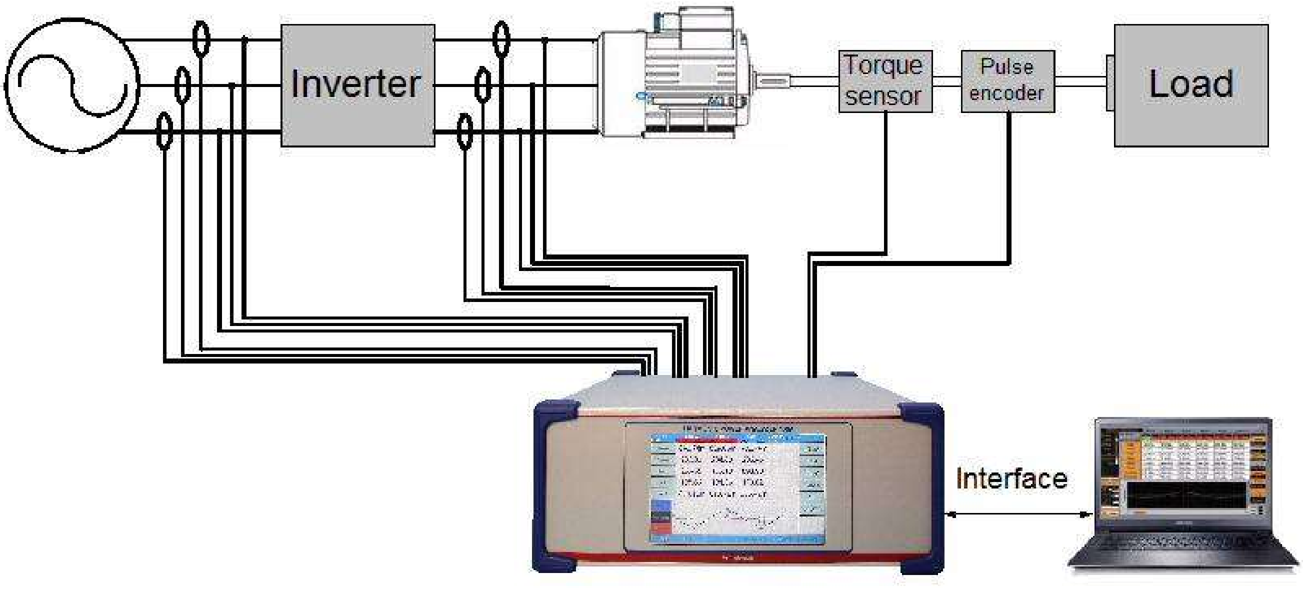



Torque and power versus slip. Motor is star connected. It is operated by 50Hz power line.




Power Factor, efficiency, and phase current versus slip.

## 10.5 MEASUREMENT OF START-UP BEHAVIORS OF INVERTER DRIVEN INDUCTION MOTOR

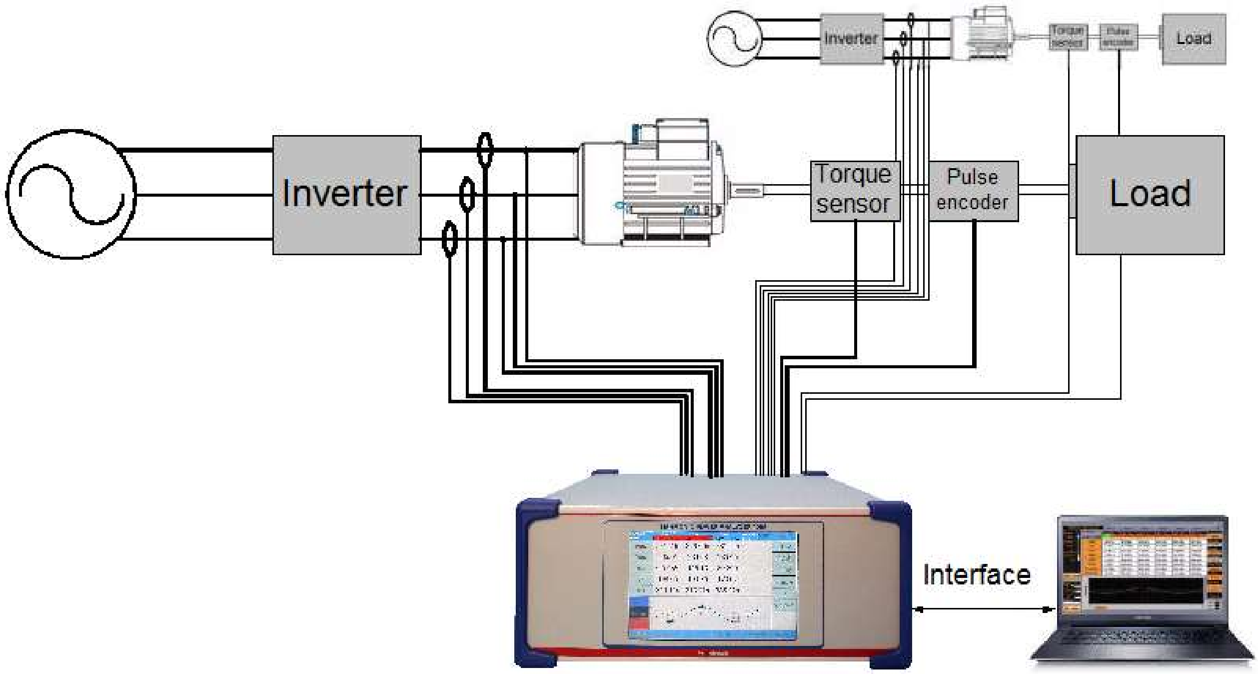



**Select *LOGGING Mode***

Select voltage- and current ranges such that at start-up no range overload occurs. Select current- or external synchronization **to all installed phases on the 108A**, set “CYCLE” to 1, 2, 3, or any other value. Apply the synchronization to all phases installed in the Power Analyzer. Finally start the system.

If you selected DYCLE = 1 the 108A sends every period one data set per phase to the PC. A 6-phase instrument sends 6 data sets to the PC, phase 1 first. Each data set contains: Frequency, A, V, W, PF, VA, Wh, and VAh. A 6-phase 108A transmits 6 data sets per 20ms (maximum speed). Stop the measurement when the system is in steady state and analyze the data using EXCEL.

## 10.6 Simultaneous Measurement of 2 Synchronous Motors (PMSM, BLDC)



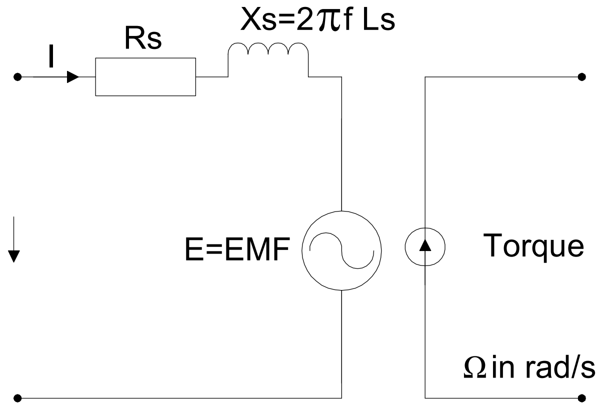

A wide range of synchronous motors are on the market (PMSM, IPMSM, BLDC). The power consumption ranges from mW to 500kW. Many different constructions are in use. They all have in common that the magnetic field rotation (2 phase or 3 phase) is electronically generated. A wide range of speeds (rpm) are available.

## 10.7 Advantage of the 108A Power Analyzer

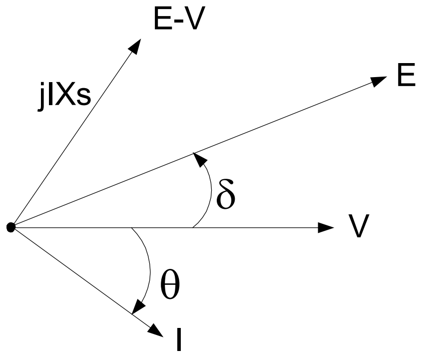
For medium size-, small-, and very small motors the 108A provides per phase 3 direct current inputs: 1mA-2A, (for small motors) 15mA-7A, and 1A to 40A (for medium size motors). For very large motors high precision (0.004 %) broad band current sensors up to 700A are available.

The sensor output is simply connected to the 1mA-2A input on the 108A. To display actual currents, scaling per phase is available. Also, analog inputs and speed inputs can be scaled. The 108A measure all motor parameters, current, voltage, power, and their harmonics, impedance, and phase angles simultaneously. This is important because electronically generated waves include harmonics (BLDC) and noise (PMSM).

## 10.8 CIRCUIT MODEL OF A SYNCHRONOUS MOTOR




Synchroneous Motor Circuit Model of one phase




Phasor representation neglecting Rs.

Normally, in a synchronous motor $R_s$ is much smaller than $X_s$.

## 10.9 FROM A BLOCKED ROTOR TEST

Rs + Xs can be determined (Rs and Xs are somewhat current dependent). Measure impedance and phase angle $\theta$: $Z = Rs + j2\pi f\ Ls$. From this simple model the electromotive force E and power angle $\delta$ can be calculated.

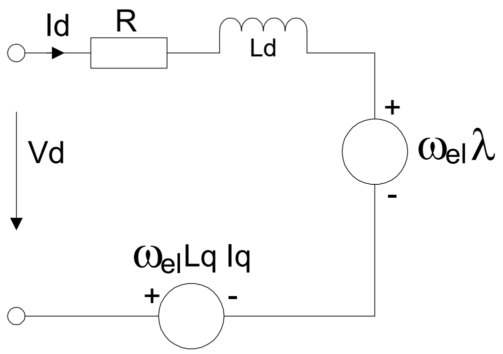
Maximum torque developed by a PMSM-, IPMSM, or BLDC-motor depends very much on its construction. The torque is a function of power angle $\delta$. Their main advantages are low loss and the ability to run at very high speeds (IPMSM).

(There is no need to go through the trouble to perform the mathematics of Clark Transformation followed by the Park Transformation to get to the d, q - coordinates. It remains the proof that $Ls = \frac{1}{3}\sqrt{Ld^2+Lq^2}$. For PMSM Ld = Lq, high speed motors IPMSM Ld < Lq).

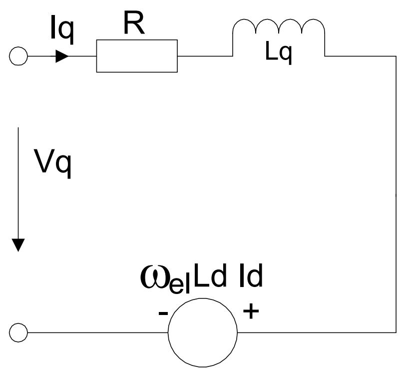
PMSM = Permanent magnet synchronous motor
IPMSM = Interior permanent magnet synchronous motor
BLDC = Brushless DC electric motor

## 10.10 DETERMINATION OF SYNCHRONOUS INDUCTANCES LD AND LQ OF IPMSM AND PMSM

The equivalent phase model of PMSM and IPMSM are shown below (PSPM = permanent magnet synchronous motors). R represents the sum of ohmic losses (Rohm) plus magnetic losses (Rm). Ld and Lq are the equivalent inductances along the d-axis (direct axis) and the q-axis (quadrature axis).




**d-axis circuit**

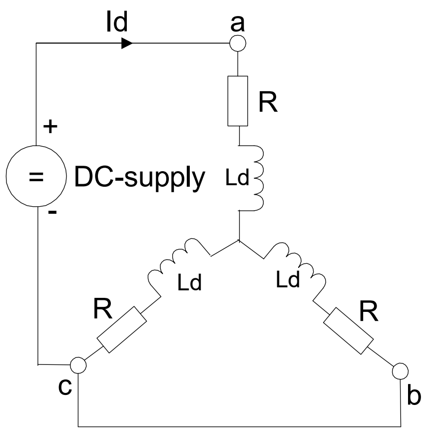



**q-axis circuit**

The ohmic losses are temperature dependent $R_{ohm} = R_o(1+\alpha\Delta t)$, the magnetic losses are magnetization dependent due to non-linearity.

Ld and Lq are measured in a locked motor shaft test. This implies ωel = 0, or the voltage sources of the equivalent circuits are zero.
Lq, and mainly Ld are somewhat current dependent.

## 10.11 MEASURE D-AXIS INDUCTANCE LD




**Alignment into d-axis**

Step 1: Align the rotor to phase a. Connect DC-supply as shown. The current Id aligns the rotor into the d-axis, electrical angle = 0°.

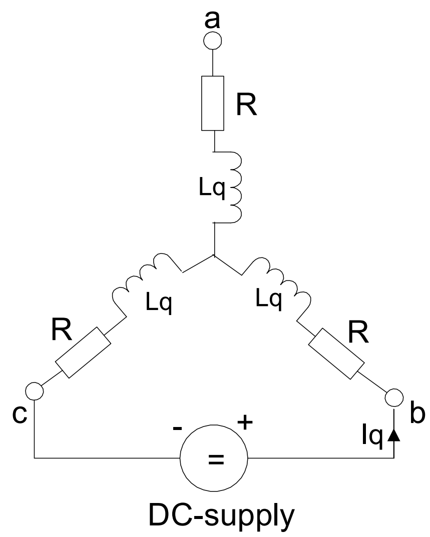
Step 2: Lock the rotor shaft.

Step 3: Replace the DC-supply by a variable frequency AC-Source. Apply current Id.

Step 4: From the 108A display read frequency f, |Z01|, Phi01, (use current synchronization).

Step 5: Calculate: R = 0.667 • |Z01|cos (Phi01)
Xd = 0.667 · |Z01| sin (Phi01)
Ld = Xd / 2πf

## 10.12 MEASURE Q-AXIS INDUCTANCE LQ




Alignment into q-axis

Step 1: Current Iq aligns the rotor into the q-axis, electrical angle = 90°.

Step 2: Lock the rotor shaft firmly, Iq generates torque.

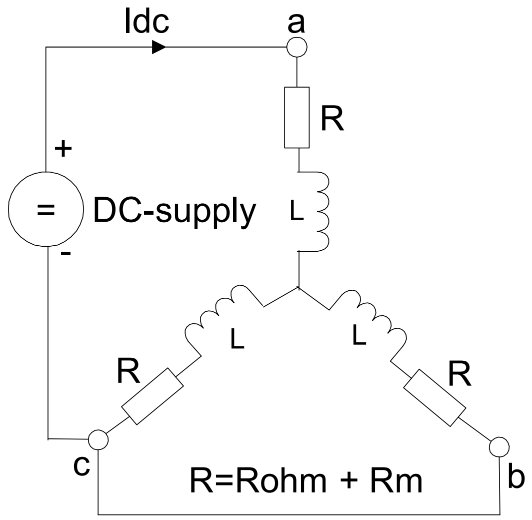
Step 3: Replace the DC-Supply by a variable frequency AC-Source. Apply current Iq.

Step 4: From the 108A display read frequency, |Z01|, Phi01, (use current synchronization).

Step 5: Calculate: R = 0.5 |Z01|cos (Phi01)
Xq = 0.5 |Z01| sin (Phi01)
Lq = Xq / 2πf

Step 6: Repeat step 5 at different current levels. Plot Lq versus current.

## 10.13 MEASURE OHMIC COMPONENT OF LOSS RESISTANCE R = ROHM + RM



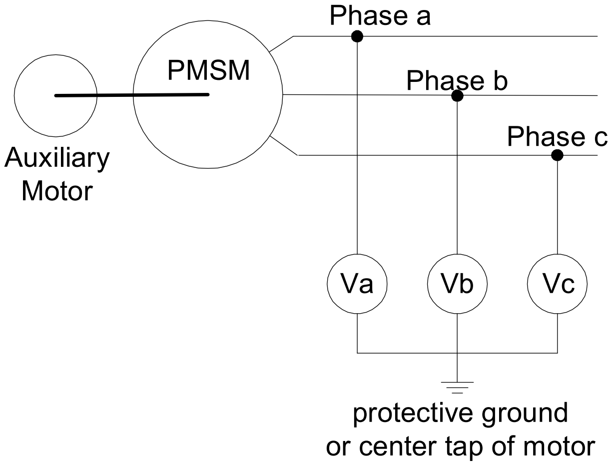

Step 1: Connect DC power supply.

Step 2: Measure Vdc, Idc, and Pdc using 108A.

Step 3: Calculate Rohm = Pdc / $I^2$dc

## 10.14 Back – EMF (BEMF)

To measure the BEMF the shaft of a PMSM / IPMSM is turned by an auxiliary motor at constant speed $\omega_{el}$.




Step 1: Connect Va, Vb, Vc to phase 1, 2, 3 of the 108A. (use voltage synchronization).

Step 2: Display V01a, V01b, V01c the fundamental of voltage and frequency.

Step 3: Calculate the BEMF peak value.

Vapeak = 1.41 · V01a
Vbpeak = 1.41 · V01b
Vcpeak = 1.41 · V01c

Calculate k= Vpeak / 2πf [Vs / rad].
k is a constant used for motor control.

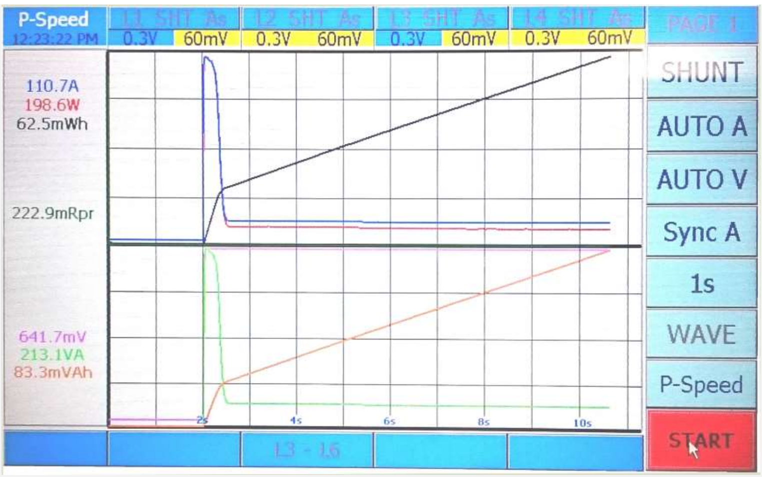
## 10.15 Transient Performance of Synchronous Motors

The 108A also measures motors in transient state (start-up, speed change, load change) using the Logging measure mode or the Power-Speed measure mode.

### Logging Mode

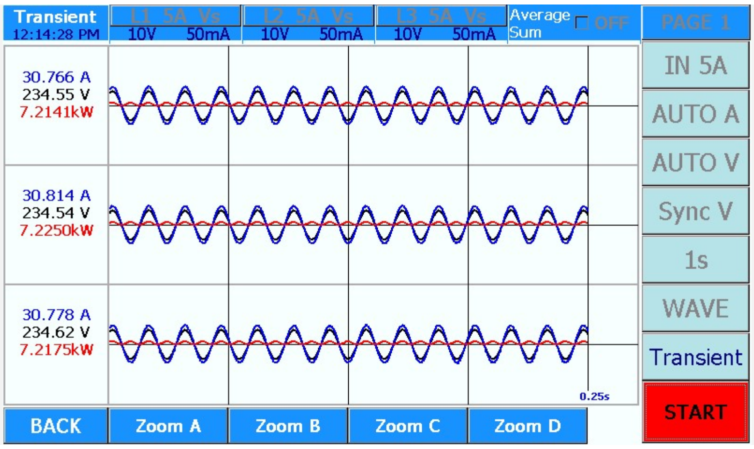

At end of programmed time interval (1, 2, 3, … periods), frequency, A, V, PF, VA, Wh, and VAh of each phase are transmitted to the PC. Data are stored. In EXCEL graphs can be generated.

### Power Speed Mode




Use it for high speed IPMSM with fast changing signal frequency. In 20ms intervals averaged current and voltage, 3-phase power, 3-phase apparent power, and speed (rpm) are sent to PC. In EXCEL graphs like power versus rpm can be drawn. Plots on the 108A display are drawn.

### Transient wave




At operating points of interest the simultaneous wave forms of all 6 phases can be viewed (current, voltage and power). To view details sectors of wave forms A, B, C, or D can be expanded.

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