

**phase**trac

**M2000**

**ADVANCED  
POWER QUALITY ANALYZER**



## **Production Manual & Specifications**

- **Advanced (cycle by cycle) Electrical Network Analysis**
- **Complete network harmonics analysis, up to 63<sup>rd</sup> harmonic**
- **High visibility, 5" graphic LCD screen with backlight**
- **Displays neutral voltage and current**
- **Comprehensive data logging**
- **Feeder transformer analysis**
- **Compliance monitoring of international power quality standards**
- **Flexible design, allows system customization**
- **Up to 2048KB of flash memory**
- **User-friendly PC software (Power Monitoring Software)**
- **A variety of isolated digital and analog inputs and outputs**
- **Multiple communication protocols**
- **Menu driven operation**
- **Easy installation, configuration and use**



## Features

### Metered Values

- True RMS measurements
- Advanced, real-time, cycle by cycle measurements, at 128 samples per cycle. Real-time values averaged over 8 through 256 cycles for easy reading
- Choice of models ranging from essential measurements only (Volts, currents, frequency and powers) to over 2000 electrical parameters
- Min/Max values
- Four quadrant readings (power, power factor)
- Displays neutral voltage and current

### Time-of-Use (TOU)

- Time-of-Use information is automatically stored for each predefined period
- Power Monitoring Software software calculates electricity costs according to varying tariffs (based on time, season etc.)

### Power Quality

- Waveform display and capturing, at 128 samples per cycle
- Harmonics analysis, up to 63<sup>rd</sup> harmonic (individual, THD, K and crest factors)
- Sag/Swell recording (magnitude, duration and trigger events)

### Compliance Monitoring

- Compliance monitoring of international power quality standards
- These monitoring operate on all product series (e.g. the harmonics level is tested even if the meter doesn't include harmonics display)

### Logging & Recording

- Up to 2048KB of flash memory
- High speed data recording for short duration critical events
- Logging of over 2000 parameters at scheduled intervals or by set-points
- Min/Max recording of key parameters
- Logging of setup changes, set-point and power quality events
- Precise timestamp synchronized to external GPS (optional)

### Input, Output & Relays

- On board relay can be controlled automatically by internal set-points
- Optional 4 digital inputs and 2 outputs for multiple purposes, such as synchronization to utility meter or to generate energy pulsing (Wh, VAh and VAh)

### Graphic Display & User Interface

- Extra large graphic LCD screen
- High visibility (FSTN technology)
- Bright Backlight
- Characters are displayed in varying sizes to enhance visibility from long distances
- The user interface offers an easy to use, installation and configuration menu driven operation

### Communication

- Optional RS-485 or RS-232 communication port
- Supported protocols: Neptune protocol - Phasetrac's unique Advanced communication protocol and ModBus RTU
- Baud rate of up to 115200 BPS
- Fully automated baud rate setup

### Structure

- Allows easy adaptation of the unit to current and future requirements
- Easy upgrading of the firmware (internal software)

### Network Types

- Supports any network connection configuration (3 and 4 Wire, Wye and Delta, single-phase etc.)
- Feeder transformer (or local generator) current and power analysis (see Applications section)

### Software

- User-friendly PC software (Power Monitoring Software)
- Includes on-line help for easy use

### Direct Phase Measurements:

$$V_i = \frac{1}{\sqrt{2}} \sqrt{\sum_n V_{n,i}^2} \quad I_i = \frac{1}{\sqrt{2}} \sqrt{\sum_n I_{n,i}^2}$$

#### Indexes

i - phases index  
n - harmonic index

#### Harmonic values:

$V_{n,i}$  - value of n'th harmonic at phase i of the phase voltage  
 $I_{n,i}$  - value of n'th harmonic at phase i of the mains currents

#### RMS values:

$V_i$  - RMS value at phase i of the phase voltage  
 $I_i$  - RMS value at phase i of the mains current

### THD Computations:

$$THD_i = \frac{\sqrt{\sum_{n,n \neq 1} T_{n,i}^2}}{T_{1,i}}$$

**Harmonic values:**  
 $THD_i$  - THD of parameter T at phase i  
 $T_{n,i}$  - value of parameter T at the n'th harmonic of phase i.

### Mains Power and Power Factor Computations:

$$P_i = \frac{1}{2} \sum_n V_{n,i} I_{n,i} \cos \varphi_{n,i} \quad \cos \varphi_i = \frac{P_i}{\sqrt{P_i^2 + Q_i^2}}$$

$$Q_i = \frac{1}{2} \sum_n V_{n,i} I_{n,i} \sin \varphi_{n,i}$$

$$\sum P = \sum_i P_i \quad \cos \varphi_{avr} = \frac{\sum P}{\sqrt{\sum P^2 + \sum Q^2}}$$

$$\sum Q = \sum_i Q_i$$

#### Harmonic values:

$\varphi_{n,i}$  - phase difference between phase voltage and mains current at the n'th harmonic and phase i

#### RMS values:

$P_i$  - total active power (for all harmonics) at phase i.  
 $Q_i$  - total reactive power (for all harmonics) at phase i.  
 $\sum P$  - total active power (for all phases)  
 $\sum Q$  - total reactive power (for all phases)

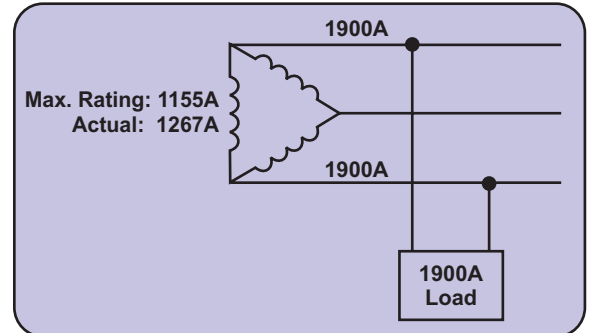
# Applications

## Network Types

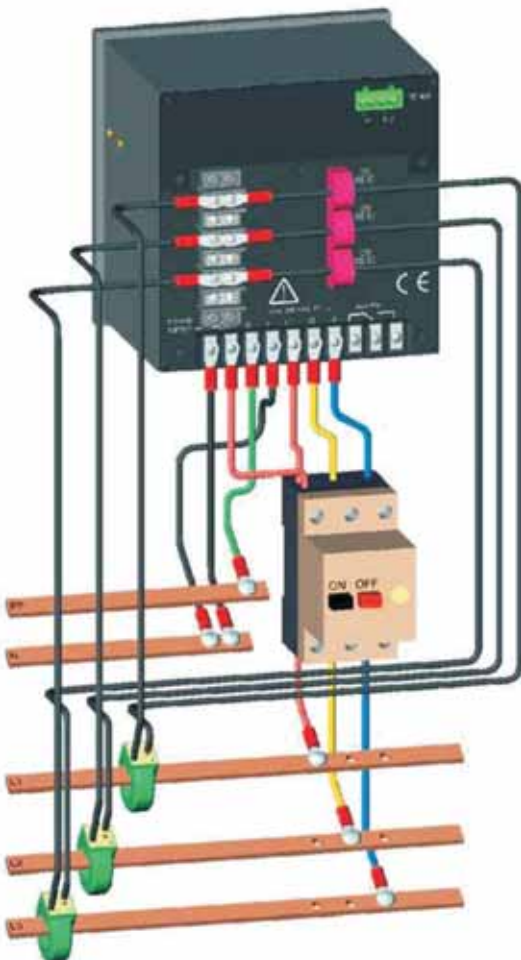
The Power Analyzer supports any network connection configuration, such as 3 and 4 wire, Wye and Delta, and single-phase. The connection is either direct (up to 347/600V AC) or using a Potential Transformer (PT). Minimum burden on the Current Transformers (CTs) is achieved by connecting the CTs without a physical contact. Delta network use 2 or 3 Ct's and Wye networks use 3 or 4 CT's.

## Feeder Transformer Analysis

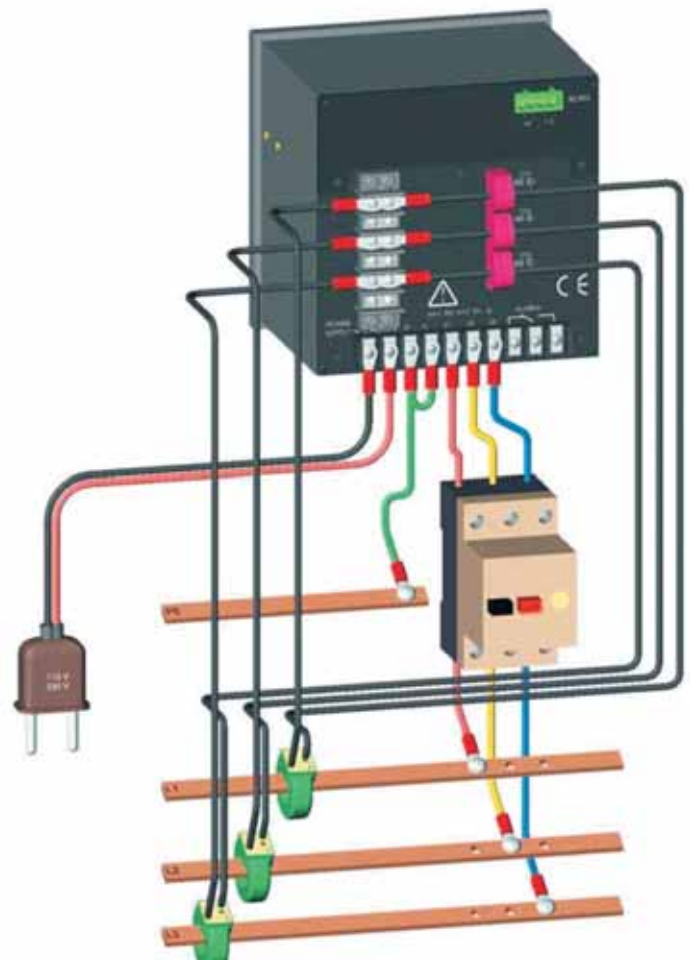
When the system is configured as a Delta network, it displays the L-to-L current and power, in addition to the line currents and total power. The system measures the line current from the CTs and calculates the current and power inside the feeder transformer (or generator). In completely balanced networks, the internal currents are 1/33 of the line currents. In many cases, the network is not balanced and the internal currents are different from these expected. This can be explained with the following hypothetical example: A transformer designed for a maximum current per phase of 2000A, therefore each internal line is designed for a maximum of 1155A ( $2000/33$ ). The network includes only one phase to phase load of 1900A between phases L1 and L2 and nothing on L3. The transformer appears incorrectly to have a 95% load ( $1900/2000$ ). The currents are divided into 67% on L1-L2 line and 33% on L1-L3 and L3-L2 lines, resulting in 1267A on the L1-L2 line, and the transformer is overloaded by 10%. Phasetrac's unique L-to-L current and power algorithm displays this information, enabling maximum network monitoring.



## Connection Diagrams



Typical Connection in a Wye Network



Typical Connection in a Delta Network

## Main Menu

MAIN MENU

10:16

Line Currents

Line to Line Voltages

Volt-Amp-Hz Meters

kVA-kW-PF Meters

kVA-kW-kVAr Meters

Energy Meters

Waveforms

Harmonic Analysis

>>>

More...

CANCEL
ENTER
▲
▼

### Measurement Level

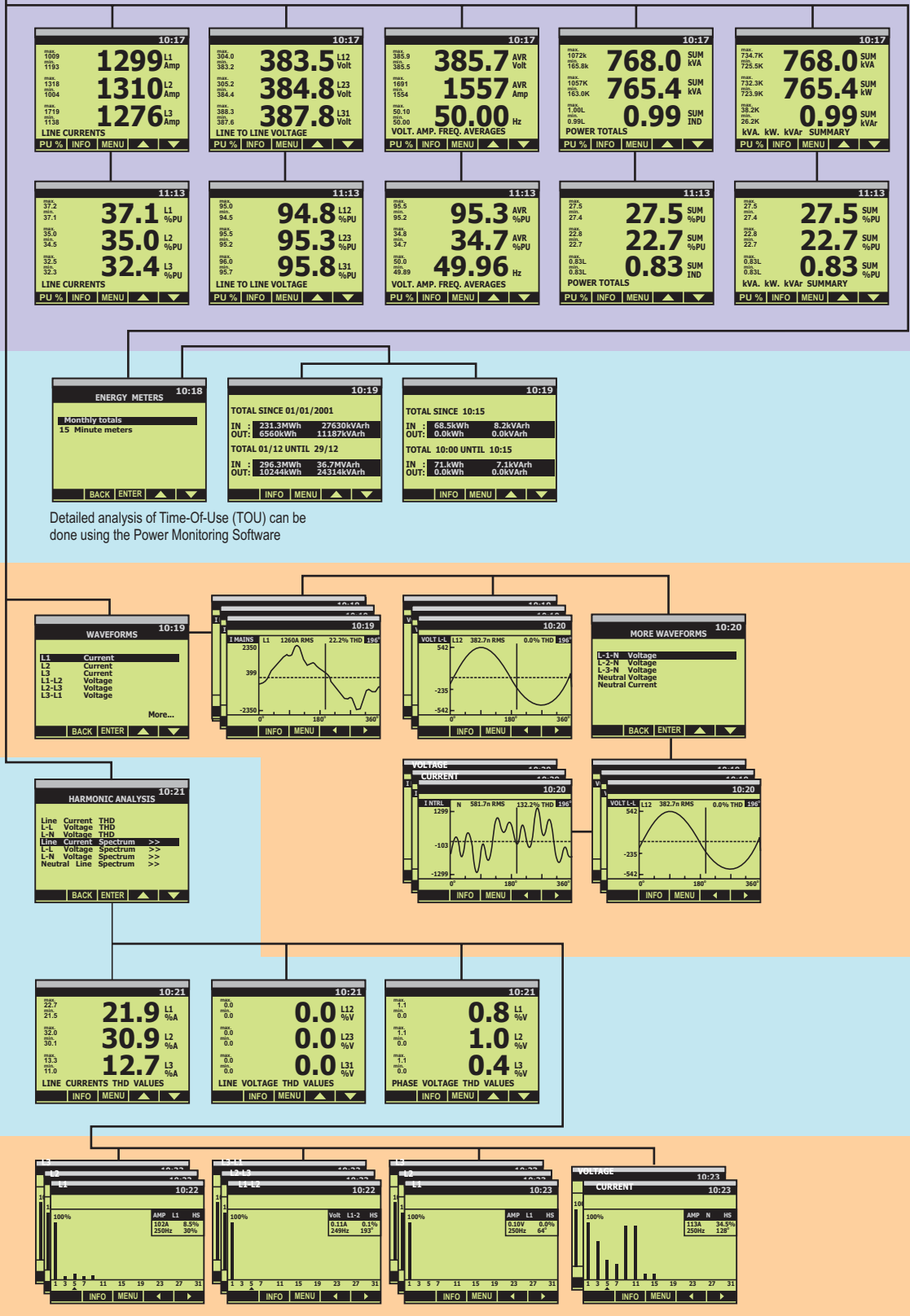
1

2

3

4

## Display Screens



## Main Menu (Cont.)

MORE MAIN MENU 10:23

Power Factor Meters  
kVar Phase Meters  
kVA Phase Meters  
kW Phase Meters  
L-N Voltage Meters  
Neutral Conductor  
-----  
Setup Parameters >>

BACK ENTER

Measurement Level

1 2 3 4

10:24

0.99 L1 IND

0.95 L2 IND

1.00 L3 IND

TRUE POWER FACTOR

INFO MENU

10:24

56.9 L1 kVar

86.5 L2 kVar

30.7 L3 kVar

REACTIVE POWER METERS

PU% INFO MENU

10:24

400.4 L1 kVA

288.9 L2 kVA

347.5 L3 kVA

APPARENT POWER METERS

PU% INFO MENU

10:24

286.8 L1 kW

190.4 L2 kW

254.4 L3 kW

ACTIVE POWER METERS

PU% INFO MENU

10:25

224.8 L1 Volt

224.6 L2 Volt

224.4 L3 Volt

PHASE TO NEUTRAL VOLTAGES

PU% INFO MENU

10:25

0.8 N Volt

664.4 N Amp

98.3 N %A

NEUTRAL VOLTAGE & CURRENT

INFO MENU

11:13

1.64 L1 %PU

17.1 L2 %PU

13.5 L3 %PU

REACTIVE POWER METERS

PU% INFO MENU

11:13

29.6 L1 %PU

27.8 L2 %PU

25.1 L3 %PU

APPARENT POWER METERS

PU% INFO MENU

11:13

24.7 L1 %PU

22.2 L2 %PU

22.0 L3 %PU

ACTIVE POWER METERS

PU% INFO MENU

11:13

95.3 L1 %PU

95.3 L2 %PU

95.1 L3 %PU

PHASE TO NEUTRAL VOLTAGES

PU% INFO MENU

10:25

SETUP PARAMETERS

Display Contrast

Display Refresh Rate

MODBUS Slave address

Installation

BACK ENTER

10:26

SLAVE ADDRESS

Please select the slave address for MODBUS RTU protocol: 1

CANCEL CLOSE

## Step-by-step installation assistant

The screens include automatic default and user friendly help screen.

10:26

Welcome to the Installation Wizard.

PLEASE READ THE INSTALLATION INSTRUCTIONS CAREFULLY BEFORE EXECUTING THIS PROCEDURE.

BACK NEXT

10:25

DATE & TIME SETTING

Current Date: 22/1/2001

Current Time: 10:26:26

The above is correct

Modify the above

BACK NEXT

10:26

NETWORK TYPE

Please select the network type:

L-V <100V - 1000V>

HV/HV <1kV - 400kV>

BACK NEXT

10:26

NOMINAL VOLTAGE

Please select Network nominal voltage:

40.0kV

BACK NEXT

10:26

PT SECONDARY

Please select the SECONDARY rating of the voltage readings step-down transformer

40.0kV/400V

BACK NEXT

10:26

NETWORK CONFIGURATION

Please select the connection type:

Three-phase, WYE

Three-phase, DELTA

Single-phase, L-N

Single-phase, L-L

HELP BACK NEXT

10:27

SETTING OF MAINS CT

Please select the MAINS current transformer (CT):

10000A/5A

(ratio = 2000)

BACK NEXT

10:29

MAIN CT POLARITY

Measured Active Power: (Select to edit polarity)

L1. 397kW (normal)

L2. 275kW (normal)

L3. 391kW (normal)

Accept the above

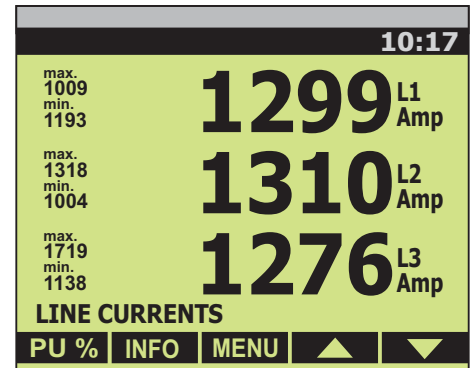
HELP CANCEL SELECT

- Notes:
- \* These detailed display screens are for WYE network configuration
  - \* Other configurations have similar screens



## Large Digit Screen

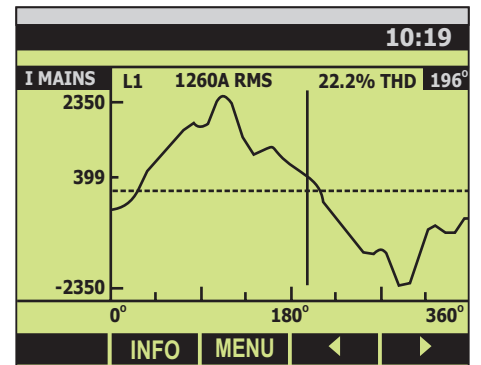
Permits simultaneous display of 9 parameters: 3 measured values plus 3 minimum and 3 maximum. Parameters can be mixed, such as average voltage, current and power factor. This unique feature allows analysis of the foremost parameters at a glance, without touching the unit. The PU % buttons displays the values as a percentage from their nominal rating.



## Waveform Screen

### 128 samples/cycle

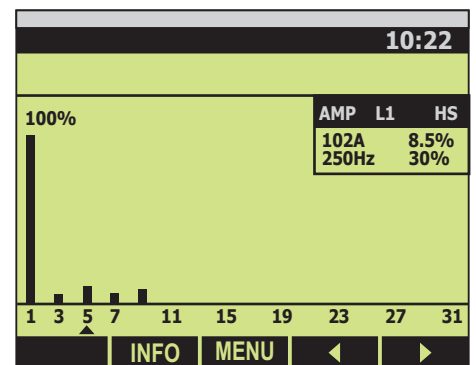
This large graphic display allows easy monitoring of transients of 130/156 $\mu$ S (at 60/50Hz). The display includes detailed information for each wave: the type and phase, THD, RMS, peak & bottom values plus value at cursor position.



## Harmonics Screen

### 63 harmonics

The graphic display enables inspection of the harmonics pollution at a glance. The display includes detailed information for each harmonic: type, phase, number of the harmonic, the value in amperes/volts and in percent, the angle and the frequency.



Measurement Level

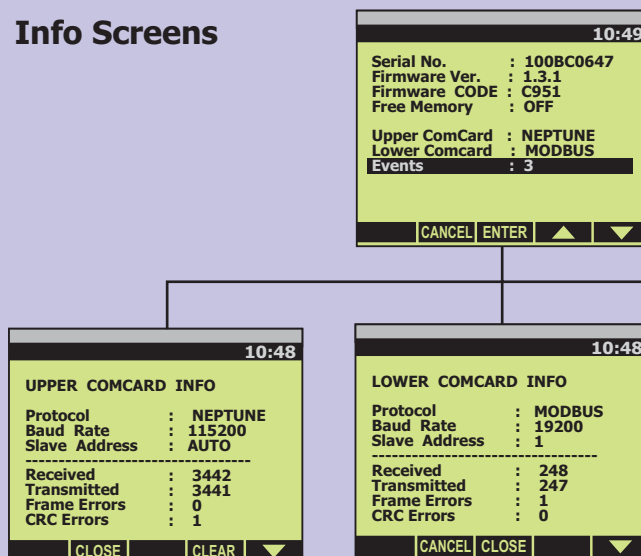
1

2

3

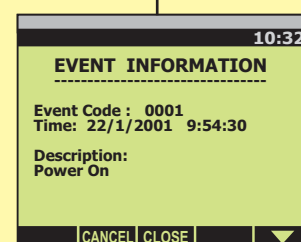
4

## Info Screens



Additional event-specific information is displayed.

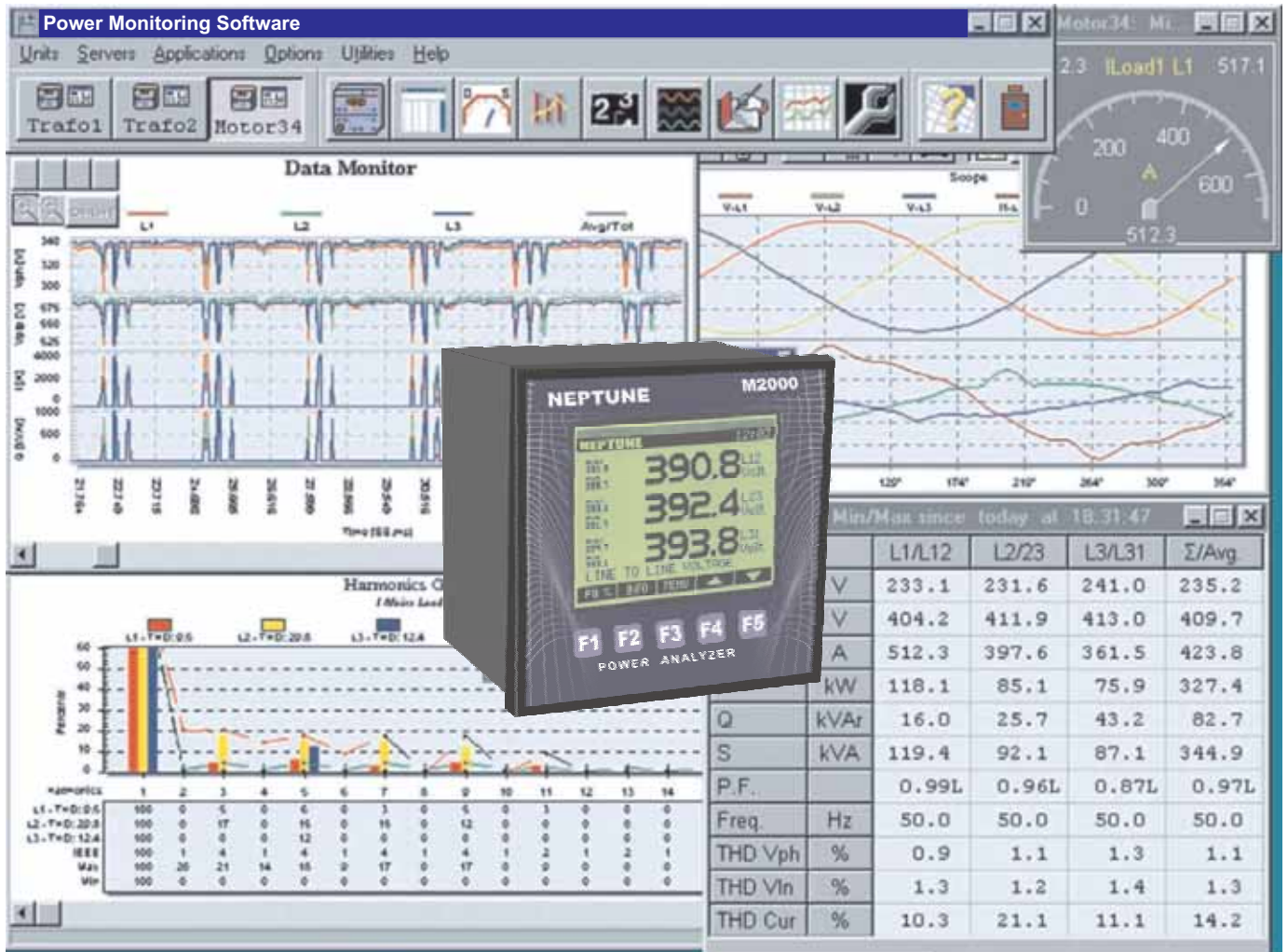
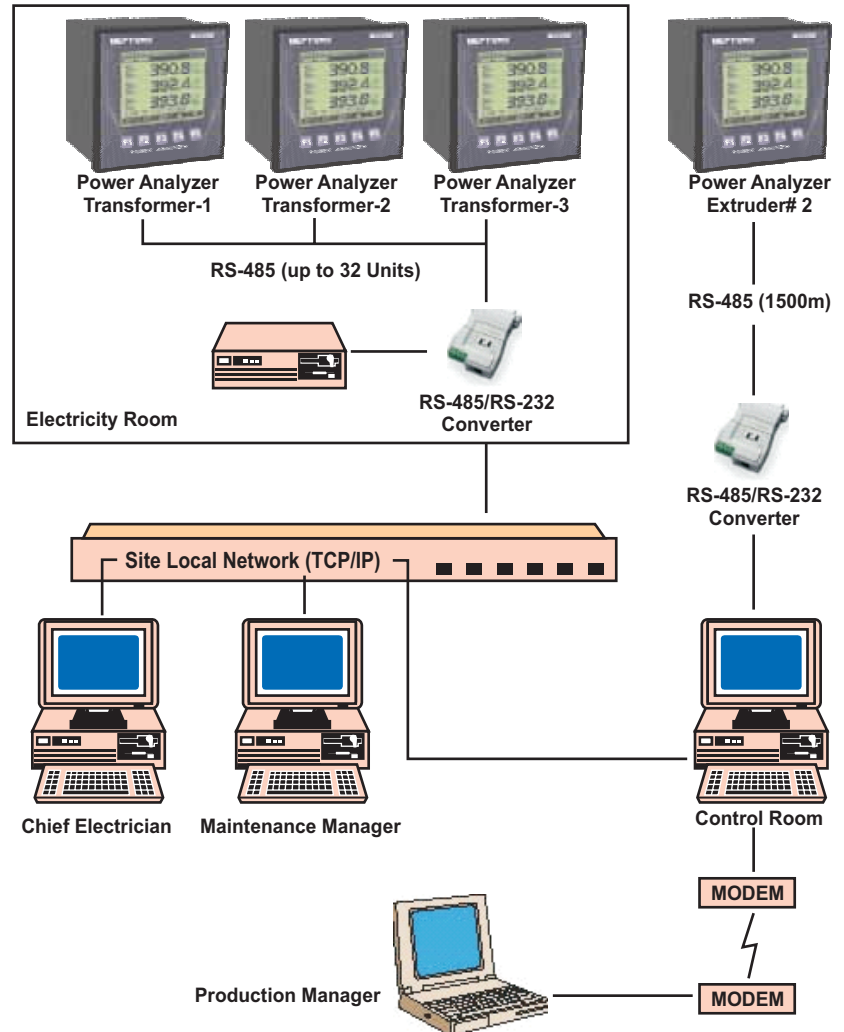
Detailed event information is accessed using Power Monitoring Software



# Power Monitoring Software

## General

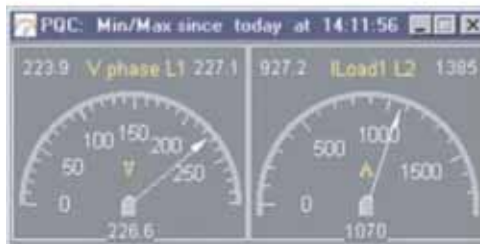
This easy-to-use software displays the system's status, as well as the measurement results on numerous screens running under Windows (95, 98, me, NT and 2000). Power Monitoring Software integrates all Phasetrac systems, allowing power quality analysis, cost allocation, circuit optimization, demand & power factor monitoring. Power Monitoring Software includes real-time measurements, as well as comprehensive data logging and power quality analysis features. All screens allow customization, printing and exporting of data. The network version enables complete intra-net and Internet operation, as well as modem access.





## Real Time Measurements

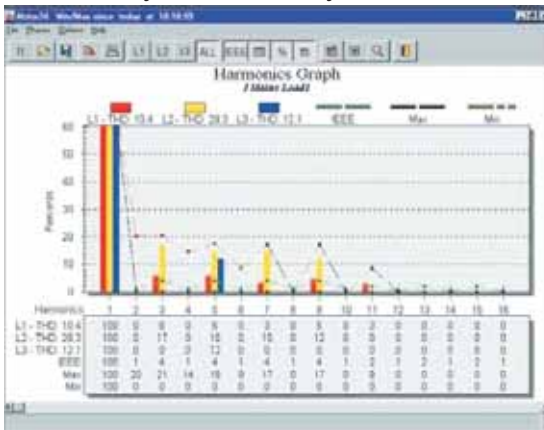
Provides clearly visible real time values, with minimums and maximums.



| Table B3: Min/Max since today at 13:30:30 |      |       |       |       |       |
|-------------------------------------------|------|-------|-------|-------|-------|
|                                           |      | L1/L2 | L2/3  | L3/L1 | Z/Avg |
| V Ph                                      | V    | 220.6 | 221.1 | 219.7 | 220.5 |
| V Line                                    | V    | 382.5 | 382.0 | 380.6 | 381.7 |
| I                                         | A    | 325.2 | 323.5 | 288.1 | 312.3 |
| P                                         | kW   | 69.6  | 69.9  | 62.9  | 202.4 |
| Q                                         | kVar | 15.8  | 7.4   | 1.5   | 24.7  |
| S                                         | kVA  | 71.7  | 71.5  | 63.3  | 206.5 |
| P.F.                                      |      | 0.98L | 0.99L | 1.00L | 0.99L |
| Freq.                                     | Hz   | 50.0  | 50.0  | 50.0  | 50.0  |
| THD Vph                                   | %    | 1.3   | 1.5   | 1.5   | 1.4   |
| THD Vln                                   | %    | 1.1   | 1.0   | 1.0   | 1.0   |
| THD Cur                                   | %    | 8.9   | 19.6  | 14.7  | 14.4  |

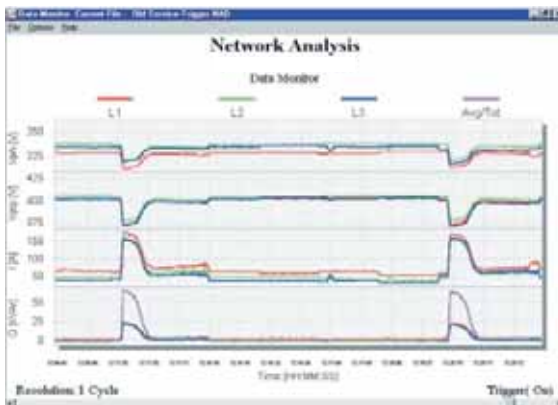
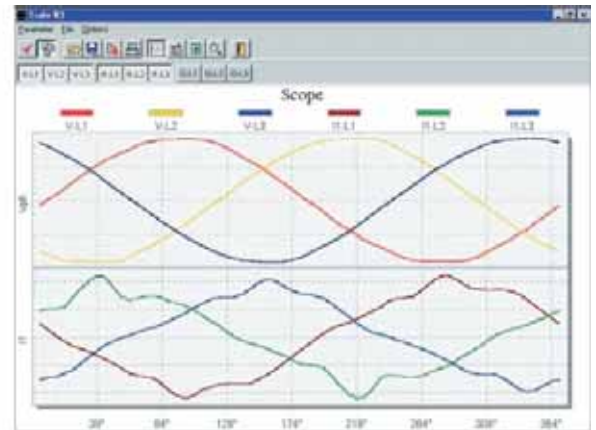
## Harmonics Analysis

Displays the harmonics spectrum both as a graph and as a table, in addition to harmonics analysis parameters (THD, K-Factor and Crest-Factor). Compliance monitoring of international power quality standards, such as IEEE-519, allows easy network analysis.



## Scope

Displays waves and their phase shifting, and enables detection of existing or potential power quality problems.



## Data Logging

Enables comprehensive network analysis by logging over 2000 parameters per record. It can be set to record data either on pre-defined intervals (from 1 cycle to 99 hours) or according to network events. The recording volume and time is limited only by the size of the computer's hard disk.

## Data Monitoring

Displays the recorded data in either on-line or off-line mode. The on-line mode displays the data while simultaneously recording it for maximum power analysis control.

## Report Generator

Creates user-defined or preset reports (such as load profile and power quality) reports. The reports are easily defined using a word processor (such as Microsoft Word).

## Time-of-Use (TOU)

Displays the Time-of-Use information stored in the analyzer, in addition to calculation of energy costs, according to virtually any utility tariff structure.

## Events

The event screen is used for retrieving, monitoring and analyzing the events information from the analyzer.





## Specifications

## Ordering Information

**M2000- 3 1 2 - 2 ....**

|                            |                                                     |
|----------------------------|-----------------------------------------------------|
| LCD Display Size           | : 94x76 mm                                          |
| LCD Display Resolution     | : Graphic 160x128 pixels                            |
| LCD Display Type           | : FSTN, LED backlight                               |
| Overall Dimensions         | : 144x144x120 mm [HxWxD]                            |
| Panel Cutout               | : 138x138 mm                                        |
| Weight                     | : 1.4 kg                                            |
| Ambient Temperature        | : -20°C - +55°C                                     |
| Storage Temperature        | : -25°C - +65°C                                     |
| Direct Voltage Measurement | : 347/600 VAC Max.                                  |
| Current Measurement        | : ..5A (1A)                                         |
| Relay Alarm                | : Max. 2A 250VAC                                    |
| EMC Compatibility          | : EN61000-4-2/3/4/5,<br>ENV50204, ENV50141          |
| Safety Standards           | : EN61010-1, EN50439-1, UL508                       |
| Protection Class           | : IP40                                              |
| Analog Channels            | : 7<br>4 x Voltage Channels<br>3 x Current Channels |
| Communication (optional)   | : Neptune (Protocol), ModBus RTU                    |
| Power Supply               | : 110 or 230v, 50/60 Hz                             |
| Power Consumption          | : 15 VA                                             |
| Harmonics Analysis         | : 1 through 63rd                                    |

**Product Series (1-4)** \_\_\_\_\_

**Standard Version (1)** \_\_\_\_\_

**Communication:** \_\_\_\_\_

0 - None

1 - Single Neptune Port

2 - Single Neptune/Modbus Port

3 - Dual Neptune/Modbus Port

**Power Supply:** \_\_\_\_\_

1 - 110v 50/60 Hz

2 - 220v 50/60 Hz

**Additional Cards:** \_\_\_\_\_

Blank - None

M - Memory Expansion

D - Digital I/O (4 in, 2 out)

A - Analog Output (0-20mA, 4-20mA, +/- 1mA)

**Additional options available.**

**Please contact Neptune for details.**

## Model Information

| Options                                                                                                                                           | Product Series  |                  |                  |                   | Displayed Phases   | Accur. (%)<br>(FS)±1dgt |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------|------------------|-------------------|--------------------|-------------------------|
|                                                                                                                                                   | 1               | 2                | 3                | 4                 |                    |                         |
| Full Instrumentation<br>Wiring Diagnostics<br>ANSI C12.1 Accuracy                                                                                 | •               | •                | •                | •                 |                    |                         |
| Frequency                                                                                                                                         | •               | •                | •                | •                 | L1,L2, L3, Avg     | 0.1                     |
| Current, per Phase                                                                                                                                | •               | •                | •                | •                 | N                  | 0.2                     |
| Current, Neutral                                                                                                                                  | •               | •                | •                | •                 | L12, L23, L31, Avg | 0.2                     |
| Current, L-to-L (Transformer)                                                                                                                     | •               | •                | •                | •                 | L12, L23, L31, Avg | 0.2                     |
| Volts, L-to-L                                                                                                                                     | •               | •                | •                | •                 | L1, L2, L3, Avg    | 0.2                     |
| Volts, L-to-N                                                                                                                                     | •               | •                | •                | •                 | N                  | 0.2                     |
| Volts, Neutral                                                                                                                                    | •               | •                | •                | •                 |                    |                         |
| Real Power (kW)                                                                                                                                   | •               | •                | •                | •                 | L1, L2, L3, Sum    | 0.4                     |
| Reactive Power (kVAR)                                                                                                                             | •               | •                | •                | •                 | L1, L2, L3, Sum    | 0.4                     |
| Apparent Power (kVA)                                                                                                                              | •               | •                | •                | •                 | L1, L2, L3, Sum    | 0.4                     |
| Power Factor                                                                                                                                      | •               | •                | •                | •                 | L1, L2, L3, Sum    | 0.4                     |
| Time-of-Use (TOU):<br>- Real Energy (kWh)<br>- Reactive Energy (kVARh)<br>- Energy Accumulation Modes: in, out, net, total                        |                 | •                | •                | •                 | Sum<br>Sum         | 0.5<br>0.5              |
| THD (Current, Volts, L- to-L and L- to-N)                                                                                                         |                 | •                | •                | •                 | L1, L2, L3, Avg, N | 0.2                     |
| K-Factor (Current, Volts, L- to-L and L- to-N)                                                                                                    |                 | •                | •                | •                 | L1, L2, L3, Avg, N | 0.2                     |
| Harmonics (Current, Volts, L-to-L and L- to-N)                                                                                                    |                 | •                | •                | •                 | L1, L2, L3, N      | 0.2                     |
| Waveforms (Current, Volts, L- to-L and L- to-N)<br>Min/Max Readings                                                                               | •               | •                | •                | •                 | L1, L2, L3, N      | 0.2                     |
| Event Logging (coming soon)<br>Data Logging (coming soon)<br>Data/Time Stamping<br>Flash Memory (Kilo Bytes)<br>Maximum Flash Memory (Kilo Bytes) | •<br>256<br>256 | •<br>512<br>1024 | •<br>512<br>1024 | •<br>1024<br>2048 |                    |                         |
| RS-422/485 Communication Port - Neptune Protocol                                                                                                  | ○               | ○                | ○                | ○                 |                    |                         |
| RS-422/485 Communication Port - ModBus/RTU                                                                                                        | ○               | ○                | ○                | ○                 |                    |                         |
| Onboard Alarm                                                                                                                                     | •               | •                | •                | •                 |                    |                         |

• - included      ○ - optional

Specifications are subject to change without notification.

Sold & Serviced by:

**NEPTUNE SYSTEMS PVT. LTD.**

Sales & Marketing Office :

A-11, Sec.-59, Noida-201301 (UP) (INDIA)

Tel: 0120-3069000, 3069040, 3069042

Fax: 0120-3069041

E-mail: enquiry@neptuneindia.com

Web: www.neptuneindia.com



Network & Power Quality Analysis by:

**NAAC ENERGY CONTROLS (P) LIMITED**

Office & Works :

C-135, Phase-II-Extn., (Hosiery Complex),  
Noida-201305 (UP) INDIA.

Tel.: 0120-4221631-34 Fax : 0120-4221635

Mob.: 9811199085

E-mail : info@naacenergy.com

Web: www.naacenergy.com