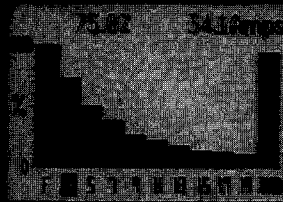# Harmonic / Power Analyzer

600V AC/DC MAX

VOLTAGE

COM

AMPS

## HA-1000
## HA-2000

User's Manual

*Harmonalyzer*™

Harmonic / Power
Analyzer

Model HA-2000

AMPROBE

# AMPROBE®

<table>
<tr><td width="50%" valign="top">

## Precautions for Personal
## and
## Instrument Protection

### IMPORTANT

1. Before using any electrical instrument, it should be checked to make certain it is operating properly.

2. In many instances, you will be working with dangerous levels of voltages and/or current, therefore, it is important that you should avoid direct contact with any uninsulated, current carrying surfaces. Appropriate insulated gloves, safety glasses and protective clothing should be worn.

3. Before attaching anything to the conductor, make sure the voltage present is not beyond the range of the instrument.

4. When not in use, keep the instrument in its carrying case to protect it from damage.

5. When the *Harmonalyzer*™ will not be used for a long period of time, remove the batteries and place them in the six holes in the carrying case.

⚠ **CAUTION** - Refer to explanation on pg. 9 of this manual.

▣ Double Insulation

</td></tr>
</table>

## CONTENTS

# LIMITED WARRANTY

Your AMPROBE instrument has a limited warranty against defective materials and/or workmanship for one year from date of purchase, provided in the opinion of the factory, the instrument has not been tampered with or abused. Should your instrument fail due to defective materials and/or workmanship during the one year period, return it along with a copy of your dated bill of sale which must identify your instrument by model number and manufacturer's number.

**Above limited warranty covers repair and replacement of the instrument only and no other obligation is stated or implied. AMPROBE shall not be liable for any loss or damage arising out of the use or misuse of this product.**

For your protection, please use this instrument as soon as possible. If unit is damaged or is ever in need of repair, please call AMPROBE at (516) 593-5600 to obtain a Return of Materials Authorization (RMA) number. The unit should then be securely wrapped to prevent further damage in transit, insured and sent along with proof of date of purchase to:

Service Division
**AMPROBE INSTRUMENT**
**630 Merrick Road (For U.P.S.)**
**P.O. Box 329 (For P.P.)**
**Lynbrook, NY 11563-0329**

Outside of the U.S.A., your AMPROBE
representative will assist you.

*for technical assistance call 1-800-477-VOLT*

# INTRODUCTION

After years of research into the cause and effect of power harmonics and hundreds of hours working with electric industry professionals, Amprobe engineers recognized that harmonic problems were prevalent throughout the commercial and industrial facilities in this country. However, the diagnosis of these problems was not happening due to the perceived complexity of the problem, and the high cost, in both time and money, of the analysis equipment. It became clear that there was a need for an economically-priced instrument that could simplify these diagnoses. Amprobe has succeeded in this task.

The *Harmonalyzer* couldn't be simpler: the three buttons quickly walk you through the complete analysis. We've taken out all the unnecessary information and left you with exactly what you need to do the job.

Low price doesn't mean low accuracy either. The *Harmonalyzer's* accuracy is the same as, or better than, our top multimeters.

The memory and download feature on the HA-2000 allows quick and easy data retrieval and documentation.

The *Harmonalyzer* is an excellent analysis tool that will precisely indicate your harmonic distortion levels. It will not, however, prescribe a solution to your harmonics problem. We have included some examples beginning on page 18 that may help you get started. May you enjoy using your *Harmonalyzer* as much as we enjoyed building it!

**Please Read This Manual Carefully.**

## GENERAL

There are two *Harmonalyzer* models: HA-1000 and HA-2000. Both units come in a carrying case lined with foam that protects the unit from damage (Cat No. HACC).

Each HA-1000 includes:
- *Harmonalyzer* HA-1000
- HACT-1 Current transducer
- MTL-15 Voltage leads
- HA3R Memory pad & pencil
- HACC Carrying Case
- User's Manual

Each HA-2000 includes:
- *Harmonalyzer* HA-2000
- HACT-2 Current Transducer
- HAVL-2 Voltage leads and crocodile clips
- HA3R Memory pad & pencil
- HADISC *Harmona-Link* tm software
- HADC Data cord for download
- HACC Carrying Case
- User's Manual

## WHAT ARE HARMONICS ?

Any periodic distorted wave can be broken down into a series of sine waves each having an integer multiple of the 60 Hz fundamental frequency. The sine wave at 120 Hz is the 2nd harmonic, 180 Hz is the 3rd, and so on. **Harmonic distortion is a steady-state** problem and must not be confused with short- term phenomena like spikes, sags or surges.
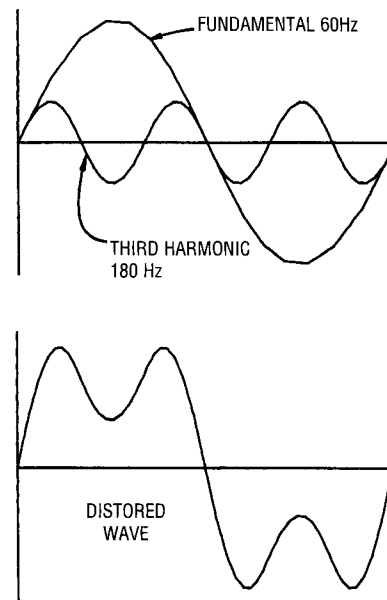


## WHAT CAUSES HARMONICS ?

Anything that alters the sine wave or only uses a part of the sine wave will cause distortion and therefore, harmonics. Switch-mode power supply's (computers), variable frequency drives, and high efficiency ballasts are some examples.

## WHAT PROBLEMS DO THEY CAUSE?

In general, the even-numbered harmonics, 2nd, 4th, etc., do not cause the majority of the problems. This is why we chose not to show them on the *Harmonalyzer's* display, but included them in the download.

Triplen harmonics, odd multiples of 3, combine on the neutral to create a potentially dangerous overheating situation: 2 to 3 times the phase current could be present. The 5th, 11th, and other negative sequence harmonics will oppose the normal flow of current through motors causing them to work harder and reduce their lives.

In general, the higher the harmonic number the less energy it has, and the less impact it will have on your equipment (except for transformers).

## OPERATION

Your *Harmonalyzer* has been shipped to you with the batteries already installed to allow immediate operation and usage.

Turn the *Harmonalyzer* 'ON' by pressing any button: ◄, ■ or ►.
The Amprobe logo will appear on the display. If the display is too light or dark adjust the contrast by pressing ■ and ► simultaneously to lighten or ■ and ◄ to darken.
During normal operation, pressing the ■ button will either select the highlighted menu option or return you to the main menu. Pressing the ◄ button will move the cursor up or to the left. Pressing the ► button will move the cursor down or to the right.

The HA-2000 has a backlighted display which can be turned on and off by pressing all three buttons ◄, ■, and ► at once.

The *Harmonalyzer* will turn itself off automatically after 2 1/2 minutes of non-use. There is also a menu option to turn it off. In either case, the data that is in the buffer * will remain there until you replace it with new data or remove the batteries.
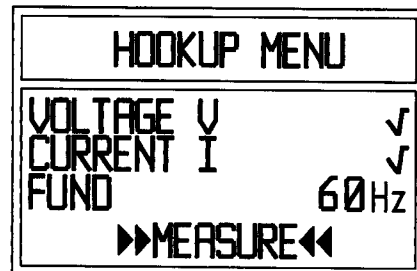
*The buffer is a temporary memory location where all new data is stored. To store this data permanently, see the Data Operations section.

**Replacing the batteries:** When the battery icon appears in the top left corner of the screen, it is an indication that your battery power is low. (Before replacing the batteries, save new measurement data in memory) Turn slotted head screw on back of unit 1/4 turn. Replace with 6 AA Alkaline cells.
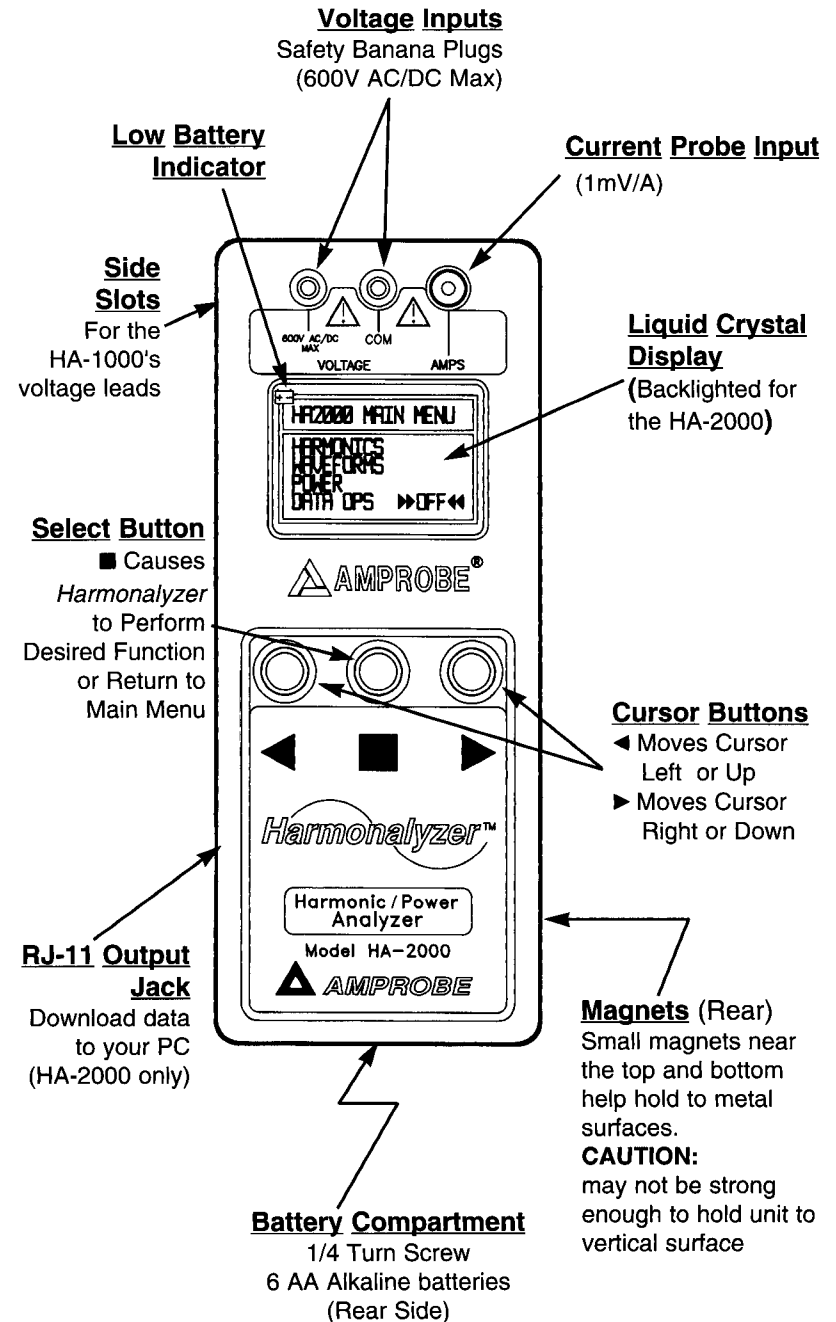
## TAKING A MEASUREMENT

Pressing ◄ and ► simultaneously will display the HOOK-UP MENU:

Pressing ■ will cause a √ to appear

```
┌─────────────────────┐
│    HOOKUP MENU       │
├─────────────────────┤
│ VOLTAGE V         √  │
│ CURRENT I         √  │
│ FUND          60Hz   │
│     ▶▶MEASURE◀◀      │
└─────────────────────┘
```

after VOLTAGE and change the last selection from MAIN MENU to MEASURE. You have just selected Voltage as the input to be measured. If you wish to take a measurement of both voltage and current simultaneously press ► once

**Voltage Inputs**
Safety Banana Plugs
(600V AC/DC Max)

**Low Battery Indicator**

**Current Probe Input**
(1mV/A)

**Side Slots**
For the HA-1000's voltage leads

**Liquid Crystal Display**
(Backlighted for the HA-2000)

**Select Button**
■ Causes *Harmonalyzer* to Perform Desired Function or Return to Main Menu

**Cursor Buttons**
◄ Moves Cursor Left or Up
► Moves Cursor Right or Down

**RJ-11 Output Jack**
Download data to your PC (HA-2000 only)

**Magnets** (Rear)
Small magnets near the top and bottom help hold to metal surfaces.
**CAUTION:**
may not be strong enough to hold unit to vertical surface

**Battery Compartment**
1/4 Turn Screw
6 AA Alkaline batteries
(Rear Side)

to bring the cursor down to CURRENT and then select it by pressing ■.
A √ should appear after CURRENT. Bring cursor down to "FUND" Press ■ to change selected frequency of electrical system you are measuring (50 or 60Hz). When frequency indicated is correct, move cursor to 'MEASURE (If you make a mistake, pressing ■ again will remove the √).

Before selecting MEASURE, make sure you have made the proper voltage and/or current connections:

> ⚠ **Do not apply more than 600VRMS to input terminals. Exceeding this limit creates a shock hazard and may damage the instrument**

1. Connect the voltage leads to the *Harmonalyzer* by plugging the angled safety banana plugs into the voltage jacks at the top of the unit. If using the HA-2000, select either the probes or the crocodile clips and connect them to the other end of the leads.
2. Connect the current transducer (CT) by inserting its plug into the AMPS jack at the top of the unit.
3. Using proper safety procedures, attach the common (COM) voltage lead to neutral or ground. Attach the other lead to the line. Reversing these connections will cause

decreased accuracies.
4. Clamp the CT around the line conductor with the AMPROBE logo facing the load.
Select MEASURE on the HOOK-UP MENU:
'MEASURING ...' will appear on the display for 3 to 9 seconds:
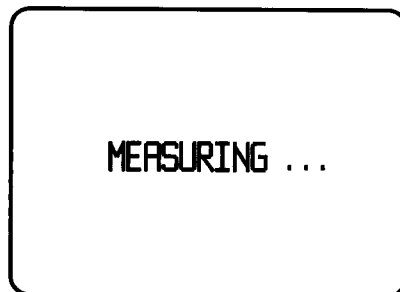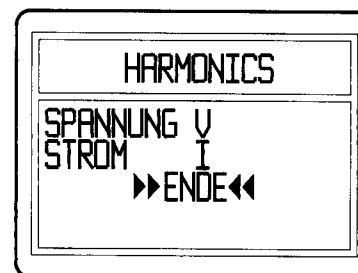


When the MAIN MENU appears, the measurement is complete. The *Harmonalyzer* has just taken a 'snapshot' of your current and voltage waveforms, performed all calculations, and stored all of the data in the buffer memory. You can now remove the leads and CT from the conductors.

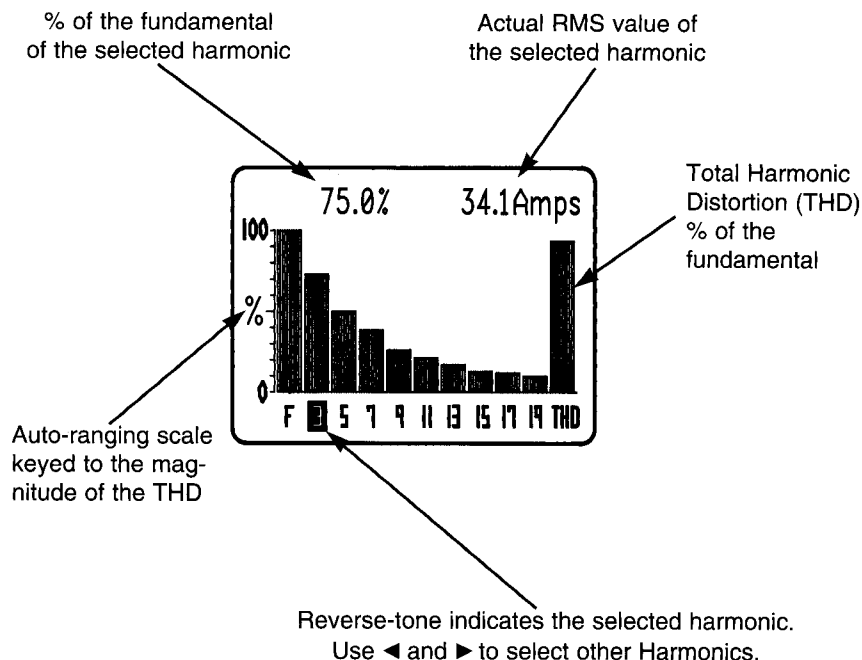**Note: Returning to the Hook-up Menu will erase the buffer.**
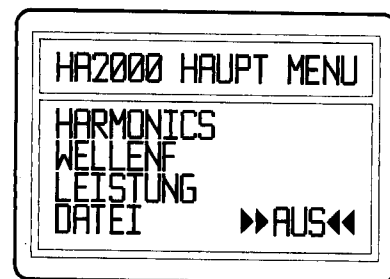


## VIEWING THE DATA



Select the information you wish to see by moving the cursor up or down and select the highlighted option. The HA-1000 Main Menu will not have POWER as an option.
If you had measured both VOLTAGE and CURRENT, selecting either HARMONICS or WAVEFORM will require a choice between the two.
Press ■ to select the highlighted option.

## HARMONICS DISPLAY

% of the fundamental of the selected harmonic

Actual RMS value of the selected harmonic



Total Harmonic Distortion (THD) % of the fundamental

Auto-ranging scale keyed to the magnitude of the THD

Reverse-tone indicates the selected harmonic. Use ◄ and ► to select other Harmonics.

The bar-graph depicts the relative magnitude of the odd harmonics and Total Harmonic Distortion (THD). The scale is **auto-ranging** and will vary from 0 to 5% up to 0 to 1000% depending on the magnitude of the THD. This feature makes it easy to see which harmonics are significant and which are not. The characters at the bottom of the display refer to the individual harmonics: 'F' is the fundamental and is typically 60 Hz; '3' is the third harmonic and is 3 times the fundamental, or 180 Hz; '5' is the fifth harmonic at 300 Hz; and so on. THD is the Total Harmonic Distortion and is calculated by taking the square root of the sum of the squares of the first 31 harmonics divided by the square of the fundamental:
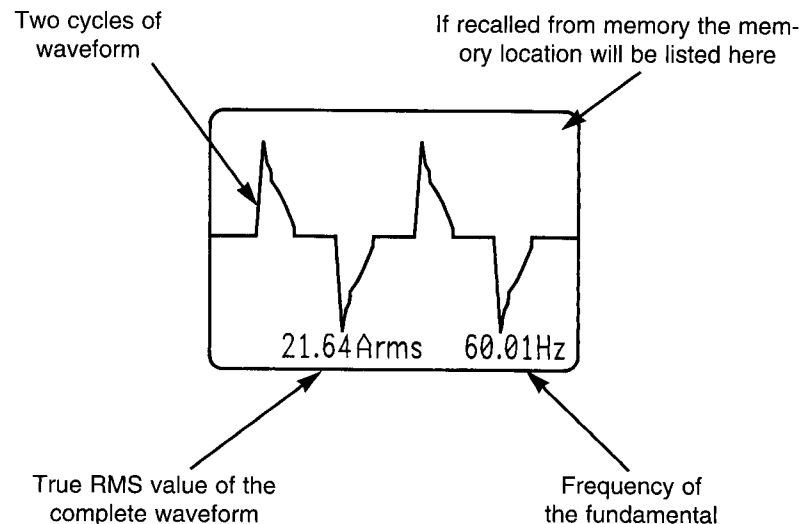
$$THD = \sqrt{\sum_{n=2}^{31} \frac{h_n^2}{f^2}}$$

THD is <u>not</u> the direct sum of each harmonic. See example #4 on page 20. Since all harmonics are relative to the fundamental, the fundamental is always 100%. At ranges below 100%, the bar above the 'F' will have an arrow showing that it goes to 100%.

Pressing the ▶ button repeatedly will move the cursor from the 'F' thru each harmonic. The value at the top left will indicate each magnitude as a percentage of the fundamental. This will help you to quickly determine whether you have a problem. The value at the top right is the actual value, in Volts or Amps, of the selected harmonic. This will help in determining how big your harmonic cancellation equipment needs to be. Pressing the ■ button will return you to the MAIN MENU.

## WAVEFORM DISPLAY

Two cycles of waveform

If recalled from memory the memory location will be listed here

21.64Arms    60.01Hz

True RMS value of the complete waveform

Frequency of the fundamental

The waveform display lets you see how the waveform actually looks, along with its True RMS value and the frequency of the fundamental.
Pressing the ◄ or ▶ buttons will remove the numbers from the display if they are obscuring your view of the waveform.
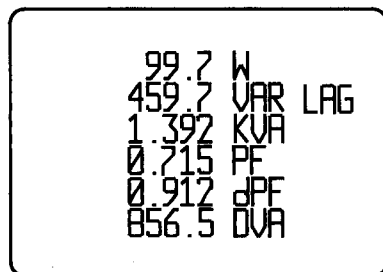
You can calculate the True RMS value yourself by taking the square root of the sum of the squares of the individual harmonics.

$$I_{RMS} \text{ or } V_{RMS} = \sqrt{f^2 + h_3^2 + ... h_{19}^2}$$
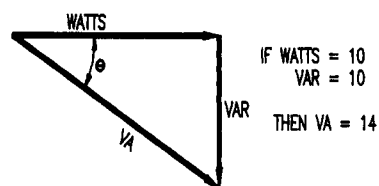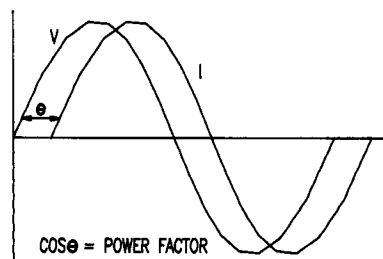
The example on page 20 illustrates this.

## POWER DISPLAY
(HA-2000 only)

```
 99.2 W
459.2 VAR LAG
1.392 KVA
0.715 PF
0.912 dPF
856.5 DVA
```

Power data is derived from comparing the voltage waveform to the current waveform. You must measure both for power data to appear.



COSθ = POWER FACTOR



WATTS

IF WATTS = 10
VAR = 10
THEN VA = 14

VAR

VA

θ

**POWER TRIANGLE**

The above diagram depicts the effect of adding inductive loads to an electrical system.

## WATTS, WORKING POWER
## REACTIVE (NON-WORKING) POWER
## APPARENT POWER
## TRUE POWER FACTOR
## DISPLACEMENT POWER FACTOR
## DISTORTION POWER

With a purely resistive load the voltage and current waves lie on top of each other, reducing phase angle θ to zero and making the Watts equal the VA's. Adding inductive or capacitive loads will cause the current waveform to be displaced from the voltage. Inductive loads will cause the current to 'LAG' the voltage as shown at left, and capacitive loads will cause a 'LEAD'ing current. The effect of this is that power is 'wasted' in magnetizing the inductors and charging the capacitors. This non-working power is Volt-Ampere Reactive (VAR), and causes the Apparent Power (VA) to be larger than the working power (Watts). The utility has to generate more VA's in order for you to get the same amount of watts. Power Factor (cos θ) is an indicator of how efficiently the generated power is utilized.

Adding distortion to the system complicates the calculations and adds a third dimension to the power triangle:
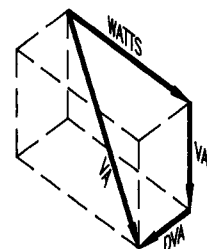


IF WATTS = 10
VAR = 10
DVA = 10
THEN VA = 17.3

DVA, Distortion Volt-Amperes is also non-working power. You can see that it also increases the VA, requiring even more power to be generated in order to perform the same amount of work.

**Working Power, Watts** is the summation of the apparent powers attributed to each harmonic:

$$\sum_{n=1}^{31} V_{RMS\,n} \times I_{RMS\,n} \cos \Theta_{DIS\,n}$$

**Reactive Power, VAR** is the non-working power needed to charge capacitors and magnetize inductors:

$$\sum_{n=1}^{31} V_{RMS\,n} \times I_{RMS\,n} \sin \Theta_{DIS\,n}$$

'LAG' in the display indicates a negative VAR or an inductive load. 'LEAD' indicates a positive VAR or a capacitive load.

Note: If watts are negative,

reverse either the direction of the transducer or swap the voltage leads, and re-measure. This action will also change the LEAD/LAG indication.

**Apparent Power, VA** is the total power required to be generated to provide the desired working power output. The calculation is straightforward:

$$V_{RMS} \times I_{RMS} = VA$$

**True Power Factor, PF** takes into account the phase angle differences between each harmonic and is the best indication of how efficiently the system is utilizing the power generated.

**Displacement Power Factor dPF** is based solely on the fundamental frequency's (60 Hz) phase angle and will equal the True PF when no harmonics are present. dPF will always be greater than the PF when harmonics are present.

**Distortion Volt -Amperes, DVA** is the non-working power needed to produce harmonics.

## DATA OPERATIONS DISPLAY

```
┌─────────────────────────┐
│ ┌─────────────────────┐ │
│ │  DATA OPERATIONS    │ │
│ │ SAVE                │ │
│ │ RECALL              │ │
│ │ DELETE              │ │
│ │ DOWNLOAD  ▶▶EXIT◀◀  │ │
│ └─────────────────────┘ │
└─────────────────────────┘
```
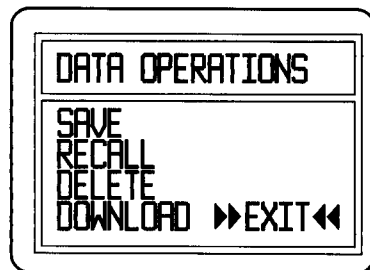
This display enables you to save measurements for later recall or download to your PC (HA-2000). The SAVE, RECALL and DELETE functions have access to 21 locations. However, each screen only holds 7 locations, so to view more you must select 'MORE' a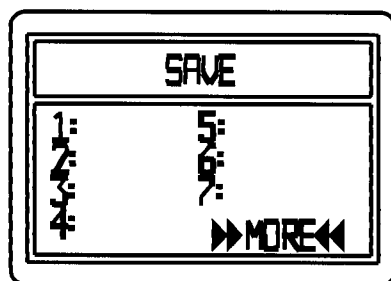t the bottom of the display. To exit these displays, you can either return directly to the Hook-Up Menu by pressing ◀ and ▶ simultaneously, or advance to the last screen by selecting 'MORE' and then selecting 'EXIT'. Select 'EXIT' again to return to the MAIN MENU.

## SAVE DISPLAY

```
┌─────────────────────────┐
│ ┌─────────────────────┐ │
│ │        SAVE         │ │
│ │ 1:          5:      │ │
│ │ 2:          6:      │ │
│ │ 3:          7:      │ │
│ │ 4:       ▶▶MORE◀◀   │ │
│ └─────────────────────┘ │
└─────────────────────────┘
```

Up to 21 waveforms can be saved in the *Harmonalyzer's* non-volatile memory.
The memory is powered by a seperate lithium cell that has an expected life of eleven years.
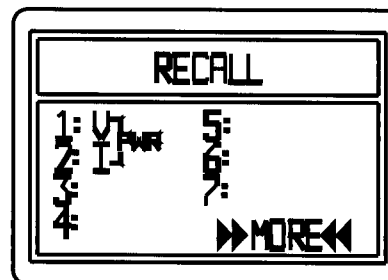
Select the next available memory location by using the ◀ or ▶ buttons and then pressing the ■ button. If saving a single waveform measurement a V or I will appear in that location. If saving a measurement of both voltage and current, a V will appear in that location, an I will appear in the next location and for the HA-2000, PWR will link the two locations. This is referred to as a 'Power Pair'.

In order for you to remember which measurement is in which location, we have provided a separate memory pad and pencil to record the specifics of each measurement.

NOTE: You cannot save a Power Pair in memory locations 7, 14 or 21. Also, you cannot save on top of another waveform, it must first be deleted. This feature keeps you from accidentally losing a measurement by recording over it.
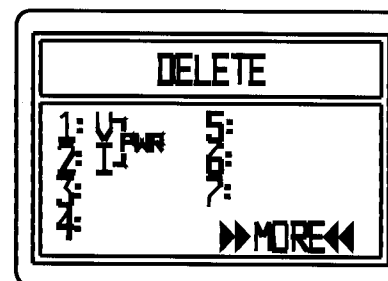
To return to the DATA OPERATIONS MENU advance the cursor to the last memory location screen and select 'EXIT'.

## RECALL DISPLAY

```
┌─────────────────────────┐
│ ┌─────────────────────┐ │
│ │       RECALL        │ │
│ │ 1: V PWR    5:      │ │
│ │ 2: I        6:      │ │
│ │ 3:          7:      │ │
│ │ 4:       ▶▶MORE◀◀   │ │
│ └─────────────────────┘ │
└─────────────────────────┘
```

Move cursor to the location desired and select it using the ■ button. To select a Power Pair, put cursor at either location. 'REPROCESSING' will appear at the top of the display. When the *Harmonalyzer* is done recalculating the data, the MAIN MENU will appear. You can exit the 'RECALL' display without selecting a waveform by proceeding to the last location and selecting 'EXIT'.

## DELETE DISPLAY

```
┌─────────────────────────┐
│ ┌─────────────────────┐ │
│ │       DELETE        │ │
│ │ 1: V PWR    5:      │ │
│ │ 2: I        6:      │ │
│ │ 3:          7:      │ │
│ │ 4:       ▶▶MORE◀◀   │ │
│ └─────────────────────┘ │
└─────────────────────────┘
```

Select the location you wish to delete and press ■ . The V or I

or Power Pair will vanish. Advance past the 21st memory location to EXIT and return to the Data Operations Menu.

## DOWNLOAD
**(HA-2000 only)**

Selecting DOWNLOAD will cause the H*armonalyzer* to prepare itself to transfer all 21 memory locations to your Personal Computer. 'DOWNLOAD WHEN READY' will be diplayed. Prior to this, however, you must connect the *Harmonalyzer* to your computer and load the *Harmona-Link™* software. Included in the HA-2000 kit is a data cord and a 3 1/2" floppy disk

.

The Data Cord (HADAPT) is three feet long, terminated at both ends with an RJ-11 plug and includes an RJ-11/DB-9 Adapter. Most computers have a nine pin (DB-9) serial communication port for data transfer. Plug the DB-9 connector into your DB-9 input port. Plug the other end of the cord into the *Harmonalyzer*. If you do not have a DB-9 input jack on your computer, please consult your computer vendor or an electronics store. (You may have to free up a port by unplugging your mouse or adapt up to a DB-25 jack).

The *Harmona-Link™* Version 1 software was written for MS-DOS 3.3 or greater. Load the disk into your computer, ' **type 'Install' <enter>, then CD/ WVM <enter>, then HA <enter>'**, and it will display a MAIN MENU. With your *Harmonalyzer* displaying 'DOWNLOAD WHEN READY', enter 'D' on your computer.The *Harmona-Link™* software communicates with the *Harmonalyzer* and transfers the contents of the memory bank. When your PC indicates that 'the download is complete' you may disconnect the *Harmonalyzer*. In addition to the information displayed on the *Harmonalyzer,* the *Harmona-Link™* software will also show you the odd and even harmonics to the 31$^{st}$.

The Crest factor (C$_f$): $\dfrac{\text{PEAK}}{\text{RMS}}$

the Form factor (F$_f$): $\dfrac{\text{RMS}}{\text{AVG}}$

and the K factor:

$$\frac{\sum\limits_{h=1}^{31} (h^2 \times (fh)^2)}{\sum\limits_{h=1}^{31} (fh)^2}$$

where fh is the % harmomics and h the harmonics number.

Please Note:
Proper interpretation of the data produced by the *Harmonalyzer* is essential for a correct diagnosis of the problem. For example, a high K-factor value does not necessarily require a transformer change. % loading, location of measurement, etc, will dictate whether action is required.

## EXAMPLE #1
## THREE-PHASE POWER MEASUREMENT - DELTA



**Figure 1**



**Figure 2**

Measurement Procedure:
#1a. Clamp the CT around the phase A conductor with the Amprobe logo facing the load.
 b. Attach the 'com' voltage lead to the 'B' lug.
 c. Attach the other ('hot') voltage lead to the 'A' lug. (See figure 1)
#2. Select both Current and Voltage from the *Harmonalizer's* Hook-up menu, take a measurement and store it in memory.
#3a. Clamp the CT around the phase C conductor with the Amprobe logo facing the load.
 b. Leave the 'com' voltage lead attached to the 'b' lug.
 c. Attach the other ('hot') voltage lead to the 'C' lug. (See Figure 2).
#4. Select both current and voltage from the Harmonalizer's Hook-up menu, take a measurement and store it in memory.
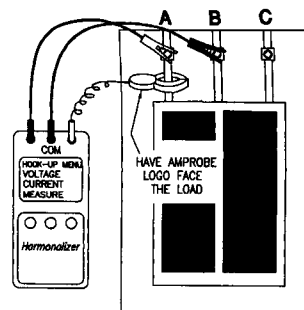
Calculations:
Total KW (working power) is the sum of the two KW values.

$$KW_{TOT} = KW_{A-B} + KW_{C-B}$$

Total KVA (apparent power) is the larger of the two KVA readings multiplied by 1.732.

$$KVA_{TOT} = maxKVAx\ 1.732$$

Power Factor is KW divided by KVA:

$$PF = \frac{KW_{TOT}}{KW_{TOT}}$$

Example:

| Phase A referenced to B | Phase C referenced to B |
|---|---|
| 69.13 KW | 51.42 KW |
| 16.73 KVAR LAG | 53.10 KVAR LAG |
| 71.90 KVA | 75.70 KVA |
| 0.96 PF | 0.67 PF |
| 0.97 dPF | 0.70 dPF |
| 10.52 KDVA | 16.32 KDVA |

$$KW_{TOT} = 69.13 + 51.42 = 120.55$$
$$KVA_{TOT} = 75.70 \times 1.732 = 131.12$$
$$PF = \frac{120.55}{131.12} = 0.92$$

## EXAMPLE #2
## THREE-PHASE POWER MEASUREMENT - WYE
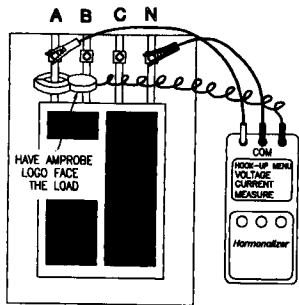


Measurement Procedure:

#1a. Clamp the CT around the phase A conductor with the Amprobe logo facing the load.

  b. Attach the 'com' voltage lead to the Neutral lug.

  c. Attach the other ('hot') voltage lead to the 'A' lug. (See figure at left)

#2. Select both Current and Voltage from the *Harmonalizer's* Hook-up menu, take a measurement and store it in memory.

#3. Repeat steps 1 and 2 for both the 'B' and 'C' phases, keeping the 'com' lead connected to the Neutral lug.

Calculations:

Total KW (working power) is the sum of the three KW values.

$$KW_{TOT} = KW_A + KW_B + KW_C$$

Total KVA (apparent power) is the sum of the three KVA readings:

$$KVA_{TOT} = KVA_A + KVA_B + KVA_C$$

Power Factor is KW divided by KVA:

$$PF = \frac{KW_{TOT}}{KVA_{TOT}}$$

Example:

| Phase A | Phase B | Phase C |
|---|---|---|
| 1200 W | 1500 W | 304 W |
| 146 VAR LAG | 217 VAR LAG | 98 VAR LAG |
| 1300 VA | 1500 VA | 320 VA |
| 0.90 PF | 0.99 PF | 0.95 PF |
| 0.98 dPF | 0.98 dPF | 0.95 dPF |
| 202 DVA | 215 DVA | 15 DVA |

$$KW_{TOT} = 1200 + 1500 + 304 = 3004$$

$$KVA_{TOT} = 1300 + 1500 + 320 = 3120$$

$$PF = \frac{3004}{3120} = 0.96$$

## EXAMPLE #3:

An electrical contractor was given the task of improving the power factor in a facility powered by a 2000 KVA, 13.8 KV/480V transformer. Using the *Harmonalyzer* HA-2000 at the secondary of the transformer, he measured the following:

| | | |
|---|---|---|
| Voltage THD | = | 4.0% |
| Current THD | = | 19.5% |
| I $^{3RD}$ | = | 1.1% |
| I $^{5TH}$ | = | 16.0% |
| I $^{7TH}$ | = | 2.9% |
| Working Power | = | 355 KW |
| True Power Factor (PF) | = | 0.53 |

The large percentage of fifth and seventh harmonics indicate a 6-pulse variable speed drive. It was determined by a filter manufacturer that a 600 KVA harmonic filter, tuned to the fifth harmonic, would not only improve the power factor to near unity, but would also reduce the distortion levels. After installation, the *Harmonalyzer* measured the following:

| | | |
|---|---|---|
| Voltage THD | = | 1.3% |
| Current THD | = | 11.4% |
| I $^{3RD}$ | = | 1.0% |
| I $^{5TH}$ | = | 4.8% |
| I $^{7TH}$ | = | 1.8% |
| Working Power | = | 325 KW |
| True Power Factor (PF) | = | 0.95 |

## EXAMPLE # 4:

The following pages are copies of the data from the *Harmona-Link* ™ software showing a measurement of both voltage and current. The following sample calculations employ the harmonic values from this data.

| | |
|---|---|
| **True RMS** | $= \sqrt{F^2 + h_2^2 + h_3^2 + h_4^2 + \ldots + h_{31}^2}$ |
| **Amps RMS** | $= \sqrt{(153.2)^2 + (0.9)^2 + (15.7)^2 + (0.8)^2 + (12.3)^2 + \ldots}$ |
| **Amps RMS** | $= 154.6$ |
| **Volts RMS** | $= \sqrt{(118.2)^2 + (0.4)^2 + (3.2)^2 + (0.2)^2 + \ldots}$ |
| **Volt RMS** | $= 118.3$ |
| **THD** | $= 100 \dfrac{\sqrt{h_2^2 + h_3^2 + h_4^2 + \ldots h_{31}^2}}{f}$ |
| **Amps THD** | $= 100 \dfrac{\sqrt{(0.9)^2 + (15.7)^2 + (0.8)^2 + \ldots}}{153.2}$ |
| **Amps THD** | $= 13.6\%$ |
| **Voltage THD** | $= 100 \dfrac{\sqrt{(0.4)^2 + (3.2)^2 + (0.2)^2 + \ldots}}{118.2}$ |
| **Voltage THD** | $= 3.9\%$ |

## Left panel (page 21)

AMPROBE PHASE A
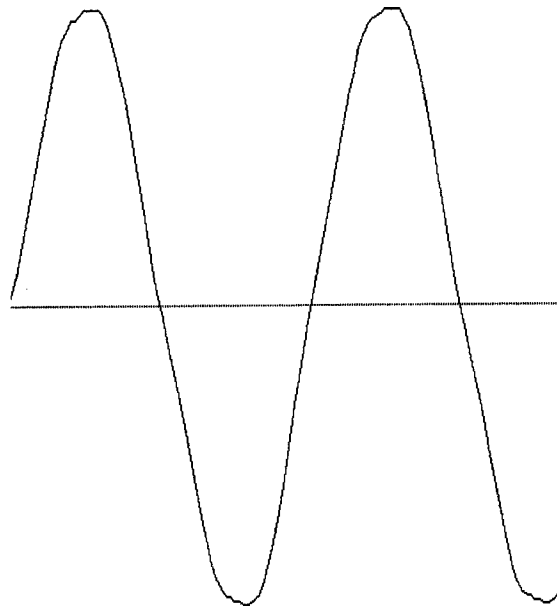
CIRCUIT
--------

165.2 Volts peak
118.3 Volts rms
105.5 Volts avg
  1.7 Volts dc

1.40 Crest factor
1.12 Form factor

```
POWER DATA
------------
Power data is
located in the
related I file
```

60.00 Hz (fund)

File  VR3

Date  04-14-94

| H | % | Vrms | H | % | Vrms |
|---|-----|-----|----|-----|-----|
| 2 | 0.4 | 0.4 | 3 | 2.7 | 3.2 |
| 4 | 0.1 | 0.2 | 5 | 2.6 | 3.0 |
| 6 | 0.3 | 0.3 | 7 | 0.7 | 0.8 |
| 8 | 0.2 | 0.3 | 9 | 0.4 | 0.5 |
| 10 | 0.1 | 0.1 | 11 | 0.0 | 0.0 |
| 12 | 0.1 | 0.1 | 13 | 0.2 | 0.3 |
| 14 | 0.1 | 0.2 | 15 | 0.3 | 0.3 |
| 16 | 0.1 | 0.1 | 17 | 0.2 | 0.2 |
| 18 | 0.2 | 0.2 | 19 | 0.2 | 0.2 |
| 20 | 0.2 | 0.2 | 21 | 0.1 | 0.1 |
| 22 | 0.2 | 0.2 | 23 | 0.2 | 0.3 |
| 24 | 0.0 | 0.0 | 25 | 0.1 | 0.1 |
| 26 | 0.2 | 0.3 | 27 | 0.2 | 0.2 |
| 28 | 0.2 | 0.2 | 29 | 0.2 | 0.2 |
| 30 | 0.1 | 0.1 | 31 | 0.2 | 0.2 |

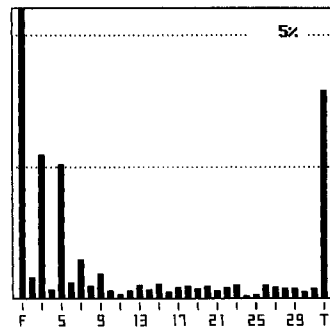| Even | 0.7 | 0.9 | Odd | 3.9 | 4.6 |
|------|-----|-----|-----|-----|-----|
|      |     |     | Triplen | 2.8 | 3.3 |

Total Harmonic Distortion  3.9  4.7

AMPROBE PHASE A

File  VR3          Date  04-14-94

Fundamental  118.2 Volts rms
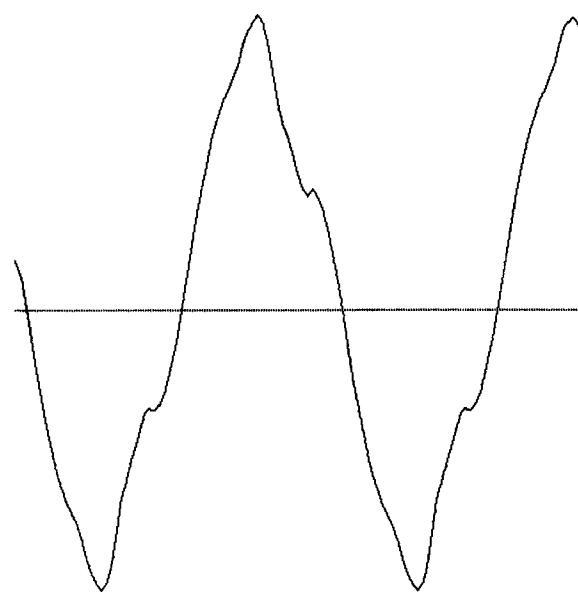
Harmonic       4.7 Volts rms

Total        118.3 Volts rms

DC Component   1.7 Volts

Transformer K factor    1.1

## Right panel (page 22)

AMPROBE PHASE A

CIRCUIT
--------

249.7 Amps peak
154.6 Amps rms
137.6 Amps avg
  6.3 Amps dc

1.61 Crest factor
1.12 Form factor

```
POWER DATA
------------
18033.2 W
  2.1 kVAR Lead
 18.4 kVA
 .993 Disp PF
 .982 True PF
  2.7 Dist kVA
```

60.00 Hz (fund)

File  AR4

Date  04-14-94

| H | % | Arms | H | % | Arms |
|----|-----|-----|----|------|------|
| 2 | 0.6 | 0.9 | 3 | 10.2 | 15.7 |
| 4 | 0.5 | 0.8 | 5 | 8.0 | 12.3 |
| 6 | 0.9 | 1.4 | 7 | 1.9 | 2.9 |
| 8 | 0.6 | 0.9 | 9 | 0.9 | 1.4 |
| 10 | 0.6 | 1.0 | 11 | 1.3 | 1.9 |
| 12 | 0.7 | 1.1 | 13 | 1.6 | 2.4 |
| 14 | 0.5 | 0.8 | 15 | 0.6 | 0.9 |
| 16 | 0.6 | 0.9 | 17 | 0.5 | 0.8 |
| 18 | 0.5 | 0.7 | 19 | 0.3 | 0.5 |
| 20 | 0.5 | 0.8 | 21 | 0.5 | 0.8 |
| 22 | 0.5 | 0.8 | 23 | 0.4 | 0.5 |
| 24 | 0.3 | 0.5 | 25 | 0.6 | 0.9 |
| 26 | 0.4 | 0.7 | 27 | 0.4 | 0.5 |
| 28 | 0.6 | 0.9 | 29 | 0.5 | 0.8 |
| 30 | 0.4 | 0.7 | 31 | 0.5 | 0.8 |

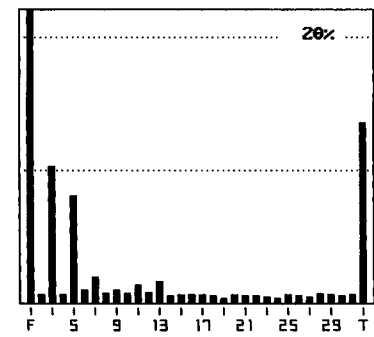| Even | 2.2 | 3.4 | Odd | 13.4 | 20.5 |
|------|-----|-----|-----|------|------|
|      |     |     | Triplen | 10.4 | 15.9 |

Total Harmonic Distortion  13.6  20.8

AMPROBE PHASE A

File  AR4          Date  04-14-94

Fundamental  153.2 Amps rms

Harmonic      20.8 Amps rms

Total        154.6 Amps rms

DC Component   6.3 Amps

Transformer K factor    1.6

# SPECIFICATIONS

## RANGES

**Voltage**     1-600    Vrms AC/DC
               1000     Volts peak

**Current**     1-1000   Amps rms AC

**Power**     0-600    Kilowatts (HA-2000 only)

**Frequency**   40-65    Hz
**readout**

## HARMONICS

**HA-1000**     First 19 odd harmonics plus THD

**HA-2000**     First 19 odd harmonics plus THD
displayed on unit; first 31 harmonics
plus THD when downloaded to your
PC using the *Harmona-Link™* software

## ACCURACIES

**True RMS**    Voltage    ±2% of reading
               Current    ±2% of reading
                            (without current transducer)

**Harmonics**   Voltage    ±2% +6 LSD *
**%**           Current    ±2% +6 LSD *
               THD (>1%)   ±1% of reading +3 LSD *
                     * when fundamental (f) is 60Hz ±0.1 Hz

**Power**     Watts, VA, VARs, ±2% of reading
           PF, dPF        ±0.01

**Frequency**   ±0.1 Hz

**Memory**    21 non-volatile, user-addressable, protected
locations. Powered by non-user-serviceable
lithium cell with an expected life of eleven years.

**Download**    EIA-232-E (RS-232) Interface via RJ-11
**(HA-2000 only)**   telephone jack. Optically isolated, 9.6K baud rate
*Harmona-Link™* software: 3 1/2" floppy disk,
MS-DOS® 3.3 or greater, 640 KB required.
Provides full harmonic analysis
(to 31st) along with crest factor, form factor,
K factor and power data.

## DISPLAY

Super twisted liquid crystal with adjustable contrast.
Backlight (HA-2000 only)

## GENERAL

Auto-Off
Auto Ranging
Unit size: 8.62" x 3.50" x 1.76" (219x89x50mm)
Unit weight: 1.22 lbs (0.55 kg)
Case size: 11" x 15 1/2" x 4" (394 x 279 x 102mm)
Weight of HA-2000 kit: 4.56 lbs (2.069 kg)
Operating Conditions: 32° to 122° F (0° to 50° C)RH < 85%
Storage Conditions: -4° to 140° F (-2° to 60° C)RH < 90%
Battery: Six alkaline 'AA' cells, ANSI/NEDA 15A, IEC-LR6
Life: 24 hrs continuous with backlight off
        8 hrs continuous with backlight on
Instrument case material: Flame retardant ABS911
Case Breakdown Voltage - 3000V
Insulation Coordination: Installation Category III, Polution Degree 2.

## ACCESSORIES

Current Transducer .............. # HACT-1 & HACT-2
Range .....................................1-1000A
Frequency ............................. 20-2000Hz
Output .....................................1mV AC per 1 Amp AC
Accuracy   ............................... ±1% of reading
Case breakdown voltage ..... 3000V
Jaw capacity .......................... 2 " dia. or 2000 MCM
Output leads .......................... 3.5 mm phono jacks
Voltage Leads ....................... HAVL-2

## Catalog # HA-1000 includes:

HA-1000 *Harmonalyzer™*, MTL-15 voltage leads,
HACT-1 Current transducer, HA3R Memory pad & pencil
and HACC carrying case.

## Catalog # HA-2000 includes:

HA-2000 *Harmonalyzer™*, HAVL-2 voltage leads,
HACT-2 Current transducer, HADAPT Data cord,
*Harmona-Link™* software (HADISC)
HA3R Memory pad & pencil and HACC carrying case.