Harmonic Characteristic for Household Load

Panida Boonyaritdachochai

The 12th PQSynergy
International Conference and Exhibition
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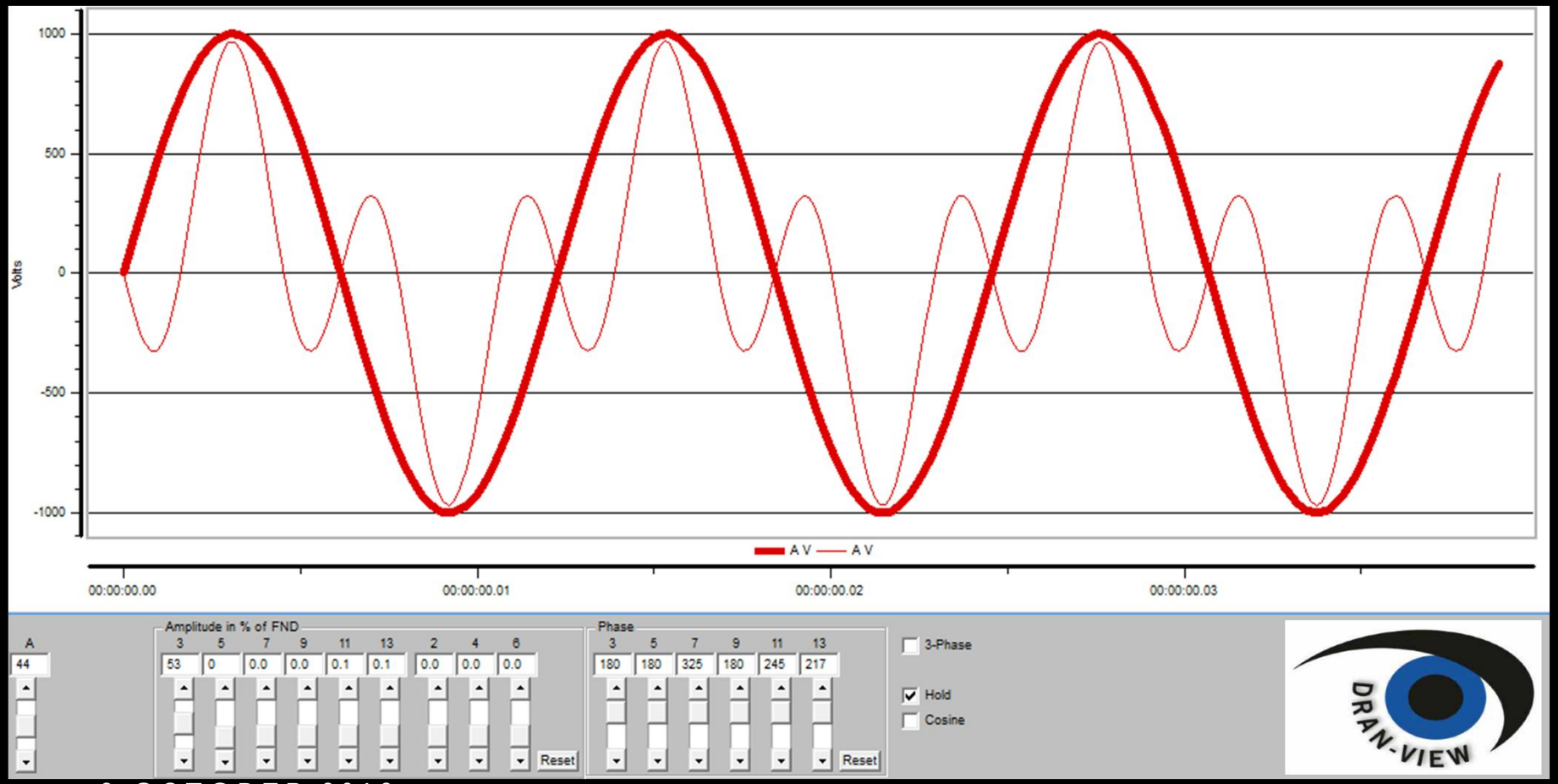
Overview

- Electrical equipment Evaluated in household
- Current waveform distortion for each individual equipment
- Energy Usage
- Detrimental effect on the equipment of utility and end-user
- Standards for Harmonic

Electronic Equipment in Household

Definition of Harmonic

- **Harmonic is the measure of waveform distortion.**

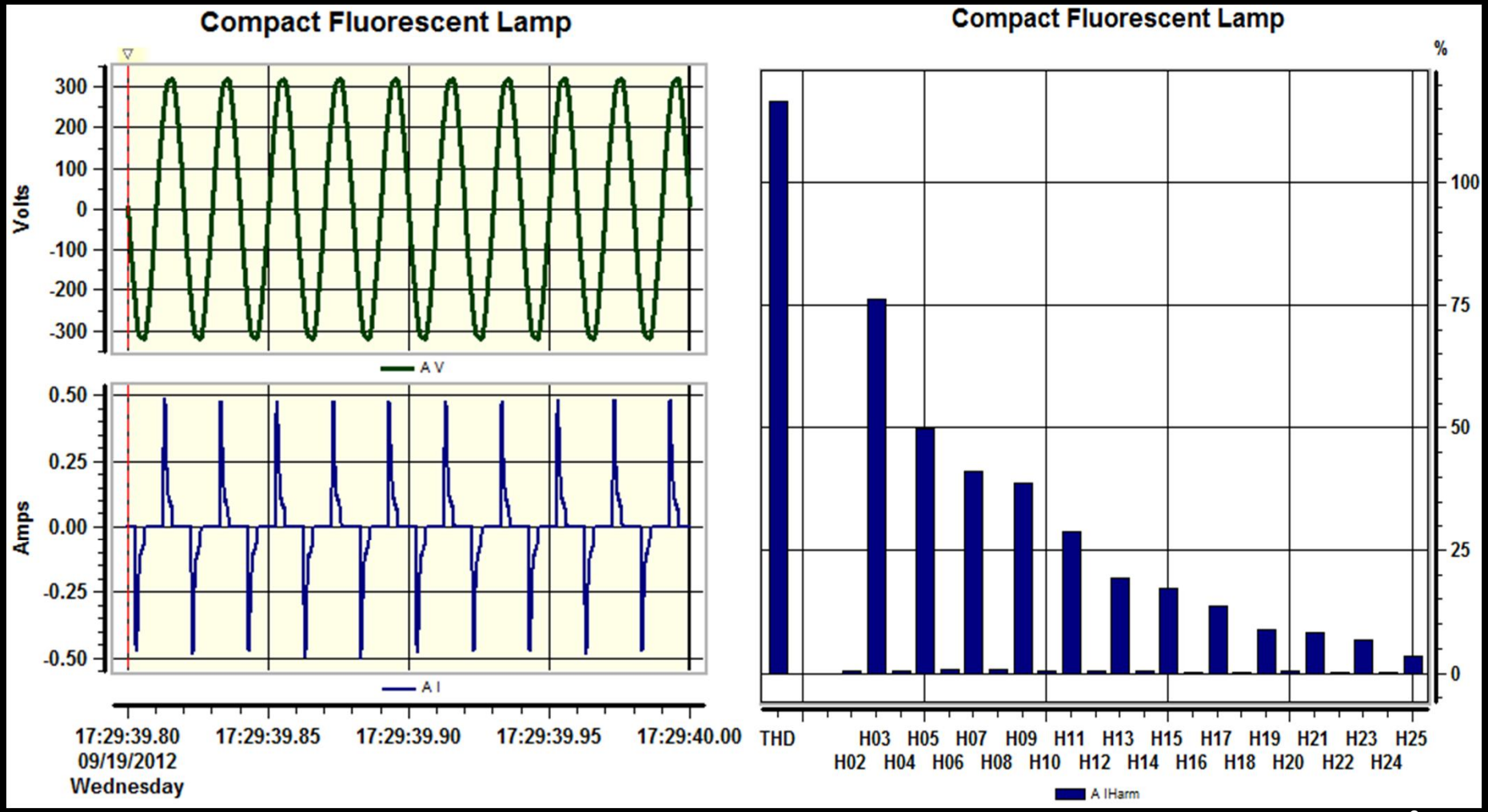


Measurement by EP1

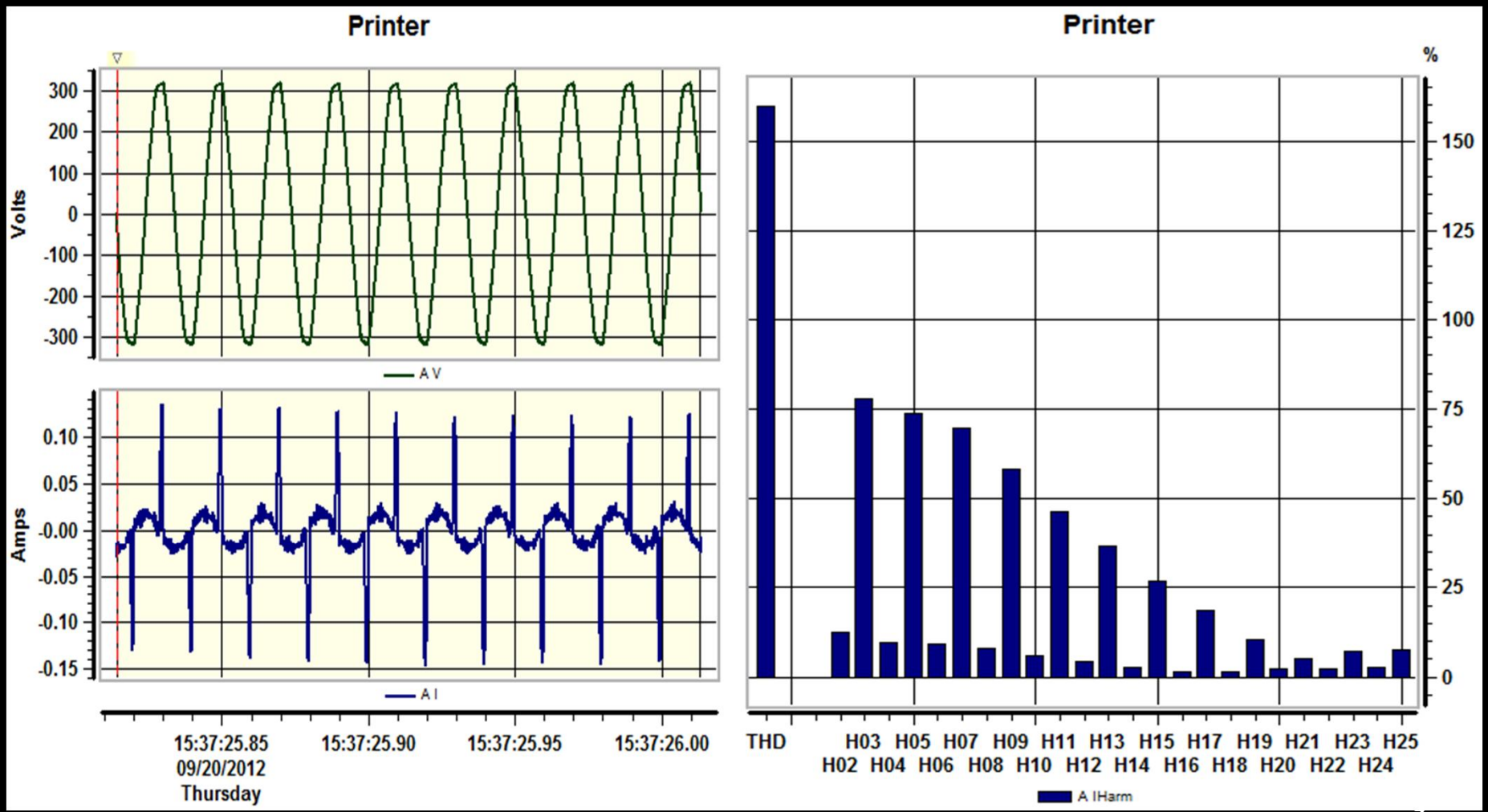
TR2510

Current Separator

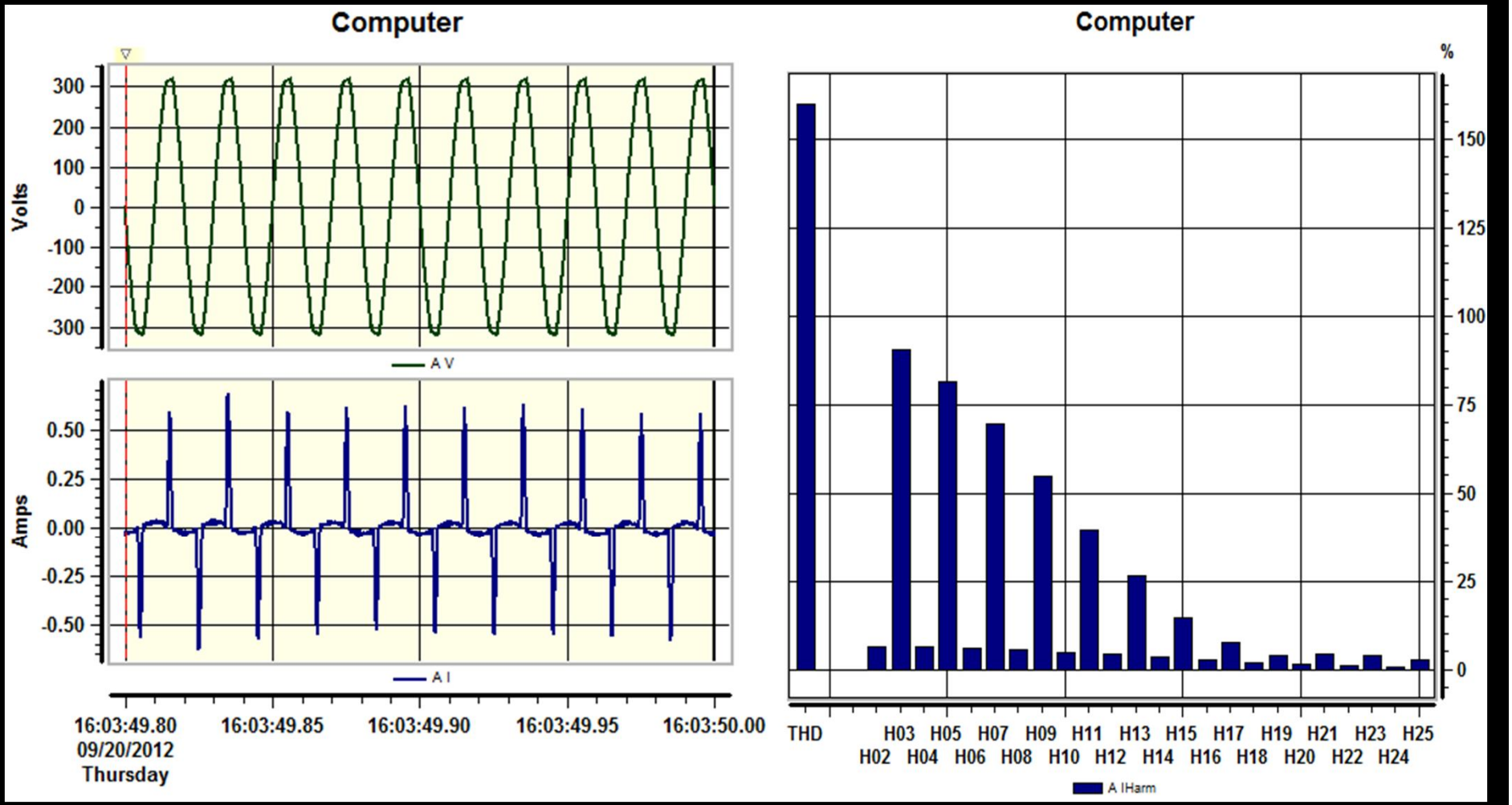
Compact Fluorescent



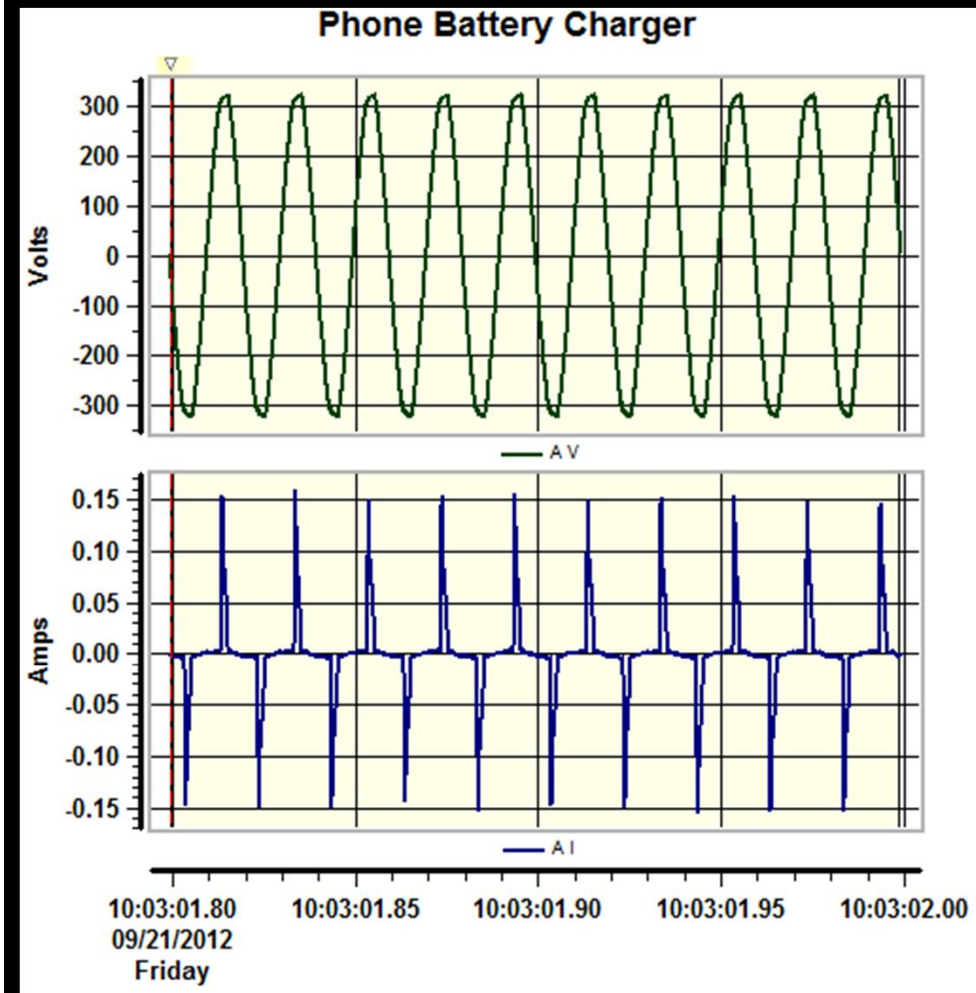
Printer

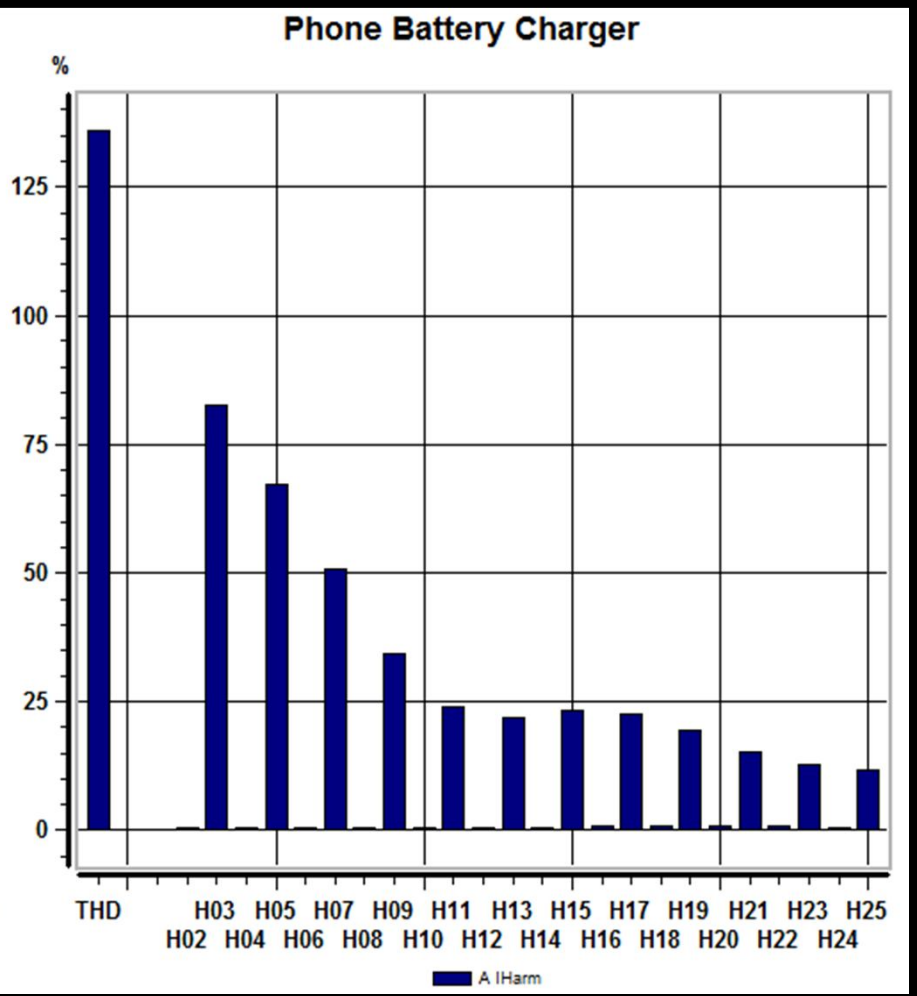

Printer
Volts
300
200
100
0
-100
-200
-300
A V
Amps
0.10
0.05
-0.00
-0.05
-0.10
-0.15
A I
15:37:25.85
09/20/2012
Thursday
15:37:25.90
15:37:25.95
15:37:26.00
Printer
%
150
125
100
75
50
25
0
THD
H02 H03 H04 H05 H06 H07 H08 H09 H10 H11 H12 H13 H14 H15 H16 H17 H18 H19 H20 H21 H22 H23 H24 H25
A IHarm

Notebook

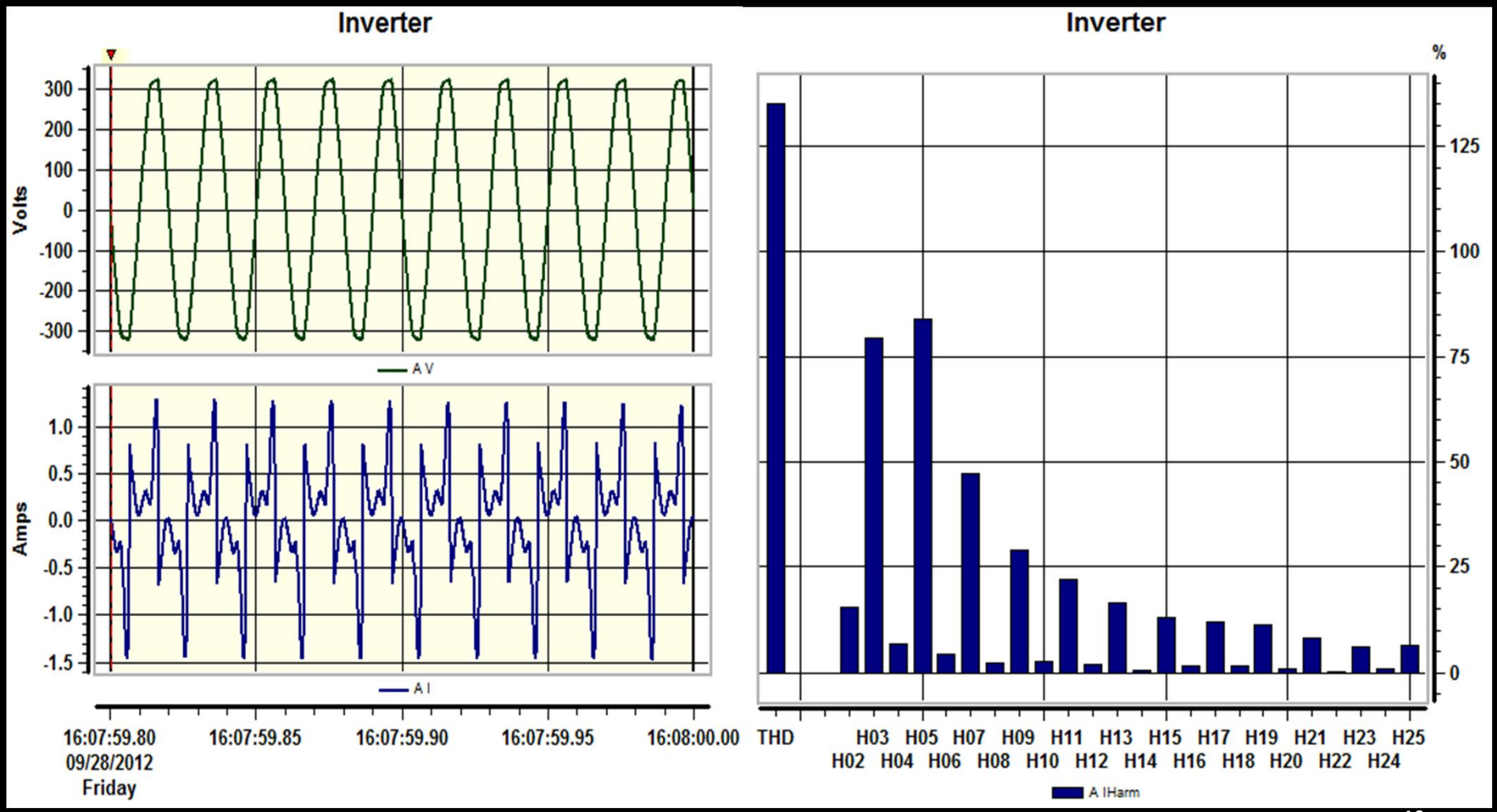

Computer
Volts
300
200
100
0
-100
-200
-300
AV
Amps
0.50
0.25
0.00
-0.25
-0.50
AI
16:03:49.80
09/20/2012
Thursday
16:03:49.85
16:03:49.90
16:03:49.95
16:03:50.00
Computer
%
150
125
100
75
50
25
0
THD
H02 H03 H04 H05 H06 H07 H08 H09 H10 H11 H12 H13 H14 H15 H16 H17 H18 H19 H20 H21 H22 H23 H24 H25
AIHarm

Phone Battery Charger

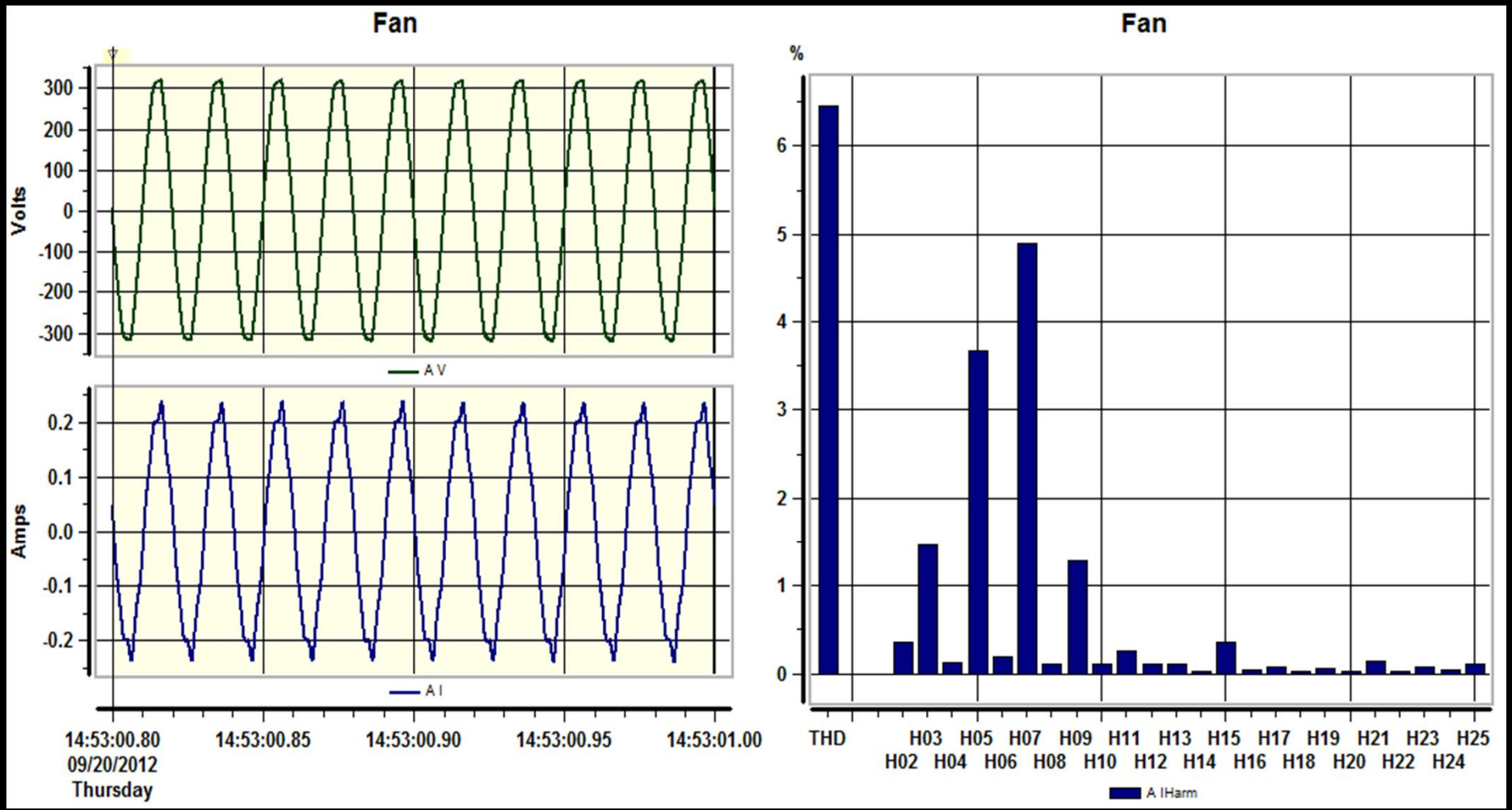




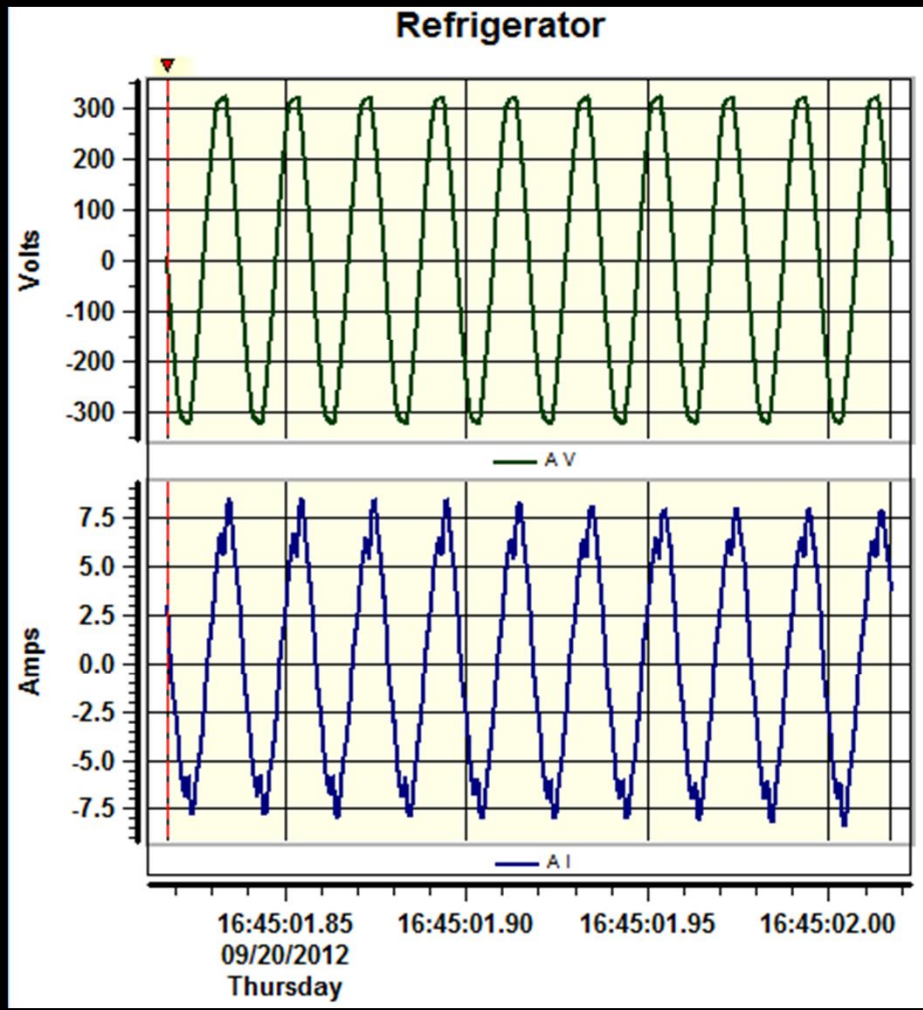
UPS Input

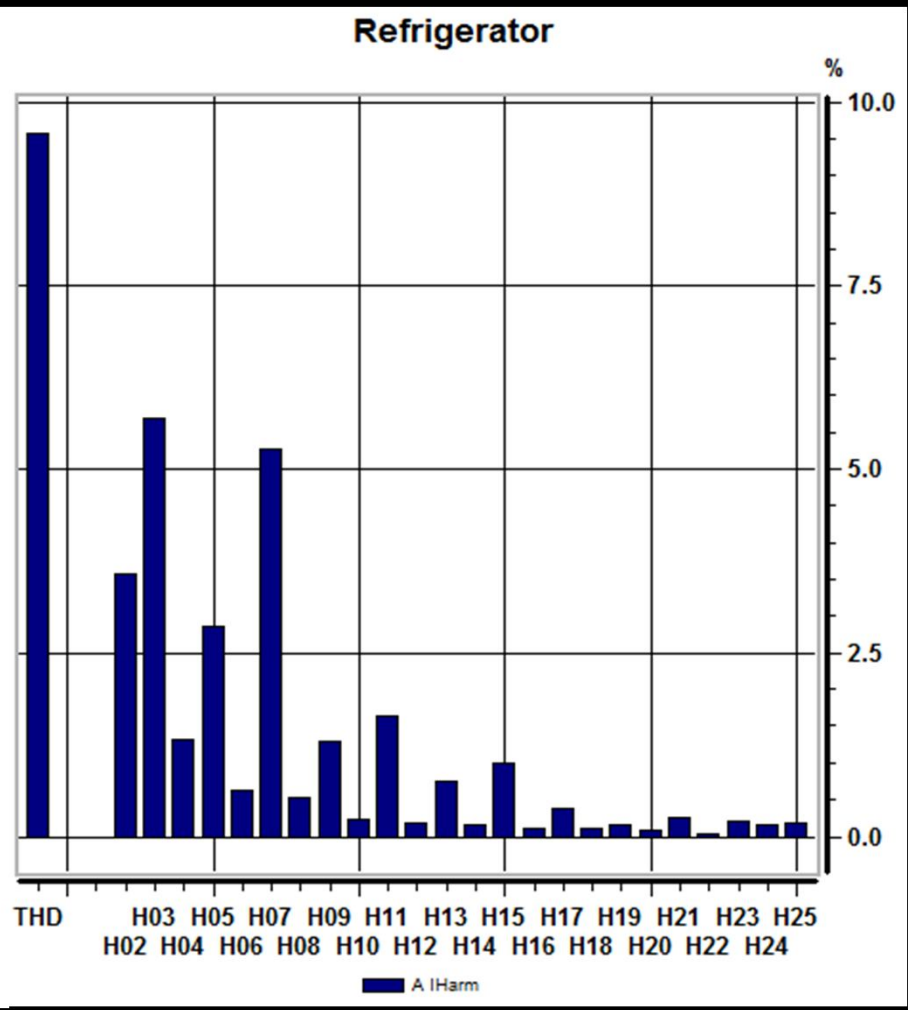

Inverter
Volts
300
200
100
0
-100
-200
-300
A V
Amps
1.0
0.5
0.0
-0.5
-1.0
-1.5
A I
16:07:59.80
09/28/2012
Friday
16:07:59.85
16:07:59.90
16:07:59.95
16:08:00.00
Inverter
%
125
100
75
50
25
0
THD
H02 H03 H04 H05 H06 H07 H08 H09 H10 H11 H12 H13 H14 H15 H16 H17 H18 H19 H20 H21 H22 H23 H24 H25
A IHarm

Fan

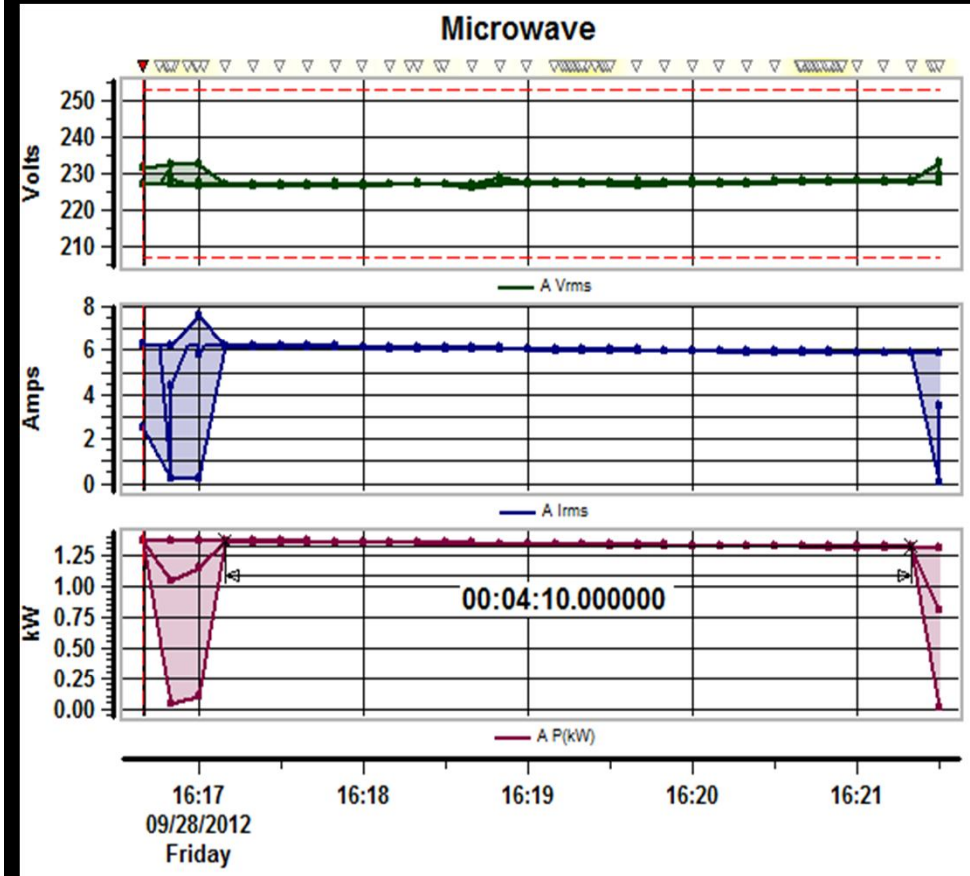

Fan
Volts
300
200
100
0
-100
-200
-300
AV
Amps
0.2
0.1
0.0
-0.1
-0.2
AI
14:53:00.80
09/20/2012
Thursday
14:53:00.85
14:53:00.90
14:53:00.95
14:53:01.00
Fan
%
6
5
4
3
2
1
0
THD
H02
H03
H04
H05
H06
H07
H08
H09
H10
H11
H12
H13
H14
H15
H16
H17
H18
H19
H20
H21
H22
H23
H24
H25
AIHarm

Refrigerator

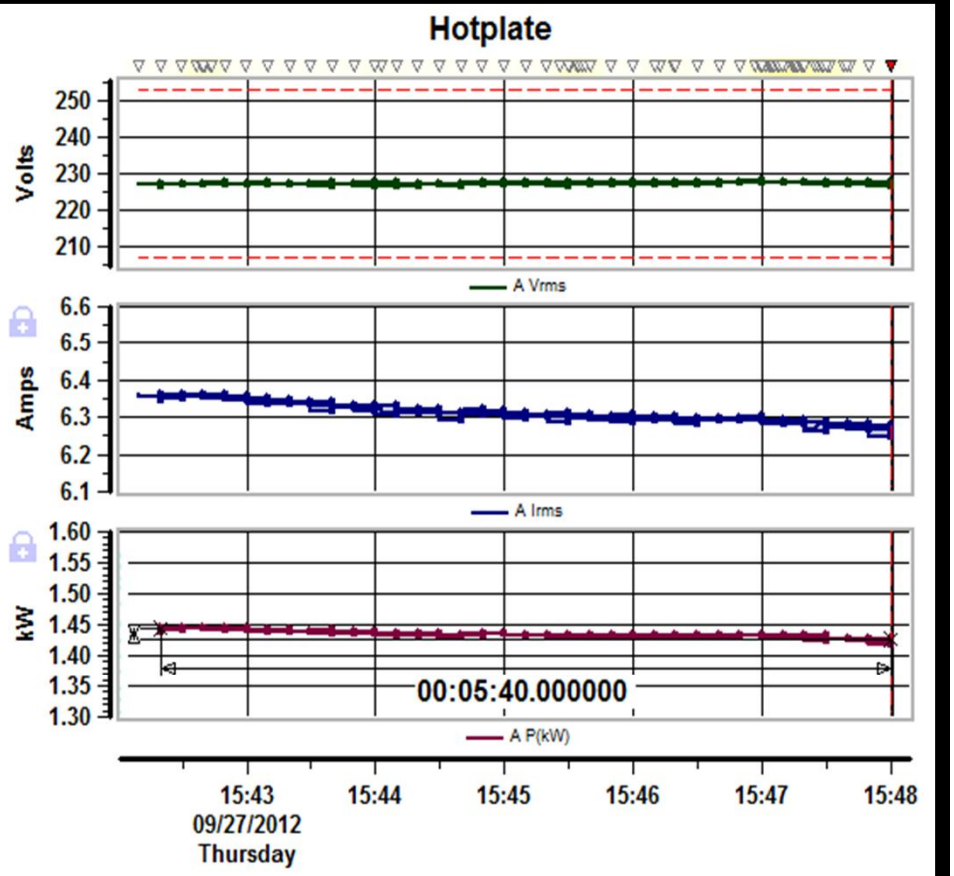




Energy Usage



	Avg
AVrms	227.3
AIrms	5.963
AP(kW)	1.319



	Avg
AVrms	227.2
AIrms	6.313
AP(kW)	1.434

Energy Usage

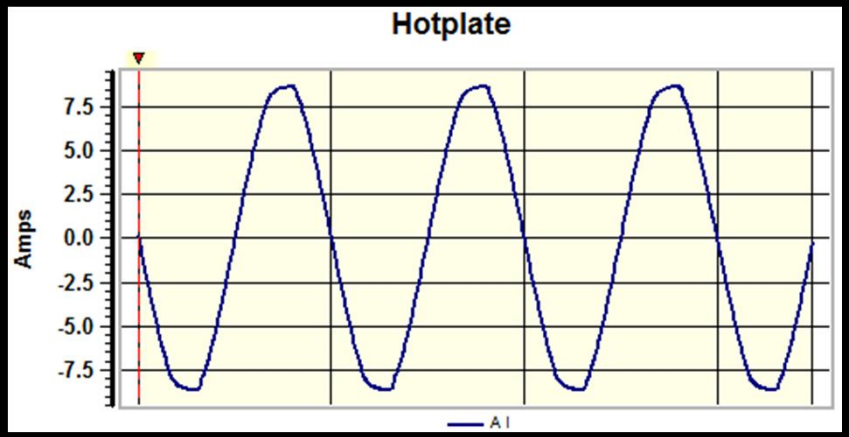
	Microwave	Hotplate
Power (kW)	1.319	1.434
Boiling Time (minutes)	4.20	5.40
Consumption (kWhr)	0.090	0.129
Electricity Cost ($ Cents)	1.442	2.065

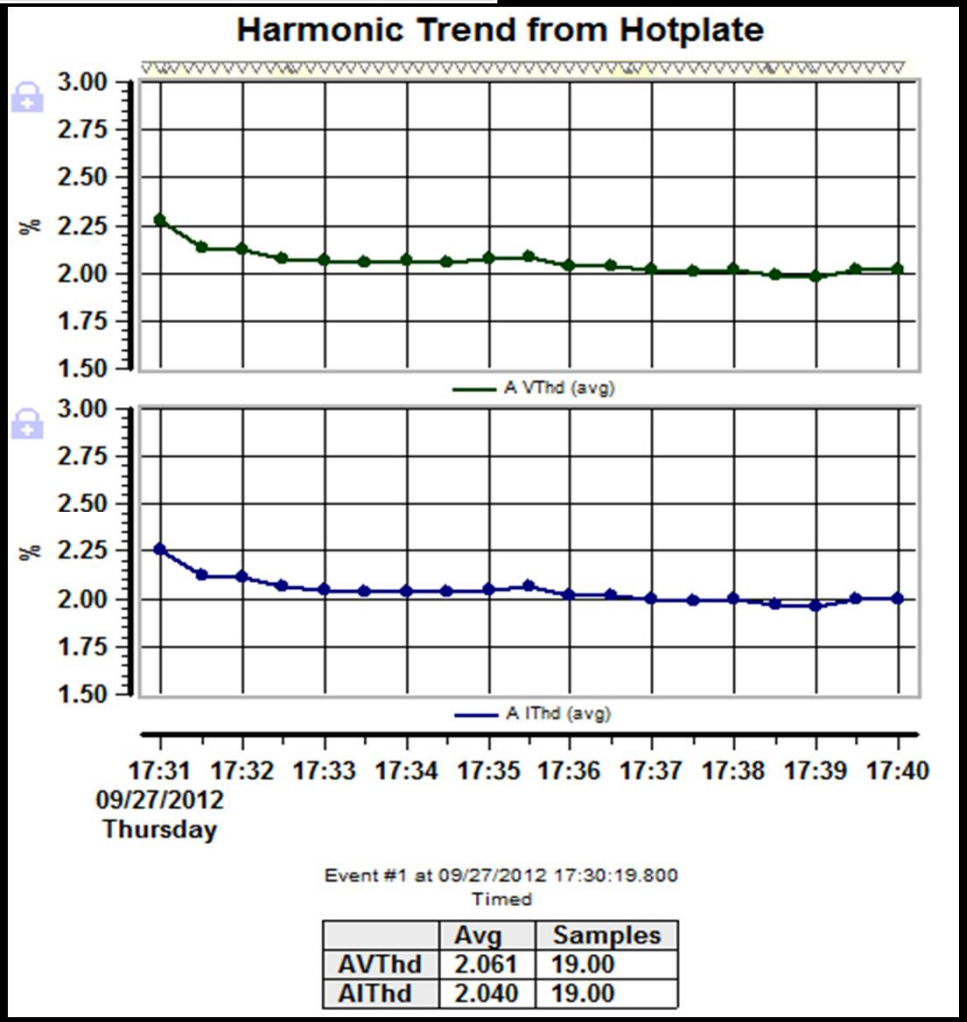
Save $$$ 0.62

- **Boil water 500 ml for 100 ˚C**
- **Water container is not controlled.**
- **Electricity cost is average cost about 16 $ cents / kWhr.**

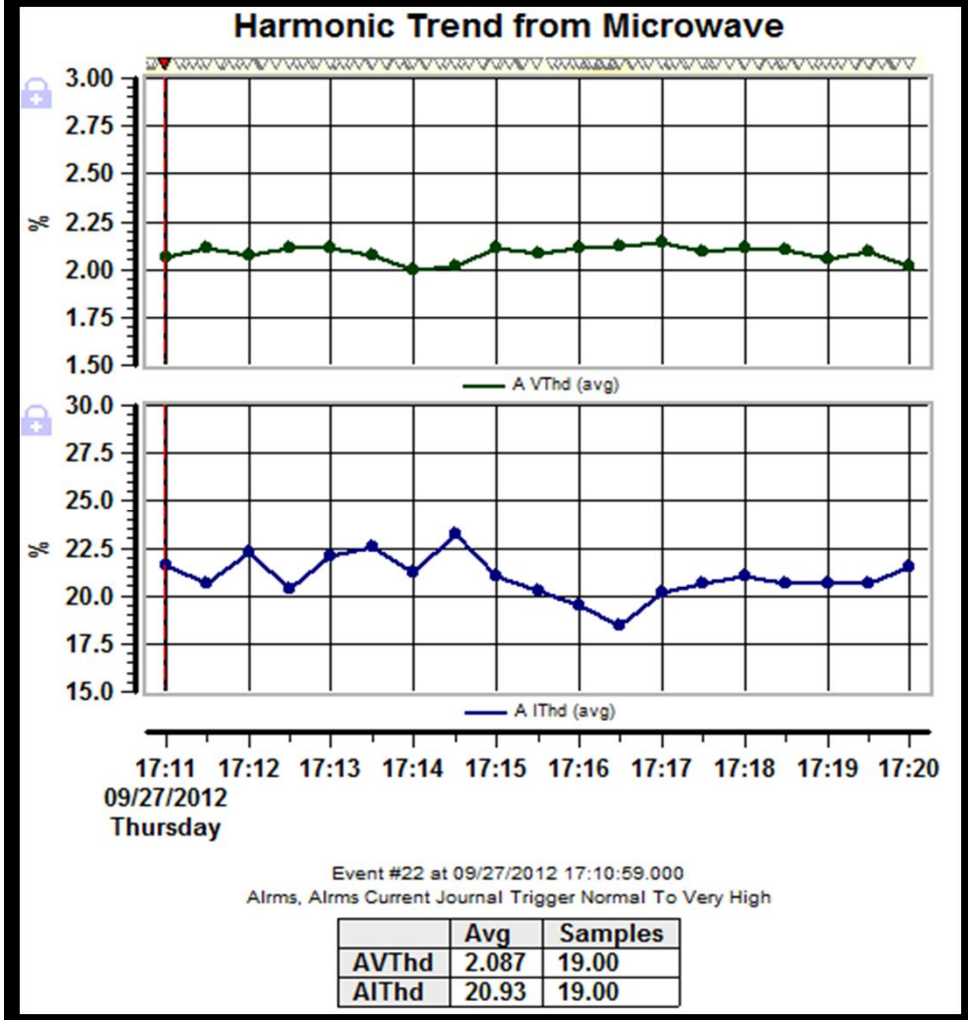
Harmonic Trend

- Voltage distortion does not change and has corresponding graph with current distortion because of iTHD is only 2% of FND.
- vTHD has value about 2% of FND because harmonic from electrical system.



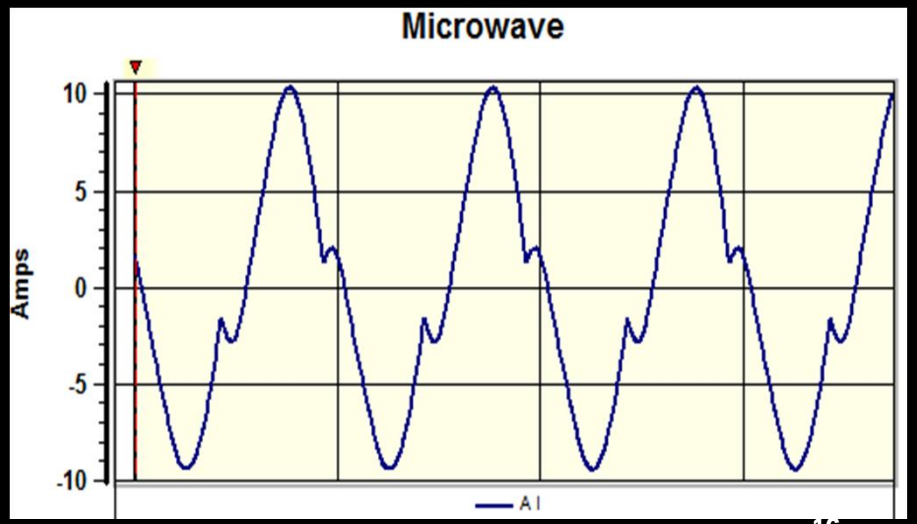


Discussion



	Avg	Samples
AVThd	2.087	19.00
AIThd	20.93	19.00

- vTHD is about 2% of FND while iTHD is 21% of FND.
- Voltage measure from transformer which connect with an unknown load.



Detrimental Effect on the equipment

- **Capacitors –** heating and dielectric stress, fuse failure, failure operation, explosion due to impedance reduced with higher frequency.
- **Motor** - heating, mechanical vibration and noise
- **Transformer –** Higher frequency harmonic currents cause increased core loss due to eddy currents and hysteresis, resulting in more heating than would occur at fundamental.
- **Relays** – incorrect tripping, different impedance than the setting.
- **Circuit Breaker –** failure to interrupt currents, breaker failure, the peak sensing of the harmonic current is usually higher than normal.
- **Communication system –** noise in telephone system

IEEE 519-1992

- IEEE adopted standard for harmonics in 1992. It is referred to as "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems"

- IEEE519 sets limits on Total Harmonic Distortion (THD) for the utility side of the meter and Total Demand Distortion (TDD) for the end-user side of the meter.

IEC61000-4-7

- Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected.

- This part of IEC 61000 is applicable to instrumentation intended for measuring spectral components in the frequency range up to 9 kHz which are superimposed on the fundamental of the power supply systems at 50 Hz and 60 Hz.

Conclusions

- Household single phase non linear load generate harmonic current because of switching load, electronic ballast, UPS.
- As large quantity of using harmonic generating load, this effect on equipment in power system i.e. transformer, motor, capacitors etc.
- The IEEE 519, IEC61000-4-7 standards are recommended limits for harmonics in power system.

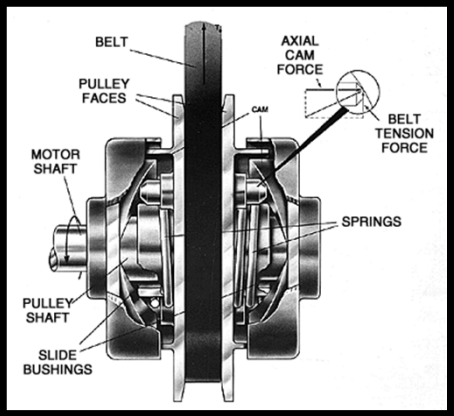
!! Questions !!

Power Quality (Thailand) Co., Ltd.

panidab@powerquality.co.th

Cause of Harmonic

- Harmonics add to the fundamental frequency (50 Hz) for voltage and current and distort as 2, 3, 4, … times of 50 Hz.



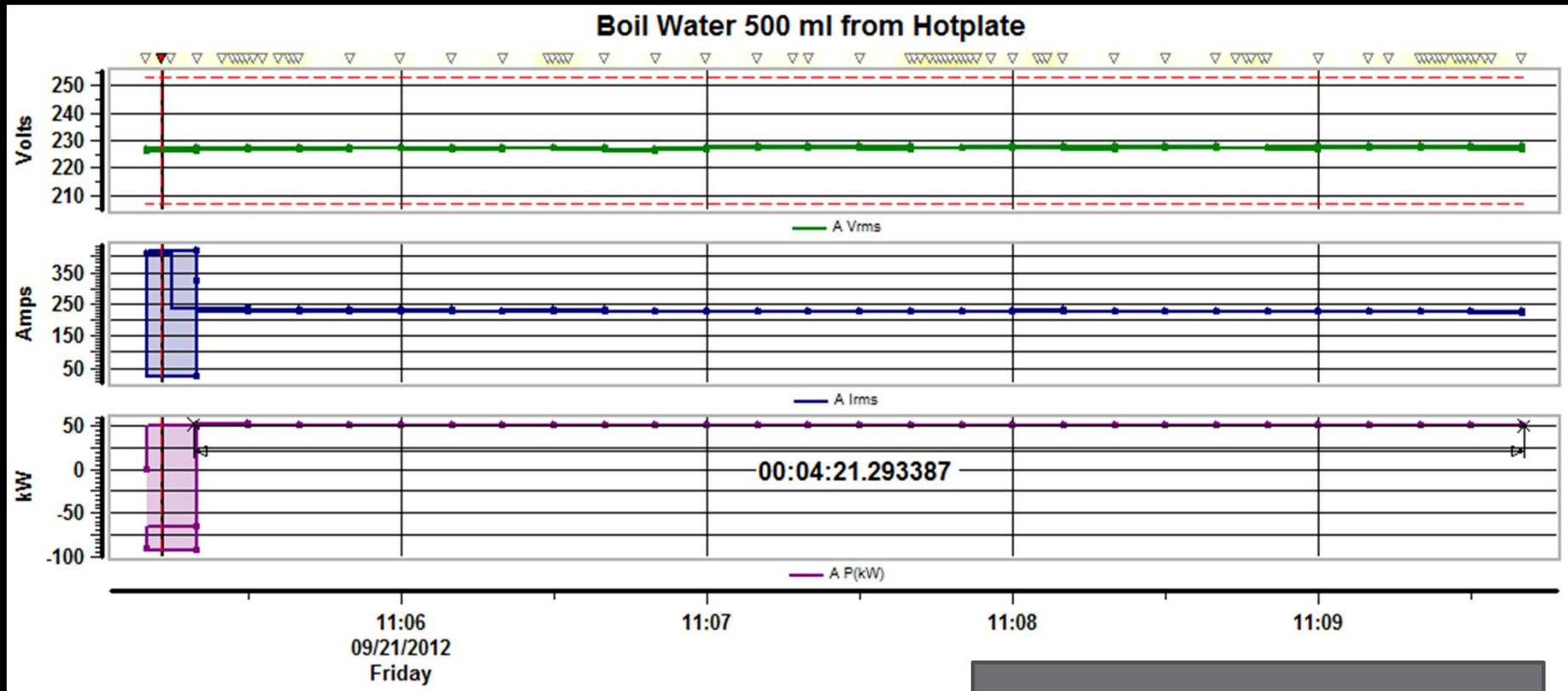
- Usually caused by non-linear loads
  - adjustable speed drive
  - solid state heating control
  - electronic ballasts for fluorescent lighting
  - switched-mode power supply in computer
  - rectifiers
  - electronic office machines

Eliminated Harmonics

- Most common solution is to use “harmonic filter” containing inductors and capacitors to pass the high frequency current to ground.
- Design Equipment to withstand the heating effects of harmonic, design K-factor for TR.
- Properly design and specify equipment that is the source of harmonics or the cause of amplifying harmonics.

2 OCTOBER 2012

Energy Consumption VS Harmonic Emission

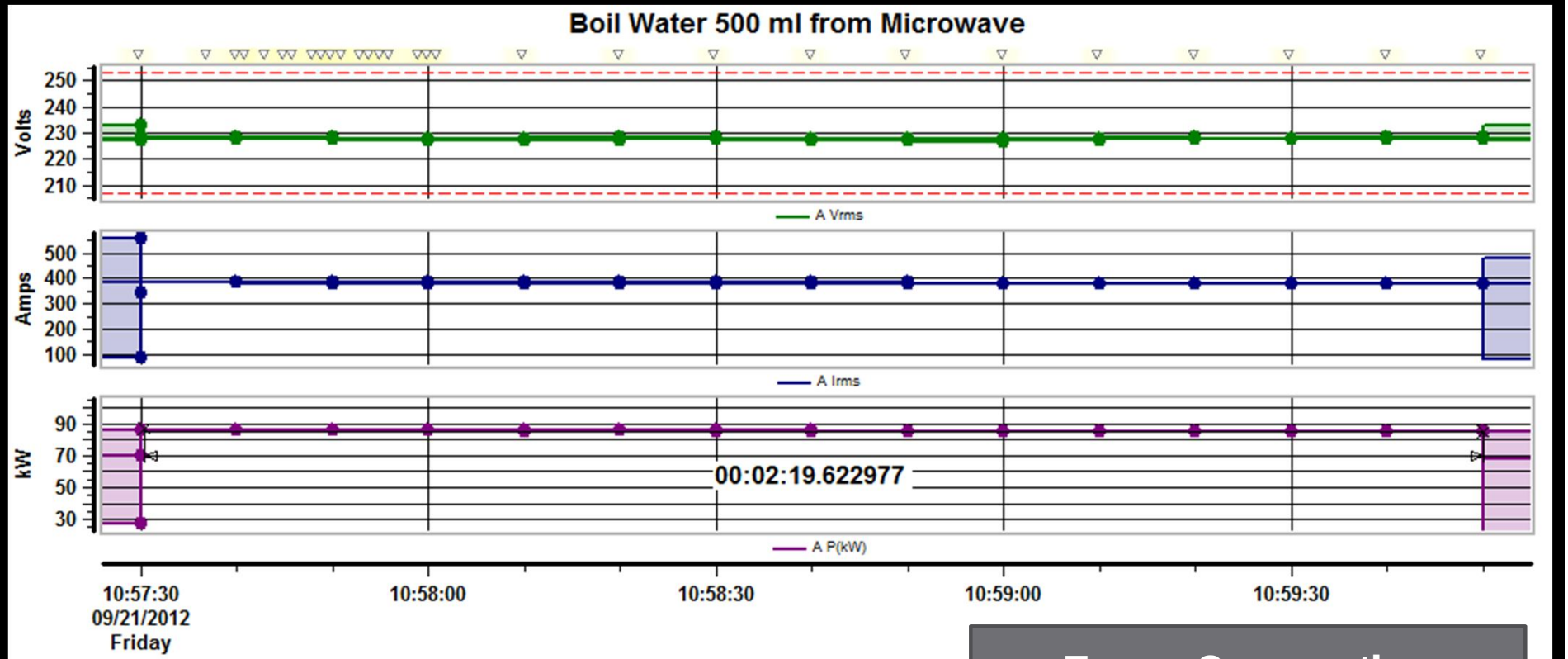


Event #2 at 09/21/2012 11:05:12.800
Snapshot

	Avg
AVrms	227.5
AIrms	321.8
AP(kW)	51.12

Energy Consumption:
(51.12 kW)*(4.21/60 hr)
= 3.587 kWhr

Energy Consumption VS Harmonic Emission



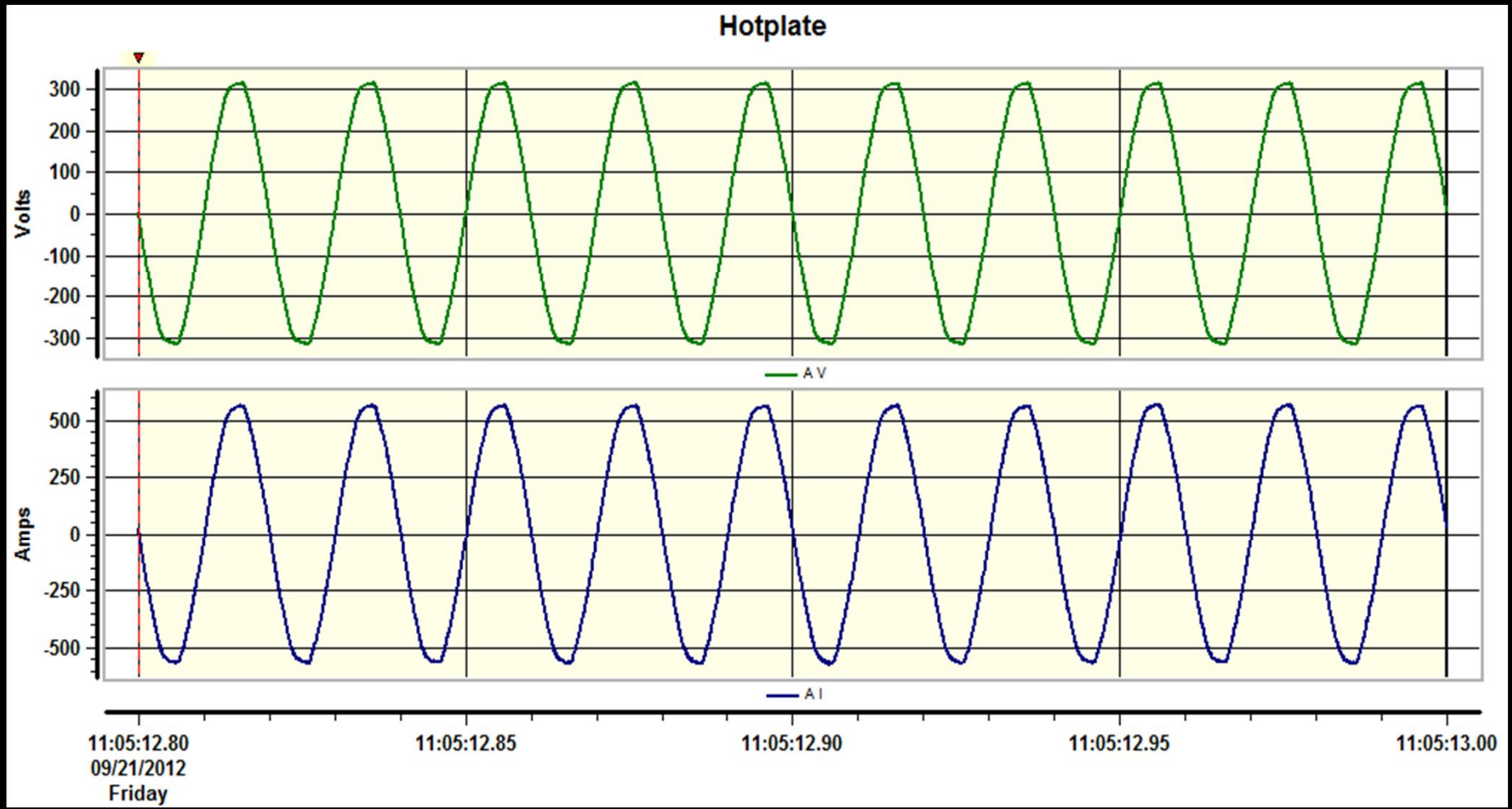
Event #42 at 09/21/2012 11:01:09.800
Timed

	Avg
AVrms	227.7
AIrms	378.8
AP(kW)	84.35

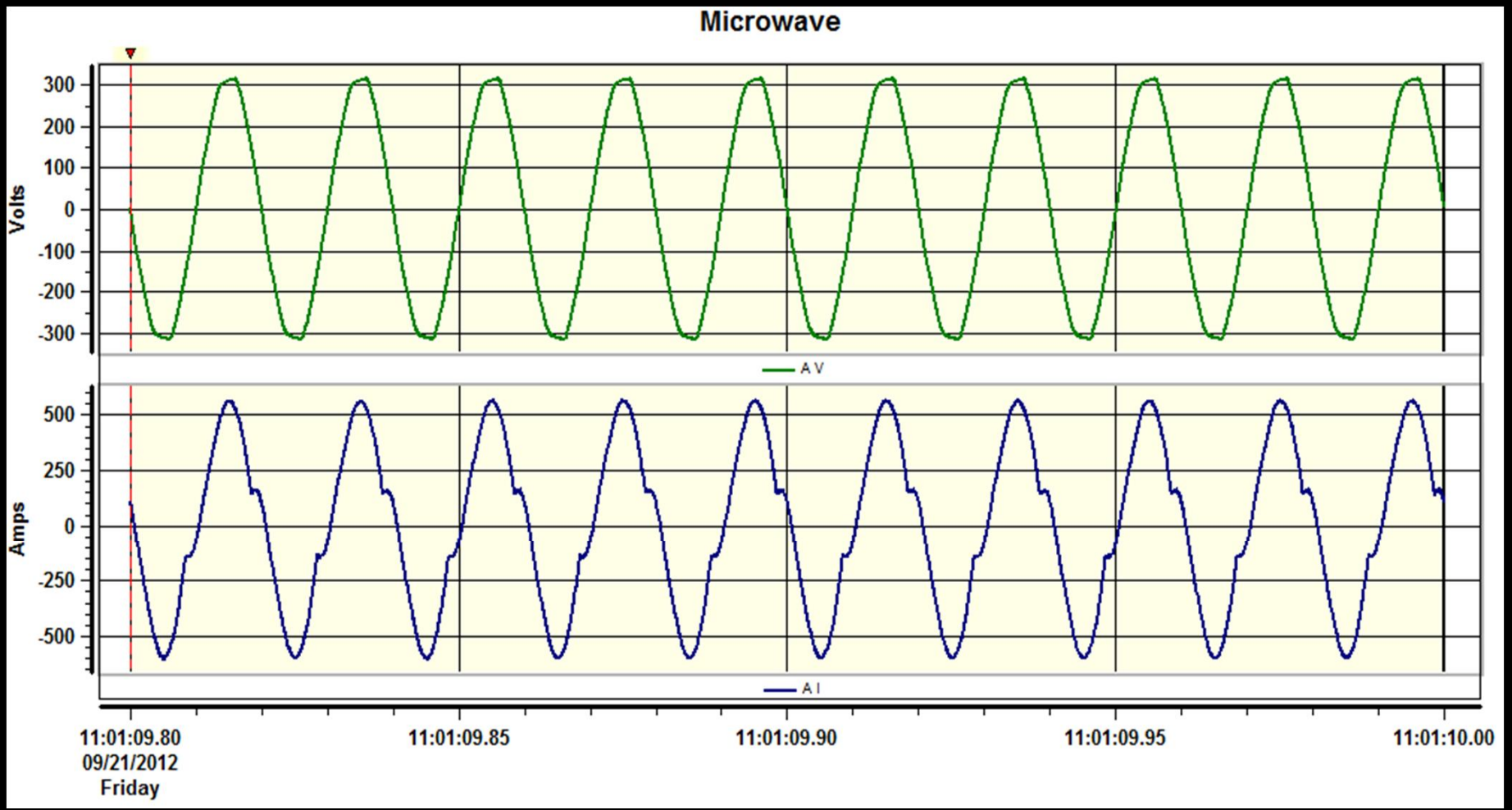
Energy Consumption:
(84.35 kW)*(2.19/60 hr)
= 3.079 kWhr

Hotplate


OSTOMI

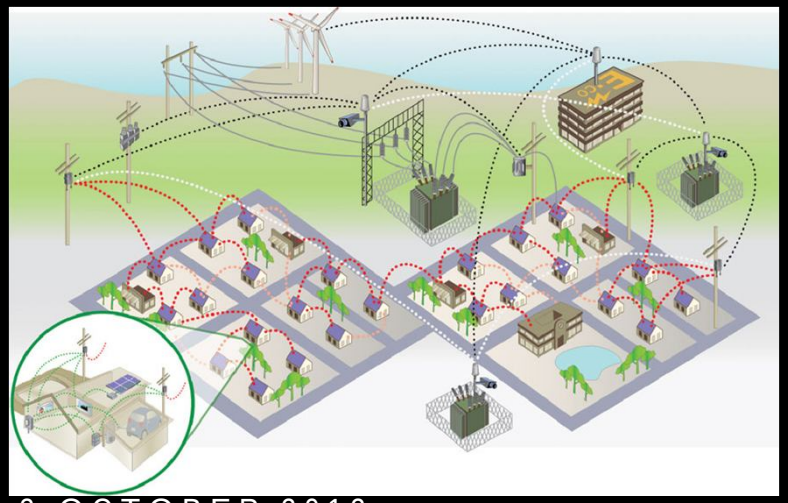

Hotplate
Volts
300
200
100
0
-100
-200
-300
AV
Amps
500
250
0
-250
-500
AI
11:05:12.80
09/21/2012
Friday
11:05:12.85
11:05:12.90
11:05:12.95
11:05:13.00

Microwave


Microwave
Volts
300
200
100
0
-100
-200
-300
AV
Amps
500
250
0
-250
-500
AI
11:01:09.80
09/21/2012
Friday
11:01:09.85
11:01:09.90
11:01:09.95
11:01:10.00

Discussion

- Microwave consumes energy to boil water 500 ml less than the hotplate.
- Microwave has current waveform distortion.
- Many of electricity equipment in household are generating current distortion to the electrical system.
- Think of the large scale household or industry



Discussion

- Microwave has current waveform distortion.