Power losses associated with stand-by chargers

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Abstract:

Many average households across the United States may not realize how much power is saved by simply removing the plug from the receptacle when not being used. A misconception with stand-by/portable chargers is; if a device is not connected to the charger, but the charger is still connected to the wall, then the charger will not consume power. That statement is false. The following report will demonstrate how much power is lost in an average household. When a reference is made to an average house, I will refer to a 4 bedroom single family home. The house will have an average of 2 bathrooms and a garage. I will also test the power quality of the home, where the current is distributed across several frequencies, not just the normal 60 Hz. The project will consist of a detailed analysis of stand-by home chargers that are left plugged in but are not connected to the device that is meant to charge. Stand-by chargers will include the following but are not limited to; Cell phone chargers, Cordless telephone chargers, MP3/ IPod chargers, laptop chargers, facial hair trimmers/ shavers, and Television sets that are remotely operated.

The study was conducted in the city of Santa Maria California, approximately 30 miles south of Cal Poly San Luis Obispo. According to the city records department, there are 23, 986 single family homes within city limits. This city consumes roughly 44232.58 Kilowatts hours per day.

Introduction:

As many household devices are becoming more efficient and the utility industry is becoming more aware of how to conserve power, there is still a simple and crucial step to help conserve power, un-plug a device from the wall when not in use. As simple as the idea may sound, the amount of power conserved accumulates and this report will demonstrate the amount of savings. The report will include the effects of transformers that are used in the devices that will be tested. Step-down transformers are widely used in houses to step down the input voltage of approximately 120 V to a voltage that can be used in appliances or devices of approximately 10 V or less.

With a device plugged into a wall socket, a path will remain and allow the current to flow through the transformer, as illustrated in Figure 1. [4] Many devices have transformers that will cause this effect and are unknown to the homeowner of the amount of power loss associated with such devices.

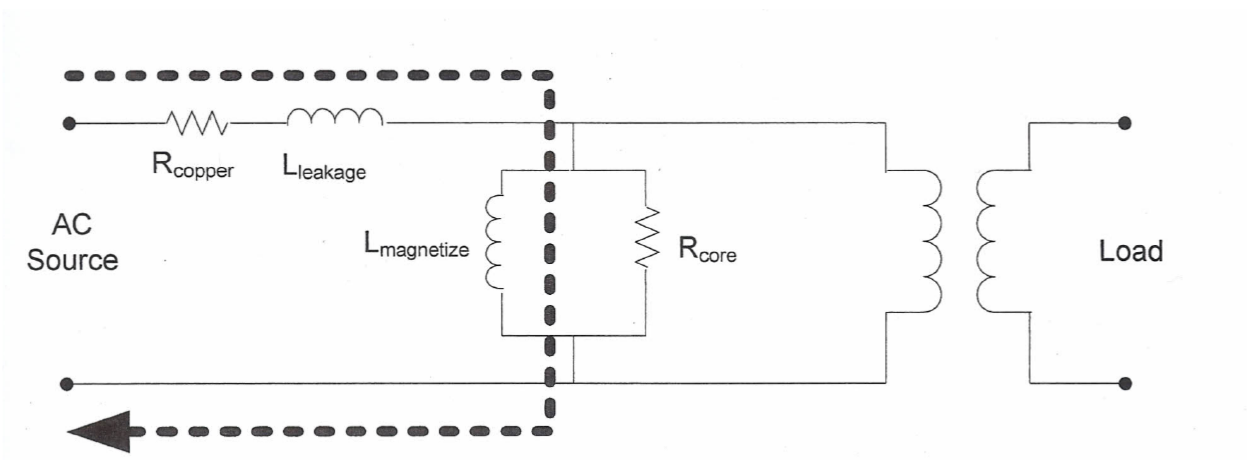


Figure 1: Path of current in a transformer connected to a wall socket

Testing Procedures:

Equipment Used

Yokogawa Digital AC Meter Type 2504

Fluke 115 True RMS Multimeter

5 Receptacles

12 CFL light bulbs Rated at 12 Watts each

Powersight PS 3000 Power Analyzer

Powersight software Manager

AC power supply as an infinite bus

Set Up

In order to set-up the test equipment, a simple circuit will be utilized in order to test for the power consumed and test for the power lost in the system. In order to test for power lost, the current or the load will be measured at the receptacle. Figure 2, is a demonstration on how the current will be measured. A device will draw power and at constant voltage of 120 Volts and the current will vary from device to device. The test bench will be set up with the power meter connected, as in the schematic below.

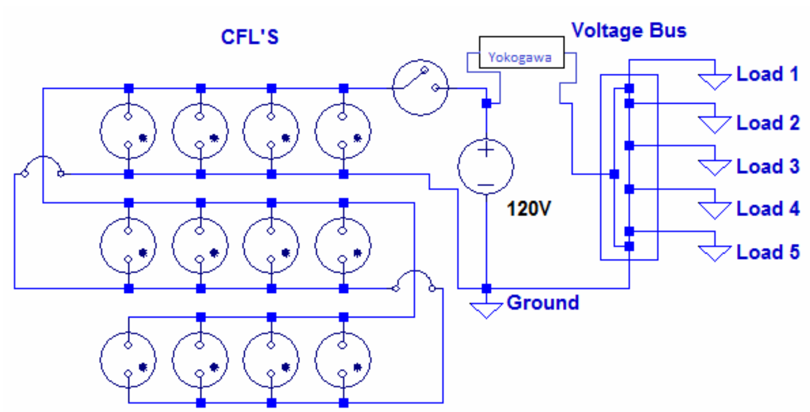


Figure 2: Schematic of test bench

Table 1: Devices used for the power quality test

Load	Device Type
1	HD TV
2	Satellite Receiver
3	Blu-ray player
4	Gaming system
5	Surround Sound stereo system

Testing

Each device will be tested in 5 different operations. The first testing procedure will be with a charger plugged in, but not connected to the device. The second test procedure will be with the device connected to the charger, but with the device powered off or in stand-by mode. The third test will be with the device turned on. The fourth test will be with devices that have no external chargers plugged in but powered off, i.e. television sets. The final test procedure will be with the same no external chargers, but powered on. The data from the power meter will be gathered, tabulated, and entered in Table 2.

Power Quality Meter set up schematics

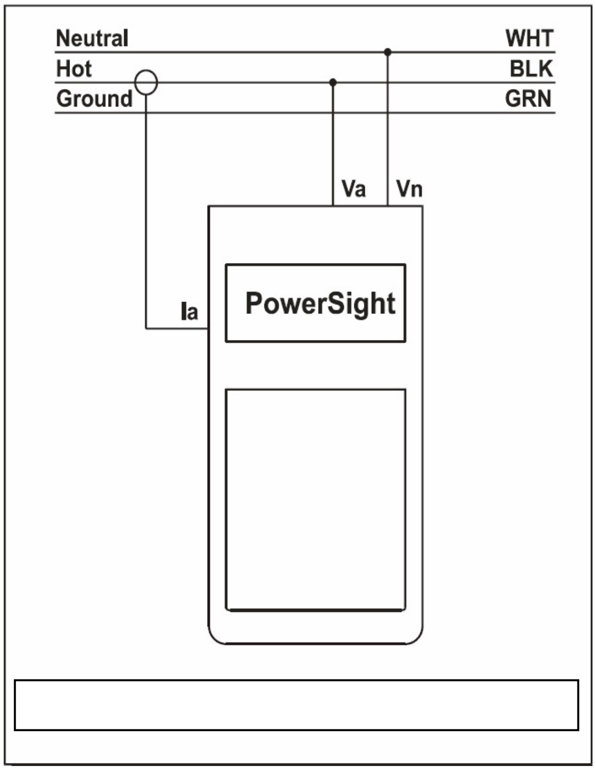


Figure 3: Basic Single-Phase Connection

The power quality meter schematic is shown in Figure 3 [6]. I_a is the current probe that will collect data for the current being used in the system, V_a is the single phase voltage probe that will collect voltage data, and the V_n is the neutral probe that will be used in conjunction with the V_a as a positive (+) and negative (-) polarities to collect proper voltage data. The wires that are mentioned above are Neutral, Hot, and Ground and are color coded as from the power cord that is used to connect to the wall socket. Figure 4 and Figure 5 below illustrates the set up.

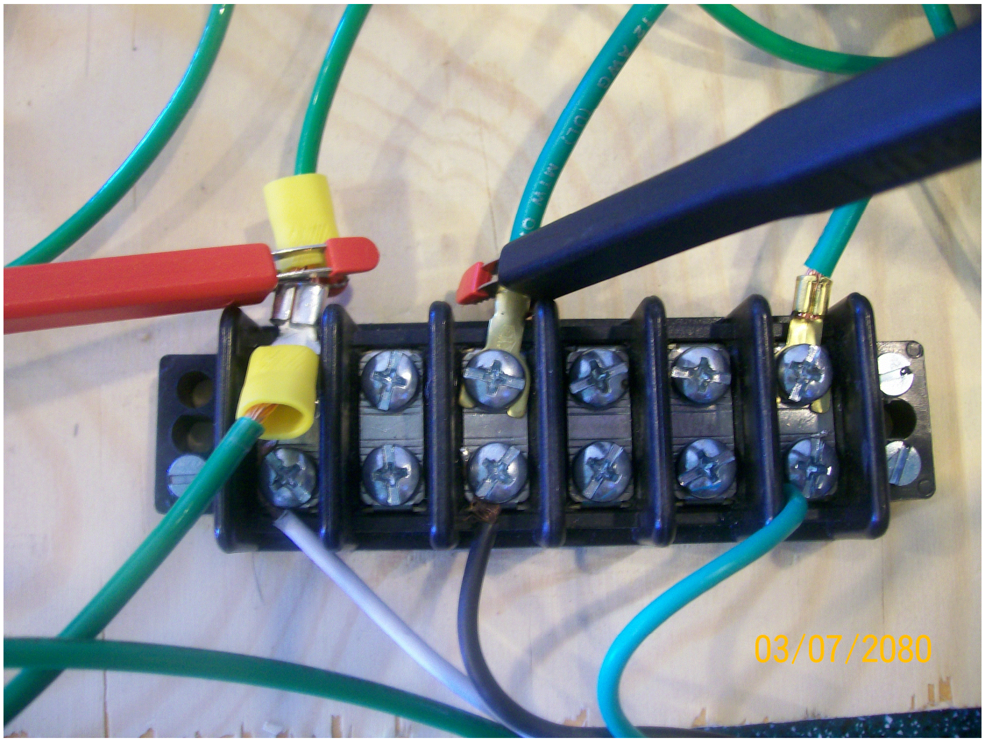


Figure 4: Picture of Voltage bus with the connections

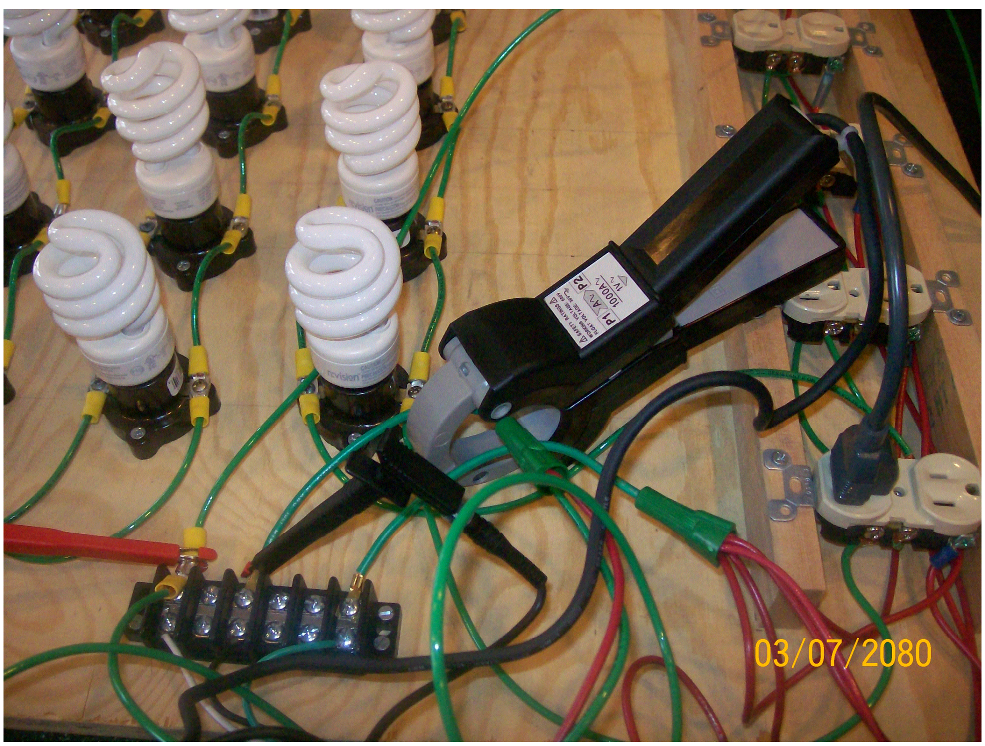


Figure 5: PowerSight Set up for the Harmonics testing

Harmonics Testing Set up

Total Harmonic Distortion (THD), is the measurement of noise in the signal that is being measured. The THD is a ratio that sums all the voltages and currents in their respective frequencies over the first voltage or current which uses the fundamental frequency of 60 Hz. Figure 6 is the equation for the THD for voltages. The same equation is used to test THD for currents.

Since we are collecting voltage and current readings, the PowerSight will graph the THD and is labeled as Figure 10. In order to test for the harmonic distortion in the system, several devices were plugged into the test bench See Table 1. For the testing procedures, 12 CFL lights are also connected to the system. Three tests were performed while using the Powersight 3000. The first test had all the devices plugged in, but powered off or on stand-by mode. The CFL's were also part of the circuit but powered off as well. The second test had the devices powered on, and the CFL's powered OFF. The last test had the devices powered on and the CFL's were powered ON. For the graphs, reactive power, power factor and real power were graphed.

$$\mathrm{THD} = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \cdots + V_n^2}}{V_1}$$

Figure 6: Total Harmonic Distribution for Voltages [5]

Test Results:

The data collected from the Yokogawa Digital AC meter are tabulated in Table 2. Several devices used in the test have an external battery that needs to be charged, i.e. cell phones chargers. The remaining devices do not have an external battery; however, they are constantly plugged in, i.e. television sets. Additionally, the total watts lost when a device is plugged in and not charging or turned off is 184.41 Watts, which amounts to about 1.8441 Kilowatts-hour per day.

The first column, Device Type, is the actual devices used that are found in average household. The brand of the device has been left out as not to promote a specific brand. Additional devices may be present or removed, but the devices used represent an approximation of what may be found in an average household.

The second column, No Load (mA), is the amount of current in milliamps that the device uses while the device is plugged in, not charging or stand-by mode. The reference voltage used in this experiment is 120 Volts. Several cell phone chargers were used and all had an average usage of power. The biggest loss of power was the personal computer and monitor. They were tested on standby or sleep mode with the screen saver on as no-load test. It was discovered that it consumed more power in the screen saver mode than when powered on.

The third column, Power No load (W), is the amount of real power in watts consumed by the charger of the device or while the device is on stand-by. The power consumed in column three is of great significance because it demonstrates the use of power while the devices are plugged in but not charging or on stand-by mode. Many manufactures take into account that the device will consume power when plugged in and not charging a device, powered off or in stand-by mode by adding external clocks to the device. For example when a device plugged in is powered off, an external clock will remain constant so long the device is not disconnected from the wall. Another example is the use of a LED screen to illustrate the time and or date when the device is powered off .i.e. VCR’s.

It was assumed that an average household will leave many devices plugged in for about 10 hours a day. This assumption is used in the calculation to determine the total lost power in 1 day.

(Total power under no load conditions * hour of non use)/ (1Watt/ 1000 Kilowatt)

(184.41 Watts * 10 hours per day)/ (1 Watt/ 1000 Kilowatt) = **1.8441 Kilowatts-hour per day**

Data from test

Table 2: Test results using the Yokogawa Digital AC Meter

Device Type	No load (mA)	Power No load (W)
LCD HD TV	177.2	18.04
Blu-Ray Player	15.2	0.21
HD Receiver	281.4	21.05
Game System	25.9	0.89
Surround Sound System	125.7	10.4
Electric Shaver	4.20	.31
Cell phone Charger	2.10	0.1
Cell phone Charger	2.40	0.14
TV	149.20	10.8
TV	23.50	0.55
Satellite TV Receiver	74.20	5.83
Tape Player	44.40	4.35
Portable DVD player	21.10	0.82
CD Player	41.80	3.69
Stereo Receiver	14.20	0.99
Satellite TV Receiver	80.20	6.07
VCR	22.90	1.26
Cell phone Charger	1.50	0.07
Cell phone Charger	2.60	0.13
Cell phone Charger	3.20	0.17
Speakers PC	46.10	1.78
Laptop	16.00	0.34
PC	1155.00	103.3
Monitor	285.90	23.2
Printer	78.10	5.8
Wireless Router	3.10	0.17
Kitchen Radio / Remote	33.50	3.13
Camera	6.00	0.16
Microwave	23.70	2.5
Coffee Pot	93.30	1.7
House Phone	15.30	0.41
House Phone	15.30	0.41
House Phone	15.30	0.41
Garage Battery Charger	93.40	5.82
TOTALS	2367.50	184.41

Data from harmonics testing

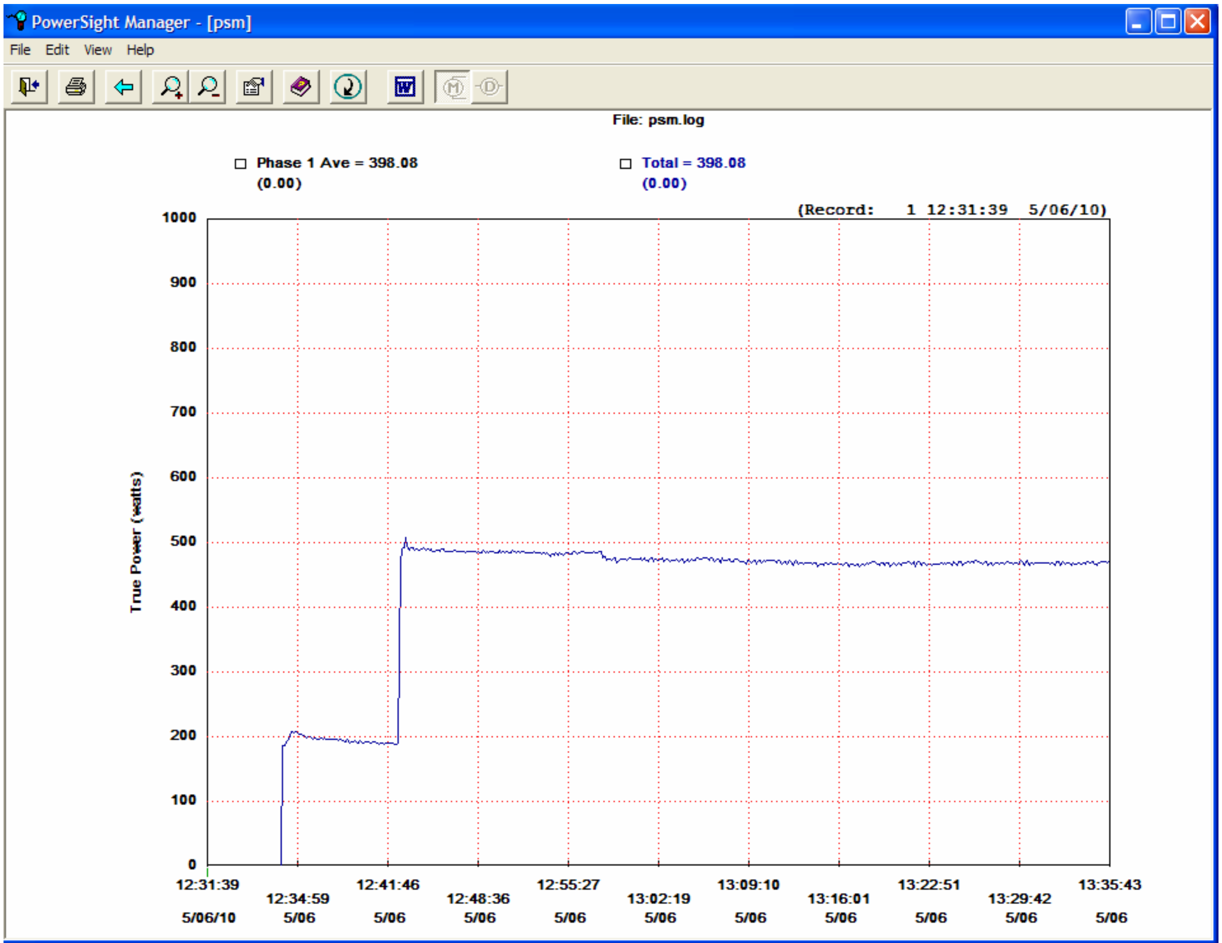


Figure 7: Real power (Watts) as a function of time

The graph represents the amount of real power, in Watts, consumed by the devices. From time 12:31:39 to time 12:33:00, the graphs show no consumption. From the Figure 7, there is a constant voltage of 120 Volts, and since the PowerSight Meter is not sensitive to low currents, the graph in Figure 7 shows no current. Never the less there is current being consumed by the devices in this period of time. The actual power consumed is 50.59 Watts. The devices were plugged in and not powered on. The time from 12:33:01 to 12:41:50, the devices are plugged in, powered on but the CFL's are not connected to the test bench. The graph jumps to 200 Watts. From time 12:41:51 to 13:35:43, the devices are plugged in, powered on and the CFL's are turned on. The power steps to 490 Watts. The only power that is of concern to the test is the first result of 50.59 Watts.

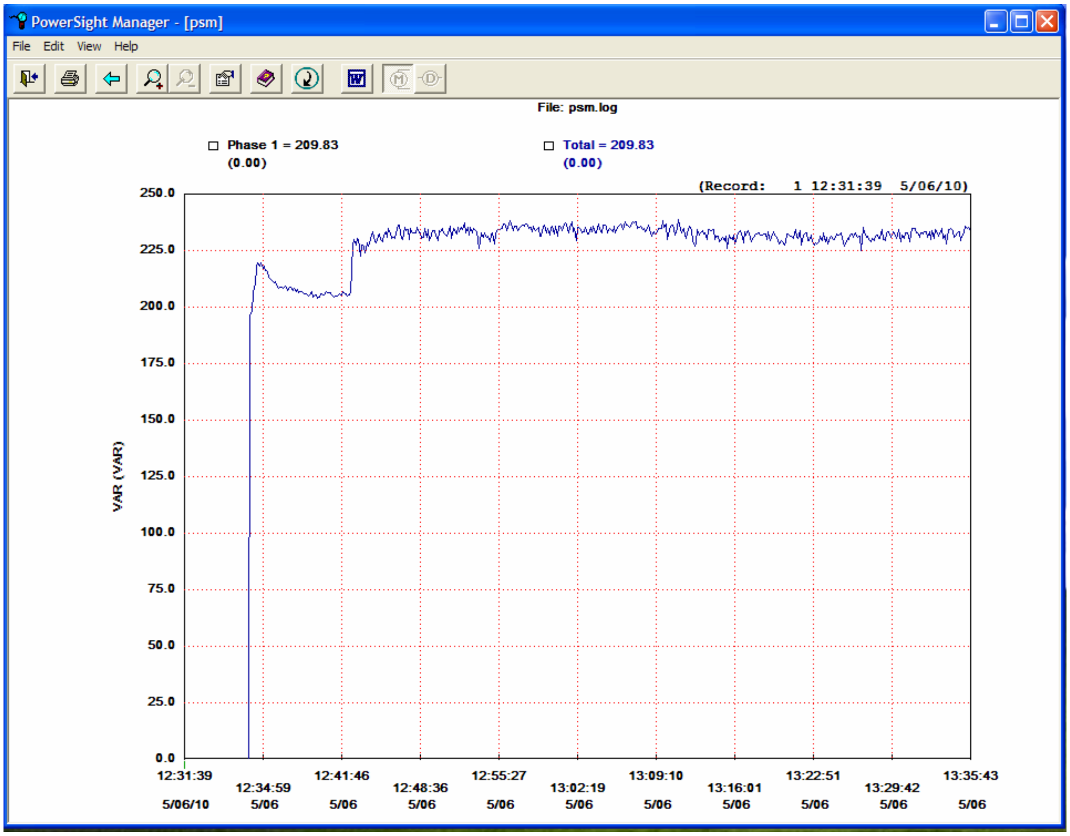


Figure 8: Reactive power as a function of time

The graph indicates the amount of reactive power (VAR's) absorbed in the devices as a function of time. Reactive power is an important part of the analysis due to the amount of power lost because its effect of the power factor. Figure 10 demonstrates that the more reactive power, then more the power factor decreases, this is due to the angle between the apparent power and real power. From the time 12:31:39 to 12:33:00, the devices are connected to the test bench, but not powered on, also the CFL's are not connected to the test bench, and therefore no reactive power is absorbed. From time 12:33:01 to 12:41:50, a step occurs of approximately 215 VAR's. From time 12:41:51 to 13:35:43 is when all the devices are turned on and the CFL's are also powered on which the reactive power took another step to 235 VAR's.

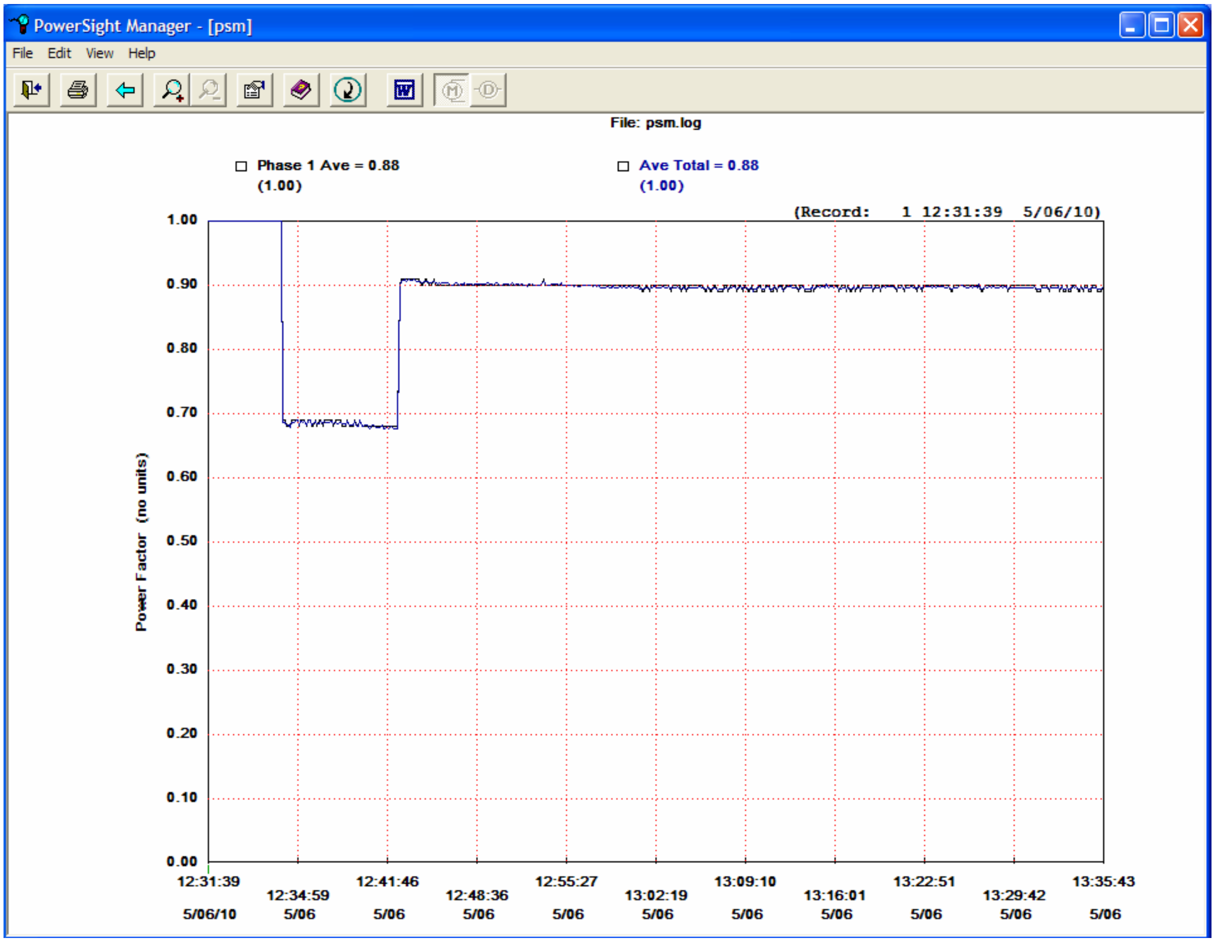


Figure 9: The power factor as a function of time.

Power factor is the ratio of real power (Watts) over apparent power (VA). The power factor (PF)could either be lagging or leading depending if the system is a capacitive load or inductive load. As Figure 9 demostrates from time 12:31:39 to 12:33:00, the devices are plugged in and in stand-by or in sleep mode, the power factor is at unity or 1.0. Once the devices are powered on from time 12:33:00 to 12:41:46, the power factor drops below .70 or 70%. This demostrates more reactive power in the devices than real power. In order to correct the drop in PF, a capacitive load or inductive load is used in a method called power factor correction. Since the CFL's have a capcitive load when powered on, the power factor stabalizes to approximatly .90 or 90% as seen from time 12:41:46 to 13:35:43. Moreover, Figure 7 demostrates the dramatic jump in real power to increase the power factor.

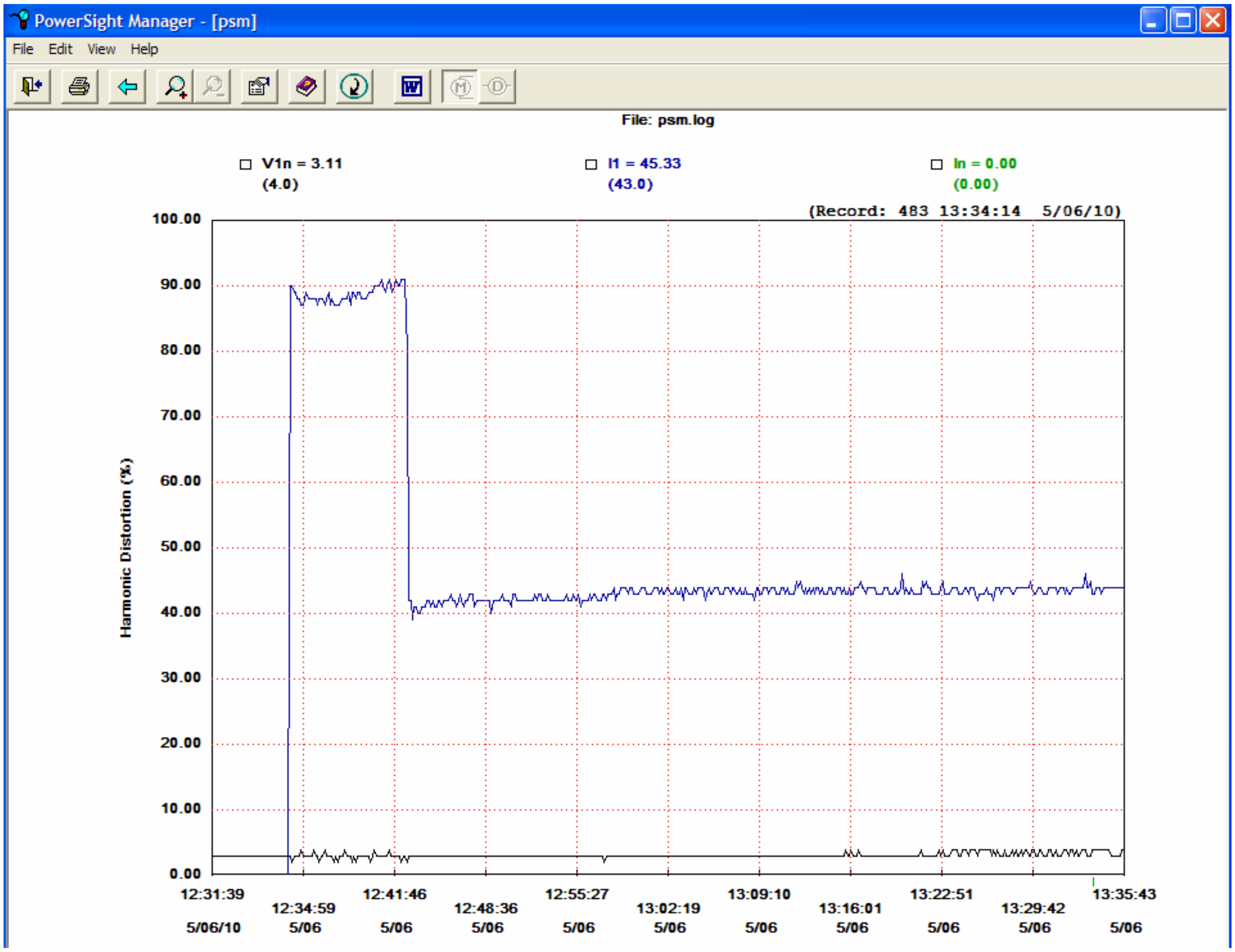
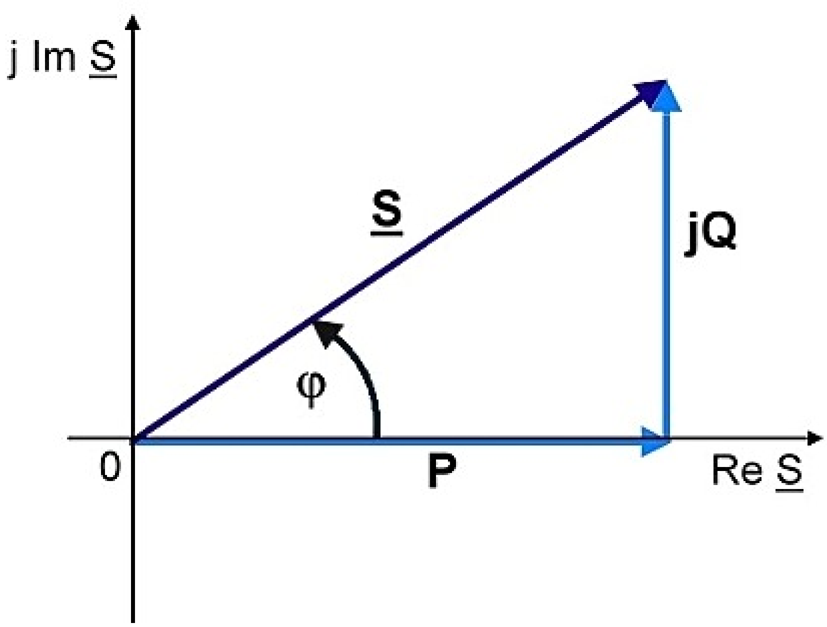


Figure 10: Total Harmonics Distortion of the current as a function of time

The blue set of data points is the current THD or load while the black set of data points is the voltage THD as a function of time. Three analysis types are tested and are explained as time frames. In the first time frame from 12:31:39 to 12:33:00 the system show no current distortion, not until after 12:33:00 to 12:41:46 when the devices were powered up and where the THD jumps to 90 %. This shows how the devices affect the system and there is substantial distortion. From 12:41:46 to 13:35:43, the CFL's are turned on and reduce the distortion in the system.

Power Factor Triangle

Figure 11 [1] is the power triangle widely used in Electrical Engineering. It demonstrates how the different types of power affect the power factor. The cosine of the angle (□) between the apparent power and real power is the power factor. Therefore, Figures 6, 7, and 8 demonstrates the use of the power triangle. Figure 9 shows a PF of 1.0, and then drops to .70, this is due to the reactive power in the devices and the increase in the reactive power increases the angle (□) and lowers the PF. After a short period the PF increases to .90, this is due to an increase in real power and little increase in reactive power and the angle between the two decreases, hence an increase in PF.



Real Power (P)

Reactive Power (Q)

Apparent Power (|S|)

Figure 11: Power triangle

Possible Solutions:

Currently the only way to limit the amount of power lost in an average household when using stand-by chargers is to disconnect the plug from the wall. A wall socket with nothing connected to it will not consume any power. There are several solutions to limit, or eliminate the loss of power in a household, from very simple to somewhat complex. A simple solution to the problem is to unplug the device from the wall, then using a power strip if multiple devices are used at the outlet. A more complex solution is the ability to turn off the wall socket or receptacle remotely.

A power strip will handle several devices connected to it while giving a device a steady flow of current and constant voltage. Additionally, a power strip that has a turn off switch will work just a great at eliminating losses while the devices are not being used. While a power strip offers a great way to use multiple devices on a given wall socket, there are several limitations.

The first limitation to have a power strip to limit the power losses associated with the device, when the power strip is tucked under a desk and a phone charger and other portable chargers are connected to it, but it is inconvenient to unplug, or turn off the switch of the power stip. When tucked under the desk, it makes it uncomfortable to disconnect the charger from the power strip, or turn off the power strip. Another limitation to having a power strip is that a homeowner may only use devices that can be unplugged at any time. For example, a television on a power strip and a surround sound system not in use, but plugged in may not be convenient due to the losses of the surround sound and an inconvenience to turn off the television set.

Manufactures make use of the lost power in a device. However, such techniques currently are in place today, but are inefficient. As describe before, many devices use the lost power to incorporate a clock on the device. Another use of the lost power is to incorporate memory to device for connivance. An internal clock or settings individual to the user make the use of lost power easier for a homeowner. There is a better solution to this. Even though it is the easiest, it may not be the most feasible. Installing a

reachable battery on the side of the device will do fine to keep a clock working while the device is powered on.

Future solutions can incorporate a wall plug to detect low current levels and turn off and then power back on when a high current flow is detected. This will allow a homeowner to leave a charger plugged in, and only turn on when a device is plugged into the charger. Another future solution will be to include a remote control power strip to the wall socket, or a remote control wall socket. Again, to limit the power lost of the household and save energy, especially during peak hours.

Conclusion:

The biggest loss of power was the computer, monitor and printer. The three were tested while in the sleep mode or on stand-by. The combination of the three had a total power usage of 132.3 Watts. That amounts to 1.32 Kilowatts of used power while in stand-by or sleep mode. The total is extremely high and retests were conducted to confirm the results. The study was only done in a home; nonetheless, many computers are widely used in every location.

As the many manufactures of the devices mentioned in the study become more energy efficient, there is still a need to conserve power. The devices by themselves do not make a sufficient impact in the loss of power; however, it does accumulate with time. Moreover, the amount of lost power may be small in any given day; nevertheless, it has a direct impact on the way a utility company may charge a homeowner. By eliminating the excessive power losses in the devices, this will help conserve power and save money in the end.

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