SBS & UPS Tutorial

One would not normally expect to find power protection on the mind of the average person, unless they have recently suffered through a power event that caused the loss of valuable computer files or worse, equipment damage. Determining the solution to prevent a reoccurrence can be even more frustrating as one has to attempt to research enough knowledge to make the right decision for his specific power quality problem in a power protection market that is so large and competitive; it has become unintentionally misleading. They may go down to their local home improvement center, describe the problem, only to be told that a surge protected plug strip should be the solution. They go home thinking the problem is solved, and it's not the solution. Next they may go to a computer store and are told that they need a UPS. After clarifying a UPS has nothing to do with a parcel service, they are shown thirty different models and sizes. This results in more research and wrenching decisions. In the end this "one solution fits all" approach often does not prevent the problem encountered from happening again.

The situation is not hopeless and one does not have to become an Electrical Engineer to resolve the majority of the power problems encountered by the average end-user.

The following will guide you through successfully determining the type and level of power protection equipment required for your specific environment.

What is a Standby Power Supply (SBS), an Uninterruptible Power Supply (UPS) and why do they not provide the same level of power protection?

This is often not clearly understood, because the term Uninterruptible Power Supply is often used to refer to a wide range of power protection products. It is often deceptively used to describe the Standby Backup Supply (SBS), which only solves a minimal number of power quality problems. It is appropriately used to define the true On-line Uninterruptible Power Supply (UPS), capable of removing or eliminating the greatest number of power quality problems.

To better understand this in today's UPS market, one can purchase an SBS for as little as $50.00, while a true On-line UPS will cost more. There is a big difference between the performances of the SBS and On-line UPS.

There are three basic design types, each offering more power protection than the proceeding. If manufacturer is honest, they state the design type clearly on the product box or specification sheet. The three design types are:

OFF-LINE (SBS), the lowest grade.
LINE-INTERACTIVE (SBS), the middle grade.
ON-LINE (UPS), the highest grade

<u>The Off-line SBS</u>

The Off-line SBS offers the bare bones power protection of basic surge protection and battery backup. Through this type of SBS your equipment is connected directly to incoming utility power with the same voltage transient clamping devices used in a common surge protected plug strip connected across the power line. When the incoming utility voltage falls below a predetermined level the SBS turns on its internal DC-AC inverter circuitry, which is powered from an internal storage battery. The SBS then mechanically switches the connected equipment on to its DC-AC inverter output. The switch over time is stated by most manufacturers as being less than 4 milliseconds, but typically can be as long as 25 milliseconds depending on the amount of time it takes the SBS to detect the lost utility voltage.

When selecting this type of an SBS, be aware that your computer equipment, as well as most electronic equipment is designed for use in the United States. As such it was designed to operate from a 120 volt, 60 Hertz (Hz), <u>sinewave</u> utility source. Most Off-line SBS products on the market today only provide a sinewave output to your equipment when operating normally from the utility line. When they switch to their internal DC-AC inverter they may only provide a square wave, modified square wave or quasi-sinewave, <u>not a pure sinewave</u>. In many cases your equipment may appear to operate normally on these

waveforms, but over time may be damaged by them. If you decide only minimal protection is needed, an off-line SBS offers, it is always best to select an SBS or UPS that states it has an inverter with a true sinewave output. You should also be aware that most off-line SBS units will not be capable of accepting additional battery packs for extended battery operation. To keep the cost down and prevent overheating, their inverters are designed to only operate as long as the internal battery capacity allows. For your reference units of all three design types typically provide from 5 to 15 minutes of battery back-up time when loaded to their full output capacity. Slightly longer backup times can be achieved by overrating the SBS or UPS size.

The Line-Interactive SBS

The Line-interactive SBS offers the same bare bones surge protection and battery back-up as the off-line, except it has the added feature of minimal voltage regulation while the SBS is operating from the utility source. This SBS design came about due to the off-line SBSs inability to provide an acceptable output voltage to the connected equipment during "brown-out" conditions. A "brown-out" happens when the utility voltage remains excessively low for a sustained period. Under these conditions the off-line SBS would go to battery operation and if the brown-out was sustained long enough, the SBS battery would become fully discharged, turn the power off to the connected equipment and not be able to be turned back on until the utility voltage returned to normal. To prevent this from happening a voltage regulating transformer was added, hence the term line-interactive was born. This feature really does help as low voltage utility conditions are common. The down side for this design, most of the units available have to switch to battery momentarily when making transformer voltage adjustments and this can be a bit annoying in a quiet home office on a bad power day.

Again when selecting a Line-interactive SBS it is always best to select a model with a true sinewave output. Several manufacturers have models available that will accept extended battery packs to provide additional battery runtime. This type of SBS typically costs more than the off-line type, but is worth the additional cost.

The On-line UPS

The On-line UPS provides the highest level of power protection for the serious home office user. It does typically cost more, but like all electronic equipment today the cost is coming down as the technology advances. The true advantage to the on-line UPS is its ability to provide an electrical firewall between the incoming utility power and your sensitive electronic equipment. While the off-line and line-interactive designs leaves your equipment connected directly to the utility power with minimal surge protection, the On-line UPS provides an electronic layer of insulation from power quality problems. This is accomplished inside the UPS in several tiers of circuits.

First the incoming AC utility voltage is passed through surge protected rectifier stage where it is converter to a Direct Current (DC) and is heavily filtered by large capacitors. This tier removes line noise, high voltage transients, harmonic distortion and all 50/60 Hertz frequency related problems. The capacitors also act as an energy storage reservoir giving the UPS the ability to "ride-through" momentary power interruptions. The battery is also connected to this tier and takes over as the energy source in the event of a utility loss. This makes the transition between utility and battery power seamless, without an interruption.

The filtered DC is sent into the next tier, a voltage regulator stage. In the regulator stage the DC voltage is tightly regulated and fed to a second set of storage capacitors. The regulator stage gives the UPS its ability to sustain a constant output even during sustained brown-out or low line conditions. The additional stored energy in the second set of capacitors yields even more ride-through time.

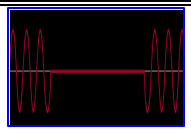
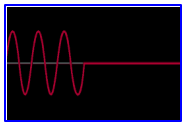
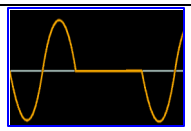
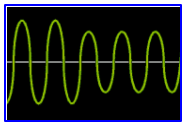
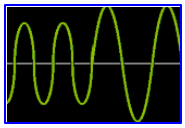
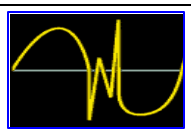
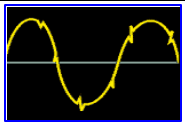
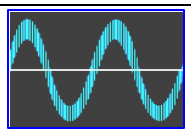
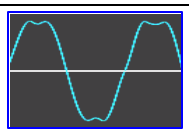
The regulated DC voltage is next fed to the Inverter stage where a totally new 50/60 Hertz, true AC sinewave output power is made. This tier gives the UPS a new, clean output with superior voltage and frequency regulation ready for connection to any sensitive equipment.

The On-line UPS can give the home office user other benefits like frequency conversion for operating equipment designed for a 60 Hertz utility source on European 50 hertz utility power, or the reverse. The

continuous duty inverter also allows for the connection of large extended battery packs, giving the home office user battery run times in excess of (4) hours. Many On-line UPS models offer a feature called Input Power Factor Correction". This feature will be discussed further on this chapter.

Power Quality Problems

The following is an overview of the typical power quality problems encountered. Give special attention to the unit type vs. the problems addressed for each type of power problem.

Power Quality Problem	Waveform	Description	Effect	Will the SBS or UPS Solve?
Temporary Interruption		Planned or accidental total loss of utility power in a localized area of the community. Seconds to minutes	Equipment shutdown, loss of work and data, file and hard disk and operating system (OS) corruption, loss of fiber optic, T1 and ISDN connections.	Off-line - Yes Line-interactive - Yes On-line - Yes
Long-Term Interruption		Planned or accidental total loss of utility power in a localized area of the community. Minutes to hours	Equipment shutdown, loss of work and data, file and hard disk and OS corruption, loss of fiber optic, T1 and ISDN connections	Off-line - No Line-interactive – 95% No On-line - Yes
Momentary Interruption		Very short planned or accidental power loss. Milliseconds to seconds	Computer hangs, computer and network equipment reboots or hangs, loss of work and data, file and hard disk and OS corruption	Off-line - Maybe Line-interactive - Maybe On-line - Yes
Sag or Under-Voltage		A decrease in utility voltage Sags – Milliseconds to a few seconds • Under-voltage – Longer than a few seconds	Shrinking display screens, equipment hang or reset, equipment power supply damage, Computer hangs, computer and network equipment reboots or hangs, loss of work and data, file and hard disk and OS corruption	Off-line - No Line-interactive - Yes On-line - Yes
Swell or Over-Voltage		An increase in Utility voltage Swell -- Milliseconds to a few seconds • Over-voltage – Longer than a few seconds	Permanent equipment damage, Computer hangs, computer and network equipment reboots or hangs, loss of work and data, file and hard disk and OS corruption	Off-line - No Line-interactive - Yes On-line - Yes
Transient, Impulse or Spike		A sudden change in voltage up to several hundred to thousands of volts Microseconds	Network Errors, Burned or damaged equipment and circuitry, Computer hangs, computer and network equipment reboots or hangs, loss of work and data, file and hard disk and OS corruption	Off-line - Yes Line-interactive - Yes On-line – Yes, Higher level of protection.
Notch		A disturbance of opposite polarity from the waveform Microseconds	Slow LAN due to excessive errors, audible noise in telephone and audio equipment	Off-line - No Line-interactive - No On-line - Yes
Noise		An unwanted electrical signal of high frequency from other equipment Sporadic	Slow LAN due to excessive errors, audible noise in telephone and audio equipment. Equipment hangs.	Off-line - No Line-interactive - No On-line - Yes
Harmonic Distortion		An alteration of the pure sinewave (sinewave distortion), due to non-linear loads such as computer switching power supplies.	Causes motors, transformers and wiring to overheat, lowers operating efficiency of office equipment,	Off-line - No Line-interactive - No On-line - Yes

How do I select the right size UPS for my equipment?

As far as SBS and UPS equipment is concerned "size does matter, but bigger is not necessarily better". In choosing SBS and UPS equipment, selecting a model of the proper size is central. Selecting an SBS or UPS that is too small to provide enough power for the equipment you need protected should be avoided. It may result in having to return the unit for a larger model, or cause the SBS or UPS to fail. As a good portion of the purchase price of an SBS or UPS is directly related to its size or output capacity, selecting one that is too large for your needs will be a waste of money. More important it may be the difference between buying an over-sized SBS providing limited protection, or the correct size On-line UPS, which gives a much greater level of power protection.

The size of SBS and UPS units indicates their output power capacity. This rating is in VA (volt/amperes) or kVA (thousand volt amperes) which is preceded by a number like 500VA or 2kVA. To the lay person this can be confusing, because the power consumption label located on most equipment is typically rated in watts or amps, not VA. When the rating is specified in VA, it can become more confusing, as the input power factor of the equipment must also be considered. Most SBS and UPS manufacturers state the output power of their UPS products in Watts or Amps somewhere on their product box or in their published specifications. Most manufacturers make their product specifications available on their web sites.

To determine the input watts required to power a specific piece of equipment, multiply the input current (in AMPS) required operating the equipment times the utility voltage. In the United States the utility voltage is 120Vac, so for a piece of equipment requiring 5 Amps, one would multiply (5 x 120) = 600 watts. Do not confuse the input plug rating of a piece of electrical equipment, (15, 20 or 30 Amps) as the actual current required to operate the equipment. The actual input current required is usually specified on a label located somewhere on the equipment...

Determining the power requirements for computers (the simple rule of thumb).

For the majority of PC and Mac based computers having up to a combination of four hard and one CDROM drive, with one monitor (up to 19"), one network router or modem, selecting a UPS with a 350 watt output will be more than adequate.

Determining the power requirements for your computers (the absolutely safe method).

Should you have more equipment that needs to be protected, or are unsure of the previous method do the following?

1. Write down all of the stated input currents and wattage requirement for every piece of equipment to be protected and convert any current ratings to watts, add them up to determine the total wattage requirement. Be suspect of any individual current ratings that state 15 amps as it is highly unlikely that any office equipment would require that much current. This usually represents the full current rating of the typical electrical outlet found in most households and offices in the U.S.

Remember the stated input rating on computers and other electrical equipment in most cases represents the worst case requirements.

What you should know about laser printers, laser copiers and faxes machines. Incorporating a laser printer, copier or any other equipment incorporating a heating element called a "fuser" can cause SBS and UPS unit problems. The best approach is to avoid **connecting them to any SBS or UPS.** The fuser randomly switches on and off, requiring a substantial amount of current with every on cycle. We have determined that to successfully power a typical laser printer requires an SBS or UPS capable of more that 1200 watts. Additionally many or these devices do not work properly with a SBS or UPS that does not have a true sinewave output. Should it be necessary to protect this type of equipment, install a separate over sized SBS or UPS that powers only that piece of equipment?

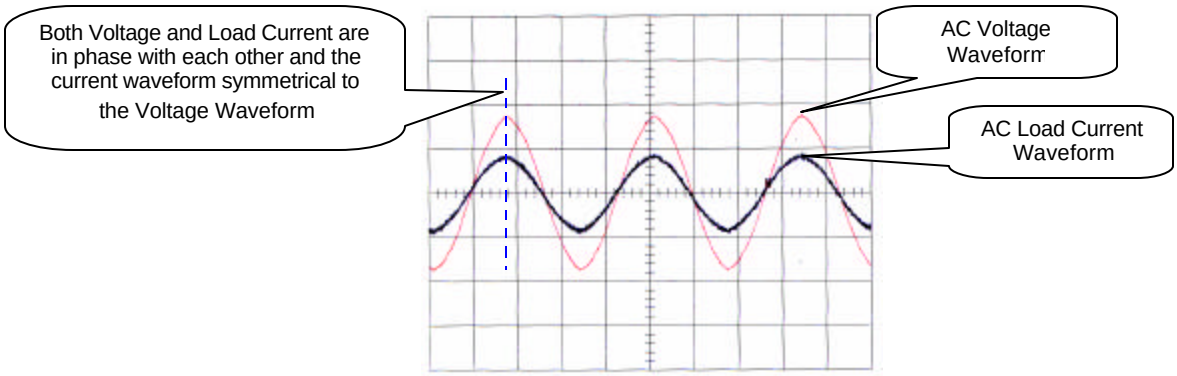
The following section covering Power Factor is given for your reference only. An understanding of the subject in not an absolute requirement for the average user but a basic understanding of the concept and benefits may be helpful.

"What is Power Factor?"

Power factor is associated with any alternating current (AC) power source such as standard wall outlet.

Power factor is the ratio between the Watts (W) and the Volt Amps (VA) drawn by an electrical load (computer, electric range, etc.), where the Watts is the "real" load power and the Volt Amps is the 'apparent" load power. It is the measure of how effectively the alternating current is being converted into useful work output, and more particularly, is a good indicator of the effect of the load current on the efficiency of the AC source.

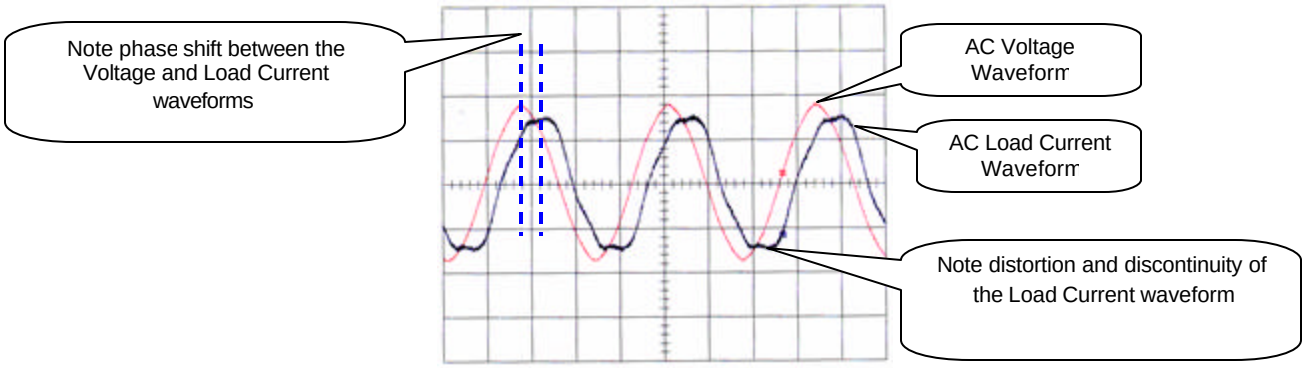
All alternating current will cause losses in the supply and distribution system. A load with a power factor of 1.0, (referred to as unity power factor) will result in the most efficient loading of the supply. A load with a power factor of 0.5 will result in much higher losses in the supply system.



Oscilloscope Plot of a 1.0 (unity) Power Factor

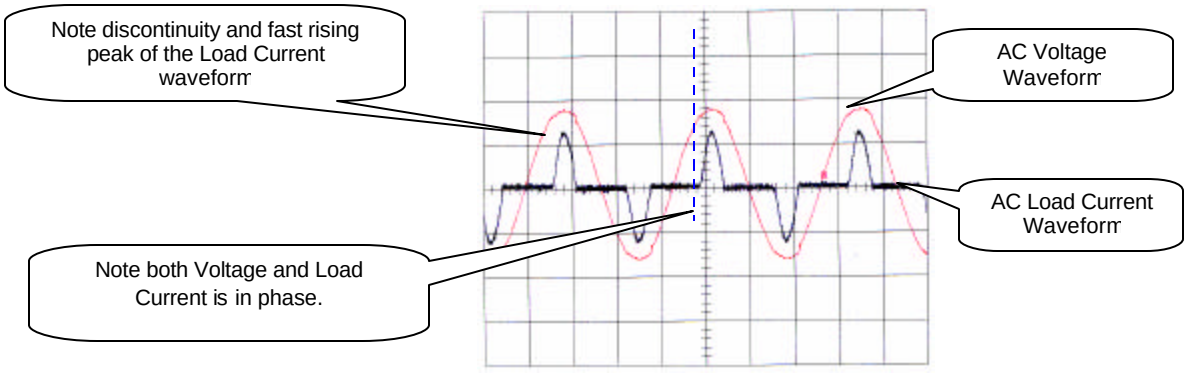
A poor power factor can be the result of either a significant phase difference between the AC Voltage and AC Current measured at the load, or can be due to a high harmonic content or a distorted/discontinuous load current waveform.

Poor load current phase angle is generally the result of an inductive load such as a motor, power transformer, lighting ballasts, welder or induction furnace.



Oscilloscope Plot of a 0.7 Power Factor Caused by a Motor Load

A distorted Load Current waveform can be the result of a non-linear load such as a rectifier, variable speed drive, discharge lighting, or a switching power supply typically found in most computers and sophisticated electronic equipment.



Oscilloscope Plot of a 0.7 Power Factor Caused by a Non-linear Load

"The Influence of Power Factor"

The National Electric Code limits the continuous current drawn through the equipment line cord to 80% of the rating of the receptacle. For the standard 15 A receptacle (NEMA 5-15R) the limit is 0.8 x 15 = 12 Amps

This limits the Apparent Power to S = V RMS x A RMS = 120 x 12 = 1440VA for a 120 volt utility line

$$\text{Power Factor} = \frac{\text{Real Power (Watts)}}{\text{Apparent Power (VA)}}$$

Real Power (Watts) = Apparent Power x P.F.

Apparent Power (VA) = Volts (RMS) x Amps (RMS)

But only the Real Power (Watts) is useable power and with the typical computer load power factor of 0.65 to 0.70 the available useful power

Real Power (Watts) = 1440VA x P.F. = 1440 x .7 = **1008Watts**

If the P.F. is only 0.65

Real Power (Watts) = 1440 x .65 = **936 Watts**

When using an "Off Line" or "Line Interactive UPS", the load power factor is not changed, and the efficiency may be 97%

Therefore, the useful power is:

a) 1008 x .97 = **978 Watts** (P.F. = 0.7)
b) 936 x .97 = **908 Watts** (P.F. = 0.65)

If more power is required, one solution would be to use one of our "On Line" UPSs, with input power factor correction, such as the Falcon SG Series. With an AC-to-AC efficiency of 85%, the power available becomes:

Real Power (Watts) = 1440VA x 1.0 x 0.85 **= 1224Watts**

Which represents a 25% to 35% increase relative to the power available with "Off Line" or "Line Interactive" Standby Backup Supplies.

Another significant benefit of using an "On Line" UPS with input power factor correction, is that the input current total harmonic distortion will typically be less than 8% and therefore the current crest factor, which is the ratio of peak current to RMS current will be close to the ideal value for a sinewave of 1.414. Assuming a crest factor of 1.5 and the 12A RMS current value, the peak current would be:

Ipeak = I RMS x C.F. = 12 x 1.5 = **18A**

In contrast, without power factor correction the typical load crest factor will be 2.5 to 3.0 and the

Ipeak = 12 x 2.5 = 30A to 12 x 3.0 = **36A**

In other words, the output power is 25 to 35% higher but the peak input current is 40 to 50% lower.

For some scenarios, an extremely low input current distortion is needed, either to reduce the voltage distortion of the utility voltage when the source has relatively low capacity and therefore high impedance, or to minimize the low frequency conducted emissions. These applications are typically specialized military or scientific with the packaging generally specified by the customer. To meet this demanding requirement, Falcon Electric offers board level Uninterruptible Power Supply (UPS) and Low Input Current Distortion Power Factor Correction modules. They achieve a very low (<3%) Input Current Distortion. They are available with ratings from 1kVA to 4kVa.

Falcon Electric SG Series UPS units are available with ratings available from 800VA to 6kVA. **These input power factor corrected On-line UPSs will assure a 0.97 to 0.99 power factor at your wall outlet regardless of what is connect to the UPS output.**

What is an" intelligent or microprocessor based SBS or UPS", an "RS-232 UPS interface", SNMP/HTTP support and "UPS shutdown and management software"?

It is truly the age of the microprocessor. You can find them in almost any piece of electrical and electronic equipment today, even your coffee pot. They have been added to the products to perform complex control functions, reporting, user interface functions, and add convenience. The SBS or UPS is no exception. Microprocessors are being incorporated into the least costly SBS models today. They have reduced the overall cost of the SBS and UPS, increased performance and reliability, in addition to facilitating advanced communications and management capabilities. The most visible and valuable are the functions that relate to management and communications. The following is a brief overview of a few of these functions.

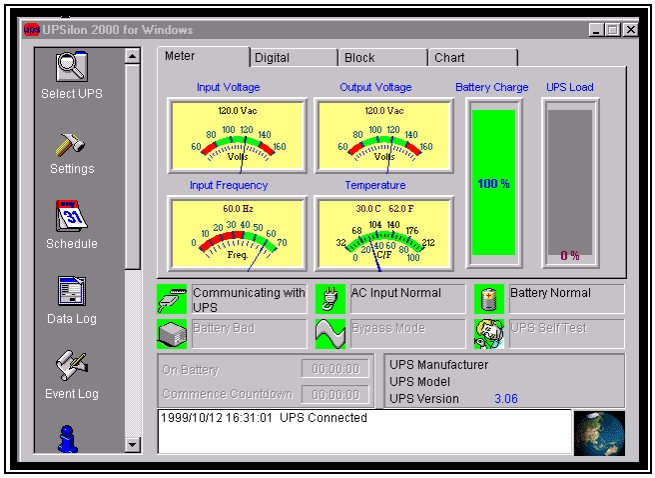
The RS-232 or USB Interface using shutdown and management software.

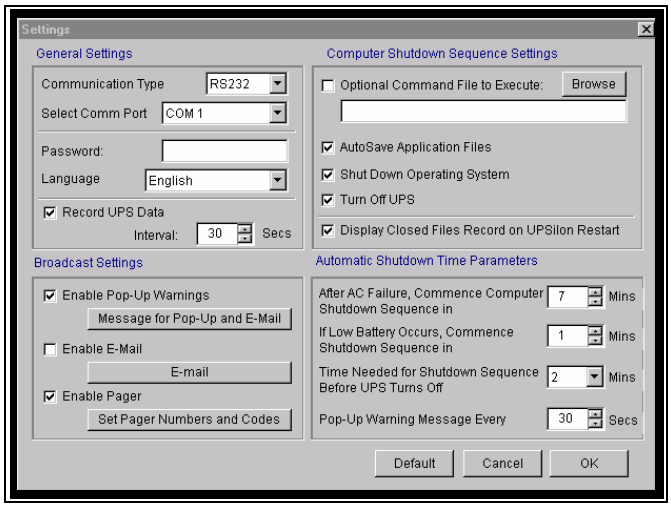
All intelligent SBS and UPS units on the market today support UPS/Computer cross communications, usually through a RS-232 based DB-9 or USB connector located on the SBS or UPS rear panel. An interconnection cable for connecting the SBS or to a computer is also provided. Computer shutdown and management software is either supplied or available at an additional cost to facilitate cross communications between the SBS or UPS, and the connected computer Operating System Software (OS). All versions of MS Windows, Mac OS or LINUX or UNIX OS are typically supported. Why this sophistication? Most of these operating systems need to be properly shutdown to prevent them from

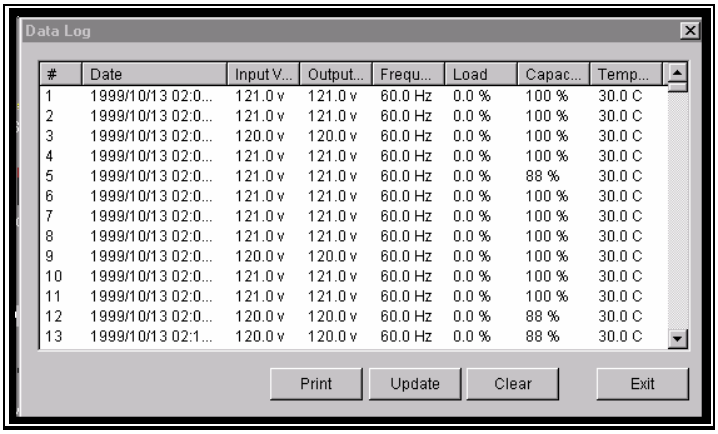
being damaged. SBS and UPS management software has a small program that runs as a demon (invisible) process in the background. Many SBS and UPS software will automatically save and name all open work files prior to initiating the shutdown. This gives the user the security of knowing their work is safe, even if they walk away forgetting to save the file.

The software typically supports advanced monitoring, data logging and programmable, time specific automatic shutdown and startup in addition to power basic monitoring and logging functions. Some software supports the monitoring of several units connected via a LAN.

TYPICAL UPS MANAGEMENT SOFTWARE SCREENS







Some of the management software available today can send a telephone page or an email to the user in the event of a power abnormality or in the event of an SBS or UPS failure.

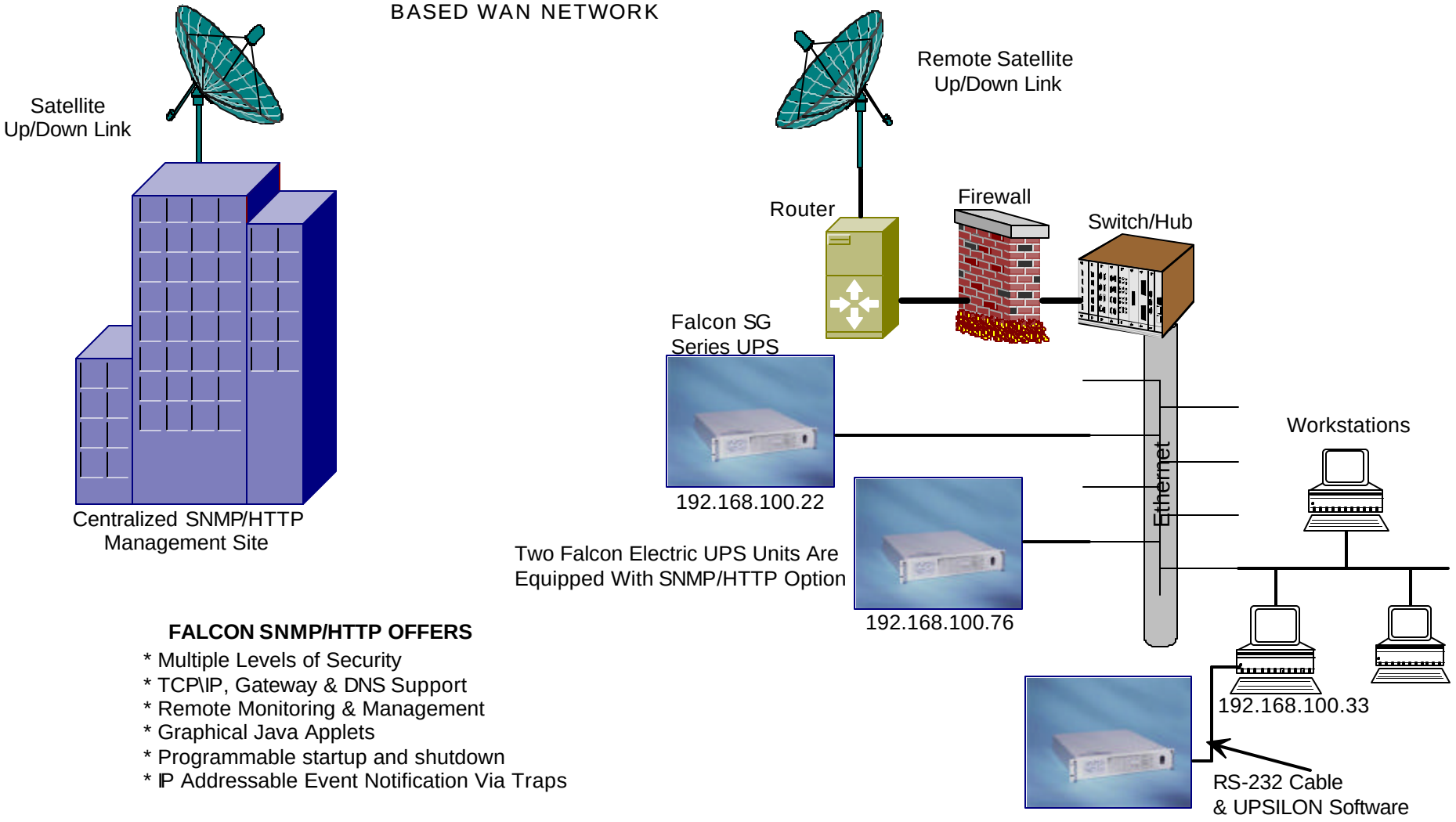
Monitoring and management software usually will not work between SBS or UPS units manufactured by differing companies. This is due to no UPS industry standard RS-232 or USB protocol. A few manufacturers like Falcon Electric Inc. have imbedded multiple manufacturers' protocols into their intelligent SBS and UPS models, but this does not seem to be a growing trend in the rest of the market.

SNMP and HTTP Support

Many manufacturers offer Simple Network Management Protocol (SNMP) and Hypertext Transmission Protocol (HTTP) communications board or adaptor options. Due to the aforementioned lack of a standardized RS-232 protocol, SBS and UPS manufacturers have joined forces to develop an industry wide SNMP protocol standard. This standard facilitates the remote management, monitoring and control of UPS products using common Network Management Software (NMS) or web browser. The device allows for the direct connection of the SBS or UPS to a TCP/IP addressable Ethernet LAN. The SNMP portion of the protocol requires expensive Network Management Software (NMS) running on a remote computer. The HTTP function allows the use of an inexpensive web browser to provide world wide remote monitoring and management of SBS and UPS units.

Please see the following applications...

TYPICAL TCP/IP
BASED WAN NETWORK



FALCON SNMP/HTTP OFFERS

* Multiple Levels of Security
* TCP\IP, Gateway & DNS Support
* Remote Monitoring & Management
* Graphical Java Applets
* Programmable startup and shutdown
* IP Addressable Event Notification Via Traps

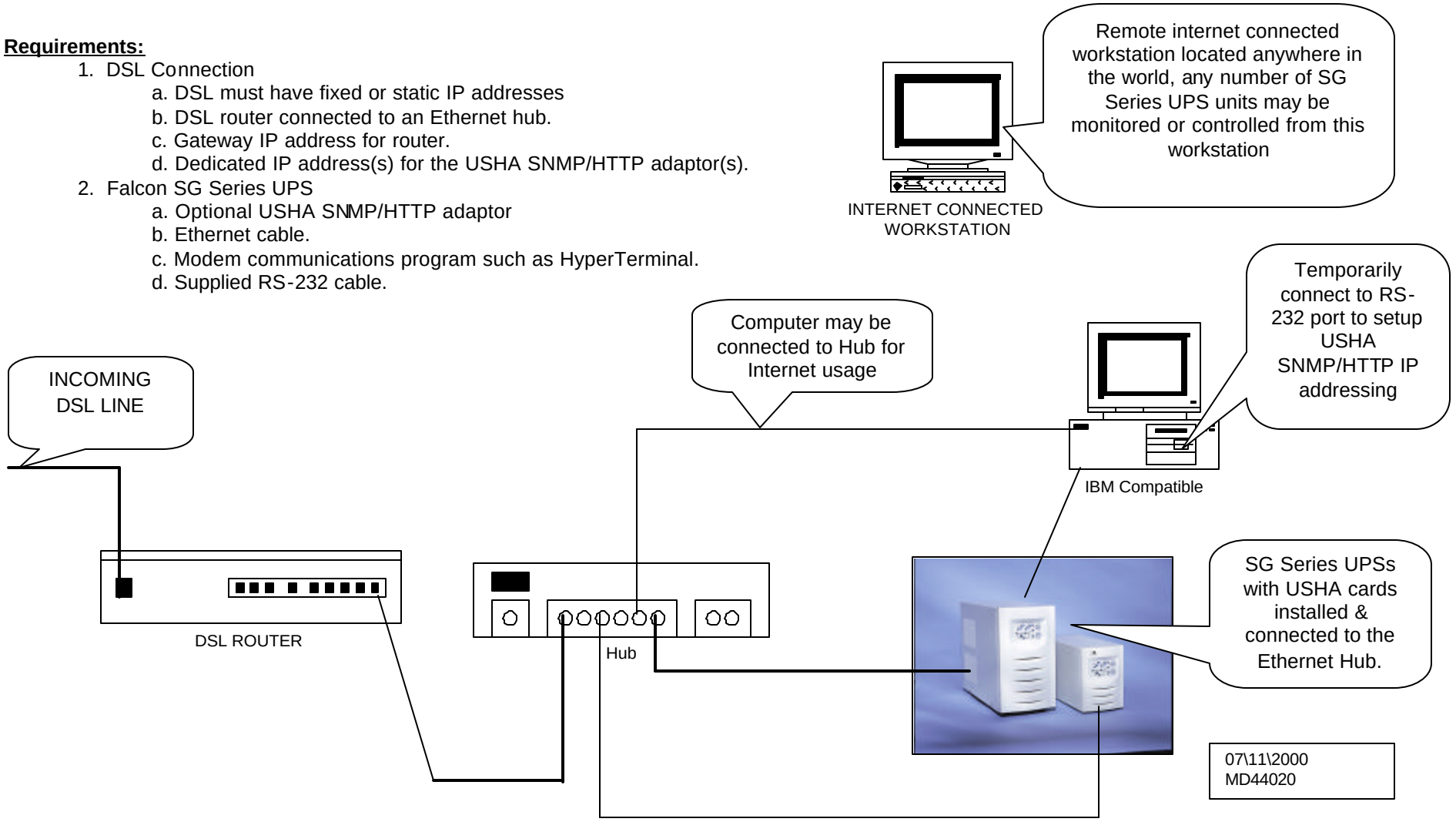
REMOTE MONITORING & CONTROL OF FALCON UPS OR FREQUENCY CONVERTERS FROM ANY CENTRAL LOCATION IN THE WORLD VIA A TCP/IP BASED NETWORK

SNMP --- Simple Network Management Protocol (Requires NMS Software)
HTTP --- Hyper Text Transmission Protocol (Use any web browser)

MANAGING & MONITORING THE SG SERIES UPS FROM ANYWHERE IN THE WORLD OVER THE INTERNET USING DSL

Requirements:

1. DSL Connection
   a. DSL must have fixed or static IP addresses
   b. DSL router connected to an Ethernet hub.
   c. Gateway IP address for router.
   d. Dedicated IP address(s) for the USHA SNMP/HTTP adaptor(s).
2. Falcon SG Series UPS
   a. Optional USHA SNMP/HTTP adaptor
   b. Ethernet cable.
   c. Modem communications program such as HyperTerminal.
   d. Supplied RS-232 cable.



We have covered a lot of ground concerning power protection for the home office, and at this point you should be able to make good, sound decisions as to the specific level of power protection you may require. As power protection is an insurance policy, don't under estimate the amount of protection you need. The old axiom is true. 'Don't gamble more than you can afford to lose".