Common Mistakes Made in Selecting & Using Power Monitors

“So you want to buy a power monitor.”

A Presentation by
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October 2009

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Introduction

"So you want to buy a power monitor."

This statement can be the start of a very long, frustrating and complex process.

This presentation along with the accompanying paper is intended to help the prospective buyer with a thoughtful and organized approach to determining needs and evaluating alternatives.

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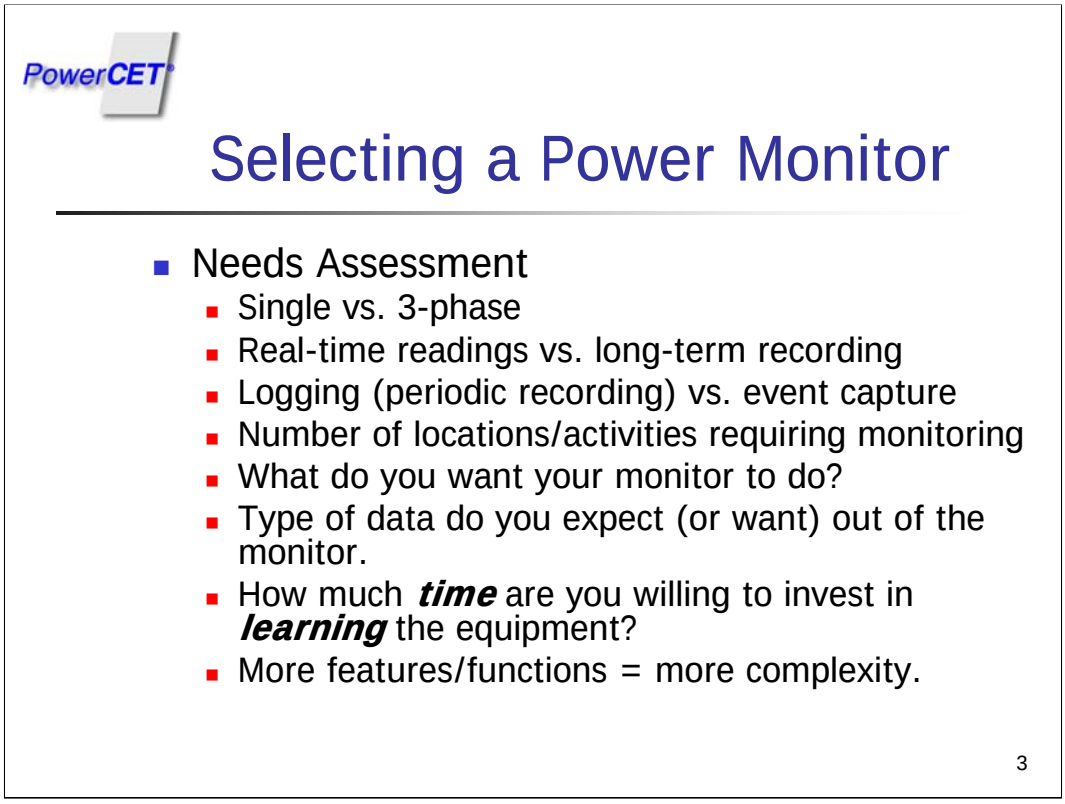
Every salesman will claim that HIS power monitor is the best!

No wonder there is confusion.

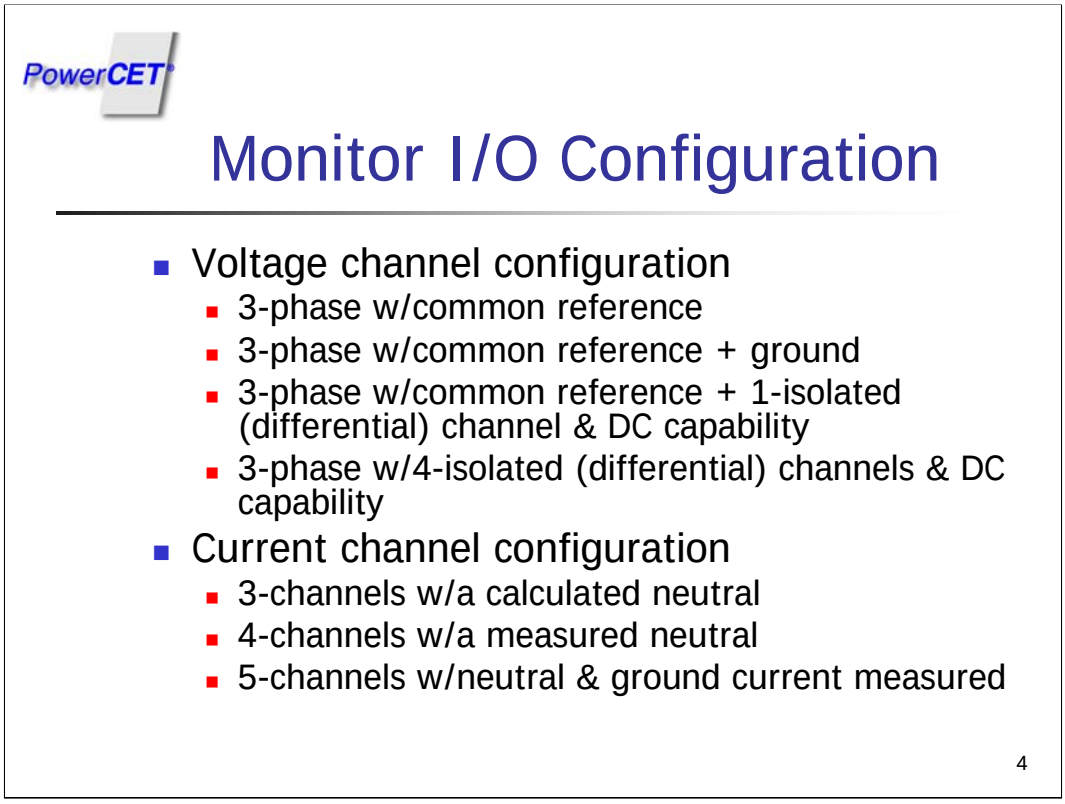
Burying a power monitor is kind of like buying a car…do your homework and figure out how much "car" you want and with what options before you ever talk with the salesman.

Also remember the salesman will always make it look easy…that's what salesman do…they practice demonstrating the equipment! On the flip-side, once you start talking to the salesman and he/she can't effectively demonstrate the equipment is the really the unit you want to buy?

Think about it!!!



1. First figure out what it is that you want to do with the monitor.
2. Start with the basics…single vs 3-phase can make a significant difference in cost. DON'T BELIEVE THE CLAIM THAT YOU CAN DO 3-PHASE MONITORING WITH A SINGLE PHASE MONITOR…THIS ONLY WORKS ON BALANCED LOADS AND THEN YOU HAD BETTER HOPE THERE IS NOTHING WRONG ON THE CHANNELS YOU DON'T SEE.
3. Is the "monitor" going to be used as a real-time meter? If so, then a lot of the memory features and software issues go away. A good example of a "real-time" use for a 3-phase monitor as a meter might be for facilities engineer that just needs to see the voltage/current in real-time while servicing the equipment.
4. If recording/logging is a need then make sure you understand how the measurement is being made…cycle-by-cycle or periodic samples. In the case of a rapidly cycling load the periodic sampling would NOT be a good choice.
5. How many monitors do you need? [DISCUSSED LATER] Sometimes it is possible to substitute technology…more monitors…for time. Using multiple monitors speeds up the task and improves the quality of the data.



Examples on next side.

Voltage channel configuration:

1. If Neutral-to-Ground (NG) measurements are desired then you need to select a monitor that has 5-voltage leads or 4-differential (independent) channels.
2. DC measurement capability can be very useful in some troubleshooting activities. Also, testing UPS equipment requires DC capabilities.
3. Having at lest one independent (isolated) channel is useful in some troubleshooting activities or when you want to compare two different power sources.
4. To measure neutral current or not. If measured neutral current is desired then you need to select a monitor with a minimum of 4-current channels.

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Monitor I/O Configurations

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Note: Equipment selected simply to demonstrate different voltage and current channel configurations.

Top Left = Hioki 3197 : **3-Phase voltage** w/common…NO NEUTAL-TO-GROUND capability. **3-Current channels**…neutral current not measured…calculated from phase currents, includes ground/leakage current. No d-c capability

Top Right = Fluke 430 Series: **3-Phase voltage** w/Neutral and Ground…N-G measurement capable. **4-Current channels** …measured neutral current. No d-c capability.

Center = Hioki 3196: **3-Phase voltage** w/common plug 4th differential channel for N-G or d-c measurements. **4-Current channels** …measured neutral current.

Lower Left = Fluke 1750: **3-Phase voltage** w/Neutral and Ground…N-G measurements capable. **5-Current channels** …can measure both neutral and ground current or zero-sum. No d-c capability.

Lower Right = Dranetz-BMI PX5 (same for other DB products): **4 independent voltage channels** can be configured as desired. **4-Current channels** …can measure neutral current and software (DranView) can calculate theoretical neutral and obtain net current. Also, all channels are capable of d-c measurements.

Monitor Features & Specifications

- Integrated display
- Memory storage...removable???
- Networking capabilities
- Event triggering (cross-channel)
- Environmental specifications
  - Temperature
  - EMI / RFI
- Input channel configuration
- DC Measurement Capability

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Integrated Display: can be useful in setting thing up, but most of the time no one is looking at it. Some monitors are configured by computer or PDA…or in some cases a limited 3 or 4 line display. User preference…color touch screens are sexy!

Memory Storage: Having a removable memory card can be very helpful…other wise it will be necessary to take the computer to the monitor or the monitor to the computer.

Networking Capabilities: A nice feature, but can be a problem to configure and for remote access you have firewall issues. Probably OK for in plant applications.

Event Triggering (cross-channel): In my opinion, the most important feature…without this I would NOT buy the monitor. You need to see what is happening on the other channels when there is a trigger.

Environmental Specifications: Think about where this equipment is going to be used. Most of the monitors do not have what I would call robust environmental specifications. Typical temperature operating range is 32F to 122F.

Input Channel Configuration: If you have a requirement to monitor multiple sources then independent (isolated) channels should be considered. Do you need to measure neutral?

DC Measurement Capability: Having the ability to measure DC voltage and current can be a big plus in some situations…UPS testing/commissioning/troubleshooting, etc.

Measurement Capabilities

- Standards conformance
  - IEC, IEEE, EN, etc.
- Sampling
- Hi-speed sampling (transient capture)
- Control of event recording…thresholds?
- Variable pre/post event trigger capture
- Measured vs. Derived Neutral

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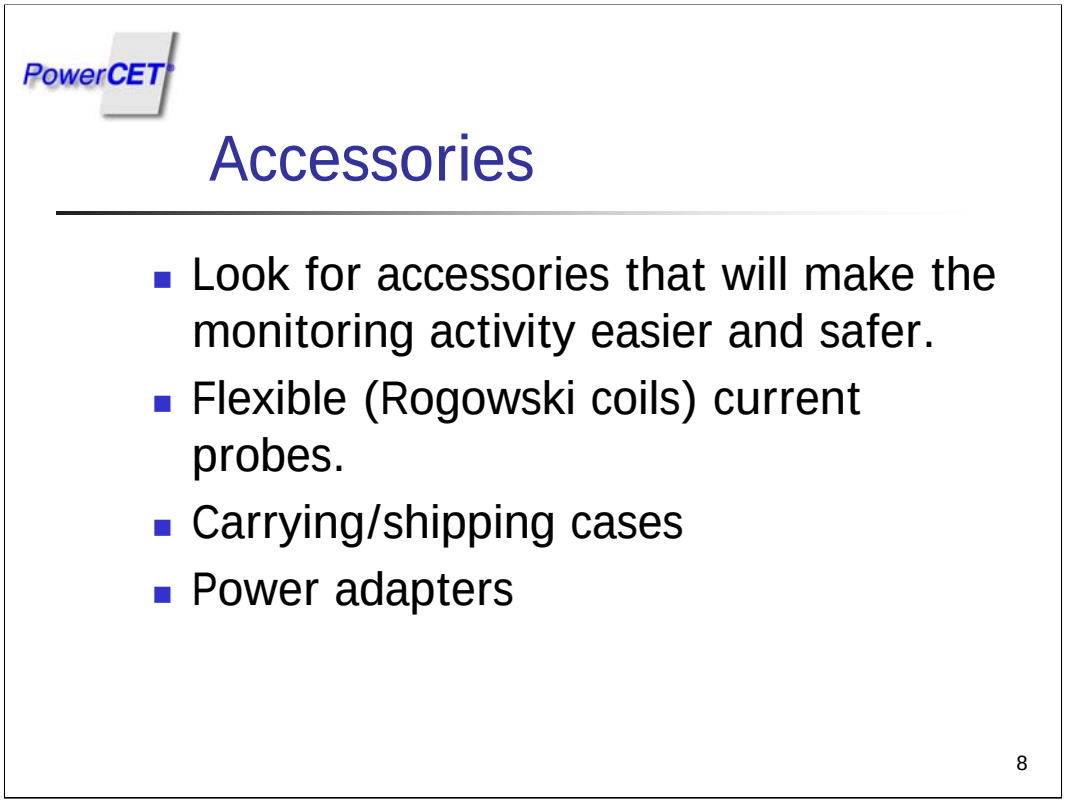
Standards: Here in the US there is not nearly the concern about the IEC/EN standards as there is in other parts of the world. Most monitors will meet the international standards in order to be competitive in the marketplace.

Sampling: Typical is 256 samples/cycle which is adequate for almost all applications..

Hi-Speed Sampling: Some equipment is equipped with a separate HF trigger…ranging from 1MS/Sec to 5MS/Sec. Typically the incoming voltage signal is split…one path is for the low speed 256 samples/cycle and the other through a high-pass filter (filters out 60Hz) and is controlled by a peak detect. HF sampling ranges from 1MS/Sec to 5MS/Sec.

Thresholds: Automatic or adjustable? Don't assume that the "automatic" or wizard setup will be optimal…it is someone else's idea of what you need to capture. There are endless arguments as to the benefit of settable thresholds. I'm a control freq, so I like being able to set the thresholds as needed…it does require more knowledge and understanding about what you are trying to capture…the challenge is to get the right amount of data, not all the data.

Pre/Post Event Trigger Capture: The ability to capture several cycles of pre trigger event data is very useful as well as having the ability to capture multiple cycles post trigger. The largest post trigger capture that I'm aware of it with the DB PG4400 and PX5 at 10,000 cycles post trigger. Again, the trick is the right number of cycles for the condition not every cycle.



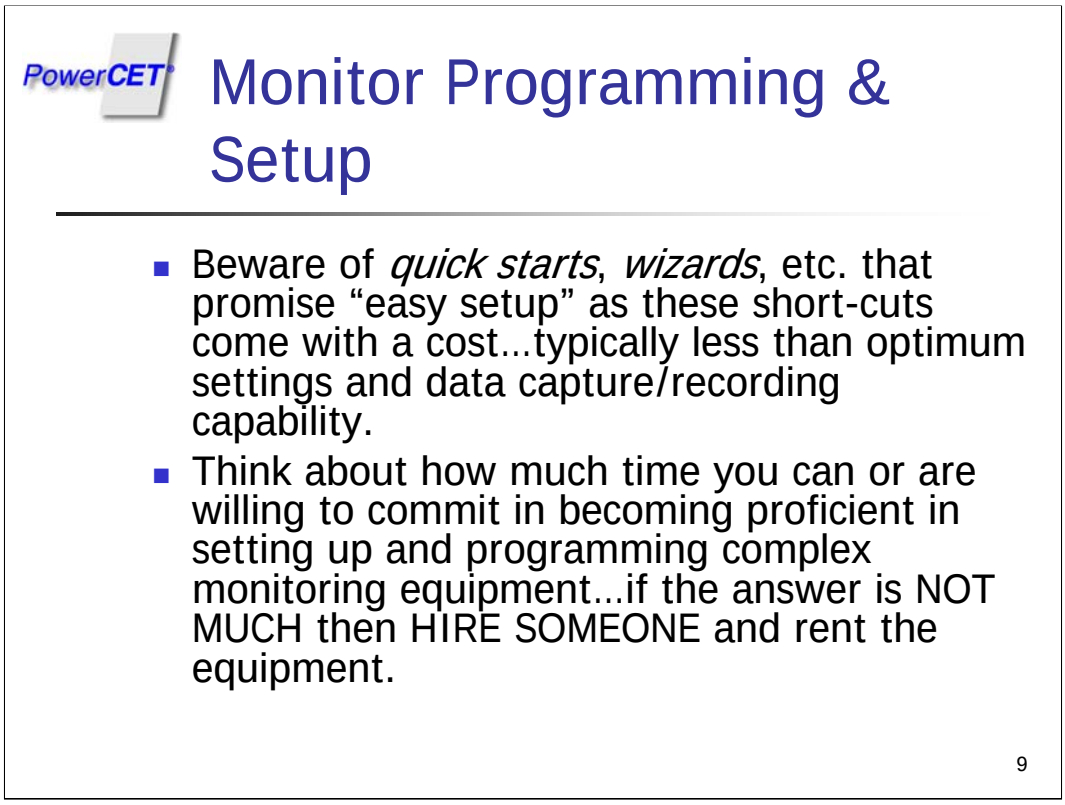
Accessories…

Make your life easier by looking for accessories that will make monitoring easier and safer.

The Rogowski coil or flexible current probe…sometimes called "ropes"…is certainly one of these accessories. The "coil" outputs a proportional voltage signal to an integrator circuit which conditions the signal for the input to the power monitors current channel. Most all monitors expect a "voltage" signal on the input current channel…terminate any current probe with the correct resistance and you get a voltage signal that should work with the power monitor. Most power monitor manufacturer's price their current probes at a premium…the major difference is usually the connector.

Carrying/shipping cases: Most manufacturers offer cases that are just barely big enough for the basic equipment . You are probably better off buying a case that will support all of the required equipment…probably about 50% of the cost.

Power Adapters: Now, I'm talking about some type of adapter that allows the user to get 120Vac (or the required d-c voltage) to power the monitoring equipment from the source being monitored. There are seldom convenience receptacles in the power room. DB makes a multi-tap transformer with 120Vac output ($550+) and Summit Technologies makes an auto-AC-sensing device with 12Vdc out for the monitor ($295).

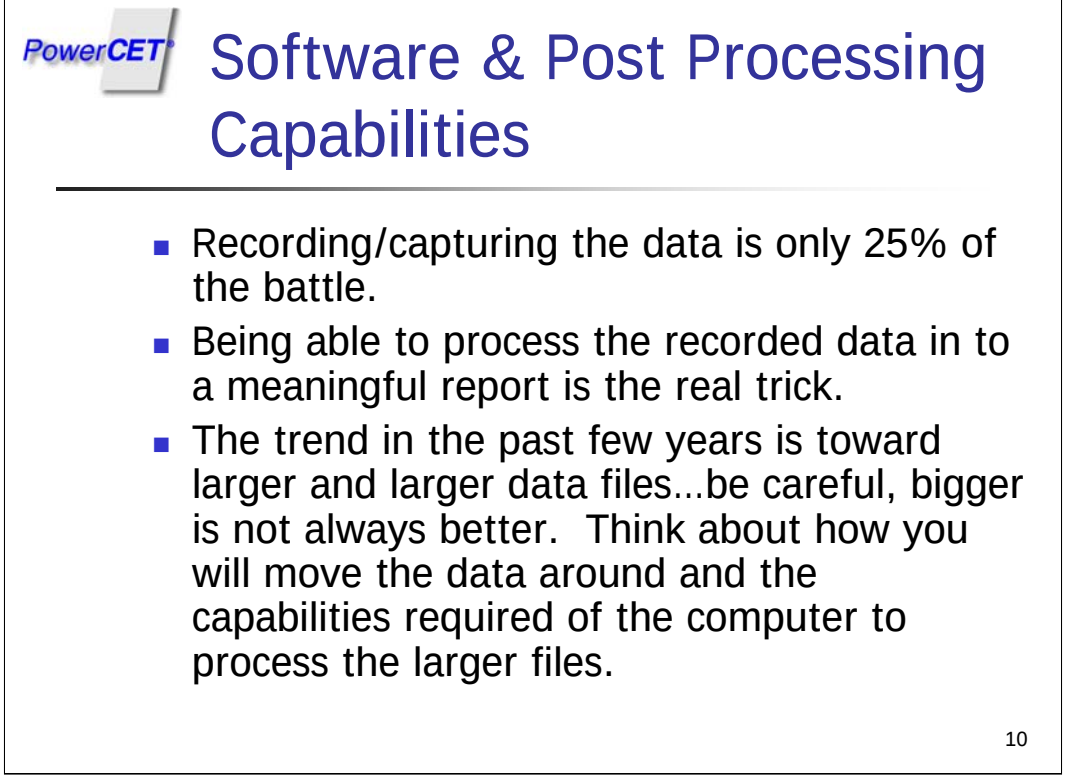


Most monitors are going to require some programming and setup.

Some will feature quick starts, wizards, etc. to aid the user in getting the equipment configured and ready to collect data. The problem is that these “short cuts” are seldom anywhere close to what is really needed. Again, the measurements and thresholds are someone else's idea of what the a specific conditions requires…HOW CAN THAT POSSIBLY BE?

My experience is that the wizards and easy-starts seldom result in the collection of the appropriate data. Remember that the electrical environment is dynamic (always changing) and it is possible to record a lot of anomalies which have no relationship to equipment/process problems.

If you are selecting a monitor that requires configuration then consider how much time you are willing to invest in learning how to do it effectively. If you don’t have the time or interest then don’t buy the monitor…hire someone qualified and rent the equipment…you will ultimately be much happier and probably resolve the problem/condition more economically.



Processing the recorded data is probably the harder task.

The quality and capability of the power monitoring software is all over the map. DB probably has the best and most capable software today with their Dran-View program…it has a lot of features and capabilities which in turn can make it a little complex for the average user. This is another place where you need to decide how much time you are willing to invest.

The old RPM meter had a “report writer” which would regurgitate all of the recorded data in to a 65 page summarization…which was referred to as a report. Keep in mind there was no “analysis” and every report was basically the same.

Also consider that more memory is not necessarily better! Computers can “choke” on large data files…you also have the problem of moving the files from the monitor to the computer and then from computer to computer. IF YOU HAVE AN UNLIMITED BUDGET AND CAN AFFORD A CRAY COMPUTER THEN PROCESSING LARGER FILES SHOULD NOT BE A PROBLEM.

I get a question a week from some user that is looking for larger and large memory cards so they can record more data…no thought as to if they can even process it. More data sometimes leads to ANALYSIS PARALYSIS!

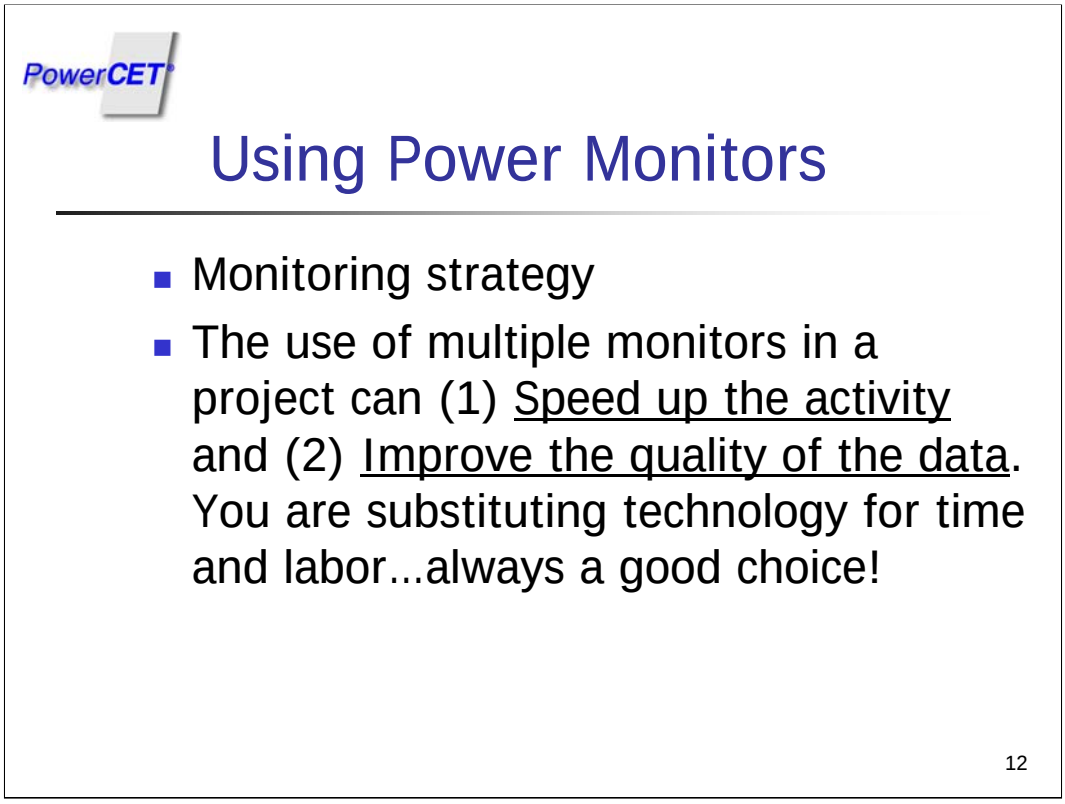
In most cases the salesman hopes he doesn't see you again until it's time to buy another power monitor…after all his job is selling equipment, not teaching you how to use it.

Most monitor manufacturer's have an under staffed customer support capability…after all it is a cost center. They certainly want you to be successful, but would really like not to get involved. Also, don't expect the customer support people to analyze the recorded data for you…three things: (1) it is NOT their job; (2) they are probably not qualified to do it and; (3) there is a liability issue…suppose they do it wrong!!!

Repair / Calibration: Find out who and how much ($$$). It would be nice to know their MTBF or some type of failure data, but you won't get it.

Updating: How is the equipment updated…I have several meters that end up being sent back to the manufacturer every time we try to flash the memory with the firmware update…sometimes the process is not perfect.

Understand that non of the manufacturer's will tell you that they just released a new version of firmware or software…you need to check their web site on a regular basis.



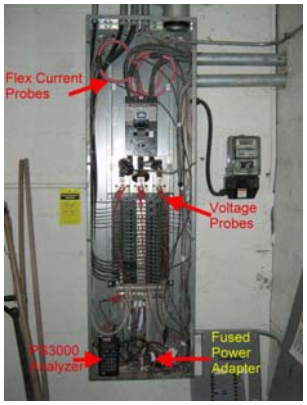
Think about how you plan to deploy the monitor(s).

Everyone shy's away from buying (or using/renting) multiple monitors as to expensive…actually the analysis is flawed.

Using multiple monitors, simultaneous monitoring across a facility, (1) speeds up the activity and (2) improves the quality of the data. What's really happening is that technology, monitoring equipment, is being substituted for time and labor…it is ALWAYS a good choice.

Other Considerations

- Safety...NFPA 70E, OSHA, etc.
- Installation techniques
  - Use flexible current probes...safer and easier to install.
  - Hide the monitor inside enclosure if possible.
  - Label monitoring location.



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Safety should always be our #1 concern and consideration.

If you are planning on installing a power monitor you will need, in addition to an understanding of the monitoring equipment, to be aware of and trained in the proper use of PPE (personal protective equipment), NFPA 70E, OSHA, etc.

The best arrangement when installing monitoring equipment is to completely enclose it in the panelboard or cabinet…this type of installation meets safety considerations as well as security concerns. See photo.

Another consider is to always label the monitoring location…let people know what's going on.

NOTE: A set of 8.5"x11" signs (pdf) can be downloaded from the PowerCET web site http://www.powercet.com/downloads/index.cfm?list=PQReferences. The files are named:

Power_Monitoring_"Danger"_Sign

Power_Monitoring_"Caution"_Sign

Power_Monitoring_"Warning"_Sign

Be Alert to Conditions in the Field

- What is the problem in the photo on the right?

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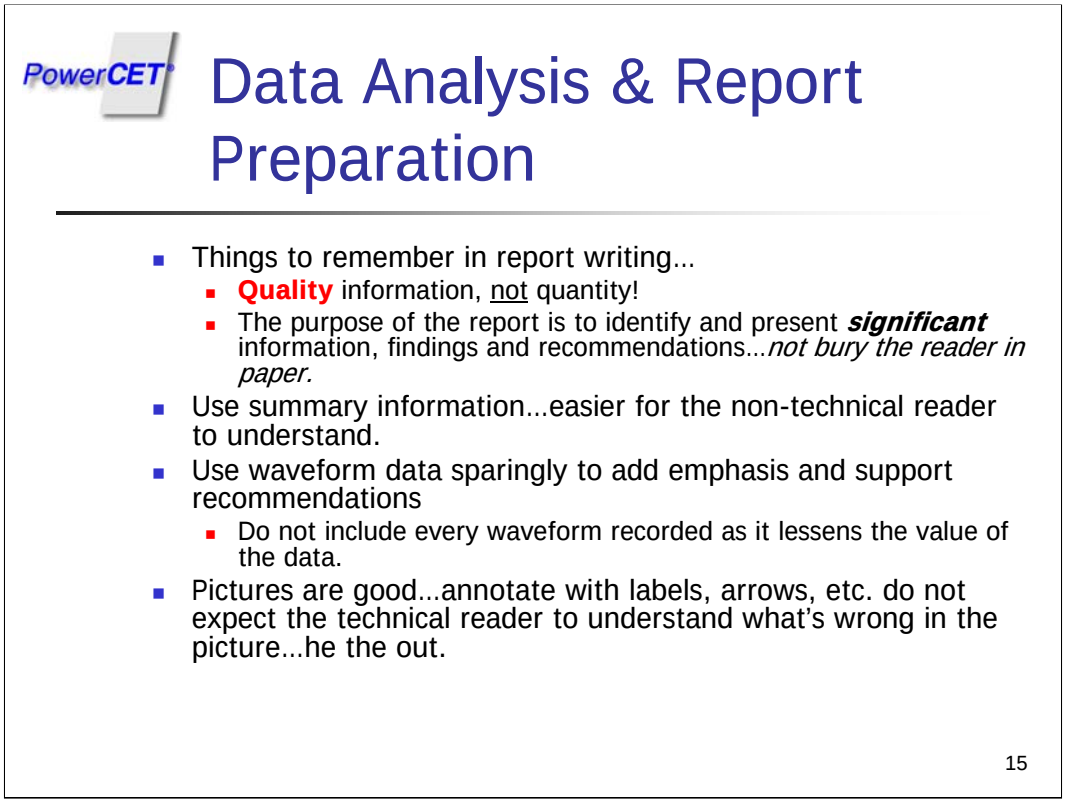
Test question…What's wrong in the picture.

Answer: Parallel feeders should be mirrors of one another. In the photo phase B and neutral are in the bottom conduit and phases A & C in the top conduit. What we have here is an "induction" heater.



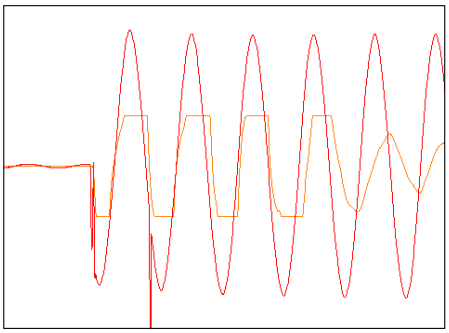
The last thing most people want to do is write the report.

This is a list of suggestions that should make it easier and also result in a better report.

The sooner your write the report the better…even if you don't finalize it get the basics done and then clean it up later. If you wait days/weeks/months the "span of forgetfulness" will come in to play and the report will suffer.

Don't Believe Everything the Monitor "Records"

- Just because a computer printed it out doesn't make it true.
- What are the TWO things wrong in the waveform graphic at the right?



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People tend to believe everything the power monitor "spits" out.

The "test of reasonableness" needs to be applied to all monitoring data.

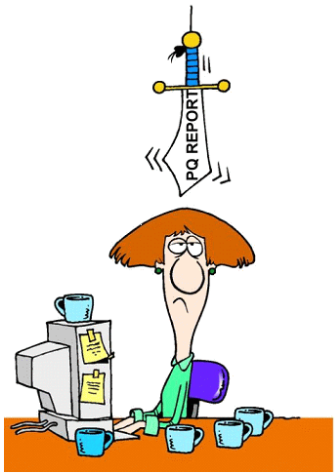
In the waveform graphic there are two things wrong. One is a problem with the software and the other is with the hardware being used.

#1. Software: The impulse on the second negative half-cycle is in the wrong place. The software places it one cycle later than it should be. This was a "know" problem with the RPM software.

#2. The current waveform shows a saturated current probe…the flat-topping of the current waveform is the result of current exceeding the range of the current probe. Typically this gets "interpreted" as 5^{th} & 7^{th} harmonics…WRONG!!!

Report Organization

- Executive Summary
  - Written after the main report is complete.
- Introduction / Overview / Background
- Methodology
- Key Findings & Recommendations
- Summary
- Appendices



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Here is a simple outline or organization for a report.

Introduction/Overview/Background: Keep it simple. A few sentences describing what is being done and why is all that is needed.

Methodology: What equipment was used and what process was followed…again a few sentences is all that is required.

Key Finding & Recommendations: Number the findings. Keep it simple and brief. Use graphics and pictures to help in the understanding. Annotate pictures with arrows or labels…don't assume the reader will know what you are talking about. I typically follow the KEY FINDING with the associated RECOMMENDATION…usually in a different colored type face to make it standout. [Note: Clients seem to like having Key Finding follow by Recommendation so they don't have to page back and forth.]

Summary: Summarize the important points and recommendations…keep it brief…usually words only as the pictures and graphics are in the earlier sections of the report.

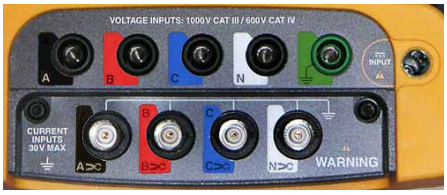
Appendices: Add any additional support documentation that is USEFUL…do not add things just "bulk" up the report.

Executive Summary: If the report is more that 6 or 8 pages you might want an executive summary… never ever more than 2 pages …1 page is better…pictures and graphics are good. *Remember executives have a very short attention span.*

Quick Market Survey

- What's out there?
  - Single Phase
  - Poly-phase
    - Differential Voltage Channels
    - Common Return
    - Measured Neutral vs. Derived

PQ Instrument Inputs



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AEMC

- 3945 & 8335 PowerPad
  - Probably a good choice for building facilities 3-phase applications.
  - Proprietary current interface.
- DataView software

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AEMC PowerPad

The 8335 PowerPad is the newest monitor from AEMC and adds a 4th current channel for direct measurement of neutral current as well as significantly expanded internal memory.

Dranetz-BMI
(Gossen-Metrawatt)

- Portable Monitors
  - PowerXplorer PX5
    - Dual Digitizer…1Ms/s for transient capture
  - PowerGuide 4400
  - PowerVisa 440
    - Distribution ONLY!
    - A PG4400 w/fewer features
    - Fewer pre-programmed setups
    - Limited to 100 post-cycle capture.

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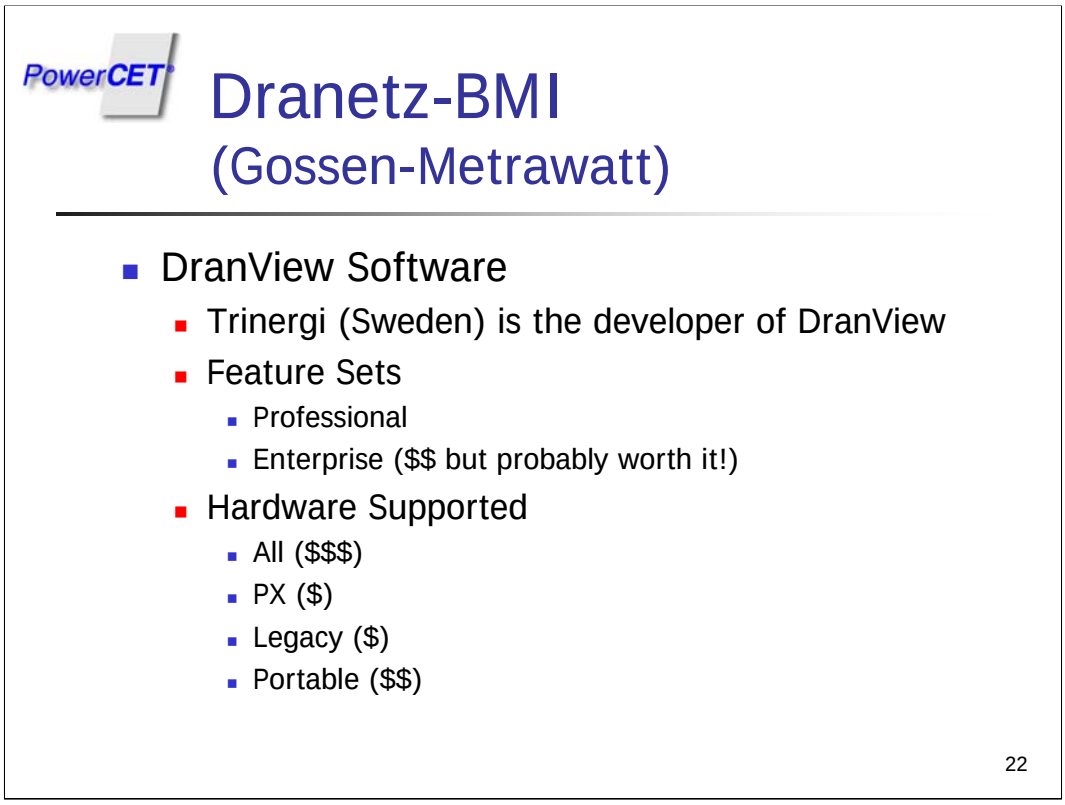
The Dranetz-BMI (DB) family of portable monitors:

DB has recently added the EP1 … EnergyPlatform…to the family of products.

The PX5, 4400 and 440 are event recorders that also log all of the parameters. The EP1 is focused at the energy application, but without all the event triggers and has only limited event capability.

The PowerVisa 440 is probably the best deal and when combined with the DranView 6 software is a very capable monitor. [Note: The PV440 is sold through distribution and was DB answer to the Fluke 430-series.]

The PX5 has some useful capabilities, but they come with a price…DB really wants you to buy the PX5 as the profit margins are quite high for this product.



DranView 6 Software

No question this is by far the best software in the market today.

It comes in two versions…Professional and Enterprise…my recommendation is to go for the Enterprise as it has many more useful features that can post-process recorded data in a number of ways.

Fluke (LEM / Amprobe)

- 430-Series
  - Beautiful Display
  - “Single Minded”
  - Not Intuitive
  - No Removable Memory
- FlukeView software
  - Limited Capabilities
- 1750 Power Recorder
- RPM Power Recorder
  - PAS & Scenario software

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Fluke Power Monitors

The Fluke family of power monitors is really a collection of various repackaged power monitors from companies that Fluke has purchased over the years.

The strength of the Fluke-430 series is the display and use as a real-time 3-phase meter.

The Fluke 1750 is the follow-on to the RPM Power Recorder but without the popular RPM Report Writer software. Biggest problem with the 1750 is that it is still somewhat of a “work in progress.” It captures massive amounts of data and you spend a lot of time looking for the event(s). If you are looking for a portable monitor where you don’t have to worry about thresholds then this could be a good choice…you will pay for it on the data analysis side thought.

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Fluke 1750

- What were they thinking????
  - Power monitors are not always installed in the most ***pristine*** environments
  - A place for dust, dirt, containments…it is going to be a problem!

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Power monitor design issues:

Sometimes I wish the designers would have to actually have to use their designs in the field.

Think about where all this equipment gets designed…in a lab, on a workbench. Little thought or understand of the real-world environment in which the equipment will be place is ever considered.

The best is a warning that the “equipment should not be used in high electromagnetic fields.” Gee…if you are not going to use it on the power system with all those pesky transformers, drives, etc. I wonder where they think one would use a power monitor????

Fluke (LEM / Amprobe)

- Other...Pick one any one!!!
  - 1735 3-Phase Power Logger (LEM Analysts 3Q)
  - 1740 3-Phase PQ/Logger (LEM Memobox)
  - 1760 3-Phase PQ Recorder (LEM Topas)
  - DM-II 3-Phase Logger/Recorder (Amprobe)
  - DM-III 3-Phase PQ Recorder (Amprobe)

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Fluke has a monitor for every use and everyone's budget…pick one!

Hioki

- 3196
  - Probably the best hardware platform…if you are looking to replace a Dranetz 658 this is probably your best bet.
  - Restrictive current probe interface…0.5v full-scale.

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Hioki 3196 (and 3197 smaller version):

Solid hardware platform, missing a few parameters, but can be used effectively.

HiView Pro software is (or should be) a work in progress.

Hioki

- 3197
  - Competes directly with AEMC 3945
  - Good for energy, load studies and 3-phase PQ monitoring.
- Hi-View software
  - Getting better…still a long ways to go.

Summit Technology

- PowerSight PS250
- PowerSight PS3000
- PowerSight PS4500
- PowerSight Manager (PSM) Software

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PowerSight:

Small and simple to use. Has a simple report generator (writer) of logging information. The PS4000/PS4500 is the only product that works on a cycle-by-cycle basis…all the other monitors sample 2 cycles every second.

The PS4500 utilizes Bluetooth for communications with the monitor and support the use of a PDA for setup and operational verification…a big deal when you think about the NFPA 70E arc flash issues. Using the PDA or laptop with Bluetooth it is possible to service the monitoring equipment without having to open the cabinet/panelboard.

PMI

- Eagle series
  - Powered from Interface
  - Wireless or USB Comm
  - -30°C to +55°C
  - Small Size 5.4”x3”x1.25”
  - 0-600Vac
  - 0-5000A (flex probes)

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The PMI Eagle series monitors offer significant size advantages and have a number of nice features. Biggest limitation is probably memory.

Power Standards Lab (PSL) PQube AC Power Monitor

- No software...firmware controlled by ini file.
- Modular
- Networkable / automated reporting
- Universal file format (csv).
- Under $3.5K w/CTs
- Visit PowerCET's PQube at www.71.141.70.60

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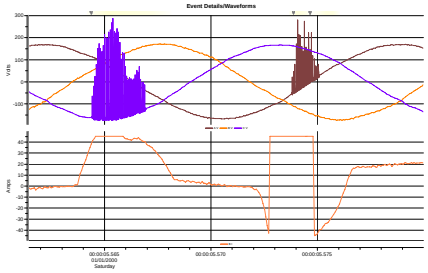
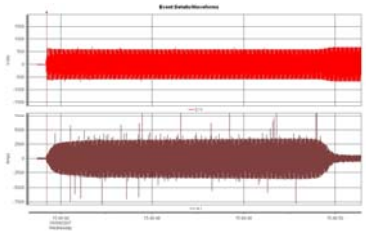
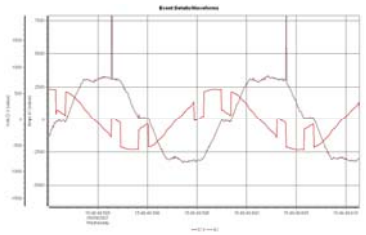
The PQube is the "new kid on the block" and has certainly changed the playing field. The unit is well thought out and has break-through pricing…hardware costs around $2K without current probes. In addition it is very easy to administrate in a network environment and virtually runs its self.

The modular approach and size make it a logical choice for any number of applications.

Cross-Talk Between Channels







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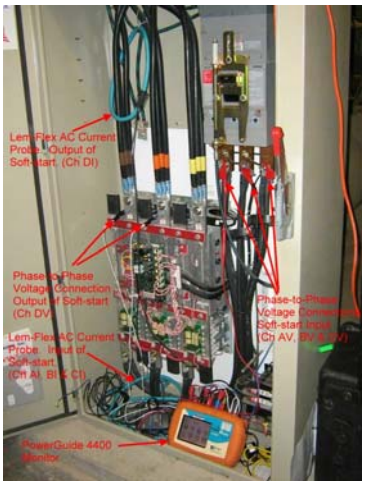
The three graphics in this slide show cross-talk between the voltage and current channels on the Dranetz-BMI monitoring products.

If the user doesn't understand what they are seeing and believes this to be a "real" event there could be significant consequences from the expenditure of resources on a "non-problem."

Users MUST understand the characteristics and limitations of their monitoring equipment…I doubt you will find this in any applications note.

Cross-Talk... Where it Comes From

- Flex current probes do not have good noise immunity.
- Fast dv/dt and di/dt from SCR switching couple.
- Coupled signal often multiplied by scaling factor!
- 1V of noise becomes 1000V transient with a scale factor of 1000.



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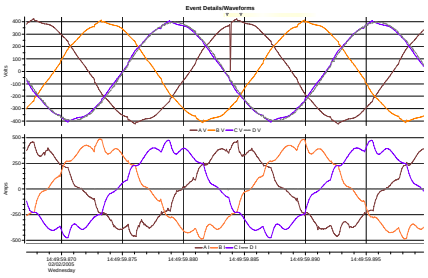
Fortunately some of the newer flex current probes…especially those from PROSyS, the PRO~flex series…seem to have improved immunity to noise.

It is important to understand that any noise that finds its way from the voltage channels into the current channels may be multiplied by the scaling factor for the current probe…in some cases the multiplier is between 1000 and 2000 which can make a 1V signal look like 1000A or 2000A transient.

Phantom Impulse

- Large voltage excursion
- No corresponding change in current.
- Always occurs at or near 90°
- Conclusion...it is not real!



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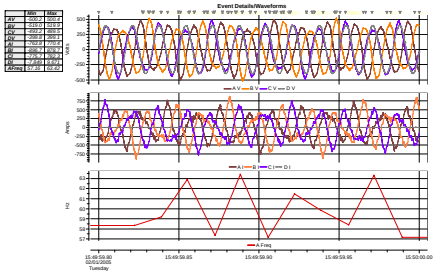
Always, always, always apply the " test of reasonableness" to any data. If you have a 500V transient and there is no corresponding anomalies on the current waveform it probably is not real.

UPS Oscillations

- UPS output oscillations
- Frequency plot is post processed and based on zero crossings of Phase A voltage.



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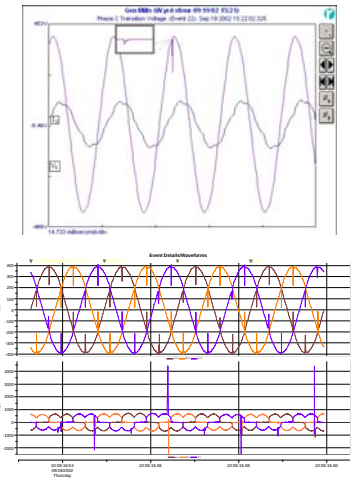
Most power monitors don't really do a good job of measureing frequency. Typically they average the time between zero crossings or a 20 or 30 cycle sample to determine a frequency value.

Capturing a series of waveforms allows the cycle by cyble frequency to be calculated by the software…DranView to the rescue.

Once you understand how power monitors measure frequency it is a simple matter to capture (record) a series of waveforms and calculate the cycle by cycle frequency for any frequency stability testing requirements…beats the heck out of the old Asto-Med recorders.

Adaptive Thresholds

- When things are not as they seem.
  - Adaptive thresholds can make a noisy site look quiet…something to be said for thresholds.
  - Ideal world…can I have both???



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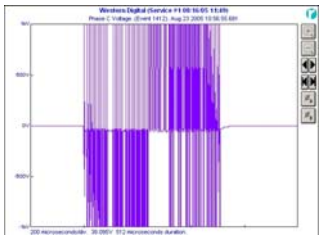
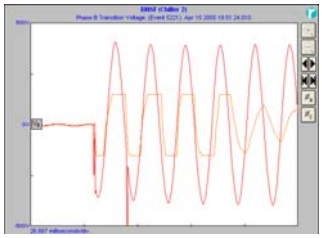
Well the “adaptive thresholds” in the old RPM monitor seemed like a good idea…and it is as long as you don’t have a very noisy environment.

In the graphics above the RPM simply did not record the notches from the large current fed drives.

Is it Real?

- Top
  - Memory problem in RPM...not a real event.
- Bottom
  - Oops...1-cycle impulse delay???





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Some “other” problems with the RPM software that has probably fooled user for years.

Closing Comments

- Monitoring Needs Assessment
  - Infrequent Use = Rent w/Applications Support
  - Frequent Use = Purchase
  - What's going to be monitored
    - Event
    - Energy
- Learning Curve
  - Hardware
  - Software
- Don't Buy More Monitor Than You Need

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Conclusion - 1

- The following are the four most common reasons for selecting a power monitor...
  - Company reputation (brand recognition)
  - Looks / demonstration
  - Price (in this case low price...first time buyers generally select the wrong product)
  - Liked the salesman (do not under estimate the “people buy from people” factor)

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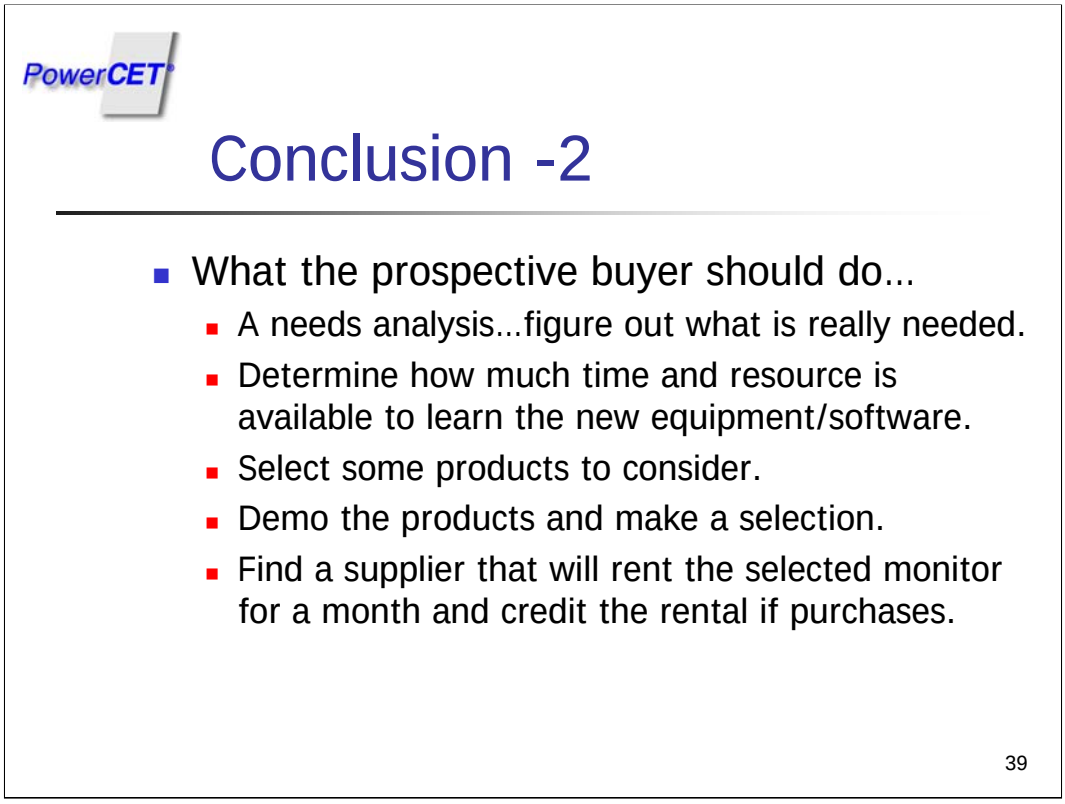
Company Reputation: Name recognition…you blow your nose on a Kleenex…that would be a tissue. Has nothing to do with the equipments capabilities.

NOTE: Ask the group which monitor has the best name recognition…I’ll bet it’s Dranetz.

Looks/Demonstration: “Wow..it looks really cool!” Color displays, touch screens, package/trim color, etc. This is called MARKETING guy’s…next time your are in the electronics store walk up to the wall/aisle with the surge suppressors…which one(s) are you drawn to? I’ll bet it is the one with color!!!

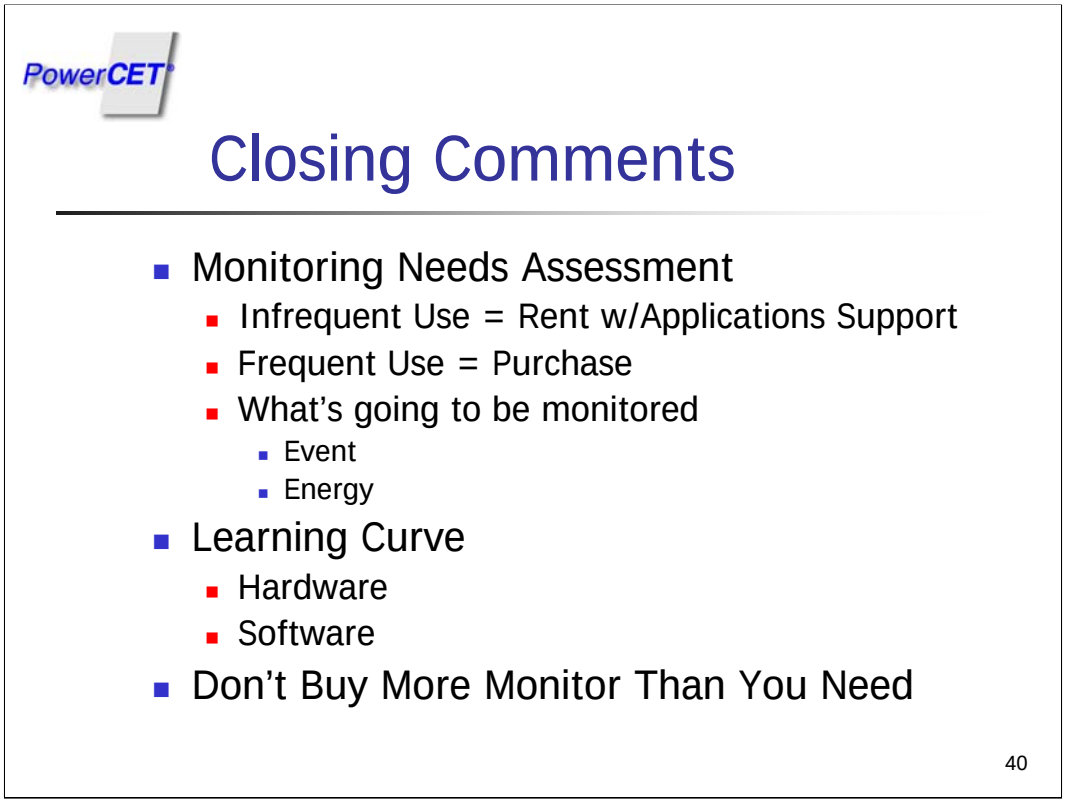
Price: What you really want is good price performance…which may not be cheapest product.

Like Salesman: Basically “people buy from people.” If you like the sales person and they relate to you…which, btw they should be capable of doing…it is easy to buy from them…even if it is the wrong product.



Basically DO YOUR HOMEWORK FIRST!!!

If you prepare properly you (the buyer) won't get sucked in by the items Conclusion-1 (previous slide)



I can not stress to much the importance of the NEEDS ASSESSMENT.

Think about how often the monitor is likely to be used?

What's going to be monitored?

Would you be better off renting the equipment and expertise when needed?

If you are not willing to make the investment in learning the equipment and software then you should really consider the rental for both equipment and expertise…consultant.

If you need is simple load studies or energy monitoring what do you need a high end power quality analyzer for? You can probably buy 3 or 4 energy loggers for the price of one PQ analyzer.

Why *PowerCET*?

- PowerCET enjoys a unique position in the industry and has developed relationships with most of the major manufacturers of power monitoring equipment.
- PowerCET provides education programs on both general power quality and energy issues as well as operational skills training on using various power monitors.
- We use these very same monitors in our own consulting practice so who better to show you how to be successful than someone already using the equipment in the real-world.
- PowerCET can...
  - Help you select the right monitor for your application and needs,
  - Provide the training on how to get the most out of your purchase
  - Provide on-going applications support and knowledge based education
  - Provide calibration and repair service/support for all of your monitoring equipment

If All Else Fails...
...Call the Expert!