# VIRTUAL INSTRUMENTATION AND ITS USE IN ELECTRICITY DISTRIBUTION

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**Abstract**

In opposite to traditional hardware centered instrumentation systems **V**irtual **I**nstrumentation, represents software centered systems. Basically it consisting industry-standard PC computer or workstation equipped with a powerful application software, plug in boards and driver software. In the same time it is a high performance measurement and automation system.
While we cannot change the software and hardware capabilities of traditional vendor defined instruments it is easy to do so with virtual instrumentation.
First when you bought a traditional instrument you had to study the user manual, with virtual instrument you have to make application. For this purpose you need to complete four steps: system specification system setup,software development and system test and calibration.
Here are some examples for virtual instrumentation in electricity distribution:
Power quality measurements and monitoring
Transient(event) recorders,oscilopertubograf
Testing protective relays
Testing circuit breakers
Testing battery systems
In virtual instrumentation these are typical data acquisition **DAQ** systems for test and control.

Keywords : Virtual instrumentation,data acquisition

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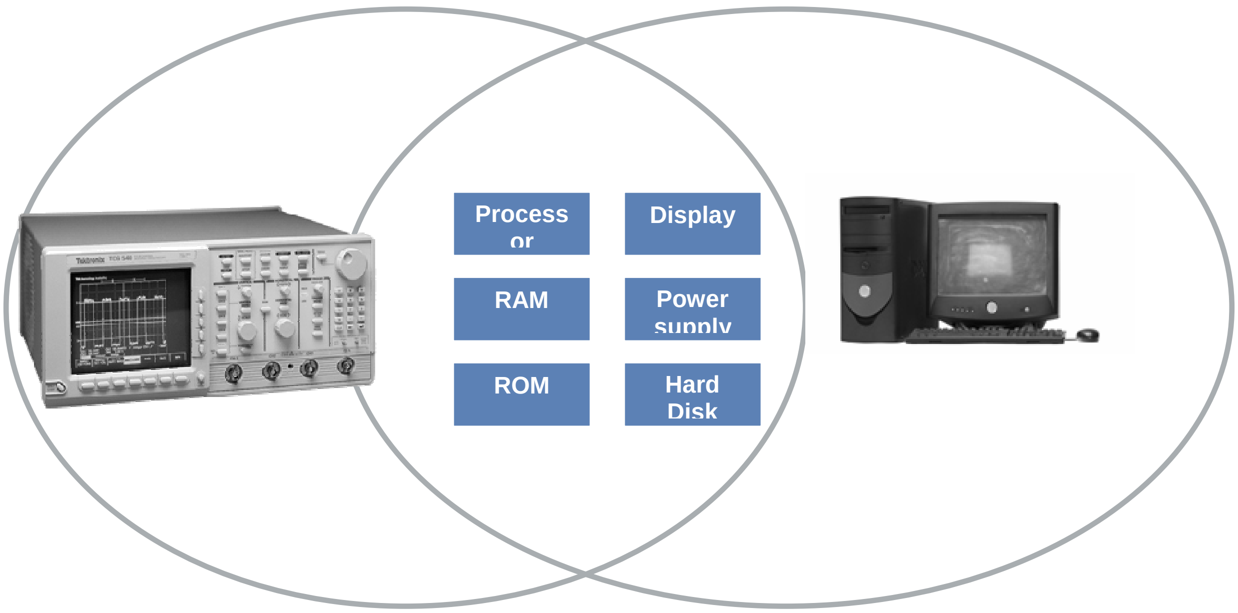
**VIRTUAL INSTRUMENTATION (VI)**

If you were to open the box of a traditional instrument like an oscilloscope, you would see measurement circuitry that captures the real-world signal in digital form, as well a processor, memory, power supply, display with buttons, knobs, etc. Also inside the instrument is a software that is pre-written by the vendor to do a specific measurement. This software is embedded in ROM or a hard disk, and the user cannot change it. It is a closed, fixed-function device that has limited flexibility. The essence of virtual instrumentation is the realization that the computer functionality inside these boxes is already available in standard PCs—and is much more powerful and less cost.
Virtual instrumentation leverages the PC to eliminate the duplication of computer components inside traditional boxes, giving users a more powerful, lower cost, and more flexible solution.

Traditional – vendor defined instrumentation Virtual instrumentation




**DEVELOPING A DAQ SYSTEM**

**System specification**

System specification accounts for 7% of the total cost of data acquisition[1].
A typical data acquisition system based on virtual instrumentation consists of five parts:
**1.Sensors or signals**. In electricity distribution voltages and currents from transformers.Voltages from switches and relays.
**2.Signal conditioning hardware**. Because of high voltages in electricity distribution we use transformer for isolation and voltage attenuators.Also current clamps for current input.Optically isolated digital I/O for and from switches and relays.
**3.DAQ hardware**. Measurment hardware,plug in boards.
**4.Measurment Services software.** A layer between the hardware and application software,provides configuration and installation services,a programming interface,self calibration and other features.
**5.Application level software.** This is the software we need to develop using standard programming environment such as Visual Basic,C,or LabVIEW.

**System setup**

System setup accounts for 23% of the total cost of data acquisition[1].
What hardware we need to build our DAQ system?
Sampling architecture,sampling rate,accuracy,triggering, sensors,these are important factors to be considered when choosing a proper hardware for measure analog signals.
Architecture means multiplexed or simultaneous sampling.Sampling rate is the rate at which data is sampled,for accurate shape representation sample 5-10 x the highest frequency signal being measured. For example multiplexed DAQ card whith 16 analog inputs and 500 ks/s will sample each channel with 31,25 ks/s.Undersampling may result in the misrepresentation of the measured signal that we call aliasing.Accuracy is the specification of entire DAQ device it consists of resolution,nonlinearity, temperature drift,system noise,amplifier gain and offset errors.For example the 12 bit DAQ supplies 4096 levels of resolution over $\pm$10V measuring range (5mV) but the absolute accuracy is much smaller.For 240 VAC voltage measuring the absolute accuracy is < 60mV.When measuring current the application software must linearly convert voltage back to current since DAQ devices cannot directly measure current,so I=Vin/R (where Vin is input voltage and R is resistor that we use for conversion).
The next equation determine the code width which is the smallest signal change that system can detect

Code width= $\frac{Range}{Gain \times 2^{\mathrm{Re}\,solution}}$ .To determine the minimum current value that you can measure divide code width with resistor value used in conversion.Range is 20 V if you measure signal between -10 to 10V.Gain is determined by input limits of the application and is apply to amplify or attenuate the signal,expressed in decibels

Gain= 20 Log (f).

Triggering causes the device to read data into the PC,you can choose analog or digital triggering.
When measuring high voltages we need conditioning and isolation because DAQ devices measure at a range of only -10 to 10V.

**Software development**

Software development accounts for 30% of the total cost of data acquisition[1].
For sortware development we use configuration-based tools and programming tools.
Configuration-based tools offer simplicity but have limited functionality and we can use them for test and design. Programming tools offer maximum flexibility for your data acquisition application through a graphical or text-based programming environment and can be used in a variety of different application spaces, including test, control, and design.
Let us build a VI in graphical programming language that can measure voltage from multifunction DAQ device,
make spectral measurements and write it to a file.
First you create DAQ task,a collection of one or more channels,timing,triggering,and other properties.
This is what we call configuration and measurement or generation.So we create an analog input task with voltage to measure,select input range,task timing and number of samples to read also define task triggering mode.
You can use a configuration management interface built into DAQ Measurement Services software to view and configure all measurement software and hardware in your system.This allows you to set properties and parameters of hardware, verify hardware setup with device selftests and test panel windows, and self-calibrate data acquisition hardware. In addition, it provides connection diagrams.
Figure 2 is a configuration window with connection diagram and figure 3 is a test panel.

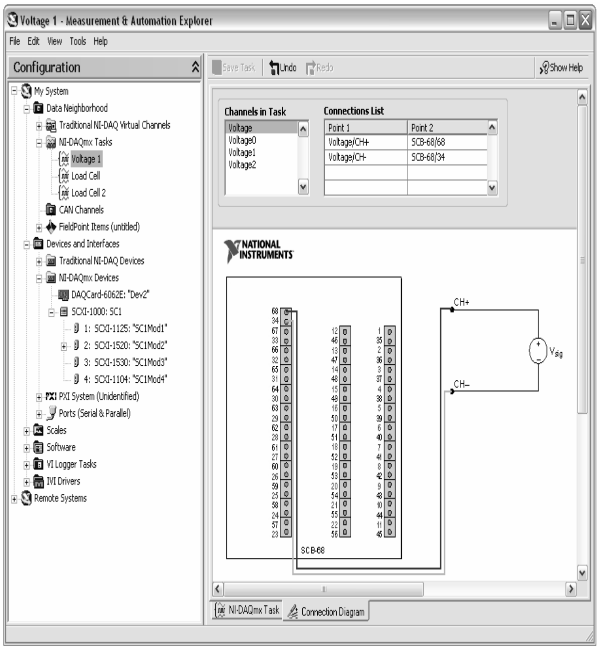



Figure 2

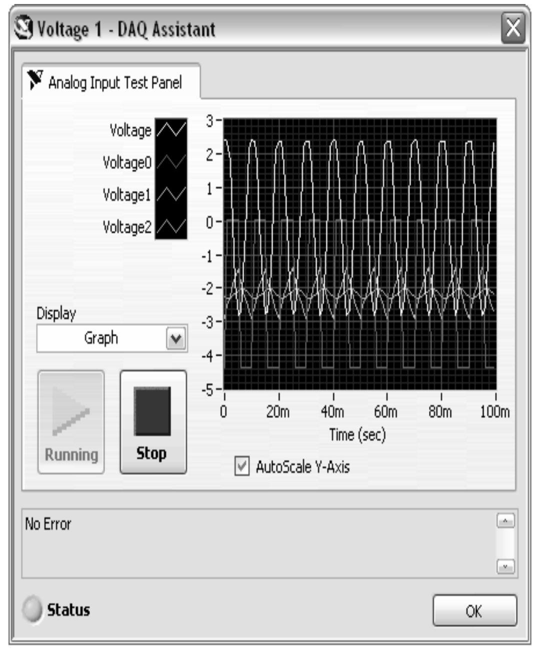



Figure 3

Then you build a user interface,or front panel,with controls and indicators.Controls are knobs,push buttons,dials and other input mechanisms.Indicators are graphs,LEDs,and other output displays.
As you put objects on the front panel they appear on the block diagram,now you can add code by wiring this objects and using functions and structures to control front panel objects.Block diagram contains this code.Figure 4 shows user interface or front panel and figure 5 block diagram.

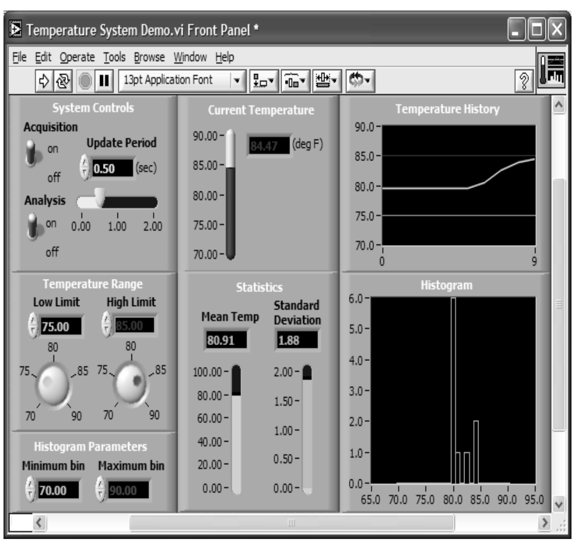



Figure 4.

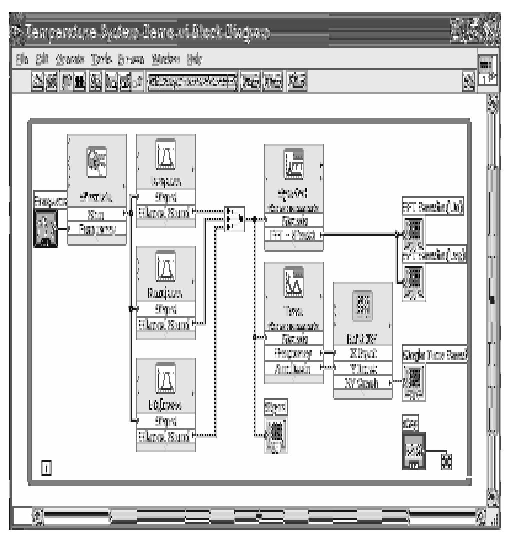


Figure 5.

**System test and calibration**

Software development accounts for 4% of the total cost of data acquisition[1].
Analog-to-digital converters (ADC) and programmable amplifiers are characterized by nonlinearities and drift due to time and temperature. Compensating for these inherent sources of error requires device self-calibration.Data acquisition devices use an onboard precision voltage reference to perform a two-point calibration for a single measurement range. This method fails to protect against localized nonlinearities over the range of the ADC. Additionally, because this method only calibrates at a single input range, measurements that scan multiple channels at varying input ranges are limited in accuracy by the tolerance of a resistor network.
Some devices incorporate linearization and calibration engines which calibrates at thousands of voltage levels and at all input ranges.They use pulse width modulation (PWM) in conjunction with a high precision voltage reference. The duty cycle of the PWM is used to vary the voltage level, enabling self-calibration at multiple points. Calibration constants are generated and stored in an onboard EEPROM to model the nonlinearity of the ADC and correct subsequent measurements.

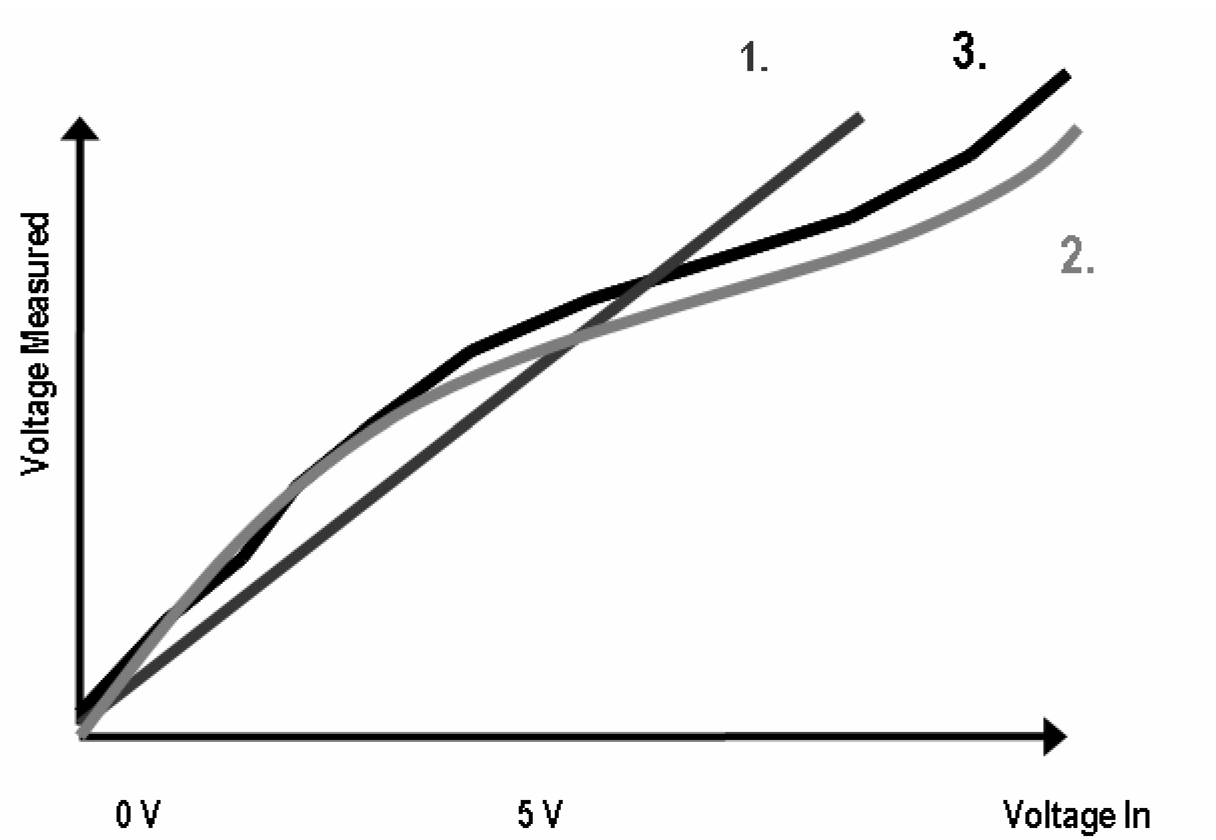



Figure 6

Legend
1.Two point calibration measures at 0V (ground) and 5V (precision source) and applies linear correction to all measurements.
2.Polynomial correction from multiple calibration points.
3.All analog to digital converters are nonlinear.

**Conclusion**

A recent study of data acquisition (DAQ) showed that 64 percent of the total cost of data acquisition is attributed to development time costs. The total cost of data acquisition is not only the price of the software and hardware but also the cost of development. These hidden costs are often overlooked but they actually can make up the majority of the total cost of the system. Hidden costs include system specification, setup, software development, and system test and calibration.

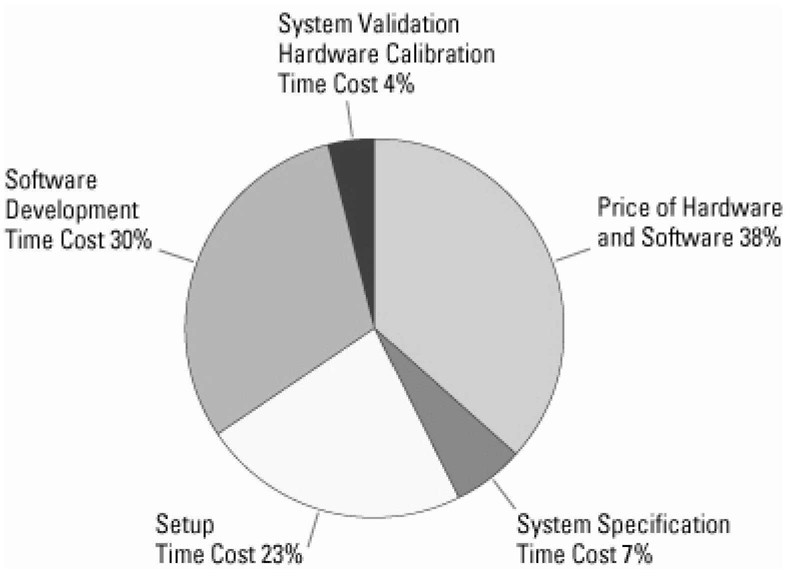



Figure 7.

[1]National Instruments,2004,Survey of DAQ Customers and Prospects,n=377
[2]National Instruments,2002,DAQ SCB-68 User Manual,5-5