

VIRTUAL INSTRUMENT OR MEASURING SYSTEM?

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Abstract: The paper relates to the description of Virtual Instrument (VI). A new conceptual model of a virtual instrument is proposed. The model describes not only measuring devices, but also devices that can generate signals both analogue and digital. A compatibility between this model and a model of SCPI devices is shown. A new proposition for description of measurement equipment is also proposed. It makes more clear the classification of measurement equipment and enables one to differ a virtual instrument from a measuring system with a graphic user interface.

Keywords: virtual instruments, measuring systems

1 INTRODUCTION

Virtual-reality techniques enable us to move in a world created by computers, not existing in reality, to operate devices which are not real devices, to create quite new possibilities in developing new ideas. Virtual reality has come to metrology as virtual instrumentation. Virtual instruments are the fourth generation of measuring devices. The term „Virtual Instrument“ (VI) can be interpreted in the various ways [1],[2],[3],[4],[5],[6]. This problem was considered by the author in [7],[8],[9],[10],[11].

Analysing various definitions one can say that there is no universal industry-defined terminology of what composes a VI. Criteria, which allow us to qualify a measurement equipment as a VI and to differentiate a VI from a measuring system with a graphic user interface (GUI), are not well described. The acceptance of a graphical method of software designing as an attribute of VIs seems to be objectionable. After detail discussion a new definition of a virtual instrument was proposed [9]:

„Virtual Instrument can be described as an instrument composed of a general-purpose computer equipped with cost-effective measurement hardware blocks (internal and/or external) and software, that perform functions of traditional instrument determined both by hardware and software, and operated by means of specialised graphics on the computer screen“.

Virtual instrument consists usually of PC-type computer and measurement hardware units, as: data acquisition boards, signal generating boards, VXI modules, IEEE-488 instruments, RS-232 instruments and others. Each unit can be connected directly to PC bus (as plug-in board), or via interface (as external unit). Virtual instrument can be bought or designed and built by user, who defines it's functions and features designing appropriate software. The software integrates PC and measurement hardware units, creating new virtual instrument; so this software is the integrated part of the instrument. The functionality of the VI depends on software processing technique. Structure of software part of virtual instrument is shown on Figure 1.

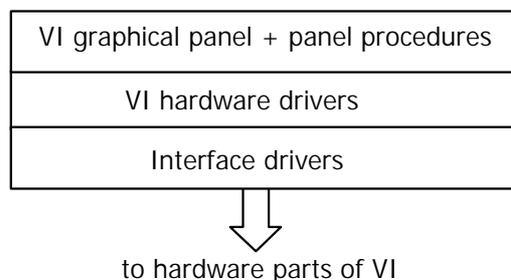


Figure 1. Structure of software part of virtual instrument.

The front panel of VI is the *graphical panel* presented on the computer screen, that comprises a graphic representation of conventional controls (e.g.. buttons, potentiometers, switches) and indicators (e.g. digital and analogue indicators, displays, oscillograms). The advanced graphic features of modern

computers allow for implementing very realistic user interface, that is similar to the real one. The graphical panel is supported by a set of software procedures, that perform all measurement, communication and control functions. The distinguish feature of this software is „event method“ of work. The program is staying in the idle state. When the user changes a setting on the graphic panel (e.g. pushes the button or chooses the function), the event is generated from the panel to the panel software. The procedure, appropriate to the event, is performed (e.g. sending the function setting to the hardware). When the procedure is finished, the program returns to the idle state, and is waiting there for the next event. So, the program is the set of event procedures. *VI hardware drivers* consist of a set of function, that are used for communication with a hardware part of VI (for example: sending of settings, triggering of measurement, receiving of results). *Interface drivers* covers programs for management of standard interface buses (e.g. IEC-625, VXI, RS-485, Internet) or/and non-standard one (for example PC-bus).

Virtual instrument became a new quality in measurement techniques. But it's definition is not equivalent in meaning. There are two possibilities of this definition interpretation: *standard* or *extended*. According to the first interpretation, an equipment can be qualified as a VI, when its hardware part and software part cannot operate separately as a measuring instrument. According to the second interpretation, an equipment can be also qualified as a VI in this case, when its hardware part can operate separately as the stand-alone measuring instrument, but software part emulates a graphical front panel on the PC screen to control remotely the instrument. Then the software does not create any new quality, does not change its functions and capabilities.

The author proposes to interpret this definition in a strict sense (standard interpretation). Then software creates a new metrological quality, creates a new measuring function. Such an interpretation enables one to differ a VI from a measuring system with a GUI.

In this paper a new conceptual models of a virtual instrument are proposed, that describe not only measuring devices, but also devices that can generate signals both analogue and digital. A compatibility between these models and a model of SCPI devices is shown. A new proposition for description of measurement equipment is also proposed. It makes more clear the classification of measurement equipment and enables one to differ a virtual instrument from a measuring system with a graphic user interface.

2 A NEW CONCEPTUAL MODEL OF VIRTUAL INSTRUMENTS

A conceptual model of virtual instruments, presented in [8], [9], [10], was concerned to measuring instruments. This model can describes only measuring devices. But there are also devices that can generate signals both analogue and digital. So, a new conceptual models of virtual instruments can be proposed, that describe both measuring and generating devices. These models are presented on Fig. 2 and Fig. 3.

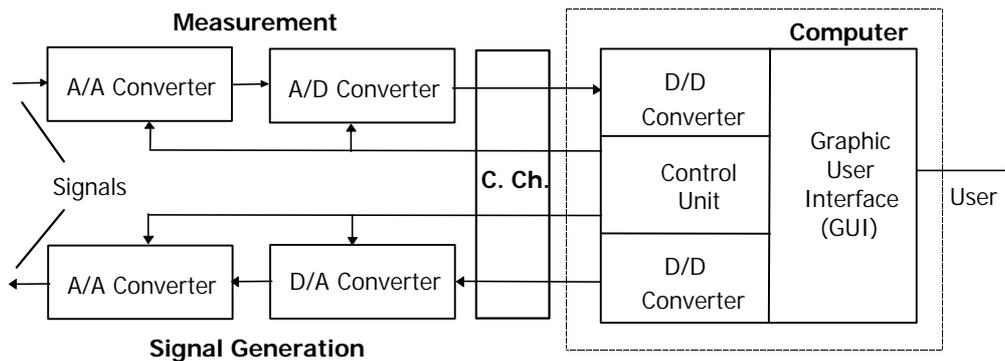


Figure 2. Structure of virtual instrument using data acquisition and generation modules.
(C. Ch. - communication channel)

The virtual instrument can consist of all above elements or their subset. It can also cover many measurement and/or generation hardware parts. Instead of traditional instrument, there is possible to realise a multiple VI based on one set of the hardware part. For example: using multi-input data acquisition plug-in board connected to PC one can design virtual multimeter, spectrum analyser, oscilloscope, signal generator, and others. A communication channel enables one to connect hardware parts of VI not only by using traditional channels (as IEEE-488, RS-232 or μ P-bus, etc.), but also using radiocommunication tools (e.g. GSM), cable network (e.g. Internet) and others.

The structure of VI is similar to SCPI (Standard Commands for Programmable Instruments) device model [12], which is presented in modified form on Fig. 4: A/A converters of VI correspond to INPut

3 A NEW WAY FOR DESCRIPTION OF MEASUREMENT EQUIPMENT

Each instrument channel consists of three main functional parts: signal acquisition or generation (F_1), data processing (F_2), data presentation (user interface) (F_3). Their technical realisation (R_1 , R_2 , R_3) depends on a type of an instrument. The methods of each function realisation enable us to qualify a measurement channel as a traditional instrument, or as a VI, or as a measuring system with a GUI. Three sets of the realisation may be described as follows:

$$R_1 = F_1(H) + F_2(H) + F_3(H) \quad \Rightarrow \quad \text{TI} \quad (1)$$

$$R_2 = F_1(H) + F_2(H) + F_3(S) \quad \Rightarrow \quad \text{MS/VI} \quad (2)$$

$$R_3 = F_1(H) + F_2(S) + F_3(S) \quad \Rightarrow \quad \text{VI} \quad (3)$$

where:

F_1 - functions of data acquisition or signal generation (A/A+A/D or D/A+A/A conversions),

F_2 - functions of data processing (D/D),

F_3 - functions of data presentation (user interface),

H - hardware realisation,

S - software realisation (performed by general-purpose computer),

with that:

if the function F_k is a set of functions F_k^n ,

$$F_k = \sum F_k^n, \quad (4)$$

then the rule of the logical sum is applied to combine F_k , where $F_k^n(H) = 0_{\log}$, and $F_k^n(S) = 1_{\log}$; it means that if there is even one F_k^n realised by software, then $F_k = F_k(S)$.

TI - traditional instrument,

MS - measuring system with GUI,

VI - virtual instrument;

The first realisation (R_1) corresponds to a traditional instrument (analogue or digital), in which all functions are realised by hardware encapsulated in stand-alone box. The third realisation (R_3) concerns to typical VI, when only a data acquisition or signal generation functions are performed by hardware (A/A and A/D converters or D/A and A/A converters) and all remaining functions - by software (PC). Measurement function cannot be separately performed by hardware part of a VI. This hardware part - usually reduced to minimum - is not a complete measurement channel. Software part (performed by a PC) is an integrated part of an instrument. As an example of that instrument, a cheap spectrum analyser is given: the data acquisition PC-1200 board (National Instruments) is inserted into the IBM PC; the computer calculates FFT spectrum and the results are displayed on the PC screen. As an another example, a wattmeter, consisting of stand-alone IEEE-488 voltmeter and ampermeter connected with PC, is presented. A power is calculated by the PC using voltage and current values measured by the IEEE-488 instruments. Software creates a new instrument - a wattmeter. A hardware part of this instrument is in a form of stand-alone other instruments, but a measurement function of the VI is different from functions of each stand-alone instrument. Another version of such solution is based on voltage and current transducers [14],[19]. The second realisation (R_2) asks for the attention. Data acquisition, generation and processing functions (F_1 and F_2) are implemented by hardware, data presentation function (F_3) is performed by computer software as a GUI. The realisation can correspond to a VI or to a measuring system with a GUI dependably on the F_2 hardware realisation method and on interpretation of the VI definition. Two main cases can be considered:

- a hardware part of the instrument cannot operate separately as a measuring instrument; there is no hardware realisation of user interface (Fig.2); (e.g.: voltage/digital converter in a form of plug-in module, that can be used to design of a virtual voltmeter);
- an instrument contains its own hardware realisation of user interface (Fig. 3), (e.g.: stand-alone instrument - Fig.5, or set of instruments - Fig.6), a computer displays a GUI that emulates the operations of the instrument (instruments) but do not create any new measurement function.

In all these cases, measurement functions are determined by hardware part of a instrument. Software performs only a graphical user interface. Such instrumentation is usually called as a measuring system equipped with a GUI. Can the system be qualified as a virtual instrument? Accepting extended interpretation of a VI (when software front panel is a sufficient attribute of a VI), both above systems could be qualified as virtual instruments. But accepting interpretation of a VI in a strict sense (when VI hardware part connected to a PC is not able to perform separately these function, that are performed together with the PC software as a VI), only the first system can be qualified as a virtual instrument; the second - could be called as a measuring system with GUI or as a remote controlled instrument, where instruments could be connected to PC directly (Fig.5) or via network (Fig.6) [20],[21]. So, a VI can be qualified as a measuring system, but not every measuring system can be qualified as a VI. Acceptance of the interpretation of a VI definition in a strict sense makes more clear the classification of measurement equipment.



Figure 5. Virtual instrument or measuring system (instrument connected to PC via IEEE-488-bus) ?

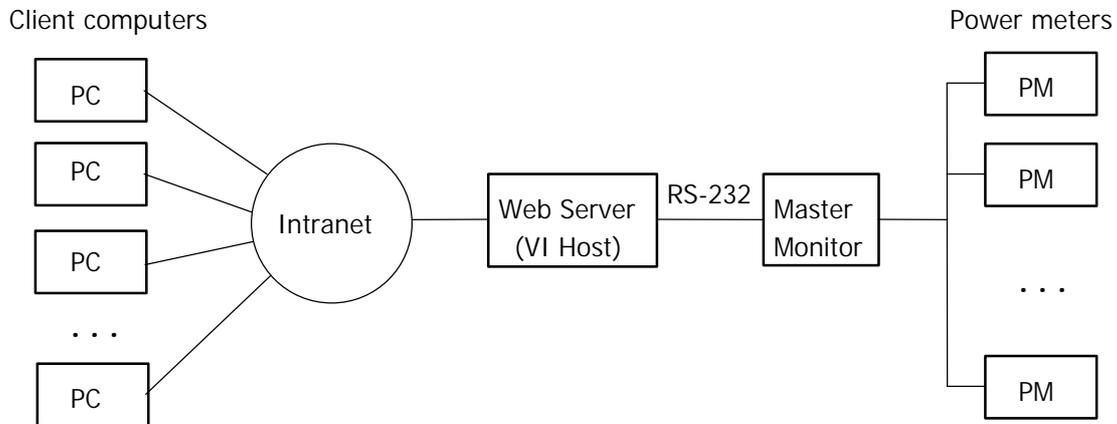


Figure 6. Virtual instrument or measuring system (a set of power meters connected to PC via Intranet) ?

4 CONCLUSIONS

The author proposes to interpret the definition of a VI in a strict sense. It means that an equipment can be qualified as a VI, when its hardware part and software part cannot operate separately as a measuring instrument. Then software creates a new metrological quality, creates a new measuring function. Such an interpretation enables one to differ a VI from a measuring system with a GUI. The first aim of the paper is to propose a new conceptual model of a virtual instrument, that describes not only measuring devices, but also devices that can generate signals both analogue and digital. A compatibility between this model and a model of SCPI devices testifies a novelty of virtual instruments. The second aim is to propose also a new way for description of measurement equipment, that makes more clear the classification of measurement equipment and enables one to differ a virtual instrument from a measuring system with a graphic user interface.

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