Virtual Instrument for Estimation of the Short-Circuit Equivalent Parameters of a Asynchronous Motor

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Abstract

In this paper work, using LabView graphical programming environment are implemented the virtual instrumentation concept, realizing a virtual instrument which can be used at the short-circuit testing of asynchronous motor, in searching and testing laboratories of electrical machine and drives, from university or preuniversity system from scientifique world or industry. This virtual instrument permits the estimation of parameters to the electrical equivalent circuit. This can be realized rapidly and cheap using a PC and a data acquisition interface. In order to realize this program which represent this virtual instrument, we used the simulation of a monophasated currents and tensions system.

Key words: *Asynchronous Motor's Short-circuit Testing, Measurement's Virtual Instruments, Parameters of the Equivalent Electrical Circuit.*

Introduction

In learning process, but especially before the practical solve of an experiment and in researching-projecting activity are used more and more in our days ways and instruments of replacing; not only for the object, process or observing phenomenon, measured or studied but only for instruments or ways which measured different of it's parametres.

For this, it has a benefit from high performances of PC's (memory, speed, calculation capacity) and using soft programs like Visual Basic, C/C++ and LabView graphical programming environment (which can be considered a real standard in graphic programming domain) have been obtain so called Virtual Measurement Instrument –VIs; these are application programs from who command elements have graphical representations equal with correspondent elements from frontal blocks of classical measurement instruments.

The short circuit test on the asynchronous machine is similar to the short circuit test on the transformers and the wiring diagram are given in (fig. 1. a). In the short circuit test, a reduction on the applied voltage is achieved by inserting an RT (Tension Regulation) in series with the stator terminals of the motor. With RT helping has been applicant a variant tension from 0 value to U_{kN} value, for who the line current is equal with motor's nominal current. Usually, the test are making at $U_{1k} = (0.15 \div 0.25) \cdot U_{1n}$.
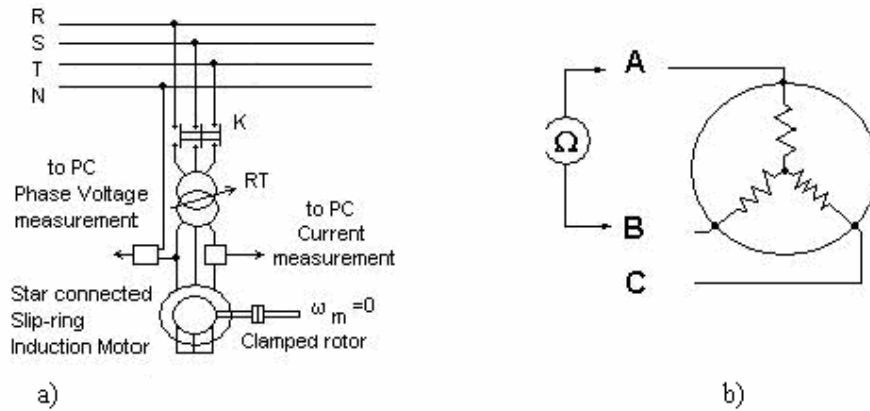
Fig. 1 . The wiring diagram:

a) - for the shortcircuit test ; b) for estimate phase's resistance R_1 (b)

Starting resistors should be short circuited during the test. Calculate the per-phase resistance R_1 allowing for +5% skin effect:

$$R_1 = \frac{R_{average} \cdot (1 + 0.05)}{2} \tag{1}$$

where:

$$R_{average} = \frac{R_{AB} + R_{BC} + R_{AC}}{3} \tag{2}$$

R_{AB}, R_{BC} and R_{AC} are resistances measured (fig.1. b) between bounds adding two by two from winding's stator star connected.

The per-phase active power is calculated from the rms values of the line current I_k, the phase voltage U_k and the phase:

$$P_k = U_k \cdot I_k \cdot \cos \varphi \tag{3}$$

With the rotor blocked (s=1) and with a reduced voltage applied to the stator terminals, the magnetizing branch current is negligibly, therefore the shunt branch ($R_m\|X_m$) (fig. 2. a) in the equivalent circuit can be neglected (fig. 2. b).
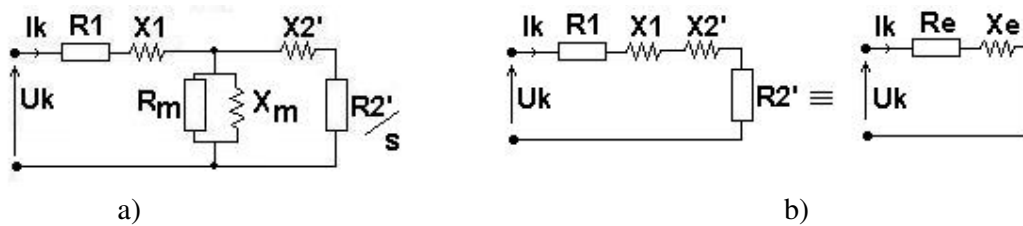

a)   b)

Fig. 2.

The equivalent short circuit parameters can be calculated as:

- the per-phase equivalent impedance: $\quad Z_{ek} = R_{ek} + jX_{ek} = \dfrac{U_k}{I_k}$ (4)

- the per-phase equivalent resistance: $\quad R_{ek} = \dfrac{P_{ek}}{I_{ek}^2} = R_1 + R_2'$ (5)

- the per-phase equivalent reactance: $\quad X_{ek} = \sqrt{Z_{ek}^2 - R_{ek}^2}$ (6)

When we know phase's stator resistance R_1 (that was measured) and the per-phase equivalent resistance R_{ek} (that was calculated) has been determining rotor's resistance referred to stator side:

$$R_2' = R_{ek} - R_1 \tag{7}$$

Similar to the transformers and supposing that the leakage reactance R_{ek} is divided equally between the primary and the secondary windings have been determining stator's reactance X_1 and rotor's reactance referred to stator side X_2':

$$X_1 = X_2' = \frac{X_{ek}}{2} \tag{8}$$

Virtual instrument presentation and description

Virtual instrument has been "written" using graphical objects offered by LabView graphical programming environment, (v.7 Express). It is presented user interface (*Front Panel*) which are composed by graphical objects like: tuning buttons, knobs, push buttons, indicators, graphs, LED's and the code using VIs to control the front panel objects. The *Block Diagram* contains this code.

Front Panel

The front panel of the test Virtual Instruments (VI) are given in (fig. 3). In the central part is placed a graph where the tension's and current's waveforms are displays. With horizontal and vertical cursors helping, are determined with precession different instantaneous values of tension, current and phase angle (in degrees).

In the left part of graph are placed some controls with are established input size of instruments: the resistance values R_{AB}, R_{AC}, R_{BC} before measured with an precision ohmmeter; the phase angle determined earlier; maximal values of tension's and current's.

In the right part of graph are placed the indicators with are displays numerical values of: the stator winding resistance R_1 that was measured; the rms values of the phase voltage U_k and the line current I_k; the active power P_k (corresponding to the loss in windings at short-circuit);

the equivalent circuits parameters: the equivalent impedance Z_{ek}, the equivalent resistance R_{ek}, the equivalent reactance X_{ek}, the leakage reactance of the stator winding X_1, the leakage reactance of the rotor winding referred to stator side X_2', rotor winding resistance referred to stator side R_2'.

In the downside part of graph, in the left corner are placed an switch ON-OFF; in the central part are placed two indicators wich indicated the time (hh.mm) and data (mm.dd.yyyy) of testing.
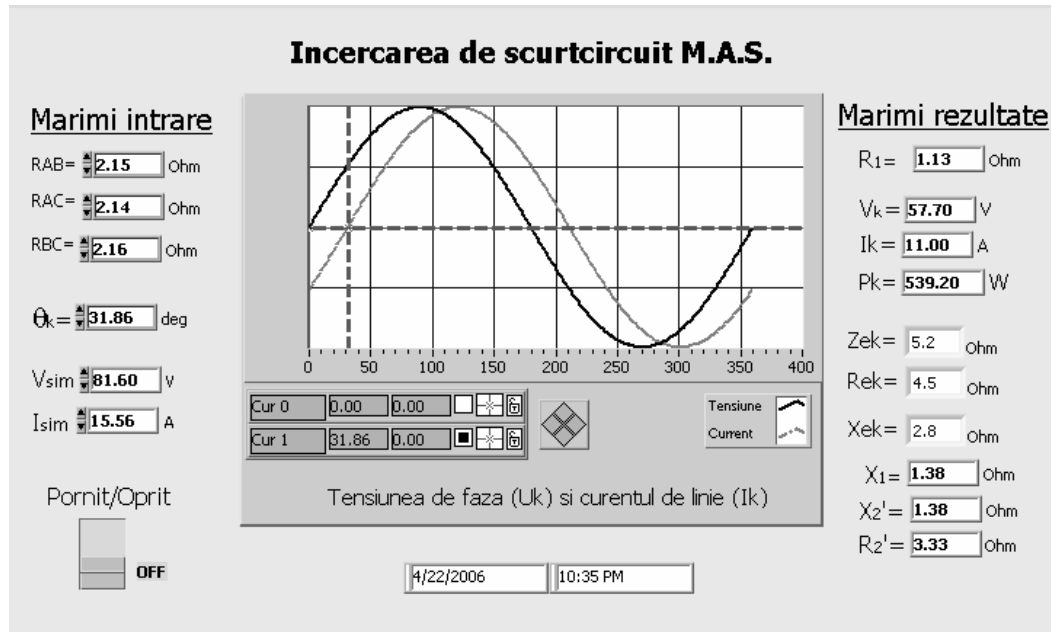

Fig. 3. – The Front Panel of the Virtual Instrument

Block Diagram

After the front panel's elements and aspect are established (with different decorative elements: lines, forms, colors) had been passing to the program step, and in fact at the realization of block diagram. It is knowing that once with the fixed on the front panel of control elements (controls and indicators), automatically in block diagram appears even these symbols. After that we can bounded then and we can complete with functions. In (fig. 4.) are presented the block diagram of the virtual instrument. After the functions have been established which that they are complain virtual instrument (Multiply, Subtract, Square Root, etc.), these together with the blocks used for simulation (current and voltage) are included in a conditional structure (type CASE structure). This structure are executed one of the two frames (True/False), depend on Boolean evolution given from switch OFF/ON which represent the conditional instruction of the structures. All of this presented elements from now (graphical blocks and structures) take part in a repetitive structure (type While), which executed them till now at the finishing terminal (right corner-downside, the "Stop if True" state) arrives logical values True.

In order to generate the signals for simulation monophase voltage and current are using two identical VIs, having inputs: samples, amplitude, phase (degrees), cycles. This VIs are founding in LabVIEW with path: *Functions»Analyse»Signal Processing»Signal*

Generation»Sine Pattern. I . They follow calculate rms for this signals using RMS.vi which are founding with path: *Functions»Analyze»Mathematics»Probability and Statistics*. Instantaneous measure for voltage and current, expressed in relative values are been represented to the same graphic, like to observe easily there evolution and their angle measurement (in degrees, with vertical cursors helping).
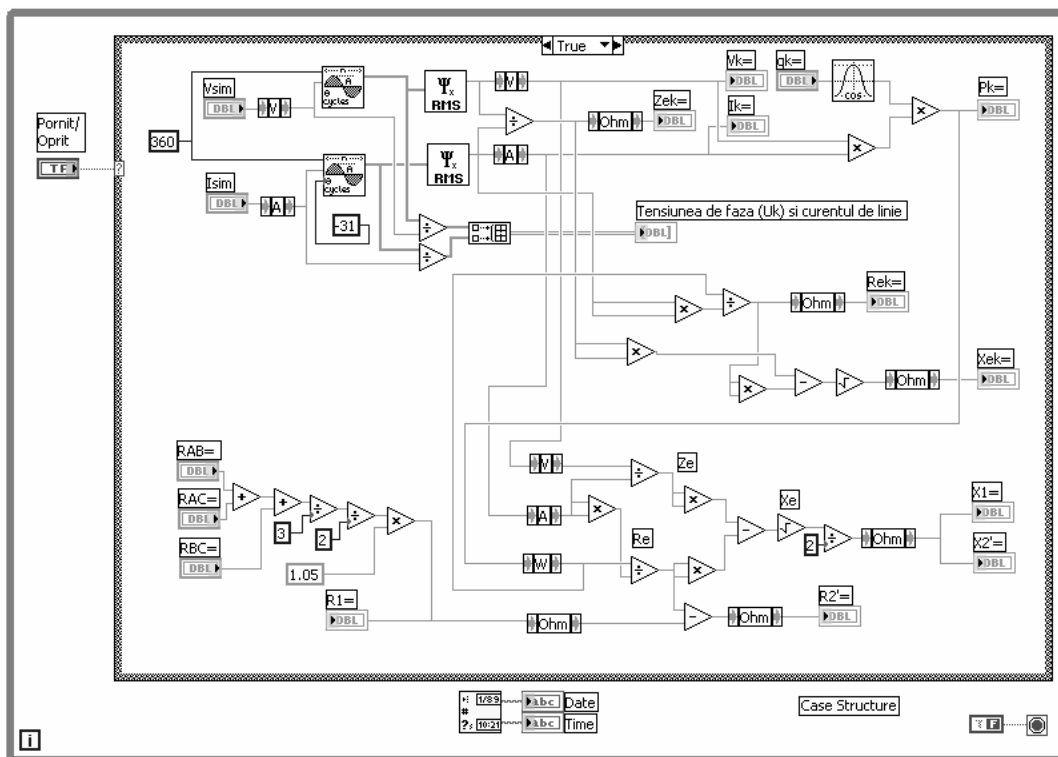

Fig. 4. – The Block Diagram of Virtual Instrument

    OBS.   The Virtual Instrument are tested in the system available that are given below:
- Slip-ring Asynchr.Motors:- stator:415 V, Y, 3~; 11 A, 1410 rpm; cos φ =0.85, 50 Hz;

- rotor:170 V, Y, 22 A

- Transducers for U-I signal conditioning and isolation purposes with Hall effect (1000 V-50 A);

- Data acquisition extern card: NI USB-6008 with 8 analog inputs (8 SE, 4 DIF.), 12-bit resolution,10 kS/s sampling frequency, 2 analog outputs (with 12-bit D/A conversion), 12 digital I/O;

- NI-DAQmx Driver's software for DAQ controls (aquisition's configuration: name of input channels, max/min input limit, sample to read, rate-Hz, etc.).

Conclusions

    Virtual measurement instruments constitutes an important element in a conception and projecting of a parameters measurement system of a monitory sing phenomenon or process. After studying step and after we establish functional and graphical, virtual instruments should be use in measurement systems, could be a serious alternative to the

classical measurement systems offered by them:

- flexibility to the measurement configuration system,
- working capacity to a complex accomplish to the acquisitions data,
- cheap costs of the equipments for high performances of the system.

In conclusions we could say that measurement systems of the present and to the future couldn't be concept without virtual instruments which had replace actual devices and dedicated measurement instruments.

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Instrument virtual pentru determinarea parametrilor schemei echivalente de scurtcircuit a unui motor asincron

Rezumat

În lucrare, folosind mediul de programare grafică LabView se implementează conceptul instrumentaţiei virtuale, realizând un instrument virtual care poate fi folosit la încercarea de scurtcircuit a unui motor asincron cu inele colectoare, în laboratoarele de încercări maşini electrice şi acţionări electrice, din învăţământul universitar şi preuniversitar, din cercetatare sau industrie. Instrumentul virtual permite determinarea parametrilor schemei electrice echivalente. Acest lucru se realizează rapid şi ieftin, folosind un PC şi o interfaţă de culegere de date. Pentru punerea la punct a programului care reprezintă instrumentul virtual se foloseşte simularea unui sistem monofazat de tensiuni şi curenţi.