System for Testing of Ripple Control Receiver Using Multifunction Plug-In Board PCI-MIO-16XE-10

by
Vladimír Haasz, František Pištínek, Michal Titìra, Jaroslav Roztoèil
College of engineering
Dept. of Measurement, Faculty of Electrical Engineering, Czech Technical University in Prague

Products Used:
LabWindows/CVI
DAQ Board PCI-MIO-16XE-10

The challenge
Design, development and realisation of low cost and high flexible compact system for testing of ripple control receivers. Designed system provides an automatic test running, a saving of measured data and a test protocol generation.

The solution
The requirement of an automatic data processing and an evaluation suggests to use a computer as a control device of a test system. This premise conducts to design a prototype of a test system using virtual instrumentation based on PC plug-in boards. This solution is cheaper and more variable than the system consists from stand-alone instruments connected by IEEE 488 bus.

Abstract
A system for the automatic quality testing of ripple control receivers based on virtual instrumentation was designed and developed. It consist of a generator of a complex testing signal (PC plug-in board and power amplifier) and of a software package used for a digital generation of a testing signal, for an autocalibration and a software calibration of the whole system and for a control of an automatic test running. The multifunction plug-in board PCI-MIO-16XE-10 from National Instruments is used for test signal generation, for measurement of output signal and for testing of status of ripple control receiver. The development software package LabWindows/CVI was used for control software package programming.

System Design and Development
Ripple control receivers (RCRs) allow distant power take-off regulation from distribution network. Using RCRs it is possible to realise a distance control of electrical appliances which are intended e.g. for heating or water warming-up etc. In this way a total load of distribution network can be controlled from central distribution centre. RCRs are operated by actuating signals which are transmitted using distribution network. These actuating signals are generated by keying of carrier wave, which is added to the line voltage. The frequency range of carrier wave is from 150 Hz to 2 kHz and its amplitude is usually from 2 V to 10 V. *A great amount of different electrical appliances controlled by RCRs means that every RCR has to respond only to actuating signal witch is intended for it. Actuating signals are discriminated by the frequency of carrier wave and by group code which is transmitted at the beginning of actuating signal.???*

The challenge of test system is to verify a correct reaction of RCR on an actuating signal (control message). This reaction is checked by monitoring of RCR switches. The RCR has to pass out following tests:

- RCR sensitivity on a change of frequency and amplitude of carrier wave
- RCR sensitivity on a harmonic disturbance. Only three harmonic components of line voltage, theirs frequencies are the nearest to the frequency of the carrier wave, are used for test purpose.
- RCR sensitivity on a non-harmonic disturbance.
- RCR sensitivity on a control message and power supply drop-out.

A special complex signal must be generated for testing of ripple control receivers. This signal consists of the basic line voltage with defined harmonic components, of the control message and of disturbing signals. A status of switches of the tested ripple control receiver has to be red in the defined time during sending a message. It brings a number of problems concerning timing.

The multifunction PC plug-in board is used for the generation of the complex test signal, for measurement of its parameters to achieved the required precision and also for the reading of the status of switches of the tested ripple control receiver. The generated low voltage signal is amplified using a power amplifier and then it is transformed to the output voltage in the range from 80 to 260 V. The block diagram of the developed system is shown in the Fig. 1. The software package LabWindows/CVI was used for developing of programme. It controls not only test signal generation and a status of switches reading, but also an automatic execution and an evaluation of the whole test.

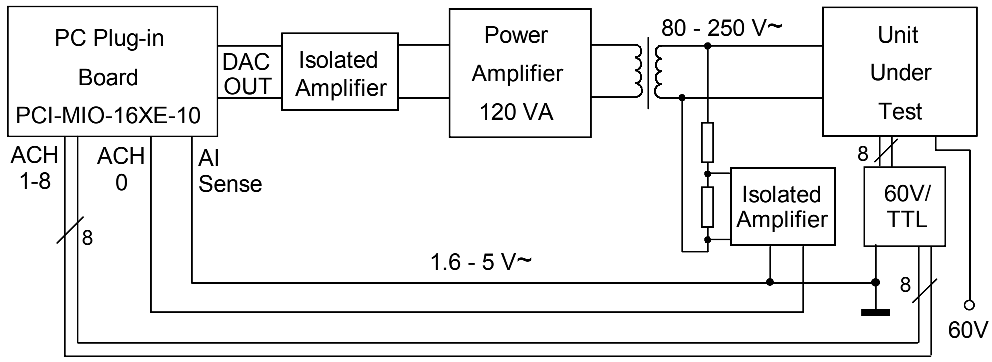

Fig. 1. Block diagram of the developed system

Test Signal Generation

A test signal can consist of six sinusoidal components. The first component is the basic line voltage, its frequency can be 50 Hz or 60 Hz. All parameters of this component can be set at the user's panel "...." (Fig. 2). The second component is keyed carrier wave (control message), its frequency is chosen by user. The parameters of carrier wave and the keying table are set at the user's panel "......." (Fig. 3). The third, fourth and fifth components are three harmonic components of line voltage, theirs frequencies are the nearest to the frequency of the carrier wave. These three components present harmonic disturbance and their occurrence are optional and theirs parameters can be set at the user's panel "......." (Fig. 4). The last component presents non-harmonic disturbance. The parameters of this component depend on user demand and its occurrence is also optional.

A good stability and a good accuracy of all parameters of the generated test signal is demanded. This requirement can be fulfilled, if the test signal is generated digitally. The table of samples of the each sinusoidal component is generated before the start of single tests for a time reduction. Then the competent data are red from this table and single components are summed to the complex test signal (all in digital form). The keying of the carrier sinusoidal wave (the message) and of some disturbing signals is possible. The final data array is stored into the computer memory, then the data are transferred into the D/A converter of a plug-in board using DMA transfer and a new data array is generated during this time. The PC plug-in board PCI-MIO16XE-10 is used for a conversion of a digital signal to an analog one in this case. The internal timer-counter is used for all timing, but the generated signal can be also synchronised with a line frequency.

The software calibration is used for both determination and correction of the reference voltage and the reference frequency of the used PC plug-in board and also for a correction of error of the resistance divider at the power output. The precise AC voltmeter connected to the power output and the counter connected to the low-voltage output serve to the determination of correct value of parameters of the basic harmonic component of output signal (Fig. 5). The values measured using external instruments are entered into a calibration table and all correction constants are recalculated.

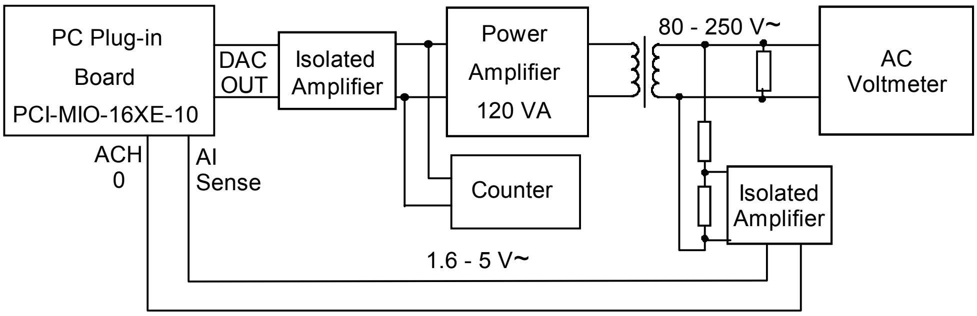

Fig. 5. Block diagram for calibration process

To set the correct RMS value of all components of the generated test signal (at the power output), an autocalibration procedure is used. The test signal at the power output is sampled using an analog input (channel 0) of the used PC plug-in board. A method of interpolated FFT [1] is used for signal processing to determine the correct RMS value of all signal components [2]. Based on this results the amplitude of all signal components on the analog output of plug-in board is corrected.

Reading The Status of Switches of Ripple Control Receiver

For an automation of tests it is necessary to observe a response of the tested receiver to the test signal in a defined time. The user can create the status table of expected switching of receiver relays using panel "...." (Fig. 6). Then the check of a relay switching is provided during the time period (with step 10 ms), which is defined in status table.

Panel

The information about the setting of relays can be red as binary data. Digital inputs of a PC plug-in board can be used for it. However, the used PC plug-in board (PCI-MIO16XE-10) does not enable to use DMA transfer for digital inputs. DMA transfer is necessary for a determination of the time of a relay switching with the demanded accuracy. Therefore, the analog inputs of the PC plug-in board are used for this purpose and the voltage level measured in the input channels 1 to 8 represent an actual position of relay contacts (see Fig. 1).

Setting The Parameters of Tests and Presentation of Results

An operating software discriminates two groups of users. These groups are called "user" and "power user". Every "user" can operate only with the Main Panel. Only parameters of automatic test process can be set at this panel (Fig. 7). It means:

- Select model of test, witch will be executed (the test model must be defined before this selection by "power user")
- Set the number of repeating of selected test
- Set the time space between two test
- *Choose the reaction of test system on RCR malfunction*

"User" can start automatic test process from this panel.

Panel

Every "power user" can operate with the Main Panel and with few sub-panels for test model and test signal parameters setting. The panel at Fig. 8 serves for test model definition. The maximal variability of the test signal is necessary for both tolerance and type tests. The "power user" is able to set following basic values using operation software:

- The amplitude and the frequency of the sinusoidal power supply.
- The amplitude and the phase shift of harmonic components, which are contained in the power supply. These harmonic components can be interrupted in defined time intervals (keying of harmonic components).
- The amplitude and the frequency of a disturbing signal, this disturbing signal can be also interrupted in defined time intervals (keying of a disturbing signal).
- The amplitude, the frequency and the time length of each control pulse in control message and the time interval between two control pulses.

The setting of all these parameters can be made using control panels in the created software package or using tables prepared in Excel for this purpose.

Panely

The results of running tests are saved on harddisk and the operating software generates test protocol at the end of automatic testing process.

Conclusion

The above mentioned system for testing of ripple control receivers shows both advantages of used solution and a number of problems, which were necessary to solve to achieve the required parameters (precision of all components of the generated signal, contemporary generation of the analog signal and reading of the logic signal etc.).

The draft of the above mentioned system for testing of ripple control receivers engaged in the competition, which was invited by company ZPA CZ - TRUTNOV. This draft was found the best of all, because it tendered the high flexibility, the minimal cost and short time of development. The test system was developed and realised in Czech Technical University in Prague, Dept. of Measurement last year and it is successfully used for developing and testing of ripple control receivers produced in ZPA CZ .

References

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