INGENIERÍA Y DESARROLLO

SCADA System for a Power Electronics Laboratory

Sistema SCADA para un laboratorio de electrónica de potencia

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Resumen

En este documento se presenta el diseño e implementación de un sistema SCADA que interconecta 8 módulos de electrónica de potencia conectados a una red CAN. Los módulos tienen aplicaciones de conversión de energía y control de máquinas eléctricas rotativas. Para realizar ensayos de conectividad y registro de señales se usa un rectificador de onda completa monofásico de 1kW de potencia, en el cual se muestrea corriente y voltaje y se obtienen parámetros como el THD, valor RMS entre otras características de las señales. Los resultados se validan contra los obtenidos a través de un osciloscopio digital FLUKE43B.
Palabras clave: SCADA, electrónica de potencia, conversión de energía eléctrica, censado remoto, CAN.

Abstract

The present paper shows the design and implementation of a SCADA system enabled to acquire signals from eight power electronics remote units plugged into a CAN bus. The power electronic modules are used for electric power conversion and electric machinery control systems. A 1KW full wave half-controlled rectifier was used as circuit under test to validate the signal acquisition and signal process to obtain the signal average, THD, RMS, and other characteristics. A digital oscilloscope FLUKE43B was used for comparison and validation purposes.
Key words: SCADA, power electronics, electric energy conversion, remote sensing, CAN industrial networks.

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1. INTRODUCTION

The word SCADA describes a large-scale, distributed measurement and control systems, commonly used to monitor or control chemical or transport processes in municipal water supply systems, electric power generation, transmission and distribution, gas and oil pipelines; and other distribution processes [1].

These systems are usually conformed by a master station, where the control software is executed with a graphical user interface which allows total interaction with remote units, nevertheless the remote units control their processes as well as protocol that allows communication between master station and remote units, as shown in Figure 1 [1], [2].

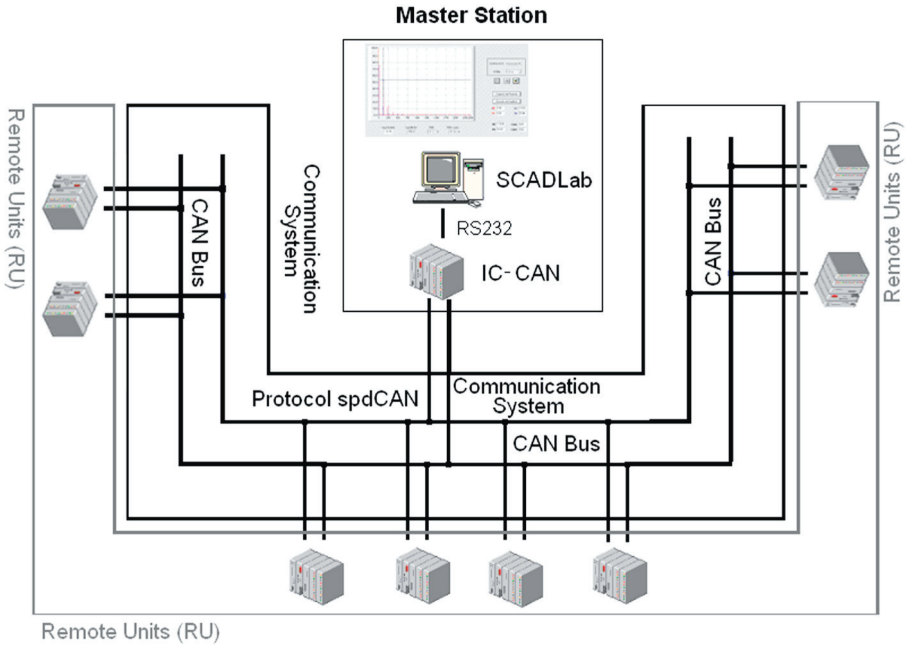

Figure 1 SCADA system architecture

In the present application, the remote units are represented by power electronic modules used for electric power conversion and electric machinery control processes.

2. THE SCADA SYSTEM

Communication System - SPDCAN

The communication protocol to supervise and program devices plugged to a CAN bus called SPDCAN, are supported by physical and data link layers of standard CAN. SPDCAN supervises 8 remote units simultaneously and uses 4 CAN messages as well as 3 kinds of frames to achieve communication.

Protocol was designed as a hybrid that works with message identifiers on the data link layer and addresses on the application layer; this way it may identify messages and the posteriori destiny address of the remote unit [1], [2], [4], [5].

In the communication system it is necessary to take into account three layers:

The Application layer: Control the receiving and processing of the messages from the master station to the remote units or vice versa, and the control actions executed with the information received, as shown in Figure 2.

The Data Link layer: Establishes the communication and verifies the adequate transmission of the information in all directions and optimizes the use of the CAN bus, as shown in Figure 3.

The Physical layer: Is the physical medium for the communication of all modules with the master station and vice versa, as shown in Figure 4.

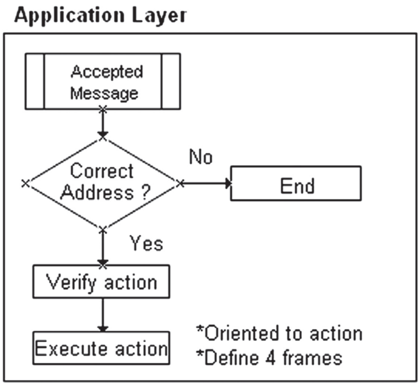

Figure 2. Application layer of SPDCAN Protocol

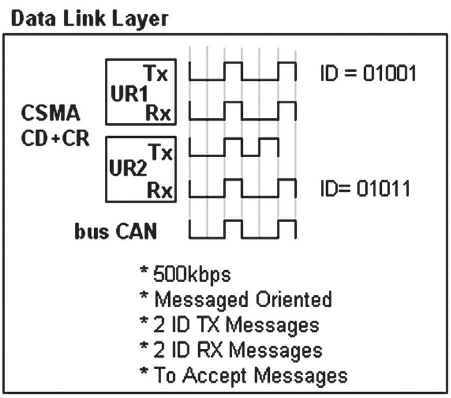

Figure 3. Data Link layer of spdCAN Protocol

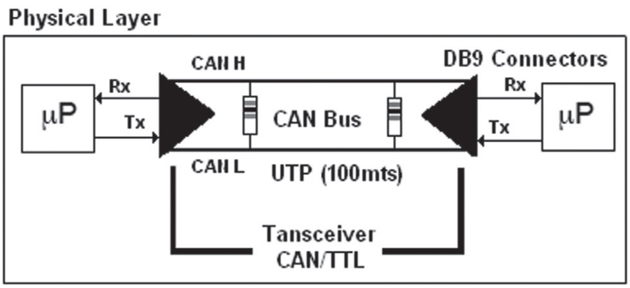

Figure 4. Physical layer of SPDCAN Protocol

Master Station [4].

The master station is conformed by two stages, the CAN Card interface, called TICAN, which is a master communication card that serves to communicate the PC and the physical layer of the CAN bus, and the application software called SCADLAB which receives and processes the information from the CAN bus trough the CAN Card Interface. Figure 5.

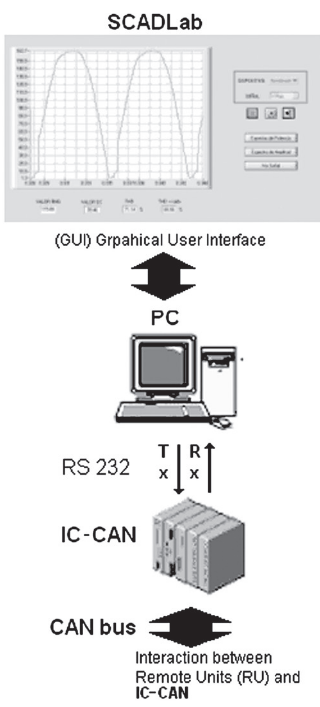

Figure 5. Block diagram of master station.

The CAN Card Interface serves for two purposes in the master station. One is to give a CAN interface and the second is to implement SPDCAN protocol to allow communication between the master station and remote units. This card communicates with SCADA application through a serial port by a RS323 interface.

The SCADLAB application has six main functions: Set up, Connection, Supervision, and Adjustment of the parameters set point, oscilloscope, and Help. SCADLAB has a graphical user interface that contains a powerful and friendly environment designed to final user. [4], [6]

The application has three different supervision modes:

- Alternating Mode: In this mode four different signals from any remote unit can be acquired and shown. When the user wants see 4 different signals simultaneously, the acquisition is multiplexed and every signal is alternated at different times. However this action is not noted by the final user as the time frame to acquire every signal is too short.

- Individual Mode: This mode acquires samples of one continual signal. The user can make different measurements over the acquired signal like the RMS (Root media square), Amplitude Spectrum, Power Spectrum, Phase Spectrum, and THD (Total harmonic distortion).

- Simultaneous Mode: This mode supervises up to 8 signals, synchronizing the start of all of them. Simultaneous mode acquires the transitory state of selected signals; starting at the time when remote units were initialized until 512 samples are taken in each signal.

3. THE REMOTE MODULES [7], [8]

To verify the adequate work of the master station and communication system, a semi controlled rectifier for 120Vac, 1KWatt, was implemented as a circuit under test.

This remote unit uses two independent processing units. The one called MRC (Module of Rectifier Controller) and the other called MDA (Module of data acquisition). On MRC the SPDCAN protocol is implemented to modify

Voltage out on the rectifier controlled by the master station. Meanwhile MDA acquires the data, sensing sequentially Voltage Out, Current Out and Shot pulse. Figure 6.

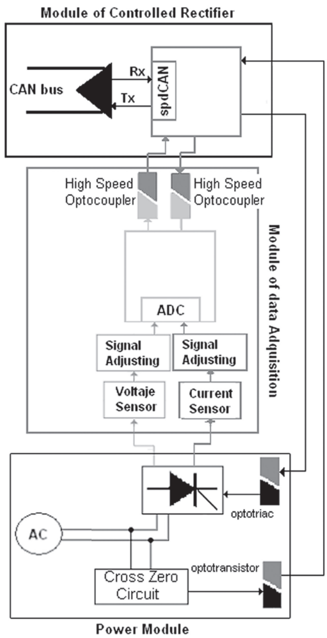

Figure 6. Block diagram of rectifier under test

Communication between MRC and MDA is serial using two opt transistors to isolate both circuits completely, avoiding the noise and interference problems that usually occur when a digital circuit is connected with a power electronics circuit.

4. TESTS TO PROVE RELIABILITY OF SYSTEM

To verify the accuracy of information obtained with SCADLAB, measurements were taken simultaneously using a Fluke 43B Siemens digital oscilloscope and SCADLAB; it was tested with an impedance of 100Ω and the highest power of 150W

On Figure. 7 a steady state Fourier analysis for an AC semi controlled rectified signal is shown by both oscilloscope and SCADLAB acquisition system in individual mode.

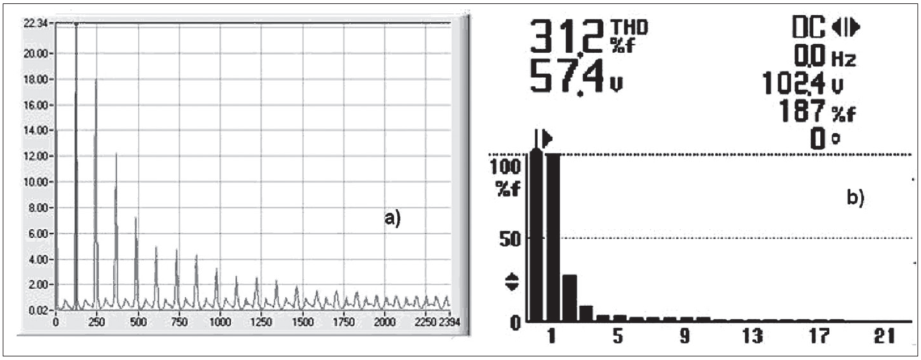

Figure 7. Rectified Signal Fourier spectrum views on
a) SCADLAB b) Fluke 43B

In Figure 8, the RMS voltage for different shot angles of the opt TRIAC where measured using SCADLAB and the Fluke 43B oscilloscope and compared. In Figure 9 the THD of the same voltages used in Figure 8 is shown and compared with the obtained with the Fluke 43B.

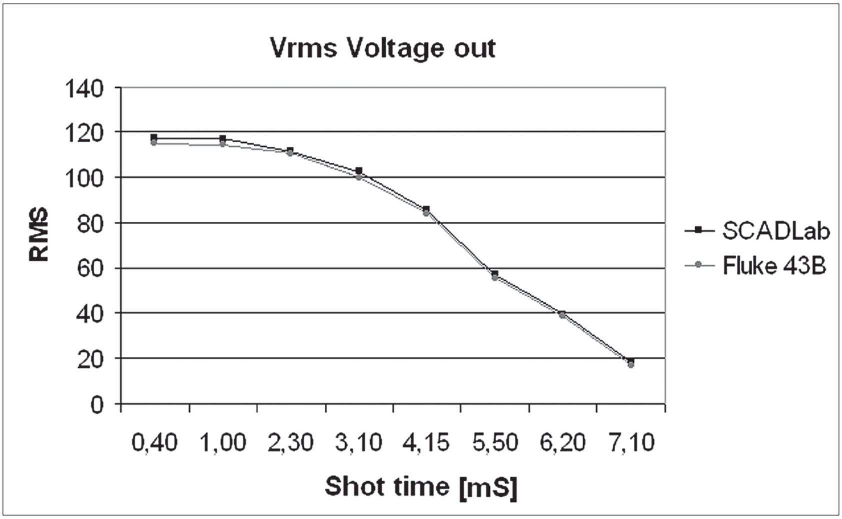

Figure 8. Comparison between value of RMS voltage obtained
by SCADLAB and Fluke 43B

As it's possible to observe on figures 9 and 10, differences between measurements taken by SCADLAB and Fluke 43B are negligible, because it sustainable that measurements obtained by SCADLAB are reliable.

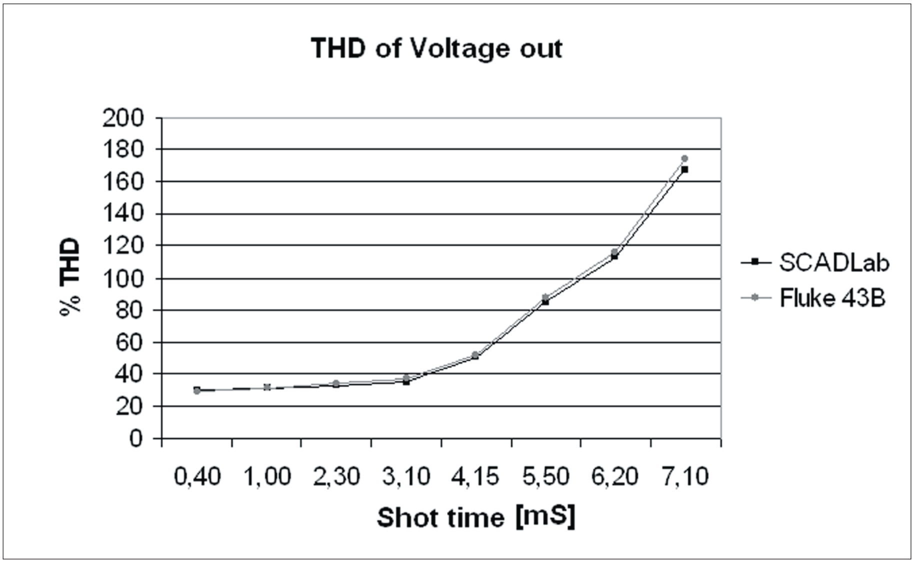

Figure 9. Comparison between value of voltage THD obtained by SCADLAB and Fluke 43B

5. CONCLUSIONS

The use of microprocessors dedicated to specific tasks, like MDA (Module of data acquisition) to acquire the signals and the MCU (Module of Control an Supervision) increases the efficiency in CAN systems, but an adequate isolation system must be considered on design of the modules.

Measurements obtained using SCADLAB have a lower error percentage than laboratory common equipment when an accurately sampling rate is selected.

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