Remote System for Monitoring, Diagnostics and Control of Switch Mode Power Supplies for Distance Learning

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***Abstract*: In the present paper a remote system for monitoring, diagnostics and control of switch mode power supplies is discussed. The main system components (programmable forward converter power supply, programmable load, 10-channel digital multi-meter, 2 channel digital oscilloscope, and a personal computer) communicate over National Instruments LabView environment. Synthesized is a soft control panel for local and remote programming.**

***Keywords:* Distance learning, Programmable power supply, LabView, Forward converter.**

I. Introduction

A main part of the education process in all engineering schools is reserved for laboratory exercises and experiments. This approach not only demonstrates the main concepts of the study but also practically proves the basic theories. On the other hand equipping and maintaining laboratories is extremely expensive in our days. The laboratory assistants are required to install the equipment, to present the experiment, to train the students and finally to generate reports. Having in mind that the labs are accessible only at equipment and lab assistant presence, this activity appears to be time consuming as well.

Things might look a way better if the main lab experiments were accessible from home 24 hours a day, 7 days a week or accessible during professor's lecture for demonstrations, theory proves and details explanations. How about if a high tech company research group gives access to its extremely expensive equipment out of regular business ours?

All theses ideas can be made true by building a flexible programmable system for remote monitoring and control of industrial equipment. Internet is giving a great chance for remote access and data exchange. Fig.1 shows a similar system. The lab experiment together with equipment is located on the left hand side. It receives commands and returns data to the system controller.

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The controller is equipped with WEB server which is publishing the results over the internet. These results are visible to N- number of remote stations. Something more! At certain conditions, the control over the system can be passed over to any remote station. In this way the remote user can exercise 100% control over the system. Of course some restrictions apply. The main is that the system can have only one controller at a time no matter remote or local.

Fig.1

A small but fully functional system for remote control, monitoring and analysis of a programmable power supply performance was built up and put into service for the purpose of this paper. A focus was given to student remote education in real conditions.

II. Researched Object

A programmable power supply based on a transformer forward converter has been researched and analyzed as shown on fig. 2

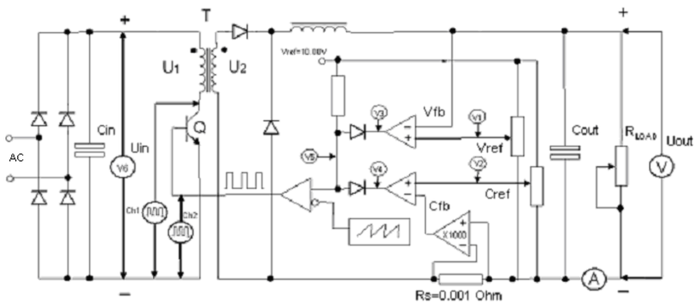

Fig. 2

The power supply operates in constant voltage as well as in constant current mode. The voltage and current references **V1** and **V2** are generated by digital potentiometers. The voltage and current error amplifier outputs **V3** and **V4** are compared between each other so active is the lower one **V5**. This approach benefits automatic mode crossover based on the power supply setup and the load. Significant points of interest are the actual signal levels of **V1** through **V6** as well as **A** and **V** readings on the DMM as designated on fig. 2 The other useful information is gathered by Ch1 and Ch2 waveforms representing **Uds** and **Ugs** across the power switch.

III. CONTROL AND MEASUREMENT SYSTEM

A. System overview

This is an open system built up of programmable instruments interfaced by GPIB cables and probes for scanning and measurement of signals that are of significant importance for the automated analysis and remote control of the whole system. For detail see fig.3 The system controller is equipped with GPIB-PCI card which serves as a system bus. All requirements for building up a GPIB network are taken care of as follows:

- max. cable length between two devices is less or equal to 2m.
- total cable length is less than 15m.
- all devices are powered up

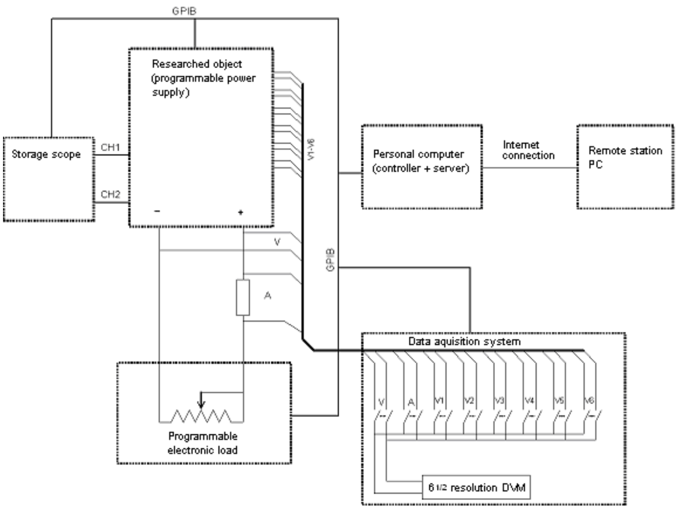

Fig. 3

B. System main components

Object under research:

-100W programmable power supply capable of delivering 10V and 10A at the output.

Peripheral instruments:

- Electronic programmable load compatible with the power supply under test.
- 10 Channel data acquisition system with 6 ½ digit resolution DVM.
- 60 MHz, 2 channel storage oscilloscope.
- System controller + web server – personal computer.
- One or more remote stations - personal computers.

C. Control and programming environment.

The control of the system is based on National Instruments LabView industrial programming environment. It benefits a graphical programming mode which gives full visualization of the algorithms as well as an enormous set of ready made routines, subroutines, modules and instrument drivers. All these features significantly reduce the development time and cost.

Installed is a program pack NI 1.70 for communication between LabView and the GPIB interface. In addition this pack supports RS 232 connectivity which is a great plus for older instruments. Both interfaces are controlled by SCPI commands that allow mixed systems. Also included is a server module which features remote control of the system over the internet. For proper remote control a minimum system requirements are needed for the remote stations. LabView basic is a must as wall as an internet browser and access. No instrument drivers are needed.

D. Soft panel

The whole system control is given to a virtual screen (fig.4). This screen is hosted by the controller and is visible to all remote stations. There is no difference in the functionality between controller and remote station.

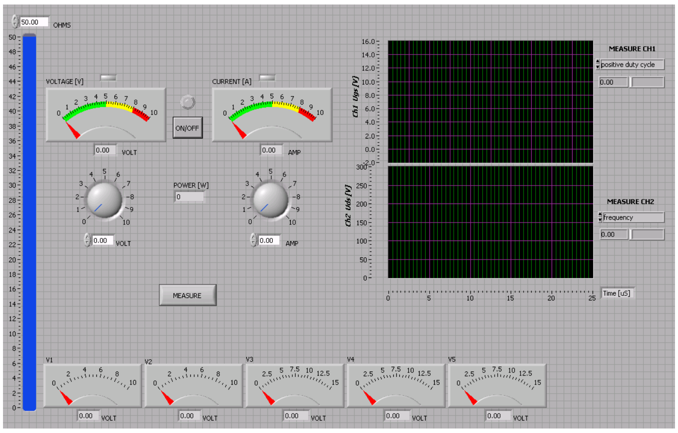

Fig. 4

The main Volt and Ammeter visualize the reading of A and V meters on fig.2

Below, the analog readings are digitalized as well. The rectangular LEDs above the main Volt and Ammeter indicate the actual mode as follows:

Voltage mode - green

Current mode - amber

Note: See fig. 5, 6, 7 and 8 for details

In between the main meters a virtual **ON/OFF** button is located. This button has two functions:

1. Activates Vref and Cref from the digital pots on fig.2
2. Activates Load reference.

Vref and Cref are adjusted by rotating the round knobs **VOLT** and **AMP.** A digital set is also available under the knobs. In between is located the watt meter which reading is refreshed

90 times a second. The analog-digital meters V1 through V5 indicate DC voltage in the corresponding points from fig.2 Due to relatively slow data transfer rates, these meters do not operate in dynamic mode. Readings are taken in constant mode by depressing **MEASURE** button. The same button activates Ch1 and Ch2 oscillogramme loading. This process requires scope setup data notification prior each measurement. Once notified the scope takes some time to apply the settings and to establish steady waveforms good for capture and transfer over the GPIB . This may take up to 20 sec. Because 8 line data bus is used, the transfer time is negligible compared to scope setup time. The main scope setup parameters are:

- ***amplitude***
- ***time base***
- ***coupling (DC)***
- ***trigger level***
- ***trigger source***
- ***trigger slope ect.***

The software features automated analysis of the results. A drop down menu is available right next to the oscillogram screens. Varieties of parameters are selectable. In result the desired parameter is calculated and displayed in proper measure units at the end of each test. The user can select between: frequency, period, rise time, fall time, max. value, min. value, RMS, duty cycle, pick to pick, overshoot ect. See fig. 5

Different modes of operation are set by adjusting the following references:

Voltage-(Vref)
Current-(Cref)
Load-(Rload).

The load is electronic and programmable, configured for constant resistance operation. This mode is accessed indirectly. The main programmable parameters are voltage and current.

Constant resistive mode is obtained by regulating either the current or voltage in order to fulfill the requirement for constant resistance. Due to the fact that the system under test (power supply and load) has two independent regulators they always operate in different modes. If the power supply is operating in constant voltage mode, then the load will operate in constant current mode and vice versa. In this way both, current and voltage are regulated in such a way, that R=U/I=const These modes are established fully automatically and depend on

Voltage-(Vref)
Current-(Cref)
Load-(Rload).

The value of the load resistor is defined by the slider position located on the left hand side of the display (fig.2)
It varies between 0 and 50 Ohm and can be set digitally either.

IV RESULTS

All results have been visualized in the research process. The main modes of operation have been analyzed, starting from no load and ending to full load.

Fig. 5 indicates the analysis at the following conditions:

Vref=1V
Cref= 10A
Rload= 50 Ohm

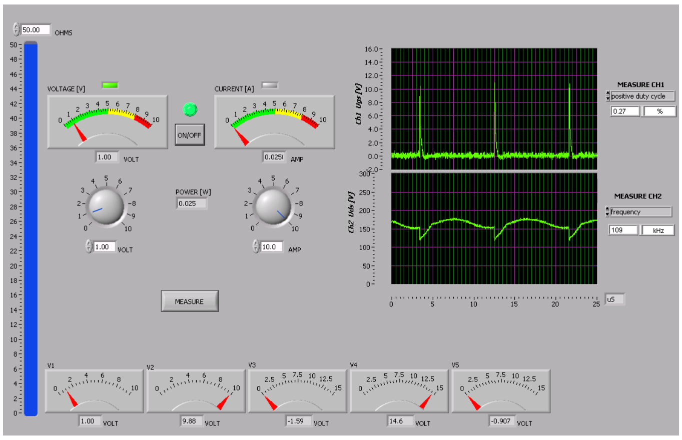

Fig. 5

These conditions put the unit under test in constant voltage mode of operation. **VOLTAGE** LED indicates that. Independently of current high reference, due to the high resistance of the load, the output current is negligible (0.025A). In accordance the output power is also minimal (0.025W) as well as the duty cycle of the power switch **Q.**

When the load is dramatically reduced the results on fig.6 are observed at the following conditions:

Vref=10V
Cref= 10A
Rload= 0.1 Ohm

Because the output current reaches its max. value 10A, then the unit under test goes into constant current mode of operation. Due to the very low load value, the voltage drop across it is insignificant 1.09V The resulting output power increases up to 10.87W and respectively the duty cycle goes up to 2,82%

Fig.7 shows full power generation (Pout=94.61W) under the following conditions:

Vref=10V
Cref= 10A
Rload= 1.05 Ohm

The unit under test is operating in constant voltage mode with duty cycle of 39.2%

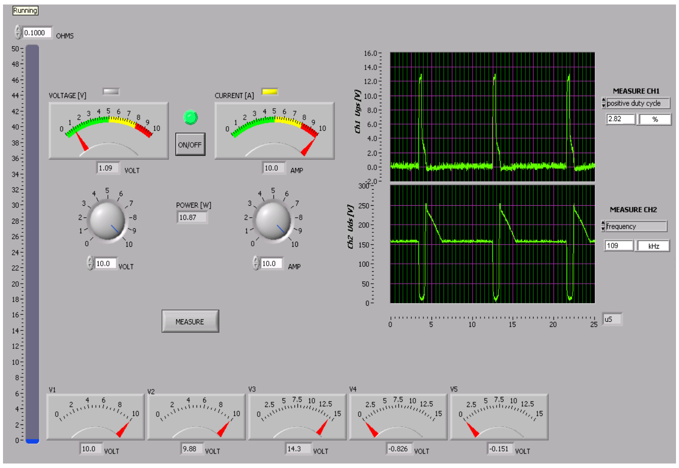

Fig. 6

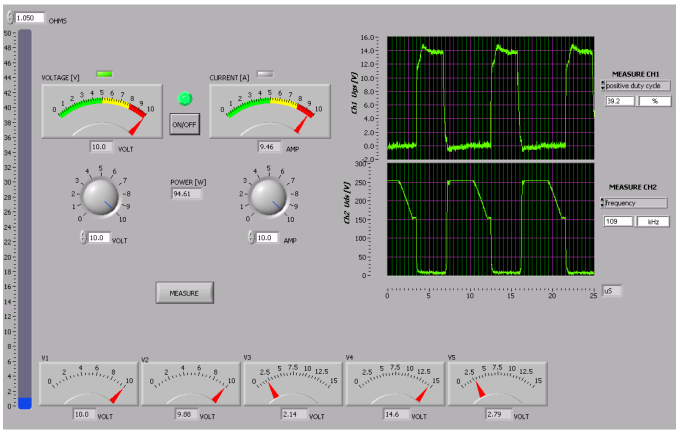

Fig. 7

The last experiment (fig. 8) represents intermediate load under the following conditions:

Vref=9.87V
Cref= 5A
Rload= 1.5 Ohm

These conditions put the unit under test in constant current mode of operation while the output power decreases to 37.48W as well as the duty cycle to 27.6%.

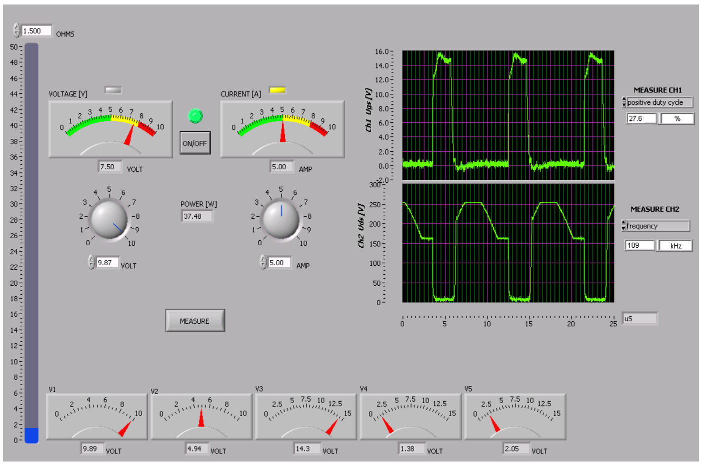

Fig. 8

IV. Conclusions

The results obtained under the current research are valuable and accurate enough for laboratory experiments headed towards student distance learning. The data generated is good for report creation and further analysis. Because the programming environment LabView operates in graphical mode, a quick and easy way is offered for further improvement and upgrade of the current version. In near future a couple of new modules will be added featuring automated plot drawing, results e-mailing and printing.

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