The instrument for measuring dark current characteristics of straw chambers modules

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Abstract

Large scale production of straw drift chambers requires efficient and fast methods of testing the quality of produced modules.

This paper describes the instrument which is capable to measure characteristics of dark currents of straw chambers modules in automated manner. It is intended for testing the LHCb Outer Tracker detector straw chambers modules during their production. It measures the dark current characteristics at any of the voltage in range from 0V to 3kV and stores them. These data will be then used at CERN for detector calibration.

I. Features

The large scale production of the straw drift chambers in the LHCb experiment requires efficient and fast methods of testing the quality of produced modules. About 800 modules with 128 straws each will be produced resulting in total production of more than 100000 straws [1].

A common and powerful test of the quality of the produced straws is the measurement of the dark currents in a function of applied high voltage. The described below instrument will rise the high voltage applied to the wires in 128 straws in defined steps for a given range and will automatically measure dark currents consecutively in each straw. In this way all the problems related to improper wire mounting can be localized and corrected in the early stage of production process. In particular, it is possible to detect quickly the shorts on the wires.

The measurement cycle setup and control is done by a computer. The instrument is equipped with RS-232 data transmission protocol. Thus it can be connected to almost any computer because usually they are provided with it as a standard. This gives a kind of portability, for example when used with a laptop. If there is a computer with a CAN driver card available then optionally CAN Bus connection can be used.

After performing the measurements it is possible to store the data on a hard disk and use them later for any purpose. This feature allows to take the characteristics of built straw chambers modules and use them for calibrating LHCb Outer Tracker detector at CERN.

The typical measured current for a straw chamber is about few nA. Using this instrument we can measure the current with 128 pA resolution in the range up to 250 µA.

II. Hardware description

A block diagram of the instrument is presented in figure 1.

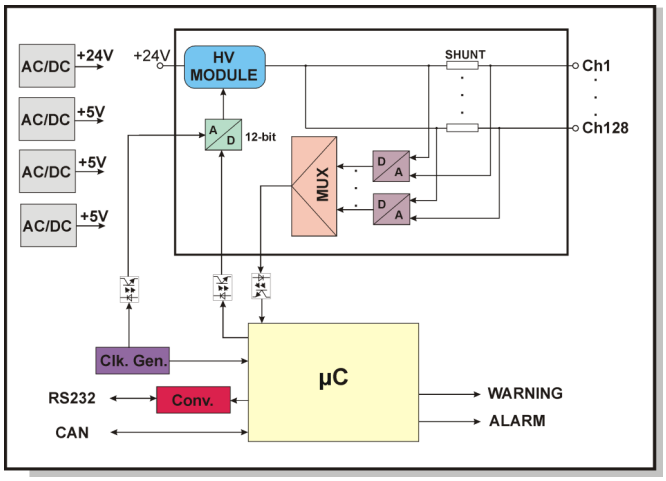

Figure 1: Block diagram of the instrument for measuring dark current characteristics of straw drift chambers modules

The High Voltage Module produces a voltage in the range from 0V up to 3kV. This output value is controlled by analogue input. The voltage of this input is set by a DAC and is in the range 0-3V which covers full HV Module output range. Then the voltage drives the shunt resistor which is in serial with a straw wire. There are 128 shunt resistors serialized with 128 straw wires and connected to HV Module output. The voltage drop on shunt resistor is measured, converted by an ADC to a digital value and sent to the microcontroller data memory through a 128:1 multiplexer. There are 128 such measurements made consecutively. The high voltage part of the instrument is isolated from digital part by optocouplers. After finishing 128 measurements the value of the high voltage output is increased, if necessary, by the defined value called voltage step and new cycle of 128 measurements begins.

When all measurements are correctly collected the microcontroller starts to send them from the memory to the host computer via RS-232 (or CAN Bus). Each received voltage value is recalculated to the corresponding current and processed in the specified manner giving the proper display on a screen.

Another microcontroller task is to receive the measurement setup from the host computer and send it to the device which controls the whole measuring process (DAC control, voltage measurements on shunt resistors, digital to analogue conversion and multiplexing). This device is realized in one Altera in-system programmable chip EPM7256. Combining it with microcontroller EECMOS program memory which is put in a socket we have the fully and easy upgradeable instrument.

The instrument printed circuit board consists of 6 layers and its dimension is 21” (533,4 mm) x 6” (152,4 mm). In a housing case, together with PCB, 4 AC/DC Power Supplies (three for 5V and one for 24V) and High Voltage Module are also mounted. The instrument is powered from 220V AC.

III. SOFTWARE DESCRIPTION

The software is intended for installation on a PC type computer. Using it we can set the measurement parameters and view collected or saved data.

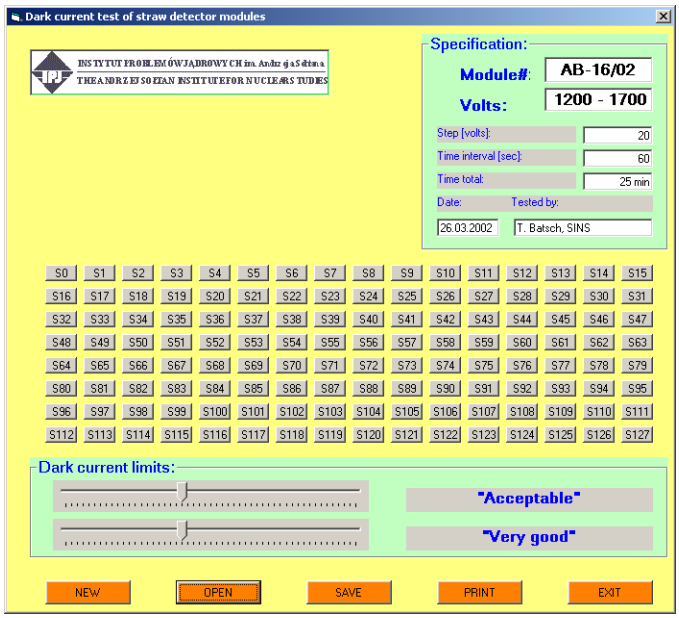

Figure 2: Program main screen

The program main screen is presented in figure 2. In the right upper corner we can see the measurement specification which consists of the tested module name, set measure parameters, a tester name and a date of the measurement.

128 buttons (named S0, S1, …, S127) which correspond to the numbers of the straw chambers of the module are located in the middle of the screen. Clicking on any of the buttons we start the action depending on what kind of measurement was done.

There are two sliders below the buttons. Using them we can set the current limits of our interest: *acceptable* – the value below which the current is not very low but acceptable and above it is too large; *very good* – the value below which the dark current is very low. When we click on a slider with the mouse and move it in any direction we can see the current value in nA displayed above the slider. This method allows to set precisely the proper current limits before or after starting the measurements.

The buttons with commands are located on the bottom of the screen. The first one is called NEW. It allows us to set the measurement parameters. After clicking on it we get the window shown in figure 3.

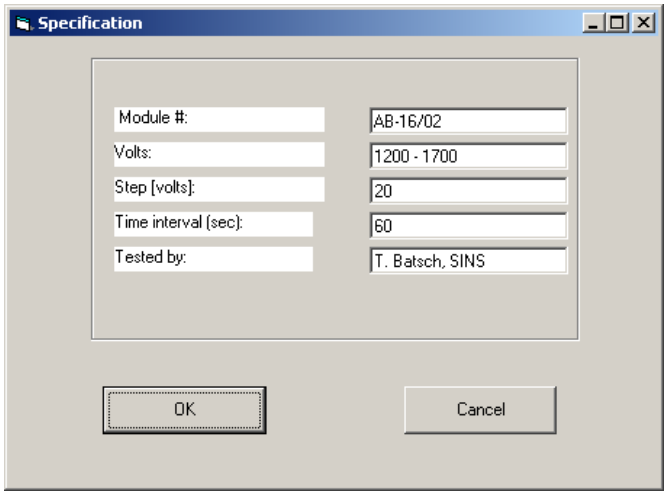

Figure 3: Measurement specification window

In the specification window we can define a module number, a measured voltage range, a step with which the voltage will be changed and a tester name. There are two types of measurements. One is in the defined voltage range with specified step and another is for only one voltage value (in this case the step is not relevant). Which of the type is served by the program is controlled by what is inserted in the *volts* field – the range or one value.

After finishing filling the fields of the specification window we can start the measurement cycle by clicking on OK button. We obtain the window presented in figure 4.

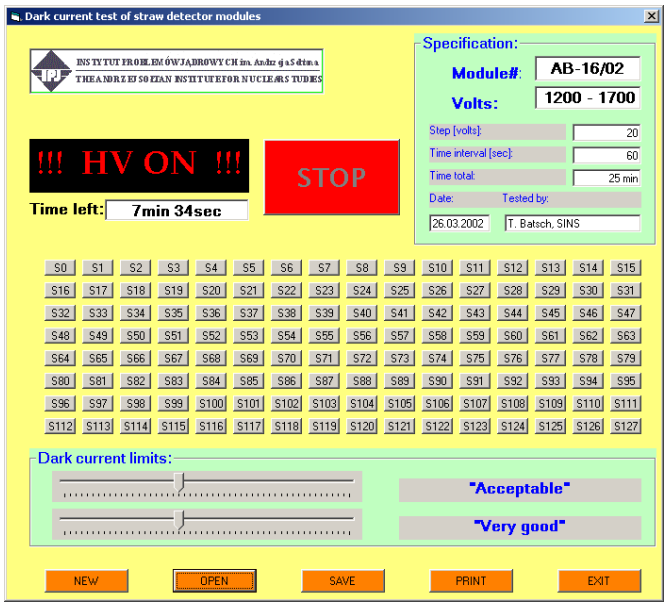

Figure 4: The screen during measurements

During the measurements we can see the blinking inscription HV ON, informing that there is the measurement performed with high voltage on. On the right of this inscription a button is placed with which we can stop the measurement in any moment. Below the inscription the approximate time left to the end of the measurements is displayed.

When the measurements are done we can start to analyse the collected data. The example screen of analysed data is shown in figure 5.

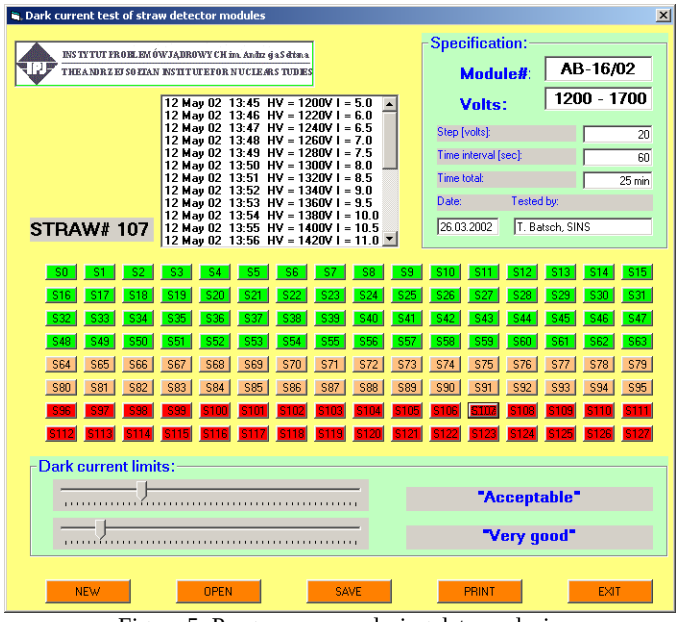

Figure 5: Program screen during data analysis

The buttons which correspond to the straw numbers take the different colours. Those straws which have very low current values are marked in green, the straws which have acceptable current values are marked in orange and in red those which have too large current. The *very good* and *acceptable* values are set with sliders.

When we click on any of the straw number button we open the window such as shown in figure 5 on the left to the specification window. The straw number is written on the left of this window and the measured current values for given voltages for that straw are displayed in it. We can scroll the data up or down to observe the interesting values.

When the measurement was done for the defined voltage range it is possible to display a plotted diagram of a current in the function of applied voltage (dark current characteristic) by clicking the right mouse button. In that case we can move a cursor over any diagram point (figure 6) and click it. The voltage and current values corresponding to the cursor location is highlighted in the small window below the diagram window.

The data can be stored on a hard disk with SAVE command. In that case the save window opens and we can specify the disk and filename to which data will be written. The data are in text format which makes it easy to use them for various purposes. The general data structure is the following:

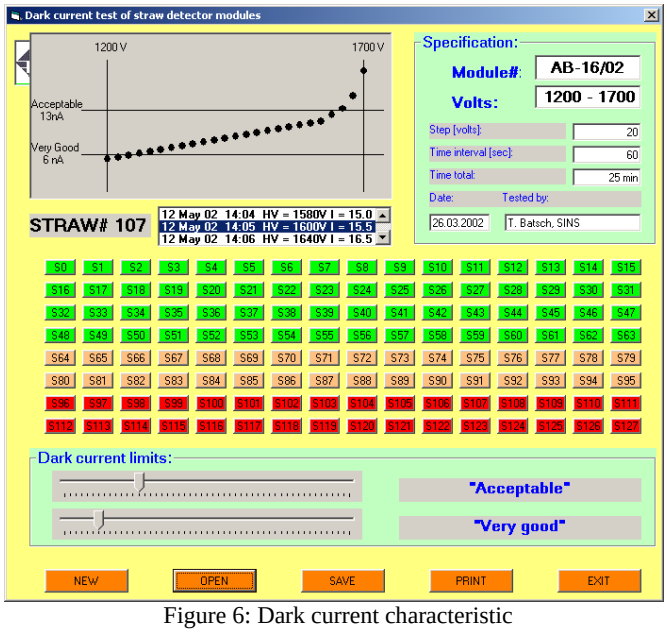

Figure 6: Dark current characteristic

- header (date, tester name, set parameters, module number),
- data (voltage and 128 current values),
- data (voltage and 128 current values),

……

- data (voltage and 128 current values),
- end of file.

It is also possible to view previously saved data. We can open the file with OPEN command. After loading a file we have a possibility to perform all described above operations.

A PRINT command makes a hardcopy of actually displayed screen.

IV. Conclusions

The described instrument is intended for use during production of straw chambers modules for LHCb experiment. It helps to locate in automated way those straws which have shorted inner wires, inspect the straws and measure their dark current characteristics. These characteristics will be used for Outer Tracker detector calibration. The automation shorts considerably the testing time. It is also possible to use the instrument in other experiments.

IV. References

[1] LHCb Outer Tracker Technical Design Report, CERN/LHCb/2001-024, 14 September 2001.