CAMAC based Test Signal Generator using Re-configurable Device

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Abstract. There are many different types of signal generators, with different purposes and applications (and at varying levels of expense). In general, no device is suitable for all possible applications. Hence the selection of signal generator is as per requirements. For SST-1 Data Acquisition System requirements, we have developed a CAMAC based Test Signal Generator module using Re-configurable device (CPLD). This module is based on CAMAC interface but can be used for testing both CAMAC and PXI Data Acquisition Systems in SST-1 tokamak. It can also be used for other similar applications. Unlike traditional signal generators, which are embedded hardware, it is a flexible hardware unit, programmable through Graphical User Interface (GUI) developed in LabVIEW application development tool. The main aim of this work is to develop a signal generator for testing our data acquisition interface for a large number of channels simultaneously. The module front panel has various connectors like LEMO and D type connectors for signal interface. The module can be operated either in continuous signal generation mode or in triggered mode depending upon application. This can be done either by front panel switch or through CAMAC software commands (for remote operation). Similarly module reset and trigger generation operation can be performed either through front panel push button switch or through software CAMAC commands. The module has the facility to accept external TTL level trigger and clock through LEMO connectors. The module can also generate trigger and the clock signal, which can be delivered to other devices through LEMO connectors. The module generates two types of signals: Analog and digital (TTL level). The analog output (single channel) is generated from Digital to Analog Converter through CPLD for various types of waveforms like Sine, Square, Triangular and other wave shape that can vary in amplitude as well as in frequency. The module is quite useful to test up to 32 channels simultaneously with different frequency TTL level square wave signal (digital signal) in a group of 8 channels. There are four such groups with similar set of frequencies. The different frequencies in group help us to test phase shifts between different channels. We have tested 32 channels of PXI Data acquisition modules simultaneously with the developed hardware.

1. Introduction
The time duration of tokamak discharge has been prolonged in accordance with the development of fusion research. At the same time demand for more number of acquisition channels from different diagnostics is increasing in various tokamaks [1]. This requires complex data acquisition systems. The simultaneous testing of large number of channels for data acquisition systems integrity demands for waveform generator devices with more number of distinguishable channel outputs. This demand for our SST-1 data acquisition system has steered us to design and develop a test signal generator module
in-house. We have developed this module for CAMAC interface but it can be used for other data acquisition systems testing. Unlike traditional signal generators, which are embedded hardware, it is a flexible hardware unit, configurable through Graphical User Interface (GUI) developed in LabVIEW application development tool. The main aim of this work is to develop a signal generator, which can alone replace a function generator, arbitrary waveform generator, or frequency generator for testing our data acquisition interface for a large number of channels simultaneously [2].

2. Hardware description

This test signal generator module is designed to generate analog signal (single channel) Sine, Square, Triangular and other wave shape that can vary in amplitude as well as in frequency. Also the module is designed generate digital signal to test up to 32 channels simultaneously with TTL level different frequency square wave signal in four identical group of 8 channels. The base frequency of the group of 8-channels is selected through module configuring GUI and the output frequency of subsequent adjacent channels, in a group, is dividing by 2 of previous channel frequency. The base frequency can be selected either through TTL level internal available clock or external clock. The module covers the TTL level output signal range from few Hz to few KHz as per present VHDL code developed and it can be varied by modifying the code. We have developed the Test signal generator using VHDL hardware description language with CPLD as target device. Basically, CPLD is an input-output in-system programmable re-configurable device which can be programmed through JTAG interface. The module is based on CAMAC interface, an IEEE standard used for nuclear instrumentation. The generator operates in one of the selectable modes through external hardware selection or software selection. The modes are continuous mode and triggered mode (Burst mode). With the use of re-configurable device (CPLD), the module becomes a flexible hardware unit, which is configurable through Graphical User Interface (GUI) developed in LabVIEW application development tool. The block diagram in figure 1 shows how various elements are connected to various buses for module operation.

![Block Diagram of CAMAC based Test Signal Generator](image)

**Figure 1.** Block Diagram of CAMAC based Test Signal Generator.

2.1. DAC section

A 12-bit Digital to Analog Converter (DAC) has been used to generate various analog signal like Sine, Triangle wave shape etc. DAC is interfaced with CPLD, which controls its operation. The analog test
signal is generated through 12-bit Digital to Analog Converter and the output range is from 0V to 10V in amplitude and up to few KHz in frequency.

2.2. Clock Generator
A crystal controlled clock generator is used to generate the internal clock. A 10 MHz crystal is used to give the basic clock of 10 MHz. The crystal-based circuit gives the better stability. The module can also run with external TTL clock from front panel LEMO.

2.3. Front panel selection
The generator operates in one of the selectable modes (Continuous mode/ Triggered mode) through external hardware selection or through software selection. Front panel selection allows manual intervention, which provides flexibility in test and measurement without GUI. There are LEMO connectors for external TTL level clock and trigger inputs. The module can also generate TTL level trigger and the clock signal, which can be delivered to other devices through LEMO connectors. The 32 channels of TTL levels square waveform of different frequency for simultaneous measurement and testing connectivity failure in interface cable, are provided through DB-connector.

2.4. Waveform Generation Circuits
The square waveform for different frequencies with TTL level output has been generated with CPLD using VHDL code. VHDL codes provide the flexibility in circuit design and waveform generation through Re-configurable device.

2.5. Control Logic Circuits
Control logic circuits are implemented in the module to control proper module functioning. These logic functions are developed by digital logic circuits. The required logic for controlling various elements is generated using combinational and sequential circuits. Control Logic Circuits have been physically implemented in CPLD. The circuit controlling commands are either issued by computer or generated by circuit itself.

2.6. CAMAC Interface Circuits
These are the interfacing circuits between module and CAMAC backplane (Dataway). These include function decoder, CAMAC control/Acknowledgement data latch circuits etc. These circuits have been implemented through VHDL code with CPLD as a target device.

3. Graphical User Interface
User-friendly software (Graphical User Interface) developed using LabVIEW application software provides convenient usage. This provides a convenient display of various settings of CAMAC Test Signal Generator Module like selection of waveform, its amplitude and frequency, mode of operation, trigger mode etc.

![Figure 2. Configuring CAMAC Test Signal Generator using GUI developed in LabVIEW.](image)
4. Test Results

The performance of Test Signal Generator module was observed under simulated condition as well as in system operation. The developed CAMAC module has been successfully tested with full load to generate test signals for CAMAC and PXI system modules for SST-1 Data Acquisition System at IPR. We have tested the performance of test signal generator for various settings like different wave shapes with variable amplitude and frequency for several hours of operation. Figure 5 shows generator analog output measured on Oscilloscope for the configuration settings of GUI in figure 2. Figure 3 and figure 4 show VHDL code simulation and acquired TTL level different frequency waveform respectively. These waveforms have rise and fall time up to few micro-seconds.

Figure 3. VHDL code simulated TTL level different frequency square waveforms.

Figure 4. TTL level different frequency square waveforms acquired in high sampled mode.

Figure 5. CAMAC Test Signal Generator Analog output measured on oscilloscope.

5. Conclusion

The main aim of this work is to develop a signal generator, which can alone replace a function generator, arbitrary waveform generator, or frequency generator for testing our data acquisition interface for a large number of channels simultaneously. This provides a very good means to test connectivity failure or malfunctioning in a bunch of diagnostics data cables/data acquisition channels. The module can be utilized to generate Sine, Square, Triangular and other wave shape that can vary in amplitude as well as in frequency [3]. The module is quite useful to test up to 32 channels simultaneously with different frequency square wave signal in a group of 8 channels. The different
sets of frequencies help us to test phase shifts between different channels. The module is suitable for the applications that require testing of multi-channel simultaneous sampling data acquisition system.

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