Contribution ID: **1** Type: **Poster presentation**

An Energy Measurement Method of High-frequency Narrow Laser Pulse based on FPGA

With the development of laser technology and high-power lasers, the width of laser pulse is becoming narrower, while the peak power is growing, so that the range of narrow laser application is becoming larger, and now the laser with the pulse width in picosecond level have been applied to the physics, chemistry, biology, quantum communication and other fields for a long time, and playing an increasingly important role. Especially, in the Quantum Key Distribution (QKD) experiment, the pulse width of the laser in transmitter is less than 1ns.

In the QKD system based on the decoy-state-BB84 protocol, a series of laser pulses with random polarization states and intensities are transmitted by the transmitter. There are four polarizations: H, V, P, N and the signal state pulse has an intensity three times of the decoy state pulse while the vacuum state pulse doesn't emit photons. The transmitter also transmits sync-light pulses which have much higher intensities to make sure the information synchronization between the transmitter and the receiver. The sync-light and signal light are coupled into one optical fiber by the WDM technology. In order to debug the system and test the stability of the lasers, the signal light is divided into two paths before coupling and one of the two is connected to the test port of the transmitter. The stability of the lasers and whether the system is working properly can be known by measuring the energy of laser pulses from the test port.

At present, the typical method to measure a laser pulse's energy is transforming the pulse to electrical signal by a photon diode (PIN). The electrical signal is also a narrow pulse, so a peak-value-hold circuit is required to hold the peak of the electrical pulse until an analog-to-digital converting process is finished. But it takes a certain long time to hold and discharge compared with the signal period, results in a low processing rate. The highest frequency is less than 1MHz on a monolithic sample-and-hold chip so far.

We designed an energy measurement method used for high-frequency narrow laser pulses based on a high performance field-programmable gate array (FPGA) chip, There are two parts contained in this method: signal conditioning and data processing. The signal conditioning part will transform the incident narrow laser pulse to electrical signal which has an appropriate width and the amplitude is linear to the energy of the laser pulse. The electrical signal will be digitalized by a high speed ADC and input to the FPGA chip in the data processing part. The amplitude of the electrical signal will be obtained by real-time calculations in the FPGA. The test result shows that the method is suitable for the laser pulse with FWHW low level with 200ps and frequency up to 20MHz.

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Session Classification: Poster session 1

Track Classification: Data Acquisition