Picosecond Oscilloscope

May 26 2009

An oscilloscope is a device for displaying signals that are too fast to be seen by the human eye. Typically the signal consists of a voltage level that changes quickly moment by moment (over millisecond to nanosecond timescales). What is seen on the screen of the scope is a waveform whose value is graphed along the vertical axis as a function of the horizontal axis representing time. An electron beam, aimed at a phosphorescent screen, is swept horizontally providing a light-trace on the screen while, coincidentally, the instantaneous voltage of the input signal is used to deflect the electron beam up or down, creating the visible trace.

The dynamic range of this whole process is the range of voltage values that can be displayed; the other important feature is the time resolution: how fine a time scale can be achieved. Conventional analog television displays use comparable technology. A trace is swept horizontally across the screen, but instead of deflecting the beam up and down, the beam is interrupted or allowed to proceed toward the phosphor screen, where the trace shows up as a bright or dark spot. The display is then scanned across the screen again in a raster pattern to build up a complete screen image (but so quickly that the human eye doesn't notice it at a rate of 30 or 60 frames per second).

For performing high-end physics, ordinary oscilloscopes and televisions aren't fast enough, and the deflection of a beam used to display an image or a short-lived signal requires a different technology, which sometimes goes by the name "streak camera." Because the electrons comprising the beam are charged particles, the signals they carry suffer unavoidable blurring where the signal strength is strongest, thereby limiting the useful dynamic range. John Heebner and colleagues at Lawrence Livermore National Lab (LLNL) recently devised a solid-state all-optical streak camera, the first to attain a time resolution near 1 picosecond while simultaneously preserving a wide dynamic range, 3000:1. In his camera, the beam being deflected consists not of charged electrons but of uncharged photons, which do not suffer from the limitations of conventional streak cameras.

He achieves an unprecedented deflection rate of a light beam by sending it through an ordinary planar waveguide whose optical properties can be nearly instantaneously modified by a separate pump laser beam incident from above. A sequential array of "transient" prisms is created by first allowing the pump beam to pass through a serrated mask. When the pump beam is properly synchronized to the signal beam to be recorded, time-of-flight at the speed of light does the rest. Because later portions of the signal encounter more prisms, that part of the signal is deflected by a greater amount than the earlier portions of the signal that had already advanced through the waveguide before the prisms turned on. The prisms persist for the duration of the sweep and disappear in time for the process to start again with the next trace. Each deflected light trace is then focused onto an array of camera pixels. The light level detected on the array thus preserves a recording, over time, of the light beam's intensity.

Heebner's device, which he calls serrated light illumination for deflection encoded recording (or SLIDER), can even be used to study short bursts of light in the X-ray region of the light spectrum. This is accomplished by first encoding the X-ray signal onto an optical beam using an optical device (a Fabry-Perot cavity) that can be modulated at picosecond timescales. This makes SLIDER potentially valuable for monitoring the brilliant bursts of X-rays streaming from fusion targets at the collision point where the multiple laser beams of LLNL's National

Ignition Facility (NIF) come together.

The benefit of the device is that it enables the recording of very fast phenomena. As the world's fastest light deflector, it can be used as a picosecond oscilloscope or for observing transient events like the miniature fusion reaction that occurs at the National Ignition Facility.

Researchers will present these results at the 2009 Conference on Lasers and Electro-Optics/International Quantum Electronics Conference (CLEO/IQEC) May 31 to June 5 at the Baltimore Convention Center in Baltimore.

Provided by Optical Society of America (news : web)

Citation: Picosecond Oscilloscope (2009, May 26) retrieved 17 April 2024 from https://phys.org/news/2009-05-picosecond-oscilloscope.html