

Broadband chaos generation and prototypes of chaos-based OTDR and RNG

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Abstract— After secure communications [1], chaos in semiconductor lasers has triggered considerable development is random number generator (RNG) [2-4] and range finding including radar [5] and optical time-domain reflectometer (OTDR) [6]. Benefiting from the bandwidth of laser chaos, the rate of RNG can reach to several Gb/s (note the off-line rate can be 100-300 Gb/s), and the spatial resolution of range finding can be improved to several centimeters [4, 5]. From the viewpoint of practical applications, it is important to provide evidence of robust and stable operation of such systems. Therefore, we demonstrate here two prototypes of OTDR and RNG based on chaotic semiconductor laser. As shown in Fig.1, using a distributed-feedback semiconductor laser with optical feedback as chaotic source, the prototype chaotic OTDR achieves a range-independent resolution of 4cm and measurable distance of about 70km. Figures 2(a)-2(c) shows the schematic setup of our RNG prototype and its photos. The RNG prototype can yield a random bit stream with a rate up to 4.5 Gb/s [7]. The measured waveform and eye pattern are plotted in Figs. 2(d) and 2(e).

In addition, there is a vital limitation to the generation rate of RNG as well as the spatial resolution of OTDR, i.e. the bandwidth of chaotic laser which is normally limited to several gigahertz by laser relaxation oscillation. Here we review three methods of generation of broadband chaos we proposed recently [8-10], listed in Fig. 3. The bandwidth of laser chaos can be improved 3-4 times, and the widest spectrum extending to 40GHz was achieved. It is believed that these results can greatly promote applications of laser chaos.

Keywords-chaos; semiconductor laser; optical time domain reflectometry; random number generation

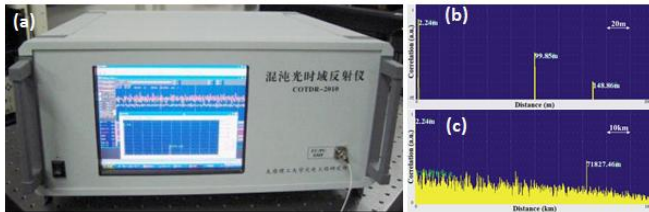


Figure 1. (a) Photo of COTDR prototype, (b) experimental results of a fiber connector and a breakpoint, and (c) of a breakpoint at 72km measured by the COTDR.

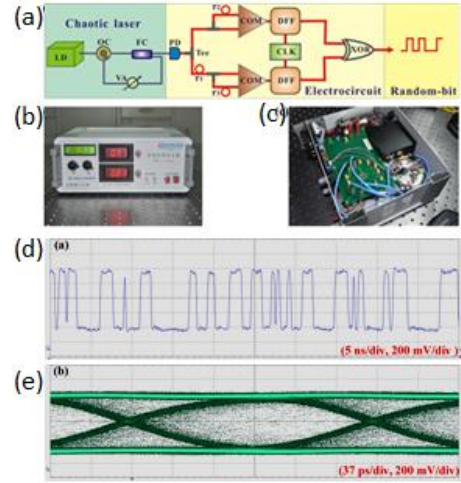


Figure 2. (a) Schematic setup of our RNG prototype based-on chaotic laser, (b), (c) photos of RNG prototype, (d) and (e) are the measured waveform and eye pattern of an output of 4.5Gb/s random bitstream.

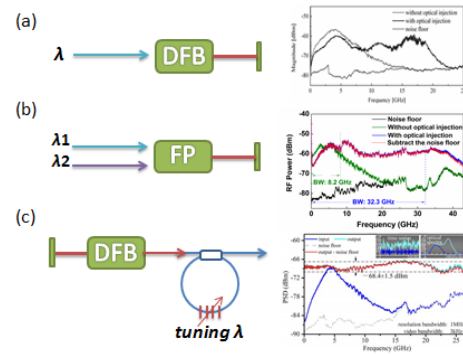


Figure 3. Three methods to generate broadband chaos using semiconductor lasers: (a) optical injection, (b) dual-wavelength optical injection, and (c) chaotic-light-injection fiber ring resonator. Left: sketched setups; right: representative experimental results.

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