THz Torch Technology for Low-cost Security Applications

Stepan Lucyszyn and Fangjing Hu
Centre for Terahertz Science and Engineering, Imperial College London, UK
s.lucyszyn@imperial.ac.uk and http://www3.imperial.ac.uk/terahertz

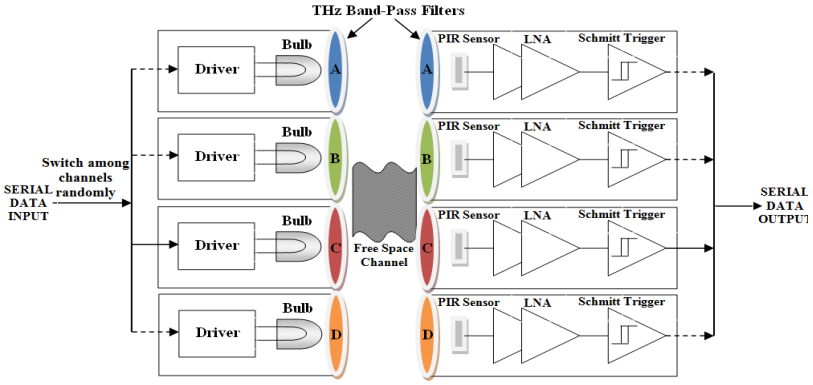
Terahertz systems are notoriously very expensive, from complete systems down to individual active devices and passive components. For this reason, there are very few ubiquitous commercial applications in the far-infrared (300 GHz to 30 THz) and mid-infrared (30 THz to 120 THz) parts of the electromagnetic spectrum; notable exceptions to this are relatively basic ultralow cost motion sensors (for applications ranging from security to energy saving lighting systems) and fire detection systems. An example of an ultralow cost wireless communications system can be found in ubiquitous near-infrared remote controls, which operate at a wavelength of 940 nm (i.e. 319 THz). This technology has been around since the early 1980s. However, to date, there has been little reported R&D into similar systems at longer wavelengths.

The *'THz Torch'* technology was recently introduced for the sole purpose of demonstrating that ubiquitous THz applications are possible if dramatic cost-reduction techniques can be introduced. Unlike most conventional THz technologies, which are based on expensive coherent signal generation and detection techniques, the *'THz Torch'* technology is based on thermal radiation; bridges the *THz gap* between electronics and photonics using thermodynamics.

In 2011, the first ever working proof-of-concept ultralow cost short-range THz wireless link was demonstrated; with a maximum data rate of just 5 bit/s over a 0.5 cm range [1]. Simple ON-OFF keying digital modulation of band-limited thermal noise was reported, operating between 25 and 50 THz. This performance quickly improved to 40 bit/s using 4-channel frequency division multiplexing (FDM) techniques [2] and then 380 bit/s over a single channel [3]. Today, 1 kbit/s has been achieved over a single channel with the promise of much faster operation as new techniques are investigated. Indeed, the *'THz Torch'* concept is still in its infancy, with many possible ultralow cost enabling technologies waiting to be investigated.

The motivation for this research can be seen from the following benefits: (1) low precision components used; (2) easy to manufacture in large volumes; (3) inherently ultralow cost; (4) contactless and so robust; (5) tuneable performance at no extra cost; (6) diverse enabling technology solutions; and (7) operation is in a virtually unused part of the electromagnetic spectrum. This last point offers covert operation for security applications. Indeed, with such large amounts of freely available spectrum and high atmospheric attenuation, there is an extremely low probability of intercept and code grabbing, making this technology ideal for security applications.

In addition to FDM, a frequency-hopping spread spectrum (FHSS) system can be implemented to further enhance the level of security, as illustrated below, where data is transmitted at different times within similar predetermined bands across the far/mid-infrared parts of the electromagnetic spectrum. With both FDM and FHSS applications, a number of standard 'off-the-shelf' filters/windows can be employed with sufficient bandwidth, selectivity and transmittance to create filter banks for multi-channel FDM and FHSS applications.



In summary, the *'THz Torch'* technology provides an additional physical layer of security with conventional communications applications that do not require high data rates but must be ultralow cost (e.g. secure RFID, smart key fobs and mobile phone links); and possibly for covert communications (e.g. DLB and night signalling). Moreover, it may well be possible to perform crude absorption spectroscopy for the detection of explosive precursors and drugs. Finally, this technology is ideal for implementing high-resolution military FIR countermeasures (e.g. thermal camouflaging, sentry decoys and IED triggers). For all these potential security applications, the *'THz Torch'* concept is worthy of further investigation.

---

1. S. Lucyszyn, H. Lu and F. Hu, "Ultra-low cost THz short-range wireless link", IEEE International Microwave Workshop Series on Millimeter Wave Integrated Technologies, Sitges, Spain, pp. 49-52, Sep. 2011
2. F. Hu and S. Lucyszyn, "Ultra-low cost ubiquitous THz security systems", Proc. of the 25th Asia-Pacific Microwave Conference (APMC2011), Melbourne, Australia, pp. 60-62, Dec. 2011 (Invited Paper)
3. F. Hu and S. Lucyszyn, "Improved 'THz torch' technology for short-range wireless data transfer", IEEE International Wireless Symposium (IWS2013), Beijing, China, Apr. 2013