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Downconverting THz Resonant Pulses upon Reception

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Abstract

This paper considers the design of a receiver for sinusoidal THz bursts. Besides the antenna problem, there are rectifying diodes to downconvert the THz into more traditional microwave frequencies.

1 Introduction

Previous papers [1–6] have considered the problem of radiating THz resonant pulses from antennas involving switched oscillators. Including focusing reflectors or lenses a THz beam can be propagated to large distances, limited by atmospheric attenuation [7]. This leads to one to choose frequencies, such as 0.3 THz, in a transmission “window” [8]. This choice is also weighted by the better beam collimation (smaller divergence) at higher frequencies.

With voltages on the order of 100 V on the transmitting switched oscillator, one can envision radiated powers on the order of some tens of watts from a single antenna. An array of such elements [5] increases this by the numer of elements N in the array (say 25 or 100). Of course this lasts for a very short time. For 30 cycles at 0.3 THz this lasts for 100 ps, so the total energy is small with, say, 20 W multiplied by 10^{-8}s times N, putting us in the μJ range. The average power depends on the PRF (pulse repetition frequency). A PRF of 1 MHz puts the average power in the Watt range.

One also needs to receive the THz bursts (e.g. damped sinusoidal pulses) in a manner which retrieves the information contained in a string of such pulses (e.g. pulse-code modulation). One approach to this problem is to rectify the RF burst. For example, if one had about 30 cycles at 0.3 THz, this would give a pulse of about 0.1 ns (or 100 ps) wide. This corresponds to a half period at about 5 GHz which can be handled by existing microwave technology.

One can take the incoming THz beam and handle it in a way similar to the transmitting antenna. (Good transmitting antennas make good receiving antennas.) Using a paraboloidal reflector (in perhaps a Cassegrain configuration) the THz beam can be concentrated on the small THz antennas. The signal from the latter can be rectified to come out at a much lower frequency which still retains the information.

2 Receiving Antennas with Demodulation

As mentioned before, the THz beam needs to be collected and focused on the receiving antenna elements. While these can be similar to the transmitting antenna elements, how these are used can be somewhat different. In the transmitter we charge up the antenna, and discharge as a switched oscillator to obtain a resonant waveform. In the receiver we want to deliver some maximum energy in some form and place where one can retrieve the information.

Figure 2.1 shows a possible scheme for demodulation using a differential full wave rectifier. Ideally we load the output with two transmission lines of characteristic impedance Z_c each, or a single differential transmission line (strip line) of characteristic impedance $2Z_c$, for extracting the maximum rectified power from the antenna. We may have capacitors as indicated to smooth out the pulse waveform, but these may not be needed as propagation of THz components along the stripline may be significantly attenuated. The THz diodes, e.g. [9, 10], will also have capacitance affecting the output. The responsivity (3000 V/W) of such diodes appears high so that we can afford significant attenuation and divergence of the incident THz wave and still receive a significant signal from the receiver.

The antenna can be any of these already considered for the transmitter (e.g. [2]). This will need to be tuned to the frequency of the transmitted waveform. The effects of the rectifier and loading transmission line will also need to be considered in this tuning.

The receiver might also be an array of such antennas [4]. In this case the signals from the various rectifiers will need to be summed by appropriate routing and recombination of the various transmission lines.

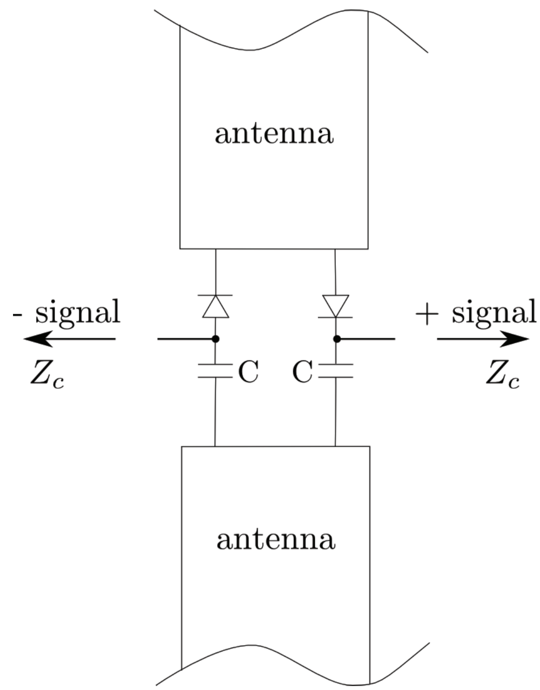

Figure 2.1: Demodulating (downconverting) antenna with full wave differential rectifier.

3 Concluding Remarks

It thus appears feasible to design an appropriate receiver for THz bursts. The downconverted signal is in a frequency band where more standard electronics can be used to retrieve the information (e.g. voice or data) modulated on the THz beam.

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