Sensor and Simulation Notes

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Meander and Zig-Zag Antennas in Periodic Resonance for THz Application

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Abstract

This paper considers the design of special kinds of meander and zig-zag antennas for THz application. The various parts of the antenna conductors (elements) are made to oscillate in phase when driven by a switched oscillator.

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1. Introduction

Previous considerations for THz antennas driven by switched oscillators [1, 2] have concentrated on electric-dipole-like antennas as radiators. Including a ground-plane parallel to the elements, of course, makes the radiation more like a quadrupole. The ground plane (less than $\lambda / 4$ behind in the dielectric) increases the radiation in a desired direction, toward a target or a reflector for better concentrating the beam.

Worth considering are more elaborate antenna designs. One approach is to use arrays, i.e., many elements. However, we would like to drive this set of elements from a single switched oscillator (either single-ended or differential [1]). This avoids the problem of synchronizing many sources with subpicosecond spread [3].

One approach to this problem uses a set of elements connected together in a quasi-transmission-line sense, with the relevant elements all acting in phase at the selected frequency. One kind of antenna that can do this is the helical antenna [7 (ch. 7)], which can operate in endfire or broadside (normal) mode. However, for our application with severe physical construction issues, we would like the antenna to be planar. One can imagine squashing the helix from one side to give a sinusoidal variation of the conductor on a single plane. Of course, this does not have the circular-polarization characteristics of a helical antenna, but may be more appropriate for linear polarization.

There is a class of antennas known as meander antennas or zig-zag antennas which look roughly like the squashed-helix geometry. However, my looking through the literature seems to find that these have been primarily considered for the increased inductance to slow the wave and make more compact antennas. A counter example of this can be found in [4]. However, the presence of a ground plane parallel to (and less than $\lambda / 4$ or so behind) the antenna plane, changes the problem considerably [8].

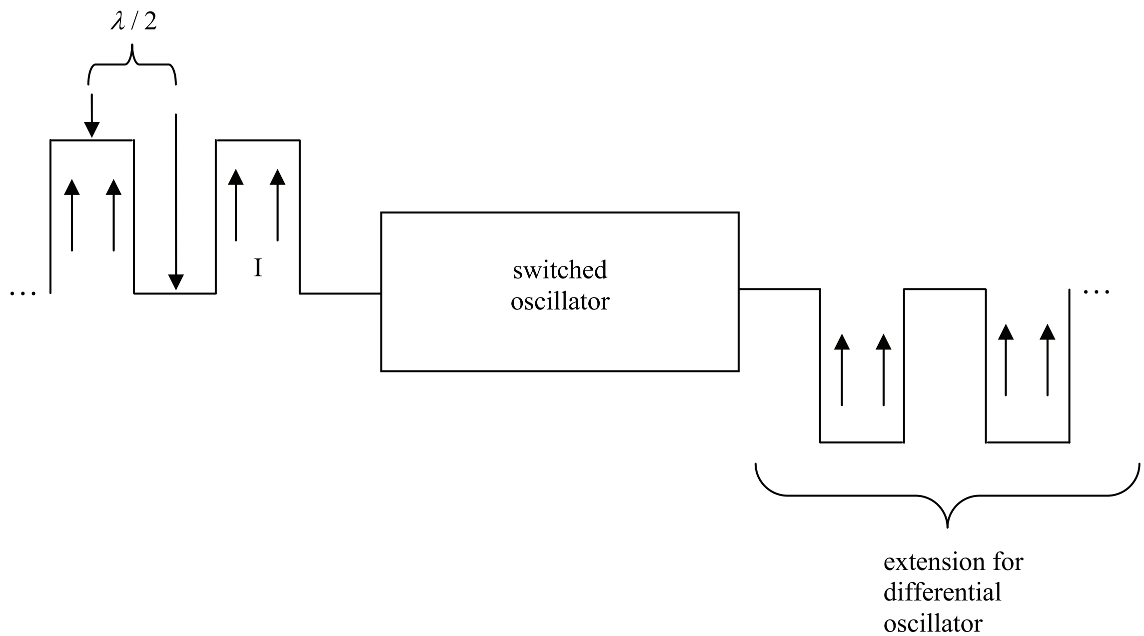
Another interesting antenna class is known as comb antennas [6] (also related to fishbone antennas). In this case we are also interested in broadside radiation due to a backing ground plane in the present application. This type of antenna has a transmission-line-like feed with periodically spaced elements transverse to this. It could also look like a log-periodic antenna, but with constant element lengths tuned to our desired frequency.

2. Meander or Zig-Zag Antenna

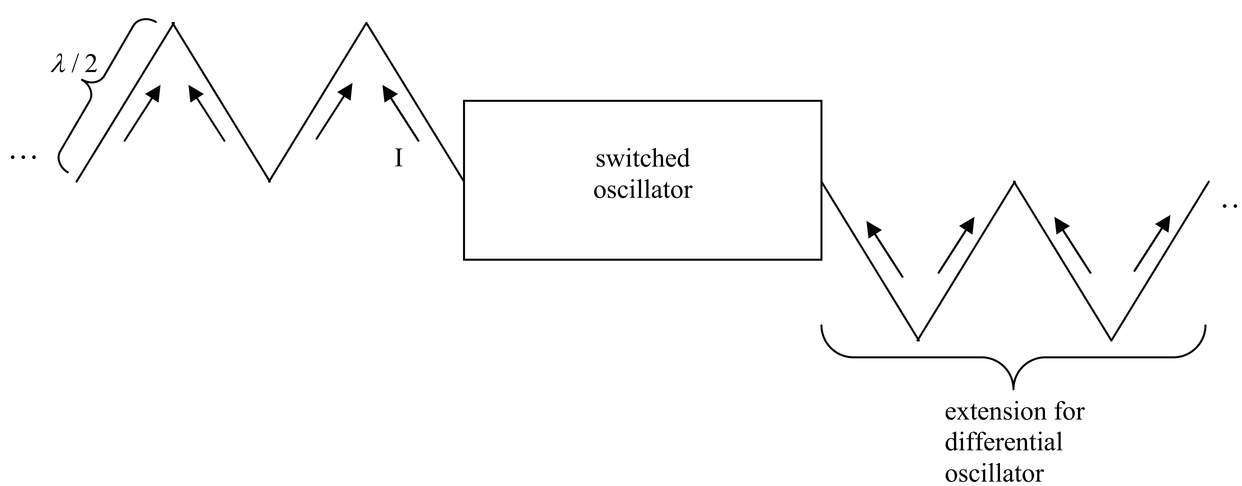
Figure 2.1 schematically shows a switched oscillator driving such antennas. Here there is the possibility of a differential switched oscillator [1] driving the (differential) antenna. While the figure shows an offset between the two parts of the antenna, these can be made more in-line by an appropriate rotation of the switched oscillator, or an appropriate modification of the initial portions of the two halves of the antenna.

Looking more closely at the switched oscillator we have the expanded diagrams in Fig. 2.2 Note that at resonance the impedance looking into the oscillator, Z_{in}, is high near a current minimum. The impedance, Z_a, looking into the antenna is relatively high. Detailed calculations will help to design the first parts of the differential antenna to set up the desired standing-wave pattern with currents on the antenna having a strong net *y* component compared to a weak *net x* component. The current on the antenna is to be sinusoidal, reversing direction on going from one part of the antenna (say a zig) to the next (say a zag). Note that the differential oscillator is itself a half wavelength, as is each "element" of the antenna.

Note that a conducting plane less than $\lambda / 4$ behind the antenna reinforces the radiation in the *z* direction. As discussed in [1], the oscillator may have another conducting surface above it (positive *z*) to both lower its transmission-line characteristic impedance and block radiation from itself.

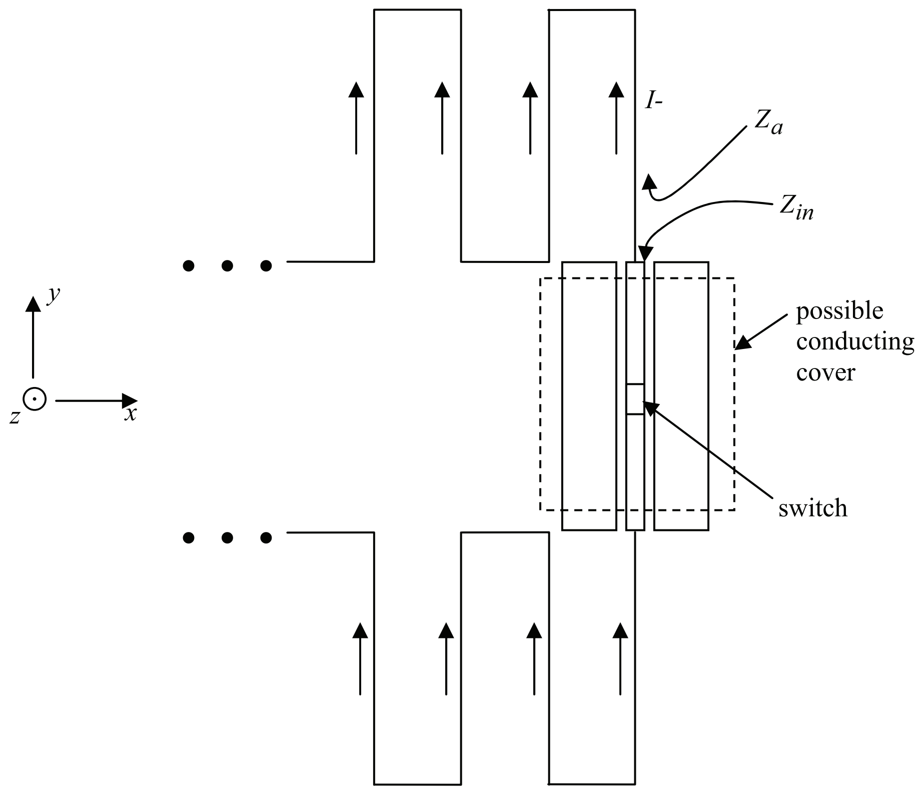


A. Meander

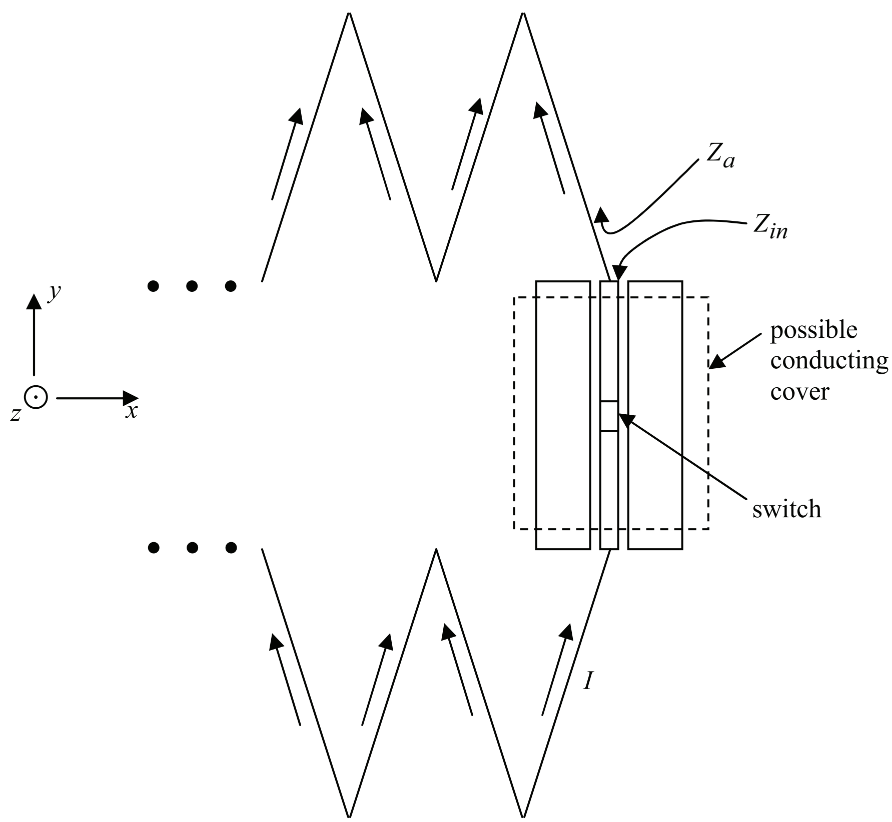


B. Zig-zag.

Fig. 2.1 Desired Current Pattern on Meander and Zig-Zag Antennas.



A. Meander



B. Zig-Zag

Fig. 2.2 Switched Oscillator Driving Antenna

3. Nonlog-Periodic Antenna

Another possible antenna design is based on what is known as a comb antenna [5, 6]. This is also known as half of a fishbone antenna. The idea here is to have a set of resonant elements which operate at the same frequency (instead of a progressive set of frequencies), with a spacing along a transmission-line-like conductor to make the elements oscillate in phase. Here we also add a backing ground plane to remove the back radiation and direct it approximately forward.

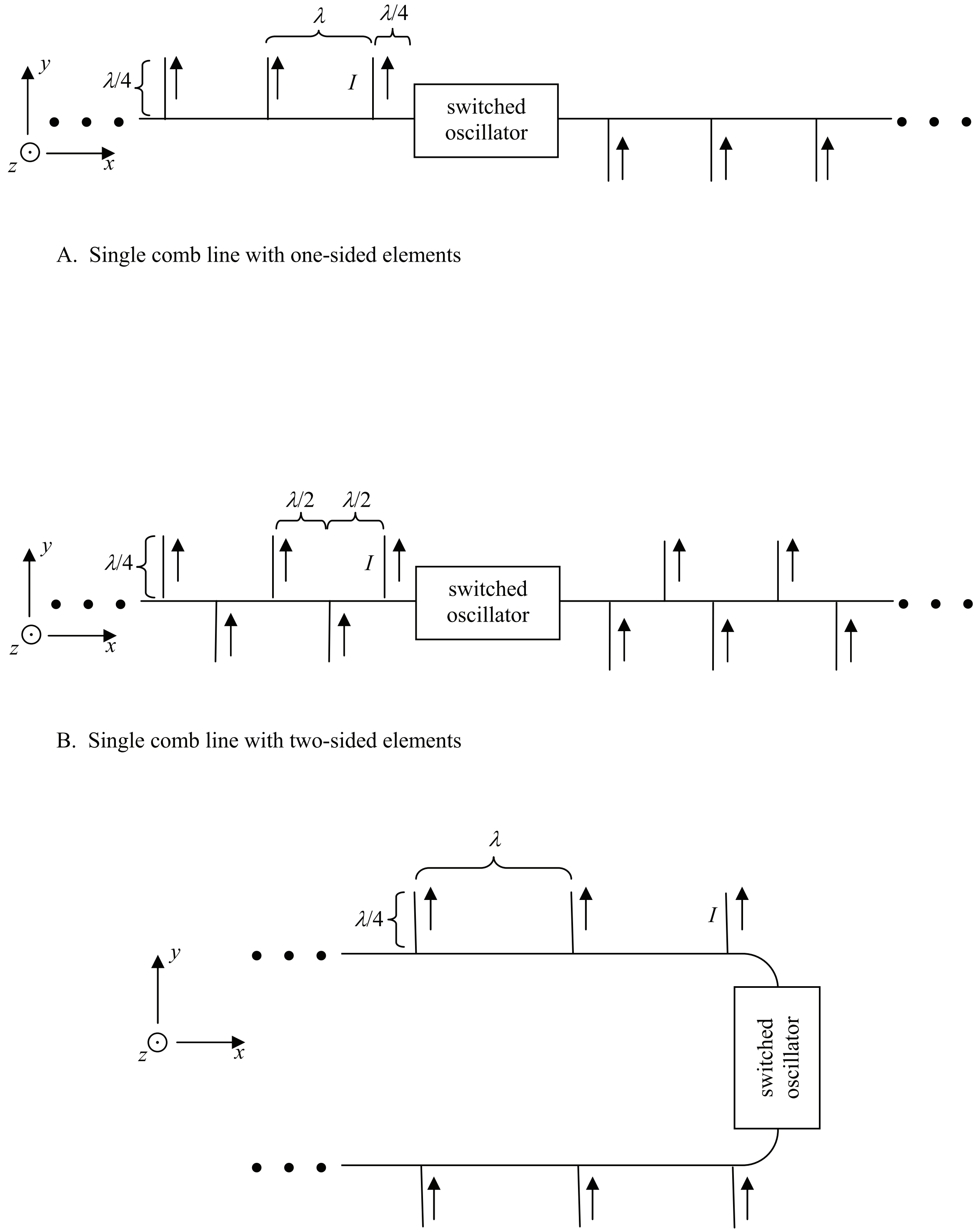
Figure 3.1 illustrates this concept. Note that there is a ground plane behind the antenna to prevent back radiation. This also forms a return line for the transmission-line conductor connecting the antenna elements. This conductor might be placed closer to the conducting plane (or the conducting plane may have a raised portion here) for less radiation. Alternately the antenna elements can be raised to give the desired approximately $\lambda / 4$ spacing from the ground plane.

Figure 3.1 shows some possible realizations of the antenna concept. One can have a single comb line with elements spaced λ (on the transmission line) in single ended or differential form as in Fig. 3.1A. This can also be constructed as what might be called a double comb line with elements $\lambda / 2$ apart alternating to opposite sides of the transmission line as in Fig. 3.1B. The comb line from a differential switched oscillator can also be folded as a double comb line as in Fig. 3C.

4. Concluding Remarks

As one can see, there are many variations on these types of antennas, driven by switched oscillators, for THz application. Here we illustrate a few. The basic idea is to design a structure, backed by a ground plane, which has elementary parts (elements) with current giving in-phase radiation.

Here we have discussed the design from a qualitative viewpoint. A good quantitative computer analysis would be useful to determine which of these design options gives the best radiation. This needs to be coupled with the construction difficulty each design presents.



C. Double comb line

Fig. 3.1 Desired Current Pattern on Comb line Antenna

References

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