Reconfigurable Antennas Based on Waveform-Selective Metasurfaces

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In this study we introduce passive, reconfigurable antennas based on recently developed waveform-selective metasurfaces. [1] These metasurfaces are composed of planar metallic sheets with periodic rectangular slits and dielectric substrates (Fig. 1a). In addition, slit edges are connected by a set of four diodes to fully rectify induced electric charges and convert the incoming energy to mostly zero frequency (Fig. 1b). This rectified energy is controlled by transient responses of a capacitor and an inductor as well as that of a resistor. Under these circumstances, the waveform-selective metasurfaces preferentially transmit signals even at the same frequency depending on the incoming waveforms or pulse widths. More specifically, this study uses an inductor-based waveform-selective metasurface and a capacitor-based waveform-selective metasurface, each of which effectively transmits a short pulse and a long pulse, respectively. Moreover, a parallel-type waveform-selective metasurface is used to more strongly transmit an intermediate pulse than others. These waveform-selective transmitting metasurfaces are deployed around a grounded monopole antenna, which radiates isotropically (Fig. 1c). However, the use of such non-uniform waveform-selective metasurfaces enables the antenna to send a signal to different directions depending on a pulse width or time slot. For instance, as seen in Fig. 1d, more energy is transmitted to receiver 1 than receivers 2 and 3 until 0.1 μs. This is because the above-mentioned inductor-based waveform-selective metasurface more strongly transmits energy than the other two waveform-selective metasurfaces. Around 1 μs and 10 μs, receiver 2 and receiver 3 accept more energy due to the parallel-type and capacitor-based waveform-selective metasurfaces, respectively. Importantly, these time scales are even longer than one cycle of the frequency used (specifically, 3.9 GHz thus about 0.25 ns for one cycle). This indicates that the frequency spectrum of the signal remains almost the same. Nonetheless, this antenna still varies its radiation pattern in response to the pulse width or time slot. Hence, our study is expected to give us an additional degree of freedom to design antennas.

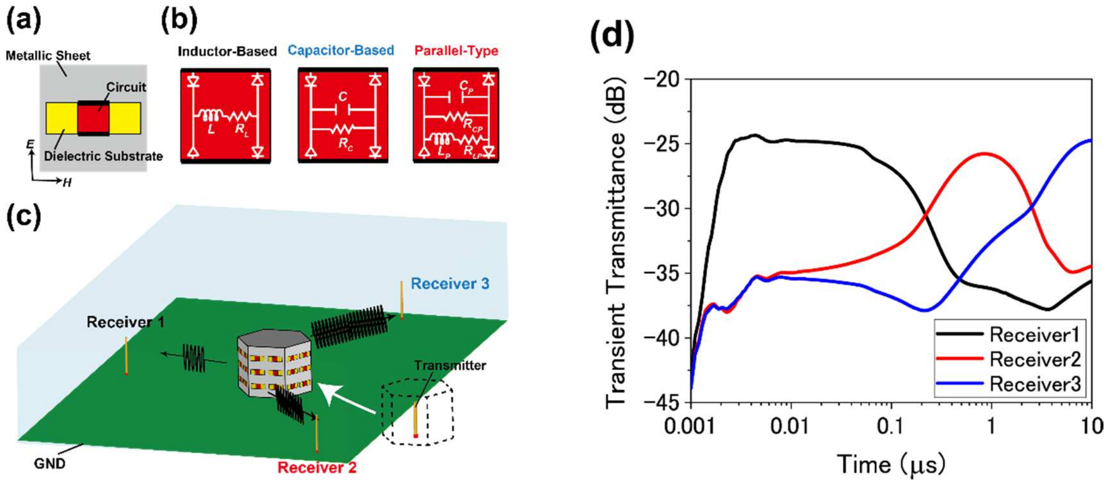

Figure 1. (a) Periodic unit cell and **(b)** circuit configuration used for each type of waveform-selective metasurface. **(c)** Designed antenna and **(d)** its performance.

Reference

[1] H. Wakatsuchi, J. Long, and D. F. Sievenpiper, “Waveform Selective Surfaces,” *Adv. Funct. Mater.*, **29**, 10, 1806386, 2019, doi: 10.1002/adfm.201806386.