Wave Controlled Reconfigurable Intelligent Surface: Non-Convex Optimization And Wideband Element Design

A wave controlled reconfigurable intelligent surface (RIS) is a novel technology currently being researched at UCI. This technology aims at making higher frequency wireless communications feasible and cost effective for 5G and future 6G communications. Many aspects of this proposed technology have yet to be realized, however currently there are two research challenges being undertaken. First, performing a nonconvex optimization on a cost function which comes from matching a desired beamforming to a pattern from rectified standing waves along a transmission line. Second, designing a dual resonant element to increase the instantaneous bandwidth from the surface. Both areas of research have yielded promising initial results.

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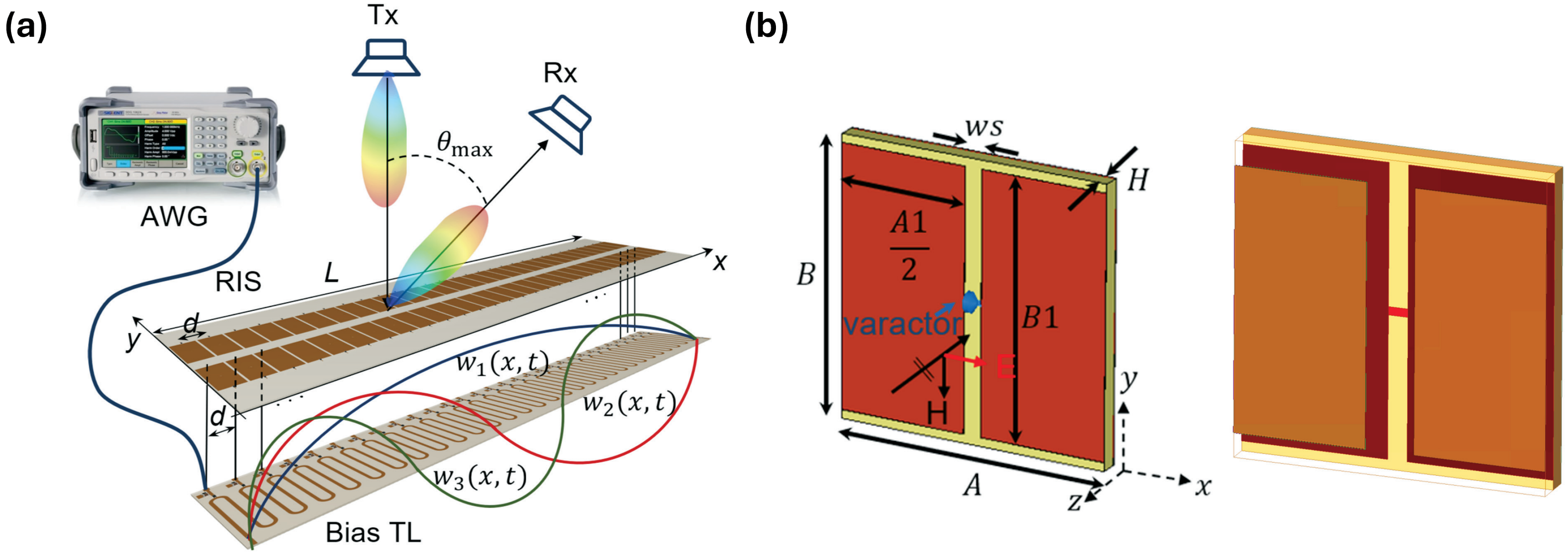
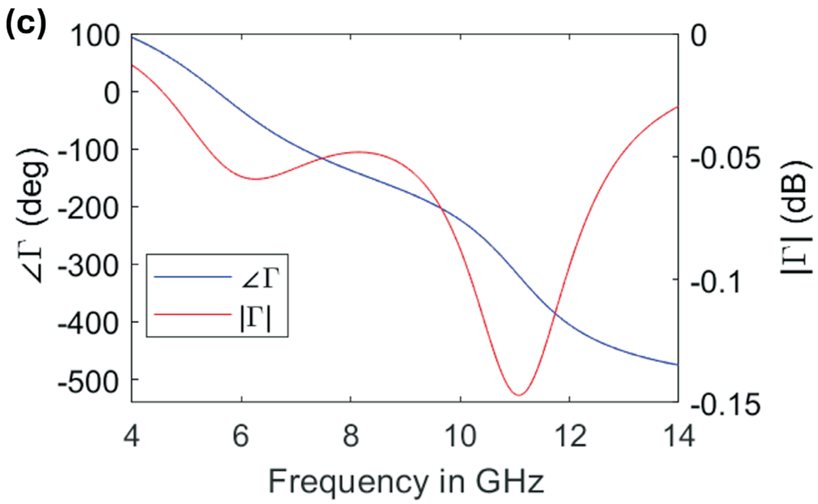


Wave Controlled reconfigurable intelligent surface design: (a) System design including an array of unit cells on the top layer used for reflecting incident waves in arbitrary directions, and a biasing transmission line on the bottom layer which supports standing waves to control the reflective characteristics of the top layer. (b) Unit cell design including the reconfigurable element for the single resonant case on the left and a previous dual resonant case on the right.



(d)

$$\hat{w}(x_m,t) = W_0 + \sum_{n=1}^{N} W_n \sin\left(\frac{n\pi x_m}{L}\right) \sin(n\omega_b t)$$

$$w_m = \max_t(\hat{w}(x_m,t))$$

$$J = \sum_{m=0}^{M-1} (v_m - w_m)^2, \qquad J = \sum_{m=0}^{M-1} [(v_m - g(w_m)) * z(v_m)]^2$$

Unit cell dual resonance and optimization problem: (c) Phase response from the shown dual resonant unit cell can obtain reflected phases of over 360 degrees allowing for a more wideband design. (d) Nonconvex optimization problem with w_m being the voltages measured to each unit cell given wave amplitudes W_n for reconfiguration, and v_m being the desired voltages applied for a desired reflection pattern analytically calculated given a specific unit cell design.