Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

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# Efficient Multi-Bit Reconfigurable Reflective Surface (RRS) for mmWave and Terahertz Applications

## Inventors

**Georgios Trichopoulos**

**Panagiotis Theofanopoulos**

## Contact

Shen Yan
shen.yan@skysonginnovations.com

Background

Reflective surfaces, including metasurfaces and reflectarray antennas, are comprised of several subwavelength (< λ/2) passive reflective elements and can steer the reflection of an incident electromagnetic wave in arbitrary directions.

Typically, reflective surfaces use one or multiple single-pull-single-through (SPST) switches (e.g., PIN diodes) leading to single or dual bit reconfigurable surfaces (e.g., reflectarray antennas). However, existing topologies require more than one switch-per-bit for more than two bits of quantization, thus leading to excess losses, require more RF components, and complex biasing networks. Moreover, fewer bits result in higher quantization errors that further decrease radiation efficiency and beam-scanning resolution.

Invention Description

Researchers at Arizona State University have developed a new topology where the RSS element operates as both an antenna and splitter/combiner allowing for scalable, multibit, single switch-per-bit RRS. Using a shunt configuration, this innovation achieves up to 4 bits of sampling on the phase of the reflected waves.

To bypass the use of a bulky splitter/combiner, the invention exploits the cavity model of the printed patch antennas to draw multiple feeding lines. When the impinging waves illuminate the surface, the signals on the antennas are split equally among the different ports. Every port is connected to a switch-terminated delay line. By tuning the state of each switch (e.g., biasing), the reflected waves are modulated and constructively added on the antenna. For top performance, the lengths of the delay lines are appropriately optimized to achieve equispaced phase states.

The topology is highly suitable for many millimeter-wave/terahertz imaging and communication applications, including signal relays. Optical reflective surfaces in the near-infrared and optical frequencies, as well as reconfigurable transmitting surfaces (RTSs) can also benefit from this core technology.

Potential Applications

- 5G and beyond wireless communications in the form of relay systems and/or large intelligent surfaces
- Millimeter-wave radars for collision avoidance and autonomous navigation
- Point-to-point ad-hoc networks including for military
- Indoor imaging for remote vital sensing and assisted living
- Low-weight, low-profile embedded radars for military applications (e.g., on airborne vehicles)

Benefits and Advantages

- Compact design avoids use of complex/lossy splitter/combiners in the limited space of the unit-cell
- Scalable to other frequency ranges (optical/infrared or microwaves) with the use of cavity-based antennas
- Increased radiation efficiency (less signal loss)
- Superior beam-scanning performance in high-resolution and high-dynamic-range applications such as radar and imaging

Research Homepage of Professor Georgios Trichopoulos