

Th2D-1

Rotman-Lens-Based Reconfigurable Intelligence Surface mmID with Energy Harvesting Capability

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Non-Line-of-Sight Problem

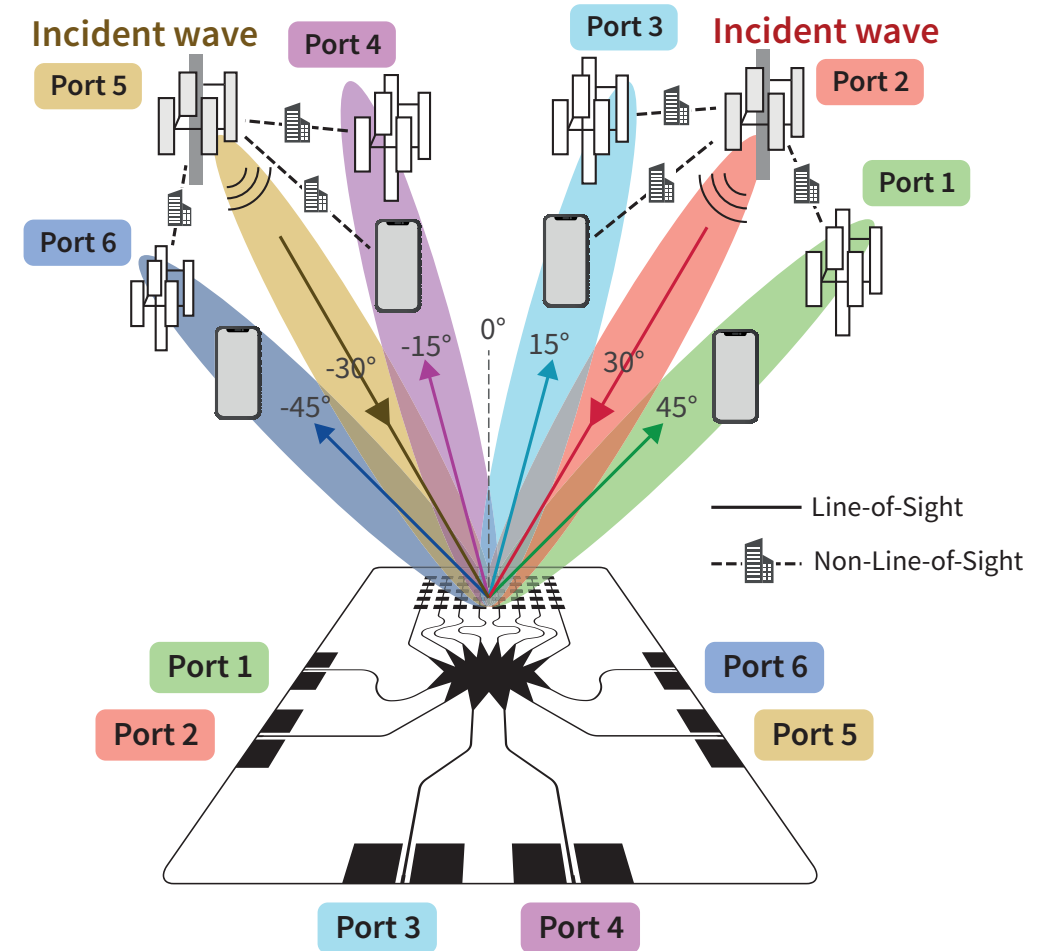
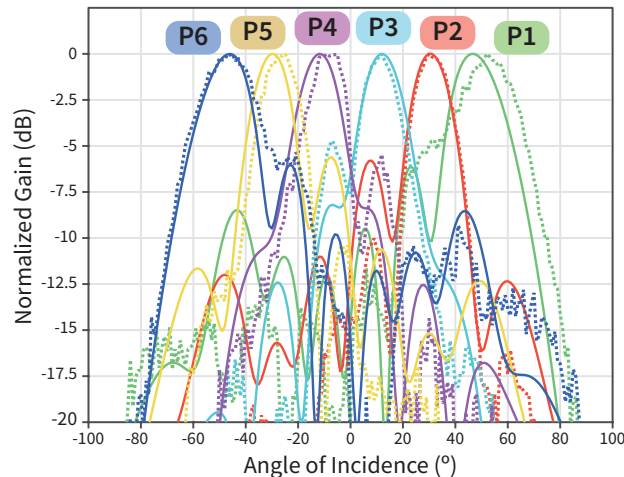
- 5G signals tend to be blocked in a complex environment
 - Smart city applications
- Current RIS Technology: Phase Arrays
 - High power consumption
 - Low frequency

Motivation

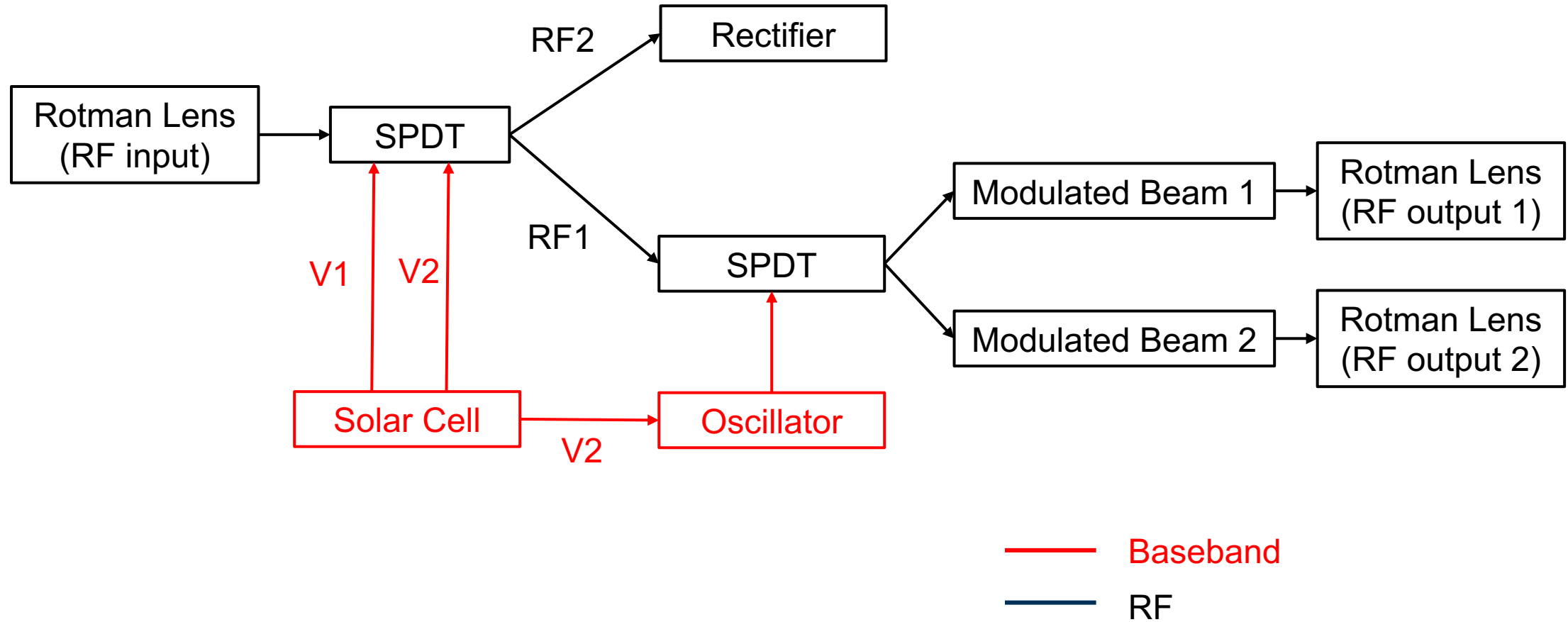
- Lack of Reconfigurable Intelligence Surface at 5G mm-Wave frequency band
 - Low power
 - Small in size

Symmetric Design

- Rotman-Lens-Based RIS
 - Passive RF Combine
 - Overcome tradeoff between gain and angular coverage
- Embedded harvester

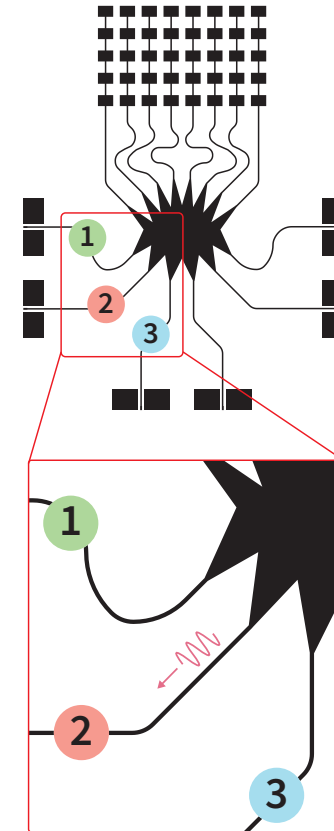


Block Diagram

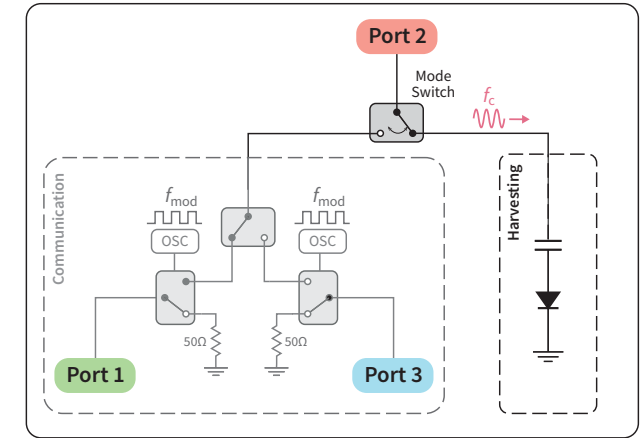


Symmetric Design

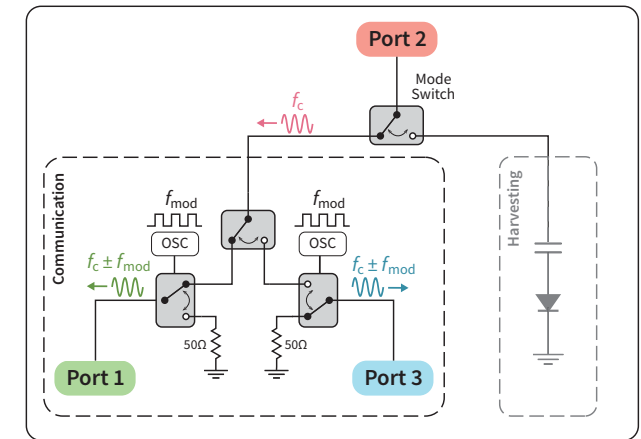
- SPDT Switch
 - Harvest vs. Communication
 - Signal direction selection
 - 270 kHz ASK Modulation
- Suppress retrodirective signals
- Delay the modulation to maximize signal strength



(a) Rotman Lens Port Layout



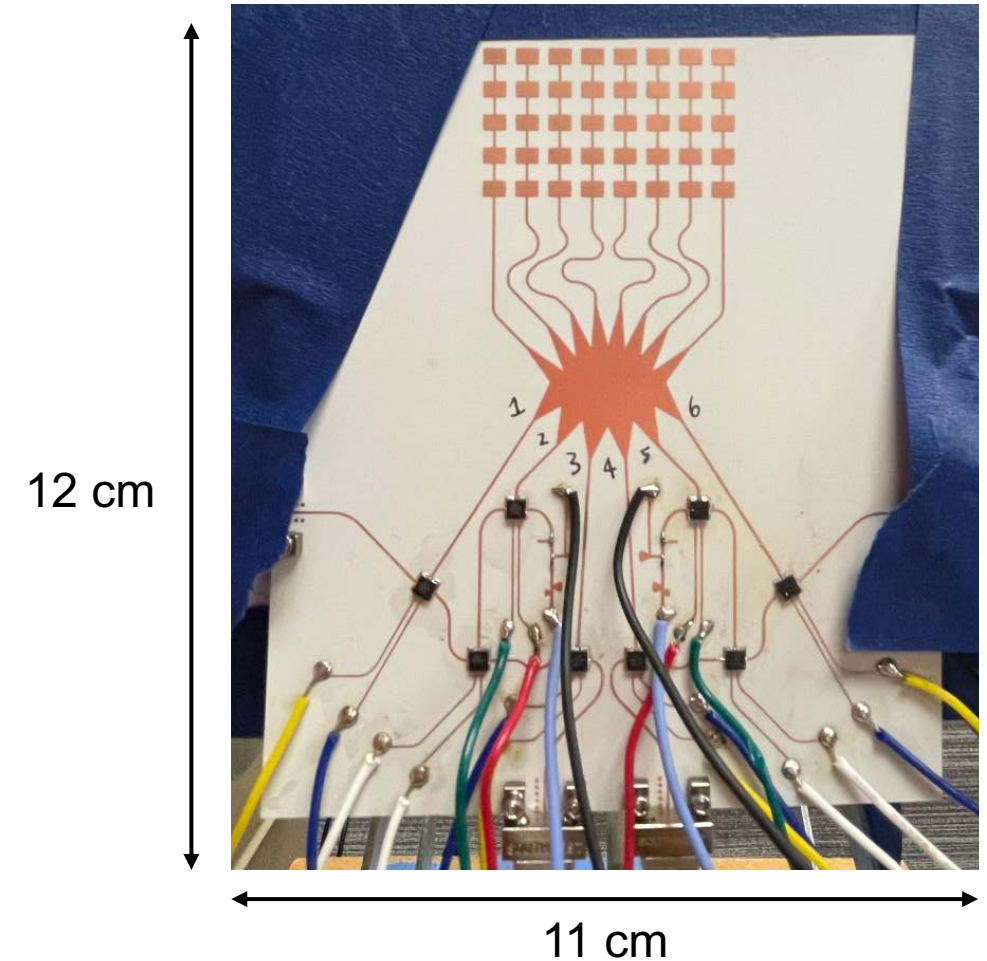
(b) RIS Design Harvesting Mode



(c) RIS Design Communication Mode

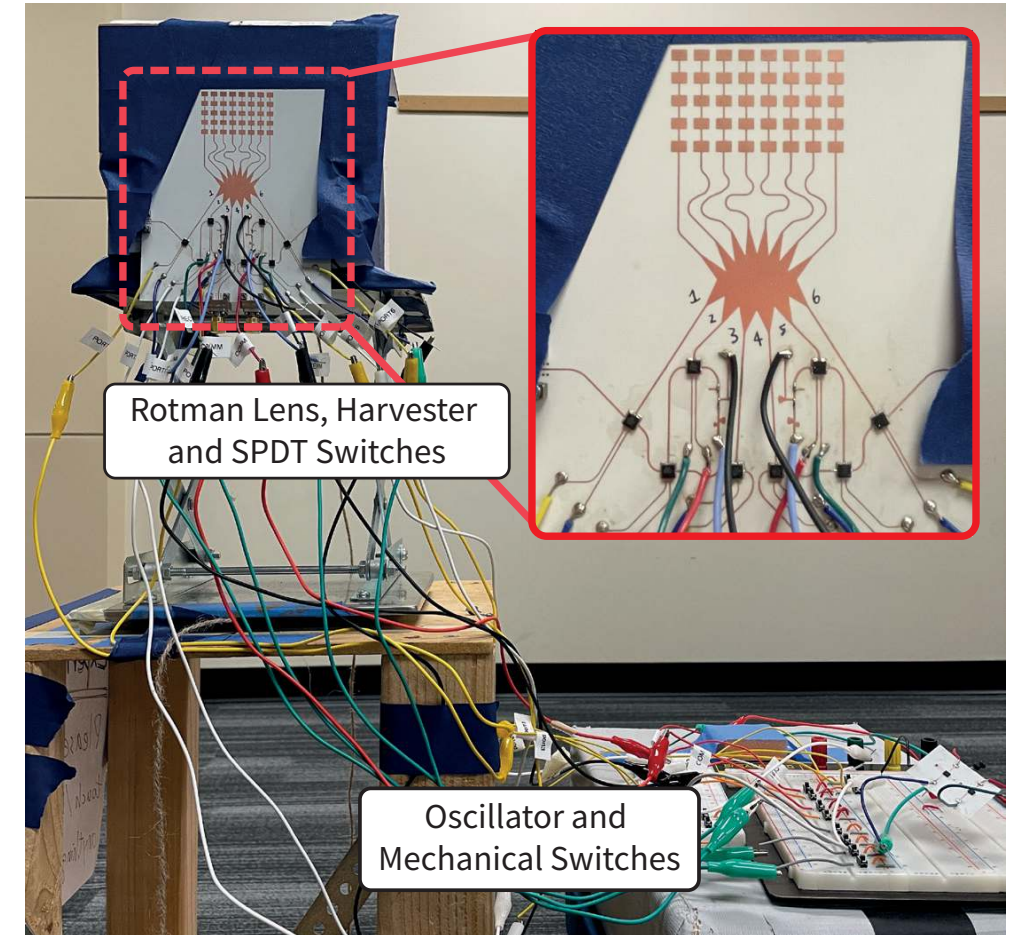
Design Fabrication

- Additive manufacturing
 - Inkjet printing
- Of-the-shelf components selection
- Much smaller size than phase arrays



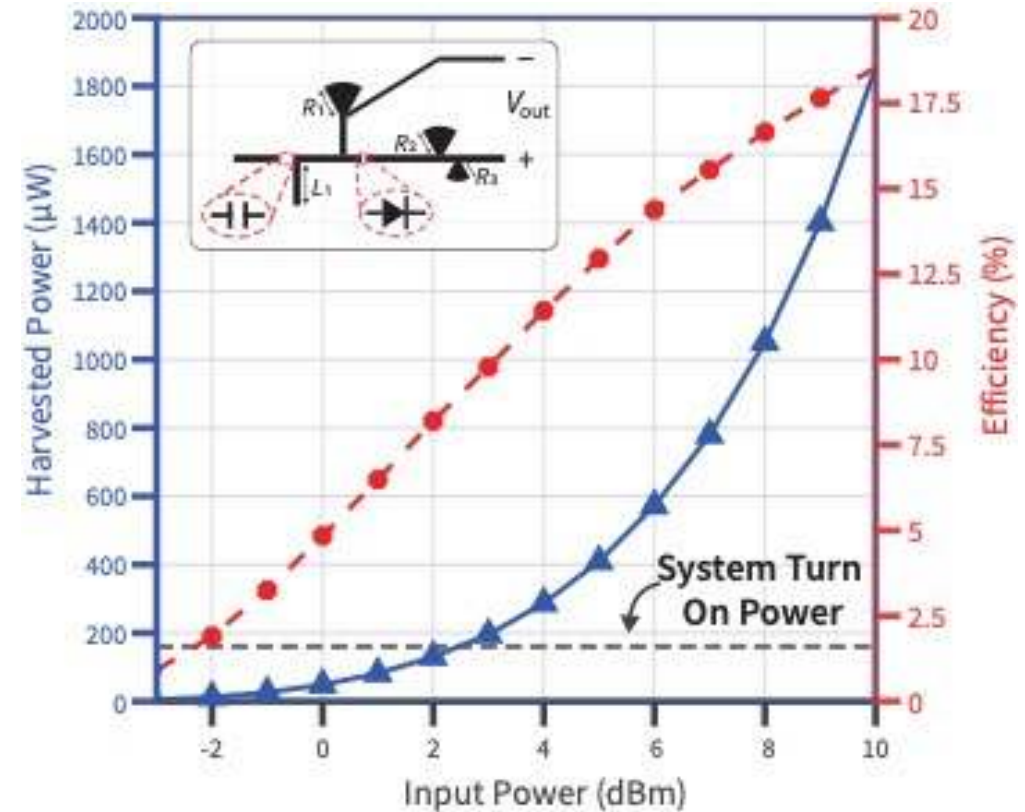
Measurement Setup

- Mechanical switch for simple control
- 1.54m from 28 GHz horn antennas with 41 dBm EIRP
- Sweeping from -70° to $+70^\circ$



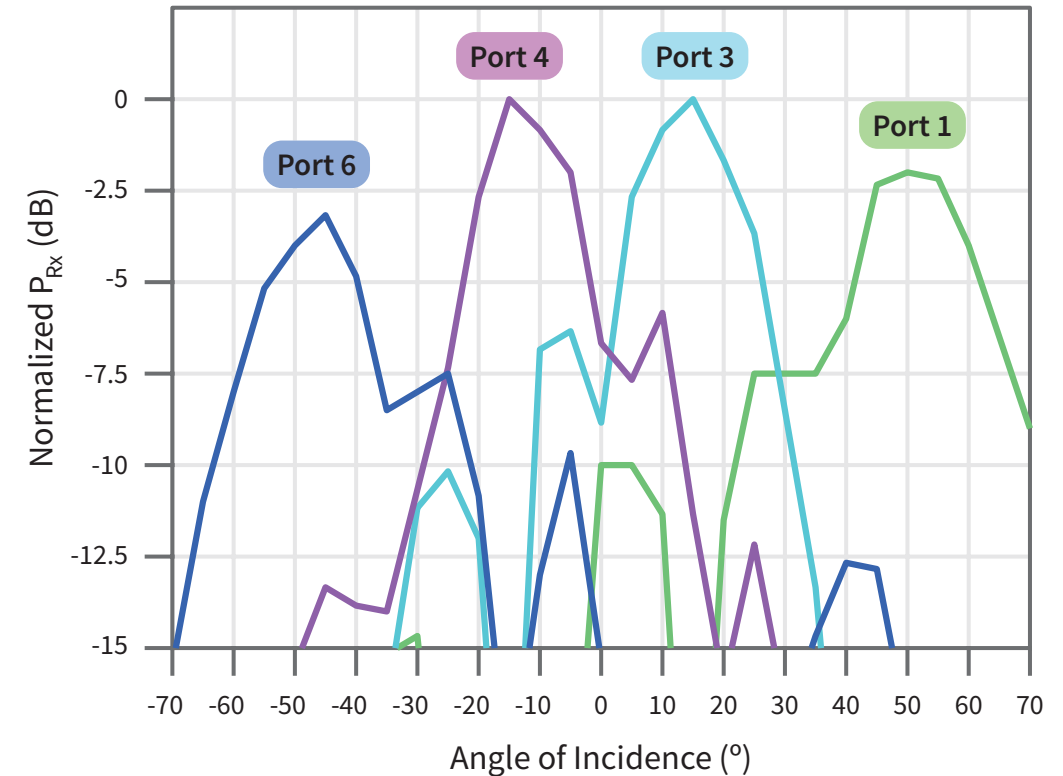
Energy Harvesting

- Half wave rectifier at 28 GHz
- System operates at 2.5 dBm input power
 - Consume 159.6 μ W



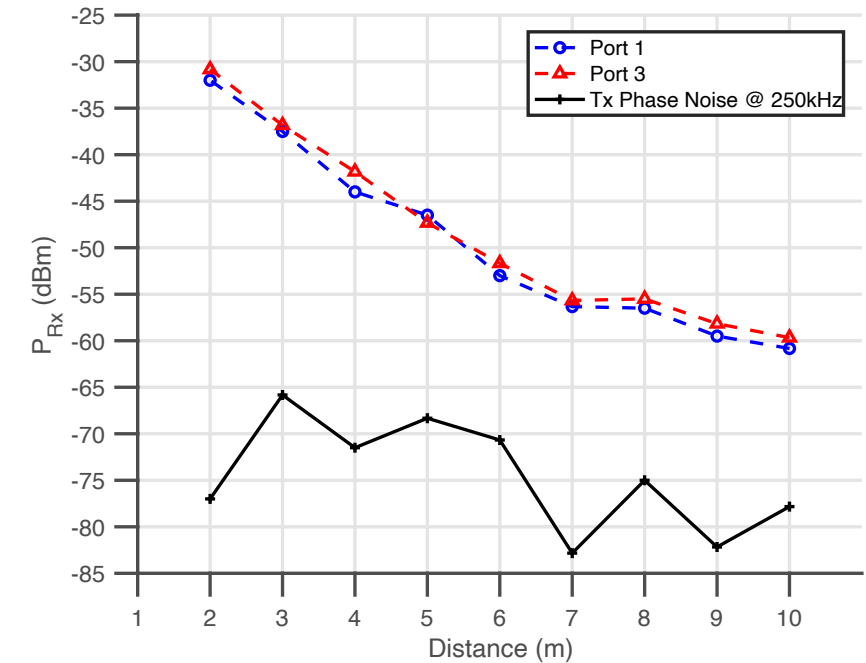
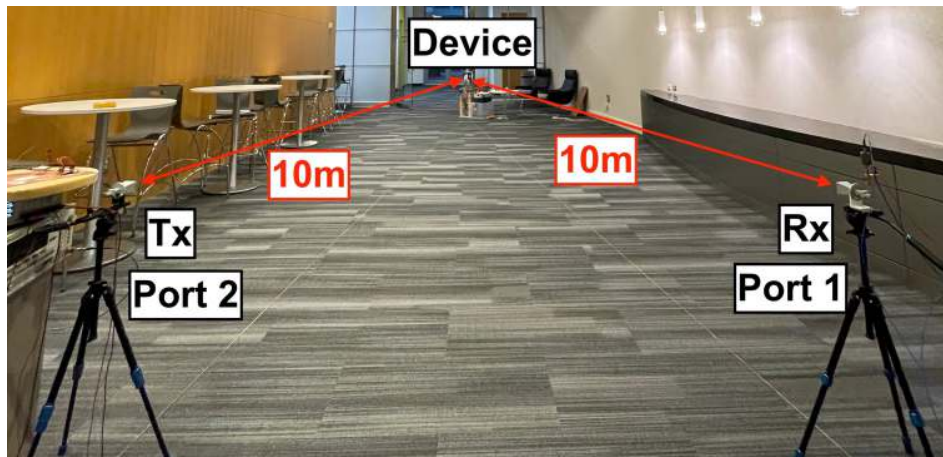
Communication

- Signal ASK modulation at 270 kHz
- Suppress retrodirective signals
- Align with Rotman Lens radiation patterns



Communication

- Tx/Rx bistatic configuration to achieve high sensitivity with co-polarized design
- Design can achieve sensitivity up to the thermal noise level of -91.9 dBm



Comparison to Existing Works

- 5G mm-Wave frequency band
- Much smaller in size
- Low power consumption
- Enabled energy harvesting feature
- Limited angle converge

Ref.	[1]	[1]	[2]	This work
Freq.	10.5 GHz	4.25 GHz	2.3 GHz	28 GHz
Footprint (cm ²)	1703	363	20794	132
Power Consumption	10 W	0.72 W	153 W	159.6 μ W
Re-direction Coverage	Elevation Azimuth	Elevation Azimuth	Elevation	Azimuth
Energy Harvesting	N/A	N/A	N/A	Enabled

Summary

- Low-power Rotman Lens-based RIS mmID
 - Energy harvesting feature
 - signal re-direction with modulation at 5G mm-Wave frequency band
- Harvest up to 11m away with 75 dBm EIRP
 - Power consumption: 159.6 μ W
- Communicate to mobile users and base stations up to 125 m away with 75 dBm EIRP
- Harvester can be optimized to increase operational range
- Can be scaled up into $N \times N$ structure

Questions?

