**SINGLE-LAYERED DOUBLE CONCENTRIC CIRCULAR RING**

1. Subwavelength Design of lambda/3 instead of lambda/2
2. 2 degrees of freedom due to two concentric rings, where R2 can be function of R1
3. 1640 elements in a 0.43 3 0.43 m2
4. 2- dB gain bandwidth has been increased from 13.6 to 24.4%.

Chart, line chart

Description automatically generated

Diagram

Description automatically generated

**PHOENIX ARRAY**

1. 225 elements with element spacing 8 mm
2. 1-dB gain bandwidth of 29%
3. Achieve 360\* phase shift with unit cell structure

Shape, circle

Description automatically generated

Diagram

Description automatically generated

**ZERO-INDEX METAMATERIAL UNIT CELL**

1. Zero Refractive Index operating at 5.2GhZ for WLAN Spectrum.
2. Gathers wave radiated from feed antenna and collimates it normally to metamaterial surface.
3. ZIM substrate provides little phase shift
4. Provides 6.2dB more BW than just using FR4 as Substrate
5. superstrate is Rogers® R04350B, thickness h2 = 0.762 mm. unit-cells are 8 x 8 and spacing of 2 mm. Spacing from radiator to the bottom layer of the ZIM superstrate is 32mm. Probe fed microstrip patch antenna with dimensions L x W = 12.6 mm x 16.5 mm.

Diagram

Description automatically generated

Chart

Description automatically generated

**MULTI RESONANT TRIPLE SQUARE RINGS**

1. 1dB gain BW of 17%
2. Linear Phase Response elements used to improve BW such as phase delay lines, slotted ground, stacked patches or multi-resonance elements
3. Reduce feed blockage by offsetting feed achieving 30.8dB and 66% radiation efficiency
4. 480 elements hexagonal shaped with 32cm diameter
5. Three concentric square rings where each side of the inner ring is equal to the side of the outer ring multiplied by the factor of S. Varying S and air gap length changes phase shift.

Chart

Description automatically generated Chart

Description automatically generated with medium confidence

**PHASE AGILITY TECHNIQUE**

1. Slots introduced in antenna to alter resonant frequency as it affects the surface current distributions on patch elements.
2. Phase change of 323.91 deg and 0.32dB reflection loss observed
3. The radii (R) of the circles are varied from 0.5mm to 2.5mm for circular slots.
4. There is no reflection loss change due to change of radii as the surface current distribution is not affected when varying width. Thus the circular slot is introduced along length of patch element to induce change in resonant frequency

Graphical user interface

Description automatically generated Chart

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A picture containing chart

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A picture containing diagram

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