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# Design of a Circular Waveguide $TM_{01}$ Mode Launcher with Wire Loop Feed

(Program Code WEPAB349)

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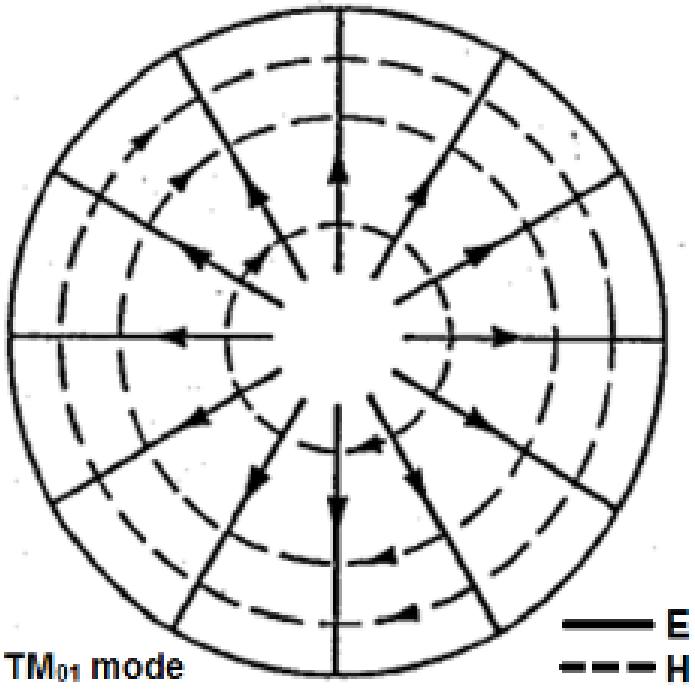
# Circular Waveguide $TM_{01}$ mode

- $TM_{01}$ mode is second mode in cylindrical waveguide (after $TE_{11}$ mode)
- Field pattern
  - Diverging E-field
  - Transverse H-field loops
- $TM_{01}$ mode cutoff

  $f_c = 2.405c/2\pi r$

  r = waveguide radius

  c = speed of light



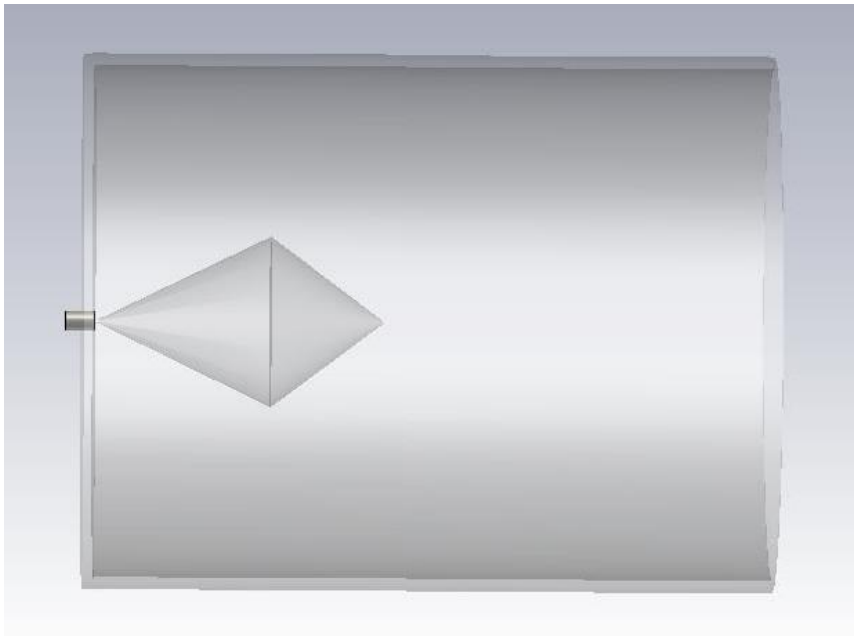
# Circular Waveguide $TM_{01}$ mode

- Useful mode for low-loss propagation (or transmission) of power using waveguides
- Lower cutoff frequency relative to $TE_{01}$ mode
- Easy generation methods
- Easy conversion to (or from) Coaxial-TEM and circular $TE_{11}$ modes.
- Accelerator cavities

# Applications of $TM_{01}$ launcher

- Generation and detection of $TM_{010}$ mode in accelerator cavity
- Waveguide rotary joint
- CPT (cone penetration test) underground sensor device
- As mode-launcher and detector in Single Wire or Single Conductor Transmission line (SWTL or SCTL or Gobau-line) communication
- Low power testing of High power microwave components

# $TM_{01}$ Launchers in literature



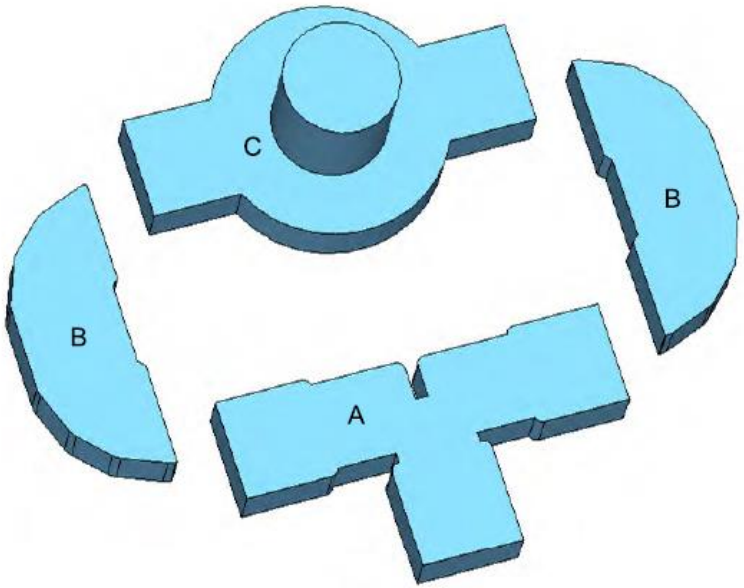
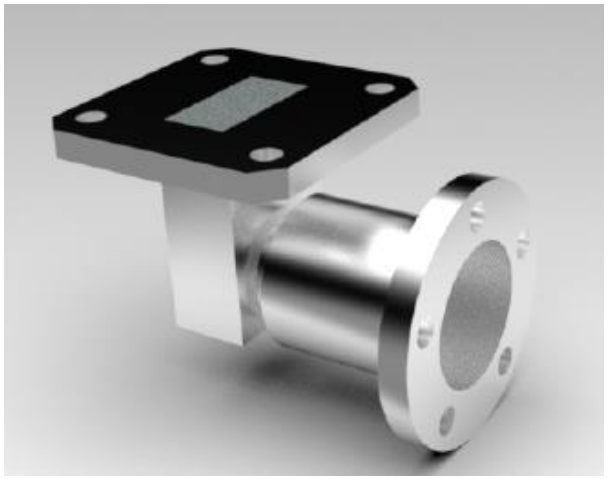
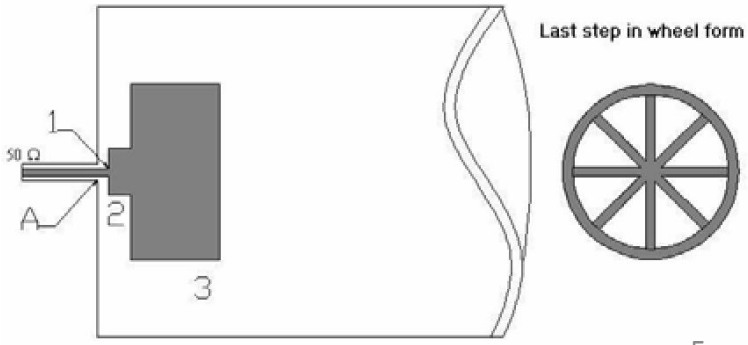
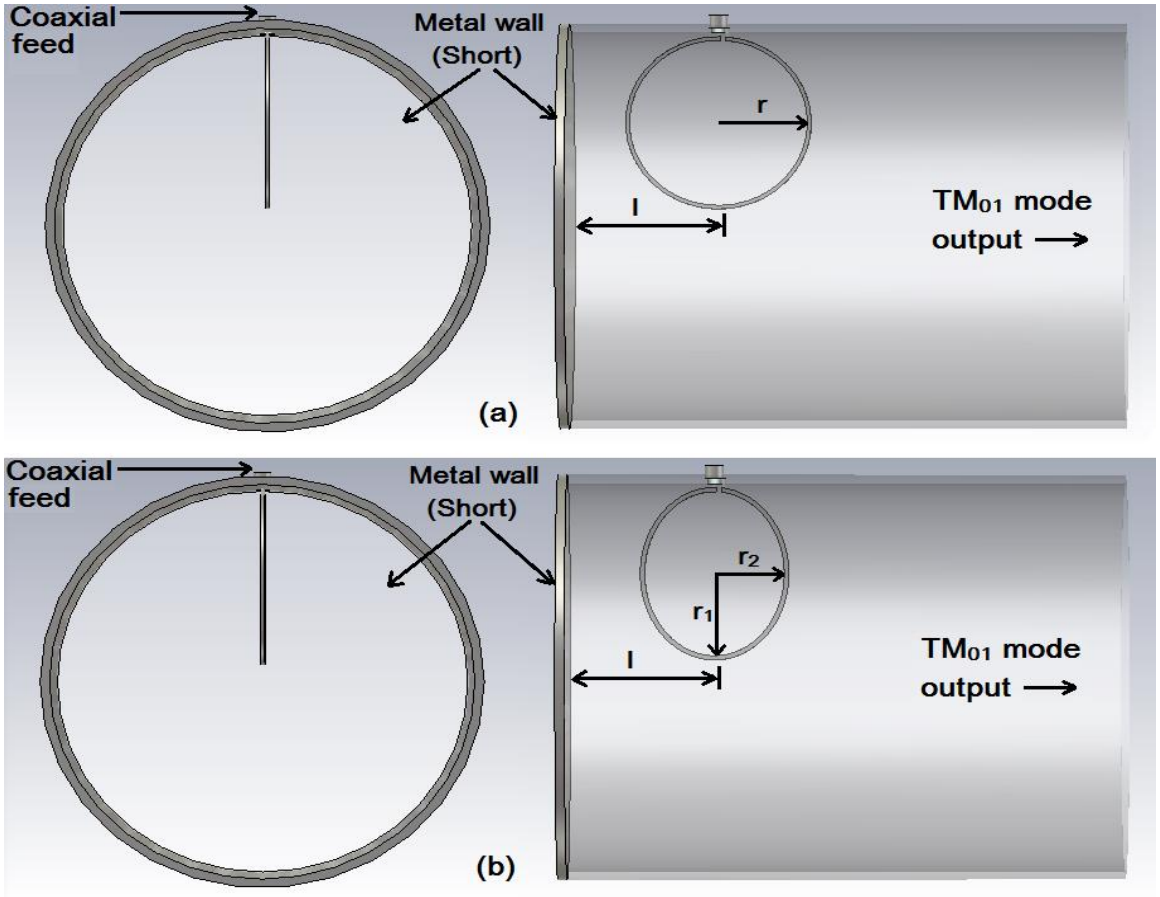



**FIGURE 1.** Different elements of the $TM_{01}$ transducer: the converting section (part C) and the full H-plane feeding network composed by the T-junction (part A) and the two 180° bends (parts B).





# The proposed launcher design

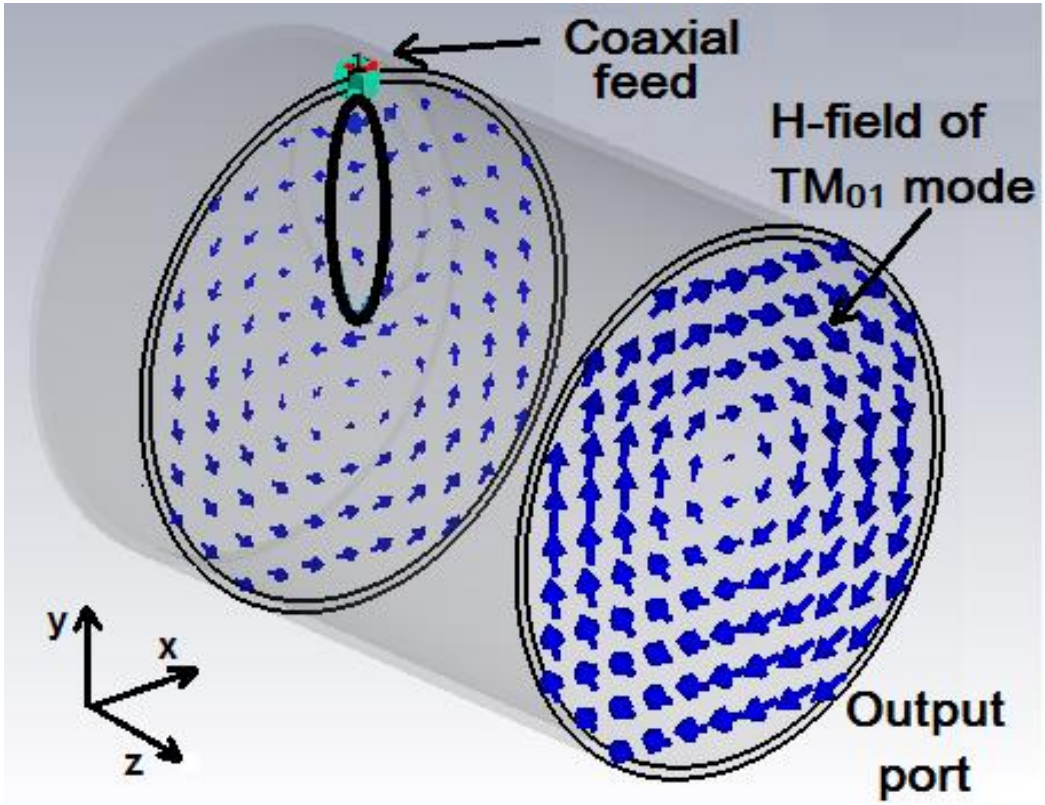



r=r1=r2

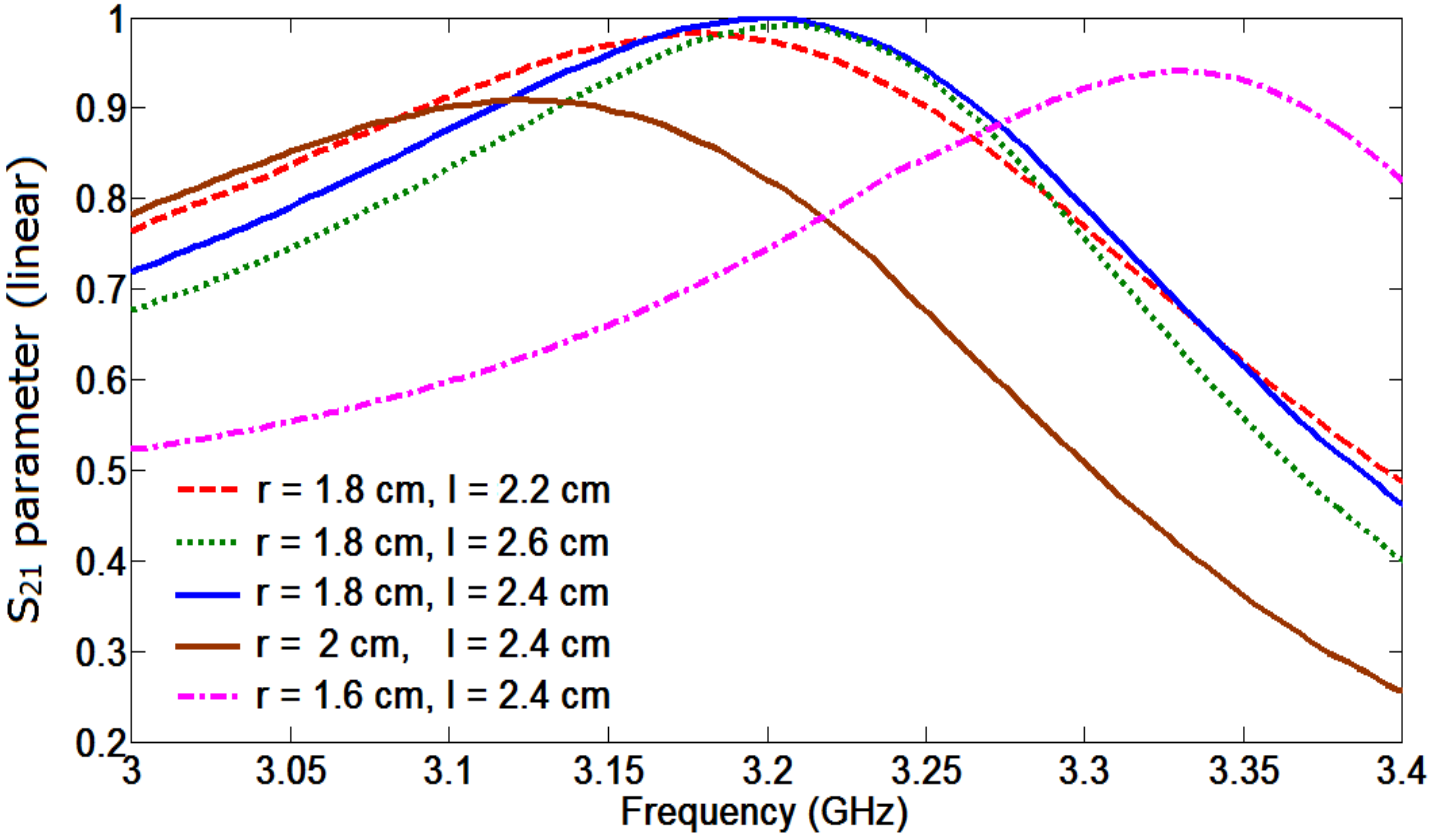
TABLE I. Design parameters of the proposed $TM_{01}$ mode launcher

| Type | $r_1$ | $r_2$ | l | $f_0$ |
|---|---|---|---|---|
| Circular loop | 1.8 cm | 1.8 cm | 2.4 cm | 3.2 GHz |
| Elliptical loop | 2.0 cm | 1.5 cm | 2.0 cm | 3.2 GHz |

# Process of $TM_{01}$ mode generation

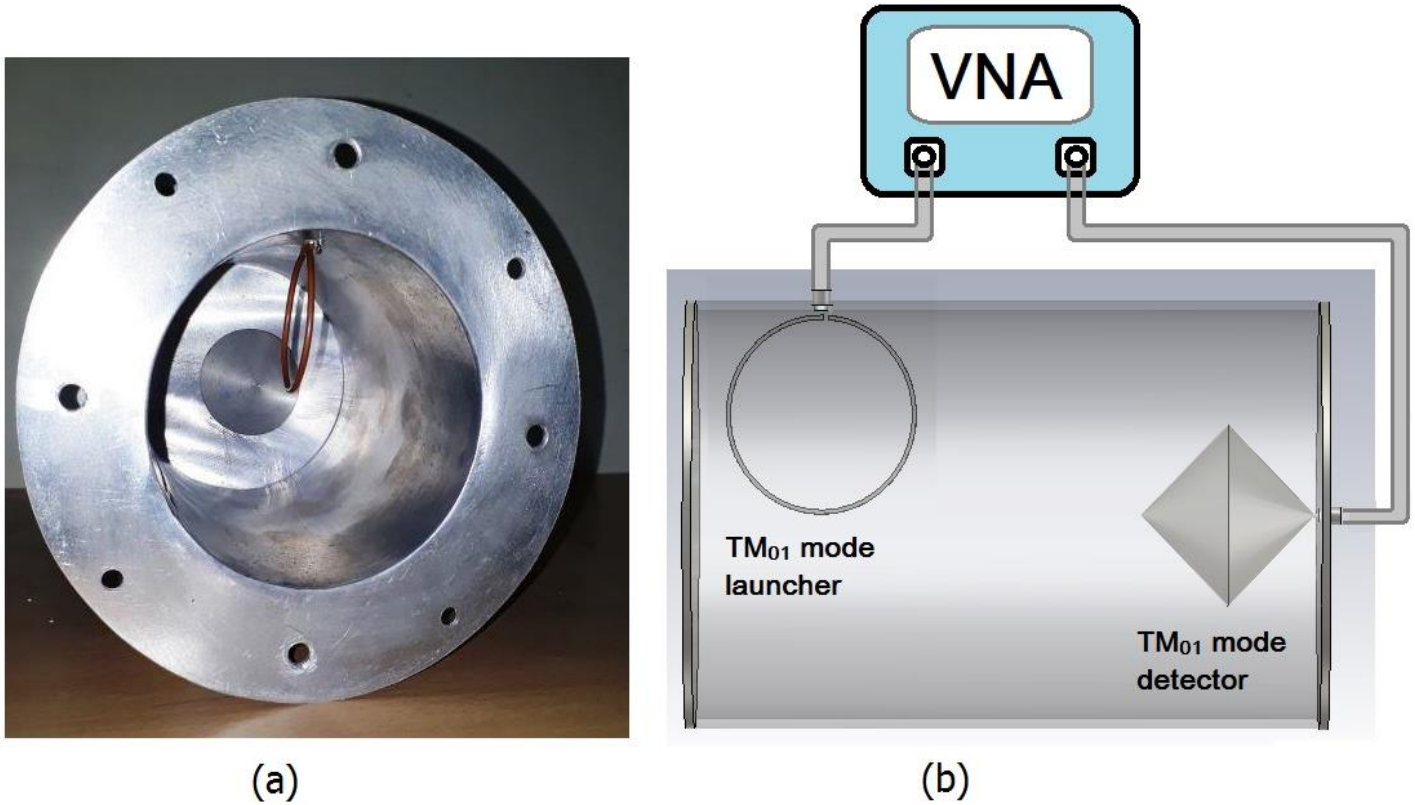


# Simulated results



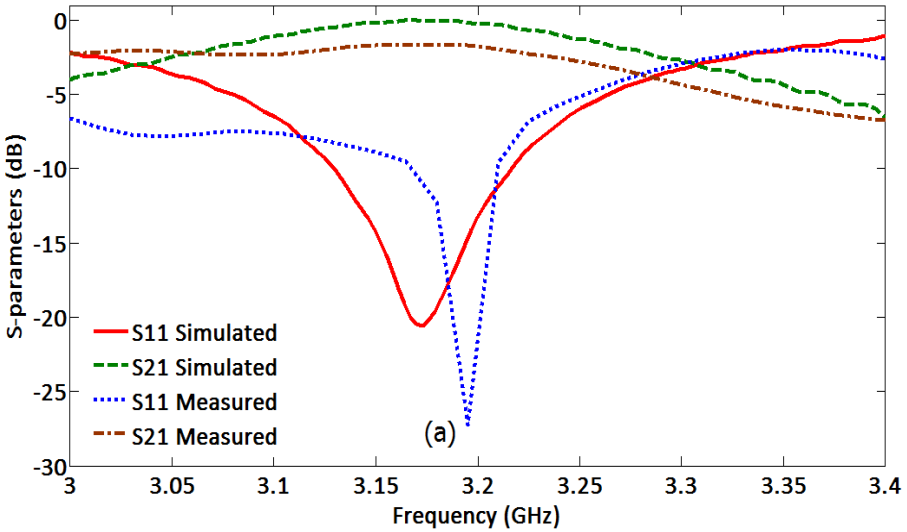

Effect of parametric variation on the $S_{21}$ parameter of the mode-launcher with Circular loop feed.

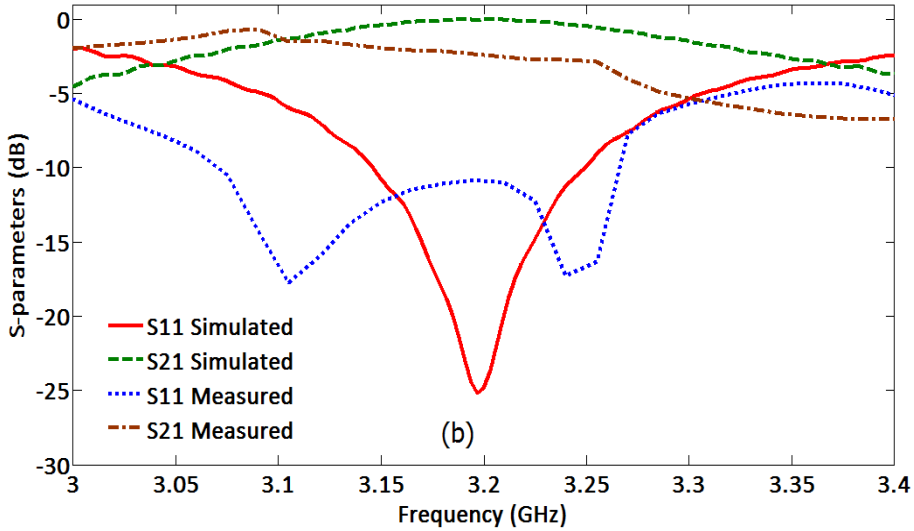
# Experimental set-up




(a) Fabricated circular loop feed mode-launcher with bi-conical detector. (short metal plate removed for inside view) and (b) Illustration of measurement setup for circular loop feed mode launcher (waveguide shown transparent).

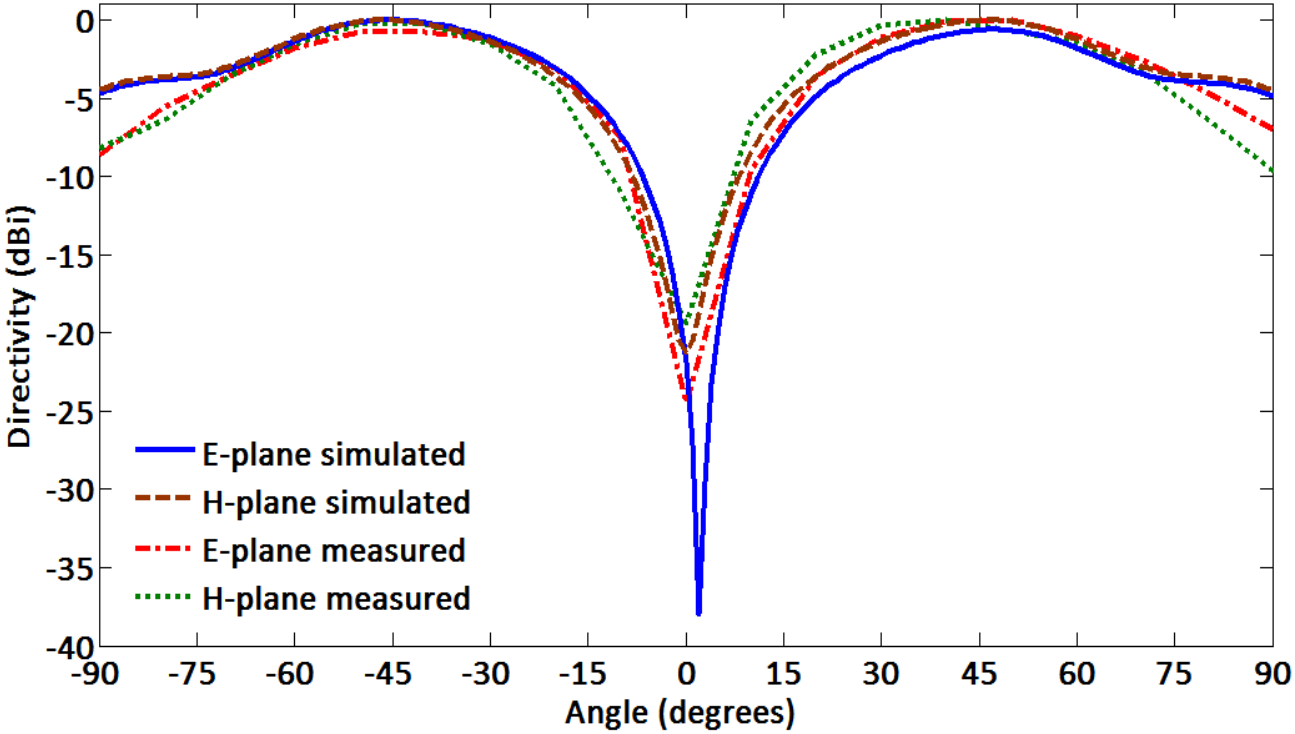
# Simulated and Measured Results




Measured S-parameters of the mode-launcher with (a) Circular and (b) Elliptical loop feed.

# Radiation pattern results




Measured radiation pattern (normalized) for the circular loop feed mode-launcher at 3.2 GHz frequency.

# Comparison of the proposed designs with previous $TM_{01}$ mode launcher designs

| Paper | $\frac{Length}{\lambda}$ | $\frac{Diameter}{\lambda}$ | $S_{21}$ peak (dB) | Relative Bandwidth | Coupling Principle |
|---|---|---|---|---|---|
| [6] | 0.58 | 1.05 | -0.01 | 33.8% | E-field |
| [7] | 1.33 | 0.42 | - | 2.2% | E-field |
| [8] | 3.59 | 0.94 | -0.01 | 3.1% | E-field |
| [9] | 0.34 | 0.9 | -0.27 | 21.5% | E-field |
| [10] | 0.38 | 0.86 | -0.08 | 16.7% | E-field |
| [11] | 0.44 | 1.08 | -0.20 | 44% | E-field |
| Circular | 0.44 | 0.96 | -0.01 | 3.1% | H-field |
| Elliptical | 0.37 | 0.96 | -0.01 | 3.1% | H-field |

# Conclusion

- Magnetic field based $TM_{01}$ mode generation
- High efficiency of conversion (upto 98%)
- Narrow bandwidth (3.1%) at operating frequency 3.2 GHz
- Compact size and shape of launcher
- Operating frequency is sensitive to the loop size

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# Thank you

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*(Prayers for happiness of everyone)*