

List of Figures

Figure 1.1.	Block diagram of a typical high power microwave (HPM) System.	3
Figure 1.2.	Schematic of a Magnetically Insulated Line Oscillator (MILO).	7
Figure 1.3.	Schematic of a Relativistic Magnetron [Barker and Schamiloglu (2001)].	8
Figure 1.4.	Schematic of a Relativistic Klystron Amplifier [Barker and Schamiloglu (2001)].	9
Figure 1.5.	Schematic of a typical Relativistic Backward Wave Oscillator (BWO) [Barker and Schamiloglu (2001)].	10
Figure 1.6.	Schematic diagram of VIRCATOR [Barker and Schamiloglu (2001)].	10
Figure 1.7.	Comparison of the microwave systems: (a) without mode converter, and (b) with mode converter.	13
Figure 1.8.	RF radiation patterns of the TE_{11} and TM_{01} modes.	13
Figure 1.9.	A typical sectoral waveguide (SWG) structure.	14
Figure 1.10.	(a) A coaxial waveguide divided into three sectorial waveguides (SWG), (b) upper semi-SWG: analogy with rectangular waveguide of width a , and (c) lower two quarter-SWG: analogy with rectangular waveguide of width $a/2$.	15
Figure 1.11.	A typical model of SWG mode converter (TEM to TE_{11}) is shown at the centre. In right-hand side, its mode pattern is shown, according to its axial positions, keeping the upper half semi-circle field vector maximum outward. Left side figure shows the separation of coaxial waveguide to SWGs.	15
Figure 2.1.	Waveguides with abrupt discontinuity	25
Figure 2.2.	TE_{11} to $TE_{11} + TM_{11}$ mode conversion through abrupt discontinuities conductor	26
Figure 2.3.	Gradual discontinuity; schematic mode converters of (a) Yang <i>et al.</i> (1995) (b) Ling and Zhou (2001)	27

(c) Yang *et al.*(1997)

(d) Lee *et al.* (2004)

- Figure 2.4.** Schematic of SWG mode converter, reported by Somov *et al.* (1998), having one SWG_{π} and three $SWG_{\pi/3}$;
1 - inner conductor of the coaxial waveguide,
2 - the outer conductor of the coaxial waveguide,
3 - longitudinal and radial diaphragm separating the waveguide into sectors,
4 - conical aligner section of the radiator,
5 - dielectric window for the emission output. **28**
- Figure 2.5.** Structure of the novel mode converter reported by Yuan *et al.* (2005).
Left: Axial view of SWG mode converter in vertical plane and horizontal plane,
Right: front view displaying four SWGs. **29**
- Figure 2.6.** Cross sectional view of different combination of SWGs to form mode converter. **29**
- Figure 2.7.** Dielectric loaded SWG mode converters design, by Chittora *et al.* (2015). **30**
- Figure 2.8.** Metallic photonic loaded SWG mode converters design, by Wang *et al.* (2015). **30**
- Figure 2.9.** Schematic of the novel circular polarization mode converter developed by Yuan *et al.* (2006). **31**
- Figure 2.10.** Schematic Eisenhart (1998) **32**
- Figure 2.11.** Schematic mode converters design by Tribak *et al.* (2013) **32**
- Figure 2.12.** Schematic of folded SWG mode converters by Wang *et al.* (2013) **33**
- Figure 2.13.** Schematic circularly polarized mode converters by Zang *et al.* (2015) **33**
- Figure 3.1.** Proposed modified SWG mode converter for TM_{01} to TE_{11} mode conversion. **38**
- Figure 3.2.** Design algorithm for the proposed TM_{01} to TE_{11} mode converter. **40**
- Figure 3.3.** Typical model (a) Photograph of metallic plates fused with the inner conductor,
(b) complete fabricated structure with a mode transducer and a conical horn antenna **42**

	(c) simulated design of TM_{01} to TE_{11} SWG mode converter.	
Figure 3.4.	Schematic diagram of measurement of radiation pattern and identifying radiated mode by varying the azimuthal position of receiving antenna.	42
Figure 3.5.	Snapshot of the experimental setup in a semi-anechoic chamber (a) mode converter is at transmitting side, while an S-band standard horn antenna is at receiving side connected with a power meter, (b) tapered section and sectoral plates in SWG mode converter, (c) tapered section and conical horn antenna at transmitting side.	43
Figure 3.6.	The procedure of mode conversion in SWG mode converter using E field monitors placed at different azimuthal positions in simulated design.	46
Figure 3.7.	Combining electric fields through all $SWG_{\pi/2}$ (of Region $II(b)$) in the coaxial waveguide (of Region $III(a)$), and showing the advantage of using <i>Plate1</i> in the SWG mode converter.	47
Figure 3.8.	Simulated model of SWG mode converter with a contour plot of electric field distribution in $x = 0$ plane at frequency 3GHz.	47
Figure 3.9.	The radiation pattern obtained and measured for the system without using the SWG mode converter, and is showing the TM_{01} mode pattern from mode transducer.	49
Figure 3.10.	Comparison of radiation pattern measurement (in H-plane), using simulation and experiment from -90° to $+90^\circ$ azimuthal angle, keeping 0° as a boresight. The radiation pattern obtained and measured for the system with the SWG mode converter is showing the TE_{11} mode pattern.	49
Figure 3.11.	Performance evaluation of mode transducer using s-parameter.	50
Figure 3.12.	Comparison of reflection loss between simulated and measured at the input end of Region $I(a)$ and the feed of mode transducer respectively.	51
Figure 3.13.	Mode conversion efficiency (in %) for desired TE_{11} mode and dominant mode TEM of the coaxial waveguide. The result is obtained in simulated design at the output end of Region $III(a)$.	52
Figure 4.1.	The typical structure of the sectoral waveguide (SWG).	61

Figure 4.2.	The typical model of TM_{01} to TE_{11} SWG mode converter with a conical horn antenna.	63
Figure 4.3.	A typical model of TM_{01} to TE_{11} SWG mode converter along their axial length.	65
Figure 4.4.	Return loss for a coaxial waveguide to SWG_{π} and a coaxial waveguide to $SWG_{\pi/2}$ transitions. The continuous coaxial waveguide has blocked by sectoral conducting block, and the remaining unblocked path provides an abrupt change in the coaxial aperture to SWG aperture. The input port is on the coaxial waveguide side where return loss has been obtained.	71
Figure 4.5.	Transmission loss for a coaxial waveguide to SWG_{π} and a coaxial waveguide to $SWG_{\pi/2}$ transitions. The input port is on the coaxial waveguide side and output port is on the SWG side.	72
Figure 4.6.	The propagation constant of SWG_{π} and $SWG_{\pi/2}$ according to variation in frequency.	72
Figure 4.7.	Scheme of the forward and backward wave at the different ports for the MMT. Fix delay length SWGs is cascaded with SWGs.	73
Figure 4.8.	Transmission loss obtained from simulation between the input port-A to output port-G has been compared with the result obtained from the analysis using input port-C to output port-G. Also, the reflection loss obtained from the simulation at the port-A has been compared with the result obtained from analysis at the input port-C and with the measured value obtained at the input end [Kumar <i>et al.</i> (2019)].	74
Figure 4.9.	Comparison of conversion efficiency obtained from simulation between the input port-A to output port-G are compared with results obtained from the MMT analysis using input port-C to output port-G	75
Figure 4.10.	Comparison of conversion efficiency obtained from simulation between the input port-A to output port-G are compared with results obtained from the MMT analysis using input port-C to output port-G, are also compared with the measured result of Kumar <i>et al.</i> (2019).	76
Figure 5.1.	(a) Design of a cylindrical sectoral waveguide mode converter for TM_{01} to TE_{11} , and all parameters in mm. (b) 3D model of mode launcher and (c) mode converter.	83

Figure 5.2.	The process of mode conversion demonstrated using the electric field at a different axial position in the cylindrical sectoral waveguide mode converter for TM_{01} to TE_{11} mode.	83
Figure 5.3	(a) Far-field radiation pattern measurement setup, (b) fabricated CSWG mode converter, (c) receiving horn antenna connected with a power meter.	84
Figure 5.4.	The simulated conversion efficiency of the mode converter for the TM_{01} mode to other modes at the output port.	85
Figure 5.5.	At 500 MW power E field pattern on the $x=0$ plane, for CSWG mode converter.	86
Figure 5.6.	S parameter results of mode launcher	87
Figure 5.7.	S parameter results of the mode converter	87
Figure 5.8.	Radiation pattern results for E plane.	88
Figure 5.9.	Weight of (a) SWG mode converter (reported in Chapter 3, [Kumar <i>et al.</i> (2019)]), (b) CSWG mode converter.	89