Polarization Conversion In Ring Resonator

File name: `TE-TM conversion.apc`

Reference: F. Morichetti and A. Melloni, "*Effects of polarization rotation in optical ring-resonator based devices*", IEEE Journal on Lightwave Technol., Vol. 24, 1, pp. 573–585, January 2006

In this example a ring resonator phase shifter is investigated. In particular, it is shown that the polarization conversion that take place in asymmetrical and bent waveguides can be strongly enhanced by the resonances of the ring.
The ring resonator has been built with discrete components (`straight` and `bend`) instead of the `phase shifter` component in order to have access to the field propagating inside the ring. The optical length of the ring is 3 mm, corresponding to a FSR=100 GHz (0.8 nm), the power coupling ratio of the directional coupler is 0.14 and waveguides are lossless.
If no coupling between TE and TM modes occurs inside the ring, the transfer function is given by

$$H(\omega) = \frac{r - \exp(-j\beta L)}{1 - r\exp(-j\beta L)}.$$

Fig. 1 shows the phase and the group delay obtained by a simulation over 100 point in the wavelength range 1550.3 nm to 1550.5 nm and, on the right, the intensity of the field recirculating inside the ring, at port 12. Note that at the resonance there is an intensity enhancement I_e=2FSR/(πB)=28 where B is the bandwidth of the device equal to 2.4 GHz.

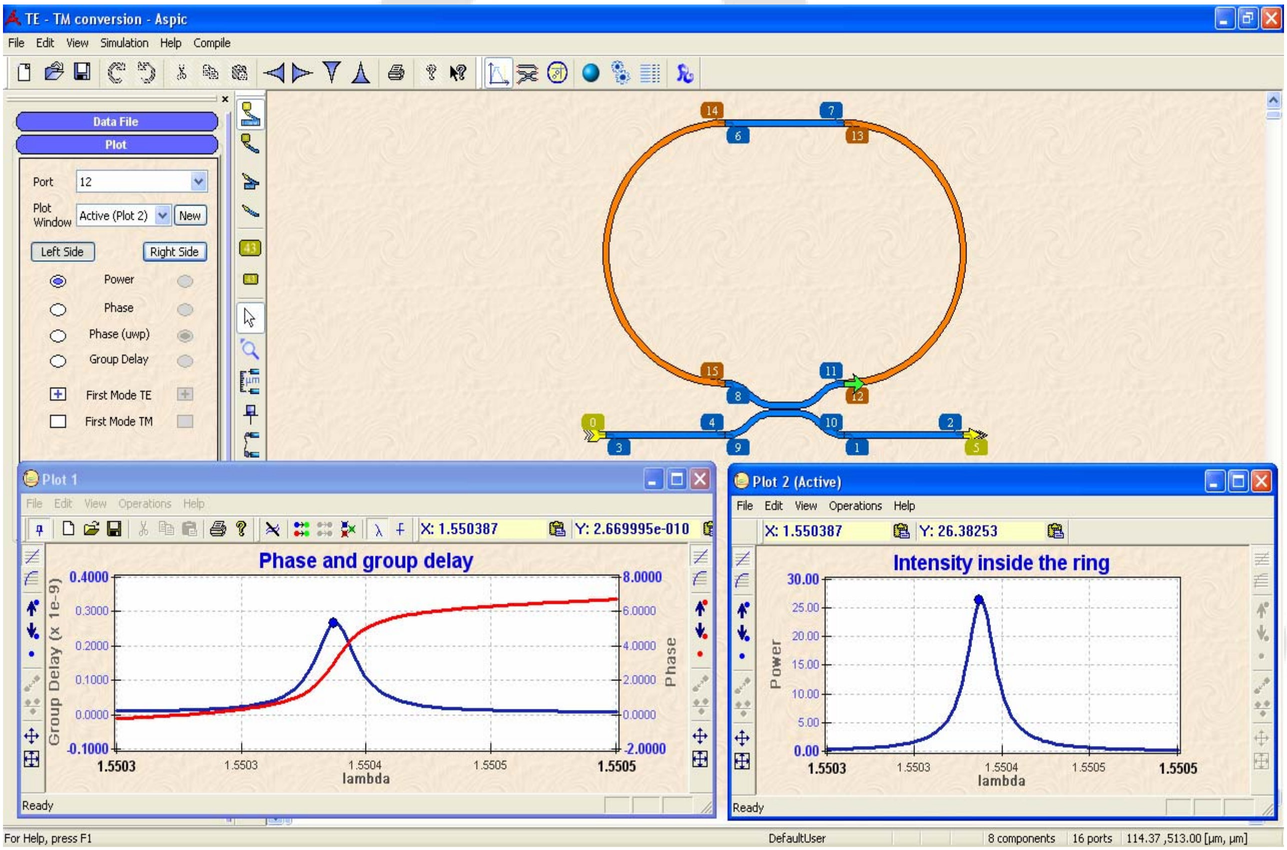

Fig. 1 – Left: phase and group delay response in absence of polarization coupling. Right: Intensity of the field recirculating in the ring.

If a small polarization conversion in the bent sections of the ring occurs, the transfer function is affected and an output TM mode is generated. To study this effect, the '*TE/TM coupling*' in the bend properties panel must be enabled and the *Beat length* parameter set to *bL*. The beat length defines the polarization coupling: with the value already set in the Variable Table (bL=8.3·10^4 μm) a total polarization conversion occurs at the resonant wavelengths. Fig. 2 shows the TE and TM output intensities for various values of *bL*. The left figure is generated by scanning the beat length (*bL*) from 1e6 to 5e4 at the resonant wavelength λ=1550.388 nm. Note that even for a very low conversion (*bL*=1e6) the TM generated at resonance is noticeable and that for *bL*=8.3e4 the conversion is complete. In the right graph the TE and TM intensity transfer functions for three values of *bL* are reported (*bL*=5; 2.4 and 1.2 times 8.3e4). As *bL* reduces the conversion increases until a total conversion occurs. In Fig. 3 it is shown how an input TE mode is completely converted to an output TM mode near the ring resonance for *bL*=8.3e4. Note also the second order transfer function, despite a single cavity is used.

Further, the user can readily test that the TE and TM group delay characteristics are identical; that the intensity enhanced is reduced because of the coupling widens the bandwidth (I_e=11); the effect of the waveguide attenuation and so on.

Fig. 2 – Left: TE and TM output intensity at resonance vs the beat length parameter; Right: TE and TM transfer function for different coupling between TE and TM.

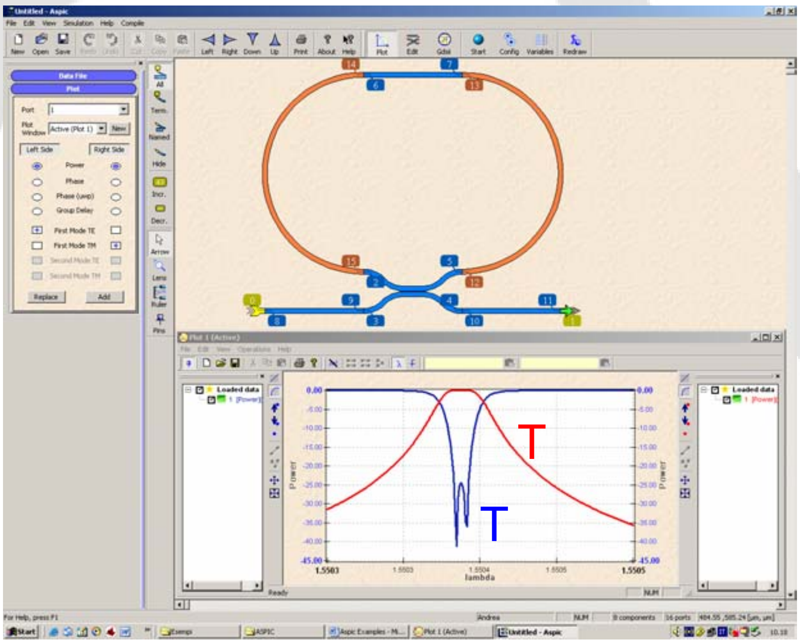

Fig. 3 – Total TE to TM conversion occurring in the ring resonator phase shifter (bL=83000)