4-Ports polarization insensitive circulator

File name: 4_ports_circulator.apc
Reference:

This example shows how to build a 4-port polarization insensitive circulator with the free space building blocks available in the Free Space Library. The circulator is shown in fig. 1 and includes two polarizing beam splitters, two Faraday rotators, two half-wavelength rotating plates and two mirrors.

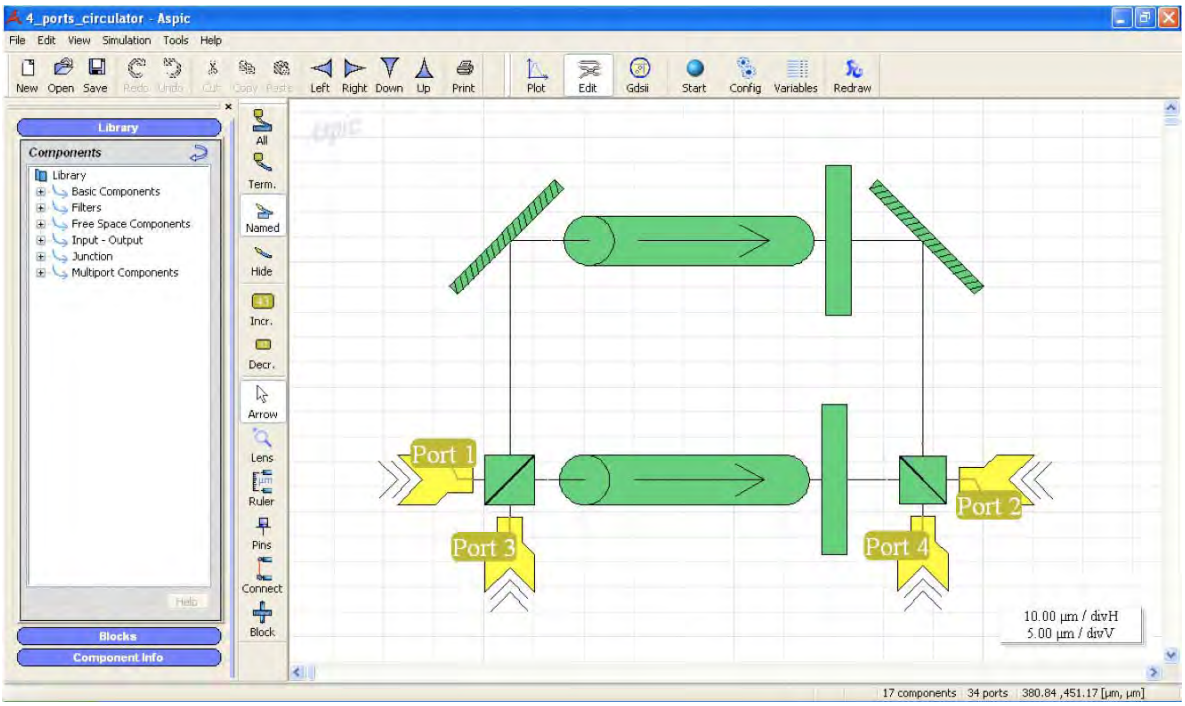

Fig. 1 – Circuit for the measurements of Stokes parameters.

The light that enters from port 1 is directed to port 2, leaving isolated the other two ports. Analogously, port 2 is connected to 3, 3 to 4 and 4 back to 1. The arrow on the Faraday rotators indicates the direction of the magnetic field that induces the nonreciprocal rotation.
Fig. 2 shows the spectral response in case the polarizing beam splitters have a finite extinction ratio equal to 20 dB and 0.2 dB of insertion loss and the waveplates are 21 half-wavelength long, that is are non zero-order. The other building blocks are ideals. The green line shows that the transmission from port 2 to port 3 suffers 0.4 dB of attenuation at the 1.55 µm central wavelength and degrades with wavelength because of the thickness of the waveplates. The red curve is the isolation of Port 1. At 1.55 µm the isolation is -14.4 dB only and increases rapidly. The bandwidth where the isolation is lower that 10 dB is readily measured thanks to the markers and is found to be 36 nm, that is 4.5 THz.
The input signal is linearly polarized at 45° and also the output one. In order to measure the total output intensity both boxes on the left side of the “TE mode” and “TM mode” lines in the Plot window must be selected with a “+”, indicating that TE and TM intensities are summed.

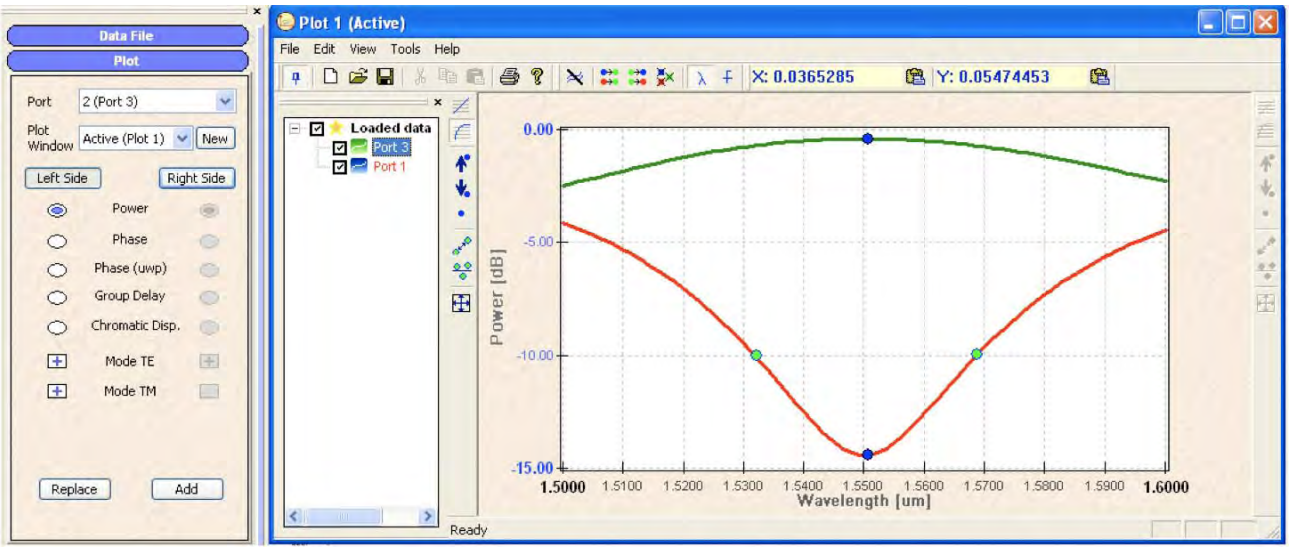

Fig. 2 – Spectral transmission characteristics from Port 2 to 3 and isolation of Port 1 in case of non-ideal components.

The effect of non-ideal Faraday rotators, lumped backreflections (with the Junction element) and insertion losses induced by some physical reasons can be easily considered and investigated. Fig. 3, as an example, shows how detrimental is the effect of a reflection on the facets of the Faraday rotators of only -20 dB and the spurious cavity effects that take place.

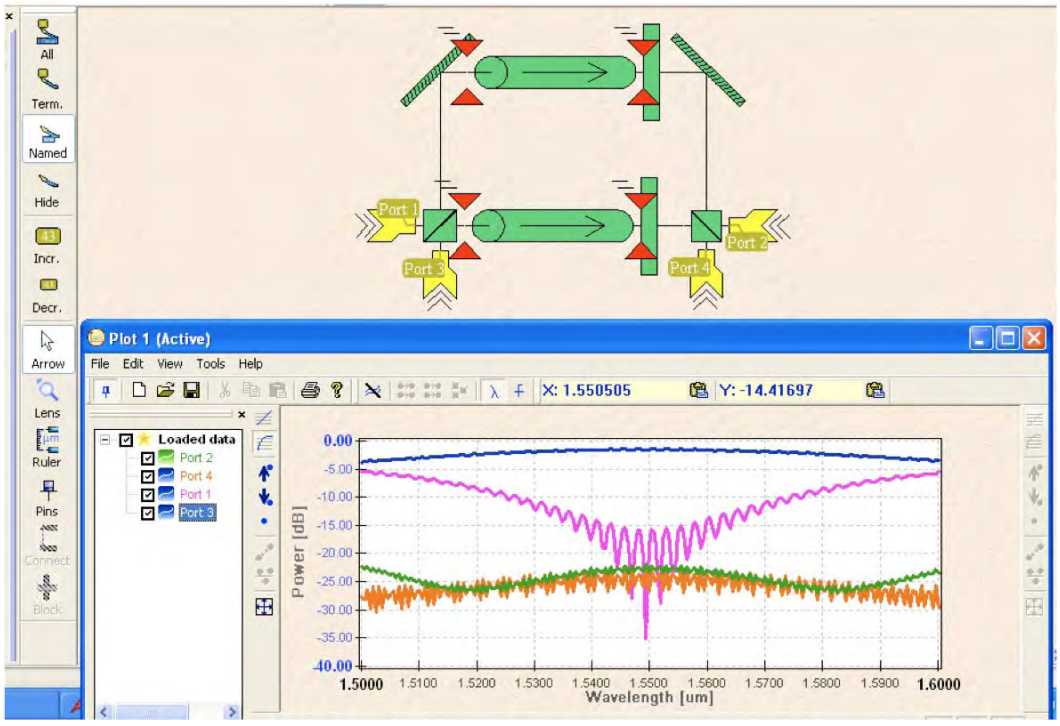

Fig. 3 – Spectral transmission characteristics at the four ports in case of non-ideal beam splitters and reflections on the Faraday rotators facets. Input is from port 2.