

Meandering Waveguide Distributed Feedback Lightwave Elements: Phasor Diagram Analysis

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Abstract— Meandering waveguide distributed feedback (DFB) structures are introduced as novel photonic lightwave circuits elements and their amplitude and phase response are studied in frequency and phasor domain. A preliminary transfer matrix method analysis is applied for taking the coupling purely directional and with constant coefficient on geometrically symmetric and anti-symmetric elements. The meandering loop mirror is the building block of all meandering waveguide based lightwave circuit elements. The simplest uncoupled meandering DFB structure exhibits Rabi splitting in the transmittance spectrum. The symmetric and antisymmetric coupled meandering waveguide DFB geometries can be utilized as band-pass, Fano, or Lorentzian filters or Rabi splitters. Meandering waveguide DFB elements with a variety of spectral responses can be designed for a variety of lightwave circuit element functions and can be implemented with generality due to the analytic approach taken. Meandering waveguide distributed feedback structures with a variety of spectral responses can be designed for a variety of lightwave circuit element functions.

1. INTRODUCTION

Distributed meandering waveguide (DMW) structures [1] show a variety of spectral behaviors with respect to the number of meandering loop mirrors (MLMs) [2] and the coupling constants (Cs) of the structure. These spectral behavior include Fano resonances, coupled resonator induced transparency (CRIT), notch, add-drop, comb, and hitless filters. What makes the DMW special is the self-coupling property intrinsic to the DMW's nature. The basic example of DMW's nature is motivated through the analogy between the so-called symmetric meandering resonator (SMR), which consists of two coupled MLMs, and the resonator enhanced Mach-Zehnder interferometer (REMZI) [3]. A SMR shows the same spectral characteristics of Fano resonances with its self-coupling property. Recently, single, distributed [4] and binary [5] self coupled optical waveguide (SCOW) resonators, which can be considered as special cases of the DMWs, are studied. Figure 1 shows the genealogy of the DMWs studied so far for their electric field intensity and phase responses [6]. In this proceeding, we present another complementary perspective to the phase characteristics of various DMWs, namely the phasor diagrams of the transmitted electric fields. The phasor diagram contains the complete information of a transmitted electric field with amplitude and phase information for all potential DMW structures.

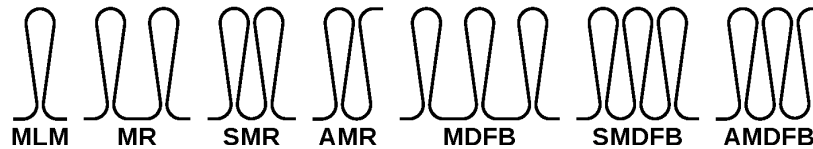


Figure 1: Genealogy of the distributed meandering waveguide structures studied in the frequency domain.

2. MEANDERING DISTRIBUTED FEEDBACK STRUCTURES

Figure 2 shows that an MDFB with 2 MLMs is capable of a phase contribution from 0 to π . There are 2 peaks (poles) in the intensity spectrum, when the normalized frequency (δ) runs from 0 to 4π . In Fig. 3, increasing the number of MLMs, results in the whole phase contribution from 0 to 2π . There are 2 peaks (poles) in the intensity spectrum, when the normalized frequency (δ) runs from 0 to 2π .

In Fig. 4, increasing the number of MLMs provides a phase interval of 4π . There are 10 peaks (poles), when the normalized frequency (δ) runs from 0 to 4π . First the blue line traverses the

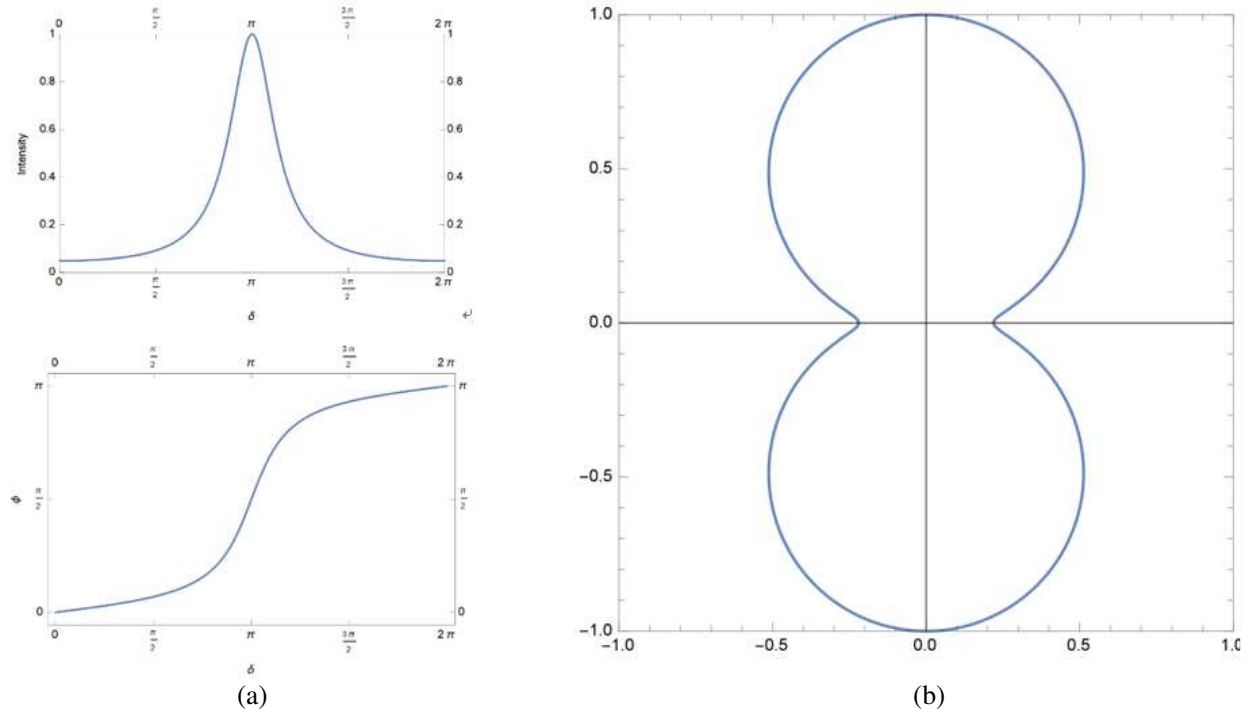


Figure 2: (a) The intensity, phase (Φ), and (b) phasor plots of an MDFB with 2 MLMs (or MR) when all coupling constants are set to 0.2. The normalized frequency (δ) runs from 0 to 2π in the intensity and phase response. Except in the phasor diagram, δ runs from 0 to 4π .

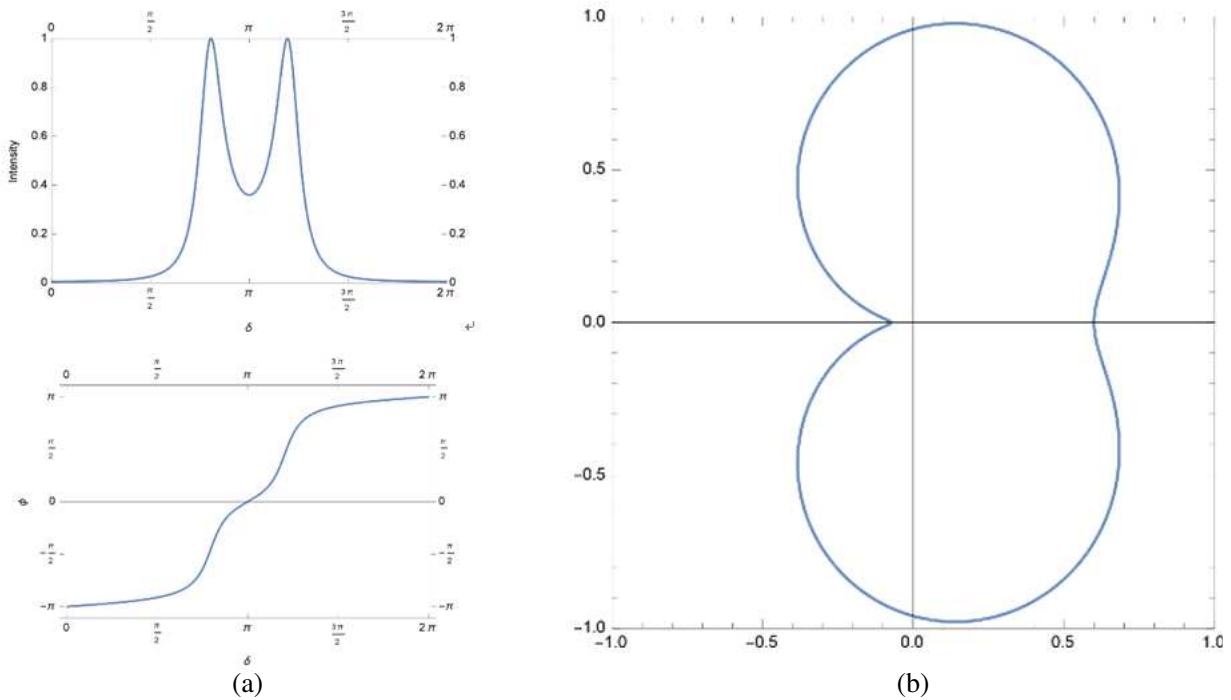


Figure 3: (a) The intensity, phase (Φ) and (b) phasor plots of an MDFB with 3 MLMs, when all coupling constants are set to 0.2. The normalized frequency (δ) runs from 0 to 2π in the intensity, phase, and phasor diagram response.

complex plane, then the orange, the green, the red, and the purple, respectively. All the coupling constants are $C = 0.2$.

3. SYMMETRIC & ANTISYMMETRIC MEANDERING RESONATOR

Figure 5 shows SMR frequency, phase and phasor diagram, depicting Fano resonances, for an SMR with 2 coupled MLMs. There are 2 peaks (poles) in the intensity spectrum, when the normalized frequency (δ) runs from 0 to 2π .

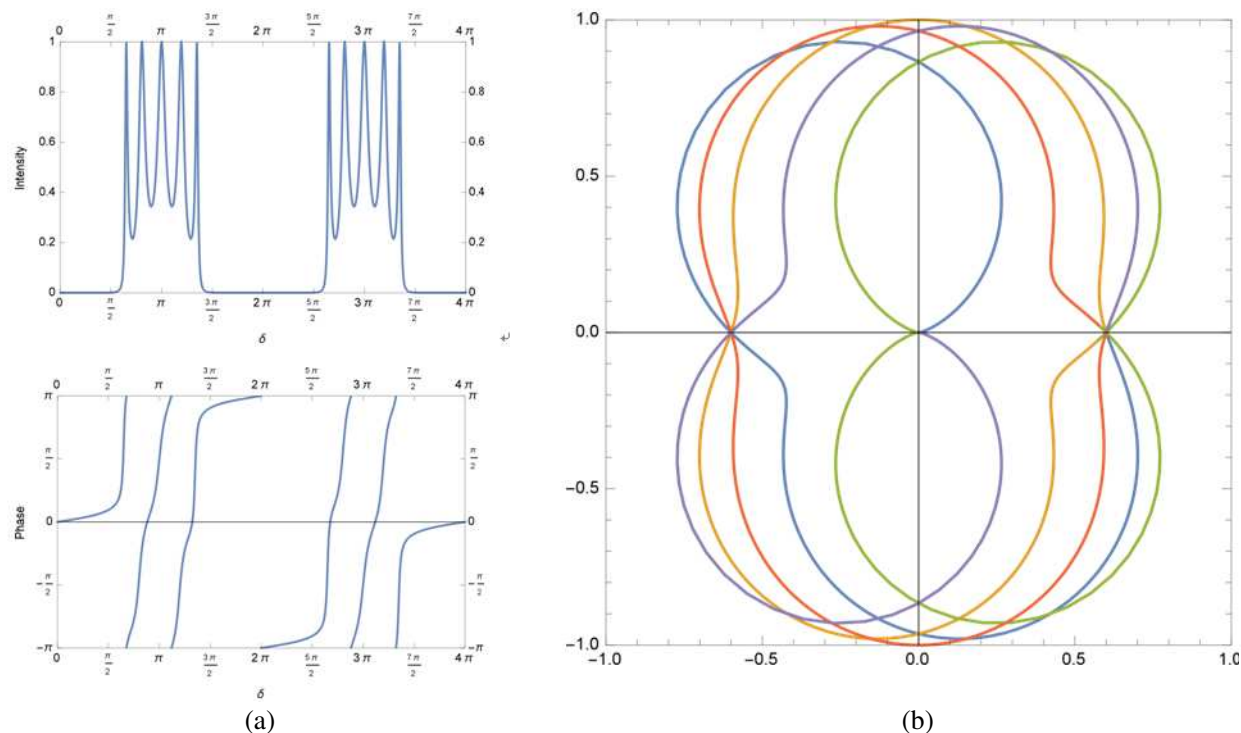


Figure 4: (a) The intensity, phase (Φ) and (b) phasor diagram of an MDFB with 6 MLMs, when the phase of the shortest path length, δ runs from 0 to 4π . The normalized frequency (δ) runs from 0 to 4π in the intensity, phase, and phasor diagram response.

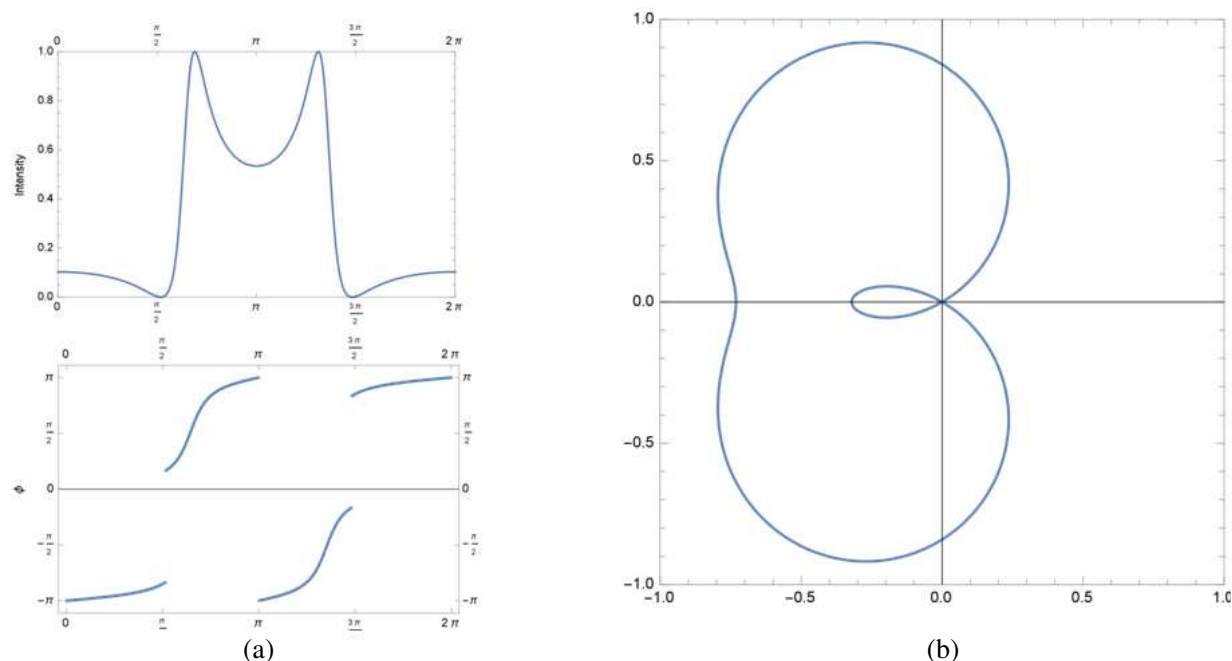


Figure 5: (a) The intensity, phase (Φ) and (b) phasor plots of an SMR, when all coupling constants are set to 0.2. The normalized frequency (δ) runs from 0 to 2π in the intensity, phase, and phasor diagram response.

Figure 6 shows an AMR frequency, phase, and phasor diagram with a narrow linewidth (orange curve) CRIT behavior for $C = 0.9$ and a broad linewidth (blue curve) CRIT behavior for $C = 0.2$. There are 2 peaks (poles) in the intensity spectrum.

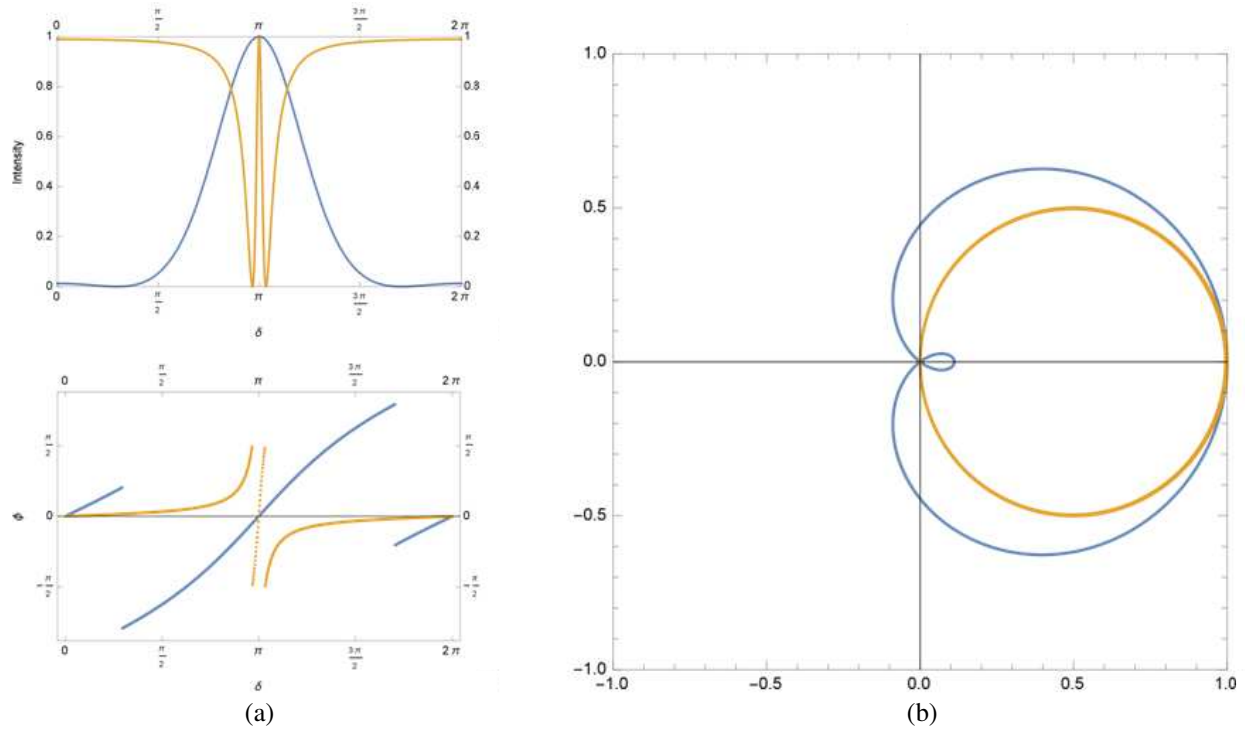


Figure 6: (a) The intensity, phase (Φ) and (b) phasor plots of an AMR, when all coupling constants are set to 0.2 (blue) and 0.9 (orange). The normalized frequency (δ) runs from 0 to 2π in the intensity, phase response, and phasor diagram response.

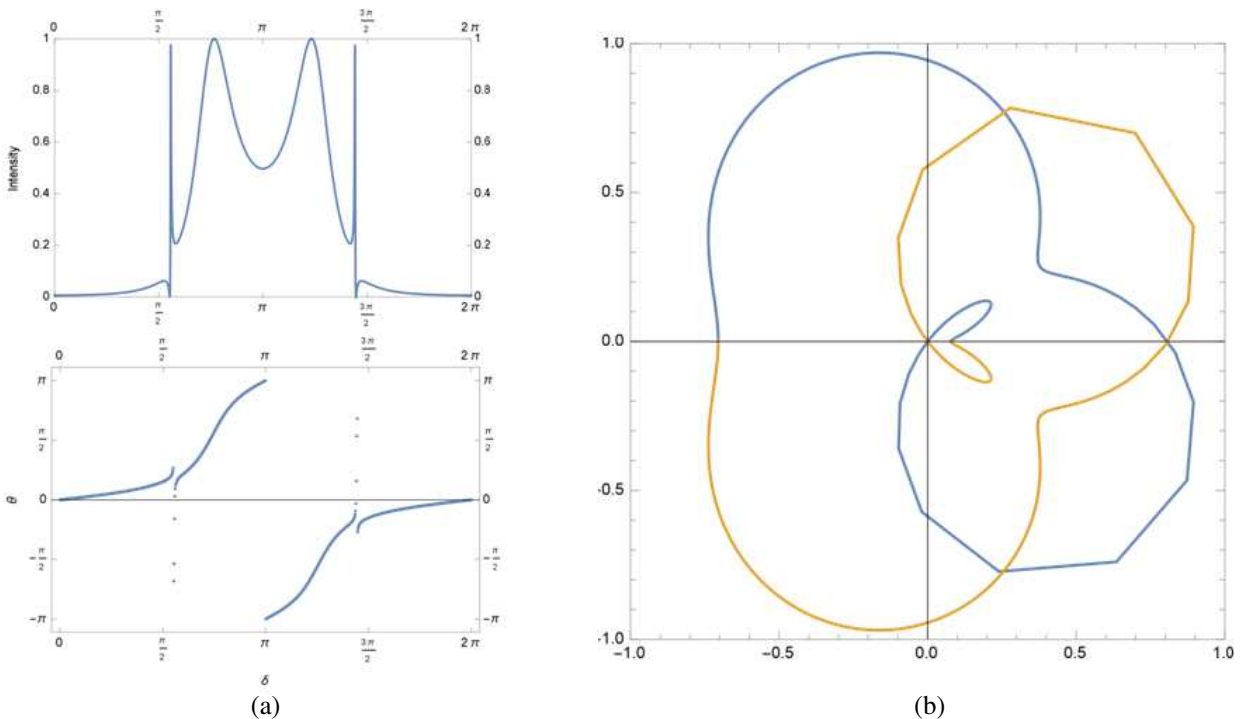


Figure 7: (a) The intensity, phase (Φ) and (b) phasor plots of an SMDFB with 3 MLMs, when all coupling constants are set to $C = 0.2$. The normalized frequency (δ) runs from 0 to 2π in the intensity, phase response, and phasor diagram response.

4. SYMMETRIC & ANTISYMMETRIC MEANDERING DISTRIBUTED FEEDBACK STRUCTURES

Figure 7 shows the SMDFB intensity, phase, and phasor diagrams as a function of the normalized frequency (δ), when all the coupling constants are set to $C = 0.2$. There are 4 peaks (poles) in the intensity spectrum. Figure 8 shows the AMDFB intensity, phase, and phasor diagrams as a function of the normalized frequency (δ), when all the coupling constants are set to $C = 0.2$. There are 3 peaks (poles) in the intensity spectrum.

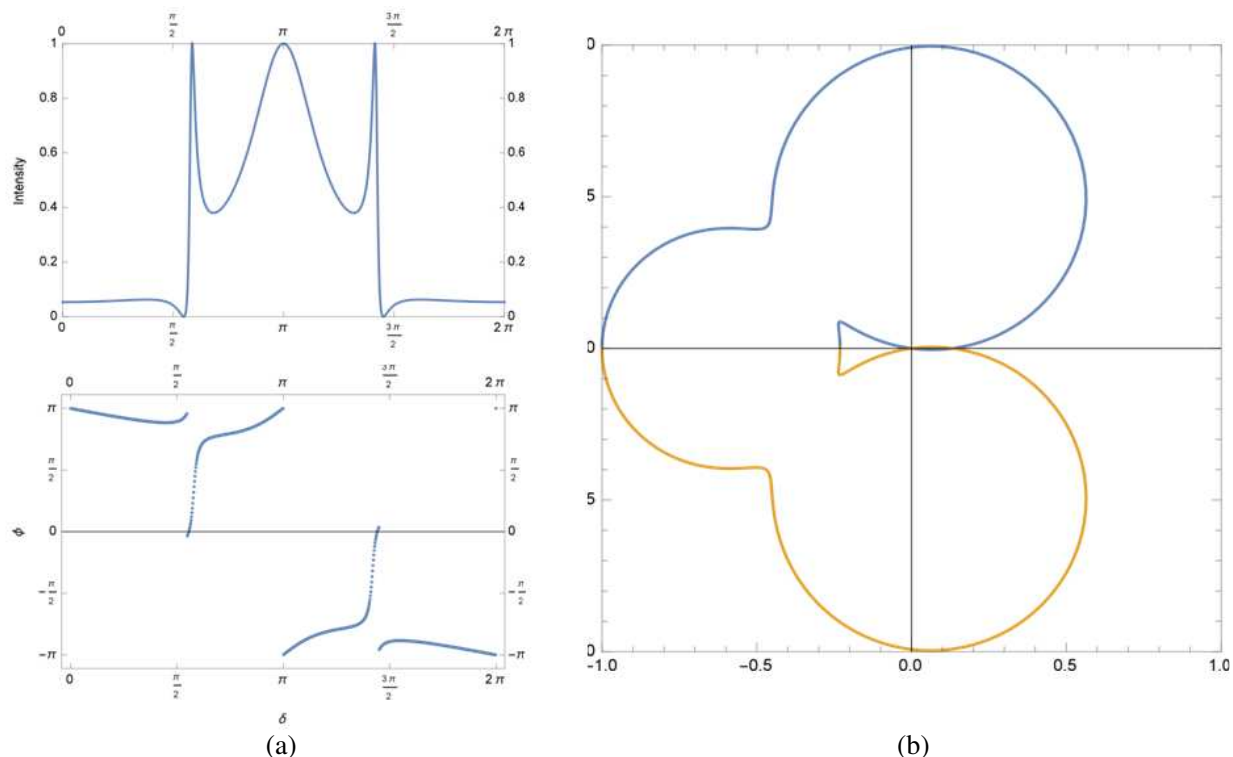


Figure 8: (a) The intensity, phase (Φ) and (b) phasor plots of an AMDFB of 2.5 MLM's, when all the coupling constants are set to $C = 0.2$. The normalized frequency (δ) runs from 0 to 2π in the intensity, phase response, and phasor diagram response.

5. CONCLUSIONS

We presented the intensity, phase, and phasor diagrams of the DMWs transmitted electric fields. The phasor diagrams give complete information of a transmitted electric field with amplitude and phase information for all the potential DMW structures.

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