Exceptional Points of Degeneracy in Linear Time-Periodic Electromagnetic Systems

Hamidreza Kazemi and Filippo Capolino
Department of Electrical Engineering and Computer Science, University of California, Irvine, California 92697, USA, e-mail: hkazemiv@uci.edu; f.capolino@uci.edu

The topic of exceptional points of degeneracy (EPDs) has received a surge of interest in the last few years due to their various applications in the RF and microwave and as well as optical regimes. An EPD is a point in the parameter space of a system at which multiple eigenmodes of the system coalesce in both their eigenvalues and eigenvectors. The concept of EPD has been vastly investigated in lossless spatially periodic structures [1, 2], and systems with loss and/or gain under parity-time (PT-) symmetry [3, 4] which has led to various potential applications such as enhancing the gain of active systems [2] and enhanced sensors [5].

We present a general theory of EPDs in periodically time-variant resonators and waveguides, in analogy to the EPDs found in space periodic structures, that do not necessarily require the presence of loss or gain. We will discuss EPDs arising from time varying phenomena in transmission lines, cavities and resonators of lumped elements. As an example, we demonstrate the concept using the LC resonator, though the formalism is general and applicable to any time periodic RF, microwave or photonic resonator. Moreover, we demonstrate the conditions for EPDs to exist in a time-periodic system with loss and/or gain and we show that a system with "zero time-average loss/gain" exhibits EPDs with purely real resonance frequencies, yet the resonator energy grows algebraically in time due to the energy exchange caused by the time modulation. As a possible application we focus on exploiting the temporally induced EPDs to build an ultra-sensitive sensor working near an EPD. This leads to a tremendous change in the system observable quantities like the resonance frequency or the quality factor.

References

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