Tutorial Title

Decomposition into Currents' Physical Components (CPC): the Fundamental of Power Theory and Compensation

Speaker

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Webpage/CV link/short bio	Leszek S. Czarnecki, IEEE Life Fellow, Distinguished Professor at Louisiana State University, Titled Professor of Technological Sciences, granted by the President of Poland. He received Ph.D., and D.Sc. degrees in electrical engineering from the Silesian University of Technology, Poland. For two years he was with the Power Engineering Section, of the National Research Council (NRC) of Canada. In 1989 Dr. Czarnecki joined the Electrical and Computer Engineering Department of Louisiana State University. For developing a power theory of three-phase systems with nonsinusoidal and asymmetrical voltages and currents and for methods of compensation of such systems he was elected to the grade of IEEE Fellow in 1996. Development of the Currents' Physical Components (CPC) – based power theory was the major professional Dr. Czarnecki's contribution to electrical engineering, for which he was nominated to the IEEE Proteus Charles Steinmetz Award. In 2019 Stanford University, USA, recognized Dr. Leszek S. Czarnecki as the World's 2% best faculty. A book titled: Powers in Compensation in Circuits with Nonsinusoidal Currents, is currently printed by Oxford University Press. Leszek S. Czarnecki was decorated by the President of Poland, for activity in the United States of America, aimed at the acceptance of Poland in NATO, with the Knight Cross of the Medal of Merit of the Republic of Poland. www.czarnecki.study

Abstract

The tutorial will present the fundamentals of the Currents' Physical Components (CPC) decomposition of single-phase and three-phase currents and importance of the CPC for understanding power properties of electrical circuits, and consequently, for developing the power theory of circuits with nonsinusoidal voltages and currents.

Investigations on power properties, definition of powers, and on compensation in circuits with distorted waveforms of voltages and currents have a more than a century-long history, with hundreds of scientists involved and several different concepts of power theory (PT) developed. The CPC-based PT is one of them and the most advanced. A short history of research on power theory and the results obtained will be presented.

The CPC decomposition reveals all physical phenomena responsible for the degradation of the effectiveness of energy transfer from its sources to customers' loads, regardless of the circuit complexity and its properties. The circuit could be a single-phase or a three-phase circuit with or without a neutral conductor. The load could be balanced or unbalanced, linear, nonlinear, or a sort of power electronics load with periodically varying parameters. The supply voltage can not only be distorted but also asymmetrical. Therefore, the power theory (PT)-founded on the CPC decomposition is the first power theory that is founded entirely on physical fundamentals.

This physical background of the CPC creates conditions for developing methods of compensation, aimed at the elevation of the effectiveness of energy transfer. It is because Currents' Physical Components are associated with distinctive physical phenomena in the circuit, or with its distinctive physical properties. Consequently, we can conclude how particular harmful components of the supply current can be reduced by reactance or switching compensators, and how their parameters can be calculated or controlled. Therefore, the CPC-based PT is the first power theory that solves the problem of reactance compensation and hybrid, meaning reactance/switching compensation, in circuits with nonsinusoidal and/or asymmetrical supply voltages.

The CPC-based PT, currently the most advanced, not challenged as an erroneous power theory, provides a tool and a reference for investigating all studies, interpretations, and the obtained results on the power properties of electrical circuits of any complexity. It can identify misconceptions that have occurred over more than a century-long research on powers and compensation in the presence of waveform distortions. The tutorial will discuss physical phenomena that degrade the effectiveness of energy transfer in the presence of harmonics, and their effect upon the associated current components, as well as methods of their compensation. Some major misconceptions on the power properties of electrical circuits and on methods of compensation will be discussed as well.

The subjects discussed in the tutorial will be illustrated with numerical examples that will facilitate comprehension of more abstract ideas and help to see them from a practical perspective.