Nonlinear Analysis in the Frequency Domain: Theory, Method and Application

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Abstract
NONLINEAR analysis takes an important role in system analysis and design in practice from engineering problems to biological systems. Several methods are available in the literature to this aim including perturbation method, averaging method and harmonic balance method etc. Nonlinear analysis can also be conducted in the frequency domain based on the Volterra series theory. It is known that there is a considerably large class of nonlinear systems which allow a Volterra series expansion.

Recently, a systematic theory and method for nonlinear analysis, design and estimation in the frequency domain is developed using the concept of generalized frequency response functions based on the Volterra series theory. It is a reasonable development and generalization of the frequency domain theory for linear systems to nonlinear cases. Given a nonlinear system of interest subject to a specific input signal, the nonlinear output spectrum, referred to as nonlinear characteristic output spectrum (nCOS), can be derived analytically, which is an explicit polynomial expression in terms of any characteristic parameters of interest, including model parameters, input magnitude and frequency variables. Therefore, the nCOS function can directly link the desired output spectrum to the characteristic parameters to be designed, and consequently provide a straightforward insight into the analysis and design of nonlinear dynamics.
The advantages of this frequency domain method also include that it is mathematically elegant for a considerably large class of nonlinear systems (described by NDE, NARX or NBO models), not restricted to any specific inputs such as harmonic or triangle or step signals, and provides similar techniques to those for linear systems etc.

Applications of these results can be found in sound and vibration control, fault detection (non-destructive evaluation) and biological data interpretation etc. Recent advances in vibration control etc as examples will be focused in this talk.

**About the Speaker**

**Dr Xingjian Jing** received the B.S. degree from Zhejiang University, Hangzhou, China, in 1998, the M.S. degree from Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang, China, in 2001, the PhD degree in nonlinear systems and signal processing from the Department of Automatic Control and Systems Engineering, University of Sheffield, Sheffield, U.K., in 2008.

He is currently an Assistant Professor with the Department of Mechanical Engineering, the Hong Kong Polytechnic University (PolyU). Before joining in PolyU, he was a Research Fellow with the Institute of Sound and Vibration Research, University of Southampton from Aug 2008 to Nov 2009, where he worked on biomedical signal processing funded by a BBSRC (UK) project. His current research interests include: system identification, signal processing and control of complex nonlinear systems; nonlinear analysis in the frequency domain; intelligent computing methods; and their applications in nonlinear mechanical systems (sound and vibration control), nonlinear physiological systems (neural systems) and robotic systems etc.

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All are welcome!

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