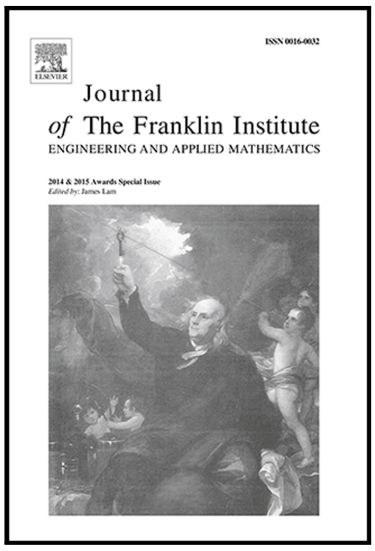

Analysis of Orbital Stability in Lure System, Based on Dynamic Harmonic Balance

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Igor Boiko

***Abstract*—A criterion of orbital stability of a limit cycle in a Lure system is formulated using the dynamic harmonic balance (DHB) principle and the describing function (DF) method. It is demonstrated that a more precise formulation of orbital stability than that provided by the Loeb's criterion can be produced. This enhancement is achieved through elimination of the assumption that is used in Loeb's criterion derivation. It is demonstrated in the paper that this assumption does not hold. An example of analysis is given.**

***Index Terms*—Lure system; Orbital stability; Describing function; Dynamic harmonic balance**

I. INTRODUCTION

ANALYSIS of orbital stability of limit cycles is an important problem in many areas of science and engineering. There exist a number of practical problems requiring analysis of orbital stability of possible limit cycles that may occur as solutions of the equations of these systems. These limit cycles may occur in such applications as the relay feedback test (Astrom and Hagglund, 1984) and various modifications of this test, limit-cycling servomechanisms, various ON-OFF and phase-lock loop systems (Gardner, 1966). Recently, the problem of orbital stability found application in the so-called hidden attractors and hidden-oscillations analysis (Leonov and Kuznetsov, 2015; Leonov, Kuznetsov and Solovyeva, 2015; Bianchi et. al., 2015). Possibly, some problems related to the periodic modes in neural networks (Rakkiyappan, et. al., 2016; Chandrasekar, Rakkiyappan and Li, 2015) can be analyzed from the perspective of orbital stability. Exact solution of this problem can be obtained through consideration of Poincare maps of the system (Khalil, 1996). Yet Poincare maps can hardly be obtained for the majority of systems that reveal limit cycle behavior. An approximate approach proposed by Loeb (1956), that is based on the describing function (DF) method (Khalil, 1996; Gelb & Vander Velde, 1968; Atherton, 1975; Slotine & Li, 1991), is conveniently used in practice instead of the exact method. However, the Loeb's criterion and other similar approaches (Miller, Michel & Krenz, 1983; 1984) are based on the assumption about the harmonic balance equation, obtained through the DF method, being valid not only at the point of the periodic motion but also for small perturbations in the vicinity of the periodic solution. Strictly speaking, this cannot be true because it contradicts the principle of finding a periodic solution through the harmonic balance. This issue is analyzed in the current paper. However, the Loeb's assumption leads to a very compact solution and a simple criterion of orbital stability, the validity of which is also supported by many examples. The recent formulation of the dynamic harmonic balance (DHB) principle (Boiko, 2012; 2015) offers an opportunity of removing the above-noted assumption in the Loeb's analysis of stability. The present paper aims at the analysis of orbital stability of periodic solutions in Lure systems, based on the DHB. The proposed criterion eliminates the inherent contradiction of the Loeb's approach.

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