A New Recognition Method for Base-excited Systems by Using the Dissipative Energy of Steady-state Responses

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The main objective of the present report is to derive a new recognition method for identifying system parameters of single-degree, base-excited systems. In addition to the theoretical derivation, the error analyses are also presented. Unlike other existing methods, the present method starts with giving a wide band, or chirp excitation to the target system, and to lock the damped natural frequency. Once the damped natural frequency is obtained, it is possible to compute the location where the phase lag is equal to $\pi/2$ (or 90°). From which, the excitation frequency is then purposely changed to that frequency and the corresponding steady-state responses are measured. In the mean time, the system dissipative energy or power needs also be recorded. In fact, the present identification formulation is to express both the mass and stiffness of the target systems in terms of two measurable parameters: the external frequency at 90° phase lag. and the system damping. The former is close related to the damped natural frequency while the latter can be identified along with measuring the input power. Provided that these two parameters are available, it is possible to recognize the system mass and stiffness by applying them to the formulations provided in the present paper. The novel formulations were then numerically simulated using the Simulink toolbox of MATLAB. The simulation results clearly showed the current recognition method can work with good accuracy. Following the numerical simulations, experimental validation was also carried out by a cantilever beam system. Even though the experimental results again verified the correctness of the method, a larger error may exist if system damping is extremely small. The reason may mainly attribute to the measurement accuracy for dissipative power and the location error from the frequency of 90° phase lag. Nevertheless, both numerical simulation and experimental results strongly suggest that the new recognition algorithm can be applied with confidence. More importantly, to the best of authors' knowledge, it is the first attempt to give such an almost-exact formulation for system parameters.

Keywords: Parameter identification, Signature analysis, Base-excited system, Dissipative energy