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**Suppression of hysteresis in a forced Van der Pol-Duffing oscillator.** (English) Zbl 1221.34126  
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**Summary:** This paper examines the suppression of hysteresis in a forced nonlinear self-sustained oscillator near the fundamental resonance. The suppression is studied by applying a rapid forcing on the oscillator. Analytical treatment based on perturbation analysis is performed to capture the entrainment zone, the quasiperiodic modulation domain and the hysteresis area as well. The analysis leads to a strategy for the suppression of hysteresis occurring between 1 : 1 frequency-locked motion and quasiperiodic response. This hysteresis suppression causes the disappearance of nonlinear effects leading to a smooth transition between the quasiperiodic and the frequency-locked responses. Specifically, it appears that a rapid forcing introduces additional apparent nonlinear stiffness which can effectively suppress hysteresis in a certain range of the rapid excitation frequency. This work is motivated by the important issue of controlling and eliminating hysteresis often undesirable in mechanical systems, in general, and in application to microscale devices, especially.

**MSC:**

**34C55** Hysteresis for ordinary differential equations  
**70K40** Forced motions for nonlinear problems in mechanics

Cited in **8** Documents

**Keywords:**

[hysteresis suppression](#); [frequency locking](#); [high-frequency excitation](#); [perturbation analysis](#)

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**References:**

- [1] Pandey, M.; Rand, R.H.; Zehnder, A.T., Perturbation analysis of entrainment in a micromechanical limit cycle oscillator, *Commun nonlinear sci numer simul*, 12, 1291-1301, (2007) · [Zbl 1124.34026](#)
- [2] Nayfeh, A.H.; Younis, M.I.; Abdel-Rahman, E.M., Dynamic pull-in phenomenon in MEMS resonators, *Nonlinear dyn*, 48, 153-163, (2007) · [Zbl 1177.74191](#)
- [3] Stephenson, A., On induced stability, *Philos mag*, 15, 233-236, (1908) · [Zbl 39.0768.01](#)
- [4] Hirsch, P., Das pendel mit oszillierendem aufhängepunkt, *Zeitschrift fur angewandte Mathematik und mechanik*, 10, 41-52, (1930) · [Zbl 56.0683.01](#)
- [5] Kapitza, P.L., Dynamic stability of a pendulum with an oscillating point of suspension, *Zurnal eksperimental'noj i teoreticeskoj fiziki*, 21, 588-597, (1951), (in Russian)
- [6] Thomsen, J.J., Some general effects of strong high-frequency excitation: stiffening, biasing, and smoothening, *J sound vib*, 253, 4, 807-831, (2002)
- [7] Jensen, J.S.; Tcherniak, D.M.; Thomsen, J.J., Stiffening effects of high-frequency excitation: experiments for an axially loaded beam, *J appl mech*, 67, 397-402, (2000) · [Zbl 1110.74497](#)
- [8] Hansen, M.H., Effect of high-frequency excitation on natural frequencies of spinning discs, *J sound vib*, 234, 4, 577-589, (2000)
- [9] Tcherniak, D.; Thomsen, J.J., Slow effect of fast harmonic excitation for elastic structures, *Nonlinear dyn*, 17, 227-246, (1998) · [Zbl 0933.74032](#)
- [10] Mann, B.P.; Koplou, M.A., Symmetry breaking bifurcations of a parametrically excited pendulum, *Nonlinear dyn*, 46, 427-437, (2006) · [Zbl 1170.70359](#)
- [11] Sah, S.M.; Belhaq, M., Effect of vertical high-frequency parametric excitation on self-excited motion in a delayed van der Pol oscillator, *Chaos solitons fract*, 37, 5, 1489-1496, (2008) · [Zbl 1142.34332](#)
- [12] Belhaq, M.; Sah, S.M., Horizontal fast excitation in delayed van der Pol oscillator, *Commun nonlinear sci numer simul*, 13, 8, 1706-1713, (2008)
- [13] Pandey, M.; Rand, R.H.; Zehnder, A.T., Frequency locking in a forced mathieu – van der pol – duffing system, *Nonlinear dyn*, (2007)
- [14] Belhaq, M.; Fahsi, A., 2:1 and 1:1 frequency-locking in fast excited Van der pol – mathieu – duffing oscillator, *Nonlinear dyn*, (2007) · [Zbl 1170.70344](#)

- [15] Blekhman, I.I., Vibrational mechanics – nonlinear dynamic effects, general approach, application, (2000), World Scientific Singapore
- [16] Belhaq, M.; Houssni, M., Quasi-periodic oscillations, chaos and suppression of chaos in a nonlinear oscillator driven by parametric and external excitations, *Nonlinear dyn*, 18, 1-24, (1999) · [Zbl 0969.70017](#)
- [17] Belhaq, M.; Guennoun, K.; Houssni, M., Asymptotic solutions for a damped non-linear quasi-periodic Mathieu equation, *Int J nonlinear mech*, 37, 445-460, (2002) · [Zbl 1346.34030](#)
- [18] Rand, R.H.; Guennoun, K.; Belhaq, M., 2:2:1 resonance in the quasi-periodic Mathieu equation, *Nonlinear dyn*, 31, 187-193, (2003)
- [19] Rand, R.; Morrison, T., 2:1:1 resonance in the quasi-periodic Mathieu equation, *Nonlinear dyn*, 40, 195-203, (2005) · [Zbl 1132.34041](#)
- [20] Sah, S.M.; Recktenwald, G.; Rand, R.H.; Belhaq, M., Autoparametric quasiperiodic excitation, *Int J nonlinear mech*, 43, 320-327, (2008)
- [21] Nayfeh, A.H.; Mook, D.T., *Nonlinear oscillations*, (1979), Wiley New York

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