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ON THE REDUCTION OF SYSTEMS WITH INCOMMENSURATE DELAYS TO A FORM WITH ZERO DYNAMICS

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A form with zero dynamics for time-delay systems is considered. The results obtained earlier for the case of commensurate delays are transferred to systems with incommensurate delays. Conditions are obtained under which the reduction to such a form is possible, and an algorithm for constructing the corresponding transformation is described.

Keywords: time-delay systems, incommensurate delays, zero dynamics.

REFERENCES

- Korovin S.K., Fomichev V.V. State observers for linear systems with uncertainty. Berlin: Walter de Gruyter, 2009, 242 p. doi: 10.1515/9783110218138. Original Russian text published in Korovin S.K., Fomichev V.V. Nablyudateli sostoyaniya dlya lineinykh sistem s neopredelennost'yu, Moscow: Fizmatlit Publ., 2007, 224 p.
- Atamas' E.I., Il'in A.V., Fomichev V.V. Inversion of vector delay systems. *Differential Equations*, 2013, vol. 49, no. 11, pp. 1329–1335. doi: 10.1134/s0012266113110013.
- 3. Isidori A. The zero dynamics of a nonlinear system: from the origin to the latest progresses of a long successful story. *European J. Control*, 2013, vol. 19, no. 5, pp. 369–378. doi: 10.1016/j.ejcon.2013.05.014.
- Zeng C., Liang S., Li H. Asymptotic properties of zero dynamics for nonlinear discretized systems with time delay via Taylor method. *Nonlinear Dynamics*, 2015, vol. 79, no. 2, pp. 1481–1493. doi: 10.1007/s11071-014-1755-9.
- Conte G., Perdon M. A notion of zero dynamics for linear, time-delay system. IFAC Proc. Volumes, 2008, vol. 41, no. 2, pp. 1255–1260. doi: 10.3182/20080706-5-KR-1001.00216.
- 6. Bejarano F. Zero dynamics normal form and disturbance decoupling of commensurate and distributed time-delay systems. *Automatica*, 2021, vol. 129, art. no. 109634. doi: 10.1016/j.automatica.2021.109634.
- Il'in A.V., Atamas' E.I., Fomichev V.V. Transformation of time-delay systems to a form with zero dynamics. Dokl. Math., 2018, vol. 97, no. 3, pp. 203–206. doi: 10.1134/S106456241803002X.
- Morse A. Ring models for delay-differential systems. Automatica, 1976, vol. 12, no. 5, pp. 529–531. doi: 10.1016/0005-1098(76)90013-3.
- Fomichev V.V., Kraev A.V., Rogovskiy A.I. Reduction of systems to a form with relative degree using dynamic output transformation. *Differential Equations*, 2017, vol. 53, no. 5, pp. 686–700. doi: 10.1134/S0012266117050123.
- Fabianska A., Quadrat A. Applications of the Quillen–Suslin theorem to multidimensional systems theory. In: Grobner bases in control theory and signal processing. Berlin; Boston: De Gruyter, 2011, pp. 23–106. doi: 10.1515/9783110909746.23.

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