

## TIME-VARYING COEFFICIENTS NEUTRAL DIFFERENTIAL EQUATIONS: ON ASYMPTOTIC PROPERTIES

ANES MOULAI-KHATIR

*Abstract.* The main purpose of the present paper is to investigate asymptotic properties of a class of neutral differential equations of the form

$$\frac{d}{dx}[x(t) + \beta(t)x(t - \sigma)] + a(t)g(x(t)) + b(t)f(x(t - \tau)) + c(t) \int_{t-\delta}^t x(s)ds = e(t). \quad (1)$$

Using the Lyapunov direct method, the condition of stability of trivial solution for equation (1) with  $e(t) = 0$  is given. With respect to  $e(t) \neq 0$ , the boundedness of solutions of equation (1) is also obtained. Two examples are provided to illustrate the results.

*Mathematics subject classification (2020):* 34K20, 34D20.

*Keywords and phrases:* Asymptotic properties, Lyapunov function, boundedness, neutral differential equations.

### REFERENCES

- [1] SABRI ARIK, *A modified Lyapunov functional with application to stability of neutral-type neural networks with time delays*, J. Franklin Inst., 356 (1): 276–291, Jan 2019.
- [2] SABRI ARIK, *New Criteria for Stability of Neutral-Type Neural Networks With Multiple Time Delays*, IEEE Trans. Neural Networks Learn. Syst., 31 (5): 1504–1513, Jun 2019.
- [3] SABRI ARIK, *New Criteria for Stability of Neutral-Type Neural Networks With Multiple Time Delays*, IEEE Trans. Neural Networks Learn. Syst., 31 (5): 1504–1513, May 2020.
- [4] EMEL BICER, *An Asymptotic Result for neutral differential equations*, Applied Mathematics and Non-linear Sciences, 5 (1): 189–194, Mar 2020.
- [5] R. D. DRIVER, *Ordinary and Delay Differential Equations*, Springer New York, 2012.
- [6] MICHAEL GIL', *Stability of Neutral Functional Differential Equations*, Springer. Atlantis Press, 2014.
- [7] K. GOPALSAMY, *Stability and Oscillations in Delay Differential Equations of Population Dynamics*, Springer Netherlands, 2013.
- [8] JACK K. HALE, *Theory of Functional Differential Equations*, Springer, 1977.
- [9] JACK K. HALE AND SJOERD M. VERDUYN LUNEL, *Introduction to Functional Differential Equations*, Springer-Verlag New York, 1993.
- [10] V. KOLMANOVSKII, A. MYSHKIS, *Applied Theory of Functional Differential Equations*, Kluwer, 1992.
- [11] P. T. NAM AND V. N. PHAT, *An improved stability criterion for a class of neutral differential equations*, Appl. Math. Lett., 22 (1): 31–35, Jan 2009.
- [12] JU H. PARK, *LMI optimization approach to asymptotic stability of certain neutral delay differential equation with time-varying coefficients*, Appl. Math. Comput., 160 (2): 355–361, Jan 2005.
- [13] LEPING SUN, *Asymptotic stability for the system of neutral delay differential equations*, Appl. Math. Comput., 218 (2): 337–345, Sep 2011.
- [14] YUAN GONG SUN AND LONG WANG, *Note on asymptotic stability of a class of neutral differential equations*, Appl. Math. Lett., 19 (9): 949–953, Sep 2006.
- [15] CEMIL TUNC, *Asymptotic stability of solutions of a class of neutral differential equations with multiple deviating arguments*, Bulletin mathématique de la Société des Sciences Mathématiques de Roumanie, 57 (105) (1): 121–130, 2014.

- [16] CEMIL TUNC, *On the uniform asymptotic stability to certain first order neutral differential equations*, *Cubo (Temuco)*, 16: 111–120, 00 2014.
- [17] ZHONGSHENG WANG, HANLIN HE, AND XIAOXIN LIAO, *Stability Analysis of Uncertain Neural Networks with Delay*, Springer, Berlin, Heidelberg, Aug 2004.