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Neural networks and statistical decision making for fault diagnosis of PM linear synchronous machines. (English) Zbl 1483.93454

Summary: A novel fault diagnosis method that is based on neural networks and statistical decision making is proposed for permanent magnet linear synchronous machines (PMLSM). Such a type of electric machines is widely used in traction of Maglev electric trains, in several mechatronic systems, as well as in electric power generation through wave energy conversion. First a neural network with Gauss-Hermite activation function is used for modelling the dynamics of the PMLSM. The neural network is used as the fault-free model of the PMLSM. Next, to perform fault diagnosis, the output of the neural network is compared against the output that is measured in real-time from the PMLSM, when both the NN and the electric machine receive the same input. Thus, the residuals’ sequence is generated. It is proven that the sum of the squares of the residuals’ vectors, being weighted by the inverse of the associated covariance matrix, is a stochastic variable (statistical test) that follows the $\chi^2$ distribution. The $\chi^2$ or the $\chi^2$ confidence intervals of the $\chi^2$ distribution with degrees of freedom to be equal to the dimension of the residuals’ vector provide a statistical test for inferring with a high confidence level if the PMLSM has undergone a failure or not.

MSC:
93C95 Application models in control theory
62P30 Applications of statistics in engineering and industry; control charts
68T07 Artificial neural networks and deep learning

Keywords:
permanent magnet linear synchronous machines; Gauss-Hermite neural networks; residuals sequence; $\chi^2$ distribution; statistical fault diagnosis

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