# UNIVERSITI TEKNOLOGI MARA

# ARTIFICIAL NEURAL NETWORK (ANN) AS POST-PROCESSING STAGE FOR CHEMICALLY SELECTIVE FIELD EFFECT TRANSISTOR (CHEMFET) SENSOR SELECTIVITY BASED-ON ION CONCENTRATION

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Thesis submitted in fulfillment
of the requirements for the degree of
**Master of Science**

**Faculty of Electrical Engineering**

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# CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 13th October 2015 to conduct the final examination of Nurhakimah Binti Abd Aziz on his Master of Science thesis entitled " Artificial Neural Network (ANN) as Post-Processing Stage for Chemically Selective Field Effect Transistor (CHEMFET) Sensor Selectivity Based-On Ion Concentration " in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The panel of Examiners was as follows:

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# AUTHOR'S DECLARATION

I declare that the work in this thesis/dissertation was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

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# ABSTRACT

The chemically-sensitive field-effect transistor (CHEMFET) sensor is one of derivative of ion-sensitive field-effect transistor (ISFET) sensor which is sensitive to dedicated chemical species. ISFET sensor structure is improvement from metal oxide semiconductor field-effect transistor (MOSFET). One of the challenges that faced by CHEMFET sensor is the need to perform high selectivity on a variety of ions in mixed solution. The main purpose of this study is to improve the estimation of main ion in the presence of interfering ions of CHEMFET sensor signal, particularly potassium ion (K+) in interfering ammonium ions (NH4+) by implementing and exploring artificial neural network specifically supervised and unsupervised learning as post-processing stage. In this study, the sensor voltage response was acquired to act as input data while sample concentrations which set from $10^{-6}$ to $10^{-1}$ mol/L was used as target for training data. The sensor voltage response used has been measured and also generated based on CHEMFET sensor modeling by using MATLAB software. Firstly, the backpropagation learning for feed-forward multilayer perceptron (MLP) and Radial Basis Function (RBF) supervised neural network was designed in MATLAB software. The findings have shown that compared to RBF network, MLP neural network with 10 hidden neurons used in this study capable to perform for estimation of main ion concentration in mixed solution and also was verified as the optimum model. This is confirmed based on statistical analysis validation via regression analysis that shows with R-factor of 0.9011. Other than developing supervised learning, this study also was focusing on exploration of unsupervised learning mainly in blind source separation (BSS) algorithm to separate the interface signal. From simulation, the original sources of CHEMFET sensor are proven statistically independent which are be able to recover by ICA and the Fast Independent Component Analysis (FastICA) function achieves the separation of the main and interfering ion activities. A hardware implementation of optimized supervised neural network for CHEMFET sensor also was carried out in this study involved with 16-bit microcontroller board. By implementing neural network using 16-microcontroller board, the previous performance obtained by MLP network could be verified and compared with the performance that will attained by 16-microcontroller board. As the conclusion, the neural network proposed in this study is able to improve the selectivity of CHEMFET sensor in the presence of unintended ions.

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