Farhad Elyasichamazkoti, Evan Benoit, Dawn Sweeney, Cynthia Furse, "Machine Learning for Spread Spectrum Time-Domain Reflectometry Impedance Measurement," Review of Progress in Quantitative Nondestructive Evaluation (QNDE), online, July 28-30, 2021

Spread spectrum time-domain reflectometry (SSTDR) has been widely used to detect and locate electrical faults and disjunctions in airplane cabling, undersea communication cables, railway switching networks, and photovoltaic (PV) systems. In this paper, we aim to explore the ability of using SSTDR to extract the complex impedance of an unknown load connected to a transmission line. Because SSTDR can be used on live electrical system, this could be useful for troubleshooting active electrical systems without de-energizing or disconnecting them. Complex impedances are commonly measured with inductance-capacitance-resistance (LCR) meters or a vector network analyzer (VNA). These are expensive devices typically limited to use on non-energized systems. Time domain reflectometry (TDR) has been used to extract complex impedances, also typically on non-energized systems. Several impedance extraction algorithms such as inversion theory and steepest descent inversion have been used. This paper uses SSTDR and a machine learning technique for complex impedance estimation in a potentially energized electrical environment where the reflected signal might be noisy, attenuated, or affected by environmental factors. A multiple complex regression model is applied in this study to train a network for estimating complex impedance. Multiple linear regression models the relationship between a dependent variable and independent variables. To train this network, we needed to create a dataset that was built by simulating extracted complex impedance from SSTDR responses in the frequency domain. Moreover, we must use the observed impedance extracted from SSTDR as our dependent variable and use ideal impedances as an independent variable in the training process. First, training of the multiple regression model is done on the training dataset. From this trained network, all the optimal and robust coefficients of the model are obtained. We can predict and evaluate any new complex impedance from its SSTDR response by fitting the model to the new data. In this work we compare the forecasted impedances with the actual results and calculate the model evaluation metrics for different ranges of impedance, frequency, noise level, and SSTDR test parameters. This work shows how SSTDR can be used to measure complex impedance in noisy, energized electrical systems.