tLOSS: a collaborative machine learning platform for predicting AC losses in HTS devices

Miguel Vieira
Dep. of Electrical and Computers Engineering
NOVA School of Science and Technology (FCT NOVA)
Caparica, Portugal
mre.vieira@campus.fct.unl.pt

João Rosas
NOVA School of Science and Technology (FCT NOVA)
Centre of Technology and Systems (CTS UNINOVA)
Caparica, Portugal
jrosas@uninova.pt

João Murta-Pina
NOVA School of Science and Technology (FCT NOVA)
Centre of Technology and Systems (CTS UNINOVA)
Caparica, Portugal
jmmp@fct.unl.pt

Roberto de Oliveira
Institute for Advanced Automotive Propulsion Systems
University of Bath
Bath, United Kingdom
ro363@bath.ac.uk

Henrique Simas
Dep. of Electrical and Computers Engineering
NOVA School of Science and Technology (FCT NOVA)
Caparica, Portugal
h.simas@campus.fct.unl.pt

Masoud Ardestani
Dep. of Electrical and Computers Engineering
NOVA School of Science and Technology (FCT NOVA)
Caparica, Portugal
s.ardestani@campus.fct.unl.pt

***Abstract*—This work describes an open access platform for data-driven modelling of AC losses in high-temperature superconducting devices, as opposed to computationally intensive, time-consuming numerical methods. The platform is being developed in the frame of the Portuguese project tLOSS.**

***Keywords*—AC losses, Data-Driven Modelling, High Temperature Superconductivity (HTS), Open-Access Platform**

I. INTRODUCTION (*HEADING 1*)

High-Temperature Superconducting (HTS) devices are usually modelled and simulated by the Finite Element Method (FEM), due to its accuracy and ability to address multiphysics problems. Yet, the non-linearity of HTS properties or huge width-to-thickness ratios, makes FEM extremely computationally intensive, leading to unreasonable processing times in the optimization of devices, when, e.g., thousands of configurations need to be simulated and assessed. Improved FEM formulations have been developed, as the T-A, instead of the widely spread H-formulation [1], but this is still a major impediment to HTS technologies dissemination. There is an opportunity for the development of data-driven based approaches, from the field of Artificial Intelligence (AI), for modelling and simulating the behavior of HTS devices [2].

Data-driven approaches use data (from experiments and/or simulation) to learn patterns in it. The built computational models can be used for obtaining predictions of distinct conditions instantly. The ability of these approaches to build generalised models with adequate accuracy depends on the disposal of large amounts of data from diverse operating conditions.

This work describes one major outcome of the Portuguese project tLOSS, a web platform for the collaborative modelling and prediction of HTS losses.

II. DATA-DRIVEN MODELLING METHODOLOGY

A. Modelling Workflow

The developed data-driven methodology assumes that losses on the HTS active parts of a device are related to the behavior of losses in its constitutive elements, namely the tape, coil and windings. In addition, this also prevents issues in the learning algorithms, as overfitting, providing the developed tools with higher generalisation ability. The modelling workflow and the techniques used in each stage

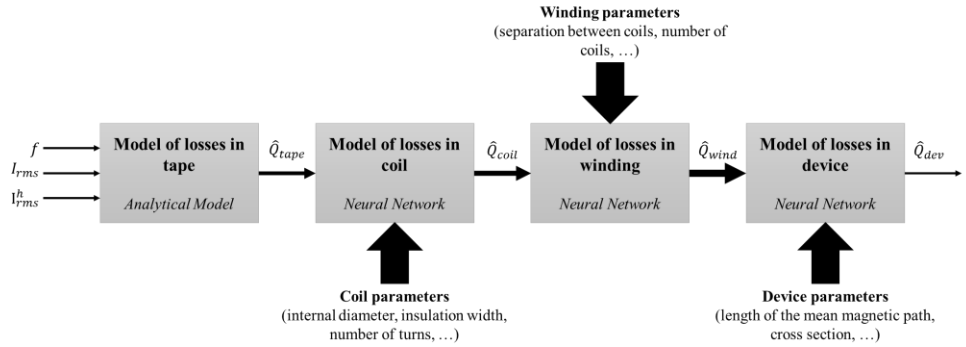

Fig. 1. Modelling workflow of tLOSS, addressing all the constitutive elements of a device, namely tape, coil, winding and device. $\hat{Q}_{dev}$ are the predicted losses in the HTS parts of the device for a given condition of frequency, f, rms current, I_{rms}, and rms (vector of) current harmonics, $\mathbf{I}_{rms}^{h}$. Intermediary losses in isolated components are also provided, namely in the tape, $\hat{Q}_{tape}$, coil, $\hat{Q}_{coil}$, and winding, $\hat{Q}_{wind}$.

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(analytical or artificial neural networks), are represented in Fig. 1).

B. *Ontology*

To provide data structuring and to allow for the adequate sharing of data, an evolving ontology was developed for tLOSS, addressing each stage/item of the methodology. An example for the item Coil is shown in Fig. 5. The values of each of the shown attributes (e.g., data related to simulation or experiments) need to be specified when uploading the data and are available when downloading it.

III. tLOSS Platform

A. *Development Frameworks*

tLOSS platform is provided as a web application, where different frameworks were used in its development. In the fron-tend, Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), and JavaScript were chosen. For the back-end, pure Hypertext Preprocessor (PHP) code and phpMyAdmin (which supports the MariaDB open source relational databases to store profiles from users) were selected.

B. *Use Cases*

The platform allows uploading and downloading data of losses relatively to the items of the methodology, as well as building and using models with the available data. A diagram of use cases is shown in Fig. 2.

C. *Functionalities*

Several functionalities are available in the tLOSS platform, as mentioned, namely related to creation of profiles, to fully exploit the existing data services; data upload, download and visualisation; or modelling and predicting losses concerning the different items of the methodology. Means to credit data providers are also available.

The first release of the platform will soon be made available for the community and full details and examples will be provided in the Workshop.

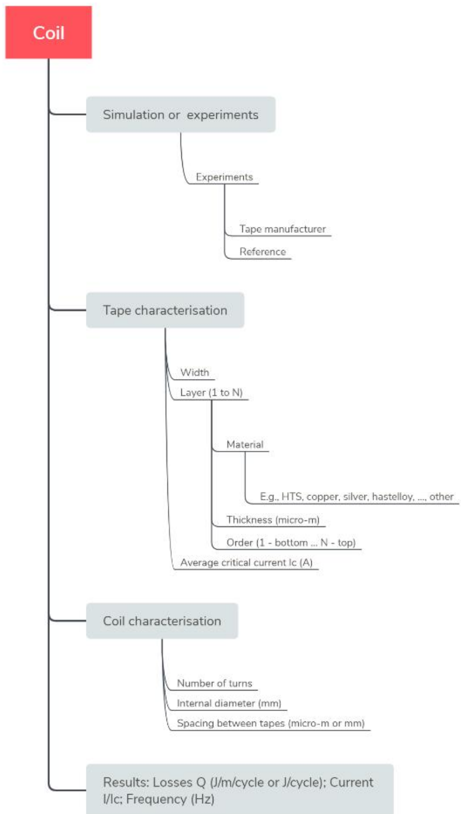

Fig. 5. Example of the tLOSS ontology for item Coil.

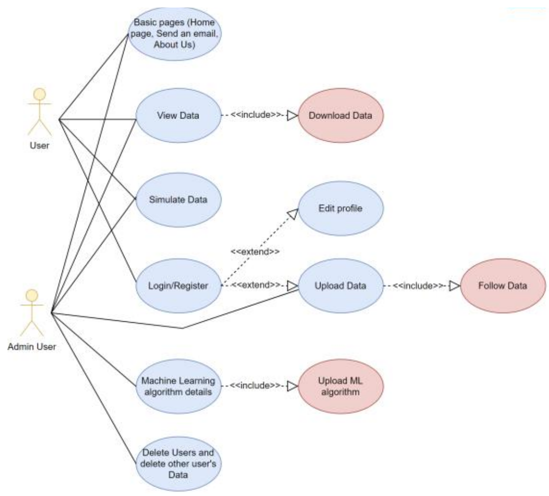

Fig. 2. tLOSS platform use cases diagram.

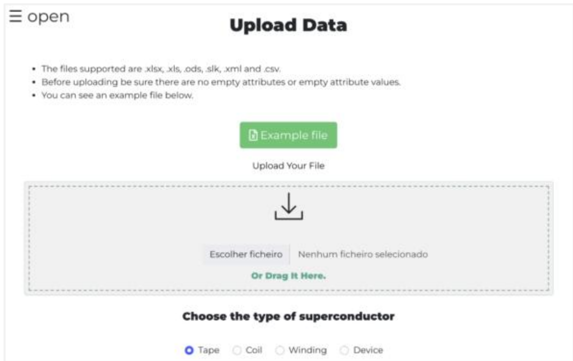

Fig. 3. Data upload in the tLOSS platform.

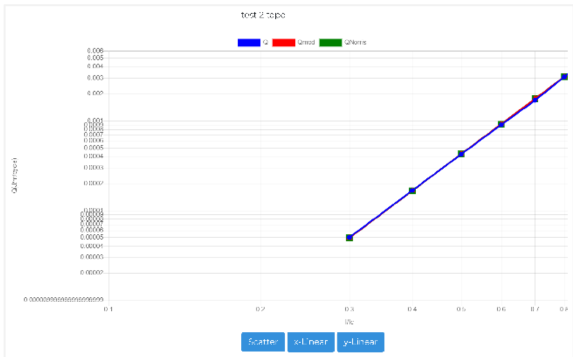

Fig. 4. Example of data visualisation of uploaded losses in a tape, automatic modelling by an exponential, and Norris curve comparison.

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