Final deliverable

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Abstract **This document presents the final report on Task 5.1 – Harness Components Modelling**

Keyword List Electrical components, harness, models

1. INTRODUCTION

The main objective of this task was the modelling of the electrical components present in common aircrafts in a “power consumption” point of view.

Electrical components can be divided into two groups:

- Equipment: power supplies, instruments, electrical closets, passenger equipment, motors, generators, …
- Harness, strands and wires, whose function is data and power transmission between equipments.

The inputs of this task are the user knowledge, technical characteristics of the equipments and validation results. The outputs of this task are mathematical models, specification of needs for the user interface modelling tools (task 5.2) and some model files useable by the simulator. Then the aim is to use mathematical models to define the kind of behaviour to model and the capabilities of the user interface for model edition. This way, the user can create any model using the graphical tools and the technical data he owns.

2. PACK’ELEC SIMULATOR MODELS

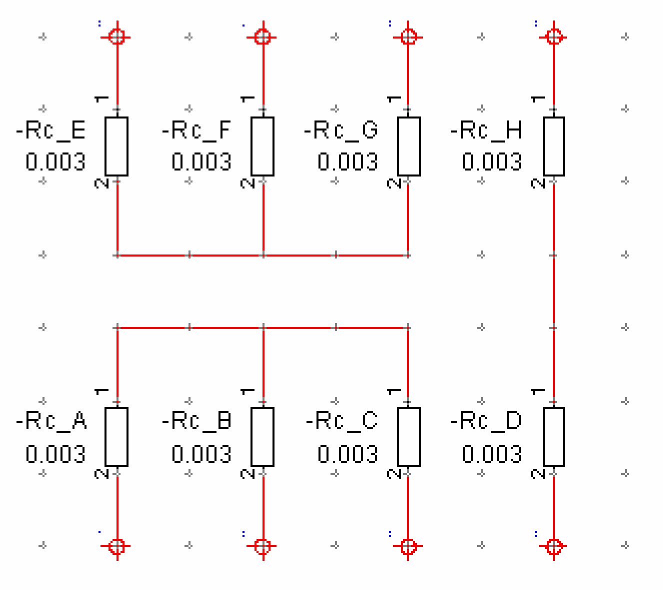
The first objective was to obtain mathematical models with different levels of abstraction describing the behavior of the requested electrical components, without considering model implementation for simulator.

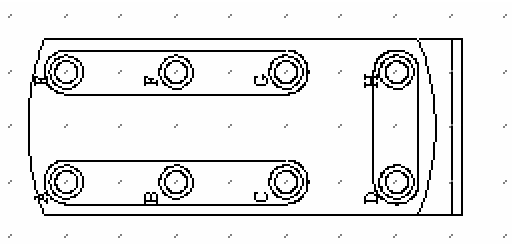
Some libraries of components were created using the Pack’Elec simulator developed by Algo’tech. The models were defined graphically using simpler components modelled previously. The use of this simulator had two main advantages:

- The previous knowledge Algo’tech already had in this field.
- The set of component libraries that could be reused to develop more complex models.

Among these models of electrical components we can mention some connectors, motors, generators, transformers. Different types of motors and generators were taken into account, such as synchronous, asynchronous or DC. In some cases, single-phase and three-phase models were developed, and in different configurations, such as in star or in triangle connection. These models were made from more basic components, like resistances, capacitances, inductances and voltage or current sources.

In the following figure the equivalent electric circuit of a connection module is shown in the left side:

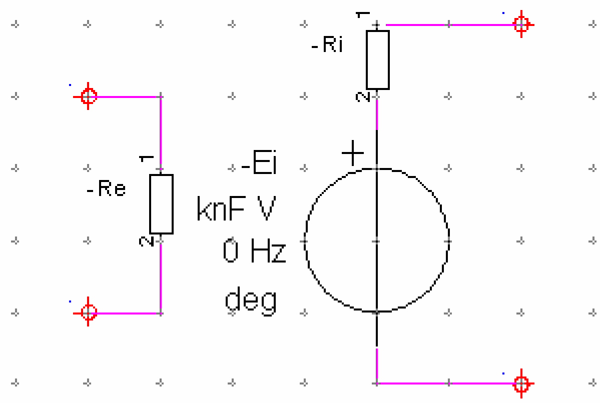




It is built from simple resistances that represent the internal connections of the module. The value of these resistances depends on the characteristics of the connector. The external connections of the module, in order to allow this component to be part of a more complex circuit, are indicated by red circles.

The left diagram represents the functional behavior of the connection module. The user interface diagram or symbol for this component can be seen in the right figure.

As an example of a more complicated electrical component, a model of the DC machine (motor or generator) is presented in the following image:



The above diagram corresponds to a DC machine in independent excitation configuration. The stator (inductor) of the machine is modelled by a simple resistance, and the rotor (induced) is represented by a resistance in series with a DC voltage source to take into account the voltage induced across the coils terminals because of the rotary movement of the machine. The value of this voltage depends on the velocity of the rotor (n), the magnetic flux by pole (F) and a design constant of the coils (k). These parameters could be accessible to end user of the simulator to allow him to study the response of the machine in different operation modes.

In some cases other coils are added to the DC machine to improve its response (to reduce the reaction of the induced), like commutation or compensation coils. To model this effect an extra resistance is added to the diagram in series with the previous rotor resistance.

There are other equivalent electric circuits depending on the excitation configuration. If the excitation current comes from the DC machine itself, we can distinguish three more configurations:

- Parallel configuration: the inductor coil is in parallel with the induced coil.
- Serial configuration: the inductor coil is in series with the induced coil.
- Mixed configuration: one part of the inductor coil is in series and another in parallel with the induced coil.

3. VHDL-AMS MODELS

Translation tools analyze the block diagram view, get the model information and store the structured data in an ".ini" file. The Model Editor of the simulator uses these structures to read and modify some features and parameters of the models.

The language chosen, to allow the end user of the simulator to change some aspects of the models, is VHDL-AMS: Analog and Mixed-Signal extension to the Very High Speed Integrated Circuit Hardware (VHDL). After the translation and the possible changes introduced by the end user, these files are checked and compiled to be understandable by the simulator. One of the main characteristics of this language and an important reason for its election is its behavioral modeling capability for discrete, continuous and mixed systems. The continuous systems are described using differential algebraic equations. VHDL-AMS also provides mixed-discipline modeling, so different domains such as electrical and thermal can be described and simulated in a single entity.

The main features of this language are presented below:

- **Mixed-signal modeling**: The Break statement in VHDL-AMS is used to express the discontinuities in a continuous-time system and sometimes serves as a means of communication between discrete-event and continuous-time parts of a design. Quantities can be used in conjunction with discrete-event signals to represent the behavior of a mixed-signal system. Terminals represent the nodes across or through which the quantities are defined.

- **Behavioral modeling**: The behavior of a continuous-time system can be described using a set of Differential Algebraic Equations (DAEs), which can be represented using Simultaneous statements in VHDL-AMS. These Simultaneous statements express explicit differential and algebraic equations that determine the values of the quantities of a model. Signals express the discrete-event behavior of a system.

- **Signal Flow Semantics**: VHDL-AMS supports conservative semantics (e.g. Kirchoff's laws for electrical circuits) to model physical systems and non-conservative semantics to model the signal flow representation of any system.

- **Mixed-technology modeling**: VHDL-AMS supports any physical system that can be described using a set of Differential Algebraic Equations (DAEs), or as a set of communicating processes. Nature represents a physical domain for a conservative system.

- **Transparency**: VHDL-AMS has no primitive models which are part of the language. The designer has the flexibility of modeling his/her own view of the system either behavioral or structural.

Concerning the VHDL-AMS files it must be said that basic electric components are defined in a behavioural architecture and stored in a library. More complex models are defined from these basic components according to a structural architecture of VHDL-AMS files. The final target is to complete a model library containing VHDL-AMS files describing all the electric components detailed in the ATA-24 electrical chapter.

In conclusion, although not all the electrical components present in a common ATA-24 list have been modelled the work done in this task served as a necessary input for other tasks in this project.