

Simusol: Simulating thermal systems using Sceptre and Dia

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Abstract. *This paper shows how two specific programs Sceptre and Dia have been used to develop Simusol, a tool for simulating thermal systems.*

The thermal system must be outlined with Dia which has to be extended with a specially prepared thermal circuit sheet. The resulting XML Dia-file is translated, by Simusol, into several text files, one of them with input data for Sceptre to simulate the system. Using output from Sceptre, Simusol prepares text files with input data for Gnuplot to represent results. So, in some sense, Simusol converts graphics to code to simulate de system.

All the used software, Simusol included, is free; most of it distributed under the GPL license: GNU/Linux, Dia —which works with XML and SVG files—, Sceptre, Perl, f2c, gcc and Gnuplot.

1. Introduction

Inenco Institute, *Renewable Energy Research Institute*, is quite interested in developing tools to simulate the behavior of thermal systems.

When a system, formally described by some equations, has to be simulated with a computer program, it is represented by a specific data scheme.

Sceptre makes possible to numerically simulate electric circuits; and thermal systems can be seen as electric circuits.

Many times, a diagram describing the system is a very good visual help to the person who has to prepare the alphanumeric data.

Nowadays, there are software such as Dia, which give more than a visual help: Dia makes possible to completely automatize the translation of the diagram.

At Inenco, we tried to simulate circuits, combining Sceptre and Dia capabilities.[Saravia and Alía, 2001], [Alia et al, 2002].

2. Sceptre

Sceptre was designed as “a unified system of digital computer programs by which the electrical engineer can communicate with the computer to determine the DC. transient or AC response of electronic circuits”. [Becker and Novender, 1999].

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One could also say that, when used to calculate transient responses, it is a tool to solve systems of linear differential equations. Coefficients of the equations need not to be constant.

Electric circuits diagrams are quite frequently used and universally understood, so it is almost sure that any person, before using Sceptre, will draw a diagram for his or her circuit. In order to use Sceptre, the person will identify each element with a name and also will identify the points of connection between elements. There are Sceptre rules to follow—which are quite simple—to accomplish this identification. Then the input file for Sceptre will have lines describing each element and also the required outputs. For example “R1, 1-2= 0.239464” means that “the resistor 1 which is connected between nodes 1 and 2 has a value of 0.0416667 ohms” (see Figure 1). And if the current through that resistor were required there will be, under “OUTPUTS”, a line containing “IR1”; which will mean the current through resistor 1, from node 1 to node 2.

There are several ways of making mistakes when preparing the input file for Sceptre:

1. syntax errors,
2. one or more elements forgotten,
3. wrong connection points,
4. wrong values.

Some of these errors may be not detected by Sceptre: it will simply simulate a different circuit.

Sceptre is written in FORTRAN. Version 00.317 can be downloaded from <ftp://novilux.fh-friedberg.de/pub/sceptre/sceptre-00.317.tar.gz>

Inenco developed a special version of GNU/Linux, to help people run Sceptre from a CDROM [Saravia and Saravia, 2000].

3. Sceptre for thermal systems

It is also well known that thermal systems can be thought of as electrical circuits with energy flux as current and temperature differences as voltage differences. In this way, the components of thermal circuits can be interpreted as resistors, capacitors, and current or voltage sources. [Kreider and Kreith, 1981], [Duffie and Beckman, 1974].

Therefore, Sceptre is also useful to calculate the transient response of thermal circuits.

4. Dia

“Dia is a vector-based drawing tool similar to Win32 OS Visio . . . It is ideal when the diagram has shapes that recur and are connected by lines. . . Dia is extensible through the use of *sheets* which contain collection of shapes for use in diagrams”. [Toga, 2001].

Dia home page: <http://www.lysator.liu.se/~alla/dia.html>. Now, version 0.91 can be downloaded. But version 0.88 is also good for Simusol.

5. Dia and a sheet for thermal circuit

One of the sheets Dia comes with is the “circuit sheet” which contains many shapes to represent different electronic elements. So, one can draw beautiful electronic diagrams using Dia. But those shapes are not designed to receive an identification. It is not difficult to redefine the shapes adding an identification for them; but we chose another way.

Instead of using electric element shapes for thermal simulations, we decided to use new symbols, so the person who has to draw the diagram —using Dia— can forget about the electrical analogy and concentrate on the thermal aspects.

We designed a *thermal circuit sheet* with several shapes described in SVG format; and one more shape — a C-programmed one— borrowed from the *UML sheet*.

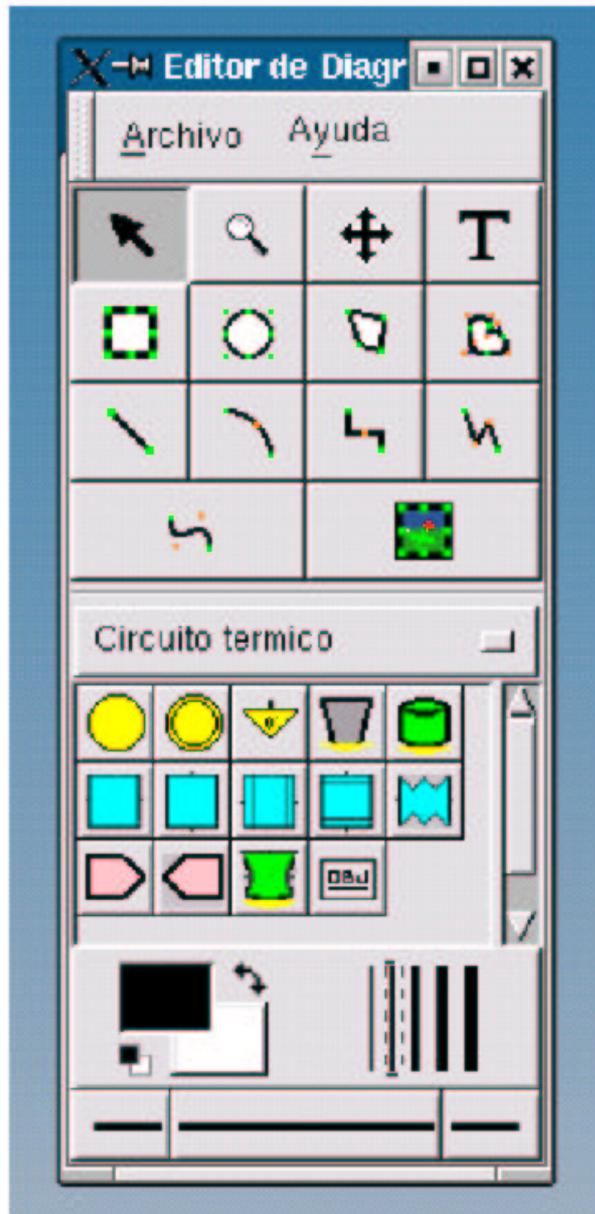


Figure 1: "Thermal circuit" sheet ("Circuito Termico")

The three first shapes under the `Circuito termico` title represent nodes; the nine next shapes represent simple thermal elements; next one stands for any defined model: some combination of connected elements; we use the last one, from the *UML sheet*, to put textual data in.

A diagram representing a thermal circuit can have errors; for example:

1. elements not properly connected.
2. elements or nodes not properly identified.
3. elements without a value or values without an element
4. functions or tables not properly defined

6. Simusol

Simusol consists of several Perl scripts. It translates Dia diagrams into Sceptre input data using the Perl module XML::Parser. The translation is possible because of the well designed Dia XML format.

Because the values we have to feed Sceptre with, are not the values of thermal or geometric properties, but the values of the equivalent electric properties, one has to be specially careful to avoid the mentioned fourth type of error (page 2).

For example, the value to assign to a resistor representing the heat conduction through a wall, depends on more than one wall property. More generally, we can distinguish three types of thermal elements which through the electrical analogy became resistors: conducting resistors, convecting resistors, radiative resistors. Even for each one of them, we use different formulas to get their values in ohms, depending, for example, on the involved geometry.

Simusol is started from a terminal by, for example, `simusol tanque` if `tanque` is a diagram file; if everything is OK, it shows the graphs representing the results of simulation. It also produces some other interesting files.

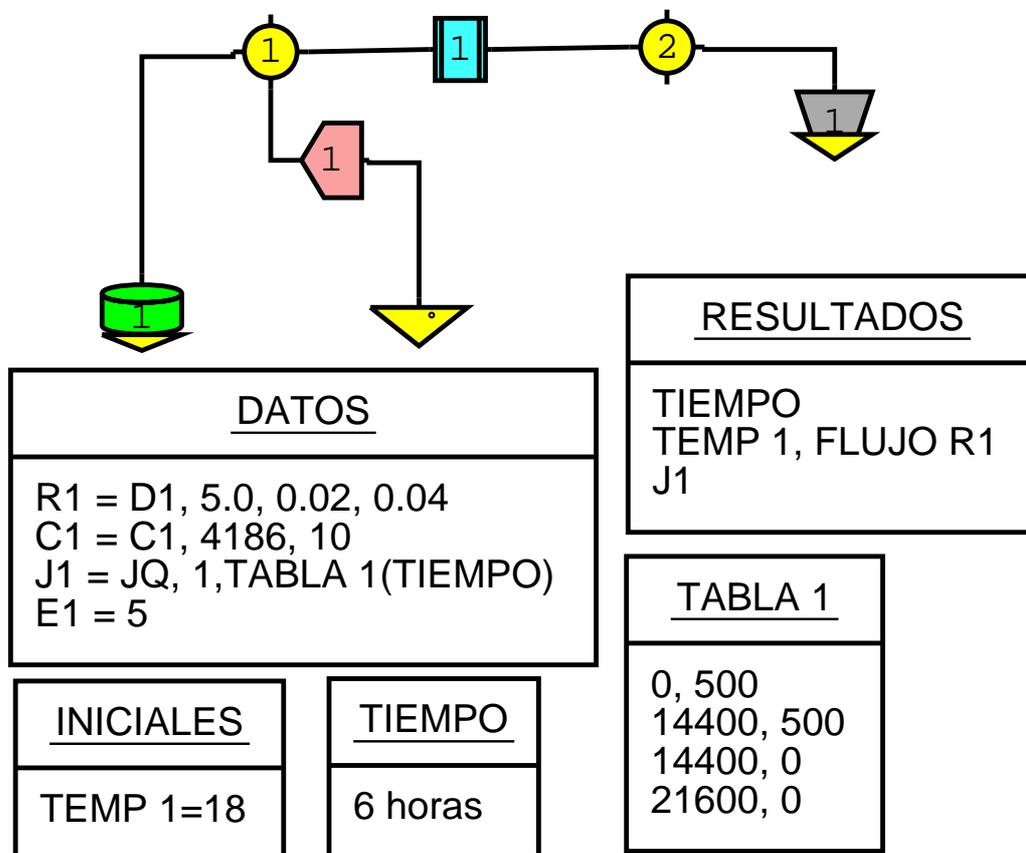


Figure 2: A thermal circuit, drawn with Dia

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CIRCUIT DESCRIPTION
Archivo producido por S I M U S O L: simusoll.pl
para S C E P T R E
tanque.d, a partir del archivo-diagrama tanque
ELEMENTS
C1, 1-0 = 41860.
E1, 0-2 = 5
J1, 0-1 = T1(TIME)
R1, 1-2 = 0.1
DEFINED PARAMETERS
PA1 = T1(TIME)
OUTPUTS
VC1,IR1,J1
INITIAL CONDITIONS
VC1 = 18
FUNCTIONS
TABLE 1
0, 500
14400, 500
14400, 0
21600, 0
RUN CONTROLS
X PLOT DIMENSION = 0
START TIME = 0
STOP TIME = 21600
INTEGRATION ROUTINE = TRAP
END

```

Figure 3: Part of the input file for Sceptre; it corresponds to fig. 2

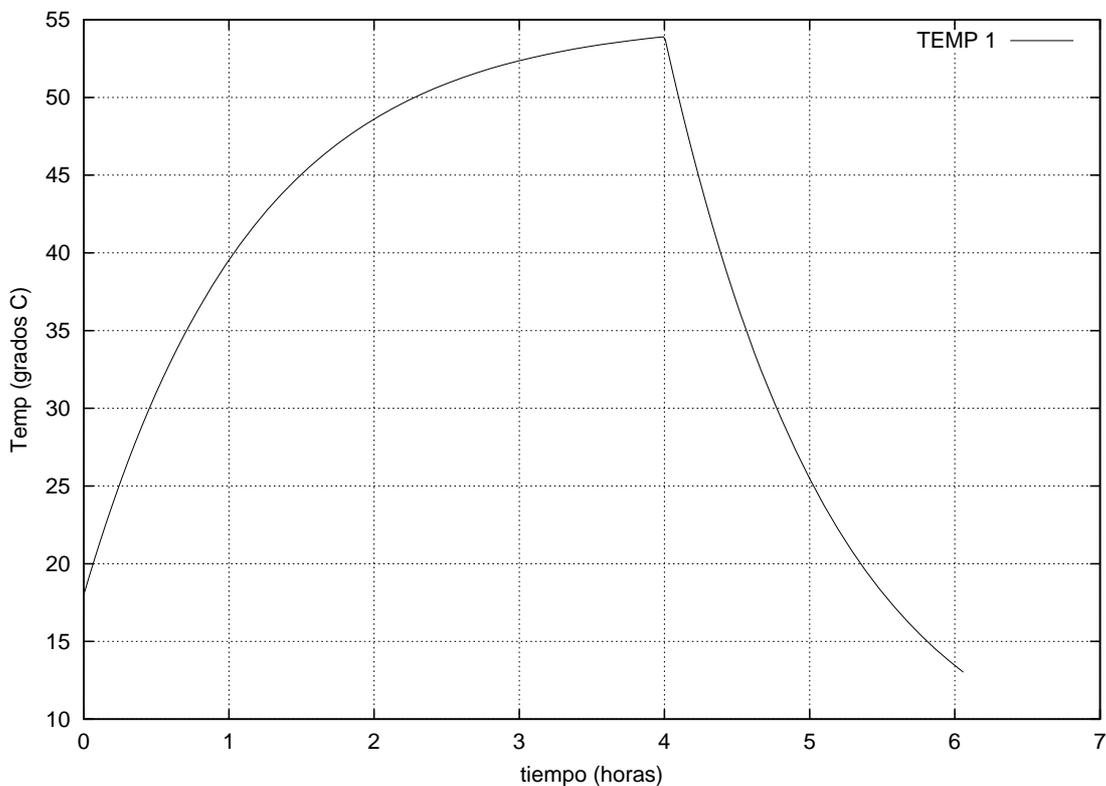


Figure 4: One of the graphs; it corresponds to fig. 2

It is easier for people to visually verify correct connection lines between elements than to tell Sceptre about them. So, it is good to have Simusol to interpret the diagram.

Simusol detects some errors of diagrams (page 4) and informs the user about them. It also interprets message errors given by Sceptre related to simulation.

Simusol is been used by several investigators, among them([Quiroga et al., 2001], [Cadena et al, 2001]); and some students who have helped to detect programming errors and to improve its characteristics. Our thanks to all of them.

At the moment, we continue working to improve the facilities to communicate with Simusol and to take advantage of some features of Sceptre. About Dia, we would like to be able to program “buttons” in Dia’s canvas in order to be able to start Simusol without using a terminal.

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