TRIAXIAL high current AIS & GIS.

An alternative idea for worldwide use, for lower cost power systems.

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1) INTRODUCTION

In this article I disclose an idea for an alternative design to be used in Air Insulated Switchgear (AIS) and Gas Insulated Switchgear (GIS). When I had this idea, some 20 years ago, it was based in two facts:

a) observing the performance of triaxial cables used in measuring circuits of high-power testing laboratories (before the wider use of optical fibers) and,

b) the practical experience, as a high-power testing engineer, of using along 15 years, in short circuit tests 63kA - 3s, homemade coaxial conductors (copper cables inside an aluminum tube 6" IPS with lengths 40 m). The objective was to have a low inductance path enabling the lab to reach higher short circuit test currents.

So, what is written here is an idea based on the real use of something of the same nature, used in the real life. Before reading the next lines, I suggest that you read my curriculum vitae in the link above

The intention is to disclose the concepts of this technology for use all over the World. I think this can be particularly useful for developing countries. I became motivated to write about it when I had the opportunity to help Cigrè working group WG B3-43 to write the brochure 740 - Contemporary Design of Low-Cost Substations in Developing Countries (August 2018).

A point to observe is that I could develop this idea only because I used simulation software instead of expensive laboratory tests. I used the software SwitchgearDesign, created by me, to check the design requirements (temperature rise, short circuit electrodynamical forces, overpressures of internal arc and others). Having at least one testing labs in a country is essential for having an electric industry. However, even when labs are not available, many things can be developed with small investments in training of use of testing simulations.

I want to validate the results of the simulations presented here, using laboratory test results. So, if any manufacturer, all over the World, is going to do laboratory tests for this technology, I can give assistance on this at (almost) no cost. Check the details in the final part of this article and contact me. I can communicate in many languages face to face using Skype or video conference.

3 – CURRENT TECHNOLOGIES FOR AIS AND GIS AND THEIR TECHNICAL REQUIREMENTS

The main technologies currently used in AIS and GIS are presented in Figures 1 to 5. Switchgear here means, mainly low voltage, medium voltage and high voltage (up to 230 kV) sets, busbar systems, panels, cubicles and similar.

Figure 1 - Medium Voltage Cubicle AIS

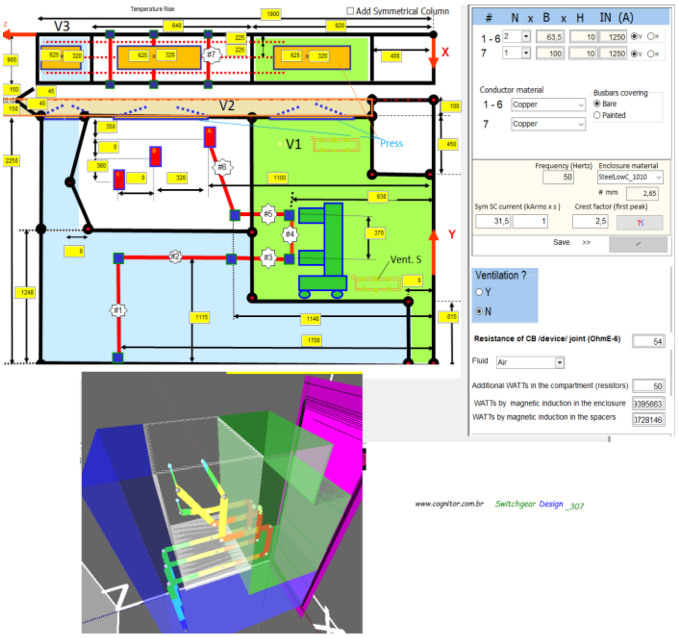


Figure 2 - Low Voltage Cubicle AIS

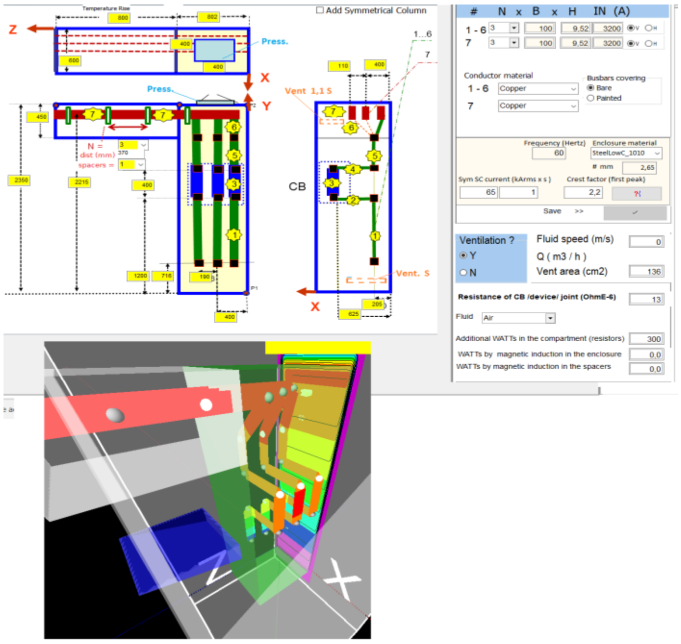


Figure 3 – Medium and Low Voltage busducts AIS

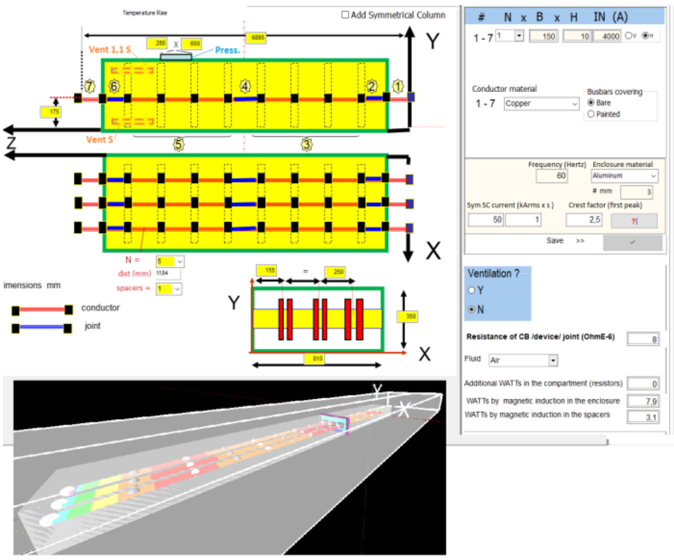


Figure 4 – Single Phase GIS

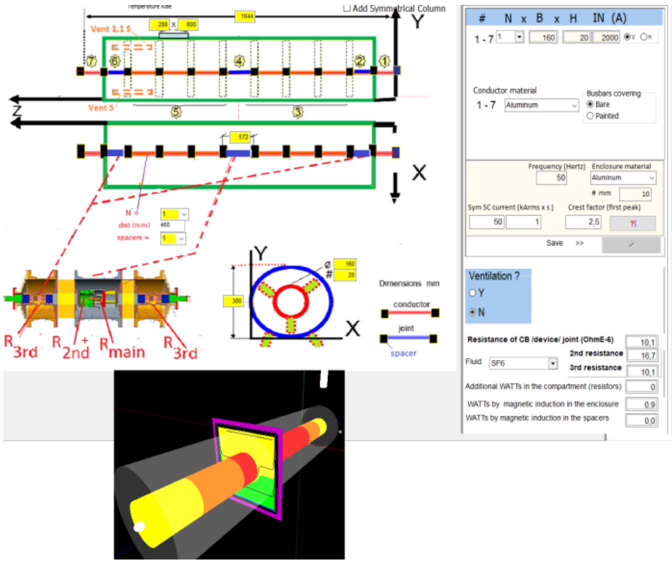
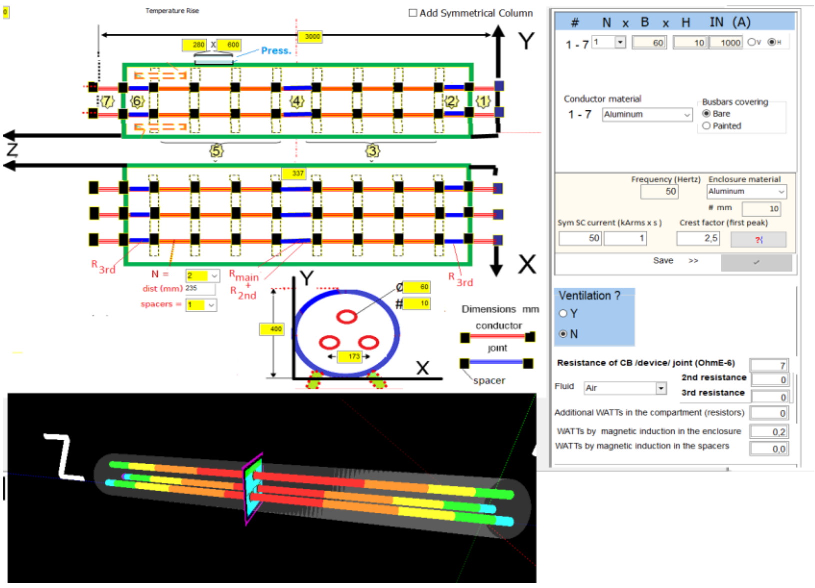


Figure 5 – Three Phase GIS



The requirements to attend, when developing such products, are related to:

a) TEMPERATURE RISE TESTS: involve permanent currents from some 400 A to high values like 10.000 A. Usually ventilation and low resistance connections are key factors to optimize the design (References [1] and [2])

b) ELECTRODYNAMICAL FORCES & MECHANICAL STRESSES: May reach tons at high short circuit levels. The effects are verified in the short time withstand current and crest tests. Currents are in the range 10kA rms to some 80 to 100 KA rms associated with high asymmetry factors like 2.6 to 3.0 (Reference [1])

c) INTERNAL ARC: need to support high internal overpressures and erosion of the parts (Reference [3])

These 3 requirements are the more expensive to deal with because involve the use of expensive high-power testing laboratories. There are few labs in the World and using them means costs around 3000 to 14000 USD per day.

Nowadays testing simulations, like the ones used in this article, permit to do the initial steps of a design development without doing tests. At the end of the process, type tests are necessary to get a performance test report to be used in the new product commercialization.

In addition to the tests above, DIELECTRIC tests like AC applied voltage and atmospheric impulse withstand and MECHANICAL tests are also necessary. These ones are not so expensive, and simulations are not necessary.

3 – THE NEW (SFC) ALTERNATIVE FOR AIS & GIS (Figure 6)

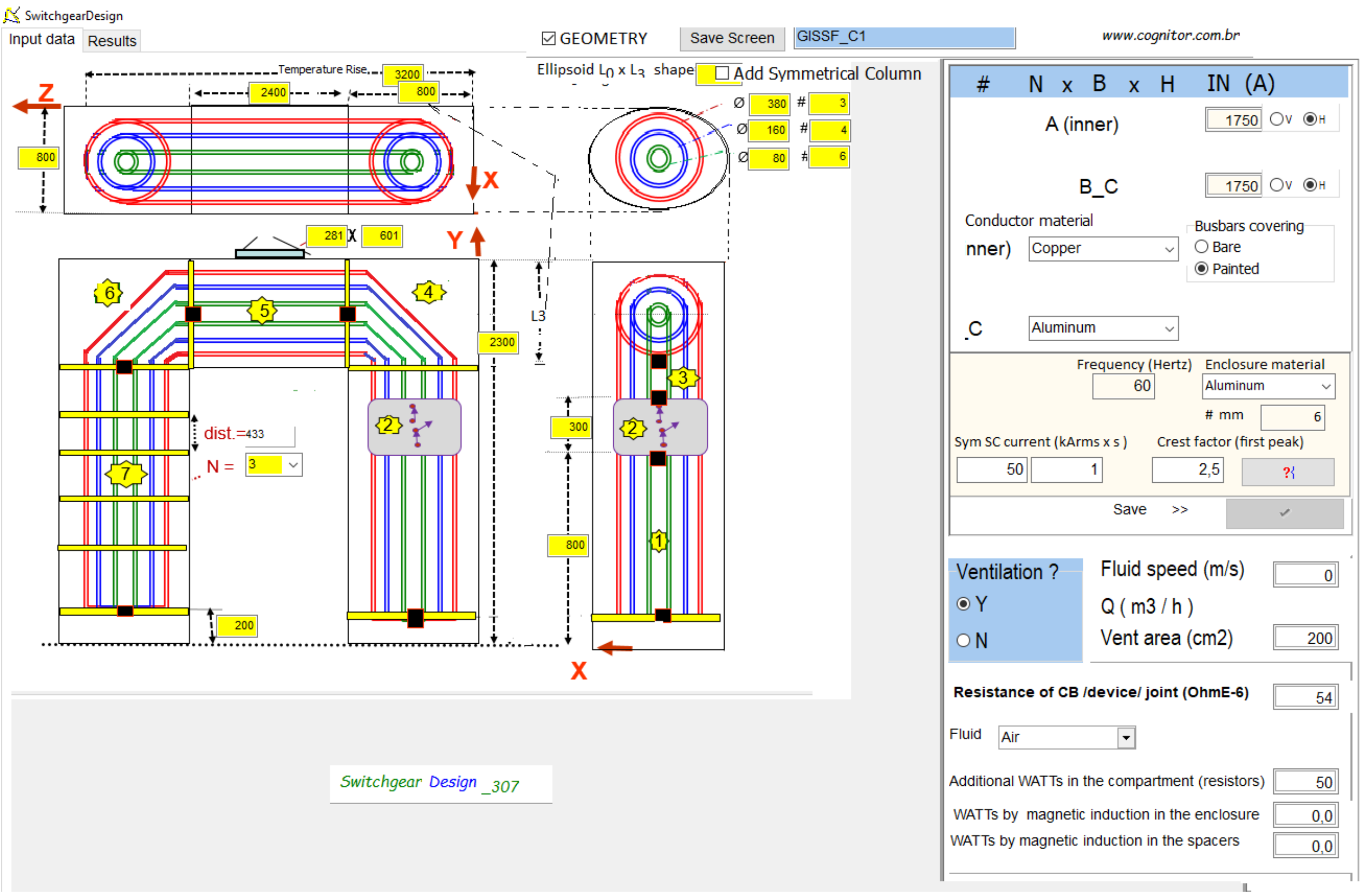
The new concept is presented in Figure 6. If we compare it with Figure 2 (conventional), the differences are:

(a) in Figure 2 there is only one vertical compartment (with a switching device - in the right side).

(b) The conductors of the 3 phases of Figure 6 are concentric while in the conventional AIS of Figure 2 they are arranged in the same plane, side by side.

The alternative design in Figure 6 comprises three concentric conductors of elliptical or circular cross section. In this article, to simplify, we will use only a circular cross section. Each of the 3 conductors carries the electric current of one of the phases A, B and C. Conductors can be made of aluminum or copper or even steel (if very low values of current). Externally to the 3 conductors there is an external grounded metallic enclosure made of steel or aluminum. The function of this enclosure is basically to avoid the contact of people with the energized conductors of the phases.

Figure 6 – The SFC alternative for AIS and GIS



The enclosure could even be made of an insulated material like polyester reinforced with fiber glass. Usually these constructions are for indoor use, but it is possible to adapt the material of the external enclosure for outdoor use. With small adaptations you may even use these constructions underground to avoid the use of the horrible, antiesthetic and sometimes dangerous (by proximity inside urban areas) aerial systems in distribution networks at the of 12 kV or 13,8 kV.

In developing countries, still trying to solve the basic problems of infrastructure, education, health, corruption and violence, the aesthetics and the use of aerial distribution systems physically near to people is a factor of less relevance. Aerial systems are unacceptable in urban areas of developed countries

A technical aspect to consider is that, as the concentric conductors of each phase do not have "electric" symmetry (beyond different diameters and thickness) the inductances and capacitances of each phase are different. So, if you have a long busbar system or a "weak" system, the concept of transposition of the phases may be used.

4 – VANTAGES AND DISADVANTAGES OF THE NEW ALTERNATVE FOR AIS- GIS

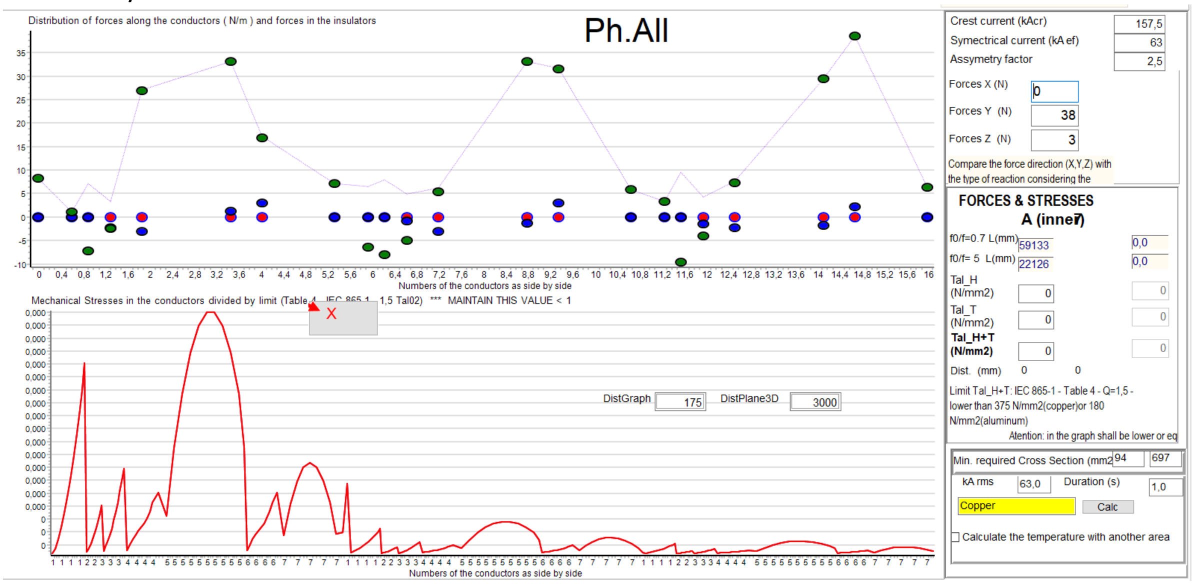
The only disadvantage is the fact that it is something not yet used, even in the non-commercial market. Technology innovations need a maturation time to arrive to the market. People tend to postpone changes even when their current conditions are not good. In general, the argument used to postpone something is that it is more expensive than the current practices. Here the barrier is to do the initial testing that, in this article, is replaced by testing simulations using SwitchgearDesign. Considering this, lets describe the technical advantages in fast words

4.1 – ELECTRODYNAMICAL FORCES AND STRESSES ARE MUCH LOWER IN THIS TECHNOLOGY

Since the phase conductors are concentric, the magnetic effects are very small even near the corners (References [4] to [6]). This enable the use of bigger distances between supports of the conductors. In a deeper sense, the reasons why triaxial measuring cables are used to reduce electromagnetic noises are the same reasons for having lower "forces". When you have 2 or 3 conductors, side by side, as in Figure 2, the magnetic fields are much higher. Higher magnetic fields mean higher mechanical forces during short circuits.

In Figure 7 there is an example of "design values" for the electrodynamical forces and mechanical stresses developed in a typical medium voltage "new technology" switchgear like Figure 6 (63kArms -asymmetry factor 2.6). The values are (almost) negligible. As the values are lower the design of supports will be dictated mainly by own weight and not by the electrodynamic forces. The use of elliptical profiles (like a beam) enable the use of bigger distance between supports than could be possible with circular aluminum tubes, like the ones used in high voltage substations.

Figure 7 – Electrodynamic forces



4.2 – TEMPERATURE RISE TESTS

For high permanent electric currents, to attend the temperature rise requirements specified in technical standards, is the main design factor, from the point of view of costs. The design parameters are explained in IEC 62271-307. The key factors for optimizing the design are the use of ventilation (or fluid movement), the use of wider dissipation surfaces of hot conductors and the use of lower resistance connections. (References [7] to [10]).

The concentric arrangement of conductors enables to create closed paths of forced ventilation and the use of ventilation holes spaced of a certain distance extracting the heat from central conductors

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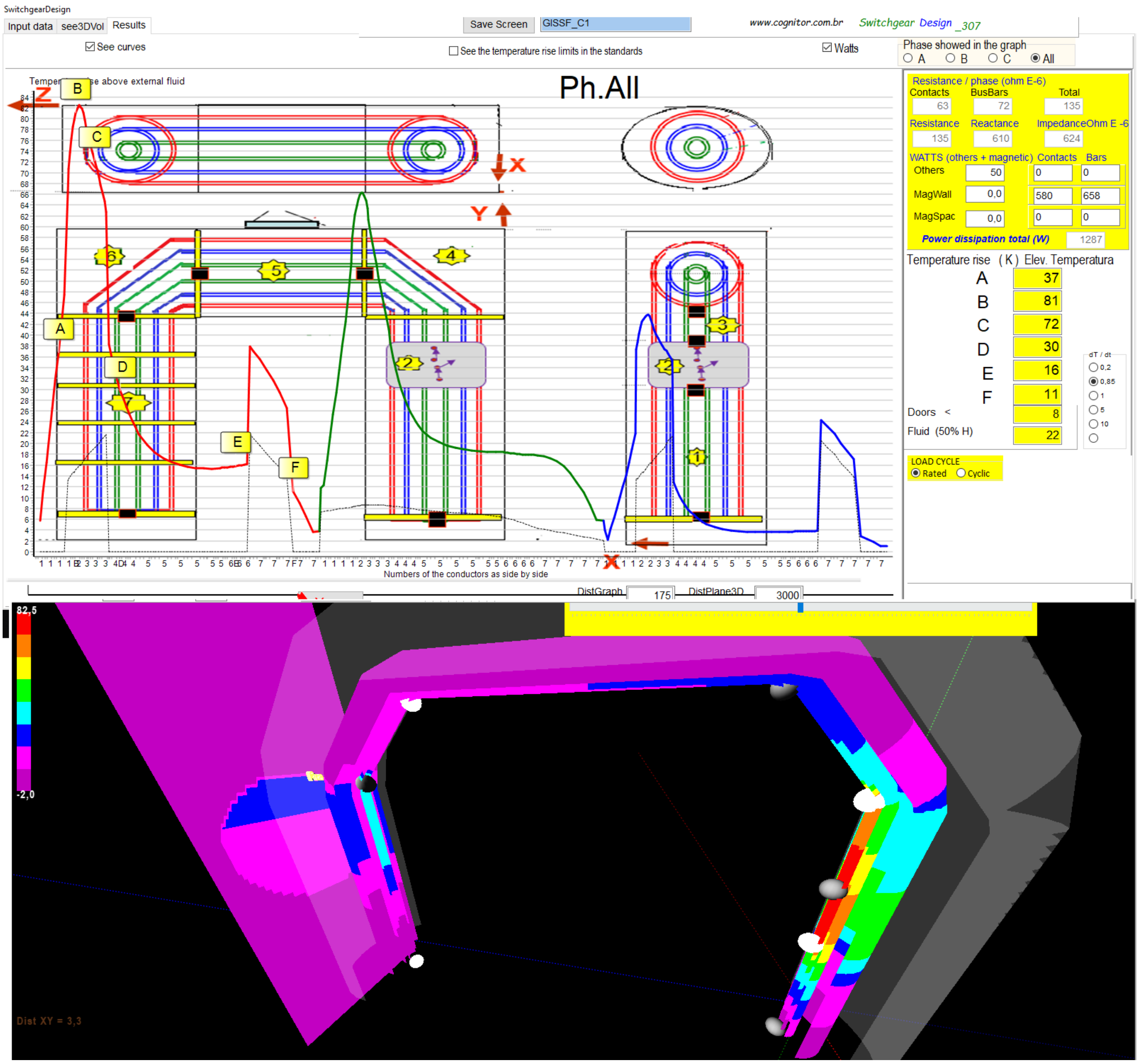
In Figure 8 there is an example of “design values” in a simulated temperature rise test.

Figure 8 – Temperature rise test simulation



4.3 – Internal arc

The use of the concentric conductors facilitates the control of internal arc pressures because volumes and paths are well defined and enable the use of fast overpressure relief devices. There is a lot of information about these concepts in References [2] and [3]

4.4 – Dielectric aspects

The main advantage is the fact that using rounded conductor profiles reduce the use of edges and so, enable the use of lower electric fields and smaller distances between conductors.

4.5 – Magnetic field effects (exposure levels from legislation)
The effect of magnetic fields due to the proximity, considering the legislation on the theme, is much smaller because the sum of the external field after the enclosure is almost zero.

5 - FINAL COMMENTS

This article discloses an idea for a new alternative of AIS and GIS. The target audience are electromechanical designers from all countries all over the World. That's why I am publishing it, first, in the social networks in Internet and not in the highly specialized technical events and publications. I think that experient designers will understand what is between the lines and may assess by themselves the potential of the idea. My feeling is that this technology is particularly interesting for developing countries.

In case of doubts or needing my help write me to the emails (my phones and Skype are below)

sergiofeitoza@cognitor.com.br or sergiofeitozacosta@gmail.com.

Before writing me, please follow these steps:

a) Go first to the site CDBaby https://store.cdbaby.com/Artist/SergioFeitoza

It is a well-known music site and there you will see 6 or more songs composed by me, in English, for download. Download at least one of them before writing me. This step is essential even if it seems a little bit strange.

b) After this, write me about your doubts, identifying clearly yourself and your company (your name, company name and email). The idea is that I intend to help small / medium companies who are really interested to develop products with this technology. Interested here means, for example, that will invest in doing some small temperature rise tests to check the performance. Unfortunately, I do not have free time to give support to individuals, consultants or free-lancers. For electrical engineers intending to develop a M. Sc I possibly can help free.

By the way, for the people interested please have in mind that, in the next two years I will be changing my professional activities from 80% engineering / 20% music production to 20%/80%. That´s why it is time for me to pass ahead some free engineering ideas. Look in the lower part of my Cognitor to understand better

site http://www.cognitor.com.br

I hope that this idea about the new technology can be useful to many companies.

Make a good use of this free idea and good luck!!

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