CHRES CONSORTIUM OF HYBRID RESILIENT ENERGY SYSTEMS

DE-NA0003982

UPRM's CHRES Summer Research Program 2023

# MATHEMATICAL MODEL OF HYBRID DC MICROGRID

PRESENTED BY: DANESY SANTOS

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***Education***

- Master's degree at UPRM
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***Courses***: INEL 4211

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# Introduction

The study of hybrid microgrids has increased due to the constant growth in the implementation of renewable energy sources in recent years, due to its greater reliability and operational efficiency than conventional AC microgrids and, in turn, causing less environmental impact.

Consequently, mathematical modeling is a very useful tool to guarantee an optimal operation that provides minimum operating costs and satisfies the operational and demand constraints.

In short, this allows you to save effort, time and money in most of your applications.

# Mathematical model using MATLAB/SIMULINK

In science and engineering, mathematical models are widely used to accurately describe physical phenomena, which is essential to ensure safety in the design process.

A model is defined as a set of equations that describe the dynamic behavior of a system, representing it with the necessary precision to adequately carry out its study.

The crucial components for the modeling of the Hybrid DC microgrid include the modeling of generation sources, the modeling of rectification and inversion operations, as well as losses, transmission lines and loads.

# Hybrid DC Microgrid Components

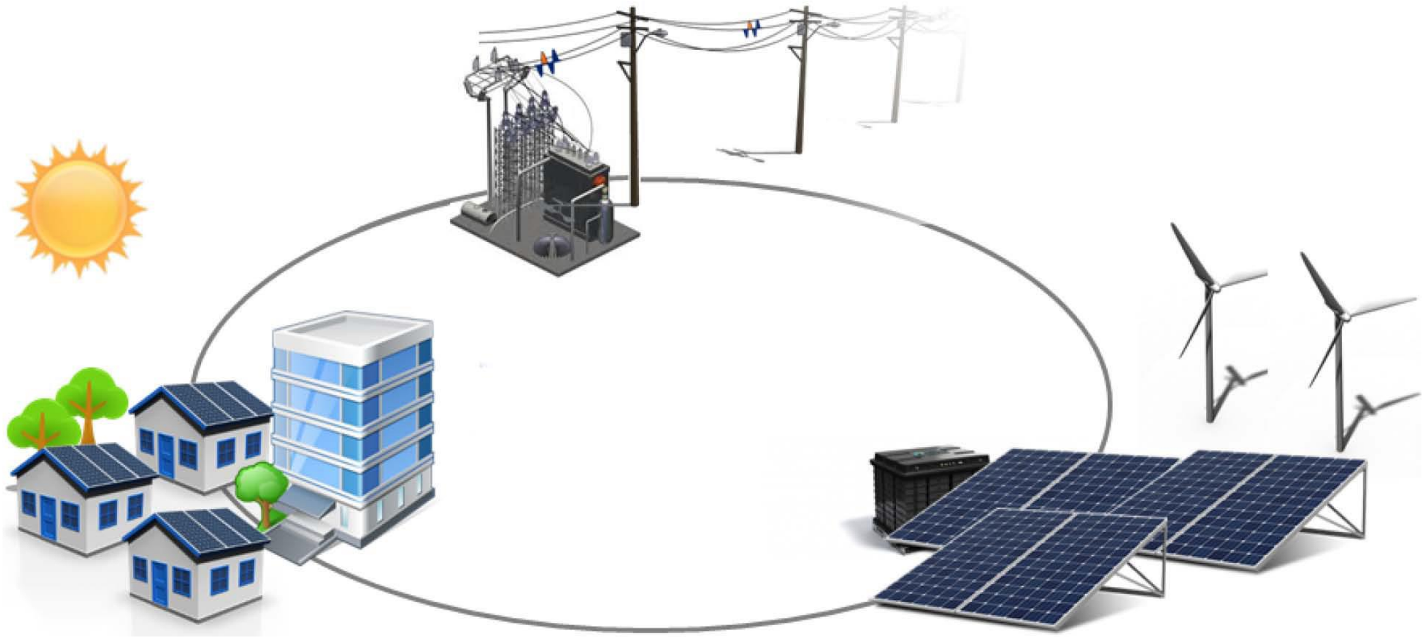

Figure 1. Microgrid  example. [6]

- PV ARRAY/TEG/Battery
- DC-DC CONVERTER
- INVERTERS
- TRANSMISSION LINE
- LOADS

# Diagram

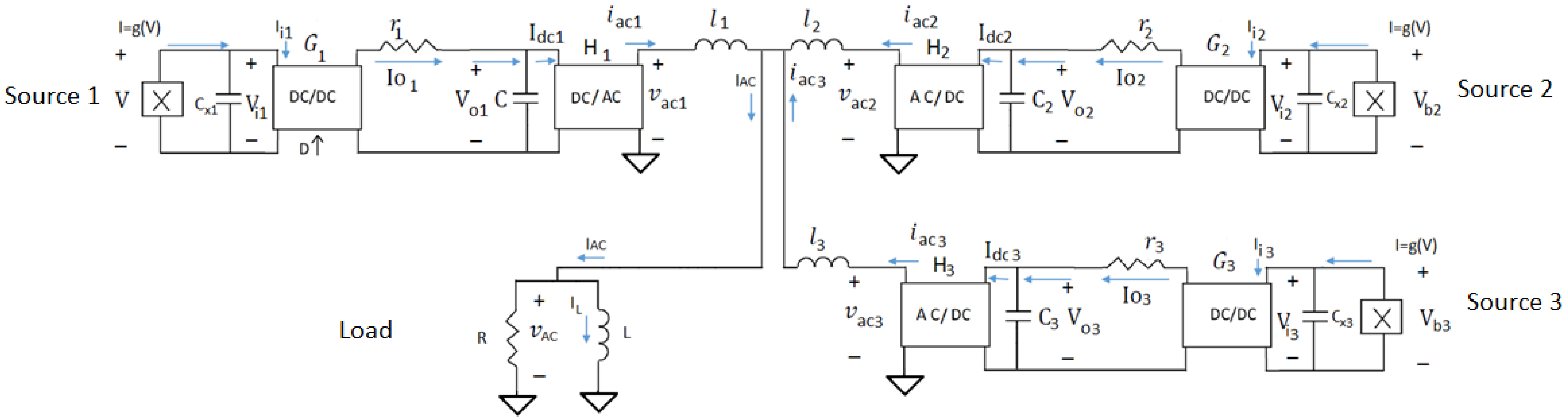


Figure 2. Hybrid DC Microgrid

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# Matlab Simulink Model

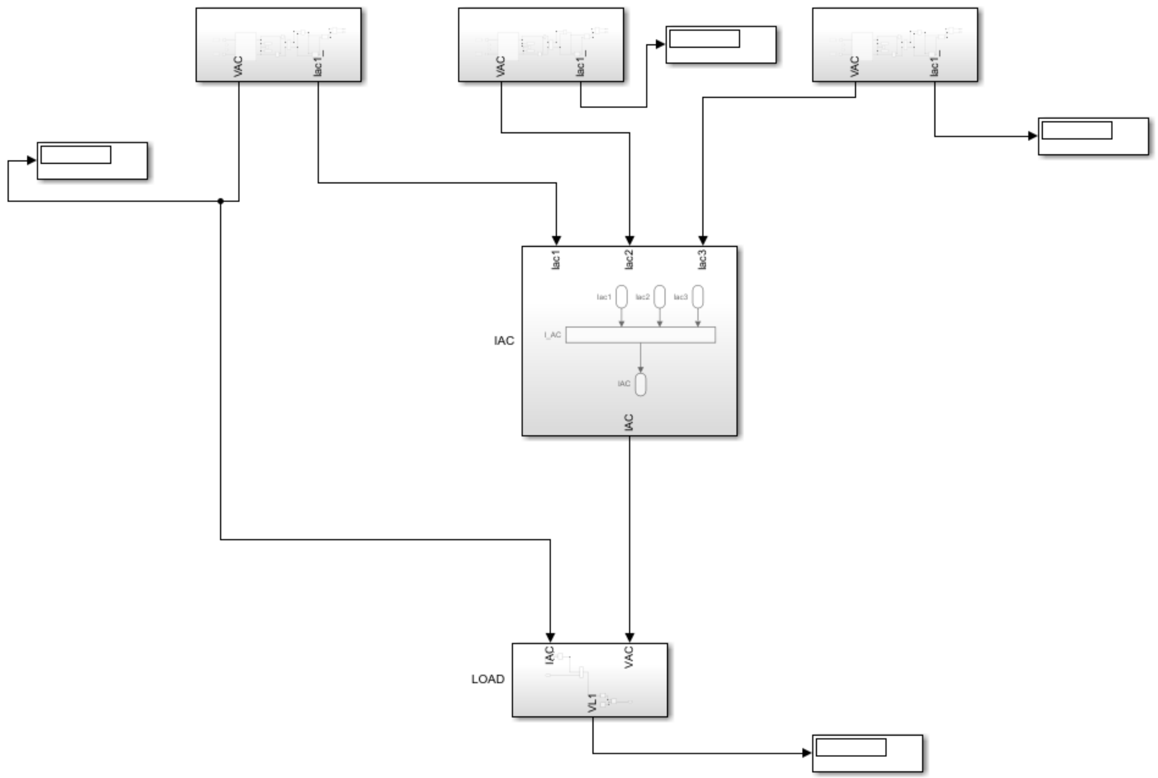
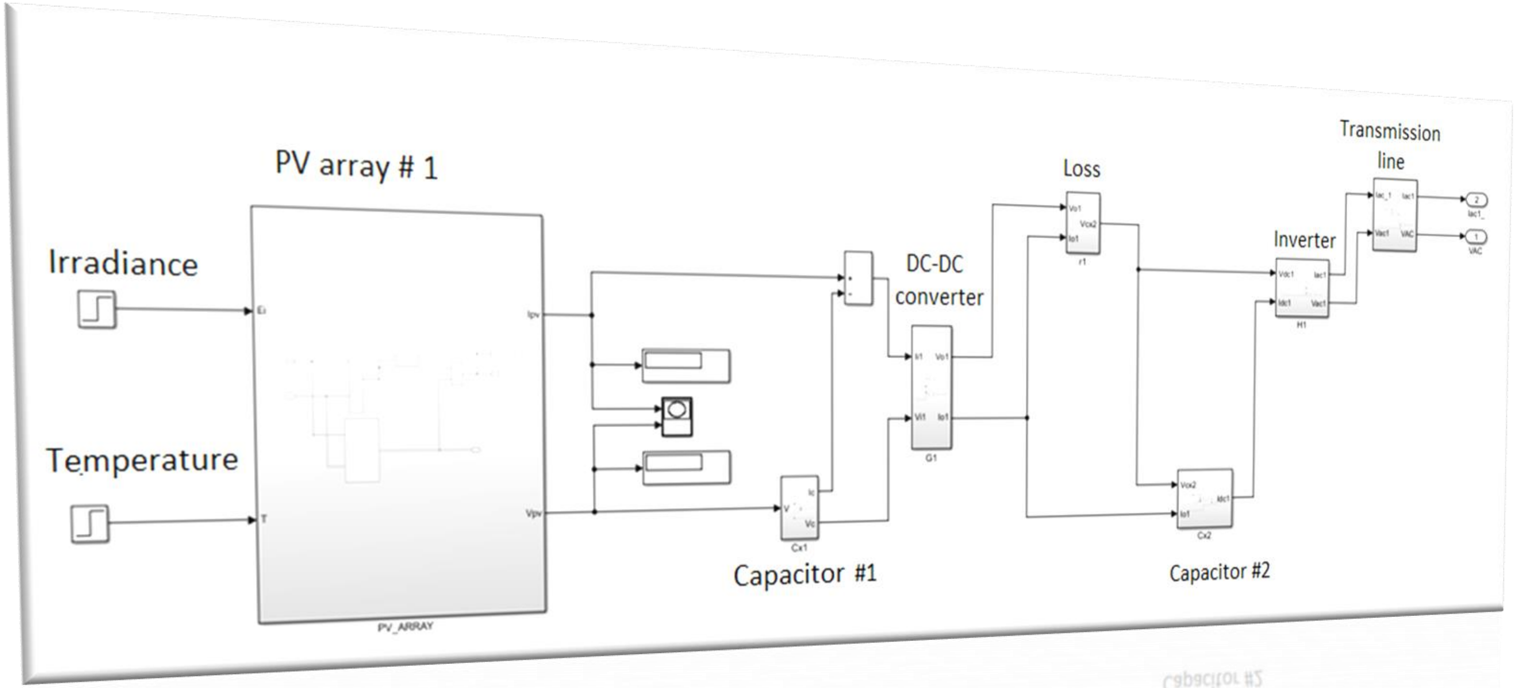



Figure 3. Hybrid DC Microgrid Matlab/ Simulink model.

# Model System for Source 1
# PV array system




PV array model

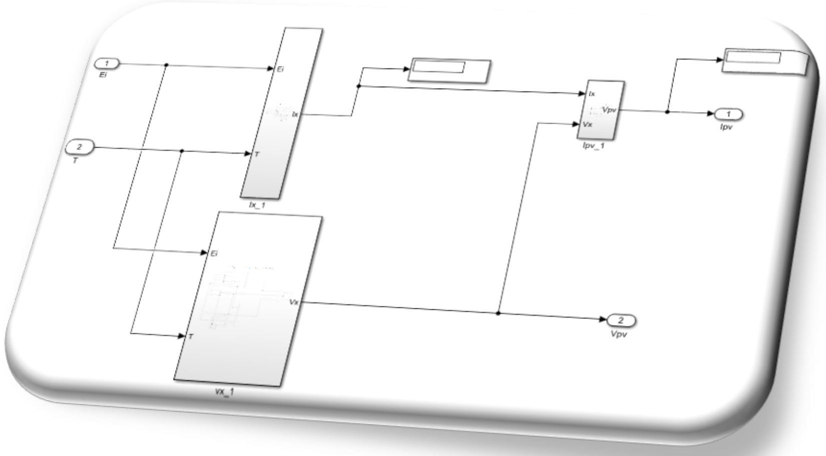


Figure 4. PV array Model system.

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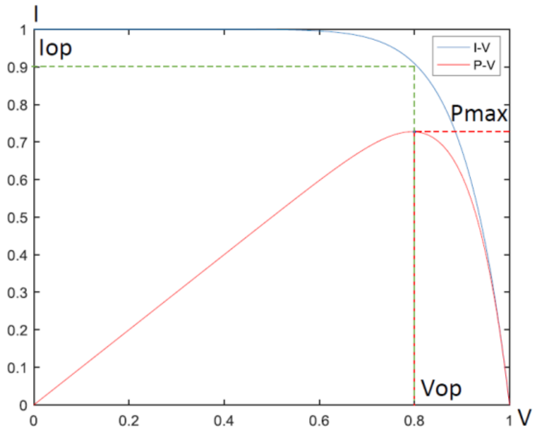
# Photovoltaic Module

Solar energy has received special attention during the last years since renewable energy alternatives should be considered to have more reliable and cleaner energy systems.

The Photovoltaics module, shown in Fig. 5, taking as base the manufacturer datasheet. [3].

In this case, we worked with Dr. Ortiz's mathematical model for solar panels.



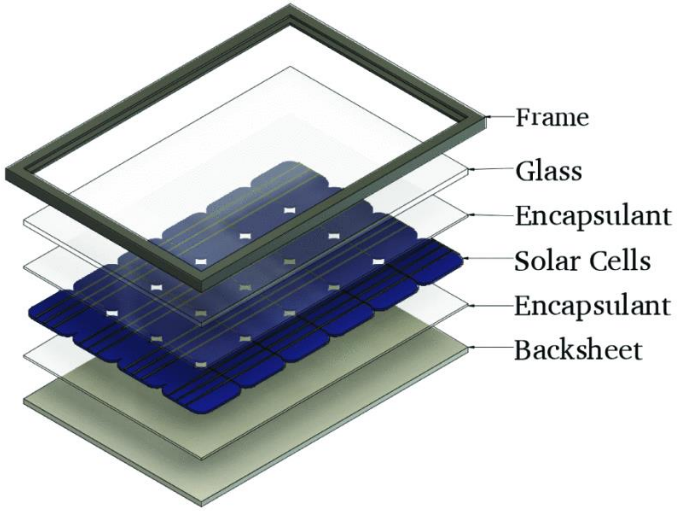




Figure 5. PV array Cell [3].

# Model System for Source 2
# Non-Ideal Battery

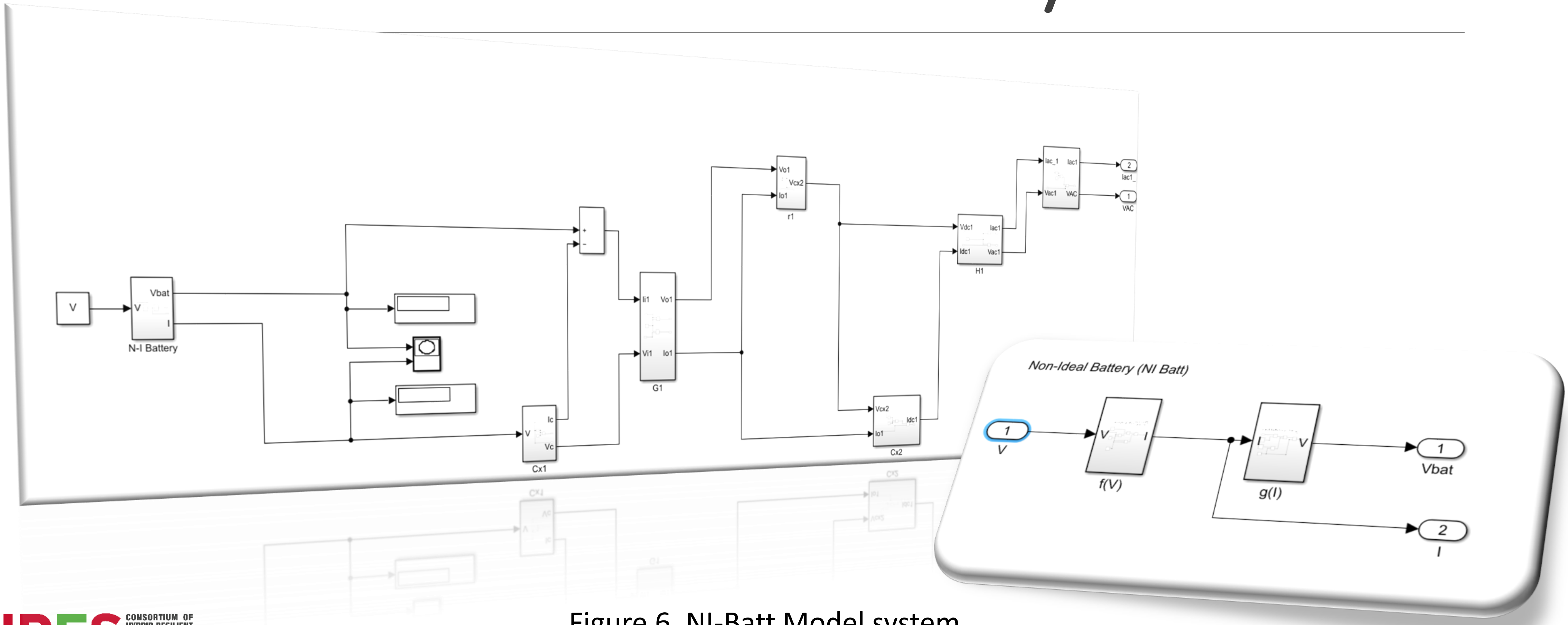



Figure 6. NI-Batt Model system.

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# NON-Ideal Battery

The mathematical model for Non-Ideal Battery (NI-Batt), presented in equations 1, and 2, considers the shape of I − V curve along with their boundary conditions. The NI-Batt model considers the empirical formulation based on the operation and measurements of several Non-Ideal Battery and data observed in the literature like different NI-Batt manufacturer characteristic curves.

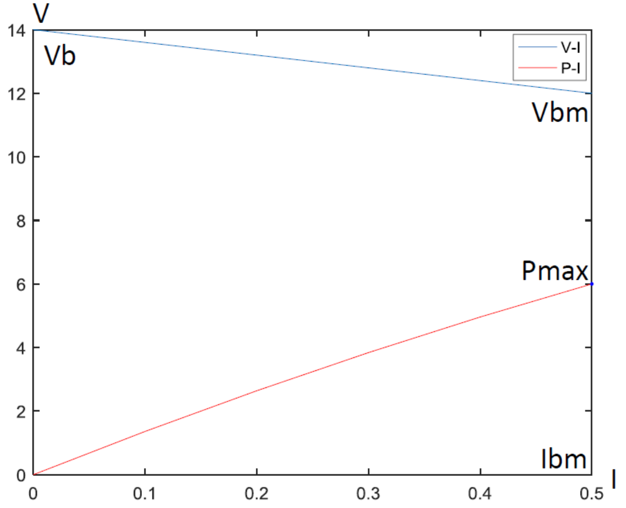


Figure 7. I-V Curve Non-Ideal Battery (NI-Batt).

$$V = g(I) = Vb + (Vb_m - Vb) \cdot \frac{I}{Ib_m} \quad (1)$$

$$I = f(V) = g^{-1}(V) = \frac{Ib_m \cdot (V - Vb)}{(Vb_m - Vb)} \quad (2)$$

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# Model System for Source 3
# Thermoelectric generator (TEG)

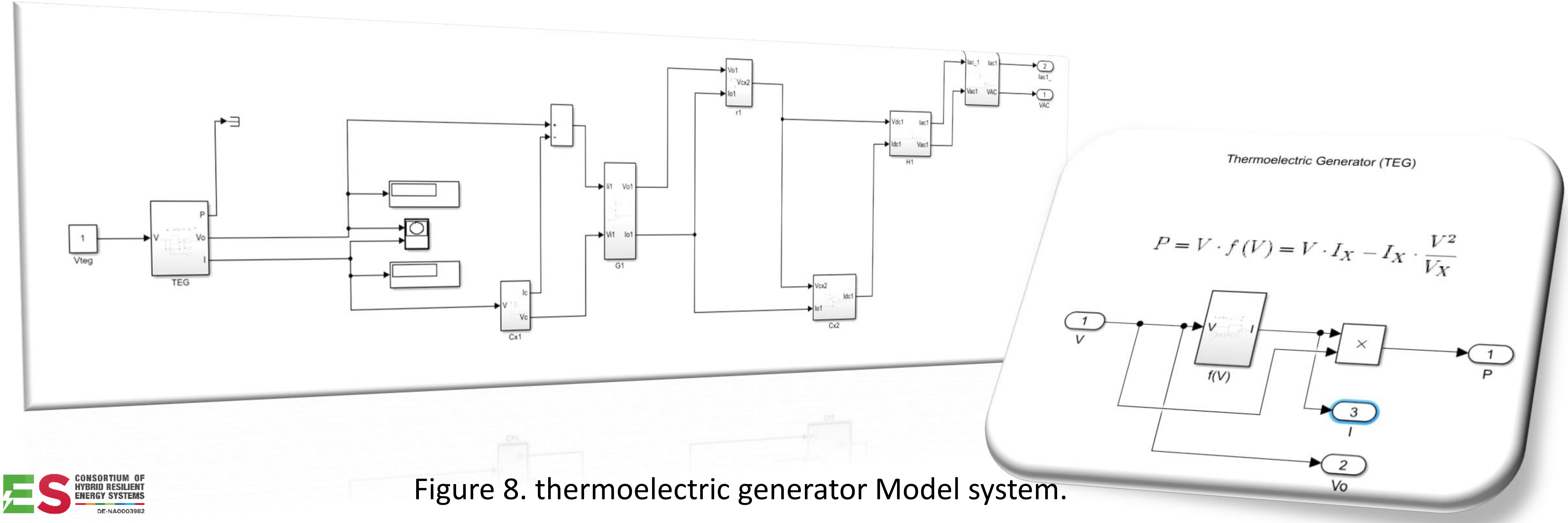
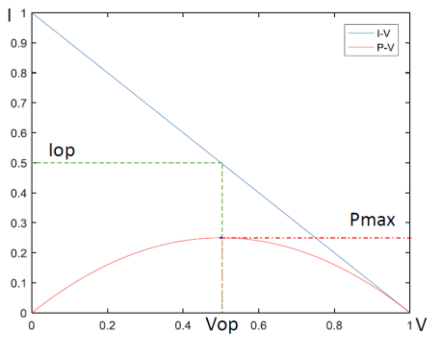



Figure 8. thermoelectric generator Model system.

# Thermoelectrical Generator (TEG)

Thermoelectric Generators Electromechanical systems usually result in less than ideal efficiency due to power losses in the form of heat. If we could harvest this excess energy, we could feed it into household grids to power other electrical loads.

A thermoelectric generator (TEG) has the capacity to convert thermal energy into electricity based on the Seedbeck effect, where the power output is dependent on the temperature difference. Thus, by connecting the hot junction to our heating system and the cold junction to cooling element, it is possible to retake some of the excess energy produced by the system. [4].



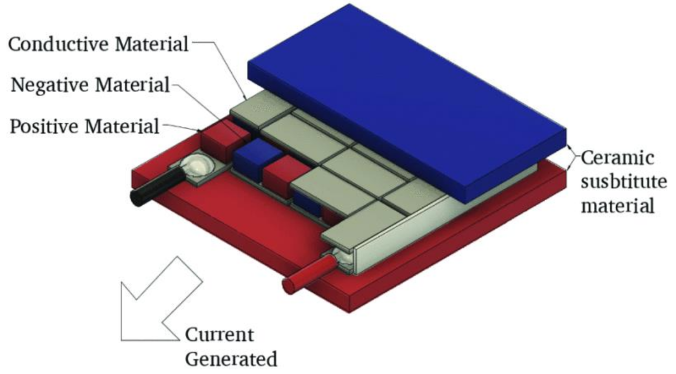




Figure 9. thermoelectric generator [3].

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# Other components of the system.

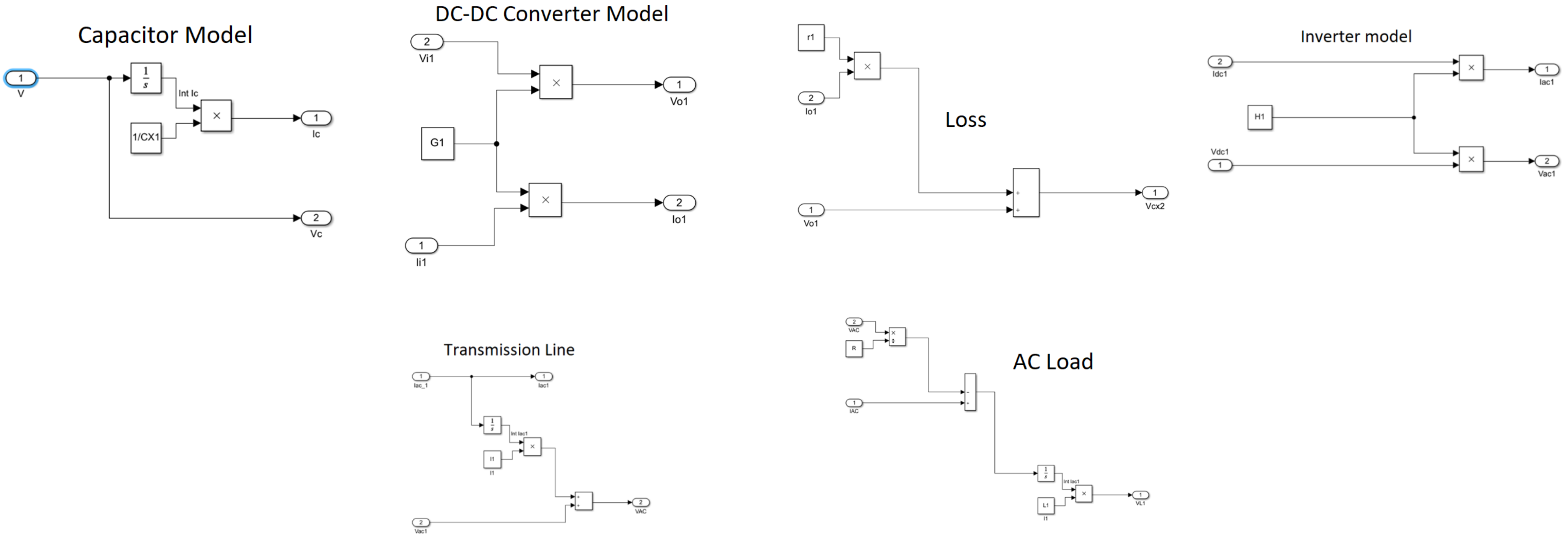


Figure 10. Components Models .

# Results

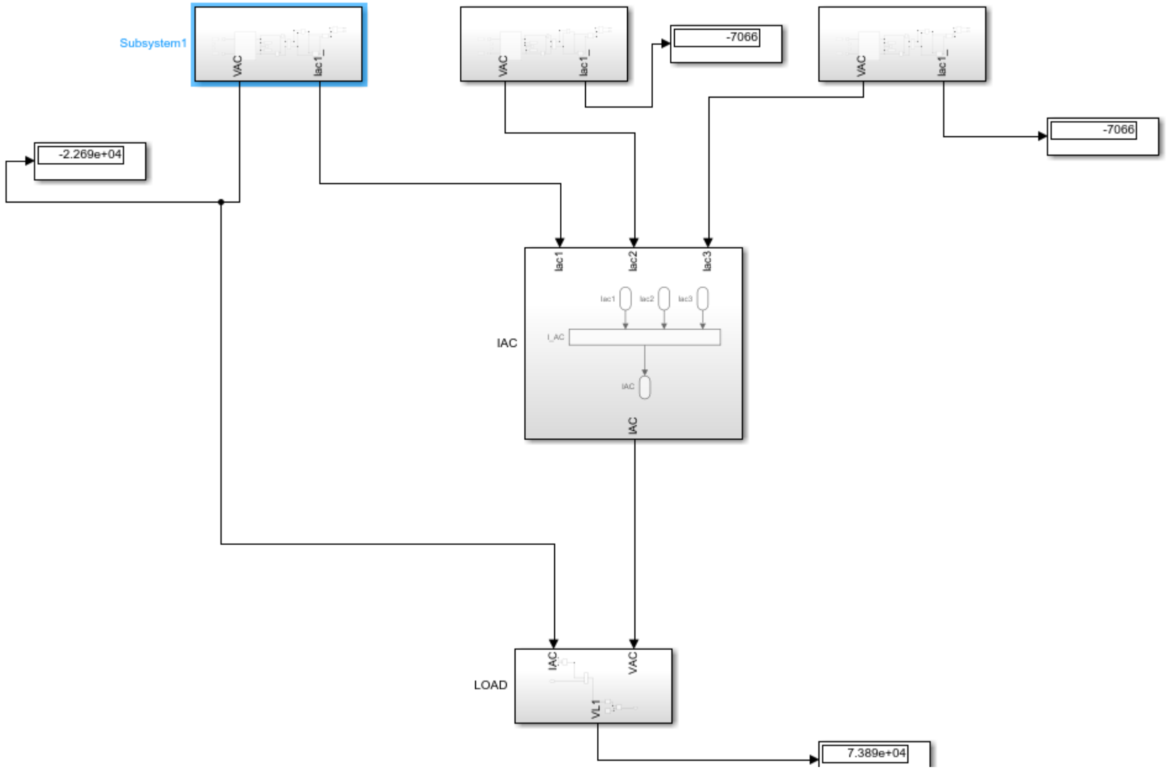


Figure 11. Test results.

# Future works

Create a model of multiple DC sources interconnected in a DC microgrid, working at the same time to satisfy resistive AC loads at all times, regardless of weather conditions, using renewable sources as a future option for critical loads such as hospitals, commercial or residential buildings, business, schools or residences.

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# Conclusions

Based on the results obtained so far, we can predict the behavior of DC microgrids using Matlab/Simulink on mathematical models of DC microgrids with multiple sources, which allows us to save time and money by predicting their success or failure before Start a physical project. as well as detect possible failures, thus being able to make the necessary changes before its implementation, in order to size the capacity of the batteries according to the demand and the generation capacities of the sources and losses of the system in general, since we it gives a reliable enough prediction to make important decisions about it.

# References


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# Thanks!

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