Modelado de Baterías Recargables con MATLAB y Simulink

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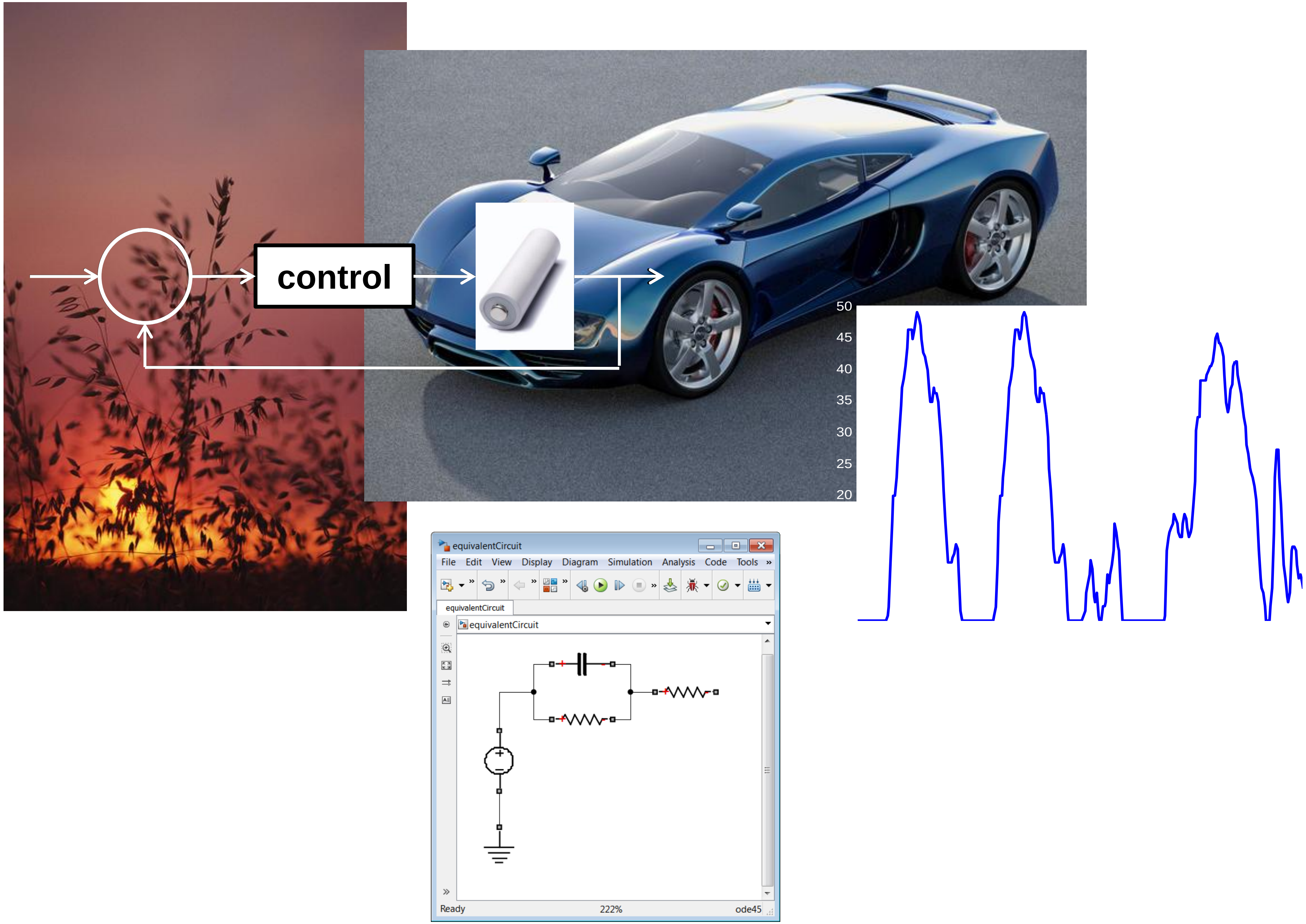
Senior Application Engineer


control
50
45
40
35
30
25
20
equivalentCircuit
File Edit View Display Diagram Simulation Analysis Code Tools
equivalentCircuit
equivalentCircuit
Ready
222%
ode45

Temperatura

SOC

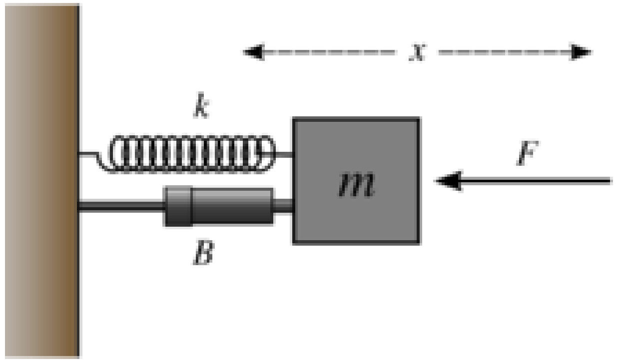
Edad

Demo

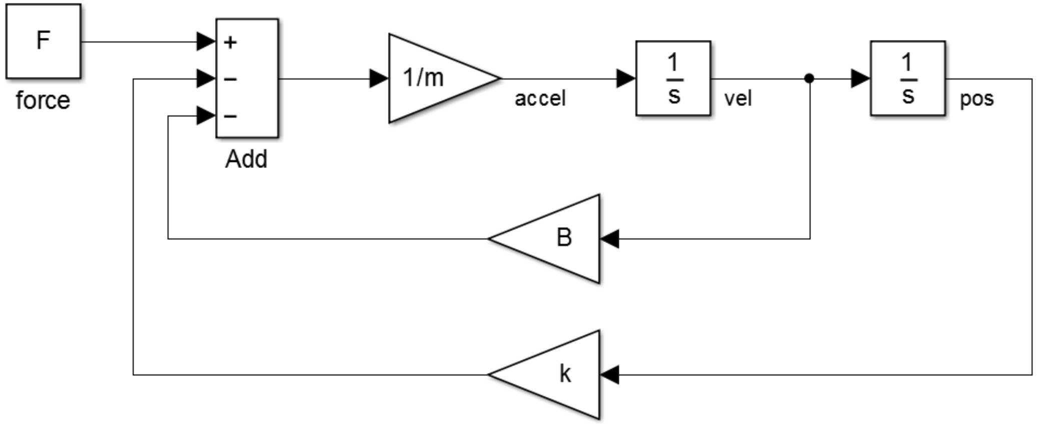
Agenda

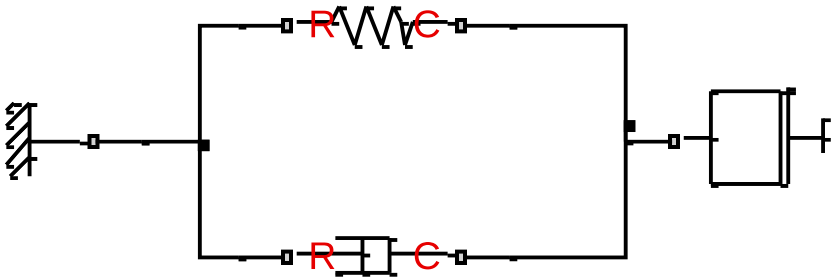
- Modelado Físico
- Estimación de Parámetros
- Simulación

Modelado Físico

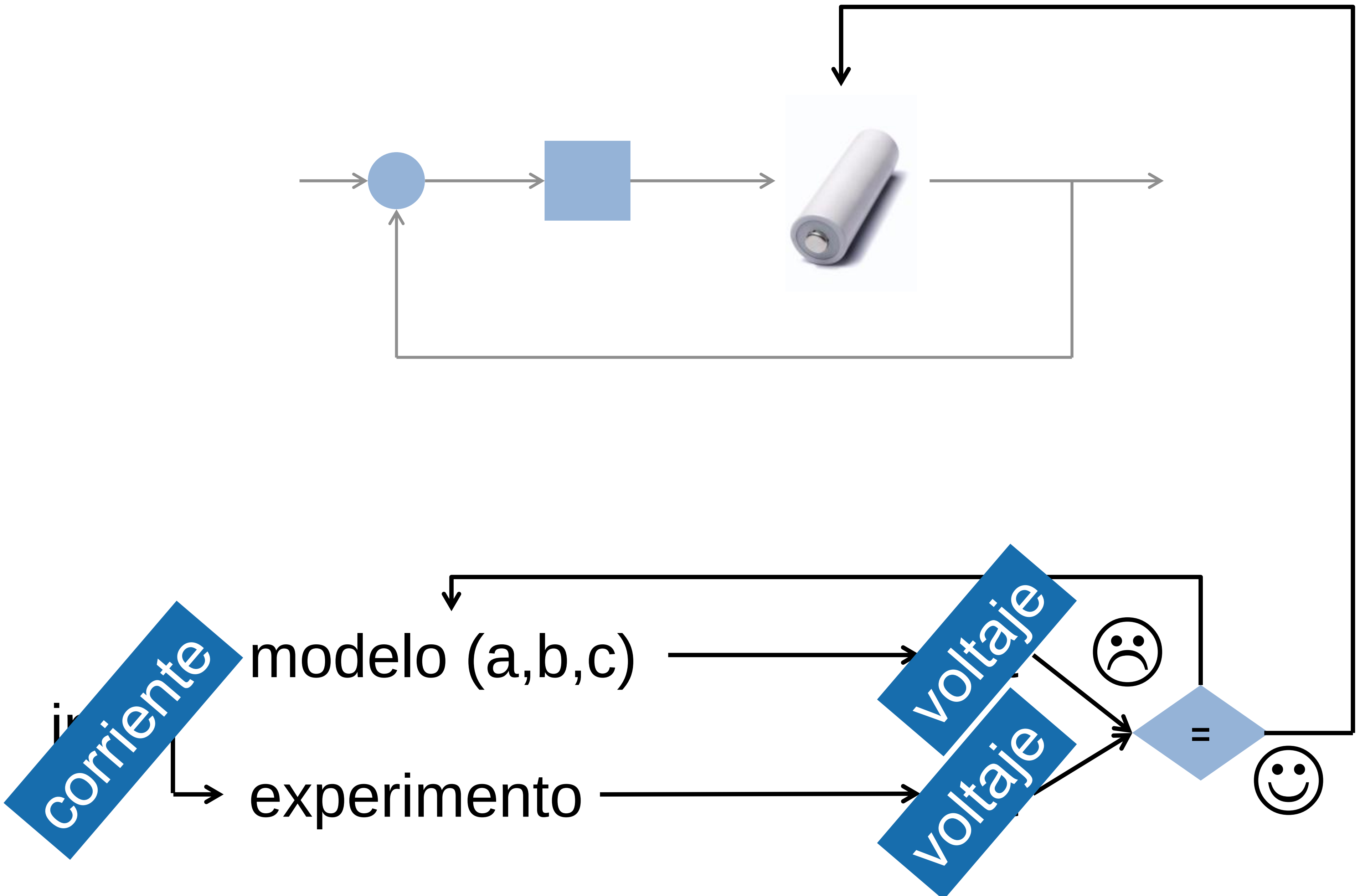


$$m\ddot{x} + B\dot{x} + kx = F$$



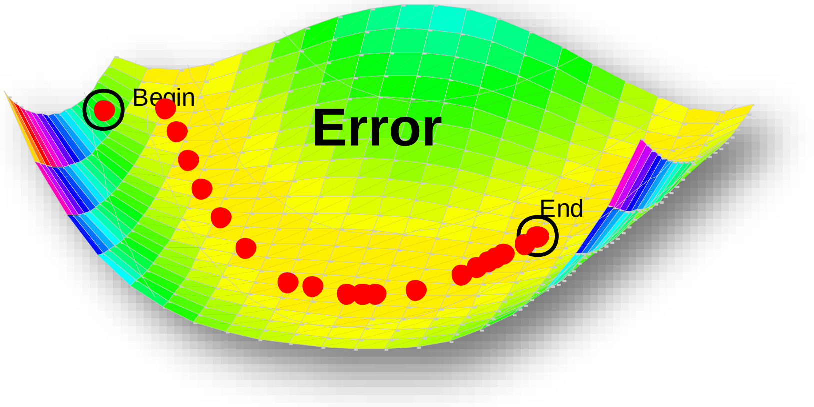


Estimación de Parámetros

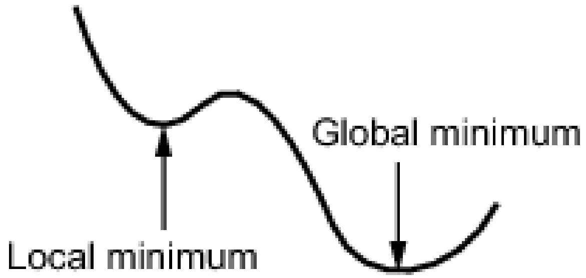

corriente
modelo (a,b,c)
experimento
voltaje
voltaje
=

Un Problema de Optimización

- Función Objetivo



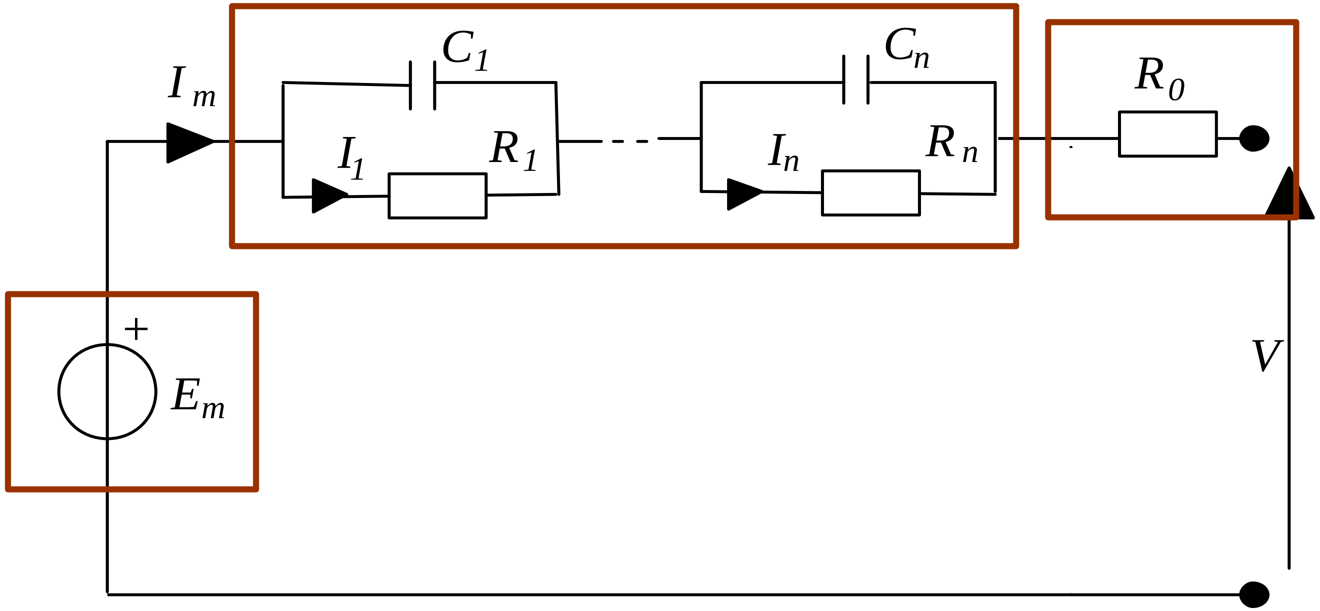
- Condiciones Iniciales



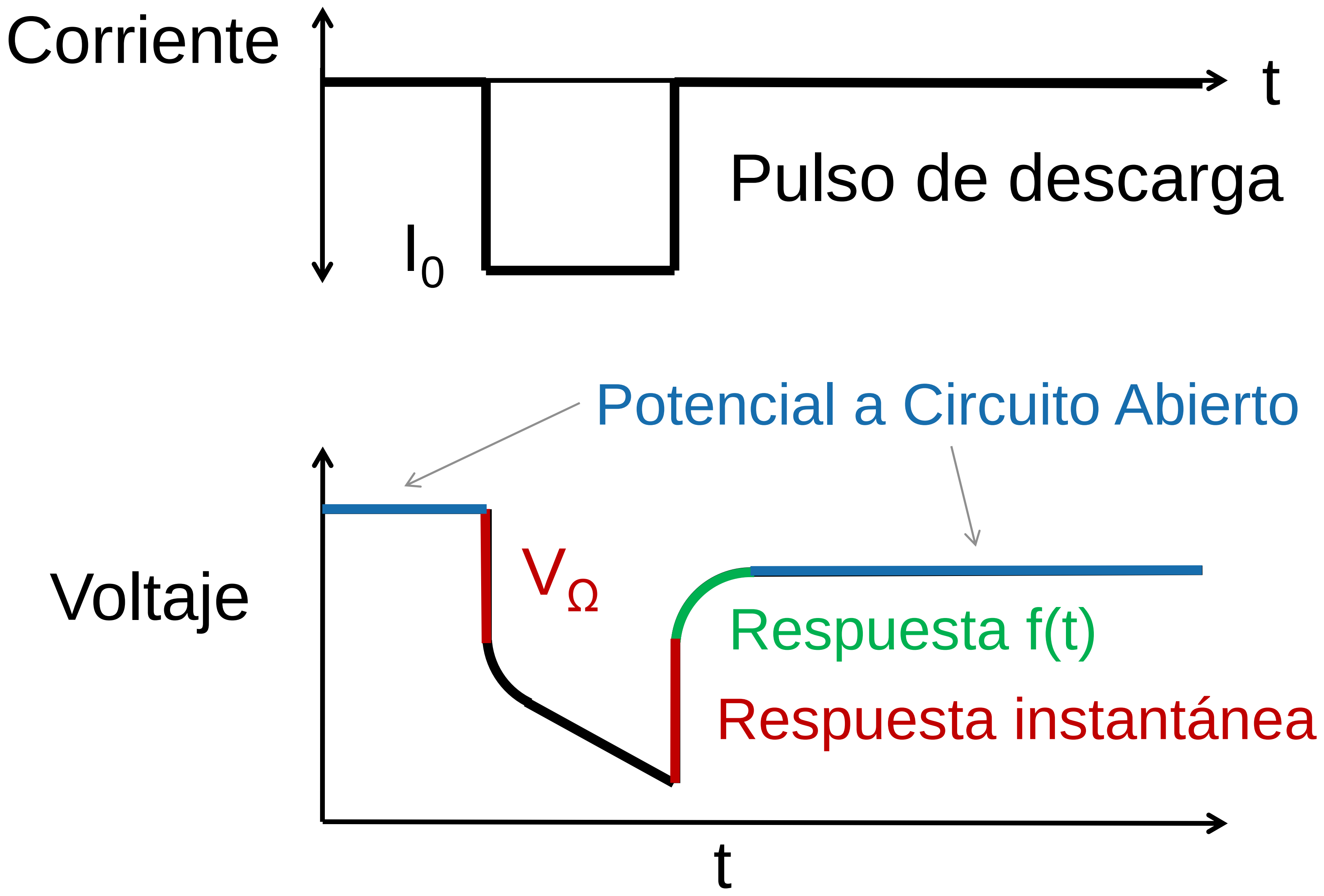
Demo

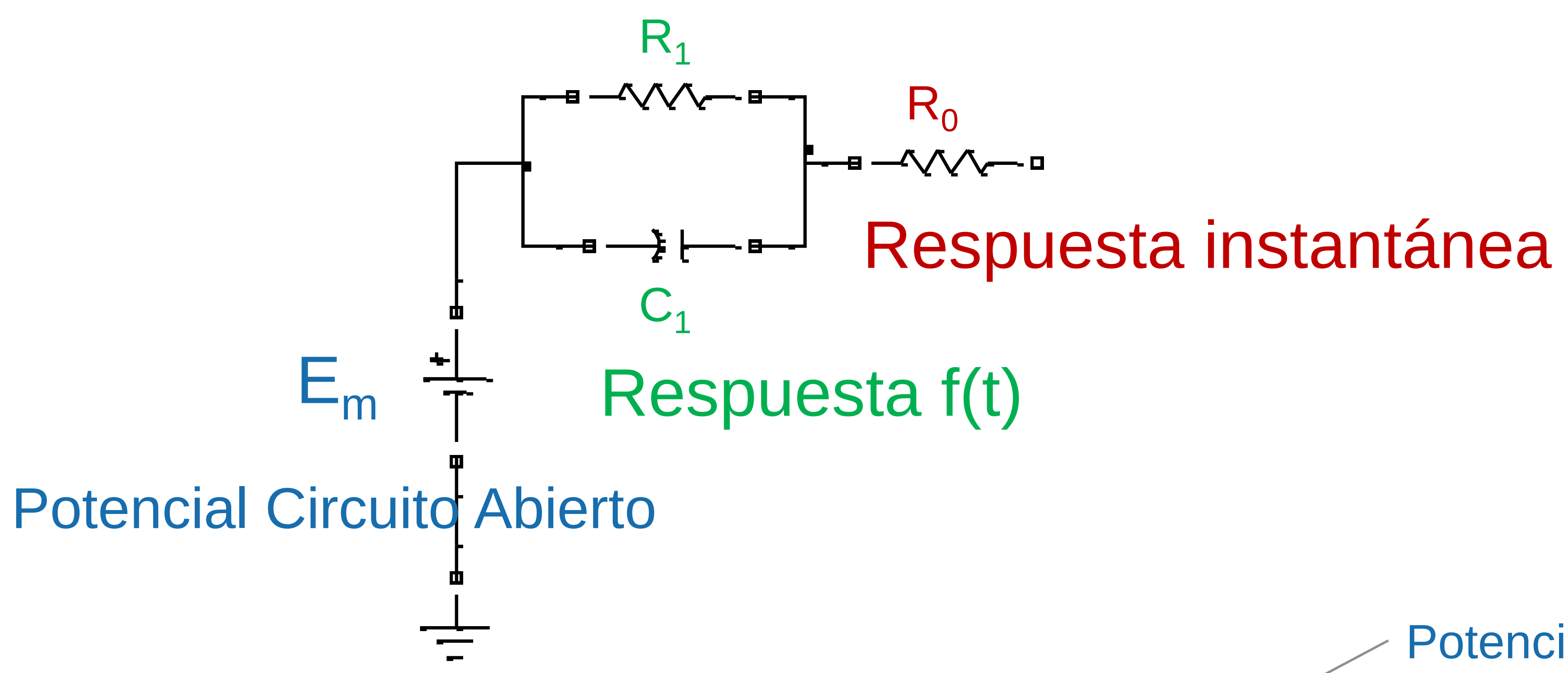
Temperatura?

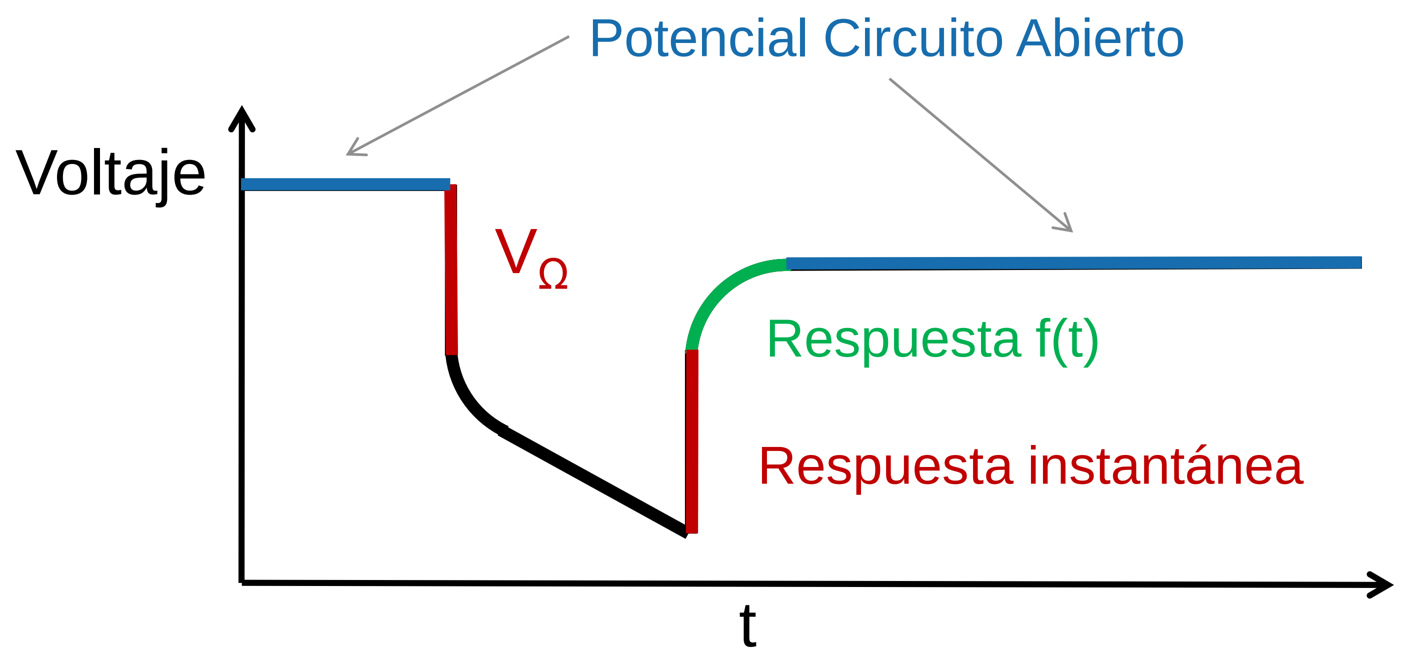
Circuito Equivalente



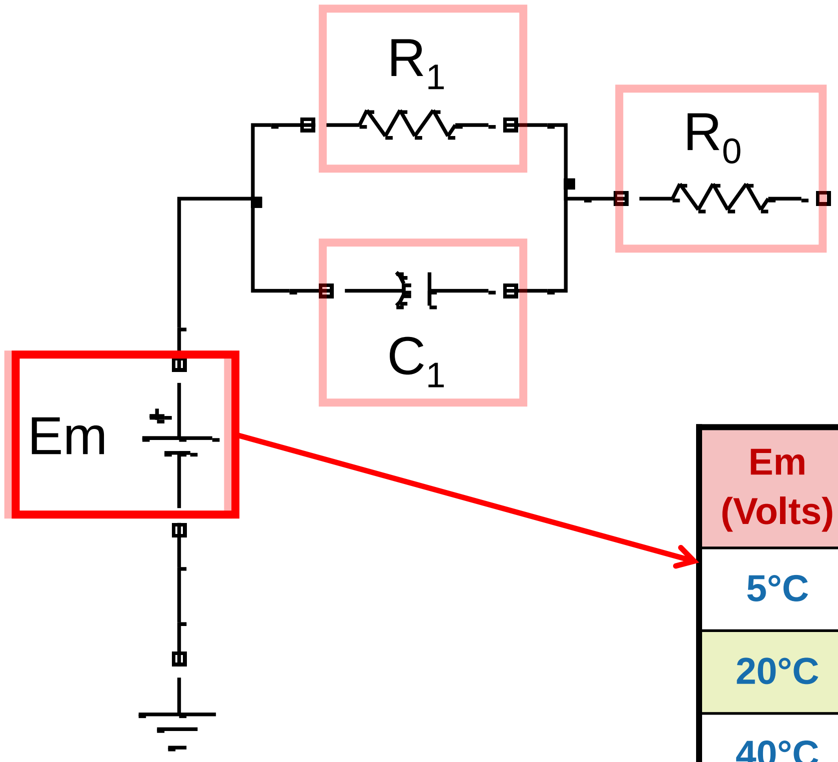
Pulso de Descarga



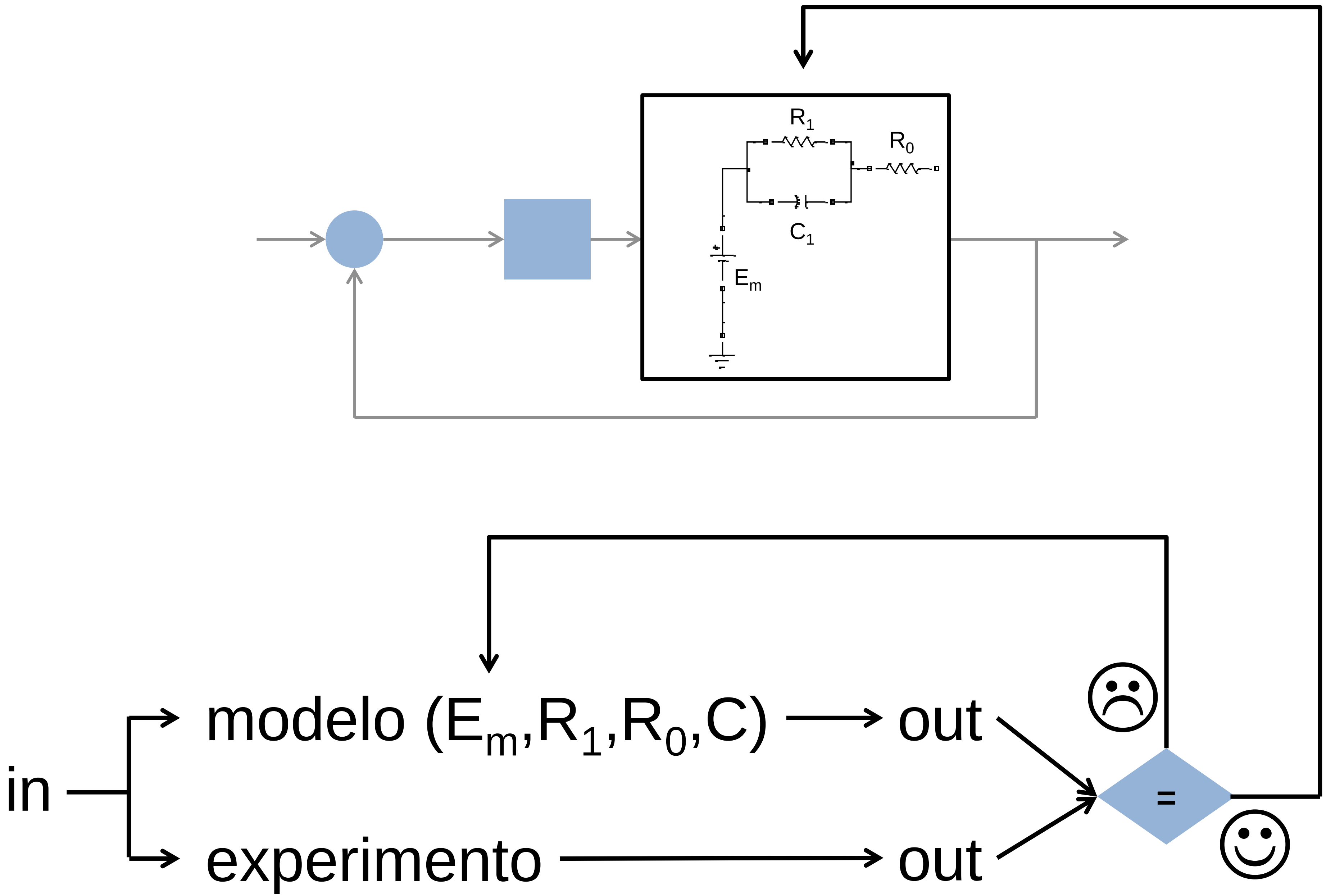

R1
R0
Respuesta instantánea
C1
Em
Respuesta f(t)
Potencial Circuito Abierto


Potencial Circuito Abierto
Voltaje
VΩ
Respuesta f(t)
Respuesta instantánea
t

Tablas de Look-up

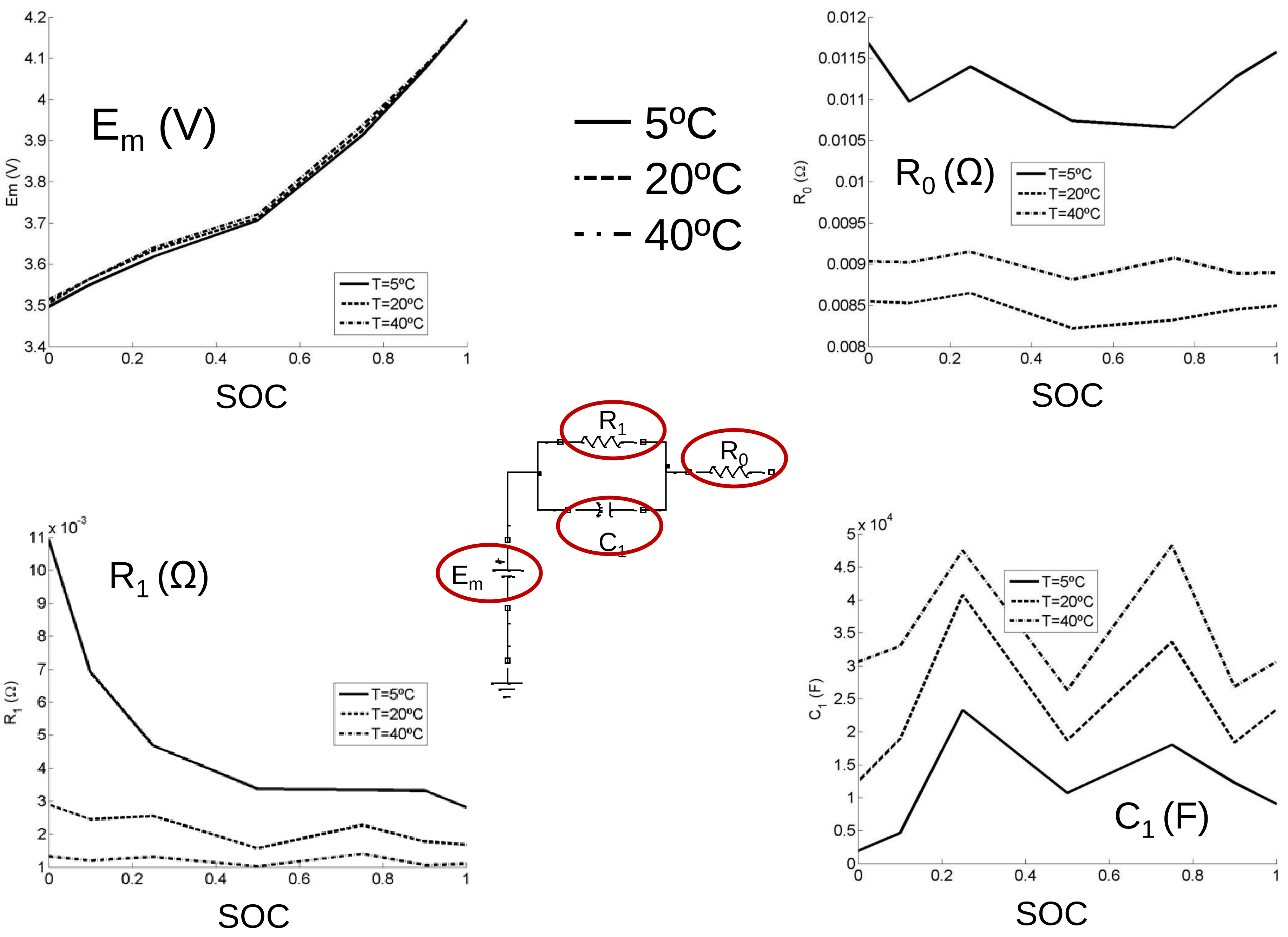


Em (Volts)	SOC 1	SOC 0.9	SOC 0.8	…	SOC 0
5°C					
20°C					
40°C					



R_1
R_0
C_1
E_m
modelo (E_m,R_1,R_0,C)
out
in
experimento
out
=

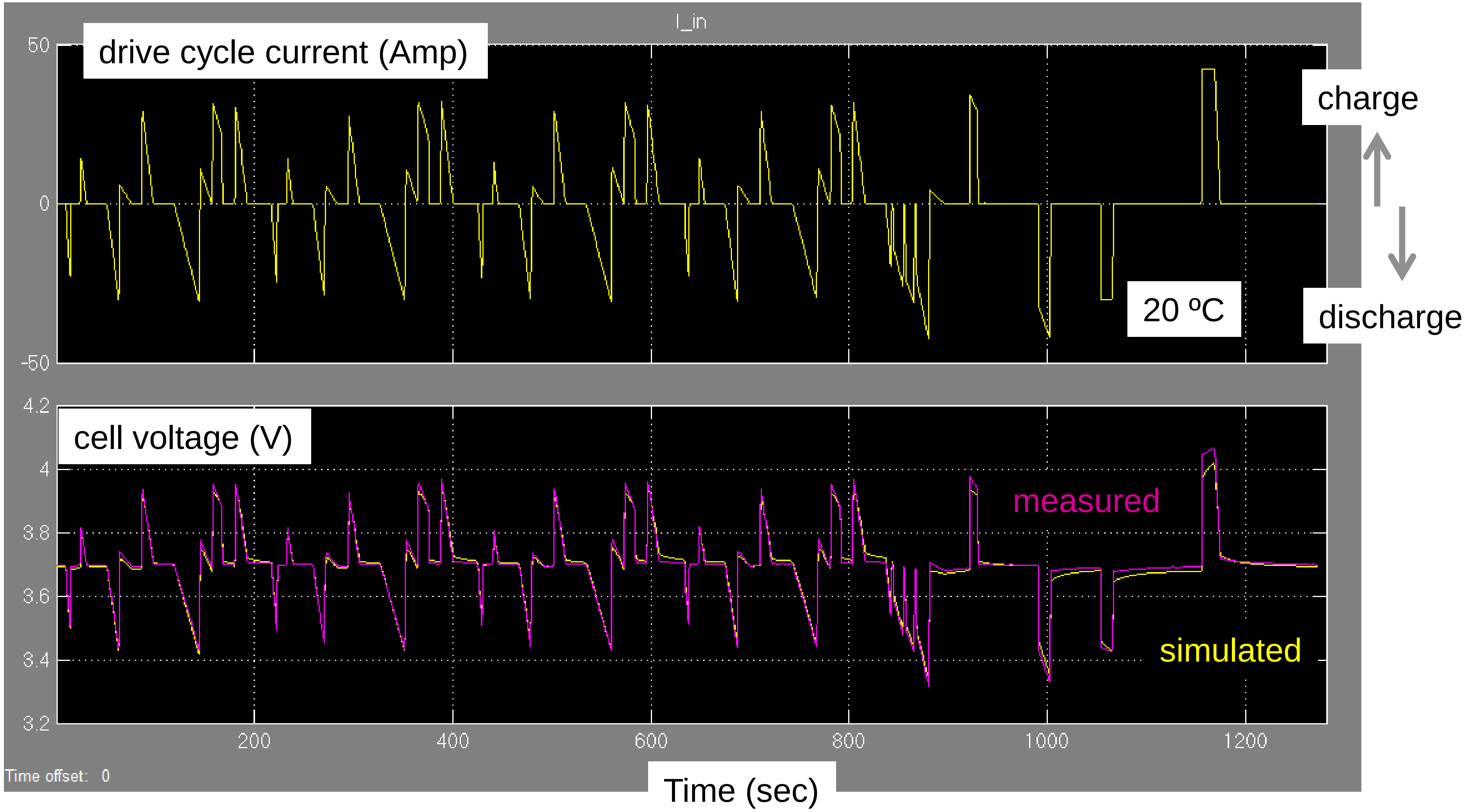
Demo



Em (V)
Em (V)
SOC
T=5ºC
T=20ºC
T=40ºC
5ºC
20ºC
40ºC
R0 (Ω)
R0 (Ω)
SOC
R1
R0
C1
Em
x 10-3
R1 (Ω)
R1 (Ω)
SOC
x 10^4
C1 (F)
C1 (F)
SOC

Validación

New European Drive Cycle



Good agreement

Simulación

Resumen

- Modelado Físico
  - No-causal
  - Topología modelo ~ Sistema real
- Estimación de Parámetros
  - Optimización
  - Ajuste del modelo a mediciones
- Simulación

High Fidelity Electrical Model with Thermal Dependence for Characterization and Simulation of High Power Lithium Battery Cells

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Abstract— The growing need for accurate simulation of advanced lithium cells for powertrain electrification demands fast and accurate modeling schemes. Additionally, battery models must account for thermal effects because of the paramount importance of temperature in kinetic and transport phenomena of electrochemical systems. This pa-

OCV	open circuit voltage (V)
P_s	power dissipated inside the cell (W)
Q_e	extracted charge from cell (Ah)
R_n	resistor n, where n is a natural number (Ω)
R_T	convection resistance (W^1 m^{-2} K^{-1}))

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SAE International

Battery Model Parameter Estimation Using a Layered Technique: An Example Using a Lithium Iron Phosphate Cell

2013-01-1547

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Robyn Jackey, Michael Saginaw, Pravesh Sanghvi and Javier Gazzarri
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ABSTRACT

Lithium battery cells are commonly modeled using an equivalent circuit with large lookup tables for each circuit element, allowing flexibility for the model to closely match measured data. Pulse discharge curves and charge curves are collected experimentally to characterize the battery performance at various operating points. It can be extremely difficult to fit the simulation model to the experimental data using optimization algorithms, due to the number of values in the lookup tables.

optimization algorithm. The optimization adjusts parameters to minimize error between each experimental battery data set and the corresponding simulated results, given identical input signals [1,2, 3, 4].

Pulse curves help to provide a high-fidelity representation of battery performance, including the transient response, at multiple state-of-charge (SOC) values [4, 5, 6]. To incorporate this high-fidelity representation into equivalent circuit models requires the nonlinear circuit elements to be very flexible to the operating conditions and states of the battery cell. Lookup tables are frequently used to provide this flexibility [1, 2, 3, 4,

SAE International

Simplified Extended Kalman Filter Observer for SOC Estimation of Commercial Power-Oriented LFP Lithium Battery Cells

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ABSTRACT

The lithium iron phosphate (LFP) cell chemistry is finding wide acceptance for energy storage on-board hybrid electric vehicles (HEVs) and electric vehicles (EVs), due to its high intrinsic safety, fast charging, and long cycle life. However, three main challenges need to be addressed for the accurate estimation of their state of charge (SOC) at runtime:

- Long voltage relaxation time to reach its open circuit voltage (OCV) after a current pulse

INTRODUCTION

The LFP olivine has emerged as one of the favored cathode materials for lithium ion batteries, especially for use as a rechargeable energy storage device (RESS) on-board HEVs and EVs, thanks to its high intrinsic safety [1], capacity for fast charging, and long cycle life [2]. Recent research and development advancements in this cell technology, especially the commercial launch of high-power LFP cells, have led to these cells matching the performance of the latest super-capacitors over short time periods (up to 30 seconds).

Gazzarri, J., Shrivastava, N., Jackey, R., and Borghesani, C., *Battery Pack Modeling, Simulation, and Deployment on a Multicore Real Time Target. SAE Int. J. Aerosp.* 7(2):207-213, 2014
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Battery Pack Modeling, Simulation, and Deployment on a Multicore Real Time Target

Javier Gazzarri, Nishant Shrivastava, Robyn Jackey, and Craig Borghesani
MathWorks

ABSTRACT

Battery Management System (BMS) design is a complex task requiring sophisticated models that mimic the electrochemical behavior of the battery cell under a variety of operating conditions. Equivalent circuits are well-suited for this task because they offer a balance between fidelity and simulation speed, their parameters reflect direct experimental observations, and they are scalable. Scalability is particularly important at the real time simulation stage, where a model of the battery pack runs on a real-time simulator that is physically connected to the peripheral hardware in charge of monitoring and control. With modern battery systems comprising hundreds of cells, it is important to employ a modeling and simulation approach that is capable of handling numerous simultaneous instances of the basic unit cell while maintaining real time performance.

Available at *mathworks.com/batterypack*

Gracias!