LEM

Life Energy Motion

Fluxgate Virtual Sensor

Atef LEKDIM

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Life Energy Motion

Agenda

- Introduction
- Model Builder
- Livelink with Matlab
- Results
- Conclusion

Introduction

- All applications that require high precision

Automotive:

-RCDs for On/Out Board Chargers (CDTs , CDSR )

-Battery management systems (CABs )

Health equipments:

-MRI scanners (ITL , …)

Renewable energies:

- Solar energy (, …)

- Others

Model Builder

- Magnetic field physic

- Composant 1 *(comp 1)*
  - Definitions
  - Géométrie 1
  - Materials
  - Champs magnétiques *(mf)*
  - Electrical Circuit *(cir)*
  - Events *(ev)*
  - General Form PDE *(g)*
  - Meshes
- Study 1
  - Step 1: Coil Geometry Analysis
  - Step 2: Time Dependent
  - Solver Configurations
- Results

Anisotropy included along the radius

Coordinate System Selection

Coordinate system:

Cylindrical System 2 (sys2)

Constitutive Relation B-H

Magnetization model:

Relative permeability

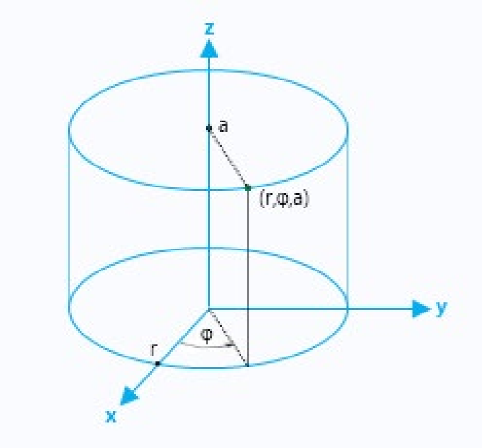
$\mathbf{B} = \mu_0 \mu_r \mathbf{H}$

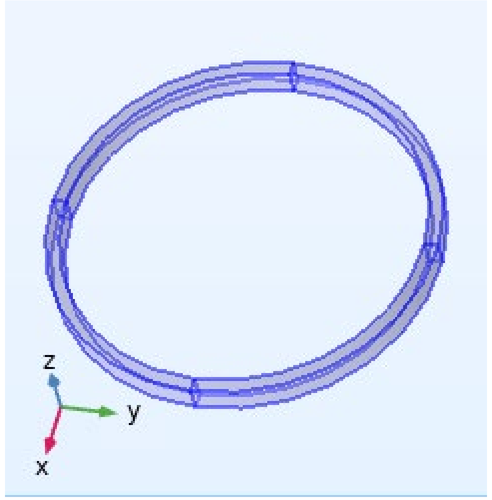
Relative permeability:

μ_r User defined

5	0	0	
0	MuZ(abs(-mf.Bx*sin(sys2....	0	1
0	0	MuZ(abs(-mf.Bx*sin(sys2....	

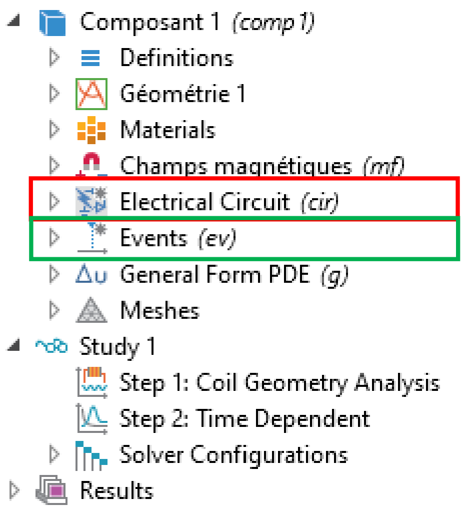
Diagonal

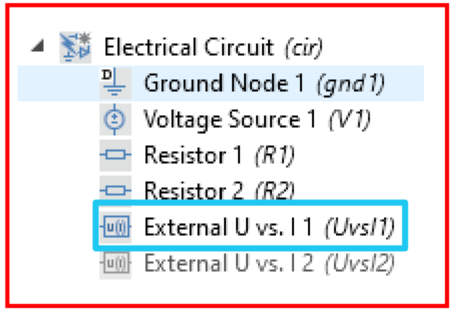


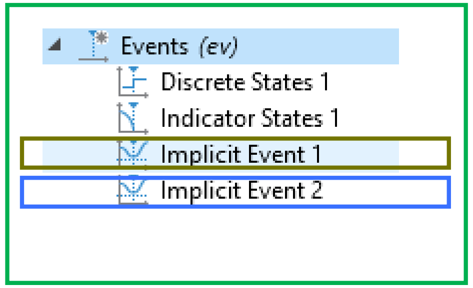


Model Builder

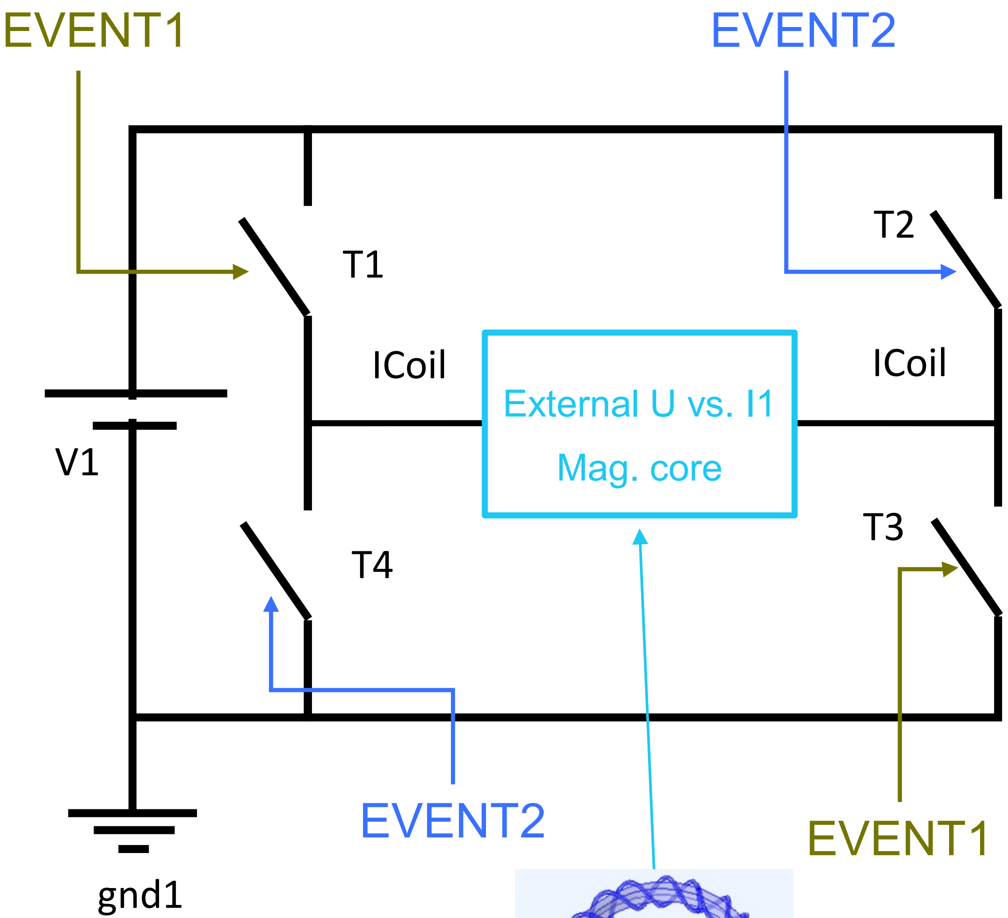
- Electrical circuit and Events modules
  - Saturate the magnetic material both sides (fluxgate principale)

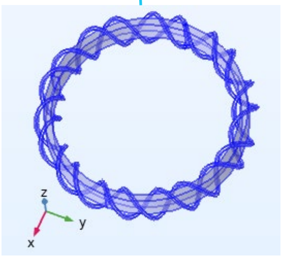






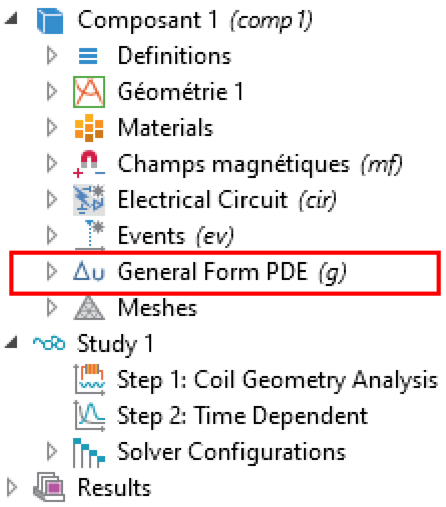
Control of transistors

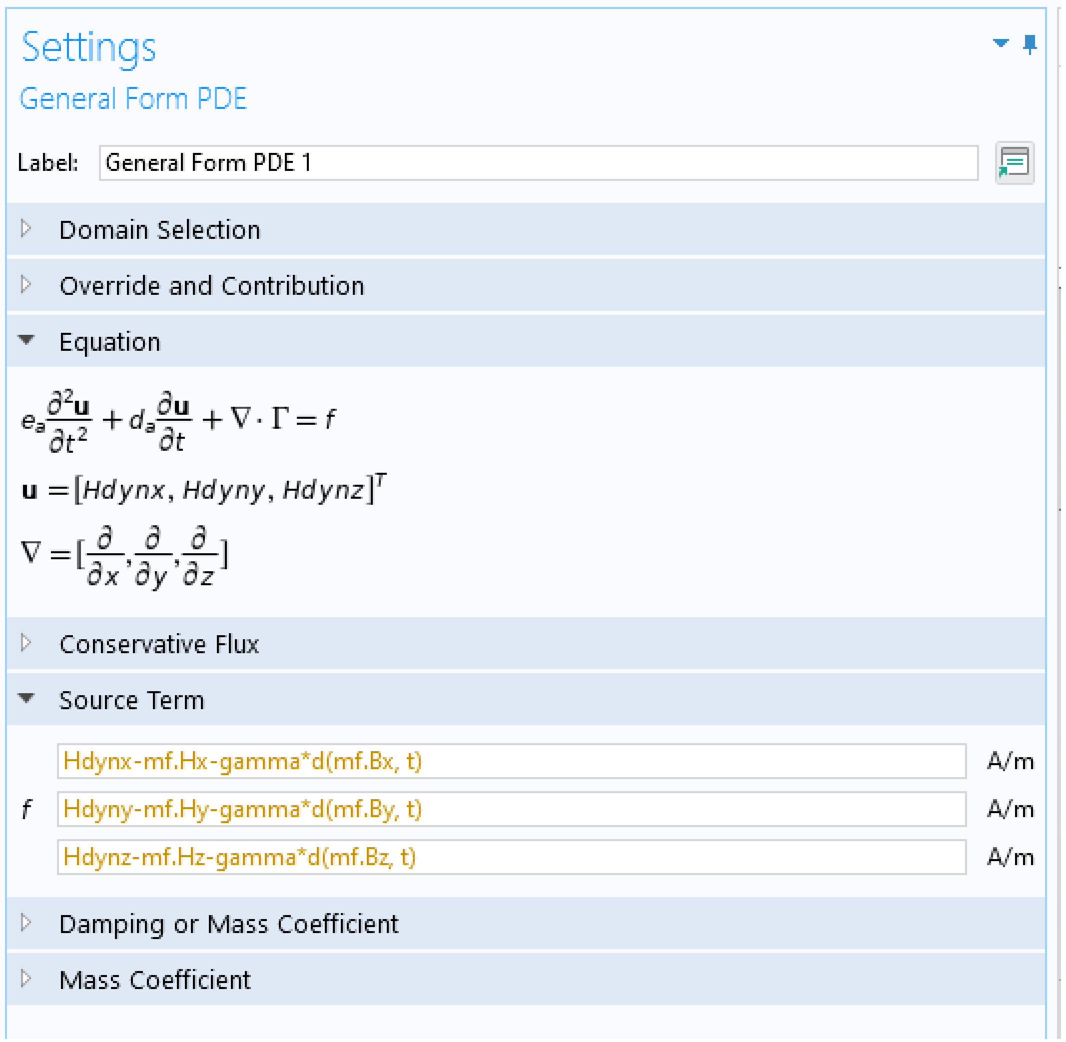




Model Builder

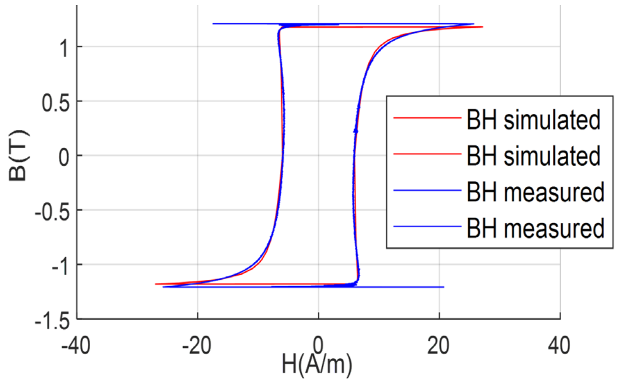
- General Form PDE module





Basic magnetic model

$$H_{\text{dyn}}(B) = H_{stat}(B) + \gamma \times \frac{\text{d}B}{\text{d}t}$$



LiveLink with Matlab

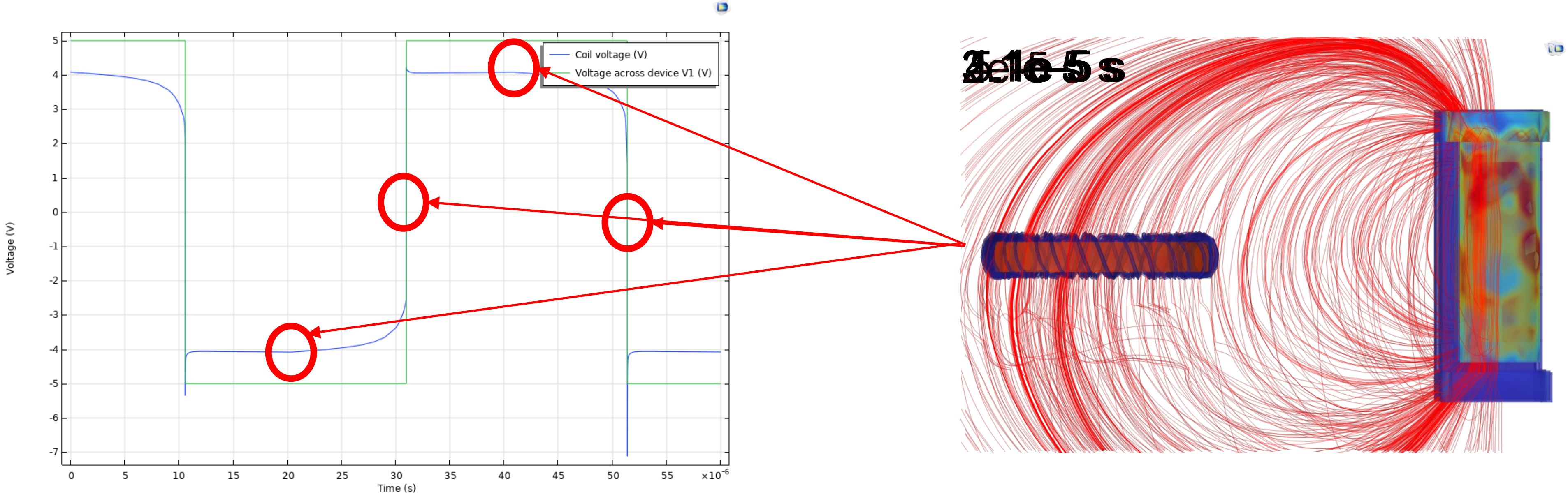
- Basic livelink Matlab script steps
  - Loading the COMSOL model
  - Matlab main loop
    - Setting model parameters
    - Run the simulation
    - Extraction of simulation data
    - Post processing

Virtual_fluxgate_sensor.m

```
%*********************loading of the COMSOL model*************************
model=mphopen('Virtual_fluxgate_sensor');
%mphlaunch(model)
i=1;ii=1;iii=1;
for ii=1:length(Ileak)
for iii=1:length(ANGLE)
for i=1:length(I1)
%*****************setting of the parameters*****************************  ...
 model.param.set('Ileak', [num2str(Ileak(ii)) '[A]']);
 model.param.set('Irelay_0', [num2str(Irelay_0) '[A]']);
 model.param.set('ANGLE', [num2str(ANGLE(iii)) '[A]']);
 model.param.set('I1', [num2str(I1(i)) '[A]']);
 model.param.set('I2', [num2str(I2(i)) '[A]']);
 model.param.set('I3', [num2str(I3(i)) '[A]']);
% model.param.set('I0', [num2str(I0) '[A]']);
 model.param.set('Ns', [num2str(Ns) '[1]']);
% model.param.set('gamma', [num2str(gamma) '[1]']); ...
figure
mphgeom(model,'geom1','facealpha',0.5)
%************************Run COMSOL Model  ****************************
model.result.table('tbl2').clearTableData
tic
model.study('std1').run
temps_simul(i,1)=toc/60
% %**********************COMSOL data extraction*************************  ...
MMM=mphtable(model,'tbl2');
MM=MMM.data;
%model.result.table('tbl2').save([PathName,'With all shieldings Ileak=',num2s
figure
mphplot(model,'pg36','rangenum',12)
%*************************Sensor measurements*****************************
Measurements(:,iii+(ii-1)*2)=Sensor_PostProcess_function(MM,Long_moy,Cross_Se
%save(strcat(PathName,strtok('Extraction parametres tripahse Ileak0A With all
clear MMM MM
end
end
end
```

Results

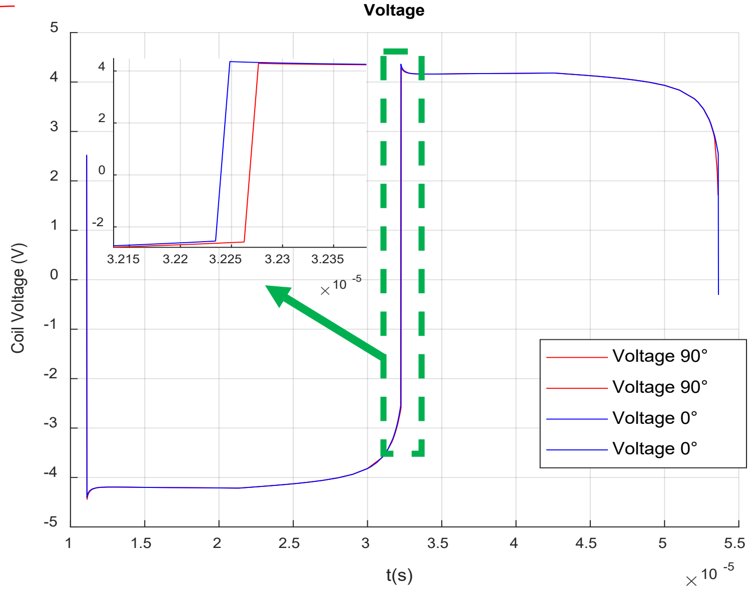
- Results over simulation time

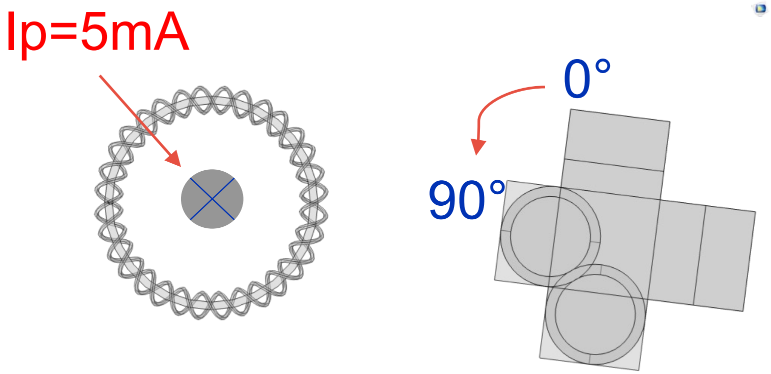


Results

- Sensor electrical results with respect to relay orientation

Matlab Post Processing results





Channels	Ref (relay off)	0° rot.	90° rot.	0° error (%)	90° error(%)
Analog	0.00351	0.00358	0.00356	+1.8	+1.3
Digital	0.00296	0.00263	0.00198	-11	-33.3

The digital channel is highly sensitive to electromagnetic pollutions

Conclusion

- The realised virtual sensor is useful for
  - continuous improvement,
  - simulating extreme conditions that can't be easily set in real life,
  - simulating customer environment for better integration of the sensor
- Next steps
  - External material DLL model (issue with time-stepping implementation)
  - Application builder

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Thank you for your attention
Q&A