

Altair Flux[™]

2D Example: Contactor optimization with Flux and HyperStudy

altairhyperworks.com

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1 Description

Introduction

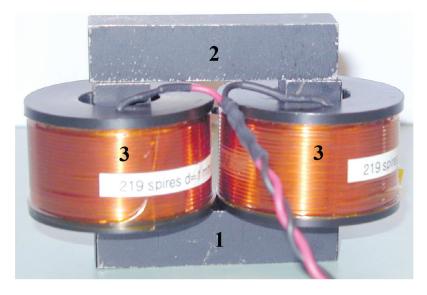
The goal of this document is to describe how to use HyperStudy, HyperWorks's multi-disciplinary design exploration tool to study a device described under Flux 2D. The study in HyperStudy covers DOE, Optimization and Stochastic approaches. The optimization will consist to obtain a force of 200 N on the mobile part.

Data computed	Magnetic force
Application	Magneto Static
Feature used	Flux HyperStudy coupling

Studied device

The studied device is an electromagnetic contactor composed by:

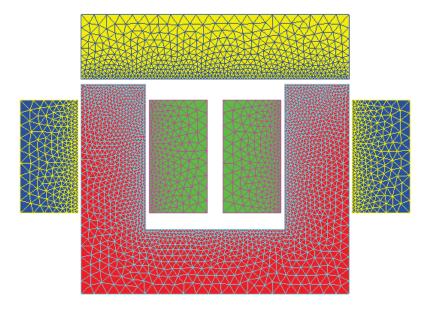
- 1. U magnetic core
- 2. Magnetic mobile part
- 3. Coils supplied by an amp-turn number (AT)



2 Flux Project

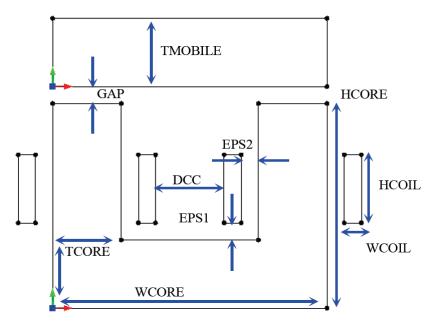
Flux 2D geometry and mesh

The following picture shows the device designed in Flux 2D:



Flux 2D geometry parameters

The following picture shows the geometric parameters used in the geometry definition:



There is also one physical parameter **AT** for the amp-turn number.

Starting Flux project

The starting Flux project is the 2D_Contactor.FLU.

It contains:

- the parameterized geometry of the device
- the mesh
- the physics definition (application, materials, regions, coils)

The sensor **FORCE** has been created to compute the force on the mobile part.

😓 Edit Sensor[FORCE]
Name of the sensor *
FORCE
Comment
Results \ Evaluation mode \
Type of sensor
Predefined (Energy, force, Torque,)
Magnetic force 🔹
Computation domain
Face regions 🔹
Face regions
MOBILE

Next, the I/O parameter **FORCE_Y** has been created to store only the Y component of the sensor response.

Edit Physical parameter[FORCE_Y]
Name of the Physical parameter *
FORCE_Y
Comment
Definition \ Property \
Type of Physical parameter
Parameter defined by a formula
Expression *
Abs(Comp(2,FORCE)) f()

The project has been solved with **REFERENCEVALUES** solving scenario.

The sensor and the I/O parameter are evaluated automatically. For instance, for FORCE_Y:

١.	Definition Property \	
	Current value	
	171.89619517025045	

Generating the link file from Flux

Here are the steps to generate the link file F2HST from Flux. After having done this you can close the Flux project and Flux.

1. Open the dialogue box:

Click on Generate component for HyperStudy coupling in the Solving menu

Senerate component for Hypers	Study coupling (for H	yperStudy 2019.1 and later) 🛛 🗪
Component name *		
4HST		
Overwrite component if exist		
⊖ yes		
🔍 no		
Directory to save component		
, · · · · · · · · · · · · · · · · · · ·		<u>></u>
Component scenario		
		-
Destroppeding withou file		
Postprocessing python file		
I	0	
Available parameters	 Component inputs 	
	Add	CORE
Geometric Physical \		WCOIL
HCOIL 🔶		HCOIL
DEPTH	Add all	EPS1
EPS1		GAP
GAP RINF_INT	Remove all	EPS2
RINF_EXT		TMOBILE
EPS2		DCC
TMOBILE		AT
DCC 🗾		
	-Component output	
Available parameters	Add	Selected parameters
Geometric Physical	Add	FORCE_Y
LINPOS_MOBILE_PART		
ELFORC_MOBILE_PART	Add all	
AT		
FORCE_Y	Remove all	
🕅 OK Cancel		

- 2. Define the Component name, for example: 4HST
- 3. Go to **Component inputs** section and choose input parameters: Add TCORE, WCOIL, HCOIL, EPS1, GAP, EPS2, TMOBILE, DCC, AT
- 4. Go to **Component outputs** section and choose the outputs:



Add FORCE_Y

5. Validate by clicking on OK

4HST.F2HST file has been created.

The Flux project has been duplicated and registered under the name: 4HST.F2HST.FLU

The memory values specified manually or by default in the Flux Supervisor options are written in the F2HST file when generating the component for HyperStudy from Flux. By default, HyperStudy will launch Flux with these values.										
HyperStudy. So,	are unnecessary high, before generating th nimum required to so	e component, a si	uggestion is to t	une the memory						
🕀 Options										
LanguageRecent filesFile typesShortcutsMacrosMemoryParallel computingParallel computing	User Dynamic (Beta version) Sk 3D		1 1 1 1 1 1 1	12 % 3968 MiB / 33683						
Graphic mode	Numerical memory	Character memory	GUI memory	System memory						
Graphic mode Network ports Debug			26 %	19 %						
Network ports Debug User mode		3 %								
Network ports Debug	52 % 2048 MiB	3 % 128 MiB	1024 MiB	768 MiB						

If you would like to change the memory values after generating the component, you can do it directly in HyperStudy using the solver arguments for Flux in the **Solver Input Arguments** field:

	Active	Label	Varname	Model Type	Resource	Solver Input File	Solver Execution Script	Solver Input Arguments
1	V	Model 1	m_1	🕀 Flux	E:\tmp\Contactor_HyperStudy_Case1\4HST.F2HST 📂	hst_input.hstp	🕀 Flux (HstSolver_Flux)	-batch -env_MEMSIZC3=2147483648



3 HyperStudy Project

This chapter covers the following:

- 3.1 Setup (p. 9)
- 3.2 DOE (p. 11)
- 3.3 Optimization (p. 14)
- 3.4 Stochastic (Reliability of the optimum solution) (p. 16)
- 3.5 Export study archive (p. 18)

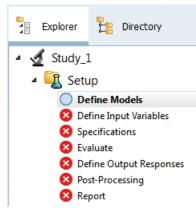
3.1 Setup

Procedure

1. Open HyperStudy and Start a New Study in the same directory where .F2HST and .F2HST.FLU files are located:

🔬 Untitled - I	HyperStudy 2	017.2 (16.1	167319)							
File Edi	t View	Tools	Applications	Help						
New Op	Den Save Study	Close	Undo Redo Edit	Browsers Me View	essages Back	Apply Navigate	Next	Add App	Remove roach	Import Archive
Explore	er 🔡 (Directory	🕂 Star	: 📔 Tutor	ials					
Start: Recent Studies New Study D:\\St							3a.xml			Quick St
	Label:	Study_1								
	Varname: Location	_								
	D: \dn	navrudieva	Mes_documents\Valo	risation \Exemple_H	HST_FluxSupervisor\fil	es			•	1
									ОК	Cancel

2. Select Define Models in Setup and define a Flux model:



Click on **Directory** and **drag & drop** the 4HST.F2HST into the graphical interface.



The Flux model is automatically created and the tabs are populated.

New Open Save Close	Undo Redo Edit	Browsers Message View	es Back	Import Variables Next Navigate	Add Remove	Import Archive	Export Archive Package Reports Collaborate	
Explorer Directory Name		ine Models 📰	ve Model	Model Resources				
study_lock.xml		Active Label Varname Model Type Resource 1 Implement Implement Implement Implement Implement				Solver input file Solver execution script hst_input.hstp Image: Flux (HstSolver_Flux)		
 Study_1.xml Flux2D_log.py Flux2D.report Flux2D.log ContactorOptimization (2). HST.F2G.FLU HIST.F2G 2D_Contactor.FLD 	Xr)						

3. Click on Import Variables.

Input variables appear in **Define Input Variables**.

🖌 🛃 Study_1		🗄 🛛 Add In	put Variable	🔀 Remove	e Input Variable			
🛛 🗓 Setup								
Define Models		Active	Label	Varname	Lower Bound	Nominal	Upper Bound	Comment
Oefine Input Variables	1	V	TCORE	var_1	18.000000	20.000000	22.000000	GEOM
Specifications	2	V	WCOIL	var_2	16.200000	18.000000	19.800000	GEOM
Evaluate Define Output Responses	3	V	HCOIL	var_3	31.500000	35.000000	38.500000	GEOM
Define Output Responses Post-Processing	4	V	EPS1	var_4	4.5000000	5.0000000	5.5000000	GEOM
8 Report	5	V	GAP	var_5	1.3500000	1.5000000	1.6500000	GEOM
-	6	V	EPS2	var_6	0.9000000	1.0000000	1.1000000	GEOM
	: 7	V	TMOBILE	var_7	18.000000	20.000000	22.000000	GEOM
	8	V	DCC	var_8	4.5000000	5.0000000	5.5000000	GEOM
	9	V	AT	var_9	900.00000	1000.0000	1100.0000	PHYS

4. Go to Specifications.

Select **Nominal run**. It allows performing one run at nominal values.

5. Go to Evaluate and click on Evaluate Tasks.

It runs Flux in batch, solves the project and recovers the results.

6. Go to Define Output Responses. The Flux results are automatically recovered.

 Study_1 Setup 		🛨 Add (Output Respon	se 🗵	Remove Outpu	t Response
O Define Models		Active	Label	Varname	Expression	Value
Ø Define Input Variables	1	V	FORCE_Y	r_1	ds_1[0]	171.90637
Specifications						
Svaluate						
Define Output Responses						
Post-Processing						
Report						

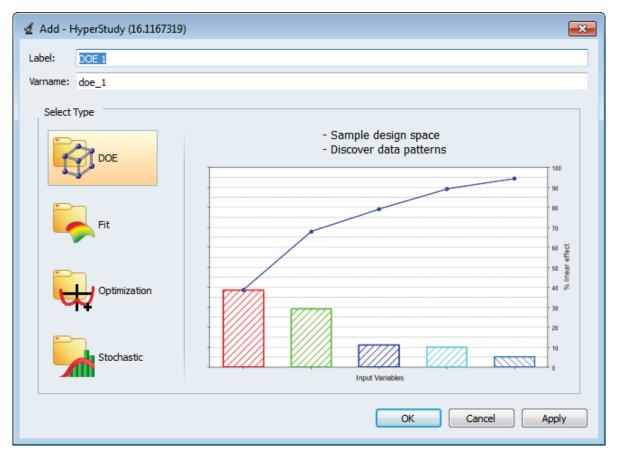


3.2 DOE

Procedure

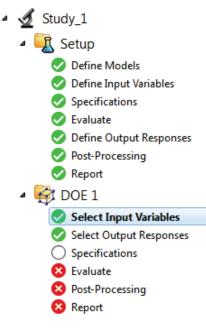
1. Add DOE approach.

Right-click in the data tree and select Add.



DOE 1 approach appears in the data tree. **Select Input Variables** and **Select Output Responses** are automatically copied from the **Setup**.





- 2. Go to Select Input Variables and disable GAP parameter.
- 3. Go to Specifications.

Select Fractional Factorial, Resolution V. Click on Apply.

🛛 💽 Setup									
🥏 Define Models		Mode	Label	Varname	Details	^		Valu	e
🥏 Define Input Variables	1	0	Modified Extensible Lattice Sequence	Mels			Resolution	V	-
Specifications	2	0	D - Optimal	DOpt			Number of runs	64	
📀 Evaluate	3	۲	Fractional Factorial	FracFact			Use Inclusion Matrix		
Define Output Responses Post-Processing	4	0	Full Factorial	FullFact					
Report	5	\odot	Plackett Burman	PlackBurm		=			
4 🙀 DOE 1	6	\bigcirc	🔯 Taguchi	Taguchi		-	:		
Select Input Variables	7	\odot	Central Composite	Ccd			:		
🤣 Select Output Responses	8	0	Box Behnken	Box	Exceeds maximum of (7) variables.				
Specifications	9	0	Latin HyperCube	LatinHyperCube					
😣 Evaluate	10	0	Latin HyperCube Hammersley	Hammersley					
Post-Processing Report	11	0	🗴 User Defined	User		-			
Керон	12	0	🕈 Run Matrix	RunMatrix			Settings	L Levels	5
	13	0	None	None		-	W Socialitys	1 20100	ď

4. Go to Evaluate. Activate the option Multi-execution in the right top corner.

Note: The number of concurrent Flux jobs should be chosen depending on the cores available on the machine and the RAM required to run all the jobs.

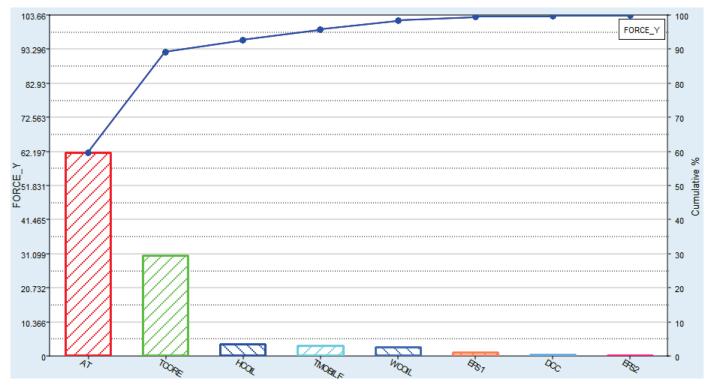
	Multi-Execution - 8							
Ŀ	2	Multi-Execution						
8	3 Jobs		▲ ▼					
C		Log output						



Click on **Evaluate Tasks**.

5. Go to Post Processing.

Click on Pareto Plot tab.



The effects of variables on output responses are plotted in hierarchical order (highest to lowest). Hashed lines with a positive slope indicates a positive effect. If a variable increases, the output response will also increase. Hashed lines with a negative slope indicates a negative effect. Increasing the variables lowers the output response.

The less influential parameters are **EPS1**, **DCC** and **EPS2**. We will exclude them for the optimization.



3.3 Optimization

Procedure

- 1. Add Optimization approach.
- 2. Go to Select Input Variables. Disable EPS1, DCC, EPS2 and GAP.
- **3.** Go to **Define Output Responses**. Define an **Objective** of **System Identification** type applied on **FORCE_Y** to reach a target value of 200 N. **Apply**.

Add Objective		🙁 Remo	ve Objective					
	Active	Label	Varname	Туре		Apply On	Evaluate From	Target Value
1	1	Objective 1	obj_1	System Identification	•	<pre> % FORCE_Y(r_1) </pre>	> Solver	200.00000

4. Go to Specifications.

An optimization algorithm is automatically proposed by HyperStudy. Click on **Apply**, then **Next**.

	Mode	Label	Varname	Details					
1	۲	V Adaptive Response Surface Method	ARSM						
2	\odot	📢 Global Response Search Method	GRSM						
7	0	Www Sequential Optimization and Reliability Assessment	SORA	Random design/parameter variables necessary					
	Show more								

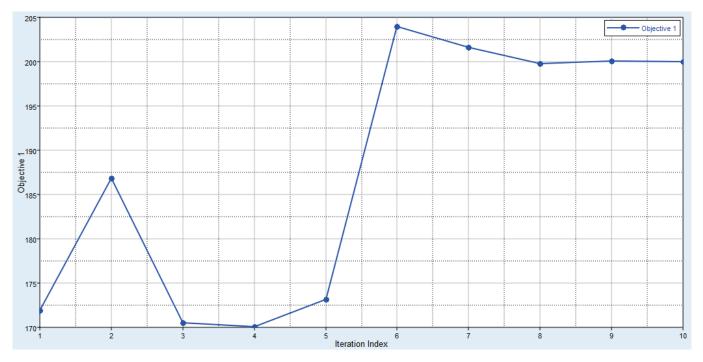
- 5. Click on Evaluate Tasks.
- 6. Stay in Evaluate to analyze the results.

The optimum solution is available in the **Iteration History** tab (green line in the chart). The objective (199,998 N) has been reached in only 10 iterations (10 evaluations in this case) starting from the initial value (171,906 N).

1	🔁 Go to Directory 🛛 📂 Browse files									
	tCORE	"]+ WCOIL	"]+ HCOIL	"]+ TMOBILE	Ľ[+ AT	🍰 FORCE_Y	¥ Objective1	Iteration Index		
1	20.000000	18.000000	35.000000	20.000000	1000.0000	171.90637	171.90637	1		
2	22.000000	18.000000	35.000000	20.000000	1000.0000	186.80921	186.80921	2		
3	20.000000	19.800000	35.000000	20.000000	1000.0000	170.54405	170.54405	3		
4	20.000000	18.000000	38.500000	20.000000	1000.0000	170.09980	170.09980	4		
5	20.000000	18.000000	35.000000	22.000000	1000.0000	173.13390	173.13390	5		
6	20.000000	18.000000	35.000000	20.000000	1100.0000	203.98381	203.98381	6		
7	22.000000	16.200000	31.500000	22.000000	1027.4161	201.64353	201.64353	7		
8	21.791509	16.312135	31.571400	21.950073	1027.3852	199.76414	199.76414	8		
9	21.810931	16.308238	31.564990	21.954658	1027.6215	200.04434	200.04434	9		
10	21.808892	16.309763	31.567942	21.952604	1027.6109	199.99820	199.99820	10		



Iteration Plot shows the optimization progress through the iterations until the objective is reached.







3.4 Stochastic (Reliability of the optimum solution)

Procedure

- 1. Add Stochastic approach.
- 2. Go to Select Input Variables.
 - a. Disable EPS1, DCC, EPS2 and GAP.
 - **b.** Copy the optimum values for **TCORE**, **WCOIL**, **HCOIL**, **TMOBILE** and **AT** from **Iteration History** tab in **Optimization** approach and paste them in the **Nominal** column in the **Stochastics** approach.

	Active	Label	Varname	me Lower Bound Nominal		Upper Bound	Comment	
1	V	TCORE	var_1	21.608892	21.808892	22.008892	GEOM	
2	V	WCOIL	var_2	16.109763	16.309763	16.509763	GEOM	
3	V	HCOIL	var_3	31.367942	31.567942	31.767942	GEOM	
4		EPS1	var_4	4.5000000	5.0000000	5.5000000	GEOM	
5		GAP	var_5	1.3500000	1.5000000	1.6500000	GEOM	
6		EPS2	var_6	0.9000000	1.0000000	1.1000000	GEOM	
7	V	TMOBILE	var_7	21.752604	21.952604	22.152604	GEOM	
8		DCC	var_8	4.5000000	5.0000000	5.5000000	GEOM	
9		AT	var_9	1026.6109	1027.6109	1028.6109	PHYS	

c. Edit Lower and Upper Bounds:

```
TCORE, WCOIL, HCOIL, TMOBILE: ±0.2 ; AT: ±1
```

Lower Bou	und	Nominal	Upper	Bound	Comment		
21.608892		21.808892	22.00889		GEOM .		
16.109763		Lower Bour	nd	1	Nominal	Upper I	Bound
31.367942		21.608892		21.80889	2	22.008892	
4.5000000		Set Range					
1.3500000							
0.9000000		Percent:) +/-
21.752604							
4.5000000		Value:	0.2				+/-
1026.6109							
					ОК	Cancel	Apply

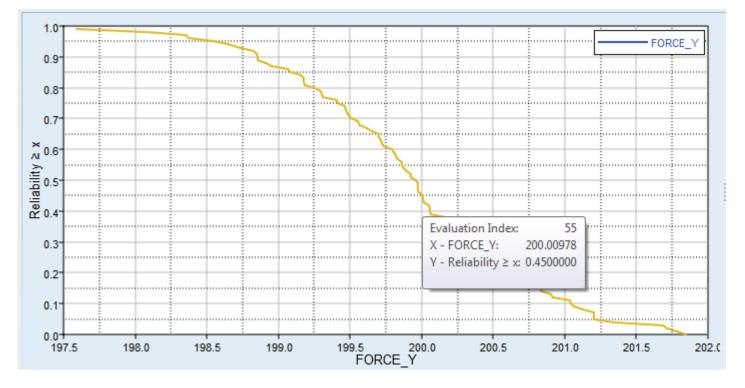
3. Go to **Specifications**.



Select Hammersley with 100 runs. Apply, then Next.

- 4. Evaluate Tasks.
- 5. Go to Post Processing.

In the **Reliability Plot** tab you can check what is the reliability (in %) to have **FORCE_Y**=200 N.





3.5 Export study archive

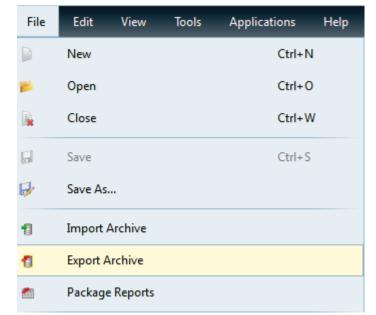
Introduction

In order to store your study in reduced file size, or to be able to share it easily with a colleague, you can use the **Export Archive** functionality available in HyperStudy. It allows creating archives by packaging all the files used in the study. Once imported in HyperStudy such an archive allows restoring the complete study as it has been done initially.

Procedure

In order to export an archive you need to do the following steps:

1. Go to menu File and click on Export Archive.



2. Give a name (by default the name of the HyperStudy xml study is taken).

Study_1.hstx	
Study archive (*.hstx)	

3. Click on Save.

It creates an hstx file in the working directory.

