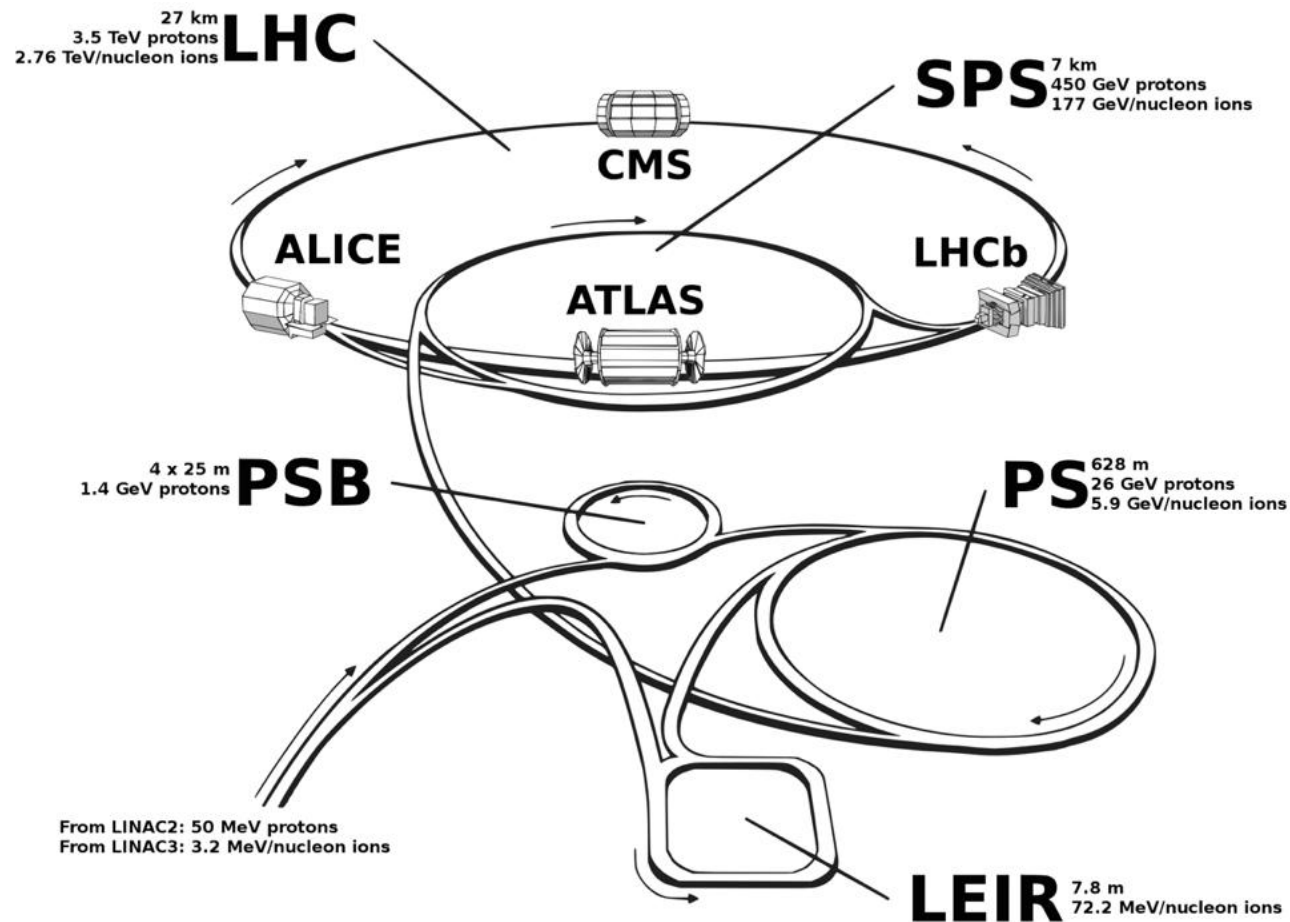


Software pentru standul de încercări al motoarelor pas cu pas folosite în LHC la CERN



ENGINEERING
DEPARTMENT



GREC LUCIAN MIRCEA

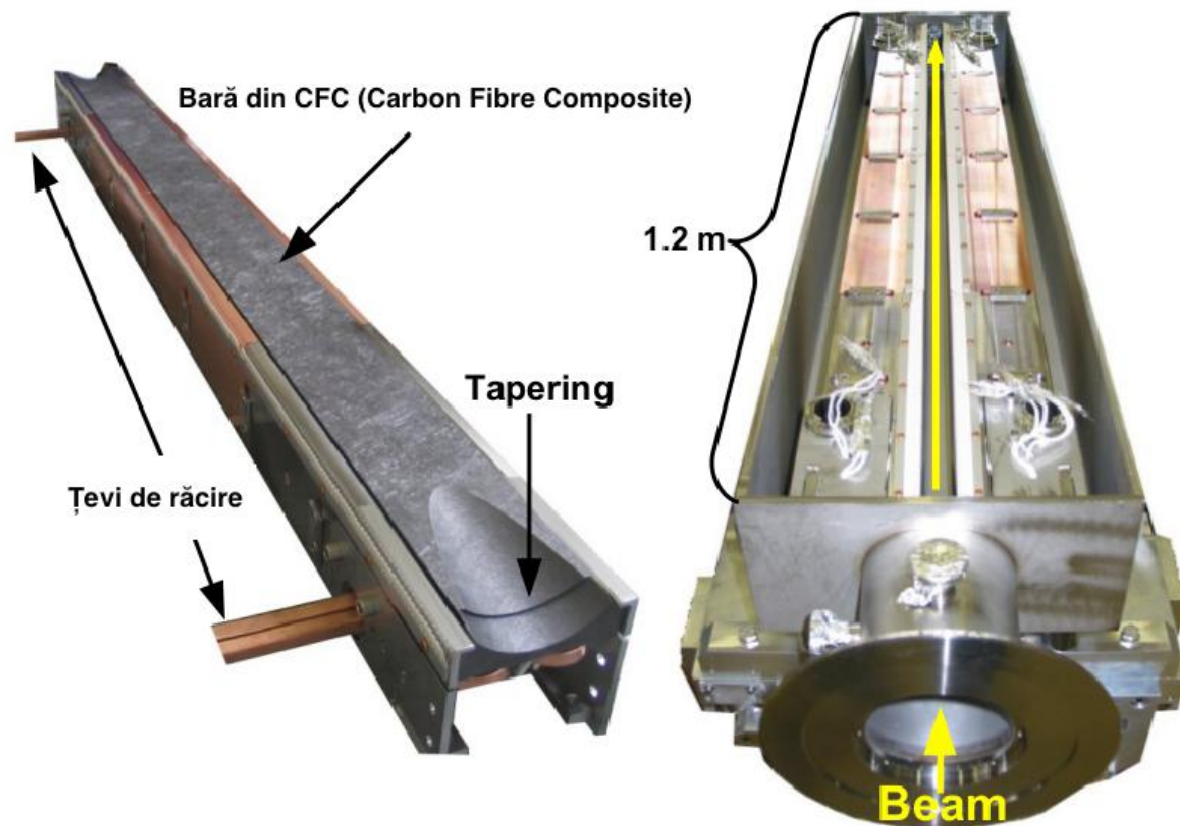
iunie 2016

Cuprins

- Introducere
- Colimatoare
- Standul de testare al plăcilor de comandă pentru motoare pas cu pas
- Test 1 - "Steps test"
- Test 2 - "Currents test"
- Test 3 - "Repeatability test"
- Test 4 - "Transient test in FOC"
- Secvența de automatizare a testelor
- Concluzii



Colimatoarele



Colimator cu 2 bare

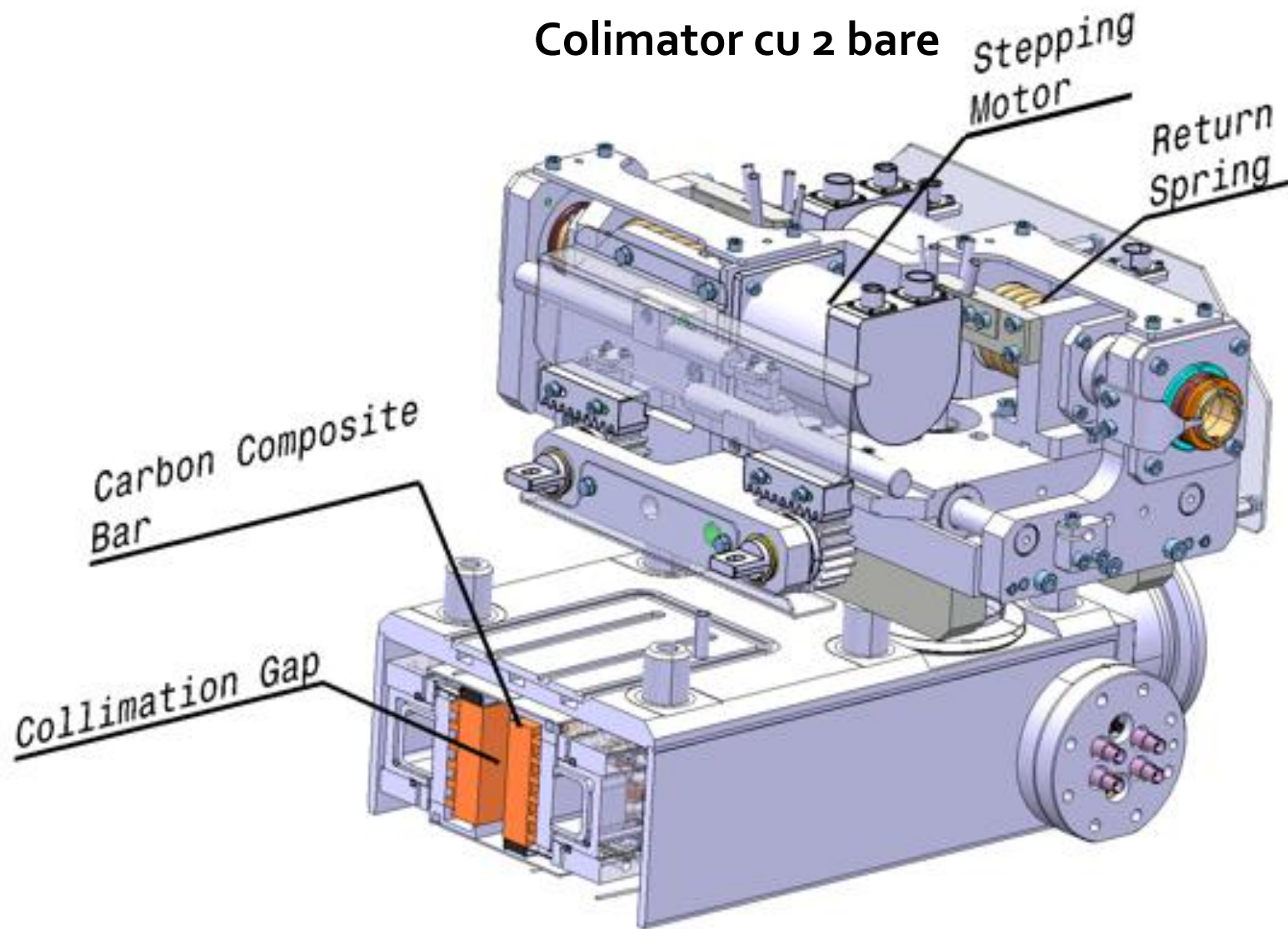
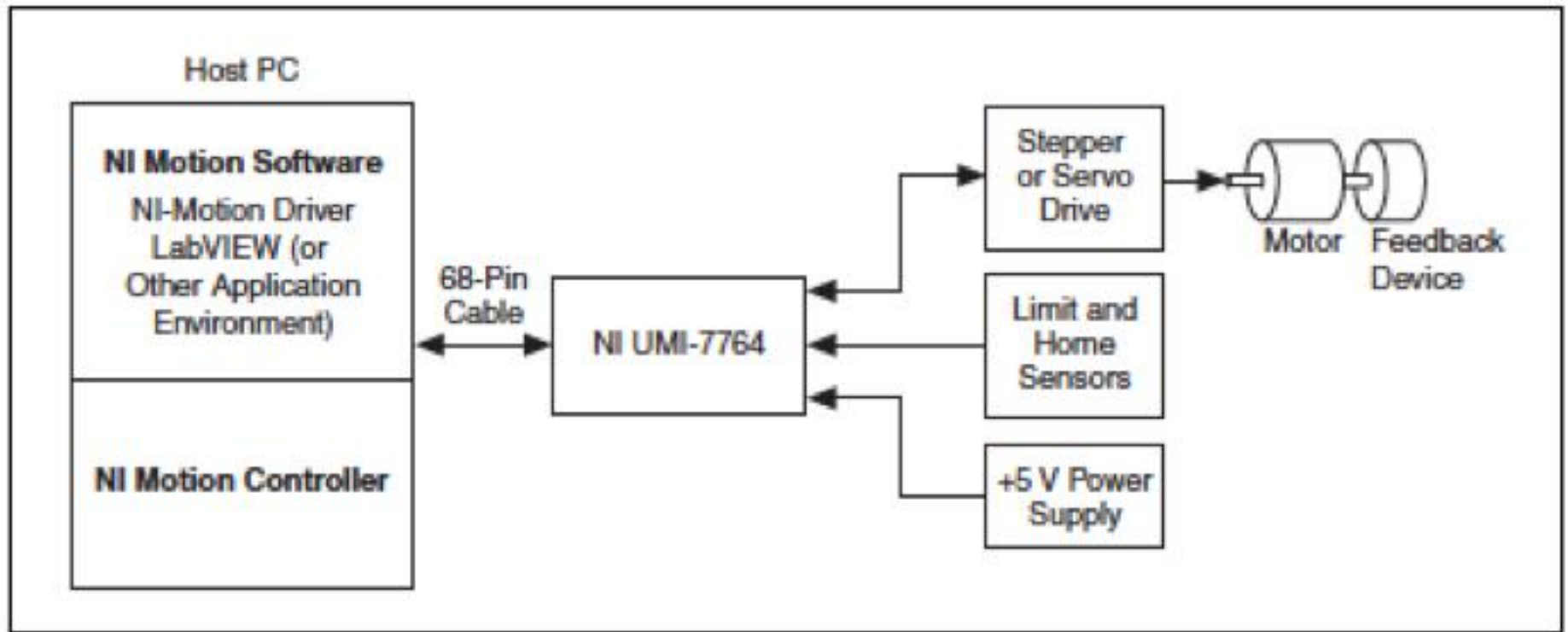
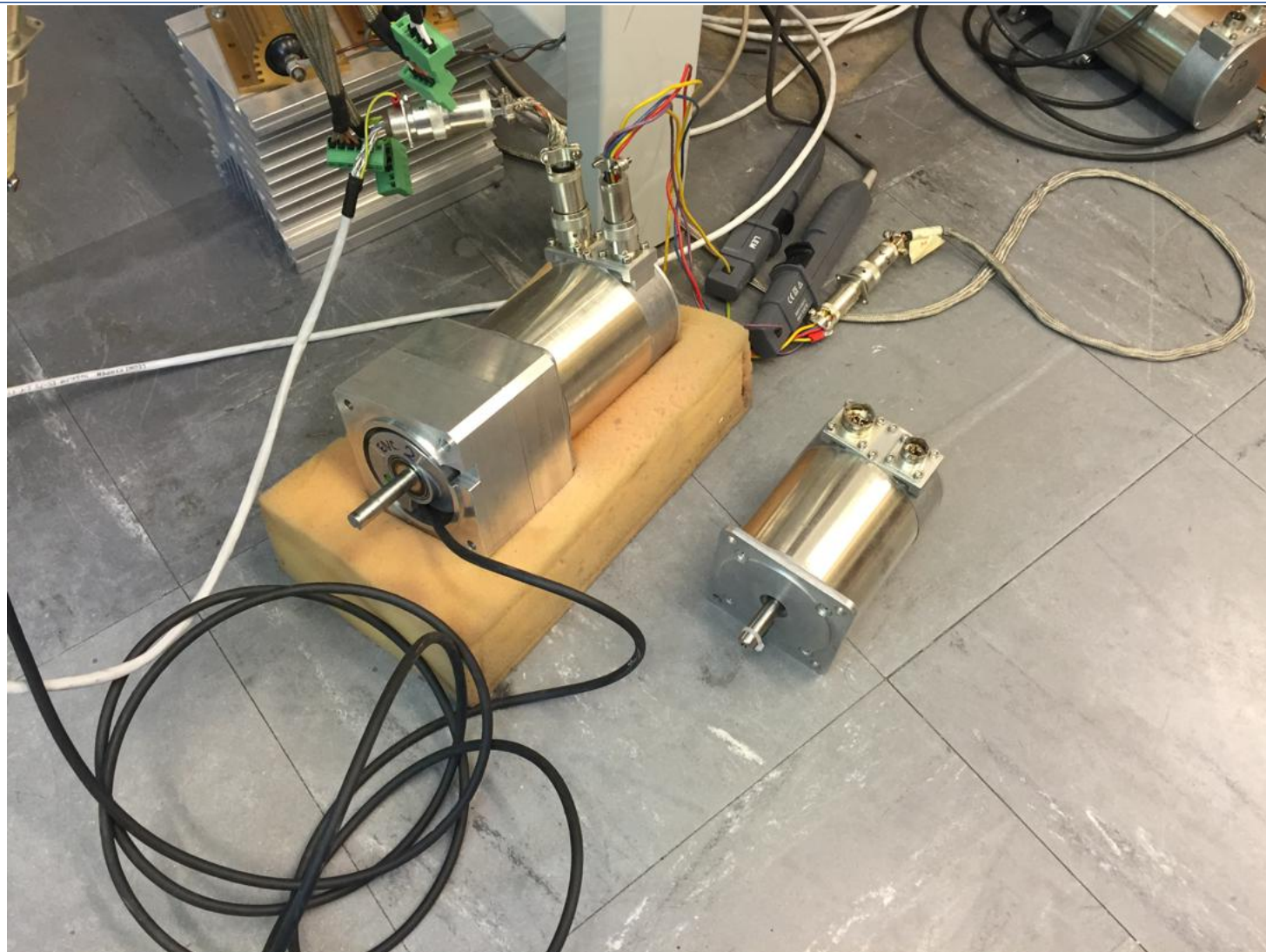


Diagrama bloc a standului de teste

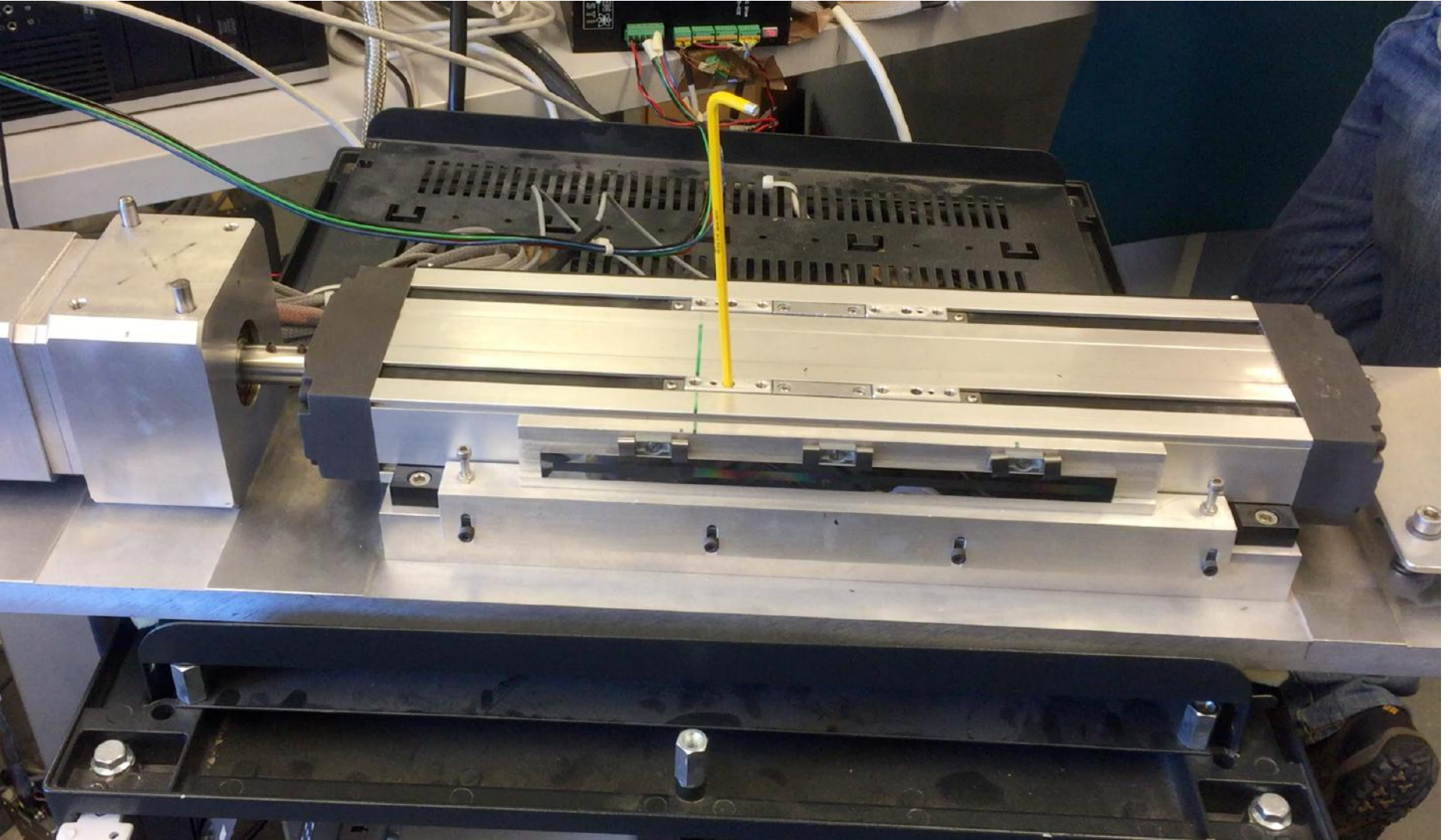


Motorul folosit cu traductorii de curent





Alternare între modul de comandă standard și control vectorial-FOC



Panoul de configurare

Operational

Tests

Connection

Configuration

Park Transform

DSP Communication

Manual Control

Test control

Temperatures

Plot Tests

Code Tools

Linear testbench

o change online

h H-tuning

f foc

OPERATION

Code Version

R

55

Stepping Mode

W

-1

R

-1

o

Third Harmonic (%)

W

120

R

120

o

Iref (mA)

W

1000

R

1000

o

h

Drive Working Mode

W

STD

R

FOC

o

Cable length (m)

W

720

R

-1

State of the main drive SM

R

MAIN_SM_INIT

0

State of the drive running SM

R

ST_HOLD

0

Current state of the acquisition

R

NO_ACQ_REQUEST

0

Find encoder index result

R

EXECUTING

1

Theta_0 calibration result

R

EXECUTING

1

ACQUISITION

Acquisition Type

W

3

R

20

o

Slow acquisition - Wait cycles

W

1

R

1

CURRENT CONTROLLER PARAMETERS

Controller Leq (*1e-4 H)

W

300

R

300

T chopping (kClks)

W

3000

R

3000

Bcl (Hz)

W

1300

R

1500

T controller (*1e-6 s)

W

40

R

20

Filter Leq (*1e-5 H)

W

1140

R

1794

AA Filter Freq (Hz)

W

8000

R

20

CABLE PARAMETERS

Motor Rw + Conn. R (mOhm)

W

3700

R

3700

h

Cable R (*10 mOhm/km)

W

2300

R

2300

h

Cable L (*0.1 mH/km)

W

6

R

6

Cable C (*0.1 nF/km)

W

487

R

487

LIMITS

Temperature Limit (C)

W

80

R

80

Phase Current Limit (*0.1 A)

W

60

R

60

Power S. Current Limit (*0.1 A)

W

60

R

60

Voltage Limit (V)

W

150

R

150

Voltage Supply Threshold (V)

R

6553!

ENCODERS

Encoder 1 - Theta 0

W

720

R

720

o

Encoder 2 - Theta 0

W

720

R

720

o

Encoder 1 - N bits

W

20

R

20

oo

Encoder 2 - N bits

W

20

R

20

oo

Encoder used

W

20

R

20

Apply R2E comp. table

W

No

R

No

o

R2E comp. table successfully applied

R

No

MECHANICAL CONTROLLER PARAMETERS

Mec. Controller Freq (Hz)

W

20

R

20

Max I_q (mA)

W

20

R

20

f

o

Max Speed (*0.1*mec. turns/s)

W

20

R

20

f

o

I_d (mA)

W

20

R

20

f

o

Theta error instability limit [0.001*deg]

W

300

R

1

o

Theta error threshold [0.001*degrees]

W

720

R

1

o

Filter Order

W

2

Cutoff freq (Hz)

W

1000

Mec. Controller K

0.10387821496

20

Mec. Controller C1

0.0001665478

20

Mec. Controller C2

0.03206596524

20

Mec. Controller C_Theta

80.39409637451

20

ERRORS

150

Error Log

0

0

0

0

0

0

0

0

0

0

Clear Log

WARNINGS

6553!

Warning Log

0

0

0

0

0

0

0

0

0

0

Clear Log

Ack. warning

Override current warning

Read warnings and errors

(A) Phase A Current

20

(A) Phase B Current

20

(A) I_q

20

(A) I_q_ref

20

θ (Rad||Turns)

20

20

ω (Rad||Turns/s)

20

20

(A) Max Phase A Current

20

(A) Max Phase B Current

20

(A) Max I_q

20

(A) Max I_q_ref

20

(Rad||Turns/s) Max ω

20

20

RESET Max Values

ACTIONS

Driver Address

1

Change Working Mode

Measure Cable Length

Calib. Theta 0

Find Enc. Index

Launch Test

0

R

60

Test step iq time limit[ms]

W

8000

R

1

Test step iq theta limit[turns]

W

5

R

1

Edit Aux 1

W

0

R

0

Edit Aux 2

W

0

R

0

Edit Aux 3

W

0

R

0

Edit Aux 4

W

0

R

0

ModBus Register

RUN_COMMAND_ADDRESS

Write value

1

Edit register

Read value

1

Read register

Reconfigure Upon Next REBOOT

Location of searching file

G:\Departments\AB\Groups\

Configuration OK?

Communicating

NEW CONFIGURATION

Edit all (1)

Save file from DSP

Save file from GUI

Read all (2)

Load file to DSP

Load file to GUI

FULL CONFIGURATION

Software Enable

Software Disable

Refresh

RESET DSP (SW)

Start Acquisition

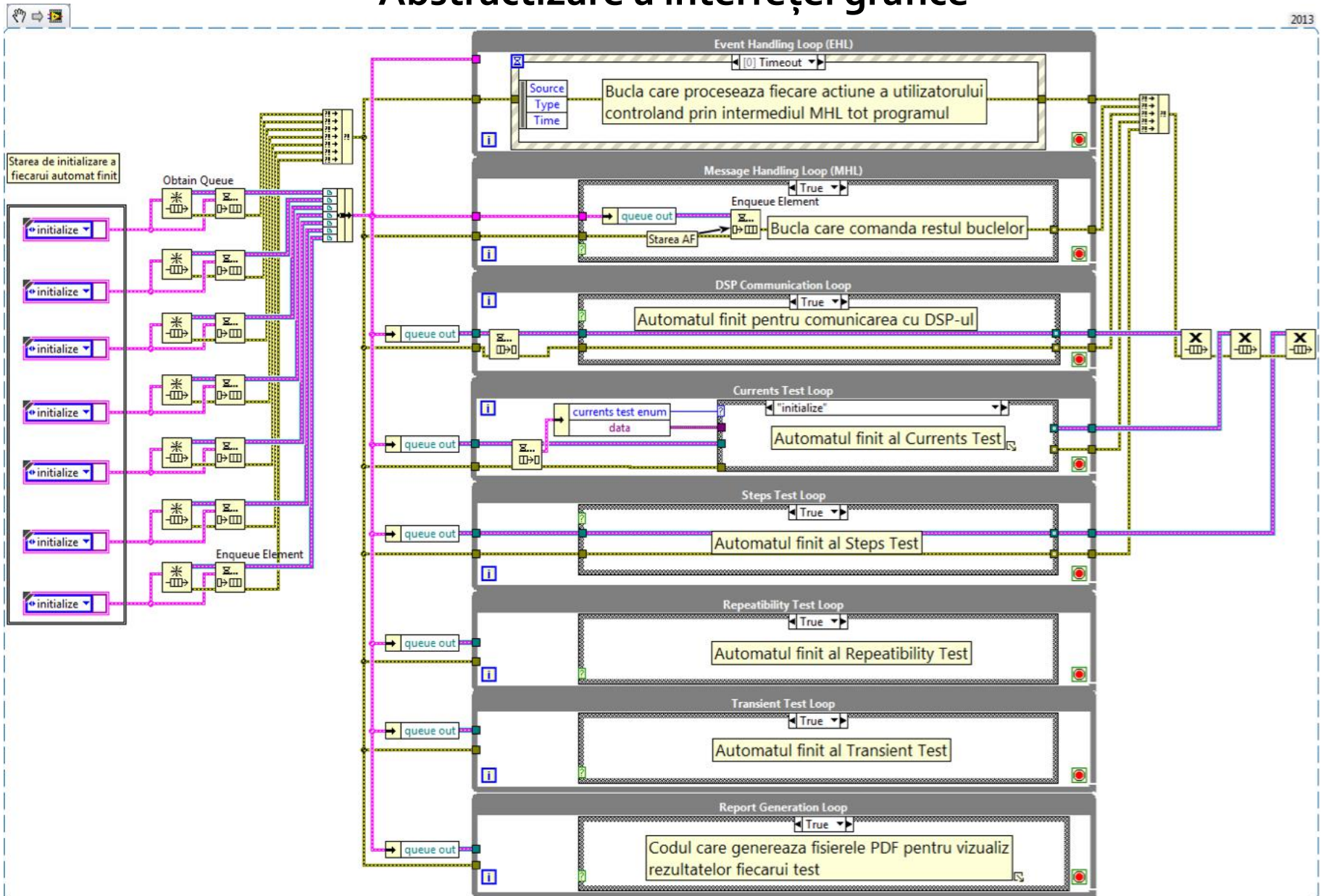
RUN 200

HALT

KILL

Abstractizare a interfeței grafice

2013



Testul 1 - "Steps test"

Operational

Tests

Multi-test

Steps Test

Curents Test

Repeatability Test

Transient Test

Steps Test: sends the steps sequence configured in the table "Steps Test Parameters" to the motor.
1. After the driver is fully configured, click the button "Start Steps Test"
2. Wait until all the data are saved and the test finishes.

▶ Start Steps test

■ STOP the test

S.Test Active

Tests
1

Cycles
0

Next state
idle

Steps Test Parameters

Step mode	Turns/s	Turns	Stop time[s]	Step length[ms]	
0 half	10ms	2	2	0	3

Nr of tests
2

Nr of Cycles
1

Encoder (number of bytes)
16

timeout of 1 test [s]
10

Step no. limit ± 32000
if SW stepping is used

☒ SW stepping

☐ Alternate STD/FOC

☐ Continuous cycle

☒ Generate report after test

File to store data
G:\Departments\AB\Groups\ATB\LP\Equipment Controls\Step
Motor Driver\Working folder\Lucian\GUI with modifications\GUI
V4.1 - Project\data

Load test

Test Error
No Error

Error when saving

Report comments: 3
Comment Example

Rezultatul testului 1 - "Steps test"

DSP Configuration	
Parameters	Values
3rd harmonic [%]	12.0
Code version	169
Cable length [m]	0
Iref [A]	2.0
Tchopping [kClks]	3000
TController [s]	4.000000E-5
Temp limit [C deg.]	80
Voltage limit [V]	160
Current limit	7.0
Theta-0	11439

Test Configuration	
Parameter	Value
N. Tests	4
N. Cycles	4

Comments:
Comment Example

Test	Stem Mode	Step Mode target (deg)	Speed (turns/s)	N. Turns	Target (deg)	Mean achieved (deg)	Error				
							Mean (deg)	Std (deg)	Max (deg)	Min (deg)	N. Cycles
1	Full Step Mode (1Phase)	1.8	2	20	7200	7199.80	-0.19501	0.02080	-0.16479	-0.20874	4
2	Half Step Mode	0.9	2	-20	-7200	-7.20E+03	0.15106	0.00549	0.15381	0.14282	4
3	Quarter Step Mode	0.45	2	20	7200	7199.88	-0.11810	0.00549	-0.10986	-0.12085	4
4	4000 Step Mode	0.09	2	-20	-7200	-7.20E+03	0.17303	0.00549	0.17578	0.16479	4

User:
Date: 02/19/2016

Steps Test

Equipment, Controls and Electronics Section
EN-STI Group



Testul 2 - "Currents test"

Operational
Tests

Multi-test
Steps Test
Currents Test
Repeatability Test
Transient Test

Test
Get statistics

Currents Test: executes the currents test according to the information filled in in the array below

Start the currents test
STOP the test
C.Test Active
oscilloscope next state
idle

Currents Test Parameters

Step Mode
Step length[ms]
Steps

0
full 1 phase on (-1)
200ms
40
5

timeout of 1 test [s]
Generate report after test
SW stepping
SW stepping only works when acquiring through the DSP

Current measurement from:
DSP
Oscilloscope

Iref[mA]
2830

Variables names

Ch1	Ch2	Ch3	Ch4
ImotA	ImotB	step	

Oscilloscope channels

Channel (0: Channel 1)	Channel (0: Channel 1)	Channel (0: Channel 1)	Channel (0: Channel 1)
Channel 1 0	Channel 2 1	Channel 3 2	Channel 1 0
Vertical Coupling (0: A1M) D1M 1	Vertical Coupling (0: A1M) D1M 1	Vertical Coupling (0: A1M) DC 4	Vertical Coupling (0: A1M) DC 4
Probe Attenuation (-1) 1	Probe Attenuation (-1) 1	Probe Attenuation (-1) 1	Probe Attenuation (-1) 10
Vertical Offset (0.0 V) 0	Vertical Offset (0.0 V) 0	Vertical Offset (0.0 V) 0	Vertical Offset (0.0 V) 0
Vertical Range (0.0 V) 7	Vertical Range (0.0 V) 7	Vertical Range (0.0 V) 30	Vertical Range (0.0 V) 5
☒ active	☒ active	☒ active	☐ active

Trigger

Trigger Level (0.0 V) 5
Trigger Slope (0: Rising) Rising 0
Trigger Source (0: Channel 1) Channel 3 2

Oscilloscope name

TCP/IP0::169.254.218.74::inst0::INSTR
Max sampling rate 1MS/s
Folder name data

File to store data

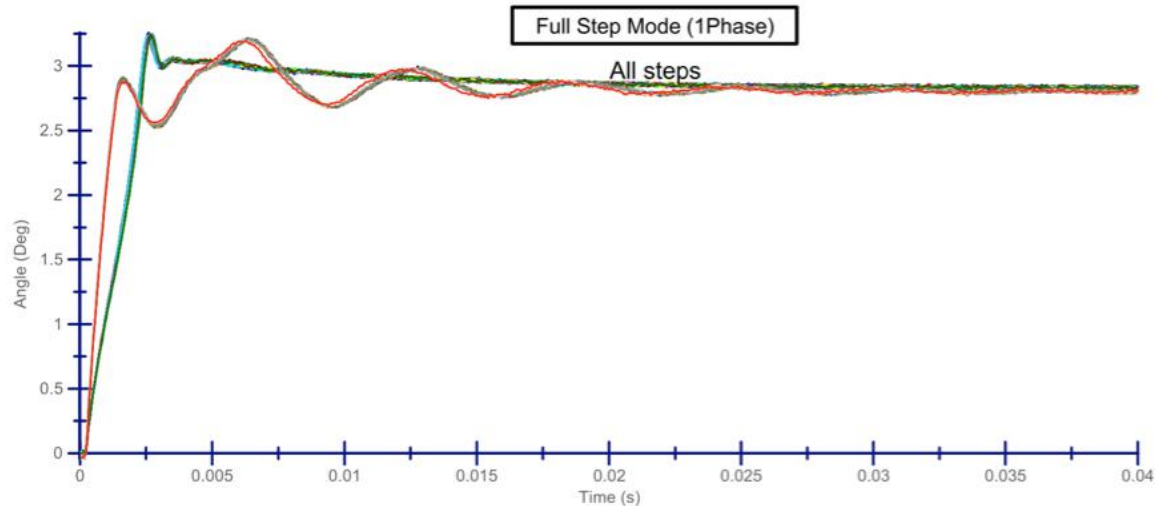
G:\Departments\AB\Groups\ATB\LP\Equipment Controls\Step Motor Driver\Working folder\Lucian\GUI with modifications\GUI V4.1 - Project\data

Software Enable
Software Disable
Refresh
RESET DSP (SW)
Start Acquisition
RUN 200
HALT
KILL

Rezultatul testului 2 - "Currents test"

DSP Configuration	
Parameters	Values
3rd harmonic [%]	12.0
Code version	169
Cable length [m]	0
Iref [A]	2.8
Tchopping [kCiks]	3000
TController [s]	4.000000E-5
Temp limit [C deg.]	80
Voltage limit [V]	160
Current limit	7.0
Theta-0	11439

Test Configuration	
Parameter	Value
Step Mode	Full (1Phase)
Time length	200ms
Stepping rate	40



Index	Overshoot (%)	Rise Time (ms) (10-90%)	Settling Time (ms) (within 5% final value)	Error's RMS (Deg)
Av.	13.489	1.357	9.676	0.057
Max	14.440	1.880	13.400	0.082
Min	12.010	0.880	5.880	0.031

User: L.Grec
Date: 02/19/2016

Currents Test
Equipment Controls and Electronics Section
EN-STI Group



Testul 3 - "Repeatability test"

Operational Tests

Multi-test Steps Test Currents Test Repeatability Test Transient Test

Stepper Test: sends the steps sequence configured in the table "Stepper Test Parameters" to the motor.
 1. First, configure the driver in the tab "Configuration"
 2. After the driver is fully configured, click the button "Start the stepper test"
 3. Wait until all the data are saved and the test finishes.

Repeatability Test Parameters

Step Mode	Velocity	Direction	Steps	Step length
0 full 1 phase on (-1)	200	1	10	3
full 1 phase on (-1)	200	-1	10	3
half	400	1	400	0
half	400	-1	400	0

Final Position (Deg) 0.00

Nr of tests 2
 Nr of Cycles 1
 timeout of 1 test [s] 10
 Test Error 2 No Error

Waiting time (ms) 20
 Mean encoder position:
 N Samples 20 dt (ms) 1

Generate Report after Test
☒ SW stepping

Error when saving ☐
 Report comments:
 Comment Example

Start Repeatability test STOP the test R.Test Active Tests 5 Cycles 2 oscilloscope next state 2 idle

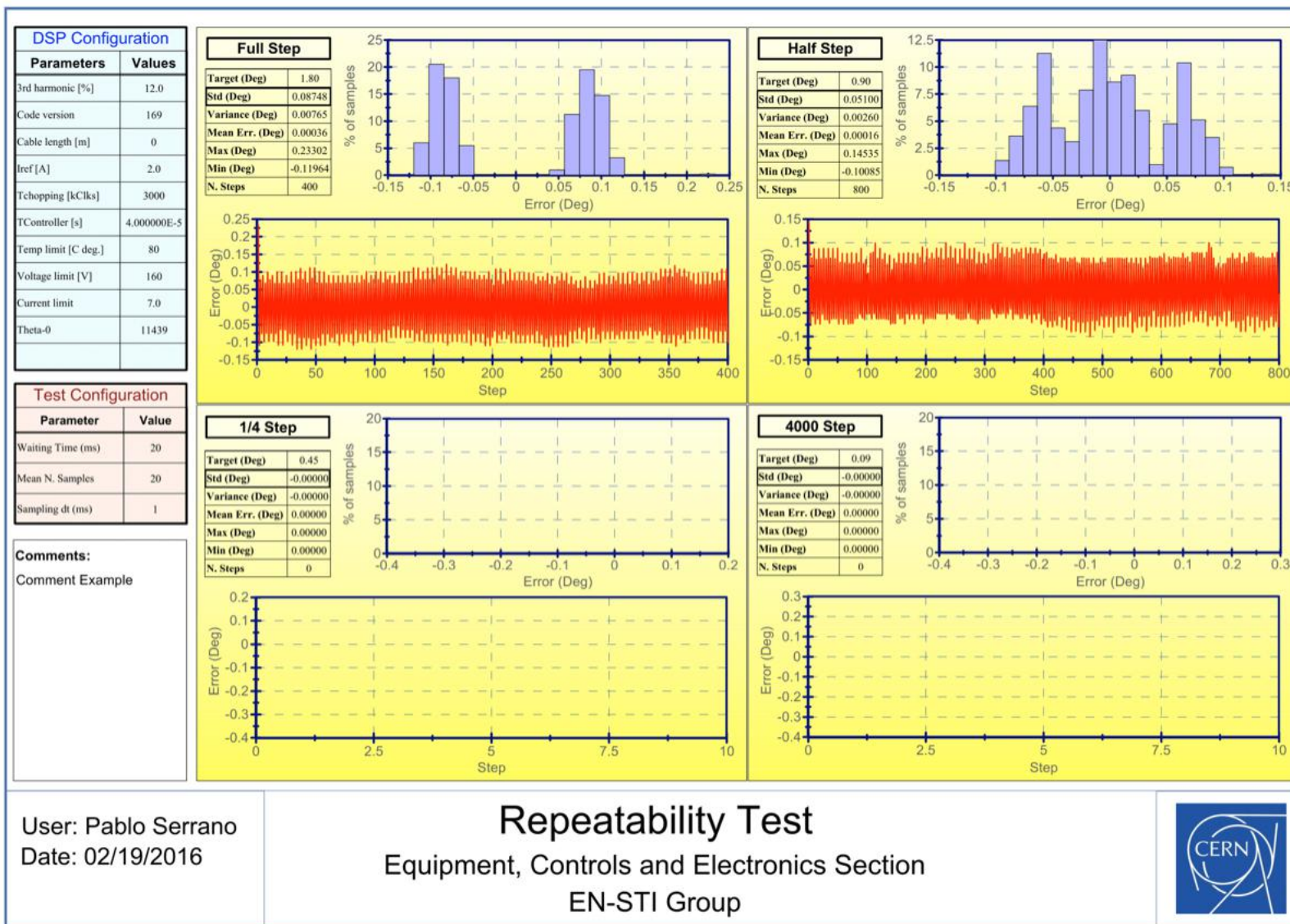
Encoder Position (Deg) vs Step number Plot 0

Error (Deg) vs Step number Plot 0

G:\Departments\AB\Groups\ATB\LP\Equipment Controls\Step Motor Driver\Working folder\Lucian\GUI with modifications\GUI V4.1 - Project\data

Software Enable Software Disable Refresh RESET DSP (SW) Start Acquisition RUN 200 HALT KILL

Rezultatul testului 3 - "Repeatability test"



Testul 4 - "Transient test in FOC"

Operational Tests

Multi-test Steps Test Currents Test Repeatability Test **Transient Test**

Stepper Test: sends the steps sequence configured in the table "Stepper Test Parameters" to the motor.
1. First, configure the driver in the tab "Configuration"
2. After the driver is fully configured, click the button "Start the stepper test"
3. Wait until all the data are saved and the test finishes.

Start Transient test **STOP the test** T.Test Active Tests 6 Cycles 3 oscilloscope next state 3
1 0 idle

Transition Test Parameters

Step Mode	Velocity	Steps	Repetitions	St.Length[ms]
0 full 1 phase on (-1)	200	1	10	0
full 1 phase on (-1)	200	-1	10	0
half	400	1	100	0
half	400	-1	100	0

Nr of tests: 2
timeout of 1 test [s]: 10
Encoder counts/rev: 32768

☐ Continuous cycle
☐ Enable Capture (Oscilloscope)
Capture time (ms): 100 (max 1000 ms)
Mean encoder position:
N Samples: 100 dt (ms): 1
☒ Generate Report after Test
☐ SW stepping

Report comments: 2
Comment Example

Transient Graph

Angle(deg)

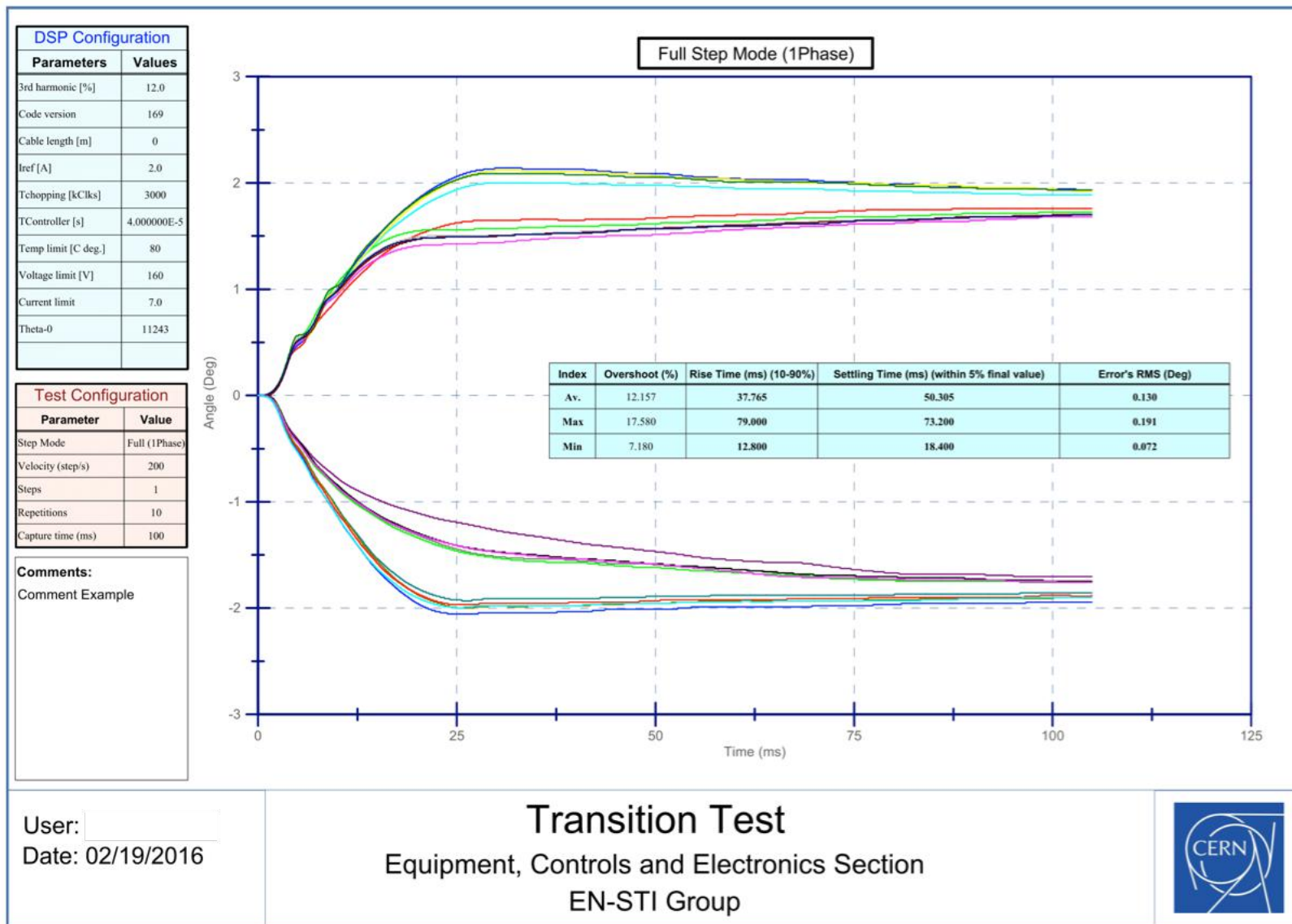
Time[ms]

Plot 0 Plot 1 Plot 2 Plot 3 Plot 4 Plot 5

File to store data
G:\Departments\AB\Groups\ATB\LP\Equipment Controls\Step Motor Driver\Working folder\Lucian\GUI with modifications\GUI V4.1 - Project\data

Software Enable Software Disable Refresh RESET DSP (SW) Start Acquisition RUN 200 HALT KILL

Rezultatul testului 4 - "Transient test in FOC"



Secvența de automatizare a testelor

