Institutul Național de Cercetare-Dezvoltare pentru Fizică și Inginerie Nucleară „Horia Hulubei”

Sistem de poziționare micrometrică cu control de la distanță

LHCb Romania | www.nipne.ro/dpp/Collab/LHCb/

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Ședință de grup

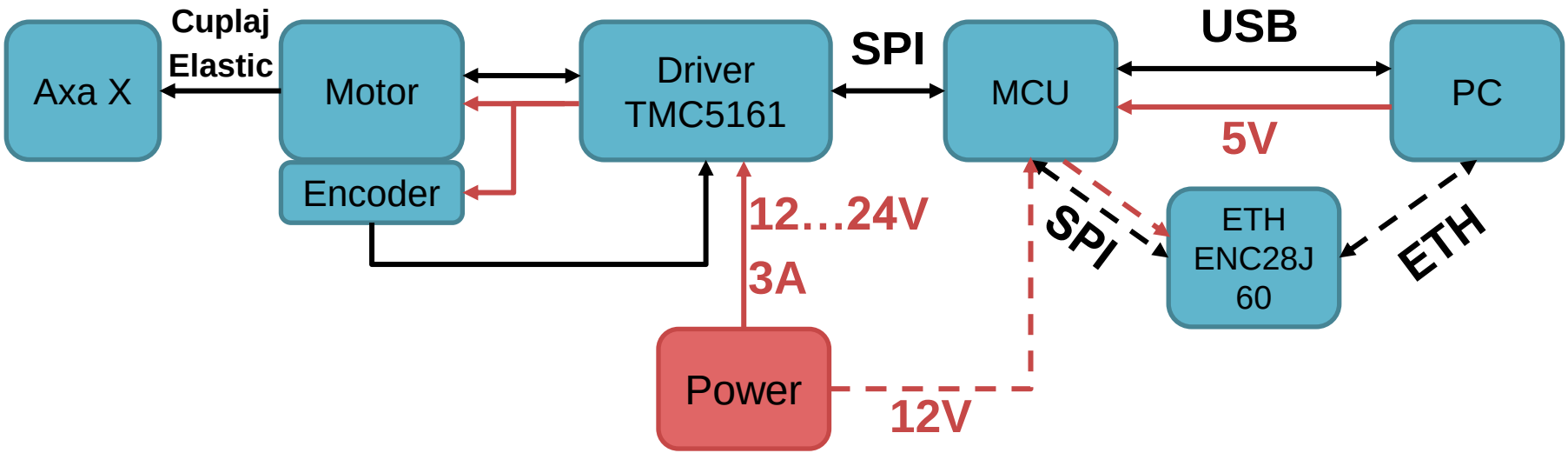
26.08.2022

Cuprins

Motivația temei

- Implementarea unui sistem de poziționare cu control la distanță pentru alinierea cu precizie micrometrică a dispozitivelor supuse testării cu fascicolul de particule sau laser.
- Soluția abordată constă într-un sistem mecanic cu șurub, cuplat la un motor controlat de modulul TMC5161 Motion Controller, ambele produse de Trinamic.

Schema Bloc


Axa X
Cuplaj Elastic
Motor
Encoder
Driver TMC5161
SPI
MCU
USB
PC
5V
12…24V
3A
Power
12V
SPI
ETH ENC28J 60
ETH

Hardware

Specificații mecanice (axa X)

- Diametru șurub – 16 mm
- Pas șurub – 0.5 mm
- Lungime ghidaj – 1 m

Encoder TMCS-40-6.35-10k-AT-01

- Rezoluție – 40 000 incrementări
- Tensiune alimentare – 5 V DC
- Curent – 110 mA

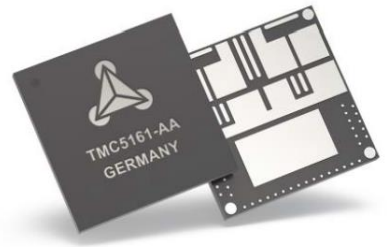
Motor QSH5718-76-28-189-10k

- 200 pași/rotație -> 1.8°/pas
- Microstepping – max 256 micropași
- Cuplu – 189 Ncm
- Curent – 2.8 A max

Hardware – cont.

Driver TMC5161

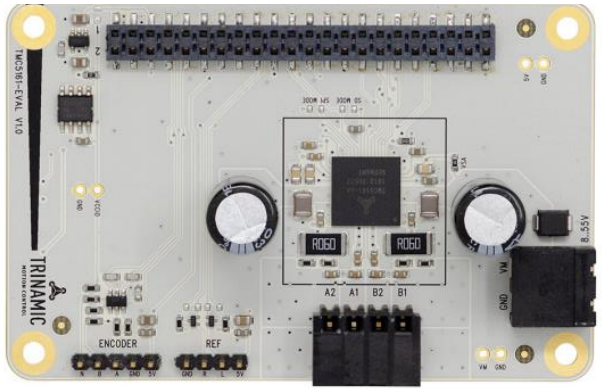
- Soluție HW produsă de Trinamic
- Curent motor – 3.5 A max
- Tensiune alimentare – 8..40 V DC
- Interfață SPI/UART
- SixPoint Ramp motion controller
- StealthChop silent PWM mode
- SpreadCycle smart mixed decay
- DcStep load dependent speed
- StallGuard2 load detection
- CoolStep automated current scaling



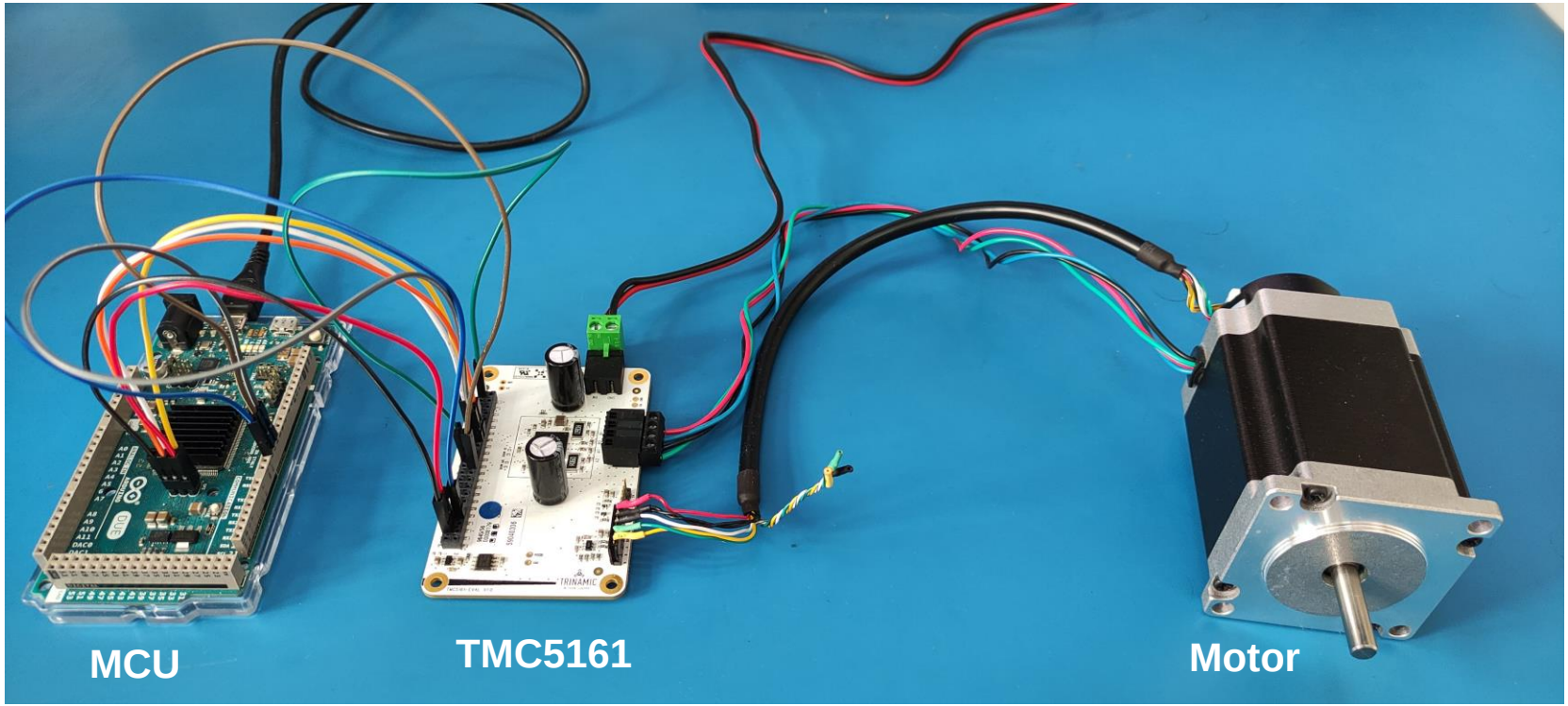
dcStep™

coolStep™

stallGuard2™



Hardware



Software

Firmware MCU

- Dezvoltat in Aduino IDE
- Bazat pe librăria open-source TMC-API dezvoltată de Trinamic
- Trimite instrucțiuni și primește date de la Driver prin intermediul interfeței SPI
- Arhitectura Firmware bazată pe State Machine

src > ic > C TMC5161.c > tmc5161_periodicJob(TMC5161TypeDef *, uint32_t)

```c
/*
 * TMC5161.c
 *
 *  Created on: 13.06.2017
 *      Author: LK
 */

#include "TMC5161.h"

// => SPI wrapper
extern void tmc5161_readWriteArray(uint8_t channel, uint8_t *data);
// <= SPI wrapper

void tmc5161_writeDatagram(TMC5161TypeDef *tmc5161, uint8_t address, uint8_t x1, uint8_t x2, uint8_t x3, uint8_t x4)
{
    uint8_t data[5] = { address | TMC5161_WRITE_BIT, x1, x2, x3, x4 };
    tmc5161_readWriteArray(tmc5161->config->channel, &data[0]);

    int value = x1;
    value <<= 8;
    value |= x2;
    value <<= 8;
    value |= x3;
    value <<= 8;
    value |= x4;

    // Write to the shadow register and mark the register dirty
    address = TMC_ADDRESS(address);
    tmc5161->config->shadowRegister[address] = value;
    tmc5161->registerAccess[address] |= TMC_ACCESS_DIRTY;
    tmc5161->SPIStatus = data[0];
}

void tmc5161_writeInt(TMC5161TypeDef *tmc5161, uint8_t address, int32_t value)
{
    tmc5161_writeDatagram(tmc5161, address, BYTE(value, 3), BYTE(value, 2), BYTE(value, 1), BYTE(value, 0));
}

int32_t tmc5161_readInt(TMC5161TypeDef *tmc5161, uint8_t address)
{
    address = TMC_ADDRESS(address);

    // register not readable -> shadow register copy
    if(!TMC_IS_READABLE(tmc5161->registerAccess[address]))
        return tmc5161->config->shadowRegister[address];

    uint8_t data[5] = {0, 0, 0, 0, 0};

    data[0] = address;
    tmc5161_readWriteArray(tmc5161->config->channel, &data[0]);

    data[0] = address;
    tmc5161_readWriteArray(tmc5161->config->channel, &data[0]);

    tmc5161->SPIStatus = data[0];

    return _8_32(data[1], data[2], data[3], data[4]);
}
```

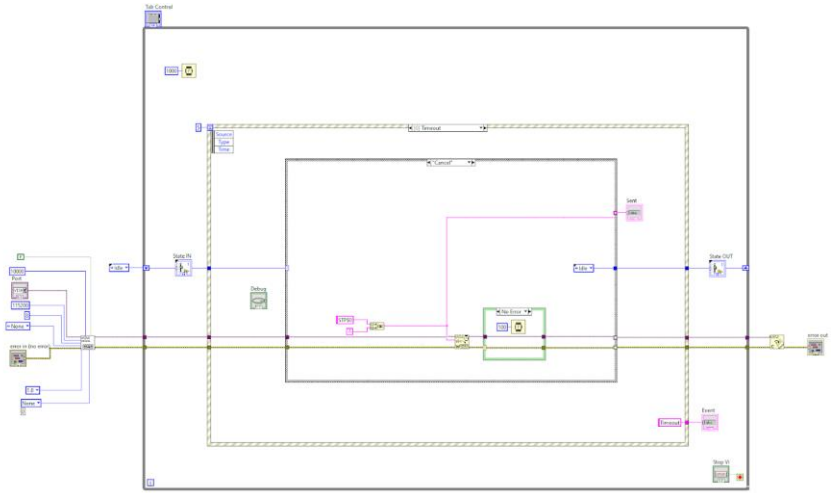
TMC-Pos-System.ino

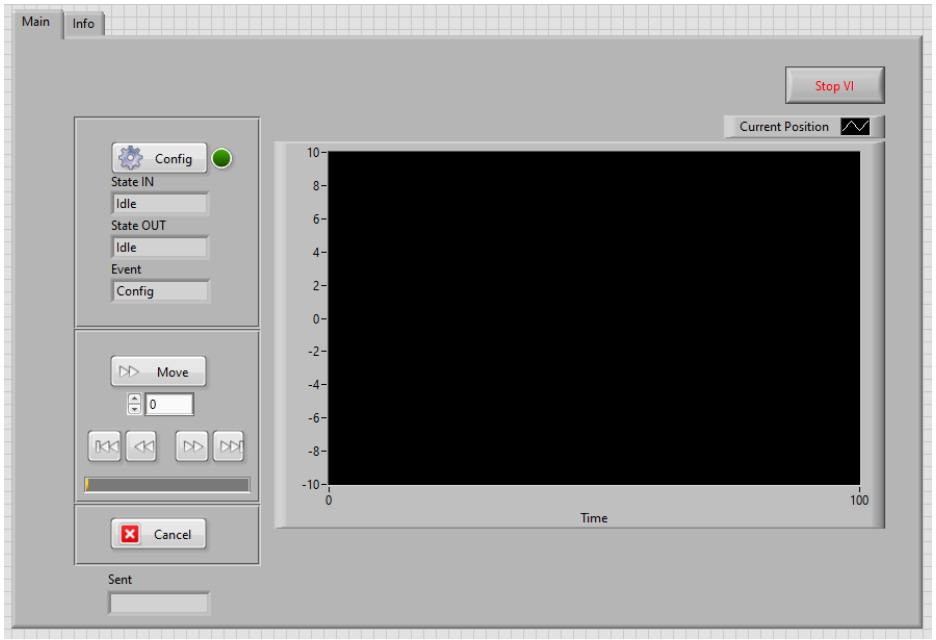
```c
#pragma once

extern "C" {
#include "src/ic/TMC5161.h"
}

#include <SPI.h>
#include <GOTStateMachine.h>

#define CS_1 4  //TMC5161 Chip Select
// #define CLKOUT 3  //Arduino Clock
#define DRV_EN 2    //Driver Enable
#define SPI_MODE 3  //SPI mode pin

//           Wiring
//Arduino Pins / Eval Board Pins
//   MOSI 32 SPI1_SDI         ORANGE
//   MISO 33 SPI1_SDO         YELLOW
//   SCK  31 SPI1_SCK         WHITE
//4  CS_1 30 SPI1_CSN         GREY
//2  DIO  8  DIO0 (DRV_ENN)   BLUE
//   DIO  23 CLK16            GREEN; use internal clk instead
//3  DIO  22 SPI_MODE         BROWN
//   GND  3  GND              BLACK
//   +5V  5  +5V              RED

//SPI Settings: clock speed 3MHz, MSB first, SPI_MODE3 (?; p.21)
SPISettings settings(4000000, MSBFIRST, SPI_MODE3);

//TMC-API "objects"
TMC5161TypeDef TMC5161;
ConfigurationTypeDef config;

//State machine object
GOTStateMachine stateMachine(50);

//State def
void stateSelfCheck();
void stateInit();
void stateIdle();
void stateMove();
void stateError();
void stateReset();
void stateShutdown();

static bool flagDebug;          //SPI transfer debug flag
static uint32_t VMAX = 200000;  //default VMAX, doesn't really to be changed
static bool flagInput = false;
```

Software – cont.

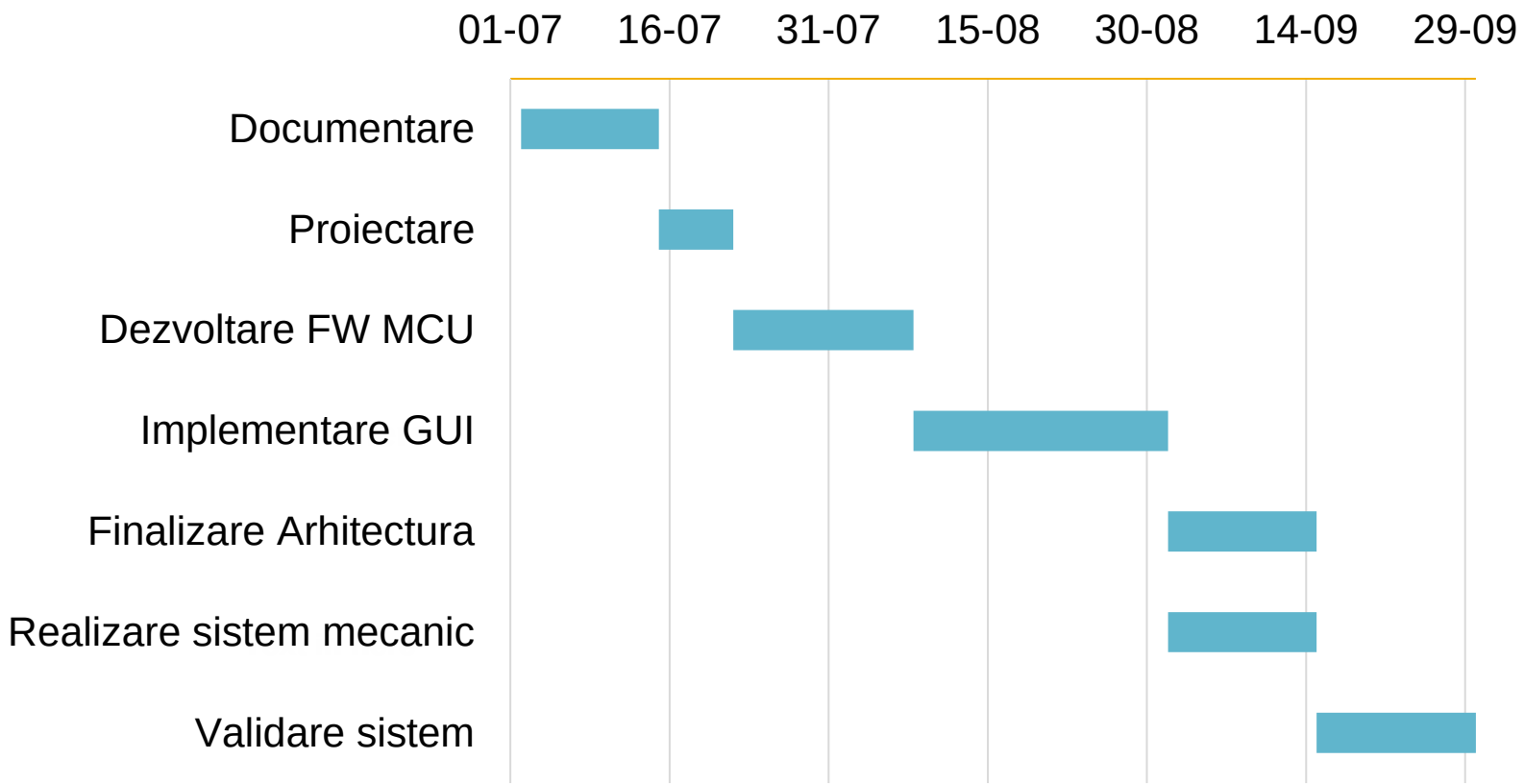
GUI

- Dezvoltat în NI LabVIEW
- Activitate in desfășurare, termen limită septembrie





Grafic Implementare



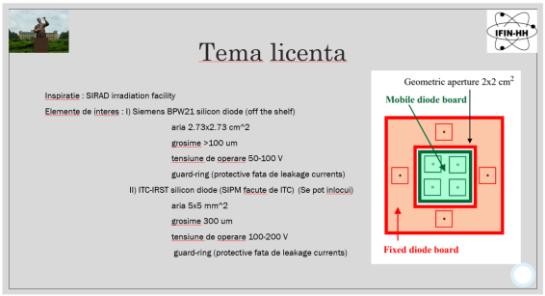
Concluzii

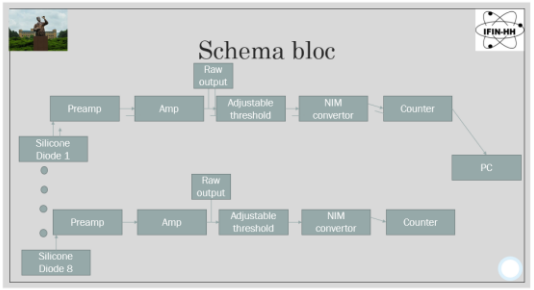
Lucruri învățate pe parcursul acestui proiect:

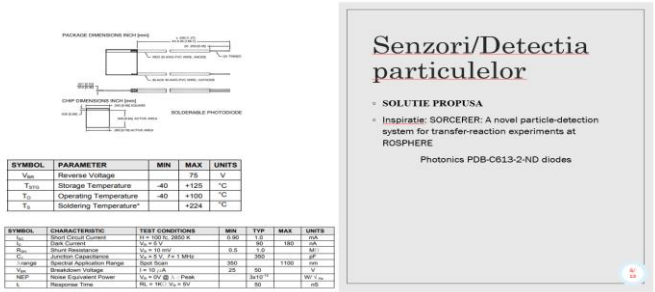
- Proiectarea și implementarea unei soluții complete
- Sisteme mecanice, problemele și soluțiile specific lor
- Adaptarea și completarea unei librării existente
- LabVIEW; limbaje de programare vizuale
- Organizarea și planificarea unui proiect

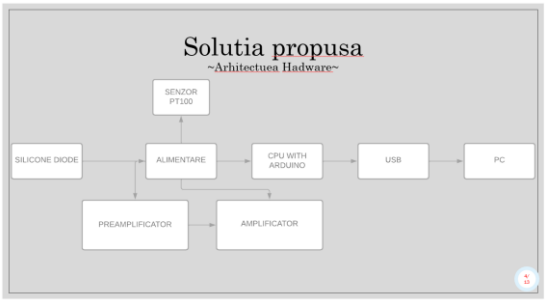
Direcții viitoare

- *Proiectare si implementare un sistem de monitorizare fascicol de particule accelerate*



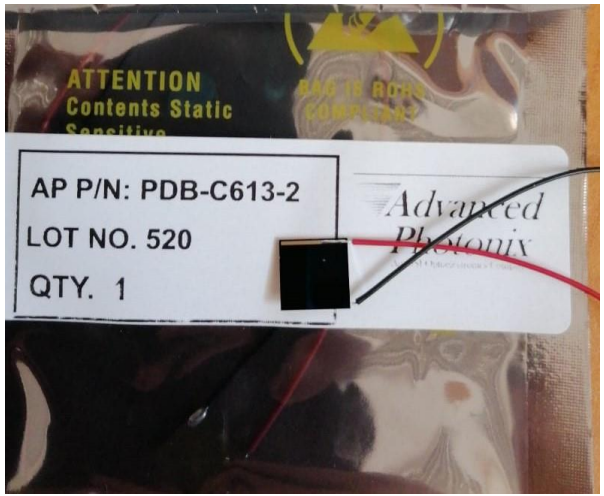






Slide-uri preluate cu acordul lui Radu JOMIRU din prezentarea Raport Activitate NOIEMBRIE

Direcții viitoare



Direcții viitoare

- *Documentare bibliografica (Octombrie-Noiembrie)*

Surse bibliografice:

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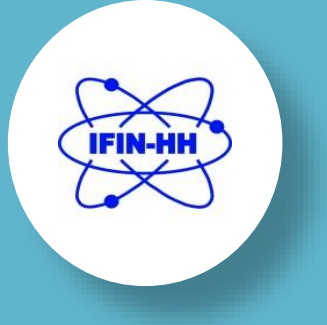

Vă mulțumesc pentru atenție!

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