

# TITLE: DEVELOPMENT OF ALGORITHM FOR CONTROLLING CALIBRATION SOURCE AND MEASURING TEMPERATURE OF THE SOURCE

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## ABSTRACT

*Digital Signal Processors (DSP) take real-world signals like voice, audio, video, temperature, pressure, or positions that have been digitized and then mathematically manipulate them. A DSP is designed for performing mathematical functions like add, subtract, multiply and divide very quickly. Signals need to be processed so that the information that they contain can be displayed, analyzed, or converted to another type of signal that may be of use and understand. In the real world, transducers detect signals such as sound, light, temperature or pressure and give analog signals. These analog signals are digitized and manipulate by DSP.*

*High temperature black body source is used as calibration Source in millimeter wave frequency range and this gives analog output. Digital Signal Processing converts the analog output in numerical form. In this paper; we have accomplished the interface of calibration source with PLC to control the calibration source and communication interface between PLC and CODAC core system to make a central Graphical User Interface. This GUI displays the temperature of thermocouples connected to calibration source and the set value temperature. The major challenges and issues are to integrate and communicate all controlling and measuring hardware as well as software and implement an algorithm for the calibration source.*

**Keyword:** - Calibration Source, Programmable Logic Controller (PLC), Siemens Step 7, CODAC (Control Object, Data, Access and Communication) Core System.

## 1. INTRODUCTION

The Electron Cyclotron Emission (ECE) diagnostic is being designed and developed to be used for the ITER project located in southern France for the measurements of plasma electron temperature profile with good spatial and temporal resolutions and to obtain information on non-thermal electron populations and the power loss due to ECE.

The calibration source is used as temperature source for ECE diagnosis. Thermocouples are connected at various distances on the hotplate to check the temperature of the surface at various points. I have implemented one algorithm to control the temperature of this hot plate with the help of one software.

To make such software to control and monitor the calibration source, first, the controller hardware of the calibration source is connected to the PLC through Ethernet.

Now, the next step is to make a project in CODAC Core System which generates all monitor signals as well as one control signal and the Graphical User Interface (GUI). So, it can be used as the controlling and monitoring software for calibration source.

After completion of the project, it is copied in the CPU of the PLC. Then one algorithm is created and implemented in Siemens Step 7 software which is the software for PLC programming.

Calibration source has its own hardware controller which is used to control, monitor and operate the hardware but to facilitate remote, safe, reliable and standalone or synchronized mode of operation of the ECE diagnostic system (with ITER Central Control Systems).

## 2. THEORITICAL WORK

### 2.1 Hardware and Softwares

The hot body calibration source consists of three main parts; an emissive surface, a heating element and surface measurement arrangement. The emissive surface shall be fabricated separately. A high temperature hot plate available in the market shall be used as a heating element and there shall be a provision for the surface temperature measurement inside this hot plate.

A PLC is an industrial computer control system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices. Almost any production line, machine function, or process can be greatly enhanced using this type of control system. However, the biggest benefit in using a PLC is the ability to change and replicate the operation or process while collecting and communicating vital information. Another advantage of a PLC system is that it is modular. That is, you can mix and match the types of Input and Output devices to best suit your application.

The ITER CODAC (Control, Data Access and Communication) system can be thought of as the brain and central nervous system of ITER. It physically connects all plant systems using computer networks and makes sure they speak the same language.

### 2.2 Algorithm Implemented

#### Step:1 Read Actual Temperature

- Step:1.1** Read Actual Temperature 1 and store in MD30
- Step:1.2** Read Actual Temperature 2 and store in MD32
- Step:1.3** Read Actual Temperature 3 and store in MD34
- Step:1.4** Read Actual Temperature 4 and store in MD36
- Step:1.5** Read Actual Temperature 5 and store in MD38
- Step:1.6** Read Actual Temperature 6 and store in MD40
- Step:1.7** Read Actual Temperature 7 and store in MD42
- Step:1.8** Read Actual Temperature 8 and store in MD44
- Step:1.9** Read Actual Temperature 9 and store in MD46

#### Step:2 PID Temperature Control Function

- Step:2.1** Get the Read temp value from MD 32
- Step:2.2** Apply the set value from memory MD42 to PID logic
- Step:2.3** Get the error signal in comparison of read temp and set value
- Step:2.4** Apply Proportional function to error signal
  - i.  $T_p = K_p \cdot e(t)$
- Step:2.5** Apply Integral function on error signal
  - ii.  $T_I = K_I \int e(t) dt$
- Step:2.6** Apply derivative function on error signal
  - iii.  $T_D = K_D \cdot \frac{de(t)}{dt}$
- Step:2.7** Get the calculated error signal as controller output
- Step:2.8** Store the controller output at memory location MD38.

#### Step:3 Read Output Of PID Function

- Step:3.1** Get the controller output to memory location MD 30 to MD38

- Step:3.2** Apply the high limit and low limit on controller output  
**Step:3.3** Get the controller output value from memory address MD38  
**Step:3.4** apply to analog module at address PQW 320

**Step:4 CODAC Core Software integrate and develop GUI**

- Step:4.1** Move the temp1 value from MD30 to DB100.DBD58  
**Step:4.2** Move the temp2 value from MD31 to DB100.DBD62  
**Step:4.3** Move the temp3 value from MD32 to DB100.DBD66  
**Step:4.4** Move the temp4 value from MD33 to DB100.DBD70  
**Step:4.5** Move the temp5 value from MD34 to DB100.DBD74  
**Step:4.6** Move the temp6 value from MD35 to DB100.DBD78  
**Step:4.7** Move the temp7 value from MD36 to DB100.DBD82  
**Step:4.8** Move the temp8 value from MD37 to DB100.DBD86

**Step:5 Control Heater Temperature From CODAC Core GUI**

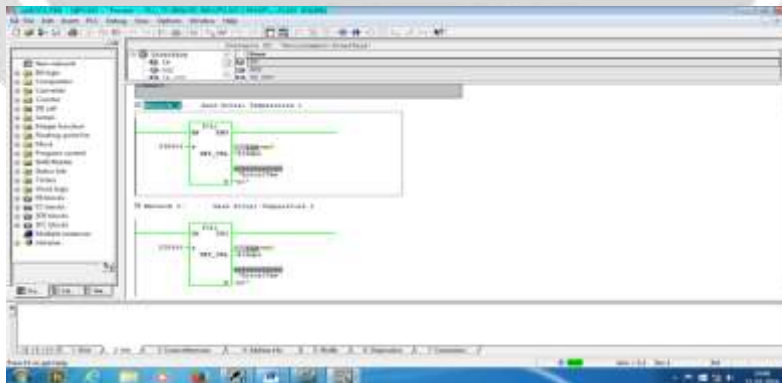
- Step:5.1** Assign the set value to variableD2\_U9\_00.HEAT0001 at memory address DB101.DBD0  
**Step:5.2** Move the set value from memory address DB101.DBD0 to MD42

### 3. IMPLEMENTATION

#### 3.1 PLC Programming

##### a. Read Actual Temperature

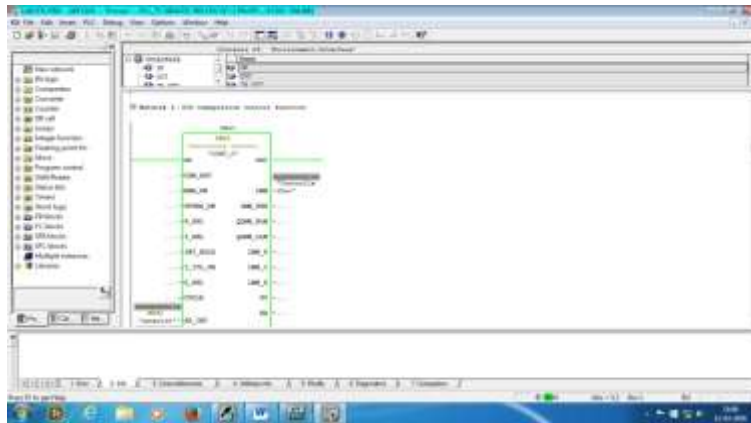
Here, the PLC block is used to read the temperature value of the thermocouples which are connected to the calibration source as temperature source. Here we have 2 thermocouples. So, we have taken 2 blocks to read the temperature from hardware to the PLC.



(a). Read Actual Temperature

##### b. PID Temperature Control Function

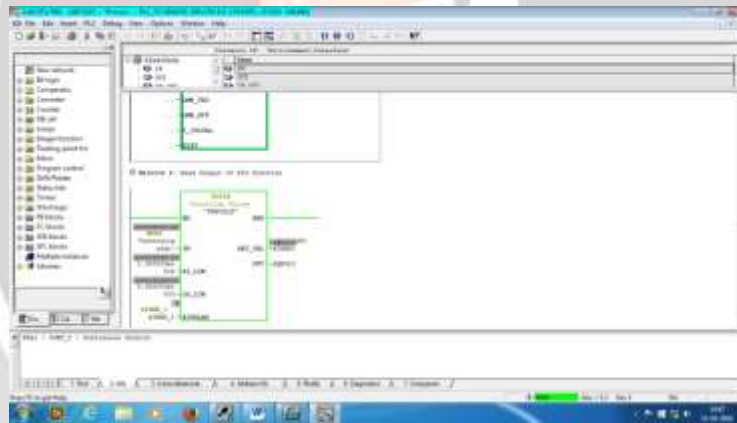
The PID temperature control function is used to control and manage the temperature value of the thermocouples attached to the calibration source hardware. It takes the value of temperature from the hardware and performs PID logic on that. So the result can be forwarded to CODAC Core System.



(b). PID Temperature Control Function

c. Read Output Of PID Function

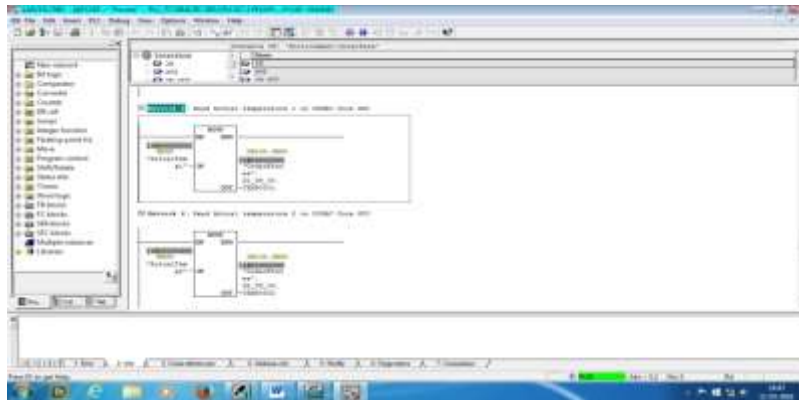
This block is used to read the output value of the PID function. So the result can be forwarded to CODAC Core System.



(c). Output Of PID Function

d. Read Actual Temperatures in CODAC Core GUI

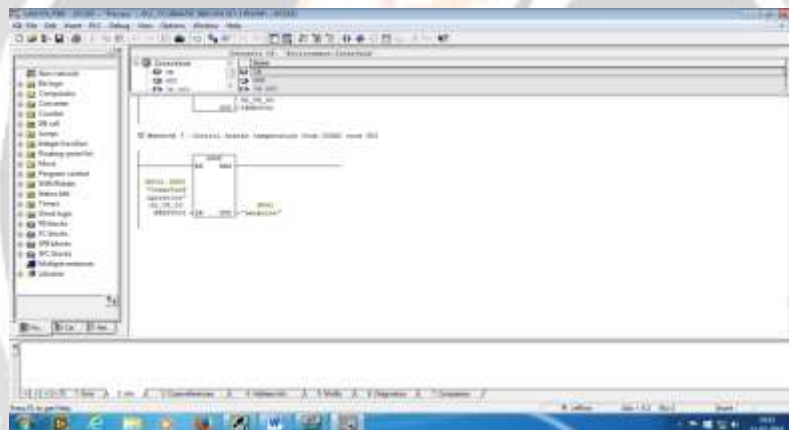
Here, the PLC block is used to read the temperature value of the thermocouples which are connected to the calibration source as temperature source. Here we have 2 thermocouples. So, we have taken 2 blocks to read the temperature from hardware to the CODAC Core GUI.



(d). Actual Temperatures in CODAC Core GUI

e. Control Heater Temperature From CODAC Core GUI

Here, in our system, one heater signal is used to control and manage the temperature values of all the thermocouples connected to it.



(e). Control Heater Temperature From CODAC Core GUI

**3.2 Data Acquisition**

The below snap shows the output of CODAC Core GUI. Here the temperature values of thermocouples which are connected to the calibration source on various points are displayed. The result shows that if the temperature is low, then it displays in red color. If the temperature is medium, then it displays in white color. And if the value reaches to the high degree, it shows in yellow color. This is done because of alarm handling mechanism.





#### 4. CONCLUSIONS

This paper presented about CODAC core plant control system for the ECE (Electron Cyclotron Emission) diagnostic system. In this paper, we presented about the algorithm for the calibration source operation. This work will focus on the configuration of hardware with the real-time environment. Parameters like CPU, memory, interferometer, spectrometer will be included in existing approach in order to obtain a more accurate result. Our objective is to facilitate remote, safe, reliable and standalone or synchronized mode of operation (with ITER Central Control Systems).

#### 5. ACKNOWLEDGEMENT

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#### 6. REFERENCES

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