WEINTEK LABS., INC.

Oven Temperature Control

FB PID Application

Demo Project

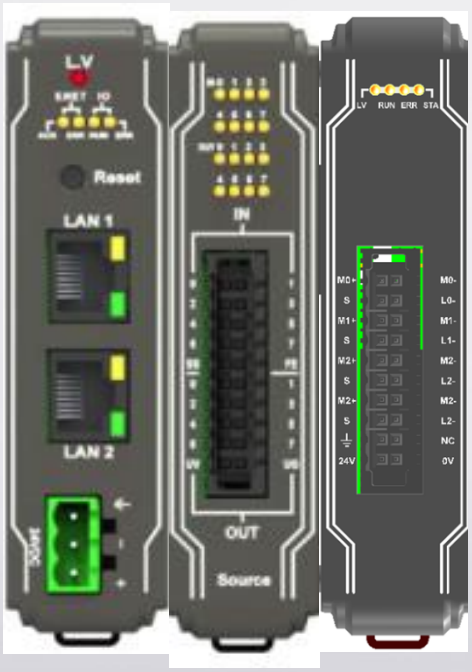
Contents

1. Overview and System Operation

Overview

This demo project introduces how to use a SSR (Solid State Relay) to control the AC power to achieve PWM (Pulse Width Modulation) for temperature control, and then use PID Function Block developed by Weintek for automatic calibration.

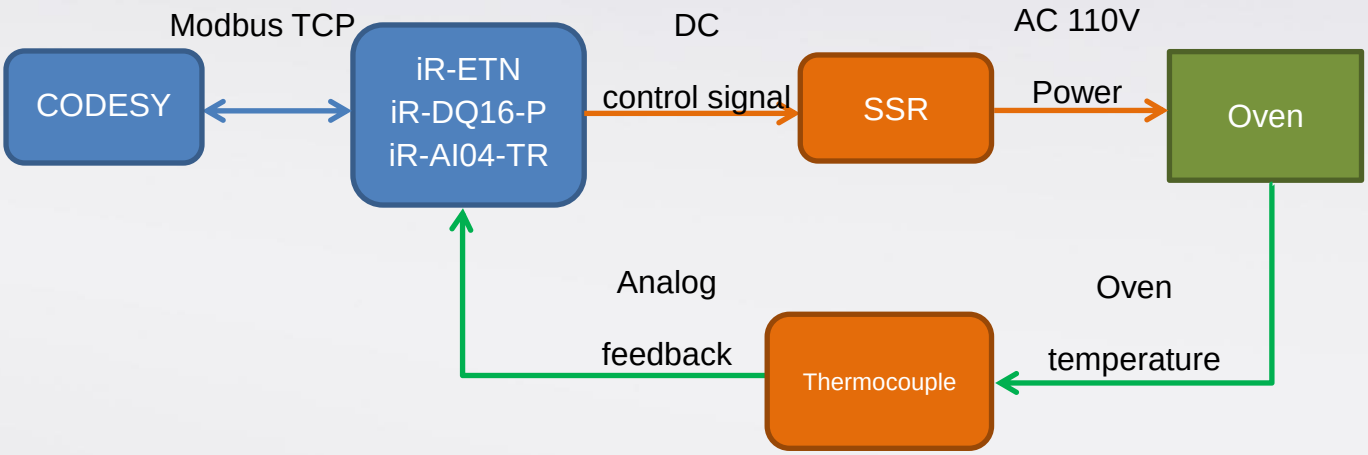
System Operation



Sequence	0	1	2
Module	iR-ETN	iR-DM16-P	iR-AI04-TR

Oven Temperature Control

Signal path:



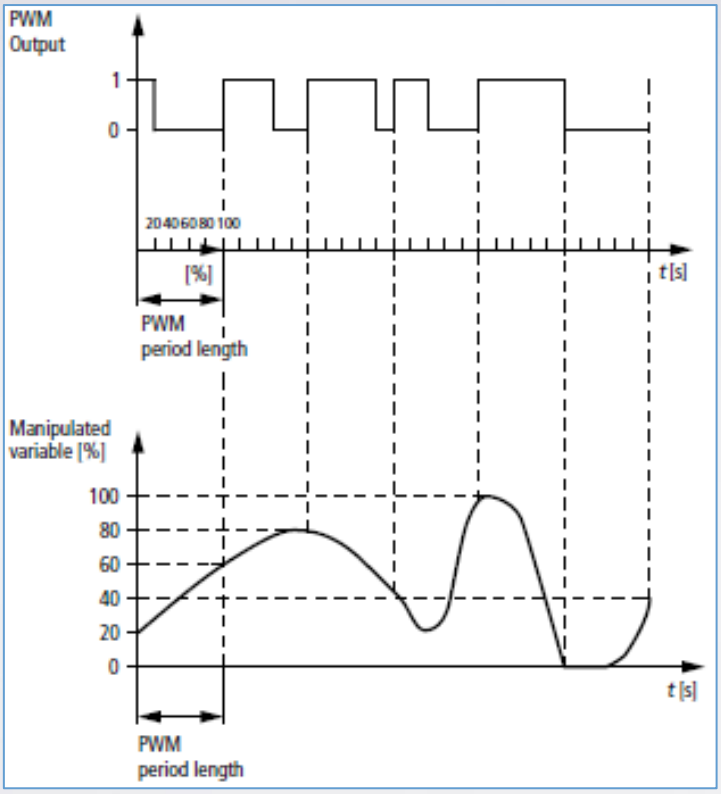
Connect CODESYS with iR-ETN (Coupler) via Ethernet to control iR-DQ16-P's (Module) digital output.

iR-DQ16-P can control the ON time of AC 110V.

Thermocouple can detect the oven temperature and send feedback to iR-AI04-TR for the PID to determine the next cycle of ON time.

*PWM (Pulse Width Modulation):

PID controller can calculate the Duty Cycle, which stands for the period of time the output signal = True.



2. Weintek Library Function Block

PID

PID control can be achieved using the Analog module and Function Block developed by Weintek.

For more information on Weintek Library and PID Function Block, please see the following manual:

UM018017E_ CODESYS_Weintek_Library_UserManual_20190305_eng

This Demo Project document will focus on how to implement PID temperature control.

PID control has two output modes: Manual Mode / Automatic Mode, each mode is set using different parameters.

For Manual Mode (Manual = TRUE), MV (Manipulated Value) is the same as Mout. Other parameters are not effective for the output value.

For Automatic Mode (Manual = FALSE), the output is controlled by PID, and the relating parameters are: Kp, Ki, Kd, Tf, BIAS, Time_Base, Error_Deadband. Autotune is an available function which eliminates the need to configure the parameters.

When Run & Autotune = TRUE, activate full power (MV=MV_MAX) until PV reaches SV. Wait until the PV drops under SV (MV=MV_Min), activate full power again. When PV equals to SV for the second time, Autotune is completed (Auto=FALSE), and calibration of Kp, Ki, Kd, Tf is also completed. Please see Chapter 4 in this document for more information on PV curve.

PWM

Use the Function Block of PWM (Pulse Width Modulation), input PWM's Period and Duty, and output starts when Q=TRUE.

For example, When the period of time of output is 10 seconds, and the period of time in which Q=True is 2.5 seconds, then Period = T#10S; Duty = 25

3. Configuration Steps

Declaration

```
PROGRAM PLC_PRG
VAR
    PID : weintek.PID;
    xRun, xDir, xQE, xDE, xAutoTune : BOOL ;
    rSV,rPV,rAuto_Deadband,rBIAS,rMV,rI_MV : REAL ;
    rTime_Base : REAL := 0.1 ;
    rError_Deadband : REAL := 0.0 ;
    rMV_Max : REAL := 100.0 ;
    rMV_Min : REAL  := 0.0 ;
    PWM : weintek.PWM ;
    rTemp : REAL ;
```

Declare relating variables and give initial values.

ST Program

```
1   rTemp2 :=INT_TO_REAL(TR0) ;
2   rPV := rTemp2 / 10 ;
3   PID(
4       Manual:= xManual,
5       Run:= xRun,
6       SV:= rSV,
7       PV:= rPV,
8       Dir:= xDir,
9       MV_Manual:= rMV_Manual,
10      MV_Max:= rMV_Max,
11      MV_Min:= rMV_Min,
12      Auto_Deadband:= rAuto_Deadband,
13      Bias:= rBIAS,
14      Time_Base:= rTime_Base,
15      Error_Deadband:= rError_Deadband,
16      MV=> rMV,
17      I_MV=> rI_MV,
18      Kp:= PVar.rKp,
19      Ki:= PVar.rKi,
20      Kd:= PVar.rKd,
21      Tf:=PVar.rTf,
22      AutoTune:= xAutoTune);
23
24  PWM(Enable:=xRun,Period:=timPeriod,Duty:=rMV,Q=> xOut);
25  DO0 := xOut ;
26
```

1-2: Convert INT (temperature input) to REAL

3-22: Variables in PID Function Block

24-25: Convert PID. MV to PWM's Duty and then output by DO0.

Mapping

DO0=> %QX0.0 (Control output of SSR)

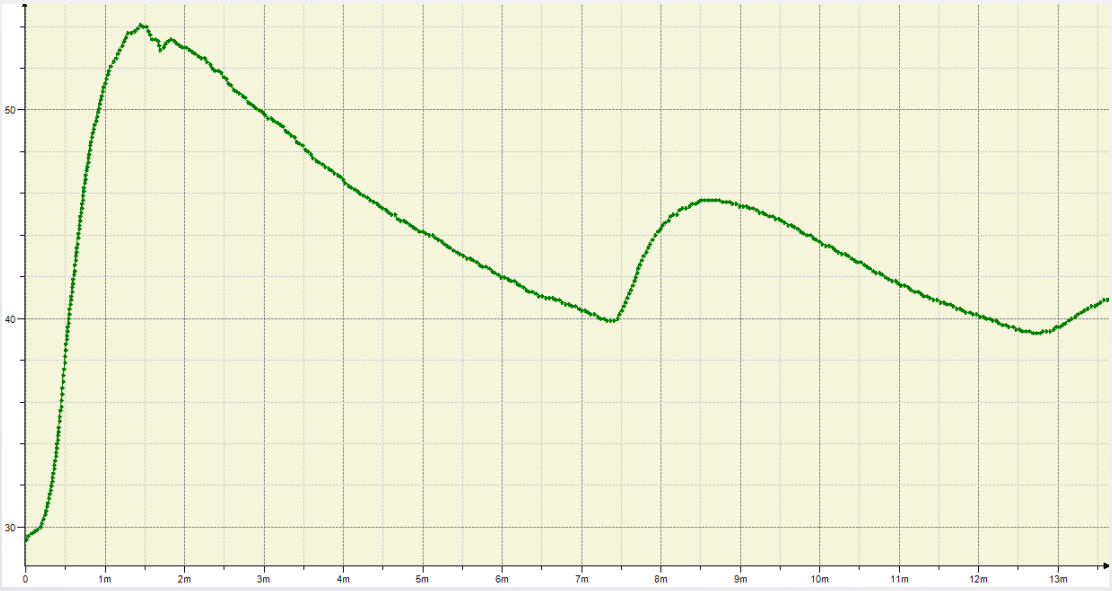
TR0=> %IW0 (Temperature Input)

4. Temperature Control

The following green curve is a temperature curve where it starts from 28°C and reaches the target temperature 40°C (SV).

Auto Tuning

Kp, Ki, Kd, Tf will be the reference values for Auto Tune, and the temperature curve is shown below.



Auto Tune process:

Activate full power until the temperature reaches SV.

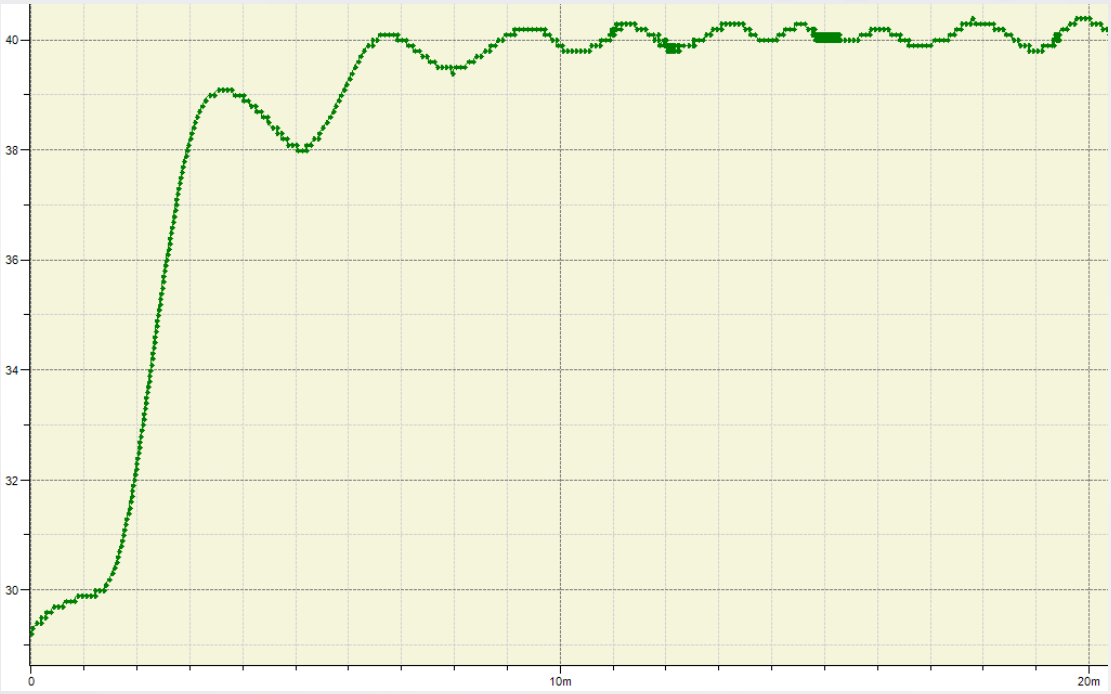
Activate full power again when the temperature drops under SV.

Auto Tune is completed when the temperature drops under SV again.

At this moment, Kp, Ki, Kd, Tf will be automatically calculated and output.

Auto Tuned Curve

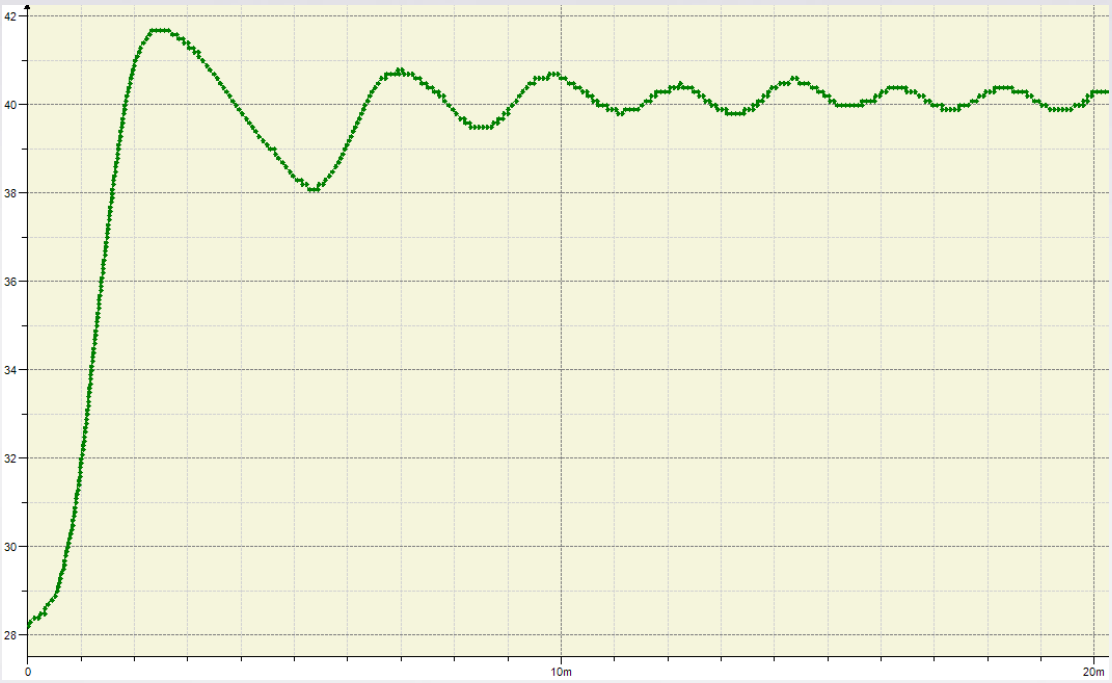
Use the Kp, Ki, Kd, Tf parameters and heat again, the temperature curve is shown below.



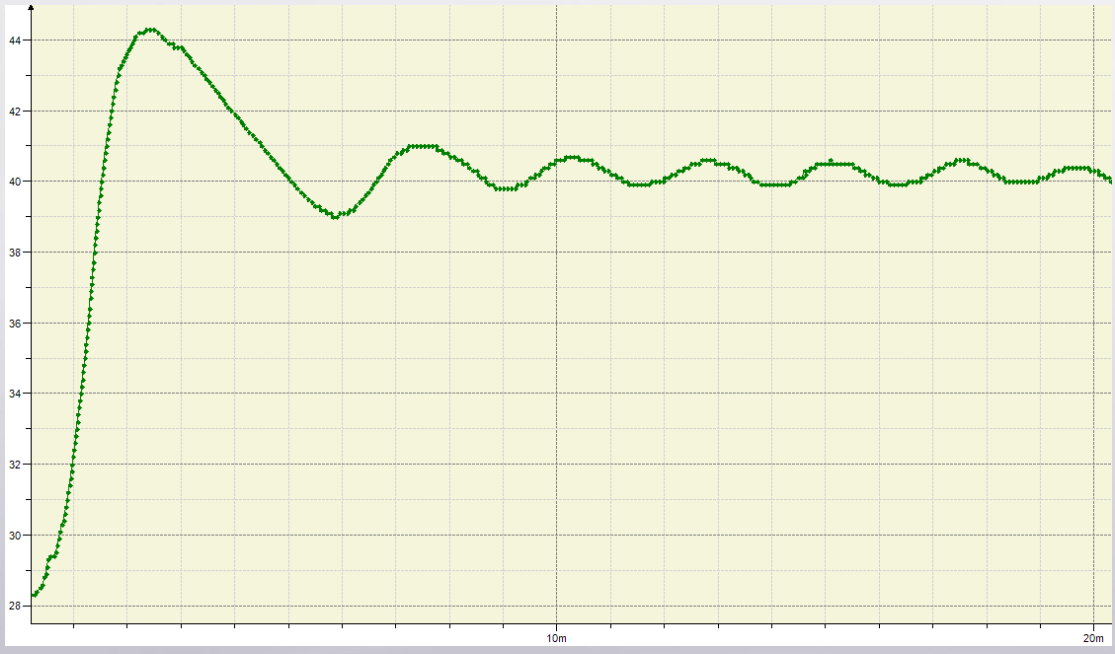
The maximum overshoot is less than SV, so the user may manually configure relating parameters.

Tuning Manually

Set a lower Kp and then heat again, the temperature curve is shown below.



As shown above, the maximum overshoot goes greater than SV, but with a longer convergence time (longer than 10 minutes). Configure Ki and then heat again, the temperature curve is shown below.



Temperature curve shown after tuning