An MPiec Temperature Control Solution using Yaskawa Toolbox and SLIO

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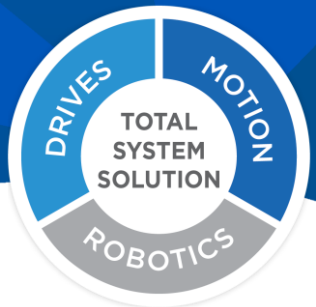
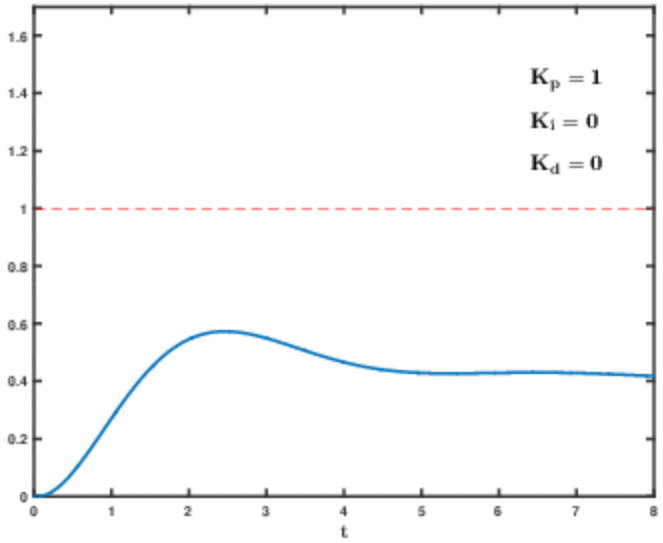


Solution Overview

- **What is it?**
  - A function block that automatically maintains a heating element within a few percent of a desired temperature.
- **What's inside?**
  - Reading and writing tuning data to a file
  - CalculateGains "autotuning"
  - PIDControl "run"
- **Hardware**
  - VIPA SLIO or MPiec LIO

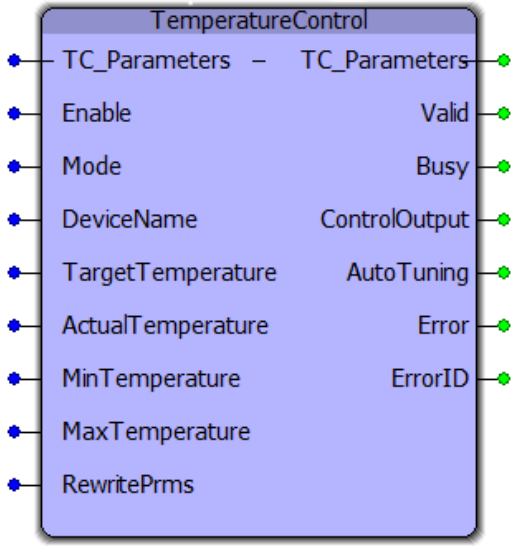
PID Tuning at a Glance

- **Proportional-Integral-Derivative control**
  - Calculates difference between target value and present value of a system. Then adjusts the output based on the P, I, and D terms to reduce the difference.
  - A practical example of PID control is in the cruise control system of a car.



- **P, I, and D gains**
  - The auto tuning function block automatically calculates these terms using a control method algorithm after monitoring how the system responds to an input.

Function Block Overview



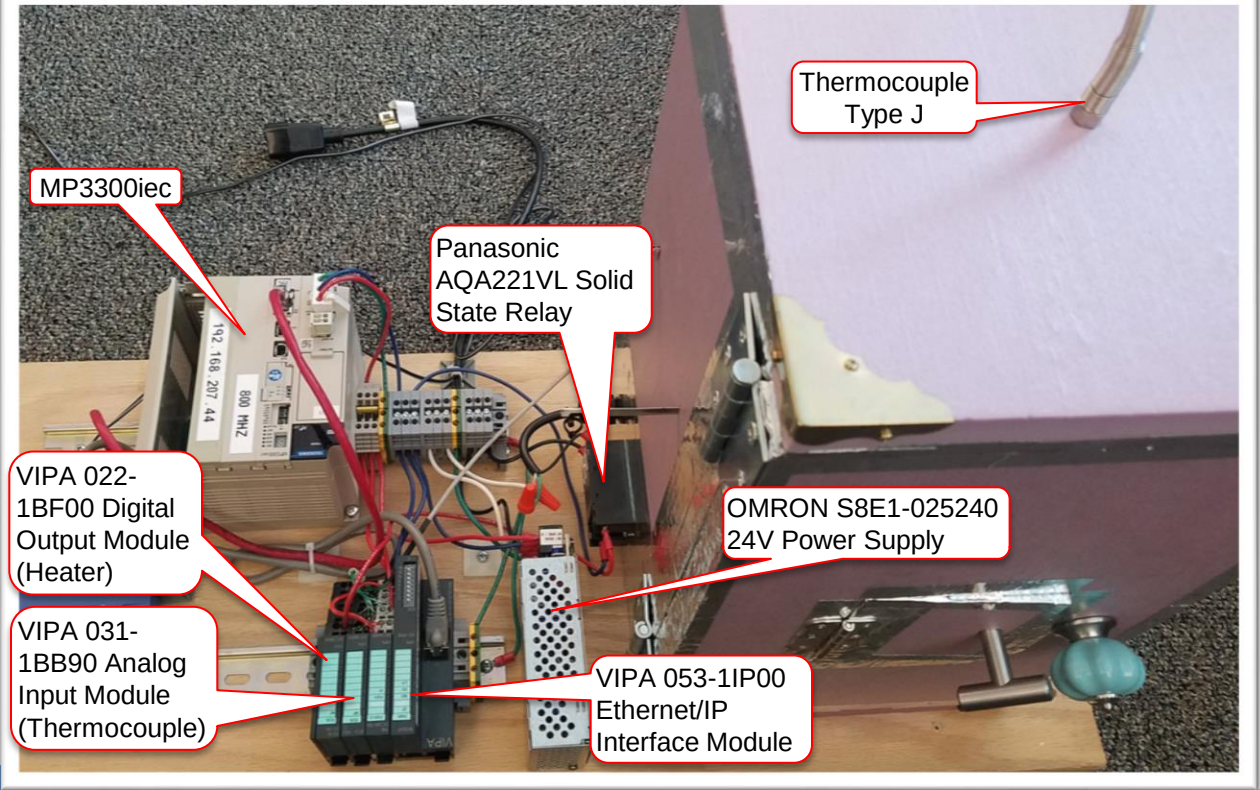
Name	Type	Description
TC_Parameters	TempControlStruct	
Version	UDINT	Version of the TempControlStruct [yyyymmdd]
AutotuneCycles	INT	The number of oscillations to calculate gains for
IgnoreCycles	INT	The number of oscillations to ignore before calculating gains
AutotuneTimeout	DINT	Maximum amount of time in minutes to spend autotuning (0 = infinite)
TuningComplete	BOOL	Denotes whether tuning has been completed or not
ResponseType	INT	Response type: Slow (1), Medium (2), Fast (3)
OutputBias	LREAL	Optional control output offset to be calculated based on setpoint
PIDParameters	PIDStruct	Structure containing all parameters necessary for PID control
Kp	LREAL	Proportional Gain
Ki	LREAL	Integral Gain
Kd	LREAL	Derivative Gain
Ti	LREAL	Integral Time
Td1	LREAL	Derivative Time for Divergent Inputs
Td2	LREAL	Derivative Time for Convergent Inputs
IUL	LREAL	Integral Upper Limit
ILL	LREAL	Integral Lower Limit
UpperLimit	LREAL	P+I+D Correction Upper Limit
LowerLimit	LREAL	P+I+D Correction Lower Limit
DeadBand	LREAL	Dead band limit
Ts	LREAL	

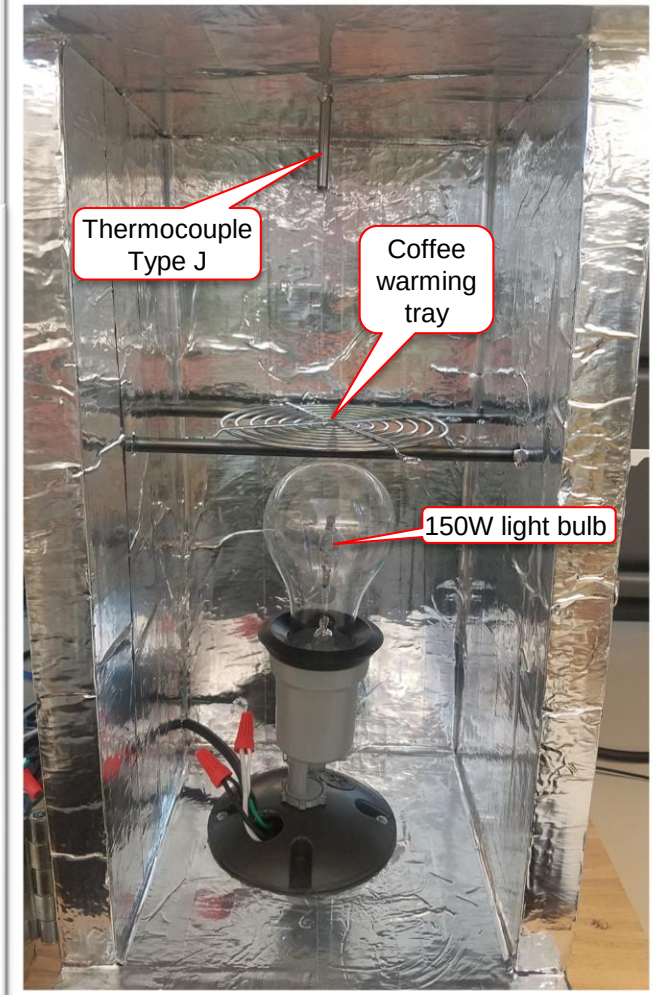
ControlOutput = ControlOutput + OutputBias*TargetTemperature

Parameter Values

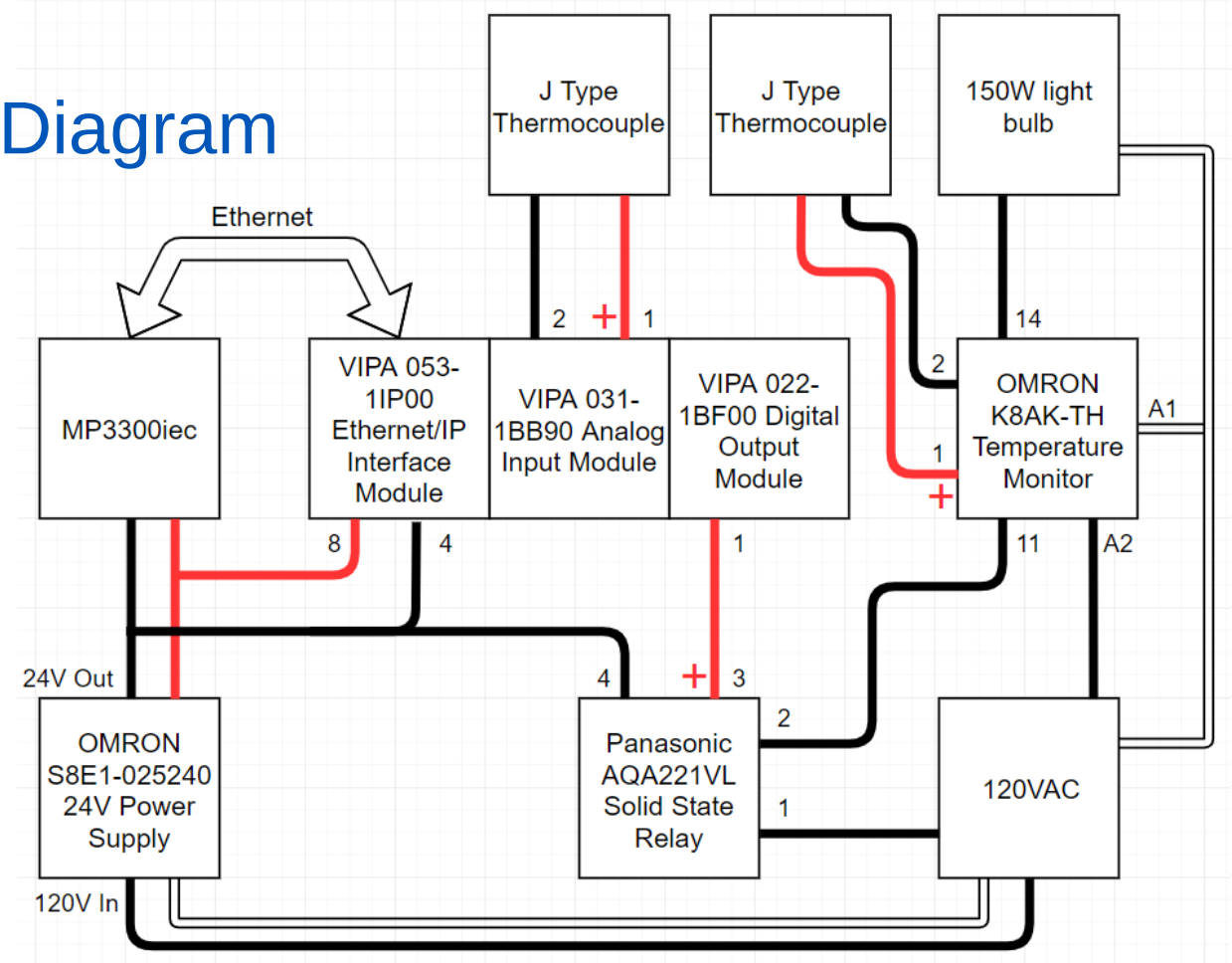
*	Parameter	Data Type	Description	
VAR_IN_OUT				
V	TC_Parameters	TempControlStruct	Structure containing the parameters for operating the Temperatuer Control function.	
VAR_INPUT				Default
B	Enable	BOOL	The function will continue to execute every scan while Enable is held high and there are no errors.	FALSE
V	Mode	INT	0: Normal operation. The function block looks for a previously stored DeviceName file and runs. If the file is not found, then an Autotuning process starts. Upon successful autotuning, the system runs normally. 1: Force autotuning before running, even if the DeviceName file already exists.	INT#0
V	DeviceName	STRING	The name of the device being controlled. This will be used when writing the TC_Parameters to a file on the controller flash file system.	N/A
V	TargetTemperature	LREAL	The target temperature value.	LREAL#0.0
V	ActualTemperature	LREAL	The current temperature value.	LREAL#0.0
V	MinTemperature	LREAL	Minimum allowable temperature. An Error will be generated if the ActualTemperature goes below this value and the ControlOutput will be set to zero. If unconnected or set to zero, an operating value of -200.0 will be assumed	LREAL#-200.0
V	MaxTemperature	LREAL	Maximum allowable temperature. An Error will be generated if exceeded and the ControlOuptut will be set to zero. If unconnected or set to zero, an operating value of 400.0 will be assumed.	LREAL#400.0
V	RewritePrms	BOOL	Rewrites the TC_Parameters to the DeviceName file to update any changes made manually after the autotuning process.	FALSE
VAR_OUTPUT				
B	Valid	BOOL	Indicates that the function is operating normally and the outputs of the function are valid. This block does not set the Valid output until autotuning has been completed.	
B	Busy	BOOL	In the case of a function block with an Enable input, a Busy output indicates the function is operating, but not ready to provide Valid information. (No Error). Busy will be high when calculating gains or performing file operations. Reset to low when Done, CommandAborted, or Error is true.	
V	ControlOutput	LREAL	Output value from the PID control block. The range of values is 0.0 - 100.0.	
B	AutoTuning	BOOL	Indicates if the function is performing autotuning.	
B	Error	BOOL	Set high if an error has occurred during the execution of the function block. This output is cleared when 'Execute' or 'Enable' goes low.	
B	Error ID	UINT	If Error is true, this output provides the Error ID. This output is reset when 'Enable' goes low.	

Oven Example: Overview



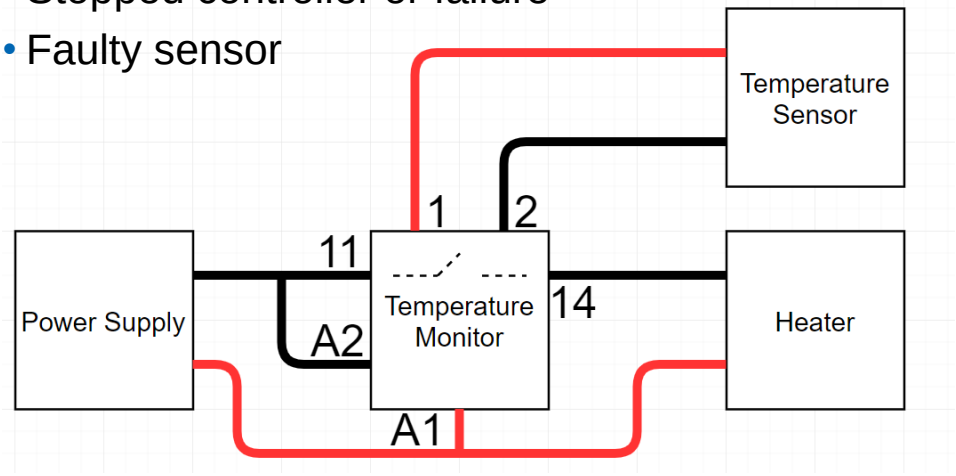


Wiring Diagram

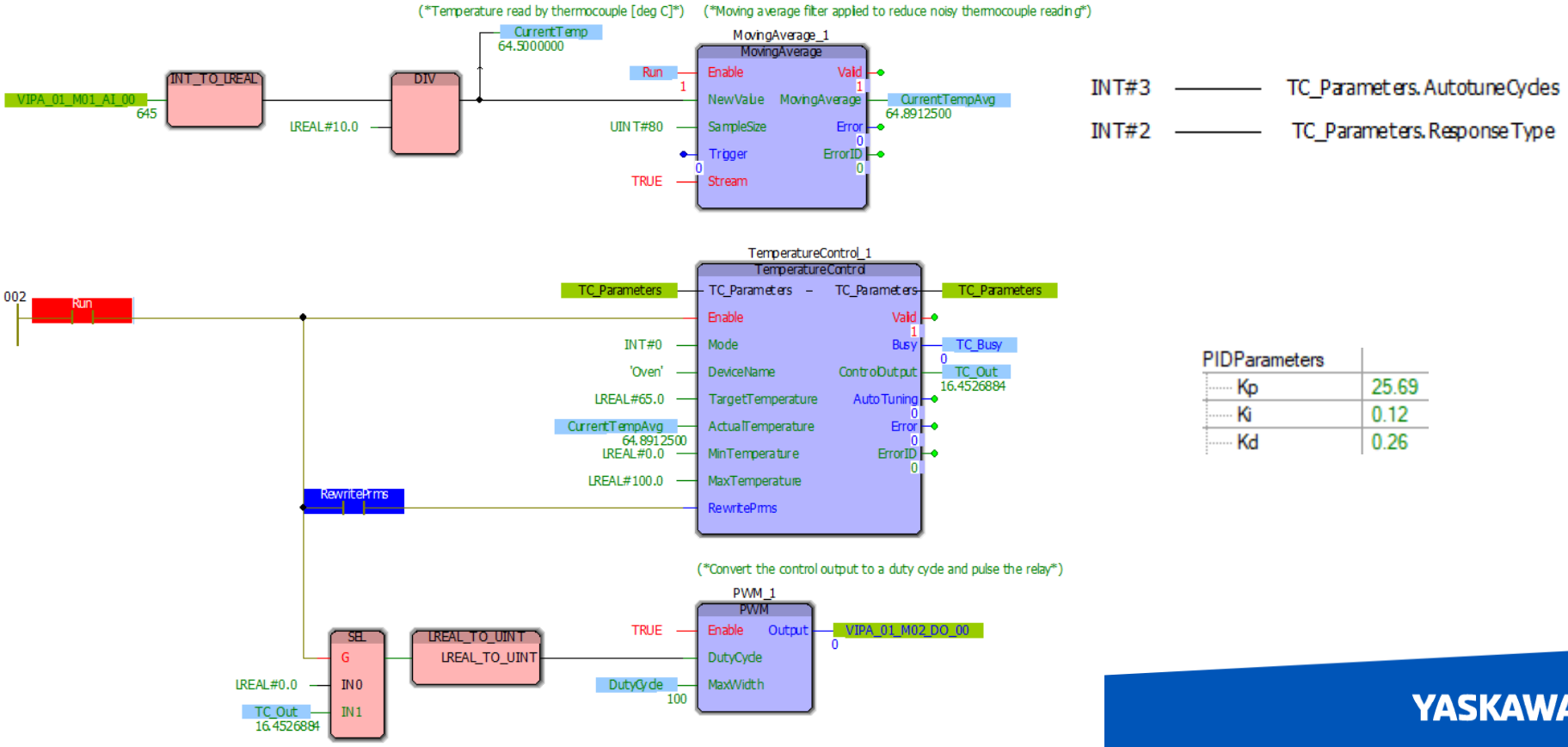


Safety Relay

- Breaks the heater connection if system is above temperature
- Hardware based safety redundancy
- Protects against:
  - Stopped controller or failure
  - Faulty sensor



Oven Example: Application Code



PIDParameters	
Kp	25.69
Ki	0.12
Kd	0.26

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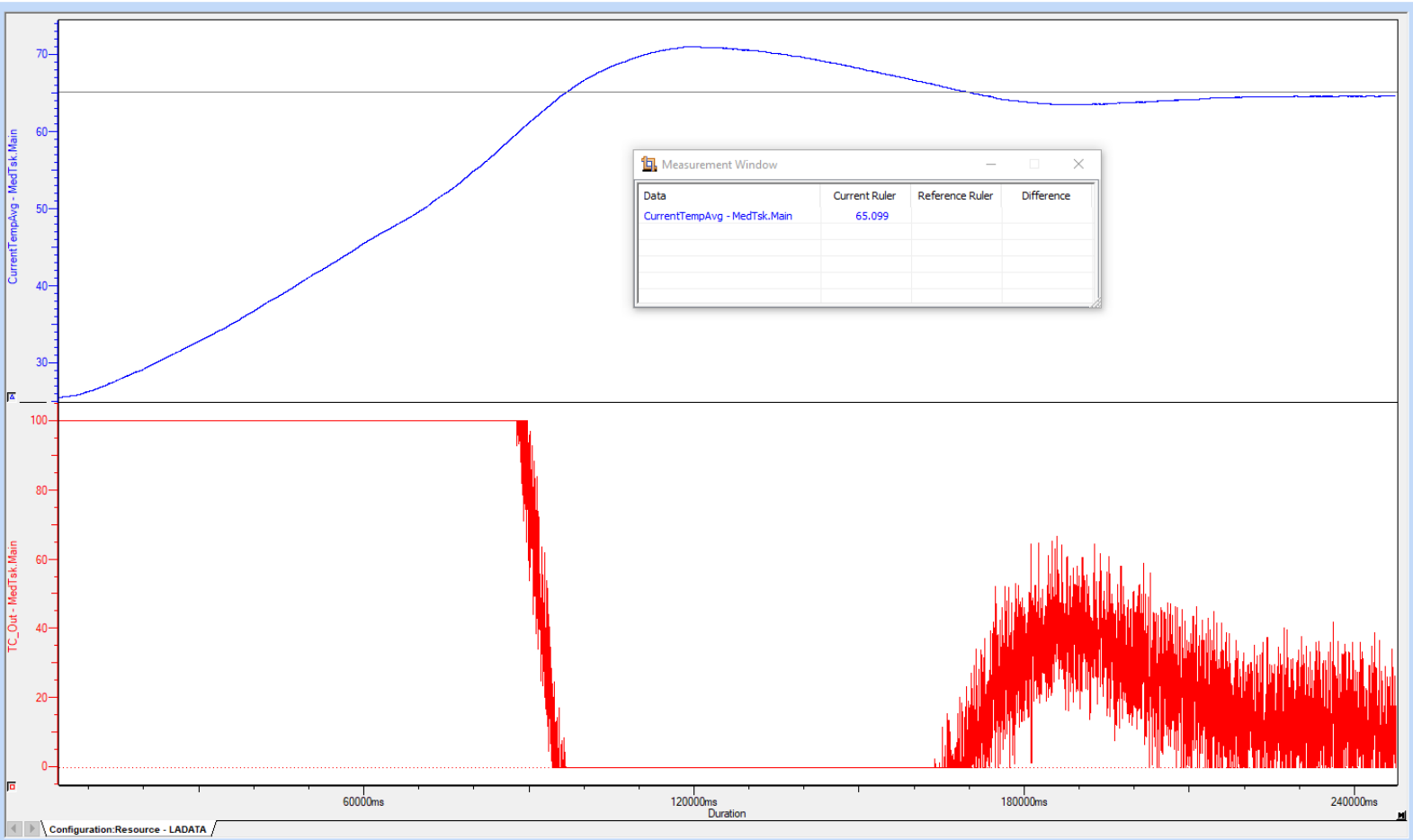
Logic Analyzer
CurrentTempAvg - MedTsk.Main
70
60
50
40
30
Measurement Window
Data
Current Ruler
Reference Ruler
Difference
CurrentTempAvg - MedTsk.Main
65.099
TC_Out - MedTsk.Main
100
80
60
40
20
0
60000ms
120000ms
180000ms
240000ms
Duration
Configuration:Resource - LADATA

Fine Adjustments for Increased Performance

Independently Adjusting Parameters to Solve Issues		
Symptom	**Solution**	**Watch out**
The system takes a long time to reach the set temperature	Increase Kp	Increased overshoot, instability
The system is overshooting the target temperature	Increase Kd	Increase in time to reach set temperature
The system takes a long time to settle at a temperature (oscillating), or is unstable	Increase Kd	Increase in time to reach set temperature
The temperature settled above/below where it should be (steady-state error)	Increase Ki	Increased overshoot, instability

Effects of *increasing* a parameter independently

Parameter	Rise time	Overshoot	Settling time	Steady-state error	Stability
K_p	Decrease	Increase	Small change	Decrease	Degrade
K_i	Decrease	Increase	Increase	Eliminate	Degrade
K_d	Minor change	Decrease	Decrease	No effect in theory	Improve if K_d small

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