Manual
Reflow controller REFLOW001-USB

Features

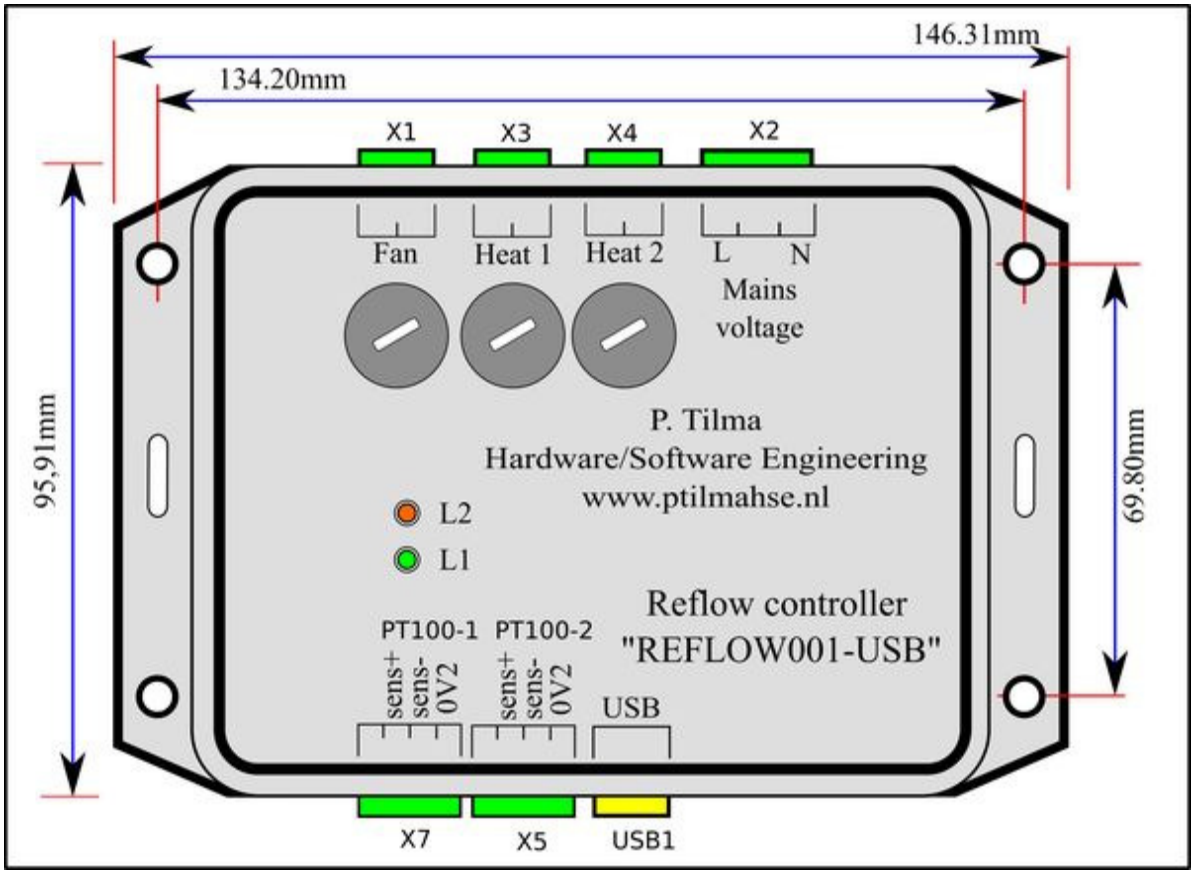
- Connector for mains input.
- Connectors for 2 temperature sensors (PT100)
- Connectors for 2 heating elements and fan (triac)
- Onboard real time clock
- Mains voltage zero crossing detection
- Universal serial bus (USB) interface
- Standard HID class device driver
- Microcontroller based design
- Dimensions enclosure : 146,31 x 95,91 x 35,25 mm.

Section 1 - **Contents**

Section 2 - **General description**

The REFLOW001-USB controller makes it possible to use a kitchen toaster oven for reflow soldering purposes. By means of a USB connection the controller communicates with a desktop computer. Different temperature profiles can be configured and stored with the desktop application. These profiles then can be uploaded to the USB connected hardware. After the user has selected a profile the reflow soldering proces can be started. An embedded PID algorythm takes care that the oven temperature follows the choosen profile as close as possible. During reflow, soldering proces variables are displayed.

Section 3 - **Dimensions and connections**



Connector X1	Signal name	Description
Pin 1	li	Fan
Pin 2	triac1-mt2	Fan

Connector X3	Signal name	Description
Pin 1	Li	Heater 1
Pin 2	triac3-mt2	Heater 1

Connector X4	Signal name	Description
Pin 1	Li	Heater 2
Pin 2	triac5-mt2	Heater 2

Connector X2	Signal name	Description
Pin 1	ne	mains neutral
Pin 2		not connected
Pin 3	li	mains live

Connector X7	Signal name	Description
Pin 1	vref	Pt100 ref. voltage
Pin 2	tsens2+	Pt100 Sens +
Pin 3	tsens2-	Pt100 Sens-
Pin 4	0v1	Pt100 Ground

Connector X5	Signal name	Description
Pin 1	vref	Pt100 ref. voltage
Pin 2	tsens1+	Pt100 sens +
Pin 3	tsens1-	Pt100 sens -
Pin 4	0v1	Pt100 ground

Connector USB1	Signal name	Description
Pin 1	vusb	+5V
Pin 2	d-	Data -
Pin 3	d+	Data +
Pin 4	0v1	Ground

Section 4 - **Technical specifications**

Electrical	Operating conditions	Max. ratings
Supply voltage	220VAC	
Supply current	25mA @ 5V	
Fan output	220VAC/10A	200mA
Heater 1 output	220VAC/10A	
Heater 2 output	220VAC/10A	

Mechanical	
Enclosure dimension (length x width x height)	146,31mm x 95,91mm x 35,25
Enclosure material	ABS plastic
Enclosure mounting holes	
Connector fan	Phoenix MSTBA2,5/2-G-5,08
Connector heating element 1	Phoenix MSTBA2,5/2-G-5,08
Connector heating element 2	Phoenix MSTBA2,5/2-G-5,08
Connector mains input voltage	Phoenix MSTBA2,5/3-G-5,08
Connector Pt100 1	Phoenix MC1,5/4-G-3,81
Connector Pt100 2	Phoenix MC1,5/4-G-3,81
Connector USB	Device USB type B

Environmental	
Operating temperature	-20°C .. +20°C
Humidity	
Protection	

USB interface	
Interface	USB 2.0 Full speed (12 Mbits/s)
Device class	HID (Human Interface Device)
Connector	Standard USB B

Software	
USB	Full speed
Driver	HID (Human Interface Device)
Desktop application	Windows/x86
Vendor ID and product ID	VID=0x10c4 PID=0x8A18

Section 5 - **Hardware/firmware description**

The REFLOW001-USB contains the following functional blocks :
Power supply :
For the 3.3V logic supply a linear regulator is used. In normal operating mode the regulator is fed by the transformer/rectifier combination. If the controller is connected to a desktop computer and no mains voltage is applied to the board then the regulator is fed by the USB +5V voltage. Without mains voltage it is possible to perform configuration or calibration operations.

Microcontroller :
An 8-bit microcontroller is programmed for a number of tasks :

1 - Reading state of pushbuttons
2 - Get raw Pt100 sensor data through SPI interface and convert that data into calibrated temperature values.
3 - Store configuration data from desktop computer in non-volatile memory.
4 - During reflow, execution of the PID algorythm.
5 - Mains voltage zero crossing detection.
6 - Synchronising output switching with mains voltage
7 - Calculation of dutycycle for 2 heater outputs.

USB serial interface :
The microcontroller contains an "USB function controller". This controller and some code make REFLOW001-USB act as a USB HID device.

Mains zero crossing detection :
A bidirectional optocoupler connected to the secondary side of the transformer gives a digital signal which is connected to an interupt pin of the microcontroller.

PT100 interface :
Resistance variations or digitised by a 24-bit AD converter.
Digital output data from the converter is via SPI transferred to the microcontroller. The microcontrollers program converts the raw data to calibrated temperatures.

Fan and heater outputs :
Galvanically isolated triacs are used for controlling air circulation (fanspeed) and heat generation. The on- and offswitching of all triacs only occur when the mains AC voltage is close to 0 (zero crossing detection).

Pushbutton inputs :
2 pushbuttons are connected to digital input lines of the microcontroller.

Led outputs :
Three leds are connected to digital output lines of the microcontroller. Software determines when the leds will be blinking. Onboard SMD led : 100ms on, 900ms off, Led L1 :, Led L2 :.

Real time clock :

A real time clock/calendar keeps track of the time. Through the I2C interface the microcontroller reads from or writes to the device. In absence of power there is an automatic switchover to a BR1225 battery.

Section 6 - **HID class device**

The REFLOW001-USB conforms to the USB HID Class specification version 1.1. After the controller has been connected with your desktop computer, the device will automatically be identified as a HID class device. The desktops operating system will then load a HID class device driver. The host now can send and receive data by sending and requesting reports in control or interrupt transfers.

Section 7 - **Communication protocol**

Commands are implemented for testing, real time clock, configuration, calibration and reflow control. The supplied PC application program makes use of these different commands.

Test			
USB transfer	Report id	Report size	Defines used in software for report id and report size (_REPORTID or _REPORTSIZE)
Control	0x01	0x17	GET_SOFTWARE_VERSION_
Control	0x02	0x01	TOGGLE_L1_LED_
Control	0x03	0x01	TOGGLE_L2_LED_
Control	0x04	0x01	TOGGLE_SMD_LED_
Control	0x05	0x02	GET_POWER_SOURCE_
Control	0x06	0x02	GET_NUMBER_USB_INTERUPTS_
Control	0x07	0x02	GET_DEVICE_ADDRES_
Control	0x08	0x0f	GET_PT100_ONE_TEMPERATURE_
Control	0x09	0x0f	GET_PT100_TWO_TEMPERATURE_
Control	0x0a	0x09	TEST_TEMPERATURE_CONTROL_START_
Control	0x0b	0x09	TEST_TEMPERATURE_CONTROL_STOP_
Control	0x0c	0x04	GET_TEMPERATURE_RATE_
Control	0x0d	0x03	TEST_CONVEXION_FAN_
Control	0x0e	0x03	TEST_TOP_HEATER_
Control	0x0f	0x03	TEST_BOTTOM_HEATER_
Control	0x10	0x01	GET_PUSHBUTTONS_
Control	0x11	0x02	GET_NUMBER_ZEROCROSSINGS_
Control	0x12	0x03	GET_RUNTIME_INFO_
Control	0x13	0x3f	GET_PID_RUNTIME_INFO_1_
Control	0x14	0x02	GET_PID_RUNTIME_INFO_2_
Control	0x15	0x01	RESET_IDLE_SAMPLENUMBER_

Real time clock			
USB transfer	Report id	Report size	Defines used in software for report id and report size (_REPORTID or _REPORTSIZE)
Control	0x20	0x0c	SET_RTC_
Control	0x21	0x0c	GET_RTC_
Control	0x22	0x01	START_RTC_
Control	0x23	0x01	STOP_RTC_
Control	0x24	0x0a	GET_RTC_STATUS_

Configuration			
USB transfer	Report id	Report size	Defines used in software for report id and report size (_REPORTID or _REPORTSIZE)
Control	0x30	0x01	SET_TEMPERATURE_PROFILE_NUMBER_
Control	0x31	0x01	GET_TEMPERATURE_PROFILE_NUMBER_
Control	0x32	0x3c	SET_TEMPERATURE_CONFIG_PART0_
Control	0x33	0x3c	SET_TEMPERATURE_CONFIG_PART1_
Control	0x34	0x3c	SET_TEMPERATURE_CONFIG_PART2_
Control	0x35	0x3c	SET_TEMPERATURE_CONFIG_PART3_
Control	0x36	0x3c	SET_TEMPERATURE_CONFIG_PART4_
Control	0x37	0x3c	SET_TEMPERATURE_CONFIG_PART5_
Control	0x38	0x3c	SET_TEMPERATURE_CONFIG_PART6_
Control	0x39	0x3c	SET_TEMPERATURE_CONFIG_PART7_
Control	0x3a	0x3c	SET_TEMPERATURE_CONFIG_PART8_
Control	0x3b	0x3c	SET_TEMPERATURE_CONFIG_PART9_
Control	0x3c	0x3c	SET_TEMPERATURE_CONFIG_PART10_
Control	0x3d	0x3c	GET_TEMPERATURE_CONFIG_PART0_
Control	0x3e	0x3c	GET_TEMPERATURE_CONFIG_PART1_
Control	0x3f	0x3c	GET_TEMPERATURE_CONFIG_PART3_
Control	0x40	0x3c	GET_TEMPERATURE_CONFIG_PART3_
Control	0x41	0x3c	GET_TEMPERATURE_CONFIG_PART4_

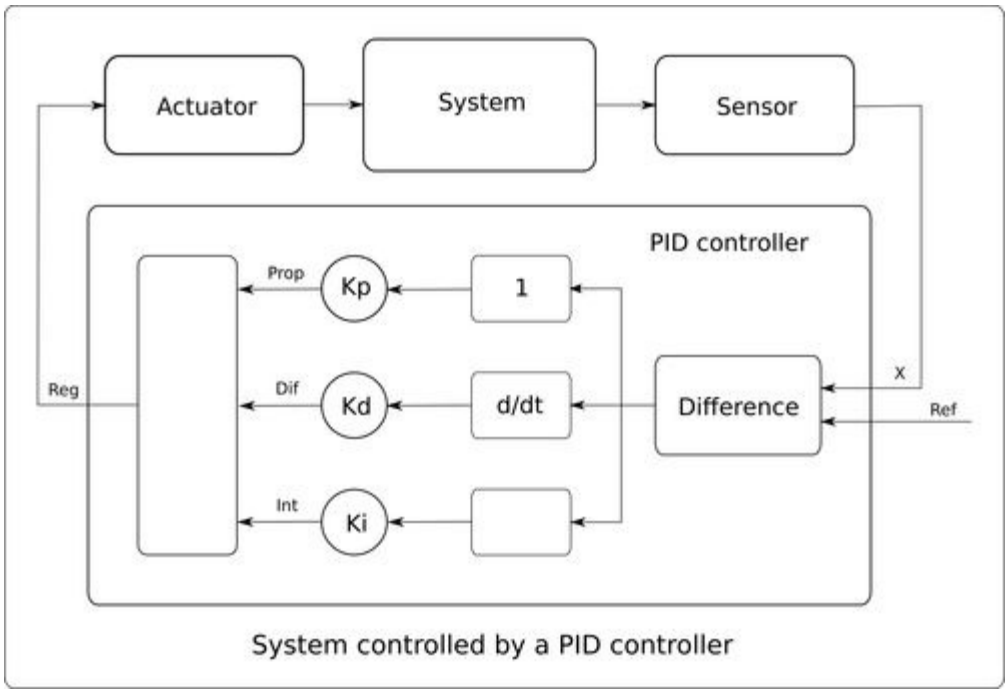
Control	0x42	0x3c	GET_TEMPERATURE_CONFIG_PART5_
Control	0x43	0x3c	GET_TEMPERATURE_CONFIG_PART6_
Control	0x44	0x3c	GET_TEMPERATURE_CONFIG_PART7_
Control	0x45	0x3c	GET_TEMPERATURE_CONFIG_PART8_
Control	0x46	0x3c	GET_TEMPERATURE_CONFIG_PART9_
Control	0x47	0x3c	GET_TEMPERATURE_CONFIG_PART10_
Control	0x48	0x01	INIT_EMBEDDED_DB_
Control	0x49	0x01	INIT_ALL_NONVOLATILE_
Control	0x4a	0x02	SET_SENSOR_USE_REPORTID
Control	0x4b	0x02	GET_SENSOR_USE_REPORTID

Calibration			
USB transfer	Report id	Report size	Defines used in software for report id and report size (_REPORTID or _REPORTSIZE)
Control	0x50	0x04	SET_CALIBRATION_TEMP1_
Control	0x51	0x04	SET_CALIBRATION_TEMP2_

Reflow control			
USB transfer	Report id	Report size	Defines used in software for report id and report size (_REPORTID or _REPORTSIZE)
Control	0x60	0x01	START_REFLOW_
Control	0x61	0x01	STOP_REFLOW_
Interupt in	0x62	0x0c	TEMPERATURE_PT100_1_
Interupt in	0x63	0x0c	TEMPERATURE_PT100_2_
Interupt in	0x64	0x19	PID_CONTROL_DATA_

Section 8 - **PID regulation**

The following image and text originate from a ST application note. The firmware of the REFLOW001-USB contains a PID algorythm which follows this document.



"A PID controller consists first of a unit to calculate the difference between the desired value and the actual value. The calculated error signal is fed to three units to calculate the multiple of the error (proportional part, Prop), the rate of changing of the error (differential part, Dif), and the up-to-now sum of the error (integral part, Int). All three components are weighted by corresponding factors (Kp, Kd, Ki) and summed to get the final value (Reg) used by the actuator to influence the system.
When such PID controller is implemented in a microcontroller the above action must be performed periodically, the period being short enough

compared to the response time of the regulated system. This again calls for periodic sampling, calculation and generation of values."

A reflow session uses 1 out of 10 possible profiles. A profile contains temperature information but also four parameters (sample period, Kp, Kd, Ki) which determine the behaviour of the software PID controller.

Section 9 - **PT100 temperature sensor**

Two PT100 temperature sensors can be connected to REFLOW001-USB. The PID controlller uses for its input (= actual or current temperature) one of the following :

1 - Sensor 1 temperature

2 - Sensor 2 temperature

3 - Mean value of sensor 1 and sensor 2 temperatures.

Which value the PID controller uses can be configured in menu "Reflow->Calibration".

In menu "Reflow-> Calibration" you can calibrate the PT100 temperature sensors. The procedure is as follows :

Section 10 - **Profiles**

A temperature profile has 10 different phases and is defined by

1 - profile description
2 - PID control parameters
3 - begintemperature and endtemperature for each phase
4 - speed convexion fan for each phase
5 - duration for each phase

Ten profiles can be stored on the harddisk. Profiles stored on your desktop computer's harddisk can be regarded as a backup. Also ten profiles can be stored in the REFLOW001-USB hardware. A reflow session always uses a profile stored in the REFLOW001-USB hardware.

Window "Reflow -> Profile configuration" gives the following possibilities :

1 - modify profile data
2 - store profile onto harddisk
3 - read profile from harddisk
4 - write profile to REFLOW001-USB
5 - read profile from REFLOW001-USB
6 - graphical display of profile data

Section 11 - **Controlling the reflow proces**

A number of application windows have been implemented because of development, debugging or test purposes. For starting, monitor and stopping a reflow proces only a few windows will be used.

Window USB -> Human interface device (Hid)
In this window you have to open the USB connection with the REFLOW001-USB controller.

Window Reflow -> Control and display :
After choosing a profile number (1 .. 10) the reflow proces can be started with the button "Start reflow soldering". During the proces information will be displayed in graphical and alphanumeric form. The proces can be prematurely stopped by pressing "Stop reflow soldering".

Section 12 - **PC application screenshots**

Section 13 - **Package contents**

Items	Qty	Manufacturer + type	
Fully assembled enclosure	1	Circuit board	P. Tilma HSE : REFLOW001-USBa
	1	Enclosure	Hammond : 1591XXBFL
	3	Fuseholder	Multicomp : MCHTC-30M
	3	Fuse	
USB cable (2m)	1		
2 pole plug	3	Phoenix : MSTB 2,5/2-ST-5.08	
3 pole plug	1	Phoenix : MSTB 2,5/2-ST-5.08	
4 pole plug	2	Phoenix : MC1,5/4-ST-3,81	
pt100 probe	1	Sensorshop24 : LG-2-PT100-1.0-4L	
pt100 probe	1	Sensorshop24 : EF1G-PT100A-1.0-200-4L	

Section 14 - **STANDARD LEGAL STUFF**

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