Datasheet

DS001051

AS7050

Analog Frontend for Vital Sign Monitoring

v1-00 • 2022-Mar-31

Content Guide

1 General Description

The AS7050 Biosignal Sensor Analog Frontend is the next generation Vital Sign Sensor. It enables the user to detect biosignals such as photoplethysmogram (PPG), electrocardiogram (ECG) and galvanic skin resistance (GSR). PPG is the most used HRM method. It measures the pulse rate by sampling light modulated by the blood vessels, which expand and contract as blood pulses through them. ECG is the reference for any measurement of the biopotential generated by the heart.

Compared to the previous ams OSRAM biosignal sensor generation, AS7050 is a biosignal converting unit. The AS7050 provides up to 8 LED driver outputs, samples up to 6 photodiode inputs and supports external electrodes. This enables the highest flexibility for several LED and photodiode arrangements in different applications. Furthermore, the AS7050 Biosignal Sensor Analog Frontend provides 2 ADC channels for simultaneous PPG and ECG measurements and an automatic photodiode offset control.

The embedded ECG analog front-end satisfies IEC 60601-2-47 requirements.

The AS7050’s low-power design and small form factor are particularly well suited to application in fitness bands, smartwatches, sports watches, smart patches and earbuds. In these cases, board space is limited, and users look for extended, multi-day intervals between battery recharges. Thin package dimension makes the AS7050 suitable for height constrained solutions like earbuds.

1.1 Key Benefits & Features

The benefits and features of AS7050, Analog Frontend for Vital Sign Monitoring are listed below:

Figure 1:
Added Value of Using AS7050

Benefits	Features
High flexible LED/photodiode configuration.	Up to 8 LED drivers and 6 photodiode input pins.
Allows smallest application size e.g. narrow HRM measurement band.	Small Wafer-Level-Chip-Scale-Package (WLCSP).
Electrocardiogram ECG with dry electrodes.	Embedded low noise analog front-end for ECG signals acquisition.
Enables blood pressure measurements.	Synchronized PPG and ECG acquisition.
Good HRM measurement quality.	Low noise analog front-end for PPG acquisition
Additional information for end user.	Analog electrical front-end (e.g. for temperature sensing using a NTC or galvanic skin resistivity (GSR)).
Long operating time.	Hardware sequencer to offload processor. Adjustable LED driver with current control.
Ready for blood oxygen measurement	2 PPG channels useable in simultaneous mode available
Acquiring several bio signals in parallel	ECG and PPG channels separated and simultaneous useable

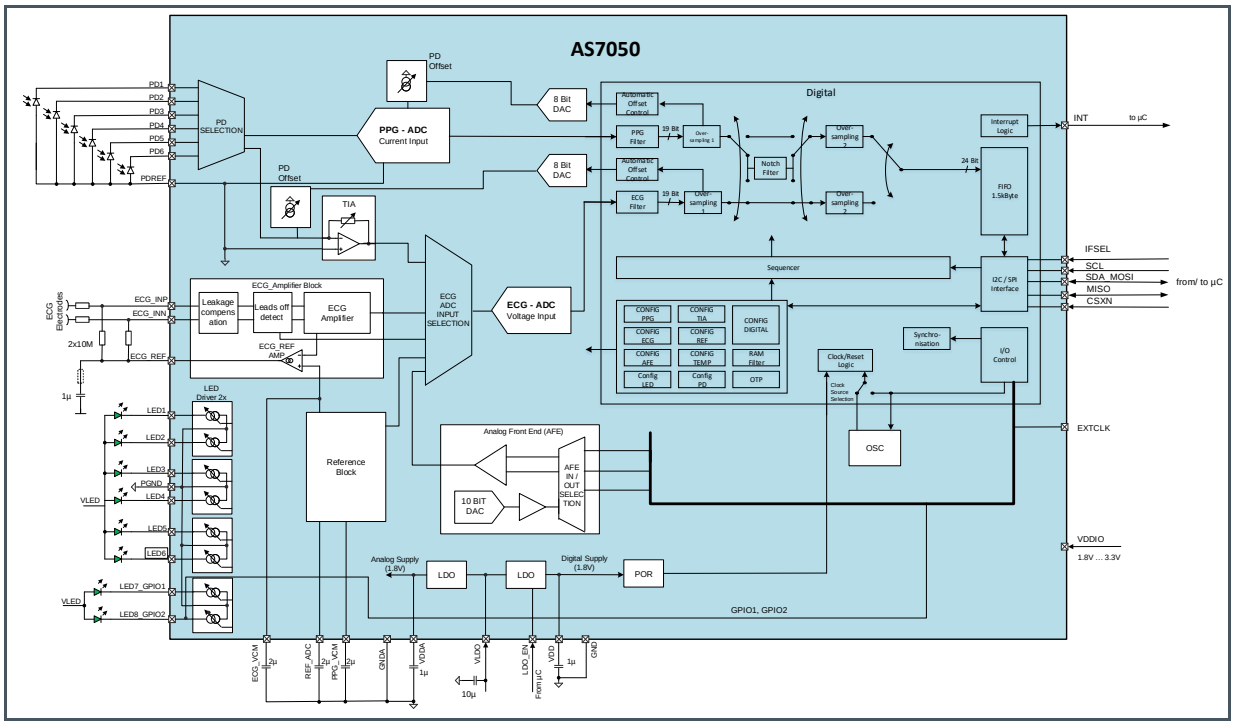
1.2 Applications

- Optical sensor platform
- Fitness band
- Smart watch
- Smart patches
- Heart rate monitor
- Hearables
- ECG monitoring
- Cuff-less blood pressure measurements

1.3 Block Diagram

The functional blocks of this device are shown below:

Figure 2 :
Functional Blocks of AS7050



2 Ordering Information

Ordering Code	Package	Marking	Delivery Form	Delivery Quantity
AS7050-BWLM	WLCSP	n.a.	Tape & Reel	500 pcs/reel
AS7050-BWLT	WLCSP	n.a.	Tape & Reel	10000 pcs/reel

3 Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under “Operating Conditions” is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Figure 3:
Electrical Characteristics of AS7050

Symbol	Parameter	Min	Max	Unit	Comments
Electrical Parameters					
V_{DD}	Digital Supply Voltage		1.98	V	
V_{DDA}	Analog Supply Voltage		1.98	V	
V_{DDIO}	IO Supply Voltage		6	V	
V_{IN}	Input Pin Voltage to Ground pins GPIO1/2	-0.3	V_{DDIO}+0.3 V max. 6 V	V	Internal diode to V_{DDIO}
$V_{IN-OTHER}$	Input Pin Voltage to Ground pins SCL/SDA_MOSI/MISO/CSXN/INT/EXTCLK	-0.3	V_{DDIO}+0.3 V max. 6 V	V	internal diode to V_{DDIO}
V_{LDO_EN}	Input Pin Voltage to Ground pins LDO_EN	-0.3	V_{LDO}+0.3 V max. 6 V	V	internal diode to V_{LDO}
$V_{VD1/2/3/4/5/6}$	Voltage at Pins VD1,VD2,VD3,VD4,VD5,VD6		6	V	
$V_{VD7/8\_INTERNAL}$	Voltage Between Internal Pin of VD7-VD8 to GND		V_{DDIO}+0.3 V	V	Internal diode between current source (internal node at anode of the LED if the pin has an LED otherwise VD7/8 pin) and V_{DDIO}
$V_{IN-LDO1}$	Input Pin Voltage to Ground for pin V_LDO	-0.3	6	V	EN_LDO > 1.3 V
$V_{IN-LDO2}$	Input Pin Voltage to Ground for pin V_LDO	-0.3	VDD+0.3 V max. 2 V	V	EN_LDO = 0 V Diode to V_{DD} and V_{DDA}
$V_{IN-VDDA\_DIODE}$	Input Pin Voltage to Ground pins for ECG_INP/ECG_INN/ECG_REF/ECG_VCM/PPG_VCM/REF_ADC/PD1/PD2/PD3/PD4/PD5/PD6/PDREF	-0.3	V_{DDA}+0.3 V max. 2 V	V	Diode to V_{DDA}
$V_{GNDA-PGND}$	Analog to Power Ground Voltage Difference		±0.3	V	
$V_{GNDA-GND}$	Analog to Digital Ground Voltage Difference		±0.3	V	
I_{SCR}	Input Current (latch-up immunity)		±100	mA	JEDEC JESD78 Connect specified capacitor on SIGREF and V_LDO during latch-up test.
I_{LEDON}	Average LED ON Current		35	mA	DC current with all LEDs ON during all 8 time slots(2)

Symbol	Parameter	Min	Max	Unit	Comments
Electrostatic Discharge					
ESD_{HBM}	Electrostatic Discharge HBM		±2.0	kV	JS-001-2017
Temperature Ranges and Storage Conditions					
T_{STRG}	Storage Temperature Range	-40	125	°C	
T_{AMB}	Operating Free-air Temperature	-30	85	°C	
T_{BODY}	Package Body Temperature		260	°C	IPC/JEDEC J-STD-020(1)
RH_{NC}	Relative Humidity (non-condensing)	5	85	%	
MSL	Moisture Sensitivity Level		1		Maximum floor life time unlimited @ 30°C/85% RH_{max}

(1) The reflow peak soldering temperature (body temperature) is specified according to IPC/JEDEC J-STD-020 “Moisture/Reflow Sensitivity Classification for Non-hermetic Solid State Surface Mount Devices.”

(2) The minimal time slot time is 125 µs. It defines the time when you can start next sub-sample conversion. 8 sub-samples forming one sample. Within one sample you can chose any combination of LED and PD (e.g. sub-sample 1: LED1 and PD 3, subsample 2: LED3 and PD2 ….). Also if one subsample is completed in 32 µs you cannot start the next subsample immediately, you need to wait the beginning of new time slot (which is 125 µs after beginning of sub-sample start).

4 Electrical Characteristics

All limits are guaranteed. The parameters with Min and Max values are guaranteed with production tests or SQC (Statistical Quality Control) methods.

Figure 4:
Electrical Characteristics of AS7050

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DD}	Supply voltage		1.7	1.8	1.98	V
V_{DDA}	Analog positive supply voltage		1.7	1.8	1.98	V
V_{DDIO}			V_{DD}	3.3	6	V
I_{DDA}	Supply current in power down mode	LDO_EN=0V, VLDO = VDDA		0.07		µA
	Supply current in idle mode	lf_osc_on=1		0.07		µA
	Supply current PPG ADC active	en_bg=1, en_vcm_ppg=1, en_bias=1, sel_opamp=0, ppg_en=1, ppg_mod_en=1, pll_on=1, hf_osc_on=1		9.55		mA
	Supply current ECG ADC active	en_bg=1, en_vcm_ecg=1, en_ref=1, en_bias=1, sel_opamp=0, ecg_en=1, ecg_mod_en=1, ecg_ibuf_en=1, pll_on=1, hf_osc_on=1		5.55		mA
	Supply current ECG Amplifier active	ecg_amp_en=1, ecg_ina1_en=1, ecg_ref_enable=1, ecg_ina2_en=1		0.26		mA

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
	Supply current TIA active	tia_en = 1		1.39		mA
	Supply current AFE active	afe_dac_en = 1, afe_dac_buf_en=1, afe_gain_stage_en=1, afe_ref_buf_en=1		114.7		µA
I_{VDD}	Supply current in power down mode	LDO_EN=0V, VLDO = VDDA		1.1		µA
	Supply current in idle mode	lf_osc_on=1		2.92		µA
	Supply current PPG ADC active	en_bg=1, en_vcm_ppg=1, en_bias=1, sel_opamp=0, ppg_en=1, ppg_mod_en=1, pll_on=1, hf_osc_on=1		0.80		mA
	Supply current ECG ADC active	en_bg=1, en_vcm_ecg=1, en_ref=1, en_bias=1, sel_opamp=0, ecg_en=1, ecg_mod_en=1, ecg_ibuf_en=1, pll_on=1, hf_osc_on=1		0.80		mA
I_{VDDIO}	Supply current in power down mode	LDO_EN=0V, VLDO = VDDA		0.14		µA
f_{EXTCLK}	External clock frequency		2		4	MHz
$f_{Sampling,ECG}$	Sampling frequency				8	kHz
$f_{Sampling,PPG}$	Sampling frequency				1	kHz
Photodiode						
I_{OS}	DAC offset current full scale range	ppg_ios_fs=0		1		µA
		ppg_ios_fs=1		2		
		ppg_ios_fs=2		4		

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		ppg_ios_fs=3		8		
		ppg_ios_fs=4		16		
		ppg_ios_fs=5		32		
		ppg_ios_fs=6		64		
		ppg_ios_fs=7		128		
C_{PD}	Total photodiode capacitance connected to PPG_ADC	0 V reserve voltage		60	300	pF
I_{PD}	Photo current input	RTIA (TIA gain) values 9.375 kΩ-1.2 MΩ; (∑ signal range 1 µA-64 µA)	0		64	µA
ECG						
V_{IN_SIG}	Input signal ECG	Max ECG input signal according to IEC 60601-2-47, chapter 201.12.4.4.101	-10		10	mV
$V_{IN\_DC\_OFF}$	Input DC offset	Max ECG DC Offset voltage according to IEC60601-2-47, chapter 201.12.4.4.101	-300		300	mV
$V_{Noise, p-v}$	Input-related peak to valley noise	Measured at the output of ECG amplifier in the frequency range of f_{IN} according to IEC 60601-2-47, chapter 201.12.4.4.106			50	µV
R_{IN}	Input Impedance	According to IEC 60601-2-47, chapter 201.12.4.4.102		100		MΩ
V_{ECG_REF}	ECG_REF voltage	ecg_ref_enable = 1		0.8		V
$V_{ECG\_ref\_in}$	ECG Ref Input voltage	Input from reference block		0.8		V
ECG-MODE DSM Interface						
ECG_CR	ECG conversion rate	19-bit resolution		8		kSps
ECG_P_TOTAL	Power consumption			5		mA

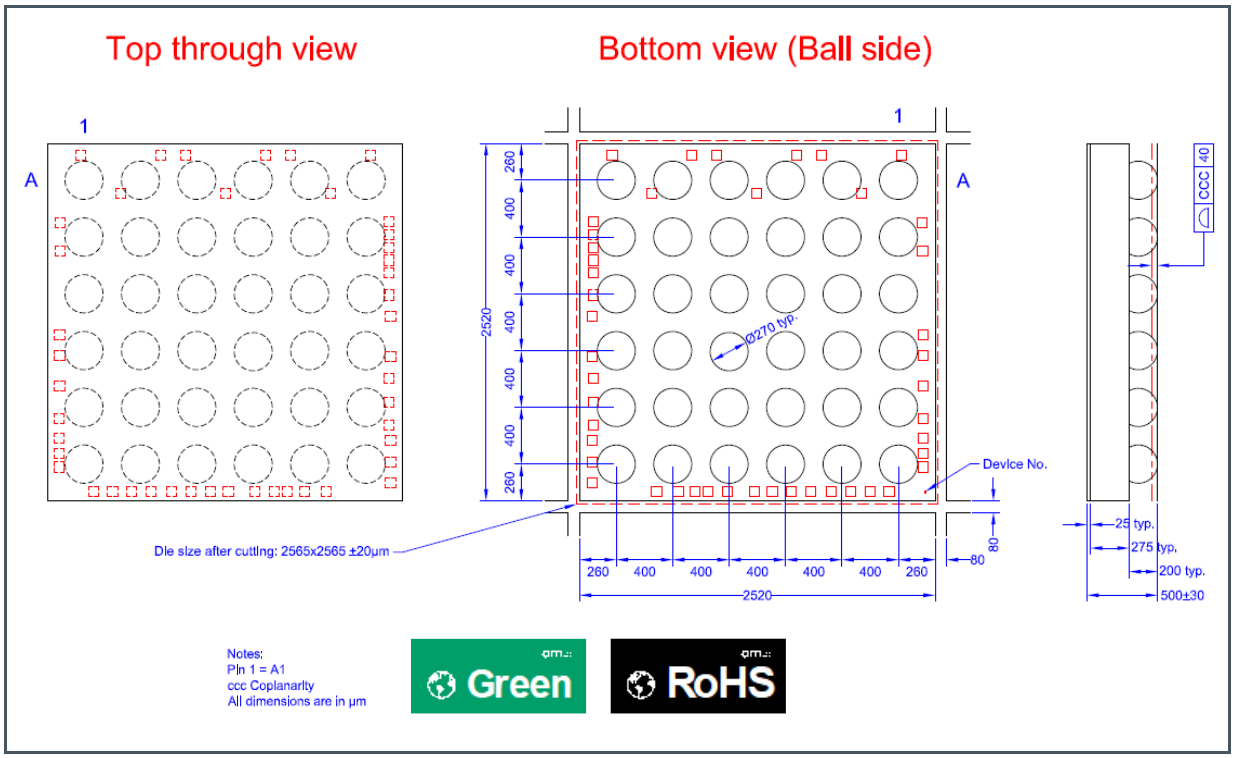
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ECG_RES	ECG Resolution		19			bits
ECG_ENOB	ENOB			17		bits
V_{ECGADC_REFP}	Positive reference voltage			1.6		V
LED Driver						
V_{LED}	LED pad voltage				5	V
LED Driver 1-6						
I_{LED}	Allowed operating LED output current	led_ictrl = 127		150.00		mA
		led_ictrl = 255		300.00		mA
V_{Compl_1}	Compliance voltage	led_ictrl = 0 … 127			0.3	V
		led_ictrl = 128 … 255			0.85	V
LED Driver 7-8						
I_{LED}	Allowed operating LED output current	led_ictrl = 128		50.00		mA
V_{Compl_1}	Compliance voltage	led_ictrl = 0 … 127			0.3	V
Reference Block						
V_{ECG_VCM}	Reference voltage	SEL_REF=0, at T=27 °C		0.8		V
V_{REF_ADC}	Reference voltage	Trimmed reference voltage, SEL_REF=0, at T=27 °C		1.6		V
V_{PPG_VCM}	Reference voltage	SEL_REF=0, at T=27 °C		0.8		V
TSEN_OUT	Temperature sensor output voltage	At room temperature		636		mV
TSEN_TK	Temperature sensor temperature coefficient of the output voltage	-40 °C to 105 °C		-2.03		mV/°C

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Analog Front End						
V_{OUT_DAC}	Output voltage DAC	dac_value<9:0> 0x3FF REF_ADC=1.6 V		1.6		V
V_{OUT_AFE}	Output voltage range AFE		0.3		1.4	V
R_{RANGE}	Bias resistor trimming range	Across process and voltage corners, 25 °C		500		kΩ
C_{GPIO}	Load capacitance GPIO1/2				50	pF
LDO						
V_{LDO}		HV power supply if LDO_EN >1.26 V	2.3		5.5	V
		if LDO_EN < 0.56 V		V_{DD}		V
V_{LDO1V8}	Output voltage	Output voltage in operating mode		1.8		V
C_{LDO}	Output capacitance	External blocking capacitance		1		µF
GPIO						
V_{IH}	Input high	Switching threshold while rising edge of input signal is introduced	0.54		1.26	V
V_{IL}	Input low	Switching threshold while falling edge of input signal is introduced	0.54		1.26	V
V_{OH}	Output high	Pin's source load current is 2 mA condition: E2=E4="1" (full available driver strength)			V_{DDIO}-0.4	V
V_{OL}	Output low	Pin's sink load current is 2 mA condition: E2=E4="1" (full available driver strength)			0.4	V
SDA_MOSI, SCL, EXTCLK, CSXN, IFSEL, LDO_EN						
V_{IH}	Input high	Switching threshold while rising edge of input signal is introduced	0.54		1.26	V

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IL}	Input low	Switching threshold while falling edge of input signal is introduced	0.54		1.26	V
f_{Clock_SPI}	SPI clock frequency			10		MHz
SDA_MOSI, MISO						
V_{OH}	Output high	Pin's source load current is 6 mA condition: E2=E4="1" (full available driver strength)			V_{DDIO}-0.4	V
V_{OL}	Output low	Pin's sink load current is 6 mA condition: E2=E4="1" (full available driver strength)			0.4	V
INT						
V_{OH}	Output high	Pin's source load current is 2 mA condition: E2=E4="1" (full available driver strength)			V_{DDIO}-0.4	V
V_{OL}	Output low	Pin's sink load current is 2 mA condition: E2=E4="1" (full available driver strength)			0.4	V

5 Package Drawings & Markings

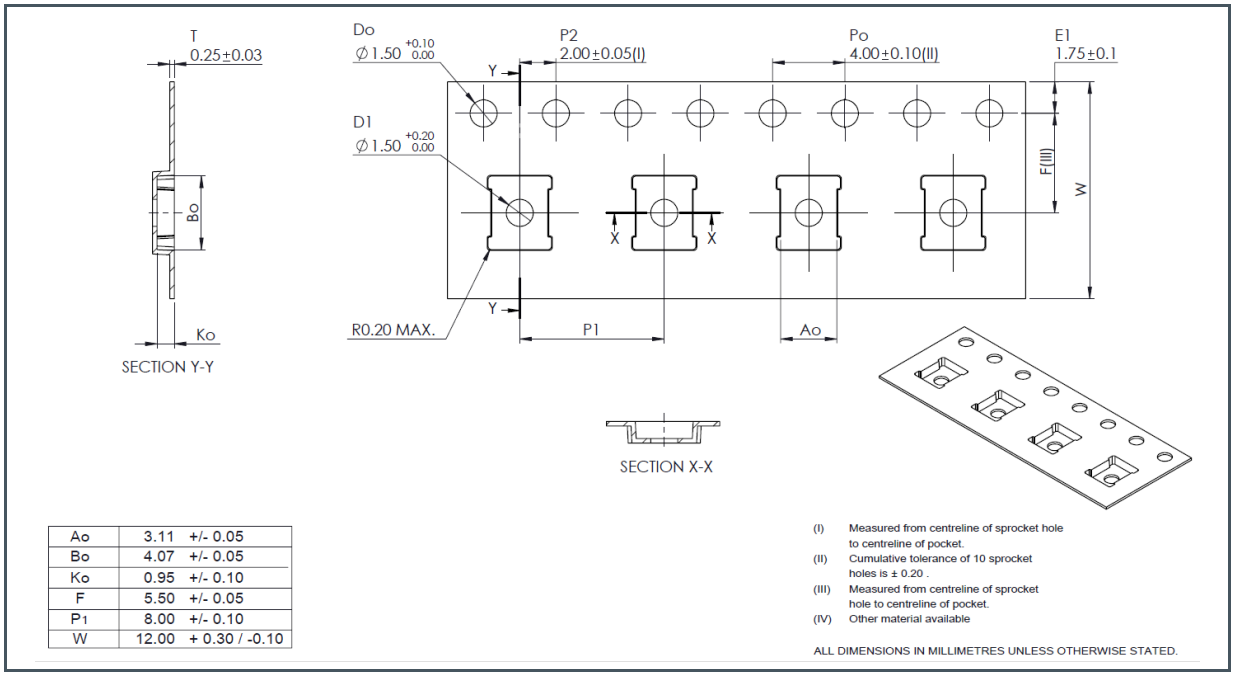
Figure 5:
Package Outline Drawing



(1) All dimensions are in micrometers. Angles in degrees.
(2) Dimensioning and tolerancing conform to ASME Y14.5M-1994.
(3) This package contains no lead (Pb).
(4) This drawing is subject to change without notice.

6 Tape & Reel Information

Figure 6:
Tape Dimensions



Ao	3.11 +/- 0.05
Bo	4.07 +/- 0.05
Ko	0.95 +/- 0.10
F	5.50 +/- 0.05
P1	8.00 +/- 0.10
W	12.00 + 0.30 / -0.10

(I) Measured from centreline of sprocket hole to centreline of pocket.
(II) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
(III) Measured from centreline of sprocket hole to centreline of pocket.
(IV) Other material available

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

7 Soldering & Storage Information

Figure 7:
Solder Reflow Profile Graph

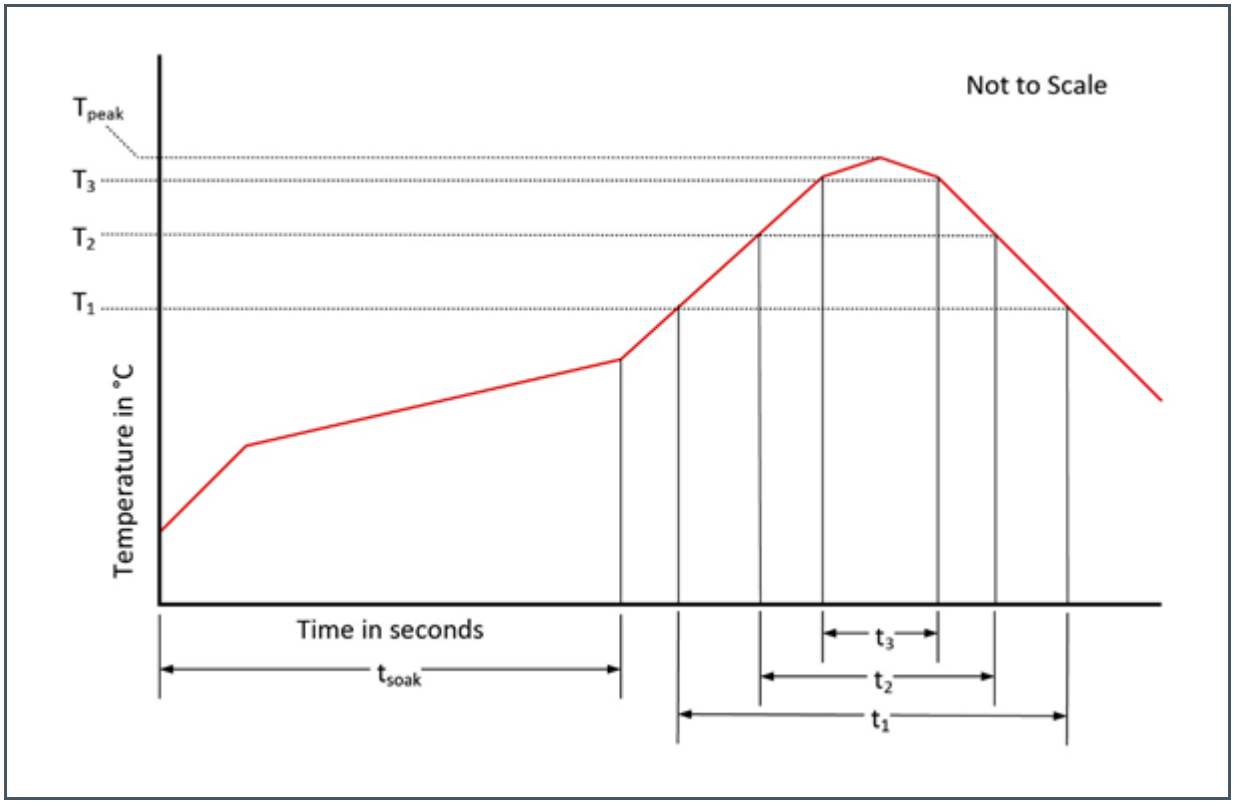


Figure 8:
Solder Reflow Profile

Parameter	Reference	Device
Average temperature gradient in preheating		2.5 °C/s
Soak time	t_{soak}	2 to 3 minutes
Time above 217 °C (T1)	t_1	Max 60 s
Time above 230 °C (T2)	t_2	Max 50 s
Time above T_{peak} – 10 °C (T3)	t_3	Max 10 s
Peak temperature in reflow	T_{peak}	260 °C
Temperature gradient in cooling		Max −5 °C/s

8 Revision Information

Changes from previous version to current revision v1-00	Page
This short datasheet is derived from v3-00 of full datasheet	

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

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