

AP928

Flash Microcontroller with LCD Driver for Docking Application

Datasheet

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1. OVERVIEW

The AP928 is a controller IC for docking application with remote control function and LCD driver. AP928 also supports real time clock with 12/24 hour display format and dual alarm clock timer. Built-in with LCD driver and support for docking system of prevalent music players and mobile phones, AP928 is suitable for a wide range of audio applications that have build-in clock alarm, radio and docking features.

2. APPLICATIONS

2.1. Target Applications

- Docking system
- Clock radio
- Bluetooth application

2.2. Application Features

2.2.1 Docking Control Features

- Docking control through front panel buttons or remote controller
- Device charging through docking system
- Support Apple Authentication Coprocessor

2.2.2 Clock and Alarm Features

- 12/24 hour clock display mode selectable by user
- Dual alarm clocks
- User selectable alarm mode – wake-to-buzzer, wake-to-radio or wake-to-docked device

- Fixed snooze feature
- Programmable sleep timer

2.2.3 Radio Features

- Auto/Manual radio station scanning
- Programmable radio station memory (independent memory slots for FM and AM)

2.2.4 Other System Features

- Support 24 segment x 4 common or 6 common, 1/3 bias LCD display
- Automatic detection of AC power
- Low standby current

3. ORDERING INFORMATION

ORDERING NUMBER	PINS	PACKAGE
AP928-LQ-L	100	LQFP

4. PIN CONFIGURATION

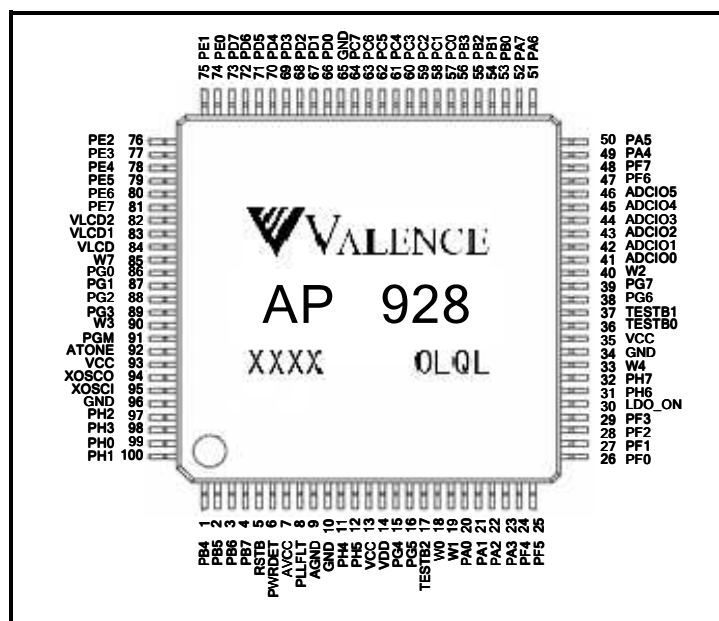


Figure 1 100-Pin LQFP Package of AP928

5. BLOCK DIAGRAM

The following diagram shows the system blocks embedded in AP928.

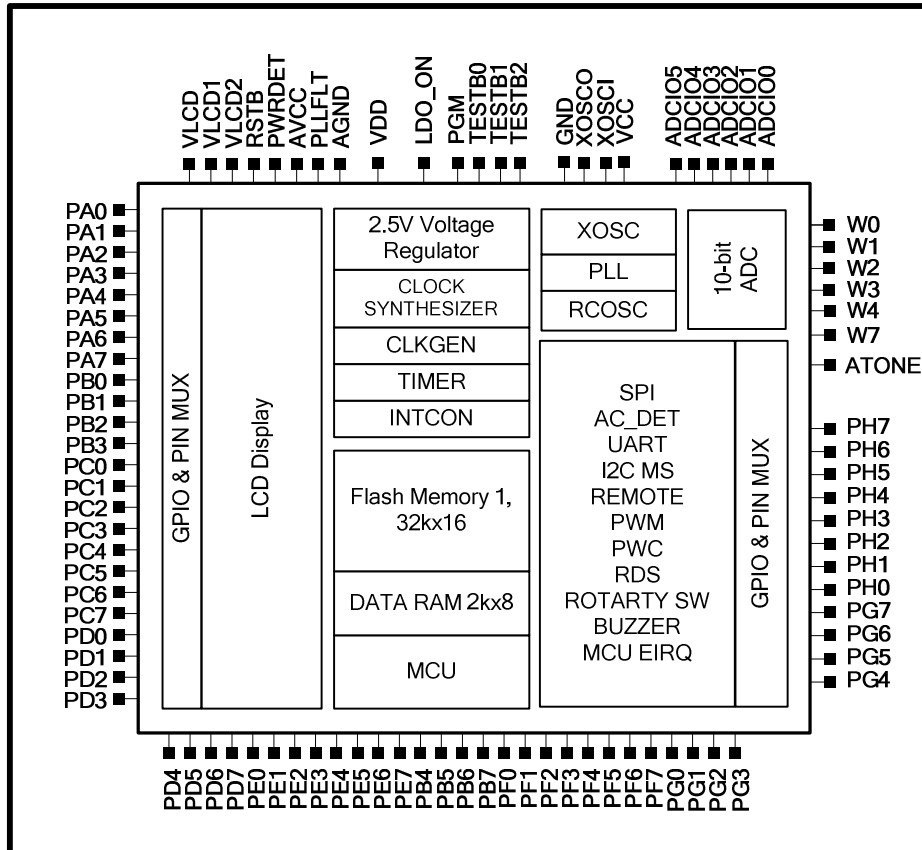


Figure 2 Internal Block Diagram of AP928

6. BUILT-IN PERIPHERALS

- High performance 8 bit CPU
 - Support C language programming
- 64k byte program flash
- 2 kbyte data RAM
- Interrupt controller
 - 15 interrupt sources
- Watchdog reset
- Real time clock
- Embedded RC oscillator
- Programmable timer
 - 3 units
- Pulse width modulation
 - 3 units
- LCD driver
 - 24 segment x 4 common or 6 common, 1/3 bias LCD display
- 10-bit ADC
 - 6 channels
- AC line frequency detection unit
- IR remote transmit and receive control unit
- Buzzer unit
 - output level control available
- Rotary type switch counter unit
- UART interface
 - 2 units
- I2C interface
 - 3 channels
- SPI interface
 - 1 channel
- Selectable oscillator option
 - XOSC : low speed 32.768kHz
 - RCOSC: 8MHz internal RC oscillator

7. PIN DESCRIPTION

Pin	Name	Alternative Function	Type	Pullup /down	Descriptions
1	PB4	SPIDIO	IO,S	PU	General purpose IO port / SPI data IO
2	PB5	SPICLK	IO,S	PU	General purpose IO port / SPI clock IO
3	PB6	SPIDI	IO,S	PU	General purpose IO port / SPI data input
4	PB7		IO,S	PU	General purpose IO port
5	RSTB		I,S	U	Active low chip reset input
6	PWRDET		IA	-	Low-voltage detect
7	AVCC				Analog supply voltage
8	PLLFLT		OA		PLL filter
9	AGND				Analog ground
10	GND				Ground
11	PH4	RCK	IO,S	PU	General purpose IO port or rotary switch counter input
12	PH5	RDATA	IO,S	PU	General purpose IO port or rotary switch counter input
13	VCC				3.3V Power supply
14	VDD				LDO output
15	PG4	PWM3O	IO,S	PU	General purpose IO port / PWM 3 output
16	PG5		IO,S	PU	General purpose IO port
17	TESTB2		IO		Active low chip test enable / Flash Program SDO
18	W0		IO,S	PU	General purpose IO port / external interrupt
19	W1		IO,S	PU	General purpose IO port / external interrupt
20	PA0	I2C0CLK	IO,S	PU	General purpose IO port / I2C0 clock output
21	PA1	I2C0DAT	IO,S	PU	General purpose IO port / I2C0 data IO port
22	PA2	PWM02	IO,S	PU	General purpose IO port / PWM 2 output
23	PA3	REMO/PWCI	IO,S	PU	General purpose IO port / Remote receiver input / PWC input
24	PF4	RCK	IO,S	PU	General purpose IO port or rotary switch counter input
25	PF5	RCD	IO,S	PU	General purpose IO port or rotary switch counter input
26	PF0	TX0	IO,S	PU	General purpose IO port or UART0 TX output
27	PF1	RX0	IO,S	PU	General purpose IO port or UART0 RX input
28	PF2	BOUT0	IO,S	PU	General purpose IO port or UART0 clock output
29	PF3	PWM01	IO,S	PU	General purpose IO port / PWM 1 output
30	LDO_ON		I,S		LDO Enable
31	PH6		IO,S	PU	General purpose IO port
32	PH7		IO,S	PU	General purpose IO port
33	W4	PWCI	IO,S	PU	General purpose IO port / external interrupt / PWC input
34	GND				Ground
35	VCC				3.3V Power supply
36	TESTB0		I,S	PU	Active low chip test enable / Flash Program SDI
37	TESTB1		I,S	PU	Active low chip test enable / Flash Program SCLK
38	PG6	TONE	IO,S	PU	General purpose IO port / buzzer output
39	PG7		IO,S	PU	General purpose IO port
40	W2		IO,S	PU	General purpose IO port / external interrupt
41	ADCIO0		IO,S		ADC input channel 0 / General purpose IO port
42	ADCIO1		IO,S		ADC input channel 1 / General purpose IO port
43	ADCIO2		IO,S		ADC input channel 2 / General purpose IO port
44	ADCIO3		IO,S		ADC input channel 3 / General purpose IO port
45	ADCIO4		IO,S		ADC input channel 4 / General purpose IO port
46	ADCIO5		IO,S		ADC input channel 5 / General purpose IO port
47	PF6	I2C1CLK	IO,S	PU	General purpose IO port / I2C1 clock output
48	PF7	I2C1DAT	IO,S	PU	General purpose IO port / I2C1 data IO port
49	PA4	TONE	IO,S	PU	General purpose IO port / buzzer output
50	PA5	BOUT1	IO,S	PU	General purpose IO port / UART1 clock output
51	PA6	COM6 / TX1	IO,S,L	PU	General purpose IO port / LCD common 6 / UART1 TX output
52	PA7	COM5 / RX1	IO,S,L	PU	General purpose IO port / LCD common 5 / UART1 RX input
53	PB0	COM4	IO,S,L	PU	General purpose IO port / LCD common 4
54	PB1	COM3	IO,S,L	PU	General purpose IO port / LCD common 3
55	PB2	COM2	IO,S,L	PU	General purpose IO port / LCD common 2
56	PB3	COM1	IO,S,L	PU	General purpose IO port / LCD common 1
57	PC0	SEG1	IO,S,L	PU	General purpose IO port / LCD segment 1
58	PC1	SEG2	IO,S,L	PU	General purpose IO port / LCD segment 2
59	PC2	SEG3	IO,S,L	PU	General purpose IO port / LCD segment 3
60	PC3	SEG4	IO,S,L	PU	General purpose IO port / LCD segment 4
61	PC4	SEG5	IO,S,L	PU	General purpose IO port / LCD segment 5
62	PC5	SEG6	IO,S,L	PU	General purpose IO port / LCD segment 6

Pin	Name	Alternative Function	Type	Pullup/down	Descriptions
63	PC6	SEG7	IO,S,L	PU	General purpose IO port / LCD segment 7
64	PC7	SEG8	IO,S,L	PU	General purpose IO port / LCD segment 8
65	GND				Ground
66	PD0	SEG9 / LCDD0	IO,S,L	PU	General purpose IO port / LCD segment 9 / 8-bit LCD Controller interface
67	PD1	SEG10 / LCDD1	IO,S,L	PU	General purpose IO port / LCD segment 10 / 8-bit LCD Controller interface
68	PD2	SEG11 / LCDD2	IO,S,L	PU	General purpose IO port / LCD segment 11 / 8-bit LCD Controller interface
69	PD3	SEG12 / LCDD3	IO,S,L	PU	General purpose IO port / LCD segment 12 / 8-bit LCD Controller interface
70	PD4	SEG13 / LCDD4	IO,S,L	PU	General purpose IO port / LCD segment 13 / 8-bit LCD Controller interface
71	PD5	SEG14 / LCDD5	IO,S,L	PU	General purpose IO port / LCD segment 14 / 8-bit LCD Controller interface
72	PD6	SEG15 / LCDD6	IO,S,L	PU	General purpose IO port / LCD segment 15 / 8-bit LCD Controller interface
73	PD7	SEG16 / LCDD7	IO,S,L	PU	General purpose IO port / LCD segment 16 / 8-bit LCD Controller interface
74	PE0	SEG17 / LCDWRB	IO,S,L	PU	General purpose IO port / LCD segment 17 / 8-bit LCD Controller interface
75	PE1	SEG18 / LCDRDB	IO,S,L	PU	General purpose IO port / LCD segment 18 / 8-bit LCD Controller interface
76	PE2	SEG19 / LCDA0	IO,S,L	PU	General purpose IO port / LCD segment 19 / 8-bit LCD Controller interface
77	PE3	SEG20 / LCDCSB	IO,S,L	PU	General purpose IO port / LCD segment 20 / 8-bit LCD Controller interface
78	PE4	SEG21	IO,S,L	PU	General purpose IO port / LCD segment 21
79	PE5	SEG22	IO,S,L	PU	General purpose IO port / LCD segment 22
80	PE6	SEG23	IO,S,L	PU	General purpose IO port / LCD segment 23
81	PE7	SEG24	IO,S,L	PU	General purpose IO port / LCD segment 24
82	VLCD2				1/3 x VLCD voltage
83	VLCD1				2/3 x VLCD voltage
84	VLCD				LCD driver supply voltage
85	W7	ACIN	I,S	U	AC detection input / General purpose IO port / external interrupt
86	PG0	TX1	IO,S,L	PU	General purpose IO port / UART1 TX output
87	PG1	RX1	IO,S,L	PU	General purpose IO port / UART1 RX input
88	PG2	BOUT1	IO,S,L	PU	General purpose IO port / UART1 clock output
89	PG3	IR_TX	IO,S,L	PU	General purpose IO port
90	W3		IO,S	PU	General purpose IO port / external interrupt
91	PGM		I,S	D	Flash Program Enable / Flash Program SCLR
92	ATONE	SDO	OA		Tone output with level control
93	VCC				3.3V Power supply
94	XOSCO		O		32.768kHz oscillator output
95	XOSCI		I		32.768kHz oscillator input
96	GND				Ground
97	PH2	PWMO3P	IO,S	PU	General purpose IO port / PWM3 complementary output 1
98	PH3	PWMO3N	IO,S	PU	General purpose IO port / PWM3 complementary output 2
99	PH0	I2C2CLK	IO,S	PU	General purpose IO port / I2C2 clock output
100	PH1	I2C2DAT	IO,S	PU	General purpose IO port / I2C2 data IO port

I - Input pin
 O - Output pin
 IO - Bidirectional pin
 IA - Analog input pin
 OA - Analog output pin

S - CMOS Schmitt Trigger
 (P)U - (Programmable) Pull-up
 (P)D - (Programmable) Pull-down
 L - LCD Pad
 0,1,Z - Logic state 0, Logic state 1, High impedance

8. ELECTRICAL SPECIFICATION

8.1. Absolute Maximum Rating

Item	Symbol	Rating	Unit
Power Supply Voltage (logic)	VCC	-0.5 to 6.0	V
Power Supply Voltage (analog)	AVDD	-0.5 to 6.0	V
Power Supply Voltage (LCD)	VLCD/VLCD1/VLCD2	-0.5 to 6.0	V
Input Voltage	V _{IN}	-0.5 to VCC+0.5	V
Power Dissipation (Ta = 70°C)	Pd	TBD	mW
Storage Temperature	T _{STG}	-20 to 125	°C
Operating Temperature	T _{opr}	0 to 70	°C

8.2. Recommended Operating Condition

Item	Symbol	Min.	Typ.	Max.	Unit
Power Supply Voltage (logic)	VCC	2.7	-	3.6	V
Power Supply Voltage (analog)	AVDD	2.7	-	3.6	V
Power Supply Voltage (LCD)	VLCD VLCD1 VLCD2	- VLCD2 0	- - -	VCC VLCD VLCD1	V
Input Voltage (digital)	V _{IN}	0	-	VCC	V
Input Voltage (analog)	V _{IN}	0	-	VCC	V
Operating Temperature	T _{OPR}	0	-	70	°C

8.3. Leakage Current and Capacitance

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
I _{IN}	Input current	No pull-up or pull-down	-10	-	10	μA
I _{OZ}	Tri-state leakage current		-10	-	10	μA
C _{IN}	Input capacitance *Note1		-	-	5	pF
C _{IN}	Output capacitance *Note1		-	-	5	pF
C _{BID}	Bidirectional buffer capacitance *Note1		-	-	5	pF

*Note1: capacitance value are specified without the package

8.4. DC Electrical Characteristics

(VCC=3.3V±10%, AVDD=3.3V±10%, operating temperature = 0°C - 70°C unless specified otherwise)

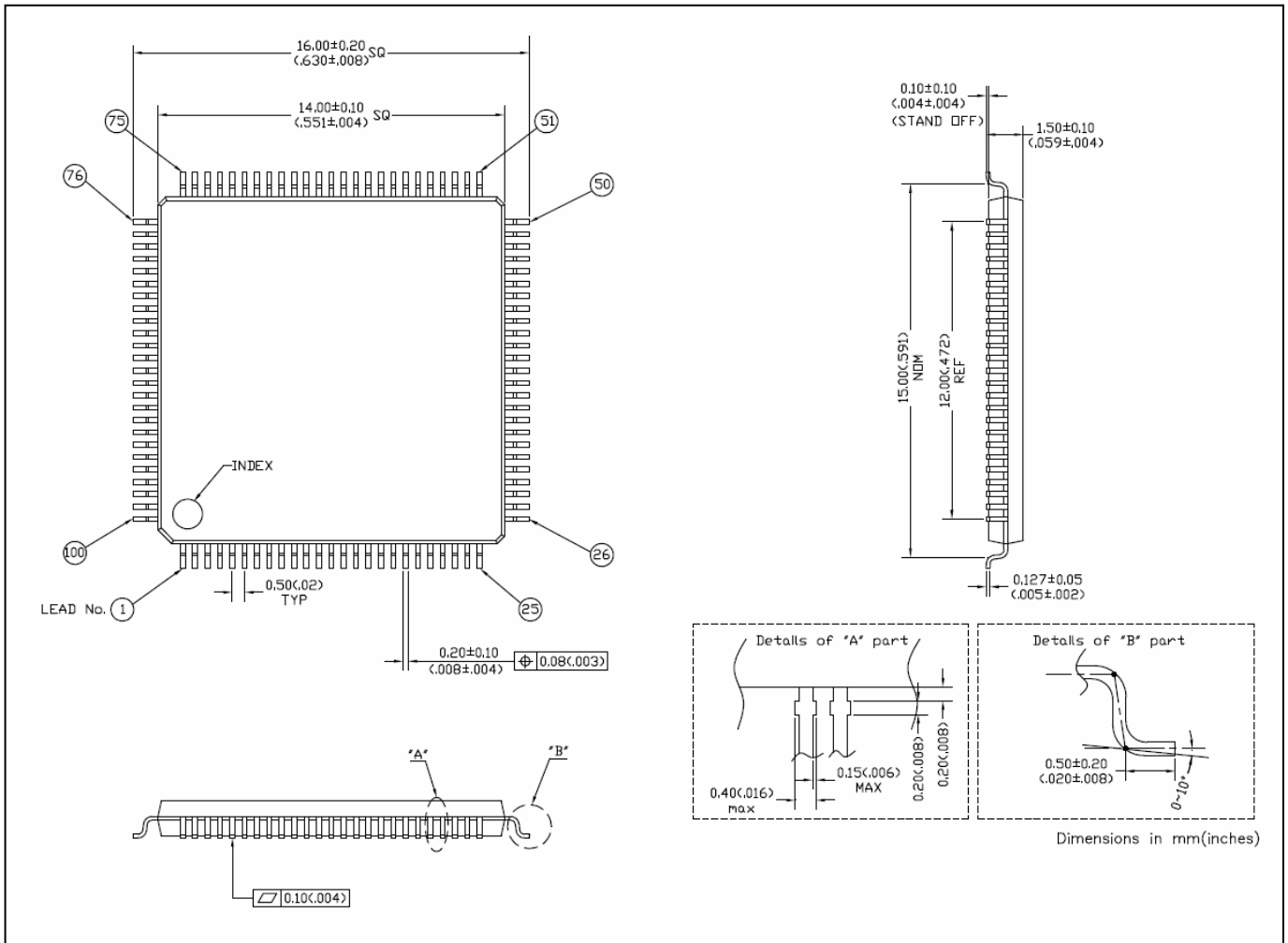
Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V _{CC}	Supply Voltage (logic)	Core operating mode Clock mode	2.7 2.4	-	3.6 3.6	V
AV _{DD}	Supply Voltage (analog)	Core operating mode Clock mode	2.7 2.4	-	3.6 3.6	V
V _{IH}	Input high voltage		0.7*VCC	-	-	V
V _{IL}	Input low voltage		-	-	0.3*VCC	V
R _{PU}	Pull-up resistance except SEG/LCD pads	V _{IN} = 0V	115	160	240	kΩ
R _{PU2}	Pull-up resistance for SEG/LCD pads	V _{IN} = 0V	38	50	80	kΩ
R _{PD}	Pull-down resistance	V _{IN} = VCC	92	140	240	kΩ
I _{OL}	Output low current	VOL = 0.4V *Note4	4.3	5.7	-	mA
I _{OH}	Output high current	VOH = VCC-0.4V *Note4	2.2	2.9	-	mA
I _{dd_opr}	Core operating current	*Note2	-	7	10	mA
I _{dd_idle}	Clock Mode current	VCC=3.3V, T=25°C *Note3	-	80	100	μA

*Note2: LCD is ON. The CPU clock source is from the internal PLL clock. No active load is being driven. All inputs = 0V or VCC.

*Note3: LCD is ON. The CPU clock source is from the 32kHz oscillator pads. No active load is being driven. All inputs = 0V or VCC.

*Note4: Excluding PLLFLT, ATONE, XOSC.

9. PACKAGE INFORMATION



10. SOLDERING INDICATION

This section gives a very brief insight to a complex technology. There is no soldering method that is ideal for all surface mount IC packages. Wave soldering can still be used for certain surface mount ICs, but it is not suitable for fine pitch SMDs. In these situations reflow soldering is recommended.

1. Reflow Soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stenciling or pressure-syringe dispensing before package placement.

Several methods exist for reflowing; for example, convection or convection/infrared heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 250°C. The top-surface temperature of the packages should preferably be kept below 220 °C for thick/large packages, and below 235 °C for small/thin packages.

2. Wave Soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used, the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch:
 - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
 - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time is 4 seconds at 250°C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

3. Manual Soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

4. Suitability of Surface Mount IC Packages for Wave and Reflow Soldering Methods

Package	Soldering Method	
	Wave	Reflow ⁽¹⁾
BGA, HBGA, LFBGA, SQFP, TFBGA	Not suitable ⁽²⁾	Suitable
HBCC, HLQFP, HSQFP, HSOP, HTQFP, HTSSOP, HVQFN, SMS	Not suitable	Suitable
PLCC (3), SO, SOJ	Suitable	Suitable
LQFP, QFP, TQFP	Not recommended ⁽³⁾⁽⁴⁾	Suitable
SSOP, TSSOP, VSO	Not recommended ⁽⁵⁾	Suitable

Notes

- All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect).
- These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).
- If wave soldering is considered, the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
- Wave soldering is only suitable for LQFP, TQFP and QFP packages with a pitch equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch equal to or smaller than 0.65 mm.
- Wave soldering is only suitable for SSOP and TSSOP packages with a pitch equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch equal to or smaller than 0.5 mm.



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