5V, 5A, 1.2MHz Synchronous Boost Converter

Features

- **92% Effiicency Synchronous Boost Converter With 1000-mA Output Current From 1.8V Input**
- **Stable with Low ESR Output Capacitors**
- **Fixed 1.2MHz Oscillator Frequency**
- **Low EMI Converter (Integrated Anti-Ringing Function)**
- **Low Battery Output**
- **Integrated Power Save Mode Operation to Improve Light Load Efficiency**
- **Load Disconnected During Shutdown**
- **Output Current-Limit Protection**
- **Over Temperature Protection**
- **Under Voltage Protection**
- **Enable/Shutdown Function**
- **Available in TQFN4x4-16 and DFN3x3-12 Packages**
- **Lead Free and Green Devices Available (RoHS Compliant)**

General Description

The APW7277 is a synchronous rectifier, fixed switching frequency (1.2MHz typical), and current-mode step-up regulator. The device allows use of small inductors and output capacitors for USB devices. The current-mode control scheme provides fast transient response and good output voltage accuracy.

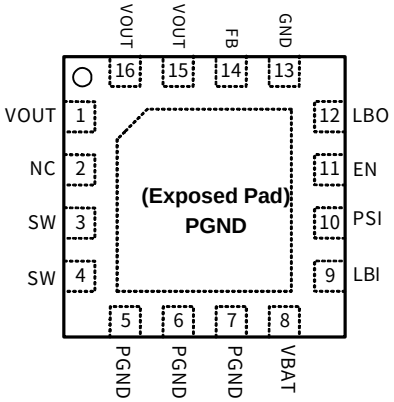
At light loads, the APW7277 will automatically enter in Pulse Frequency Modulation (PFM) operation to reduce the dominant switching losses. During PFM operation, the IC consumes very low quiescent current and maintains high efficiency over the complete load range. The APW7277 also includes current-limit and over-temperature shutdown to prevent damage in the event of an output overload.

The APW7277 is available in 4mmx4mm TQFN4x4-16 and DFN3x3-12 packages.

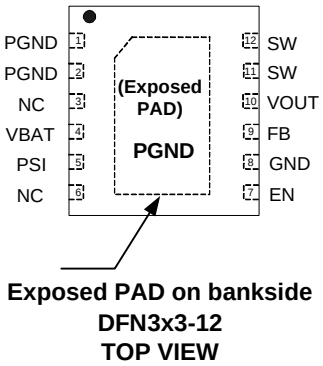
Applications

- **Power Bank**
- **Tablet**
- **Portable Equiment**

Pin Configuration



TQFN4x4-16
Top View



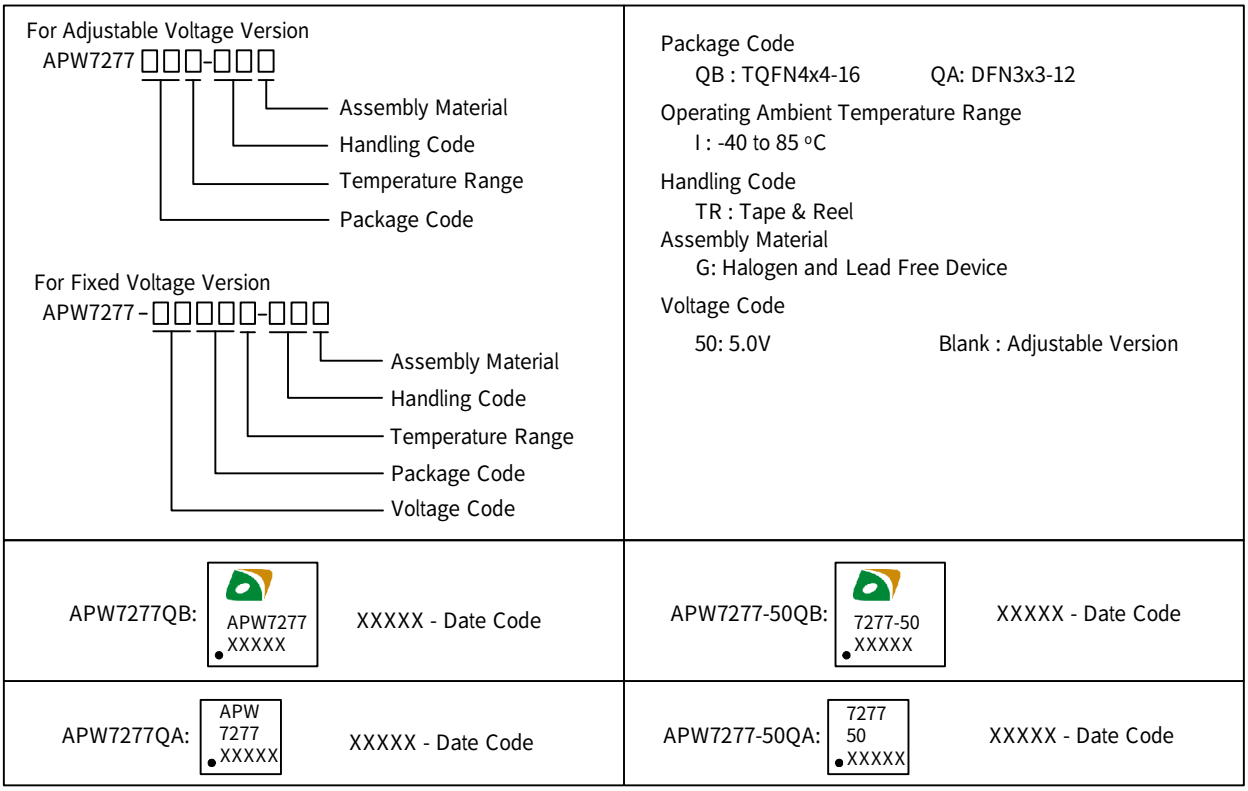
Exposed PAD on bankside
DFN3x3-12
TOP VIEW

ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

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Rev. A.2 - Sep, 2013

Ordering and Marking Information



Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020C for MSL classification at lead-free peak reflow temperature. ANPEC defines "Green" to mean lead-free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

Absolute Maximum Ratings (Note 1)

Symbol	Parameter		Rating	Unit
V_{OUT}	Output and IC Supply Voltage (V_{OUT} to GND)		-0.3 ~ 7	V
V_{BAT}	Converter Supply Voltage (V_{BAT} to GND)		-0.3 ~ 7	V
V_{SW}	SW to GND Voltage	>30ns	-0.3 ~ 7	V
		<30ns	-3 ~ 9	V
	LBI, SYNC, EN, LBO and FB to GND Voltage		-0.3 ~ 7	V
	PGND to GND		-0.3 ~ +0.3	V
P_D	Power Dissipation		-	W
T_J	Maximum Junction Temperature		150	°C
T_{STG}	Storage Temperature		-65 ~ 150	°C
T_{SDR}	Maximum Lead Soldering Temperature (10 Seconds)		260	°C

Note1: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

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Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Junction-to-Ambient Resistance in free air (Note 2)		°C/W
	TQFN4x4-16	40	
	DFN3x3-12	50	
θ_{JC}	Junction-to-Case Resistance		°C/W
	TQFN4x4-16	15	
	DFN3x3-12	20	

Note 2 : θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air.

Recommended Operating Conditions (Note 3)

Symbol	Parameter		Range	Unit
V_{OUT}	Output and IC Supply Voltage (V_{OUT} to GND)		2.7 ~ 5.5	V
V_{BAT}	Converter Supply Voltage (V_{BAT} to GND)		1.8 ~ V_{OUT}	V
V_{SW}	SW to GND Voltage	>30ns	-0.3 ~ V_{OUT}+0.3	V
		<30ns	-3 ~ V_{OUT}+3	V
	LBI, PSI, EN, LBO to GND Voltage		0 ~ V_{OUT}	V
T_A	Ambient Temperature		-40 ~ 85	°C
T_J	Junction Temperature		-40 ~ 125	°C

Note 3 : Refer to the typical application circuit

Electrical Characteristics

Unless otherwise specified, these specifications apply over V_{BAT}=3.3V, V_{OUT}=5V and T_A= 25 °C.

Symbol	Parameter	Test Conditions	APW7277			Unit
			Min	Typ	Max	
SUPPLY VOLTAGE AND CURRENT						
V_{BAT}	Converter Supply Voltage Range		1.8	-	5.5	V
V_{OUT}	Converter Output and IC Supply Voltage	V_{BAT} (Operation Max)=V_O/1.1	3.0	-	5.5	V
I_{DD1}	No Switching Quiescent Current	Measured from VOUT, V_{FB}=0.6V, V_{OUT}=3.3V	-	40	60	µA
$I_{VBAT-SD}$	V_{BAT} Quiescent Current	V_{EN}=GND, V_{BAT}=3.3V (Isolate VBAT & VOUT)	-	0.1	1	µA
V_{UVLO}	V_{BAT} Under Voltage Lockout Threshold	Rising	1.6	1.7	1.8	V
REFERENCE AND OUTPUT VOLTAGE						
V_{REF}	Regulated Feedback Voltage		490	500	510	mV
I_{FB}	FB Input Leakage Current		-100	-	100	nA
	Over Temperature Protection Hysteresis(note 4)	T_J Falling	-	30	-	°C

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Electrical Characteristics

Unless otherwise specified, these specifications apply over V_{BAT}=3.3V, V_{OUT}=5V and T_A= 25 °C.

Symbol	Parameter	Test Conditions	APW7277			Unit
			Min	Typ	Max	
INTERNAL POWER SWITCH						
F_{OSC}	Switching Frequency	FB=GND	900	1200	1500	MHz
R_{N-FET}	N-FET Switch On Resistance	V_{OUT}=5V	-	55	-	mΩ
R_{P-FET}	P-FET Switch On Resistance	V_{OUT}=5V	-	55	-	mΩ
	N-FET Current Limit	V_{OUT}=5V	4.5	5.5	-	A
	Dead-time (note 4)	V_{OUT}=3.3V~5V	-	10	-	ns
D_{MAX}	SW Maximum Duty Cycle		85	95	-	%
	PFM Current Limit		-	700	-	mA
CONTROL STAGE						
EN	EN Input Low Threshold		-	-	0.4	V
	EN Input High Threshold		1	-	-	V
	Internal Pull Low		-	500	-	kΩ
PSI	PSI Input Low Threshold		-	-	0.4	V
	PSI Input High Threshold		1	-	-	V
I_{EN}	EN Input Leakage Current	V_{EN}=1.5V	-	3	5	µA
I_{PSI}	PSI Input Leakage Current	V_{PSI}=1.5V	-	0.4	1	µA
LOW BATTER INDICATOR						
V_{LBI}	LBI Voltage Threshold		490	500	510	mV
	LBI Input Hysteresis		-	10	-	mV
	LBI Input Current		-	10	100	nA
	LBO Output Low Voltage	I_{LBO}=100uA	-	400	-	Ω
	LBO Output Low Current		-	-	10	mA
	LBO Output Leakage Current	V_{LBO}=5V	-	0.01	0.1	µA
ZERO CURRENT DETECT						
V_{ZC}	P-FET Zero Current Detect		-	+100	-	mA
PROTECTION						
	V_{FB} Under Voltage Protection		-	80	-	%V_{REF}
T_{OTP}	Over Temperature Protection (note 4)	T_J Rising	-	150	-	°C
	Over Temperature Protection Hysteresis(note 4)	T_J Falling	-	30	-	°C

Note 4: Guaranteed by design, not production tested.

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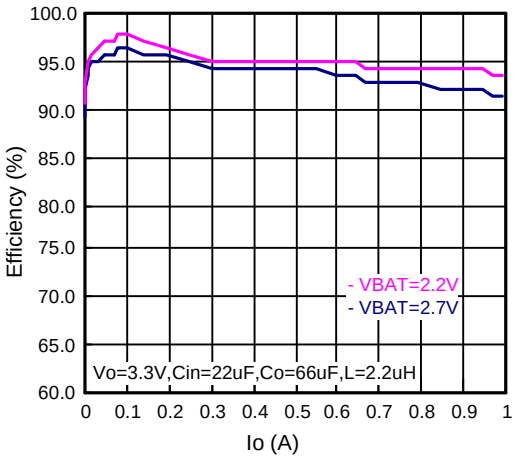
Pin Description

PIN	NAME	FUNCTION
1,15,16	VOUT	Converter Output and IC Supply Voltage.
2	NC	No Internal Connection.
3,4	SW	Converter Switch Pin. Connect inductor here.
5,6,7	PGND	Power Ground. Connect these pins to GND.
8	VBAT	Converter Supply Voltage.
9	LBI	Low Battery Indicator.
10	PSI	Power Saving Input. Force V_{PSI} exceed 1V enter PFM. Left V_{PSI} below 0.4V enter PWM mode.
11	EN	Device Enable Control Input. Force V_{EN} exceed 1V enable the device. Left V_{EN} below 0.4V to shutdown.
12	LBO	Low Battery Output.
13	GND	Signal Ground. Connect this pin to PGND.
14	FB	Converter Feedback Input.
Exposed Pad	PGND	Power Ground. Tie this pin to the ground island/plane through the lowest impedance connection available.

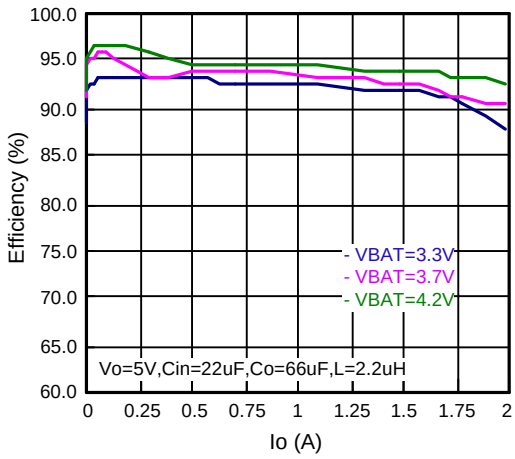
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Typical Operating Characteristics

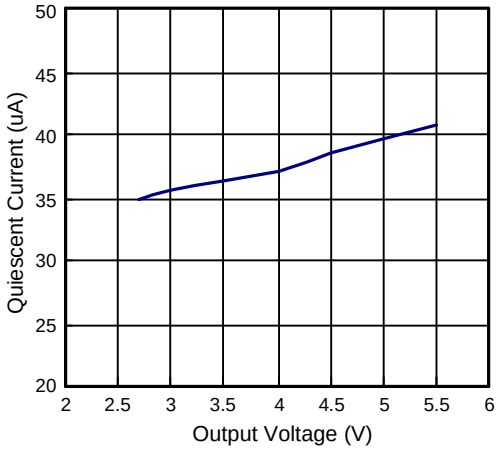
Efficiency VS Io



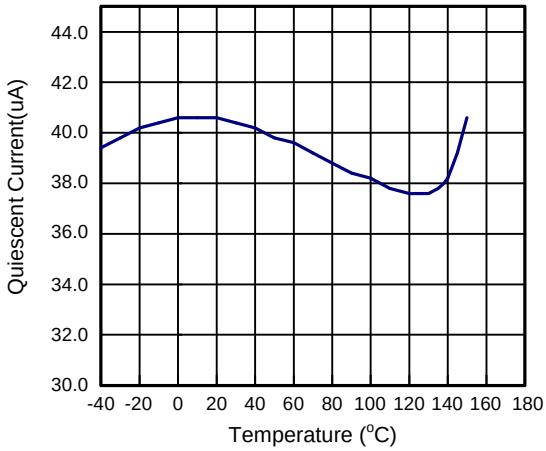
Efficiency VS Io



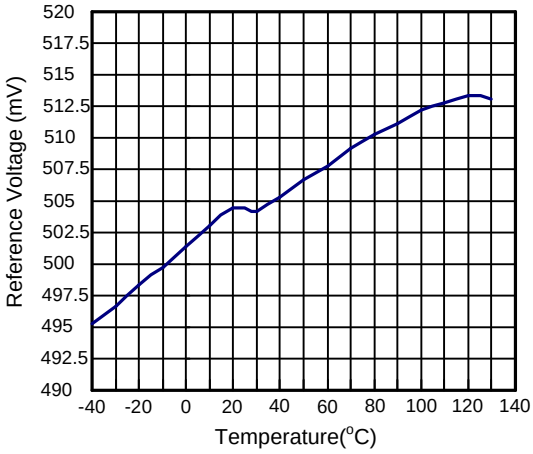
Quiescent Current VS Output Voltage



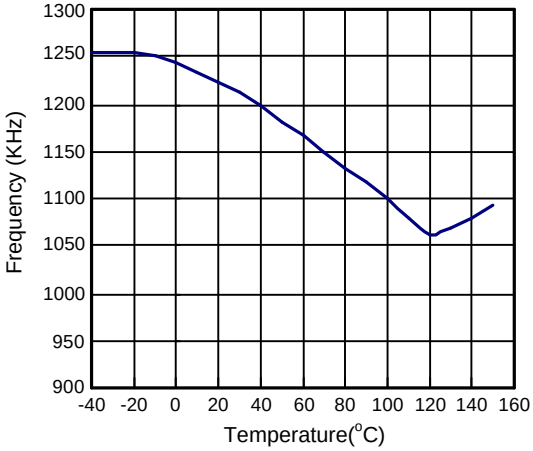
Quiescent Current VS Temperature



Reference Voltage VS Temperature



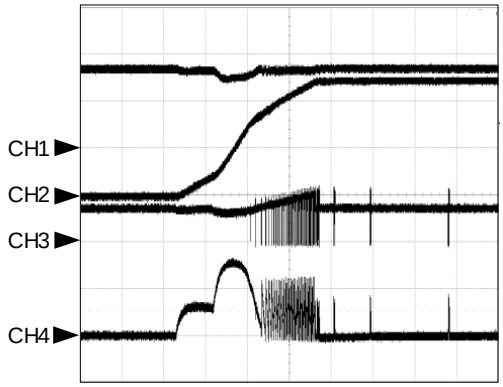
Frequency VS Temperature



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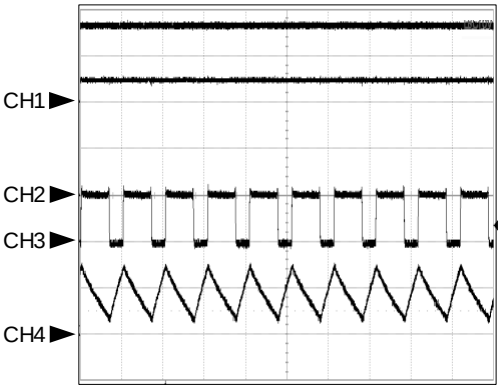
Operating Wavrforms

Power on EN



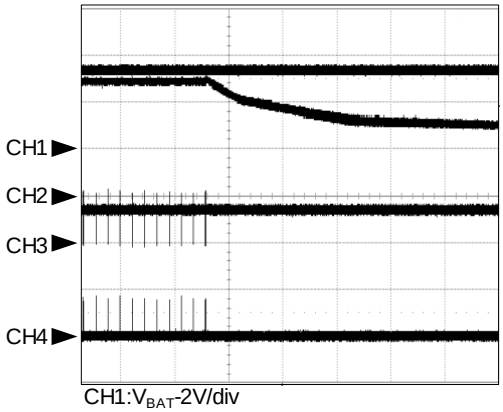
CH1:V_{BAT}-2V/div
CH2:V_{OUT}-2V/div
CH3:V_{SW}-5V/div
CH4:I_L-1A/div
Time:100us/div

Normal Operation



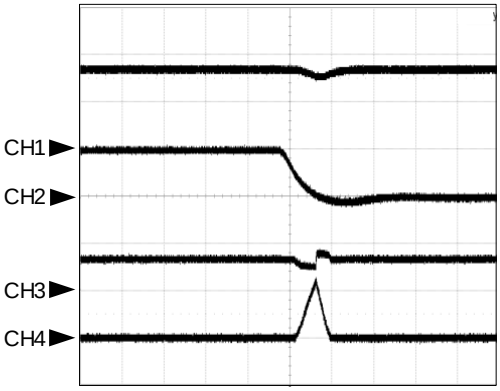
CH1:V_{BAT}-2V/div
CH2:V_{OUT}-2V/div
CH3:V_{SW}-5V/div
CH4:I_L-500mA/div
Time:1us/div

Power off EN



CH1:V_{BAT}-2V/div
CH2:V_{OUT}-2V/div
CH3:V_{SW}-5V/div
CH4:I_L-1A/div
Time:100us/div

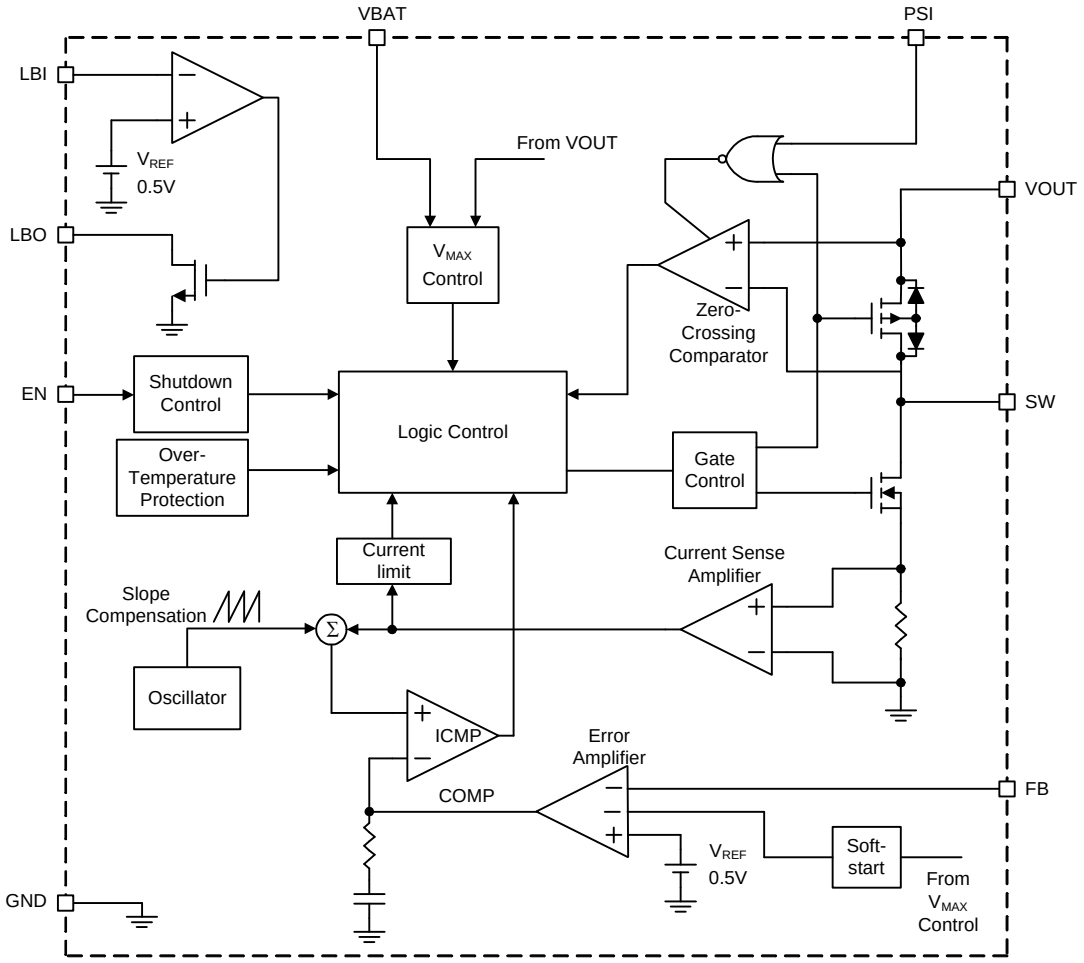
UVP



CH1:V_{BAT}-2V/div
CH2:V_{OUT}-5V/div
CH3:V_{SW}-5V/div
CH4:I_L-1A/div
Time:10us/div

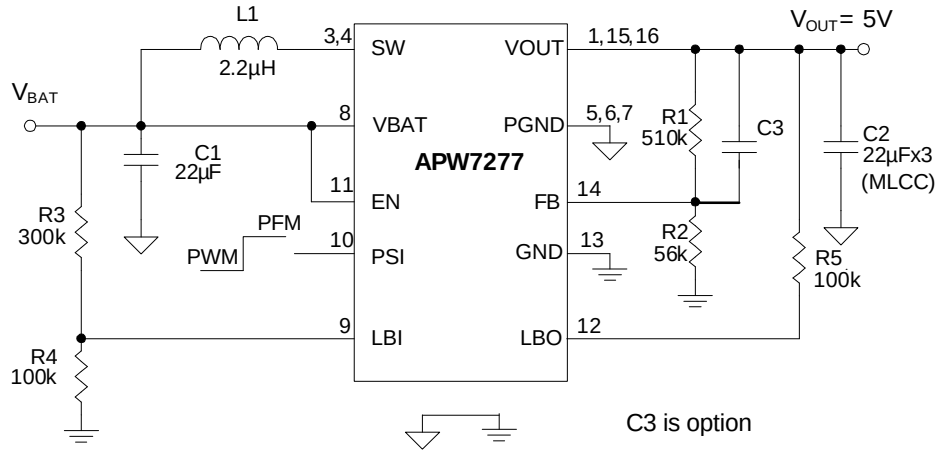
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Block Diagram

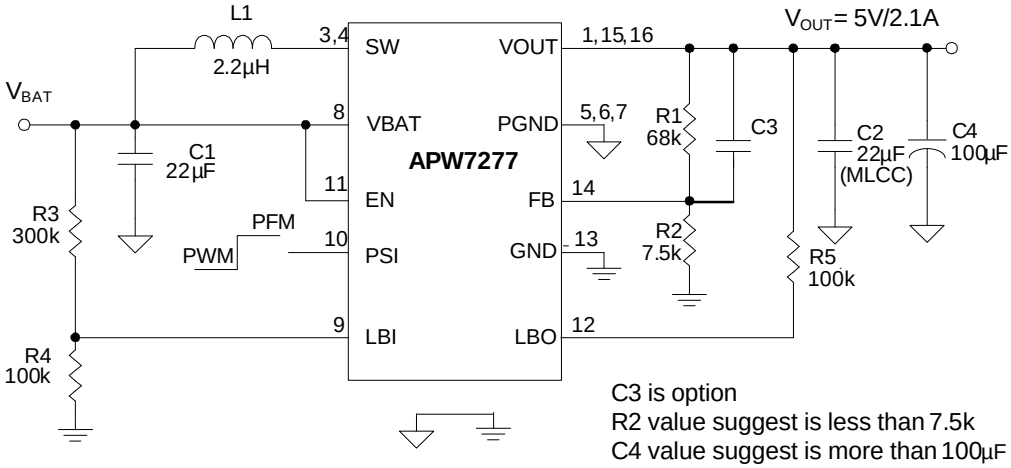


Typical Application Circuits

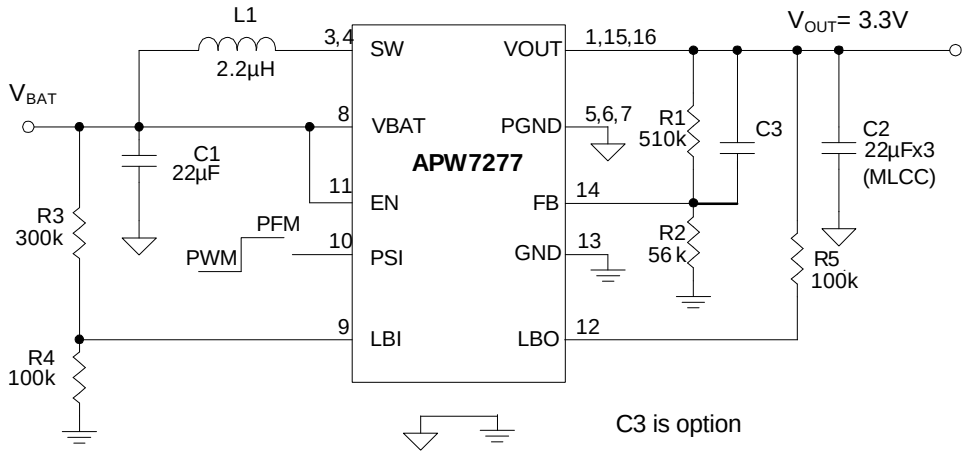
Typical Application



Power Bank Application



2 Cell Alkaline Application



Function Description

Main Control Loop

The APW7277 is a constant frequency, synchronous rectifier, and current-mode switching regulator. In normal operation, the internal N-channel power MOSFET is turned on each cycle when the oscillator sets an internal RS latch and turned off when an internal comparator (ICMP) resets the latch. The peak inductor current which ICMP resets the RS latch is controlled by the voltage on the COMP node, which is the output of the error amplifier (EAMP). An external resistive divider connected between V_{OUT} and ground allows the EAMP to receive an output feedback voltage V_{FB} at FB pin. When the load current increases, it causes a slightly decrease in V_{FB} relative to the 0.5V reference, which in turn causes the COMP voltage to increase until the average inductor current matches the new load current.

Start-up

A start-up oscillator circuit is integrated in the APW7277. When the device enables, the circuit pumps the output voltage high. Once the output voltage reaches 1.6V (typ), the main DC-DC circuitry turns on and boosts the output voltage to the final regulation voltage.

Automatic PFM/PWM mode Switch

The APW7277 is a fixed frequency PWM peak current modulation control step-up converter. At light loads, the APW7277 will automatically enter in pulse frequency modulation operation to reduce the dominant switching losses. In PFM operation, the inductor current may reach zero or reverse on each pulse. A zero current comparator turns off the P-channel synchronous MOSFET, forcing DCM(Discontinuous Current Mode) operation at light load. These controls get very low quiescent current, help to maintain high efficiency over the complete load range.

Synchronous Rectification

The internal synchronous rectifier eliminates the need for an external Schottky diode, thus reducing cost and board space. During the cycle off-time, the P-FET turns on and shunts the FET body diode. As a result, the synchronous rectifier significantly improves efficiency without the addition of an external component. Conversion efficiency can be as high as 92%.

Load Disconnect

Driving EN to ground places the APW7277 in shutdown mode. When in shutdown, the internal power MOSFET turns off, all internal circuitry shuts down and the quiescent supply current reduces to 1μA maximum.

A special circuit is applied to disconnect the load from the input during shutdown the converter. In conventional synchronous rectifier circuits, the back-gate diode of the high-side P-FET is forward biased in shutdown and allows current flowing from the battery to the output. However, this device uses a special circuit, which takes the cathode of the back-gate diode of the high-side P-FET and disconnects it from the source when the regulator is shutdown. The benefit of this feature for the system design engineer is that the battery is not depleted during shutdown of the converter. No additional components must be added to the design to make sure that the battery is disconnected from the output of the converter.

Current-Limit Protection

The APW7277 monitors the inductor current, flowing through the N-FET, and limits the current peak at current-limit level to prevent loads and the APW7277 from damages during overload conditions.

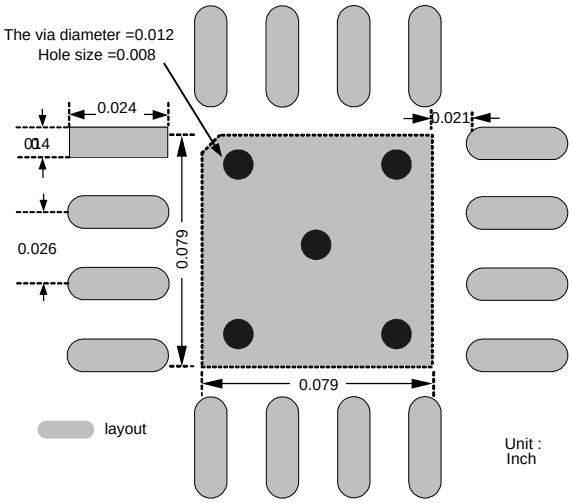
Over-Temperature Protection (OTP)

The over-temperature circuit limits the junction temperature of the APW7277. When the junction temperature exceeds 150°C, a thermal sensor turns off the both N-FET and P-FET, allowing the devices to cool. The thermal sensor allows the converters to start a soft-start process and regulate the output voltage again after the junction temperature cools by 30°C. The OTP is designed with a 30°C hysteresis to lower the average Junction Temperature (T_J) during continuous thermal overload conditions, increasing the lifetime of the device.

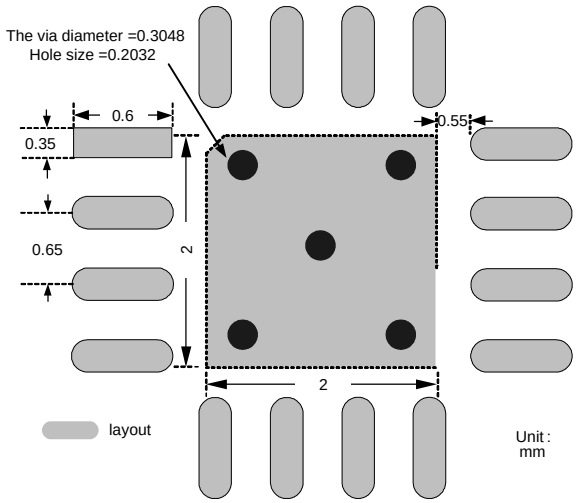
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Application Information

Recommended Minimum Footprint



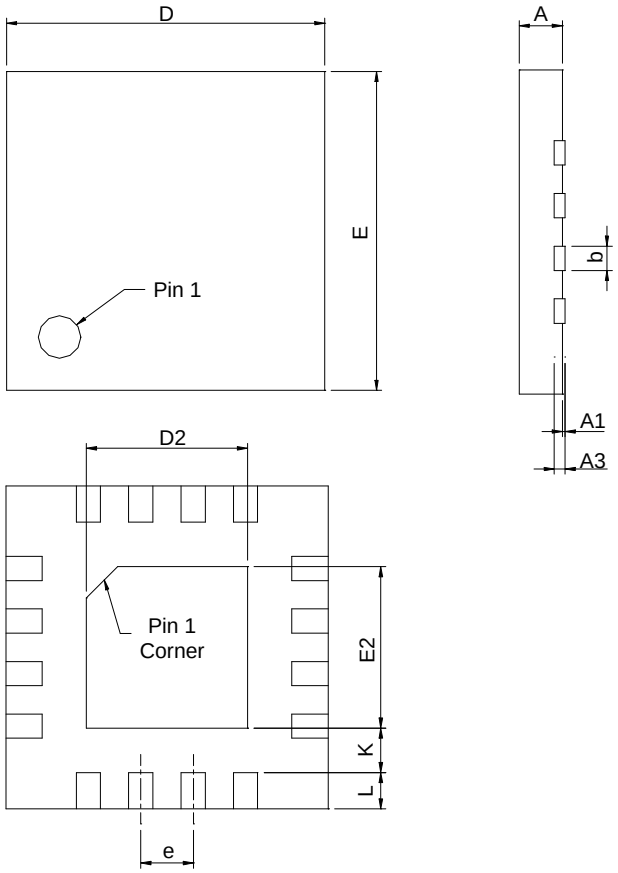
TQFN4x4-16



TQFN4x4-16

Package Information

TQFN4x4-16

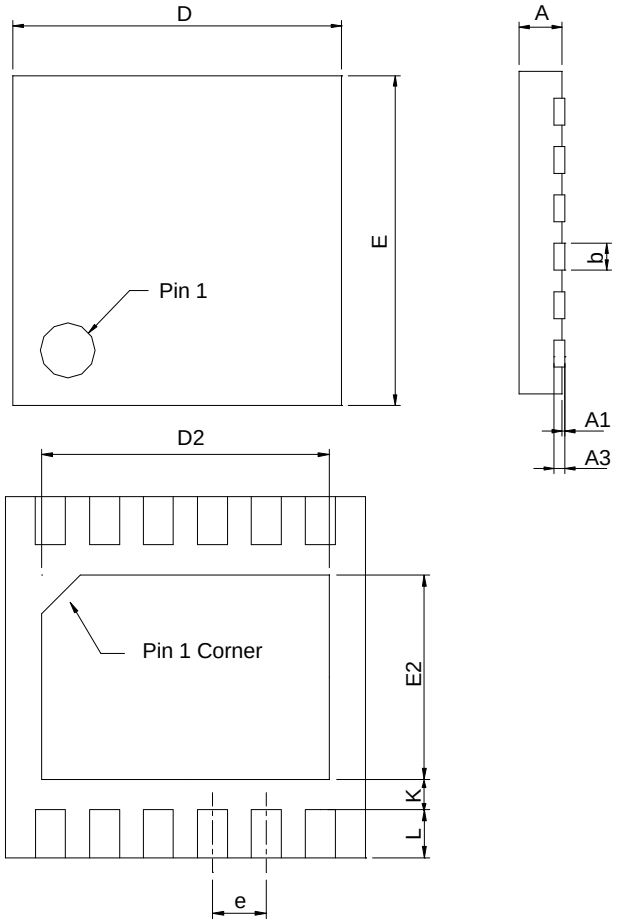


SYMBOL	TQFN4x4-16			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.25	0.35	0.010	0.014
D	3.90	4.10	0.154	0.161
D2	1.90	2.10	0.075	0.083
E	3.90	4.10	0.154	0.161
E2	1.90	2.10	0.075	0.083
e	0.65 BSC		0.026 BSC	
L	0.40	0.50	0.016	0.020
K	0.20		0.008	

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Package Information

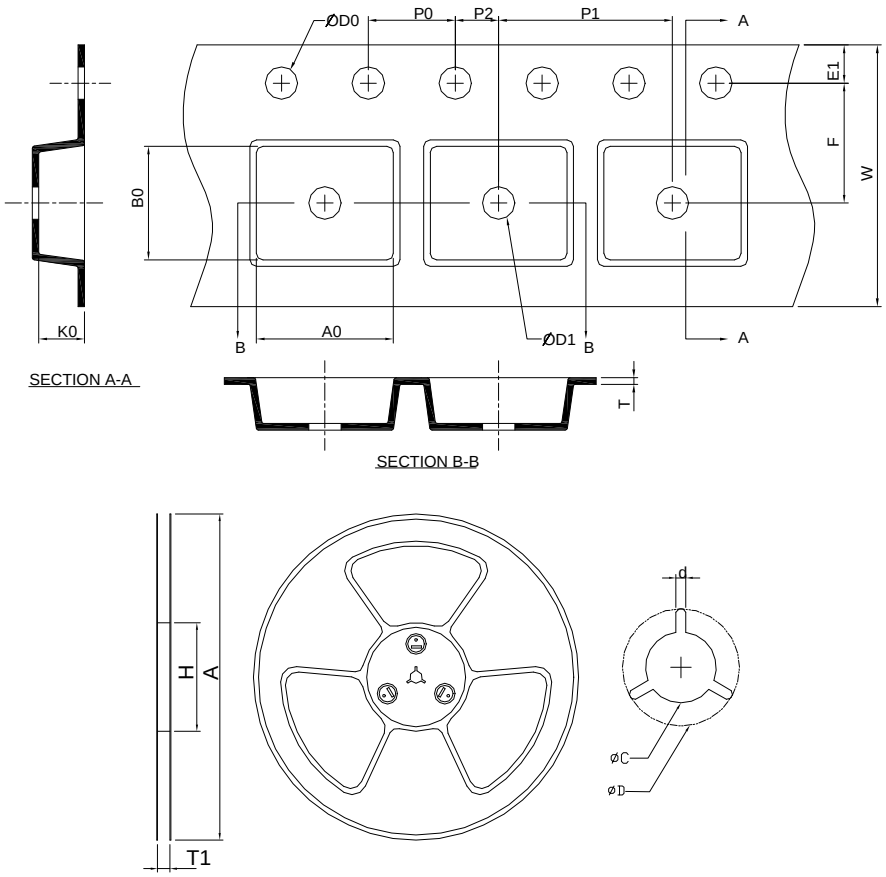
DFN3x3-12



SYMBOL	DFN3x3-12			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.80	1.00	0.031	0.039
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.18	0.30	0.007	0.012
D	2.90	3.10	0.114	0.122
D2	2.20	2.70	0.087	0.106
E	2.90	3.10	0.114	0.122
E2	1.40	1.75	0.055	0.069
e	0.45 BSC		0.018 BSC	
L	0.30	0.50	0.012	0.020
K	0.20		0.008	

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Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
TQFN4x4-16	330.0±2.00	50 MIN.	12.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	12.0±0.30	1.75±0.10	5.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	8.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	4.30±0.20	4.30±0.20	1.30±0.20
Application	**A**	**H**	**T1**	**C**	**d**	**D**	**W**	**E1**	**F**
DFN3x3-12	330±2.00	50 MIN.	12.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	12.0±0.30	1.75±0.10	5.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	8.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	3.30±0.20	3.30±0.20	1.30±0.20

(mm)

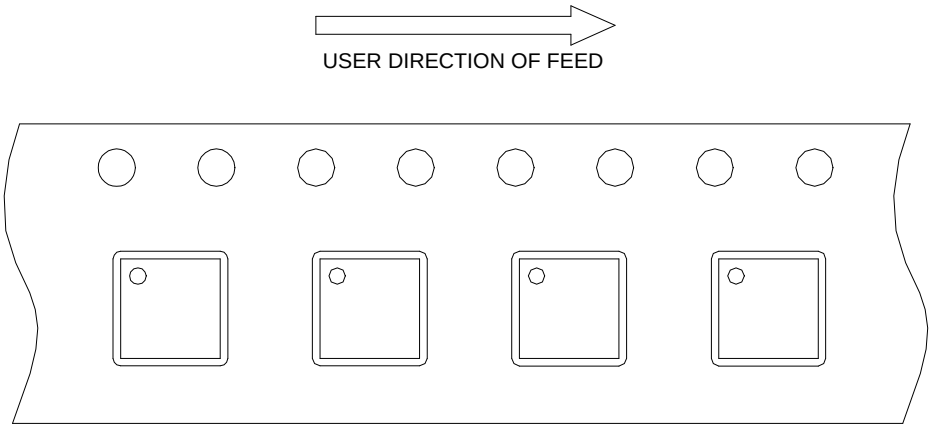
Devices Per Unit

Package Type	Unit	Quantity
TQFN4x4-16	Tape & Reel	3000
DFN3x3-12	Tape & Reel	3000

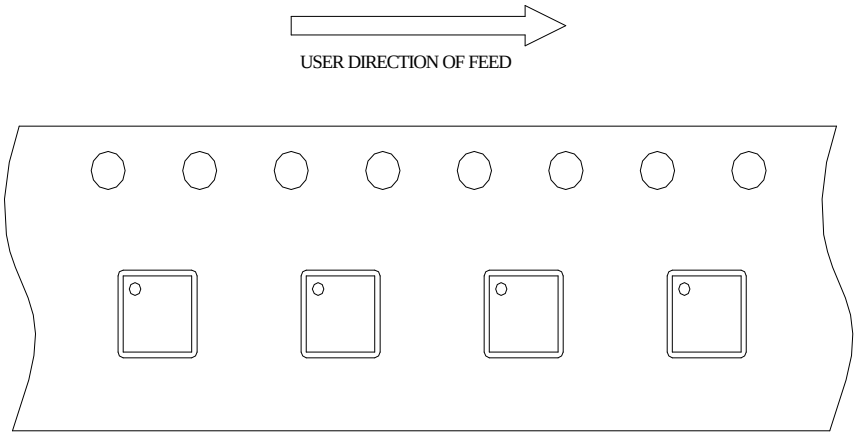
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Taping Direction Information

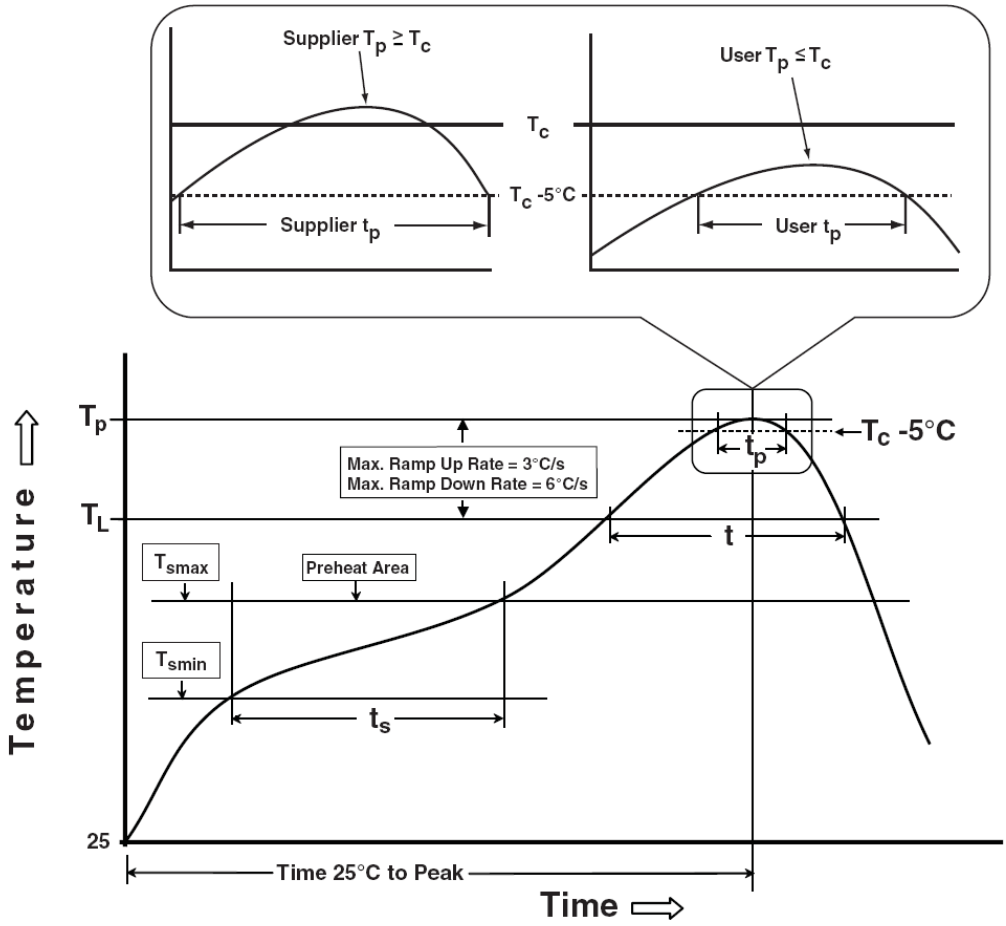
TQFN4x4-16



DFN3x3-12



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak Temperature min (T_{smin}) Temperature max (T_{smax}) Time (T_{smin} to T_{smax}) (t_s)	100 °C 150 °C 60-120 seconds	150 °C 200 °C 60-120 seconds
Average ramp-up rate (T_{smax} to T_P)	3 °C/second max.	3°C/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	183 °C 60-150 seconds	217 °C 60-150 seconds
Peak package body Temperature (T_p)*	See Classification Temp in table 1	See Classification Temp in table 2
Time (t_P)** within 5°C of the specified classification temperature (T_c)	20** seconds	30** seconds
Average ramp-down rate (T_p to T_{smax})	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.
* Tolerance for peak profile Temperature (T_p) is defined as a supplier minimum and a user maximum. ** Tolerance for time at peak profile temperature (t_p) is defined as a supplier minimum and a user maximum.		

Table 1. SnPb Eutectic Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 ³350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2. Pb-free Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm – 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HOLT	JESD-22, A108	1000 Hrs, Bias @ T_j=125°C
PCT	JESD-22, A102	168 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	500 Cycles, -65°C~150°C
HBM	MIL-STD-883-3015.7	VHBM≧2KV
MM	JESD-22, A115	VMM≧200V
Latch-Up	JESD 78	10ms, 1_{tr}≧100mA

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