Ultra-Low Power PMU with 30V Linear Charger and 5V Boost Converter

DESCRIPTION

ETA9897 is an ultra-low power PMU with 2 modules: a 30V single cell Li^+ battery linear charger and a 5V boost synchronous converter with true-shutoff function. The linear charger fully integrated constant current (CC) / constant voltage (CV) control module and charge FET, with minimal external devices. It also has pre-charge function for trickle charging deeply discharged battery and its fast charge current can be programmed by an external resistor. When CV charge stage is entered, charge will be terminated once the charge current drops to 1/10 of the programmed value. A "STAT" pin is also available to indicate the charge status. And the low power 5V boost converter is capable of delivering 0.4A current at 5V output. It can be shut down by pulling ENBST low, it will disconnect the output from the BAT to further decrease the system standby power. Its 1.4MHz switching frequency enable a very small external inductor with inductance as low as 2.2uH. The ETA9897, as a whole, is an ideal for the system solution that requires very low standby power and compact PCB board size.

ETA9897 is housed in a ESOP8 package.

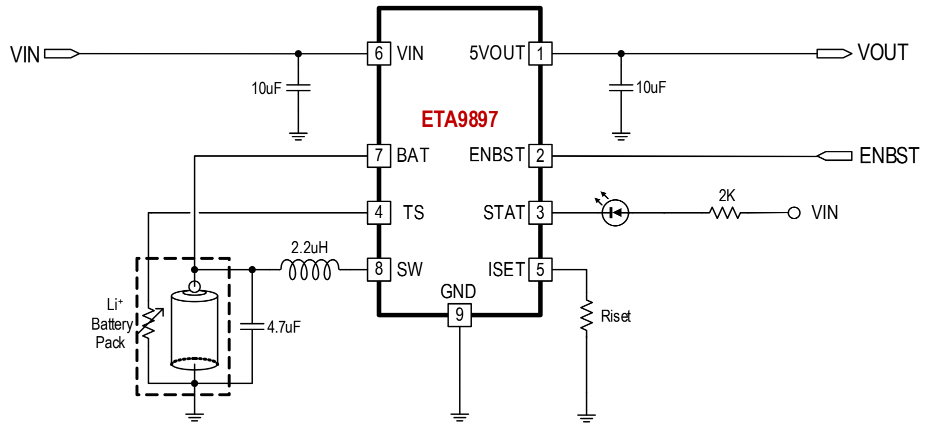
FEATURES

- Ultra low IQ when No switching: 1.2uA
- 30V input standoff voltage
- 4.2V charge termination voltage
- Charge current programmable, up to 1.2A
- Output Disconnect and SCP at 5V output
- 5V/0.4A Output Power
- Up to 94% Efficiency for boost converter
- Operation over JEITA Range via Battery NTC
- Logic Control Shutdown and Thermal shutdown
- ESOP8 Package
- RoHS Compliant

APPLICATIONS

- TWS BT earbuds charge case
- Bluetooth application
- Battery powered IOT module
- Power Bank

TYPICAL APPLICATION

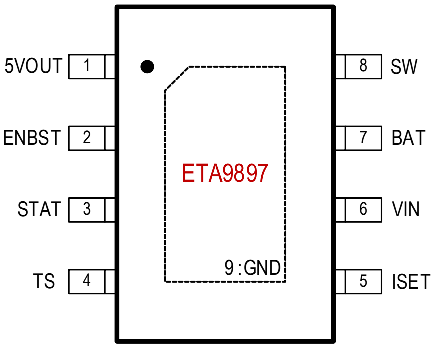


ORDERING INFORMATION

PART No.	PACKAGE	TOP MARK	Pcs/Reel
ETA9897E8A	ESOP8	ETA9897 YWW2L	4000

PIN CONFIGURATION

Top View



ESOP-8

ABSOLUTE MAXIMUM RATINGS

(Note: Exceeding these limits may damage the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.)

VIN Voltage.. –0.3V to 30V
BAT Voltage.. –0.3V to 6.5V
All other pins Voltage................................ –0.3V to 6.5V
SW to ground current ....Internally limited
Operating Temperature Range ....–40°C to 85°C
Storage Temperature Range ....–55°C to 150°C
Thermal Resistance θ_{JA} θ_{JC}
ESOP8..............................50..............10...............°C/W
Lead Temperature (Soldering 10sec) ....260°C
ESD HBM (Human Body Mode) 2KV

ELECTRICAL CHARACTERISTICS

(V_{BAT}=3.8V, V_{IN}=5V, V_{OUT} = 5V, unless otherwise specified. Typical values are at TA = 25°C.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
LINEAR CHARGER					
Input Standoff Voltage		30			V
V_{IN} Under-voltage Lockout Threshold	V_{IN} from Low to High	3.1	3.3	3.5	V
V_{IN} Under-voltage Lockout Hysteresis			0.2		V
V_{IN}–V_{BAT} Lockout Threshold Voltage	V_{IN} from Low to High	70	150	230	mV
	V_{IN} from High to Low	20	70	130	
Input Over-Voltage Protection Voltage	V_{IN} rising, hys=0.1V	6.4	6.65	6.9	V
Input Voltage Range for Charging		4.5		6.4	V
VINDPM Voltage Threshold	Adaptor Mode		4.3		V
Maximum Charge Current		1	1.2	1.4	A
BAT Pin Current	Sleep Mode, V_{IN} = GND			1	uA
	Charging Terminated, V_{BAT} = 4.5V		6	10	uA
Input Standby Current	V_{IN}=5V, TS=Low		100		uA
Input Active Supply Current	Charging Terminated, V_{IN}=5V, V_{BAT}=4.5V		0.3	0.5	mA
Power FET “ON” Resistance (Between VIN and BAT)			0.6		Ω
Soft-Start Time			40		ms
Battery Regulation Output Voltage	Riset = 1K, I_{BAT} = 40mA	4.16	4.2	4.24	V
Battery Hot Regulation Output Voltage	Riset = 1K, I_{BAT} = 40mA	4.02	4.06	4.1	V
Charge Current Range	Riset = 0.54K to 10.8K	50		1000	mA

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Dropout Voltage	V_{BAT}=4.15V, Riset=0.54K, Adjust V_{IN} until I_{BAT}=0.5A		320	500	mV
Charge Current Accuracy	Riset=1K	510	540	580	mA
Precharge Threshold Voltage	V_{BAT} Rising	2.45	2.60	2.75	V
Precharge Threshold Voltage Hysteresis	V_{BAT} Falling		100		mV
Precharge Current		14	20	24	%ICHRG
Termination Current		6	10	14	%ICHRG
Recharge BAT Threshold Voltage	Normal	50	100	150	mV
	Hot temp	60	110	160	mV
TS Bias Current	V_{Ts}=0.3V		50		µA
10K TS Bias Current when Charging is Disabled	V_{TS}=0V		30		µA
I_{TS} is Reduced Prior to Entering TTDM to Keep Cold Thermistor from Entering TTDM	V_{TS}=1.525V		5		µA
Termination and Timer Disable Mode Threshold–Enter			1600		mV
Hysteresis Exiting TTDM			100		mV
TS Voltage where I_{TS} is Reduced to Keep Thermistor from Entering TTDM			1475		mV
Low Temperature CHG Pending (0°C)			1230		mV
Hysteresis at 0°C			86		mV
Low Temperature, Half Charge (10°C)			790		mV
Hysteresis at 10°C			35		mV
High Temperature at 4.1V (45°C)			278		mV
Hysteresis at 45°C			11		mV
High Temperature Disable (60°C)			178		mV
Hysteresis at 60°C			11		mV
Charge Enable Threshold, (10K TS)			90		mV
HYS below VTS-EN-10K to Disable, (10K TS)			10		mV
Junction Temperature in Constant Temperature Mode			110		°C
Thermal Shutdown Temperature			155		°C
Thermal Shutdown Hysteresis			25		°C
STAT Pin Weak Pull-Down Current	V_STAT=5V			1	µA
STAT Pin Output Low Voltage	I_STAT= 5mA		0.7	1.4	V
Precharge Safety Timer			1800		s
Total Safety Timer			36000		s

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
BOOST CONVERTER					
Quiescent Current at V_{OUT}	No load, No Switching		1	3	μA
Shutdown Supply Current at V_{BAT}	V_{ENBST} =GND		0.5		μA
V_{BAT} Startup Voltage	I_{OUT}=1mA		0.8		V
V_{BAT} Operation Voltage	After Start-up	1.0		4.5	V
Output Voltage at 5V		4.85	5	5.15	V
Switching Frequency			1.4		MHz
NMOS Switch On Resistance	I_{SW}=100mA		220		mΩ
PMOS Switch On Resistance	I_{SW}=100mA		160		mΩ
SW Leakage Current	V_{OUT}=5.2V,V_{EN}=GND,V_{SW}=5.2V or V_{SW}= GND			10	μA
NMOS Switch Current Limit			1		A
Start-up Current Limit			1		A
Short Circuit Hiccup time	ON		1.3		ms
	OFF		33		ms
ENBST Input Current	V_{EN}=5V or V_{EN}=GND	-1	0	1	μA
ENBST High Voltage	V_{OUT}=5V	1.2			V
ENBST low Voltage	V_{OUT}=5V			0.4	V
Thermal Shutdown	Rising, Hysteresis=25°C		160		°C

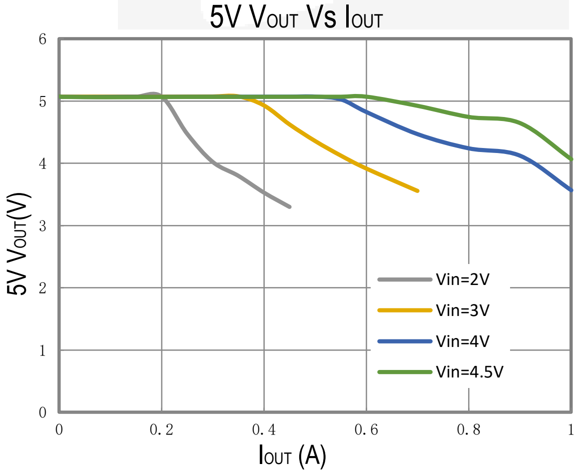
PIN DESCRIPTION

PIN #	NAME	DESCRIPTION
1	VOUT	Output pin. Bypass with a 10μF or larger ceramic capacitor closely between this pin and GND
2	ENBST	Enable pin for the boost converter. Drive this pin high to enable the part, low to disable.
3	STAT	Low (FET on) indicates charging and Open Drain (FET off) indicates no charging or charge completed.
4	TS	Temperature Sense Pin. The value of TS thermistor is 10K at 25 ºC. Floating TS pin or pulling it high drives the IC to enter TTDM, which disables TS monitoring, timer and termination. Pulling TS low disables the IC. If the TS function is not needed, connect this pin to GND with an external 10K resistor. Connecting A 250K resistor from TS to GND can prevent IC from entering TTDM when removing the battery with thermistor.
5	ISET	Fast Charge Current Setting Pin. Program, Monitor the charge current and Shutdown. This pin set to 1.5V in constant-current mode. The fast charge current can be calculated using the following formula: $I_{BAT}(mA)=\frac{1}{R_{set}(K)}\times 540$ The ISET pin can also be used to switch the charger to shutdown mode by disconnecting the program resistor from ground.
6	VIN	Input Power Pin. Bypass with at least a 4.7uF capacitor to GND.
7	BAT	Connected to the battery positive terminal. Bypass with a 4.7uF ceramic capacitor to GND
8	SW	Inductor Connection. Connect an inductor Between SW and the regulator output.

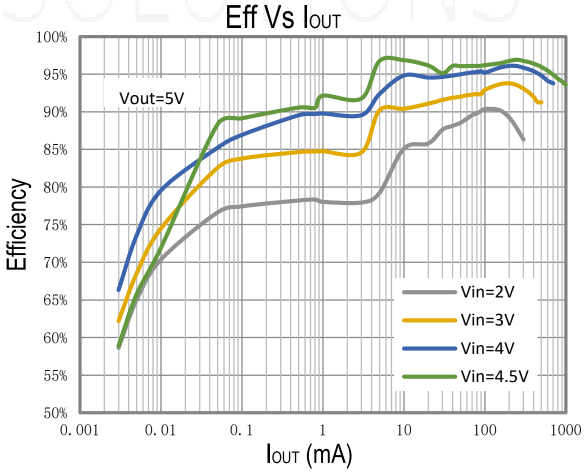
TYPICAL CHARACTERISTICS

(Typical values are at T_A = 25ºC unless otherwise specified.)

5V V_{OUT} Vs I_{OUT}



Eff Vs I_{OUT}



APPLICATION INFORMATION

ETA9897 is an ultra low power PMU with 2 modules: a 30V single cell Li^+ battery linear charger and a 5V boost synchronous converter with true-shutoff function.

Power-Down or Undervoltage Lockout (UVLO)

The ETA9897 is in power down mode if the IN pin voltage is less than UVLO. The part is considered "dead" and all the pins are high impedance. Once the IN voltage rises above the UVLO threshold the IC will enter Sleep Mode or Active mode depending on the battery voltage.

Power Up

The IC is alive after the IN voltage ramps above UVLO (see Sleep Mode), resets all logic and timers, and starts to perform many of the continuous monitoring routines. Typically the input voltage quickly rises through the UVLO and sleep states where the IC declares power good, starts the safety timer and enables the STAT pin.

Sleep Mode

If the IN pin voltage is between VBAT+VSLEEP and UVLO, the charge current is disabled, the safety timer counting stops (not reset) and the STAT pins are high impedance. As the input voltage rises and the charger exits sleep mode, the safety timer continues to count, charge is enabled and the STAT pin returns to its previous state

New Charge Cycle

A new charge cycle is started when any of these events occur:

- A valid power source is applied
- The chip is enabled/disabled using TS pin
- Exit of termination/Timer Disable Mode (TTDM)
- Detection of batter insertion
- BAT voltage drops below the VRCH threshold.

The STAT signal is active only during the first charge cycle. Exiting TTDM or the BAT voltage falling below VRCH will not activate the STAT signal if it is already in the open-drain (off) state.

Over Voltage Protection (OVP)

If the input source applies an overvoltage, the pass FET, if previously on, will turn off. The timer ends and the STAT pin go to a high impedance state. Once the overvoltage returns to a normal voltage, timer continues, charge continues and the STAT pin goes low after a 25 ms deglitch.

STAT Termination Indication (STAT)

The charge pin has an internal open drain FET which is on (pulls down GND) during the first charge only (independent of TTDM) and is turned off once the battery reaches voltage regulation and the charge current tapers to the termination threshold the charger current is reduced to nearly 1/10 the programmed value. The charge pin is high impedance in sleep mode and OVP and return to its previous state once the condition is removed. Cycling input power, pulling the TS pin low and releasing or entering pre-charge mode causes the STAT pin to go reset (go low if power is good and a discharged battery is attached) and is considered the start of a first charge.

CHARGING STATE	STAT FET
First charge after VIN applied	ON
Refresh Charge	OFF
OVP	
SLEEP	
TEMP FAULT	ON for 1st Charge

VINDPM

The VINDPM feature is used to detect an input source voltage that is folding back (voltage dropping), reaching its current limit due to excessive load. When the input voltage drops to the VINDPM threshold the internal pass FET starts to reduce the current until there is no further drop in voltage at the input. This would prevent a source with voltage less than VINDPM to power the battery. This works well with current limited adaptors the nominal voltage is above 4.3V. This is an added safety feature that helps protect the source from excessive loads.

Programming Charge Current

The charge current is programmable by setting the value of a precision resistor connected from the ISET pin to ground. The charge current out of the BAT pin can be determined at any time by monitoring the ISET pin voltage using the following equation:

$$I_{BAT}(\mathrm{mA}) = \frac{1}{R_{set}(K)} \times 540$$

Pre-charge and Charge Termination

The termination and pre-charge are set internally at 10% and 20% respectively the programmed value.

Battery Temperature Monitoring

The ETA9897's TS function for the device is designed to follow the new JEITA temperature standard for Li-Ion and Li-Pol batteries. There are now four thresholds, 60°C, 45°C, 10°C, and 0°C. Normal operation occurs between 10°C and 45°C. If between 0°C and 10°C the charge current level is cut in half and if between 45°C and 60°C the regulation voltage is reduced to 4.06V

The TS feature is implemented using an internal 50uA current source to bias the thermistor (designed for use with a 10k TS β= 3370 (SEMITEC 103AT-2 or Mitsubishi TH05-3H103F) connected from the TS terminal to GND. If this feature is not needed, a fixed 10k can be placed between TS and GND to allow normal operation. This may be done if the host is monitoring the thermistor and then the host would determine when to pull the TS terminal low to disable charge.

The TS terminal has two additional features, when the TS terminal is pulled low or floated/driven high. A low disables charge and a high puts charger in TTDM. Above 60° C or below 0° C, the charge is disable. Once the thermistor reaches -10° C, the TS current folds back to keep a cold thermistor (between -10° C and -50° C) from placing the IC in the TTDM mode. If the TS terminal is pulled low into disable mode, the current is reduced to 30uA.

Termination and Timer Disable Mode (TTDM) - TS Terminal High

The battery charger is in TTDM when the TS terminal goes high from removing thermistor (removing battery pack/floating the TS terminal) or by pulling the TS terminal up to the TTDM threshold.

When entering TTDM, the 10 hour safety timer is held in reset and termination is disabled. A battery detect routine is run to see if the battery was removed or not. If the battery was removed then the STAT terminal will go to its high impedance state if not already there. If a battery is detected the STAT terminal does not change states until the current tapers to the termination threshold, where the STAT terminal goes to its high impedance state if not already there (the regulated output will remain on).
The charging profile does not change (still has pre-charge, fast-charge constant current and constant voltage modes). This implies the battery is still charged safely and the current is allowed to taper to zero. When coming out of TTDM, the battery detect routine is run and if a battery is detected, then a new charge cycle begins and the STAT LED turns on.

If TTDM is not desired upon removing the battery with the thermistor, one can add a 237-k resistor between TS and GND to disable TTDM. This keeps the current source from driving the TS terminal into TTDM. This creates 0.1°C error at hot and a 3°C error at cold.

Safety Timer

The pre-charge timer is set to 30 minutes. The pre-charge current, can be programmed to off-set any system load, making sure that the 30 minutes is adequate. The fast charge timer is fixed at 10 hours and can be increased real time by going into thermal regulation, VINDPM. The timer clock slows by a factor of 2, resulting in a clock than counts half as fast when in these modes. If either the 30 minutes or ten hours timer times out, the charging is terminated and the STAT terminal goes high impedance if not already in that state. The timer is reset by disabling the IC, cycling power or going into and out of TTDM.

Termination and Recharge

Once the BAT terminal goes above VRCH, (reaches voltage regulation) and the current tapers down to the termination threshold, the STAT terminal goes high impedance and a battery detect route is run to determine if the battery was removed or the battery is full. If the battery is present, the charge current will terminate. If the battery was removed along with the thermistor, then the TS terminal is driven high and the charge enters TTDM. If the battery was removed and the TS terminal is held in the active region, then the battery detect routine will continue until a battery is inserted.

After termination, if the OUT terminal voltage drops to VRCH (100mV below regulation) then a new charge is initiated, but the STAT terminal remains at a high impedance (off).

Battery Detect Routine

The battery detect routine should check for a missing battery while keeping the BAT terminal at a useable voltage. Whenever the battery is missing the STAT terminal should be high impedance. The battery detect routine is run when entering and exiting TTDM to verify if battery is present. On power-up, if battery voltage is greater than VRCH threshold, a battery detect routine is run to determine if a battery is present. The battery detect routine is disabled while the IC has a TS fault

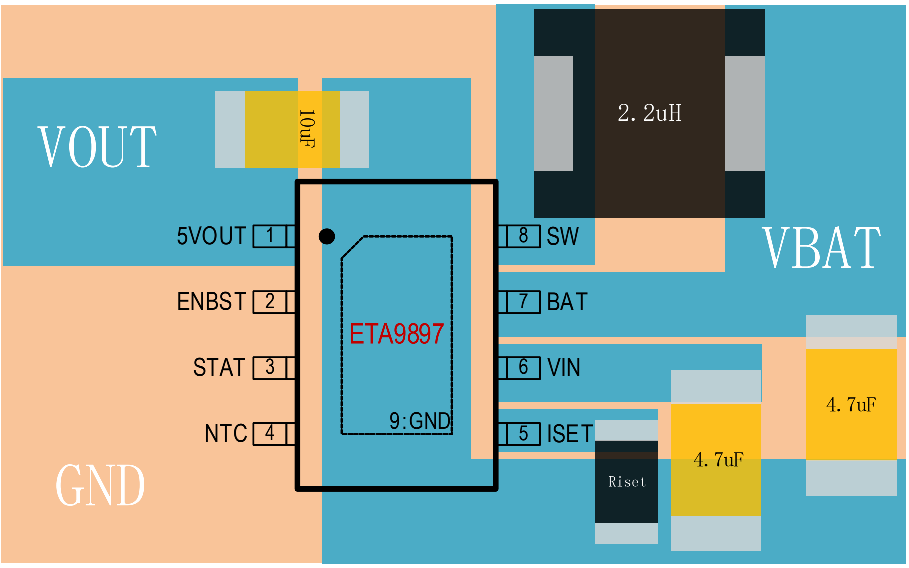
Ultra low current consumption at Light Load Boost Operation

Traditionally, a fixed constant frequency PWM DC/DC regulator always switches even when the output load is small. When energy is shuffling back and forth through the power MOSFETs, power is lost due to the finite RDSONs of the MOSFETs and parasitic capacitances. At light load, this loss is prominent and efficiency is therefore very low. ETA9897 employs a proprietary control scheme that improves efficiency in this situation by enabling the device into a power saving mode during light load and the no load quiescent current can be lower than 5μA.

Output (VOUT pin) Short-Circuit Protection

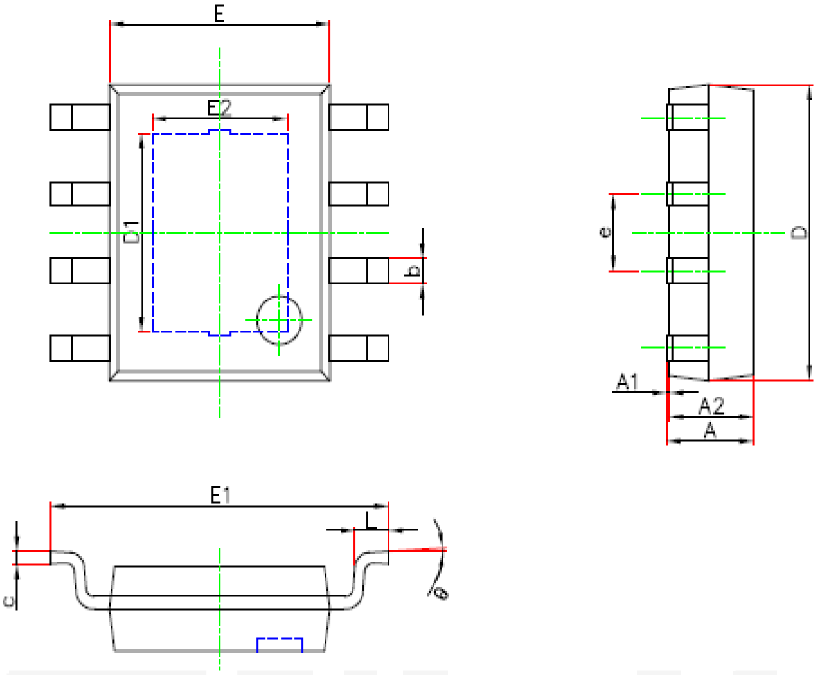
Unlike most step-up converters, the ETA9897 allows for short circuits on the output. In the event of a short circuit, the device first turns off the NMOS when the sensed current reaches the current limit. When OUT drops below IN, the device then enters a linear charge period with the current limited same as with the start-up period. In addition, the thermal shutdown circuits disable switching if the die temperature rises above 160°C.

PCB GUIDELINES



PACKAGE OUTLINE

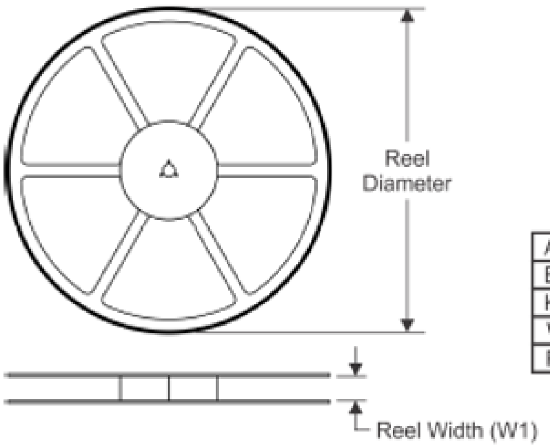
Package: ESOP8



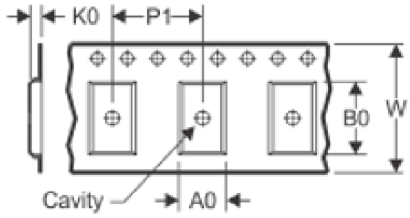
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.300	1.700	0.051	0.067
A1	0.000	0.100	0.000	0.004
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

TAPE AND REEL INFORMATION

REEL DIMENSIONS

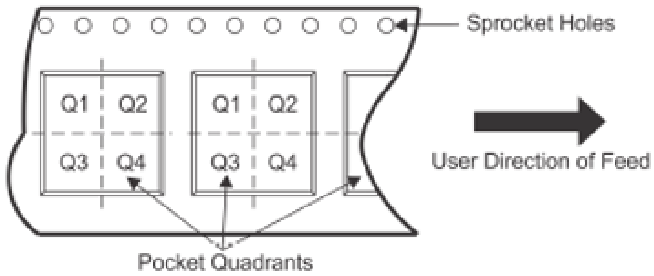


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Device	Package Type	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
ETA9897E8A	ESOP8	8	4000	330	12.7	6.6	5.4	2.05	8	12	Q1