ETA4257

1.2A/40V Fully Integrated Linear Charger for 1 Cell Li-ion Battery

DESCRIPTION

ETA4257 is a single cell, fully integrated constant current (CC)/constant voltage (CV) Li-ion battery charger. Its compact package with minimum external components requirement makes the ETA4257 ideal for portable applications. No external sense resistor or blocking diode is necessary for the ETA4257. Build-in thermal feedback mechanism regulates the charge current to control the die temperature during high power operation or at elevated ambient temperature. The ETA4257 has a pre-charge function for trickle charging deeply discharged batteries. The fast charge current can be programmed by an external resistor. CV regulation mode is automatically enabled once the battery's charging curve reaches the constant voltage portion. The output current then decays and is finally terminated once the charge current drops to 1/5 of the programmed value. The ETA4257 keeps monitoring the battery voltage and enables a new charge cycle once the voltage drops by 200mV below the CV value.

ETA4257 is in an DFN3x3-10 package.

FEATURES

◆ 40V input standoff voltage
◆ 4.2V charge termination voltage
◆ 2.6V trickle charge threshold
◆ Charge current programmable, up to 1.2A
◆ 400nA BAT current when no charging
◆ Soft-start limits in-rush current
◆ Fault and Charge Status Indicator
◆ DFN3x3-10

APPLICATIONS

◆ E-cigarette
◆ Toys
◆ Bluetooth applications
◆ Li-ion battery powered devices

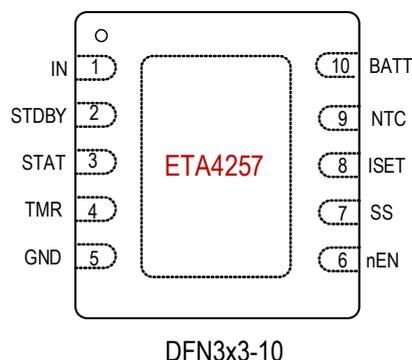### TYPICAL APPLICATION
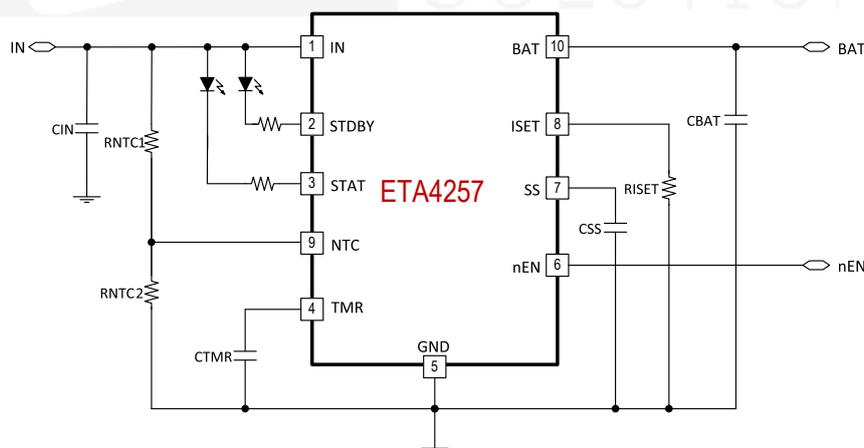
ORDERING INFORMATION

PART No.	PACKAGE	TOP MARK	Pcs/Reel
ETA4257D3K	DFN3x3-10	ETA4257 YWW2L	5000

ETA4257

PIN CONFIGURATION

IN	1		10	BATT
STDBY	2		9	NTC
STAT	3	ETA4257	8	ISET
TMR	4		7	SS
GND	5		6	nEN

DFN3x3-10

ABSOLUTE MAXIMUM RATINGS

VIN Voltage ....–0.3V to 40V

BAT, STDBY, STAT, NTC, nEN Voltage ....–0.3V to 16V

All other pin Voltage....................................-0.3V to 6V

Operating Temperature Range..............–40°C to 85°C

Storage Temperature Range ....–55°C to 150°C

Thermal Resistance Θ_{JC} Θ_{JA}

DFN3x3-10 ....12............50................ °C/W

Lead Temperature (Soldering, 10sec) ....260°C

ELECTRICAL CHARACTERISTICS

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

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Standoff Voltage				40	V
Input Over-Voltage Protection Voltage	V_{IN} rising, hys=0.4V	6.8	7	7.3	V
Input Voltage Range for Charging		4.25		6	V
Input Supply Current	Charge Mode		0.3	2	mA
	Standby Mode (Charge Terminated)		100	200	µA
	Shutdown Mode (ISET Not Connected, nEN=V_{IN}, V_{IN}<V_{BAT}, or V_{IN}<VULO)		30	60	µA
Regulated Output (Float) Voltage	Rset = 10K, I_{BAT} = 40mA	4.16	4.2	4.24	V
BAT Pin Current	Rset = 3.6K, Current Mode, V_{BAT}=3.8V	465	515	565	mA
	Rset = 1.6K to 8K, Current Mode	90	100	110	%ICHRG
	Standby Mode, V_{BAT} = 4.2V		2	3	µA
	Shutdown Mode, ISET Not Connected	0	0.4	0.7	µA
	Sleep Mode, V_{IN} = 0V	0	0.4	0.7	µA
Trickle Charge Current	V_{BAT} < V_{TRIKL}	4	12	20	%ICHRG
Trickle Charge Threshold Voltage	V_{BAT} Rising	2.45	2.60	2.75	V
Trickle Charge Hysteresis Voltage			100		mV
VIN Under-voltage Lockout Threshold	From V_{IN} Low to High	3.3	3.6	3.9	V
VIN Under-voltage Lockout Hysteresis		0.4	0.55	0.65	V
nEN Pull-Down Resistance			2		MΩ

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
nEN Threshold	nEN Pin Rising, Charger Disable	1.6			V
	nEN Pin Falling, Charger Enable			0.6	
VIN–VBAT Lockout Threshold Voltage	V_{IN} from Low to High	70	150	230	mV
	V_{IN} from High to Low	20	70	130	
Termination Current Threshold		13	20	27	%ICHRG
ISET Pin Voltage	Current Mode, V_{BAT}=4V	0.9	1	1.1	V
STAT/STDBY Pin Weak Pull-Down Current	V_STAT = 5V		0.1		µA
STAT/STDBY Pin Output Low Voltage	I_STAT or I_STDBY= 2.5mA		0.7	1.4	V
Recharge BAT Threshold Voltage	V_{FLOAT} - V_{RECHRG}	100	200	300	mV
Junction Temperature in Constant Temperature Mode			110		°C
Power FET "ON" Resistance (Between VCC and BAT)			0.85		Ω
Soft-Start Time	I_{BAT} = 0 to I_{BAT} = 90% Full Current, C_{SS}=0.1uF		80		ms
ISET Pin Pull-Up Current			1		µA
NTC Threshold, Cold	Charger Suspended		43		% VIN
NTC Threshold, Hot	Charger Suspended		6		% VIN
NTC Threshold Hysteresis			2		% VIN
NTC Disable Threshold	Tie NTC to GND		0.1		V
NTC Input Leakage			0	1	µA
Oscillation Frequency	C_{TMR}=1uF		15		Hz

PIN DESCRIPTION

PIN#	NAME	DESCRIPTION
1	IN	Input, 40V standoff voltage, and with OVP function, UVLO=3.6V, when UVLO is about reached, decrease charge current first when reached to 3.8V
2	STDBY	Open drain, pull low when charge terminated
3	STAT	Open drain, pull low in charging, high when charge terminated, togging when the battery is in fault condition
4	TMR	Oscillator Period Timer. Connect a timing capacitor between this pin and GND to set the oscillator period.
5	GND	Ground
6	nEN	Charge Enable. An input "Low" signal at this pin or pin floating will enable the IC
7	SS	Soft-Start. Connect a capacitor to ground to set the soft-start time. The rising time constant is SS 800000*C_{SS} , where C_{SS} is in µF.

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PIN#	NAME	DESCRIPTION
8	ISET	Charge current setting. Program, Monitor the charge current and Shutdown. This pin set to 1V in constant-current mode. The charge current can be calculated using the following formula: $$I_{BAT}(mA) = \frac{1850}{R_{set}\ (K\Omega)}$$ The ISET pin can also be used to switch the charger to shutdown mode by disconnecting the program resistor from ground.
9	NTC	Negative Thermal Coefficient (NTC) Thermistor Pin. Connect a 500kΩ resistor from this pin to the IN pin and a 100kΩ NTC resistor (within the battery pack) from this pin to ground. If NTC function is not used, replace NTC resistor with a regular 100kΩ resistor from this pin to ground. Do not leave this pin floating.
10	BATT	Battery node. Has to withstand 15V, and reverse connecting protection. Current from battery into BATT pin should be less than 1uA.

TYPICAL CHARACTERISTICS

IBAT Vs. VBAT

Charge output voltage vs. chage current

VBAT Vs. VIN

IBAT Vs. VIN
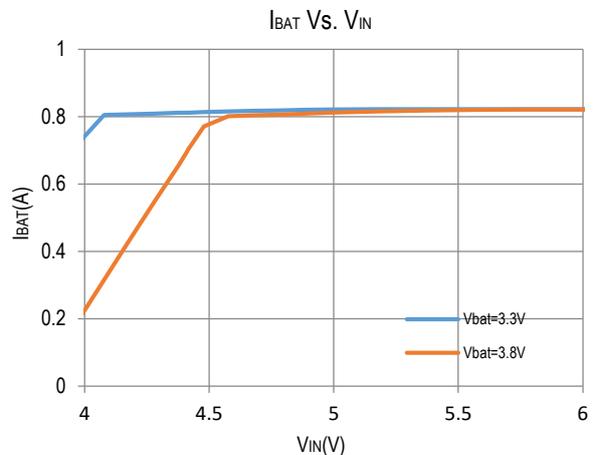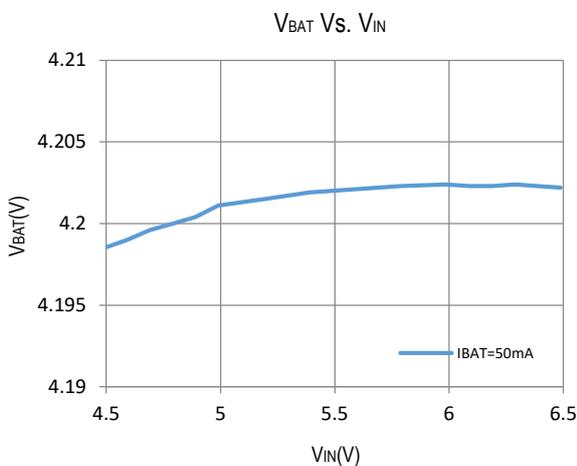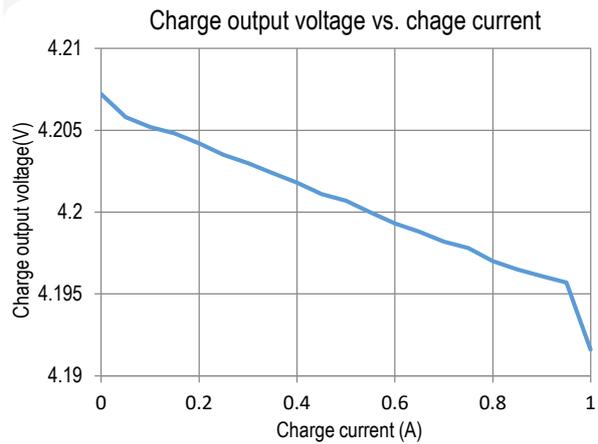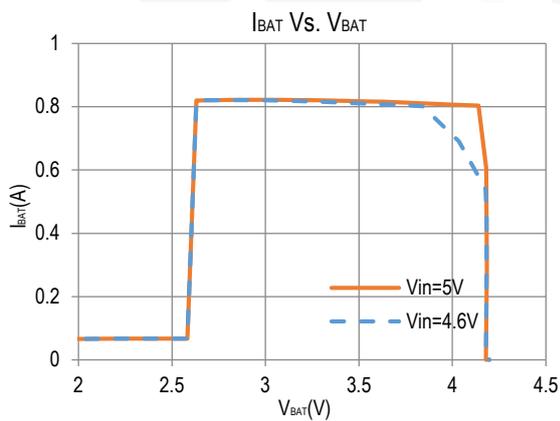
FUNCTIONAL DECRIPTIONS

The ETA4257 is a single cell, fully integrated constant current (CC)/constant voltage (CV) Li-ion battery charger. It can deliver up to 1200mA of charge current with a final float voltage accuracy of 1%. The ETA4257 has a build-in thermal regulation circuitry that ensures its safe operation. No blocking diode or external current sense resistor is required; hence reduce the external components for a basic charger circuit to two. The ETA4257 is also capable of operating from a USB power source.

Normal Charge Cycle

The ETA4257 initiates a charge cycle once the voltage at the VIN pin rises above the UVLO threshold level. A 1% precision resistor needs to be connected from the ISET pin to ground. If the voltage at the BAT pin is less than 2.6V, the charger enters trickle charge mode. In this mode, the charge current is reduced to nearly 1/10 the programmed value until the battery voltage is raised to a safe level for full current charging.

The charger switches to constant-current mode as the BAT pin voltage rises above 2.6V, the charge current is thus resumed to full programmed value. When the final float voltage (4.2V) is reached, the ETA4257 enters constant-voltage mode and the charge current begins to decrease until it drops to 1/5 of the preset value and ends the charge cycle1

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 is 1850 times of the current out of the ISET pin. The charge current out of the BAT pin can be determined at any time by monitoring the ISET pin voltage using the following equation:

$$I_{BAT}(mA) = \frac{1850}{R_{set}(K\Omega)}$$

Charge Termination

The ETA4257 keeps monitoring the ISET pin during the charging process. It terminates the charge cycle when the charge current falls to 1/5 the programmed value after the final float voltage is reached. When the ISET pin voltage falls below 200mV for longer than tTERM (typically 1ms), charging is terminated. The charge current is latched off and the ETA4257 enters standby mode, where the input supply current drops to 100µA. (Note: termination is disabled in trickle charging and thermal limiting modes).

During charging, the transient response of the circuit can cause the ISET pin to fall below 200mV temporarily before the battery is fully charged, thus can cause a premature termination of the charge cycle. A 1ms filter time on the termination comparator can prevent this from happening. Once the average charge current drops below 1/5 the programmed value, the ETA4257 terminates the charge cycle and ceases to provide any current through the BAT pin. In this state, all loads on the BAT pin must be supplied by the battery.

The ETA4257 constantly monitors the BAT pin voltage in standby mode and resume another charge cycle if this voltage drops below the recharge threshold. User can also manually restart a charge cycle in standby mode either by removing and then reapplied the input voltage or restart the charger using the ISET pin.

Charge Status Indicator (STAT and STDBY pin)

There are 2 different states of the charge status, one is IN CHRGING, and the other is CHARGING FINISHED. STAT is the pin to pull low during IN CHARGING status, become high impedance in CHARGING FINISHED status and togging in fault condition. And STDBY pin just works the opposite way, pulling low after charge finished, and high impedance when in charging.

High Temperature Fold-back

Build-in feedback circuitry mechanism can reduce the value of the programmed charge current once the die temperature tends to rise above 50°C, hence prevents the temperature from further increase and ensure device safe operation.
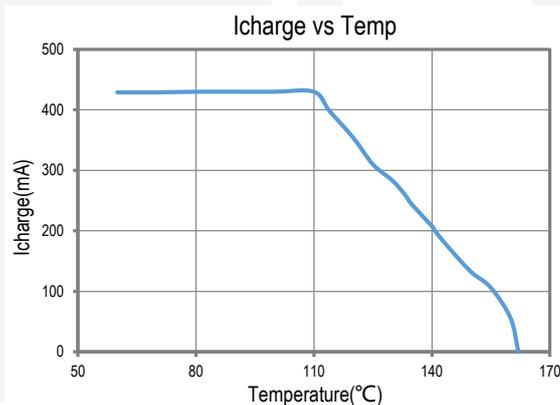
Under-voltage Lockout (UVLO)

Build-in under-voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VIN rises above the under-voltage lockout threshold. The UVLO circuit has a built-in hysteresis of 500mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if VIN falls to within 80mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until VIN rises 200mV above the battery voltage.

Manual Shutdown

There are two methods can disable the IC charger:
1. Driver the EN pin to high.
2. Floating the ISET pin by removing the resistor from ISET pin to ground.
Once one of above conditions happen, it can put the device in shutdown mode. The battery drain current is thus reduced to 400nA and the supply current to <50µA. Reconnecting the resistor back or driver EN pin high will restart a new charge cycle.

Automatic Recharge

After the termination of the charge cycle, the ETA4257 constantly monitors the BAT pin voltage and starts a new charge cycle when the battery voltage falls below 4 V, keeping the battery at fully charged condition. ISET pin output enters a strong pull-down state during recharge cycles.
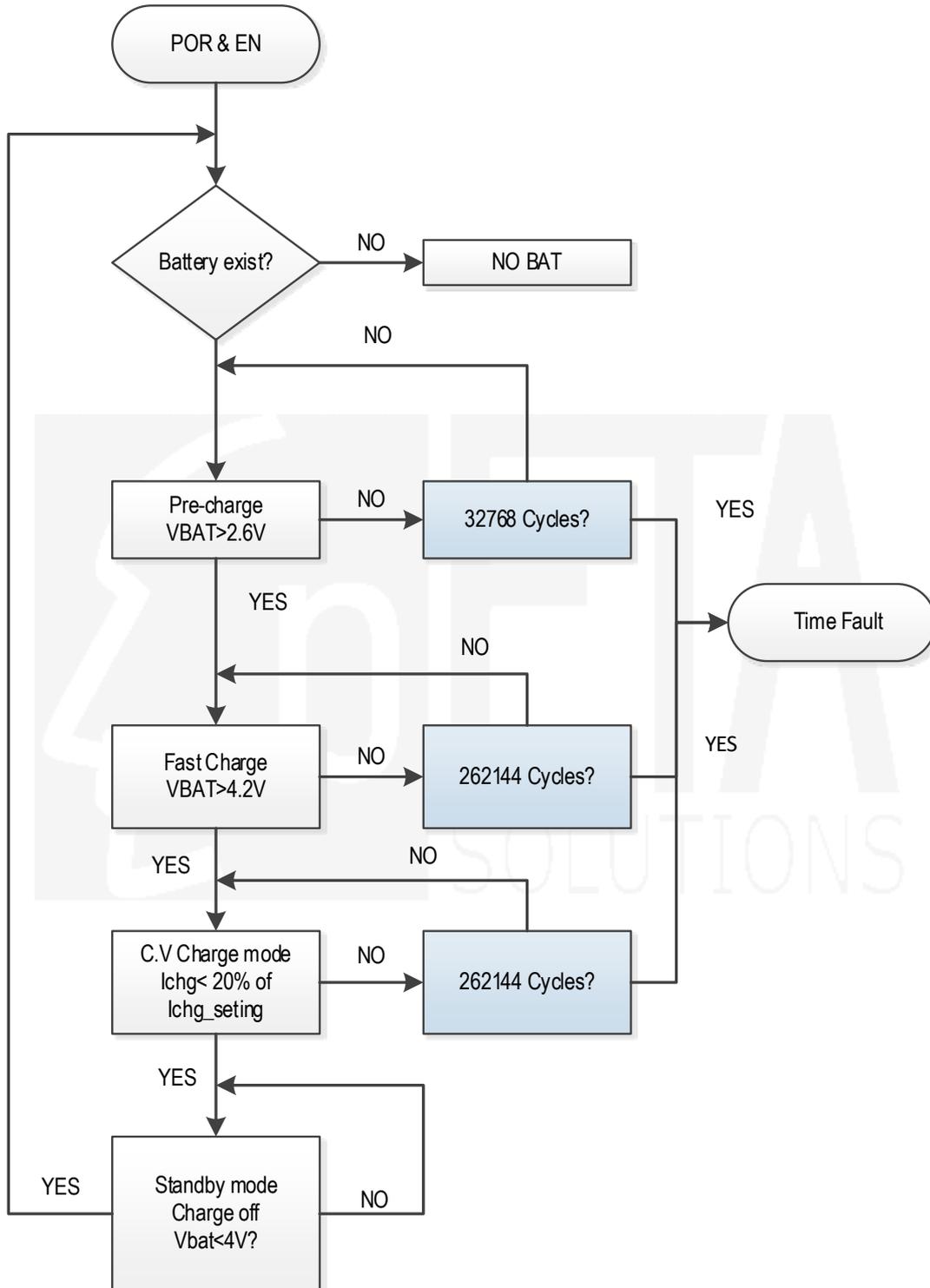
Battery Temperature Monitoring

ETA4257 continuously monitors temperature by measuring the voltage of NTC pin. A negative or positive temperature coefficient thermistor and an external voltage divider typically develop this voltage. ETA4257 compares this voltage against its internal 43%VIN and 6%VIN thresholds to determine if charging is allowed. The temperature sensing circuit is immune to any fluctuation in VIN, since both the external voltage divider and the internal thresholds 43%VIN and 6%VIN are referenced to VIN. If the NTC pin is connected to GND, it will disable the temperature-sensing feature.

Timer Operation

The TMR pin is used to set the internal oscillator frequency, $F_{OSC} = 15Hz \times \frac{1uF}{C_{TMR}(uF)}$

The on-chip timer will start to count down after initial power-up or every time it is enabled. This timer will limit the max trickle-charge time to 32768 internal oscillating cycles. If the charger stays in trickle mode for longer than 32768 cycles, it will be terminated and a fault state will be set to STAT pin. After fault reporting, the charger can be re-initiated only by recycling the power supply or nEN signal. If the charger successfully goes through trickle charge within the allowed time limit, it will start CC charging and then CV charging. If the total charge time exceeds 262144 cycles and the battery full has not been qualified, the charger will be terminated and a fault will also be set by flashing STAT pin at the rate of half the internal oscillation frequency. This function prevents charging a dead battery for prolonged duration. The timer function can be disabled by shorting TMR to ground.

Chart Flow

```
        ┌──────────────┐
        │   POR & EN   │
        └──────┬───────┘
               │
               ▼
          ◇ Battery exist? ──NO──▶ [ NO BAT ]
               │
               │ (NO loop back)
               ▼
    ┌──────────────────┐  NO   ┌──────────────────┐  YES
    │ Pre-charge       │──────▶│  32768 Cycles?   │──────▶ ( Time Fault )
    │ VBAT>2.6V        │       └──────────────────┘
    └────────┬─────────┘
          YES │
               ▼
    ┌──────────────────┐  NO   ┌──────────────────┐  YES
    │ Fast Charge      │──────▶│  262144 Cycles?  │──────▶ ( Time Fault )
    │ VBAT>4.2V        │       └──────────────────┘
    └────────┬─────────┘
          YES │
               ▼
    ┌──────────────────┐  NO   ┌──────────────────┐
    │ C.V Charge mode  │──────▶│  262144 Cycles?  │
    │ Ichg< 20% of     │       └──────────────────┘
    │ Ichg_seting      │
    └────────┬─────────┘
          YES │
               ▼
    ┌──────────────────┐
    │ Standby mode     │── NO ──▶
    │ Charge off       │
    │ Vbat<4V?         │── YES ──▶
    └──────────────────┘
```

PCB GUIDELINES
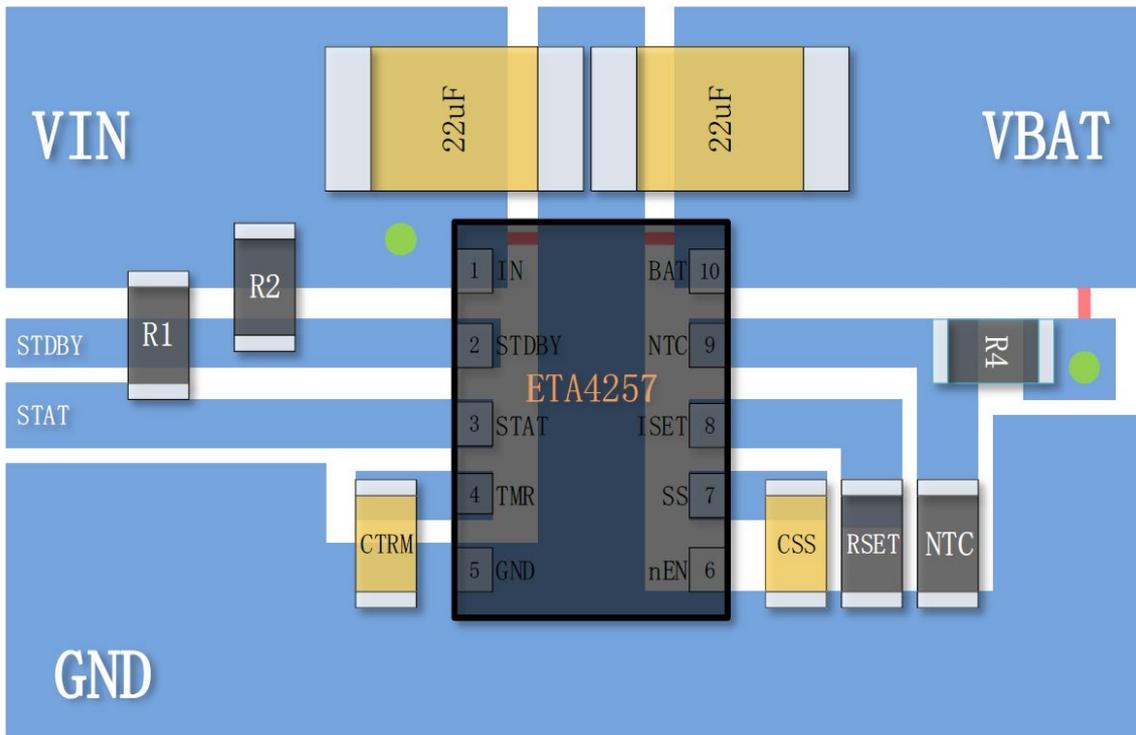
PACKAGE OUTLINE

Package: DFN3x3-10
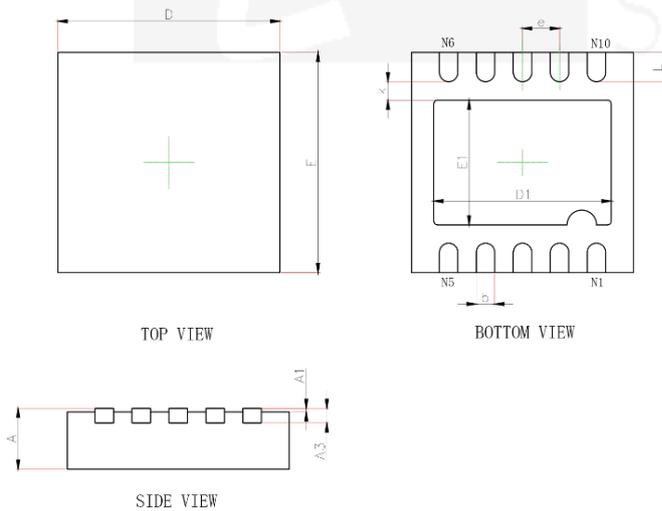
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	2.924	3.076	0.115	0.121
E	2.924	3.076	0.115	0.121
D1	2.300	2.500	0.091	0.098
E1	1.600	1.800	0.063	0.071
k	0.200MIN.		0.008MIN.	
b	0.200	0.300	0.008	0.012
e	0.500TYP.		0.020TYP.	
L	0.324	0.476	0.013	0.019

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
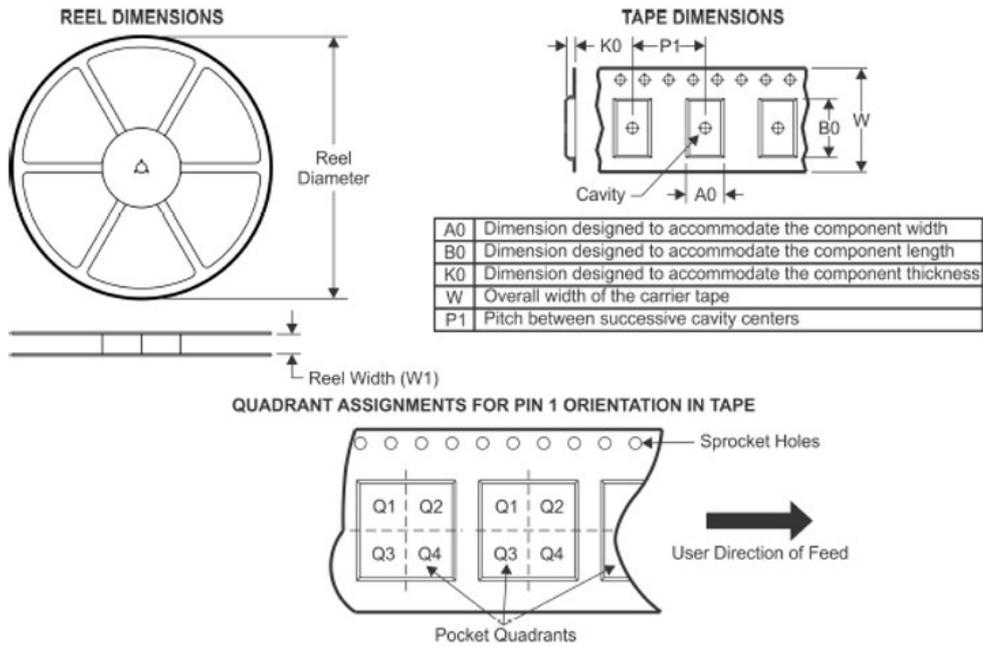
Device	Package Type	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
ETA4257D3K	DFN3x3-10	10	5000	330	12.4	3.35	3.35	1.13	8	12	Q1