36V/1A Standalone Single-Cell Linear Charger

General Description

The ET95153 is a highly advanced linear charger for single-cell Li-Ion and Li-Polymer batteries. The device is ideally suited for portable applications due to the small package and low number of external components required.

The device employs a full charge algorithm with trickle current, constant current (CC), constant voltage (CV) modes, charge termination and automatic recharge. The device supports charge current up to 1A, programmed by an external resistor. The device can withstand an input voltage up to 36V, which can protect the charger from the accidental insertion of a high voltage supply or a hot insertion. The device can withstand a BAT voltage up to 17V, which is suited for power battery applications. Without an input supply, the battery leakage current is only 5nA typical.

The device provides various safety features for battery charging, including input under voltage lockout (UVLO), input over-voltage protection (OVP), battery reverse connection protection, and thermal regulation protection that is implemented by reducing the charge current when the junction temperature reaches 140°C.

Features

- Easy-to-use Standalone Single-Cell Charger
- High Input Voltage Linear Charger
  - Support Up to 7V Operating Input Voltage with 36V Absolute Maximum Input Rating
  - Maximum BAT Withstand Voltage Up to 17V
  - Programmable Up to 1A Fast Charge Current
  - -0.5%/+1% Regulated Output Voltage Accuracy
  - Trickle Current 10% of Fast Charge Current
  - Termination Current 10% of Fast Charge Current
- High Integration
  - Integrated Reverse Blocking MOSFET
  - Built-in Charge Current Sensing
  - Internal Loop Compensation
  - Integrated Charge Status Indication
- Support Full Charge Cycle of Trickle Current Mode, Constant Current (CC) Mode, Constant Voltage (CV) Mode, Charge Termination and Automatic Recharge
- BAT Leakage Current 5nA Typical

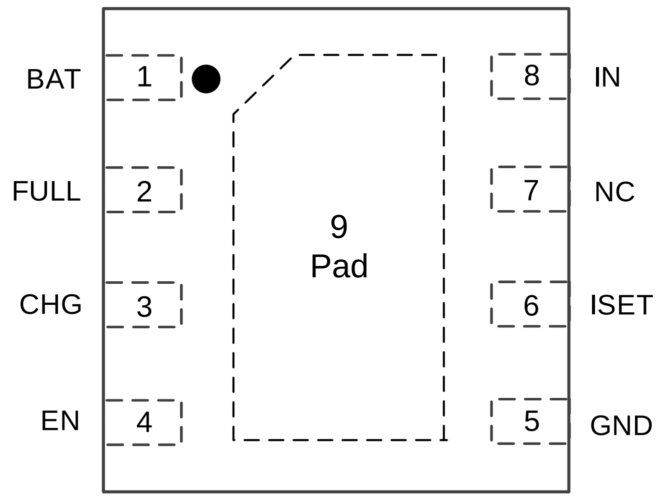
- Protection Features
  - Input Under-voltage Lockout (UVLO)
  - Input Over-voltage Protection (OVP)
  - Battery Reverse Connection Protection
  - Thermal Regulation
- RoHS Compliant and 100% Lead (Pb)-Free
- Part No. and Package Information：

Part No.	V_{FLOAT}	Package	Reel	MSL
ET95153Y	4.2V	DFN8 (3mm×3mm)	3k/Reel	Level 3
ET95153HY	4.35V	DFN8 (3mm×3mm)	3k/Reel	Level 3

Application

- Wireless Speaker
- Cordless Power Tools
- Gaming Devices
- Portable Media Players
- Handheld Battery-Powered Devices
- Charging Docks and Cradles
- Power Bank
- E-Cigarettes

Pin Configuration



Top View

Figure 1. Pin Configuration

Pin Function

Pin No.	Pin Name	Description
1	BAT	Battery Pin. Connect to the battery, A 1-10μF capacitor is needed typically.
2	FULL	Open-Drain Status Output. When the device is in charging state, the FULL pin is pulled high by an external pull-up resistor. When the charge cycle is completed, the pin is pulled low by an internal NMOS.
3	CHG	Open-Drain Charge Status Output. When the device is in charging state, the CHG pin is pulled low by an internal NMOS. When the charge cycle is completed, the internal NMOS turned-off, the pin could be pulled high by an external pull-up resistor.
4	EN	Charge Enable Input. Low active.
5	GND	GND. Connect to the system ground.
6	ISET	Fast Charge Current Program Pin. Connect this pin with an external resistor R_{ISET} to GND to program the fast charge current.
7	NC	No Connection.
8	IN	Positive Supply Voltage Input. Place a 4.7Ω resistor and a 1-10μF ceramic capacitor in series from IN to GND, and place the components as close as possible to IC.
9	PAD	Ground reference for the device that is also the thermal pad used to conduct heat from the device.

Block Diagram

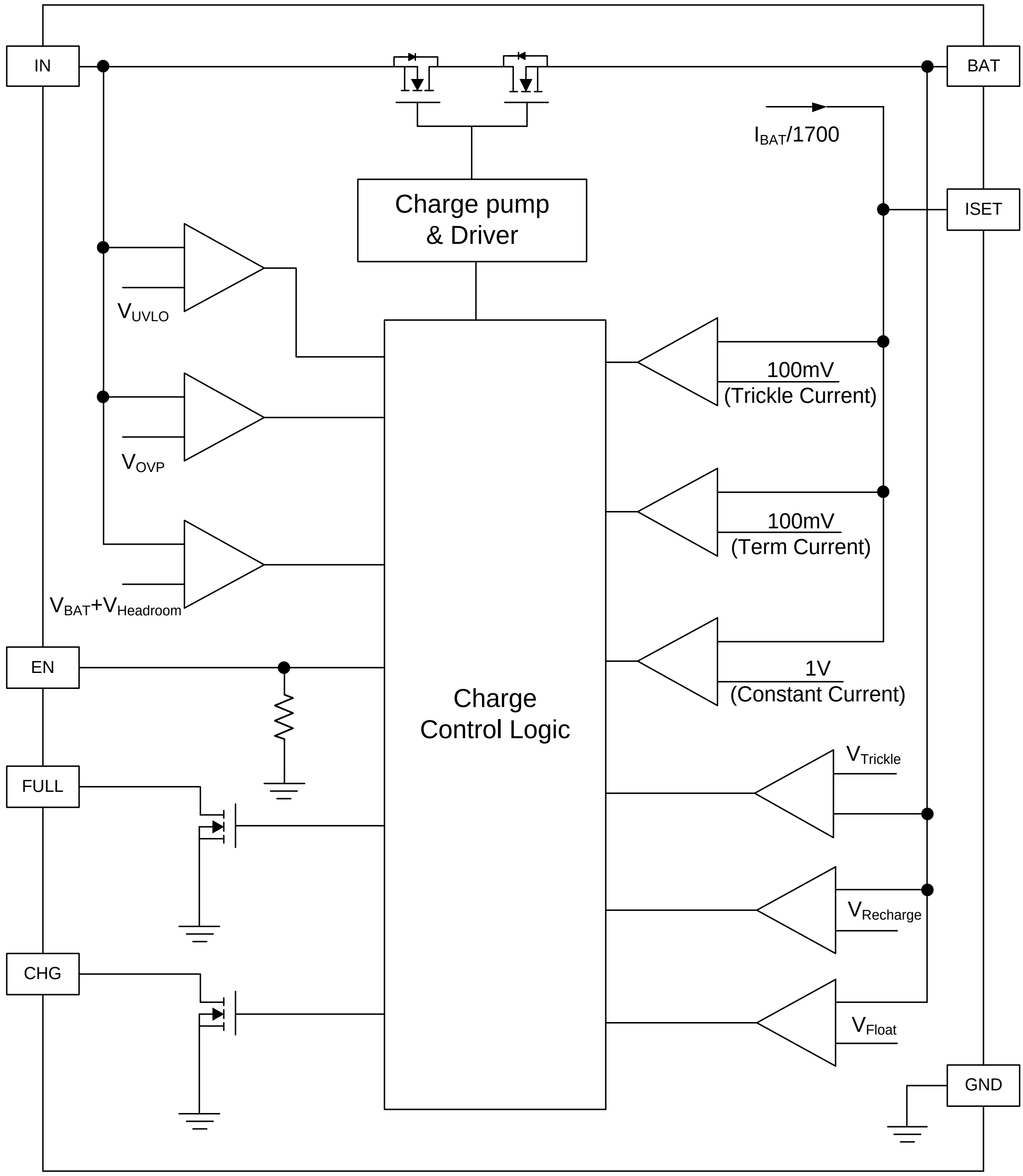


Figure 2. Block Diagram

Absolute Maximum Ratings[3]

Symbol	Parameter	Value	Unit
V_{IN}	IN to GND	-0.3 to +36	V
V_{CHG} V_{FULL}	CHG, FULL to GND	-0.3 to +28	V
V_{BAT}	BAT to GND	-5 to +17 [1]	V
V_{EN} V_{ISET}	EN, ISET Pin to GND	-0.3 to +6.5	V
T_{STG}	Storage Temperature Range	-65 to +150	°C
T_{JMAX}	Maximum Junction Temperature	+150	°C
V_{ESD}	Human Body Model [2](All pin to GND)	±2000	V
	Charged Device Model [2]	±500	
T_{SOLD}	Maximum Soldering Temperature (at leads, 10 sec)	+260	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

Note1: 17V Pulsed, 1s maximum.

Note2: This device series incorporates ESD protection and is tested by the following methods:

ESD Human Body Model tested per ESDA/JEDEC JS-001-2017.

ESD Charged Device Model tested per ESD22-C101.

Note3: 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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability

Recommended Operating Conditions

Symbol	Characteristic	Min	Max	Unit
V_{IN}	Input Voltage	4.5	6	V
I_{CHG}	Maximum Charge Current		1	A
T_J	Operating Junction Temperature Range	-20	140	°C
T_A	Operating Ambient Temperature Range	-20	+85	°C

Electrical Characteristics

V_{IN}=5V, T_A=25°C for typical values (unless otherwise noted).

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
INPUT VOLTAGE AND CURRENT						
V_{IN}	Input Voltage Range		4.5	5	6	V
$I_{STANDBY}$	Input Standby Current	Standby mode (Charge terminated) V_{EN}=0V		100		uA
I_{SHDN}	Input Shutdown Current	V_{EN}=5V		22		uA
V_{UVLO}	Under Voltage Lockout of V_{IN}	V_{IN} Rising	3.3	3.5	3.7	V
V_{UVLO_HYS}	V_{UVLO} Hysteresis	V_{IN} Falling		200		mV
V_{OVP}	Over-Voltage Protection Threshold Voltage	V_{IN} Rising	6.7	7	7.3	V
V_{OVP_HYS}	OVP Hysteresis	V_{IN} Falling		250		mV
BAT LEAKAGE CURRENT						
I_{BAT_LEAK}	Battery Leakage Current	V_{IN} Floating, V_{BAT}=4.2V		5		nA
BATTTERY CHARGER						
V_{FLOAT}	Regulated Output Voltage	ET95153Y	4.179	4.2	4.242	V
		ET95153HY	4.328	4.35	4.394	V
I_{CHG}	Fast Charge Current	R_{ISET}=3.4kΩ, Constant Current Mode	460	500	540	mA
		R_{ISET}=17kΩ, Constant Current Mode	90	100	110	mA
I_{EOC}	End of Charge Current	R_{ISET}=3.4kΩ, Constant Voltage Mode		10%		I_{CC}
I_{TC}	Trickle Charge Current	V_{BAT}<V_{PRE}, R_{ISET}=3.4kΩ		10%		I_{CC}
V_{PRE}	Trickle Charge Threshold Voltage	V_{BAT} Rising	2.75	2.9	3.05	V
V_{PRE_HYS}	Trickle Charge Hysteresis Voltage	V_{BAT} Falling		200		mV
V_{RECHG}	Battery Recharge Voltage Difference Threshold (V_{FLOAT} -V_{RECHRG})	V_{BAT} Falling	100	150	200	mV
$V_{HEADROOM}$	V_{IN}-V_{BAT} threshold Voltage	V_{BAT}=3.7V, V_{IN} Rising	80	130	180	mV
$V_{HEADROOM\_HYS}$	V_{IN}-V_{BAT} threshold Voltage Hysteresis	V_{BAT}=3.7V, V_{IN} Falling		60		mV
T_{FOLD}	Junction Temperature Limit	Thermal Foldback Protection State		140		°C
R_{DS}	IN-BAT MOSFET on-resistance	Charge Current=500mA		750		mΩ

Electrical Characteristics (Continued)

V_{IN}=5V, T_A=25°C for typical values (unless otherwise noted).

ISET/CHG/FULL PINs						
V_{ISET_CC}	ISET Pin Voltage	Constant Current Mode		1		V
V_{ISET_TC}		Trickle Current Mode		0.1		V
V_{STAT}	CHG/FULL Pin Output Low Voltage	I_{STAT}=5mA			0.5	V
I_{STAT}	CHG/FULL Pin Sink Current				5	mA
EN PIN						
V_{EN_ON}	EN Logic-Low Voltage Threshold	EN Falling			0.4	V
V_{EN_OFF}	EN Logic-High Voltage Threshold	EN Rising	1.4			V
I_{EN}	EN pin leakage current	V_{EN}=5V			1	uA

Detailed Description

Overview

The ET95153 is a highly advanced linear charger with up to 1A maximum charge current for single cell Li-Ion and Li-Polymer batteries. The device charges the battery with full charge cycle: trickle current mode, constant current mode (CC), constant voltage mode (CV), charge termination and recharge. The typical charge profile can be showed as the figure below.

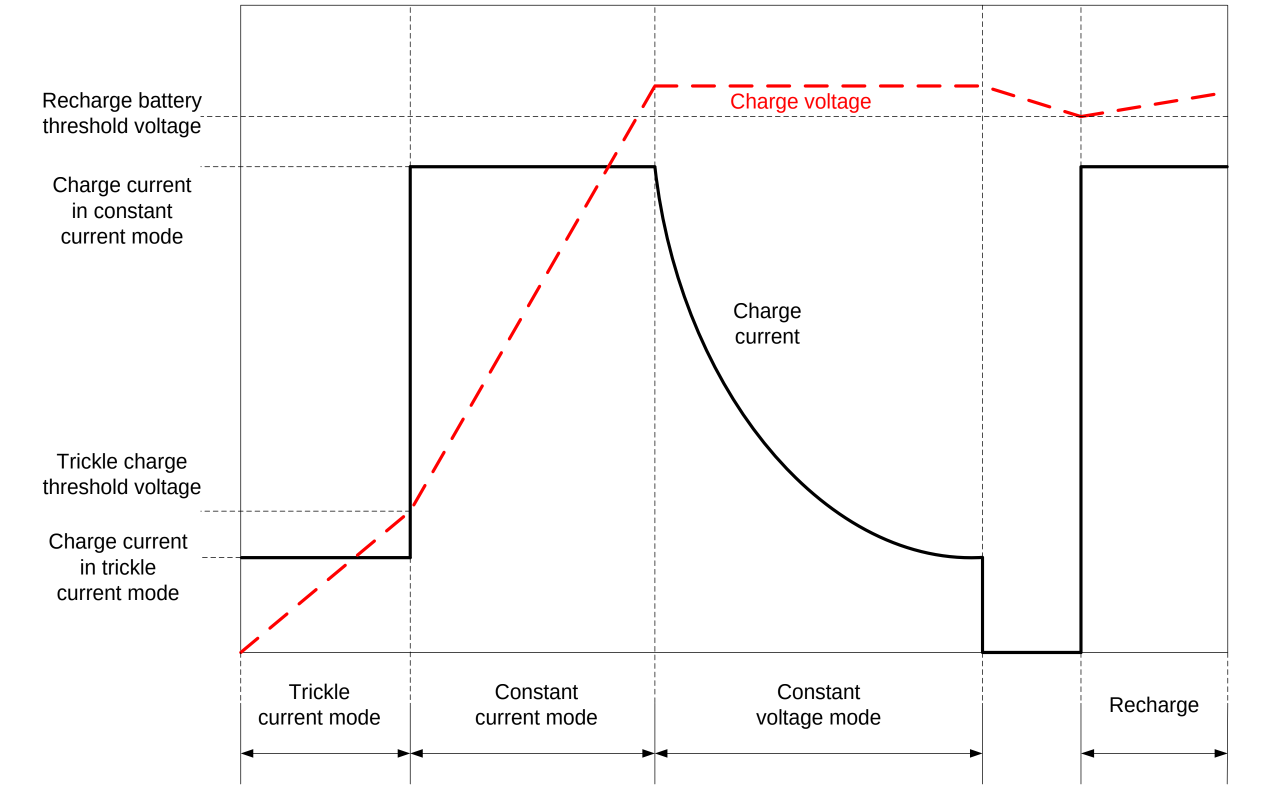


Figure 3. Charging Curve

When the battery voltage is lower than Trickle Charge Threshold Voltage (V_{PRE}, 2.9V typical), the device charges in the trickle current mode, the charge current will be set to Trickle Charge Current (I_{TC}), which is approximately 10% of the ISET programmed Fast Charge Current (I_{CHG}) to bring the battery voltage up to a safe level for full current charging. When the battery voltage rises to V_{PRE}, the device enters the constant current mode, where the charge current is 100%I_{CHG}. When the battery voltage approaches the Regulated Output Voltage (V_{FLOAT}), the device goes to constant voltage mode, the charge current starts to decrease. When the charge current is lower than the Termination Current threshold (I_{EOC}), which is 10%I_{CHG}, the device will terminate the charging.

The device will automatically recharge the battery while the battery voltage drops ΔV_{RECHRG} (150mV, typical) from the Regulated Output Voltage (V_{FLOAT})

ISET Programming Fast Charge Current

The Fast Charge Current (I_{CHG}) is set by a resistor (R_{ISET}) connecting from the ISET pin to GND. The relationship between I_{CHG} and the programming resistance is established by the following formula:

$$I_{CHG} = \frac{V_{ISET} \times 1700}{R_{ISET}} \quad (1)$$

Where V_{ISET}=1V typical.

Charge Termination and Automatic Recharge

A charge cycle will be terminated when the charge current falls to I_{EOC} (10%I_{CHG}, typical), as the battery voltage reached V_{FLOAT}. The function is implemented by monitoring the ISET pin voltage and comparing to a 100mV threshold voltage. When the ISET pin voltage falls below 100mV for longer than 1ms typically, the charging will be terminated.

Once the charge cycle is terminated, the ET95153 continuously monitors the voltage on the BAT pin by a comparator. A new charge cycle starts when the battery voltage drops by a voltage difference ΔV_{RECHRG} (150mV, typical) from V_{FLOAT}, which means the battery level drops to approximately 80% to 90% capacity. This ensures that the battery always keeps at or near a fully charged condition.

Under-Voltage Lockout (UVLO) and Minimum Headroom Voltage

An internal UVLO circuit monitors the input voltage and keeps the device in Shutdown mode until the input supply rises above the UVLO threshold. The UVLO circuitry has a built-in hysteresis of 200mV. The UVLO circuit always be active.

Again, the input supply must be $V_{HEADROOM}$ (130mV, typical) higher than the battery voltage before the ET95153 become operational. Whenever the input supply is below the UVLO threshold or lower than a voltage of $V_{HEADROOM}$ above the BAT pin, the ET95153 is in Shutdown mode.

Enable Function

The ET95153 features an enable/disable function. An input "Low" signal or floating connection on EN pin will enable the device. To ensure the device to be active, the EN low voltage level must be lower than 0.4V. The device will enter the Shutdown mode when the voltage on the EN pin is higher than 1.4V. If the enable function is not needed in a specific application, the EN pin can be shorted to GND or left floating to keep the device continuously active.

Charge Status Indicator (CHG & FULL)

When the input voltage is above the V_{UVLO} and above the voltage of V_{BAT}+$V_{Headroom}$, but lower than V_{OVP} (V_{IN}<V_{OVP}), CHG and FULL pins have two different states: strong pull-down (~5mA) and high impedance. The strong pull-down state of CHG implemented by an internal NMOS indicates that the ET95153 is in a charge cycle. After the charge current decreased to I_{EOC} in CV mode and then charging terminated, the CHG pin will become high impedance, the FULL pin will become pull-down state.

Function	CHG	FULL
Charging	Low	Hi-Z
Charge Terminated	Hi-Z	Low

Thermal Regulation Foldback

An internal thermal regulation foldback loop reduces charge current if the junction temperature reaches a preset value of approximately 140°C to prevent further temperature rise. This function protects the device from excessive temperature and allows the user to get the limits of the power handling capability of a given circuit board without the risk of damaging the device. The charge current can be set according to typical ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions.

Charge termination function will not be active when thermal foldback regulation protection is happening.

Application Information

Thermal Consideration

Due to low efficiency of linear charging, the most important factor is thermal design, which is a direct function of input voltage, output charge current and thermal impedance between the battery charger and the ambient cooling air.

The power dissipation can be calculated approximately:

$$P_D = (V_{IN} - V_{BAT}) \times I_{BAT} \tag{2}$$

Where PD is the power dissipation, V_{IN} is the input supply voltage, V_{BAT} is the battery voltage and I_{BAT} is the charge current.

The worst-case situation is when the device has transitioned from the trickle current mode to the constant current mode. In this situation, the battery charger has to dissipate the maximum power.

In this case, with a 5V input voltage source, 1A fast charge current, the max power dissipation could be:

$$P_{DMAX} = (5V - 2.9V) \times 1A = 2.1W \tag{3}$$

This power dissipation with the battery charger in the DFN8 package may cause thermal regulation foldback to reduce the charge current. Then a trade-off must be made between the charge current and thermal requirements of the charger.

External Capacitors

In order to maintain good stability in the whole charge cycle, a capacitance of 1-10μF is recommended to bypass the BAT pin to GND. In addition, the battery and interconnections appear inductive at high frequencies. These elements are in the control feedback loop during constant voltage mode. Therefore, the bypass capacitance may be necessary to compensate for the inductive nature of thew battery pack.

ISET Resistor

In order to assure the accuracy of the charge current, better than 1% precision resistance is recommended.

Layout Consideration

For optimum voltage regulation, place the battery pack as close as possible to the device's BAT and GND pins. This is recommended to minimize voltage drops along the high current-carrying PCB traces. If the PCB layout is used as a heat sink, adding many vias in the heat sink pad can help conduct more heat to the PCB backplane, thus reducing the maximum junction temperature. It is also recommended to place the capacitor C_{IN} and C_{OUT} as close as possible to the corresponding pins and the GND pin.

Application Circuit

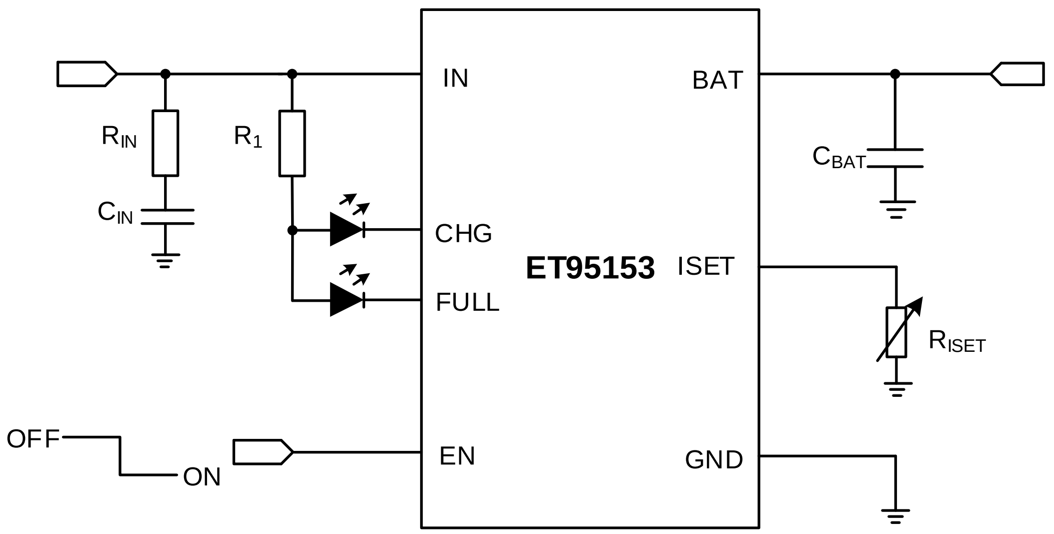
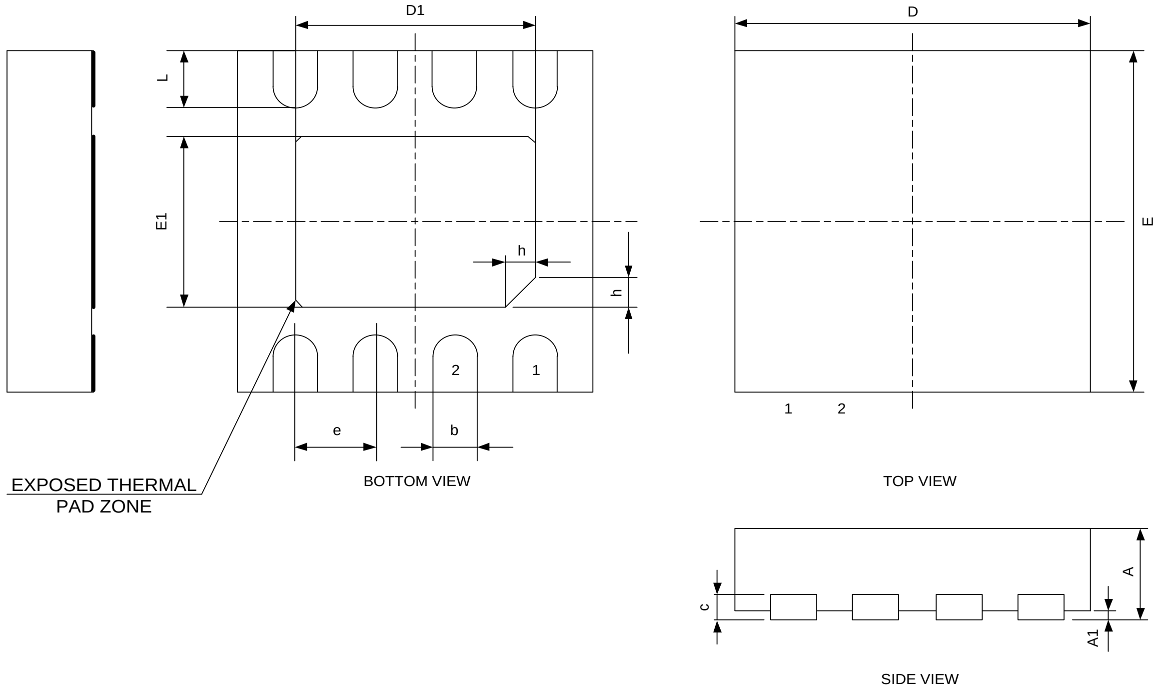


Figure 4. Typical Application Circuit of ET95153

Package Dimension

DFN8(3.0mm*3.0mm)

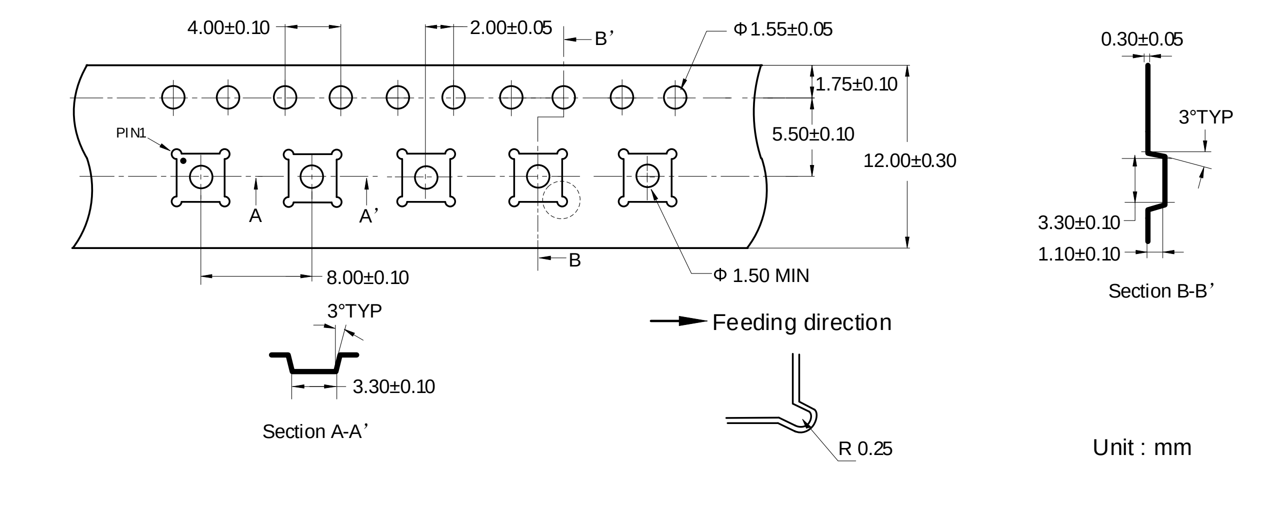


COMMON DIMENSIONS

(Unit : mm)

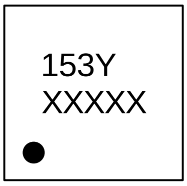
SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	-	0.02	0.05
b	0.26	0.28	0.31
c	0.19	0.20	0.23
D	2.90	3.00	3.10
D1	2.25	2.30	2.35
e	0.65 BSC		
E	2.90	3.00	3.10
E1	1.45	1.50	1.60
L	0.25	0.30	0.35
h	0.20	0.25	0.30

Tape Information



Marking Code

ET95153Y



153Y- Part Number

XXXXX - Tracking Number

Note: XXXXX (Tracking Number) is variable, according to the wafer lot number.

Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
1.0	2025-08-09	Official Version	Chenzx	Zhujy	Liujy
1.1	2025-08-11	Update Function block Add ET95153H	Chenzx	Zhujy	Liujy
1.2	2025-08-14	Update BAT leakage 5nA BAT rate 17V	Chenzx	Zhujy	Liujy
1.3	2025-09-05	Update name:ET95153Y	Chenzx	Zhujy	Liujy
1.4	2025-10-15	Update Format	Chenzx	Zhujy	Liujy