36V Input Withstand Voltage, Built-in Frequency Jitter Function with Optimized EMI Characteristics Maximum 3A Synchronous Step-down 2 to 5 Series Multi-type Lithium Battery Charging Management IC

General Description

The IU5380C is a synchronous step-down charging management IC with a high-voltage tolerance of 36V at the interface and a wide input range of 9~26V. It supports 2~5 series lithium batteries/lithium-ion polymer batteries and lithium iron phosphate batteries of various specifications . The IU5380C integrates a power MOS and adopts a synchronous switching architecture, which requires only a few peripheral components in applications. This can effectively reduce the size of the overall solution and lower the BOM cost.

The IU5380C has a maximum charging current capacity of 3A, and the charging current can be flexibly adjusted via an external resistor. It also features a built-in frequency jitter function, which significantly optimizes EMI characteristics.

The IU5380C has four built-in loops to control the charging process, namely the constant current (CC) loop, the constant voltage (CV) loop, the chip temperature regulation loop, and the input adaptive loop that can intelligently adjust the charging current to prevent over - loading the adapter output and match all adapters. The IU5380C can flexibly set different constant - voltage charging values by connecting resistors of different resistances through an external port, thus adapting to single-cell lithium batteries of different specifications.

It has comprehensive protection functions, including input under voltage voltage protection, battery over voltage and short circuit protection, battery temperature protection (NTC function), and chip over temperature protection. In addition, the chip monitors the entire charging process through two externally connected LED indicators.

Features

- Synchronous Step-down Charging
- The Charging Current is Externally Adjustable.
- Wide Input Range: 9~26V
- The Number of Battery Cells is Selectable through External Pins
- Input Current Adaptive Function, and The Adaptive Point is Externally Adjustable
- NTC Function
- The Constant Voltage Charging Voltage can be Adjusted Independently to Adapt to Lithium Batteries of Different Specifications
- Input withstand voltage: 36V
- The BAT Terminal has a Voltage Tolerance of 36V, a High Voltage Transistor is Integrated Internally
- 500KHz Switching Frequency
- With Two Charging Status Indicators
- Built-in Frequency Jitter Function, Which Significantly Optimizes EMI Characteristics
- Chip Over Temperature Protection, and The Chip Temperature is Adaptively Adjusted
- Input Under Voltage Protection
- Battery Short Circuit and Over Voltage Protection

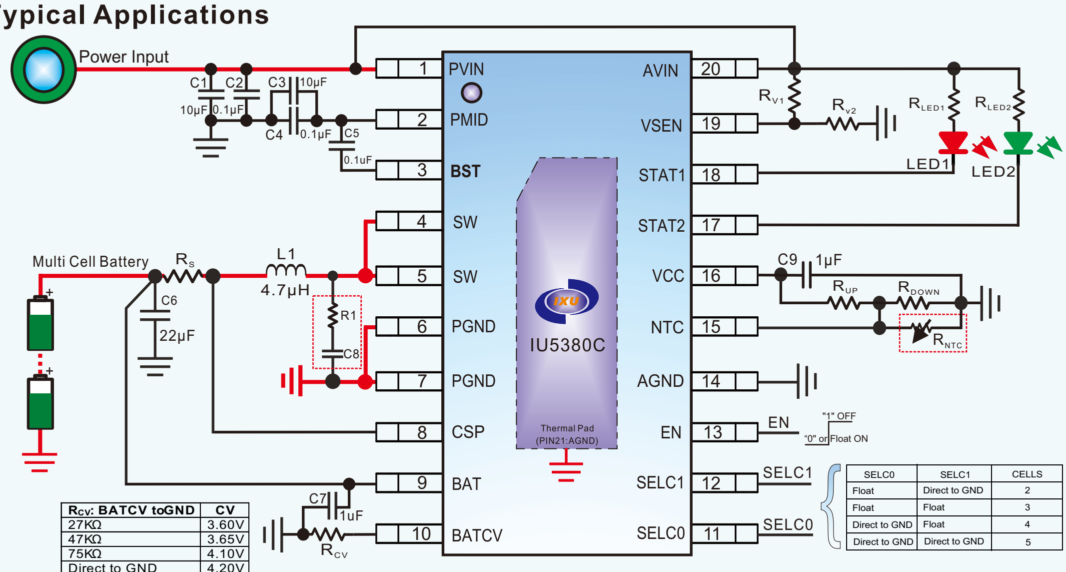
Applications

- 3.6V/3.65V Lithium Iron Phosphate Battery Pack
- 4.1V/4.2V/4.35V/4.4V Lithium Battery Pack
- Bluetooth Speaker
- Massage equipment

Package

- TSSOP20-PP

Typical Applications



R_{CV}: BATCV toGND	CV
27KΩ	3.60V
47KΩ	3.65V
75KΩ	4.10V
Direct to GND	4.20V
110KΩ	4.35V
Float	4.40V

SELC0	SELC1	CELLS
Float	Direct to GND	2
Float	Float	3
Direct to GND	Float	4
Direct to GND	Direct to GND	5

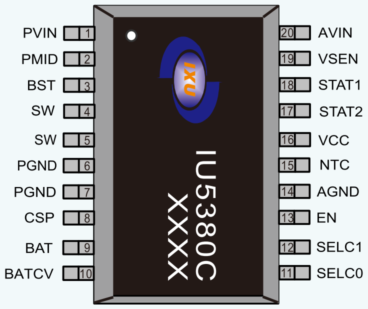
IU5380C Application Circuit

Notes:

(1) The saturation current value of the L1 power inductor must be greater than the set charging current, with sufficient margin.
(2) The power resistor RS is used to set the charging current value. Its CSP tap must be made close to the corresponding terminal, and the CSP wire should not be routed near the inductor.
(3) The BAT tap of the power resistor RS is close to and passes through its sampling capacitor (which must be close to the RS resistor port). Other chip capacitors should be placed as close to the chip pins as possible.
(4) Pins 18 and 17 of the chip, namely the STAT1 and STAT2 pins, are output pins with an open-drain (OD) structure, outputting a 0 level or a high-impedance state. When not in use, it is recommended to directly connect them to the ground.
(5) When the NTC function is not in use, directly connect the NTC pin to the ground.
(6) In the figure, RV2 at the VSEN pin must be greater than 10KΩ.
(7) To optimize the EMI, R1 and C8 in the figure can be added.
(8) The red solid lines in the figure represent the paths for high - current flow.

PIN Configuration and Functions

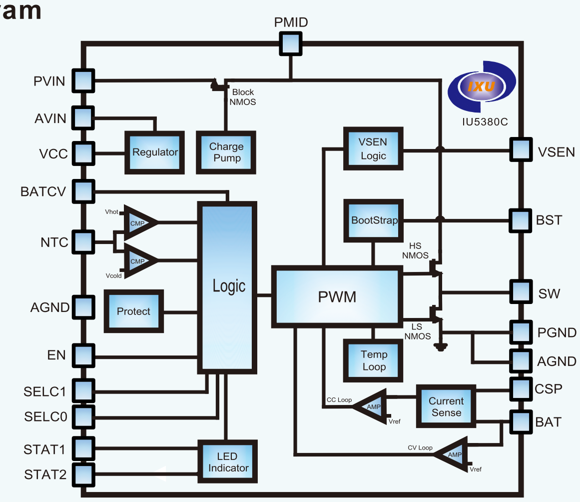
IU5380C



TSSOP20-PP
TOP VIEW

PIN	NAME	TYPE	DESCRIPTION
1	PVIN	P	Input power supply
2	PMID	P	The common connection point between the reverse blocking MOS and the switching power MOS
3	BST	P	Bootstrap capacitor connection terminal
4 , 5	SW	I	Switching node, inductor connection terminal
6 , 7	PGND	-	Power ground
8	CSP	I	Positive input terminal for battery charging current detection
9	BAT	I	Battery connection terminal
10	BATCV	O	Port for setting the floating charge voltage of batteries with different specifications
11	SELC0	I	One of the pins for battery cell number selection
12	SELC1	I	One of the pins for battery cell number selection
13	EN	I	Enable port. A low level or a floating state enables and initiates charging, while a high level turns off the charging.
14	AGND	-	Analog ground
15	NTC	I	Thermistor input terminal, which detects the battery temperature by connecting an external thermistor.
16	VCC	P	Internal low voltage analog power supply output terminal
17	STAT2	O	Charging status indication port 2, which outputs 0 or a high-impedance state.
18	STAT1	O	Charging status indication port 2, which outputs 0 or a high-impedance state.
19	VSEN	I	Pin for input adaptive function
20	AVIN	P	Input analog power supply
Thermal PAD	AGND	-	Analog ground

Functional Block Diagram



Absolute Maximum Ratings [1]

SYMBOL	PARAMETER	VALUE	UNIT
VMAX	PVIN, AVIN, PMID, BST, SW, CSP, BAT, NTC, STAT1, STAT2, VSEN	-0.3~36	V
	EN, VCC, BATCV, SELC1, SELC0	-0.3~6	V
T_J	Junction operating temperature range	-40~150	℃
T_{STG}	Storage temperature range	-55~150	℃
T_{SDR}	Lead temperature (Soldering, 10 sec.)	260	℃

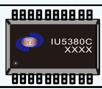
Recommended Operating Conditions

SYMBOL	PARAMETER	VALUE	UNIT
V_{IN}	Input power supply voltage (AVIN, PVIN)	9~24	V
T_J	Junction operating temperature range	-40~125	℃
T_A	Ambient temperature range	-40~85	℃

Thermal Information [2]

SYMBOL	PARAMETER	VALUE	UNIT
θ_{JA}	Package thermal resistance - chip to environment thermal resistance	36	℃/W
θ_{JC}	Package thermal resistance - chip to Package Surface Thermal Resistance	17	℃/W

Ordering Information

Device	Package Type	Device Marking	Package size	Tape Width	Quantity
IU5380C	TSSOP20L-PP		13”	8mm	5000 units

ESD Ratings

HBM (Human Body Model) -- ±2kV

MM (Machine model) -- ±200V

1. The above parameters are only the limit values of device operation. It is not recommended that the working conditions of the device exceed the limit values. Otherwise, the reliability and life of the device will be affected, and even permanent damage will be caused.
2. Where the PCB board is placed in IU5380C, a heat dissipation design is needed. The heat sink at the bottom of IU5380C is connected with the heat sink area of PCB board.

Electrical Characteristics (VIN=12V , R_S=25mΩ , L=4.7uH , T_A=25℃ , unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VIN	Supply voltage		9		26	V
V_{ACOK}	ACOK voltage threshold	V_{IN}-V_{BAT}		0.4		V
VIN_{UVLO}	VIN under voltage lockout threshold	VIN Falling		3.6		V
ΔVIN_{UVLO}	VIN under voltage lockout hysteresis			200		mV
I_Q	Input quiescent current	V_{NTC}=5V		2.5		mA
I_{SD}	Input shutdown current	V_{EN}=5V		30		μA
I_{BAT}	Battery leakage current	NO VIN, V_{EN}=0V		7		μA
		VIN=12V, V_{EN}=0V battery is fully charged		40		
		VIN=12V, V_{EN}=5V battery is fully charged		6		
V_{CV}	Charging floating charge voltage per battery cell	R_{CV}=27KΩ	3.564	3.6	3.636	V
		R_{CV}=47KΩ	3.613	3.65	3.687	
		R_{CV}=75KΩ	4.059	4.1	4.141	
		BATCV to GND	4.158	4.2	4.242	
		R_{CV}=110KΩ	4.306	4.35	4.394	
		BATCV Float	4.356	4.4	4.444	
V_{RCH}	Re-charging voltage threshold per battery cell	V_{BAT} Falling		Vcv-0.1		V

Electrical Characteristics (VIN=12V , R_S=25mΩ , L=4.7uH , T_A=25℃ , unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{TRK}	Trickle to constant current voltage threshold per battery cell	V_{CV}=3.6V/3.65V V_{BAT} Rising		2.5		V
		V_{CV}=4.1V/4.2V /4.35V/4.4V V_{BAT} Rising		2.8		
V_{SHORT}	Battery short circuit voltage threshold per battery cell	V_{CV}=4.1V/4.2V /4.35V/4.4V V_{BAT} Rising		1		V
V_{OVPB}	BAT end over voltage protection voltage per battery cell	V_{BAT} Rising		1.1V_{CV}		V
V_{SENSE}	Current detection clamp voltage			50		mV
I_{CC}	CC charge mode current	R_S=25mΩ	1.8	2	2.2	A
I_{TC}	TC charge mode current			10%		I_{CC}
I_{BF}	Terminate charge current			10%		I_{CC}
V_{cold}	NTC low temperature falling threshold	Percentage of VCC		80		%
V_{cold_hys}	NTC Low temperature protection hysteresis	Percentage of VCC		0.74		%
V_{hot}	NTC high temperature rising threshold	Percentage of VCC		45		%
V_{hot_hys}	NTC high temperature protection hysteresis	Percentage of VCC		0.74		%

Electrical Characteristics (VIN=12V , R_S=25mΩ , L=4.7uH , T_A=25℃ , unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{ENL}	EN Enable Low Level Threshold				0.4	V
V_{ENH}	EN Enable High Level Threshold		1.4			V
F_{SW}	Maximum switching frequency			500		KHz
T_{REG}	Thermal regulation threshold			120		℃
T_{SD}	Thermal shutdown temperature			150		℃
ΔT	Thermal shutdown temperature hysteresis			40		℃

IU5380C Application Points

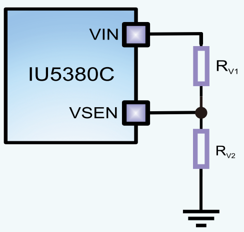
1. Charge Process

The IU5380C adopts a complete TC/CC/CV charging process. When the voltage of the battery is lower than the trickle charge point, the system charges with the I_{TC} charging current; when the voltage of the battery is higher than the trickle charge point, the system charges with the I_{CC} charging current; when the battery voltage approaches the set floating charge voltage, the system enters the constant voltage charging mode, and the charging current continuously decreases. When the charging current is lower than I_{BF}, the system will stop charging. After the battery is fully charged, if the battery voltage drops to the set recharging voltage due to self-discharge or power consumption by the load, the system will resume the charging state.

2. Adaptive Input Current Limit Function

The IU5380C has a built in special loop that can automatically adjust the magnitude of the charging current, preventing the input DC power supply from entering an over driven state, and thus avoiding the phenomenon of pulling down the adapter caused by any improper settings. A large charging current will cause the input power supply voltage to drop. As the power supply voltage drops, the input terminal of the internal adaptive loop operational amplifier also drops accordingly. When it drops to the internal reference value, the built in adaptive loop will automatically adjust the system duty cycle, reducing the charging current and the driving pressure on the input power supply, so that the input voltage at the chip pins is fixed at the set value VIN_{AJ}.

When two resistors, R_{V1} and R_{V2} (must be greater than 10KΩ), are externally connected to the VSEN pin of the chip, the specific calculation formula for the lowest value VIN_{AJ} to which the input voltage at the chip pin can be reduced is as follows:



$$VIN_{AJ}=\frac{1*(R_{V1}+R_{V2})}{R_{V2}}$$

When the VSEN pin of the chip is connected to VCC, this function will be disabled.

3. Protection Function

The IU5380C has a complete set of battery charging protection functions. When there is an over voltage at the output terminal, or an over-temperature of the chip, the system charging will be prohibited until the protection state is released. When the battery voltage is lower than V_{SHORT}, the output short-circuit protection function is activated, and the battery is charged with the trickle current value. When the input voltage is lower than the undervoltage protection threshold VIN_{UVLO}, all the main functional modules of the chip will be turned off to prevent the system from malfunctioning due to the excessively low power supply voltage.

4. Charging Indication Function

The STAT1 and STAT2 pins of the chip are status indication pins, which output a 0-level voltage or a high impedance state. If instead of connecting to an LED light, they are directly connected to the main control unit, a pull-up resistor must be used to convert the high-impedance state into a definite high-level voltage.

(1) Charging process:
The STAT2 port outputs a high-impedance state, and the LED light is turned off;
The STAT1 port outputs a low level, and the LED light is constantly on.

(2) Charging completed:
The STAT2 port outputs a low level, and the LED light is constantly on;
The STAT1 port outputs a high-impedance state, and the LED light is turned off.

(3) In the case of battery overvoltage, battery short circuit, abnormal battery temperature detected at the NTC port, or chip overheating, the LED lights of the two status ports flash alternately at a frequency of 1.5Hz.

(4) In the case of undervoltage at the input terminal or when the chip is in the non-enabled mode, both ports output a high-impedance state, and all LED lights are turned off.

(5) After the system is powered on, if no battery is detected, the two LED lights will flash alternately several times and then change to the charging completed state. When the battery is connected again, after maintaining the charging completed state for approximately 4 seconds, it will change to the current corresponding charging state.

5. Charging Current Setting

The constant current charging current can be set through resistance R_S, and the specific calculation formula is as follows:

$$I_{CC}=\frac{50mV}{R_S(m\Omega)}(A)$$

If you need to obtain a charging current of 2A I_{CC}, select a detection resistor R_S with a resistance value of 25mΩ. Thus, the charging current I_{TC} of the TC stage is determined by the following formula:

$$I_{TC}=10\%I_{CC}=\frac{5mV}{R_S(m\Omega)}(A)$$

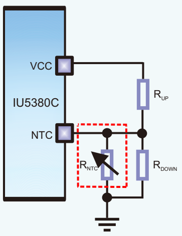
Note that since a large current of the magnitude of the set constant-current charging current will flow through the corresponding RS, it is necessary to select an RS resistor with a sufficient rated power.

6. Chip Temperature Adaptive Adjustment Function

The chip is equipped with a temperature adaptive adjustment loop. When the chip is in the charging process, if the temperature rises to 120℃, the temperature control loop begins to work. The charging current gradually decreases, and the chip temperature will decrease accordingly. Finally, the chip temperature will stabilize at the set value, thereby protecting the chip.

7. NTC Resistor Setting

Battery charging supports NTC protection function, and the temperature of the battery is detected through the NTC pin. When NTC detects that the battery temperature is within the set temperature window range, it charges normally; When NTC detects that the battery temperature is below the set low temperature protection point or above the set high temperature protection point, it stops charging and alarms. If the NTC function is not used, the pin must be grounded. The following figure shows the high-temperature reference points and low-temperature reference points set internally through voltage divider resistors, with the low-temperature reference point being GVDD*80% and the high-temperature reference point being GVDD*45%. Set the temperature range for normal operation of NTC by selecting appropriate external resistors.



$$\frac{R_{DOWN}//R_{NTC\_Cold}}{R_{UP}+R_{DOWN}//R_{NTC\_Cold}}=80\%$$

$$\frac{R_{DOWN}//R_{NTC\_Hot}}{R_{UP}+R_{DOWN}//R_{NTC\_Hot}}=45\%$$

In the above equation, R_{NTC_Cold} is the resistance value corresponding to the NTC resistor at the set low temperature point, and R_{NTC_Hot} is the resistance value corresponding to the NTC resistor at the set high temperature point. Due to the fact that R_{DOWN} and R_{UP} resistors can be independently set for low and high temperature windows, This enables the chip to meet most NTC resistor models, which brings great convenience to applications. The relationship between resistance R_{DOWN}, R_{UP}, and NTC resistance can be given by the following formula based on the above definition:

$$R_{UP}=\frac{35*R_{NTC\_Hot}*R_{NTC\_Cold}}{36*(R_{NTC\_Cold}-R_{NTC\_Hot})}$$

$$R_{DOWN}=\frac{35*R_{NTC\_Hot}*R_{NTC\_Cold}}{9*R_{NTC\_Cold}-44*R_{NTC\_Hot}}$$

8. Frequency Jitter Function

The IU5380C has a built-in frequency jitter function. The system will superimpose a slight jitter (i.e., extended frequency) on the normal operating frequency point, so that the energy will not be concentrated at a fixed frequency point, which greatly improves the EMI characteristics of the system.

9. Setting of Battery Floating Charge Voltage

The IU5380C can flexibly set different constant voltage charging voltage values by connecting resistors with different resistance values through an external port BATCV, so as to be compatible with single lithium batteries of different specifications.

R_{CV}: BATCV to GND	CV
27KΩ	3.60V
47KΩ	3.65V
75KΩ	4.10V
Direct to GND	4.20V
110KΩ	4.35V
Float	4.40V

10. Setting of the Number of Battery Cells

The IU5380C can flexibly set different numbers of battery cells by either leaving the two external ports SELC0 and SELC1 floating or directly grounding them.

SELC0	SELC1	CELLS
Float	Direct to GND	2
Float	Float	3
Direct to GND	Float	4
Direct to GND	Direct to GND	5

11. Selection of Inductance Value

To select an appropriate inductance value, it is necessary to make a trade-off among cost, size, and efficiency. An inductor with a lower inductance value corresponds to a smaller size, but it will generate higher ripple current, higher hysteresis loss, and a higher output capacitance. Conversely, a larger inductance value is beneficial for obtaining lower ripple current and a smaller output filter capacitance, but it will lead to higher power loss due to the inductor's DC resistance (DCR). According to practical experience, in the worst-case scenario, the inductor ripple current should not exceed 30% of the maximum charging current. Under a given input voltage, the maximum inductor current ripple occurs at the switching point between trickle charging and constant current charging. The inductance value can be estimated according to the following formula:

$$L=\frac{VIN-V_{TRK}}{\Delta I_{L\_MAX}}*\frac{V_{TRK}}{VIN*F_{SW}}$$

Among them, VIN, V_{TRK} and F_{SW} represent the input voltage, the switching point between trickle charging and constant current charging, and the operating frequency of the system respectively. ΔI_{L_MAX} is the maximum inductor ripple current, which is generally taken as 30% of the constant current charging current, as shown below:

$$\Delta I_{L\_MAX} = 30\% * I_{CC}$$

At the same time, it should be noted that a certain margin should be left for the saturation current value of the selected inductor. Generally, at least an additional 0.5A should be added on the basis of the maximum peak current. For higher system efficiency, the DC resistance value of the selected inductor should be at least less than 50mΩ.

12. Selection of Input Capacitor

The input capacitor is used to absorb the input peak current from the step - down architecture. When selecting an input capacitor, ensure that the temperature rise caused by the ripple current does not exceed 10°C. Use ceramic capacitors with X5R or X7R dielectrics because they have low ESR and a small temperature coefficient. For most applications, use a 10μF capacitor. In addition, a small capacitor of at least 1μF as close as possible to the chip pin is usually required. For an input voltage as high as 10V, considering the spikes during input insertion, select a 22μF input capacitor with a rated voltage of at least 25V.

13. Selection of Output Capacitor

The output capacitor is connected in parallel with the battery. It can absorb high - frequency switching peak currents and smooth the output voltage. Its impedance must be much smaller than that of the battery to ensure that it can absorb most of the high - frequency current. Ceramic capacitors with a small ESR and a small volume can be selected. The value of the output voltage ripple is given by the following formula:

$$\Delta r_O = \frac{\Delta V_O}{V_O} = \frac{1 - \frac{V_O}{VIN}}{8 C_O F_S^2 L}$$

In order to ensure an output battery voltage accuracy of ±1%, the maximum output voltage ripple should not be higher than 1%. The maximum output voltage ripple occurs at the minimum battery voltage and the maximum input voltage during constant current charging.

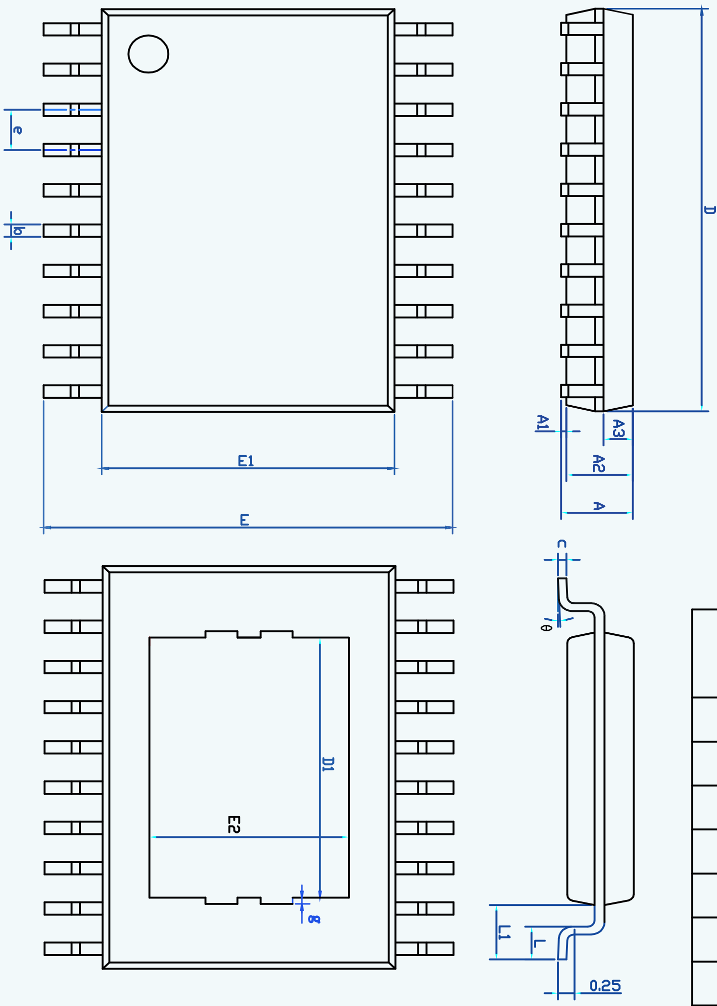
14. Precautions for PCB

The PCB shown on our company's DEMO board is only for reference, and it does not mean that customers must layout and route their own products exactly according to the DEMO. Please carry out the layout and routing according to the actual components used and the product requirements, but there are some general principles:

- The power traces should be as wide as possible, and the chip should be powered by a separate power trace.
- The ground wires should be routed on the same layer to avoid via jumpers, and at the same time, they should be short and thick.
- The SW traces should be as short as possible to reduce EMI.
- The connections between the inductor and the RS resistor should be short and thick, and avoid via jumpers.
- The capacitors at the power supply end should be placed as close to the chip as possible.

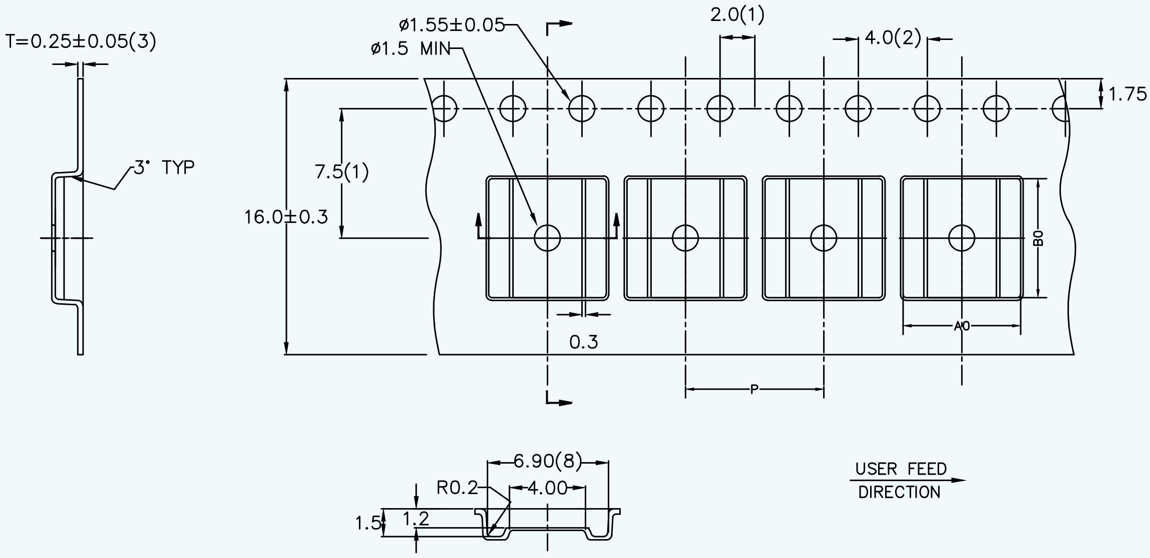
Package Information

IU5380C TSSOP20-PP PACKAGE OUTLINE DIMENSIONS (units:mm)



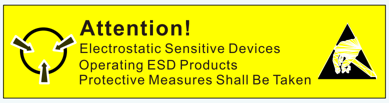
SYMBOL	MI LLIMETER		
	MIN	NOM	MAX
A	——	——	1. 20
A1	0. 04	0. 08	0. 12
A2	0. 95	1. 00	1. 05
A3	0. 39	0. 44	0. 49
b	0. 20	——	0. 29
c	0. 13	——	0. 18
D	6. 40	6. 50	6. 60
D1	4. 10REF		
E	6. 30	6. 40	6. 50
E1	4. 30	4. 40	4. 50
E2	2. 90REF		
e	0. 65BSC		
L	0. 50	0. 60	0. 70
L1	1. 00REF		
θ	0°	——	8°
g	0. 10REF		

TAPE AND REEL INFORMATION



A0	B0	K0	P	P0	E	F	D0	P2	T	W
6.65±0.1	6.80±0,1	1.5±0.1	8.0±0.1	4.0±0.1	1.75±0.1	7.5±0.1	1.55±0.05	2.0±0.1	0.25±0.05	16±0.3

NOTES:
1. MEASURED FROM THE CENTERLINE OF SPROCKET HOLE TO CENTERLINE OF THE POCKET HOLE AND FROM THE CENTERLINE OF SPROCKET HOLE TO CENTERLINE OF THE POCKET
2. CUMULATIVE TOLERANCE OF 10 SPROCKET HOLES IS ±0.20
3. THIS THICKNESS IS APPLICABLE AS MEASURED AT THE EDGE OF THE TAPE
4. MATERIAL: CONDUCTIVE POLYSTYRENE
5. DIM IN MM
6. ALLOWABLE CAMBER TO BE 1mm PER 100mm IN LENGTH, NON–CUMULATIVE OVER 250mm
7. UNLESS OTHERWISE SPECIFIED, TOLERANCE ±0.10
8. MEASUREMENT POINT TO BE 0.3 FROM BOTTOM POCKET .
9. SURFACE RESISTIVITY LESS THAN OR EQUAL TO 1.0X10E6 OHMS/SQUARE .



Precautions for MOS Circuit Operation:

Static electricity can be generated in many places. The following precautions can effectively prevent MOS circuit from being damaged due to the sound of electrostatic discharge:

- Operators shall be grounded through anti-static wrist strap.
- The equipment enclosure must be grounded.
- Tools used during assembly must be grounded.
- Conductor packaging or anti-static materials must be used for packaging or transportation.

Declaration:

•Shanghai IXU Micro-electronics Co., Ltd. reserves the right to make changes to the manual without prior notice! Customers should obtain the latest version of the material before use and verify whether the relevant information is complete and up-to-date.

•Any semiconductor product has a certain possibility of failure or malfunction under specific conditions. The buyer is responsible for complying with safety standards and taking safety measures when using products from Shanghai IXU Micro-electronics Co., Ltd. for system design and complete machine manufacturing, in order to avoid potential risks of failure that may cause personal injury or property damage!

•The pursuit of enhancing product quality is endless. Shanghai IXU Micro-electronics Co., Ltd. will wholeheartedly provide customers with even better products!