Application Note: AN_SY6288

Low Loss Power Distribution Switch
Preliminary Specification

General Description

SY6288 is an ultra-low $R_{DS(ON)}$ switch with current limiting function to protect the power source from over current and short circuit conditions.

Ordering Information

SY6288□(□□)□

- Temperature Code
- Package Code
- Optional Spec Code

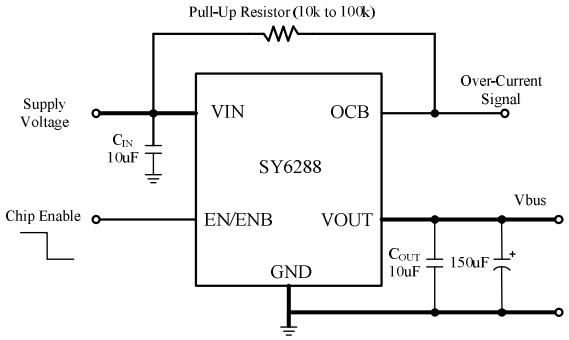
Temperature Range: -40°C to 85°C

Ordering Number	Package type	Note
SY6288AAAC	SOT23-5	0.6A/Active High
SY6288ACAC	MSOP8	0.6A/Active High
SY6288AFAC	SO8	0.6A/Active High
SY6288BAAC	SOT23-5	0.6A/Active Low
SY6288BCAC	MSOP8	0.6A/Active Low
SY6288BFAC	SO8	0.6A/Active Low
SY6288CAAC	SOT23-5	2A/Active High
SY6288CCAC	MSOP8	2A/Active High
SY6288CFAC	SO8	2A/Active High
SY6288C1CAC	MSOP8	1.5A/Active High
SY6288C2CAC	MSOP8	1.5A/Active High
SY6288C4CAC	MSOP8	2A/Active High
SY6288DAAC	SOT23-5	2A/Active Low
SY6288DCAC	MSOP8	2A/Active Low
SY6288DFAC	SO8	2A/Active Low
SY6288D1AAC	SOT23-5	1.5A/Active Low
SY6288D1CAC	MSOP8	1.5A/Active Low
SY6288D1FAC	SO8	1.5A/Active Low
SY6288D2CAC	MSOP8	1.5A/Active Low

Features

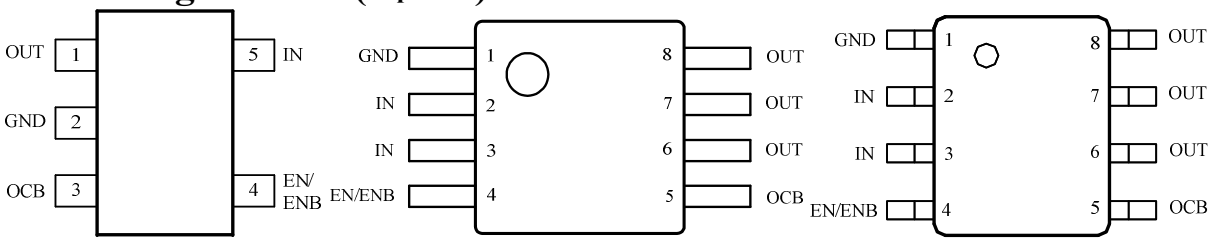
- Distribution voltages: 2.5V to 5.5V
- Over temperature shutdown and automatic retry
- Reverse blocking (no body diode)
- At shutdown, OUT can be forced higher than IN
- Fault flag (OCB) output for over current and fault conditions
- Automatic output discharge at shutdown
- Built-in softstart
- 0.4ms rise time
- RoHS Compliant and Halogen Free
- Two Enable polarities and three current levels
  - SY6288A: Active High/0.6A
  - SY6288B: Active Low/0.6A
  - SY6288C: Active High/2A
  - SY6288C1: Active High/1.5A
  - SY6288C2: Active High/1.5A
  - SY6288C4: Active High/2A
  - SY6288D: Active Low/2A
  - SY6288D1: Active Low/1.5A
  - SY6288D2: Active Low/1.5A
- Compact packages minimize board space: SOT23-5, SO8, MSOP8
- UL certification NO. 20100428-E333762
  TUV certification NO. R501887690001

Typical Application Circuit



Note: A low-ESR 150uF aluminum electrolytic or tantalum between VOUT and GND is strongly recommended.

Pin Configurations (Top View)



Part Number	Package type	Top Mark①
SY6288AAAC	SOT23-5	CW*xyz*
SY6288ACAC	MSOP8	ABT*xyz*
SY6288AFAC	SO8	AAJ*xyz*
SY6288BAAC	SOT23-5	DB*xyz*
SY6288BCAC	MSOP8	ABD*xyz*
SY6288BFAC	SO8	AAL*xyz*
SY6288CAAC	SOT23-5	DF*xyz*
SY6288CCAC	MSOP8	ABU*xyz*
SY6288CFAC	SO8	AAM*xyz*
SY6288C1CAC	MSOP8	ADK*xyz*
SY6288C2CAC	MSOP8	ADL*xyz*
SY6288C4CAC	MSOP8	AEX*xyz*
SY6288DAAC	SOT23-5	BU*xyz*
SY6288DCAC	MSOP8	ABE*xyz*
SY6288DFAC	SO8	AAN*xyz*
SY6288D1AAC	SOT23-5	DS*xyz*
SY6288D1CAC	MSOP8	ACK*xyz*
SY6288D1FAC	SO8	ACJ*xyz*
SY6288D2CAC	MSOP8	AEH*xyz*

Note①： ***x=year code, y=week code, z= lot number code.***

Functional Pin Description

Pin Name	Pin Number (SO8, MSOP8)	Pin number (SOT23-5)	Pin Description
IN	2,3	5	Input pin
GND	1	2	Ground pin
OUT	6,7,8	1	Output pin
EN- SY6288A/C/C1/C2/C4 ENB- SY6288B/D/D1/D2	4	4	ON/OFF control. Don't float. EN: high enable. ENB: low enable.
OCB	5	3	Open Drain Fault Flag

Absolute Maximum Ratings (Note 1)

All pins---------- 6V
Power Dissipation, P_D @ T_A = 25°C SOT23-5/MSOP8/SO8---------- 0.4/0.5/0.65W
Package Thermal Resistance (Note 2)
SOT23-5/MSOP8/SO8, θ_{JA} ---------- 250/150/90°C/W
SOT23-5/MSOP8/SO8, θ_{JC} ---------- 130/ 65/ 45°C/W
Junction Temperature Range ---------- 150°C
Lead Temperature (Soldering, 10 sec.) ----------260°C
Storage Temperature Range ---------- -65°C to 150°C
ESD Susceptibility (Note 2)
HBM (Human Body Mode) ---------- 2kV
MM (Machine Mode) ---------- 200V

Recommended Operating Conditions (Note 3)

IN---------- 2.5V to 5.5V
EN/ENB---------- -0.3V to V_{IN}+0.3V
All other pins ---------- 0-5.5V
Junction Temperature Range ---------- -40°C to 125°C
Ambient Temperature Range ---------- -40°C to 85°C

Electrical Characteristics

(V_{IN} = 5V, C_L=1uF, per channel, T_A = 25°C unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range		V_{IN}		2.5		5.5	V
Shutdown Input Current		I_{SHDN}	Open load, switch off		0.1	1	μA
			Output grounded, switch off		0.1	1	μA
Quiescent Supply Current		I_Q	Open load, switch on		32		μA
FET RON		$R_{DS(ON)}$	SOT23-5(SY6288A/B/C/D/D1)	60	80	100	mΩ
			MSOP8 (SY6288A/B/C/C1/C4)	60	80	100	mΩ
			MSOP8 (SY6288C2/ D1/D2)	50	70	90	mΩ
			MSOP8 (SY6288D)	57	70	83	mΩ
			SO8(SY6288A/B/C/D/D1)	65	85	105	mΩ
Current Limit		I_{LIM}	SY6288A/B	0.8	1.2	1.6	A
			SY6288C/D	2.1	2.9	3.7	A
			SY6288C1	1.6	2.4	3.2	A
			SY6288C2/D2	1.5	1.75	2	A
			SY6288D1	1.6	2.5	3.7	A
			SY6288C4	2.5	2.9	3.7	A
Short Circuit Output Current		I_{OS}	MSOP8 (SY6288D),OUT connected to GND device enabled.	1.2	1.8	2.4	A
EN/ $\overline{EN}$ Threshold	Logic-Low Voltage	V_{IL}				0.8	V
	Logic-High Voltage	V_{IH}		2			V
IN UVLO Threshold		$V_{IN,UVLO}$				2.4	V
IN UVLO Hysteresis		$V_{IN,HYS}$			0.1		V
Turn-ON Time		T_{ON}	R_L=5 Ω, C_L=1uF		400		μs
OCB Low Resistance		R_{OCB}			10		Ω
OCB Delay Time		T_{OCB_Delay}			10		ms
OUT Shutdown Discharge Resistance		R_{DIS}			10		Ω
Thermal Shutdown Temperature		T_{SD}			150		°C
Thermal Shutdown Hysteresis					20		°C

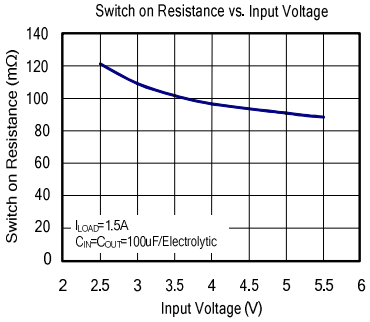
Note 1: Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

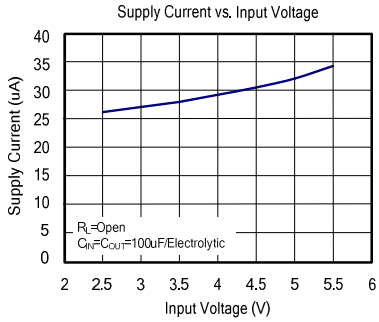
Note 2: θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

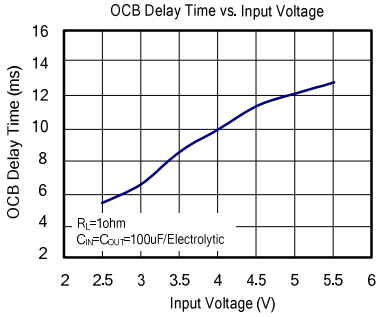
Note 3: The device is not guaranteed to function outside its operating conditions

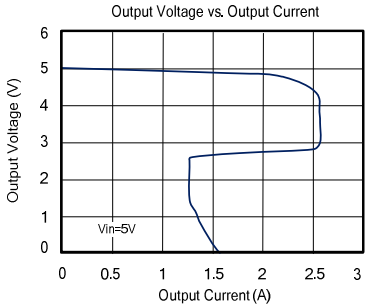
Typical Operating Characteristics

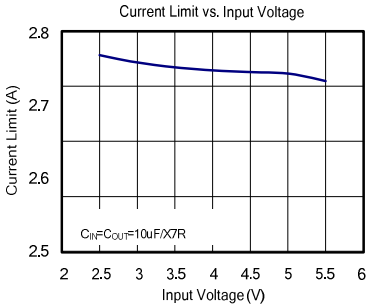
(SY6288DFAC)

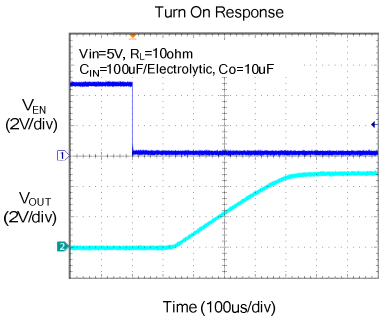


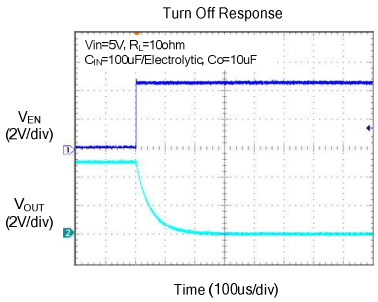


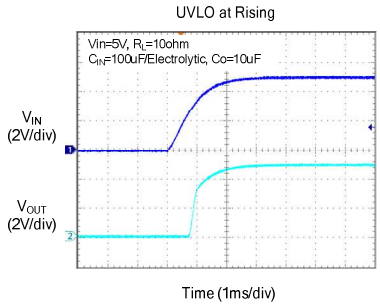


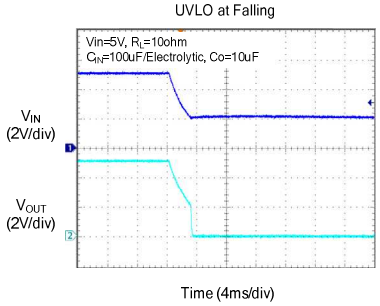


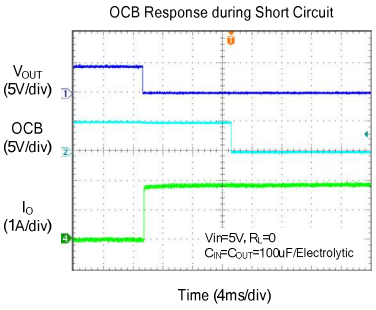


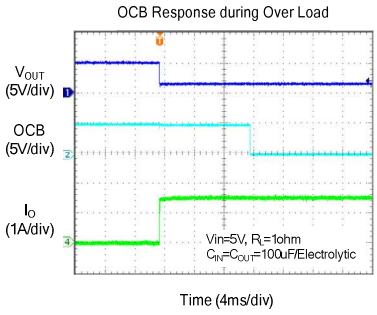


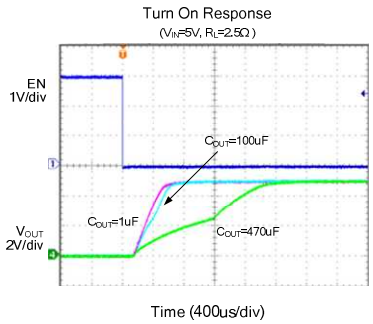


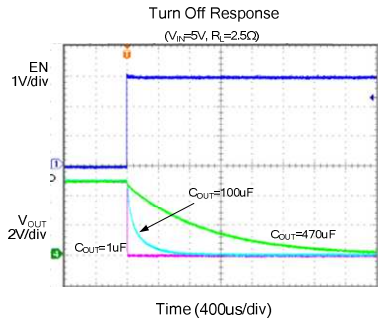


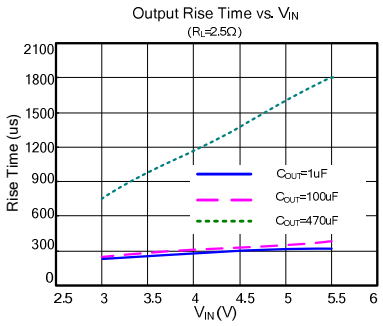


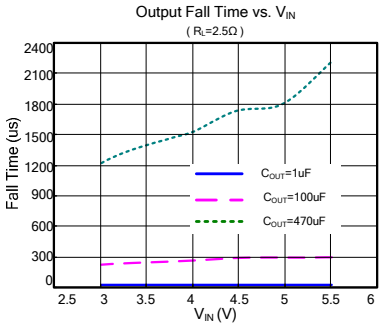

OCB Response during Short Circuit
VOUT (5V/div)
OCB (5V/div)
IO (1A/div)
Vin=5V, RL=0
CIN=COUT=100uF/Electrolytic
Time (4ms/div)

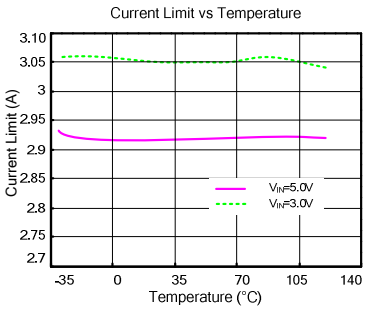

OCB Response during Over Load
VOUT (5V/div)
OCB (5V/div)
IO (1A/div)
Vin=5V, RL=1ohm
CIN=COUT=100uF/Electrolytic
Time (4ms/div)


Turn On Response
(VIN=5V, RL=2.5Ω)
EN 1V/div
VOUT 2V/div
COUT=100uF
COUT=1uF
COUT=470uF
Time (400us/div)

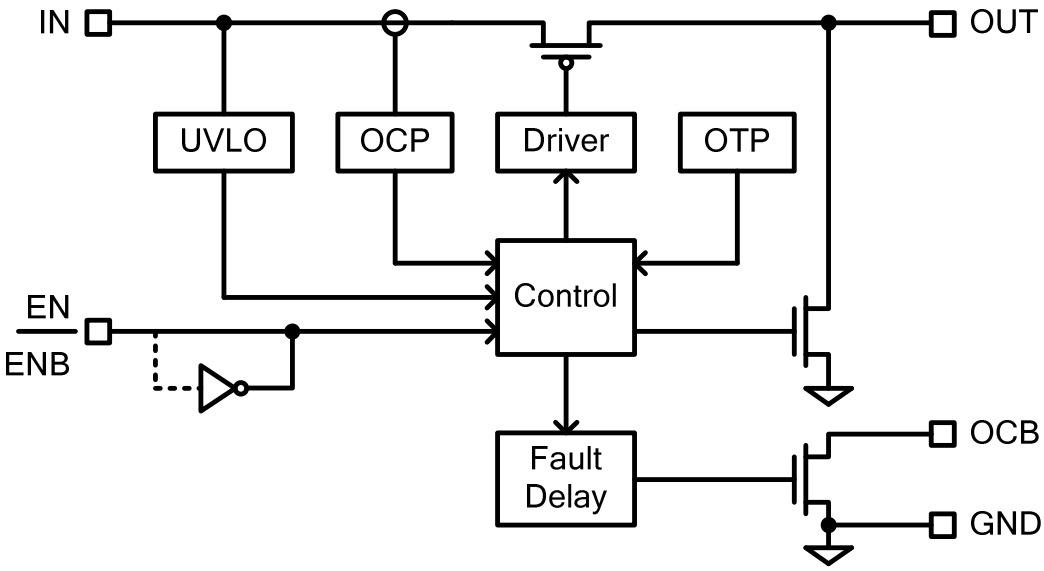

Turn Off Response
(VIN=5V, RL=2.5Ω)
EN 1V/div
VOUT 2V/div
COUT=100uF
COUT=1uF
COUT=470uF
Time (400us/div)


Output Rise Time vs. VIN
(RL=2.5Ω)
Rise Time (us)
2100
1800
1500
1200
900
600
300
0
2.5
3
3.5
4
4.5
5
5.5
6
VIN (V)
COUT=1uF
COUT=100uF
COUT=470uF


Output Fall Time vs. VIN
(RL=2.5Ω)
Fall Time (us)
2400
2100
1800
1500
1200
900
600
300
0
2.5
3
3.5
4
4.5
5
5.5
6
VIN (V)
COUT=1uF
COUT=100uF
COUT=470uF


Current Limit vs Temperature
Current Limit (A)
3.10
3.05
3
2.95
2.9
2.85
2.8
2.75
2.7
-35
0
35
70
105
140
Temperature (°C)
VIN=5.0V
VIN=3.0V

Block diagram



Operation

The SY6288 is a current limited P-channel MOSFET power switch designed for high-side load-switching applications. There is no parasitic body diode between drain and source of the MOSFET, so the SY6288 prevents current flow from out to input when out being externally forced to a higher voltage than vin when chip is disabled.

Over-current protection

When the over-current condition is sensed, the gate of the pass switch is modulated to achieve constant output current. Under output short circuit conditions, the normal current limit folded back 50%. If the over current condition presists for a long enough time, the junction temperature may exceed 150C, and over-temperature protection will shut down the part. Once the chip temperature drops to 130C, the part will restart.

Fault Flag (OCB)

The OCB output is asserted (active low) when an overtemperature shutdown condition is encountered or after overcurrent condition persists for 10ms. The output remains asserted until the overcurrent or overtemperature condition is removed. Connecting a heavy capacitive load to an enabled device can cause a momentary overcurrent condition; however, no false reporting on OCB occurs due to the 10-ms deglitch circuit. OCB is not deglitched when the switch is turned OFF due to an overtemperature shutdown.

Supply Filter Capacitor

In order to prevent the input voltage drooping during hot-plug events, a 10uF ceramic capacitor form V_{IN} to GND is strongly recommended. However, higher capacitor values could reduce the voltage droop on the input further. Furthermore, an output short will cause ringing on the input without the input capacitor. It could destroy the internal circuitry when the input transient exceed 6V which is the absolute maximum supply voltage even for a short duration.

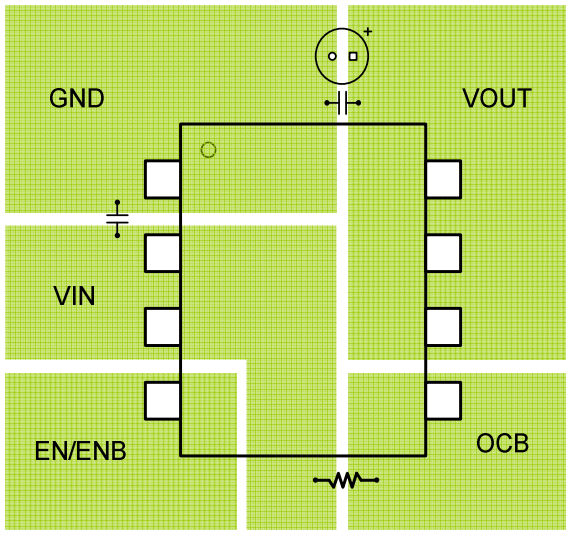
Output Filter Capacitor

Between V_{OUT} and GND, a low-ESR 150uF alumimum electrolytic or tantalum capacitor is strongly recommended to meet the 330mV maximum droop requirement. Standard bypass methods should be used to minimize inductance and resistance between the bypass capacitor and the downsteam connector. This will reduce EMI and improve the transient performance. If long cables are connected to the output terminals, an anti-parallel schottky diode such as BAT54 is suggested to be placed in parallel with the output terminals to absorb the negative ringing due to the cable inductance.

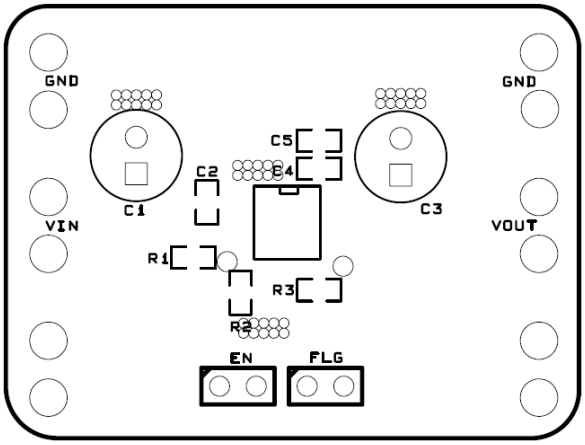
PCB Layout Guide

For best performance of the SY6288 , the following guidelines must be strictly followed:

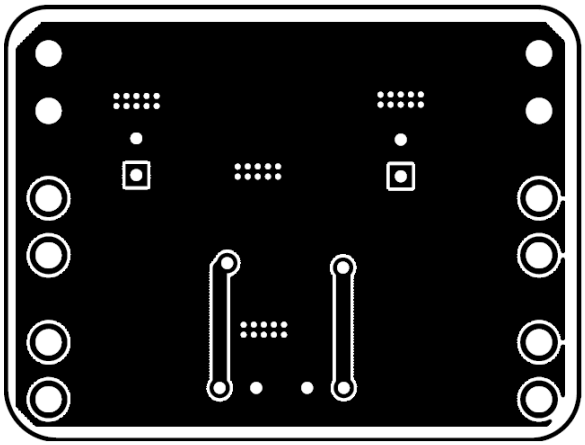
- Keep all V_{BUS} traces as short and wide as possible and use at least 2 ounce copper for all V_{BUS} traces.
- Place a ground plane under all circuitry to lower both resistance and inductance and improve DC and transient performance.
- A low-ESR 150uF aluminum electrolytic or tantalum capacitor between VOUT and GND is strongly recommended.
- Locate the output capacitor as close to the connectors as possible to lower impedance(mainly inductance) between the port and the capacitor and improve transient performance.
- Input and output capacitors should be placed closed to the IC and connected to ground plane to reduce noise coupling.
- Locate the ceramic bypass capacitors as close as possible to the VIN pins and VOUT pins of SY6288.



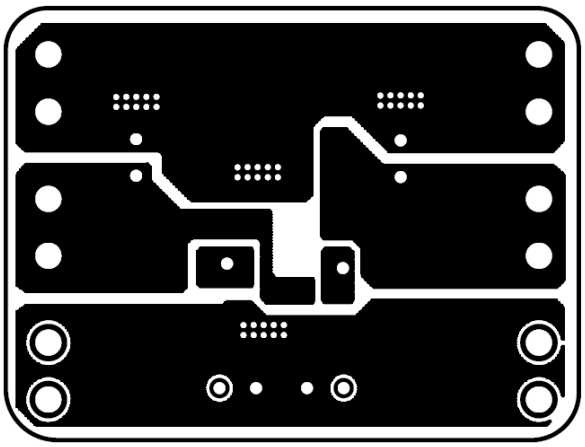
PCB Layout Guide(SO8)



PCB Top Over Layer (SO8)

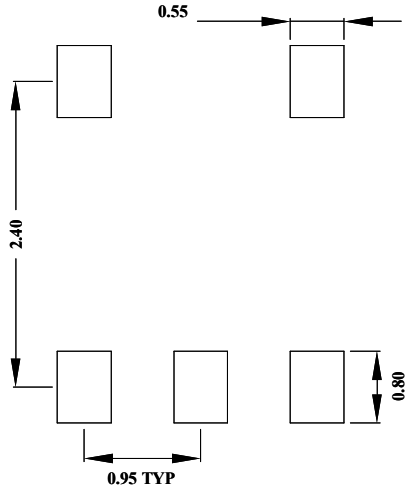


PCB Bottom Layer (SO8)

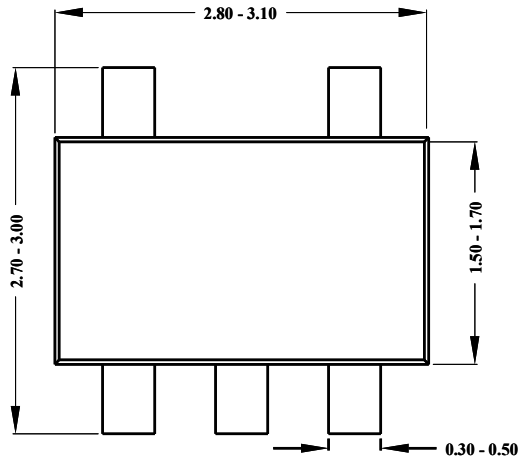


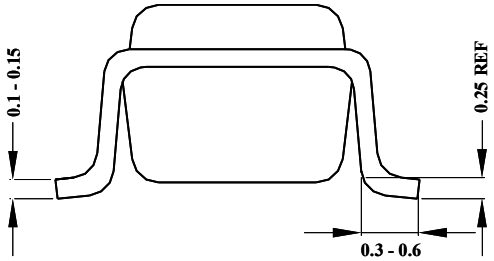
PCB Top Layer (SO8)

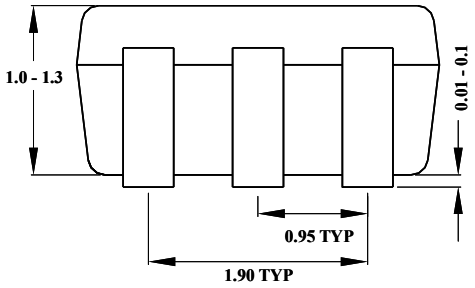
SOT23-5 Package outline & PCB layout design



Recommended Pad Layout

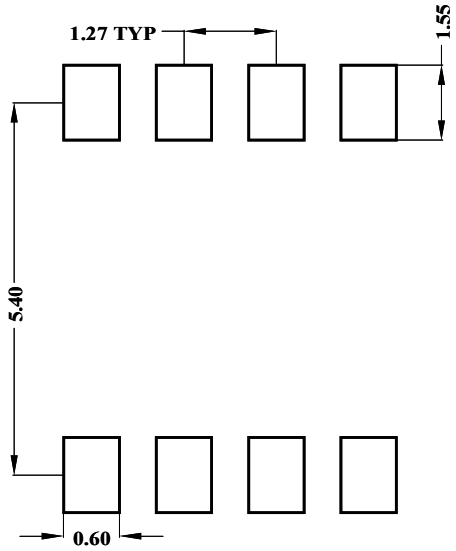




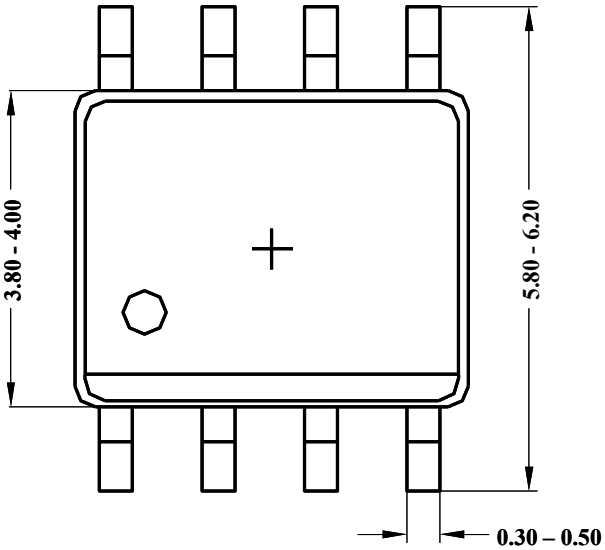


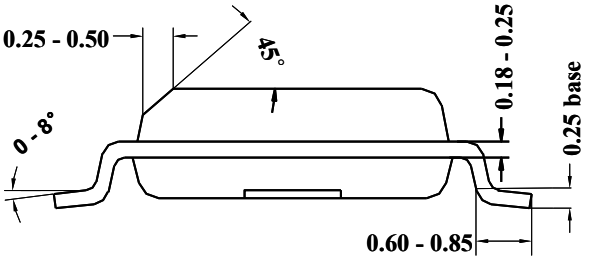
Notes: All dimensions are in millimeters. All dimensions don't include mold flash & metal burr.

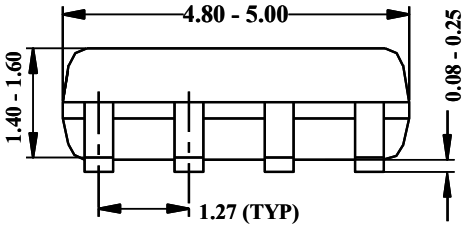
SO8 Package outline & PCB layout design



Recommended Pad Layout

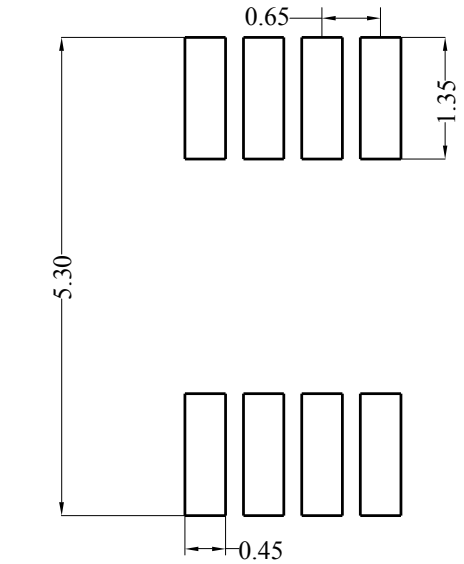




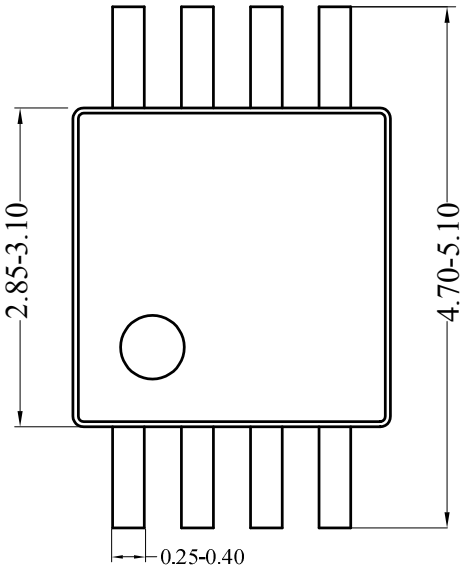


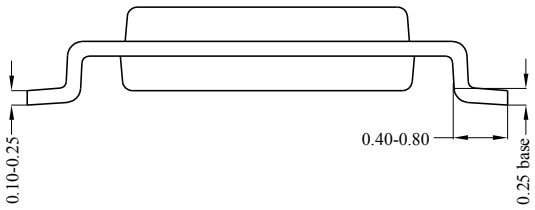
Notes: All dimensions are in millimeters.
All dimensions don't include mold flash & metal burr.

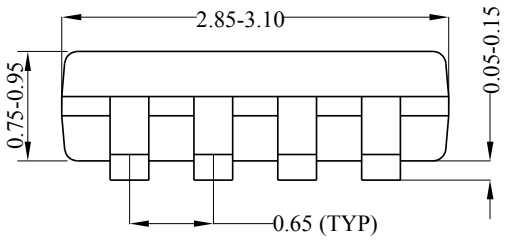
MSOP8 Package outline & PCB layout design



Recommended Pad Layout





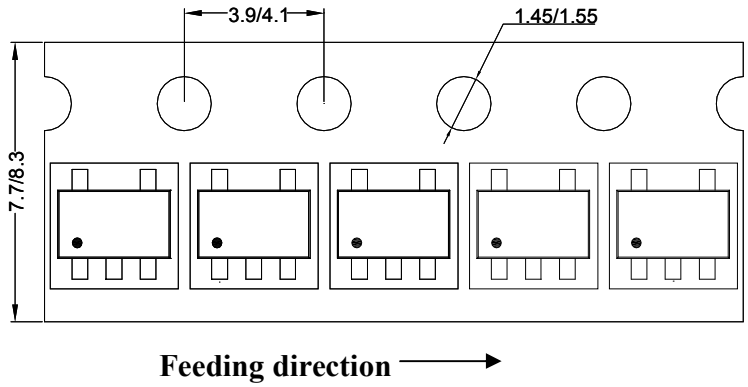


Notes: All dimensions are in millimeters. All dimensions don't include mold flash & metal burr.

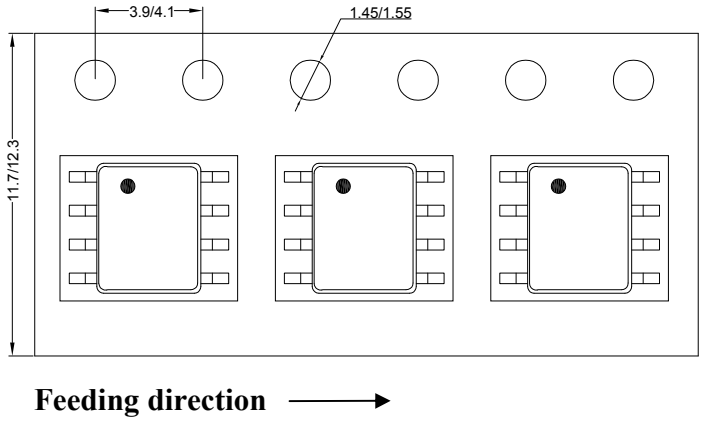
Taping & Reel Specification

1. Taping orientation

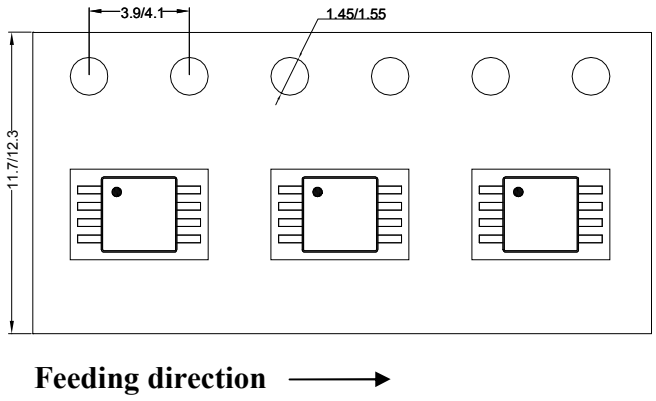
SOT23-5



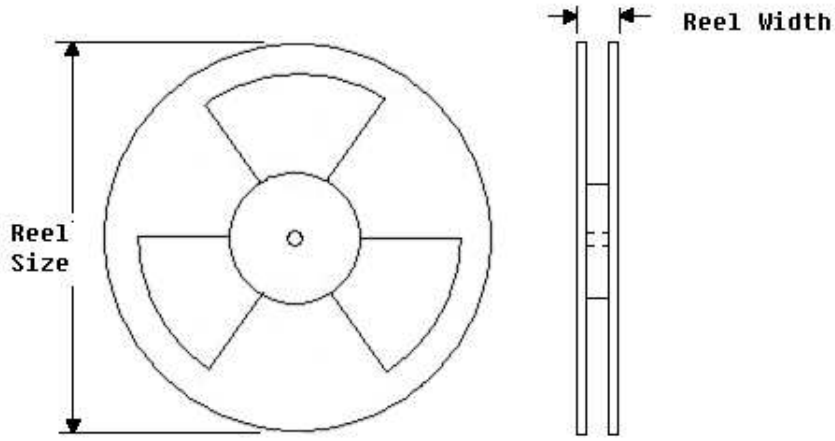
SOP8



MSOP8



2. Carrier Tape & Reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Reel width(mm)	Trailer length(mm)	Leader length (mm)	Qty per reel
SOT23-5	8	4	7"	8.4	280	160	3000
SOP8	12	8	13"	12.4	400	400	2500
MSOP8	12	8	13"	12.4	400	400	3000

3. Others: NA