AP1201

Single-Channel Power Distribution Switch

■ Features

- 100mΩ typical on-resistance
- 2.7V to 5.5V input voltage
- Adjustable current-limit 0.7A to 1.25A (AP1201A/C)
- Fixed current-limit (1.25A) for AP1201B
- Fault flag with internal delay circuit
- 1 μA typical off-state supply current
- 65 μA typical on-state supply current
- Output can be forced higher than input (off-state)
- Thermal shutdown
- 2.4V typical under voltage lockout (UVLO)
- Slow turn-on (soft-start) and fast turn-off
- Enable Active-High or active-Low
- SOT23-5L, SOT23-6L and SOT89-5L packages

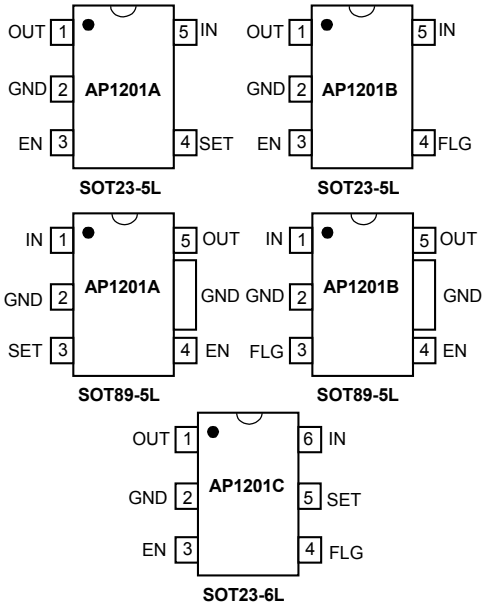
■ Applications

- USB Power Switch
- Battery-charger circuits
- Hot plug-in power supplies

■ General Description

The AP1201 series are integrated high-side power switch with enable, flag functions and adjustable current-limit 0.7A to 1.25A, optimized for self-powered and bus-powered Universal Serial Bus (USB) applications. The AP1201 series support the following USB requirements: each switch channel supplies up to 700mA as required by USB downstream devices; the switch's low on-resistance meets USB voltage drop requirements; fault current is limited to typically 900mA~1.25A; and a flag output is available to indicate fault conditions to the local USB controller. Soft start eliminates the momentary voltage drop on the upstream port that may occur when the switch is enabled in bus-powered applications.
Additional features include thermal shutdown to prevent catastrophic switch failure from high-current loads, under voltage lockout (UVLO) to ensure that the device remains off unless there is a valid input voltage present, and 3.3V and 5V logic compatible enable inputs.

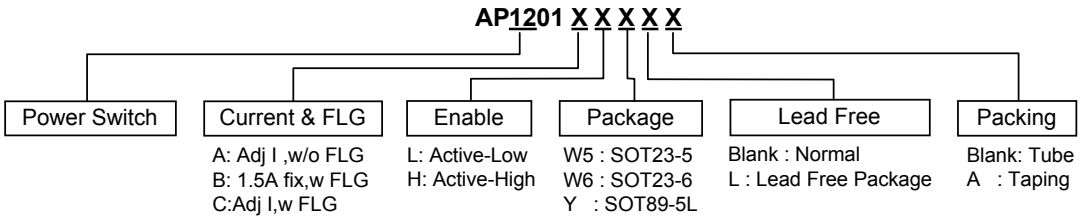
■ Pin Assignments



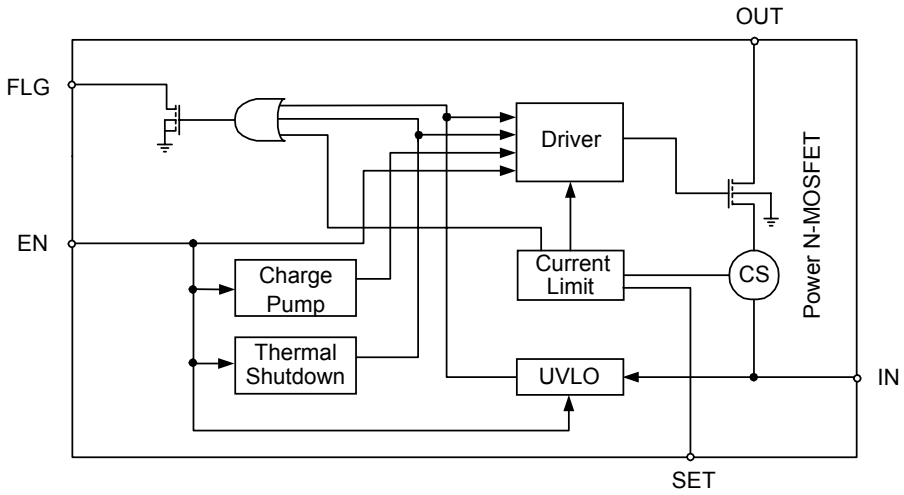
■ Pin Descriptions

Name	Descriptions
EN	Enable: Logic-compatible Enable input. (H: active high, L: active low). Do not float.
FLG	Fault Flag: Active-low, open-drain output. Indicates over current, UVLO, and thermal shutdown.
GND	Ground: Supply return.
IN	Supply Input: Output MOSFET drain. Also supplies IC's internal circuitry. Connect to positive supply.
OUT	Switch Output: Output MOSFET source. Typically connect to switched side of load.
SET	Current limit set input. A resistor pull high to set current-limit value (A, C type only).

■ Ordering Information



■ Block Diagram



■ Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{IN}	Supply Voltage	+7	V
V_{FLG}	Fault Flag Voltage	+7	V
I_{MAX}	Maximum Continuous Current	1.5	A
V_{OUT}	Output Voltage	+7	V
V_{EN}	Control Input	–0.3 to +15	V
T_S	Storage Temperature	-65 to +150	^oC
T_{LEAD}	Lead Temperature	260	^oC
V_{ESD}	ESD (HBM) Rating, (Note 2)	4	KV

■ Operating Ratings (Note 3)

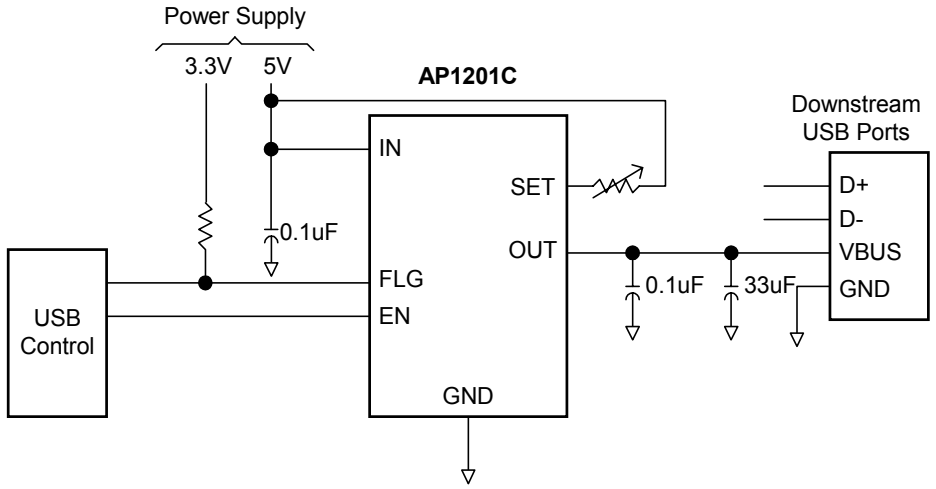
Symbol	Parameter	Rating	Unit
V_{IN}	Supply Voltage	+2.7 to +5.5	V
T_A	Ambient Operating Temperature	-40 to +85	°C
PD	SOT89-5, SOT23-5, SOT23-6	Internal Limited	
Θ_{JC}	SOT89-5	100	°C/W
Θ_{JC}	SOT23-5, SOT23-6	300	°C/W

■ Electrical Characteristics (Under Operating Conditions) V_{in}=+5V;T_A=25°C; unless noted.

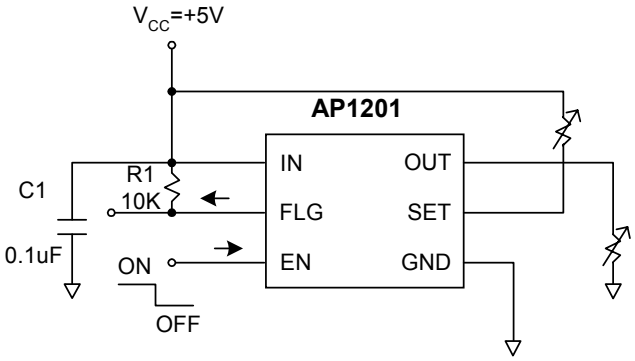
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
I_{CC}	Supply Current	Switch off, OUT = open (Note 4)		0.1	1	μA
		Switch on, OUT = open (Note 4)		65	110	μA
V_{IT}	Enable Input Threshold	low-to-high transition(Note 4)		1.7	2.4	V
		high-to-low transition(Note 4)	0.8	1.4		V
I_{EN}	Enable Input Current	V_{EN} =0V to 5.5V	-1	± 0.01	1	μA
C_{EN}	Enable Input Capacitance			1		pF
$R_{DS(ON)}$	Switch Resistance	V_{IN} =5V, I_{OUT} =500mA		100	120	mΩ
T_{OND}	Output Turn-On Delay	R_L =10Ω		30		μs
T_r	Output Turn-On Rise Time	R_L =10Ω		0.75		ms
T_{OFFD}	Output Turnoff Delay	R_L =10Ω		1	20	μs
T_f	Output Turnoff Fall Time	R_L =10Ω		0.15		μs
I_{LEAK}	Output Leakage Current				10	μA
I_{LIM}	Current-Limit R_{LOAD}=1Ω	AP1201B	1.0	1.25	1.8	A
	Short-circuit Current	AP1201B	--	1.25	--	A
	Adj Current Limit Typical Value	AP1201A/C	0.7	--	1.25	A
T_{TS}	Over-temperature Shutdown Threshold	T_J increasing		140		°C
		T_J decreasing		130		°C
R_{FO}	Error Flag Output Resistance	V_{IN} = 5V, I_L = 10mA		10	25	Ω
		V_{IN} = 3.3V, I_L = 10mA		15	40	Ω
t_D	FLG Output Delay Time		1	2	5	ms
I_{FOH}	Error Flag Off Current	V_{FLAG} = 5V		0.01	1	μA
UVLO	UVLO Threshold	V_{IN} = increasing		2.5		V
		V_{IN} = decreasing		2.3		V

Note 1. Exceeding the absolute maximum rating may damage the device.
Note 2. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF.
Note 3. The device is not guaranteed to function outside its operating rating.
Note 4. Off is $V_{EN} \leqq 0.8$Vand on is $V_{EN} \geqq 2.4$V for the AP1201X-H. Off is $V_{EN} \geqq 2.4$V and on is $V_{EN} \leqq 0.8$V for the AP1201X-L. The enable input has approximately 200mV of hysteresis. See control threshold charts.

■ Typical Application Circuit



■ Test Circuit



■ Function Description

Error Flag
An open-drained output of an N-channel MOSFET, the FLG output is pulled low to signal the following fault conditions: input under-voltage, output current limit, and thermal shutdown.

Current Limit
The current limit is set externally. It protects the output MOSFET switches from damage due to undesirable short circuit conditions or excess inrush current often encountered during hot plug-in. The low limit of the current limit threshold of the AP1201 allows a minimum current of 0.9A through the MOSFET switches. A current limit condition will signal the error flag. A resistor from SET to VIN sets the current-Limit value.

$I_{LIM(MAX)}$ ~ 1.4X $I_{LIM(TYP)}$
$I_{LIM(MIN)}$ ~ 0.8X $I_{LIM(TYP)}$

AP1201 Rset		
R_{SET} (Ω)	Current Limit Threshold (A) Typical value	
	(Vout = 5V)	(Vout = 3.3V)
10K	0.71	0.69
20K	0.92	0.90
30K	1.01	1.00
40K	1.05	1.02
60K	1.10	1.08
80K	1.15	1.11
100K	1.19	1.16
200K	1.22	1.20
floating	1.25	1.23

Thermal Shutdown
When the chip temperature exceeds 140ºC for any reason, the thermal shutdown function enables and turns off MOSFET's switch and signals the error flag. A hysteresis of 10ºC prevents the MOSFETs from turning back on until the chip temperature drops to below 130ºC.

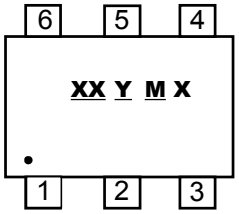
Supply Filtering
A 0.1µF to 1µF bypass capacitor from IN to GND, located near the device, is strongly recommended to control supply transients. Without a bypass capacitor, an output short may cause sufficient ringing on the input (from supply lead inductance) to damage internal control circuitry.

Transient Droop Requirements
USB supports dynamic attachment (hot plug-in) of peripherals. A current surge is caused by the input capacitance of downstream device. Ferrite beads are recommended in series with all power and ground connector pins. Ferrite beads reduce EMI and limit the inrush current during hot-attachment by filtering high-frequency signals.

Short Circuit Transient
Bulk capacitance provides the short-term transient current needed during a hot-attachment event. With a 33µF, 16V tantalum or 100µF, 10V electrolytic capacitor mounted close to downstream connector per port should provide transient drop protection.

Printed Circuit Layout
The power circuitry of USB printed circuit boards requires a customized layout to maximize thermal dissipation and to minimize voltage drop and EMI.

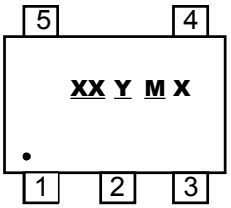
■ Marking Information



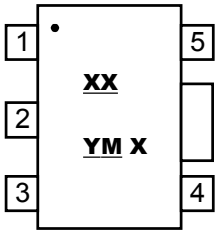
SOT23-6L

XX : Identification code
(See Appendix)
Y : Year: 0-9
M : Month: A~L

X : Blank : normal
L : Lead Free Package



SOT23-5L



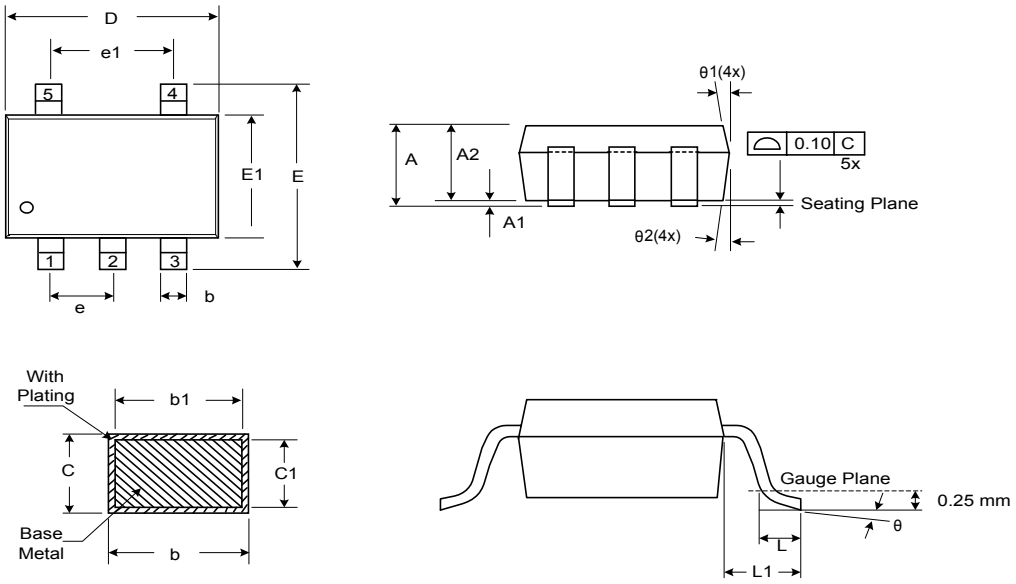
SOT89-5L

Appendix

Part Number	Package	Identification Code
AP1201AL	SOT23-5/SOT89-5	FL
AP1201CL	SOT23-6	FL
AP1201AH	SOT23-5/SOT89-5	FH
AP1201CH	SOT23-6	FH
AP1201BL	SOT23-5/SOT89-5	F1
AP1201BH	SOT23-5/SOT89-5	F2

■ Package Information

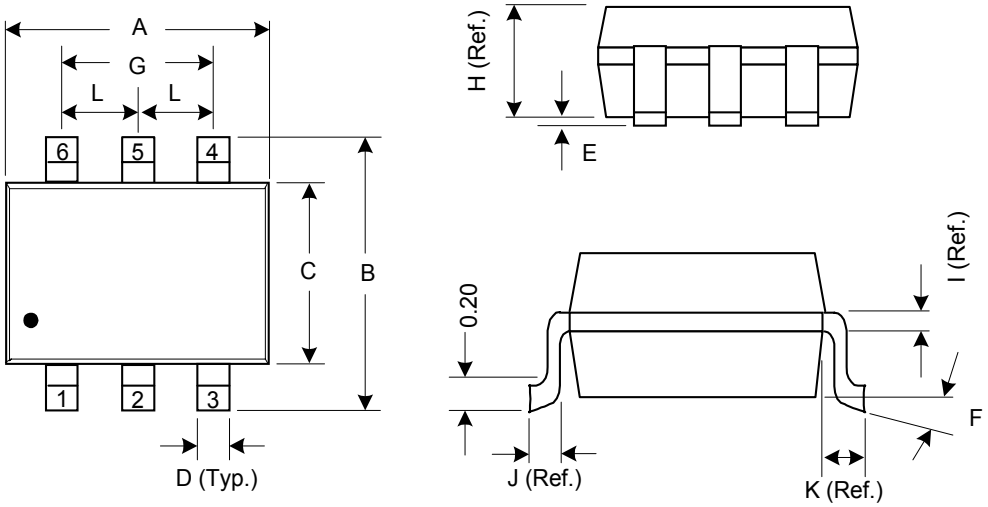
(1) Package Type: SOT23-5L



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.05	1.20	1.35	0.041	0.047	0.053
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	1.00	1.10	1.20	0.039	0.043	0.047
b	0.25	-	0.55	0.010	-	0.022
b1	0.25	0.40	0.45	0.010	0.016	0.018
c	0.08	-	0.20	0.003	-	0.008
c1	0.08	0.11	0.15	0.003	0.004	0.006
D	2.70	2.85	3.00	0.106	0.112	0.118
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
L	0.35	0.45	0.55	0.014	0.018	0.022
L1	0.60 Ref.			0.024 Ref.		
e	0.95 Bsc.			0.037 Bsc.		
e1	1.90 Bsc.			0.075 Bsc.		
θ	0^o	5^o	10^o	0^o	5^o	10^o
θ 1	3^o	5^o	7^o	3^o	5^o	7^o
θ 2	6^o	8^o	10^o	6^o	8^o	10^o

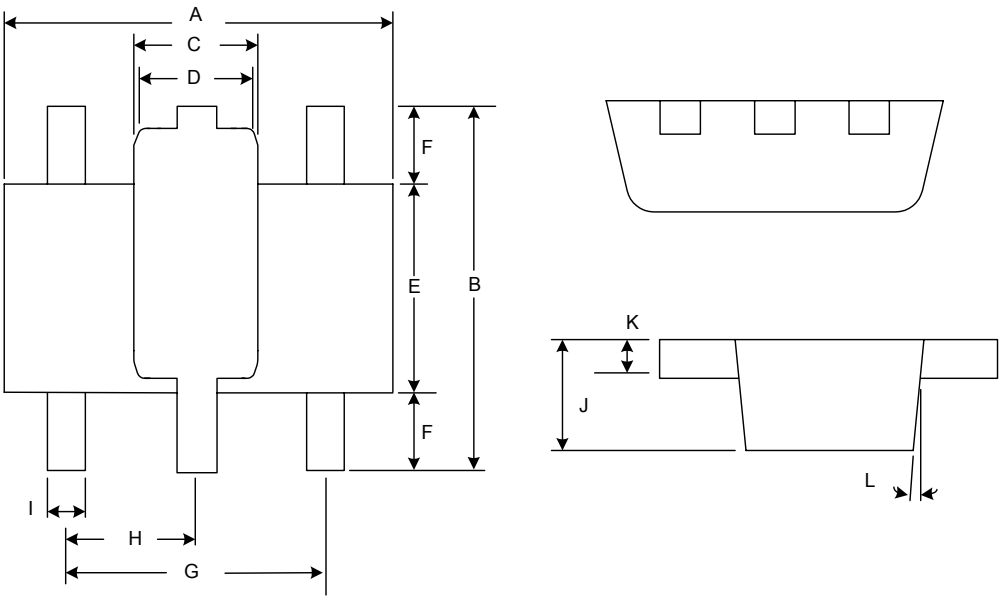
■ Package Information (Continued)

(2) Package Type: SOT23-6L



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	2.70	2.90	3.10	0.106	0.114	0.122
B	2.60	2.80	3.00	0.102	0.110	0.118
C	1.40	1.60	1.80	0.055	0.063	0.071
D	0.30	0.43	0.55	0.012	0.017	0.022
E	0	0.05	0.10	0.000	0.002	0.004
F	0^o	-	10^o	0^o	-	10^o
G	1.90 Ref.			0.075 Ref.		
H	1.20 Ref.			0.047 Ref.		
I	0.12 Ref.			0.005 Ref.		
J	0.37 Ref.			0.015 Ref.		
K	0.60 Ref.			0.024 Ref.		
L	0.95 Ref.			0.037 Ref.		

(3) Package Type: SOT89-5L



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	4.40	4.50	4.60	0.173	0.177	0.181
B	4.05	4.15	4.25	0.159	0.163	0.167
C	1.50	1.60	1.70	0.059	0.063	0.067
D	1.30	1.40	1.50	0.051	0.055	0.059
E	2.40	2.50	2.60	0.094	0.098	0.102
F	0.80	-	-	0.031	-	-
G	3.00 Ref.			0.118 Ref.		
H	1.50 Ref.			0.059 Ref.		
I	0.40	0.46	0.52	0.016	0.018	0.020
J	1.40	1.50	1.60	0.055	0.059	0.063
K	0.35	0.39	0.43	0.014	0.015	0.017
L	5^{o} Typ.			5^{o} Typ.		