3.3A Charger Interface, Wide Input CC/CV Buck Converter for QC2.0/QC3.0/PE+2.0 And FCP

General Description

The AT8805 is a high-efficiency synchronous-rectified buck converter with an internal power switch. With internal low RDS(ON) switches, the high-efficiency buck converter is capable of delivering up to 3.3A output current for charger interface and a wide input voltage range from 8V to 32V. It operates in either CV (Constant Output Voltage) mode or CC (Constant Output Current) mode and provides a current limitation function. The AT8805 has a constant output voltage 5.2V/9V/12V for Qualcomm® Quick Charge™ 3.0/2.0(QC2.0/QC3.0) that is detected from D+ and D- line and automatically detects whether a connected Powered Device (PD) is Quick Charge (QC2.0/QC3.0) capable before enabling output voltage adjustment. If a PD not compliant to Quick Charge (QC2.0/QC3.0) is detected, the AT8805 disables output voltage adjustment to ensure safe operation with legacy 5.2V only USB PDs.

AT8805 is a USB secondary side fast-charging converter, supporting Qualcomm® Quick Charge™ 3.0 (QC 3.0) High Voltage Dedicated Charging Port (HVDCP) Class A specification.

AT8805 allows for selection of the output voltage of an AC/DC USB adapter based on commands from the Portable Device (PD) being powered. Selecting a higher charging voltage will reduce the charging current for a given power level resulting in reduced IR drops and increased system efficiency. Another advantage of QC3.0 is a decreased battery charging time and a reduced PD system cost thanks to the ability to select an optimum charging voltage. This eliminates the need for costly DC/DC converters within the PD. The USB-bus voltage can be controlled in discreet steps from 3.6 V up to 12.1V. The output current is limited not to exceed maximum allowable power level.

Other features for the buck converter include internal soft-start, adjustable external CC (Constant Output Current) limit setting, built-in fixed line-compensation, short circuit protection, VIN/VOUT over voltage protection, and over temperature protection. It is available in space saving VDFN6x5-8L and VDFN5x6-10L packages.

Features

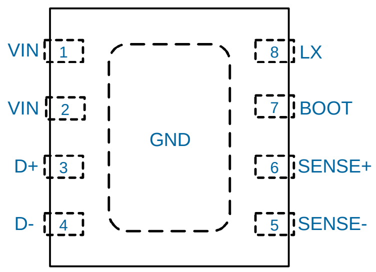
- □ **Wide Input Voltage Range from 8V to 32V , Absolute Maximum Rating 36V**
- □ **Up to 3.3A Output Current**
- □ **CV/CC Mode Control (Constant Voltage and Constant Current)**
- □ **Automatic Selection of D+/D- Mode for an Attached Device**
  - ■ **D+/D- Divider Mode 2.7V and 2.7V**
  - ■ **D+/D- 1.2V Mode**
  - ■ **D+/D- Shorted Mode (BC 1.2)**
- □ **Internal QC2.0/QC3.0/PE+1.1/PE+2.0/FCP Protocol and USB Type C**

- Wide Output Voltage Range: 3.6V to 12.1V
- Output Voltage Accuracy➔ ±1.5%
- Fixed 125kHz Frequency Operation
- Up to 95% Conversion Efficiency
- Fixed Cable Compensation Voltage
- Adjustable External CC (Constant Output Current) Limit Setting➔ 39mΩ = 3.3A
- CC (Constant Output Current) Limit Accurarcy➔ ±3%
- VIN/VOUT Over Voltage Protection , Over Temperature Protections , Short Circuit Protection
- VDFN6x5-8L and VDFN5x6-10L Packages
- RoHS Compliant and Halogen Free

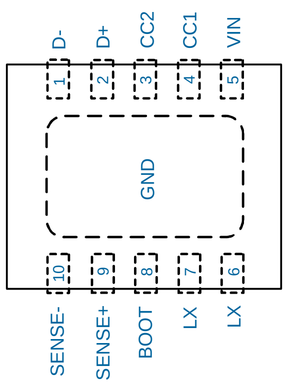
Applications

- Adaptor and Battery Charger
- Rechargeable Portable Devices
- Car Charger

Pin Configuration



VDFN6x5-8L



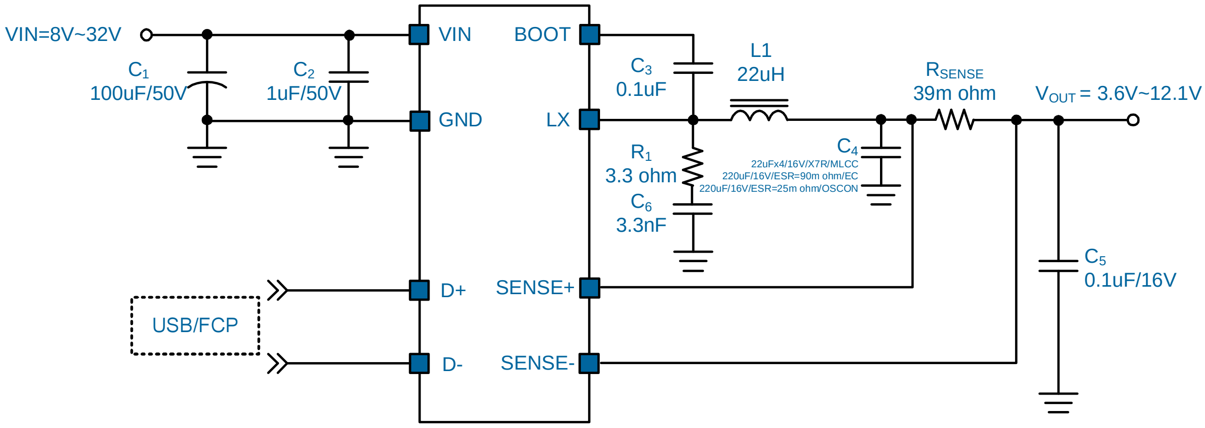
VDFN5x6-10L

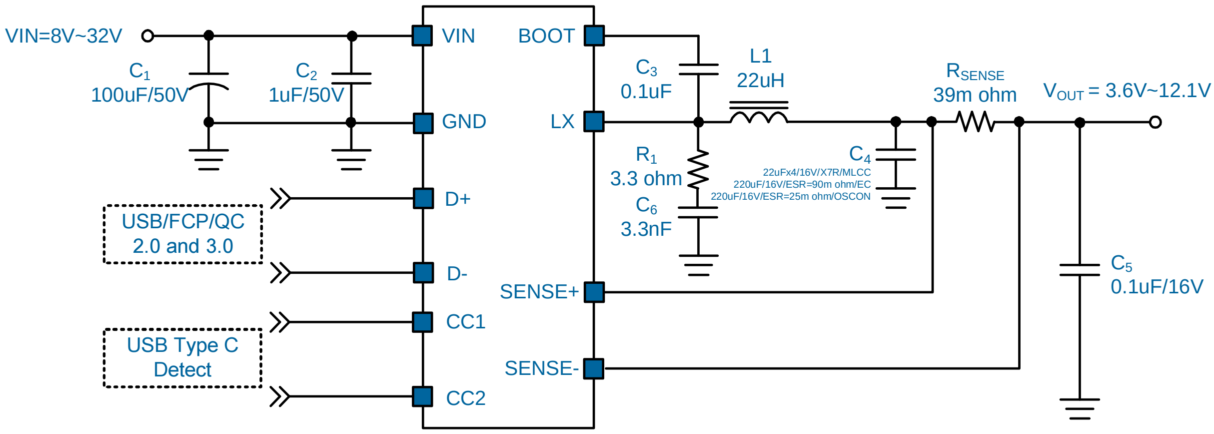
Ordering and Marking Information

Order Number	Package Type	Top Marking
AT8805ZDF8	VDFN6x5-8L	AT8805ZDF8
AT8805ZDFA	VDFN5x6-10L	AT8805ZDFA

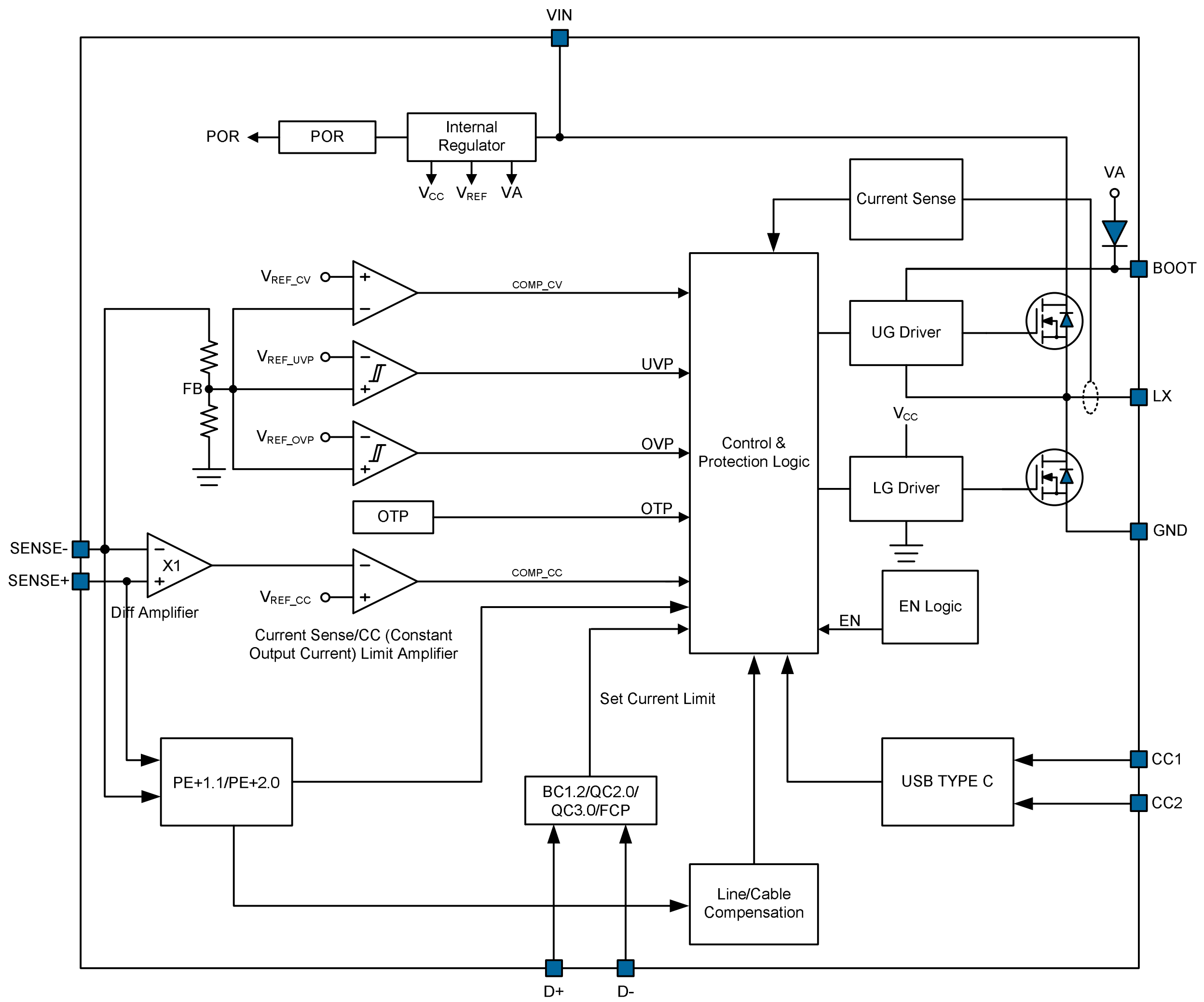
Note: Aplustek products are compatible with the current IPC/JEDEC J-STD-020 requirement. They are halogen-free, RoHS compliant and 100% matte tin (Sn) plating that are suitable for use in SnPb or Pb-free soldering processes.

Typical Application Circuit





Function Blocks



Function Pin Description

Pin No		Pin Name	Pin Function
8pin	10pin		
1,2	5	VIN	**Power Supply Input.** Input voltage that supplies current to the output voltage and powers the internal control circuit. Bypass the input voltage with a minimum 1uFx1 X5R or X7R ceramic capacitor.
---	4	CC1	**USB Type C Port CC1 Input Connection.** CC1 Voltage On Source Side.
---	3	CC2	**USB Type C Port CC2 Input Connection.** CC2 Voltage On Source Side.
3	2	D+	**USB Port D+ Input Connection.** USB D+ data line input.

4	1	D-	**USB Port D- Input Connection.** USB D- data line input.
5	10	SENSE-	**The Current Sense Input (-) Pin.** Adjustable line and cable compensation voltage.
6	9	SENSE+	**The Current Sense Input (+) Pin.** Adjustable line and cable compensation voltage.
7	8	BOOT	**Bootstrap Supply for the Floating Upper Gate Driver.** Connect the bootstrap capacitor C BOOT between BOOT pin and the LX pin to form a bootstrap circuit. The bootstrap capacitor provides the charge to turn on the upper MOSFET. Typical value for C BOOT is 0.1uF or greater. Ensure that C BOOT is placed near the IC.
8	6,7	LX	**Internal Switches Output.** Connect this pin to the output inductor.
E-pad	E-pad	GND	**Ground.** Ground of the buck converter. The exposed pad is the main path for heat convection and should be well-soldered to the PCB for best thermal performance.

Absolute Maximum Ratings

(Note1)

Supply Input Voltage, VIN ---------- -0.3V to +36V

LX Voltage to GND ---------- -0.3V to + (VIN + -0.3V)

D+/D-/CC1/CC2 Pin Voltage ---------- -0.3V to +6.0V

SENSE+/SENSE- Pin Voltage ---------- -0.3V to +14V

Storage Temperature Range ---------- -65^{o}C to +150^{o}C

Junction Temperature ---------- 150^{o}C

Lead Temperature (Soldering, 10 sec) ---------- 260^{o}C

ESD Rating (Note 2)

D+/D-/Sense- Pin

- HBM (Human Body Mode) ---------- 4kV
- MM (Machine Mode) ---------- 400V

Other Pins

- HBM (Human Body Mode) ---------- 2kV
- MM (Machine Mode) ---------- 200V

Thermal Characteristics

Package Thermal Resistance (Note 3)

VDFN6x5 - 8L θ_{JA}	45°C/W
VDFN6x5 - 8L θ_{JC}	4°C/W
VDFN5x6 - 10L θ_{JA}	45°C/W
VDFN5x6 - 10L θ_{JC}	4°C/W

Power Dissipation, P_D @ T_A = 25°C

VDFN6x5 - 8L	2.2W
VDFN5x6 - 10L	2.2W

Recommended Operation Conditions

(Note 4)

Operating Junction Temperature Range	-40°C to +125°C
Operating Ambient Temperature Range	-40°C to +85°C
Supply Input Voltage, V_{IN}	+8V to 32V

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. Devices are ESD sensitive. Handling precaution recommended.

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

Note 4. The device is not guaranteed to function outside its operating conditions.

Electrical Characteristics

(V_{CC} = 12V, T_A = +25^{o}C unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Supply Input Section						
Input operation range	Vin		8	--	32	V
Vin UVLO threshold	Vin,on	Vin Rising	--	7.5	--	V
	Vin,off	Vin Falling		7		V
Over Voltage Protection Voltage	Vin,ovp	Vin ,ovp Rising	32.8	--	--	V
		Vin,ovp Falling	32.3	--	--	V
Normal Operation Current	Iop	No switching	--	1	1.5	mA
Standby current	Isb	Type C detection	--	--	150	uA
Power Switches Section						
Hi-Side Switch On Resistance	RDS(ON)		--	80	--	mohm
Low-Side Switch On Resistance	RDS(ON)		--	50	--	mohm
Oscillation Frequency	Fosc		--	125	--	kHz
Maximum Duty Cycle	DMAX		96	98	99	%
Output Voltage and Soft Start						
Output Voltage Accuracy	△Vout	Vin = 12V, Vout = 5.2V, only for C2.0/QC3.0/FCP	-1.5	--	+1.5	%
		Vin = 12V, Vout = 9V, only for QC2.0/QC3.0	-1.5	--	+1.5	%
		Vin = 12V, Vout = 9.2V, only for FCP	-1.5	--	+1.5	%
		Vin = 24V, Vout = 12V, only for QC2.0/QC3.0	-1.5	--	+1.5	%
		Vin = 24V, Vout = 12.1V, only for FCP	-1.5	--	+1.5	%
Soft Start Time	Tss		--	10	--	mS
Current Sense Amplifier						
Voltage Difference Between SENSE+ and SENSE- at CC Mode Operation	△Vsen	Vout = 5.2V	127	130	133	mV
Output Cable Resistance Compensation						
Fixed Line Compensation		VOUT = 5.2V, IO = 2.5A measured at VSENSE	110	150	190	mV

Electrical Characteristics

(V_{CC} = 12V, T_A = +25°C unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Protection Section						
CC (Constant Output Current) Limit		RSENSE = 39mW, VOUT = 5.2V	3.25	3.33	3.41	A
Output Voltage needs to collapse threshold		Into CC (Constant Output Current) Limit. Only for QC2.0/3.0 and MTK	2.85	3.10	3.35	V
Output Over Voltage Protection		measured at VSENSE-	--	10	--	%
Output Under Voltage Protection		Vout = 9.2V, only for FCP	--	6.7	--	Mohm
		Vout = 12.1V, only for FCP	--	10	--	Mohm
Thermal Shutdown Temprature	TSD		--	150	--	℃
Thermal Shutdown Hysteresis	TSDHYS		--	20	--	℃
High Voltage Dedicated Charging Port (D+/D-)						
Data Detect Voltage	VDAT_REF		0.25	0.35	0.4	V
Output Voltagte Selection Reference	VSEL_REF	2.0V Reference for Selection HVDCP Voltage	1.8	2	2.2	V
Current Limit for HVDCP at Any Output Voltage	IHVDCP_MIN	All HVDCP's must output this current at minimum	500	--	--	mA
D- Low Glitch Filter Time	TGLITCHP_DM_LOW	After D+/- A are open and Rdm_dwn is asserted, how long should HVDCP expect D- to stay low before being pulled high.	1			mS
D- High Glitch Filter Time	TGLITCHP_DM_HIGH	After D+/- A are open and Rdm_dwn is asserted, how long after a portable device sees D- go low, before it makes first voltage request and pulls D-high.	40			mS
D+ High Glitch Filter Time	TGLITCHP_BC_Done	After BC1.2 Detection is complete, HVDCP	1		1.5	S
Output Voltage Glitch Filter Time	TGLITCHP_V_CHANGE	Glitch filter after D+/- toggle before HVDCP attempts to change output voltage	20	40	60	mS

Unplug Vbus Discharge	TV_UNPLUG	Time for Vbus to discharge to 5.2V in HVDCP on unplug	--	--	500	mS
D+/D- HVDCP Short Time	TD+_D-_SHORT	Time for D+/D- to short on HVDCP	--	10	20	mS
D+D- Capacitance	CDCP_PWR	Equivalent capacitance on D+ and D- to GND	--	--	1	nF
Data Line Leakage	RDAT_LKG		300	--	1500	kohm
D- Pull Down Resistance	RD-_DWN		12	15	18	kohm
BC 1.2 DCP Mode (Short Mode)						
D+ to D- Resistance During DCP Mode	RDCP_DAT		--	20	40	ohm
D+ Output Voltage	VDP_1.2V+	Vin= 12V	1.12	1.2	1.28	V
D- Output Voltage	VDM_1.2V+	Vin= 12V	1.12	1.2	1.28	V
D+ Output Impedance	RDP_1.2V	ID+ = -5uA	80	102	İ30	kohm
D- Output Impedance	RDM_1.2V	ID- = -5uA	80	102	İ30	kohm
Divider Mode (2.7V/2.7V)						
D+ Output Voltage	VD+_2.7V	Vin= 12V	2.57	2.7	2.84	V
D- Output Voltage	VD-_2.7V	Vin= 12V	2.57	2.7	2.84	V
D+ Output Impedance	RD+_2.7V	ID+ = -5uA	--	36	--	kohm
D- Output Impedance	RD-_2.7V	ID- = -5uA	--	36	--	kohm

Function Descriptions

CV/CC Mode Control

The AT8805 provides CV/CC function. It operates in either CV (Constant Output Voltage) mode or CC (Constant Output Current) mode. The function provides a current limitation function and adjusts external current limit setting (Default=3.3A). In the CV mode, the output voltage is controlled within $\pm$1.5%. In the CC mode, the output current variation is less than $\pm$3% of the nominal value which can be set up to 3.3A by the current sensing resistor.
When Output current increase until it reaches the CC limit set by the R_{SENSE} resistor. At this point, the device will transition from regulating output voltage to regulating output current, and the output voltage will drop with increasing load.

The CC (Constant Output Current) limit is set at 3.3A by default with an external resistance R_{SENSE} = 39mΩ, When the (SENSE1+) - (SENSE1-) voltage gets higher than 130mV and reaches the current limit, the driver is turned off. The CC (Constant Output Current) limit is set according to the following equation:

CC (Constant Output Current) Limit

Output Cable Resistance Compensation

In charger applications, the large load will cause voltage drop in the output cable. The AT8805 has a built-in cable compensation function. When the load increases, the cable compensator will increase an adjustable regulation of the error amplifier that can make the output voltage constant. Use the curve and table to adjust internal the reference voltage values for fixed USB cable compensation by outside resistance R_{SENSE} = 39mΩ (default), as shown in Figure 1 and Table 1.The fixed cable compensation is calculated as follows:

$$V_{COMP} = I_{LOAD} \times R_{COMP}$$

R_{COMP}(mΩ)	60
I_{LOAD}(mA)	Fixed USB Cable Compensation Voltage (mV)
0	0
500	0
1000	60
1500	90
2000	120
2500	150
3000	180

Table 1 USB Cable Compensation Application Table

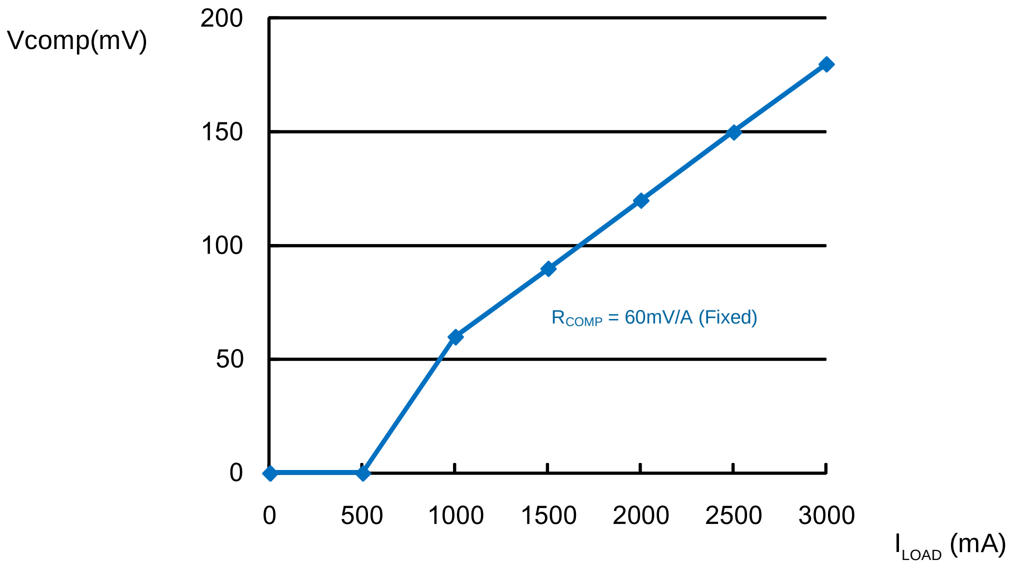


Figure 1 USB Cable Compensation at a Fixed Resistor Divider Value

Current Limit Protection

The AT8805 continuously monitors the inductor current, when the inductor current is higher than current limit threshold, the current limit function activates and forces the upper switch turning off to limit inductor current cycle by cycle.

Output Short Circuit Protection

The AT8805 provides output short circuit protection function. Once the output loader short-circuits, the SCP will be triggered then always hiccup, the hiccup cycle time is set by an internal counter. When the SCP condition is removed or disappears, the converter will resume normal operation and the hiccup status will terminate.

Output Over Voltage Protection

The AT8805 provides output over voltage protection. Once the output voltage (measured the at SENSE- pin) gets higher than OVP threshold, the OVP will be triggered to shut down the converter. When the OVP condition disappears, the converter will resume normal operation and resume the normal state automatically.

Over Temperature Protection

The OTP is triggered and shuts down the uP9616 if the junction temperature is higher than 150°C The OTP is a Non-latch type protection. The uP9616 automatically initiates another soft start cycle if the junction temperature drops below 130°C.

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High Voltage Dedicated Charging Port (HVDCP) Mode

After power-up pins D+ and D- of AT8805 are shorted with impedance R_{DCP_DAT} and internal reference voltage V_{REF} is set to V_{BUS} voltage 5.2V. The device is in a BC1.2 compatible mode. If a portable device compatible with the Qualcomm Quick Charge specification is connected, a negotiation between HVDCP and PD is executed. Once the negotiation is successful the AT8805 opens D+ and D- short connection and D- is pulled down with a R_{DM_DWN}. The AT8805 enters HVDCP mode. It monitors D+ and D- inputs. Based on the specified control patterns, the internal voltage reference value V_{REF} is adjusted in order to increase or decrease output voltage to the required value.

The AT8805 is available in Class A version. Class A allows to change the output voltage up to VBUS = 12V. If the unplug event is detected the decoder circuitry turns-on an internal current sink, which discharges the output capacitors to a safe voltage level. If the AT8805 is set to a Continuous mode it responds to the PD requests in a Single request mode. It does not support Group request mode.

HVDCP Continuous Mode

The continuous mode of operation leverages the previously unused state in QC2.0. If the portable devices try and utilize this mode, it applies voltages on D+ and D- per Table 2. Assuming the HVDCP supports this mode of operation, it will glitch filter the request as it currently does, using TGLITCH_V_CHANGE(40ms). Before the portable device can begin to increment or decrement the voltage, it must wait TV_NEW_REQUEST_CONT before pulling D+ and D- high or low. Once this time has finished, the portable device now attempts to increment or decrement the voltage. To increment, the portable device sends a pulse of width TACTIVE by pulling D+ to VDP_UP and then must return D+ to VDP_SRC for TINACTIVE.

Portable Device		HVDCP Class A
D+	D-	Output Voltage
0.6V	GND	5.2V
3.3V	0.6V	9V
0.6V	0.6V	12V
0.6V	3.3V	Continuous Mode
3.3	3.3	Previous Voltage

Table2. HVDCP detection voltage coding and status

Note: GND is not forced by the portable device. The portable device shall go High-Z and the HVDCP pulls D- low through Rdm_dwn. This is to prevent misdetection when current flowing through GND causes the GND in the portable device to be at a higher voltage relative to HVDCP GND. Care should be taken in the portable device as this can result in a negative relative voltage on D- as seen by the portable device.

Application Information

Output Inductor Selection

Output inductor selection is usually based on the considerations of inductance, rated current value, size requirements and DC resistance (DCR).

The inductance is chosen based on the desired ripple current. Large value inductors result in lower ripple currents and small value inductors result in higher ripple currents. Higher V_{IN} or V_{OUT} also increases the ripple current as shown in the equation below. A reasonable starting point for setting ripple current is ΔI_L = 900mA (30% of 3000mA).

Maximum current ratings of the inductor are generally specified in two methods: permissible DC current and saturation current. Permissible DC current is the allowable DC current that causes 40ºC temperature raise. The saturation current is the allowable current that causes 10% inductance loss. Make sure that the inductor will not saturate over the operation conditions including temperature range, input voltage range, and maximum output current. If possible, choose an inductor with rated current higher than 5A so that it will not saturate even under current limit condition.

The size requirements refer to the area and height requirement for a particular design. For better efficiency, choose a low DC resistance inductor. DCR is usually inversely proportional to size.

Different core materials and shapes will change the size, current and price/current relationship of an inductor. Toroid or shielded pot cores in Ferrite or Permalloy materials are small and don't radiate much energy, but generally cost more than powdered iron core inductors with similar electrical characteristics. The choice of which style inductor to use often depends on the price vs. size requirements and any radiated field/EMI requirements.

Input Capacitor Selection

The input capacitor needs to be carefully selected to maintain sufficiently low ripple at the supply input of the converter. A low ESR capacitor is highly recommended. Since large current flows in and out of this capacitor during switching, its ESR also affects efficiency.

The input capacitance needs to be higher than 22uF. The best choice is the ceramic type and low ESR electrolytic types may also be used provided that the RMS ripple current rating is higher than 50% of the output current. In the case of the electrolytic types, they can be further away if a small parallel 1uF ceramic capacitor is placed right close to the IC. A 100uF elecrolytic capacitor and 1uF ceramic capacitor are recommended and placed close to VIN and GND pins, with the shortest traces possible.

Output Capacitor Selection

The ESR of the output capacitor determines the output ripple voltage and the initial voltage drop following a high slew rate load transient edge. The output ripple voltage can be calculated as:

$$\Delta V_{OUT} = \Delta I_C \times (ESR + \frac{1}{8 \times f_{OSC} \times C_{OUT}})$$

Where f_{osc} = operating frequency, C_{OUT} = output capacitance and ΔI_C = ΔI_L = ripple current in the inductor. The ceramic capacitor with low ESR value provides the low output ripple and low size profile.

In the case of electrolytic capacitors, the ripple is dominated by R_{ESR} multiplied by the ripple current. Connect a 220uF electrolytic capacitor at output SENSE+ terminal for good performance and low output ripple and place output capacitors as close as possible to the device.

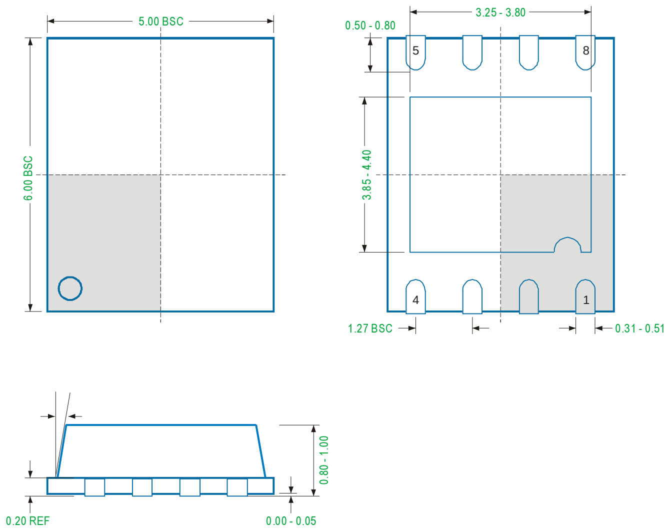
In the case of ceramic output capacitors, R_{ESR} is very small and does not contribute to the output ripple. Connect a 0.1uF ceramic capacitor at output SENSE- terminal for good performance and place output capacitors as close as possible to the device.

PCB Layout Consideration

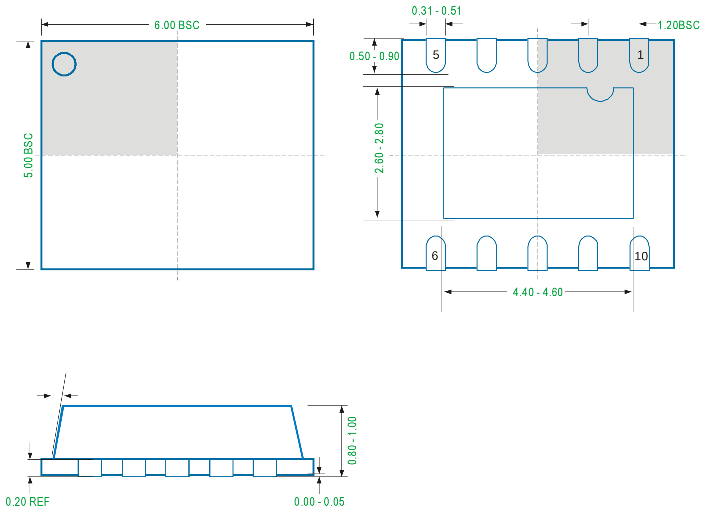
The PCB layout is an important step to maintain the high performance of the AT8805. High switching frequencies and relatively large peak currents make the PCB layout a very important part of all high frequency switching power supply design. Both the high current and the fast switching nodes demand full attention to the PCB layout to save the robustness of the AT8805 through the PCB layout. Improper layout might show the symptoms of poor load or line regulation, radiate excessive noise at ground or input, output voltage shifts, stability issues, unsatisfying EMI behavior or worsened efficiency. Follow the PCB layout guidelines for optional performances of AT8805.

Package Information

VDFN6x5 - 8L



VDFN5x6 - 10L



Note

1.Package Outline Unit Description:

BSC: Basic. Represents theoretical exact dimension or dimension target

MIN: Minimum dimension specified.

MAX: Maximum dimension specified.

REF: Reference. Represents dimension for reference use only. This value is not a device specification.

TYP. Typical. Provided as a general value. This value is not a device specification.

2.Dimensions in Millimeters.

3.Drawing not to scale.

4.These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.