Description

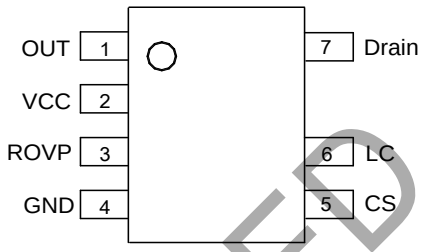
The AL1678-20B/10B/08B is a universal AC input (85 to 277 V_{AC}), high efficiency and high accuracy Buck LED driver. The AL1678-20B/10B/08B topology provides accurate constant current over line and load regulation with tight tolerance ±3%, operating at boundary conduction mode (BCM) to ease in EMI/EMC qualification and testing to meet the latest regulatory laws.

The AL1678-20B/10B/08B single buck stage system works with a single winding inductor and high voltage MOSFET included, therefore, can use fewer external components and create a low bill of material (BOM) cost solution. The AL1678-20B/10B/08B has rich protection features to enhance the system safety and reliability. It has thermal fold back function, which can reduce the output current when the driver's temperature is higher than the setting value.

The AL1678-20B/10B/08B is available in SO-7 package.

Pin Assignments

(Top View)



SO-7

Features

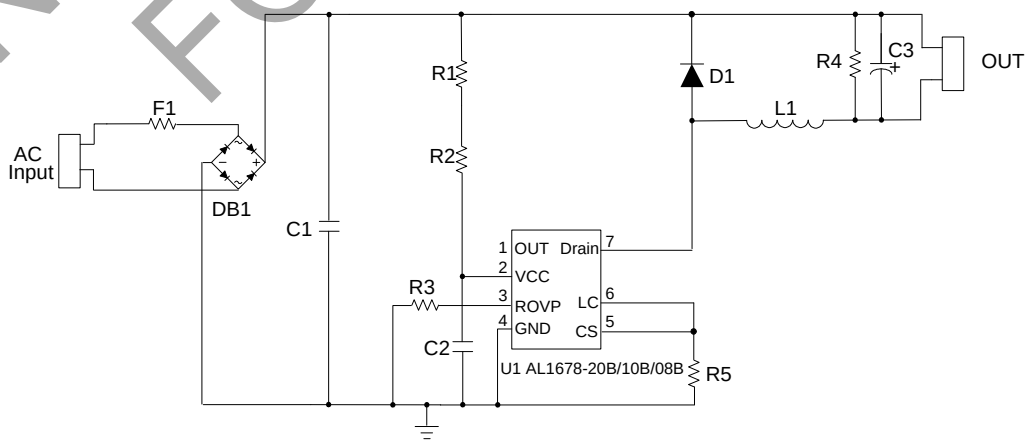
- > 90% Efficiency
- Valley Switching to Achieve Low Switching Loss
- Universal 85 to 277 V_{AC} Input Range
- Internal MOSFET up to 500V
- Tight Current Sense Tolerance: ±3%
- Low Start-Up Current: 170μA
- Low Operation Current: 100μA (Static)
- Single Winding Inductor
- Internal Protections
  - Under Voltage Lock Out (UVLO)
  - Leading-Edge Blanking (LEB)
  - Output Open/Short Protection
  - Open-Load and Reload Detection
  - Thermal Fold-Back Function
  - Over Temperature Protection (OTP)
- SO-7 Package
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

Applications

- Retrofit LED Lamps
- High Voltage DC-DC LED Driver
- General Purpose Constant Current Source

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Applications Circuit



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Pin Descriptions

Pin Number	Pin Name	Function
1	OUT	Internal power MOSFET's source
2	VCC	Power supply for the device
3	ROVP	Setting the open voltage of the output
4	GND	Ground
5	CS	Current sensing
6	LC	Line compensation pin
7	Drain	Internal high voltage MOSFET's drain

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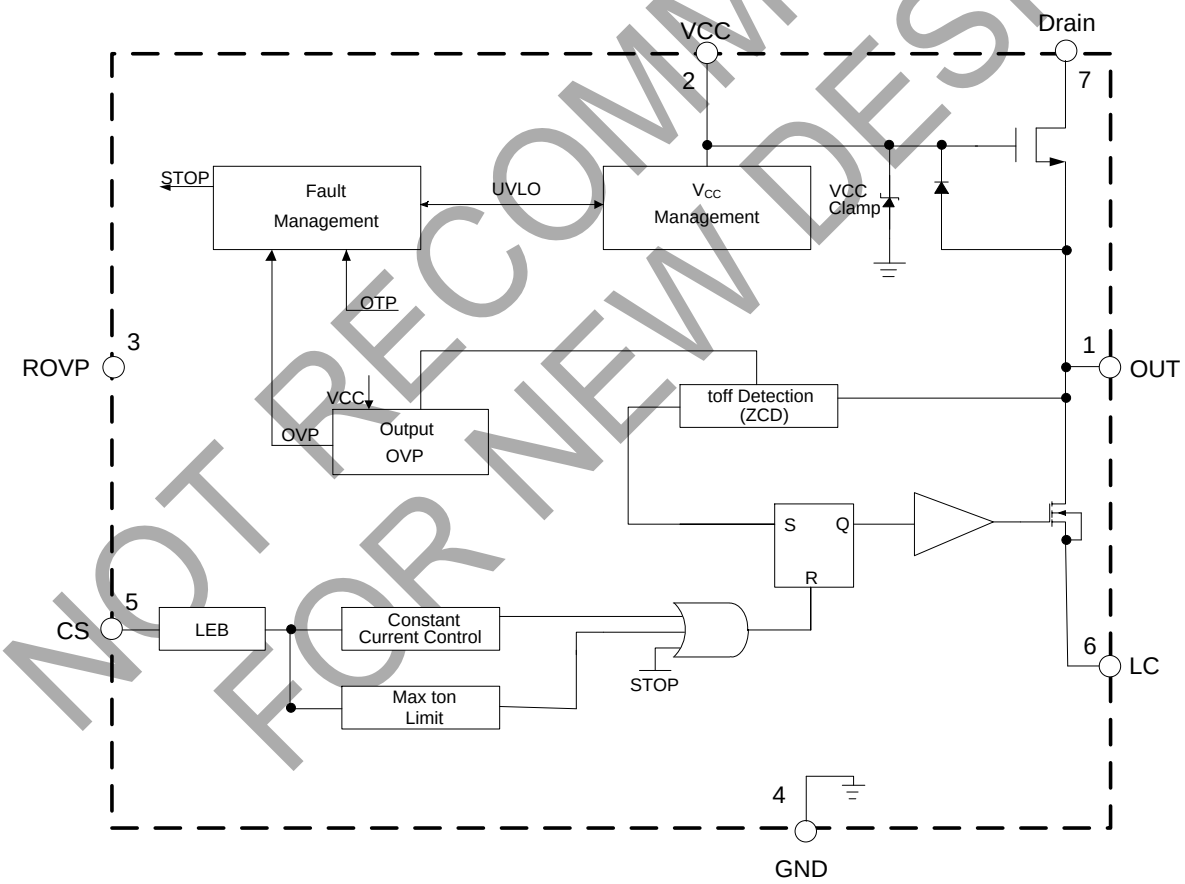
Functional Block Diagram



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Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.) (Note 4)

Symbol	Parameter		Rating	Unit
V_{CC}	Power Supply Voltage		18	V
V_{Drain}	Voltage on Drain Pin	AL1678-20B	500	V
		AL1678-10B	500	V
		AL1678-08B	500	V
I_D	Continuous Drain Current (T_C = +25°C)	AL1678-20B	2.0	A
		AL1678-10B	1.0	A
		AL1678-08B	0.8	A
V_{CS}	Voltage on CS Pin		-0.3 to 7	V
V_{ROVP}	Voltage on ROVP Pin		-0.3 to 7	V
T_J	Operating Junction Temperature		-40 to +150	°C
T_{STG}	Storage Temperature		-65 to +150	°C
T_{LEAD}	Lead Temperature (Soldering, 10s)		+260	°C
P_D	Power Dissipation and Thermal Characteristics (T_A = +50°C)		0.65	W
θ_{JA}	Thermal Resistance (Junction to Ambient)		190	°C/W
—	ESD (Human Body Model)		2000	V
	ESD (Machine Model)		200	V

Note 4: Stresses greater than those listed under *Absolute Maximum Ratings* can 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 under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.

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Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
T_A	Ambient Temperature (Note 5)	-40	+105	°C

Note 5: The device can operate normally at +125°C ambient temperature under the condition that the junction temperature is less than +150°C.

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Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
UVLO Section						
$V_{TH(ST)}$	Startup Threshold	—	—	14.5	—	V
$V_{OPR(Min)}$	Minimal Operating Voltage	After Turn On	—	8.5	—	V
V_{CC_Clamp}	V_{CC} Clamp Voltage	—	—	16.2	—	V
Standby Current Section						
I_{ST}	Start-Up Current	V_{CC} = $V_{TH(ST)}$-0.5V, Before Start Up	—	170	—	μA
$I_{CC(OPR)}$	Operating Current	Static	—	100	—	μA
Internal High Voltage MOSFET						
$R_{DS(ON)}$	Drain-Source on State Resistance	AL1678-20B	—	5.4	6	Ω
		AL1678-10B	—	10	12	
		AL1678-08B	—	16	20	
I_{DS}	Continuous Drain-Source Current	AL1678-20B	—	—	2.0	A
		AL1678-10B	—	—	1.0	
		AL1678-08B	—	—	0.8	
V_{DS}	Drain-Source Voltage	AL1678-20B	500	—	—	V
		AL1678-10B	500	—	—	
		AL1678-08B	500	—	—	
I_{DSS}	Drain-Source Leakage Current	V_{DS} = 500V, V_{GS} = 0, T_C = +25°C (AL1678-20B)	—	—	1	μA
		V_{DS} = 500V, V_{GS} = 0, T_C = +25°C (AL1678-10B)	—	—	1	
		V_{DS} = 500V, V_{GS} = 0, T_C = +25°C (AL1678-08B)	—	—	1	
Thermal Foldback Section And ROVP Section						
T_{REG}	Overheating Temperature Regulation (Note 6)	—	—	+140	—	°C
V_{ROVP}	Reference Voltage of ROVP Pin	—	—	0.46	—	V
Current Sense Section						
V_{CS-REF}	Current Sense Reference	—	0.388	0.400	0.412	V
t_{ON_MIN}	Minimum t_{ON}	—	400	—	700	ns
t_{ON_MAX}	Maximum t_{ON}	—	—	35	—	μs
t_{OFF_MAX}	Maximum t_{OFF}	—	—	200	—	μs
t_{OFF_MIN}	Minimum t_{OFF} (Note 6)	—	—	6	—	μs
$t_{D(H-L)}$	Delay to Output (Note 6)	—	50	150	250	ns
Over Temperature Protection Section						
—	Shutdown Temperature (Notes 6 & 7)	—	—	+170	—	°C

Notes: 6. These parameters, although guaranteed by design, are not 100% tested in production.
7. The device will latch when OTP happens and the device won't operate constantly at this temperature.

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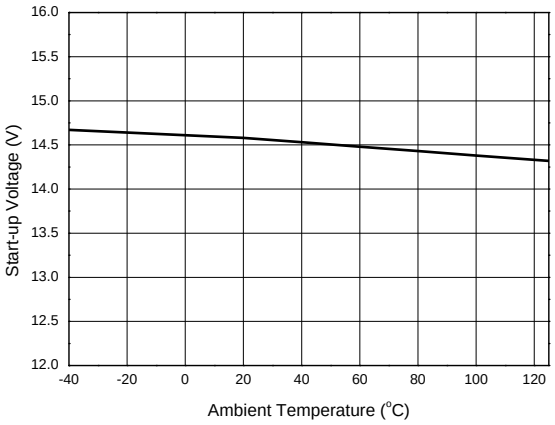
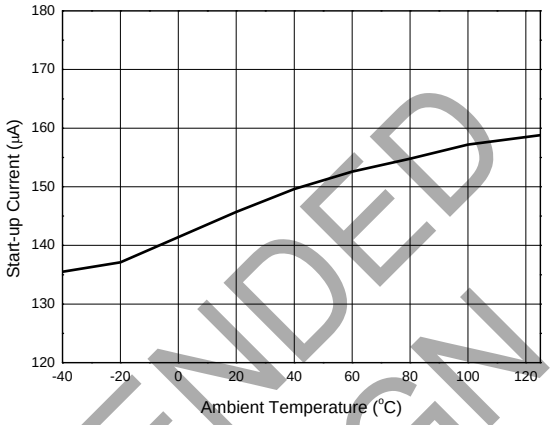
Performance Characteristics (Note 8)

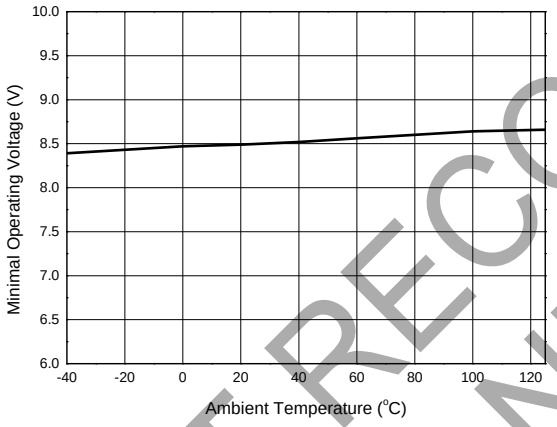
Start-Up Voltage vs. Ambient Temperature



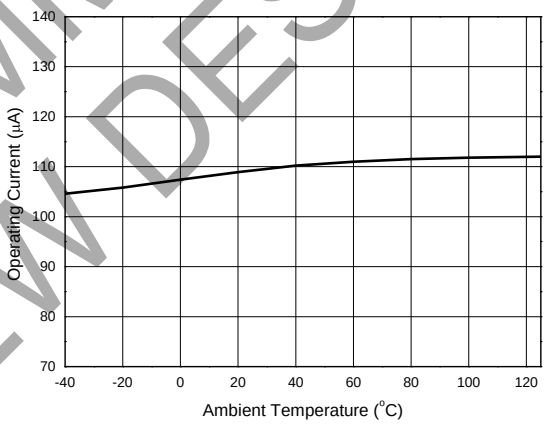
Start-Up Current vs. Ambient Temperature



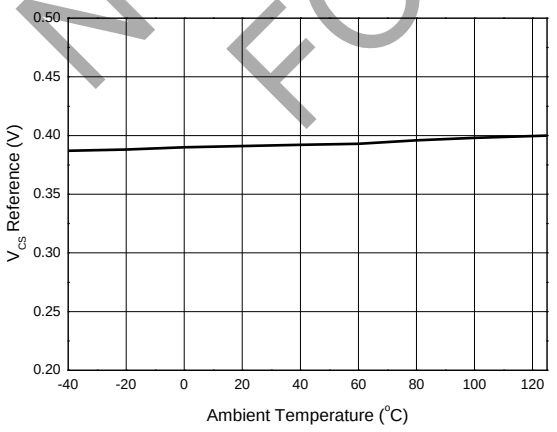
Minimal Operating Voltage vs. Ambient Temperature



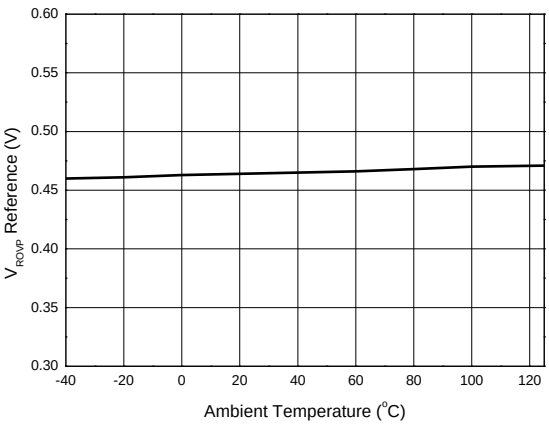
Operating Current vs. Ambient Temperature



V_{CS} Reference vs. Ambient Temperature



V_{ROVP} Reference vs. Ambient Temperature



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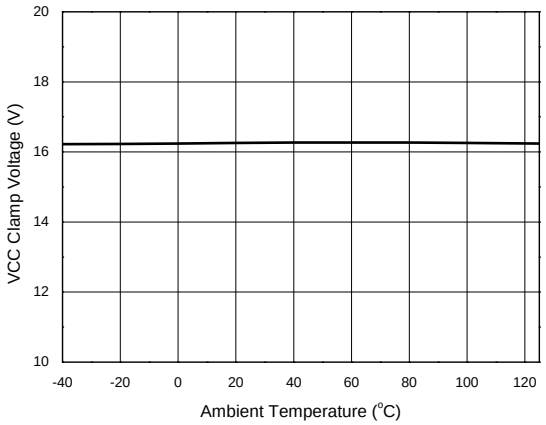
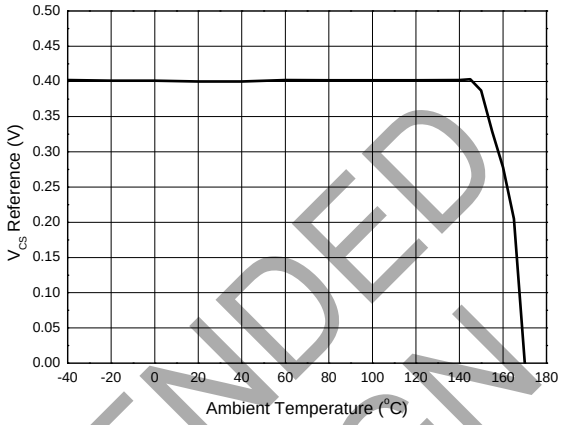
Performance Characteristics (Note 8) (continued)

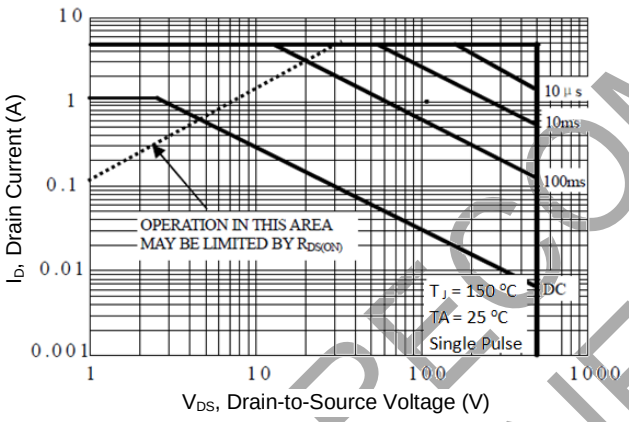
VCC Clamp Voltage vs. Ambient Temperature



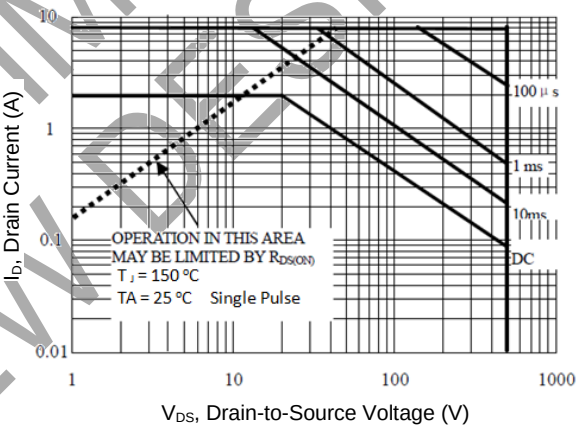
V_{CS} Reference vs. Ambient Temperature



Integrated 500V/1A MOSFET SOA (Note 9)



Integrated 500V/2A MOSFET SOA (Note 9)



Notes: 8. These electrical characteristics are tested under DC condition. The ambient temperature is equal to the junction temperature of the device.
9. The MOSFET SOA curve is tested under the TO-251 package type.

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Application Information

The AL1678-20B/10B/08B is designed for single inductor buck application, it is an extremely low BOM cost solution widely used in non-isolate situation. It operates as boundary conduction mode (BCM) which can get a good EMI performance. The device internally integrates a 500V high voltage MOSFET. The AL1678-20B/10B/08B adopts a novel method to detect the t_{OFF} time and realize an extremely low operation current, so the device does not need the auxiliary winding for V_{CC} supply and detects the t_{OFF} time. It also has a good constant current control which can guarantee the system current accuracy.

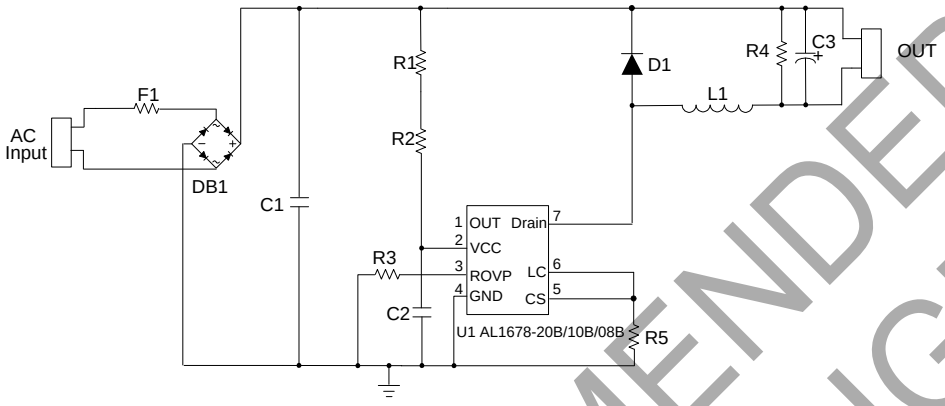

Figure 1. Typical Application Circuit

Design Parameters

Setting the Current Sense Resistor R5

The AL1678-20B/10B/08B uses peak current control method to obtain constant current control and senses the peak current of the inductor cycle by cycle. The sample value is compared with the internal 0.4V reference, when the sample value is up to 0.4V, the IC control the internal MOSFET turned off.

So the peak current of the inductance is

$$I_{peak} = \frac{V_{CS\_REF}}{R5}$$

Where,

V_{CS_REF} is the reference of the current sense, and the typical value is 0.4V.

R5 is the current sense resistor.

In no PF buck topology, the system operates at boundary conduct mode, so the output current is

$$I_{o\_mean} = \frac{1}{2} \cdot I_{peak}$$

So, the current sense resistor R5 is determined:

$$R5 = \frac{1}{2} \cdot \frac{V_{CS\_REF}}{I_{o\_mean}}$$

Inductance Selection (L1)

The AL1678-20B/10B/08B controls the system operating at boundary conduction mode, and the system's operating frequency does not keep constant because of the fluctuation of the bus voltage, set the minimum switching frequency f_{min} at the maximum bus voltage, and buck inductance value L1 is:

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Application Information (continued)

$$L1 = \frac{(\sqrt{2}V_{in\_rms} - V_o) \cdot R5 \cdot V_o}{V_{CS\_REF} \cdot \sqrt{2}V_{in\_rms} \cdot f_{\min}}$$

Where,

V_o is the output voltage.

V_{in_rms} is the RMS value of the input voltage.

According to the faraday's law of induction, the winding number of the inductance can be got:

$$N_{L1} = \frac{L1 \cdot I_{peak}}{A_e \cdot B_m} = \frac{L1 \cdot V_{CS\_REF}}{A_e \cdot B_m \cdot R5}$$

Where,

A_e is the core effective area.

B_m is the maximum magnetic flux density.

The AL1678-20B/10B/08B has designed the minimum t_{ON} time and maximum t_{ON} time, the t_{ON_MIN} is about 700ns and the t_{ON_MAX} time is about 35µs. In buck topology we can get the equation V_{in_rms}-V_O = L*I_{peak}/t_{ON}. If the inductance is very small, it leads to the t_{ON} becoming smaller, when the system's t_{ON} is smaller than t_{ON_MIN}, the device can't detect the peak current of the system leading to wrong output current. While if the inductance is very large, it leads to the t_{ON} becoming longer, when the system's t_{ON} is longer than the t_{ON_MAX}, the system will trigger OVP, and the LED will flicker. So the suitable value of the inductance is very important.

The AL1678-20B/10B/08B has also designed the minimum t_{OFF} time and the maximum t_{OFF} time, the t_{OFF_MIN} time is about 6µs and t_{OFF_MAX} time is about 200µs. In buck topology we can get the equation V_O = L*I_{peak}/t_{OFF}. If the inductance is very small, it leads to the t_{OFF} becoming much smaller, when the system's t_{OFF} is smaller than t_{OFF_MIN}, the system will enter DCM mode, and the output current will be wrong. While if the inductance is very large, it leads to the t_{OFF} becoming much longer, when the system's t_{OFF} is longer than the t_{OFF_MAX}, the system will enter CCM mode, and the output current will also be wrong. So the suitable value of the inductance is very important.

Consider these parameters, two examples of the typical application inductance is recommended as below:

System Spec	Inductance Value	System Frequency	t_{ON_MIN}	t_{OFF}
60V/150mA (85 to 277V_{AC})	2.3mH	60kHz (230V_{AC})	2.5µs (265V_{AC})	11.5µs
42V/100mA (85 to 277V_{AC})	2.5mH	62kHz (230V_{AC})	1.7µs (265V_{AC})	12.1µs

Fault Protection

Setting Output Open Voltage

The AL1678-20B/10B/08B has output open voltage protection, and the output voltage is controlled when the LED is open, which can prevent the output voltage increasing to a very high value. This feature can help the system designer to select a smaller volume capacitor. The output voltage is set by the external resistor R3 shown in Figure 1.

When the LED is open, the t_{OFF} time can be calculated as

$$t_{OFF} = \frac{L1 \cdot V_{CS\_REF}}{V_{OVP} \cdot R5}$$

Where,

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Application Information (continued)

V_{OVP} is the output open voltage.

When the LED is open, the output voltage is set by R3, and R3 is

$$R3 = \frac{V_{ROVP\_REF} \cdot t_{OFF}}{40 \cdot C_{REF} \cdot V_{CS\_REF}} = \frac{V_{ROVP\_REF} \cdot L1}{40 \cdot C_{REF} \cdot V_{OVP} \cdot R5}$$

Where,

V_{ROVP_REF} is the internal ROVP pin 0.46V's reference.

C_{REF} is the internal 6pF capacitor.

Output Short Protection

When the LED is shorted, the device can't detect the demagnetization time, the device controls the system operation at 5K's low frequency.

Thermal Fold Back Function

AL1678-20B/10B/08B has thermal fold back function, it adopts self-adaptive control method which can prevent the system breaking down caused by high temperature. The overheating temperature is set at +140°C, when the temperature of the IC is higher than +140°C the device will decrease the reference of the CS linearly till OTP happens. By this way, the device can control the system's output power at high ambient temperature, so the quantity of heat of the system can be controlled and temperature of the system is controlled, So the safety of the system at high temperature is got enhanced.

Over Temperature Protection

The AL1678-20B/10B/08B has OTP protection function. When the temperature is increased to +170°C, the IC will trigger over temperature protection which leads to a latch operating mode. When OTP happens, the system can restart under the condition that the system's AC source supply is powered off first.

Recommended Applications

The AL1678-20B/10B/08B integrates different MOSFET to adapt different wattage application. And the output current is limited by the internal integrated MOSFET and the SO-7 package's heat dissipation capability. And the minimum output voltage is limited by the LEB time, the minimum output voltage is recommended to 15V. So the recommended application is given below:

Device	Output Power Coverage	Maximum Output Current (Note 10)	Minimum Output Voltage
AL1678-20B	≤15W	≤240mA	15V
AL1678-10B	≤10W	≤180mA	15V
AL1678-08B (Note 11)	≤8W	≤120mA	15V

Note 10: The higher output current is possible with extra power dissipation solution.

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Ordering Information

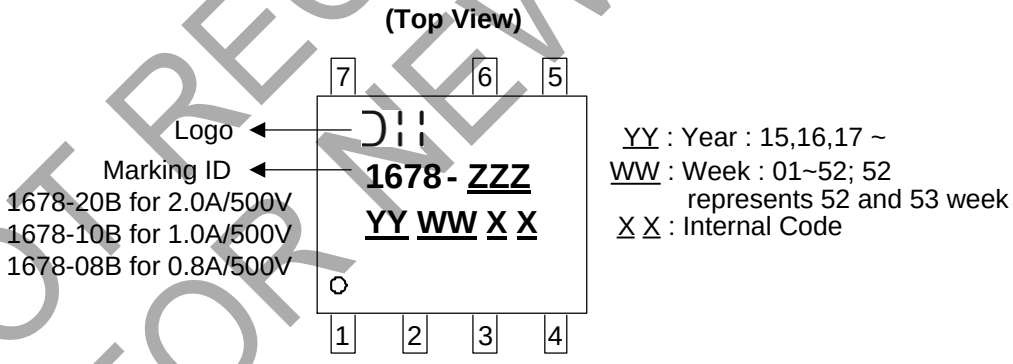
AL1678 - XX X XX - 13

Product Name	Current Option	MOSFET Voltage	Package	Packing
	08 : 0.8A 10 : 1.0A 20 : 2.0A	B: 500V	S7 : SO-7	13 :13" Tape & Reel

Part Number	Package Code	Package	13" Tape and Reel	
			Quantity	Part Number Suffix
AL1678-20BS7-13	S7	SO-7	4000/Tape & Reel	-13
AL1678-10BS7-13	S7	SO-7	4000/Tape & Reel	-13
AL1678-08BS7-13 (Note 11)	S7	SO-7	4000/Tape & Reel	-13

Note 11: The AL1678-08BS7-13 is still under development and not orderable.

Marking Information



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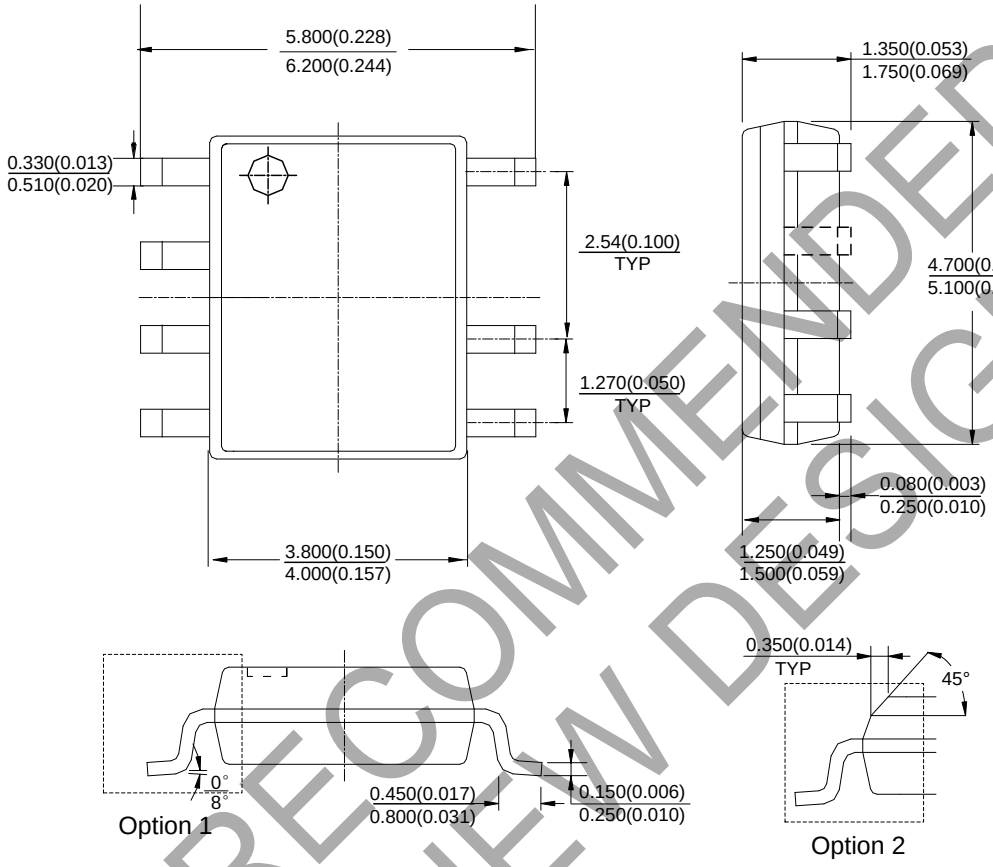
Package Outline Dimensions (All dimensions in mm (inch).)

Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SO-7



Note: Eject hole, oriented hole and mold mark is optional.

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Suggested Pad Layout

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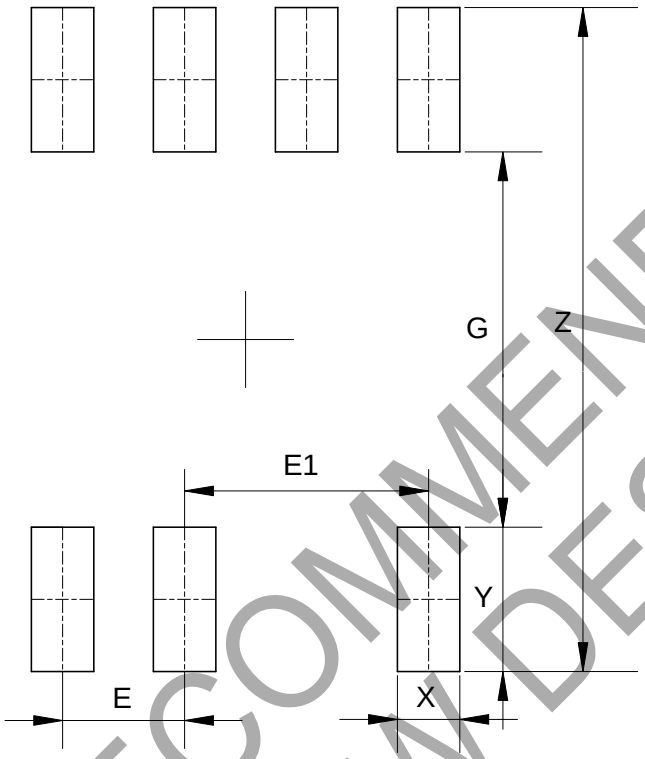
(1) Package Type: SO-7



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E (mm)/(inch)	E1 (mm)/(inch)
Value	6.900/0.272	3.900/0.154	0.650/0.026	1.500/0.059	1.270/0.050	2.540/0.100

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