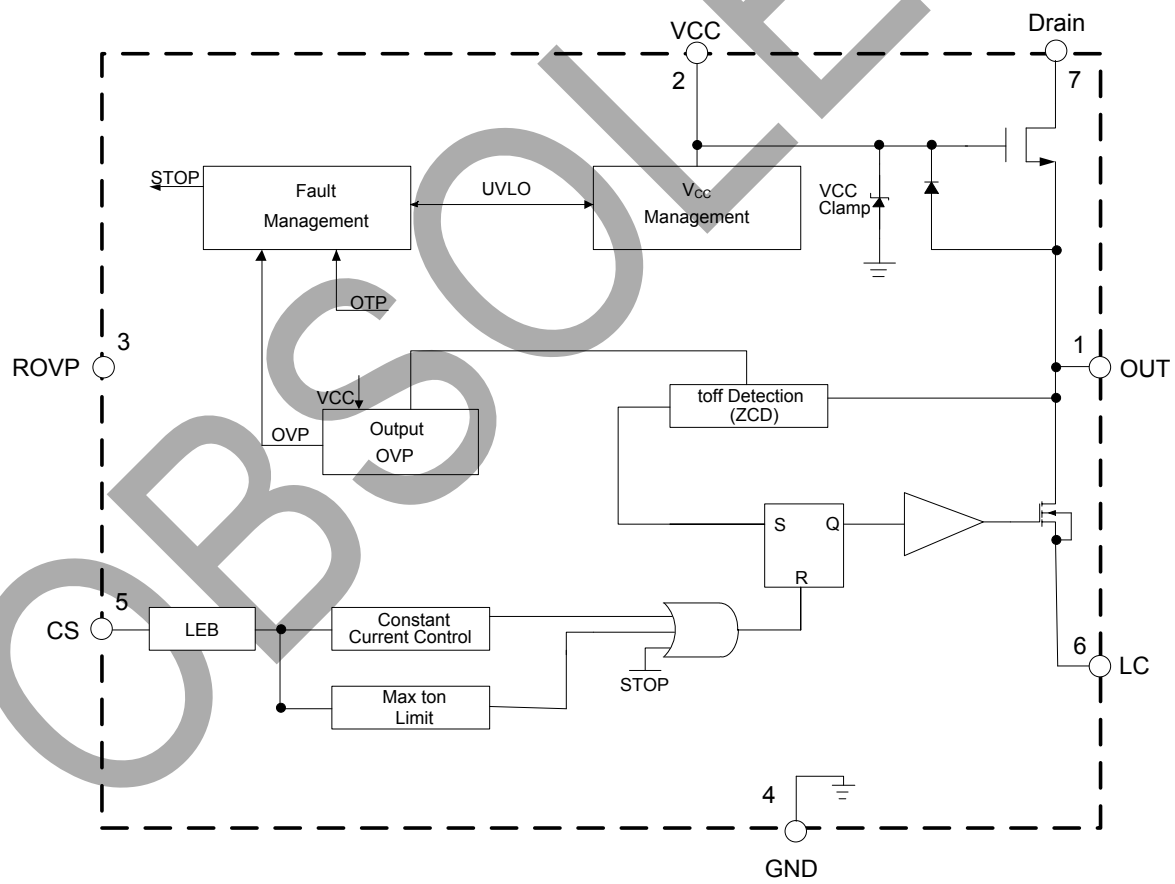
Pin Descriptions

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

Functional Block Diagram



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.

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.

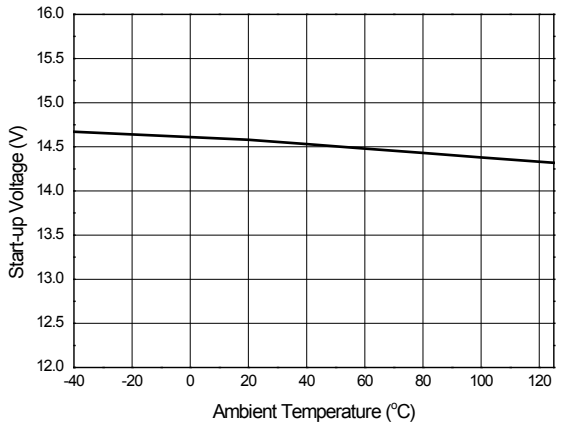
Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

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

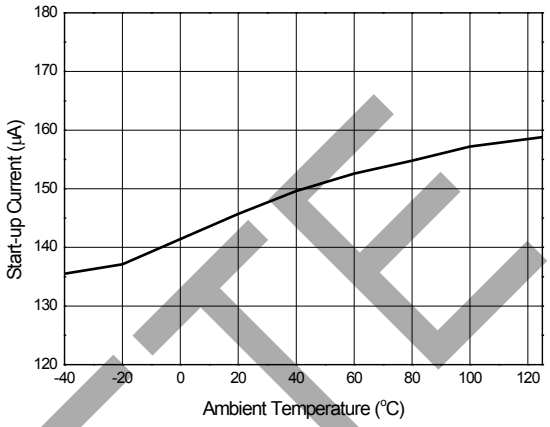
Notes: 6. These parameters, although guaranteed by design, are not 100% tested in production.
7. The device will latch when OTP happens and the device won't operate constantly at this temperature.

Performance Characteristics (Note 8)

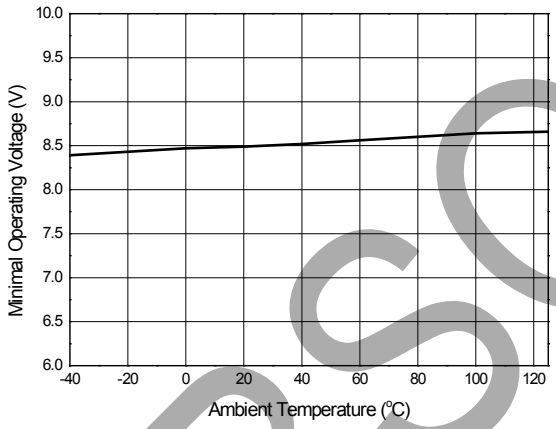
Start-Up Voltage vs. Ambient Temperature



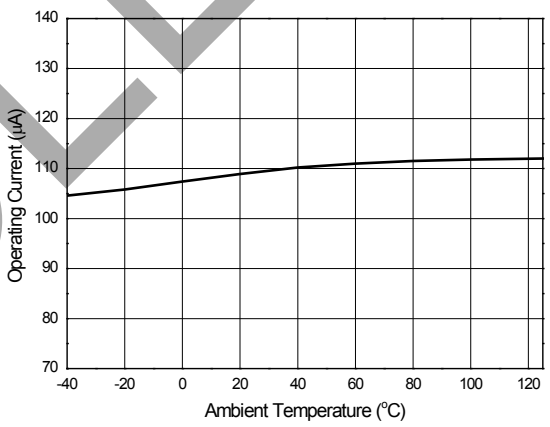
Start-Up Current vs. Ambient Temperature



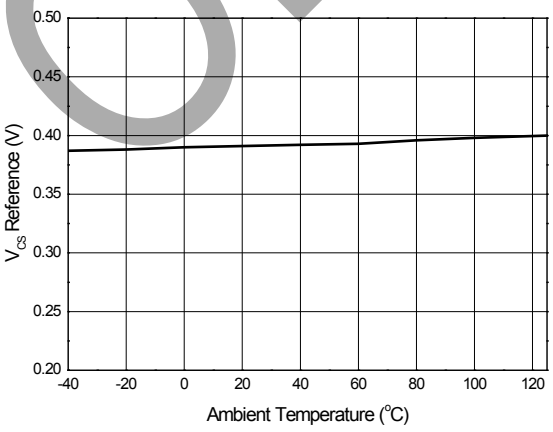
Minimal Operating Voltage vs. Ambient Temperature



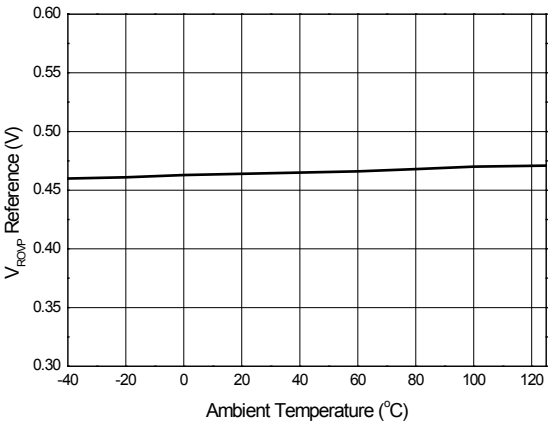
Operating Current vs. Ambient Temperature



V_{CS} Reference vs. Ambient Temperature

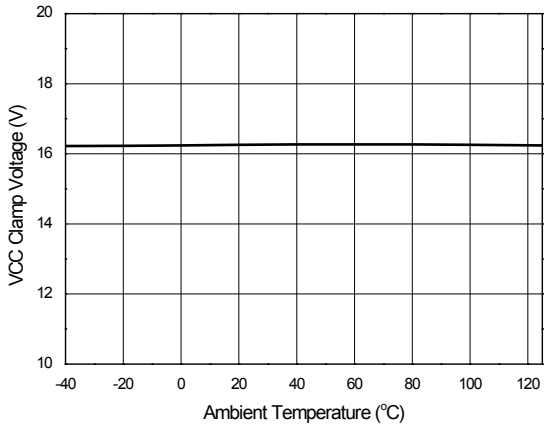


V_{ROVP} Reference vs. Ambient Temperature

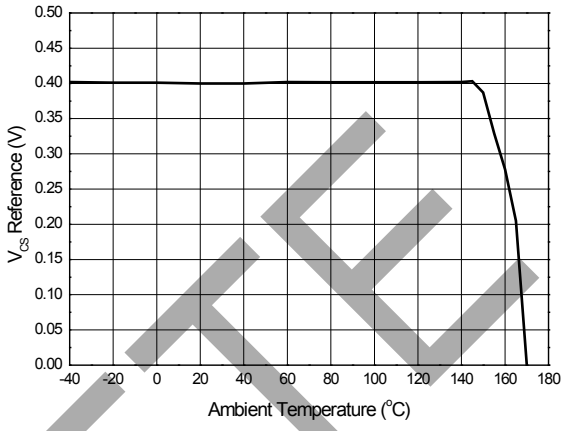


Performance Characteristics (Note 8) (continued)

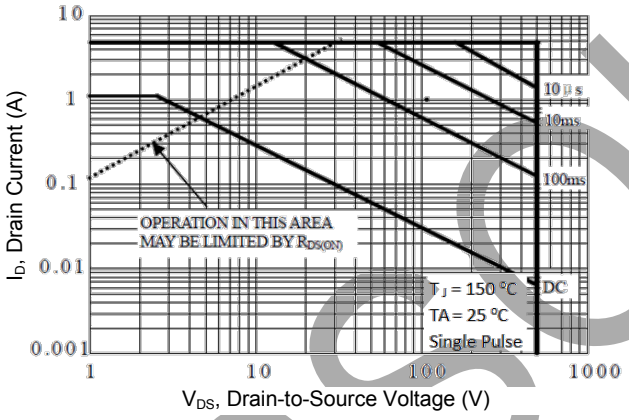
VCC Clamp Voltage vs. Ambient Temperature



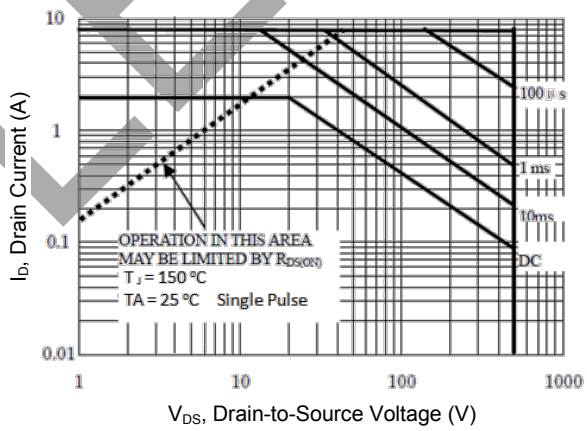
V_{CS} Reference vs. Ambient Temperature



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.

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.

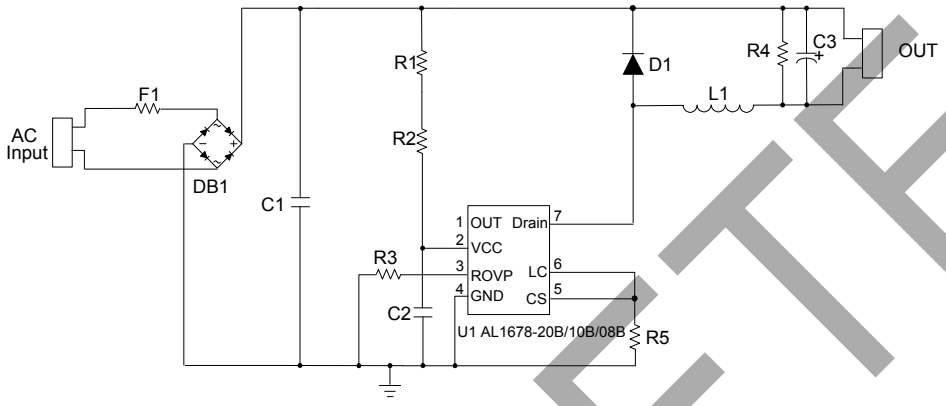


Figure 1. Typical Application Circuit

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:

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,

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.

Ordering Information

AL1678 - XX X XX - 13

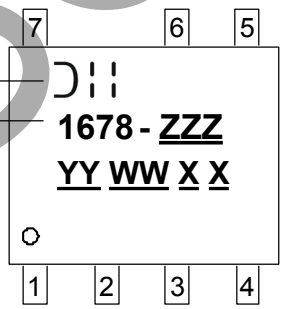
Product Name	Current Option	MOSFET Voltage	Package	Packing
	08 : 0.8A 10 : 1.0A 20 : 2.0A	B: 500V	S7 : SO-7	13 :13" Tape & Reel

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

(Top View)



Logo

Marking ID

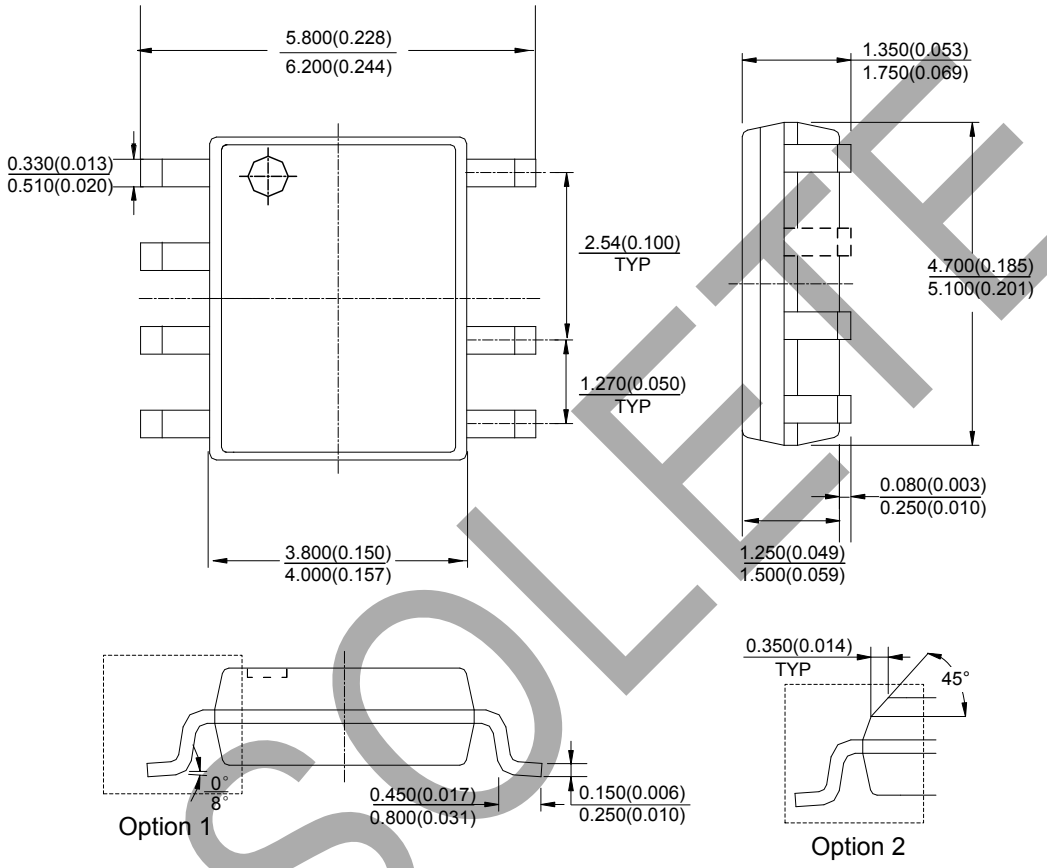
1678-20B for 2.0A/500V
1678-10B for 1.0A/500V
1678-08B for 0.8A/500V

YY : Year : 15,16,17 ~
WW : Week : 01~52; 52 represents 52 and 53 week
X X : Internal Code

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

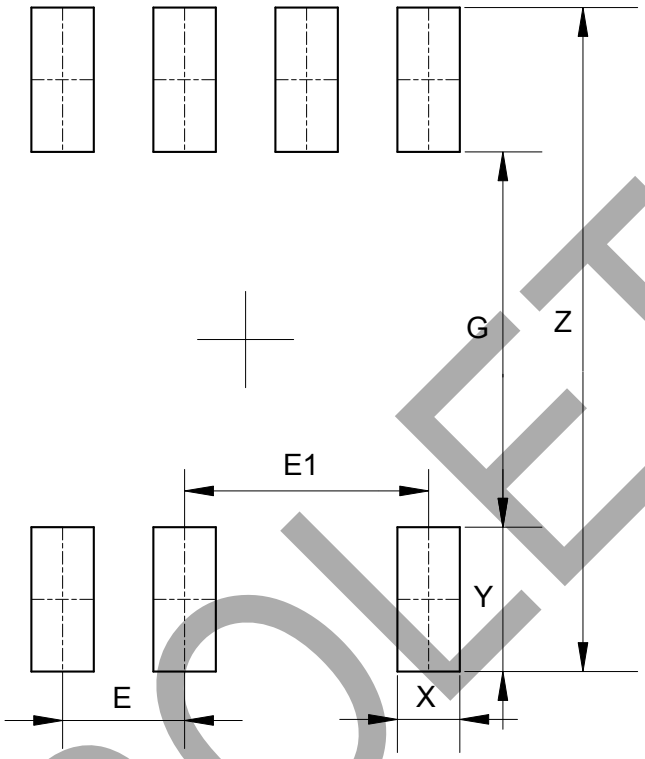


Note: Eject hole, oriented hole and mold mark is optional.

Suggested Pad Layout

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

(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

IMPORTANT NOTICE

DIODES INCORPORATED MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

Diodes Incorporated and its subsidiaries reserve the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. Diodes Incorporated does not assume any liability arising out of the application or use of this document or any product described herein; neither does Diodes Incorporated convey any license under its patent or trademark rights, nor the rights of others. Any Customer or user of this document or products described herein in such applications shall assume all risks of such use and will agree to hold Diodes Incorporated and all the companies whose products are represented on Diodes Incorporated website, harmless against all damages.

Diodes Incorporated does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel. Should Customers purchase or use Diodes Incorporated products for any unintended or unauthorized application, Customers shall indemnify and hold Diodes Incorporated and its representatives harmless against all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized application.

Products described herein may be covered by one or more United States, international or foreign patents pending. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks.

This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes Incorporated.

LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

A. Life support devices or systems are devices or systems which:

1. are intended to implant into the body, or
2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

www.diodes.com