High-Efficiency, Step-Down DC/DC Controller

FEATURES

- High Efficiency (up to 95%).
- Low Quiescent Current at 90μA.
- Pulse-Skipping and Pulse-Frequency Modulation.
- Inputs-Uncommitted Current Sense Comparator.
- Duty Cycle Adjustable.
- 90KHz to 280KHz Oscillator Frequency.
- Power-Saving Shutdown Mode (8μA Typical).
- Push-Pull Driver Output.

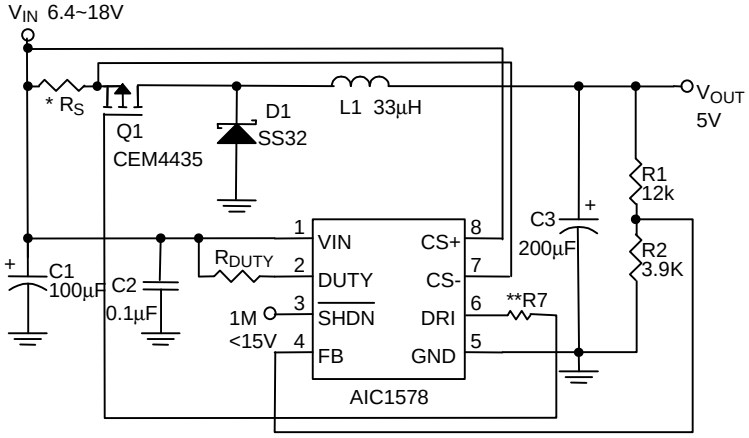
APPLICATIONS

- LCD Monitors
- Notebook Computers
- Step-Down DC/DC Controller Module.
- Constant Current Source for Battery Chargers.

DESCRIPTION

The AIC1578 is a high performance step-down DC/DC controller, designed to drive an external P-channel MOSFET to generate programmable output voltages. Two main schemes of Pulse-Skipping and Pulse-Frequency Modulation are employed to maintain low quiescent current and high conversion efficiency under wide ranges of input voltage and loading condition. The AIC1578 delivers 10mA to 2A of output current with 87%~93% efficiency at V_{IN}=9V, V_{OUT}=5V condition. A current sense comparator with both inverting and non-inverting input uncommitted is included to provide the crucial function of either current limit protection or constant output current control. When the AIC1578 is used in a high-side current sensing step-down constant current source, the efficiency is typically greater than 90%. Duty cycle can be adjusted to greater than 90% by connecting a resistor from DUTY pin to V_{IN}. Quiescent current is about 90μA and can be reduced to 8μA in shutdown mode. Switching frequency being in around 90KHz to 280KHz range, small size switching components are ideal for battery powered portable equipment.

■ TYPICAL APPLICATION CIRCUIT



* R_S should not be omitted so that inrush current won't be too high.

$$I_P = I_{O,MAX} + \frac{V_O(V_{IN} - V_O)}{2V_{IN} \times f_S \times L}$$

$$R_S = \frac{V_{TH}}{I_P} = \frac{50mV}{I_P} = \frac{0.1V_{IN}f_S L}{2V_{IN}f_S L I_{O,MAX} + V_{IN}V_O - V_O^2}$$

V_{IN}: Input voltage
V_{OUT}: Output voltage
f_S: Working frequency
L= Inductor value
$I_{O,MAX}$: Maximum Output current
V_{TH}: Current Limit Sense Threshold
**V_{IN}>15V, R7=15Ω
V_{IN}≤15V, R7=0Ω

DC/DC Buck Converter

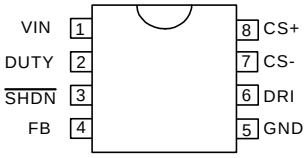
■ ORDERING INFORMATION

AIC1578XXXX

- PACKING TYPE
  TR: TAPE & REEL
  TB: TUBE
- PACKAGING TYPE
  S: SMALL OUTLINE
  N: PLASTIC DIP
- C: Commercial
  P: Lead Free Commercial
  (Available for PS only)

PIN CONFIGURATION

SO-8
TOP VIEW



Example: AIC1578CSTR
→ in SO-8 Package & Taping & Reel Packing Type
(CN is not available in TR packing)
AIC1578PSTR
→ in SO-8 Lead Free Package & Taping & Reel Packing Type

■ ABSOLUTE MAXIMUM RATINGS

VIN Supply Voltage 20V

DUTY Voltage 20V

$\overline{SHDN}$ Voltage 15V

Storage Temperature Range ..... -65°C~ 150°C

Recommended Operating Conditions

VIN Supply Voltage ..... 18V±1%

Ambient Temperature Range ..... 0°C~ 70°C

Junction Temperature Range ..... 0°C~ 100°C

■ TEST CIRCUIT

Refer to TYPICAL APPLICATION CIRCUIT.

■ ELECTRICAL CHARACTERISTICS (V_{IN}= 13V, T_A=25°C, unless otherwise specified.)

PARAMETERS	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Operation Voltage		4		20	V
Quiescent Current	V_{FB} = 1.5V		90	160	μA
Shutdown Mode Current	$V_{\overline{SHDN}}$ = 0V		8	20	μA
Internal Reference Voltage		1.195	1.22	1.245	V
Driver Sinking "ON Resistance"			16		Ω
Driver Sourcing "ON Resistance"			11		Ω
Current Limit Sense Threshold	V_{CS+} = 13V	50	70	90	mV
Shutdown Threshold		0.6	0.9	1.2	V
$\overline{SHDN}$ Pin Leakage Current	$V_{\overline{SHDN}}$ < 15V			1	μA
Duty Cycle	V_{DUTY} = V_{IN}	70	75	80	%
Oscillator Frequency	V_{DUTY} = V_{IN}		225		KHz

TYPICAL PERFORMANCE CHARACTERISTICS

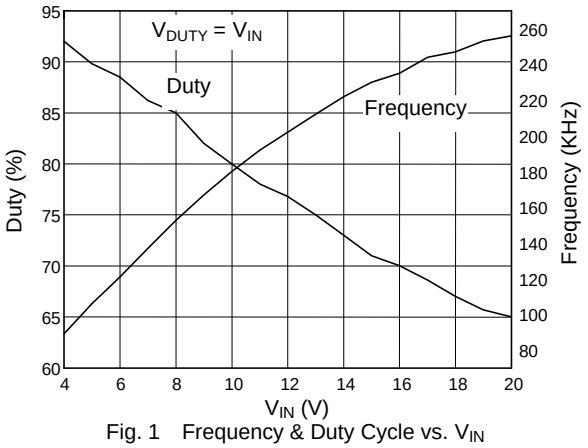


Fig. 1 Frequency & Duty Cycle vs. V_{IN}

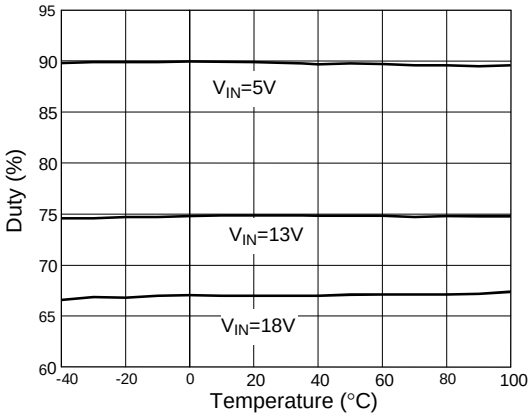


Fig. 2 Duty Cycle vs. Temperature

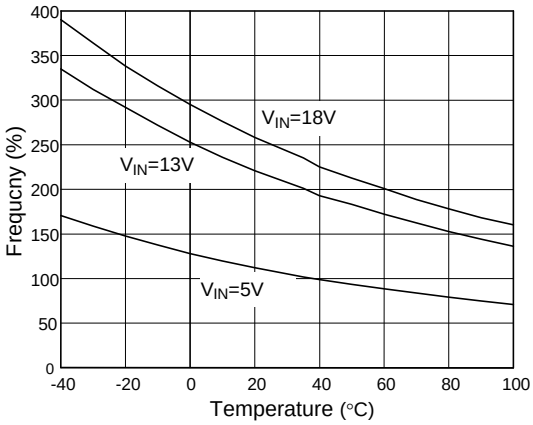


Fig. 3 Frequency vs. Temperature

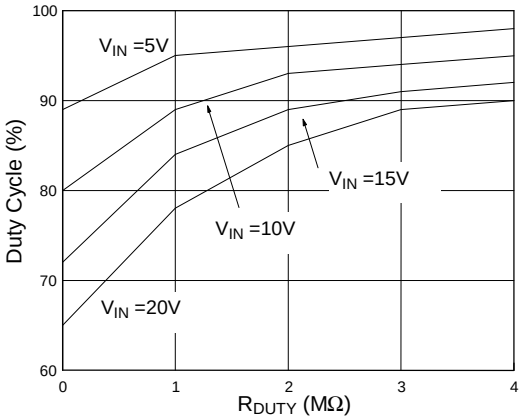


Fig. 4 Duty Cycle vs. R_{DUTY}

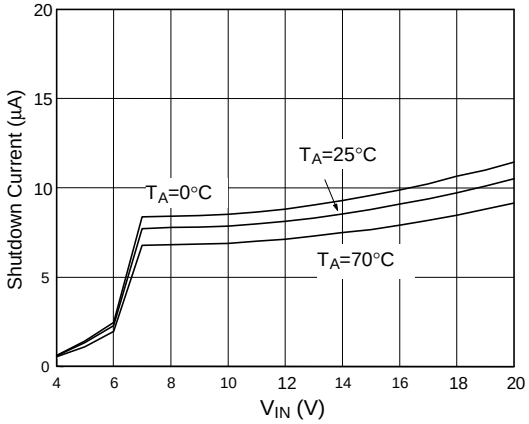


Fig. 5 Shutdown vs. V_{IN}

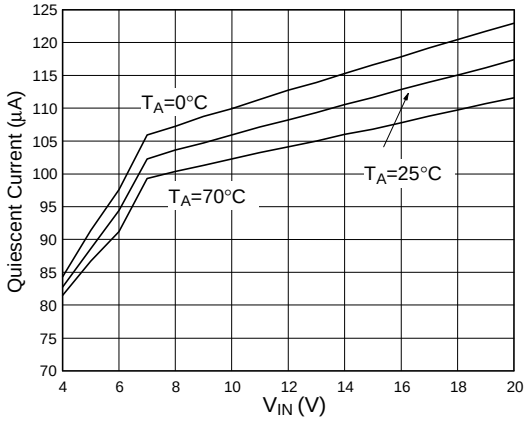
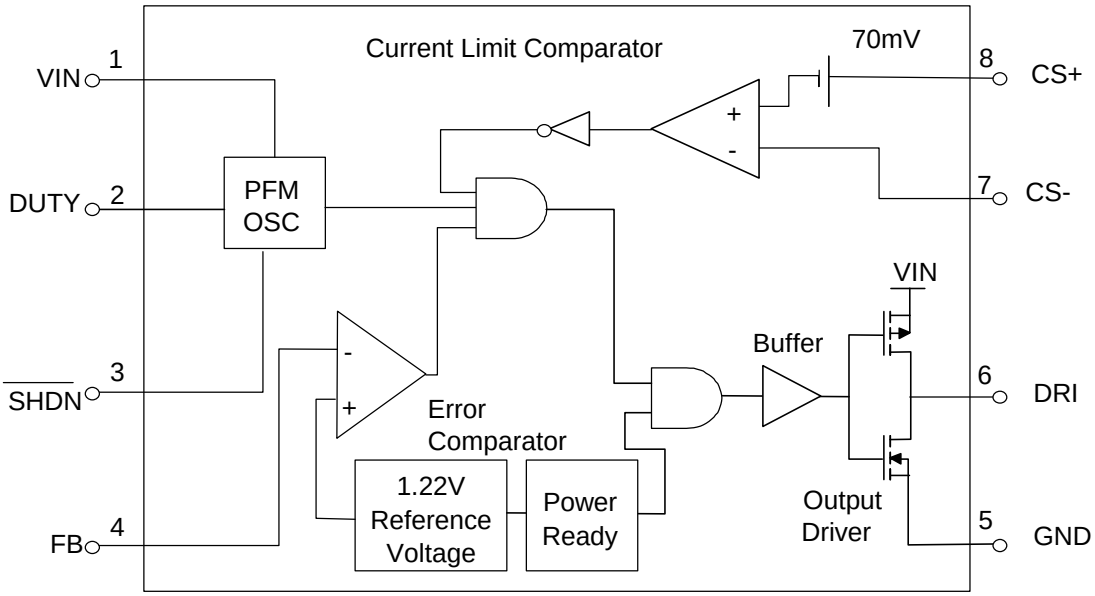


Fig. 6 Quiescent Current vs. V_{IN}

BLOCK DIAGRAM



PIN DESCRIPTIONS

PIN 1: VIN - Input supply voltage, ranged from 4V to 18V is recommended.

PIN 2: DUTY - Duty cycle adjustment pin. To be tied to the VIN pin directly or through a resistor R_{DUTY} to adjust oscillator duty cycle. R_{DUTY} must be over 1MΩ if V_{IN}=20V.
See TYPICAL PERFORMANCE CHARACTERISTICS.

PIN 3: $\overline{SHDN}$ - Logical input to shutdown the chip:
$V_{\overline{SHDN}}$ = High for normal operation.
$V_{\overline{SHDN}}$ = Low for shutdown.
This pin should not be floating or be forced to over 15V. In shutdown mode DRI pins is at high level.

PIN 4: FB - Feedback comparator input, to compare the feedback voltage with the internal reference voltage. Connecting a resistor R1 to converter output node and a resistor R2 to ground yields the output voltage:

V_{OUT}=1.22 x (R1+R2)/ R2

PIN 5: GND - Power ground.

PIN 6: DRI - Push-pull driver output to drive an external P-channel MOSFET or PNP transistor. When driving a PNP bipolar transistor, a base resistor and a capacitor to the base of PNP are recommended.

PIN 7: CS- - Current sense comparator inverting input. This pin voltage should go over 2V but not to exceed V_{IN} voltage.

PIN 8: CS+ - Current sense comparator non-inverting input. This pin voltage should go over 2V but not to exceed V_{IN} voltage.

■ APPLICATION EXAMPLES

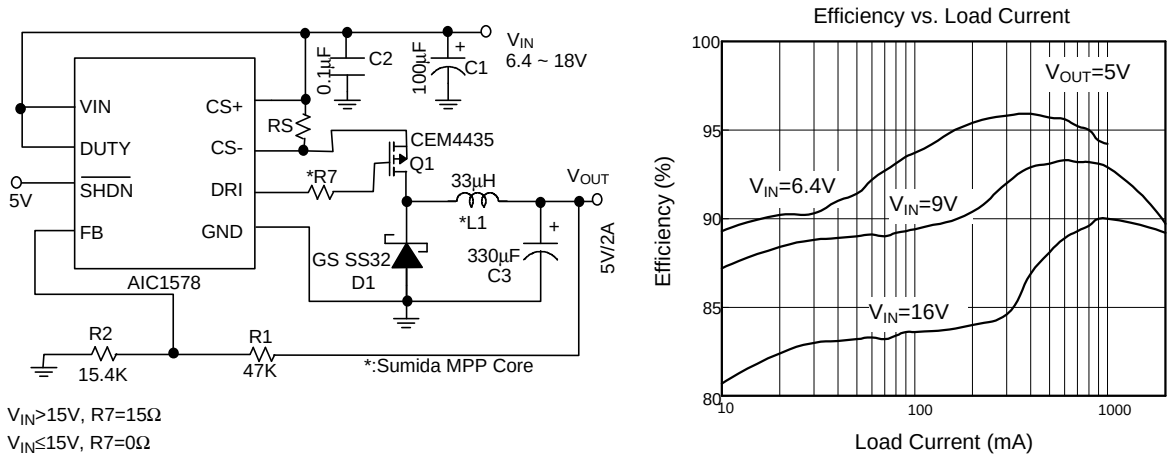


Fig. 7 5V Step-Down Converter

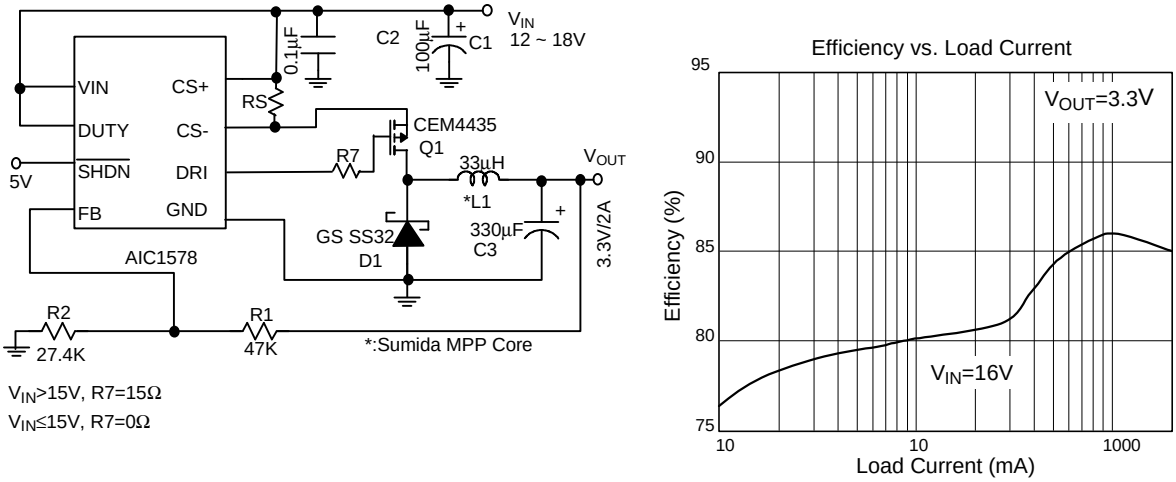
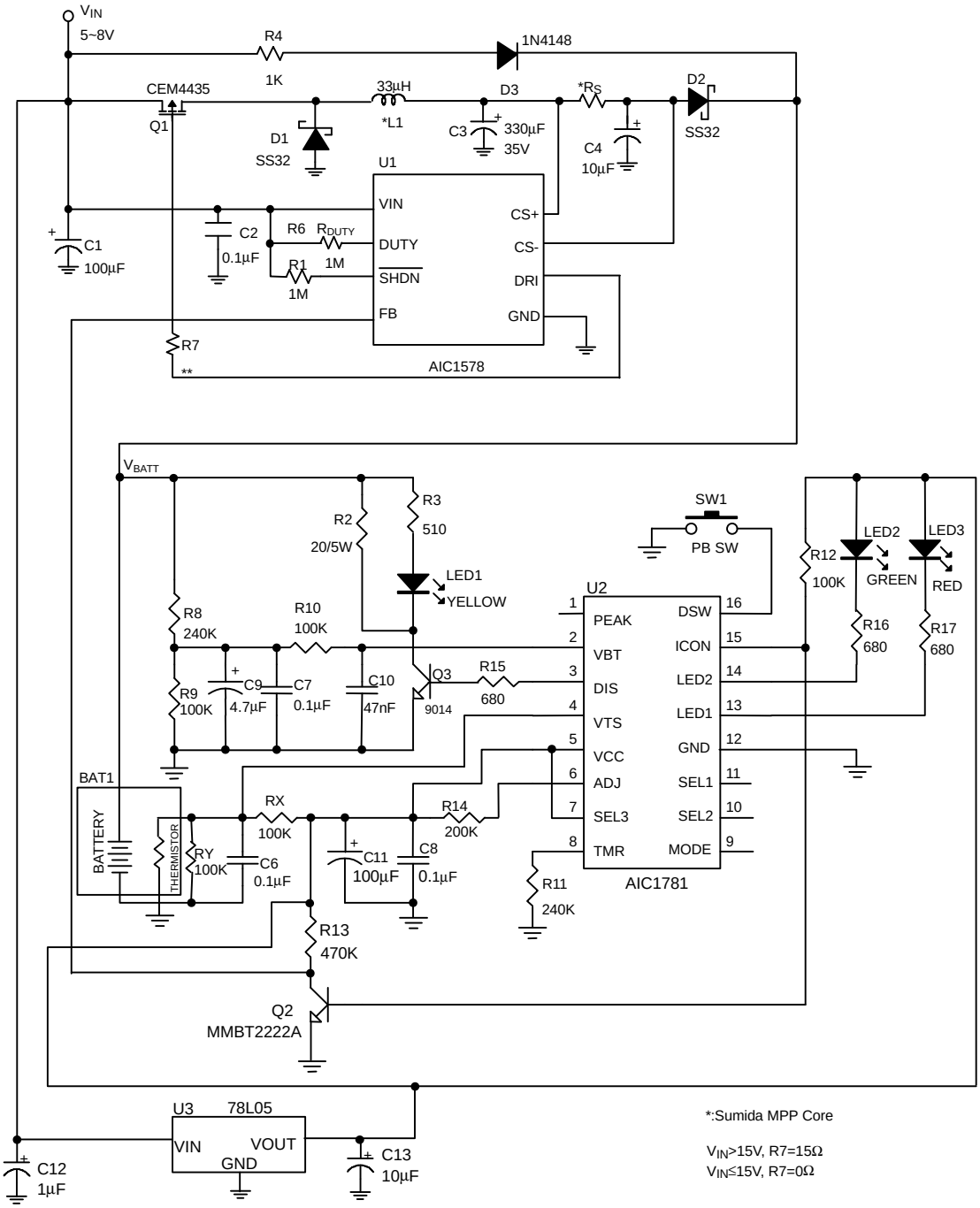


Fig. 8 3.3V Step-Down Converter

■ APPLICATION EXAMPLES (Continued)



NOTE: R_S =0.1Ω, charge current =0.5A ±10%, V_{IN}>V_{BATT} +3.5V
R_S =0.05Ω, charge current =1A±10%, V_{IN}>V_{BATT} +4V
R_S =0.033Ω, charge current =1.5A ±10%, V_{IN}>V_{BATT} +4.5V
Efficiency>90%, measured at CS- node
3~5 NiMH/NiCd Cells

Fig. 9 Battery Charge Circuit with High-Side Current Sensing Constant Current Source

APPLICATION INFORMATION

Short Circuit Protection Design

1. As we know, Short Circuit Protection (abbreviated as SCP) does not always exist in the DC-DC converter circuit. The fact is usually the DC-DC converter provides the circuits attached to VOUT with low power or low voltage. Sometimes it has less concern about safety. And its probability of short-circuit is quite low. That gives users reasons to ignore the use of SCP circuit. However, we would still like to point out the importance of the protection. With SCP, the system will be well protected in any situation. Two SCP circuits are introduced as follows for your reference.

2. Design1: shown as Fig. 10.
   Method: Add a fast fuse to V_{OUT}.
   Fuse select guide: Fuses, which can take the start up current, and break down fast on unexpected current.
   Note: Replacement of fuse is needed after short circuit.

3. Design 2: shown as Fig. 11.
   Method: Add a SCP circuit
   Note: 1. The time constant, which is directly related to R1 and C1, has a serious effect on the circuit.
   2. Circuit can be recovered by removing the short circuit event from the system.
   3. The condition for applying this design is V_{OUT} ≥3V.

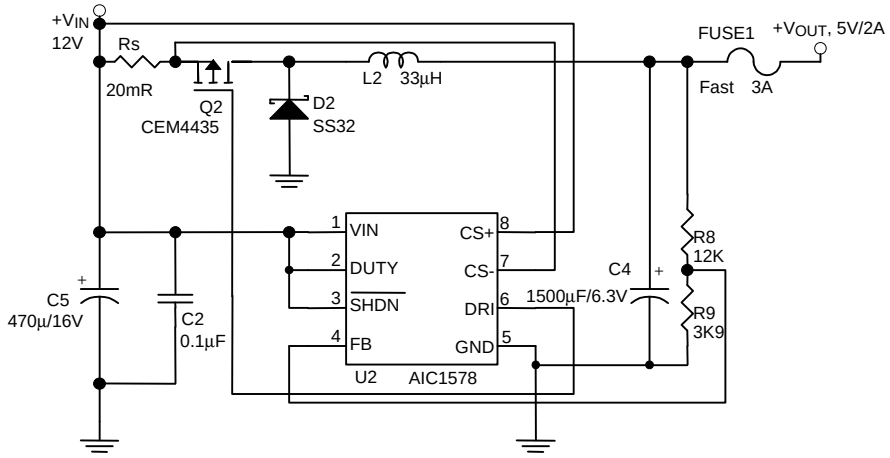


Fig 10. Add a Fast Fuse Solution

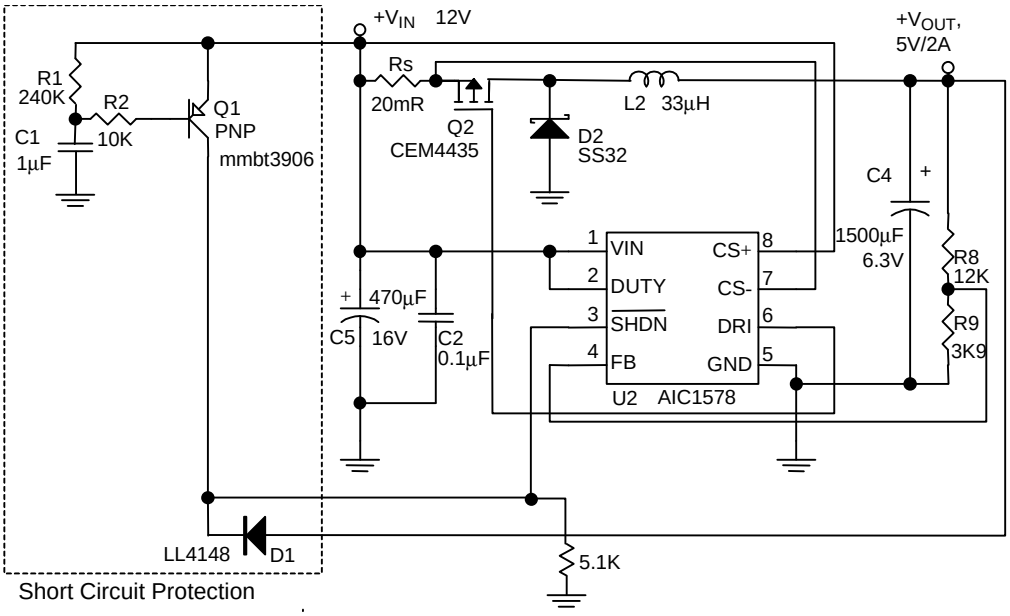
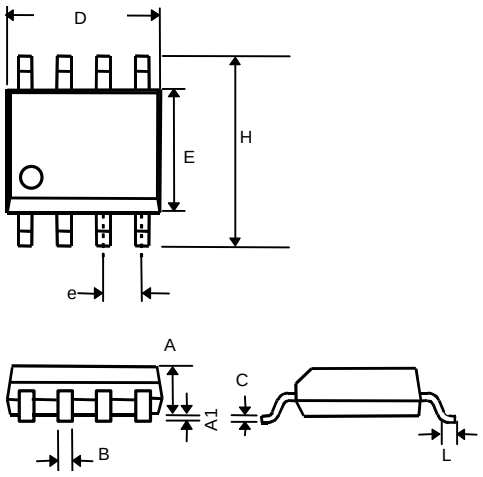


Fig 11. Add A Short Circuit Protection Circuit Solution

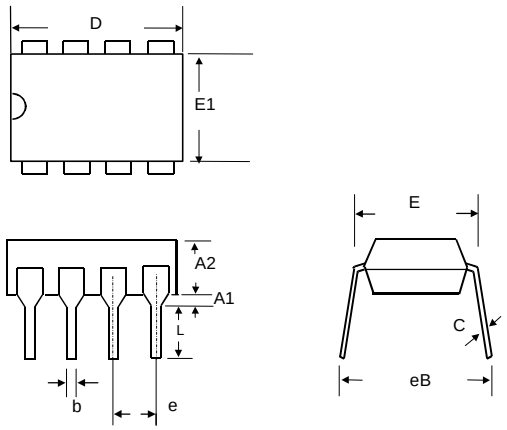
■ PHYSICAL DIMENSIONS (unit: mm)

- **8 LEAD PLASTIC SO (CS) (PS)**



SYMBOL	MIN	MAX
A	1.35	1.75
A1	0.10	0.25
B	0.33	0.51
C	0.19	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27(TYP)	
H	5.80	6.20
L	0.40	1.27

8 LEAD PLASTIC DIP (CN)



SYMBOL	MIN	MAX
A1	0.381	—
A2	2.92	4.96
b	0.35	0.56
C	0.20	0.36
D	9.01	10.16
E	7.62	8.26
E1	6.09	7.12
e	2.54 (TYP)	
eB	—	10.92
L	2.92	3.81