DESCRIPTION

The A7576 of regulators is monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 3A load with excellent line and load regulation. The A7576 is available in fixed output voltages of 3.3V, 5V, 12V,15V and an adjustable output version.

Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation and a fixed-frequency oscillator.

The A7576 offers a high-efficiency replacement for popular three-terminal linear regulators.

It significantly reduces the size of the heat sink, and in some cases, no heat sink is required. A standard series of inductors, optimized for use with the A7576, is available from several manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

Other features include a guaranteed ±4% tolerance on the output voltage within the specified input voltage and output load conditions, and ±10% tolerance on the oscillator frequency.

An external shutdown function is included, featuring a typical standby current of 50μA. The output switch provides cycle-by-cycle current limiting as well as thermal shutdown protection to ensure complete safety under fault conditions.

The A7576 is available in the TO-220 and TO-263-5 packages.

ORDERING INFORMATION

Package Type	Part Number	
TO-263-5 SPQ: 500pcs/Reel	S5	A7576S5VR-ADJ
		A7576S5VR-33
		A7576S5VR-50
		A7576S5VR-120
		A7576S5VR-150
TO-220 SPQ: 50pcs/Tube, 1,000K/Box	T5	A7576T5VU-ADJ
		A7576T5VU-33
		A7576T5VU-50
		A7576T5VU-120
		A7576T5VU-150
Note	R: Tape & Reel ; U: Tube V: Halogen free Package	
AiT provides all RoHS products		

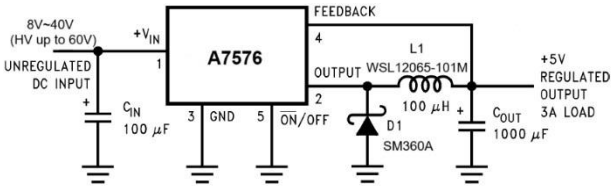
FEATURES

- 3.3V, 5V, 12V, 15V and adjustable output versions
- High efficiency
- Guaranteed 3A output current
- Requires only 4 external components
- 52 kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode
- Uses readily available standard inductors
- Thermal shutdown and current limit protection
- Adjustable version output voltage range, 1. 23V to 37V ± 4 % max over line and load conditions

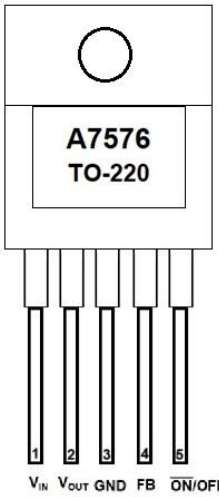
APPLICATION

- Simple high- efficiency step -down (buck) regulator
- Efficient pre-regulator for linear regulators
- On-card switching regulators
- Positive to negative converter (Buck-Boost)

TYPICAL APPLICATION

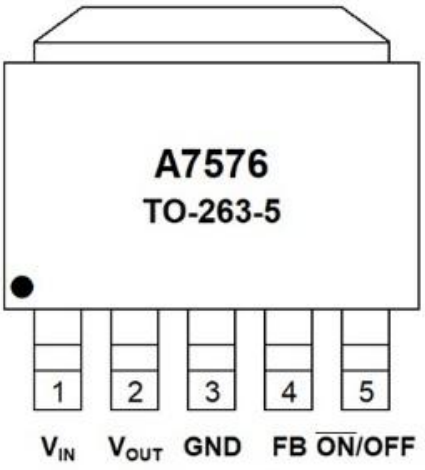


PIN DESCIPTION



TO-220, T5

Top View



TO-263-5, S5

Top View

Pin#	Symbol	Function
1	V_{IN}	Input Voltage Pin
2	V_{OUT}	Output Voltage Pin
3	GND	Ground Pin
4	FB	Feed Back Pin
5	$\overline{ON}$/OFF	$\overline{ON}$/OFF Pin

ABSOLUTE MAXIMUM RATINGS

V_{IN}, Maximum Supply Voltage		40V
$\overline{ON}$/OFF, Pin Input Voltage		- 0.3 V≤V≤+V_{IN} V
V_{OUT}, Output Voltage to Ground (Steady State)		-1V
P_{DMAX}, Power Dissipation		Internally Limited
P_{JA} *, Thermal Resistance (Junction to Ambient, No Heat sink, Free Air)	TO-220 TO-263-5	50 ℃/W
T_{STG}, Power Dissipation		- 65~+ 150℃
T_{JA}, Maximum Junction Temperature		150℃
T_{LEAD}, Lead Temperature (Soldering, 1 0 sec)		260℃
ESD, ESD Susceptibility (Human Body Model)		2000V

Stresses above may 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 in the Electrical Characteristics are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

*If the TO-263-5 package is used, the thermal resistance can be reduced by increasing the PC board copper area thermally connected to the package. Using 0.5 square inches of copper area, θ_{JA} is 50°C/W, with 1 square inch of copper area, θ_{JA} is 37°C/W, and with 1.6 or more square inches of copper area, θ_{JA} is 32°C/W.

RECOMMENDED OPERATING CONDITIONS

	MIN.	MAX.	Units
V_{IN}, Supply Voltage	7	37	V
T_{OPR}, Operating Temperature Range	-40	125	℃

ELECTRICAL CHARACTERISTICS

T_A=25℃, unless otherwise specified

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Device Parameters						
Feedback Bias Current	Ib	Adjustable version only, V_{OUT} = 5V		50	100	nA
Oscillator Frequency	fo	(Note 7)	47	52	58	kHz
Saturation Voltage	V_{SAT}	I_{OUT} = 3 A (Note:3)		1.4	1.8	V
Max. Duty Cycle (ON)	DC	(Note 7)	93	98		%
Current Limit	I_{CL}	(Note 4, 6)	3.5	5.8	7.5	A
Output Leakage Current	I_L	Output= 0V (Note 5,6)			2	mA
		Output= -1V		7.5	30	mA
Quiescent Current	I_Q	(Note 5)		5	10	mA
Standby Quiescent Current	I_{STBY}	pin = 5V (OFF)		50	200	μA
$\overline{ON}$/OFF Control						
$\overline{ON}$/ OFF Pin Logic Input Level	V_{IH}	V_{OUT} = 0V	1.4	2.0	2.2	V
	V_{IL}	V_{OUT} = nominal output voltage	0.8	1.0	1.2	V
$\overline{ON}$/ OFF Pin Input Current	I_{IH}	$\overline{ON}$/ OFF pin = 5V (OFF)		12	30	μA
	I_{IL}	$\overline{ON}$/ OFF pin = 0V (ON)		0	10	μA
A7576 - 3. 3V						
Output Voltage	V_{OUT}	V_{IN} = 12V, I_O = 500mA	3.234	3.300	3.366	V
		6V≤V_{IN} ≤ 40V 0.5A ≤ I_{LOAD} ≤ 3A	3.168	3.300	3.432	V
Efficiency	η	V_{IN} = 12V, I_{LOAD} = 3A		75		%

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
A7576 - 5. 0V						
Output Voltage	V_{OUT}	V_{IN} =12V, I_O = 500mA	4 .900	5.000	5.100	V
		8V≤V_{IN}≤ 40V 0.5A ≤ I_{LOAD} ≤ 3A	4 .750	5.000	5 .250	V
Efficiency	η	V_{IN} = 12V, I_{LOAD} = 3A		77		%
A7576 - 12V						
Output Voltage	V_{OUT}	V_{IN} = 25V, I_O = 500mA	11.760	12.000	12.240	V
		15V ≦ V_{IN} ≦ 40V, 0.5A ≦ I_{LOAD}≦ 3A	11.400	12.000	12.660	V
Efficiency	η	V_{IN} = 12V, I_{LOAD} = 3A		88		%
A7576 - 15V						
Output Voltage	V_{OUT}	V_{IN} = 25V, I_O = 500mA	14.700	15.000	15.300	V
		18V ≦ V_{IN} ≦ 40V, 0.5A ≦ I_{LOAD}≦ 3A	14.250	15.000	15.750	V
Efficiency	η	V_{IN} = 18V, I_{LOAD} = 3A		88		%
A7576 - ADJ						
Feedback voltage	V_{OUT}	V_{IN} = 12V, I_O = 500mA, V_{OUT} = 5V	1.217	1.230	1.243	V
		8V≤V_{IN} ≤ 40V, V_{OUT} = 5V 0. 5A ≤ I_{LOAD} ≤ 3A	1.180	1.230	1.280	V
Efficiency	η	V_{IN} = 12V, LOAD = 3A, V_{OUT} = 5V		77		%

Note:

1. Absolute maximum ratings indicate limits beyond which the device may be damaged. Operating ratings indicate that the device should be able to operate under these conditions, but the specified performance is not guaranteed.

Limit value. For guaranteed specifications and test conditions, see Electrical Characteristics.

2. External components such as diodes, inductors, input and output capacitors will affect the performance of the switching regulator system. When the A7576 is applied to the test circuit shown in Figure 2, the system

It can be shown as the system parameters section in the white gas characteristics.

3. Output source current. There are no diodes, inductors or capacitors connected to the output pins.

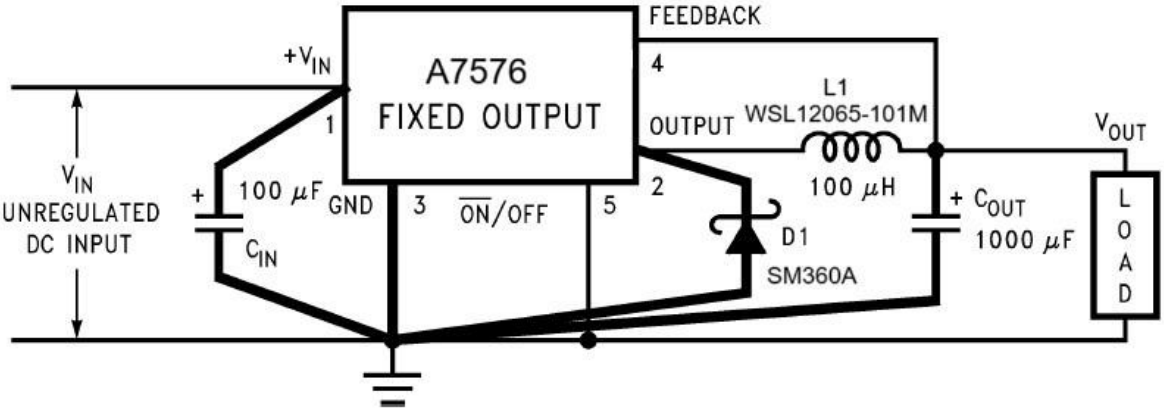
4. Disconnect the feedback pin from the output and connect it to 0V.

5. Disconnect the feedback pin from the output and connect it to +12V for adjustable models and 3.3V, 5.0V models, and to +25V for 12V, 15V models, so that the output transistor is "cut off".

6. V_{IN}=40V (60V for high voltage model).

7. When the output is short-circuited or overloaded, the regulated output voltage will drop by about 40% of the nominal output voltage. At this time, the oscillation frequency drops to about 11kHz. This self-protection feature reduces the minimum duty cycle from 5% to about 2% to reduce the average loss of the integrated circuit.

Fig 1. Fixed Output Voltage Versions



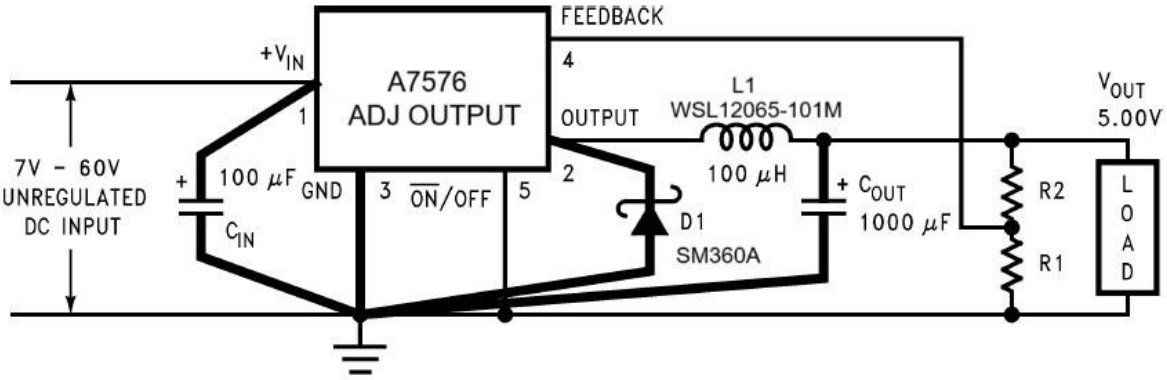
C_{IN}= 100 µF, 75V, Aluminum Electrolytic

C_{OUT} — 1000 µF, 25V, Aluminum Electrolytic

D1 — Schottky, SM360A or high current SM560A

L1 — 100 µH, WSL12065-101M or higher current inductor

Fig 2. Adjustable Output Voltage Versions



Where V_{REF}=1.23V ; 1KΩ≦R1≦5KΩ $V_{OUT}=V_{REF}(1+R2/R1)$; $R2=R1(V_{OUT}/V_{REF}-1)$

C_{IN}= 100 µF, 75V, Aluminum Electrolytic

C_{OUT} — 1000 µF, 25V, Aluminum Electrolytic

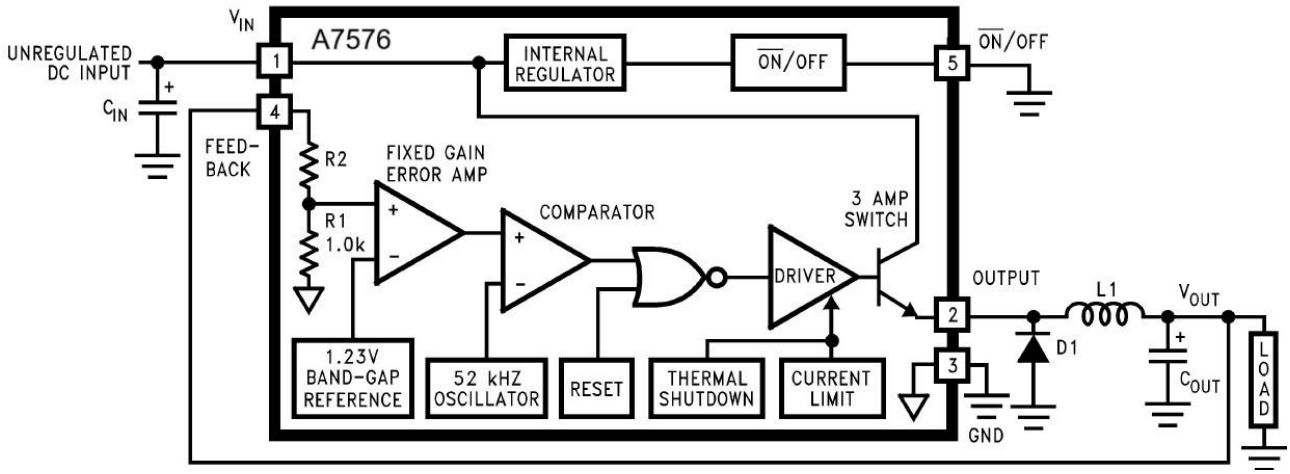
D1 — Schottky, SM360A or high current SM560A

L1 — 100 µH, WSL12065-101M or higher current inductor

R1 — 2k, 0.1%

R2 — 6.12k, 0.1%

BLOCK DIAGRAM



DETAILED INFORMATION

Input Capacitor (CIN)

To maintain stability, the regulator input pin must be bypassed with at least a 100μF electrolytic capacitor. The capacitor's leads must be kept short and located near the regulator. If the operating temperature range includes temperatures below - 25°C, the input capacitor value may need to be larger. With most electrolytic capacitors, the capacitance value decreases and the ESR increases with lower temperatures and age.

Paralleling a ceramic or solid tantalum capacitor will increase the regulator's stability at cold temperatures.

Inductor Selection

All switching regulators have two basic modes of operation: continuous and discontinuous. The difference between the two types relates to the inductor current, whether it is flowing continuously or if it drops to zero for a period of time in the normal switching cycle. Each mode has distinctively different operating characteristics, which can affect the regulator's performance and requirements. The A7576 can be used for both continuous and discontinuous modes of operation.

When using inductor values shown in the inductor's selection guide, the peak-to-peak inductor ripple current will be approximately 20% to 30% of the maximum DC.

With relatively heavy load currents, the circuit operates continuously (inductor current always flowing). Still, under light load conditions, the circuit will be forced to the discontinuous mode (inductor current falls to zero for some time). This discontinuous mode of operation is perfectly acceptable. For light loads (less than approximately 300mA) it may be desirable to operate the regulator in the discontinuous mode, primarily because of the lower inductor values required for the discontinuous mode. The selection guide chooses inductor values suitable for continuous mode operation, but if the inductor value chosen is

Prohibitively high, the designer should investigate the possibility of discontinuous operation.

This type of construction makes for an inexpensive inductor, but since the magnetic flux is not completely contained within the core, it generates more electromagnetic interference (EMI). This EMI can cause problems in sensitive circuits or can give incorrect scope readings because of induced voltages in the scope probe.

An inductor should not be operated beyond its maximum rated current because it may saturate. When an inductor begins to saturate, the inductance decreases rapidly, and the inductor begins to look mainly resistive (the DC resistance of the winding). This will cause the switch current to rise very rapidly. Different inductor types have different saturation characteristics, and this should be kept in mind when selecting an inductor. The inductor manufacturer's data sheets include current and energy limits to avoid inductor saturation.

Inductor Ripple Current

When the switcher is operating in continuous mode, the inductor current waveform ranges from a triangular to a sawtooth type of waveform (depending on the input voltage). For a given input voltage and output voltage, the peak-to-peak amplitude of this inductor current waveform remains constant. As the load current rises or falls, the entire sawtooth current waveform also rises or falls. The average DC value of this waveform is equal to the DC load current (in the buck regulator configuration). If the current load drops to a low enough level, the bottom of the sawtooth current waveform will reach zero, and the switcher will change to a discontinuous mode of operation.

This is a perfectly acceptable mode of operation. Any buck switching regulator (no matter how large the inductor value is) will be forced to run discontinuously if the load current is light enough.

Catch Diode

Buck regulators require a diode to provide a return path for the inductor current when the switch is off. This diode should be located close to the A7576 using short leads and short printed circuit traces. Because of their fast-switching speed and low forward voltage drop, Schottky diodes provide the best efficiency, especially in low-output-voltage switching regulators (less than 5V).

Fast-Recovery, High-Efficiency, or Ultra-Fast-Recovery diodes are also suitable, but some types with an abrupt turn-off characteristic may cause instability and EMI problems. A fast recovery diode with soft recovery characteristics is a better choice. Standard 60 Hz diodes (e.g., 1N4001 or 1N5400, etc.) are also not suitable.

Output Capacitor

An output capacitor is required to filter the output voltage and is needed for loop stability. The capacitor should be located near the A7576 using short pc board traces. Standard aluminum electrolytic are usually adequate, but low E SR types are recommended for low output ripple voltage and good stability. The ESR of a capacitor depends on many factors, some of which are: the value, the voltage rating, physical size, and the type of construction. In general, low-value or low-voltage (less than 12V) electrolytic capacitors usually have a higher ESR number.

The amount of output ripple voltage is primarily a function of the ESR (Equivalent Series Resistance) of the output capacitor and the amplitude of the inductor ripple current (ΔI_{IND}). See the section on inductor ripple current in Application Hints. The lower capacitor values (220μF – 1000μF) will allow typically 50mV to 150mV of output ripple voltage, while larger-value capacitors will reduce the ripple to approximately 20mV to 50mV. Output Ripple Voltage = (ΔI_{IND}) (ESR of C_{OUT}). To further reduce the output ripple voltage, several standard

electrolytic capacitors may be paralleled, or a higher-grade capacitor may be used. Such capacitors are often called “high-frequency,” “low-inductance,” or “low-ESR.” These will reduce the output ripple to 10 mV or 20 mV.

However, when operating in continuous mode, reducing the ES R below 0.03Ω can cause instability in the regulator. Tantalum capacitors can have a very low ESR and should be carefully evaluated if it is the only output capacitors. Because of their good low-temperature characteristics, tantalum can be used in parallel with aluminum electrolytics, with the tantalum making up 10 % or 20 % of the total capacitance. The capacitor’s ripple current rating at 52 kHz should be at least 50 % higher than the peak-to-peak inductor ripple current.

Output Voltage Ripple and Transients

The output voltage of a switching power supply will contain a sawtooth ripple voltage at the switcher frequency, typically about 1% of the output voltage, and may also contain short voltage spikes at the peaks of the sawtooth waveform. The output ripple voltage is due mainly to the inductor sawtooth ripple current multiplied by the ES R of the output capacitor. The voltage spikes are present because of the fast-switching action of the output switch and the parasitic inductance of the output filter capacitor. To minimize these voltage spikes, special low-inductance capacitors can be used, and their lead lengths must be kept short. Wiring inductance, stray capacitance, as well as the scope probe used to evaluate these transients all contribute to the amplitude of these spikes. An additional small LC filter (20 μH & 100 μF) can be added to the output to further reduce the amount of output ripple and transients. A 10x reduction in output ripple voltage and transients is possible with this filter.

Feedback Connection

The A7576 (fixed voltage versions) feedback pin must be wired to the output voltage point of the switching power supply. When using the adjustable version, physically locate both output voltage programming resistors near the A7576 to avoid picking up unwanted noise.

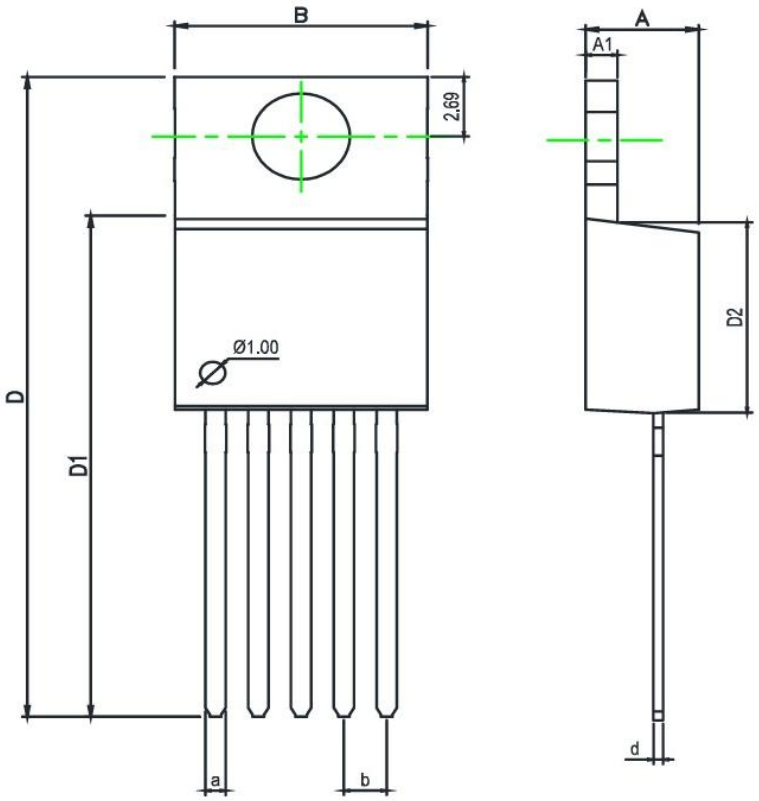
Avoid using resistors greater than 100kΩ because of the increased chance of noise pickup.

$\overline{\text{ON}}$/ OFF Input

For normal operation, the $\overline{\text{ON}}$/ OFF pin should be grounded or driven with a low-level TTL voltage (typically below 1.6V). To put the regulator into standby mode, drive this pin with a high-level TTL or C MOS signal. The to + V_{IN} without a resistor in series with it. The be left open.

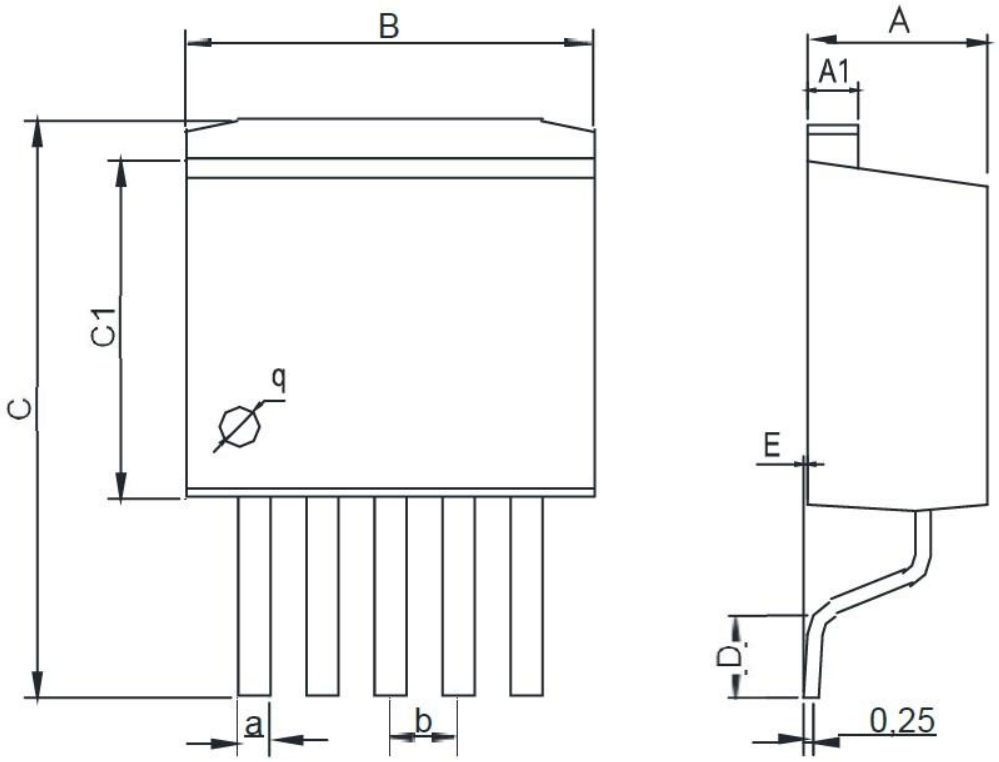
PACKAGE INFORMATION

Dimension in TO-220 (Unit: mm)



Symbol	Min.	Max.
A	4.52	4.62
A1	1.25	1.29
B	10.00	10.30
D	28.20	28.90
D1	22.40	22.60
D2	8.69	8.79
a	1.68	1.77
d	0.33	0.42
b	1.70 BSC	

Dimension in TO-263-5 (Unit: mm)



Symbol	Min.	Max.
A	4.45	4.62
A1	1.22	1.32
B	10.00	10.40
C	13.70	14.60
C1	8.40	8.90
D	1.90	2.10
E	0	0.20
a	0.71	0.97
b	1.70 BSC	

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