



150kHz, 3A PWM Buck DC/DC Converter

Features

- Output voltage: Fixed 3.3V, 5V, 12V and adjustable output (1.23V to 38.5V) versions.
- Fixed switching frequency, 150KHz $\pm 15\%$.
- Voltage mode non-synchronous PWM control.
- Thermal-shutdown and current-limit protection.
- ON/OFF shutdown control input.
- Short Circuit Protection (SCP).
- Operating voltage up to 40V.
- Output load current up to 3A.
- Low-power standby mode.
- Built-in switching transistor on chip.
- 5-Lead TO-263 and TO-220 packages.
- RoHS-compliant, halogen-free.

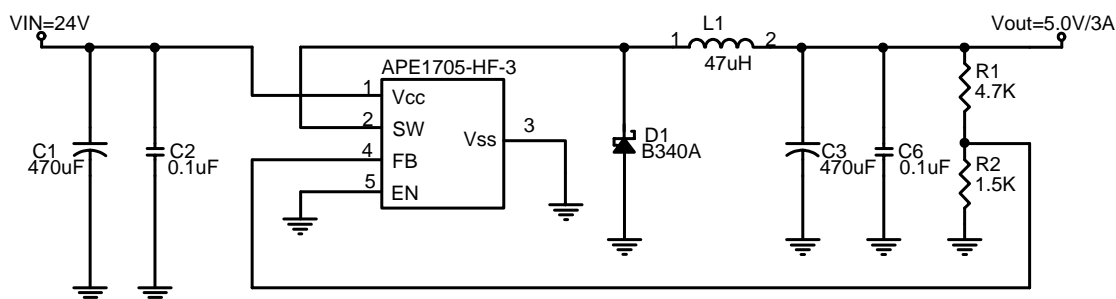
Description

The APE1705-HF-3 series consists of step-down DC-DC converters with the ability to drive a 3A load without an external switching transistor, saving board space.

The external shutdown function can be controlled by logic level signals to put the device in standby mode. The internal compensation allows feedback control for good line and load regulation without external components. Thermal shutdown protection prevents damage from excessive operating temperatures and output current limiting protects the device from damage. Excess current when VFB is below 0.5V results in reduced switching frequency. The APE1705-HF-3 series operate at a switching frequency of 150kHz, allowing smaller sized filter components than with lower frequencies. Output voltage has a guaranteed $\pm 4\%$ tolerance under specified input voltage and output load conditions, and a tolerance on the switching frequency of $\pm 15\%$.

The APE1705-HF-3 series are available with an adjustable output voltage, or fixed output voltages of 3.3V, 5V or 12V, and are supplied in either a 5-lead TO-263 or 5-lead TO-220 package.

Typical Application



Ordering information

| APE1705X-XX-HF-3TX | | Packing Type: |
|--------------------|-----------------|---|
| Package Type: | Output Voltage: | TR: Tape and reel for TO263-5L TB: Tubes for TO220-5L, 5LR |
| S: TO263-5L | 33: 3.3V | |
| P: TO220-5L | 50: 5.0V | |
| PR: TO220-5LR | 12: 12V | |
| | Blank: ADJ | |

Examples:

APE1705S-33-HF-3TR 3.3V fixed output in RoHS-compliant, halogen-free TO-263-5L, shipped on tape and reel (800 pcs/reel).

APE1705PR-HF-3TB adjustable output in RoHS-compliant, halogen-free TO-220-5LR, shipped in tubes.



Absolute Maximum Ratings (at $T_A = 25^\circ\text{C}$)

| Characteristics | Symbol | Rating | Unit |
|--|------------|--------------------------|--------------------|
| Maximum Supply Voltage | V_{CC} | +45 | V |
| ON/OFF Pin Input Voltage | V_{EN} | -0.3 to 40 | V |
| Feedback Pin Voltage (for ADJ version) | V_{FB} | -0.3 to 20 | V |
| Output Voltage to Ground (for Fixed version) | V_{OUT} | 0.7 to 45 | V |
| Power Dissipation Internally limited | PD | $(T_J - T_A) / R_{thJA}$ | W |
| Storage Temperature Range | T_{ST} | -65 to +150 | $^\circ\text{C}$ |
| Operating Temperature Range | T_{OP} | -40 to +125 | $^\circ\text{C}$ |
| Operating Supply Voltage | V_{OP} | +4.5 to +40 | V |
| Thermal Resistance from Junction to case | R_{thJC} | 3.5 | $^\circ\text{C/W}$ |
| Thermal Resistance from Junction to ambient | R_{thJA} | 25 | $^\circ\text{C/W}$ |

Note: R_{thJA} is measured with a PCB copper area (must be connected to V_{SS} pins) of approximately 3 in² (Multi-layer).

Electrical Characteristics

(Unless otherwise specified, $T_A=25^\circ\text{C}$, $V_{CC}=12\text{V}$ for 3.3V, 5V, adjustable version and $V_{CC}=18\text{V}$ for the 12V version. $I_{LOAD} = 0.2\text{A}$)

| Characteristics | Symbol | Conditions | Min | Typ | Max | Units |
|--|------------------------|--|-----|-------|-------------|------------------|
| Quiescent Current | I_{CCQ} | $V_{FB}=12\text{V}$ force driver off | | 4 | 8 | mA |
| Feedback bias current | I_{FB} | $V_{FB}=1.3\text{V}$ (Adjustable version only) | | -10 | -50 -100 | nA |
| Shutdown supply Current | I_{SD} | EN pin=5V $V_{CC}=40\text{V}$ | | 100 | 200 300 | uA |
| Oscillator frequency | F_{OSC} | | 127 | 150 | 173 | kHz |
| Oscillator frequency during short circuit protection | F_{SCP} | (Adjustable) When $V_{FB}<0.5\text{V}$ | | 60 | | kHz |
| | | (Fixed) When $< V_{OUT} \times 40\%$ | | 60 | | kHz |
| Max. Duty Cycle (ON) | DC | $V_{FB}=0\text{V}$ force driver on | | 100 | | % |
| Min. Duty Cycle (OFF) | | $V_{FB}=12\text{V}$ force driver off | | 0 | | |
| Current limit | I_{CL} | Peak current, no outside circuit $V_{FB}=0\text{V}$ force driver on | 3.5 | | | A |
| Load Regulation($\Delta V_{OUT}/V_{OUT}$) | ΔV_{OUT} | $I_{OUT} = 0.2$ to 3A | - | 0.6 | 1.2 | % |
| Saturation voltage | V_{SAT} | $I_{OUT}=3\text{A}$, no outside circuit $V_{FB}=0\text{V}$ force driver on | | 1.3 | 1.4 1.5 | V |
| SW pin=0V | SW pin leakage current | I_{SWL} No outside circuit $V_{FB}=12\text{V}$ force driver off | | | -200 | uA |
| SW pin=-0.8V | | | | -5 | | mA |
| EN pin logic input threshold voltage | V_{IL} | Low (regulator ON) | - | 1.3 | 0.6 | V |
| | V_{IH} | High (regulator OFF) | 2.0 | | - | |
| EN pin logic input current | I_H | $V_{EN}=2.5\text{V}$ (OFF) | | -0.1 | -5 | uA |
| EN pin input current | I_L | $V_{EN}=0.5\text{V}$ (ON) | | -0.01 | -1 | |
| Thermal shutdown Temp | TSD | | | 135 | | $^\circ\text{C}$ |



Electrical Characteristics (cont.)

| version | Characteristics | Symbol | Conditions | Min | Typ | Max | Units |
|--------------|-------------------------|-----------|--|-----------------|------|-----------------|-------|
| APE1705-ADJ | Output Feedback voltage | V_{FB} | $4.5V < V_{CC} < 40V$ $0.2A < I_{LOAD} < 3A$ V_{OUT} programmed for 3V | 1.193 /1.180 | 1.23 | 1.267 /1.280 | V |
| | Efficiency | η | $V_{CC} = 12V, I_{LOAD}=3A$ | | 74 | | % |
| APE1705-3.3V | Output voltage | V_{OUT} | $4.75V < V_{CC} < 40V$ $0.2A < I_{LOAD} < 3A$ | 3.168 /3.135 | 3.3 | 3.432 /3.465 | V |
| | Efficiency | η | $V_{CC} = 12V, I_{LOAD}=3A$ | | 75 | | % |
| APE1705-5.0V | Output voltage | V_{OUT} | $7V < V_{CC} < 40V$ $0.2A < I_{LOAD} < 3A$ | 4.80 /4.75 | 5.0 | 5.20 /5.25 | V |
| | Efficiency | η | $V_{CC} = 12V, I_{LOAD}=3A$ | | 80 | | % |
| APE1705-12V | Output voltage | V_{OUT} | $15V < V_{CC} < 40V$ $0.2A < I_{LOAD} < 3A$ | 11.52 /11.40 | 12 | 12.48 /12.60 | V |
| | Efficiency | η | $V_{CC} = 24V, I_{LOAD} = 3A$ | | 89 | | % |

THIS PRODUCT IS SENSITIVE TO ELECTROSTATIC DISCHARGE, PLEASE HANDLE WITH CAUTION.

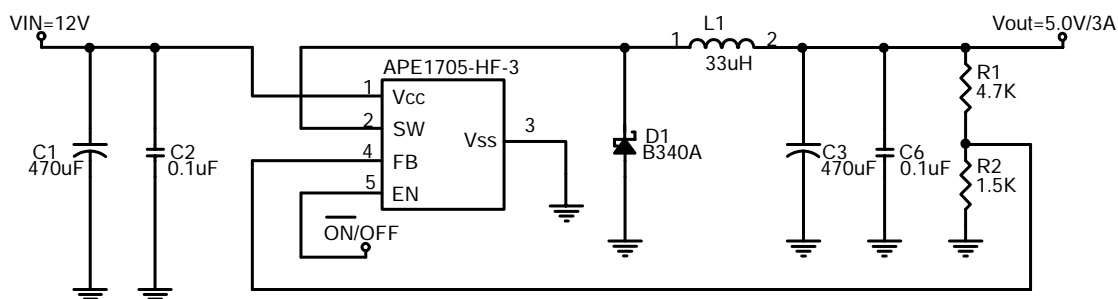
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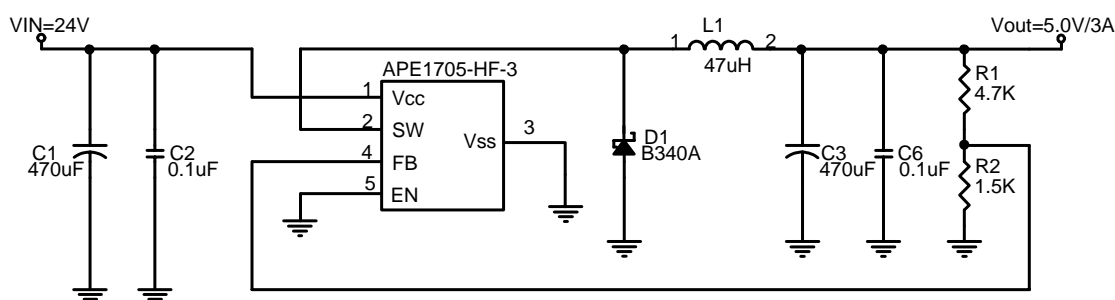


Typical Application Circuits

(1) $V_{IN}=12V$



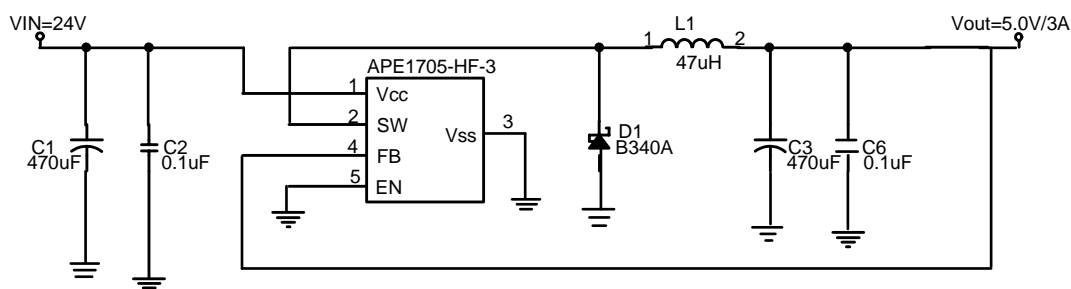
(2) $V_{IN}=24V$



$$V_{out} = V_{FB} \times \left(1 + \frac{R1}{R2}\right), V_{FB} = 1.23V, R2 = 0.7k\Omega \sim 3k\Omega$$

| V_{OUT} | $R2$ | $R1$ |
|-----------|------|------|
| 5.0V | 1.5k | 4.7k |
| 3.3V | 1.5k | 2.5k |
| 2.5V | 1.5k | 1.5k |

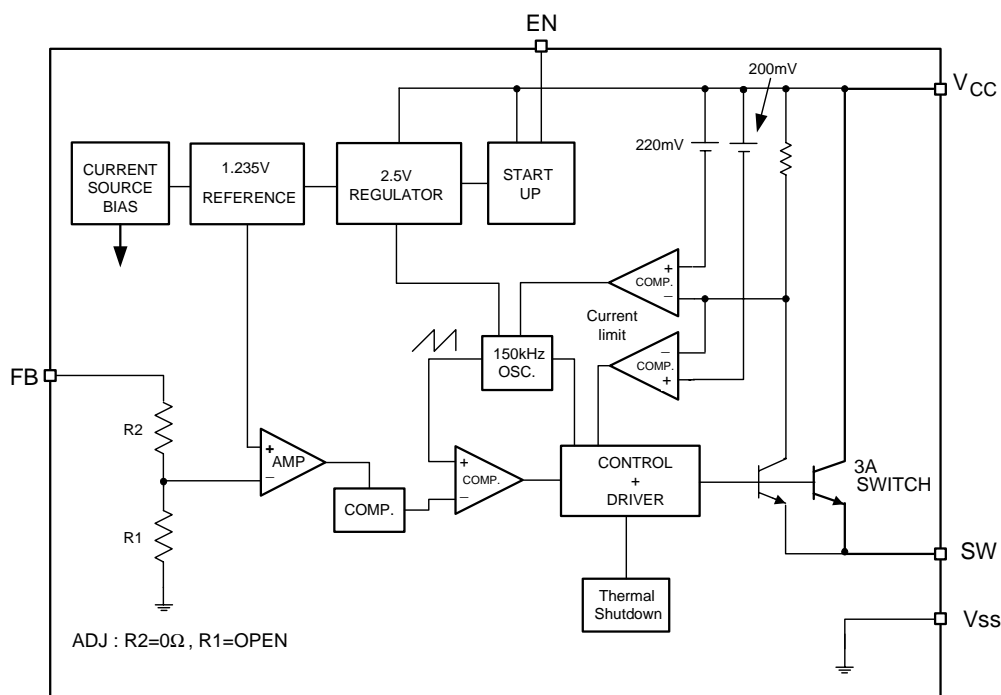
(3) Fixed Output Voltage Version



| L1 recommended values ($I_{OUT}=3A$) | | | | |
|--|------|------|---------|------|
| V_{OUT} | 2.5V | 3.3V | 5V | 12V |
| $V_{IN}=12V$ | 33uH | 33uH | 33~47uH | NA |
| $V_{IN}=24V$ | 33uH | 33uH | 47uH | 68uH |

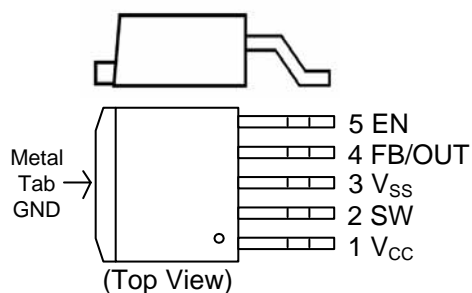


Block Diagram



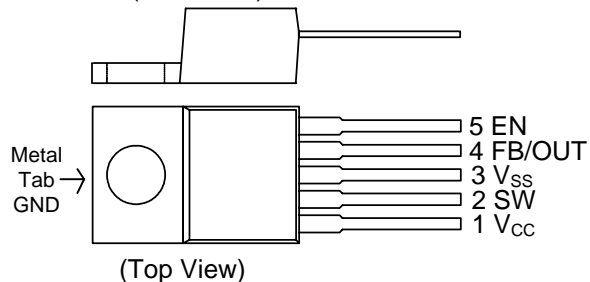
Pin Assignment

TO263-5L (Side View)

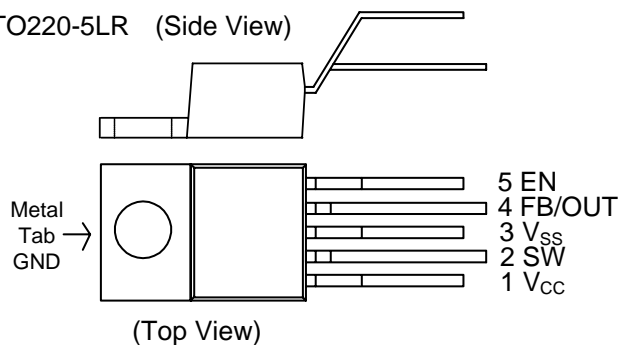


| Name | Description |
|-----------------|---|
| V _{CC} | Operating voltage input |
| SW | Switching output |
| V _{SS} | GND pin |
| FB | Output voltage feedback control for ADJ version |
| OUT | Output voltage feedback control |
| EN | ON/OFF Shutdown |

TO220-5L (Side View)



TO220-5LR (Side View)





Functional Description

Pin Functions

V_{CC}

This is the positive input supply for the IC switching regulator. A suitable input bypass capacitor must be present at this pin to minimize voltage transients and to supply the switching currents needed by the regulator.

V_{SS}

Circuit ground.

SW

Internal switch. The voltage at this pin switches between $(+V_{CC} - V_{SAT})$ and approximately $-0.5V$, with a duty cycle of approximately V_{OUT} / V_{CC} . To minimize coupling to sensitive circuitry, the PC board copper area connected to this pin should be minimized.

Feedback

Senses the regulated output voltage to complete the feedback loop.

EN

Allows the switching regulator circuit to be shutdown using logic level signals thus dropping the total input supply current to approximately 100uA. Pulling this pin below a threshold voltage of approximately 1.3V turns the regulator on, and pulling this pin above 1.3V (up to a maximum of V_{CC}) shuts the regulator down. If this shutdown feature is not needed, the EN pin can be wired to the ground pin.

Thermal Considerations

The TO-263-5L package needs a heat sink under most conditions. The size of the heat sink depends on the input voltage, the output voltage, the load current and the ambient temperature. The APE1705 junction temperature rises above ambient temperature for a 3A load and different input and output voltages.

The data for these curves was taken with the APE1705 (TO263-5L package) operating as a buck-switching regulator in an ambient temperature of 25°C (still air). These temperature increments are all approximate and are affected by many factors. Higher ambient temperatures require more heatsinking.



Functional Description (cont.)

For the best thermal performance, wide copper traces and generous amounts of printed circuit board copper (needs to be connected to the Vss pins) should be used in the board layout, (One exception is the SW(switch) pin, which should not have large areas of copper.) Large areas of copper provide the best transfer of heat (lower thermal resistance) to the surrounding air, and moving air lowers the thermal resistance even further.

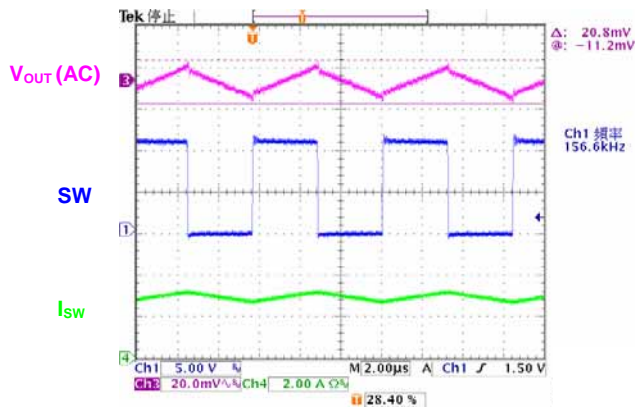
Package thermal resistance and junction temperature increments are all approximate. The increments are affected by a lot of factors. Some of these factors include board size, shape, thickness, position, location, and even board temperature. Other factors are: trace width, total printed circuit copper area, copper thickness, single or double-sided, multi-layer board and the amount of solder on the board.

The effectiveness of the PC board to dissipate heat also depends on the size, quantity and spacing of other components on the board, as well as whether the surrounding air is still or moving. Furthermore, some of these components such as the catch diode will add heat to the PC board and the heat can vary as the input voltage changes. For the inductor, depending on the physical size, type of core material and the DC resistance, it could either act as a heat sink taking heat away from the board, or it could add heat to the board.

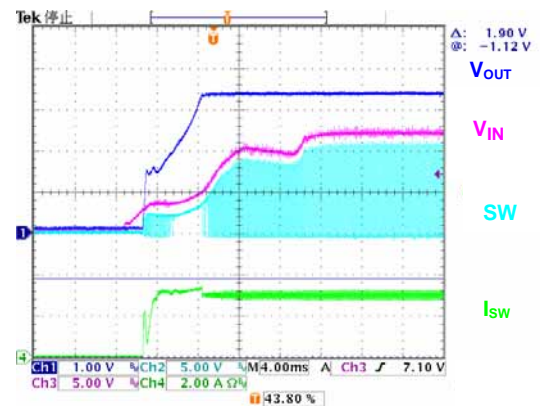


Typical Characteristics

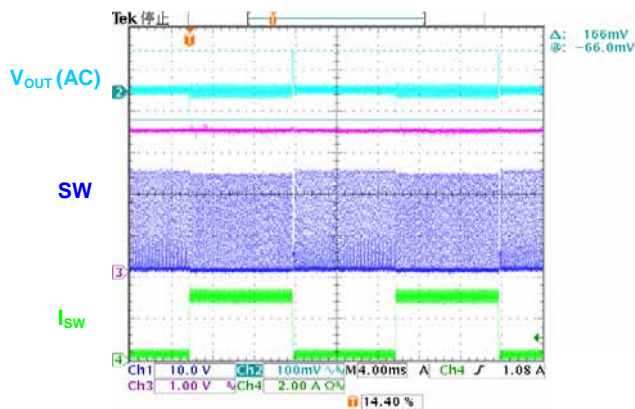
Output Ripple
($V_{IN}=12V$, $V_{OUT}=5V$, $I_{OUT}=3A$)



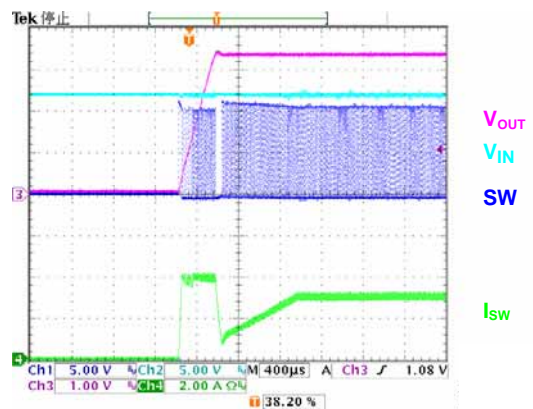
Power on test wave
($V_{IN}=12V$, $V_{OUT}=5V$, $I_{OUT}=3A$)



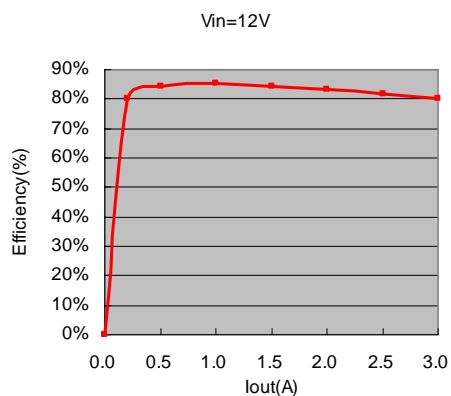
Load Transient Response
($V_{IN}=12V$, $V_{OUT}=5V$, $I_{OUT}=0.2\sim 3A$)



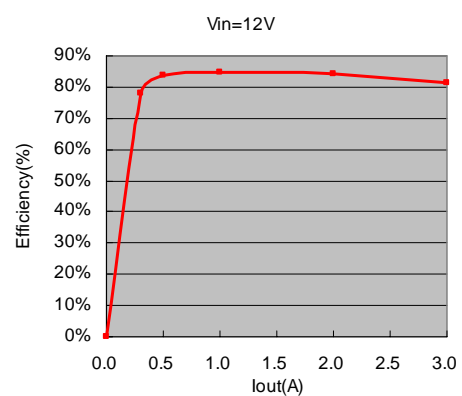
EN on test wave
($V_{IN}=12V$, $V_{OUT}=5V$, $I_{OUT}=3A$)



Efficiency
($V_{IN}=12V$, $V_{OUT}=5.0V$)

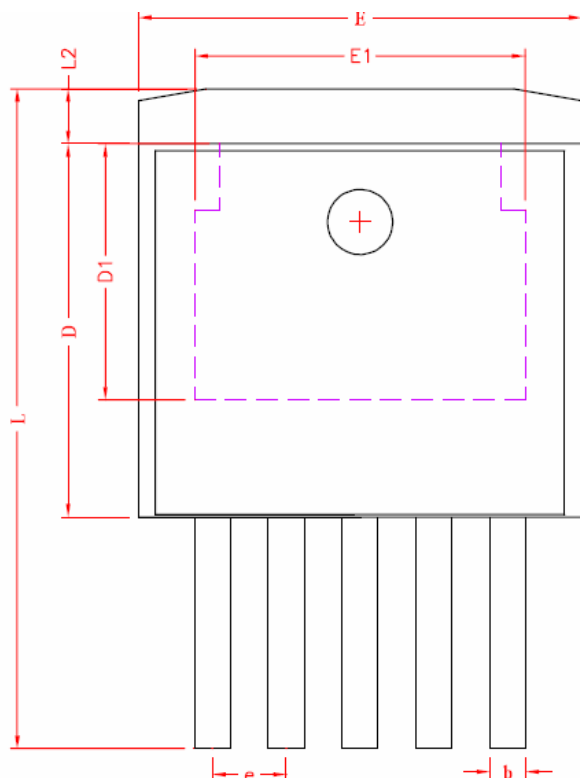


Efficiency
($V_{IN}=24V$, $V_{OUT}=5.0V$)

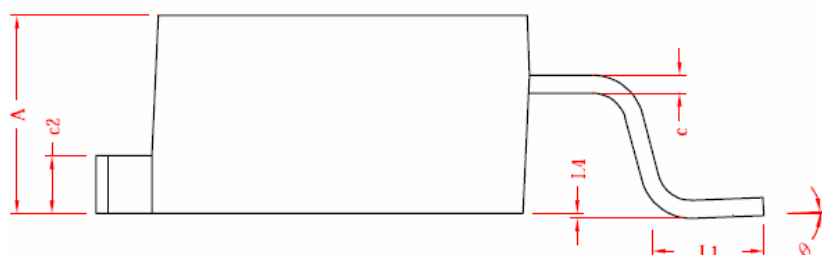




Package Dimensions: TO-263-5L

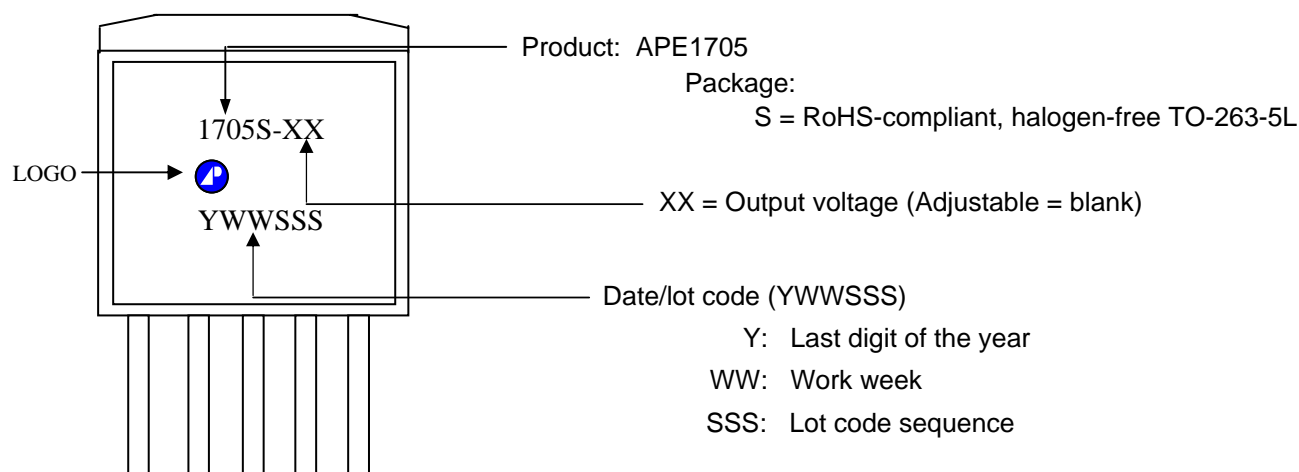


| SYMBOLS | Millimeters | | |
|----------|-------------|-------|-------|
| | MIN | NOM | MAX |
| A | 4.40 | 4.60 | 4.80 |
| b | 0.66 | 0.79 | 0.91 |
| L4 | 0.00 | 0.15 | 0.30 |
| c | 0.36 | 0.43 | 0.50 |
| L1 | 2.29 | 2.54 | 2.79 |
| E | 9.80 | 10.10 | 10.40 |
| E1 | 7.60 | | |
| c2 | 1.25 | 1.35 | 1.45 |
| L2 | 1.27 | | |
| D | 8.60 | 8.80 | 9.00 |
| D1 | 5.90 | | |
| e | 1.70 | | |
| L | 14.60 | 15.20 | 15.80 |
| θ | 0° | 4° | 8° |



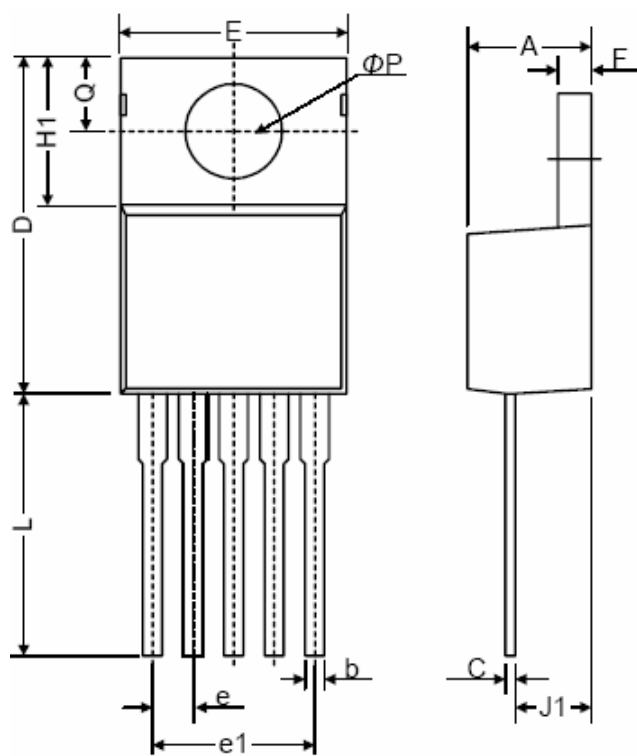
1. All dimensions are in millimeters.
2. Dimensions do not include mold protrusions.

Marking Information: TO-263-5L





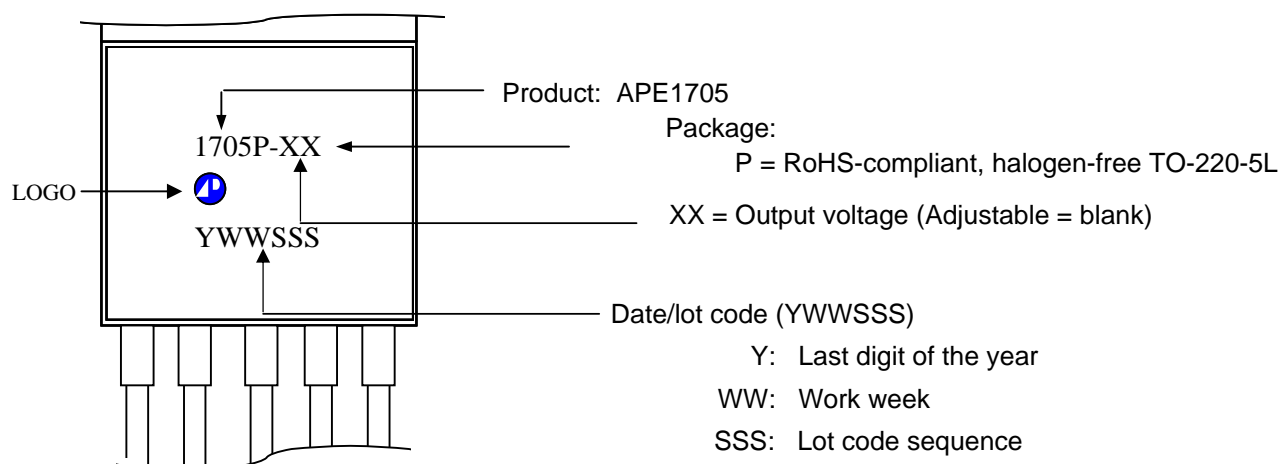
Package Dimensions: TO-220-5L



| SYMBOLS | Millimeters | | |
|----------|-------------|-------|-------|
| | MIN | NOM | MAX |
| A | 4.07 | 4.45 | 4.82 |
| b | 0.76 | 0.89 | 1.02 |
| C | 0.36 | 0.50 | 0.64 |
| D | 14.22 | 14.86 | 15.50 |
| E | 9.78 | 10.16 | 10.54 |
| e | 1.57 | 1.71 | 1.85 |
| e1 | 6.68 | 6.81 | 6.93 |
| F | 1.14 | 1.27 | 1.40 |
| H1 | 5.46 | 6.16 | 6.86 |
| J1 | 2.29 | 2.74 | 3.18 |
| L | 13.21 | 13.97 | 14.73 |
| ϕP | 3.68 | 3.81 | 3.94 |
| Q | 2.54 | 2.73 | 2.92 |

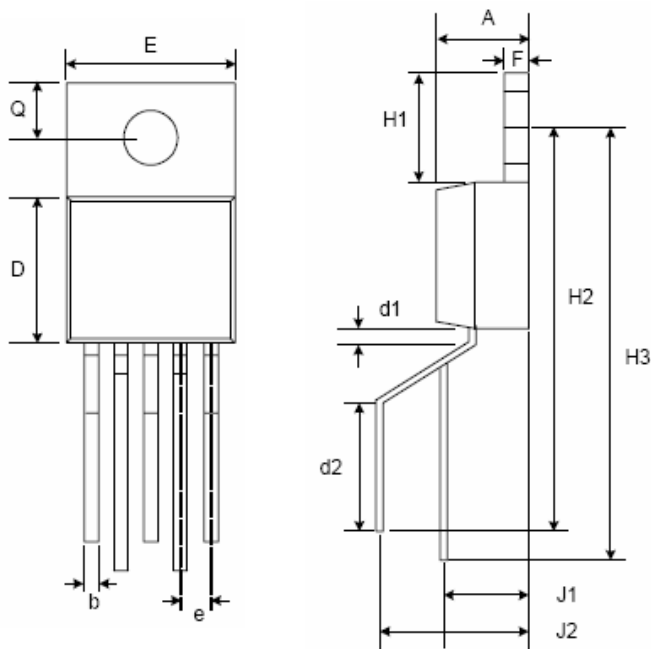
1. All dimensions are in millimeters.
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Marking Information: TO-220-5L

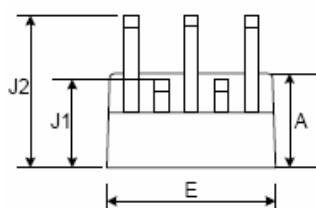




Package Dimensions: TO-220-5LR



| SYMBOLS | Millimeters | | |
|---------|-------------|-------|-------|
| | MIN | NOM | MAX |
| A | 4.40 | 4.6 | 4.70 |
| b | 0.70 | 0.80 | 0.90 |
| D | 8.40 | 8.70 | 8.90 |
| d1 | 1.00 | | |
| d2 | 6.30 | | |
| E | 9.91 | 10.16 | 10.41 |
| e | 1.60 | 1.70 | 1.80 |
| F | 1.20 | 1.25 | 1.30 |
| H1 | 6.40 | | |
| H2 | 20.8 | 21.60 | 22.4 |
| H3 | 23.90 | 24.70 | 25.50 |
| J1 | 3.7 | 4.50 | 5.3 |
| J2 | 8.40 | | |
| Q | 2.50 | 2.80 | 3.00 |



1. All dimensions are in millimeters.
2. Dimensions do not include mold protrusions.

Marking Information: TO-220-5LR

