150KHz, 3A PWM Buck DC/DC Converter

❖ GENERAL DESCRIPTION

The APE1705 series are monolithic IC designed for a step-down DC/DC converter, and own the ability of driving a 3A load without additional transistor. It saves board space. The external shutdown function can be controlled by logic level and then come into standby mode. The internal compensation makes feedback control having good line and load regulation without external design. Regarding protected function, thermal shutdown is to prevent over temperature operating from damage, and current limit is against over current operating of the output switch. If current limit function occurs and V_{FB} is down below 0.5V, the switching frequency will be reduced. The APE1705 series operates at a switching frequency of 150KHz thus allow smaller sized filter components than what would be needed with lower frequency switching regulators. Other features include a guaranteed ±4% tolerance on output voltage under specified input voltage and output load conditions, and ±15% on the oscillator frequency. The output version included fixed 3.3V, 5V, 12V, and an adjustable type. The chips are available in a 5-Lead TO-263 and 5-Lead TO-220 package.

❖ FEATURES

- Output voltage: 3.3V, 5V, 12V and adjustable output version.
- Adjustable version output voltage range, 1.23V to 38.5V.
- 150KHz ±15% fixed switching frequency.
- Voltage mode non-synchronous PWM control.
- Thermal-shutdown and current-limit protection.
- ON/OFF shutdown control input.
- Short Circuit Protect (SCP).
- Operating voltage can be up to 40V.
- Output load current: 3A.
- 5-Lead TO-263 and TO-220 Pb-Free packages.
- Low power standby mode.
- Built-in switching transistor on chip.

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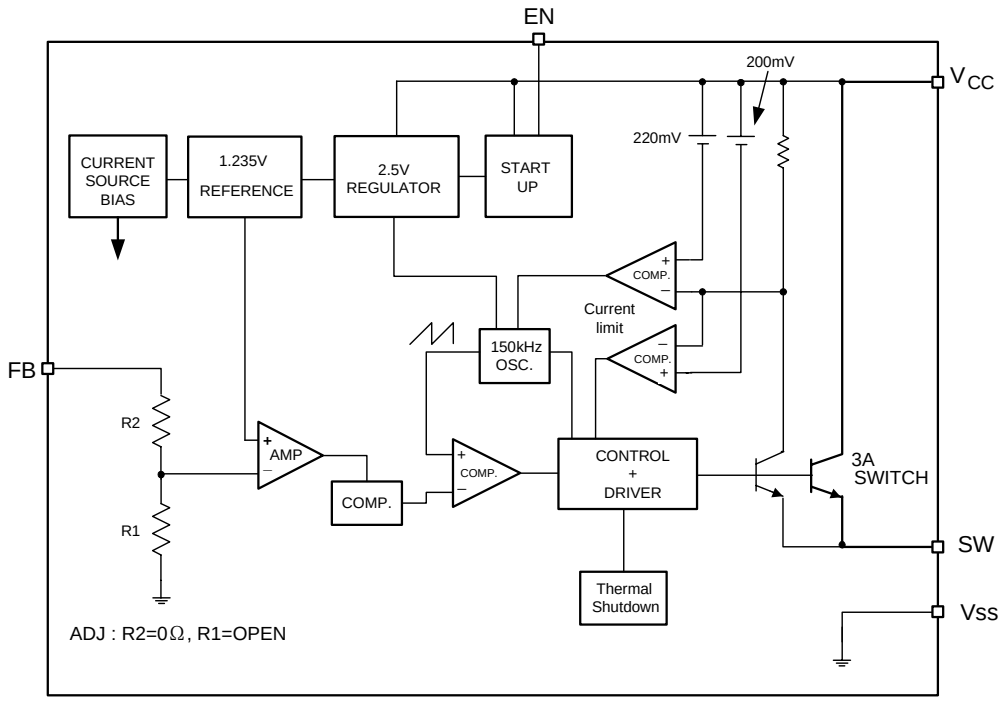
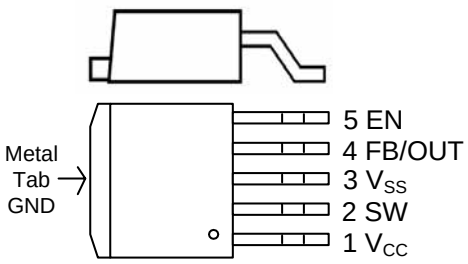
❖ BLOCK DIAGRAM



❖ PIN ASSIGNMENT

The package of APE1705 are TO263-5L and TO220-5L(R); the pin assignment is given by:

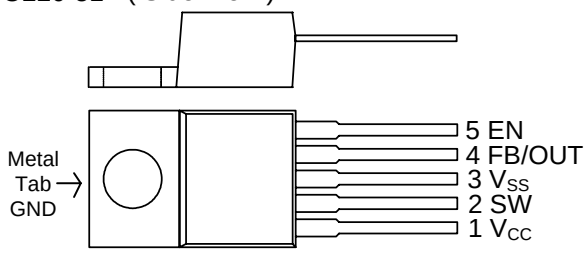
TO263-5L (Side View)



(Top View)

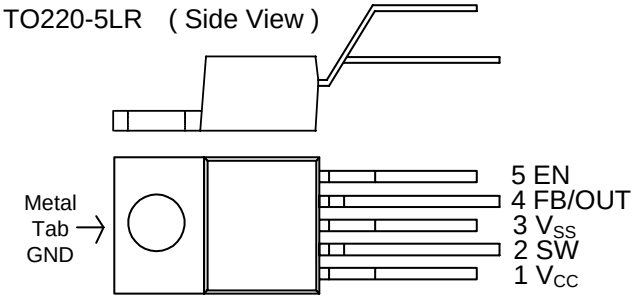
Name	Description
V_{CC}	Operating voltage input
SW	Switching output
V_{SS}	GND pin
FB	Output voltage feedback control for ADJ version
OUT	Output voltage feedback control
EN	ON/OFF Shutdown

TO220-5L (Side View)



(Top View)

TO220-5LR (Side View)



(Top View)

❖ ORDER INFORMATION

Order Information

APE1705X -XX

Package Type	Output Voltage
S: TO263-5L	33:3.3V
P :TO220-5L	50:5.0V
PR:TO220-5L-R	12: 12V
	Blank:ADJ

❖ MARKING INFORMATION

Top Marking

ADJ

1705X → Part number

YWWSSS → ID code: internal

WW: 01~52

Year : 6 = 2006

FIX

1705X → Part number

-50 → Output Voltage

YWWSSS → ID code: internal

WW: 01~52

Year : 6 = 2006

❖ Absolute Maximum Ratings

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	$(T_J-T_A) / \theta_{JA}$	W
Storage Temperature Range	T_{ST}	-65 to +150	°C
Operating Temperature Range	T_{OP}	-40 to +125	°C
Operating Supply Voltage	V_{OP}	+4.5 to +40	V
Thermal Resistance from Junction to case	θ_{JC}	TO263=3.5,TO220=3.5	°C/W
Thermal Resistance from Junction to ambient	θ_{JA}	TO263=25,TO220=25	°C/W

Note : θ_{JA} is measured with the PCB copper area(need connect to V_{SS} pins) of approximately 3 in^2 (Multi-layer).

❖ Electrical Characteristics (Unless otherwise specified, Ta=25°C, V_{CC}=12V for 3.3V, 5V, adjustable version and V_{CC}=18V for the 12V version. ILOAD = 0.2A)

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

❖ Electrical Characteristics (Continued)

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		%

Specifications with boldface type are for full operating temperature range, the other type are for TJ=25ºC.

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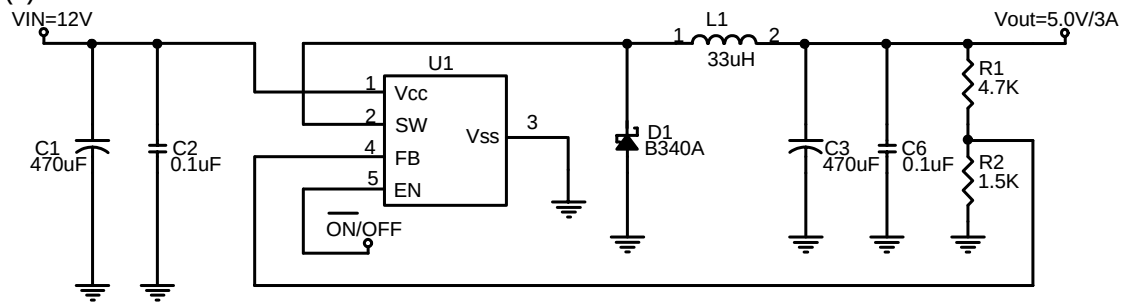
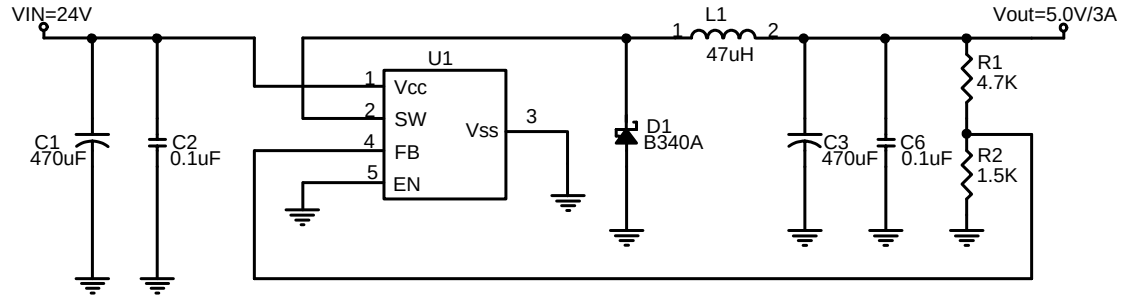
❖ Application Circuit

(1) VIN=12V



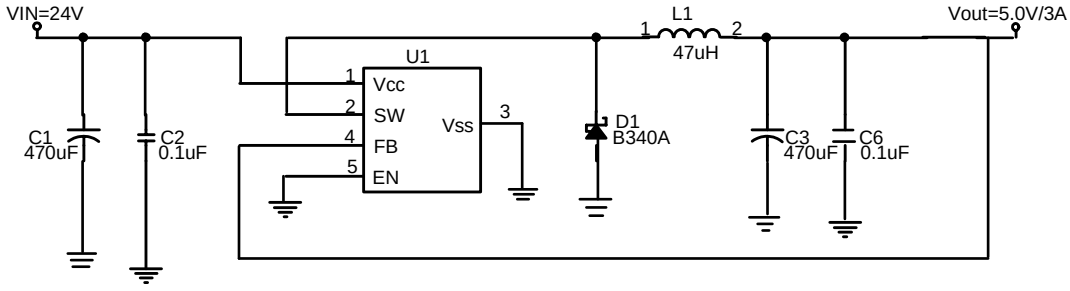
(2) VIN=24V



$$Vout = V_{FB} \times (1 + \frac{R1}{R2}),\ V_{FB} = 1.23V,\ R2 = 0.7K \sim 3K$$

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 recommend value (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

❖ Function Descriptions

Pin Functions

Vcc

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

Vss

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 Vcc) 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℃ (still air). These temperature increments are all approximate and are affected by many factors. Higher ambient temperatures requires more heat sinker.

❖ Function Descriptions (Continued)

For the best thermal performance, wide copper traces and generous amounts of printed circuit board copper (need connect to the V_{SS} 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.

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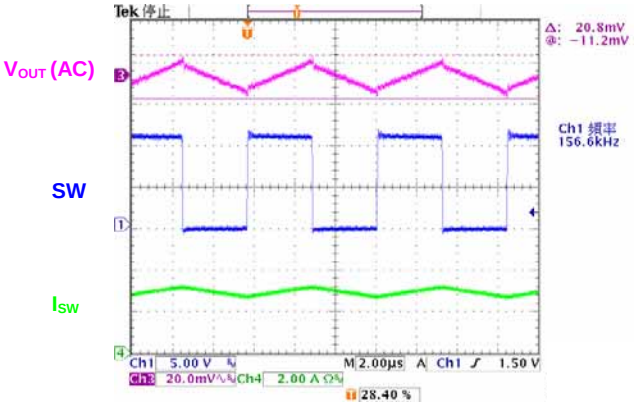
❖ Typical Characteristics

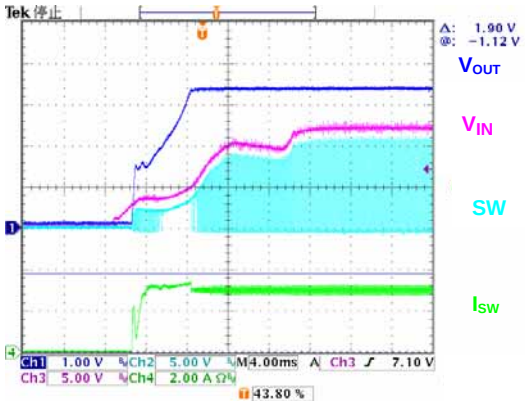
Output Ripple

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



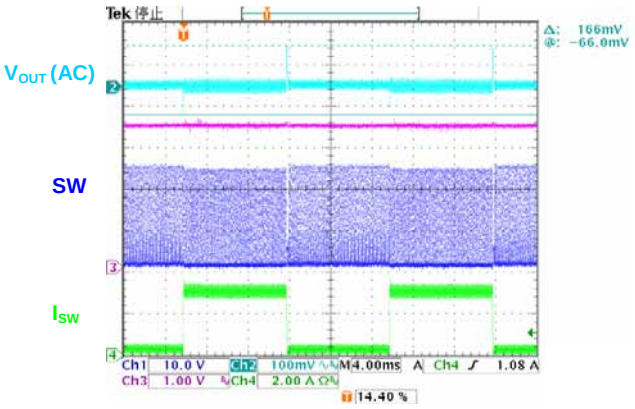
Power on test wave

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



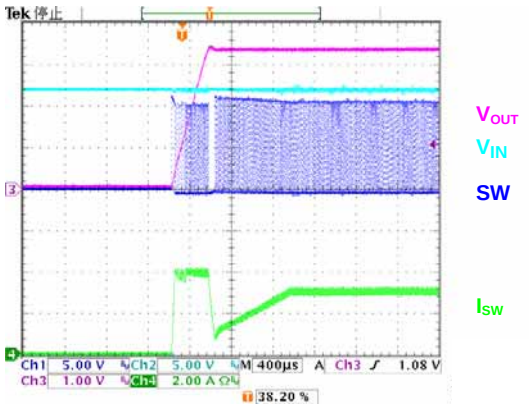
Load Transient Response

(V_{IN}=12V, V_{OUT}=5V, I_{OUT}=0.2~3A)



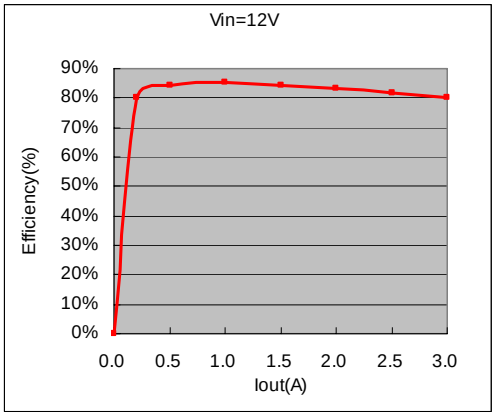
EN on test wave

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



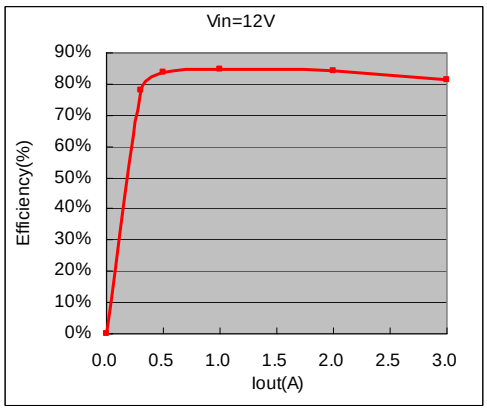
Efficiency

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

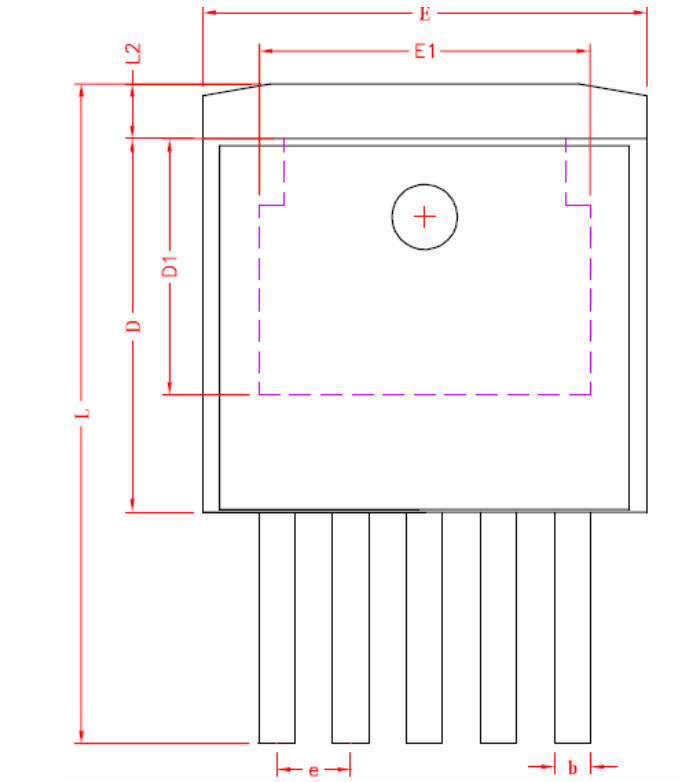


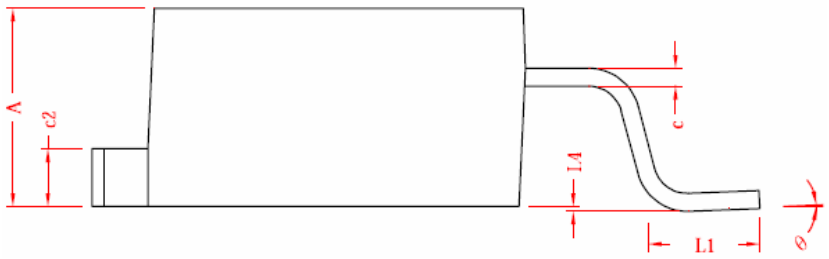
Efficiency

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



Package Outline : TO-263-5L



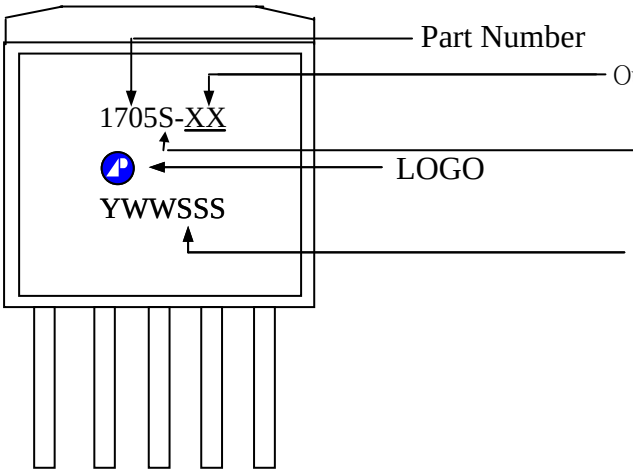


SYMBOLS	Millimeters		
	MIN	NOM	MAX
A	4.40	4.60	4.80
b	0.66	0.79	0.91
L4	0.00	0.15	0.30
c	0.36	0.43	0.50
L1	2.29	2.54	2.79
E	9.80	10.10	10.40
E1		7.60	
c2	1.25	1.35	1.45
L2		1.27	
D	8.60	8.80	9.00
D1		5.90	
e		1.70	
L	14.60	15.20	15.80
θ	0°	4°	8°

1.All Dimensions Are in Millimeters.

2.Dimension Does Not Include Mold Protrusions.

Part Marking Information & Packing : TO-263-5L

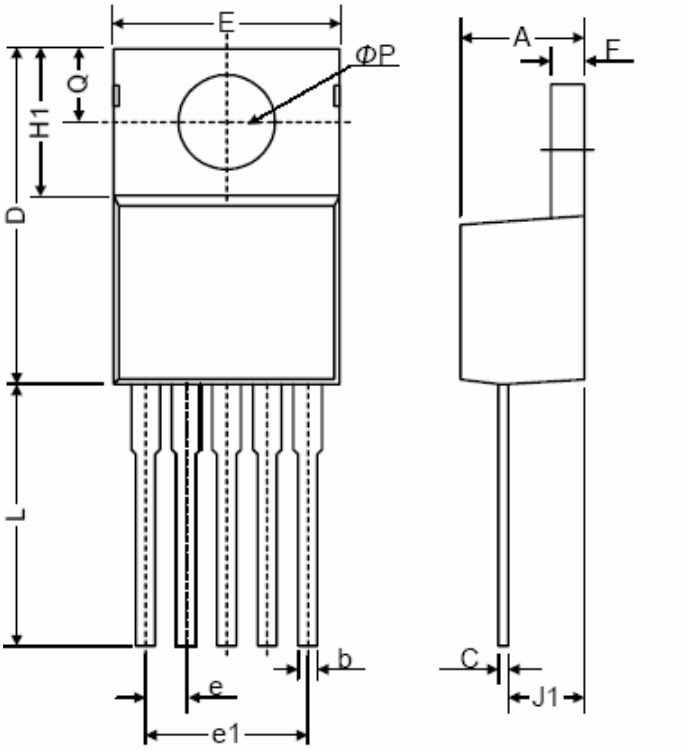


Y：Last Digit Of The Year

WW：Week

SSS：Sequence

Package Outline : TO-220-5L

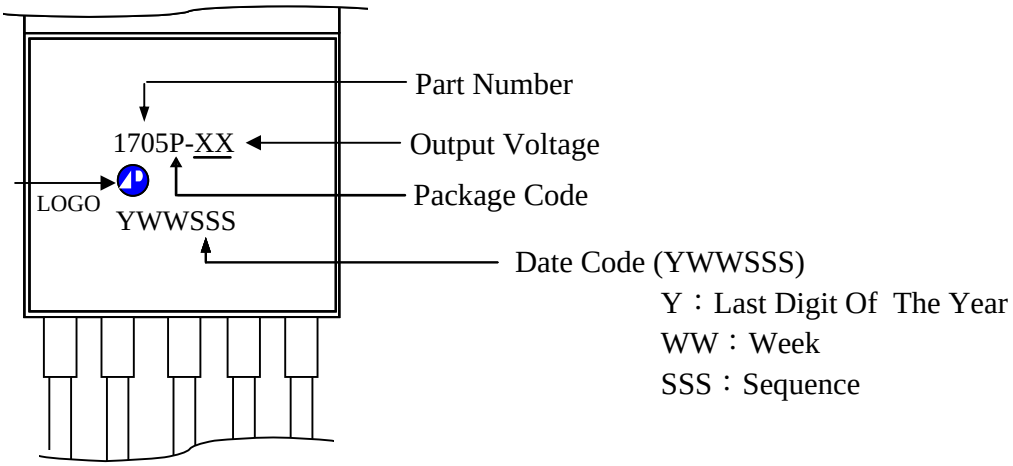


SYMBOLS	Millimeters		
	MIN	NOM	MAX
A	4.07	4.45	4.82
b	0.76	0.89	1.02
C	0.36	0.50	0.64
D	14.22	14.86	15.50
E	9.78	10.16	10.54
e	1.57	1.71	1.85
e1	6.68	6.81	6.93
F	1.14	1.27	1.40
H1	5.46	6.16	6.86
J1	2.29	2.74	3.18
L	13.21	13.97	14.73
φp	3.68	3.81	3.94
Q	2.54	2.73	2.92

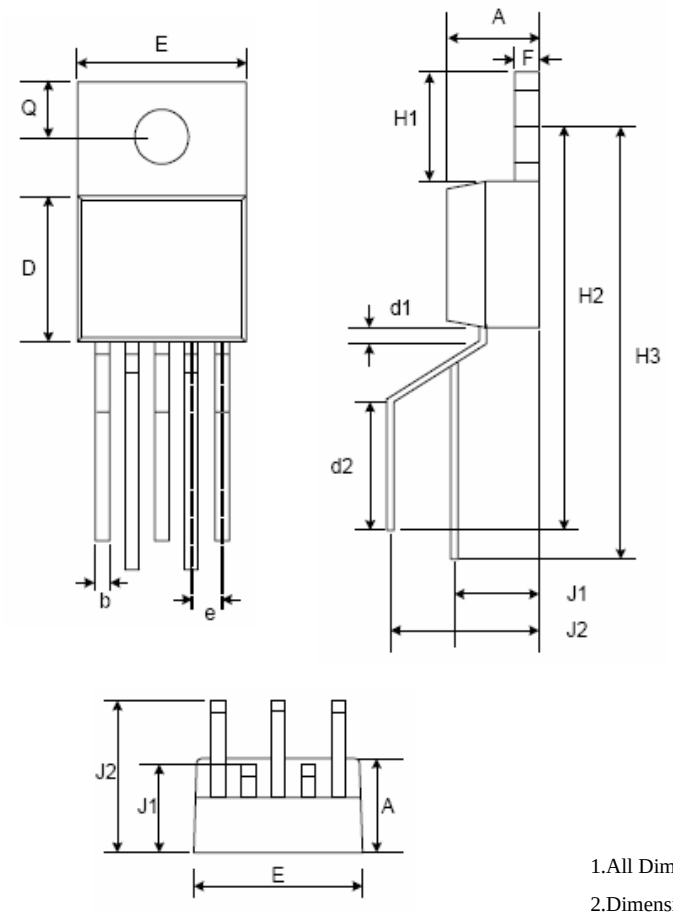
1.All Dimensions Are in Millimeters.

2.Dimension Does Not Include Mold Protrusions.

Part Marking Information & Packing : TO-220-5L



Package Outline : 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 Dimension Are In Millimeters.

2.Dimension Does Not Include Mold Protrusions.

Part Marking Information & Packing : TO-220-5LR