

LM2576/LM2576HV Series SIMPLE SWITCHER® 3A Step-Down Voltage Regulator

General Description

The LM2576 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving 3A load with excellent line and load regulation. These devices are 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 LM2576 series offers a high-efficiency replacement for popular three-terminal linear regulators. It substantially 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 LM2576 are available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

Other features include a guaranteed $\pm 4\%$ tolerance on output voltage within specified input voltages and output load conditions, and $\pm 10\%$ on the oscillator frequency. External shutdown is included, featuring 50 μA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

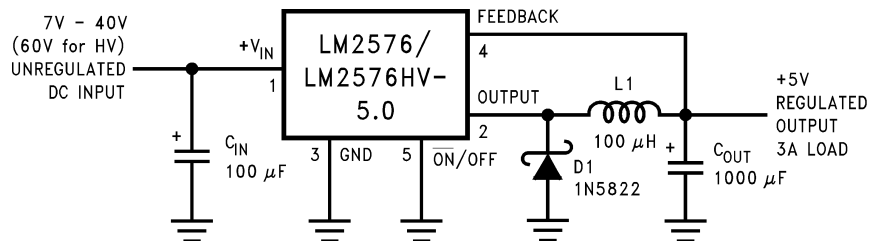
Features

- 3.3V, 5V, 12V, 15V, and adjustable output versions
- Adjustable version output voltage range, 1.23V to 37V (57V for HV version) $\pm 4\%$ max over line and load conditions
- Guaranteed 3A output current
- Wide input voltage range, 40V up to 60V for HV version
- Requires only 4 external components
- 52 kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode
- High efficiency
- Uses readily available standard inductors
- Thermal shutdown and current limit protection
- P+ Product Enhancement tested

Applications

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

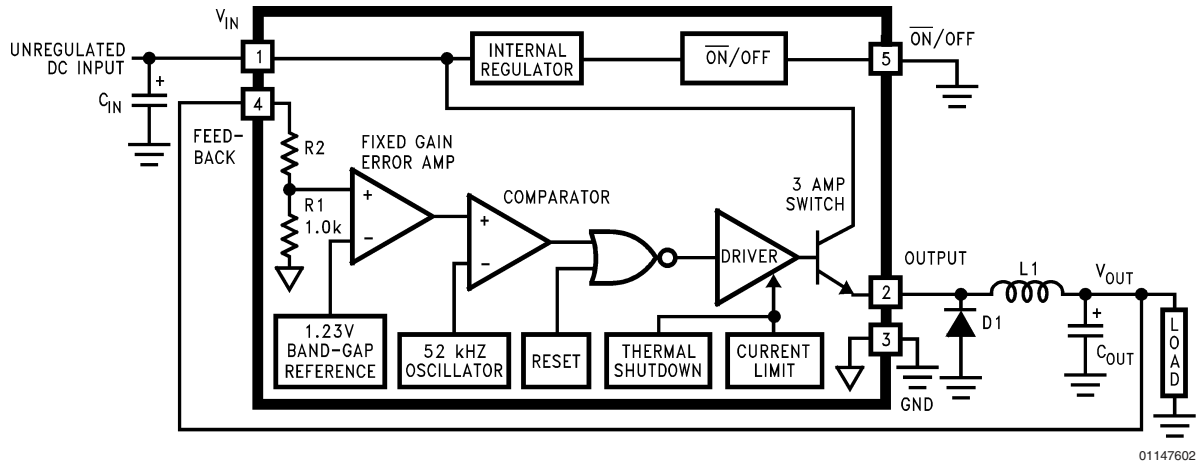
Typical Application (Fixed Output Voltage Versions)



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FIGURE 1.

Block Diagram



3.3V R2 = 1.7k
 5V, R2 = 3.1k
 12V, R2 = 8.84k
 15V, R2 = 11.3k
 For ADJ. Version
 R1 = Open, R2 = 0Ω
 Patent Pending

Ordering Information

Temperature Range	Output Voltage					NS Package Number	Package Type
	3.3	5.0	12	15	ADJ		
-40°C ≤ T _A ≤ 125°C	LM2576HVS-3.3	LM2576HVS-5.0	LM2576HVS-12	LM2576HVS-15	LM2576HVS-ADJ	TS5B	TO-263
	LM2576S-3.3	LM2576S-5.0	LM2576S-12	LM2576S-15	LM2576S-ADJ		
	LM2576HVSX-3.3	LM2576HVSX-5.0	LM2576HVSX-12	LM2576HVSX-15	LM2576HVSX-ADJ	Tape & Reel	
	LM2576SX-3.3	LM2576SX-5.0	LM2576SX-12	LM2576SX-15	LM2576SX-ADJ		
	LM2576HVT-3.3	LM2576HVT-5.0	LM2576HVT-12	LM2576HVT-15	LM2576HVT-ADJ	T05A	TO-220
	LM2576T-3.3	LM2576T-5.0	LM2576T-12	LM2576T-15	LM2576T-ADJ		
	LM2576HVT-3.3	LM2576HVT-5.0	LM2576HVT-12	LM2576HVT-15	LM2576HVT-ADJ	T05D	
	Flow LB03	Flow LB03	Flow LB03	Flow LB03	Flow LB03		
LM2576T-3.3	LM2576T-5.0	LM2576T-12	LM2576T-15	LM2576T-ADJ			
Flow LB03	Flow LB03	Flow LB03	Flow LB03	Flow LB03			

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Maximum Supply Voltage	
LM2576	45V
LM2576HV	63V
$\overline{\text{ON}}$ /OFF Pin Input Voltage	$-0.3\text{V} \leq V \leq +V_{\text{IN}}$
Output Voltage to Ground (Steady State)	-1V
Power Dissipation	Internally Limited
Storage Temperature Range	-65°C to $+150^{\circ}\text{C}$
Maximum Junction Temperature	150°C

Minimum ESD Rating

(C = 100 pF, R = 1.5 k Ω)

2 kV

Lead Temperature

(Soldering, 10 Seconds)

 260°C **Operating Ratings**

Temperature Range

LM2576/LM2576HV

 $-40^{\circ}\text{C} \leq T_{\text{J}} \leq +125^{\circ}\text{C}$

Supply Voltage

LM2576

40V

LM2576HV

60V

**LM2576-3.3, LM2576HV-3.3
Electrical Characteristics**

Specifications with standard type face are for $T_{\text{J}} = 25^{\circ}\text{C}$, and those with **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-3.3 LM2576HV-3.3		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit <i>Figure 2</i>					
V_{OUT}	Output Voltage	$V_{\text{IN}} = 12\text{V}$, $I_{\text{LOAD}} = 0.5\text{A}$ Circuit of <i>Figure 2</i>	3.3	3.234 3.366	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576	$6\text{V} \leq V_{\text{IN}} \leq 40\text{V}$, $0.5\text{A} \leq I_{\text{LOAD}} \leq 3\text{A}$ Circuit of <i>Figure 2</i>	3.3	3.168/ 3.135 3.432/ 3.465	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576HV	$6\text{V} \leq V_{\text{IN}} \leq 60\text{V}$, $0.5\text{A} \leq I_{\text{LOAD}} \leq 3\text{A}$ Circuit of <i>Figure 2</i>	3.3	3.168/ 3.135 3.450/ 3.482	V V(Min) V(Max)
η	Efficiency	$V_{\text{IN}} = 12\text{V}$, $I_{\text{LOAD}} = 3\text{A}$	75		%

**LM2576-5.0, LM2576HV-5.0
Electrical Characteristics**

Specifications with standard type face are for $T_{\text{J}} = 25^{\circ}\text{C}$, and those with *Figure 2* **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-5.0 LM2576HV-5.0		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit <i>Figure 2</i>					
V_{OUT}	Output Voltage	$V_{\text{IN}} = 12\text{V}$, $I_{\text{LOAD}} = 0.5\text{A}$ Circuit of <i>Figure 2</i>	5.0	4.900 5.100	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576	$0.5\text{A} \leq I_{\text{LOAD}} \leq 3\text{A}$, $8\text{V} \leq V_{\text{IN}} \leq 40\text{V}$ Circuit of <i>Figure 2</i>	5.0	4.800/ 4.750 5.200/ 5.250	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576HV	$0.5\text{A} \leq I_{\text{LOAD}} \leq 3\text{A}$, $8\text{V} \leq V_{\text{IN}} \leq 60\text{V}$ Circuit of <i>Figure 2</i>	5.0	4.800/ 4.750 5.225/ 5.275	V V(Min) V(Max)

LM2576-5.0, LM2576HV-5.0**Electrical Characteristics** (Continued)

Specifications with standard type face are for $T_J = 25^\circ\text{C}$, and those with *Figure 2* **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-5.0 LM2576HV-5.0		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit <i>Figure 2</i>					
η	Efficiency	$V_{IN} = 12\text{V}$, $I_{LOAD} = 3\text{A}$	77		%

LM2576-12, LM2576HV-12**Electrical Characteristics**

Specifications with standard type face are for $T_J = 25^\circ\text{C}$, and those with **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-12 LM2576HV-12		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit <i>Figure 2</i>					
V_{OUT}	Output Voltage	$V_{IN} = 25\text{V}$, $I_{LOAD} = 0.5\text{A}$ Circuit of <i>Figure 2</i>	12	11.76 12.24	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576	$0.5\text{A} \leq I_{LOAD} \leq 3\text{A}$, $15\text{V} \leq V_{IN} \leq 40\text{V}$ Circuit of <i>Figure 2</i>	12	11.52/ 11.40 12.48/ 12.60	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576HV	$0.5\text{A} \leq I_{LOAD} \leq 3\text{A}$, $15\text{V} \leq V_{IN} \leq 60\text{V}$ Circuit of <i>Figure 2</i>	12	11.52/ 11.40 12.54/ 12.66	V V(Min) V(Max)
η	Efficiency	$V_{IN} = 15\text{V}$, $I_{LOAD} = 3\text{A}$	88		%

LM2576-15, LM2576HV-15**Electrical Characteristics**

Specifications with standard type face are for $T_J = 25^\circ\text{C}$, and those with **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-15 LM2576HV-15		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit <i>Figure 2</i>					
V_{OUT}	Output Voltage	$V_{IN} = 25\text{V}$, $I_{LOAD} = 0.5\text{A}$ Circuit of <i>Figure 2</i>	15	14.70 15.30	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576	$0.5\text{A} \leq I_{LOAD} \leq 3\text{A}$, $18\text{V} \leq V_{IN} \leq 40\text{V}$ Circuit of <i>Figure 2</i>	15	14.40/ 14.25 15.60/ 15.75	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576HV	$0.5\text{A} \leq I_{LOAD} \leq 3\text{A}$, $18\text{V} \leq V_{IN} \leq 60\text{V}$ Circuit of <i>Figure 2</i>	15	14.40/ 14.25 15.68/ 15.83	V V(Min) V(Max)
η	Efficiency	$V_{IN} = 18\text{V}$, $I_{LOAD} = 3\text{A}$	88		%

LM2576-ADJ, LM2576HV-ADJ**Electrical Characteristics**

Specifications with standard type face are for $T_J = 25^\circ\text{C}$, and those with **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-ADJ LM2576HV-ADJ		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit <i>Figure 2</i>					
V_{OUT}	Feedback Voltage	$V_{IN} = 12\text{V}$, $I_{LOAD} = 0.5\text{A}$ $V_{OUT} = 5\text{V}$, Circuit of <i>Figure 2</i>	1.230	1.217 1.243	V V(Min) V(Max)
V_{OUT}	Feedback Voltage LM2576	$0.5\text{A} \leq I_{LOAD} \leq 3\text{A}$, $8\text{V} \leq V_{IN} \leq 40\text{V}$ $V_{OUT} = 5\text{V}$, Circuit of <i>Figure 2</i>	1.230	1.193/ 1.180 1.267/ 1.280	V V(Min) V(Max)
V_{OUT}	Feedback Voltage LM2576HV	$0.5\text{A} \leq I_{LOAD} \leq 3\text{A}$, $8\text{V} \leq V_{IN} \leq 60\text{V}$ $V_{OUT} = 5\text{V}$, Circuit of <i>Figure 2</i>	1.230	1.193/ 1.180 1.273/ 1.286	V V(Min) V(Max)
η	Efficiency	$V_{IN} = 12\text{V}$, $I_{LOAD} = 3\text{A}$, $V_{OUT} = 5\text{V}$	77		%

**All Output Voltage Versions
Electrical Characteristics**

Specifications with standard type face are for $T_J = 25^\circ\text{C}$, and those with **boldface type** apply over full Operating Temperature Range. Unless otherwise specified, $V_{IN} = 12\text{V}$ for the 3.3V, 5V, and Adjustable version, $V_{IN} = 25\text{V}$ for the 12V version, and $V_{IN} = 30\text{V}$ for the 15V version. $I_{LOAD} = 500\text{mA}$.

Symbol	Parameter	Conditions	LM2576-XX LM2576HV-XX		Units (Limits)
			Typ	Limit (Note 2)	
DEVICE PARAMETERS					
I_b	Feedback Bias Current	$V_{OUT} = 5\text{V}$ (Adjustable Version Only)	50	100/ 500	nA
f_O	Oscillator Frequency	(Note 11)	52	47/ 42 58/ 63	kHz kHz (Min) kHz (Max)
V_{SAT}	Saturation Voltage	$I_{OUT} = 3\text{A}$ (Note 4)	1.4	1.8/ 2.0	V V(Max)
DC	Max Duty Cycle (ON)	(Note 5)	98	93	% %(Min)
I_{CL}	Current Limit	(Notes 4, 11)	5.8	4.2/ 3.5 6.9/ 7.5	A A(Min) A(Max)
I_L	Output Leakage Current	(Notes 6, 7): Output = 0V Output = -1V Output = -1V	7.5	2 30	mA(Max) mA mA(Max)
I_Q	Quiescent Current	(Note 6)	5	10	mA mA(Max)
I_{STBY}	Standby Quiescent Current	\overline{ON} /OFF Pin = 5V (OFF)	50	200	μA $\mu\text{A}(\text{Max})$

All Output Voltage Versions

Electrical Characteristics (Continued)

Specifications with standard type face are for $T_J = 25^\circ\text{C}$, and those with **boldface type** apply over full Operating Temperature Range. Unless otherwise specified, $V_{IN} = 12\text{V}$ for the 3.3V, 5V, and Adjustable version, $V_{IN} = 25\text{V}$ for the 12V version, and $V_{IN} = 30\text{V}$ for the 15V version. $I_{LOAD} = 500\text{ mA}$.

Symbol	Parameter	Conditions	LM2576-XX LM2576HV-XX		Units (Limits)
			Typ	Limit (Note 2)	

DEVICE PARAMETERS

θ_{JA}	Thermal Resistance	T Package, Junction to Ambient (Note 8)	65		$^\circ\text{C/W}$
θ_{JA}		T Package, Junction to Ambient (Note 9)	45		
θ_{JC}		T Package, Junction to Case	2		
θ_{JA}		S Package, Junction to Ambient (Note 10)	50		

ON /OFF CONTROL Test Circuit *Figure 2*

V_{IH}	$\overline{\text{ON}} / \text{OFF}$ Pin	$V_{OUT} = 0\text{V}$	1.4	2.2/2.4	V(Min)
V_{IL}	Logic Input Level	$V_{OUT} = \text{Nominal Output Voltage}$	1.2	1.0/0.8	V(Max)
I_{IH}	$\overline{\text{ON}} / \text{OFF}$ Pin Input Current	$\overline{\text{ON}} / \text{OFF}$ Pin = 5V (OFF)	12	30	μA $\mu\text{A}(\text{Max})$
		$\overline{\text{ON}} / \text{OFF}$ Pin = 0V (ON)	0	10	μA $\mu\text{A}(\text{Max})$

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: All limits guaranteed at room temperature (standard type face) and at temperature extremes (bold type face). All room temperature limits are 100% production tested. All limits at temperature extremes are guaranteed via correlation using standard Statistical Quality Control (SQC) methods.

Note 3: External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2576/LM2576HV is used as shown in the *Figure 2* test circuit, system performance will be as shown in system parameters section of Electrical Characteristics.

Note 4: Output pin sourcing current. No diode, inductor or capacitor connected to output.

Note 5: Feedback pin removed from output and connected to 0V.

Note 6: Feedback pin removed from output and connected to +12V for the Adjustable, 3.3V, and 5V versions, and +25V for the 12V and 15V versions, to force the output transistor OFF.

Note 7: $V_{IN} = 40\text{V}$ (60V for high voltage version).

Note 8: Junction to ambient thermal resistance (no external heat sink) for the 5 lead TO-220 package mounted vertically, with $\frac{1}{2}$ inch leads in a socket, or on a PC board with minimum copper area.

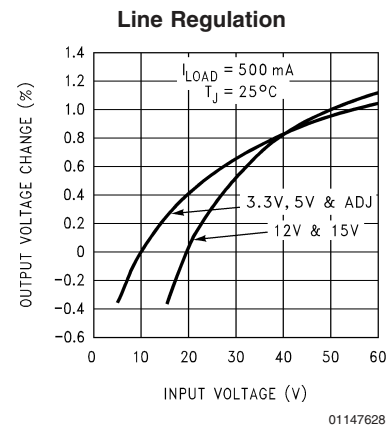
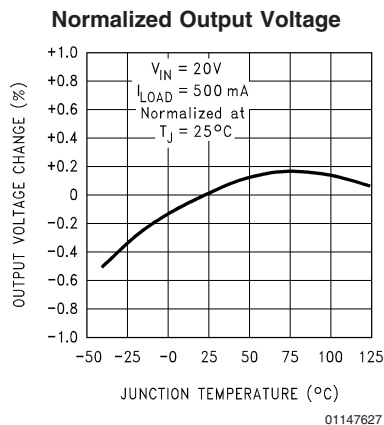
Note 9: Junction to ambient thermal resistance (no external heat sink) for the 5 lead TO-220 package mounted vertically, with $\frac{1}{4}$ inch leads soldered to a PC board containing approximately 4 square inches of copper area surrounding the leads.

Note 10: If the TO-263 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 .

Note 11: The oscillator frequency reduces to approximately 11 kHz in the event of an output short or an overload which causes the regulated output voltage to drop approximately 40% from the nominal output voltage. This self protection feature lowers the average power dissipation of the IC by lowering the minimum duty cycle from 5% down to approximately 2%.

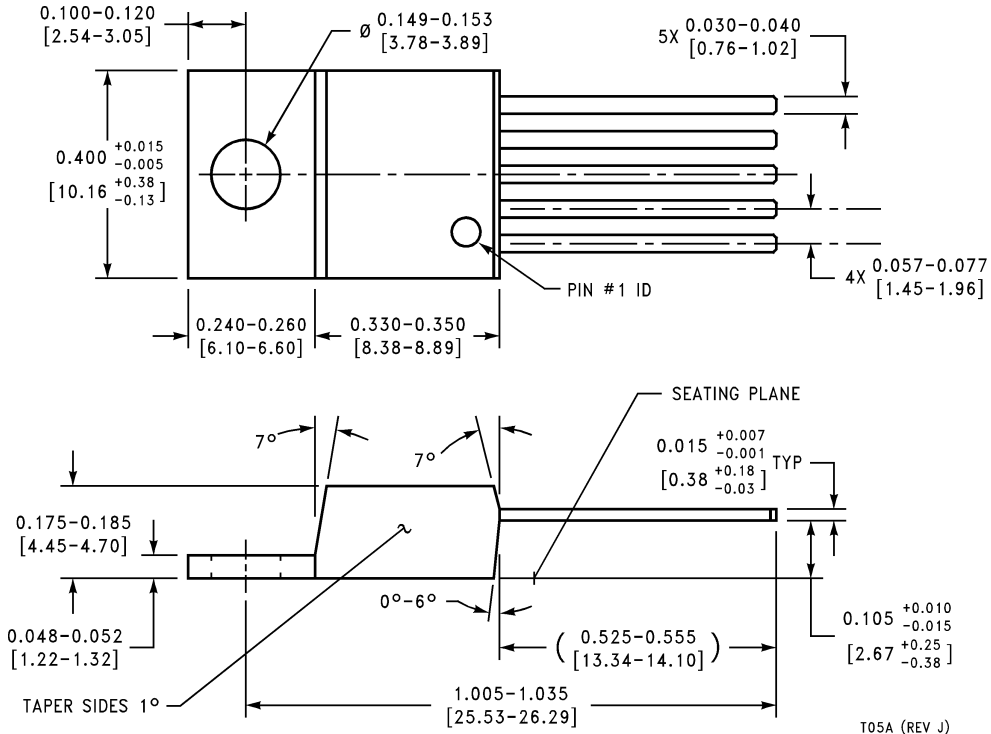
Typical Performance Characteristics

(Circuit of *Figure 2*)



Physical Dimensions inches (millimeters)

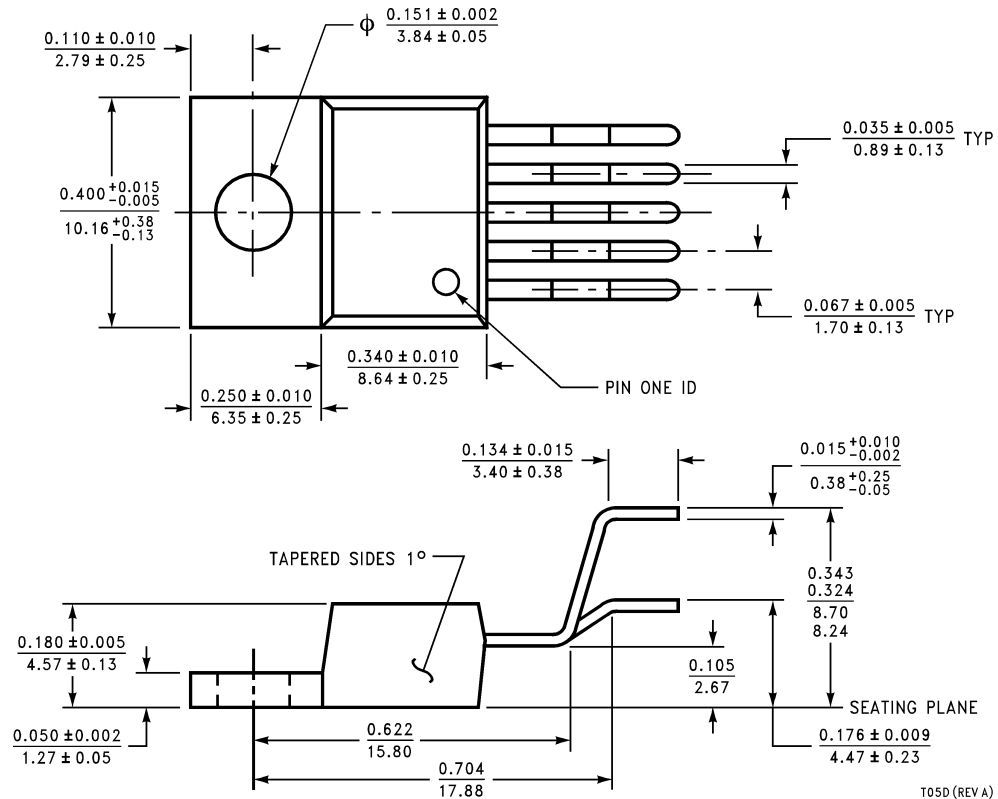
unless otherwise noted



5-Lead TO-220 (T)
Order Number LM2576T-3.3, LM2576HVT-3.3,
LM2576T-5.0, LM2576HVT-5.0, LM2576T-12,
LM2576HVT-12, LM2576T-15, LM2576HVT-15,
LM2576T-ADJ or LM2576HVT-ADJ
NS Package Number T05A

T05A (REV J)

Physical Dimensions

 inches (millimeters) unless otherwise noted (Continued)


Bent, Staggered 5-Lead TO-220 (T)

Order Number LM2576T-3.3 Flow LB03, LM2576T-XX Flow LB03, LM2576HVT-3.3 Flow LB03,
 LM2576T-5.0 Flow LB03, LM2576HVT-5.0 Flow LB03,
 LM2576T-12 Flow LB03, LM2576HVT-12 Flow LB03,
 LM2576T-15 Flow LB03, LM2576HVT-15 Flow LB03,
 LM2576T-ADJ Flow LB03 or LM2576HVT-ADJ Flow LB03
 NS Package Number T05D