# LM2576xx シリーズ SIMPLE SWITCHER®、電力コンバータ 3A 降圧型電圧レギュレータ

## 1 特長

- 利用可能な新製品:
  - LMR51430 4.5～36V、3A、500kHz および 1.1MHz 同期整流コンバータ
  - LM76003 3.5～60V、3.5A、300kHz～2.2MHz 同期整流コンバータ
- 市場投入の迅速化:
  - TLVM13630 3～36V、3A、200kHz～2.2MHz 電源モジュール
- 3.3V、5V、12V、15V、および可変出力のバージョン
- 可変出力電圧バージョンの出力電圧範囲は 1.23V～37V (HV バージョンは最大 57V)、入力と負荷の全条件で許容誤差は ±4% 以内
- 3A の出力電流を規定
- 広い入力電圧範囲:最大 40V (HV バージョンは最大 60V)
- 必要な外付け部品はわずか 4 個
- 52kHz 固定周波数の内部発振器
- TTL シャットダウン機能、低消費電力のスタンバイ・モード
- 高効率
- 容易に入手可能な標準インダクタを使用
- WEBENCH® Power Designer により、LM76003 を使用するカスタム設計を作成

## 2 アプリケーション

- モーター・ドライブ
- 商用ネットワークとサーバーの PSU (電源)
- 家電製品
- 試験および計測機器

## 3 概要

LM2576 シリーズのレギュレータは、モノリシックな IC で、降圧型 (バック) スイッチング・レギュレータのすべてのアクティブ機能を提供し、優れたラインおよび負荷レギュレーションで 3A の負荷を駆動できます。3.3V、5V、12V、15V の固定出力電圧版と可変出力版があります。

これらのレギュレータは、必要な外部部品の数が最小限で、簡単に使用でき、フォールト保護と固定周波数発振器が内蔵されています。

LM2576 シリーズは、一般的な 3 端子のリニア・レギュレータを置き換えることができる高効率な製品です。これらの製品により、ヒート・シンクのサイズが大幅に減少し、条件によってはヒート・シンクが不要になります。

LM2576 とともに使用するため最適化された標準シリーズのインダクタがいくつかの製造元から入手可能です。このため、スイッチング電源の設計が大幅に簡素化されます。

その他の特長として、指定された入力電圧および出力負荷の条件において出力電圧の許容誤差が ±4%、発振器の周波数の許容誤差が ±10% であることが挙げられます。外部シャットダウンが搭載されており、スタンバイ電流は 50μA (標準値) です。出力スイッチにはサイクル単位の電流制限と、障害状態における完全な保護を行うためのサーマル・シャットダウンが含まれています。

LM76003 は、外付けコンポーネントがほとんど不要であり、EMI と熱性能のために簡単かつ最適に PCB をレイアウトできるようにピン配置が設計されています。仕様を比較するには、デバイス比較表を参照してください。

**パッケージ情報**

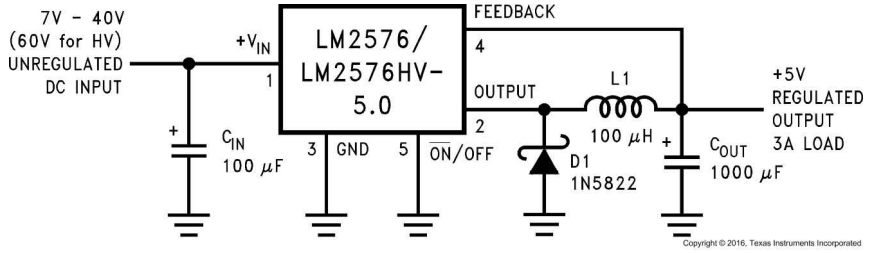
| 部品番号 | パッケージ(1) | 本体サイズ (公称) |
|---|---|---|
| LM2576<br>LM2576HV | KC (TO-220、5) | 10.16mm × 8.51mm |
| | KTT (DDPAK/TO-263、5) | 10.16mm × 8.42mm |

(1) 利用可能なパッケージについては、このデータシートの末尾にある注文情報を参照してください。

**製品情報**

| 部品番号 | 最大電源電圧(1) |
|---|---|
| LM2576 | 40V |
| LM2576HV | 60V |

(1) デバイス比較表を参照してください。




**固定出力電圧バージョンの代表的なアプリケーションの図**

英語版の TI 製品についての情報を翻訳したこの資料は、製品の概要を確認する目的で便宜的に提供しているものです。該当する正式な英語版の最新情報は、www.ti.com で閲覧でき、その内容が常に優先されます。TI では翻訳の正確性および妥当性につきましては一切保証いたしません。実際の設計などの前には、必ず最新版の英語版をご参照くださいますようお願いいたします。

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## 4 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

**Changes from Revision F (May 2021) to Revision G (March 2023)** — **Page**

- LMR51430 および TLVM13630 製品フォルダの情報を追加 ... 1
- 商標の情報を更新 ... 1
- デバイス情報表のフォーマットを更新 ... 1
- Updated trademark information ... 16

**Changes from Revision E (June 2020) to Revision F (May 2021)** — **Page**

- LM76003 の販売促進のための情報を追加 ... 1
- 文書全体にわたって表、図、相互参照の採番方法を更新 ... 1

**Changes from Revision D (January 2016) to Revision E (June 2020)** — **Page**

- LMR33630 に関する情報を追加 ... 1

**Changes from Revision C (April 2013) to Revision D (January 2016)** — **Page**

- 「ESD 定格」表、「機能説明」セクション、「デバイスの機能モード」セクション、「アプリケーションと実装」セクション、「電源に関する推奨事項」セクション、「レイアウト」セクション、「デバイスおよびドキュメントのサポート」セクション、「メカニカル、パッケージ、および注文情報」セクションを追加。 ... 1
- Moved the thermal resistance data from the *Electrical Characteristics: All Output Voltage Versions* table to the *Thermal Information* table ... 4

**Changes from Revision B (April 2013) to Revision C (April 2013)** — **Page**

- Changed layout of National Data Sheet to TI format ... 3


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# 5 Pin Configuration and Functions

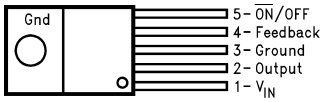



**図 5-1. KC Package 5-Pin TO-220 Top View**

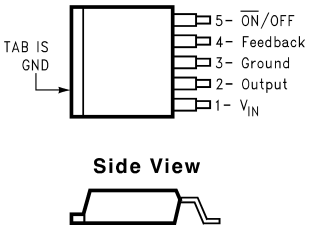



**図 5-2. KTT Package 5-PIN DDPAK/TO-263 Top View**

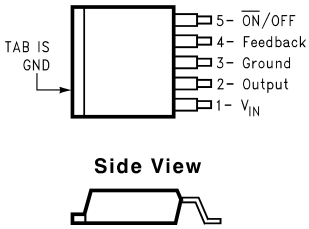



**図 5-3. DDPAK/TO-263 (S) Package 5-Lead Surface-Mount Package Top View**

**表 5-1. Pin Functions**

| PIN | | I/O(1) | DESCRIPTION |
|---|---|---|---|
| NO. | NAME | | |
| 1 | $V_{IN}$ | I | Supply input pin to collector pin of high-side transistor. Connect to power supply and input bypass capacitors CIN. Path from $V_{IN}$ pin to high frequency bypass $C_{IN}$ and GND must be as short as possible. |
| 2 | OUTPUT | O | Emitter pin of the power transistor. This is a switching node. Attached this pin to an inductor and the cathode of the external diode. |
| 3 | GROUND | — | Ground pin. Path to $C_{IN}$ must be as short as possible. |
| 4 | FEEDBACK | I | Feedback sense input pin. Connect to the midpoint of feedback divider to set VOUT for ADJ version or connect this pin directly to the output capacitor for a fixed output version. |
| 5 | $\overline{ON}$/OFF | I | Enable input to the voltage regulator. High = OFF and low = ON. Connect to GND to enable the voltage regulator. Do not leave this pin float. |
| — | TAB | — | Connected to GND. Attached to heatsink for thermal relief for TO-220 package or put a copper plane connected to this pin as a thermal relief for DDPAK package. |

(1) I = INPUT, O = OUTPUT

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# 6 Specifications

## 6.1 Absolute Maximum Ratings

over the recommended operating junction temperature range of -40°C to 125°C (unless otherwise noted)(1) (2)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Maximum supply voltage | LM2576 | | 45 | V |
| | LM2576HV | | 63 | |
| $\overline{ON}$ /OFF pin input voltage | | −0.3V ≤ V ≤ +$V_{IN}$ | | V |
| Output voltage to ground | (Steady-state) | −1 | | V |
| Power dissipation | | Internally Limited | | |
| Maximum junction temperature, $T_J$ | | | 150 | °C |
| Storage temperature, $T_{stg}$ | | −65 | 150 | °C |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.

## 6.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1) | ±2000 | V |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

## 6.3 Recommended Operating Conditions

over the recommended operating junction temperature range of -40°C to 125°C (unless otherwise noted)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Temperature | LM2576, LM2576HV | −40 | 125 | °C |
| Supply voltage | LM2576 | | 40 | V |
| | LM2576HV | | 60 | |

## 6.4 Thermal Information

| THERMAL METRIC(1) (2) (3) | | LM2576, LM2576HV | | UNIT |
|---|---|---|---|---|
| | | KTT (TO-263) | KC (TO-220) | |
| | | 5 PINS | 5 PINS | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 42.6 | 32.4 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 43.3 | 41.2 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 22.4 | 17.6 | °C/W |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 10.7 | 7.8 | °C/W |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 21.3 | 17 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | 0.4 | 0.4 | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953 and the *Using New Thermal Metrics* applications report, SBVA025.
(2) The package thermal impedance is calculated in accordance with JESD 51-7
(3) Thermal Resistances were simulated on a 4-layer, JEDEC board.


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## 6.5 Electrical Characteristics: 3.3 V

Specifications are for $T_J$ = 25°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS TEST CIRCUIT 図 8-3 and 図 8-9(1)** | | | | | | | |
| $V_{OUT}$ | Output Voltage | $V_{IN}$ = 12 V, $I_{LOAD}$ = 0.5 A<br>Circuit of 図 8-3 and 図 8-9 | | 3.234 | 3.3 | 3.366 | V |
| $V_{OUT}$ | Output Voltage: LM2576 | 6 V ≤ $V_{IN}$ ≤ 40 V, 0.5 A ≤ $I_{LOAD}$ ≤ 3 A<br>Circuit of 図 8-3 and 図 8-9 | $T_J$ = 25°C | 3.168 | 3.3 | 3.432 | V |
| | | | Applies over full operating temperature range | 3.135 | | 3.465 | |
| $V_{OUT}$ | Output Voltage: LM2576HV | 6 V ≤ $V_{IN}$ ≤ 60 V, 0.5 A ≤ $I_{LOAD}$ ≤ 3 A<br>Circuit of 図 8-3 and 図 8-9 | $T_J$ = 25°C | 3.168 | 3.3 | 3.45 | V |
| | | | Applies over full operating temperature range | 3.135 | | 3.482 | |
| η | Efficiency | $V_{IN}$ = 12 V, $I_{LOAD}$ = 3 A | | | 75% | | |

(1) 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 図 8-3 and 図 8-9, system performance is as shown in *セクション 6.10*.

## 6.6 Electrical Characteristics: 5 V

Specifications are for $T_J$ = 25°C for the 図 8-3 and 図 8-9 (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS TEST CIRCUIT 図 8-3 and 図 8-9(1)** | | | | | | | |
| $V_{OUT}$ | Output Voltage | $V_{IN}$ = 12 V, $I_{LOAD}$ = 0.5 A<br>Circuit of 図 8-3 and 図 8-9 | | 4.9 | 5 | 5.1 | V |
| $V_{OUT}$ | Output Voltage LM2576 | 0.5 A ≤ $I_{LOAD}$ ≤ 3 A,<br>8 V ≤ $V_{IN}$ ≤ 40 V<br>Circuit of 図 8-3 and 図 8-9 | $T_J$ = 25°C | 4.8 | 5 | 5.2 | V |
| | | | Applies over full operating temperature range | 4.75 | | 5.25 | |
| $V_{OUT}$ | Output Voltage LM2576HV | 0.5 A ≤ $I_{LOAD}$ ≤ 3 A,<br>8 V ≤ $V_{IN}$ ≤ 60 V<br>Circuit of 図 8-3 and 図 8-9 | $T_J$ = 25°C | 4.8 | 5 | 4.75 | V |
| | | | Applies over full operating temperature range | 5.225 | | 5.275 | |
| η | Efficiency | $V_{IN}$ = 12 V, $I_{LOAD}$ = 3 A | | | 77% | | |

(1) 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 図 8-3 and 図 8-9, system performance is as shown in *セクション 6.10*.

## 6.7 Electrical Characteristics: 12 V

Specifications are for $T_J$ = 25°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS TEST CIRCUIT 図 8-3 and 図 8-9(1)** | | | | | | | |
| $V_{OUT}$ | Output Voltage | $V_{IN}$ = 25 V, $I_{LOAD}$ = 0.5 A<br>Circuit of 図 8-3 and 図 8-9 | | 11.76 | 12 | 12.24 | V |
| $V_{OUT}$ | Output Voltage LM2576 | 0.5 A ≤ $I_{LOAD}$ ≤ 3 A,<br>15 V ≤ $V_{IN}$ ≤ 40 V<br>Circuit of 図 8-3 and 図 8-9 and | $T_J$ = 25°C | 11.52 | 12 | 12.48 | V |
| | | | Applies over full operating temperature range | 11.4 | | 12.6 | |
| $V_{OUT}$ | Output Voltage LM2576HV | 0.5 A ≤ $I_{LOAD}$ ≤ 3 A,<br>15 V ≤ $V_{IN}$ ≤ 60 V<br>Circuit of 図 8-3 and 図 8-9 | $T_J$ = 25°C | 11.52 | 12 | 12.54 | V |
| | | | Applies over full operating temperature range | 11.4 | | 12.66 | |

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Specifications are for $T_J$ = 25°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| η | Efficiency | $V_{IN}$ = 15 V, $I_{LOAD}$ = 3 A | | 88% | | |

(1) 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 図 8-3 and 図 8-9, system performance is as shown in *セクション 6.10*.

## 6.8 Electrical Characteristics: 15 V

over operating free-air temperature range (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS TEST CIRCUIT 図 8-3 and 図 8-9(1)** | | | | | | | |
| $V_{OUT}$ | Output Voltage | $V_{IN}$ = 25 V, $I_{LOAD}$ = 0.5 A<br>Circuit of 図 8-3 and 図 8-9 | | 14.7 | 15 | 15.3 | V |
| $V_{OUT}$ | Output Voltage<br>LM2576 | 0.5 A ≤ $I_{LOAD}$ ≤ 3 A,<br>18 V ≤ $V_{IN}$ ≤ 40 V<br>Circuit of 図 8-3 and 図 8-9 | $T_J$ = 25°C | 14.4 | 15 | 15.6 | V |
| | | | Applies over full operating temperature range | 14.25 | | 15.75 | |
| $V_{OUT}$ | Output Voltage<br>LM2576HV | 0.5 A ≤ $I_{LOAD}$ ≤ 3 A,<br>18 V ≤ $V_{IN}$ ≤ 60 V<br>Circuit of 図 8-3 and 図 8-9 | $T_J$ = 25°C | 14.4 | 15 | 14.25 | V |
| | | | Applies over full operating temperature range | 15.68 | | 15.83 | |
| η | Efficiency | $V_{IN}$ = 18 V, $I_{LOAD}$ = 3 A | | | 88% | | |

(1) 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 図 8-3 and 図 8-9, system performance is as shown in *セクション 6.10*.

## 6.9 Electrical Characteristics: Adjustable Output Voltage

over operating free-air temperature range (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS TEST CIRCUIT 図 8-3 and 図 8-9(1)** | | | | | | | |
| $V_{OUT}$ | Feedback voltage | $V_{IN}$ = 12 V, $I_{LOAD}$ = 0.5 A<br>$V_{OUT}$ = 5 V,<br>Circuit of 図 8-3 and 図 8-9 | | 1.217 | 1.23 | 1.243 | V |
| $V_{OUT}$ | Feedback Voltage<br>LM2576 | 0.5 A ≤ $I_{LOAD}$ ≤ 3 A,<br>8 V ≤ $V_{IN}$ ≤ 40 V<br>$V_{OUT}$ = 5 V, Circuit of 図 8-3 and 図 8-9 | $T_J$ = 25°C | 1.193 | 1.23 | 1.267 | V |
| | | | Applies over full operating temperature range | 1.18 | | 1.28 | |
| $V_{OUT}$ | Feedback Voltage<br>LM2576HV | 0.5 A ≤ $I_{LOAD}$ ≤ 3 A,<br>8 V ≤ $V_{IN}$ ≤ 60 V<br>$V_{OUT}$ = 5 V, Circuit of 図 8-3 and 図 8-9 | $T_J$ = 25°C | 1.193 | 1.23 | 1.273 | V |
| | | | Applies over full operating temperature range | 1.18 | | 1.286 | |
| η | Efficiency | $V_{IN}$ = 12 V, $I_{LOAD}$ = 3 A, $V_{OUT}$ = 5 V | | | 77% | | |

(1) 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 図 8-3 and 図 8-9, system performance is as shown in *セクション 6.10*.

## 6.10 Electrical Characteristics: All Output Voltage Versions

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP(1) | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS TEST CIRCUIT 図 8-3 and 図 8-9(2)** | | | | | | | |
| $I_b$ | Feedback Bias Current | $V_{OUT}$ = 5 V (Adjustable Version Only) | $T_J$ = 25°C | 100 | 50 | | nA |
| | | | Applies over full operating temperature range | 500 | | | |


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over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP(1) | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $f_O$ | Oscillator Frequency(7) | $T_J$ = 25°C | | 47 | 52 | 58 | kHz |
| | | Applies over full operating temperature range | | 42 | | 63 | |
| $V_{SAT}$ | Saturation Voltage | $I_{OUT}$ = 3 A (3) | $T_J$ = 25°C | | 1.4 | 1.8 | V |
| | | | Applies over full operating temperature range | | | 2 | |
| DC | Max Duty Cycle (ON)(4) | | | 93% | 98% | | |
| $I_{CL}$ | Current Limit(3) (7) | $T_J$ = 25°C | | 4.2 | 5.8 | 6.9 | A |
| | | Applies over full operating temperature range | | 3.5 | | 7.5 | |
| $I_L$ | Output Leakage Current | Output = 0 V<br>Output = −1 V<br>Output = −1 V (5) (6) | | 2 | 7.5 | 30 | mA |
| $I_Q$ | Quiescent Current(5) | | | | 5 | 10 | mA |
| $I_{STBY}$ | Standby Quiescent Current | $\overline{ON}$ /OFF Pin = 5 V (OFF) | | | 50 | 200 | µA |
| **$\overline{ON}$ /OFF CONTROL TEST CIRCUIT 図 8-3 and 図 8-9** | | | | | | | |
| $V_{IH}$ | $\overline{ON}$ /OFF Pin Logic Input Level | $V_{OUT}$ = 0 V | $T_J$ = 25°C | 2.2 | 1.4 | | V |
| | | | Applies over full operating temperature range | 2.4 | | | |
| $V_{IL}$ | | $V_{OUT}$ = Nominal Output Voltage | $T_J$ = 25°C | | 1.2 | 1 | V |
| | | | Applies over full operating temperature range | | | 0.8 | |
| $I_{IH}$ | $\overline{ON}$ /OFF Pin Input Current | $\overline{ON}$ /OFF Pin = 5 V (OFF) | | | 12 | 30 | µA |
| $I_{IL}$ | | $\overline{ON}$ /OFF Pin = 0 V (ON) | | | 0 | 10 | µA |

(1) All limits specified at room temperature (25°C) unless otherwise noted. All room temperature limits are 100% production tested. All limits at temperature extremes are specified through correlation using standard Statistical Quality Control (SQC) methods.
(2) 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 図 8-3 and 図 8-9, system performance is as shown in *セクション 6.10*.
(3) Output pin sourcing current. No diode, inductor or capacitor connected to output.
(4) Feedback pin removed from output and connected to 0V.
(5) Feedback pin removed from output and connected to +12 V for the Adjustable, 3.3-V, and 5-V versions, and +25 V for the 12-V and 15-V versions, to force the output transistor OFF.
(6) $V_{IN}$ = 40 V (60 V for high voltage version).
(7) 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%.

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## 6.11 Typical Characteristics

(Circuit of 図 8-3 and 図 8-9)

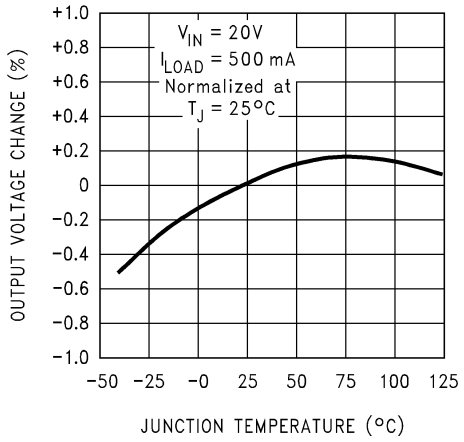



**図 6-1. Normalized Output Voltage**

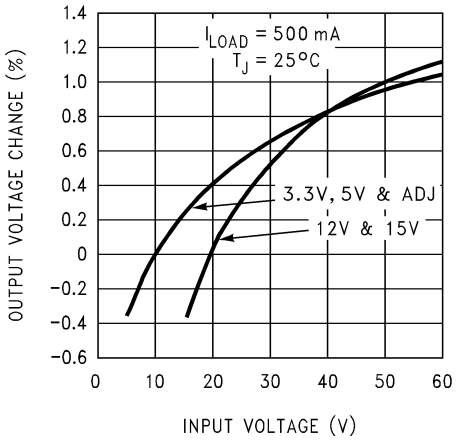



**図 6-2. Line Regulation**

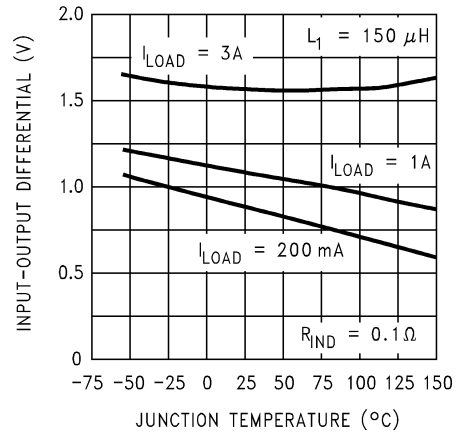



**図 6-3. Dropout Voltage**

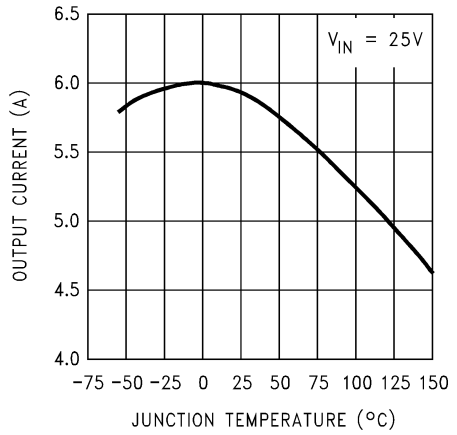



**図 6-4. Current Limit**

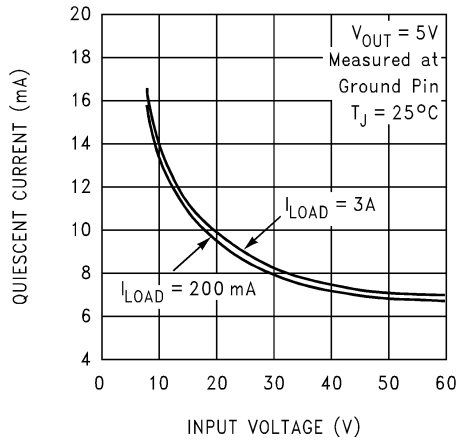



**図 6-5. Quiescent Current**

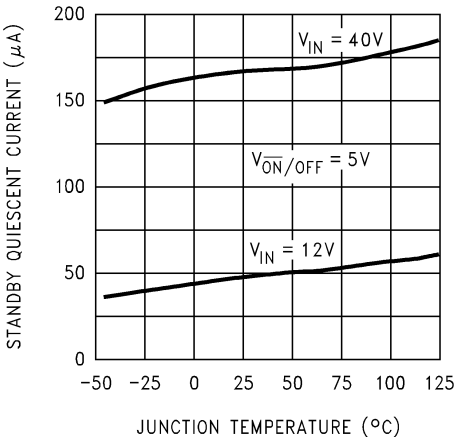



**図 6-6. Standby Quiescent Current**


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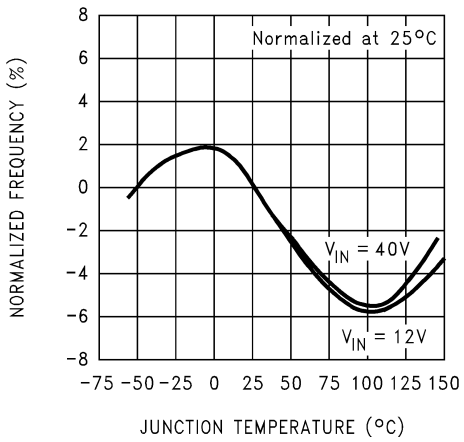



**図 6-7. Oscillator Frequency**

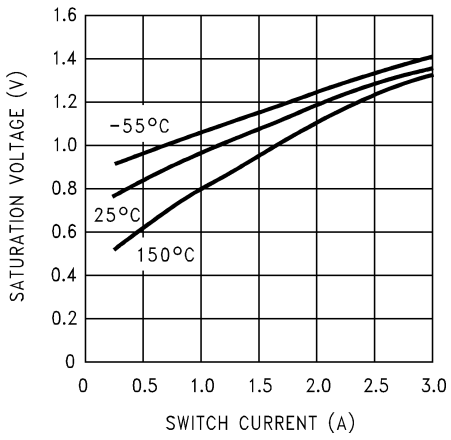



**図 6-8. Switch Saturation Voltage**

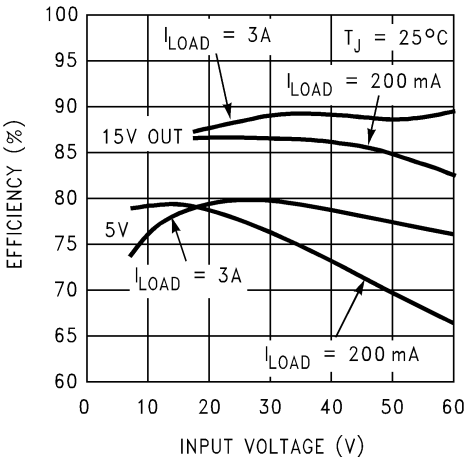



**図 6-9. Efficiency**

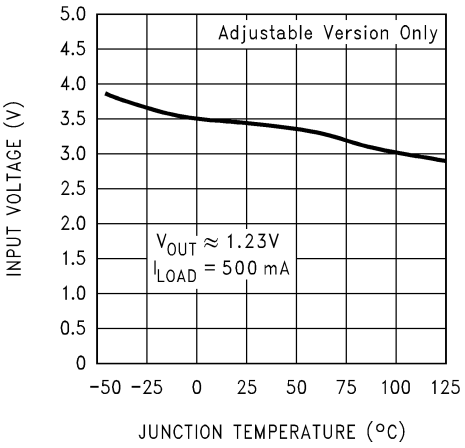



**図 6-10. Minimum Operating Voltage**

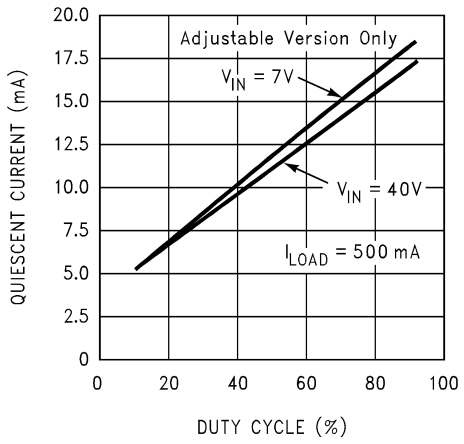



**図 6-11. Quiescent Current vs Duty Cycle**

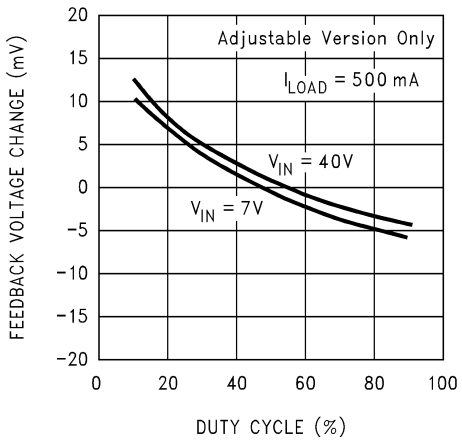



**図 6-12. Feedback Voltage vs Duty Cycle**

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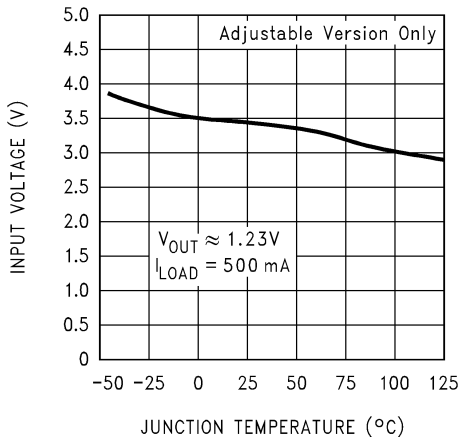



**図 6-13. Minimum Operating Voltage**

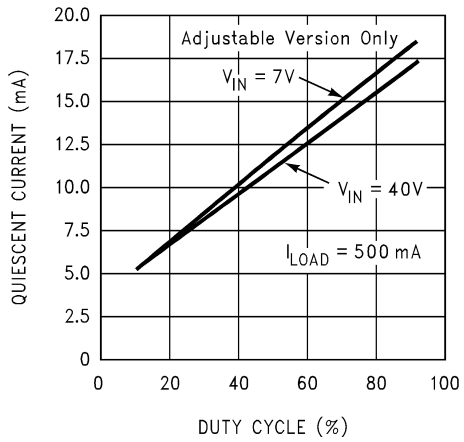



**図 6-14. Quiescent Current vs Duty Cycle**

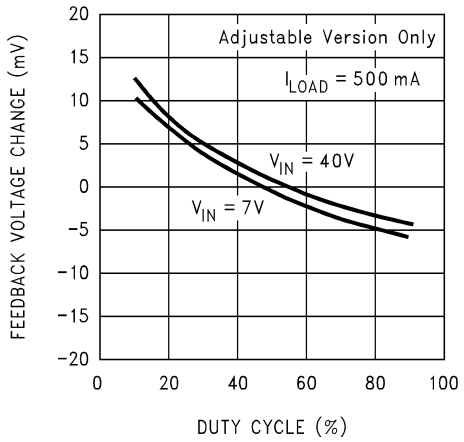



**図 6-15. Feedback Voltage vs Duty Cycle**

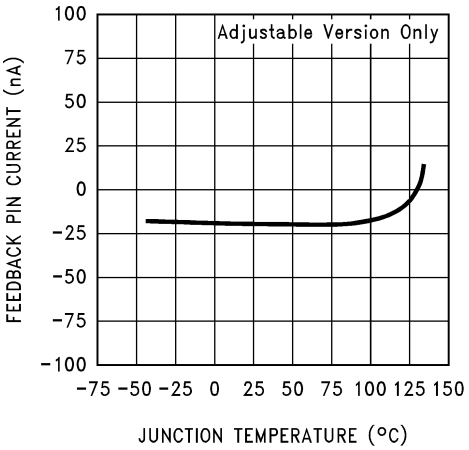
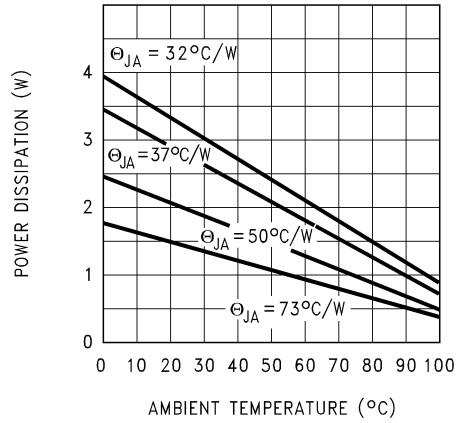
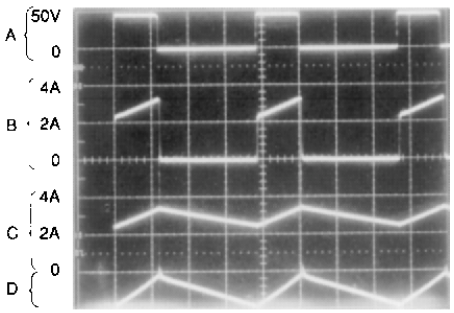



**図 6-16. Feedback Pin Current**




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

**図 6-17. Maximum Power Dissipation (DDPAK/ TO-263)**




$V_{OUT}$ = 15 V A: Output Pin Voltage, 50 V/div B: Output Pin Current, 2 A/div C: Inductor Current, 2 A/div D: Output Ripple Voltage, 50 mV/div, AC-Coupled**Horizontal Time Base: 5 µs/div**

**図 6-18. Switching Waveforms**


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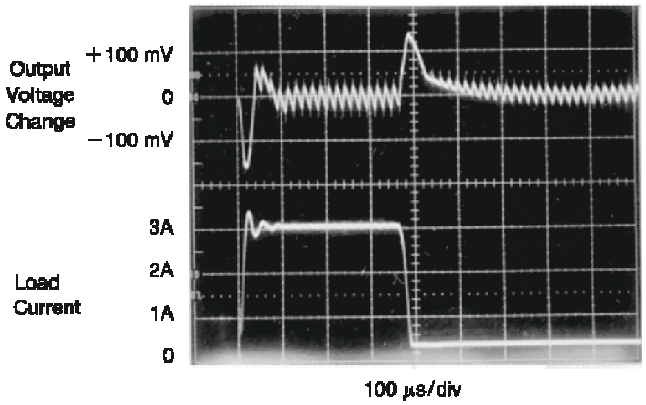


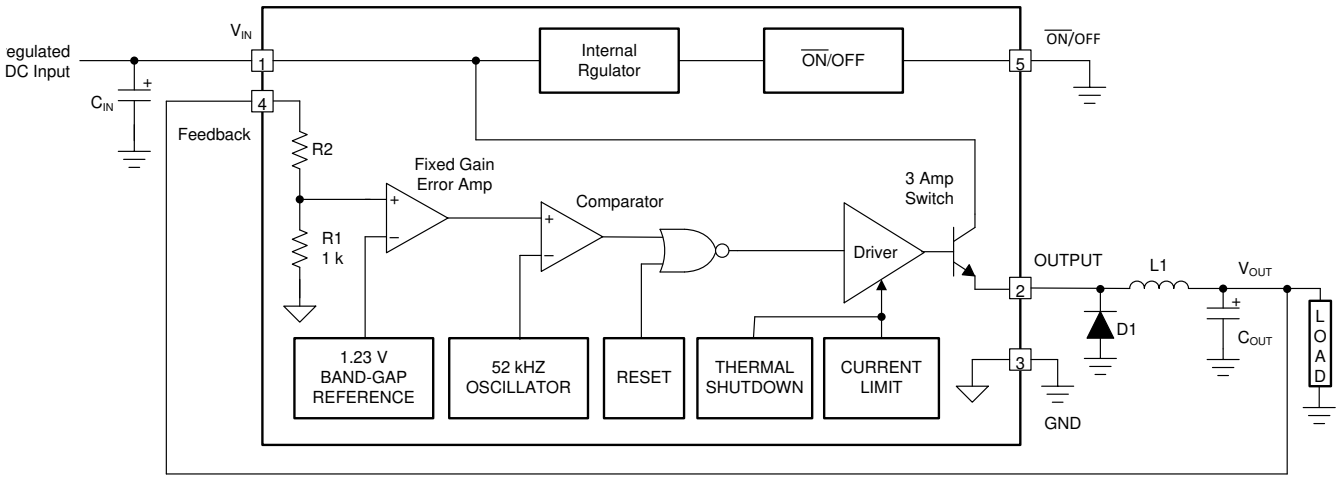

**図 6-19. Load Transient Response**

# 7 Detailed Description

## 7.1 Overview

The LM2576 SIMPLE SWITCHER® power converter regulator is an easy-to-use, non-synchronous step-down DC-DC converter with a wide input voltage range from 40 V to up to 60 V for a HV version. It is capable of delivering up to 3-A DC load current with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, 15 V, and an adjustable output version. The family requires few external components, and the pin arrangement was designed for simple, optimum PCB layout.

## 7.2 Functional Block Diagram




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

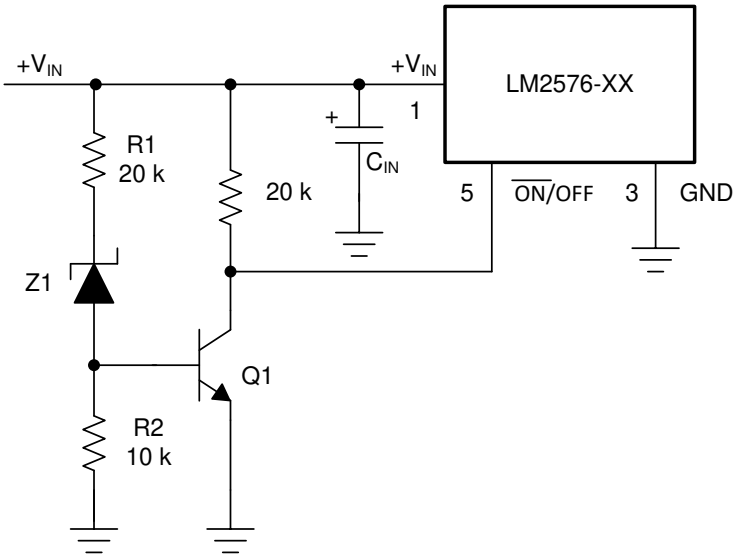
## 7.3 Feature Description

### 7.3.1 Undervoltage Lockout

In some applications it is desirable to keep the regulator off until the input voltage reaches a certain threshold. 図 7-1 shows an undervoltage lockout circuit that accomplishes this task, while 図 7-2 shows the same circuit applied to a buck-boost configuration. These circuits keep the regulator off until the input voltage reaches a predetermined level.

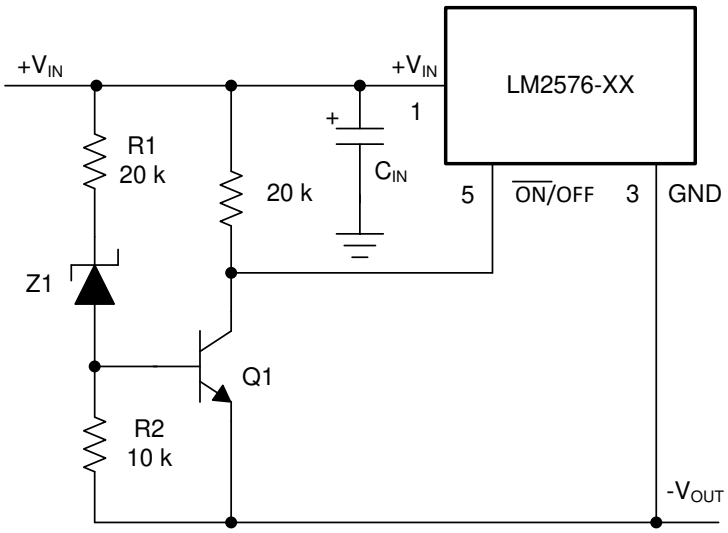
$$V_{TH} \approx V_{Z1} + 2V_{BE}(Q1) \quad (1)$$


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Complete circuit not shown.

**図 7-1. Undervoltage Lockout for Buck Circuit**




Complete circuit not shown (see 図 8-1).

**図 7-2. Undervoltage Lockout for Buck-Boost Circuit**

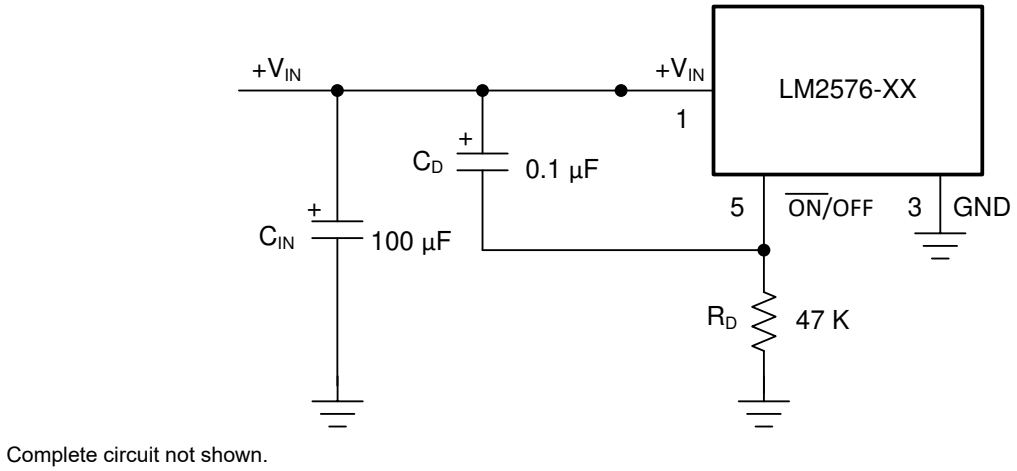
### 7.3.2 Delayed Start-Up

The $\overline{\text{ON}}$ /OFF pin can be used to provide a delayed start-up feature as shown in 図 7-3. With an input voltage of 20 V and for the part values shown, the circuit provides approximately 10 ms of delay time before the circuit begins switching. Increasing the RC time constant can provide longer delay times. But excessively large RC time constants can cause problems with input voltages that are high in 60-Hz or 120-Hz ripple, by coupling the ripple into the $\overline{\text{ON}}$ /OFF pin.

### 7.3.3 Adjustable Output, Low-Ripple Power Supply

図 7-4 shows a 3-A power supply that features an adjustable output voltage. An additional LC filter that reduces the output ripple by a factor of 10 or more is included in this circuit.

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Complete circuit not shown.

**図 7-3. Delayed Start-Up**

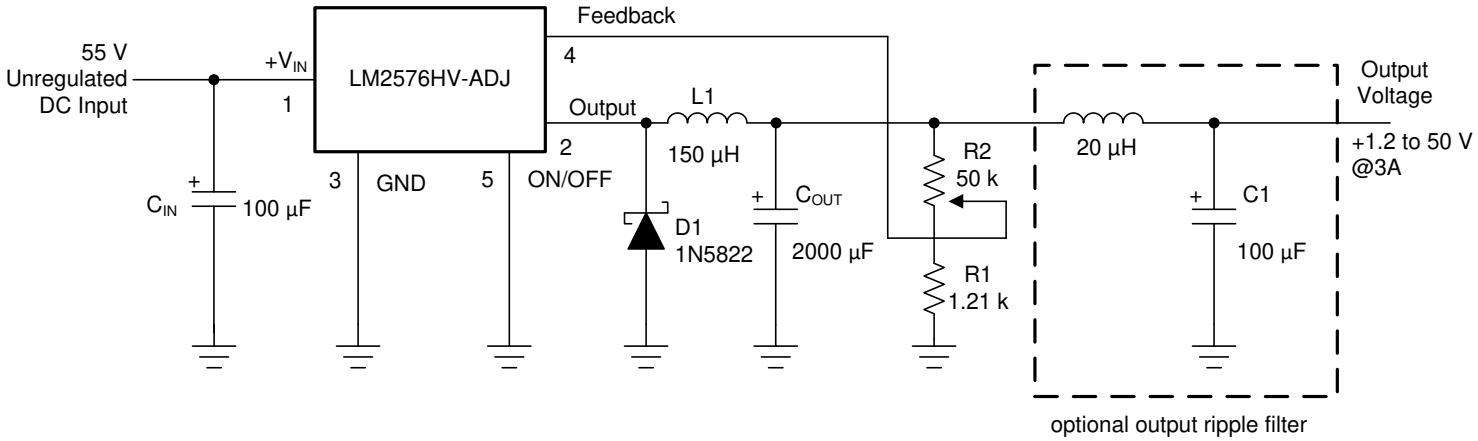



**図 7-4. 1.2-V to 55-V Adjustable 3-A Power Supply With Low Output Ripple**

## 7.4 Device Functional Modes

### 7.4.1 Shutdown Mode

The $\overline{ON}$/OFF pin provides electrical ON and OFF control for the LM2576. When the voltage of this pin is higher than 1.4 V, the device is in shutdown mode. The typical standby current in this mode is 50 µA.

### 7.4.2 Active Mode

When the voltage of the $\overline{ON}$/OFF pin is below 1.2 V, the device starts switching, and the output voltage rises until it reaches the normal regulation voltage.

### 7.4.3 Current Limit

The LM2576 device has current limiting to prevent the switch current from exceeding safe values during an accidental overload on the output. This current limit value can be found in *セクション 6.10* under the heading of $I_{CL}$.

The LM2576 uses cycle-by-cycle peak current limit for overload protection. This helps to prevent damage to the device and external components. The regulator operates in current limit mode whenever the inductor current exceeds the value of $I_{CL}$ given in *セクション 6.10*. This occurs if the load current is greater than 3 A, or the converter is starting up. Keep in mind that the maximum available load current depends on the input voltage, output voltage, and inductor value. The regulator also incorporates short-circuit protection to prevent inductor current run-away. When the voltage on the FB pin (ADJ) falls below about 0.58 V the switching frequency is


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dropped to about 11 kHz. This allows the inductor current to ramp down sufficiently during the switch OFF-time to prevent saturation.

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# 8 Application and Implementation

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Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

## 8.1 Application Information

### 8.1.1 Input Capacitor ($C_{IN}$)

To maintain stability, the regulator input pin must be bypassed with at least a 100-µF electrolytic capacitor. The capacitor leads must be kept short, and placed near the regulator.

If the operating temperature range includes temperatures below −25°C, the input capacitor value can 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 increases the regulator stability at cold temperatures. For maximum capacitor operating lifetime, the RMS ripple current rating of the capacitor must be greater than:

$$1.2\left(\frac{t_{ON}}{T}\right)(I_{LOAD}) \tag{2}$$

Where for a buck regulator:

$$\frac{t_{ON}}{T} = \frac{V_{OUT}}{V_{IN}} \tag{3}$$

Where for a buck-boost regulator:

$$\frac{t_{ON}}{T} = \frac{|V_{OUT}|}{|V_{OUT}| + V_{IN}} \tag{4}$$

### 8.1.2 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 performance and requirements.

The LM2576 (or any of the SIMPLE SWITCHER power converter family can be used for both continuous and discontinuous modes of operation.

The inductor value selection guides in 図 8-4 through 図 8-8 are designed for buck regulator designs of the continuous inductor current type. When using inductor values shown in the inductor selection guide, the peak-to-peak inductor ripple current is approximately 20% to 30% of the maximum DC current. With relatively heavy load currents, the circuit operates in the continuous mode (inductor current always flowing), but under light load conditions, the circuit is forced to the discontinuous mode (inductor current falls to zero for a period of time). This discontinuous mode of operation is perfectly acceptable. For light loads (less than approximately 300 mA), it can 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 must investigate the possibility of discontinuous operation.

Inductors are available in different styles such as pot core, toriod, E-frame, bobbin core, and so on, as well as different core materials, such as ferrites and powdered iron. The bobbin core is the least expensive type, and consists of wire wrapped on a ferrite rod core. This type of construction makes for an inexpensive inductor;


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however, because the magnetic flux is not completely contained within the core, the bobbin core 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.

The inductors listed in the selection chart include ferrite pot core construction for AIE, powdered iron toroid for Pulse Engineering, and ferrite bobbin core for Renco.

An inductor must not operate beyond its maximum-rated current because it can 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), causing the switch current to rise very rapidly. Different inductor types have different saturation characteristics, and this must be considered when selecting an inductor.

The inductor manufacturer's data sheets include current and energy limits to avoid inductor saturation.

### 8.1.3 Inductor Ripple Current

When the switcher is operating in the 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 load current drops to a low enough level, the bottom of the sawtooth current waveform reaches zero, and the switcher changes 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) is forced to run discontinuous if the load current is light enough.

### 8.1.4 Output Capacitor

An output capacitor is required to filter the output voltage and is needed for loop stability. The capacitor must be placed near the LM2576 using short PCB traces. Standard aluminum electrolytics are usually adequate, but TI recommends low ESR types for low output ripple voltage and good stability. The ESR of a capacitor depends on many factors, including: the value, the voltage rating, physical size, and the type of construction. In general, low value or low voltage (less than 12 V) electrolytic capacitors usually have higher ESR numbers.

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 ($\Delta I_{IND}$). See セクション *8.1.3*.

The lower capacitor values (220 µF to 1000 µF) allows typically 50 mV to 150 mV of output ripple voltage, while larger-value capacitors reduces the ripple to approximately 20 mV to 50 mV.

$$\text{Output Ripple Voltage} = (\Delta I_{IND})\ (\text{ESR of } C_{OUT}) \tag{5}$$

To further reduce the output ripple voltage, several standard electrolytic capacitors can be paralleled, or a higher-grade capacitor can be used. Such capacitors are often called *high-frequency*, *low-inductance*, or *low-ESR*. These reduces the output ripple to 10 mV or 20 mV. However, when operating in the continuous mode, reducing the ESR below 0.03 Ω can cause instability in the regulator.

Tantalum capacitors can have a very low ESR, and must be carefully evaluated if it is the only output capacitor. Because of their good low temperature characteristics, a tantalum can be used in parallel with aluminum electrolytics, with the tantalum making up 10% or 20% of the total capacitance.

The ripple current rating of the capacitor at 52 kHz must be at least 50% higher than the peak-to-peak inductor ripple current.

### 8.1.5 Catch Diode

Buck regulators require a diode to provide a return path for the inductor current when the switch is off. This diode must be placed close to the LM2576 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 5 V). Fast-recovery, high-efficiency, or ultra-fast

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recovery diodes are also suitable, but some types with an abrupt turnoff characteristic can cause instability and EMI problems. A fast-recovery diode with soft recovery characteristics is a better choice. Standard 60-Hz diodes (for example, 1N4001 or 1N5400, and so on) are also *not suitable*. See 表 8-3 for Schottky and *soft* fast-recovery diode selection guide.

### 8.1.6 Output Voltage Ripple and Transients

The output voltage of a switching power supply contains a sawtooth ripple voltage at the switcher frequency, typically about 1% of the output voltage, and can 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 ESR of the output capacitor (see *セクション 8.1.2*).

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 and 100 µF) can be added to the output (as shown in 図 7-4) to further reduce the amount of output ripple and transients. A 10 × reduction in output ripple voltage and transients is possible with this filter.

### 8.1.7 Feedback Connection

The LM2576 (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 LM2576 to avoid picking up unwanted noise. Avoid using resistors greater than 100 kΩ because of the increased chance of noise pickup.

### 8.1.8 $\overline{\text{ON}}$ /OFF INPUT

For normal operation, the $\overline{\text{ON}}$ /OFF pin must be grounded or driven with a low-level TTL voltage (typically below 1.6 V). To put the regulator into standby mode, drive this pin with a high-level TTL or CMOS signal. The $\overline{\text{ON}}$ /OFF pin can be safely pulled up to $+V_{IN}$ without a resistor in series with it. The $\overline{\text{ON}}$ /OFF pin must not be left open.

### 8.1.9 Inverting Regulator

図 8-1 shows a LM2576-12 in a buck-boost configuration to generate a negative 12-V output from a positive input voltage. This circuit bootstraps the ground pin of the regulator to the negative output voltage, then by grounding the feedback pin, the regulator senses the inverted output voltage and regulates it to −12 V.

For an input voltage of 12 V or more, the maximum available output current in this configuration is approximately 700 mA. At lighter loads, the minimum input voltage required drops to approximately 4.7 V.

The switch currents in this buck-boost configuration are higher than in the standard buck-mode design, thus lowering the available output current. Also, the start-up input current of the buck-boost converter is higher than the standard buck-mode regulator, and this can overload an input power source with a current limit less than 5 A. Using a delayed turn-on or an undervoltage lockout circuit (described in *セクション 8.1.10*) can allow the input voltage to rise to a high enough level before the switcher can be allowed to turn on.

Because of the structural differences between the buck and the buck-boost regulator topologies, the buck regulator design procedure section can not be used to select the inductor or the output capacitor. The recommended range of inductor values for the buck-boost design is between 68 µH and 220 µH, and the output capacitor values must be larger than what is normally required for buck designs. Low input voltages or high output currents require a large value output capacitor (in the thousands of micro Farads).

The peak inductor current, which is the same as the peak switch current, can be calculated in 式 6:


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$$I_p \approx \left(\frac{I_{LOAD}(V_{IN} + |V_{OUT}|)}{V_{IN}} + \frac{V_{IN}|V_{OUT}|}{V_{IN} + |V_{OUT}|}\right)\left(\frac{1}{2L_1 f_{OSC}}\right) \quad (6)$$

where $f_{osc}$ = 52 kHz

Under normal continuous inductor current operating conditions, the minimum $V_{IN}$ represents the worst case. Select an inductor that is rated for the peak current anticipated.

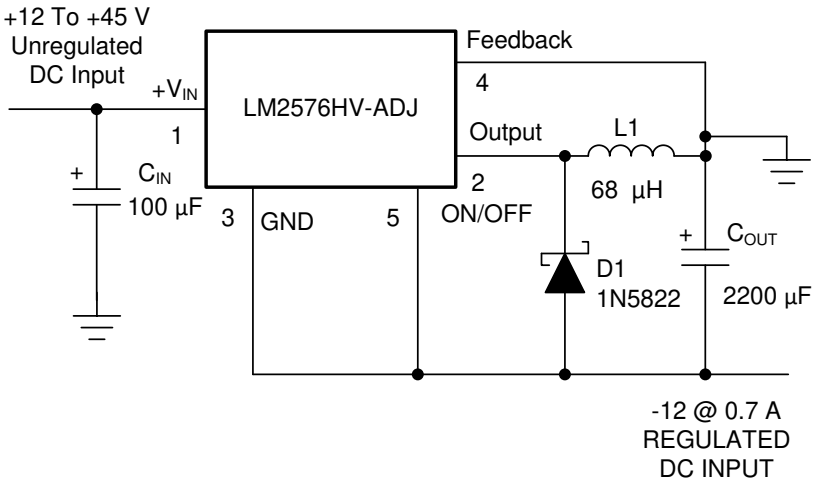
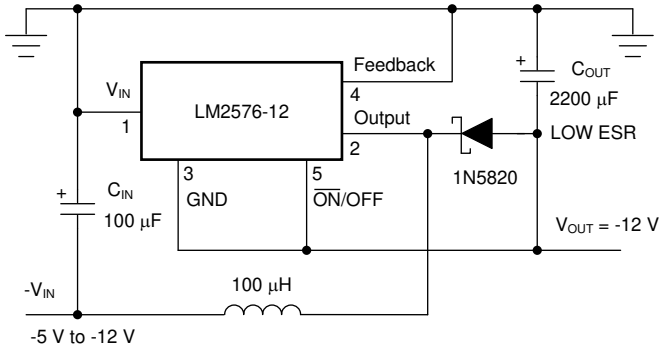



**図 8-1. Inverting Buck-Boost Develops −12 V**

Also, the maximum voltage appearing across the regulator is the absolute sum of the input and output voltage. For a −12-V output, the maximum input voltage for the LM2576 is +28 V, or +48 V for the LM2576HV.

### 8.1.10 Negative Boost Regulator

Another variation on the buck-boost topology is the negative boost configuration. The circuit in 図 8-2 accepts an input voltage ranging from −5 V to −12 V and provides a regulated −12-V output. Input voltages greater than −12 V causes the output to rise above −12 V, but does not damage the regulator.




Typical Load Current 400 mA for $V_{IN}$ = −5.2 V 750 mA for $V_{IN}$ = −7 V Heat sink can be required.

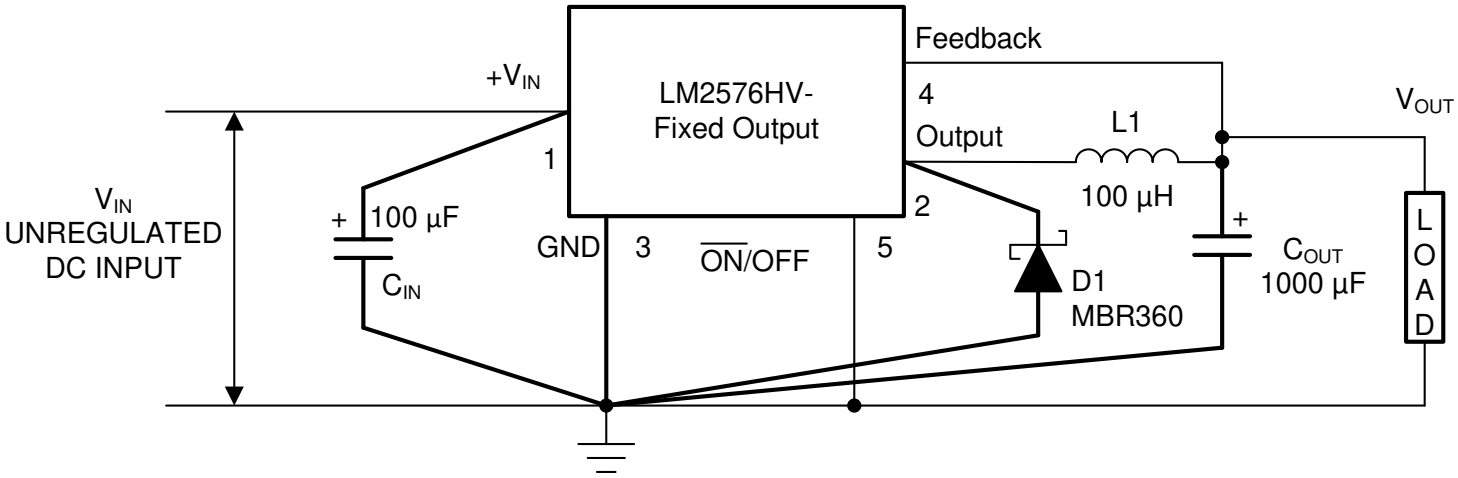
**図 8-2. Negative Boost**

Because of the boosting function of this type of regulator, the switch current is relatively high, especially at low input voltages. Output load current limitations are a result of the maximum current rating of the switch. Also, boost regulators can not provide current-limiting load protection in the event of a shorted load, so some other means (such as a fuse) can be necessary.

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## 8.2 Typical Applications

### 8.2.1 Fixed Output Voltage Version




$C_{IN}$ — 100-µF, 75-V, Aluminum Electrolytic $C_{OUT}$ — 1000-µF, 25-V, Aluminum Electrolytic $D_1$ — Schottky, MBR360 $L_1$ — 100 µH, Pulse Eng. PE-92108 $R_1$ — 2 k, 0.1% $R_2$ — 6.12 k, 0.1%

**図 8-3. Fixed Output Voltage Versions**

#### *8.2.1.1 Design Requirements*

表 8-1 lists the design parameters of this example.

**表 8-1. Design Parameters**

| DESIGN PARAMETER | EXAMPLE VALUE |
|---|---|
| Regulated Output Voltage (3.3 V, 5 V, 12 V, or 15 V), $V_{OUT}$ | 5 V |
| Maximum Input Voltage, $V_{IN}$(Max) | 15 V |
| Maximum Load Current, $I_{LOAD}$(Max) | 3 A |

#### *8.2.1.2 Detailed Design Procedure*

##### 8.2.1.2.1 Custom Design with WEBENCH® Tools

Click here to create a custom design using the WEBENCH Power Designer.

1. Start by entering your $V_{IN}$, $V_{OUT}$ and $I_{OUT}$ requirements.
2. Optimize your design for key parameters like efficiency, footprint and cost using the optimizer dial and compare this design with other possible solutions from Texas Instruments.
3. WEBENCH Power Designer provides you with a customized schematic along with a list of materials with real time pricing and component availability.
4. In most cases, you will also be able to:
   - Run electrical simulations to see important waveforms and circuit performance,
   - Run thermal simulations to understand the thermal performance of your board,
   - Export your customized schematic and layout into popular CAD formats,
   - Print PDF reports for the design, and share your design with colleagues.

##### 8.2.1.2.2 Inductor Selection (L1)

1. Select the correct Inductor value selection guide from 図 8-4, 図 8-5, 図 8-6, or 図 8-7. (Output voltages of 3.3 V, 5 V, 12 V or 15 V respectively). For other output voltages, see the design procedure for the adjustable version. Use the selection guide shown in 図 8-5.


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2. From the inductor value selection guide, identify the inductance region intersected by $V_{IN}$(Max) and $I_{LOAD}$(Max), and note the inductor code for that region. From the selection guide, the inductance area intersected by the 15-V line and 3-A line is L100.
3. Identify the inductor value from the inductor code, and select an appropriate inductor from the table shown in 図 8-4. Part numbers are listed for three inductor manufacturers. The inductor chosen must be rated for operation at the LM2576 switching frequency (52 kHz) and for a current rating of 1.15 × $I_{LOAD}$. For additional inductor information, see *セクション 8.1.2*. Inductor value required is 100 µH from the table in 図 8-4. Choose AIE 415-0930, Pulse Engineering PE92108, or Renco RL2444.

#### 8.2.1.2.3 Output Capacitor Selection ($C_{OUT}$)

1. The value of the output capacitor together with the inductor defines the dominate pole-pair of the switching regulator loop. For stable operation and an acceptable output ripple voltage, (approximately 1% of the output voltage) TI recommends a value between 100 µF and 470 µF. We choose $C_{OUT}$ = 680-µF to 2000-µF standard aluminum electrolytic.
2. The voltage rating of the capacitor must be at least 1.5 times greater than the output voltage. For a 5-V regulator, a rating of at least 8 V is appropriate, and TI recommends a 10-V or 15-V rating. Capacitor voltage rating = 20 V. Higher voltage electrolytic capacitors generally have lower ESR numbers, and for this reason it can be necessary to select a capacitor rated for a higher voltage than can normally be needed.

#### 8.2.1.2.4 Catch Diode Selection (D1)

1. The catch-diode current rating must be at least 1.2 times greater than the maximum load current. Also, if the power supply design must withstand a continuous output short, the diode must have a current rating equal to the maximum current limit of the LM2576. The most stressful condition for this diode is an overload or shorted output condition. For this example, a 3-A current rating is adequate.
2. The reverse voltage rating of the diode must be at least 1.25 times the maximum input voltage. Use a 20-V 1N5823 or SR302 Schottky diode, or any of the suggested fast-recovery diodes shown in 表 8-3.

#### 8.2.1.2.5 Input Capacitor ($C_{IN}$)

An aluminum or tantalum electrolytic bypass capacitor located close to the regulator is needed for stable operation. A 100-µF, 25-V aluminum electrolytic capacitor located near the input and ground pins provides sufficient bypassing.

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### 8.2.1.3 Application Curves

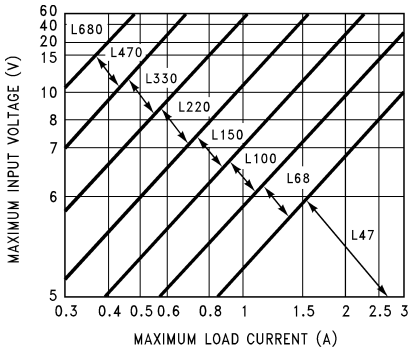



図 8-4. LM2576(HV)-3.3

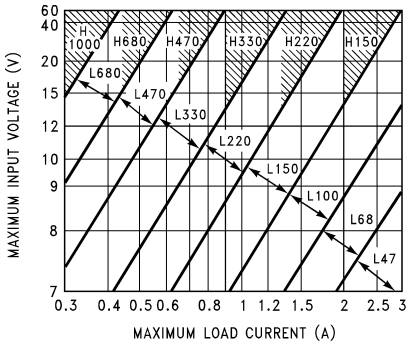



図 8-5. LM2576(HV)-5.0

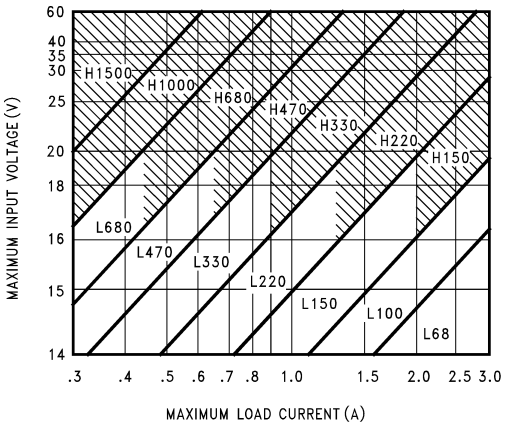



図 8-6. LM2576(HV)-12

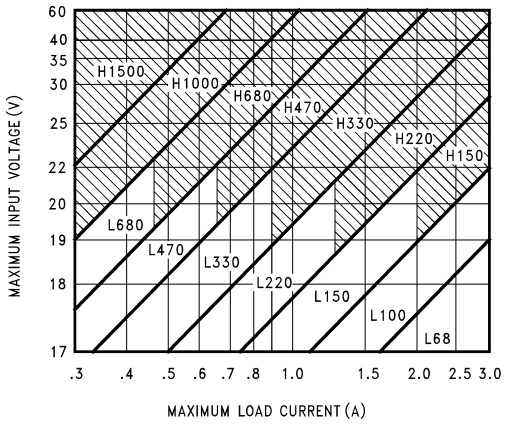



図 8-7. LM2576(HV)-15

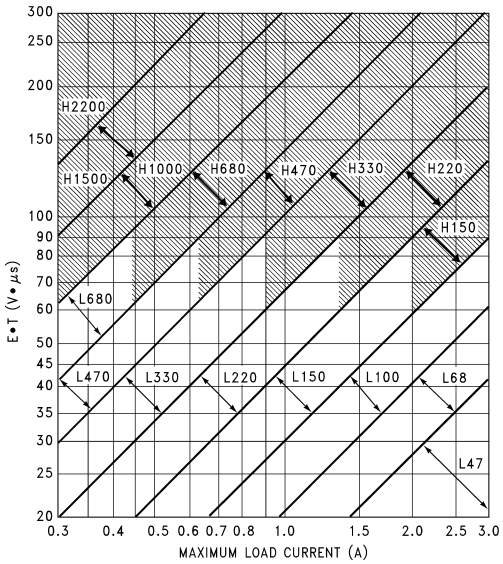
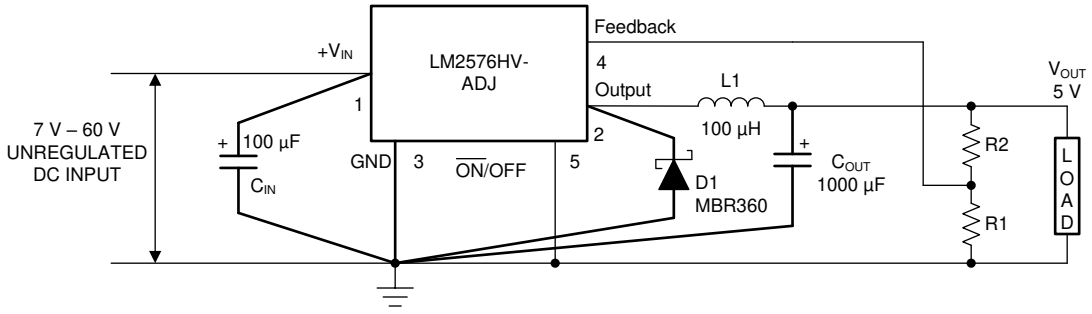



図 8-8. LM2576(HV)-ADJ


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### 8.2.2 Adjusted Output Voltage Version




$$V_{OUT} = V_{REF}\left(1 + \frac{R_2}{R_1}\right)$$

$$R_2 = R_1\left(\frac{V_{OUT}}{V_{REF}} - 1\right)$$ where $V_{REF}$ = 1.23 V, R1 between 1 k and 5 k

**図 8-9. Adjustable Output Voltage Version**

#### *8.2.2.1 Design Requirements*

表 8-2 lists the design parameters of this example.

**表 8-2. Design Parameters**

| DESIGN PARAMETER | EXAMPLE VALUE |
|---|---|
| Regulated Output Voltage, $V_{OUT}$ | 10 V |
| Maximum Input Voltage, $V_{IN}$(Max) | 25 V |
| Maximum Load Current, $I_{LOAD}$(Max) | 3 A |
| Switching Frequency, F | Fixed at 52 kHz |

#### *8.2.2.2 Detailed Design Procedure*

##### 8.2.2.2.1 Programming Output Voltage

Select R1 and R2, as shown in 図 8-9.

Use 式 7 to select the appropriate resistor values.

$$V_{OUT} = V_{REF}\left(1 + \frac{R_2}{R_1}\right) \text{ where } V_{REF} = 1.23\ V \tag{7}$$

$R_1$ can be between 1k and 5k. *(For best temperature coefficient and stability with time, use 1% metal film resistors)*

$$R_2 = R_1\left(\frac{V_{OUT}}{V_{REF}} - 1\right) = 1\ k\Omega\left(\frac{10\ V}{1.23\ V} - 1\right) \quad Select\ R_1 = 1K\Omega \tag{8}$$

$R_2$ = 1 k (8.13 − 1) = 7.13 k, closest 1% value is 7.15 k

##### 8.2.2.2.2 Inductor Selection (L1)

1. Calculate the inductor Volt • microsecond constant, E • T (V • µs), from 式 9:

$$E \times T = \left(V_{IN} - V_{OUT}\right)\frac{V_{OUT}}{V_{IN}} \times \frac{1000}{F(\text{in kHz})}\left(V \times \mu s\right) \tag{9}$$

   Calculate E • T (V • µs)

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$$E \times T = (25 - 10) \times \frac{10}{25} \times \frac{1000}{52} = 115\ V \times \mu s \quad (10)$$

2. Use the E • T value from the previous formula and match it with the E • T number on the vertical axis of the Inductor value selection guide shown in 図 8-8.

   E • T = 115 V • µs
3. On the horizontal axis, select the maximum load current.

   $I_{LOAD}$(Max) = 3 A
4. Identify the inductance region intersected by the E • T value and the maximum load current value, and note the inductor code for that region.

   Inductance Region = H150
5. Identify the inductor value from the inductor code, and select an appropriate inductor from the table shown in 表 8-4. Part numbers are listed for three inductor manufacturers. The inductor chosen must be rated for operation at the LM2576 switching frequency (52 kHz) and for a current rating of 1.15 × $I_{LOAD}$. For additional inductor information, see *セクション 8.1.2*.

   Inductor Value = 150 µH

   Choose from *AIE part #415-0936, Pulse Engineering part #PE-531115*, or *Renco part #RL2445*.

#### 8.2.2.2.3 Output Capacitor Selection ($C_{OUT}$)

1. The value of the output capacitor together with the inductor defines the dominate pole-pair of the switching regulator loop. For stable operation, the capacitor must satisfy 式 :

   $$C_{OUT} \geq 13{,}300 \frac{V_{IN(Max)}}{V_{OUT} \times L(\mu H)} (\mu F)$$

   式 yields capacitor values between 10 µF and 2200 µF that satisfies the loop requirements for stable operation. But to achieve an acceptable output ripple voltage, (approximately 1% of the output voltage) and transient response, the output capacitor can need to be several times larger than 式 yields.

   $$COUT \geq 13{,}300 \frac{25}{10 \times 150} = 22.2\ \mu F$$

   However, for acceptable output ripple voltage select

   $C_{OUT}$ ≥ 680 µF

   $C_{OUT}$ = 680-µF electrolytic capacitor
2. The capacitor voltage rating must be at last 1.5 times greater than the output voltage. For a 10-V regulator, TI recommends a rating of at least 15 V or more. Higher voltage electrolytic capacitors generally have lower ESR numbers, and for this reason it can be necessary to select a capacitor rate for a higher voltage than can normally be needed.

#### 8.2.2.2.4 Catch Diode Selection (D1)

1. The catch-diode current rating must be at least 1.2 times greater than the maximum load current. Also, if the power supply design must withstand a continuous output short, the diode must have a current rating equal to the maximum current limit of the LM2576. The most stressful condition for this diode is an overload or shorted output. See 表 8-3. For this example, a 3.3-A current rating is adequate.
2. The reverse voltage rating of the diode must be at least 1.25 times the maximum input voltage. Use a 30-V 31DQ03 Schottky diode, or any of the suggested fast-recovery diodes in 表 8-3.


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#### 8.2.2.2.5 Input Capacitor ($C_{IN}$)

An aluminum or tantalum electrolytic bypass capacitor located close to the regulator is needed for stable operation. A 100-µF aluminum electrolytic capacitor located near the input and ground pins provides sufficient bypassing.

**表 8-3. Diode Selection Guide**

| $V_R$ | SCHOTTKY | | FAST RECOVERY | |
|---|---|---|---|---|
| | 3 A | 4 A to 6 A | 3 A | 4 A to 6 A |
| 20 V | 1N5820<br>MBR320P<br>SR302 | 1N5823 | The following diodes are all rated to 100-V<br>31DF1<br>HER302 | The following diodes are all rated to 100-V<br>50WF10<br>MUR410<br>HER602 |
| 30 V | 1N5821<br>MBR330<br>31DQ03<br>SR303 | 50WQ03<br>1N5824 | | |
| 40 V | 1N5822<br>MBR340<br>31DQ04<br>SR304 | MBR340<br>50WQ04<br>1N5825 | | |
| 50 V | MBR350<br>31DQ05<br>SR305 | 50WQ05 | | |
| 60 V | MBR360<br>DQ06<br>SR306 | 50WR06<br>50SQ060 | | |

**表 8-4. Inductor Selection by Manufacturer's Part Number**

| INDUCTOR CODE | INDUCTOR VALUE | SCHOTT(1) | PULSE ENG.(2) | RENCO(3) |
|---|---|---|---|---|
| L47 | 47 µH | 671 26980 | PE-53112 | RL2442 |
| L68 | 68 µH | 671 26990 | PE-92114 | RL2443 |
| L100 | 100 µH | 671 27000 | PE-92108 | RL2444 |
| L150 | 150 µH | 671 27010 | PE-53113 | RL1954 |
| L220 | 220 µH | 671 27020 | PE-52626 | RL1953 |
| L330 | 330 µH | 671 27030 | PE-52627 | RL1952 |
| L470 | 470 µH | 671 27040 | PE-53114 | RL1951 |
| L680 | 680 µH | 671 27050 | PE-52629 | RL1950 |
| H150 | 150 µH | 671 27060 | PE-53115 | RL2445 |
| H220 | 220 µH | 671 27070 | PE-53116 | RL2446 |
| H330 | 330 µH | 671 27080 | PE-53117 | RL2447 |
| H470 | 470 µH | 671 27090 | PE-53118 | RL1961 |
| H680 | 680 µH | 671 27100 | PE-53119 | RL1960 |
| H1000 | 1000 µH | 671 27110 | PE-53120 | RL1959 |
| H1500 | 1500 µH | 671 27120 | PE-53121 | RL1958 |
| H2200 | 2200 µH | 671 27130 | PE-53122 | RL2448 |

(1) Schott Corporation, (612) 475-1173, 1000 Parkers Lake Road, Wayzata, MN 55391.
(2) Pulse Engineering, (619) 674-8100, P.O. Box 12235, San Diego, CA 92112.
(3) Renco Electronics Incorporated, (516) 586-5566, 60 Jeffryn Blvd. East, Deer Park, NY 11729.

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## 8.3 Power Supply Recommendations

As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance generate voltage transients which can cause problems. For minimal inductance and ground loops, the length of the leads indicated by heavy lines must be kept as short as possible. Single-point grounding (as indicated) or ground plane construction must be used for best results. When using the adjustable version, physically locate the programming resistors near the regulator, to keep the sensitive feedback wiring short.

## 8.4 Layout

### 8.4.1 Layout Guidelines

Board layout is critical for the proper operation of switching power supplies. First, the ground plane area must be sufficient for thermal dissipation purposes. Second, appropriate guidelines must be followed to reduce the effects of switching noise. Switch mode converters are very fast switching devices. In such cases, the rapid increase of input current combined with the parasitic trace inductance generates unwanted L di/dt noise spikes. The magnitude of this noise tends to increase as the output current increases. This noise can turn into electromagnetic interference (EMI) and can also cause problems in device performance. Therefore, take care in layout to minimize the effect of this switching noise. The most important layout rule is to keep the AC current loops as small as possible. 図 8-10 shows the current flow in a buck converter. The top schematic shows a dotted line which represents the current flow during the top-switch ON-state. The middle schematic shows the current flow during the top-switch OFF-state. The bottom schematic shows the currents referred to as AC currents. These AC currents are the most critical because they are changing in a very short time period. The dotted lines of the bottom schematic are the traces to keep as short and wide as possible. This also yields a small loop area reducing the loop inductance. To avoid functional problems due to layout, review the PCB layout example. Best results are achieved if the placement of the LM2576 device, the bypass capacitor, the Schottky diode, RFBB, RFBT, and the inductor are placed as shown in 図 8-11.TI also recommends using 2-oz copper boards or heavier to help thermal dissipation and to reduce the parasitic inductances of board traces. See *AN-1229 SIMPLE SWITCHER® PCB Layout Guidelines application report* for more information.

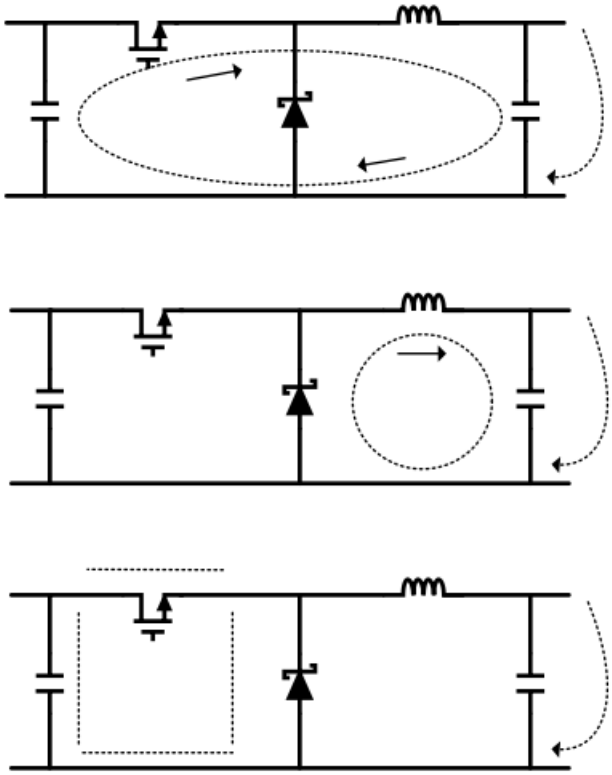


**図 8-10. Current Flow in Buck Application**


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### 8.4.2 Layout Example

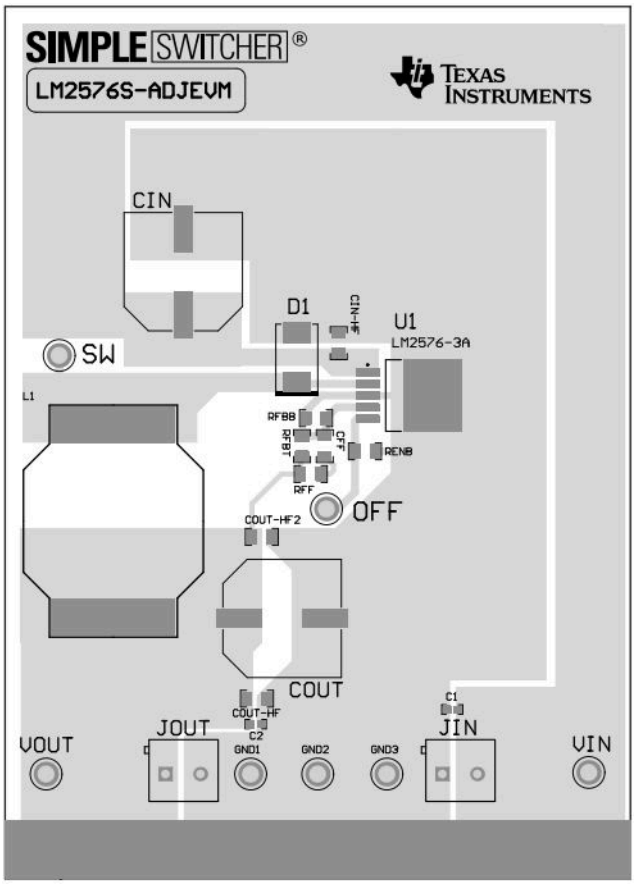



**図 8-11. LM2576xx Layout Example**

### 8.4.3 Grounding

To maintain output voltage stability, the power ground connections must be low-impedance (see 図 8-3 and 図 8-9). For the 5-lead TO-220 and DDPAK/TO-263 style package, both the tab and pin 3 are ground and either connection can be used, as they are both part of the same copper lead frame.

### 8.4.4 Heat Sink and Thermal Considerations

In many cases, only a small heat sink is required to keep the LM2576 junction temperature within the allowed operating range. For each application, to determine whether or not a heat sink is required, the following must be identified:

1. Maximum ambient temperature (in the application).
2. Maximum regulator power dissipation (in application).
3. Maximum allowed junction temperature (125°C for the LM2576). For a safe, conservative design, a temperature approximately 15°C cooler than the maximum temperatures must be selected.
4. LM2576 package thermal resistances $\theta_{JA}$ and $\theta_{JC}$.

Total power dissipated by the LM2576 can be estimated in 式 11:

$$P_D = (V_{IN})(I_Q) + (V_O/V_{IN})(I_{LOAD})(V_{SAT}) \quad (11)$$

where

- $I_Q$ (quiescent current) and $V_{SAT}$ can be found in *セクション 6.11* shown previously,

- $V_{IN}$ is the applied minimum input voltage, $V_O$ is the regulated output voltage,
- and $I_{LOAD}$ is the load current.

The dynamic losses during turnon and turnoff are negligible if a Schottky type catch diode is used.

When no heat sink is used, the junction temperature rise can be determined by 式 12:

$$\Delta T_J = (P_D)\ (\theta_{JA}) \tag{12}$$

To arrive at the actual operating junction temperature, add the junction temperature rise to the maximum ambient temperature.

$$T_J = \Delta T_J + T_A \tag{13}$$

If the actual operating junction temperature is greater than the selected safe operating junction temperature determined in step 3, then a heat sink is required.

When using a heat sink, the junction temperature rise can be determined by 式 13:

$$\Delta T_J = (P_D)\ (\theta_{JC} + \theta_{interface} + \theta_{Heat\ sink}) \tag{14}$$

The operating junction temperature is:

$$T_J = T_A + \Delta T_J \tag{15}$$

As in 式 15, if the actual operating junction temperature is greater than the selected safe operating junction temperature, then a larger heat sink is required (one that has a lower thermal resistance).


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# 9 Device and Documentation Support

## 9.1 Device Support

### 9.1.1 Device Nomenclature

#### *9.1.1.1 Definition of Terms*

**BUCK REGULATOR** A switching regulator topology in which a higher voltage is converted to a lower voltage. Also known as a step-down switching regulator.

**BUCK-BOOST REGULATOR** A switching regulator topology in which a positive voltage is converted to a negative voltage without a transformer.

**DUTY CYCLE (D)** Ratio of the output switch on-time to the oscillator period. For buck regulator:

$$D = \frac{t_{ON}}{T} = \frac{V_{OUT}}{V_{IN}} \tag{16}$$

For buck-boost regulator:

$$D = \frac{t_{ON}}{T} = \frac{|V_{OUT}|}{|V_{OUT}| + V_{IN}} \tag{17}$$

**CATCH DIODE OR CURRENT STEERING DIODE** The diode which provides a return path for the load current when the LM2576 switch is OFF.

**EFFICIENCY (η)** The proportion of input power actually delivered to the load.

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{P_{OUT}}{P_{OUT} + P_{LOSS}} \tag{18}$$

**CAPACITOR EQUIVALENT SERIES RESISTANCE (ESR)** The purely resistive component of a real capacitor impedance (see 図 9-1). It causes power loss resulting in capacitor heating, which directly affects the capacitor operating lifetime. When used as a switching regulator output filter, higher ESR values result in higher output ripple voltages.

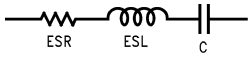



**図 9-1. Simple Model of a Real Capacitor**

Most standard aluminum electrolytic capacitors in the 100 µF–1000 µF range have 0.5Ω to 0.1Ω ESR. Higher-grade capacitors (low-ESR, high-frequency, or low-inductance) in the 100 µF to 1000 µF range generally have ESR of less than 0.15Ω.

**EQUIVALENT SERIES INDUCTANCE (ESL)** The pure inductance component of a capacitor (see 図 9-1). The amount of inductance is determined to a large extent on the capacitor construction. In a buck regulator, this unwanted inductance causes voltage spikes to appear on the output.

**OUTPUT RIPPLE VOLTAGE** The AC component of the switching regulator output voltage. It is usually dominated by the output capacitor ESR multiplied by the inductor ripple current ($\Delta I_{IND}$). The peak-to-peak value of this sawtooth ripple current can be determined by reading *セクション 8.1.3*.

**CAPACITOR RIPPLE CURRENT** RMS value of the maximum allowable alternating current at which a capacitor can be operated continuously at a specified temperature.

**STANDBY QUIESCENT CURRENT ($I_{STBY}$)** Supply current required by the LM2576 when in the standby mode ( $\overline{ON}$ /OFF pin is driven to TTL-high voltage, thus turning the output switch OFF).

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| | |
|---|---|
| **INDUCTOR RIPPLE CURRENT ($\Delta I_{IND}$)** | The peak-to-peak value of the inductor current waveform, typically a sawtooth waveform when the regulator is operating in the continuous mode (vs. discontinuous mode). |
| **CONTINUOUS/ DISCONTINUOUS MODE OPERATION** | Relates to the inductor current. In the continuous mode, the inductor current is always flowing and never drops to zero, vs. the discontinuous mode, where the inductor current drops to zero for a period of time in the normal switching cycle. |
| **INDUCTOR SATURATION** | The condition which exists when an inductor cannot hold any more magnetic flux. When an inductor saturates, the inductor appears less inductive and the resistive component dominates. Inductor current is then limited only by the DC resistance of the wire and the available source current. |
| **OPERATING VOLT MICROSECOND CONSTANT ($E \cdot T_{op}$)** | The product (in VoIt•µs) of the voltage applied to the inductor and the time the voltage is applied. This $E \cdot T_{op}$ constant is a measure of the energy handling capability of an inductor and is dependent upon the type of core, the core area, the number of turns, and the duty cycle. |

### 9.1.2 Development Support

#### *9.1.2.1 Custom Design with WEBENCH® Tools*

Click here to create a custom design using the WEBENCH Power Designer.

1. Start by entering your $V_{IN}$, $V_{OUT}$ and $I_{OUT}$ requirements.
2. Optimize your design for key parameters like efficiency, footprint and cost using the optimizer dial and compare this design with other possible solutions from Texas Instruments.
3. WEBENCH Power Designer provides you with a customized schematic along with a list of materials with real time pricing and component availability.
4. In most cases, you will also be able to:
   - Run electrical simulations to see important waveforms and circuit performance,
   - Run thermal simulations to understand the thermal performance of your board,
   - Export your customized schematic and layout into popular CAD formats,
   - Print PDF reports for the design, and share your design with colleagues.

## 9.2 Documentation Support

### 9.2.1 Related Documentation

For related documentation, see the following:

*AN-1229 SIMPLE SWITCHER® PCB Layout Guidelines application report*

## 9.3 サポート・リソース

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## 9.6 静電気放電に関する注意事項



この IC は、ESD によって破損する可能性があります。テキサス・インスツルメンツは、IC を取り扱う際には常に適切な注意を払うことを推奨します。正しい取り扱いおよび設置手順に従わない場合、デバイスを破損するおそれがあります。

ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

## 9.7 用語集

テキサス・インスツルメンツ用語集　　この用語集には、用語や略語の一覧および定義が記載されています。

# 10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM2576HVS-12/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-12 P+ |
| LM2576HVS-12/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-12 P+ |
| LM2576HVS-3.3/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-3.3 P+ |
| LM2576HVS-3.3/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-3.3 P+ |
| LM2576HVS-5.0/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-5.0 P+ |
| LM2576HVS-5.0/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-5.0 P+ |
| LM2576HVS-ADJ/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-ADJ P+ |
| LM2576HVS-ADJ/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-ADJ P+ |
| LM2576HVSX-12/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-12 P+ |
| LM2576HVSX-12/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-12 P+ |
| LM2576HVSX-3.3/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-3.3 P+ |
| LM2576HVSX-5.0/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-5.0 P+ |
| LM2576HVSX-ADJ/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576 HVS-ADJ P+ |
| LM2576HVT-12/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | - | LM2576HVT -12 P+ |
| LM2576HVT-12/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -12 P+ |
| LM2576HVT-12/NOPB | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -12 P+ |

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM2576HVT-12/NOPB.B | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -12 P+ |
| LM2576HVT-15/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | - | LM2576HVT -15 P+ |
| LM2576HVT-15/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -15 P+ |
| LM2576HVT-15/NOPB | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -15 P+ |
| LM2576HVT-15/NOPB.B | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -15 P+ |
| LM2576HVT-5.0/LF02 | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | - | LM2576HVT -5.0 P+ |
| LM2576HVT-5.0/LF02.B | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -5.0 P+ |
| LM2576HVT-5.0/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | - | LM2576HVT -5.0 P+ |
| LM2576HVT-5.0/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -5.0 P+ |
| LM2576HVT-5.0/NOPB | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -5.0 P+ |
| LM2576HVT-5.0/NOPB.B | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -5.0 P+ |
| LM2576HVT-ADJ/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | - | LM2576HVT -ADJ P+ |
| LM2576HVT-ADJ/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -ADJ P+ |
| LM2576HVT-ADJ/NOPB | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -ADJ P+ |
| LM2576HVT-ADJ/NOPB.B | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576HVT -ADJ P+ |
| LM2576S-12/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -12 P+ |
| LM2576S-12/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -12 P+ |

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM2576S-3.3/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -3.3 P+ |
| LM2576S-3.3/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -3.3 P+ |
| LM2576S-5.0/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -5.0 P+ |
| LM2576S-5.0/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -5.0 P+ |
| LM2576S-ADJ/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -ADJ P+ |
| LM2576S-ADJ/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 45 \| TUBE | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -ADJ P+ |
| LM2576SX-3.3/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -3.3 P+ |
| LM2576SX-3.3/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -3.3 P+ |
| LM2576SX-5.0/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -5.0 P+ |
| LM2576SX-5.0/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -5.0 P+ |
| LM2576SX-ADJ/NOPB | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -ADJ P+ |
| LM2576SX-ADJ/NOPB.B | Active | Production | DDPAK/ TO-263 (KTT) \| 5 | 500 \| LARGE T&R | ROHS Exempt | SN | Level-3-245C-168 HR | -40 to 125 | LM2576S -ADJ P+ |
| LM2576T-12/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -12 P+ |
| LM2576T-12/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -12 P+ |
| LM2576T-12/NOPB | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -12 P+ |
| LM2576T-12/NOPB.B | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -12 P+ |
| LM2576T-15/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -15 P+ |

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM2576T-15/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -15 P+ |
| LM2576T-15/NOPB | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -15 P+ |
| LM2576T-15/NOPB.B | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -15 P+ |
| LM2576T-3.3/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -3.3 P+ |
| LM2576T-3.3/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -3.3 P+ |
| LM2576T-3.3/NOPB | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -3.3 P+ |
| LM2576T-3.3/NOPB.B | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -3.3 P+ |
| LM2576T-5.0/LF02 | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -5.0 P+ |
| LM2576T-5.0/LF02.B | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -5.0 P+ |
| LM2576T-5.0/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -5.0 P+ |
| LM2576T-5.0/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -5.0 P+ |
| LM2576T-5.0/NOPB | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -5.0 P+ |
| LM2576T-5.0/NOPB.B | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -5.0 P+ |
| LM2576T-ADJ/LF02 | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -ADJ P+ |
| LM2576T-ADJ/LF02.B | Active | Production | TO-220 (NEB) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -ADJ P+ |
| LM2576T-ADJ/LF03 | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -ADJ P+ |
| LM2576T-ADJ/LF03.B | Active | Production | TO-220 (NDH) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -ADJ P+ |

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM2576T-ADJ/NOPB | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -ADJ P+ |
| LM2576T-ADJ/NOPB.B | Active | Production | TO-220 (KC) \| 5 | 45 \| TUBE | Yes | SN | Level-1-NA-UNLIM | -40 to 125 | LM2576T -ADJ P+ |

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

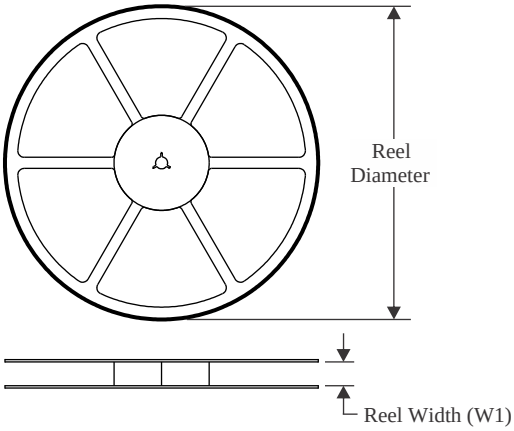
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

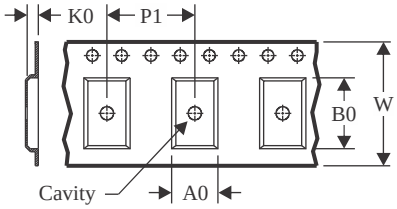
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

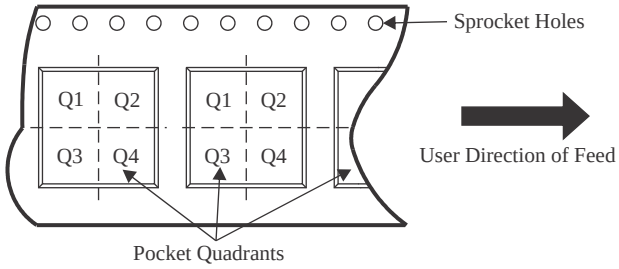



**TAPE DIMENSIONS**




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

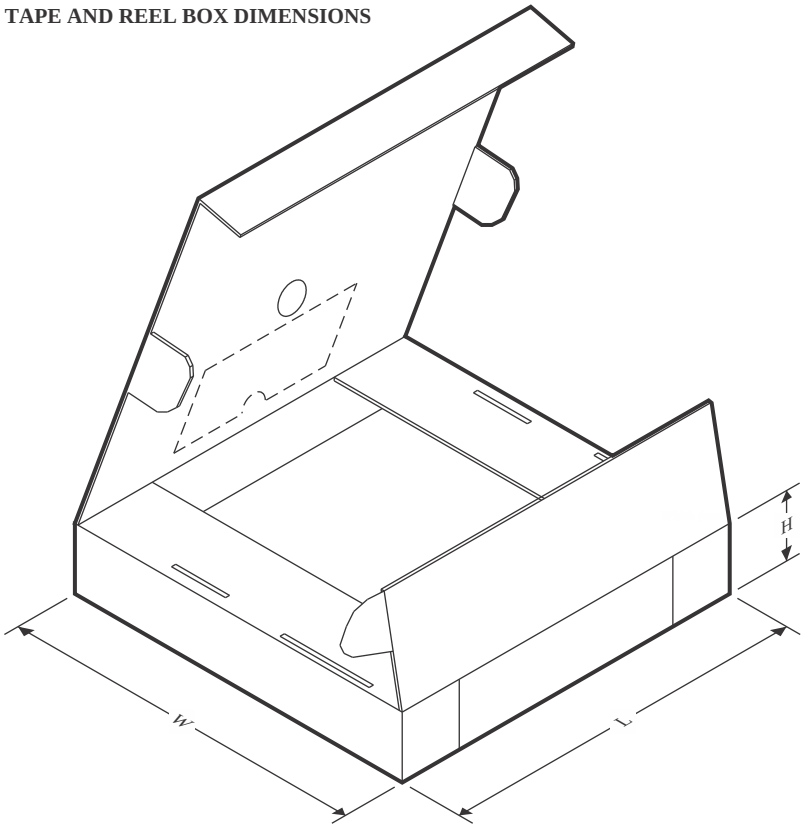
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM2576HVSX-12/NOPB | DDPAK/ TO-263 | KTT | 5 | 500 | 330.0 | 24.4 | 10.75 | 14.85 | 5.0 | 16.0 | 24.0 | Q2 |
| LM2576HVSX-3.3/NOPB | DDPAK/ TO-263 | KTT | 5 | 500 | 330.0 | 24.4 | 10.75 | 14.85 | 5.0 | 16.0 | 24.0 | Q2 |
| LM2576HVSX-5.0/NOPB | DDPAK/ TO-263 | KTT | 5 | 500 | 330.0 | 24.4 | 10.75 | 14.85 | 5.0 | 16.0 | 24.0 | Q2 |
| LM2576HVSX-ADJ/NOPB | DDPAK/ TO-263 | KTT | 5 | 500 | 330.0 | 24.4 | 10.75 | 14.85 | 5.0 | 16.0 | 24.0 | Q2 |
| LM2576SX-3.3/NOPB | DDPAK/ TO-263 | KTT | 5 | 500 | 330.0 | 24.4 | 10.75 | 14.85 | 5.0 | 16.0 | 24.0 | Q2 |
| LM2576SX-5.0/NOPB | DDPAK/ TO-263 | KTT | 5 | 500 | 330.0 | 24.4 | 10.75 | 14.85 | 5.0 | 16.0 | 24.0 | Q2 |
| LM2576SX-ADJ/NOPB | DDPAK/ TO-263 | KTT | 5 | 500 | 330.0 | 24.4 | 10.75 | 14.85 | 5.0 | 16.0 | 24.0 | Q2 |

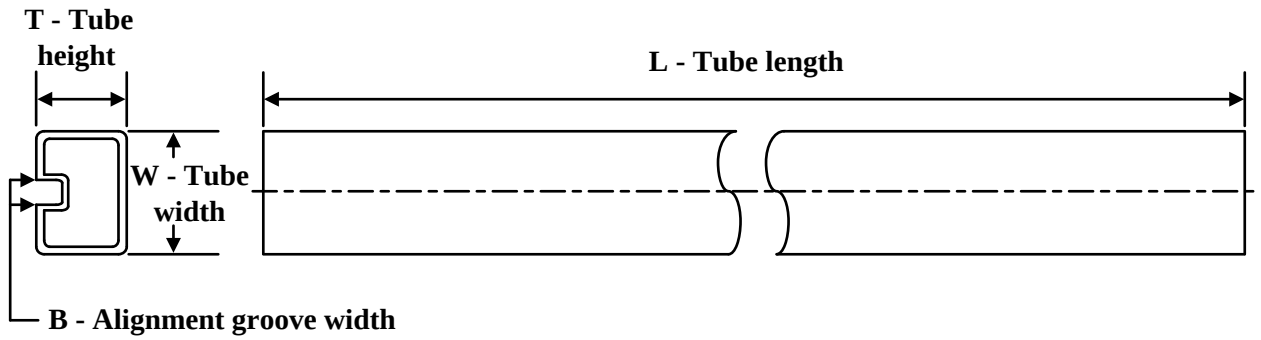
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LM2576HVSX-12/NOPB | DDPAK/TO-263 | KTT | 5 | 500 | 356.0 | 356.0 | 45.0 |
| LM2576HVSX-3.3/NOPB | DDPAK/TO-263 | KTT | 5 | 500 | 356.0 | 356.0 | 45.0 |
| LM2576HVSX-5.0/NOPB | DDPAK/TO-263 | KTT | 5 | 500 | 356.0 | 356.0 | 45.0 |
| LM2576HVSX-ADJ/NOPB | DDPAK/TO-263 | KTT | 5 | 500 | 356.0 | 356.0 | 45.0 |
| LM2576SX-3.3/NOPB | DDPAK/TO-263 | KTT | 5 | 500 | 356.0 | 356.0 | 45.0 |
| LM2576SX-5.0/NOPB | DDPAK/TO-263 | KTT | 5 | 500 | 356.0 | 356.0 | 45.0 |
| LM2576SX-ADJ/NOPB | DDPAK/TO-263 | KTT | 5 | 500 | 356.0 | 356.0 | 45.0 |

## TUBE

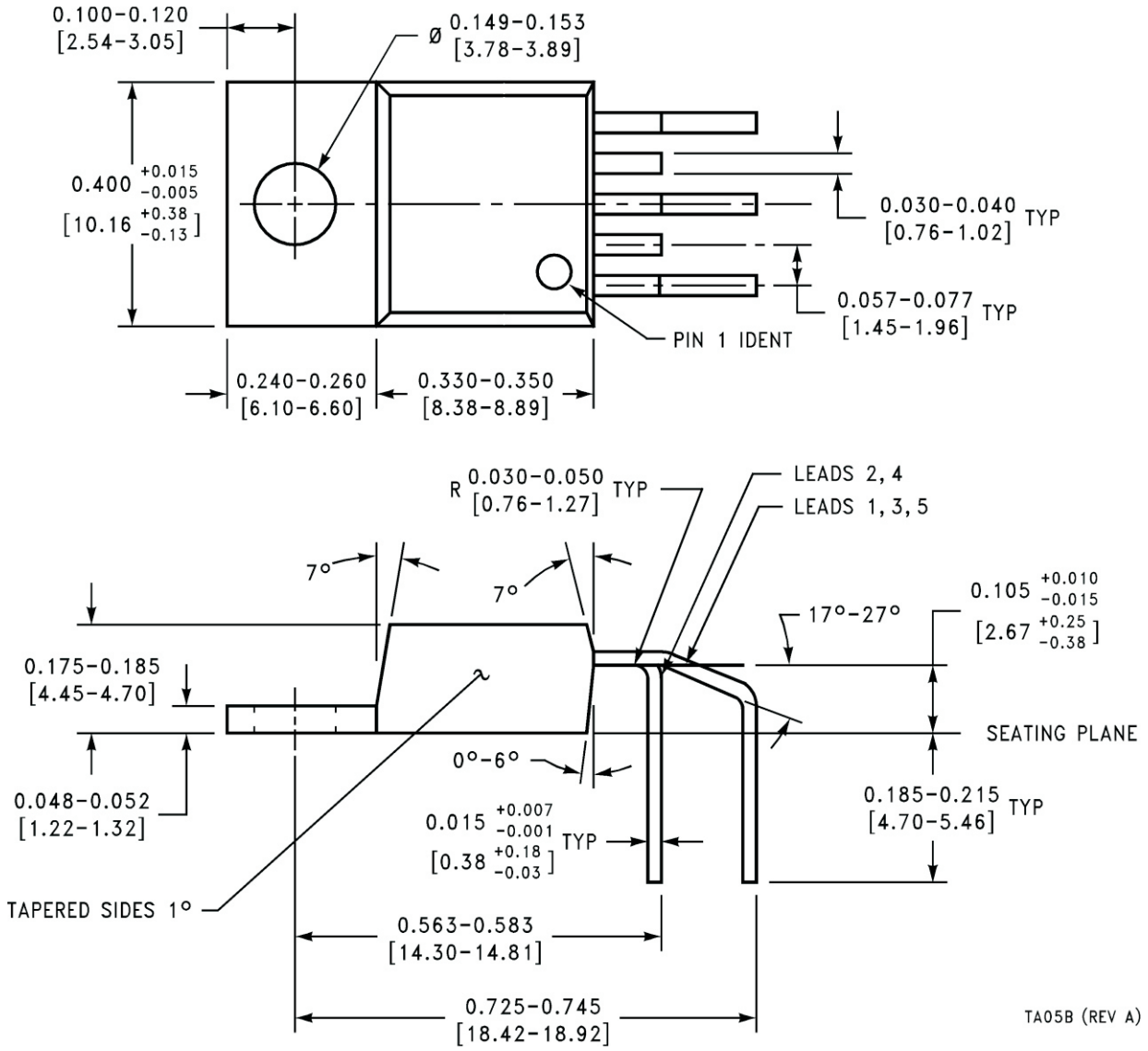



*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| LM2576HVS-12/NOPB | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576HVS-12/NOPB.B | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576HVS-3.3/NOPB | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576HVS-3.3/NOPB.B | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576HVS-5.0/NOPB | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576HVS-5.0/NOPB.B | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576HVS-ADJ/NOPB | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576HVS-ADJ/NOPB.B | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576HVT-12/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-12/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-12/NOPB | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576HVT-12/NOPB.B | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576HVT-15/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-15/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-15/NOPB | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576HVT-15/NOPB.B | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576HVT-5.0/LF02 | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-5.0/LF02.B | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-5.0/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-5.0/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-5.0/NOPB | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576HVT-5.0/NOPB.B | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576HVT-ADJ/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-ADJ/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576HVT-ADJ/NOPB | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576HVT-ADJ/NOPB.B | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576S-12/NOPB | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576S-12/NOPB.B | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576S-3.3/NOPB | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| LM2576S-3.3/NOPB.B | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576S-5.0/NOPB | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576S-5.0/NOPB.B | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576S-ADJ/NOPB | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576S-ADJ/NOPB.B | KTT | TO-263 | 5 | 45 | 502 | 25 | 8204.2 | 9.19 |
| LM2576T-12/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-12/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-12/NOPB | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576T-12/NOPB.B | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576T-15/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-15/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-15/NOPB | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576T-15/NOPB.B | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576T-3.3/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-3.3/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-3.3/NOPB | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576T-3.3/NOPB.B | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576T-5.0/LF02 | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-5.0/LF02.B | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-5.0/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-5.0/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-5.0/NOPB | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576T-5.0/NOPB.B | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576T-ADJ/LF02 | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-ADJ/LF02.B | NEB | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-ADJ/LF03 | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-ADJ/LF03.B | NDH | TO-220 | 5 | 45 | 502 | 30 | 30048.2 | 10.74 |
| LM2576T-ADJ/NOPB | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |
| LM2576T-ADJ/NOPB.B | KC | TO-220 | 5 | 45 | 502 | 33 | 6985 | 4.06 |

NEB0005B

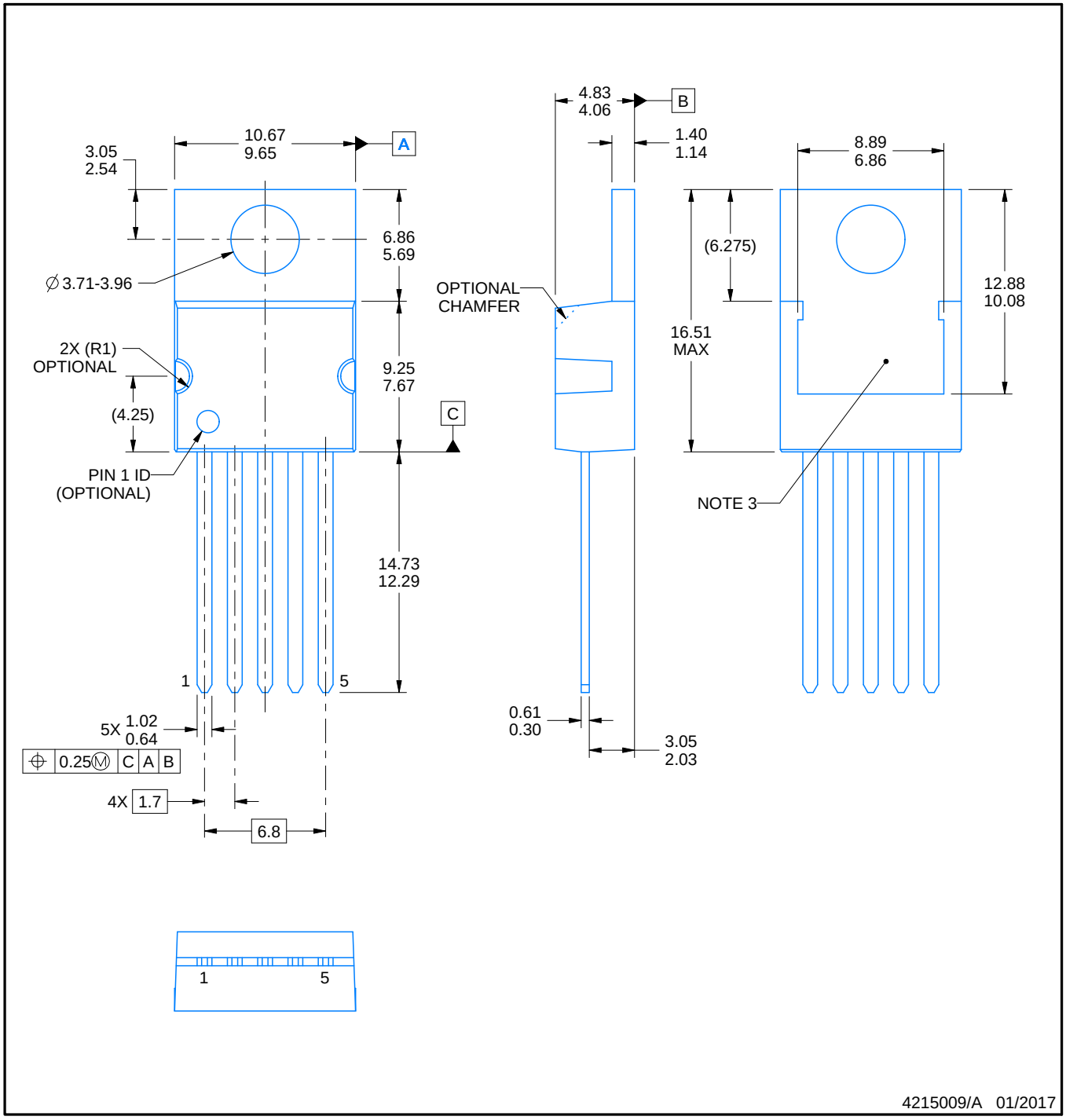

0.100–0.120
[2.54–3.05]
Ø 0.149–0.153
[3.78–3.89]
0.400 +0.015 −0.005
[10.16 +0.38 −0.13]
0.030–0.040 TYP
[0.76–1.02]
0.057–0.077 TYP
[1.45–1.96]
PIN 1 IDENT
0.240–0.260
[6.10–6.60]
0.330–0.350
[8.38–8.89]
R 0.030–0.050 TYP
[0.76–1.27]
LEADS 2, 4
LEADS 1, 3, 5
7°
7°
17°–27°
0.105 +0.010 −0.015
[2.67 +0.25 −0.38]
0.175–0.185
[4.45–4.70]
SEATING PLANE
0°–6°
0.048–0.052
[1.22–1.32]
0.185–0.215 TYP
[4.70–5.46]
0.015 +0.007 −0.001 TYP
[0.38 +0.18 −0.03]
TAPERED SIDES 1°
0.563–0.583
[14.30–14.81]
0.725–0.745
[18.42–18.92]
TA05B (REV A)

# KC0005A

# PACKAGE OUTLINE

## TO-220 - 16.51 mm max height

TO-220




NOTES:

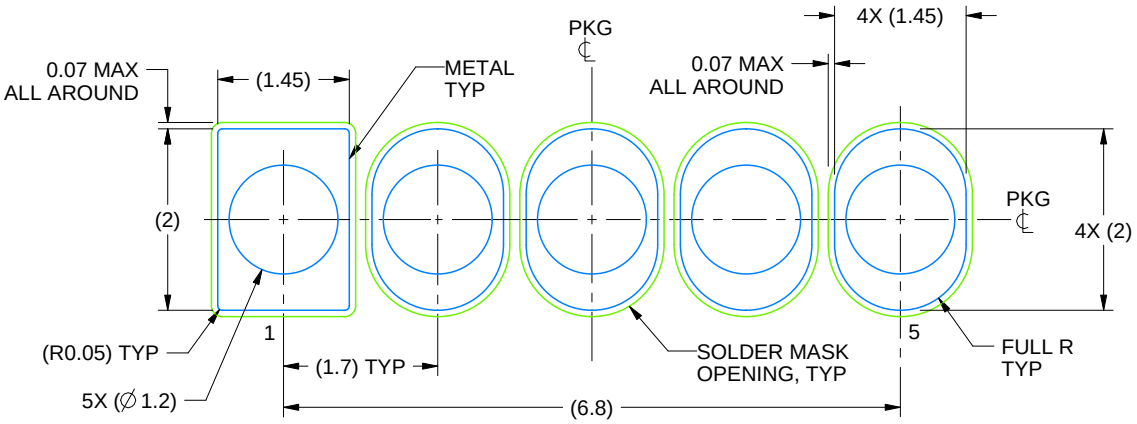
1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Shape may vary per different assembly sites.

# EXAMPLE BOARD LAYOUT

## KC0005A

## TO-220 - 16.51 mm max height

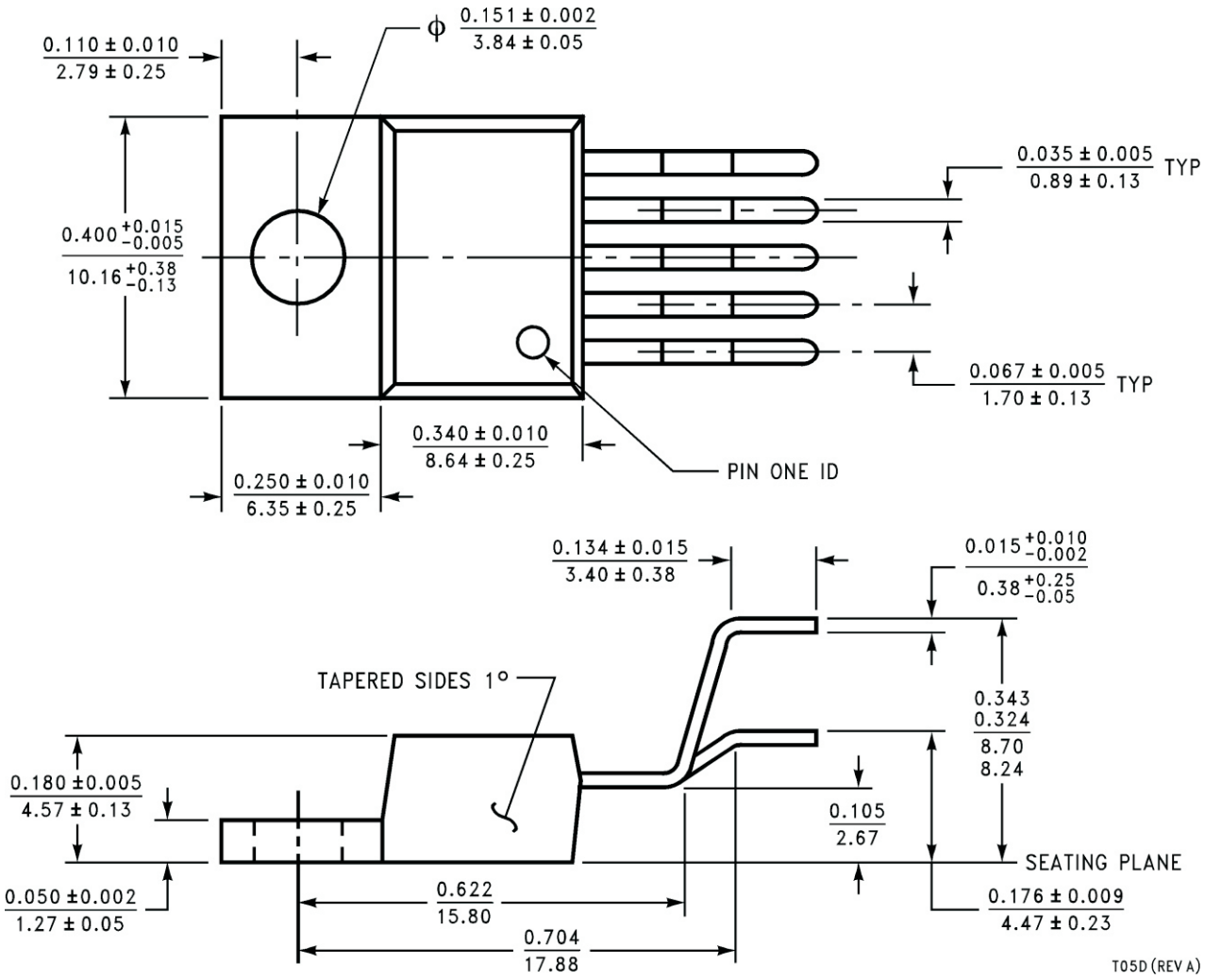
TO-220



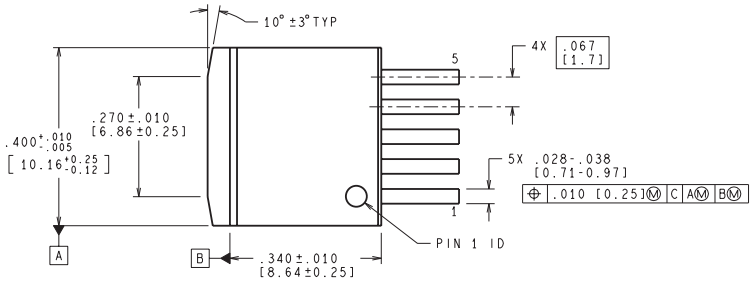

LAND PATTERN
NON-SOLDER MASK DEFINED
SCALE:12X

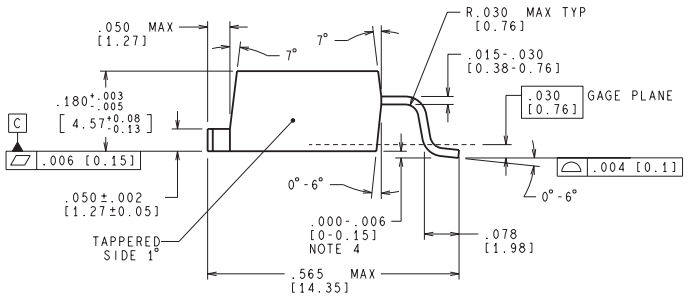
4215009/A 01/2017

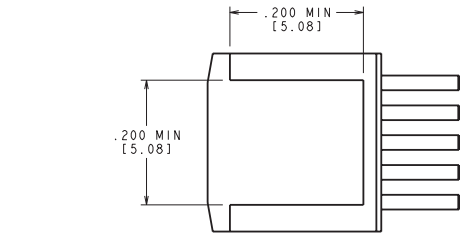
NDH0005D


0.110 ± 0.010
2.79 ± 0.25
ϕ 0.151 ± 0.002
3.84 ± 0.05
0.035 ± 0.005
0.89 ± 0.13
TYP
0.400 +0.015 −0.005
10.16 +0.38 −0.13
0.067 ± 0.005
1.70 ± 0.13
TYP
0.340 ± 0.010
8.64 ± 0.25
PIN ONE ID
0.250 ± 0.010
6.35 ± 0.25
0.134 ± 0.015
3.40 ± 0.38
0.015 +0.010 −0.002
0.38 +0.25 −0.05
TAPERED SIDES 1°
0.343
0.324
8.70
8.24
0.180 ±0.005
4.57 ± 0.13
0.105
2.67
SEATING PLANE
0.050 ±0.002
1.27 ± 0.05
0.622
15.80
0.176 ± 0.009
4.47 ± 0.23
0.704
17.88
T05D (REV A)

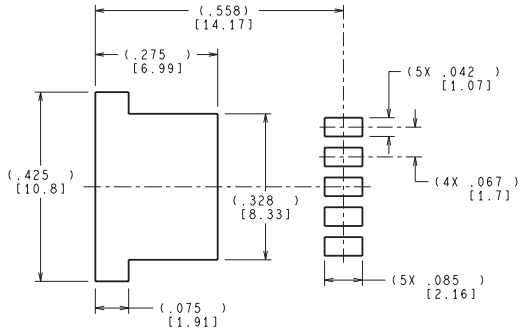
# KTT0005B




BOTTOM SIDE OF PACKAGE




LAND PATTERN RECOMMENDATION

CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY

TS5B (Rev D)

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