MIC4576

200kHz Simple 3A Buck Regulator

The Infinite Bandwidth Company™

General Description

The MIC4576 is a series of easy to use fixed and adjustable BiCMOS step-down (buck) switch-mode voltage regulators. The 200kHz MIC4576 duplicates the pinout and function of the 52kHz LM2576. The higher switching frequency may allow up to a 2:1 reduction in output filter inductor size.

The MIC4576 is available in 3.3V, and 5V fixed output versions or a 1.23V to 33V adjustable output version. Both versions are capable of driving a 3A load with excellent line and load regulation.

The feedback voltage is guaranteed to ±2% tolerance for adjustable versions, and the output voltage is guaranteed to ±3% for fixed versions, within specified voltages and load conditions. The oscillator frequency is guaranteed to ±10%.

In shutdown mode, the regulator draws less than 200µA standby current. The regulator performs cycle-by-cycle current limiting and thermal shutdown for protection under fault conditions.

This series of simple switch-mode regulators requires a minimum number of external components and can operate using a standard series of inductors. Frequency compensation is provided internally.

The MIC4576 is available in TO-220 (T) and TO-263 (U) packages for the industrial temperature range.

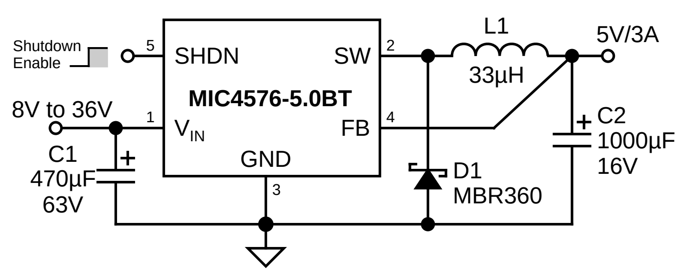
Features

- Fixed 200kHz operation
- 3.3V, 5V, and adjustable output versions
- Voltage over specified line and load conditions:
  - Fixed version: ±3% max. output voltage
  - Adjustable version: ±2% max. feedback voltage
- Guaranteed 3A switch current
- Wide 4V to 36V input voltage range
- Wide 1.23V to 33V output voltage range
- Requires minimum external components
- < 200µA typical shutdown mode
- 75% efficiency (adjustable version > 75% typical)
- Standard inductors are 25% of typical LM2576 values
- Thermal shutdown
- Overcurrent protection
- 100% electrical thermal limit burn-in

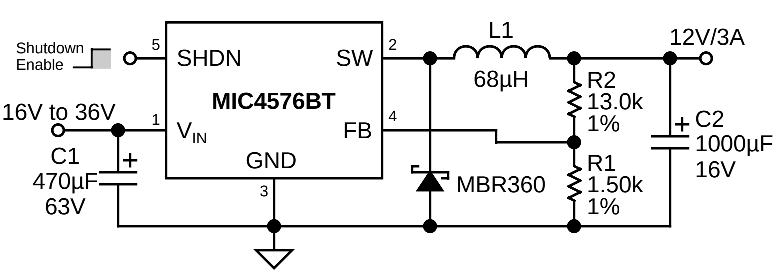
Applications

- Simple high-efficiency step-down (buck) regulator
- Efficient preregulator for linear regulators
- On-card switching regulators
- Positive-to-negative converter (inverting buck-boost)
- Battery Charger
- Negative boost converter
- Step-down to 3.3V for Intel Pentium™ and similar microprocessors

Typical Applications



Fixed Regulator



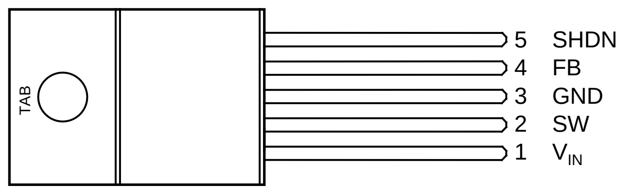
Adjustable Regulator

Micrel, Inc. • 1849 Fortune Drive • San Jose, CA 95131 • USA • tel + 1 (408) 944-0800 • fax + 1 (408) 944-0970 • http://www.micrel.com

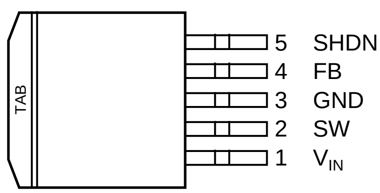
Ordering Information

Part Number	Voltage	Temperature Range	Package
MIC4576-3.3BT	3.3V	–40°C to +85°C	TO-220-5
MIC4576-5.0BT	5.0V	–40°C to +85°C	TO-220-5
MIC4576BT	Adjustable	–40°C to +85°C	TO-220-5
MIC4576-3.3BU	3.3V	–40°C to +85°C	TO-263-5
MIC4576-5.0BU	5.0V	–40°C to +85°C	TO-263-5
MIC4576BU	Adjustable	–40°C to +85°C	TO-263-5

Pin Configuration



5-Lead TO-220 (T)



5-Lead TO-263 (U)

Pin Description

Pin Number	Pin Name	Pin Function
1	V_{IN}	Supply Voltage (Input): Unregulated +4V to +36V supply voltage.
2	SW	Switch (Output): Emitter of NPN output switch. Connect to external storage inductor and Shottky diode.
3, TAB	GND	Ground
4	FB	Feedback (Input): Output voltage feedback to regulator. Connect to output of supply for fixed versions. Connect to 1.23V tap of resistive divider for adjustable versions.
5	SHDN	Shutdown (Input): Logic low enables regulator. Logic high (> 2.4V) shuts down regulator.

Absolute Maximum Ratings

Supply Voltage (V_{IN}) .... +40V
Shutdown Voltage (V_{SHDN}) .... –0.3V to +36V
Output Switch (V_{SW}), Steady State .... –1V
Feedback Voltage (V_{FB}) [Adjustable] .... +3.8V
Storage Temperature .... –65°C to +150°C

Operating Ratings

Supply Voltage (V_{IN}) .... +36V
Junction Temperature .... +150°C
Package Thermal Resistance
TO-220, TO-263 (θ_{JA}) .... 65°C/W
TO-220, TO-263 (θ_{JC}) .... 2°C/W

Electrical Characteristics

V_{IN} = 12V; I_{LOAD} = 500mA; T_J = 25°C, **bold** values indicate –40°C ≤ T_J ≤ +85°C; unless noted.

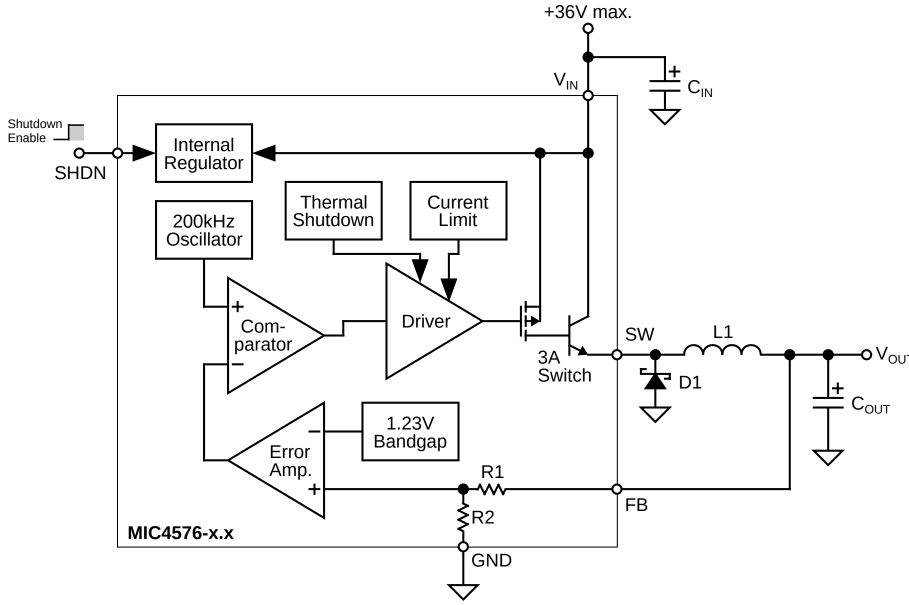
Parameter	Condition	Min	Typ	Max	Units
MIC4576 [Adjustable]					
Feedback Voltage		1.217	1.230	1.243	V
Feedback Voltage	8V ≤ V_{IN} ≤ 36V, 0.5A ≤ I_{LOAD} ≤ 3A	1.193 **1.180**	1.230	1.267 **1.280**	V V
Efficiency	I_{LOAD} = 3A, **Note 1**		77		%
Maximum Duty Cycle (On)	V_{FB} = 1.0V	90	95		%
Output Leakage Current	V_{IN} = 36V, V_{FB} = 1.5V output = 0V output = –1V		 0 7.5	 2 30	 mA mA
Quiescent Current	V_{FB} = 1.5V		5	10	mA
Feedback Bias Current			50	100 **500**	nA nA
MIC4576-3.3					
Output Voltage		3.234	3.3	3.366	V
Output Voltage	6V ≤ V_{IN} ≤ 36V, 0.5A ≤ I_{LOAD} ≤ 3A	3.168 **3.135**	3.3	3.432 **3.465**	V V
Efficiency	I_{LOAD} = 3A		72		%
Maximum Duty Cycle (On)	V_{FB} = 2.5V	90	95		%
Output Leakage Current	V_{IN} = 36V, V_{FB} = 4.0V output = 0V output = –1V		 0 7.5	 2 30	 mA mA
Quiescent Current	V_{FB} = 4.0V		5	10	mA
MIC4576-5.0					
Output Voltage		4.900	5.0	5.100	V
Output Voltage	8V ≤ V_{IN} ≤ 36V, 0.5A ≤ I_{LOAD} ≤ 3A	4.800 **4.750**	5.0	5.200 **5.250**	V V
Efficiency	I_{LOAD} = 3A		77		%
Maximum Duty Cycle (On)	V_{FB} = 4.0V	90	95		%
Output Leakage Current	V_{IN} = 36V, V_{FB} = 6.0V output = 0V output = –1V		 0 7.5	 2 30	 mA mA
Quiescent Current	V_{FB} = 6.0V		5	10	mA

Parameter	Condition	Min	Typ	Max	Units
MIC4576 / -3.3 / -5.0					
Oscillator Frequency		180	200	220	kHz
Saturation Voltage	I_{OUT} = 3A		1.7	2.3 **2.5**	V V
Current Limit	peak current, t_{ON} ≤ 3µs; V_{FB} = 0V	4.2 **3.5**	5.2	7.9 **8.5**	A A
Standby Quiescent Current	V_{SHDN} = 5V (regulator off), V_{FB} = 0V		50	200	µA
SHDN Input Logic Level	V_{OUT} = 0V (regulator off)	2.2 **2.4**	1.4		V V
	V_{OUT} = 3.3V or 5V (regulator on)		1.2	1.0 **0.8**	V V
SHDN Input Current	V_{SHDN} = 5V (regulator off) V_{SHDN} = 0V (regulator on)	 –10	4 0.01	30 10	µA µA

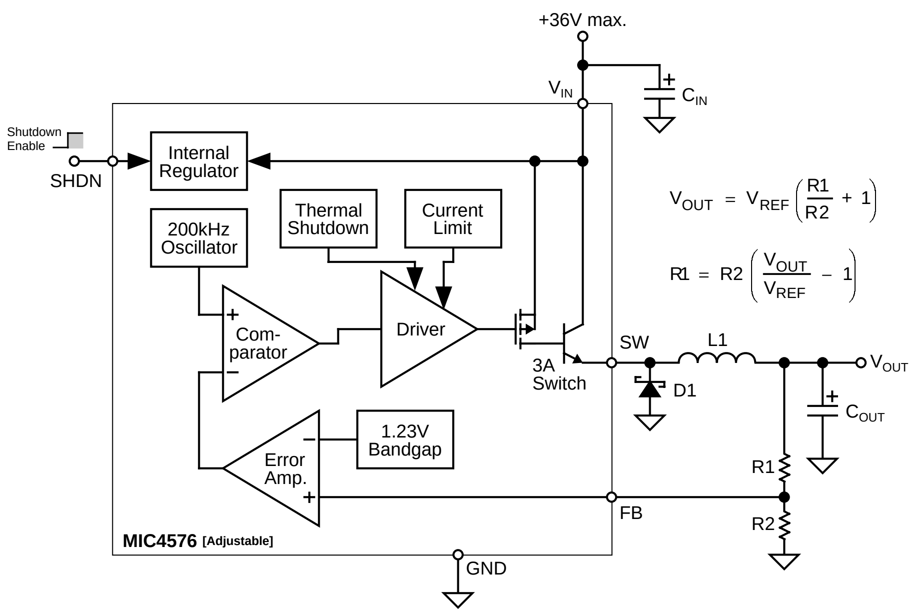
General Note: Devices are ESD protected, however, handling precautions are recommended.

Note 1: V_{OUT} = 5V

Block Diagrams



Block Diagram with External Components
Fixed Step-Down Regulator



$$V_{OUT} = V_{REF}\left(\frac{R1}{R2} + 1\right)$$

$$R1 = R2\left(\frac{V_{OUT}}{V_{REF}} - 1\right)$$

Block Diagram with External Components
Adjustable Step-Down Regulator

Functional Description

The MIC4576 is a variable duty cycle switch-mode regulator with an internal power switch. Refer to the block diagrams.

Supply Voltage

The MIC4576 operates from a +4V to +36V unregulated input. Highest efficiency operation is from a supply voltage around +15V.

Enable/Shutdown

The shutdown (SHDN) input is TTL compatible. Ground the input if unused. A logic-low enables the regulator. A logic-high shuts down the internal regulator which reduces the current to typically 50µA.

Feedback

Fixed versions of the regulator have an internal resistive divider from the feedback (FB) pin. Connect FB directly to the output line.

Adjustable versions require an external resistive voltage divider from the output voltage to ground, connected from the 1.23V tap to FB.

Duty Cycle Control

A fixed-gain error amplifier compares the feedback signal with a 1.23V bandgap voltage reference. The resulting error amplifier output voltage is compared to a 200kHz sawtooth waveform to produce a voltage controlled variable duty cycle output.

A higher feedback voltage increases the error amplifier output voltage. A higher error amplifier voltage (comparator inverting input) causes the comparator to detect only the peaks of the sawtooth, reducing the duty cycle of the comparator output. A lower feedback voltage increases the duty cycle.

Output Switching

When the internal switch is on, an increasing current flows from the supply V_{IN}, through external storage inductor L1, to output capacitor C_{OUT} and the load. Energy is stored in the inductor as the current increases with time.

When the internal switch is turned off, the collapse of the magnetic field in L1 forces current to flow through fast recovery diode D1, charging C_{OUT}.

Output Capacitor

External output capacitor C_{OUT} provides stabilization and reduces ripple.

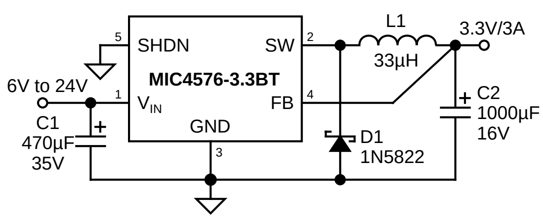
Return Paths

During the on portion of the cycle, the output capacitor and load currents return to the supply ground. During the off portion of the cycle, current is being supplied to the output capacitor and load by storage inductor L1, which means that D1 is part of the high-current return path.

Applications Information

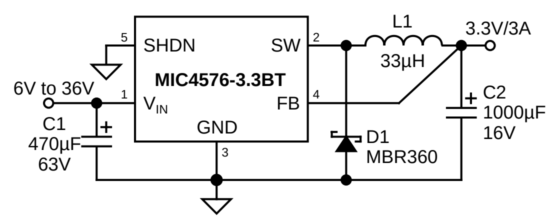
The applications circuits that follow have been constructed and tested. Refer to Application Note 15 for additional information, including efficiency graphs and manufacturer's addresses and telephone numbers for most circuits.

For a mathematical approach to component selection and circuit design, refer to Application Note 14.



C1	Nichicon	UPL1V471MPH, ESR = 0.046Ω
C2	Nichicon	UPL1C221MPH, ESR = 0.047Ω
D1	Motorola	1N5822
L1	Coiltronics	PL52C-33-1000, DCR = 0.036Ω
L1	Bi	HM77-30004, DCR = 0.045Ω, **Note 2**

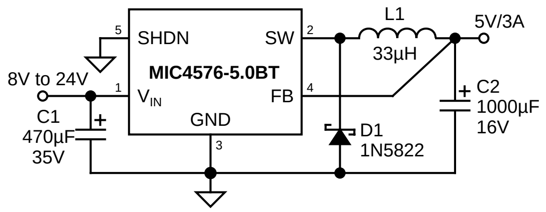
Figure 1. 6V–24V to 3.3V/3A Buck Converter Through Hole



C1	Nichicon	UPL1J471MRH, ESR = 0.039Ω
C2	Nichicon	UPL1C102MPH, ESR = 0.047Ω
D1	Motorola	MBR360
L1	Coiltronics	PL52C-33-1000 DCR = 0.036
L1	Bi	HM77-30004, DCR = 0.045Ω, **Note 2**

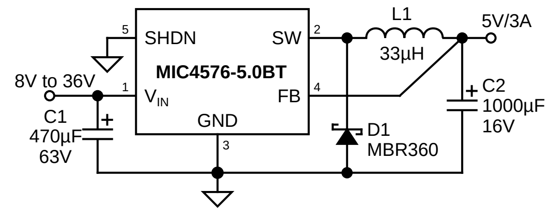
Figure 2. 6V–36V to 3.3V/3A Buck Converter Through Hole

Note 2: Surface-mount component.



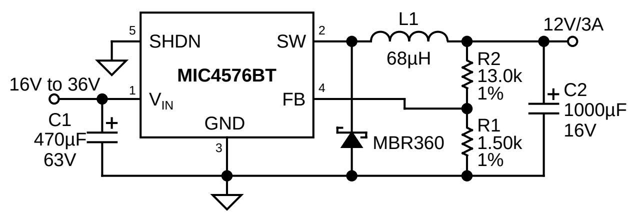
C1	Nichicon	UPL1J471MPH, ESR = 0.046Ω
C2	Nichicon	UPL1C102MPH, ESR = 0.047Ω
D1	Motorola	MBR5822
L1	Coiltronics	PL52C-33-1000, DCR = 0.036
L1	Bi	HM77-30004, DCR = 0.045Ω, **Note 2**

Figure 3. 8V–24V to 5V/3A Buck Converter Through Hole



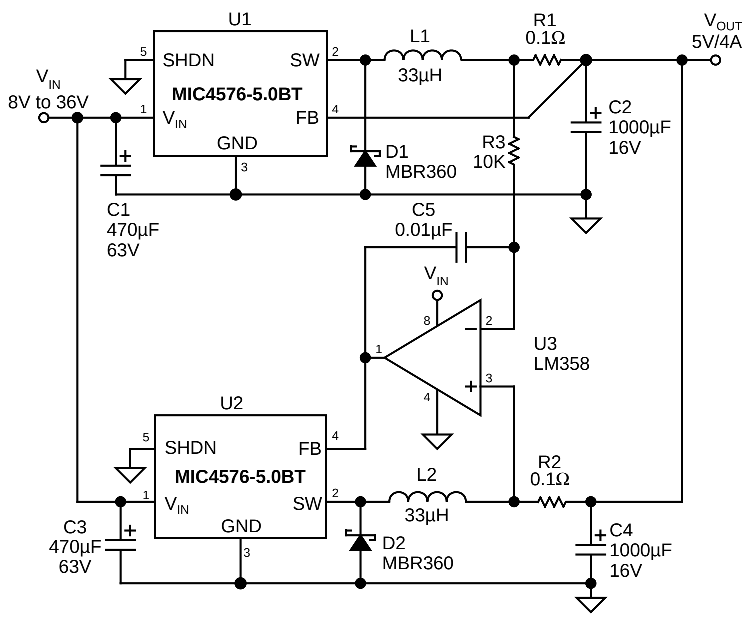
C1	Nichicon	UPL1J471MRH, ESR = 0.039Ω
C2	Nichicon	UPL1C102MPH, ESR = 0.047Ω
D1	Motorola	MBR360
L1	Coiltronics	PLS2C-33-1000, DCR = 0.036
L1	Bi	HM77-30004, DCR = 0.045Ω, **Note 2**

Figure 4. 8V–36V to 5V/3A Buck Converter Through Hole



C1	Nichicon	UPL1J471MPH, ESR = 0.039Ω
C2	Nichicon	UPL1C102MPH, ESR = 0.047Ω
D1	Motorola	MBR360
L1	Bi	HM77-29006, DCR = 0.08Ω

Figure 5. 16V–36V to 12V/3A Buck Converter Through Hole

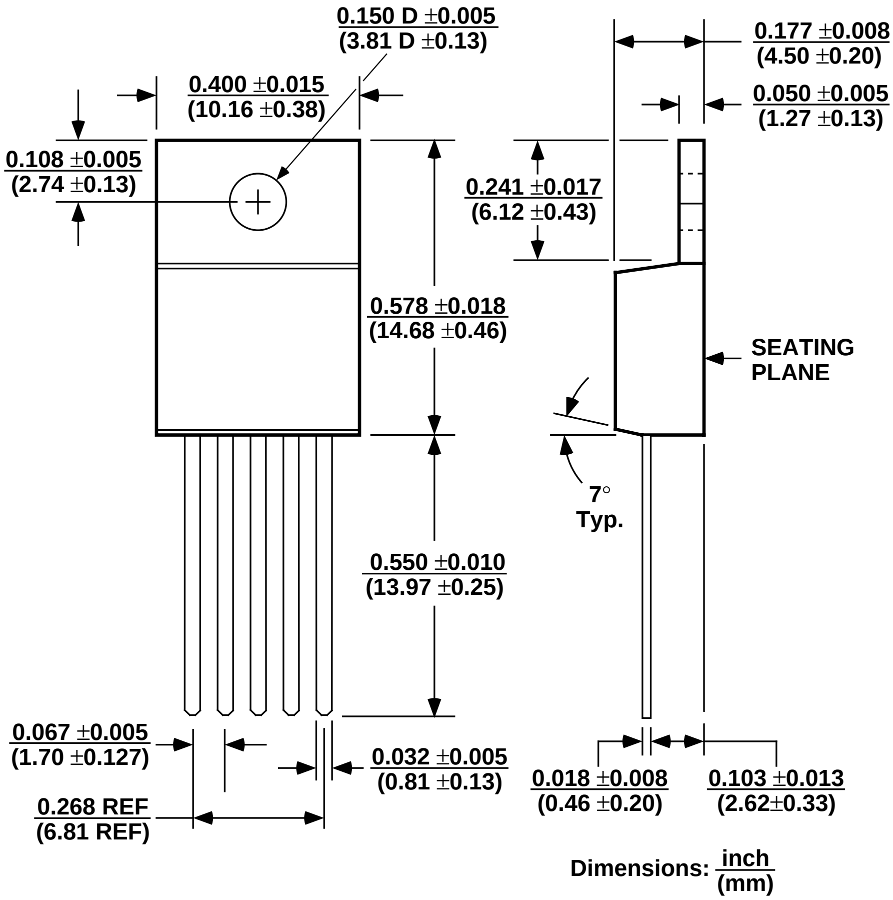


C1, C3	Nichicon	UPL1J471MRH, ESR = 0.039Ω
C2, C4	Nichicon	UPL1C102MPH, ESR = 0.047Ω
D1, D2	Motorola	MBR360
L1, L2	Coiltronics	PL52C-33-1000, DCR = 0.036
R1, R2	KRL	SP-1-A1-0R100J
U3	National	LM358

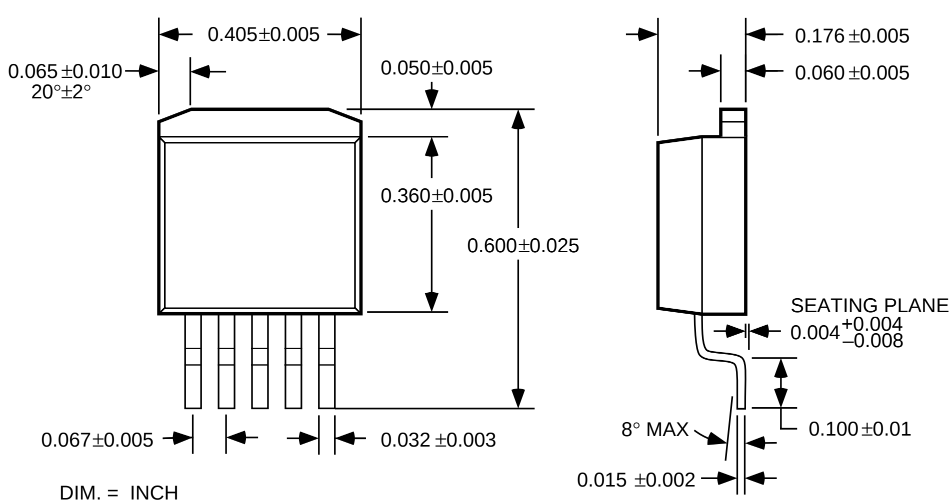
Figure 6. Parallel Switching Regulators

Note 2: Surface-mount component.

Package Information



5-Lead TO-220 (T)



5-Lead TO-263 (U)

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