

#### General Description

The MIC4575 is a series of easy to use fixed and adjustable BiCMOS step-down (buck) switch-mode voltage regulators. The 200kHz MIC4575 duplicates the pinout and function of the 52kHz LM2575. The higher switching frequency may allow up to a 2:1 reduction in output filter inductor size.

The MIC4575 is available in 3.3V, and 5V fixed output versions or a 1.23V to 20V adjustable output version. Both versions are capable of driving a 1A load with excellent line and load regulation.

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

In shutdown mode, the regulator draws less than 200 $\mu$ A 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 MIC4575 is available in TO-220 (T) and TO-263 (U) packages for the industrial temperature range.

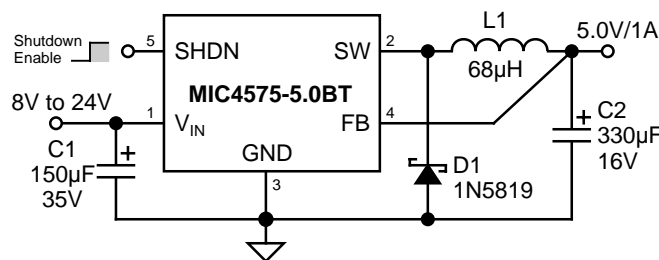
#### Features

- Fixed 200kHz operation
- 3.3V, 5V, and adjustable output versions
- Voltage over specified line and load conditions:
  - Fixed version:  $\pm 3\%$  max. output voltage
  - Adjustable version:  $\pm 2\%$  max. feedback voltage
- Guaranteed 1A switch current
- Wide 4V to 24V input voltage range
- Wide 1.23V to 20V output voltage range
- Requires minimum external components
- < 200 $\mu$ A typical shutdown mode
- 75% efficiency (adjustable version > 75% typical)
- Standard inductors and capacitors are 25% of typical LM2575 values.
- Thermal shutdown
- Overcurrent protection
- 100% electrical thermal limit burn-in

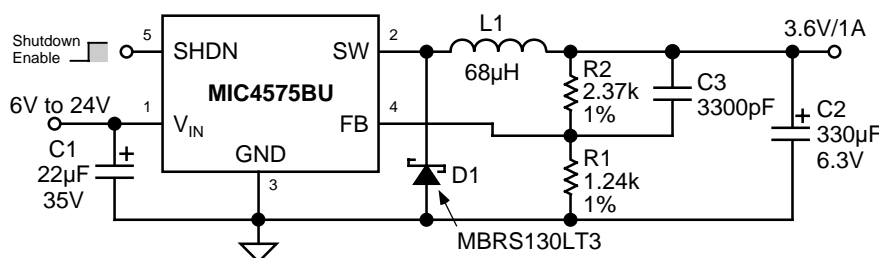
#### Applications

- 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 6V to 3.3V for Intel Pentium™ and similar microprocessors

#### Typical Applications



Fixed Regulator

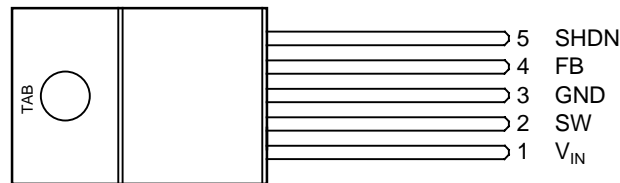


Adjustable Regulator

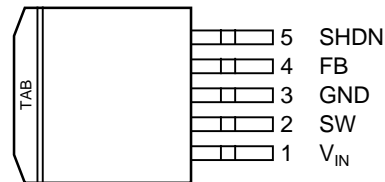
## Ordering Information

| Part Number   | Voltage    | Temperature Range | Package       |
|---------------|------------|-------------------|---------------|
| MIC4575-3.3BT | 3.3V       | -40°C to +85°C    | 5-lead TO-220 |
| MIC4575-5.0BT | 5.0V       | -40°C to +85°C    | 5-lead TO-220 |
| MIC4575BT     | Adjustable | -40°C to +85°C    | 5-lead TO-220 |
| MIC4575-3.3BU | 3.3V       | -40°C to +85°C    | 5-lead TO-263 |
| MIC4575-5.0BU | 5.0V       | -40°C to +85°C    | 5-lead TO-263 |
| MIC4575BU     | Adjustable | -40°C to +85°C    | 5-lead TO-263 |

## 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 +40V supply voltage.  |
| 2          | SW       | Switch (Output): Emitter of NPN output switch. Connect to external storage inductor and Schottky 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 ( $V_{IN}$ ) <b>Note 1</b> ..... | +40V           |
| Shutdown Voltage ( $V_{SHDN}$ ) .....           | -0.3V to +36V  |
| Output Switch ( $V_{SW}$ ) steady state .....   | -1V            |
| Storage Temperature ( $T_S$ ) .....             | -65°C to 150°C |

**Operating Ratings**

|  |        |
|--|--------|
| Supply Voltage ( $V_{IN}$ ) .....      | +24V   |
| Junction Temperature .....             | +150°C |
| Package Thermal Resistance             |        |
| TO-220, TO-263 ( $\theta_{JA}$ ) ..... | 65°C/W |
| TO-220, TO-263 ( $\theta_{JA}$ ) ..... | 2°C/W  |

**Electrical Characteristics**

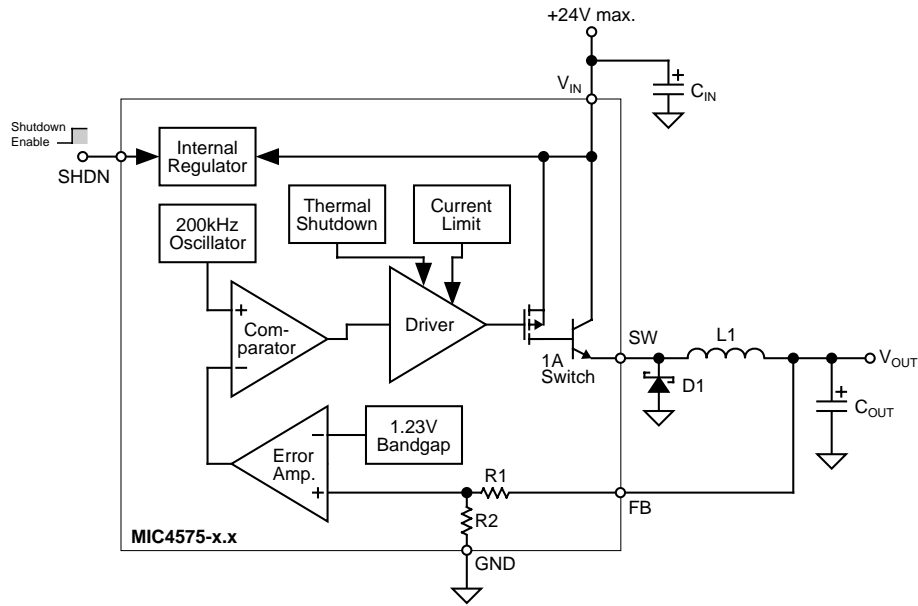
$V_{IN} = 12V$ ;  $I_{LOAD} = 200mA$ ;  $T_J = 25^\circ C$ , **bold** values indicate  $-40^\circ C \leq T_J \leq +85^\circ C$ ; unless noted.

| Parameter                    | Condition  | Min                   | Typ       | Max                   | Units              |
|------------------------------|--|-----------------------|-----------|-----------------------|--------------------|
| <b>MIC4575 [Adjustable]</b>  |  |                       |           |                       |                    |
| Feedback Voltage             |  | 1.217                 | 1.230     | 1.243                 | V                  |
| Feedback Voltage             | $8V \leq V_{IN} \leq 24V$ , $0.2A \leq I_{LOAD} \leq 1A$           | 1.193<br><b>1.180</b> | 1.230     | 1.267<br><b>1.280</b> | V<br>V             |
| Efficiency                   | $I_{LOAD} = 1A$ , $V_{OUT} = 5V$                                   |                       | 77        |                       | %                  |
| Feedback Bias Current        |  |                       | 50        | 100<br><b>500</b>     | nA<br>nA           |
| <b>MIC4575-3.3</b>           |  |                       |           |                       |                    |
| Output Voltage               |  | 3.234                 | 3.3       | 3.366                 | V                  |
| Output Voltage               | $6V \leq V_{IN} \leq 24V$ , $0.2A \leq I_{LOAD} \leq 1A$           | 3.168<br><b>3.135</b> | 3.3       | 3.432<br><b>3.465</b> | V<br>V             |
| Efficiency                   | $I_{LOAD} = 1A$  |                       | 72        |                       | %                  |
| <b>MIC4575-5.0</b>           |  |                       |           |                       |                    |
| Output Voltage               |  | 4.900                 | 5.0       | 5.100                 | V                  |
| Output Voltage               | $8V \leq V_{IN} \leq 24V$ , $0.2A \leq I_{LOAD} \leq 1A$           | 4.800<br><b>4.750</b> | 5.0       | 5.200<br><b>5.250</b> | V<br>V             |
| Efficiency                   | $I_{LOAD} = 1A$  |                       | 77        |                       | %                  |
| <b>MIC4575 / -3.3 / -5.0</b> |  |                       |           |                       |                    |
| Oscillator Frequency         |  | 180                   | 200       | 220                   | kHz                |
| Saturation Voltage           | $I_{OUT} = 1A$   |                       | 1         | 1.3<br><b>1.5</b>     | V<br>V             |
| Maximum Duty Cycle (On)      | FB connected to 0V   | 90                    | 95        |                       | %                  |
| Current Limit                | Peak Current, $t_{ON} \leq 3\mu s$                                 | 1.7<br><b>1.3</b>     | 2.2       | 3.0<br><b>3.2</b>     | A<br>A             |
| Output Leakage Current       | $V_{IN} = 24V$ , FB connected to 0V<br>Output = 0V<br>Output = -1V |                       | 0<br>7.5  | 2<br>30               | mA<br>mA           |
| Quiescent Current            |  |                       | 5         | 10                    | mA                 |
| Standby Quiescent Current    | SHDN = 5V (regulator off)  |                       | 50        | 200                   | $\mu A$            |
| SHDN Input Logic Level       | $V_{OUT} = 0V$ (regulator off)                                     | 2.2<br><b>2.4</b>     | 1.4       |                       | V<br>V             |
| SHDN Input Current           | $V_{OUT} = 3.3$ or $5V$ (regulator on)                             |                       | 1.2       | 1.0<br><b>0.8</b>     | V<br>V             |
|                              | SHDN = 5V (regulator off)<br>SHDN = 0V (regulator on)              | -10                   | 4<br>0.01 | 30<br>10              | $\mu A$<br>$\mu A$ |

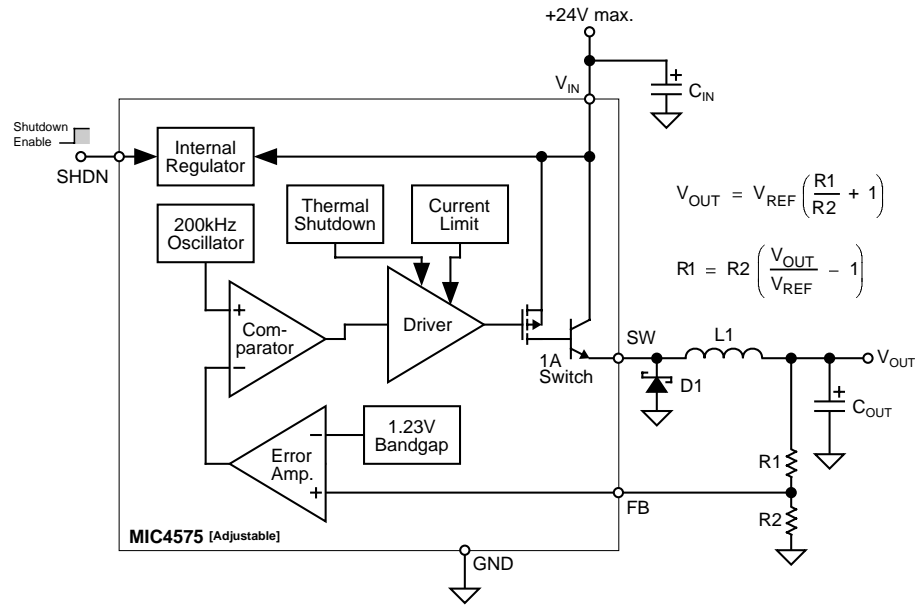
**General Note:** Devices are ESD protected, however, handling precautions are recommended.

**Note 1:** The MIC4575 is not guaranteed to survive a short circuit to ground for input voltage above 24V.

Block Diagrams



**Block Diagram with External Components  
Fixed Step-Down Regulator**



**Block Diagram with External Components  
Adjustable Step-Down Regulator**

## Functional Description

The MIC4575 is a variable duty cycle switch-mode regulator with an internal power switch. Refer to the block diagrams.

### Supply Voltage

The MIC4575 operates from a +4V to +24V 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 50 $\mu$ A.

### 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.

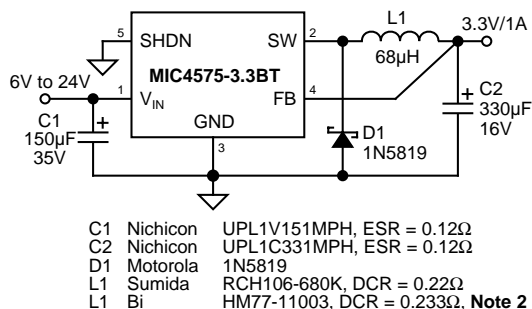
### Return Paths

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.

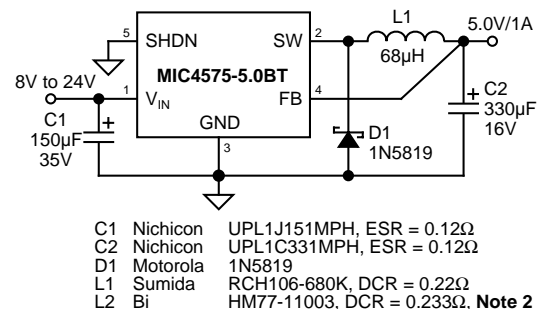
## Applications Information

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.

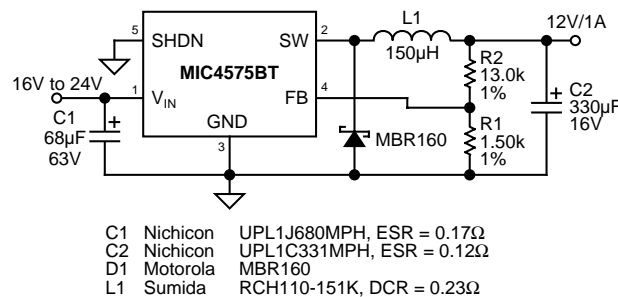
For a mathematical approach to component selection and circuit design, refer to Application Note 14.



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



**Figure 2. 8V–24V to 5V/1A Buck Converter Through Hole**



**Figure 3. 16V–24V to 12V/1A Buck Converter, Through Hole**

**Note 2:** Surface-mount component.

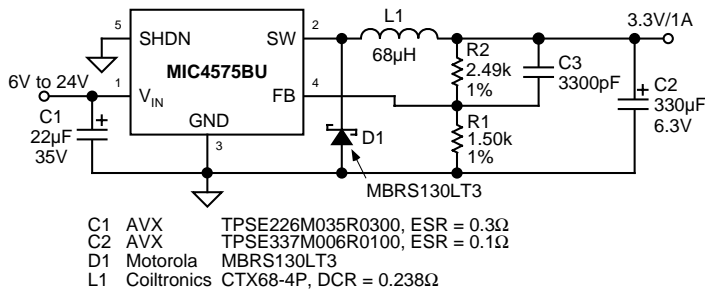


Figure 4. 6V–24V to 3.3V/1A Buck Converter Low-Profile Surface Mount

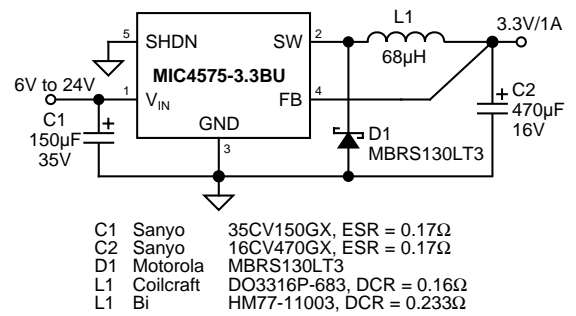


Figure 7. 6V–24V to 3.3V/1A Buck Converter Lower-Cost Surface Mount

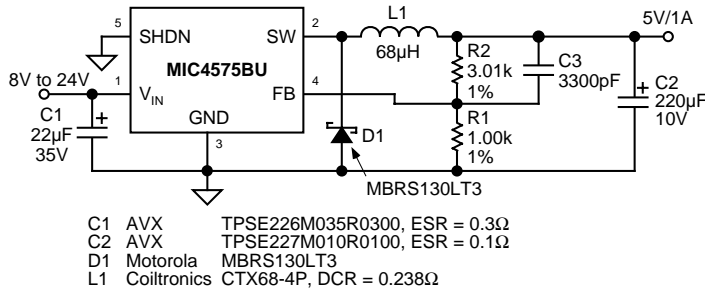


Figure 5. 8V–24V to 5V/1A Buck Converter Low-Profile Surface Mount

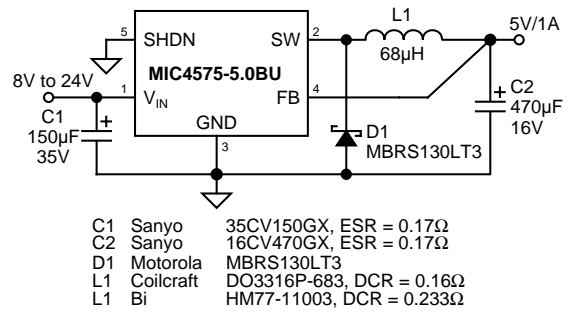


Figure 8. 8V–24V to 5V/1A Buck Converter Lower-Cost Surface Mount

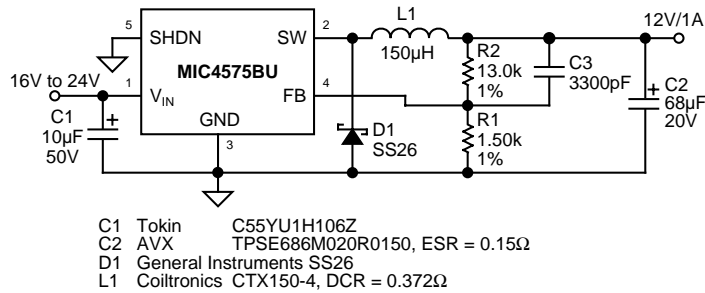


Figure 6. 16V–24V to 12V/1A Buck Converter Low-Profile Surface Mount

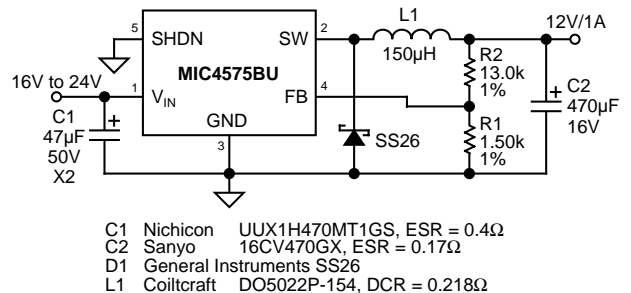


Figure 9. 16V–24V to 12V/1A Buck Converter Lower-Cost Surface Mount

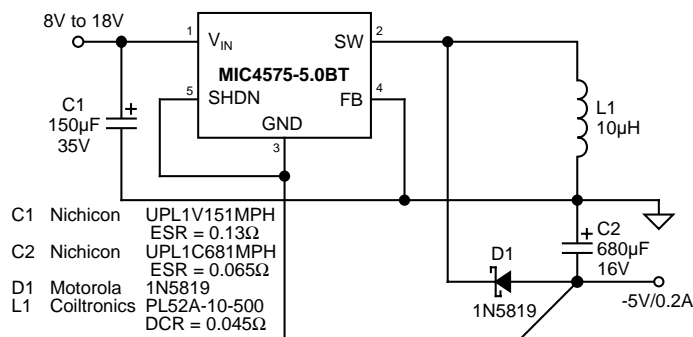
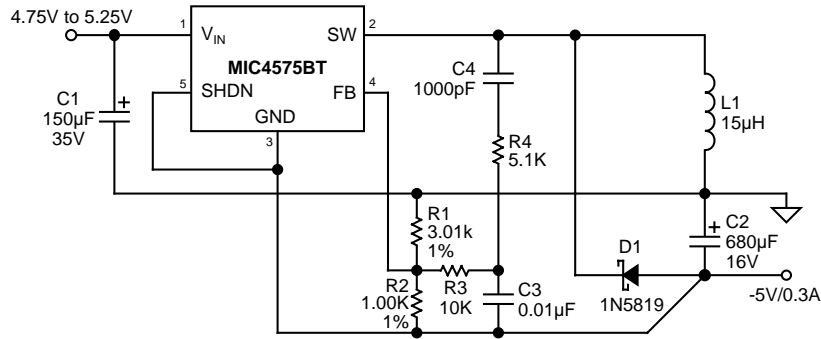
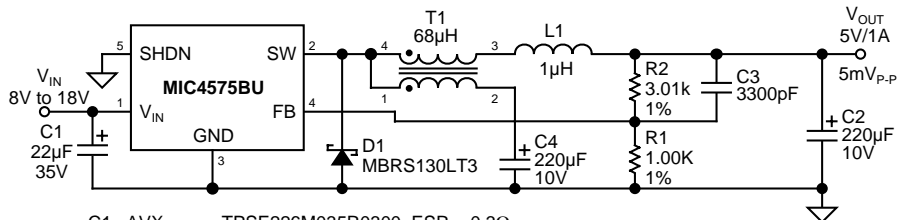


Figure 10. 8V–18V to -5V/0.2A Buck-Boost Converter Through Hole



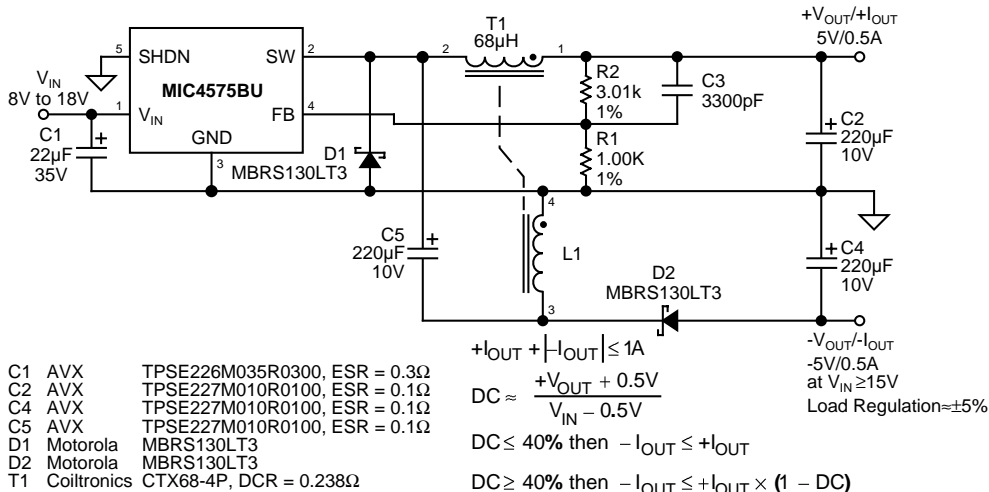
- C1 Nichicon UPL1V151MPH, ESR = 0.12Ω
- C2 Nichicon UPL1C681MPH, ESR = 0.065Ω
- D1 Motorola 1N5819
- L1 Coiltronics PL52A-15-500, DCR = 0.054Ω

**Figure 11. 5V to -5V/0.3A Buck-Boost Converter Through Hole**



- C1 AVX TPSE226M035R0300, ESR = 0.3Ω
- C2 AVX TPSE227M010R0100, ESR = 0.1Ω
- C3 AVX TPSE227M010R0100, ESR = 0.1Ω
- D1 Motorola MBRS130LT3
- T1 Coiltronics CTX68-4P, DCR = 0.238Ω
- L1 Coilcraft DO1608C-102

**Figure 12. Low Output-Noise Regulator (5mV Output Ripple)**



- C1 AVX TPSE226M035R0300, ESR = 0.3Ω
  - C2 AVX TPSE227M010R0100, ESR = 0.1Ω
  - C3 AVX TPSE227M010R0100, ESR = 0.1Ω
  - C4 AVX TPSE227M010R0100, ESR = 0.1Ω
  - C5 AVX TPSE227M010R0100, ESR = 0.1Ω
  - D1 Motorola MBRS130LT3
  - D2 Motorola MBRS130LT3
  - T1 Coiltronics CTX68-4P, DCR = 0.238Ω
- $+I_{OUT} + |-I_{OUT}| \leq 1A$   
 $DC \approx \frac{+V_{OUT} + 0.5V}{V_{IN} - 0.5V}$   
 $DC \leq 40\%$  then  $-I_{OUT} \leq +I_{OUT}$   
 $DC \geq 40\%$  then  $-I_{OUT} \leq +I_{OUT} \times (1 - DC)$
- $+V_{OUT}/+I_{OUT}$  5V/0.5A  
 $-V_{OUT}/-I_{OUT}$  -5V/0.5A at  $V_{IN} \geq 15V$   
 Load Regulation = ±5%

**Figure 13. Split ±5V Supply**

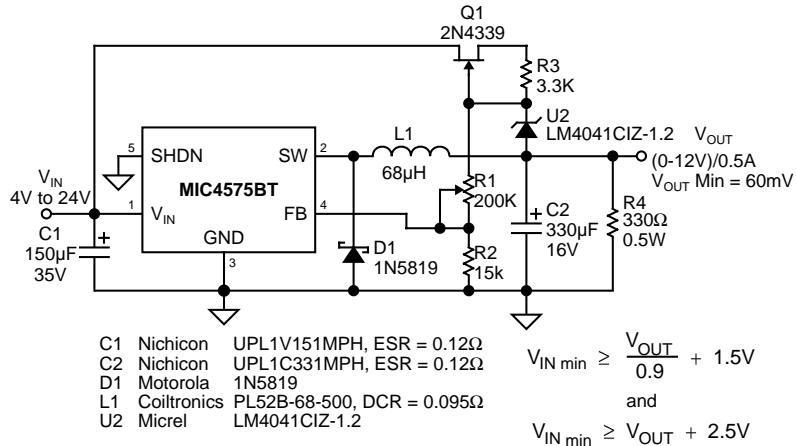


Figure 14. Adjustable (0V–12V) Output-Voltage Regulator

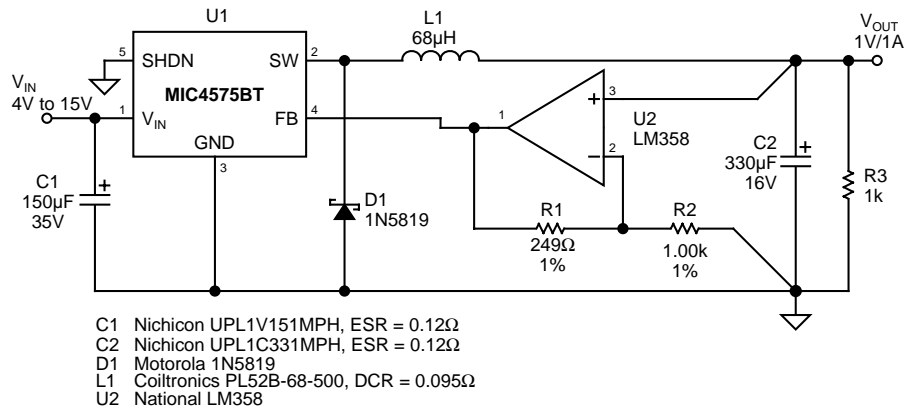


Figure 15. Low Output-Voltage Regulator (1V)

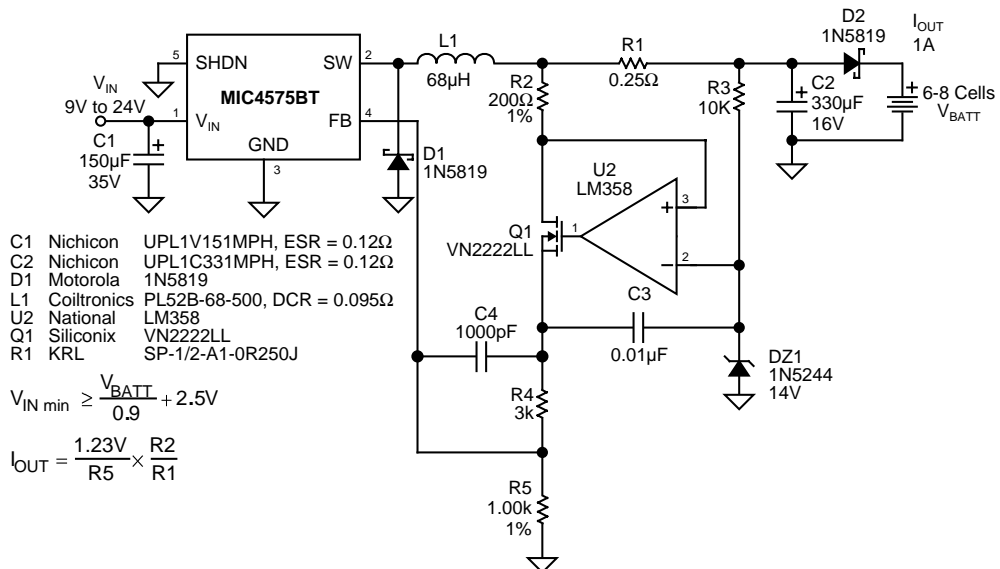


Figure 16. 1A Battery Charger (6–8 cells)



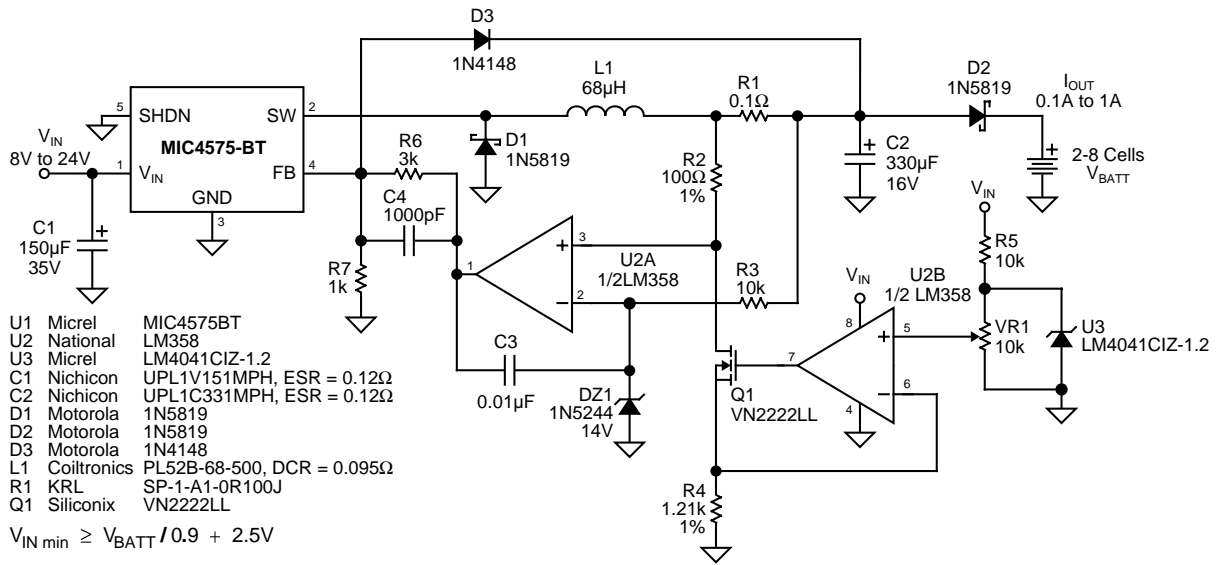


Figure 17. 0.1A-1A Variable-Current Battery Charger

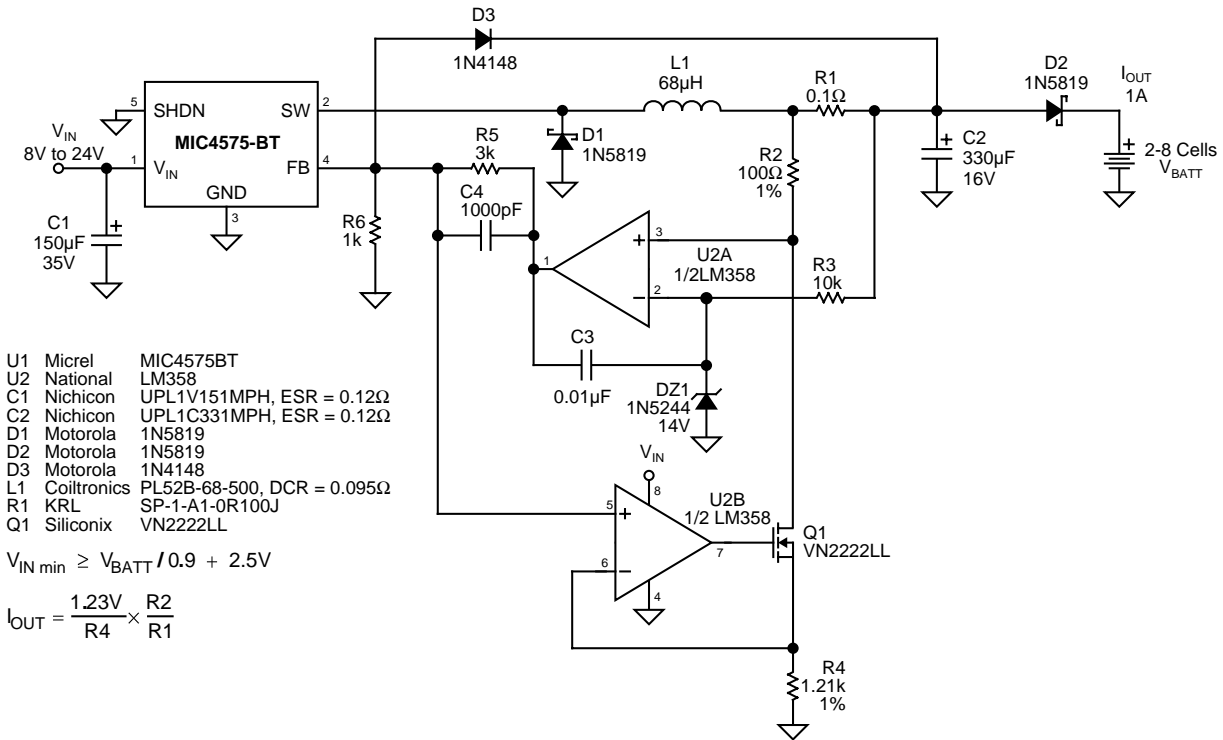


Figure 18. 1A Battery Charger (2-8 Cells)

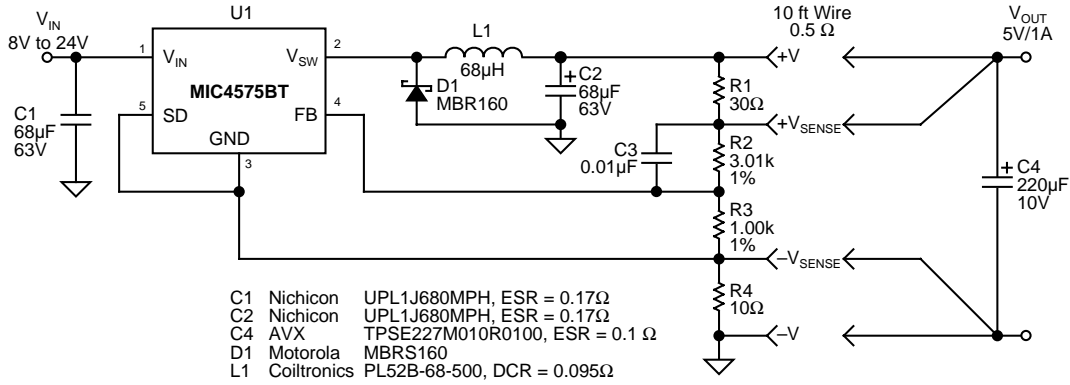


Figure 19. Remote-Sensing Regulator

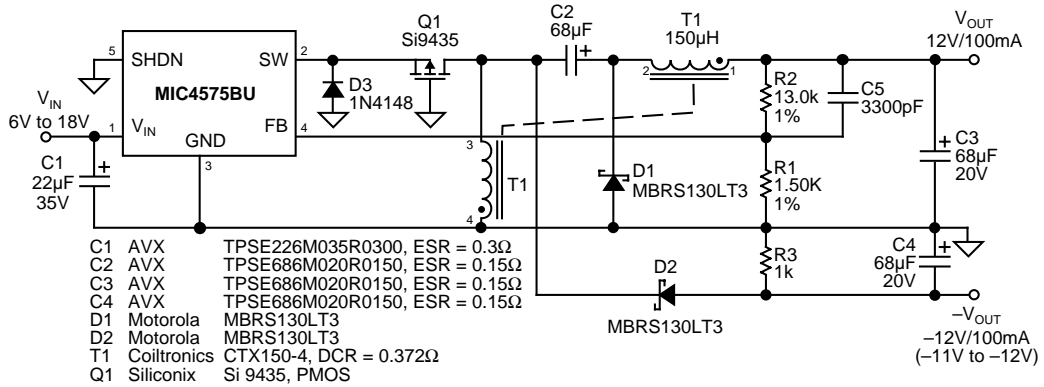


Figure 20. 6V-18V to Split ±12V/100mA Supply

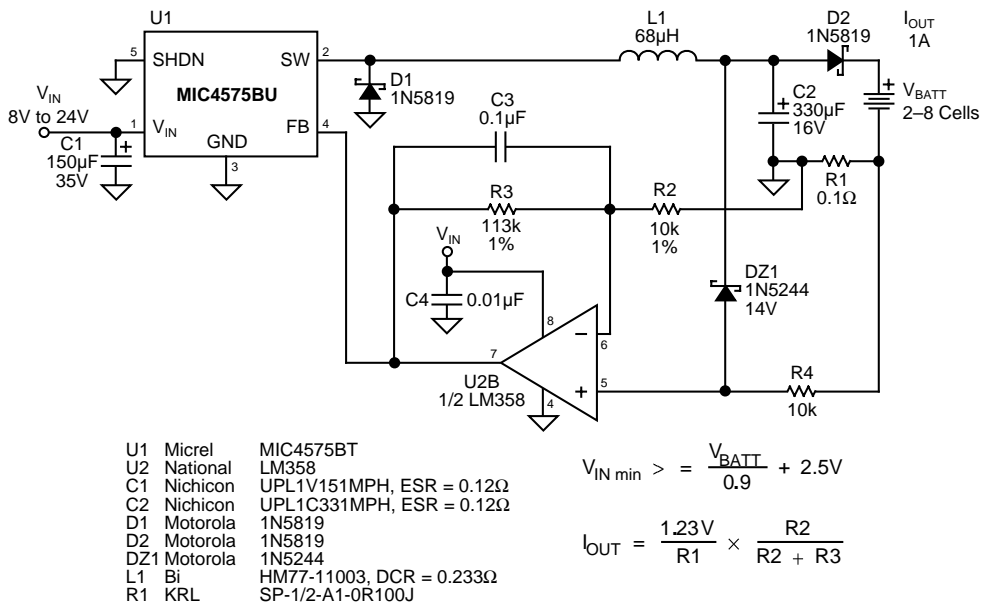
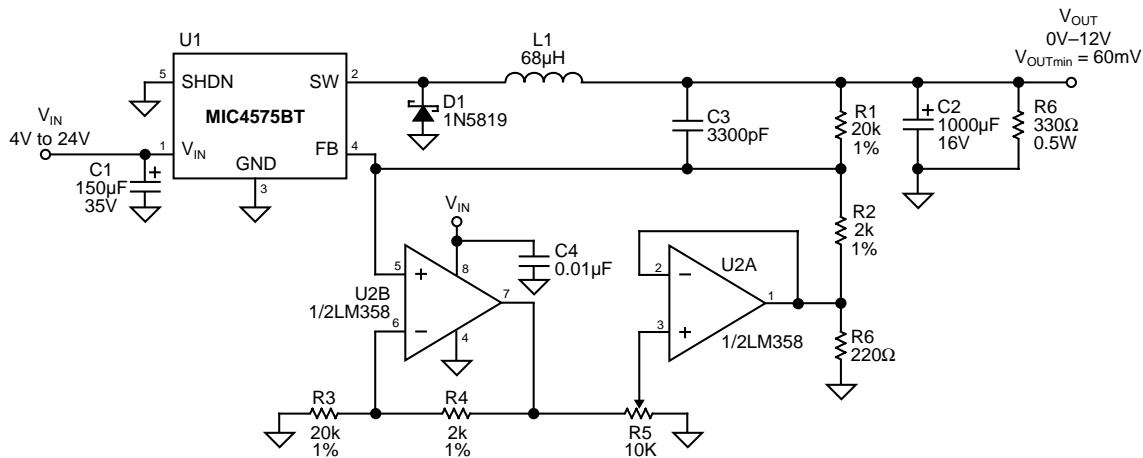
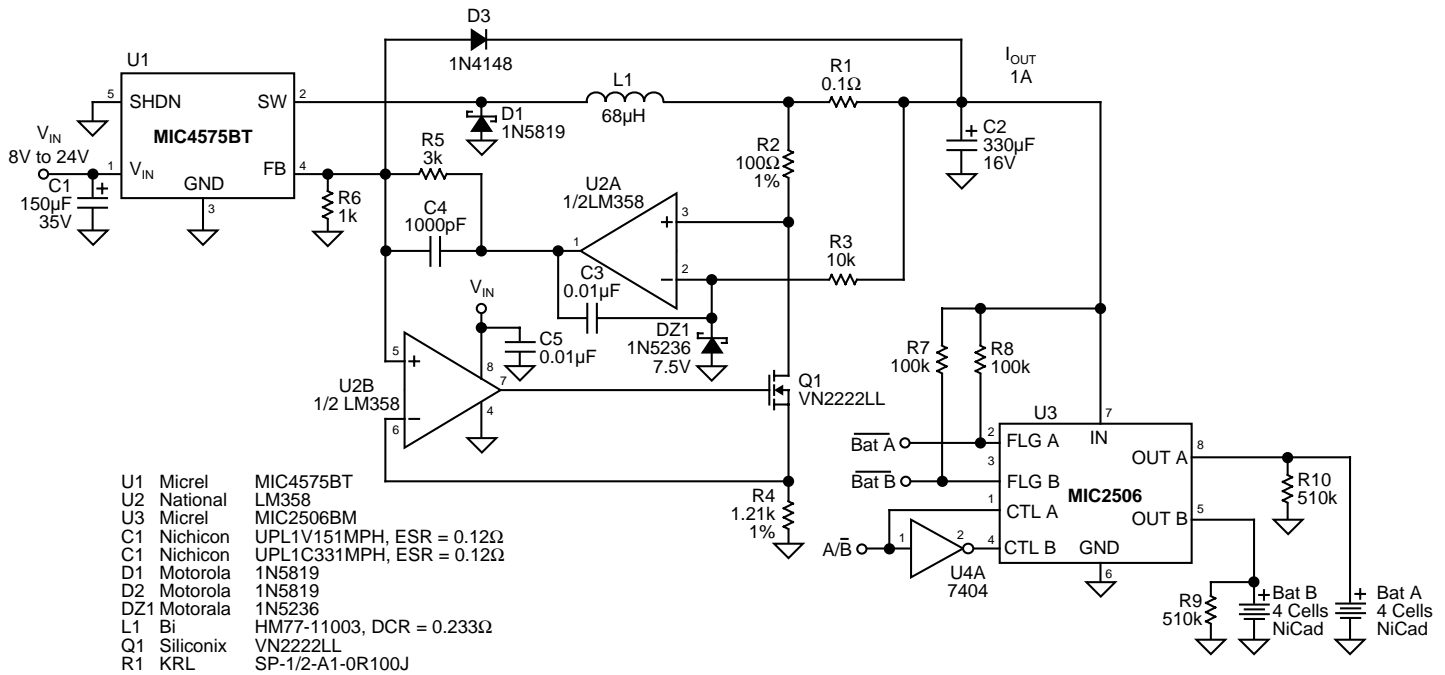


Figure 21. 1A Battery Charger



- |    |          |                           |  |
|----|----------|---------------------------|--|
| U1 | Micrel   | MIC4575BT                 | $V_{IN\ min} > = \frac{V_{OUT}}{0.9} + 2.5V$                 |
| U2 | National | LM358                     | $V_{OUT\ max} = 1.23V \times \left(1 + \frac{R1}{R2}\right)$ |
| C1 | Nichicon | UPL1V151MPH, ESR = 0.12Ω  | R1 = R3 and R2 = R4  |
| C2 | Nichicon | UPL1C102MPH, ESR = 0.047Ω |  |
| D1 | Motorola | 1N5819                    |  |
| L1 | Bi       | HM77-11003, DCR = 0.233Ω  |  |

Figure 22. Improved Adjustable Output-Voltage Regulator (0V-12V)



- |     |           |                          |
|-----|-----------|--------------------------|
| U1  | Micrel    | MIC4575BT                |
| U2  | National  | LM358                    |
| U3  | Micrel    | MIC2506BM                |
| C1  | Nichicon  | UPL1V151MPH, ESR = 0.12Ω |
| C2  | Nichicon  | UPL1C331MPH, ESR = 0.12Ω |
| D1  | Motorola  | 1N5819                   |
| D2  | Motorola  | 1N5819                   |
| DZ1 | Motorola  | 1N5236                   |
| L1  | Bi        | HM77-11003, DCR = 0.233Ω |
| Q1  | Siliconix | VN2222LL                 |
| R1  | KRL       | SP-1/2-A1-0R100J         |

Figure 23. Switchable Battery-Pack Charger

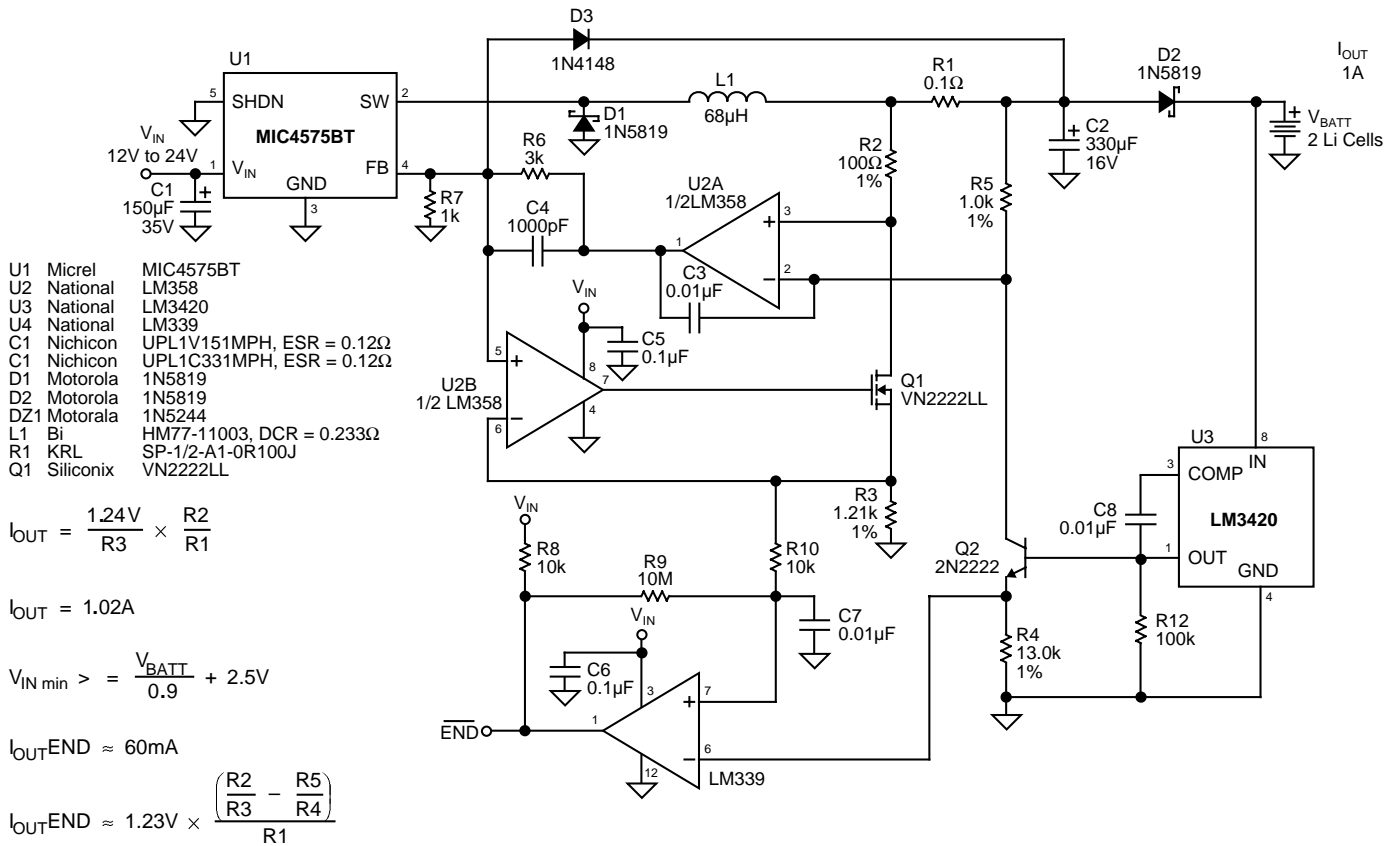


Figure 24. Lithium-Ion Battery Charger with End-of-Charge Flag

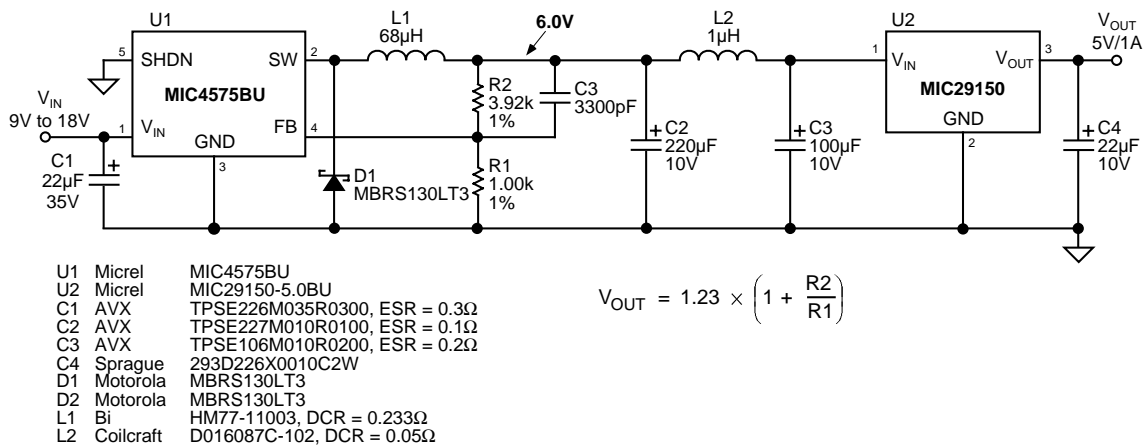


Figure 25. Low Output-Noise Regulator (<1mV)