Analog and Interface Solutions

MICROCHIP

Portable Power Conversion Design Guide



www.microchip.com/analog

Design Guide
Introduction and Contents

Portable power conversion applications present unique and challenging design considerations. Innovative, small electronics require solutions with small footprints. In order to maintain battery life, portable applications require both high conversion efficiency and low standby power dissipation. Multi-cell battery packs may require step-down (buck) conversions and single cell batteries often require step-up (boost) conversions to maintain consistent power levels while the batteries discharge. Some products require constant voltage regulation for microcontrollers, sensors or RF signal processing; while some circuits need constant current regulation for backlighting or battery charging. Microchip offers a broad array of solutions which feature small package sizes, high-efficiency, low standby power, accuracy and versatility solutions to solve these portable power conversion challenges.

Table of Contents

Step-Down (Buck) Switch Mode Power Converters 2
Linear (Low Drop Out) Regulators 9
Step-Up (Boost) Switch Mode Power Converters 12
Backlighting Solutions with Switching Regulators 17
Backlighting Solutions with Charge Pump DC/DC Converters 19
Linear Battery Chargers 20
Programmable Battery Chargers 22
Application Notes and Demonstration Boards 24

DC/DC Conversion
Step-Down (Buck) Switch Mode Power Converters

Step-Down (Buck) Switch Mode Power Converters

For wide input range voltage sources and high output current applications switch-mode power converters offer a significant increase in efficiency compared to linear regulators. This results in longer battery run time in portable applications. Step-down or buck converters are used to regulate an output voltage that is always lower than the source voltage. Using inductors and capacitors for energy storage allows buck converters to commonly be more than 90% efficient, and under some circumstances they can be more than 95% efficient.

Microchip offers a wide selection of buck converters and PWM controllers. Many of them are specifically designed to convert power from NiMH, Ni-Cd, Li-Ion, Alkaline multi-cell or 12/24V SLA batteries. Converters integrate power MOSFET switches used to commutate the supply current, while controllers rely on external power MOSFETs in diodes to switch the converter current. Synchronous converters rely on two MOSFETs working together to control the current flow, while asynchronous converters replace one MOSFET with a freewheeling power diode. Synchronous converters deliver higher efficiency for low output voltages, especially less than 3.3V, while asynchronous converters work well for higher output voltages.

DC/DC Conversion

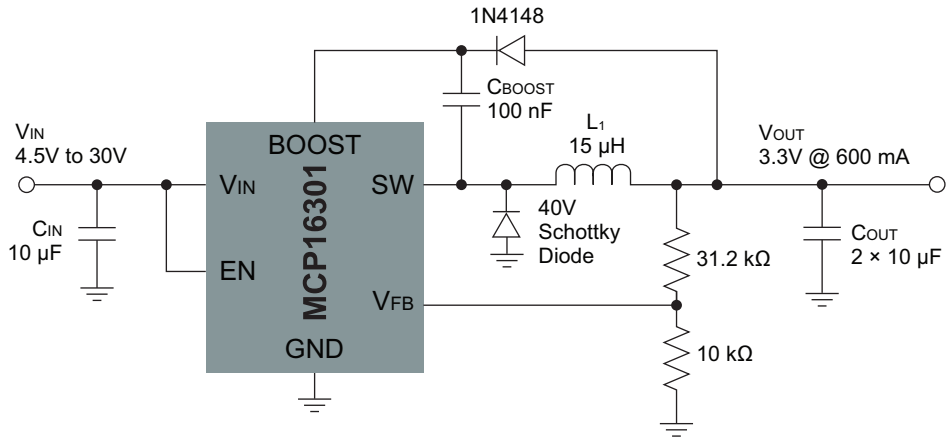
Step-Down (Buck) Switch Mode Power Converters

MCP16301/H 36V Input Voltage Non-Synchronous Buck Converter

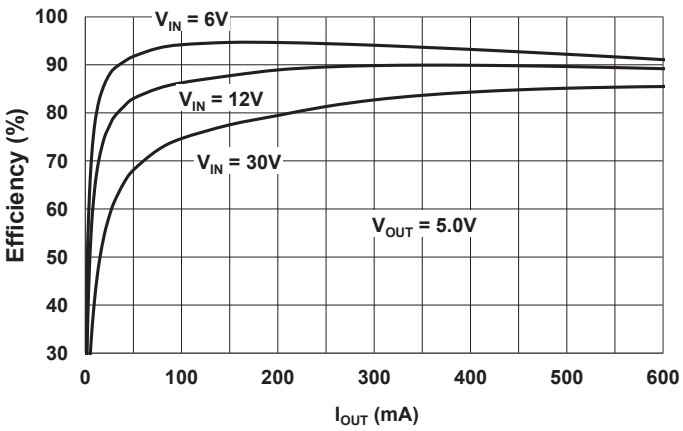
The MCP16301 is a highly integrated, high-efficiency, fixed-frequency, step-down DC-DC converter in a popular 6-pin SOT-23 package. This converter operates from voltage sources up to 30V, including the integrated high-side switch, fixed-frequency Peak Current Mode Control, internal compensation, peak current limit and over-temperature protection. This device allows you to build DC/DC conversion circuits with minimal external components.

- 12V and 24V industrial/SLA battery input DC-DC conversion
- Up to 96% typical efficiency
- Wide input voltage range:
  - 4.0V to 30V (MCP16301)
  - 4.7V to 36V (MCP16301H)
- Output voltage range: 2.0V to 15V
- 2% output voltage accuracy
- Integrated 460 mΩ n-channel buck switch
- 600 mA output current
- 500 kHz fixed frequency
- Adjustable output voltage
- Low device shutdown current
- Peak current mode control
- Internal compensation
- Stable with ceramic capacitors
- Internal soft-start
- Cycle-by-cycle peak current limit
- Under voltage lockout (UVLO) at 3.5V
- Extended –40 to +125°C operating temperature range
- Over-temperature protection
- D2PAK package linear regulator replacement
- Available in 6-pin SOT-23 package

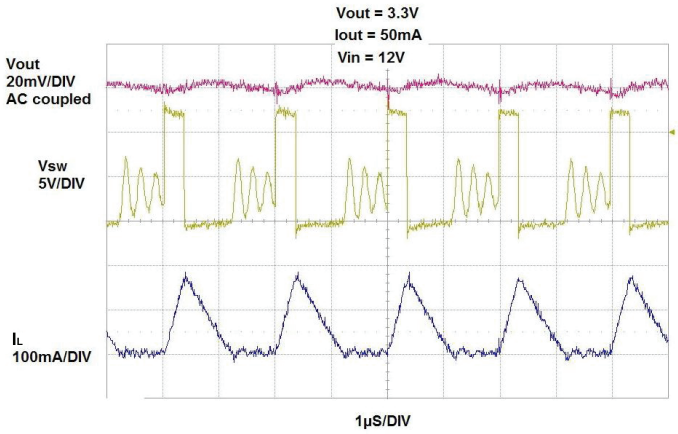
Example MCP16301 Non-Synchronous Buck Regulator Application Circuit



Typical MCP16301 Power Conversion Efficiency with a Fixed 5.0V Output



MCP16301 Light Load Operation



DC/DC Conversion

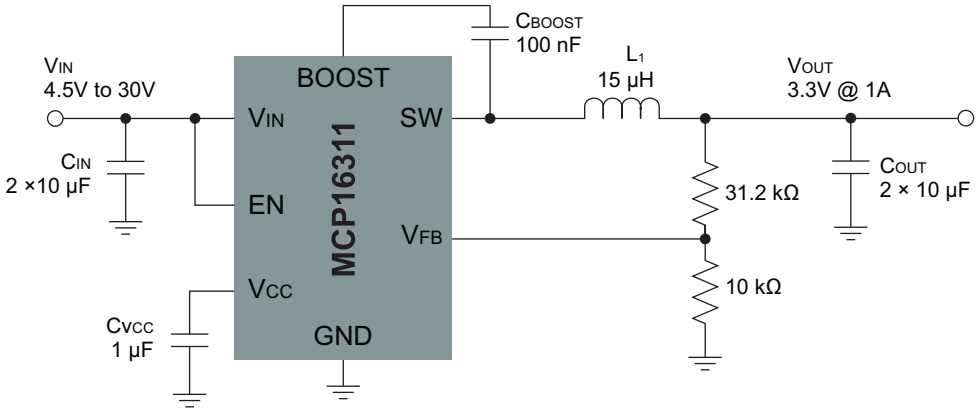
Step-Down (Buck) Switch Mode Power Converters

MCP16311/2 30V Input, High-Efficiency, Integrated Synchronous Buck Regulator

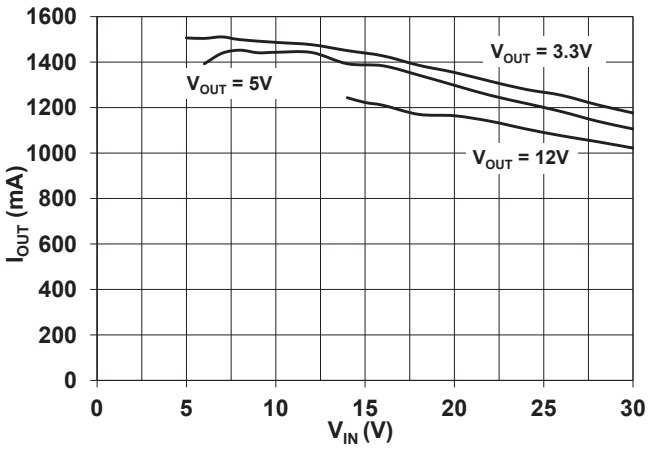
The MCP16311 is a compact, high-efficiency, fixed-frequency PWM/PFM, synchronous step-down DC-DC converter in a 8-pin MSOP or 2 × 3 TDFN package that operates from input voltage sources up to 30V. Integrated features include a high-side and a low-side switch, fixed-frequency Peak Current Mode Control, internal compensation, peak-current limit and over-temperature protection. The MCP16311 provides all the active functions for local DC-DC conversion, with fast transient response and accurate regulation.

- Up to 95% efficiency
- Wide 4.4V to 30V input voltage range
- Wide 2.0V to 24V output voltage range
- Integrated high-performance n-channel low- and high-side switches: 170 mΩ low-side MOSFET, 300 mΩ high-side MOSFET
- Stable 0.8V reference voltage
- Automatic pulse-frequency modulation/pulse-width modulation (PFM/PWM) operation (on MCP16311), or 500 kHz PWM only operation (on MCP16312)
- Low 3 µA (typical) device shutdown current
- Low 44 µA device quiescent current (when not switching in PFM Mode)
- Internal compensation
- Internal soft-start: 300 µs turn on
- Peak current mode control
- Cycle-by-cycle peak current limit
- Under-voltage lockout (UVLO) at 3.6V (typical) with 0.5V of hysteresis
- Thermal shutdown at 150°C, with 25°C hysteresis

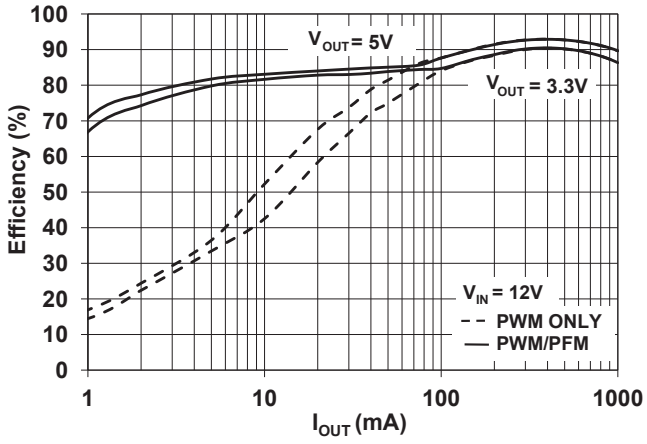
Example MCP16311 Synchronous Buck Regulator Application Circuit



MCP16311 Ouput Current Capability



Typical MCP16311 Efficiency, with and without PFM Operation Enabled



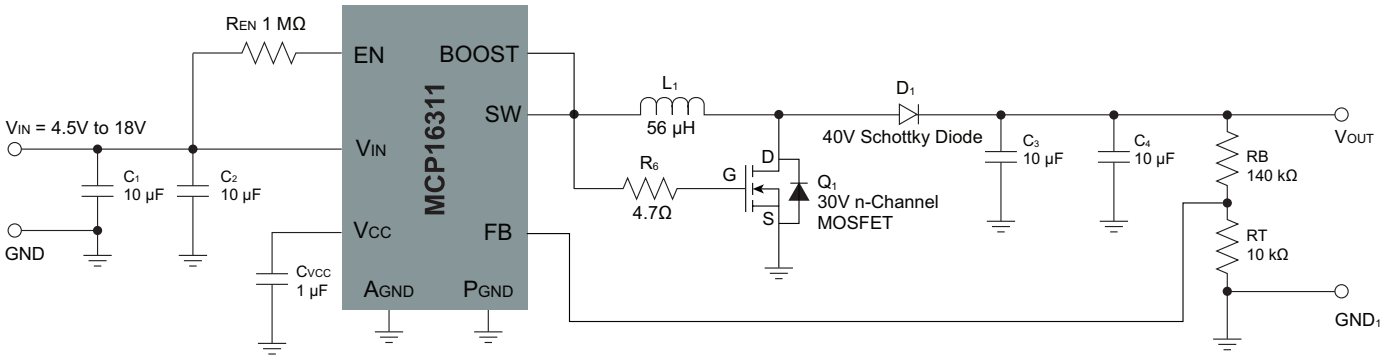
DC/DC Conversion

Step-Down (Buck) Switch Mode Power Converters

MCP16311 12V Buck-Boost Application

Some power supplies require the ability step the voltage up or down from the input to the output. This is particularly useful in battery-powered applications where the battery voltage may be above or below the desired output voltage, depending on the type of battery used or battery charge remaining. By adding a few additional circuit components, the MCP16311 can be adapted to work in a buck-boost topology that would address this issue. The application can either buck or boost the input voltage in order to maintain the output voltage, operating from a 6V to 18V input and providing up to 300 mA of output current.

MCP16311 Buck-Boost Application Circuit



DC/DC Conversion

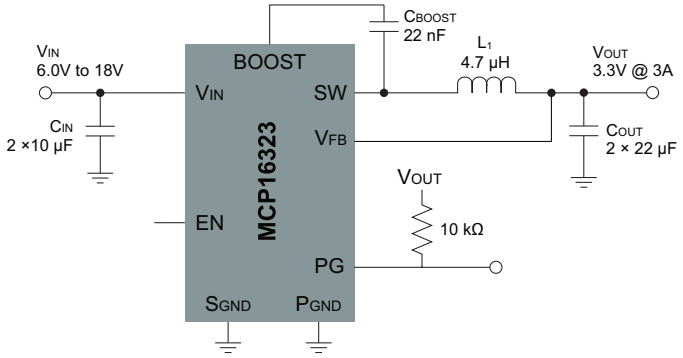
Step-Down (Buck) Switch Mode Power Converters

MCP16323 3A Synchronous Buck DC/DC Converter

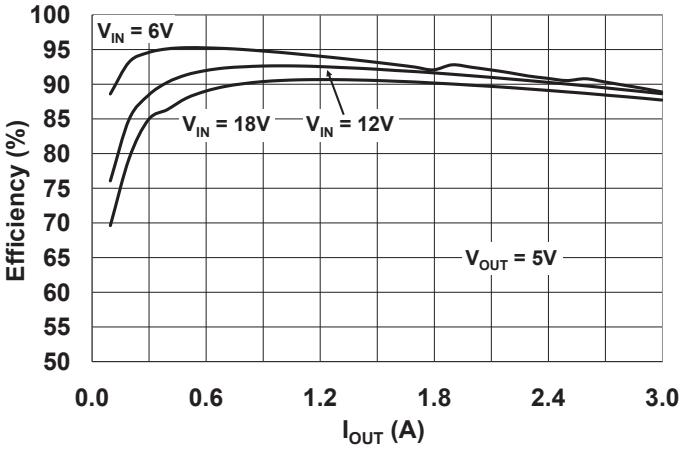
The MCP16323 is a fully integrated synchronous buck dc/dc converter that operates from 6V to 18V input, regulates the output voltage to any level between 0.9V to 5V, and supplies load currents up to 3A. Operating at a fixed 1 MHz switching frequency offers small external inductor and capacitor sizes, minimizing board space. Integrating both high- and low-side switches results in a compact, high-efficiency converter circuit. The device is available in a 3 × 3 mm QFN package with exposed pad to reduce the thermal resistance from junction to case. With both adjustable and fixed output voltage options, this device provides flexibility for generating custom output voltages or minimizing external resistor dividers and obtaining fixed output voltages. The internal peak current mode control architecture results in fast transient response, minimizing the change in output voltage with dynamic load conditions. Small ceramic capacitors are used at the input and output for space-constrained applications.

- Up to 95% typical efficiency
- Wide 6.0V to 18V input voltage range
- 3A output current
- Multiple fixed output voltage options: 0.9V, 1.5V, 1.8V, 2.5V, 3.3V, 5.0V with 2% output voltage accuracy
- Adjustable version output voltage range: 0.9V to 5.0V with 1.5% reference voltage accuracy
- Integrated 180 mΩ n-channel high-side switch
- Integrated 120 mΩ n-channel low-side switch
- 1 MHz fixed frequency operation with pulse skipping for efficient operation in light load conditions
- Low device shutdown current
- Peak current mode control
- Internal compensation
- Stable with ceramic capacitors
- Internal soft-start
- Cycle-by-cycle peak current limit
- Under-voltage lockout (UVLO) at 5.75V
- Over-temperature protection
- Over-voltage protection will tri-state the SW outputs to prevent damage if the output exceeds 103% of the regulation voltage
- VOUT voltage status reported with the power good output pin
- Available in 16-pin QFN (3 × 3 mm) package with exposed thermal pad

MCP16323 Typical Application Circuit



Typical MCP16323 Efficiency with a 5V Fixed Output



DC/DC Conversion

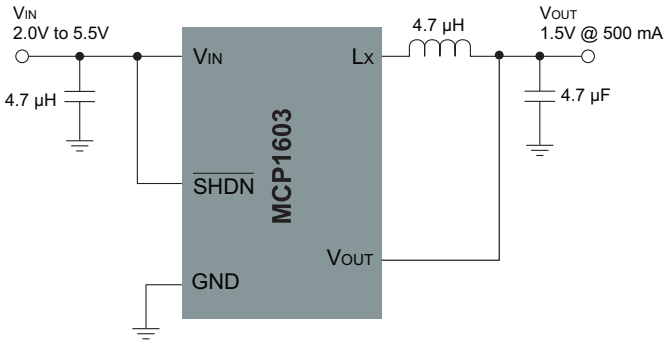
Step-Down (Buck) Switch Mode Power Converters

MCP1603/L/B Synchronous Buck Regulators

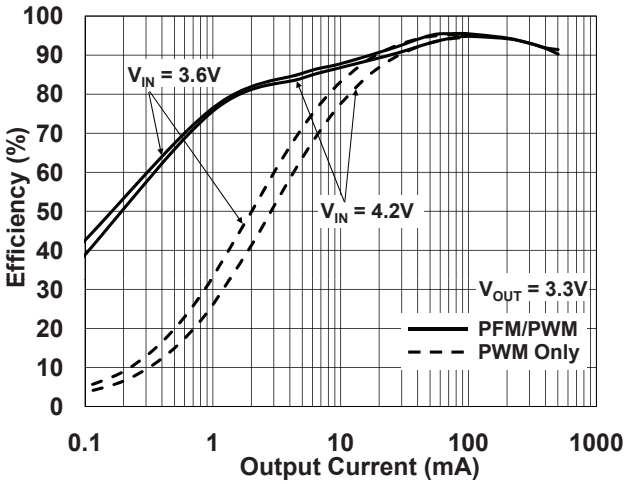
The MCP1603 is a family of highly efficient, fully integrated 500 mA synchronous buck regulators. The 2.7V to 5.5V input range makes these ideally suited for battery powered applications, including one-cell Li-ion; two- or three-cell NiMH; or two- or three-cell NiCd power sources. With heavy loads, the MCP1603/L operates in a 2.0 MHz fixed frequency PWM mode which provides a low-noise, low output voltage ripple, small-footprint solution. With light loads, the MCP1603/L automatically changes operation to a PFM mode to minimize quiescent current consumption, improving battery run time. These two modes allow the MCP1603/L to achieve the best possible efficiency over the entire load current range. The MCP1603B, in contrast, only switches in PWM mode, maintaining a low output voltage ripple over a wide output load range in noise-sensitive applications (audio or RF). Only three additional external components are required for a complete converter solution when using the fixed voltage options, or a flexible output voltage can be produced with a resistive divider on the adjustable output device options. The low-profile, small-footprint packages also enable the system solution to be achieved with minimal size.

- Typical efficiency over 90%
- Supplies up to 500 mA of output current
- Low 45 µA typical PFM quiescent current
- Low 0.1 µA typical shutdown current
- Adjustable output voltage range: 0.8V to 4.5V
- Fixed output voltage options: 1.2V, 1.5V, 1.8V, 2.5V, and 3.3V
- 2.0 MHz operation
- Automatic PWM to PFM mode transitions (MCP1603/L) or PWM only operation (MCP1603B)
- 100% duty cycle operation
- Internally compensated
- Under-voltage lockout (UVLO) at 2.3V
- Over-temperature protection
- Space-saving 5-lead TSOT and 8-pin 2 × 3 DFN packages

MCP1603 Typical Application Circuit



Typical MCP1603 Efficiency



DC/DC Conversion

Step-Down (Buck) Switch Mode Power Converters

Device	Output	Input Voltage Range (V)	Output Voltage Range (V)	Control Scheme	Features	Packages
MCP1603/B/L	Fixed or Adjustable	2.7–5.5	0.8–4.5	PFM/PWM or PWM Only	2 MHz operation, UVLO, PFM/PWM (MCP1603/L) or PWM only (MCP1603B) mode, over-temperature protection, low quiescent current, low shutdown current	5-pin TSOT, 8-pin 2 × 3 DFN
TC1303A/B/C	Fixed or Adjustable	2.7–5.5	0.8–4.5	PFM/PWM	UVLO, over-temperature protection, output short circuit protection, power good output, independent shutdown, synchronous buck and LDO combination device	10-pin DFN, 10-pin MSOP
TC1304	Fixed or Adjustable	2.7–5.5	0.8–4.5	PFM/PWM	UVLO, over-temperature protection, output short circuit protection, power-good output, synchronous buck and LDO combination, sequenced startup and shutdown	10-pin DFN, 10-pin MSOP
TC1313	Fixed or Adjustable	2.7–5.5	0.8–4.5	PFM/PWM	UVLO, output short circuit protection, over-temperature protection, independent shutdown for buck and LDO outputs	10-pin DFN, 10-pin MSOP
MCP16301	Adjustable	4–30	2–15	PWM	Asynchronous, internal compensation, UVLO, 500 kHz operation, low output ripple, over-temperature protection, extended temperature rating	6-pin SOT-23
MCP16301H	Adjustable	4.7–36	2–15	PWM	Asynchronous, internal compensation, UVLO, 500 kHz operation, low output ripple, over-temperature protection, extended temperature rating	6-pin SOT-23
MCP16311/2	Adjustable	4.4–30	2–24	PFM/PWM or PWM Only	Synchronous, internal compensation, UVLO, 500 kHz operation, low output ripple, over-temperature protection, extended temperature rating	8-pin MSOP, 8-pin 2 × 3 TDFN
MCP16321/2	Fixed or Adjustable	6–24	0.9–5	PWM	1A or 2A, synchronous, internal compensation, UVLO, 1 MHz operation, power good output, over-temperature protection, extended temperature rating	16-pin 3 × 3 QFN
MCP16323	Fixed or Adjustable	6–18	0.9–5	PWM	3A, synchronous, internal compensation, UVLO, 1 MHz operation, power good output, over-temperature protection, extended temperature rating	16-pin 3 × 3 QFN

DC/DC Conversion
Linear Regulators

Linear Regulators

Linear regulators provide a precise regulated voltage to the system load from a varying input voltage source. Compared to switching regulators, they are generally smaller, simpler, and can benefit from reduced electrical noise. They are generally less efficient than buck regulators, but for small voltage changes or low currents the absolute power losses may be small.

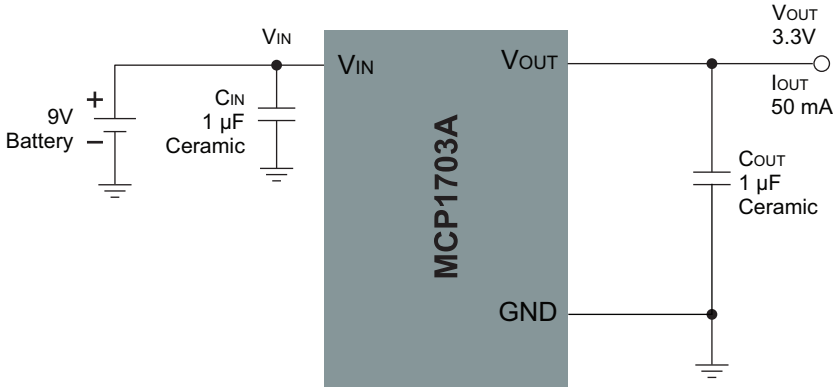
There are trade-offs when selecting the proper LDO. Regulation tolerance, dropout voltage, power supply ripple rejection (PSRR), dynamic performance, quiescent current, power dissipation capability and protection features can be important device capabilities. Microchip's LDO product line can address a wide input voltage range with some LDOs capable of withstanding 40V transients. We offer devices that consume ultra-low power with input quiescent currents as low as 20 nA; disable load circuits for low-power standby operation using shutdown inputs; filter noisy inputs with PSRR as high as 90 dB; and enjoy robust operation with integrated over-current protection, short-circuit protection, high-temperature operation capabilities, and over-temperature protection features.

MCP1703A Low Quiescent Current 16 V Low Dropout Linear Regulator

The MCP1703A is a CMOS, low dropout voltage regulator with 250 mA maximum output current. Working with voltages up to 16V and consuming only 2 µA of quiescent current, it is an ideal solution for applications using 9V alkaline, Li-ion, or multi-cell power sources. It is available in space-efficient SOT-23A and SOT-89 packages; or in a thermally capable 3-pin SOT-223 and 8-pin 2 × 3 DFN.

- Wide 2.7V to 16V input operating voltage range
- Supports load currents up to 250 mA
- Low 2.0 µA typical quiescent current
- Low ground current when operating in dropout
- Fast startup time
- Low dropout voltage, 625 mV typical @ 250 mA for VR = 2.8V
- 0.4% Typical output voltage tolerance
- Many standard output voltage options: 1.2V, 1.5V, 1.8V, 2.5V, 2.8V, 3.0V, 3.3V, 4.0V, 5.0V
- Stable with 1.0 µF to 22 µF ceramic output capacitance
- Short-circuit protection
- Over-temperature protection

MCP1703A Typical Application Circuit



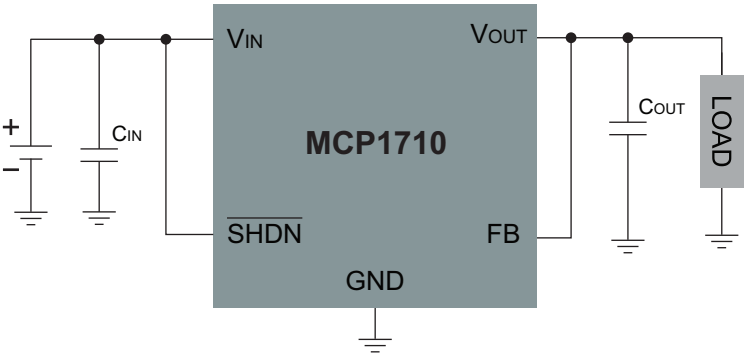
DC/DC Conversion
Linear Regulators

MCP1710 Ultra-Low Quiescent Current LDO Regulator

The MCP1710 is low dropout (LDO) linear regulator that provides up to 200 mA of current to the load while maintaining an ultra-low 20 nA of quiescent current consumption, and it comes in a tiny 2 × 2 DFN package.

- Ultra-low 20 nA (typical) quiescent current
- Ultra-low 0.1 nA typical shutdown supply current
- 200 mA output current capability for V_{OUT} < 3.5V
- 100 mA output current capability for V_{OUT} > 3.5V
- Wide 2.5V to 5.5V input operating voltage range
- Standard output voltages: 1.2V, 1.8V, 2.5V, 3.3V, 4.2V
- Low 450 mV (maximum) dropout voltage at 200 mA
- Stable with a 1.0 µF ceramic output capacitor
- Over-current protection
- Space-saving, 8-lead plastic 8-pin 2 × 2 VDFN package

MCP1710 Typical Application Circuit

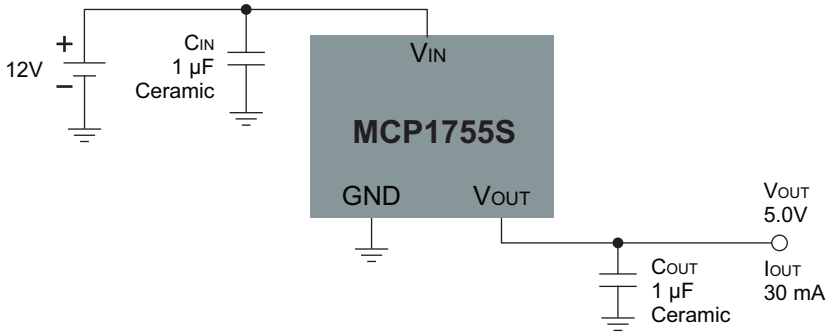


MCP1755 300 mA, 16V, High-Performance LDO

The MCP1755 and MCP1755S are 16V, high PSRR voltage regulators with short-circuit current fold-back. These regulators provide up to 300 mA of output current and accept a continuous input voltage from 3.6V to 16V, making them ideal for automotive and commercial 12V DC systems. Delivering 80 dB of ripple rejection at 1 kHz, these devices are ideal for AC-sensitive applications like GFCI and AFCI circuit breaker designs. The current fold-back feature gradually reduces the device current down to 30 mA under short-circuit conditions to protect against damage. When the short is removed, the device will recover and continue operating.

- High noise rejection, typical PSRR 80 dB at 1 kHz
- Low 68 µA typical quiescent current
- Wide 3.6V to 16.0V input operating voltage range
- Supplies up to 300 mA output current for all output voltages
- Low 300 mV typical dropout voltage with a 300 mA load
- High output accuracy, 0.85% typical output range
- Standard output voltage options: 1.8V, 2.5V, 2.8V, 3.0V, 3.3V, 4.0V, 5.0V
- Tight output tolerance ±2.0 % over entire operating temperature range
- Stable with minimum 1.0 µF output capacitance
- Power good output
- Shutdown input
- Short-circuit protection with true output current fold-back
- Over-temperature protection

MCP1755 Typical Application Circuit



DC/DC Conversion
Linear Regulators

Device	Max. Input Voltage (V)	Output Voltage Range (V)	Output Current (mA)	Typical Quiescent Current (µA)	Typical Dropout Voltage at Max. I_{OUT} (mV)	Features	Packages
MCP1700	6.0	1.2–5.0	250	1.6	178	Shutdown, power good output with adjustable delay	3-pin SOT-23A, 3-pin SOT-89, 3-pin TO-92
MCP1703A	16	1.2–5.0	250	2	625	Low quiescent current, low ground current in dropout	3-pin SOT-23A, 3-pin SOT-89, 3-pin SOT-223, 8-pin 2 × 3 DFN
MCP1710	5.5	1.2–4.2	200	0.02	450	Ultra low quiescent current	8-pin 2 × 2 DFN
MCP1725	6.0	0.8–5.0	500	120	210	Shutdown, power good output with adjustable delay	8-pin 2 × 3 DFN, 8-pin SOIC
MCP1726	6.0	0.8–5.0	1000	140	250	Shutdown, power good output with adjustable delay	8-pin 2 × 3 DFN, 8-pin SOIC
MCP1727	6.0	0.8–5.0	1000	140	330	Shutdown, power good output with adjustable delay	8-pin 2 × 3 DFN, 8-pin SOIC
MCP1754	16	1.8–5.0	150	56	300	Shutdown, power good, high PSRR, true current fold-back protection	5-pin SOT-23, 3-pin SOT-223, 3-pin SOT-89, 8-pin 2 × 3 DFN
MCP1754S	16	1.8–5.0	150	56	300	High PSRR, true current fold-back protection	3-pin SOT-23A, 3-pin SOT-89, 3-pin SOT-223, 8-pin 2 × 3 DFN
MCP1755	16	1.8–5.0	300	68	300	Shutdown, power good, high PSRR, true current fold-back protection	5-pin SOT-23, 3-pin SOT-223, 3-pin SOT-89, 8-pin 2 × 3 DFN
MCP1755S	16	1.8–5.0	300	68	300	High PSRR, true current fold-back protection	3-pin SOT-23A, 3-pin SOT-89, 3-pin SOT-223, 8-pin 2 × 3 DFN
MCP1804	28	1.8–18	150	50	1300	Shutdown	3-pin SOT-23A, 3-pin SOT-89, 5-pin SOT-89, 8-pin 2 × 3 DFN
MCP1824	6.0	0.8–5.0	300	120	200	Shutdown, power good	5-pin SOT-223, 5-pin SOT-23
TC1016	6.0	1.8–3.0	80	50	150	Shutdown	5-pin SC-70
TC1017	6.0	1.8–4.0	150	53	285	Shutdown	5-pin SC-70, SOT-23A

DC/DC Conversion

Step-Up (Boost) Switch Mode Power Converters

Step Up (Boost) Switch Mode Power Converters

Boost converters increase the unregulated input voltage to a regulated output (unlike buck converters, which always reduce the input voltage). Conceptually, both types of circuits use switched electromagnetic components to store energy and maintain efficiency. Boost converters are commonly used in single- and two-cell Alkaline, NiMH and new non-rechargeable lithium battery applications.

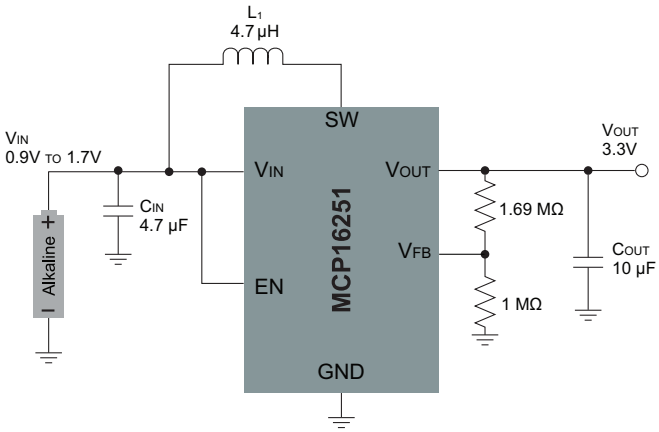
Microchip offers several boost converter solutions with integrated MOSFETs that are capable of starting and operating from a single-cell battery (0.8V input, or less in some cases). Many devices offer pulse width modulation (PWM) and pulse frequency modulation (PFM) modes of operation. PWM mode switches at constant frequency to minimize output ripple and noise while delivering high-efficiency power conversion at high output loads. PFM mode dynamically reduces the switching frequency, sometimes even allowing increased the output ripple, in order to dramatically reducing switching losses and improve efficiency in light load conditions. Taking advantage of these functions, the MCP1640 and MCP16251/2 device families (and many other Microchip parts) can automatically transition between PFM and PWM as the output current demand changes. In some applications, the output ripple introduced by PFM mode may be too noisy for the desired circuit performance. For these designs, the MCP1640B device can operate in PWM mode only, providing a low output ripple voltage and reducing electrical noise. Many of these boost regulators can be disabled with a shutdown input signal; several are available with true load disconnect (open the circuit from input to output) or with bypass (connected input and output) operation during shutdown. Integrated boost converters are small-footprint, high-efficiency power conversion solutions for many portable applications.

MCP16251 Ultra-Low Quiescent Current, PFM/PWM Synchronous Boost Regulator with True Output Disconnect or Input/Output Bypass Options

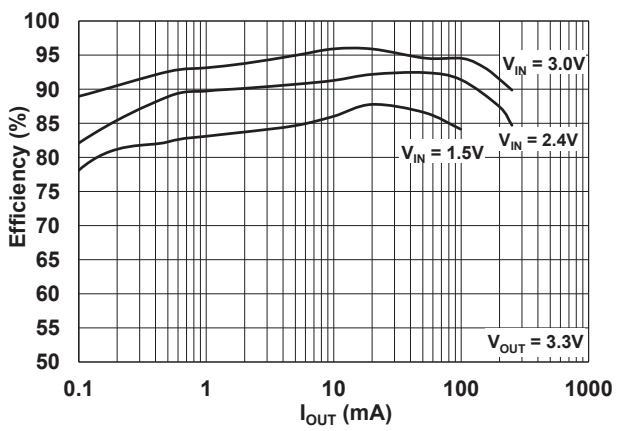
One of the advantages of the MCP16251/2 over other boost regulators is its low quiescent current (4 µA). This, combined with the PFM mode operation and a high resistance feedback voltage divider, results in a converter that greatly increases the run time of battery-powered applications at low load.

- Typical efficiency up to 96%
- High current output:
  - I_{OUT} > 100 mA at V_{OUT} = 3.3V and V_{IN} = 1.2V
  - I_{OUT} > 250 mA at V_{OUT} = 3.3V and V_{IN} = 2.4V
  - I_{OUT} > 225 mA at V_{OUT} = 5.0V and V_{IN} =3.3V
- Ultra-low device quiescent current:
  - Output quiescent current less than 4 µA typical (device is not switching, V_{OUT} > V_{IN})
  - Input sleep current less than 1 µA (device is not switching, V_{OUT} > V_{IN}, no load)
  - Typical no load input current of 14 µA (device is switching)
  - 0.6 µA typical shutdown current
- Low 0.82V start-up voltage
- Low 0.35V minimum operating input voltage
- Maximum input voltage ≤ V_{OUT} < 5.5V
- Adjustable output from 1.8V to 5.5V
- 1.23V feedback voltage
- Automatic PFM/PWM operation:
  - 500 kHz PWM operation
  - 100 mV typical PFM output ripple
- Internal synchronous rectifier
- Internal compensation
- Inrush current limiting
- Internal soft-start (1.5 ms typical)
- Selectable, logic-controlled shutdown states:
  - True load disconnect option (MCP16251)
  - Input to output bypass option (MCP16252)
- Anti-ringing control
- Over-temperature protection
- Available in 6-lead SOT-23 and 8-lead 2 × 3 TDFN packages

MCP16251 Typical Application Circuit



MCP16251 Typical Circuit Efficiency



DC/DC Conversion

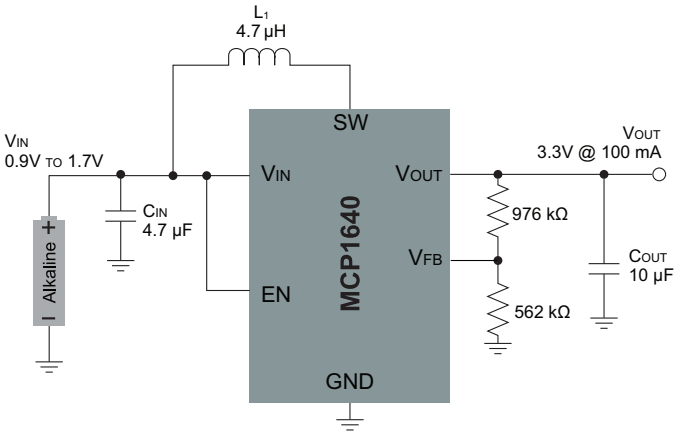
Step-Up (Boost) Switch Mode Power Converters

MCP1640 High Performance PFM/PWM Synchronous Boost Converter with True Output Disconnect or Input/Output Bypass Options

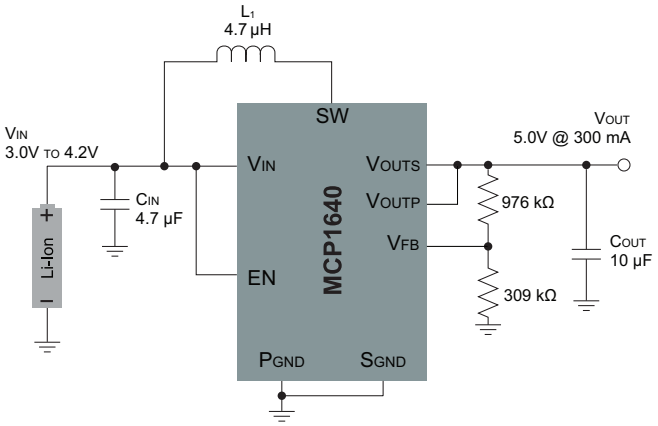
The MCP1640 is a compact, high-efficiency, fixed-frequency, synchronous step-up DC-DC converter. It provides an easy-to-use power supply solution for applications powered by one-, two-, or three-cell alkaline, NiCd, NiMH; one-cell Li-ion; or one-cell Li-polymer batteries. It provides very high efficiency through integration of the low-resistance n-channel boost switch and synchronous p-channel switch, and is available with PFM/PWM, PWM only, true load disconnect or bypass options.

- Typical efficiency up to 96%
- High current output:
  - I_{OUT} > 100 mA at V_{OUT} = 3.3V and V_{IN} = 1.2V
  - I_{OUT} > 350 mA at V_{OUT} = 3.3V and V_{IN} = 2.4V
  - I_{OUT} > 350 mA at V_{OUT} = 5.0V and V_{IN} =3.3V
- Low 0.65V typical start-up input voltage (3.3V V_{OUT} at 1 mA)
- Low 0.35V typical operating input voltage (3.3V V_{OUT} at 1 mA)
- Wide 2.0V to 5.5V adjustable output voltage range
- Maximum input voltage ≤ V_{OUT} < 5.5V
- High frequency 500 kHz PWM operation, with PFM and PWM device options:
  - Automatic PFM/PWM operation (MCP1640/C)
  - PWM only, PFM operation disabled (MCP1640B/D)
- Selectable, logic-controlled, shutdown states:
  - True load disconnect option (MCP1640/B)
  - Input to output bypass option (MCP1640C/D)
- Low < 1 µA shutdown current (all states)
- Low 19 µA typical device quiescent current
- Internal synchronous rectifier
- Internal compensation
- Inrush current limiting
- Internal soft-start
- Low noise, anti-ringing control
- Over-temperature protection
- Available in 6-lead SOT-23 and 8-lead 2 × 3 DFN packages

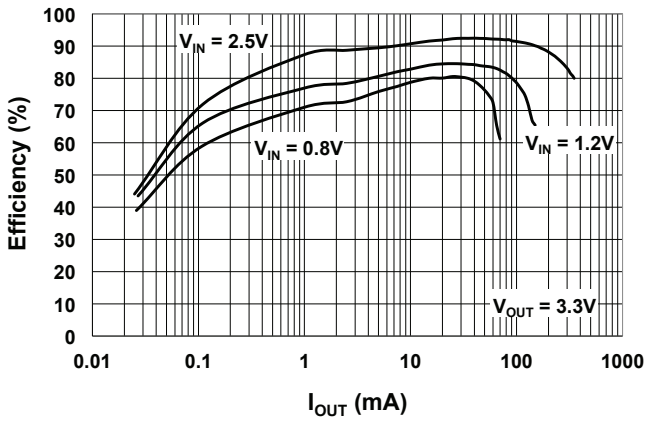
MCP1640 Application Circuit Using a Single Cell Alkaline Battery



MCP1640 Application Circuit Using a Single Cell Li-ion Battery



MCP1640 Typical Efficiency for a 3.3V Output



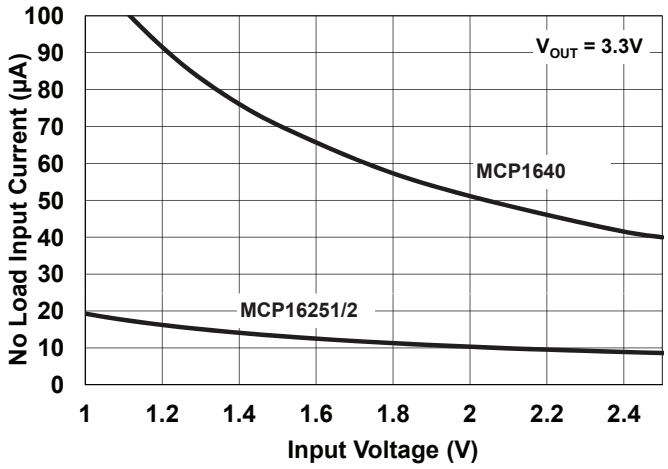
DC/DC Conversion

Step-Up (Boost) Switch Mode Power Converters

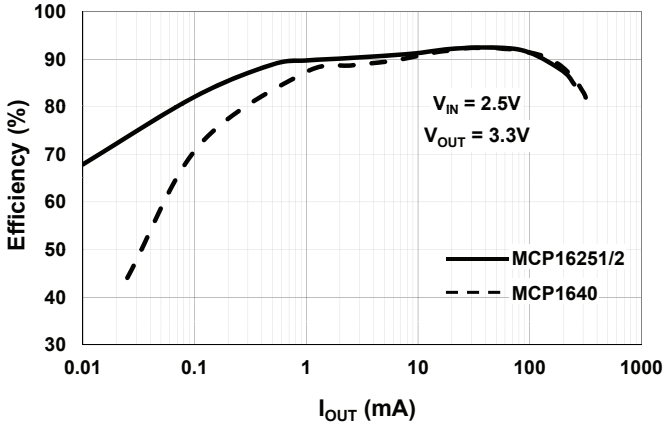
Performance Tradeoffs – Matching the Boost Converter to the Load Requirements

In many cases, light or no load conditions have very different requirements than high load conditions. This tradeoff can be readily observed by comparing the MCP1640 and MCP16251. The MCP1640 offers higher current capability, handing peak loads up to 350 mA compared to only 225 mA for MCP16251. However, the MCP16251 reduces the input quiescent current drawn from the battery even further than the MCP1640, and the MCP16251 PFM mode offers higher efficiency at light load conditions. An 80% quiescent current reduction extends battery run time for applications that operate for long periods of time in sleep mode. When powering a 100 µA load, the MCP16251 is nearly 12% more efficient than the MCP1640. Applications that draw high currents may need the additional power capability of the MCP1640, while applications with significant operating time at low or no load conditions may benefit from the reduced power consumption of the MCP16251.

No Load Input Current Requirements for MCP1640 and MCP16251



Light Load Efficiency of MCP1640 and MCP16251



DC/DC Conversion

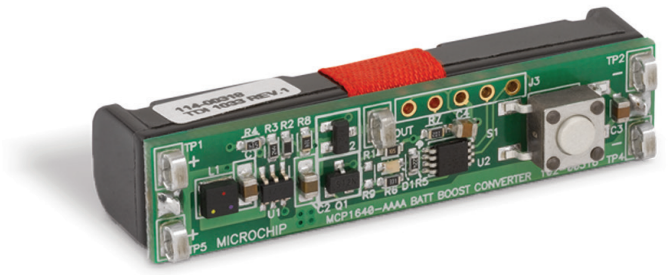
Step-Up (Boost) Switch Mode Power Converters

AAAA Battery Boost Circuit

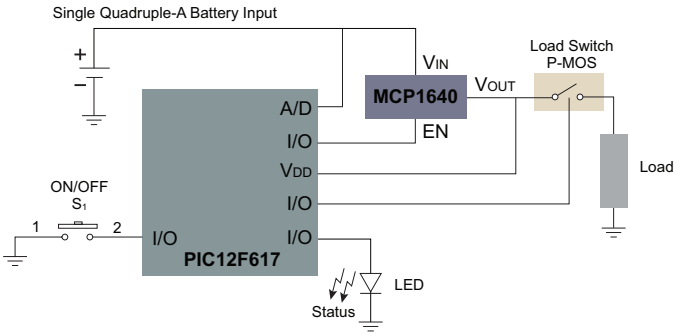
An MCP1640 boost converter and PIC12F microcontroller can create a simple power solution which will deliver a 3.3V output from a single alkaline battery cell, with very low power consumption and long battery run time, especially in low-current applications. The circuit will run in standby mode, with the PIC12F617 in sleep mode and the MCP1640 disabled, consuming only a few µA from the battery (in shutdown mode the MCP1640 typically consumes 0.75 µA). A charged capacitor will maintain the output until the comparator on the PIC® microcontroller detects a low voltage. If the output capacitor voltage drops too far, the PIC microcontroller will turn on the MCP1640, which will operate normally until the output capacitor is charged, and then the microcontroller will disable the boost converter again. When the MCP1640 is in normal operating mode, the no load input current is approximately 70 µA at 1.5V input. By pulsing the MCP1640's enable at low frequency, this method reduces the average input current by up to 80%.

This circuit is implimented in the MCP1640 Single Quadruple-A Battery Boost Converter Reference Design, available through Microchip.

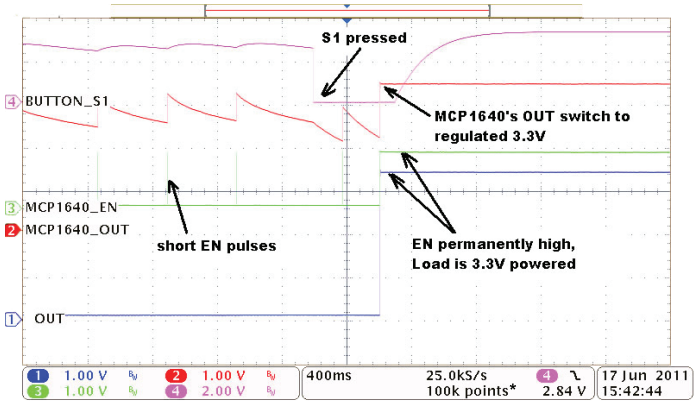
MCP1640 Single Quadruple-A Battery Boost Coverter Demonstration Board (MCP1640RD-4ABC)



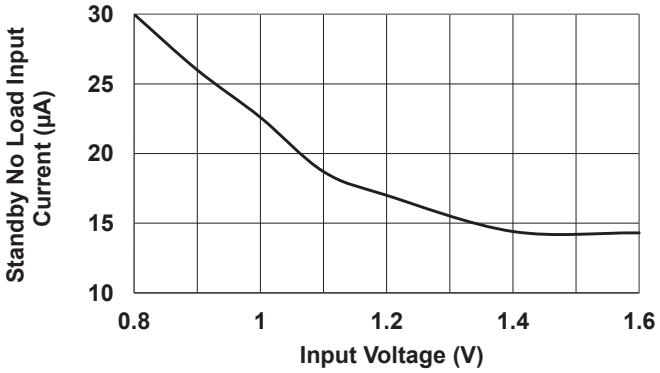
MCP1640 Boost Converter Reference Design Circuit



MCP1640 Boost Converter Reference Design Behavior During Operation



MCP1640 Boost Converter Reference Design No Load Input Current



DC/DC Conversion

Step-Up (Boost) Switch Mode Power Converters

Device	Output	Input Voltage Range (V)	Output Voltage Range (V)	Control Scheme	Features	Packages
MCP1623/4	Adjustable	0.35/ 0.65–5.0	2–5.5	PFM/PWM or PWM Only	425 mA peak current limit, 500 kHz synchronous operation, PFM/PWM (MCP1624) or PWM only (MCP1623) mode switching operation, internal compensation, over-temperature protection, 19 µA quiescent current, < 1 µA shutdown current, true output disconnect	6-pin SOT-23, 8-pin 2 × 3 TDFN
MCP16251/2	Adjustable	0.35/ 0.82–5.0	1.8–5.5	PFM/PWM	650 mA peak current limit, 500 kHz synchronous operation, internal compensation, over-temperature protection, 4 µA quiescent current, 0.6 µA shutdown current, true output disconnect (MCP16251) or input to output bypass (MCP16252) options, ± 3% output accuracy	6-pin SOT-23, 8-pin 2 × 3 TDFN
MCP1640/B/C/D	Adjustable	0.35/ 0.65–5.0	2–5.5	PFM/PWM or PWM Only	800 mA peak current limit, 500 kHz synchronous operation, internal compensation, over-temperature protection, 19 µA quiescent current, < 1 µA shutdown current, true output disconnect (MCP1640/B) or input to output bypass (MCP1640C/D) options, ± 3% output accuracy	6-pin SOT-23, 8-pin 2 × 3 TDFN

Backlighting Solutions
Switching Regulators

Switching Regulators

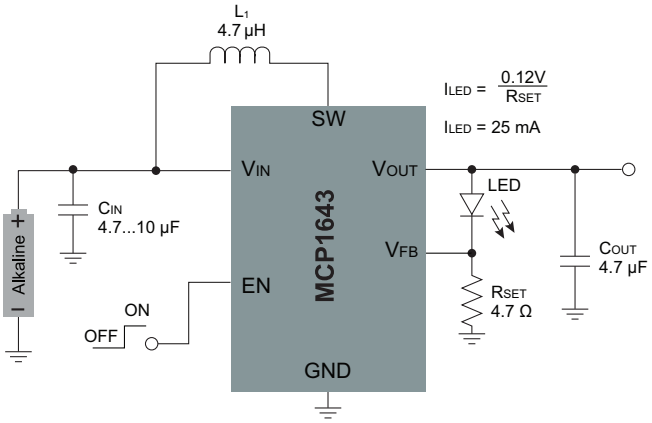
Efficient backlighting in portable applications presents a number of unusual power supply design challenges. Like all portable circuits as in all portable designs, board area is at a premium and minimizing power consumption is essential for maximizing battery run time. Commonly, LED forward voltages are unique potentials within the circuit; they may be higher or lower than the battery voltage, and different from the voltages needed to power the microcontrollers and peripheral components. In addition, since the current flow through LEDs is exponentially dependent on voltage, brightness control and LED longevity both require accurate, measured and controllable current delivery.

LED Backlighting with MCP1643: Synchronous Boost Constant Current Regulator

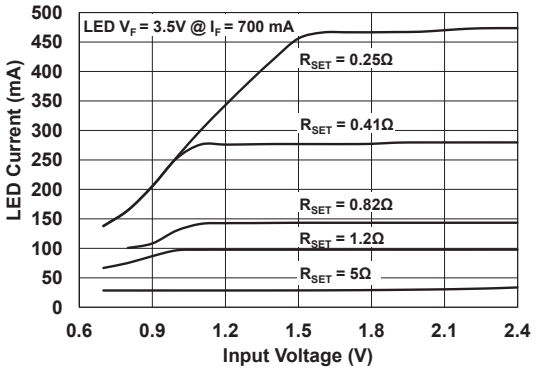
MCP1643 is a compact, high-efficiency, fixed-frequency, synchronous step-up LED driver with constant current that can operate from one- and two-cell alkaline, NiMH and NiCd batteries. With an output of up to 5V, the device can drive a single white or blue LED; or pairs of red, green, and yellow LEDs connected in series. In addition, the 550 mA load current capability is enough to drive high-brightness LEDs with high current requirements, or sets of matched LEDs connected in parallel. Current is read from the voltage on a low-impedance sense resistor connected to the feedback pin, with minimal power losses compared to other current measurement techniques. For visible blinking or dimming, the enable pin can be toggled with a PWM signal to switch the power supply and LED load on and off. (At frequencies approximately 50 Hz or faster the blinking light should appear dimmed, and not visibly flickering.) Finally, the over-voltage protection feature limits the output to 5V, protecting the power circuit in the event of an open circuit or load failure.

- Constant current drive capability with a low component count, area-efficient circuit
- 1 MHz PWM synchronous boost operation with up to 550 mA output current
- Low-voltage reference input to maximize LED efficiency conversion (VFB = 120 mV)
- Capable of start up with only 0.65V input, and continuous operation with an input above 0.5V
- Low 1.2 µA shutdown current
- Over-voltage protection halts device operation (floating output) if the LED fails or is disconnected
- Up to 90% efficiency
- 240 µs soft start time
- Available in tiny footprint 8-lead 2 × 3 DFN or 8-pin MSOP packages

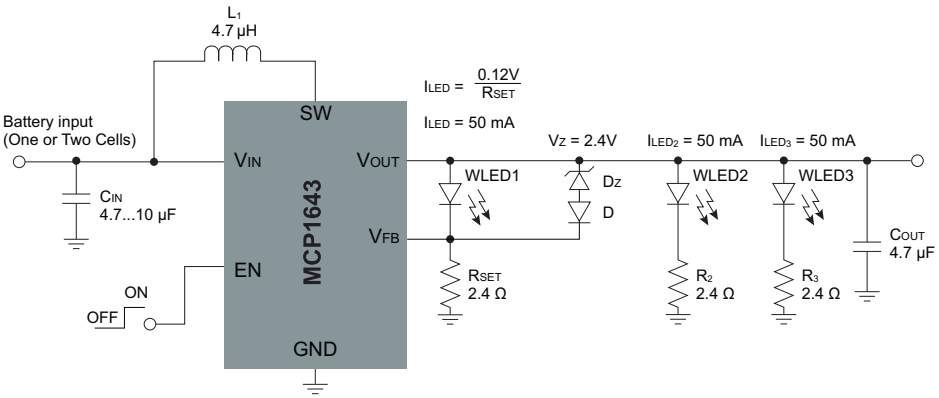
MCP1643 LED Drive Application with a Single LED



MCP1643 LED Output Current as a Function of Input Voltage and Sense Resistor



MCP1643 LED Drive Application with Multiple Parallel LEDs

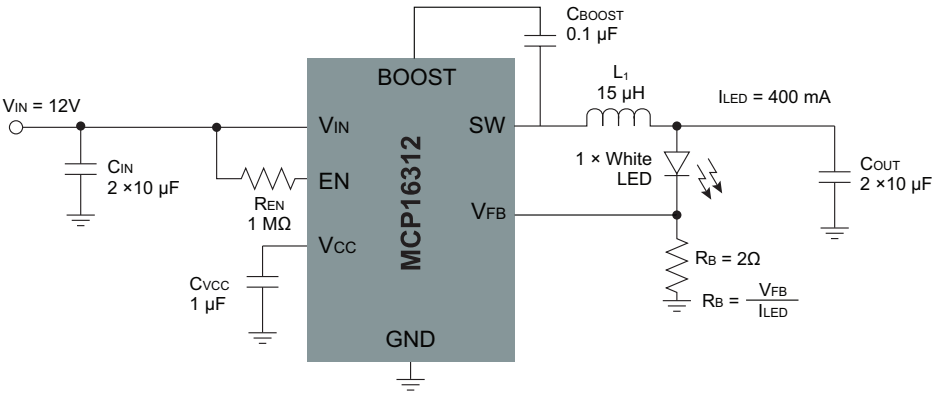


Backlighting Solutions
Switching Regulators

MCP16312 Buck Converter LED Application

The MCP16312 buck converter can be used as a constant current source to drive one or more LEDs. Starting from the standard buck circuit, the anode of the LED load is connected at the buck coverter output. Using a sense resistor between the LED cathode and ground will produce a constant voltage at constant current, and this voltage can be used as the feedback signal into the buck converter. The control loop in the MCP16312 will adjust the duty cycle of the internal MOSFETs, regulating to a constant voltage on the sense resistor, corresponding to a constant output current in the LED string.

MCP16312 Buck Converter LED Application Circuit

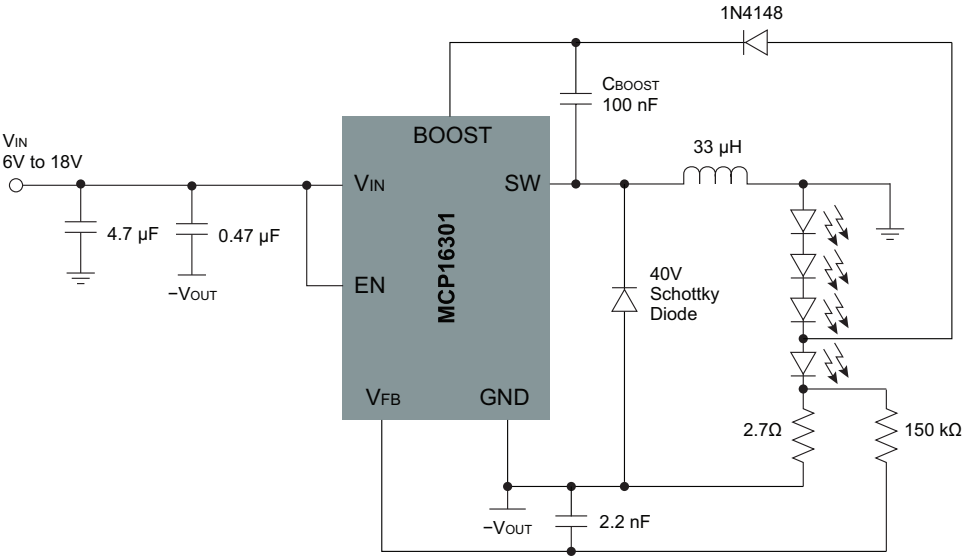


MCP16301 Ćuk LED Application

While it is typically operated as a buck regulator, the MCP16301 can be creatively designed into a low component count Ćuk circuit. It will operate from 6 V to 18 V in, producing a regulated output and supplying up to 300 mA of current. This is an excellent solution for LED drive applications, capable of driving multiple LEDs in series (up to 15V). Due to both the low number of components (as few as eleven) and readily available small size surface mount component options (mostly 0603 surface mount packages), this design can be implemented in a very small board area.

This circuit is implemented in the MCP16301 High Voltage Single Inductor Ćuk LED Demo Board, available through Microchip.

MCP16301 Ćuk Converter Circuit



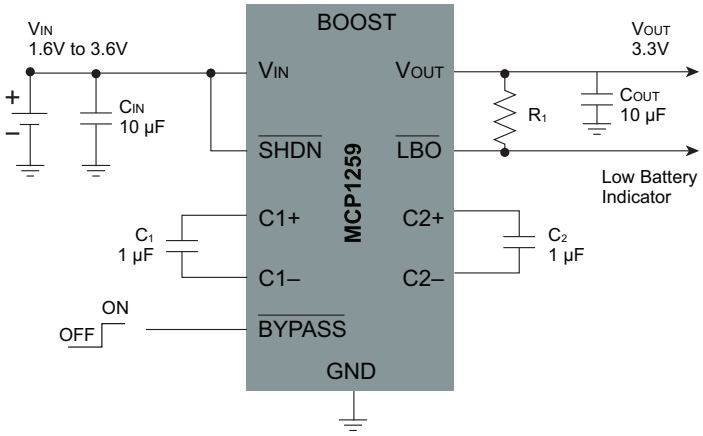
Backlighting Solutions
Charge Pump DC/DC Converters

Charge Pump DC/DC Converters

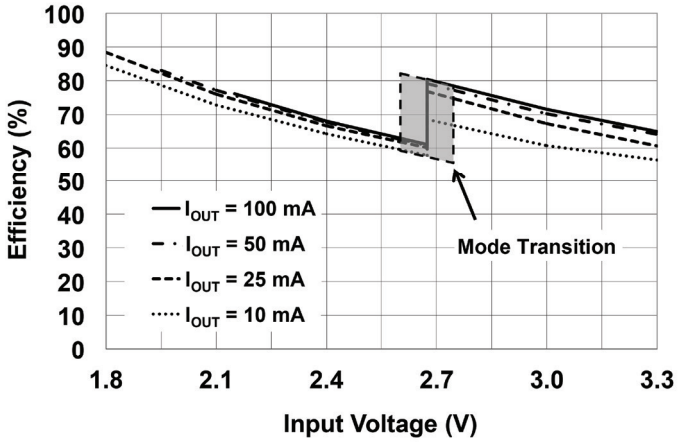
The MCP1256, MCP1257, MCP1258 and MCP1259 are inductorless, positive regulated charge pump DC/DC converters. Generating a regulated 3.3V output voltage from a 1.8V to 3.6V input, they are specifically designed for applications operating from two-cell alkaline, two-cell Ni-Cd, two-cell Ni-MH, or one primary lithium coin cell battery. These devices automatically switch from 1.5× to 2× boost operation modes to maintain high efficiency. In addition, at light output loads the MCP1256 and MCP1257 can be placed in a sleep mode, lowering the quiescent current while maintaining the regulated output voltage. Alternatively, the MCP1258 and MCP1259 provide a bypass feature connecting the input voltage to the output. This allows for real-time clocks, microcontrollers or other system devices to remain biased with virtually no current being consumed by the MCP1258 or MPC1259. In normal operation, the charge pumps switch at a fixed 650 kHz, avoiding sensitive IF bands, and the output voltage ripple is below 20 mV_{P-P} at load currents up to 100 mA. The MCP1256 and MCP1258 feature a power-good output that can be used to detect out-of-regulation conditions. The MCP1257 and MCP1259 feature a low battery indication that issues a warning if the input voltage drops below a preset voltage threshold. Extremely low supply current and few external parts (4 capacitors) make these devices ideal for small, battery powered applications. A Shutdown mode is also provided for further power reduction. The devices incorporate thermal and short-circuit protection.

- High accuracy 3.3V ± 3.0% output voltage
- Accepts 1.8V to 3.6V input voltages
- Supplies up to 100 mA output current
- Low 20 mV_{P-P} output voltage ripple
- Integrated thermal shutdown and short circuit protection
- Uses small ceramic capacitors
- Operates at 650 kHz switching frequency
- Low-power sleep mode feature on MCP1256/7
- Bypass mode on MCP1258/9
- Low-power 0.1 µA shutdown mode
- Shutdown input compatible with 1.8V logic
- Soft-start circuitry to minimize inrush current
- Available in 10-pin 3 × 3 DFN or 10-pin MSOP packages

MCP1259 Charge Pump Backlighting Circuit



MCP1259 Power Conversion Efficiency



Battery Management
Linear Battery Chargers

Linear Battery Chargers

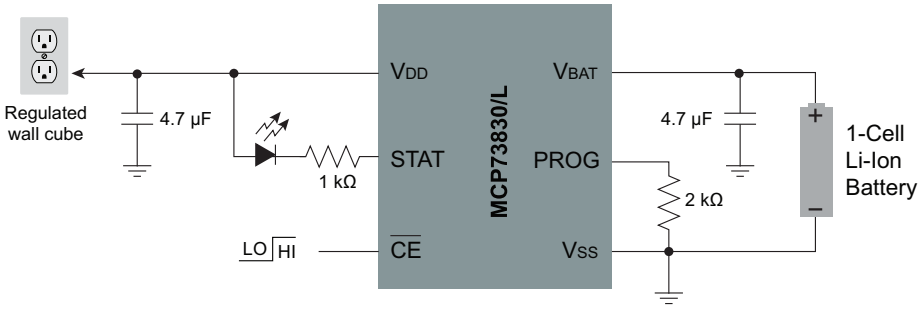
In battery-powered systems, the quality of the charging circuit plays a key role in the life and reliability of the battery. Microchip offers a complete line of linear Li-Ion battery chargers. To further reduce design size, cost and complexity, the Li-Ion Charge Management Controllers provide a reliable, low-cost and high accuracy voltage regulation solution with few external components. The MCP73830L Li-Ion linear charger was developed specifically for low-charge current applications. Charge currents as low as 20 mA can be controlled using a programmable resistor. Single- and two-cell LiFePO4 batteries can be charged using the MCP738123/213 linear chargers. In order to supply world-class portable devices, most of Microchip's Li-Ion/LiFePO4 Battery Management Controllers are equipped with thermal regulation, reverse discharge protection, safety charge timer and integrated current sensing. The programmable constant charge current can assist you in meeting different application requirements with a single resistor. Along with their small physical size, the low number of external components required makes Microchip's battery management ICs ideally suited for portable applications.

MCP73830 Single Cell, Li-Ion/Li-Polymer Batter Charge Management Controllers

The MCP73830 battery chargers contain a large number of features for creating long life, long run time, fast charging battery circuits. Including options for battery preconditioning, programmable charge currents, end-of-charge thresholds and elapse timers, these charging devices maximize fuel capacity and minimize charge time while maintaining battery life in low-component-count, small-area circuits perfectly suited for portable applications.

- Complete linear charge management controller
- High 0.75% accuracy preset voltage regulation
- Programmable charge current:
  - 100 mA to 1A for MCP73830
  - 20 mA to 100 mA for MCP73830L
- Available with or without a preconditioning mode, which decreases charge current to 10% of the typical current when the battery voltage is below the preconditioning threshold
- Available with or without a fixed 1 hour preconditioning timer to stop the charge cycle when the battery is not charging properly
- Soft start to minimize inrush current
- Fixed 0 to 4 hour elapse timer
- Available in options for 7.5% or 10% current thresholds to trigger automatic end-of-charge termination
- Chip enable input (CE)
- Under-voltage lockout (UVLO)
- Automatic power-down
- Integrated thermal regulation
- Wide –40°C to +85°C operating temperature range
- Available in small footprint 6-pin TDFN (2 × 2 × 0.75 mm) packages

Typical Application Circuit for the MCP73830L (Low Current, 20 to 200 mA) and MCP73830 (High Current, 100 mA to 1A) Battery Charger Solutions



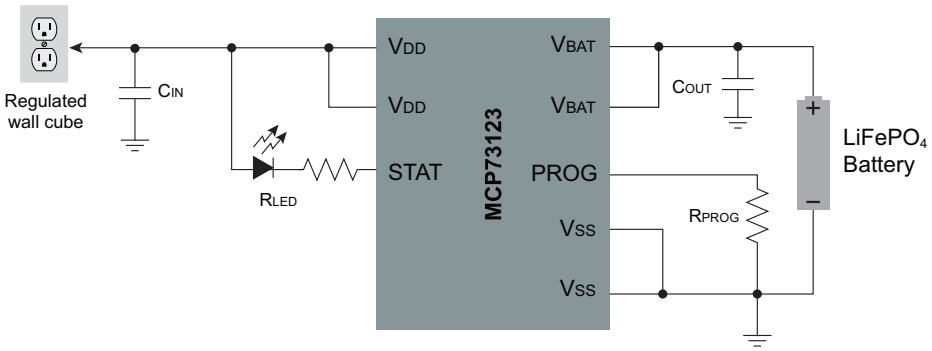
Battery Management
Linear Battery Chargers

MCP73113, MCP73123: Battery Charge Management Controllers

In addition to the features of the MCP73830, these battery chargers also include charge status outputs, over-voltage protection and more options for end-of-charge thresholds, safety timers and charge currents. Also available are the MCP73213 (Li-ion) and MCP73223 (LiFePO4), with higher voltage capabilities to charge two cells in series.

- Programmable charge current: 130 mA to 1.1A
- Charge status output
- Selectable 5%, 7.5%, 10% or 20% automatic end-of-charge
- Elapse safety timer: 4 hour, 6 hour, 8 hour or disable
- Over-voltage protection
- Available in 10-pin 3 × 3 DFN packages

Typical Application Circuit for the MCP73123 (LiFePO4) and MCP73113 (Li-ion) Battery Chargers



Selected Products: Integrated FET Linear Battery Charger

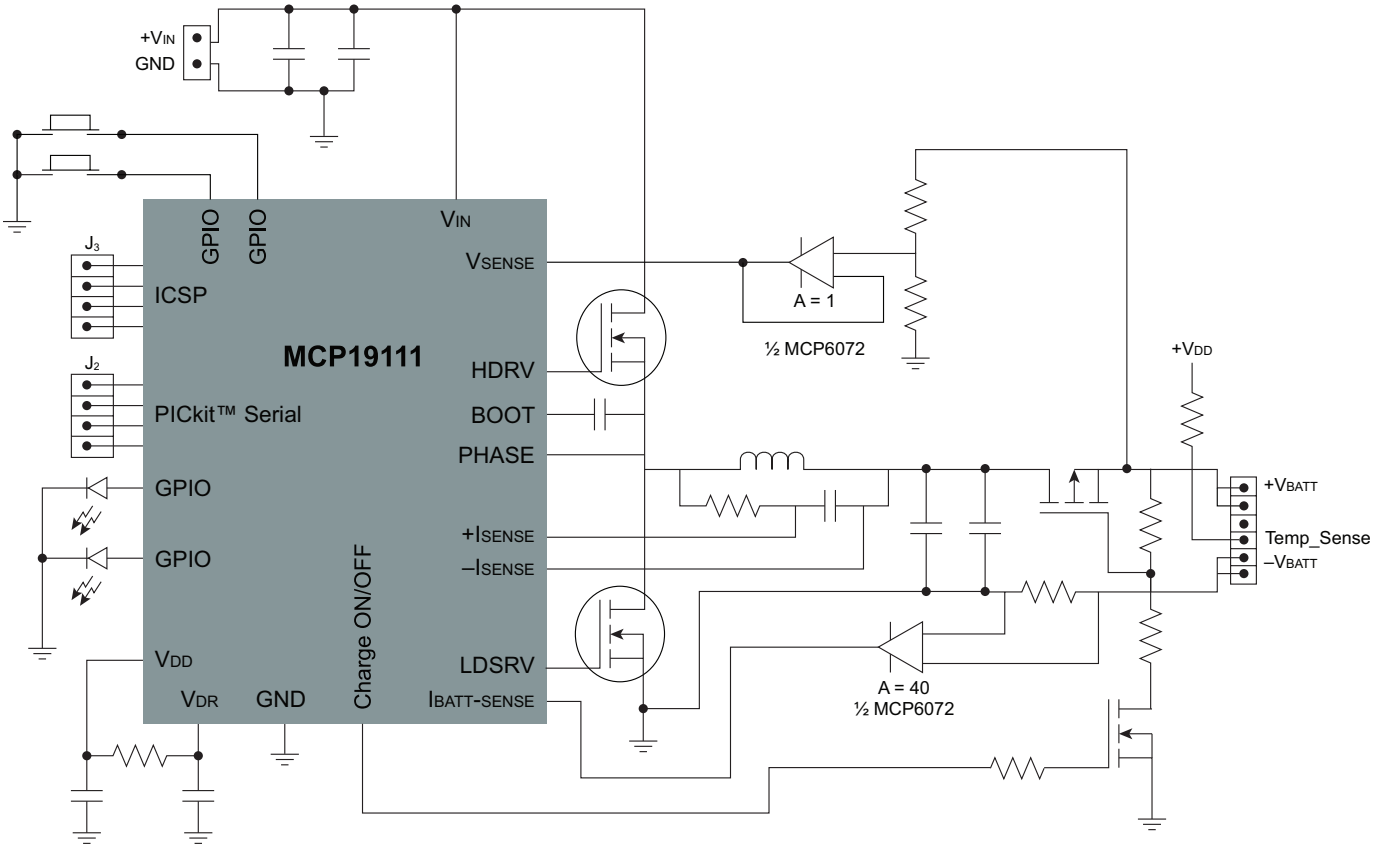
Device Family	Cells	Vcc Range (V)	Features
MCP73XXX	1/2	4–16	Li-Ion and LiFePO4, High Current, 0.5% Voltage Reg.
MCP73811/2	1	3.75–6	USB Selectable Charge Current, Thermal Reg.
MCP73831/2/3/4	1	3.75–6	Programmable Charge Current, Thermal Reg., UVLO, Preconditioning and End-of-Charge
MCP73837/8	1	3.7–6	Dual Input (USB, DC, Adapter), Auto Input Switchover
MCP73871	1	3.9–6	Integrated System Load Sharing and Battery Charge Management

Battery Management
Programmable Battery Chargers

MCP19111 Switching Battery Charger Circuit

Designs for wide input range, high output power multi-chemistry battery chargers are used for many battery-powered applications. The MCP19111 programmable battery charger reference design operates from an input range of 6V to 28V and can be configured to charge NiMH, Li-Ion and LiFeO4 batteries in multiple series and parallel configurations. The reference design uses the MCP19111 Digitally Enhanced Power Analog PWM controller to step down higher input voltages to lower output voltage while regulating the current or voltage to properly charge the selected battery chemistry. A graphical user interface (GUI) is configured prior to starting the charge profile for the desired battery load. Once configured, the MCP19111 flash memory stores the charge settings for subsequent charge cycles.

Simplified MCP19111 Programmable Multi-Chemistry Battery Charger



MCP19111 Features

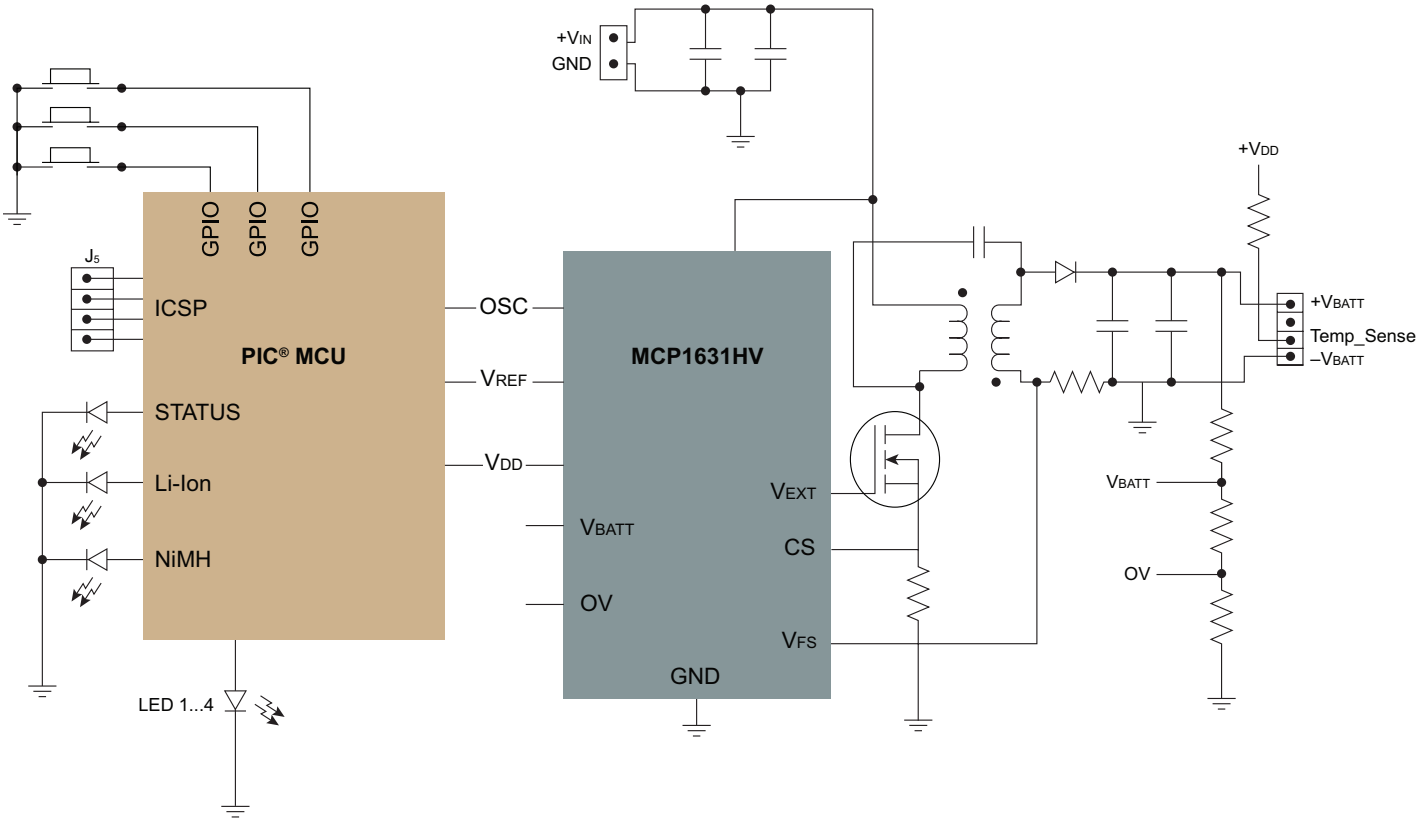
- Single channel
- VIN Range: 4.5V to 32.0V
- Integrated, synchronous MOSFET driver:
  - Logic-level drive (5V)
  - 2A source/4A sink drive current
- Fully programmable (12F core)
  - MPLAB® X IDE support, GUI-configurable
  - 4 k word Flash, 256b RAM
  - Internal, adjustable analog compensation
  - Adjustable deadtime/current limit/UVLO/OVLO/…
  - Configurable switching frequency: 100 kHz to 1.2 MHz
  - Up to 12 general purpose I/O
  - PMBus/I²C™ communication interface
- Master/slave synch frequency
- Available in 28-lead 5 × 5 mm QFN

Battery Management
Programmable Battery Chargers

MCP1631 Switching Battery Charger Circuit

The MCP1631 Analog PWM Controller with integrated ×10 current sense amplifier, Battery Voltage Divider Buffer Amplifier, MOSFET driver, high-speed Over Voltage Detection and Pulse Width Modulation controller, combined with a PIC microcontroller, is used to develop intelligent battery chargers. The combination of the dedicated analog PWM controller with a PIC MCU creates highly versatile charging solutions. The MCP1631HV provides the analog circuitry needed to drive several power train topologies (SEPIC, Flyback, Boost) while the PIC MCU is used to develop the programmable charge algorithm to adapt to the number of series batteries and their chemistry. The block diagram below represents a SEPIC solution used to charge NiMH or Li-Ion batteries.

MCP1631HV SEPIC Programmable Multi-Chemistry Battery Charger



MCP1631 Features

- High-speed analog PWM controller (2 MHz operation)
- Can pair with a microcontroller for “Intelligent” power system development
- Peak current mode control (MCP1631/MCP1631HV)
- Voltage mode control (MCP1631V/MCP1631VHV)
- High voltage options operate to +16V input:
  - MCP1631HV current mode
  - MCP1631VHV voltage mode
- Regulated output voltage options:
  - +5.0V or +3.3V
  - 250 mA maximum current
- External oscillator input sets switching frequency and maximum duty cycle limit
- External reference input sets regulation voltage or current
- Error amplifier, battery current ISNS amplifier, battery voltage VSNS amplifier integrated
- Integrated over-voltage comparator
- Integrated high current low side MOSFET driver (1A peak)
- Shutdown mode reduces I_Q to 2.4 µA (typical)
- Internal over-temperature protection
- Under-voltage lockout (UVLO)
- Available in 20-lead 4 × 4 mm QFN (MCP1631/MCP1631V only), 20-lead TSSOP or 20-lead SSOP

Related Support Material

Application Notes

The following application notes are available on the Microchip web site: www.microchip.com.

AN793: Power Management in Portable Applications: Understanding the Buck Switch Mode Power Converter

This is an in-depth application note describing the design of buck topology switch mode power supplies for use in portable applications.

AN947: Power Management in Portable Applications: Charging Lithium-Ion/Lithium-Polymer Batteries

This application note focuses on the fundamentals of charging Lithium-Ion/Lithium-Polymer batteries, including a linear, stand-alone solution utilizing Microchip's MCP73841.

AN960: New Components and Design Methods Bring Intelligence to Battery Charger Applications

Leveraging the benefits of digital and mixed-signal power supply designs, this application note describes solutions for intelligent battery charger designs capable of handing battery removal, reverse polarity, short circuits and other situations. This application note covers battery reference material, basic switch mode power supply converter trade-offs, and a complete battery charger system design with fuel gauge.

AN968: Simple Synchronous Buck Regulator – MCP1612

This application note contains all of the information needed to design a synchronous buck converter using the MCP1612, including an implemented design example with measured power conversion results.

AN1088: Selecting the Right Battery System for Cost-Sensitive Portable Applications

This application note describes design tradeoffs in battery chemistry, charging, product cost and product size, including application examples.

AN1156: Battery Fuel Measurement Using Delta-Sigma ADC Devices

The fuel used (mAH) and fuel remaining (mAH) in a battery can be calculated by tracking the discharging and charging currents over time. This application note describes the use of ADC devices to perform these functions.

AN1311: Single-Cell Input Boost Converter Design

A variety of single-cell input synchronous boost converters can be designed using the MCP1640B/C/D family of devices. This document shows different performance tradeoffs and features present in these designs.

AN1337: Optimizing Battery Life in DC Boost Converters Using MCP1640

This application note details practical considerations for efficient circuit operation using the MCP1640 device in applications intended for long battery life.

AN1385: Using the MCP16301 Design Analyzer

The MCP16301 design analyzer provides efficiency and stability information for the power supply designs using the MCP16301 buck converter.

AN1541: Using the MCP19111 Design Tools

The MCP19111 offers incredible flexibility for advanced power supply designs. This document illustrates a design example using MCP19111 design tools to unlock the unique features of the digitally enhanced power analog controller.

MCP19111 – Buck Power Supply, Graphical User Interface User's Guide

This guide discusses the MPLAB X IDE plug-in software available to help program the MCP19111 for customized buck topology power supply designs.

Related Support Material

Evaluation Boards

Microchip offers a number of boards to help evaluate device families. Contact your local Microchip sales office for a demonstration.

AAAA Clock Demo

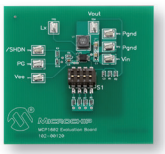
A PIC microcontroller performs basic clock functions on a LCD display using a single AAAA battery boosted up to 3.3V using a MCP1624. The demo includes capacitive touch controls and battery fuel measurement.

MCP1252 Charge Pump Backlight Demonstration Board (MCP1252DM-BKLT)



The MCP1252 charge pump is set up for biasing backlighting or driving other LED applications, with intensity, dimming and disabling features.

MCP1602 Evaluation Board (MCP1602EV)

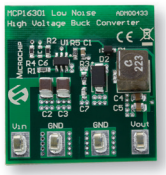


The board evaluates the PFM and PWM operation of the MCP1602 buck regulator step down the input voltage, with selectable output voltages.

MCP16251 and MCP1640B Synchronous Boost Converters Evaluation Board (ADM00458)

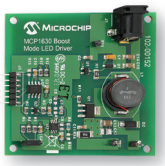
Two boost converters are available, with selectable output voltage levels and enable/disable capability.

MCP16301 5V/600mA Low Noise Evaluation Board (ADM00433)



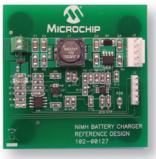
The MCP16301 boost converter runs at high frequency to obtain a high efficiency 5V regulated output with minimal radiated noise for use in sensitive applications.

MCP1630 Boost Mode LED Driver Demo Board (MCP1630DM-LED2)



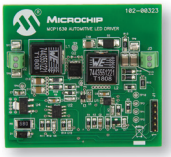
The MCP1630 takes an input voltage between 9 and 16V DC, and boosts it to provide a constant 350 or 700 mA (selectable) current for powering up to a 30W string of LEDs.

MCP1630 NiMH Battery Charger Demonstration Board (MCP1630DM-NMC1)



The MCP1630 is interfaced to the PIC16LF818 to develop a fault-tolerant NiMH battery charger with fuel gauge capability using a 1 MHz SEPIC converter.

MCP1630V Bi-directional Four-Cell Li-Ion Charger Reference Design (MCP1630RD-DDBK3)



The MCP1630V is set up to boost a low source voltage to charge four Li-Ion series cells, or current can be reversed to provide regulated output from the Four-cell Li-Ion battery pack to other circuits.

MCP1630 Li-Ion Multi-Bay Battery Charger Reference Design (MCP1630RD-LIC1)

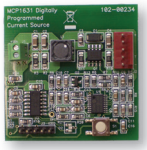
This circuit is capable of charging two single-cell Li-Ion battery packs in parallel utilizing an input voltage of 10V to 30V, providing a constant current—constant voltage charge with preconditioning, cell temperature monitoring and battery pack fault monitoring.

MCP16301 High-Voltage Buck-Boost Demo Board (ADM00399)



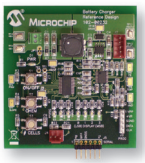
Using small surface-mount components in a minimal board area, this board is designed to operate from a 5V to 30V input and regulate the output to 12V.

MCP1631HV Digitally-Controlled Programmable Current Source Reference Design (MCP1631RD-DCPC1)



The MCP1631HV is set up in a SEPIC power converter which, combined with a PIC16F616 microcontroller, can function as a current source for driving LEDs in multiple series or parallel configurations, charging NiMH, NiCd, and Li-ion batteries.

MCP1631HV Multi-Chemistry Battery Charging Reference Design (MCP1631RD-MCC2)



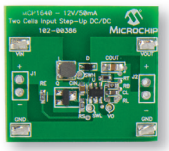
Using a PIC16F883 microcontroller in combination with the MCP1631HV high-speed analog PWM controller, this design can charge one to five NiMH or NiCd batteries; one- or two-cell Li-Ion batteries; or drive one or two 1W LEDs.

Related Support Material

MCP16323 Evaluation Board (ADM00427)

This small footprint, high-current-density buck circuit provides up to 3A at 3V from an input voltage between 6.0 and 18V.

MCP1640 12V/50 mA Two Cells Input Boost Converter Reference Design (ARD00386)

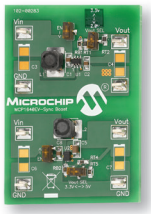


Using inputs between 2.0 and 5.0V typical of a two-cell battery pack, this MCP1640 boost converter can generate high 9, 12 or 24V outputs.

MCP1640 Single Quad-A Battery Boost Converter Reference Design (MCP1640RD-4ABC)

This design uses a single quad-A battery and boosts the 1.5V input to a 3.3V output, including an enable feature to greatly reduce the standby current consumption.

MCP1640 Sync Boost Converter Evaluation Board (MCP1640EV-SBC)



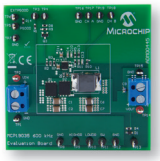
Using input voltages between 0.35V and 5.5V, the MCP1640 generates either a 2.0, 3.3 or 5.0V regulated output (provided the input voltage is below the output voltage).

MCP1643 Synchronous Boost LED Constant Current Regulator Evaluation Board (ADM00435)



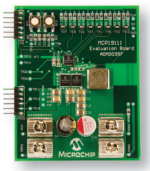
Powered by one-cell or two-cell Alkaline, NiCd or NiMH batteries, the MCP1643 is used in a compact, high-efficiency, fixed-frequency, step-up DC/DC converter optimized as an LED constant current generator, with a minimum number of external components for applications.

MCP19035 600 kHz Synchronous Buck Controller Evaluation Board (ADM00445)



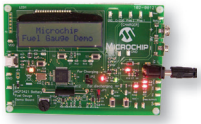
This is a compact, highly efficient, step-down voltage regulator that will convert the input voltage rail (typically 12V) to a regulated 1.8V output voltage with 10A of current.

MCP19111 Evaluation Board (ADM00397)



The MCP19111 evaluation board demonstrates the MCP19111 operation in a synchronous buck topology. Nearly all operation and control parameters are programmable using the integrated PIC microcontroller core.

MCP3421 Fuel Gauge Demo Board (MCP3421DM-BFG)



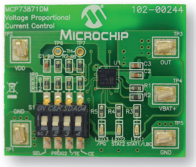
Measures and displays battery voltage, discharge current, usage for non-rechargeable batteries, and can be programmed to additionally recharge and calculate the remaining usage for a rechargeable Li-Ion battery.

MCP73113 OVP Single Cell Li-Ion Battery Charger Evaluation Board (MCP73113EV-1SOVP)



This design charges a Li-Ion battery at 500 mA or 1000 mA. It includes LED status indicators, precondition, termination, and auto-recharge features, at a fixed 4.20V output.

MCP73871 Demo Board with Voltage Proportional Current Control (MCP73871DM-VPCC)

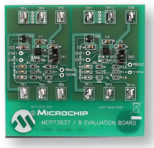


When the input voltage is present, the MCP73871 board can charge a single-cell Li-Ion or Li-polymer battery while powering a load, or when the input voltage is removed, it can power the load from the battery. The circuit features input current limits, constant current/constant voltage charging and LED indicators for charge status.

MCP73X23 OVP Lithium Iron Phosphate Battery Charger Evaluation Board (MCP73X23EV-LFP)

This board contains two circuits: an MCP73123 design to charge a single-cell LiFePO4 battery and a MCP73223 implementation to charge a dual-cell LiFePO4 battery.

MCP73837/8 AC/USB Dual-Input Battery Charger Evaluation Board (MCP7383XEV-DIBC)



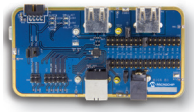
Using the minimum number of components, this complete battery charge management circuit automatically selects between AC-adapter or USB-port power sources.

Related Support Material

Also Check the Following Demonstration Boards on Our Website



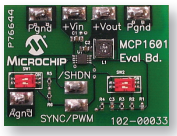
UCS1001 Evaluation Board (ADM00540)



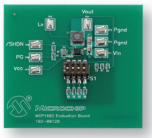
UCS1002 Programmable USB Port Power Evaluation Board (ADM00497)



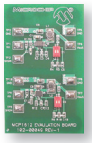
MCP1256/7/8/9 Charge Pump Evaluation Board (MCP1256/7/8/9EV)



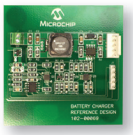
MCP1601 Buck Regulator Evaluation Board (MCP1601EV)



MCP1602 Evaluation Board (MCP1602EV)



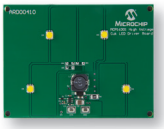
MCP1612 Synchronous Buck Regulator Evaluation Board (MCP1612EV)



MCP1630 Low-Cost Li-Ion Battery Charger Reference Design (MCP1630RD-LIC2)



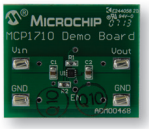
MCP16301 High Voltage Buck-Boost Demo Board (ADM00399)



MCP16301 High-Voltage Single-Inductor Ćuk LED Driver Demo Board (ARD00410)



MCP1632 300 kHz Boost Converter Demo Board (ADM00530)



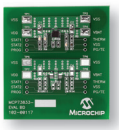
MCP1710 Demo Board (ADM00468)



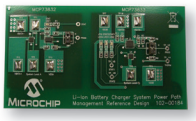
MCP73213 OVP Dual-Cell Li-Ion Battery Charger Evaluation Board (MCP73213EV-2SOVP)



MCP73831 Evaluation Kit (MCP73831EV)



MCP73833 Li-Ion Battery Charger Evaluation Board (MCP73833EV)



MCP7383X Li-Ion System Power Path Management Reference Design (MCP7383XRD-PPM)



MCP73871 Evaluation Board (MCP73871EV)

Support

Microchip is committed to supporting its customers in developing products faster and more efficiently. We maintain a worldwide network of field applications engineers and technical support ready to provide product and system assistance. In addition, the following service areas are available at **www.microchip.com:**

- **Support** link provides a way to get questions answered fast: **http://support.microchip.com**
- **Sample** link offers evaluation samples of any Microchip device: **http://sample.microchip.com**
- **Forum** link provides access to knowledge base and peer help: **http://forum.microchip.com**
- **Buy** link provides locations of Microchip Sales Channel Partners: **www.microchip.com/sales**

Training

If additional training interests you, then Microchip can help. We continue to expand our technical training options, offering a growing list of courses and in-depth curriculum locally, as well as significant online resources – whenever you want to use them.

- Technical Training Centers and Other Resources: **www.microchip.com/training**
- MASTERs Conferences: **www.microchip.com/masters**
- Worldwide Seminars: **www.microchip.com/seminars**
- eLearning: **www.microchip.com/webseminars**

Sales Office Listing

AMERICAS

Atlanta
Tel: 678-957-9614
Austin
Tel: 512-257-3370
Boston
Tel: 774-760-0087
Chandler
Tel: 480-792-7200
Chicago
Tel: 630-285-0071
Cleveland
Tel: 216-447-0464
Dallas
Tel: 972-818-7423
Detroit
Tel: 248-538-2250
Houston
Tel: 281-894-5983
Indianapolis
Tel: 317-773-8323
Los Angeles
Tel: 949-462-9523
New York
Tel: 631-435-6000
San Jose
Tel: 408-735-9110
Toronto
Tel: 905-673-0699

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Denmark - Copenhagen
Tel: 45-4450-2828
France - Paris
Tel: 33-1-69-53-63-20
Germany - Dusseldorf
Tel: 49-2129-3766400
Germany - Munich
Tel: 49-89-627-144-0
Germany - Pforzheim
Tel: 49-7231-424750
Italy - Milan
Tel: 39-0331-742611
Italy - Venice
Tel: 39-049-7625286
Netherlands - Drunen
Tel: 31-416-690399
Poland - Warsaw
Tel: 48-22-3325737
Spain - Madrid
Tel: 34-91-708-08-90
Sweden - Stockholm
Tel: 46-8-5090-4654
UK - Wokingham
Tel: 44-118-921-5800

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733
China - Beijing
Tel: 86-10-8569-7000
China - Chengdu
Tel: 86-28-8665-5511
China - Chongqing
Tel: 86-23-8980-9588
China - Hangzhou
Tel: 86-571-87928115
China - Hong Kong SAR
Tel: 852-2943-5100
China - Nanjing
Tel: 86-25-8473-2460
China - Qingdao
Tel: 86-532-8502-7355
China - Shanghai
Tel: 86-21-5407-5533
China - Shenyang
Tel: 86-24-2334-2829
China - Shenzhen
Tel: 86-755-8864-2200
China - Wuhan
Tel: 86-27-5980-5300
China - Xiamen
Tel: 86-592-2388138
China - Xian
Tel: 86-29-8833-7252
China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444
India - New Delhi
Tel: 91-11-4160-8631
India - Pune
Tel: 91-20-3019-1500
Japan - Osaka
Tel: 81-6-6152-7160
Japan - Tokyo
Tel: 81-3-6880-3770
Korea - Daegu
Tel: 82-53-744-4301
Korea - Seoul
Tel: 82-2-554-7200
Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Malaysia - Penang
Tel: 60-4-227-8870
Philippines - Manila
Tel: 63-2-634-9065
Singapore
Tel: 65-6334-8870
Taiwan - Hsin Chu
Tel: 886-3-5778-366
Taiwan - Kaohsiung
Tel: 886-7-213-7830
Taiwan - Taipei
Tel: 886-2-2508-8600
Thailand - Bangkok
Tel: 66-2-694-1351

3/12/14

Microcontrollers • Digital Signal Controllers • Analog • Memory • Wireless

Information subject to change. The Microchip name and logo, the Microchip logo, dsPIC, MPLAB and PIC are registered trademarks and PICDEM, PICtail, mTouch and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries. All other trademarks mentioned herein are property of their respective companies. © 2014, Microchip Technology Incorporated. All Rights Reserved. Printed in the U.S.A. 5/14

DS30009610F

MICROCHIP

www.microchip.com

Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, AZ 85224-6199

ENTEGRECİ

Bu belge www.entegreci.com üzerinden sunulmaktadır.

Elektronik komponent tedarikinde Entegreci

Entegreci, Eskişehir merkezli, Türkiye geneline satış yapan bir elektronik komponent mağazasıdır. Entegreler (IC), mikrodenetleyiciler, transistörler, diyotlar, pasif elemanlar, konnektörler, modüller ve geliştirme kartları tek adetten seri üretim adetlerine kadar satılır. Ürün sayfalarında güncel stok durumunu, fiyatı ve datasheet bağlantısını bulabilirsiniz.

Parça koduyla arama

Üretici parça numarasını yazın; stok ve fiyatı hemen görün.

www.entegreci.com

Ürün kategorileri

Entegreden kapasitöre tüm elektronik komponent kategorileri.

Kategorilere göz atın

Üreticiler

Aradığınız üreticinin ürünlerini tek sayfada inceleyin.

Üreticileri görün

Toplu alım ve teklif

Listede olmayan ya da yüksek adetli parçalar için teklif isteyin.

Teklif isteyin

www.entegreci.com | **destek@entegreci.com** | **0850 305 90 34**

Entegreci is an online electronic components store based in Türkiye. Search by manufacturer part number to see stock, prices and datasheets for integrated circuits, microcontrollers, transistors, passive components and connectors, or request a quote for parts that are not listed.

Bu sayfa Entegreci tarafından eklenmiştir. Belgenin önceki sayfaları asıl yayıncısına aittir ve içeriği değiştirilmemiştir; en güncel sürüm için belgenin yayıncısına başvurun.