Analog and Interface Product Solutions

Battery Power Applications Design Guide

Powering Your Portable Design

Design ideas in this guide are based on many of Microchip's Power Management products. A complete device list and corresponding data sheets for these products can be found at **www.microchip.com.**

www.microchip.com/battery

DC/DC Conversion

Linear Regulators

Closed loop control with linear regulators. Often the voltage source is "incompatible" with the load. A buffer needs to be placed between the source and load to regulate or control the voltage and/or current.

Linear regulators provide closed loop control to "regulate" the voltage at the load. A basic linear regulator has three main components: an operational amplifier, a voltage reference and a pass transistor. The main purpose of a linear regulator is to produce a constant, accurate output voltage at a lower magnitude than the input voltage.

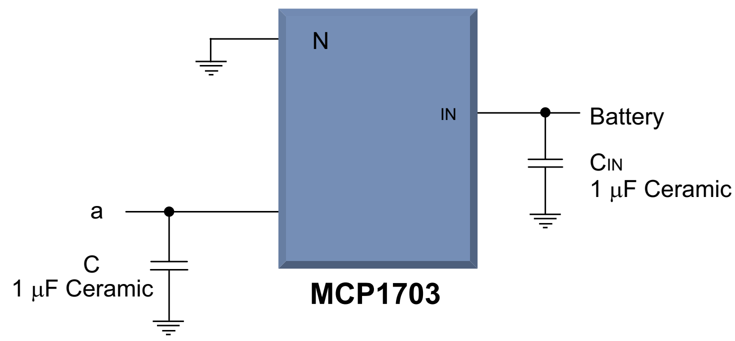
Beyond the basics, linear regulators often offer additional features: overcurrent protection, thermal protection and reversed polarity protection to name a few.

Microchip offers a line of CMOS, low dropout linear regulators. A low dropout regulator is a type of linear regulator designed to minimize the saturation voltage of the output transistor and to minimize the gate drive requirements. LDOs can operate with a very small input to output differential.

MCP1703 Linear Regulator Features

- 2.0 µA Typical Quiescent Current
- Input Operating Voltage Range: 2.7V to 16V
- Low Dropout Voltage:
  – 625 mV (typ.) @ 250 mA (V_{OUT} = 2.8V)
- 250 mA Output Current for Output Voltages ≥ 2.5V
- 200 mA Output Current for Output Voltages < 2.5V
- High-Accuracy Output Voltage: ±2% (max.)
- Low Temperature Drift: ±100 ppm/°C (typ.)
- Excellent Line Regulation: 0.2%/V (typ.)
- Package Options: 3-pin SOT-23A, 3-pin SOT-89 and 3-pin SOT-223
- Short Circuit Protection and Thermal Shutdown Protection
- Stable with 1.0 µF to 22 µF Output Capacitance

MCP1703 Linear Regulator



Product Specifications: Linear Regulators

Device	Max. Input Voltage	Output Voltage (V)	Output Current (mA)	Typical Active Current (µA)	Typical Dropout Voltage @ Max. IOUT (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/SOT-89, 3-pin TO-92
MCP1702	13.2	1.2-5.0	250	2	650	Low quiescent current	3-pin SOT-23A, 3-pin SOT-89, TO-92-3
MCP1703	16	1.2-5.0	250	2	625	Low quiescent current	3-pin SOT-23A, 3-pin SOT 89, 3-pin SOT-223
MCP1725	6.0	0.8-5.0	500	120	210	Shutdown, Power good output with adjustable delay	8-pin 2x3 DFN, SOIC-8 Pb-free
MCP1726	6.0	0.8-5.0	1000	140	250	Shutdown, Power good output with adjustable delay	8-pin 2x3 DFN, SOIC-8 Pb-free
MCP1727	6.0	0.8-5.0	1000	140	330	Shutdown, Power good output with adjustable delay	8-pin 2x3 DFN, SOIC-8 Pb-free
MCP1804	28	1.8-18	150	50	1300	Shutdown	3-pin SOT-23A, 3-pin SOT-89, 5-pin SOT-23, 5-pin SOT-89
MCP1824	6	0.8-5.0	300	120	200	Shutdown, Power good	5-pin SOT-223, 5-pin SOT-23
MCP1827/ MCP1827S	6.0	0.8-5.0	1500	120	330	Shutdown, Power good	DDPAK-5, TO-220-5 Pb-free
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
TC2185	6.0	1.8-3.3	150	55	140	Shutdown, Reference bypass input	5-pin SOT-23A
TC2186	6.0	1.8-3.3	150	55	140	Shutdown, Error output	5-pin SOT-23A

DC/DC Conversion

Switch-mode Power Converter

Employing a switch-mode power converter. Another approach to transferring the battery energy to the system load is to employ a switch-mode power converter. The primary advantage of a switch-mode power converter is that it can, ideally, accomplish power conversion and regulation at 100% efficiency. All power loss is due to non-ideal components and power loss in the control circuit.

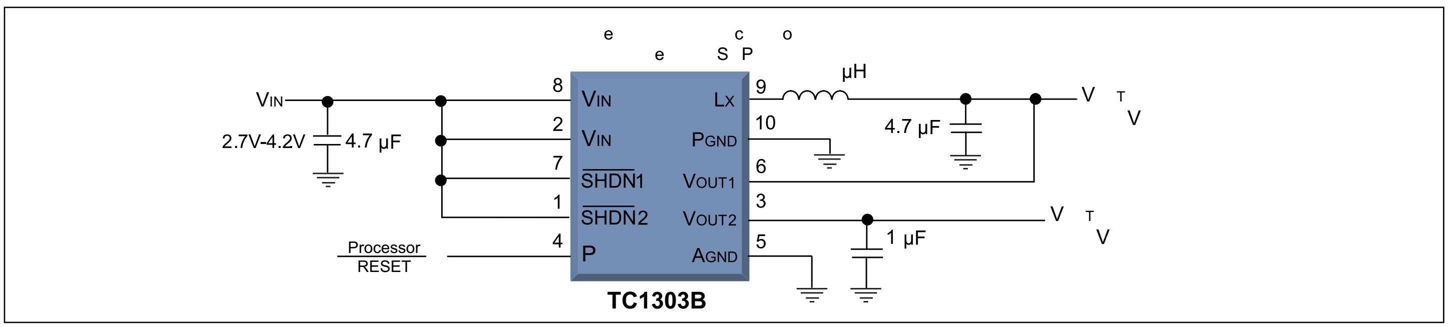
The buck converter is an inductor based switch-mode power converter used to step-down an input source to a lower magnitude output. The buck converter goes by many names: voltage step-down converter, DC-to-DC converter, chopper converter, etc. No matter what the name, inductor based, buck derived, switch-mode converters account for 80% to 90% of all converters sold.

Microchip offers inductor based buck regulators and controllers. The distinction is whether or not the switch (MOSFET) is internal to the device (regulator) or controlled externally (controller). The schematic represented here depicts a MCP1601 buck regulator with its associated external components.

TC1303B Synchronous Buck Regulator + LDO Features

- Dual-Output Regulator (500 mA Buck Regulator and 300 mA Low-Dropout Regulator)
- Power-Good Output with 300 ms Delay
- Total Device Quiescent Current = 65 µA (typ.)
- Independent Shutdown for Buck and LDO Outputs
- Both Outputs Internally Compensated
- Synchronous Buck Regulator:
  - Typical Efficiency: Over 90%
  - 2.0 MHz Fixed-Frequency PWM (Heavy Load)
  - Low Output Noise
  - Automatic PWM/PFM Mode Transition
  - Adjustable (0.8-4.5V) and Standard Fixed-Output Voltages (0.8V, 1.2V, 1.5V, 1.8V, 2.5V, 3.3V)
- Low-Dropout Regulator:
  - Low-Dropout Voltage = 137 mV (Typical @ 200 mA)
  - Standard Fixed-Output Voltages (1.5V, 1.8V, 2.5V, 3.3V)
- Power-Good Function: TC1303B Monitors LDO Output
- Small 10-pin 3x3 DFN or MSOP Package Options
- Operating Junction Temperature Range: -40°C to +125°C
- UVLO (Under Voltage Lock Out)
- Output Short Circuit Protection
- Overtemperature Protection
- Excellent Bluetooth Applications

TC1303B Synchronous Buck Regulator



Product Specifications: Switching Regulators/Controllers

Device	Output	Buck/Boost	Input Voltage Range (V)	Output Voltage (V)	Control Scheme	Features	Packages
MCP1601	Adjustable	Step-Down	2.7-5.5	0.9 to VIN	PWM/PFM/LDO	UVLO, Auto switching, LDO	8-pin MSOP
MCP1603	Fixed or Adjustable	Step-Down	2.7-5.5	0.8-4.5	PFM/PWM	UVLO, Automatic PWM to PFM mode transition, Overtemperature protection, Low quiescent current, Low shutdown current	5-pin TSOT 8-pin 2x3 DFN
MCP1612	Adjustable	Step-Down	2.7-5.5	0.8-5.5	PWM	UVLO, Soft-start, 1.4 MHz, 1A	8-pin MSOP/DFN
TC105	Fixed	Step-Down	2.2-10	3.0-5.0	PFM/PWM	Low-power shutdown mode	5-pin SOT-23A
TC110	Fixed	Step-Up	2.0-10	3.0-5.0	PFM/PWM	Soft-start, Low-power shutdown mode	5-pin SOT-23A
TC115	Fixed	Step-Up	0.9-10	3.0-5.0	PFM/PWM	Feedback voltage sensing, Low-power shutdown mode	5-pin SOT-89
TC1303A/ B/C	Fixed or Adjustable	Step-Down	2.7-5.5	0.8-4.5	PFM/PWM	UVLO, Overtemperature protection, Output short circuit protection, Power-good, Independent shut down, Synchronous buck + LDO	10-pin DFN 10-pin MSOP
TC1304	Fixed or Adjustable	Step-Down	2.7-5.5	0.8-4.5	PFM/PWM	UVLO, Overtemperature protection, Output short circuit protection, Power-good, synchronous buck + LDO, Sequenced startup and shutdown	10-pin DFN 10-pin MSOP
TC1313	Fixed or Adjustable	Step-Down	2.7-5.5	0.8-4.5	PFM/PWM	UVLO, Output short circuit protection Overtemperature protection, Independent shutdown for buck and LDO outputs	10-pin DFN 10-pin MSOP

MCP1603 Synchronous Buck Regulator

The MCP1603 is a highly efficient, fully integrated 500 mA synchronous buck regulator whose 2.7V to 5.5V input voltage range makes it ideally suited for applications powered from 1-cell Li-Ion or 2-cell/3-cell NiMH/NiCd batteries. At heavy loads, the MCP1603 operates in the 2.0 MHz fixed frequency PWM mode which provides a low noise, low output ripple, small-size solution. When the load is reduced to light levels, the MCP1603 automatically changes operation to a PFM mode to minimize quiescent current draw from the battery. No intervention is necessary for a smooth transition from one mode to another. These two modes of operation allow the MCP1603 to achieve the highest efficiency over the entire operating current range.

The MCP1603 is available with either an adjustable or fixed output voltage. The available fixed output voltage options are 1.2V, 1.5V, 1.8V, 2.5V and 3.3V. When a fixed option is used, only three additional small external components are needed to form a complete solution. Couple this with the low profile, small foot print packages and the entire system solution is achieved with minimal size. Additional protection features include: UVLO, overtemperature and overcurrent protection.

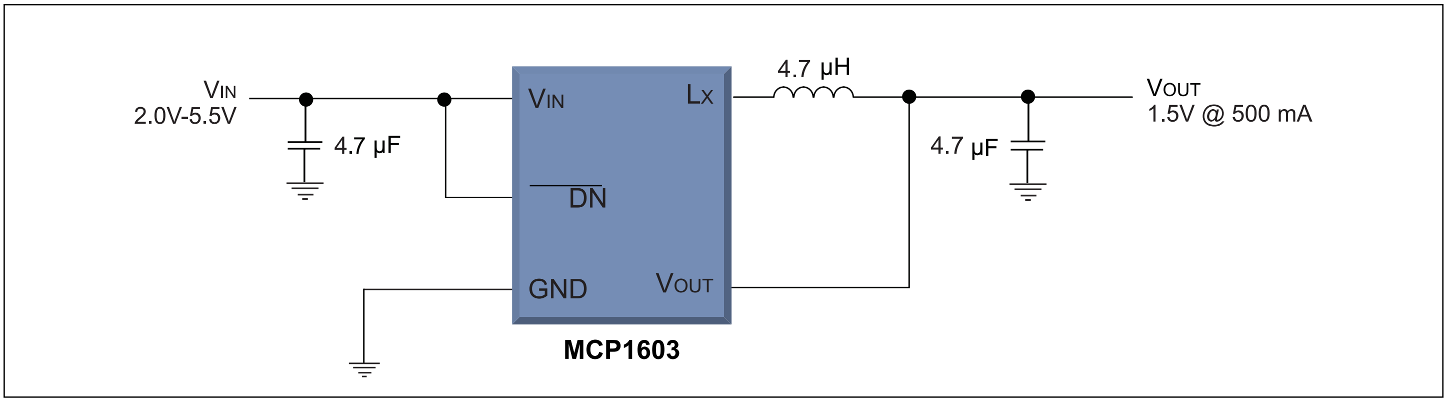
MCP1603 Synchronous Buck Regulator Features

- Over 90% Typical Efficiency
- Output Current Up To 500 mA
- Low Quiescent Current = 45 µA, typical
- Low Shutdown Current = 0.1 µA, typical
- Adjustable Output Voltage: 0.8V to 4.5V
- Fixed Output Voltage:
  - 1.2V, 1.5V, 1.8V, 2.5V, and 3.3V
- 2.0 MHz Fixed-Frequency PWM (Heavy Load)
- Automatic PWM to PFM Mode Transition
- 100% Duty Cycle Operation
- Internally Compensated
- Undervoltage Lockout (UVLO)
- Overtemperature Protection
- Space Saving Packages:
  - 5-lead TSOT
  - 8-pin 2x3 DFN

Applications

- Cellular Telephones
- Portable Computers
- Organizers/PDAs
- USB Powered Devices
- Digital Cameras
- Portable Equipment
- +5V or +3.3V Distributed Systems

MCP1603 Synchronous Buck Regulator



Li-Ion Battery Management

Li-Ion Battery Charge Management Control

Linear charge management control. Far too often, the battery charging system is given low priority, especially in cost sensitive applications. However, the quality of the charging system plays a key role in the life and reliability of the battery.

Microchip offers a complete line of linear Li-Ion battery chargers. The Li-Ion Charge Management Controllers provide a reliable, low-cost and high accuracy voltage regulation solution with few external components. In an effort to further reduce the size, cost and complexity. The MCP7383X family provides fully integrated charge management controllers for single-cell Li-Ion and Li-Polymer batteries with four voltage regulation options (4.2V, 4.35V, 4.40V, 4.50V) available.

In order to supply world-class portable devices, most of Microchip's Li-Ion 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 customers in meeting different applications 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.

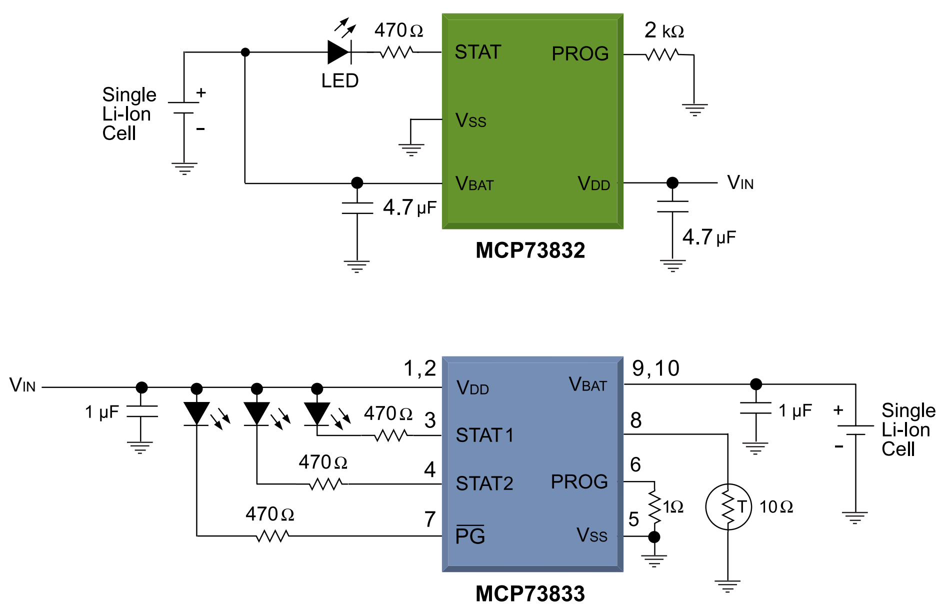
MCP73832 Battery Charger Features

- Linear Charge Management Controller
- Integrated Pass Transistor
- Integrated Current Sense
- Reverse Discharge Protection
- High Accuracy Preset Voltage Regulation: +0.75%
- Four Voltage Regulation Options:
  - 4.20V, 4.35V, 4.40V and 4.50V
- Programmable Charge Current
- Selectable Preconditioning
- Selectable End-of-Charge Control
- Charge Status Output
- Automatic Power-Down
- Thermal Regulation
- Temperature Range: -40°C to +85°C
- Packaging:
  - 8-pin 2x3 DFN
  - 5-lead SOT-23

Additional MCP73833 Battery Charger Features

- Programmable Charge Current: 1A Maximum
- Two Charge Status Outputs
- Low-Dropout Linear Regulator Mode
- Numerous Selectable Options Available for a Variety of Applications
- Available Packages:
  - 10-pin 3x3 DFN
  - MSOP-10

Regulated 3.3V, Low-Ripple Charge Pump with Low-Operating Current Sleep Mode or Bypass Mode



Li-Ion Battery Management

Selected Product Specifications: Battery Charger Family

Device	Mode	# of Cells	Vcc Range (V)	Max. Voltage Regulation	Int/Ext FET	Features
MCP73113	Linear	1	4-16	±0.5%	Int	6.5V Overvoltage protection
MCP73114	Linear	1	4-16	±0.5%	Int	5.8V Overvoltage protection
MCP73123	Linear	1	4-16	±0.5%	Int	6.5V Overvoltage protection, LiFePO4 charging
MCP73213	Linear	2	4-16	±0.6%	Int	13V Overvoltage protection
MCP73223	Linear	2	4-16	±0.6%	Int	13V Overvoltage protection, LiFePO4 charging
MCP73811	Linear	1	3.75-6	±1.0%	Int	USB selectable charge current, Thermal regulation, Automatic power-down, Charge enable
MCP73812	Linear	1	3.75-6	±1.0%	Int	Programmable charge current, Thermal regulation, Automatic power-down, Charge enable
MCP73826	Linear	1	4.5-5.5	±1.0%	Ext	Small size
MCP73827	Linear	1	4.5-5.5	±1.0%	Ext	Mode indicator, Charge current monitor
MCP73828	Linear	1	4.5-5.5	±1.0%	Ext	Temperature monitor
MCP73831	Linear	1	3.75-6	±.75%	Int	Programmable charge current, Thermal regulation, UVLO, Preconditioning and end-of-charge ratio options
MCP73832	Linear	1	3.75-6	±.75%	Int	Programmable charge current, Thermal regulation, UVLO, Preconditioning and end-of-charge ratio options
MCP73833	Linear	1	3.75-6	±.75%	Int	Programmable charge current, Thermal regulation, UVLO, Preconditioning and end-of-charge ratio options
MCP73834	Linear	1	3.75-6	±.75%	Int	Programmable charge current, Thermal regulation, UVLO, Preconditioning and end-of-charge ratio options
MCP73837	Linear	1	3.7-6	±0.75%	Int	Dual input (USB, DC, input from adapter), Auto switching, UVLO, Thermal regulation, Thermistor input, Power good output
MCP73838	Linear	1	3.7-6	±0.75%	Int	Dual input (USB, DC, input from adapter), Auto switching, UVLO, Thermal regulation, Timer enable input
MCP73841	Linear	1	4.5-12	±0.5%	Ext	Safety charge timers, Temperature monitor
MCP73842	Linear	2	8.7-12	±0.5%	Ext	Safety charge timers, Temperature monitor
MCP73843	Linear	1	4.5-12	±0.5%	Ext	Safety charge timers
MCP73844	Linear	2	8.7-12	±0.5%	Ext	Safety charge timers
MCP73853	Linear	1	4.5-5.5	±0.5%	Int	USB control, Safety charge timers, Temperature monitor, Thermal regulation
MCP73855	Linear	1	4.5-5.5	±0.5%	Int	USB control, Safety charge timers, Thermal regulation
MCP73861	Linear	1	4.5-12	±0.5%	Int	Safety charge timers, Temperature monitor, Thermal regulation
MCP73862	Linear	2	8.7-12	±0.5%	Int	Safety charge timers, Temperature monitor, Thermal regulation
MCP73863	Linear	1	4.5- 12	±0.5%	Int	Programmable safety charge timer, Temperature monitor, Thermal regulation, Programmable charge current, Auto recharge, Status and fault indicator
MCP73864	Linear	2	8.7-12	±0.5%	Int	Programmable safety charge timer, Temperature monitor, Thermal regulation, Programmable charge current, Auto recharge, Status and fault indicator

Li-Ion Battery Management

Intelligent Power Control Systems

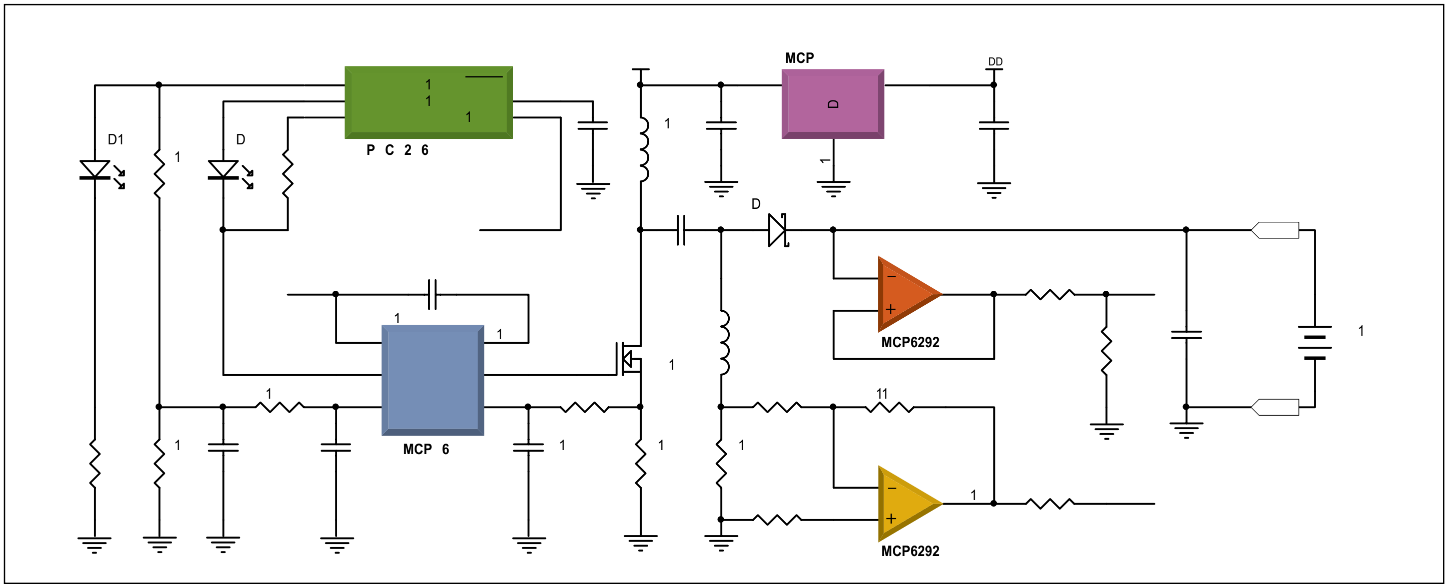
Intelligent, switch-mode charge management control. The MCP1630 is a high-speed, microcontroller-adaptable, Pulse-Width Modulator (PWM) used to develop intelligent power control systems. Combined with a microcontroller, the MCP1630 regulates output voltage or current by controlling the power-system duty cycle. In the power control system, the microcontroller can be used to digitally adjust the output voltage or current by controlling the voltage reference applied to the MCP1630; thereby bringing digital control to the analog PWM function.

The fast comparator of the MCP1630 enables this device to be used as an excellent current mode controller. With a typical response time of 12 ns, the MCP1630 comparator provides a very tight limit to the maximum switch current over a wide range of input voltages.

MCP1630 PWM Features

- High-Speed PWM Operation: –12 ns Current Sense to Output Delay
- Operating Temperature Range: -40°C - +125°C
- Precise Peak Current Limit: ±5%
- CMOS Output Driver (Drives MOSFET Driver or Low-Side N-channel MOSFET Directly)
- External Oscillator Input (from PIC® Microcontroller)
- External Voltage Reference Input (for Adjustable Voltage or Current Output Application)
- Peak Current Mode Operation to 1 MHz
- Low Operating Current: 2.8 mA, typical
- Fast Output Rise and Fall Times: 5.9 ns, 6.2 ns
- Under-voltage Lockout
- Output Short Circuit Protection
- Overtemperature Protection

Switch-mode, Li-Ion Battery Charger Circuits



Product Specifications: MCP1630 PWM Controller

Device	Input Voltage Range (V)	Current Sense-to-Output Delay	Control Scheme	Ext. Oscillator Range	Operating Temperature Range	Packages
MCP1630	3.0-5.5	12 nS typ.	Cycle-by-Cycle Peak Current Control	1.0 MHz	-40°C to +125°C	8-pin MSOP

Product Specifications: PIC12F683 Microcontroller

Device	Bytes	OTP/Flash Words	RAM Bytes	I/O Pins	8-bit ADC Channels	Comparators	Timers/ WDT	Max. Speed MHz	Other Features	Packages
PIC12F683	3584	2048	128	6	4 x 10-bit	1	1 16-bit, 2 8-bit, 1 WDT	20	Internal 8 MHz oscillator	8-pin PDIP/SOIC/DFN

Product Specifications: MCP6292 Op Amp

Device	# Per Package	GBWP	Iq typ. (µA)	Vos Max. (mV)	Operating Voltage (V)	Packages
MCP6292	2	10 MHz	1000	3	2.4-5.5	8-pin PDIP/SOIC/MSOP

Product Specifications: MCP1702 Low Dropout Positive Voltage Regulator

Device	Max. Input Voltage (V)	Output Voltage (V)	Output Current (mA)	typ. Active Current (µA)	typ. Dropout Voltage (mV)	Packages
MCP1702	13.2	1.2-5.0	200-250	2	650	3-pin SOT-23A/SOT-89/TO-92

Biased Backlighting

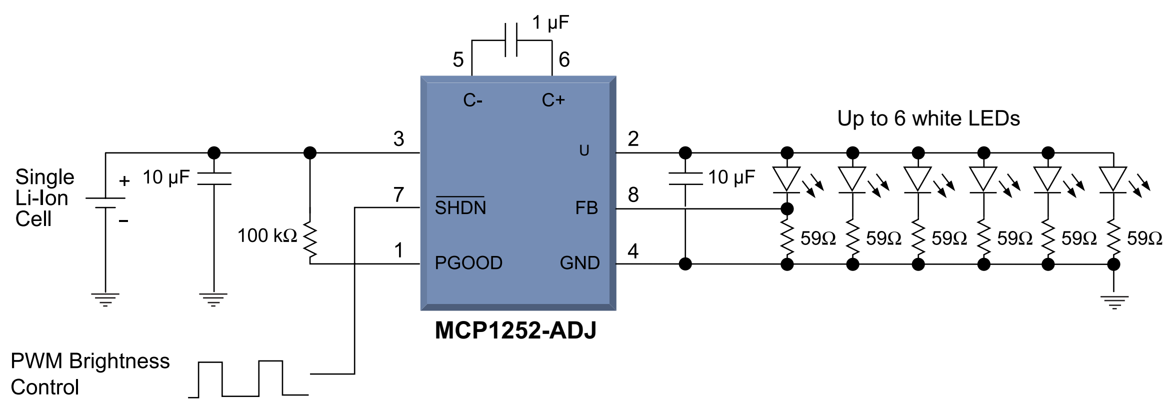
The MCP1252-ADJ is an inductorless, positive-regulated charge pump DC/DC converter. The device generates an adjustable output voltage. It is specifically designed for applications requiring low noise and high efficiency and is able to deliver up to 120 mA output current. The device allows the input voltage to be lower or higher than the output voltage, by automatically switching between buck/boost operation.

Today's new color displays require a pure white light for backlighting. White light emitting diodes have become the component of choice. The MCP1252-ADJ is an excellent choice for biasing the backlighting. Light intensity is controlled uniformly through the use of ballast resistors. The peak intensity is set by the feedback to the MCP1252-ADJ. Dimming is accomplished by pulse-width modulating the shutdown pin of the device.

MCP1252 Charge Pump Features

- Inductorless, Buck/Boost, DC/DC Converter
- Low Power: 80 µA (typ.)
- 120 mA Output Current
- Wide Operating Temperature Range: -40°C to +85°C
- Thermal Shutdown and Short-Circuit Protection
- Uses Small Ceramic Capacitors
- Low Power Shutdown Mode: 0.1 µA (typ.)
- Shutdown Input Compatible with 1.8V Logic
- V_{IN} Range: 2.0V to 5.5V

White LED Backlighting Circuit with Regulated Charge Pump



Product Specifications: Regulated Charge Pump DC/DC Converters

Device	Input Voltage Range (V)	Output Voltage (V)	Max. Input Current (µA)	Typical Active Output Current (mA)	Features	Packages
MCP1252-33X50	2.7-5.5	Selectable 3.3-5.0V	120	120 mA for V_{IN}>3.0V	Power good output, 650 kHz oscillator	8-pin MSOP
MCP1252-ADJ	2.0-5.5	Adjustable 1.5V-5.5V	120	120 mA for V_{IN}>3.0V	Power good output, 650 kHz oscillator	8-pin MSOP
MCP1253-33X50	2.7-5.5	Selectable 3.3-5.0V	120	120 mA for V_{IN}>3.0V	Power good output, 1 MHz oscillator	8-pin MSOP
MCP1253-ADJ	2.0-5.5	Adjustable 1.5V-5.5V	120	120 mA for V_{IN}>3.0V	Power good output, 1 MHz oscillator	8-pin MSOP
MCP1256	1.8-3.6	3.3	10	100 mA	Power good output, Inductorless 1.5x, 2x dual mode, Thermal shutdown and Short circuit protection	10-pin MSOP and 10-pin 3x3 DFN
MCP1257	1.8-3.6	3.3	10	100 mA	Power good output, Inductorless 1.5x, 2x dual mode, Thermal shutdown and Short circuit protection	10-pin MSOP and 10-pin 3x3 DFN
MCP1258	1.8-3.6	3.3	10	100 mA	Power good output, Inductorless 1.5x, 2x dual mode, Thermal shutdown and Short circuit protection	10-pin MSOP and 10-pin 3x3 DFN
MCP1259	1.8-3.6	3.3	10	100 mA	Power good output, Inductorless 1.5x, 2x dual mode, Thermal shutdown and Short circuit protection	10-pin MSOP and 10-pin 3x3 DFN

Mmicrochip also offers inverting or doubling charge pumps, multi-function charge pumps and inverting and doubling charge pumps. See the Microchip web site for complete specifications www.microchip.com.

MCP1256/7/8/9 Regulated 3.3V, Low-Ripple Charge Pump with Low-Operating Current Sleep Mode or Bypass Mode

The MCP1256, MCP1257, MCP1258 and MCP1259 are inductorless, positive regulated charge pump DC/DC converters. The devices generate a regulated 3.3V output voltage from a 1.8V to 3.6V input. The devices are specifically designed for applications operating from 2-cell alkaline, Ni-Cd, or Ni-MH batteries or by one primary lithium MnO2 (or similar) coin cell battery.

The MCP1256, MCP1257, MCP1258 and MCP1259 provide high efficiency by automatically switching between 1.5x and 2x boost operation. 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 output voltage ripple is below 20 mVPP at load currents up to 100 mA. Normal operation occurs at a fixed switching frequency of 650 kHz, avoiding interference with sensitive IF bands.

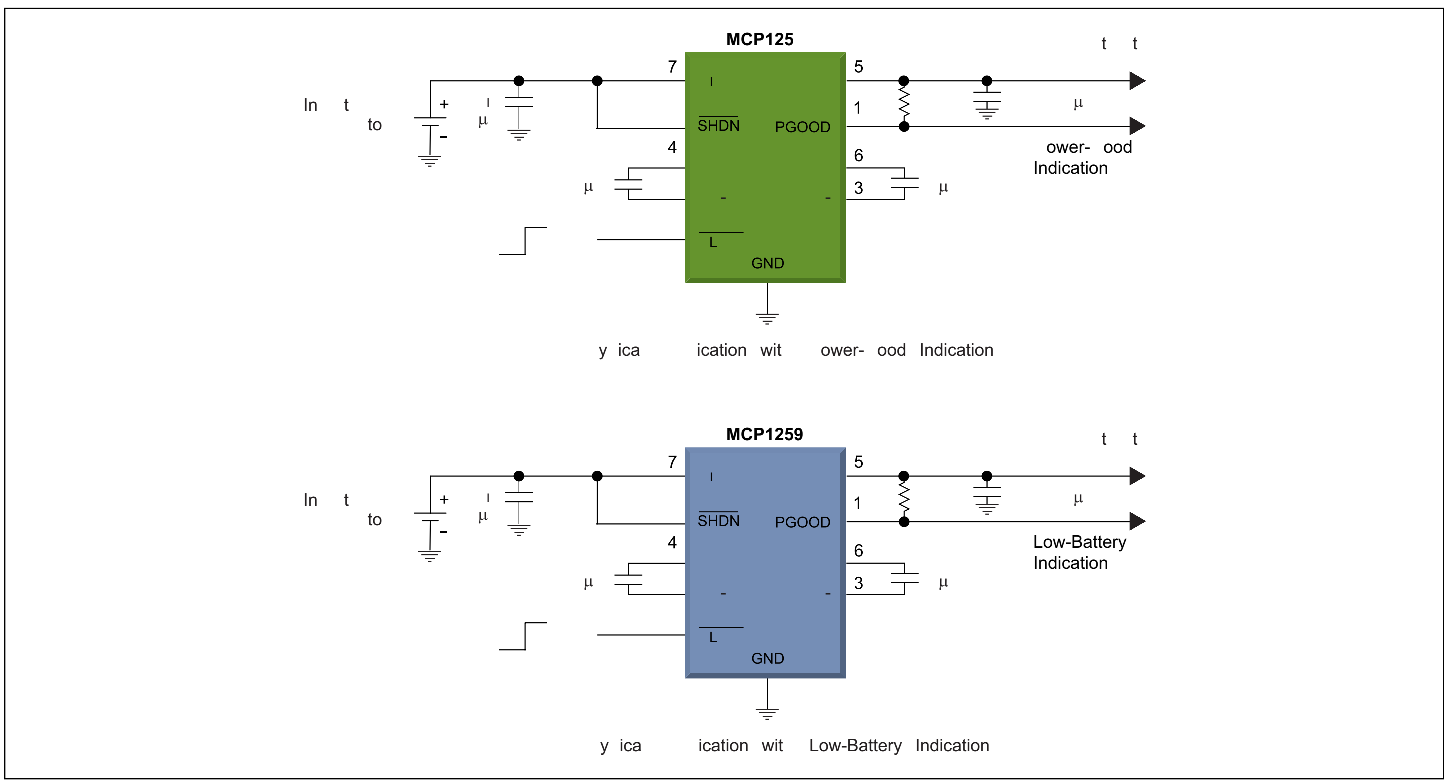
The MCP1256 and MCP1258 feature a power-good output that can be used to detect out-of-regulation conditions. The MCP1257 and MCP1259 feature a low battery indication that issues a warning if the input voltage drops below a preset voltage threshold.

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. Two packages are offered: 10-pin MSOP and 10-pin 3x3 DFN. The devices are completely characterized over the junction temperature range of -40°C to +125°C.

MCP1256/7/8/9 Charge Pump Features

- Inductorless 1.5x, 2x Boost DC/DC Converter
- Output Voltage: 3.3V
- High Output Voltage Accuracy: ±3.0% (V_{OUT} Fixed)
- Output Current Up To 100 mA
- 20m V_{PP} Output Voltage Ripple
- Thermal Shutdown and Short Circuit Protection
- Uses Small Ceramic Capacitors
- Switching Frequency: 650 kHz
- Low-Power Sleep Mode: MCP1256/7
- Bypass Mode: MCP1258/9
- Low-Power Shutdown Mode: 0.1 µA (typ.)
- Shutdown Input Compatible with 1.8V Logic
- V_{IN} Range: 1.8V to 3.6V
- Soft-Start Circuitry to Minimize Inrush Current
- Temperature Range: -40°C to +125°C
- Packaging:
  - 10-pin 3x3 DFN
  - 10-pin MSOP

Regulated 3.3V, Low-Ripple Charge Pump with Low-Operating Current Sleep Mode or Bypass Mode



Backlighting

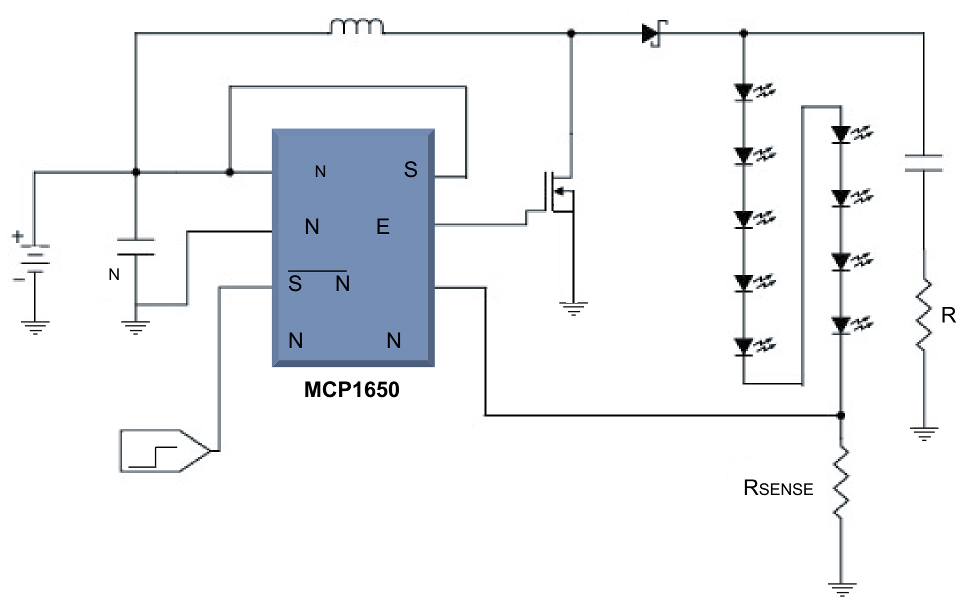
Driving White LED's

Driving white light emitting diodes in series. An alternative to the MCP1252 backlighting approach is to drive the white light emitting diodes in series. The series connection provides improved brightness matching between the diodes since they all operate with the same current. Light intensity is adjusted by controlling the current through the diodes. The MCP1650 is a boost controller that can be used to bias the diodes in series as depicted below.

MCP1650 Features

- Output Power Capability Over 5 Watts
- Output Voltage Capability From 3.3V to Over 100V
- 750 kHz Gated Oscillator Switching Frequency
- Adaptable Duty Cycle for Battery or Wide-Input, Voltage-Range Applications
- Input Voltage Range: 2.0V to 5.5V
- Capable of SEPIC and Flyback Topologies
- Shutdown Control with I_Q < 0.1 µA (typ.)
- Low Operating Quiescent Current: I_Q = 120 µA
- Voltage Feedback Tolerance (0.6%, Typical)
- Popular MSOP-8 Package
- Peak Current Limit Feature
- Two Under Voltage Lock Out (UVLO) Options: 2.0V or 2.55V
- Operating Temperature Range: -40°C to +125°C

White LED Backlighting Circuit with Boost Controller



Product Specifications: Boost Controllers

Device	Output	Buck/Boost	Input Voltage Range (V)	Output Voltage (V)	Control Scheme	Features	Packages
MCP1650	Adjustable	Step-Up	2.7-5.5	2.5 to Ext. Tx. Limited	Constant Frequency, 2 Fixed DC	2 duty cycles for min. and max. loads, shutdown, UVLO, Soft-start	8-pin MSOP
MCP1651	Adjustable	Step-Up	2.7-5.5	2.5 to Ext. Tx. Limited	Constant Frequency, 2 Fixed DC	2 duty cycles for min. and max. loads, Shutdown, Low battery detect, UVLO, Soft-start	8-pin MSOP
MCP1652	Adjustable	Step-Up	2.7-5.5	2.5 to Ext. Tx. Limited	Constant Frequency, 2 Fixed DC	2 duty cycles for min. and max. loads, Shutdown, Power good indicator, UVLO, Soft-start	8-pin MSOP
MCP1653	Adjustable	Step-Up	2.7-5.5	2.5 to Ext. Tx. Limited	Constant Frequency, 2 Fixed DC	2 duty cycles for min. and max. loads, Shutdown, Low battery detect, Power good indicator, UVLO, Soft-start	10-pin MSOP

Related Support Material

Application Notes

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

AN246: Driving the Analog Inputs of a SAR A/D Converter
Driving any A/D Converter (ADC) can be challenging if all issues and trade-offs are not well understood from the beginning. With Successive Approximation Register (SAR) ADCs, the sampling speed and source impedance should be taken into consideration if the device is to be fully utilized. In this application note we will delve into the issues surrounding the SAR Converter's input and conversion nuances to insure that the converter is handled properly from the beginning of the design phase. We will also review the specifications available in most A/D Converter data sheets and identify the important specifications for driving your SAR. From this discussion, techniques will be explored which can be used to successfully drive the input of the SAR A/D Converter. Since most SAR applications require an active driving device at the converter's input, the final subject will be to explore the impact of an operational amplifier on the analog-to-digital conversion in terms of DC as well as AC responses.

AN693: Understanding A/D Converter Performance Specifications
The purpose of this application note is to describe the specifications used to quantify the performance of A/D converters and give the reader a better understanding of the significance of those specifications in an application. Although the information presented here is applicable to all A/D converters, specific attention is given to features of the standalone and PIC® microcontrollers with A/D converters.

AN793: Power Management in Portable Applications: Understanding the Buck Switchmode Power Converter
Powering today's portable world poses many challenges for system designers. The use of batteries as a prime power source is on the rise. As a result, a burden has been placed on the system designer to create sophisticated systems utilizing the batteries full potential.

Each application is unique, but one common theme rings through: ***maximize battery capacity usage***. This theme directly relates to how efficiently the energy from the batteries is converted and transferred to the system load. No single method is ideal for all applications. Linear regulators, switched capacitor charge pumps and inductor based switchmode power converters are all employed. Each method has its associated advantages and disadvantages. It is the particular application with its individual requirements that determines which method will be the best to use.

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. In particular, a linear, stand-alone solution utilizing Microchip's MCP73841 will be explored.

AN948: Efficiently Powering Nine White LEDs with the MCP1650
The number of applications that utilize white LEDs has steadily increased due to the increased usage of Liquid Crystal Displays (LCDs) in automotive and cellular telephone displays, PDAs, handheld electronic games and computer monitors. In order to view the information on these displays, a light source is needed. Typically, this light source has been provided by Cold Cathode Florescent Tubes (CCFT). However, since designers are tasked with improving efficiency, lowering cost and decreasing size, white LEDs are now being used. Powering white LEDs, which have a forward drop (VF) of 3.6V, typically, becomes more difficult when the application requires multiple LEDs. In this Application Note, a solution using the MCP1650 is discussed and shown to be greater than 85% efficient.

AN960: New Components and Design Methods Bring Intelligence to Battery Charger Applications
This application note will describe a typical intelligent battery charger power system application. As with most real life applications, there are many demands made on the power system designer to protect the system in the case of battery removal, plugging the battery in backwards, reverse polarity at the input, a battery shorting and even more unimaginable situations. A complete battery charger, fuel gauge system design will be presented as an example of the mixed signal design method. Battery reference material and basic switchmode power supply converter trade-offs are covered in the beginning of this application note.

AN968: Simple Sychronous Buck Regulator – MCP1612
This application note contains all of the information needed to design a synchronous buck converter using the MCP1612. It also contains a real-world design example with measured laboratory data.

AN1088: Selecting the Right Battery System for Cost-Sensitive Portable Applications While Maintaining Excellent Quality
Portable electronic devices have played an important role in a person's daily digital life and have changed the way people live and work. Commonly seen portable electronic devices are: cellular phones, media players, digital cameras, digital camcorders, handheld GPS, digital readers and PDAs. With the emerging technologies that are available today, portable electronic designers are trying to integrate more features into thinner and smaller form-factors while maximizing the battery life.

Related Support Material

AN1156: Battery Fuel Measurement Using Delta-Sigma ADC Devices

The battery fuel status indicator is a common feature of the battery-supported handheld devices. The battery fuel measurement is achieved by measuring the discharging and charging currents in real time. The discharging current is the current coming out from the battery and the charging current is the current flowing into the battery. The fuel used (mAH) and the fuel remaining (mAH) are calculated by tracking the discharging and charging currents over time. The fuel used is the total discharged current over time and the remaining fuel is simply the subtraction of the fuel used from the fully charged fuel.

Evaluation Boards

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

MCP1252DM-BKLT: MCP1252 Charge Pump Backlight Demonstration Board

The MCP1252 Charge Pump Backlight LED Demo Board demonstrates the use of a Charge Pump device in an LED application. The board also serves as a platform to evaluate the MCP1252 device in general. The MCP1252-ADJ is an excellent choice for biasing the backlighting or driving other LED applications. Light intensity is controlled uniformly through the use of ballast resistors. The peak intensity is set by the feedback to the MCP1252-ADJ. Dimming is accomplished by pulse width modulating the shutdown pin of the device.

The board also features a PIC10F206 microcontroller in a SOT-23 package, which is used to provide an enable signal to the MCP1252. The PIC microcontroller also accepts a push-button input that allows the user to adjust the white LEDs to five different light intensities, in addition to placing the system in a standby mode that consumes less than 1 µA of current (typical).

MCP1252EV: MCP1252/53 Evaluation Kit

The MCP1252/3 Evaluation Board is an evaluation kit designed to support Microchip's MCP1252-33X50, MCP1252-ADJ, MCP1253-33X50 and MCP1253-ADJ low noise, positive-regulated charge pump devices. The evaluation kit is fully assembled and tested. The kit is useful for evaluating simple stand-alone operation or for evaluating applications interfaced with a microcontroller.

MCP1256/7/8/9EV: MCP1256/7/8/9 Charge Pump Evaluation Board

The MCP1256/7/8/9 Charge Pump Evaluation Board is an evaluation and demonstration tool for Microchip's MCP1256/7/8/9 Regulated 3.3V, Low-Ripple Charge Pumps with Low Operating Current Sleep mode or Bypass mode. The design provides for dynamic versatility. The MCP1256/7/8/9 Charge Pump Evaluation Board is setup to evaluate simple, stand-alone, DC-to-DC conversion. Two evaluation circuits are provided, demonstrating the versatility of the MCP1256/7/8/9 device family. One evaluation circuit utilizes the MCP1256, demonstrating the Sleep mode feature along with a power good indication. The other evaluation circuit utilizes the MCP1259, demonstrating the unique Bypass mode feature along with a low battery indication. When connected, the MCP1256/7/8/9 devices can be evaluated in a variety of applications.

MCP1601EV: MCP1601 Buck Regulator Evaluation Board

The MCP1601 Buck Regulator Evaluation Board demonstrates Microchip's MCP1601 Synchronous Buck Regulator, developed for battery powered applications as well as distributed power applications. The MCP1601 Evaluation Board is capable of operation over the entire 2.7V to 5.5V input range of the MCP1601 device. Two 2-position DIP switches are used, one to select the output voltage (1.8V, 2.05V, 2.45V or 3.28V) and one that turns the MCP1601 on and off with the other position selecting the mode of operation (PWM-pulse width modulation or PFM-pulse frequency modulation). Surface mount test points are used to apply power and load in addition to probing several points in the test circuit.

MCP1612EV: MCP1612 Synchronous Buck Regulator Evaluation Board

The MCP1612 Synchronous Buck Regulator Evaluation Board features Microchip's 1A 1.4 MHz synchronous buck regulator in two buck converter applications. The first application uses the MCP1612 in an 8-lead MSOP package. This converter has four (0.8V, 1.0V, 1.2V and 1.4V) selectable output voltages available. The second application features the MCP1612 in an 8-pin DFN package. This converter also has four (0.8V, 1.7V, 2.4V and 3.3V) selectable output voltages. A shutdown terminal is also provided for each converter.

MCP1650EV: MCP1650 Boost Controller Evaluation Board

The MCP1650 Boost Controller Evaluation Board demonstrates Microchip's MCP165X Boost Controller product family in two high-power, boost-converter applications. The first application features the MCP1651 (8-pin MSOP) with the low battery detect feature and provides a regulated 5V output with an input voltage range of 2.8V to 4.8V. The second application uses the MCP1653 (10-pin MSOP), with both low battery detect and power good features. The input voltage for this application is 3.3V, with the output boosted to 12V.

Related Support Material

MCP1630DM-DDBK1: MCP1630 1A Bias Supply Demo Board

The MCP1630 1A Bias Supply Demo Board is used to evaluate Microchip's MCP1630 used in a SEPIC power converter application. The MCP1630 1A Bias Supply Demo Board is capable of providing a regulated output from an input voltage of 9V. The regulated output voltage is selectable at 3.3V or 5V. The regulated output remains constant for an output load range of 0A to 1A. An LED indicates the presence of output voltage.

MCP1630DM-NMC1: MCP1630 NiMH Battery Charger Demonstration Board

The MCP1630 High Speed PWM is interfaced to the PIC16LF818 to develop a complete NiMH battery charger with fuel gauge capability. The MCP1630 is used to regulate the battery charge current and protect the SEPIC power train against an open circuit (removed battery) or a shorted battery. The high speed (12ns current sense to output) capability of the MCP1630 is used to switch the SEPIC converter at 1 MHz, minimizing external inductor and capacitor cost, while the PIC16LF818 performs the complex NiMH battery charger timing functions. Both the MCP1630 and PICLF818 protect the battery and circuit in the event of a fault.

MCP1630RD-DDBK3: MCP1630V Bidirectional 4 Cell Li-Ion Charger Reference Design

As high power portable applications continue to gain in popularity, more innovative techniques are needed to charge the batteries while also providing a low regulated voltage to the system's high end digital electronics. For example, laptop computers, portable test equipment, portable printers, etc., all require more power than a single or two cell Li-Ion battery pack can efficiently store. As a result, three or four series Li-Ion cell packs are used to store the necessary that power these high end applications. The result is a high DC voltage used to store the energy requiring a difficult high voltage to low voltage dc-dc conversion. The MCP1630V bi-directional 4 Cell Li-Ion Charger Reference Design can be used to evaluate a design that boosts a low source voltage to charge four Li-Ion series cells while providing energy to the system simultaneously. When the source is removed, the same power train used to charge the battery pack provides a low regulated voltage to operate the system.

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

The MCP1630 Multi-Bay Li-Ion Charger is used to evaluate Microchip's MCP1630 used in a SEPIC power converter application. The MCP1630 Multi-Bay Li-Ion Charger is capable of charging two single-cell, Li-Ion battery packs in parallel utilizing an input voltage of 10V to 30V (battery packs are not included). Multiple boards can be daisy-chained for additional charger bays. The MCP1630 Multi-Bay Li-Ion Charger is intended for use in pseudo-smart battery charger applications utilizing battery packs containing Microchip's PS700 Battery Monitor. Standard battery packs can be utilized as well. The MCP1630 Multi-Bay Li-Ion Charger provides a constant current – constant voltage charge with preconditioning, cell temperature monitoring and battery pack fault monitoring. Each charger bay provides a status and fault indication. The MCP1630 Multi-Bay Li-Ion Charger automatically detects the insertion or removal of a battery pack.

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

The MCP1630 Low-Cost Li-Ion Battery Charger is used to evaluate Microchip's MCP1630 in a SEPIC power converter application. As provided, the MCP1630 Low-Cost Li-Ion Battery Charger is capable of charging a single-cell, Li-Ion battery pack from an input voltage of 6V to 18V. The MCP1630 Low-Cost Li-Ion Battery Charger provides a constant current, constant voltage charge with preconditioning, cell temperature monitoring and battery pack fault monitoring. Also, the charger provides a status or fault indication. The MCP1630 Low-Cost Li-Ion Battery Charger automatically detects the insertion or removal of a battery pack.

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

The MCP73113 OVP Single-Cell Li-Ion Battery Charger Evaluation Board demonstrates the features of Microchip's MCP73113 "Single-Cell Li-Ion/Li-Polymer Battery Charge Management Controller with Input Overvoltage Protection".

The MCP73113 OVP Single-Cell Li-Ion Battery Charger Evaluation Board is designed with two charging currents. The default value is 500 mA and when PROG via is tied to ground, the two parallel resistors output 1000 mA charging current to a Li-Ion battery. One blue LED status output allows the user to learn if the MCP73113 is in charging state or not. The MCP73113 OVP Single-Cell Li-Ion Battery Charger Evaluation Board comes with an installed MCP73113 device in 3mm x 3mm DFN package. The factory preset battery regulation voltage is 4.20V with precondition, termination and auto recharge features.

The MCP73113 OVP Single-Cell Li-Ion Battery Charger Evaluation Board is designed to observe the performance and features on the circuits via multiple test points. Circuits can also be implemented into suitable applications without additional work.

Related Support Material

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

The MCP73X23 Lithium Iron Phosphate Battery Charger Evaluation Board demonstrates the features of Microchip's MCP73123 and MCP73223 "Lithium Iron Phosphate (LiFePO4) Battery Charge Management Controller with Input Overvoltage Protection". The MCP73X23 Lithium Iron Phosphate Battery Charger Evaluation Board is designed with two independent circuits. The MCP73123 is designed to charge a single-cell LiFePO4 battery, while the MCP73223 charges a dual-cell LiFePO4 battery. Both circuits offer two different fast charging currents. The default value of fast charging current is 500 mA and when PROG via is tie to ground, the two parallel resistors output 1000 mA fast charging current to a battery pack. One blue LED status output allows user to learn if the MCP73123/223 is in charging state or not. The MCP73X23 Lithium Iron Phosphate Battery Charger Evaluation Board comes with installed MCP73123 and MCP73223 devices in 3 mm x 3 mm DFN packages. The factory preset battery regulation voltage is 3.6V for the MCP73123 and 7.2V for the MCP73223 with 10% precondition current, 10% termination current set point, automatic recharge and 6.5V over voltage protection threshold voltage. The MCP73X23 Lithium Iron Phosphate Battery Charger Evaluation Board is designed to observe the performance and features of Microchip's MCP73123 and MCP73223. Circuits can also be implemented into suitable applications without extra work.

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

The MCP73837/8 AC/USB Dual Input Battery Charger Evaluation Board demonstrates Microchip's stand-alone Linear Li-Ion Battery Chargers - MCP73837 and MCP73838. The MCP73837/8 require only minimum components to implement a complete battery charge management circuit. The MCP73837/8 are designed to select AC-Adapter or USB-Port Power Source automatically where AC-Adapter provides the charge current when both sources are present.

The MCP73837/8 AC/USB Dual Input Battery Charger Evaluation Board comes with a 10-pin DFN MCP73837 and a 10-pin MSOP MCP73838 pre-installed. The different packages can be easily evaluated by replacing the device, a resistor and a LED where the patterns have been pre-designed on the board layout.

MCP73871EV: MCP73871 Evaluation Board

The MCP73871 Evaluation Board is designed to demonstrate Microchip's stand-alone linear Li-Ion battery charger with system power path and load sharing management control solution. The system load is also supported by the Li-Ion battery when input power is disconnected. A number of device options allow the MCP73871 device to be utilized in a variety of applications. Refer to the MCP73871 data sheet (DS22090).

Typical applications for the reference design are: smart phones, PDA, portable media players, MP3 Players, digital cameras, handheld medical devices, bluetooth headsets, ultra-mobile PC and portable communicators.

MCP73831EV: MCP73831 Evaluation Kit

Two evaluation boards are provided in the MCP73831 Evaluation Kit. The boards are set up to evaluate simple, stand-alone, linear charging of single cell Li-Ion/Li-Polymer battery packs (the battery packs are not included). Each board design provides constant current charging followed by constant voltage charging with automatic charge termination. In addition, the MCP73831-2AC board provides preconditioning of deeply depleted cells. Each board design provides evaluation of the MCP73831 in two package options: a SOT-23-5 and a 8-pin 2x3 DFN for higher power handling capability.

MCP7384XEV: MCP7384X Li-Ion Battery Charger Evaluation Board

The MCP7384X Li-Ion Battery Charger Evaluation Board features three circuits utilizing the MCP73841, MCP73842 and MCP73843 devices to demonstrate simple, stand-alone, linear charging of single or dual cell Lithium-Ion/Lithium-Polymer battery packs (the battery packs are not included).

Also check out the following demonstration boards:

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

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

MCP73833EV: MCP73833 Li-Ion Battery Charger Evaluation Board

MCP73871DM-VPCC: MCP73871 Demo Board with Voltage Proportional Current Control

Stand-Alone Analog and Interface Portfolio

Thermal Management
- Temperature Sensors
- Fan Speed Controllers/ Fan Fault Detectors

Power Management
- LDO & Switching Regulators
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- System Supervisors
- Voltage Detectors
- Voltage References
- Li-Ion/Li-Polymer Battery Chargers

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- Op Amps
- Programmable Gain Amplifiers
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- Ionization Smoke Detectors
- Ionization Smoke Detector Front Ends
- Piezoelectric Horn Drivers

Mixed-Signal
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- Digital Potentiometers
- D/A Converters
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Interface
- CAN Peripherals
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Analog and Interface Attributes

Robustness
- MOSFET Drivers lead the industry in latch-up immunity/stability
- High performance LIN and CAN transceivers

Low Power/Low Voltage
- Op Amp family with the lowest power for a given gain bandwidth
- 600 nA/1.4V/14 kHz bandwidth op amps
- 1.8V charge pumps and comparators
- 1.6 µA LDOs
- Low power ADCs with one-shot conversion

Integration
- One of the first to market with integrated LDO with Reset and Fan Controller with temperature sensor
- PGA integrates MUX, resistive ladder, gain switches, high-performance amplifier, SPI interface
- Industry's first 12-bit quad DAC with non-volatile EEPROM
- Delta-Sigma ADCs feature on-board PGA and voltage reference
- Highly integrated charging solutions for Li-ion and LiFePO4 batteries

Space Savings
- Resets and LDOs in SC70 package, A/D and D/A converters in SOT-23 package
- CAN and IrDA® Standard protocol stack embedded in an 18-pin package

Accuracy
- Low input offset voltages
- High gains

Innovation
- Low pin-count embedded IrDA Standard stack, FanSense™ technology
- Select Mode™ operation
- Industry's first op amp featuring on-demand calibration via mCal technology
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