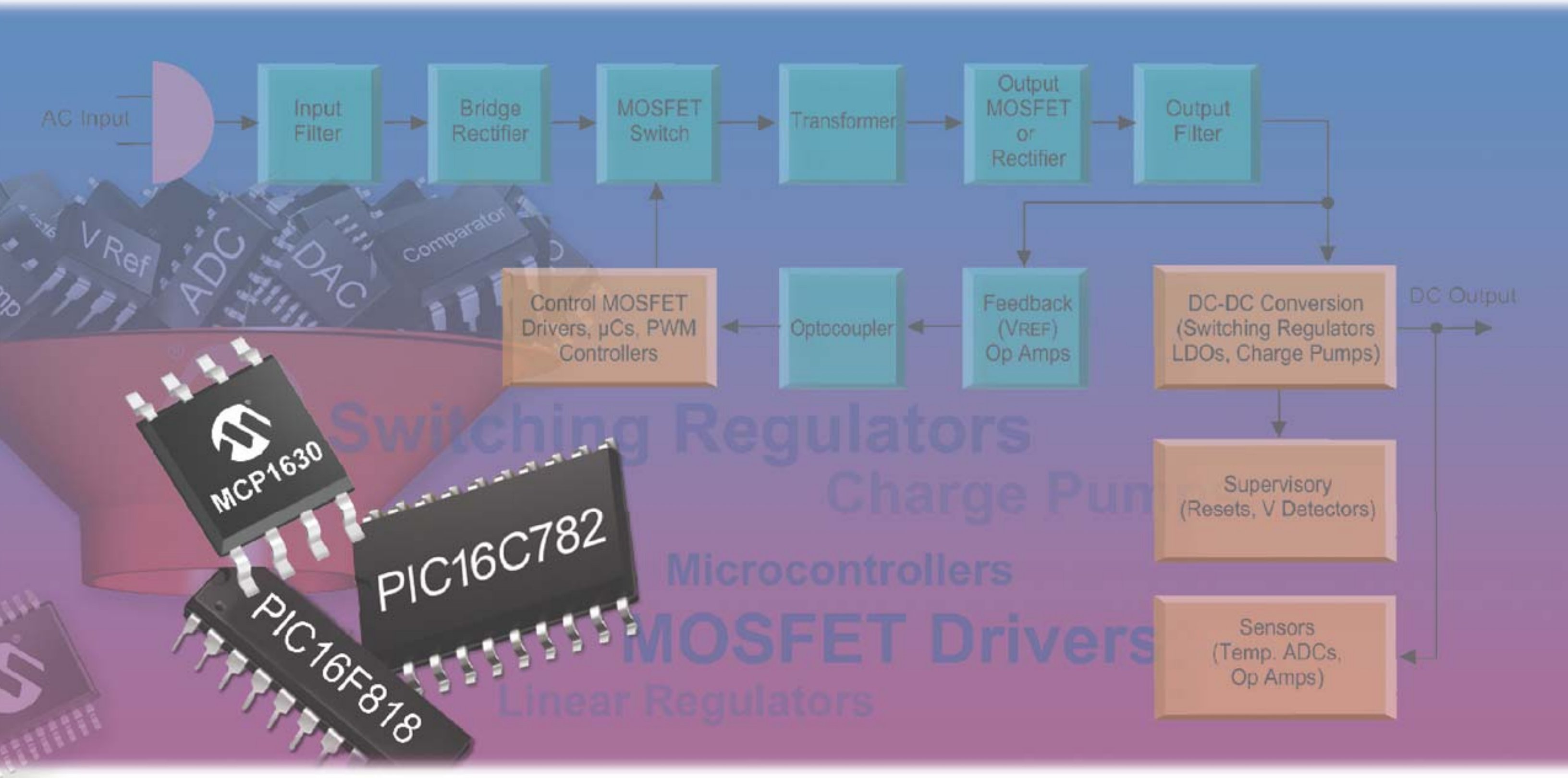
MICROCHIP

Power Solutions Design Guide

AC-DC and DC-DC Converters For Power Design Challenges



Design ideas in this guide use the following devices. A complete device list and corresponding data sheets for these products can be found at **www.microchip.com**

Switching Regulators	Charge Pumps	Linear Regulators	Microcontroller Supervisors	PICmicro® Microcontrollers	MOSFET Drivers	PWM Controllers
MCP1601	MCP1252	MCP1726	MCP102	PIC10F206	TC1410	MCP1630
MCP1612	MCP1256	TC1017	MCP121	PIC16F684	TC4423	
MCP1650	MCP1259	TC1262	MCP131	PIC16F785	TC4427	
TC1303	TC7660H	TC1300		PIC16F818		
		TC2117				

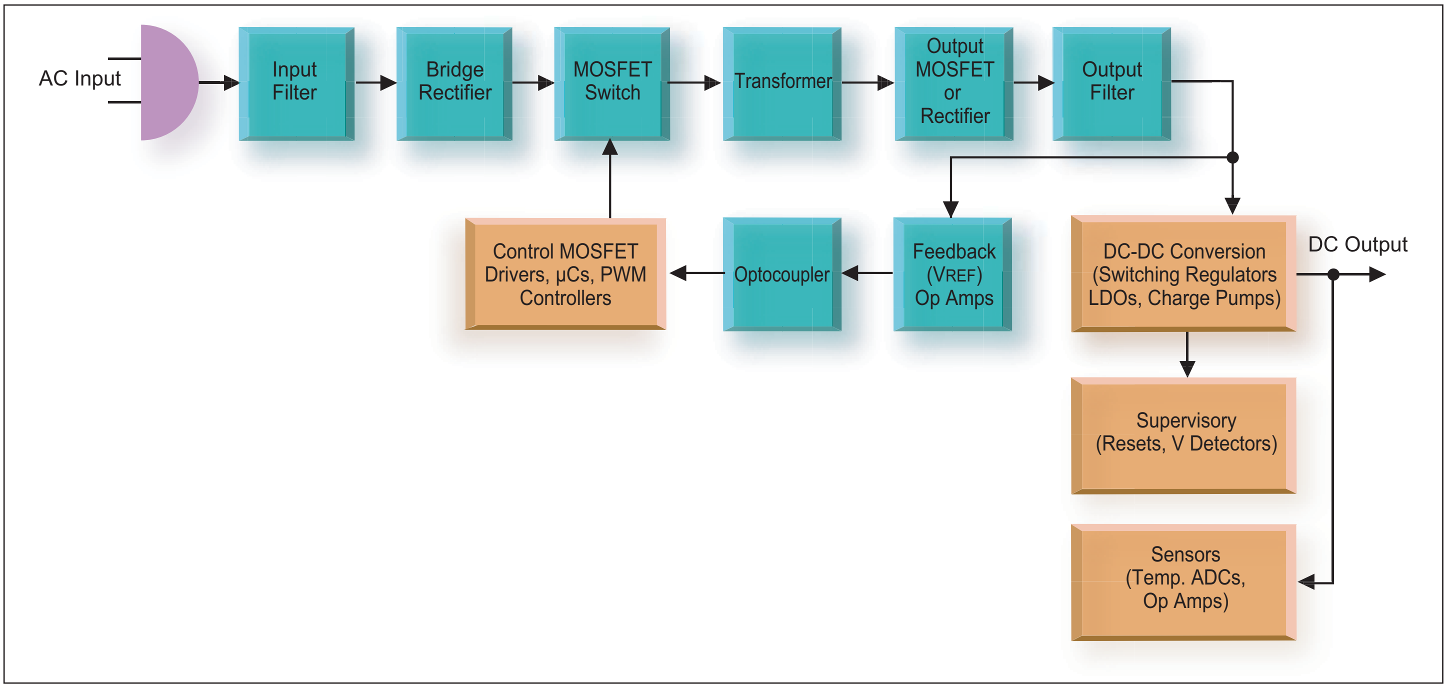
INTRODUCTION: AC-DC CONVERSION

In most power electronic applications, the power input is in the form of a 50 Hz or 60 Hz sine-wave AC voltage provided by the electric utility, which is then converted to a DC voltage. Increasingly, the trend is to convert the input AC into DC in an uncontrolled manner, using rectifiers and diodes. As such, the power flow can only be from the utility AC side to the DC side. A majority of applications such as switching DC power supplies, motor drives, servo drives, and so on, use such uncontrolled rectifiers. In most of these applications, the rectifiers are supplied directly from the utility source without a 50/60 Hz transformer. The avoidance of this costly and bulky transformer is important in most modern applications.

In non-power, factor-corrected applications, the DC output voltage of the rectifier circuit should be as ripple-free as possible. Therefore, a large capacitor is connected as a filter on the DC side. This capacitor gets charged to a value close to the peak of the AC input voltage. The DC link voltage is then converted for use throughout the system.

This design guide describes basic techniques for converting the generated DC link voltage for use throughout a system.

AC-DC Conversion Block Diagram



DC-DC CONVERSION

The Microchip **PIC16F785** is a mixed analog/digital microcontroller that combines the popular PIC® microcontroller architecture with new mixed-signal peripherals. The resulting devices change many of the old conventions of embedded design and open up new application possibilities for the microcontroller.

One application that is well suited for the PIC16F785's unique peripheral set is a switchmode, DC-DC converter. This solution provides an enormous amount of design flexibility.

The PIC16F785 can be used in a variety of switchmode architectures, allowing for diverse input and output voltages. Depicted below is a block diagram for a single-output flyback converter used to convert the DC link voltage to an intermediate DC bus voltage.

PIC16F785 Key Features:

- Complete Programmability
- Enormous Flexibility
- Six Peripherals, including 8x8-bit A-D, 8-bit D-A, V_{REF}, Op Amp, 2x comparators, programmable switchmode controller

MOSFET Driver Key Features:

- High Peak Output Current: 1.5A
- Wide Operating Supply Voltage: 4.5V to 18V
- Current Consumption: Inputs Low -0.4 mA; Inputs High -8 mA
- Single Supply Operation
- Low Output Impedance: 6Ω

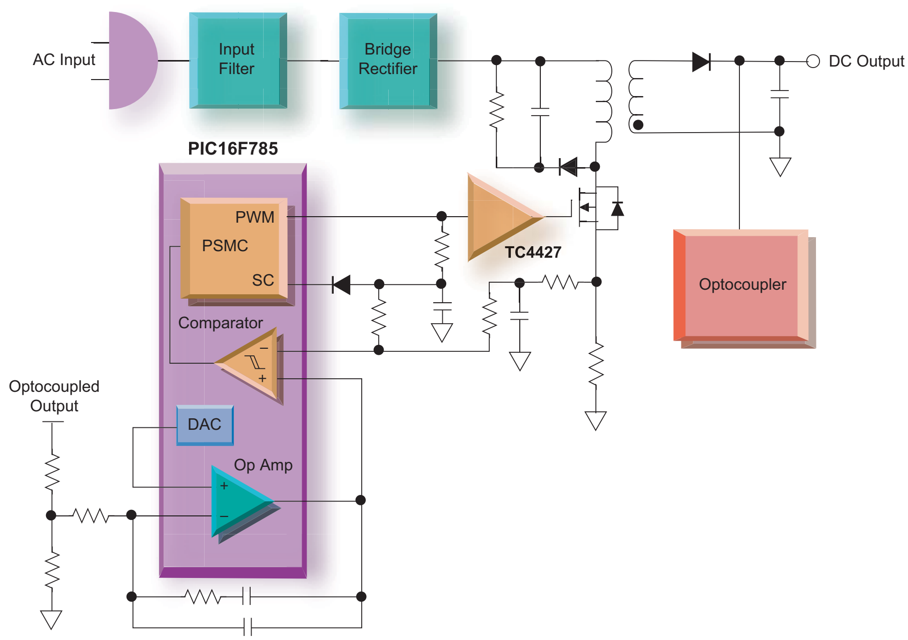
PIC16F785 Applications:

- Security and Remote Sensors
- Appliance Motor-control
- Automotive Applications
- Switchmode Power Supplies
- Switchmode Battery Chargers

MOSFET Driver Applications:

- Switchmode Power Supplies
- Pulse Transformer Drive
- Clock Line Driver
- Coax Cable Driver

Flyback Converter Circuit



Selected Product Specifications

Device	Program Memory Bytes	RAM Bytes	I/O Pins	ADC Channels	Comp.	Timers/WDT	Max. Speed (MHz)	Other Features	Packages
PIC16F785	1792	128	16	8x8 bit	2	1 16-bit, 1 8-bit, 1 WDT	20	Precision V_{REF}, Op Amp, PSMC, 4 MHz Internal OSC, DAC	20P, 20SO, 20SS, 20JW

Device	Configuration	Operating Temp. Range (°C)	Peak Output Current (mA)	Output Resistance (R_H/R_L) (Max. Ω @ 25°C)	Max. Supply Voltage (V)	Input/Output Delay (td1, td2)[1] (ns)	Packages
TC1410	Single, Inverting	-40 to +85	0.5	22/22	16	30/30	8PDIP, 8SOIC, 8MSOP
TC4423	Dual, Inverting	-40 to +125	3	5/5	18	33/38	8PDIP, 16SOIC (W), 8DFN
TC4427	Dual, Non-inverting	-40 to +125	1.5	10/10	18	20/40	8PDIP, 8SOIC, 8DFN, 8MSOP

Note 1: td1 - delay time from input low-to-high transition to output transition, td2 = delay time from input high-to-low transition to output transition

DC-DC CONVERSION

Often the intermediate DC bus voltage is “incompatible” with portions of the system load. Further post regulation is needed to control the voltage and/or current to the load.

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, (LDOs). A low dropout regulator is a type of linear regulator designed to minimize the saturation of the output transistor and to minimize the drive requirements. LDOs can operate with a very small input-to-output differential.

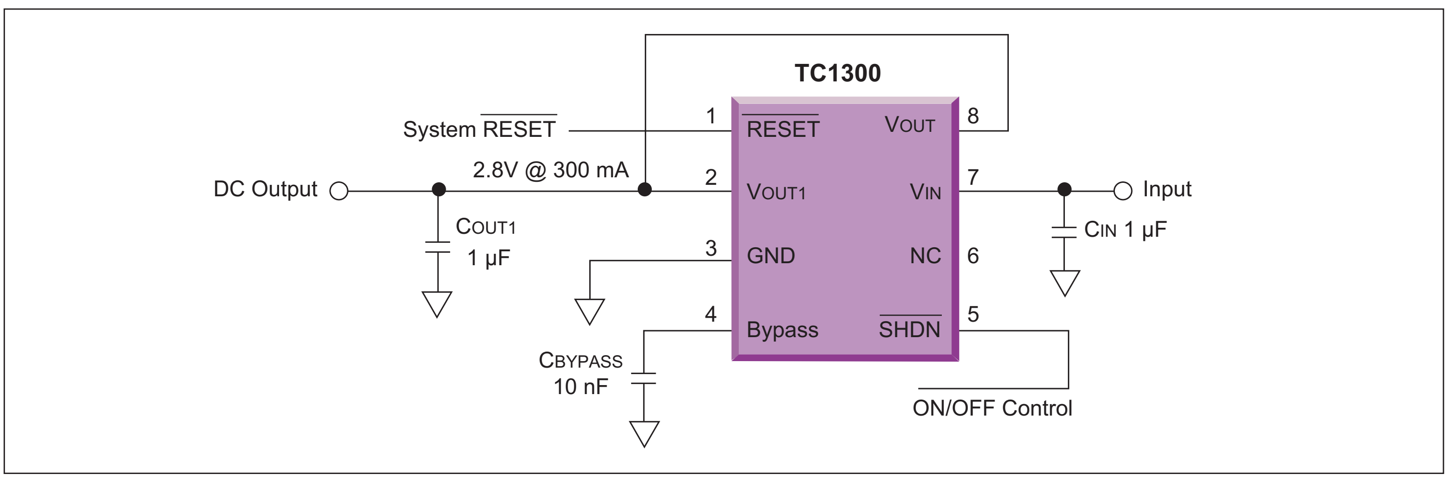
TC1300 Key Features:

- LDO with Microcontroller Reset Monitor Functionality
- Low Dropout Voltage: V_{OUT1} = 210 mV @ 300 mA
- Supply Current: 80 µA, (Typical)
- Reference Bypass Input for Low Noise Operation
- Output Stable with a Minimum of 1 µF Ceramic Output Capacitor
- RESET Duration: 300 msec. (Typical)
- Power-saving Shutdown Mode
- Wake-up from SHDN: 10 µsec. (Typical)
- Operating Junction Temperature Range: -40°C to +125°C
- Overtemperature and Overcurrent Protection
- Small 8-pin MSOP Package

TC1300 Applications:

- Cellular Phones
- Pagers
- Personal Digital Assistants (PDA)
- Laptops, MP3 Players, Hand-held Meters
- Industrial Control, Optical Modules
- Datacom Equipment
- Modems
- Flash Module Cards
- PC Cards

Linear Regulator Circuit



Selected Product Specifications

Device	Max. Input Voltage (V)	Output Voltage	Output Current (mA)	Typical Active Current (µA)	Typical Dropout Voltage @ Max. I_{OUT} (mV)	Features	Packages
TC1017	6.0	1.8, 2.6, 2.7, 2.8, 2.85, 2.9, 3.0, 3.3, 4.0	150	53	285	Shutdown	5SC-70, 5SOT-23
TC1262	6.0	2.5, 2.8, 3.0, 3.3, 5.0	500	80	350	–	3TO-220, 3DDPAK, 3SOT-223
TC1300	6.0	2.5, 2.7, 2.8, 2.85, 3.0, 3.3	300	80	210	Shutdown, reference bypass input, LDO plus RESET output	8MSOP
TC2117	6.0	1.8, 2.5, 3.0, 3.3	800	80	600	–	3DDPAK, 3SOT-223
MCP1726	6.0	0.8, 1.2, 1.8, 2.5, 3.3, 5.9, ADJ	1000	140	150	Shutdown, Power good	8DFN, 8SOIC

DC-DC CONVERSION

Another approach to post-regulating the intermediate DC bus voltage is to employ a switchmode power converter. The primary advantage of a switchmode power converter is that they 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 circuitry.

The buck converter is an inductor-based switchmode 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, direct converter or chopper converter.

No matter what the name, inductor-based, buck derived, switchmode 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.

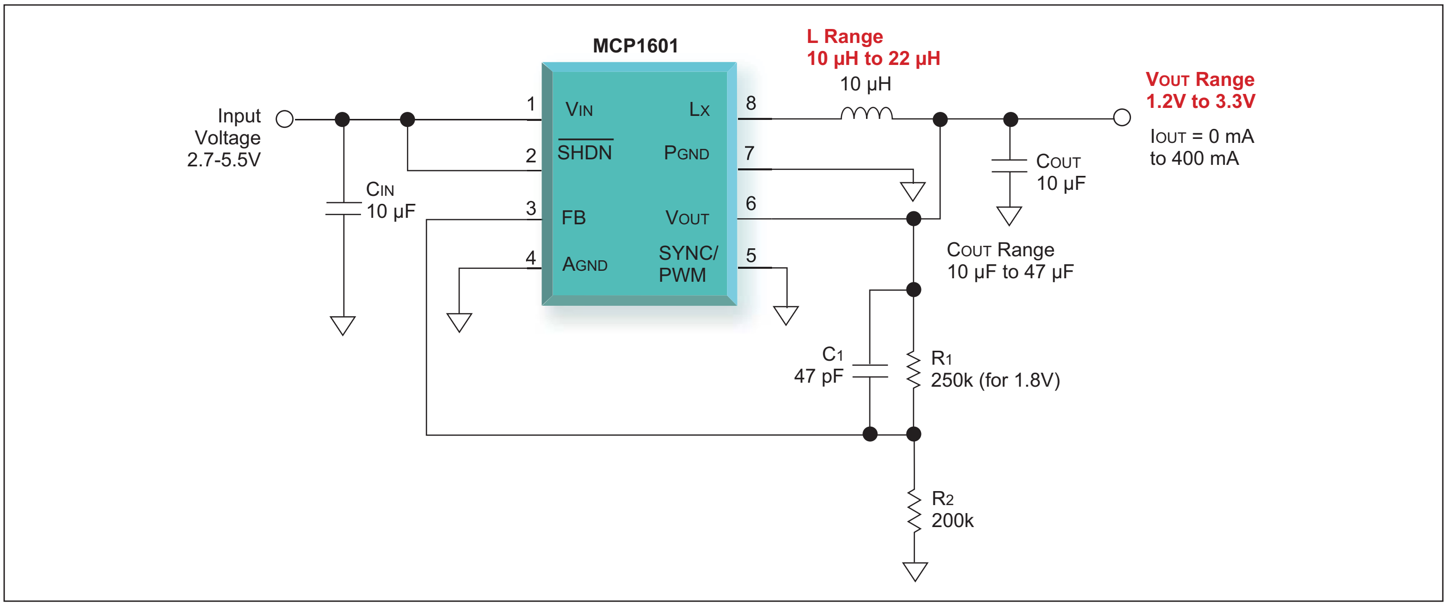
MCP1601 Key Features:

- 3 Operating Modes: PWM, PFM and LDO
- Integrated Buck and Synchronous Switches
- Ceramic or Electrolytic Input/Output Filtering Capacitors
- 750 kHz Fixed Switching Frequency
- Oscillator Synchronization to 1 MHz PWM Mode
- Auto-Switching from PWM/PFM Operation
- 100% Duty Cycle Capable for Low Input Voltage
- 500 mA Continuous Output Current Capability
- Integrated Undervoltage Lockout (UVLO) Protection
- Integrated Overtemperature Protection
- Integrated Soft-start Circuitry
- Low Output Voltage Capability to 0.9V

MCP1601 Applications:

- Low-power Handheld CPUs and DSPs
- Cellular Phones
- Organizers and PDAs
- Digital Cameras
- +3.3V or +5V Distributed Voltages
- USB-powered Devices

Buck Converter Circuit



Selected Product Specifications

Device	Input Voltage Range	Output Voltage (V)	Operating Temp. Range (°C)	Control Scheme	Switching Frequency (kHz)	Typical Active Current (µA)	Output Current (mA)	Features	Packages
MCP1601	2.7 to 5.5	0.9V to VIN	-40 to +85	PFM/PWM LDO	750	825 (PWM) 125 (PFM)	500	UVLO, auto-switching, LDO	8MSOP
MCP1612	2.7 to 5.5	0.8V to VIN	-40 to +85	Constant Frequency PWM	1400	5000	1000	Overall efficiency >94% soft-start, overtemperature and overcurrent protection	8MSOP, 8DFN
MCP1650	2.7 to 5.5	2.5 to ext. tx limited	-40 to +125	Constant Frequency, 2 Fixed DC	750	120	560/440	2 duty cycles for min. and max. loads, shutdown control, UVLO, soft-start	8MSOP

DC-DC CONVERSION

Often systems require multiple output voltages. The **TC1303** combines a 500 mA synchronous buck regulator and 300 mA low-dropout linear regulator with a power-good monitor to provide a highly integrated solution. The unique combination of an integrated buck switching regulator and low-dropout linear regulator provides the lowest system cost for dual-output voltage applications that require one lower processor core voltage and one higher bias voltage.

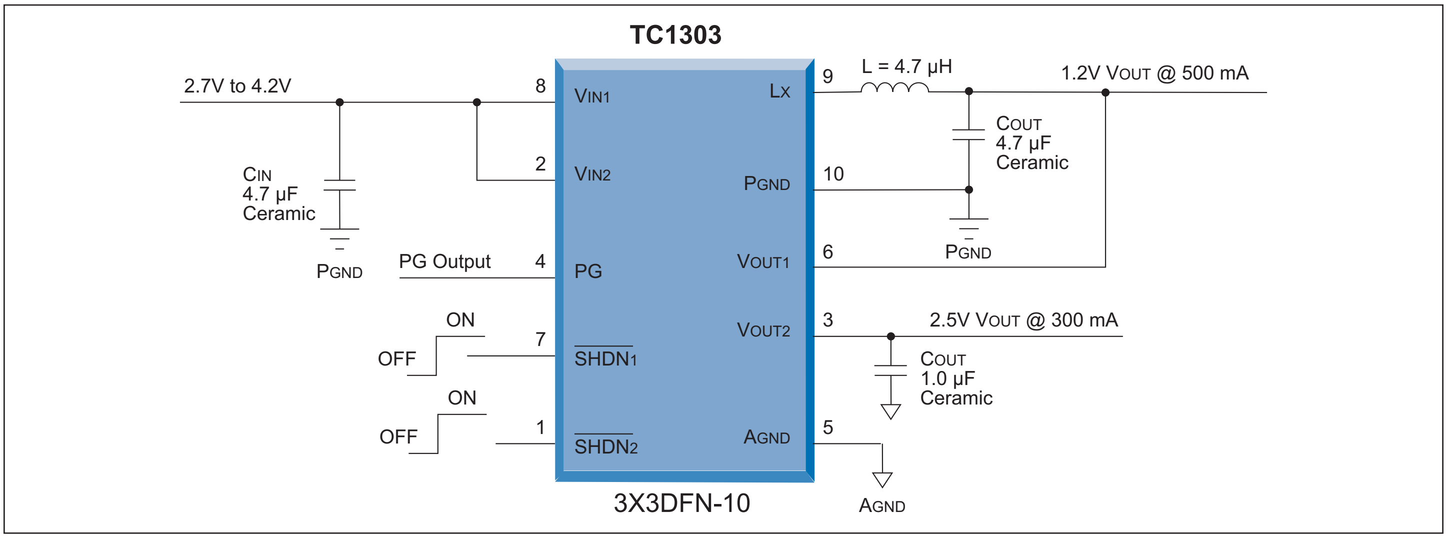
TC1303 Key Features:

- Dual-Output Regulator (500 mA Buck Regulator and 300 mA Low-Dropout Linear Regulator)
- Power-good Monitor on the Buck Output with 300 mS Delay
- Both Outputs Internally Compensated
- Independent Shutdown for the Buck and Linear Outputs
- Automatic PWM to PFM Mode Transition
- Undervoltage Lockout (UVLO)
- Output Short Circuit and Overtemperature Protection
- Small 10-Pin 3x3mm DFN and MSOP Packages

TC1303 Applications:

- Cellular Phones
- Portable Computers
- USB Powered Devices
- Handheld Medical Instruments
- Organizers and PDAs

TC1303 Dual Regulator (500 mA Buck and 300 mA LDO)



Selected Product Specifications

Device	Input Voltage Range (V)	Output Voltage (V)	Operating Temp. Range (°C)	Control Scheme	Switching Frequency (kHz)	Typical Active Current (µA)	Output Current (mA)	Features	Packages
TC1303	2.7 to 5.5	0.8 to 4.5	-40 to +85	PFM/PWM	2000	65	500/300	Dual regulator, shutdown control, power-good, UVLO, soft-start, overtemperature and overcurrent protection	10MSOP, 10DFN

DC-DC CONVERSION

The **TC7660H** is an inductorless, switched capacitor (charge pump) DC-DC converter. The device converts a +1.5V to +10V input voltage to a corresponding -1.5V to -10V output using only two low-cost capacitors, eliminating inductors and their associated cost, size and EMI.

Alternatively, the TC7660H can be employed to achieve positive voltage multiplication with the addition of two external diodes.

Depicted here is the TC7660H utilized as a simple negative converter and positive voltage multiplier.

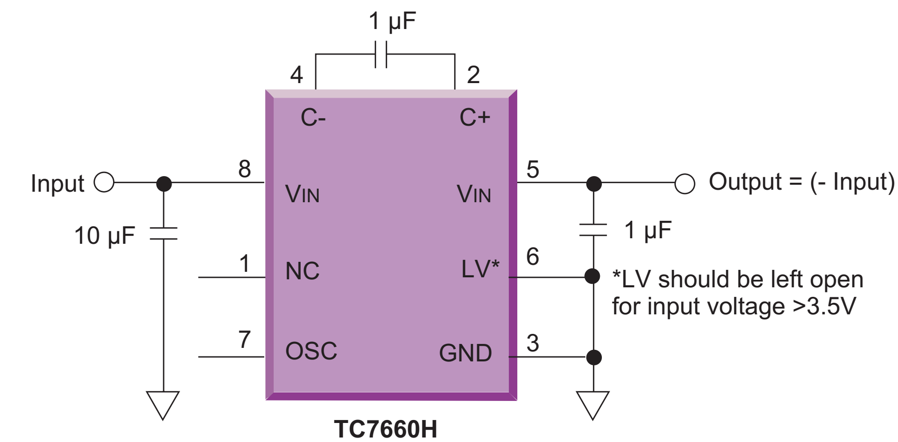
TC7660H Key Features:

- Inductorless DC-DC Converter
- Voltage Conversion Efficiency: 99.7%
- Power Conversion Efficiency: 85%
- Wide Input Operating Range: 1.5V to 10V

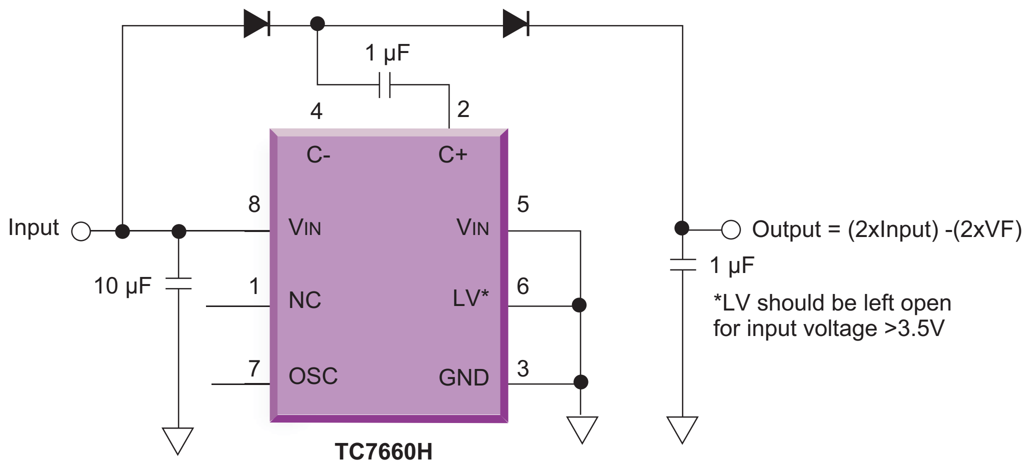
TC7660H Applications:

- Sensor Interface
- Process Control
- Data Acquisition
- Battery-operated Systems

Simple Negative Converter



Positive Voltage Multiplier



Selected Product Specifications

Device	Input Voltage Range (V)	Output Voltage (V)	Operating Temp. Range (°C)	Max. Input Current(1) (µA)	Typical Active Output Current (mA)	Features	Packages
TC7660H	1.5 to 10	V_{OUT} = -V_{IN} or V_{OUT} = 2 V_{IN}	-40 to +85	1,000	20	120 kHz oscillator	8PDIP, 8SOIC
MCP1252	2.1/2.7 to 5.5 2.0 to 5.5	Selectable 3.3V or 5.0V or Adjustable 1.5V to 5.5V	-40 to +85	120	120 mA for V_{IN} > 3.0V	Power-Good output, 650 kHz oscillator	8MSOP
MCP1256	1.8 to 3.6	3.3	-40 to +125	20; SLEEP mode	100 mA for V_{IN} > 2.2V	1.5x, 2x Regulated conversion, Fixed frequency, SLEEP mode, Power-Good output	10MSOP, 10DFN
MCP1259	1.8 to 3.6	3.3	-40 to +125	2; BYPASS mode	100 mA for V_{IN} > 2.2V	1.5x, 2x Regulated conversion, Fixed frequency, BYPASS mode, Low-Battery output	10MSOP, 10DFN

Note 1: Measured at VDD = 5.0V at 25°C and no load.

DC VOLTAGE MONITORING

The **MCP102, MCP121** and **MCP131** are low-cost, precision system voltage supervisors designed to keep a microcontroller in reset until the system voltage has reached the proper level and stabilized. These devices also operate as protection from brown-out conditions when the supply voltage drops below a safe operating level.

The MCP102, MCP121 and MCP131 expand the choices available to the system designer by offering a wide range of output types, reset trip points and package options. These devices are functionally equivalent and pin-compatible with many industry standard supervisory products, offering easy migration to a lower power solution.

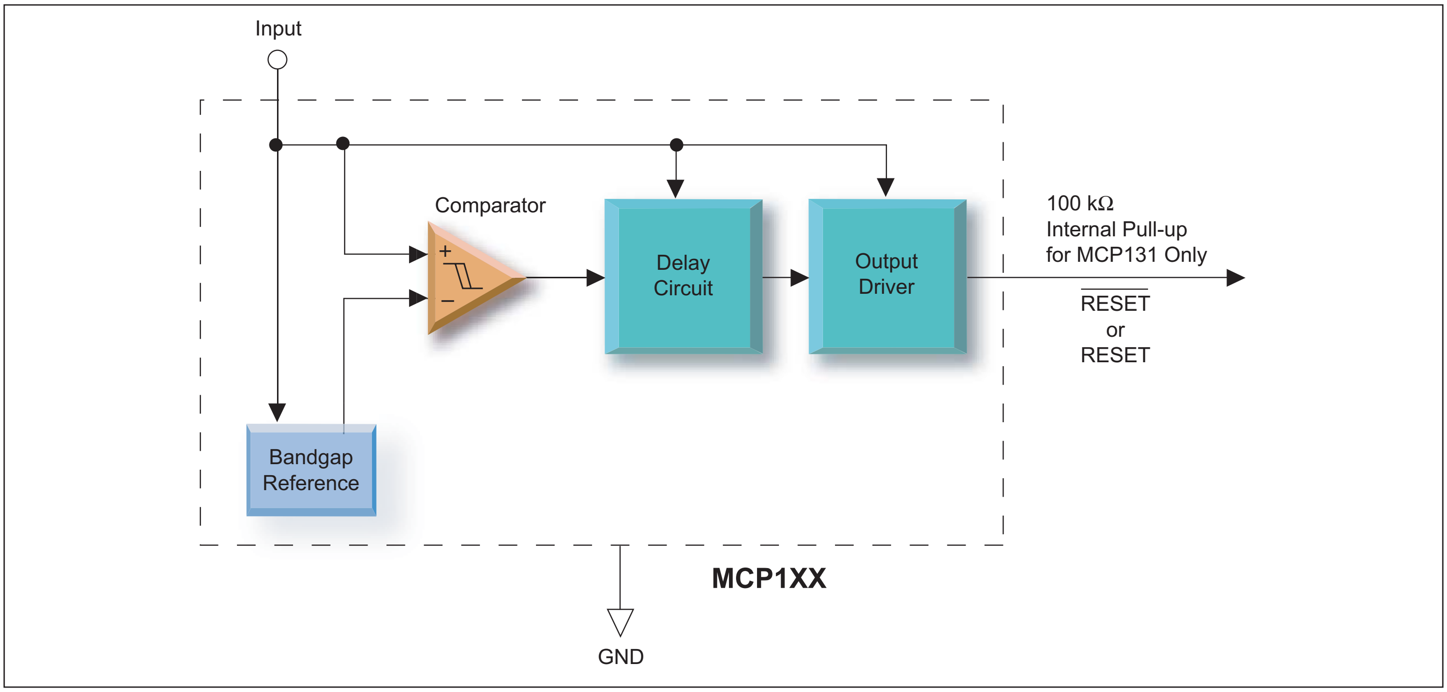
MCP102, MCP121 and MCP131 Key Features:

- Multiple Trip Voltage Points Range from 1.9-4.75V
- Industrial Temperature Range: -40°C to +125°C
- Reset Type: Active-low
- Output: Open-drain
  - MCP102: Push-pull
  - MCP121: Open-drain
  - MCP131: Open-drain with Internal 95 kΩ Pull-up
- 100k Internal Pull-up (MCP131)
- Typical Supply Current: >1 µA
- Industry-standard Packaging:
  - SC-70-3, SOT-23-3, TO-92-3
- Lead-free Packaging

MCP102, MCP121 and MCP131 Applications:

- Digital Potentiometers
- CD-Player
- Routers
- Computers
- Intelligent Instruments
- Portable Battery-powered Equipment

Voltage Supervisor Circuit



Selected Product Specifications

Device	Vcc Voltage Range (V)	Operating Temp. Range (°C)	Nomimal Reset Voltage (V)	Reset Type	Output	Typical Reset Pulse-Width (ms)	Typical Supply Current (µA)	Packages
MCP102	1.0 to 5.5	-40 to +125	1.9, 2.32, 2.63, 2.93, 3.08, 4.38, 4.63	Active-low	CMOS Push-pull	120	1	3SC-70, 3SOT-23B, 3TO-92
MCP121	1.0 to 5.5	-40 to +125	1.9, 2.32, 2.63, 2.93, 3.08, 4.38, 4.63	Active-low	Open-drain	120	1	3SC-70, 3TO-92, 3SOT-23B
MCP131	1.0 to 5.5	-40 to +125	1.9, 2.32, 2.63, 2.93, 3.08, 4.38, 4.63	Active-low	Open-drain	120	1	3SC-70, 3SOT-23B, 3TO-92

HIGH-SPEED MICROCONTROLLER, PULSE-WIDTH MODULATOR

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 duty cycle, frequency of operation and 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.

Depicted is a typical NiMH battery charger application. A Single-Ended Primary Inductive Converter (SEPIC) is used to provide a constant charge current to the series-connected batteries. The MCP1630 is used to regulate the charge current by monitoring the current through the battery sense resistor and providing the proper pulse width.

The PIC16F818 monitors the battery voltage to provide a termination to the charge current. Additional features (trickle charge, fast charge, overvoltage protection, etc.) can be added to the system utilizing the programmability of the microcontroller and the flexibility of the MCP1630.

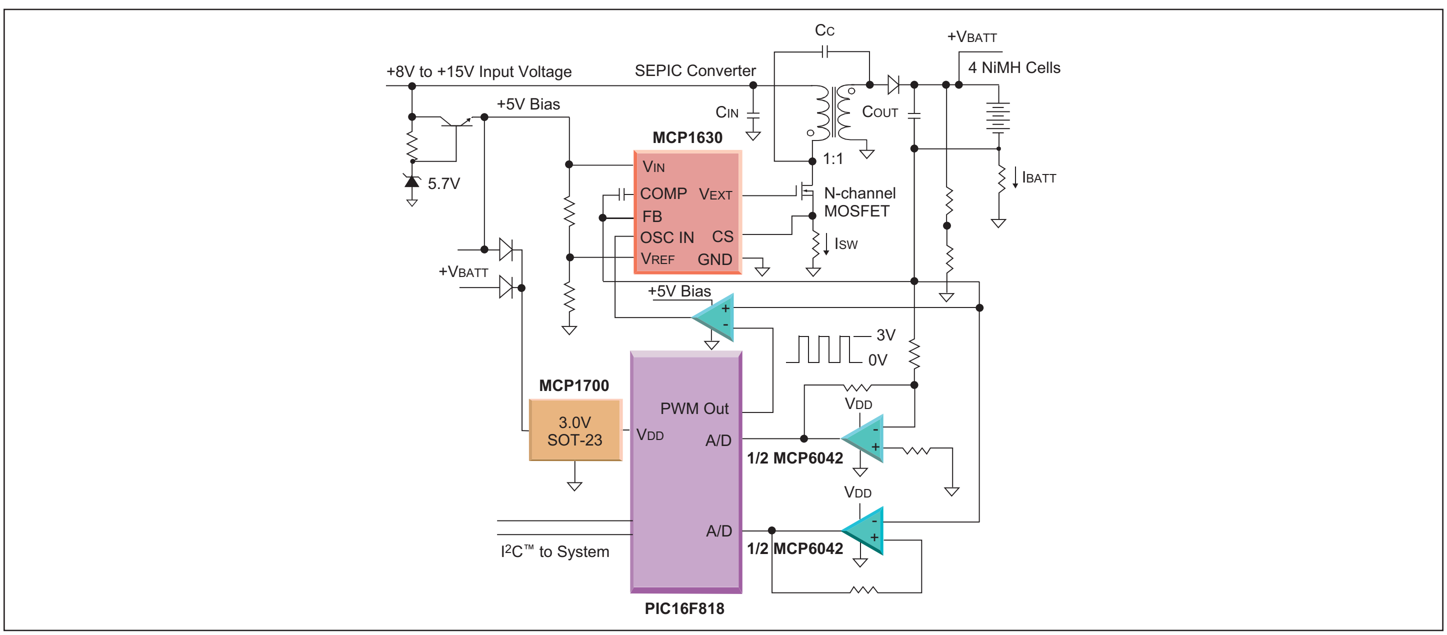
MCP1630 Key Features:

- High-speed PWM Operation:
  - 12 ns Current Sense-to-Output Delay
- Operating Temperature Range: -40°C to +125°C
- Precise Peak Current Limit: ±5%
- CMOS Output Driver (Drives MOSFET Driver or Low-side N-channel MOSFET Directly)
- External Oscillator Input (from PICmicro® 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 and 6.2 ns
- Undervoltage Lockout (UVLO)
- Output Short Circuit Protection
- Overtemperature Protection

MCP1630 Applications:

- Intelligent Power Systems
- Smart Battery Charger Applications
- Multiple Output and Multiple Phase Converters
- Output Voltage Calibration
- AC Power Factor Correction
- VID Capability (Programmed and Calibrated by PIC® MCU)
- Buck/Boost/Buck-Boost/SEPIC/Flyback/Isolated Converters
- Parallel Power Supplies

MCP1630 NiMH Battery Charger and Fuel Gauge Application Diagram



Selected Product Specifications

Device	Input Voltage Range (V)	Output Voltage (V)	Operating Temp. Range (°C)	Switching Frequency (kHz)	Typical Active Supply Current (µA)	Output Current (mA)	Features	Packages
MCP1630	2.7 to 5.5	VSS + 0.2V to VDD – 0.2V	-40 to +125	1000	3.5	±10	UVLO, current sense to VEXT, response <25 ns	8MSOP

Device	Program Memory Bytes	RAM Bytes	I/O Pins	ADC Channels	Comp.	Timers/WDT	Max. Speed (MHz)	Other Features	Packages
PIC16F818	1792	128	16	5x10 bit	–	1 16-bit, 2 8-bit, 1 WDT	20	8 MHz internal oscillator	18P, 18SO, 20SS, 28ML

DIGITAL CONTROL IN POWER SUPPLIES

Power supplies are increasingly utilizing digital control to enhance the performance of various topologies. Whether it is a low-cost, 6-pin microcontroller used as a soft-start controller/sequencer for point-of-load converters or a higher-performance microcontroller offering serial communications, microcontrollers offer unmatched flexibility and deterministic control in a wide range of power supply applications.

As the leader in 8-bit microcontrollers, Microchip's PIC® microcontroller family offers one of the widest range of microcontrollers, ranging from small, very compact microcontrollers to high pin-count, large memory devices to support advance algorithms and user configuration options.

The PIC microcontrollers are available in small packaging options such as SOT-23 and QFN to accommodate the most compact of DC-DC brick designs, extended temperature ranges (up to 125°C) and a proprietary Flash technology that sets the industry-standard for reliability and data retention.

Depicted is a digital control added to a boost converter. The application is partitioned such that the loop closure, power MOSFET drive and cycle-by-cycle current limiting are in the analog domain, performed by the MCP1630. The PIC10F206 adds digital control and incorporates features such as soft-start, under voltage lockout (UVLO), and over-temperature protection.

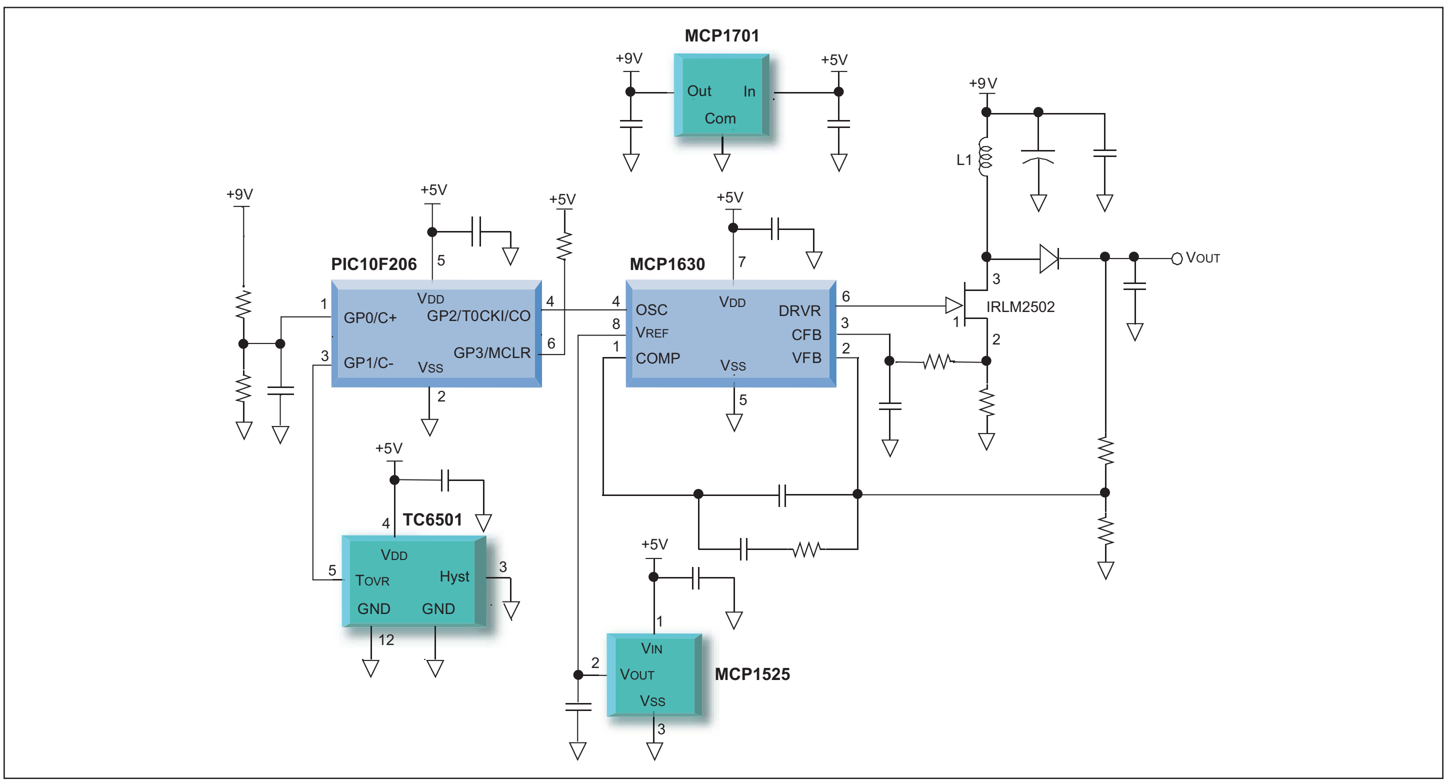
Key Features of PIC® Microcontrollers:

- Wide Operating Voltages (2.0-5.5V)
- Wide Operating Temperature Range
- Wide Selection of Products;
  (6-pin to 80-pins, 0.5-128 Kbytes Program Memory)
- Peripherals Include:
  - Up to 12-bit On-board A/D
  - PWM Outputs
  - Data EEPROM
  - Serial Communications

PIC® Microcontroller Applications:

- DC-DC Soft-start
- Programmable Voltage/Current Supply
- Point-of-load Sequencing
- Intelligent Temperature Compensation
- Overvoltage and Overcurrent Handling

Digitally Controlled Boost Converter Diagram



Selected Product Specifications*

Device	Program Memory (Bytes)	RAM (Bytes)	Operating Voltage (V)	ADC Channels	Max. Speed (MHz)	Digital Peripherals	Packages
PIC10F206	768	24	2.0-5.5	–	4	1 8-bit, 1 WDT	8PDIP, 6SOT-23
PIC16F684	3584	128	2.0-5.5	8 x 10-bit	20	1 16-bit, 2 8-bit, 1 WDT	14PDIP, 14SL, 14TST

*More than 200 products are available for various power-control needs.

RELATED SUPPORT MATERIALS

The following Application Notes and Technical Briefs are available on the Microchip web site: **www.microchip.com.**

Application Notes

AN216: *DC-DC Converter Controller Using a PICmicro® Microcontroller*

In many applications, a DC/DC Converter is used to produce a regulated voltage or current, derived from an unregulated power supply, or from a battery. Examples of these applications include battery chargers, electronic air purifiers, emergency exit signs and distributed power systems. In some of those applications, a dedicated Switched Mode Power Supply (SMPS) Controller IC is used in conjunction with a microcontroller. In other applications, however, a dedicated SMPS Controller IC may be overkill. An alternative approach is to generate a low-cost SMPS function in a smart microcontroller, such as the PIC16C620A. This application note covers a method of using the microcontroller to perform simple SMPS control functions.

AN765: *Using Microchip's Micropower LDOs*

Microchip's family of micropower LDOs utilize low-voltage CMOS process technology. These LDOs provide similar ripple rejection and dropout characteristics as their bipolar equivalents, but are significantly more efficient. A typical bipolar regulator has base current equal to 1-2% of the output load, whereas Microchip's LDOs have approximately 60 μA, resulting in a total operating current lower than their bipolar counterparts. In addition, Microchip's LDOs can be placed in a Shutdown mode, further enhancing their effectiveness in low-power applications.

AN766: *Pin-compatible CMOS Upgrades to Bipolar LDOs*

Bipolar Low Dropout Regulators (LDOs) have become common-place in a variety of portable applications, such as cell phones, pagers and PDAs. Their popularity stems from small packaging, high output current capability and precision output voltage specifications. However, the bipolar process technology from which these devices are fabricated brings inherent disadvantages, such as excessive supply current. This application note outlines the advantages of small geometry CMOS LDOs over bipolar LDOs and provides comparative test data of key regulator specifications for a popular pin-compatible bipolar LDO over Microchip's CMOS LDOs.

AN786: *Considerations for Driving Power MOSFETs in High-current, Switchmode Regulators*

The low on-resistance and high-current carrying capability of power MOSFETs make them preferred switching devices in SMPS power supply design. However, designing with these devices is not as straightforward as with their bipolar counterparts. Unlike bipolar transistors, power MOSFETs have a considerable gate capacitance that must be charged beyond the threshold voltage, $V_{GS(TH)}$, to achieve turn-on. The gate driver must provide a high enough output current to charge the equivalent gate capacitance, C_{EI}, within the time required by the system design.

AN792: *A Method to Determine How Much Power a SOT-23 Can Dissipate in an Application*

This application note introduces a simple method to measure the thermal resistance from junction-to-ambient for small SMT components in your design. Using this method, designers can verify thermal performance in their specific applications and gain insight that will be valuable for new designs.

In addition to introducing a simple method for measuring power dissipation capability, this application note provides basic heat transfer concepts that are applicable to small SMT packages and discusses the fundamentals of thermal resistance. The measurement of thermal resistance for several examples are provided.

AN793: *Power Management in Portable Applications; Understanding the Buck Switchmode Power Converter*

This application note focuses on the fundamentals of inductor-based switchmode power converters. This is a "grass roots" approach to understanding switchmode power converters. Specifically, the basic buck circuit topology and its associated waveforms are examined, both empirically and mathematically.

All known switchmode power converters can be derived from combinations of the basic buck and or boost converters, along with some form of transformation function.

Roughly 85% of today's switchmode power converters are derived from the buck topology. Understanding its operation is essential to switchmode power converter design.

AN797: *TC4426/27/28 System Design Practice*

The TC4426/4427/4428 are high-speed power MOSFET drivers built using Microchip's tough CMOS process. They are improved versions of the earlier TC426/427/428 family of high-speed power MOSFET drivers (with which they are pin- compatible) and are capable of giving reliable service in far more demanding electrical environments. They will not latch up under any conditions within their power and voltage ratings. They are not subject to damage when up to 5V of noise spiking (of either polarity) occurs on the ground pin. They can accept, without damage or logic upset, up to 500 mA of reverse current (of either polarity) being forced back into their outputs. All terminals are fully protected against up to 4 kV of electrostatic discharge.

AN799: *Matching MOSFET Drivers to MOSFETs*

This application note discusses the details of MOSFET driver power dissipation in relation to MOSFET gate charge and operating frequency. It also demonstrates how to match MOSFET driver current drive capability and MOSFET gate charge based on desired turn-on and turn-off times of the MOSFET. Microchip offers many variations of MOSFET drivers in various packages, which allows the designer to select the optimal MOSFET driver for the MOSFET(s) being used in their application.

RELATED SUPPORT MATERIALS

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

This application note describes 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.

Technical Briefs

TB053: *Generating High Voltage Using the PIC16C781/782*

This technical brief introduces the boost converter topology operating in discontinuous mode. As an example, a simple 9V to 170V DC-DC converter is designed based on this topology and is used to provide power to a three-digit Nixie tube display. The PIC16C782 is used to control the DC-DC converter and provides data decoding for the display. To make the display useful, the PICmicro® microcontroller (MCU) samples a temperature sensor and displays the results.

TB081: *Soft-start Controller For Switching Power Supplies*

This technical brief describes a microcontroller-based, soft-start controller circuit for a switching power supply. Start-up is a stressful time for the power driver section of a switching power supply. Because the output voltage is initially zero, the feedback error initially jumps to its maximum. The large feedback error then drives the loop filter to its limit, which drives the power switching transistors in the driver section of the power supply at their maximum rating. This condition continues until the output voltage of the power supply approaches its nominal value. Microchip offers a number of boards to help you evaluate device families. Contact your local Microchip sales office for a demonstration.

TB085: *A Simple Circuit for Driving Microcontroller-Friendly PWM Generators*

This application note examines a design which combines the PIC10F206, a 6-pin SOT-23 microcontroller, with the MCP1630. The power supply design presented is a full, proportional-feedback continuous inductor current, current-mode, boost power supply generating 15 V_{OUT} at .25 Amps from a 9 VDC input. The PIC10F206 generates the clock for the MCP1630 and through that control, implements the previous list of features.

Evaluation/Demo Boards and User Guides

Evaluation/Demo Boards and User Guides are available for the following devices featured in this guide.

MCP1601 Buck Regulator Evaluation Board

The MCP1601 Evaluation Board (Rev. 1) is designed to demonstrate the use of the MCP1601 Synchronous Buck Regulator in a step-down, inductor-based DC-DC converter application.

MCP1601 Evaluation Board (Rev 1) User's Guide, (DS51511)

This document describes the capabilities of the MCP1601 Evaluation Board (Rev. 1) and discussed how to select the desired synchronous converter operating mode. It also demonstrates how to program the output voltage.

MCP1630 NiMH Battery Charger Demonstration Board

The MCP1630 NiMH Battery Charger Demo Board is a complete stand-alone constant current battery charger and simple fuel gauge for four Nickel Metal Hydride series batteries. This board supports the use of the MCP1630, MCP1700, TC1047A, TC54, MCP6042 and the PIC16F818.

The input voltage range for the demo board is 8V to 15V. The output is capable of charging four NiMH batteries with up to 1.6V per cell at a fast charge rate of 500 mA constant current. Input terminals are provided to apply an input voltage to the charger. Output terminals are also provided as a way to connect the external NiMH batteries or a simulated battery load.

MCP1630 NiMH Demonstration Board User's Guide, (DS51505)

This user's guide contains general information that will be useful to know before using the MCP1630 Battery Charger NiMH Demo Board.

TC1303B Buck Regulator LDO Demonstration Board

The TC1303B Dual-Output Regulator with Power-Good Output Demo Board can be used to evaluate the TC1303B device over the input voltage range and output current range for both the synchronous buck regulator output and the low-dropout linear regulator output.

TC1303B Dual-Output Regulator with Power-Good Output User's Guide, (DS51563)

This user's guide contains general information that will be useful to know before using the TC1303B Dual-Output Regulator with Power-Good Output Demo Board.

ANALOG AND INTERFACE PRODUCTS

Stand-Alone Analog and Interface Portfolio

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

Power Management
- LDO & Switching Regulators
- Charge Pump DC/DC Converters
- Power MOSFET Drivers
- PWM Controllers
- System Supervisors
- Voltage Detectors
- Voltage References

Battery Management
- Li-Ion/Li-Polymer Battery Chargers
- Smart Battery Managers

Linear
- Op Amps
- Programmable Gain Amplifiers
- Comparators
- Linear Integrated Devices

Mixed-Signal
- A/D Converter Families
- Digital Potentiometers
- D/A Converters
- V/F and F/V Converters
- Energy Measurement ICs

Interface
- CAN Peripherals
- Infrared Peripherals
- LIN Transceiver
- Serial Peripherals
- Ethernet Controller

Analog and Interface Attributes

Robustness
- MOSFET Drivers lead the industry in latch-up immunity/stability

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
- Lowest power 12-bit ADC in a SOT-23 package

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

Space Savings
- Resets and LDOs in SC70, A/D converters in a 5-lead 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

For more information, visit the Microchip web site at: www.microchip.com

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