LM5020,LM5025,LM5030

PWM DC-DC Controllers with Built-In Start-Up Regulators Simplify Switching Power Supply Design

Literature Number: SNVA568

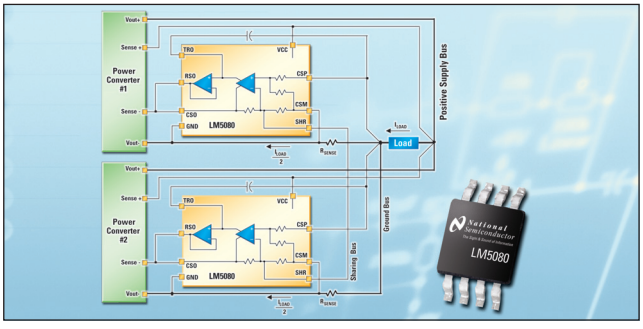
Vol. III, Issue 10

ANALOG edge℠

DESIGN idea: Simplified Power Supply Design ▶

Featured Products

Modular Current Sharing Controller



The LM5080 is a simple and cost-effective load-share controller that provides all of the functions required to balance the currents delivered from multiple power converters operated in parallel. The LM5080 implements an average program method of active load share control which adjusts the output voltage of individual power stages either up or down to deliver nearly equal currents to a common load. The average program method improves stability and reduces the output voltage tolerance when compared to other common load sharing methods. The LM5080 supports two common applications for load share controllers: external control in which the load share circuit balances currents between separate power modules (bricks), and internal control where the load share circuit is integrated into the voltage regulation loop of each power converter module or circuit.

Features

- Single-wire star link current share bus
- No precision external resistors necessary
- 3V to 15V bias voltage range
- Adaptable for high or low side current sensing
- Flexible architecture allows 4 modes of operation:
  - Negative remote sense adjustment
  - Positive remote sense adjustment
  - Trim or reference adjustment
  - Feedback divider adjustment

The LM5080 is available in MSOP-8 packaging and is ideal for use in consumer electronics, industrial test equipment, data communications systems, automotive power systems, distributed power systems, and battery-powered applications.

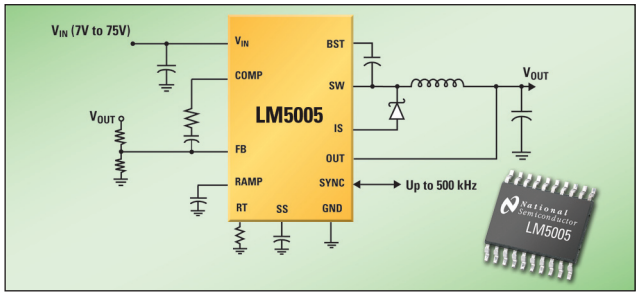
www.national.com/pf/LM/LM5080.html

First 7V to 75V Input, 2.5A Buck Regulator

The LM5005 high-voltage switching regulator features all of the functions necessary to implement an efficient high-voltage buck regulator using a minimum of external components. This easy-to-use regulator includes a 75V N-Channel buck switch with an output current capability of 2.5A. The regulator control method is based upon current-mode control utilizing an emulated current ramp. Current-mode control provides inherent line feed-forward, cycle-by-cycle current limiting, and ease of loop compensation. The use of an emulated control ramp reduces noise sensitivity of the pulse-width modulation circuit, allowing reliable control of very small duty cycles necessary in high input voltage applications. The operating frequency is programmable from 50 kHz to 500 kHz.

Features

- Integrated 75V power MOSFET supports load currents up to 2.5A
- Adjustable output voltage from 1.225V
- Unique, easy-to-use emulated peak current mode control topology enables high frequency operation at V_{IN} up to 75V
- Programmable switching frequency with bi-directional synchronization capability simplifies system design
- Highly integrated, high-speed, full-feature PWM regulator reduces overall solution size



The LM5005 is available in a power enhanced TSSOP-20 package featuring an exposed die attach pad to aid thermal dissipation. It is ideal for use in consumer electronics, telecommunications, data communications systems, automotive power systems, and distributed power applications.

www.national.com/pf/LM/LM5005.html

National Semiconductor
The Sight & Sound of Information

DESIGN idea

L. Haachitaba Mweene, Ph.D., Senior Applications Engineer
National Semiconductor

PWM DC-DC Controllers with Built-In Start-Up Regulators Simplify Switching Power Supply Design

Although PWM DC-DC switching power converters are based on simple topologies, making practical power supplies out of them requires the addition of various functions such as start-up bias, soft-start, switch driving, regulation, short circuit protection, over-voltage protection, over-temperature protection, etc. Today, most of these functions are usually implemented within a compact DC-DC PWM controller integrated circuit.

However, the problem of starting the DC-DC converter in telecom and other high-voltage applications (i.e., where the input voltage exceeds about 15V) is often not addressed. The controller requires a bias supply voltage to run from so that it can produce gate drive pulses and other required signals. But at turn-on the only voltage available is the input voltage, which, if it is greater than 15V, is typically too high to be used as the bias and gate drive supply voltage. It is therefore necessary to lower the input voltage to 15V or below to start-up the power supply. Once the supply is running, the output voltage or a voltage off of a transformer or inductor winding can be used to provide the bias supply for the IC.

But most DC-DC controllers are designed without start-up circuitry, and the power supply designer is expected to add a separate start-up circuit and a bias supply to them (***Figure 1a***).This improves the versatility of the PWM controllers, allowing them to be operated with a wider input voltage range, but the extra start-up circuitry they require increases in the complexity and size of the power supply.

National has solved this problem for the designer in its LM50xx family of 8V to 100V PWM controllers (which includes the LM5020, LM5025, LM5030, and others) by integrating a high-voltage start-up circuit within the IC (***Figure 1b***). This is achieved by fabricating the controller using a 100V process.

The high-input voltage can then be directly applied to the V_{IN} pin of the controller, which is the input to an internal linear voltage regulator. This regulator produces a voltage V_{CC} of about 8V that is used to provide start-up power to the controller. The V_{CC} voltage of the linear regulator is made externally accessible at the V_{CC} pin, for several reasons.

One reason is that the V_{CC} pin is the connection point in the linear regulator for an external output capacitor that keeps the V_{CC} voltage clean.

Another reason is that V_{CC} can serve as the power source for other low-voltage ICs in the circuit such as op amps, logic, and gate drivers.

The V_{CC} pin can also be used to reduce the power dissipation in the controller and to increase the efficiency of the power supply. LM50xx controllers will operate indefinitely off of the input voltage and the internally generated V_{CC}

Figure 1: Two Ways of Implementing a Start-Up Circuit for a PWM Controller

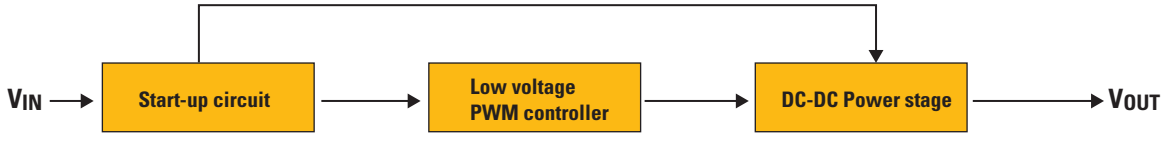


Figure 1a: Power supply built around PWM controller with discrete start-up circuit

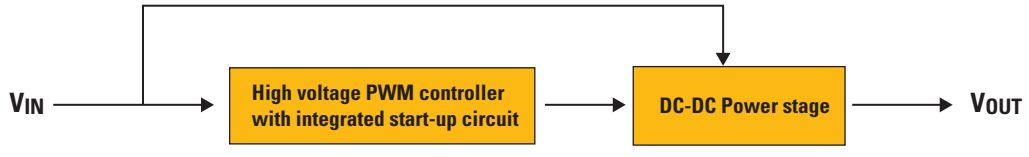


Figure 1b: Power supply built around PWM controller with integrated start-up circuit

voltage (as illustrated in ***Figure 2a*** in a flyback converter). But this leads to increased power dissipation in the IC. This dissipation is

$$PD=(V_{IN}-V_{CC})I_S$$

where I_S, the supply current of the controller is the sum of the controller quiescent current, and I_G, the frequency-dependent gate drive current. This MOSFET current is given by

$$I_G=Q_{FS}f_S$$

where Q_{GS} is the total gate charge of the MOSFET at a gate voltage of V_{CC} and f_S is the switching frequency.

P_D can be excessively large for the controller at high-input voltages, high-switching frequency, and when the IC is driving a large MOSFET that requires a significant gate-drive current.

LM50xx controllers are designed such that this power dissipation can be circumvented. In all switching power supply topologies, it is easy to derive a bias voltage from a transformer or inductor winding once the power supply has started running. In LM50xx controllers, this voltage (once available), can be applied directly to the V_{CC} pin to provide power for the IC, and can also be used to power other parts of the system. In all LM50xx controllers, if this applied voltage is greater than the 8V output of the internal regulator, the regulator shuts down, eliminating the power dissipation just described. This can lead to an efficiency improvement of 1% or more if the bias supply is properly designed. (***Figure 2b***)

Nevertheless, in lower power systems with lower input voltages it is often advantageous to dispense with the bias supply and to run the supply off of the internal linear regulator. This simplifies the supply and reduces its cost and is often used with LM50xx controllers for output power levels of up to about 30W.

Figure 2: Three Ways of Powering the LM50xx Family of PWM Controllers

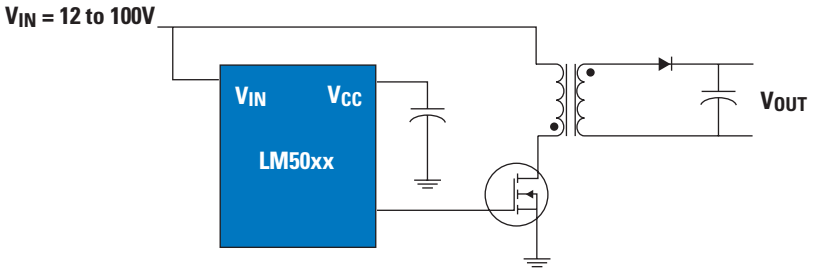


Figure 2a: PWM IC running off a high input voltage in a low power system

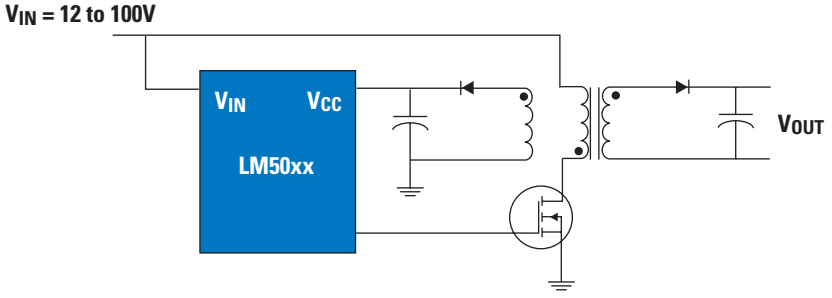


Figure 2b: PWM IC running off a bias supply in a high-power system

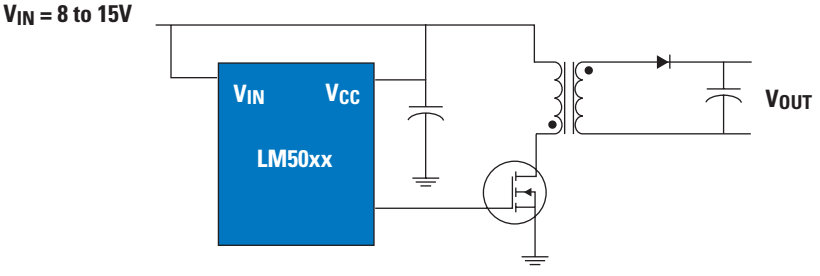


Figure 2c: PWM IC running off a low input voltage

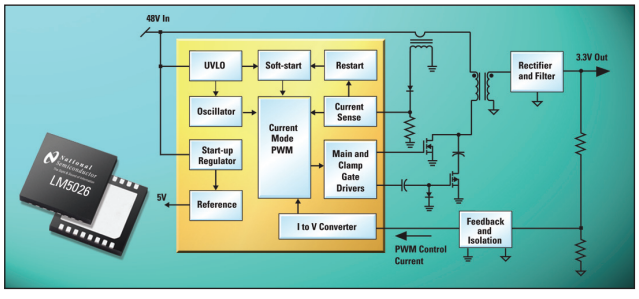
If the input voltage lies between 8 and 15V, the LM50xx controllers are particularly easy to power. The V_{IN} and V_{CC} pins can simply be tied together and to the input voltage, which then directly powers the controller. (***Figure 2c***). If the voltage exceeds 15V the two pins cannot be tied together, and the input voltage has to be higher than about 12V in order for the controller to start up.

In summary, National Semiconductor's high-voltage PWM controllers with integrated start-up regulators allow the power supply designer to reduce circuit complexity, solution size, component costs, design time, and to increase circuit reliability. ■

Featured Products

Current-Mode Controller for Forward Converters with Active-Clamp Reset

The LM5026 PWM controller contains all of the features necessary to implement power converters utilizing the active clamp/reset technique with current-mode control. With the active-clamp technique, higher efficiencies and greater power densities can be realized compared with conventional catch winding or RDC clamp/reset techniques. The device can be configured to control either a P-Channel or N-Channel clamp switch. The main gate driver features a compound configuration, consisting of both MOS and Bipolar devices, providing superior gate drive characteristics. Additional features include line under-voltage lockout, cycle-by-cycle current limit, PWM slope compensation, soft-start, 1 MHz capable oscillator with synchronization input/output capability, precision reference, and thermal shutdown.



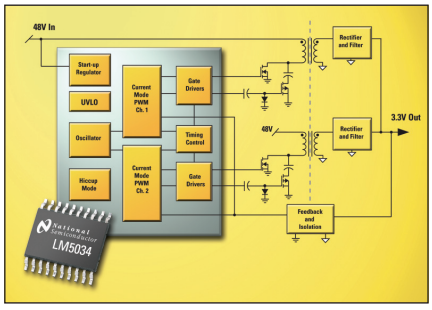
Features

- Wide range (8V to 100V) start-up bias regulator
- Two high-speed power MOSFET drivers: 3A main output driver and 1A clamp driver
- User-programmable maximum duty-cycle and UVLO hysteresis thresholds
- User-programmable gate driver overlap and dead-time
- Versatile dual-mode over-current protection with hiccup mode delay timer

The LM5026 is available in TSSOP-16 or thermally enhanced LLP-16 packaging and is ideal for use in telecommunications power systems, +42V automotive power systems, -48V distributed power systems, industrial power supplies, and multi-output power supplies.

www.national.com/pf/LM/LM5026.html

Industry's First 100V Dual Interleaved Active Clamp Current-Mode Controllers



The LM5032 and LM5034 are flexible controllers that can be configured to control either two independently regulated outputs or a single, high-current output from two primary power stages. In the first case, the two PWM channels operate 180 degrees out of phase with one another, or are interleaved, which reduces the input ripple current. In the single-output configuration, the interleaving also reduces ripple current in the output filter capacitor. The LM5032 controller can be used for designing dual-interleaved boost, flyback or standard forward converters. The LM5034 controller is specifically designed for interleaved forward converters with active clamp transformer reset.

Features

- Two independent current-mode controllers
- Interleaved single or dual output operation
- Compound 2.5A main FET gate drivers
- Active clamp FET gate drivers
- Integrated 100V start-up regulator
- Up to 1 MHz switching frequency programmed by a single resistor
- Programmable maximum duty cycle
- Adjustable soft-start and input undervoltage sensing
- Adjustable deadtime between main and active clamp gate drivers

The LM5032/34 are available in TSSOP-16 (LM5032) and TSSOP-20 (LM5034) packaging and are ideal for use in telecom infrastructure, networking, industrial, and automotive power supplies.

www.national.com/pf/LM/LM5032.html
www.national.com/pf/LM/LM5034.html

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		
	TI E2E Community Home Page		e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265