

Wide-input dc/dc modules offer maximum design flexibility

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Introduction

When a system designer specifies a nonisolated dc/dc power module, considering the needed input voltage range is equally as important as considering the required performance attributes and features. Generally, nonisolated modules have either a narrow or a wide input voltage range. Narrow-input modules typically have a nominal input voltage of 3.3, 5, or 12 V. For systems that operate from a tightly regulated input bus—such as those that do not use battery backup—a narrow-input module is often adequate since the input remains fairly stable.

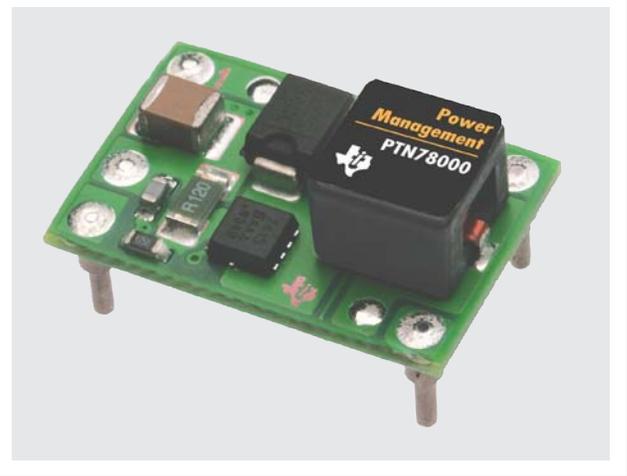
Offering greater flexibility, wide-input modules operate within a range of 7 to 36 V, which includes the popular 12- or 24-V industrial bus. This enables a single module to be used for generating multiple voltages. These modules are ideal for industrial controls, HVAC systems, vehicles, medical instrumentation, and other applications that use a loosely regulated distribution bus. In addition, systems powered by a rectifier/battery charger with lead-acid battery backup almost always require wide-input modules. System designers who choose power supplies may want to take a close look at the latest generation of wide-input dc/dc modules.

What are they?

Wide-input voltage modules are available in three basic types: positive output, positive-to-negative output, and boost output. These modules are designed to operate from a loosely regulated industrial bus input (12 or 24 V nominal) while maintaining a regulated output. Modules from the Texas Instruments (TI) PTN78 series (one of which is shown in Figure 1), for example, accept an input from 7 to 36 V and deliver an output voltage from 2.5 to 12.6 V at 1.5, 3, or 6 A. The output voltage is set with a single external resistor.

Newer wide-input modules are available in double-sided, open-frame construction to minimize cost and weight and to simplify thermal management. The modules are constructed entirely from surface-mount components (including magnetic devices) and are designed for fully automated assembly to help keep manufacturing costs as low as possible. The module's compact packaging yields significant space savings on the PC board and allows the device to be placed close to its load.

Figure 1. TI's PTN78000 module



Wide-input power modules typically integrate input and output capacitors. However, additional input or output capacitors may be needed on the host PC board if there are long input lines to the module coupled with high di/dt requirements or if very low-noise outputs are required.

Most wide-input modules feature an industrial operating temperature range of -40 to $+85^{\circ}\text{C}$. They offer efficiencies as high as 95% and can deliver their full-rated output current at temperatures of up to 60°C with only 200 LFM of airflow.

TI's PTN78 series uses large (up to 0.08-inch-diameter) interconnect pins. The large pins help extend a module's current-carrying capacity so that it requires fewer pins, which saves board space. In the pick-and-place operation during assembly, the module's pins are placed on the PC board along with its other components. This eliminates the need for a secondary pin-attach operation, simplifying assembly.

Wide-input modules also employ built-in functionality such as soft start, on/off inhibit control, current-limit protection, overtemperature protection, and an undervoltage lockout feature to prevent system failure. The devices are available in surface-mount or horizontal through-hole packages. The newer devices like the PTN78 series are designed for RoHS and lead-free compliance.

Input voltage considerations for positive step-down modules

The majority of nonisolated wide-input modules are step-down switching regulators. To keep the output in regulation, the input voltage must exceed the output by a minimum differential voltage due to the limitations of the pulse width modulation (PWM) internal control circuit. This differential voltage can be used to define the maximum advisable ratio between the device's input and output voltages.

As an example, TI's PTN78000W accepts an input from 7 to 36 V and has an adjustable output voltage range from 2.5 to 12.6 V with a single resistor, R_{SET} . Requirements for satisfactory performance of this module are as follows:

- For output voltages lower than 10 V, the minimum input voltage is $(V_O + 2\text{ V})$ or 7 V, whichever is higher.
- For output voltages equal to 10 V and higher, the minimum input voltage is $V_O + 2.5\text{ V}$.
- The maximum input voltage is $(10 \times V_O)$ or 36 V, whichever is less.

Table 1 shows the operating input voltage range for common output bus voltages.

Table 1. PTN78000W standard R_{SET} values for common output voltages

REQUIRED V_O (V)	STANDARD R_{SET} VALUE	ACTUAL V_O (V)	OPERATING V_I RANGE (V)
2.5	Open	2.5	7 to 25
3.3	78.7 k Ω	3.306	7 to 33
5	21 k Ω	4.996	7 to 36
12	732 Ω	12.002	14.5 to 36

Positive-to-negative modules

Positive-to-negative, wide-input modules are buck-boost switching regulators that accept a positive input voltage and produce a negative dc output voltage. The devices are well suited for telecom, industrial tests and measurement, instrumentation, distributed power, and general-purpose circuits.

Latest-generation modules like TI's PTN78000A provide high-efficiency, positive-to-negative voltage conversion for loads of up to 1.5 A. The module has a wide input voltage range of 7 to 29 V and an adjustable wide output voltage range of -3.3 to -15 V. The output voltage is set with a single external resistor.

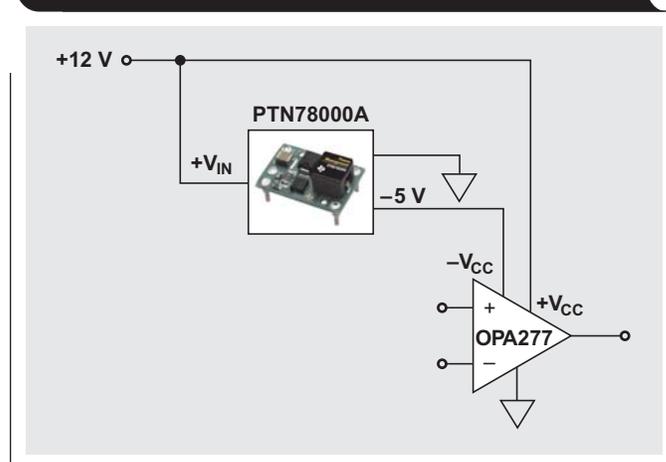
To ensure that the output remains in regulation, the input voltage must not exceed the output by a maximum differential voltage. For satisfactory performance, the maximum operating input voltage is $32 - |V_O|$. As an example, Table 2 gives the operating input voltage range for common bus output voltages.

Some operational amplifiers require positive and negative operating voltage. Figure 2 shows a PTN78000A module converting a +12-V input to a regulated -5-V output to an op amp.

Table 2. Positive step-down module standard R_{SET} values for common output voltages

REQUIRED V_O (V)	STANDARD R_{SET} VALUE	ACTUAL V_O (V)	OPERATING V_I RANGE (V)
-15	100 Ω	-14.997	9 to 17
-12	2 k Ω	-12.006	9 to 20
-5	28.7 k Ω	-5.000	9 to 27
-3.3	221 k Ω	-3.303	9 to 28.7

Figure 2. Positive-to-negative voltage conversion in an operational amplifier application



Boost modules

Boost modules provide high-efficiency, step-up voltage conversion. They generate a stable output voltage that can be adjusted by an external resistor divider. For maximum power efficiency, the integrated devices use a switching rectifier based on a PWM controller.

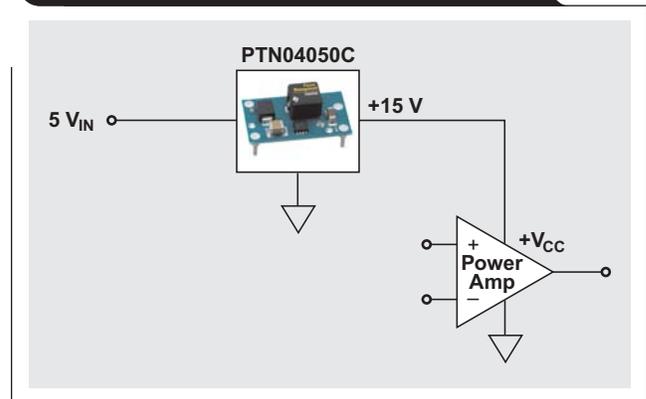
Table 3. Boost module standard R_{SET} values for common output voltages

REQUIRED V_0 (V)	STANDARD R_{SET} VALUE	ACTUAL V_0 (V)	OPERATING V_I RANGE (V)
5.0	Open	5.00	2.9 to 4.5
9.0	4.53 k Ω	9.01	2.9 to 5.5
12.0	1.33 k Ω	12.03	2.9 to 5.5
15.0	60.4 k Ω	14.99	2.9 to 5.5

TI's PTN04050C is a boost module designed for use with 3.3- or 5-V bus systems that require an additional regulated 5 to 15 V with up to 12 W of output power. The output voltage is set with a single external resistor and may be set to any value within the 5- to 15-V range. The output voltage can be as little as 0.5 V higher than the input, allowing an output voltage of 5 V with an input voltage of 4.5 V. Table 3 shows standard resistor values for several common output voltages, along with the actual output voltage that the value provides.

Target applications for boost modules include telecom, industrial tests and measurement, instrumentation, distributed power, and general-purpose circuits. With the

Figure 3. Boost module providing step-up voltage conversion for a power amplifier



ability to operate from 3.3- or 5-V bus systems, a boost module can be used together with a positive step-down module to create plus and minus voltage rails required by many analog ICs such as op amps and data converters.

The module in Figure 3 is shown operating from a +5-V input and producing a +15-V output to a power amplifier.

What's available?

The number of wide-input modules introduced to the marketplace is growing. The wide product choice facilitates precise application matching and simplifies migration to higher-current modules when needed. Table 4 lists some of the products available from TI.

Table 4. TI's wide-input, nonisolated dc/dc modules

DESCRIPTION	MODEL	INPUT VOLTAGE (V)	OUTPUT VOLTAGE (V)	OUTPUT CURRENT	PACKAGE
Positive Step-Down	PTN78000W/H	7 to 36	2.5 to 12.6/12 to 22	1.5 A	SMD, TH
	PTN78060W/H	7 to 36	2.5 to 12.6/12 to 22	3 A	SMD, TH
	PTN78020W/H	7 to 36	2.5 to 12.6/12 to 22	6 A	SMD, TH
Positive to Negative	PTN04050A	+2.9 to +7	-3.3 to -15	1 A (6 W)	SMD, TH
	PTN78000A	+7 to +29	-3.3 to -15	1.5 A (9 W)	SMD, TH
	PTN78060A	+9 to +29	-3.3 to -15	3 A (15 W)	SMD, TH
	PTN78020A	+9 to +29	-3.3 to -15	4 A (25 W)	TH
Positive Boost	PTN04050C	2.9 to 5.5	5 to 15	1 A (12 W)	SMD, TH

The ultimate in design flexibility

TI's wide-input modules provide system designers increased migration-path flexibility to accommodate evolving system power requirements. The wide-input range and output voltage combinations eliminate redesign of an existing power architecture when voltage requirements change. The following system examples show that wide-input modules are suitable for a variety of applications.

Vending machines

Wide-input modules are ideal for vending-machine applications. Vending machines connected to a wireless network help vending-machine managers perform remote diagnostics, monitor inventory levels, schedule service calls, and track real-time sales through a wireless interface. Sending data via a cell phone within each vending machine provides an instant snapshot of the user's entire vending system.

As shown in Figure 4, the wide-input modules accept the loosely regulated output (18 to 32 V) from the vending

machine's inexpensive ac/dc converter. One module is providing a 12-V/1.5-A output for the cell phone; the other is providing a 5-V/3-A output for the displays and logic PC board. Modules that can operate in an environment of -40 to +85°C are ideal for vending equipment that is placed outdoors and are effective for embedded applications in industrial and other challenging environments.

Security cameras

Wide-input modules simplify power management in security cameras. Figure 5 shows a typical power-management circuit powered by a wall-mount ac/dc adapter. A 24-V battery is used to provide emergency backup power. Because of the wide output voltage tolerance of the 24 V from the ac/dc adapter, the circuit requires dc/dc modules capable of operating over a wide input voltage range.

The wide-input modules in Figure 5 are shown operating from a 24-V input. One module is providing a 12-V output to a motor control circuit for the camera's focus and zoom

Figure 4. Vending-machine application

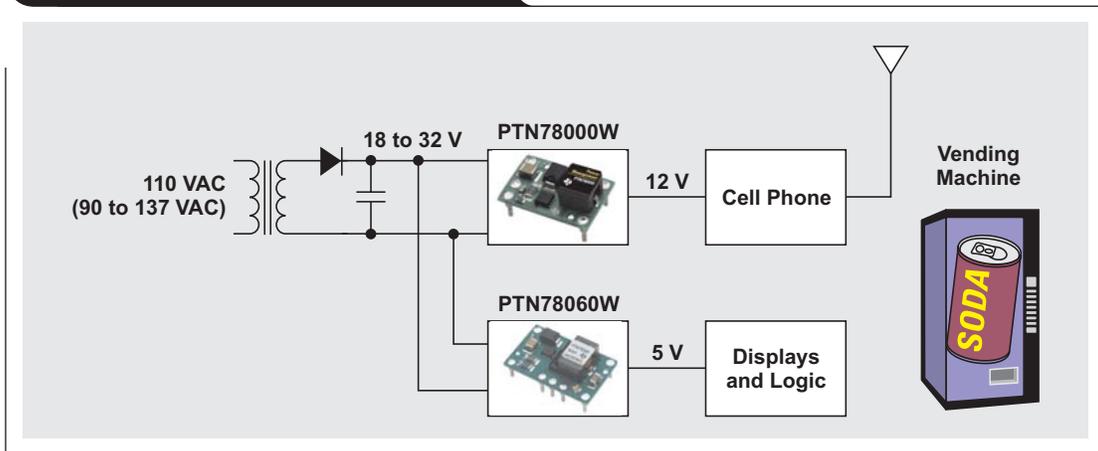


Figure 5. Security-camera application

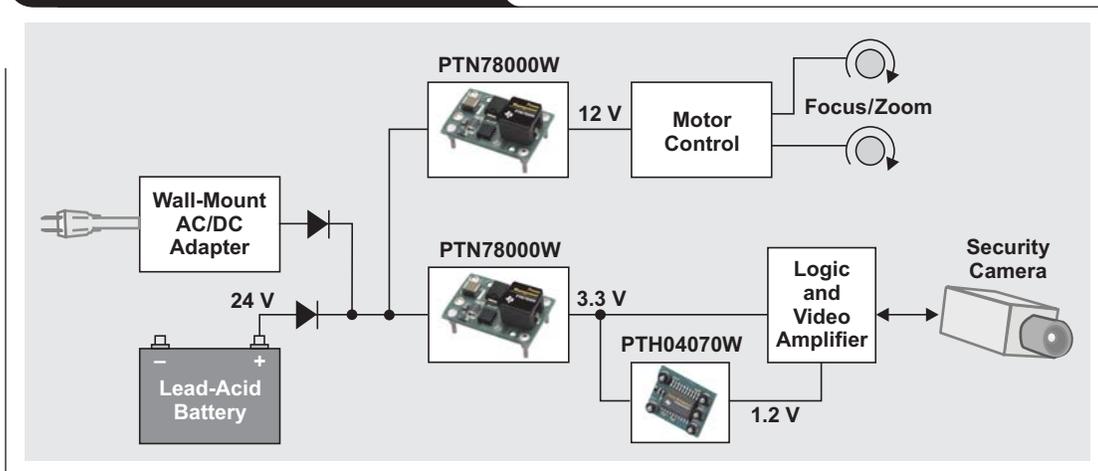
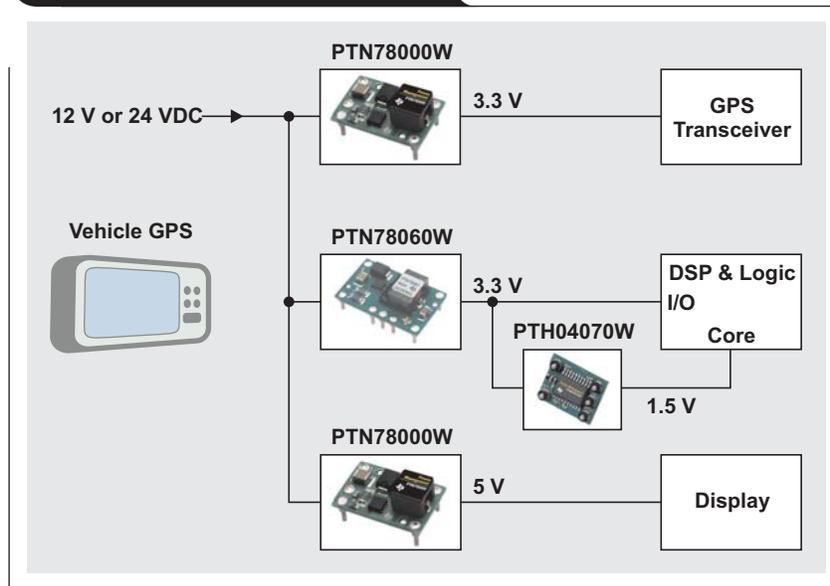


Figure 6. Vehicle GPS application

functions. The other module is providing a 3.3-V output to a video amplifier and a nonisolated module, which is producing a 1.2-V output for a DSP's core voltage.

Vehicle GPS systems

Wide-input modules provide high-efficiency, step-down voltage conversion for a wide variety of vehicle GPS navigation systems. Aftermarket dash-mount GPS systems such as those from Garmin, Magellan, and other manufacturers are popular applications. There are also marine GPS systems and golf carts that use GPS-based range finders. More advanced applications include commercial truck and rail-car monitoring systems. These small, self-contained units, about the size of a paperback novel, have no display. They consist of a black box that enables a central tracking center to monitor the position of entire fleets or rail cars.

As shown in Figure 6, vehicle GPS systems need to be powered by either 12 V (in a car) or 24 V (in a truck or bus). One module provides a 3.3-V/1.5-A output to a GPS transceiver and a 5-V/1.5-A output to the LCD display. The other module provides a 3.3-V/3-A output for the DSP's I/O voltage. It also powers a nonisolated module that delivers a 1.5-V/3-A output for the core voltage.

Purchasing flexibility

The commercial availability of wide-input modules offers purchasing flexibility. Leading distributors provide samples and production quantities in volume for quick design qualification or last-minute changes. Numerous output

voltage and current combinations as well as package options are offered.

Large OEMs prefer to work with a small base of approved suppliers to keep costs down. With a wide input voltage range and adjustable output, one module can be used in a variety of applications. Using fewer modules reduces the number of parts that OEMs must keep in stock.

Summary

System designers are employing increasing numbers of nonisolated dc/dc power modules in their designs. Wide-input, nonisolated modules provide precise power at the load and a great deal of flexibility, helping system designers cope with changes in power requirements. These modules provide all the active functions for local dc/dc conversion with fast transient response and accurate regulation in the smallest possible PC board area. Their wide operating voltage range makes them ideal for industrial, battery-powered, and advanced computing and server applications that use a loosely regulated distribution bus.

Related Web sites

power.ti.com

www.ti.com/sc/device/partnumber

Replace *partnumber* with PTH04070W, PTN04050A, PTN04050C, PTN78000A, PTN78000H, PTN78000W, PTN78020A, PTN78020H, PTN78020W, PTN78060A, PTN78060H, or PTN78060W

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