P O W E R DESIGN FAQs

Frequently Asked Questions:

PULSE-WIDTH MODULATION

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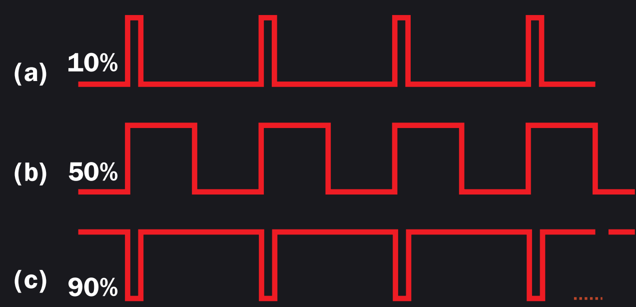
Why PWM?

Switch-mode converters employ a power semiconductor switch (usually a MOSFET) to drive a magnetic element (transformer or inductor) whose rectified output produces a dc voltage. Efficiencies exceeding 90% are common, about twice that of a linear regulator.

A switch-mode converter varies its dc output current in response to load changes. One widely used approach is pulse-width modulation (PWM), which controls the power switch output power by varying its ON and OFF times. The ratio of ON time to the switching period time is the duty cycle. Figure 1 shows three different variations of the PWM duty cycle: 10%, 50%, and 90%. The higher the duty cycle, the higher the power semiconductor switch output power.

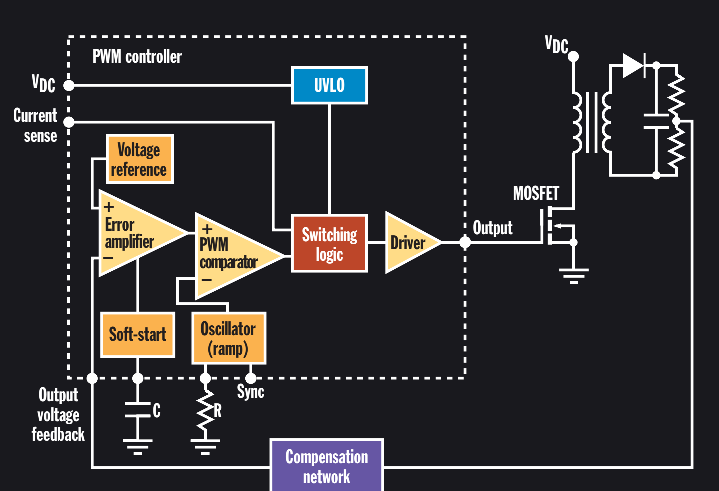


1. PWM signals for 10% (a), 50% (b), and 90% (c) duty cycles. The maximum duty cycle for most available PWM ICs is usually from 50% to 100%.

What is the configuration of a PWM circuit?

Figure 2 shows a simplified PWM controller employed in a switch-mode converter. In operation, a fraction of the dc output voltage feeds back to the error amplifier, which causes the comparator to control the PWM ON and OFF times. If the power MOSFET's filtered output changes, the feedback adjusts the duty cycle to maintain the output voltage at the desired level.

To generate the PWM signal, the error amplifier accepts the feedback signal input and a stable voltage reference to produce an output related to the difference of the two inputs. The comparator compares the error amplifier's output voltage with the ramp (sawtooth) from the oscillator, producing a modulated pulse width. The comparator output is applied to the switching logic, whose output goes to the output driver for the external power MOSFET. The switching logic provides the capability to enable or disable the PWM signal applied to the power MOSFET.



2. This simplified circuit shows the main components of a typical voltage-mode PWM controller IC. Because the PWM IC is a part of feedback circuit, the input to the error amplifier must employ a frequency-compensation network to ensure system stability.

What is the difference between voltage- and current-mode PWM controllers?

The circuit shown in Figure 2 is a voltage-mode PWM controller in which the error amplifier output is compared to a voltage ramp from the oscillator to determine the output pulse width. A current mode PWM replaces the oscillator ramp with a ramp that is proportional to the current in the magnetic element.

What is the UVLO circuit?

The undervoltage-lockout (UVLO) circuit sets the operational dc input voltage range of the PWM controller. There are two UVLO thresholds. When the UVLO turn-on threshold is exceeded, the PWM controller turns ON. If dc input voltage falls below the UVLO's turn-off threshold, the PWM controller turns off.

What output configurations are available? PWM controllers may have single-ended or dual outputs. Dual output types are intended for either push-pull, bridge, or synchronous rectifier MOSFETs. In these configurations, the PWM controller must either accurately set the two outputs dead time or prevent their overlap. If both outputs were allowed to be ON simultaneously it would increase power dissipation and EMI. Some PWM controllers include special circuits to control dead time or overlap.

Why use current sensing?

Most PWM controller ICs provide current-limiting protection by sensing the output current. If the current-sense input exceeds a specific threshold, it terminates the present cycle (cycle-by-cycle current limit).

Circuit layout is critical when using a current-sense resistor, which must be a low inductance type. Locate the capacitor associated with the current-sense filter capacitor very close to, and connected directly to, the PWM IC pin. Also, all the noise-sensitive, low-power ground connections should be connected together near the IC GND, and a single connection should be made to the power ground (sense resistor ground point).

What sets the PWM frequency?

In most PWM controller ICs, a single external resistor or capacitor sets the oscillator frequency. To set a desired oscillator frequency, use the equation in the controller datasheet to calculate the resistor value.

Can the PWM frequency be synchronized to an external clock?

Some PWM converters include the ability to synchronize the oscillator to an external clock with a frequency that is either higher or lower than the frequency of the internal oscillator. If there is no requirement for synchronization, connect the sync pin to GND to prevent noise interference.

What is the purpose of the soft-start circuit?

The soft-start feature allows the power converter to gradually reach the initial steady state operating point, thus reducing start-up stresses and surges. In most PWM ICs an external capacitor establishes the soft-start time. ED Online 8242

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PRODUCT Q&As

Active-Clamp-Voltage-Mode PWM Controller

National Semiconductor's LM5025 PWM controller can be configured for power converters with either a p-channel clamp switch or an n-channel active clamp switch. This active clamp technique provides higher efficiencies and greater power densities than conventional catch winding or RDC clamp/reset techniques. It has two control outputs: main power switch control and active clamp switch. The active clamp output can set either a guaranteed overlap time for a p-channel switch or a guaranteed deadtime for an n-channel switch. The LM5025 is available in TSSOP-16 and LLP-16 packages.

100-V Current-Mode PWM Controller

Employing current-mode control, the LM5020 high-voltage PWM controller eases loop compensation design while providing inherent line feed-forward. Its oscillator frequency range is 1 MHz and total propagation delays are less than 100 ns. The LM5020-1 has an 80% maximum duty cycle and slope compensation. The LM5020-2 has a 50% maximum duty cycle. MSOP-10 and LLP-10 packages are available.

100-V Push-Pull and Bridge PWM Controllers

National's LM5030 (MSOP-10) and LM5033 (thermally enhanced LLP-10) high-voltage PWM controllers contain all the features needed to implement push-pull and half-/full-bridge topologies. Applications include closed-loop current-mode converters with a highly regulated output voltage, or an open-loop "dc transformer" such as an Intermediate Bus Converter (IBC) with an efficiency of greater than 95%. Both controllers include a start-up regulator that operates over a 15- to 100-V input range, and they contain two alternating gate-driver outputs with guaranteed deadtime.

Cascaded PWM Controller

National's LM5041 PWM controller can configure either current-fed or voltage-fed buck, push-pull or bridge power converters. Push-pull outputs operate at 50% duty cycle at one-half the switching frequency of a buck stage. A unique timer provides either overlap time in current-fed applications or dead time for voltage-fed applications. Push-pull MOSFETs can operate directly from internal 1.5-A gate drivers, while the buck stage uses the LM5100 high-voltage gate driver. Includes 15- to 100-V start-up regulator.

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