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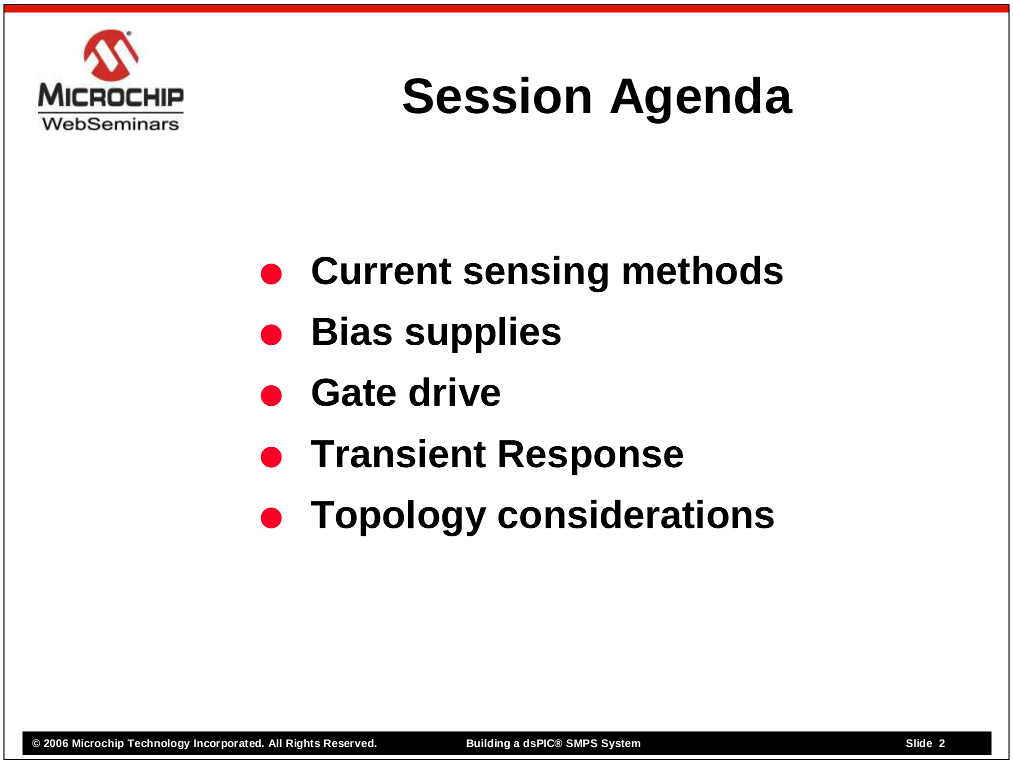
Building a dsPIC® SMPS system

Welcome to the Building a SMPS dsPIC System Web seminar



This is the agenda for this course.

We will cover a wide variety of issues that arise during the design of a switch mode power supply, including:

Methods for sensing current, bias supplies, gate drive issues, transient response, and how topology choices affect system design.

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Current Measurement Techniques

- Resistor
- Current Transformer
- Hall Effect
- Inductor
- MOSFET Voltage Drop
- Sense FETs

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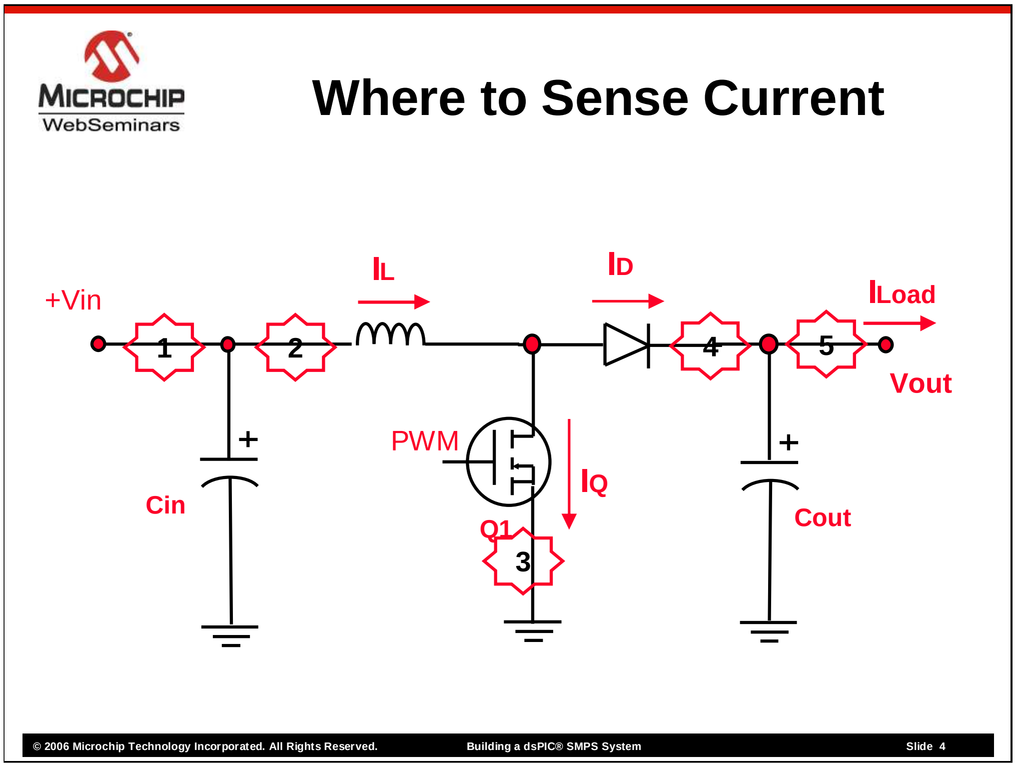
Resistors are the most common and lowest cost method for current sensing. Typically a low ohmage resistor (10 – 100 milliohms) is inserted in the current path, and the voltage drop across the resistor is measured and the current is computed. This method dissipates power, reduces the system efficiency, and the associated voltage drop can affect output voltage regulation. If the measured node is at high voltage potential, then additional circuitry may be required for voltage translation.

A current transformer is a transformer where a low resistance primary winding is placed in series with the current path. The transformer provides voltage translation and scaling, but it can not be used for DC currents. The transformer is also bulky and may be expensive.

The Hall Effect sensor has a coil that is placed in series with the current flow and a Hall effect sensor and amplifier. The Hall Effect sensor can monitor AC and DC currents but these sensors are very expensive.

Inductor current sensing can done by monitoring the voltage across the inductor's resistance. Slow because of required filtering.

The MOSFET has an intrinsic source to drain resistance Rds(on). The voltage drop across the MOSFET is an indication of the current flow. The Rds(on) value varies from device to device and with temperature. This method does not provide for high accuracy. The Sense FET is a FET that has an extra terminal for sensing the voltage across a small subsection of the FET. It has the same issues with temperature and unit variations.



In this Boost Converter example, we show the possible locations where current can be measured in a SMPS circuit and the associated advantages and disadvantages of each choice.

1. Measuring average input current has little benefit.

2. Measuring inductor current is very useful in current mode control, but the high common mode voltage at this node (2) requires circuitry for level shifting for use by the controller.

3. Peak inductor current can be measured at this node just before the transistor is turned off. This location has the advantage that this node is close to ground potential which minimizes current sense circuitry complexity.

4. Peak inductor current can be sensed at Node 4, but like node 2, a high common mode voltage exists which can complicate the current sense circuitry.

5. The load current is measured at node 5. Because the capacitor also supplies current to the load, this node is not a useful point to measure current for traditional current mode control systems. This location is a good point to measure current for load sharing, and it is also a great place to monitor load current transients for modern digital power converter control systems. Classical control systems are limited in their response time by the inductor and output capacitor. The SMPS dsPIC can immediately detect load transients at the output.

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Bias Supply

- Bias Supply provides power to PWM controller and transistor drivers.
- Bias supply options:
  - Linear regulator(s)
  - Switch mode regulator
  - Boot Strap

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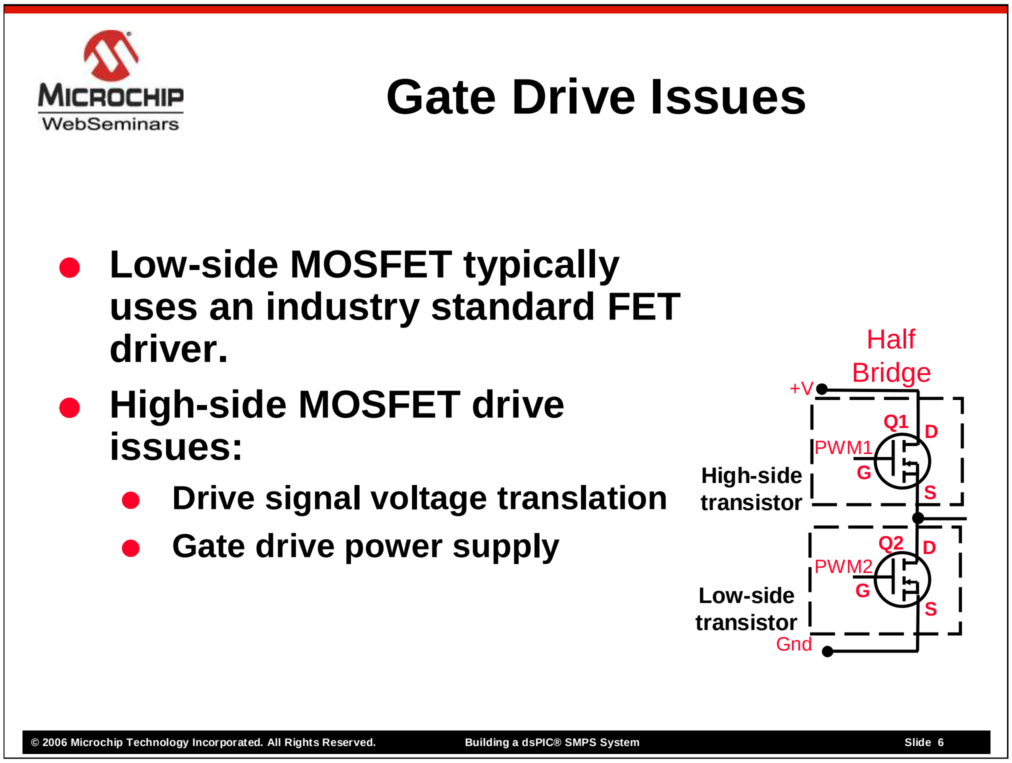
The bias supply is the power supply for the power supply controller and transistor drive circuitry.

The simplest approach is to use three terminal linear regulators to regulate the input supply voltage down to the voltage required for the controller. Most linear regulators have a limited input voltage range, typically 25 to 30 volts is the maximum input specification. Power dissipation becomes a problem with high voltage inputs. The bias supply may dissipate more power than the entire supply !

Multiple voltage requirements, one for the controller, an another for the MOSFET gate drivers further complicates the design of the bias supply.

Small switch mode voltage regulators are available for supplying low power (< 2 watt) that are designed to operate with input voltages of 380 VDC. These devices are often designed to operate with a small transformer. The transformer enables multiple bias supply voltages to be obtained inexpensively with multiple output windings.

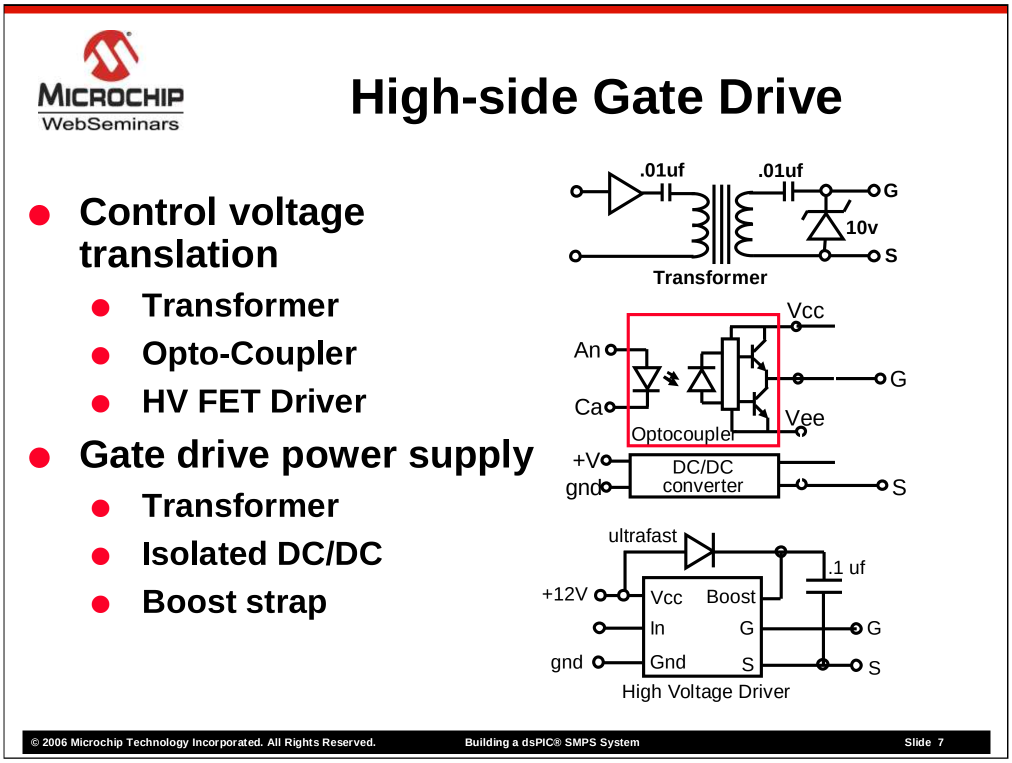
The boot strap approach uses a linear regulator just to supply power for a few moments. When the controller begins operating, a transformer winding, or a buck converter provides power to operate the pwm control circuitry, and the linear regulator is turned off. This approach can be very cost effective and efficient.



The gate drive for low-side transistors, where the source terminal is tied to the controller's ground (Vss) pin, is easily implemented with an industry standard FET driver such as Microchip's TC442x family of devices.

The high-side transistors in bridge circuits, buck converters, buck-boost converters, and two-transistor forward converters present a couple of issues: translating the gate control signal up above the source pin voltage, and providing a floating power supply to the gate drive circuit.

In some low voltage (< 20V) high-side applications, P-channel MOSFETs can be used to ease the difficulty of driving the high side transistors. In higher voltage applications, p-channel devices encounter the same gate drive issues as n-channel devices.



High speed optocouplers can provide thousands of volts of isolation between its inputs and outputs. But optocouplers are expensive and slow with propagation times of 100 nsec to 1 microsecond. They require a power source to run the gate driver circuitry such as small DC/DC converters. These DC/DC converters, available in small SIP packages, add cost. The advantage of optocouplers is that they can provide any duty cycle ratio and their operation is independent of the operation of the power supply, a handy feature when debugging a system.

High voltage gate drivers are expensive but offer a wide range of operating speeds, 30 nsec to 900 nsec. They use a high voltage silicon process to perform signal voltage translation. The high voltage drivers use a boot-strap voltage supply to supply power for the gate drive circuitry. The boot-strap circuit requires the transistors to be switching, and there are dutycycle and frequency limitations.

The transformer coupled high-side driver is the lowest cost circuit and can operate up to 500 KHz. The transformer based driver has the advantage that the transformer can couple energy as well as the control signal. Transformers operate on a constant volts-seconds basis so that narrow pulse widths create voltage spikes, and extremes of duty cycle ratios are difficult to support.

Key Support Documents

Device Selection Reference	Document #
General Purpose and Sensor Family Data Sheet	DS70083
Motor Control and Power Conv. Data Sheet	DS70082
dsPIC30F Family Overview	DS70043

Base Design Reference	Document #
dsPIC30F Family Reference Manual	DS70046
dsPIC30F Programmer's Reference Manual	DS70030
MPLAB® C30 C Compiler User's Guide	DS51284
MPLAB ASM30, LINK30 & Utilities User	DS51317
dsPIC® Language Tools Libraries	DS51456

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For more information, here are references to some important documents that contain a lot of information about the dsPIC30F family of devices.

The Family Reference Manual contains detailed information about the architecture and peripherals, whereas the Programmer's Reference Manual contains a thorough description of the instruction set.

Key Support Documents

Microchip Web Sites: www.microchip.com/smps
www.microchip.com/16-bit

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For device data sheets, Family Reference Manuals, and other related documents please visit the following Microchip websites.

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 Advanced Power Supply Topics Slide 10

If you have stayed this far in the presentation you have some idea which of our 16-bit families are best suited to your application. You also have some idea what software and resource are available to assist with your design.

Finally your are probably interested in the PIC24F family which will help to keep me busy. SO , Thank you for your time and I hope our 16-bit families can help with your next designs.