Digitally Enhanced Analog Power Control
Agenda

- Digital Power Benefits
- Paying the Price for Digital Power
  - Has this limited the growth?
- Bridging the Gap from Analog to Digital or Digital to Analog?
- Introducing Digitally Enhanced Power Analog Solutions “DEPA”
- DEPA Applications
  - POL, LED Lighting, Battery Chargers and Intelligent DC/DC Converters
- Demo’s
Digital Power Benefits

- Communication
- Flexible Configuration
  - UVLO, Startup, Shutdown
- Flexible Fault Handling
  - Over-Current, Over Voltage, Short Circuit
- Intelligent
  - Adapts to Changing Environments
  - Adapts to different Loads
- Reports Status and Diagnostics
- Increases Integration?
Price of Digital Power

- What’s the cost?
  - Complexity, Speed and Integration
- Sense $V_{\text{OUT}} / I_{\text{PK}} / V_{\text{IN}}$?
- Dynamic Performance / Transient Response
- A/D Sampling Speed
- Hardware PWM Resolution
  - Example
- Is Digital Control Digital Power?
- Digitally Enhanced Power Analog
  - Analog Power Drawbacks
What is Digitally-Enhanced Power Analog?

In Power Conversion Control…

**Digital Control**

Techniques

- PWM Generator Peripheral
- Controller - MCU (Coefficients & Operating Set point)
- A/D Conv.
- MOSFET Driver
- "Digital" Control

**Analog Control**

Techniques

- PWM Comp.
- Error Amp
- Compensator
- Controller
- V_{REF}
- MOSFET Driver
- V_{FB}
- Comp
- "Analog" Control
Digital Loop Closure
Digital Loop Closure

- Digital Control

V_s \rightarrow \text{Power Stage} \rightarrow \text{LC Filter} \rightarrow V_o

\mu C/DSP

Clock \rightarrow \text{DPWM} \rightarrow \text{Signal Processor} \rightarrow \text{ADC} \rightarrow \text{Scale}

Comm.

House Keeping
Digital Control

PWM Output → DPWM → Signal Processor → ADC → Analog Input

Quick real time
Quick High precision
Digital Control

- **Analog-to-Digital Converter**
  - Produces digital data that represents output voltage and/or current
  - Resolution and ADC reference voltage set the precision to which the output can be maintained
    - Finite resolution leads to quantization effects
Digital Control

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**Digital Pulse Width Modulator**

- Performs same drive signal generation as its analog counterpart
- Does so by “calculating” and then “timing” the desired ON and OFF periods
  - Finite resolution leads to quantization effects
Digital Control

- **Quantization Effects - A digital phenomenon**
  - Analog control provides “infinite” resolution
    - Limited by loop gain, thermal effects, and system noise
  - Digital control provides a finite set of discrete “set points” resulting from the resolution of the “quantizing elements” in the system
    - Two elements in this represented example: ADC and DPWM
● **Quantization Effects - ADC**

- Resolution is defined as the number of states that can be uniquely represented
  - n bit resolution can assume $2^n$ states
- ADC resolution ensures that the set point tolerance can be met

**Example:**

$V_O = 3.3V \pm 1\%$

Required resolution $= \Delta V_O = 1\%$

ADC bits required $= n$

$= \text{int} \left[ \log_2 \left( \frac{V_O}{\Delta V_O} \right) \right]$

$= \text{int} \left[ \log_2 (100) \right] = 7$
Digital Control

- Quantization Effects - ADC

Low ADC Resolution and Speed

High Signal Distortion

Signal Reconstruction

High ADC Resolution and Speed

Low Signal Distortion
Digital Control

- Quantization Effects - DPWM
  - Minimum required number of DPWM states equals $2^{n+1}$
    - If less, the system will appear to hunt for a stable output value
  - System clock sets the maximum number of bits that can be generated in a fixed time period

Example 1:
- ADC Resolution = 7
- Required DPWM resolution = 8
- Desired switching frequency = 1MHz
- Required system clock = $1\text{MHz} \times 2^8 = 256\text{MHz}$!!

- Maximum switching speed = $30\text{MHz} / 2^7 = 234\text{kHz}$
Digital Control

“Control” Law Processor

- Typically a PI or PID (Proportional Integral Derivative) style
  - Controls dc level and dynamic response characteristics of the control loop
  - Represented as mathematical coefficients; manipulated to adjust system performance
- Translates digital representation of output voltage into pulse duration (duty cycle) information used by the DPWM
- Does not affect the resolution of the system
Digital Control

- **Advantages**
  - “Tunable” system on-the-fly
  - Independent of thermal drift, aging, and component tolerance limitations
  - Precise control loop related parameters

- **Disadvantages**
  - Quantization errors
  - Limited system switching frequency
Has Digital Control Slowed the Adoption of Digital Power?

● “Non-Digital Power Applications”
  ● Point of Load Converters
    ● Limited in Power, Size, Cost and Efficiency are highly valued
  ● DC/DC LED Drivers
    ● Application Drives Feature Set
    ● Dimming / Diagnostics / Binning / Temp Comp
  ● DC/DC Battery Charging
    ● Intelligence, Programmability, Wide Range of Power
  ● “Smart DC/DC Converters”
Bridging the Gap

● What’s Wrong with Analog Solutions?
   ● No Flexibility
   ● No Adaptability
   ● No Communication

● No Intelligence…
Adding Intelligence to Analog

- Unique Technology
- Design Tools / Programmers
- PIC Micro…Mid Range Core Versatility
- Add Analog Process
  - Different than Digital Process
- Add High Voltage Capability
- Add NDMOS for Efficiency
- Add Proprietary Integrated Features
Digitally Enhanced Power Analog Controller with Integrated Synchronous Driver
Digitally Enhanced Power Controller
Basic Solution Architecture

Digitally-Enhanced Power Analog

**MCU**

- GPIO
- ADC
- Comm Interface

**Analog Controller/Driver**

- Internal Bias Supply
- Error Amp
- Synchronous, High-Side/ Low-Side MOSFET Driver
- Current Sense
- Compensation Network

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Synchronous Buck Topology

- $V_{IN}$
- $V_{OUT}$
MCP19111 Synchronous Buck
High/Low-Side Topology Support

Digitally-Enhanced Power Analog

- Analog Controller/Driver
  - 5V Bias Supply - Internal
  - Internal/External 5V Bias Supply
  - High-Side Driver (w/ level shifter)
  - High-Side Deadtime Adjustment
  - Low-Side Driver
  - Low-Side Deadtime Adjustment
  - Hardware Protection (UVLO/DVLO/Ilim/etc...)
  - Current Sense
  - Internally Adjustable Compensation
  - Calibration/Scaling
- Setpoints
- + EA
- 8-bit
- MCU PIC12F Core
- 8-bit Flash Mem 4k word
- RAM 256B
- GPIO
- I2C Comm
- ADC

V_IN
Synchronous Buck Topology

V_OUT

5V Bias Supply - External (25mA)
Boo Supply
High-Drive Logic Level
Phase
Low-Drive, Logic Level
Differential Current Sense
Differential Voltage Sense

Calibration/Scaling
Vref

Microchip Technology Inc.
MCP19111
Digitally Enhanced Power Analog Controller

Single Phase Synchronous Buck
- $V_{IN}$ Range: 4.5V to 32V
- $V_{OUT}$ Range: 0.5V to 3.6V
  - Greater with output divider
- Coarse and Fine $V_{REF}$ DAC
- Integrated MOSFET Driver:
  - Logic-Level Drive (5V)
  - 2A Source/4A Sink Drive Current
- Programmable Analog Controller:
  - Switching Freq: 100kHz to 1.6MHz
  - Analog Control: Control Loop Compensation, Slope Compensation, Peak Current Limit (Level & LEB Delay), Gate Drive Deadtime
  - Thresholds: $V_{IN}$ UVLO, $I_{OUT}$ CS Amp Gain, Soft-Start Rate, $V_{OUT}$ Setpoint, $V_{OUT}$ Trim, $V_{OUT}$ OV/UV,
  - Measure: $V_{IN}$, $V_{OUT}$, Internal Temp + 8 Ext Ch
  - Master/Slave Mode $\rightarrow$ Multi-phase operation
- Programmable Digital Core:
  - Midrange Core (2 MIPS), 4kW Self-Write Flash, 256B RAM
  - (2) 16-bit Timers, (1) 8-bit Timer, (1) PWM, 12 GPIO
  - MSSP w/Enhanced PMBus Support

Microchip Technology Inc.
Device Communication
MCP19111 Communication

- I²C™ Communication
  - Open drain clock and data lines
- SMBus Alert Pin
  - GBP4 open drain pin
- Two address registers
  - Device specific address register
  - SMBus alert address register
    - When activated, device will respond to either address
- Have a PMBus stack in the MPLAB X project
MCP191111 Calibration
Calibration Words

● 16 Calibration words at 2080h-208Fh

● Read only, they are not erased with program memory.

● Contains calibration for amplifier offsets, band gap, temperature measurement, oscillator, output differential amplifier.

● Calibration words 2080h to 2083h need to be moved to specific SFRs.

   ● DOVCAL, OSCCAL, VROCAL, BGRCAL, TTACAL, ZROCAL
# Calibration Word Read Example

## REGISTER 4-3: CONFIG – CALIBRATION WORD 1 (ADDRESS: 2080h)

<table>
<thead>
<tr>
<th>U-0</th>
<th>U-0</th>
<th>R/P-1</th>
<th>R/P-1</th>
<th>R/P-1</th>
<th>R/P-1</th>
<th>U-0</th>
<th>R/P-1</th>
<th>R/P-1</th>
<th>R/P-1</th>
<th>R/P-1</th>
<th>R/P-1</th>
<th>R/P-1</th>
<th>R/P-1</th>
<th>R/P-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DOV3</td>
<td>DOV2</td>
<td>DOV1</td>
<td>DOV0</td>
<td></td>
<td>FCAL6</td>
<td>FCAL5</td>
<td>FCAL4</td>
<td>FCAL3</td>
<td>FCAL2</td>
<td>FCAL1</td>
<td>FCAL0</td>
<td></td>
</tr>
</tbody>
</table>

**bit 13**

**V\text{OUT}** Differential Amp Offset

**Oscillator Calibration**

**197h**

**OSCCAL**

**198h**

**DOVCAL**

**199h**

**TTACAL**

**19Ah**

**BGRCAL**

**19Bh**

**VROCAL**

**19Ch**

**ZROCAL**

**19Dh**

**19Eh**
Calibration Word Read Example

```assembly
banksel PMADR
movlw 0x20
movwf PMADR ; MS Byte of Program Address to read
movlw 0x80
movwf PMADL ; LS Byte of Program Address to read
bsf PMCON1, CALSEL
bsf PMCON1, RD ; Program Memory read
nop ; First instruction after memory read executes
nop ; instruction here is ignored as memory is read
;nop ; in 2nd cycle after read

movf PMDATH, W ; W = MS Byte of Program Memory
banksel DOVCAL
movwf DOVCAL ; Move W to DOVCAL

banksel PMDATL
movf PMDATL, W ; W = LS Byte of Program Memory
banksel OSCCAL
movwf OSCCAL ; Move W to OSCCAL
```
MCP19111
Bench Test Mode

- Ability to look at internal signals
  - 17 different circuit nodes
  - Multiplexer and buffer
  - BUFFCON register controls signals
  - Alternate GPIO pin function
bit 4-0  ANSEL<4:0>: MUX Control bits
00000 = Voltage proportional to current in the inductor
00001 = Demanded current plus the added slope comp ramp
00010 = Input to current loop, output of the demand mux
00011 = Band gap reference
00100 = Reference voltage for the VREG output
00101 = Internal version of the VREG output
00110 = RE_FRACT_PART
00111 = Analog voltage proportional to internal temperature
01000 = Internal ground of current measurement circuitry
01001 = Reference for over voltage comparator
01010 = Reference for under voltage comparator
01011 = Output of the error amplifier
01100 = Demanded current from remote master
01101 = Demanded current modified by the slave gain amplifier
01110 = 1/12 divided down VIN
01111 = DC Inductor Current
11101 = OC Reference
Minimal Register Configuration
; Configuring the switching frequency
banksel T2CON
clrf T2CON
clrf TMR2
clrf PWMPHL ; no phase shift
movlw 0x13
movwf PWMRL ; max allowed duty cycle ~ 75%
movlw 0x19
movwf PR2 ; switching frequency ~ 300kHz
bsf T2CON, 2 ; enable Timer2

; Configuring analog SFRs
banksel VINLVL
movlw 0x9A
movwf VINLVL ; set UVLO to about 11V
movlw 0x88
movwf DEADCON ; set driver dead time
movlw 0x0D
movwf CMPZCON ; set compensation values
movlw 0x32
movwf DEADCON
movlw 0x05
movwf SLPCRCON ; set slope compensation
movlw 0x71
movwf OVCCON ; set Vout = 1.8V
movlw 0x80
movwf OVFCON ; enable Vout DAC
movlw 0x80
movwf VZCCON
movlw 0x80
movwf VZCCON

; Configuring the device
banksel PE1
clrf PE1
movlw b'00001001'
movwf ABECON ; enable current measurement & control loop

banksel VZCCON
movlw 0x80
movwf VZCCON

banksel ATSTCON
bcf ATSTCON, 0 ; enable driver
## MCP19111 Design Analyzer

### Input Parameters for Design

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designator</th>
<th>Value</th>
<th>Units</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage</td>
<td>$V_{IN}$</td>
<td>12</td>
<td>V</td>
<td>$4.5 \leq V_{IN} \leq 30$</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>$V_{OUT}$</td>
<td>1.8</td>
<td>V</td>
<td>$0.6 \leq V_{OUT} \leq 3.6$</td>
</tr>
<tr>
<td>Output Current</td>
<td>$I_{OUT}$</td>
<td>30</td>
<td>mA</td>
<td>$0 \leq I_{OUT} \leq 30$</td>
</tr>
<tr>
<td>Switching Frequency</td>
<td>$F_s$</td>
<td>300</td>
<td>kHz</td>
<td>$100 \leq F_s \leq 1200$</td>
</tr>
<tr>
<td>Input Voltage Ripple</td>
<td>$V_{RIN}$</td>
<td>100</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Minimum Input Voltage</td>
<td>$V_{IN,MIN}$</td>
<td>9</td>
<td>V</td>
<td>$4.5 \leq V_{IN,MIN} \leq V_{IN}$</td>
</tr>
<tr>
<td><strong>Step Load Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Output Current</td>
<td>$I_{OH}$</td>
<td>7.5</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Low Output Current</td>
<td>$I_{OL}$</td>
<td>2.5</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Output Voltage Overshoot</td>
<td></td>
<td>100</td>
<td>mV</td>
<td></td>
</tr>
</tbody>
</table>

Use Default EVAL Board Components and Compensation

Use Recommended Components and Compensation

![Step Load Diagram](image)
MCP19111 Programming GUI

The diagram illustrates the connection between the MCP19111 Plugin and the MCP19111 Project through Read/Write sources. The MCP19111 Plugin is connected to MPLAB X GUI, which in turn connects to the MCP19111 Project. This setup facilitates the programming and monitoring of the MCP19111 part.
Digitally Enhanced Power Analog Applications
Point of Load or “POL”

- 5V to 24V Inputs
  - Low $V_{\text{OUT}}$, High $I_{\text{OUT}}$ Applications
  - Memory, Processors, FPGA, etc..
  - Small Geometries (sub 1.8V Power)
  - Current from 3A to 30A+
MCP19111 Eval Board and POL Converter Board

- $V_{IN} = 6V$ to $16V$
- $I_{OUT} = 30A$ with airflow
- $F_{SW} = 100kHz$ to $1.2MHz$

**Programmable Features**

- Switching Frequency
- Output Voltage
  - Fine and Course
- Dead Time
- Output OV and UV
- Over Current Protection
- Compensation
- Current Sense Gain
MCP19111 Eval Board and POL Converter Board

- MCP87XXX Series MOSFETs
  - MCP87050 HS MOSFET – 5.0mΩ $R_{DS(ON)}$
  - MCP87018 LS MOSFET – 1.8mΩ $R_{DS(ON)}$

- Optimized PCB Layout
  - Short, wide traces for all power paths
    - Vin, Pground, PHASE, Gate Drive, BOOT, etc.
  - Split ground plane
  - Input/Output ceramic capacitors
MCP19111
Switching Frequency Control

- Controlled by writing to PR2 register
  - TMR2 counts up to reach PR2
  - Adjustable from 100kHz to 1.6MHz
    - Larger FETs may require external regulator on $V_{DR}$ at very high switching frequencies.

From the MCP19111 Datasheet

**EQUATION 3-2: GATE DRIVE CURRENT**

$$I_{DRIVE} = (Q_{gHIGH} + Q_{gLOW}) \times F_{SW}$$

Where:
- $I_{DRIVE}$ is the current required to drive the external MOSFETs
- $Q_{gHIGH}$ is the total gate charge of the high-side MOSFET
- $Q_{gLOW}$ is the total gate charge of the low-side MOSFET
- $F_{SW}$ is the switching frequency
MCP19111 Waveforms
Switching Frequency Control

Time (s)

600kHz
450kHz
300kHz
150kHz
MCP19111
Over Current Protection

- Voltage drop across high-side MOSFET sensed
  - Cycle-by-cycle peak current limit
  - Controlled by writing to OCCON register
  - Adjustable range: 160mV to 625mV drop
  - Leading edge blanking of 114nS, 213nS, 400nS, 780nS
  - When OC occurs, OCIF Flag is set, hardware resets

- Customized fault handling
  - User’s firmware dictates procedure
    - Ex. Restart 3 times, if fault still exists then shutdown
MCP19111
Cycle by Cycle OC Protection

Hardware providing cycle-by-cycle limit

$V_{\text{IN}} = 12\text{V}$
$V_{\text{OUT}} = 2.5\text{V}$
$F_{\text{SW}} = 200\text{ kHz}$
HS MOSFET $R_{\text{DSon}} = 18\text{ m}\Omega$

OC Set = 160 mV drop
OC Trip = 10A peak (calculated)
OC LEB = 400 nS
MCP19111
Output Short Circuit

Firmware providing OC shutdown

$V_{IN} = 12V$
$V_{OUT} = 2.5V$
$F_{SW} = 200 \text{ kHz}$
HS MOSFET $R_{DSon} = 18 \text{ m}\Omega$

OC Set = 160 mV drop
OC Trip = 10A peak (calculated)
OC LEB = 400 nS
MCP19111
Dead Time Control

- Controlled by writing to DEADCON register
  - 4 bits for HDLY, adjustable from 11nS to 71nS
  - 4 bits for LDLY, adjustable from 4nS to 64nS
  - Very important to optimize efficiency, especially with High Speed (Low Parasitic Capacitance) MOSFETs

From the MCP19111 Datasheet
MOSFET Switching Loss

- MOSFET Low Capacitance Technology
  - Lower Switching Losses Increases Efficiency!

\[ P = \frac{1}{2} (t \times I \times V) \times F_{SW} \]
Microchip Technology Inc.

MOSFET Body Diode Loss

- Optimized Dead Times
  - Keeping current out of the diode reduces reverse recovery losses and conduction losses

![Diagram showing MOSFET and diode voltage waveforms with optimized gate drive and existing driver comparisons.](image-url)
Digitally Enhanced Power Analog Applications Continued
MCP19111 Applications
DC/DC LED Lighting

- Buck Converter High Power LED Lighting
- Applications
  - Automotive (Optics to Distribute Light)
  - Adaptive Lighting
  - Communicating with LED Lighting
  - Commercial LED Lighting
MCP19111 Applications
DC/DC LED Lighting

- Synchronous Buck Converter LED Evaluation Board
- $V_{\text{IN}} = 8\text{V} \text{ to } 32\text{V}$
- Programmable current
- Provides current regulation using a sense resistor
- Two LEDs in series
- Hardware dimming and software dimming
MCP19111 Applications
Charging Batteries

- Multi-Chemistry (Programmable Current Source)
- Wide $I_{OUT}$ Range
  - Pre-Charge, Fast Charge, Termination
  - NiMH, Li-Ion, Pb-Acid Battery Profiles
Multi-Chemistry Battery Charger

- Sync Buck Multi-Chemistry Battery Charger Evaluation Board
- 1-4 Cell Li-Ion
- NiMH, NiCd, Pb Acid
- $V_{\text{IN}} = 4.5\text{V} \text{ to } 32\text{V}$
- Programmable Charging current up to 8A
- PIC core provides ability to design custom charging curves, protections, etc.
MCP19111 Applications
High Output Voltage

- Output of higher than 3.6V are possible with the MCP19111 by connecting the +V<sub>SEN</sub> pin to a voltage divider
- Care must be taken to ensure voltage rating compliance on all pins
MCP19111 Applications
High Output Voltage

- $V_{\text{IN}} = 6\text{V to 32V}$
- $I_{\text{OUT}}$ up to 5A
- Switchable between 4 voltage options using buttons
  - 3.5V, 5V, 10V, 12V
  - LED Indication
- Current sensing using resistor
- Utilizes MCP19110
  - Same as MCP19111 in 4x4QFN package, minus 4 pins and debug capability
MCP19111
Output Voltage Control

- Controlled by writing to OVCCON and OVFCON registers

**REGISTER 6-10: OVCCON: OUTPUT VOLTAGE SET POINT COARSE CONTROL REGISTER**

<table>
<thead>
<tr>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVC7</td>
<td>OVC6</td>
<td>OVC5</td>
<td>OVC4</td>
<td>OVC3</td>
<td>OVC2</td>
<td>OVC1</td>
<td>OVC0</td>
</tr>
</tbody>
</table>

bit 7

bit 7-0  
\[ \text{OVC}<7:0>: \text{Output Voltage Set Point Coarse Configuration bits} \]

\[ \text{oVC}<7:0> = \frac{V_{\text{OUT}}}{15.8 \text{ mV}} + 15.8 \text{ mV} \]

**REGISTER 6-11: OVFCON: OUTPUT VOLTAGE SET POINT FINE CONTROL REGISTER**

<table>
<thead>
<tr>
<th>R/W-0</th>
<th>U-0</th>
<th>U-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOUTEN</td>
<td>—</td>
<td>—</td>
<td>OVF4</td>
<td>OVF3</td>
<td>OVF2</td>
<td>OVF1</td>
<td>OVF0</td>
</tr>
</tbody>
</table>

bit 7

bit 7  
\[ \text{VOUTEN}: \text{Output Voltage DAC Enable bit} \]

1 = Output Voltage DAC is enabled
0 = Output Voltage DAC is disabled

bit 6-5  
**Unimplemented:** Read as ‘0’

bit 4-0  
\[ \text{OVF}<4:0>: \text{Output Voltage Set Point Coarse Configuration bits} \]

\[ \text{OVF}<4:0> = \frac{V_{\text{OUT}} - V_{\text{OUT COARSE}}}{0.8 \text{ mV}} \]

**Output Voltage can be programmed to < 0.1% accuracy**
MCP19111 Waveforms
High Output Voltage
MCP19111 Applications
Power Supply Modules

- Small footprint lends itself to very high power density applications
  - MCP19111 – 5x5mm DFN, 28 Leads
  - MCP19110 – 4x4mm DFN, 24 Leads
- Programmability allows module designer to use the same part number for many different modules
- GPIO for communication, $P_{GOOD}$, Enable, etc
MCP19111 Applications
Power Supply Modules

- $V_{IN} = 6V$ to $16V$
- $V_{OUT} = 0.9$ to $3.3V$
- $I_{OUT} = 30A+$
- Utilizes the MCP19110, the GWS30B25 Dual MOSFET, EPCOS inductor
- Inductor “floats” over the PCB
- 66uF input ceramic cap, 300uF output ceramic cap
- 1” x 0.75” PCB
- POWER DENSITY!
MCP19111 Applications
Synchronized Multi-Output

- $V_{IN} = 6V$ to $16V$
- $I_{OUT} = 30A+$ per output
- Utilizes 4x MCP19110 power supply modules
- Switching waveforms synchronized 90° out of phase
  - Simplifies input filtering
- PIC core allows easy control of start-up sequence
MCP19111 Waveforms
Synchronized Multi-Output
MCP19111 RECAP

- Extremely versatile part
  - POL, DC-DC LED Lighting, Battery Chargers, Modules, HV Output, Multi-rail, etc
  - PIC core allows the flexibility, fault handling, and communication of a digital solution while offering the speed, resolution, and low quiescent current of an analog solution
  - Flexibility = higher efficiency!
  - Small footprint = high power density!

- MCP87XXX MOSFETs
  - FAST, ROBUST
Our Analog & Memory Enables Providing Complete Solutions

- Digital Pot
- Precision Voltage Reference
- RF Transmit/Receive
- High Voltage I/Os
- IR Communications
- Motors Drivers
- Sensors
- Amplifiers
- Filters
- A/D
- Power Management - Regulators - Supervisory
- Power
- Microcontrollers
- Power Drivers
- D/A
- LCD Drivers
- LED Drivers
- Non-volatile Memory
- Serial SRAM
- Transceivers - RS232/485 - CAN bus - USB
- Bus Communication - CAN bus - USB
- Digital Peripherals - PWM - RTCC
- Encryption (KeeLoq® ICs) Speech Co-Processing
- Smoke Detector ICs
- Piezoelectric Horn Drivers
- Amplifiers
- Filters
- A/D
- Power Management - Regulators - Supervisory
- Power
- Microcontrollers
Additional Resources

- Product Landing Page

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The MCP19111 is a mid-voltage (4.5-32V) analog-based PWM controller family with an integrated 8-bit PIC(R) Microcontroller. This unique product combines the performance of a high-speed analog solution, including high-efficiency and fast transient response, with the configurability and communication interface of a digital solution. Combining these solution types creates a new family of devices that maximizes the strengths of each technology to create a more cost-effective, configurable, high-performance power conversion solution. The MCP1911x family, when combined with Microchip's MCP87xxx MOSFETs, or any low-FOM MOSFET, produce high-efficiency (>96%) DC/DC power-conversion solutions.