Core Independent Peripherals
For 8-bit PIC® Microcontrollers

Unique Integrated Peripherals for 8-bit PIC Microcontrollers

8-bit MCUs featuring Core Independent Peripherals

- Configurable Logic Cell (CLC)
  Integrated combinational and sequential logic

- Complementary Waveform/Output Generator (CWG/COG)
  Flexible input source waveform generator for power & motor control

- Numerically Controlled Oscillator (NCO)
  Linear PWM frequency control for lighting & power control

- Programmable Switch Mode Controller (PSMC)
  Advanced 16-bit PWM for power, motor & lighting control

www.microchip.com/8bit
Overview

Microchip is the leader in 8-bit microcontrollers by continually investing and expanding upon the PIC® microcontroller line-up. Emphasis is persistently focused on reducing costs while developing products with a strong mix of peripherals such as LCD drive, PWM, ADC, comparators, timers and communication. Beyond standard peripherals, Microchip is constantly bringing additional value to PIC microcontrollers by developing unique and exclusive peripherals. These unique peripherals allow embedded engineers to simplify their designs and create ever more creative applications and products. This innovation is demonstrated by some of the following PIC microcontroller integrated peripherals.

### 8-bit Peripheral Highlights

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<th>Flash</th>
<th>RAM</th>
<th>Pins</th>
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*PWM inclusive of PWM, CCP, ECCP and PSMC.

**Total PWM channels is the sum of external channels available via PWM, CCP, ECCP, HRPWM, CWG, COG and PSMC.

***HRPWM available via implementation of CLC and NCO, please see app note AN1476.

### Development Support

#### Development Boards

- PICDEM™ Lab Development Kit (DM163045)
- PICkit™ Low Pin Count Development Board (DM164130-9)
- PIC10F32X Development Board (AC103011)
- PICkit™ 28-pin Demo Board (DM164120-3)

#### Programmer/Debuggers

- PICkit 3 (PG164130)
- MPLAB® ICD 3 (DV164035)
- MPLAB REAL ICE™ In-Circuit Debugger (DV244005)

### IDE/Compiler

- MPLAB X IDE
- MPLAB XC8 Compiler
8-bit Peripheral Highlights

Configurable Logic Cell (CLC)
_Easily Create Custom Combination and Sequential Logic_

Key Features
- User configurable real time logic control
  - CLC configuration GUI for quick turn development
- Combinational Logic Functions
  - AND/OR/XOR/NOT/NAND/NOR/XNOR
- State Functions/Clock
  - D Flip-Flop, JK Flip-Flop, D Latch, SR Latch
- Input sources
  - Pins
  - Peripherals
- Output available to:
  - External pins
  - Other peripherals
- Operation while in Sleep

Benefits
- Increases on chip interconnection of peripherals and I/O
- Integrates hardware functions and saves board space
- Software control of Combinational/Sequential Logic
- Saves program code space and frees up CPU cycles

Example Applications
- Data modulation
- Power sequencing
- Manchester/IrDA encoder
- Event sequencing
- Conditional signaling
- General purpose logic
- Customizable circuitry

Example: Phase Shifted Data Modulator
_Combinational and Sequential logic can easily be designed using on-chip hardware._
8-bit Peripheral Highlights

**Complementary Waveform Generator (CWG), Complimentary Output Generator (COG)**

**Key Features**
- Provides non-overlapping complementary waveform
- Various input sources inclusive of:
  - Comparators, PWM, CLC, NCO
- Blanking control for transient filtering 1 (available with COG)
- Phase control for output delay 2 (available with COG)
- Independent rise and fall 3, 4
- Dead band control
- Auto shutdown/restart
- Polarity control

**Benefits**
- Works with multiple peripherals
- Fewer components and less space
- Lower power
- Improved switching efficiencies

**Example Applications**
- Switch mode power supplies
- LED/fluorescent lighting
- Battery charger
- Motor drive
- Power factor correction
- Class D audio amplifiers

**Complementary Output Generator (COG)**

**Example: Half Bridge Circuit Using CWG**
- Automates generation of the complementary waveforms necessary for Half Bridge control
- Programmable dead band control to protect against shoot through
- Auto Shutdown can be based on external inputs, software, CLC, or other peripherals
- Programmable blanking control available to filter out transient inputs

**Example: LED Buck Converter**
- Switching frequency determined by the PWM
- Enables synchronous switching, increasing power conversion efficiency
- Programmable dead band control protects the synchronous switches against shoot through
- Advanced features to provide auto shutdown, auto restart, and polarity control
8-bit Peripheral Highlights

Numerically Controlled Oscillator (NCO)
Oscillator Capabilities with True Linear Frequency Control

Key Features
- Up to 20-bit frequency resolution
- Multiple internal and external clock sources available
- 16b numeric frequency control
  - 625 kHz max output with 20MHz oscillator
  - 0.03 Hz min step size with 31kHz internal oscillator
- 2 Output modes
  - Fixed 50% Duty Cycle
  - Pulse Frequency Modulation (PFM)

Benefits
- True linear frequency control
- Increased frequency resolution

Example Applications
- Fluorescent ballast and LED lighting control
- Motor drivers
- Modems
- Class D audio amplifiers
- Ultrasonic ranging

Example: Fluorescent Lighting Control
- Use the NCO to create linear frequencies for start-up and dimming control
- Lower power and extend life of fluorescent bulb

![Diagram of PIC® Microcontroller with NCO and ADC](image)

NCO provides linear control over entire range

![Graph showing light output versus frequency](image)
8-bit Peripheral Highlights

High Resolution PWM (HRPWM)
*Full Range PWM Resolution at High Frequency*

**Key Features**
- Enables high switching frequency designs
- Variable PWM resolution
- Up to 17 bits effective resolutions at 500 kHz

**Benefits**
- Reduced sizing of inductors and capacitors
- Reduced BOM cost and improved EMI
- Precision LED color mixing, smooth dimming and brightness control
- Higher efficiency power conversion designs

**Example Applications**
- Power supplies
- DC/DC converters
- LED lighting/color mixing
- Motor control
- Flourescent ballast
- Resonant power supply

HRPWM

**Input Sources**

- System Clock
- PWM
- Comparator
- External Pin

Conventional PWM vs. HRPWM

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<th>Conventional PWM</th>
<th>HRPWM</th>
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</thead>
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<tr>
<td><strong>PWM Resolution</strong></td>
<td>16b</td>
<td>Variable</td>
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<tr>
<td><strong>PWM Clock Frequency</strong></td>
<td>16 MHz</td>
<td>16 MHz</td>
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<tr>
<td><strong>Target Switching Frequency</strong></td>
<td>500 kHz</td>
<td>500 kHz</td>
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<tr>
<td><strong>Target Period Width</strong></td>
<td>(1 \div 500 \text{ kHz} = 2 \mu s)</td>
<td>(1 \div 500 \text{ kHz} = 2 \mu s)</td>
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<tr>
<td><strong>Best PWM Pulse Adjustment</strong></td>
<td>(1 \div 16 \text{ MHz} = 62.5 \text{ ns})</td>
<td>(15.26 \text{ ps})*</td>
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<tr>
<td><strong>Maximum Number of Steps per Period</strong></td>
<td>(2 \mu s + 62.5 \text{ ns} = 32)</td>
<td>(2 \mu s \div 15.26 \text{ ps} = 131,072)</td>
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<td><strong>Effective Full Range PWM Resolution</strong></td>
<td>(\log_{2}32 = 5 \text{ bits})</td>
<td>(\log_{2}131,072 = 17 \text{ bits})</td>
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</table>

*Reference application note AN1476 for calculation*
8-bit Peripheral Highlights

Programmable 16-bit Switch Mode Controller (PSMC)

Advanced PWM Capabilities and Integrated Analog Enabling High Performance with Minimal External Circuity CPU Bandwidth

Key Features
- Various clock sources: external, system clock, independent 64 MHz
- Various input sources: comparators, external pins
- Blanking control for transient filtering
- Single 16-bit PWM
  - With up to 6 steerable outputs
- Complementary 16-bit PWM
  - With up to 3 steerable output pairs
- Independent rising/falling edge control
- Dead band with independent rise and fall control
- Polarity control/auto shutdown and restart
- Flexible PWM output modes:
  - Push/pull, pulse skipping, 3-phase, fixed duty cycle, brushed DC with forward/reverse
- Output gating: externally controlled activate/deactivate

Example: Buck Converter Driving LED Array
- High Efficiency closed-loop control with fast switching speeds
- Cost effective integration enabling significant BOM reductions

Benefits
- Customizable high speed PWM with increased resolution and control
- Simplifies the implementation of applications such as: motor control, lighting and power supplies

Example Applications
- Power Supplies / Conversion
  - DC/DC (power bricks), Power factor correction
- Lighting
  - LED, Backlighting, Automotive, HID, Lamp Ballast
- Motor Control
  - BLDC, AC induction, 3 Phase
- Battery Charging / Monitoring
- General purpose applications requiring high resolution PWM

![Diagram of PIC16F178X and Programmable Switch Mode Controller (PSMC)]
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