Adding Intelligence and Flexibility to Your Designs With the Core Independent Peripherals

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MCU Product Portfolio Growth

- 8-bit
- 16-bit
- 32-bit

Year:
- 1991
- 1993
- 1995
- 1997
- 1999
- 2001
- 2003
- 2005
- 2007
- 2009
- 2011

Growth: 0 to 1000
8-bit Product Family

Flexible Intelligence Made Easy!

- **Migration** 6-100 pin
- **Code compatibility** 0.5KB to 128KB
- **Performance** up to 15 MIPs
- **Unified Tool Suite**
- **Peripherals** to meet your needs
  - USB, Ethernet, CAN, LIN, RS-485, I2C, SPI, RF
  - PWM, CLC, NCO, CWG, PSMC, LCD, Multiplier,
  - ADC’s, Comparators, DACs, Op Amps
- **Low Power** Operation
  - Sleep Currents ~15nA
  - Active Currents ~35uA/MHz
- **Cost Effective** Embedded control
8-bit MCUs Are Everywhere

- General Purpose
- Connectivity
- Human Machine Interface
- Power Supplies
- Lighting
- Motor Control
- Security & Authentication

MCU8
PIC10/12
PIC16/18
CLC – Configurable Logic Cell
   Integrated combinational and sequential logic

CWG – Complementary Waveform Generator
   Non-overlapping waveform generator with selectable inputs

COG – Complementary Output Generator
   Enhanced non-overlapping waveform generator

NCO – Numerically Controlled Oscillator
   Industry’s most precise, linear, low-cost PWM

PSMC – Programmable Switch Mode Controller
   Advanced, customizable high-speed 16-bit PWM module
Configurable Logic Cell (CLC)

Easily create custom combinational and sequential logic

- User-configurable, real-time logic control
- Combinational Logic Functions
  - AND/OR/XOR/NOT/NAND/NOR/XNOR
- State Functions / Clock
  - D, SR, JK
- External or Internal Input
  - 16 input sources per module
  - 1 output to pins or 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
Configurable Logic Cell

555 Timer
Glue Logic
Encoder IC
Sequential Logic

Code-free implementation with many PIC® MCUs
Use “CLC Configuration Tool GUI”
for easy CLC programming
Free Download from MCU product Web pages at
http://www.microchip.com
Delay Block – Makes use of CLC for fast switching

- Uses PIC10F322 (6-pin)
  - Utilizes CLC to act as signal pass-through
  - Customers can create custom rising and falling edge delays
  - Useful for correcting timing issues and for switch debouncing
  - Developed on 10F322 demo board (part #AC103011)

Rising edge Delay

In this mode, only the rising edge has a delay, and the falling edge will drop immediately.

Falling edge Delay (Pulse extender)

In this mode, the rising edge will come up immediately, and the falling edge will be delayed.

Rising and Falling edge Delay
Complementary Waveform Generator (CWG)

Complementary non-overlapping waveforms with enhanced capabilities

- **Various input sources:**
  - Comparators, PWM, CLC, NCO
- **Key Features:**
  - Auto Shutdown and Restart
  - Polarity Control
  - Deadband Control
    - Independent rise and fall control

**Benefits**
- Works with multiple peripherals
- Fewer components
- Runs up to 16MHz for better clock resolution

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**Input Sources**
- Comparator
  - PWM
  - NCO
  - CLC

**CWG**
- Source Input
- Out0
- Out1

**Complementary Outputs**
1 – rising edge deadband control
2 – falling edge deadband control
Complementary Output Generator (COG)

Complementary waveforms with **even more** enhanced capabilities

- **Various input sources:**
  - Comparators, PWM

- **Key Features:**
  - Auto Shutdown and Restart
  - Polarity Control
  - Deadband Control
    - Independent rise & fall control
  - Phase Control for output delay
  - Blanking Control for filtering transients on switching power supplies

- **Benefits**
  - Works with multiple peripherals
  - Fewer components
  - Runs up to 16 MHz for better clock resolution

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**Input Sources**

- Comparator
- PWM

**COG**

- Source Input
- Out0
- Out1

**Complementary Outputs**

1. rising edge deadband control
2. falling edge deadband control
3. phase control
4. blanking control
Application Example:
High-Power LED Flashlight

PIC12F752 Internal Connections for LED Control

- PWM
- 5bit DAC
- Comparator

Complimentary Output Generator (COG)
1 of 2 available outputs utilized
Frequency determined by PWM
Provides dead-band control for the synchronous switches
Provides blanking control to prevent transient behavior

PIC12F752 Microcontroller
- MCP14628 MOSFET Driver
- LED drive and closed loop control determined by current sense and temperature
- Synchronous Buck Regulator controlled by PIC12F752 microcontroller for maximum efficiency
- CREE XML LED
- 1000 lumen output at 10W
- LED current sense and feedback to sustain constant light output
- Real time temperature monitoring of LED for fail-safe operation

MCP703 LDO
- 7.2V
- 5V

Magnetic selector ring
- Multiple hall effect sensors to determine position of magnetic ring

5bit Digital Analog Converter (DAC)
- Allows the use of smaller current sense resistor
- High resolution eliminates external Op-amp
- Less power consumption and better efficiency

High Performance Comparators
- 40ns response time

* Magnetic selector ring design can be replaced to accommodate mechanical push-buttons and switches
** Battery capacity can be scaled to accommodate specific mechanical capacity and desired run-times
High Power LED Flashlight
Advanced Control and Increased Efficacy

Rotating Magnetic Selector Ring
(Align marker on ring with image)
• Off
• Low power (60 lumens)
• Medium power (200 lumens)
• High power (~1000 lumens)
• SOS (custom pattern)

Notes:
• Due to the sealed design of the flashlight enclosure, the magnetic selector ring requires hall effect sensors to determine position. As a result, the PIC12F752 is in sleep during the “Off” state sensing changes in selector position.
• Design could be modified to accommodate mechanical and/or mTouch buttons/sliders.
20W Dimmable LED Driver

20W AC-DC Flyback Power Supply
- PIC12F752 Controlled
  - Integrated peripherals including:
    - DAC, COG, Fast Comps
- MCP1416 FET Driver
- Active 0.95 PFC
- ~85% Efficiency

0-100% Triac Dimmable
- Universal Triac Support

Communications Capable
- DALI/DMX512
- Wireless

Cree LEDs

AC Input

PIC12F752
MCP1416
Cree LEDs
Numerically Controlled Oscillator (NCO)

- Up to 17-bit frequency resolution
  - High-resolution PWM
- Variable output modes
  - Fixed Duty Cycle (FDC)
    - 50% duty cycle
  - Pulse Frequency Modulation (PFM)
    - Adjustable pulse width

![Diagram of NCO](image-url)

- Increment / Decrement (16-bit)
- Accumulator (20-bit)
- Output Generation
- NCO OUT (FDC)
- NCO OUT (PFM)
Numerically Controlled Oscillator (NCO)

Increment value = $2^{16} = 0 \rightarrow 65,535$

Accumulator = Stays constant $2^{20} = 1,048,576$

$$F_{NCO} = \left( \frac{F_{OSC}}{\text{Accumulator}} \right) \text{Increment value}$$

So, as the Increment value ↑, $F_{NCO}$ ↑
Thus giving you a linear change in NCO Frequency.

$PR2$ is not constant

$PR2 = 2^8 = 0 \rightarrow 255$

$$F_{PWM} = \left( \frac{F_{OSC}}{4 \left( PR2 + 1 \right)} \right)$$

So, as the $PR2$ ↑, $F_{osc}$ ↓
Thus giving you a more nonlinear change in PWM frequency.
High-Resolution PWM (HRPWM)

- 17-bit PWM capability at high frequency
  - Utilizes integrated NCO and CLC (application note available soon)
- Higher Frequency → Reduced sizing of inductors and capacitors
- Induced jitter with improved EMC performance

Input Sources

- System Clock
- PWM
- Comparator
- External Pin

HRPWM Output

- Clock Period
- Variable PWM Duty Cycle
- 17-bit

Max Steps

- Max # Steps = $2^{17} = 131,072$
Application Example:
Resonant Half-Bridge Power Supply

- The linear characteristic of the NCO allows for a simplified control function, which executes faster, ensures shorter delays and improves stability of the control loop.

The higher resolution of the NCO allows for finer control of the power supply.
Dimmable Fluorescent Ballast

100W Resonant Power Supply
- PIC16F1508 Controlled
  - Integrated peripherals including:
    - DAC, CLC, Comps, PWM, NCO
- 50kHz Switching Frequency
- MCP1416 FET Driver
- Active PFC
- ~90% Efficiency

0-100% Dimmable
- NCO linear frequency control

Communications Capable
- DALI/DMX512
- Wireless
Programmable Switch Mode Controller (PSMC)

**Advanced PWM capabilities for power supplies, motor and lighting controls**

- **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 output control
- Dead band with independent rise & fall control
- Polarity Control / Auto Shutdown & Restart
- Flexible PWM Output Modes:
  - Push/Pull, Pulse Skipping, 3-phase, Fixed Duty Cycle, Brushed DC with forward/reverse
- Output Gating – externally controlled activate/de-activate

**Benefits:**

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

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**Input Sources**

1 – blanking control

**Electrical Transient**

**64 MHz Clock**

**Comparator**

**External**

**Source Input**

1

**PSMC**

Out0
Out1
Out2
Out3
Out4
Out5

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**(6) Single PWM Outputs**

or

**(3) Complimentary Pair Outputs**

2 – Independent rising/falling output control
3 – rising edge deadband control
4 – falling edge deadband control
Application Example: LED Buck Converter

- High-Efficiency, closed-loop control with fast switching speeds
- Cost-effective integration with BOM reductions
  - OpAmp, voltage reference, reduced size of inductors, capacitors, and resistors

PSMC Programmable Switch Mode Controller

- 16-bit PWM with dedicated 64 MHz clock
- 6 steerable outputs or 3 steerable output pairs
- Blanking Control for transient filtering
- Independent rising/falling output control
- Deadband with independent rise & fall control
- Polarity Control / Auto Shutdown & Restart

PIC16F17xx

- 64 MHz Clock

Comparator

- 8-bit DAC
- 10/12b ADC

FVR

Rail – Rail 50 nS response time for high-speed switching frequency

Overvoltage monitor with PSMC auto-shutdown

8-bit DAC with FVR input @1.024V equating to 4 mV resolution

System Health Monitor: Output voltage, temperature, & current

Voltage divider to prevent overvoltage of load

Fast switching frequency allows use of smaller inductor and capacitor

High voltage MOSFET Drive Stage

Resistive Temperature Sensor

Real-time temperature monitoring of LEDs for fail-safe operation

Current sense and feedback to sustain constant current

PSMC Programmable Switch Mode Controller

Synchronous Buck Regulator controlled by PIC16F178X microcontroller for maximum efficiency

6 steerable outputs or 3 steerable output pairs

Blanking Control for transient filtering

Independent rising/falling output control

Deadband with independent rise & fall control

Polarity Control / Auto Shutdown & Restart

Rail – Rail OpAmp in Gain operation allows use of smaller current-sense resistor for less loss

Real-time temperature monitoring of LEDs for fail-safe operation

Current sense and feedback to sustain constant current

Application Example:
LED Buck Convertor

- High-Efficiency, closed-loop control with fast switching speeds
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Real-time temperature monitoring of LEDs for fail-safe operation

Current sense and feedback to sustain constant current
10W Wireless LED Driver

10W DC-DC SEPIC Power Supply
- PIC16F1783 Controlled
  - Integrated peripherals including: 8-bit DAC, PSMC, and OpAmps
- 9-24V DC Input → 24V DC Output with ~90% Efficiency
- Current Mode Control
- Software PI Control
- Variable Frequency: 400 kHz → 700 kHz
- MCP1416 FET Driver
- MCP16322 Voltage Regulator

Wireless Communications
- MRF24J40MA MiWi™ Module

0-100% Dimming Support
- 0-10V Control
- MiWi Radio Control
- DALI/DMX512 Capable
# New Peripherals Collaterals

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MCU Overview
## Features/Memory

### PIC10F32X and PIC1xF150X

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<th>Features/Memory</th>
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<td>PIC10F32X</td>
<td>896B / 0EE / 64B</td>
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<td></td>
<td>3x 8-bit A/D, 2xPWM</td>
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<td>Mid-Range Core</td>
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<td>PIC12F1501</td>
<td>1.75KB / 0EE / 64B</td>
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<td>4x 10-bit A/D</td>
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<td>1x Comp, DAC,</td>
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<td></td>
<td>2x CLC, CWG, NCO,</td>
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<td>4x PWM</td>
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<td>PIC16F1507</td>
<td>3.5KB / 0EE / 128B</td>
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<td>12x 10-bit A/D, DAC,</td>
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<td>2x Comp, MSSP,</td>
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<td>4x CLC, CWG, NCO,</td>
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<td>4x PWM</td>
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<tr>
<td>PIC16F1508</td>
<td>7KB / 0EE / 256B</td>
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<td>12x 10-bit A/D, DAC,</td>
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<td>2x Comp, EUSART,</td>
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<td>MSSP, 4x PWM,</td>
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<td>PIC16F1509</td>
<td>14KB / 0EE / 512B</td>
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<td>12x 10-bit A/D, DAC,</td>
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<td>4x CLC, CWG, NCO,</td>
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### Low Pin Count Enhanced and Midrange Core

Feature-Optimized Peripheral Set with XLP

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**Microchip**

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PIC12F752 and PIC16F753
8-bit Low-Cost Midrange Core

Features/Memory

PIC12/(HV)F752
1.75KB / 0EE / 64B
4x 10-bit A/D
2xFast Comp, 5-bit DAC, CCP, COG

PIC16/(HV)F753
3.5KB/ 0EE / 128B
8x 10-bit A/D
2xFast Comp, Op Amp, 9-bit DAC, CCP, COG

8 Pin 14 Pin
Development Tools
Development Support

**Programmer/Debuggers**
- PICkit 3 (PG164130)
- MPLAB ICD3 (DV164035)
- MPLAB PM3 (DV007004)

**IDE/Compiler**
- MPLAB X IDE
- MPLAB XC8 Compiler

**Development Boards**
- PICkit 28-pin Demo Board (DM164120-3)
- F1 Evaluation Platform (DM164130-1)
New F1 + Low Voltage Starter Kit
And Motor Control Add-ons

**F1 Low Voltage Board**
- A platform for general purpose & low voltage development for any F1 Core devices

**Motor Control Add-on Boards Common Features**
- Motor current limiting adjustment
- 12V plug with voltage regulation
- Debug header
- Pin connector for additional power connections
- 5A fuse
PIC10F32X Development Board

- Populated with the PIC10F322 6-pin MCU
- Factory programmed with CWG, NCO and CLC demo software
- Prototype area for development purposes
- User’s Guide and source code available
- Part # AC103011
Common Lighting Protocol Support
- DMX512, DALI, RF (coming soon), future support

Master & Slave with commissioning
- DALI support for custom zones & scenes

Dimming Support & Custom Capabilities
FREE ‘C’ Library Stack (DALI, DMX512)

Controller Boards
- Populated with PIC16F1947 controlling:
  - LCD
  - Communications
  - LED constant current control
- CREE 4 color LED with Gaggione LED optic
- Slider Potentiometer, LCD
- Power Supply and analog drivers

DALI adapters
- Screw terminals & RJ45 connectors
- Isolated DALI interface
- Current limited DALI power supply (jumper option)

DMX512 adapters
mTouch™ Capacitive Keys/Slider Evaluation Kit
DM183026-2

- 4 Motherboards
  - PIC16F1937
  - PIC18F46J50
  - PIC24FJ64GB106
  - PIC32MX795F512H

- 4 Sensor Boards
  - 2-Channel Slider
  - 4-Channel Slider
  - 8 Keys Direct Sense
  - 12-Key Matrix

- PICkit™ Serial Analyzer
  - Program & Debug

- Graphical User Interface

- Metal over Capacitive Accessory Kit
  (AC183026, Sold Separately)
Thank You!