Device included in this Data Sheet:

PIC16C505

High-Performance RISC CPU:
- Only 33 instructions to learn
- Operating speed:
  - DC - 20 MHz clock input
  - DC - 200 ns instruction cycle
- Direct, indirect and relative addressing modes for data and instructions
- 12-bit wide instructions
- 8-bit wide data path
- 2-level deep hardware stack
- Eight special function hardware registers
- Direct, indirect and relative addressing modes for data and instructions
- All single cycle instructions (200 ns) except for program branches which are two-cycle

Peripheral Features:
- 11 I/O pins with individual direction control
- 1 input pin
- High current sink/source for direct LED drive
- Timer0: 8-bit timer/counter with 8-bit programmable prescaler

Pin Diagram:

<table>
<thead>
<tr>
<th>Device</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program</td>
<td>Data</td>
</tr>
<tr>
<td>PIC16C505</td>
<td>1024 x 12</td>
</tr>
</tbody>
</table>

Special Microcontroller Features:
- In-Circuit Serial Programming (ICSP™)
- Power-on Reset (POR)
- Device Reset Timer (DRT)
- Watchdog Timer (WDT) with dedicated on-chip RC oscillator for reliable operation
- Programmable Code Protection
- Internal weak pull-ups on I/O pins
- Wake-up from Sleep on pin change
- Power-saving Sleep mode
- Selectable oscillator options:
  - INTRC: Precision internal 4 MHz oscillator
  - EXTRC: External low-cost RC oscillator
  - XT: Standard crystal/resonator
  - HS: High speed crystal/resonator
  - LP: Power saving, low frequency crystal

CMOS Technology:
- Low-power, high-speed CMOS EPROM technology
- Fully static design
- Wide operating voltage range (2.5V to 5.5V)
- Wide temperature ranges
  - Commercial: 0°C to +70°C
  - Industrial: -40°C to +85°C
  - Extended: -40°C to +125°C
- < 1.0 μA typical standby current @ 5V
- Low power consumption
  - < 2.0 mA @ 5V, 4 MHz
  - 15 μA typical @ 3.0V, 32 kHz for TMR0 running in SLEEP mode
  - < 1.0 μA typical standby current @ 5V
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• The Microchip Corporate Literature Center; U.S. FAX: (480) 786-7277

When contacting a sales office or the literature center, please specify which device, revision of silicon and data sheet (include literature number) you are using.

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• Fill out and mail in the reader response form in the back of this data sheet.
• E-mail us at webmaster@microchip.com.

We appreciate your assistance in making this a better document.
1.0 GENERAL DESCRIPTION

The PIC16C505 from Microchip Technology is a low-cost, high-performance, 8-bit, fully static, EPROM/ROM-based CMOS microcontroller. It employs a RISC architecture with only 33 single word/single cycle instructions. All instructions are single cycle (200 μs) except for program branches, which take two cycles. The PIC16C505 delivers performance an order of magnitude higher than its competitors in the same price category. The 12-bit wide instructions are highly symmetrical resulting in a typical 2:1 code compression over other 8-bit microcontrollers in its class. The easy to use and easy to remember instruction set reduces development time significantly.

The PIC16C505 product is equipped with special features that reduce system cost and power requirements. The Power-On Reset (POR) and Device Reset Timer (DRT) eliminate the need for external reset circuitry. There are five oscillator configurations to choose from, including INTRC internal oscillator mode and the power-saving LP (Low Power) oscillator mode. Power saving SLEEP mode, Watchdog Timer and code protection features improve system cost, power and reliability.

The PIC16C505 is available in the cost-effective One-Time-Programmable (OTP) version, which is suitable for production in any volume. The customer can take full advantage of Microchip’s price leadership in OTP microcontrollers, while benefiting from the OTP’s flexibility.

The PIC16C505 product is supported by a full-featured macro assembler, a software simulator, an in-circuit emulator, a ‘C’ compiler, a low-cost development programmer and a full featured programmer. All the tools are supported on IBM® PC and compatible machines.

1.1 Applications

The PIC16C505 fits in applications ranging from personal care appliances and security systems to low-power remote transmitters/receivers. The EPROM technology makes customizing application programs (transmitter codes, appliance settings, receiver frequencies, etc.) extremely fast and convenient. The small footprint packages, for through hole or surface mounting, make this microcontroller perfect for applications with space limitations. Low-cost, low-power, high-performance, ease of use and I/O flexibility make the PIC16C505 very versatile even in areas where no microcontroller use has been considered before (e.g., timer functions, replacement of “glue” logic and PLD’s in larger systems, and coprocessor applications).
### TABLE 1-1: PIC16C505 DEVICE

<table>
<thead>
<tr>
<th></th>
<th>PIC16C505</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clock</strong></td>
<td><strong>Maximum Frequency of Operation (MHz)</strong></td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td><strong>EPROM Program Memory</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Data Memory (bytes)</strong></td>
</tr>
<tr>
<td><strong>Peripherals</strong></td>
<td><strong>Timer Module(s)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Wake-up from SLEEP on pin change</strong></td>
</tr>
<tr>
<td><strong>Features</strong></td>
<td><strong>I/O Pins</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Input Pins</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Internal Pull-ups</strong></td>
</tr>
<tr>
<td></td>
<td><strong>In-Circuit Serial Programming</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Number of Instructions</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Packages</strong></td>
</tr>
</tbody>
</table>

The PIC16C505 device has Power-on Reset, selectable Watchdog Timer, selectable code protect, high I/O current capability and precision internal oscillator.

The PIC16C505 device uses serial programming with data pin RB0 and clock pin RB1.
2.0 PIC16C505 DEVICE VARIETIES

A variety of packaging options are available. Depending on application and production requirements, the proper device option can be selected using the information in this section. When placing orders, please use the PIC16C505 Product Identification System at the back of this data sheet to specify the correct part number.

2.1 UV Erasable Devices

The UV erasable version, offered in a ceramic windowed package, is optimal for prototype development and pilot programs.

The UV erasable version can be erased and reprogrammed to any of the configuration modes.

**Note:** Please note that erasing the device will also erase the pre-programmed internal calibration value for the internal oscillator. The calibration value must be saved prior to erasing the part.

Microchip’s PICSTART® PLUS and PRO MATE® II programmers all support programming of the PIC16C505. Third party programmers also are available; refer to the Microchip Third Party Guide, (DS00104), for a list of sources.

2.2 One-Time-Programmable (OTP) Devices

The availability of OTP devices is especially useful for customers who need the flexibility of frequent code updates or small volume applications.

The OTP devices, packaged in plastic packages, permit the user to program them once. In addition to the program memory, the configuration bits must also be programmed.

2.3 Quick-Turnaround-Production (QTP) Devices

Microchip offers a QTP Programming Service for factory production orders. This service is made available for users who choose not to program medium to high quantity units and whose code patterns have stabilized. The devices are identical to the OTP devices but with all EPROM locations and fuse options already programmed by the factory. Certain code and prototype verification procedures do apply before production shipments are available. Please contact your local Microchip Technology sales office for more details.

2.4 Serialized Quick-Turnaround Production (SQTPSM) Devices

Microchip offers a unique programming service, where a few user-defined locations in each device are programmed with different serial numbers. The serial numbers may be random, pseudo-random or sequential.

Serial programming allows each device to have a unique number, which can serve as an entry-code, password or ID number.
3.0 ARCHITECTURAL OVERVIEW

The high performance of the PIC16C505 can be attributed to a number of architectural features commonly found in RISC microprocessors. To begin with, the PIC16C505 uses a Harvard architecture in which program and data are accessed on separate buses. This improves bandwidth over traditional von Neumann architecture where program and data are fetched on the same bus. Separating program and data memory further allows instructions to be sized differently than the 8-bit wide data word. Instruction opcodes are 12 bits wide, making it possible to have all single word instructions. A 12-bit wide program memory access bus fetches a 12-bit instruction in a single cycle. A two-stage pipeline overlaps fetch and execution of instructions. Consequently, all instructions (33) execute in a single cycle (200ns @ 20MHz) except for program branches.

The Table below lists program memory (EPROM) and data memory (RAM) for the PIC16C505.

<table>
<thead>
<tr>
<th>Device</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Program</td>
</tr>
<tr>
<td>PIC16C505</td>
<td>1024 x 12</td>
</tr>
</tbody>
</table>

The PIC16C505 can directly or indirectly address its register files and data memory. All special function registers, including the program counter, are mapped in the data memory. The PIC16C505 has a highly orthogonal (symmetrical) instruction set that makes it possible to carry out any operation on any register using any addressing mode. This symmetrical nature and lack of ‘special optimal situations’ make programming with the PIC16C505 simple yet efficient. In addition, the learning curve is reduced significantly.

The PIC16C505 device contains an 8-bit ALU and working register. The ALU is a general purpose arithmetic unit. It performs arithmetic and Boolean functions between data in the working register and any register file.

The ALU is 8-bits wide and capable of addition, subtraction, shift and logical operations. Unless otherwise mentioned, arithmetic operations are two’s complement in nature. In two-operand instructions, one operand is typically the W (working) register. The other operand is either a file register or an immediate constant. In single operand instructions, the operand is either the W register or a file register.

The W register is an 8-bit working register used for ALU operations. It is not an addressable register.

Depending on the instruction executed, the ALU may affect the values of the Carry (C), Digit Carry (DC), and Zero (Z) bits in the STATUS register. The C and DC bits operate as a Borrow and digit borrow out bit, respectively, in subtraction. See the SUBWF and ADDWF instructions for examples.

A simplified block diagram is shown in Figure 3-1, with the corresponding device pins described in Table 3-1.
<table>
<thead>
<tr>
<th>Name</th>
<th>DIP Pin #</th>
<th>SOIC Pin #</th>
<th>I/O/P Type</th>
<th>Buffer Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RB0</td>
<td>13</td>
<td>13</td>
<td>I/O</td>
<td>TTL/ST</td>
<td>Bi-directional I/O port/ serial programming data. Can be software programmed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>for internal weak pull-up and wake-up from SLEEP on pin change. This buffer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>is a Schmitt Trigger input when used in serial programming mode.</td>
</tr>
<tr>
<td>RB1</td>
<td>12</td>
<td>12</td>
<td>I/O</td>
<td>TTL/ST</td>
<td>Bi-directional I/O port/ serial programming clock. Can be software programmed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>for internal weak pull-up and wake-up from SLEEP on pin change. This buffer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>is a Schmitt Trigger input when used in serial programming mode.</td>
</tr>
<tr>
<td>RB2</td>
<td>11</td>
<td>11</td>
<td>I/O</td>
<td>TTL</td>
<td>Bi-directional I/O port.</td>
</tr>
<tr>
<td>RB3/MCLR/VPP</td>
<td>4</td>
<td>4</td>
<td>I</td>
<td>TTL/ST</td>
<td>Input port/master clear (reset) input/programming voltage input. When</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>configured as MCLR/VPP, this pin is an active low reset to the device.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Voltage on MCLR/VPP must not exceed VDD during normal device operation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Can be software programmed for internal weak pull-up and wake-up from SLEEP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>on pin change. Weak pull-up only when configured as RB3. ST when configured</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>as MCLR.</td>
</tr>
<tr>
<td>RB4/OSC2/CLKOUT</td>
<td>3</td>
<td>3</td>
<td>I/O</td>
<td>TTL</td>
<td>Bi-directional I/O port/oscillator crystal output. Connections to crystal or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>resonator in crystal oscillator mode (XT and LP modes only, RB4 in other</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>modes). Can be software programmed for internal weak pull-up and wake-up</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>from SLEEP on pin change. In EXTRC and INTRC modes, the pin output can be</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>configured to CLKOUT, which has 1/4 the frequency of OSC1 and denotes the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>instruction cycle rate.</td>
</tr>
<tr>
<td>RB5/OSC1/CLKIN</td>
<td>2</td>
<td>2</td>
<td>I/O</td>
<td>TTL/ST</td>
<td>Bidirectional I/O port/oscillator crystal input/external clock source input</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(RB5 in Internal RC mode only, OSC1 in all other oscillator modes). TTL input</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>when RB5, ST input in external RC oscillator mode.</td>
</tr>
<tr>
<td>RC0</td>
<td>10</td>
<td>10</td>
<td>I/O</td>
<td>TTL</td>
<td>Bi-directional I/O port.</td>
</tr>
<tr>
<td>RC1</td>
<td>9</td>
<td>9</td>
<td>I/O</td>
<td>TTL</td>
<td>Bi-directional I/O port.</td>
</tr>
<tr>
<td>RC2</td>
<td>8</td>
<td>8</td>
<td>I/O</td>
<td>TTL</td>
<td>Bi-directional I/O port.</td>
</tr>
<tr>
<td>RC3</td>
<td>7</td>
<td>7</td>
<td>I/O</td>
<td>TTL</td>
<td>Bi-directional I/O port.</td>
</tr>
<tr>
<td>RC4</td>
<td>6</td>
<td>6</td>
<td>I/O</td>
<td>TTL</td>
<td>Bi-directional I/O port.</td>
</tr>
<tr>
<td>RC5/T0CKI</td>
<td>5</td>
<td>5</td>
<td>I/O</td>
<td>ST</td>
<td>Bi-directional I/O port. Can be configured as T0CKI.</td>
</tr>
<tr>
<td>Vdd</td>
<td>1</td>
<td>1</td>
<td>P</td>
<td>—</td>
<td>Positive supply for logic and I/O pins</td>
</tr>
<tr>
<td>Vss</td>
<td>14</td>
<td>14</td>
<td>P</td>
<td>—</td>
<td>Ground reference for logic and I/O pins</td>
</tr>
</tbody>
</table>

Legend: I = input, O = output, I/O = input/output, P = power, — = not used, TTL = TTL input, ST = Schmitt Trigger input
3.1 Clocking Scheme/Instruction Cycle

The clock input (OSC1/CLKIN pin) is internally divided by four to generate four non-overlapping quadrature clocks namely Q1, Q2, Q3 and Q4. Internally, the program counter is incremented every Q1, and the instruction is fetched from program memory and latched into the instruction register in Q4. It is decoded and executed during the following Q1 through Q4. The clocks and instruction execution flow is shown in Figure 3-2 and Example 3-1.

3.2 Instruction Flow/Pipelining

An instruction cycle consists of four Q cycles (Q1, Q2, Q3 and Q4). The instruction fetch and execute are pipelined such that fetch takes one instruction cycle, while decode and execute takes another instruction cycle. However, due to the pipelining, each instruction effectively executes in one cycle. If an instruction causes the program counter to change (e.g., GOTO) then two cycles are required to complete the instruction (Example 3-1).

A fetch cycle begins with the program counter (PC) incrementing in Q1.

In the execution cycle, the fetched instruction is latched into the Instruction Register (IR) in cycle Q1. This instruction is then decoded and executed during the Q2, Q3 and Q4 cycles. Data memory is read during Q2 (operand read) and written during Q4 (destination write).

---

**EXAMPLE 3-1: INSTRUCTION PIPELINE FLOW**

1. MOVLW 03H  
2. MOVWF PORTB  
3. CALL SUB_1  
4. BSF PORTB, BIT1

All instructions are single cycle, except for any program branches. These take two cycles, since the fetch instruction is “flushed” from the pipeline, while the new instruction is being fetched and then executed.
4.0 MEMORY ORGANIZATION

PIC16C505 memory is organized into program memory and data memory. For the PIC16C505, a paging scheme is used. Program memory pages are accessed using one STATUS register bit. Data memory banks are accessed using the File Select Register (FSR).

4.1 Program Memory Organization

The PIC16C505 devices have a 12-bit Program Counter (PC).

The 1K x 12 (0000h-03FFh) for the PIC16C505 are physically implemented. Refer to Figure 4-1. Accessing a location above this boundary will cause a wrap-around within the first 1K x 12 space. The effective reset vector is at 0000h, (see Figure 4-1). Location 03FFh contains the internal clock oscillator calibration value. This value should never be overwritten.

Note 1: Address 0000h becomes the effective reset vector. Location 03FFh contains the MOVLW XX INTERNAL RC oscillator calibration value.
4.2 Data Memory Organization

Data memory is composed of registers or bytes of RAM. Therefore, data memory for a device is specified by its register file. The register file is divided into two functional groups: Special Function Registers and General Purpose Registers.

The Special Function Registers include the TMR0 register, the Program Counter (PCL), the Status Register, the I/O registers (ports) and the File Select Register (FSR). In addition, Special Function Registers are used to control the I/O port configuration and prescaler options.

The General Purpose Registers are used for data and control information under command of the instructions.

For the PIC16C505, the register file is composed of 8 Special Function Registers, 24 General Purpose Registers and 48 General Purpose Registers that may be addressed using a banking scheme (Figure 4-2).

4.2.1 GENERAL PURPOSE REGISTER FILE

The General Purpose Register file is accessed, either directly or indirectly, through the File Select Register FSR (Section 4.8).

**FIGURE 4-2: PIC16C505 REGISTER FILE MAP**

| File Address | 00h | 01h | 02h | 03h | 04h | 05h | 06h | 07h | 08h | 09h | 0Ah | 0Bh | 0Ch | 0Dh | 0Eh | 0Fh |
|--------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 00h          | INDF(1) | 20h | 40h | 60h |
| 01h          | TMR0 | | | |
| 02h          | PCL | | | |
| 03h          | STATUS | | Addresses map back to addresses in Bank 0. | |
| 04h          | FSR | | | |
| 05h          | OSCCAL | | | |
| 06h          | PORTB | | | |
| 07h          | PORTC | | | |
| 08h          | General Purpose Registers | 2Fh | 4Fh | 6Fh |
| 09h          | General Purpose Registers | 30h | 50h | 70h |
| 0Ah          | General Purpose Registers | | | |
| 0Bh          | General Purpose Registers | | | |
| 0Ch          | General Purpose Registers | | | |
| 0Dh          | General Purpose Registers | | | |
| 0Eh          | General Purpose Registers | | | |
| 0Fh          | General Purpose Registers | | | |

**Note 1:** Not a physical register.
4.2.2 SPECIAL FUNCTION REGISTERS

The Special Function Registers (SFRs) are registers used by the CPU and peripheral functions to control the operation of the device (Table 4-1).

The Special Function Registers can be classified into two sets. The Special Function Registers associated with the "core" functions are described in this section. Those related to the operation of the peripheral features are described in the section for each peripheral feature.

**TABLE 4-1: SPECIAL FUNCTION REGISTER (SFR) SUMMARY**

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
<th>Value on Power-On Reset</th>
<th>Value on All Other Resets(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h</td>
<td>INDF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>xxxx xxxx yyyy yyyy</td>
<td></td>
</tr>
<tr>
<td>01h</td>
<td>TMR0</td>
<td>8-bit real-time clock/counter</td>
<td>6-bit</td>
<td>4-bit</td>
<td>3-bit</td>
<td>2-bit</td>
<td>1-bit</td>
<td>0-bit</td>
<td></td>
<td>xxxx xxxx yyyy yyyy</td>
<td></td>
</tr>
<tr>
<td>02h(1)</td>
<td>PCL</td>
<td>Low order 8 bits of PC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1111 1111 1111 1111</td>
<td></td>
</tr>
<tr>
<td>03h</td>
<td>STATUS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0001 1xxx q00q q00q</td>
<td></td>
</tr>
<tr>
<td>04h</td>
<td>FSR</td>
<td>Indirect data memory address pointer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>110x xxxx yyyy yyyy</td>
<td></td>
</tr>
<tr>
<td>05h</td>
<td>OSCCAL</td>
<td>CAL5</td>
<td>CAL4</td>
<td>CAL3</td>
<td>CAL2</td>
<td>CAL1</td>
<td>CAL0</td>
<td></td>
<td></td>
<td>1000 00--- yyyy yyyy</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>TRISB</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
<td>--11 1111 --11 1111</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>TRISC</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
<td>--11 1111 --11 1111</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>OPTION</td>
<td>RBWU</td>
<td>RBPU</td>
<td>TOCS</td>
<td>TOSE</td>
<td>PSA</td>
<td>PS2</td>
<td>PS1</td>
<td>PS0</td>
<td>1111 1111 1111 1111</td>
<td></td>
</tr>
<tr>
<td>06h</td>
<td>PORTB</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>RB5</td>
<td>RB4</td>
<td>RB3</td>
<td>RB2</td>
<td>RB1</td>
<td>--xx xxxx yyyy yyyy</td>
</tr>
<tr>
<td>07h</td>
<td>PORTC</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>RC5</td>
<td>RC4</td>
<td>RC3</td>
<td>RC2</td>
<td>RC1</td>
<td>--xx xxxx yyyy yyyy</td>
</tr>
</tbody>
</table>

Legend: Shaded cells not used by Port Registers, read as ‘0’, — = unimplemented, read as ‘0’, x = unknown, u = unchanged, q = depends on condition.

**Note 1:** If reset was due to wake-up on pin change, then bit 7 = 1. All other resets will cause bit 7 = 0.

**Note 2:** Other (non-power-up) resets include external reset through MCLR, watchdog timer and wake-up on pin change reset.
4.3 STATUS Register

This register contains the arithmetic status of the ALU, the RESET status and the page preselect bit.

The STATUS register can be the destination for any instruction, as with any other register. If the STATUS register is the destination for an instruction that affects the Z, DC or C bits, then the write to these three bits is disabled. These bits are set or cleared according to the device logic. Furthermore, the TO and PD bits are not writable. Therefore, the result of an instruction with the STATUS register as destination may be different than intended.

For example, CLRF STATUS will clear the upper three bits and set the Z bit. This leaves the STATUS register as 000u u1uu (where u = unchanged).

It is recommended, therefore, that only BCF, BSF and MOVWF instructions be used to alter the STATUS register, because these instructions do not affect the Z, DC or C bits from the STATUS register. For other instructions, which do affect STATUS bits, see Instruction Set Summary.

REGISTER 4-1: STATUS REGISTER (ADDRESS:03h)

<table>
<thead>
<tr>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R/W-0</th>
<th>R-1</th>
<th>R-1</th>
<th>R/W-x</th>
<th>R/W-x</th>
<th>R/W-x</th>
<th>R = Readable bit</th>
<th>W = Writable bit</th>
<th>U = Unimplemented bit, read as '0'</th>
<th>n = Value at POR reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBWUF</td>
<td>-----</td>
<td>PA0</td>
<td>TO</td>
<td>PD</td>
<td>Z</td>
<td>DC</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bit7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>bit0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

bit 7: RBWUF: I/O reset bit
- 1 = Reset due to wake-up from SLEEP on pin change
- 0 = After power up or other reset

bit 6: Unimplemented

bit 5: PA0: Program page preselect bits
- 1 = Page 1 (200h - 3FFh)
- 0 = Page 0 (000h - 1FFh)
Each page is 512 bytes.
Using the PA0 bit as a general purpose read/write bit in devices which do not use it for program page preselect is not recommended, since this may affect upward compatibility with future products.

bit 4: TO: Time-out bit
- 1 = After power-up, CLRWDT instruction, or SLEEP instruction
- 0 = A WDT time-out occurred

bit 3: PD: Power-down bit
- 1 = After power-up or by the CLRWDT instruction
- 0 = By execution of the SLEEP instruction

bit 2: Z: Zero bit
- 1 = The result of an arithmetic or logic operation is zero
- 0 = The result of an arithmetic or logic operation is not zero

bit 1: DC: Digit carry/borrow bit (for ADDWF and SUBWF instructions)
ADDWF
- 1 = A carry from the 4th low order bit of the result occurred
- 0 = A carry from the 4th low order bit of the result did not occur
SUBWF
- 1 = A borrow from the 4th low order bit of the result did not occur
- 0 = A borrow from the 4th low order bit of the result occurred

bit 0: C: Carry/borrow bit (for ADDWF, SUBWF and RRF, RLF instructions)
ADDWF
- 1 = A carry occurred
- 0 = A carry did not occur
SUBWF
- 1 = A borrow did not occur
- 0 = A borrow occurred
RRF or RLF
Load bit with LSB or MSB, respectively
4.4 OPTION Register

The OPTION register is a 8-bit wide, write-only register, which contains various control bits to configure the Timer0/WDT prescaler and Timer0.

By executing the OPTION instruction, the contents of the W register will be transferred to the OPTION register. A RESET sets the OPTION<7:0> bits.

REGISTER 4-2: OPTION REGISTER

<table>
<thead>
<tr>
<th>RBWU</th>
<th>RBPU</th>
<th>T0CS</th>
<th>T0SE</th>
<th>PSA</th>
<th>PS2</th>
<th>PS1</th>
<th>PS0</th>
</tr>
</thead>
<tbody>
<tr>
<td>bit7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

bit 7: **RBWU**: Enable wake-up on pin change (RB0, RB1, RB3, RB4)
- 1 = Disabled
- 0 = Enabled

bit 6: **RBPU**: Enable weak pull-ups (RB0, RB1, RB3, RB4)
- 1 = Disabled
- 0 = Enabled

bit 5: **T0CS**: Timer0 clock source select bit
- 1 = Transition on T0CKI pin (overrides TRIS<RC57>)
- 0 = Transition on internal instruction cycle clock, Fosc/4

bit 4: **T0SE**: Timer0 source edge select bit
- 1 = Increment on high to low transition on the T0CKI pin
- 0 = Increment on low to high transition on the T0CKI pin

bit 3: **PSA**: Prescaler assignment bit
- 1 = Prescaler assigned to the WDT
- 0 = Prescaler assigned to Timer0

bit 2-0: **PS<2:0>**: Prescaler rate select bits

<table>
<thead>
<tr>
<th>Bit Value</th>
<th>Timer0 Rate</th>
<th>WDT Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>1 : 2</td>
<td>1 : 1</td>
</tr>
<tr>
<td>001</td>
<td>1 : 4</td>
<td>1 : 2</td>
</tr>
<tr>
<td>010</td>
<td>1 : 8</td>
<td>1 : 4</td>
</tr>
<tr>
<td>011</td>
<td>1 : 16</td>
<td>1 : 8</td>
</tr>
<tr>
<td>100</td>
<td>1 : 32</td>
<td>1 : 16</td>
</tr>
<tr>
<td>101</td>
<td>1 : 64</td>
<td>1 : 32</td>
</tr>
<tr>
<td>110</td>
<td>1 : 128</td>
<td>1 : 64</td>
</tr>
<tr>
<td>111</td>
<td>1 : 256</td>
<td>1 : 128</td>
</tr>
</tbody>
</table>

**Note:** If TRIS bit is set to ‘0’, the wake-up on change and pull-up functions are disabled for that pin (i.e., note that TRIS overrides OPTION control of RBPU and RBWU).
4.5 OSCCAL Register

The Oscillator Calibration (OSCCAL) register is used to calibrate the internal 4 MHz oscillator. It contains six bits for calibration.

**Note:** Please note that erasing the device will also erase the pre-programmed internal calibration value for the internal oscillator. The calibration value must be read prior to erasing the part, so it can be reprogrammed correctly later.

After you move in the calibration constant, do not change the value. See Section 7.2.5

REGISTER 4-3: OSCCAL REGISTER (ADDRESS 05h) PIC16C505

<table>
<thead>
<tr>
<th>R/W-1</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>U-0</th>
<th>U-0</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL5</td>
<td>CAL4</td>
<td>CAL3</td>
<td>CAL2</td>
<td>CAL1</td>
<td>CAL0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

bit 7-2: **CAL<5:0>:** Calibration

bit 1-0: Unimplemented read as ‘0’

**Note:** Please note that erasing the device will also erase the pre-programmed internal calibration value for the internal oscillator. The calibration value must be read prior to erasing the part, so it can be reprogrammed correctly later.

After you move in the calibration constant, do not change the value. See Section 7.2.5
4.6 Program Counter

As a program instruction is executed, the Program Counter (PC) will contain the address of the next program instruction to be executed. The PC value is increased by one every instruction cycle, unless an instruction changes the PC.

For a GOTO instruction, bits 8:0 of the PC are provided by the GOTO instruction word. The PC Latch (PCL) is mapped to PC<7:0>. Bit 5 of the STATUS register provides page information to bit 9 of the PC (Figure 4-3).

For a CALL instruction, or any instruction where the PCL is the destination, bits 7:0 of the PC again are provided by the instruction word. However, PC<8> does not come from the instruction word, but is always cleared (Figure 4-3).

Instructions where the PCL is the destination, or Modify PCL instructions, include MOVWF PC, ADDWF PC, and BSF PC,5.

Note: Because PC<8> is cleared in the CALL instruction or any Modify PCL instruction, all subroutine calls or computed jumps are limited to the first 256 locations of any program memory page (512 words long).

4.6.1 EFFECTS OF RESET

The Program Counter is set upon a RESET, which means that the PC addresses the last location in the last page (i.e., the oscillator calibration instruction.) After executing MOVLW XX, the PC will roll over to location 00h and begin executing user code.

The STATUS register page preselect bits are cleared upon a RESET, which means that page 0 is pre-selected.

Therefore, upon a RESET, a GOTO instruction will automatically cause the program to jump to page 0 until the value of the page bits is altered.

4.7 Stack

PIC16C505 devices have a 12-bit wide hardware push/pop stack.

A CALL instruction will push the current value of stack 1 into stack 2 and then push the current program counter value, incremented by one, into stack level 1. If more than two sequential CALLs are executed, only the most recent two return addresses are stored.

A RETLW instruction will pop the contents of stack level 1 into the program counter and then copy stack level 2 contents into level 1. If more than two sequential RETLW's are executed, the stack will be filled with the address previously stored in level 2. Note that the W register will be loaded with the literal value specified in the instruction. This is particularly useful for the implementation of data look-up tables within the program memory.

Note 1: There are no STATUS bits to indicate stack overflows or stack underflow conditions.

Note 2: There are no instructions mnemonics called PUSH or POP. These are actions that occur from the execution of the CALL, RETLW, and instructions.
4.8 **Indirect Data Addressing: INDF and FSR Registers**

The INDF register is not a physical register. Addressing INDF actually addresses the register whose address is contained in the FSR register (FSR is a pointer). This is indirect addressing.

**EXAMPLE 4-1: INDIRECT ADDRESSING**

- Register file 07 contains the value 10h
- Register file 08 contains the value 0Ah
- Load the value 07 into the FSR register
- A read of the INDF register will return the value of 10h
- Increment the value of the FSR register by one (FSR = 08)
- A read of the INDR register now will return the value of 0Ah.

Reading INDF itself indirectly (FSR = 0) will produce 00h. Writing to the INDF register indirectly results in a no-operation (although STATUS bits may be affected).

A simple program to clear RAM locations 10h-1Fh using indirect addressing is shown in Example 4-2.

**EXAMPLE 4-2: HOW TO CLEAR RAM USING INDIRECT ADDRESSING**

```
movlw 0x10         ;initialize pointer
movwf FSR          ;to RAM
NEXT                
clf INDF            ;clear INDF register
incf FSR,F         ;inc pointer
btfsc FSR,4         ;all done?
goto NEXT          ;NO, clear next
CONTINUE            :
                     ;YES, continue
```

The FSR is a 5-bit wide register. It is used in conjunction with the INDF register to indirectly address the data memory area.

The FSR<4:0> bits are used to select data memory addresses 00h to 1Fh.

The device uses FSR<6:5> to select between banks 0:3.

**FIGURE 4-4: DIRECT/INDIRECT ADDRESSING**

<table>
<thead>
<tr>
<th>(FSR)</th>
<th>Direct Addressing</th>
<th>(FSR)</th>
<th>Indirect Addressing</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>bank select</td>
<td>6</td>
<td>bank</td>
</tr>
<tr>
<td>5</td>
<td>location select</td>
<td>5</td>
<td>location select</td>
</tr>
<tr>
<td>4</td>
<td>0 (opcode)</td>
<td>4</td>
<td>(opcode)</td>
</tr>
<tr>
<td>0</td>
<td>00</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>01</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Data</td>
<td>00h</td>
<td>00h</td>
<td>Addresses map back</td>
</tr>
<tr>
<td>Memory(1)</td>
<td>0Fh</td>
<td>Bank 0</td>
<td>to addresses in Bank 0.</td>
</tr>
<tr>
<td>10h</td>
<td>1Fh</td>
<td>1Fh</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3Fh</td>
<td>3Fh</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5Fh</td>
<td>5Fh</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7Fh</td>
<td>7Fh</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank 0</td>
<td>Bank 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank 1</td>
<td>Bank 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank 2</td>
<td>Bank 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** For register map detail see Section 4.2.
5.0 I/O PORT
As with any other register, the I/O register can be written and read under program control. However, read instructions (e.g., MOVF PORTB, W) always read the I/O pins independent of the pin’s input/output modes. On RESET, all I/O ports are defined as input (inputs are at hi-impedance) since the I/O control registers are all set.

5.1 PORTB
PORTB is an 8-bit I/O register. Only the low order 6 bits are used (RB<5:0>). Bits 7 and 6 are unimplemented and read as ‘0’s. Please note that RB3 is an input only pin. The configuration word can set several I/O’s to alternate functions. When acting as alternate functions, the pins will read as ‘0’ during port read. Pins RB0, RB1, RB3 and RB4 can be configured with weak pull-ups and also with wake-up on change. The wake-up on change and weak pull-up functions are not pin selectable. If pin 4 is configured as MCLR, weak pull-up is always off and wake-up on change for this pin is not enabled.

5.2 PORTC
PORTC is an 8-bit I/O register. Only the low order 6 bits are used (RC<5:0>). Bits 7 and 6 are unimplemented and read as ‘0’s.

5.3 TRIS Registers
The output driver control register is loaded with the contents of the W register by executing the TRIS f instruction. A ‘1’ from a TRIS register bit puts the corresponding output driver in a hi-impedance mode. A ‘0’ puts the contents of the output data latch on the selected pins, enabling the output buffer. The exceptions are RB3, which is input only, and RC5, which may be controlled by the option register. See Register 4-2.

**Note:** A read of the ports reads the pins, not the output data latches. That is, if an output driver on a pin is enabled and driven high, but the external system is holding it low, a read of the port will indicate that the pin is low.

The TRIS registers are “write-only” and are set (output drivers disabled) upon RESET.

5.4 I/O Interfacing
The equivalent circuit for an I/O port pin is shown in Figure 5-1. All port pins except RB3, which is input only, may be used for both input and output operations. For input operations, these ports are non-latching. Any input must be present until read by an input instruction (e.g., MOVF PORTB, W). The outputs are latched and remain unchanged until the output latch is rewritten. To use a port pin as output, the corresponding direction control bit in TRIS must be cleared (= 0). For use as an input, the corresponding TRIS bit must be set. Any I/O pin (except RB3) can be programmed individually as input or output.

**FIGURE 5-1: EQUIVALENT CIRCUIT FOR A SINGLE I/O PIN**

- **Note 1:** I/O pins have protection diodes to VDD and VSS.
- **Note 2:** See Table 3-1 for buffer type.
### TABLE 5-1: SUMMARY OF PORT REGISTERS

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
<th>Value on Power-On Reset</th>
<th>Value on All Other Resets</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>TRISB</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>--11 1111</td>
<td>--11 1111</td>
</tr>
<tr>
<td>N/A</td>
<td>TRISC</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>--11 1111</td>
<td>--11 1111</td>
</tr>
<tr>
<td>N/A</td>
<td>OPTION</td>
<td>RBPU</td>
<td>RBWU</td>
<td>TOCS</td>
<td>TOSE</td>
<td>PSA</td>
<td>PS2</td>
<td>PS1</td>
<td>PS0</td>
<td>1111 1111</td>
<td>1111 1111</td>
</tr>
<tr>
<td>03h</td>
<td>STATUS</td>
<td>PBWUF</td>
<td>—</td>
<td>PAO</td>
<td>TO</td>
<td>PD</td>
<td>Z</td>
<td>DC</td>
<td>C</td>
<td>0001 1xxx (1)</td>
<td>q00q quuu</td>
</tr>
<tr>
<td>06h</td>
<td>PORTB</td>
<td>—</td>
<td>—</td>
<td>RB5</td>
<td>RB4</td>
<td>RB3</td>
<td>RB2</td>
<td>RB1</td>
<td>RB0</td>
<td>--xx xxxx</td>
<td>--uu uuuu</td>
</tr>
<tr>
<td>07h</td>
<td>PORTC</td>
<td>—</td>
<td>—</td>
<td>RC5</td>
<td>RC4</td>
<td>RC3</td>
<td>RC2</td>
<td>RC1</td>
<td>RC0</td>
<td>--xx xxxx</td>
<td>--uu uuuu</td>
</tr>
</tbody>
</table>

Legend: Shaded cells not used by Port Registers, read as '0', — = unimplemented, read as '0', x = unknown, u = unchanged, q = depends on condition.

**Note 1:** If reset was due to wake-up on pin change, then bit 7 = 1. All other rests will cause bit 7 = 0.

### 5.5 I/O Programming Considerations

#### 5.5.1 BI-DIRECTIONAL I/O PORTS

Some instructions operate internally as read followed by write operations. The **BCF** and **BSF** instructions, for example, read the entire port into the CPU, execute the bit operation and re-write the result. Caution must be used when these instructions are applied to a port where one or more pins are used as input/outputs. For example, a **BSF** operation on bit5 of PORTB will cause all eight bits of PORTB to be read into the CPU, bit5 to be set and the PORTB value to be written to the output latches. If another bit of PORTB is used as a bi-directional I/O pin (say bit0) and it is defined as an input at this time, the input signal present on the pin itself would be read into the CPU and rewritten to the data latch of this particular pin, overwriting the previous content. As long as the pin stays in the input mode, no problem occurs. However, if bit0 is switched into output mode later on, the content of the data latch may now be unknown.

Example 5-1 shows the effect of two sequential read-modify-write instructions (e.g., **BCF**, **BSF**, etc.) on an I/O port.

A pin actively outputting a high or a low should not be driven from external devices at the same time in order to change the level on this pin (“wired-or,” “wired-and”). The resulting high output currents may damage the chip.

#### EXAMPLE 5-1: READ-MODIFY-WRITE INSTRUCTIONS ON AN I/O PORT

```assembly
;Initial PORTB Settings
; PORTB<5:3> Inputs
; PORTB<2:0> Outputs

; PORTB latch PORTB pins
;-------------------------
BCF PORTB, 5 ;--01 -ppp --11 pppp
BCF PORTB, 4 ;--10 -ppp --11 pppp
MOVlw 007h ;
TRIS PORTB ;--10 -ppp --11 pppp

;Note that the user may have expected the pin values to be --00 pppp. The 2nd BCF caused RB5 to be latched as the pin value (High).
```

### 5.5.2 SUCCESSIVE OPERATIONS ON I/O PORTS

The actual write to an I/O port happens at the end of an instruction cycle, whereas for reading, the data must be valid at the beginning of the instruction cycle (Figure 5-2). Therefore, care must be exercised if a write followed by a read operation is carried out on the same I/O port. The sequence of instructions should allow the pin voltage to stabilize (load dependent) before the next instruction causes that file to be read into the CPU. Otherwise, the previous state of that pin may be read into the CPU rather than the new state. When in doubt, it is better to separate these instructions with a **NOP** or another instruction not accessing this I/O port.
This example shows a write to PORTB followed by a read from PORTB.

Data setup time = \((0.25 \cdot T_{CY} - T_{PD})\)

where: \(T_{CY}\) = instruction cycle.
\(T_{PD}\) = propagation delay

Therefore, at higher clock frequencies, a write followed by a read may be problematic.
6.0 TIMER0 MODULE AND TMR0 REGISTER

The Timer0 module has the following features:
- 8-bit timer/counter register, TMR0
  - Readable and writable
- 8-bit software programmable prescaler
- Internal or external clock select
  - Edge select for external clock

Figure 6-1 is a simplified block diagram of the Timer0 module.

Timer mode is selected by clearing the T0CS bit (OPTION<5>). In timer mode, the Timer0 module will increment every instruction cycle (without prescaler). If TMR0 register is written, the increment is inhibited for the following two cycles (Figure 6-2 and Figure 6-3). The user can work around this by writing an adjusted value to the TMR0 register.

Counter mode is selected by setting the T0CS bit (OPTION<5>). In this mode, Timer0 will increment either on every rising or falling edge of pin T0CKI. The T0SE bit (OPTION<4>) determines the source edge. Clearing the T0SE bit selects the rising edge. Restrictions on the external clock input are discussed in detail in Section 6.1.

The prescaler may be used by either the Timer0 module or the Watchdog Timer, but not both. The prescaler assignment is controlled in software by the control bit PSA (OPTION<3>). Clearing the PSA bit will assign the prescaler to Timer0. The prescaler is not readable or writable. When the prescaler is assigned to the Timer0 module, prescale values of 1:2, 1:4,..., 1:256 are selectable. Section 6.2 details the operation of the prescaler.

A summary of registers associated with the Timer0 module is found in Table 6-1.

FIGURE 6-1: TIMER0 BLOCK DIAGRAM

Note 1: Bits T0CS, T0SE, PSA, PS2, PS1 and PS0 are located in the OPTION register.
2: The prescaler is shared with the Watchdog Timer (Figure 6-5).
FIGURE 6-2: TIMER0 TIMING: INTERNAL CLOCK/NO PRESCALE

FIGURE 6-3: TIMER0 TIMING: INTERNAL CLOCK/PRESCALE 1:2

TABLE 6-1: REGISTERS ASSOCIATED WITH TIMER0

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
<th>Value on Power-On Reset</th>
<th>Value on All Other Resets</th>
</tr>
</thead>
<tbody>
<tr>
<td>01h</td>
<td>TMR0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>xxxx xxxx xxxxxxxxxx</td>
<td>uuuu uuuu uuuuu</td>
</tr>
<tr>
<td>N/A</td>
<td>OPTION</td>
<td>RBWU</td>
<td>RBPU</td>
<td>T0CS</td>
<td>T0SE</td>
<td>PSA</td>
<td>PS2</td>
<td>PS1</td>
<td>PS0</td>
<td>1111 1111 11111111</td>
<td>1111 1111 11111111</td>
</tr>
<tr>
<td>N/A</td>
<td>TRISC</td>
<td>--</td>
<td>--</td>
<td>RC5</td>
<td>RC4</td>
<td>RC3</td>
<td>RC2</td>
<td>RC1</td>
<td>RC0</td>
<td>--11 1111 1111</td>
<td>--11 1111 1111</td>
</tr>
</tbody>
</table>

Legend: Shaded cells not used by Timer0, = unimplemented, x = unknown, u = unchanged.
6.1 Using Timer0 with an External Clock

When an external clock input is used for Timer0, it must meet certain requirements. The external clock requirement is due to internal phase clock (TOSC) synchronization. Also, there is a delay in the actual incrementing of Timer0 after synchronization.

6.1.1 EXTERNAL CLOCK SYNCHRONIZATION

When no prescaler is used, the external clock input is the same as the prescaler output. The synchronization of T0CKI with the internal phase clocks is accomplished by sampling the prescaler output on the Q2 and Q4 cycles of the internal phase clocks (Figure 6-4). Therefore, it is necessary for T0CKI to be high for at least 2TOSC (and a small RC delay of 20 ns) and low for at least 2TOSC (and a small RC delay of 20 ns). Refer to the electrical specification of the desired device.

When a prescaler is used, the external clock input is divided by the asynchronous ripple counter-type prescaler, so that the prescaler output is symmetrical. For the external clock to meet the sampling requirement, the ripple counter must be taken into account. Therefore, it is necessary for T0CKI to have a period of at least 4TOSC (and a small RC delay of 40 ns) divided by the prescaler value. The only requirement on T0CKI high and low time is that they do not violate the minimum pulse width requirement of 10 ns. Refer to parameters 40, 41 and 42 in the electrical specification of the desired device.

6.1.2 TIMER0 INCREMENT DELAY

Since the prescaler output is synchronized with the internal clocks, there is a small delay from the time the external clock edge occurs to the time the Timer0 module is actually incremented. Figure 6-4 shows the delay from the external clock edge to the timer incrementing.

**FIGURE 6-4: TIMER0 TIMING WITH EXTERNAL CLOCK**

External Clock Input or
Prescaler Output (2)

External Clock/Prescaler
Output After Sampling

Increment Timer0 (Q4)

Timer0

Q1 I Q2 I Q3 I Q4 Q1 I Q2 I Q3 I Q4 Q1 I Q2 I Q3 I Q4 Q1 I Q2 I Q3 I Q4

Small pulse
misses sampling

(1)

(3)

Note 1: Delay from clock input change to Timer0 increment is 3Tosc to 7Tosc. (Duration of Q = Tosc). Therefore, the error in measuring the interval between two edges on Timer0 input = ± 4Tosc max.

2: External clock if no prescaler selected; prescaler output otherwise.

3: The arrows indicate the points in time where sampling occurs.
6.2 **Prescaler**

An 8-bit counter is available as a prescaler for the Timer0 module or as a postscaler for the Watchdog Timer (WDT), respectively (Section 7.6). For simplicity, this counter is being referred to as “prescaler” throughout this data sheet. Note that the prescaler may be used by either the Timer0 module or the WDT, but not both. Thus, a prescaler assignment for the Timer0 module means that there is no prescaler for the WDT, and vice-versa.

The PSA and PS<2:0> bits (OPTION<3:0>) determine prescaler assignment and prescale ratio.

When assigned to the Timer0 module, all instructions writing to the TMR0 register (e.g., CLRF 1, MOVWF 1, BSF 1,x, etc.) will clear the prescaler. When assigned to WDT, a CLRWDT instruction will clear the prescaler along with the WDT. The prescaler is neither readable nor writable. On a RESET, the prescaler contains all ‘0’s.

### 6.2.1 Switching Prescaler Assignment

The prescaler assignment is fully under software control (i.e., it can be changed “on-the-fly” during program execution). To avoid an unintended device RESET, the following instruction sequence (Example 6-1) must be executed when changing the prescaler assignment from Timer0 to the WDT.

**EXAMPLE 6-1: CHANGING PRESCALER (TIMER0→WDT)**

1. CLRWD
   - Clear WDT
2. CLRF TMR0
   - Clear Timer0 & Prescaler
3. MOVWF '00xx1111'b
   - These 3 lines (5, 6, 7) are required only if desired
4. OPTION
5. CLRWD
   - PS<2:0> are 000 or 001
6. MOVWF '00xx1xxx'b
7. OPTION
   - desired WDT rate

To change prescaler from the WDT to the Timer0 module, use the sequence shown in Example 6-2. This sequence must be used even if the WDT is disabled. A CLRWDT instruction should be executed before switching the prescaler.

**EXAMPLE 6-2: CHANGING PRESCALER (WDT→TIMER0)**

CLRWD
- Clear WDT and prescaler
MOVWF 'xxxx0xxx'
- Select TMR0, new prescale value and clock source

OPTION

---

**FIGURE 6-5: BLOCK DIAGRAM OF THE TIMER0/WDT PRESCALER**

- **Note:** T0CS, T0SE, PSA, PS<2:0> are bits in the OPTION register.
7.0 SPECIAL FEATURES OF THE CPU

What sets a microcontroller apart from other processors are special circuits to deal with the needs of real-time applications. The PIC16C505 microcontroller has a host of such features intended to maximize system reliability, minimize cost through elimination of external components, provide power saving operating modes and offer code protection. These features are:

- Oscillator selection
- Reset
  - Power-On Reset (POR)
  - Device Reset Timer (DRT)
  - Wake-up from SLEEP on pin change
- Watchdog Timer (WDT)
- SLEEP
- Code protection
- ID locations
- In-circuit Serial Programming
- Clock Out

The PIC16C505 has a Watchdog Timer, which can be shut off only through configuration bit WDTE. It runs off of its own RC oscillator for added reliability. If using HS, XT or LP selectable oscillator options, there is always an 18 ms (nominal) delay provided by the Device Reset Timer (DRT), intended to keep the chip in reset until the crystal oscillator is stable. If using INTRC or EXTRC, there is an 18 ms delay only on VDD power-up. With this timer on-chip, most applications need no external reset circuitry.

The SLEEP mode is designed to offer a very low current power-down mode. The user can wake-up from SLEEP through a change on input pins or through a Watchdog Timer time-out. Several oscillator options are also made available to allow the part to fit the application, including an internal 4 MHz oscillator. The EXTRC oscillator option saves system cost while the LP crystal option saves power. A set of configuration bits are used to select various options.

7.1 Configuration Bits

The PIC16C505 configuration word consists of 12 bits. Configuration bits can be programmed to select various device configurations. Three bits are for the selection of the oscillator type, one bit is the Watchdog Timer enable bit, and one bit is the MCLR enable bit. Seven bits are for code protection (Register 7-1).

<table>
<thead>
<tr>
<th>CP</th>
<th>CP</th>
<th>CP</th>
<th>CP</th>
<th>CP</th>
<th>MCLRE</th>
<th>CP</th>
<th>WDTE</th>
<th>FOSC2</th>
<th>FOSC1</th>
<th>FOSC0</th>
<th>Register: CONFIG Address(2): 0FFh</th>
</tr>
</thead>
<tbody>
<tr>
<td>bit11</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>bit0</td>
</tr>
<tr>
<td>bit 11-6, 4: CP Code Protection bits (1)(2)(3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>bit 5: MCLRE: RB3/MCLR pin function select</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1 = RB3/MCLR pin function is MCLR</td>
<td></td>
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<tr>
<td>0 = RB3/MCLR pin function is digital I/O, MCLR internally tied to VDD</td>
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<tr>
<td>bit 3: WDTE: Watchdog timer enable bit</td>
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<tr>
<td>1 = WDT enabled</td>
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<tr>
<td>0 = WDT disabled</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>bit 2-0: FOSC&lt;1:0&gt;: Oscillator Selection bits</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>111 = external RC oscillator/CLKOUT function on RB4/OSC2/CLKOUT pin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>110 = external RC oscillator/RB4 function on RB4/OSC2/CLKOUT pin</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>101 = internal RC oscillator/CLKOUT function on RB4/OSC2/CLKOUT pin</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>100 = internal RC oscillator/RB4 function on RB4/OSC2/CLKOUT pin</td>
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<td></td>
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<tr>
<td>011 = invalid selection</td>
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<tr>
<td>010 = HS oscillator</td>
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<td></td>
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<tr>
<td>001 = XT oscillator</td>
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<td></td>
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<tr>
<td>000 = LP oscillator</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: 03FFh is always uncode protected on the PIC16C505. This location contains the MOVLWxx calibration instruction for the INTRC.

Note 2: Refer to the PIC16C505 Programming Specifications to determine how to access the configuration word. This register is not user addressable during device operation.

Note 3: All code protect bits must be written to the same value.
7.2 Oscillator Configurations

7.2.1 OSCILLATOR TYPES

The PIC16C505 can be operated in four different oscillator modes. The user can program three configuration bits (FOSC<2:0>) to select one of these four modes:

- LP: Low Power Crystal
- XT: Crystal/Resonator
- HS: High Speed Crystal/Resonator
- INTRC: Internal 4 MHz Oscillator
- EXTRC: External Resistor/Capacitor

7.2.2 CRYSTAL OSCILLATOR / CERAMIC RESONATORS

In HS, XT or LP modes, a crystal or ceramic resonator is connected to the RB5/OSC1/CLKIN and RB4/OSC2/CLKOUT pins to establish oscillation (Figure 7-1). The PIC16C505 oscillator design requires the use of a parallel cut crystal. Use of a series cut crystal may give a frequency out of the crystal manufacturers specifications. When in HS, XT or LP modes, the device can have an external clock source drive the RB5/OSC1/CLKIN pin (Figure 7-2).

FIGURE 7-1: CRYSTAL OPERATION (OR CERAMIC RESONATOR) (HS, XT OR LP OSC CONFIGURATION)

Note 1: See Capacitor Selection tables for recommended values of C1 and C2.
2: A series resistor (RS) may be required for AT strip cut crystals.
3: RF approx. value = 10 MΩ.

TABLE 7-1: CAPACITOR SELECTION FOR CERAMIC RESONATORS - PIC16C505

<table>
<thead>
<tr>
<th>Osc Type</th>
<th>Resonator Freq</th>
<th>Cap. Range C1</th>
<th>Cap. Range C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>XT</td>
<td>4.0 MHz</td>
<td>30 pF</td>
<td>30 pF</td>
</tr>
<tr>
<td>HS</td>
<td>16 MHz</td>
<td>10-47 pF</td>
<td>10-47 pF</td>
</tr>
</tbody>
</table>

These values are for design guidance only. Since each resonator has its own characteristics, the user should consult the resonator manufacturer for appropriate values of external components.

TABLE 7-2: CAPACITOR SELECTION FOR CRYSTAL OSCILLATOR - PIC16C505

<table>
<thead>
<tr>
<th>Osc Type</th>
<th>Resonator Freq</th>
<th>Cap. Range C1</th>
<th>Cap. Range C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP</td>
<td>32 kHz</td>
<td>15 pF</td>
<td>15 pF</td>
</tr>
<tr>
<td>XT</td>
<td>200 kHz</td>
<td>47-68 pF</td>
<td>47-68 pF</td>
</tr>
<tr>
<td></td>
<td>1 MHz</td>
<td>15 pF</td>
<td>15 pF</td>
</tr>
<tr>
<td></td>
<td>4 MHz</td>
<td>15 pF</td>
<td>15 pF</td>
</tr>
<tr>
<td>HS</td>
<td>20 MHz</td>
<td>15-47 pF</td>
<td>15-47 pF</td>
</tr>
</tbody>
</table>

Note 1: For VDD > 4.5V, C1 = C2 ≥ 30 pF is recommended.

These values are for design guidance only. Rs may be required to avoid overdriving crystals with low drive level specification. Since each crystal has its own characteristics, the user should consult the crystal manufacturer for appropriate values of external components.
7.2.3 EXTERNAL CRYSTAL OSCILLATOR CIRCUIT

Either a prepackaged oscillator or a simple oscillator circuit with TTL gates can be used as an external crystal oscillator circuit. Prepackaged oscillators provide a wide operating range and better stability. A well-designed crystal oscillator will provide good performance with TTL gates. Two types of crystal oscillator circuits can be used: one with parallel resonance, or one with series resonance.

Figure 7-3 shows implementation of a parallel resonant oscillator circuit. The circuit is designed to use the fundamental frequency of the crystal. The 74AS04 inverter performs the 180-degree phase shift that a parallel oscillator requires. The 4.7 kΩ resistor provides the negative feedback for stability. The 10 kΩ potentiometers bias the 74AS04 in the linear region. This circuit could be used for external oscillator designs.

**FIGURE 7-3: EXTERNAL PARALLEL RESONANT CRYSTAL OSCILLATOR CIRCUIT**

![External Parallel Resonant Crystal Oscillator Circuit Diagram](image)

Figure 7-4 shows a series resonant oscillator circuit. This circuit is also designed to use the fundamental frequency of the crystal. The inverter performs a 180-degree phase shift in a series resonant oscillator circuit. The 330 Ω resistors provide the negative feedback to bias the inverters in their linear region.

**FIGURE 7-4: EXTERNAL SERIES RESONANT CRYSTAL OSCILLATOR CIRCUIT**

![External Series Resonant Crystal Oscillator Circuit Diagram](image)

7.2.4 EXTERNAL RC OSCILLATOR

For timing insensitive applications, the RC device option offers additional cost savings. The RC oscillator frequency is a function of the supply voltage, the resistor (Rext) and capacitor (Cext) values, and the operating temperature. In addition to this, the oscillator frequency will vary from unit to unit due to normal process parameter variation. Furthermore, the difference in lead frame capacitance between package types will also affect the oscillation frequency, especially for low Cext values. The user also needs to take into account variation due to tolerance of external R and C components used.

Figure 7-5 shows how the R/C combination is connected to the PIC16C505. For Rext values below 2.2 kΩ, the oscillator operation may become unstable, or stop completely. For very high Rext values (e.g., 1 MΩ) the oscillator becomes sensitive to noise, humidity and leakage. Thus, we recommend keeping Rext between 3 kΩ and 100 kΩ.

Although the oscillator will operate with no external capacitor (Cext = 0 pF), we recommend using values above 20 pF for noise and stability reasons. With no or small external capacitance, the oscillation frequency can vary dramatically due to changes in external capacitances, such as PCB trace capacitance or package lead frame capacitance.

The Electrical Specifications section shows RC frequency variation from part to part due to normal process variation. The variation is larger for larger values of R (since leakage current variation will affect RC frequency more for large R) and for smaller values of C (since variation of input capacitance will affect RC frequency more).

Also, see the Electrical Specifications section for variation of oscillator frequency due to VDD for given Rext/Cext values, as well as frequency variation due to operating temperature for given R, C and VDD values.

**FIGURE 7-5: EXTERNAL RC OSCILLATOR MODE**

![External RC Oscillator Mode Diagram](image)
7.2.5  INTERNAL 4 MHz RC OSCILLATOR

The internal RC oscillator provides a fixed 4 MHz (nominal) system clock at \( V_{DD} = 5\text{V} \) and 25°C, see Electrical Specifications section for information on variation over voltage and temperature.

In addition, a calibration instruction is programmed into the last address of memory, which contains the calibration value for the internal RC oscillator. This location is always protected, regardless of the code protect settings. This value is programmed as a `MOVlw XX` instruction where `XX` is the calibration value, and is placed at the reset vector. This will load the `W` register with the calibration value upon reset and the `PC` will then roll over to the users program at address `0x000`. The user then has the option of writing the value to the `OSCCAL` Register (05h) or ignoring it.

`OSCCAL`, when written to with the calibration value, will “trim” the internal oscillator to remove process variation from the oscillator frequency.

| Note: | Please note that erasing the device will also erase the pre-programmed internal calibration value for the internal oscillator. The calibration value must be read prior to erasing the part so it can be reprogrammed correctly later. |

For the PIC16C505, only bits <7:2> of `OSCCAL` are implemented.

7.3  RESET

The device differentiates between various kinds of reset:

a) Power on reset (POR)

b) `MCLR` reset during normal operation

c) `MCLR` reset during SLEEP

d) WDT time-out reset during normal operation

e) WDT time-out reset during SLEEP

f) Wake-up from SLEEP on pin change

Some registers are not reset in any way, they are unknown on POR and unchanged in any other reset. Most other registers are reset to “reset state” on power-on reset (POR), `MCLR`, WDT or wake-up on pin change reset during normal operation. They are not affected by a WDT reset during SLEEP or `MCLR` reset during SLEEP, since these resets are viewed as resumption of normal operation. The exceptions to this are `TO`, `PD` and `RBWUF` bits. They are set or cleared differently in different reset situations. These bits are used in software to determine the nature of reset. See Table 7-3 for a full description of reset states of all registers.
### TABLE 7-3:  RESET CONDITIONS FOR REGISTERS

<table>
<thead>
<tr>
<th>Register</th>
<th>Address</th>
<th>Power-on Reset</th>
<th>MCLR Reset</th>
<th>WDT time-out</th>
<th>Wake-up on Pin Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>—</td>
<td>0000 0000</td>
<td>0000 0000</td>
<td>0000 0000</td>
<td>0000 0000</td>
</tr>
<tr>
<td>INDF</td>
<td>00h</td>
<td>xxxxx xxxxx</td>
<td>0000 0000</td>
<td>0000 0000</td>
<td>0000 0000</td>
</tr>
<tr>
<td>TMR0</td>
<td>01h</td>
<td>xxxxx xxxxx</td>
<td>0000 0000</td>
<td>0000 0000</td>
<td>0000 0000</td>
</tr>
<tr>
<td>PC</td>
<td>02h</td>
<td>1111 1111</td>
<td>1111 1111</td>
<td>1111 1111</td>
<td>1111 1111</td>
</tr>
<tr>
<td>STATUS</td>
<td>03h</td>
<td>0001 1xxx</td>
<td>0001 1xxx</td>
<td>0001 1xxx</td>
<td>0001 1xxx</td>
</tr>
<tr>
<td>FSR</td>
<td>04h</td>
<td>110x xxxx</td>
<td>110x xxxx</td>
<td>110x xxxx</td>
<td>110x xxxx</td>
</tr>
<tr>
<td>OSCCAL</td>
<td>05h</td>
<td>1000 00--</td>
<td>1000 00--</td>
<td>1000 00--</td>
<td>1000 00--</td>
</tr>
<tr>
<td>PORTB</td>
<td>06h</td>
<td>--xx xxxxxx</td>
<td>--xx xxxxxx</td>
<td>--xx xxxxxx</td>
<td>--xx xxxxxx</td>
</tr>
<tr>
<td>PORTC</td>
<td>07h</td>
<td>--xx xxxxxx</td>
<td>--xx xxxxxx</td>
<td>--xx xxxxxx</td>
<td>--xx xxxxxx</td>
</tr>
<tr>
<td>OPTION</td>
<td>—</td>
<td>--11 1111</td>
<td>--11 1111</td>
<td>--11 1111</td>
<td>--11 1111</td>
</tr>
<tr>
<td>TRISB</td>
<td>—</td>
<td>--11 1111</td>
<td>--11 1111</td>
<td>--11 1111</td>
<td>--11 1111</td>
</tr>
<tr>
<td>TRISC</td>
<td>—</td>
<td>--11 1111</td>
<td>--11 1111</td>
<td>--11 1111</td>
<td>--11 1111</td>
</tr>
</tbody>
</table>

Legend:  
'u' = unchanged,  
x = unknown,  
'-' = unimplemented bit, read as '0',  
'q' = value depends on condition.

**Note 1:** Bits <7:2> of W register contain oscillator calibration values due to MOVLW XX instruction at top of memory.

**Note 2:** See Table 7-7 for reset value for specific conditions.

**Note 3:** If reset was due to wake-up on pin change, then bit 7 = 1. All other resets will cause bit 7 = 0.

### TABLE 7-4:  RESET CONDITION FOR SPECIAL REGISTERS

<table>
<thead>
<tr>
<th></th>
<th>STATUS Addr: 03h</th>
<th>PCL Addr: 02h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power on reset</td>
<td>0001 1xxx</td>
<td>1111 1111</td>
</tr>
<tr>
<td>MCLR reset during normal operation</td>
<td>000u uuuu</td>
<td>1111 1111</td>
</tr>
<tr>
<td>MCLR reset during SLEEP</td>
<td>0001 0uuu</td>
<td>1111 1111</td>
</tr>
<tr>
<td>WDT reset during SLEEP</td>
<td>0000 0uuu</td>
<td>1111 1111</td>
</tr>
<tr>
<td>WDT reset normal operation</td>
<td>0000 uuuu</td>
<td>1111 1111</td>
</tr>
<tr>
<td>Wake-up from SLEEP on pin change</td>
<td>1001 0uuu</td>
<td>1111 1111</td>
</tr>
</tbody>
</table>

Legend:  
'u' = unchanged,  
x = unknown,  
'-' = unimplemented bit, read as '0'.
7.3.1 MCLR ENABLE

This configuration bit when unprogrammed (left in the ‘1’ state) enables the external MCLR function. When programmed, the MCLR function is tied to the internal VDD, and the pin is assigned to be a I/O. See Figure 7-6.

![Figure 7-6: MCLR SELECT](image)

7.4 Power-On Reset (POR)

The PIC16C505 family incorporates on-chip Power-On Reset (POR) circuitry, which provides an internal chip reset for most power-up situations.

The on-chip POR circuit holds the chip in reset until VDD has reached a high enough level for proper operation. To take advantage of the internal POR, program the RB3/MCLR/VPP pin as MCLR and tie through a resistor to VDD or program the pin as RB3. An internal weak pull-up resistor is implemented using a transistor. Refer to Table 10-1 for the pull-up resistor ranges. This will eliminate external RC components usually needed to create a Power-on Reset. A maximum rise time for VDD is specified. See Electrical Specifications for details.

When the device starts normal operation (exits the reset condition), device operating parameters (voltage, frequency, temperature, ...) must be met to ensure operation. If these conditions are not met, the device must be held in reset until the operating parameters are met.

A simplified block diagram of the on-chip Power-On Reset circuit is shown in Figure 7-7.

The Power-On Reset circuit and the Device Reset Timer (Section 7.5) circuit are closely related. On power-up, the reset latch is set and the DRT is reset. The DRT timer begins counting once it detects MCLR to be high. After the time-out period, which is typically 18 ms, it will reset the reset latch and thus end the on-chip reset signal.

A power-up example where MCLR is held low is shown in Figure 7-8. VDD is allowed to rise and stabilize before bringing MCLR high. The chip will actually come out of reset TＤＲＴ msec after MCLR goes high.

In Figure 7-9, the on-chip Power-On Reset feature is being used (MCLR and VDD are tied together or the pin is programmed to be RB3). The VDD is stable before the start-up timer times out and there is no problem in getting a proper reset. However, Figure 7-10 depicts a problem situation where VDD rises too slowly. The time between when the DRT senses that MCLR is high and when MCLR and VDD actually reach their full value, is too long. In this situation, when the start-up timer times out, VDD has not reached the VDD (min) value and the chip may not function correctly. For such situations, we recommend that external RC circuits be used to achieve longer POR delay times (Figure 7-9).

**Note:** When the device starts normal operation (exits the reset condition), device operating parameters (voltage, frequency, temperature, ...) must be met to ensure operation. If these conditions are not met, the device must be held in reset until the operating conditions are met.

For additional information refer to Application Notes “Power-Up Considerations” - AN522 and “Power-up Trouble Shooting” - AN607.
FIGURE 7-7: SIMPLIFIED BLOCK DIAGRAM OF ON-CHIP RESET CIRCUIT

FIGURE 7-8: TIME-OUT SEQUENCE ON POWER-UP (MCLR PULLED LOW)

FIGURE 7-9: TIME-OUT SEQUENCE ON POWER-UP (MCLR TIED TO VDD): FAST VDD RISE TIME
7.5 Device Reset Timer (DRT)

In the PIC16C505, the DRT runs any time the device is powered up. DRT runs from RESET and varies based on oscillator selection and reset type (see Table 7-5).

The DRT operates on an internal RC oscillator. The processor is kept in RESET as long as the DRT is active. The DRT delay allows VDD to rise above VDD min. and for the oscillator to stabilize.

Oscillator circuits based on crystals or ceramic resonators require a certain time after power-up to establish a stable oscillation. The on-chip DRT keeps the device in a RESET condition for approximately 18 ms after MCLR has reached a logic high (VIH MCLR) level. Thus, programming RB3/MCLR/VPP as MCLR and using an external RC network connected to the MCLR input is not required in most cases, allowing for savings in cost-sensitive and/or space restricted applications, as well as allowing the use of the RB3/MCLR/VPP pin as a general purpose input.

The Device Reset time delay will vary from chip to chip due to VDD, temperature and process variation. See AC parameters for details.

The DRT will also be triggered upon a Watchdog Timer time-out. This is particularly important for applications using the WDT to wake from SLEEP mode automatically.

Reset sources are POR, MCLR, WDT time-out and Wake-up on pin change. (See Section 7.9.2, Notes 1, 2, and 3, page 37.)

7.6 Watchdog Timer (WDT)

The Watchdog Timer (WDT) is a free running on-chip RC oscillator, which does not require any external components. This RC oscillator is separate from the external RC oscillator of the RB5/OSC1/CLKIN pin and the internal 4 MHz oscillator. That means that the WDT will run even if the main processor clock has been stopped, for example, by execution of a SLEEP instruction. During normal operation or SLEEP, a WDT reset or wake-up reset generates a device RESET.

The TO bit (STATUS<4>) will be cleared upon a Watchdog Timer reset.

The WDT can be permanently disabled by programming the configuration bit WDTE as a ‘0’ (Section 7.1). Refer to the PIC16C505 Programming Specifications to determine how to access the configuration word.

<table>
<thead>
<tr>
<th>Oscillator Configuration</th>
<th>POR Reset</th>
<th>Subsequent Resets</th>
</tr>
</thead>
<tbody>
<tr>
<td>IntRC &amp; ExtRC</td>
<td>18 ms (typical)</td>
<td>300 µs (typical)</td>
</tr>
<tr>
<td>HS, XT &amp; LP</td>
<td>18 ms (typical)</td>
<td>18 ms (typical)</td>
</tr>
</tbody>
</table>

Note: When VDD rises slowly, the TDRT time-out expires long before VDD has reached its final value. In this example, the chip will reset properly if, and only if, V1 ≥ VDD min.
7.6.1 WDT PERIOD

The WDT has a nominal time-out period of 18 ms, (with no prescaler). If a longer time-out period is desired, a prescaler with a division ratio of up to 1:128 can be assigned to the WDT (under software control) by writing to the OPTION register. Thus, a time-out period of a nominal 2.3 seconds can be realized. These periods vary with temperature, VDD and part-to-part process variations (see DC specs). Under worst case conditions (VDD = Min., Temperature = Max., max. WDT prescaler), it may take several seconds before a WDT time-out occurs.

7.6.2 WDT PROGRAMMING CONSIDERATIONS

The CLRWD T instruction clears the WDT and the postscaler, if assigned to the WDT, and prevents it from timing out and generating a device RESET. The SLEEP instruction resets the WDT and the postscaler, if assigned to the WDT. This gives the maximum SLEEP time before a WDT wake-up reset.

FIGURE 7-11: WATCHDOG TIMER BLOCK DIAGRAM

TABLE 7-6: SUMMARY OF REGISTERS ASSOCIATED WITH THE WATCHDOG TIMER

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
<th>Value on Power-On Reset</th>
<th>Value on All Other Resets</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>RBWU</td>
<td>RBPU</td>
<td>T0CS</td>
<td>T0SE</td>
<td>PSA</td>
<td>PS2</td>
<td>PS1</td>
<td>PS0</td>
<td></td>
<td>1111 1111</td>
<td>1111 1111</td>
</tr>
</tbody>
</table>

Legend: Shaded boxes = Not used by Watchdog Timer, — = unimplemented, read as '0', u = unchanged.
7.7  **Time-Out Sequence, Power Down, and Wake-up from SLEEP Status Bits (TO/PD/RBWUF)**

The TO, PD, and RBWUF bits in the STATUS register can be tested to determine if a RESET condition has been caused by a power-up condition, a MCLR or Watchdog Timer (WDT) reset.

**TABLE 7-7: TO/PD/RBWUF STATUS AFTER RESET**

<table>
<thead>
<tr>
<th>RBWUF</th>
<th>TO</th>
<th>PD</th>
<th>RESET caused by</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>WDT wake-up from SLEEP</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>u</td>
<td>WDT time-out (not from SLEEP)</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>MCLR wake-up from SLEEP</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Power-up</td>
</tr>
<tr>
<td>0</td>
<td>u</td>
<td>u</td>
<td>MCLR not during SLEEP</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>Wake-up from SLEEP on pin change</td>
</tr>
</tbody>
</table>

**Legend:** u = unchanged  
**Note 1:** The TO, PD, and RBWUF bits maintain their status (u) until a reset occurs. A low-pulse on the MCLR input does not change the TO, PD, and RBWUF status bits.

7.8  **Reset on Brown-Out**

A brown-out is a condition where device power (VDD) dips below its minimum value, but not to zero, and then recovers. The device should be reset in the event of a brown-out.

To reset PIC16C505 devices when a brown-out occurs, external brown-out protection circuits may be built, as shown in Figure 7-12 and Figure 7-13.

**FIGURE 7-12: BROWN-OUT PROTECTION CIRCUIT 1**

This circuit will activate reset when VDD goes below Vz + 0.7V (where Vz = Zener voltage).  
**Note 1:** Pin must be confirmed as MCLR.

**FIGURE 7-13: BROWN-OUT PROTECTION CIRCUIT 2**

This brown-out circuit is less expensive, although less accurate. Transistor Q1 turns off when VDD is below a certain level such that:

\[
VDD \cdot \frac{R1}{R1 + R2} = 0.7V
\]

**Note 1:** Pin must be confirmed as MCLR.

**FIGURE 7-14: BROWN-OUT PROTECTION CIRCUIT 3**

This brown-out protection circuit employs Microchip Technology’s MCP809 microcontroller supervisor. There are 7 different trip point selections to accommodate 5V to 3V systems.
7.9 Power-Down Mode (SLEEP)

A device may be powered down (SLEEP) and later powered up (Wake-up from SLEEP).

7.9.1 SLEEP

The Power-Down mode is entered by executing a SLEEP instruction.

If enabled, the Watchdog Timer will be cleared but keeps running, the TO bit (STATUS<4>) is set, the PD bit (STATUS<3>) is cleared and the oscillator driver is turned off. The I/O ports maintain the status they had before the SLEEP instruction was executed (driving high, driving low or hi-impedance).

It should be noted that a RESET generated by a WDT time-out does not drive the MCLR pin low.

For lowest current consumption while powered down, the T0CKI input should be at VDD or VSS and the RB3/MCLR/VPP pin must be at a logic high level (VIHMC) if MCLR is enabled.

7.9.2 WAKE-UP FROM SLEEP

The device can wake-up from SLEEP through one of the following events:

1. An external reset input on RB3/MCLR/VPP pin, when configured as MCLR.
2. A Watchdog Timer time-out reset (if WDT was enabled).
3. A change on input pin RB0, RB1, RB3 or RB4 when wake-up on change is enabled.

These events cause a device reset. The TO, PD, and RBWUF bits can be used to determine the cause of device reset. The TO bit is cleared if a WDT time-out occurred (and caused wake-up). The PD bit, which is set on power-up, is cleared when SLEEP is invoked. The RBWUF bit indicates a change in state while in SLEEP at pins RB0, RB1, RB3 or RB4 (since the last file or bit operation on RB port).

Caution: Right before entering SLEEP read the input pins. When in SLEEP, wake up occurs when the values at the pins change from the state they were in at the last reading. If a wake-up on change occurs and the pins are not read before reentering SLEEP, a wake-up will occur immediately even if no pins change while in SLEEP mode.

The WDT is cleared when the device wakes from sleep, regardless of the wake-up source.

7.10 Program Verification/Code Protection

If the code protection bit has not been programmed, the on-chip program memory can be read out for verification purposes.

The first 64 locations and the last location (OSCCAL) can be read, regardless of the code protection bit setting.

7.11 ID Locations

Four memory locations are designated as ID locations where the user can store checksum or other code-identification numbers. These locations are not accessible during normal execution, but are readable and writable during program/verify.

Use only the lower 4 bits of the ID locations and always program the upper 8 bits as ‘0’s.
7.12 In-Circuit Serial Programming

The PIC16C505 microcontrollers can be serially programmed while in the end application circuit. This is simply done with two lines for clock and data, and three other lines for power, ground, and the programming voltage. This allows customers to manufacture boards with unprogrammed devices, and then program the microcontroller just before shipping the product. This also allows the most recent firmware or a custom firmware to be programmed.

The device is placed into a program/verify mode by holding the RB1 and RB0 pins low while raising the MCLR (VPP) pin from VIL to VIHH (see programming specification). RB1 becomes the programming clock and RB0 becomes the programming data. Both RB1 and RB0 are Schmitt Trigger inputs in this mode.

After reset, a 6-bit command is then supplied to the device. Depending on the command, 14 bits of program data are then supplied to or from the device, depending if the command was a load or a read. For complete details of serial programming, please refer to the PIC16C505 Programming Specifications.

A typical in-circuit serial programming connection is shown in Figure 7-15.
8.0 INSTRUCTION SET SUMMARY

Each PIC16C505 instruction is a 12-bit word divided into an OPCODE, which specifies the instruction type, and one or more operands which further specify the operation of the instruction. The PIC16C505 instruction set summary in Table 8-2 groups the instructions into byte-oriented, bit-oriented, and literal and control operations. Table 8-1 shows the opcode field descriptions.

For byte-oriented instructions, 'f' represents a file register designator and 'd' represents a destination designator. The file register designator is used to specify which one of the 32 file registers is to be used by the instruction.

The destination designator specifies where the result of the operation is to be placed. If 'd' is '0', the result is placed in the W register. If 'd' is '1', the result is placed in the file register specified in the instruction.

For bit-oriented instructions, 'b' represents a bit field designator which selects the number of the bit affected by the operation, while 'f' represents the number of the file in which the bit is located.

For literal and control operations, 'k' represents an 8 or 9-bit constant or literal value.

<table>
<thead>
<tr>
<th>Table 8-1: Opcode Field Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
</tr>
<tr>
<td>f</td>
</tr>
<tr>
<td>W</td>
</tr>
<tr>
<td>b</td>
</tr>
<tr>
<td>k</td>
</tr>
<tr>
<td>x</td>
</tr>
<tr>
<td>d</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>label</td>
</tr>
<tr>
<td>TOS</td>
</tr>
<tr>
<td>PC</td>
</tr>
<tr>
<td>WDT</td>
</tr>
<tr>
<td>TO</td>
</tr>
<tr>
<td>PD</td>
</tr>
<tr>
<td>dest</td>
</tr>
<tr>
<td>[ ]</td>
</tr>
<tr>
<td>( )</td>
</tr>
<tr>
<td>→</td>
</tr>
<tr>
<td>&lt; &gt;</td>
</tr>
<tr>
<td>∈</td>
</tr>
<tr>
<td>italics</td>
</tr>
</tbody>
</table>

All instructions are executed within a single instruction cycle, unless a conditional test is true or the program counter is changed as a result of an instruction. In this case, the execution takes two instruction cycles. One instruction cycle consists of four oscillator periods. Thus, for an oscillator frequency of 4 MHz, the normal instruction execution time is 1 \( \mu \text{s} \). If a conditional test is true or the program counter is changed as a result of an instruction, the instruction execution time is 2 \( \mu \text{s} \).

Figure 8-1 shows the three general formats that the instructions can have. All examples in the figure use the following format to represent a hexadecimal number:

\[ 0x\text{hhh} \]

where 'h' signifies a hexadecimal digit.

**FIGURE 8-1: GENERAL FORMAT FOR INSTRUCTIONS**

<table>
<thead>
<tr>
<th>Byte-oriented file register operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPCODE</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bit-oriented file register operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPCODE</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Literal and control operations (except GOTO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPCODE</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Literal and control operations - GOTO instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPCODE</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
### TABLE 8-2: INSTRUCTION SET SUMMARY

<table>
<thead>
<tr>
<th>Mnemonic, Operands</th>
<th>Description</th>
<th>Cycles</th>
<th>12-Bit Opcode</th>
<th>Status Affected</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDWF f,d</td>
<td>Add W and f</td>
<td>1</td>
<td>0001 11df fffe</td>
<td>C,DC,Z</td>
<td>1,2,4</td>
</tr>
<tr>
<td>ANDWF f,d</td>
<td>AND W with f</td>
<td>1</td>
<td>0001 01df fffe</td>
<td>Z</td>
<td>2,4</td>
</tr>
<tr>
<td>CLRF f</td>
<td>Clear f</td>
<td>1</td>
<td>0000 011f fffe</td>
<td>Z</td>
<td>4</td>
</tr>
<tr>
<td>CLRW –</td>
<td>Clear W</td>
<td>1</td>
<td>0000 0010 fffe</td>
<td>Z</td>
<td></td>
</tr>
<tr>
<td>COMF f,d</td>
<td>Complement f</td>
<td>1</td>
<td>0010 01df fffe</td>
<td>Z</td>
<td></td>
</tr>
<tr>
<td>DECF f,d</td>
<td>Decrement f</td>
<td>1</td>
<td>0000 11df fffe</td>
<td>Z</td>
<td>2,4</td>
</tr>
<tr>
<td>DECFSZ f,d</td>
<td>Decrement f, Skip if 0</td>
<td>1(2)</td>
<td>0010 11df fffe</td>
<td>None</td>
<td>2,4</td>
</tr>
<tr>
<td>INCf, d</td>
<td>Increment f</td>
<td>1</td>
<td>0010 10df fffe</td>
<td>Z</td>
<td>2,4</td>
</tr>
<tr>
<td>INCFSZ f,d</td>
<td>Increment f, Skip if 0</td>
<td>1(2)</td>
<td>0011 11df fffe</td>
<td>None</td>
<td>2,4</td>
</tr>
<tr>
<td>IORWF f,d</td>
<td>Inclusive OR W with f</td>
<td>1</td>
<td>0001 00df fffe</td>
<td>Z</td>
<td>2,4</td>
</tr>
<tr>
<td>MOVF f,d</td>
<td>Move f</td>
<td>1</td>
<td>0010 00df fffe</td>
<td>Z</td>
<td>2,4</td>
</tr>
<tr>
<td>MOVWF f</td>
<td>Move W to f</td>
<td>1</td>
<td>0000 001f fffe</td>
<td>None</td>
<td>1,4</td>
</tr>
<tr>
<td>NOP –</td>
<td>No Operation</td>
<td>1</td>
<td>0000 0000 fffe</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>RLF f,d</td>
<td>Rotate left f through Carry</td>
<td>1</td>
<td>0011 01df fffe</td>
<td>C</td>
<td>2,4</td>
</tr>
<tr>
<td>RRF f,d</td>
<td>Rotate right f through Carry</td>
<td>1</td>
<td>0011 00df fffe</td>
<td>C</td>
<td>2,4</td>
</tr>
<tr>
<td>SUBWF f,d</td>
<td>Subtract W from f</td>
<td>1</td>
<td>0000 10df fffe</td>
<td>C,DC,Z</td>
<td>1,2,4</td>
</tr>
<tr>
<td>SWAPF f,d</td>
<td>Swap f</td>
<td>1</td>
<td>0011 10df fffe</td>
<td>None</td>
<td>2,4</td>
</tr>
<tr>
<td>XORWF f,d</td>
<td>Exclusive OR W with f</td>
<td>1</td>
<td>0001 10df fffe</td>
<td>Z</td>
<td>2,4</td>
</tr>
</tbody>
</table>

#### BIT-ORIENTED FILE REGISTER OPERATIONS

<table>
<thead>
<tr>
<th>Mnemonic, Operands</th>
<th>Description</th>
<th>Cycles</th>
<th>12-Bit Opcode</th>
<th>Status Affected</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCF f, b</td>
<td>Bit Clear f</td>
<td>1</td>
<td>0100 bbbf fffe</td>
<td>None</td>
<td>2,4</td>
</tr>
<tr>
<td>BSF f, b</td>
<td>Bit Set f</td>
<td>1</td>
<td>0101 bbbf fffe</td>
<td>None</td>
<td>2,4</td>
</tr>
<tr>
<td>BTFSC f, b</td>
<td>Bit Test f, Skip if Clear</td>
<td>1(2)</td>
<td>0110 bbbf fffe</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>BTFSS f, b</td>
<td>Bit Test f, Skip if Set</td>
<td>1(2)</td>
<td>0111 bbbf fffe</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

#### LITERAL AND CONTROL OPERATIONS

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Description</th>
<th>Cycles</th>
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<th>Status Affected</th>
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<td>AND literal with W</td>
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<td>Z</td>
<td>1</td>
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<tr>
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<td>2</td>
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<td>None</td>
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<td>None</td>
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<tr>
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<td>None</td>
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</tr>
<tr>
<td>IORLW k</td>
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<td>1</td>
<td>1101 kkkk kkkk</td>
<td>Z</td>
<td></td>
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<td>1100 kkkk kkkk</td>
<td>None</td>
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<td>Return, place Literal in W</td>
<td>2</td>
<td>1000 kkkk kkkk</td>
<td>None</td>
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<td>SLEEP –</td>
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<td>0000 0000 0011 TO, PD</td>
<td>None</td>
<td></td>
</tr>
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<td>TRIS f</td>
<td>Load TRIS register</td>
<td>1</td>
<td>0000 0000 0ffe None</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>XORLW k</td>
<td>Exclusive OR Literal to W</td>
<td>1</td>
<td>1111 kkkk kkkk</td>
<td>Z</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** The 9th bit of the program counter will be forced to a ‘0’ by any instruction that writes to the PC except for GOTO. (Section 4.6)

**Note 2:** When an I/O register is modified as a function of itself (e.g. MOVF PORTB, 1), the value used will be that value present on the pins themselves. For example, if the data latch is ‘1’ for a pin configured as input and is driven low by an external device, the data will be written back with a ‘0’.

**Note 3:** The instruction TRIS f, where f = 6 causes the contents of the W register to be written to the tristate latches of PORTB. A ‘1’ forces the pin to a hi-impedance state and disables the output buffers.

**Note 4:** If this instruction is executed on the TMR0 register (and, where applicable, d = 1), the prescaler will be cleared (if assigned to TMR0).
ADDWF Add W and f
Syntax: \([ \text{label} ] \) ADDWF \( f,d \)
Operands: \( 0 \leq f \leq 31 \)
\( d \in [0,1] \)
Operation: \((W) + (f) \rightarrow (\text{dest})\)
Status Affected: C, DC, Z
Encoding:
\[
\begin{array}{c}
0001 \\
11df \\
nffe
\end{array}
\]
Description: Add the contents of the W register and register \('f'.\) If \('d' = 0, the result is stored in the W register. If \('d' = 1', the result is stored back in register \('Y'.\)

Words: 1
Cycles: 1
Example: ADDWF FSR, 0

Before Instruction
\[
\begin{array}{c}
W = 0x17 \\
FSR = 0xC2
\end{array}
\]
After Instruction
\[
\begin{array}{c}
W = 0xD9 \\
FSR = 0xC2
\end{array}
\]

ANDWF AND W with f
Syntax: \([ \text{label} ] \) ANDWF \( f,d \)
Operands: \( 0 \leq f \leq 31 \)
\( d \in [0,1] \)
Operation: \((W) .AND. (f) \rightarrow (\text{dest})\)
Status Affected: Z
Encoding:
\[
\begin{array}{c}
0001 \\
01df \\
nffe
\end{array}
\]
Description: The contents of the W register are AND'ed with register \('f'.\) If \('d' = 0, the result is stored in the W register. If \('d' = 1', the result is stored back in register \('Y'.\)

Words: 1
Cycles: 1
Example: ANDWF FSR, 1

Before Instruction
\[
\begin{array}{c}
W = 0x17 \\
FSR = 0xC2
\end{array}
\]
After Instruction
\[
\begin{array}{c}
W = 0x17 \\
FSR = 0x02
\end{array}
\]

ANDLW And literal with W
Syntax: \([ \text{label} ] \) ANDLW \( k \)
Operands: \( 0 \leq k \leq 255 \)
Operation: \((W) .AND. (k) \rightarrow (W)\)
Status Affected: Z
Encoding:
\[
\begin{array}{c}
1110 \\
kkkk \\
kkkk
\end{array}
\]
Description: The contents of the W register are AND'ed with the eight-bit literal \('k'.\) The result is placed in the W register.

Words: 1
Cycles: 1
Example: ANDLW 0x5F

Before Instruction
\[
\begin{array}{c}
W = 0xA3
\end{array}
\]
After Instruction
\[
\begin{array}{c}
W = 0x03
\end{array}
\]

BCF Bit Clear f
Syntax: \([ \text{label} ] \) BCF \( f,b \)
Operands: \( 0 \leq f \leq 31 \)
\( 0 \leq b \leq 7 \)
Operation: \(0 \rightarrow (f < b>)\)
Status Affected: None
Encoding:
\[
\begin{array}{c}
0100 \\
bbbb \\
nffe
\end{array}
\]
Description: Bit \('b' in register \('f' is cleared.

Words: 1
Cycles: 1
Example: BCF FLAG_REG, 7

Before Instruction
\[
\begin{array}{c}
\text{FLAG\_REG} = 0xC7
\end{array}
\]
After Instruction
\[
\begin{array}{c}
\text{FLAG\_REG} = 0x47
\end{array}
\]
### BSF Bit Set f

**Syntax:**

\[
\text{[ label ] BSF f,b}
\]

**Operands:**

\[
0 \leq f \leq 31 \\
0 \leq b \leq 7
\]

**Operation:**

\[
1 \rightarrow (f<b>)
\]

**Status Affected:** None

**Encoding:**

\[
0101 \ bbbf \ ffff
\]

**Description:** Bit 'b' in register 'f' is set.

**Words:** 1

**Cycles:** 1

**Example:**

Before Instruction

FLAG_REG = 0x0A

After Instruction

FLAG_REG = 0x8A

### BTFSC Bit Test f, Skip if Clear

**Syntax:**

\[
\text{[ label ] BTFSC f,b}
\]

**Operands:**

\[
0 \leq f \leq 31 \\
0 \leq b \leq 7
\]

**Operation:**

skip if \((f<b>) = 0\)

**Status Affected:** None

**Encoding:**

\[
0110 \ bbbf \ ffff
\]

**Description:** If bit 'b' in register 'f' is 0, then the next instruction is skipped. If bit 'b' is 0, then the next instruction fetched during the current instruction execution is discarded, and a NOP is executed instead, making this a 2 cycle instruction.

**Words:** 1

**Cycles:** 1(2)

**Example:**

Before Instruction

PC = address (HERE)

After Instruction

If FLAG<1> = 0,

PC = address (FALSE);

If FLAG<1> = 1,

PC = address (TRUE)

### BTFSS Bit Test f, Skip if Set

**Syntax:**

\[
\text{[ label ] BTFSS f,b}
\]

**Operands:**

\[
0 \leq f \leq 31 \\
0 \leq b < 7
\]

**Operation:**

skip if \((f<b>) = 1\)

**Status Affected:** None

**Encoding:**

\[
0111 \ bbbf \ ffff
\]

**Description:** If bit 'b' in register 'f' is '1', then the next instruction is skipped. If bit 'b' is '1', then the next instruction fetched during the current instruction execution is discarded, and a NOP is executed instead, making this a 2 cycle instruction.

**Words:** 1

**Cycles:** 1(2)

**Example:**

Before Instruction

PC = address (HERE)

After Instruction

If FLAG<1> = 0,

PC = address (FALSE);

If FLAG<1> = 1,

PC = address (TRUE)
### CALL Subroutine Call

**Syntax:**
\[ \text{[label]} \text{ CALL } k \]

**Operands:**
0 ≤ k ≤ 255

**Operation:**
(PC) + 1 → Top of Stack;
k → PC<7:0>;
(STATUS<6:5>) → PC<10:9>;
0 → PC<8>

**Status Affected:** None

**Encoding:**
1001  \( \text{kkkk} \)  \( \text{kkkk} \)

**Description:**
Subroutine call. First, return address (PC+1) is pushed onto the stack. The eight bit immediate address is loaded into PC bits <7:0>. The upper bits PC<10:9> are loaded from STATUS<6:5>, PC<8> is cleared. CALL is a two cycle instruction.

**Words:** 1

**Cycles:** 2

**Example:**
HERE CALL THERE

Before Instruction
PC = address (HERE)

After Instruction
PC = address (THERE)
TOS = address (HERE + 1)

### CLRW Clear W

**Syntax:**
\[ \text{[label]} \text{ CLRW} \]

**Operands:** None

**Operation:**
00h → (W);
1 → Z

**Status Affected:** Z

**Encoding:**
0000 0100 0000

**Description:**
The W register is cleared. Zero bit (Z) is set.

**Words:** 1

**Cycles:** 1

**Example:** CLRW

Before Instruction
W = 0x5A

After Instruction
W = 0x00
Z = 1

### CLRWDT Clear Watchdog Timer

**Syntax:**
\[ \text{[label]} \text{ CLRWDT} \]

**Operands:** None

**Operation:**
00h → WDT;
0 → WDT prescaler (if assigned);
1 → T0;
1 → PD

**Status Affected:** T0, PD

**Encoding:**
0000 0000 0100

**Description:**
The CLRWDT instruction resets the WDT. It also resets the prescaler, if the prescaler is assigned to the WDT and not Timer0. Status bits T0 and PD are set.

**Words:** 1

**Cycles:** 1

**Example:** CLRWDT

Before Instruction
WDT counter = ?

After Instruction
WDT counter = 0x00
WDT prescale = 0
T0 = 1
PD = 1
### COMF  Complement f

**Syntax:**
\[
\text{[ label] } \text{COMF } f,d
\]

**Operands:**
\[0 \leq f \leq 31\]
\[d \in [0,1]\]

**Operation:**
\[(f) \rightarrow (\text{dest})\]

**Status Affected:**
\[Z\]

**Encoding:**
\[
\begin{array}{cccc}
0 & 0 & 1 & 0 \text{df} \\
& & & ffff
\end{array}
\]

**Description:**
The contents of register 'f' are complemented. If 'd' is 0, the result is stored in the W register. If 'd' is 1, the result is stored back in register 'f'.

**Words:**
1

**Cycles:**
1

**Example:**
\[
\text{COMF REG1, 0}
\]

**Before Instruction**
\[
\text{REG1} = 0x13
\]

**After Instruction**
\[
\text{REG1} = 0x13 \\
W = 0xEC
\]

### DECF  Decrement f

**Syntax:**
\[
\text{[ label] } \text{DECF } f,d
\]

**Operands:**
\[0 \leq f \leq 31\]
\[d \in [0,1]\]

**Operation:**
\[(f) - 1 \rightarrow (\text{dest})\]

**Status Affected:**
\[Z\]

**Encoding:**
\[
\begin{array}{cccc}
0 & 0 & 0 & 0 \text{df} \\
& & & ffff
\end{array}
\]

**Description:**
Decrement register 'f'. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is placed back in register 'f'.

**Words:**
1

**Cycles:**
1

**Example:**
\[
\text{DECF CNT, 1}
\]

**Before Instruction**
\[
\text{PC} = \text{address (HERE)}
\]

**After Instruction**
\[
\text{CNT} = \text{CNT - 1}; \\
\text{if CNT = 0,} \\
\text{PC = \text{address (CONTINUE)}}; \\
\text{if CNT \neq 0,} \\
\text{PC = \text{address (HERE+1)}}
\]

### DECFSZ  Decrement f, Skip if 0

**Syntax:**
\[
\text{[ label] } \text{DECFSZ } f,d
\]

**Operands:**
\[0 \leq f \leq 31\]
\[d \in [0,1]\]

**Operation:**
\[(f) - 1 \rightarrow d; \text{ skip if result = 0}\]

**Status Affected:**
None

**Encoding:**
\[
\begin{array}{cccc}
0 & 0 & 1 & 0 \text{df} \\
& & & ffff
\end{array}
\]

**Description:**
The contents of register 'f' are decremented. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is placed back in register 'f'.

If the result is 0, the next instruction, which is already fetched, is discarded and a \text{NOP} is executed instead making it a two cycle instruction.

**Words:**
1

**Cycles:**
1(2)

**Example:**
\[
\text{HERE DECFSZ CNT, 1} \\
\text{GOTO LOOP} \\
\text{CONTINUE}
\]

### GOTO  Unconditional Branch

**Syntax:**
\[
\text{[ label] } \text{GOTO } k
\]

**Operands:**
\[0 \leq k \leq 511\]

**Operation:**
\[k \rightarrow PC<8:0>; \text{ STATUS}<6:5> \rightarrow PC<10:9>\]

**Status Affected:**
None

**Encoding:**
\[
\begin{array}{cccc}
1 & 0 & 1 & k \text{kk} \\
& & & kkkk
\end{array}
\]

**Description:**
\text{GOTO} is an unconditional branch. The 9-bit immediate value is loaded into PC bits <8:0>. The upper bits of PC are loaded from STATUS<6:5>. \text{GOTO} is a two cycle instruction.

**Words:**
1

**Cycles:**
2

**Example:**
\[
\text{GOTO THERE}
\]

**After Instruction**
\[
\text{PC = \text{address (THERE)}}
\]
### INCF

**Increment f**

**Syntax:**  
\[ label \] INCF f, d

**Operands:**  
0 ≤ f ≤ 31  
d ∈ [0, 1]

**Operation:**  
(f) + 1 → (dest)

**Status Affected:**  
Z

**Encoding:**  
0010 10df ffff

**Description:**  
The contents of register 'f' are incremented. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is placed back in register 'f'.

**Words:**  
1

**Cycles:**  
1

**Example:**  
\[ label \] INCF CNT, 1

**Before Instruction**

- CNT = 0xFF
- Z = 0

**After Instruction**

- CNT = 0x00
- Z = 1

---

### INCFSZ

**Increment f, Skip if 0**

**Syntax:**  
\[ label \] INCFSZ f, d

**Operands:**  
0 ≤ f ≤ 31  
d ∈ [0, 1]

**Operation:**  
(f) + 1 → (dest), skip if result = 0

**Status Affected:**  
None

**Encoding:**  
0011 11df ffff

**Description:**  
The contents of register 'f' are incremented. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is placed back in register 'f'.

If the result is 0, then the next instruction, which is already fetched, is discarded and a NOP is executed instead making it a two cycle instruction.

**Words:**  
1

**Cycles:**  
1 (2)

**Example:**  
HERE INCFSZ CNT, 1  
GOTO LOOP
CONTINUE •

**Before Instruction**

- PC = address (HERE)

**After Instruction**

- CNT = CNT + 1;
- if CNT = 0,  
  PC = address (CONTINUE);
- if CNT ≠ 0,  
  PC = address (HERE +1)
IORLW Inclusive OR literal with W

Syntax: [ label ] IORLW k

Operands: 0 ≤ k ≤ 255

Operation: (W) .OR. (k) → (W)

Status Affected: Z

Encoding:

| 1101 | kkkk | kkkk |

Description: The contents of the W register are OR'ed with the eight bit literal 'k'. The result is placed in the W register.

Words: 1

Cycles: 1

Example: IORLW 0x35

Before Instruction
W = 0x9A

After Instruction
W = 0xBF
Z = 0

IORWF Inclusive OR W with f

Syntax: [ label ] IORWF f,d

Operands: 0 ≤ f ≤ 31
d ∈ [0,1]

Operation: (W).OR. (f) → (dest)

Status Affected: Z

Encoding:

| 0001 | 00df | ffff |

Description: Inclusive OR the W register with register 'f'. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is placed back in register 'f'.

Words: 1

Cycles: 1

Example: IORWF RESULT, 0

Before Instruction
RESULT = 0x13
W = 0x91

After Instruction
RESULT = 0x13
W = 0x93
Z = 0

MOVF Move f

Syntax: [ label ] MOVF f.d

Operands: 0 ≤ f ≤ 31
d ∈ [0,1]

Operation: (f) → (dest)

Status Affected: Z

Encoding:

| 0010 | 00df | ffff |

Description: The contents of register 'f' are moved to destination 'd'. If 'd' is 0, destination is the W register. If 'd' is 1, the destination is file register 'f'. 'd' = 1 is useful as a test of a file register since status flag Z is affected.

Words: 1

Cycles: 1

Example: MOVF FSR, 0

After Instruction
W = value in FSR register

MOVLW Move Literal to W

Syntax: [ label ] MOVLW k

Operands: 0 ≤ k ≤ 255

Operation: k → (W)

Status Affected: None

Encoding:

| 1100 | kkkk | kkkk |

Description: The eight bit literal 'k' is loaded into the W register. The don't cares will assembled as 0s.

Words: 1

Cycles: 1

Example: MOVLW 0x5A

After Instruction
W = 0x5A

Move Literal to W
MOVWF Move W to f

Syntax: \[ label \]    MOVWF     f
Operands: 0 ≤ f ≤ 31
Operation: (W) → (f)
Status Affected: None
Encoding: 0000 001f ffff
Description: Move data from the W register to register 'f'.
Words: 1
Cycles: 1
Example: MOVWF TEMP_REG
Before Instruction
TEMP_REG = 0xFF
W = 0x4F
After Instruction
TEMP_REG = 0x4F
W = 0x4F

NOP No Operation

Syntax: \[ label \]    NOP
Operands: None
Operation: No operation
Status Affected: None
Encoding: 0000 0000 0000
Description: No operation.
Words: 1
Cycles: 1
Example: NOP

OPTION Load OPTION Register

Syntax: \[ label \]    OPTION
Operands: None
Operation: (W) → OPTION
Status Affected: None
Encoding: 0000 0000 0010
Description: The content of the W register is loaded into the OPTION register.
Words: 1
Cycles: 1
Example: OPTION
Before Instruction
W = 0x07
After Instruction
OPTION = 0x07

RETLLW Return with Literal in W

Syntax: \[ label \]    RETLW   k
Operands: 0 ≤ k ≤ 255
Operation: k → (W);
          TOS → PC
Status Affected: None
Encoding: 1000 kkkk kkkk
Description: The W register is loaded with the eight bit literal 'k'. The program counter is loaded from the top of the stack (the return address). This is a two cycle instruction.
Words: 1
Cycles: 2
Example: CALL TABLE ;W contains ;table offset ;value.
          • ;W now has table ;value.
          •
          •
          • TABLE ADDWF PC ;W = offset RETLW k1 ;Begin table RETLW k2 ;
          •
          •
          •
          •
          •
          •
          •
          •
          •
          •
          • RETLW kn ; End of table
Before Instruction
W = 0x07
After Instruction
W = value of k8
<table>
<thead>
<tr>
<th>RLF</th>
<th>Rotate Left f through Carry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syntax:</td>
<td>([ \text{label} ] ) RLF \ f,d</td>
</tr>
<tr>
<td>Operands:</td>
<td>(0 \leq f \leq 31) (d \in [0,1])</td>
</tr>
<tr>
<td>Operation:</td>
<td>See description below</td>
</tr>
<tr>
<td>Status Affected:</td>
<td>C</td>
</tr>
<tr>
<td>Encoding:</td>
<td>(0011\ 01df\ ffff)</td>
</tr>
<tr>
<td>Description:</td>
<td>The contents of register 'f' are rotated one bit to the left through the Carry Flag. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is stored back in register 'f'.</td>
</tr>
<tr>
<td>Words:</td>
<td>1</td>
</tr>
<tr>
<td>Cycles:</td>
<td>1</td>
</tr>
<tr>
<td>Example:</td>
<td>RLF \ REG1,0</td>
</tr>
<tr>
<td>Before Instruction</td>
<td>REG1 = 1110 0110 (C = 0)</td>
</tr>
<tr>
<td>After Instruction</td>
<td>REG1 = 1110 0110 (W = 1100 1100) (C = 1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RRF</th>
<th>Rotate Right f through Carry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syntax:</td>
<td>([ \text{label} ] ) RRF \ f,d</td>
</tr>
<tr>
<td>Operands:</td>
<td>(0 \leq f \leq 31) (d \in [0,1])</td>
</tr>
<tr>
<td>Operation:</td>
<td>See description below</td>
</tr>
<tr>
<td>Status Affected:</td>
<td>C</td>
</tr>
<tr>
<td>Encoding:</td>
<td>(0011\ 00df\ ffff)</td>
</tr>
<tr>
<td>Description:</td>
<td>The contents of register 'f' are rotated one bit to the right through the Carry Flag. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is placed back in register 'f'.</td>
</tr>
<tr>
<td>Words:</td>
<td>1</td>
</tr>
<tr>
<td>Cycles:</td>
<td>1</td>
</tr>
<tr>
<td>Example:</td>
<td>RRF \ REG1,0</td>
</tr>
<tr>
<td>Before Instruction</td>
<td>REG1 = 1110 0110 (C = 0)</td>
</tr>
<tr>
<td>After Instruction</td>
<td>REG1 = 1110 0110 (W = 0111 0011) (C = 0)</td>
</tr>
<tr>
<td>SLEEP</td>
<td>Enter SLEEP Mode</td>
</tr>
<tr>
<td>-------</td>
<td>------------------</td>
</tr>
<tr>
<td>Syntax:</td>
<td><code>[label] SLEEP</code></td>
</tr>
<tr>
<td>Operands:</td>
<td>None</td>
</tr>
<tr>
<td>Operation:</td>
<td>00h → WDT; 0 → WDT prescaler; 1 → TO; 0 → PD</td>
</tr>
<tr>
<td>Status Affected:</td>
<td>TO, PD, RBWUF</td>
</tr>
<tr>
<td>Encoding:</td>
<td>0000 0000 0011</td>
</tr>
<tr>
<td>Description:</td>
<td>Time-out status bit (TO) is set. The power down status bit (PD) is cleared. RBWUF is unaffected. The WDT and its prescaler are cleared. The processor is put into SLEEP mode with the oscillator stopped. See section on SLEEP for more details.</td>
</tr>
<tr>
<td>Words:</td>
<td>1</td>
</tr>
<tr>
<td>Cycles:</td>
<td>1</td>
</tr>
<tr>
<td>Example:</td>
<td>SLEEP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SUBWF</th>
<th>Subtract W from f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syntax:</td>
<td><code>[label] SUBWF f,d</code></td>
</tr>
<tr>
<td>Operands:</td>
<td>0 ≤ f ≤ 31 d ∈ [0,1]</td>
</tr>
<tr>
<td>Operation:</td>
<td>(f) − (W) → (dest)</td>
</tr>
<tr>
<td>Status Affected:</td>
<td>C, DC, Z</td>
</tr>
<tr>
<td>Encoding:</td>
<td>0000 10df ffff</td>
</tr>
<tr>
<td>Description:</td>
<td>Subtract (2's complement method) the W register from register 'f'. If 'd' is 0, the result is stored in the W register. If 'd' is 1, the result is stored back in register 'f'.</td>
</tr>
<tr>
<td>Words:</td>
<td>1</td>
</tr>
<tr>
<td>Cycles:</td>
<td>1</td>
</tr>
</tbody>
</table>

**Example 1:**
```
SUBWF REG1, 1
```
Before Instruction
```
REG1 = 3  
W = 2    
C = ?
```
After Instruction
```
REG1 = 1  
W = 2    
C = 1    
```
; result is positive

**Example 2:**
```
Before Instruction
REG1 = 2  
W = 2    
C = ?
```
After Instruction
```
REG1 = 0  
W = 2    
C = 1    
```
; result is zero

**Example 3:**
```
Before Instruction
REG1 = 1  
W = 2    
C = ?
```
After Instruction
```
REG1 = FF  
W = 2    
C = 0    
```
; result is negative
**SWAPF**  
**Swap Nibbles in f**

**Syntax:**  
\[ \text{[label]} \text{ SWAPF } f,d \]

**Operands:**  
0 ≤ f ≤ 31  
d ∈ [0,1]

**Operation:**  
\( (f<3:0>) \rightarrow (\text{dest}<7:4>); \)  
\( (f<7:4>) \rightarrow (\text{dest}<3:0>) \)

**Status Affected:**  
None

**Encoding:**  
0011 10df ffff

**Description:**  
The upper and lower nibbles of register 'f' are exchanged. If 'd' is 0, the result is placed in W register. If 'd' is 1, the result is placed in register 'f'.

**Words:**  
1

**Cycles:**  
1

**Example**  
\text{SWAPF REG1, 0}

Before Instruction  
REG1 = 0xA5

After Instruction  
REG1 = 0xA5  
W = 0x5A

---

**TRIS**  
**Load TRIS Register**

**Syntax:**  
\[ \text{[label]} \text{ TRIS } f \]

**Operands:**  
f = 6

**Operation:**  
(W) \rightarrow TRIS register f

**Status Affected:**  
None

**Encoding:**  
0000 0000 0fff

**Description:**  
TRIS register 'f' (f = 6 or 7) is loaded with the contents of the W register

**Words:**  
1

**Cycles:**  
1

**Example**  
\text{TRIS PORTB}

Before Instruction  
W = 0xA5

After Instruction  
TRIS = 0xA5

---

**XORLW**  
**Exclusive OR literal with W**

**Syntax:**  
\[ \text{[label]} \text{ XORLW } k \]

**Operands:**  
0 ≤ k ≤ 255

**Operation:**  
(W) \cdot \text{XOR} \cdot k \rightarrow (W)

**Status Affected:**  
Z

**Encoding:**  
1111 kkkk kkkk

**Description:**  
The contents of the W register are XOR'ed with the eight bit literal 'k'. The result is placed in the W register.

**Words:**  
1

**Cycles:**  
1

**Example**  
\text{XORLW 0xAF}

Before Instruction  
W = 0xB5

After Instruction  
W = 0x1A

---

**XORWF**  
**Exclusive OR W with f**

**Syntax:**  
\[ \text{[label]} \text{ XORWF } f,d \]

**Operands:**  
f = 6  
d ∈ [0,1]

**Operation:**  
(W) \cdot \text{XOR} \cdot (f) \rightarrow (\text{dest})

**Status Affected:**  
Z

**Encoding:**  
0001 10df ffff

**Description:**  
Exclusive OR the contents of the W register with register 'f'. If 'd' is 0, the result is stored in the W register. If 'd' is 1, the result is stored back in register 'f'.

**Words:**  
1

**Cycles:**  
1

**Example**  
\text{XORWF REG,1}

Before Instruction  
REG = 0xAF  
W = 0xB5

After Instruction  
REG = 0x1A  
W = 0xB5
9.0 DEVELOPMENT SUPPORT

The PICmicro® microcontrollers are supported with a full range of hardware and software development tools:

- Integrated Development Environment
  - MPLAB™ IDE Software
- Assemblers/Compilers/Linkers
  - MPASM Assembler
  - MPLAB-C17 and MPLAB-C18 C Compilers
  - MPLINK/MPLIB Linker/Librarian
- Simulators
  - MPLAB-SIM Software Simulator
- Emulators
  - MPLAB-ICE Real-Time In-Circuit Emulator
  - PICMASTER®/PICMASTER-CE In-Circuit Emulator
  - ICEPIC™
- In-Circuit Debugger
  - MPLAB-ICD for PIC16F877
- Device Programmers
  - PRO MATE® II Universal Programmer
  - PICSTART® Plus Entry-Level Prototype Programmer
- Low-Cost Demonstration Boards
  - SIMICE
  - PICDEM-1
  - PICDEM-2
  - PICDEM-3
  - PICDEM-17
  - SEEVAL®
  - KEELoo®

9.1 MPLAB Integrated Development Environment Software

- The MPLAB IDE software brings an ease of software development previously unseen in the 8-bit microcontroller market. MPLAB is a Windows®-based application which contains:
  - Multiple functionality
    - editor
    - simulator
    - programmer (sold separately)
    - emulator (sold separately)
  - A full featured editor
  - A project manager
  - Customizable tool bar and key mapping
  - A status bar
  - On-line help

MPLAB allows you to:

- Edit your source files (either assembly or 'C')
- One touch assemble (or compile) and download to PICmicro tools (automatically updates all project information)
- Debug using:
  - source files
  - absolute listing file
  - object code

The ability to use MPLAB with Microchip’s simulator, MPLAB-SIM, allows a consistent platform and the ability to easily switch from the cost-effective simulator to the full featured emulator with minimal retraining.

9.2 MPASM Assembler

MPASM is a full featured universal macro assembler for all PICmicro MCU's. It can produce absolute code directly in the form of HEX files for device programmers, or it can generate relocatable objects for MPLINK.

MPASM has a command line interface and a Windows shell and can be used as a standalone application on a Windows 3.x or greater system. MPASM generates relocatable object files, Intel standard HEX files, MAP files to detail memory usage and symbol reference, an absolute LST file which contains source lines and generated machine code, and a COD file for MPLAB debugging.

MPASM features include:

- MPASM and MPLINK are integrated into MPLAB projects.
- MPASM allows user defined macros to be created for streamlined assembly.
- MPASM allows conditional assembly for multi purpose source files.
- MPASM directives allow complete control over the assembly process.

9.3 MPLAB-C17 and MPLAB-C18 C Compilers

The MPLAB-C17 and MPLAB-C18 Code Development Systems are complete ANSI 'C' compilers and integrated development environments for Microchip’s PIC17CXXX and PIC18CXXX family of microcontrollers, respectively. These compilers provide powerful integration capabilities and ease of use not found with other compilers.

For easier source level debugging, the compilers provide symbol information that is compatible with the MPLAB IDE memory display.
9.4 **MPLINK/MPLIB Linker/Librarian**

MPLINK is a relocatable linker for MPASM and MPLAB-C17 and MPLAB-C18. It can link relocatable objects from assembly or C source files along with pre-compiled libraries using directives from a linker script.

MPLIB is a librarian for pre-compiled code to be used with MPLINK. When a routine from a library is called from another source file, only the modules that contains that routine will be linked in with the application. This allows large libraries to be used efficiently in many different applications. MPLIB manages the creation and modification of library files.

MPLINK features include:
- MPLINK works with MPASM and MPLAB-C17 and MPLAB-C18.
- MPLINK allows all memory areas to be defined as sections to provide link-time flexibility.

MPLIB features include:
- MPLIB makes linking easier because single libraries can be included instead of many smaller files.
- MPLIB helps keep code maintainable by grouping related modules together.
- MPLIB commands allow libraries to be created and modules to be added, listed, replaced, deleted, or extracted.

9.5 **MPLAB-SIM Software Simulator**

The MPLAB-SIM Software Simulator allows code development in a PC host environment by simulating the PICmicro series microcontrollers on an instruction level. On any given instruction, the data areas can be examined or modified and stimuli can be applied from a file or user-defined key press to any of the pins. The execution can be performed in single step, execute until break, or trace mode.

MPLAB-SIM fully supports symbolic debugging using MPLAB-C17 and MPLAB-C18 and MPASM. The Software Simulator offers the flexibility to develop and debug code outside of the laboratory environment making it an excellent multi-project software development tool.

9.6 **MPLAB-ICE High Performance Universal In-Circuit Emulator with MPLAB IDE**

The MPLAB-ICE Universal In-Circuit Emulator is intended to provide the product development engineer with a complete microcontroller design tool set for PICmicro microcontrollers (MCUs). Software control of MPLAB-ICE is provided by the MPLAB Integrated Development Environment (IDE), which allows editing, “make” and download, and source debugging from a single environment. Interchangeable processor modules allow the system to be easily reconfigured for emulation of different processors. The universal architecture of the MPLAB-ICE allows expansion to support new PICmicro microcontrollers.

The MPLAB-ICE Emulator System has been designed as a real-time emulation system with advanced features that are generally found on more expensive development tools. The PC platform and Microsoft® Windows 3.x/95/98 environment were chosen to best make these features available to you, the end user.

MPLAB-ICE 2000 is a full-featured emulator system with enhanced trace, trigger, and data monitoring features. Both systems use the same processor modules and will operate across the full operating speed range of the PICmicro MCU.

9.7 **PICMASTER/PICMASTER CE**

The PICMASTER system from Microchip Technology is a full-featured, professional quality emulator system. This flexible in-circuit emulator provides a high-quality, universal platform for emulating Microchip 8-bit PICmicro microcontrollers (MCUs). PICMASTER systems are sold worldwide, with a CE compliant model available for European Union (EU) countries.

9.8 **ICEPIC**

ICEPIC is a low-cost in-circuit emulation solution for the Microchip Technology PIC16C5X, PIC16C6X, PIC16C7X, and PIC16CXXX families of 8-bit one-time-programmable (OTP) microcontrollers. The modular system can support different subsets of PIC16C5X or PIC16CXXX products through the use of interchangeable personality modules or daughter boards. The emulator is capable of emulating without target application circuitry being present.

9.9 **MPLAB-ICD In-Circuit Debugger**

Microchip’s In-Circuit Debugger, MPLAB-ICD, is a powerful, low-cost run-time development tool. This tool is based on the flash PIC16F877 and can be used to develop for this and other PICmicro microcontrollers from the PIC16CXXX family. MPLAB-ICD utilizes the In-Circuit Debugging capability built into the PIC16F87X. This feature, along with Microchip’s In-Circuit Serial Programming protocol, offers cost-effective in-circuit flash programming and debugging from the graphical user interface of the MPLAB Integrated Development Environment. This enables a designer to develop and debug source code by watching variables, single-stepping and setting break points. Running at full speed enables testing hardware in real-time. The MPLAB-ICD is also a programmer for the flash PIC16F87X family.
9.10 PRO MATE II Universal Programmer

The PRO MATE II Universal Programmer is a full-featured programmer capable of operating in stand-alone mode as well as PC-hosted mode. PRO MATE II is CE compliant.

The PRO MATE II has programmable VDD and VPP supplies which allows it to verify programmed memory at VDD min and VDD max for maximum reliability. It has an LCD display for instructions and error messages, keys to enter commands and a modular detachable socket assembly to support various package types. In stand-alone mode the PRO MATE II can read, verify or program PICmicro devices. It can also set code-protect bits in this mode.

9.11 PICSTART Plus Entry Level Development System

The PICSTART programmer is an easy-to-use, low-cost prototype programmer. It connects to the PC via one of the COM (RS-232) ports. MPLAB Integrated Development Environment software makes using the programmer simple and efficient.

PICSTART Plus supports all PICmicro devices with up to 40 pins. Larger pin count devices such as the PIC16C92X, and PIC17C76X may be supported with an adapter socket. PICSTART Plus is CE compliant.

9.12 SIMICE Entry-Level Hardware Simulator

SIMICE is an entry-level hardware development system designed to operate in a PC-based environment with Microchip’s simulator MPLAB-SIM. Both SIMICE and MPLAB-SIM run under Microchip Technology’s MPLAB Integrated Development Environment (IDE) software. Specifically, SIMICE provides hardware simulation for Microchip’s PIC12C5XX, PIC12C5XX, and PIC16C5X families of PICmicro 8-bit microcontrollers. SIMICE works in conjunction with MPLAB-SIM to provide non-real-time I/O port emulation. SIMICE enables a developer to run simulator code for driving the target system. In addition, the target system can provide input to the simulator code. This capability allows for simple and interactive debugging without having to manually generate MPLAB-SIM stimulus files. SIMICE is a valuable debugging tool for entry-level system development.

9.13 PICDEM-1 Low-Cost PICmicro Demonstration Board

The PICDEM-1 is a simple board which demonstrates the capabilities of several of Microchip’s microcontrollers. The microcontrollers supported are: PIC16C5X (PIC16C54 to PIC16C58A), PIC16C61, PIC16C62X, PIC16C71, PIC16C8X, PIC17C42, PIC17C43 and PIC17C44. All necessary hardware and software is included to run basic demo programs. The users can program the sample microcontrollers provided with the PICDEM-1 board, on a PRO MATE II or PICSTART-Plus programmer, and easily test firmware. The user can also connect the PICDEM-1 board to the MPLAB-ICE emulator and download the firmware to the emulator for testing. Additional prototype area is available for the user to build some additional hardware and connect it to the microcontroller socket(s). Some of the features include an RS-232 interface, a potentiometer for simulated analog input, push-button switches and eight LEDs connected to PORTB.

9.14 PICDEM-2 Low-Cost PIC16CXX Demonstration Board

The PICDEM-2 is a simple demonstration board that supports the PIC16C62, PIC16C64, PIC16C65, PIC16C73 and PIC16C74 microcontrollers. All the necessary hardware and software is included to run the basic demonstration programs. The user can program the sample microcontrollers provided with the PICDEM-2 board, on a PRO MATE II programmer or PICSTART-Plus, and easily test firmware. The MPLAB-ICE emulator may also be used with the PICDEM-2 board to test firmware. Additional prototype area has been provided to the user for adding additional hardware and connecting it to the microcontroller socket(s). Some of the features include a RS-232 interface, push-button switches, a potentiometer for simulated analog input, a Serial EEPROM to demonstrate usage of the I²C bus and separate headers for connection to an LCD module and a keypad.

9.15 PICDEM-3 Low-Cost PIC16CXXX Demonstration Board

The PICDEM-3 is a simple demonstration board that supports the PIC16C923 and PIC16C924 in the PLCC package. It will also support future 44-pin PLCC microcontrollers with a LCD Module. All the necessary hardware and software is included to run the basic demonstration programs. The user can program the sample microcontrollers provided with the PICDEM-3 board, on a PRO MATE II programmer or PICSTART Plus with an adapter socket, and easily test firmware. The MPLAB-ICE emulator may also be used with the PICDEM-3 board to test firmware. Additional prototype area has been provided to the user for adding hardware and connecting it to the microcontroller socket(s). Some of the features include an RS-232 interface, push-button switches, a potentiometer for simulated analog input, a thermistor and separate headers for connection to an external LCD module and a keypad. Also provided on the PICDEM-3 board is an LCD panel, with 4 commons and 12 segments, that is capable of displaying time, temperature and day of the week. The PICDEM-3 provides an additional RS-232 interface and Windows 3.1 software for showing the demultiplexed LCD signals on a PC. A simple serial interface allows the user to construct a hardware demultiplexer for the LCD signals.
9.16 PICDEM-17

The PICDEM-17 is an evaluation board that demonstrates the capabilities of several Microchip microcontrollers, including PIC17C752, PIC17C756, PIC17C762, and PIC17C766. All necessary hardware is included to run basic demo programs, which are supplied on a 3.5-inch disk. A programmed sample is included, and the user may erase it and program it with the other sample programs using the PRO MATE II or PICSTART Plus device programmers and easily debug and test the sample code. In addition, PICDEM-17 supports down-loading of programs to and executing out of external FLASH memory on board. The PICDEM-17 is also usable with the MPLAB-ICE or PICMASTER emulator, and all of the sample programs can be run and modified using either emulator. Additionally, a generous prototype area is available for user hardware.

9.17 SEEVAL Evaluation and Programming System

The SEEVAL SEEPROM Designer’s Kit supports all Microchip 2-wire and 3-wire Serial EEPROMs. The kit includes everything necessary to read, write, erase or program special features of any Microchip SEEPROM product including Smart Serials™ and secure serials. The Total Endurance™ Disk is included to aid in trade-off analysis and reliability calculations. The total kit can significantly reduce time-to-market and result in an optimized system.

9.18 KeeLOQ Evaluation and Programming Tools

KeeLOQ evaluation and programming tools support Microchips HCS Secure Data Products. The HCS evaluation kit includes an LCD display to show changing codes, a decoder to decode transmissions, and a programming interface to program test transmitters.
**TABLE 9-1: DEVELOPMENT TOOLS FROM MICROCHIP**

<table>
<thead>
<tr>
<th>Device</th>
<th>MPLAB® C17 Compiler</th>
<th>MPLAB® C18 Compiler</th>
<th>MFASM/MPLINK</th>
<th>PICMASTER/CE</th>
<th>ICEPIC™ Low-Cost In-Circuit Emulator</th>
<th>MPLAB® ICE in-Circuit Debugger</th>
<th>PROMATE™ II Universal Programmer</th>
<th>SIMICE</th>
<th>PICDEM-1</th>
<th>PICDEM-2</th>
<th>PICDEM-3</th>
<th>PICDEM-4A</th>
<th>PICDEM-17</th>
<th>Kiel Log® Evaluation Kit</th>
<th>Kiel Log Transponder Kit</th>
<th>microID™ Programmer’s Kit</th>
<th>microID™ Developer’s Kit</th>
<th>125 kHz Anticollision microID Developer’s Kit</th>
<th>13.56 MHz Anticollision microID Developer’s Kit</th>
<th>MOP210 CAN Developer’s Kit</th>
<th>Demo Boards and Eval Kits</th>
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<tbody>
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<td>PIC12CXXX</td>
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<td>microID™ Programmer’s Kit</td>
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<tr>
<td>125 kHz Anticollision microID Developer’s Kit</td>
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<td>13.56 MHz Anticollision microID Developer’s Kit</td>
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<td>MOP210 CAN Developer’s Kit</td>
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</tbody>
</table>

* Contact the Microchip Technology Inc. web site at www.microchip.com for information on how to use the MPLAB® ICE In-Circuit Debugger (DV164001) with PIC16C62, 63, 64, 65, 72, 73, 74, 76, 77.

** Contact Microchip Technology Inc. for availability date.

† Development tool is available on select devices.
10.0 ELECTRICAL CHARACTERISTICS - PIC16C505

Absolute Maximum Ratings†

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature under bias</td>
<td>–40°C to +125°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>–65°C to +150°C</td>
</tr>
<tr>
<td>Voltage on ( V_{DD} ) with respect to ( V_{SS} )</td>
<td>0 to +7 V</td>
</tr>
<tr>
<td>Voltage on MCLR with respect to ( V_{SS} )</td>
<td>0 to +14 V</td>
</tr>
<tr>
<td>Voltage on all other pins with respect to ( V_{SS} )</td>
<td>–0.6 V to ( (V_{DD} + 0.6 \text{ V}) )</td>
</tr>
<tr>
<td>Total Power Dissipation</td>
<td>700 mW</td>
</tr>
<tr>
<td>Max. Current out of ( V_{SS} ) pin</td>
<td>150 mA</td>
</tr>
<tr>
<td>Max. Current into ( V_{DD} ) pin</td>
<td>125 mA</td>
</tr>
<tr>
<td>Input Clamp Current, ( I_{IK} ) (( V_{I} &lt; 0 ) ( \text{ or } V_{I} &gt; V_{DD} ))</td>
<td>±20 mA</td>
</tr>
<tr>
<td>Output Clamp Current, ( I_{OK} ) (( V_{O} &lt; 0 ) ( \text{ or } V_{O} &gt; V_{DD} ))</td>
<td>±20 mA</td>
</tr>
<tr>
<td>Max. Output Current sunk by any I/O pin</td>
<td>25 mA</td>
</tr>
<tr>
<td>Max. Output Current sourced by any I/O pin</td>
<td>25 mA</td>
</tr>
<tr>
<td>Max. Output Current sourced by I/O port</td>
<td>100 mA</td>
</tr>
<tr>
<td>Max. Output Current sunk by I/O port</td>
<td>100 mA</td>
</tr>
</tbody>
</table>

**Note 1:** Power Dissipation is calculated as follows:

\[ P_{DIS} = V_{DD} \times (I_{DD} - \sum IOH) + \sum ((V_{DD}-VOH) \times IOH) + \sum (VOL \times IOL) \]

†NOTICE: Stresses above those listed under "Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.
FIGURE 10-1: PIC16C505 VOLTAGE-FREQUENCY GRAPH, $0 \leq T_A \leq +70^\circ C$

Note 1: The shaded region indicates the permissible combinations of voltage and frequency.

2: The maximum rated speed of the part limits the permissible combinations of voltage and frequency. Please reference the Product Identification System section for the maximum rated speed of the parts.

FIGURE 10-2: PIC16C505 VOLTAGE-FREQUENCY GRAPH, $-40 \leq T_A \leq 0^\circ C$, $+70^\circ C \leq T_A \leq +125^\circ C$

Note 1: The shaded region indicates the permissible combinations of voltage and frequency.

2: The maximum rated speed of the part limits the permissible combinations of voltage and frequency. Please reference the Product Identification System section for the maximum rated speed of the parts.
FIGURE 10-3: PIC16LC505 VOLTAGE-FREQUENCY GRAPH, -40°C ≤ TA ≤ +85°C

Note 1: The shaded region indicates the permissible combinations of voltage and frequency.

2: The maximum rated speed of the part limits the permissible combinations of voltage and frequency. Please reference the Product Identification System section for the maximum rated speed of the parts.
10.1 DC CHARACTERISTICS: PIC16C505-04 (Commercial, Industrial, Extended)  
PIC16C505-20(Commercial, Industrial, Extended)

<table>
<thead>
<tr>
<th>Parm. No.</th>
<th>Characteristic</th>
<th>Sym</th>
<th>Min</th>
<th>Typ(1)</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>D001</td>
<td>Supply Voltage</td>
<td>VDD</td>
<td>3.0</td>
<td>5.5</td>
<td>V</td>
<td></td>
<td>See Figure 10-1 through Figure 10-3</td>
</tr>
<tr>
<td>D002</td>
<td>RAM Data Retention Voltage(2)</td>
<td>VDD</td>
<td>—</td>
<td>1.5*</td>
<td>—</td>
<td>V</td>
<td>Device in SLEEP mode</td>
</tr>
<tr>
<td>D003</td>
<td>VDD Start Voltage to ensure Power-on Reset</td>
<td>VDD</td>
<td>—</td>
<td>VSS</td>
<td>—</td>
<td>—</td>
<td>See section on Power-on Reset for details</td>
</tr>
<tr>
<td>D004</td>
<td>VDD Rise Rate to ensure Power-on Reset</td>
<td>SVDD</td>
<td>0.05*</td>
<td>—</td>
<td>—</td>
<td>V/ms</td>
<td>See section on Power-on Reset for details</td>
</tr>
<tr>
<td>D010</td>
<td>Supply Current(3)</td>
<td>IDD</td>
<td>—</td>
<td>0.8</td>
<td>1.4</td>
<td>mA</td>
<td>Fosc = 4MHz, VDD = 5.5V, WDT disabled (Note 4)*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.6</td>
<td>1.0</td>
<td>mA</td>
<td>Fosc = 4MHz, VDD = 3.0V, WDT disabled (Note 4)</td>
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<td></td>
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<td></td>
<td>3</td>
<td>7</td>
<td>mA</td>
<td>Fosc = 10MHz, VDD = 3.0V, WDT disabled (Note 6)</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>4</td>
<td>12</td>
<td>mA</td>
<td>Fosc = 20MHz, VDD = 4.5V, WDT disabled</td>
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<td></td>
<td></td>
<td>4.5</td>
<td>16</td>
<td>mA</td>
<td>Fosc = 20MHz, VDD = 5.5V, WDT disabled*</td>
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<td></td>
<td>19</td>
<td>27</td>
<td>µA</td>
<td>Fosc = 32kHz, VDD = 3.0V, WDT disabled (Note 6)</td>
</tr>
<tr>
<td>D020</td>
<td>Power-Down Current (5)</td>
<td>IPD</td>
<td>—</td>
<td>0.25</td>
<td>4</td>
<td>µA</td>
<td>VDD = 3.0V (Note 6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4</td>
<td>5.5</td>
<td>µA</td>
<td>VDD = 4.5V* (Note 6)</td>
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<td></td>
<td>3</td>
<td>8</td>
<td>µA</td>
<td>VDD = 5.5V, Industrial</td>
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<td></td>
<td>5</td>
<td>14</td>
<td>µA</td>
<td>VDD = 5.5V, Extended Temp.</td>
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<tr>
<td>D022</td>
<td>WDT Current(6)</td>
<td>ΔIWD</td>
<td>—</td>
<td>2.2</td>
<td>5</td>
<td>µA</td>
<td>VDD = 3.0V (Note 6)</td>
</tr>
</tbody>
</table>

1A          | LP Oscillator Operating Frequency | Fosc | 0    | —    | 200 | kHz   | All temperatures |
1A          | RC Oscillator Operating Frequency | 0    | —    | —    | 4   | MHz   | All temperatures |
1A          | XT Oscillator Operating Frequency | 0    | —    | —    | 4   | MHz   | All temperatures |
1A          | HS Oscillator Operating Frequency | 0    | —    | 20   | 20  | MHz   | All temperatures |

* These parameters are characterized but not tested.

**Note 1:** Data in the Typical ("Typ") column is based on characterization results at 25°C. This data is for design guidance only and is not tested.

**Note 2:** This is the limit to which Vdd can be lowered in SLEEP mode without losing RAM data.

**Note 3:** The supply current is mainly a function of the operating voltage and frequency. Other factors such as bus loading, oscillator type, bus rate, internal code execution pattern and temperature also have an impact on the current consumption.

a) The test conditions for all IDD measurements in active operation mode are:
   - OSC1 = external square wave, from rail-to-rail; all I/O pins tristated, pulled to VSS, T0CKI = VDD, MCLR = VDD; WDT enabled/disabled as specified.
   - For standby current measurements, the conditions are the same, except that the device is in SLEEP mode.

b) For standby current measurements, the conditions are the same, except that the device is in SLEEP mode.

**Note 4:** Does not include current through Rext. The current through the resistor can be estimated by the formula:
   \( I_R = \frac{VDD}{2R_{ext}} \) (mA) with Rext in kOhm.

**Note 5:** The power down current in SLEEP mode does not depend on the oscillator type. Power down current is measured with the part in SLEEP mode, with all I/O pins in hi-impedance state and tied to VDD or VSS.

**Note 6:** Commercial temperature range only.
### 10.2 DC CHARACTERISTICS: PIC16LC505-04 (Commercial, Industrial)

<table>
<thead>
<tr>
<th>Parm. No.</th>
<th>Characteristic</th>
<th>Sym</th>
<th>Min</th>
<th>Typ(1)</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>D001</td>
<td>Supply Voltage</td>
<td>VDD</td>
<td>2.5</td>
<td>—</td>
<td>5.5</td>
<td>V</td>
<td>See Figure 10-1 through Figure 10-3</td>
</tr>
<tr>
<td>D002</td>
<td>RAM Data Retention Voltage(2)</td>
<td>VDR</td>
<td>—</td>
<td>1.5*</td>
<td>—</td>
<td>V</td>
<td>Device in SLEEP mode</td>
</tr>
<tr>
<td>D003</td>
<td>VDD Start Voltage to ensure</td>
<td>VPOR</td>
<td>—</td>
<td>VSS</td>
<td>—</td>
<td>V</td>
<td>See section on Power-on Reset for details</td>
</tr>
<tr>
<td>D004</td>
<td>VDD Rise Rate to ensure</td>
<td>SVDD</td>
<td>0.05*</td>
<td>—</td>
<td>—</td>
<td>V/ms</td>
<td>See section on Power-on Reset for details</td>
</tr>
<tr>
<td>D010</td>
<td>Supply Current(3)</td>
<td>I DD</td>
<td>—</td>
<td>0.8</td>
<td>1.4</td>
<td>mA</td>
<td>FOSC = 4MHz, VDD = 5.5V, WDT disabled (Note 4)*</td>
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<tr>
<td></td>
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<td></td>
<td>0.4</td>
<td>0.8</td>
<td>—</td>
<td>mA</td>
<td>FOSC = 4MHz, VDD = 2.5V, WDT disabled (Note 4)</td>
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<td>15</td>
<td>23</td>
<td>—</td>
<td>μA</td>
<td>FOSC = 32kHz, VDD = 2.5V, WDT disabled (Note 6)</td>
</tr>
<tr>
<td>D020</td>
<td>Power-Down Current (5)</td>
<td>IPD</td>
<td>—</td>
<td>0.25</td>
<td>3</td>
<td>μA</td>
<td>VDD = 2.5V (Note 6)</td>
</tr>
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<td></td>
<td></td>
<td>0.25</td>
<td>4</td>
<td>—</td>
<td>μA</td>
<td>VDD = 3.0V * (Note 6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>8</td>
<td>—</td>
<td>μA</td>
<td>VDD = 5.5V Industrial</td>
</tr>
<tr>
<td>D022</td>
<td>WDT Current(5)</td>
<td>ΔIWDT</td>
<td>—</td>
<td>2.0</td>
<td>4</td>
<td>μA</td>
<td>VDD = 2.5V (Note 6)</td>
</tr>
</tbody>
</table>

| 1A        | LP Oscillator Operating Frequency       | FOSC| 0   | —      | 200 | kHz    | All temperatures |
|           | RC Oscillator Operating Frequency       |     | 0   | —      | 4   | MHz    | All temperatures |
|           | XT Oscillator Operating Frequency       |     | 0   | —      | 4   | MHz    | All temperatures |
|           | HS Oscillator Operating Frequency       |     | 0   | —      | 4   | MHz    | All temperatures |

* These parameters are characterized but not tested.

**Note 1:** Data in the Typical ("Typ") column is based on characterization results at 25°C. This data is for design guidance only and is not tested.

**Note 2:** This is the limit to which VDD can be lowered in SLEEP mode without losing RAM data.

**Note 3:** The supply current is mainly a function of the operating voltage and frequency. Other factors such as bus loading, oscillator type, bus rate, internal code execution pattern and temperature also have an impact on the current consumption.

- OSC1 = external square wave, from rail-to-rail; all I/O pins tristated, pulled to Vss, T0CKI = Vdd, MCLR = Vdd; WDT enabled/disabled as specified.

- For standby current measurements, the conditions are the same, except that the device is in SLEEP mode.

**Note 4:** Does not include current through Rext. The current through the resistor can be estimated by the formula:

\[ I_{R} = \frac{V_{DD}}{2R_{ext}} \text{ (mA)} \] with Rext in kOhm.

**Note 5:** The power down current in SLEEP mode does not depend on the oscillator type. Power down current is measured with the part in SLEEP mode, with all I/O pins in hi-impedance state and tied to VDD or Vss.

**Note 6:** Commercial temperature range only.
10.3 DC CHARACTERISTICS: PIC16C505-04 (Commercial, Industrial, Extended)  
PIC16C505-20(Commercial, Industrial, Extended)  
PIC16LC505-04 (Commercial, Industrial)

### Standard Operating Conditions (unless otherwise specified)
- Operating temperature: $0°C \leq T_A \leq +70°C$ (commercial)  
- $-40°C \leq T_A \leq +85°C$ (industrial)  
- $-40°C \leq T_A \leq +125°C$ (extended)

Operating voltage $V_{DD}$ range as described in DC spec Section 10.1 and Section 10.3.

<table>
<thead>
<tr>
<th>Param No.</th>
<th>Characteristic</th>
<th>Sym</th>
<th>Min</th>
<th>Typ†</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
</table>
| D030      | Input Low Voltage | VIL | VSS | 0.8V | V   | 0.15VDD | V | For all $4.5 \leq V_{DD} \leq 5.5V$
| D030A     | with TTL buffer  | VSS | —   | 0.15VDD | V | otherwise |
| D031      | with Schmitt Trigger buffer | VSS | —   | 0.2VDD | V | otherwise |
| D032      | MCLR, RC5/T0CKI (in EXTRC mode) | VSS | —   | 0.2VDD | V |            |
| D033      | OSC1 (in XT, HS and LP) | VSS | —   | 0.3VDD | V | Note 1 |
| D040      | Input High Voltage | VIH | 2.0 | —    | VDD | $4.5 \leq V_{DD} \leq 5.5V$
| D040A     | with TTL buffer  | 2.0 | —   | VDD | V | otherwise |
| D041      | with Schmitt Trigger buffer | 0.8VDD | —   | VDD | V | For entire $V_{DD}$ range |
| D042      | MCLR, RC5/T0CKI | 0.8VDD | —   | VDD | V |            |
| D042A     | OSC1 (XT, HS and LP) | 0.8VDD | —   | VDD | V |            |
| D043      | OSC1 (in EXTRC mode) | 0.8VDD | —   | VDD | V |            |
| D070      | GPIO weak pull-up current (Note 4) | IPUR | 50  | 250  | 400 | μA | $V_{DD} = 5V, V_{PIN} = V_{SS}$ |
| D060      | Input Leakage Current (Notes 2, 3) | IIL | —   | —    | $\pm 1$ | μA | $V_{SS} \leq V_{PIN} \leq V_{DD}$, Pin at hi-impedance |
| D061      | GP3/MCLRi (Note 5) | —   | —   | $\pm 30$ | μA | $V_{SS} \leq V_{PIN} \leq V_{DD}$ |
| D061A     | GP3/MCLRi (Note 6) | —   | —   | $\pm 5$ | μA | $V_{SS} \leq V_{PIN} \leq V_{DD}$ |
| D063      | OSC1 | —   | —   | $\pm 5$ | μA | $V_{SS} \leq V_{PIN} \leq V_{DD}$, XT, HS and LP osc configuration |
| D080      | Output Low Voltage | VOL | —   | 0.6V | V | $I_{OL} = 8.5\,mA, V_{DD} = 4.5V$, $-40°C \leq +85°C$ |
| D080A     | —   | —   | 0.6V | V | $I_{OL} = 7.0\,mA, V_{DD} = 4.5V$, $-40°C \leq +125°C$ |
| D083      | OSC2 | —   | —   | 0.6V | V | $I_{OL} = 1.6\,mA, V_{DD} = 4.5V$, $-40°C \leq +85°C$ |
| D083A     | —   | —   | 0.6V | V | $I_{OL} = 1.2\,mA, V_{DD} = 4.5V$, $-40°C \leq +125°C$ |

† Data in “Typ” column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

### Note 1:  
In EXTRC oscillator configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the PIC16C505 be driven with external clock in RC mode.

### Note 2:  
The leakage current on the MCLR pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

### Note 3:  
Negative current is defined as coming out of the pin.

### Note 4:  
Does not include GP3. For GP3 see parameters D061 and D061A.

### Note 5:  
This spec. applies to GP3/MCLR configured as external MCLR and GP3/MCLR configured as input with internal pull-up enabled.

### Note 6:  
This spec. applies when GP3/MCLR is configured as an input with pull-up disabled. The leakage current of the MCLR circuit is higher than the standard I/O logic.
## DC CHARACTERISTICS

### Standard Operating Conditions (unless otherwise specified)

- **Operating temperature**: $0°C \leq T_A \leq 70°C$ (commercial)
- $-40°C \leq T_A \leq +85°C$ (industrial)
- $-40°C \leq T_A \leq +125°C$ (extended)

Operating voltage $V_{DD}$ range as described in DC spec Section 10.1 and Section 10.3.

### Param No. | Characteristic | Sym | Min | Typ† | Max | Units | Conditions
--- | --- | --- | --- | --- | --- | --- | ---
D090 | Output High Voltage I/O ports/CLKOUT (Note 3) | $V_{OH}$ | $V_{DD} - 0.7$ | — | — | V | $I_{OH} = -3.0\, mA$, $V_{DD} = 4.5\, V$, $-40°C$ to $+85°C$
D090A | | $V_{DD}$ | $0.7$ | — | — | V | $I_{OH} = -2.5\, mA$, $V_{DD} = 4.5\, V$, $-40°C$ to $+125°C$
D092 | OSC2 | $V_{DD}$ | $0.7$ | — | — | V | $I_{OH} = -1.3\, mA$, $V_{DD} = 4.5\, V$, $-40°C$ to $+85°C$
D092A | | $V_{DD}$ | $0.7$ | — | — | V | $I_{OH} = -1.0\, mA$, $V_{DD} = 4.5\, V$, $-40°C$ to $+125°C$
D100 | Capacitive Loading Specs on Output Pins | $C_{OSC2}$ | — | — | 15 | pF | In XT, HS and LP modes when external clock is used to drive OSC1.
D101 | All I/O pins and OSC2 | $C_{IO}$ | — | — | 50 | pF | —

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

**Note 1:** In EXTRC oscillator configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the PIC16C505 be driven with external clock in RC mode.

**Note 2:** The leakage current on the MCLR pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

**Note 3:** Negative current is defined as coming out of the pin.

**Note 4:** Does not include GP3. For GP3 see parameters D061 and D061A.

**Note 5:** This spec applies to GP3/MCLR configured as external MCLR and GP3/MCLR configured as input with internal pull-up enabled.

**Note 6:** This spec applies when GP3/MCLR is configured as an input with pull-up disabled. The leakage current of the MCLR circuit is higher than the standard I/O logic.
<table>
<thead>
<tr>
<th>VDD (Volts)</th>
<th>Temperature (°C)</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RB0/RB1/RB4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>–40</td>
<td>38K</td>
<td>42K</td>
<td>63K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>42K</td>
<td>48K</td>
<td>63K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>42K</td>
<td>49K</td>
<td>63K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>50K</td>
<td>55K</td>
<td>63K</td>
<td>W</td>
</tr>
<tr>
<td>5.5</td>
<td>–40</td>
<td>15K</td>
<td>17K</td>
<td>20K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>18K</td>
<td>20K</td>
<td>23K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>19K</td>
<td>22K</td>
<td>25K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>22K</td>
<td>24K</td>
<td>28K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>RB3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>–40</td>
<td>285K</td>
<td>346K</td>
<td>417K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>343K</td>
<td>414K</td>
<td>532K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>368K</td>
<td>457K</td>
<td>532K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>431K</td>
<td>504K</td>
<td>593K</td>
<td>W</td>
</tr>
<tr>
<td>5.5</td>
<td>–40</td>
<td>247K</td>
<td>292K</td>
<td>360K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>288K</td>
<td>341K</td>
<td>437K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>306K</td>
<td>371K</td>
<td>448K</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>351K</td>
<td>407K</td>
<td>500K</td>
<td>W</td>
</tr>
</tbody>
</table>

* These parameters are characterized but not tested.
10.4 Timing Parameter Symbology and Load Conditions - PIC16C505

The timing parameter symbols have been created following one of the following formats:

1. $T_{\text{ppS}2\text{ppS}}$
2. $T_{\text{ppS}}$

<table>
<thead>
<tr>
<th>T</th>
<th>F</th>
<th>T</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lowercase subscripts (pp) and their meanings:

<table>
<thead>
<tr>
<th>pp</th>
<th>to</th>
<th>mc</th>
<th>MCLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ck</td>
<td>CLKOUT</td>
<td>osc</td>
<td>oscillator</td>
</tr>
<tr>
<td>cy</td>
<td>cycle time</td>
<td>os</td>
<td>OSC1</td>
</tr>
<tr>
<td>drt</td>
<td>device reset timer</td>
<td>t0</td>
<td>T0CKI</td>
</tr>
<tr>
<td>io</td>
<td>I/O port</td>
<td>wdt</td>
<td>watchdog timer</td>
</tr>
</tbody>
</table>

Uppercase letters and their meanings:

<table>
<thead>
<tr>
<th>S</th>
<th>F</th>
<th>P</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall</td>
<td>R</td>
<td>Rise</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>V</td>
<td>Valid</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>Z</td>
<td>Hi-impedance</td>
</tr>
</tbody>
</table>

FIGURE 10-4: LOAD CONDITIONS - PIC16C505

Pin
\[\text{Pin} \rightarrow \text{CL} \rightarrow V_{\text{SS}}\]

$CL = 50 \text{ pF}$ for all pins except OSC2

$15 \text{ pF}$ for OSC2 in XT, HS or LP modes when external clock is used to drive OSC1
10.5 Timing Diagrams and Specifications

FIGURE 10-5: EXTERNAL CLOCK TIMING - PIC16C505

![Timing Diagram](image)

TABLE 10-2: EXTERNAL CLOCK TIMING REQUIREMENTS - PIC16C505

<table>
<thead>
<tr>
<th>Parameter No.</th>
<th>Sym</th>
<th>Characteristic</th>
<th>Min</th>
<th>Typ(1)</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Fosc</td>
<td>External CLIN Frequency(2)</td>
<td>DC</td>
<td>4</td>
<td>MHz</td>
<td>DC</td>
<td>XT osc mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DC</td>
<td>4</td>
<td>MHz</td>
<td>DC</td>
<td>HS osc mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DC</td>
<td>20</td>
<td>MHz</td>
<td>DC</td>
<td>HS osc mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DC</td>
<td>200</td>
<td>kHz</td>
<td>DC</td>
<td>LP osc mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oscillator Frequency(2)</td>
<td>DC</td>
<td>4</td>
<td>MHz</td>
<td>0.1</td>
<td>XT osc mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>MHz</td>
<td>4</td>
<td>HS osc mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>kHz</td>
<td>DC</td>
<td>LP osc mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External CLIN Period(2)</td>
<td>250</td>
<td>—</td>
<td>ns</td>
<td>XT osc mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50</td>
<td>—</td>
<td>ns</td>
<td>HS osc mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>—</td>
<td>μs</td>
<td>LP osc mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oscillator Period(2)</td>
<td>250</td>
<td>—</td>
<td>ns</td>
<td>EXTRC osc mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>250</td>
<td>10,000</td>
<td>ns</td>
<td>XT osc mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>250</td>
<td>250</td>
<td>ns</td>
<td>HS osc mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50</td>
<td>250</td>
<td>ns</td>
<td>HS osc mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>μs</td>
<td>LP osc mode</td>
<td></td>
</tr>
</tbody>
</table>

* These parameters are characterized but not tested.

Note 1: Data in the Typical ("Typ") column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

2: All specified values are based on characterization data for that particular oscillator type under standard operating conditions with the device executing code. Exceeding these specified limits may result in an unstable oscillator operation and/or higher than expected current consumption.

When an external clock input is used, the “max” cycle time limit is “DC” (no clock) for all devices.
## TABLE 10-2: EXTERNAL CLOCK TIMING REQUIREMENTS - PIC16C505 (CONTINUED)

<table>
<thead>
<tr>
<th>AC Characteristics</th>
<th>Standard Operating Conditions (unless otherwise specified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature</td>
<td>$0°C \leq TA \leq +70°C$ (commercial),</td>
</tr>
<tr>
<td></td>
<td>$-40°C \leq TA \leq +85°C$ (industrial),</td>
</tr>
<tr>
<td></td>
<td>$-40°C \leq TA \leq +125°C$ (extended)</td>
</tr>
<tr>
<td>Operating Voltage $V_{DD}$ range is described in Section 10.1</td>
<td></td>
</tr>
</tbody>
</table>

### Parameter No. | Sym | Characteristic | Min | Typ(1) | Max | Units | Conditions |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>TosL, TosH</td>
<td>Clock in (OSC1) Low or High Time</td>
<td>50*</td>
<td>—</td>
<td>—</td>
<td>ns</td>
<td>XT oscillator</td>
</tr>
<tr>
<td>4</td>
<td>TosR, TosF</td>
<td>Clock in (OSC1) Rise or Fall Time</td>
<td>—</td>
<td>—</td>
<td>25*</td>
<td>ns</td>
<td>XT oscillator</td>
</tr>
</tbody>
</table>

* These parameters are characterized but not tested.

**Note 1:** Data in the Typical (“Typ”) column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

2: All specified values are based on characterization data for that particular oscillator type under standard operating conditions with the device executing code. Exceeding these specified limits may result in an unstable oscillator operation and/or higher than expected current consumption.

When an external clock input is used, the “max” cycle time limit is “DC” (no clock) for all devices.

## TABLE 10-3: CALIBRATED INTERNAL RC FREQUENCIES - PIC16C505

<table>
<thead>
<tr>
<th>AC Characteristics</th>
<th>Standard Operating Conditions (unless otherwise specified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature</td>
<td>$0°C \leq TA \leq +70°C$ (commercial),</td>
</tr>
<tr>
<td></td>
<td>$-40°C \leq TA \leq +85°C$ (industrial),</td>
</tr>
<tr>
<td></td>
<td>$-40°C \leq TA \leq +125°C$ (extended)</td>
</tr>
<tr>
<td>Operating Voltage $V_{DD}$ range is described in Section 10.1</td>
<td></td>
</tr>
</tbody>
</table>

### Parameter No. | Sym | Characteristic | Min* | Typ(1) | Max* | Units | Conditions |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Internal Calibrated RC Frequency</td>
<td>3.65</td>
<td>4.00</td>
<td>4.28</td>
<td>MHz</td>
<td>$V_{DD} = 5.0V$</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Internal Calibrated RC Frequency</td>
<td>3.55</td>
<td>4.00</td>
<td>4.31</td>
<td>MHz</td>
<td>$V_{DD} = 2.5V$</td>
</tr>
</tbody>
</table>

* These parameters are characterized but not tested.

**Note 1:** Data in the Typical (“Typ”) column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.
FIGURE 10-6: I/O TIMING - PIC16C505

TABLE 10-4: TIMING REQUIREMENTS - PIC16C505

<table>
<thead>
<tr>
<th>Parameter No.</th>
<th>Sym</th>
<th>Characteristic</th>
<th>Min</th>
<th>Typ(1)</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>TosH2ioV</td>
<td>OSC1↑ (Q1 cycle) to Port out valid(2,3)</td>
<td>—</td>
<td>—</td>
<td>100*</td>
<td>ns</td>
</tr>
<tr>
<td>18</td>
<td>TosH2iol</td>
<td>OSC1↑ (Q2 cycle) to Port input invalid (I/O in hold time)(2)</td>
<td>TBD</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>19</td>
<td>TioV2osH</td>
<td>Port input valid to OSC1↑ (I/O in setup time)</td>
<td>TBD</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>20</td>
<td>TioR</td>
<td>Port output rise time(3)</td>
<td>—</td>
<td>10</td>
<td>25**</td>
<td>ns</td>
</tr>
<tr>
<td>21</td>
<td>TioF</td>
<td>Port output fall time(3)</td>
<td>—</td>
<td>10</td>
<td>25**</td>
<td>ns</td>
</tr>
</tbody>
</table>

* These parameters are characterized but not tested.
** These parameters are design targets and are not tested.

Note 1: Data in the Typical ("Typ") column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

2: Measurements are taken in EXTRC mode.

3: See Figure 10-4 for loading conditions.
FIGURE 10-7: RESET, WATCHDOG TIMER, AND DEVICE RESET TIMER TIMING - PIC16C505

Note 1: I/O pins must be taken out of hi-impedance mode by enabling the output drivers in software.
2: Runs in MCLR or WDT reset only in XT, LP and HS modes.

TABLE 10-5: RESET, WATCHDOG TIMER, AND DEVICE RESET TIMER - PIC16C505

<table>
<thead>
<tr>
<th>Parameter No.</th>
<th>Sym</th>
<th>Characteristic</th>
<th>Min</th>
<th>Typ(1)</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>TmCL</td>
<td>MCLR Pulse Width (low)</td>
<td>2000*</td>
<td>—</td>
<td>—</td>
<td>ns</td>
<td>VDD = 5.0 V</td>
</tr>
<tr>
<td>31</td>
<td>Twdt</td>
<td>Watchdog Timer Time-out Period (No Prescaler)</td>
<td>9*</td>
<td>18*</td>
<td>30*</td>
<td>ms</td>
<td>VDD = 5.0 V (Commercial)</td>
</tr>
<tr>
<td>32</td>
<td>TDRT</td>
<td>Device Reset Timer Period(2)</td>
<td>9*</td>
<td>18*</td>
<td>30*</td>
<td>ms</td>
<td>VDD = 5.0 V (Commercial)</td>
</tr>
<tr>
<td>34</td>
<td>TioZ</td>
<td>I/O Hi-impedance from MCLR Low</td>
<td>—</td>
<td>—</td>
<td>2000*</td>
<td>ns</td>
<td></td>
</tr>
</tbody>
</table>

* These parameters are characterized but not tested.
Note 1: Data in the Typical ("Typ") column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

TABLE 10-6: DRT (DEVICE RESET TIMER PERIOD) - PIC16C505

<table>
<thead>
<tr>
<th>Oscillator Configuration</th>
<th>POR Reset</th>
<th>Subsequent Resets</th>
</tr>
</thead>
<tbody>
<tr>
<td>IntRC &amp; ExtRC</td>
<td>18 ms (typical)</td>
<td>300 µs (typical)</td>
</tr>
<tr>
<td>XT, HS &amp; LP</td>
<td>18 ms (typical)</td>
<td>18 ms (typical)</td>
</tr>
</tbody>
</table>
TABLE 10-7: TIMER0 CLOCK REQUIREMENTS - PIC16C505

<table>
<thead>
<tr>
<th>Parm No.</th>
<th>Sym</th>
<th>Characteristic</th>
<th>Min</th>
<th>Typ(1)</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>T0H</td>
<td>T0CKI High Pulse Width</td>
<td>No Prescaler</td>
<td>0.5 TCY + 20°</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>With Prescaler</td>
<td>10°</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>41</td>
<td>T0L</td>
<td>T0CKI Low Pulse Width</td>
<td>No Prescaler</td>
<td>0.5 TCY + 20°</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>With Prescaler</td>
<td>10°</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>42</td>
<td>T0P</td>
<td>T0CKI Period</td>
<td>20 or TCY + 40° N</td>
<td>—</td>
<td>—</td>
<td>ns</td>
<td>Whichever is greater. N = Prescale Value (1, 2, 4, ..., 256)</td>
</tr>
</tbody>
</table>

* These parameters are characterized but not tested.

Note 1: Data in the Typical ("Typ") column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.
11.0 DC AND AC CHARACTERISTICS - PIC16C505

The graphs and tables provided in this section are for design guidance and are not tested. In some graphs or tables, the data presented are outside specified operating range (e.g., outside specified VDD range). This is for information only and devices will operate properly only within the specified range.

The data presented in this section is a statistical summary of data collected on units from different lots over a period of time. “Typical” represents the mean of the distribution while “max” or “min” represents (mean + 3σ) and (mean – 3σ) respectively, where σ is standard deviation.

FIGURE 11-1: CALIBRATED INTERNAL RC FREQUENCY RANGE VS. TEMPERATURE (VDD = 5.0V) (INTERNAL RC IS CALIBRATED TO 25°C, 5.0V)

FIGURE 11-2: CALIBRATED INTERNAL RC FREQUENCY RANGE VS. TEMPERATURE (VDD = 2.5V) (INTERNAL RC IS CALIBRATED TO 25°C, 5.0V)
TABLE 11-1: DYNAMIC IDD (TYPICAL) - WDT ENABLED, 25°C

<table>
<thead>
<tr>
<th>Oscillator</th>
<th>Frequency</th>
<th>VDD = 3.0V(1)</th>
<th>VDD = 5.5V</th>
</tr>
</thead>
<tbody>
<tr>
<td>External RC</td>
<td>4 MHz</td>
<td>240 µA(2)</td>
<td>800 µA(2)</td>
</tr>
<tr>
<td>Internal RC</td>
<td>4 MHz</td>
<td>320 µA</td>
<td>800 µA</td>
</tr>
<tr>
<td>XT</td>
<td>4 MHz</td>
<td>300 µA</td>
<td>800 µA</td>
</tr>
<tr>
<td>LP</td>
<td>32 kHz</td>
<td>19 µA</td>
<td>50 µA</td>
</tr>
<tr>
<td>HS</td>
<td>20 MHz</td>
<td>N/A</td>
<td>4.5 mA</td>
</tr>
</tbody>
</table>

**Note 1:** LP oscillator based on VDD = 2.5V

**Note 2:** Does not include current through external R&C.
FIGURE 11-5: IOH vs. VOH, VDD = 2.5 V

FIGURE 11-6: IOH vs. VOH, VDD = 5.5 V

FIGURE 11-7: IOL vs. VOL, VDD = 2.5 V

FIGURE 11-8: IOL vs. VOL, VDD = 5.5 V
11.0 PACKAGING INFORMATION

11.1 Package Marking Information

### 14-Lead PDIP (300 mil)

Example

```
XXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXX
AABBCDE
```

```
16C505-04I/P
BUILT 4 SPEED
9904SAZ
```

### 14-Lead SOIC (150 mil)

Example

```
XXXXXXXXXXX
AABBCDE
```

```
16C505-04I
9904SAZ
```

### 14-Lead Windowed Ceramic (300 mil)

Example

```
XXX

XXXXXX
```

```
JW

16C505
```

---

**Legend:**

| MM...M | Microchip part number information |
| XX...X | Customer specific information* |
| AA     | Year code (last 2 digits of calendar year) |
| BB     | Week code (week of January 1 is week ‘01’) |
| C      | Facility code of the plant at which wafer is manufactured |
|        | O = Outside Vendor |
|        | C = 5” Line |
|        | S = 6” Line |
|        | H = 8” Line |
| D      | Mask revision number |
| E      | Assembly code of the plant or country of origin in which part was assembled |

**Note:** In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line thus limiting the number of available characters for customer specific information.

* Standard OTP marking consists of Microchip part number, year code, week code, facility code, mask rev#, and assembly code. For OTP marking beyond this, certain price adders apply. Please check with your Microchip Sales Office. For QTP devices, any special marking adders are included in QTP price.
14-Lead Plastic Dual In-line (P) – 300 mil (PDIP)

<table>
<thead>
<tr>
<th>Units</th>
<th>INCHES(^*)</th>
<th>MILLIMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Pins</td>
<td>n</td>
<td>14</td>
</tr>
<tr>
<td>Pitch</td>
<td>p</td>
<td>.100</td>
</tr>
<tr>
<td>Top to Seating Plane</td>
<td>A</td>
<td>.140</td>
</tr>
<tr>
<td>Molded Package Thickness</td>
<td>A2</td>
<td>.115</td>
</tr>
<tr>
<td>Base to Seating Plane</td>
<td>A1</td>
<td>.015</td>
</tr>
<tr>
<td>Shoulder to Shoulder Width</td>
<td>E</td>
<td>.300</td>
</tr>
<tr>
<td>Molded Package Width</td>
<td>E1</td>
<td>.240</td>
</tr>
<tr>
<td>Overall Length</td>
<td>D</td>
<td>.740</td>
</tr>
<tr>
<td>Tip to Seating Plane</td>
<td>L</td>
<td>.125</td>
</tr>
<tr>
<td>Lead Thickness</td>
<td>c</td>
<td>.008</td>
</tr>
<tr>
<td>Upper Lead Width</td>
<td>B1</td>
<td>.045</td>
</tr>
<tr>
<td>Lower Lead Width</td>
<td>B</td>
<td>.014</td>
</tr>
<tr>
<td>Overall Row Spacing</td>
<td>eB</td>
<td>.310</td>
</tr>
<tr>
<td>Mold Draft Angle Top</td>
<td>(\alpha)</td>
<td>5</td>
</tr>
<tr>
<td>Mold Draft Angle Bottom</td>
<td>(\beta)</td>
<td>5</td>
</tr>
</tbody>
</table>

\(^*\)Controlling Parameter

Notes:
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.
- JEDEC Equivalent: MS-001
- Drawing No. C04-005
### PIC16C505

**14-Lead Plastic Small Outline (SL) – Narrow, 150 mil (SOIC)**

<table>
<thead>
<tr>
<th>Units</th>
<th>INCHES*</th>
<th>MILLIMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension Limits</td>
<td>MIN</td>
<td>NOM</td>
</tr>
<tr>
<td>Number of Pins</td>
<td>n</td>
<td>14</td>
</tr>
<tr>
<td>Pitch</td>
<td>p</td>
<td>.050</td>
</tr>
<tr>
<td>Overall Height</td>
<td>A</td>
<td>.053</td>
</tr>
<tr>
<td>Molded Package Thickness</td>
<td>A2</td>
<td>.052</td>
</tr>
<tr>
<td>Standoff</td>
<td>A1</td>
<td>.004</td>
</tr>
<tr>
<td>Overall Width</td>
<td>E</td>
<td>.228</td>
</tr>
<tr>
<td>Molded Package Width</td>
<td>E1</td>
<td>.150</td>
</tr>
<tr>
<td>Overall Length</td>
<td>D</td>
<td>.337</td>
</tr>
<tr>
<td>Chamfer Distance</td>
<td>h</td>
<td>.010</td>
</tr>
<tr>
<td>Foot Length</td>
<td>L</td>
<td>.016</td>
</tr>
<tr>
<td>Foot Angle</td>
<td>φ</td>
<td>0</td>
</tr>
<tr>
<td>Lead Thickness</td>
<td>c</td>
<td>.008</td>
</tr>
<tr>
<td>Lead Width</td>
<td>B</td>
<td>.014</td>
</tr>
<tr>
<td>Mold Draft Angle Top</td>
<td>α</td>
<td>0</td>
</tr>
<tr>
<td>Mold Draft Angle Bottom</td>
<td>β</td>
<td>0</td>
</tr>
</tbody>
</table>

*Controlling Parameter

**Notes:**

- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010” (0.254mm) per side.
- JEDEC Equivalent: MS-012
- Drawing No. C04-065
PIC16C505

14-Lead Ceramic Side brazed Dual In-line with Window (JW) – 300 mil

<table>
<thead>
<tr>
<th>Units</th>
<th>INCHES*</th>
<th>MILLIMETERS</th>
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</thead>
<tbody>
<tr>
<td>Dimension Limits</td>
<td>MIN</td>
<td>NOM</td>
</tr>
<tr>
<td>Number of Pins</td>
<td>n</td>
<td>14</td>
</tr>
<tr>
<td>Pitch</td>
<td>p</td>
<td>.100</td>
</tr>
<tr>
<td>Top to Seating Plane</td>
<td>A</td>
<td>.142</td>
</tr>
<tr>
<td>Top of Body to Seating Plane</td>
<td>A2</td>
<td>.100</td>
</tr>
<tr>
<td>Standoff</td>
<td>A1</td>
<td>.025</td>
</tr>
<tr>
<td>Package Width</td>
<td>E1</td>
<td>.280</td>
</tr>
<tr>
<td>Overall Length</td>
<td>D</td>
<td>.693</td>
</tr>
<tr>
<td>Tip to Seating Plane</td>
<td>L</td>
<td>.130</td>
</tr>
<tr>
<td>Lead Thickness</td>
<td>c</td>
<td>.008</td>
</tr>
<tr>
<td>Upper Lead Width</td>
<td>B1</td>
<td>.052</td>
</tr>
<tr>
<td>Lower Lead Width</td>
<td>B</td>
<td>.016</td>
</tr>
<tr>
<td>Overall Row Spacing</td>
<td>eB</td>
<td>.296</td>
</tr>
<tr>
<td>Window Diameter</td>
<td>W</td>
<td>.161</td>
</tr>
<tr>
<td>Lid Length</td>
<td>T</td>
<td>.440</td>
</tr>
<tr>
<td>Lid Width</td>
<td>U</td>
<td>.260</td>
</tr>
</tbody>
</table>

*Controlling Parameter

JEDEC Equivalent: MS-015

Drawing No. CD4-107
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__________________________________________________________________________

2. How does this document meet your hardware and software development needs?

__________________________________________________________________________

3. Do you find the organization of this data sheet easy to follow? If not, why?

__________________________________________________________________________

4. What additions to the data sheet do you think would enhance the structure and subject?

__________________________________________________________________________

5. What deletions from the data sheet could be made without affecting the overall usefulness?

__________________________________________________________________________

6. Is there any incorrect or misleading information (what and where)?

__________________________________________________________________________

7. How would you improve this document?

__________________________________________________________________________

8. How would you improve our software, systems, and silicon products?

__________________________________________________________________________
PIC16C505 Product Identification System

<table>
<thead>
<tr>
<th>PART NO. -XX X /XX XXX</th>
<th>Pattern: Special Requirements</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Package:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SL = 150 mil SOIC</td>
<td>a) PIC16C505-04/P</td>
</tr>
<tr>
<td></td>
<td>P = 300 mil PDIP</td>
<td>Commercial Temp., PDIP Package, 4 MHz, normal VDD limits</td>
</tr>
<tr>
<td></td>
<td>JW = 300 mil Windowed Ceramic Side Brazed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temperature Range:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- I = 0°C to +70°C</td>
<td>b) PIC16C505-04/SL</td>
</tr>
<tr>
<td></td>
<td>E = -40°C to +125°C</td>
<td>Industrial Temp., SOIC package, 4 MHz, normal VDD limits</td>
</tr>
<tr>
<td></td>
<td>Frequency Range:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>04 = 4 MHz (XT, INTRC, EXTRC OSC)</td>
<td>c) PIC16C505-04/IP</td>
</tr>
<tr>
<td></td>
<td>20 = 20 MHz (HS OSC)</td>
<td>Industrial Temp., PDIP package, 4 MHz, normal VDD limits</td>
</tr>
<tr>
<td></td>
<td>Device</td>
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</tr>
<tr>
<td></td>
<td>PIC16C505</td>
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</tr>
<tr>
<td></td>
<td>PIC16LC505</td>
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<td>PIC16C505T (Tape &amp; reel for SOIC only)</td>
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<tr>
<td></td>
<td>PIC16LC505T (Tape &amp; reel for SOIC only)</td>
<td></td>
</tr>
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</table>

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