APPENDIX B:
GLOSSARY

Absolute Addressing: This addressing mode specifies the address of data with the instruction.

Accumulator: Register used for storing the result after most ALU operations; available with 8-bit microcontrollers.


Address: A unique identification number (or locator) for source or destination of data. An address specifies the register or memory location of an operand involved in the instruction.

Addressing Mode: The manner in which a microcontroller determines the effective address of source and destination operands in an instruction.

Address Register: A register used to store the address (memory location) of data.

Address Space: The number of storage location in a microcontroller’s memory that can be directly addressed by the CPU. The addressing range is determined by the number of address lines on the CPU.

American Standard Code for Information Interchange (ASCII): An 8-bit code commonly used with microcontrollers for representing alphanumeric codes. Decimal numbers 0 through 9 are represented by 30 (Hex) through 39 (Hex) in EBCDIC.


Arithmetic and Logic Unit (ALU): A digital circuit which performs arithmetic and logic operations on two n-bit numbers.

Assembler: A program that translates an assembly language program into a machine language program.

Assembly Language: A type of microcontroller programming language that uses a semi-English-language statement.

Asynchronous Operation: The execution of a sequence of steps such that each step is initiated upon completion of the previous step.

Base address: An address that is used to convert all relative addresses in a program to absolute (machine) addresses.

Baud Rate: Rate of data transmission in bits per second.

Big Endian: This convention is used to store a 16-bit number such as 16-bit data in two bytes of memory locations as follows: the low memory address stores the high byte while the high memory address stores the low byte. The Motorola/Freescale HC11 8-bit microcontroller follows the big Indian format.
Binary-Coded Decimal (BCD): The representation of 10 decimal digits, 0 through 9, by their corresponding 4-bit binary number.

Bit: An abbreviation for a binary digit. A unit of information equal to one of two possible states (one or zero, on or off, true or false).

Branch: The branch instruction allows the computer to skip or jump out of program sequence to a designated instruction either unconditionally or conditionally (based on conditions such as carry or sign).

Breakpoint: Allows the user to execute the section of a program until one of the breakpoint conditions is met. It is then halted. The designer may then single step or examine memory and registers. Typically breakpoint conditions are program counter address or data references. Breakpoints are used in debugging assembly language programs.

Buffer: A temporary memory storage device designed to compensate for the different data rates between a transmitting device and a receiving device (for example, between a CPU and a peripheral). Current amplifiers are also referred to as buffers.

Bus: A collection of wires that interconnects computer modules.

Bus Arbitration: Bus operation protocols (rules) that guarantee conflict-free access to a bus. Arbitration is the process of selecting one respondent from a collection of several candidates that concurrently request service.

Bus Cycle: The period of time in which a microcontroller carries out read or write operations.

CCP: CCP stands for Capture, Compare, and PWM (Pulse Width Modulation). The CCP module is implemented in the PIC18F4321 as an on-chip feature to provide measurement and control of time-based pulse signals. The capture mode can be used to measure the period of an incoming periodic waveform connected to the PIC18F’s CCP pin. The Compare mode can be used to turn ON a device such as a pump, connected to the PIC18F’s CCP pin, after a specified amount of time. As an example, the Compare mode can be used in a chemical plant to turn a pump OFF after filling a tank for 50 seconds. The PWM (Pulse Width Modulation) mode can be used to generate a square wave on the PIC18F’s CCP pin with a user-specified frequency and duty cycle.

Central Processing Unit (CPU): The brain of a computer containing the ALU, register section, and control unit.

Chip: An Integrated Circuit (IC) package containing digital circuits.

CISC: Complex Instruction Set Computer. The Control unit is designed using microprogramming. Contains a large instruction set. Difficult to pipeline compared to RISC.

Clock: Timing signals providing synchronization among the various components in a microcontroller. Analogous to heartbeats of a human being.

CMOS: Complementary MOS. Dissipates low power, offers high density and speed compared to TTL.

Compiler: A program which translates the source code written in a high-level programming language into machine language that is understandable to the microcontroller.
Computer: The basic blocks of a computer are the central processing unit (CPU), the memory, and the input/output (I/O).

Condition Code Register: Contains information such as carry, sign, zero, and overflow based on ALU operations.

Control Unit: Part of the CPU; its purpose is to translate or decode instructions read (fetched) from the main memory into the Instruction Register.

Data: Basic elements of information represented in binary form (that is, digits consisting of bits) that can be processed or produced by a microcontroller. Data represents any group of operands made up of numbers, letters, or symbols denoting any condition, value, or state. Typical microcontroller operand sizes include: a byte (8 bits), or a word, which typically contains 2 bytes (16-bits).

Debugger: A program that executes and debugs the object program generated by the assembler or compiler. The debugger provides a single stepping, breakpoints, and program tracing.

Decoder: A chip, when enabled, selects one of $2^n$ output lines based on $n$ inputs.

Digital to Analog (D/A) Converter: Converts binary number to analog signal.

Diode: Two terminal electronic switch.

Directly Addressable Memory: The memory address space in which the microcontroller can directly execute programs. The maximum directly addressable memory is determined by the number of the microcontroller’s address pins.

DRAM: See Dynamic RAM.

Duty Cycle: The duty cycle of a periodic waveform is defined as the percentage of the time the pulse is high in a clock period.

Dynamic RAM: Stores data as charges in capacitors and therefore, must be refreshed since capacitors can hold charges for a few milliseconds. Hence, requires refresh circuitry.

EAROM (Electrically Alterable Read-Only Memory): Same as EEPROM or E$^2$PROM. Can be programmed one line at a time without removing the memory from its sockets. This memory is also called read-mostly memory since it has much slower write times than read times.

Editor: A program that produces an error-free source program, written in assembly or high-level languages.

EEPROM or E$^2$PROM: Same as EAROM (see EAROM).

Effective Address: The final address used to carry out an instruction. Determined by the addressing mode.

EPROM (Erasable Programmable Read-Only Memory): Can be programmed and erased all programs in an EPROM chip using ultraviolet light. The chip must be removed from the circuit board for programming.

Exclusive-OR: The output is 0, if inputs are same; otherwise; the output is 1.
Extended Binary-Coded Decimal Interchange Code (EBCDIC): An 8-bit code sometimes used with computers for representing alphanumeric codes. Normally used by IBM. Decimal numbers 0 through 9 are represented by F0 (Hex) through F9 (Hex) in EBCDIC.

Firmware: Microprogram is sometimes referred to as firmware to distinguish it from hardwired control (purely hardware method).

Flag(s): An indicator, often a single bit, to indicate some conditions such as trace, carry, zero, and overflow.

Flash Memory: Utilizes a combination of EPROM and EEPROM technologies. Used in cellular phones and digital cameras. Also, used to hold program memory on the PIC18F microcontroller.

Flip-Flop: One-bit memory.

Gate: Digital circuits which perform logic operations.

Handshaking: Data transfer via exchange of control signals between the microprocessor and an external device.

Hardware: The physical electronic circuits (chips) that make up the microcontroller.

Hardwired Control: Used for designing the control unit using all hardware.

Harvard CPU architecture: The CPU uses separate instruction and data memory units along with separate buses for instructions and data.

HCMOS: High speed CMOS. Provides high density and consumes low power.

Hexadecimal Number System: Base-16 number system.

High-Level Language: A type of programming language that uses a more understandable human-oriented language such as C.

HMOs: High-density MOS reduces the channel length of the NMOS transistor and provides increased density and speed in VLSI circuits.

I²C (Inter-Integrated Circuit): I²C is synchronous and is based on master/slave operation. This protocol uses two pins; one for clock and one for data. Any number of masters and slaves can be connected. The I²C protocol specifies that in a multimaster/multislave system, the master that initiates a data transfer on the bus is considered as the bus master with all the slave devices connected to the bus as the slaves.

Immediate Address: An address that is used as an operand by the instruction itself.

Implied Address: An address is not specified, but is contained implicitly in the instruction.

Index: A number (typically 8-bit signed or 16-bit unsigned) is used to identify a particular element in an array (string). The index value typically contained in a register is utilized by the indexed addressing mode.

Indexed Addressing: The effective address of the instruction is determined by the sum of the address and the contents of the index register. Used to access arrays.

Index Register: A register used to hold a value used in indexing data, such as when a value is used in indexed addressing to increment a base address contained within an instruction.
Appendix B: Glossary

**Indirect Address:** A register holding a memory address to be accessed.

**Instruction:** Causes the microcontroller to carry out an operation on data. A program contains instructions and data.

**Instruction Cycle:** The sequence of operations that a microcontroller has to carry out while executing an instruction.

**Instruction Register (IR):** A register storing instructions.

**Instruction Set:** Lists all the instructions that the microcontroller can execute.

**Internal Interrupt:** Activated internally by exceptional conditions such as completion of A/D conversion.

**Interpreter:** A program that executes a set of machine language instructions in response to each high-level statement in order to carry out the function.

**Interrupt I/O:** An external device can force the microcontroller to stop executing the current program temporarily so that it can execute another program known as the interrupt service routine.

**Interrupts:** A temporary break in a sequence of a program, initiated externally or internally, causing control to jump to a routine, which performs some action while the program is stopped.

**I/O (Input/Output):** Describes that portion of a microcontroller that exchanges data between the microcontroller system and an external device.

**I/O Port:** A register that contains control logic and data storage used to connect a microcontroller to external peripherals.

**Inverting Buffer:** Performs NOT operation. Current amplifier.

**Keyboard:** Has a number of push button-type switches configured in a matrix form (rows x columns).

**Keybounce:** When a mechanical switch opens or closes, it bounces (vibrates) for a small period of time (about 10-20 ms) before settling down.

**Large-Scale Integration (LSI):** An LSI chip contains 100 to 1000 gates.

**LCD:** Liquid Crystal Display. Displays numbers, and several ASCII characters along with graphics. Furthermore, the LCD consumes low power. Because of inexpensive price of the LCD these days, they have been becoming popular. The LCD’s are widely used in notebook computers.

**LED:** Light Emitting Diode. Typically, a current of 10 ma to 20 ma flows at 1.7v to 2.4v drop across it.

**Little Endian:** This convention is used to store a 16-bit number such as 16-bit data in two bytes of memory locations as follows: the low memory address stores the low byte while the high memory address stores the high byte. The PIC18F microcontroller follows the little-endian format.

**Loops:** A programming control structure where a sequence of microcontroller instructions are executed repeatedly (looped) until a terminating condition (result) is satisfied.
**Machine Code:** A binary code (composed of 1’s and 0’s) that a microcontroller understands.

**Machine Language:** A type of microcontroller programming language that uses binary or hexadecimal numbers.

**Macroinstruction:** Commonly known as an instruction; initiates execution of a complete microprogram. Example includes assembly language instructions.

**Macroprogram:** The assembly language program.

**Mask:** A pattern of bits used to specify (or mask) which bit parts of another bit pattern are to be operated on and which bits are to be ignored or “masked” out. Uses logical AND operation.

**Mask ROM:** Programmed by a masking operation performed on the chip during the manufacturing process; its contents cannot be changed by user.

**Maskable Interrupt:** Can be enabled or disabled by executing typically the interrupt instructions.

**Memory:** Any storage device which can accept, retain, and read back data.

**Memory Access Time:** Average time taken to read a unit of information from the memory.

**Memory Address Register (MAR):** Stores the address of the data.

**Memory Cycle Time:** Average time lapse between two successive read operations.

**Memory Map:** A representation of the physical locations within a microcontroller’s addressable main memory.

**Memory-Mapped I/O:** I/O ports are mapped as memory locations, with every connected device treated as if it were a memory location with a specific address. Manipulation of I/O data occurs in “interface registers” (as opposed to memory locations); hence there are no input (read) or output (write) instructions used in memory-mapped I/O.

**Microcode:** A set of instructions called “microinstructions” usually stored in a ROM in the control unit of a microcontroller’s CPU to translate instructions of a higher-level programming language such as assembly language programming.

**Microcomputer:** Consists of a microprocessor, a memory unit, and an input/output unit.

**Microcontroller:** Typically includes a CPU, memory, I/O, timer, A/D (Analog to Digital) converter in the same chip.

**Microinstruction:** Some microcontrollers have an internal memory called control memory. This memory is used to store a number of codes called microinstructions. These microinstructions are combined to design the instruction set of the microcontroller.

**Microprocessor:** CPU on a single chip. The Central Processing Unit (CPU) of a microcomputer.

**Microprogramming:** Some microcontrollers use microprogramming to design the instruction set. Each instruction in the Instruction register initiates execution of a microprogram stored typically in ROM inside the control unit to perform the required operation.
Appendix B: Glossary

Multiplexer: A hardware device which selects one of n input lines and produces it on the output.

Nested Subroutine: A commonly used programming technique in which one subroutine calls another subroutine.

Nibble: A 4-bit word.

Non-inverting Buffer: Input is same as output. Current amplifier.

Nonmaskable Interrupt: Occurrence of this type of interrupt cannot be ignored by microcontroller and even though interrupt capability of the microcontroller is disabled. Its effect cannot be disabled by instruction.

Non-Multiplexed: A non-multiplexed microcontroller pin that assigns a unique function as opposed to a multiplexed microcontroller pin defining two functions on time-shared basis.

Object Code: The binary (machine) code into which a source program is translated by a compiler, assembler, or interpreter.

Ones Complement: Obtained by changing 1’s to 0’s, and 0’s to 1’s of a binary number.

One-Pass Assembler: This assembler goes through the assembly language program once and translates the assembly language program into a machine language program. This assembler has the problem of defining forward references. See Two-Pass Assembler.

Op Code (Operation Code): Part of an instruction defining the operation to be performed.

Operand: A datum or information item involved in an operation from which the result is obtained as a consequence of defined addressing modes. Various operand types contain information, such as source address, destination address, or immediate data.

Operating System: Consists of a number of program modules to provide resource management. Typical resources include CPU, disks, and printers.

Page: Some microcontrollers, divide the memory locations into equal blocks. Each of these blocks is called a page and contains several addresses.

Parallel Operation: Any operation carried out simultaneously with a related operation.

Parallel Transmission: Each bit of binary data is transmitted over a separate wire.

Parity: The number of 1’s in a word is odd for odd parity and even for even parity.

Peripheral: An I/O device capable of being operated under the control of a CPU through communication channels. Examples include disk drives, keyboards, CRT’s, printers, and modems.

Personal Computer: Low-cost, affordable microcomputer normally used by an individual for word processing and Internet applications.

Physical Address Space: Address space is defined by the address pins of the microcontroller.

Pipeline: A technique that allows a microcontroller processing operation to be broken down into several steps (dictated by the number of pipeline levels or stages) so that the individual step outputs can be handled by the microcontroller in parallel. Often used
to fetch the processor’s next instruction while executing the current instruction, which considerably speeds up the overall operation of the microcontroller. Overlaps instruction fetch with execution.

**Pointer:** A storage location (usually a register within a microcontroller) that contains the address of (or points to) a required item of data or subroutine.

**Polled Interrupt:** A software approach for determining the source of interrupt in a multiple interrupt system.

**POP Operation:** Reading from the top or bottom of stack.

**Port:** A register through which the microcontrollers communicate with peripheral devices.

**Primary or Main Memory:** Storage that is considered internal to the microcontroller. The microcontroller can directly execute all instructions in the main memory. The maximum size of the main memory is defined by the number of address pins in the CPU.

**Processor Memory:** A set of CPU registers for holding temporary results when a computation is in progress.

**Program:** A self-contained sequence of computer software instructions (source code) that, when converted into machine code, directs the computer to perform specific operations for the purpose of accomplishing some processing task. Contains instructions and data.

**Program Counter (PC):** A register that normally contains the address of the next instruction to be executed in a program.

**Programmed I/O:** The microcontroller executes a program to perform all data transfers between the microcontroller system and external devices.

**PROM (Programmable Read-Only Memory):** Can be programmed by the user by using proper equipment. Once programmed, its contents cannot be altered.

**Protocol:** A list of data transmission rules or procedures that encompass the timing, control, formatting, and data representations by which two devices are to communicate. Also known as hardware “handshaking”, which is used to permit asynchronous communication.

**PUSH Operation:** Writing to the top or bottom of stack.

**Random Access Memory (RAM):** A read/write memory. RAMs (static or dynamic) are volatile in nature (in other words, information is lost when power is removed).

**Read-Only-Memory (ROM):** A memory in which any addressable operand can be read from, but not written to, after initial programming. ROM storage is nonvolatile (information is not lost after removal of power).

**Reduced Instruction Set Computer (RISC):** A simple instruction set is included. The RISC architecture maximizes speed by reducing clock cycles per instruction. The control unit is designed using hardwired control. Easier to implement pipelining.

**Register:** A high-speed memory usually constructed from flip-flops that are directly accessible to the CPU. It can contain either data or a specific location in memory that stores word(s) used during arithmetic, logic, and transfer operations.
Register Indirect: Uses a register which contains the address of data.

Relative Address: An address used to designate the position of a memory location in a routine or program.

RISC: See Reduced Instruction Set Computer.

Routine: A group of instructions for carrying out a specific processing operation. Usually refers to part of a larger program. A routine and subroutine have essentially the same meaning, but a subroutine could be interpreted as a self-contained routine nested within a routine or program.

SDRAM: Synchronous DRAM. This chip contains several DRAMs internally. The control signals and address inputs are sampled by the SDRAM by a common clock.

Secondary Memory Storage: An auxiliary data storage device that supplements the main (primary) memory of a computer. It is used to hold programs and data that would otherwise exceed the capacity of the main memory. Although it has a much slower access time, secondary storage is less expensive. Examples include floppy and hard disks.

Sequential Circuit: Combinational circuit with memory.

Serial Transmission: Only one line is used to transmit the complete binary data bit by bit.

Seven-Segment LED: Contains an LED in each of the seven segments. Can display numbers.

Signed Number: A signed binary number, on the other hand, includes both positive and negative numbers. It is represented in the microcontroller in two’s-complement form. For example, the decimal number +15 is represented in 8-bit two’s-complement form as 00001111 (binary) or 0F (hexadecimal). The decimal number -15 can be represented in 8-bit two’s-complement form as 11110001 (binary) or F1 (hexadecimal). Also, the most significant bit (MSB) of a signed number represents the sign of the number. For example, bit 7 of an 8-bit number, bit 15 of a 16-bit number, and bit 31 of a 32-bit number represent the signs of the respective numbers. A “0” at the MSB represents a positive number; a “1” at the MSB represents a negative number.

Single-Chip Microcomputer: Microcomputer (CPU, memory, and input/output) on a chip.

Single-chip Microprocessor: Microcomputer CPU (microprocessor) on a chip.

Single Step: Allows the user to execute a program one instruction at a time and examine contents of memory locations and registers.

Software: consists of a collection of programs that contain instructions and data for performing a specific task in a microcontroller.

Source Code: The assembly language program written by a programmer using assembly language instructions. This code must be translated to the object (machine) code by the assembler before it can be executed by the microcontroller.

SPI (Serial Peripheral Interface): The main purpose of the SPI is to replace parallel interfaces by avoiding routing of parallel buses in a PCB (Printed Circuit Board). The SPI protocol is based on the principle that a bit from an 8-bit shift register can be shifted out on
a single pin and, a bit can be shifted into another pin. SPI protocol can also be used for data transfer between the CPU (master) and slave devices such as flash memory and ADC.

**SRAM:** See Static RAM.

**Stack:** An area of read/write memory typically used by a microcontroller during subroutine calls or occurrence of an interrupt. The microcontroller saves in the stack the contents of the program counter before executing the subroutine or program counter contents and other status information before executing the interrupt service routine. Thus, the microcontroller can return to the main program after execution of the subroutine or the interrupt service routine. The stack is a last in/first out (LIFO) read/write memory (RAM) that can also be manipulated by the programmer using PUSH and POP instructions.

**Stack Pointer:** A register used to address the stack.

**Standard I/O:** Utilizes a control pin on the CPU typically called the M/IO pin, in order to distinguish between input/output and memory; IN and OUT instructions are used for input/output operations.

**Static RAM:** Also known as SRAM. Stores data in flip-flops; does not need to be refreshed. Information is lost upon power failure unless backed up by battery.

**Status Register:** A register which contains information concerning the flags in a microcontroller.

**Subroutine:** A program carrying out a particular function and which can be called by another program known as the main program. A subroutine needs to be placed only once in memory and can be called by the main program as many times as the programmer wants.

**Synchronous Operation:** Operations that occur at intervals directly related to a clock period.

**Tracing:** Allows single stepping. A dynamic diagnostic technique permits analysis (debugging) of the program’s execution.

**Tristate Buffer:** Has three output states: logic 0, 1, and a high-impedance state. This chip is typically enabled by a control signal to provide logic 0 or 1 outputs. This type of buffer can also be disabled by the control signal to place it in a high-impedance state.

**Two’s Complement:** The two’s complement of a binary number is obtained by replacing each 0 with a 1 and each 1 with a 0 and adding one to the resulting number.

**Two-Pass Assembler:** This assembler goes through the assembly language program twice. In the first pass, the assembler assigns binary addresses to labels. In the second pass, the assembly program is translated to the machine language. No problem with forward branching.

**Unsigned Number:** An *unsigned binary number* has no arithmetic sign, therefore, are always positive. Typical examples are your age or a memory address, which are always positive numbers. An 8-bit unsigned binary integer represents all numbers from 00 through FF (0 through 255 in decimal).

**Very Large Scale Integration (VLSI):** A VLSI chip contains more than 1000 gates. More commonly, a VLSI chip is identified by the number of transistors rather than the gate count.
Appendix B: Glossary

von Neumann (Princeton) CPU architecture: uses a single memory unit and the same bus for accessing both instructions and data.

Word: The bit size of a microcontroller refers to the number of bits that can be processed simultaneously by the basic arithmetic and logic circuits of the CPU. A number of bits taken as a group in this manner is called a word.