

5. ANEXOS.

5.1 EL MICROCONTROLADOR PIC

Los PIC's son microcontroladores que usan un juego de instrucciones tipo RISC, su tipo de arquitectura es la Harvard y los fabrica una compañía llamada MICROCHIP TECHNOLOGY INC. Es importante resaltar que PIC no es un acrónimo, sin embargo muchas veces es usado como tal para describirlo como Controlador de Interfaz Periférico.

5.1.1 ENTORNO DE PROGRAMACIÓN DEL PIC

Los microcontroladores realizan diversas tareas y un sin fin de actividades sin embargo, es necesario indicarles que deben hacer cuando se presente cierta condición y como deben organizar sus periféricos de entrada y salida. La compañía microchip proporciona a sus usuarios un entorno de desarrollo freeware llamado MPLAB en donde pueden ensamblar el PIC. Otras empresas desarrollan compiladores en lenguaje C por ejemplo PIC-C COMPILER el cual también es aceptado por los PIC.

Es aquí donde, a través de un programa, se dan las instrucciones al microcontrolador y en donde se configura según las necesidades de cada usuario.

5.1.2 PROGRAMACIÓN DEL PIC


Una vez escrito el programa, se inserta a la memoria del PIC con ayuda de los programadores que son dispositivos que se usan para transferir el código, en el cual vienen las instrucciones y los comandos de ejecución, desde una computadora personal hacia el microcontrolador.

Por mencionar algunos programadores tenemos: PICStar plus, PICKit1, PICKit2, PICKit3, MPLAB-PM3,



Figura 45: Programador PICkit 3

5.2 APENDICE A: Hoja de especificaciones para el multiplexor.



FAIRCHILD
SEMICONDUCTOR™

October 1987
Revised January 1999

MM74C150 • MM82C19

16-Line to 1-Line Multiplexer 3-STATE • 16-Line to 1-Line Multiplexer

General Description

The MM74C150 and MM82C19 multiplex 16 digital lines to 1 output. A 4-bit address code determines the particular 1-of-16 inputs which is routed to the output. The data is inverted from input to output.

A strobe override places the output of MM74C150 in the logical "1" state and the output of MM82C19 in the high-impedance state.

All inputs are protected from damage due to static discharge by diode clamps to V_{CC} and GND.

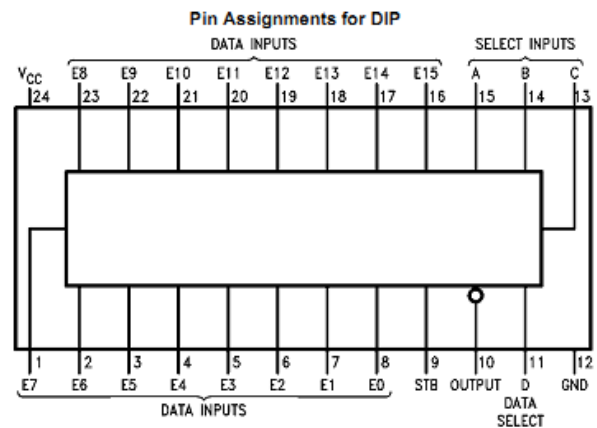
Features

- Wide supply voltage range: 3.0V to 15V
- Guaranteed noise margin: 1.0V
- High noise immunity: 0.45 V_{CC} (typ.)
- TTL compatibility: Drive 1 TTL Load

Ordering Code:

Order Number	Package Number	Package Description
MM74C150N	N24A	24-Lead plastic Dual-In-Line Package (PDIP), JEDEC MS-010, 0.600" Wide
MM82C19N	N24A	24-Lead plastic Dual-In-Line Package (PDIP), JEDEC MS-010, 0.600" Wide

Connection Diagram



Pin Assignments for DIP

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MM74C150 • MM82C19 16-Line to 1-Line Multiplexer 3-STATE • 16-Line to 1-Line Multiplexer

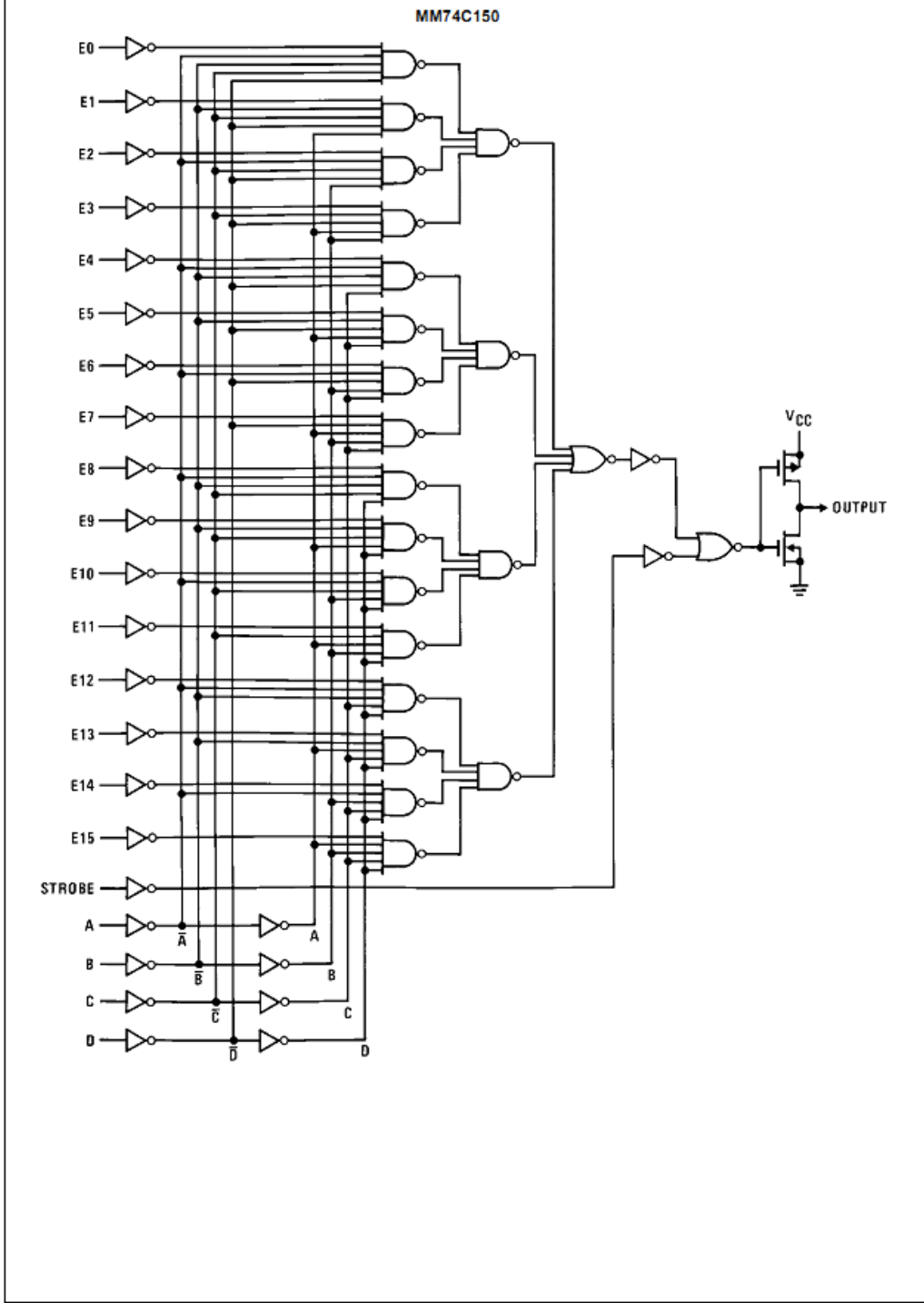
Truth Table

MM74C150

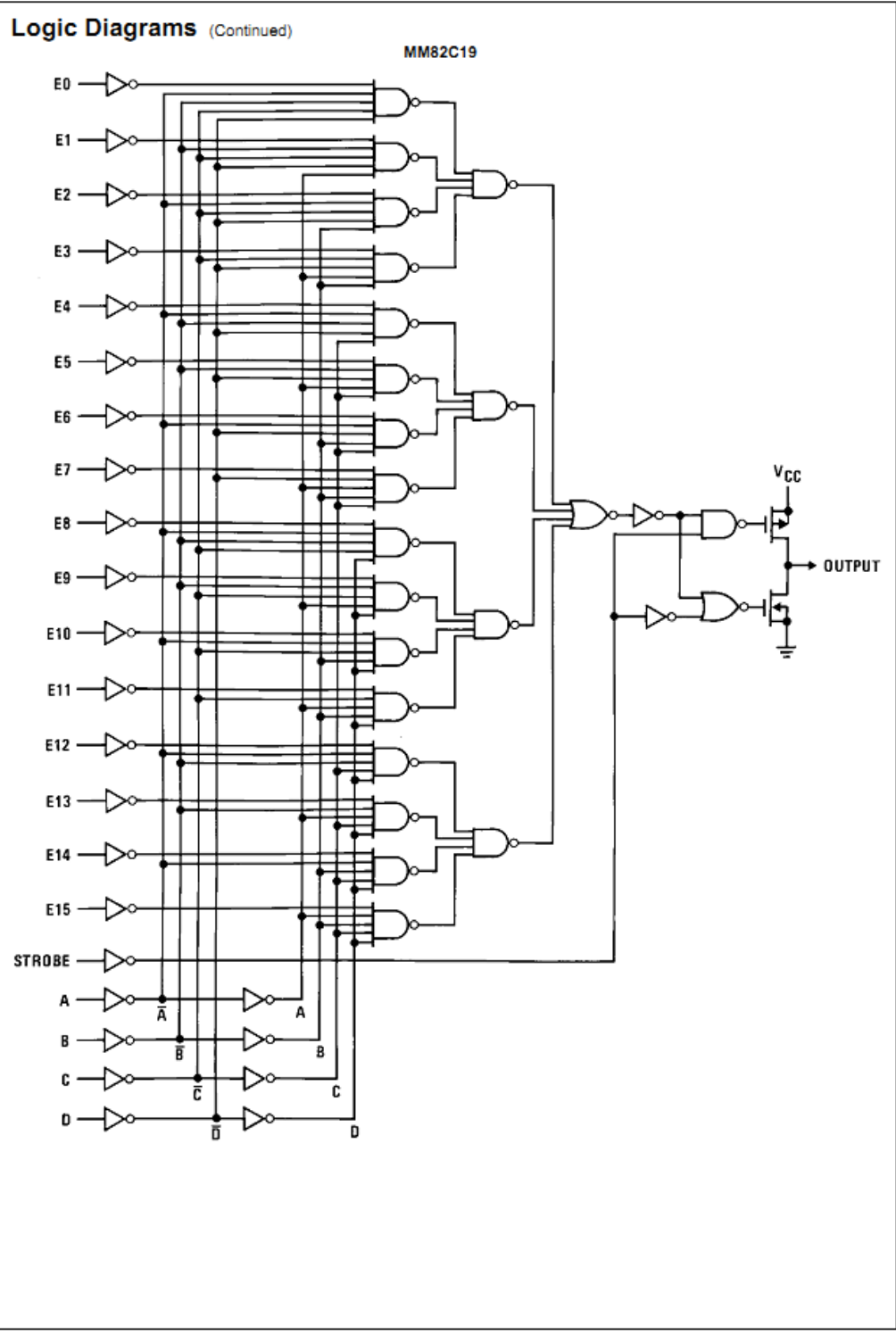
				Inputs															Output			
D	C	B	A	STROBE	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	W	
X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1 (Note 1)
0	0	0	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
0	0	0	0	0	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0
0	0	0	1	0	X	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
0	0	0	1	0	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0
0	0	1	0	0	X	X	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
0	0	1	0	0	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0
0	0	1	1	0	X	X	X	0	X	X	X	X	X	X	X	X	X	X	X	X	X	1
0	0	1	1	0	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	0
0	1	0	0	0	X	X	X	X	0	X	X	X	X	X	X	X	X	X	X	X	X	1
0	1	0	0	0	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	0
0	1	0	1	0	X	X	X	X	X	0	X	X	X	X	X	X	X	X	X	X	X	1
0	1	0	1	0	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	0
0	1	1	0	0	X	X	X	X	X	X	0	X	X	X	X	X	X	X	X	X	X	1
0	1	1	1	0	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	0
1	0	0	0	0	X	X	X	X	X	X	X	0	X	X	X	X	X	X	X	X	X	1
1	0	0	0	0	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	0
1	0	0	1	0	X	X	X	X	X	X	X	X	0	X	X	X	X	X	X	X	X	1
1	0	0	1	0	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	0
1	0	1	0	0	X	X	X	X	X	X	X	X	X	0	X	X	X	X	X	X	X	1
1	0	1	0	0	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	0
1	0	1	1	0	X	X	X	X	X	X	X	X	X	X	0	X	X	X	X	X	X	1
1	0	1	1	0	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	0
1	0	1	1	0	X	X	X	X	X	X	X	X	X	X	X	0	X	X	X	X	X	1
1	0	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	0
1	0	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	0
1	1	0	0	0	X	X	X	X	X	X	X	X	X	X	X	0	X	X	X	X	X	1
1	1	0	0	0	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	0
1	1	0	1	0	X	X	X	X	X	X	X	X	X	X	X	X	0	X	X	X	X	1
1	1	0	1	0	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	0
1	1	1	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X	X	X	1
1	1	1	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	0
1	1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X	X	1
1	1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	0
1	1	1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X	1
1	1	1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	0

Note 1: For MM72C19/MM82C19 this would be Hi-Z, everything else is the same.

Logic Diagrams



MM74C150 • MM82C19



Absolute Maximum Ratings (Note 2)		V_{CC}	18V
Voltage at Any Pin	-0.3V to $V_{CC}+0.3V$	Lead Temperature (soldering, 10 seconds)	260°C
Operating Temperature Range	-40°C to +85°C		
Storage Temperature Range	-65°C to +150°C		
Power Dissipation			
Dual-In-Line	700 mW		
Small Outline	500 mW		
Operating V_{CC} Range	3.0V to 15V		

Note 2: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. Except for "Operating Temperature Range" they are not meant to imply that the devices should be operated at these limits. The Electrical Characteristic table provides conditions for actual device operation.

DC Electrical Characteristics

Min/Max limits apply across temperature range unless otherwise noted.

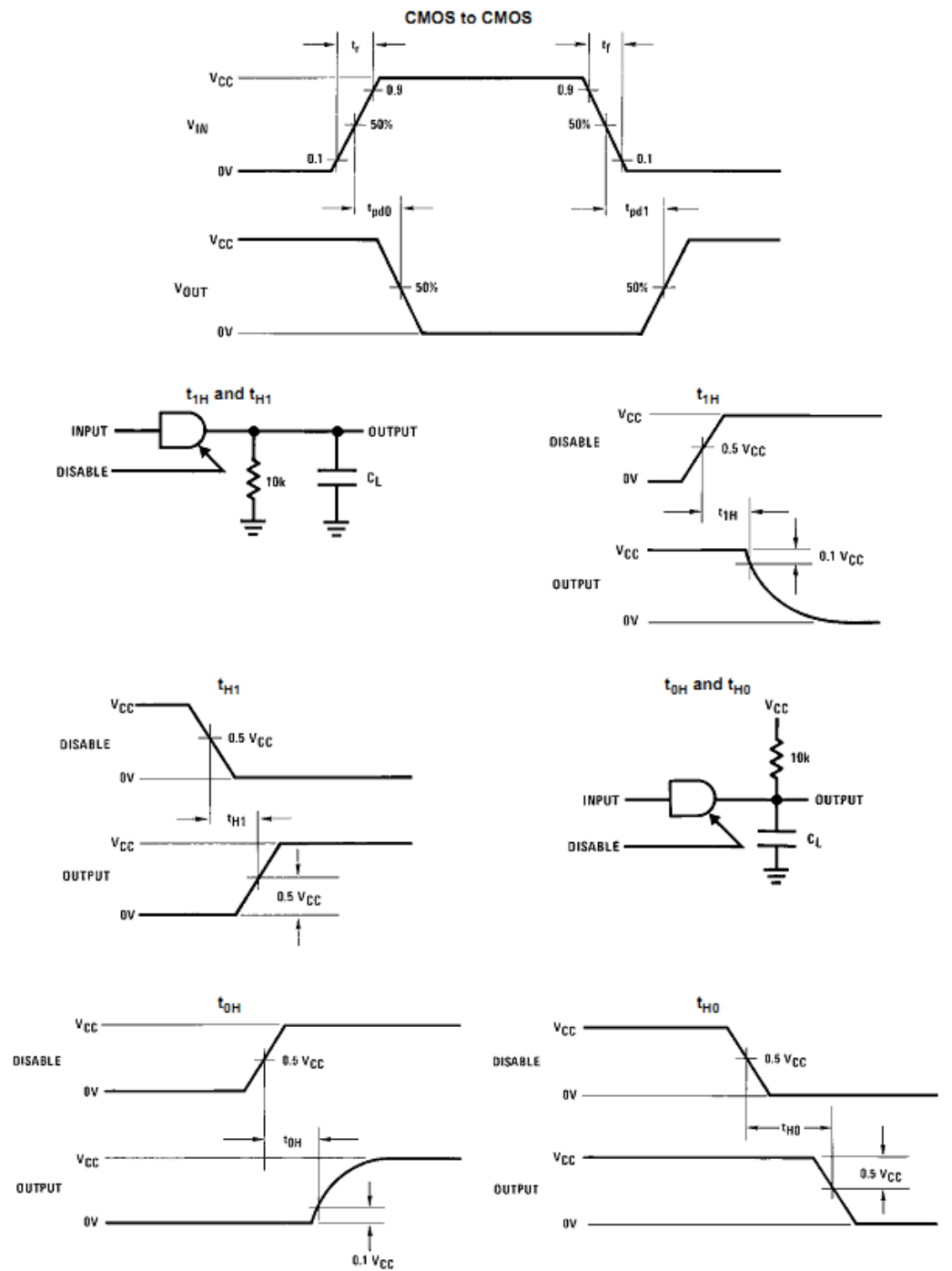
Symbol	Parameter	Conditions	Min	Typ	Max	Units
CMOS to CMOS						
$V_{IN(1)}$	Logical "1" Input Voltage	$V_{CC} = 5.0V$ $V_{CC} = 10V$	3.5 8.0			V
$V_{IN(0)}$	Logical "0" Input Voltage	$V_{CC} = 5.0V$ $V_{CC} = 10V$			1.5 2.0	V
$V_{OUT(1)}$	Logical "1" Output Voltage	$V_{CC} = 5.0V, I_O = -10 \mu A$ $V_{CC} = 10V, I_O = -10 \mu A$	4.5 9.0			V
$V_{OUT(0)}$	Logical "0" Output Voltage	$V_{CC} = 5.0V, I_O = +10 \mu A$ $V_{CC} = 10V, I_O = +10 \mu A$			0.5 1.0	V
$I_{IN(1)}$	Logical "1" Input Current	$V_{CC} = 15V, V_{IN} = 15V$		0.005	1.0	V
$I_{IN(0)}$	Logical "0" Input Current	$V_{CC} = 15V, V_{IN} = 0V$	-1.0	-0.005		μA
I_{OZ}	Output Current in High Impedance State MM82C19	$V_{CC} = 15V, V_O = 15V$ $V_{CC} = 15V, V_O = 0V$	-1.0	0.005 -0.005	1.0	μA
I_{CC}	Supply Current	$V_{CC} = 15V$		0.05	300	μA
CMOS/LPTTL Interface						
$V_{IN(1)}$	Logical "1" Input Voltage	74C, 82C, $V_{CC} = 4.75V$	$V_{CC}-1.5$			V
$V_{IN(0)}$	Logical "0" Input Voltage	74C, 82C, $V_{CC} = 4.75V$			0.8	V
$V_{OUT(1)}$	Logical "1" Output Voltage	74C, 82C, $V_{CC} = 4.75V, I_O = -1.6 mA$	2.4			V
$V_{OUT(0)}$	Logical "0" Output Voltage	74C, 82C, $V_{CC} = 4.75V, I_O = 1.6 mA$			0.4	V
Output Drive (Short Circuit Current)						
I_{SOURCE}	Output Source Current (P-Channel)	$V_{CC} = 5.0V, V_{OUT} = 0V, T_A = 25^\circ C$	-4.35	-8		mA
I_{SOURCE}	Output Source Current (P-Channel)	$V_{CC} = 10V, V_{OUT} = 0V, T_A = 25^\circ C$	-20	-40		mA
I_{SINK}	Output Sink Current (N-Channel)	$V_{CC} = 5.0V, V_{OUT} = V_{CC}, T_A = 25^\circ C$	4.35	8		mA
I_{SINK}	Output Sink Current (N-Channel)	$V_{CC} = 10V, V_{OUT} = V_{CC}, T_A = 25^\circ C$	20	40		mA

AC Electrical Characteristics (Note 3) $T_A = 25^\circ\text{C}$, $C_L = 50\text{ pF}$, unless otherwise noted

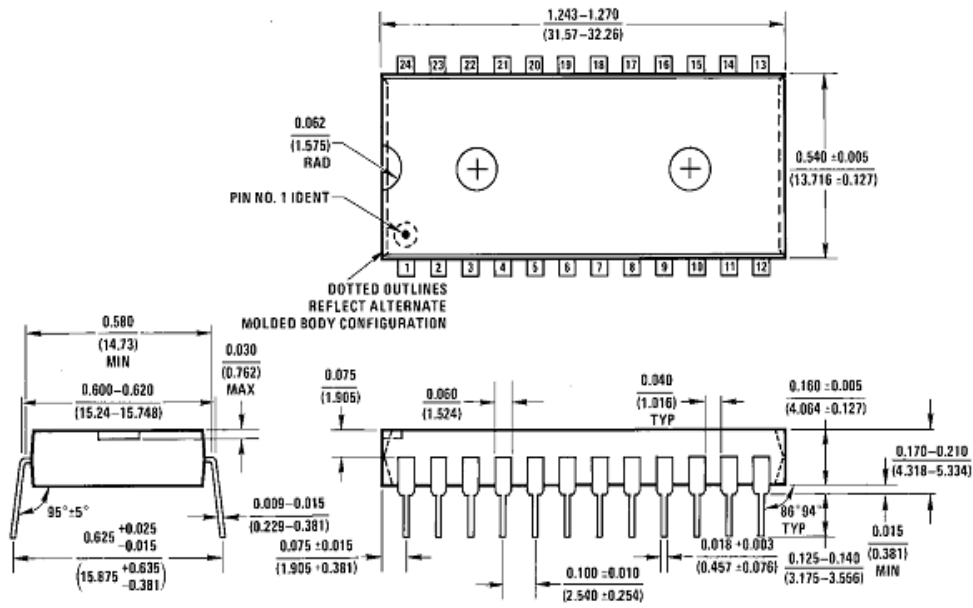
Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{pd0} , t_{pd1}	Propagation Delay Time to a Logical "0" or Logical "1" from Data Inputs to Output	$V_{CC} = 5.0\text{V}$		250	600	ns
		$V_{CC} = 10\text{V}$		110	300	ns
		$V_{CC} = 5.0\text{V}$, $C_L = 150\text{ pF}$		290	650	ns
		$V_{CC} = 10\text{V}$, $C_L = 150\text{ pF}$		120	330	ns
t_{pd0} , t_{pd1}	Propagation Delay Time to a Logical "0" or Logical "1" from Data Select Inputs to Output	$V_{CC} = 5.0\text{V}$		290	650	ns
		$V_{CC} = 10\text{V}$		120	330	ns
t_{pd0} , t_{pd1}	Propagation Delay Time to a Logical "0" or Logical "1" from Strobe to Output MM74C150	$V_{CC} = 5.0\text{V}$		120	300	ns
		$V_{CC} = 10\text{V}$		55	150	ns
t_{1H} , t_{0H}	Delay from Strobe to High Impedance State MM82C19	$V_{CC} = 5.0\text{V}$, $R_L = 10\text{k}$, $C_L = 5\text{ pF}$		80	200	ns
		$V_{CC} = 10\text{V}$, $R_L = 10\text{k}$, $C_L = 5\text{ pF}$		60	150	ns
t_{H1} , t_{H0}	Delay from Strobe to Logical "1" Level or to Logical "0" Level (from High Impedance State) MM82C19	$V_{CC} = 5.0\text{V}$, $R_L = 10\text{k}$, $C_L = 5\text{ pF}$		80	250	ns
		$V_{CC} = 10\text{V}$, $R_L = 10\text{k}$, $C_L = 5\text{ pF}$		30	120	ns
C_{IN}	Input Capacitance	Any Input (Note 4)		5.0		pF
C_{OUT}	Output Capacitance MM82C19	(Note 4)		11.0		pF
C_{PD}	Power Dissipation Capacitance	(Note 5)		100		pF

Note 3: AC Parameters are guaranteed by DC correlated testing.**Note 4:** Capacitance is guaranteed by periodic testing.**Note 5:** C_{PD} determines the no load AC power consumption of any CMOS device. For complete explanation, see Family Characteristics, application note AN-80.

Switching Time Waveforms



Physical Dimensions inches (millimeters) unless otherwise noted



24-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-010, 0.600" Wide
Package Number N24A

N24A (REV D)

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5.3 APENDICE B: Hoja de especificaciones para el transistor.



**COMPLEMENTARY SILICON PLASTIC
POWER TRANSISTORS**

... designed for use in general purpose power amplifier and switching applications.

FEATURES:

* Collector-Emitter Sustaining Voltage -

- $V_{CE(sus)}$ = 40V(Min)- TIP31, TIP32
- 60V(Min)- TIP31A, TIP32A
- 80V(Min)- TIP31B, TIP32B
- 100V(Min)-TIP31C, TIP32C

* Collector-Emitter Saturation Voltage- $V_{CE(sat)}$ = 1.2V(Max) @ $I_C = 3.0 A$

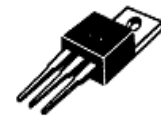
* Current Gain-Bandwidth Product $f_T = 3.0 MHz (Min) @ I_C = 500 mA$

NPN	PNP
TIP31	TIP32
TIP31A	TIP32A
TIP31B	TIP32B
TIP31C	TIP32C

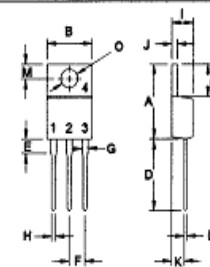
**3 AMPERE
COMPLEMENTARY SILICON
POWER TRANSISTORS
40-100 VOLTS
40 WATTS**

MAXIMUM RATINGS

Characteristic	Symbol	TIP31 TIP32	TIP31A TIP32A	TIP31B TIP32B	TIP31C TIP32C	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	100	V
Collector-Base Voltage	V_{CBO}	40	60	80	100	V
Emitter-Base Voltage	V_{EBO}	5.0				V
Collector Current - Continuous - Peak	I_C	3.0 5.0				A
Base Current	I_B	1.0				A
Total Power Dissipation @ $T_C = 25^\circ C$ Derate above $25^\circ C$	P_D	40 0.32				W W/ $^\circ C$
Operating and Storage Junction Temperature Range	T_J, T_{STG}	-65 to +150				$^\circ C$



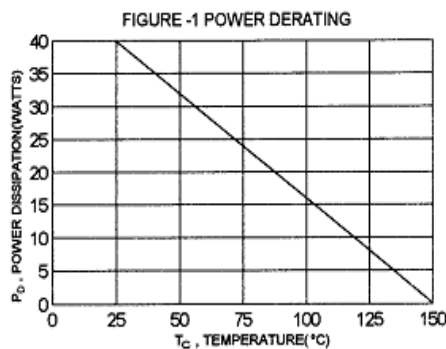
TO-220



PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR (CASE)

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Case	$R_{\theta jc}$	3.125	$^\circ C/W$



DIM	MILLIMETERS	
	MIN	MAX
A	14.68	15.31
B	9.78	10.42
C	5.01	6.52
D	13.06	14.62
E	3.57	4.07
F	2.42	3.66
G	1.12	1.36
H	0.72	0.96
I	4.22	4.98
J	1.14	1.38
K	2.20	2.97
L	0.33	0.55
M	2.48	2.98
O	3.70	3.90

TIP31, TIP31A, TIP31B, TIP31C NPN / TIP32, TIP32A, TIP32B, TIP32C PNP

ELECTRICAL CHARACTERISTICS ($T_c = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) ($I_c = 30\text{ mA}$, $I_B = 0$)	TIP31, TIP32 TIP31A, TIP32A TIP31B, TIP32B TIP31C, TIP32C	$V_{CEO(sus)}$	40 60 80 100	V
Collector Cutoff Current ($V_{CE} = 30\text{ V}$, $I_B = 0$) ($V_{CE} = 60\text{ V}$, $I_B = 0$)	TIP31, TIP32, TIP31A, TIP32A TIP31B, TIP32B, TIP31C, TIP32C	I_{CEO}	0.3 0.3	mA
Collector Cutoff Current ($V_{CE} = 40\text{ V}$, $V_{EB} = 0$) ($V_{CE} = 60\text{ V}$, $V_{EB} = 0$) ($V_{CE} = 80\text{ V}$, $V_{EB} = 0$) ($V_{CE} = 100\text{ V}$, $V_{EB} = 0$)	TIP31, TIP32 TIP31A, TIP32A TIP31B, TIP32B TIP31C, TIP32C	I_{CES}	0.2 0.2 0.2 0.2	mA
Emitter Cutoff Current ($V_{EB} = 5.0\text{ V}$, $I_C = 0$)		I_{EBO}	1.0	mA

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 1.0\text{ A}$, $V_{CE} = 4.0\text{ V}$) ($I_C = 3.0\text{ A}$, $V_{CE} = 4.0\text{ V}$)	h_{FE}	25 10	50	
Collector-Emitter Saturation Voltage ($I_C = 3.0\text{ A}$, $I_B = 375\text{ mA}$)	$V_{CE(sat)}$		1.2	V
Base-Emitter On Voltage ($I_C = 3.0\text{ A}$, $V_{CE} = 4.0\text{ V}$)	$V_{BE(on)}$		1.8	V

DYNAMIC CHARACTERISTICS

Current Gain - Bandwidth Product (2) ($I_C = 500\text{ mA}$, $V_{CE} = 10\text{ V}$, $f_{TEST} = 1\text{ MHz}$)	f_T	3.0		MHz
Small Signal Current Gain ($I_C = 500\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1\text{ kHz}$)	h_{fe}	20		

(1) Pulse Test: Pulse width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$

(2) $f_T = |h_{fe}| \cdot f_{TEST}$

FIGURE 2 - SWITCHING TIME EQUIVALENT CIRCUIT

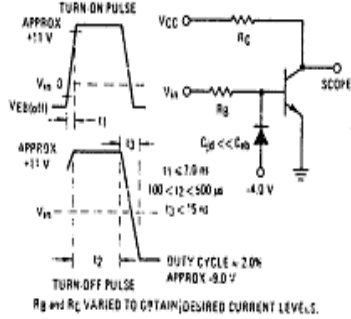


FIG-3 TURN-ON TIME

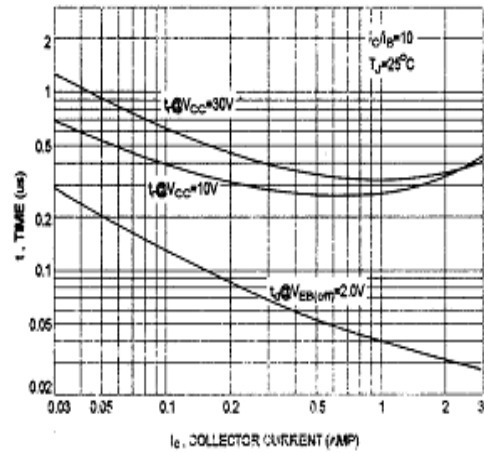


FIG-4 DC CURRENT GAIN

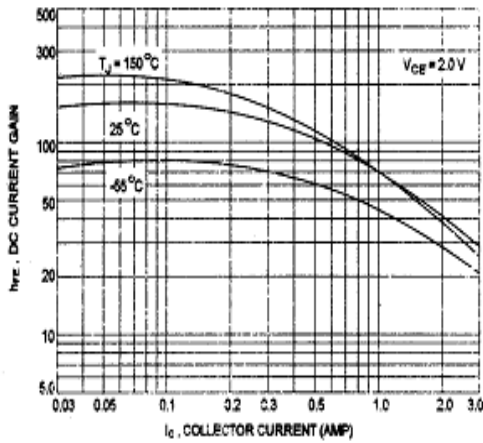


FIG-5 TURN-OFF TIME

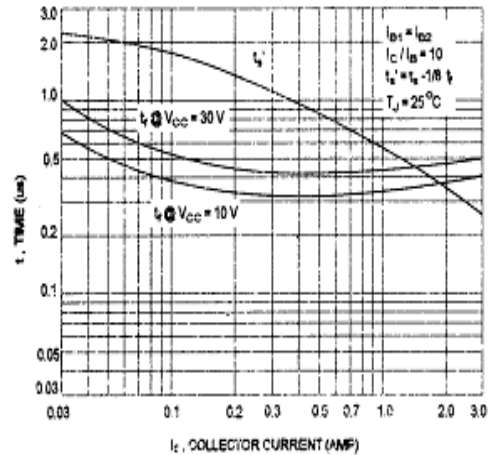
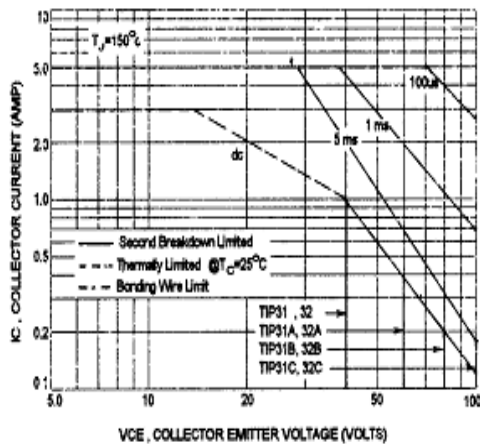


FIG-6 ACTIVE REGION SAFE OPERATING AREA



There are two limitation on the power handling ability of a transistor: average junction temperature and second breakdown safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than curves indicate.

The data of FIG-6 curve is base on $T_{j(pk)} = 150^\circ\text{C}$; T_C is variable depending on power level, second breakdown pulse limits are valid for duty cycles to 10% provided $T_{j(pk)} \leq 150^\circ\text{C}$. At high case temperatures, thermal limitation will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIG-7 COLLECTOR SATURATION REGION

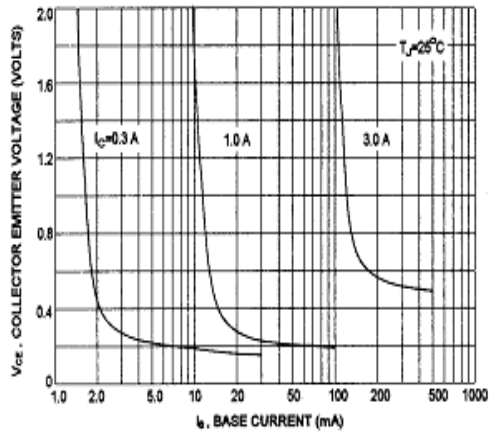


FIG-8 CAPACITANCES

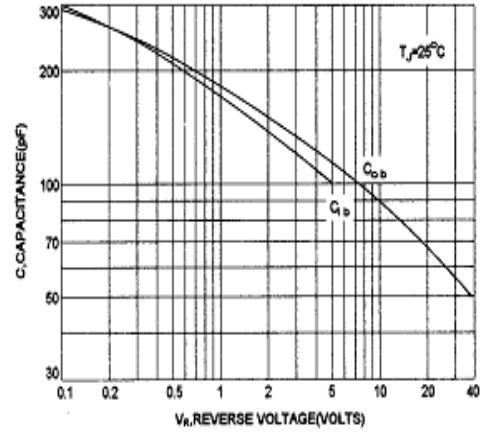


FIG-9 "ON" VOLTAGE

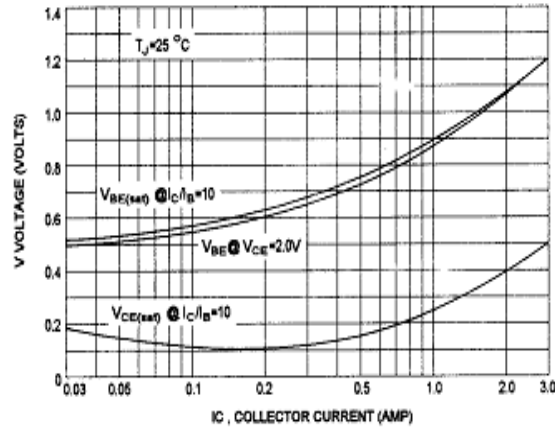
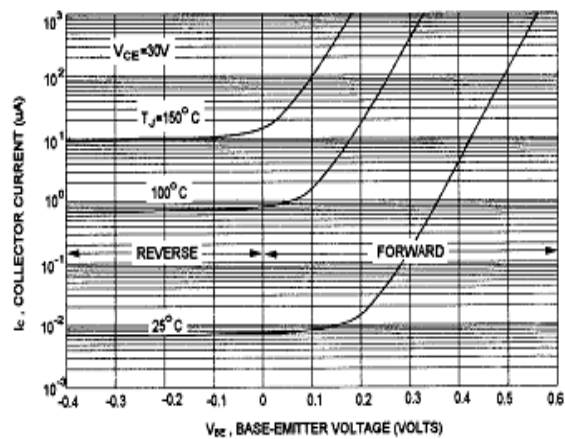


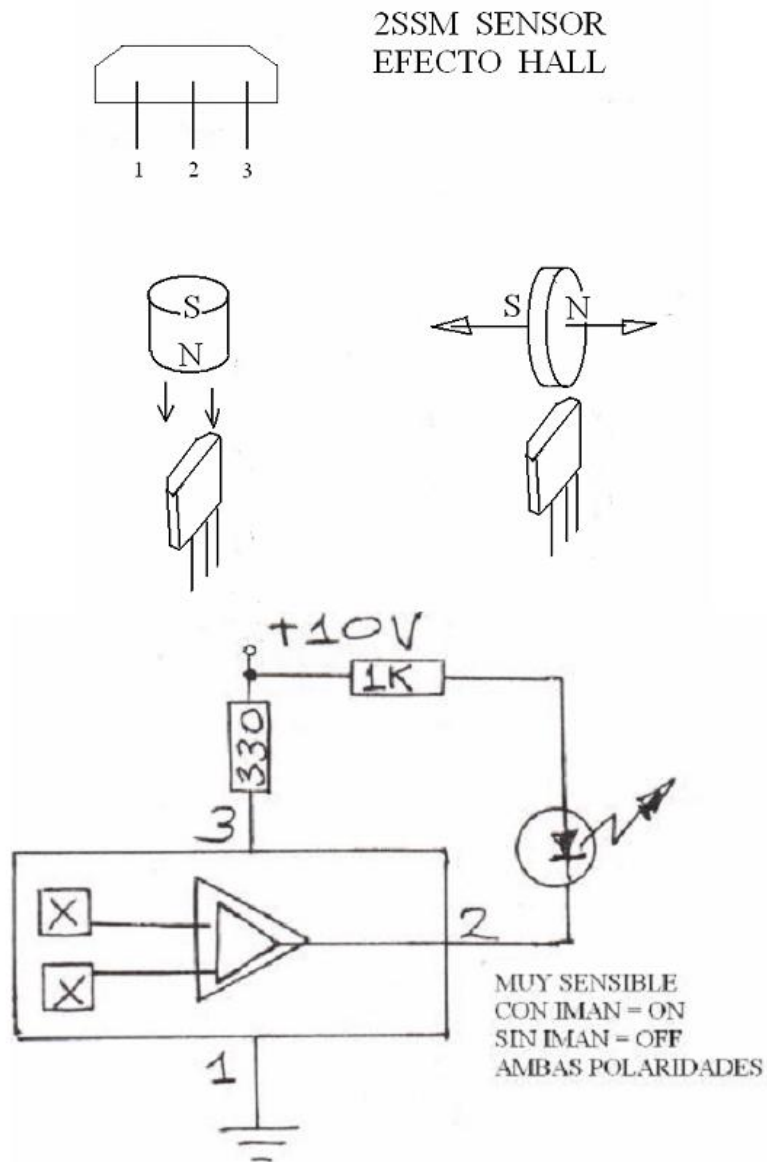
FIG-10 COLLECTOR CUT-OFF REGION



5.4 APENDICE C: Hoja de especificaciones para el sensor de efecto hall.

SENSOR DE EFECTO HALL

El **efecto Hall** consiste en la aparición de un campo eléctrico en un conductor cuando es atravesado por un campo magnético. A este campo eléctrico se le llama **campo Hall**. Este efecto fue descubierto en 1879 por el físico estadounidense Edwin Herbert Hall.



Los sensores basados en efecto Hall constan de un elemento conductor o semiconductor y un imán. Cuando un objeto ferromagnético se aproxima al sensor, el campo que

provoca el imán en el elemento se debilita. Así se puede determinar la proximidad de un objeto, siempre que sea ferromagnético.

Aplicaciones de sensores de efecto Hall

Una de las aplicaciones de los sensores por efecto Hall que más se ha instalado en la industria, en especial en la automotriz, es como reemplazo del sensor inductivo (basado en un imán permanente y una bobina). Dado que en este caso el sensor, por estar implementado por un semiconductor, tiene la capacidad de poseer electrónica integrada, la señal que sale de los sensores por efecto Hall para uso como detectores de proximidad por lo general ya está amplificada y condicionada, de modo que su utilización es mucho más directa, fácil y económica.

Se utilizan también chips por efecto Hall como interruptores accionados por el campo magnético de un imán. Un caso concreto es en los sensores de los sistemas de alarma (aquellos que se colocan en puertas y ventanas, para detectar su apertura). Estos interruptores tienen la ventaja de no sufrir fricción al ser accionados, ya que el único elemento que toma contacto es el campo magnético. Son utilizados en teclados de alta eficiencia, y estos mismos interruptores se pueden usar como sensores de choque (contacto físico), posición de un mecanismo, cuentavueltas, límite de carrera y otras detecciones mecánicas dentro y en el exterior de un robot.

En robótica las aplicaciones también son vastas por ejemplo para contar las vueltas de una llanta se pone el imán en la llanta y el sensor en la carcasa y cada vez que pase el imán contara una vuelta esta señal de conteo podemos meterla a un microcontrolador y este comparar el conteo de las dos llantas y hacer un refresco para verificar que las vueltas que ha dado una llanta y otra sean iguales, así podemos asegurar que un robot vaya derecho y no verse afectado por alguna piedra que haya atorado una llanta y desviado a nuestro robot móvil.

Transistor: Dispositivo electrónico de material semiconductor (germanio, silicio) capaz de controlar una corriente eléctrica, amplificándola y/o conmutándola. Posee tres conexiones: Colector, Emisor y Base.

Transistor de efecto Hall: Dispositivo electrónico de material semiconductor (germanio, silicio) capaz de controlar una corriente eléctrica, amplificándola y/o conmutándola donde la base se dispara por la presencia de un campo magnético. Posee tres conexiones: Colector, Emisor y Base.
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PIC16F627A/628A/648A

Data Sheet

FLASH-Based

8-Bit CMOS Microcontrollers



PIC16F627A/628A/648A

18-pin FLASH-Based 8-Bit CMOS Microcontrollers

High Performance RISC CPU:

- Operating speeds from DC - 20 MHz
- Interrupt capability
- 8-level deep hardware stack
- Direct, Indirect and Relative Addressing modes
- 35 single word instructions
 - All instructions single cycle except branches

Special Microcontroller Features:

- Internal and external oscillator options
 - Precision Internal 4 MHz oscillator factory calibrated to $\pm 1\%$
 - Low Power Internal 37 kHz oscillator
 - External Oscillator support for crystals and resonators.
- Power saving SLEEP mode
- Programmable weak pull-ups on PORTB
- Multiplexed Master Clear/Input-pin
- Watchdog Timer with independent oscillator for reliable operation
- Low voltage programming
- In-Circuit Serial Programming™ (via two pins)
- Programmable code protection
- Brown-out Reset
- Power-on Reset
- Power-up Timer and Oscillator Start-up Timer
- Wide operating voltage range. (2.0 - 5.5V)
- Industrial and extended temperature range
- High Endurance FLASH/EEPROM Cell
 - 100,000 write FLASH endurance
 - 1,000,000 write EEPROM endurance
 - 100 year data retention

Low Power Features:

- Standby Current:
 - 100 nA @ 2.0V, typical
- Operating Current:
 - 12 μ A @ 32 kHz, 2.0V, typical
 - 120 μ A @ 1 MHz, 2.0V, typical
- Watchdog Timer Current
 - 1 μ A @ 2.0V, typical
- Timer1 oscillator current:
 - 1.2 μ A @ 32 kHz, 2.0V, typical
- Dual Speed Internal Oscillator:
 - Run-time selectable between 4 MHz and 37 kHz
 - 4 μ s wake-up from SLEEP, 3.0V, typical

Peripheral Features:

- 16 I/O pins with individual direction control
- High current sink/source for direct LED drive
- Analog comparator module with:
 - Two analog comparators
 - Programmable on-chip voltage reference (VREF) module
 - Selectable internal or external reference
 - Comparator outputs are externally accessible
- Timer0: 8-bit timer/counter with 8-bit programmable prescaler
- Timer1: 16-bit timer/counter with external crystal/clock capability
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Capture, Compare, PWM module
 - 16-bit Capture/Compare
 - 10-bit PWM
- Addressable Universal Synchronous/Asynchronous Receiver/Transmitter USART/SCI

Device	Program Memory	Data Memory		I/O	CCP (PWM)	USART	Comparators	Timers 8/16-bit
	FLASH (words)	SRAM (bytes)	EEPROM (bytes)					
PIC16F627A	1024	224	128	16	1	Y	2	2/1
PIC16F628A	2048	224	128	16	1	Y	2	2/1
PIC16F648A	4096	256	256	16	1	Y	2	2/1

PIC16F627A/628A/648A

1.0 GENERAL DESCRIPTION

The PIC16F627A/628A/648A are 18-Pin FLASH-based members of the versatile PIC16CXX family of low cost, high performance, CMOS, fully-static, 8-bit microcontrollers.

All PICmicro[®] microcontrollers employ an advanced RISC architecture. The PIC16F627A/628A/648A have enhanced core features, eight-level deep stack, and multiple internal and external interrupt sources. The separate instruction and data buses of the Harvard architecture allow a 14-bit wide instruction word with the separate 8-bit wide data. The two-stage instruction pipeline allows all instructions to execute in a single-cycle, except for program branches (which require two cycles). A total of 35 instructions (reduced instruction set) are available, complemented by a large register set.

PIC16F627A/628A/648A microcontrollers typically achieve a 2:1 code compression and a 4:1 speed improvement over other 8-bit microcontrollers in their class.

PIC16F627A/628A/648A devices have integrated features to reduce external components, thus reducing system cost, enhancing system reliability and reducing power consumption.

The PIC16F627A/628A/648A has 8 oscillator configurations. The single-pin RC oscillator provides a low cost solution. The LP oscillator minimizes power consumption, XT is a standard crystal, and INTOSC is a self-contained precision two-speed internal oscillator. The

HS is for High-Speed crystals. The EC mode is for an external clock source.

The SLEEP (Power-down) mode offers power savings. Users can wake-up the chip from SLEEP through several external interrupts, internal interrupts and RESETS.

A highly reliable Watchdog Timer with its own on-chip RC oscillator provides protection against software lock-up.

Table 1-1 shows the features of the PIC16F627A/628A/648A mid-range microcontroller families.

A simplified block diagram of the PIC16F627A/628A/648A is shown in Figure 3-1.

The PIC16F627A/628A/648A series fits in applications ranging from battery chargers to low power remote sensors. The FLASH technology makes customizing application programs (detection levels, pulse generation, timers, etc.) extremely fast and convenient. The small footprint packages makes this microcontroller series ideal for all applications with space limitations. Low cost, low power, high performance, ease of use and I/O flexibility make the PIC16F627A/628A/648A very versatile.

1.1 Development Support

The PIC16F627A/628A/648A family is supported by a full-featured macro assembler, a software simulator, an in-circuit emulator, a low cost in-circuit debugger, a low cost development programmer and a full-featured programmer. A Third Party "C" compiler support tool is also available.

TABLE 1-1: PIC16F627A/628A/648A FAMILY OF DEVICES

		PIC16F627A	PIC16F628A	PIC16F648A	PIC16LF627A	PIC16LF628A	PIC16LF648A
Clock	Maximum Frequency of Operation (MHz)	20	20	20	4	4	4
	FLASH Program Memory (words)	1024	2048	4096	1024	2048	4096
Memory	RAM Data Memory (bytes)	224	224	256	224	224	256
	EEPROM Data Memory (bytes)	128	128	256	128	128	256
	Timer module(s)	TMR0, TMR1, TMR2	TMR0, TMR1, TMR2	TMR0, TMR1, TMR2	TMR0, TMR1, TMR2	TMR0, TMR1, TMR2	TMR0, TMR1, TMR2
Peripherals	Comparator(s)	2	2	2	2	2	2
	Capture/Compare/PWM modules	1	1	1	1	1	1
	Serial Communications	USART	USART	USART	USART	USART	USART
	Internal Voltage Reference	Yes	Yes	Yes	Yes	Yes	Yes
Features	Interrupt Sources	10	10	10	10	10	10
	I/O Pins	16	16	16	16	16	16
	Voltage Range (Volts)	3.0-5.5	3.0-5.5	3.0-5.5	2.0-5.5	2.0-5.5	2.0-5.5
	Brown-out Reset	Yes	Yes	Yes	Yes	Yes	Yes
	Packages	18-pin DIP, SOIC, 20-pin SSOP, 28-pin QFN	18-pin DIP, SOIC, 20-pin SSOP, 28-pin QFN	18-pin DIP, SOIC, 20-pin SSOP, 28-pin QFN	18-pin DIP, SOIC, 20-pin SSOP, 28-pin QFN	18-pin DIP, SOIC, 20-pin SSOP, 28-pin QFN	18-pin DIP, SOIC, 20-pin SSOP, 28-pin QFN

All PICmicro[®] Family devices have Power-on Reset, selectable Watchdog Timer, selectable Code Protect and high I/O current capability. All PIC16F627A/628A/648A Family devices use serial programming with clock pin RB6 and data pin RB7.

PIC16F627A/628A/648A

2.0 PIC16F627A/628A/648A DEVICE VARIETIES

A variety of frequency ranges and packaging options are available. Depending on application and production requirements, the proper device option can be selected using the information in the PIC16F627A/628A/648A Product Identification System, at the end of this data sheet. When placing orders, please use this page of the data sheet to specify the correct part number.

2.1 FLASH Devices

FLASH devices can be erased and re-programmed electrically. This allows the same device to be used for prototype development, pilot programs and production.

A further advantage of the electrically erasable FLASH is that it can be erased and reprogrammed in-circuit, or by device programmers, such as Microchip's PICSTART[®] Plus, or PRO MATE[®] II programmers.

2.2 Quick-Turnaround-Production (QTP) Devices

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

2.3 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.



PIC18F2455/2550/4455/4550

Data Sheet

28/40/44-Pin, High-Performance,
Enhanced Flash, USB Microcontrollers
with nanoWatt Technology



MICROCHIP PIC18F2455/2550/4455/4550

28/40/44-Pin, High-Performance, Enhanced Flash, USB Microcontrollers with nanoWatt Technology

Universal Serial Bus Features:

- USB V2.0 Compliant
- Low Speed (1.5 Mb/s) and Full Speed (12 Mb/s)
- Supports Control, Interrupt, Isochronous and Bulk Transfers
- Supports up to 32 Endpoints (16 bidirectional)
- 1 Kbyte Dual Access RAM for USB
- On-Chip USB Transceiver with On-Chip Voltage Regulator
- Interface for Off-Chip USB Transceiver
- Streaming Parallel Port (SPP) for USB streaming transfers (40/44-pin devices only)

Power-Managed Modes:

- Run: CPU on, Peripherals on
- Idle: CPU off, Peripherals on
- Sleep: CPU off, Peripherals off
- Idle mode Currents Down to 5.8 μ A Typical
- Sleep mode Currents Down to 0.1 μ A Typical
- Timer1 Oscillator: 1.1 μ A Typical, 32 kHz, 2V
- Watchdog Timer: 2.1 μ A Typical
- Two-Speed Oscillator Start-up

Flexible Oscillator Structure:

- Four Crystal modes, including High-Precision PLL for USB
- Two External Clock modes, Up to 48 MHz
- Internal Oscillator Block:
 - 8 user-selectable frequencies, from 31 kHz to 8 MHz
 - User-tunable to compensate for frequency drift
- Secondary Oscillator using Timer1 @ 32 kHz
- Dual Oscillator Options allow Microcontroller and USB module to Run at Different Clock Speeds
- Fail-Safe Clock Monitor:
 - Allows for safe shutdown if any clock stops

Peripheral Highlights:

- High-Current Sink/Source: 25 mA/25 mA
- Three External Interrupts
- Four Timer modules (Timer0 to Timer3)
- Up to 2 Capture/Compare/PWM (CCP) modules:
 - Capture is 16-bit, max. resolution 5.2 ns ($T_{CY}/16$)
 - Compare is 16-bit, max. resolution 83.3 ns (T_{CY})
 - PWM output: PWM resolution is 1 to 10-bit
- Enhanced Capture/Compare/PWM (ECCP) module:
 - Multiple output modes
 - Selectable polarity
 - Programmable dead time
 - Auto-shutdown and auto-restart
- Enhanced USART module:
 - LIN bus support
- Master Synchronous Serial Port (MSSP) module Supporting 3-Wire SPI (all 4 modes) and I²C™ Master and Slave modes
- 10-Bit, Up to 13-Channel Analog-to-Digital Converter (A/D) module with Programmable Acquisition Time
- Dual Analog Comparators with Input Multiplexing

Special Microcontroller Features:

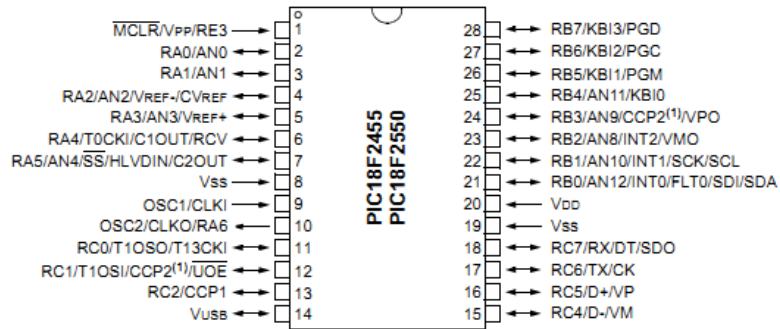
- C Compiler Optimized Architecture with Optional Extended Instruction Set
- 100,000 Erase/Write Cycle Enhanced Flash Program Memory Typical
- 1,000,000 Erase/Write Cycle Data EEPROM Memory Typical
- Flash/Data EEPROM Retention: > 40 Years
- Self-Programmable under Software Control
- Priority Levels for Interrupts
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT):
 - Programmable period from 41 ms to 131s
- Programmable Code Protection
- Single-Supply 5V In-Circuit Serial Programming™ (ICSP™) via Two Pins
- In-Circuit Debug (ICD) via Two Pins
- Optional Dedicated ICD/ICSP Port (44-pin, TQFP package only)
- Wide Operating Voltage Range (2.0V to 5.5V)

Device	Program Memory		Data Memory		I/O	10-Bit A/D (ch)	CCP/ECCP (PWM)	SPP	MSSP		EUSART	Comparators	Timers 8/16-Bit
	Flash (bytes)	# Single-Word Instructions	SRAM (bytes)	EEPROM (bytes)					SPI	Master I ² C™			
PIC18F2455	24K	12288	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F2550	32K	16384	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F4455	24K	12288	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3
PIC18F4550	32K	16384	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3

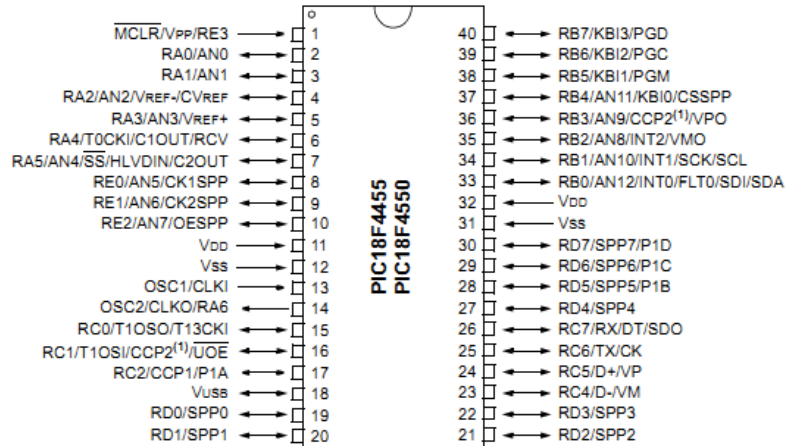
PIC18F2455/2550/4455/4550

Pin Diagrams

28-Pin PDIP, SOIC



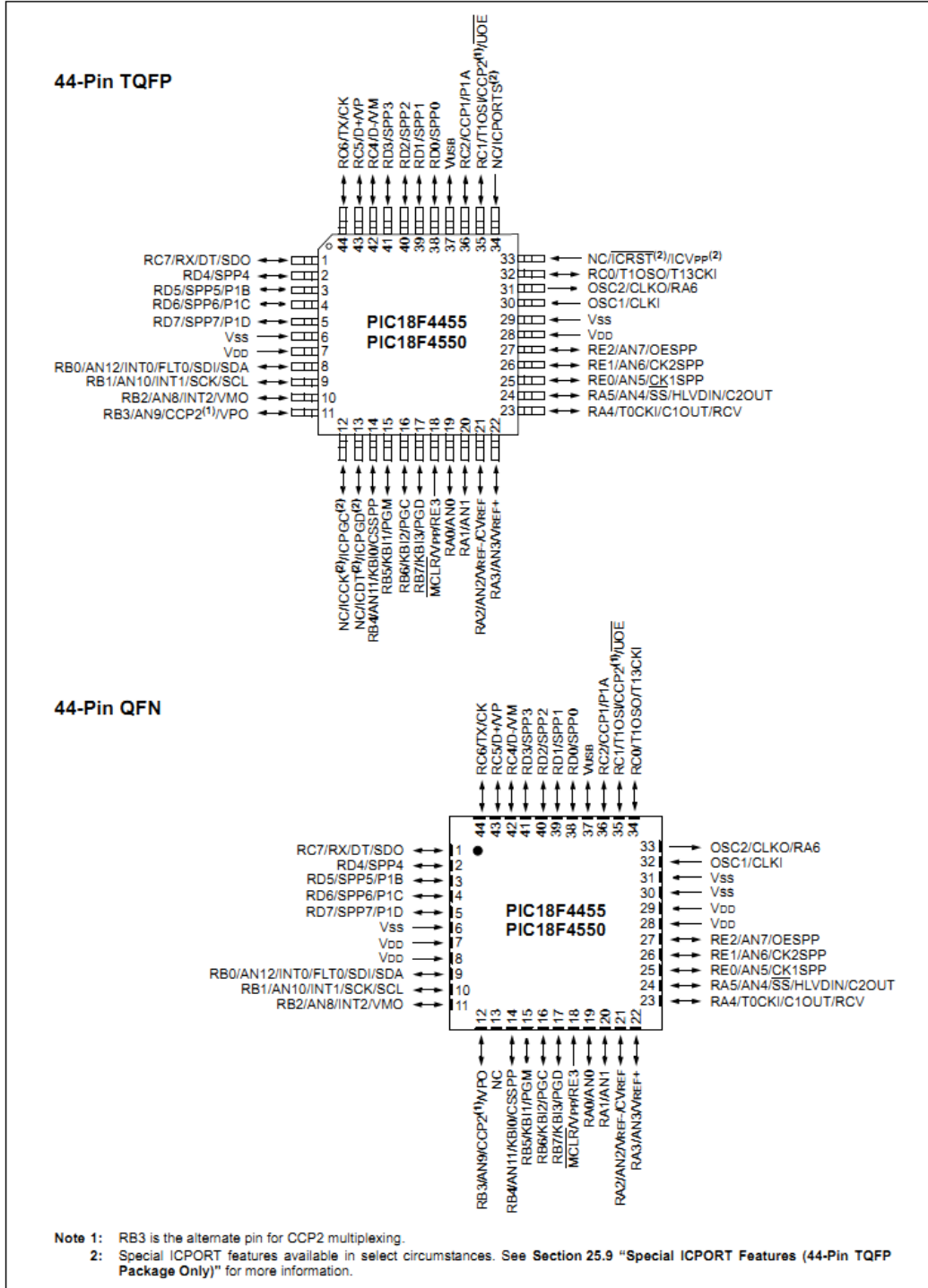
40-Pin PDIP



Note 1: RB3 is the alternate pin for CCP2 multiplexing.

PIC18F2455/2550/4455/4550

Pin Diagrams (Continued)



PIC18F2455/2550/4455/4550

1.0 DEVICE OVERVIEW

This document contains device-specific information for the following devices:

- PIC18F2455
- PIC18F2550
- PIC18F4455
- PIC18F4550
- PIC18LF2455
- PIC18LF2550
- PIC18LF4455
- PIC18LF4550

This family of devices offers the advantages of all PIC18 microcontrollers – namely, high computational performance at an economical price – with the addition of high-endurance, Enhanced Flash program memory. In addition to these features, the PIC18F2455/2550/4455/4550 family introduces design enhancements that make these microcontrollers a logical choice for many high-performance, power sensitive applications.

1.1 New Core Features

1.1.1 nanoWatt TECHNOLOGY

All of the devices in the PIC18F2455/2550/4455/4550 family incorporate a range of features that can significantly reduce power consumption during operation. Key items include:

- **Alternate Run Modes:** By clocking the controller from the Timer1 source or the internal oscillator block, power consumption during code execution can be reduced by as much as 90%.
- **Multiple Idle Modes:** The controller can also run with its CPU core disabled but the peripherals still active. In these states, power consumption can be reduced even further, to as little as 4%, of normal operation requirements.
- **On-the-Fly Mode Switching:** The power-managed modes are invoked by user code during operation, allowing the user to incorporate power-saving ideas into their application's software design.
- **Low Consumption in Key Modules:** The power requirements for both Timer1 and the Watchdog Timer are minimized. See **Section 28.0 "Electrical Characteristics"** for values.

1.1.2 UNIVERSAL SERIAL BUS (USB)

Devices in the PIC18F2455/2550/4455/4550 family incorporate a fully featured Universal Serial Bus communications module that is compliant with the USB Specification Revision 2.0. The module supports both low-speed and full-speed communication for all supported data transfer types. It also incorporates its own on-chip transceiver and 3.3V regulator and supports the use of external transceivers and voltage regulators.

1.1.3 MULTIPLE OSCILLATOR OPTIONS AND FEATURES

All of the devices in the PIC18F2455/2550/4455/4550 family offer twelve different oscillator options, allowing users a wide range of choices in developing application hardware. These include:

- Four Crystal modes using crystals or ceramic resonators.
- Four External Clock modes, offering the option of using two pins (oscillator input and a divide-by-4 clock output) or one pin (oscillator input, with the second pin reassigned as general I/O).
- An internal oscillator block which provides an 8 MHz clock ($\pm 2\%$ accuracy) and an INTRC source (approximately 31 kHz, stable over temperature and VDD), as well as a range of 6 user-selectable clock frequencies, between 125 kHz to 4 MHz, for a total of 8 clock frequencies. This option frees an oscillator pin for use as an additional general purpose I/O.
- A Phase Lock Loop (PLL) frequency multiplier, available to both the High-Speed Crystal and External Oscillator modes, which allows a wide range of clock speeds from 4 MHz to 48 MHz.
- Asynchronous dual clock operation, allowing the USB module to run from a high-frequency oscillator while the rest of the microcontroller is clocked from an internal low-power oscillator.

Besides its availability as a clock source, the internal oscillator block provides a stable reference source that gives the family additional features for robust operation:

- **Fail-Safe Clock Monitor:** This option constantly monitors the main clock source against a reference signal provided by the internal oscillator. If a clock failure occurs, the controller is switched to the internal oscillator block, allowing for continued low-speed operation or a safe application shutdown.
- **Two-Speed Start-up:** This option allows the internal oscillator to serve as the clock source from Power-on Reset, or wake-up from Sleep mode, until the primary clock source is available.

PIC18F2455/2550/4455/4550

1.2 Other Special Features

- **Memory Endurance:** The Enhanced Flash cells for both program memory and data EEPROM are rated to last for many thousands of erase/write cycles – up to 100,000 for program memory and 1,000,000 for EEPROM. Data retention without refresh is conservatively estimated to be greater than 40 years.
- **Self-Programmability:** These devices can write to their own program memory spaces under internal software control. By using a bootloader routine, located in the protected Boot Block at the top of program memory, it becomes possible to create an application that can update itself in the field.
- **Extended Instruction Set:** The PIC18F2455/2550/4455/4550 family introduces an optional extension to the PIC18 instruction set, which adds 8 new instructions and an Indexed Literal Offset Addressing mode. This extension, enabled as a device configuration option, has been specifically designed to optimize re-entrant application code originally developed in high-level languages such as C.
- **Enhanced CCP Module:** In PWM mode, this module provides 1, 2 or 4 modulated outputs for controlling half-bridge and full-bridge drivers. Other features include auto-shutdown for disabling PWM outputs on interrupt or other select conditions, and auto-restart to reactivate outputs once the condition has cleared.
- **Enhanced Addressable USART:** This serial communication module is capable of standard RS-232 operation and provides support for the LIN bus protocol. The TX/CK and RX/DT signals can be inverted, eliminating the need for inverting buffers. Other enhancements include Automatic Baud Rate Detection and a 16-bit Baud Rate Generator for improved resolution. When the microcontroller is using the internal oscillator block, the EUSART provides stable operation for applications that talk to the outside world without using an external crystal (or its accompanying power requirement).
- **10-Bit A/D Converter:** This module incorporates programmable acquisition time, allowing for a channel to be selected and a conversion to be initiated, without waiting for a sampling period and thus, reducing code overhead.
- **Dedicated ICD/ICSP Port:** These devices introduce the use of debugger and programming pins that are not multiplexed with other microcontroller features. Offered as an option in select packages, this feature allows users to develop I/O intensive applications while retaining the ability to program and debug in the circuit.

1.3 Details on Individual Family Members

Devices in the PIC18F2455/2550/4455/4550 family are available in 28-pin and 40/44-pin packages. Block diagrams for the two groups are shown in Figure 1-1 and Figure 1-2.

The devices are differentiated from each other in six ways:

1. Flash program memory (24 Kbytes for PIC18FX455 devices, 32 Kbytes for PIC18FX550 devices).
2. A/D channels (10 for 28-pin devices, 13 for 40/44-pin devices).
3. I/O ports (3 bidirectional ports and 1 input only port on 28-pin devices, 5 bidirectional ports on 40/44-pin devices).
4. CCP and Enhanced CCP implementation (28-pin devices have two standard CCP modules, 40/44-pin devices have one standard CCP module and one ECCP module).
5. Streaming Parallel Port (present only on 40/44-pin devices).

All other features for devices in this family are identical. These are summarized in Table 1-1.

The pinouts for all devices are listed in Table 1-2 and Table 1-3.

Like all Microchip PIC18 devices, members of the PIC18F2455/2550/4455/4550 family are available as both standard and low-voltage devices. Standard devices with Enhanced Flash memory, designated with an "F" in the part number (such as PIC18F2550), accommodate an operating V_{DD} range of 4.2V to 5.5V. Low-voltage parts, designated by "LF" (such as PIC18LF2550), function over an extended V_{DD} range of 2.0V to 5.5V.