W78C154

Winbond
Electronics Corp.

8-BIT MICROCONTROLLER

GENERAL DESCRIPTION

The W78C154 is an single-chip 8-bit microcontroller that is functionally compatible with the standard 80C52 microcontroller series. Like the W78C52, the W78C154 has the following features (except that it has 16K bytes of on-chip ROM, and P1.6 and P1.7 are open-drain output. *See Page 12 Application Note.*) 256 bytes of on-chip scratchpad RAM, four 8-bit bidirectional parallel ports, three 16-bit timer/counters, one full duplex serial port, a six-source two-level interrupt structure, an on-chip oscillator and clock circuitry.

The W78C154 microcontroller has two power reduction modes, idle mode and power-down mode, both of which are software selectable. The idle mode turns off the processor clock but allows for continued peripheral operation. The power-down mode stops the crystal oscillator for minimum power consumption. The external clock can be stopped at any time and in any state without affecting the processor.

FEATURES

- 8-bit CMOS microcontroller
- Fully static design
- Low standby current at full supply voltage
- DC-40 MHz operation
- 256 bytes of on-chip scratchpad RAM
- 16K bytes of on-chip mask ROM
- 64K bytes program memory address space
- 64K bytes data memory address space
- Four 8-bit bidirectional ports
- Additional open-drain output port pins: P1.6 and P1.7
- Three 16-bit timer/counters
- One full duplex serial port
- Boolean processor
- Six-source, two-level interrupt capability
- Built-in power management
- Code protection
- Packages:
  - DIP 40: W78C154-16/24/33/40
  - PLCC 44: W78C154P-16/24/33/40
  - QFP 44: W78C154F-16/24/33/40

9852354 0000729 105

Winbond Electronics Corp.

PIN CONFIGURATIONS

40-Pin DIP (W78C154)

T2, P1.0	1	40	VCC
T2EX, P1.1	2	39	P0.0, AD0
P1.2	3	38	P0.1, AD1
P1.3	4	37	P0.2, AD2
P1.4	5	36	P0.3, AD3
P1.5	6	35	P0.4, AD4
P1.6	7	34	P0.5, AD5
P1.7	8	33	P0.6, AD6
RST	9	32	P0.7, AD7
RXD, P3.0	10	31	$\overline{EA}$
TXD, P3.1	11	30	ALE
$\overline{INT0}$, P3.2	12	29	$\overline{PSEN}$
$\overline{INT1}$, P3.3	13	28	P2.7, A15
T0, P3.4	14	27	P2.6, A14
T1, P3.5	15	26	P2.5, A13
$\overline{WR}$, P3.6	16	25	P2.4, A12
$\overline{RD}$, P3.7	17	24	P2.3, A11
XTAL2	18	23	P2.2, A10
XTAL1	19	22	P2.1, A9
VSS	20	21	P2.0, A8

44-Pin PLCC (W78C154P)
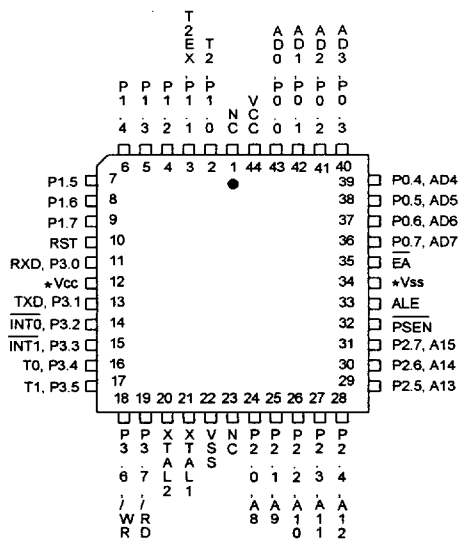
44-Pin QFP (W78C154F)

*It is recommended that connect Vcc to pin 12 and Vss to pin 34 in PLCC.
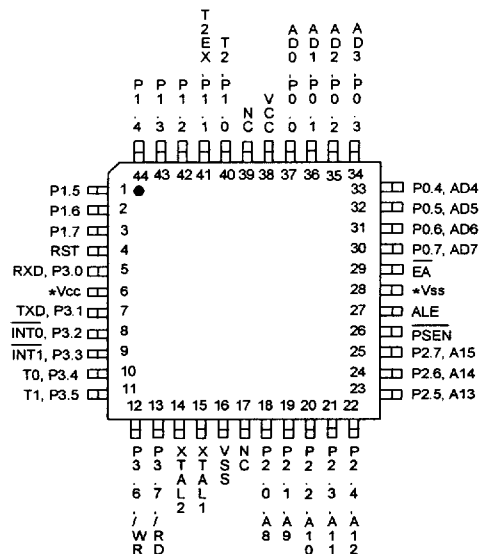
*It is recommended that connect Vcc to pin 6 and Vss to pin 28 in PQFP.

9852354 0000730 927

Winbond
Electronics Corp.

PIN DESCRIPTION

P0.0–P0.7

Port 0, Bits 0 through 7. Port 0 is a bidirectional I/O port. This port also provides a multiplexed low order address/data bus during accesses to external memory.

P1.0–P1.7

Port 1, Bits 0 through 7. Port 1 is a bidirectional I/O port. Pins P1.0 to P1.5 have internal pull-ups, while P1.6 and P1.7 are open-drain configured. External pull-ups 4.7K to 10K resistor are required for P1.6 and P1.7 while P1 is used as a output port. Pins P1.0 and P1.1 also serve as T2 (Timer 2 external input) and T2EX (Timer 2 capture/reload trigger), respectively.

P2.0–P2.7

Port 2, Bits 0 through 7. Port 2 is a bidirectional I/O port with internal pull-ups. This port also provides the upper address bits for accesses to external memory.

P3.0–P3.7

Port 3, Bits 0 through 7. Port 3 is a bidirectional I/O port with internal pull-ups. All bits have alternate functions, which are described below:

PIN	ALTERNATE FUNCTION
P3.0	RXD Serial Receive Data
P3.1	TXD Serial Transmit Data
P3.2	$\overline{\text{INT0}}$ External Interrupt 0
P3.3	$\overline{\text{INT1}}$ External Interrupt 1
P3.4	T0 Timer 0 Input
P3.5	T1 Timer 1 Input
P3.6	$\overline{\text{WR}}$ Data Write Strobe
P3.7	$\overline{\text{RD}}$ Data Read Strobe

$\overline{\text{EA}}$

External Address Input, active low. This pin forces the processor to execute out of external ROM. This pin should be kept low for all W78C32 operations.

RST

Reset Input, active high. This pin resets the processor. It must be kept high for at least two machine cycles in order to be recognized by the processor.

ALE

Address Latch Enable Output, active high. ALE is used to enable the address latch that separates the address from the data on Port 0. ALE runs at 1/6th of the oscillator frequency. A single ALE pulse is skipped during external data memory accesses. ALE goes to a high state during reset with a weak pull-up.

Winbond
Electronics Corp.

PSEN

Program Store Enable Output, active low. $\overline{PSEN}$ enables the external ROM onto the Port 0 address/data bus during fetch and MOVC operations. $\overline{PSEN}$ goes to a high impedance state during reset with a weak pull-up.

XTAL1

Crystal 1. This is the crystal oscillator input. This pin may be driven by an external clock.
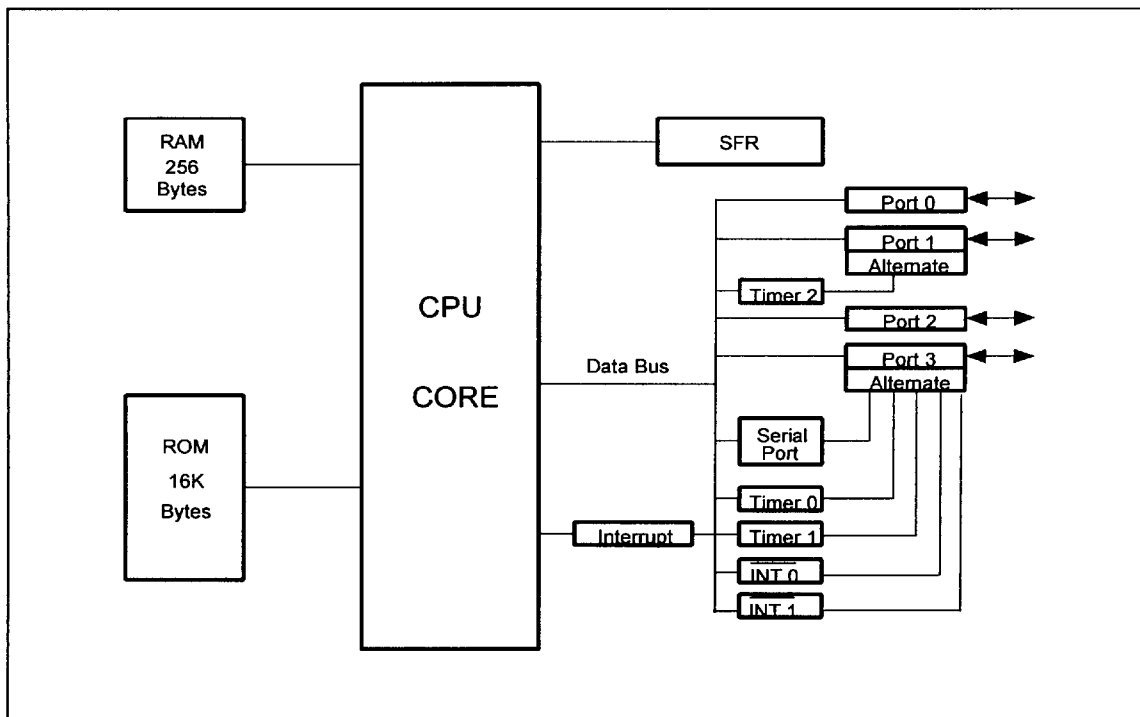
XTAL2

Crystal 2. This is the crystal oscillator output. It is the inversion of XTAL1.

Vss, Vcc

Power Supplies. These are the chip ground and positive supplies.

BLOCK DIAGRAM

Winbond
Electronics Corp.

FUNCTION DESCRIPTION

The W78C154 architecture consists of a core controller surrounded by various registers, four general purpose I/O ports, 256 bytes of RAM, three timer/counters, and a serial port. The processor supports 111 different opcodes and references both a 64K program address space and a 64K data storage space.

Timers 0, 1, and 2

Timers 0, 1, and 2 each consist of two 8-bit data registers. These are called TL0 and TH0 for Timer 0, TL1 and TH1 for Timer 1, and TL2 and TH2 for Timer 2. The TCON and TMOD registers provide control functions for timers 0, 1. The T2CON register provides control functions for Timer 2. RCAP2H and RCAP2L are used as reload/capture registers for Timer 2.

The operations of Timer 0 and Timer 1 are the same as in the W78C51. Timer 2 is a special feature of the W78C154: it is a 16-bit timer/counter that is configured and controlled by the T2CON register. Like Timers 0 and 1, Timer 2 can operate as either an external event counter or as an internal timer, depending on the setting of bit C/T2 in T2CON. Timer 2 has three operating modes: capture, auto-reload, and baud rate generator. The clock speed at capture or auto-reload mode is the same as that of Timers 0 and 1.

Clock

The W78C154 is designed to be used with either a crystal oscillator or an external clock. Internally, the clock is divided by two before it is used. This makes the W78C154 relatively insensitive to duty cycle variations in the clock.

Crystal Oscillator

The W78C154 incorporates a built-in crystal oscillator. To make the oscillator work, a crystal must be connected across pins XTAL1 and XTAL2. In addition, a load capacitor must be connected from each pin to ground, and a resistor must also be connected from XTAL1 to XTAL2 to provide a DC bias when the crystal frequency is above 24 MHz.

External Clock

An external clock should be connected to pin XTAL1. Pin XTAL2 should be left unconnected. The XTAL1 input is a CMOS-type input, as required by the crystal oscillator. As a result, the external clock signal should have an input one level of greater than 3.5 volts.

Power Management

Idle Mode

The idle mode is entered by setting the IDL bit in the PCON register. In the idle mode, the internal clock to the processor is stopped. The peripherals and the interrupt logic continue to be clocked. The processor will exit idle mode when either an interrupt or a reset occurs.

Power-down Mode

When the PD bit of the PCON register is set, the processor enters the power-down mode. In this mode all of the clocks, including the oscillator are stopped. The only way to exit power-down mode is by a reset.

Reset

9852354 0000733 636

Winbond Electronics Corp.

The external RESET signal is sampled at S5P2. To take effect, it must be held high for at least two machine cycles while the oscillator is running.

An internal trigger circuit in the reset line is used to deglitch the reset line when theW78C154 is used with an external RC network. The reset logic also has a special glitch removal circuit that ignores glitches on the reset line.

During reset, the ports are initialized to FFH, the stack pointer to 07H, PCON (with the exception of bit 4) to 00H, and all of the other SFR registers except SBUF to 00H. SBUF is not reset.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
DC Power Supply	V_{DD}–V_{SS}	-0.3	+7.0	V
Input Voltage	V_{IN}	V_{SS} -0.3	V_{DD} +0.3	V
Operating Temperature	T_A	0	70	°C
Storage Temperature	T_{ST}	-55	+150	°C

Note: Exposure to conditions beyond those listed under Absolute Maximum Ratings may adversely affect the life and reliability the device.

DC CHARACTERISTICS

V_{CC}–V_{SS} = 5V ±10%, T_A = 25° C, $F_{OSC.}$ = 20 MHz unless otherwise specified.

PARAMETER	SYM.	TEST CONDITIONS	SPECIFICATION		UNIT
			MIN.	MAX.	
Operating Voltage	V_{DD}		4.5	5.5	V
Operating Current	I_{DD}	No load V_{DD} = 5.5V	-	35	mA
Idle Current	I_{IDLE}	Idle mode V_{DD} = 5.5V .	-	7	mA
Power Down Current	I_{PWDN}	Power-down mode V_{DD} = 5.5V	-	50	µA
Input Low Voltage (except $\overline{EA}$, P1.6, P1.7)	V_{IL}		0	0.2 V_{DD} -0.1	V
Input Low Voltage $\overline{EA}$	V_{IL1}		0	0.2 V_{DD} -0.3	V
Input Low Voltage P1.6, P1.7	V_{IL2}		0	0.3 V_{DD}	V

■ 9852354 0000734 572 ■

Winbond
Electronics Corp.

DC Characteristics, continued

PARAMETER	SYM.	TEST CONDITIONS	SPECIFICATION		UNIT
			MIN.	MAX.	
Input High Voltage (except $\overline{EA}$, P1.6, P1.7)	VIH		0.2 VDD +0.9	VDD +0.2	V
Input High Voltage XTAL1, RST	VIH1		0.7 VDD	VDD +0.2	V
Input High Voltage P1.6, P1.7	VIH2		0.7 VDD	6.0	V
Output Low Voltage P1, P2, P3 (except P1.6, P1.7)	VOL	IOL = +1.6 mA	-	0.45	V
Output Low Voltage P0, ALE, $\overline{PESN}$	VOL1	IOL = +3.2 mA	-	0.45	V
Output Low Voltage P1.6, P1.7	VOL2	IOL = +3.0 mA	-	0.4	V
Output High Voltage P1, P2, P3, ALE, $\overline{PESN}$ (except P1.6, P1.7)	VOH	IOH = -60 μA	2.4	-	V
Output High Voltage P0 (in external bus mode)	VOH1	IOH = -800 μA	2.4	-	V
Logical 0 Input Current P1, P2, P3 (except P1.6, P1.7)	IIL1	VDD = 5.5V VIN = 0V	-75	-10	μA
Input Current RST [*1]	IIL2	VDD = 5.5V VIN = 5.5V	37	110	μA
Logical 1-to-0 Transition Current P1, P2, P3 [*2] (except P1.6, P1.7)	ITL	VDD = 5.5V VIN ≈ 2V [*2]	-650	-	μA
Input Leakage Current P0, $\overline{EA}$	IL1	VDD = 5.5V 0V < VIN < 5.5V	-10	10	μA
Input Leakage Current P1.6, P1.7	IL2	VDD = 5.5V 0V < VIN < 6.0V	-10	10	μA

Notes:.

*1. The RST pin has an internal pull-down resistor of about 50K to 150K.

*2. Pins of P1, P2 and P3 source a transition current when they are being externally driven from 1 to 0. The transition current reaches its maximum value when VI is approximately 2V.

9852354 0000735 409

Winbond
Electronics Corp.

AC CHARACTERISTICS

The AC specifications are a function of the particular process used to manufacture the part, the ratings of the I/O buffers, the capacitive load, and the internal routing capacitance. Most of the specifications can be expressed in terms of multiple input clock periods (TCP), and actual parts will usually experience less than a ±20 nS variation. The numbers below represent the performance expected from a 1.2 micron CMOS process when using 2 and 4 mA output buffers.

Clock Input Waveform
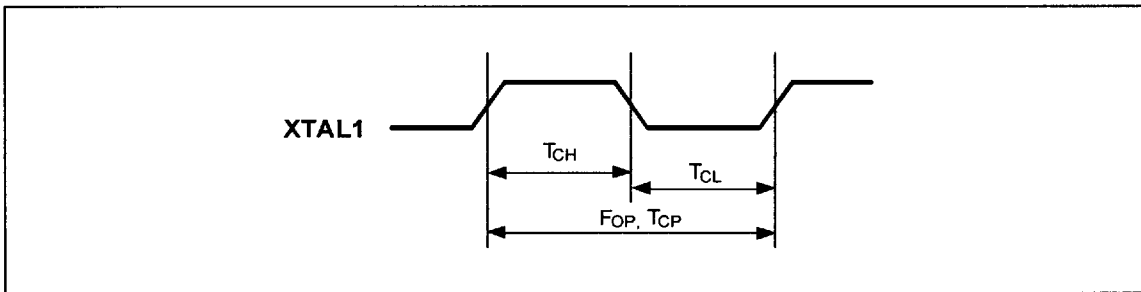
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	NOTES
Operating Speed	F_{OP}	0	-	40	MHz	1
Clock Period	T_{CP}	25	-	-	nS	2
Clock High	T_{CH}	10	-	-	nS	3
Clock Low	T_{CL}	10	-	-	nS	3

Notes:

1. The clock may be stopped indefinitely in either state.
2. The T_{CP} specification is used as a reference in other specifications.
3. There are no duty cycle requirements on the XTAL1 input.

Program Fetch Cycle

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	NOTES
Address Valid to ALE Low	T_{AAS}	1 T_{CP} -Δ	-	-	nS	4
Address Hold after ALE Low	T_{AAH}	1 T_{CP} -Δ	-	-	nS	1, 4
ALE Low to $\overline{PSEN}$ Low	T_{APL}	1 T_{CP} -Δ	-	-	nS	4
$\overline{PSEN}$ Low to Data Valid	T_{PDA}	-	-	2 T_{CP}	nS	2

Program Fetch Cycle, continued

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	NOTES
Data Hold after $\overline{PSEN}$ High	T_{PDH}	0	-	1 T_{CP}	nS	3
Data Float after $\overline{PSEN}$ High	T_{PDZ}	0	-	1 T_{CP}	nS	
ALE Pulse Width	T_{ALW}	2 T_{CP} -Δ	2 T_{CP}	-	nS	4
$\overline{PSEN}$ Pulse Width	T_{PSW}	3 T_{CP} -Δ	3 T_{CP}	-	nS	4

Notes:
1. P0.0–P0.7, P2.0–P2.7 remain stable throughout entire memory cycle.
2. Memory access time is 3 T_{CP}.
3. Data have been latched internally prior to $\overline{PSEN}$ going high.
4. "Δ" (due to buffer driving delay and wire loading) is 20 nS.

Data Read Cycle

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	NOTES
ALE Low to $\overline{RD}$ Low	T_{DAR}	3 T_{CP} -Δ	-	3 T_{CP} +Δ	nS	1, 2
$\overline{RD}$ Low to Data Valid	T_{DDA}	-	-	4 T_{CP}	nS	1
Data Hold after $\overline{RD}$ High	T_{DDH}	0	-	2 T_{CP}	nS	
Data Float after $\overline{RD}$ High	T_{DDZ}	0	-	2 T_{CP}	nS	
$\overline{RD}$ Pulse Width	T_{DRD}	6 T_{CP} -Δ	6 T_{CP}	-	nS	2

Notes:
1. Data memory access time is 8 T_{CP}.
2. "Δ" (due to buffer driving delay and wire loading) is 20 nS.

Data Write Cycle

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
ALE Low to $\overline{WR}$ Low	T_{DAW}	3 T_{CP} -Δ	-	3 T_{CP} +Δ	nS
Data Valid to $\overline{WR}$ Low	T_{DAD}	1 T_{CP} -Δ	-	-	nS
Data Hold from $\overline{WR}$ High	T_{DWD}	1 T_{CP} -Δ	-	-	nS
$\overline{WR}$ Pulse Width	T_{DWR}	6 T_{CP} -Δ	6 T_{CP}	-	nS

Note: "Δ" (due to buffer driving delay and wire loading) is 20 nS.

Port Access Cycle

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Port Input Setup to ALE Low	T_{PDS}	1 T_{CP}	-	-	nS
Port Input Hold from ALE Low	T_{PDH}	0	-	-	nS
Port Output to ALE	T_{PDA}	1 T_{CP}	-	-	nS

Note: Ports are read during S5P2, and output data becomes available at the end of S6P2. The timing data are referenced to ALE, since it provides a convenient reference.
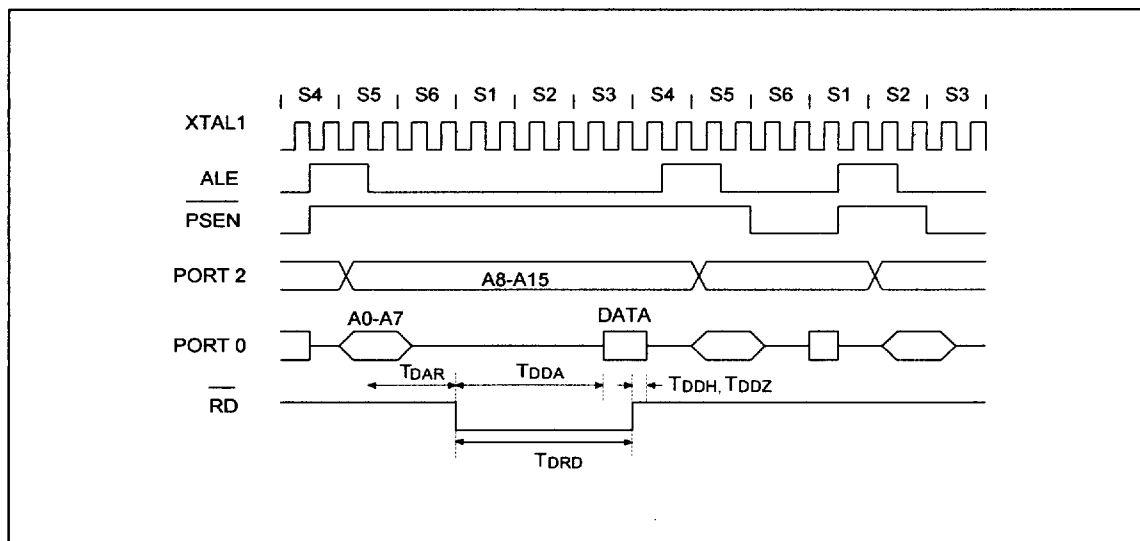
Winbond
Electronics Corp.

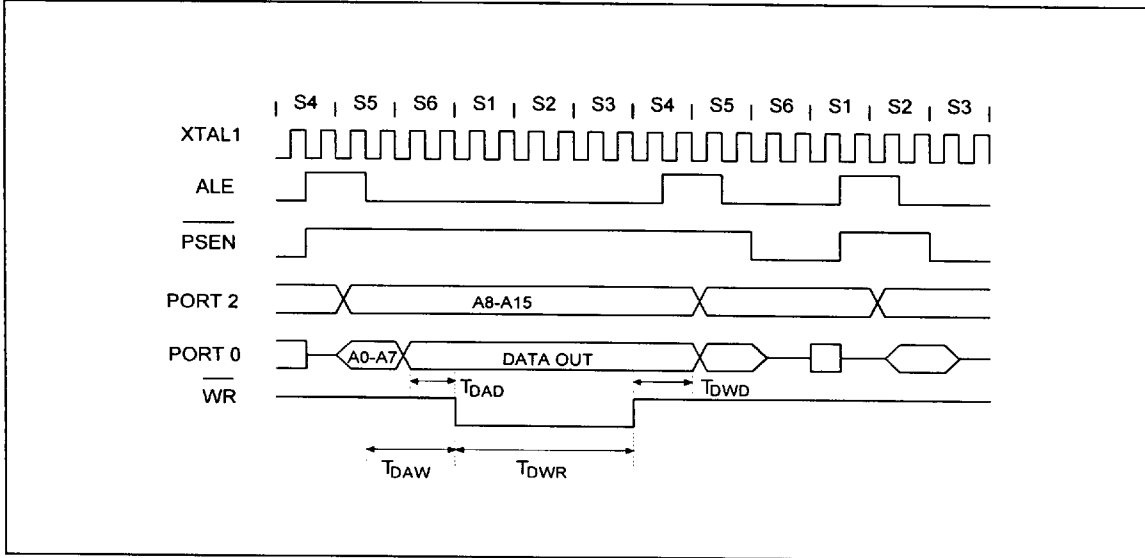## TIMING WAVEFORMS

Program Fetch Cycle

Data Read Cycle

9852354 0000738 118

Winbond
Electronics Corp.
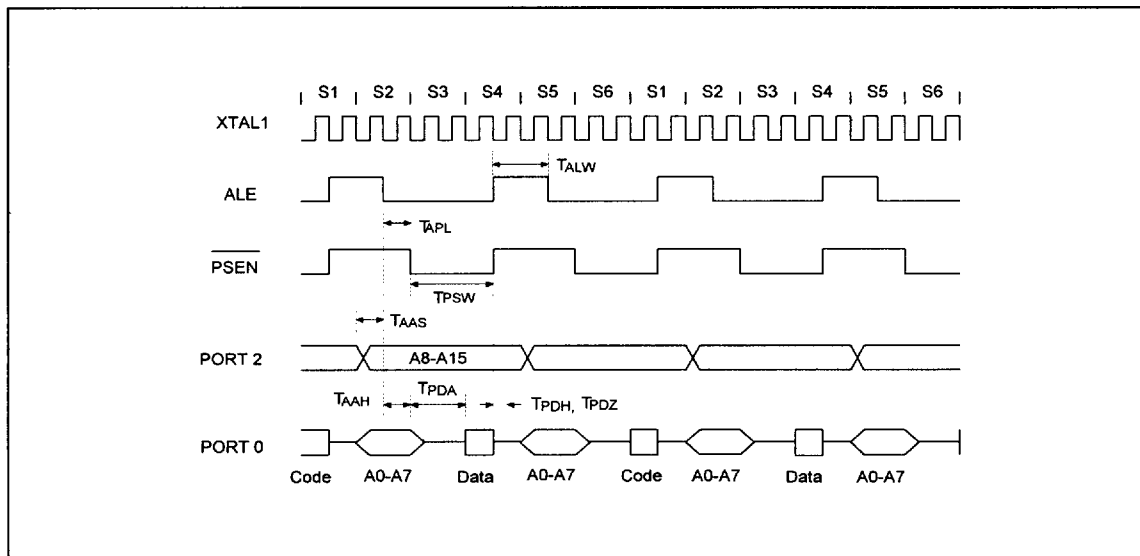
Timing Waveforms, continued

Data Write Cycle

Port Access Cycle

9852354 0000739 054

Winbond Electronics Corp.
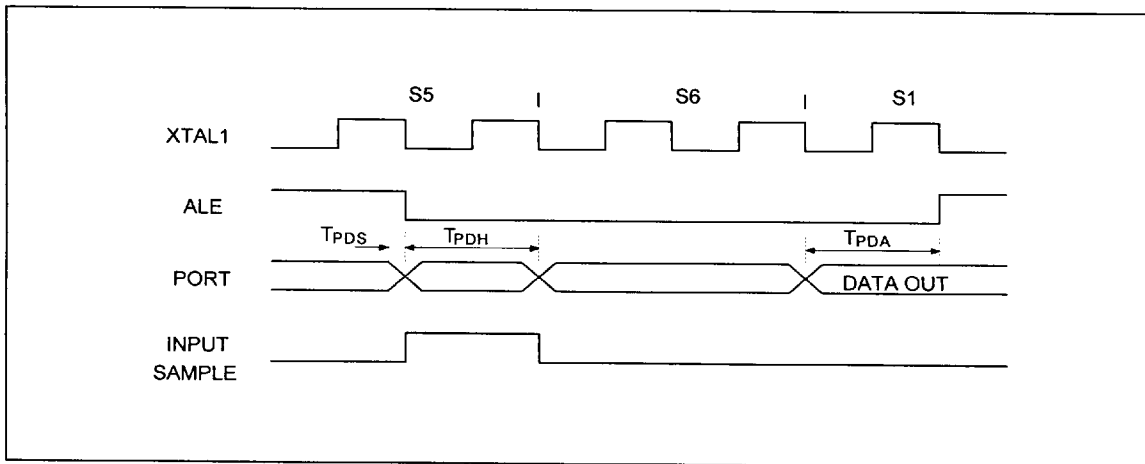
APPLICATION NOTE

1. Application

(1) It is recommanded to use port1.6 & port1.7 as an input port due to the port1.6 & port1.7 is an open drain.

(2) An approximate 4.7K to 10K pull-up resistor is required when port1.6 & port1.7 is used as output port.
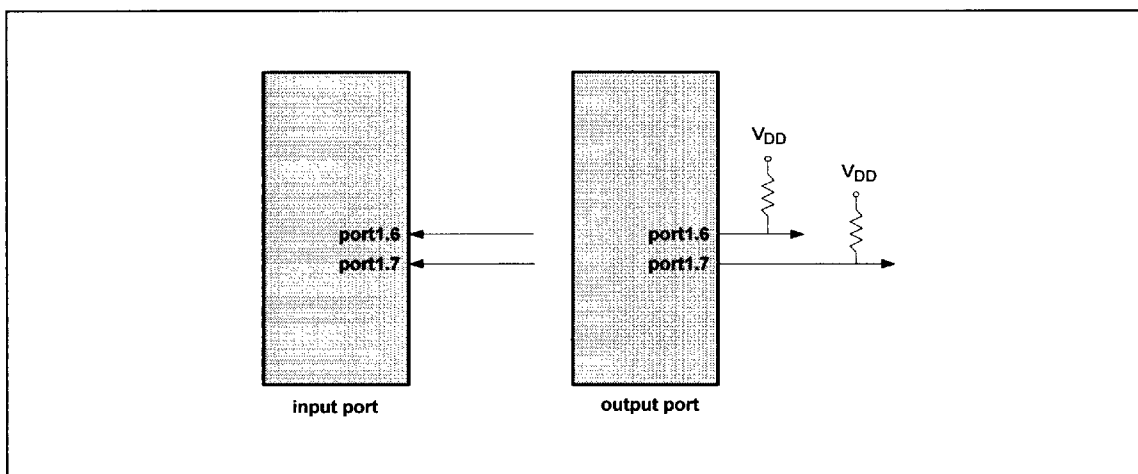
2. Verification & Emulation

(1) WHC8302 verification board (W78V58B on board) and W78958B emulation chip will check W78C154 except port1.6 & port1.7 as output mode.

W78V58B	Port1.6 & Port1.7	Pull-ups
W78V958B	Port1.6 & Port1.7	Pull-ups
W78C154	Port1.6 & Port1.7	Open Drain

(2) The specification of W78C154 is exclusive, therefore, the dc characteristics are not fully compatible with W78V58B and W78958B, however the function is still the same as W78V58B and W78958B.

TYPICAL APPLICATION CIRCUITS

Expanded External Program Memory and Crystal
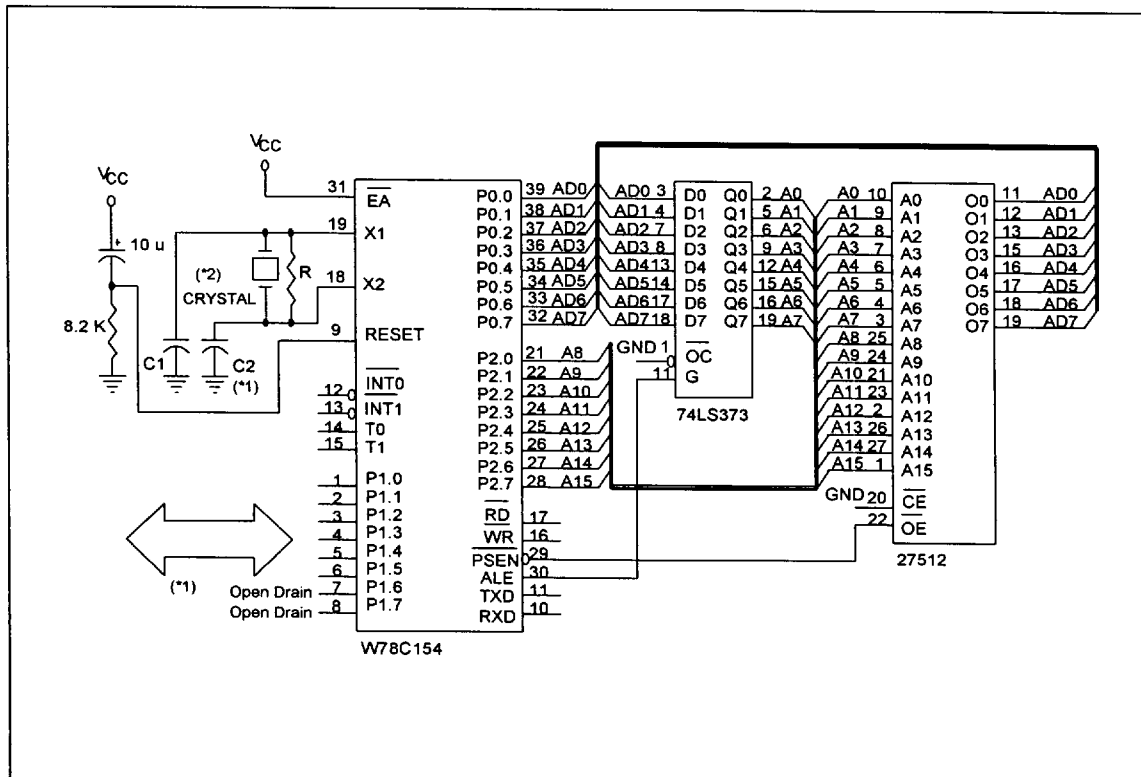
Figure A

CRYSTAL	C1	C2	R
16 MHz	30P	30P	–
24 MHz	15P	15P	–
33 MHz	10P	10P	6.8K
40 MHz	5P	5P	6.8K

Above table shows the reference values for crystal applications.
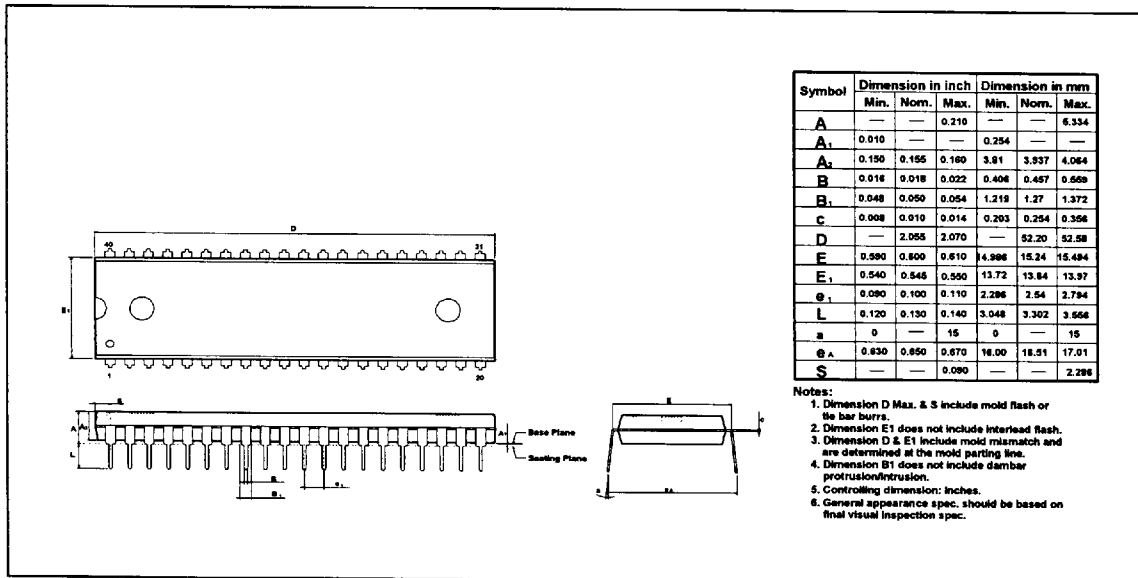
Notes:

1. C1, C2, R components refer to Figure A.

2. An approximately 4.7K to 10K pull-ups resistor is required for P1.6 and P1.7 when they are used as output port.

- 13 -

Typical Applicatin Circuits, continued

Expanded External Data Memory and Oscillator

Figure B

Winbond Electronics Corp.

PACKAGE DIMENSIONS

40-pin DIP

Symbol	Dimension in inch			Dimension in mm		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	—	—	0.210	—	—	5.334
A1	0.010	—	—	0.254	—	—
A2	0.150	0.155	0.160	3.81	3.937	4.064
B	0.016	0.018	0.022	0.406	0.457	0.559
B1	0.048	0.050	0.054	1.219	1.27	1.372
c	0.008	0.010	0.014	0.203	0.254	0.356
D	—	2.055	2.070	—	52.20	52.58
E	0.590	0.600	0.610	14.986	15.24	15.494
E1	0.540	0.545	0.550	13.72	13.84	13.97
e1	0.090	0.100	0.110	2.286	2.54	2.794
L	0.120	0.130	0.140	3.048	3.302	3.556
a	0	—	15	0	—	15
eA	0.630	0.650	0.670	16.00	16.51	17.01
S	—	—	0.090	—	—	2.286

Notes:
1. Dimension D Max. & S include mold flash or tie bar burrs.
2. Dimension E1 does not include interlead flash.
3. Dimension D & E1 include mold mismatch and are determined at the mold parting line.
4. Dimension B1 does not include dambar protrusion/intrusion.
5. Controlling dimension: inches.
6. General appearance spec. should be based on final visual inspection spec.

44-pin PLCC

Symbol	Dimension in inch			Dimension in mm		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	—	—	0.185	—	—	4.699
A1	0.020	—	—	0.508	—	—
A2	0.145	0.150	0.155	3.683	3.81	3.937
b1	0.026	0.028	0.032	0.66	0.711	0.813
b	0.016	0.018	0.022	0.406	0.457	0.559
c	0.008	0.010	0.014	0.203	0.254	0.356
D	0.648	0.653	0.658	16.46	16.59	16.71
E	0.648	0.653	0.658	16.46	16.59	16.71
e	0.050 BSC			1.27 BSC		
GD	0.590	0.610	0.630	14.99	15.49	16.00
GE	0.590	0.610	0.630	14.99	15.49	16.00
HD	0.680	0.690	0.700	17.27	17.53	17.78
HE	0.680	0.690	0.700	17.27	17.53	17.78
L	0.090	0.100	0.110	2.286	2.54	2.794
y	—	—	0.004	—	—	0.10

Notes:
1. Dimension D & E do not include interlead flash.
2. Dimension b1 does not include dambar protrusion/intrusion.
3. Controlling dimension: inches.
4. General appearance spec. should be based on final visual inspection spec.

9852354 0000743 585

Winbond
Electronics Corp.

Package Dimensions, continued

44-pin QFP
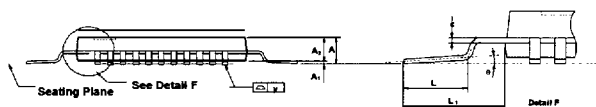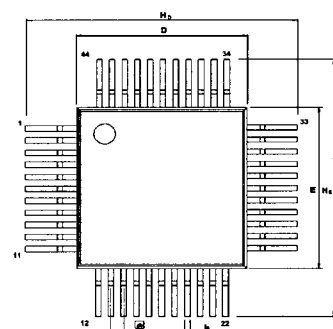
Symbol	Dimension in inch			Dimension in mm		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	—	—	—	—	—	—
A₁	0.002	0.01	0.02	0.05	0.25	0.5
A₂	0.075	0.081	0.087	1.90	2.05	2.20
b	0.01	0.014	0.018	0.25	0.35	0.45
c	0.004	0.006	0.010	0.101	0.152	0.254
D	0.390	0.394	0.398	9.9	10.00	10.1
E	0.390	0.394	0.398	9.9	10.00	10.1
e	0.025	0.031	0.036	0.635	0.80	0.952
H_D	0.510	0.520	0.530	12.95	13.2	13.45
H_E	0.510	0.520	0.530	12.95	13.2	13.45
L	0.025	0.031	0.037	0.65	0.8	0.95
L₁	0.051	0.063	0.075	1.295	1.6	1.905
y	—	—	0.003	—	—	0.08
θ	0°	—	7°	0°	—	7°

Notes:
1. Dimension D & E do not include interlead flash.
2. Dimension b does not include dambar protrusion/intrusion.
3. Controlling dimension: Millimeter
4. General appearance spec. should be based on final visual inspection spec.

Note: All data and specifications are subject to change without notice.

9852354 0000744 411