



TP2804

8051 MICROCONTROLLER WITH 64K FLASH AND ISP

General Description

The TP2804 is an 8-bit microcontroller which has an in-system programmable FLASH EPROM for firmware updated. Its instruction set is fully compatible with the standard 8051. It contains a 64K-byte FLASH EPROM, 512-byte on-chip RAM, four 8-bit bi-directional and bit-addressable I/O ports, an additional 4-bit I/O port, three 16-bit timer/counters and one serial port.

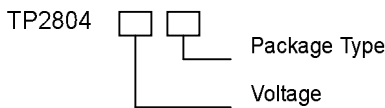
Applications

- LCD Monitor
- LCD TV

Features

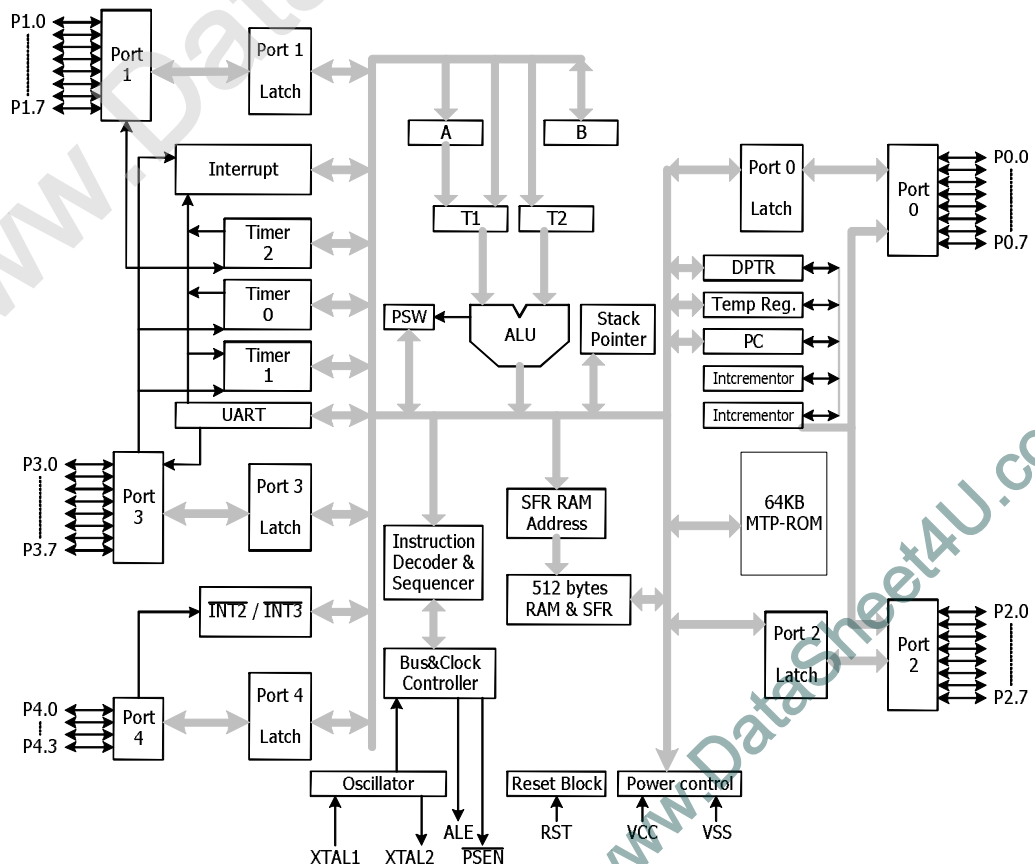
- Fully static design of 8-bit CMOS microcontroller
- Running clock up to 40MHz
- 64K-byte FLASH EPROM
- Low standby current at full supply voltage
- 512-byte on-chip RAM (including 256-byte AUX-RAM, software selectable)
- 64K-byte program memory address space and 64K-byte data memory address space
- Four 8-bit bi-directional ports
- One 4-bit multipurpose programmable port
- Three 16-bit timer/counters
- One full duplex serial port
- Eight-source and two-level interrupt capability
- Built-in power management
- Code protection
- Two voltage types: 3.3V and 5V
- Package Forms: DIP40, PLCC44 and PQFP44

Ordering Information



Voltage	L: 3.3V H: 5V
Package Type	P: DIP C: PLCC Q: PQFP

Block Diagram



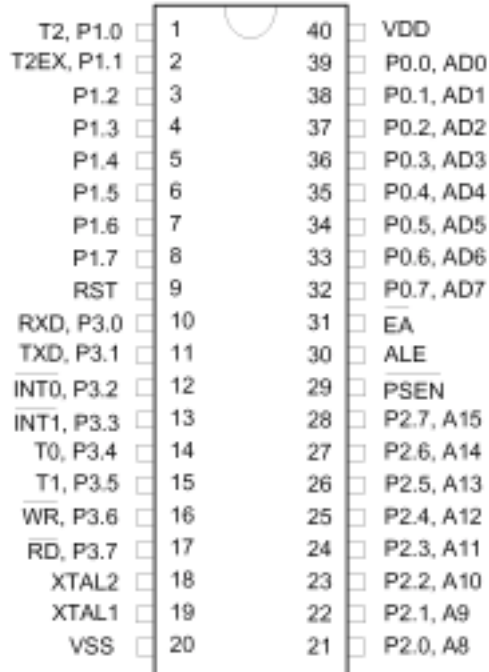


TP2804

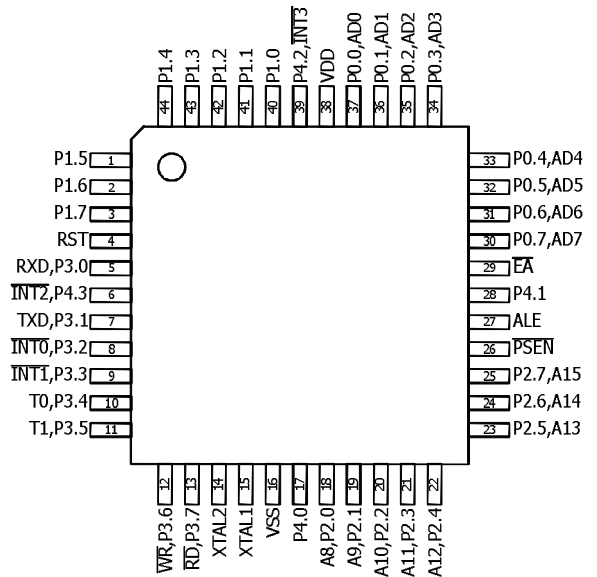
8051 MICROCONTROLLER WITH 64K FLASH AND ISP

Pin Configuration

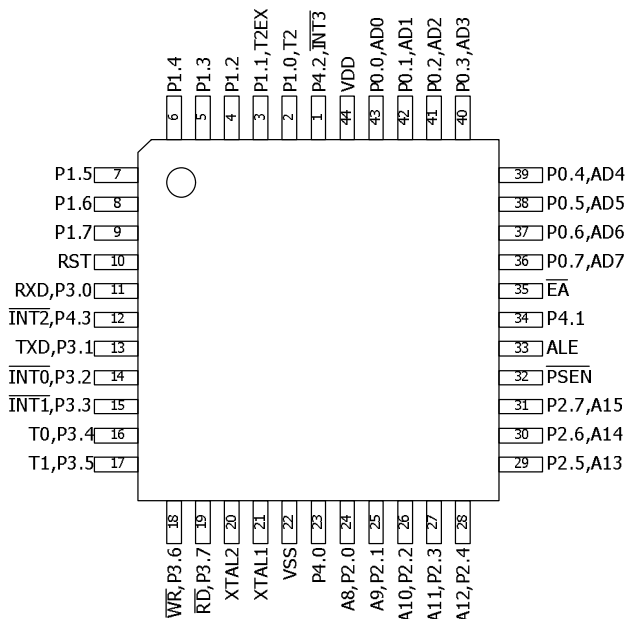
40-PIN DIP



44-PIN PQFP



44-PIN PLCC





Pin Description

Symbol	Type	Description
\overline{EA}	I	EXTERIAL ACCESS ENABLE: This pin should be forced to high level and the program counter is within the 64 KB area.
\overline{PSEN}	O/H	PROGRAM STORE ENABLE: When internal ROM access is performed, no \overline{PSEN} strobe signal output is originated from this pin.
ALE	O/H	ADDRESS LATCH ENABLE: ALE is used to enable the address latch that separates the address from the data on Port 0. ALE runs at 1/6 th of the oscillator frequency. An ALE pulse is omitted during external data memory accesses.
RST	I/L	RESET: A high on this pin for two machine cycles resets the device while the oscillator is running.
XTAL1	I	CRYSTAL 1: This is the crystal oscillator input. The pin may be driven by an external clock.
XTAL2	O	CRYSTAL 2: This is the crystal oscillator output. It is the inversion of XTAL1.
V_{SS}	I	GROUND: Ground potential.
V_{DD}	I	POWER SUPPLY: Supply voltage for operation.
P0.0 - P0.7	I/O/D	PORT 0: Function is the same as that of standard 8051.
P1.0 - P1.7	I/O/H	PORT 1: Function is the same as that of standard 8051.
P2.0 - P2.7	I/O/H	PORT 2: Function is the same as that of standard 8051.
P3.0 - P3.7	I/O/H	PORT 3: Function is the same as that of standard 8051.
P4.0 - P4.3	I/O/H	PORT 4: A bi-directional I/O port with internal pull-ups.

NOTES: TYPE I: input; O: output; I/O: bi-directional; H: pull-high; L: pull-low; D: open drain.

Functional Description

The TP2804 architecture consists of a core controller surrounded by various registers, four general-purpose I/O port, 512-byte RAM, three timer/counters, a serial port. Its processor supports 111 different opcodes and references, both 64K program address space and 64K data storage space.

RAM

The internal data RAM of TP2804 has 512 bytes and is divided into two banks: scratchpad 256-byte RAM and 256-byte AUX-RAM. These RAMs are addressed by different ways:

- RAM 00H-7FH can be addressed directly and indirectly as the same as in 8051. Address pointers are R0 and R1 of the selected register bank.
- RAM 80H-FFH can only be addressed indirectly as the same as in 8051. Address pointers are R0 and R1 of the selected registers bank.
- AUX-RAM 00H-FFH is addressed indirectly as the same way to access external data memory

with the MOVX instruction. Address pointers are R0 and R1 of the selected register bank and DPTR register. The AUX-RAM is disabled after a reset. Setting the bit 4 in CHPCON register will enable the access to on-chip AUX-RAM.

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 and 1. The T2CON register provides control functions for Timer 2. RCAP2H and RCAP2L are used as auto-reload or capture registers for Timer 2 as it in 8051.

The operations of Timer 0 and Timer 1 are the same as the standard 8051. Timer 2 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.



$\overline{INT2}$, $\overline{INT3}$

Two additional external interrupts, $\overline{INT2}$ and $\overline{INT3}$, whose functions are similar to those of external interrupt 0 and 1 in the XICON (External Interrupt Control) register. The XICON register is bit-addressable but is not a standard register in the standard 8051. Its address is at 0C0H. To set/clear bits in the XICON register, one can use the "SETB ($\overline{INT3}$) bit" instruction.

XICON – external interrupt control (C0H)

PX3	EX3	IE3	IT3	PX2	EX2	IE2	IT2
-----	-----	-----	-----	-----	-----	-----	-----

PX3: External interrupt 3 priority high if set.

EX3: External interrupt 3 enable if set.

IE3: If IT3 = 1, IE3 is set/cleared automatically by hardware when interrupt is detected/served.

IT3: External interrupt 3 is falling-edge/low-level triggered when this bit is set/cleared by software.

PX2: External interrupt 2 priority high if set.

EX2: External interrupt 2 enable if set.

IE2: If IT2 = 1, IE2 is set/cleared automatically by hardware when interrupt is detected/served.

IT2: External interrupt 2 is falling-edge/low-level triggered when this bit is set/cleared by software.

Eight-source Interrupt Information

Interrupt Source	Vector Address	Polling Sequence Within Priority Level	Enable Required Settings	Interrupt Type Edge/Level
External Interrupt 0	03H	0 (highest)	IE.0	TCON.0
Timer/Counter 0	0BH	1	IE.1	-
External Interrupt 1	13H	2	IE.2	TCON.2
Timer/Counter 1	1BH	3	IE.3	-
Serial Port	23H	4	IE.4	-
Timer/Counter 2	2BH	5	IE.5	-
External Interrupt 2	33H	6	XICON.2	XICON.0
External Interrupt 3	3BH	7 (lowest)	XICON.6	XICON.3

Watchdog Timer

The Watchdog timer is a free-running timer that can be programmed by the user to serve as a system monitor, a time-base generator or an event timer. It is basically a set of divider that divides the system clock and the divider output is selectable and determines the time-out interval for the time-out system monitor. This is important in the real-time control applications. In case of power glitches or electro-magnetic interference, the processor may begin to execute errant code. If this is left unchecked, the entire system may crash. The watchdog time-out selection will result in different time-out values depending on the clock speed, and the watchdog timer will be disabled on reset. In general, software should restart the watchdog timer to put it into a known state. The control bits that support the watchdog timer are discussed as follows:

NOTES:

- ENW: Enable watchdog if set.
- CLRW: Clear watchdog timer and prescaler if set. This flag will be cleared automatically.
- WIDL: If this bit is set, the watchdog is enabled under IDLE mode. If cleared, the watchdog is disabled under IDLE mode. Default is cleared.
- PS2, PS1, PS0: Watchdog prescaler timer select. Prescaler is selected when set PS2~0 as follows:

PS2	PS1	PS0	Prescaler Select
0	0	0	2
0	1	0	4
0	0	1	8
0	1	1	16
1	0	0	32
1	0	1	64
1	1	0	128
1	1	1	256

Watchdog Timer Control Register (8FH)

Bit	7	6	5	4	3	2	1	0
	ENW	CLRW	WIDL	-	-	PS2	PS1	PS0



Clock

The TP2804 should be used with either a crystal oscillator or an external clock. Internally, the clock is divided by twelve before it is used by default. This makes the TP2804 relatively insensitive to duty cycle variations in the clock.

Crystal Oscillator

The TP2804 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. Consequently, the external clock signal should have an input of one level greater than 3.5 volts.

Power Management

Idle Mode

By setting the IDL bit in the PCON register, the idle mode is set up. 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 in the PCON register is set, the processor enters the power-down mode. In this mode, all of the clocks are stopped including the oscillator. To exit from the power-down mode, it is by a hardware reset or external interrupts $\overline{INT0}$ to $\overline{INT3}$ when enabled and set to edge triggered.

Reset

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 the TP2804 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.



TP2804 Special Function Registers (SFRs) and Reset Values

F8									FF
F0	+B 00000000								F7
E8	ISP_CTRL 00000000	ISP_ADDR 00000000							EF
E0	+ACC 00000000								E7
D8	+P4 xxxx1111								DF
D0	+PSW 00000000								D7
C8	+T2CON 00000000		RCAP2L 00000000	RCAP2H 00000000	TL2 00000000	TH2 00000000			CF
C0	XICON 00000000								C7
B8	+IP 00000000							CHPCON 0xx00000	BF
B0	+P3 00000000								B7
A8	+IE 00000000								AF
A0	+P2 11111111								A7
98	+SCON 00000000	SBUF xxxxxxx							9F
90	+P1 11111111								97
88	+TCON 00000000	TMOD 00000000	TL0 00000000	TL1 00000000	TH0 00000000	TH1 00000000		WDTC 00000000	8F
80	+P0 11111111	SP 00000111	DPL 00000000	DPH 00000000				PCON 00110000	87

In-System Programming Control Register (CHPCON)

The TP2804 equips one main Flash EPROM bank of 64K bytes for application program, but it can be set for a maximum of 4K-byte loader program and 60K-byte application program. **The size of application program depends on the content (bit5~bit7) of address FFFFh in the 64K bytes. If one unit is 512 bytes, user can set for eight different units (000~111). For example, if the data of address FFFFh is 000XXXXb, the application program range is from address 0000h to EFFFh and loader program range is from address F000h to FFFFh. If the data of address FFFFh is**

001XXXXb, the application program range is from address 0000h to F1FFh and loader program range is from address F200h to FFFFh and so on. User can enter ISP mode with two different ways. One is by software, for example, using "JMP F000h" to loader program address. The other is by hardware. In the normal operation, the microcontroller executes the code in the 64K bytes. If the content of application program needs to be modified, the TP2804 allows user to activate the In-System Programming (ISP) mode by setting the CHPCON register.

CHPCON (BFH)

Bit	Name	Function
7	SWRESET	When this bit is and FPROGEN are set to 1, it will enforce microcontroller reset to initial condition just like power on rest.
6	-	Reserve.
5	-	Reserve.
4	ENAUSTRAM	1: Enable on-chip AUX-RAM. 0: Disable the on-chip AUX-RAM
3	-	Reserve
2	0	Must set to 0.
1	0	Must set to 0
0	FPROGEN	FLASH EPROM Programming Enable. = 1: enable. The microcontroller enter the in-system programming mode. = 0: disable. The on-chip flash memory is read-only. In-system programmability is disabled.

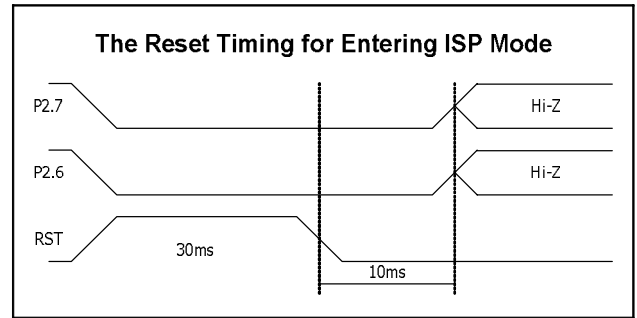


TP2804

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ISP_CTRL(E8H)

Bit	Name	Function
7	ISP_EN	1:ISP enable
6	-	Reserve.
5	-	Reserve.
4	1	Must 1
3	0	Must 0
2	ERASE	Erase bit
1	Write	Program write into AUX RAM
0	READ	Read program from AUX RAM



ISP_ADDR(E9H)

Bit	Name	Function
7	ADD7	Address bit 7
6	ADD6	Address bit 6
5	ADD5	Address bit 5
4	ADD4	Address bit 4
3	ADD3	Address bit 3
2	ADD2	Address bit 2
1	ADD1	Address bit 1
0	ADD0	Address bit 0

Hardware Enter ISP MODE

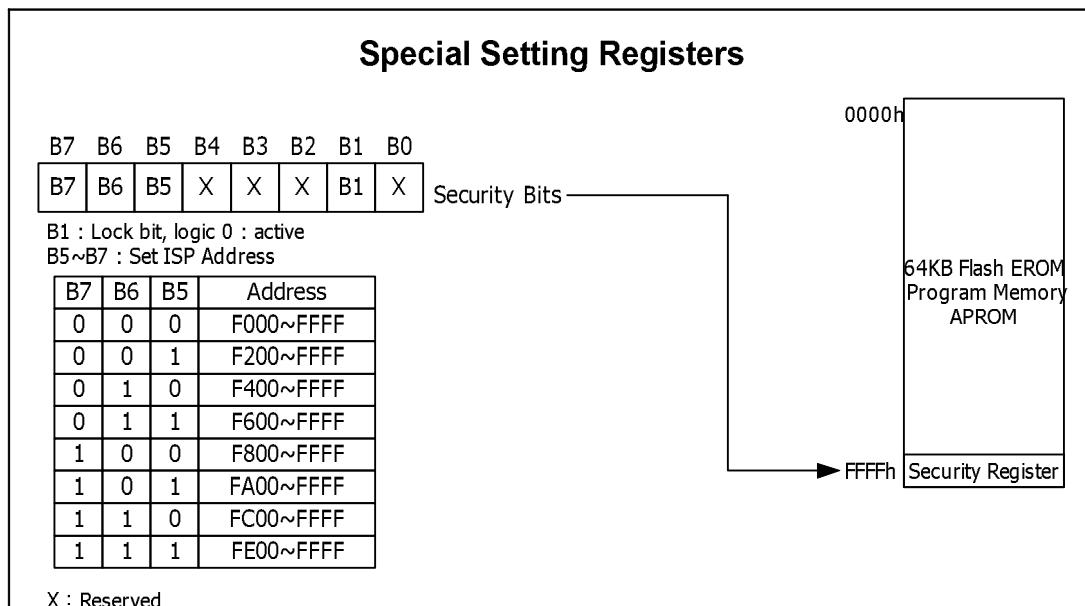
When the reset pin of TP2804 is at high level and any of the two conditions described below is fit in.

P4.3	P2.7	P2.6	Mode
X	L	L	ISP
L	X	X	ISP

Security

During the on-chip FLASH EPROM programming mode, the FLASH EPROM can be programmed and verified repeatedly. Until the code inside the FLASH EPROM is confirmed OK, the code can be protected. The protection of FLASH EPROM and those operations on it are described below.

The TP2804 has several Special Setting Registers, including the Security Register that cannot be programmed from low to high. They can only be reset through erases-all operation.



Lock bit

This bit is used to protect the customer's program code in the TP2804. It may be set after the programmer finishes the programming and verifies the sequence.

Once this bit is set to logic 0, both the Flash EROM data and Setting Registers cannot be accessed again.



Absolute Maximum Ratings

($V_{DD}-V_{SS} = 5V \pm 10\%$ for TP2804H, $V_{DD}-V_{SS} = 3.3V \pm 10\%$ for TP2804L)

Parameter	Symbol	Min	Max	Unit
DC Power Supply	$V_{DD}-V_{SS}$	-0.3	$V_{DD}+1$	V
Input Voltage	V_{IN}	$V_{SS}-0.3$	$V_{DD}+0.3$	V
Operation 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 of the device.

DC Electrical Characteristics

($V_{DD}-V_{SS} = 5V \pm 10\%$ for TP2804H, $V_{DD}-V_{SS} = 3.3V \pm 10\%$ for TP2804L, $T_A = 25^\circ\text{C}$, $F_{osc} = 12\text{MHz}$, unless otherwise specified)

Parameter	Symbol	Min	Max	Unit	Test Condition
Operating Voltage	V_{DD}	$0.9 V_{DD}$	$1.1 V_{DD}$	V	RST = 1, P0 = V_{DD}
Operating Current	I_{DD}	-	20/8	mA	No load, $V_{DD} = 5V/3.3V$
Idle Current	I_{IDLE}	-	6/3	mA	Idle mode, $V_{DD} = 5V/3.3V$
Power Down Current	I_{PWDN}	-	100	μA	Power-down mode, $V_{DD} = 5V/3.3V$
Input Current P1, P2, P3, P4	I_{IN1}	-50	+10	μA	$V_{IN} = 0V$ or V_{DD}
Input Current RST	I_{IN2}	-10	+300	μA	$0 < V_{IN} < V_{DD}$
Input Low Voltage P0, P1, P3, P4, \overline{EA}	V_{IL1}	0	$0.2V_{DD}-0.2$	V	V_{DD}
Input Low Voltage RST	V_{IL2}	0	$0.2V_{DD}-0.2$	V	V_{DD}
Input Low Voltage XTAL1 ^(*4)	V_{IL3}	0	$0.2V_{DD}-0.3$	V	V_{DD}
Output Low Voltage P1, P2, P3, P4, \overline{EA}	V_{IH1}	3.5/2.6	$V_{DD}+0.2$	V	$V_{DD} = 5.5V/3.3V$
Input High Voltage RST	V_{IH2}	3.5/2.6	$V_{DD}+0.2$	V	$V_{DD} = 5.5V/3.3V$
Input High Voltage XTAL1 ^(*4)	V_{IH3}	3.5/2.6	$V_{DD}+0.2$	V	$V_{DD} = 5.5V/3.3V$
Output Low Voltage P1, P2, P3, P4	V_{OL1}	-	0.45	V	$V_{DD} = 5V/3.3V$ $I_{OL} = +2\text{mA}$
Output Low Voltage P0, ALE, PSEN ^(*3)	V_{OL2}	-	0.45	V	$V_{DD} = 5V/3.3V$, $I_{OL} = +4\text{mA}$
Sink Current P1, P3, P4	I_{SK1}	-	8/6	mA	$V_{DD} = 5V/3.3V$, $V_{IN} = -0.45V$
Sink Current P0, P2, ALE, PSEN	I_{SK2}	-	8/6	mA	$V_{DD} = 5V/3.3V$, $V_{IN} = 0.45V$
Output Low Voltage P1, P2, P3, P4	V_{OH1}	2.4/2.0	-	V	$V_{DD} = 5V/3.3V$
Output High Voltage P0, ALE, PSEN ^(*3)	V_{OH2}	2.4/2.0	-	V	$V_{DD} = 5V/3.3V$
Source Current P0, P2, P3, P4	I_{S1}	-120/-80	-200/-120	μA	$V_{DD} = 5V/3.3V$, $V_{IN} = 2.4V$

NOTES:

- RST pin is an Schmitt trigger input.
- P0, ALE and /PSEN are tested in the external access mode.
- *3. XTAL1 is a CMOS input.
- *4. Pins of P1, P2, P3 and P4 can source a transition current when they are being externally driven 1 to 0. The transition current reaches its maximum value when V_{IN} approximates to 2V.



AC Electrical Characteristics

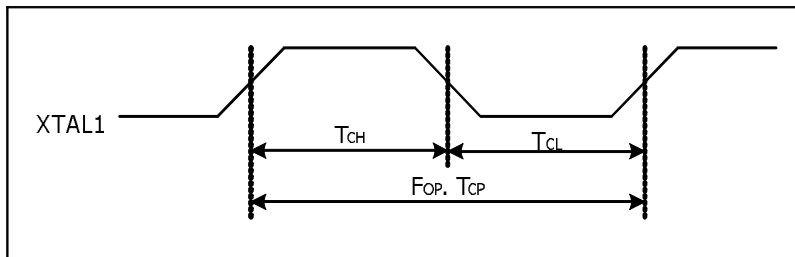
The AC specifications are a function of the particular process used to manufacture the part, the ratings of the I/O buffers, the capacitive load, and the internal routing capacitance. Most of the specifications can be expressed in terms of multiple input clock periods (T_{CP}), and actual parts will usually experience less than a ± 20 nS variation. The numbers below represent the performance expected from a 0.6 micron CMOS process when using 2 and 4 mA output buffers.

Parameter	Symbol	Min	Max	Unit	Test Conditions
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 XTAL 1 input.

Clock Input Waveform



Data Read Cycle

Parameter	Symbol	Min.	Typ.	Max.	Unit	Notes
ALE Low to /RD Low	T_{DAR}	$3 T_{CP} - \Delta$	-	$-3 T_{CP} + \Delta$	nS	1, 2
/RD Low to Data Valid	T_{DDA}	-	-	$4 T_{CP}$	nS	1
Data Hold from /RD High	T_{DDH}	0	-	$2 T_{CP}$	nS	
Data Float from /RD High	T_{DDZ}	0	-	$2 T_{CP}$	nS	
/RD Pulse Width	T_{DRD}	$6 T_{CP} - \Delta$	$6 T_{CP}$	-	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 /WR Low	T_{DAW}	$3 T_{CP} - \Delta$	-	$3 T_{CP}$	nS
Data Valid to /WR Low	T_{DAD}	$1 T_{CP} - \Delta$	-	-	nS
Data Hold from /WR High	T_{DWD}	$1 T_{CP} - \Delta$	-	-	nS
/WR Pulse Width	T_{DWR}	$6 T_{CP} - \Delta$	$6 T_{CP}$	-	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

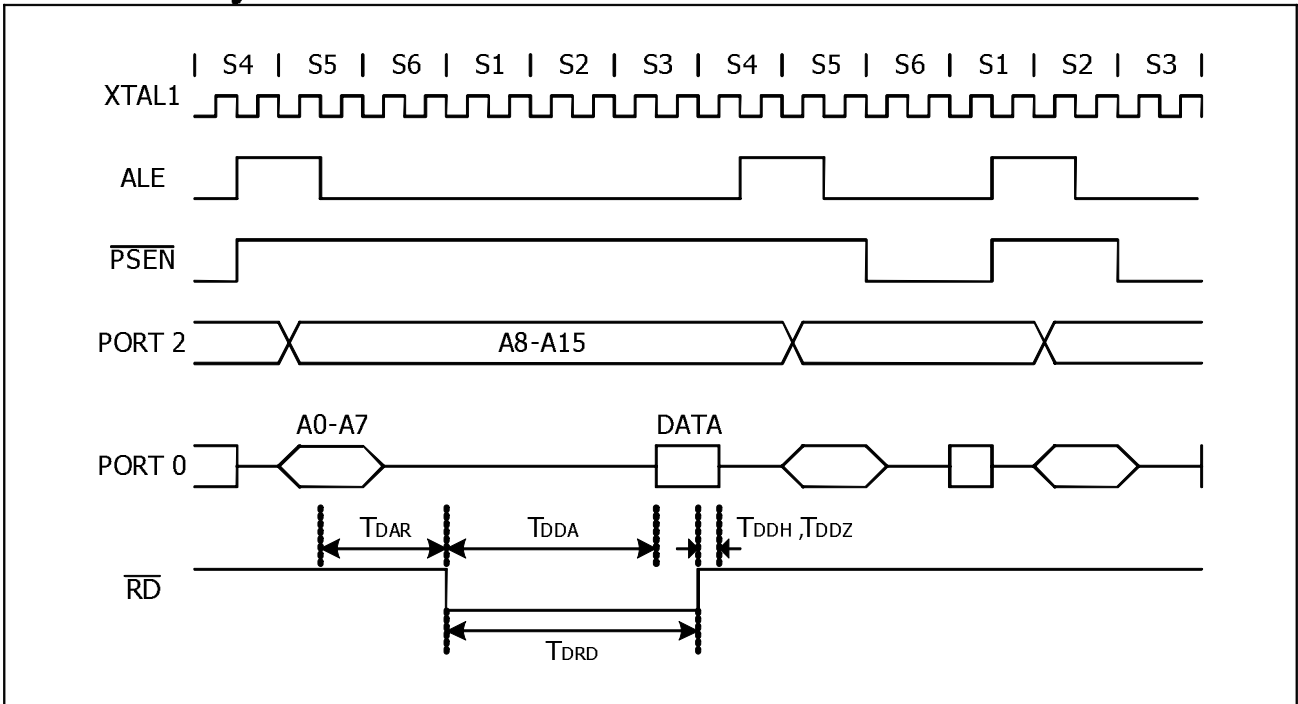
NOTES:

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

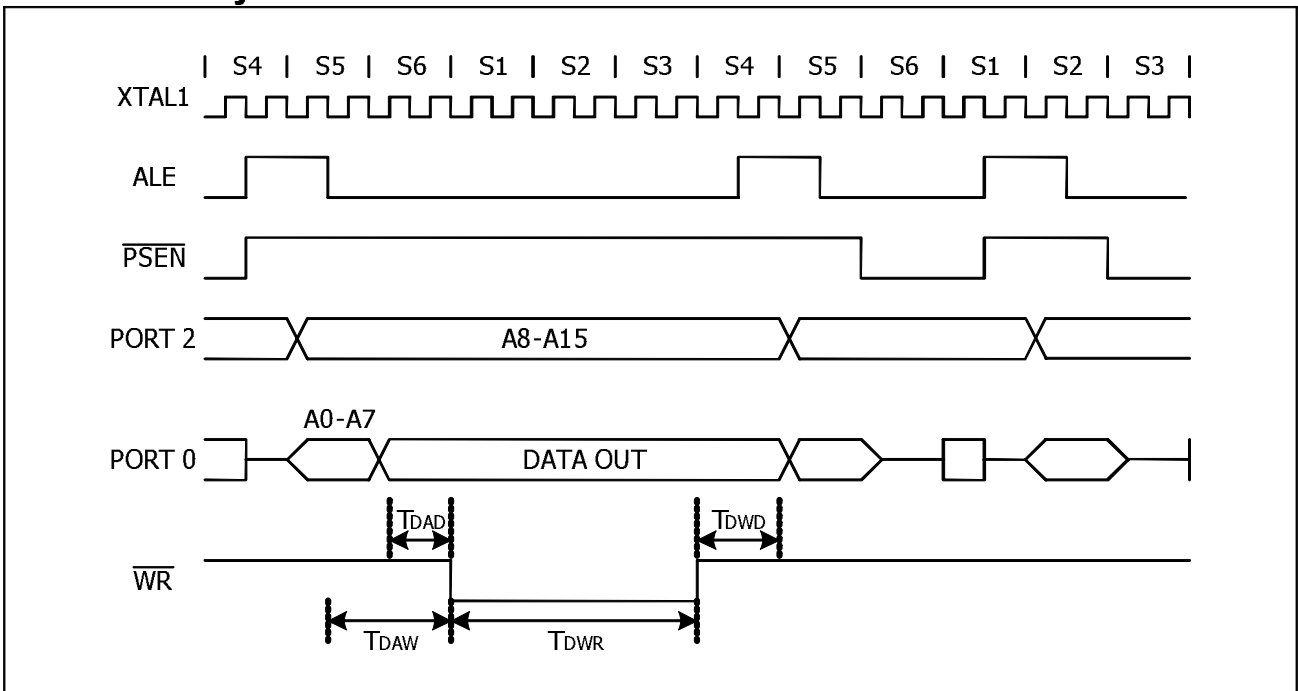


Timing Waveforms

1. Data Read Cycle



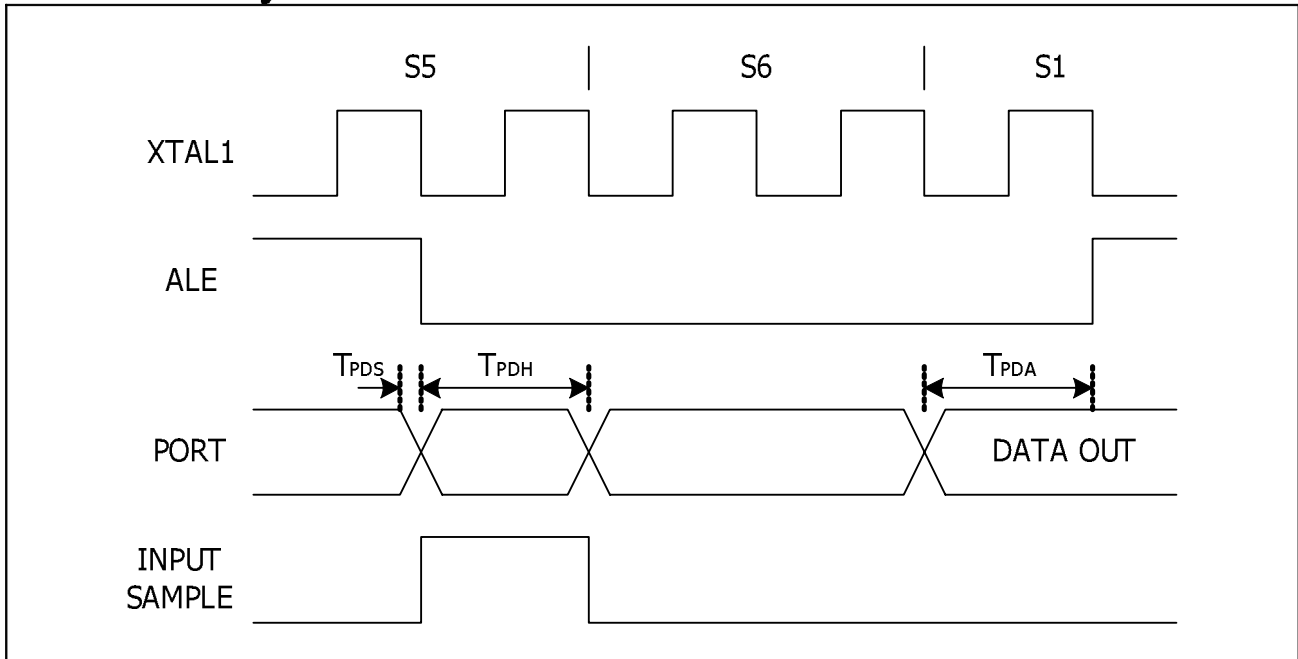
2. Data Write Cycle





Timing Waveforms (continued)

3. Port Access Cycle





Application Diagrams

1. Internal Program, Memory and Crystal

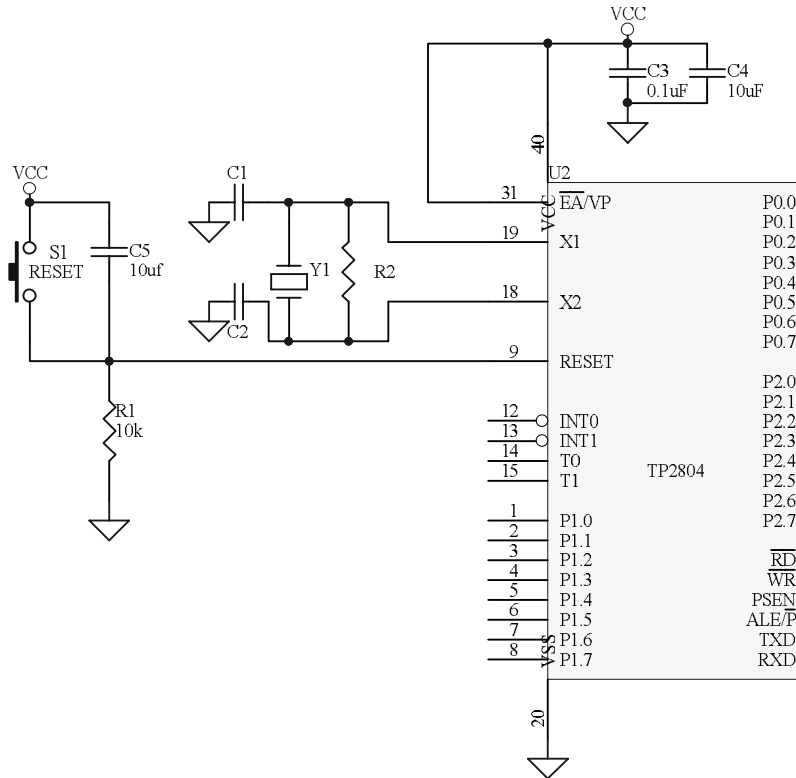


Figure A

CRYSTAL	C1	C2	R2
6MHz	47P	47P	-
16MHz	30P	30P	-
24MHz	15P	15P	-
32MHz	10P	10P	6.8K
40MHz	5P	5P	4.7K

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



TP2804

8051 MICROCONTROLLER WITH 64K FLASH AND ISP

2. Expanded External Program and Data Memory and Oscillator

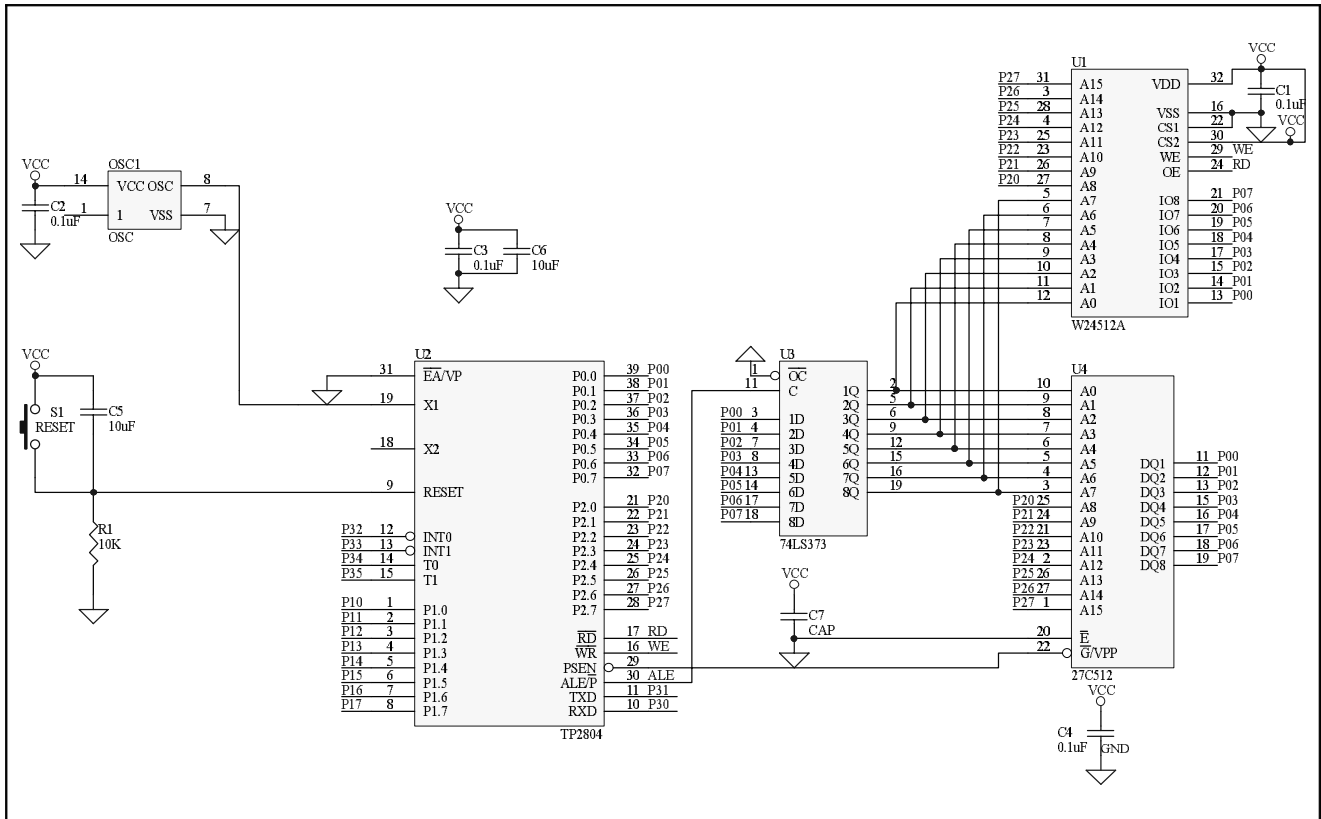
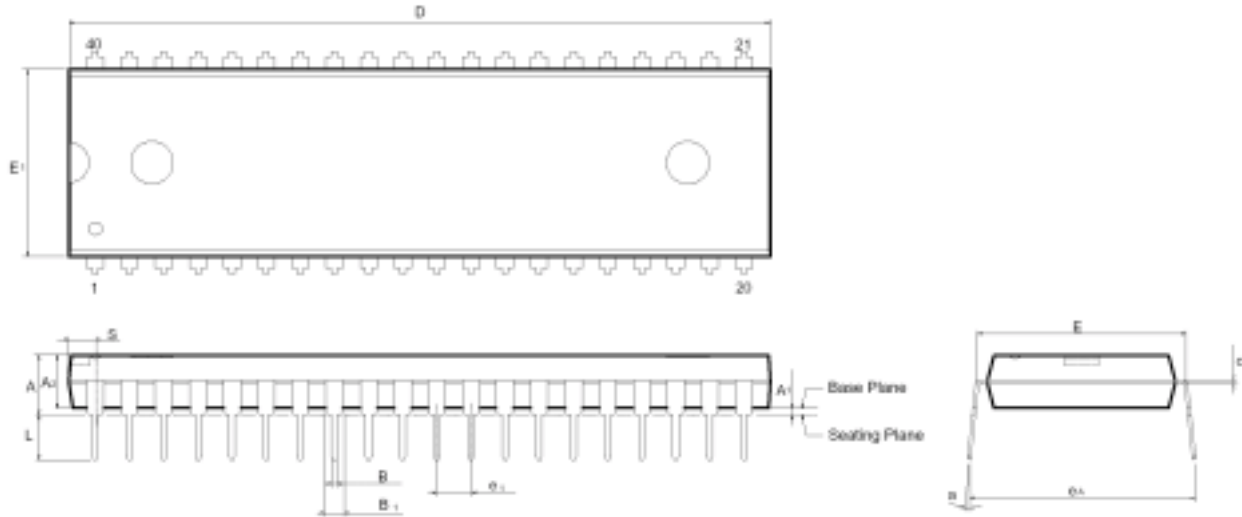


Figure B



Package Information

40-pin DIP



Unit: Millimeter

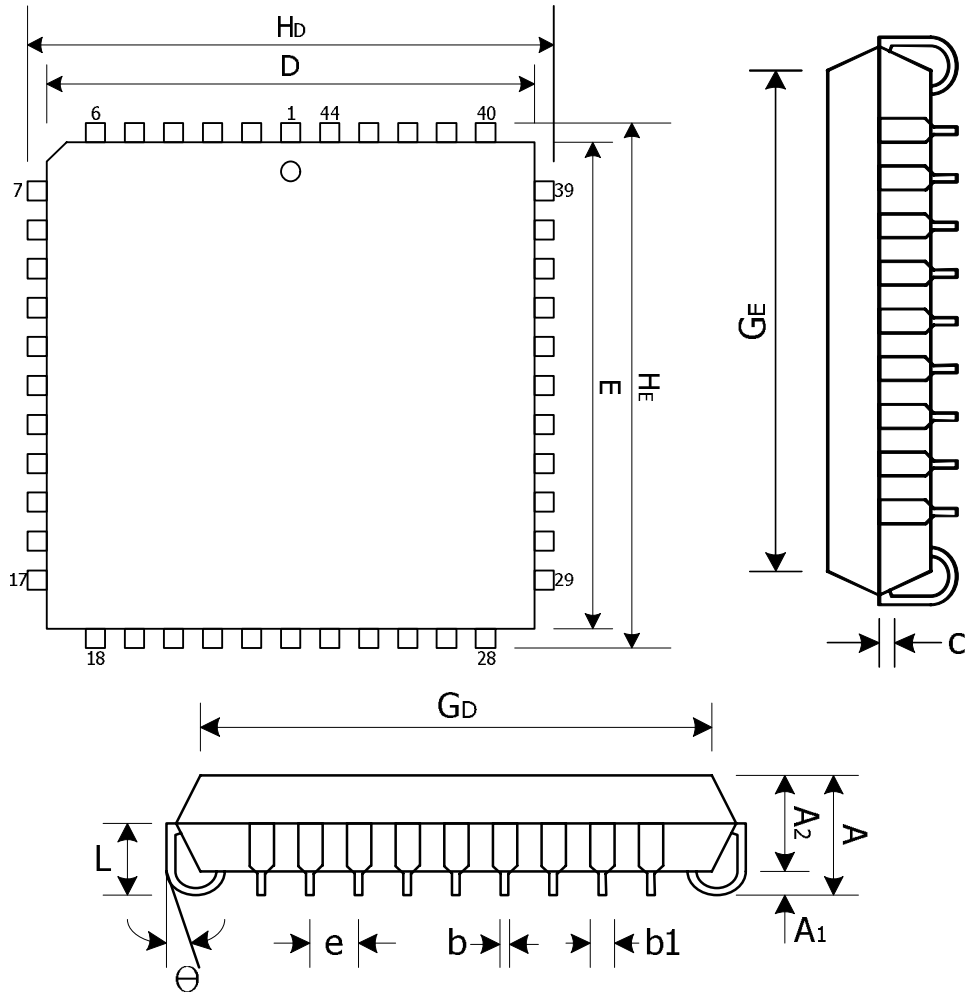
Symbol	Dimension in mm		
	Min.	Nom.	Max.
A	—	—	5.588
A1	0.381	—	—
A2	3.81	3.937	4.064
B	—	0.457	—
B1	—	1.27	—
D	52.197	52.324	52.578
E	15.24 BSC		
E1	13.716	13.843	13.97
e1	—	2.54	—
L	2.921	3.302	3.81
a	0	177.8	381
eA	16.002	16.51	17.018

NOTES:

1. Dimension D Max. includes mold flash or tie bar burrs.
2. Dimension E1 does not include interlead flash.
3. Dimensions D and E1 include mold mismatch and are determined at the mold parting line.
4. Dimension B1 does not include dam bar protrusion/intrusion.
5. JEDEC Outline: MS-011 AC



44-pin PLCC



Unit: Millimeter

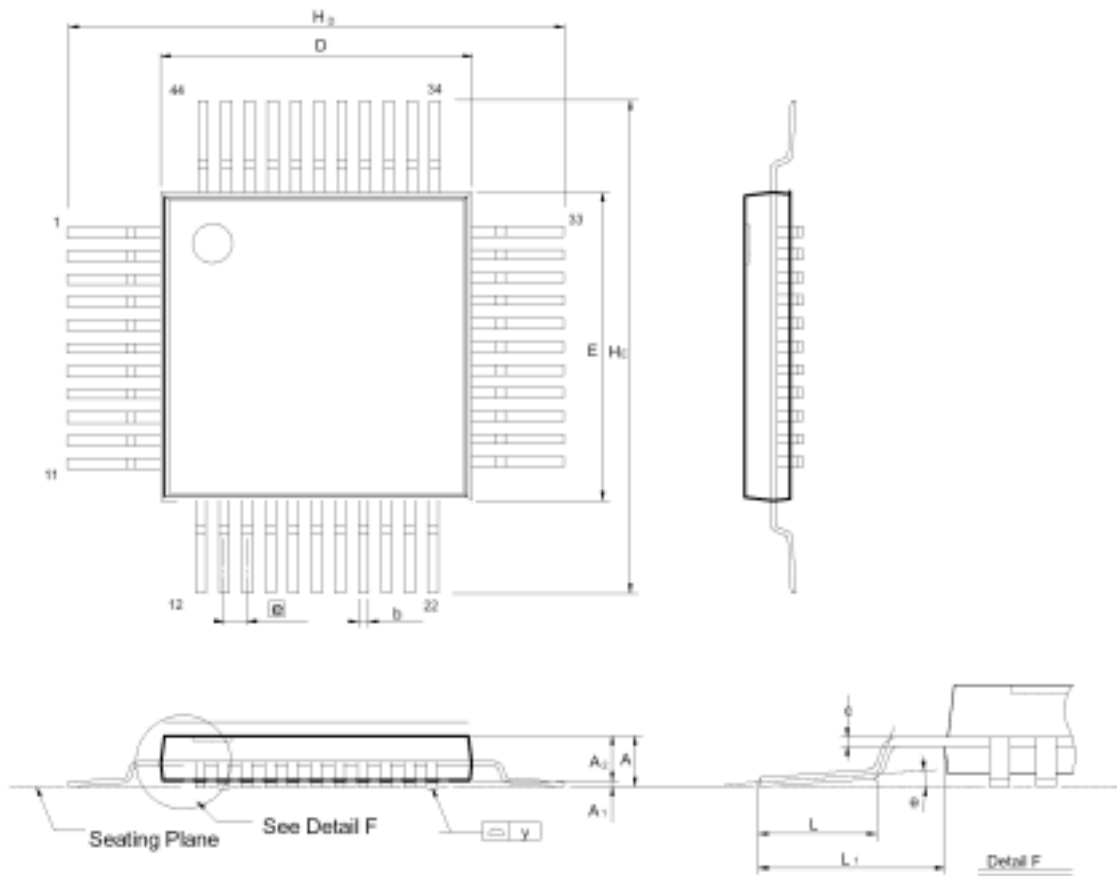
Symbol	Dimension in mm		
	Min.	Nom.	Max.
A	—	—	4.699
A1	0.508	—	—
A2	3.683	3.81	3.937
b1	0.6604	0.7112	0.8128
b	0.4064	0.4572	0.5588
c	0.1778	0.254	0.3302
D	16.4592	16.5862	16.7132
E	16.4592	16.5862	16.7132
e	1.27 BSC		
G_D	14.986	15.494	16.002
G_E	14.986	15.494	16.002
H_b	17.272	17.526	17.78
H_E	17.272	17.526	17.78
L	2.286	2.54	2.794

NOTES:

- Dimensions D and E do not include interlead flash and mold protrusion. Allowable protrusion is 10 mil per side.
- Dimension b_1 does not include dam bar protrusion/intrusion.
- JEDEC Outline: M0-047 AC.



44-pin PQFP



Unit: Millimeter

Symbol	Dimension in mm		
	Min.	Nom.	Max.
A	—	—	2.7
A ₁	0.25	—	0.5
A ₂	1.9	2.0	2.2
b	0.3 TYP.		
c	0.10	0.15	0.20
D	9.9	10.00	10.1
E	9.9	10.00	10.1
e	0.80 TYP.		
H _b	13	13.2	13.4
H _E	13	13.2	13.4
L	0.73	0.88	0.93
L ₁	—	1.6	—
y	0.10		
θ°	0°	—	7°

NOTES:

1. Dimensions D and E do not include interlead flash.
2. Dimension b does not include dam bar protrusion/intrusion.
3. JEDEC Outline: MO-108 AA-1.



TP2804

8051 MICROCONTROLLER WITH 64K FLASH AND ISP

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