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Applications of "<u>Embedded -</u> <u>Microcontrollers</u>"

Details

Product Status	Obsolete
Core Processor	80C51
Core Size	8-Bit
Speed	30/20MHz
Connectivity	UART/USART
Peripherals	POR, PWM, WDT
Number of I/O	32
Program Memory Size	-
Program Memory Type	ROMIess
EEPROM Size	-
RAM Size	768 x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	-
Oscillator Type	Internal
Operating Temperature	0°C ~ 70°C (TA)
Mounting Type	Surface Mount
Package / Case	44-LCC (J-Lead)
Supplier Device Package	44-PLCC (16.6x16.6)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/ts80c51rd2-lcb

Email: info@E-XFL.COM

Address: Room A, 16/F, Full Win Commercial Centre, 573 Nathan Road, Mongkok, Hong Kong



5. Pin Configuration



*NIC: No Internal Connection



		Pin Nu	mber	T			
Mnemonic	DIL	LCC	VQFP 1.4	Туре	Name And Function		
V _{SS}	20	22	16	Ι	Ground: 0V reference		
Vss1		1	39	Ι	Optional Ground: Contact the Sales Office for ground connection.		
V _{CC}	40	44	38	Ι	Power Supply: This is the power supply voltage for normal, idle and power-down operation		
P0.0-P0.7	39-32	43-36	37-30	I/O	Port 0 : Port 0 is an open-drain, bidirectional I/O port. Port 0 pins that have 1 written to them float and can be used as high impedance inputs. Port 0 pins mus be polarized to Vcc or Vss in order to prevent any parasitic current consumption Port 0 is also the multiplexed low-order address and data bus during access to external program and data memory. In this application, it uses strong interna pull-up when emitting 1s. Port 0 also inputs the code bytes during EPROM programming. External pull-ups are required during program verification during which P0 outputs the code bytes.		
P1.0-P1.7	1-8	2-9	40-44 1-3	I/O	Port 1: Port 1 is an 8-bit bidirectional I/O port with internal pull-ups. Port 1 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally pulled low will source current because of the internal pull-ups. Port 1 also receives the low-order address byte during memory programming and verification. Alternate functions for Port 1 include:		
	1	2	40	I/O	T2 (P1.0): Timer/Counter 2 external count input/Clockout		
	2	3	41	I	T2EX (P1.1): Timer/Counter 2 Reload/Capture/Direction Control		
	3	4	42	Ι	ECI (P1.2): External Clock for the PCA		
	4	5	43	I/O	CEX0 (P1.3): Capture/Compare External I/O for PCA module 0		
	5	6	44	I/O	CEX1 (P1.4): Capture/Compare External I/O for PCA module 1		
	6	7	45	I/O	CEX0 (P1.5): Capture/Compare External I/O for PCA module 2		
	7	8	46	I/O	CEX0 (P1.6): Capture/Compare External I/O for PCA module 3		
	8	9	47	I/O	CEX0 (P1.7): Capture/Compare External I/O for PCA module 4		
P2.0-P2.7	21-28	24-31	18-25	I/O	Port 2 : Port 2 is an 8-bit bidirectional I/O port with internal pull-ups. Port 2 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally pulled low will source current because of the internal pull-ups. Port 2 emits the high-order addresse byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @DPTR).In this application, it uses strong internal pull-ups emitting 1s. During accesses to external data memory that use 8-bit addresses (MOVX @Ri), port 2 emits the contents of the P2 SFR. Some Port 2 pins (P2.0 to P2.5) receive the high order address bits during EPROM programming and verification:		
P3.0-P3.7	10-17	11, 13-19	5, 7-13	I/O	Port 3: Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. Port 3 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally pulled low will source current because of the internal pull-ups. Some Port 3 pins (P3.4 to P3.5) receive the high order address bits during EPROM programming and verification. Port 3 also serves the special features of the 80C51 family, as listed below.		
	10	11	5	I	RXD (P3.0): Serial input port		
	11	13	7	0	TXD (P3.1): Serial output port		
	12	14	8	I	INTO (P3.2): External interrupt 0		
	13	15	9	I	INT1 (P3.3): External interrupt 1		
	14	16	10	I	T0 (P3.4): Timer 0 external input		
	15	17	11	I	T1 (P3.5): Timer 1 external input		
	16	18	12	0	WR (P3.6): External data memory write strobe		
	17	19	13	0	RD (P3.7): External data memory read strobe		



Mnemonic]	Pin Number			Name And Function
ALE/PROG	30	33	27	O (I)	Address Latch Enable/Program Pulse: Output pulse for latching the low byte of the address during an access to external memory. In normal operation, ALE is emitted at a constant rate of 1/6 (1/3 in X2 mode) the oscillator frequency, and can be used for external timing or clocking. Note that one ALE pulse is skipped during each access to external data memory. This pin is also the program pulse input (PROG) during EPROM programming. ALE can be disabled by setting SFR's AUXR.0 bit. With this bit set, ALE will be inactive during internal fetches.
PSEN	29	32	26	0	Program Store ENable: The read strobe to external program memory. When executing code from the external program memory, \overrightarrow{PSEN} is activated twice each machine cycle, except that two \overrightarrow{PSEN} activations are skipped during each access to external data memory. \overrightarrow{PSEN} is not activated during fetches from internal program memory.
EA/V _{pp}	31	35	29	I	External Access Enable/Programming Supply Voltage: $\overline{\text{EA}}$ must be externally held low to enable the device to fetch code from external program memory locations 0000H and 3FFFH (RB) or 7FFFH (RC), or FFFFH (RD). If EA is held high, the device executes from internal program memory unless the program counter contains an address greater than 3FFFH (RB) or 7FFFH (RC) $\overline{\text{EA}}$ must be held low for ROMless devices. This pin also receives the 12.75V programming supply voltage (V _{PP}) during EPROM programming. If security level 1 is programmed, $\overline{\text{EA}}$ will be internally latched on Reset.
XTAL1	19	21	15	Ι	Crystal 1: Input to the inverting oscillator amplifier and input to the internal clock generator circuits.
XTAL2	18	20	14	0	Crystal 2: Output from the inverting oscillator amplifier



5.1. Pin Description for 64/68 pin Packages

Port 4 and Port 5 are 8-bit bidirectional I/O ports with internal pull-ups. Pins that have 1 written to them are pulled high by the internal pull ups and can be used as inputs.

As inputs, pins that are externally pulled low will source current because of the internal pull-ups.

Refer to the previous pin description for other pins.

	PLCC68	SQUARE VQFP64 1.4
VSS	51	9/40
VCC	17	8
P0.0	15	6
P0.1	14	5
P0.2	12	3
P0.3	11	2
P0.4	9	64
P0.5	6	61
P0.6	5	60
P0.7	3	59
P1.0	19	10
P1.1	21	12
P1.2	22	13
P1.3	23	14
P1.4	25	16
P1.5	27	18
P1.6	28	19
P1.7	29	20
P2.0	54	43
P2.1	55	44
P2.2	56	45
P2.3	58	47
P2.4	59	48
P2.5	61	50
P2.6	64	53
P2.7	65	54
P3.0	34	25
P3.1	39	28

Table	2.	64/68	Pin	Packages	Configuration
I GOIC		0.00		I uchages	Comparation



	PLCC68	SQUARE VQFP64 1.4
P3.2	40	29
P3.3	41	30
P3.4	42	31
P3.5	43	32
P3.6	45	34
P3.7	47	36
RESET	30	21
ALE/PROG	68	56
PSEN	67	55
EA/VPP	2	58
XTAL1	49	38
XTAL2	48	37
P4.0	20	11
P4.1	24	15
P4.2	26	17
P4.3	44	33
P4.4	46	35
P4.5	50	39
P4.6	53	42
P4.7	57	46
P5.0	60	49
P5.1	62	51
P5.2	63	52
P5.3	7	62
P5.4	8	63
P5.5	10	1
P5.6	13	4
P5.7	16	7



6.2. Dual Data Pointer Register Ddptr

The additional data pointer can be used to speed up code execution and reduce code size in a number of ways.

The dual DPTR structure is a way by which the chip will specify the address of an external data memory location. There are two 16-bit DPTR registers that address the external memory, and a single bit called DPS = AUXR1/bit0 (See Table 4.) that allows the program code to switch between them (Refer to Figure 3).



Figure 3. Use of Dual Pointer

 Table 4. AUXR1: Auxiliary Register 1

AUXR1 Address 0A2H		-	-	-	-	GF3	-	-	DPS
	Reset value	X	Х	X	Х	0	Х	Х	0

Symbol	Function					
-	Not implemen	Not implemented, reserved for future use. ^a				
DPS	Data Pointer S	Data Pointer Selection.				
	DPS	Operating Mode				
	0	DPTR0 Selected				
	1	DPTR1 Selected				
GF3	This bit is a general purpose user flag ^b .					

a. User software should not write 1s to reserved bits. These bits may be used in future 8051 family products to invoke new feature. In that case, the reset value of the new bit will be 0, and its active value will be 1. The value read from a reserved bit is indeterminate.

b. GF3 will not be available on first version of the RC devices.

Application

Software can take advantage of the additional data pointers to both increase speed and reduce code size, for example, block operations (copy, compare, search ...) are well served by using one data pointer as a 'source' pointer and the other one as a "destination" pointer.



6.4. Timer 2

The timer 2 in the TS80C51RX2 is compatible with the timer 2 in the 80C52.

It is a 16-bit timer/counter: the count is maintained by two eight-bit timer registers, TH2 and TL2, connected in cascade. It is controlled by T2CON register (See Table 6) and T2MOD register (See Table 7). Timer 2 operation is similar to Timer 0 and Timer 1. C/T2 selects $F_{OSC}/12$ (timer operation) or external pin T2 (counter operation) as the timer clock input. Setting TR2 allows TL2 to be incremented by the selected input.

Timer 2 has 3 operating modes: capture, autoreload and Baud Rate Generator. These modes are selected by the combination of RCLK, TCLK and $CP/\overline{RL2}$ (T2CON), as described in the Atmel Wireless & Microcontrollers 8-bit Microcontroller Hardware description.

Refer to the Atmel Wireless & Microcontrollers 8-bit Microcontroller Hardware description for the description of Capture and Baud Rate Generator Modes.

In TS80C51RX2 Timer 2 includes the following enhancements:

- Auto-reload mode with up or down counter
- Programmable clock-output

6.4.1. Auto-Reload Mode

The auto-reload mode configures timer 2 as a 16-bit timer or event counter with automatic reload. If DCEN bit in T2MOD is cleared, timer 2 behaves as in 80C52 (refer to the Atmel Wireless & Microcontrollers 8-bit Microcontroller Hardware description). If DCEN bit is set, timer 2 acts as an Up/down timer/counter as shown in Figure 5. In this mode the T2EX pin controls the direction of count.

When T2EX is high, timer 2 counts up. Timer overflow occurs at FFFFh which sets the TF2 flag and generates an interrupt request. The overflow also causes the 16-bit value in RCAP2H and RCAP2L registers to be loaded into the timer registers TH2 and TL2.

When T2EX is low, timer 2 counts down. Timer underflow occurs when the count in the timer registers TH2 and TL2 equals the value stored in RCAP2H and RCAP2L registers. The underflow sets TF2 flag and reloads FFFFh into the timer registers.

The EXF2 bit toggles when timer 2 overflows or underflows according to the direction of the count. EXF2 does not generate any interrupt. This bit can be used to provide 17-bit resolution.



It is possible to use timer 2 as a baud rate generator and a clock generator simultaneously. For this configuration, the baud rates and clock frequencies are not independent since both functions use the values in the RCAP2H and RCAP2L registers.



Figure 6. Clock-Out Mode $C/\overline{T2} = 0$



6.5.1. PCA Capture Mode

To use one of the PCA modules in the capture mode either one or both of the CCAPM bits CAPN and CAPP for that module must be set. The external CEX input for the module (on port 1) is sampled for a transition. When a valid transition occurs the PCA hardware loads the value of the PCA counter registers (CH and CL) into the module's capture registers (CCAPnL and CCAPnH). If the CCFn bit for the module in the CCON SFR and the ECCFn bit in the CCAPMn SFR are set then an interrupt will be generated (Refer to Figure 9).



Figure 9. PCA Capture Mode



6.5.2. 16-bit Software Timer / Compare Mode

The PCA modules can be used as software timers by setting both the ECOM and MAT bits in the modules CCAPMn register. The PCA timer will be compared to the module's capture registers and when a match occurs an interrupt will occur if the CCFn (CCON SFR) and the ECCFn (CCAPMn SFR) bits for the module are both set (See Figure 10).



* Only for Module 4

Figure 10. PCA Compare Mode and PCA Watchdog Timer

Before enabling ECOM bit, CCAPnL and CCAPnH should be set with a non zero value, otherwise an unwanted match could happen. Writing to CCAPnH will set the ECOM bit.

Once ECOM set, writing CCAPnL will clear ECOM so that an unwanted match doesn't occur while modifying the compare value. Writing to CCAPnH will set ECOM. For this reason, user software should write CCAPnL first, and then CCAPnH. Of course, the ECOM bit can still be controlled by accessing to CCAPMn register.



6.5.4. Pulse Width Modulator Mode

All of the PCA modules can be used as PWM outputs. Figure 12 shows the PWM function. The frequency of the output depends on the source for the PCA timer. All of the modules will have the same frequency of output because they all share the PCA timer. The duty cycle of each module is independently variable using the module's capture register CCAPLn. When the value of the PCA CL SFR is less than the value in the module's CCAPLn SFR the output will be low, when it is equal to or greater than the output will be high. When CL overflows from FF to 00, CCAPLn is reloaded with the value in CCAPHn. This allows updating the PWM without glitches. The PWM and ECOM bits in the module's CCAPMn register must be set to enable the PWM mode.



Figure 12. PCA PWM Mode

6.5.5. PCA Watchdog Timer

An on-board watchdog timer is available with the PCA to improve the reliability of the system without increasing chip count. Watchdog timers are useful for systems that are susceptible to noise, power glitches, or electrostatic discharge. Module 4 is the only PCA module that can be programmed as a watchdog. However, this module can still be used for other modes if the watchdog is not needed. Figure 10 shows a diagram of how the watchdog works. The user pre-loads a 16-bit value in the compare registers. Just like the other compare modes, this 16-bit value is compared to the PCA timer value. If a match is allowed to occur, an internal reset will be generated. This will not cause the RST pin to be driven high.

In order to hold off the reset, the user has three options:

- 1. periodically change the compare value so it will never match the PCA timer,
- 2. periodically change the PCA timer value so it will never match the compare values, or
- 3. disable the watchdog by clearing the WDTE bit before a match occurs and then re-enable it.

The first two options are more reliable because the watchdog timer is never disabled as in option #3. If the program counter ever goes astray, a match will eventually occur and cause an internal reset. The second option is also not recommended if other PCA modules are being used. Remember, the PCA timer is the time base for all modules; changing the time base for other modules would not be a good idea. Thus, in most applications the first solution is the best option.

This watchdog timer won't generate a reset out on the reset pin.



Software may examine FE bit after each reception to check for data errors. Once set, only software or a reset can clear FE bit. Subsequently received frames with valid stop bits cannot clear FE bit. When FE feature is enabled, RI rises on stop bit instead of the last data bit (See Figure 14. and Figure 15.).







Figure 15. UART Timings in Modes 2 and 3

6.6.2. Automatic Address Recognition

The automatic address recognition feature is enabled when the multiprocessor communication feature is enabled (SM2 bit in SCON register is set).

Implemented in hardware, automatic address recognition enhances the multiprocessor communication feature by allowing the serial port to examine the address of each incoming command frame. Only when the serial port recognizes its own address, the receiver sets RI bit in SCON register to generate an interrupt. This ensures that the CPU is not interrupted by command frames addressed to other devices.

If desired, you may enable the automatic address recognition feature in mode 1. In this configuration, the stop bit takes the place of the ninth data bit. Bit RI is set only when the received command frame address matches the device's address and is terminated by a valid stop bit.

To support automatic address recognition, a device is identified by a given address and a broadcast address.

NOTE: The multiprocessor communication and automatic address recognition features cannot be enabled in mode 0 (i.e. setting SM2 bit in SCON register in mode 0 has no effect).



6.6.3. Given Address

Each device has an individual address that is specified in SADDR register; the SADEN register is a mask byte that contains don't-care bits (defined by zeros) to form the device's given address. The don't-care bits provide the flexibility to address one or more slaves at a time. The following example illustrates how a given address is formed. To address a device by its individual address, the SADEN mask byte must be 1111 1111b. For example:

SADDR	0101	0110b
SADEN	1111	1100b
Given	0101	01XXb

The following is an example of how to use given addresses to address different slaves:

Slave A:	SADDR <u>SADEN</u> Given	1111 0001b <u>1111 1010b</u> 1111 0X0Xb
Slave B:	SADDR <u>SADEN</u> Given	1111 0011b <u>1111 1001b</u> 1111 0XX1b
Slave C:	SADDR <u>SADEN</u> Given	1111 0010b <u>1111 1101b</u> 1111 00X1b

The SADEN byte is selected so that each slave may be addressed separately.

For slave A, bit 0 (the LSB) is a don't-care bit; for slaves B and C, bit 0 is a 1. To communicate with slave A only, the master must send an address where bit 0 is clear (e.g. 1111 0000b).

For slave A, bit 1 is a 1; for slaves B and C, bit 1 is a don't care bit. To communicate with slaves B and C, but not slave A, the master must send an address with bits 0 and 1 both set (e.g. 1111 0011b).

To communicate with slaves A, B and C, the master must send an address with bit 0 set, bit 1 clear, and bit 2 clear (e.g. 1111 0001b).

6.6.4. Broadcast Address

A broadcast address is formed from the logical OR of the SADDR and SADEN registers with zeros defined as don't-care bits, e.g.:

0101	0110b
1111	1100b
1111	111Xb
	0101 1111 1111

The use of don't-care bits provides flexibility in defining the broadcast address, however in most applications, a broadcast address is FFh. The following is an example of using broadcast addresses:

Slave A:	SADDR <u>SADEN</u> Broadcast	1111 0001b <u>1111 1010b</u> 1111 1X11b,
Slave B:	SADDR <u>SADEN</u> Broadcast	1111 0011b <u>1111 1001b</u> 1111 1X11B,
Slave C:	SADDR= <u>SADEN</u> Broadcast	1111 0010b <u>1111 1101b</u> 1111 1111b

For slaves A and B, bit 2 is a don't care bit; for slave C, bit 2 is set. To communicate with all of the slaves, the master must send an address FFh. To communicate with slaves A and B, but not slave C, the master can send and address FBh.



6.6.5. Reset Addresses

On reset, the SADDR and SADEN registers are initialized to 00h, i.e. the given and broadcast addresses are XXXX (all don't-care bits). This ensures that the serial port will reply to any address, and so, that it is backwards compatible with the 80C51 microcontrollers that do not support automatic address recognition.

SADEN - Slave Address Mask Register (B9h)

7	6	5	4	3	2	1	0

Reset Value = 0000 0000b Not bit addressable

SADDR - Slave Address Register (A9h)

7	6	5	4	3	2	1	0

Reset Value = 0000 0000b Not bit addressable



6.10. Hardware Watchdog Timer

The WDT is intended as a recovery method in situations where the CPU may be subjected to software upset. The WDT consists of a 14-bit counter and the WatchDog Timer ReSeT (WDTRST) SFR. The WDT is by default disabled from exiting reset. To enable the WDT, user must write 01EH and 0E1H in sequence to the WDTRST, SFR location 0A6H. When WDT is enabled, it will increment every machine cycle while the oscillator is running and there is no way to disable the WDT except through reset (either hardware reset or WDT overflow reset). When WDT overflows, it will drive an output RESET HIGH pulse at the RST-pin.

6.10.1. Using the WDT

To enable the WDT, user must write 01EH and 0E1H in sequence to the WDTRST, SFR location 0A6H. When WDT is enabled, the user needs to service it by writing to 01EH and 0E1H to WDTRST to avoid WDT overflow. The 14-bit counter overflows when it reaches 16383 (3FFFH) and this will reset the device. When WDT is enabled, it will increment every machine cycle while the oscillator is running. This means the user must reset the WDT at least every 16383 machine cycle. To reset the WDT the user must write 01EH and 0E1H to WDTRST. WDTRST is a write only register. The WDT counter cannot be read or written. When WDT overflows, it will generate an output RESET pulse at the RST-pin. The RESET pulse duration is 96 x T_{OSC} , where $T_{OSC} = 1/F_{OSC}$. To make the best use of the WDT, it should be serviced in those sections of code that will periodically be executed within the time required to prevent a WDT reset.

To have a more powerful WDT, a 2^7 counter has been added to extend the Time-out capability, ranking from 16ms to 2s @ $F_{OSC} = 12$ MHz. To manage this feature, refer to WDTPRG register description, Table 24. (SFR0A7h).

Table 23. WDTRST Register

WDTRST Address (0A6h)

	7	6	5	4	3	2	1
Reset value	Х	Х	Х	Х	Х	Х	Х

Write only, this SFR is used to reset/enable the WDT by writing 01EH then 0E1H in sequence.



6.11. ONCETM Mode (ON Chip Emulation)

The ONCE mode facilitates testing and debugging of systems using TS80C51Rx2 without removing the circuit from the board. The ONCE mode is invoked by driving certain pins of the TS80C51Rx2; the following sequence must be exercised:

- Pull ALE low while the device is in reset (RST high) and $\overline{\text{PSEN}}$ is high.
- Hold ALE low as RST is deactivated.

While the TS80C51Rx2 is in ONCE mode, an emulator or test CPU can be used to drive the circuit Table 26. shows the status of the port pins during ONCE mode.

Normal operation is restored when normal reset is applied.

Table 25. External Pin Status during ONCE Mode

ALE	PSEN	SEN Port 0 Port 1		Port 2	Port 3	XTAL1/2
Weak pull-up	Weak pull-up	Float	Weak pull-up	Weak pull-up	Weak pull-up	Active



7. TS83C51RB2/RC2/RD2 ROM

7.1. ROM Structure

The TS83C51RB2/RC2/RD2 ROM memory is divided in three different arrays:

•	the code array:	es.
•	the encryption array:	s.
•	the signature array:	es.

7.2. ROM Lock System

The program Lock system, when programmed, protects the on-chip program against software piracy.

7.2.1. 7.2.1. Encryption Array

Within the ROM array are 64 bytes of encryption array that are initially unprogrammed (all FF's). Every time a byte is addressed during program verify, 6 address lines are used to select a byte of the encryption array. This byte is then exclusive-NOR'ed (XNOR) with the code byte, creating an encrypted verify byte. The algorithm, with the encryption array in the unprogrammed state, will return the code in its original, unmodified form.

When using the encryption array, one important factor needs to be considered. If a byte has the value FFh, verifying the byte will produce the encryption byte value. If a large block (>64 bytes) of code is left unprogrammed, a verification routine will display the content of the encryption array. For this reason all the unused code bytes should be programmed with random values. This will ensure program protection.

7.2.2. Program Lock Bits

The lock bits when programmed according to Table 28. will provide different level of protection for the on-chip code and data.

	Program	Lock Bits					
Security level	LB1	LB2	LB3	Protection description			
1	U	U	U	No program lock features enabled. Code verify will still be encrypted by the encryption array if programmed. MOVC instruction executed from external program memory returns non encrypted data.			
2	Р	U	U	MOVC instruction executed from external program memory are disabled from fetching code bytes from internal memory, \overline{EA} is sampled and latched on reset.			
3	U	P U Same as level This security		Same as level 1+ Verify disable. This security level is only available for 51RDX2 devices.			

Table	28.	Program	Lock	bits
-------	-----	---------	------	------

U: unprogrammed

P: programmed

7.2.3. Signature bytes

The TS83C51RB2/RC2/RD2 contains 4 factory programmed signatures bytes. To read these bytes, perform the process described in section 8.3.

7.2.4. Verify Algorithm

Refer to 8.3.4.



8. TS87C51RB2/RC2/RD2 EPROM

8.1. EPROM Structure

The TS87C51RB2/RC2/RD2 EPROM is divided in two different arrays:

•	the code array:
•	the encryption array:
In	addition a third non programmable array is implemented:
•	the signature array:

8.2. EPROM Lock System

The program Lock system, when programmed, protects the on-chip program against software piracy.

8.2.1. Encryption Array

Within the EPROM array are 64 bytes of encryption array that are initially unprogrammed (all FF's). Every time a byte is addressed during program verify, 6 address lines are used to select a byte of the encryption array. This byte is then exclusive-NOR'ed (XNOR) with the code byte, creating an encrypted verify byte. The algorithm, with the encryption array in the unprogrammed state, will return the code in its original, unmodified form.

When using the encryption array, one important factor needs to be considered. If a byte has the value FFh, verifying the byte will produce the encryption byte value. If a large block (>64 bytes) of code is left unprogrammed, a verification routine will display the content of the encryption array. For this reason all the unused code bytes should be programmed with random values. This will ensure program protection.

8.2.2. Program Lock Bits

The three lock bits, when programmed according to Table 29.8.2.3., will provide different level of protection for the on-chip code and data.

Program Lock Bits				Protection description					
Security level	LB1	LB2	LB3						
1	U	U	U	No program lock features enabled. Code verify will still be encrypted by the encryption array if programmed. MOVC instruction executed from external program memory returns non encrypted data.					
2	Р	U	U	MOVC instruction executed from external program memory are disabled from fetching code bytes from internal memory, \overline{EA} is sampled and latched on reset, and further programming of the EPROM is disabled.					
3	U	Р	U	Same as 2, also verify is disabled.					
4	U	U	Р	Same as 3, also external execution is disabled.					

Table 29	. Program	Lock	bits
----------	-----------	------	------

U: unprogrammed,

P: programmed

WARNING: Security level 2 and 3 should only be programmed after EPROM and Core verification.

8.2.3. Signature bytes

The TS87C51RB2/RC2/RD2 contains 4 factory programmed signatures bytes. To read these bytes, perform the process described in section 8.3.





* See Table 31. for proper value on these inputs

Figure 18. Set-Up Modes Configuration

8.3.3. Programming Algorithm

The Improved Quick Pulse algorithm is based on the Quick Pulse algorithm and decreases the number of pulses applied during byte programming from 25 to 1.

To program the TS87C51RB2/RC2/RD2 the following sequence must be exercised:

- Step 1: Activate the combination of control signals.
- Step 2: Input the valid address on the address lines.
- Step 3: Input the appropriate data on the data lines.
- Step 4: Raise \overline{EA}/VPP from VCC to VPP (typical 12.75V).
- Step 5: Pulse ALE/PROG once.
- Step 6: Lower \overline{EA}/VPP from VPP to VCC

Repeat step 2 through 6 changing the address and data for the entire array or until the end of the object file is reached (See Figure 19.).

8.3.4. Verify algorithm

Code array verify must be done after each byte or block of bytes is programmed. In either case, a complete verify of the programmed array will ensure reliable programming of the TS87C51RB2/RC2/RD2.

P 2.7 is used to enable data output.

To verify the TS87C51RB2/RC2/RD2 code the following sequence must be exercised:

- Step 1: Activate the combination of program and control signals.
- Step 2: Input the valid address on the address lines.
- Step 3: Read data on the data lines.

Repeat step 2 through 3 changing the address for the entire array verification (See Figure 19.)

The encryption array cannot be directly verified. Verification of the encryption array is done by observing that the code array is well encrypted.



10.3. DC Parameters for Standard Voltage

TA = 0°C to +70°C; V_{SS} = 0 V; V_{CC} = 5 V ± 10%; F = 0 to 40 MHz. TA = -40°C to +85°C; V_{SS} = 0 V; V_{CC} = 5 V ± 10%; F = 0 to 40 MHz.

Table 32. DC Parameters in Standard Voltage

Symbol	Parameter	Min	Тур	Max	Unit	Test Conditions
V _{IL}	Input Low Voltage	-0.5		0.2 V _{CC} - 0.1	V	
V _{IH}	Input High Voltage except XTAL1, RST	$0.2 V_{CC} + 0.9$		V _{CC} + 0.5	v	
V _{IH1}	Input High Voltage, XTAL1, RST	0.7 V _{CC}		V _{CC} + 0.5	V	
V _{OL}	Output Low Voltage, ports 1, 2, 3, 4, 5 ⁽⁶⁾			0.3 0.45 1.0	V V V	$I_{OL} = 100 \ \mu A^{(4)}$ $I_{OL} = 1.6 \ m A^{(4)}$ $I_{OL} = 3.5 \ m A^{(4)}$
V _{OL1}	Output Low Voltage, port 0 ⁽⁶⁾			0.3 0.45 1.0	V V V	$I_{OL} = 200 \ \mu A^{(4)}$ $I_{OL} = 3.2 \ m A^{(4)}$ $I_{OL} = 7.0 \ m A^{(4)}$
V _{OL2}	Output Low Voltage, ALE, PSEN			0.3 0.45 1.0	V V V	$\begin{split} I_{OL} &= 100 \; \mu A^{(4)} \\ I_{OL} &= 1.6 \; m A^{(4)} \\ I_{OL} &= 3.5 \; m A^{(4)} \end{split}$
V _{OH}	Output High Voltage, ports 1, 2, 3, 4, 5	V _{CC} - 0.3 V _{CC} - 0.7 V _{CC} - 1.5			V V V	$\begin{split} I_{OH} &= -10 \; \mu A \\ I_{OH} &= -30 \; \mu A \\ I_{OH} &= -60 \; \mu A \\ V_{CC} &= 5 \; V \pm 10\% \end{split}$
V _{OH1}	Output High Voltage, port 0	V _{CC} - 0.3 V _{CC} - 0.7 V _{CC} - 1.5			V V V	$I_{OH} = -200 \ \mu A$ $I_{OH} = -3.2 \ m A$ $I_{OH} = -7.0 \ m A$ $V_{CC} = 5 \ V \pm 10\%$
V _{OH2}	Output High Voltage, ALE, PSEN	V _{CC} - 0.3 V _{CC} - 0.7 V _{CC} - 1.5			V V V	$I_{OH} = -100 \ \mu A$ $I_{OH} = -1.6 \ m A$ $I_{OH} = -3.5 \ m A$ $V_{CC} = 5 \ V \pm 10\%$
R _{RST}	RST Pulldown Resistor	50	90 ⁽⁵⁾	200	kΩ	
I _{IL}	Logical 0 Input Current ports 1, 2, 3, 4, 5			-50	μΑ	Vin = 0.45 V
I _{LI}	Input Leakage Current			±10	μΑ	0.45 V < Vin < V _{CC}
I _{TL}	Logical 1 to 0 Transition Current, ports 1, 2, 3, 4, 5			-650	μA	Vin = 2.0 V
C _{IO}	Capacitance of I/O Buffer			10	pF	$Fc = 1 MHz$ $TA = 25^{\circ}C$
I _{PD}	Power Down Current		20 (5)	50	μΑ	$2.0 \ V < V_{CC} < 5.5 \ V^{(3)}$
I _{CC} under RESET	Power Supply Current Maximum values, X1 mode: ⁽⁷⁾			1 + 0.4 Freq (MHz) @12MHz 5.8 @16MHz 7.4	mA	$V_{CC} = 5.5 V^{(1)}$