CMOS single-chip 8-bit MCU with Remote control and IR learning

Main features

- **8-bit Microcontroller With High Speed 8051 CPU**
- **Basic MCU Function**
  - 16KB Flash Code Memory
  - 2048bytes XRAM + 256byte IRAM
- **Built-in Analog Function**
  - Power-On Reset and Low Voltage Detect Reset
  - Internal 12MHz RC Oscillator (±1.0%, after tuning T_A = -20 ~ +70°C)
  - Watchdog Timer RC Oscillator (1MHz)
- **Peripheral Features**
  - USART 8-bit x 1-ch, SPI 8-bit x 1-ch, I2C 8-bit x 1ch
  - Internal IR driver, Internal IR learning
  - T-key scan available
- **I/O and Packages**
  - Up to 13 programmable I/O lines with 16QFN/16SOPN
  - 16QFN/16SOPN
- **Operating Conditions**
  - 1.71V to 3.6V Voltage Range
  - -20°C to 70°C Temperature Range
- **Application**
  - IR blaster, IR receiver, Remocon

A96R136

Data Sheet

V 1.6

Aug., 2021

Revision History

Version	Date	Revision list
0.0	2017.06.05	-.
0.1	2017.06.17	Published this book.
0.2	2018.04.24	Added 16SOPN PKG
1.0	2018.05.21	Released version. Port structure fix, Add PxIO comment
1.1	2018.07.10	Removed WLCSP PKG
1.2	2018.10.31	Updated BODR, Nomenclature and Appendix DJNZ Rn, rel
1.3	2019.03.11	Updated REMOUT VOL,IOL. Updated Learning minimum voltage
1.4	2019.04.18	Updated DC characteristics PVT conditions
1.5	2019.06.26	Updated Learning Amplifier characteristics
1.6	2021.09.14	Updated secion 7.5, 7.16 and 7.18 Add the phrase "NOTE" Updated secion 7.19. Internal RC stabilization Updated secion 3, 6, 7 pharase “NOTE” Updated section 7.8, 7.9 Learning Respose Time CHARACTERISTICS Updated Phrases. 7.9, 7.17, 7.19, 7.20 Section. “The value is guaranteed by design and is not tested.”

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Version 1.6

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1 Overview

1.1 Description

The A96R136 is advanced CMOS 8-bit microcontroller with FLASH (16KB). This is powerful microcontroller which provides a highly flexible and cost effective solution to many embedded control applications. This provides the following features : 16KB of FLASH, 256 bytes of IRAM, 2048 bytes of XRAM, general purpose I/O, 8/16-bit timer/counter, watchdog timer, watch timer, SPI, USART, I2C, on-chip POR and LVI(BOD), 8/16-bit PWM output, on-chip oscillator, Internal IR driver and IR learning circuit including OP-AMP. The A96R136 also supports power saving modes to reduce power consumption.

1.2 Features

- **CPU**
  - 8-bit CISC core (8051 Compatible, 2 clocks per cycle)
- **ROM (FLASH) Capacity**
  - 16KB Flash with self-read and write capability
  - In-System Programming(ISP)
  - Endurance : 10,000 times
  - Retention : 10 years
- **256 bytes IRAM**
- **2048 bytes XRAM**
- **General Purpose I/O (GPIO)**
  - Normal I/O : 13 Ports (P0, P1,P2)
- **Boot Loader Protection**
- **Internal IR driver**
  - Carrier generator
- **Internal IR Learning with OP-AMP**
- **Timer/Counter**
  - Basic Interval Timer (BIT) 8-bit × 1-ch
  - Watch Dog Timer (WDT) 8-bit × 1-ch
    1MHz internal RC oscillator for WDT
  - WT for IR learning
  - 8-bit × 2-ch (T0/T1)
  - 16-bit × 2-ch (T2/T3)
- **Programmable Pulse Generation**
  - Pulse generation (by T0/T2)
  - 8-bit PWM (by T1/T3)
- **SPI**
  - 8-bit × 1-ch
- **USART**
  - 8-bit USART × 1-ch
- **I2C**
  - I2C × 1-ch
- **Power On Reset**
  - Reset release level (Typ. 1.3V)
- **Low Voltage Reset**
  - 1.52V(reset or indicator)
- **Low Voltage Indicator**
  - 5 levels detect (1.63V /1.80V / 2.00V / 2.20V / 2.40V)
- **Interrupt Sources**
  - External Interrupts
    (EINT0 ~EINT5) (6)
  - Timer(0/1/2/3) (4)
  - Remocon(1)
  - IRI (1)
  - USART Tx, Rx (2)
  - SPI (Shared USART)(1)
  - I2C (1)
  - WT(1)
  - WDT (1)
  - BIT (1)
  - FLASH (1)
  - LVI(BOD) (1)
  - Keyscan(1)
  - Pin Change Interrupt(1)
- **Internal RC Oscillator**
  - Internal RC frequency: 12MHz ±1.0%
    After tuning (T_A= -20 ~ +70°C)
- **Power Down Mode**
  - STOP, SLEEP mode
- **Minimum Instruction Execution Time**
  - 200ns (@12MHz clock, 2cycle per clock = 6MIPS)
- **Operating Temperature**
  - –20 ~ +70℃
- **Package Type**
  - 16QFN,16SOPN

1.3 Ordering information

Device Name	Flash	XRAM	IRAM	Package

A96R136AUN	16KB	2048 bytes	256 bytes	16 QFN
A96R136AEN				16 SOPN

Table 1.1 Ordering Information of A96R136

1.3.1 Device Nomenclature

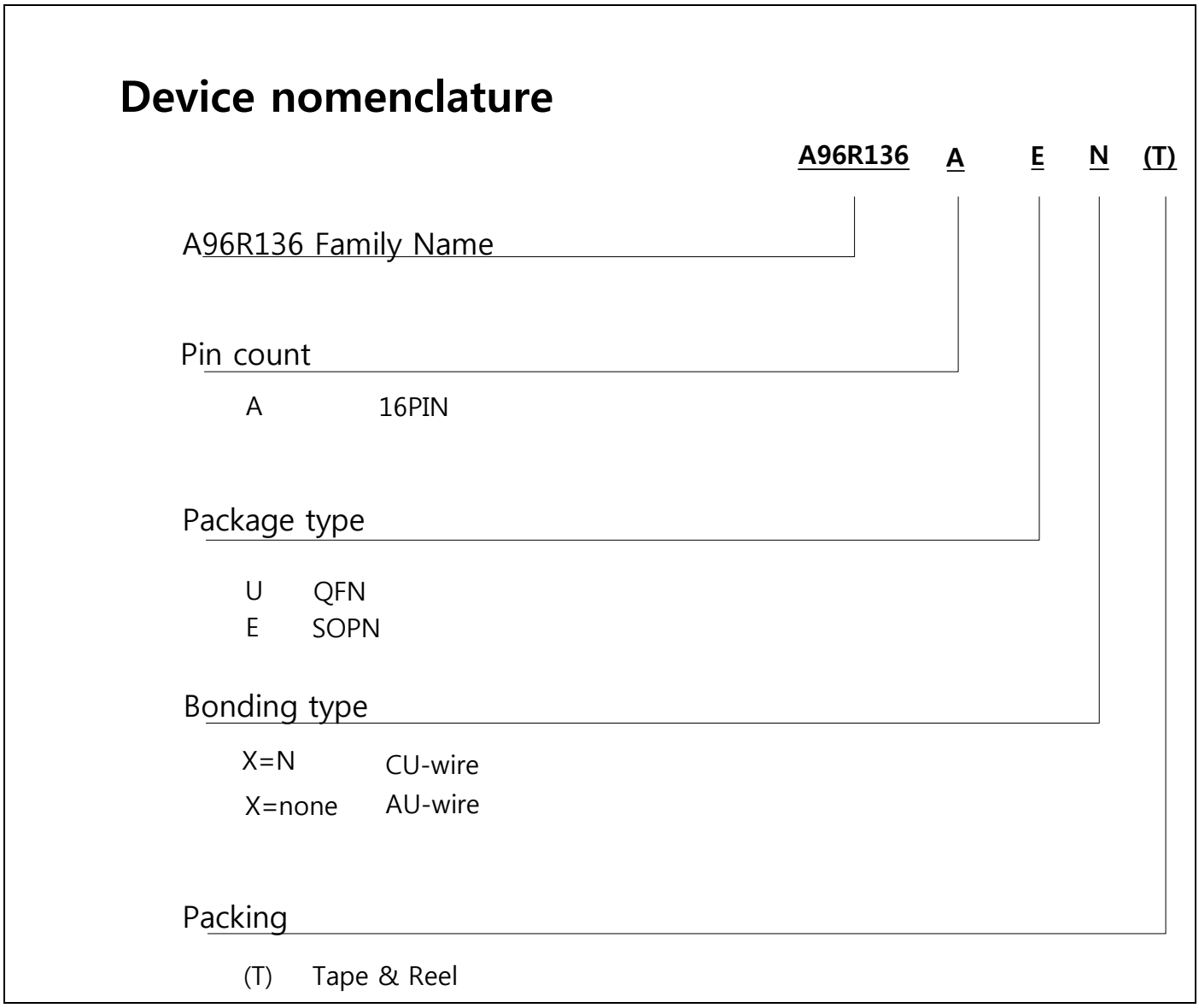


Figure 1.1 Device Nomenclature

1.4 Development tools

1.4.1 Compiler

ABOV Semiconductor does not provide compiler. It is recommended that you consult a compiler provider.
The A96R136 core is Mentor 8051 and the ROM size is smaller than 16KB. Therefore, developer can use the standard 8051 compiler from other providers.

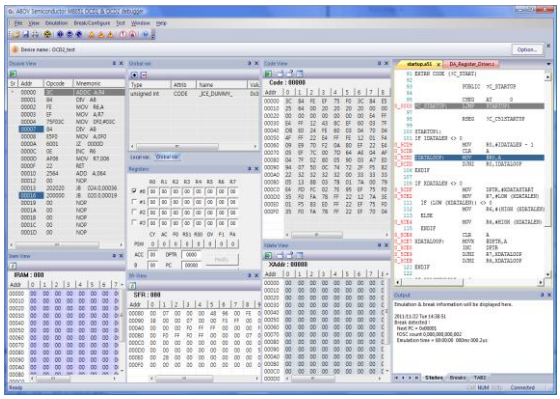
1.4.2 OCD(On-chip debugger) emulator and debugger

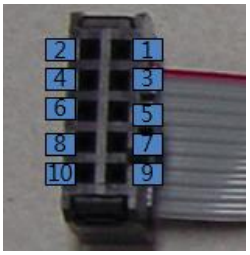
The OCD (On Chip Debug) emulator supports ABOV Semiconductor's 8051 series MCU emulation. The OCD interface uses two-wire connection between PC and MCU which is attached to user's system. The OCD can read or change the value of MCU internal memory and I/O peripherals. And the OCD also controls MCU internal debugging logic, it means OCD controls emulation, step run, monitoring, etc.
The OCD debugger program works on Microsoft-Windows NT, 2000, XP, Vista (32-bit) operating system. If you want to see more details, please refer to OCD debugger manual. You can download debugger S/W and manual from our web-site (http://www.abov.co.kr).

Connection:

- DSCL (A96R136 P1[0] port)
- DSDA (A96R136 P1[1] port)

OCD connector diagram: Connect OCD with user system





2. VDD
4. GND
6. Serial Clock (DSCL)
8. Serial Data (DSDA)

Figure 1.2 debugger and pin description

1.4.3 Programmer

To program or download user code into the ROM of A96R136, ABOV semiconductor provides several tools. As a single programmer which can program only one chip at a time, there are E-PGM+ and PGMPlusLC-II. On the other hand, you can program multi-chips at a time by using a gang programmer. Gang programmer, E-GANG6, can program up to 6 devices simultaneously

1.4.3.1 E-PGM+

E-PGM+ is a single write tool for ABOV MCUs.

Features :

- Support ABOV / ADAM devices
- 2~5 times faster than S-PGM+
- Main controller : 32 bit MCU @72MHz
- Buffer memory : 1MB

Figure 1.3 E-PGM+

1.4.3.2 PGMPlusLC-II

PGMPlusLC-II is for ISP (In System Programming). It is used to program or erase the MCU which is already mounted on the target board using 10pin cable.

Features :

- PGMPlusLC-II is low cost writing tool
- USB interface is supported
- No need for USB driver installation

- Connect to the external power adaptor (5V@2A)
- Fast 32-bit Cortex-M3 MCU is used

- Support high voltage up to max 18V
- PGMPlusLC-II is based on PC environment
- PGMPlusLC-II is faster than PGMplusLC
- Transmission Speed of 64KB/s

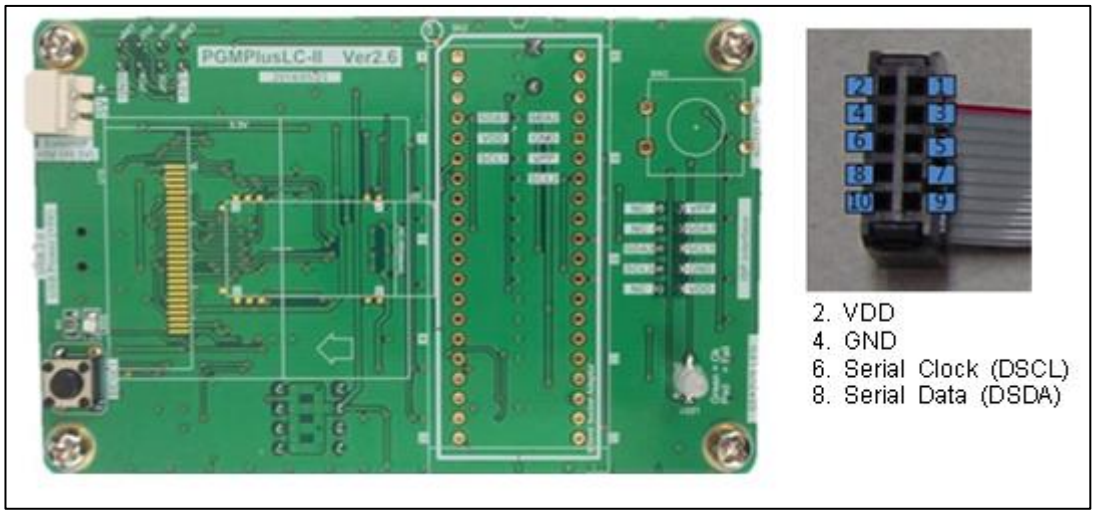


Figure 1.4 PGMPlusLC-II

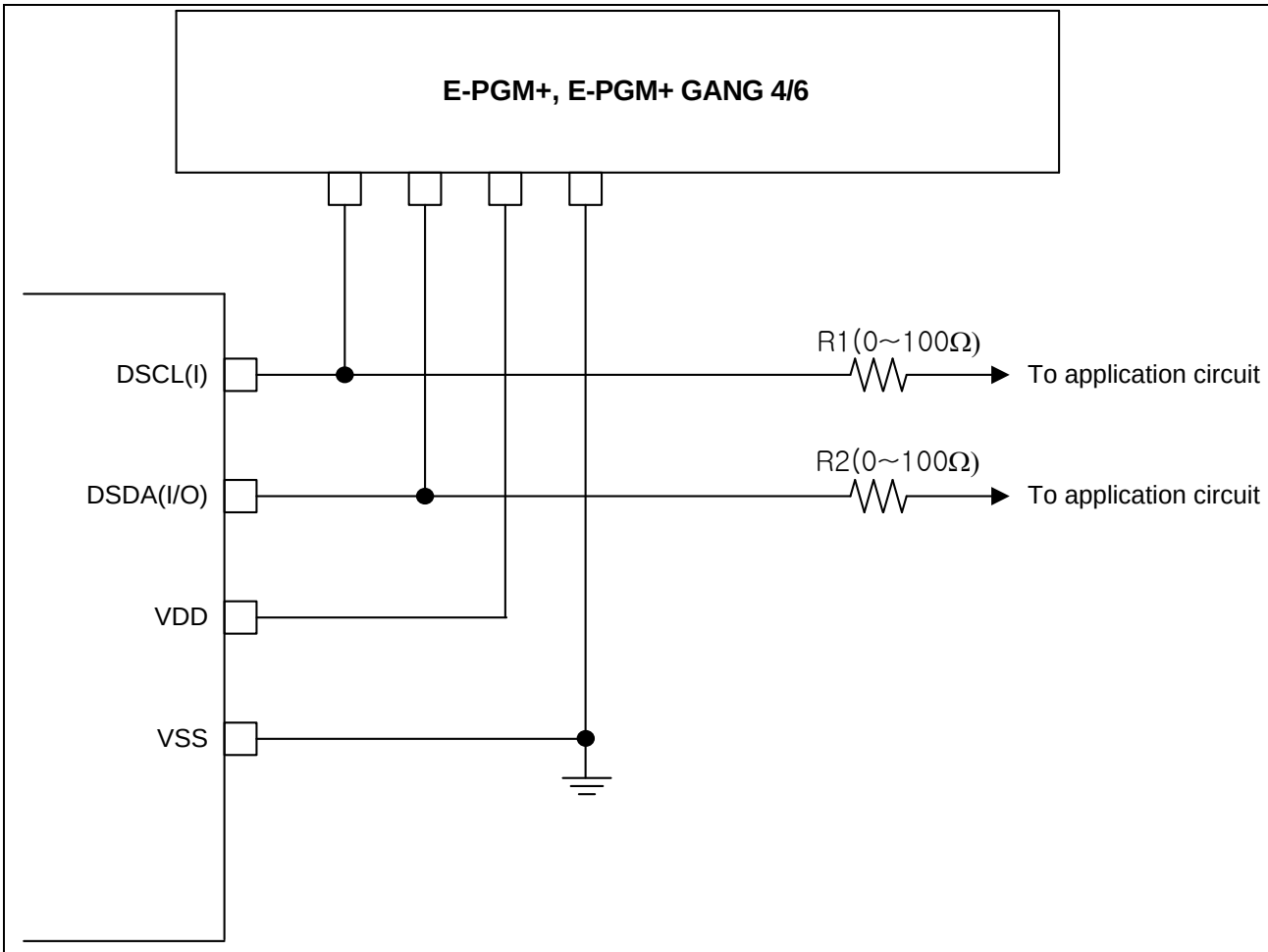
1.4.3.3 E-GANG4(6)

The gang programmer, E-GANG4/(6) can program maximum4(6) MCUs at a time. So it is mainly used in mass production line. As gang programmer is standalone type, it does not require host PC.

Figure1.5 Gang programmer

1.4.4 Circuit design guide

At the FLASH programming, the programming tool needs 4 signal lines that are DSCL, DSDA, VDD, and VSS. When you design the PCB circuits, you should consider the usage of these signal lines for the on-board programming.
Please be careful to design the related circuit of these signal pins because rising/falling timing of DSCL and DSDA is very important for proper programming.



NOTE)

1. In on-board programming mode, very high-speed signal will be provided to pin DSCL and DSDA. And it will cause some damages to the application circuits connected to DSCL or DSDA port if the application circuit is designed as high speed response such as relay control circuit. If possible, the I/O configuration of DSDA, DSCL pins had better be set to input mode.

The value of R1 and R2 is recommended value and it varies with circuit of system.

Figure1.6 PCB Design guide for on board programming

2 Block diagram

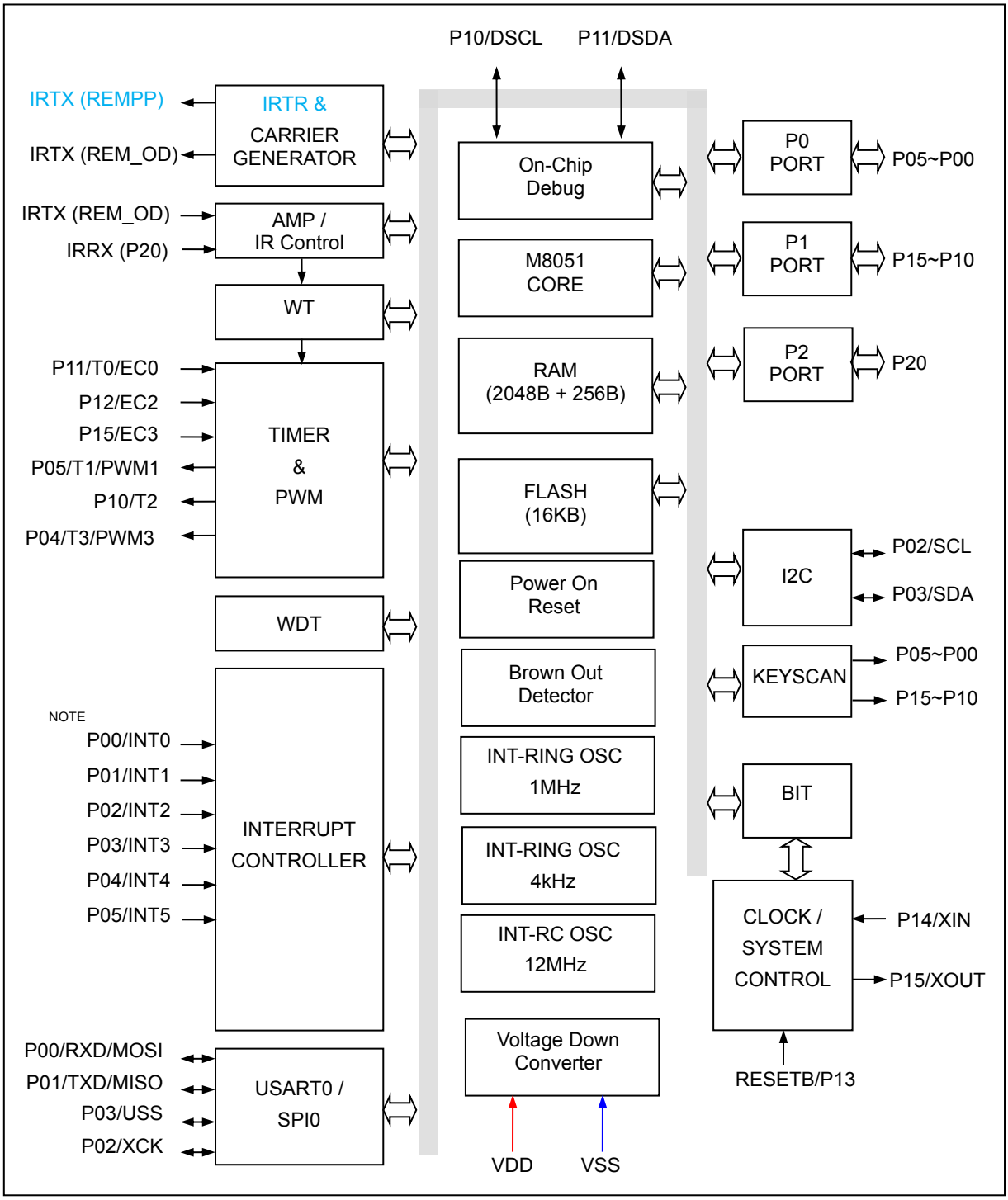


Figure 2.1 Block diagram of A96R136

3 Pin assignment

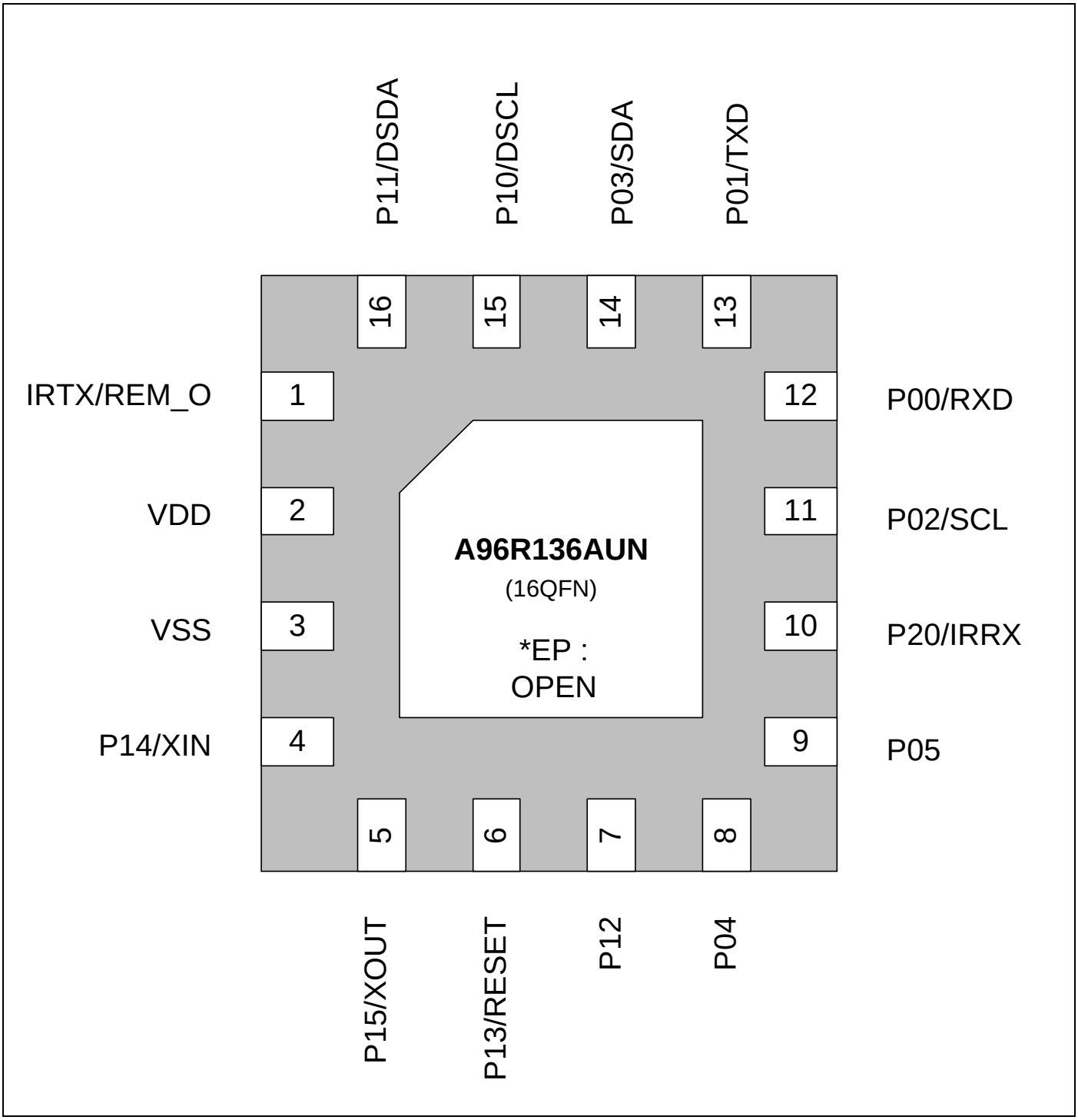


Figure 3.1 16 QFN Pin-out of A96R136

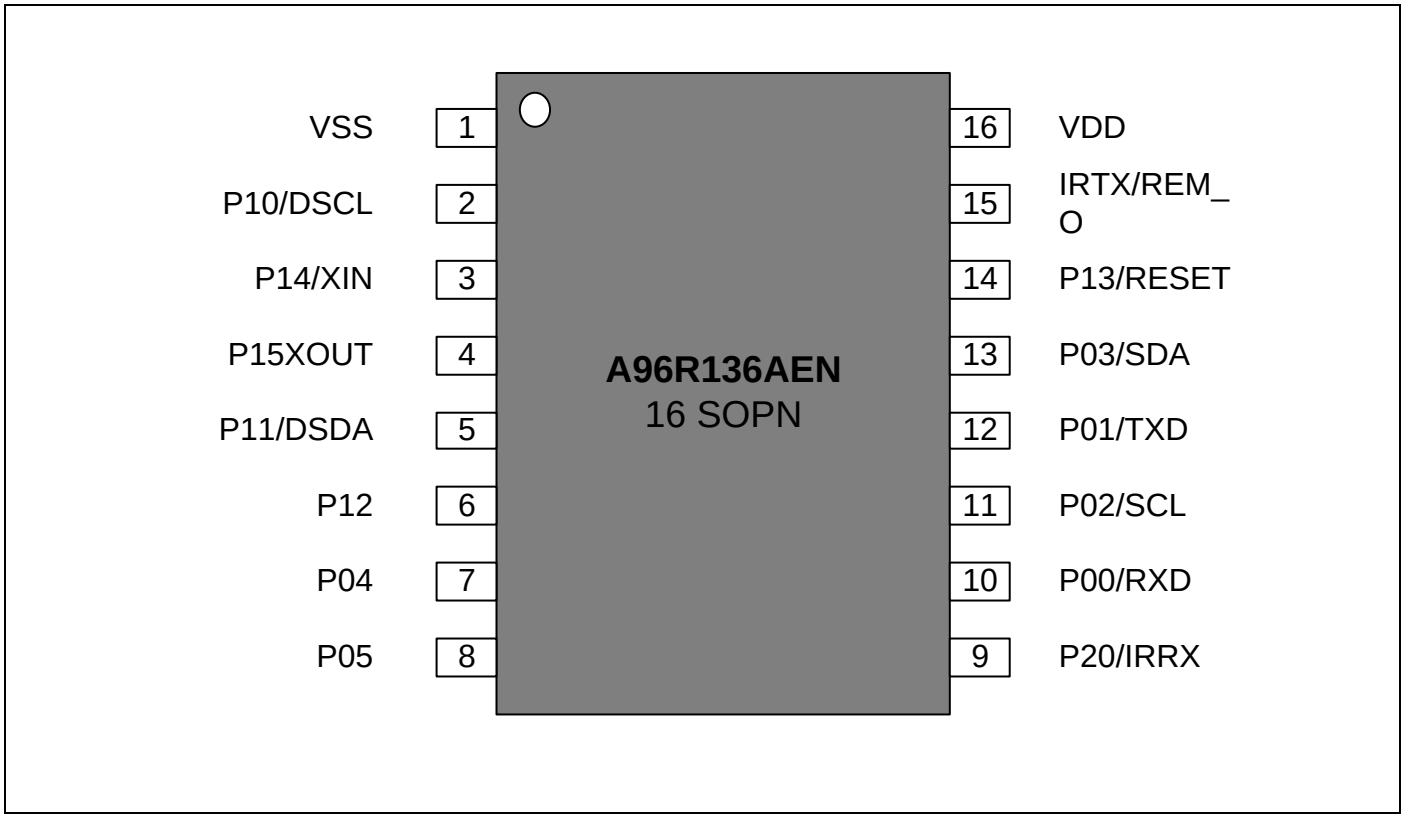
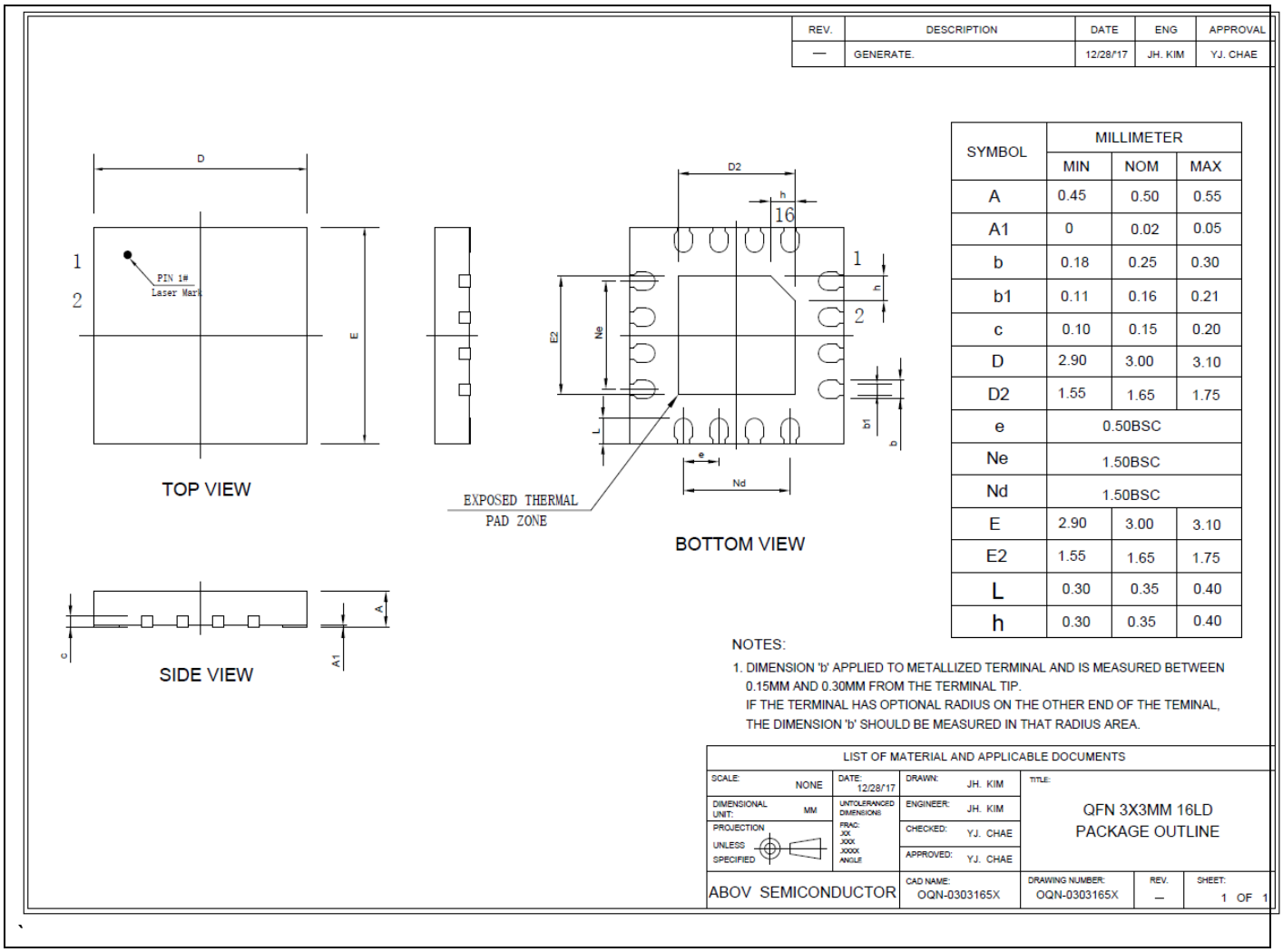


Figure 3.2 16 SOPN Pin-out of A96R136

4 Package Diagram



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.45	0.50	0.55
A1	0	0.02	0.05
b	0.18	0.25	0.30
b1	0.11	0.16	0.21
c	0.10	0.15	0.20
D	2.90	3.00	3.10
D2	1.55	1.65	1.75
e	0.50BSC		
Ne	1.50BSC		
Nd	1.50BSC		
E	2.90	3.00	3.10
E2	1.55	1.65	1.75
L	0.30	0.35	0.40
h	0.30	0.35	0.40

Figure 4.2 PKG DIMENSION (16 QFN)

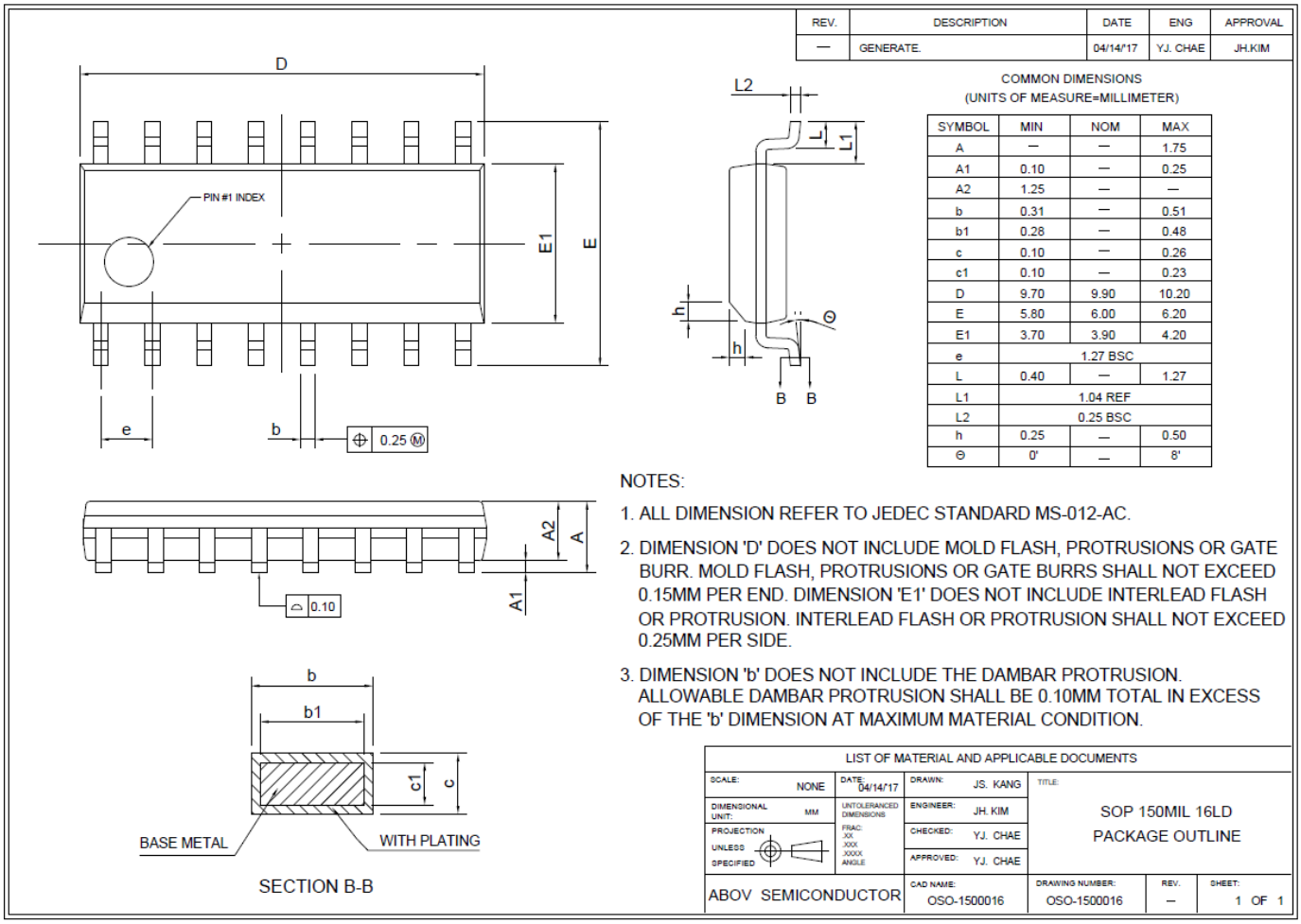


Figure 4.3 PKG DIMENSION (16 SOPN)

5 Pin Description

PIN Name	I/O	Function	@RESET	Shared with
P00	I/O	- 6-bit I/O port, P0. - Can be set in input or output mode bitwise. - Internal pull-up resistor can be activated by setting PxnPU bit in PxPU register when this port is used as input port. - Can be configured as an open drain output mode by setting PxnOD bit in PxOD register.	Input	INT0 NOTE1 / RXD/MOSI
P01				INT1 NOTE1 / TXD/MISO
P02				INT2 NOTE1 / SCL/XCK
P03				INT3 NOTE1 / SDA/USS
P04				INT4 NOTE1 / T3
P05				INT5 NOTE1 / T1
P10	I/O	6-bit I/O port, P1. - Can be set in input or output mode bitwise. - Internal pull-up resistor can be activated by setting PxnPU bit in PxPU register when this port is used as input port. - Can be configured as an open drain output mode by setting PxnOD bit in PxOD register.	Input	T2/DSCL
P11				T0/DSDA/EC0
P12				EC2
P13				RESETB
P14				XIN
P15				XOUT/EC3
IRTX	O	1-bit I/O port. - REM open-drain output	Output	-
P20	I/O	1-bit I/O port. - IRRX CMOS input	Input	IRRX
VDD	P	Main power supply	-	
VSS	P	Ground	-	

Table 5.1 Normal Pin description

6 Port Structures

6.1 General Purpose I/O Port

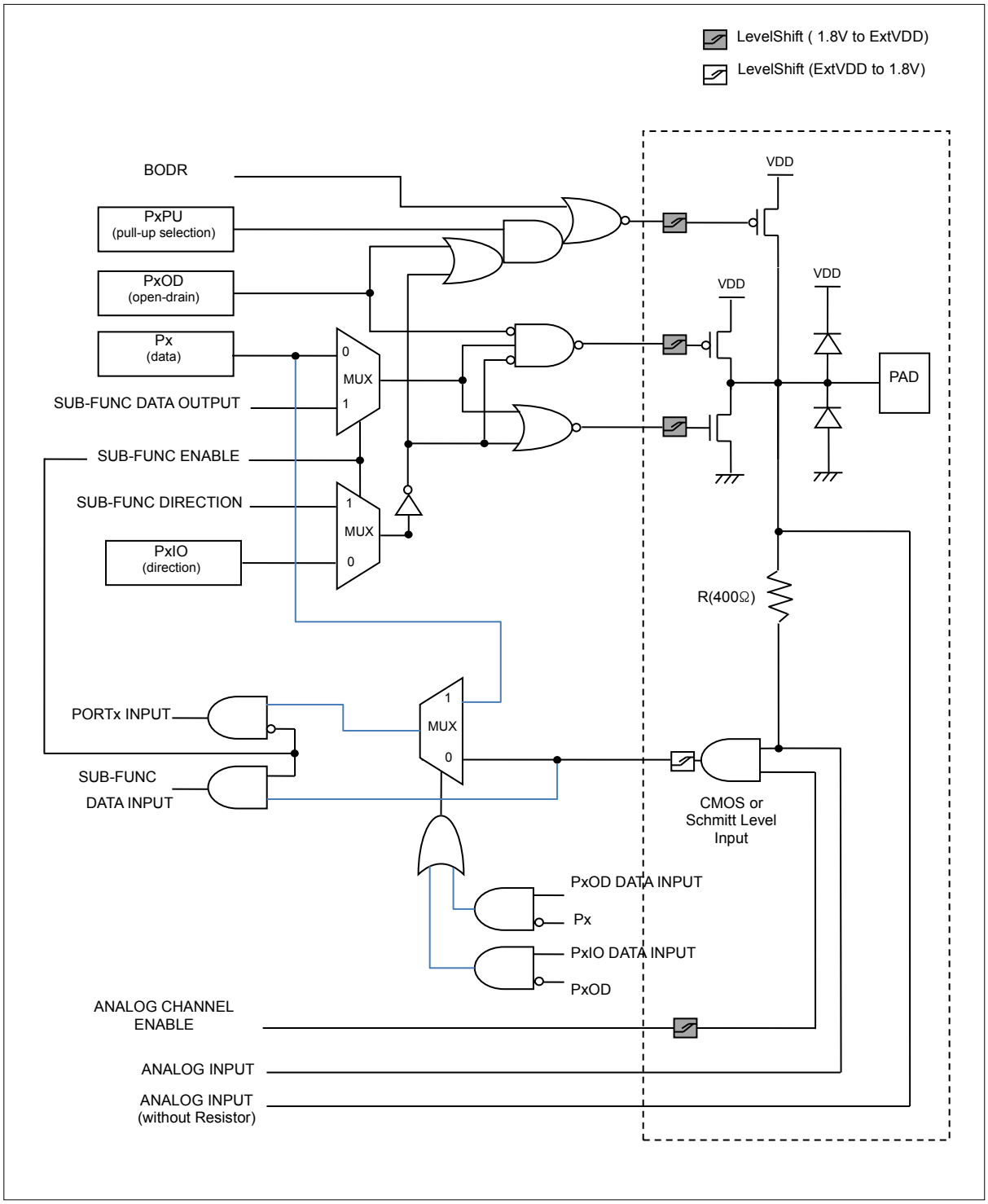


Figure 6.1 General Purpose I/O Port

*Note : In order to use in input mode, Push-Pull should be set in PxOD.

6.2 External Interrupt I/O Port

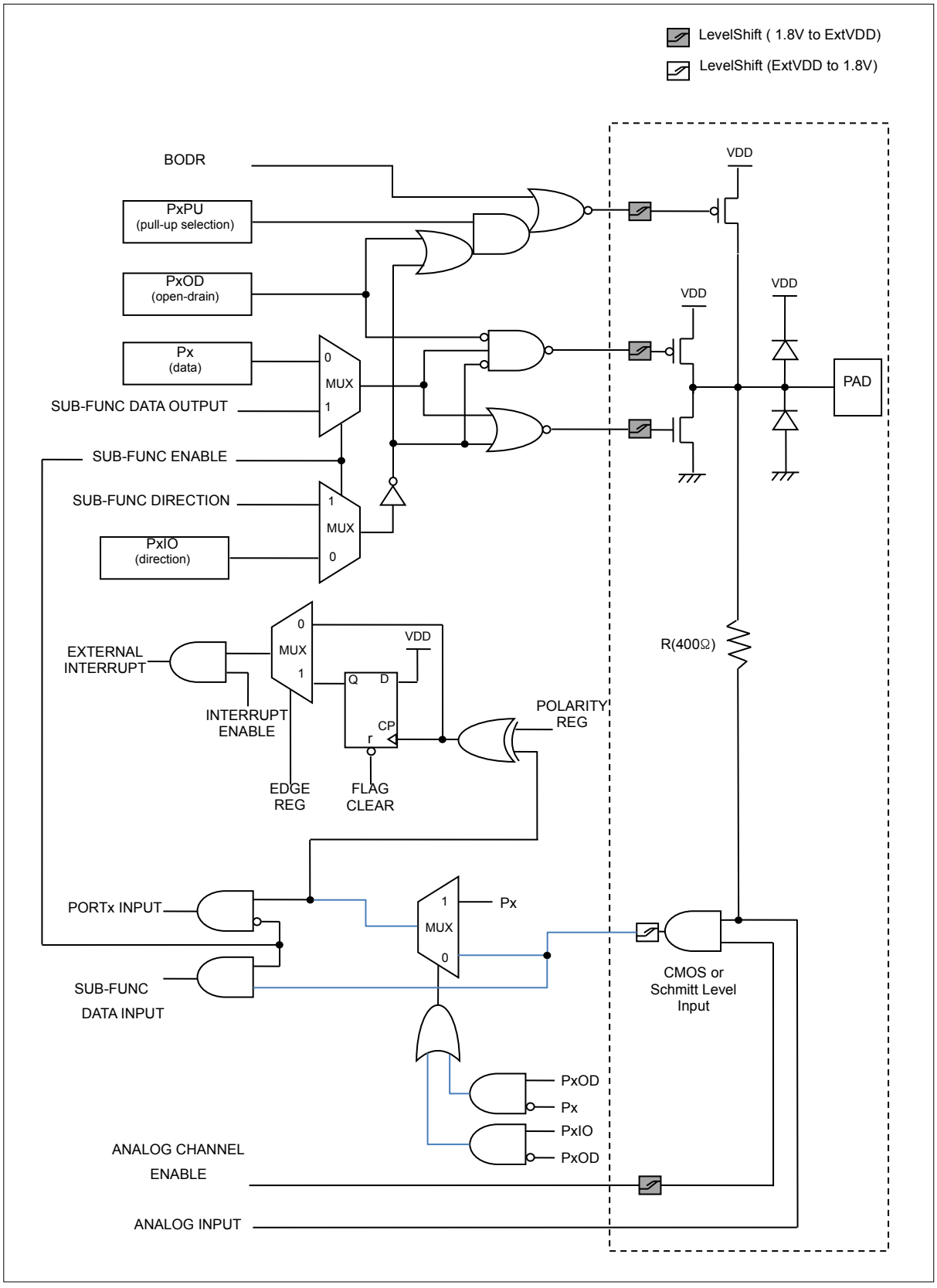


Figure 6.2 I/O with external interrupt function

6.3 External Interrupt I/O Port with drive strength selection

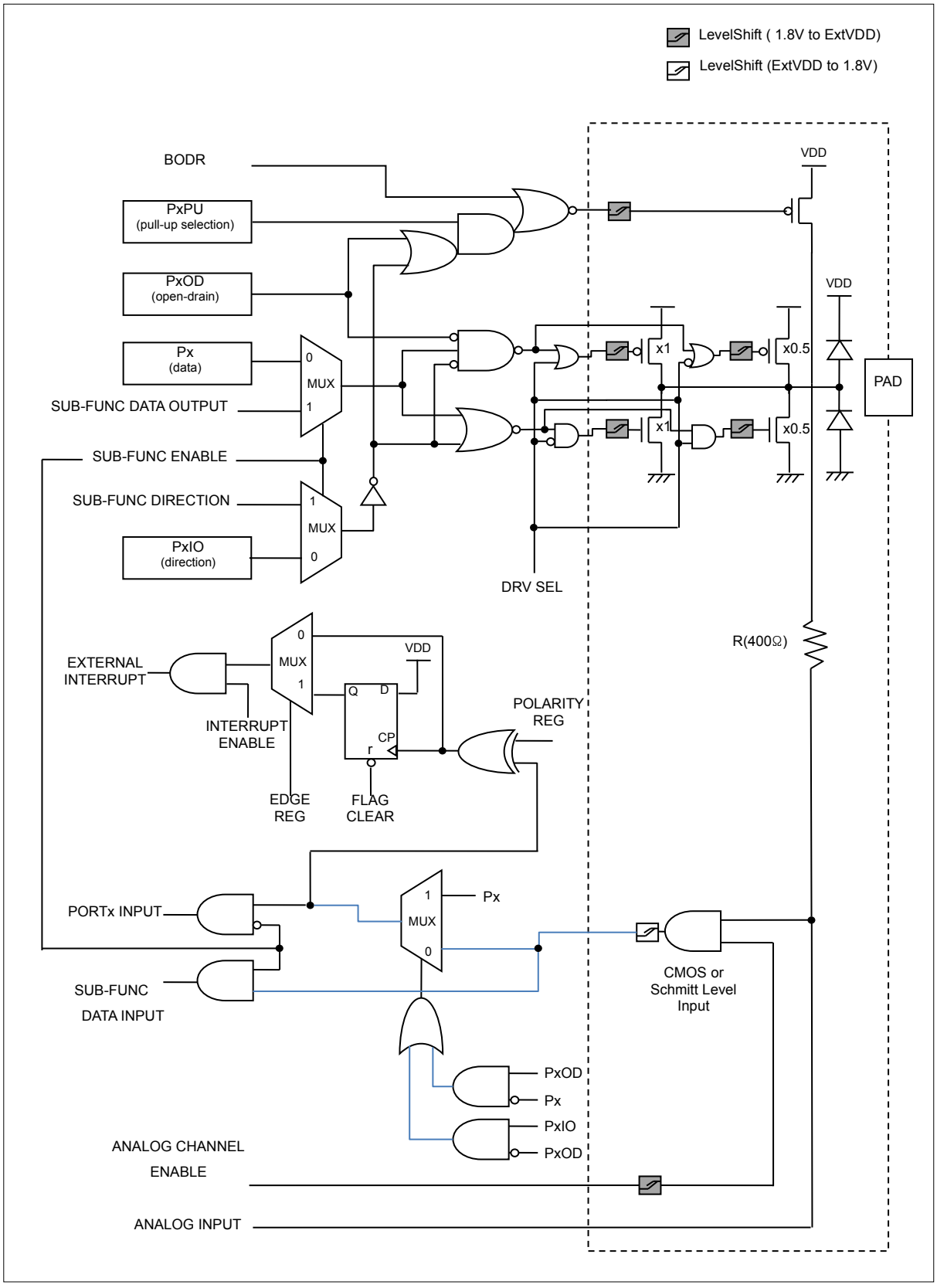


Figure 6.3 I/O with external interrupt function & selectable drive strength

6.4 REM OD Port

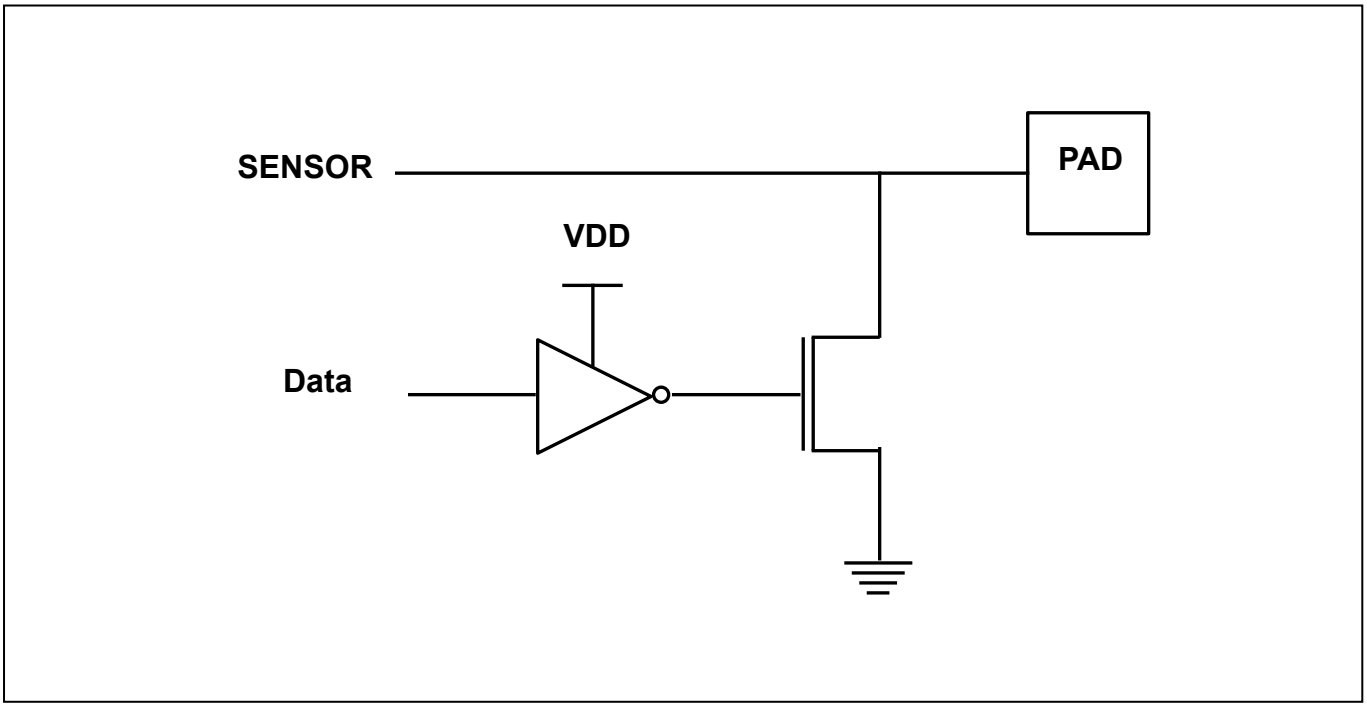


Figure 6.4 REM_OD Port

7 Electrical Characteristics

7.1 Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Supply Voltage NOTE	VDD	-0.3~+4.0	V
	VSS	-0.3~+0.3	V
Normal Voltage Pin	VI	-0.3~VDD+0.3	V
	VO	-0.3~VDD+0.3	V
	IOH	10	mA
	∑IOH	80	mA
	IOL	20	mA
	∑IOL	160	mA
Total Power Dissipation	PT	600	mW
Storage Temperature	TSTG	-45~+125	℃

Table 7.1 Absolute Maximum Ratings

NOTE Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

7.2 Recommended Operating Conditions

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Supply Voltage	VDD		1.71	-	3.6	V
	VDD_IR		1.71	-	3.6	V
Operating Temperature	T_{OPR}		-20	-	70	℃
Operating Frequency	F_{OPR}		1	-	12	MHz

Table 7.2 Recommended Operating Conditions

7.3 BROWN OUT DETECTOR(BOD) CHARACTERISTICS

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Detection Level	V_{BODR}	NOTE	1.49	1.52	1.57	V
	V_{BODI0}	NOTE	1.60	1.63	1.69	V
	V_{BODI1}	NOTE	1.70	1.80	1.90	V
	V_{BODI2}	NOTE	1.90	2.00	2.10	V
	V_{BODI3}	NOTE	2.10	2.20	2.30	V
	V_{BODI4}	NOTE	2.30	2.40	2.50	V
Startup time	t_{BODS}			30	50	us
Detection time	t_{BODD}		1.6	2		us
Operating Current	IDD	-	-	20	40	uA

Table 7.3 Brown Out Detector Characteristics

NOTE V_{BODR} is a voltage level and BODR flag indicating it can generate internal reset due to voltage drop. When the external power drops below the V_{BODR} voltage level, the BOD detects the power condition and makes the device enter STOP-like mode called BOD mode. When the external power is restored, a BOD reset is generated according to pre-defined sequence and the device is initialized. $V_{BODI0/1/2/3/4}$ also indicate voltage levels and BODI0/1/2/3/4 are these flags. When the external power drops below the level indicated in above table, the associated flag is set to '1' and these values can be read through the BODSR register. These flags may be used to monitor the status of battery charging.

7.4 RAM Data Retention CHARACTERISTICS

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Data Retention Supply Voltage	V_{DR}		1.0			V
Data Retention Supply Current	I_{DR}	VDD=1.0V			20	uA

Table 7.4 RAM data retention Characteristics

7.5 FLASH CHARACTERISTICS

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Flash Read Supply Voltage	V_{READ}		V_{BODR}		3.6	V
Flash write Supply Voltage	V_{WRITE}	NOTE1	1.6		3.6	V
Page Erase Time NOTE2	t_{ERS}	32bytes		2.5		ms
Page Program Time NOTE2	t_{PGM}	1byte ~ 32bytes		2.5		ms
Program/Erase Cycle			10,000			Cycles
Data Retention			10			Years

Table 7.5 FLASH Characteristics

NOTE1 The recommended minimum voltage of FLASH write is V_{BODI0}. If FLASH is to be written, the VDD level has to be checked with V_{BODI0}.

NOTE2 Flash erase and program time should be set 2.5ms that is recommended time to guarrantee retention and endurance

7.6 Internal RC Oscillator CHARACTERISTICS

Parameter	Symbol	Condition		MIN	TYP	MAX	Unit
IRC Frequency	f_{IRC}				12		MHz
IRC Frequency Variability NOTE	f_{IRC_VAR}	VDD = 1.71V~3.6V	T_A = +15˚C ~ +40˚C	-0.5	-	+0.5	%
			T_A = -20˚C ~ +70˚C	-1.0	-	+1.0	

Table 7.6 Internal RC Oscillator Characteristics

NOTE : It is possible to proceed with user trim

7.7 Internal RING Oscillator CHARACTERISTICS

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Supply Voltage	VDD		V_{BODR}	-	3.6	V
Frequency	f_{IRING}	-20~+70℃	0.5	1	1.5	MHz
Tolerance	$f_{RINGTOL}$	-20~+70℃	-50	-	+50	%

Table 7.7 Internal RING Oscillator Characteristics

7.8 Learning Amplifier CHARACTERISTICS

(T_A = -20°C ~ +70°C)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
IR AMP Input Low Detection	I_{DL}	Pull up register 120kΩ Input signal 38KHz	1.6	-	-	uA
IR AMP Input High Detection	I_{DH}		-	-	0.2	uA
IR AMP Learning Voltage Range	V_{LR}		1.71		3.6	V
IR Learning distance Range	D_{LR}	Room Temp. 60k~200kΩ	0.5		20	cm

Table 7.8 Learning Amplifier Characteristics

7.9 Learning Respose Time CHARACTERISTICS

(T_A = -20°C ~ +70°C)

Parameter[NOTE]	Symbol	Condition	MIN	TYP	MAX	Unit
IR Learning response time(rising)	T_{LR}	Pull up register 120kΩ Carrier Frequency 24kHz Tryangular waveform	-	200	350	ns
IR Learning response time(Falling)	T_{LF}		-	100	150	ns
IR Learning response time(rising)	T_{LR}	Pull up register 120kΩ Carrier Frequency 100kHz Tryangular waveform	-	90	120	ns
IR Learning response time(Falling)	T_{LF}		-	150	250	ns

Table 7.9 IR Learning Response time Characteristics

[NOTE] The value is guaranteed by design and is not tested.

7.10 POWER-ON RESET CHARACTERISTICS

(T_A = -20°C ~ +70°C)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
RESET Release Level(Rising)	V_{PORr}	-		1.3		V
RESET Release Level(Falling)	V_{PORf}	-		1.1		
POR Current	I_{POR}	-		0.5		uA

Table 7.10 Power-On Reset Characteristics

7.11 DC CHARACTERISTICS

(T_A = -20°C ~ +70°C)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Input Low Voltage	VIL	VDD=1.71V~3.6V	0	-	0.2VDD	V
Input High Voltage	VIH	VDD=1.71V~3.6V	0.8VDD	-	VDD	V
Output Low Voltage of P0, P1 and P2	VOL	VDD=3.6V, IOL= 10mA VDD=1.71V, IOL= 5mA	-	0.3	0.5	V
Output High Voltage of P0, P1 and P2	VOH	VDD=3.6V, IOH= -5mA VDD=1.71V, IOH= -3mA	VDD-1.0	VDD-0.4	-	V
Output Low Voltage of P0[3:2]	VOL2 NOTE1	VDD=3.6V, IOL= 10mA VDD=1.71V, IOL= 5mA	-	0.5	-	V
Output High Voltage of P0[3:2]	VOH2 NOTE1	VDD=3.6V, IOH= -5mA VDD=1.71V, IOH= -3mA	VDD-0.3	VDD-0.6	-	V
REM_OD Output Low current	REM_IOL	VDD = 1.71V VDD = 1.8V VDD = 3.6V(@ T_A = -25°C)	125 200 700			mA
REM_OD Sink Current	IREM_OD	VDD=1.71V~3.6V VREM_OD ≥ 0.25V	200			mA
Input High Leakage Current	IIH	VDD=1.71V~3.6V			1	uA
Input Low Leakage Current	IIL	VDD=1.71V~3.6V	-1			uA
Pull-Up Resistors	RPU	VDD=1.71V~3.6V, V_{IN} = 0V	40	70	100	kΩ
Power Supply Current	IDD1	RUN Mode, f_{XIN}=12MHz@3.6V	-	2.5	4.0	mA
Power Supply Current	IDD2	SLEEP Mode, f_{XIN}=12MHz@3.6V	-	1.6	3.0	mA
Power Supply Current	IDD3	STOP Mode @3.6V NOTE2	-	1	15	uA
	IDD4	STOP Mode @3.6V T-key strobe		1.5	15	uA

Table 7.11 DC Characteristics

NOTE1 P0[3:2] only when corresponding PMISC3[7:6] bit is set to '1'

NOTE2 If the device is in stop mode, BOD is disabled automatically

7.12 AC Characteristics

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Parameter	Symbol	PIN	MIN	TYP	MAX	Unit
Operating Frequency	fMCP	XIN	0	-	12	MHz
System Clock Cycle Time	tSYS	-	83	-		ns
Oscillation Stabilization Time (8MHz) @Ceramic	tMST1	XIN, XOUT	-	-	10	ms
External Clock “H” or “L” Pulse Width	tCPW	XIN	40	-	-	ns
External Clock Transition Time	tRCP,tFCP	XIN	-	-	10	ns
Interrupt Input Width	tIW	INT0~INT5	-	10	-	ns
RESETB Input Pulse “L” Width	tRST	RESETB	-	8	-	us

Table 7.12 AC Characteristics

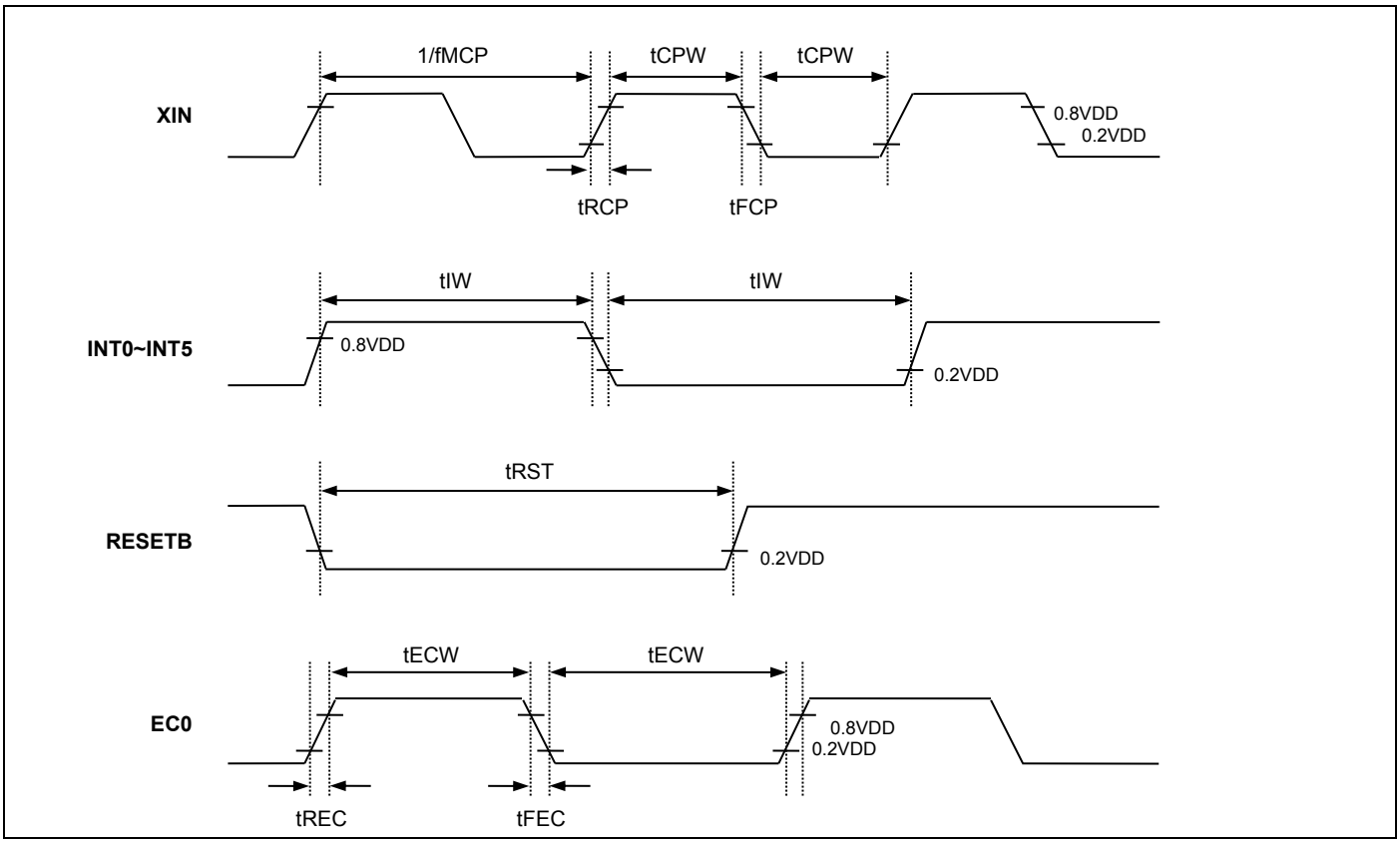


Figure 7.1 AC Timing

7.13 I2C CHARACTERISTICS

The following table and figure show the timing codition of SDA and SCL bus lines for I²C bus devices.

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Parameter NOTE1	Symbol	STANDARD MODE		FAST MODE		Unit
		Min	Max	Min	Max	
SCL clock frequency	f_{SCL}	0	100	0	400	kHz
Hold time after (repeated) START condition. After this period, the first clock pulse is generated	$t_{HD;STA}$	4.0	-	0.6	-	us
LOW period of the SCL clock	t_{LOW}	4.7	-	1.3	-	us
HIGH period of the SCL clock	t_{HIGH}	4.0	-	0.6	-	us
Setup time for a repeated START condition	$t_{SU;STA}$	4.7	-	0.6	-	us
Data hold time	$t_{HD;DAT}$	0	3.45	0	0.9	us
Data setup time	$t_{SU;DAT}$	100	-	100	-	ns
Clock/data fall time	t_F	0	300	0	300	ns
Clock/data rise time	t_R	0	1000	0	300	ns
Setup time for STOP condition	$t_{SU;STO}$	4.0	-	0.6	-	us
Bus free time between a STOP and START condition	t_{BUF}	4.7	-	1.3	-	us

Table 7.13 Timing characteristics of I2C

NOTE1 All timing is shown with respect to 20% VDD and 80% VDD.

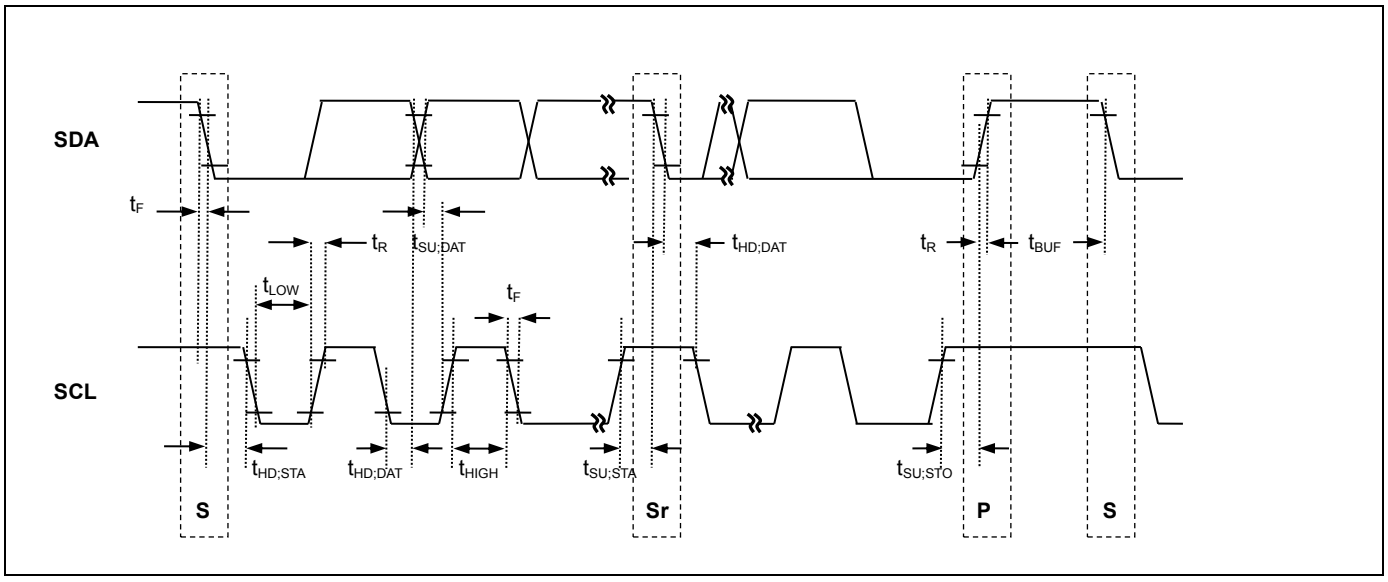


Figure 7.2 Timing diagram of I2C

7.14 USART Characteristics

The following table and figure show the timing condition of USART in SPI or Synchronous mode of operation. The USART is one of peripherals in A96R136.[NOTE1].

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Parameter	Symbol[NOTE2]	MIN	MAX	Unit
System clock period(@12Mhz)	t_{SCLK}	83	1000	ns
Clock (XCK) period				
Master	t_{XCK}	2	1024	t_{SCLK}
Slave	t_{XCK}	4	-	
Lead time				
Master	t_{LEAD}		0.5	tXCK
Slave	t_{LEAD}	0.5		
Lag time				
Master	t_{LAG}		0.5	tXCK
Slave	t_{LAG}	0.5		
Data setup time (inputs)				
Master	t_{SIM}	30		ns
Slave	t_{SIS}	30		
Data hold time (inputs)				
Master	t_{HIM}	1		t_{SCLK}
Slave	t_{HIS}	1		
Data setup time (outputs)				
Master	t_{SOM}	30		ns
Slave	t_{SOS}	30		
Data hold time (outputs)				
Master	t_{HOM}	30		ns
Slave	t_{HOS}	30		
Disable time	t_{DIS}	1		t_{SCLK}

Table 7.14 Timing characteristics of USART in SYNC. or SPI mode of operations

[NOTE1] In synchronous mode, Lead and Lag time with respect to SS pin is ignored. And the case of UCPHA=0 is also applied to SPI mode only.

[NOTE2] All timing is shown with respect to 20% VDD and 80% VDD.

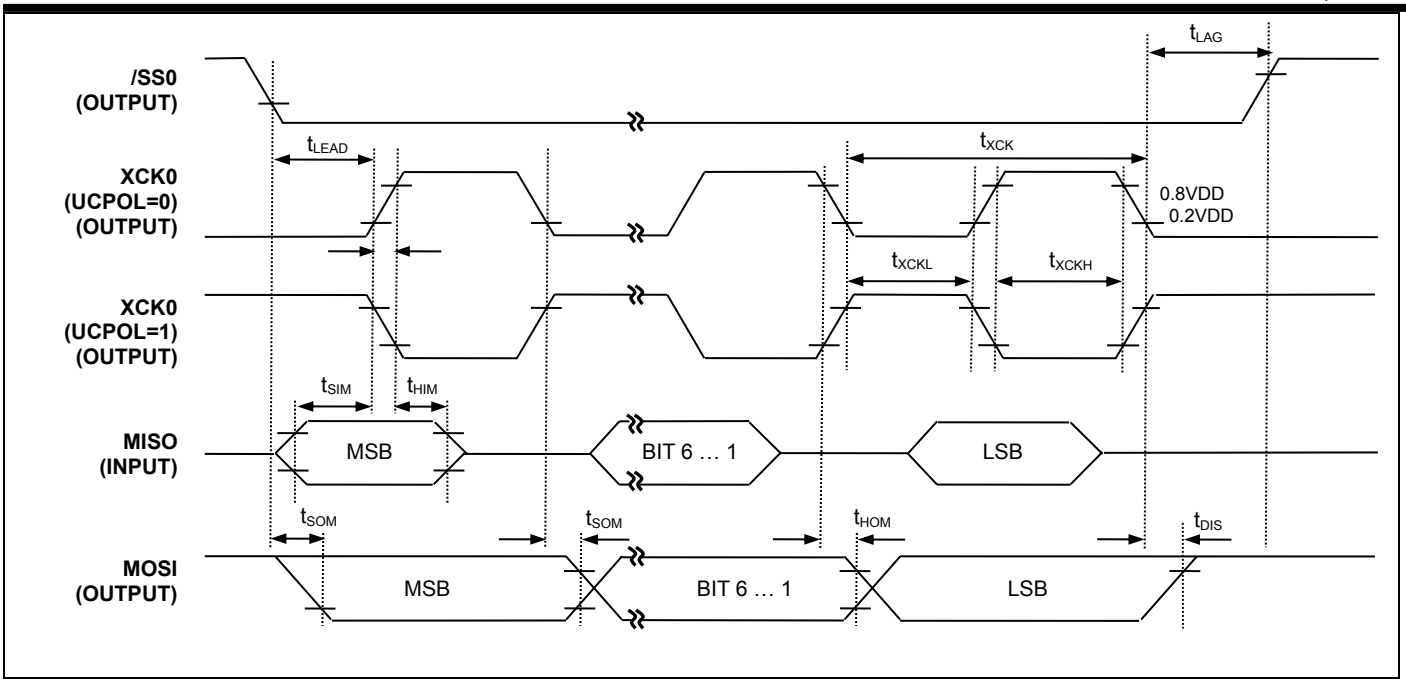


Figure 7.3 SPI master mode timing (UCPHA = 0, MSB first)

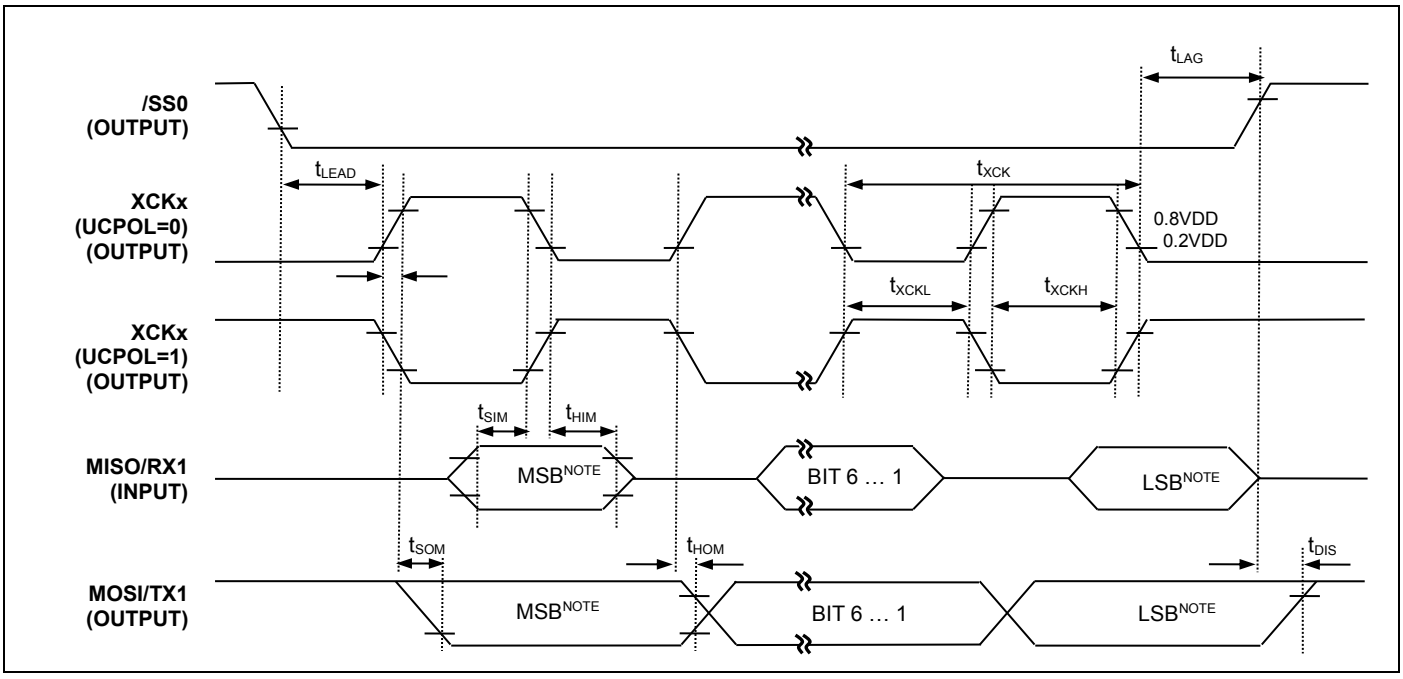


Figure 7.4 SPI / Synchronous master mode timing (UCPHA = 1, MSB first)

NOTE When in Synchronous mode, the START bit becomes MSB and the 1st or 2nd STOP bit becomes LSB.

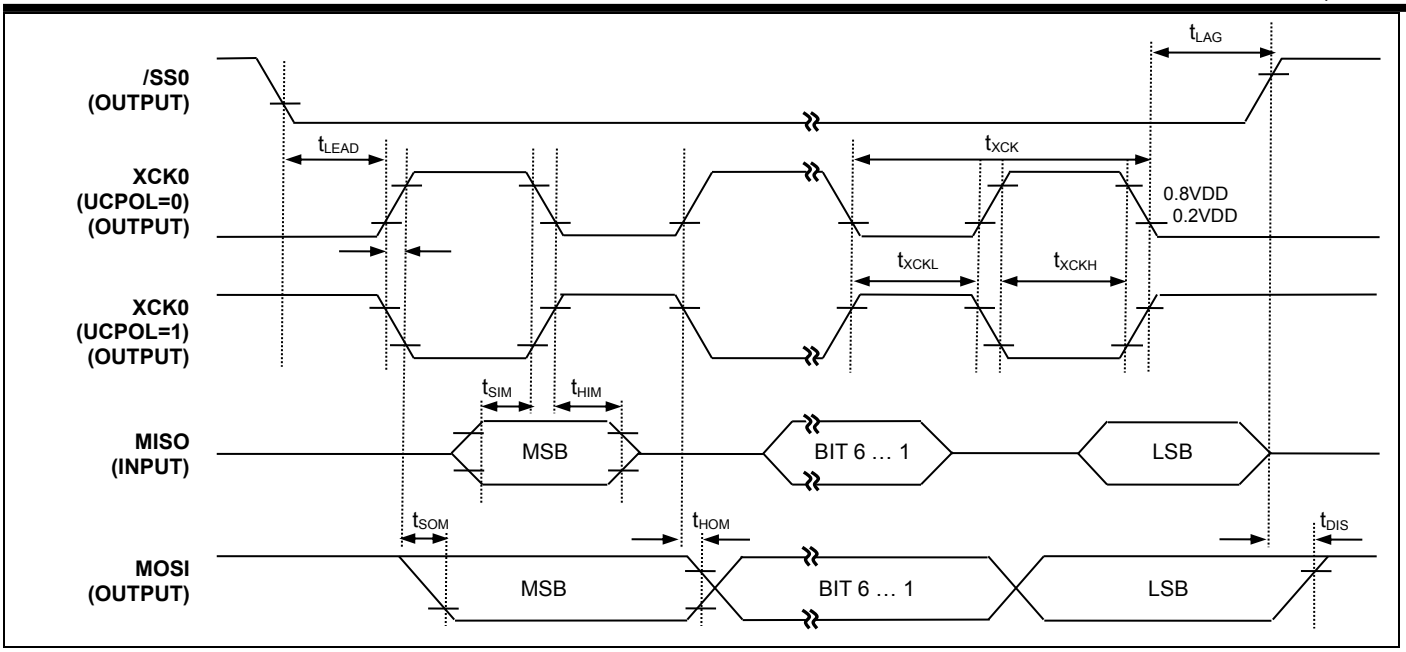


Figure 7.5 SPI slave mode timing (UCPHA = 0, MSB first)

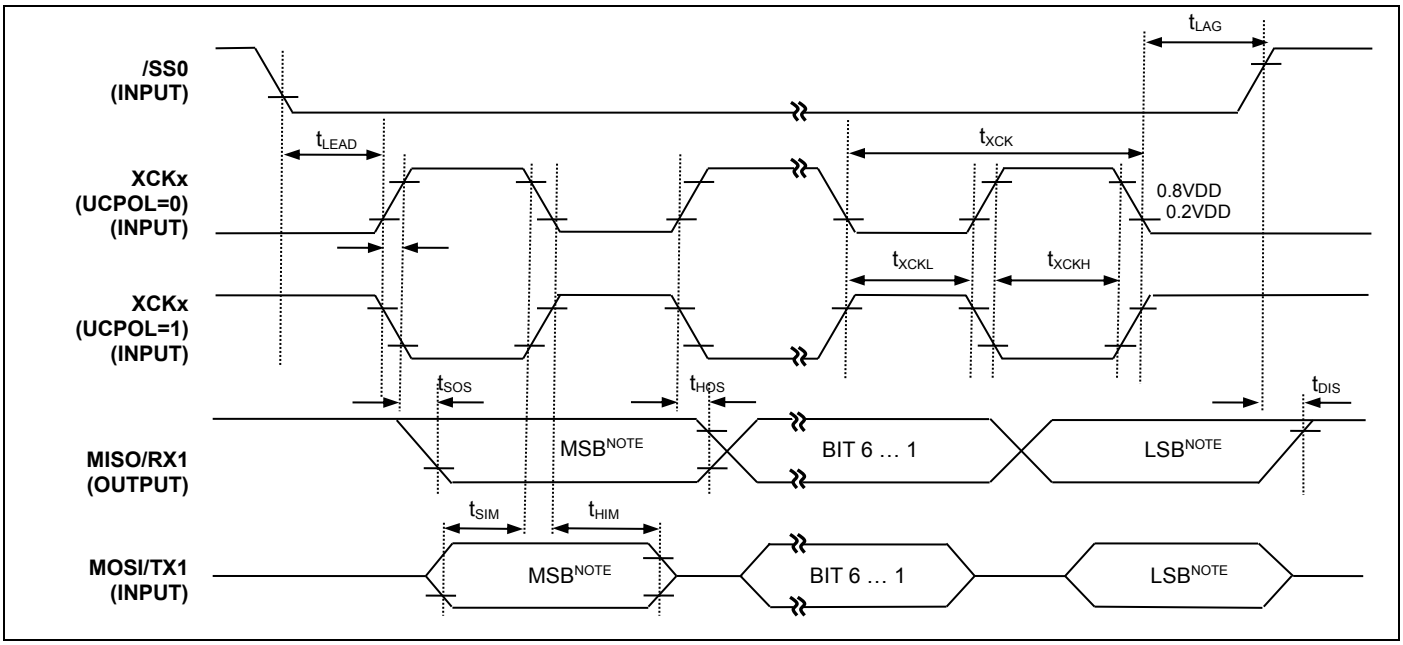


Figure 7.6 SPI / Synchronous slave mode timing (UCPHA = 1, MSB first)

NOTE When in Synchronous mode, the START bit becomes MSB and the 1st or 2nd STOP bit becomes LSB.

7.15 T-key Scan CHARACTERISTICS

The following table and figure show the timing condition of T-Key .T-key scan is available as an option in MCU stop mode

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Parameter NOTE	Symbol	MIN	TYP	MAX	Unit
Strobe start time	t_{LEAD}	1	3	5	ms
Strobe rising time	t_{HIGH}	-	2	-	us
Strobe falling time	t_{LOW}	-	1	-	us
Strobe Duty time	t_{DUTY}	-	800	1000	us
Strobe period	t_{PERIOD}	-	13	15	ms
Strobe end to strobe start time	t_{GAP}	-	250	400	us
KS interrupt to Stop mode wake up time	t_{LAG}	-	10 NOTE1	-	ms
T-key strobe current consumption		-	1.5	15	uA

Table 7.15 Timing characteristics of T-key scan in MCU stop mode

NOTE When main clock is in 12Mhz condition.

NOTE1 When BCCR register value is 0x57(default) condition.

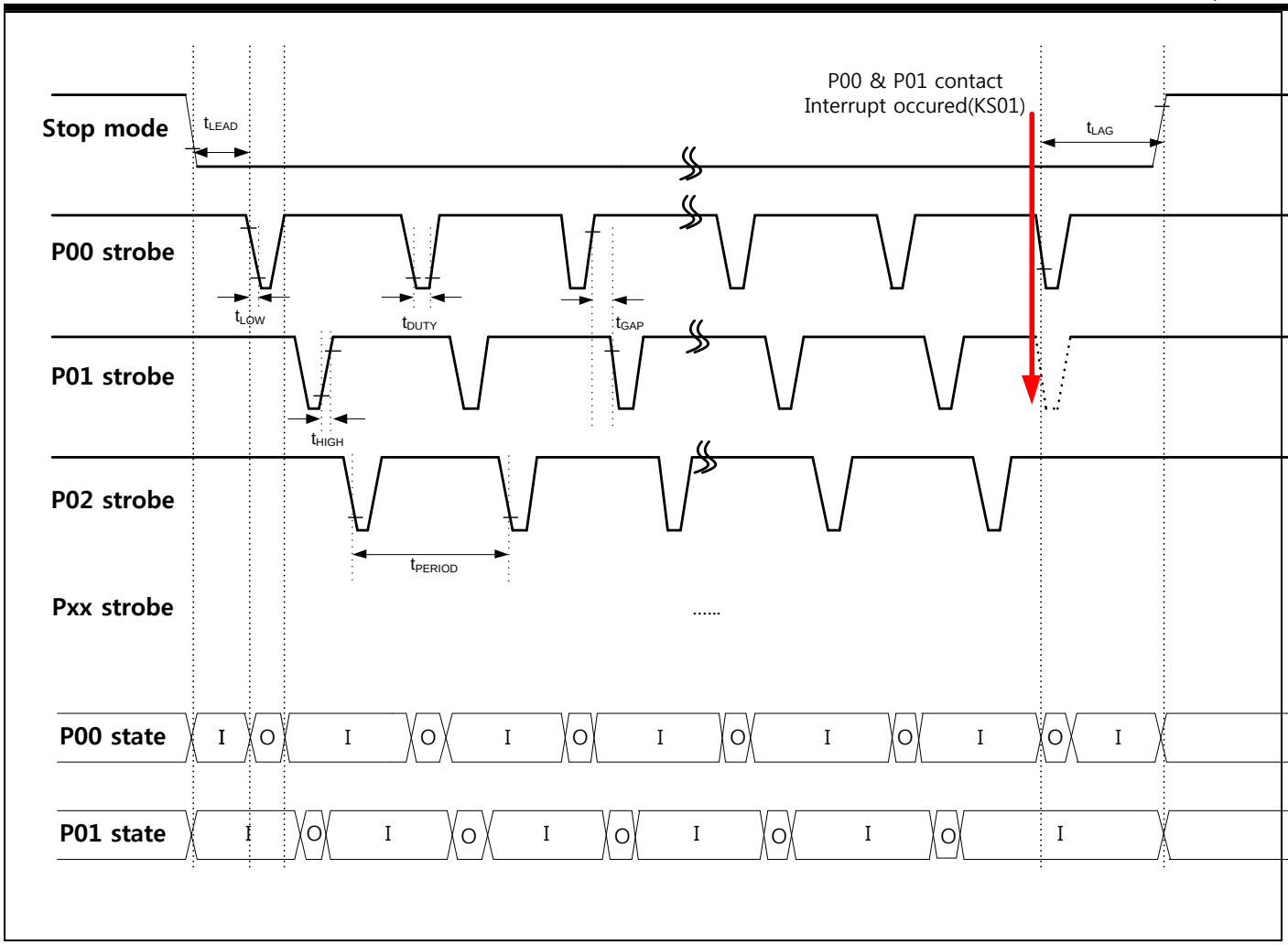


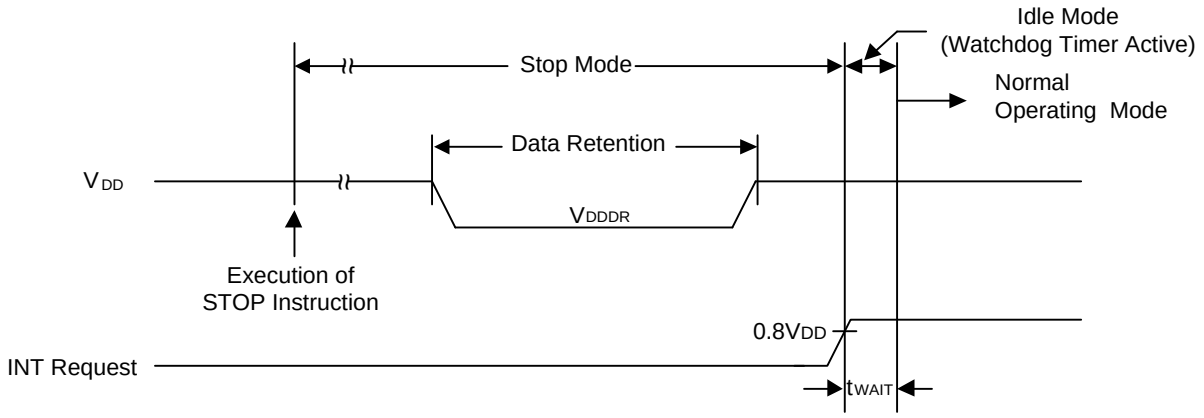
Figure 7.7 T-key Scan timing

7.16 Data Retention Voltage in Stop Mode

(T_A = -20°C ~ +70°C, VDD = Vpor ~ 3.6V)

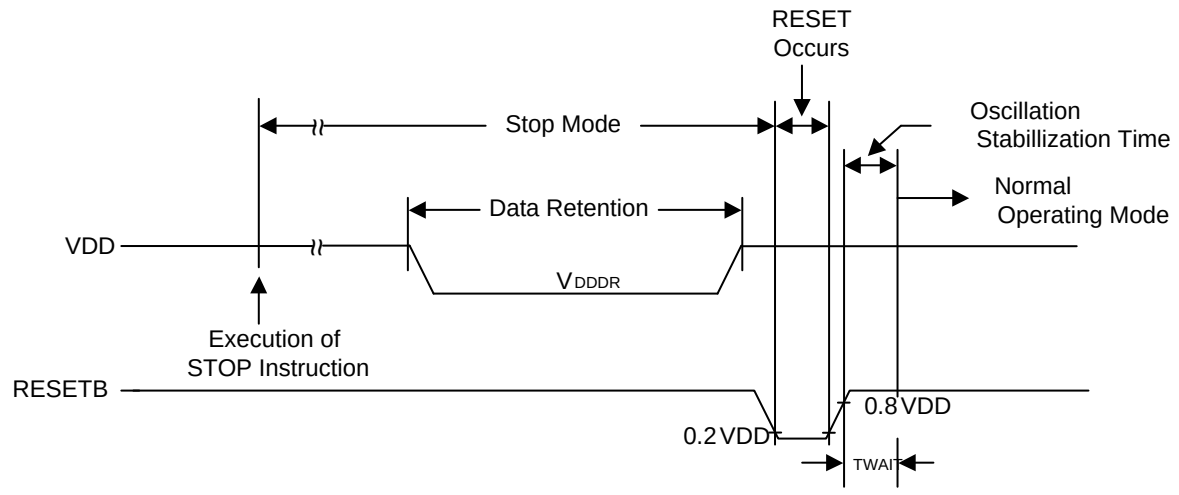
Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Data retention supply voltage	V_{DDDR}	–	Vpor	–	Vmax	V
Data retention supply current	I_{DDDR}	V_{DDR} = 1.65V(T_A = 25°C), Stop mode	–	–	1	uA

Table 7.16 Data Retention Voltage in Stop Mode



NOTE: tWAIT is the same as (the selected bit overflow of BIT) X 1/(BIT Clock)

Figure 7.8 Stop Mode Release Timing when Initiated by an Interrupt



NOTE : tWAIT is the same as (4096 X 4 X 1/fx) (16.4ms @ 1MHz)

Figure 7.9 Stop Mode Release Timing when Initiated by RESETB

7.17 Input/Output Capacitance

(T_A = -20°C ~ +70°C, VDD = 1.71~3.6V)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Input Capacitance	C_{IN}	fx= 1MHz Unmeasured pins are connected to VSS	–	–	10 NOTE	pF
Output Capacitance	C_{OUT}					
I/O Capacitance	C_{IO}					

Table 7.17 Input/Output Capacitance

NOTE The value is guaranteed by design and is not tested.

7.18 Main Clock Oscillator Characteristics

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Oscillator	Parameter	Condition	MIN	TYP	MAX	Unit
Crystal	Main oscillation frequency	1.71V – 3.6V	1	–	12.0	MHz
Ceramic Oscillator	Main oscillation frequency	1.71V – 3.6V	1	–	12.0	MHz
External Clock	XIN input frequency	1.71V – 3.6V	1	–	12.0	MHz

Table 7.18 Main Clock Oscillator Characteristics

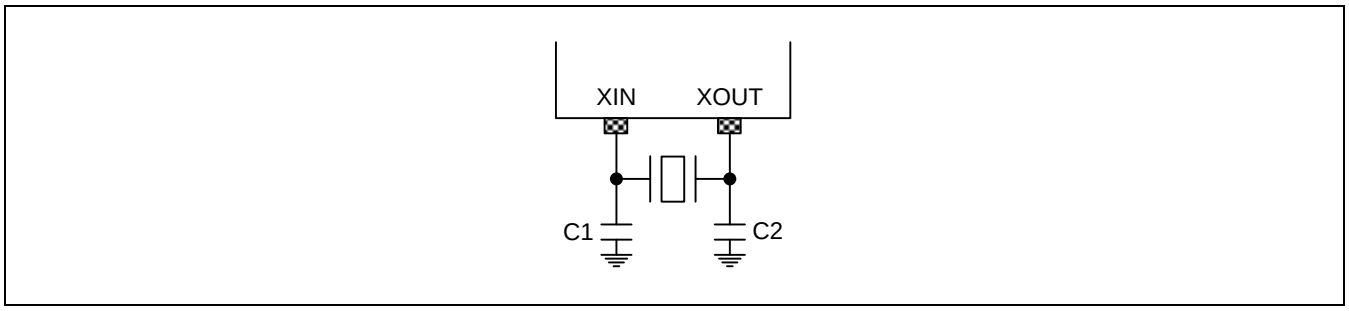


Figure7.10 Crystal/Ceramic Oscillator

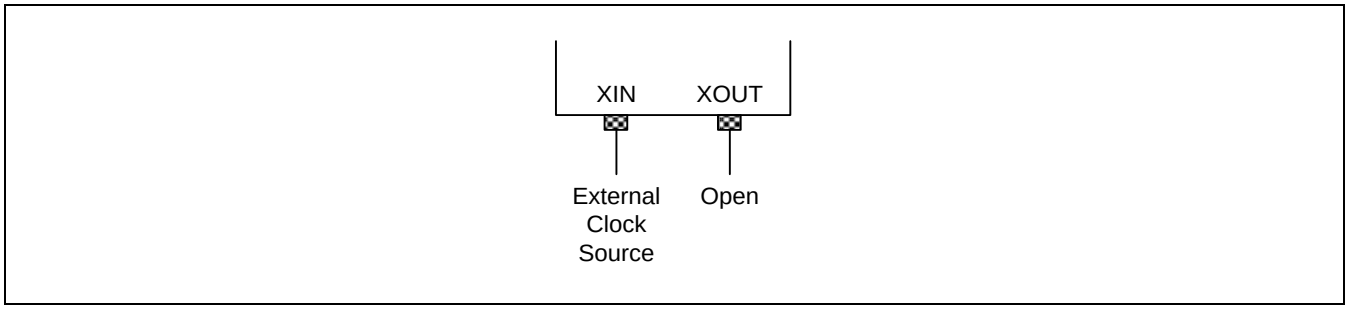


Figure 7.11 External Clock

7.19 Main Oscillation Stabilization Characteristics

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Oscillator	Parameter	MIN	TYP	MAX	Unit
Crystal	fx > 4MHz, VDD = 1.71V ~ 3.6V,	–	NOTE –	15	ms
	fx > 1MHz, VDD = 1.71V, T_A=-20°C			60	
Ceramic	-	–	NOTE –	10	ms
External Clock	f_{XIN} = 1 to 12MHz XIN input high and low width (t_{XH}, t_{XL})	42	NOTE –	1250	ns

Table 7.19 Main Oscillation Stabilization Characteristics

NOTE The value is guaranteed by design and is not tested.

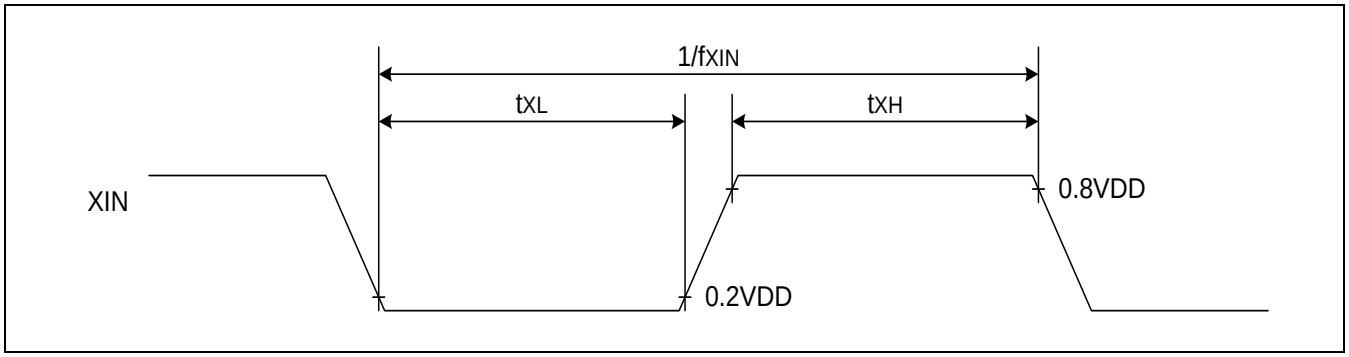


Figure 7.12 Clock Timing Measurement at XIN

7.20 Internal Oscillation Stabilization Characteristics

(T_A = -20°C ~ +70°C, VDD = 1.71V ~ 3.6V)

Oscillator	Parameter	MIN	TYP	MAX	Unit
Internal RC	f_X = 12MHz	-	10 NOTE	20	us

Table 7.20 Internal Oscillation Stabilization Characteristics

NOTE The value is guaranteed by design and is not tested.

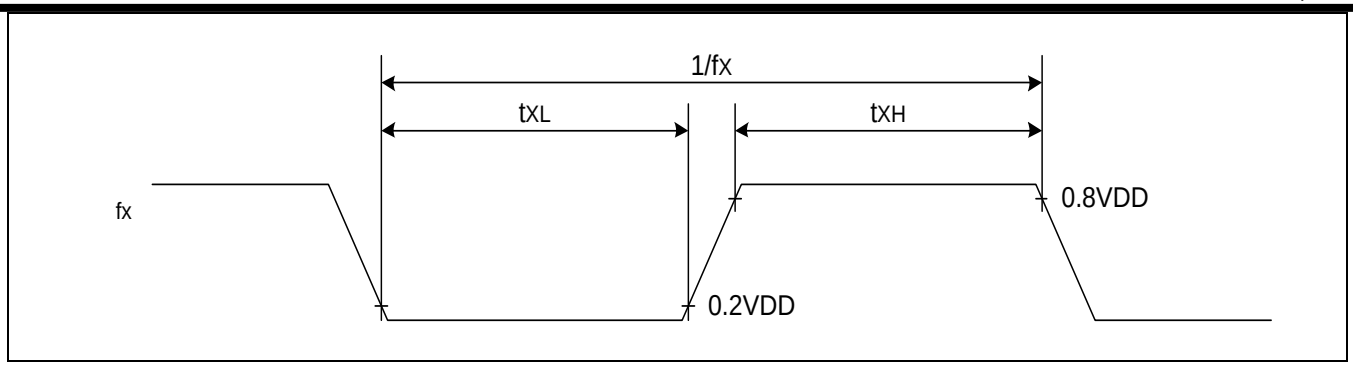


Figure 7.13 Clock Timing Measurement at fx

7.21 Operating Voltage Range

(T_A = -20°C ~ +70°C)

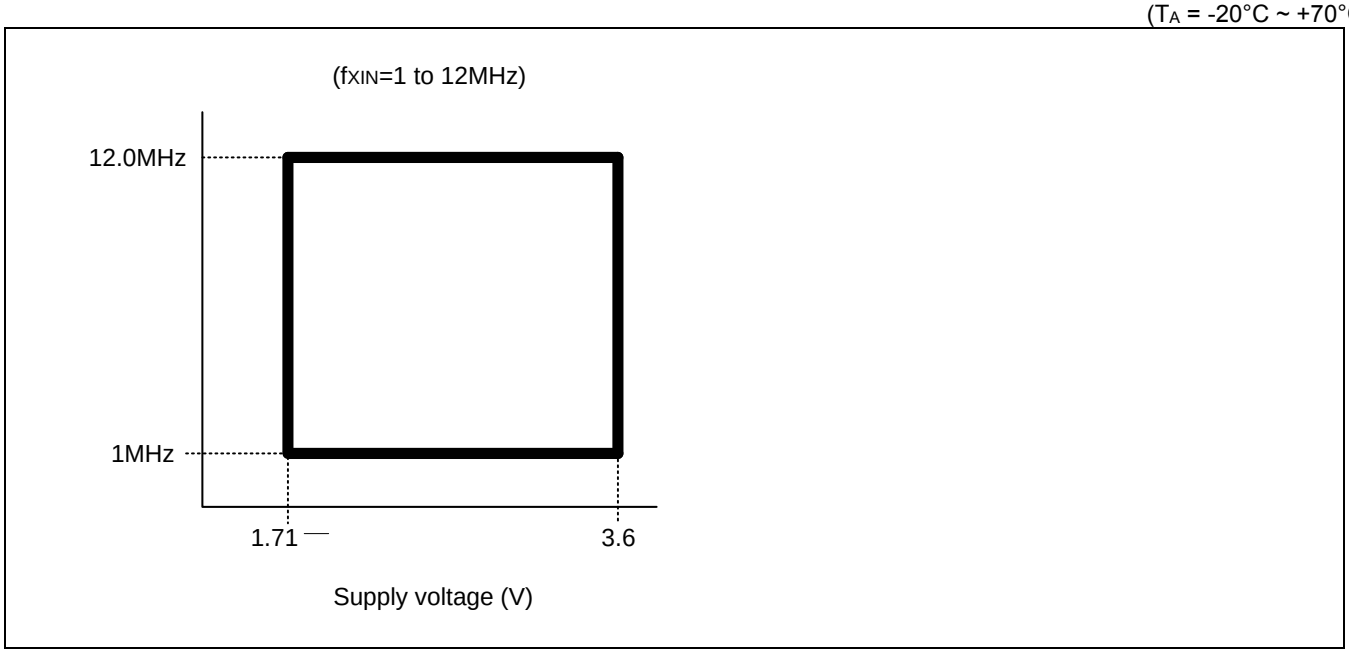


Figure 7.14 Operating Voltage Range

7.22 REM_PP_OUT PORT CHARACTERISTICS

(T_A = -20°C ~ +70°C)

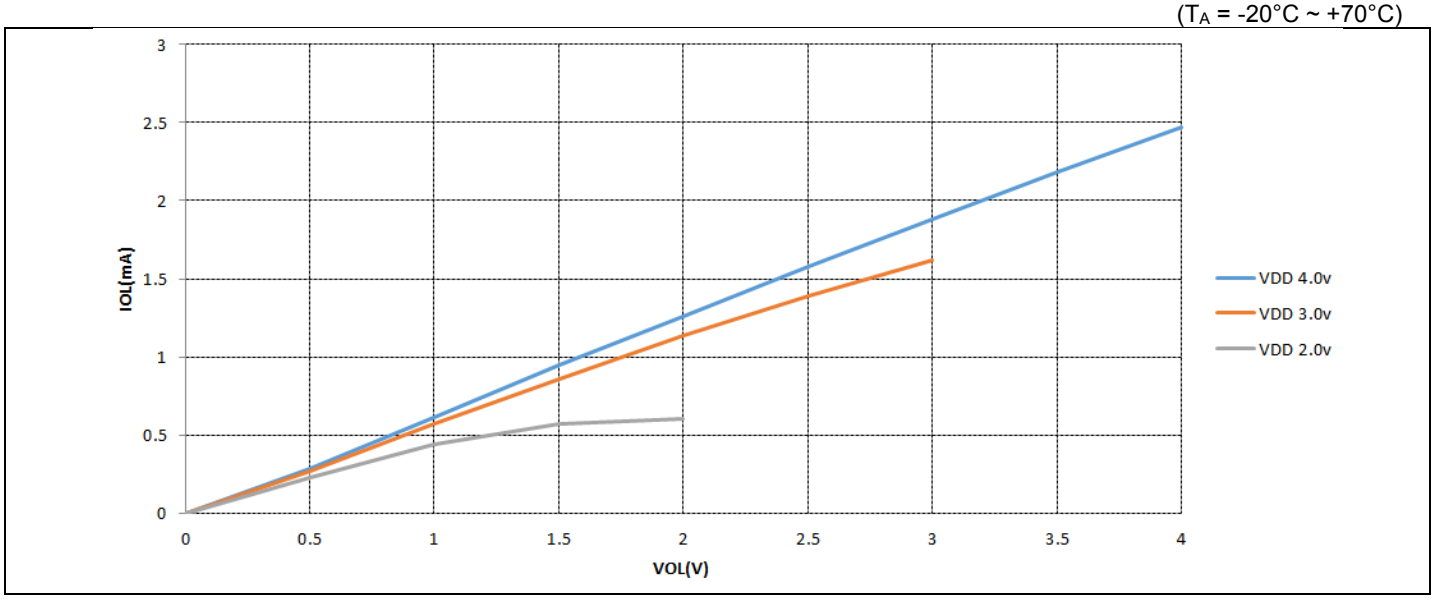


Figure 7.15 IOL vs VOL for REM_PP_OUT

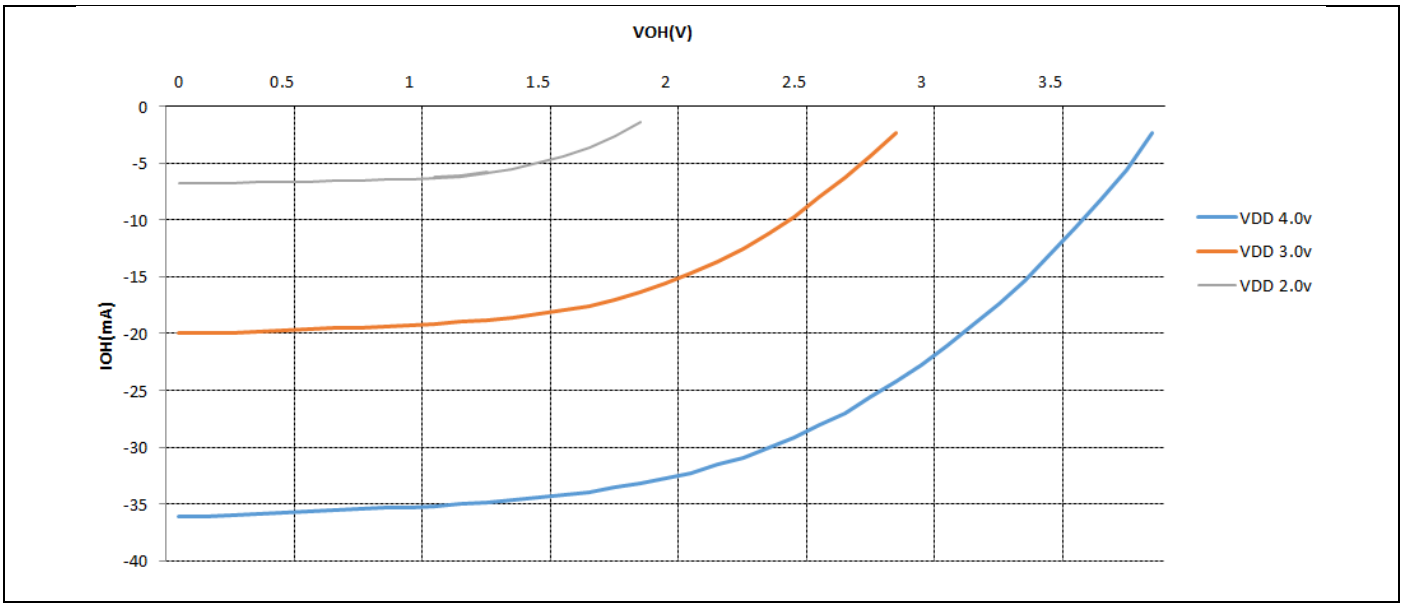


Figure 7.16 IOH vs VOH for REM_PP_OUT

7.23 REM_OD_OUT PORT CHARACTERISTICS

The characteristics of REM_OD_OUT are related with VDD_IR, not VDD.

(T_A = -20°C ~ +70°C)

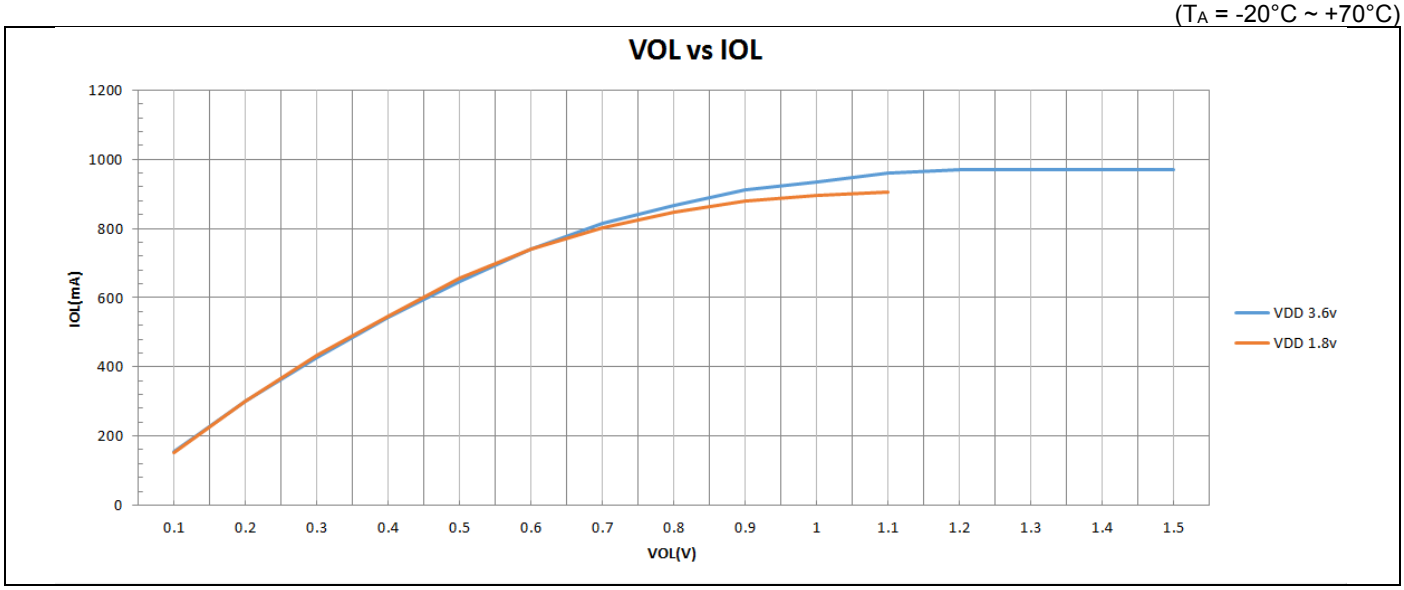


Figure 7.17 IOL vs IOH for REM_OD_OUT

The characteristics of REM_PP_OUT are related with VDD, not VDD_IR.

8. APPENDIX

A. Instruction Table

The instruction length of M8051W can be 1, 2, or 3 bytes as listed in the following table. It takes 1, 2, or 4 cycles for the CPU to execute an instruction. The cycle is composed of two internal clock periods.

ARITHMETIC				
Mnemonic	**Description**	**Bytes**	**Cycles**	**Hex code**
ADD A,Rn	Add register to A	1	1	28-2F
ADD A,dir	Add direct byte to A	2	1	25
ADD A,@Ri	Add indirect memory to A	1	1	26-27
ADD A,#data	Add immediate to A	2	1	24
ADDC A,Rn	Add register to A with carry	1	1	38-3F
ADDC A,dir	Add direct byte to A with carry	2	1	35
ADDC A,@Ri	Add indirect memory to A with carry	1	1	36-37
ADDC A,#data	Add immediate to A with carry	2	1	34
SUBB A,Rn	Subtract register from A with borrow	1	1	98-9F
SUBB A,dir	Subtract direct byte from A with borrow	2	1	95
SUBB A,@Ri	Subtract indirect memory from A with borrow	1	1	96-97
SUBB A,#data	Subtract immediate from A with borrow	2	1	94
INC A	Increment A	1	1	04
INC Rn	Increment register	1	1	08-0F
INC dir	Increment direct byte	2	1	05
INC @Ri	Increment indirect memory	1	1	06-07
DEC A	Decrement A	1	1	14
DEC Rn	Decrement register	1	1	18-1F
DEC dir	Decrement direct byte	2	1	15
DEC @Ri	Decrement indirect memory	1	1	16-17
INC DPTR	Increment data pointer	1	2	A3
MUL AB	Multiply A by B	1	4	A4
DIV AB	Divide A by B	1	4	84
DA A	Decimal Adjust A	1	1	D4

LOGICAL				
Mnemonic	**Description**	**Bytes**	**Cycles**	**Hex code**
ANL A,Rn	AND register to A	1	1	58-5F
ANL A,dir	AND direct byte to A	2	1	55
ANL A,@Ri	AND indirect memory to A	1	1	56-57
ANL A,#data	AND immediate to A	2	1	54
ANL dir,A	AND A to direct byte	2	1	52
ANL dir,#data	AND immediate to direct byte	3	2	53
ORL A,Rn	OR register to A	1	1	48-4F
ORL A,dir	OR direct byte to A	2	1	45
ORL A,@Ri	OR indirect memory to A	1	1	46-47
ORL A,#data	OR immediate to A	2	1	44
ORL dir,A	OR A to direct byte	2	1	42
ORL dir,#data	OR immediate to direct byte	3	2	43
XRL A,Rn	Exclusive-OR register to A	1	1	68-6F
XRL A,dir	Exclusive-OR direct byte to A	2	1	65
XRL A, @Ri	Exclusive-OR indirect memory to A	1	1	66-67

XRL A,#data	Exclusive-OR immediate to A	2	1	64
XRL dir,A	Exclusive-OR A to direct byte	2	1	62
XRL dir,#data	Exclusive-OR immediate to direct byte	3	2	63
CLR A	Clear A	1	1	E4
CPL A	Complement A	1	1	F4
SWAP A	Swap Nibbles of A	1	1	C4
RL A	Rotate A left	1	1	23
RLC A	Rotate A left through carry	1	1	33
RR A	Rotate A right	1	1	03
RRC A	Rotate A right through carry	1	1	13

DATA TRANSFER				
Mnemonic	**Description**	**Bytes**	**Cycles**	**Hex code**
MOV A,Rn	Move register to A	1	1	E8-EF
MOV A,dir	Move direct byte to A	2	1	E5
MOV A,@Ri	Move indirect memory to A	1	1	E6-E7
MOV A,#data	Move immediate to A	2	1	74
MOV Rn,A	Move A to register	1	1	F8-FF
MOV Rn,dir	Move direct byte to register	2	2	A8-AF
MOV Rn,#data	Move immediate to register	2	1	78-7F
MOV dir,A	Move A to direct byte	2	1	F5
MOV dir,Rn	Move register to direct byte	2	2	88-8F
MOV dir,dir	Move direct byte to direct byte	3	2	85
MOV dir,@Ri	Move indirect memory to direct byte	2	2	86-87
MOV dir,#data	Move immediate to direct byte	3	2	75
MOV @Ri,A	Move A to indirect memory	1	1	F6-F7
MOV @Ri,dir	Move direct byte to indirect memory	2	2	A6-A7
MOV @Ri,#data	Move immediate to indirect memory	2	1	76-77
MOV DPTR,#data	Move immediate to data pointer	3	2	90
MOVC A,@A+DPTR	Move code byte relative DPTR to A	1	2	93
MOVC A,@A+PC	Move code byte relative PC to A	1	2	83
MOVX A,@Ri	Move external data(A8) to A	1	2	E2-E3
MOVX A,@DPTR	Move external data(A16) to A	1	2	E0
MOVX @Ri,A	Move A to external data(A8)	1	2	F2-F3
MOVX @DPTR,A	Move A to external data(A16)	1	2	F0
PUSH dir	Push direct byte onto stack	2	2	C0
POP dir	Pop direct byte from stack	2	2	D0
XCH A,Rn	Exchange A and register	1	1	C8-CF
XCH A,dir	Exchange A and direct byte	2	1	C5
XCH A,@Ri	Exchange A and indirect memory	1	1	C6-C7
XCHD A,@Ri	Exchange A and indirect memory nibble	1	1	D6-D7

BOOLEAN				
Mnemonic	**Description**	**Bytes**	**Cycles**	**Hex code**
CLR C	Clear carry	1	1	C3
CLR bit	Clear direct bit	2	1	C2
SETB C	Set carry	1	1	D3
SETB bit	Set direct bit	2	1	D2
CPL C	Complement carry	1	1	B3
CPL bit	Complement direct bit	2	1	B2
ANL C,bit	AND direct bit to carry	2	2	82
ANL C,/bit	AND direct bit inverse to carry	2	2	B0

ORL C,bit	OR direct bit to carry	2	2	72
ORL C,/bit	OR direct bit inverse to carry	2	2	A0
MOV C,bit	Move direct bit to carry	2	1	A2
MOV bit,C	Move carry to direct bit	2	2	92

BRANCHING				
Mnemonic	**Description**	**Bytes**	**Cycles**	**Hex code**
ACALL addr 11	Absolute jump to subroutine	2	2	11→F1
LCALL addr 16	Long jump to subroutine	3	2	12
RET	Return from subroutine	1	2	22
RETI	Return from interrupt	1	2	32
AJMP addr 11	Absolute jump unconditional	2	2	01→E1
LJMP addr 16	Long jump unconditional	3	2	02
SJMP rel	Short jump (relative address)	2	2	80
JC rel	Jump on carry = 1	2	2	40
JNC rel	Jump on carry = 0	2	2	50
JB bit,rel	Jump on direct bit = 1	3	2	20
JNB bit,rel	Jump on direct bit = 0	3	2	30
JBC bit,rel	Jump on direct bit = 1 and clear	3	2	10
JMP @A+DPTR	Jump indirect relative DPTR	1	2	73
JZ rel	Jump on accumulator = 0	2	2	60
JNZ rel	Jump on accumulator ≠ 0	2	2	70
CJNE A,dir,rel	Compare A, direct jne relative	3	2	B5
CJNE A,#d,rel	Compare A, immediate jne relative	3	2	B4
CJNE Rn,#d,rel	Compare register, immediate jne relative	3	2	B8-BF
CJNE @Ri,#d,rel	Compare indirect, immediate jne relative	3	2	B6-B7
DJNZ Rn,rel	Decrement register, jnz relative	2	2	D8-DF
DJNZ dir,rel	Decrement direct byte, jnz relative	3	2	D5

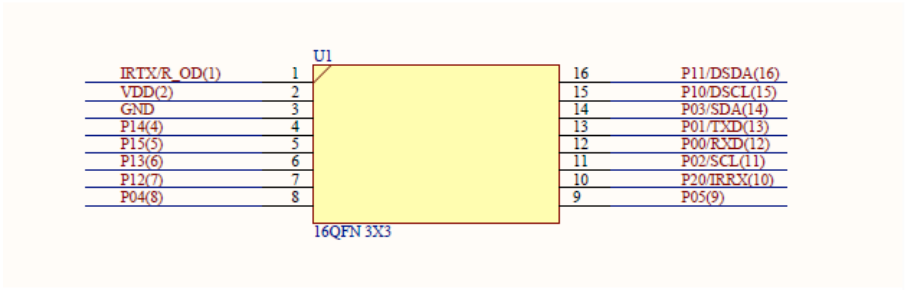
MISCELLANEOUS				
Mnemonic	**Description**	**Bytes**	**Cycles**	**Hex code**
NOP	No operation	1	1	00

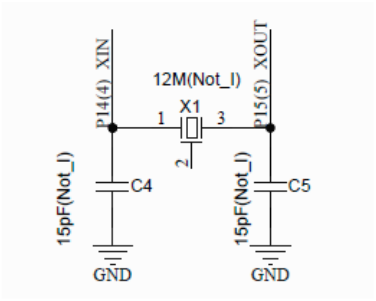
ADDITIONAL INSTRUCTIONS (selected through EO[7:4])				
Mnemonic	**Description**	**Bytes**	**Cycles**	**Hex code**
MOVC @(DPTR++),A	M8051W/M8051EW-specific instruction supporting software download into program memory	1	2	A5
TRAP	Software break command	1	1	A5

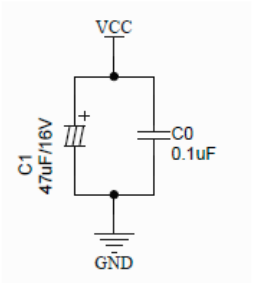
In the above table, an entry such as E8-EF indicates a continuous block of hex opcodes used for 8 different registers, the register numbers of which are defined by the lowest three bits of the corresponding code. Non-continuous blocks of codes, shown as 11→F1 (for example), are used for absolute jumps and calls, with the top 3 bits of the code being used to store the top three bits of the destination address.

The CJNE instructions use the abbreviation #d for immediate data; other instructions use #data.

A. External OSC example schematic.







In fact, the parts are not necessarily worth the IRC must be used in order to obtain a satisfactory error rate. Use common parts

Demo Board Conditions are as follows.

- 12MHz oscillator : HC-49S(+- 20ppm)
- External Osc. Capacitor : ELEPARTS(C1608C0G120J50V) 12pF~15pF Tolerance +-0.25pF

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