

1T 8051
8-bit Microcontroller

NuMicro[®] Family
MS51 Series
Product Brief

The information described in this document is the exclusive intellectual property of Nuvoton Technology Corporation and shall not be reproduced without permission from Nuvoton.

Nuvoton is providing this document only for reference purposes of NuMicro microcontroller based system design. Nuvoton assumes no responsibility for errors or omissions.

All data and specifications are subject to change without notice.

For additional information or questions, please contact: Nuvoton Technology Corporation.

www.nuvoton.com

1 GENERAL DESCRIPTION

The NuMicro® MS51 series is an embedded Flash type, 8-bit high performance 1T 8051-based microcontroller. The instruction set is fully compatible with the standard 80C51 and performance enhanced.

The MS51 series contains up to 32 Kbytes main Flash called APROM, in which the contents of User Code reside. The Flash supports In-Application-Programming (IAP) function, which enables on-chip firmware updates. IAP also makes it possible to configure any block of User Code array to be used as non-volatile data storage, which is written by IAP and read by IAP or MOVC instruction. There is an additional Flash called LDRROM, in which the Boot Code normally resides for carrying out In-System-Programming (ISP). The LDRROM size is configurable with a maximum of 4 Kbytes. To facilitate programming and verification, the Flash allows to be programmed and read electronically by parallel Writer or In-Circuit-Programming (ICP). Once the code is confirmed, user can lock the code for security.

The MS51 series provides rich peripherals including 256 Bytes of SRAM, up to 2 Kbytes of auxiliary RAM (XRAM), Up to 30 general purpose I/O, two 16-bit Timers/Counters 0/1, one 16-bit Timer2 with three-channel input capture module, one Watchdog Timer (WDT), one Self Wake-up Timer (WKT), one 16-bit auto-reload Timer3 for general purpose or baud rate generator, two UARTs with frame error detection and automatic address recognition, one SPI, one I²C, up to 12 enhanced PWM output channels, and one 12-bit ADC. The peripherals are equipped with 18 sources with 4-level-priority interrupts capability.

The MS51 series is equipped with two clock sources and supports switching on-the-fly via software. The clock sources include internal clock inputs, 10 kHz internal oscillator, and one 24 MHz internal precise oscillator that is factory trimmed to $\pm 1\%$ at room temperature. MS51 series provides additional power monitoring detection such as power-on reset and 4-level brown-out detection, which stabilizes the power-on/off sequence for a high reliability system design.

The MS51 series microcontroller consumes very low power with two economic power modes to reduce power consumption — Idle and Power-down mode, which are software selectable. Idle mode turns off the CPU clock but allows continuing peripheral operation. Power-down mode stops the whole system clock for minimum power consumption. The system clock of the MS51 series can also be slowed down by software clock divider, which allows for a flexibility between execution performance and power consumption.

2 FEATURES

- **Operating Characteristics**

- Voltage range: 2.4 V to 5.5 V
- Temperature range: -40°C to +105°C

- **CPU**

- Fully static design 8-bit high performance 1T 8051-based CMOS microcontroller.
- Instruction set fully compatible with MCS-51.
- 4-priority-level interrupts capability.
- Dual Data Pointers (DPTRs).

- **Memories**

- Up to 32 Kbytes Flash
- Configurable 4/3/2/1 Kbytes of LDROM, which provides flexibility to user developed Boot Code.
- Up to 2 Kbytes SRAM
- 256 Bytes on-chip RAM.
- Flash Memory accumulated with pages of 128 Bytes each.
- Built-in In-Application-Programmable (IAP).
- Code lock for security.

- **Clocks**

- 16 MHz high-speed internal oscillator trimmed to $\pm 1\%$ when V_{DD} 5.0V, $\pm 4\%$ in all conditions.
- 24 MHz high-speed internal oscillator trimmed $\pm 1\%$ when V_{DD} 5.0V, $\pm 4\%$ in all conditions.
- 10 kHz low-speed internal oscillator.
- On-the-fly clock source switch via software.

- **Peripherals**

- Standard interrupt pins $\overline{INT0}$ and $\overline{INT1}$.
- Two 16-bit Timers/Counters 0 and 1 compatible with standard 8051.
- One 16-bit Timer 2 with three-channel input capture module and 9 input pin can be selected.
- One 16-bit auto-reload Timer 3, which can be the baud rate clock source of UARTs.
- One 16-bit PWM counter interrupt for timer.
- One programmable Watchdog Timer (WDT) clocked by dedicated 10 kHz internal source.

- One dedicated Self Wake-up Timer (WKT) for self-timed wake-up for power reduced modes.
- Two full-duplex UART ports with frame error detection and automatic address recognition. TXD and RXD pins of UART0 exchangeable via software.
- Three smart card ports support ISO7816-3 compliant T=0, T=1 and support full-duplex UART mode (32K Flash supported)
- One SPI port with master and slave modes, up to 12 Mbps when system clock is 24 MHz.
- One I²C bus with master and slave modes, up to 400 kbps data rate.
- Up to six pairs, twelve channels of pulse width modulator (PWM) output, with different modes and Fault Brake function for motor control.
- Eight channels of pin interrupt, shared for all I/O ports, with variable configuration of edge/level detection.
- One 12-bit ADC, supports up to 15 channels with 500 kbps converting rate
- Up to 30 general purpose I/O pins and 1 input-only pin. All output pins have individual 2-level slew rate control.
- Up to 20mA high current sink/source
- Programmable pull-ups pull-lows

- **Power management**

- Two power reduced modes: Idle and Power-down mode.

- **Power monitor**

- Brown-out detection (BOD) with low power mode available, 4-level selection, interrupt or reset options.
- Power-on reset (POR).

- **Strong ESD and EFT immunity**

- ESD HBM pass 8 kV
- EFT ± 4.4 kV
- Latch-up pass 150 mA

- **96-bit Unique ID (UID)**

- **128-bit Unique Customer ID (UCID)**

- **2-Byte (16-bit) PDID**

3 BLOCK DIAGRAM

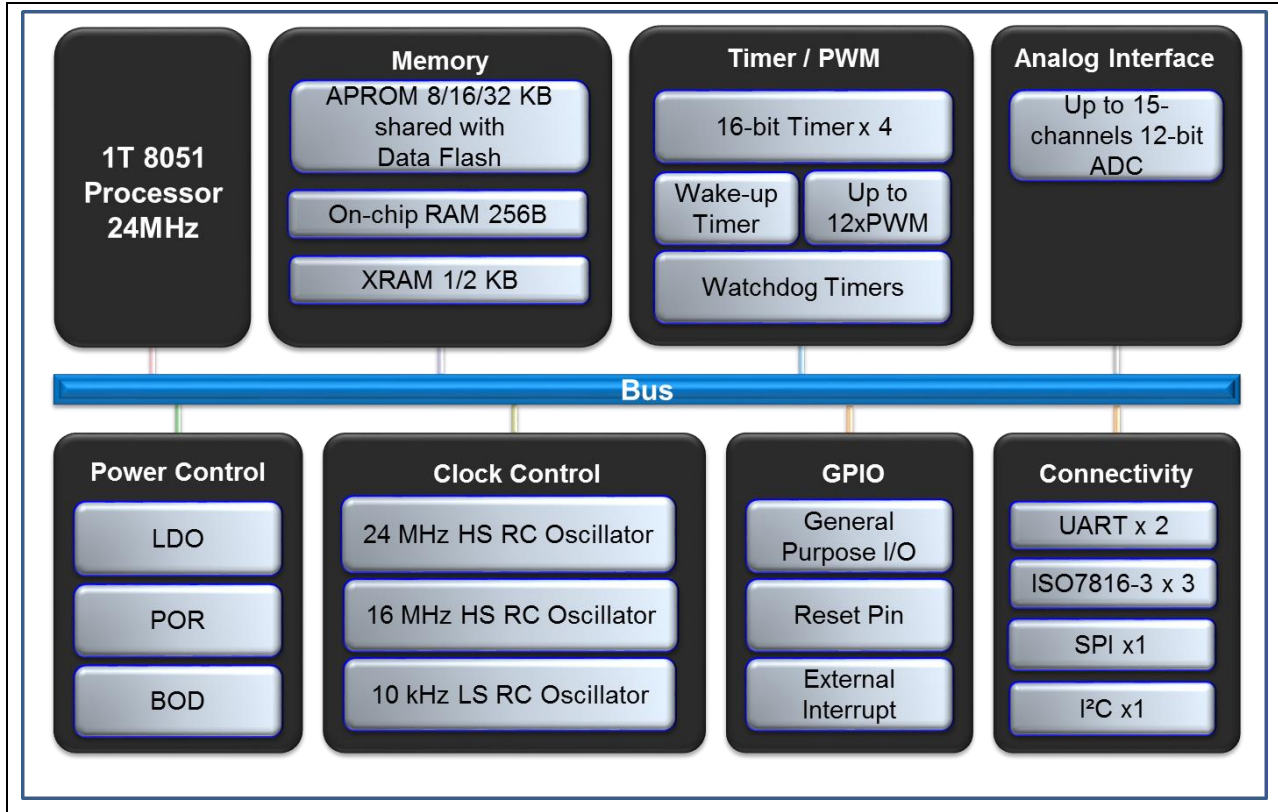


Figure 3-1 NuMicro® MS51 Block Diagram

4 PARTS INFORMATION

MS51 Series Naming Rule

MS	51	F	B	9	A	E
Core	Line	Package	Flash	SRAM	Reserve	Temperature
1T 8051	51: Base	B: MSOP10 (3x3 mm) D: TSSOP14 (4.4x5.0 mm) F: TSSOP20 (4.4x6.5 mm) E:TSSOP28 (4.4x9.7 mm) U: SOP28 (300 mil) O: SOP20 (300 mil) T: QFN33 (4x4 mm) P: LQFP32 (7x7 mm) L: LQFP48 (7x7 mm) S: LQFP64 (7x7 mm)	A: 8 KB B: 16 KB C: 32 KB D: 64 KB	0: 2 KB 1: 4 KB 2: 8/12 KB 9: 1 KB		E:-40°C ~ 105°C

MS51 Series Selection Guide

Part Number	Flash (KB)	SRAM (KB)	ISP ROM (KB) ^[1]	I/O	Timer/	PWM	Connectivity				ADC(12-Bit)	Package
							ISO-7816 ^[2]	UART	SPI	I ² C		
MS51BA9AE	8	1	4*	8	4	5	-	2	-	1	5-ch	MSOP10
MS51DA9AE	8	1	4*	12	4	5	-	2	1	1	7-ch	TSSOP14
MS51XB9AE	16	1	4*	18	4	6	-	2	1	1	8-ch	QFN20 ^[3]
MS51XB9BE	16	1	4*	18	4	6	-	2	1	1	8-ch	QFN20 ^[3]
MS51FB9AE	16	1	4*	18	4	6	-	2	1	1	8-ch	TSSOP20
MS51FC0AE	32	2	4*	18	4	10	3	2	1	1	10-ch	TSSOP20
MS51XC0BE	32	2	4*	18	4	10	3	2	1	1	10-ch	QFN20
MS51EC0AE	32	2	4*	26	4	12	3	2	1	1	15-ch	TSSOP28
MS51TC0AE	32	2	4*	30	4	12	3	2	2	1	15-ch	QFN33
MS51PC0AE	32	2	4*	30	4	12	3	2	2	1	15-ch	LQFP32

Note:

1. ISP ROM programmable 1K/2K/3K/4KB Flash for user program loader (LDROM) share from ARPOM.
2. ISO-7816 configurable as UART2.
3. Detailed package information please refer to Chapter 7

5 PIN CONFIGURATION

5.1 MS51 Series Pin Diagram

5.1.1 MS51 Series LQFP32 Diagram

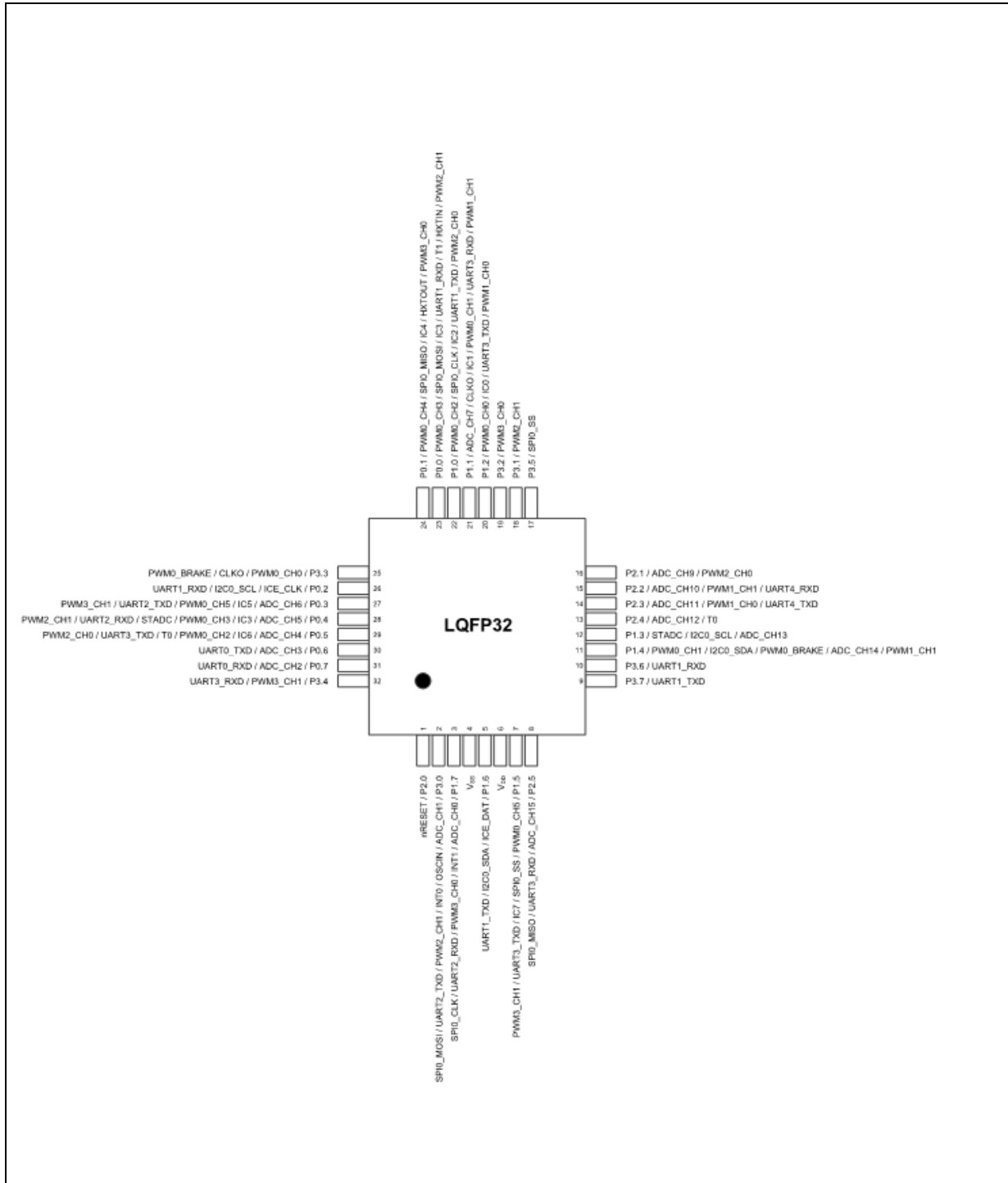


Figure 5-1 MS51 Series LQFP-32 -pin Diagram

5.1.2 MS51 Series QFN33 Diagram

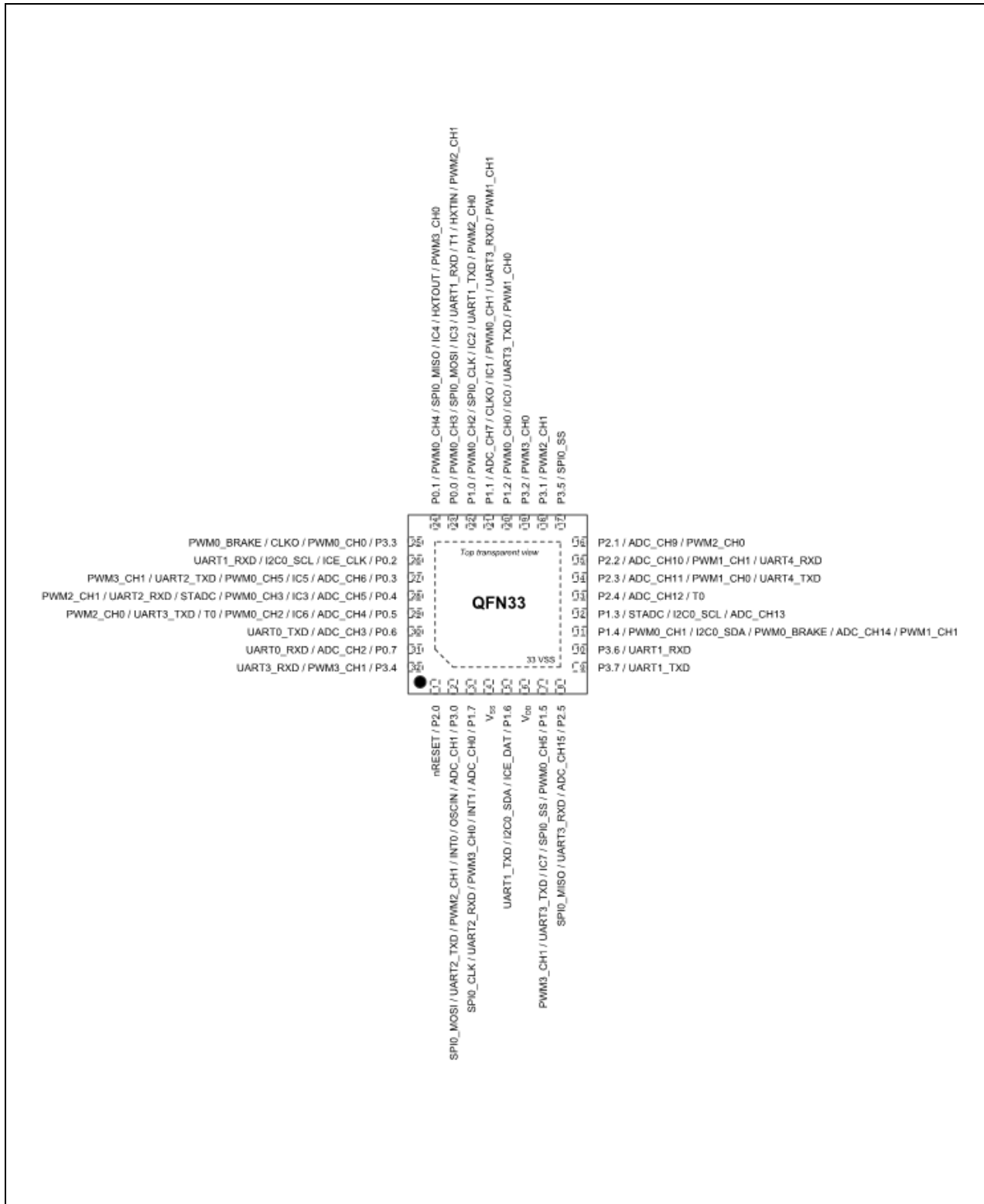


Figure 5-2 MS51 Series QFN-33 -pin Diagram

5.1.3 MS51 Series TSSOP28 Diagram

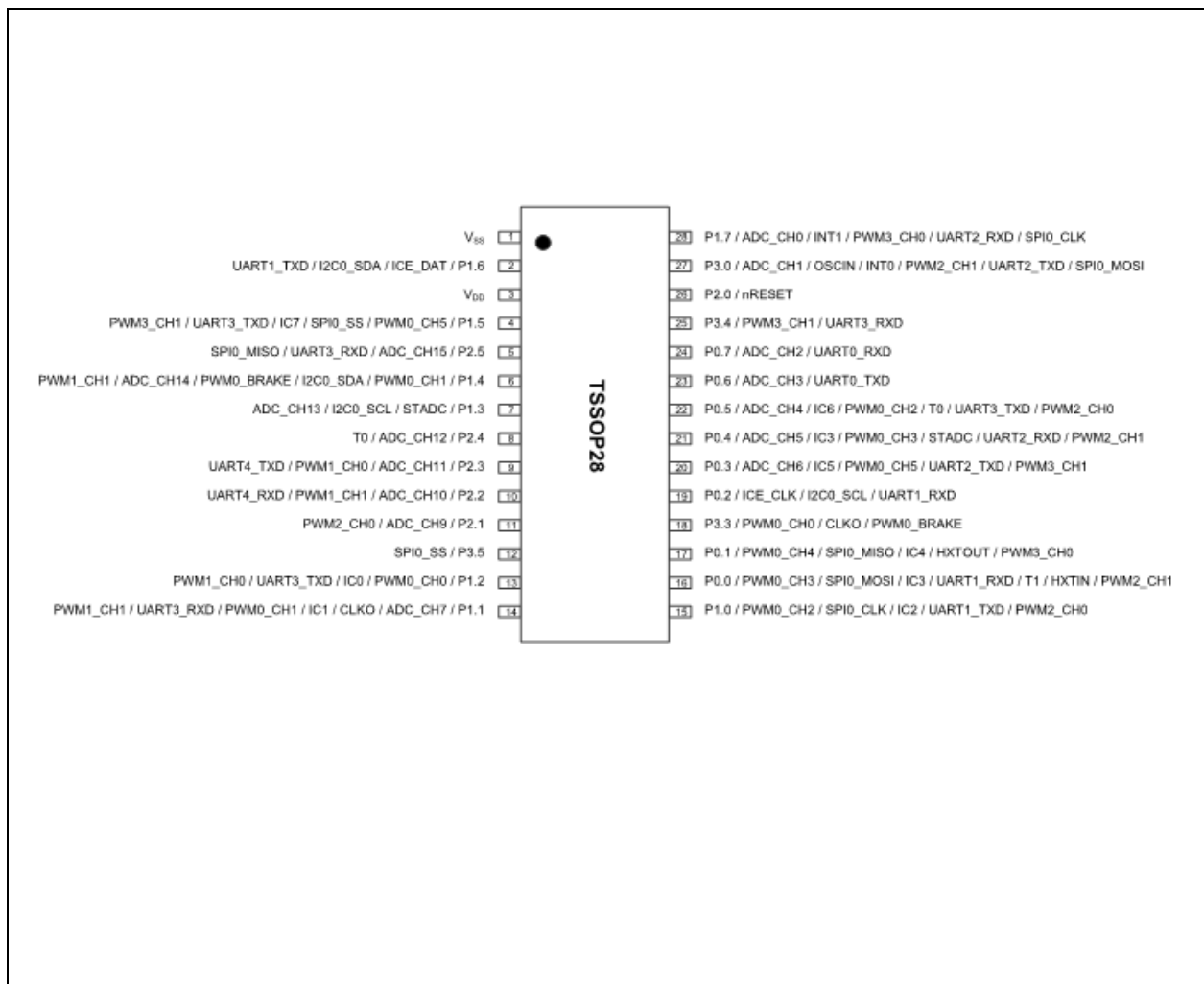


Figure 5-3 MS51 Series TSSOP-28 -pin Diagram

5.1.4 MS51FC0AE TSSOP20 Diagram

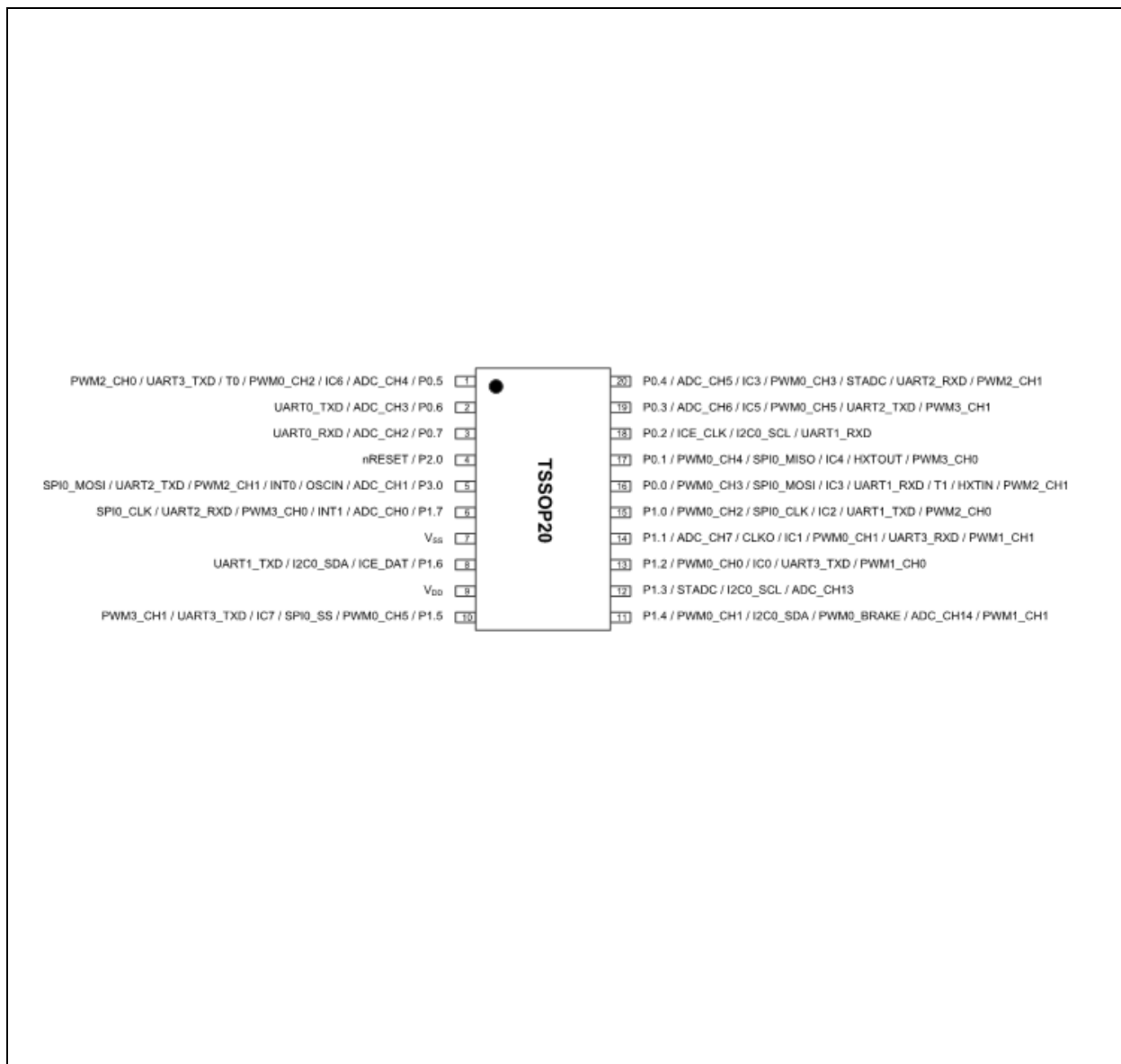


Figure 5-4 MS51 Series TSSOP-20 -pin Diagram

5.1.5 MS51XC0BE QFN20 Diagram

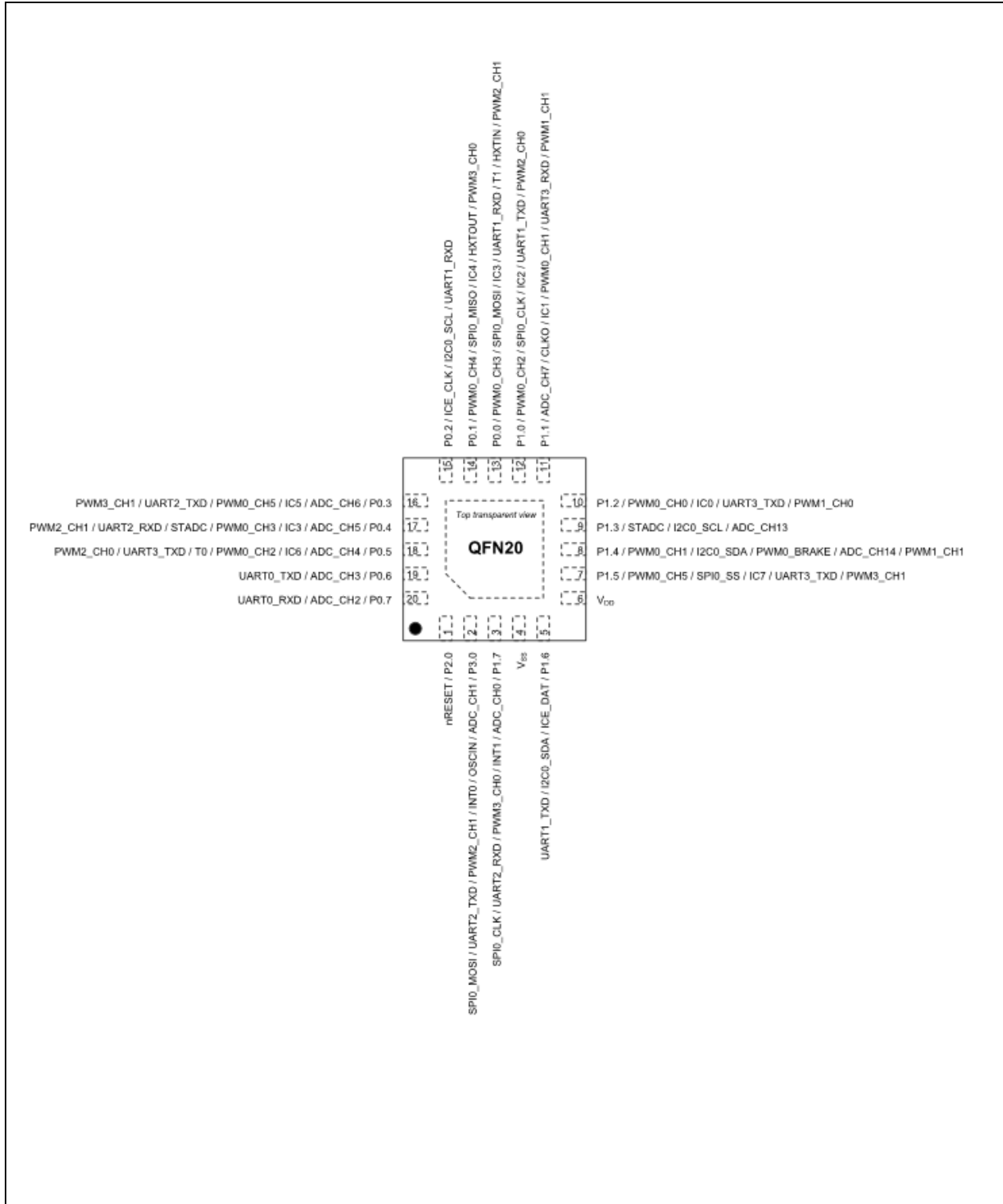


Figure 5-5 MS51 Series QFN-20 -pin Diagram

5.1.6 MS51 Series TSSOP20 Diagram

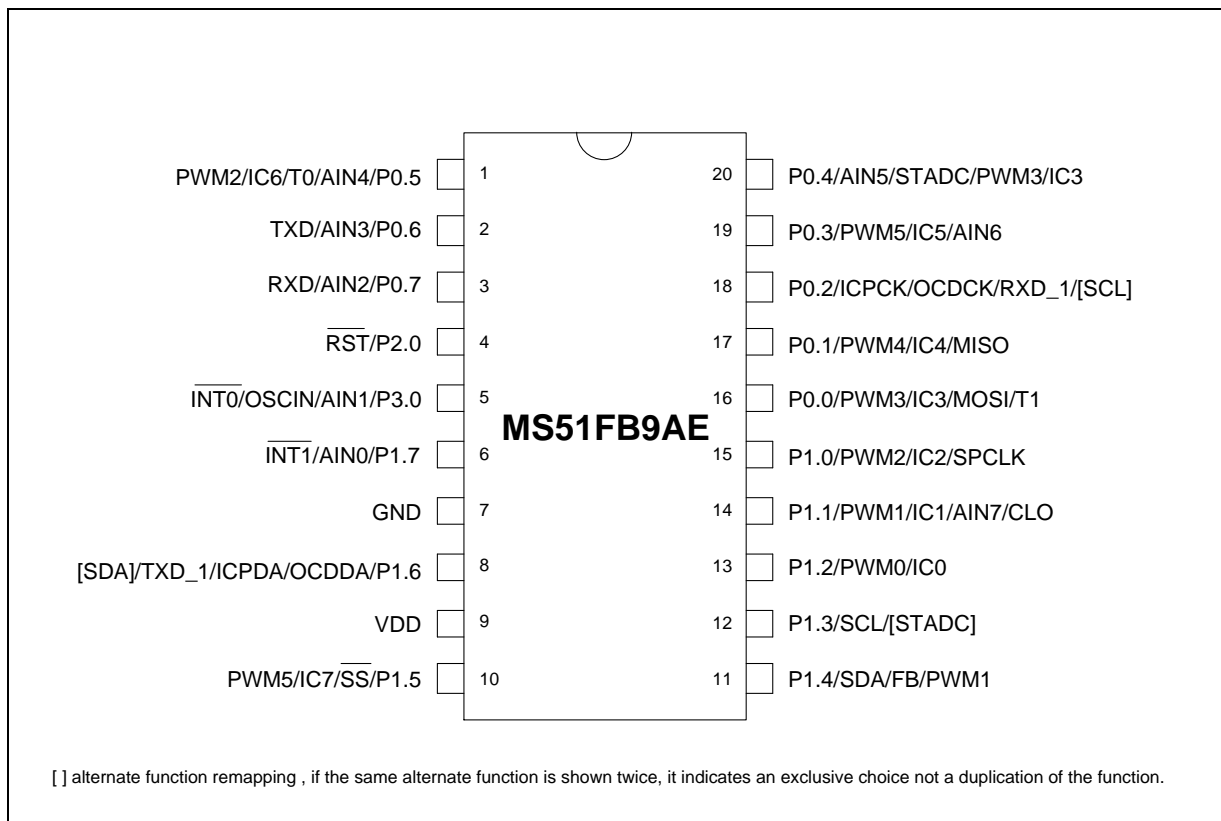


Figure 5-6 MS51 Series TSSOP-20 -pin Diagram

5.1.7 MS51 Series QFN20 Pin Diagram

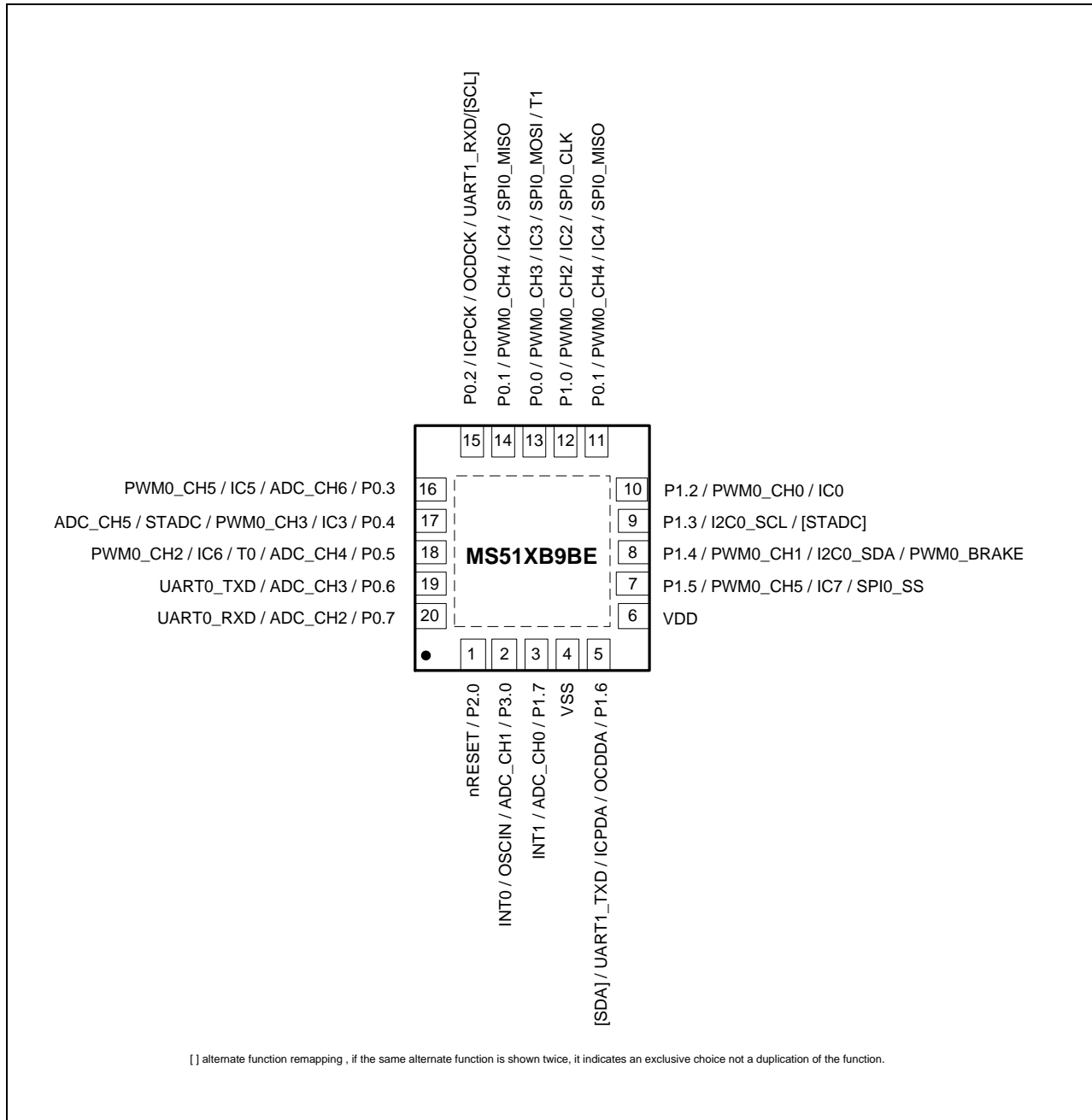


Figure 5-7 MS51 Series QFN-20-pin Diagram

5.1.8 MS51 Series QFN20 Pin Diagram

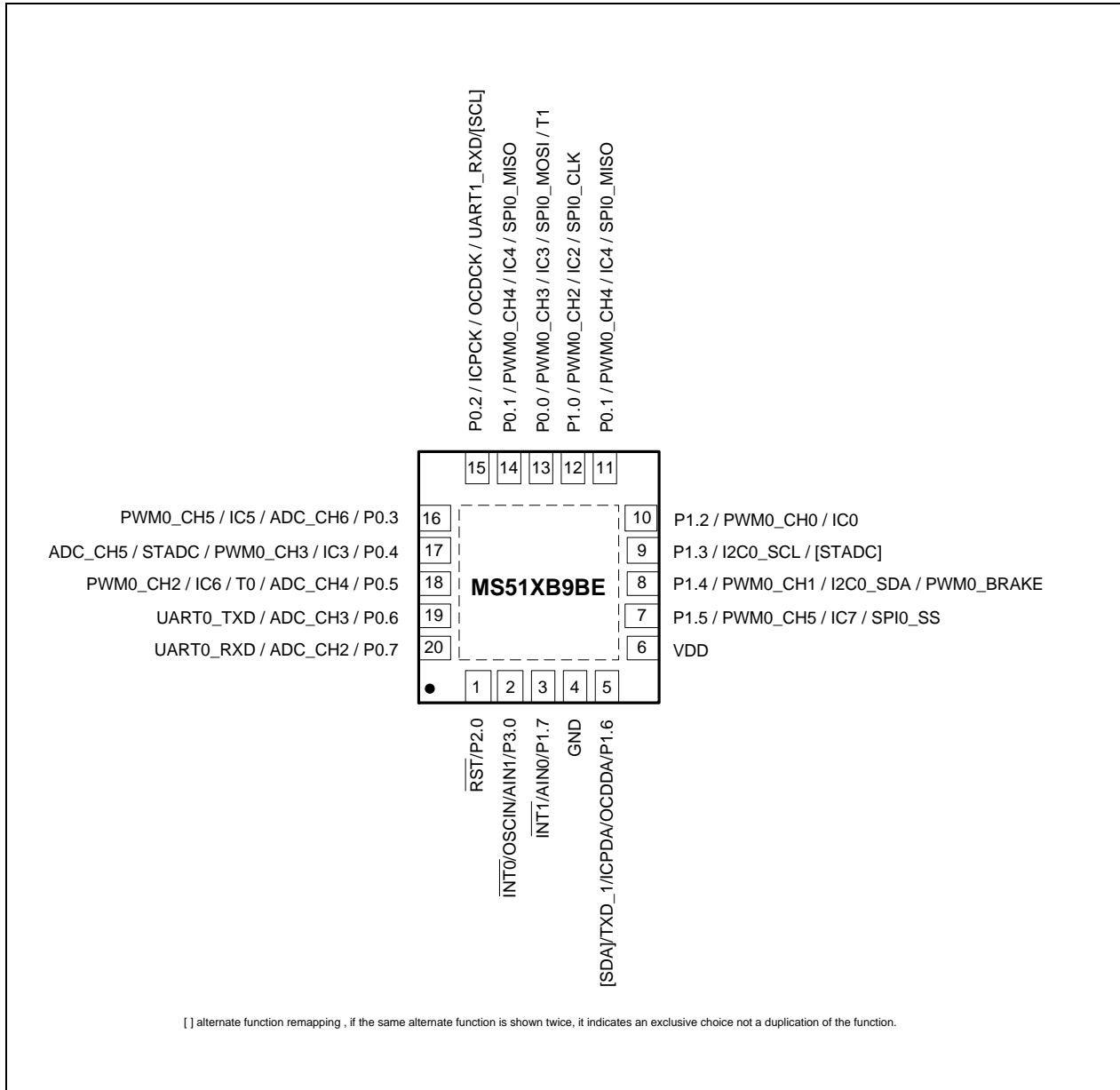


Figure 5-8 MS51 Series QFN-20-pin Diagram

5.1.9 MS51 Series TSSOP14 Pin Diagram

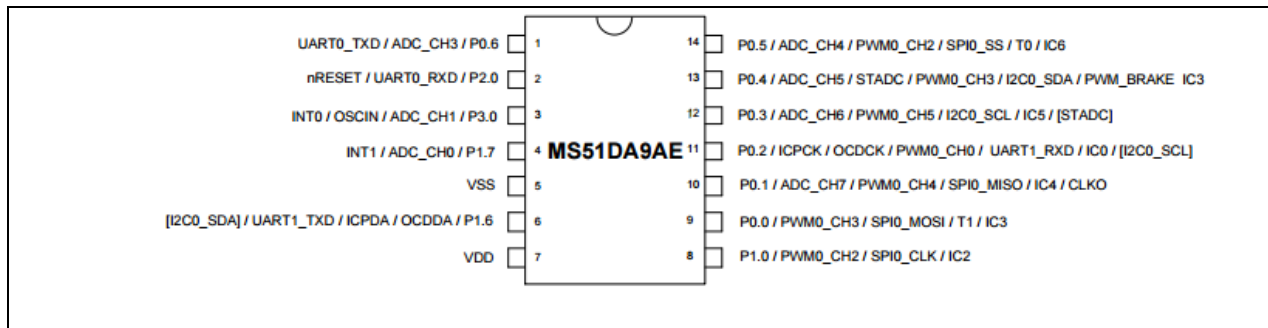


Figure 5-9 MS51 Series TSSOP-14-pin Diagram

5.1.10 MS51 Series MSOP10 Pin Diagram

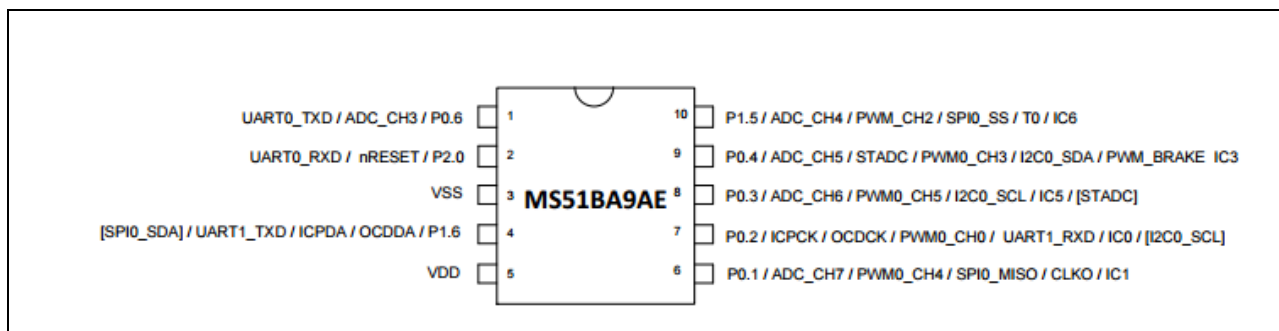


Figure 5-10 MS51 Series MSOP-10-pin Diagram

6 UTILITIES

6.1 Programmer and Debugger

Nu-Link	Basic full speed USB2.0 hardware debugger/programmer
Nu-Link-Pro	Advance hardware debugger/programmer with programming counter
Nu-Link 2.0	Advance high speed USB2.0 hardware debugger/programmer with multi-functions
Nu-Link-Gang	Off-line hardware programmer supports up to four chips programming for mass-production
ISP	In system programming, a software programming tool support UART/USB
ICP	In Chip Programming, a software programming tool support Nu-Link programmer

6.2 Development Environment

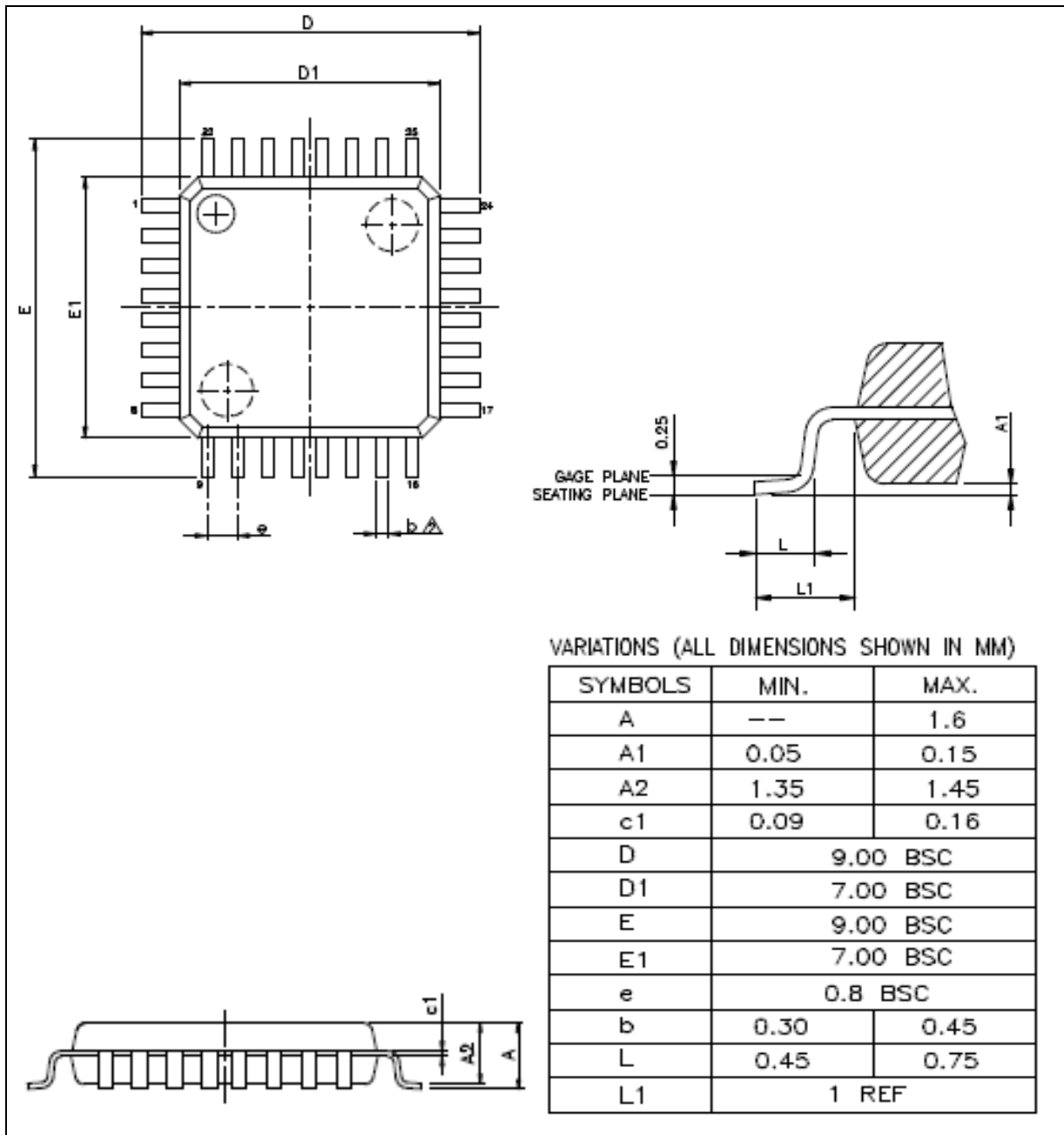
Programming IDE	Keil C-51, IAR EW8051
Software Package	Board Support Package(BSP), Sample Code,
Development IDE	NuTool Pin-View, NuTool-PinView, NuTool-ClockConfig

6.3 Development Board

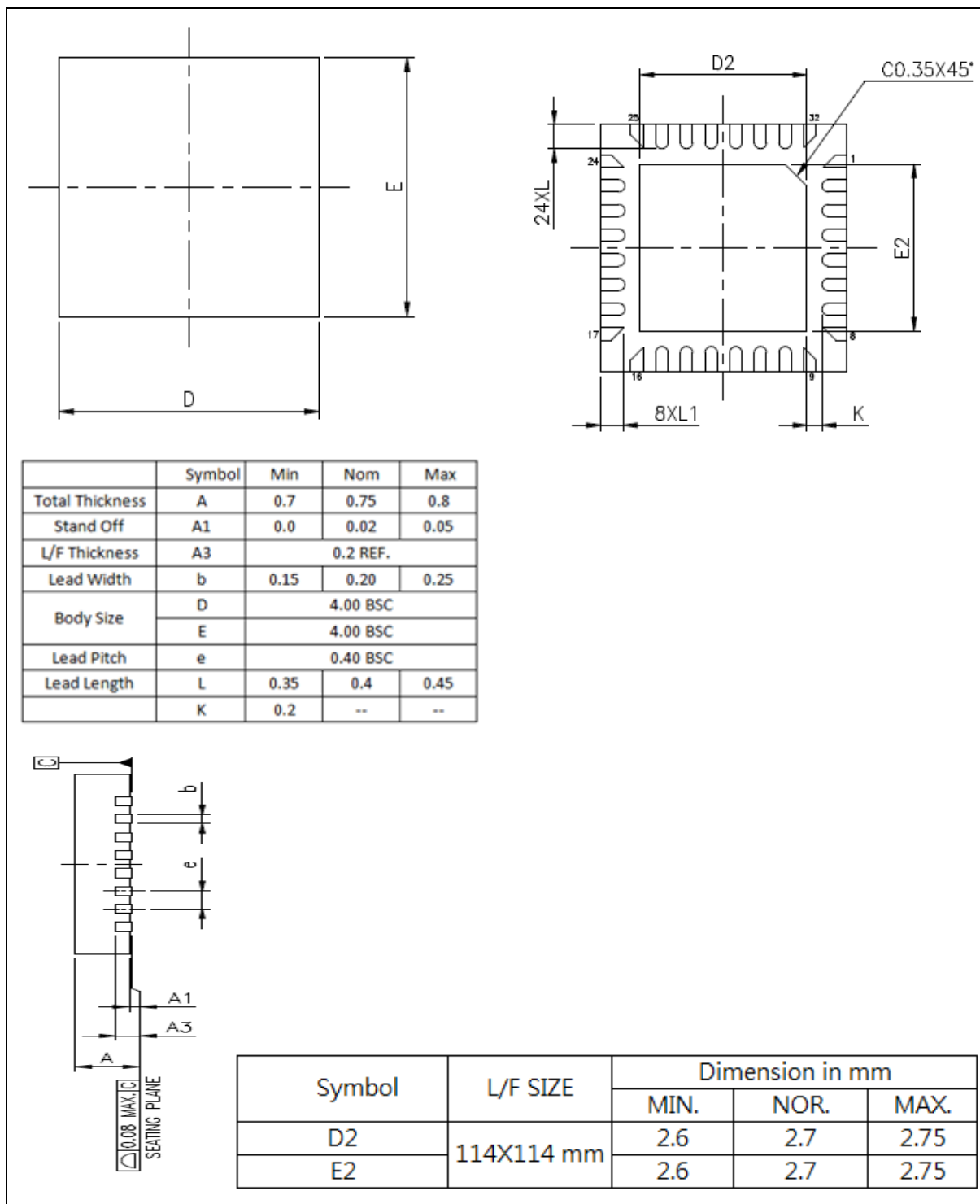
EVB NuMaker	Part Number	Feature
NT-MS51FB	MS51XB9AE MS51FB9AE MS51XB9BE	Support Expand Connector, Arduino Uno Interface
NT-MS51DA	MS51DA9AE MS51BA9AE	
NK-MS51PC	MS51FC0AE MS51XC0BE MS51EC0AE MS51TC0AE MS51PC0AE	

7 PACKAGE DIMENSIONS

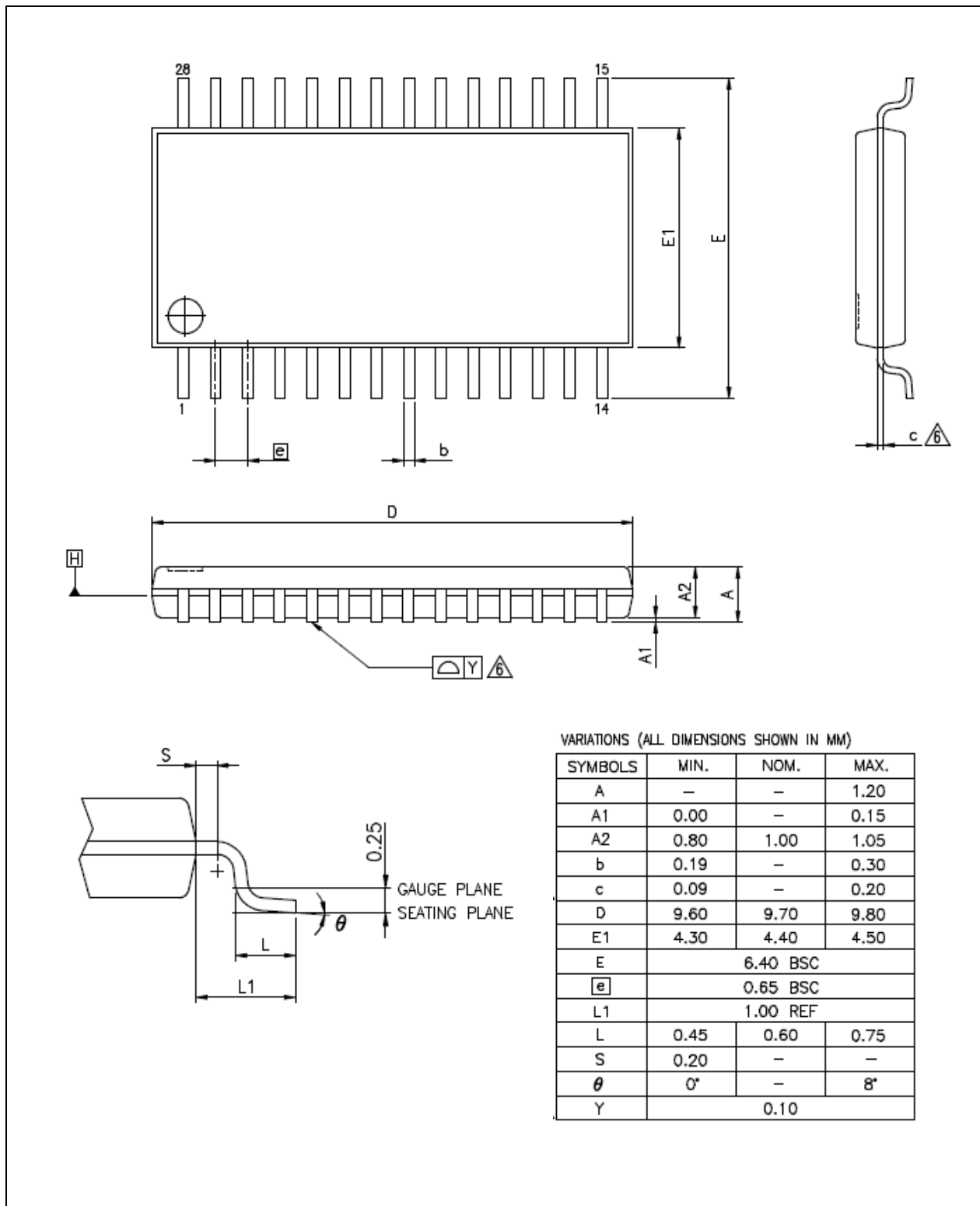
7.1 LQFP 32 (7x7x1.4 mm) for MS51PC0AE



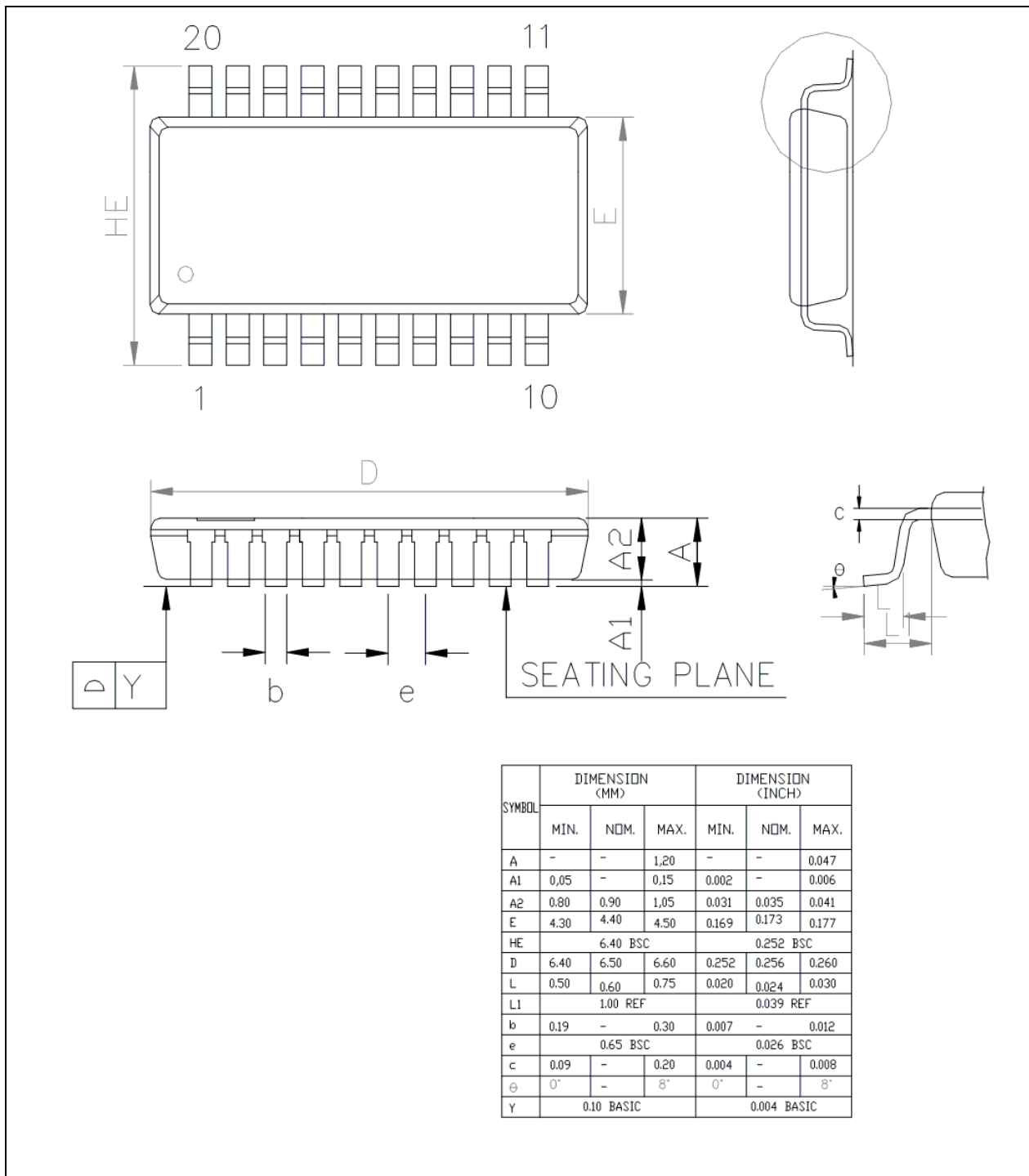
7.2 QFN 33 (4x4x0.8 mm) for MS51TC0AE



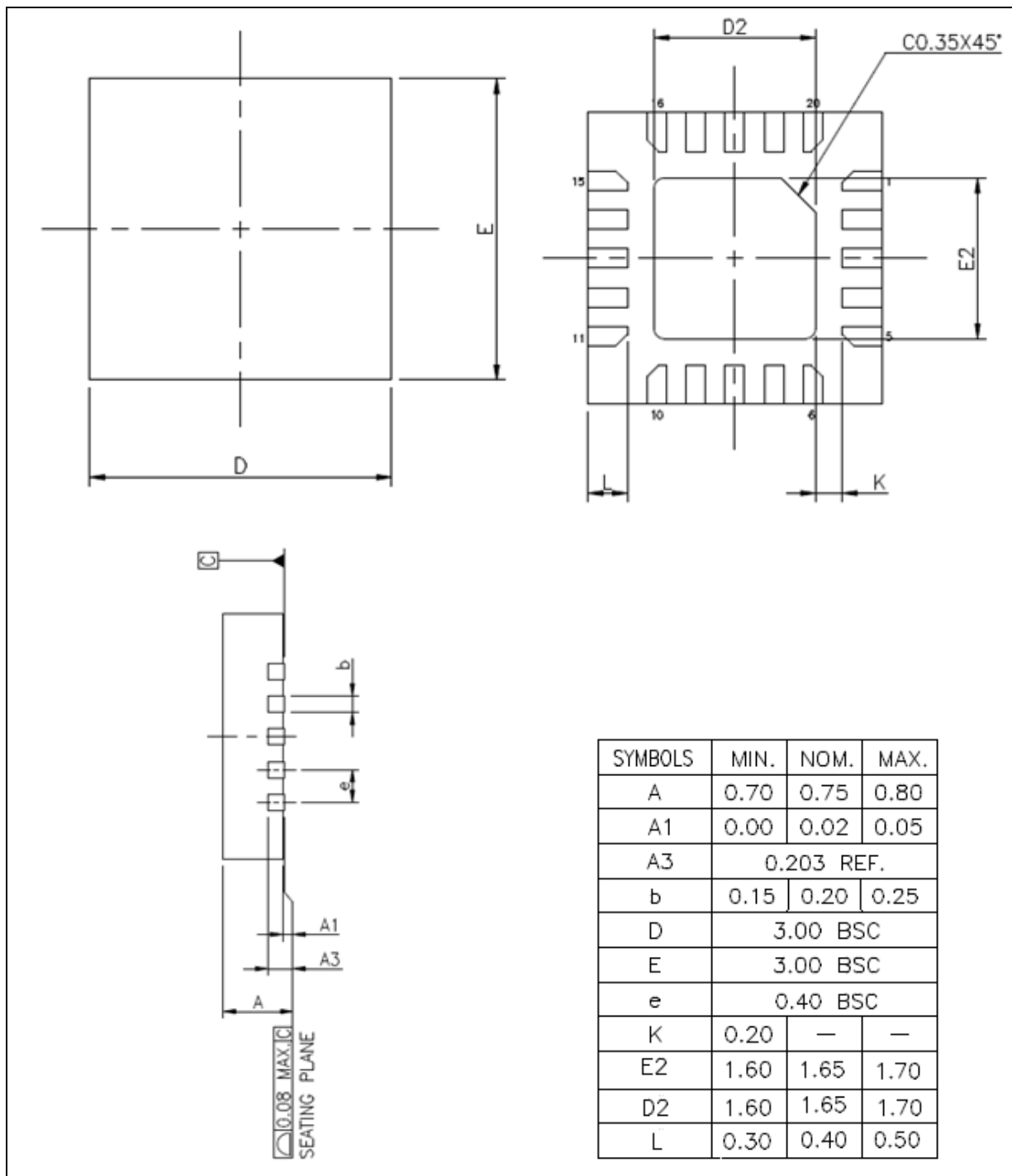
7.3 TSSOP 28 (4.4x9.7x1.0 mm) for MS51EC0AE



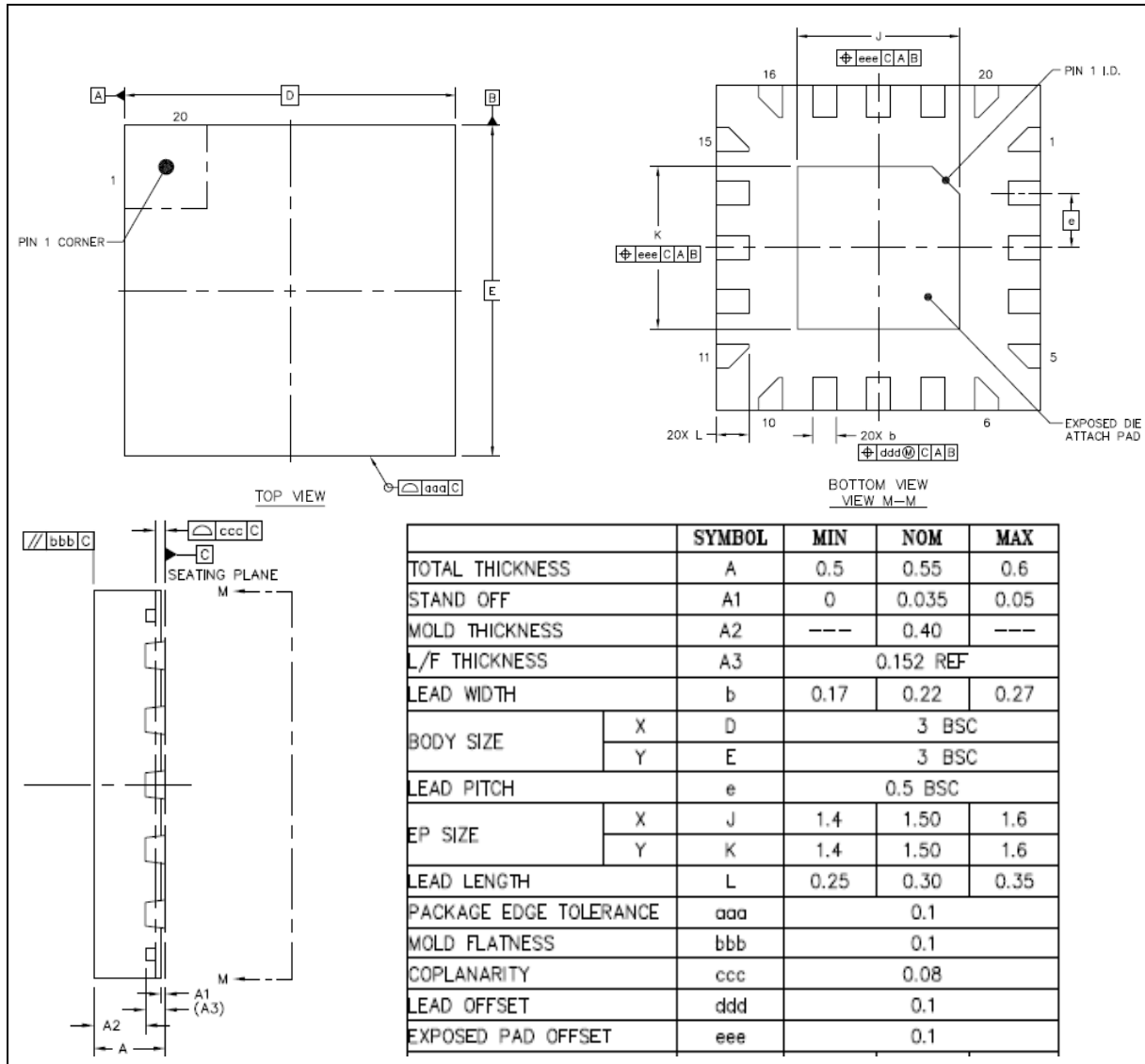
7.4 TSSOP 20-Pin (4.4x6.5x0.9 mm) for MS51FB9AE & MS51FC0AE



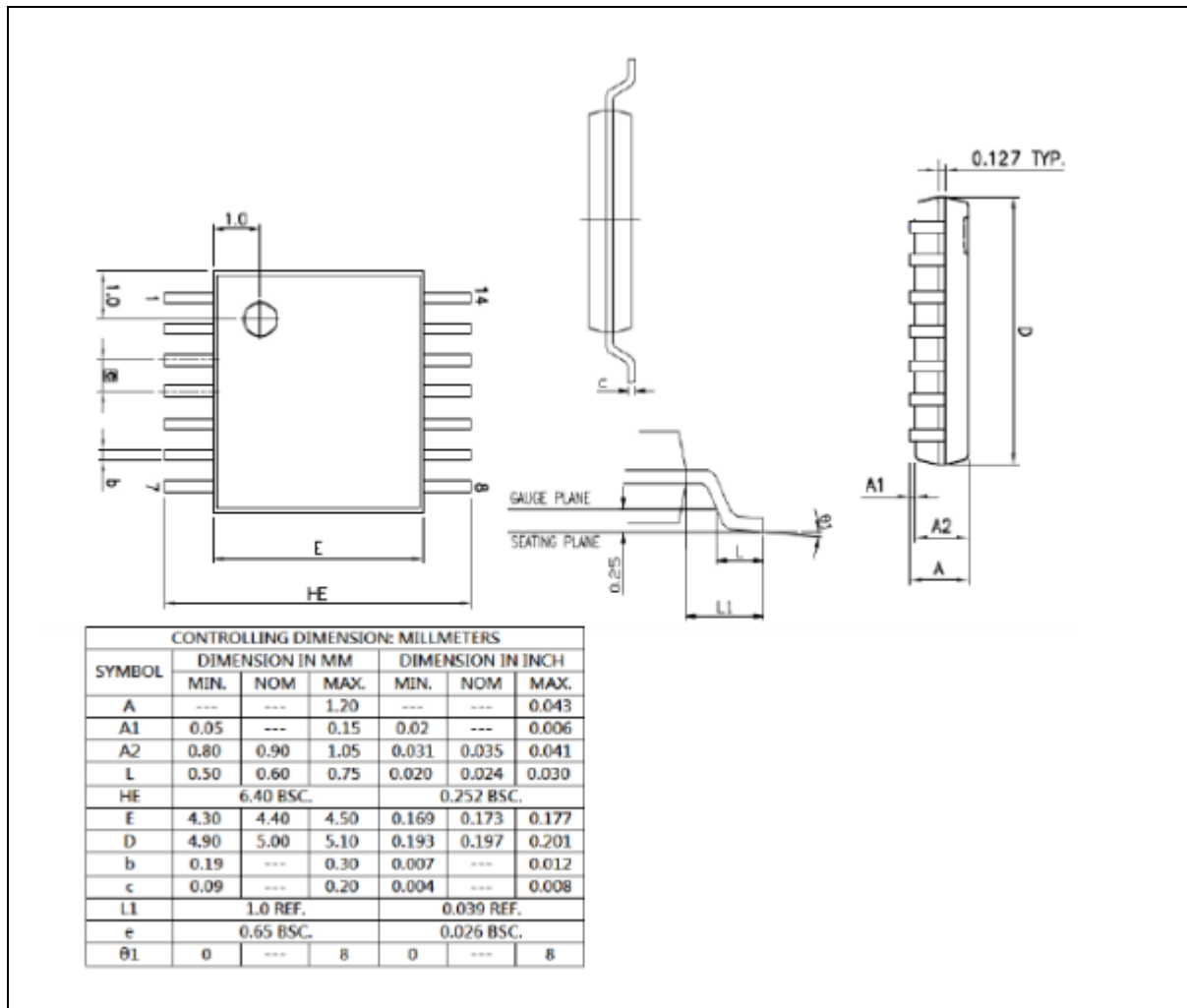
7.5 QFN 20 (3.0x3.0 mm) for MS51XB9AE



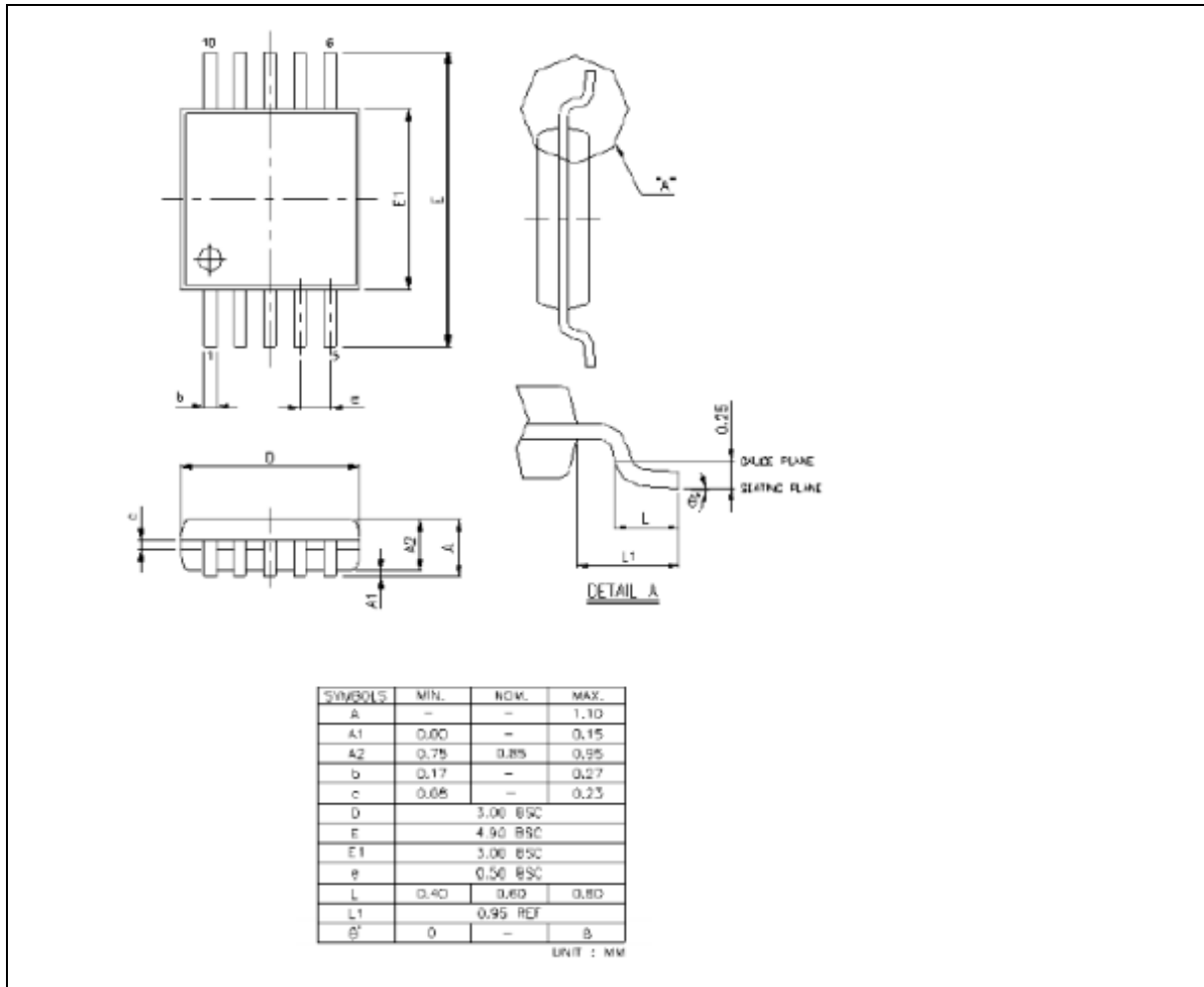
7.6 QFN 20 (3.0x3.0 mm) for MS51XB9BE & MS51XC0BE



7.7 TSSOP 14 (4.4x5.5 mm) for MS51DA9AE



7.8 MSOP 10 (3x3 mm) for MS51BA9AE



8 REVISION HISTORY

Date	Revision	Description
2019.02.19	1.00	Initial version.
2019.06.24	1.01	Added Part number: MS51DA9AE & MS51 BA9AE
2019.08.01	2.00	Added Part number: MS51FC0AE MS51XC0BE MS51EC0AE MS51TC0AE MS51PC0AE

Important Notice

Nuvoton Products are neither intended nor warranted for usage in systems or equipment, any malfunction or failure of which may cause loss of human life, bodily injury or severe property damage. Such applications are deemed, "Insecure Usage".

Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

All Insecure Usage shall be made at customer's risk, and in the event that third parties lay claims to Nuvoton as a result of customer's Insecure Usage, customer shall indemnify the damages and liabilities thus incurred by Nuvoton.

*Please note that all data and specifications are subject to change without notice.
All the trademarks of products and companies mentioned in this datasheet belong to their respective owners.*