

MArm[®] Cortex[®]-M
32-bit Microcontroller

NuMicro[®] Family
M251/M252 Series
Preliminary Product Brief

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Rev. 0.20

M251/M252 SERIES PRELIMINARY PRODUCT BRIEF

1 GENERAL DESCRIPTION

The NuMicro® M251/M252 series is a low-power microcontroller platform based on Arm® Cortex®-M23 core for Armv8-M architecture. It runs up to 48 MHz with 16 ~ 256 Kbytes embedded Flash memory and 8 ~ 32 Kbytes embedded SRAM, 4 Kbytes Flash loader memory (LDROM) for In-System Programming (ISP). The 32-bit low-power microcontrollers supports wide supply voltage from 1.8 ~ 5.5V and operating temperature range from -40 ~ +105 °C.

Low-power Technology for IoT application

The NuMicro® M251/M252 series behaves low power consumption in Normal Run mode 138µA/MHz at 48MHz, Idle mode 60µA/MHz, power down mode 2.5µA (RTC on, RAM retention), power down mode 1.5µA (RTC off, RAM retention) and Deep Power-down mode. The NuMicro® M251/M252 series integrates RTC with independent VBAT voltage source pin to support low power mode with main power off and VBAT only. It's low power, wide supply voltage and fast wake-up features make it suitable for battery-powered IoT applications.

Programmable Serial Interface (PSIO)

The NuMicro® M251/M252 series provides up to 8-channels Nuvoton proprietary interface, named as "Programmable Serial I/O" (PSIO), that is capable of generating specific waveform to emulate arbitrary serial communication protocols to connect with specific peripherals by PSIO hardware engine. PSIO can be treated as extension of popular serial communication standard (UART, SPI, I²C...etc.), niche serial communication standard and proprietary protocol (SPI-like protocol for LED-lighting application...etc.). This PSIO hardware engine can simulate comprehensive serial communication protocol with low CPU loading, low control complexity and high timing precision at the same time. High elasticity and flexibility makes PSIO being a powerful and useful tool while connecting to diverse peripherals.

Voltage Adjustable Interface (VAI) - Support 2nd I/O voltage without level-shifter

The NuMicro® M251/M252 series integrates Voltage Adjustable Interface (VAI), up to 6 I/O pins to support the 2nd I/O voltage from 1.65 ~ 5.5V to save level shifter components while connecting to external devices. These 6 I/O pins can be configured as UART/SPI/ I²C bus by software setting.

eExecute-Only-Memory (XOM) - Protect the intelligent property of developers

The NuMicro® M251/M252 series provides 1-region programmable eExecute-Only-Memory (XOM) to secure critical program codes. The AES 256/192/128 hardware accelerator and Pseudo Random Number Generator (PRNG) are built-in for data encryption. A tamper detection pin is implemented to avoid malicious damage from hacker. Accompany with 96-bit Unique Identification (UID) and 128-bit Unique Customer Identification (UCID) to enhance the product security.

Crystal-less USB 2.0 full speed device interface

Part Numbers of M252 series are all based on M251, it supports a crystal-less USB 2.0 full speed device that can generate precise frequency required by USB protocol without the need of external crystal to reduce the BOM cost and PCB size.

Rich Pheripherals for comprehensive product application scenarios

The NuMicro® M251/M252 series is equipped with plenty of peripherals such as Timers, Watchdog Timers, RTC, PDMA, External Bus Interface (EBI), UART, Universal Serial Control Interface (USCI), QSPI, SPI/I²S, I2C, ISO-7816-3, GPIOs, up to 24 channels of PWM, makes it highly suitable for connecting comprehensive external modules and LED lighting control. The NuMicro® M251/M252 series integrates high performance analog front-end circuit blocks, such as 16 channels of 12-bit 880 kSPS ADC, 12-bit 1 MSPS DAC, analog comparator, operational amplifier, temperature sensor, low voltage reset (LVR) and brown-out detector (BOD) to enhance product performance, reduce external components and form factor simultaneously.

The NuMicro® M251/M252 series provides 31 product types. The package types of the M251/M252 series include TSSOP20 (4.4mm x 6.5mm) 、TSSOP28 (4.4mmx9.7mm) 、QFN33 (5mm x 5mm) 、LQFP48 (7mm x 7mm) 、LQFP64 (7mm x 7mm)和LQFP128 (14mm x 14mm). Pin-to-pin compatible in same package makes optimizing product features and performance easily.

Nuvoton NuMaker M251/M252 evaluation boards and Nu-Link debugger are available for evaluation and product development. 3rd Party IDEs such as Keil MDK, IAR EWARM and Eclipse IDE with GNU GCC compilers, are also supported.

| Product Line | UART | I ² C | QSPI | SPI/ I ² S | PSIO | USCI | Timer | PWM | PDMA | EBI | ADC | DAC | ACMP | OPA | USB |
|--------------|------|------------------|------|-----------------------|------|------|-------|-----|------|-----|-----|-----|------|-----|-----|
| M251/M252 | 3 | 2 | 1 | 1 | 8 | 3 | 4 | 24 | 8 | 1 | 16 | 1 | 2 | 1 | 1 |

Table 1-1 NuMicro® M251/M252 Series Key Features Support Table

The NuMicro® M251/M252 series is suitable for a wide range of applications such as:

- Smart Home / Smart Home Appliance
- Industrial Control / Industrial Automation
- Smart City
- IoT Device
- Security Alarm System
- Electronic Payments
- Communication Modules
- Portable Wireless Data Collector
- Smart Door lock
- Handheld Medical Device
- (GPS) Location Tracker
- Electronic Shelf Labels (ESL)

2 FEATURES

- **Operating Characteristics**
 - Voltage range: 1.8V ~ 5.5V
 - Temperature range: -40°C ~ +105°C
 - EFT 4.4 KV
 - ESD HBM 6 KV
- **Core**
 - Arm® Cortex®-M23 processor, Armv8-M, 48MHz
 - 32-bit H/W multiplier/divide
- **Memories**
 - 16 ~ 256KB Flash
 - 8 ~ 32KB SRAM
 - 4KB LDRAM
 - 1-region eXecute-Only-Memory (XOM)
 - ISP/ICP/IAP programming
- **Clocks**
 - 4 ~ 32 MHz external high speed crystal oscillator (HXT) for precise timing operation
 - 32.768 kHz external low speed crystal oscillator (LXT) for RTC function and low-power system operation
 - 48 MHz internal high speed RC oscillator (HIRC) for system operation (Factory pre-trimmed to ± 0.25% and frequency deviation ±2% over entire temperature from -40 ~ +105 °C)
 - 4.032 MHz internal high speed RC oscillator (MIRC) for system operation
 - 38.4 kHz internal low speed RC oscillator (LIRC) for Watchdog Timer and wake-up operation.
- **Power management**
 - Integrated with Power-on Reset, Brown-out Reset and Low Voltage Reset
 - Built-in LDO
 - Support RTC with independent V_{BAT} voltage source pin
- **Low Power Consumption**
 - 138 µA/MHz in operating mode
 - 60 µA/MHz in idle mode
 - 2.5 µA in Power down mode (RTC on, RAM retention)
 - 1.5 µA in Power down mode (RTC off, RAM retention)
 - 1.3 µA in Deep Power down mode
- **RTC**
 - Supports external power pin V_{BAT} (Standalone V_{BAT} for RTC power domain)
- **Timers**
 - Up to four 32-bit timers
- **PDMA**
 - Up to 8 channels
- **PWM**
 - Up to 24-channels PWM
 - Supports trigger ADC
 - Maximum clock frequency up to 96 MHz
- Supports independent mode for PWM output/Capture input channel
- Supports complementary mode for 3 complementary paired PWM output channel
- **Analog**
 - Up to 16 channels 12-bit 880 kSPS ADC
 - Up to 2 sets of rail-to-rail comparators (ACMP)
 - Up to 1 set of 12-bit 1 MSPS voltage type DAC
 - Up to 1 set of Operational Amplifier (OPA)
- **Communication interfaces**
 - Up to 3 sets of UART interface
 - Up to 2 sets of I²C interface
 - Up to 1 set of QSPI interface
 - Up to 1 set of SPI/ I²S interface (Configured as SPI or I²S)
 - Up to 1 set of Smart Card Interface (ISO-7816-3)
 - Up to 3 sets of USCI (Configured as UART, SPI or I²C)
 - 16/8-bits EBI (External Bus Interface) interface
- **VAI (Voltage Adjustable Interface)**
 - Up to 6 I/O pins to support the 2nd I/O voltage from 1.65 ~ 5.5V, applied voltage to the V_{DDIO} pin
- **PSIO (Programmable Serial I/O)**
 - PSIO (Programmable Serial I/O) is capable of generating specific waveform to emulate arbitrary serial communication protocols to connect with specific peripherals by PSIO hardware engine.
 - Up to 8 PSIO pins
- **USB**
 - Up to 1 set of USB 2.0 full speed device with on-chip PHY (crystal-less design)
- **Utility Support**
 - Arm® Keil MDK and IAR EWARM IDE support for debugging
 - Free GNU compiler with Eclipse IDE support
 - ICP (In Circuit Programmer) support for updating internal code via Nu-Link debugger
 - ISP (In System Programmer) support for updating internal code through UART, SPI, I²C, RS-485 peripheral interface
 - PinView for real time monitor the status of all IO pins
 - PinConfigure tool for pin assignment, initial code generation and OrCAD/Protel part generation
 - ClockConfigure tool for generating the initial source code of system clock
- **96-bit Unique ID (UID)**
- **128-bit Unique Customer ID (UCID)**
- **Packages**
 - TSSOP20 (4.4mm x 6.5mm), TSSOP28 (4.4mmx9.7mm), QFN33 (5mm x 5mm), LQFP48 (7mm x 7mm), LQFP64 (7mm x 7mm), LQFP128 (14mm x 14mm)

3 BLOCK DIAGRAM

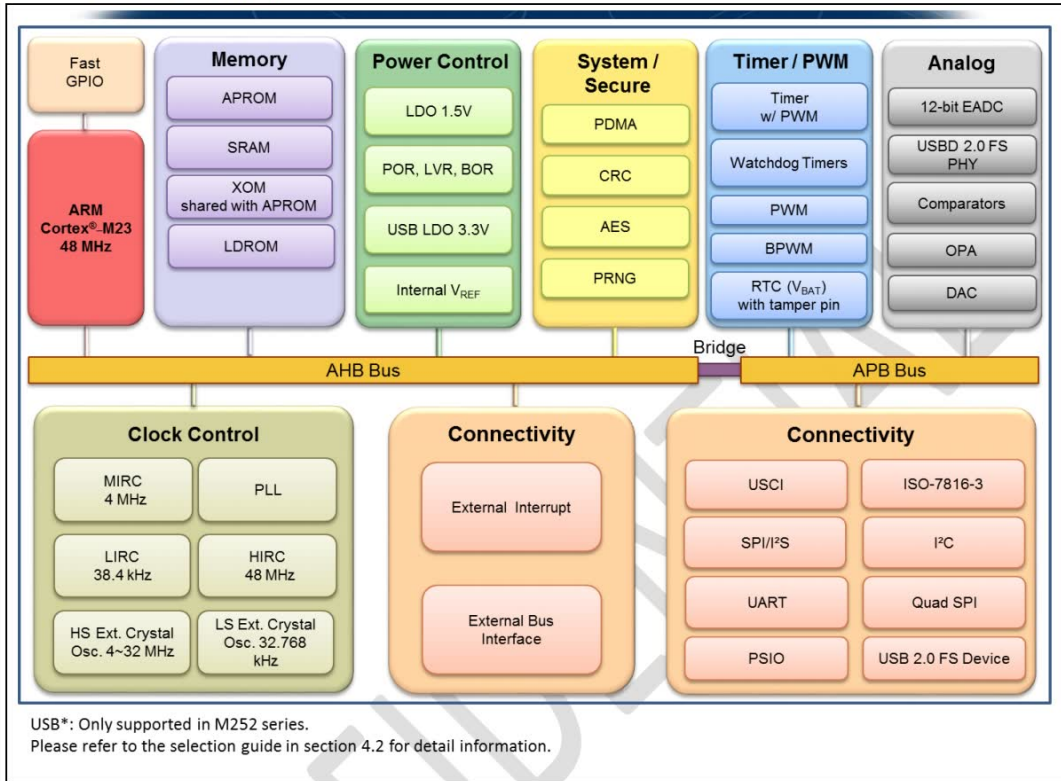


Figure 3-1 NuMicro® M251/M252 Block Diagram

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4 PARTS INFORMATION

4.1 M251/M252 Series Naming Rule

| M2 | 51 | S | G | 6 | A | E |
|-------------|-------------|----------------------------|------------------------|------------------------|---------|-------------------|
| Core | Line | Package | Flash | SRAM | Reserve | Temperature |
| Cortex®-M23 | 31: Control | F: TSSOP20 (4.4x6.5 mm) | B: 16 KB C: 32 KB | 0: 2 KB 1: 4 KB | | E: -40°C ~ +105°C |
| | 32: USB | E: TSSOP28 (4.4x9.7 mm) | D: 64 KB E: 128 KB | 2: 8/12 KB 3: 16 KB | | |
| | | Z: QFN33 (5x5 mm) | G: 256 KB I: 512 KB | 6: 32 KB 8: 64 KB | | |
| | | L: LQFP48 (7x7 mm) | | A: 96 KB | | |
| | | S: LQFP64 (7x7 mm) | | | | |
| | | K: LQFP128 (14x14 mm) | | | | |
| | | | | | | |

4.2 M251/M252 Series Selection Guide

4.2.1 M251 Control Series

| PART NUMBER | M251FB2AE | M251FC2AE | M251EB2AE | M251EC2AE | M251ZB2AE | M251ZC2AE | M251ZD2AE | M251LC2AE | M251LD2AE | M251LE3AE | M251LG6AE | M251SC2AE | M251SD2AE | M251SE3AE | M251SG6AE | M251KE3AE | M251KG6AE | |
|---------------------|----------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--|
| Flash (KB) | 16 | 32 | 16 | 32 | 16 | 32 | 64 | 32 | 64 | 128 | 256 | 32 | 64 | 128 | 256 | 128 | 256 | |
| SRAM (KB) | 8 | 8 | 8 | 8 | 8 | 8 | 12 | 8 | 12 | 16 | 32 | 8 | 12 | 16 | 32 | 16 | 32 | |
| ISP Loader ROM (KB) | 4 | | | | | | | | | | | | | | | | | |
| I/O | 15 | 23 | | 26 | | | 41 | | | 54 | | 53 | | 85 | | | | |
| Timer/PWM | 4 | | | | | | | | | | | | | | | | | |
| PWM | 9 | 11 | | 12 | | | 24 | | | | | | | | | | | |
| WDT/WWDT | 1 | | | | | | | | | | | | | | | | | |
| Connectivity | USCI | 1 | | | 2 | | | 3 | | | | | | | | | | |
| | UART | 2 | | | 3 | | | | | | | | | | | | | |
| | QSPI | 1 | | | | | | | | | | | | | | | | |
| | SPI/I ² S | - | | | 1 | | | | | | | | | | | | | |
| | I ² C | 2 | | | | | | | | | | | | | | | | |
| | SC/UART | 1 | | | | | | | | | | | | | | | | |
| | PSIO | - | | | 4 | | | 8 | | 4 | | 8 | | | | | | |
| 12-bit ADC | 7 | 9 | 10 | | | 12 | | | 16 | | | | | | | | | |
| ACMP | - | | | 2 | | | | | | | | | | | | | | |
| DAC | - | | | | | | | | | 1 | - | | 1 | - | | 1 | | |
| OPA | - | | | | | | | | | 1 | - | | 1 | - | | 1 | | |
| PDMA | 5 | | | | | 8 | | | 5 | | 8 | | | | | | | |
| Crypto | - | | | | | | | | | 1 | - | | 1 | - | | 1 | | |
| Tamper pin | - | | | | | | | | | | | 1 | | | | | | |
| V _{BAT} | - | | | | | | | | | | | | 1 | | | | | |
| Package | TSSOP20 | TSSOP28 | | QFN33 | | | LQFP48 | | | LQFP64 | | | LQFP128 | | | | | |

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4.2.2 M252 USB Series

| PART NUMBER | M252FC2AE | M252EC2AE | M252ZC2AE | M252ZD2AE | M252LC2AE | M252LD2AE | M252LE3AE | M252LG6AE | M252SC2AE | M252SD2AE | M252SE3AE | M252SG6AE | M252KE3AE | M252KG6AE | |
|--------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--|
| Flash (KB) | 32 | 32 | 32 | 64 | 32 | 64 | 128 | 256 | 32 | 64 | 128 | 256 | 128 | 256 | |
| SRAM (KB) | 8 | 8 | 8 | 12 | 8 | 12 | 16 | 32 | 8 | 12 | 16 | 32 | 16 | 32 | |
| SP Loader ROM (KB) | 4 | | | | | | | | | | | | | | |
| I/O | 11 | 19 | 22 | | 37 | | | 50 | | 49 | | 81 | | | |
| Timer/PWM | 4 | | | | | | | | | | | | | | |
| PWM | 7 | 11 | 12 | 20 | 24 | | | | | | | | | | |
| WDT/WWDT | 1 | | | | | | | | | | | | | | |
| Connectivity | USCI | 1 | | 2 | | 3 | | 2 | | 3 | | | | | |
| | UART | 2 | | | 3 | | | | | | | | | | |
| | QSPI | 1 | | | | | | | | | | | | | |
| | SPI //I ² S | - | | | 1 | | | | | | | | | | |
| | I ² C | 2 | | | | | | | | | | | | | |
| | SC/UART | 1 | | | | | | | | | | | | | |
| | USB | 1 | | | | | | | | | | | | | |
| | PSIO | - | | | 4 | | | 8 | | 4 | | 8 | | | |
| 12-bit ADC | 3 | 9 | 10 | | 12 | | | 16 | | | | | | | |
| ACMP | - | | | 2 | | | | | | | | | | | |
| DAC | - | | | | | | | 1 | - | | 1 | - | | 1 | |
| OPA | - | | | | | | | 1 | - | | 1 | - | | 1 | |
| PDMA | 5 | | | | | 8 | | | 5 | | 8 | | | | |
| Crypto | - | | | | | | 1 | | - | | 1 | - | | 1 | |
| Tamper pin | - | | | | | | | | | | 1 | | | | |
| V _{BAT} | - | | | | | | | | | | 1 | | | | |
| Package | TSSOP20 | TSSOP28 | QFN33 | | LQFP48 | | | LQFP64 | | | | LQFP128 | | | |

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5 PIN CONFIGURATION

5.1 M251 Series Pin Diagram

5.1.1 M251 Series TSSOP 20-Pin Diagram

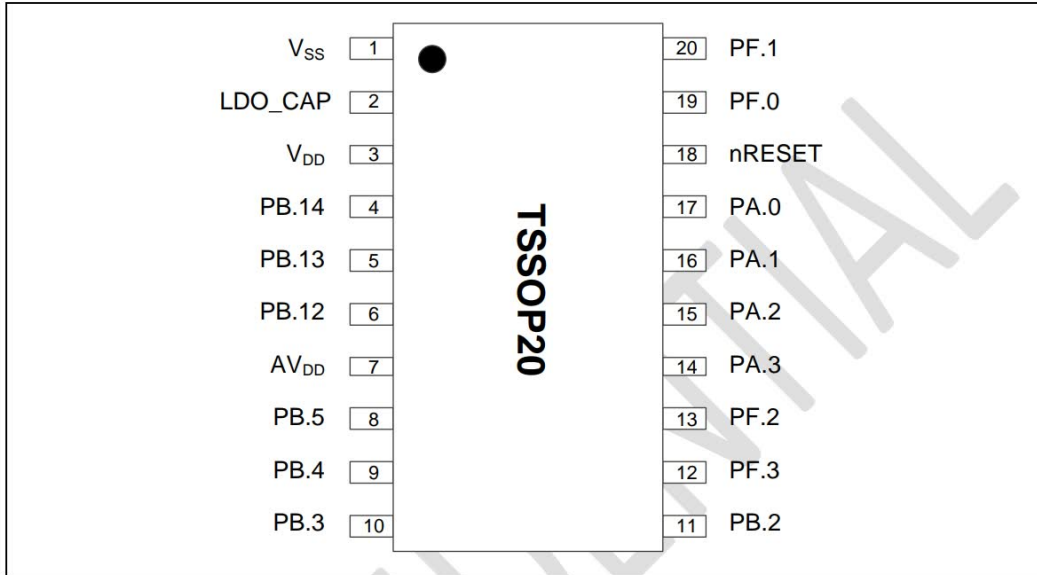


Figure 5-1 M251 Series TSSOP 20-pin Diagram

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5.1.2 M251 Series TSSOP 28-Pin Diagram

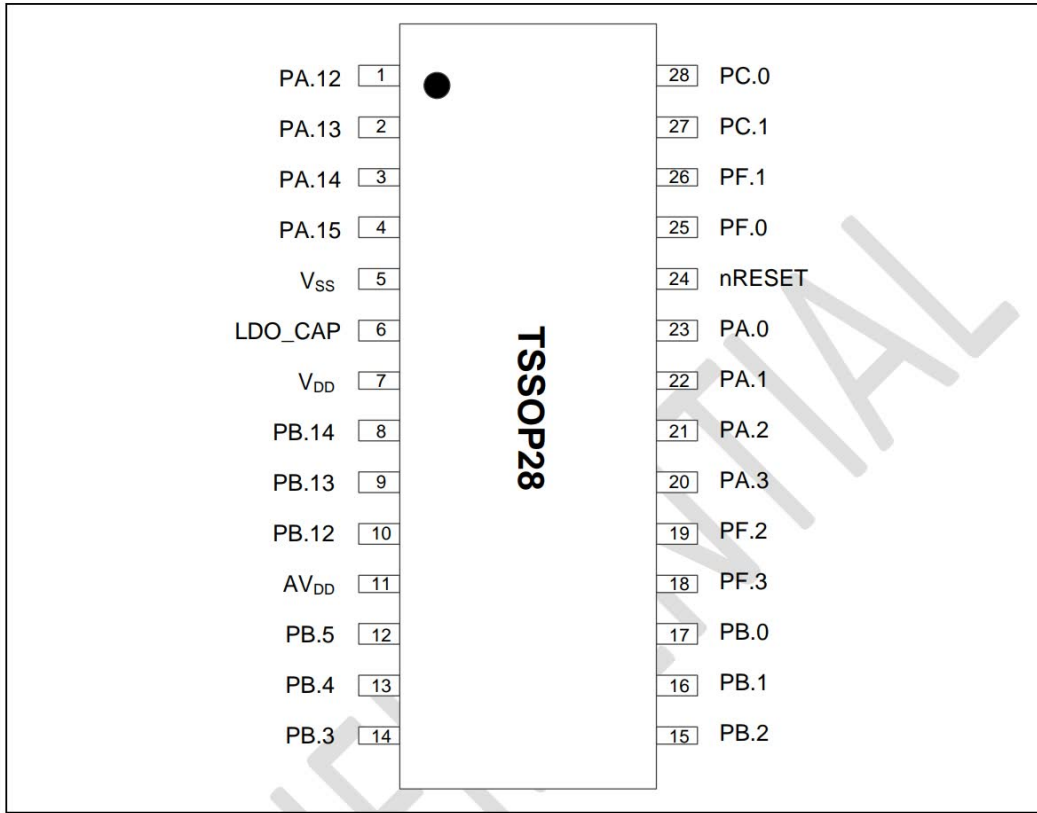


Figure 5-2 M251 Series TSSOP 28-pin Diagram

M251/M252 SERIES PRELIMINARY PRODUCT BRIEF

5.1.3 M251 Series QFN 33-Pin Diagram

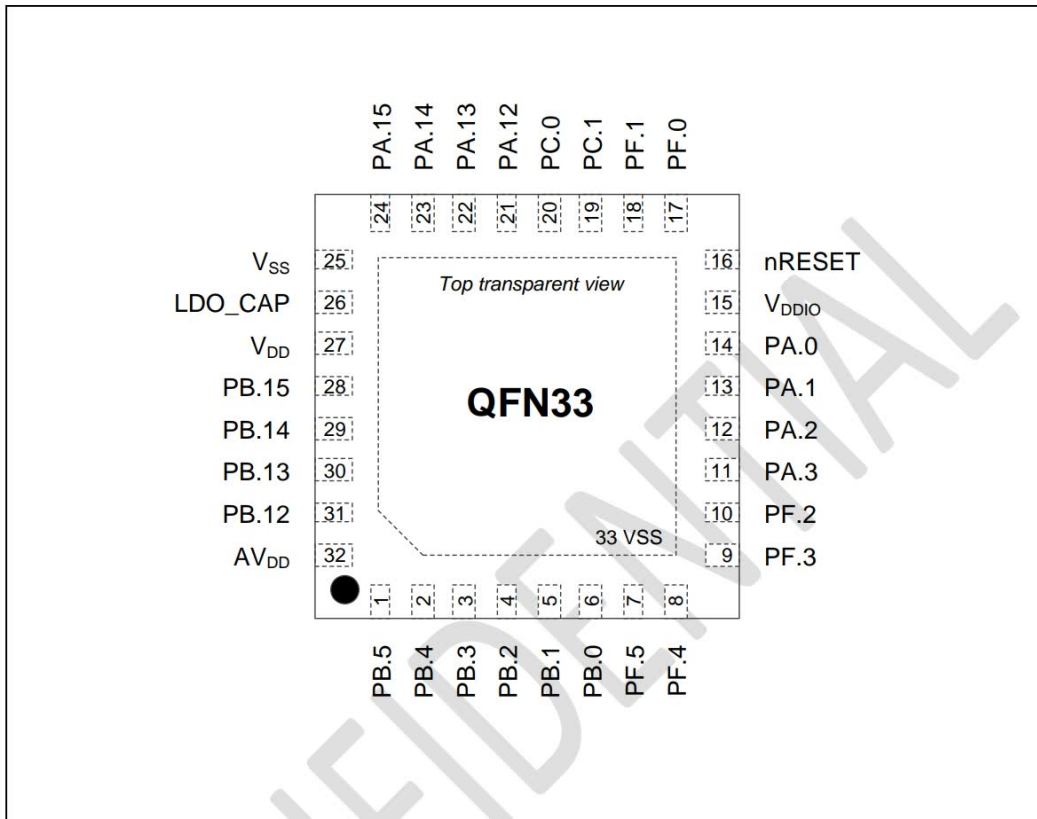


Figure 5-3 M251 Series QFN 33-pin Diagram

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5.1.4 M251 Series LQFP 48-Pin Diagram

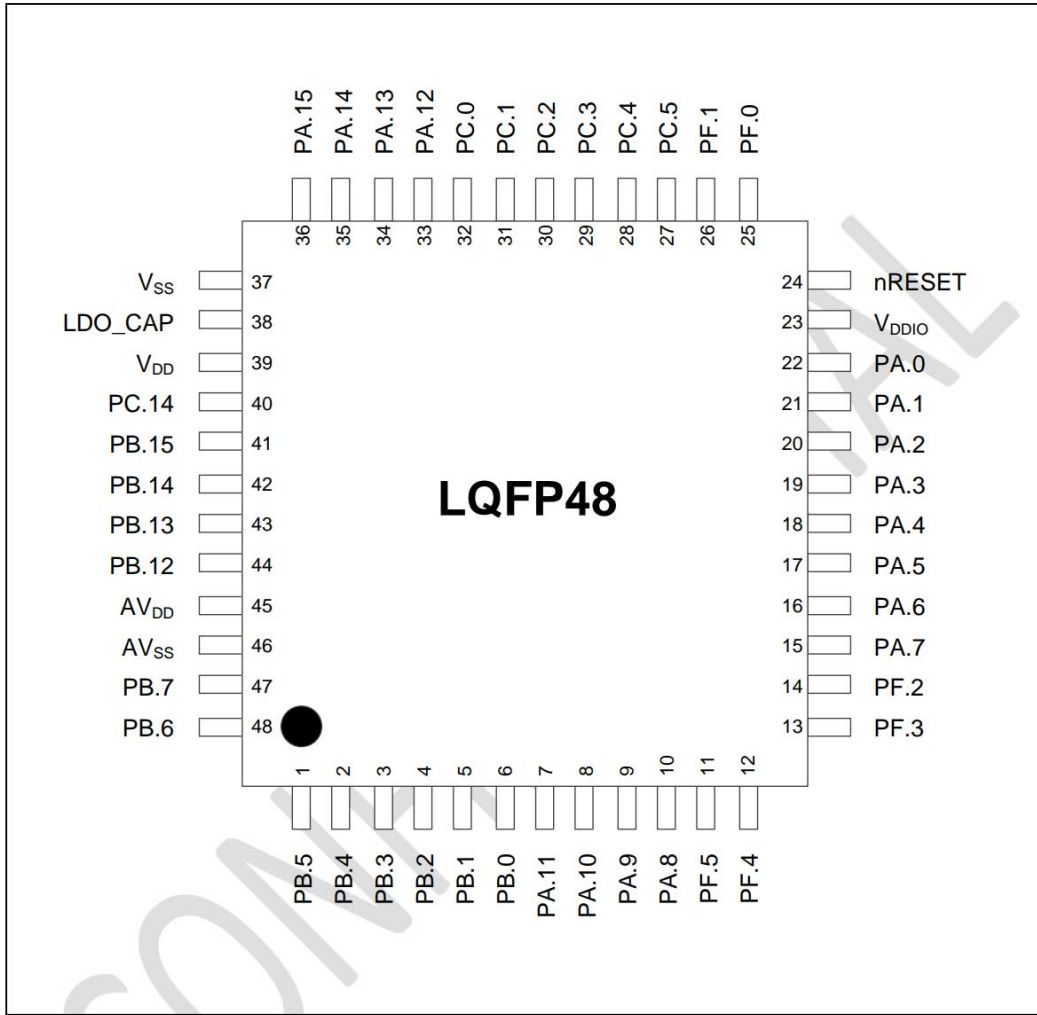


Figure 5-4 M251 Series LQFP 48-pin Diagram

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5.1.5 M251 Series LQFP 64-Pin Diagram

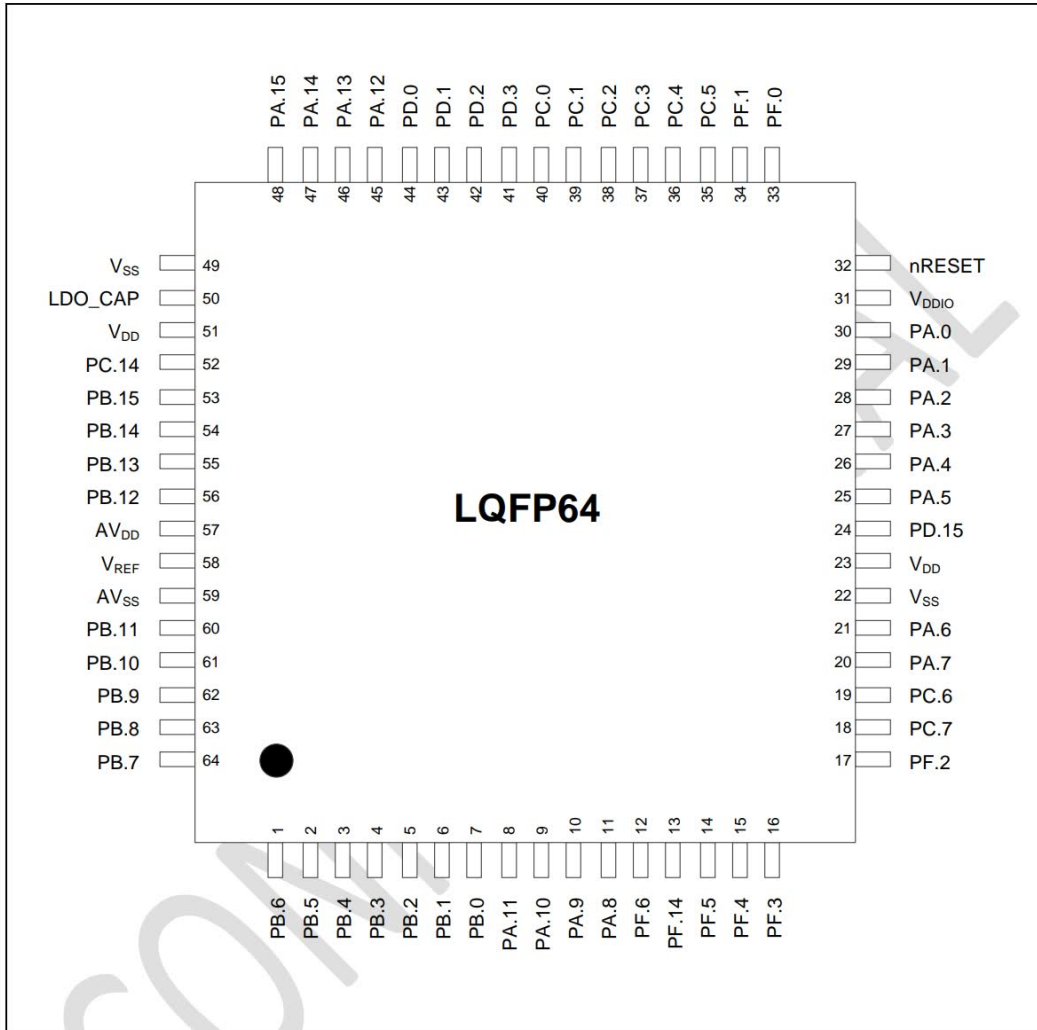


Figure 5-5 NuMicro® M251 Series LQFP 64-pin Diagram

5.1.6 M251 Series LQFP 128-Pin Diagram

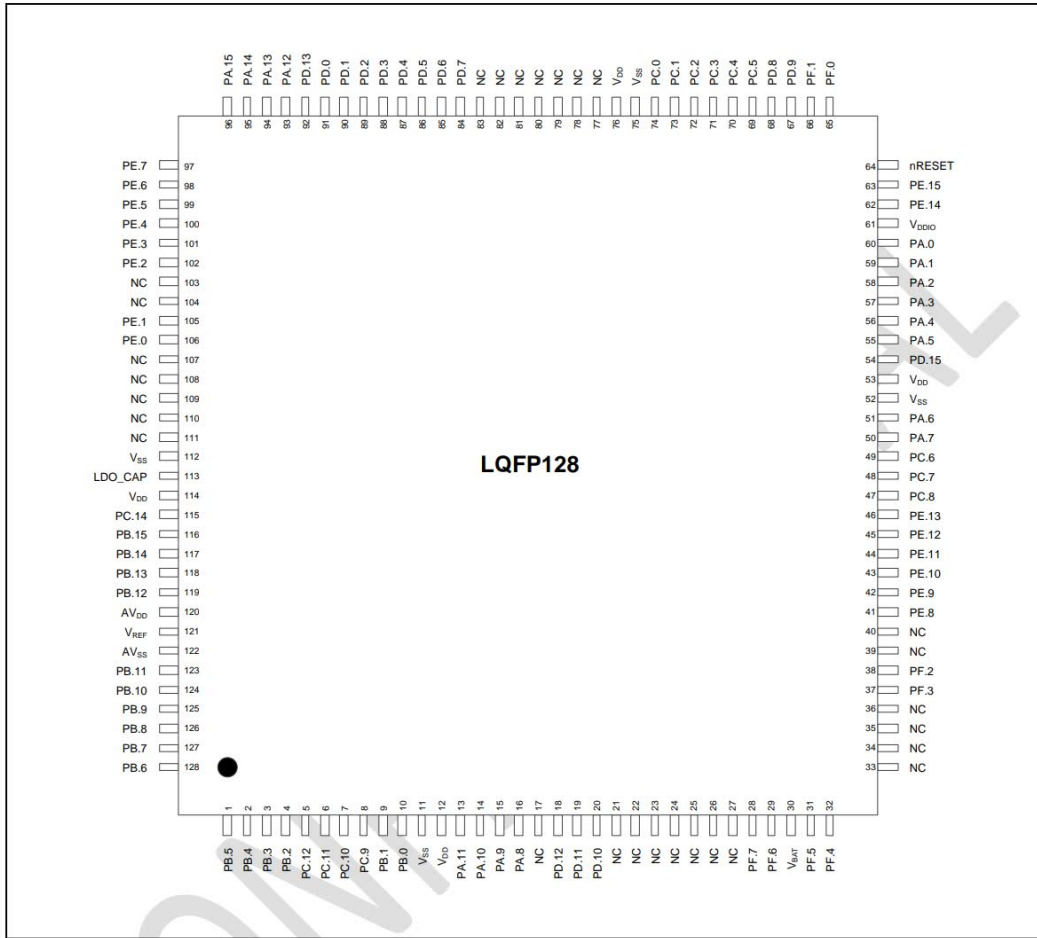


Figure 5-6 NuMicro® M251 Series LQFP 128-pin Diagram

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5.2 M252 Series Pin Diagram

5.2.1 M252 Series TSSOP 20-Pin Diagram

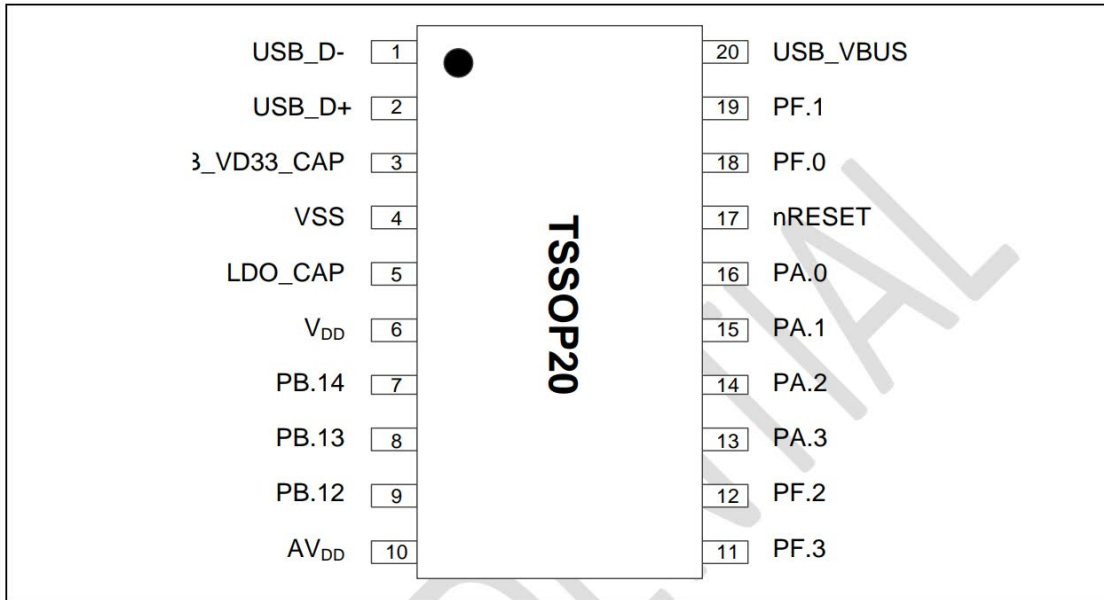


Figure 5-7 NuMicro® M252 Series TSSOP 20-pin Diagram

5.2.2 M252 Series TSSOP 28-Pin Diagram

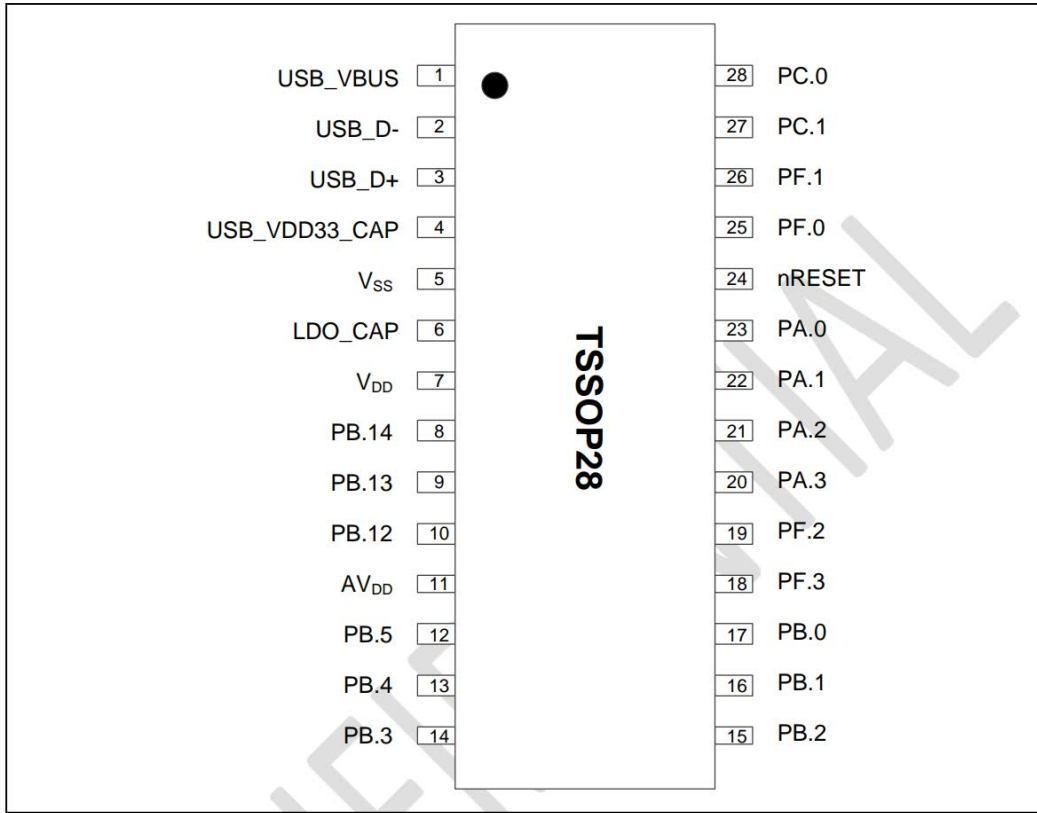


Figure 5-8 NuMicro® M252 Series TSSOP 28-pin Diagram

5.2.3 M252 Series QFN 33-Pin Diagram

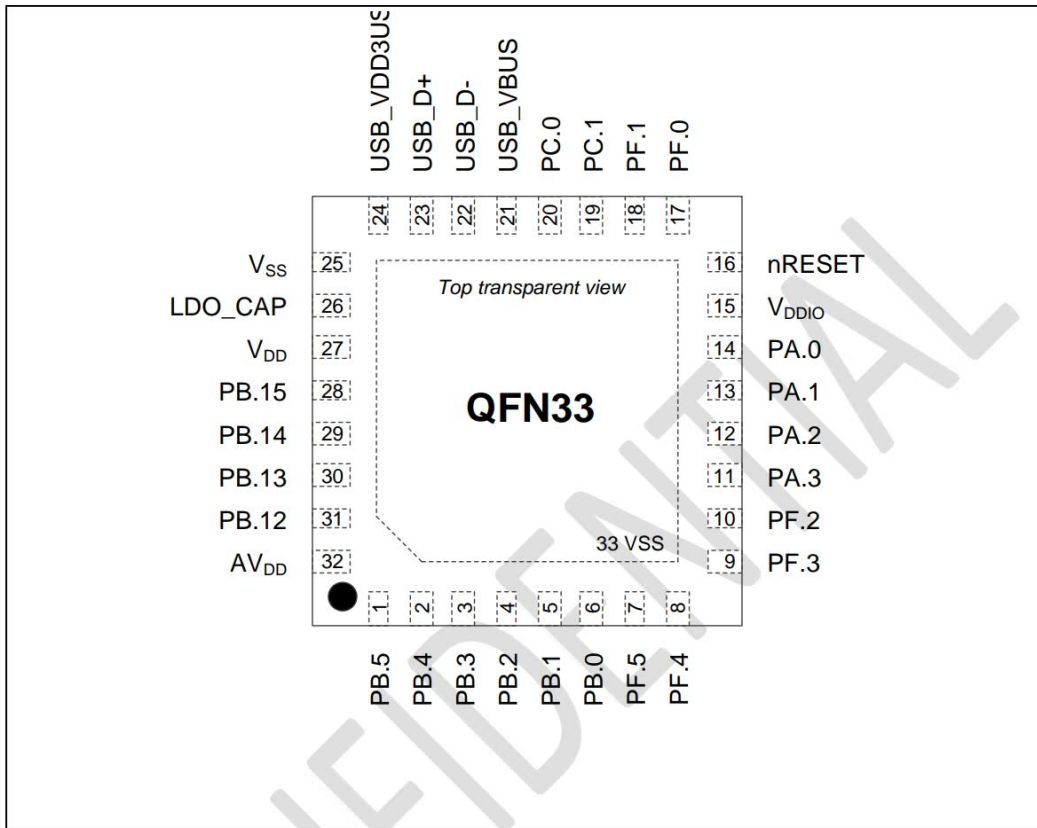


Figure 5-9 NuMicro® M252 Series QFN 33-pin Diagram

5.2.4 M252 Series LQFP 48-Pin Diagram

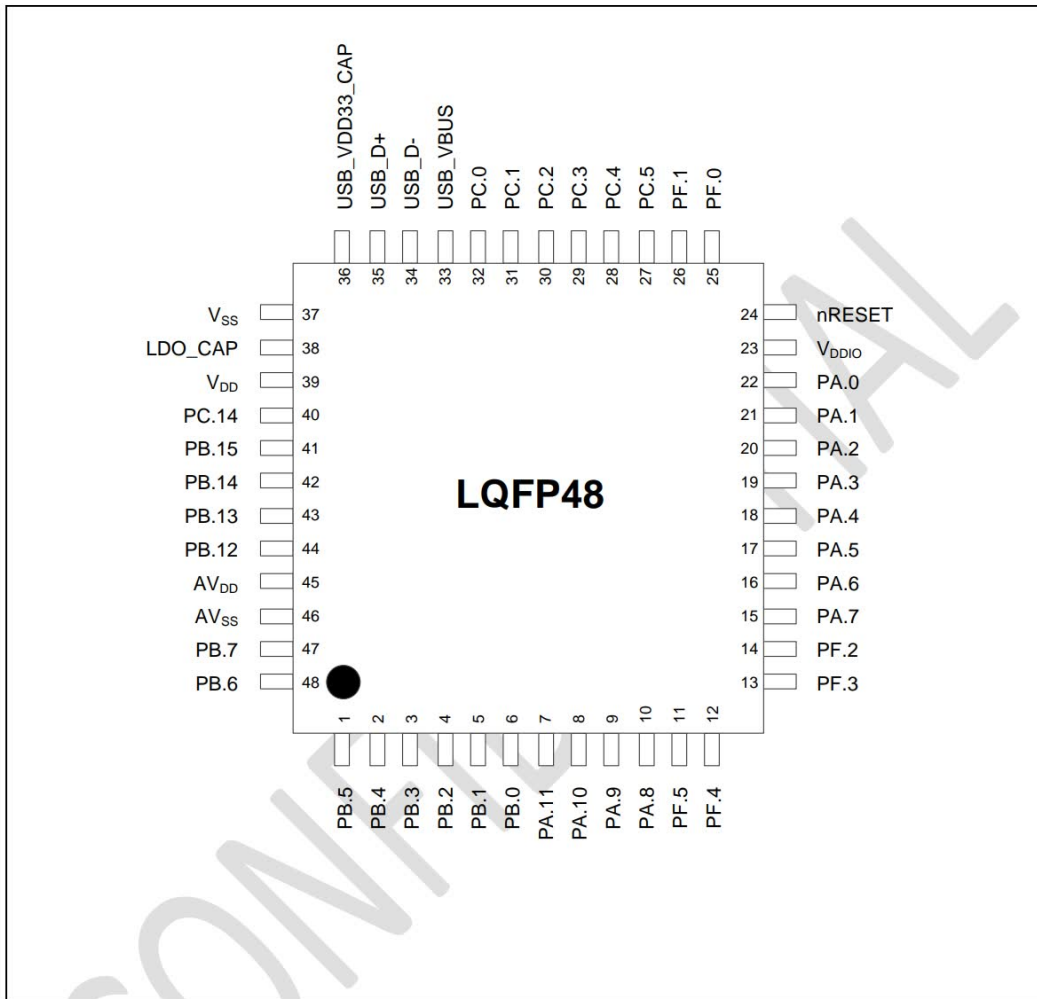


Figure 5-10 NuMicro® M252 Series LQFP 48-pin Diagram

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5.2.5 M252 Series LQFP 64-Pin Diagram

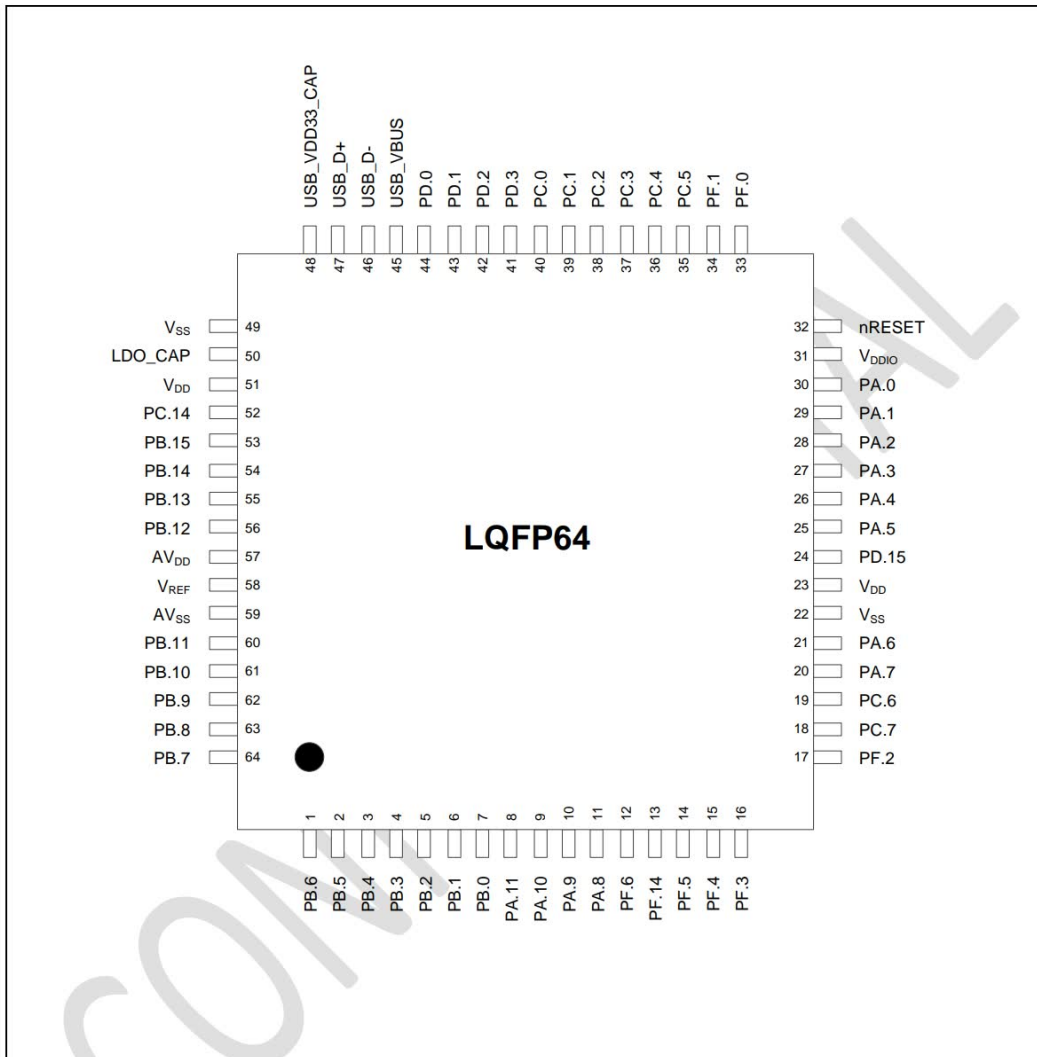


Figure 5-11 NuMicro® M252 Series LQFP 64-pin Diagram

5.2.6 M252 Series LQFP 128-Pin Diagram

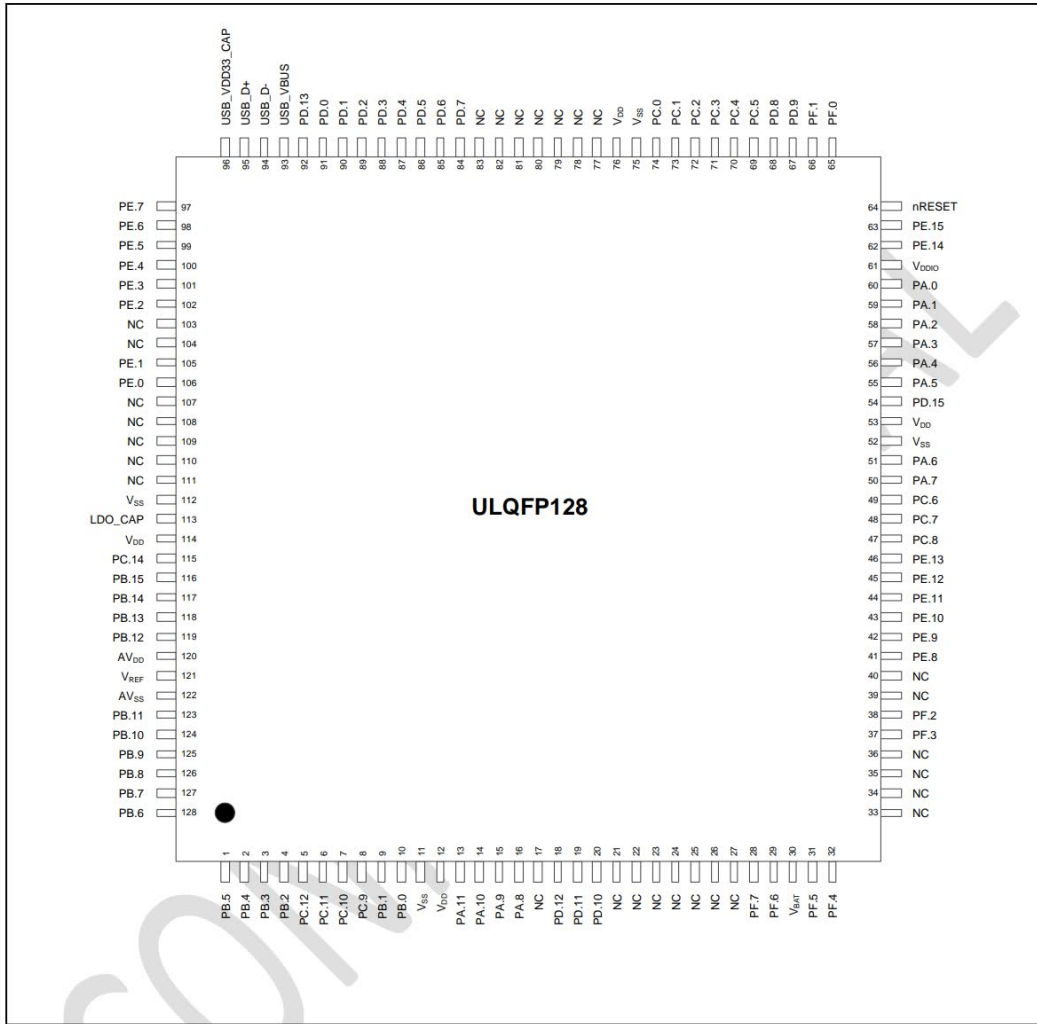


Figure 5-12 NuMicro® M252 Series LQFP 128-pin Diagram

M251/M252 SERIES PRELIMINARY PRODUCT BRIEF

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

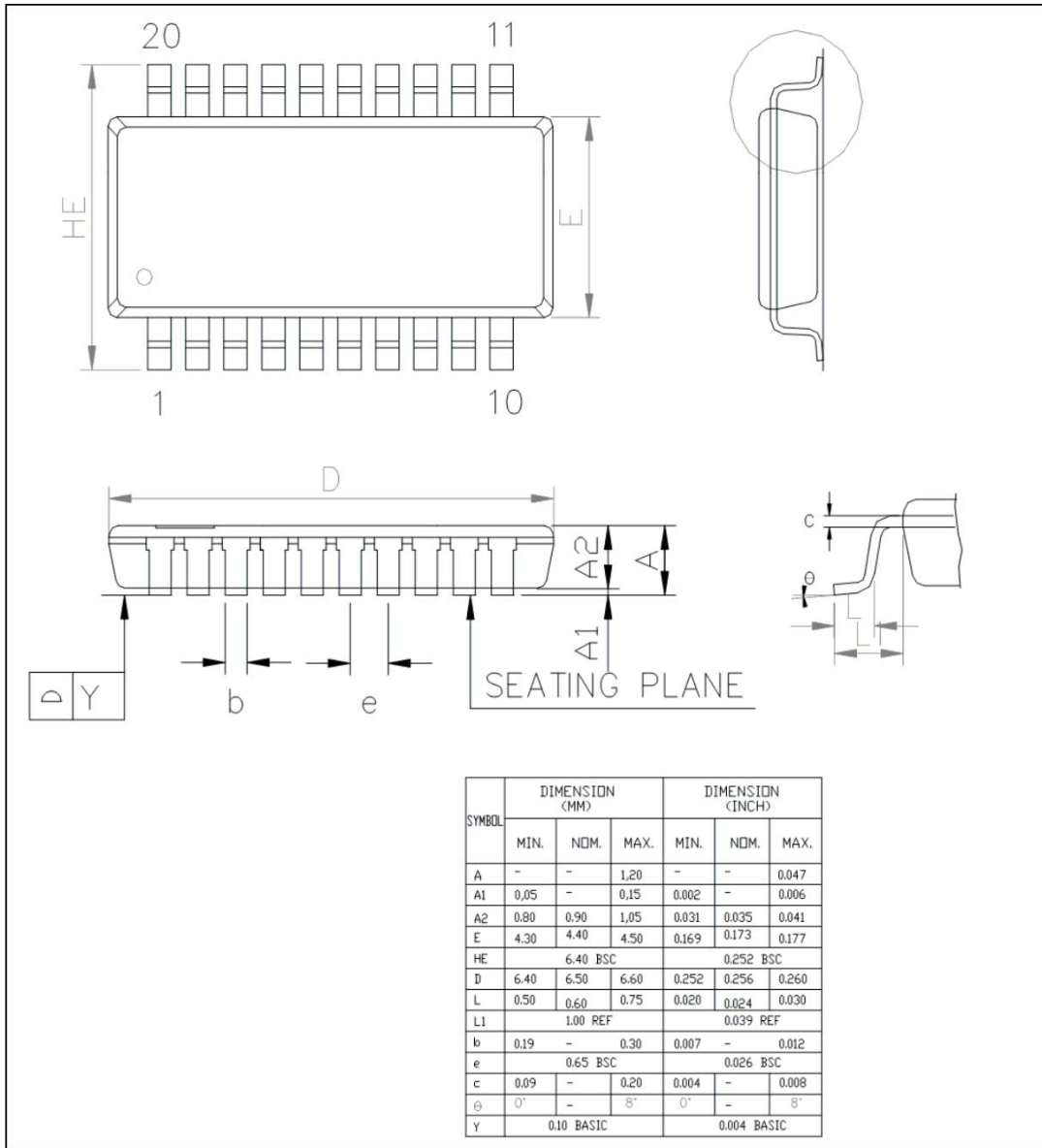
| | |
|------------------|---|
| Programming IDE | Keil MDK, IAR, NuEclipse(GCC) |
| Software Package | Board Support Package(BSP), Sample Code, |
| Development IDE | NuTool PinView, NuTool PinConfig, NuTool ClockConfig, NuConsole |
| RTOS | Mbed, FreeRTOS, Amazon FreeRTOS, Ali-OS |
| HMI | Support emWin with font create tool and easy GUI builder |
| Programming IDE | Keil MDK, IAR, NuEclipse(GCC) |

6.3 Development Board

| EVB NuMaker | Part Number | Feature |
|-------------|--|---|
| NK-M251ZC | M251ZC2AE, M251EC2AE, M251FC2AE M251ZB2AE, M251EB2AE, M251FB2AE | Support Expand Connector, Arduino Uno Interface |
| NK-M251SD | M251SD2AE, M251LD2AE, M251ZD2AE M251SC2AE, M251LC2AE, | |
| NK-M251KE | M251KE3AE, M251SE3AE, M251LE3AE | |
| NK-M251KG | M251KG6AE, M251SG6AE, M251LG6AE | |
| NK-M252ZC | M252ZC2AE, M252EC2AE, M252FC2AE | |
| NK-M252SD | M252SD2AE, M252LD2AE, M252ZD2AE M252SC2AE, M252LC2AE, | |
| NK-M252KE | M252KE3AE, M252SE3AE, M252LE3AE | |
| NK-M252KG | M252KG6AE, M252SG6AE, M252LG6AE | |

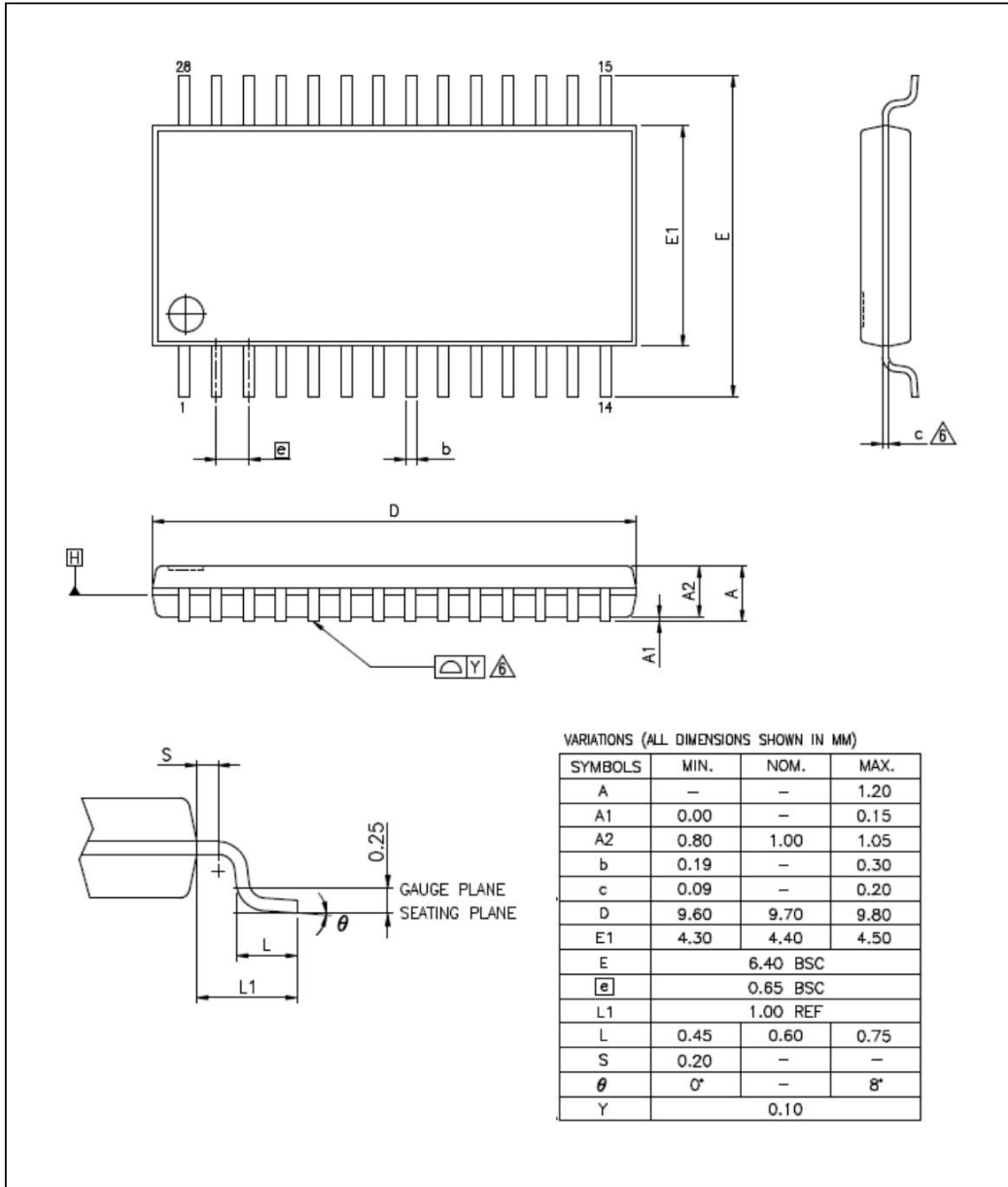
7 PACKAGE DIMENSIONS

7.1 TSSOP 20-Pin (4.4x6.5x0.9 mm³)

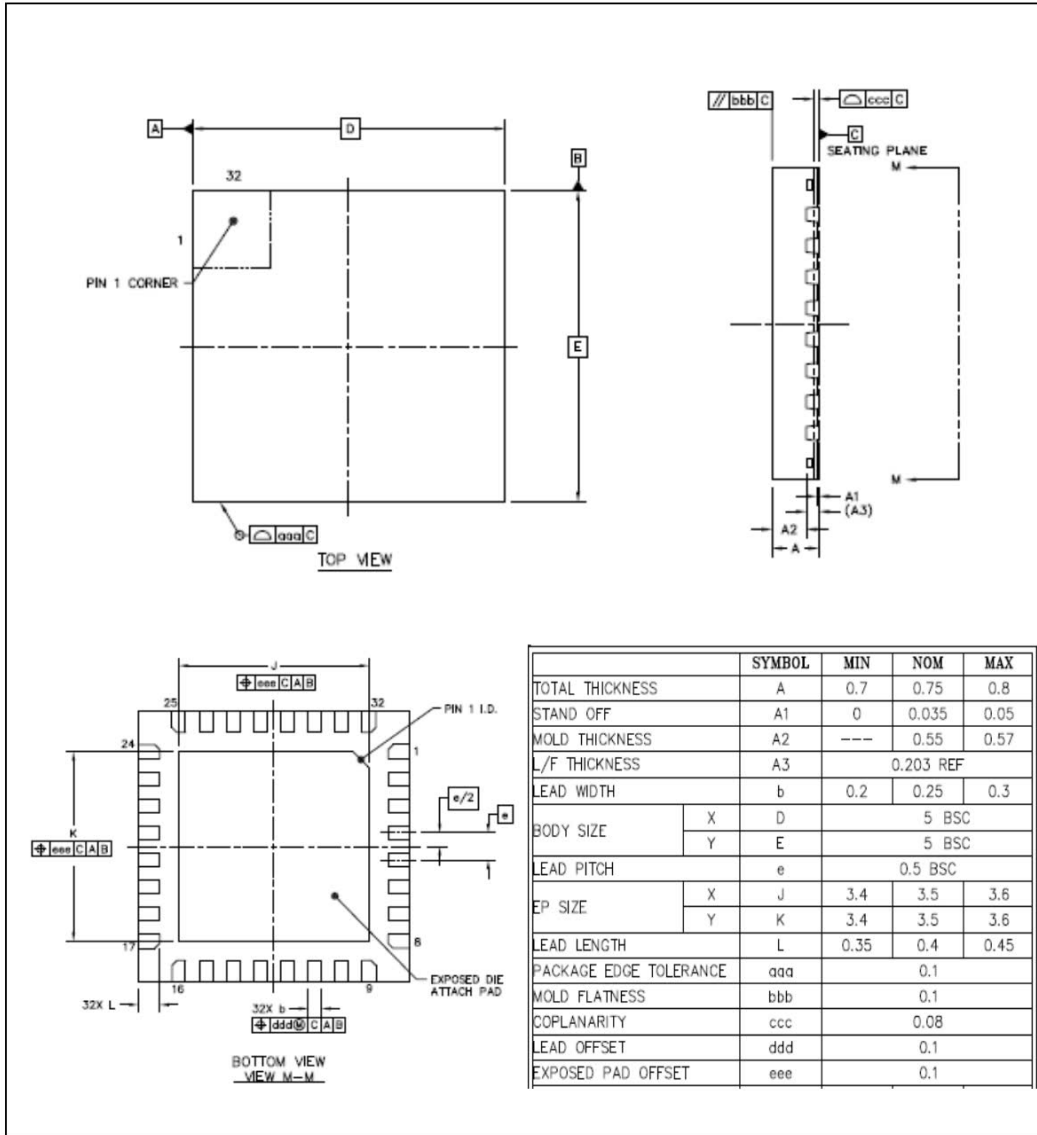


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7.2 TSSOP 28-Pin (4.4x9.7x1.0 mm³)

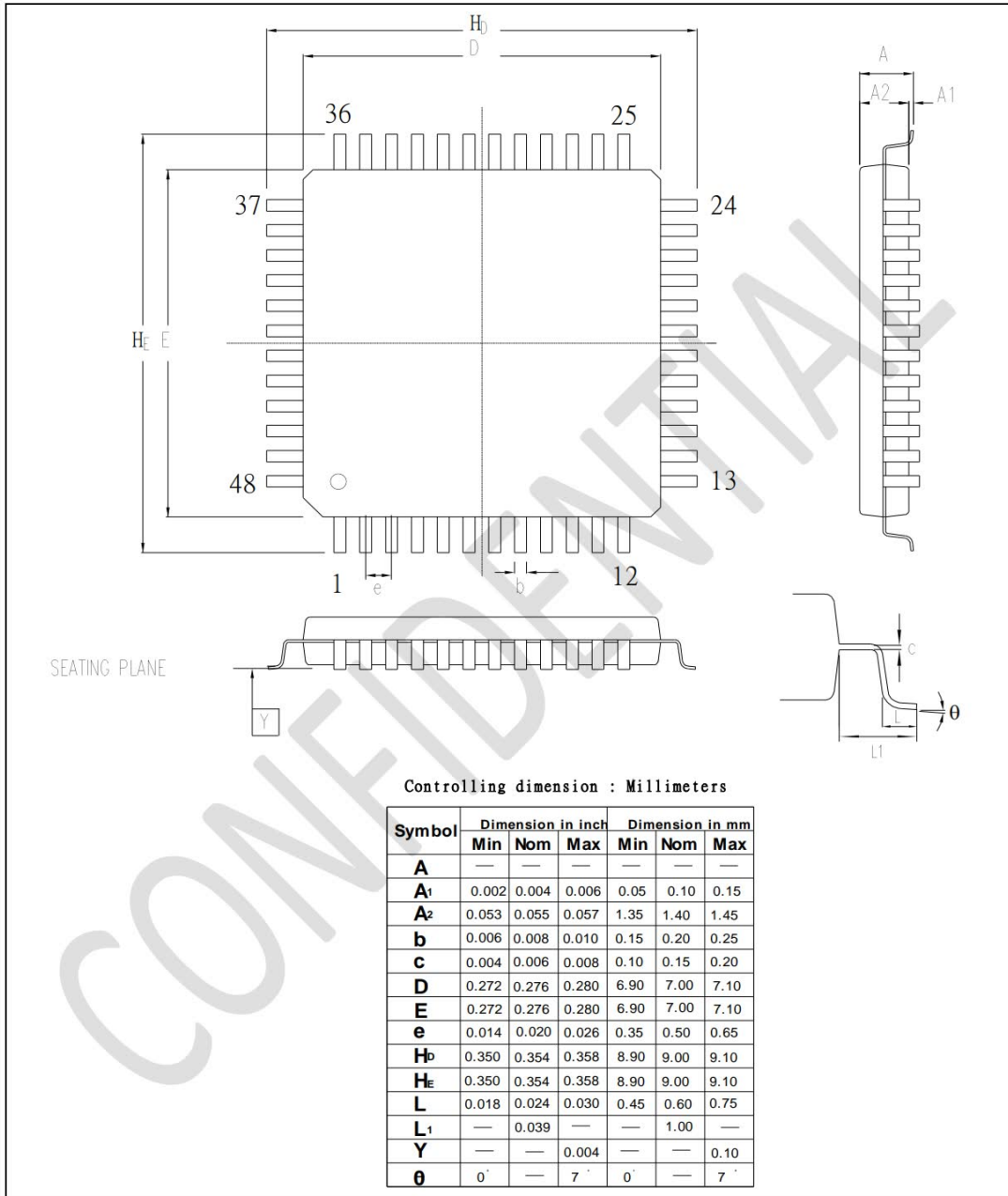


7.3 QFN 33-pin (5X5x0.8 mm³, Pitch: 0.50 mm)



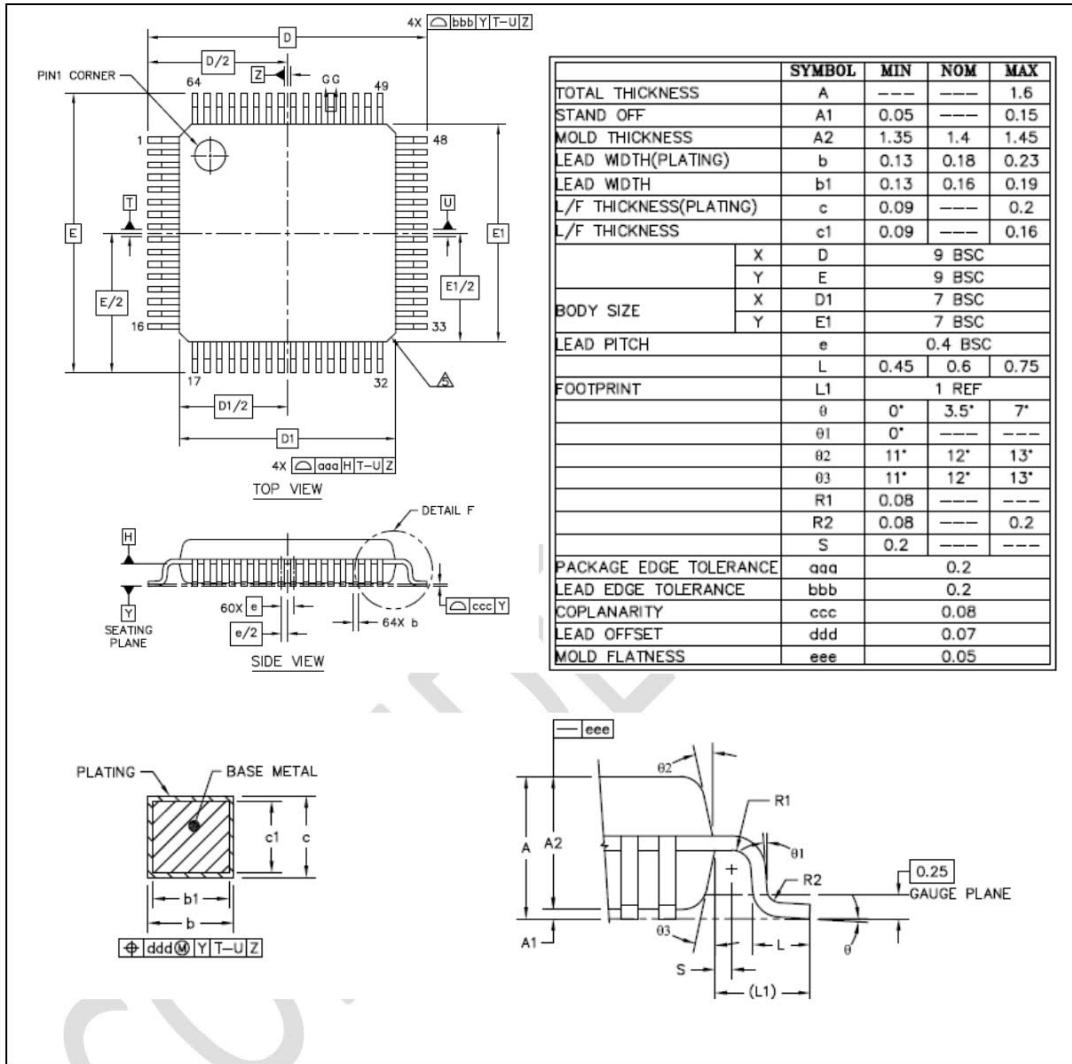
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7.4 LQFP 48-pin (7x7x1.4 mm³, footprint 2.0mm)



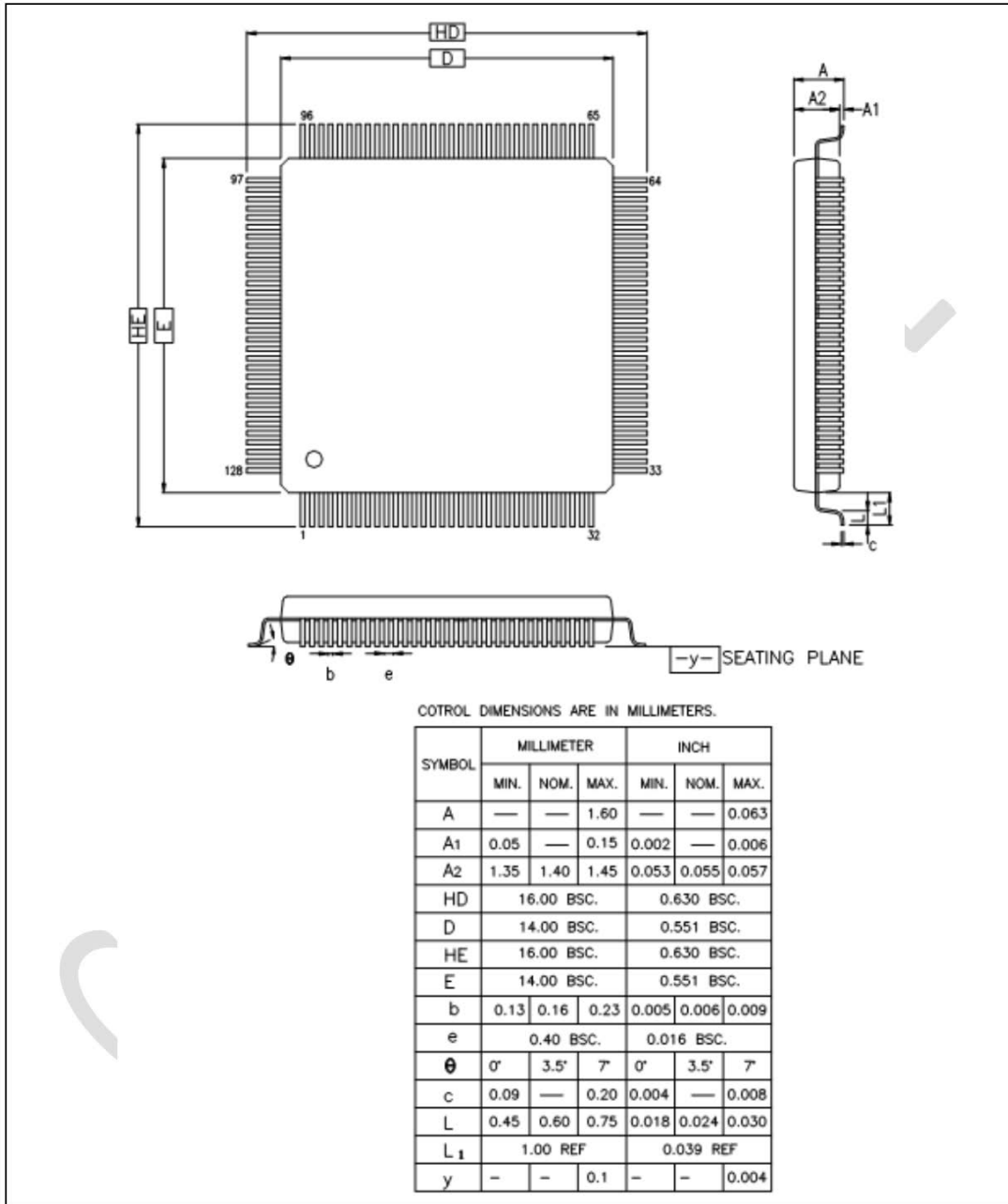
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7.5 LQFP 64-pin (7x7x1.4 mm³, footprint 2.0mm)



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7.6 LQFP 128-pin (14x14x1.4 mm³, footprint 2.0mm)



8 REVISION HISTORY

| Date | Revision | Description |
|------------|----------|---|
| 2018.12.14 | 0.10 | Preliminary version |
| 2019.02.12 | 0.20 | Preliminary version – Update chapter format |

CONFIDENTIAL

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.

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