1.1 Overview

1.1.1 Overview

The MN103S is a 32-bit microcontroller combining ease of use intended for programs development in the C language with a simple, high-performance architecture made possible through pursuit of cost performance.

Built around a compact 32-bit CPU with a basic instruction word length of 1 byte, this LSI includes internal memory for instructions and data, a clock generator, bus controller, interrupt controller, watchdog timer, standard peripheral circuitry such as timers and serial interfaces, PWM circuit best suited to controlling 3-phase motors and A/D converters for motor position control. The MN103S Series' high-speed CPU coupled with abundance of peripheral features provides an easy means of developing low-cost, high-performance and multifunctional system on chip for motor and power control applications requiring fast response - a feature previously unavailable with conventional microcontrollers.

1.1.2 Product Summary

This manual describes the following model.

Table:1.1.1 Product Summary

Model	ROM Size	RAM Size	Classification
MN103SFM9K	256 K	8 K	Flash EEPROM version

1.2 Hardware Functions

CPU Core
MN103S core
4 GB of linear address space (for instructions / data)
LOAD/STORE architecture with 5-stage pipeline
46 basic instructions + 4 extension instructions
6 addressing modes
Instruction set of 1 byte in word length
Machine cycle: 16.7 ns (oscillation frequency: 10 MHz, 6 multiply)
Operation mode: Normal mode

Oscillation Circuit
External high-speed oscillation (crystal/ ceramic)

Clock Multiplication Circuit
External high-speed oscillation is multiplied by 4, 6 and 8.

Operating voltage
3.6 V to 5.5 V

Guaranteed operating temperature
-40 °C to 85 °C

Internal Memory
ROM 256 Kbytes RAM 8 Kbytes

Interrupts
Non-maskable interrupt:
Watchdog timer overflow interrupts, System error interrupts

Internal interrupts: 47 interrupts
<Timer Interrupts>
Timer 0 underflow interrupts
Timer 1 underflow interrupts
Timer 2 underflow interrupts
Timer 3 underflow interrupts
Timer 4 underflow interrupts
Timer 5 underflow interrupts
Timer 6 underflow interrupts
Timer 7 underflow interrupts
Timer 8 overflow/underflow interrupts
Timer 8 compare/capture A interrupts
Timer 8 compare/capture B interrupts
Timer 9 overflow/underflow interrupts
Timer 9 compare/capture A interrupts
Timer 9 compare/capture B interrupts
Timer 10 overflow/underflow interrupts
Timer 10 compare/capture A interrupts
Timer 10 compare/capture B interrupts
Timer 11 overflow/underflow interrupts
Timer 11 compare/capture A interrupts
Timer 11 compare/capture B interrupts
Timer 12 overflow/underflow interrupts
Timer 12 compare/capture A interrupts
Timer 12 compare/capture B interrupts

Timer 13 overflow/underflow interrupts
Timer 13 compare/capture A interrupts
Timer 13 compare/capture B interrupts
Timer 14 underflow interrupts
Timer 15 underflow interrupts
Timer 16 underflow interrupts
Timer 17 underflow interrupts

<Serial Interface>
Serial 0 reception interrupts
Serial 0 transmission interrupts
Serial 1 reception interrupts
Serial 1 transmission interrupts
Serial 2 reception interrupts
Serial 2 transmission interrupts

<PWM>
PWM0 overflow interrupts
PWM0 underflow interrupts
PWM1 overflow interrupts
PWM1 underflow interrupts

<A/D interrupt>
A/D 0 conversion complete interrupt
A/D 0 conversion complete B interrupt
A/D 1 conversion complete interrupt
A/D 1 conversion complete B interrupt
A/D 2 conversion complete interrupt

External interrupts: 9 interrupts
Interrupt pins: IRQ00 to IRQ08
Interrupt detection condition:
Edge (rising edge, falling edge), both edges, High-level detection, Low-level detection
Noise filter's filtering is possible at all conditions.

Timer Counter

8-bit timer 12 sets
16-bit timer 6 sets

Timer 0 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count
- Count clock source, TM0IO pin input
  IOCLK, IOCLK/8, IOCLK/32, IOCLK/128, Timer 1 underflow,
  Timer 2 underflow, TM0IO pin input

Timer 1 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count,
  Cascade connection function
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, Timer 0 underflow,
  Timer 2 underflow, TM1IO pin input

Timer 2 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count, Cascade connection function
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, IOCLK/128, Timer 0 underflow, Timer 1 underflow,
  TM2IO pin input

Timer 3 (8-bit timer for general use)

- Interval timer, Timer pulse output, Event count, Cascade connection function
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, TM3IO pin input,
  Timer 0 underflow, Timer 1 underflow, Timer 2 underflow,

Timer 4 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count,
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, IOCLK/128, TM4IO pin input,
  Timer 5 underflow, Timer 6 underflow

Timer 5 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count, Cascade connection function
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, Timer 4 underflow,
  Timer 6 underflow, TM5IO pin input

Timer 6 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count, Cascade connection function
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, IOCLK/128, TM6IO pin input,
  Timer 4 underflow, Timer 5 underflow

Timer 7 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count, Cascade connection function
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, TM7IO pin input, Timer 4 underflow,
  Timer 5 underflow, Timer 6 underflow

Timer 8 (16-bit timer for general use)
- Interval timer, Timer pulse output, Event count, PWM output, input capture,
  one-shot output, external trigger start
- Count clock source
  IOCLK, IOCLK/8, IOCLK/64, Timer 2 underflow, TM8BIO pin input

Timer 9 (16-bit timer for general use)
- Interval timer, Timer pulse output, Event count, PWM output, input capture,
  one-shot output, external trigger start
- Count clock source
  IOCLK, IOCLK/8, IOCLK/64, Timer 3 underflow,
  TM9BIO pin input

Timer 10 (16-bit timer for general use)
- Interval timer, Timer pulse output, Event count, PWM output, input capture,
  one-shot output, external trigger start
- Count clock source
  IOCLK, IOCLK/8, Timer 0 underflow, Timer 1 underflow,
  TM10BIO pin input

Timer 11 (16-bit timer for general use)
- Interval timer, Timer pulse output, Event count, PWM output,
  input capture, one-shot output, external trigger start
- Count clock source
  IOCLK, IOCLK/8, Timer 4 underflow, Timer 5 underflow, TM11IO pin input

Timer 12 (16-bit timer for general use)

- Interval timer, trigger start 3-phase PWM, AD conversion start
- Count clock source
  MCLK, MCLK/8, IOCLK, IOCLK/8, Timer 6 underflow, Timer 7 underflow

Timer 13 (16-bit timer for general use)
- Interval timer, trigger start 3-phase PWM, AD conversion start
- Count clock source
  MCLK, MCLK/8, IOCLK, IOCLK/8, Timer 6 underflow, Timer 7 underflow

Timer 14 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count, Baud rate timer
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, IOCLK/128, Timer 15 underflow, Timer 16 underflow, TM14IO pin input

Timer 15 (8-bit timer for general use)
- Interval timer, Baud rate timer, Cascade connection function
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, Timer 14 underflow, Timer 16 underflow

Timer 16 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count, Baud rate timer, Cascade connection function
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, IOCLK/128, Timer 14 underflow, Timer 15 underflow, TM16IO pin input

Timer 17 (8-bit timer for general use)
- Interval timer, Timer pulse output, Event count, Cascade connection function
- Count clock source
  IOCLK, IOCLK/8, IOCLK/32, TM17IO pin input, Timer 14 underflow, Timer 15 underflow, Timer 16 underflow

Watchdog Timer

Detection time 6.55 ms to 1677.72 ms (oscillation frequency 10 MHz)
Generates non-maskable interrupts at detection
Generates hard-reset at second consecutive overflow

A /D Converter

A/D0
- Resolution 10 bits
- Minimum conversion time 1.0 µsec
- Channels 8 channels (ADIN00 to ADIN05, ADIN18, ADIN19)
- Use of 3 converters allows simultaneous sampling of 3 phases
- A/D conversion start trigger is in synchronization with complementary 3-phase PWM cycle and 16-bit timer

A/D1
- Resolution 10 bits
- Minimum conversion time 1.0 µsec
- Channels 8 channels (ADIN02 to ADIN09)
- Use of 3 converters allows simultaneous sampling of 3 phases
- A/D conversion start trigger is in synchronization with complementary 3-phase PWM cycle and 16-bit timer

A/D2

- Resolution 10 bits
- Minimum conversion time 1.0 µsec
- Channels 16 channels (ADIN00, ADIN01, ADIN06 to ADIN19)
- Use of 3 converters allows simultaneous sampling of 3 phases
- A/D conversion start trigger is in synchronization with complementary 3-phase PWM cycle and 16-bit timer

Complementary 3-phase PWM output 2 channels

- Min. resolution: 33.3 nsec
- Triangular and saw-tooth waves output
- Incorporates a dead time insertion circuit
- Can overwrite registers by double buffer during PWM operation
- PWM output protection circuit supporting external interrupts
- Output timing varying function

Serial Interface 3 channels

Serial 0 (Full duplex UART/synchronous serial interface)

Synchronous serial interface
- Overrun error detection
- Transfer clock source
  1/2 and 1/16 of timer 14 underflow, 1/2 and 1/16 of timer 15 underflow, and 1/2 and 1/16 of timer 16 underflow, SBT0 pin
- Can be selected as the first bit to be transferred,
  Any transfer size from 7 to 8 bits can be selected.
- Maximum transfer rate: 3.0 Mbps

Full duplex UART
- Parity error, overrun error, and flaming error detection
- Transfer clock source
  1/16 of timer 14 underflow, 1/16 of timer 15 underflow, and 1/16 of timer 16 underflow,
- Can be selected as the first bit to be transferred,
  Any transfer size from 7 to 8 bits can be selected.
- Continuous transmission, reception, and transmission/reception
- Maximum transfer rate: 375 kbps

Serial 1 (Full duplex UART/synchronous serial interface)

Synchronous serial interface
- Overrun error detection
- Transfer clock source
  1/2 and 1/16 of timer 14 underflow, 1/2 and 1/16 of timer 15 underflow, and 1/2 and 1/16 of timer 16 underflow, SBT1 pin
- Can be selected as the first bit to be transferred,
  Any transfer size from 7 to 8 bits can be selected.
- Maximum transfer rate: 3.0 Mbps

Full duplex UART
- Parity error, overrun error, and flaming error detection
- Transfer clock source
  1/16 of timer 14 underflow, 1/16 of timer 15 underflow, and 1/16 of timer 16 underflow,
- Can be selected as the first bit to be transferred,
  Any transfer size from 7 to 8 bits can be selected.
- Continuous transmission, reception, and transmission/reception
- Maximum transfer rate: 375 kbps

Serial 2 (Full duplex UART/synchronous serial interface)

Synchronous serial interface
- Overrun error detection
- Transfer clock source
  1/2, 1/4, 1/16, and 1/64 of timer 14 underflow,
  1/2, 1/4, 1/16, and 1/64 of timer 15 underflow,
  1/2, 1/4, 1/16, and 1/64 of timer 16 underflow,
  IOCLK/2, IOCLK/4, SBT2 pin
- Can be selected as the first bit to be transferred,
  Any transfer size from 2 to 8 bits can be selected.
- Continuous transmission, reception, and transmission/reception
- Maximum transfer rate: 5.0 Mbps

Full duplex UART
- Parity error, overrun error and flaming error detection
- Transfer clock source
  1/32, 1/64, 1/256, and 1/1024 of timer 14 underflow,
  1/32, 1/64, 1/256, and 1/1024 of timer 15 underflow,
  1/32, 1/64, 1/256, and 1/1024 of timer 16 underflow,
  IOCLK/32, IOCLK/64
- Can be selected as the first bit to be transferred,
  Any transfer size from 7 to 8 bits can be selected.
- Continuous transmission, reception, and transmission/reception
- Maximum transfer rate: 300 kbps

Regulator — incorporates regulator, and use of 5 V power supply is possible

Power Supply Detection (Auto reset circuit)
Detection level 3.6 V to 4.3 V
When power supply voltage is under detection level, reset is generated.

Port / pins	I/O ports	81 pins
	Motor control output	12 pins
	External interrupt	9 pins
	A/D input	20 pins
	Special pins	17 pins
	Reset input pin	1 pin
	Oscillation pin	2 pins
	Test pin	3 pins
	Power pin	11 pins

Package — QFP100 (18 mm square, 0.65 mm pitch)
Code name — QFP100-P-1818B

1.3 Pin Description

1.3.1 Pin Configuration

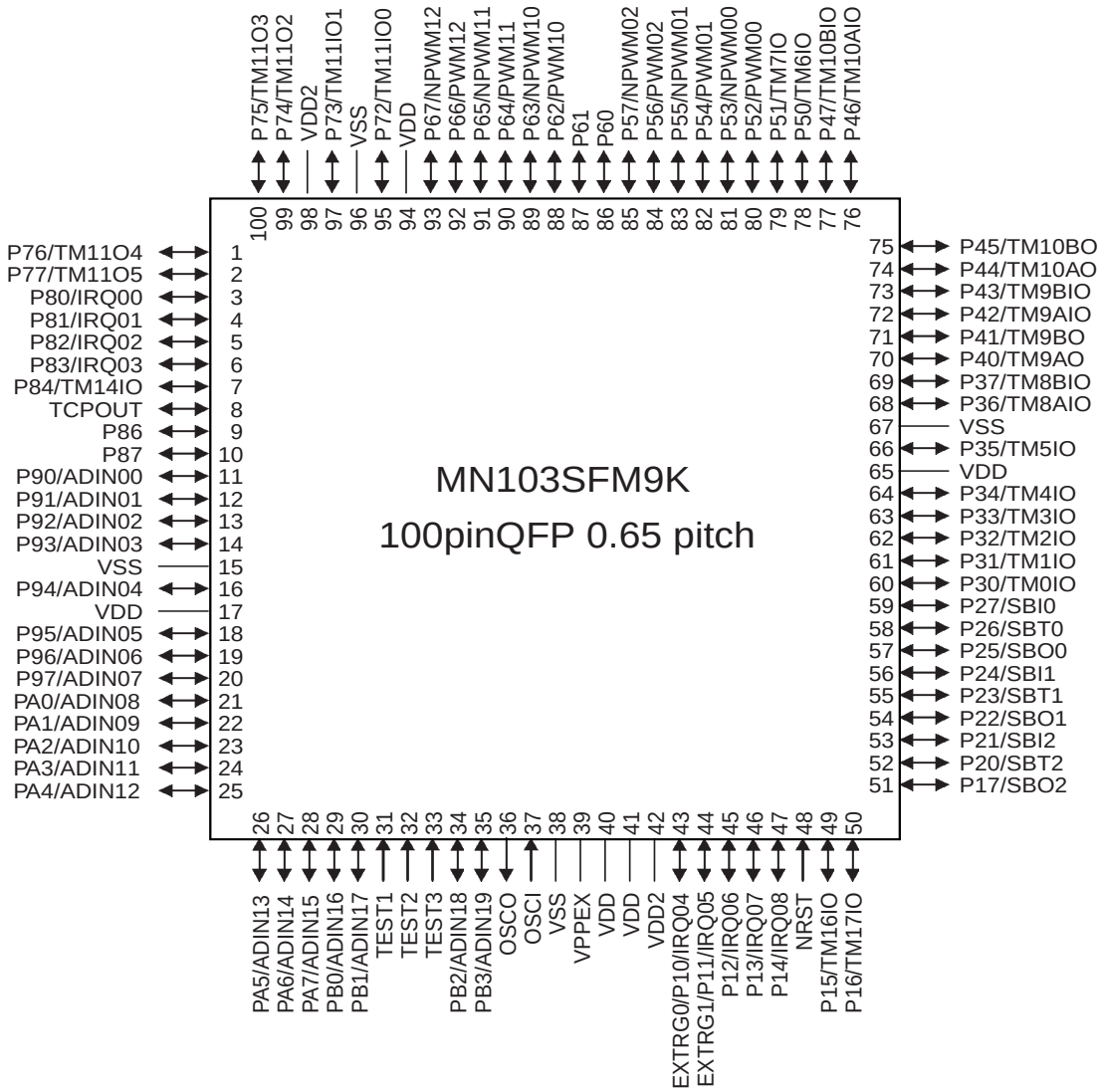

Figure:1.3.1 Pin Configuration

1.3.2 Pin Specification

Table:1.3.1 Pin Specification

Pin	Special functions	I/O	Direction control	Pin control	Function description
P07	NRST	in/out	-	-	Reset input
P10	IRQ04/EXTRG0	in/out	P10D	P10R	External interrupt input 4/ Trigger pin 0 for on-board debugging
P11	IRQ05/EXTRG1	in/out	P11D	P11R	External interrupt input 5/ Trigger pin 1 for on-board debugging
P12	IRQ06	in/out	P12D	P12R	External interrupt input 6
P13	IRQ07	in/out	P13D	P13R	External interrupt input 7
P14	IRQ08	in/out	P14D	P14R	External interrupt input 8
P15	TM16IO	in/out	P15D	P15R	Timer 16 input / output
P16	TM17IO	in/out	P16D	P16R	Timer 17 input / output
P17	SBO2	in/out	P17D	P17R	Serial 2 transmission data output
P20	SBT2	in/out	P20D	P20R	Serial 2 clock I/O
P21	SBI2	in/out	P21D	P21R	Serial 2 reception data input
P22	SBO1	in/out	P22D	P22R	Serial 1 transmission data output
P23	SBT1	in/out	P23D	P23R	Serial 1 clock I/O
P24	SBI1	in/out	P24D	P24R	Serial 1 reception data input
P25	SBO0	in/out	P25D	P25R	Serial 0 transmission data output
P26	SBT0	in/out	P26D	P26R	Serial 0 clock I/O
P27	SBI0	in/out	P27D	P27R	Serial 0 reception data input
P30	TM0IO	in/out	P30D	P30R	Timer 0 I/O
P31	TM1IO	in/out	P31D	P31R	Timer 1 I/O
P32	TM2IO	in/out	P32D	P32R	Timer 2 I/O
P33	TM3IO	in/out	P33D	P33R	Timer 3 I/O
P34	TM4IO	in/out	P34D	P34R	Timer 4 I/O
P35	TM5IO	in/out	P35D	P35R	Timer 5 I/O
P36	TM8AIO	in/out	P36D	P36R	Timer 8A I/O
P37	TM8BIO	in/out	P37D	P37R	Timer 8B I/O
P40	TM9AO	in/out	P40D	P40R	Timer 9A output
P41	TM9BO	in/out	P41D	P41R	Timer 9B output
P42	TM9AIO	in/out	P42D	P42R	Timer 9A I/O
P43	TM9BO	in/out	P43D	P43R	Timer 9B I/O
P44	TM10AO	in/out	P44D	P44R	Timer 10A output
P45	TM10BO	in/out	P45D	P45R	Timer 10B output
P46	TM10AIO	in/out	P46D	P46R	Timer 10A I/O
P47	TM10BIO	in/out	P47D	P47R	Timer 10B I/O
P50	TM6IO	in/out	P50D	P50R	Timer 6 I/O
P51	TM7IO	in/out	P51D	P51R	Timer 7 I/O
P52	PWM00	in/out	P52D	P52R	3-phase PWM0 signal output 0
P53	NPWM00	in/out	P53D	P53R	3-phase PWM0 signal reverse output 0
P54	PWM01	in/out	P54D	P54R	3-phase PWM0 signal output 1
P55	NPWM01	in/out	P55D	P55R	3-phase PWM0 signal reverse output 1
P56	PWM02	in/out	P56D	P56R	3-phase PWM0 signal output 2
P57	NPWM02	in/out	P57D	P57R	3-phase PWM0 signal reverse output 2
P60	-	in/out	P60D	P60R	-
P61	-	in/out	P61D	P61R	-
P62	PWM10	in/out	P62D	P62R	3-phase PWM1 signal output 0
P63	NPWM10	in/out	P63D	P63R	3-phase PWM1 signal reverse output 0
P64	PWM11	in/out	P64D	P64R	3-phase PWM1 signal output 1
P65	NPWM11	in/out	P65D	P65R	3-phase PWM1 signal reverse output 1
P66	PWM12	in/out	P66D	P66R	3-phase PWM1 signal output 2
P67	NPWM12	in/out	P67D	P67R	3-phase PWM1 signal reverse output 2
P72	TM11IO0	in/out	P72D	P72R	Timer 11 I/O 0
P73	TM11IO1	in/out	P73D	P73R	Timer 11 I/O 1
P74	TM11O2	in/out	P74D	P74R	Timer 11 output 2
P75	TM11O3	in/out	P75D	P75R	Timer 11 output 3
P76	TM11O4	in/out	P76D	P76R	Timer 11 output 4
P77	TM11O5	in/out	P77D	P77R	Timer 11 output 5

Pin	Special functions	I/O	Direction control	Pin control	Function description
P80	IRQ00	in/out	P80D	P80R	External interrupt input 0
P81	IRQ01	in/out	P81D	P81R	External interrupt input 1
P82	IRQ02	in/out	P82D	P82R	External interrupt input 2
P83	IRQ03	in/out	P83D	P83R	External interrupt input 3
P84	TM14IO	in/out	P84D	P84R	Timer 14 I/O
P86	-	in/out	P86D	P86R	-
P87	-	in/out	P87D	P87R	-
P90	ADIN00	in/out	P90D	P90R	AD analog signal input 0
P91	ADIN01	in/out	P91D	P91R	AD analog signal input 1
P92	ADIN02	in/out	P92D	P92R	AD analog signal input 2
P93	ADIN03	in/out	P93D	P93R	AD analog signal input 3
P94	ADIN04	in/out	P94D	P94R	AD analog signal input 4
P95	ADIN05	in/out	P95D	P95R	AD analog signal input 5
P96	ADIN06	in/out	P96D	P96R	AD analog signal input 6
P97	ADIN07	in/out	P97D	P97R	AD analog signal input 7
PA0	ADIN08	in/out	PA0D	PA0R	AD analog signal input 8
PA1	ADIN09	in/out	PA1D	PA1R	AD analog signal input 9
PA2	ADIN10	in/out	PA2D	PA2R	AD analog signal input 10
PA3	ADIN11	in/out	PA3D	PA3R	AD analog signal input 11
PA4	ADIN12	in/out	PA4D	PA4R	AD analog signal input 12
PA5	ADIN13	in/out	PA5D	PA5R	AD analog signal input 13
PA6	ADIN14	in/out	PA6D	PA6R	AD analog signal input 14
PA7	ADIN15	in/out	PA7D	PA7R	AD analog signal input 15
PB0	ADIN16	in/out	PB0D	PB0R	AD analog signal input 16
PB1	ADIN17	in/out	PB1D	PB1R	AD analog signal input 17
PB2	ADIN18	in/out	PB2D	PB2R	AD analog signal input 18
PB3	ADIN19	in/out	PB3D	PB3R	AD analog signal input 19

1.3.3 Pin Functions

Table:1.3.2 Pin Functions

Name	TQFP 48 Pin No.	I/O	Other Function	Function	Description
VDD VDD VDD VDD VDD	17 40 41 65 94	-		Power supply pin	Power pin for 5 V, digital IO. Apply 5 V to all of pins and connect capacitor of over 10 μF between all of the VDD and VSS pins. (allocate near the pins) It is recommended that total capacitance between all of the VDD and VSS is more than 10-times capacitance between all of the VDD2 and VSS.
VDD2 VDD2	42 98	-		Power supply pin	Power pin for 1.8 V, digital IO Connect capacitor of over 1 μF between all of the VDD2 and VSS pins. (allocate near the pins)
VSS VSS VSS VSS	15 38 67 96	-		Power supply pin	GND for digital
VPPEX	39	-		Power supply pin	Power for flash EEPROM Connect with VDD.
OSC1 OSC0	37 36	input output	-	Clock input pin Clock output pin	Extend ceramic or crystal oscillators or input a clock to OSC1.
NRST	48	input	-	Reset pins (negative logic)	This pin resets the chip when power is turned on and contains an internal pull-up resistor. Setting this pin “L” level initialize the internal state of the device. Thereafter, setting the input to “H” level releases the reset. The hardware waits for the system clock to stabilize, then processes the reset interrupt. Connect capacitor of over 0.1 μF between NRST and VSS pins.
P10 P11 P12 P13 P14 P15 P16 P17	43 44 45 46 47 49 50 51	I/O	IRQ04/ EXTRG0 IRQ05/ EXTRG1 IRQ06 IRQ07 IRQ08 TM6IO TM7IO SBO2	I/O port 1	8-bit CMOS I/O port. Each bit can be set individually as either an input or output by the P1DIR register. A pull-up resistor for each bit can be selected individually by the P1PLU register. At reset, the input mode (P10 to P17) is selected, and pull-up resistor is disable.
P20 P21 P22 P23 P24 P25 P26 P27	52 53 54 55 56 57 58 59	I/O	SBT2 SBI2 SBO1 SBT1 SBI1 SBO0 SBT0 SBI0	I/O port 2	8-bit CMOS I/O port. Each bit can be set individually as either an input or output by the P2DIR register. A pull-up resistor for each bit can be selected individually by the P2PLU register. At reset, the input mode (P20 to P27) is selected, and pull-up resistor is disable.
P30 P31 P32 P33 P34 P35 P36 P37	60 61 62 63 64 66 68 69	I/O	TM0IO TM1IO TM2IO TM3IO TM4IO TM5IO TM8AIO TM8BIO	I/O port 3	8-bit CMOS I/O port. Each bit can be set individually as either an input or output by the P3DIR register. A pull-up resistor for ech bit can be selected individually by the P3PLU register. At reset, the input mode (P30 to P37) is selected, pull-up resistor is disable.

Name	TQFP 48 Pin No.	I/O	Other Function	Function	Description
P40 P41 P42 P43 P44 P45 P46 P47	70 71 72 73 74 75 76 77	I/O	TM9AIO TM9BIO TM9AIO TM9BIO TM10AO TM10BO TM10AIO TM10BIO	I/O port 4	8-bit CMOS I/O port. Each bit can be set individually as either an input or output by the P4DIR register. A pull-up resistor for each bit can be selected individually by the P4PLU register. At reset, the input mode (P40 to P47) is selected and pull-up resistor is disable.
P50 P51 P52 P53 P54 P55 P56 P57	78 79 80 81 82 83 84 85	I/O	TM6AO TM7BO PWM00 NPWM00 PWM01 NPWM01 PWM02 NPWM02	I/O port 5	8-bit CMOS I/O port. Each bit can be set individually as either an input or output by the P5DIR register. A pull-up resistor for each bit can be selected individually by the P5PLU register. At reset, the input mode (P50 to P57) is selected and pull-up resistor is disable.
P60 P61 P62 P63 P64 P65 P66 P67	86 87 88 89 90 91 92 93	I/O	 PWM10 NPWM10 PWM11 NPWM11 PWM12 NPWM12	I/O port 6	8-bit CMOS I/O port. Each bit can be set individually as either an input or output by the P6DIR register. A pull-up resistor for each bit can be selected individually by the P6PLU register. At reset, the input mode (P60 to P67) is selected and pull-up resistor is disable.
P72 P73 P74 P75 P76 P77	95 97 99 100 1 2	I/O	TM11IO0 TM11IO1 TM11O2 TM11O3 TM11O4 TM11O5	I/O port 7	6-bit CMOS I/O port. Each bit can be set individually as either an input or output by the P7DIR register. A pull-up resistor for each bit can be selected individually by the P7PLU register. At reset, the input mode (P72 to P77) is selected and pull-up resistor is disable.
P80 P81 P82 P83 P84 P86 P87	3 4 5 6 7 9 10	I/O	IRQ00 IRQ01 IRQ02 IRQ03 TM14IO	I/O port 8	7-bit CMOS input port. Each bit can be set individually as either an input or output by the P8PLU register. A pull-up resistor for each bit can be selected individually by the P8PLU register. At reset, the input mode (P80 to P87) is selected and pull-up resistor is disable.
P90 P91 P92 P93 P94 P95 P96 P97	11 12 13 14 16 18 19 20	I/O	ADIN00 ADIN01 ADIN02 ADIN03 ADIN04 ADIN05 ADIN06 ADIN07	I/O port 9	8-bit CMOS input port. Each bit can be set individually as either an input or output by the P9DIR register. A pull-up resistor for each bit can be selected individually by the P9PLU register. At reset, the input mode (P90 to P97) is selected and pull-down resistor is disable.
PA0 PA1 PA2 PA3 PA4 PA5 PA6 PA7	21 22 23 24 25 26 27 28	I/O	ADIN08 ADIN09 ADIN10 ADIN11 ADIN12 ADIN13 ADIN14 ADIN15	I/O port A	8-bit CMOS input port. Each bit can be set individually as either an input or output by the PADIR register. A pull-up resistor for each bit can be selected individually by the PAPLU register. At reset, the input mode (PA0 to PA7) is selected and pull-down resistor is disable.
PB0 PB1 PB2 PB3	29 30 34 35	I/O	ADIN16 ADIN17 ADIN18 ADIN19	I/O port B	4-bit CMOS input port. Each bit can be set individually as either an input or output by the P8DIR register. A pull-up resistor for each bit can be selected individually by the P8PLU register. At reset, the input mode (P40 to P47) is selected and pull-down resistor is disable.

Name	TQFP 48 Pin No.	I/O	Other Function	Function	Description
SB00 SB01 SB02	57 54 51	Output	P25 P22 P17	Serial interface transmission out-put pin	Transmission data output pins for serial interface 0, 1, and 2. Select output mode by the P1DIR and P2DIR registers and serial pin function by the P1MD and P2MD registers. These can be used as normal I/O pins when the serial interface is not used.
SBI0 SBI1 SBI2	59 56 53	Input	P27 P24 P21	Serial interface reception data input pin	Reception data input pins for serial interface 0, 1, and 2. Pull-up resistor can be selected by the P2PLU register. Select input mode by the P2DIR register. These can be used as normal I/O pins when the serial interface is not used.
SBT0 SBT1 SBT2	58 55 52	I/O	P26 P23 P20	Serial interface clock I/O pin	Clock I/O pins for serial interface 0, 1, and 2. Pull-up resistor can be selected by the P2PLU register. Select I/O mode by the P2DIR register and serial pin function by the P2MD register. These can be used as normal I/O pins when the serial interface is not used.
TM0IO TM1IO TM2IO TM3IO TM4IO TM5IO TM6IO TM7IO TM14IO TM16IO TM17IO	60 61 62 63 64 66 78 79 7 49 50	I/O	P30 P31 P32 P33 P34 P35 P50 P51 P84 P15 P16	Timer I/O pin	Event counter input and timer pulse output pin for 8-bit timer 0 to 7, and 14 to 17. To use this pin as event counter input, select input mode by the P1, 3, 5, and 8DIR regis-ters. In input mode, pull-up resistor can be selected by the P1, 3, 5, and 8PLU registers. To use this pin as timer pulse output, select timer output pin by the P1,3,5, and 8MD registers and set to output mode by the P1,3,5, and 8DIR registers. These can be used as normal I/O pins when these are not used as timer I/O pins.
TM8AIO TM8BIO TM9AIO TM9BIO TM10AIO TM10BIO TM11IO0 TM11IO1	68 69 72 73 76 77 95 97	I/O	P36 P37 P42 P43 P46 P47 P72 P73	Timer I/O pin	Event counter input, toggle output, and PWM output pin for 16-bit timer 8 to 11. To use this pin as event counter input, select input mode by the P3, 4, and 7DIR registers. In input mode, pull-up resistor can be selected by the P3, 4, and 7PLU register. To use this as timer output and PWM output, select timer output pin by the P3, 4, and 7MD registers, and set to output mode by the P3, 4, and 7DIR register. These can be used as normal I/O pins when these are not used as timer I/O pins.
TM9AO TM9BO TM10AO TM10BO	70 71 74 75	Output	P40 P41 P44 P45	Timer output pin	PWM output pin for 16-bit timer 9 and 10. To use this pin as timer output and PWM out-put, select timer output pin by the P4MD reg-ister and set to output mode by the P4DIR register. These can be used as normal I/O pins when these are not used as timer I/O pins.
TM11IO0 TM11IO1 TM11O2 TM11O3 TM11O4 TM11O5	95 97 99 100 1 2	Output	P72 P73 P74 P75 P76 P76 P77	PWM output pin	Motor control PWM signal output pin for 16-bit timer 11. PWM signal for 16-bit timer 11 is output to 6 pins simultaneously. To use this pin as PWM output, select timer output pin by the P7MD register and set to output mode by the P7DIR register. These can be used as normal I/O pins when these are not used as timer I/O pins.

Name	TQFP 48 Pin No.	I/O	Other Function	Function	Description
ADIN00 ADIN01 ADIN02 ADIN03 ADIN04 ADIN05 ADIN06 ADIN07 ADIN08 ADIN09 ADIN10 ADIN11 ADIN12 ADIN13 ADIN14 ADIN15 ADIN16 ADIN17 ADIN18 ADIN19	11 12 13 14 16 18 19 20 21 22 23 24 25 26 27 28 29 30 34 35	Input	P90 P91 P92 P93 P94 P95 P96 P97 PA0 PA1 PA2 PA3 PA4 PA5 PA6 PA7 PB0 PB1 PB2 PB3	Analogue input pin	Analogue input pins for an 20-channel, 10-bit 3 A/D converters. These can be used as normal I/O pins when these are not used as analog input.
IRQ00 IRQ01 IRQ02 IRQ03 IRQ04 IRQ05 IRQ06 IRQ07 IRQ08	3 4 5 6 43 44 45 46 47	Input	P80 P81 P82 P83 P10/ EXTRG0 P11/ EXTRG1 P12 P13 P14	External interrupt pin	External interrupt input pins. The valid edge can be selected. Set whether both edges are detected or not by the edge detection register (IRQEDGESEL). When it is set not to detect both edges, select rising edge, falling edge, H level, or L level by the external interrupt condition specification register (EXTMD0 and EXTMD1). When it is set to detect both edges, select rising edge by the external interrupt condition setting register.
PWM00 PWM01 PWM02 PWM10 PWM11 PWM12	80 82 84 88 90 92	Output	P52 P54 P56 P62 P64 P66	Motor control PWM signal output pin	Motor control 3-phase PWM signal output pin Select PWM signal output pin by the P5MD and P6MD registers and set to PWM output by the PWMOFF register. These can be used as normal I/O pins when these is not used as PWM signal output pin.
NPWM00 NPWM01 NPWM02 NPWM11 NPWM12 NPWM13	81 83 85 89 91 93	Output	P53 P55 P57 P63 P65 P67	Motor control PWM signal reverse output pin	Motor control 3-phase PWM signal revers output pin. Select PWM signal output pin by the P5MD and P6MD registers and set to PWM output by the PWMOFF register. These can be used as normal I/O pins when these is not used as PWM signal output pin.
TEST1 TEST2 TEST3 TCPOUT	31 32 33 8	Input	-	Test signal input	Test signal input pin built-in pull-up resistor. Pull-up with resistor of 1 kΩ or more. Select a fixed to “L” for TCPOUT.

VPPEX is a power supply for flash EEPROM rewriting. Its potential should be the same as VDD.

1.4 Block Diagram

1.4.1 Block Diagram

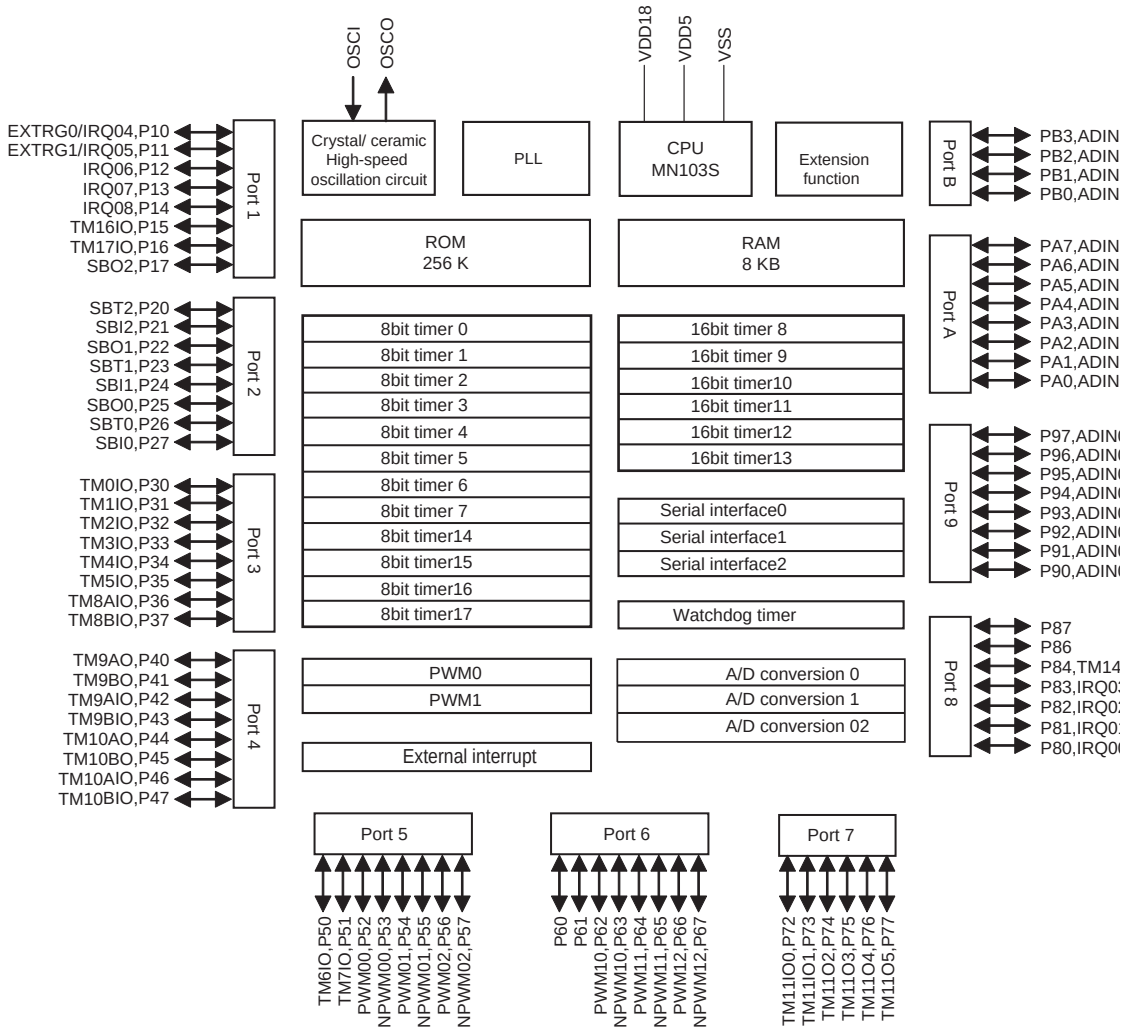

Figure:1.4.1 Block Diagram

1.5 Electrical Characteristics

This LSI manual describes the standard specification.

Electrical characteristics given in this section are preliminary and subject to change without notice. When using LSI, contact our sales office for product specifications.

Model	CMOS LSI
Application	General-purpose
Function	CMOS 32-bit 1 chip microcontroller

1.5.1 Absolute Maximum Ratings

V_{SS}=0.0 V

Parameter		Symbol	Rating	Unit
A1	External supply voltage	V_{DD}	-0.3 to +7.0	V
A2	Internal supply voltage	V_{DD2}	-0.3 to +2.5	V
A3	Input pin voltage	V_{I1}	-0.3 to V_{DD} +0.3 (upper limit: 7.0)	V
A4	I/O pin voltage	V_{IO}	-0.3 to V_{DD} +0.3 (upper limit: 7.0)	V
A5	Peak output current	I_{OPEAK}	±15	mA
A6	Typ. range output current	I_{OAVG}	±8	mA
A7	Operating ambient temperature	T_{OPR}	-40 to +85	°C
A8	Storage temperature	T_{STG}	-40 to +125	°C
A9	Power dissipation	P_D	750	mW

Note: The absolute maximum ratings are the limit values beyond which the LSI may be damaged. It is not guarantee the operation in these conditions. The rating of the average output current is applied for the period of any 100 ms.

Note: It cannot supply the internal power supply voltage to a circuit except this LSI.

1.5.2 Operating Conditions

V_{SS}=0.0 V
Ta= -40 °C to +85 °C

Parameter		Symbol	Conditions	Limits			Unit
				Min.	Typ.	Max.	
B1	External supply voltage1	V_{DD}	-	V_{RST}	5.0	5.5	V

Note) For power supply detection level V_{RST}, refer to “Auto reset circuit characteristics”.

V_{DD} = V_{RST} to 5.5 V
V_{SS} = 0.0 V
Ta= -40 °C to +85 °C

Oscillation

Parameter		Symbol	Conditions	Limits			Unit
				Min.	Typ.	Max.	
B2	Input frequency	F_{OSC}	-	5.0	-	15	MHz
B3	Internal feedback resistor	R_{FB}	-	-	1.2	-	MΩ

Note) Capacity value differs depending on oscillators to be used. Consult the oscillator mamufacture for the appropriate circuit constant.

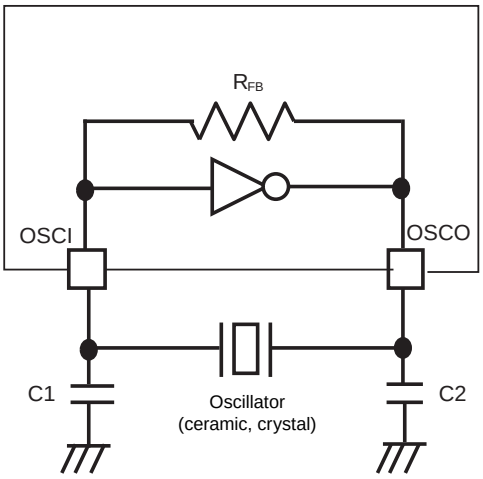

Figure:1.5.1 Oscillation

V_{DD} = 5.0 V
V_{SS} = 0.0 V
Ta= -40 °C to +85 °C

Parameter		Symbol	Conditions	Limits			Unit
				Min.	Typ.	Max.	
External clock input 1 OSCI (OSCO left open)							
B4	Clock frequency	Fcp	-	5.0	-	15.0	MHz
B5	High-level pulse width	twh1	Figure:1.5.2	25.0	-	-	ns
B6	Low-level pulse width	twl1		25.0	-	-	ns
B7	Rise time	twr1	Figure:1.5.2	-	-	5.0	ns
B8	Fall time	twf1		-	-	5.0	ns

Note: Be sure that the clock duty ratio is 45 % to 55 %.

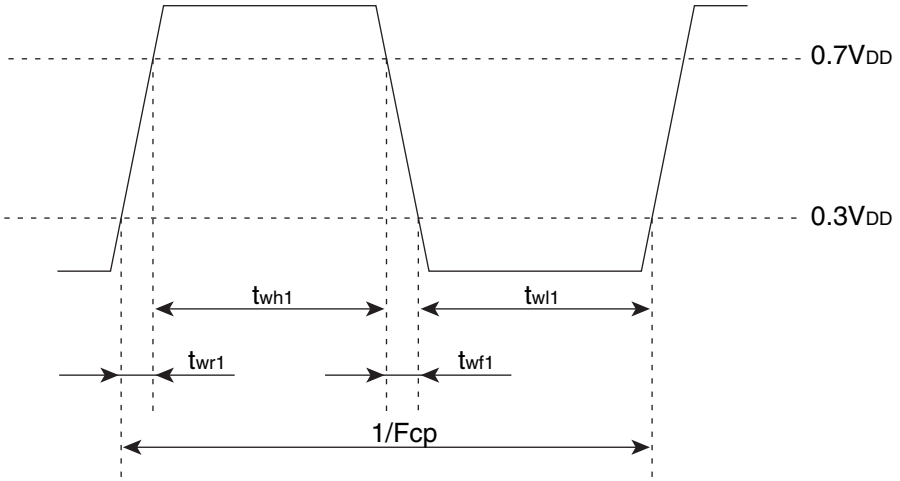

Figure:1.5.2 OSCI Timing Chart

1.5.3 DC Characteristics

V_{SS}=0.0 V
Ta= -40 °C to +85 °C
Output pin left open

DC Characteristics

Parameter		Symbol	Conditions	Limits		Unit
				Typ.	Max.	
C1	Power supply current in NORMAL mode	I_{DD1}	V_{DD} = 5.0 V F_{OSC} = 10 MHz, PLL is used. MCLK= 60 MHz, IOCLK =30 MHz Peripheral circuits are stopped.	20	-	mA
C2		I_{DD2}	V_{DD} = 5.0 V F_{OSC} = 10 MHz, PLL is used. MCLK= 60 MHz, IOCLK =30 MHz Peripheral circuits are operating.	-	35	mA

V_{DD} = 5.0 V
V_{SS} = 0.0 V
Ta= -40 °C to +85 °C

Parameter		Symbol	Conditions	Limits			Unit
				Min.	Typ.	Max.	
Input pins1 NRST, TEST1, TEST2							
C3	Input voltage High level	V_{IH1}	-	V_{DD} x 0.7	-	V_{DD}	V
C4	Input voltage Low level	V_{IL1}	-	V_{SS}	-	V_{DD} x 0.3	V
C5	Internal Pull-up resistor	R_{IO1}	V_{DD} =5.0 V, V_{IN} = 0 V	15	30	60	k

V_{DD} = 5.0 V
V_{SS} = 0.0 V
Ta= -40 °C to +85 °C

Parameter		Symbol	Conditions	Limits			Unit
				Min.	Typ.	Max.	
Input pins 2 VPPEX, TEST3							
C6	Input voltage High level	V_{IH2}	-	V_{DD} x 0.7	-	V_{DD}	V
C7	Input voltage Low level	V_{IL2}	-	V_{SS}	-	V_{DD} x 0.3	V

V_{DD} = 5.0 V
V_{SS} = 0.0 V
Ta= -40 °C to +85 °C

Parameter		Symbol	Conditions	Limits			Unit
				Min.	Typ.	Max.	
I/O pin P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P60 to P67, P72 to P77, P80 to P87, P90 to P97, PA0 to PA7, PB0 to PB3							
C8	Input voltage High level	V_{IH4}	–	V_{DD} x 0.7	-	V_{DD}	V
C9	Input voltage Low level	V_{IL4}	–	V_{SS}	-	V_{DD} x 0.3	V
C10	Input leak current	I_{LK4}	–	-	-	± 5	µA
C11	Internal pull-up resistor	R_{IO4}	V_{DD} = 5.0 V, V_{IN} = 0 V	15	30	60	kΩ
C12	Output voltage High level	V_{OH4}	V_{DD} = 5.0 V, I_{OH} = -2.5 mA	4.5	-	-	V
C13	Output voltage Low level	V_{OL4}	V_{DD} = 5.0 V, I_{OL0} = 2.5 mA	-	-	0.5	V

1.5.4 Analog Characteristics

V_{DD} = 5.0 V
V_{SS} = 0.0 V
A/D0, A/D1, A/D2 Ta= -40 °C to +85 °C

Parameter		Symbol	Conditions	Limits			Unit
				Min.	Typ.	MAx.	
D1	Resolution	-	-	-	-	10	Bits
D2	Non-linearity error	INLE	Sampling time ≥ 150 ns A/D conversion clock ≤ 30 MHz	-	-	±2	LSB
D3	Differential linearity error	DNLE		-	-	±3	LSB
D4	Zero transition voltage	-		-20	-	20	mV
D5	Full-scale transition voltage	-		4980	-	5020	mV
D6	A/D conversion time	-	-	1.0	-	-	µs
D7	Analog input voltage	V_{IA}	-	V_{SS}	-	V_{DD}	V
D8	Analog input leakage current	I_{IA}	Unselected channel V_{ADIN} = 0 V to V_{DD}	-	-	±10	µA
D9	Power supply current during operation (VDD pin)	I_{AD}	A/D conversion clock = 30 MHz	-	1	-	mA

V_{SS} = 0.0 V
Auto-reset Ta= -40 °C to +85 °C

Parameter		Symbol	Conditions	Limits			Unit
				Min.	Typ.	MAx.	
D10	Power supply voltage detection level	V_{RST}	-	3.6	-	4.3	V
D11	Change rate of power supply voltage	ΔV_{DD}	-	0.2	-	-	ms/V

Note: Connect 0.1 µF capacitor between NRST and VSS pins. .

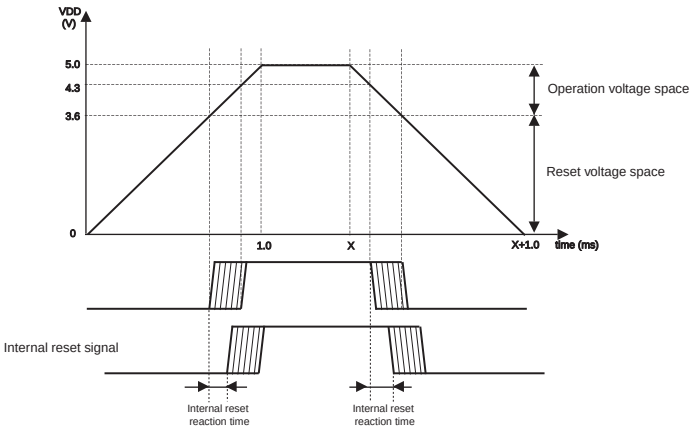

Figure:1.5.3 Auto Reset Circuit Characteristics

1.5.5 AC Characteristics

Reset signal input timing

V_{DD} = 5.0 V
V_{SS} = 0.0 V
Ta= -40 °C to +85 °C

Parameter		Symbol	Conditions	Limits			Unit
				Min.	Typ.	Max.	
E1	Reset signal pulse width (NRST)	t_{NRSTW}	-	1	-	-	µs

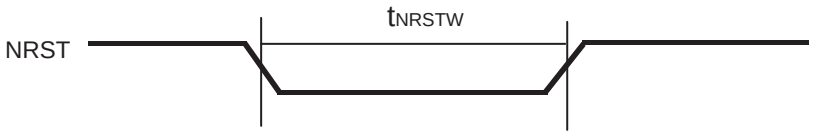

Figure:1.5.4 Reset Signal Pulse Width

1.5.6 Flash EEPROM E/W Characteristics

V_{SS} = 0.0 V

Parameter		Symbol	Conditions	Limits			Unit
				MIN	TYP	MAX	
F1	Power supply voltage at E/W	V_{DDEW}		V_{RST}	-	5.5	V
F2	Ambient temperature at E/W	V_{OPREW}		-40	-	85	°C
F3	Permissible rewriting times	E_{MAX1}	Large sector (32 KB)	1,000	-	-	Times
F4	Permissible rewriting times	E_{MAX2}	Small sector (8 KB)	100,000	-	-	Times
F5	Data retention time	T_{HOLD}		10	-	-	Years

1.6 Package Dimension

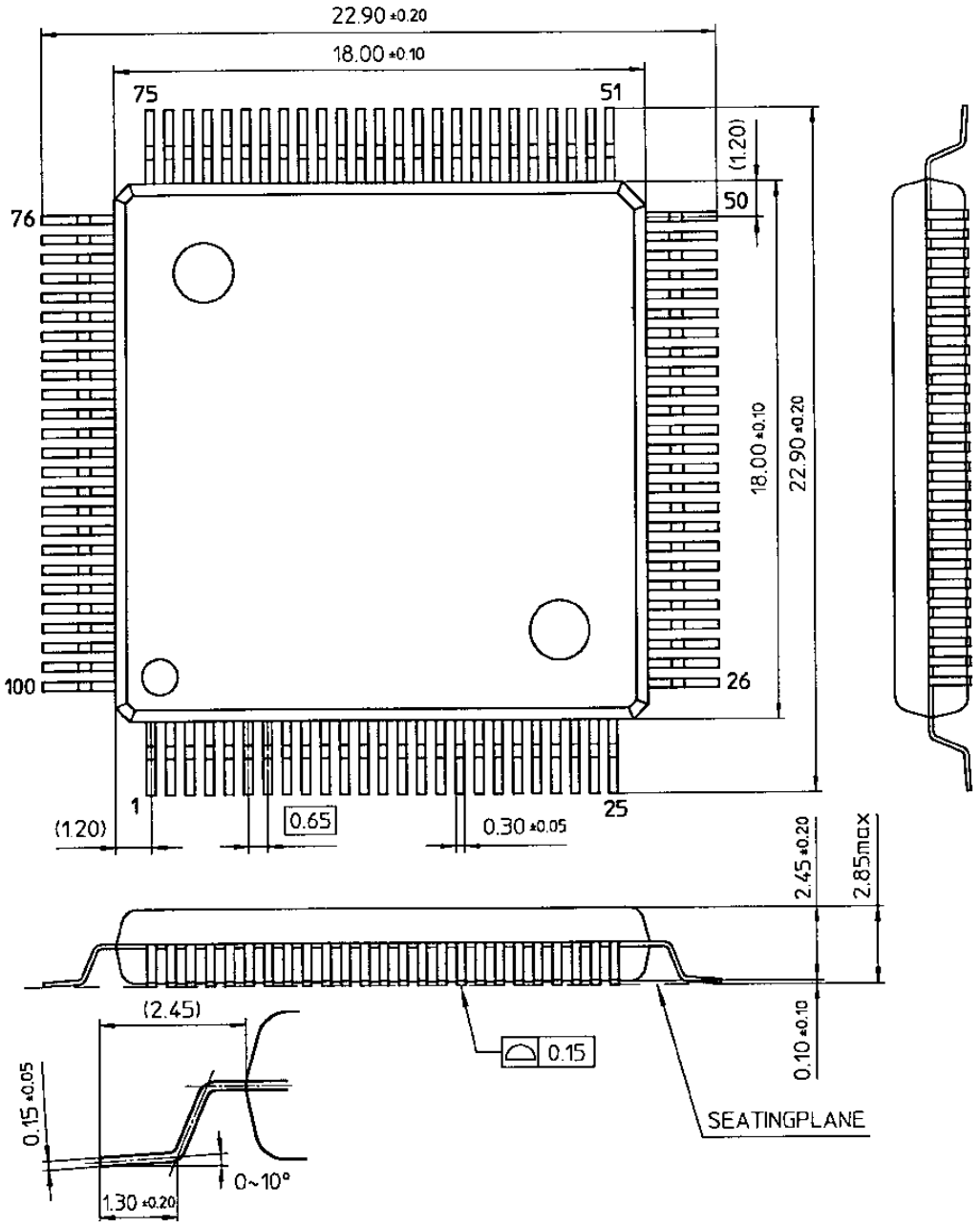

Figure:1.6.1 Package Dimension

The external dimensions of the package are subject to change. Before using this product, please obtain product specifications from the sales offices.

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