



Precision Analog-to-Digital Converter (ADC) and Digital-to-Analog Converter (DAC) with 8051 Microcontroller and Flash Memory

FEATURES

ANALOG FEATURES

- 24-BITS NO MISSING CODES
- 22-BITS EFFECTIVE RESOLUTION AT 10Hz
 - Low Noise: 75nV
- PGA FROM 1 TO 128
- PRECISION ON-CHIP VOLTAGE REFERENCE:
 - Accuracy: 0.2%
 - Drift: 5ppm/°C
- 8 DIFFERENTIAL/SINGLE-ENDED CHANNELS
- ON-CHIP OFFSET/GAIN CALIBRATION
- OFFSET DRIFT: 0.02ppm/°C
- GAIN DRIFT: 0.5ppm/°C
- ON-CHIP TEMPERATURE SENSOR
- SELECTABLE BUFFER INPUT
- BURNOUT DETECT
- 8-BIT CURRENT DAC

DIGITAL FEATURES

Microcontroller Core

- 8051 COMPATIBLE
- HIGH SPEED CORE:
 - 4 Clocks per Instruction Cycle
- DC TO 33MHz
- ON-CHIP OSCILLATOR
- PLL WITH 32kHz CAPABILITY
- SINGLE INSTRUCTION 121ns
- DUAL DATA POINTER

Memory

- UP TO 8kB FLASH DATA MEMORY
- FLASH MEMORY PARTITIONING
- ENDURANCE 1M ERASE/WRITE CYCLES,
100 YEAR DATA RETENTION
- IN-SYSTEM SERIALLY PROGRAMMABLE
- FLASH MEMORY SECURITY
- 1kB BOOT ROM
- PROGRAMMABLE WAIT STATE CONTROL

Peripheral Features

- 16 I/O PINS
- ADDITIONAL 32-BIT ACCUMULATOR
- TWO 16-BIT TIMER/COUNTERS
- SYSTEM TIMERS
- PROGRAMMABLE WATCHDOG TIMER
- FULL DUPLEX UART
- BASIC SPI™
- BASIC I²C™
- POWER MANAGEMENT CONTROL
- INTERNAL CLOCK DIVIDER
- IDLE MODE CURRENT < 200µA
- STOP MODE CURRENT < 100nA
- PROGRAMMABLE BROWNOUT RESET
- PROGRAMMABLE LOW VOLTAGE DETECT
- 20 INTERRUPT SOURCES

GENERAL FEATURES

- PACKAGE: TQFP-48
- LOW POWER: 4mW
- INDUSTRIAL TEMPERATURE RANGE:
–40°C to +85°C
- POWER SUPPLY: 2.7V to 5.25V

APPLICATIONS

- INDUSTRIAL PROCESS CONTROL
- INSTRUMENTATION
- LIQUID/GAS CHROMATOGRAPHY
- BLOOD ANALYSIS
- SMART TRANSMITTERS
- PORTABLE INSTRUMENTS
- WEIGH SCALES
- PRESSURE TRANSDUCERS
- INTELLIGENT SENSORS
- PORTABLE APPLICATIONS
- DAS SYSTEMS

PRODUCT PREVIEW



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PRODUCT PREVIEW information concerns products in the formative or design phase of development. Characteristic data and other specifications are design goals. Texas Instruments reserves the right to change or discontinue these products without notice.

PACKAGE/ORDERING INFORMATION

PRODUCT	FLASH MEMORY	PACKAGE-LEAD	PACKAGE DESIGNATOR ⁽¹⁾	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
MSC1200Y2	4k	TQFP-48	PFB	–40°C to +85°C	MSC1200Y2	MSC1200Y2PFBT	Tape and Reel, 250
MSC1200Y2	4k	"	"	"	"	MSC1200Y2PFBR	Tape and Reel, 2000
MSC1200Y3	8k	TQFP-48	PFB	–40°C to +85°C	MSC1200Y3	MSC1200Y3PFBT	Tape and Reel, 250
MSC1200Y3	8k	"	"	"	"	MSC1200Y3PFBR	Tape and Reel, 2000

NOTE: (1) For the most current specifications and package information, refer to our web site at www.ti.com/msc.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

Analog Inputs	
Input Current	100mA, Momentary
Input Current	10mA, Continuous
Input Voltage	AGND – 0.5V to AV _{DD} + 0.5V
Power Supply	
DV _{DD} to DGND	–0.3V to 6V
AV _{DD} to AGND	–0.3V to 6V
AGND to DGND	–0.3V to +0.3V
V _{REF} to AGND	–0.3V to AV _{DD} + 0.3V
Digital Input Voltage to DGND	–0.3V to DV _{DD} + 0.3V
Digital Output Voltage to DGND	–0.3V to DV _{DD} + 0.3V
Maximum Junction Temperature	+150°C
Operating Temperature Range	–40°C to +85°C
Storage Temperature Range	–65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C
Package Power Dissipation	822mW
Output Current All Pins	200mA
Output Pin Short Circuit	10s
Thermal Resistance, Junction-to-Ambient (θ _{JA})	73°C/W
Thermal Resistance, Junction-to-Case (θ _{JC})	12.8°C/W
Digital Outputs	
Output Current	100mA, Continuous
I/O Source/Sink Current	100mA
Power Pin Maximum	300mA

NOTE: (1) Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.



ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

MSC1200Yx FAMILY FEATURES

FEATURES ⁽¹⁾	MSC1200Y2 ⁽²⁾	MSC1200Y3 ⁽²⁾
Flash Program Memory (Bytes)	Up to 4k	Up to 8k
Flash Data Memory (Bytes)	Up to 4k	Up to 8k
Internal Scratchpad RAM (Bytes)	128	128

NOTES: (1) All peripheral features are the same on all devices; the flash memory size is the only difference. (2) The last digit of the part number (N) represents the onboard flash size = (2^N)kBytes.

ELECTRICAL CHARACTERISTICS: AV_{DD} = 5V

All specifications from T_{MIN} to T_{MAX}, DV_{DD} = +2.7V to 5.25V, f_{MOD} = 15.625kHz, PGA = 1, Buffer ON, f_{DATA} = 10Hz, Bipolar, and V_{REF} = (REF IN+) – (REF IN–) = +2.5V, unless otherwise noted.

PARAMETER	CONDITION	MSC1200Yx			UNITS
		MIN	TYP	MAX	
ANALOG INPUT (AIN0-AIN7, AINCOM)					
Analog Input Range	Buffer OFF	AGND – 0.1		AV _{DD} + 0.1	V
	Buffer ON	AGND + 50mV		AV _{DD} – 1.5	V
Full-Scale Input Voltage Range	(In+) – (In–) See Figure 4			±V _{REF} /PGA	V
Differential Input Impedance	Buffer OFF		5/PGA		MΩ
Input Current	Buffer ON		0.5		nA
Bandwidth					
Fast Settling Filter	–3dB		0.469 • f _{DATA}		
Sinc ² Filter	–3dB		0.318 • f _{DATA}		
Sinc ³ Filter	–3dB		0.262 • f _{DATA}		
Programmable Gain Amplifier	User-Selectable Gain Ranges	1		128	
Input Capacitance	Buffer ON		4		pF
Input Leakage Current	Multiplexer Channel Off, T = +25°C		0.5		pA
Burnout Current Sources	Sensor Input Open Circuit		±2		μA
ADC OFFSET DAC					
Offset DAC Range		8	±V _{REF} /(2 • PGA)		V
Offset DAC Monotonicity					Bits
Offset DAC Gain Error			±1.5		% of Range
Offset DAC Gain Error Drift			1		ppm/°C

ELECTRICAL CHARACTERISTICS: $AV_{DD} = 5V$ (Cont.)

All specifications from T_{MIN} to T_{MAX} , $DV_{DD} = +2.7V$ to $5.25V$, $f_{MOD} = 15.625kHz$, $PGA = 1$, Buffer ON, $f_{DATA} = 10Hz$, Bipolar, and $V_{REF} \equiv (REF\ IN+) - (REF\ IN-) = +2.5V$, unless otherwise noted.

PARAMETER	CONDITION	MSC1200Yx			UNITS
		MIN	TYP	MAX	
SYSTEM PERFORMANCE					
Resolution		24			Bits
ENOB			22		Bits
Output Noise			See Typical Characteristics		
No Missing Codes	Sinc ³ Filter	24			Bits
Integral Nonlinearity	End Point Fit, Differential Input			± 0.0015	%FSR
Offset Error	After Calibration		7.5		ppm of FS
Offset Drift ⁽¹⁾	Before Calibration		0.02		ppm of FS/°C
Gain Error ⁽²⁾	After Calibration		0.005		%
Gain Error Drift ⁽¹⁾	Before Calibration		0.5		ppm/°C
System Gain Calibration Range		80		120	% of FS
System Offset Calibration Range		-50		50	% of FS
Common-Mode Rejection	At DC	100	115		dB
	$f_{CM} = 60Hz$, $f_{DATA} = 10Hz$		130		dB
	$f_{CM} = 50Hz$, $f_{DATA} = 50Hz$		120		dB
	$f_{CM} = 60Hz$, $f_{DATA} = 60Hz$		120		dB
	$f_{SIG} = 50Hz$, $f_{DATA} = 50Hz$		100		dB
	$f_{SIG} = 60Hz$, $f_{DATA} = 60Hz$		100		dB
Normal Mode Rejection	At DC, dB = $-20\log(\Delta V_{OUT}/\Delta V_{DD})^{(3)}$		88		dB
Power-Supply Rejection					dB
VOLTAGE REFERENCE INPUTS					
Reference Input Range	REF IN+, REF IN-	0.0		$AV_{DD}^{(2)}$	V
ADC V_{REF}	$V_{REF} \equiv (REF\ IN+) - (REF\ IN-)$	0.3	2.5	AV_{DD}	V
Common-Mode Rejection	At DC		110		dB
Input Current ⁽⁴⁾	$V_{REF} = 2.5V$, ADC Only		10		μA
DAC Reference Current	For Each DAC, 5V Reference		25		μA
ON-CHIP VOLTAGE REFERENCE					
Output Voltage	$V_{REFH} = 1$ at $+25^{\circ}C$, $PGA = 1, 2, 4, 8$ $V_{REFH} = 0$	2.495	2.5 1.25	2.505	V V
Power-Supply Rejection Ratio			65		dB
Short-Circuit Current Source			8		mA
Short-Circuit Current Sink			50		μA
Short-Circuit Duration	Sink or Source		Indefinite		
Drift			5		ppm/°C
Output Impedance	Sourcing 100 μA		3		Ω
Startup Time from Power ON	$C_{REFOUT} = 0.1\mu F$		8		ms
Temperature Sensor					
Temperature Sensor Voltage	$T = +25^{\circ}C$		115		mV
Temperature Sensor Coefficient			375		$\mu V/^{\circ}C$
IDAC OUTPUT CHARACTERISTICS					
Full-Scale Output Current	Maximum $V_{REF} = 2.5V$		25		mA
Maximum Short-Circuit Current Duration			Indefinite		
Compliance Voltage			$AV_{DD} - 1.5$		V
Relative Accuracy	Over Full Range		0.185		% of FSR
Zero Code Error			0.5		% of FSR
Full-Scale Error			-0.4		% of FSR
Gain Error			-0.6		% of FSR
ANALOG POWER-SUPPLY REQUIREMENTS					
Power-Supply Voltage	AV_{DD}	4.75		5.25	V
Analog Current	Analog OFF, PDAD = 1		< 1		nA
ADC Current	$I_{ADC} + I_{VREF}$ I_{ADC} PGA = 1, Buffer OFF		200		μA
	PGA = 128, Buffer OFF		500		μA
	PGA = 1, Buffer ON		240		μA
	PGA = 128, Buffer ON		850		μA
VDAC Current	I_{VDAC} Excluding Load Current External Reference		250		μA
V_{REF} Supply Current	I_{VREF} ADC ON, V_{DAC} OFF		250		μA

NOTES: (1) Calibration can minimize these errors. (2) The gain calibration cannot have a REF IN+ of more than $AV_{DD} - 1.5V$ with buffer ON. To calibrate gain, turn buffer off. (3) DV_{OUT} is change in digital result. (4) 12pF switched capacitor at f_{SAMP} clock frequency.

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ELECTRICAL CHARACTERISTICS: $AV_{DD} = 3V$ (Cont.)

All specifications from T_{MIN} to T_{MAX} , $AV_{DD} = +3V$, $DV_{DD} = +2.7V$ to $5.25V$, $f_{MOD} = 15.625kHz$, $PGA = 1$, Buffer ON, $f_{DATA} = 10Hz$, and Bipolar, $V_{REF} \equiv (REF\ IN+) - (REF\ IN-) = +1.25V$, unless otherwise noted.

PARAMETER	CONDITION	MSC1200Yx			UNITS
		MIN	TYP	MAX	
POWER-SUPPLY REQUIREMENTS					
Power-Supply Voltage	AV_{DD}	2.7		3.6	V
Analog Current	Analog OFF, PDAD = 1		< 1		nA
ADC Current	$I_{ADC} + I_{VREF}$		200		μA
	I_{ADC}		500		μA
	PGA = 1, Buffer OFF		240		μA
	PGA = 128, Buffer OFF		850		μA
VDAC Current	PGA = 1, Buffer ON		250		μA
V_{REF} Current	PGA = 128, Buffer ON		250		μA
	Excluding Load Current External Reference				

NOTES: (1) Calibration can minimize these errors. (2) The gain calibration cannot have a REF IN+ of more than $AV_{DD} - 1.5V$ with buffer ON. To calibrate gain, turn buffer off. (3) DV_{OUT} is change in digital result. (4) 12pF switched capacitor at f_{SAMP} clock frequency.

DIGITAL CHARACTERISTICS: $DV_{DD} = 2.7V$ to $5.25V$

All specifications from T_{MIN} to T_{MAX} , unless otherwise specified.

PARAMETER	CONDITION	MSC1200Yx			UNITS
		MIN	TYP	MAX	
POWER-SUPPLY REQUIREMENTS					
	DV_{DD}	2.7		3.6	V
	Normal Mode, $f_{OSC} = 1MHz$		1.3		mA
	Normal Mode, $f_{OSC} = 8MHz$		6		mA
	Stop Mode		100		nA
	DV_{DD}	4.75		5.25	V
	Normal Mode, $f_{OSC} = 1MHz$		2.2		mA
	Normal Mode, $f_{OSC} = 8MHz$		14		mA
	Stop Mode		100		nA
DIGITAL INPUT/OUTPUT (CMOS)					
Logic Level: V_{IH} (except XIN pin)	$V_{IH} = DV_{DD}$ or $V_{IH} = 0V$	$0.6 \cdot DV_{DD}$		DV_{DD}	V
V_{IL} (except XIN pin)		DGND		$0.2 \cdot DV_{DD}$	V
Ports 1 and 3, Input Leakage Current, Input Mode		-10	0	+10	μA
Pin XIN Input Leakage Current			0		μA
V_{OL} , Ports 1 and 3, All Output Modes	$I_{OL} = 1mA$	DGND		0.4	V
V_{OL} , Ports 1 and 3, All Output Modes	$I_{OL} = 30mA$, 3V (20mA)		1.5		V
V_{OH} , Ports 1 and 3, Strong Drive Output	$I_{OH} = 1mA$	$DV_{DD} - 0.4$	$DV_{DD} - 0.1$	DV_{DD}	V
V_{OH} , Ports 1 and 3, Strong Drive Output	$I_{OH} = 30mA$, 3V (20mA)		$DV_{DD} - 1.5$		V
Ports 1 and 3 Pull-Up Resistors			9		k Ω
Pin Pull-Up Resistors			9		k Ω
Pin RST, Pull-Down Resistor	Flash Programming Mode Only		200		k Ω

FLASH MEMORY CHARACTERISTICS: $DV_{DD} = 2.7V$ to $5.25V$

$t_{USEC} = 1\mu s$, $t_{MSEC} = 1ms$

PARAMETER	CONDITION	MSC1200Yx			UNITS
		MIN	TYP	MAX	
Flash Memory Endurance		100,000	1,000,000		cycles
Flash Memory Data Retention		100			Years
Mass and Page Erase Time	Set with FER Value in FTCON	10			ms
Flash Memory Write Time	Set with FWR Value in FTCON	30		40	μs

AC ELECTRICAL CHARACTERISTICS⁽¹⁾⁽²⁾: DV_{DD} = 2.7V to 5.25V

SYMBOL	FIGURE	PARAMETER	2.7V to 3.6V		4.75V to 5.25V		UNITS
			MIN	MAX	MIN	MAX	
System Clock							
f _{OSC} ⁽³⁾	A	External Crystal Frequency (f _{OSC})	1	16	1	33	MHz
1/t _{OSC} ⁽³⁾	A	External Clock Frequency (f _{OSC})	0	16	1	33	MHz
f _{OSC} ⁽³⁾	A	External Ceramic Resonator Frequency (f _{OSC})	1	12	1	12	MHz
External Clock							
t _{HIGH}	A	HIGH Time ⁽⁴⁾	15		10		ns
t _{LOW}	A	LOW Time ⁽⁴⁾	15		10		ns
t _R	A	Rise Time ⁽⁴⁾		5		5	ns
t _F	A	Fall Time ⁽⁴⁾		5		5	ns

NOTES: (1) Parameters are valid over operating temperature range, unless otherwise specified. (2) Load capacitance for outputs = 80pF. (3) t_{CLK} = 1/f_{OSC} = one oscillator clock period for clock divider = 1. (4) These values are characterized but not 100% production tested.

EXPLANATION OF THE AC SYMBOLS

Each Timing Symbol has five characters. The first character is always 't' (= time). The other characters, depending on their positions, indicate the name of a signal or the logical status of that signal. The designators are:

C—Clock

D—Input Data

H—Logic Level HIGH

I—Instruction (program memory contents)

L—Logic Level LOW

Q—Output Data

t—Time

V—Valid

X—No Longer a Valid Logic Level

Z—Float

Examples: (1) t_{AVLL} = Time for address valid to ALE LOW. (2) t_{LLPL} = Time for ALE LOW to PSEN LOW.

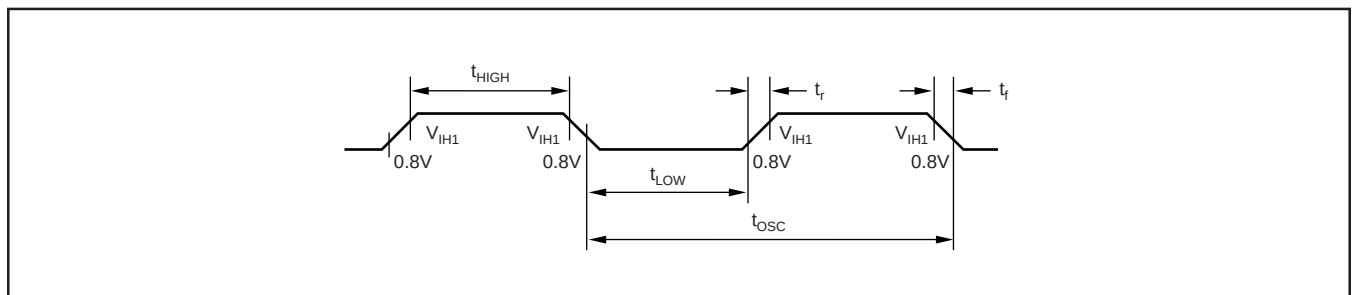


FIGURE A. External Clock Drive CLK.

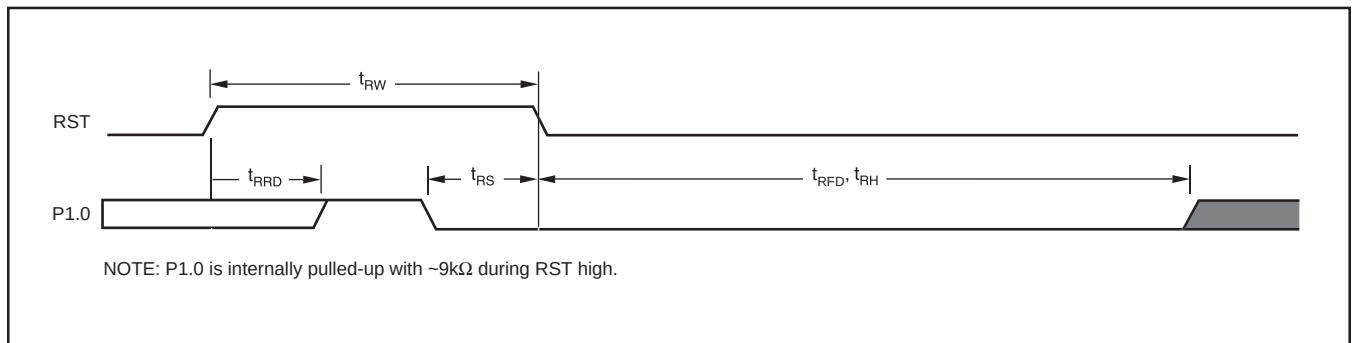
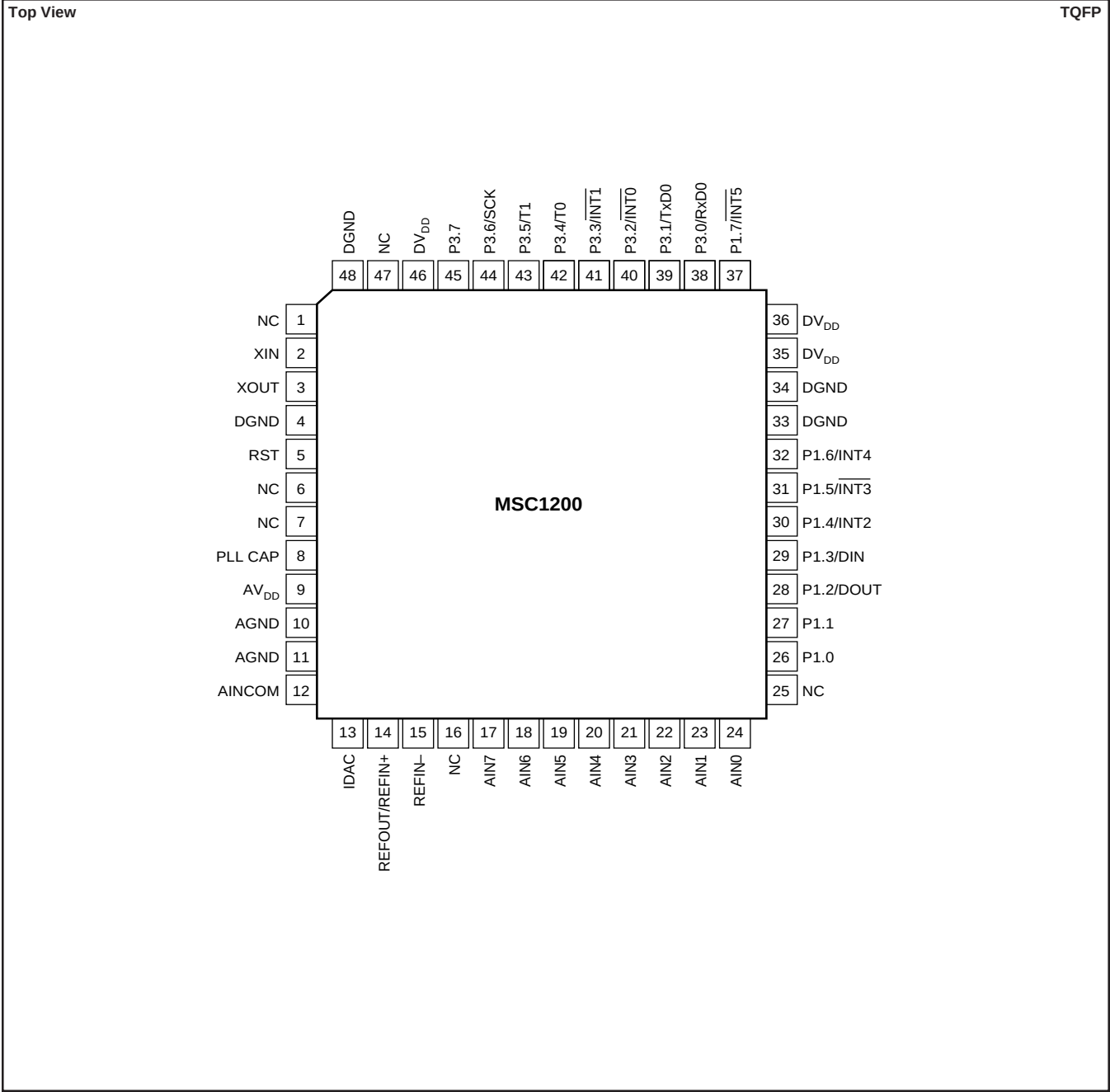


FIGURE B. Serial Flash Programming Power-On Timing.

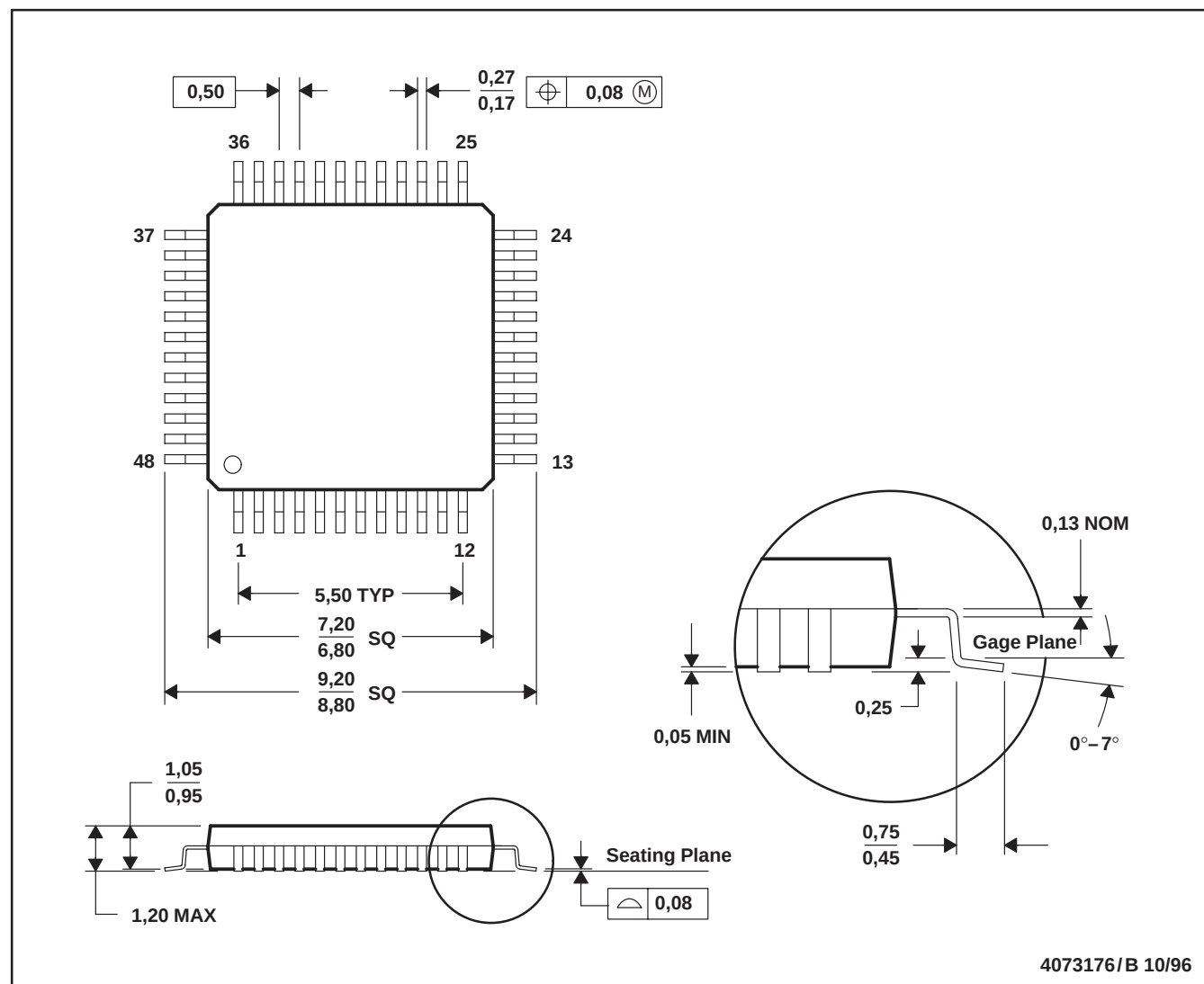
SYMBOL	PARAMETER	MIN	MAX	UNIT
t _{RW}	RST width	2 t _{osc}	—	ns
t _{RRD}	RST rise to P1.0 internal pull high	—	5	μs
t _{RFD}	RST falling to p1.0 start	—	(2 ¹⁷ + 512) t _{osc}	ns
t _{RS}	Input signal to RST falling setup time	t _{osc}	—	ns
t _{RH}	RST falling to input signal hold time	(2 ¹⁷ + 512) t _{osc}	—	ns



PRODUCT PREVIEW

PIN DESCRIPTIONS

PIN #	NAME	DESCRIPTION																											
1,6,7,16,25,47	NC	No Connection																											
2	XIN	The crystal oscillator pin XIN supports parallel resonant AT cut crystals and ceramic resonators. XIN can also be an input if there is an external clock source instead of a crystal.																											
3	XOUT	The crystal oscillator pin XOUT supports parallel resonant AT cut crystals and ceramic resonators. XOUT serves as the output of the crystal amplifier.																											
4, 33, 34, 48	DGND	Digital Ground																											
5	RST	A HIGH on the reset input for two t_{OSC} periods will reset the device.																											
8	PLL CAP																												
9	AV _{DD}	Analog Power Supply																											
10, 11	AGND	Analog Ground																											
12	AINCOM	Analog Common for Single-Ended Inputs																											
13	IDAC	IDAC Output																											
14	REFOUT/REF IN+	Voltage Reference Output/ Voltage Reference Positive Input																											
15	REF IN–	Voltage Reference Negative Input																											
17	AIN7	Analog Input Channel 7																											
18	AIN6	Analog Input Channel 6																											
19	AIN5	Analog Input Channel 5																											
20	AIN4	Analog Input Channel 4																											
21	AIN3	Analog Input Channel 3																											
22	AIN2	Analog Input Channel 2																											
23	AIN1	Analog Input Channel 1																											
24	AIN0	Analog Input Channel 0																											
26-32, 37	P1.0-P1.7	Port 1 is a bidirectional I/O port. The alternate functions for Port 1 are listed below. Port 1—Alternate Functions: <table border="1"> <thead> <tr> <th>PORT</th><th>ALTERNATE</th><th>MODE</th></tr> </thead> <tbody> <tr> <td>P1.0</td><td>N/A</td><td></td></tr> <tr> <td>P1.1</td><td>N/A</td><td></td></tr> <tr> <td>P1.2</td><td>DOUT</td><td>Serial Data Out</td></tr> <tr> <td>P1.3</td><td>DIN</td><td>Serial Data In</td></tr> <tr> <td>P1.4</td><td>INT2</td><td>External Interrupt 2</td></tr> <tr> <td>P1.5</td><td>INT3</td><td>External Interrupt 3</td></tr> <tr> <td>P1.6</td><td>INT4</td><td>External Interrupt 4</td></tr> <tr> <td>P1.7</td><td>N/A</td><td></td></tr> </tbody> </table>	PORT	ALTERNATE	MODE	P1.0	N/A		P1.1	N/A		P1.2	DOUT	Serial Data Out	P1.3	DIN	Serial Data In	P1.4	INT2	External Interrupt 2	P1.5	INT3	External Interrupt 3	P1.6	INT4	External Interrupt 4	P1.7	N/A	
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P1.6	INT4	External Interrupt 4																											
P1.7	N/A																												
38-45	P3.0-P3.7	Port 3 is a bidirectional I/O port. The alternate functions for Port 3 are listed below. Port 3—Alternate Functions: <table border="1"> <thead> <tr> <th>PORT</th><th>ALTERNATE</th><th>MODE</th></tr> </thead> <tbody> <tr> <td>P3.0</td><td>RxD0</td><td>Serial Port 0 Input</td></tr> <tr> <td>P3.1</td><td>TxD0</td><td>Serial Port 0 Output</td></tr> <tr> <td>P3.2</td><td>INT0</td><td>External Interrupt 0</td></tr> <tr> <td>P3.3</td><td>INT1</td><td>External Interrupt 1</td></tr> <tr> <td>P3.4</td><td>T0</td><td>Timer 0 External Input</td></tr> <tr> <td>P3.5</td><td>T1</td><td>Timer 1 External Input</td></tr> <tr> <td>P3.6</td><td>SCK</td><td>SCK</td></tr> <tr> <td>P3.7</td><td>N/A</td><td></td></tr> </tbody> </table>	PORT	ALTERNATE	MODE	P3.0	RxD0	Serial Port 0 Input	P3.1	TxD0	Serial Port 0 Output	P3.2	INT0	External Interrupt 0	P3.3	INT1	External Interrupt 1	P3.4	T0	Timer 0 External Input	P3.5	T1	Timer 1 External Input	P3.6	SCK	SCK	P3.7	N/A	
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P3.4	T0	Timer 0 External Input																											
P3.5	T1	Timer 1 External Input																											
P3.6	SCK	SCK																											
P3.7	N/A																												
35, 36, 46	DV _{DD}	Digital Power Supply																											

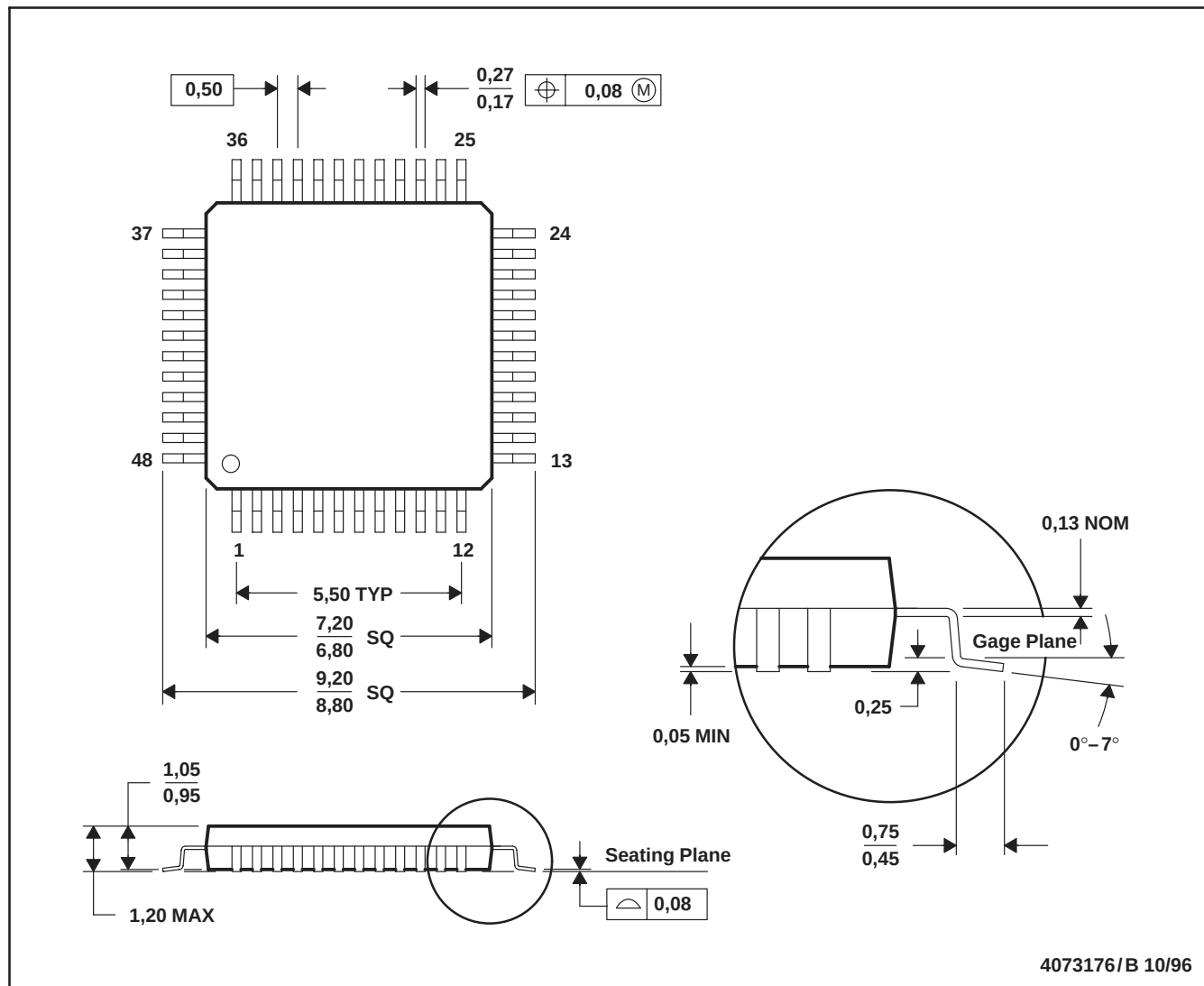


- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Falls within JEDEC MS-026

PRODUCT PREVIEW

PFB (S-PQFP-G48)

PLASTIC QUAD FLATPACK



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-026

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