

OKI SemiconductorThis version: Sep. 1998
Previous version: Mar. 1996

MSM6408

High speed and High performance 4-Bit Microcontroller

GENERAL DESCRIPTION

The MSM6408 microcontroller is a low-power, single-chip device implemented in complementary metal-oxide semiconductor technology.

The MSM6408 is optimized for high-speed processing and complicated-control applications, in which conventional microcontrollers are difficult to use.

FEATURES

- Mask ROM : 8096 words $\times$ 8 bits
- RAM (including the stack area) : 256 words $\times$ 4 bits
- I/O port
 - Input-output port : 8 ports $\times$ 4 bits
 - Input port : 1 port $\times$ 4 bits

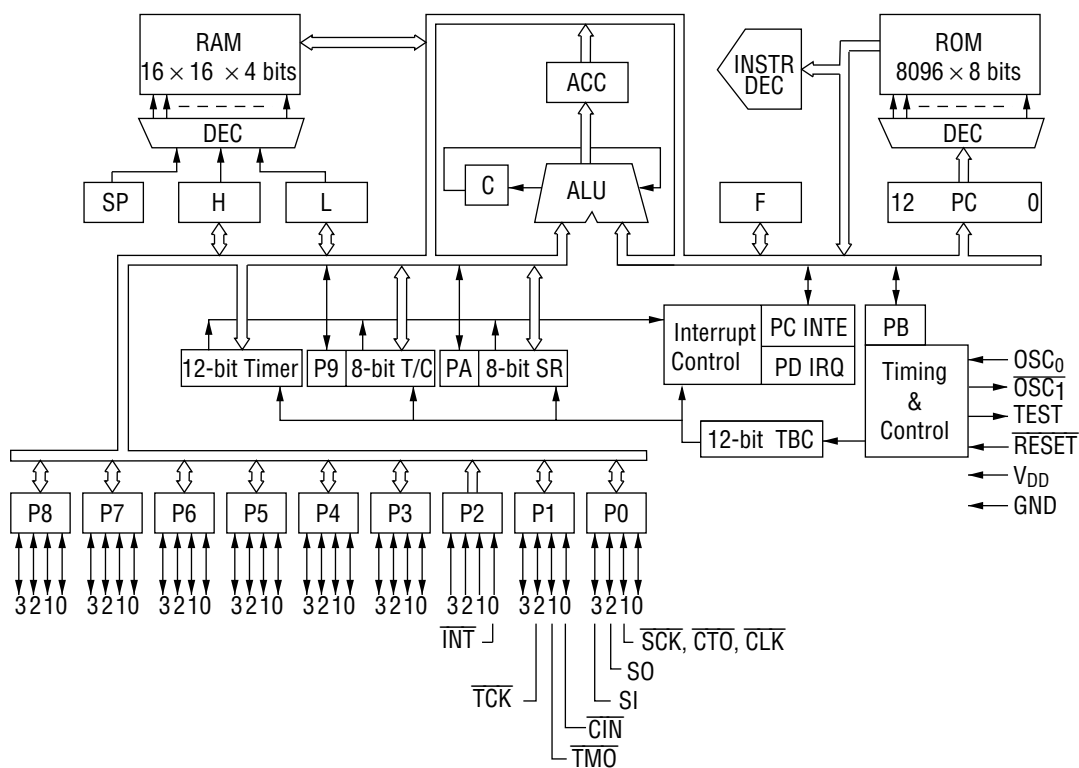
4 bits are for input ports having a latch; the other 32 bits are for input/output ports that allow bit manipulation
- Three built-in counters : 12-bit time-base counter
12-bit programmable timer
8-bit high-speed programmable timer/event counter
- Built-in 8-bit serial I/O register (with 3-bit counter)
- Five interrupts with five priority levels (4 internal, 1 external)
- 32 stack levels (in RAM)
- Power down features
- Minimum instruction execution time : 1.0 μ s @ 4.0 MHz clock
- Instruction systems suitable for control
- Fully static operation
- Low power consumption
- Single 5 V power supply
- Package options:

42-pin plastic DIP (DIP42-P-600-2.54)	(Product name : MSM6408-xxxRS)
44-pin plastic QFP (QFP44-P-910-0.80-K)	(Product name : MSM6408-xxxGS-K)
44-pin plastic QFP (QFP44-P-910-0.80-2K)	(Product name : MSM6408-xxxGS-2K)

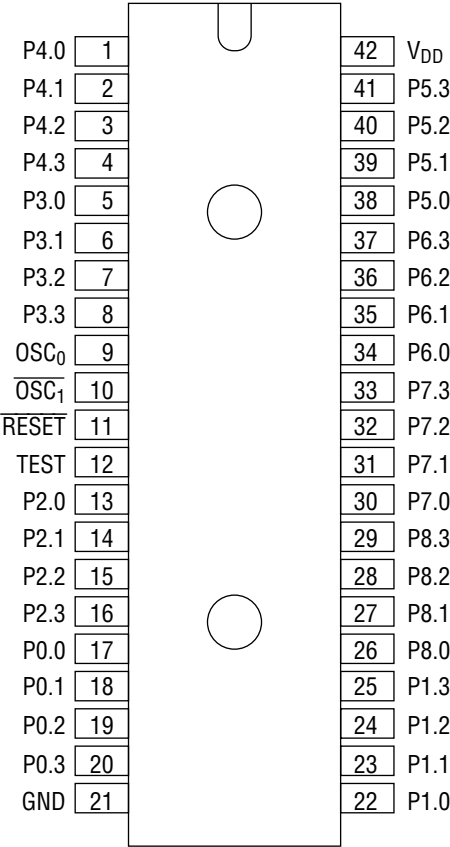
xxx indicates a code number.



BLOCK DIAGRAM

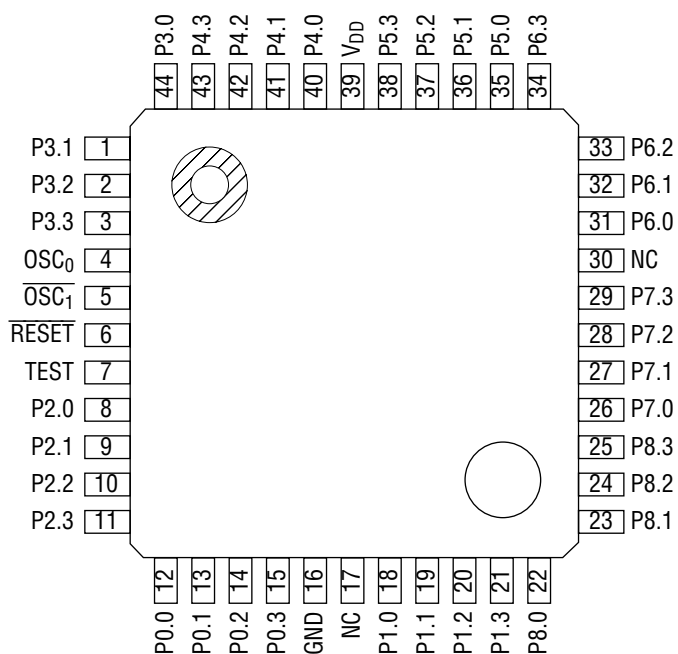


PIN CONFIGURATION (TOP VIEW)



42-Pin Plastic DIP

PIN CONFIGURATION (TOP VIEW) (continued)



NC : No-connection pin

44-Pin Plastic QFP

PIN DESCRIPTIONS

Symbol	Type	Description	During reset
P0.0 P0.1/ $\overline{\text{SCK}}$ P0.2/SO P0.3/SI	I/O	P0.1 is shared with serial clock ($\overline{\text{SLK}}$) input/output. P0.2 is shared with serial data (SO) output. P0.3 is shared with serial data (SI) input.	"1"
P1.0/ $\overline{\text{CIN}}$ P1.1/ $\overline{\text{TMO}}$ P1.2/ $\overline{\text{TCK}}$ P1.3	I/O	P1.0 is shared with counter input ($\overline{\text{CIN}}$). P1.1 is shared with timer output ($\overline{\text{TMO}}$). P1.2 is shared with timer clock input ($\overline{\text{TCK}}$).	"1"
P2.0/ $\overline{\text{INT}}$ P2.1 P2.2 P2.3	I	P2.0 is shared with external interrupt input ($\overline{\text{INT}}$). } Input ports with a latch, with built-in pull-up resistor.	The latch is reset.
P3.0 to 3.3	I/O	—	"1"
P4.0 to 4.3	I/O	—	"0"
P5.0 to 5.3	I/O	—	"0"
P6.0 to 6.3	I/O	—	"0"
P7.0 to 7.3	I/O	—	"0"
P8.0 to 8.3	I/O	—	"0"
OSC ₀ OSC ₁	I O	Crystal connection pins for clock oscillation.	Oscillation waveform
TEST	O	(Test pin for manufacturer)	Pulse output
$\overline{\text{RESET}}$	I	Input pin for system reset.	—
V _{DD} GND	—	Power supply voltage pins.	—

Note: 1. The pins except for pins P2.0 to P2.3 are pseudo bidirectional ports.
 2. When each port is used for output, the MSM6408 can drive one TTL (one input).

INSTRUCTION LIST

	Mnemonic	Code	Byte	Cycle	Description
Load, Push, Pop	LAI n	9n	1	1	$A \leftarrow n$
	LLI n	8n	1	1	$L \leftarrow n$
	LHLI nn	15nn	2	2	$HL \leftarrow nn$
	LMI nn	14nn	2	2	$M(w) \leftarrow nn$
	LAL	21	1	1	$A \leftarrow L$
	LLA	2D	1	1	$L \leftarrow A$
	LAH	22	1	1	$A \leftarrow H$
	LHA	2E	1	1	$H \leftarrow A$
	LAM	38	1	1	$A \leftarrow M$
	LMA	2F	1	1	$M \leftarrow A$
	LAM+	24	1	1	$A \leftarrow M, L \leftarrow L + 1, \text{Skip if } L = 0$
	LAM-	25	1	1	$A \leftarrow M, L \leftarrow L - 1, \text{Skip if } L = F$
	LMA+	26	1	1	$M \leftarrow A, L \leftarrow L + 1, \text{Skip if } L = 0$
	LMA-	27	1	1	$M \leftarrow A, L \leftarrow L - 1, \text{Skip if } L = F$
	LAMM n_2	39-3B	1	1	$A \leftarrow M, H \leftarrow H \forall n_2$
	LAMD mm	10mm	2	2	$A \leftarrow Md$
	LMAD mm	11mm	2	2	$Md \leftarrow A$
	LMTD mm	19mm	2	3	$Md(w) \leftarrow T (M(w), A), T = \text{ROM table}$
	LMCT	3E59	2	2	$M(w) \leftarrow CT$
	LCTM	3E51	2	2	$CT \leftarrow M(w)$
	LMSR	3E5A	2	2	$M(w) \leftarrow SR$
	LSRM	3E52	2	2	$SR \leftarrow M(w)$
	LTMM	3E50	2	2	$TM \leftarrow (M(w), A)$
	PUSH	1C	1	3	$ST \leftarrow C, A, H, L, SP \leftarrow SP - 4$
	POP	1D	1	3	$C, A, H, L, \leftarrow ST \quad SP \leftarrow SP + 4$
Exchange	X	28	1	1	$A \leftrightarrow M$
	XM n_2	29-2B	1	1	$A \leftrightarrow M, H \leftarrow H \forall n_2$
	X+	3C	1	1	$A \leftrightarrow M, L \leftarrow L + 1, \text{Skip if } L = 0$
	X-	2C	1	1	$A \leftrightarrow M, L \leftarrow L - 1, \text{Skip if } L = F$
Increment/ Decrement	INA	30	1	1	$A \leftarrow A + 1, \text{Skip if } A = 0$
	INM	33	1	1	$A \leftarrow M + 1, \text{Skip if } M = 0$
	INL	31	1	1	$L \leftarrow L + 1, \text{Skip if } L = 0$

INSTRUCTION LIST (continued)

	Mnemonic	Code	Byte	Cycle	Description
Increment/Decrement	INH	32	1	1	$H \leftarrow H + 1$, Skip if $M = 0$
	INMD mm	12mm	2	2	$Md \leftarrow Md + 1$, Skip if $Md = 0$
	DCA	34	1	1	$A \leftarrow A - 1$, Skip if $A = F$
	DCM	37	1	1	$M \leftarrow M - 1$, Skip if $M = F$
	DCL	35	1	1	$L \leftarrow L - 1$, Skip if $L = F$
	DCH	36	1	1	$H \leftarrow H - 1$, Skip if $H = F$
	DCMD mm	13mm	2	2	$Md \leftarrow Md - 1$, Skip if $Md = F$
Arithmetic	ADS	02	1	1	$A \leftarrow A + M$, Skip if $Cy = 1$
	ADCS	01	1	1	$A, C \leftarrow A + M + C$, Skip if $Cy = 1$
	ADC	03	1	1	$A, C \leftarrow A + M + C$
	AIS n	3E4n	2	2	$A \leftarrow A + n$, Skip if $Cy = 1$
	DAA	06	1	1	$A \leftarrow A + 6$
	DAS	0A	1	1	$A \leftarrow A + 10$
	AND	0D	1	1	$A \leftarrow A \wedge M$
	OR	05	1	1	$A \leftarrow A \vee M$
	EOR	04	1	1	$A \leftarrow A \vee M$
	CMA	0B	1	1	$A \leftarrow \overline{A}$
	CIA	0C	1	1	$A \leftarrow \overline{A} + 1$
	RAL	0E	1	1	Rotate left with C
	RAR	0F	1	1	Rotate right with C
	TC	09	1	1	Skip if $C = 1$
	SC	07	1	1	$C \leftarrow 1$
	RC	08	1	1	$C \leftarrow 0$
Compare	CAI n	3E0n	2	2	Skip if $A = n$
	CLI n	3E2n	2	2	Skip if $L = n$
	CPI p, n	17pn	2	2	Skip if $Pp = n$
	CMI n	3E1n	2	2	Skip if $M = n$
	CAM	16	1	1	Skip if $A = M$
Bit manipulation	TAB n_2	54-57	1	1	Skip if $Abit(n_2) = 1$
	RAB n_2	64-67	1	1	$Abit(n_2) \leftarrow 0$
	SAB n_2	74-77	1	1	$Abit(n_2) \leftarrow 1$
	TMB n_2	58-5B	1	1	Skip if $Mbit(n_2) = 1$
	RMB n_2	68-6B	1	1	$Mbit(n_2) \leftarrow 0$

INSTRUCTION LIST (continued)

	Mnemonic	Code	Byte	Cycle	Description
Bit manipulation	SMB n	78-7B	1	1	Mbit (n_2) $\leftarrow$ 1
	TFB n_2	5C-5F	1	1	Skip if Fbit (n_2) = 1
	RFB n_2	6C-6F	1	1	Fbit (n_2) $\leftarrow$ 0
	SFB n_2	7C-7F	1	1	Fbit (n_2) $\leftarrow$ 1
	TPB n_2	50-53	1	1	Skip if Pbit (n_2) = 1
	RPB n_2	60-63	1	1	Pbit (n_2) $\leftarrow$ 0
	SPB n_2	70-73	1	1	Pbit (n_2) $\leftarrow$ 1
	TPBD pn_2	30 p_{0-3}	2	2	Skip if Ppbit (n_2) = 1
	RPBD pn_2	3D p_{4-7}	2	2	Ppbit (n_2) = 0
	SPBD pn_2	3D p_{8-B}	2	2	Ppbit (n_2) = 1
Interrupt	MEI	3E60	2	2	MEIF $\leftarrow$ 1
	MDI	3E61	2	2	MEIF $\leftarrow$ 0
	EITB	3DC9	2	2	EITBF $\leftarrow$ 1
	EITM	3DCA	2	2	EITMF $\leftarrow$ 1
	EICT	3DCB	2	2	EICTF $\leftarrow$ 1
	EIEX	3DC8	2	2	EIEXF $\leftarrow$ 1
	DITB	3DC5	2	2	EITBF $\leftarrow$ 0
	DITM	3DC6	2	2	EITMF $\leftarrow$ 0
	DICT	3DC7	2	2	EICTF $\leftarrow$ 0
	DIEX	3DC4	2	2	EIEXF $\leftarrow$ 0
	TITB	3DC1	2	2	Skip if EITBF = 1
	TITM	3DC2	2	2	Skip if EITMF = 1
	TICT	3DC3	2	2	Skip if EICTF = 1
	TIEX	3DC0	2	2	Skip if EIEXF = 1
	TQEX	3D20	2	2	Skip if IRQEX = 1
	TQTB	3DD0	2	2	Skip if IRQTB = 1
	TQTM	3DD1	2	2	Skip if IRQTM = 1
	TQCT	3DD2	2	2	Skip if IRQCT = 1
	TQSR	3DD3	2	2	Skip if IRQSR = 1
	RQEX	3D24	2	2	IRQ EX $\leftarrow$ 0
	RQTB	3DD4	2	2	IRQ TB $\leftarrow$ 0
	RQTM	3DD5	2	2	IRQ TM $\leftarrow$ 0
	RQCT	3DD6	2	2	IRQ CT $\leftarrow$ 0
	RQSR	3DD7	2	2	IRQ SR $\leftarrow$ 0

INSTRUCTION LIST (continued)

	Mnemonic	Code	Byte	Cycle	Description
Counter/Shift register control	ECT	3DBB	2	2	CTF←1 (start)
	ESR	3DBA	2	2	SRF←1 (start)
	DCT	3DB7	2	2	CTF←0 (stop)
	DSR	3DB6	2	2	SRF←0 (stop)
	TCT	3DB3	2	2	Skip if CTF = 1
	TSR	3DB2	2	2	Skip if SRF = 1
Branch	JCP a ₆	C0-FF	1	1	PC←a ₆
	JP a ₁₂	4a ₁₂	2	2	PC←a ₁₂
	LJP a ₁₃	3F	3	4	PC←a ₁₃
	CZP a	Ba	1	4	ST←PC + 1, PC←2a, SP←SP - 4
	CAL a ₁₂	Aa ₁₂	2	4	ST←PC + 2, PC←a ₁₂ , SP←SP - 4
	RT	IE	1	4	PC←ST, SP←SP + 4
	RTS	IF	1	4	PC←ST, SP←SP + 4, Unconditional skip
	JA	IA	1	1	PC←(PC←A) + 1
Input/Output	JM	IB	1	2	PC←(M(w), A)
	IP	20	1	1	A←P
	IPD p	3DpD	2	2	A←Pp
	OP	23	1	1	P←A
	OPD p	3DpC	2	2	Pp←A
CPU control	NOP	00	1	1	No operation
	HALT	3DB8	2	2	Halt CPU
	STOP	3DB9	2	2	Stop clock

Notes: a : ROM address data
m : RAM address data
n : Immediate data
p : Port address data

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage	V_{DD}	$T_a = 25^{\circ}\text{C}$	-0.3 to +7	V
Input Voltage	V_I		-0.3 to V_{DD}	V
Output Voltage	V_O		-0.3 to V_{DD}	V
Power Dissipation	P_D	$T_a = 25^{\circ}\text{C}$ per package	200	mW
		$T_a = 25^{\circ}\text{C}$ per output	50	mW
Storage Temperature	T_{STG}	—	-55 to +150	$^{\circ}\text{C}$

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Condition	Range	Unit
Power Supply Voltage	V_{DD}	$f_{OSC} \leq 1 \text{ MHz}$	3 to 6	V
		$f_{OSC} \leq 4.0 \text{ MHz}$	4.5 to 5.5	V
Data-Hold Voltage	V_{DDH}	$f_{OSC} = 0 \text{ Hz}$	2 to 6	V
Operating Temperature	T_{op}	—	-40 to +85	$^{\circ}\text{C}$
Fan Out	N	MOS load	15	—
		TTL load	1	

ELECTRICAL CHARACTERISTICS

DC Characteristics

(V_{DD} = 5 V ±10%, Ta = -40 to +85°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
"H" Input Voltage *1, *2	V _{IH}	—	2.4	—	V _{DD}	V
"H" Input Voltage *3, *4	V _{IH}	—	3.6	—	V _{DD}	V
"L" Input Voltage	V _{IL}	—	-0.3	—	+0.8	V
"H" Output Voltage *1, *5	V _{OH}	I _O = -15 µA	4.2	—	—	V
"L" Output Voltage *1	V _{OL}	I _O = 1.6 mA	—	—	0.4	V
"L" Output Voltage *5	V _{OL}	I _O = 15 µA	—	—	0.4	V
Input Current *3	I _{IH} /I _{IL}	V _I = V _{DD} /0 V	—	—	15/-15	µA
Input Current *2, *4	I _{IH} /I _{IL}	V _I = V _{DD} /0 V	—	—	1/-30	µA
"H" Output Current *1	I _{OH}	V _O = 2.4 V	-0.1	—	—	mA
"H" Output Current *1	I _{OH}	V _O = 0.4 V	—	—	-1.2	mA
Input Capacitance	C _I	f = 1 MHz, Ta = 25°C	—	5	—	pF
Output Capacitance	C _O		—	7	—	
Power Supply Current (In Stopped State)	I _{DDS}	V _{DD} = 2 V, no load, Ta = 25°C	—	0.2	5	µA
		No load	—	1	100	µA
Power Supply Current	I _{DD}	Crystal oscillation f = 4 MHz, no load	—	6	12	mA

*1 Applied to P0, P1, P3, P4, P5, P6, P7 and P8

*2 Applied to P2

*3 Applied to OSC₀*4 Applied to $\overline{\text{RESET}}$ *5 Applied to $\overline{\text{OSC}}_1$

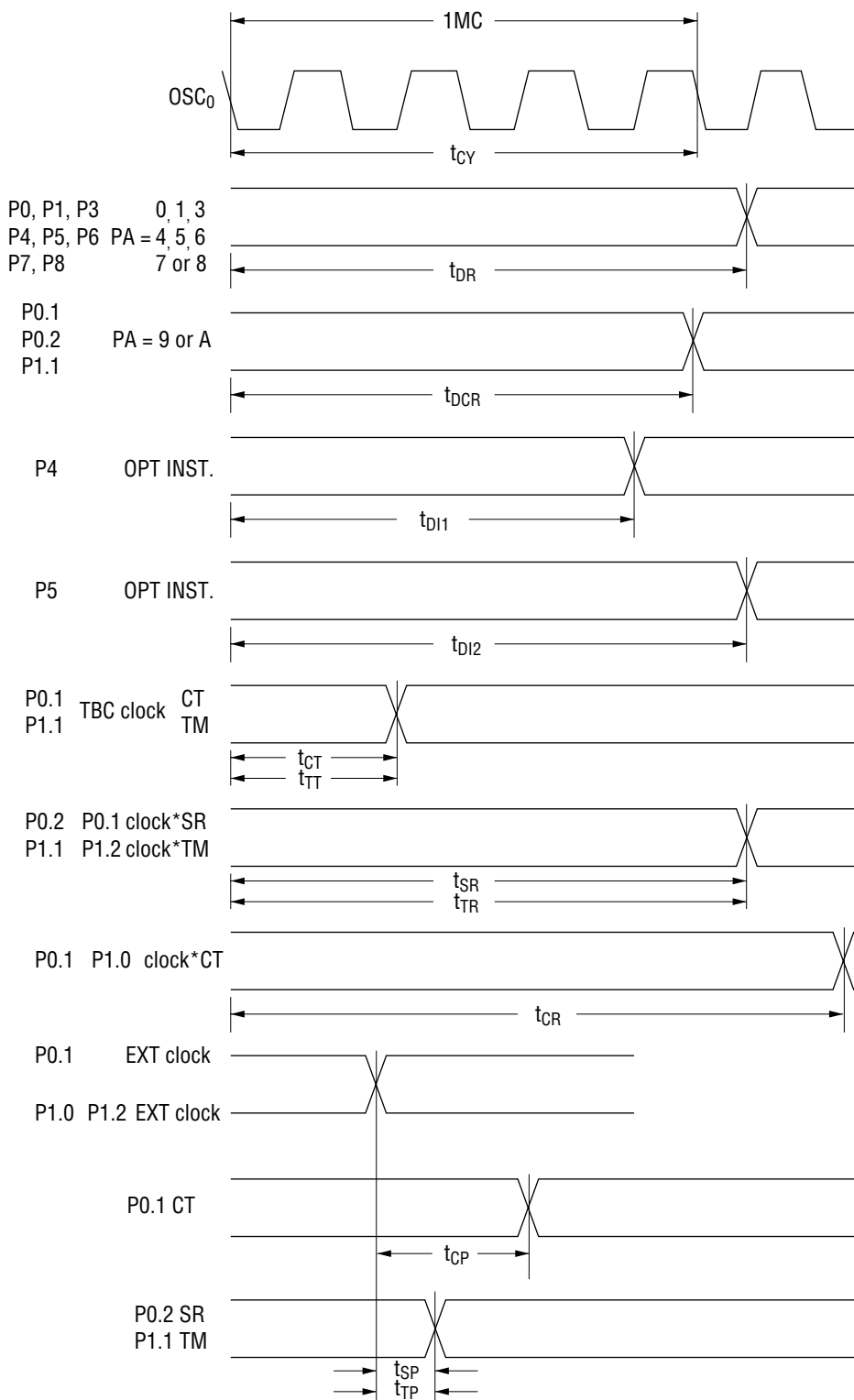
AC Characteristics

(V_{DD} = 5 V ±10%, Ta = -40 to +85°C)

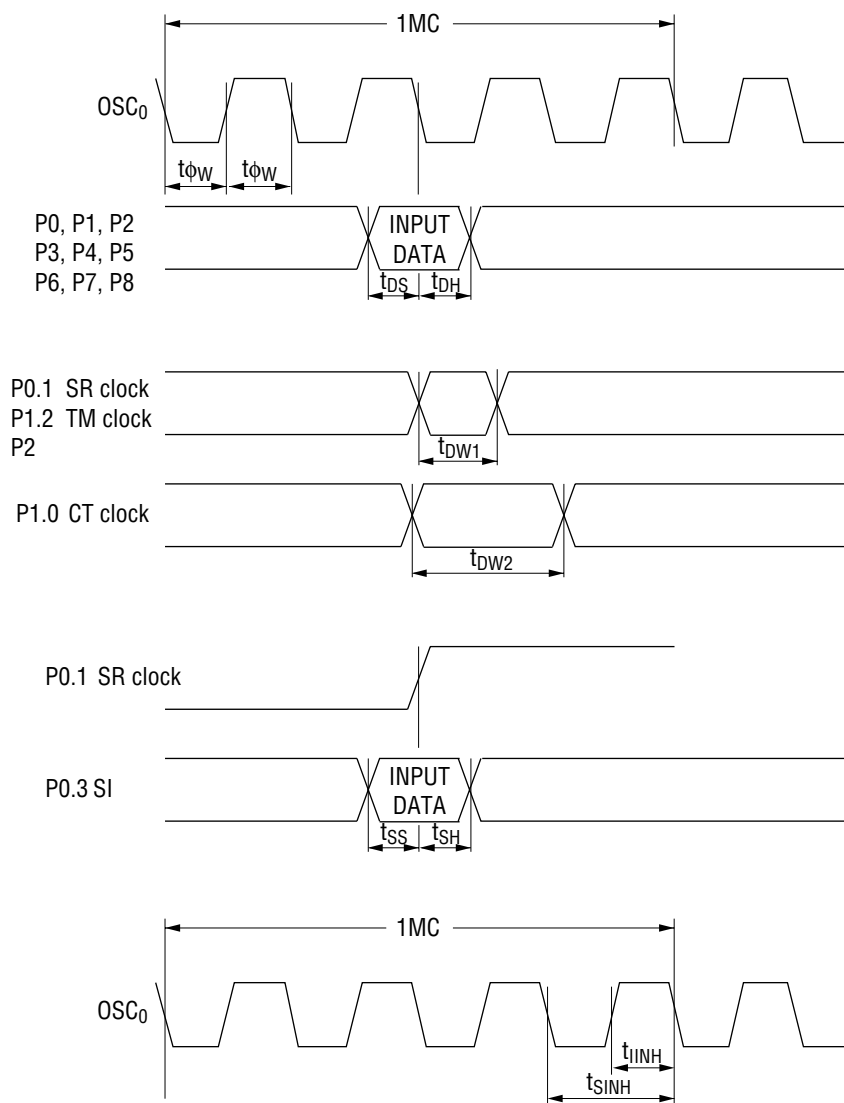
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Clock (OSC ₀) Pulse Width	t _{φW}	—	125	—	—	ns
Cycle Time	t _{CY}	—	1	—	—	μs
Input Data Setup Time	t _{DS}	—	120	—	—	ns
Input Data Hold Time	t _{DH}	—	120	—	—	ns
SR/TM Clock Pulse Width	t _{WS} /t _{WT}	—	120	—	—	ns
CT Clock Pulse Width	t _{WC}	—	2/8 t _{CY} + 120	—	—	ns
P2 Input Data Clock Pulse Width	t _{WP}	—	120	—	—	ns
SR Data Setup Time	t _{SS}	—	120	—	—	ns
SR Data Hold Time	t _{SH}	—	120	—	—	ns
Data Delay Time	t _{DR}	C _L = 15 pF	—	—	t _{CY} + 300	ns
Data Delay Time at Mode Switching	t _{DCR}	C _L = 15 pF	—	—	7/8 t _{CY} + 300	ns
Data Delay Time at OPT Instruction	t _{DI1}	C _L = 15 pF	—	—	6/8 t _{CY} + 300	ns
Data Delay Time at OPT Instruction	t _{DI2}	C _L = 15 pF	—	—	7/8 t _{CY} + 300	ns
CT/TM Data Delay Time Using TBC Clock	t _{CT} /t _{TT}	C _L = 15 pF	—	—	2/8 t _{CY} + 360	ns
SR/TM Data Delay Time Using PORT Clock	t _{SR} /t _{TR}	C _L = 15 pF	—	—	t _{CY} + 480	ns
CT Data Delay Time Using PORT Clock	t _{CR}	C _L = 15 pF	—	—	10/8 t _{CY} + 480	ns
CT Data Delay Time Using External Clock	t _{CP}	C _L = 15 pF	—	—	2/8 t _{CY} + 360	ns
SR/TM Data Delay Time Using External Clock	t _{SP} /t _{TP}	C _L = 15 pF	—	—	360	ns
SR Clock Invalid Time	t _{SINH}	—	2/8 t _{CY}	—	—	ns
INT Invalid Time	t _{IINH}	—	1/8 t _{CY}	—	—	ns

Timing Diagrams

Output Conditions



Input Conditions



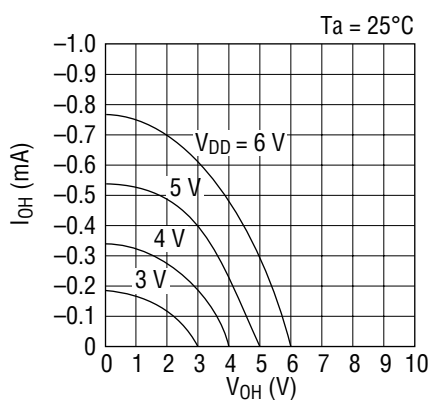
t_{SINH} : P0.1 (SR clock) INH period during LMSR INST.

(Note: P0.1 is used for clock of SR.)

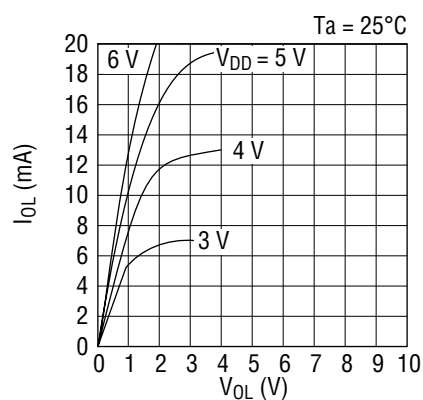
t_{IINH} : P2.0 (interrupt) INH period during RPB and RPB D INST.

Operating Characteristics

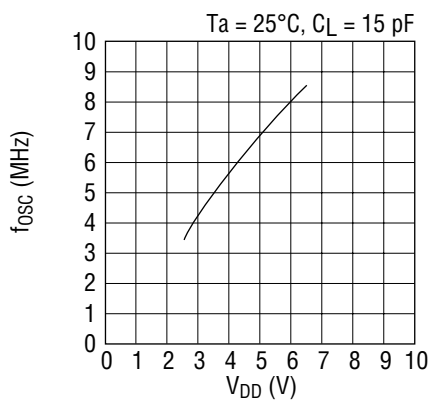
Typ. Current (I_{OH}) vs Voltage (V_{OH}) for High State Output



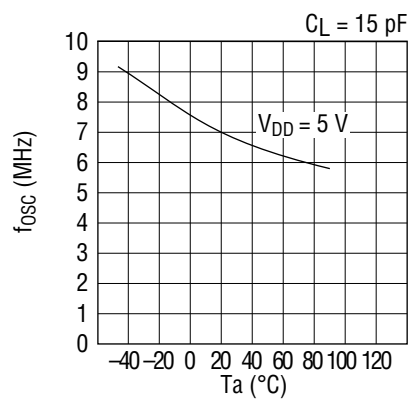
Typ. Current (I_{OL}) vs Voltage (V_{OL}) for Low State Output

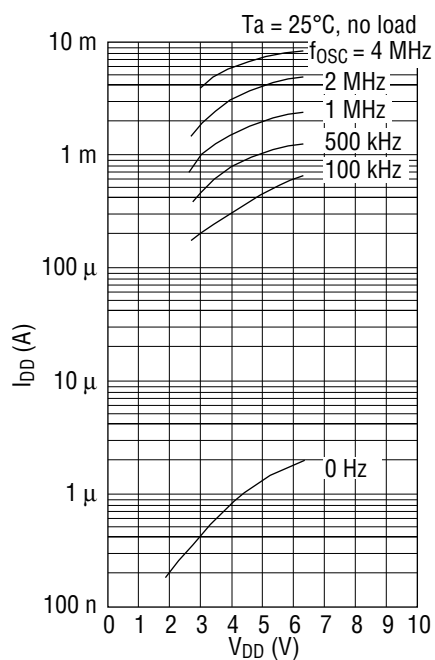


Typ. Maximum Oscillator Frequency (f_{OSC}) vs Supply Voltage (V_{DD})



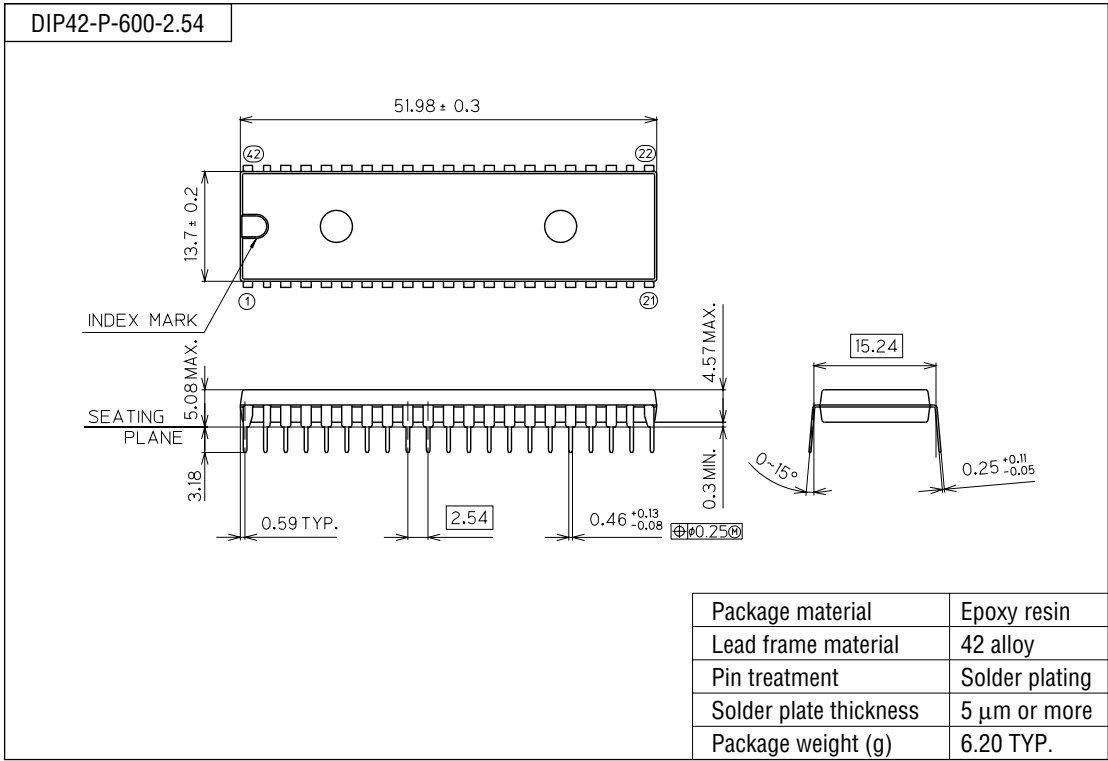
Typ. Maximum Oscillator Frequency (f_{OSC}) vs Temperature (T_a)



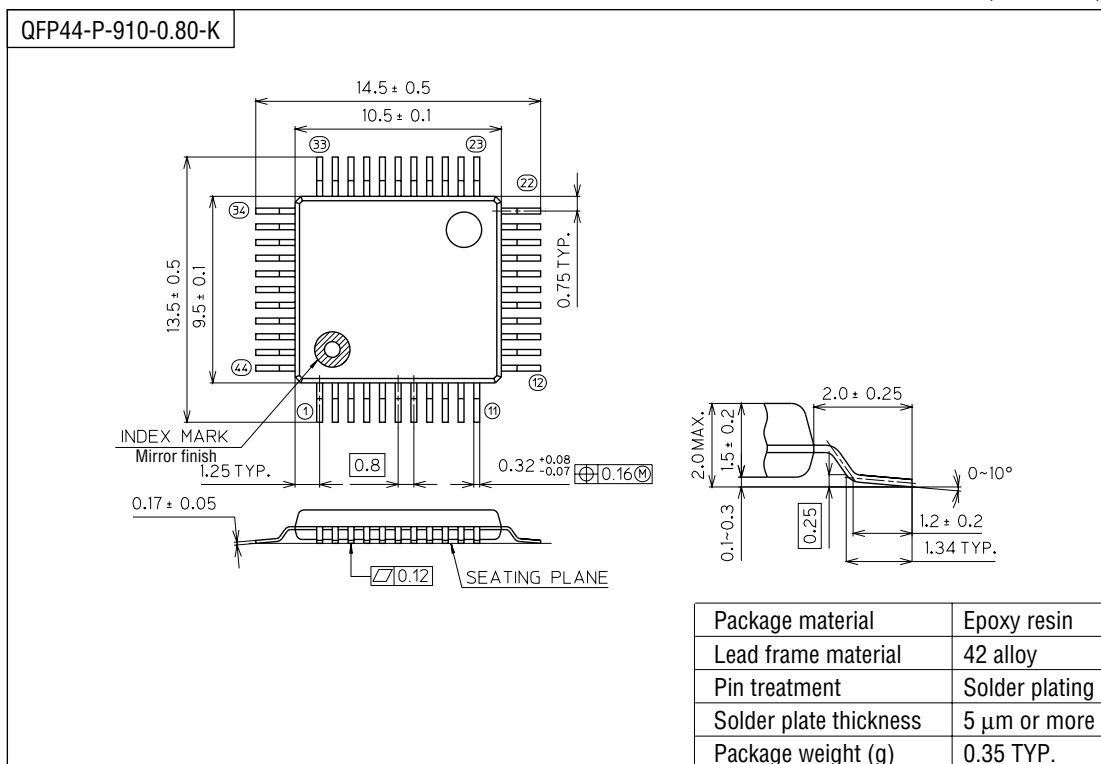
Operating Characteristics (continued)Typ. Supply Current (I_{DD}) vs Supply Voltage (V_{DD})

PACKAGE DIMENSIONS

(Unit : mm)



(Unit : mm)

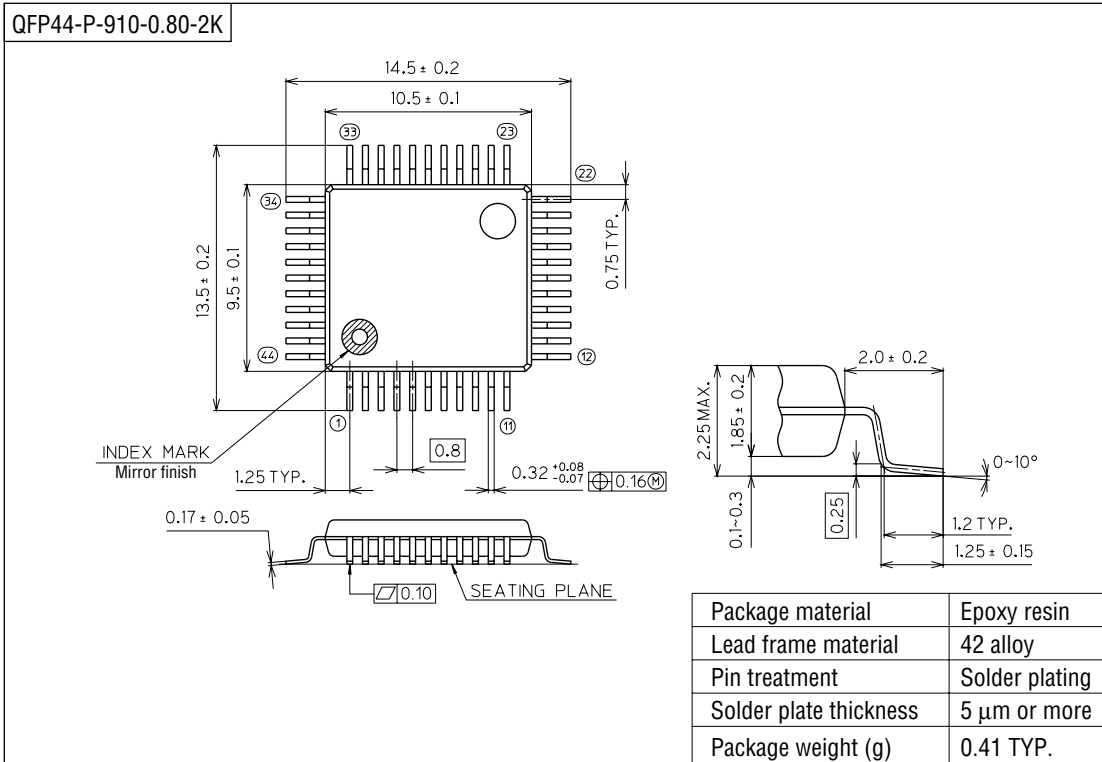


Notes for Mounting the Surface Mount Type Package

The SOP, QFP, TSOP, SOJ, QFJ (PLCC), SHP and BGA are surface mount type packages, which are very susceptible to heat in reflow mounting and humidity absorbed in storage.

Therefore, before you perform reflow mounting, contact Oki's responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

(Unit : mm)



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