Ordering number: EN 3113B

CMOS LSI

SANYO No. 3113B

LC66304A, 66306A, 66308A

4K/6K/8K-BYTE ROM-CONTAINED SINGLE-CHIP 4-BIT MICROCOMPUTER FOR CONTROL-ORIENTED APPLICATIONS

General Description

The LC66304A, 66306A, 66308A are 42-pin package type CMOS 4-bit single-chip microcomputers. They contain a ROM, a RAM, I/O ports, a dual 8-bit serial interface, a 4-channel comparator input, a dual 3-level input port, a 12-bit timer, an 8-bit timer, and provide 8 interrupt sources with 8 vector addresses.

Features

(1) On-chip 4K-byte/6K-byte/8K-byte ROM, 512x4-bit RAM
(2) Instruction set with 128 instructions common with the LC665XX series
(3) I/O ports ----- 36 pins
(4) 8-bit serial interface ----- 2 lines (16-bit cascade connection available)
(5) Minimum instruction cycle time ----- 0.92μs (4.3MHz external clock input mode)
(6) Powerful timer function and prescaler
  12-bit timer-used interval timer, event counter, pulse width measurement, burst pulse output
  8-bit timer-used interval timer, event counter, PWM output, burst pulse output
  12-bit prescaler-used time base function
(7) Powerful 8-source 8-vector interrupt function
  External interrupt: 3 sources, 3 vector addresses
  Internal iterrupt: 5 sources, 5 vector addresses (timer: 2 sources, serial I/O: 2 sources, prescaler)
(8) Flexible I/O function
  Comparator input, 3-level input, 20mA drive output, 15V breakdown voltage, pull-up/open drain selectable by option
(9) Runaway detection function (option)
(10) 8-bit input/output function
(11) HALT/HOLD mode-used power-down function
(12) Package: DIP42S, QFP48E (QIP48E)
(13) Evaluation LSI: LC66599 (evaluation chip) + EVA850/800-TB6630X, LC66E308 (microcomputer with EPROM)

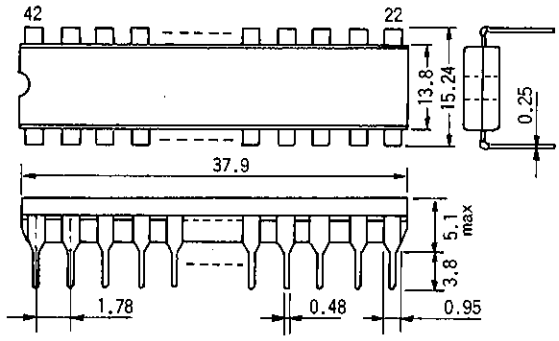
Series Lineup

Type No.	Pins	ROM capacity	RAM capacity	Package	Remark
LC66304A/306A/308A	42,48	4K/6K/8KB	512W	DIP42S, QFP48E	Available
LC66354A/356A/358A	42,48	4K/6K/8KB	512W	DIP42S, QFP48E	Available
LC66354S/356S/358S	44	4K/6K/8KB	512W	QFP44M	Under development
LC66E308	42,48	EPROM 8KB	512W	DIC42S, QFC48 with window	Available
LC66P308	42,48	OTPROM 8KB	512W	DIP42S, QFP48E	Available
LC66404A/406A/408A	42,48	4K/6K/8KB	512W	DIP42S, QFP48E	Available
LC66E408	42,48	EPROM 8KB	512W	DIC42S, QFC48 with window	Available
LC66P408	42,48	OTPROM 8KB	512W	DIP42S, QFP48E	Available
LC66506B/508B/512B/516B	64	6K/8K/12K/16KB	512W	DIP64S, QFP64A	Available
LC66556A/558A/562A/566A	64	6K/8K/12K/16KB	512W	DIP64S, QFP64E	Available
LC66354B/356B/358B	42,48	4K/6K/8KB	512W	DIP42S, QFP48E	Available
LC66556B/558B	64	6K/8K	512W	DIP64S, QFP64E	Under development
LC66562B/566B	64	12K/16KB	512W	DIP64S, QFP64E	Available
LC66E516	64	EPROM 16KB	512W	DIC64S, QFC64 with window	Available
LC66P516	64	OTPROM 16KB	512W	DIP64S, QFP64E	Available

SANYO Electric Co.,Ltd. Semiconductor Business Headquarters
TOKYO OFFICE Tokyo Bldg.,1-10,1 Chome, Ueno, Taito-ku, TOKYO, 110 JAPAN

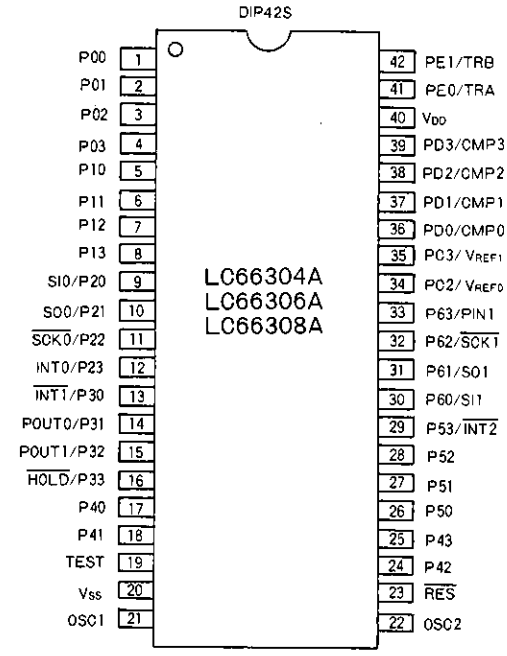
Package Dimensions 3025B

(unit : mm)



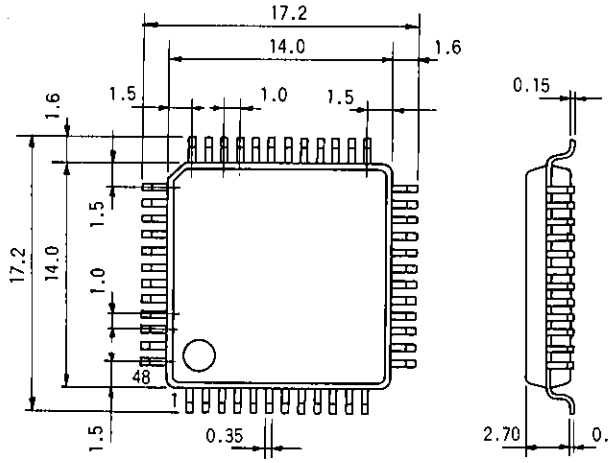
SANYO : DIP42S

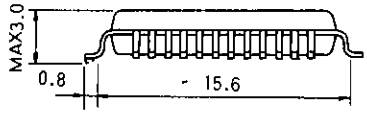
Pin Assignment



Package Dimensions 3156

(unit : mm)

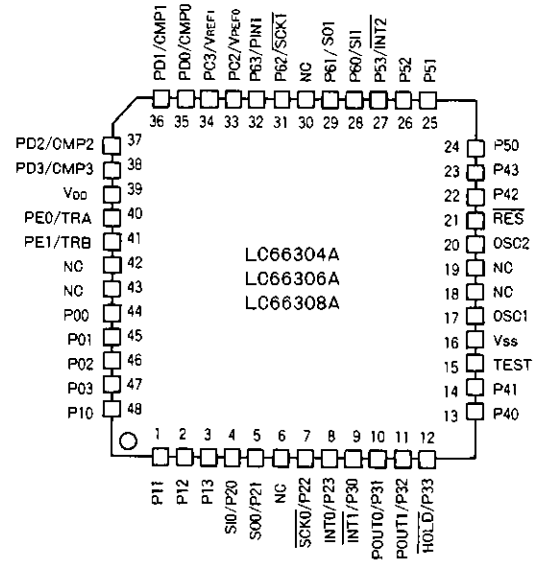




SANYO : QFP48E(QIP48E)

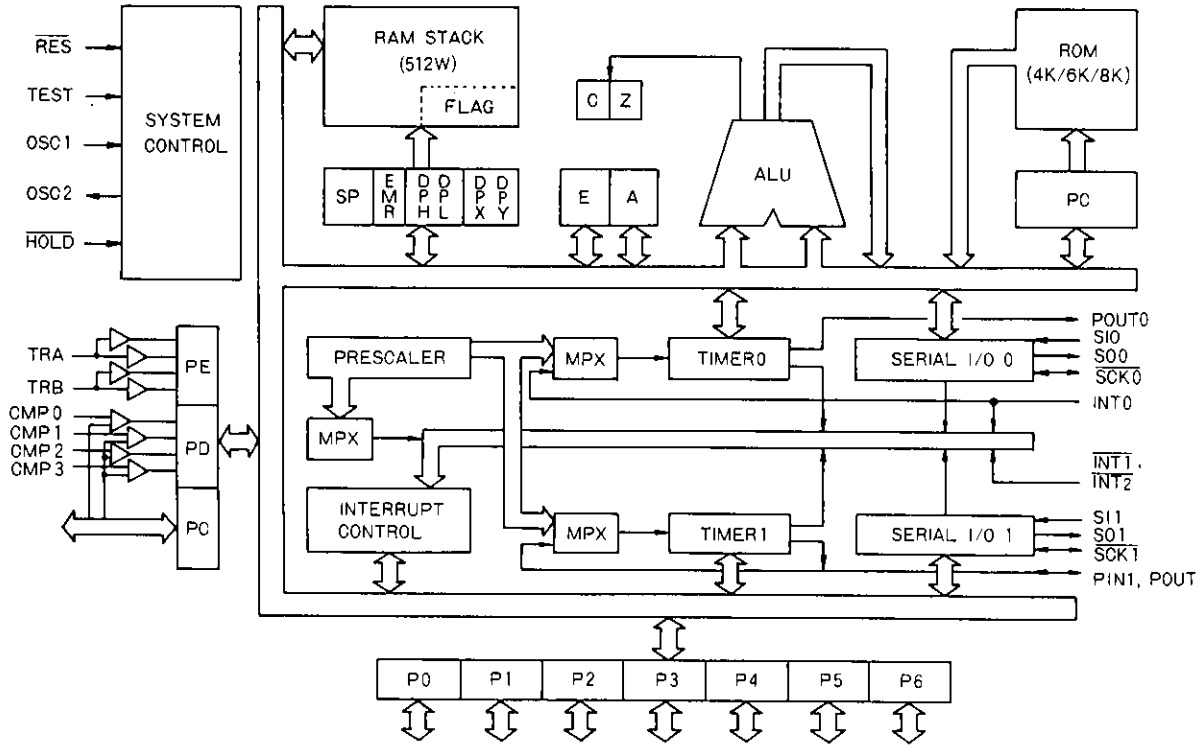
Pin Assignment

QFP48E(QIP48E)



Note) Reflow soldering is recommended for QFP (QIP) packages.
Please consult your local representative for information on solder-bath immersion of the device.

System Block Diagram



Pin Description

Pin Name	I/O	Functions	Output Driver Type	Option	During Reset
P00 P01 P02 P03	I/O	Input/output common port P00 to P03 • 4-bit and single-bit input/output • P00 to P03: Provided with HALT mode control function	• Pch: Pu MOS type • Nch: Sink medium current type	• With Pu MOS or Nch OD output • Output level during reset	H or L (option)
P10 P11 P12 P13	I/O	Input/output common port P10 to P13 • 4-bit and signle-bit input/output	• Pch: Pu MOS type • Nch: Sink medium current type	• With Pu MOS or Nch OD output • Output level during reset	H or L (option)
P20/SI0 P21/SO0 P22/$\overline{SCK0}$ P23/INT0	I/O	Input/output common port P20 to P23 • 4-bit and single-bit input/output • P20: Common with serial input SI0 • P21: Common with serial output SO0 • P22: Common with serial clock $\overline{SCK0}$ • P23: Common with INT0 interrupt and timer 0-used event count, pulse width measurement input	• Pch: CMOS type • Nch: Sink medium current type • +15V breakdown voltage at Nch OD configuration	• CMOS or Nch OD output	H
P30/$\overline{INT1}$ P31/POUT0 P32/POUT1	I/O	Input/output common port P30 to P32 • 3-bit and single-bit input/output • P30: Common with $\overline{INT1}$ interrupt request • P31: Common with burst pulse output from timer 0 • P32: Common with burst pulse output, PWM output from timer 1	• Pch: CMOS type • Nch: Sink medium current type • +15 breakdown voltage at Nch OD configuration	• CMOS or Nch OD output	H
P33/$\overline{HOLD}$	I	HOLD mode control input • The HOLD mode is entered by executing the HOLD instruction at $\overline{HOLD}$=L. • The CPU is restarted by setting the $\overline{HOLD}$ to H level at the HOLD mode. • Usable as input port P33 with P30 to P32 • Even if the $\overline{RES}$ is brought to L level when the P33/$\overline{HOLD}$ is at L level, the CPU is not reset. So this pin must be H level when V_{DD} has risen to a point where the CPU can operate properly.			

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Pin Name	I/O	Functions	Output Driver Type	Option	During Reset
P40 P41 P42 P43	I/O	Input/output port P40 to P43 • 4-bit and single-bit input/output • 8-bit input/output with P50 to P53 • 8-bit output of ROM data with P50 to P53	• Pch: Pu MOS type • Nch: Sink medium current type • +15 breakdown voltage at Nch OD configuration	• With Pu MOS or Nch OD output	H
P50 P51 P52 P53/$\overline{INT2}$	I/O	Input/output port P50 to P53 • 4-bit and single-bit input/output • 8-bit input/output with P40 to P43 • 8-bit output of ROM data with P40 to P43 • P53: Common with $\overline{INT2}$ interrupt request	• Pch: Pu MOS type • Nch: Sink medium current type • +15 breakdown voltage at Nch OD configuration	• With Pu MOS or Nch OD output	H
P60/SI1 P61/SO1 P62/$\overline{SCK1}$ P63/PIN1	I/O	Input/output common port P60 to P63 • 4-bit and single-bit input/output • P60: Common with serial input SI1 • P61: Common with serial output SO1 • P62: Common with serial clock $\overline{SCK1}$ • P63: Common with event counter input of timer 1	• Pch: CMOS type • Nch: Sink medium current type • +15V breakdown voltage at Nch OD configuration	• CMOS or Nch OD output	H
PC2/VREF0 PC3/VREF1	I/O	Input/output common port PC2 to PC3 • 2-bit and single-bit input/output • PC2: Common with VREF0 comparator comparison voltage pin • PC3: Common with VREF1 comparator comparison voltage pin	• Pch: CMOS type • Nch: Sink medium current type	• CMOS or Nch OD output	H
PD0/CMP0 PD1/CMP1 PD2/CMP2 PD3/CMP3	I	Input-only port PD0 to PD3 • The comparator input is software-selectable. • The comparison voltage of PD0 is VREF0. • The comparison voltage of PD1 to PD3 is VREF1. • The comparator is specified in units of PD0,PD1, (PD2, PD3).			Normal input
PE0/TRA PE1/TRB	I	Input-only port • The 3-level input port is software-selectable.			Normal input

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OSC1 OSC2	I O	Pins for externally connecting R, C or a ceramic resonator for system clock generation. For the external clock mode, the OSC2 pin is left open and the OSC1 pin is used for input.		• Ceramic resonator OSC, RC OSC, or external clock	
$\overline{RES}$	I	System reset input pin • When the $\overline{RES}$ is brought to L level at P33/$\overline{HOLD}$=H, the CPU is initialized.			
TEST	I	CPU test pin Connected to V_{SS} at the operating mode			
V_{DD} V_{SS}		Power supply pins			

Remarks: Output with Pu MOS ---------- Output with pull-up MOS transistor
CMOS output ---------- Complementary output
OD output ---------- Open drain output

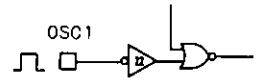
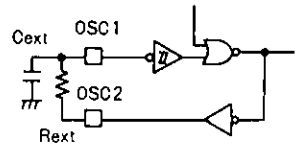
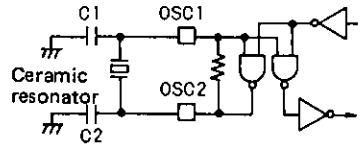
User Options

(1) Options of ports 0, 1 output level during reset

For input/output ports 0, 1 either of the following two output levels may be selected in a group of 4 bits during reset by option

Option Name	Conditions, etc.
1. Output during reset: "H" level	All of 4 bits of ports 0, 1
2. Output during reset: "L" level	All of 4 bits of ports 0, 1

(2) Oscillator Circuit Options

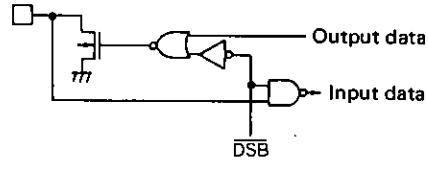
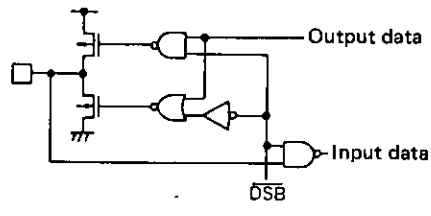
Option Name	Circuit	Conditions, etc.
1. External clock		• Input: Schmitt type
2. 2-pin RC OSC		• Input: Schmitt type
3. Ceramic resonator OSC		

(3) Watchdog timer option

The presence or absence of the runaway detection function (watchdog timer) may be selected by option.

(4) Options of port output configuration

For each port of P0, P1, P2, P3 (except P33/$\overline{\text{HOLD}}$), P4, P5, P6, PC, either of the following two output configurations may be selected by option (in bit units).

Option Name	Circuit	Conditions, etc.
1. Open drain type output		P2, P3, P5, P6: Schmitt input
2. Output with pull-up resistance		P2, P3, P5, P6: Schmitt input CMOS output (P2, P3, P6, PC)or Pu MOS output (P0, P1, P4, P5) is selected according to Pch Tr drive capacity.

Main Specifications

(1) Absolute Maximum Ratings at Ta=25°C, V_{SS}=0V

Parameter	Symbol	Applicable Pins, Remarks	Conditions	Limits	Unit	Note
Maximum Supply Voltage	V_{DD} max	V_{DD}		−0.3to+7.0	V	
Input Voltage	V_{IN}(1)	P2,P3(except P33/$\overline{HOLD}$), P4,P5,P6		−0.3to+15.0	V	1
	V_{IN}(2)	Other inputs		−0.3toV_{DD}+0.3	V	2
Output Voltage	V_{OUT}(1)	P2,P3(except P33/$\overline{HOLD}$), P4,P5,P6		−0.3to+15.0	V	1
	V_{OUT}(2)	Other outputs		−0.3toV_{DD}+0.3	V	2
Output Current per Pin	I_{ON}	P0,P1,P2,P3(except P33/$\overline{HOLD}$),PC,P4 P5,P6		20	mA	3
	−I_{OP}(1)	P0,P1,P4,P5		2	mA	4
	−I_{OP}(2)	P2,P3(except P33/$\overline{HOLD}$), P6,PC		4	mA	4
Total Pin Current	ΣI_{ON}(1)	P0,P1,P2,P3(except P33/$\overline{HOLD}$),P40,P41		75	mA	3
	ΣI_{ON}(2)	P5,P6,P42,P43,PC		75	mA	3
	−ΣI_{OP}(1)	P0,P1,P2,P3(except P33/$\overline{HOLD}$),P40,P41		25	mA	4
	−ΣI_{OP}(2)	P5,P6,P42,P43,PC		25	mA	4
Allowable Power Dissipation	Pd max	Ta=−30 to +70°C	DIP 42S (QFP 48E)	600 (430)	mW	5
Operating Temperature	Topr			−30to+70	°C	
Storage Temperature	Tstg			−55to+125	°C	

(Note 1) Applicable only when the open drain output type is selected. If other type than the open drain output is selected, the specification indicated in the column for other pins applies.
(Note 2) For OSC input/output, up to self OSC level is allowable.
(Note 3) Sink current
(Note 4) Source current (applicable only when the pull-up output type or CMOS output type is selected)
(Note 5) Reflow soldering is recommended for QFP packages.
Please consult your local representative for information on solder-bath immersion of the device.

(2) Allowable Operating Conditions at Ta=−30 to +70°C, V_{SS}=0V unless otherwise specified

Parameter	Symbol	Applicable Pins	Conditions		Limits			Unit	Note
				V_{DD}(V)	min	typ	max		
Operating Voltage	V_{DD}	V_{DD}			4.0	5.0	6.0	V	
Data Retention Voltage	V_{DD}(H)	V_{DD}	HOLD mode		1.8		6.0	V	
"H"-Level Input Voltage	V_{IH}(1)	P2,P3(except P33/$\overline{HOLD}$), P4,P5,P6	Output Nch Tr OFF	4.0to6.0	0.75V_{DD}		+13.5	V	1
	V_{IH}(2)	P33/$\overline{HOLD}$, $\overline{RES}$, OSC1	Output Nch Tr OFF	4.0to6.0	0.75V_{DD}		V_{DD}	V	2
	V_{IH}(3)	P0,P1,PC,PD,PE	Output Nch Tr OFF	4.0to6.0	0.7V_{DD}		V_{DD}	V	3
	V_{IH}(4)	PE	3-level input mode	4.0to6.0	0.8V_{DD}		V_{DD}	V	

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Parameter		Symbol	Applicable Pins	Conditions		Limits			Unit	Note
					V_{DD}(V)	min	typ	max		
"M"-Level Input Voltage		V_{IM}	PE	3-level input mode	4.0to6.0	0.4V_{DD}		0.6V_{DD}	V	
Common-Mode Input Voltage Range		V_{CMM}	PC2,PC3,PD	Comparator input mode	4.0to6.0	1.0		V_{DD}−1.5	V	
"L"-Level Input Voltage		V_{IL}(1)	P2,P3(except P33/$\overline{HOLD}$), P5,P6, $\overline{RES}$,OSC1	Output Nch Tr OFF	4.0to6.0	V_{SS}		0.25V_{DD}	V	2
		V_{IL}(2)	P33/$\overline{HOLD}$		1.8 to6.0	V_{SS}		0.25V_{DD}	V	
		V_{IL}(3)	P0, P1, P4, PC, PD, PE, TEST	Output Nch Tr OFF	4.0to6.0	V_{SS}		0.3V_{DD}	V	3
		V_{IL}(4)	PE	3-level input mode	4.0to6.0	V_{SS}		0.2V_{DD}	V	
Operating Frequency (Instruction Cycle Time)		f_{OP} (T_{CYC})			4.0to6.0	0.4 (10)		4.35 (0.92)	MHz (μs)	
External Clock Input Conditions	Frequency	f_{ext}	OSC1	See Fig. 1. The OSC1 is used for input and the OSC2 is left open. (OSC option: External clock input)	4.0to6.0	0.4		4.35	MHz	
	Pulse Width	textH textL		See Fig. 1. The OSC1 is used for input and the OSC2 is left open. (OSC option: External clock input)	4.0to6.0	70			ns	
	Rise/Fall Time	textR textF		See Fig. 1. The OSC1 is used for input and the OSC2 is left open. (OSC option: External clock input)	4.0to6.0			30	ns	
Self OSC Conditions	Ceramic Resonator OSC: OSC Frequency	f_{CF}	OSC1, OSC2	See Fig. 2. 4MHz	4.0to6.0		4.0		MHz	
	Ceramic Resonator OSC: OSC Stabilizing Period	tCFS		Fig. 3 4MHz	4.0to6.0			10	ms	
	External Constants for RC OSC	Cext Rext	OSC1, OSC2	See Fig. 4.	4.0to6.0		100 2.7		pF kΩ	

(Note 1) Applicable to pins of open drain type. For P33/$\overline{HOLD}$, V_{IH}(2) applies.
P2, P3, P6 of CMOS output type cannot be used as input pin.

(Note 2) Applicable to pins of open drain type.

(Note 3) When PE is used for 3-level input, V_{IH}(4), V_{IM}, V_{IL}(4) apply. PC of CMOS output type cannot be used as input pin.

(3) Electrical Characteristics at Ta=−30 to +70°C, V_{SS}=0V unless otherwise specified

Parameter	Symbol	Applicable Pins	Conditions		Limits			Unit	Note
				V_{DD}(V)	min	typ	max		
"H"-Level Input Current	I_{IH}(1)	P2,P3 (except P33/$\overline{HOLD}$), P4,P5,P6	V_{IN}=13.5V Output Nch Tr OFF	4.0to6.0			5.0	μA	1
	I_{IH}(2)	P0, P1, OSC1, $\overline{RES}$, P33/$\overline{HOLD}$	V_{IN}=V_{DD} Output Nch Tr OFF	4.0to6.0			1.0	μA	1
	I_{IH}(3)	PC2,PC3,PD,PE	V_{IN}=V_{DD} Output Nch Tr OFF	4.0to6.0			1.0	μA	1
"L"-Level Input Current	I_{IL}(1)	Inputs other than PC2,PC3,PD,PE	V_{IN}=V_{SS} Output Nch Tr OFF	4.0to6.0	−1.0			μA	2
	I_{IL}(2)	PC2, PC3, PD, PE	V_{IN}=V_{SS} Output Nch Tr OFF	4.0to6.0	−1.0			μA	2
"H"-Level Output Voltage	V_{OH}(1)	P2, P3 (except P33/$\overline{HOLD}$), P6, PC	I_{OH}=−1 mA	4.0to6.0	V_{DD}−1.0			V	3
			I_{OH}=−0.1mA	4.0to6.0	V_{DD}−0.5			V	3
	V_{OH}(2)	P0, P1, P4, P5	I_{OH}=−200μA	4.5	2.4			V	4
			I_{OH}=−130μA	4.5to5.5	V_{DD}−1.35			V	4
Output Pull-up Current	I_{PO}	P0, P1, P4, P5	V_{IN}=V_{SS}	6.0	−1.6			mA	4
"L"-Level Output Voltage	V_{OL}(1)	P0, P1, P2, P3, P4, P5, P6, PC (except P33/$\overline{HOLD}$)	I_{OL}=1.6mA	4.0to6.0			0.4	V	
	V_{OL}(2)	P0,P1,P2,P3,P4,P5, P6(except P33/$\overline{HOLD}$)	I_{OL}=10mA	4.0to6.0			1.5	V	
Output OFF-State Leakage Current	I_{OFF}(1)	P2,P3,P4,P5,P6	V_{IN}=13.5V	4.0to6.0			5.0	μA	5
	I_{OFF}(2)	P0, P1, PC	V_{IN}=V_{DD}	4.0to6.0			1.0	μA	5
Comparator Offset Voltage	V_{OFF}	PD	V_{IN}=1.0V to V_{DD}−1.5V	4.0to6.0		±50	±300	mV	
Schmitt Characteristics: Hysteresis Voltage	V_{HYS}	P2,P3,P5,P6,$\overline{RES}$, OSC1 (RC,EXT)		4.0to6.0		0.1V_{DD}		V	
Schmitt Characteristics: "H"-Level Threshold Voltage	Vt H				0.5V_{DD}		0.75V_{DD}	V	
Schmitt Characteristics: "L"-Level Threshold Voltage	Vt L				0.25V_{DD}		0.5V_{DD}	V	
RC OSC Frequency	fRC	OSC1, OSC2	See Fig. 4. C=100pF±5% R=2.7kΩ±1%	4.0to6.0	2.0	3.0	4.0	MHz	

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Parameter			Symbol	Applicable Pins		Conditions	Limits				Unit	Note
							VDD(V)	min	typ	max		
Serial Clock	Cycle Time	Input	tCKCY	SCK0, SCK1		Timing of Fig. 5 and timing load of Fig. 6.	4.0to6.0	0.9			μs	
		Output					4.0to6.0	2.0			TCYC	
	"L"/"H"-Level Pulse Width	Input	tCKL				4.0to6.0	0.4			μs	
		Output	tCKH				4.0to6.0	1.0			TCYC	
	Rise/Fall Time	Output	tCKR tCKF				4.0to6.0			0.1	μs	
Serial Input	Data Setup Time		tICK	SI0, SI1		Timing of Fig. 5, specified for SCK0, SCK1 rise (↑)	4.0to6.0	0.3			μs	
	Data Hold Time		tCKI				4.0to6.0	0.3			μs	
Serial Output	Output Delay Time		tCKO	SO0, SO1		Timing of Fig. 5 and timing load of Fig. 6, specified for SCK0, SCK1 fall (↓)	4.0to6.0			0.3	μs	
Pulse Input Conditions	"H"/"L"-Level Pulse Width at INT0		tI0H tI0L	INT0	Fig.7.	• Condition under which the INT0 interrupt is accepted • Condition under which the event counter/pulse width measure input by timer 0 is accepted	4.0to6.0	2			TCYC	
	Interrupt Input "H"/"L"-Level Pulse Width at Other than INT0		tI1H tI1L	INT1, INT2		• Condition under which each interrupt is accepted		2			TCYC	
	"H"/"L"-Level Pulse Width at PIN1		tPINH tPINL	PIN1		• Condition under which the event counter input by timer 1 is accepted		2			TCYC	
	"H"/"L"-Level Pulse Width at RES		tRSH tRSL	RES		• Condition under which a reset is caused		3			TCYC	
Comparator Response Time			TRS	PD	Fig.8.		4.0to6.0			30	μs	
Current Dissipation at Operating Mode			IDD OP	VDD		4MHz ceramic resonator OSC	4.0to6.0		4.5	8	mA	6
						4MHz external clock			6.5	11	mA	
						RC OSC			4.0	8	mA	

Continued on next page.

Continued from preceding page.

Parameter	Symbol	Applicable Pins	Conditions	VDD(V)	Limits min	Limits typ	Limits max	Unit	Note
Current Dissipation at HALT Mode	IDDHALT	VDD	4MHz ceramic resonator OSC	4.0to6.0		1.0	2.5	mA	
			4MHz external clock			2	3.5	mA	
			RC OSC			1.2	2.5	mA	
Current Dissipation at HOLD Mode	IDDHOLD	VDD		1.8to6.0		0.01	10	μA	

(Note 1) The input/output common ports are of open drain output type with output Nch transistor OFF. When the CMOS output type is selected, the input/output common ports cannot be used as the input pins.

(Note 2) The input/output common ports are of open drain output type with output Nch transistor OFF. The specification for pull-up output type is specified by output pull-up current IPO. When CMOS output type is selected, the input/output common ports cannot be used as the input pins.

(Note 3) CMOS output type and output Nch transistor OFF.

(Note 4) Pull-up output type and output Nch transistor OFF.

(Note 5) Open drain output type and output Nch transistor OFF.

(Note 6) Reset mode.

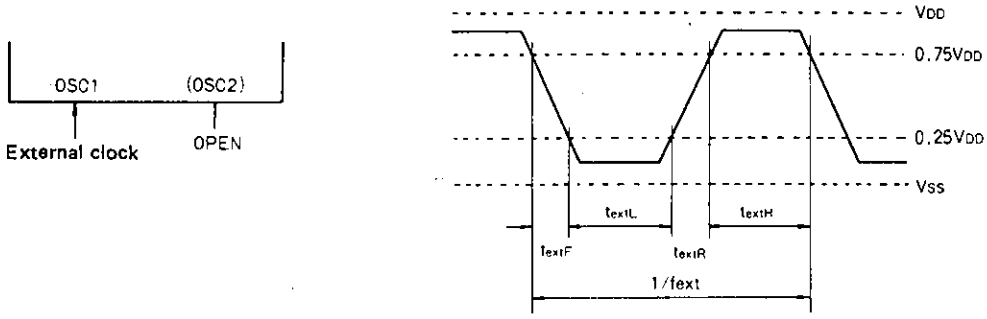


Fig. 1 External Clock Input Waveform

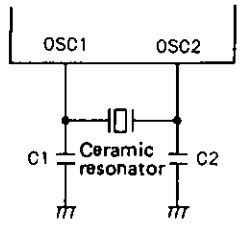


Fig. 2 Ceramic Resonator OSC Circuit

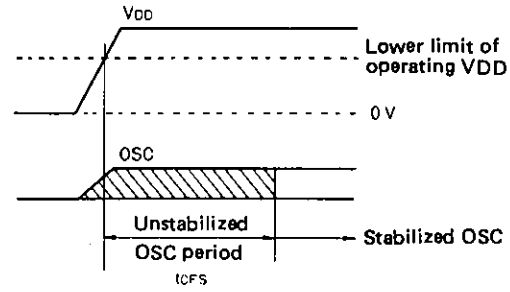


Fig. 3 OSC Stabilizing Period

External capacitor type	4 MHz (Murata) CSA4.00MG	C1	33pF±10%
		C2	33pF±10%
	4 MHz (Kyocera) KBR4.0MS	C1	33pF±10%
		C2	33pF±10%
On-chip capacitor type	4 MHz (Murata) CST4.00MG		
	4 MHz (kyocera) KBR-4.0MES		

Table 1 Ceramic Resonator OSC-Guaranteed Constants

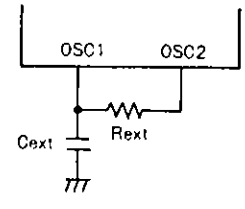


Fig. 4 RC OSC

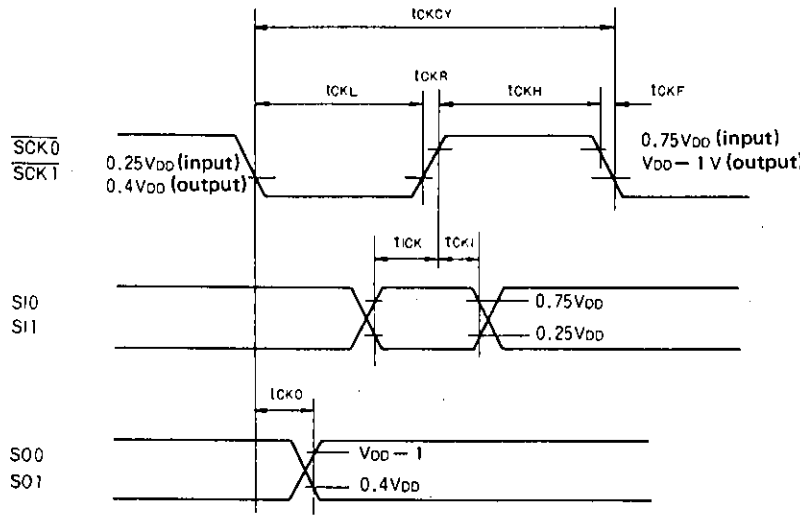


Fig. 5 Serial Input/Output Timing

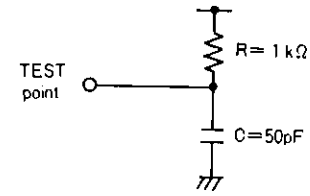


Fig. 6 Timing Load

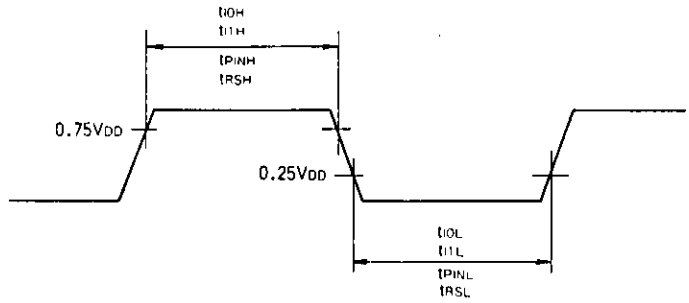


Fig. 7 INT0, $\overline{\text{INT1}}$, $\overline{\text{INT2}}$, PIN1, $\overline{\text{RES}}$ Input Timing

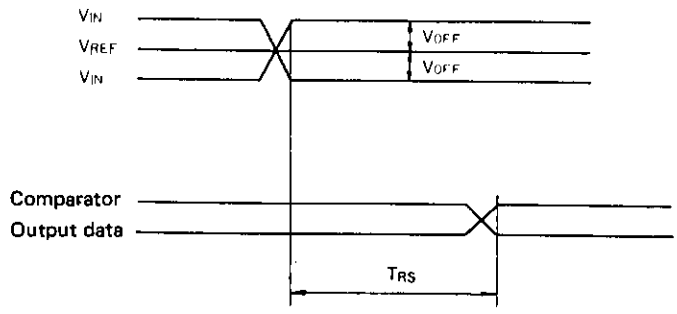


Fig. 8 Timing of Comparator Response Time T_{RS}

RC OSC Characteristic of the LC66304A, 66306A, 66308A

Fig. 9 shows the RC OSC characteristic of the LC66304A, 66306A, 66308A. For the variation range of RC OSC frequency of the LC66304A, 66306A, 66308A, the following are guaranteed at the external constants only shown below.

External constants Cext=100pF, Rext=2.7kΩ

2.0MHz≦f_{RC}≦4.0MHz (Ta=−30°C to +70°C, V_{DD}=4.0 to 6.0V)

If any other constants than specified above are used, the range of Rext=T.B.DkΩ to T.B.DkΩ, Cext=T.B.DpF to T.B.DpF must be observed. (See Fig. 9.)

(Note 10) The OSC frequency at V_{DD}=4.0 to 6.0V, Ta=−30 to +70°C must be within the operation clock frequency range (0.4 to 4.3MHz).

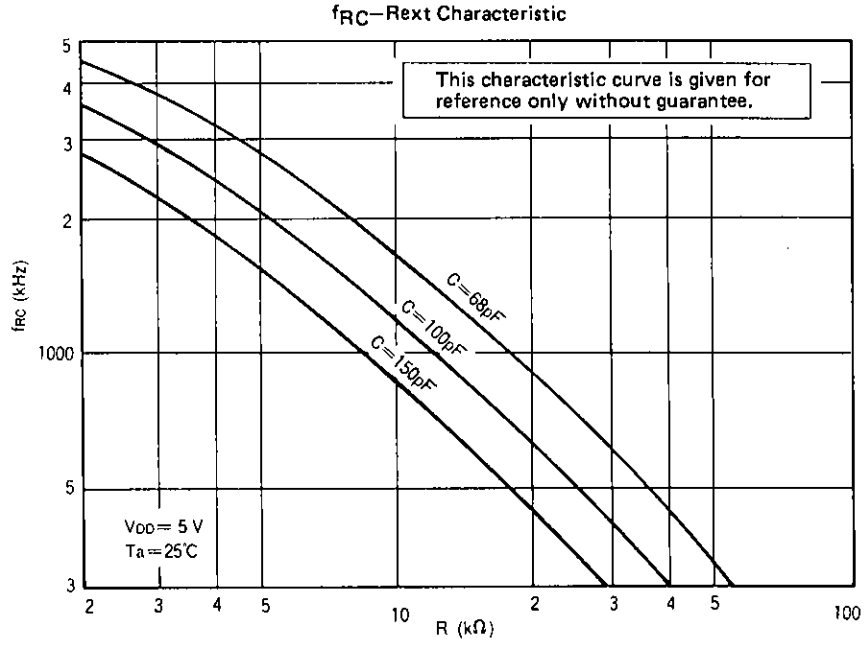
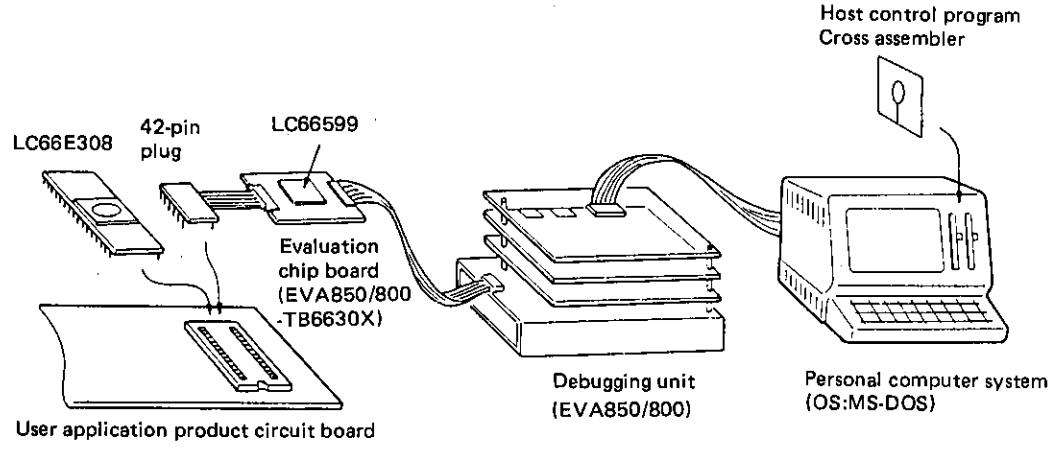


Fig. 9 RC OSC Frequency Data (Typ.)

Application Development Tools

The programs for the LC66304A, 66306A, 66308A microcomputers can be developed on the MS-DOS personal computer system (IBM-PC model system). Cross assembler for this system is provided. To help the user develop programs for the LC66304A, 66306A, 66308A microcomputers, the following development tools are prepared:



Appearance of Application Development Tools

(1) Program debugging unit (EVA850/800)

The program debugging unit (EVA850/800) is an emulator that includes the EPROM WRITE function and the serial data communications interface function between the unit itself and external systems (host computer, etc.). Application programs can be developed, corrected, and debugged at the machine language level. The debugging function can be carried out through break, step and trace operations. (Use the MPM6630X as the monitor ROM on the EVA850/800 debugging unit.)

(2) Evaluation chip board (EVA850/800-TB6630X)

The evaluation chip board sends control signals to the user application board through the 42-pin connector. Data is transferred between the I/O ports on the evaluation chip board and the user application board through the 42-pin connector. If the LC66599 evaluation chip is connected to the 42-pin plug by the output cable, the data from the LC66599 microcomputer is converted into the LC66304A, 66306A, 66308A-bound data by the plug. There are jumper connectors on the evaluation chip board. They are used to select options and status levels. Therefore, using these jumper connectors, the same input/output formats and functions as those of the LC66304A, 66306A, 66308A microcomputers can be selected on the evaluation chip board.

Jumpers

Type	OSC		Reset type selection		Power supply to the user application board through the evaluation chip board	
Jumper name	Jumper 1 (J1)		Jumper 2 (J2)		Jumper 3 (J3)	
Jumper setting and mode	EXT	External clock	INT	Reset by the RUN instruction from the host computer.	ON	VDD supply to the user application board through the evaluation chip board output.
	RC	RC OSC				
	CF	CF OSC	EXT	Reset by the reset circuit on the user application board	OFF	Power supply to the user application board from an independent power source (from the evaluation chip board)

Switch 9 (SW9)

Type	Output level selection for ports 0,1 at the reset				Watchdog timer function selection	
Switch name	P0HL		P1HL		WDC	
Switch setting and mode	+5V	Port 0 "H"	+5V	Port 1 "H"	+5V	Watchdog timer function selected
	GND	Port 0 "L"	GND	Port 0 "L"	GND	Watchdog timer function not selected

Switches SW1 to SW8: Pull-up resistor option select

① Set to ON when on-chip pull-up resistor is used. Set to OPEN when open drain output type is selected.

② Selectable for each pin.

(3) Cross assembler

Cross assembler name (File name)	Target machine	Restriction on program development
LC663S.EXE	LC66304A, 66306A, 66308A(LC66E308/P308) (LC66599)	Restriction on SB instruction • LC66304A : SB 0 only usable • LC66306A/308A : SB 0, SB 1 usable (LC66E308/P308) • (LC66599) : SB 0, SB 1, SB 2, SB 3 usable

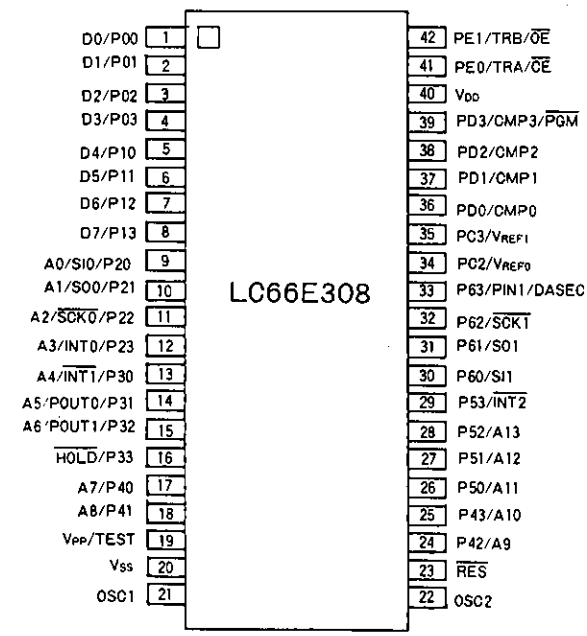
(4) Simulation chip (For details, refer to the catalog of the LC66E308.)
The simulation chip (LC66E308) is an EPROM-contained microcomputer. Using the dedicated conversion board (W66EP308D), you can write programs in the EPROM with a commercially available PROM writer. Then, you can incorporate the simulation chip into an application product to monitor actual operations.

① Case outline
The LC66E308 is the same as the LC66304A, 66306A, 66308A in pin assignment and functions. The pin assignment is shown below.

② Option
Using the on-chip EPROM data (option data area and definition are shown on the next page), you can specify the options (level at port 0, 1 reset mode, watchdog timer, port output configuration) of a microcomputer to be evaluated. Thus, you can perform evaluation using the same peripheral as the board of the equipment to be mass-produced.

Pin Assignment

DIC42S with window



Option Data Area and Definition

ROM Area	Bit	Option		Relation between Option and Data
2000H	7 6 5	Unused		Fixed at 0
	4	OSC option		1=Ceramic resonator OSC 0=RC OSC, external clock
	3	Unused		Fixed at 0
	2	P1	Level at reset mode	1="H" level 0="L" level
	1	P0		
	0	Watchdog timer option		1=Available, 0=Unavailable
2001H	7	P13	Output configuration	1=PU, 0=OD
	6	P12		
	5	P11		
	4	P10		
	3	P03	Output configuration	1=PU, 0=OD
	2	P02		
	1	P01		
	0	P00		
2002H	7	Unused		Fixed at 0
	6	P32	Output configuration	1=PU, 0=OD
	5	P31		
	4	P30		
	3	P23	Output configuration	1=PU, 0=OD
	2	P22		
	1	P21		
	0	P20		
2003H	7	P53	Output configuration	1=PU, 0=OD
	6	P52		
	5	P51		
	4	P50		
	3	P43	Output configuration	1=PU, 0=OD
	2	P42		
	1	P41		
	0	P40		
2004H	7～4	Unused		
	3	P63	Output configuration	1=PU, 0=OD
	2	P62		
	1	P61		
	0	P60		
2005H	7～0	Unused		Fixed at 0
2006H	7～0	Unused		Fixed at 0
2007H	7～4	Unused		Fixed at 0
	3	PC3	Output configuration	1=PU, 0=OD
	2	PC2		
	1 0	Unused		Fixed at 0

LC6630X SERIES INSTRUCTION SET (BY FUNCTION)

Symbol	Description
AC	: Accumulator
E	: E register
CF	: Carry flag
ZF	: Zero flag
HL	: Data pointer DPH, DPL
XY	: Data pointer DPX, DPY
M	: Data memory
M (HL)	: Data memory contents specified by data pointer DPH, DPL
M (XY)	: Data memory contents specified by supplementary data pointer DPX, DPY
M2 (HL)	: 2-word data memory contents specified by data pointer DPH, DPL. In this case, the accessed data memory area address must be multiples of 2 (even address).
SP	: Stack pointer
M2 (SP)	: 2-word data memory contents specified by stack pointer
M4 (SP)	: 4-word data memory contents specified by stack pointer
in	: n-bit immediate data
t2	: Bit specification

t2	11	10	01	00
Bit	2^3	2^2	2^1	2^0

PCh	: Bits 8 to 11 of PC
PCm	: Bits 4 to 7 of PC
PCl	: Bits 0 to 3 of PC
Fn	: User's flag n=0 to 15
TIMER0	: Timer 0
TIMER1	: Timer 1
SIO	: Serial register
P	: Port
P (i4)	: Port contents specified by 4-bit immediate data
INT	: Interrupt enable flag
( ),[ ]	: Contents
←	: Transfer direction and operation result
∀	: Exclusive logical sum
∧	: Logical product
∨	: Logical sum
+	: Addition
−	: Subtraction
¯	: 1's complement

Instruction type	Mnemonics		Instruction code $D_7D_6D_5D_4$	Instruction code $D_3D_2D_1D_0$	Bytes	Cycles	Function	Description	Status flags affected	Remarks
Accumulator manipulation instructions	CLA	Clear AC	1 0 0 0	0 0 0 0	1	1	AC←0 (Equivalent to LAI 0)	Clears AC.	ZF	Only the first instruction is effective if executed continuously (skip function).
	DAA	Decimal adjust AC in addition	1 1 0 0 0 0 1 0	1 1 1 1 0 1 1 0	2	2	AC←(AC)+6 (Equivalent to ADI 6)	Adds 6 to AC.	ZF	
	DAS	Decimal adjust AC in subtraction	1 1 0 0 0 0 1 0	1 1 1 1 1 0 1 0	2	2	AC←(AC)+10 (Equivalent to ADI 0AH)	Adds 10 to AC.	ZF	
	CLC	Clear CF	0 0 0 1	1 1 1 0	1	1	CF←0	Clears CF.	CF	
	STC	Set CF	0 0 0 1	1 1 1 1	1	1	CF←1	Sets CF.	CF	
	CMA	Complement AC	0 0 0 1	1 0 0 0	1	1	AC←$\overline{(AC)}$	Gives 1's complement of (invert) AC.	ZF	
	IA	Increment AC	0 0 0 1	0 1 0 0	1	1	AC←(AC)+1	Adds 1 to AC.	ZF, CF	
	DA	Decrement AC	0 0 1 0	0 1 0 0	1	1	AC←(AC)−1	Subtracts 1 from AC.	ZF, CF	
	RAR	Rotate AC right through CF	0 0 0 1	0 0 0 0	1	1	AC_3←(CF), ACn←(ACn+1), CF←(AC_0)	Rotates AC right through CF.	CF	
	RAL	Rotate AC left through CF	0 0 0 0	0 0 0 1	1	1	AC_0←(CF), ACn+1←(ACn), CF←(AC_3)	Rotates AC left through CF.	CF, ZF	
	TAE	Transfer AC to E	0 1 0 0	0 1 0 1	1	1	E←(AC)	Transfers the AC contents to the E register.		
	TEA	Transfer E to AC	0 1 0 0	0 1 1 0	1	1	AC←(E)	Transfers the E register contents to AC.	ZF	
	XAE	Exchange AC with E	0 1 0 0	0 1 0 0	1	1	(AC)↔(E)	Exchanges the contents of the AC and E register.		
Memory manipulation instructions	IM	Increment M	0 0 0 1	0 0 1 0	1	1	M(HL)←(M(HL))+1	Adds 1 to M(HL).	ZF, CF	
	DM	Decrement M	0 0 1 0	0 0 1 0	1	1	M(HL)←(M(HL))−1	Subtracts 1 from M(HL).	ZF, CF	
	IMDR i8	Increment M direct	1 1 0 0 I_7 I_6 I_5 I_4	0 1 1 1 I_3 I_2 I_1 I_0	2	2	M(i8)←(M(i8))+1	Adds 1 to M(i8).	ZF, CF	
	DMDR i8	Decrement M direct	1 1 0 0 I_7 I_6 I_5 I_4	0 0 1 1 I_3 I_2 I_1 I_0	2	2	M(i8)←(M(i8))−1	Subtracts 1 from M(i8).	ZF, CF	
	SMB t2	Set M data bit	0 0 0 0	1 1 t_1 t_0	1	1	(M(HL), t2)←1	Sets a bit specified by t1,t0 of M(HL).		
	RMB t2	Reset M data bit	0 0 1 0	1 1 t_1 t_0	1	1	(M(HL), t2)←0	Resets a bit specified by t1,t0 of M(HL).	ZF	
Operation/Comparison instructions	AD	Add M to AC	0 0 0 0	0 1 1 0	1	1	AC←(AC)+(M(HL))	Adds together the contents of AC and M(HL) in binary and stores the result in AC.	ZF, CF	
	ADDR i8	Add M direct to AC	1 1 0 0 I_7 I_6 I_5 I_4	1 0 0 1 I_3 I_2 I_1 I_0	2	2	AC←(AC)+(M(i8))	Adds together the contents of AC and M(i8) in binary and stores the result in AC.	ZF, CF	
	ADC	Add M to AC with CF	0 0 0 0	0 0 1 0	1	1	AC←(AC)+(M(HL))+(CF)	Adds together the contents of AC, M(HL), and CF in binary and stores the result in AC.	ZF, CF	
	ADI i4	Add immediate data to AC	1 1 0 0 0 0 1 0	1 1 1 1 I_3 I_2 I_1 I_0	2	2	AC←(AC)+I_3,I_2,I_1,I_0	Adds together the contents of AC and immediate data in binary and stores the result in AC.	ZF	
	SUBC	Subtract AC from M with CF	0 0 0 1	0 1 1 1	1	1	AC←(M(HL))−(AC)−$\overline{(CF)}$	Subtracts the contents of AC from M(HL) with CF in binary and stores the result in AC.	ZF, CF	CF=0 if there is a borrow while CF=1 if there is no borrow.
	ANDA	AND M with AC then store AC	0 0 0 0	0 1 1 1	1	1	AC←(AC)∧(M(HL))	Performs a logical AND operation between AC and M(HL) and stores the result in AC.	ZF	
	ORA	OR M with AC then store AC	0 0 0 0	0 1 0 1	1	1	AC←(AC)∨(M(HL))	Performs a logical OR operation between AC and M(HL) and stores the result in AC.	ZF	
	EXL	Exclusive OR M with AC then store AC	0 0 0 1	0 1 0 1	1	1	AC←(AC)∀(M(HL))	Performs a logical exclusive OR operation between AC and M(HL) and stores the result in AC.	ZF	
	ANDM	AND M with AC then store M	0 0 0 0	0 0 1 1	1	1	M(HL)←(AC)∧(M(HL))	Performs a logical AND operation between AC and M(HL) and stores the result in M(HL).	ZF	
	ORM	OR M with AC then store M	0 0 0 0	0 1 0 0	1	1	M(HL)←(AC)∨(M(HL))	Performs a logical OR operation between AC and M(HL) and stores the results in M(HL).	ZF	

Instruction type	Mnemonics		Instruction code $D_7D_6D_5D_4$	Instruction code $D_3D_2D_1D_0$	Bytes	Cycles	Function	Description	Status flags affected	Remarks
Operation/Comparison instructions	CM	Compare AC with M	0 0 0 1	0 1 1 0	1	1	$\overline{(M,HL)}) + (AC) + 1$	Compares the contents of AC and M(HL) and then sets/resets the carry flag (CF) and zero flag (ZF). Comparison relations: (M(HL))>(AC) CF=0 ZF=0; (M(HL))=(AC) CF=1 ZF=1; (M(HL))<(AC) CF=1 ZF=0	ZF, CF	
	CI i4	Compare AC with immediate data	1 1 0 0 1 0 1 0	1 1 1 1 $I_3 I_2 I_1 I_0$	2	2	$\overline{I_3 I_2 I_1 I_0} + (AC) + 1$	Compares the contents of the accumulator (AC) and immediate data I3I2I1I0 and sets/resets the zero flag (ZF) and carry flag (CF). Comparison relations: $I_3 I_2 I_1 I_0$>AC CF=0 ZF=0; $I_3 I_2 I_1 I_0$=AC CF=1 ZF=1; $I_3 I_2 I_1 I_0$<AC CF=1 ZF=0	ZF, CF	

	CLI i4	Compare DP_L with immediate data	1 1 0 0
			1 0 1 1
				1 1 1 1
				$I_3 I_2 I_1 I_0$
					2	2	ZF←1
							if(DP_L) = $I_3 I_2 I_1 I_0$
							ZF←0
							if(DP_L) ≠ $I_3 I_2 I_1 I_0$
								Compares the contents of DP_L and immediate data and sets the zero flag (ZF) if they are equal, or resets the flag if not equal.	ZF	

	CMB t2	Compare AC bit with M data bit	1 1 0 0
			1 1 0 1
				1 1 1 1
				0 0 t_1 t_0
					2	2	ZF←1
							if(AC, t2) = (M(HL), t2)
							ZF←0
							if(AC, t2) ≠ (M(HL), t2)
								Compares the contents of AC and M(HL) bit specified by the 2 bits (t1 and t2) of the instruction and sets the zero flag (ZF) if they are equal, or resets the flag if not equal.	ZF	

Load/store instructions	LAE	Load AC and E from M2 (HL)	0 1 0 1	1 1 0 0	1	1	AC←M(HL) E←M(HL+1)	Loads the contents of M2(HL) into the AC and the E register.		
	LAI i4	Load AC with immediate data	1 0 0 0	$I_3 I_2 I_1 I_0$	1	1	AC←$I_3 I_2 I_1 I_0$	Loads immediate data into AC.	ZF	Only the first instruction is effective if executed continuously (skip function).
	LADR i8	Load AC from M direct	1 1 0 0 $I_7 I_6 I_5 I_4$	0 0 0 1 $I_3 I_2 I_1 I_0$	2	2	AC←(M(i8))	Loads the contents of M(i8) into AC.	ZF	
	S	Store AC to M	0 1 0 0	0 1 1 1	1	1	M(HL)←(AC)	Stores the contents of AC into M(HL).		
	SAE	Store AC and E to M2 (HL)	0 1 0 1	1 1 1 0	1	1	M(HL)←(AC) M(HL+1)←(E)	Stores the contents of AC and the E register into M2(HL).		
	LA reg	Load AC from M(reg)	0 1 0 0	1 0 t_0 0	1	1	AC←(M(reg))	Loads the contents of M(reg) into AC. reg is either an HL or XY. reg: HL t0=0; XY t0=1	ZF	
	LA reg,I	Load AC from M(reg) then increment reg	0 1 0 0	1 0 t_0 1	1	2	AC←(M(reg)) DP_L←(DP_L)+1 or DP_Y←(DP_Y)+1	Loads the contents of M(reg) into the accumulator (AC). reg is either an HL or XY. After loading, increments the contents of DP_L or DPY. Refer to the LA reg instruction for the relationship between reg and t0.	ZF	ZF status depends on DPLorDPY increment result.
	LA reg, D	Load AC from M(reg) then decrement reg	0 1 0 1	1 0 t_0 1	1	2	AC←(M(reg)) DP_L←(DP_L)−1 or DP_Y←(DP_Y)−1	Loads the contents of M(reg) into AC. reg is either an HL or XY. After loading, decrements the contents of DP_L or DPY. Refer to the LA reg instruction for the relationship between reg and t0.	ZF	ZF status depends on DPLorDPY decrement result.
	XA reg	Exchange AC with M (reg)	0 1 0 0	1 1 t_0 0	1	1	(AC)↔(M(reg))	Exchanges the contents of AC and M(reg). reg is either an HL or XY. reg: HL t0=0; XY t0=1		
	XA reg,I	Exchange AC with M (reg) then increment reg	0 1 0 0	1 1 t_0 1	1	2	(AC)↔(M(reg)) DP_L←(DP_L)+1 or DP_Y←(DP_Y)+1	Exchanges the contents of AC and M(reg). reg is either an HL or XY. After exchanging, increments the contents of DP_L or DPY. Refer to the XA reg instruction for the relationship between reg and t0.	ZF	ZF status depends on DPLorDPY increment result.
	XA reg, D	Exchange AC with M (reg) then decrement reg	0 1 0 1	1 1 t_0 1	1	2	(AC)↔(M(reg)) DP_L←(DP_L)−1 or DP_Y←(DP_Y)−1	Exchanges the contents of AC and M(reg). reg is either an HL or XY. After exchanging, decrements the contents of DP_L or DPY. Refer to the XA reg instruction for the relationship between reg and t0.	ZF	ZF status depends on DPLorDPY decrement result.
	XADR i8	Exchange AC with M direct	1 1 0 0 $I_7 I_6 I_5 I_4$	1 0 0 0 $I_3 I_2 I_1 I_0$	2	2	(AC)↔(M(i8))	Exchanges the contents of AC and M(i8).		

Instruction type	Mnemonics		Instruction code $D_7D_6D_5D_4$	Instruction code $D_3D_2D_1D_0$	Bytes	Cycles	Function	Description	Status flags affected	Remarks
Load/store instructions	LEAI i8	Load E & AC with immediate data	1 1 0 0 I_7 I_6 I_5 I_4	0 1 1 0 I_3 I_2 I_1 I_0	2	2	E ← I_7 I_6 I_5 I_4 AC ← I_3 I_2 I_1 I_0	Loads immediate data i8 into the E register and the accumulator (AC).		
	RTBL	Read table data from program ROM	0 1 0 1	1 0 1 0	1	2	E, AC ← (ROM(PCh, E, AC))	First, replace the contents of lower 8 bits of PC with the E register and AC contents. Then, loads the ROM data at an address specified by the new contents of the lower 8 bits of PC into the E register and AC.		
	RTBLP	Read table data from program ROM then output to P4, 5	0 1 0 1	1 0 0 0	1	2	Port 4, 5 ← (ROM(PCh, E, AC))	First, replaces the contents of lower 8 bits of AC with the E register and AC contents. Then, outputs the ROM data at an address specified by the new contents of the lower 8 bits of PC to ports 4 and 5.		
Data pointer manipulation instructions	LDZ i4	Load DP_H with zero and DP_L with immediate data respectively	0 1 1 0	I_3 I_2 I_1 I_0	1	1	DP_H ← 0 DP_L ← I_3 I_2 I_1 I_0	Loads the data of 0 (zero) and immediate data i4 into the DP_H and DP_L respecitively.		
	LHI i4	Load DP_H with immediate data	1 1 0 0 0 0 0 0	1 1 1 1 I_3 I_2 I_1 I_0	2	2	DP_H ← I_3 I_2 I_1 I_0	Loads immediate data i4 into the DP_H.		
	LLI i4	Load DP_L with immediate data	1 1 0 0 0 0 0 1	1 1 1 1 I_3 I_2 I_1 I_0	2	2	DP_L ← I_3 I_2 I_1 I_0	Loads immediate data i4 into the DP_L.		
	LHLI i8	Load DP_H, DP_L with immediate data	1 1 0 0 I_7 I_6 I_5 I_4	0 0 0 0 I_3 I_2 I_1 I_0	2	2	DP_H ← I_7 I_6 I_5 I_4 DP_L ← I_3 I_2 I_1 I_0	Loads immediate data into the DP_H and DP_L.		
	LXYI i8	Load DP_X, DP_Y with immediate data	1 1 0 0 I_7 I_6 I_5 I_4	0 0 1 0 I_3 I_2 I_1 I_0	2	2	DP_X ← I_7 I_6 I_5 I_4 DP_Y ← I_3 I_2 I_1 I_0	Loads immediate data into the DPX and DPY.		
	IL	Increment DP_L	0 0 0 1	0 0 0 1	1	1	DP_L ← (DP_L) + 1	Increments the contents of the DP_L by 1.	ZF	
	DL	Decrement DP_L	0 0 1 0	0 0 0 1	1	1	DP_L ← (DP_L) − 1	Decrements the contents of the DP_L by 1.	ZF	
	IY	Increment DP_Y	0 0 0 1	0 0 1 1	1	1	DP_Y ← (DP_Y) + 1	Increments the contents of the DPY by 1.	ZF	
	DY	Decrement DP_Y	0 0 1 0	0 0 1 1	1	1	DP_Y ← (DP_Y) − 1	Decrements the contents of the DPY by 1.	ZF	
	TAH	Transfer AC to DP_H	1 1 0 0 1 1 1 1	1 1 1 1 0 0 0 0	2	2	DP_H ← (AC)	Transfers the contents of the accumulator (AC) to the DP_H.		
	THA	Transfer DP_H to AC	1 1 0 0 1 1 1 0	1 1 1 1 0 0 0 0	2	2	AC ← (DP_H)	Transfers the contents of the DP_H to the AC.	ZF	
	XAH	Exchange AC with DP_H	0 1 0 0	0 0 0 0	1	1	(AC) ↔ (DP_H)	Exchanges the contents of the accumulator (AC) and the DP_H.		
	TAL	Transfer AC to DP_L	1 1 0 0 1 1 1 1	1 1 1 1 0 0 0 1	2	2	DP_L ← (AC)	Transfers the contents of the accumulator (AC) to the DP_L.		
	TLA	Transfer DP_L to AC	1 1 0 0 1 1 1 0	1 1 1 1 0 0 0 1	2	2	AC ← (DP_L)	Transfers the contents of the DP_L to the accumulator (AC).	ZF	
	XAL	Exchange AC with DP_L	0 1 0 0	0 0 0 1	1	1	(AC) ↔ (DP_L)	Exchanges the contents of the AC and DP_L.		
	TAX	Transfer AC to DP_X	1 1 0 0 1 1 1 1	1 1 1 1 0 0 1 0	2	2	DP_X ← (AC)	Transfers the contents of the accumulator (AC) to the DPX.		
	TXA	Transfer DP_X to AC	1 1 0 0 1 1 1 0	1 1 1 1 0 0 1 0	2	2	AC ← (DP_X)	Transfers the contents of DPX to the AC.	ZF	
	XAX	Exchange AC with DP_X	0 1 0 0	0 0 1 0	1	1	(AC) ↔ (DP_X)	Exchanges the contents of the AC and DPX.		
	TAY	Transfer AC to DP_Y	1 1 0 0 1 1 1 1	1 1 1 1 0 0 1 1	2	2	DP_Y ← (AC)	Transfers the contents of the accumulator (AC) to the DPY.		
	TYA	Transfer DP_Y to AC	1 1 0 0 1 1 1 0	1 1 1 1 0 0 1 1	2	2	AC ← (DP_Y)	Transfers the contents of the DPY to the AC.	ZF	
	XAY	Exchange AC with DP_Y	0 1 0 0	0 0 1 1	1	1	(AC) ↔ (DP_Y)	Exchanges the contents of the accumulator (AC) and the DPY.		
Flag manipulation instructions	SFB n4	Set flag bit	0 1 1 1	$n_3n_2n_1n_0$	1	1	Fn ← 1	Sets a flag specified by n4.		
	RFB n4	Reset flag bit	0 0 1 1	$n_3n_2n_1n_0$	1	1	Fn ← 0	Resets a flag specified by n4.	ZF	
Jump/subroutine instructions	JMP addr	Jump in the current bank	1 1 1 0 P_7 P_6 P_5 P_4	P_{11} P_{10} P_9 P_8 P_3 P_2 P_1 P_0	2	2	PC12 ← PC12 PC11~0 ← P_{11} ~ P_0	Jumps to an address specified by immediate data P_{11} ~ P_0 in the current bank.		When executed immediately after the BANK instruction, PC12 ← (PC12)
	JPEA	Jump to the address stored at E and AC in the current page	0 0 1 0	0 1 1 1	1	1	PC12 ~ PC8 ← PC12 ~ PC8 PC7 ~ 4 ← (E) PC3 ~ 0 ← (AC)	Jumps to an address specified by the contents of the E register and accumulator (AC) which have replaced the contents of lower 8 bits of the program counter (PC).		

Instruction type	Mnemonics		Instruction code $D_7D_6D_5D_4$	Instruction code $D_3D_2D_1D_0$	Bytes	Cycles	Function	Description	Status flags affected	Remarks
Jump/subroutine instructions	CAL addr	Call subroutine	0 1 0 1 $P_7P_6P_5P_4$	0 $P_{10}P_9P_8$ $P_3P_2P_1P_0$	2	2	PC12-11←0 PC10~0←P_{10}~P_0 M4(SP)←(CF, ZF, PC13~0) SP←(SP)-4	Calls a subroutine.		
	CZP addr	Call sudroutine in the zero page	1 0 1 0	$P_3P_2P_1P_0$	1	2	PC12~6, PC1~0←0 PC5~2←P_3~P_0 M4(SP)←(CF, ZF, PC13~0) SP←SP-4	Calls a subroutine in page 0 of bank 0.		
	BANK	Change bank	0 0 0 1	1 0 1 1	1	1		Changes memory banks and register banks.		
	PUSH reg	Push reg on M2(SP)	1 1 0 0 1 1 1 1	1 1 1 1 1 i_1 i_0 0	2	2	M2(SP)←(reg) SP←(SP)-2	Stores the contents of reg into the M2(SP) and then subtracts 2 from the stack pointer (SP). reg: HL (i_1 i_0 = 0 0); XY (0 1); AE (1 0); Inhibited (1 1)		
	POP reg	Pop reg off M2(SP)	1 1 0 0 1 1 1 0	1 1 1 1 1 i_1 i_0 0	2	2	SP←(SP)+2 reg←(M2(SP))	Stores the contents of reg into the M2(SP) and then increments the contents of the stack pointer (SP) by 2 and loads the contents of M2 (SP) into a reg. Refer to the PUSH reg instruction for the relationship between I1I0 and reg.		
	RT	Return from subroutine	0 0 0 1	1 1 0 0	1	2	SP←(SP)+4 PC←(M4(SP))	Returns execution from a subroutine or interrupt processing routine back to the routine that called it. The contents of the carry flag (CF) and zero flag (ZF) are not returned from the stack area.		
	RTI	Return from interrupt routine	0 0 0 1	1 1 0 1	1	2	SP←(SP)+4 PC←(M4(SP)) CF, ZF←(M4(SP))	Returns execution from a subroutine or interrupt processing routine back to the routine that called it. The contents of the carry flag (CF) and zero flag (ZF) are returned from the stack area.	ZF, CF	
Branch instructions	BAt2 addr	Branch on AC bit	1 1 0 1 $P_7P_6P_5P_4$	0 0 t_1 t_0 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(AC, t2)=1	Transfers execution to an address specified by the contents of P7 to P0 in the current page if a bit specified by immediate data t1t0 of AC is 1 (program branch).		
	BNAt2 addr	Branch on no AC bit	1 0 0 1 $P_7P_6P_5P_4$	0 0 t_1 t_0 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(AC, t2)=0	Transfers execution to an address specified by the contents of P7 to P0 in the current page if a bit specified by immediate data t1t0 of AC is 0 (program branch).		
	BMt2 addr	Branch on M bit	1 1 0 1 $P_7P_6P_5P_4$	0 1 t_1 t_0 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(M(HL), t2)=1	Transfers execution to an address specified by the contents of P7 to P0 in the current page if a bit specified by immediate data t1t0 of M(HL) is 1 (program branch).		
	BNMt2 addr	Branch on no M bit	1 0 0 1 $P_7P_6P_5P_4$	0 1 t_1 t_0 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(M(HL), t2)=0	Transfers execution to an address specified by the contents of P7 to P0 in the current page if a bit specified by immediate data t1t0 of M(HL) is 0 (program branch).		
	BPt2 addr	Branch on Port bit	1 1 0 1 $P_7P_6P_5P_4$	1 0 t_1 t_0 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(P(DP_L), t2)=1	Transfers execution to an address specified by the contents of P7 to P0 in the current page if a bit specified by immediate data t1t0 of the port accessed by DP_L is 1 (program branch).		Used to manipulate internal control registers if executed immediately after the BANK instruction. In this case, the internal control registers must be readable.
	BNPt2 addr	Branch on no Port bit	1 0 0 1 $P_7P_6P_5P_4$	1 0 t_1 t_0 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(P(DP_L), t2)=0	Transfers execution to an address specified by the contents of P7 to P0 in the current page if a bit specified by immediate data t1t0 of the port accessed by DP_L is 0 (program branch).		Same as above.
	BC addr	Branch on CF	1 1 0 1 $P_7P_6P_5P_4$	1 1 0 0 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(CF)=1	Transfers execution to an address specified by the contents of P7 to P0 in the current page if the content of the carry flag (CF) is 1 (program branch).		
	BNC addr	Branch on no CF	1 0 0 1 $P_7P_6P_5P_4$	1 1 0 0 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(CF)=0	Transfers execution to an address specified by the contents of P7 to P0 in the current page if the content of the carry flag (CF) is 0 (program branch).		
	BZ addr	Branch on ZF	1 1 0 1 $P_7P_6P_5P_4$	1 1 0 1 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(ZF)=1	Transfers execution to an address specified by the contents of P7 to P0 in the current page if the content of the zero flag (ZF) is 1 (program branch).		
	BNZ addr	Branch on no ZF	1 0 0 1 $P_7P_6P_5P_4$	1 1 0 1 $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(ZF)=0	Transfers execution to an address specified by the contents of P7 to P0 in the current page if the content of the zero flag (ZF) is 0 (program branch).		

Instruction type	Mnemonics		Instruction code $D_7D_6D_5D_4$	Instruction code $D_3D_2D_1D_0$	Bytes	Cycles	Function	Description	Status flags affected	Remarks
Branch instructions	BFn4 addr	Branch on flag bit	1 1 1 1 $P_7P_6P_5P_4$	$n_3n_2n_1n_0$ $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(Fn)=1	Transfers execution to an address specified by the contents of P7 to P0 in the current page if the content of the flag specified by n3n2n1n0 is 1. The flag is one of the 16 flags.		
	BNFn4 addr	Branch on no flag bit	1 0 1 1 $P_7P_6P_5P_4$	$n_3n_2n_1n_0$ $P_3P_2P_1P_0$	2	2	PC7~0←$P_7P_6P_5P_4$ $P_3P_2P_1P_0$ if(Fn)=0	Transfers execution to an address specified by the contents of P7 to P0 in the current page if the content of the flag specified by n3n2n1n0 is 0. The flag is one of the 16 flags.		
Input/output instructions	IP0	Input port 0 to AC	0 0 1 0	0 0 0 0	1	1	AC←(P0)	Inputs the contents of port 0 to the accumulator (AC).	ZF	
	IP	Input port to AC	0 0 1 0	0 1 1 0	1	1	AC←(P(DP_L))	Inputs the contents of port accessed by DP_L to the accumulator (AC).	ZF	
	IPM	Input port to M	0 0 0 1	1 0 0 1	1	1	M(HL)←(P(DP_L))	Inputs the contents of port accessed by DP_L to the M(HL).		
	IPDR i4	Input port to AC direct	1 1 0 0 0 1 1 0	1 1 1 1 I_3 I_2 I_1 I_0	2	2	AC←(P(i4))	Inputs the contents of port accessed by i4 to the accumulator (AC).	ZF	
	IP45	Input port 4,5 to E, AC respectively	1 1 0 0 1 1 0 1	1 1 1 1 0 1 0 0	2	2	E ←(P(4)) AC←(P(5))	Inputs the contents of ports 4 and 5 to the E register and accumulator (AC) respectively.		
	OP	Output AC to port	0 0 1 0	0 1 0 1	1	1	P(DP_L)←(AC)	Outputs the contents of the accumulator (AC) to a port accessed by DP_L.		
	OPM	Output M to port	0 0 0 1	1 0 1 0	1	1	P(DP_L)←(M(HL))	Outputs the contents of the M(HL) to a port accessed by DP_L.		
	OPDR i4	Output AC to port direct	1 1 0 0 0 1 1 1	1 1 1 1 I_3 I_2 I_1 I_0	2	2	P(i4)←(AC)	Outputs the contents of the accumulator (AC) to a port accessed by i4.		
	OP45	Output E, AC to port 4,5 respectively	1 1 0 0 1 1 0 1	1 1 1 1 0 1 0 1	2	2	P(4)←(E) P(5)←(AC)	Outputs the contents of the E register and accumulator (AC) to ports 4 and 5 respectively.		
	SPB t2	Set port bit	0 0 0 0	1 0 t_1 t_0	1	1	[P(DP_L), t2]←1	Sets a bit specified by immediate data t1t0 of a port accessed by DP_L.		
	RPB t2	Reset port bit	0 0 1 0	1 0 t_1 t_0	1	1	[P(DP_L), t2]←0	Resets a bit specified by immediate data t1t0 of a port accessed by DP_L.	ZF	
	ANDPDR i4, p4	AND port with immediate data then output	1 1 0 0 I_3 I_2 I_1 I_0	0 1 0 1 $P_3P_2P_1P_0$	2	2	P(P_3~P_0)←(P(P_3~P_0))∨I_3~I_0	Performs a logical AND operation between the contents of a port specified by P3 to P0 and immediate data I3I2I1I0 and outputs the resulted product to the port.	ZF	
	ORPDR i4, p4	OR port with immediate data then output	1 1 0 0 I_3 I_2 I_1 I_0	0 1 0 0 $P_3P_2P_1P_0$	2	2	P(P_3~P_0)←(P(P_3~P_0))∨I_3~I_0	Performs a logical OR operation between the contents of a port specified by P3 to P0 and immediate data I3I2I1I0 and outputs the resulted sum to the port.	ZF	
Timer control instructions	WTTM0	Write timer 0	1 1 0 0	1 0 1 0	1	2	TIMER0←(M2(HL)), (AC)	Writes the contents of the M(HL) and the accumulator (AC) to the timer 0 reload register.		
	WTTM1	Write timer 1	1 1 0 0 1 1 1 1	1 1 1 1 0 1 0 0	2	2	TIMER1←(E), (AC)	Writes the contents of the E register and the accumulator (AC) to the timer 1 reload register.		
	RTIM0	Read timer 0	1 1 0 0	1 0 1 1	1	2	M2(HL), AC←(TIMER0)	Reads the contents of the timer 0 counter into the M2(HL) and the accumulator (AC).		
	RTIM1	Read timer 1	1 1 0 0 1 1 1 1	1 1 1 1 0 1 0 1	2	2	E, AC←(TIMER1)	Reads the contents of the timer 1 counter into the E register and the accumulator (AC).		
	START0	Start timer 0	1 1 0 0 1 1 1 0	1 1 1 1 0 1 1 0	2	2	Start timer 0 counter	Starts the timer 0 counter operation.		
	START1	Start timer 1	1 1 0 0 1 1 1 0	1 1 1 1 0 1 1 1	2	2	Start timer1 counter	Starts the timer 1 counter operation.		
	STOP0	Stop timer 0	1 1 0 0 1 1 1 1	1 1 1 1 0 1 1 0	2	2	Stop timer 0 counter	Stops the timer 0 counter operation.		
	STOP1	Stop timer 1	1 1 0 0 1 1 1 1	1 1 1 1 0 1 1 1	2	2	Stop timer1 counter	Stops the timer 1 counter operation.		

Instruction type	Mnemonics		Instruction code		Bytes	Cycles	Function	Description	Status flags affected	Remarks
			$D_7D_6D_5D_4$	$D_3D_2D_1D_0$						
Interrupt control instructions	MSET	Set Interrupt Master Enable Flag	1 1 0 0 0 1 0 1	1 1 0 1 0 0 0 0	2	2	MSE←1	Sets the interrupt master enable flag.		
	MRESET	Reset Interrupt Master Enable Flag	1 1 0 0 1 0 0 1	1 1 0 1 0 0 0 0	2	2	MSE←0	Resets the interrupt master enable flag.		
	EIH i4	Enable interrupt high	1 1 0 0 0 1 0 1	1 1 0 1 I_3 I_2 I_1 I_0	2	2	EDIH←(EDIH)∨i4	Sets the interrupt enable flag.		
	EIL i4	Enable interrupt low	1 1 0 0 0 1 0 0	1 1 0 1 I_3 I_2 I_1 I_0	2	2	EDIL←(EDIL)∨i4	Sets the interrupt enable flag.		
	DIH i4	Disable interrupt high	1 1 0 0 1 0 0 1	1 1 0 1 I_3 I_2 I_1 I_0	2	2	EDIH←(EDIH)∧$\overline{i4}$	Resets the interrupt enable flag.	ZF	
	DIL i4	Disable interrupt low	1 1 0 0 1 0 0 0	1 1 0 1 I_3 I_2 I_1 I_0	2	2	EDIL←(EDIL)∧$\overline{i4}$	Resets the interrupt enable flag.	ZF	
	WTSP	Write SP	1 1 0 0 1 1 0 1	1 1 1 1 1 0 1 0	2	2	SP←(E), (AC)	Transfers the contents of the E register and accumulator (AC) to the stack area.		
	RSP	Read SP	1 1 0 0 1 1 0 1	1 1 1 1 1 0 1 1	2	2	E, AC←(SP)	Transfers the contents of the stack area to the E register and accumulator (AC).		
Standby control instructions	HALT	HALT	1 1 0 0 1 1 0 1	1 1 1 1 1 1 1 0	2	2	HALT	Selects the HALT mode.		
	HOLD	HOLD	1 1 0 0 1 1 0 1	1 1 1 1 1 1 1 1	2	2	HOLD	Selects the HOLD mode.		
Serial I/O control instructions	STARTS	Start serial I/O	1 1 0 0 1 1 1 0	1 1 1 1 1 1 1 0	2	2	START SI/O	Starts the SIO operation mode.		
	WTSIO	Write serial I/O	1 1 0 0 1 1 1 0	1 1 1 1 1 1 1 1	2	2	SIO ←(E), (AC)	Writes the contents of the E register and accumulator (AC) to the SIO register.		
	RSIO	Read serial I/O	1 1 0 0 1 1 1 1	1 1 1 1 1 1 1 1	2	2	E, AC←(SIO)	Reads the contents of the SIO register into the E register and the accumulator (AC).		
Other instructions	NOP	No operation	0 0 0 0	0 0 0 0	1	1	No operation	A dummy instruction that is coded 00H and has no effect when executed. Just one machine cycle signal reaches the CPU.		
	SB i2	Select bank	1 1 0 0 1 1 0 0	1 1 1 1 0 0 I_1 I_0	2	2	PC12←I_1 I_0	Selects memory banks.		