Ordering number: EN 3928A

CMOS LSI

SANYO

No. 3928A

LC66354A, LC66356A, LC66358A

4-bit Microcontrollers with Built-in ROM

OVERVIEW

The LC66354A, LC66356A and LC66358A are 4-bit microcontrollers with built-in 4, 6 and 8 Kbyte ROMs, respectively. They incorporate RAM, input/output ports, a serial interface, a comparator and timers in a single chip.

The LC66354A, LC66356A and LC66358A feature a large instruction set compatible with that of the LC66000 series devices. They are functionally identical to the LC66306A, LC66308A, LC66E308 and LC66P308, but have a different supply voltage range and hold-mode release time.

The LC66354A, LC66356A and LC66358A operate from a 5 V supply and are available in 42-pin DIPs and 48-pin QIPs.

FEATURES

- 4, 6 or 8 Kbyte ROM and 512-word, 4-bit RAM
- Instruction set compatible with the LC665XX series
- 8-bit serial interface which supports 16-bit cascade connection
- 1.96 µs minimum cycle time at 3.0 to 5.5 V, and 3.92 µs, at 2.2 to 5.5 V
- 12-bit timer for timeout function, event counter, pulse measurement and rectangular waveform generation
- 8-bit timer for timeout function, event counter, pulsewidth modulated output and rectangular waveform generation
- 12-bit pre-scaler for timebase function
- Three external interrupt inputs
- Five internal interrupt sources (two for the timers, two for the serial I/O and one for the pre-scaler)
- 20 mA driver outputs with 15 V withstand voltage
- Ternary-level and comparator inputs
- I/O pull-up resistor and open-drain options
- Runaway detection option
- Halt and hold modes for program-controlled power-down
- LC66599 evaluation chip, EVA850/800-TB6630X debugger, LC66E308 EPROM and LC66P308 PROM development tools available
- 5 V supply
- 42-pin DIP and 48-pin QIP

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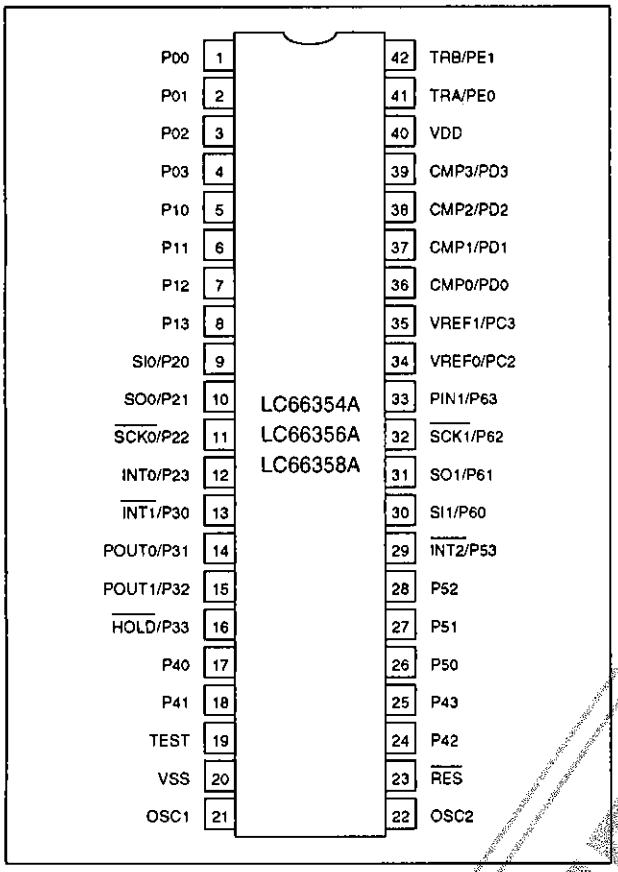
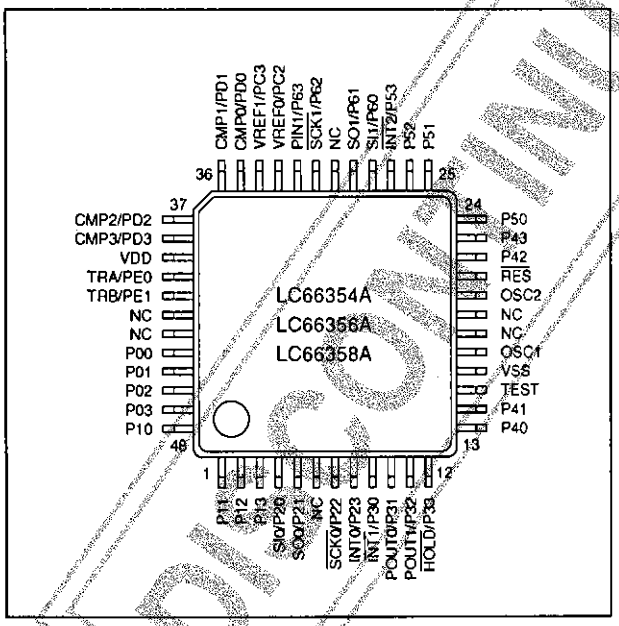
PIN ASSIGNMENT

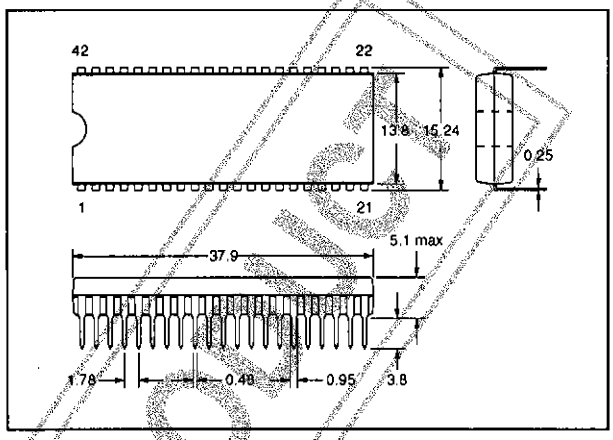




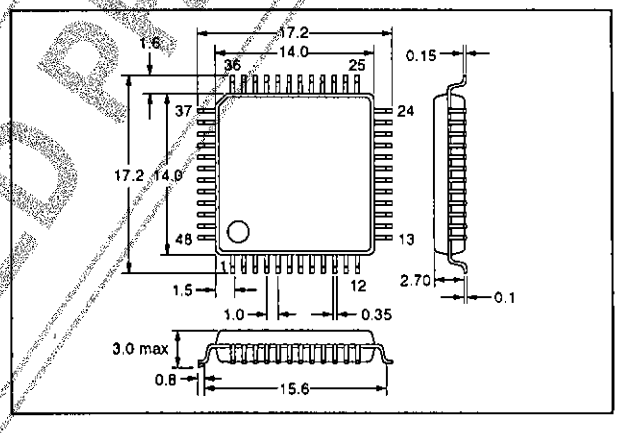
PACKAGE DIMENSIONS

Unit: mm

3025B-DIP42S



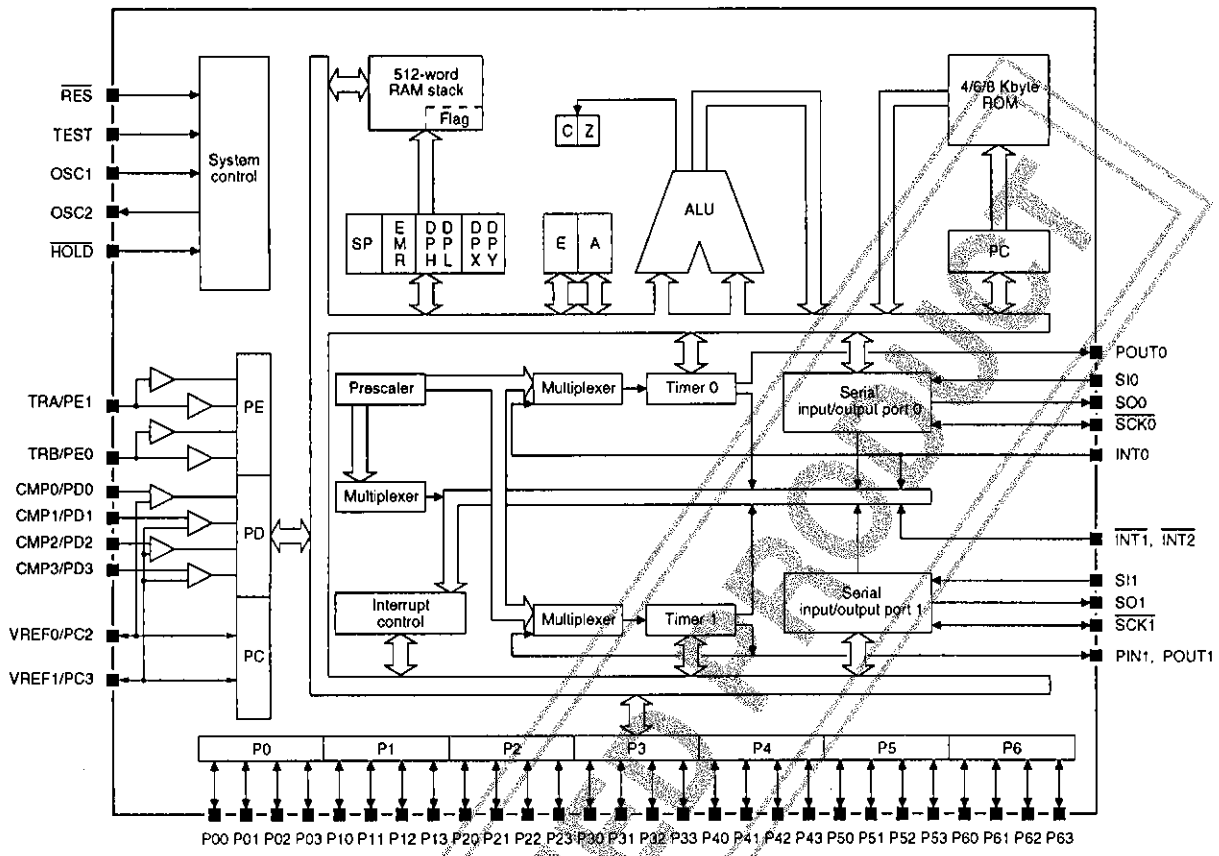
3156-QIP48E



Note

Reflow soldering is recommended for QIP packages. Please consult your local representative for further information.

BLOCK DIAGRAM



PIN DESCRIPTION

Number		Name	Description
DIP42S	QIP48E		
1	44	P00	4-bit input/output port P0 (P00 to P03)
2	45	P01	
3	46	P02	
4	47	P03	
5	48	P10	4-bit input/output port P1 (P10 to P13)
6	1	P11	
7	2	P12	
8	3	P13	
9	4	SI0/P20	Multiplexed 4-bit input/output port P2 (P20 to P23), serial input 0 (SI0), serial output 0 (SO0), serial clock 0 ($\overline{SCK0}$) and interrupt request 0 ($\overline{INT0}$)
10	5	SO0/P21	
11	7	$\overline{SCK0}$/P22	
12	8	$\overline{INT0}$/P23	
13	9	$\overline{INT1}$/P30	Multiplexed 4-bit input/output port P3 (P30 to P33), interrupt request 1 ($\overline{INT1}$), timer outputs (POUT0 and POUT1) and hold-mode control input ($\overline{HOLD}$)
14	10	POUT0/P31	
15	11	POUT1/P32	
16	12	$\overline{HOLD}$/P33	

Number		Name	Description
DIP42S	QIP48E		
17	13	P40	4-bit input/output port P4 (P40 to P43)
18	14	P41	
24	22	P42	
25	23	P43	
19	15	TEST	CPU test input
20	16	VSS	Ground
21	17	OSC1	External oscillator connections
22	20	OSC2	
23	21	$\overline{RES}$	Reset input
26	24	P50	Multiplexed 4-bit input/output port P5 (P50 to P53) and interrupt request 2 ($\overline{INT2}$)
27	25	P51	
28	26	P52	
29	27	$\overline{INT2}$/P53	
30	28	SI1/P60	Multiplexed 4-bit input/output port P6 (P60 to P63), serial input 1 (SI1), serial output 1 (SO1), serial clock 1 ($\overline{SCK1}$) and event counter input (PIN1)
31	29	SO1/P61	
32	31	$\overline{SCK1}$/P62	
33	32	PIN1/P63	
34	33	VREF0/PC2	Multiplexed 2-bit input/output port PC (PC2 and PC3), comparator 0 reference voltage input (VREF0) and comparators 1, 2 and 3 reference voltage input (VREF1)
35	34	VREF1/PC3	
36	35	CMP0/PD0	Multiplexed 4-bit input port PD (PD0 to PD3) and comparator inputs (CMP0 to CMP3)
37	36	CMP1/PD1	
38	37	CMP2/PD2	
39	38	CMP3/PD3	
40	39	VDD	5 V supply
41	40	TRA/PE0	Multiplexed 2-bit input port PE (PE0 to PE1) and ternary inputs (TRA and TRB)
42	41	TRB/PE1	
–	6, 18, 19, 30, 42, 43	NC	No connection

SPECIFICATIONS

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Supply voltage range	V_{DD}	−0.3 to 7.0	V
Ports P2 to P6 (excluding P33) input voltage range. See note 1.	V_{I1}	−0.3 to 15.0	V
Input voltage range for all inputs. See note 2.	V_{I2}	−0.3 to V_{DD} + 0.3	V
Ports P2 to P6 (excluding P33) output voltage range. See note 1.	V_{O1}	−0.3 to 15.0	V

Parameter	Symbol	Rating	Unit
Output voltage range for all outputs. See note 2.	V_{O2}	−0.3 to V_{DD} + 0.3	V
Ports P0, P1, P4 and P5 output source current	$-I_{OP1}$	2	mA
Ports P2, P3 (excluding P33), P6 and PC output source current	$-I_{OP2}$	4	mA
Ports P0 to P6 (excluding P33) and PC output sink current	I_{ON}	20	mA
Ports P0 to P3 (excluding P33), P40 and P41 total sink current	ΣI_{ON1}	75	mA
Ports P42, P43, P5, P6 and PC total sink current	ΣI_{ON2}	75	mA
Ports P0 to P3 (excluding P33), P40 and P41 total source current	$-\Sigma I_{OP1}$	25	mA
Ports P42, P43, P5, P6 and PC total source current	$-\Sigma I_{OP2}$	25	mA
Power dissipation (DIP42S)	P_{D1}	600	mW
Power dissipation (QIP48E)	P_{D2}	430	mW
Operating temperature range	Topr	−30 to 70	°C
Storage temperature range	T_{stg}	−55 to 125	°C

Notes

1. Open-drain output configuration option
2. All output configuration options

Recommended Operating Conditions

T_a = 25 °C, V_{SS} = 0 V

Parameter	Symbol	Rating	Unit
Supply voltage	V_{DD}	5	V
Supply voltage range for 1.96 ≤ t_{CYC} ≤ 10 µs operation	V_{DD}	3.0 to 5.5	V
Supply voltage range for 3.92 ≤ t_{CYC} ≤ 10 µs operation		2.2 to 5.5	
Hold-mode supply voltage range for data retention	V_{DD}	1.8 to 5.5	V

Electrical Characteristics

V_{DD} = 2.2 to 5.5 V, V_{SS} = 0 V, T_a = −30 to 70 °C unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Supply current	I_{DD}	2 MHz ceramic resonator, V_{DD} = 3.0 to 5.5 V	–	1.5	4.0	mA
		2 MHz external clock, V_{DD} = 3.0 to 5.5 V	–	1.5	4.0	
		1 MHz ceramic resonator	–	1.0	4.0	
Halt-mode supply current	I_{DDHT}	2 MHz ceramic resonator, V_{DD} = 3.0 to 5.5 V	–	0.8	1.5	mA
		2 MHz external clock, V_{DD} = 3.0 to 5.5 V	–	0.8	1.5	
		1 MHz ceramic resonator	–	0.5	1.5	
Hold-mode supply current	I_{DDHD}	V_{DD} = 1.8 to 5.5 V	–	0.01	10.0	µA

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Ports P2, P3 (excluding P33), P5 and P6, $\overline{RES}$ and OSC1 LOW-level input voltage	V_{IL1}	Output n-channel transistor OFF. See note 1.	V_{SS}	–	$0.2V_{DD}$	V
$\overline{HOLD}$/P33 LOW-level input voltage	V_{IL2}	V_{DD} = 1.8 to 5.5 V	V_{SS}	–	$0.2V_{DD}$	V
Ports P0, P1, P4, PC, PD and PE, and TEST LOW-level input voltage	V_{IL3}	Output n-channel transistor OFF. See note 1.	V_{SS}	–	$0.25V_{DD}$	V
Port PE LOW-level input voltage	V_{IL4}	Ternary input levels, V_{DD} = 2.7 to 5.5 V	V_{SS}	–	$0.2V_{DD}$	V
Port PE MID-level input voltage	V_{IM}	Ternary input levels, V_{DD} = 2.7 to 5.5 V	$0.4V_{DD}$	–	$0.6V_{DD}$	V
Ports P2 to P6 (excluding P33) HIGH-level input voltage	V_{IH1}	Output n-channel transistor OFF. See notes 1 and 2.	$0.8V_{DD}$	–	13.5	V
$\overline{HOLD}$/P33, $\overline{RES}$ and OSC1 HIGH-level input voltage	V_{IH2}	Output n-channel transistor OFF. See note 2.	$0.8V_{DD}$	–	V_{DD}	V
Ports P0, P1, PC, PD and PE HIGH-level input voltage	V_{IH3}	Output n-channel transistor OFF. See note 1.	$0.75V_{DD}$	–	V_{DD}	V
Port PE LOW-level input voltage	V_{IH4}	Ternary input levels, V_{DD} = 2.7 to 5.5 V	$0.8V_{DD}$	–	V_{DD}	V
Ports P0 to P6 (excluding P33) and PC LOW-level output voltage	V_{OL}	I_{OL} = 1.6 mA	–	–	0.4	V
		I_{OL} = 3 mA	–	–	1.5	
		I_{OL} = 8 mA, V_{DD} = 3.0 to 5.5 V	–	–	1.5	
Ports P2, P3 (excluding P33), P6 and PC HIGH-level output voltage	V_{OH1}	I_{OH} = –1 mA, V_{DD} = 3.0 to 5.5 V. See note 3.	V_{DD} – 1.0	–	–	V
		I_{OH} = –0.5 mA. See note 3.	V_{DD} – 1.0	–	–	
		I_{OH} = –0.1 mA. See note 3.	V_{DD} – 0.5	–	–	
Ports P0, P1, P4 and P5 HIGH-level output voltage	V_{OH2}	I_{OH} = –50 µA, V_{DD} = 3.0 to 5.5 V. See note 4.	V_{DD} – 1.0	–	–	V
		I_{OH} = –30 µA, V_{DD} = 3.0 to 5.5 V. See note 4.	V_{DD} – 0.5	–	–	
		I_{OH} = –30 µA. See note 4.	V_{DD} – 1.0	–	–	
		I_{OH} = –20 µA. See note 4.	V_{DD} – 0.5	–	–	
Ports PC2 and PD0 in-phase, comparator input voltage range	V_{CMM1}	V_{DD} = 2.7 to 5.5 V	1.5	–	V_{DD}	V
Ports PC3 and PD1 to PD3 in-phase, comparator input voltage range	V_{CMM2}	V_{DD} = 2.7 to 5.5 V	V_{SS}	–	V_{DD} – 1.5	V
Ports PD1 to PD3 comparator offset voltage	V_{OS1}	V_I = V_{SS} to V_{DD} – 1.5 V, V_{DD} = 2.7 to 5.5 V	–	±50	±300	mV
Port PD0 comparator offset voltage	V_{OS2}	V_I = 1.5 V to V_{DD}, V_{DD} = 2.7 to 5.5 V	–	±50	±300	mV
Ports P2, P3, P5 and P6, and $\overline{RES}$ and OSC1 Schmitt-trigger LOW-level threshold voltage	V_{TL}		$0.2V_{DD}$	–	$0.5V_{DD}$	V

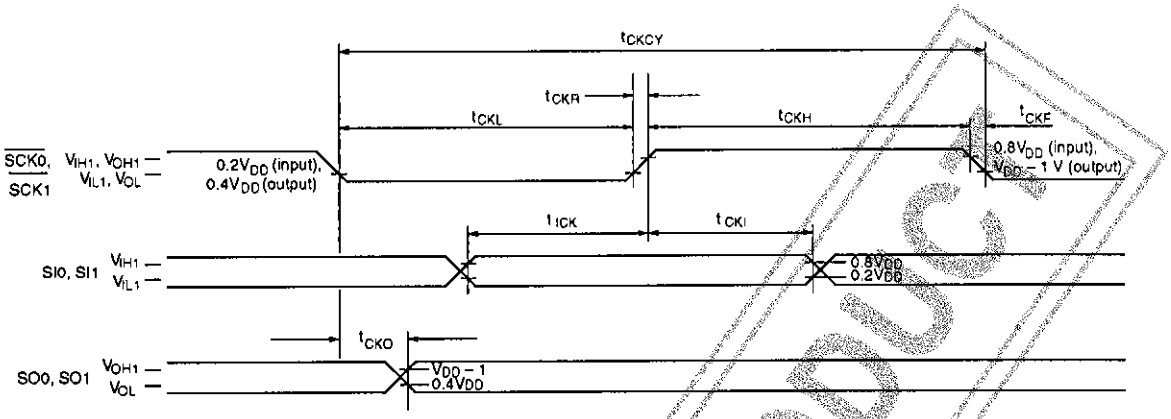
Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Ports P2, P3, P5, and P6, and $\overline{RES}$ and OSC1 Schmitt-trigger HIGH-level threshold voltage	V_{IH}		$0.5V_{DD}$	–	$0.8V_{DD}$	V
Ports P2, P3, P5 and P6, $\overline{RES}$ and OSC1 Schmitt-trigger hysteresis voltage	V_{HYS}		–	$0.1V_{DD}$	–	V
Ports PC, PD and PE LOW-level input current	I_{IL1}	$V_I = V_{SS}$, output n-channel transistor OFF. See note 2.	–1.0	–	–	µA
LOW-level input current for all other inputs	I_{IL2}	$V_I = V_{SS}$, output n-channel transistor OFF. See note 2.	–1.0	–	–	µA
Ports P2 to P6 (excluding P33) HIGH-level input current	I_{IH1}	V_I = 13.5 V, output n-channel transistor OFF. See notes 1 and 2.	–	–	5.0	µA
Ports P0, P1 and P33, and $\overline{RES}$ and OSC1 HIGH-level input current	I_{IH2}	$V_I = V_{DD}$, output n-channel transistor OFF. See notes 1 and 2.	–	–	1.0	µA
Ports PC, PD and PE HIGH-level input current	I_{IH3}	$V_I = V_{DD}$, output n-channel transistor OFF. See notes 1 and 2.	–	–	1.0	µA
Ports P2 to P6 output leakage current	I_{OFF1}	V_I = 13.5 V. Output n-channel transistor OFF. See note 2.	–	–	5.0	µA
Ports P0, P1 and PC output leakage current	I_{OFF2}	$V_I = V_{DD}$. Output n-channel transistor OFF. See note 2.	–	–	1.0	µA
Ports P0, P1, P4 and P5 output current with pull-up option	I_{PO}	$V_I = V_{SS}$, V_{DD} = 5.5 V. Output n-channel transistor OFF. See note 4.	–1.6	–	–	mA
Ceramic resonator input frequency	f_{CF}	V_{DD} = 3.0 to 5.5 V, 2 MHz resonator	–	2.0	–	MHz
		1 MHz resonator	–	1.0	–	
Ceramic resonator input stabilization time	t_{CFS}	V_{DD} = 3.0 to 5.5 V, 2 MHz resonator	–	–	10	ms
		1 MHz resonator	–	–	10	
OSC1 external clock input frequency	f_{ext}	V_{DD} = 3.0 to 5.5 V	0.4	–	2.03	MHz
			0.4	–	1.02	

Notes

1. Ports with CMOS output configuration option cannot be used as input ports.
2. Open-drain output configuration option
3. CMOS output configuration option
4. Pull-up output configuration option

Timing Characteristics

Serial input/output timing

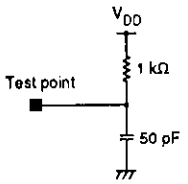


V_{DD} = 2.2 to 5.5 V, V_{SS} = 0 V, T_a = −30 to 70 °C

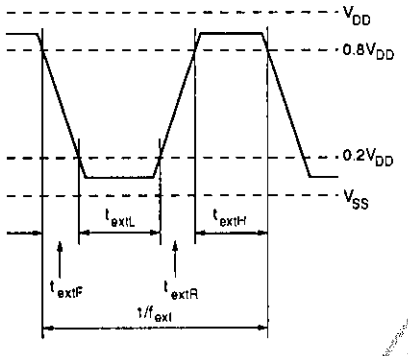
Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Instruction cycle time	t_{CYC}	t_{CYC} = 0.4 to 2.03 MHz, V_{DD} = 3.0 to 5.5 V	10	–	1.96	µs
		t_{CYC} = 0.4 to 1.02 MHz	10	–	3.92	
$\overline{SCK0}$ and $\overline{SCK1}$ serial clock input cycle time	t_{CKCY}	V_{DD} = 3.0 to 5.5 V	1.9	–	–	µs
			3.9	–	–	
$\overline{SCK0}$ and $\overline{SCK1}$ serial clock output cycle time			$2t_{CYC}$	–	–	
$\overline{SCK0}$ and $\overline{SCK1}$ serial clock input pulsewidth	t_{CKL}	V_{DD} = 3.0 to 5.5 V	0.9	–	–	µs
			1.9	–	–	
$\overline{SCK0}$ and $\overline{SCK1}$ serial clock output pulsewidth			t_{CYC}	–	–	
$\overline{SCK0}$ and $\overline{SCK1}$ serial clock output rise time	t_{CKR}		–	–	0.1	µs
$\overline{SCK0}$ and $\overline{SCK1}$ serial clock output fall time	t_{CKF}		–	–	0.1	µs
SI0 and SI1 serial data setup time	t_{ICK}		0.6	–	–	µs
SI0 and SI1 serial data hold time	t_{CKI}		0.6	–	–	µs
SO0 and SO1 serial data output delay	t_{CKO}	V_{DD} = 3.0 to 5.5 V	–	–	0.6	µs
			–	–	0.9	

Note

Each test input and output has an RC load as shown in the following figure.



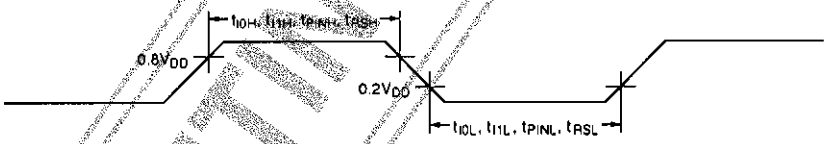
External clock timing



V_{DD} = 2.2 to 5.5 V, V_{SS} = 0 V, T_a = −30 to 70 °C

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
OSC1 external clock LOW-level input pulsewidth	t_{extL}	V_{DD} = 3.0 to 5.5 V	100	–	–	ns
			200	–	–	
OSC1 external clock HIGH-level input pulsewidth	t_{extH}	V_{DD} = 3.0 to 5.5 V	100	–	–	ns
			200	–	–	
OSC1 external clock input rise time	t_{extR}		–	–	30	ns
OSC1 external clock input fall time	t_{extF}		–	–	30	ns

Interrupt and reset timing

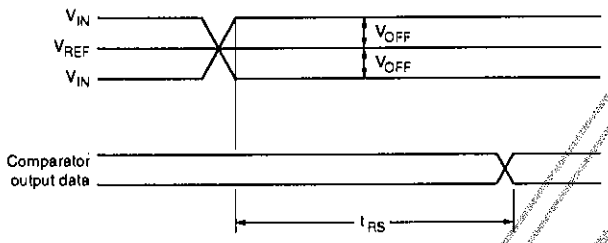


V_{DD} = 2.2 to 5.5 V, V_{SS} = 0 V, T_a = −30 to 70 °C

Parameter	Symbol	Rating			Unit
		min	typ	max	
INT0 LOW-level pulsewidth	t_{I0L}	2t_{CYC}	–	–	µs
INT0 HIGH-level pulsewidth	t_{I0H}	2t_{CYC}	–	–	µs
$\overline{INT1}$ and $\overline{INT2}$ LOW-level pulsewidth	t_{I1L}	2t_{CYC}	–	–	µs
$\overline{INT1}$ and $\overline{INT2}$ HIGH-level pulsewidth	t_{I1H}	2t_{CYC}	–	–	µs
PIN1 LOW-level input pulsewidth	t_{PINL}	2t_{CYC}	–	–	µs
PIN1 HIGH-level input pulsewidth	t_{PINH}	2t_{CYC}	–	–	µs
$\overline{RES}$ LOW-level input pulsewidth	t_{RSL}	3t_{CYC}	–	–	µs
$\overline{RES}$ HIGH-level input pulsewidth	t_{RSH}	3t_{CYC}	–	–	µs

Comparator output timing

V_{DD} = 2.7 to 5.5 V, V_{SS} = 0 V, T_a = –30 to 70 °C



Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Port PD comparator response time	t_{RS}	V_{DD} = 2.7 to 5.5 V	–	–	20	ms

INPUT AND OUTPUT FUNCTIONS

The LC66354A, LC66356A and LC66358A have many multiplexed pins whose function is controlled by software. The function of each pin is described in table 1.

Table 1. Pin functions

Name	Function
P00	Ports P00 to P03 can be addressed as either a 4-bit port or four, single-bit ports. They also have halt-mode control functions. Level after reset is set by user option.
P01	
P02	
P03	
P10	Ports P10 to P13 can be addressed as either a 4-bit port or four, single-bit ports. Level after reset is set by user option.
P11	
P12	
P13	
SI0/P20	Ports P20 to P23 can be addressed as either a 4-bit port or four, single-bit ports. Port P20 also functions as a serial data input, P21 as a serial data output, P22 as a serial data clock and P23 as an interrupt request, pulsewidth measurement and event counter input using timer 0. HIGH-level after reset
SO0/P21	
$\overline{SCK0}$/P22	
INT0/P23	
$\overline{INT1}$/P30	Ports P30 to P32 can be addressed as either a 3-bit port, a 4-bit port with P33 or three, single-bit ports. Port P30 also functions as an interrupt request input, P31 as a square-wave output from timer 0, and P32 as a square-wave output and a PWM output from timer 1. HIGH-level after reset
POUT0/P31	
POUT1/P32	
$\overline{HOLD}$/P33	Port P33 can be addressed as either a 4-bit port with P30 to P32 or a single-bit port. It functions as the hold-mode control input when P33 is LOW and the HOLD instruction is executed. The CPU restarts when P33 goes HIGH again. Reset signals are ignored whenever $\overline{HOLD}$/P33 is LOW, including when not in hold mode.
P40	Ports P40 to P43 can be addressed as either a 4-bit port, four, single-bit ports or an 8-bit port with P50 to P53. HIGH-level after reset
P41	
P42	
P43	

Table 1. Pin functions—continued

Name	Function
P50	Ports P50 to P53 can be addressed as either a 4-bit port, four, single-bit ports or an 8-bit port with P40 to P43. Port P53 also functions as an interrupt request input. HIGH-level after reset.
P51	
P52	
$\overline{INT2}$/P53	
SI1/P60	Ports P60 to P63 can be addressed as either a 4-bit port or four, single-bit ports. Port P60 also functions as a serial data input, P61 as a serial data output, P62 as a serial data clock and P63 as the timer 1 event counter input. HIGH-level after reset.
SO1/P61	
$\overline{SCK1}$/P62	
PIN1/P63	
VREF0/PC2	Ports PC2 and PC3 can be addressed as either a 2-bit port or two, single-bit ports. Port PC2 also functions as the reference voltage input for comparator 0, and PC3, as the reference voltage input for comparators 1, 2 and 3. HIGH-level after reset
VREF1/PC3	
CMP0/PD0	Ports PD0 to PD3 can be addressed as either a 4-bit port or four, single-bit ports. They also function as comparator inputs. Normal input after reset
CMP1/PD1	
CMP2/PD2	
CMP3/PD3	
TRA/PE0	Ports PE0 to PE1 can be addressed as either a 2-bit port or two, single-bit ports. They also function as ternary-level inputs. Normal input after reset
TRB/PE1	
OSC1	OSC1 and OSC2 function as the external ceramic resonator connections. When an external clock is used, OSC2 is left open.
OSC2	
$\overline{RES}$	When $\overline{RES}$ goes LOW while $\overline{HOLD}$/P33 is HIGH, the CPU is reset.
TEST	CPU test input. Normally connected to ground

USER OPTIONS

Oscillator Options

There are two user options for the oscillator—an external clock and a ceramic resonator. An external RC oscillator is not supported. The internal circuits of OSC1 and OSC2 and connections for the external clock and ceramic resonator options are shown in figures 1and 2, respectively. Note the Schmitt-trigger input for the external clock option.

Figure 1. External clock option

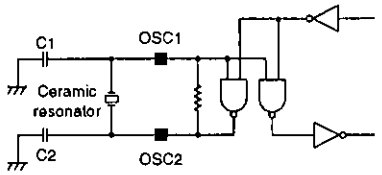


Figure 2. Ceramic resonator option

Output Options

There are two user options for the output configuration of each port—n-channel open drain and p-channel, active pull-up as shown in figures 3and 4, respectively. Ports P2, P3, P5 and P6 have Schmitt-trigger inputs in both output configurations.

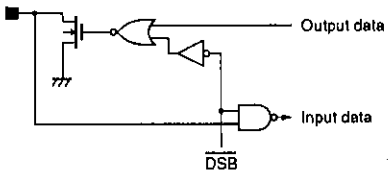


Figure 3. N-channel open-drain option

The p-channel pull-up option for all ports is identical. However, the ports are classified as pull-up or CMOS according to the drive capability of the p-channel transistor. Ports P0, P1, P4 and P5 are classified as pull-up, and ports P2, P3, P6 and PC, as CMOS.

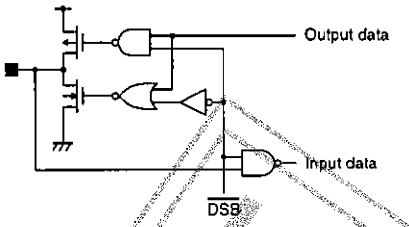


Figure 4. P-channel pull-up option

Note that the n-channel open-drain outputs for ports P2 to P6 have a maximum withstand voltage of 15 V.

Output Level After Reset Option

The output level of ports P0 and P1 after a CPU reset is user selectable.

Watchdog Timer Option

A watchdog timer is also available to prevent program runaway.

SPECIFYING OPTIONS

The user-addressable memory is in the range 0000H to 2007H. Addresses 0000H to 1FFFH are for user programs, and addresses 2000H to 2007H, for option specification. The option specification is coded using the information shown in table 2. Refer to the *LC66S Jump Optimizing Cross Assembler Manual* for setting information.

Table 2. User options

Address	Data bit	Parameter	Option	
			0	1
2000H	D0	Watchdog timer function	No	Yes
	D1	Port P0 level after reset	LOW	HIGH
	D2	Port P1 level after reset	LOW	HIGH
	D3	No function	Set to 0	
	D4	Oscillator	RC oscillator or external clock	Ceramic resonator
	D5 to D7	No function	Set to 0	
2001H	D0	Port P00 output configuration	Open-drain	Pull-up
	D1	Port P01 output configuration		
	D2	Port P02 output configuration		
	D3	Port P03 output configuration		
	D4	Port P10 output configuration	Open-drain	Pull-up
	D5	Port P11 output configuration		
	D6	Port P12 output configuration		
	D7	Port P13 output configuration		

Table 2. User options—continued

Address	Data bit	Parameter	Option	
			0	1
2002H	D0	Port P20 output configuration	Open-drain	CMOS
	D1	Port P21 output configuration		
	D2	Port P22 output configuration		
	D3	Port P23 output configuration		
	D4	Port P30 output configuration	Open-drain	CMOS
	D5	Port P31 output configuration		
	D6	Port P32 output configuration		
	D7	No function	Set to 0	
2003H	D0	Port P40 output configuration	Open-drain	Pull-up
	D1	Port P41 output configuration		
	D2	Port P42 output configuration		
	D3	Port P43 output configuration		
	D4	Port P50 output configuration	Open-drain	Pull-up
	D5	Port P51 output configuration		
	D6	Port P52 output configuration		
	D7	Port P53 output configuration		
2004H	D0	Port P60 output configuration	Open-drain	CMOS
	D1	Port P61 output configuration		
	D2	Port P62 output configuration		
	D3	Port P63 output configuration		
	D4 to D7	No function	Set to 0	
2005H	D0 to D7	No function	Set to 0	
2006H	D0 to D7	No function	Set to 0	
2007H	D0, D1	No function	Set to 0	
	D2	Port PC2 output configuration	Open-drain	CMOS
	D3	Port PC3 output configuration		
	D4 to D7	No function	Set to 0	

The assembler execute command when specifying programs and options using a Sanyo cross assembler is LC66S.EXE.

APPLICATION NOTES

Reference Clock

The external circuit for a ceramic resonator is shown in figure 5, and the corresponding recommended resonator and component values, in table 3. The oscillator stabilization characteristics are shown in figure 6.

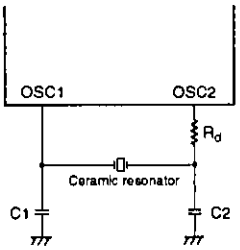


Figure 5. Ceramic resonator

Table 3. Recommended ceramic resonators

Ceramic resonator	R_d	C1	C2
2 MHz Murata CSA-2.00MG	0 Ω	33 pF ±10%	33 pF ±10%
2 MHz Kyocera KBR-2.0MS	0 Ω	47 pF ±10%	47 pF ±10%
1 MHz Murata CSB1000J	2.2 kΩ ±5%	100 pF ±10%	100 pF ±10%
1 MHz Kyocera KBR1000H	0 Ω	100 pF ±10%	100 pF ±10%

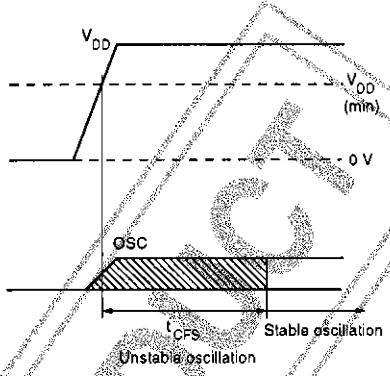


Figure 6. Ceramic resonator stabilization time

The external clock input connection is OSC1. The remaining oscillator connection, OSC2, should be left open as shown in figure 7.

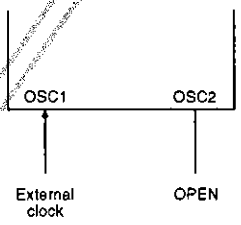


Figure 7. External clock connection

DEVELOPMENT TOOLS

Program development for the LC6635X series microcontrollers can be performed using a cross assembler running on an IBM-compatible personal computer under MS-DOS. A number of other development tools are available to help simplify and speed up the development process—the EVA800/850 debugger, the EVA800/850-TB6630X evaluation chip board, the LC66599 evaluation chip, and the LC66E308 EPROM or LC66P308 PROM, shown in figure 8.

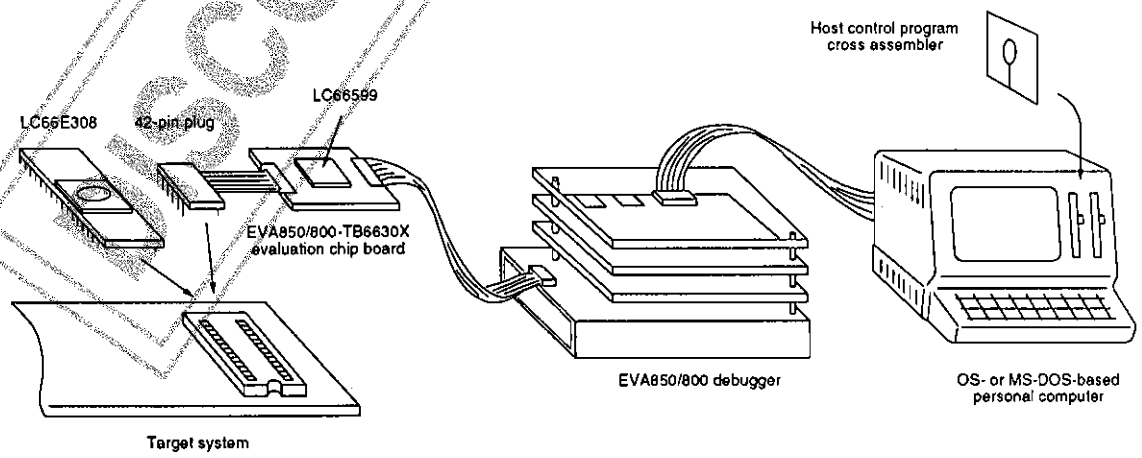


Figure 8. Development tools

Program Debugger

The EVA800/850 communicates with an external host computer using a standard serial interface. It performs basic debugging functions, including breakpoints, single-stepping and tracing under MPM6630X debug monitor software control. It also includes an EPROM programmer.

Evaluation System

The evaluation chip board, which holds the LC66599 evaluation chip, has a 42-pin connector which plugs directly into the socket of a target system. Jumpers and switches configure the initial device options and states as shown in tables 4and 5.

Table 4. Jumper settings

Jumper 1		Jumper 2		Jumper 3	
Oscillator		Reset method		Target system supply source	
EXT	External clock	INT (a)	Reset on a RUN command from the host computer	ON (a)	Supply power from the evaluation chip board output
RC	RC oscillator				
CF	Ceramic filter resonator	EXT (b)	Reset by the target system reset circuit	OFF (b)	Separate evaluation chip and target system supplies

Table 5. Switches 9 to 11

Switch 11		Switch 10		Switch 9	
Port 0 output level on reset		Port 1 output level on reset		Watchdog timer enable	
ON	All outputs HIGH	ON	All outputs HIGH	ON	Watchdog timer enabled
OFF	All outputs LOW	OFF	All outputs LOW	OFF	Watchdog timer disabled

Switches 1 to 8 select the internal pull-up resistor option. When a switch is ON, the corresponding output pin has an internal pull-up resistor, and when OFF, the corresponding pin is an open-drain output.

Cross Assembler

The cross assembler execute file, LC66S.EXE, can be used for the devices shown in table 6. Refer to the *LC66S Jump Optimizing Cross Assembler Manual* for operating information.

Table 6. Cross assembler compatibility

Cross assembler	Target device	Bank instructions supported
LC66S.EXE	LC66354A	SB0
	LC66356A, LC66E308, LC66P308	SB0,SB1
	LC66599	SB0, SB1, SB2, SB3

Simulation Chip

The LC66E308 is an LC66 series microprocessor with an 8-Kbyte EPROM which is used to set the user options for simulation. It can be programmed by a standard EPROM programmer using the W66EP308D/408D (DIP) or W66EP308Q/408Q (QIP) adapter boards. The LC66E308 is pin- and functionally-compatible with the LC66354A, LC66356A and LC66358A devices. Note that the hold-mode release time and electrical specifications of the LC66E308 differ from those of the LC66354A, LC66356A and LC66358A.

The LC66E308, shown in figure 9, can be configured to match the target device by programming certain EPROM locations. These locations set the reset level of ports 0 and 1, the watchdog timer enable and the port output types. Refer to the LC66E516 datasheet for further operating information.

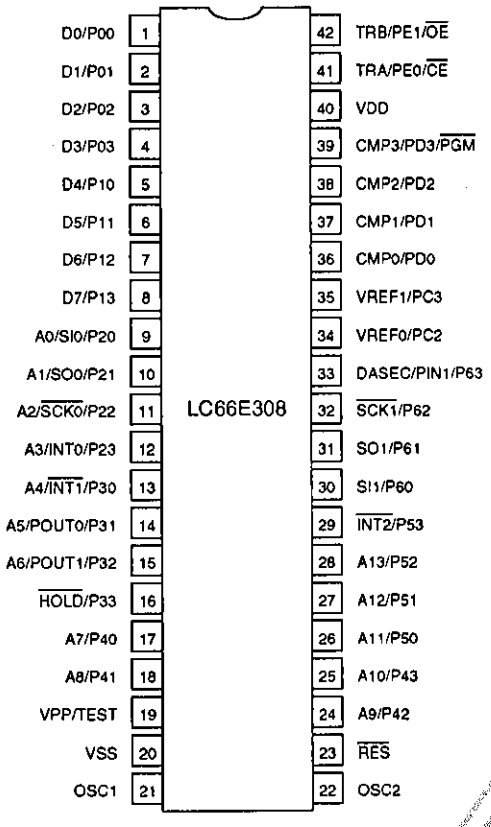


Figure 9. LC66E308 pinout

Series Comparison

A comparison of the LC6630X series characteristics with those of the LC6635X series is shown in table 7.

Table 7. Device comparison

Parameter	LC6630X series	LC6635X series
Hold-mode release hardware delay	65,536 cycles (approximately 64 ms with a 4 MHz clock)	16,384 cycles (approximately 32 ms with a 2 MHz clock and 64 ms with a 1 MHz clock)
Timer 0 contents after reset	FF0H	FFCH
Operating supply voltage and clock period	4.0 to 6.0 V for 0.92 to 10 µs (LC66304A/306A/308A), 4.5 to 5.5 V for 0.92 to 10 µs (LC66E308/P308)	2.2 to 5.5 V for 3.92 to 10 ms, 3.0 to 5.5 V for 1.96 to 10 µs

Notes

1. The LC66354A/356A/358A do not support an RC oscillator.
2. Refer to the LC66308A, LC66E308 and LC66P308 datasheets for output drive current and comparator input voltages.
3. The LC66599 evaluation chip is available for LC6630X series devices.

A breakdown of the LC66 series devices, which includes the LC6630X series, is shown in table 8.

Table 8. LC66 series devices

Device	Pins	ROM capacity	RAM capacity	Package type	Type
LC66304A/306A/308A	42	4/6/8 Kbyte ROM	512 words	DIP42S and QIP48E	Normal type 4.0 to 6.0 V/0.92 µs
LC66404A/406A/408A	42	4/6/8 Kbyte ROM	512 words	DIP42S and QIP48E	
LC66506B/508B/512B/516B	64	6/8/12/16 Kbyte ROM	512 words	DIP64S and QIP64A	
LC66354A/356A/358A	42	4/6/8 Kbyte ROM	512 words	DIP42S and QIP48E	Low-voltage type 2.2 to 5.5 V/3.92 µs
LC66354S/356S/358S	42	4/6/8 Kbyte ROM	512 words	QIP44M	
LC66556A/558A/562A/566A	64	6/8/12/16 Kbyte ROM	512 words	DIP64S and QIP64E	
LC66354B/356B/358B	42	4/6/8 Kbyte ROM	512 words	DIP42S and QIP48E	Low voltage, high-speed type 3.0 to 5.5 V/0.92 µs
LC66556B/558B	64	6/8 Kbyte ROM	512 words	DIP64S and QIP64E	
LC66562B/566B	64	12/16 Kbyte ROM	512 words	DIP64S and QIP64E	
LC66E308	42	8 Kbyte EPROM	512 words	DIC42S and QIC48	Evaluation ROMs and EPROMs with window 4.5 to 5.5 V/0.92 µs
LC66P308	42	8 Kbyte PROM	512 words	DIP42S and QIP48E	
LC66E408	42	8 Kbyte EPROM	512 words	DIC42S and QIC48	
LC66P408	42	8 Kbyte PROM	512 words	DIP42S and QIP48E	
LC66E516	64	16 Kbyte EPROM	512 words	DIC64S and QIC64	
LC66P516	64	16 Kbyte PROM	512 words	DIP64S and QIP64E	

* Under development

INSTRUCTION SET

The following abbreviations are used in the instruction set table.

AC	Accumulator	PCh	Bits 8 to 11 of the program counter
E	E register	PCm	Bits 4 to 7 of the program counter
CF	Carry flag	PCl	Bits 0 to 3 of the program counter
ZF	Zero flag	F*n*	User flags, *n* = 0 to 15
HL	Data pointer DP_H and DP_L	TIMER0	Timer 0
XY	Data pointer DP_X and DP_Y	TIMER1	Timer 1
M	Data memory	SIO	Serial port register
M (HL)	Data memory pointed to by DP_{HL}	P	Port
M (XY)	Data memory pointed to by DP_{XY}	P (i4)	Port specified by 4-bit immediate data
M2 (HL)	Two-word location of data memory at even address pointed to by DP_{HL}	INT	Interrupt enable flag
		( ), [ ]	Contents
SP	Stack pointer	←	Direction of transfer, result
M2 (SP)	Two-word location of data memory pointed to by SP	⊕	Logical exclusive-OR
		·	Logical AND
M4 (SP)	Four-word location of data memory pointed to by SP	+	Logical OR
		+	Arithmetic addition
i*n*	*n*-bit immediate data	−	Arithmetic subtraction
t2	Bit specifier		

t2	Bit
00	0
01	1
10	2
11	3

Mnemonic	Operation	Instruction code D7	D6	D5	D4	D3	D2	D1	D0	Cycles	Notation	Description	Status flags
Accumulator instructions													
CLA	Clear AC	1	0	0	0	0	0	0	0	1	AC ← 0 (equivalent to LAI 0)	Clears the contents of the accumulator. Vertical skip function available	ZF
DAA	Decimal adjust AC after addition	1 0	1 0	0 1	0 0	1 0	1	1	1 0	2	AC ← (AC) + 6 (equivalent to ADI 6)	Adds 6 to the contents of the accumulator	ZF
DAS	Decimal adjust AC after subtraction	1 0	1 0	0 1	0 0	1 1	1 0	1	1 0	2	AC ← (AC) + 10 (equivalent to ADI 0H)	Adds 10 to the contents of the accumulator	ZF
CLC	Clear CF	0	0	0	1	1	1	1	0	1	CF ← 0	Clears the carry flag	CF
STC	Set CF	0	0	0	1	1	1	1	1	1	CF ← 1	Sets the carry flag	CF
CMA	Complement AC	0	0	0	1	1	0	0	0	1	AC ← $\overline{(AC)}$	Takes the 1s complement of the contents of the accumulator	ZF
IA	Increment AC	0	0	0	1	0	1	0	0	1	AC ← (AC) + 1	Increments the contents of the accumulator by 1	ZF, CF
DA	Decrement AC	0	0	1	0	0	1	0	0	1	AC ← (AC) − 1	Decrements the contents of the accumulator by 1	ZF, CF
RAR	Rotate AC right through CF	0	0	0	1	0	0	0	0	1	AC_3 ← (CF), ACn ← (ACn + 1), CF ← (AC_0)	Shifts the contents of the accumulator right through the carry flag	CF
RAL	Rotate AC left through CF	0	0	0	0	0	0	0	1	1	AC_0 ← (CF), ACn + 1 ← (ACn), CF ← (AC_3)	Shifts the contents of the accumulator left through the carry flag	CF, ZF
TAE	Transfer AC to E	0	1	0	0	0	1	0	1	1	E ← (AC)	Copies the contents of the accumulator into register E	
TEA	Transfer E to AC	0	1	0	0	0	1	1	0	1	AC ← (E)	Copies the contents of register E into the accumulator	ZF
XAE	Exchange AC with E	0	1	0	0	0	1	0	0	1	(AC) ↔ (E)	Exchanges the contents of the accumulator and register E	

Mnemonic	Operation	Instruction code D7	D6	D5	D4	D3	D2	D1	D0	Cycles	Notation	Description	Status flags
Memory Instructions													
IM	Increment M	0	0	0	1	0	0	1	0	1	M(HL) ← [M(HL)] + 1	Increments the contents of memory location HL by 1	ZF, CF
DM	Decrement M	0	0	1	0	0	0	1	0	1	M(HL) ← [M(HL)] − 1	Decrements the contents of memory location HL by 1	ZF, CF
IMDR i8	Increment M direct	1 I_7	1 I_6	0 I_5	0 I_4	0 I_3	1 I_2	1 I_1	1 I_0	2	M(i8) ← [M(i8)] + 1	Increments the contents of the memory location specified by immediate data I_0 to I_7 by 1	ZF, CF
DMDR i8	Decrement M direct	1 I_7	1 I_6	0 I_5	0 I_4	0 I_3	0 I_2	1 I_1	1 I_0	2	M(i8) ← [M(i8)] − 1	Decrements the contents of the memory location specified by immediate data I_0 to I_7 by 1	ZF, CF
SMB t2	Set M data bit	0	0	0	0	1	1	t_1	t_0	1	[M(HL), t2] ← 1	Sets the bit in memory location HL specified by t_0 and t_1	
RMB t2	Reset M data bit	0	0	1	0	1	1	t_1	t_0	1	[M(HL), t2] ← 0	Clears the bit in memory location HL specified by t_0 and t_1	ZF
Arithmetic Instructions													
AD	Add M to AC	0	0	0	0	0	1	1	0	1	AC ← (AC) + [M(HL)]	Adds the contents of memory location HL to the contents of the accumulator and stores the result in the accumulator	ZF, CF
ADDR i8	Add M direct to AC	1 I_7	1 I_6	0 I_5	0 I_4	1 I_3	0 I_2	0 I_1	1 I_0	2	AC ← (AC) + [M(i8)]	Adds the contents of the memory location specified by immediate data I_0 to I_7 to the contents of the accumulator and stores the result in the accumulator	ZF, CF
ADC	Add M to AC with CF	0	0	0	0	0	0	1	0	1	AC ← (AC) + [M(HL)] + (CF)	Adds the contents of memory location HL to the contents of the accumulator with carry and stores the result in the accumulator	ZF, CF
ADI i4	Add immediate data to AC	1 0	1 0	0 1	0 0	1 I_3	1 I_2	1 I_1	1 I_0	2	AC ← (AC) + I_3 I_2 I_1 I_0	Adds immediate data I_0 to I_3 to the contents of the accumulator and stores the result in the accumulator	ZF
SUBC	Subtract AC from M with CF	0	0	0	1	0	1	1	1	1	AC ← [M(HL)] − (AC) − $\overline{(CF)}$	Subtracts the contents of the accumulator from the contents of memory location HL with carry and stores the result in the accumulator	ZF, CF
ANDA	AND M with AC then store in AC	0	0	0	0	0	1	1	1	1	AC ← (AC) · [M(HL)]	Takes the logical AND of the contents of the accumulator with the contents of memory location HL and stores the result in the accumulator	ZF
ORA	OR M with AC then store in AC	0	0	0	0	0	1	0	1	1	AC ← (AC) + [M(HL)]	Takes the logical OR of the contents of the accumulator with the contents of memory location HL and stores the result in the accumulator	ZF
EXL	Exclusive-OR M with AC then store in AC	0	0	0	1	0	1	0	1	1	AC ← (AC) ⊕ [M(HL)]	Takes the logical exclusive-OR of the contents of the accumulator with the contents of memory location HL and stores the result in the accumulator	ZF
ANDM	AND M with AC then store in M	0	0	0	0	0	0	1	1	1	M(HL) ← (AC) · [M(HL)]	Takes the logical AND of the contents of the accumulator with the contents of memory location HL and stores the result in the accumulator	ZF
ORM	OR M with AC then store in M	0	0	0	0	0	1	0	0	1	M(HL) ← (AC) + [M(HL)]	Takes the logical OR of the contents of the accumulator with the contents of memory location HL and stores the result in memory location HL	ZF
CM	Compare AC with M	0	0	0	1	0	1	1	0	1	$\overline{[M(HL)]}$ − (AC) − 1	Compares the contents of the accumulator with the contents of memory location HL and sets the condition flags as shown below Comparison / CF / ZF [M(HL)] > (AC) / 0 / 0 [M(HL)] = (AC) / 1 / 1 [M(HL)] < (AC) / 1 / 0	ZF, CF

Mnemonic	Operation	Instruction code D7	D6	D5	D4	D3	D2	D1	D0	Cycles	Notation	Description	Status flags
CI i4	Compare AC with immediate data	1 1	1 0	0 1	0 0	1 I_3	1 I_2	1 I_1	1 I_0	2	$\overline{I_3\ I_2\ I_1\ I_0}$ − (AC) − 1	Compares the contents of the accumulator with immediate data I_0 to I_3 and sets the condition flags as shown below Comparison: $I_3\ I_2\ I_1\ I_0$ > (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	1 0	0 1	0 1	1 I_3	1 I_2	1 I_1	1 I_0	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 the lower nibble of data pointer HL with immediate data I_0 to I_3. Sets the zero flag when equal and clears the zero flag when unequal	ZF
CMB i2	Compare AC bit with M data bit	1 1	1 1	0 0	0 1	1 0	1 0	1 I_1	1 I_0	2	ZF ← 1 if (AC, i2) = [M(HL), i2], ZF ← 0 if (AC, i2) ≠ [M(HL), i2]	Compares the bit of the accumulator specified by I_0 and I_1 with the bit of memory location HL specified by I_0 and I_1. Sets the zero flag when equal and clears the zero flag when unequal	ZF
Load and store instructions													
LAE	Load AC and E from M2(HL)	0	1	0	1	1	1	0	0	1	AC ← M(HL), E ← M(HL + 1)	Loads the contents of memory location HL into the accumulator and the contents of memory location HL + 1, into register E	
LAI i4	Load AC with immediate data	1	0	0	0	I_3	I_2	I_1	I_0	1	AC ← $I_3\ I_2\ I_1\ I_0$	Loads immediate data I_0 to I_3 into the accumulator. Vertical skip function available	ZF
LADR i8	Load AC from M direct	1 I_7	1 I_6	0 I_5	0 I_4	0 I_3	0 I_2	0 I_1	1 I_0	2	AC ← [M(i8)]	Loads the contents of the memory location specified by immediate data I_0 to I_7 into the accumulator	ZF
S	Store AC to M	0	1	0	0	0	1	1	1	1	M(HL) ← (AC)	Stores the contents of the accumulator in memory location HL	
SAE	Store AC and E to M2(HL)	0	1	0	1	1	1	1	0	1	M(HL) ← (AC), M(HL + 1) ← (E)	Stores the contents of the accumulator in memory location HL, and the contents of register E, in memory location HL + 1	
LA reg	Load AC from M(reg)	0	1	0	0	1	0	t_0	0	1	AC ← [M(reg)]	Loads the contents of the memory location specified by t_0 into the accumulator Register: HL — t_0: 0; XY — t_0: 1	ZF
LA reg, I	Load AC from M(reg) then increment reg	0	1	0	0	1	0	t_0	1	2	AC ← [M(reg)], DP_L ← (DP_L) + 1 or DPY ← (DPY) + 1	Loads the contents of the memory location specified by t_0 into the accumulator and increments the lower nibble of the corresponding memory location data pointer. Register: HL — t_0: 0; XY — t_0: 1 The zero flag is set according to the data pointer increment operation.	ZF
LA reg, D	Load AC from M(reg) then decrement reg	0	1	0	1	1	0	t_0	1	2	AC ← [M(reg)], DP_L ← (DP_L) − 1 or DPY ← (DPY) − 1	Loads the contents of the memory location specified by t_0 into the accumulator and decrements the lower nibble of the corresponding memory location data pointer. Register: HL — t_0: 0; XY — t_0: 1 The zero flag is set according to the data pointer decrement operation.	ZF
XA reg	Exchange AC with M(reg)	0	1	0	0	1	1	t_0	0	1	(AC) ↔ [M(reg)]	Exchanges the contents of the accumulator with the contents of the memory location specified by t_0 Register: HL — t_0: 0; XY — t_0: 1	

Mnemonic	Operation	Instruction code D7	D6	D5	D4	D3	D2	D1	D0	Cycles	Notation	Description	Status flags
XA reg, I	Exchange AC with M(reg) then increment reg	0	1	0	0	1	1	t_0	1	2	(AC) ↔ [M(reg)], DP_L ← (DP_L) + 1 or DP_Y ← (DP_Y) + 1	Exchanges the contents of the accumulator with the contents of the memory location specified by t_0 and increments the lower nibble of the corresponding memory location data pointer. Register: HL, t_0 = 0; XY, t_0 = 1 The zero flag is set according to the data pointer increment operation.	ZF
XA reg, D	Exchange AC with M(reg) then decrement reg	0	1	0	1	1	1	t_0	1	2	(AC) ↔ [M(reg)], DP_L ← (DP_L) − 1 or DP_Y ← (DP_Y) − 1	Exchanges the contents of the accumulator with the contents of the memory location specified by t_0 and decrements the lower nibble of the corresponding memory location data pointer. Register: HL, t_0 = 0; XY, t_0 = 1 The zero flag is set according to the data pointer decrement operation.	ZF
XADR i8	Exchange AC with M direct	1 I_7	1 I_6	0 I_5	0 I_4	1 I_3	0 I_2	0 I_1	0 I_0	2	(AC) ↔ [M(i8)]	Exchanges the contents of the accumulator with the contents of the memory location specified by immediate data I_0 to I_7	
LEAI i8	Load E and AC with immediate data	1 I_7	1 I_6	0 I_5	0 I_4	0 I_3	1 I_2	1 I_1	0 I_0	2	E ← I_7 I_6 I_5 I_4, AC ← I_3 I_2 I_1 I_0	Loads immediate data I_4 to I_7 into register E, and immediate data I_0 to I_3, into the accumulator	
RTBL	Read table data from program ROM	0	1	0	1	1	0	1	0	2	E, AC ← [ROM(PCh, E, AC)]	Loads the upper nibble of the memory location specified by the program counter (the lower 8 bits are replaced by the contents of register E and the accumulator) into register E, and the upper nibble, into the accumulator	
RTBLP	Read table data from program ROM then output to P4 and P5	0	1	0	1	1	0	0	0	2	Ports 4 and 5 ← [ROM(PCh, E, AC)]	Loads the upper nibble of the memory location specified by the program counter (the lower 8 bits are replaced by the contents of register E and the accumulator) into port P4, and the upper nibble, into port P5	
Data pointer instructions													
LDZ i4	Load DP_H with zero and DP_L with immediate data	0	1	1	0	I_3	I_2	I_1	I_0	1	DP_H ← 0, DP_L ← I_3 I_2 I_1 I_0	Clears the contents of the upper nibble of data pointer DP_{HL} and loads immediate data I_0 to I_3 into the lower nibble of data pointer DP_{HL}	
LHI i4	Load DP_H with immediate data	1 0	1 0	0 0	0 0	1 I_3	1 I_2	1 I_1	1 I_0	2	DP_H ← I_3 I_2 I_1 I_0	Loads immediate data I_0 to I_3 into the upper nibble of data pointer DP_{HL}	
LLI i4	Load DP_L with immediate data	1 0	1 0	0 0	0 1	1 I_3	1 I_2	1 I_1	1 I_0	2	DP_L ← I_3 I_2 I_1 I_0	Loads immediate data I_0 to I_3 into the lower nibble of data pointer DP_{HL}	
LHLI i8	Load DP_H, DP_L with immediate data	1 I_7	1 I_6	0 I_5	0 I_4	0 I_3	0 I_2	0 I_1	0 I_0	2	DP_H ← I_7 I_6 I_5 I_4, DP_L ← I_3 I_2 I_1 I_0	Loads immediate data I_0 to I_7 into the data pointer DP_{HL}	
LXYI i8	Load DP_X, DP_Y with immediate data	1 I_7	1 I_6	0 I_5	0 I_4	0 I_3	0 I_2	1 I_1	0 I_0	2	DP_X ← I_7 I_6 I_5 I_4, DP_Y ← I_3 I_2 I_1 I_0	Loads immediate data I_0 to I_7 into the auxiliary data pointer DP_{XY}	
IL	Increment DP_L	0	0	0	1	0	0	0	1	1	DP_L ← (DP_L) + 1	Increments the contents of the lower nibble of data pointer DP_{HL} by 1	ZF
DL	Decrement DP_L	0	0	1	0	0	0	0	1	1	DP_L ← (DP_L) − 1	Decrements the contents of the lower nibble of data pointer DP_{HL} by 1	ZF
IY	Increment DP_Y	0	0	0	1	0	0	1	1	1	DP_Y ← (DP_Y) + 1	Increments the contents of the lower nibble of auxiliary data pointer DP_{XY}	ZF
DY	Decrement DP_Y	0	0	1	0	0	0	1	1	1	DP_Y ← (DP_Y) − 1	Decrements the contents of the lower nibble of auxiliary data pointer DP_{XY}	ZF
TAH	Transfer AC to DP_H	1 1	1 1	0 1	0 1	1 0	1 0	1 0	1 0	2	DP_H ← (AC)	Copies the contents of the accumulator into the upper nibble of data pointer DP_{HL}	
THA	Transfer DP_H to AC	1 1	1 1	0 1	0 0	1 0	1 0	1 0	1 0	2	AC ← (DP_H)	Copies the contents of the upper nibble of data pointer DP_{HL} into the accumulator	ZF
XAH	Exchange AC with DP_H	0	1	0	0	0	0	0	0	1	(AC) ↔ (DP_H)	Exchanges the contents of the accumulator with the contents of the upper nibble of data pointer DP_{HL}	
TAL	Transfer AC to DP_L	1 1	1 1	0 1	0 1	1 0	1 0	1 0	1 1	2	DP_L ← (AC)	Copies the contents of the lower nibble of data pointer DP_{HL} into the accumulator	

Mnemonic	Operation	Instruction code D7	D6	D5	D4	D3	D2	D1	D0	Cycles	Notation	Description	Status flags
TLA	Transfer DP_L to AC	1	1	0	0	1	1	1	1	2	AC ← (DP_L)	Copies the contents of the accumulator into the lower nibble of data pointer DP_{HL}	ZF
		1	1	1	0	0	0	0	1				
XAL	Exchange AC with DP_L	0	1	0	0	0	0	0	1	1	(AC) ↔ (DP_L)	Exchanges the contents of the accumulator with the contents of the lower nibble of data pointer DP_{HL}	
TAX	Transfer AC to DP_X	1	1	0	0	1	1	1	0	2	DP_X ← (AC)	Copies the contents of the accumulator into the upper nibble of auxiliary data pointer DP_{XY}	
		1	1	1	1	0	0	1	0				
TXA	Transfer DP_X to AC	1	1	0	0	1	1	1	0	2	AC ← (DP_X)	Copies the contents of the upper nibble of auxiliary data pointer DP_{XY} into the accumulator	ZF
		1	1	1	0	0	0	1	0				
XAX	Exchange AC with DP_X	0	1	0	0	0	0	1	0	1	(AC) ↔ (DP_X)	Exchanges the contents of the accumulator with the contents of the upper nibble of auxiliary data pointer DP_{XY}	
TAY	Transfer AC to DP_Y	1	1	0	0	1	1	1	1	2	DP_Y ← (AC)	Copies the contents of the accumulator into the lower nibble of auxiliary data pointer DP_{XY}	
		1	1	1	1	0	0	1	1				
TYA	Transfer DP_Y to AC	1	1	0	0	1	1	1	1	2	AC ← (DP_Y)	Copies the contents of the lower nibble of auxiliary data pointer DP_{XY} into the accumulator	ZF
		1	1	1	0	0	0	1	1				
XAY	Exchange AC with DP_Y	0	1	0	0	0	0	1	1	1	(AC) ↔ (DP_Y)	Exchanges the contents of the accumulator with the contents of the lower nibble of auxiliary data pointer DP_{XY}	
Flag instructions													
SFB n4	Set flag bit	0	1	1	1	n 3	n 2	n 1	n 0	1	Fn ← 1	Sets the flag specified by n_0 to n_3	
RFB n4	Reset flag bit	0	0	1	1	n 3	n 2	n 1	n 0	1	Fn ← 0	Clears the flag specified by n_0 to n_3	ZF
Jump and call instructions													
JMP addr	Jump in the current bank	1 P 7	1 P 6	1 P 5	0 P 4	P 11 P 3	P 10 P 2	P 9 P 1	P 8 P 0	2	PC12 ← PC12, PC11 to 0 ← P_{11} to P_0	Jumps within the same bank to the address specified by the program counter (the lower 12 bits are replaced by immediate data P_0 to P_{11})	
JPEA	Jump to the address stored at E and AC in the current page	0	0	1	0	0	1	1	1	1	PC12 to PC8 ← PC12 to PC8, PC7 to 4 ← (E), PC3 to 0 ← (AC)	Jumps within the current page to the address specified by the program counter (the lower 8 bits are replaced by the contents of register E and the accumulator)	
CAL addr	Call subroutine	0 P 7	1 P 6	0 P 5	1 P 4	0 P 3	P 9 P 2	P 9 P 1	P 8 P 0	2	PC12 and 11 ← 0, PC10 to 0 ← P_{10} to P_0, M4(SP) ← (CF, ZF, PC12 to 0), SP ← (SP) − 4	Calls a subroutine at the address specified by P_0 to P_{10}	
CZP addr	Call subroutine in the zero page	1	0	1	0	P 3	P 2	P 1	P 0	2	PC12 to 6, PC1 to 0 ← 0, PC5 to 2 ← P_3 to P_0, M4(SP) ← (CF, ZF, PC12 to 0), SP ← SP − 4	Calls a subroutine within page 0 of bank 0 at the address specified by P_0 to P_3	
BANK	Change bank	0	0	0	1	1	0	1	1	1		Changes memory bank or register bank	
PUSH reg	Push reg on M2(SP)	1	1	0	0	1	1	1	0	2	M2(SP) ← (reg), SP ← (SP) − 2	Pushes the contents of the register specified by i_0 and i_1 onto the stack and decrements the stack pointer by 2	
		1	1	0	0	1	i_1	i_0	0				
POP reg	Pop reg off M2(SP)	1	1	0	0	1	1	1	0	2	SP ← (SP) + 2, reg ← [M2(SP)]	Increments the stack pointer by 2, pops the contents off the stack and moves the contents into the register specified by i_0 and i_1	
		1	1	0	0	1	i_1	i_0	0				

Register	i_1	i_0
HL	0	0
XY	0	1
AE	1	0
Illegal	1	1

Mnemonic	Operation	Instruction code D7	D6	D5	D4	D3	D2	D1	D0	Cycles	Notation	Description	Status flags
RT	Return from subroutine	0	0	0	1	1	1	0	0	2	SP ← (SP) + 4, PC ← [M4(SP)]	Returns from a subroutine or an interrupt service routine, but does not restore the state of the zero and carry flags	
RTI	Return from interrupt subroutine	0	0	0	1	1	1	0	1	2	SP ← (SP) + 4, PC ← [M4(SP)], CF, ZF ← [M4(SP)]	Returns from a subroutine or an interrupt service routine, including the state of the zero and carry flags	ZF, CF
Branch instructions													
BAt2 addr	Branch on AC bit	1 P 7	1 P 6	0 P 5	1 P 4	0 P 3	0 P 2	t_1 P 1	t_0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if (AC, t2) = 1	Tests the bit specified by immediate data t_0 and t_1 of the accumulator and, if set, branches within the same page to the address specified by P_0 to P_7	
BNAt2 addr	Branch on no AC bit	1 P 7	0 P 6	0 P 5	1 P 4	0 P 3	0 P 2	t_1 P 1	t_0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if (AC, t2) = 0	Tests the bit specified by immediate data t_0 and t_1 of the accumulator and, if not set, branches within the same page to the address specified by P_0 to P_7	
BMt2 addr	Branch on M bit	1 P 7	1 P 6	0 P 5	1 P 4	0 P 3	1 P 2	t_1 P 1	t_0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if [M(HL), t2] = 1	Tests the bit specified by immediate data t_0 and t_1 of memory location HL and, if set, branches within the same page to the address specified by P_0 to P_7	
BNMt2 addr	Branch on no M bit	1 P 7	0 P 6	0 P 5	1 P 4	0 P 3	1 P 2	t_1 P 1	t_0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if [M(HL), t2] = 0	Tests the bit specified by immediate data t_0 and t_1 of memory location HL and, if not set, branches within the same page to the address specified by P_0 to P_7	
BPt2 addr	Branch on port bit	1 P 7	1 P 6	0 P 5	1 P 4	1 P 3	0 P 2	t_1 P 1	t_0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if [P(DPL), t2] = 1	Tests the bit specified by immediate data t_0 and t_1 of the port specified by the contents of the lower nibble of data pointer DP_{HL} and, if set, branches within the same page to the address specified by P_0 to P_7. When followed by bank instructions, the internal control registers are also valid (read-only registers).	
BNPt2 addr	Branch on no port bit	1 P 7	0 P 6	0 P 5	1 P 4	1 P 3	0 P 2	t_1 P 1	t_0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if [P(DPL), t2] = 0	Tests the bit specified by immediate data t_0 and t_1 of the port specified by the contents of the lower nibble of data pointer DP_{HL} and, if not set, branches within the same page to the address specified by P_0 to P_7. When followed by bank instructions, the internal control registers are also valid (read-only registers).	
BC addr	Branch on CF	1 P 7	1 P 6	0 P 5	1 P 4	1 P 3	1 P 2	0 P 1	0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if (CF) = 1	Tests the carry flag and, if set, branches within the same page to the address specified by P_0 to P_7	
BNC addr	Branch on no CF	1 P 7	0 P 6	0 P 5	1 P 4	1 P 3	1 P 2	0 P 1	0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if (CF) = 0	Tests the carry flag and, if not set, branches within the same page to the address specified by P_0 to P_7	
BZ addr	Branch on ZF	1 P 7	1 P 6	0 P 5	1 P 4	1 P 3	1 P 2	0 P 1	1 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if (ZF) = 1	Tests the zero flag and, if set, branches within the same page to the address specified by P_0 to P_7	
BNZ addr	Branch on no ZF	1 P 7	0 P 6	0 P 5	1 P 4	1 P 3	1 P 2	0 P 1	1 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if (ZF) = 0	Tests the zero flag and, if not set, branches within the same page to the address specified by P_0 to P_7	
BFn4 addr	Branch on flag bit	1 P 7	1 P 6	1 P 5	1 P 4	n 3 P 3	n 2 P 2	n 1 P 1	n 0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if (Fn) = 1	Tests the flag specified by n_0 to n_3 and, if set, branches within the same page to the address specified by P_0 to P_7	
BNFn4 addr	Branch on no flag bit	1 P 7	0 P 6	1 P 5	1 P 4	n 3 P 3	n 2 P 2	n 1 P 1	n 0 P 0	2	PC7 to 0 ← P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 if (Fn) = 0	Tests the flag specified by n_0 to n_3 and, if not set, branches within the same page to the address specified by P_0 to P_7	
Input and output instructions													
IP0	Input port 0 to AC	0	0	1	0	0	0	0	0	1	AC ← (P0)	Loads the contents of input port P0 into the accumulator	ZF
IP	Input port to AC	0	0	1	0	0	1	1	0	1	AC ← [P(DPL)]	Loads the contents of the input port specified by the contents of the lower nibble of data pointer DP_{HL} into the accumulator	ZF
IPM	Input port to M	0	0	0	1	1	0	0	1	1	M(HL) ← [P(DPL)]	Loads the contents of the input port specified by the contents of the lower nibble of data pointer DP_{HL} into memory location HL	
IPDR i4	Input port to AC direct	1 0	1 1	0 1	0 0	1 I_3	1 I_2	1 I_1	1 I_0	2	AC ← [P(i4)]	Loads the contents of the input port specified by immediate data I_0 to I_3 into the accumulator	ZF
IP45	Input ports 4 and 5 to E and AC, respectively	1 1	1 1	0 0	0 1	1 0	1 1	1 0	1 0	2	E ← [P(4)], AC ← [P(5)]	Loads the contents of input ports P4 and P5 into register E and the accumulator, respectively	

Mnemonic	Operation	Instruction code D7	D6	D5	D4	D3	D2	D1	D0	Cycles	Notation	Description	Status flags
OP	Output AC to port	0	0	1	0	0	1	0	1	1	P(DPL) ← (AC)	Loads the contents of the accumulator into the output port specified by the contents of the lower nibble of data pointer DP_{HL}	
OPM	Output M to port	0	0	0	1	1	0	1	0	1	P(DPL) ← [M(HL)]	Loads the contents of memory location HL into the output port specified by the lower nibble of data pointer DP_{HL}	
OPDR i4	Output AC to port direct	1 0	1 1	0 1	0 1	1 I_3	1 I_2	1 I_1	1 I_0	2	P(i4) ← (AC)	Loads the contents of the accumulator into the output port specified by immediate data I_0 to I_3	
OP45	Output E and AC to ports 4 and 5, respectively	1 1	1 1	0 0	0 1	1 0	1 1	1 0	1 1	2	P(4) ← (E), P(5) ← (AC)	Loads the contents of register E and the accumulator into ports P4 and P5, respectively	
SPB t2	Set port bit	0	0	0	0	1	0	I_1	I_0	1	[P(DPL), t2] ← 1	Sets the bit specified by immediate data I_0 and I_1 of the output port specified by the lower nibble of data pointer DP_{HL}	
RPB t2	Reset port bit	0	0	1	0	1	0	I_1	I_0	1	[P(DPL), t2] ← 0	Clears the bit specified by immediate data I_0 and I_1 of the output port specified by the lower nibble of data pointer DP_{HL}	ZF
ANDPDR i4, p4	AND port with immediate data then output	1 I_3	1 I_2	0 I_1	0 I_0	0 P 3	1 P 2	0 P 1	1 P 0	2	P(P_3 to P_0) ← [P(P_3 to P_0)] • I_3 to I_0	Takes the logical AND of the contents of the port specified by P_0 to P_3 with immediate data I_0 to I_3 and loads the result into the port	ZF
ORPDR i4, p4	OR port with immediate data then output	1 I_3	1 I_2	0 I_1	0 I_0	0 P 3	1 P 2	0 P 1	0 P 0	2	P(P_3 to P_0) ← [P(P_3 to P_0)] + I_3 to I_0	Takes the logical OR of the contents of the port specified by P_0 to P_3 with immediate data I_0 to I_3 and loads the result into the port	ZF
Timer control instructions													
WTTM0	Write timer 0	1	1	0	0	1	0	1	0	2	TIMER0 ← [M2(HL)] and (AC)	Writes the contents of memory locations HL and HL + 1 and the contents of the accumulator into the timer 0 reload register	
WTTM1	Write timer 1	1 1	1 1	0 1	0 1	1 0	1 1	1 0	1 0	2	TIMER1 ← (E) and (AC)	Writes the contents of register E and the accumulator into the timer 0 reload register	
RTIM0	Read timer 0	1	1	0	0	1	0	1	1	2	M2(HL) and AC ← (TIMER0)	Reads the contents of the timer 0 counter into memory locations HL and HL + 1 and the accumulator	
RTIM1	Read timer 1	1 1	1 1	0 1	0 1	1 0	1 1	1 0	1 1	2	E and AC ← (TIMER1)	Reads the contents of the timer 1 counter into register E and the accumulator	
START0	Start timer 0	1 1	1 1	0 1	0 0	1 0	1 1	1 1	1 0	2	Start timer 0 counter	Starts the timer 0 counter	
START1	Start timer 1	1 1	1 1	0 1	0 0	1 0	1 1	1 1	1 1	2	Start timer 1 counter	Starts the timer 1 counter	
STOP0	Stop timer 0	1 1	1 1	0 1	0 0	1 0	1 1	1 1	1 0	2	Stop timer 0 counter	Stops the timer 0 counter	
STOP1	Stop timer 1	1 1	1 1	0 1	0 0	1 0	1 1	1 1	1 1	2	Stop timer 1 counter	Stops the timer 1 counter	
Interrupt control instructions													
MSET	Set interrupt Master Enable flag	1 0	1 1	0 0	0 1	1 0	1 0	0 0	1 0	2	MSE ← 1	Sets the interrupt master enable flag	
MRESET	Reset interrupt Master Enable flag	1 1	1 0	0 0	0 1	1 0	1 0	0 0	1 0	2	MSE ← 0	Clears the interrupt master enable flag	
EIH i4	Enable interrupt HIGH	1 0	1 1	0 0	0 1	1 I_3	1 I_2	0 I_1	1 I_0	2	EDIH ← (EDIH) + i4	Takes the logical OR of the interrupt mask with immediate data I_0 to I_3 and, for bits that are set, enables the corresponding active-HIGH interrupts	
EIL i4	Enable interrupt LOW	1 0	1 1	0 0	0 0	1 I_3	1 I_2	0 I_1	1 I_0	2	EDIL ← (EDIL) + i4	Takes the logical OR of the interrupt mask with immediate data I_0 to I_3 and, for bits that are set, enables the corresponding active-LOW interrupts	
DIH i4	Disable interrupt HIGH	1 1	1 0	0 0	0 1	1 I_3	1 I_2	0 I_1	1 I_0	2	EDIH ← (EDIH) • $\overline{i4}$	Takes the logical AND of the interrupt mask with the 1s complement of immediate data I_0 to I_3 and, for bits that are set, disables the corresponding active-HIGH interrupts	ZF
DIL i4	Disable interrupt LOW	1 1	1 0	0 0	0 0	1 I_3	1 I_2	0 I_1	1 I_0	2	EDIL ← (EDIL) • $\overline{i4}$	Takes the logical AND of the interrupt mask with the 1s complement of immediate data I_0 to I_3 and, for bits that are set, disables the corresponding active-LOW interrupts	ZF
WTSP	Write SP	1 1	1 1	0 0	0 1	1 1	1 0	1 1	1 0	2	SP ← (E), (AC)	Writes the contents of register E and the accumulator into the stack pointer	
RSP	Read SP	1 1	1 1	0 0	0 1	1 1	1 0	1 1	1 1	2	E, AC ← (SP)	Reads the contents of the stack pointer into register E and the accumulator	

Mnemonic	Operation	Instruction code								Cycles	Notation	Description	Status flags
		D7	D6	D5	D4	D3	D2	D1	D0				
Standby control instructions													
HALT	Halt	1	1	0	0	1	1	1	0	2	Halt	Selects halt mode	
		1	1	0	1	1	1	1	0				
HOLD	Hold	1	1	0	0	1	1	1	1	2	Hold	Selects hold mode	
		1	1	0	1	1	1	1	1				
Serial input/output control instructions													
STARTS	Start serial I/O	1	1	0	0	1	1	1	0	2	START SIO	Starts serial input/output operation	
		1	1	0	1	1	1	1	0				
WTSIO	Write serial I/O	1	1	0	0	1	1	1	1	2	SIO ← (E) and (AC)	Writes the contents of register E and the accumulator into the serial input/output port	
		1	1	0	1	1	1	1	1				
RSIO	Read serial I/O	1	1	0	0	1	1	1	1	2	E and AC ← (SIO)	Reads the serial input/output port into register E and the accumulator	
		1	1	0	1	1	1	1	1				
Miscellaneous instructions													
NOP	No operation	0	0	0	0	0	0	0	0	1	No operation	No operation for one cycle	
SB i2	Select bank	1	1	0	0	1	1	1	1	2	PC12 ← I_1 I_0	Selects the memory bank specified by immediate data I_0 and I_1	
		1	1	0	0	1	0	I_1	I_0				

Note

The range of values for i2 in the SB instruction varies according to the device. Refer to the *LC66S Jump Optimizing Cross Assembler Manual*.