HTG13J0
4-Bit Microcontroller

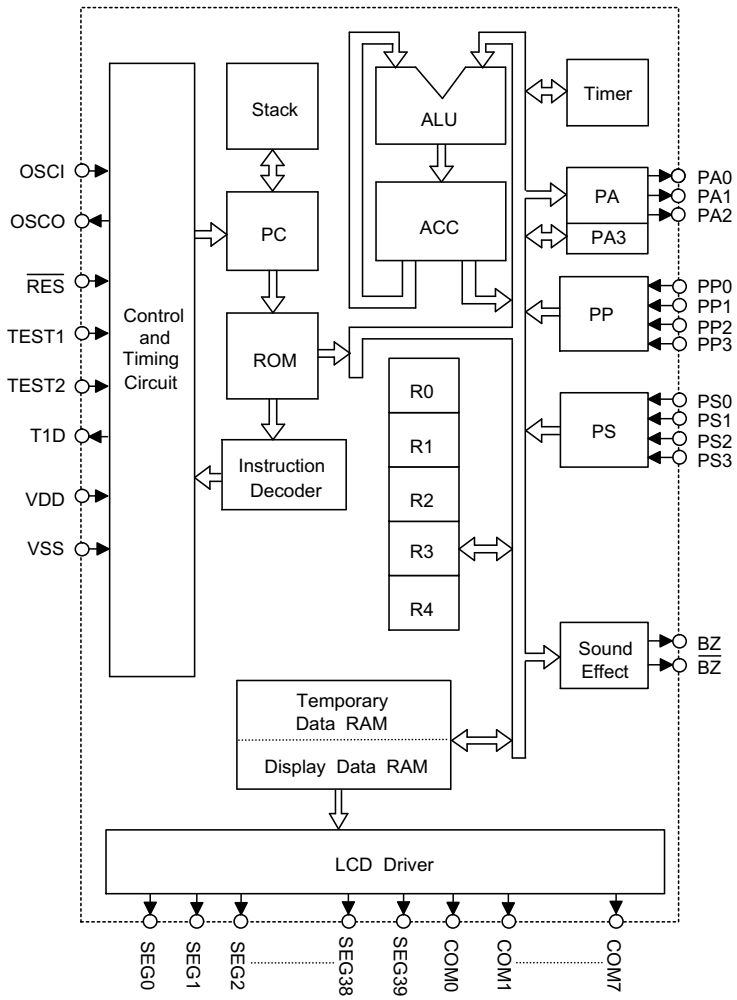
Features

Operating voltage: 2.4V~3.3V
Eight input lines
Three output lines
Five working registers
RC oscillator for system clock
8K 8 program ROM
160 4 data RAM
40 8 segment LCD driver, 1/5 bias, 1/8 duty
8-bit programmable timer with built-in frequency source
Internal timer overflow interrupt
16 kinds of programmable sound effect
One-level subroutine nesting
Halt function and wake up feature reduce power consumption
Halt instruction
8-bit table read instruction
Up to 4.0 sec instruction cycle
(1.0MHz system clock), at V_{DD}=3V
96 powerful instructions

General Description

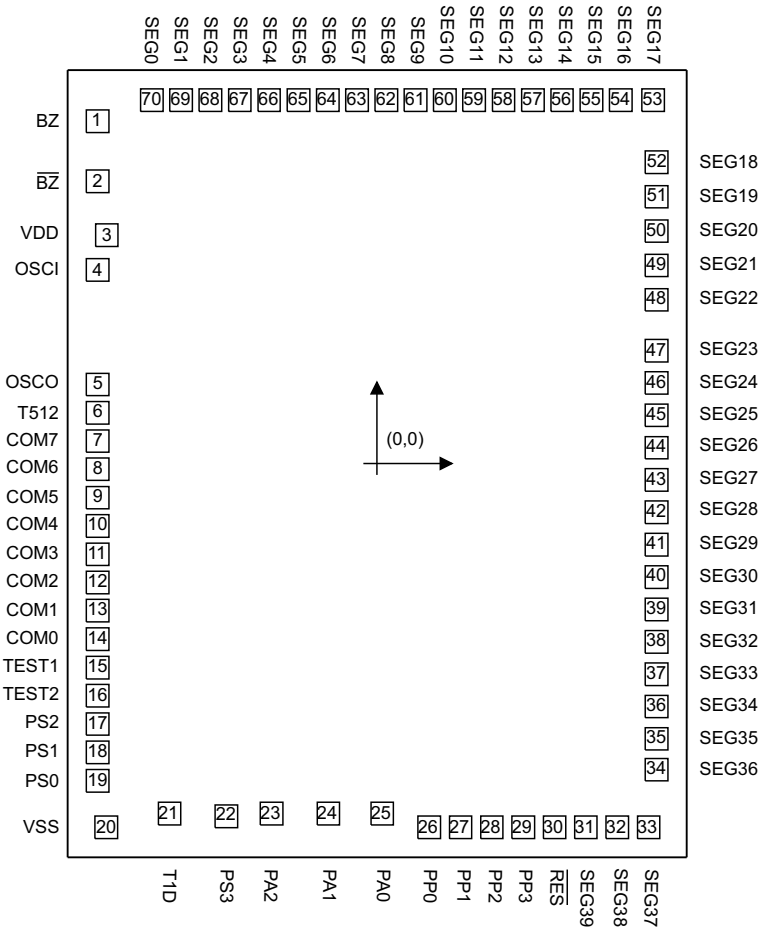
The HTG13J0 is a processor from Holtek s 4-bit stand alone single chip microcontroller specially designed for LCD product applications. It is especially suited for applications requiring low power consumption system with many LCD segments, such as calculator, scale, subsystem controller, hand-held LCD products and electronic appliances.

Block Diagram



Notes: ACC: Accumulator
PC: Program counter
R0~R4: Working registers
PA0~PA2: Output port
PP, PS: Input ports
PA3: ROM bank switch

Pad Assignment



Chip size: 2746 3552 (m)^2

* The IC substrate should be connected to VSS in the PCB layout artwork.

Pad Coordinates

Unit: m

Pad No.	X	Y	Pad No.	X	Y
1	1244.25	1523.47	36	1244.25	1080.67
2	1244.25	1256.62	37	1244.25	936.67
3	1203.75	1017.25	38	1244.25	792.67
4	1244.25	861.97	39	1244.25	648.67
5	1244.25	353.02	40	1244.25	504.67
6	1244.25	227.02	41	1244.25	360.67
7	1244.25	101.03	42	1244.25	216.68
8	1244.25	24.98	43	1244.25	72.68
9	1244.25	150.98	44	1244.25	71.32
10	1244.25	276.98	45	1244.25	215.32
11	1244.25	402.98	46	1244.25	359.33
12	1244.25	528.97	47	1244.25	503.33
13	1244.25	654.97	48	1244.25	729.22
14	1244.25	780.97	49	1244.25	882.22
15	1244.25	906.97	50	1244.25	1035.22
16	1244.25	1032.97	51	1244.25	1188.22
17	1244.25	1158.97	52	1244.25	1341.22
18	1244.25	1284.97	53	1228.95	1617.53
19	1244.25	1410.97	54	1084.95	1617.53
20	1206.45	1617.53	55	954.45	1617.53
21	923.85	1556.78	56	823.95	1617.53
22	671.40	1568.47	57	693.45	1617.53
23	469.35	1556.78	58	562.95	1617.53
24	217.35	1556.78	59	432.45	1617.53
25	22.95	1556.78	60	301.95	1617.53
26	232.20	1617.53	61	171.45	1617.53
27	371.70	1617.53	62	40.95	1617.53
28	511.20	1617.53	63	89.55	1617.53
29	650.70	1617.53	64	220.05	1617.53
30	790.20	1617.53	65	350.55	1617.53
31	929.70	1617.53	66	481.05	1617.53
32	1069.20	1617.53	67	611.55	1617.53
33	1208.70	1617.53	68	742.05	1617.53
34	1244.25	1361.03	69	872.55	1617.53
35	1244.25	1224.67	70	1003.05	1617.53

Pad Description

Pad No.	Pad name	I/O	Mask Option	Description
1 2	BZ $\overline{BZ}$	O	*	Sound effect output
3	VDD	I		Positive power supply
4 5	OSCI OSCO	I O		OSCI, OSCO are connected to resistor for internal system clock.
6 15 16 21	T512 TEST1 TEST2 T1D	O I I O		For test mode only TEST1 and TEST2 must be open when the chip is in normal operation (with internal pull high resistor).
7~14	COM7~COM0	O		Output for LCD panel common plate
17~19 22	PS2~PS0 PS3	I	Pull-high or None **	4-bit port for input only
20	VSS	I		Negative power supply, GND
23~25	PA2~PA0	O	CMOS or NMOS Open Drain	3-bit latch port for output only
26~29	PP0~PP3	I	Pull-high or None **	4-bit port for input only
30	$\overline{RES}$	I		Input to reset LSI Reset is active at logical low level.
31~70	SEG39~SEG0	O		LCD driver outputs for LCD panel segment

*: 6 internal sources deriving from system clock can be selected as sound effect clock by mask option. If Holtek s sound library is invoked, only 128K and 64K is accepted.

**: Each bit of input ports PS, PP can be a trigger source of HALT interrupt. That can be specified by mask option.

Absolute Maximum Ratings

Supply Voltage ..... 0.3V to 5.5V

Input Voltage .....V_{SS} 0.3V to V_{DD}+0.3V

Storage Temperature ..... 50 C to 125 C

Operating Temperature .....0 C to 70 C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

D.C. Characteristics

Ta=25 C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage			2.4		3.3	V
I_{DD}	Operating Current	3V	No load, f_{SYS}=500kHz		200	500	A
I_{STB}	Standby Current	3V	System halt			1	A
V_{IL1}	Input Low Voltage PS, PP	3V		0		0.6	V
V_{IH1}	Input High Voltage PS, PP	3V		2.1		3.0	V
V_{IL2}	Input Low Voltage $\overline{RES}$	3V		0		0.6	V
V_{IH2}	Input High Voltage $\overline{RES}$	3V		2.6		3.0	V
I_{OL1}	Port A, BZ and $\overline{BZ}$ Output Sink Current	3V	V_{DD}=3V, V_{OL}=0.3V	1.5	3.0		mA
I_{OH1}	Port A, BZ and $\overline{BZ}$ Output Source Current	3V	V_{DD}=3V, V_{OH}=2.7V	0.8	1.5		mA
I_{OL2}	Segment 0~7 Output Sink Current	3V	V_{LCD}=3V, V_{OL}=0.3V	80	130		A
I_{OH2}	Segment 0~7 Output Source Current	3V	V_{LCD}=3V, V_{OH}=2.7V	50	90		A
I_{OL3}	Segment 8~39 Output Sink Current	3V	V_{LCD}=3V, V_{OL}=0.3V	40	80		A
I_{OH3}	Segment 8~39 Output Source Current	3V	V_{LCD}=3V, V_{OH}=2.7V	30	60		A
I_{OL4}	Common Sink Current	3V	V_{LCD}=3V, V_{OL}=0.3V	60	120		A
I_{OH4}	Common Source Current	3V	V_{LCD}=3V, V_{OH}=2.7V	60	120		A
R_{PH}	Pull-high Resistance	3V	PS, PP, $\overline{RES}$	50		300	k

A.C. Characteristics

Ta=25 C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
f_{SYS}	System Clock	3V	R:680k ~5k	32		1000	kHz
f_{LCD}	LCD Clock	3V			512*		Hz
t_{COM}	LCD Common Period		1/8 duty		$(1/f_{LCD})$ 8		Sec
t_{CY}	Cycle Time		f_{SYS}=1.0MHz		4.0		s
t_{RES}	Reset Pulse Width			5			ms
f_{SOUND}	Sound Effect Clock				64 or 128 **		kHz

*: In general, f_{LCD} is selected and optimized by Holtek according to f_{SYS} and operating voltage.

**: Only these two clock signal frequencies are supported by the Holtek sound library.

Functional Description

Program counter – PC

The bit 13 of program memory is controlled by PA3 which can change the address of the program. There are two banks of the program memory, which are selected by PA3, every bank is 4KB ROM. The instruction "UT PA,A" is used to change the value of PA3. Then, low or high 4K ROM is selected accordingly. All instructions are not effective on crossing bank, unless the value of PA3 is changed in advance.

The 12-bit program counter (PC) controls the sequence in which the instructions stored in program ROM are executed and its contents specify a maximum of 4096 addresses.

After accessing a memory word to fetch an instruction code, the contents of the program counter are incremented by 1 or 2, then the program counter will point to the memory word containing the next instruction code.

When executing the jump instruction (JMP, JNZ, JC,JTMR...), subroutine call, internal interrupt, external interrupt or return from subroutine, the PC manipulates the program transfer by loading the address corresponding to each instruction.

Mode	Program Counter												
	PA3	PC11	PC10	PC9	PC8	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0
Initial reset	1	0	0	0	0	0	0	0	0	0	0	0	0
Internal interrupt	PA3	0	0	0	0	0	0	0	0	0	1	0	0
External interrupt	PA3	0	0	0	0	0	0	0	0	1	0	0	0
Jump, call instruction	PA3	PC11	PC10	PC9	PC8	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0
Conditional branch	PA3	@	PC10	PC9	PC8	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0
Return from subroutine	PA3	S11	S10	S9	S8	S7	S6	S5	S4	S3	S2	S1	S0

Program counter

Notes: PC11~PC0: Instruction code bits
@: PC11 keeps the current value
S11~S0: Stack register bits
PA3: Bank value bits

Program memory – ROM

The program memory is used to store program instruction which is to be executed. It is organized with 8192 8 bits and addressed by the program counter and PA3.

Certain locations in bank 0 of the program memory are reserved for specific usage:

Location 0004H
This area are reserved for TIMER interrupt service program. A timer interrupt resulting from TIMER overflow, if interrupt is enabled the CPU begins execution at location 0004H.

Location 0008H
Activating the PS or PP input pins of the processor with the interrupts enabled during HALT mode causes the program to jump to this location.

Location 0n00H~0nFFH (n=current number) and 0F00H~0FFFH.
The last 256 bytes of each page in the program memory, addressed from 0n00H to 0nFFH and 0F00H to 0FFFH can be used as a look up table. The instructions READ R4A, READ MR0A, READF R4A, READF MR0A can read the table and transfer the contents of the table to ACC and R4 or transfer to ACC and data memory addressed by register pair R1,R0 . These area may function as normal program memory depending on the requirement. Note that the page number n must be greater than zero, some locations in page 0 are reserved for specific usage as mentioned.

Certain locations in bank 1 of the program memory are reserved for specific usage:

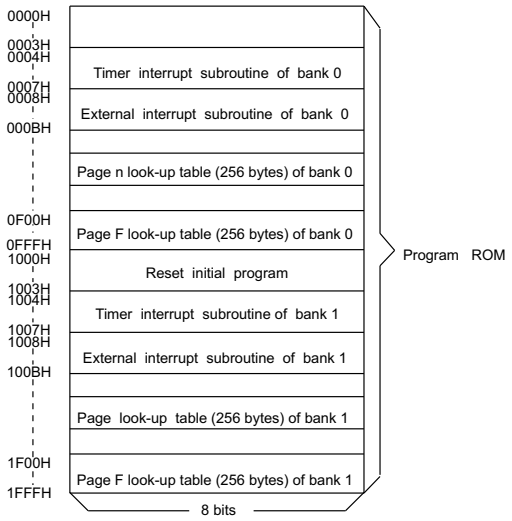
Location 1000H
This area are reserved for the initialization program. After reset, the CPU always begins execution at location 1000H.

Location 1004H
This area is reserved for TIMER interrupt service program. A timer interrupt resulting from TIMER overflow, if interrupt is enabled, the CPU begins execution at location 1004H.

Location 1008H
Activating the PS or PP input pins of the processor with the interrupts enabled during HALT mode causes the program to jump to this location.

Location 1n00H~1nFFH (n=current number) and 1F00H~1FFFH.
The last 256 bytes of each page in the program memory, addressed from 1n00H to 1nFFH and 1F00H to 1FFFH can be used as a loop up table. The instructions READ R4A, READ MR0A, READF R4A, READF MR0A can read the table and transfer the contents of the table to ACC and R4 or transfer to ACC and data memory addressed by register pair "R1,R0" These area may function as normal program memory depending on the requirement. Note that the page number n must be greater than zero, some locations in page 1 are reserved for specific usage as mentioned.

The program memory (ROM) mapping is shown below:



Program memory

In the execution of an instruction, the program counter is added before the executing phase. So a careful manipulation of READ MR0A and READ R4A is needed in the page margin.

Stack register

The stack register is a group of registers used to save the contents of the program counter (PC) and is arranged in 13 bits 1 level. One bit is used to store the carry flag. An interrupt will force the contents of the PC and the carry flag onto the stack register. A subroutine call will also cause the PC contents to be pushed onto the stack; however the carry flag will not be stored. At the end of a subroutine or an interrupt (indicated by a return instruction RET or RETI), the contents of the stack register are returned to the PC.

Executing "RETI" instruction will restore the carry flag from the stack register, but "RET" does not.

Working registers – R0,R1,R2,R3,R4

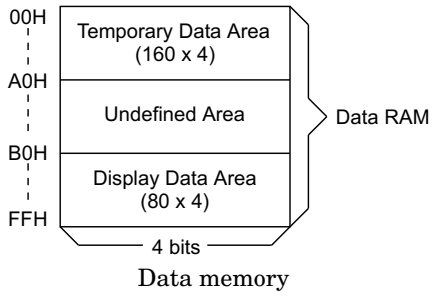
These five registers are usually used to store the frequently accessed data. The working register can be incremented (+1) or decremented (1). The JNZ Rn, address (n=0,1,4) instruction makes efficient use of the working register as a program loop counter. Also the register pairs of R1, R0 and R3, R2 can be used as the data memory pointer, when the data memory transfer instruction is executed.

Data memory – RAM

The data memory is a static RAM organized with 256 4 bit format and is used to store temporary data and display data. All of the data memory locations are indirectly addressable through the register pair "R1,R0" or "R3,R2".

There are two areas in the data memory, temporary data area and display data area. Access to the temporary data memory is made through 00H 9FH address, and access to the display data memory is made through B0H FFH address.

The locations between the temporary and display data areas are undefined and cannot be used.



Data memory

When data is written in the display area, the LCD driver automatically reads it and gene-rates an LCD driving signal.

Accumulator – ACC

The register ACC plays the most important role in data manipulation and data transfer. It is not only one of the sources of input to the ALU but also the destination of the result due to ALU. Data transfer can be performed between ACC and other registers, data memory or I/O ports.

Arithmetic and logic unit – ALU

This circuit performs arithmetic and logic operation. The ALU provides the following functions:

Arithmetic operation (ADD, ADC, SUB, SBC, DAA)

Logic operation (AND, OR, XOR)

Rotation (RL, RR, RLC, RRC)

Increment and Decrement (INC, DEC)

Branch decision (JZ, JNZ, JC, JNC...)

The ALU not only outputs the results of data operation but also sets the status of carry flag (C) in some instructions.

Timer

This is a programmable 8-bit count-up counter internal frequency sources to aid the user in counting and generate accurate time base.

The Timer is presettable and readable with software instructions. "TIMER XXH", "MOV TMRL,A" and "MOV TMRH,A" preload TIMER value. "MOV A,TMRL" and "MOV A,TMRH" read the contents of the TIMER to ACC.

The Timer is stopped by a hardware reset or "TIMER OFF" instruction and started by a TIMER ON instruction.

Once the Timer is started, it will increment to its maximum count (FFH) and overflow to zero (00H) and will not stop until there is a TIMER OFF instruction or reset. When an overflow occurs, it will set the Timer Flag (TF) simultaneously. If interrupt is enabled, the Timer circuit supports TF for internal interrupt. The state of the TF is also testable with conditional instruction JTMR.

The Timer flag is cleared after the interrupt or JTMR instruction is executed.

The frequency of internal frequency source can be selected by mask option.

$$\frac{}{2^n}$$

Where n=0, 1, 2.....13 except 6, by mask option (the sixth stage is reserved for internal use).

Interrupt

The HTG13J0 provide both internal and external interrupt modes. The DI and EI instructions are used to disable and enable the interrupts. During halt mode, if the PP or PS input pin is triggered on a high to low transition in the enable interrupt mode and the program is not within a CALL subroutine the external interrupt is activated. This causes a subroutine call to location 8 and resets the interrupt latch.

Likewise when the timer flag is set in the enable interrupt mode and the program is not within a CALL subroutine, the internal interrupt is activated. This causes a subroutine call to location 4 and resets the timer flag.

When running under a CALL subroutine or DI, the interrupt acknowledge is on hold until the RET or EI instruction is invoked. The CALL instruction should not be used within an interrupt routine as unpredictable result may occur.

If within a CALL subroutine, an interrupt occurs, the interrupt will be serviced after leaving the CALL subroutine.

The interrupts are disabled by a hardware reset or a DI instruction. They remain disabled until the EI instruction is executed.

Each input port pin can be programmed by mask option to have an external interrupt function in the HALT mode.

Initial reset

The HTG13J0 provide a $\overline{RES}$ pin for system initialization. Since the $\overline{RES}$ pin has internal pull high resistor, only an external 0.1 ~1 capacitor is needed. If the reset pulse is generated externally, it must be held low for at least 5 ms.

When $\overline{RES}$ is active, the internal block will be initialized as follows:

PA3 and PC	1000H
TIMER	Stop
Timer flag	Reset (low)
SOUND	Sound off and One sing mode
Output Port A	high (or floating state)
Interrupt	Disabled
BZ and $\overline{BZ}$ output	High level

Halt

This is a special feature of HTG13J0. It will stop the chip s normal operation and reduce power consumption. When the instruction HALT is executed, then either of the following will occur:

The system clock will be stopped

The contents of the on-chip RAM and registers remain unchanged

LCD segments and commons keep VDD voltage (i.e. LCD becomes blank)

The system can leave the HALT mode by ways of initial reset or external interrupt and wake-up from the following entry of the program counter value.

Initial reset: 1000H.
Interrupt (enabled): 1008H or 0008H.
Interrupt (disabled): next address of HALT instruction.

In HALT mode, each bit of ports PP, PS, can be used as external interrupt by mask option to wake-up the system. This signal is active in low-going transition.

Sound effect

HTG13J0 provides sound effect circuit which offers up to 16 sounds with 3 effects of tone, boom and noise. Holtek supports a sound library which have melody, alarm, machine gun shooting, etc. That can meet various requirements.

Whenever the instruction "SOUND n" or "SOUND A" is executed, the specified sound begin playing. Whenever "SOUND OFF" is executed, it terminates the singing sound immediately.

There are two singing mode, SONE mode and SLOOP mode, this is activated by "SOUND ONE" and "SOUND LOOP". In SONE mode, the sound that has been specified plays just once. In SLOOP mode, the sound being specified keeps playing repeatedly.

Since sound 0~11 contain 32 notes, sound 12~15 contain 64 notes, the later possess better sound than the former.

The frequency of sound effect circuit can be selected by mask option.

$$\frac{}{2^m}$$

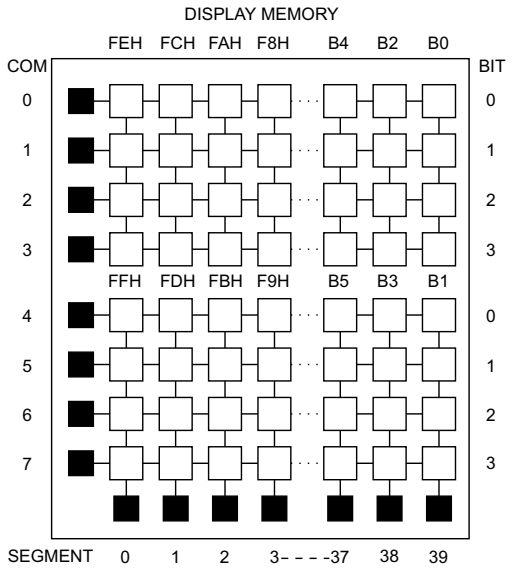
Where m=0, 1, 2, 3, 4, 5

The Holtek s sound library only supports sound clock frequency 128K or 64K. If it is desired to utilize Holtek s sound library, proper system clock and mask option should be selected.

LCD display memory

As mentioned in the data memory section, the LCD display memory is embedded in the data memory. It can be read and written to as normal data memory.

The following figure shows the mapping between display memory and LCD pattern.



LCD display memory

To turn on/off the display, the programmer just writes 1/0 to the corresponding bit of the display memory.

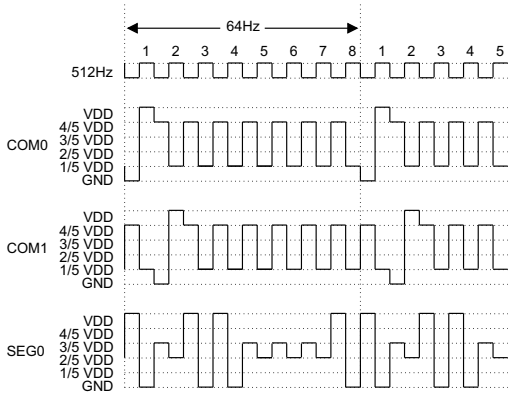
The LCD display module may have any form as long as the number commons is no more than 8 and the segment is no more than 40.

LCD driver output

The output number of the LCD driver is 40 8. That can directly drive an LCD with 1/8 duty cycle and 1/5 bias. All LCD segments are random at the initial clear mode.
The bias voltage circuit of the LCD display is built-in. No external resistor is needed.

The LCD driving clock frequency shall be fixed in 512Hz. That can not be selected by the user, and Holtek will set it according to the application.

An example of an LCD driving waveform (1/8 duty and 1/5 bias) is shown below.



Oscillator circuit

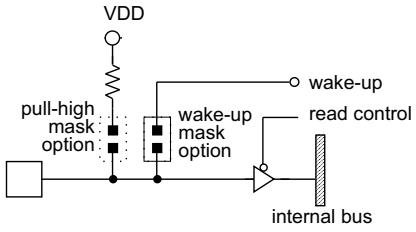
Only one external resistor is needed for HTG13J0 oscillator circuit.

The system clock is also used as the reference signal of LCD driving clock, sound effect clock, and internal TIMER frequency source.

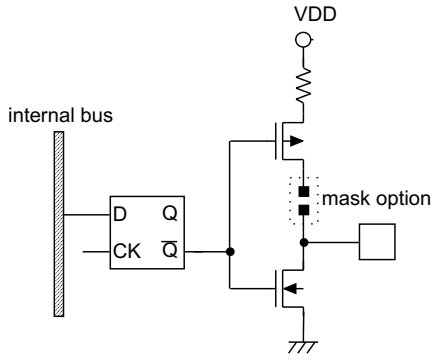
One HTG13J0 machine cycle consists of a sequence of 4 states numbered T1 to T4. Each state lasts for one oscillator period. The machine cycle is 4 s, if the system frequency is up to 1.0MHz.

Input ports PS, PP

All ports can have internal pull high resistors



determined by mask option. Every bit of the input ports PP and PS can be specified to be a trigger source to wake up the HALT interrupt by mask option. A high to low transition on one of these pins will wake up the device from a HALT status.



Output port PA0~PA2

Output port PA0~PA2

A mask option is available to select whether the output is a CMOS or open drain NMOS type. After an initial clear, the output port PA defaults high for CMOS or floating for NMOS.

Note:
PA3 controls bit 13 of the program memory. Be careful about PA3. When instruction "OUT PA,A" is operated, port A is changed as well.

Mask option

The following options are available by mask option which must be selected prior to manufacturing.

Each bit of input ports PS, PP with or without pull-high resistor.

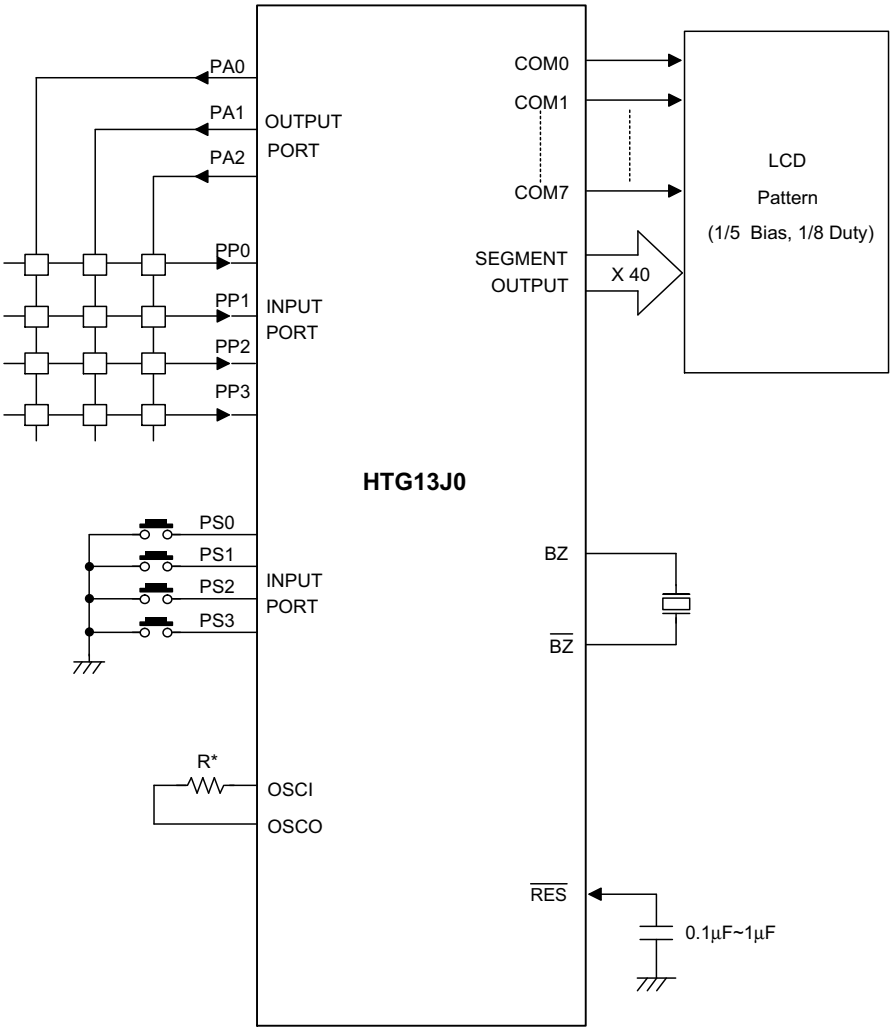
Each bit of input ports PS, PP function as HALT interrupt trigger.

Each bit of output port PA0~PA2 with CMOS or open drain NMOS.

8 bit programmable TIMER with internal frequency sources. There are 13 (the sixth stage is reserved for internal use) internal frequency sources which can be selected as clocking signal.

Six kinds of sound clock frequency:
$f_{SYS}/2^m$, m=0, 1, 2, 3, 4, 5

Application Circuits



R*: depends on the required system clock frequency (R=680k ~5k , at V_{DD}=3V)

Instruction Set Summary

Mnemonic	Description	Byte	Cycle	CF
Arithmetic				
ADD A,[R1R0]	Add data memory to ACC	1	1	
ADC A,[R1R0]	Add data memory with carry to ACC	1	1	
SUB A,[R1R0]	Subtract data memory from ACC	1	1	
SBC A,[R1R0]	Subtract data memory from ACC with borrow	1	1	
ADD A,XH	Add immediate data to ACC	2	2	
SUB A,XH	Subtract immediate data from ACC	2	2	
DAA	Decimal adjust ACC for addition	1	1	
Logic Operation				
AND A,[R1R0]	AND data memory to ACC	1	1	
OR A,[R1R0]	OR data memory to ACC	1	1	
XOR A,[R1R0]	Exclusive-OR data memory to ACC	1	1	
AND [R1R0],A	AND ACC to data memory	1	1	
OR [R1R0],A	OR ACC to data memory	1	1	
XOR [R1R0],A	Exclusive-OR ACC to data memory	1	1	
AND A,XH	AND immediate data to ACC	2	2	
OR A,XH	OR immediate data to ACC	2	2	
XOR A,XH	Exclusive-OR immediate data to ACC	2	2	
Increment and Decrement				
INC A	Increment ACC	1	1	
INC Rn	Increment register	1	1	
INC [R1R0]	Increment data memory	1	1	
INC [R3R2]	Increment data memory	1	1	
DEC A	Decrement ACC	1	1	
DEC Rn	Decrement register	1	1	
DEC [R1R0]	Decrement data memory	1	1	
DEC [R3R2]	Decrement data memory	1	1	
Data Move				
MOV A,Rn	Move register to ACC	1	1	
MOV Rn,A	Move ACC to register	1	1	
MOV A,[R1R0]	Move data memory to ACC	1	1	
MOV A,[R3R2]	Move data memory to ACC	1	1	
MOV [R1R0],A	Move ACC to data memory	1	1	
MOV [R3R2],A	Move ACC to data memory	1	1	
MOV A,XH	Move immediate data to ACC	1	1	
MOV R1R0,XXH	Move immediate data to R1 and R0	2	2	
MOV R3R2,XXH	Move immediate data to R3 and R2	2	2	
MOV R4,XH	Move immediate data to R4	2	2	

Mnemonic	Description	Byte	Cycle	CF
Rotate				
RL A	Rotate ACC left	1	1	
RLC A	Rotate ACC left through the carry	1	1	
RR A	Rotate ACC right	1	1	
RRC A	Rotate ACC right through the carry	1	1	
Input and Output				
IN A,Pi	Input port-i to ACC, port-i=PS,PP	1	1	
OUT PA,A	Output ACC to port-A	1	1	
Branch				
JMP addr	Jump unconditional	2	2	
JC addr	Jump on carry=1	2	2	
JNC addr	Jump on carry=0	2	2	
JTMR addr	Jump on timer out	2	2	
JAn addr	Jump on ACC bit n=1, n=0,1,2,3	2	2	
JZ A,addr	Jump on ACC is zero	2	2	
JNZ A,addr	Jump on ACC is not zero	2	2	
JNZ Rn,addr	Jump on register Rn not zero, n=0,1,4	2	2	
Subroutine				
CALL addr	Subroutine call	2	2	
RET	Return from subroutine or interrupt	1	1	
RETI	Return from interrupt service routine	1	1	
Flag				
CLC	Clear carry flag	1	1	0
STC	Set carry flag	1	1	1
EI	Enable interrupt	1	1	
DI	Disable interrupt	1	1	
NOP	No operation	1	1	
Timer				
TIMER XXH	Set 8 bits immediate data to TIMER	2	2	
TIMER ON	Set TIMER start counting	1	1	
TIMER OFF	Set TIMER stop counting	1	1	
MOV A,TMRL	Move low nibble of TIMER to ACC	1	1	
MOV A,TMRH	Move high nibble of TIMER to ACC	1	1	
MOV TMRL,A	Move ACC to low nibble of TIMER	1	1	
MOV TMRH,A	Move ACC to high nibble of TIMER	1	1	

Mnemonic	Description	Byte	Cycle	CF
Table Read				
READ R4A	Read ROM code of current page to R4 and ACC	1	2	
READ MR0A	Read ROM code of current page to M(R1,R0),ACC	1	2	
READF R4A	Read ROM code of page F to R4 and ACC	1	2	
READF MR0A	Read ROM code of page F to M(R1,R0),ACC	1	2	
Sound Control				
SOUND n	Active SOUND channel n	2	2	
SOUND A	Active SOUND channel with Accumulator	1	1	
SOUND ONE	Turn on SOUND one mode	1	1	
SOUND LOOP	Turn on SOUND repeat mode	1	1	
SOUND OFF	Turn off SOUND	1	1	
Miscellaneous				
HALT	Enter power down mode	2	2	

Instruction Definitions

ADC A,[R1R0] Add data memory contents and carry to accumulator

Machine Code 0 0 0 0 1 0 0 0

Description The contents of the data memory addressed by the register pair "R1,R0" and carry are added to the accumulator. Carry is affected.

Operation ACC ← ACC+M(R1,R0)+C

ADD A,XH Add immediate data to accumulator

Machine Code 0 1 0 0 0 0 0 0 0 0 0 0 d d d d

Description The specified data is added to the accumulator. Carry is affected.

Operation ACC ← ACC+XH

ADD A,[R1R0] Add data memory contents to accumulator

Machine Code 0 0 0 0 1 0 0 1

Description The contents of the data memory addressed by the register pair R1,R0" is added to the accumulator. Carry is affected.

Operation ACC ← ACC+M(R1,R0)

AND A,XH Logical AND immediate data to accumulator

Machine Code 0 1 0 0 0 0 1 0 0 0 0 0 d d d d

Description Data in the accumulator is logical AND with the immediate data specified by code.

Operation ACC ← ACC "AND" XH

AND A,[R1R0] Logical AND accumulator with data memory

Machine Code 0 0 0 1 1 0 1 0

Description Data in the accumulator is logical AND with the data memory addressed by the register pair "R1,R0".

Operation ACC ← ACC "AND" M(R1,R0)

AND [R1R0],A Logical AND data memory with accumulator

Machine Code 0 0 0 1 1 1 0 1

Description Data in the data memory addressed by the register pair "R1,R0" is logical AND with the accumulator

Operation M(R1,R0) ← M(R1,R0) "AND" ACC

CALL address Subroutine call

Machine Code 1 1 1 1 a a a a a a a a a a a a

Description The program counter bits 0 1 1 are saved in the stack. The program counter is then loaded from the directly-specified address.

Operation Stack PC+2
PC address

CLC Clear carry flag

Machine Code 0 0 1 0 1 0 1 0

Description The carry flag is reset to 0

Operation C 0

DAA Decimal Adjust accumulator

Machine Code 0 0 1 1 0 1 1 0

Description The accumulator value is adjusted to the BCD (Binary Code Decimal) code, if the contents of the accumulator is greater than 9 or C (Carry flag) is 1.

Operation If ACC>9 or CF=1 then
ACC ACC+6, C 1
else
ACC ACC, C C

DEC A Decrement accumulator

Machine Code 0 0 1 1 1 1 1 1

Description Data in the accumulator is decremented by 1. Carry flag is not affected.

Operation ACC ACC 1

DEC Rn Decrement register

Machine Code 0 0 0 1 n n n 1

Description Data in the working register "Rn" is decremented by 1. Carry flag is not affected.

Operation Rn Rn 1; Rn=R0, R1, R2, R3, R4, for n=0, 1, 2, 3, 4

DEC [R1R0] Decrement data memory

Machine Code 0 0 0 0 1 1 0 1

Description Data in the data memory specified by the register pair "R1,R0" is decremented by 1. Carry flag is not affected.

Operation M(R1,R0) M(R1,R0) 1

DEC [R3R2] Decrement data memory

Machine Code 0 0 0 0 1 1 1 1

Description Data in the data memory specified by the register pair "R3,R2" is decremented by 1. Carry flag is not affected.

Operation M(R3,R2) M(R3,R2) 1

DI Disable interrupt

Machine Code 0 0 1 0 1 1 0 1

Description Internal time-out interrupt and external interrupt are disabled.

EI Enable interrupt

Machine Code 0 0 1 0 1 1 0 0

Description Internal time-out interrupt and external interrupt are enabled.

HALT Halt system clock

Machine Code 0 0 1 1 0 1 1 1 0 0 1 1 1 1 1 1 0

Description Turn off system clock, and enter power down mode.

Operation PC (PC)+1

IN A,Pi Input port to accumulator

Machine Code 0 0 1 1 0 0 1 1 PS

0 0 1 1 0 1 0 0 PP

Description The data on port "Pi" is transferred to the accumulator.

Operation ACC Pi; Pi=PS or PP

INC A Increment accumulator

Machine Code 0 0 1 1 0 0 0 1

Description Data in the accumulator is incremented by 1. Carry flag is not affected.

Operation ACC ACC+1

INC Rn Increment register

Machine Code 0 0 0 1 n n n 0

Description Data in the working register "Rn" is incremented by 1. Carry flag is not affected.

Operation Rn Rn+1; Rn=R0, R1, R2, R3, R4 for n=0, 1, 2, 3, 4

INC [R1R0] Increment data memory

Machine Code 0 0 0 0 1 1 0 0

Description Data in the data memory specified by the register pair "R1,R0" is incremented by 1. Carry flag is not affected.

Operation M(R1,R0) M(R1,R0)+1

INC [R3R2] Increment data memory

Machine Code 0 0 0 0 1 1 1 0

Description Data memory specified by the register pair "R3,R2" is incremented by 1. Carry flag is not affected.

Operation M(R3,R2) M(R3,R2)+1

JAn address Jump if accumulator Bit n is set

Machine Code 1 0 0 n n a a a a a a a a a a

Description Bits 0~10 of the program counter are replaced with the directly-specified address, bit 11 of the program counter and PA3 of the memory bank remain, if accumulator bit n is set to 1.

Operation PC (bit 0~10) address, if ACC bit n=1 (n=0,1,2,3,)
PC PC+2, if ACC bit n=0

JC address Jump if carry is set

Machine Code 1 1 0 0 0 a a a a a a a a a a

Description Bits 0~10 of the program counter are replaced with the directly-specified address, bit 11 of the program counter and PA3 of the memory bank remain, if C (Carry flag) is set to 1.

Operation PC (bit 0~10) address, if C=1
PC PC+2, if C=0

JMP address Direct Jump

Machine Code 1 1 1 0 a a a a a a a a a a a a

Description Bits 0~11 of the program counter are replaced with the directly-specified address.

Operation PC address

JNC address Jump if carry is not set

Machine Code 1 1 0 0 1 a a a a a a a a a a

Description Bits 0~10 of the program counter are replaced with the directly-specified address, bit 11 of the program counter and PA3 of the memory bank remain, if C (Carry flag) is set to 0.

Operation PC (bit 0~10) address, if C=0
PC PC+2, if C=1

JNZ A,address Jump if accumulator is not 0

Machine Code 1 0 1 1 1 a a a a a a a a a a a a

Description Bits 0~10 of the program counter are replaced with the directly-specified address, bit 11 of the program counter and PA3 of the memory bank remain, if the accumulator is not 0.

Operation PC (bit 0~10) address, if ACC 0
PC PC+2, if ACC=0

JNZ Rn,address Jump if register is not 0

Machine Code 1 0 1 0 0 a a a a a a a a a a R0
1 0 1 0 1 a a a a a a a a a a R1
1 1 0 1 1 a a a a a a a a a a R4

Description Bits 0~10 of the program counter are replaced with the directly-specified address, bit 11 of the program counter and PA3 of the memory bank remain, if the register is not 0.

Operation PC (bit 0~10) address, if Rn 0; Rn=R0,R1,R4
PC PC+2, if Rn=0

JTMR address Jump if time-out

Machine Code 1 1 0 1 0 a a a a a a a a a a

Description Bits 0~10 of the program counter are replaced with the directly-specified address, bit 11 of the program counter and PA3 of the memory bank remain, if the TF (Timer flag) is set to 1.

Operation PC (bit 0~10) address, if TF=1
PC PC+2, if TF=0

JZ A,address Jump if accumulator is 0

Machine Code 1 0 1 1 0 a a a a a a a a a a a a

Description Bits 0~10 of the program counter are replaced with the directly-specified address, bit 11 of the program counter and PA3 of the memory bank remain, if the accumulator is 0.

Operation PC (bit 0~10) address, if ACC=0
PC PC+2, if ACC 0

MOV A,Rn Move register to accumulator

Machine Code 0 0 1 0 n n n 1

Description Data in the working register "Rn" is moved to the accumulator.

Operation ACC Rn; Rn=R0, R1, R2, R3, R4, for n=0, 1, 2, 3, 4

MOV A,TMRH Move timer to accumulator

Machine Code 0 0 1 1 1 0 1 1

Description The high nibble data of Timer counter is loaded to the accumulator.

Operation ACC TIMER (high nibble)

MOV A,TMRL Move timer to accumulator

Machine Code 0 0 1 1 1 0 1 0

Description The low nibble data of Timer counter is loaded to the accumulator.

Operation ACC TIMER (low nibble)

MOV A,XH Move immediate data to accumulator

Machine Code 0 1 1 1 d d d d

Description The 4-bit data specified by code is loaded to the accumulator.

Operation ACC XH

MOV A,[R1R0] Move data memory to accumulator

Machine Code 0 0 0 0 0 1 0 0

Description Data in the data memory specified by the register pair "R1,R0" is moved to the accumulator.

Operation ACC M(R1,R0)

MOV A,[R3R2] Move data memory to accumulator

Machine Code 0 0 0 0 0 1 1 0

Description Data in the data memory specified by the register pair "R3,R2" is moved to the accumulator.

Operation ACC M(R3,R2)

MOV R1R0,XXH Move immediate data to R1 and R0

Machine Code 0 1 0 1 d d d d 0 0 0 0 d d d d

Description The 8-bit data specified by code are loaded to the working registers R1 and R0, the high nibble of the data is loaded to R1, and the low nibble of the data is loaded to R0.

Operation R1 XH (high nibble)
R0 XH (low nibble)

MOV R3R2,XXH Move immediate data to R3 and R2

Machine Code 0 1 1 0 d d d d 0 0 0 0 d d d d

Description The 8-bit data specified by code are loaded to the working register R3 and R2, the high nibble of the data is loaded to R3, and the low nibble of the data is loaded to R2.

Operation R3 XH (high nibble)
R2 XH (low nibble)

MOV R4,XH Move immediate data to R4

Machine Code 0 1 0 0 0 1 1 0 0 0 0 0 d d d d

Description The 4-bit data specified by code are loaded to the working register R4.

Operation R4 XH

MOV Rn,A Move accumulator to register

Machine Code 0 0 1 0 n n n 0

Description Data in the accumulator is moved to the working register "Rn".

Operation Rn ACC; Rn=R0, R1, R2, R3, R4, for n=0, 1, 2, 3, 4

MOV TMRH,A Move accumulator to timer

Machine Code 0 0 1 1 1 1 0 1

Description The contents of the accumulator is loaded to the high nibble of timer counter.

Operation TIMER (high nibble) ACC

MOV TMRL,A Move accumulator to timer

Machine Code 0 0 1 1 1 1 0 0

Description The contents of the accumulator is loaded to the low nibble of timer counter.

Operation TIMER (low nibble) ACC

MOV [R1R0],A Move accumulator to data memory

Machine Code 0 0 0 0 0 1 0 1

Description Data in the accumulator is moved to the data memory specified by the register pair "R1,R0".

Operation M(R1,R0) ACC

MOV [R3R2],A Move accumulator to data memory

Machine Code 0 0 0 0 0 1 1 1

Description Data in the accumulator is moved to the data memory specified by the register pair "R3,R2".

Operation M(R3,R2) ACC

NOP No operation

Machine Code 0 0 1 1 1 1 1 0

Description Do nothing, but one instruction cycle is delayed.

OR A,XH Logical OR immediate data to accumulator

Machine Code 0 1 0 0 0 1 0 0 0 0 0 0 d d d d

Description Data in the accumulator is logical OR with the immediate data specified by code.

Operation ACC ACC "OR" XH

OR A,[R1R0] Logical OR accumulator with data memory

Machine Code 0 0 0 1 1 1 0 0

Description Data in the accumulator is logical OR with the data memory addressed by the register pair "R1,R0".

Operation ACC ACC "OR" M(R1,R0)

OR [R1R0],A Logical OR data memory with accumulator

Machine Code 0 0 0 1 1 1 1 1

Description Data in the data memory addressed by the register pair "R1,R0" is logical OR with the accumulator.

Operation M(R1,R0) M(R1,R0) "OR" ACC

OUT PA,A Output accumulator data to port A

Machine Code 0 0 1 1 0 0 0 0 PA

Description The data in the accumulator is transferred to the port-A and latched.
Note: PA3 controls bit 13 of the program memory. Be careful about PA3 when port A is changed.

Operation PA ACC

READ MR0A Read ROM code of current page to M(R1,R0) and ACC

Machine Code 0 1 0 0 1 1 1 0

Description The 8-bit ROM code (current page) addressed by ACC and R4 are moved to the data memory M(R1,R0) and accumulator. The high nibble of the ROM code is loaded to M(R1,R0) and the low nibble of the ROM code is loaded to the accumulator. The ROM code address are specified as shown below:
Current page ROM code address bit 12~8
ACC ROM code address bit 7~4
R4 ROM code address bit 3~0

Operation M(R1R0) ROM code (high nibble)
ACC ROM code (low nibble)

READ R4A

Read ROM code of current page to R4 and accumulator

Machine Code: 0 1 0 0 1 1 0 0

Description: The 8-bit ROM code (current page) addressed by ACC and M(R1,R0) are moved to the working register R4 and the accumulator. The high nibble of the ROM code is loaded to R4 and the low nibble of the ROM code is loaded to the accumulator. The ROM code address are specified below:
Current page ROM code address bit 12~8
ACC ROM code address bit 7~4
M(R1,R0) ROM code address bit 3~0

Operation:
R4 ROM code (high nibble)
ACC ROM code (low nibble)

READF MR0A

Read ROM Code of page F to M(R1,R0) and ACC

Machine Code: 0 1 0 0 1 1 1 1

Description: The 8-bit ROM code (page F) addressed by ACC and R4 are moved to the data memory M(R1,R0) and accumulator. The high nibble of the ROM code is loaded to M(R1,R0) and the low nibble of the ROM code is loaded to the accumulator.
page F ROM code address bit 12~8 are "PA3 1111"
ACC ROM code address bit 7~4
R4 ROM code address bit 3~0

Operation:
M(R1,R0) high nibble of ROM code (page F)
ACC low nibble of ROM code (page F)

READF R4A

Read ROM code of page F to R4 and accumulator

Machine Code: 0 1 0 0 1 1 0 1

Description: The 8-bit ROM code (page F) addressed by ACC and M(R1,R0) are moved to the working register R4 and the accumulator. The high nibble of the ROM code is loaded to R4 and the low nibble of the ROM code is loaded to the accumulator.
page F ROM code address bit 12~8 are "PA3 1111"
ACC ROM code address bit 7~4
M(R1,R0) ROM code address bit 3~0

Operation:
R4 high nibble of ROM code (page F)
ACC low nibble of ROM code (page F)

RET

Return from subroutine or interrupt

Machine Code: 0 0 1 0 1 1 1 0

Description: The program counter bits 0~11 are restored from the stack.

Operation: PC Stack

RETI Return from interrupt subroutine

Machine Code 0 0 1 0 1 1 1 1

Description The program counter bits 0~11 are restored from the stack. The carry flag before entering interrupt service routine is restored.

Operation PC Stack
C C (before interrupt service routine)

RL A Rotate accumulator left

Machine Code 0 0 0 0 0 0 0 1

Description The contents of the accumulator are rotated left 1 bit. Bit 3 is rotated to bit 0 and carry flag.

Operation An+1 An; An: accumulator bit n (n=0, 1, 2)
A0 A3
C A3

RLC A Rotate accumulator left through carry

Machine Code 0 0 0 0 0 0 1 1

Description The contents of the accumulator are rotated left 1 bit. Bit 3 replaces the carry bit; the carry bit is rotated into the bit 0 position.

Operation An+1 An; An: Accumulator bit n (n=0, 1, 2)
A0 C
C A3

RR A Rotate accumulator right

Machine Code 0 0 0 0 0 0 0 0

Description The contents of the accumulator are rotated right 1 bit. Bit 0 is rotated to bit 3 and carry flag.

Operation An An+1; An: Accumulator bit n (n=0, 1, 2)
A3 A0
C A0

RRC A Rotate accumulator right through carry

Machine Code 0 0 0 0 0 0 1 0

Description The contents of the accumulator are rotated right 1 bit. Bit 0 replaces the carry bit; the carry bit is rotated into the bit 3 position.

Operation An An+1; An: Accumulator bit n (n=0,1,2)
A3 C
C A0

SBC A,[R1R0] Subtract data memory contents and carry from ACC

Machine Code 0 0 0 0 1 0 1 0

Description The contents of the data memory addressed by the register pair "R1,R0" and carry are subtracted from the accumulator. Carry is affected.

Operation ACC ACC+$\overline{M(R1,R0)}$+CF

SOUND A Active SOUND channel with accumulator

Machine Code 0 1 0 0 1 0 1 1

Description The activated sound begins playing in accordance with the contents of the accumulator when the specified sound channel is matched.

SOUND LOOP Turn on sound repeat mode

Machine Code 0 1 0 0 1 0 0 1

Description The activated sound plays repeatedly.

SOUND OFF Turn off sound

Machine Code 0 1 0 0 1 0 1 0

Description The singing sound will terminate immediately.

SOUND ONE Turn on sound one mode

Machine Code 0 1 0 0 1 0 0 0

Description The activated sound plays only one time.

SOUND n Active SOUND Channel n

Machine Code 0 0 0 0 n n n n 0 1 0 0 0 1 0 1

Description The specified sound begins playing and overwriting the previous singing sound. (n=0~15)

STC Set carry flag

Machine Code 0 0 1 0 1 0 1 1

Description The carry flag is set to1.

Operation C 1

SUB A,XH Subtract immediate data from accumulator

Machine Code 0 1 0 0 0 0 0 1 0 0 0 0 d d d d

Description The specified data is subtracted from the accumulator. Carry is affected.

Operation ACC ACC+$\overline{XH}$+1

SUB A,[R1R0] Subtract data memory contents from accumulator

Machine Code 0 0 0 0 1 0 1 1

Description The contents of the data memory addressed by the register pair "R1,R0" is subtracted from the accumulator. Carry is affected.

Operation ACC ACC+$\overline{M(R1,R0)}$+1

TIMER OFF Set timer to stop counting

Machine Code 0 0 1 1 1 0 0 1

Description The Timer stops counting, when the "TIMER OFF" instruction is executed.

TIMER ON Set timer to start counting

Machine Code 0 0 1 1 1 0 0 0

Description The Timer starts counting, when the "TIMER ON" instruction is executed.

TIMER XXH Set immediate data to timer counter

Machine Code 0 1 0 0 0 1 1 1 d d d d d d d d

Description The 8-bit data specified by code is loaded to the Timer counter.

Operation TIMER XXH

XOR A,XH Logical XOR immediate data to accumulator

Machine Code 0 1 0 0 0 0 1 1 0 0 0 0 d d d d

Description Data in the accumulator is Exclusive-OR with the immediate data specified by code.

Operation ACC ACC "XOR" XH

XOR A,[R1R0] Logical XOR accumulator with data memory

Machine Code 0 0 0 1 1 0 1 1

Description Data in the accumulator is Exclusive-OR with the data memory addressed by the register pair "R1,R0".

Operation ACC ACC "XOR" M(R1,R0)

XOR [R1R0],A Logical XOR data memory with accumulator

Machine Code 0 0 0 1 1 1 1 0

Description Data in the data memory addressed by the register pair "R1,R0" is logically Exclusive-OR with the accumulator.

Operation M(R1,R0) M(R1,R0) "XOR" ACC

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