

TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

TC9316F, TC9316FA, TC9316FB

DTS MICRO CONTROLLER CONTAINING PLL, LCD DRIVER (DTS-11)

TC9316F/FA/FB are a 4bit CMOS microcontroller for digital tuning system capable of making 3V low voltage operation, and containing PLL circuit, LCD driver.

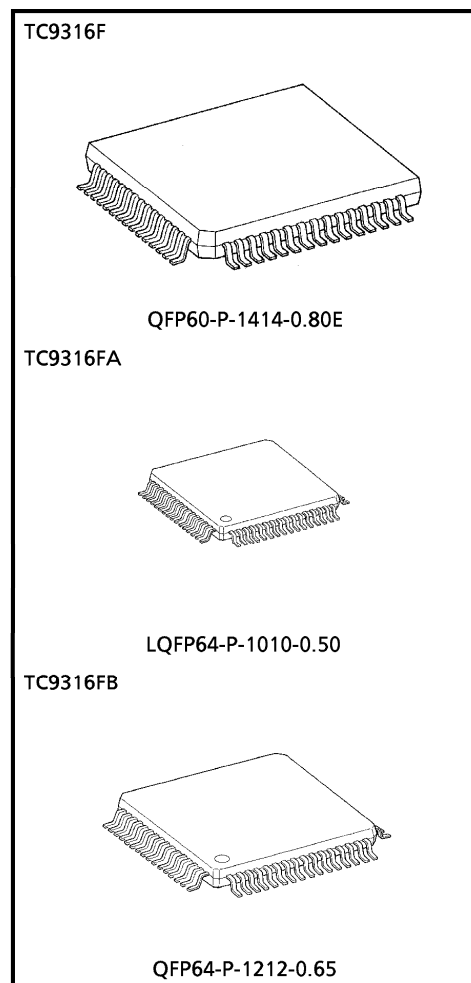
CPU has 4bit parallel addition and subtraction (AI/SI instructions, etc.), logical operation (OR and AN instructions, etc.), plural bit judge, comparison instructions (TM, SL instructions, etc.) and time base function.

The package is 60 pin mini-flat type (TC9316F), 64 pin mini-flat type (TC9316FA, TC9316FB) and has abundant I/O ports and exclusive key-input ports controlled by the powerful input/output instructions (IO, KEY instructions), besides containing PLL circuit.

By combining with the prescaler TD6134AF or TD7101F or TD7103F, it permits the configuration of DTS that receives FM/AM and TV (VHF) bands.

FEATURES

- 4bit micro controller for digital tuning system use
- It is operated with 3V single power supply.
($V_{DD} = 1.8 \sim 3.6V$)
- Back-up of data memory (RAM) and each port are easily made. (by \overline{INH} terminal)
- Built-in LCD driver (1/3 duty, 1/2 bias driving, driving frequency : 52Hz), and boosting circuit for display
- Program memory (ROM) : 16bit x 2048 steps
- Data memory (RAM) : 4bit x 128 words
- Powerful instruction set of 65 kinds. (all single word instruction)



Weight

QFP60-P-1414-0.80E	: 0.85g (Typ.)
LQFP64-P-1010-0.50	: 0.32g (Typ.)
QFP64-P-1212-0.65	: 0.45g (Typ.)

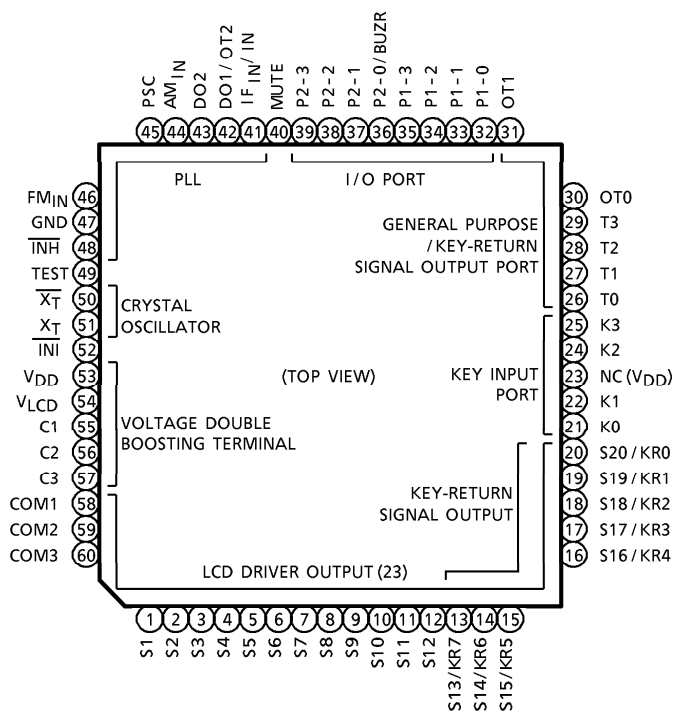
980910EBA2

- TOSHIBA is continually working to improve the quality and the reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to observe standards of safety, and to avoid situations in which a malfunction or failure of a TOSHIBA product could cause loss of human life, bodily injury or damage to property. In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent products specifications. Also, please keep in mind the precautions and conditions set forth in the TOSHIBA Semiconductor Reliability Handbook.
- The products described in this document are subject to the foreign exchange and foreign trade laws.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA CORPORATION for any infringements of intellectual property or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any intellectual property or other rights of TOSHIBA CORPORATION or others.
- The information contained herein is subject to change without notice.

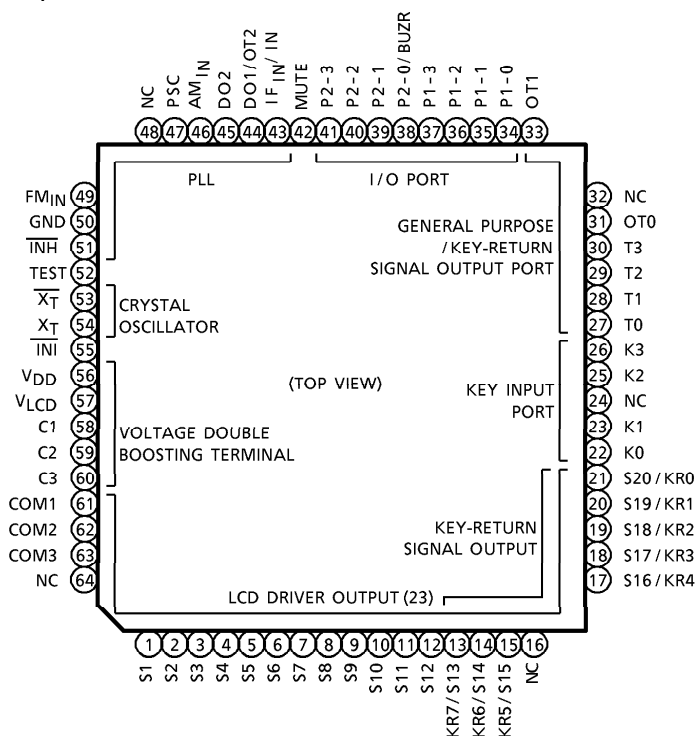
- Instruction executing time 80 μ s. (75kHz crystal connection)
- Abundant addition and subtraction instructions.
(addition instructions 12 kinds, subtraction instructions 12 kinds)
- Powerful compound judge instructions. (TMTR, TMFR, TMT, TMF, TMTN, TMFN instructions)
- Data transfer in same low address is possible.
- Indirect transfer of register is possible. (MVRD, MVRS, MVGD, MVGS instructions)
- 16 powerful general registers. (arranged in RAM)
- Stack level : 1 level
- Program memory (ROM) has no conception of page, field, and JUMP and CAL instruction can be freely made among 2048 steps.
- At the FM or TV band, swallow counter is composed by combining with prescaler TD6134AF or TD7103F, and is able to receive TV VHF band. At the AM or FM band, swallow counter is composed by combining with prescaler TD7101F, and is able to receive SW, AM, FM band.
- It is possible to freely refer to the content, 16 bits, of optional address within 1024 steps in program memory (ROM). (DAL instruction)
- Independent frequency input terminal at FM and AM (FM_{IN}, AM_{IN}), and two phase-comparator outputs. (DO1, DO2)
- 7 kinds of reference frequency can be selected with program.
- Powerful input/output instructions, (IO, KEY instructions)
- Exclusive input port (K0~K3) for key input use and abundant 23 exclusive LCD driving terminals.
- Abundant 15 I/O ports (ports for which input and output can be assigned for each bit : 8, exclusive output ports : 7)
IF_{IN} port and DO1 port are able to use IN port (exclusive input port) and OT2 port (exclusive output port) by changing instruction.
- 3 kinds of back-up mode (only CPU operating, crystal oscillation and clock stop) are possible by instructions.
- 2Hz timer F/F and 10Hz interval pulse output are contained. (Internal port for time base use)
- Locked condition of PLL can be detected.
- Universal-type IF counter is built in.
- 8 output ports in LCD segment ports (S13~S20) are able to use as Key Return Timing output ports. Exclusive output ports are not only use Key Return Timing output ports but use the others.
- 16bit universal-type IF counter is built in, it is able to detect the auto stop signal at auto-tuning mode with counting intermediate frequency of each band.
- Built-in 3V voltage regulation circuit for driving LCD.

PIN CONNECTION

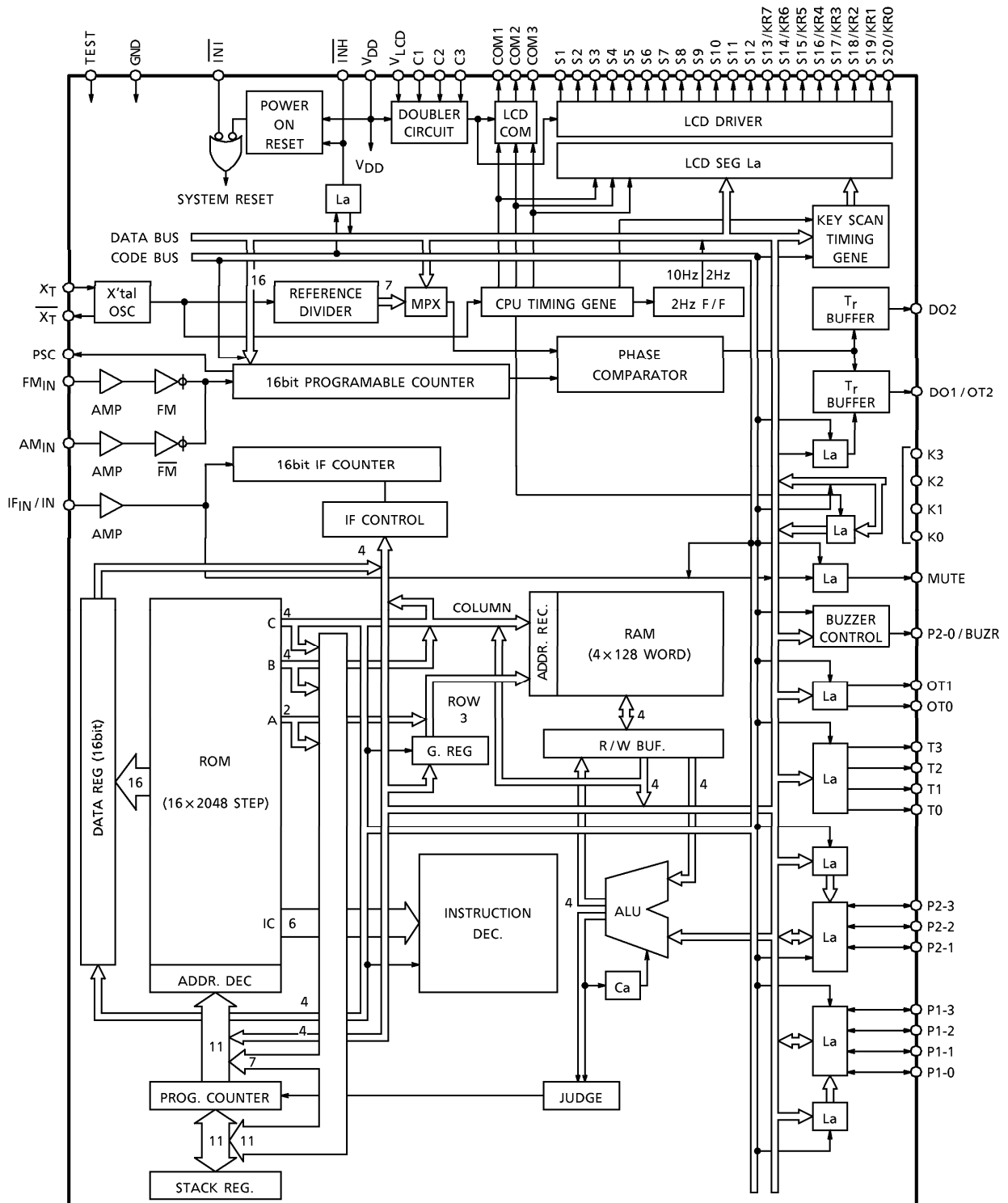
(TC9316F)



(TC9316FA, TC9316FB)

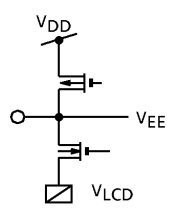
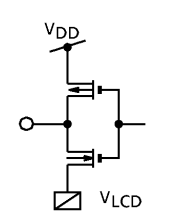
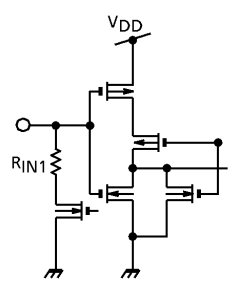


BLOCK DIAGRAM

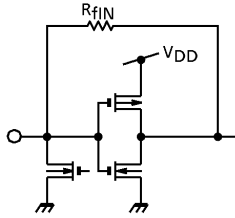
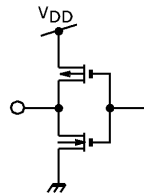
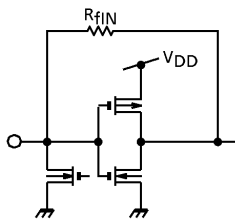
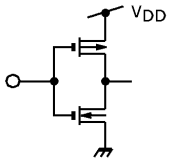
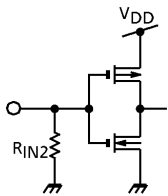


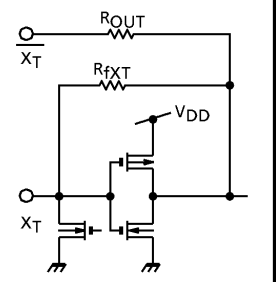
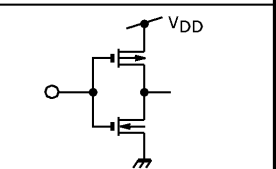
PIN FUNCTION

(Data in parentheses are for TC9316FA, TC9316FB)

PIN No.	SYMBOL	PIN NAME	EXPLANATION OF FUNCTION AND OPERATION	REMARKS
58 (61)	COM1	LCD Common Output	This is a common signal output terminal to LCD. Indication of maximum 60 segments is possible with matrix made with S1~S20. To this terminal, three value levels of V _{DD} , V _{EE} , V _{LCD} are output with 3.2ms interval and 52Hz cycle.	
59 (62)	COM2			
60 (63)	COM3			
1~12	S1~S12	LCD Segment Output	This is a segment signal output terminal to LCD. Indication of maximum 60 segments is possible with matrix made with COM1, COM2 and COM3. The data for these terminals are output by the execution of SEG instruction and MARK instruction.	
13~20 (13~15) (17~21)	S13 / KR7 ~S20 / KR0	LCD Segment Output / Key Return Output	S13 / KR7~S20 / KR0 are able to output LCD segment signal and Key Return Timing signal at same time by program. Maximum 32 (= 8 x 4) Key input be able to combine with matrix made with Key input ports K0~K3 without the other output port.	
21, 22 24, 25 (22, 23) (25, 26)	K0~K3	Key Input Port	This is a 4bit input port for key matrix input. It is able to input data of maximum total 56 key, maximum 24 key (= 6 x 4) with matrix made with Key Return Timing output port, besides maximum 32 key (8 x 4) with matrix made with LCD Segment Output S13 / KR7~S20 / KR0. All these terminals are built in pull down resistances.	

PIN No.	SYMBOL	PIN NAME	EXPLANATION OF FUNCTION AND OPERATION	REMARKS
26~29 (27~30)	T0~T3	General Purpose / Key Return Timing Output Port	This is a 6bit output port for General Purpose / Key Return Timing output. Besides use for general purpose output port, it is able to output the timing signal for key matrix by program. For making the key matrix, it is built in load resistance at N-ch FET side, useless the diode when uses Push key.	
30, 31 (31, 33)	OT0, OT1			
32~35 (34~37)	P1-0~P1-3	I/O Port	This is a 8bit general purpose I/O Port. It is possible to assign input and output for each bit by program. P2-0 is able to use as the beep sound pulse output port by program. It is able to output 3 kinds of the beep sound pulse signal by program.	
36 (38)	P2-0 / BUZR	I/O Port / Buzzer Pulse Output Port		
37~39 (34~41)	P2-1~P2-3	I/O Port		
40 (42)	MUTE	Muting Output Port	This is a 1bit output port. This is usually used as muting control signal output.	
41 (43)	IFIN / IN	If Counter Input Port / Input Port	This is an If signal input terminal of 16bit general purpose IF counter. This terminal has built-in amplifiers, and operates with C-connection and small amplitude. It is able to use as a 1bit general purpose input port by program.	
42 (44)	DO1 / OT2	Phase Comparator Output / Output port	This is a phase comparator output terminal of PLL. DO1 and DO2 are parallel outputs. Therefore, optimum filter constant can be set for each band of FM / AM. DO1 is able to use as a 1bit general purpose output port by program.	
43 (45)	DO2	Phase Comparator Output		

PIN No.	SYMBOL	PIN NAME	EXPLANATION OF FUNCTION AND OPERATION	REMARKS
44 (46)	AM _{IN}	AM Programmable Counter Input	This is a programmable counter input terminal at 12bit direct frequency-divider mode. Usually the local oscillator signal at AM band is input to this terminal. This terminal has built-in amplifiers, and operated with C-connection and small amplitude.	
45 (47)	PSC	Prescaler Control Output	This is an output terminal which controls 1/15 or 1/16 frequency-dividing mode of two modulus prescaler. This output signal controls two frequency-dividing mode of external prescaler as using programmable counter for pluse-swallow counter. "H" : 1/16, "L" : 1/15	
46 (49)	FM _{IN}	FM Programable Counter Input	This is an input terminal of programmable counter at 16bit swallow-counter mode. This terminal is input the divided frequency output signal of external prescaler, and has built-in input amplifiers and operates with C-connection and small amplitude.	
48 (51)	$\overline{\text{INH}}$	Inhibit Input	This is a signal input terminal for selecting radio mode. "H" : radio ON, "L" : radio OFF	
49 (52)	TEST	Test Input	This is an input terminal for controlling test mode control. At "H" level, test mode is made, and at "L" level, normal operation is carried out. In the test mode, the device operates as evaluator chip, and program evaluation is made possible on EPROM base through combination with external simulation board. This terminal is built in a pull-down resistance.	

PIN No.	SYMBOL	PIN NAME	EXPLANATION OF FUNCTION AND OPERATION	REMARKS
50 (53)	$\overline{X_T}$	Crystal Oscillation Terminal	This is a connecting terminal of crystal resonator. Reference crystal of 75kHz is connected. During the execution of CKSTP instruction, oscillation is automatically stopped.	
51 (54)	X_T			
52 (55)	\overline{INI}	Initializing Input	This is a system reset signal input terminal of the device. During \overline{INI} is at "L" level, reset is applied, and when it becomes "H" level, it is normal operation mode.	
54 (57)	V_{LCD}	Voltage Double Boosting Terminal	These are voltage double boosting terminal for driving LCD. Boosting capacitors are connected to these terminals. (Typ. 0.1 μ F~3.3 μ F)	—
55 (58)	C1			
56 (59)	C2			
57 (60)	C3	Reference Voltage Stabilizing Capacitor Connecting Terminal	The stabilizing capacitor of Reference Voltage is connected to this terminal for LCD driving. (Typ. 0.01 μ F~0.1 μ F)	—
53 (56)	V_{DD}	Power Supply	Power supply voltage is applied.	—
47 (50)	GND	Terminal	$V_{DD} = 1.8\sim 3.6V$ (Typ. 3.0V)	

EXPLANATION OF OPERATION

○ CPU

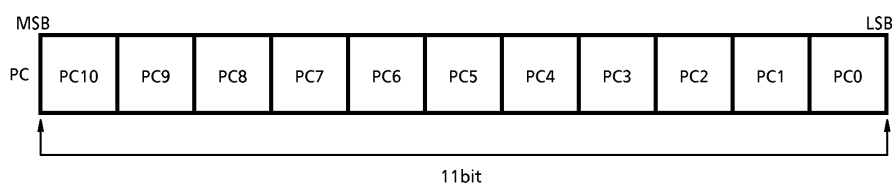
CPU is composed of program counter, stack register, ALU, program memory, data memory, G-register, carry F/F and judging circuit.

1. Program counter (PC)

Program Counter is a block to designate the address of program memory (ROM), and is composed of 11 bits binary up counter. This is cleared by system reset, and the program starts from zero address.

Usually, it's increment is made one by one everytime the one instruction is executed, but when JUMP instruction or CAL instruction is executed, the address designated at operand part of that instruction is loaded.

Further, when the instruction (AIS, SLT, TMT, RNS instructions, etc.) having skip function is executed, two increments of program counter is made if the result is the condition to be skipped, and the succeeding instruction is skipped.



2. Stack register (STACK)

This is a register composed of 1×11 bits during the execution of subroutine call instruction, the value obtained by adding +1 to the content of program counter, namely return address, is housed. The content of stack register is loaded on the program counter by the execution of return instruction. (RN, RNS instructions)

This stack level is 1 level, and nesting is 1 level.

3. ALU

ALU has binary 4 bits parallel addition and subtraction, logical operation, comparison and plural bit judge functions.

This CPU has no accumulator, and all operations directly treat the contents of data memory.

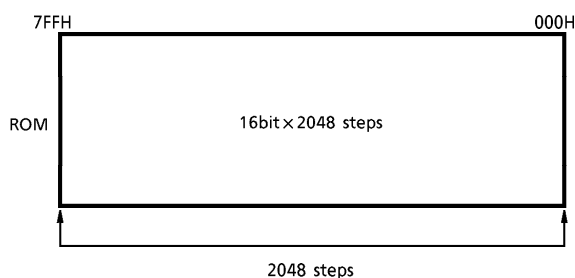
4. Program memory (ROM)

Program memory is composed of 16bit×2048 steps and is the address of 000H~7FFH.

Program memory has no concept of page or field, so JUMP instruction and CAL instruction can be freely used among 2048 steps.

Further, it is possible to use optional address of program memory as data area, and its content, 16 bits, can be loaded to the data register by executing DAL instruction.

(Note) Provide the data area at the address outside the program loop in the program memory.



(Note) In DAL instruction, the address of program memory can be designated as the data area becomes 1024 steps of 000H~3FFH.

5. Data memory (RAM)

Data memory is composed of 4bit×128 words and used for storing data.

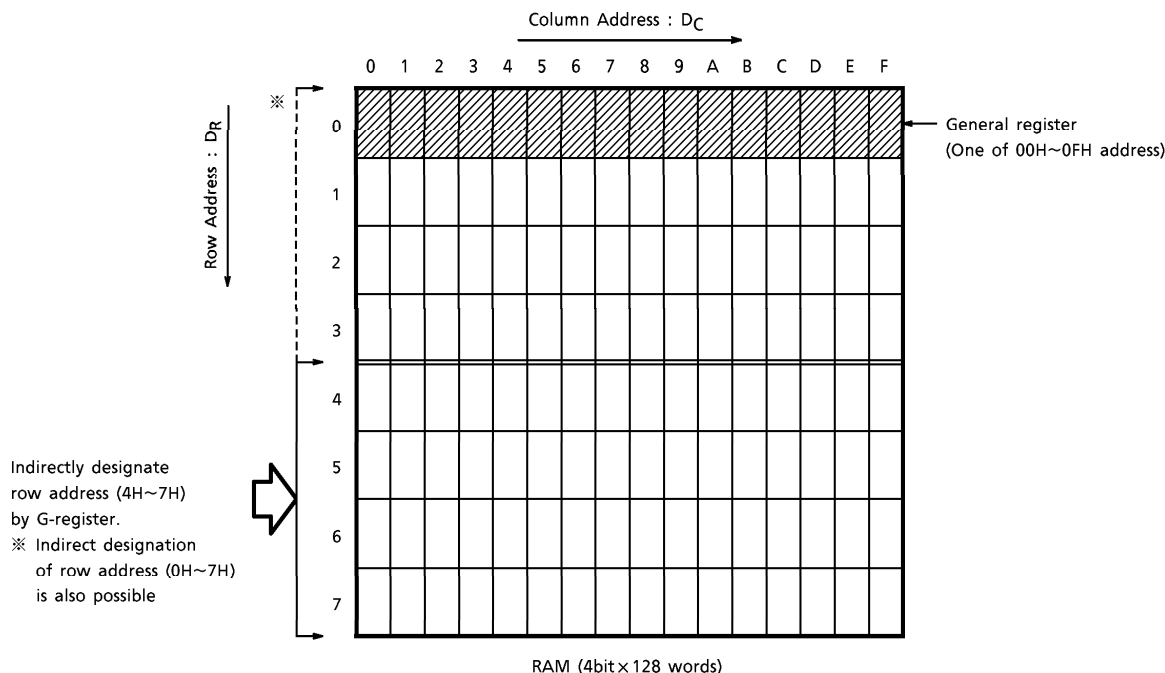
This 128 words are expressed with row address (3 bits) and column address (4 bits).

64 words (row address = 4H~7H) among the data memory are indirect addressing by G-register.

For this reason, when carrying out data processing within this territory, it is necessary to designate row address by G-register beforehand. Area of 00H~0FH address in data memory is called general register, and can be used only by designating column address (4 bits). These 16 general registers can be used for operation and transfer between data memories. Further, it can also be used as ordinary data memory.

(Note) The column address (4 bits) to designate general register becomes register number of the general register.

(Note) It is also possible to indirectly designate all of row address (= 0H~7H) by G-register.



6. G-register (G-REG.)

G-register is a 3 bits register for addressing row address ($D_R = 4H \sim 7H$) of 64 words in data memory.

Content of this register is effective during executing MVGD instruction, MVGS instruction, and is not related with the execution of other instructions.

This register is treated as one of the port, and its content is set by the execution of IO instruction among input and output instructions.

(refer to register port item 1 page 39)

7. Data register (DATA REG.)

This is a register composed of 1×16 bits. In this register, 16 bits data of optional address among the program memory is loaded during executing of DAL instruction. This register is treated as one of the port, and when KEY instruction among input and output instruction is executed, it's content is read in the data memory in 4 bits unit.

(refer to register port item 2 page 39)

8. Carry F/F (C-F/F)

This is set when carry or borrow is produced as a result of executing operational instruction, and is reset when it is not produced. Content of carry F/F changes only when addition and subtraction instruction is executed, and does not change during the execution of other instructions.

9. Judging circuit (J)

When a instruction with skip function is executed, this circuit judges it's skip condition. When skip condition is satisfied, this circuit makes two increments of program counter, and skips the succeeding instruction.

It is provided with 31 kinds of instructions having abundant skip function.

(refer to Item 11, explanation list of function and operation of instructions, ※ marked instruction page 13~19)

10. List of instruction set

65 kinds of instruction set are included, all of which consisting of one word instruction.

These instructions are expressed with 6 bits instruction code.

Higher Rank Lower Rank Rank 4 bits		00		01		10		11	
		0		1		2		3	
0000	0	AI	M, I	AD	r, M	LD	r, M	SLTI	M, I
0001	1	AIS	M, I	ADS	r, M	ST	M, r	SGEI	M, I
0010	2	AIN	M, I	ADN	r, M	MVRD	r, M	SEQI	M, I
0011	3	SI	M, I	SU	r, M	MVRS	M, r	SNEI	M, I
0100	4	SIS	M, I	SUS	r, M	MVSR	M ₁ , M ₂	SLT	r, M
0101	5	SIN	M, I	SUN	r, M	MVIM	M, I	SGE	r, M
0110	6	CAL	ADDR ₁	ORR	r, M	MVGD	r, M	SEQ	r, M
0111	7			ANDR	r, M	MVGS	M, r	SNE	r, M
1000	8	AIC	M, I	AC	r, M	PLL	M, C	TMTR	r, M
1001	9	AICS	M, I	ACS	r, M	SEG	M, C	TMFR	r, M
1010	A	AICN	M, I	ACN	r, M	MARK	M, C	TMT	M, N
1011	B	SIB	M, I	SB	r, M	IO	M, C	TMF	M, N
1100	C	SIBS	M, I	SBS	r, M	KEY	M, C	TMTN	M, N
1101	D	SIBN	M, I	SBN	r, M	WAIT	P	TMFN	M, N
1110	E	JUMP	ADDR ₁	ORIM	M, I	XORIM	M, I	DAL	ADDR ₂ , r
1111	F			ANIM	M, I	XORR	r, M	RN, RNS, CKSTP, NOOP	

11.Explanation list of function and operation of instructions (Explanation of symbols)

M	: Data memory address Normally, one of 00H~3FH address of data memory.
r	: General register One of 00H~0FH address of data memory.
PC	: Program counter (11bit)
STACK	: Stack register (11bit)
G	: G-register (3bit)
DATA	: Data register (16bit)
I	: Immediate data (4bit)
N	: Bit position (4bit)
—	: All "0"
C	: Code No. of port (4bit)
C _N	: Lower rank 3bit of port code No.
R _N	: General register No. (4bit)
ADDR ₁	: Program memory address in page 0 or 1 (10bit)
ADDR ₂	: Higher rank 6bit of program memory address in page 0
Ca	: Carry
b	: Borrow
PLL	: Port treated during the execution of PLL instruction
SEG	: Port treated during the execution of SEG instruction
MARK	: Port treated during the execution of MARK instruction
IO	: Port treated during the execution of IO instruction
KEY	: Port treated during the execution of KEY instruction
()	: Register or data memory content
[] _C	: Content of port indicated by code No. C (4bit)
[]	: Content of data memory indicated by the content of register or data memory
[] _p	: Content of program memory (16bit)
IC	: Instruction code (6bit)
※	: Instruction having skip function
D _C	: Data memory column address (4bit)
D _R	: Data memory row address (2bit)
P	: Wait condition select bit at WAIT instruction

(Note) Address 000H~3FFH of program memory address : Page 0 area
Address 400H~7FFH of program memory address : Page 1 area

INST. GR.	MNEMONIC	SKIP FUNCTION	EXPLANATION OF FUNCTION	EXPLANATION OF OPERATION	MACHINE LANGUAGE (16bit)			
					IC (6bit)	A (2bit)	B (4bit)	C (4bit)
ADDITION INSTRUCTION	AI M, I		Add immediate data to memory	$M \leftarrow (M) + I$	000000	D _R	D _C	I
	AIS M, I	※	Add immediate data to memory, then skip if carry	$M \leftarrow (M) + I$ Skip if carry	000001	D _R	D _C	I
	AIN M, I	※	Add immediate data to memory, then skip if not carry	$M \leftarrow (M) + I$ Skip if not carry	000010	D _R	D _C	I
	AIC M, I		Add immediate data to memory with carry	$M \leftarrow (M) + I + ca$	001000	D _R	D _C	I
	AICS M, I	※	Add immediate data to memory with carry, then skip if carry	$M \leftarrow (M) + I + ca$ Skip if carry	001001	D _R	D _C	I
	AICN M, I	※	Add immediate data to memory with carry, then skip if not carry	$M \leftarrow (M) + I + ca$ Skip if not carry	001010	D _R	D _C	I
	AD r, M		Add memory to general register	$r \leftarrow (r) + (M)$	010000	D _R	D _C	R _N
	ADS r, M	※	Add memory to general register, then skip if carry	$r \leftarrow (r) + (M)$ Skip if carry	010001	D _R	D _C	R _N
	ADN r, M	※	Add memory to general register, then skip if not carry	$r \leftarrow (r) + (M)$ Skip if not carry	010010	D _R	D _C	R _N
	AC r, M		Add memory to general register with carry	$r \leftarrow (r) + (M) + ca$	011000	D _R	D _C	R _N
	ACS r, M	※	Add memory to general register with carry, then skip if carry	$r \leftarrow (r) + (M) + ca$ Skip if carry	011001	D _R	D _C	R _N
	ACN r, M	※	Add memory to general register with carry, then skip if not carry	$r \leftarrow (r) + (M) + ca$ Skip if not carry	011010	D _R	D _C	R _N

INST. GR.	MNEMONIC	SKIP FUNCTION	EXPLANATION OF FUNCTION	EXPLANATION OF OPERATION	MACHINE LANGUAGE (16bit)			
					IC (6bit)	A (2bit)	B (4bit)	C (4bit)
SUBTRACTION INSTRUCTION	SI M, I		Subtract immediate data from memory	$M \leftarrow (M) - I$	000011	D _R	D _C	I
	SIS M, I	※	Subtract immediate data from memory, then skip if borrow	$M \leftarrow (M) - I$ Skip if borrow	000100	D _R	D _C	I
	SIN M, I	※	Subtract immediate data from memory, then skip if not borrow	$M \leftarrow (M) - I$ Skip if not borrow	000101	D _R	D _C	I
	SIB M, I		Subtract immediate data from memory, with borrow	$M \leftarrow (M) - I - b$	001011	D _R	D _C	I
	SIBS M, I	※	Subtract immediate data from memory with borrow, then skip if borrow	$M \leftarrow (M) - I - b$ Skip if borrow	001100	D _R	D _C	I
	SIBN M, I	※	Subtract immediate data from memory with borrow, then skip if not borrow	$M \leftarrow (M) - I - b$ Skip if not borrow	001101	D _R	D _C	I
	SU r, M		Subtract memory from general register	$r \leftarrow (r) - (M)$	010011	D _R	D _C	R _N
	SUS r, M	※	Subtract memory from general register, then skip if borrow	$r \leftarrow (r) - (M)$ Skip if borrow	010100	D _R	D _C	R _N
	SUN r, M	※	Subtract memory from general register, then skip if not borrow	$r \leftarrow (r) - (M)$ Skip if not borrow	010101	D _R	D _C	R _N
	SB r, M		Subtract memory from general register with borrow	$r \leftarrow (r) - (M) - b$	011011	D _R	D _C	R _N
	SBS r, M	※	Subtract memory from general register with borrow, then skip if borrow	$r \leftarrow (r) - (M) - b$ Skip if borrow	011100	D _R	D _C	R _N
	SBN r, M	※	Subtract memory from general register with borrow, then skip if not borrow	$r \leftarrow (r) - (M) - b$ Skip if not borrow	011101	D _R	D _C	R _N

INST. GR.	MNEMONIC	SKIP FUNCTION	EXPLANATION OF FUNCTION	EXPLANATION OF OPERATION	MACHINE LANGUAGE (16bit)			
					IC (6bit)	A (2bit)	B (4bit)	C (4bit)
COMPARISON INSTRUCTION	SLTI M, I	※	Skip if memory is less than immediate data	Skip if $(M) < I$	110000	D _R	D _C	I
	SGEI M, I	※	Skip if memory is greater than or equal to immediate data	Skip if $(M) \geq I$	110001	D _R	D _C	I
	SEI M, I	※	Skip if memory is equal to immediate data	Skip if $(M) = I$	110010	D _R	D _C	I
	SNEI M, I	※	Skip if memory is not equal to immediate data	Skip if $(M) \neq I$	110011	D _R	D _C	I
	SLT r, M	※	Skip if general register is less than memory	Skip if $(r) < (M)$	110100	D _R	D _C	R _N
	SGE r, M	※	Skip if general register is greater than or equal to memory	Skip if $(r) \geq (M)$	110101	D _R	D _C	R _N
	SEQ r, M	※	Skip if general register is equal to memory	Skip if $(r) = (M)$	110110	D _R	D _C	R _N
	SNE r, M	※	Skip if general register is not equal to memory	Skip if $(r) \neq (M)$	110111	D _R	D _C	R _N
TRANSFER INSTRUCTION	LD r, M		Load memory to general register	$r \leftarrow (M)$	100000	D _R	D _C	R _N
	ST M, r		Store general register to memory	$M \leftarrow (r)$	100001	D _R	D _C	R _N
	MVRD r, M		Move memory to destination memory referring to general register in the same row	$[D_R, (r)] \leftarrow (M)$	100010	D _R	D _C	R _N
	MVRS M, r		Move source memory referring to general register to memory in the same row	$M \leftarrow [D_R, (r)]$	100011	D _R	D _C	R _N

INST. GR.	MNEMONIC	SKIP FUNCTION	EXPLANATION OF FUNCTION	EXPLANATION OF OPERATION	MACHINE LANGUAGE (16bit)			
					IC (6bit)	A (2bit)	B (4bit)	C (4bit)
TRANSFER INSTRUCTION	MVSR M1, M2		Move memory to memory in the same row	$(D_R, D_{C1}) \leftarrow (D_R, D_{C2})$	100100	D _R	D _{C1}	D _{C2}
	MVIM M, I		Move immediate data to memory	$M \leftarrow I$	100101	D _R	D _C	I
	MVGD r, M		Move memory to destination memory referring to G-register and general register	$[(G), (r)] \leftarrow (M)$	100110	D _R	D _C	R _N
	MVGS M, r		Move source memory referring to G-register and general register to memory	$M \leftarrow [(G), (r)]$	100111	D _R	D _C	R _N
INPUT AND OUTPUT INSTRUCTION	PLL M, C		Input PLL port data to memory	$M \leftarrow [PLL]_C$	101000	D _R	D _C	0 C _N
			Output contents of memory to PLL port	$[PLL]_C \leftarrow (M)$		D _R	D _C	1 C _N
	SEG M, C		Output contents of memory to SEG port	$[SEG]_C \leftarrow (M)$	101001	D _R	D _C	1 C _N
	MARK M, C		Input MARK port data to memory	$M \leftarrow [MARK]_C$	101010	D _R	D _C	0 C _N
			Output contents of memory to MARK port	$[MARK]_C \leftarrow (M)$		D _R	D _C	1 C _N
	IO M, C		Input IO port data to memory	$M \leftarrow [IO]_C$	101011	D _R	D _C	0 C _N
			Output contents of memory to IO port	$[IO]_C \leftarrow (M)$		D _R	D _C	1 C _N
	KEY M, C		Input KEY port data to memory	$M \leftarrow [KEY]_C$	101100	D _R	D _C	0 C _N
		Output contents of memory to KEY port	$[KEY]_C \leftarrow (M)$	D _R		D _C	1 C _N	

INST. GR.	MNEMONIC	SKIP FUNCTION	EXPLANATION OF FUNCTION	EXPLANATION OF OPERATION	MACHINE LANGUAGE (16bit)			
					IC (6bit)	A (2bit)	B (4bit)	C (4bit)
LOGICAL OPERATION INSTRUCTION	ORR r, M		Logical OR of general register and memory	$r \leftarrow (r) \vee (M)$	010110	D _R	D _C	R _N
	ANDR r, M		Logical AND of general register and memory	$r \leftarrow (r) \wedge (M)$	010111	D _R	D _C	R _N
	ORIM M, I		Logical OR of memory and immediate data	$M \leftarrow (M) \vee I$	011110	D _R	D _C	I
	ANIM M, I		Logical AND of memory and immediate data	$M \leftarrow (M) \wedge I$	011111	D _R	D _C	I
	XORIM M, I		Logical exclusive OR of memory and immediate data	$M \leftarrow (M) \oplus I$	101110	D _R	D _C	I
	XORR r, M		Logical exclusive OR of general register and memory	$r \leftarrow (r) \oplus (M)$	101111	D _R	D _C	I
BIT JUDGE INSTRUCTION	TMTR r, M	※	Test general register bits by memory bits, then skip if all bits specified are true	Skip if $r [N (M)] = \text{all "1"}$	111000	D _R	D _C	R _N
	TMFR r, M	※	Test general register bits by memory bits, then skip if all bits specified are false	Skip if $r [N (M)] = \text{all "0"}$	111001	D _R	D _C	R _N
	TMT M, N	※	Test memory bits, then skip if all bits specified are true	Skip if $M (N) = \text{all "1"}$	111010	D _R	D _C	N
	TMF M, N	※	Test memory bits, then skip if all bits specified are false	Skip if $M (N) = \text{all "0"}$	111011	D _R	D _C	N
	TMTN M, N	※	Test memory bits, then not skip if all bits specified are true	Skip if $M (N) = \text{not all "1"}$	111100	D _R	D _C	N
	TMFN M, N	※	Test memory bits, then not skip if all bits specified are false	Skip if $M (N) = \text{not all "0"}$	111101	D _R	D _C	N

INST. GR.	MNEMONIC	SKIP FUNCTION	EXPLANATION OF FUNCTION	EXPLANATION OF OPERATION	MACHINE LANGUAGE (16bit)			
					IC (6bit)	A (2bit)	B (4bit)	C (4bit)
SUBROUTINE INSTRUCTION	CALL ADDR ₁		Call subroutine in page 0	STACK←(PC)+1 and PC←ADDR ₁ in page 0 or 1	000110	ADDR ₁ (10bit)		
			Call subroutine in page 1		000111			
	RN		Return to main routine	PC←(STACK)	111111	00	—	—
	RNS	※	Return to main routine and skip unconditionally	PC←(STACK) and skip	111111	01	—	—
JUMP INST.	JUMP ADDR ₁		Jump to the address specified in page 0	PC←ADDR ₁ in page 0 or 1	001110	ADDR ₁ (10bit)		
			Jump to the address specified in page 1		001111			
OTHER INSTRUCTION	WAIT P		At P="0" H, the condition is CPU waiting (Soft wait mode)	Wait at condition P	101101	P	—	—
			At P="1" H, except for clock generator, all function is waiting (Hard wait mode)				—	—
	DAL ADDR ₂ , r		Load program memory in page 0 to DATA register	DATA←[ADDR ₂ +(r)] _p in page 0	111110	ADDR ₂ (6bit)	R _N	
	CKSTP		Clock generator stop	Stop clock generator if $\overline{INH} = "0"$	111111	10	—	—
	NOOP		No operation	—	111111	11	—	—

(Note 1) During the execution of input and output instruction, control of input/output instruction is automatically carried out at the most significant bit in Code No. (C) of port.

- MSB = "1" of Code No. (C) : Output instruction
- MSB = "0" of Code No. (C) : Input instruction

(Note 2) In the TC9316F, TC9316FA, TC9316FB, only the SEG instruction is carried out output instruction in spite of Code No. (C) of MSB.

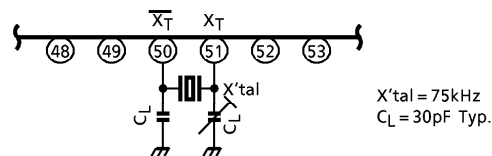
(Note 3) Among 10 bits of the program memory address assigned by DAL instruction, the lower rank of 4 bits become indirect addressing based on the content of general register.

DAL instruction executing time is 160μs.

○ Connection of crystal resonator

Connect 75kHz crystal resonator with the crystal oscillator terminals (X_T , $\overline{X_T}$ terminal) of the device as shown below. This oscillation signal is supplied to clock generator and reference frequency divider, and produced each timing signal of CPU and reference frequency signal.

Adjust the crystal oscillation frequency while monitoring LCD segment output terminal.



※ In TC9316FA, TC9316FB, $\overline{X_T}$ = pin 53, X_T = pin 54.

(Note) Use crystal resonator of low CI value and satisfactory starting characteristics.

○ System reset

System reset is applied to the device when "L" level is given to \overline{INI} terminal, or when the voltage, 0V→1.8V~3.6V is supplied to V_{DD} terminal (power on reset).

After the lapse of 100ms stand-by time succeeding to the system reset, program starts from zero address.

As power on reset function is employed usually, \overline{INI} terminal is fixed at "H" level.

(Note 1) During the system reset time and the succeeding stand-by time, LCD common output and segment output are fixed at "L" level.

(Note 2) After system reset, all of I/O ports are set at input mode, but initialization of output port and internal port (G-register, etc.) is not carried out. Especially, at the initial power on stage, content of these ports is indefinite, and therefore it is necessary to make initialization with program according to your use.

○ Back up mode

If CKSTP instruction or WAIT instruction is executed when $\overline{\text{INH}}$ terminal is at "L" level, it can select for the three kinds of back up mode.

1. Clock stop mode

If CKSTP instruction is executed when $\overline{\text{INH}}$ terminal is at "L" level, clock generator and CPU internal of the device stop operation completely, and memory back up state can be realized at low current consumption ($1\mu\text{A}$ MAX. at $V_{\text{DD}} = 3\text{V}$).

At this time, LCD display driver terminals and output ports are all fixed at "L" level or off condition. During this clock stop mode, supply voltage can be reduced down to 1.2V and used for exchange of battery.

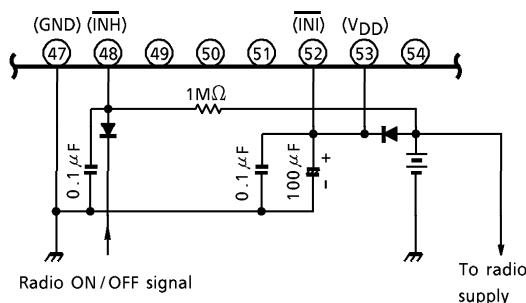
So this mode is available when the battery is changed in the radio set.

In clock stop mode, program stops at the execution address of CKSTP instruction.

The clock stop mode is released at $\overline{\text{INH}} = \text{"H"}$ level or changing the input condition of I/O port (IO0~IO3) set at input mode, and the next address is executed after the lapse of stand-by time of 100ms.

(Note 1) In the clock stop mode, the condition of output terminal is all fixed at "L" level or off but output port holds on the data just before clock stop mode.

(Note 2) When CKSTP instruction is executed during $\overline{\text{INH}} = \text{"H"}$ level, the same operation as NOOP instruction is made (Clock stop mode is not entered).



※ In TC9316FA, TC9316FB change Pin No. changes as below.

- 47→50
- 48→51
- } }
- 52→55
- 53→56

Example of the memory back up circuit using capacitor at clock stop mode

2. Waiting mode

If WAIT instruction is executed when $\overline{\text{INH}}$ terminal is at "L" level, it can select the hardware waiting mode or the software waiting mode.

1) Software waiting mode

If WAIT instruction is executed at designated operand port [P=0H], only CPU internal of the device stop operation, and software waiting mode can be realized at low current consumption. Since the other part of clock generator and display circuit operate normally, at the time of using the program of clock function, the software waiting mode is effective to realize at low current consumption during the clock operation.

2) Hardware waiting mode

If WAIT instruction is executed at designated operand part [P=1H], all the function without crystal oscillator are stopped and hardware waiting mode can be realized at lower current consumption than software waiting mode (under $100\mu\text{A}$ at $V_{\text{DD}}=3.0\text{V}$). At this time, CPU and display circuit stop operation, output terminal for LCD display is fixed at "L" level automatically.

In these waiting mode, program stops at the execution address of WAIT instruction, and waiting is released in following condition, so next address is executed.

3) Released condition of waiting mode

- Changing to $\overline{\text{INH}} = \text{"H"}$ level
- Key input terminal (K0~K3) is set at "H" level.
- 2Hz timer F/F is set at "1".
- Changing the input condition of I/O port (IO0~IO3) set at input mode
- MUTE port is set at "1".

(Note) In waiting mode, each of output terminal is held on the condition just before waiting mode.

○ I/O MAP

I/O PORT CODE	PLL (φ1)								SEG (φ2)								MARK (φ3)								IO (φ4)								KEY (φ5)																															
	Y1	Y2	Y4	Y8	Y1	Y2	Y4	Y8	Y1	Y2	Y4	Y8	Y1	Y2	Y4	Y8	Y1	Y2	Y4	Y8	Y1	Y2	Y4	Y8	Y1	Y2	Y4	Y8																																				
INPUT PORT (K)	0																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
INPUT PORT (L)	1																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	2																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	3																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	4																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	5																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	6																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	7																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	8																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	9																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	A																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	B																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	C																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	D																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	E																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
OUTPUT PORT (L)	F																																																															
	IF COUNTER																																																															
	F0								F1								F2								F3								F4								F5								F6								F7							
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															
	IF COUNTER																																																															

(Note) Only the SEG instruction is carried out OUTPUT instruction in spite of Code No. (C).

TC9316F/FA/FB-23

○ I/O map

All ports in the device are expressed by matrix of five input and output instruction (PLL instruction, SEG instruction, MARK instruction, IO instruction, KEY instruction) and 4 bits of code No.C.

Assignment of these ports is indicated previously as I/O map. In the I/O map, port names treated in the execution of each input and output instruction are assigned horizontally, while code No. of port are assigned vertically. G-register and data register are also treated as port.

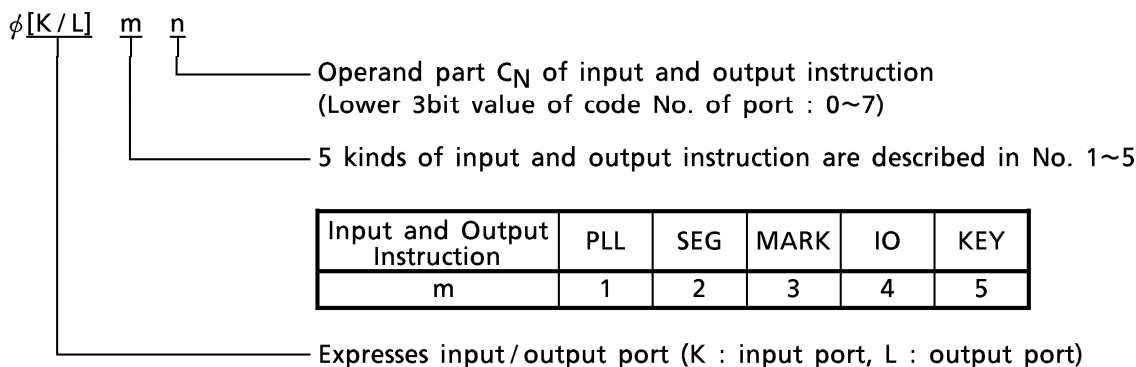
Basically, the data is treated at each port as 4 bits unit, and code No. (C) = 0H~7H are assigned to input port, while code No. (C) = 8H~FH are assigned to output port.

(Note 1) The port indicated with oblique line on I/O map is a port not existing in the device. In the execution of output instruction, when data is output to the non-existing output port, no effect is given to the content of other port or data memory. When non-existing input port is designated during the execution of input instruction, the content read into the data memory becomes indefinite.

(Note 2) Among the output ports on I/O map, ※ marked port is unused port. The data output here becomes "don't care".

(Note 3) Regarding the content of port expressed in 4 bits, Y1 corresponds to the least significant of the data of data memory, and Y8 to the most significant bit. Data of each port is all treated with positive logic.

(Note 4) Each port assigned by five input and output instruction and code No. C is coded as follows :



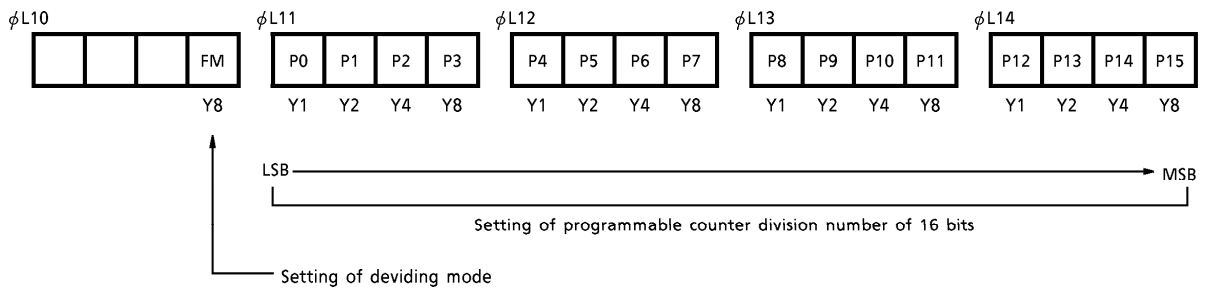
○ Programmable counter

Programmable counter block is composed of external two modulus prescaler TD6134AF, 4 bits + 12 bits programmable binary counter, and PLL output ports to control them.

1. PLL output port (ϕ L10~ ϕ L14)

The exclusive PLL port is used to control the division number and the dividing mode and made access by PLL output instruction designated operand part [$C_N=0\sim4$].

1) Structure of PLL port



2) Setting of dividing mode

Pulse swallow mode or direct dividing mode are selected by FM port. In AM band, it selects the direct dividing mode. In SW, FM, VHF or TV band, it selects pulse swallow mode combined with external two modulus prescaler, TD6134AF, TD7101F, TD7103F.

FM	DIVIDING MODE	EXAMPLE OF RECEIVING BAND	OPERATING FREQUENCY RANGE	INPUT TERMINAL	DIVISION NUMBER	PRESCALER
0	Direct diving mode	MW/LW	0.2~5.0MHz	AM _I N	n	—
1	(1/15 or 1/16) Pulse swallow mode	SW	(Note 1) 1.5~35MHz	FM _I N	n	TD7101F
	1/4 (1/15 or 1/16) Pulse swallow mode	FM	(Note 1) 50~150MHz		4·n	TD6134AF TD7101F TD7103F
	1/8 (1/15 or 1/16) Pulse swallow mode	VHF/TV	(Note 1) 50~250MHz		8·n	TD6134F TD7103F

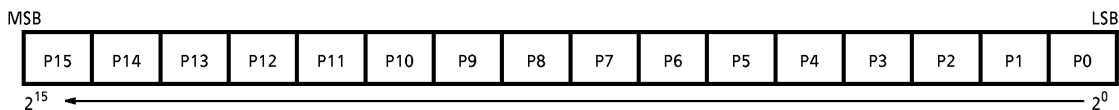
(Note 1) This shows the input frequency range to TD6134AF, TD7101F, TD7103F.

(Note 2) "n" shows the programmed division number.

3) Setting of frequency division number

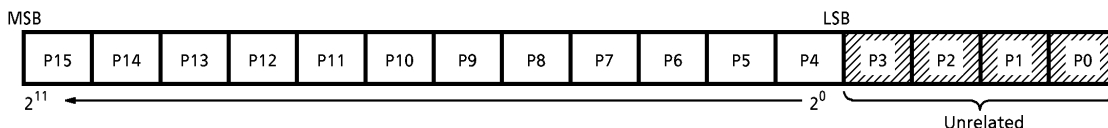
Division number of programmable counter is set on P0~P15 ports with binary.

- Pulse-swallow mode (16bit)



- * Frequency division number setting range (pulse swallow mode)
n = 210H~FFFFH (528~65535)

- Direct dividing mode (12bit)



- * Frequency division number setting range (Direct dividing mode)
n = 10H~FFFH (16~4095)

(Note 1) As the programmable counter is not provided with dividing offset, the programmable number becomes the actual frequency division number. However, in the case of FM band, the actual frequency division number becomes four times of programmed value, and in VHF/TV band, the actual frequency division number becomes eight times of programmed value in combination with prescaler TD6134AF, TD7101F and TD7103F.

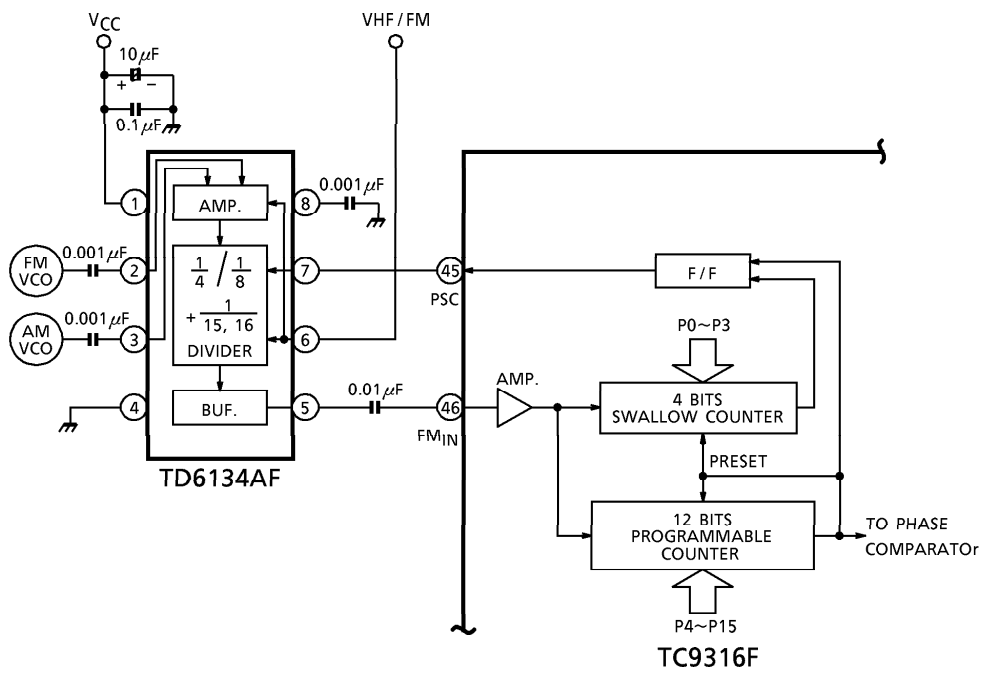
(Note 2) In case of direct dividing mode, P0~P3 port (ϕ L11) data becomes unrelated and P4 port becomes LSB.

(Note 3) Frequency division number is entirely renewed at the time of data setting of MSB port (ϕ L14). So this prevents wrong influence from giving to the lock up time. For this reason, the data of MSB port (ϕ L14) must be set at the end of division number. Even when the data setting is considered unnecessary (when the data is same as the previous one), the data setting of MSB port (ϕ L41) must be executed.

2. Circuit construction of external prescaler and programmable counter

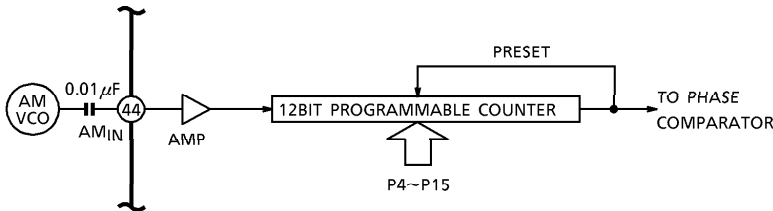
1) Circuit construction of pulse swallow dividing mode

The circuit is composed of (1/4 or 1/8 × 1/15, 1/16) 2-modulus prescaler TD6134AF, TD7101F, TD7103F and swallow counter of 4 bits and binary programmable counter of 12 bits. In the case of FM band, it selects 1/4 divider to the front stage of 2-modulus prescaler, and in VHF/TV band, it selects 1/8 divider to the front stage of 2-modulus prescaler. The block diagram including prescaler is shown as follows.



2) Circuit construction of direct dividing mode

In this case, it is unnecessary to use the external prescaler, 12 bits programmable counter is only used.



(Note) Both FM_{IN} and AM_{IN} have built-in amplifiers, and the small amplitude operation is possible through the capacitor coupling.

※ In TC9316FA, TC9316FB, THE PIN No. changes as below.

- 44→46
- 45→47
- 46→49

○ Reference frequency divider

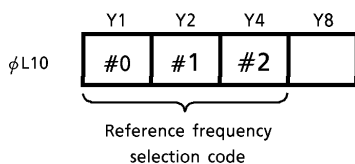
This block divides oscillating frequency of external 75kHz crystal, and produces seven kinds of PLL reference signal, 1kHz, 3kHz, 3.125kHz, 5kHz, 6.25kHz, 12.5kHz, 25kHz. Selection of reference signal is carried out with the data of REF select port.

The selected signal is supplied to the phase comparator as the reference frequency.

1. REF select port (ϕ L10)

This is an internal port to select seven kinds of reference frequency signal.

Normally, this port is made access by PLL instruction designated the operand part [$C_N = 0$] (ϕ L10).



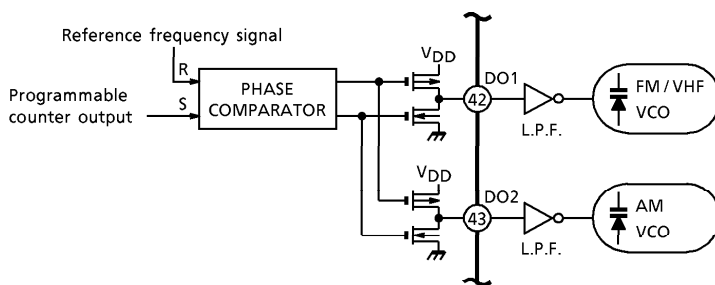
REF. output code table

#2	#1	#0		REFERENCE FREQUENCY
0	0	0	0	1kHz
0	0	1	1	3kHz
0	1	0	2	3.125kHz
0	1	1	3	5kHz
1	0	0	4	6.25kHz
1	0	1	5	12.5kHz
1	1	0	6	25kHz
1	1	1	7	REF. output is stopped

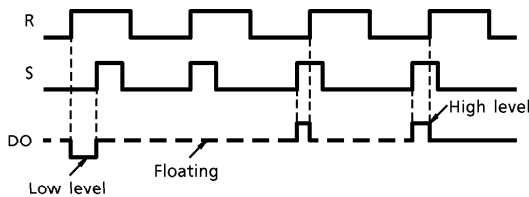
○ Phase comparator

The phase comparator outputs the error amount comparing the phase difference between the reference frequency signal supplied from the reference frequency divider and the programmable counter dividing output. VCO is controlled through low-pass filter so that the frequencies and the phase-difference of these two signals may coincide.

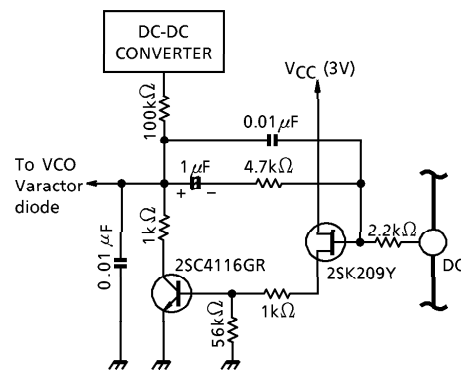
Since two tri-state buffer DO1 and DO2 terminals are parallel output from the phase comparator, the filter constant can be optimally designed for each band of FM/VHF and AM.



※ In TC9316FA, TC9316FB, THE pin No. changes as below.
42→44, 43→45



DO output timing chart



Example of active low-pass filter circuit (for reference)

DO output timing chart and example of active low-pass filter circuit structured by darlington connection of FET and transistor are shown in the above figures.

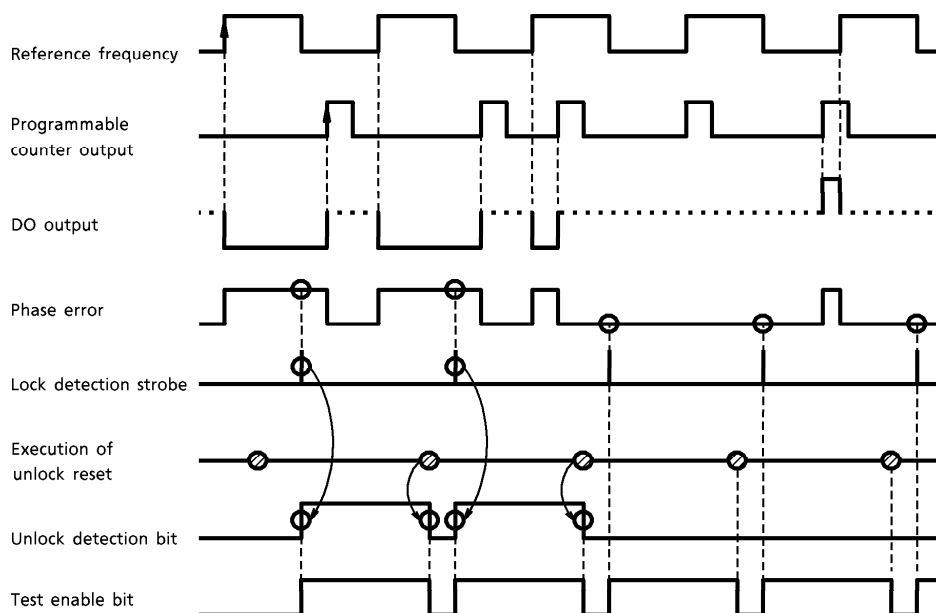
The filter circuit shown in the above figure is an example for reference, and the actual circuit should be investigated and designed conforming to the system band construction and the required characteristics.

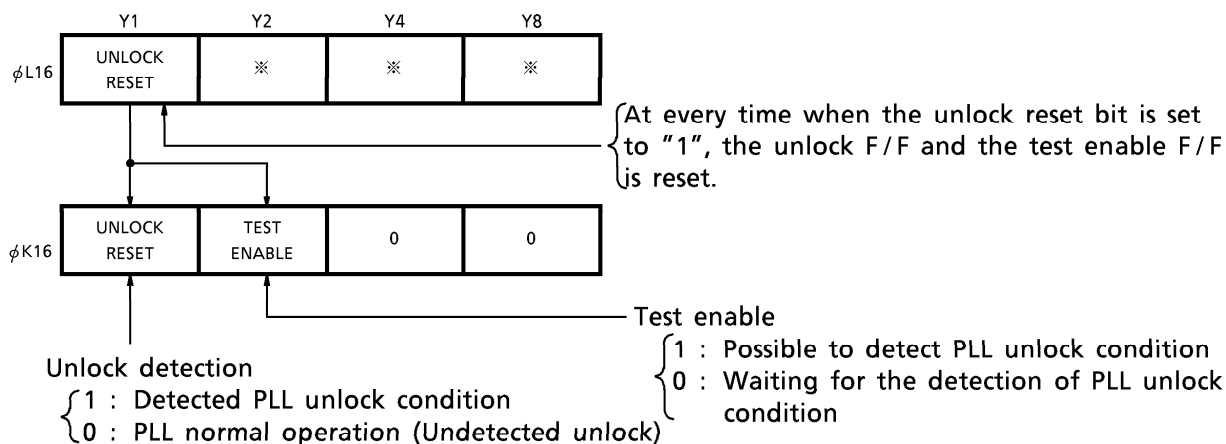
○ Unlock detection bit (ϕ LK16)

This is the bit for detecting the locked state of PLL system. When PLL system is unlocked state, namely, in the state in which the reference signal and the dividing frequency of programmable counter do not coincide, the pulse is output from the phase comparator to the unlock F/F with the cycle of the reference frequency.

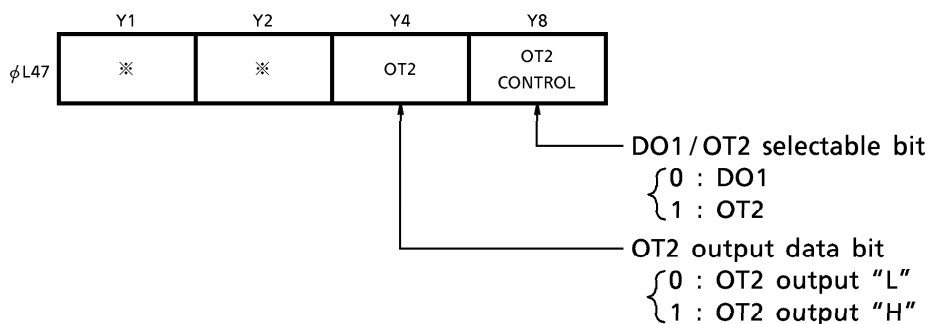
By this pulse, the unlock F/F is set. At every time when the unlock-reset bit is set to "1" by PLL output instruction designated the operand part [$C_N=6$], the unlock F/F is reset (ϕ L16). After the unlock F/F is reset, the locked condition can be detected by access the unlock detection bit with PLL input instruction (ϕ K16). Since the pulse is input with the cycle of the reference frequency, after the unlock F/F is reset, it is necessary to make access the unlock detection bit after the time exceeding the cycle of the reference frequency. If the time is shorter than the cycle, the correct locked condition can not be detected.

So the test enable F/F is prepared. Every time when the unlock reset bit is set to "1", the test enable F/F is reset and set to "1" with the unlock detection timing. In short, it is able to detect the unlock condition correctly at "1" state of the test enable bit (ϕ K16).





DO1 terminal is able to general output (OT2) by setting general output port (ϕ L47).

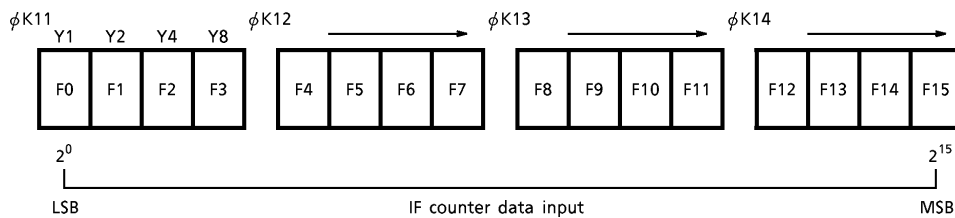


○ General IF counter

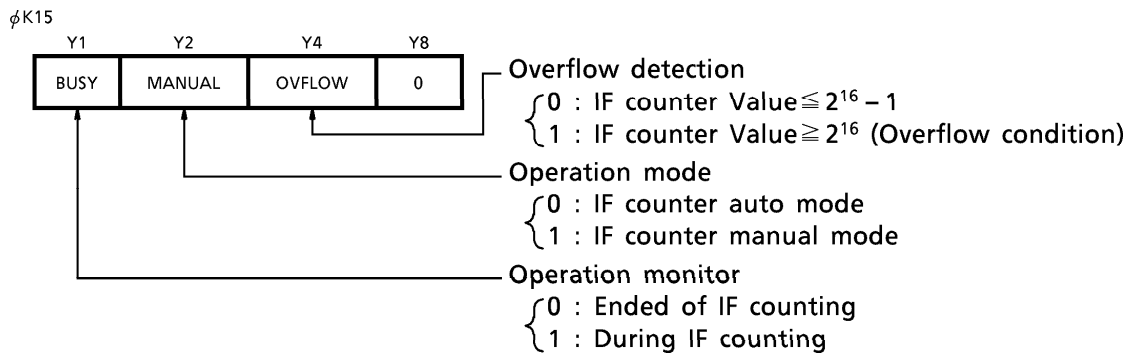
16 bits general IF counter is able to detect the auto-stop signal with counting intermediate frequency (IF) of FM or AM band at auto-tuning mode. The general IF counter is available for auto tuning function of IF counting type easily in combination with TA8132F, a AM / FM IF + MPX IC corresponding to DTS. IF counter block is composed of 16 bits binary counter and the port for IF counter control.

1. IF counter data port ($\phi K11 \sim \phi K15$)

This is the data input port for input the counted data of IF counter and operating condition. The data is read into data memory by PLL input instruction designated the operand part [$C_N = 1 \sim 5$].



The counted data of IF counter is inputted with binary from the input port, F0~F15.

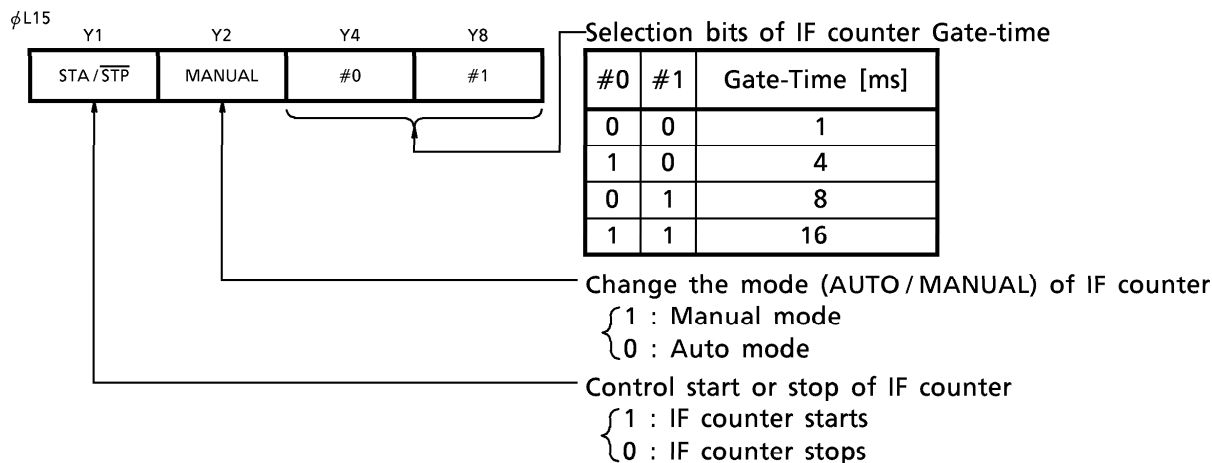


This is the input port for detecting operation condition of IF counter ($\phi K15$).

In case of using IF counter, the counted data (F0~F15) should be calculated after confirming "0" of BUSY bit (end of IF counting) and OVFLOW bit (not overflow condition).

2. IF counter control port (ϕ L15)

This is the data output port controlled for IF counter operation. This port is made access by PLL output instruction designated the operand part [$C_N = 5$].



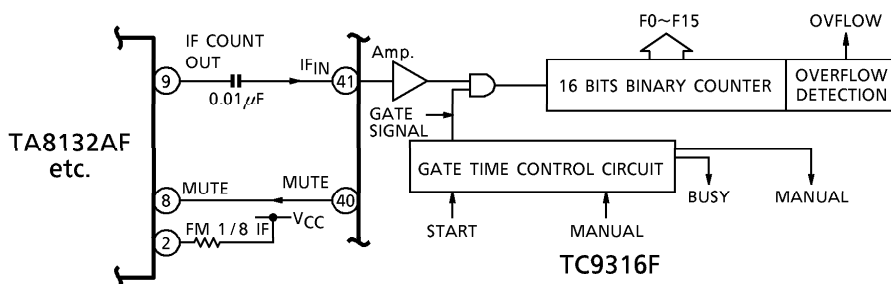
At the auto mode (MANUAL bit is set to "0"), the STA/ \overline{STP} bit is set to "1" every time, IF counter starts. IF counter counts during the gate time selected by #0, #1 bits, and it ends automatically.

At manual mode, when the STA/ \overline{STP} bit is set to "1", IF counter counts continuously until the STA/ \overline{STP} bit is set to "0".

(Note) At $\overline{INH} = "0"$, IF counter is reset by compulsorily.

3. Circuit construction of IF counter

IF counter is composed of input Amp., gate-time control circuit, 16 bits binary counter.



※ In TC9316FA, TC9316FB, Pin No. changes as below.
 41→43, 40→42

(Note) IF_{IN} terminal has built-in amplifier, and the small amplitude operation is possible through the capacitor coupling.

○ LCD driver

The TC9316F/FA/FB contains LCD driver of 1/3 duty and 1/2 bias driving (frame frequency = 104Hz). Three common terminals (COM1, COM2, COM3) output three potentials of voltage, V_{DD} , V_{EE} , V_{LCD} level respectively with 1/6 phase difference.

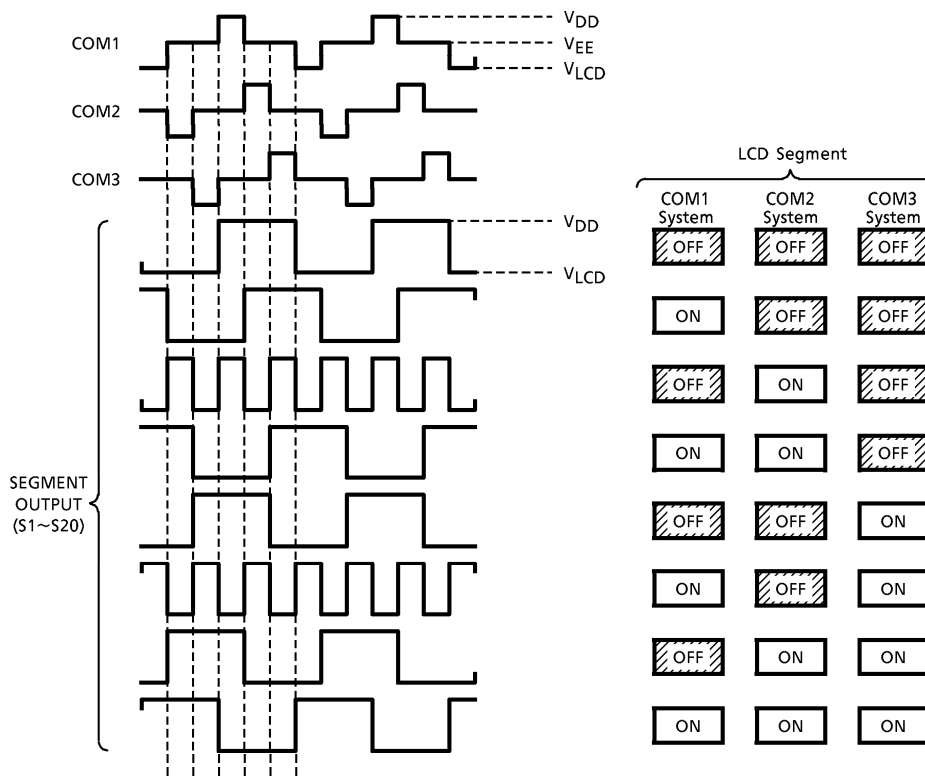
60 segments can be displayed by the combination of these common outputs and 20 segment outputs (S1~S20). That is to say, COM1 system segment COM2 system and COM3 system segment can be displayed by one segment output, what is called dynamic display method.

LCD driver does not contain segment decoder, so 60 segments can be freely used by program for 7 segment display or mark segment display.

S1~S16 segment output is controlled by execution of SEG instruction and S17~S20 segment output is by execution of MARK instruction.

1. Timing Chart of LCD Driver

Below are shown the timing chart of COM1~COM3 output wave form and four kinds of segment output wave form.

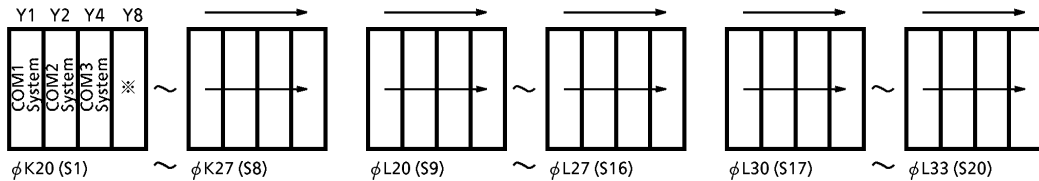


(Note) During system reset and back up mode (CKSTP instruction executing), common output and segment output are all fixed at "L" level automatically.

2. Segment port ($\phi K20 \sim \phi K27$, $\phi L20 \sim \phi L27$, $\phi L30 \sim \phi L33$)

This is a port group to output segment data. $\phi L20 \sim \phi L27$ ports are made access by SEG instruction and corresponded to S1~16.

$\phi L30 \sim \phi L33$ ports are made access by MARK output instruction and corresponded to S17~S20. At each port, Y1, Y2 and Y4 are corresponded to COM1, COM2 and COM3 system in order from LSB. MSB (Y8) port don't care. Selected port, designated segment and COM system segment turns "ON" when setted to data "1", COM system segment turns "OFF" when setted to data "0".

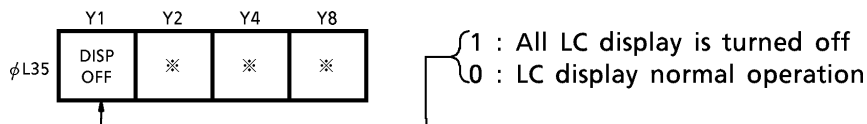


• DISP OFF bit ($\phi L35$)

This bit controls turning on or off of LC display. When data "1" is set to this bit, common outputs and segment outputs are all fixed at "L" level, all display becomes turned off. When data "0" is set to this bit, display becomes normal action. And this bit is reset to "0" after system reset.

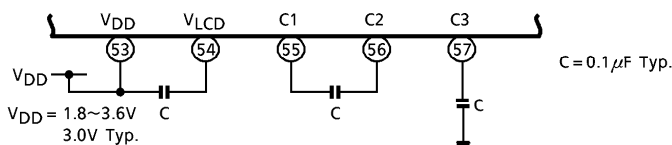
(Note) The name of segment port corresponds to the name of segment output terminal, respectively. And as the content of each port don't accept DISP OFF bit's influence, even display off made by DISP OFF bit, it is able to output the data to each segment port normally.

(Note) Decoding of segment can be made by providing the segment decode pattern in the program memory and reading it into the data memory by using DAL instruction. Therefore LCD driver doesn't have built-in segment decoder especially.



3. Voltage boosting circuit for LC display

TC9316F has built-in voltage boosting circuit for LC display, it is able to stabilize LC display driving at the low voltage operation. This circuit is composed with 1.5V reference voltage circuit (V_{EE}) and voltage double boosting circuit (V_{LCD}), be connected the boosting capacitor as follows.



※ In TC9316FA, TC9316FB, the pin No. changes as below.
53→56, 54→57, 55→58, 56→59, 57→60

○ Input and output port

1. I/O Port P1-0~P1-3 (ϕ KL41), P2-0~P2-3 (ϕ KL42)

I/O port (P1-0~P1-3, P2-0~P2-3) are 4 bits CMOS type, and is capable of making input and output setting with each bit.

Input and output setting of I/O port is made by the content of I/O control internal port.

Setting to input port can be made by setting "0" to the bit of I/O control port corresponding to I/O port, while setting to output port can be made by setting "1" in the same.

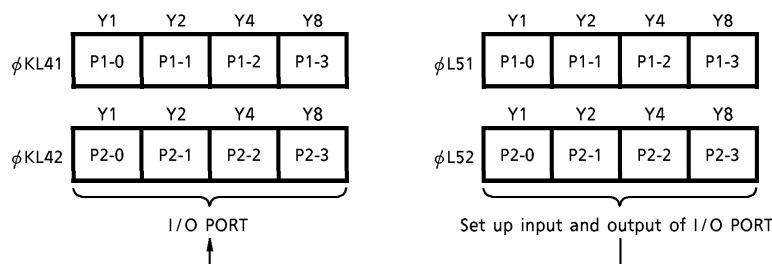
In case of input port setting, the present data input I/O port is read into the data memory by the execution of IO input instruction designated the operand part [$C_N = 1, 2$] (ϕ K41, ϕ K42). At this time, input data is set to output latch of I/O port (ϕ L41, ϕ L42) in the same.

In case of output port setting, output condition of I/O port is controlled execution of IO output instruction designated the operand part [$C_N = 1, 2$]. And the present output data of I/O port is read into the data memory by the execution of IO input instruction (ϕ K41, ϕ L42).

(Note) I/O control port is made access by KEY instruction designated the operand part [$C_N = 1, 2$]. After system reset, the content of this port is all reset to "0", and I/O port is all set up input mode.

(Note) During the clock stop mode (executing CKSTP instruction), output condition of I/O port set at output mode is all fixed at "L" level automatically, but each output latch holds on the data just before the clock stop mode.

(Note) At the time of changing input condition of P1-0~P1-3 port set at input mode, it cancels the execution of WAIT and CKSTP instructions and makes the operation restart. In case of setting "1" to I/O bit of MUTE control port, MUTE port is made to set to "1" compulsorily by the same condition.



2. General output port T0~T3 (ϕ L46), OT0, OT1 (ϕ L47)

T0~T3 and OT0, OT1 are exclusive output port of 4 bits and 2 bits.

In case of using LCD segment output for key matrix and be short for key functions. It is used as output of key return timing signal for key matrix. So the resistor is built-in at N-ch transistor side and sink current is decreased.

Therefore, of using push key, the diode can be omitted on the key matrix. Output port is made access by IO output instruction designated the operated part [$C_N=6, 7$] (ϕ L46, ϕ L47). In case of using for normal output port, take care to make the external circuit because of output impedance of "L" level increased.

(Note) During the clock stop mode (excusing CKSTP instruction), T0~T3 and OT0, OT1 output is fixed at "L" level automatically, but the content of port is held on the previous data.

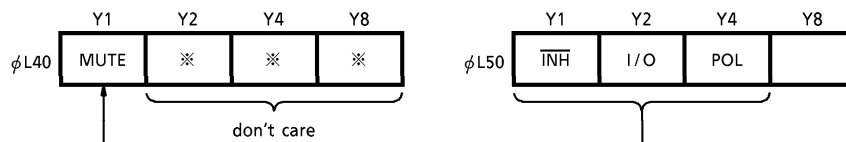


3. MUTE port (ϕ KL40)

This is a 1bit CMOS type exclusive output for muting control. Normally, it is made access by IO output instruction designated operand part [$C_N=0$] (ϕ L40).

Further, by the execution of IO input instruction designated operand part [$C_N=0$], content of present output data is read into data memory (ϕ K40).

And according to the data of MUTE control port (ϕ L50), MUTE port is controlled.



- \overline{INH} bit

In case of setting "1" to this bit, MUTE port is set to "1" compulsorily by changing of \overline{INH} input level ("L" \rightarrow "H" or "H" \rightarrow "L").

- I/O bit

In case of setting "1" to this bit, MUTE port is set to "L" compulsorily by input level changing of I/O port set at input mode.

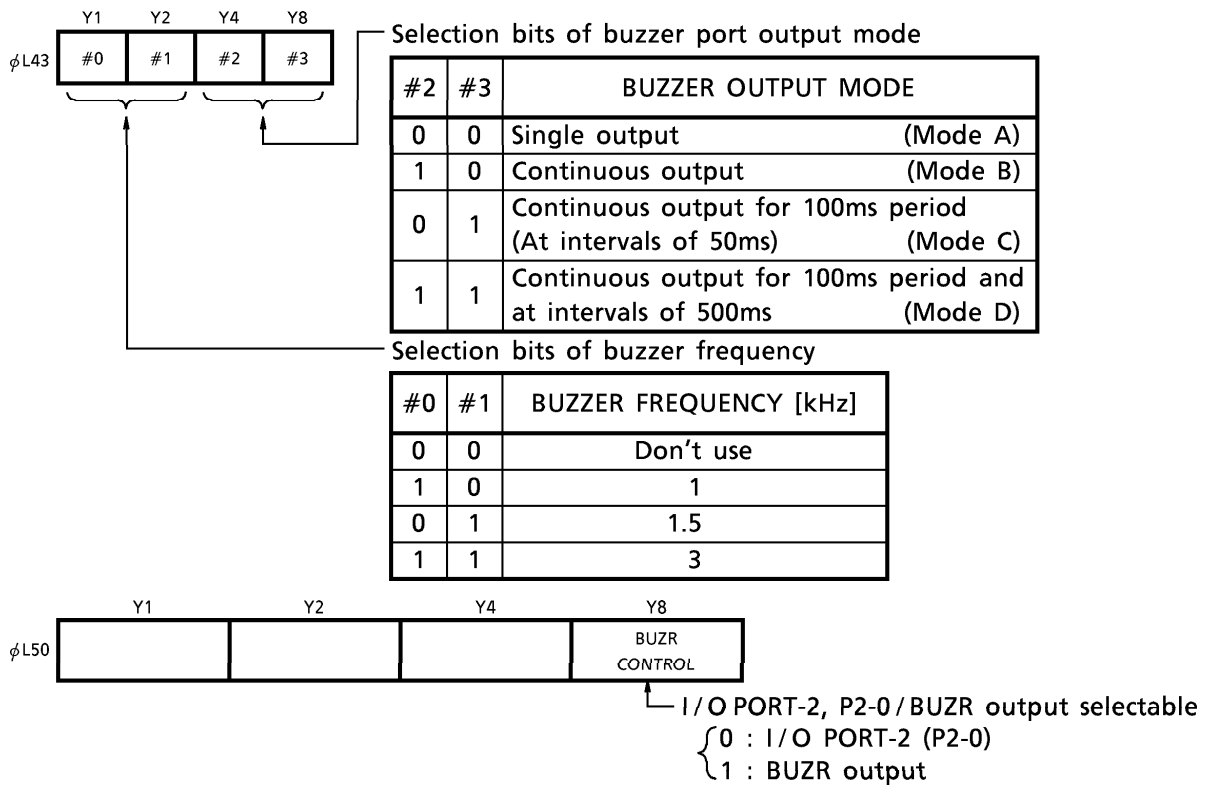
- POL bit

The bit controls output polarity of MUTE port. In case of setting "0" to this bit, the data of MUTE port is output with positive logic. In case of setting "1" to the bit, the data of MUTE port is output with negative logic.

(Note) After system reset, the content of \overline{INH} , I/O, POL each bit is reset to "0".

○ Buzzer port

Buzzer output is available as beep sound for confirmation of key operation, and as alarm sound. It uses as 1bit general output port. The buzzer output condition is controlled by buzzer control port (ϕ L43) as follows. Buzzer control port is made access by IO output instruction designated the operand part [$C_N=3$].

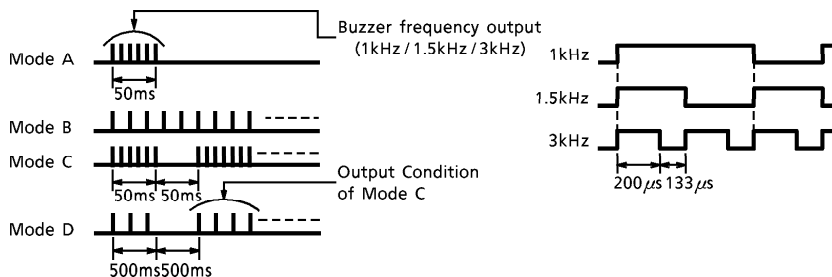


It is able to use both as BUZR output and I/O PORT (P2-0).

If BUZR CONTROL bit is setted to "1", the terminal changes from P2-0 output to BUZR output.

(Note) In case of using as general output port, output is fixed at "L" level by executing CKSTP instruction, but the content of this port is held on.

Below are shown the timing chart of buzzer signal output and buzzer frequency wave form.



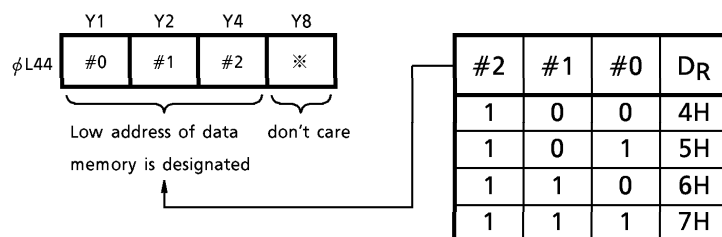
○ Register port

G-register and data register stated in the explanation of CPU are also treated as one of internal ports.

1. G-register (ϕ L44)

This is a register to make addressing of low address ($D_R = 4H \sim 7H$) of data memory during the execution of MVGD instruction and MVGS instruction. This register is made access by IO output instruction designated the operand part [$C_N = 4$].

(Note) Content of this register is effective only during the execution of MVGD instruction and MVGS instruction, and gives no effect during the execution of other instructions.

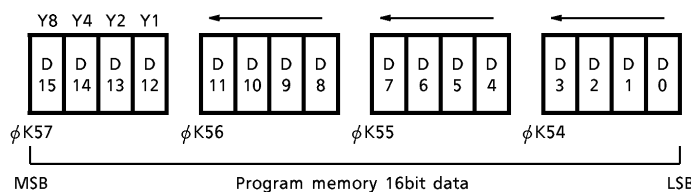


(Note) It is possible to indirectly designate all low address of data memory by setting data 0H~7H on G-register. ($D_R = 0H \sim 7H$)

2. Data register (ϕ K54~ ϕ K57)

This is 16bit register on which the data of program memory is loaded by the execution of DAL instruction. Content of this register is read into the data memory in 4bit unit by the execution of KEY input instruction designated the operand part [$C_N = 4 \sim 7$].

This register is available for the decoding of LCD segment, or for the taking of band edge data of radio and coefficient data during binary to BCD conversion.



○ Key input

The three basic key scanning methods are listed below.

- ① The general-purpose output ports (T0~T3, OT0 and OT1) function as the key source and are scanned by software.
- ② The general-purpose output ports (T0~T3, OT0 and OT1) function as the key source and are scanned by hardware.
- ③ The LCD segment output (S20 /KR0~S13 /KR7) functions as the key source and is scanned by hardware.

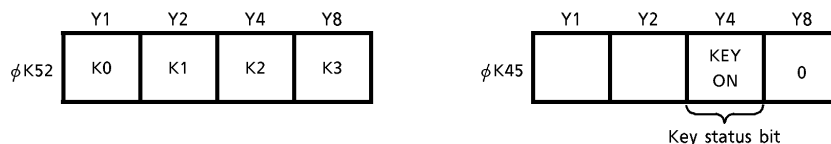
The advantages and disadvantages of these methods are listed below.

	Advantages	Disadvantages
①	<ul style="list-style-type: none"> ● Allows rapid key scanning. 	<ul style="list-style-type: none"> ● The general-purpose output ports are used for key scanning only. ● Configuration of a large number of keys is impossible.
②	<ul style="list-style-type: none"> ● Allows configuration of the largest number of keys when the general-purpose output ports are used together with the LCD segment output to construct a key matrix. 	<ul style="list-style-type: none"> ● The general-purpose output ports are used for key scanning only. ● Slow (could be faster than ③ depending on configuration).
③	<ul style="list-style-type: none"> ● The general-purpose output ports need not be used for key scanning. ● Allows configuration of a relatively large number of keys. 	<ul style="list-style-type: none"> ● Slow.

Four different key matrices can be configured by combining these three methods. Select one which suits your system.

1. Key input port (ϕ K52)

A 4bit dedicated input port whose primary use is to scan keys by software scanning. When a key input instruction specifying (CN=2) as an operand is executed, the key input pin data are loaded to data memory. When this happens, the data set in the key return control port (ϕ L53) bits for use in hardware scanning become undefined.



2. Key status bit (ϕ K45)

The key status bit ("key on") indicates the present key input status.

When an I/O input instruction specifying (CN=5) as an operand is executed, the contents of this bit are loaded to data memory.

● Key on bit

This bit outputs the results of logically OR the data from pins K0~K3.

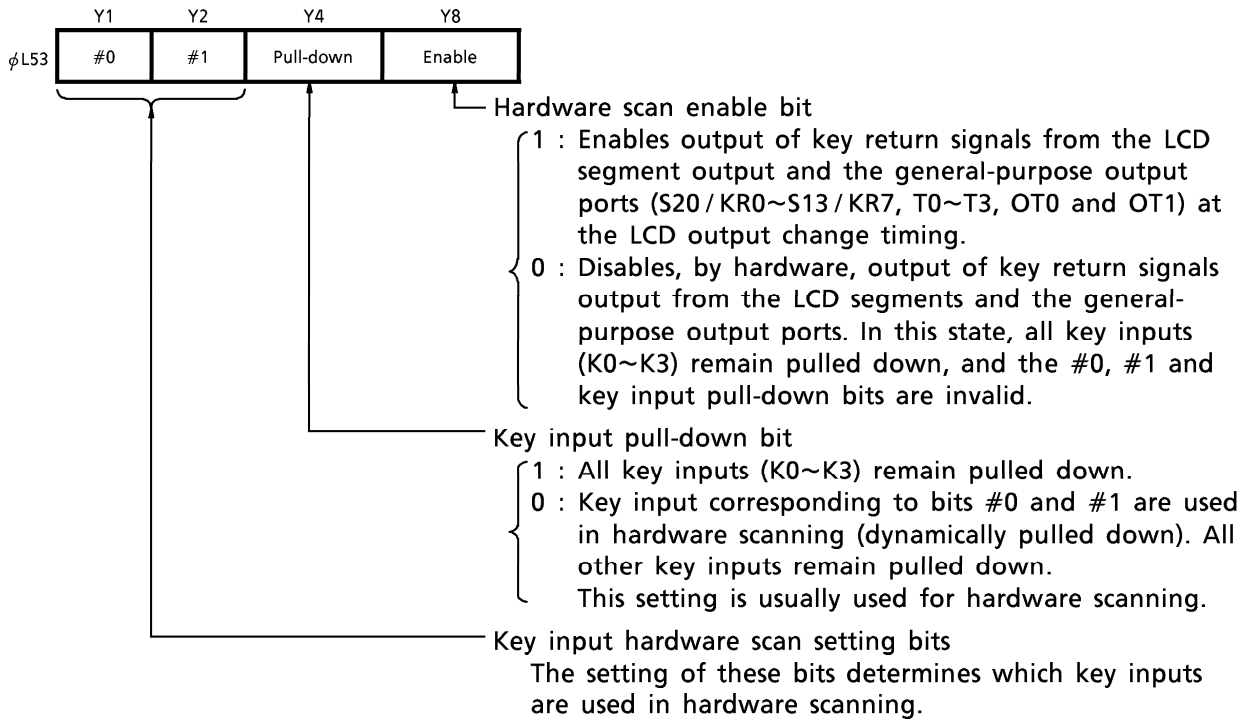
Pins set for use in hardware scanning by the key return control port (ϕ L53), however, are not logically OR.

This bit can be used to determine whether or not there is any key input.

When the key on bit is 1 (when high level is input to key input pins K0~K3), execution of the wait instruction is cancelled and operation restarts.

3. Key return control port

This port sets the key input port (K0~K3).



#1	#0	K0	K1	K2	K3
0	0	○	◇	◇	◇
0	1	○	○	◇	◇
1	0	○	○	○	◇
1	1	○	○	○	○

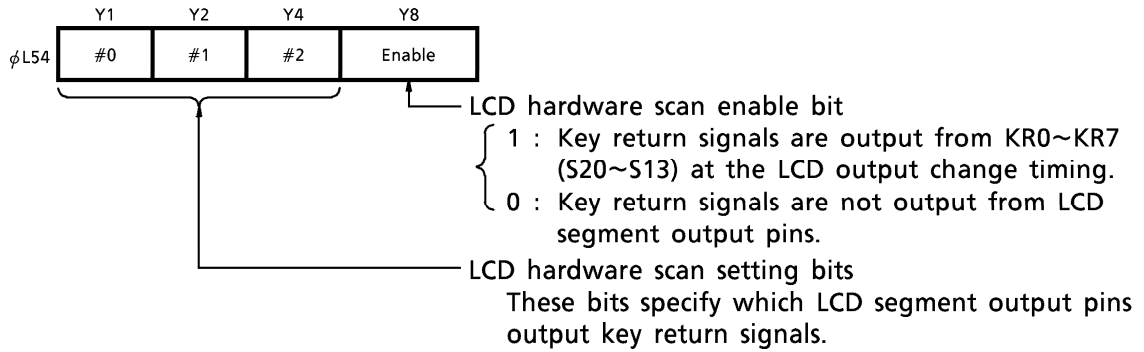
- : Dynamically pulled down at the LCD output change timing and the key input data are input to the key return ports (φK30~φK37). Bits corresponding to the key input port (φK52) become undefined. (hardware scanning)
- ◇ : Remain pulled down and data input from the key input port (φK52) are loaded to RAM (software scanning)

(Note) During execution of the wait instruction, when high level is applied to key input pins which are continuously pulled down, wait is cancelled. Wait is not cancelled, however, for other pins (pins set for hardware scanning) even when high level is applied.

(Note) When power is turned on, the hardware scan enable bit is set to 0 and the other bits are set to 1 (hardware scanning disabled).

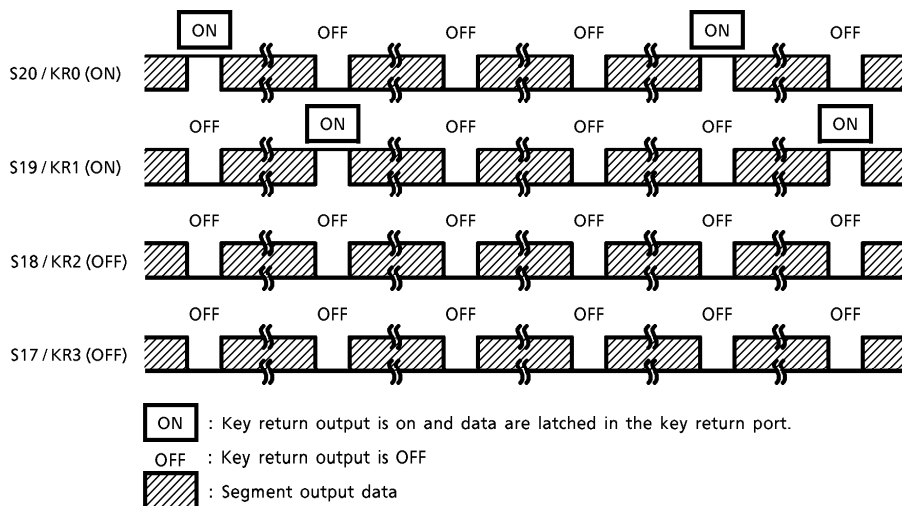
4. LCD key return control port

This port sets hardware scanning using output from the LCD segments. It determines which LCD segment output pins output key return signals for hardware scanning.



	#2	#1	#0	KEY RETURN SIGNAL OUTPUT PINS	CONCEPTUAL DIAGRAM OF OUTPUT WAVEFORMS (Numbers signify "n" in "KRn")
0	0	0	0	KR0	
1	0	0	1	KR0, KR1	
2	0	1	0	KR0~KR2	
3	0	1	1	KR0~KR3	
4	1	0	0	KR0~KR4	
5	1	0	1	KR0~KR5	
6	1	1	0	KR0~KR6	
7	1	1	1	KR0~KR7	

(Note) When bits #0, #1 and #2 are set to 1, 0 and 0, respectively (setting 1), the actual output waveforms are as shown below.



(Note) When power is turned on, only the LCD hardware scan enable bit is reset to 0.

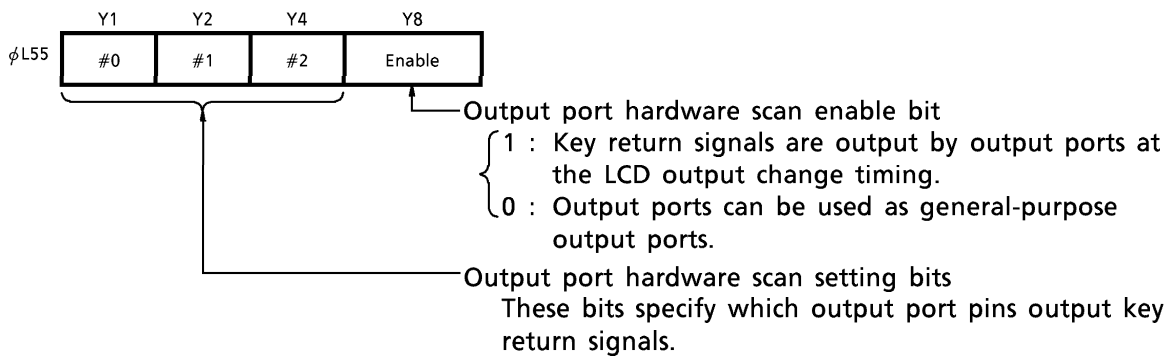
(Note) When bits #0~#2 are set according to settings 0~3, key scanning is completed in 12.8ms. When these bits are set according to settings 4~7, key scanning is completed in 25.6ms.

(Note) Off waveforms are output by all LCD segment output pins (S13~S20) which are not set for key return output.

(Note) The key return control port is disabled when the hardware scan enable bit is set to 0.

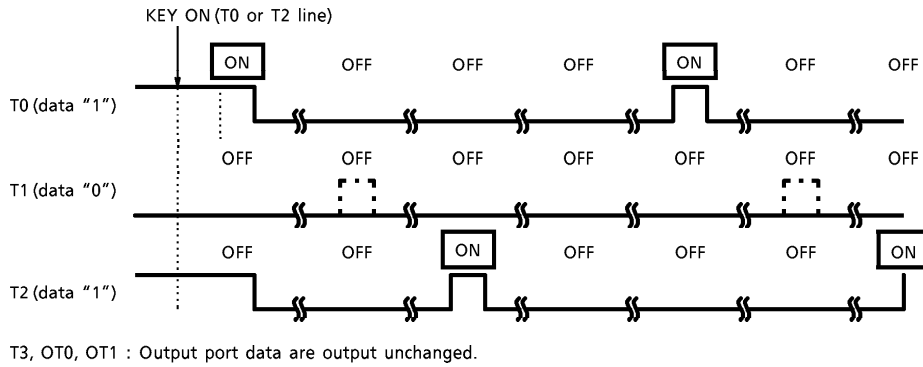
5. Output port key return control port

Sets hardware scanning using the output ports. This port determines which output port pins output key return signals for hardware scanning. The output ports are usually used together with the LCD output for hardware scanning when a large number of keys is required.



	#2	#1	#0	KEY RETURN SIGNAL OUTPUT PINS	CONCEPTUAL DIAGRAM OF OUTPUT WAVEFORMS
0	0	0	0	T0	
1	0	0	1	T0, T1	
2	0	1	0	T0~T2	
3	0	1	1	T0~T3	
4	1	0	0	T0~T3, OT0	
5	1	0	1	T0~T3, OT0, OT1	
6	1	1	0	Disabled	—
7	1	1	1	Disabled	—

(Note) When bits #0, #1 and #2 are set to 0, 1 and 0, respectively (setting 2), the actual output waveforms are as shown below.

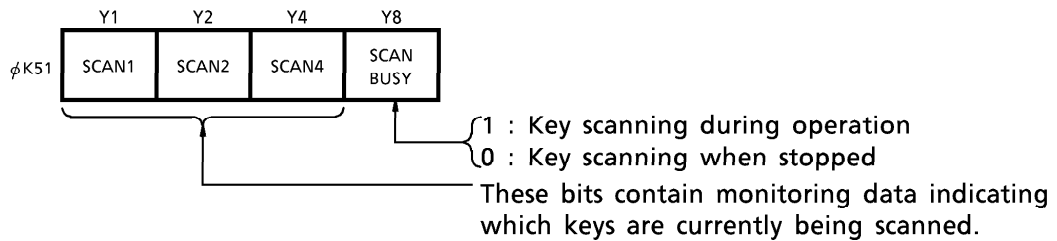


When the output port hardware scan enable bit is set to 1, the output ports continue to output data unchanged. In this state, if the line key of an output port pin which is outputting 1 is pressed, key scanning begins, key return signals are output according to the timing shown above, and the key data are latched. Only pins which are set to 1 output key return signals. There is no output from pins set to 0 (pin T1 in the above example).

- (Note) When power is turned on, only the output port hardware scan enable bit is reset to 0.
- (Note) When bits #0~#2 are set according to settings 0~3, key scanning is completed in 12.8ms. When these bits are set according to settings 4 or 5, key scanning is completed in 25.6ms.
- (Note) This port is enabled only when the key return control port hardware scan enable bit is 1 and the LCD key return control port LCD hardware scan enable bit is 0.

6. Key return digit No. port, SCAN BUSY bit

The scan busy bit detects whether keys are being scanned by key return output in sync with LCD output.



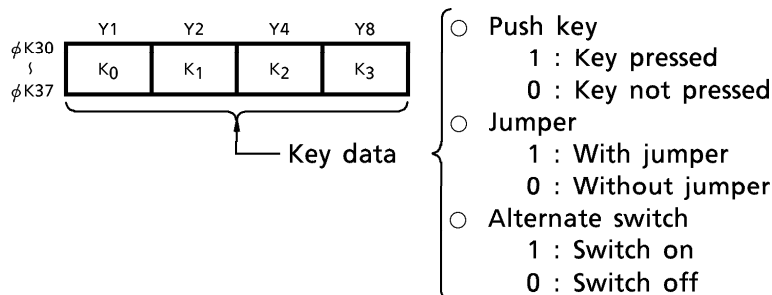
	SCAN4	SCAN2	SCAN1	SCAN DIGIT OUTPUT
0	0	0	0	KR0 or T0
1	0	0	1	KR1 or T1
2	0	1	0	KR2 or T2
3	0	1	1	KR3 or T3
4	1	0	0	KR4 or OT0
5	1	0	1	KR5 or OT1
6	1	1	0	KR6
7	1	1	1	KR7

(Note) When the output ports are set for key return signal output but no keys are being pressed, the SCAN BUSY bit becomes 0 and the SCAN1~SCAN4 bits all become 1.

(Note) When the operation is cancelled by clock stop or hard wait, the SCAN1~SCAN4 bits start from 0.

7. Key return data ports

The ϕ K30 to ϕ K37 ports store the data which result from key scanning by key return output in sync with LCD output.



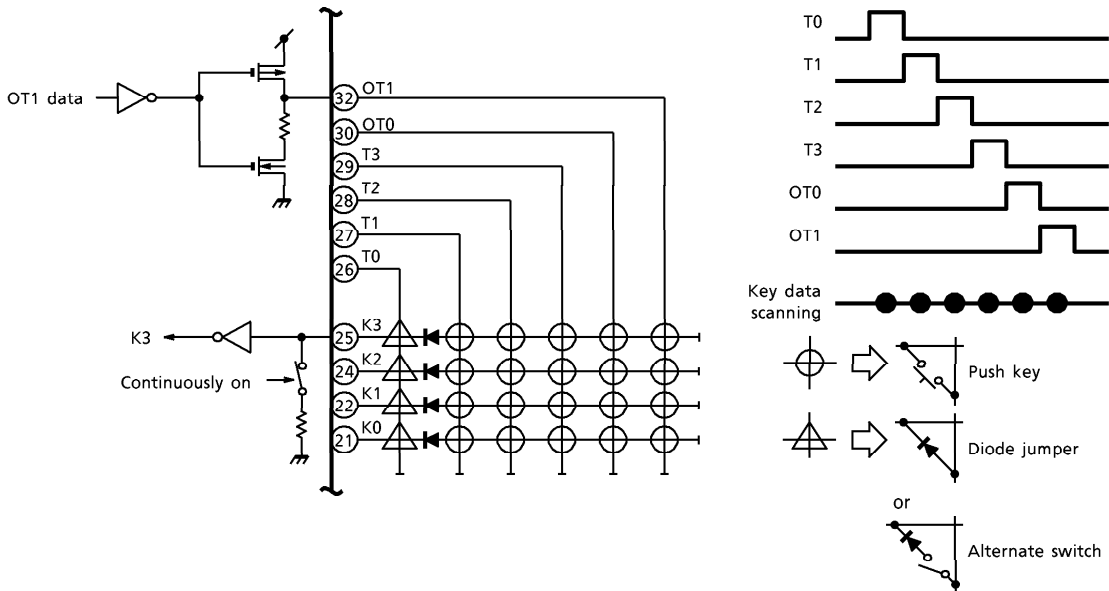
These ports are all set to 0 when the key return control port, the LCD key return control port, and the output port key return control port (ϕ L53~ ϕ L55) are set.

When one cycle of SCAN1~SCAN4 is completed, the data in these ports are loaded to RAM.

8. Key matrix configurations

The following four key matrices can be configured.

(1) Key data scanning by software (software scanning)



※ Pin numbers apply to TC9316F.

A key matrix like the one shown above is configured when key data are scanned by software.

This configuration limits key use to 4×6=24, but it allows fast key data scanning. Since T0~T3, OT0 and OT1 have built-in high resistance in their n-channel FETs, no diodes are needed to prevent reverse current when multiple keys are pressed simultaneously.

With this method, the general-purpose output port data (ϕ L46, ϕ L47) for the key lines to be scanned are set to high level. The key input port (ϕ K52) data are then loaded to memory to determine whether a key is pressed.

General-purpose output port data which are set to low level are not scanned at this time.

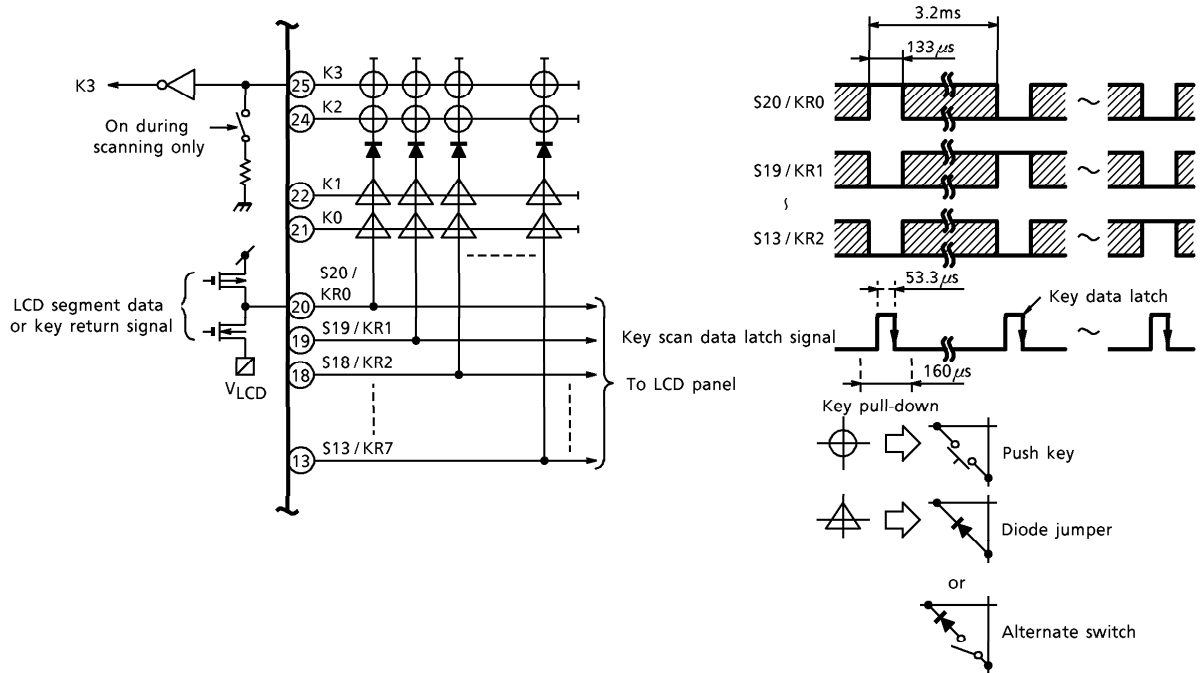
When a key is pressed, key input port data = 1 is loaded to data memory; when a key is not pressed, key input port data = 0 is loaded to data memory.

○ Port settings for software scanning

PORT NAME	SYMBOL	BIT (s)	SETTING / USE
Hardware Scan Enable Bit	ϕ L53	Y8	"0" : Disables hardware scanning.
General-Purpose (T0~T3) Output Ports (OT0, OT1)	ϕ L46 ϕ L47	Y1~Y8 Y1, Y2	} Sets scanning data (only for ports used in scanning).
Key Input Port (K0~K3)	ϕ K52	Y1~Y8	

(Note) When high level is applied to the key input pins during execution of a wait instruction (ie, during wait mode), wait is cancelled and the CPU is restarted.

(2) Key data scanning by LCD segment output (LCD hardware scanning)



※ Pin numbers apply to TC9316F.

A key matrix like the one shown above is configured when key data are loaded according to the LCD segment output. This key matrix requires diodes to prevent reverse current so be sure these diodes and the diode jumpers are connected pointing in the right direction. This configuration is used when the general-purpose ports are otherwise employed and are therefore not available for key data scanning and when fast key data scanning is unnecessary. This configuration features a maximum of $4 \times 8 = 32$ keys. With this method, the key data are scanned at the LCD output change timing. Normally, V_{DD} potential and the V_{LCD} ($V_{DD} - 3V$) potential are updated and output every 3.2ms from the LCD segment output in accordance with the segment setting. At the output change timing, the segment signal used to load the key data is set to V_{DD} potential (active), thus pulling the key input pin down to GND. If a key is pressed (or if a diode jumper is connected) at this time, voltage for one diode ($V_{DD} - \text{about } 0.6V$) is input from V_{DD} potential to the key input pin. If a key is not pressed (or if a diode jumper is not connected), GND potential is input to the key input pins. The potential input is latched in the key return data ports ($\phi K30 \sim \phi K37$) corresponding to the active LCD segment output lines. At this time, data = 1 when keys are pressed and 0 when not pressed.

○ Port settings for LCD hardware scanning

PORT NAME	SYMBOL	BITS	SETTING / USE
Key Return Control	ϕ L53	Y1~Y8	LSB ※ "1101" } Enables hardware scanning. Specifies dynamic pull-down; K0~K3 all used for hardware scanning.
LCD Key Return Control	ϕ L54	Y1~Y8	LSB "x x x 1" } Enables LCD hardware scanning. Y1, Y2 and Y4 bit settings specify which LCD segment output is used for hardware scanning.
LCD Segment Output (S20 / KR0~S13 / KR7)	—	—	Outputs key return signals.
Key Return Data	ϕ K30 ~ ϕ K37	Y1~Y8	Latches key data.

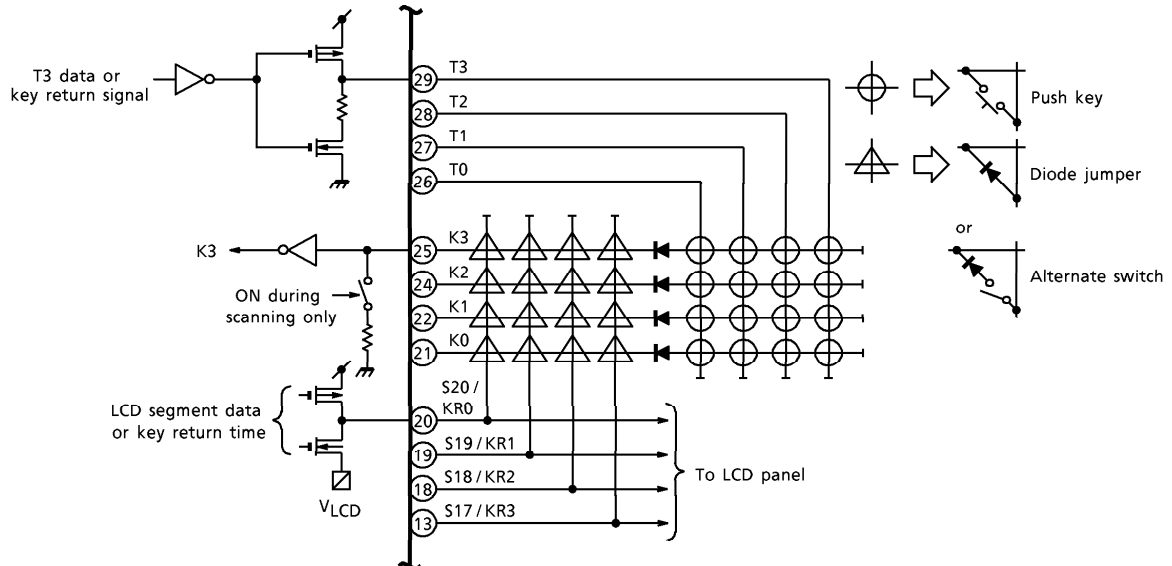
※ : The number of key input pins used for LCD hardware scanning can be switched arbitrarily by setting other data in Y1 and Y2. (Except K0, which must always be hardware scanned).

(Note) Since hardware scanning is not synchronous with CPU operation, check the key return digit number port and scan busy bit (ϕ L51) to determine the status of key data scanning.

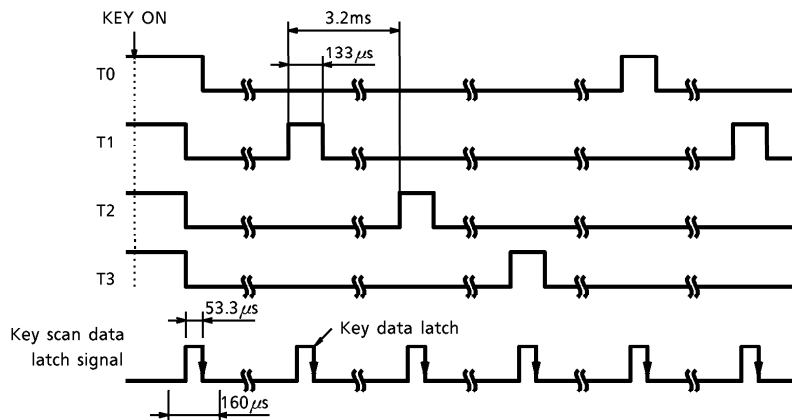
(Note) Since key data are stored in port latches, the data can be used without first loading them to data memory if necessary, by referencing the ports where the data are stored.

(Note) Key data are stored in port latches. Thus, key data can be used without loading them to memory just by referencing the ports where key data are stored as necessary. Of LCD segment output S1~S20, only S13~S20 can be used in LCD hardware scanning.

(3) Key data scanning by LCD segment output and general-purpose outputports ①
 (LCD / output port hardware scanning)



※ Pin numbers apply to TC9316F.



The LCD side output waveforms are the same as those in section 8-(2), LCD hardware scanning.

There are two ways to scan key data by the LCD segment output and general-purpose output ports. One is to construct a key matrix like the one shown above, the other is to construct a key matrix as described in the following section.

The key matrix shown above uses time division switching to utilize both the LCD segment output and general-purpose output ports for key data scanning by hardware scanning. In the above key matrix, key data are loaded using hardware scanning by switching the scanning of LCD segment output and general-purpose port by time division.

This method is used when many keys are required or when LCD hardware scanning alone is too slow. This configuration features a maximum of $4 \times 14 = 56$ keys. It usually features jumpers or alternate switches on the LCD side and push keys on the output port side. When the jumpers are scanned by the initialization routine, they rarely need to be re-scanned by the main routine, too. Here, they are scanned by initialization routine LCD hardware scanning.

The main routine switches the system to output port hardware scanning, and the push-key data are scanned. If there are fewer than 16 push keys, that is, the same number as in the example in section 8-(2) (OT0 and OT1 are not used), one cycle of hardware scanning takes 12.8ms. This is half the time required (25.6ms) for LCD hardware scanning alone.

For a description of LCD hardware scanning, see 8-2 below.

As with LCD hardware scanning, the key data are scanned at the LCD output change timing when the general-purpose output ports are used for hardware scanning. If the general-purpose output port data ($\phi L46$ and $\phi L47$) used for hardware scanning are set to high level, scanning begins when a key is pressed. While the key is being pressed, T0 outputs a sequence of V_{DD} potential (active) in sync with the 3.2ms LCD output change timing. At the same time, the key input pin is pulled down to GND. When a key is pressed at this time, voltage for one diode (V_{DD} minus approx. 0.6V) is input from V_{DD} potential to the key input pin. When a key is not pressed, GND potential is input to the key input pin.

The input potential is latched in the key return data ports ($\phi K30 \sim \phi K37$) corresponding to the active general-purpose output port lines.

At this time, data = 1 when a key is pressed; 0 when a key is not pressed.

When the key is released, key scanning stops after completion of the scan operation currently underway. The general-purpose output ports used for hardware scanning revert to high level.

○ Port settings for LCD/output port hardware scanning

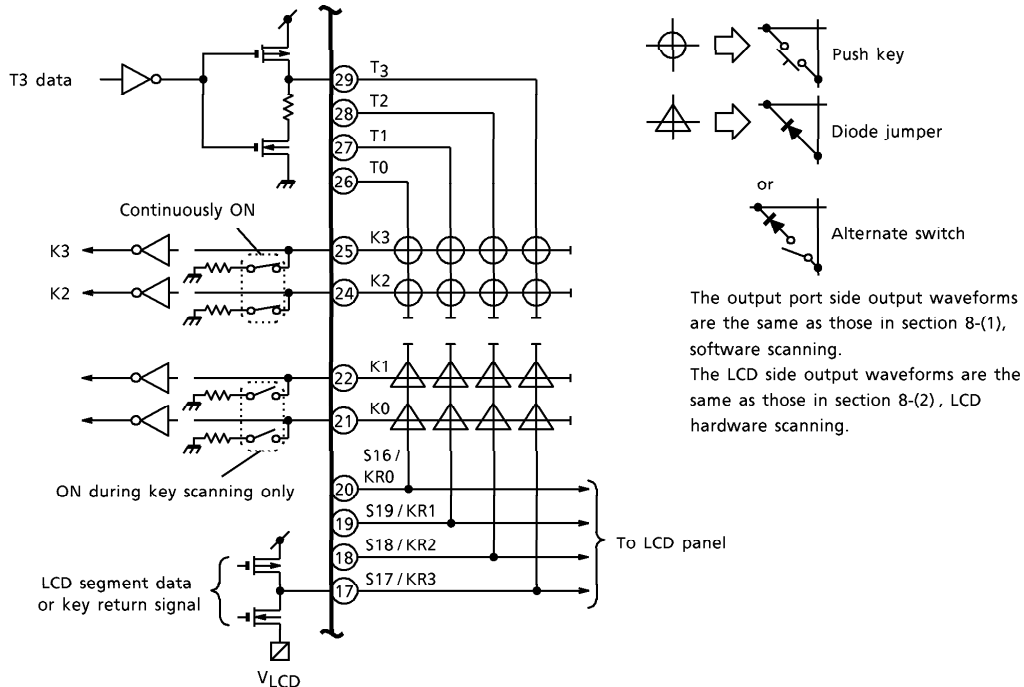
PORT NAME	SYMBOL	BITS	SETTING / USE
Key return control	ϕ L53	Y1~Y8	LSB ※ "1101" } Enables hardware scanning. Specifies dynamic pull-down; K0 to K3 all used for hardware scanning.
LCD key return control	ϕ L54	Y1~Y8	LSB " x x x 1 / 0 " } Y8 : 1 during LCD hardware scanning Y8 : 0 during output port hardware scanning Y1, Y2 and Y4 bit settings specify which LCD segment output is used for hardware scanning.
Output port key return control	ϕ K55	Y1~Y8	LSB " x x x 1 " } Enables output port hardware scanning. Y1, Y2 and Y4 bit settings specify which general-purpose output port pins are used for hardware scanning.
LCD segment output (S20 / KR0~S13 / KR7)	—	—	Outputs key return signal
General-purpose (T0~T3) output ports (OT0, OT1)	ϕ L46 ϕ L47	Y1~Y8 Y1, Y2	} Output port pins used for hardware scanning } output key return signals when they are set to 1.
Key return data	ϕ K30 ~ ϕ K37	Y1~Y8	Latches key data

※ The number of key input pins used for LCD hardware scanning can be switched arbitrarily by setting other data in Y1 and Y2. (Except K0, which must always be hardware scanned).

(Note) Since hardware scanning is not synchronous with CPU operation, check the key return digit number port and SCAN BUSY bit (ϕ L51) to determine the status of key data scanning.

(Note) Key data are stored in port latches. Thus, key data can be used without loading them to memory just by referencing the ports where key data are stored as necessary.

(4) Key data scanning by LCD segment output port and general-purpose output ports ②
 (Software + LCD hardware scanning)



※ Pin numbers apply to TC9316F

This is the second kind of key matrix which can be used to scan key data by the LCD segment output and general-purpose output ports. The key matrix is configured as shown above.

This configuration uses software scanning on the output port side and hardware scanning on the LCD side. Key data can be scanned simultaneously by both sides since dedicated key input pins are assigned to each side. As the above configuration shows, two key input pins each are assigned to the output port side and the LCD side. This allows a maximum of $2 \times 6 + 2 \times 8 = 28$ keys. This configuration is used when fast key data scanning is required; also, when jumpers are required.

For a description of software scanning, see section 8-(1); for LCD hardware scanning, see section 8-(2).

○ Port settings for software + LCD hardware scanning

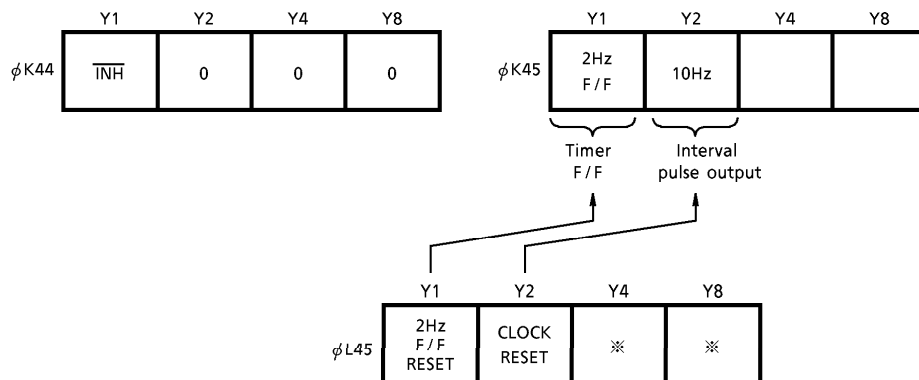
PORT NAME	SYMBOL	BITS	SETTING / USE
Key Return Control	ϕ L53	Y1~Y8	LSB "x x 01" } Enables hardware scanning. Specifies dynamic pull-down. Y1 and Y2 bit settings specify which key input pins are used for hardware scanning.
LCD Key Return Control	ϕ L54	Y1~Y8	LSB "x x x 1" } Enables LCD hardware scanning. Y1, Y2 and Y4 bit settings specify which LCD segment output is used for hardware scanning.
LCD Segment Output (S20 / KR0~S13 / KR7)	—	—	Outputs key return signal (LCD side).
Key Return Data	ϕ K30 ~ ϕ K37	Y1~?	Latches key data (LCD side).
General-Purpose Output Ports (T0~T3)	ϕ L46 ϕ L47	Y1~Y8 Y1, Y2	} Sets scanning (only sets ports used for data (scanning on output port side)
Key Input Port (?~K3)	ϕ K52	?~Y8	Reads input data (output port side).

(Note) Since hardware scanning is not synchronous with CPU operation, check the key return digit number port and SCAN BUSY bit (ϕ L51) to determine the status of key data scanning.

(Note) When high level is applied to the key input pins assigned to the output port side (software scanning) during execution of a wait instruction, wait is cancelled and the CPU is restarted.

○ Internal control port

Internal control port is used for reading into data memory the inside condition of device which must be known in the execution of program, or for resetting the inside condition of device.



1. $\overline{\text{INH}}$ input port (ϕ K44)

This is an input port for inputting the data of $\overline{\text{INH}}$ input terminal. Content of this port is read into the data memory by IO instruction designated the operand part [$C_N=4$]. Data "1" and "0" represent radio "ON" mode and "OFF" mode, respectively.

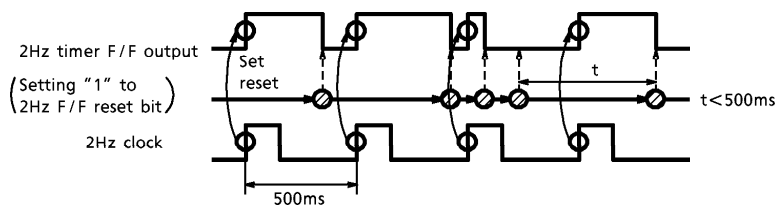
At radio off mode, it stops operating of PLL and IF counter block. When $\overline{\text{INH}}$ bit of MUTE control port is "1", MUTE port is set to "1" compulsorily by changing the data of $\overline{\text{INH}}$ input port. At $\overline{\text{INH}}$ input port is "1", it releases execution of CKSTP instruction and the operation is removed. By changing the condition of $\overline{\text{INH}}$ input port, execution of WAIT instruction is released.

2. 2Hz timer F/F (ϕ K45)

2Hz timer F/F is set by 2Hz (500ms) signal. With the execution of IO output instruction designated the operand part [$C_N=5$] this timer is reset by setting data "1" to 2Hz F/F RESET bit. This F/F output is read into the data memory by execution of IO input instruction designated the operand part [$C_N=5$].

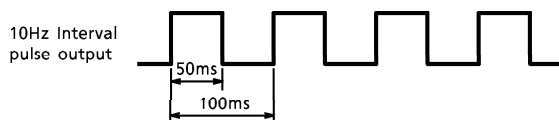
As 2Hz timer F/F is automatically set every 500ms, it is usually available for counting of clock. Since 2Hz timer F/F is reset only by 2Hz F/F RESET bit, count error takes place unless data "1" is set to 2Hz F/F RESET bit within 500ms period, and correct times is not obtainable.

(Note) Condition of 2Hz timer F/F output becomes "0" at power on reset or after execution of CKSTP instruction.



3. 10Hz interval pulse (ϕ K45)

10Hz interval pulse is output to 10Hz bit with 100ms period, duty 50% pulse. This is read into the data memory by the execution of IO input instruction designated the operand part [$C_N=5$]. This output has no flip flop and is available for mute time counting etc.



4. Other control bit (ϕ L45)

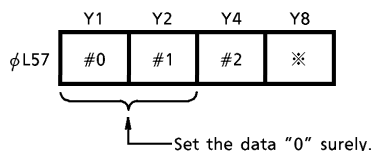
- Clock reset bit

Every time data "1" is set to this bit, clock of under 50Hz is reset (10Hz interval pulse is also reset). This bit is used for adjusting time of clock.

Accuracy of clock at this time is $-0, +0.02$ second.

5. TEST port (ϕ L57)

This is an internal port for testing function of device. It is made access by KEY output instruction designated the operand part [$C_N=7$]. Never fail to set data "0" in ordinary program.

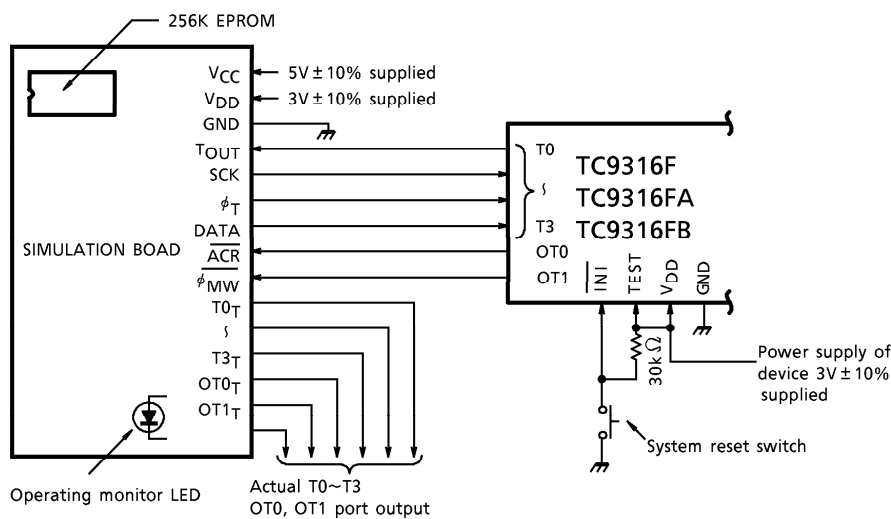


○ Application to evaluator chip

When "H" level is supplied to TEST terminal (Test mode), device operates as evaluator chip, and functional evaluation of developing program can be made by utilizing external simulation board and EPROM. In the test mode, the device operates with the program written in EPROM, irrespective of the content of program memory in the device.

As key timing output port (T0~T3) and output port (OT0, OT1) are transferred to the input and output terminal for control of simulation board at this time, actual T0~T3 and OT0, OT1 port signal are output from the simulation board side.

Below is shown connection diagram of the device and simulation board in case that it is used as evaluator chip.



(Note) Supply 3V ± 10% voltage to the device and 5V ± 10% voltage to the simulation board even during back-up mode.

(Note) Each terminal of the device except that shown above can be used normally.

(Note) In case of back-up mode (execution of CKSTP instruction), operating monitor LED on the simulation board turns off.

MAXIMUM RATINGS (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Power Supply Voltage	V _{DD}	-0.3~4.0	V
Input Voltage	V _{IN}	-0.3~V _{DD} +0.3	V
Power Dissipation	P _D	100	mW
Operating Temperature	T _{opr}	-10~60	°C
Storage Temperature	T _{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Unless otherwise specified, Ta = 25°C, V_{DD} = 3.0V)

CHARACTERISTIC	SYMBOL	TEST CIRCUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Power Supply Voltage Range	V _{DD}	—		1.8	3.0	3.6	V
Memory Holding Voltage Range	V _{HD}	—	Crystal oscillation stops (Executing CKSTP Instruction) ※	1.2	~	3.6	V
Operating Power Supply Current	I _{DD1}	—	Normal operation, output No-load	—	0.7	2.0	mA
	I _{DD2}	—	At only CPU operation (Radio off, lighting display)	—	60	150	μA
	I _{DD3}	—	At stand-by mode (Radio off, only crystal oscillation)	—	50	100	
Memory Holding Power Supply Current	I _{HD}	—	Crystal oscillation stop (Executing CKSTP instruction)	—	0.1	1.0	μA
Crystal Oscillation Frequency	f _X T	—		—	75	—	kHz
Crystal Oscillation Starting Time	t _{ST}		Crystal oscillation = 75kHz	—	—	1.0	s

Voltage double boosting circuit

Voltage Double Reference Voltage	V _{EE}	—	V _{DD} Reference (C3)	-1.2	-1.5	-1.8	V
Voltage Double Boosting Voltage	V _{LCD}	—	V _{DD} Reference (V _{LCD})	-2.4	-3.0	-3.6	
V _{LCD} Pull-down Resistance	R _{IN3}	—	(V _{LCD})	0.75	1.5	3.0	MΩ

※ Marked items are guaranteed by all conditions of V_{DD} = 1.8~3.6V, Ta = -10~60°C

CHARACTERISTIC	SYMBOL	TEST CIRCUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
----------------	--------	--------------	----------------	------	------	------	------

Programmable counter, IF counter

Operating Frequency Range	f_{IN1}	—	$V_{IN} = 0.3V_{p-p}$ (FM_{IN} , AM_{IN}) ※	0.2	~	5.0	MHz
	f_{IN2}	—	$V_{IN} = 0.3V_{p-p}$ (IF_{IN}) ※	0.35	~	12.0	
Operating Input Amplitude Range	V_{IN1}	—	$f_{IN} = 0.2 \sim 5.0\text{MHz}$ (FM_{IN} , AM_{IN}) ※	0.3	~	$V_{DD} - 0.3$	V_{p-p}
	V_{IN2}	—	$f_{IN} = 0.35 \sim 12.0\text{MHz}$ (IF_{IN}) ※	0.3	~	$V_{DD} - 0.3$	

Programmable counter, IF counter

FM _{IN} -PSC Transfer Delay Time	t_{pd}	—	$V_{IN} = 0.3V_{p-p}$, $C = 15\text{pF}$ (FM_{IN}) ※	—	—	200	ns
PSC Maximum Load Capacity	C_L	—	(PSC) ※	—	—	15	pF

LCD common output (COM1~COM3)

Output Current	"H" Level	I_{OH1}	—	$V_{LCD} = 0V$, $V_{OH} = 2.7V$	-100	-200	—	μA
	"L" Level	I_{OL1}	—	$V_{LCD} = 0V$, $V_{OL} = 0.3V$	100	200	—	

LCD segment output (S1~S20)

Output Current	"H" Level	I_{OH2}	—	$V_{LCD} = 0V$, $V_{OH} = 2.7V$	-0.5	-1.0	—	mA
	"L" Level	I_{OL2}	—	$V_{LCD} = 0V$, $V_{OL} = 0.3V$	50	100	—	μA

Key return output port, general purpose output port (T0~T3, OT0~OT1)

"H" Level Output Current	I_{OH3}	—	$V_{OH} = 2.7V$ (T0~T3)	-0.5	-1.0	—	mA
N-ch FET Side Load Resistance	R_{ON}	—	$V_{OL} = 3.0V$ (T0~T3)	75	150	300	k Ω

Mute, psc output

Output Current	"H" Level	I_{OH4}	—	$V_{OH} = 2.7V$	-300	-600	—	μA
	"L" Level	I_{OL4}	—	$V_{OL} = 0.3V$	300	600	—	

DO1/OT2, DO2 output

Output Current	"H" Level	I_{OH4}	—	$V_{OH} = 2.7V$	-300	-600	—	μA
	"L" Level	I_{OL4}	—	$V_{OL} = 0.3V$	300	600	—	
Output off-Leakage Current	I_{TL}	—	$V_{TLH} = 3.0V$, $V_{TLL} = 0V$	—	—	± 100	nA	

※ Marked items are guaranteed by all conditions of $V_{DD} = 1.8 \sim 3.6V$, $T_a = -10 \sim 60^\circ C$

CHARACTERISTIC	SYMBOL	TEST CIRCUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
----------------	--------	--------------	----------------	------	------	------	------

General purpose I/O port (P1-0~P1-3, P2-0~P2-3)

Output Current	"H" Level	I_{OH4}	—	$V_{OH} = 2.7V$	-300	-600	—	μA
	"L" Level	I_{OL4}	—	$V_{OL} = 0.3V$	300	600	—	
Input Leakage Current		I_{LI}	—	$V_{IH} = 3.0V, V_{IL} = 0V$	—	—	± 1.0	
Input Voltage	"H" level	V_{IH1}	—	—	2.4	~	3.0	V
	"L" level	V_{IL1}	—	—	0	~	0.6	

 \overline{IN} input, IF_{IN}/IN port (When using in port)

Input Leakage Current		I_{LI}	—	$V_{IH} = 3.0V, V_{IL} = 0V$	—	—	± 1.0	μA
Input Voltage	"H" Level	V_{IH2}	—	(\overline{IN} , $IN0 \sim IN3$)	2.4	~	3.0	V
	"L" Level	V_{IL2}	—	(\overline{IN} , $IN0 \sim IN3$)	0	~	0.6	

Key input port (K0~K3)

Input Pull-down Resistance		R_{IN1}	—	—	75	150	300	$k\Omega$
Input Voltage	"H" Level	V_{IH2}	—	—	1.8	~	3.0	V
	"L" Level	V_{IL2}	—	—	0	~	0.3	

 \overline{INH} input port

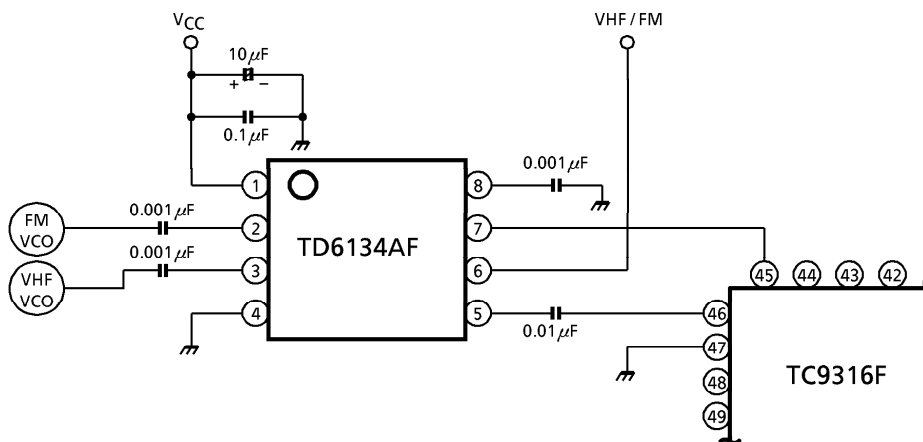
Input Leakage Current		I_{LI}	—	$V_{IH} = 3.0V, V_{IL} = 0V$	—	—	± 1.0	μA
Input Voltage	"H" Level	V_{IH3}	—	—	2.6	~	3.0	V
	"L" Level	V_{IL3}	—	—	0	~	1.2	

Others

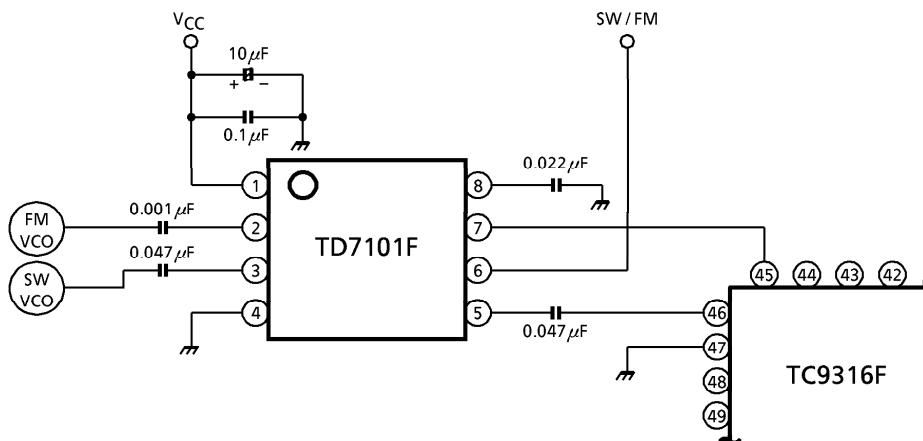
Input Pull-down Resistance		R_{IN2}	—	(TEST)	25	50	100	$k\Omega$
XT Input Feedback Resistance		R_{fXT}	—	($X_T \sim \overline{X_T}$)	3.75	7.5	15.0	$M\Omega$
$\overline{X_T}$ Output Resistance		R_{OUT}	—	($\overline{X_T}$)	50	100	200	$k\Omega$
Input Pull-down Resistance		R_{fIN}	—	($FM_{IN}, AM_{IN}, IF_{IN}$)	375	750	1500	

※ Marked items are guaranteed by all conditions of $V_{DD} = 1.8 \sim 3.6V$, $T_a = -10 \sim 60^\circ C$

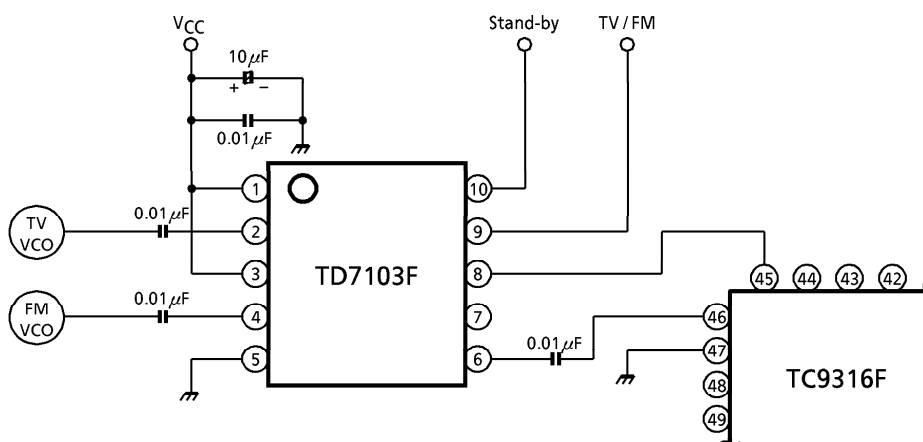
EXAMPLE OF CONNECTION TO PRESCALER TD6134AF



EXAMPLE OF CONNECTION TO PRESCALER TD7107F



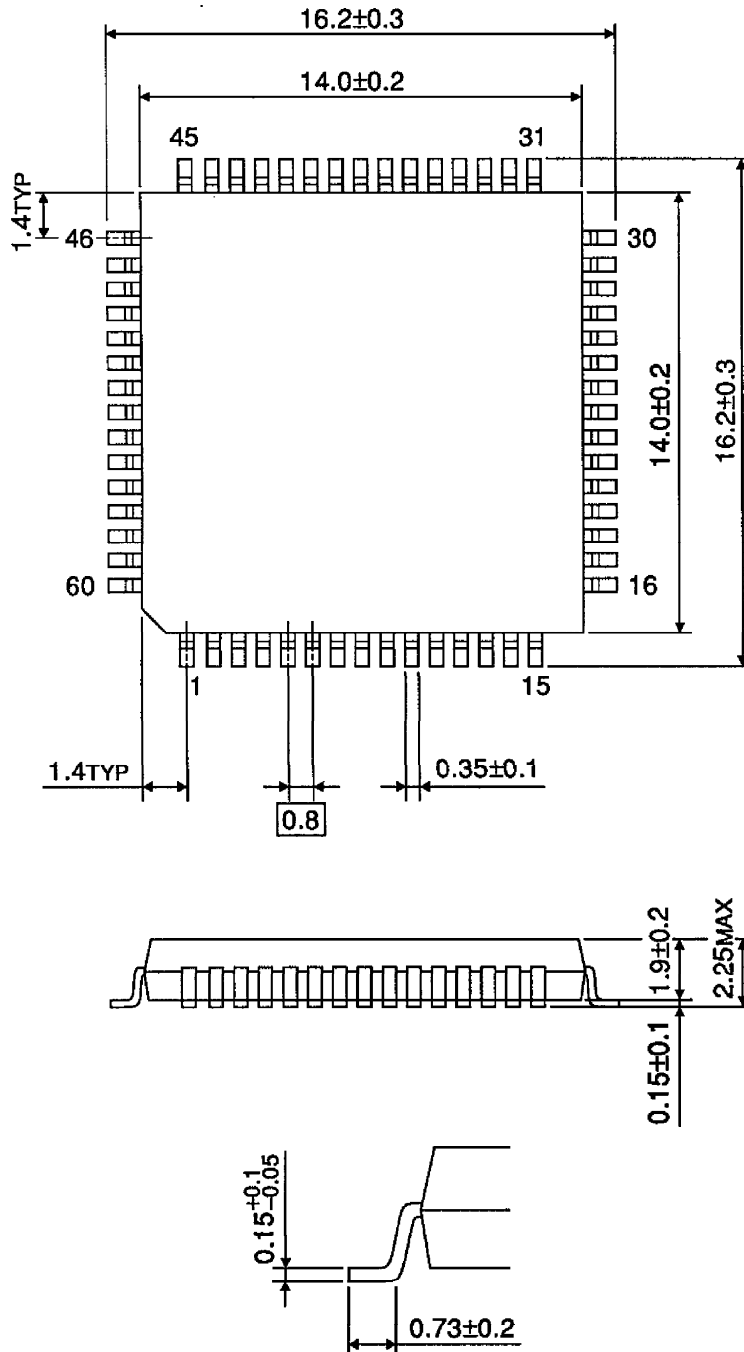
EXAMPLE OF CONNECTION TO PRESCALER TD7103F



※ TC9316FA, TC9316FB : Pin No. 45, 46 and 47 is change 47, 49 and 50.

OUTLINE DRAWING
QFP60-P-1414-0.80E

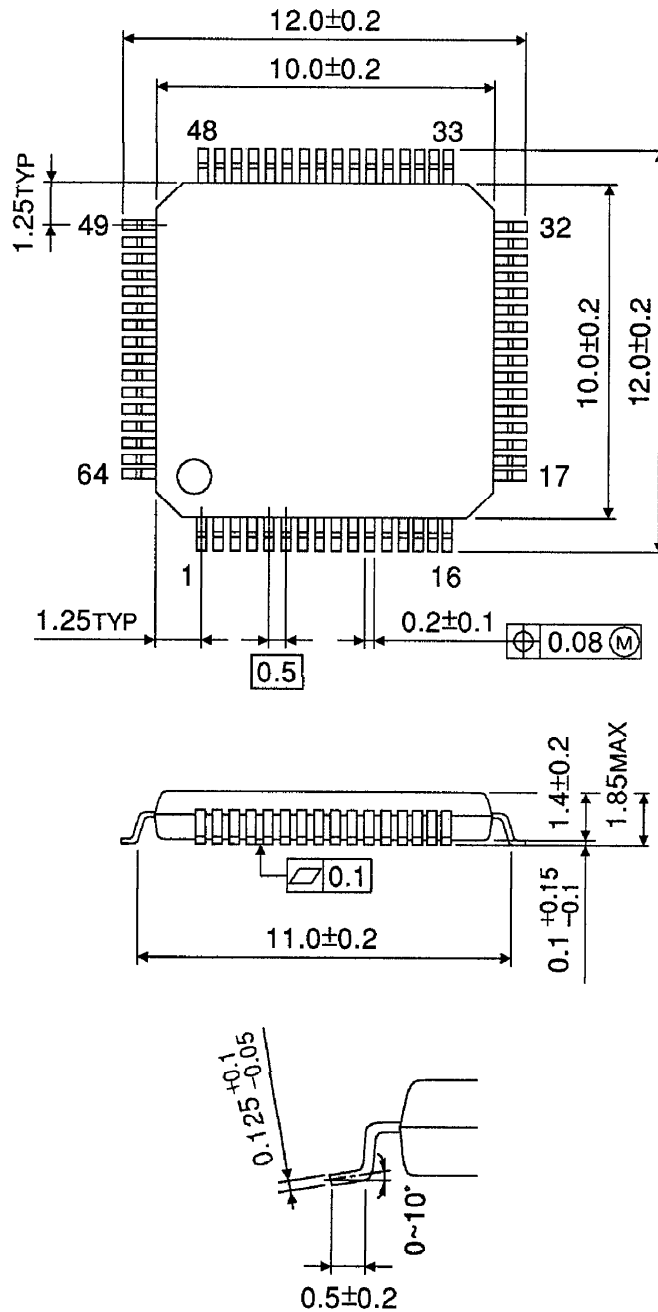
Unit : mm



Weight : 0.85g (Typ.)

OUTLINE DRAWING
LQFP64-P-1010-0.50

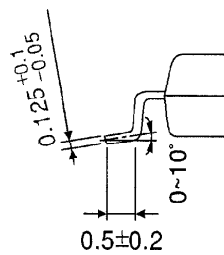
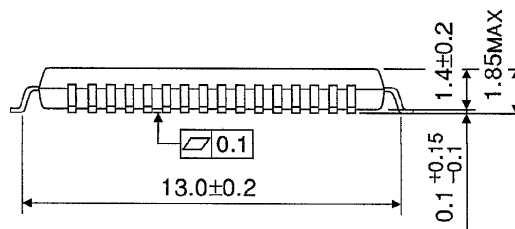
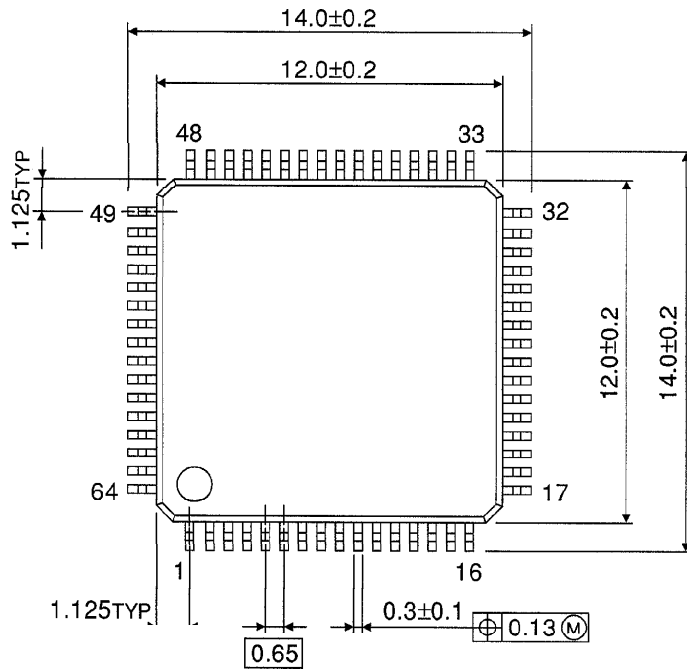
Unit : mm



Weight : 0.32g (Typ.)

OUTLINE DRAWING
QFP64-P-1212-0.65

Unit : mm



Weight : 0.45g (Typ.)