

**ON Semiconductor®**<http://onsemi.com>

LC87F7DJ2C

CMOS IC**FROM 192K byte, RAM 8K byte on-chip**

8-bit 1-chip Microcontroller

Overview

The LC87F7DJ2C is an 8-bit microcomputer that, centered around a CPU running at a minimum bus cycle time of 50ns, integrates on a single chip a number of hardware features such as 192K-byte flash ROM (onboard programmable), 8K-byte RAM, an on-chip debugger, a LCD controller/driver, sophisticated 16-bit timer/counter (may be divided into 8-bit timers), a 16-bit timer/counter (may be divided into 8-bit timers/counters or 8-bit PWMs), four 8-bit timers with a prescaler, a 16-bit timer with a prescaler (may be divided into 8-bit timers), a base timer serving as a time-of-day clock, a day and time counter, a synchronous SIO interface (with automatic block transmission/reception capabilities), an asynchronous/synchronous SIO interface, two UART ports (full duplex), an 12-bit 15-channel AD converter, two 12-bit PWM channels, a high-speed clock counter, a system clock frequency divider, a small signal detector, two remote control receive functions, and a 31-source 10-vector interrupt feature.

Features

■Flash ROM

- Capable of on-board-programming with wide range, 3.0 to 3.6V, of voltage source.
- Block-erasable in 2-byte units
- 196608 × 8 bits

■RAM

- 8192 × 9 bits

■Minimum Bus Cycle Time

- 50.0ns (20MHz) $V_{DD}=2.7$ to 3.6V

Note: The bus cycle time here refers to the ROM read speed.

* This product is licensed from Silicon Storage Technology, Inc. (USA).

■High-speed Clock Counter

- 1) Can count clocks with a maximum clock rate of 20MHz (at a main clock of 10MHz).
- 2) Can generate output real-time.

■SIO

- SIO0: 8-bit synchronous serial interface
 - 1) LSB first/MSB first mode selectable
 - 2) Built-in 8-bit baudrate generator (maximum transfer clock cycle = 4/3 tCYC)
 - 3) Automatic continuous data transmission (1 to 256 bits specifiable in 1-bit units, suspension and resumption of data transmission possible in 1-byte units)
- SIO1: 8-bit asynchronous/synchronous serial interface
 - Mode 0: Synchronous 8-bit serial I/O (2- or 3-wire configuration, 2 to 512 tCYC transfer clocks)
 - Mode 1: Asynchronous serial I/O (half-duplex, 8-data bits, 1-stop bit, 8 to 2048 tCYC baudrates)
 - Mode 2: Bus mode 1 (start bit, 8-data bits, 2 to 512 tCYC transfer clocks)
 - Mode 3: Bus mode 2 (start detect, 8-data bits, stop detect)

■UART1

- Full duplex
- 7/8/9 bit data bits selectable
- 1 stop bit (2-bit in continuous data transmission)
- Built-in baudrate generator

■UART2

- Full duplex
- 7/8/9 bit data bits selectable
- 1 stop bit (2-bit in continuous data transmission)
- Built-in baudrate generator

■AD Converter: 12 bits × 15 channels

■PWM: Multi frequency 12-bit PWM × 2 channels

■Remote Control Receiver Circuit1

- 1) Noise rejection function
(Units of noise rejection filter: about 120μs, when selecting a 32.768kHz crystal oscillator as a clock.)
- 2) Supporting reception formats with a guide-pulse of half-clock/clock/none.
- 3) Determines a end of reception by detecting a no-signal periods (No carrier).
(Supports same reception format with a different bit length.)
- 4) X'tal HOLD mode release function

■Remote Control Receiver Circuit2

- 1) Noise rejection function
(Units of noise rejection filter: about 120μs, when selecting a 32.768kHz crystal oscillator as a clock.)
- 2) Supporting reception formats with a guide-pulse of half-clock/clock/none.
- 3) Determines a end of reception by detecting a no-signal periods (No carrier).
(Supports same reception format with a different bit length.)
- 4) X'tal HOLD mode release function

■Watchdog Timer

- External RC watchdog timer
- Interrupt and reset signals selectable

■Clock Output Function

- 1) Able to output selected oscillation clock 1/1, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64 as system clock.
- 2) Able to output oscillation clock of sub clock.

■Interrupts

- 31 sources, 10 vector addresses
 - 1) Provides three levels (low (L), high (H), and highest (X)) of multiplex interrupt control. Any interrupt requests of the level equal to or lower than the current interrupt are not accepted.
 - 2) When interrupt requests to two or more vector addresses occur at the same time, the interrupt of the highest level takes precedence over the other interrupts. For interrupts of the same level, the interrupt into the smallest vector address takes precedence.

No.	Vector Address	Level	Interrupt Source
1	00003H	X or L	INT0
2	0000BH	X or L	INT1
3	00013H	H or L	INT2/T0L/INT4/remote control receiver1
4	0001BH	H or L	INT3/base timer/INT5/remote control receiver2
5	00023H	H or L	T0H/INT6
6	0002BH	H or L	T1L/T1H/INT7
7	00033H	H or L	SIO0/UART1 receive/UART2 receive/T8L/T8H
8	0003BH	H or L	SIO1/UART1 transmit/UART2 transmit
9	00043H	H or L	ADC/MIC/T6/T7/PWM4/PWM5
10	0004BH	H or L	Port 0/T4/T5

- Priority levels $X > H > L$
 - Of interrupts of the same level, the one with the smallest vector address takes precedence.
-
- IFLG (List of interrupt source flag function)
 - 1) Shows a list of interrupt source flags that caused a branching to a particular vector address (shown in the diagram above).

■Subroutine Stack Levels: 4096 levels (The stack is allocated in RAM.)**■High-speed Multiplication/Division Instructions**

- 16 bits $\times$ 8 bits (5 tCYC execution time)
- 24 bits $\times$ 16 bits (12 tCYC execution time)
- 16 bits $\div$ 8 bits (8 tCYC execution time)
- 24 bits $\div$ 16 bits (12 tCYC execution time)

■Oscillation Circuits

- RC oscillation circuit (internal): For system clock
- CF oscillation circuit: For system clock, with internal Rf and external Rd
- Crystal oscillation circuit: For low-speed system clock, with internal Rf and external Rd
- Frequency variable RC oscillation circuit (internal): For system clock
 - 1) Adjustable in $\pm 4\%$ (typ.) step from a selected center frequency.
 - 2) Measures the frequency of the source oscillation clock using the input signal from XT1 as the reference.

■System Clock Divider Function

- Can run on low current.
- The minimum instruction cycle selectable from 300ns, 600ns, 1.2 μ s, 2.4 μ s, 4.8 μ s, 9.6 μ s, 19.2 μ s, 38.4 μ s, and 76.8 μ s (at a main clock rate of 10MHz).

■Standby Function

- HALT mode: Halts instruction execution while allowing the peripheral circuits to continue operation.
(Some parts of the serial transfer function stops operation.)
 - 1) Oscillation is not halted automatically.
 - 2) Canceled by a system reset or occurrence of an interrupt

Continued on next page.

Continued from preceding page.

- HOLD mode: Suspends instruction execution and the operation of the peripheral circuits.
 - 1) The CF, RC, X'tal, and frequency variable RC oscillators automatically stop operation.
 - 2) There are three ways of resetting the HOLD mode.
 - (1) Setting the reset pin to the low level
 - (2) Setting at least one of the INT0, INT1, INT2, INT4, and INT5 pins to the specified level
 - (3) Having an interrupt source established at port 0
- X'tal HOLD mode: Suspends instruction execution and the operation of the peripheral circuits except the base timer and the remote control receiver circuit.
 - 1) The CF, RC, and frequency variable RC oscillators automatically stop operation.
 - 2) The state of crystal oscillation established when the X'tal HOLD mode is entered is retained.
 - 3) There are five ways of resetting the X'tal HOLD mode.
 - (1) Setting the reset pin to the low level
 - (2) Setting at least one of the INT0, INT1, INT2, INT4, and INT5 pins to the specified level
 - (3) Having an interrupt source established at port 0
 - (4) Having an interrupt source established in the base timer circuit
 - (5) Having an interrupt source established in the remote control receiver circuit

■On-chip Debugger

- Supports software debugging with the IC mounted on the target board.

■Package Form

- QIP100E(14×20): Lead-free type/Halogen-free type
- TQFP100(14×14): Lead-free type/Halogen-free type (Under development)

■Development Tools

- On-chip debugger: TCB87 TypeB +LC87F7DJ2C or TCB87 TypeC(3Lines Cable)+LC87F7DJ2C

■Flash ROM Programming Boards

Package	Programming boards
QIP100E(14×20)	W87FQ100
TQFP100(14×14)	W87FSQ100

■Flash ROM Programmer

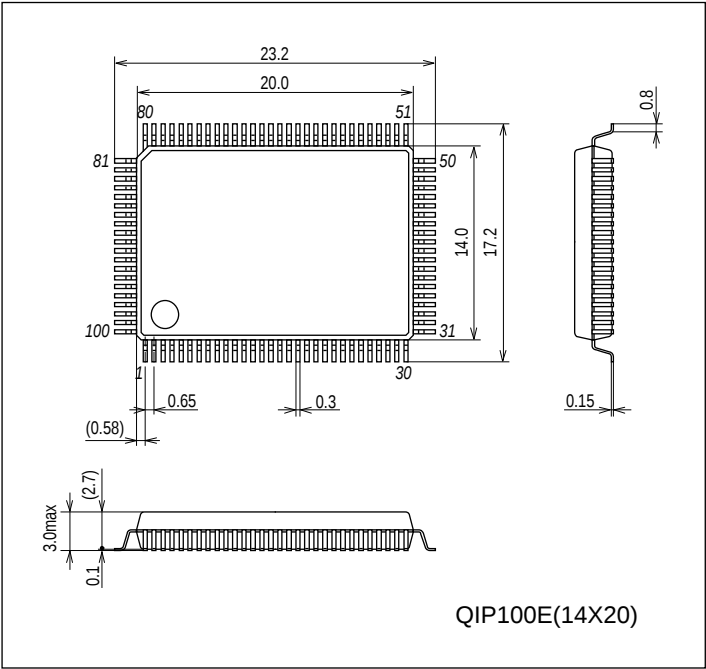
Maker		Model	Supported version	Device
Flash Support Group, Inc. (FSG)	Single	AF9708 AF9709/AF9709B/AF9709C (Including product of Ando Electric Co., Ltd)	(Note 2)	LC87F7DJ2C
	Gang	AF9723/AF9723B(Main body) (Including product of Ando Electric Co., Ltd)	(Note 2)	LC87F7DJ2C
		AF9833(Unit) (Including product of Ando Electric Co., Ltd)	(Note 2)	
Flash Support Group, Inc. (FSG) + Our company (Note 1)	Onboard Single/Gang	AF9101/AF9103(Main body) (FSG)	(Note 2)	LC87F7DJ2C
		SIB87(interface driver) (Our company model)		
Our company	Single/Gang	SKK/SKK Type B (SANYO FWS)	Application Version After 1.05 Chip Data Version After 2.23	LC87F7DJ2C
	Onboard Single/Gang	SKK-DBG Type B (SANYO FWS)		

Note 1: With the FSG onboard programmer (AF9101/AF9103) and the serial interface driver provided by Our company, PC-less standalone onboard programming is possible

Note 2: Depending on programming conditions, it is necessary to use a dedicated programming device and a program. Please contact Our company or FSG if you have any questions or difficulties regarding this matter.

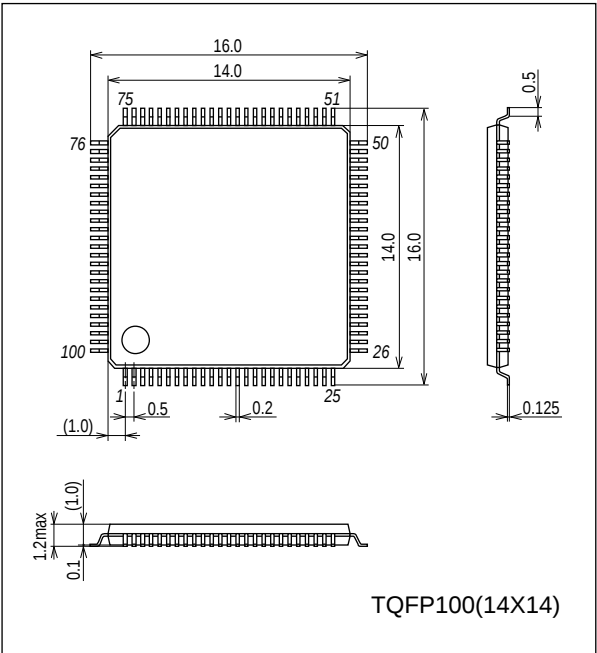
Package Dimensions

unit : mm (typ)
3151A



Package Dimensions

unit : mm (typ)
3274 [Under Development]

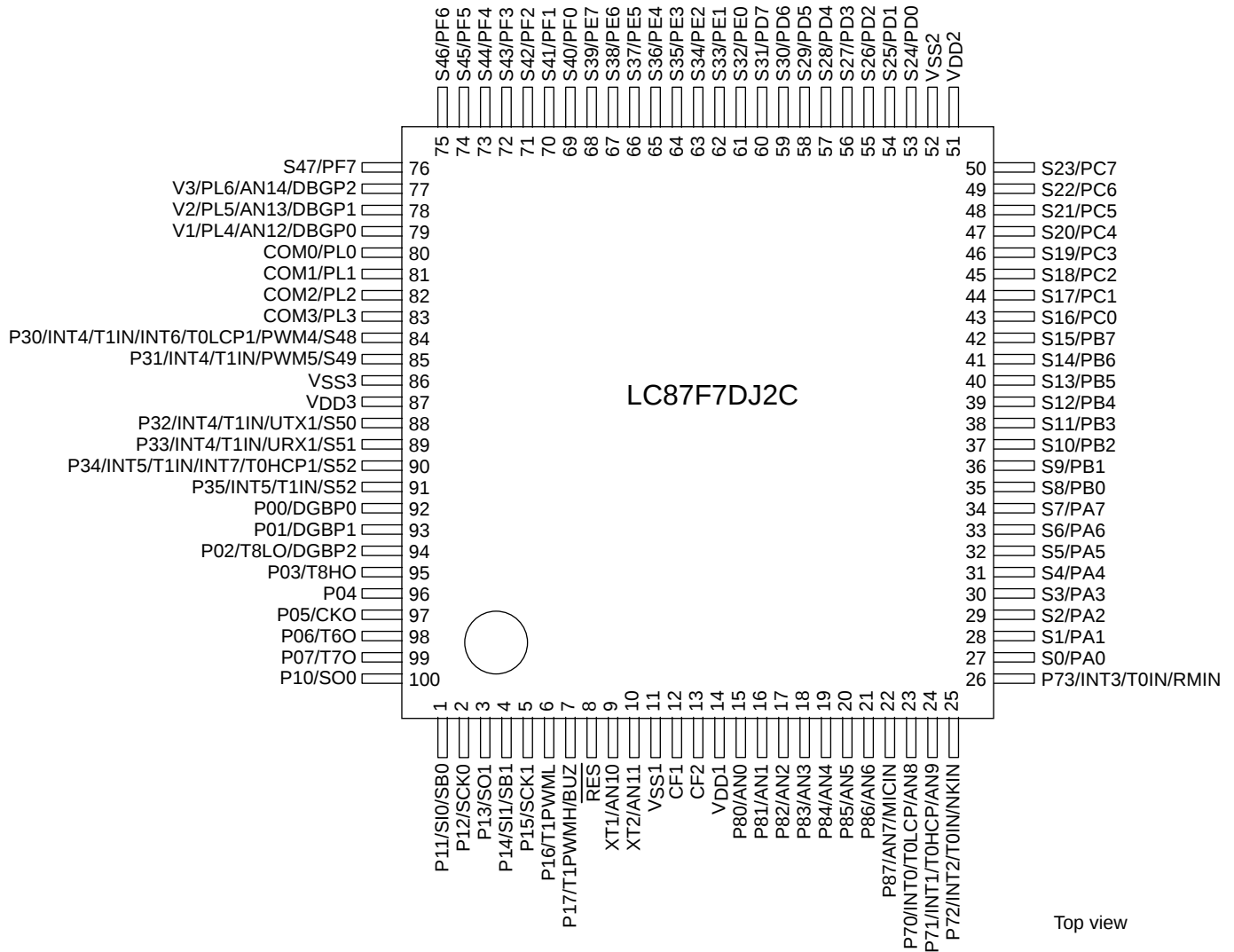


Pin Assignments



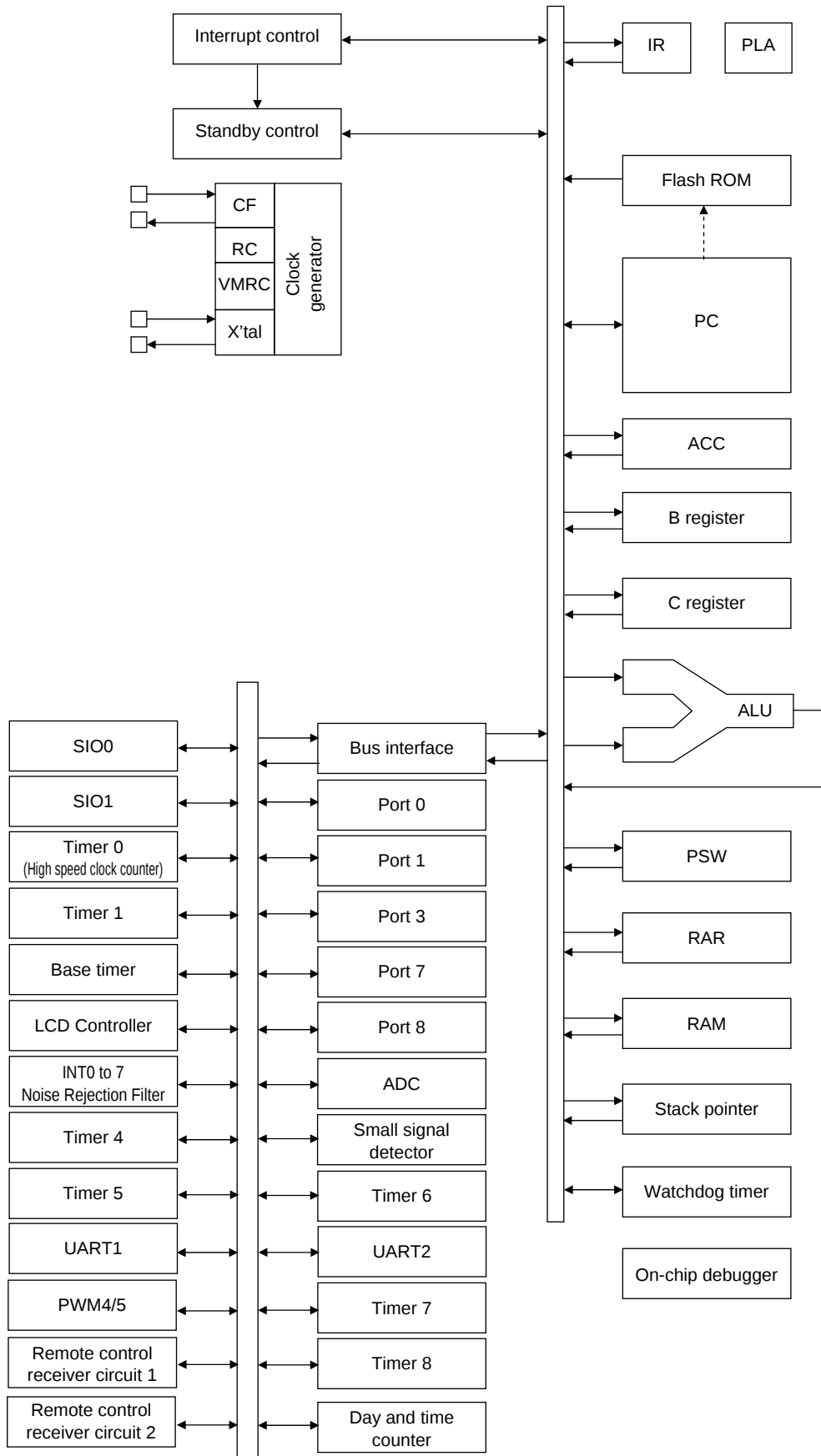
QIP100E(14×20) “Lead-free Type/Halogen-free type”

LC87F7DJ2C



TQFP100(14×14) “Lead-free type/Halogen-free type” (Under development)

System Block Diagram



Pin Description

Continued on next page.

LC87F7DJ2C

Continued from preceding page.

Pin Name	I/O	Description	Option																														
Port 7	I/O	• 4-bit I/O port • I/O specifiable in 1-bit units • Pull-up resistors can be turned on and off in 1-bit units. • Shared pins P70: INT0 input/HOLD release input/timer 0L capture input/watchdog timer output P71: INT1 input/HOLD release input/timer 0H capture input P72: INT2 input/HOLD release input/timer 0 event input/timer 0L capture input/ high speed clock counter input P73: INT3 input (with noise filter)/timer 0 event input/timer 0H capture input/ remote control receiver input AD converter input ports: AN8 (P70), AN9 (P71) Interrupt acknowledge type <table><tr><td></td><td>Rising</td><td>Falling</td><td>Rising & Falling</td><td>H level</td><td>L level</td></tr><tr><td>INT0</td><td>enable</td><td>enable</td><td>disable</td><td>enable</td><td>enable</td></tr><tr><td>INT1</td><td>enable</td><td>enable</td><td>disable</td><td>enable</td><td>enable</td></tr><tr><td>INT2</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr><tr><td>INT3</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr></table>		Rising	Falling	Rising & Falling	H level	L level	INT0	enable	enable	disable	enable	enable	INT1	enable	enable	disable	enable	enable	INT2	enable	enable	enable	disable	disable	INT3	enable	enable	enable	disable	disable	No
			Rising	Falling	Rising & Falling	H level	L level																										
INT0			enable	enable	disable	enable	enable																										
INT1			enable	enable	disable	enable	enable																										
INT2	enable	enable	enable	disable	disable																												
INT3	enable	enable	enable	disable	disable																												
P70 to P73																																	
Port 8	I/O	• 8-bit I/O port • I/O specifiable in 1-bit units • Shared pins AD converter input ports: AN0 to AN7 Small signal detector input port: MICIN (P87)	No																														
P80 to P87																																	
S0/PA0 to S7/PA7	I/O	• Segment output for LCD • Can be used as general-purpose I/O port (PA)	No																														
S8/PB0 to S15/PB7	I/O	• Segment output for LCD • Can be used as general-purpose I/O port (PB)	No																														
S16/PC0 to S23/PC7	I/O	• Segment output for LCD • Can be used as general-purpose I/O port (PC)	No																														
S24/PD0 to S31/PD7	I/O	• Segment output for LCD • Can be used as general-purpose I/O port (PD)	No																														
S32/PE0 to S39/PE7	I/O	• Segment output for LCD • Can be used as general-purpose I/O port (PE)	No																														
S40/PF0 to S47/PF7	I/O	• Segment output for LCD • Can be used as general-purpose I/O port (PF) PF6: INT6 input PF7: INT7 input	No																														
COM0/PL0 to COM3/PL3	I/O	• Common output for LCD • Can be used as general-purpose input port (PL)	No																														
V1/PL4 to V3/PL6	I/O	• LCD output bias power supply • Can be used as general-purpose input port (PL) • Shared pins AD converter input ports: AN12 (V1) to AN14 (V3) On-chip debugger pins: DBGP0 (V1) to DBGP2 (V3)	No																														
RES	Input	Reset pin	No																														
XT1	Input	• 32.768kHz crystal oscillator input pin • Shared pins General-purpose input port AD converter input port: AN10 Must be connected to V _{DD1} if not to be used.	No																														
XT2	I/O	• 32.768kHz crystal oscillator output pin • Shared pins General-purpose I/O port AD converter input port: AN11 Must be set for oscillation and kept open if not to be used.	No																														
CF1	Input	Ceramic resonator input pin	No																														
CF2	Output	Ceramic resonator output pin	No																														

Port Output Types

The table below lists the types of port outputs and the presence/absence of a pull-up resistor.

Data can be read into any input port even if it is in the output mode.

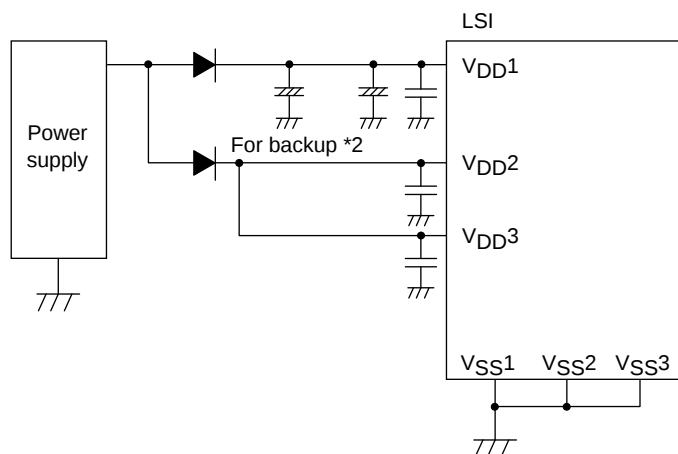
Port Name	Option Selected in Units of	Option Type	Output Type	Pull-up Resistor
P00 to P07	each bit	1	CMOS	Programmable
		2	Nch-open drain	Programmable
P10 to P17	each bit	1	CMOS	Programmable
		2	Nch-open drain	Programmable
P30 to P35	each bit	1	CMOS	Programmable
		2	Nch-open drain	Programmable
P70	-	No	Nch-open drain	Programmable
P71 to P73	-	No	CMOS	Programmable
P80 to P87	-	No	Nch-open drain	No
S0/PA0 to S47/PF7	-	No	CMOS	Programmable
COM0/PL0 to COM3/PL3	-	No	Input only	No
V1/PL4 to V3/PL6	-	No	Input only	No
XT1	-	No	Input only	No
XT2	-	No	Output for 32.768kHz crystal oscillator (Nch-open drain when in general-purpose output mode)	No

User Option List

Option Name	Option Type	Mask Version *1	Flash Version	Option Selected in Units of	Specified item
Port output form	P00 to P07	○	○	each bit	CMOS
					Nch-open drain
	P10 to P17	○	○	each bit	CMOS
					Nch-open drain
	P30 to P35	○	○	each bit	CMOS
					Nch-open drain
Program start address	-	× *2	○	-	00000H
					1FF00H

*1: Mask option selection - No change possible after the mask is completed.

*2: Program start address of the mask version is 00000h.



*1 Connect the IC as shown below to minimize the noise input to the VDD1 pin.

Be sure to electrically short the VSS1, VSS2, and VSS3 pins.

*2 The internal memory is sustained by VDD1. If none of VDD2 and VDD3 are backed up, the high level output at the ports are unstable in the HOLD backup mode, allowing through current to flow into the input buffer and thus shortening the backup time.

Make sure that the port outputs are held at the low level in the HOLD backup mode.

LC87F7DJ2C

Absolute Maximum Ratings at Ta = 25°C, VSS1 = VSS2 = VSS3 = 0V

Parameter		Symbol	Pin/Remarks	Conditions	V _{DD} [V]	Specification			
						min	typ	max	unit
Maximum supply voltage		V _{DD} max	V _{DD} 1, V _{DD} 2, V _{DD} 3	V _{DD} 1=V _{DD} 2=V _{DD} 3		-0.3		+4.6	V
supply voltage for LCD		VLCD	V1/PL4, V2/PL5, V3/PL6	V _{DD} 1=V _{DD} 2=V _{DD} 3		-0.3		V _{DD}	
Input voltage		V _I (1)	Port L XT1, CF1, $\overline{\text{RES}}$			-0.3		V _{DD} +0.3	
		V _I (2)	V _{DD} 2, V _{DD} 3			V _{SS}		V _{DD} +0.1	
Input/output voltage		V _{IO} (1)	Ports 0, 1, 3, 7, 8 Ports A, B, C Ports D, E, F, XT2			-0.3		V _{DD} +0.3	
High level output current	Peak output current	IOPH(1)	Ports 0, 1, 32 to 35	• CMOS output selected • Current at each pin		-10			mA
		IOPH(2)	Ports 30, 31	• CMOS output selected • Current at each pin		-20			
		IOPH(3)	Ports 71 to 73	Current at each pin		-5			
		IOPH(4)	Ports A, B, C Ports D, E, F	Current at each pin		-5			
	Mean output current (Note 1-1)	IOMH(1)	Ports 0, 1, 32 to 35	• CMOS output selected • Current at each pin		-7.5			
		IOMH(2)	Ports 30, 31	• CMOS output selected • Current at each pin		-15			
		IOMH(3)	Ports 71 to 73	Current at each pin		-3			
		IOMH(4)	Ports A, B, C Ports D, E, F	Current at each pin		-3			
	Total output current	ΣIOAH(1)	Ports 0, 1, 32 to 35	Total of all pins		-25			
		ΣIOAH(2)	Ports 30, 31	Total of all pins		-25			
		ΣIOAH(3)	Ports 0, 1, 3	Total of all pins		-45			
		ΣIOAH(4)	Ports 71 to 73	Total of all pins		-5			
		ΣIOAH(5)	Ports A, B, C	Total of all pins		-25			
		ΣIOAH(6)	Ports D, E, F	Total of all pins		-25			
		ΣIOAH(7)	Ports A, B, C Ports D, E, F	Total of all pins		-45			
Low level output current	Peak output current	IOPL(1)	Ports 0, 1, 32 to 35	Current at each pin				20	
		IOPL(2)	Ports 30, 31	Current at each pin				30	
		IOPL(3)	Ports 7, 8, XT2	Current at each pin				10	
		IOPL(4)	Ports A, B, C Ports D, E, F	Current at each pin				10	
	Mean output current (Note 1-1)	IOML(1)	Ports 0, 1, 32 to 35	Current at each pin				15	
		IOML(2)	Ports 30, 31	Current at each pin				20	
		IOML(3)	Ports 7, 8, XT2	Current at each pin				7.5	
		IOML(4)	Ports A, B, C Ports D, E, F	Current at each pin				7.5	
	Total output current	ΣIOAL(1)	Ports 0, 1, 32 to 35	Total of all pins				45	
		ΣIOAL(2)	Ports 30, 31	Total of all pins				45	
		ΣIOAL(3)	Ports 0, 1, 3	Total of all pins				80	
		ΣIOAL(4)	Ports 7, 8, XT2	Total of all pins				20	
		ΣIOAL(5)	Ports A, B, C	Total of all pins				45	
ΣIOAL(6)		Ports D, E, F	Total of all pins				45		
ΣIOAL(7)		Ports A, B, C Ports D, E, F	Total of all pins				80		
Maximum power dissipation		Pd max	QIP100E(14×20)	Ta=-40 to +85°C				mW	
			TQFP100(14×14)	Ta=-40 to +85°C					

Note 1-1: The mean output current is a mean value measured over 100ms.

Continued on next page.

LC87F7DJ2C

Continued from preceding page.

Parameter	Symbol	Pin/Remarks	Conditions	V _{DD} [V]	Specification			
					min	typ	max	unit
Operating ambient temperature	Topr				-40		+85	°C
Storage ambient temperature	Tstg				-55		+125	

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Allowable Operating Range at Ta = -40°C to +85°C, V_{SS1} = V_{SS2} = V_{SS3} = 0V

Parameter	Symbol	Pin/Remarks	Conditions	V _{DD} [V]	Specification			
					min	typ	max	unit
Operating supply voltage (Note 2-1)	V _{DD} (1)	V _{DD1} =V _{DD2} =V _{DD3}	0.150μs ≤ tCYC ≤ 200μs		2.7		3.6	V
Memory sustaining supply voltage	V _{HD}	V _{DD1}	RAM and register contents sustained in HOLD mode.		2.0		3.6	
High level input voltage	V _{IH} (1)	Ports 0, 3, 8 Ports A, B, C, D, E, F Port L	Output disabled	2.7 to 3.6	0.3V _{DD} +0.7		V _{DD}	
	V _{IH} (2)	Port 1 Ports 71 to 73 P70 port input/ interrupt side	• Output disabled • When INT1VTS _L =0 (P71 only)	2.7 to 3.6	0.3V _{DD} +0.7		V _{DD}	
	V _{IH} (3)	P71 interrupt side	• Output disabled • When INT1VTS _L =1	2.7 to 3.6	0.85V _{DD}		V _{DD}	
	V _{IH} (4)	P87 small signal input side	Output disabled	2.7 to 3.6	0.75V _{DD}		V _{DD}	
	V _{IH} (5)	P70 watchdog timer side	Output disabled	2.7 to 3.6	0.9V _{DD}		V _{DD}	
	V _{IH} (6)	XT1,XT2,CF1, $\overline{\text{RES}}$		2.7 to 3.6	0.75V _{DD}		V _{DD}	
Low level input voltage	V _{IL} (1)	Ports 0, 3, 8 Ports A, B, C, D, E, F Port L	Output disabled	2.7 to 3.6	V _{SS}		0.2V _{DD}	
	V _{IL} (2)	Port 1 Ports 71 to 73 P70 port input/ interrupt side	• Output disabled • When INT1VTS _L =0 (P71 only)	2.7 to 3.6	V _{SS}		0.2V _{DD}	
	V _{IL} (3)	P71 interrupt side	• Output disabled • When INT1VTS _L =1	2.7 to 3.6	V _{SS}		0.45V _{DD}	
	V _{IL} (4)	P87 small signal input side	Output disabled	2.7 to 3.6	V _{SS}		0.25V _{DD}	
	V _{IL} (5)	P70 watchdog timer side	Output disabled	2.7 to 3.6	V _{SS}		0.8V _{DD} -1.0	
	V _{IL} (6)	XT1,XT2,CF1, $\overline{\text{RES}}$		2.7 to 3.6	V _{SS}		0.25V _{DD}	
Instruction cycle time (Note 2-2)	tCYC			2.7 to 3.6	0.150		200	μs
External system clock frequency	FEXCF(1)	CF1	• CF2 pin open • System clock frequency division ratio=1/1 • External system clock duty=50±5%	2.7 to 3.6	0.1		20	MHz
			• CF2 pin open • System clock frequency division ratio=1/2	2.7 to 3.6	0.2		40	

Note 2-1: V_{DD} must be held greater than or equal to 3.0V in the flash ROM onboard programming mode.

Note 2-2: Relationship between tCYC and oscillation frequency is 3/FmCF at a division ratio of 1/1 and 6/FmCF at a division ratio of 1/2.

Continued on next page.

LC87F7DJ2C

Continued from preceding page.

Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V _{DD} [V]	min	typ	max	unit
Oscillation frequency range (Note 2-3)	FmCF(1)	CF1, CF2	• 20MHz ceramic oscillation • See Fig. 1.	2.7 to 3.6		20		MHz
	FmRC		Internal RC oscillation	2.7 to 3.6	0.3	1.0	2.0	
	FmVMRC(1)		• Frequency variable RC source oscillation • When VMRAJ2 to 0=4, VMFAJ2 to 0=0, VMSL4M=0	2.7 to 3.6		10		
	FmVMRC(2)		• Frequency variable RC source oscillation • When VMRAJ2 to 0=4, VMFAJ2 to 0=0, VMSL4M=1	2.7 to 3.6		4		
	FsX'tal	XT1, XT2	• 32.768kHz crystal oscillation • See Fig. 2.	2.7 to 3.6		32.768		kHz
Frequency variable RC oscillation usable range	OpVMRC(1)		When VMSL4M=0	2.7 to 3.6	8	10	12	MHz
	OpVMRC(2)		When VMSL4M=1	2.7 to 3.6	3.5	4	4.5	
Frequency variable RC oscillation adjustment range	VmADJ(1)		Each step of VMRAJn (Wide range)	2.7 to 3.6	8	24	64	%
	VmADJ(2)		Each step of VMFAJn (Small range)	2.7 to 3.6	1	4	8	

Note 2-3: See Tables 1 and 2 for the oscillation constants.

Electrical Characteristics at Ta = -40°C to +85°C, VSS1 = VSS2 = VSS3 = 0V

Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V _{DD} [V]	min	typ	max	unit
High level input current	I _{IH} (1)	Ports 0, 1, 3, 7, 8 Ports A, B, C Ports D, E, F Port L	• Output disabled • Pull-up resistor off • V _{IN} =V _{DD} (Including output Tr's off leakage current)	2.7 to 3.6			1	μA
	I _{IH} (2)	$\overline{RES}$	V _{IN} =V _{DD}	2.7 to 3.6			1	
	I _{IH} (3)	XT1, XT2	• For input port specification • V _{IN} =V _{DD}	2.7 to 3.6			1	
	I _{IH} (4)	CF1	V _{IN} =V _{DD}	2.7 to 3.6			15	
	I _{IH} (5)	P87 small signal input side	V _{IN} =VBIS+0.5V (VBIS: Bias voltage)	2.7 to 3.6	1.5	5.5	10	
Low level input current	I _{IL} (1)	Ports 0, 1, 3, 7, 8 Ports A, B, C Ports D, E, F Port L	• Output disabled • Pull-up resistor off • V _{IN} =V _{SS} (Including output Tr's off leakage current)	2.7 to 3.6	-1			μA
	I _{IL} (2)	$\overline{RES}$	V _{IN} =V _{SS}	2.7 to 3.6	-1			
	I _{IL} (3)	XT1, XT2	• For input port specification • V _{IN} =V _{SS}	2.7 to 3.6	-1			
	I _{IL} (4)	CF1	V _{IN} =V _{SS}	2.7 to 3.6	-15			
	I _{IL} (5)	P87 small signal input side	V _{IN} =VBIS-0.5V (VBIS : Bias voltage)	2.7 to 3.6	-10	-5.5	-1.5	

Continued on next page.

LC87F7DJ2C

Continued from preceding page.

Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V _{DD} [V]	min	typ	max	unit
High level output voltage	V _{OH} (1)	Ports 0, 1, 32 to 35	I _{OH} =-0.4mA	2.7 to 3.6	V _{DD} -0.4			V
	V _{OH} (2)	Ports 30, 31	I _{OH} =-1.6mA	2.7 to 3.6	V _{DD} -0.4			
	V _{OH} (3)	Ports 71 to 73	I _{OH} =-0.4mA	2.7 to 3.6	V _{DD} -0.4			
	V _{OH} (4)	Ports A, B, C Ports D, E, F	I _{OH} =-0.4mA	2.7 to 3.6	V _{DD} -0.4			
Low level output voltage	V _{OL} (1)	Ports 0, 1, 32 to 35 Ports 30,31 (PWM function output mode)	I _{OL} =1.6mA	2.7 to 3.6			0.4	V
	V _{OL} (2)	Ports 30, 31 (Port function output mode)	I _{OL} =5mA	2.7 to 3.6			0.4	
	V _{OL} (3)	Ports 7, 8 XT2	I _{OL} =1.6mA	2.7 to 3.6			0.4	
	V _{OL} (4)	Ports A, B, C Ports D, E, F	I _{OL} =1.6mA	2.7 to 3.6			0.4	
LCD output voltage regulation	VODLS	S0 to S53	- I_O=0mA - VLCD, 2/3VLCD,1/3VLCD level output - See Fig. 8.	2.7 to 3.6	0		±0.2	
	VODLC	COM0 to COM3	- I_O=0mA - VLCD, 2/3VLCD,1/2VLCD, 1/3VLCD level output - See Fig. 8.	2.7 to 3.6	0		±0.2	
LCD bias resistor	RLCD(1)	Resistance per one bias resister	See Fig. 8.	2.7 to 3.6		60		kΩ
	RLCD(2)	Resistance per one bias resister 1/2 mode	See Fig. 8.	2.7 to 3.6		30		
Resistance of pull-up MOS Tr.	Rpu(1)	Ports 0, 1, 3, 7 Ports A, B, C Ports D, E, F	V _{OH} =0.9V _{DD}	2.7 to 3.6	18	50	150	
Hysterisis voltage	VHYS(1)	Ports 1, 7 <u>RES</u>		2.7 to 3.6		0.1V _{DD}		V
	VHYS(2)	P87 small signal input side		2.7 to 3.6		0.1V _{DD}		
Pin capacitance	CP	All pins	- For pins other than that under test: V_{IN}=V_{SS} - f=1MHz - Ta=25°C	2.7 to 3.6		10		pF
Input sensitivity	Vsen	P87 small signal input side		2.7 to 3.6	0.12V _{DD}			Vp-p

LC87F7DJ2C

Serial I/O Characteristics at $T_a = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, $V_{SS1} = V_{SS2} = V_{SS3} = 0\text{V}$

1. SIO0 Serial I/O Characteristics (Note 4-1-1) at $V_{DD}=2.7\text{V}$ to 3.6V , $0.190\mu\text{s} \leq t_{CYC} \leq 200\mu\text{s}$

Parameter			Symbol	Pin/Remarks	Conditions	V _{DD} [V]	Specification				
							min	typ	max	unit	
Serial clock	Input clock	Frequency	tSCK(1)	SCK0(P12)	See Fig. 6.	2.7 to 3.6	2			tCYC	
		Low level pulse width	tSCKL(1)				1				
		High level pulse width	tSCKH(1)				1				
			tSCKHA(1)		• Continuous data transmission/reception mode • See Fig. 6. • (Note 4-1-2)		4				
	Output clock	Frequency	tSCK(2)	SCK0(P12)	• CMOS output selected • See Fig. 6.	2.7 to 3.6	4/3			tSCK	
		Low level pulse width	tSCKL(2)		1/2						
		High level pulse width	tSCKH(2)		1/2				tSCKH(2) +2tCYC	tSCKH(2) +(10/3) tCYC	tCYC
			tSCKHA(2)		• Continuous data transmission/reception mode • CMOS output selected • See Fig. 6.						
Serial input	Data setup time		tsDI(1)	SB0(P11), SIO(P11)	• Must be specified with respect to rising edge of SIOCLK. • See Fig. 6.	2.7 to 3.6	0.03				
	Data hold time		thDI(1)				0.03				
Serial output	Input clock	Output delay time	tdD0(1)	SO0(P10), SB0(P11)	• Continuous data transmission/reception mode • (Note 4-1-3)	2.7 to 3.6			(1/3)tCYC +0.05	μs	
			tdD0(2)		• Synchronous 8-bit mode • (Note 4-1-3)				1tCYC +0.05		
	Output clock		tdD0(3)		(Note 4-1-3)				(1/3)tCYC +0.05		

Note 4-1-1: These specifications are theoretical values. Add margin depending on its use.

Note 4-1-2: To use serial-clock-input in continuous trans/rec mode, a time from SIO0RUN being set when serial clock is "H" to the first negative edge of the serial clock must be longer than tSCKHA.

Note 4-1-3: Must be specified with respect to falling edge of SIOCLK. Must be specified as the time to the beginning of output state change in open drain output mode. See Fig. 6.

2. SIO1 Serial I/O Characteristics (Note 4-2-1)

Parameter			Symbol	Pin/Remarks	Conditions	V _{DD} [V]	Specification			
							min	typ	max	unit
Serial clock	Input clock	Frequency	tSCK(3)	SCK1(P15)	See Fig. 6.	2.7 to 3.6	2			tCYC
		Low level pulse width	tSCKL(3)				1			
		High level pulse width	tSCKH(3)				1			
	Output clock	Frequency	tSCK(4)	SCK1(P15)	• CMOS output selected • See Fig. 6.	2.7 to 3.6	2			tSCK
		Low level pulse width	tSCKL(4)				1/2			
		High level pulse width	tSCKH(4)				1/2			
Serial input	Data setup time		tsDI(2)	SB1(P14), SI1(P14)	• Must be specified with respect to rising edge of SIOCLK. • See Fig. 6.	2.7 to 3.6	0.03			
	Data hold time		thDI(2)				0.03			
Serial output	Output delay time		tdDO(4)	SO1(P13), SB1(P14)	• Must be specified with respect to falling edge of SIOCLK. • Must be specified as the time to the beginning of output state change in open drain output mode. • See Fig. 6.	2.7 to 3.6			(1/3)tCYC +0.05	μs

Note 4-2-1: These specifications are theoretical values. Add margin depending on its use.

Pulse Input Conditions at Ta = -40°C to +85°C, V_{SS1} = V_{SS2} = V_{SS3} = 0V

Parameter		Symbol	Pin/Remarks	Conditions	V _{DD} [V]	Specification			
						min	typ	max	unit
High/low level pulse width	tPIH(1) tPIL(1)		INT0(P70), INT1(P71), INT2(P72), INT4(P30 to P33), INT5(P34 to P35), INT6(P30), INT7(P34)	• Interrupt source flag can be set. • Event inputs for timer 0 or 1 are enabled.	2.7 to 3.6	1			tCYC
	tPIH(2) tPIL(2)		INT3(P73) when noise filter time constant is 1/1	• Interrupt source flag can be set. • Event inputs for timer 0 are enabled.	2.7 to 3.6	2			
	tPIH(3) tPIL(3)		INT3(P73) when noise filter time constant is 1/32	• Interrupt source flag can be set. • Event inputs for timer 0 are enabled.	2.7 to 3.6	64			
	tPIH(4) tPIL(4)		INT3(P73) when noise filter time constant is 1/128	• Interrupt source flag can be set. • Event inputs for timer 0 are enabled.	2.7 to 3.6	256			
	tPIH(5) tPIL(5)		MICIN(P87)	Condition that signal is accepted to small signal detection counter.	2.7 to 3.6	1			RMCK (Note5-1)
	tPIH(6) tPIL(6)		RMIN(P73)	Condition that signal is accepted to remote control receiver circuit.	2.7 to 3.6	4			
	tPIL(7)		RES	Resetting is enabled.	2.7 to 3.6	200			

Note 5-1: RMCK is an unit for the base clock (40tCYC/50tCYC/Sub-Clock) of remote control receiver circuit.

LC87F7DJ2C

AD Converter Characteristics at $V_{SS1} = V_{SS2} = V_{SS3} = 0V$

<12bits AD Converter Mode at $T_a = -30$ to $+70^{\circ}C$ >

Parameter	Symbol	Pin/Remarks	Conditions	$V_{DD}[V]$	Specification			
					min	typ	max	unit
Resolution	N	AN0(P80) to		2.7 to 3.6		12		bit
Absolute accuracy	ET	AN7(P87), AN8(P70),	(Note 6-1)	2.7 to 3.6			± 16	LSB
Conversion time	tCAD	AN9(P71), AN10(XT1), AN11(XT2)	• See Conversion time calculation formulas. (Note 6-2)	2.9 to 3.6	32		115	μs
				2.7 to 3.6	45		115	
Analog input voltage range	VAIN			2.7 to 3.6	V_{SS}		V_{DD}	V
Analog port input current	IAINH		$VAIN = V_{DD}$	2.7 to 3.6			1	μA
	IAINL		$VAIN = V_{SS}$	2.7 to 3.6	-1			

<8bits AD Converter Mode at $T_a = -30$ to $+70^{\circ}C$ >

Parameter	Symbol	Pin/Remarks	Conditions	$V_{DD}[V]$	Specification			
					min	typ	max	unit
Resolution	N	AN0(P80) to		2.7 to 3.6		8		bit
Absolute accuracy	ET	AN7(P87), AN8(P70),	(Note 6-1)	2.7 to 3.6			1.5	LSB
Conversion time	TCAD	AN9(P71), AN10(XT1), AN11(XT2)	• See Conversion time calculation formulas. (Note 6-2)	2.7 to 3.6	20.00		90	μs
				2.7 to 3.6	34.27		90	
Analog input voltage range	VAIN			2.7 to 3.6	V_{SS}		V_{DD}	V
Analog port input current	IAINH		$VAIN = V_{DD}$	2.7 to 3.6			1	μA
	IAINL		$VAIN = V_{SS}$	2.7 to 3.6	-1			

<Conversion time calculation formulas>

12bits AD Converter Mode: $TCAD(\text{Conversion time}) = ((52/(\text{division ratio})) + 2) \times (1/3) \times t_{CYC}$

8bits AD Converter Mode: $TCAD(\text{Conversion time}) = ((32/(\text{division ratio})) + 2) \times (1/3) \times t_{CYC}$

<Recommended Operating Conditions>

External oscillation F_{mCF} [MHz]	Operating supply voltage range V_{DD} [V]	System division ratio (SYSDIV)	Cycle time t_{CYC} [ns]	AD division ratio (ADDIV)	AD conversion time (tCAD) [μs]	
					12bit AD	8bit AD
20	2.9 to 3.6	1/1	150	1/16	41.70	25.70
15	2.7 to 3.6	1/1	200	1/16	55.6	34.27

Note 6-1: The quantization error ($\pm 1/2LSB$) must be excluded from the absolute accuracy. The absolute accuracy must be measured in the microcontroller's state in which no I/O operations occur at the pins adjacent to the analog input channel.

Note 6-2: The conversion time refers to the period from the time an instruction for starting a conversion process till the time the conversion results register(s) are loaded with a complete digital conversion value corresponding to the analog input value.

The conversion time is 2 times the normal-time conversion time when:

- The first AD conversion is performed in the 12-bit AD conversion mode after a system reset.
- The first AD conversion is performed after the AD conversion mode is switched from 8-bit to 12-bit conversion mode.

LC87F7DJ2C

Consumption Current Characteristics at Ta = -40°C to +85°C, VSS1 = VSS2 = VSS3 = 0V

Parameter	Symbol	Pin/ Remarks	Conditions	Specification				
				V _{DD} [V]	min	typ	max	unit
Normal mode consumption current (Note 7-1)	IDDOP(1)	V _{DD1} =V _{DD2} =V _{DD3}	- FmCF=15MHz ceramic oscillation mode - FmX'tal=32.768kHz crystal oscillation mode - System clock set to 12MHz side - Internal RC oscillation stopped. - Frequency variable RC oscillation stopped. 1/1 frequency division ratio	2.7 to 3.6		6.1	15.6	mA
	IDDOP(2)		- FmCF=0Hz (oscillation stopped) - FmX'tal=32.768kHz crystal oscillation mode - System clock set to internal RC oscillation - Frequency variable RC oscillation stopped. 1/2 frequency division ratio	2.7 to 3.6		0.4	1.7	
	IDDOP(3)		- FmCF=0Hz (oscillation stopped) - FmX'tal=32.768kHz crystal oscillation mode - Internal RC oscillation stopped. - System clock set to 10MHz with frequency variable RC oscillation 1/1 frequency division ratio	2.7 to 3.6		4.3	12.0	
	IDDOP(4)		- FmCF=0Hz (oscillation stopped) - FmX'tal=32.768kHz crystal oscillation mode - Internal RC oscillation stopped. - System clock set to 4MHz with frequency variable RC oscillation 1/1 frequency division ratio	2.7 to 3.6		2.1	6.6	
	IDDOP(5)		- FmCF=0Hz (oscillation stopped) - FmX'tal=32.768kHz crystal oscillation mode - System clock set to 32.768kHz side - Internal RC oscillation stopped. - Frequency variable RC oscillation stopped. 1/2 frequency division ratio	2.7 to 3.6		19.3	73	μA

Note 7-1: The consumption current value includes none of the currents that flow into the output Tr and internal pull-up resistors.

Continued on next page.

LC87F7DJ2C

Continued from preceding page.

Parameter	Symbol	Pin/ Remarks	Conditions	Specification				
				V _{DD} [V]	min	typ	max	unit
HALT mode consumption current (Note 7-1)	IDDHALT(1)	V _{DD1} =V _{DD2} =V _{DD3}	• HALT mode • FmCF=12MHz ceramic oscillation mode • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 3.6		2.7	6.8	mA
	IDDHALT(2)		• HALT mode • FmCF=0Hz (oscillation stopped) • FmX'tal=32.768kHz crystal oscillation mode • System clock set to internal RC oscillation • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	2.7 to 3.6		0.2	0.75	
	IDDHALT(3)		• HALT mode • FmCF=0Hz (oscillation stopped) • FmX'tal=32.768kHz crystal oscillation mode • Internal RC oscillation stopped. • System clock set to 10MHz with frequency variable RC oscillation • 1/1 frequency division ratio	2.7 to 3.6		1.6	4.6	
	IDDHALT(4)		• HALT mode • FmCF=0Hz (oscillation stopped) • FmX'tal=32.768kHz crystal oscillation mode • Internal RC oscillation stopped. • System clock set to 4MHz with frequency variable RC oscillation • 1/1 frequency division ratio	2.7 to 3.6		0.7	1.75	
	IDDHALT(5)		• HALT mode • FmCF=0Hz (oscillation stopped) • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	2.7 to 3.6		12.4	54.9	μA
HOLD mode consumption current	IDDHOLD(1)	V _{DD1}	• HOLD mode • CF1=V_{DD} or open (External clock mode)	2.7 to 3.6		0.06	18.4	
Timer HOLD mode consumption current	IDDHOLD(2)	V _{DD1}	• Timer HOLD mode • CF1=V_{DD} or open (External clock mode) • FmX'tal=32.768kHz crystal oscillation mode	2.7 to 3.6		10.14	34.4	

Note 7-1: The consumption current value includes none of the currents that flow into the output Tr and internal pull-up resistors.

LC87F7DJ2C

F-ROM Write Characteristics at $T_a = +10^{\circ}\text{C}$ to $+55^{\circ}\text{C}$, $V_{SS1} = V_{SS2} = V_{SS3} = 0\text{V}$

Parameter	Symbol	Pin/Remarks	Conditions	$V_{DD}[\text{V}]$	Specification			
					min	typ	max	unit
Onboard programming current	IDD _{FW} (1)	V_{DD1}	128-byte programming - Erasing current included	3.0 to 3.6				mA
Programming time	t _{FW} (1)		128-byte programming - Erasing current included - Time for setting up 128-byte data is excluded.	3.0 to 3.6				ms

UART (Full Duplex) Operating Conditions at $T_a = -40$ to $+85^{\circ}\text{C}$, $V_{SS1} = V_{SS2} = V_{SS3} = 0\text{V}$

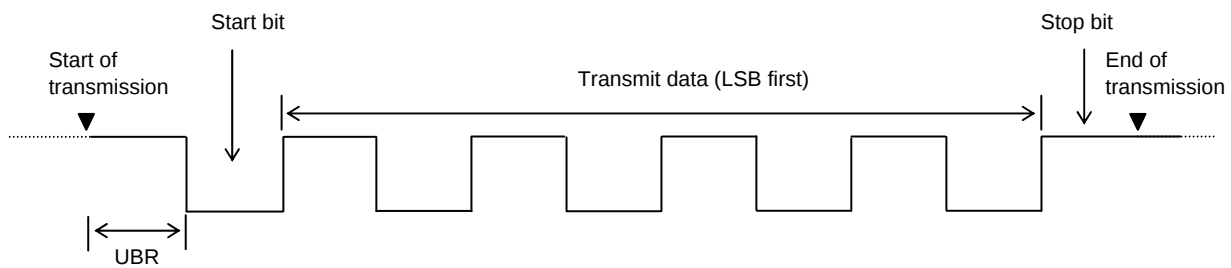
Parameter	Symbol	Pin/Remarks	Conditions	$V_{DD}[\text{V}]$	Specification			
					min	typ	max	unit
Transfer rate	UBR	UTX(P32), URX(P33)		2.7 to 3.6	16/3		8192/3	tCYC

Data length: 7/8/9 bits (LSB first)

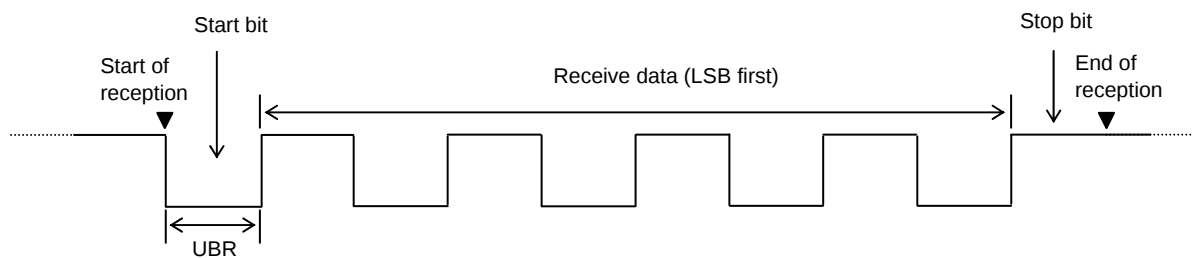
Stop bits: 1 bit (2-bit in continuous data transmission)

Parity bits: None

Example of 8-bit Data Transmission Mode Processing (Transmit Data=55H)



Example of 8-bit Data Reception Mode Processing (Receive Data=55H)



Characteristics of a Sample Main System Clock Oscillation Circuit

Given below are the characteristics of a sample main system clock oscillation circuit that are measured using a Our designated oscillation characteristics evaluation board and external components with circuit constant values with which the oscillator vendor confirmed normal and stable oscillation.

Table 1 Characteristics of a Sample Main System Clock Oscillator Circuit with a Ceramic Oscillator

Nominal Frequency	Vendor Name	Oscillator Name	Circuit Constant				Operating Voltage Range [V]	Oscillation Stabilization Time		Remarks
			C1 [pF]	C2 [pF]	Rf1 [Ω]	Rd1 [Ω]		typ [ms]	max [ms]	
20MHz	MURATA	CSTCE20M0V51-R0	(5)	(5)	Open	150	2.7 to 3.6	0.05	0.15	Values shown in parentheses are capacitance included in the oscillator
		CSTLS20M0X51-B0	(5)	(5)	Open	0	2.7 to 3.6	0.05	0.15	
15MHz		CSTCE15M0V53-RC	(15)	(15)	Open	220	2.7 to 3.6	0.05	0.15	

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized after VDD goes above the operating voltage lower limit (see Figure 4).

Characteristics of a Sample Subsystem Clock Oscillator Circuit

Given below are the characteristics of a sample subsystem clock oscillation circuit that are measured using a Our designated oscillation characteristics evaluation board and external components with circuit constant values with which the oscillator vendor confirmed normal and stable oscillation.

Table 2 Characteristics of a Sample Subsystem Clock Oscillator Circuit with a Crystal Oscillator

Nominal Frequency	Vendor Name	Oscillator Name	Circuit Constant				Operating Voltage Range [V]	Oscillation Stabilization Time		Remarks
			C3 [pF]	C4 [pF]	Rf2 [Ω]	Rd2 [Ω]		typ [s]	max [s]	
32.768kHz	EPSON TOYOCOM	MC-306	18	18	OPEN	560k	2.7 to 3.6	1.4	3.0	Applicable CL value= 12.5pF

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized after the instruction for starting the subclock oscillation circuit is executed and to the time interval that is required for the oscillation to get stabilized after the HOLD mode is reset (see Figure 4).

Note: The components that are involved in oscillation should be placed as close to the IC and to one another as possible because they are vulnerable to the influences of the circuit pattern.

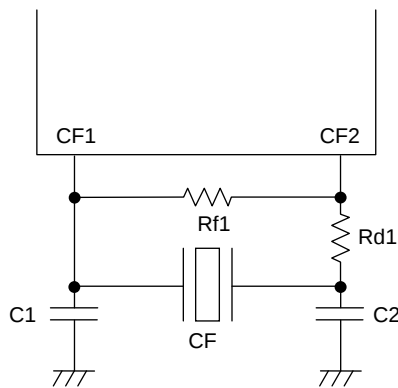


Figure 1 CF Oscillator Circuit

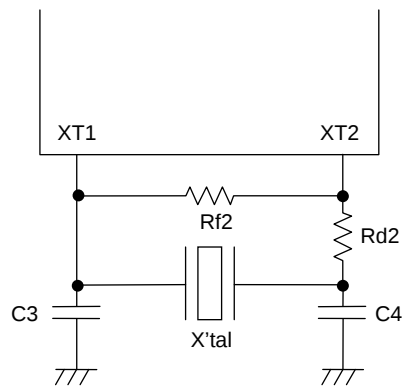


Figure 2 XT Oscillator Circuit

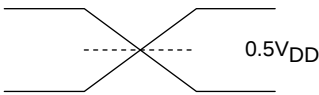
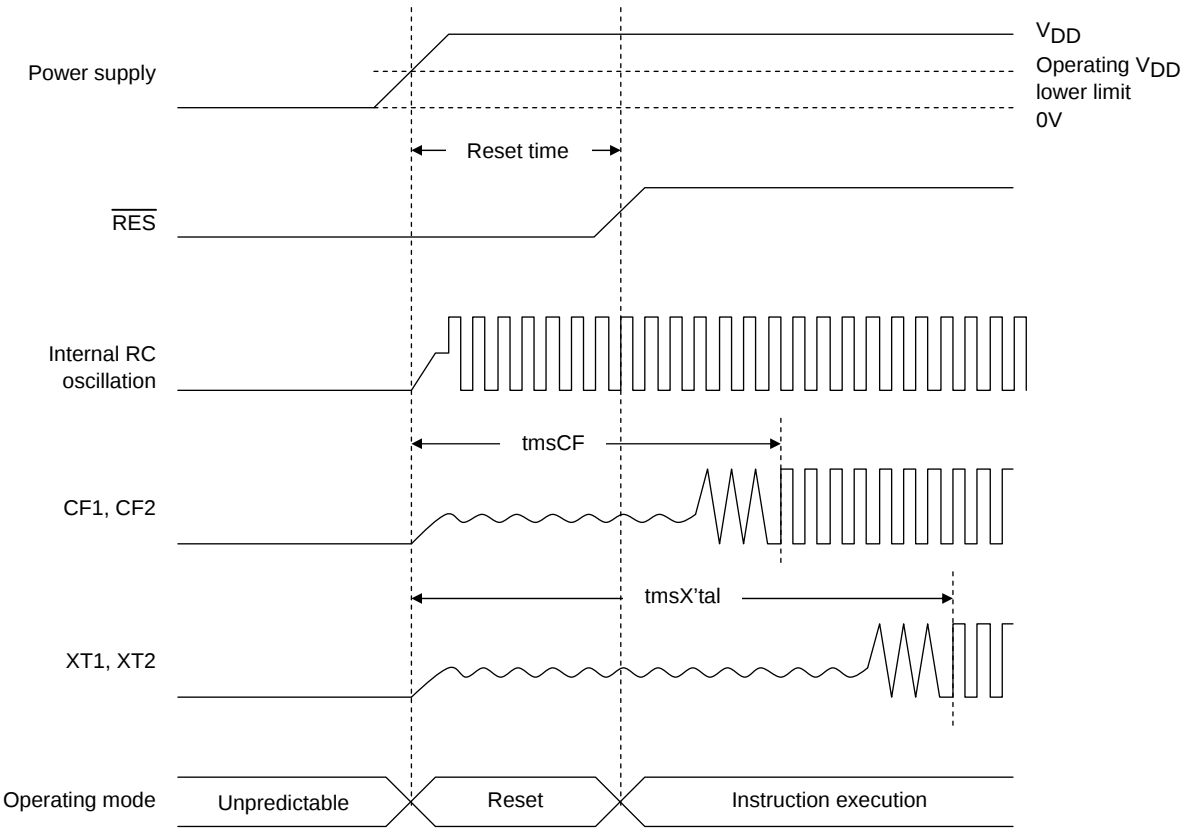
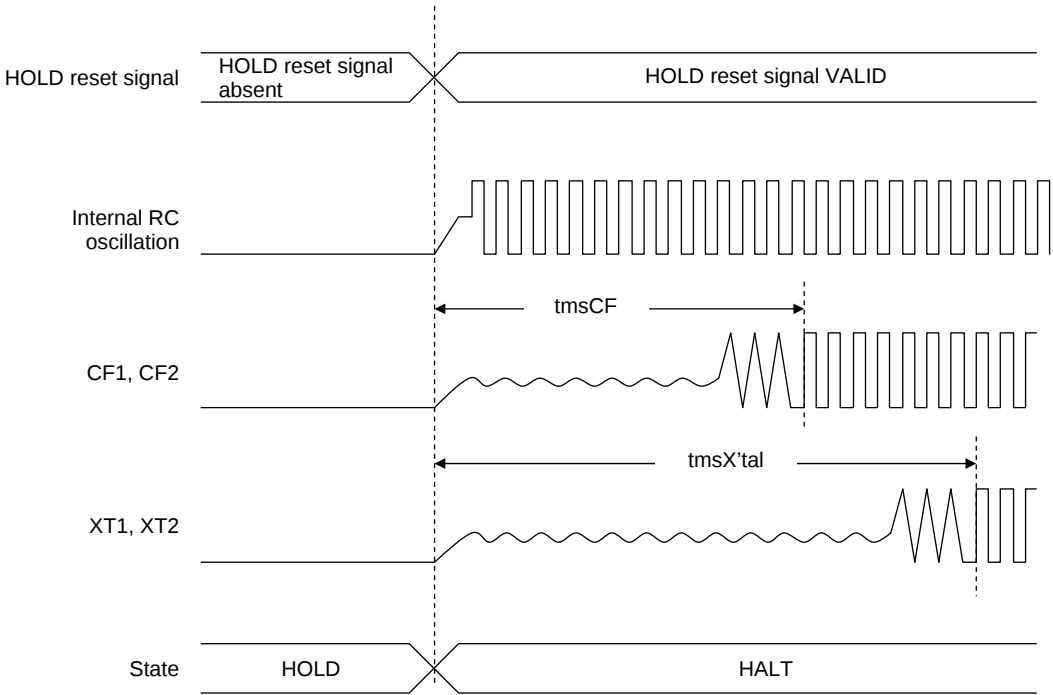


Figure 3 AC Timing Measurement Point

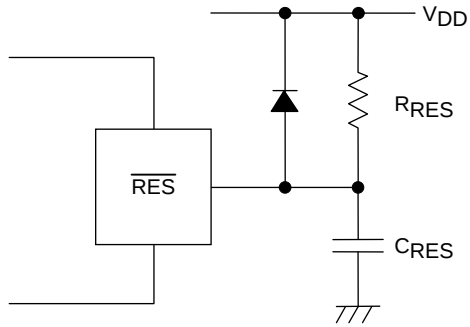


Reset Time and Oscillation Stabilization Time



HOLD Reset Signal and Oscillation Stabilization Time

Figure 4 Oscillation Stabilization Times



Note:

Determine the value of C_{RES} and R_{RES} so that the reset signal is present for a period of $200\mu s$ after the supply voltage goes beyond the lower limit of the IC's operating voltage.

Figure 5 Reset Circuit

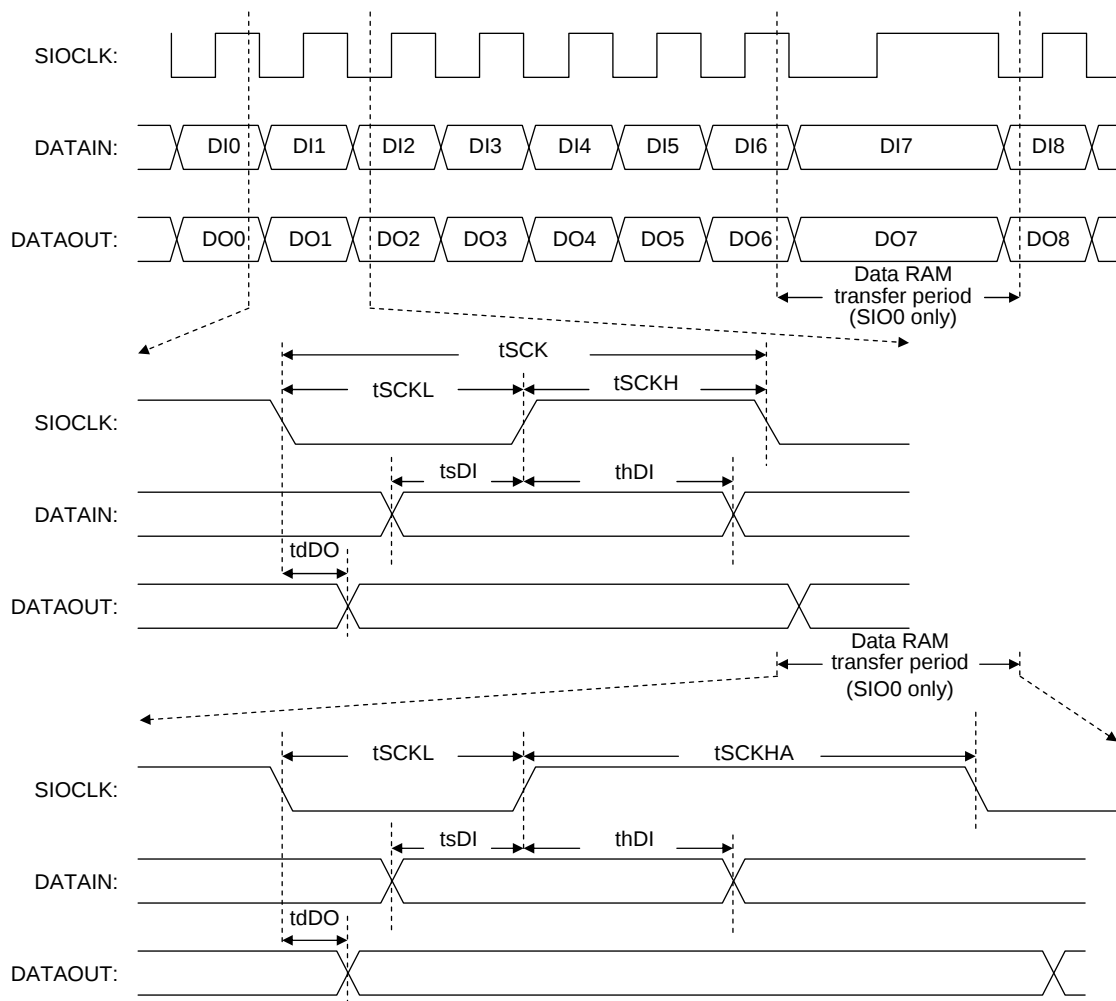


Figure 6 Serial I/O Waveforms

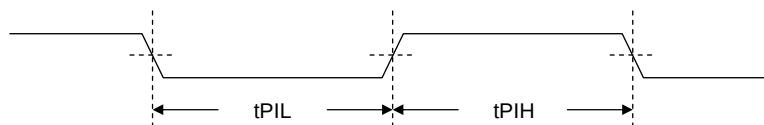


Figure 7 Pulse Input Timing Signal Waveform

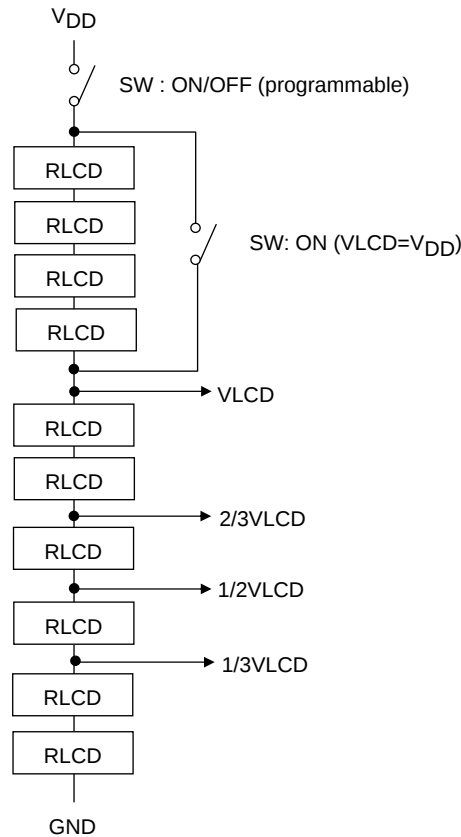


Figure 8 LCD Bias Resistor

ON Semiconductor and the ON logo are registered trademarks of Semiconductor Components Industries, LLC (SCILLC). SCILLC owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of SCILLC's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.