



# LC7233N

## Single-Chip PLL and Microcontroller with LCD Driver

### Preliminary

#### Overview

The LC7233N is a single-chip microcontroller that incorporates a 0.5 to 150 MHz phase-locked loop (PLL) and a liquid-crystal display (LCD) driver, making it ideal for digital tuners. It has a large number of input/output ports and a frequency measurement circuit.

The LC7233N features on-chip RAM and ROM, a programmable high-speed divider, a 6-bit analog-to-digital converter and a low-voltage detection reset circuit.

The LC7233N operates from a 5 V supply and is available in 64-pin QIPs.

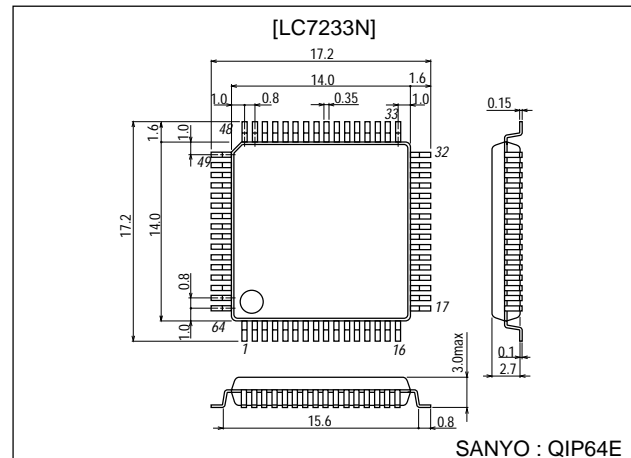
#### Features

- 0.5 to 150 MHz phase-locked loop.
- LCD driver.
- 6-bit analog-to-digital converter.
- Two 8-bit PWM digital-to-analog converters.
- Two 4-bit input ports.
- Two 4-bit input/output ports.
- 6-bit keypad matrix scan output port.
- 2-bit open-drain high-voltage output port.
- 23 mask-selectable output drivers.
- 20-bit universal counter.
- 4096 × 16-bit program ROM (001H to FFFH user addressable memory).
- 256 × 4-bit data RAM.
- Low-voltage detection reset circuit.
- Programmable high-speed divider.
- Single-word instructions.
- Four-level stack.
- PLL-unlocked flip-flop.
- Timer flip-flop.
- External interrupt.
- Programmable watchdog interrupt address.
- Standby mode.
- CPU operates down to 3.5 V and retains data down to 1.3 V.
- 5 V supply.
- 64-pin QIP.

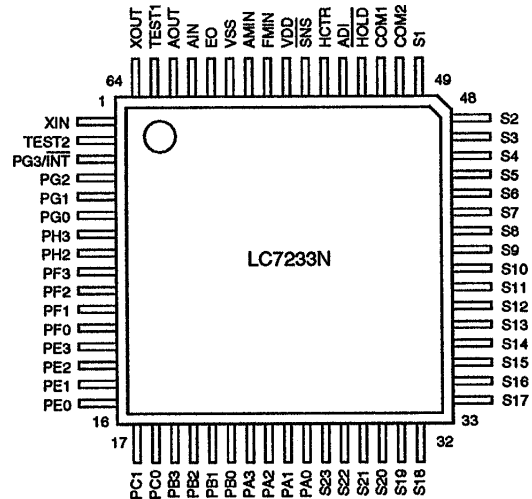
#### Package Dimensions

unit:mm

3159-QIP64E



#### Pin Assignment



Top view

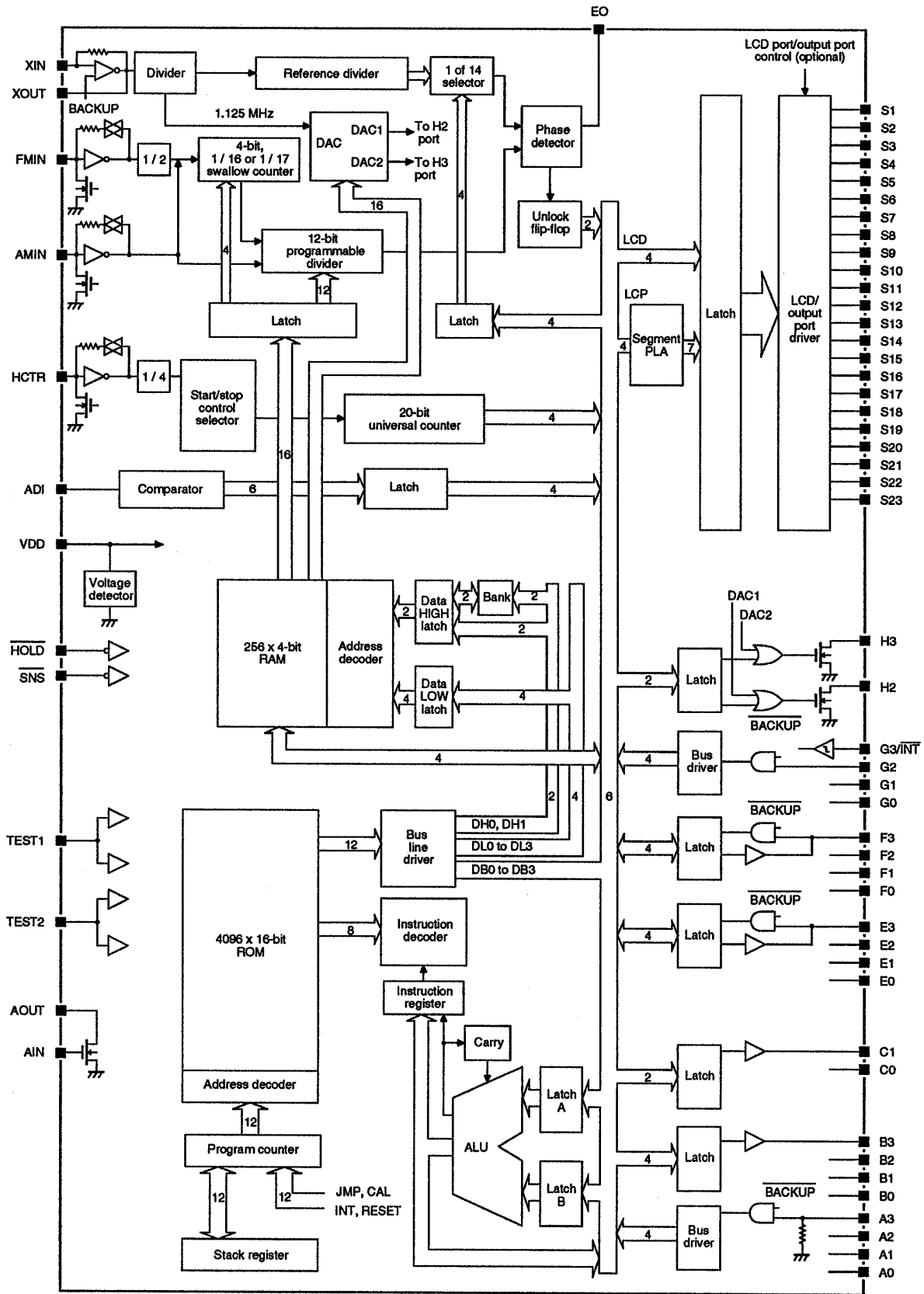
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## Block Diagram



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## Pin Description

Number	Name	Equivalent circuit	Description
1	XIN		Crystal oscillator connections
64	XOUT		
2	TEST2		Test pins
63	TEST1		
3	PG3/ $\overline{\text{INT}}$		Multiplexed input port G bit and interrupt request input
4 to 6	PG2 to PG0		Input port G
7, 8	PH1, PH0		Output port H
9 to 12	PF3 to PF0		Input/output port F
13 to 16	PE3 to PE0		Input/output port E
17, 18	PC1, PC0		Output port C
19 to 22	PB3 to PB0		Output port B
23 to 26	PA3 to PA0		Input port A
27 to 49	S23 to S1		LCD segment outputs

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Number	Name	Equivalent circuit	Description
50, 51	COM2, COM1		LCD common driver outputs
52	$\overline{\text{HOLD}}$		Hold-mode control input
55	$\overline{\text{SNS}}$		Power-fail detect
53	ADI		A/D converter input
54	HCTR		Universal counter input
56	V <sub>DD</sub>		5 V supply
57	FMIN		FM VCO input
58	AMIN		AM VCO input
59	V <sub>SS</sub>		Ground
60	EO		Phase comparator output
61	AIN		Analog input
62	AOUT		Analog output

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## Specifications

### Absolute Maximum Ratings

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	$V_{DD}$		-0.3 to +6.5	V
Port G, HOLD, ADI and SNS input voltage	$V_{I1}$		-0.3 to +13.0	V
Input voltage (other inputs)	$V_{I2}$		-0.3 to $V_{DD}+0.3$	V
Port H and AOOUT output voltage	$V_{O1}$		-0.3 to +15.0	V
Output voltage (all other outputs)	$V_{O2}$		-0.3 to $V_{DD}+0.3$	V
Port H output current	$I_{O1}$		0 to 5	mA
Ports E and F output current	$I_{O2}$		0 to 3	mA
Ports B and C output current	$I_{O3}$		0 to 1	mA
AOOUT output current	$I_{O4}$		0 to 2	mA
Allowable power dissipation	Pd max		400	mW
Operating temperature	Topr		-40 to +85	°C
Storage temperature	Tstg		-45 to +125	°C

### Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	$V_{DD}$		5	V
Supply voltage range (PLL and CPU)	$V_{DD1}$		4.5 to 5.5	V
Supply voltage range (CPU)	$V_{DD2}$		3.5 to 5.5	V
Supply voltage range for data retention	$V_{DD3}$		1.3 to 5.5	V

### Electrical Characteristics at Ta = -40 to +85°C, VDD = 3.5 to 5.5V, unless otherwise noted

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply current	$I_{DD1}$	$f_I=130\text{MHz}$ , $V_{DD}=4.5$ to $5.5\text{V}$		15	20	mA
Hold-mode supply current	$I_{DD2}$	PLL halted, $t_{CYC}=2.67\mu\text{s}$ , $V_{DD}=3.5$ to $5.5\text{V}$		1.5		mA
		PLL halted, $t_{CYC}=13.33\mu\text{s}$ , $V_{DD}=3.5$ to $5.5\text{V}$		1.0		
		PLL halted, $t_{CYC}=40.00\mu\text{s}$ , $V_{DD}=3.5$ to $5.5\text{V}$		0.7		
Standby-mode supply current	$I_{DD3}$	$V_{DD}=5.5\text{V}$ , oscillator halted, Ta=25°C			5	µA
		$V_{DD}=2.5\text{V}$ , oscillator halted, Ta=25°C			1	
Port A and PG3/ $\overline{\text{INT}}$ low-level input voltage	$V_{IL1}$		0		$0.2V_{DD}$	V
Ports E and F low-level input voltage	$V_{IL2}$		0		$0.3V_{DD}$	V
PG0 to PG2 low-level input voltage	$V_{IL3}$		0		$0.3V_{DD}$	V
HOLD low-level input voltage	$V_{IL4}$		0		$0.4V_{DD}$	V
SNS low-level input voltage	$V_{IL5}$		0		1.3	V
Port A high-level input voltage	$V_{IH1}$		$0.6V_{DD}$		$V_{DD}$	V
Ports E and F high-level input voltage	$V_{IH2}$		$0.7V_{DD}$		$V_{DD}$	V
PG0 to PG2 high-level input voltage	$V_{IH3}$		$0.7V_{DD}$		8.0	V
HOLD and PG3/ $\overline{\text{INT}}$ high-level input voltage	$V_{IH4}$		$0.8V_{DD}$		8.0	V
SNS high-level input voltage	$V_{IH5}$		2.7		8.0	V
XIN rms input amplitude	$V_{I1}$		0.5		1.5	V
FMIN rms input amplitude	$V_{I2}$		0.1		1.5	V
AMIN rms input amplitude	$V_{I3}$		0.1		1.5	V
HCTR rms input amplitude	$V_{I4}$		0.1		1.5	V
PG3/ $\overline{\text{INT}}$ input hysteresis width	$V_{HYS}$		$0.1V_{DD}$			V
ADI input voltage	$V_{I5}$		0		$V_{DD}$	V
Port A input voltage	$V_{IF}$	Port A is high impedance. Port A has $R_{PD}$ .			$0.05V_{DD}$	V
Standby threshold voltage	$V_{DET}$		2.7	3.0	3.3	V
XIN input frequency	$f_{I1}$	$V_I=0.5$ to $1.5\text{V}$	4.0	4.5	5.0	MHz
FMIN input frequency	$f_{I2}$	$V_I=0.1$ to $1.5\text{V}$ , $V_{DD}=4.5$ to $5.5\text{V}$	10		130	MHz
		$V_I=0.15$ to $1.5\text{V}$ , $V_{DD}=4.5$ to $5.5\text{V}$	10		150	
AMIN input frequency (low range)	$f_{I3}$	$V_I=0.1$ to $1.5\text{V}$ , $V_{DD}=4.5$ to $5.5\text{V}$	0.5		10.0	MHz
AMIN input frequency (high range)	$f_{I4}$	$V_I=0.1$ to $1.5\text{V}$ , $V_{DD}=4.5$ to $5.5\text{V}$	2		40	MHz
HCTR input frequency	$f_{I5}$	$V_I=0.1$ to $1.5\text{V}$ , $V_{DD}=4.5$ to $5.5\text{V}$	0.4		12.0	MHz
SNS reject pulsewidth	$P_{rej}$				50	µs
Ports A, E and F low-level input current	$I_{IL1}$	Ports E and F are high impedance. Port A has no $R_{PD}$ . $V_I=V_{SS}$			3	µA
AIN low-level input current	$I_{IL2}$	$V_I=V_{SS}$		0.01	10.0	nA
FMIN, AMIN and HCTR low-level input current	$I_{IL3}$	$V_I=V_{SS}$	4	10	30	µA

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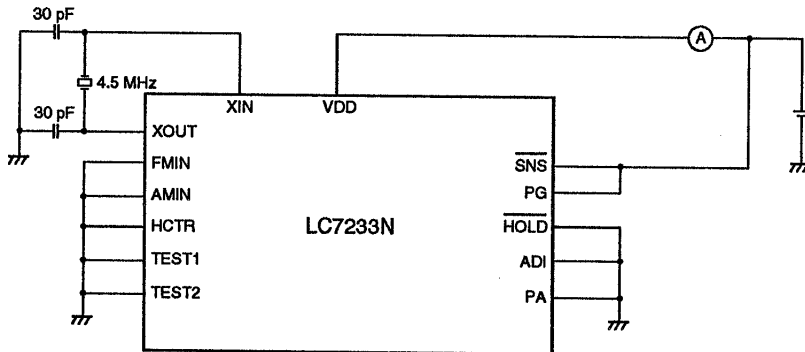
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Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
HOLD, ADI, $\overline{\text{SNS}}$ and port G low-level input current	$I_{IL4}$	$V_I=V_{SS}$			3	$\mu\text{A}$
XIN low-level input current	$I_{IL5}$	$V_I=V_{SS}$	2	5	15	$\mu\text{A}$
Ports A, E and F high-level input current	$I_{IH1}$	Ports E and F are high impedance. Port A has no $R_{PD}$ . $V_I=V_{DD}$			3	$\mu\text{A}$
Port A high-level input current	$I_{IH2}$	$V_I=V_{DD}=5.0\text{V}$ , Port A has $R_{PD}$ .		50		$\mu\text{A}$
AIN high-level input current	$I_{IH3}$	$V_I=V_{DD}$		0.01	10.0	nA
FMIN, AMIN and HCTR high-level input current	$I_{IH4}$	$V_I=V_{DD}=5.0\text{V}$	4	10	30	$\mu\text{A}$
HOLD, ADI, $\overline{\text{SNS}}$ and port G high-level input current	$I_{IH5}$	$V_I=5.5\text{V}$			3	$\mu\text{A}$
XIN high-level input current	$I_{IH6}$	$V_I=V_{DD}=5.0\text{V}$	2	5	15	$\mu\text{A}$
Ports B and C low-level output voltage	$V_{OL1}$	$I_O=50\mu\text{A}$	0.5	1.0	2.0	V
Ports E and F low-level output voltage	$V_{OL2}$	$I_O=1\text{ mA}$			1	V
Port H low-level output voltage	$V_{OL3}$	$I_O=5\text{ mA}$	0.75 (150 $\Omega$ )		2.0 (400 $\Omega$ )	V
AOUT low-level output voltage	$V_{OL4}$	$I_O=5\text{ mA}$ , $V_{AIN}=1.3\text{V}$			0.5	V
COM1 and COM2 low-level output voltage	$V_{OL5}$	$I_O=25\mu\text{A}$	0.3	0.5	0.75	V
EO low-level output voltage	$V_{OL6}$	$I_O=500\mu\text{A}$			1	V
S1 to S23 low-level output voltage	$V_{OL7}$	$I_O=0.1\text{ mA}$			1	V
XOUT low-level output voltage	$V_{OL8}$	$I_O=200\mu\text{A}$			1	V
COM1 and COM2 mid-level output voltage	$V_{M1}$	$V_{DD}=5\text{V}$ , $I_O=20\mu\text{A}$	2.0	2.5	3.0	V
Ports B and C high-level output voltage	$V_{OH1}$	$I_O=1\text{ mA}$	$V_{DD}-2.0$	$V_{DD}-1.0$	$V_{DD}-0.5$	V
Ports E and F high-level output voltage	$V_{OH2}$	$I_O=1\text{ mA}$	$V_{DD}-1.0$			V
COM1 and COM2 high-level output voltage	$V_{OH3}$	$I_O=25\mu\text{A}$	$V_{DD}-0.75$	$V_{DD}-0.5$	$V_{DD}-0.3$	V
EO high-level output voltage	$V_{OH4}$	$I_O=500\mu\text{A}$	$V_{DD}-1.0$			V
S1 to S23 high-level output voltage	$V_{OH5}$	$I_O=-0.1\text{ mA}$	$V_{DD}-1.0$			V
XOUT high-level output voltage	$V_{OH6}$	$I_O=200\mu\text{A}$	$V_{DD}-1.0$			V
Ports B, C, E and F low-level output leakage current	$I_{OFFL1}$	$V_O=V_{SS}$			3	$\mu\text{A}$
EO low-level output leakage current	$I_{OFFL2}$	$V_O=V_{SS}$		0.01	10.0	$\mu\text{A}$
Ports B, C, E and F high-level output leakage current	$I_{OFFH1}$	$V_O=V_{DD}$			3	$\mu\text{A}$
Port H high-level output leakage current	$I_{OFFH2}$	$V_O=13\text{V}$			5	$\mu\text{A}$
AOUT high-level output leakage current	$I_{OFFH3}$	$V_O=13\text{V}$			1	$\mu\text{A}$
EO high-level output leakage current	$I_{OFFH4}$	$V_O=V_{DD}$		0.01	10.0	nA
A/D converter error	$\epsilon$	$V_{DD}=4.5\text{ to }5.5\text{V}$	-1/2		1/2	lsb
Port A pull-down resistance	$R_{PD}$	$V_{DD}=5\text{V}$	75	100	200	k $\Omega$

## Test Circuits

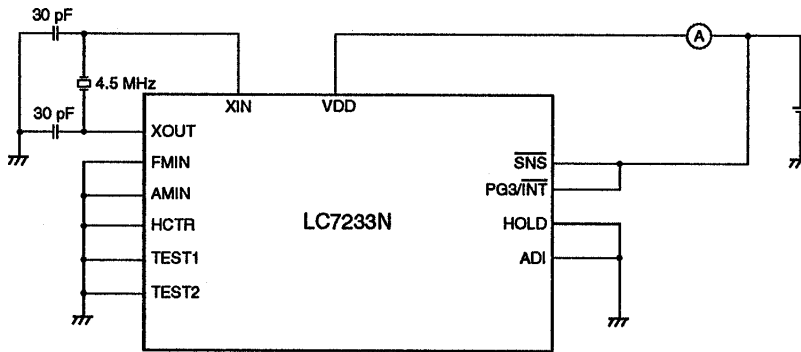
### Hold mode



### Notes

1. Ports E and F are selected as output ports.
2. Ports A to H, S1 to S23, COM1 and COM2 are open.

**Standby mode**



**Note**

Ports A to H, S1 to S23, COM1 and COM2 are open.

**Functional Description**

**LCD Driver**

The LC7233N can drive LCD segments. The LCP and LCD instructions transfer data to the LCD outputs. The LCD instruction transfers data directly to the LCD outputs. The LCP instruction converts data to 7-segment format before transfer to the outputs.

S1 to S23 are the driver outputs. The LCD frame rate is 100 Hz with a 50% duty cycle. After reset or power-up, a blank signal is present on all outputs. In standby mode, all outputs are LOW. They can be used as general-purpose outputs if the appropriate mask option is selected.

COM1 and COM2 are the LCD common driver outputs. Output drive is 50% duty with 50% bias. Upon reset or after power-up, the normal drive signals are present on these outputs. In standby mode, all outputs are LOW.

**Frequency Counter**

Frequency measurement is performed at the HCTR input by the 20-bit universal counter. The input frequency range is 0.4 to 12 MHz, which is used for measuring AM and FM IF frequencies. Capacitive coupling should be used.

**Phase-locked Loop**

The FMIN or AMIN input signal is divided down by a programmable divider, and then compared with the crystal frequency, which is also divided down using 14 selectable ratios. The phase difference between the two signals is measured using a phase detector and output on EO.

FMIN is the input pin for the FM VCO input signal. The input frequency range is 10 to 130 MHz. Capacitive coupling should be used.

AMIN is the AM VCO input. The bandwidth is adjustable in two ranges by using the PLL instruction-HIGH (2 to 40 MHz) for the SW band, and LOW (0.5 to 10 MHz), for the LW and MW bands. Capacitive coupling should be used.

**Input/Output Ports**

**Port A**

This input port has a low switching threshold, which is used for keypad matrix inputs. Pull-down resistors for all pins are available as a mask option. Note that either all or none of the pins should have pull-down resistors. In standby mode, inputs are ignored.

**Ports B and C**

These output ports have unbalanced CMOS outputs which are used as keypad matrix scan outputs. Upon reset, outputs are set LOW, and in standby mode, outputs are high impedance. The outputs can be short-circuited.

**Port E**

The transfer direction of this input/output port is selected automatically under software control. When an input instruction (IN, TPT, or TPF) is executed, port E is configured for input operation, and an output instruction (OUT, SPB or RPB), for output operation. Upon reset, all pins become inputs. In standby mode, the output drivers are high impedance and the input signals are ignored. All bits should either be inputs or outputs.

**Port F**

The transfer direction of this input/output port is selected by the FPC instruction. Each pin of this port can be set independently to be an input or output. Upon reset, all pins become inputs. In standby mode, the output drivers are high impedance and the input signals are ignored.

**Port G**

PG0 to PG2 are inputs only. PG3/ $\overline{\text{INT}}$  can be used as a standard input or as the interrupt request input. In standby mode, inputs are ignored.

## Port H

These output ports are high-voltage, n-channel open-drain drivers, which are used for switching power supplies. Upon reset and in standby mode, outputs are high impedance. Port H can also be configured as the output of DAC1 and DAC2.

## A/D Converter

The A/D converter is a 6-bit successive approximation type. The conversion cycle time is 1.28 ms. Full-scale output data is 3FH for an input of  $(63/96) \times V_{DD}$ .

## Power-fail Detection

When connected to the supply,  $\overline{SNS}$  is used as a power-fail detector.  $\overline{SNS}$  can also be used as a standard input port.

## Crystal Oscillator

The master crystal oscillator, which has a feedback resistor on-chip, requires only the connection of a 4.5 MHz crystal.

## Instruction Set

ADDR	Program memory address [12 bits]
b	Borrow
B	Bank number [2 bits]
C	Carry
DH	Data memory address high-order bits (row address) [2 bits]
DL	Data memory address low-order bits (column address) [4 bits]
I	Immediate data [4 bits]
M	Data memory address
N	Bit position [4 bits]
Pn	Port number [4 bits]
r	General register (Bank 0 addresses 00H to 0FH)
Rn	Register number [4 bits]
( )	Contents of register or memory
( )n	Contents of bit N of register or memory

## Low-power Modes

### Hold mode

When the hold-mode control pin,  $\overline{HOLD}$ , is driven LOW and the HOLDEN (hold enable) flip-flop has previously been set by an SS instruction, the LC7233N enters hold mode.

$\overline{HOLD}$  has a high-voltage input ( $V_{IH(max)} = 8.0\text{ V}$ ) which can be connected directly to the power supply.

### Standby mode

When the LC7233N is in hold mode and  $\overline{HOLD}$  is LOW, standby mode can be set by the CKSTP instruction.

### Test Pins

Two device test pins are provided-TEST1 and TEST2. These should either be tied to  $V_{SS}$  or left open.



Mnemonic	Operand		Operation	Instruction format																Notation	Description	Skip condition					
	1st	2nd		D15	D14	D13	D12	D11	D10	D9	D8	Add											D0				
												D7	D6	D5	D4	D3	D2	D1									
AD	r	M	Add M to r.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$r \leftarrow (r) + (M)$	Adds the contents of M to the contents of r and stores the result in r.		
ADS	r	M	Add M to r and skip if carry.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$r \leftarrow (r) + (M)$ , skip if carry	Adds the contents of M to the contents of r and stores the result in r. Skips if a carry is generated.	Carry
AC	r	M	Add M to r with carry.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$r \leftarrow (r) + (M) + C$	Adds the contents of M to the contents of r and C and stores the result in r.		
ACS	r	M	Add M to r with carry and skip if carry.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$r \leftarrow (r) + (M) + C$ , skip if carry	Adds the contents of M to the contents of r and C and stores the result in r. Skips if a carry is generated.	Carry	
AI	M	I	Add I to M.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$M \leftarrow (M) + I$	Adds the immediate data to the contents of M and stores the result in M.		
AIS	M	I	Add I to M and skip if carry.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$M \leftarrow (M) + I$ , skip if carry	Adds the immediate data to the contents of M and stores the result in M. Skips if a carry is generated.	Carry	
AIC	M	I	Add I to M with carry.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$M \leftarrow (M) + I + C$	Adds the immediate data to the contents of M and C and stores the result in M.		
AICS	M	I	Add I to M with carry and skip if carry.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$M \leftarrow (M) + I + C$ , skip if carry	Adds the immediate data to the contents of M and C and stores the result in M. Skips if a carry is generated.	Carry	
Subtract																											
SU	r	M	Subtract M from r.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$r \leftarrow (r) - (M)$ , skip if carry	Subtracts the contents of M from the contents of r and stores the result in r.		
SUS	r	M	Subtract M from r and skip if borrow.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$r \leftarrow (r) - (M)$ , skip if borrow	Subtracts the contents of M from the contents of r and stores the result in r. Skips if a borrow is generated.	Borrow	
SB	r	M	Subtract M from r with borrow.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$r \leftarrow (r) - (M) - b$	Subtracts the contents of M from the contents of r with borrow and stores the result in r.		
SBS	r	M	Subtract M from r with borrow and skip if borrow.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$r \leftarrow (r) - (M) - b$ , skip if borrow	Subtracts the contents of M from the contents of r with borrow and stores the result in r. Skips if a borrow is generated.	Borrow	
SI	M	I	Subtract I from M.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$M \leftarrow (M) - I$	Subtracts the immediate data from the contents of M and stores the result in M.		
SIS	M	I	Subtract I from M and skip if borrow.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$M \leftarrow (M) - I$ , skip if borrow	Subtracts the immediate data from the contents of M and stores the result in M. Skips if a borrow is generated.	Borrow	
SIB	M	I	Subtract I from M with borrow.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$M \leftarrow (M) - I - b$	Subtracts the immediate data from the contents of M with borrow and stores the result in M.		
SIBS	M	I	Subtract I from M with borrow and skip if borrow.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$M \leftarrow (M) - I - b$ , skip if borrow	Subtracts the immediate data from the contents of M with borrow and stores the result in M. Skips if a borrow is generated.	Borrow	
Compare																											
SEQ	r	M	Skip if r equals M.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$(r) - (M)$ , skip if zero	Compares the contents of r and M and skips if they are equal.	$(r) = (M)$	
SGE	r	M	Skip if r is greater than or equal to M.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn	DL	DL	$(r) - (M)$ , skip if $(r) \geq (M)$	Compares the contents of r and M and skips if r is greater than or equal to M.	$(r) (M)$	
SEI	M	I	Skip if M equals I.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$(M) - I$ , skip if zero	Compares the immediate data to the contents of M and skips if they are equal.	$(M) - I = 0$	
SGEI	M	I	Skip if M is greater than or equal to I.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	I	DL	DL	$(M) - I$ , skip if $(M) \geq I$	Compares the contents of M with the immediate data and skips if M is greater than or equal to I.	$(M) (I)$	

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Mnemonic	Operand		Operation	Instruction format																Notation	Description	Skip condition
	1st	2nd		D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0			
Logic arithmetic																						
AND	M	I	AND I with M.	0	0	1	1	0	0	DH	DL	DL								$M \leftarrow (M) \wedge I$	Calculates the logic-AND of the immediate data and the contents of M and stores the result in M.	
OR	M	I	OR I with M.	0	0	1	1	1	0	DH	DL	DL								$M \leftarrow (M) \vee I$	Calculates the logic-OR of the immediate data and the contents of M and stores the result in M.	
EXL	r	M	Exclusive-OR M with r.	0	0	1	0	0	0	DH	DL	DL								$r \leftarrow (r) \oplus (M)$	Calculates the logic-XOR of the contents of r and M, and stores the result in r.	
Load and store																						
LD	r	M	Load M into r.	1	0	0	0	0	0	DH	DL	DL								$r \leftarrow (M)$	Moves the contents of M to r.	
ST	M	r	Store r in M.	1	0	0	0	1	DH	DL	DL									$M \leftarrow (r)$	Moves the contents of r to M.	
MVRD	r	M	Move M to M addressed by Rn.	1	0	0	0	1	0	DH	DL	DL								$[DH, Rn] \leftarrow (M)$	Moves the contents of M to the address referenced by DH and Rn.	
MVRS	M	r	Move M addressed by Rn to M.	1	0	0	0	1	1	DH	DL	DL								$M \leftarrow [DH, Rn]$	Moves the contents of the memory location referenced by DH and Rn to M.	
MVSR	M <sub>1</sub>	M <sub>2</sub>	Move M to M.	1	0	0	1	0	0	DH	DL <sub>1</sub>	DL <sub>2</sub>								$[DH, DL_1] \leftarrow [DH, DL_2]$	Moves the contents of the memory location 2 to memory location 1.	
MVI	M	I	Move I to M.	1	0	0	1	0	1	DH	DL	DL								$M \leftarrow I$	Moves the immediate data to M.	
PLL	M	r	Load M to PLL registers.	1	0	0	1	1	0	DH	DL	DL								$PLLr \leftarrow (M)$	Moves the contents of M to the PLL registers.	
Bit test																						
TMT	M	N	Test bits of M and skip if true	1	0	1	0	0	1	DH	DL	DL								skip if $M(N) = \text{all } 1$	Tests the bits of memory location M specified by N. Skips if all bits are logic 1.	
TMF	M	N	Test bits of M and skip if false	1	0	1	0	1	1	DH	DL	DL								skip if $M(N) = \text{all } 0$	Tests the bits of memory location M specified by N. Skips if all bits are logic 0.	
Jump and subroutine																						
JMP	ADDR		Jump to address	1	0	1	1				ADDR (12 bits)									$PC \leftarrow ADDR$	Jumps to the address specified by ADDR.	
CAL	ADDR		Call subroutine	1	1	0	0				ADDR (12 bits)									$Stack \leftarrow (PC) + 1,$ $PC \leftarrow ADDR$	Jumps to the subroutine specified by ADDR.	
RT			Return from subroutine	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	$PC \leftarrow stack$	Returns from a subroutine.	
RTI			Return from interrupt	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	$PC \leftarrow stack$	Returns from an interrupt.	
Flag test																						
TTM	N		Test timer flip-flop	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	N	Skip if timer $F/F = 0$	Tests the timer flip-flop and skips if zero.	
TUL	N		Test PLL flip-flop	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	N	Skip if PLL $F/F = 0$	Tests the PLL-unlocked flip-flop and skips if zero.	
Status register test and set																						
SS	N		Set status register bits	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	N	$(Status\ register\ 1) N \leftarrow 1$	Sets the bits of status register 1 specified by N.	
RS	N		Reset status register bits	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	N	$(Status\ register\ 1) N \leftarrow 0$	Resets the bits of status register 1 specified by N.	
TST	N		Test status register bits and skip if true	1	1	0	1	1	1	0	0	0	0	0	0	0	0	N	Skip if (status register 2) $N = \text{all } 1$	Tests the bits of status register 2 specified by N. Skips if all bits are 1.		
TSF	N		Test status register bits and skip if false	1	1	0	1	1	1	1	0	0	0	0	0	0	0	N	Skip if (status register 2) $N = \text{all } 0$	Tests the bits of status register 2 specified by N. Skips if all bits are 0.		
Bank select																						
BANK	B		Select bank	1	1	0	1	0	0	B	0	0	0	0	0	0	0	0	0	$BANK \leftarrow B$	Selects one of four memory banks.	

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Mnemonic	Operand		Operation	Instruction format																Notation	Description	Skip condition
	1st	2nd		D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0			
Input/output																						
LCD	M	I	Move data to LCD segments.	1	1	1	0	0	0	DH	DL	DL	DIGIT	DIGIT					LCD (DIGIT) ← M	Loads the immediate data directly to the LCD driver.		
LCP	M	I	Move 7-segment data to LCD.	1	1	1	0	0	1	DH	DL	DL	DIGIT	DIGIT					LCD (DIGIT) ← PLA ← M	Converts the immediate data to 7-segment format using a PLA then transfers it to the LCD driver.		
IN	M	Pn	Move port data to M.	1	1	1	0	1	0	DH	DL	DL	P	P					M ← (port (P))	Moves the data from input port Pn to M.		
OUT	M	Pn	Move data to port.	1	1	1	0	1	1	DH	DL	DL	P	P					(port (P)) ← M	Moves the contents of memory location M to port Pn.		
SPB	Pn	N	Set port bits.	1	1	1	1	0	0	0	P	P	N	N					(port (P)) N ← 1	Sets the bits of port Pn specified by N to logic 1.		
RPB	Pn	N	Reset port bits.	1	1	1	1	0	1	0	P	P	N	N					(port (P)) N ← 0	Sets the bits of port Pn specified by N to logic 0.		
TPT	Pn	N	Test bits of port and skip if true.	1	1	1	1	1	0	1	P	P	N	N					Skip if (port (P)) N = all 1	Tests the bits of port Pn specified by N. Skips if all bits are logic 1.		
TPF	Pn	N	Test bits of port and skip if false.	1	1	1	1	1	1	1	P	P	N	N					Skip if (port (P)) N = all 0	Tests the bits of port Pn specified by N. Skips if all bits are logic 0.		
Universal counter																						
UCS	I		Set UCCW1.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	UCCW1 ← 1	Sets the universal counter flag 1.		
UCC	I		Set UCCW2.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	UCCW2 ← 1	Sets the universal counter flag 2.		
Miscellaneous																						
FPC	N		Port F direction control.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	FPC latch ← N	Defines the direction of individual pins of port F. If a bit in the port F direction register is set by FPC, the corresponding pin of port F becomes an output.		
CKSTP			Stop clock.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	Stop clock if HOLD = 0	Stops the processor clock if HOLD = 0		
NOP			No operation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No operation		

# LC7233N

## Mask Option

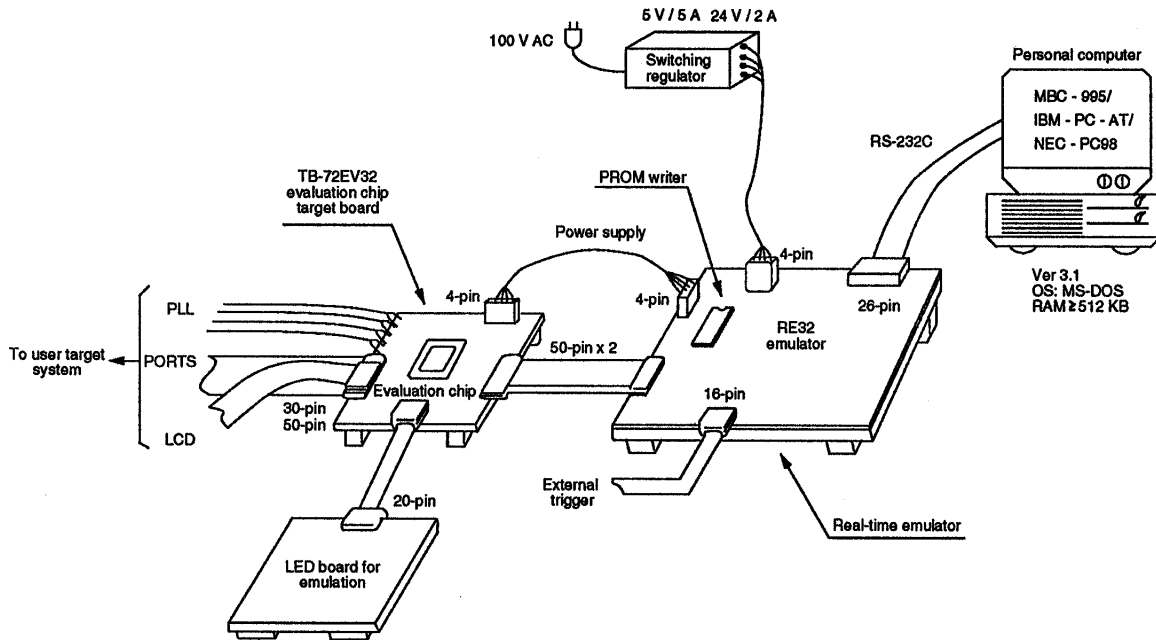
Parameter	Options
Watchdog timer (WDT)	Yes
	No
Pull-down resistors on port A (the keypad matrix input port)	Yes
	No
Instruction cycle time	2.67 μs

Parameter	Options
Instruction cycle time	13.33 μs
	40.00 μs
S1 to S23 configuration	LCD driver output port
	General-purpose output port

## Development System

The LC7223N development environment is shown in the following figure. It uses an LC72EV32 evaluation chip mounted on a TB-72EV32 target board and a multifunc-

tional emulator (RE32), which is controlled by a personal computer, to provide full debugging facilities.



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