Ordering number: EN 4160A

CMOS LSI

No. 4160A

LC7153, LC7153M

Universal Dual-PLL Frequency Synthesizers

Overview

The LC7153 and LC7153M are universal dual-PLL frequency synthesizers for use in cordless telephone applications in the USA, South Korea and Australia, and satellite broadcast tuners in the USA and Europe.

The LC7153 and LC7153M both have two PLLs with a 16-bit programmable divider to generate a 1.5 to 160 MHz local-oscillator frequency, and a phase detector. They also have a dual charge pump and fast lock-up circuitry for rapid PLL locking when changing frequency, an unlock indication output and an uncommitted output under external control. The PLLs share a 14-bit divider to generate a 320 Hz to 640 kHz reference frequency using a 10.24 MHz crystal.

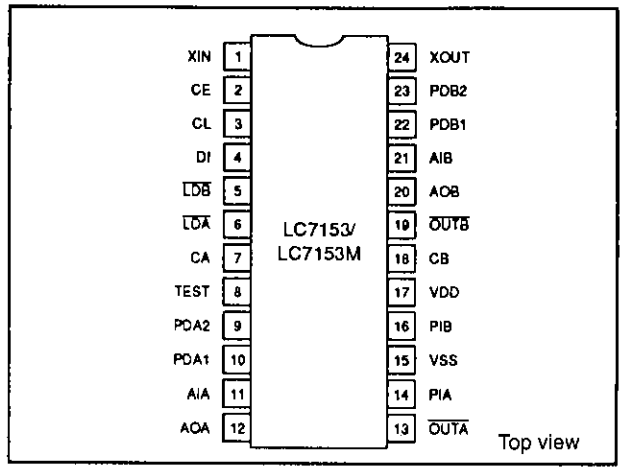
The LC7153 and LC7153M can be controlled from an external microcontroller using a C²B serial interface. They also have a standby mode for single PLL operation.

The LC7153 and LC7153M operate from a 4.0 to 5.5 V supply. The LC7153 is available in 24-pin DIPs, and the LC7153M, in 24-pin MFPs.

Features

- Dual charge pump and fast lock-up circuitry for rapid PLL locking
- PLL unlock indication
- 16-bit programmable local-oscillator divider
- 1.5 to 160 MHz local-oscillator frequency (V_{DD} = 4.0 to 5.5 V)
- 14-bit programmable reference-frequency divider
- 320 Hz to 640 kHz reference frequency using a 10.24 MHz crystal
- LPF transistor
- C²B serial interface
- 4.0 to 5.5 V supply
- 24-pin DIP (LC7153) and 24-pin MFP (LC7153M)

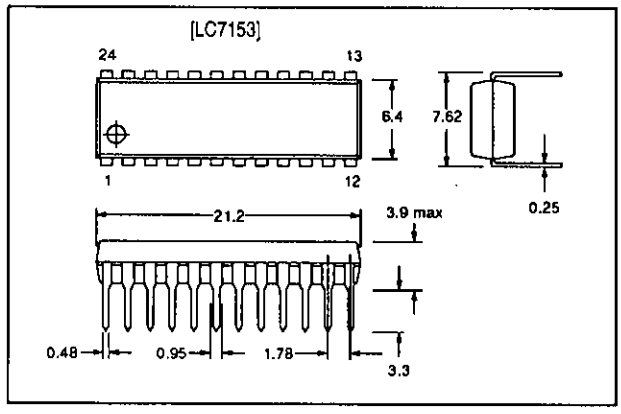
Pin Assignment



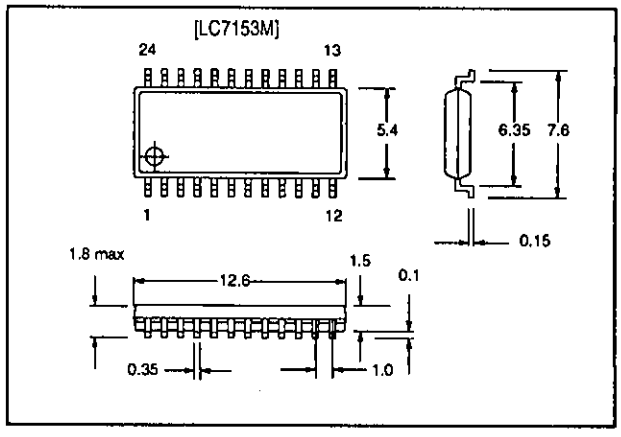
Package Dimensions

Unit: mm

3067-DIP24S

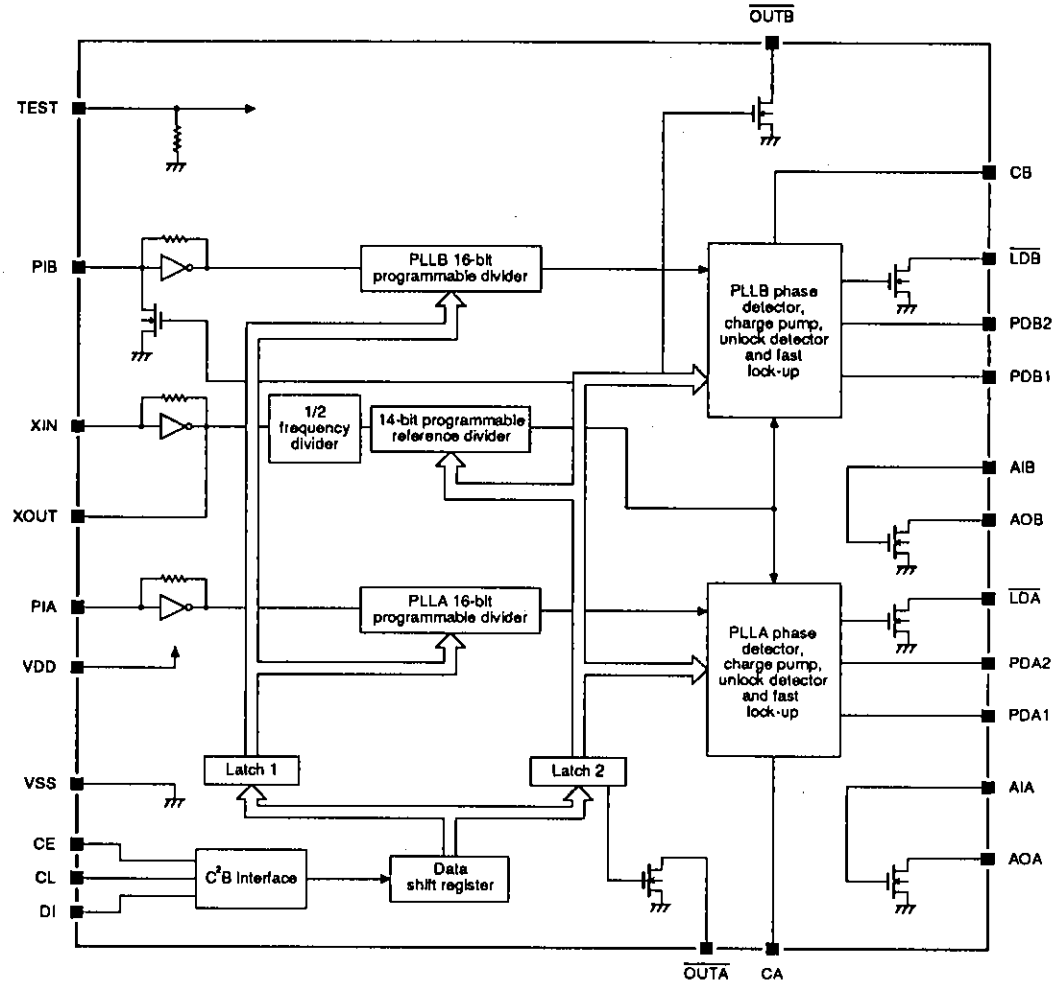


3112-MFP24S



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Block Diagram



Pin Functions

Number	Name	Function
1	XIN	Crystal oscillator input
2	CE	Chip enable input
3	CL	Clock input
4	DI	Serial data input
5	$\overline{\text{LDB}}$	PLLB unlock-detector output
6	$\overline{\text{LDA}}$	PLLA unlock-detector output
7	CA	Fast lock-up capacitor A connection
8	TEST	Test input
9	PDA2	PLLA phase-detector secondary output
10	PDA1	PLLA phase-detector main output
11	AIA	LPF transistor A input
12	AOA	LPF transistor A output
13	$\overline{\text{OUTA}}$	Uncommitted output A

Number	Name	Function
14	PIA	PLLA local-oscillator input
15	VSS	Ground
16	PIB	PLLB local-oscillator input
17	VDD	5 V supply
18	CB	Fast lock-up capacitor B connection
19	$\overline{OUTB}$	Uncommitted output B
20	AOB	LPF transistor B output
21	AIB	LPF transistor B input
22	PDB1	PLLB phase-detector main output
23	PDB2	PLLB phase-detector secondary output
24	XOUT	Crystal oscillator output

Specifications

Absolute Maximum Ratings

T_a = 25 °C

Parameter	Symbol	Ratings	Unit
Supply voltage range	V_{DD}	–0.3 to 7.0	V
CE, CL, DI, AIA and AIB input voltage range	V_{I1}	–0.3 to 7.0	V
XIN, PIA, PIB, CA, CB and TEST input voltage range	V_{I2}	–0.3 to V_{DD} + 0.3	V
$\overline{LDA}$, $\overline{LDB}$, $\overline{OUTA}$ and $\overline{OUTB}$ output current range	I_{O1}	0 to 3	mA
AOA and AOB output current range	I_{O2}	0 to 6	mA
CA and CB output current range	I_{O3}	0 to 1	mA
$\overline{LDA}$ and $\overline{LDB}$ output voltage range	V_{O1}	–0.3 to 7.0	V
AOA, AOB, $\overline{OUTA}$ and $\overline{OUTB}$ output voltage range	V_{O2}	–0.3 to 15.0	V
PDA1, PDA2, PDB1, PDB2, CA, CB and XOUT output voltage range	V_{O3}	–0.3 to V_{DD} + 0.3	V
Power dissipation	P_D	350 (LC7153)	mW
		240 (LC7153M)	
Operating temperature range	Topr	–40 to 85	°C
Storage temperature range	T_{stg}	–55 to 125	°C

(Note) Pins PIA, PIB, CA and CB have a weaker electrostatic breakdown strength than the other pins.

Recommended Operating Conditions

T_a = 25 °C

Parameter	Symbol	Ratings	Unit
Supply voltage	V_{DD}	5	V
Supply voltage range	V_{DD}	4.0 to 5.5	V

Electrical Characteristics

V_{DD} = 4.0 to 5.5 V, V_{SS} = 0 V, T_a = –40 to 85 °C unless otherwise noted

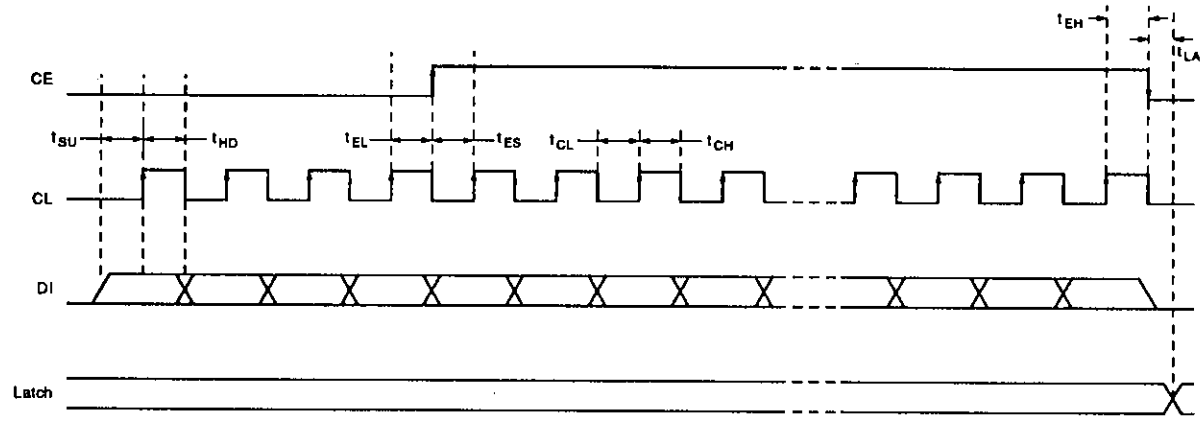
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply current	I_{DD}	V_{DD} = 4.5 V, f_I = 60 MHz. See note 1.	–	9.0	18.0	mA
		V_{DD} = 5.5 V, f_I = 160 MHz. See note 1.	–	20.0	40.0	
		V_{DD} = 4.5 V, f_I = 60 MHz. See note 2.	–	5.0	10.0	
		V_{DD} = 5.5 V, f_I = 160 MHz. See note 2.	–	11.0	22.0	
CE, CL and DI LOW-level input voltage	V_{IL1}		0	–	0.8	V
CE, CL and DI HIGH-level input voltage	V_{IH1}		2.2	–	5.5	V
PDA1 and PDB1 LOW-level output voltage	V_{OL1}	I_O = 1 mA	–	–	1.0	V
PDA2 and PDB2 LOW-level output voltage	V_{OL2}	I_O = 2 mA	–	–	1.0	V
$\overline{LDA}$, $\overline{LDB}$, $\overline{OUTA}$ and $\overline{OUTB}$ LOW-level output voltage	V_{OL3}	I_O = 2 mA	0	–	1.0	V
AOA and AOB LOW-level output voltage	V_{OL4}	I_O = 0.5 mA, V_{AIA} = V_{AIB} = 1.2 V	0	–	0.5	V
		I_O = 1 mA, V_{AIA} = V_{AIB} = 1.3 V	0	–	0.5	
PDA1 and PDB1 HIGH-level output voltage	V_{OH1}	I_O = 1 mA	V_{DD} – 1	–	–	V
PDA2 and PDB2 HIGH-level output voltage	V_{OH2}	I_O = 2 mA	V_{DD} – 1	–	–	V
$\overline{LDA}$ and $\overline{LDB}$ output voltage	V_{O1}		0	–	5.5	V
AOA, AOB, $\overline{OUTA}$ and $\overline{OUTB}$ output voltage	V_{O2}		0	–	13.0	V
CA and CB output voltage	V_{O3}		0	–	V_{DD}	V
CA and CB LOW-level threshold voltage	V_{T-}		–	–	0.2V_{DD}	V
CA and CB HIGH-level threshold voltage	V_{T+}		0.5V_{DD}	–	–	V
CE, CL and DI LOW-level input current	I_{IL1}	V_I = 0 V	–	–	5.0	µA
XIN LOW-level input current	I_{IL2}	V_I = 0 V, V_{DD} = 5.0 V	3.5	–	11	µA
PIA and PIB LOW-level input current	I_{IL3}	V_I = 0 V, V_{DD} = 5.0 V	6.0	–	18.0	µA
AIA and AIB LOW-level input current	I_{IL4}	V_I = 0 V	–	0.01	10.0	nA
TEST LOW-level input current	I_{IL5}	V_I = 0 V, V_{DD} = 5.0 V	–	–	5.0	µA
CE, CL and DI HIGH-level input current	I_{IH1}	V_I = 5.5 V	–	–	5.0	µA
XIN HIGH-level input current	I_{IH2}	V_I = 5.0 V, V_{DD} = 5.0 V	3.5	–	11.0	µA

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
PIA and PIB HIGH-level input current	I_{IH3}	V_I = 5.0 V, V_{DD} = 5.0 V	6.0	–	18.0	µA
AIA and AIB HIGH-level input current	I_{IH4}	V_I = 5.0 V	–	0.01	10.0	nA
TEST HIGH-level input current	I_{IH5}	V_I = 5.0 V, V_{DD} = 5.0 V	–	160	–	µA
$\overline{LDA}$ and $\overline{LDB}$ output leakage current	I_{OFF1}	V_O = 5.5 V	–	–	5.0	µA
PDA1, PDB1, PDA2 and PDB2 output leakage current	I_{OFF2}	V_O = 0 or 5.5 V	–	0.01	10.0	nA
AOA, AOB, $\overline{OUTA}$ and $\overline{OUTB}$ output leakage current	I_{OFF3}	V_O = 13 V	–	–	5.0	µA
CA and CB output leakage current	I_{OFF4}	V_O = 0 V or V_{DD}	–	–	100	nA
CA and CB source current	I_{S1}	V_O = 0 V, V_{DD} = 5.0 V	–95	–190	–380	µA
Fast lock-up mode 0 CA and CB sink current	$I_{S2(0)}$	V_O = 3.0 V, V_{DD} = 5.0 V	$3.5I_{S2(3)}$	$4.0I_{S2(3)}$	$4.5I_{S2(3)}$	µA
Fast lock-up mode 1 CA and CB sink current	$I_{S2(1)}$	V_O = 3.0 V, V_{DD} = 5.0 V	$2.5I_{S2(3)}$	$3.0I_{S2(3)}$	$3.4I_{S2(3)}$	µA
Fast lock-up mode 2 CA and CB sink current	$I_{S2(2)}$	V_O = 3.0 V, V_{DD} = 5.0 V	$1.5I_{S2(3)}$	$2.0I_{S2(3)}$	$2.4I_{S2(3)}$	µA
Fast lock-up mode 3 CA and CB sink current	$I_{S2(3)}$	V_O = 3.0 V, V_{DD} = 5.0 V	18	35	70	µA
XIN input frequency	f_{I1}	Capacitively coupled sine wave	1	–	13	MHz
PIA and PIB input frequency	f_{I2}	Capacitively coupled sine wave, V_{DD} = 5.0 V	1.5	–	160	MHz
XIN rms input amplitude	V_{I1}	Capacitively coupled sine wave	100	–	800	mV
PIA and PIB rms input amplitude	V_{I2}	Capacitively coupled sine wave	70	–	800	mV
Crystal oscillator frequency	f_{XTAL}	CI ≤ 50 Ω. See note 3.	4.0	10.24	13.0	MHz
XIN internal feedback resistor	R_{f1}	V_{DD} = 5.0 V	–	0.7	–	MΩ
PIA and PIB internal feedback resistor	R_{f2}	V_{DD} = 5.0 V	–	430	–	kΩ
TEST internal pull-down resistor	R_d	V_{DD} = 5.0 V	–	30	–	kΩ
XIN, PIA and PIB input capacitance	C_I		–	6.0	–	pF

Notes

1. Dual PLL, both PLLA and PLLB operating, SB = 0, f_{XTAL} = 10.24 MHz, V_{PIA} = V_{PIB} = 70 mV, all other inputs = 0 V, all outputs open
2. Standby mode, PLLB stopped, SB = 1, f_{XTAL} = 10.24 MHz, V_{PIA} = 70 mV, all other inputs = 0 V, all outputs open
3. CI is the crystal impedance. Contact Nihon Denpa Kogyo for further information.

Serial Data Input Timing



Parameter	Symbol	Conditions	Ratings		Unit
			min	max	
Data setup time	t_{SU}	10.24 MHz crystal	400	–	ns
		Other crystal frequencies	$4/f_{XTAL}$	–	
Data hold time	t_{HD}	10.24 MHz crystal	400	–	ns
		Other crystal frequencies	$4/f_{XTAL}$	–	
LOW-level chip enable time	t_{EL}	10.24 MHz crystal	400	–	ns
		Other crystal frequencies	$4/f_{XTAL}$	–	
Chip enable setup time	t_{ES}	10.24 MHz crystal	400	–	ns
		Other crystal frequencies	$4/f_{XTAL}$	–	
Chip enable hold time	t_{EH}	10.24 MHz crystal	400	–	ns
		Other crystal frequencies	$4/f_{XTAL}$	–	
LOW-level clock pulsewidth	t_{CL}	10.24 MHz crystal	400	–	ns
		Other crystal frequencies	$4/f_{XTAL}$	–	
HIGH-level clock pulsewidth	t_{CH}	10.24 MHz crystal	400	–	ns
		Other crystal frequencies	$4/f_{XTAL}$	–	
Chip enable to data latch time	t_{LA}	10.24 MHz crystal	–	400	ns
		Other crystal frequencies	–	$4/f_{XTAL}$	

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Functional Description

PLLA and PLLB Programmable Dividers

PLLA and PLLB input frequency ranges are set by Mode 2 command bits FA and FB, respectively. Their divider ratios, N_A and N_B, are set by Mode 1 command bits DA0 to DA15 and DB0 to DB15, respectively.

Programmable Reference Divider

The divider ratio, N_R, is set by Mode 2 command bits R0 to R13. The reference fequency is given by $f_{XIN}/(2 \times N_R)$.

Phase Detector

The state of the phase-detector output as a function of the divider ratio and reference frequency is shown in table 1.

Table 1. Phase-detector output states

Condition	PDA1, PDB1
$f_i/N > f_{ref}$	HIGH
$f_i/N < f_{ref}$	LOW
$f_i/N = f_{ref}$	HIGH impedance

Note
N = N_A for PLLA, and N_B for PLLB

When PLLA is unlocked, $\overline{LDA}$ is pulled LOW and both PDA1 and PDA2 are active. PLLB operates identically to PLLA. Mode 2 command bits UL0 and UL1 set the unlock phase-error threshold, and bits UE0 and UE1, the $\overline{LDA}$ and $\overline{LDB}$ output extension.

Dual Charge Pump

A typical dual charge-pump configuration is shown in figure 1. The phase-detector secondary output is active after a change in frequency, and the phase error causes the PLL to unlock. In this case, the load resistance R1 becomes R1M||R1S, decreasing the LPF time constant and the time required to lock the PLL.

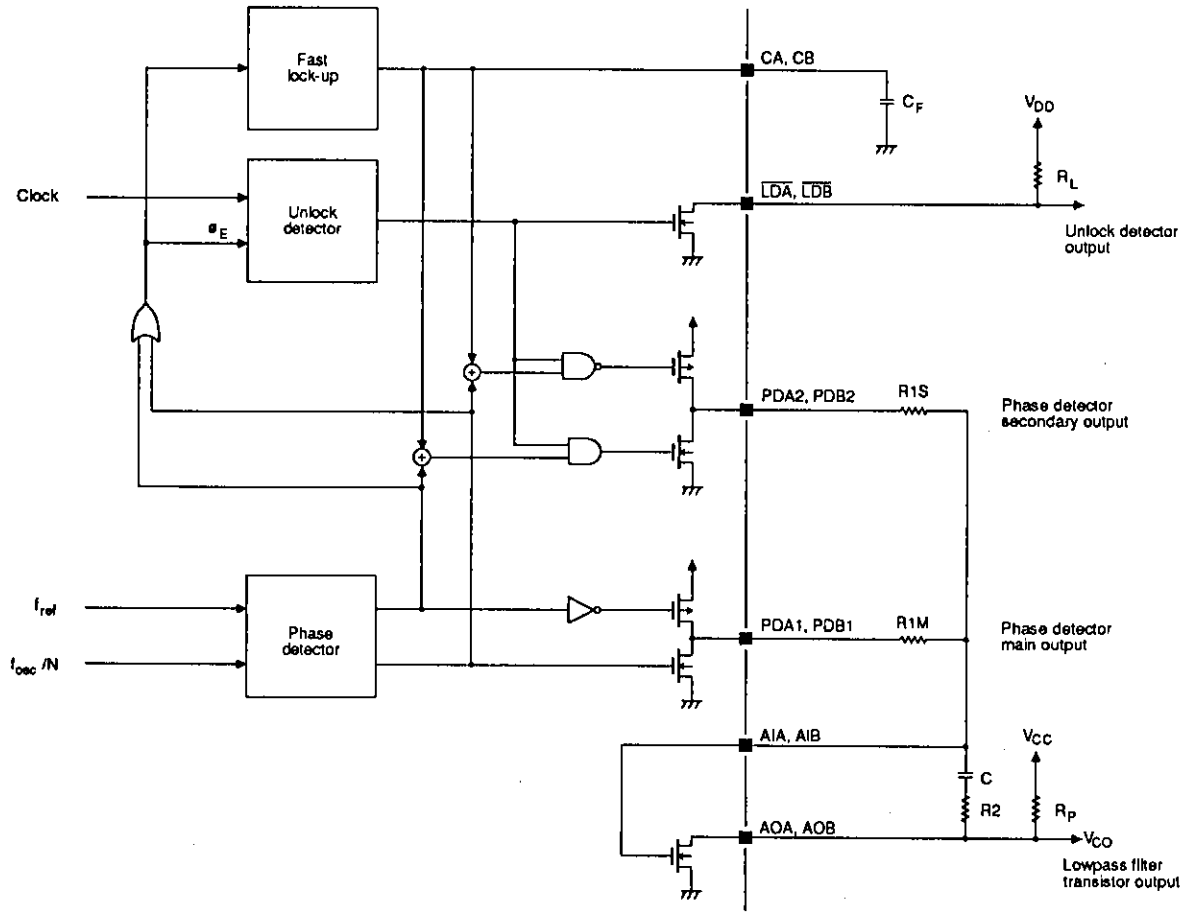


Figure 1. Dual charge-pump circuit

The phase-detector secondary output is high impedance when the PLL is locked. In this case, R1 becomes R1M, increasing the LPF time constant and improving sideband and modulation response.

Test Mode

TEST should be LOW or open for normal operation.

Serial Input Data

Serial data should be input only after f_{XIN} has become stable.

Mode 1 command format and functions

The Mode 1 command comprises the data bits which determine the PLLA and PLLB programmable divider ratios. The command format is shown in figure 2. Bits DA0 to DA15 and DB0 to DB15 determine the PLLA and PLLB programmable divider ratios, respectively. Bit DA0 is the first bit received. The range of allowable divider ratios is N = 256 (0100H) to 65535 (FFFFH).

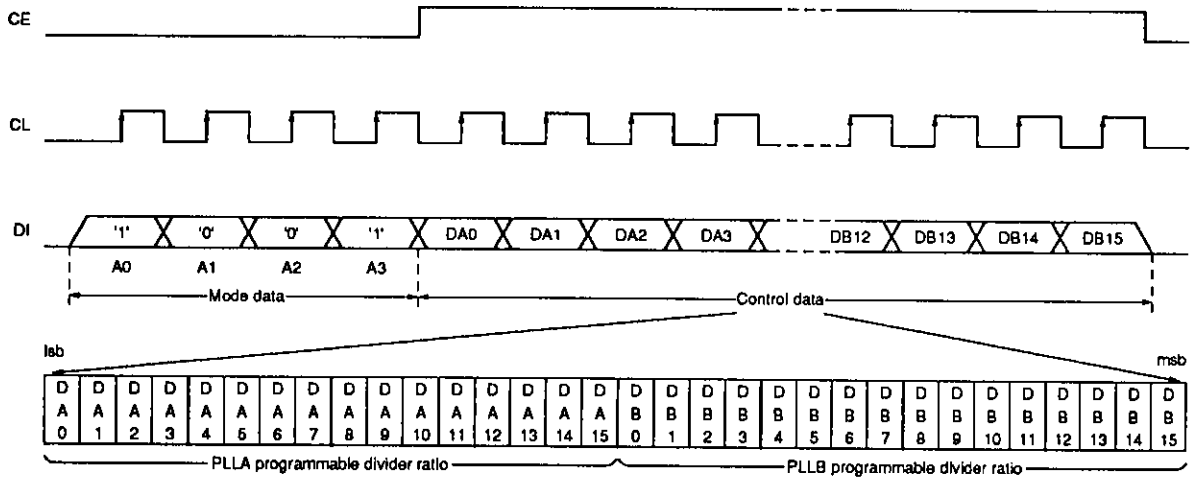


Figure 2. Mode 1 command (programmable divider data)

Mode 2 command format and functions

The Mode 2 command comprises the data bits which determine the reference frequency divider ratio and control functions. The command format is shown in figure 3. Bit R0 is the first bit received.

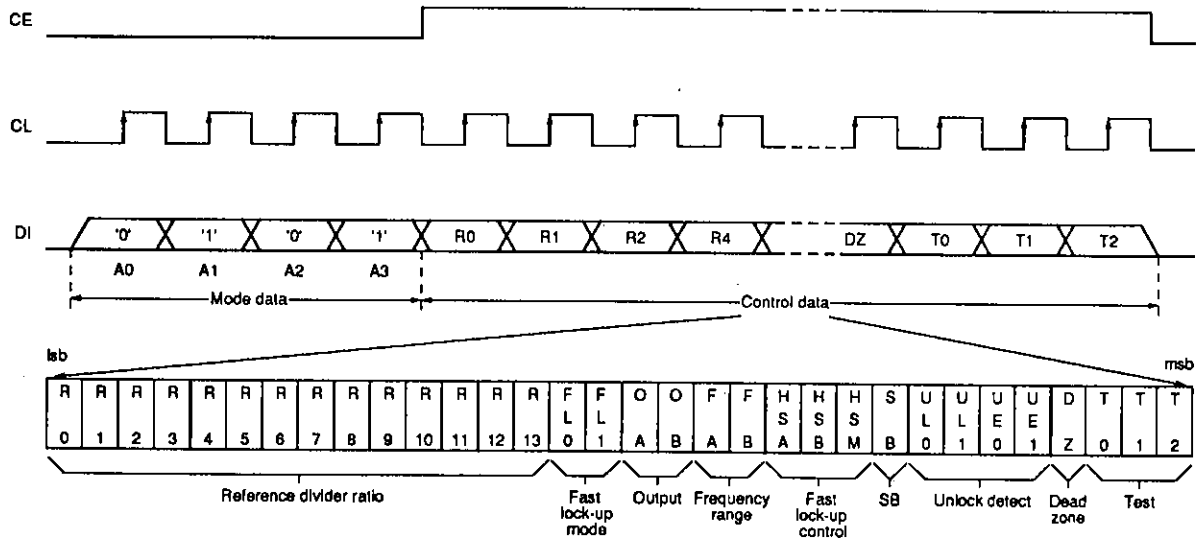


Figure 3. Mode 2 command (reference divider and control data)

Bits R0 to R13 determine the reference divider ratio. The range of allowable divider ratios is N_R = 8 (0008H) to 16383 (3FFFH).

Bits FL0 and FL1 are the fast lock-up mode select bits. The fast lock-up modes are shown in table 2. The higher the mode number, the greater the expansion width of the detected phase error signal.

Table 2. Fast lock-up mode

FL0	FL1	Fast lock-up mode
0	0	0
1	0	1
0	1	2
1	1	3

Bits OA and OB are the uncommitted output control bits. They are latched and then inverted to control $\overline{OUTA}$ and $\overline{OUTB}$, respectively. If either bit is 1, the open-drain output is pulled LOW.

Bits FA and FB are the input frequency range select bits. The PIA and PIB frequency ranges, set by FA and FB, respectively, are shown in table 3.

Table 3. Frequency ranges

FA, FB	Input frequency range	Unit
0	1.5 to 40.0	MHz
1	35 to 160	MHz

Bits HSA, HSB and HSM are the fast lock-up control bits. When HSA or HSB = 1, the fast lock-up circuits for PLLA or PLLB, respectively, are ON. When HSA or HSB = 0, the respective circuits are OFF. For use with FM, the fast lock-up circuits should be OFF. HSM determines the fast lock-up operating mode. When HSM = 0, operating mode 0 is selected and the fast lock-up only operates when the PLLs are unlocked. When HSM = 1, operating mode 1 is selected and the fast lock-up operates normally, as shown in figure 4.

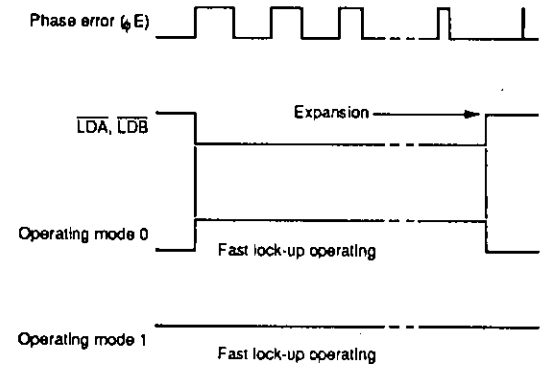


Figure 4. Fast lock-up operating modes

Bit SB is the standby mode control bit. When SB = 1, standby mode is selected. In standby mode, PLLB is stopped, PIB is pulled LOW, and PDB1 and PDB2 are high impedance. When SB = 0, normal operation is selected.

Bits UL0 and UL1 determine the unlock detection threshold. The PLL unlock detector output, $\overline{LDA}$ or $\overline{LDB}$, is pulled LOW when the phase differential between the reference and the divider inputs exceeds the threshold set by UL0 and UL1. The threshold for different crystal frequencies is shown in table 4, and the threshold for other frequencies can be calculated. The threshold is common to both PLLs. Note that a PLL will temporarily lose lock when either UL0 or UL1 is changed.

Table 4. Unlock detector thresholds

UL0	UL1	$\overline{LDA}$, $\overline{LDB}$ phase error threshold	Example phase error thresholds (μs)				
			f_{XIN} = 4 MHz	f_{XIN} = 7.2 MHz	f_{XIN} = 8 MHz	f_{XIN} = 10.24 MHz	f_{XIN} = 12.8 MHz
0	0	0	0	0	0	0	0
1	0	$\pm 4/f_{XIN}$	±1.00	±0.55	±0.50	±0.39	±0.31
0	1	$\pm 16/f_{XIN}$	±4.00	±2.22	±2.00	±1.56	±1.20
1	1	$\pm 64/f_{XIN}$	±16.00	±8.88	±8.00	±6.25	±5.00

Bits UE0 and UE1 determine the unlock extension, or delay, before the unlock detector outputs, $\overline{LDA}$ and $\overline{LDB}$, can change state. The extension for different reference frequencies is shown in table 5. However, if a phase-error threshold of zero is set using UL0 and UL1, no output extension occurs.

Table 5. $\overline{LDA}$, $\overline{LDB}$ output extension

UE0	UE1	$\overline{LDA}$, $\overline{LDB}$ output extension	Example output extensions (ms)		
			f_{ref} = 1 kHz	f_{ref} = 5 kHz	f_{ref} = 12.5 kHz
0	0	$4/f_{ref}$	4.0 (typ)	0.8	0.32
1	0	$8/f_{ref}$	8.0	1.6	0.64
0	1	$32/f_{ref}$	32.0	6.4 (typ)	2.56
1	1	$64/f_{ref}$	64.0	12.8	5.12 (typ)

Bit DZ is the dead-zone selection bit. It selects the phase-insensitive bandwidth, or dead zone, of the phase comparator. When DZ = 1, DZB mode is selected, and when DZ = 0, DZA mode. DZB mode has a larger dead zone than DZA mode.

Bits T0, T1 and T2 are test bits. They should be set to 0 for normal operation.

Typical Application

A LC7153 or LC7153M cordless telephone application circuit is shown in figure 5. The telephone is tuned to channel 1, which has a transmit VCO frequency of 46.610 MHz and a receive VCO frequency of 38.975 MHz.

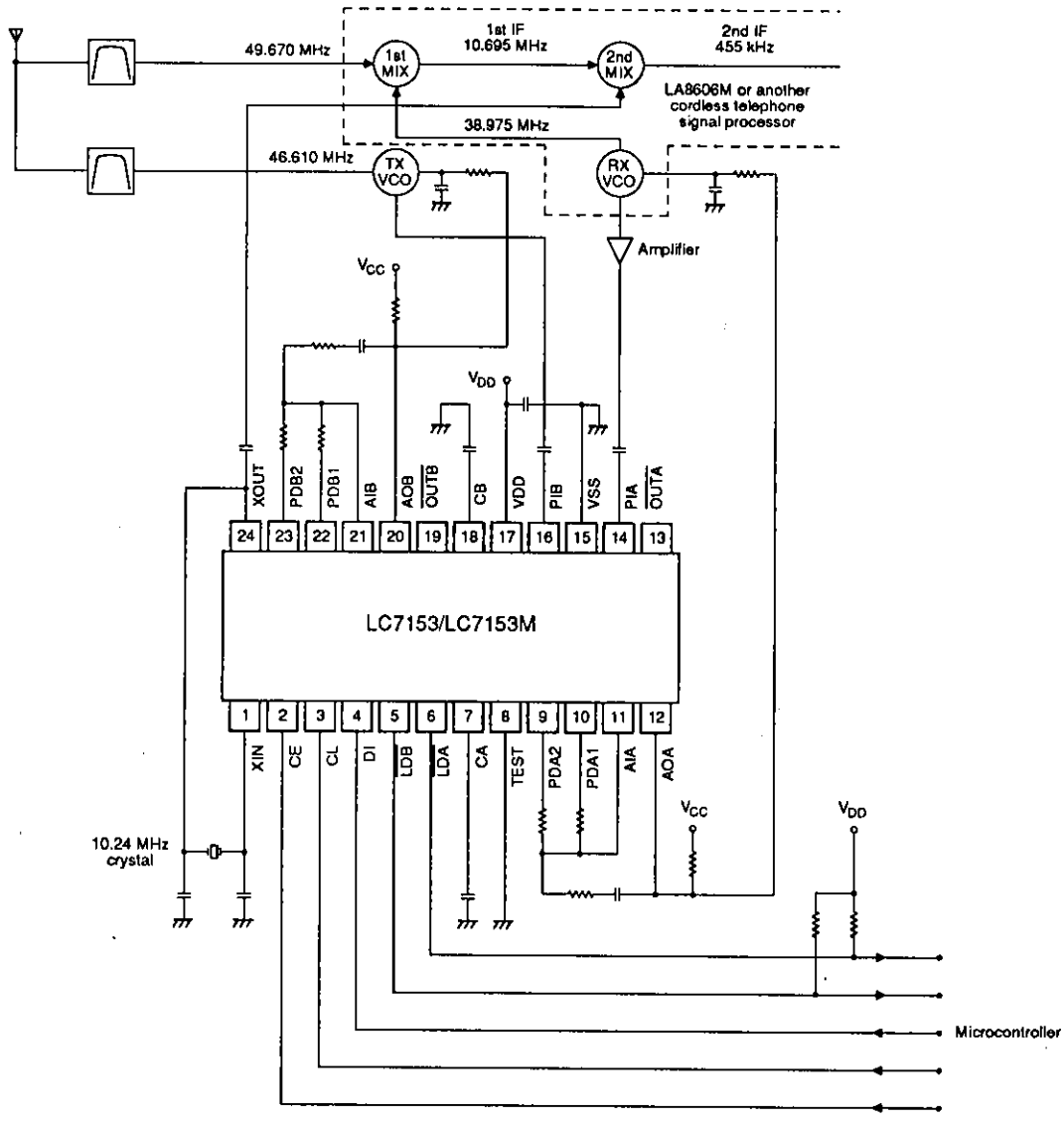


Figure 5. American 10-channel, 46/49 MHz, cordless telephone base station

For f_{ref} = 5 kHz, the divider ratios are as follows.

$$N_A = \frac{f_{IA}}{f_{ref}} = \frac{RX\ VCO}{f_{ref}} = \frac{38.975\ MHz}{5\ kHz} = 7795\ (1E73H)$$

$$N_B = \frac{f_{IB}}{f_{ref}} = \frac{TX\ VCO}{f_{ref}} = \frac{46.610\ MHz}{5\ kHz} = 9322\ (246AH)$$

$$N_R = \frac{f_{XIN}}{2 \times f_{ref}} = \frac{10.24\ MHz}{2 \times 5\ kHz} = 1024\ (400H)$$

The Mode 1 and Mode 2 commands are shown in tables 6 and 7, respectively, and in figures 6 and 7, respectively.

Table 6. Mode 1 command

Field	Value	Comment
DA0 to DA15	1E73H	PLLA divider ratio of 7795
DB0 to DB15	246AH	PLLB divider ratio of 9322

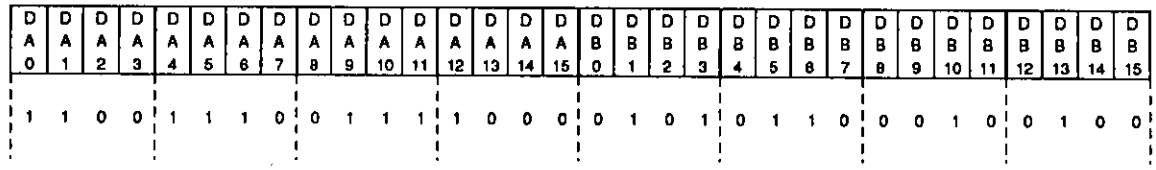


Figure 6. Mode 1 command

Table 7. Mode 2 command

Field	Value	Comment
R0 to R13	0400H	Reference divider ratio of 1024
FL0, FL1	00	Fast lock-up mode 0
OA	0	$\overline{OUTA}$ and $\overline{OUTB}$ left open.
OB	0	
FA	1	20 to 55 MHz RX VCO input frequency range
FB	1	20 to 55 MHz TX VCO input frequency range
HSA, HSB	00	PLLA and PLLB fast lock-up OFF
HSM	0	Fast lock-up operating mode 0
SB	0 or 1	Standby mode selection
UL0, UL1	11	±6.25 µs lock/unlock detection threshold
UE0, UE1	01	6.4 ms $\overline{LDA}$ and $\overline{LDB}$ output extension
DZ	1	DZB dead-zone mode
T0, T1, T2	000	Test mode deselected

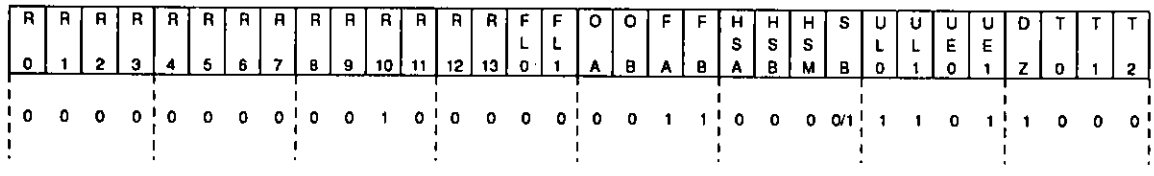


Figure 7. Mode 2 command