



LC72151V

PLL Frequency Synthesizer for Electronic Tuning in Car Audio Systems



Overview

The LC72151V is a PLL frequency synthesizer for car audio systems. It can implement high-performance multifunction tuners such as RDS tuners and features a fast locking circuit.

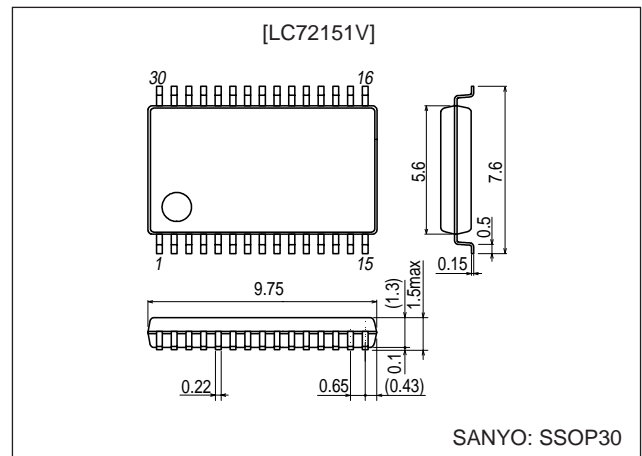
Functions

- High-speed programmable divider
 - FMIN: 10 to 160 MHz: Pulse swallower type
 - AMIN: 2 to 40 MHz: Pulse swallower type
 - 0.5 to 10 MHz: Direct division type
- IF counter
 - HCTR: 0.4 to 25 MHz: for FM IF count
 - LCTR: 10 to 500 kHz: for AM IF count
 - 1.0 to 20×10^3 Hz: for frequency measurement
- Reference frequency
 - One of 11 frequencies may be selected (when a 10.25 or 10.35 MHz crystal is used)
 - 50, 30°, 25, 12.5, 10, 9°, 6.25, 5, 3.125, 3°, 1 kHz
 - Note: Cannot be used when a 10.25 MHz crystal is used
- Phase comparator
 - Supports dead band control
 - Built-in unlock detection circuit
 - Built-in deadlock clearing circuit
- Built-in amplifier for forming an active low-pass filter
 - Built-in operational amplifier for FM high-speed locking
 - Built-in MOS transistor for AM tuning
- Built-in crystal oscillator output buffer
- I/O ports — General-purpose I/O: 2 pins
 - Four input ports (maximum)
 - Three output ports (maximum)
- Serial data I/O
 - Supports communication with the controller in the CCB format.
- Operating ranges
 - Supply voltage: 4.5 to 5.5 V (V_{DD})
 - 7.5 to 9.5 V (AV_{DD})
 - Operating temperature: -40 to +85°C
- Package
 - SSOP30

Package Dimensions

unit: mm

3191A-SSOP30



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- CCB is SANYO's original bus format and all the bus addresses are controlled by SANYO.

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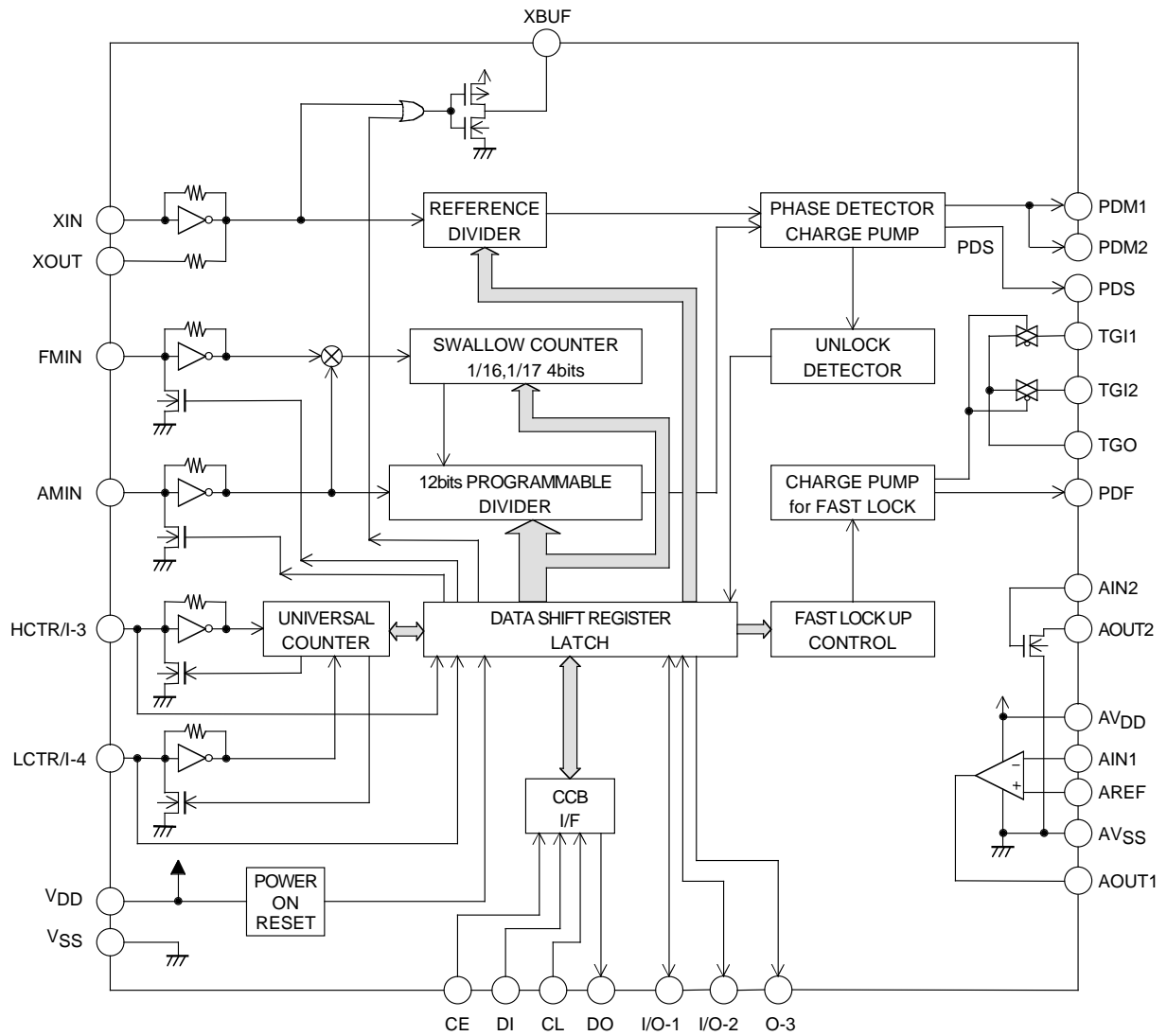
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Block Diagram



LC72151V

Specifications

Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$, $V_{SS} = AV_{SS} = 0\text{ V}$

| Parameter | Symbol | Pin | Ratings | Unit |
|-----------------------------|---------------|--|------------------------|------------------|
| Supply voltage | V_{DD} max | V_{DD}^* | -0.3 to +6.5 | V |
| | | AV_{DD}^* | -0.3 to +11.0 | |
| Maximum input voltage | V_{IN1} max | CE, CL, DI | -0.3 to +7.0 | V |
| | V_{IN2} max | XIN, FMIN, AMIN, HCTR/I-3, LCTR/I-4, AIN2, TGI1, TGI2, TGO | -0.3 to $V_{DD} + 0.3$ | |
| | V_{IN3} max | I/O-1, I/O-2 | -0.3 to +15.0 | |
| | V_{IN4} max | AIN1, AREF | -0.3 to +6.5 | |
| Maximum output voltage | V_{O1} max | DO | -0.3 to +7.0 | V |
| | V_{O2} max | XOUT, PDM1, PDM2, PDS, PDF, XBUF, TGI1, TGI2, TGO | -0.3 to $V_{DD} + 0.3$ | |
| | V_{O3} max | I/O-1, I/O-2, O-3, AOUT2 | -0.3 to +15.0 | |
| | V_{O4} max | AOUT1 | -0.3 to +11.0 | |
| Maximum output current | I_{O1} max | I/O-1, I/O-2, O-3 | 0 to 10.0 | mA |
| | I_{O2} max | DO, TGI1, TGI2, TGO, AOUT1, AOUT2 | 0 to 5.0 | |
| | I_{O3} max | XBUF | 0 to 3.0 | |
| Allowable power dissipation | P_d max | ($T_a \leq 85^\circ\text{C}$) | SSOP30 :160 | mW |
| Operating temperature | T_{opr} | | -40 to +85 | $^\circ\text{C}$ |
| Storage temperature | T_{stg} | | -55 to +125 | $^\circ\text{C}$ |

Note: Power must be applied to AV_{DD} before applying to V_{DD} and AV_{DD} must be higher than or equal to V_{DD} .

Capacitors of at least 0.1 μF must be inserted between the V_{DD} and V_{SS} , and between the AV_{DD} and AV_{SS} power supply pins.

Allowable Operating Ranges at $T_a = -40$ to 85°C , $V_{SS} = AV_{SS} = 0\text{ V}$

| Parameter | Symbol | Pin | Conditions | Ratings | | | Unit |
|--------------------------|-----------|------------------------------------|-------------------------------|-------------|-----|------------------|------|
| | | | | min | typ | max | |
| Supply voltage | V_{DD1} | V_{DD} | $V_{DD} \leq AV_{DD}$ | 4.5 | | 5.5 | V |
| | V_{DD2} | AV_{DD} | $V_{DD} \leq AV_{DD}$ | 7.5 | 8.5 | 9.5 | |
| | V_{DD3} | V_{DD} | Serial data retention voltage | 2.0 | | | |
| High-level input voltage | V_{IH1} | CE, CL, DI | | $0.7V_{DD}$ | | 6.5 | V |
| | V_{IH2} | I/O-1, I/O-2 | | $0.7V_{DD}$ | | 13 | |
| | V_{IH3} | HCTR/I-3, LCTR/I-4 | | $0.7V_{DD}$ | | V_{DD} | |
| Low-level input voltage | V_{IL1} | CE, CL, DI, I/O-1, I/O-2, LCTR/I-4 | | 0 | | $0.3V_{DD}$ | V |
| | V_{IL2} | HCTR/I-3 | | 0 | | $0.2V_{DD}$ | |
| Output voltage | V_{O1} | DO | | 0 | | 6.5 | V |
| | V_{O2} | AOUT1 | | 0 | | 9.5 | |
| | V_{O3} | I/O-1, I/O-2, O-3, AOUT2 | | 0 | | 13 | |
| Input frequency | f_{IN1} | XIN | V_{IN1}^{*1} | 7 | | 11 | MHz |
| | f_{IN2} | FMIN | V_{IN2}^{*1} | 10 | | 160 | |
| | f_{IN3} | AMIN (SNS=1) | V_{IN3}^{*1} | 2 | | 40 | |
| | f_{IN4} | AMIN (SNS=0) | V_{IN4}^{*1} | 0.5 | | 10 | |
| | f_{IN5} | HCTR/I-3 | V_{IN5}^{*1} | 0.4 | | 25 | |
| | f_{IN6} | LCTR/I-4 | V_{IN6}^{*1} | 10 | | 500 | kHz |
| | f_{IN7} | LCTR/I-4 | V_{IN7}^{*2} | 1.0 | | 20×10^3 | Hz |

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| Parameter | Symbol | Pin | Conditions | Ratings | | | Unit |
|--|--------------------|-----------------------|-----------------------|---------|------|-------|-------|
| | | | | min | typ | max | |
| Input amplitude | V _{IN1} | XIN | f _{IN1} | 200 | | 1500 | mVrms |
| | V _{IN2-1} | FMIN | f = 10 to 50 MHz | 40 | | 1500 | |
| | V _{IN2-2} | FMIN | f = 50 to 130 MHz | 20 | | 1500 | |
| | V _{IN2-3} | FMIN | f = 130 to 160 MHz | 40 | | 1500 | |
| | V _{IN3} | AMIN (SNS=1) | f _{IN3} | 40 | | 1500 | |
| | V _{IN4} | AMIN (SNS=0) | f _{IN4} | 40 | | 1500 | |
| | V _{IN5-1} | HCTR/I-3 | f = 0.4 to 25 MHz *3 | 40 | | 1500 | |
| | V _{IN5-2} | HCTR/I-3 | f = 8 to 12 MHz *4 | 70 | | 1500 | |
| | V _{IN6-1} | LCTR/I-4 | f = 10 to 400 kHz *3 | 40 | | 1500 | |
| | V _{IN6-2} | LCTR/I-4 | f = 400 to 500 kHz *3 | 20 | | 1500 | |
| V _{IN6-3} | LCTR/I-4 | f = 400 to 500 kHz *4 | 70 | | 1500 | | |
| Guaranteed crystal oscillator frequency ranges | X'tal | XIN, XOUT | *5 | 10.25 | | 10.35 | MHz |

Notes: 1. Sine wave with capacitor coupled.

2. Pulse wave with DC coupled.

3. Serial data: CTC = 0

4. Serial data: CTC = 1

5. Recommended CI value for the crystal oscillator: CI ≤ 70 Ω

The circuit constants for the crystal oscillator circuit depend on the crystal used, the printed circuit board pattern, and other items.

Therefore we recommend consulting with the manufacturer of the crystal for evaluation and reliability.

Electrical Characteristics in the Allowable Operating Ranges

| Parameter | Symbol | Pin | Conditions | Ratings | | | Unit | |
|-------------------------------|------------------|-------------------------------------|----------------------------------|------------------------|---------------------|-----|------|----|
| | | | | min | typ | max | | |
| Internal feedback resistance | Rf1 | XIN | | | 1 | | MΩ | |
| | Rf2 | FMIN | | | 500 | | kΩ | |
| | Rf3 | AMIN | | | 500 | | | |
| | Rf4 | HCTR/I-3 | | | 500 | | | |
| | Rf5 | LCTR/I-4 | | | 500 | | | |
| Internal pull-down resistance | Rpd1 | FMIN | | 50 | 100 | 300 | kΩ | |
| | Rpd2 | AMIN | | 50 | 100 | 300 | | |
| Hysteresis | V _{HIS} | CE, CL, DI, LCTR/I-4 | | | 0.1 V _{DD} | | V | |
| High-level output voltage | V _{OH1} | PDM1, PDM2, PDS, PDF | I _O = -1 mA | V _{DD} - 1.0 | | | V | |
| | V _{OH2} | AOUT1 | I _O = -2 mA | V _{DD} - 2.0 | | | | |
| | V _{OH3} | XBUF | I _O = -0.5 mA | AV _{DD} - 1.0 | | | | |
| Low-level output voltage | V _{OL1} | PDM1, PDM2, PDS, PDF | I _O = 1 mA | | | 1.0 | V | |
| | | | I _O = 2 mA | | | 2.0 | | |
| | V _{OL2} | AOUT1 | I _O = 1 mA | | | 1.0 | | |
| | V _{OL3} | XBUF | I _O = 0.5 mA | | | 1.5 | | |
| | | | I _O = 1 mA | | | 0.2 | | |
| | V _{OL4} | I/O-1, I/O-2, O-3 | I _O = 5 mA | | | 1.0 | | |
| | | | I _O = 8 mA | | | 1.6 | | |
| V _{OL5} | DO | I _O = 1 mA | | | 0.2 | | | |
| V _{OL6} | AOUT2 | I _O = 5 mA | | | 1.0 | | | |
| V _{OL7} | | I _O = 1 mA, AIN2 = 1.3 V | | | 0.5 | | | |
| High-level input current | I _{IH1} | CE, CL, DI | V _I = 6.5 V | | | 5.0 | μA | |
| | I _{IH2} | I/O-1, I/O-2 | V _I = 13 V | | | 5.0 | | |
| | I _{IH3} | HCTR/I-3, LCTR/I-4 | V _I = V _{DD} | | | 5.0 | | |
| | I _{IH4} | XIN | V _I = V _{DD} | 0.11 | | 0.9 | | |
| | I _{IH5} | FMIN, AMIN, HCTR/I-3, LCTR/I-4 | V _I = V _{DD} | 1.8 | | 15 | | |
| | I _{IH6} | AIN1, AREF | V _I = 5.5 V | | 0.01 | 100 | | nA |
| | I _{IH7} | TGI1, TGI2, TGO | V _I = V _{DD} | | | 3.0 | | μA |

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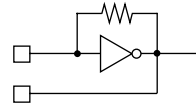
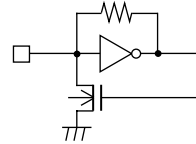
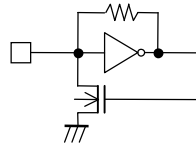
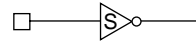
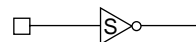
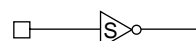
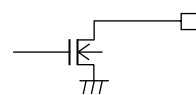


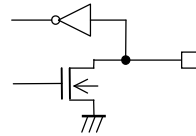
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| Parameter | Symbol | Pin | Conditions | Ratings | | | Unit |
|--|-------------------|--------------------------------|--|---------|------|-----|------|
| | | | | min | typ | max | |
| Low-level input current | I _{IL1} | CE, CL, DI | V _I = 0 V | | | 5.0 | μA |
| | I _{IL2} | I/O-1, I/O-2 | V _I = 0 V | | | 5.0 | |
| | I _{IL3} | HCTR/I-3, LCTR/I-4 | V _I = 0 V | | | 5.0 | |
| | I _{IL4} | XIN | V _I = 0 V | 0.11 | | 0.9 | |
| | I _{IL5} | FMIN, AMIN, HCTR/I-3, LCTR/I-4 | V _I = 0 V | 1.8 | | 15 | |
| | I _{IL6} | AIN1, AREF | V _I = 0 V | | 0.01 | 100 | nA |
| | I _{IL7} | TGI1, TGI2, TGO | V _I = 0 V | | | 3.0 | μA |
| Analog switch on resistance | R _{ON} | TGI1, TGI2, TGO | V _{IN} = 8.5 V, I = ±3 mA, AV _{DD} = 8.5 V | | 70 | 140 | Ω |
| | | | V _{IN} = 4.5 V, I = ±3 mA, AV _{DD} = 8.5 V | | 50 | 100 | |
| | | | V _{IN} = 0.5 V, I = ±3 mA, AV _{DD} = 8.5 V | | 70 | 140 | |
| Output off leakage current | I _{OFF1} | AOUT1 | V _O = 6.5 V | | | 5.0 | μA |
| | I _{OFF2} | I/O-1, I/O-2, O-3, AOUT2 | V _O = 13 V | | | 5.0 | |
| | I _{OFF3} | DO | V _O = 6.5 V | | | 5.0 | |
| High-level 3-state off leakage current | I _{OFFH} | PDM1, PDM2, PDS, PDF | V _O = V _{DD} | | 0.01 | 200 | nA |
| Low-level 3-state off leakage current | I _{OFFL} | PDM1, PDM2, PDS, PDF | V _O = 0 V | | 0.01 | 200 | nA |
| Input capacitance | C _{IN} | FMIN | | | 6 | | pF |
| Supply current | I _{DD1} | V _{DD} | X'tal = 10.35 MHz f _{IN2} = 160 MHz V _{IN2} = 40 mVrms | | 10 | 18 | mA |
| | I _{DD2} | V _{DD} | PLL block stopped (PLL INHIBIT) X'tal OSC operating (X'tal = 10.35 MHz) | | 0.5 | 1.5 | |
| | I _{DD3} | AV _{DD} | PLL block stopped (PLL INHIBIT) X'tal OSC stopped On-chip op-amp stopped | | | 1.5 | |
| | I _{DD4} | V _{DD} | PLL block stopped (PLL INHIBIT) X'tal OSC stopped On-chip op-amp stopped | | | 10 | μA |

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Pin Functions

| Pin No. | Symbol | Usage | Function | Pin circuit |
|---------|-----------------|-------------------------------|---|---|
| 30 1 | XIN XOUT | X'tal OSC | <ul style="list-style-type: none"> Crystal oscillator connection. (10.25 or 10.35 MHz) |  |
| 8 | FMIN | Local oscillator signal input | <ul style="list-style-type: none"> FMIN is selected by setting DVS in the control data to 1. Enters high-speed locking mode by setting SNS in the control data to 1. Enters normal mode by setting SNS in the control data to 0. Input frequency: 10 to 160 MHz The signal is transmitted to the swallow counter. The divisor can be set to a value in the range 272 to 65,535. |  |
| 9 | AMIN | Local oscillator signal input | <ul style="list-style-type: none"> AMIN is selected by setting DVS in the control data to 0. When SNS in the control data is set to 1: Input frequency: 2 to 40 MHz The signal is directly transmitted to the swallow counter. When SNS in the control data is set to 0: Input frequency: 0.5 to 10 MHz The signal is directly transmitted to the 12-bit programmable divider. The divisor can be set to a value in the range 5 to 4,095. |  |
| 29 | CE | Chip enable | <ul style="list-style-type: none"> This pin must be set to the high level when inputting serial data to the LC72151V DI pin and when outputting serial data from the DO pin. |  |
| 28 | DI | Input data | <ul style="list-style-type: none"> Serial data input for transferring data from the controller to the LC72151V. |  |
| 27 | CL | Clock | <ul style="list-style-type: none"> Data synchronization clock signal used when inputting serial data to the LC72151V DI pin and when outputting serial data from the DO pin. |  |
| 26 | DO | Output data | <ul style="list-style-type: none"> Serial data output for transferring data from the LC72151V to the controller. |  |
| 6 | V _{DD} | Power | <ul style="list-style-type: none"> LC72151V power supply. A voltage in the range 4.5 to 5.5 V must be provided when the PLL circuit is operating. The power-on reset circuit operates when power is first applied. <p>Note: Power must be applied to AV_{DD} before applied to V_{DD} and AV_{DD} must be higher than or equal to V_{DD}.</p> |  |
| 7 | V _{SS} | Ground | <ul style="list-style-type: none"> LC72151V ground. |  |
| 2 3 | I/O-1 I/O-2 | I/O ports | <ul style="list-style-type: none"> Input/output dual function pins The function will be selected according to IOC1 and IOC2 in the control data. Data = 0: Input port 1: Output port When specified as an input port: The input pin state is transmitted to the system microcontroller from DO pin. Input state = Low: data is 0 = High: data is 1. When specified as an output port: The output state will be determined according to I/O-1 and I/O-2 in the control data. Data = 0: Low = 1: Open These pin function as an input port at a power-on reset. |  |

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| Pin No. | Symbol | Usage | Function | Pin circuit |
|----------------------------|---------------------------------------|---|---|-------------|
| 5 | O-3 | Output port | <ul style="list-style-type: none"> Dedicated output pin Latches OUT3 in the control data and outputs data from O-3 pin. This pin goes open state at a power-on reset. | |
| 19 12 13 14 15 | AIN1 AREF AVDD AVSS AOUT1 | Op-amp for low-pass filter amp | <ul style="list-style-type: none"> Op-amp for PLL active low-pass filter AVSS is the analog system ground pin shared with low-pass filter Nch MOS transistor. Voltage applied to AREF pin must be 1/2 that to VDD pin. <p>Note: Power must be applied to AVDD before applied to VDD, and AVDD must be higher than or equal to VDD.</p> | |
| 24 25 | AIN2 AOUT2 | Transistor for low-pass filter amp | <ul style="list-style-type: none"> PLL active low-pass filter Nch MOS transistor Source of the transistor is connected to AVSS pin. <p>Note: Connect AVSS pin to ground in use.</p> | |
| 21 23 20 | PDM1 PDM2 PDS | Charge pump output | <ul style="list-style-type: none"> PLL charge pump output <p>When the frequency created by dividing the local oscillator signal frequency by N is higher than the reference frequency, a high level is output from the PD pin. When lower, a low level is output. The PD pin goes to the high-impedance state when the frequencies match.</p> | |
| 22 | PDF | PLL high-speed locking charge pump output | <ul style="list-style-type: none"> PLL high-speed locking charge pump output <p>When the high-speed locking mode is selected, signal pulses is output according to the frequency variation. This pin enters high-impedance state when the local oscillation frequency enters the set frequency range.</p> | |
| 18 17 16 | TGI1 TGI2 TGO | PLL high-speed locking TG | <ul style="list-style-type: none"> PLL high-speed locking active low-pass filter transmission gate input/output dual function pins <p>Note: Connect AVSS pin to ground in use.</p> | |
| 10 | HCTR/I-3 | General-purpose counter | <ul style="list-style-type: none"> HCTR is selected by setting CTS1 in the control data to 1. Input frequency: 0.4 to 25 MHz The signal is input to a divide-by-2 circuit and the result is input to a general-purpose counter. This counter can also be used as an integrating counter. The counter value is output as the result of the count, MSB first, from the DO pin. There are four measurement periods: 4, 8, 32, and 64 ms. When H/I-3 in the control data is set, this pin functions as an input port, and the value is output from the output pin DO. | |
| 11 | LCTR/I-4 | General-purpose counter | <ul style="list-style-type: none"> LCTR is selected by setting CTS1 in the control data to 1. When the LCTR is selected as described above and CTS0 is set to 1: This pin enters the frequency measurement mode. Input frequency: 10 to 500 kHz. The signal is directly transmitted to the general-purpose counter. When CTS0 is set to 0 This pin enters period measurement mode. Input frequency: 1 Hz to 20 kHz. Period can be measured either in single period or in double period. If double period measurement is selected, the frequency is 2 Hz to 40 kHz. The counter value is output as the result of the count, MSB first, from the DO pin. When L/I-4 in the control data is set: This pin functions as an input port, the value is output from the output pin DO. | |

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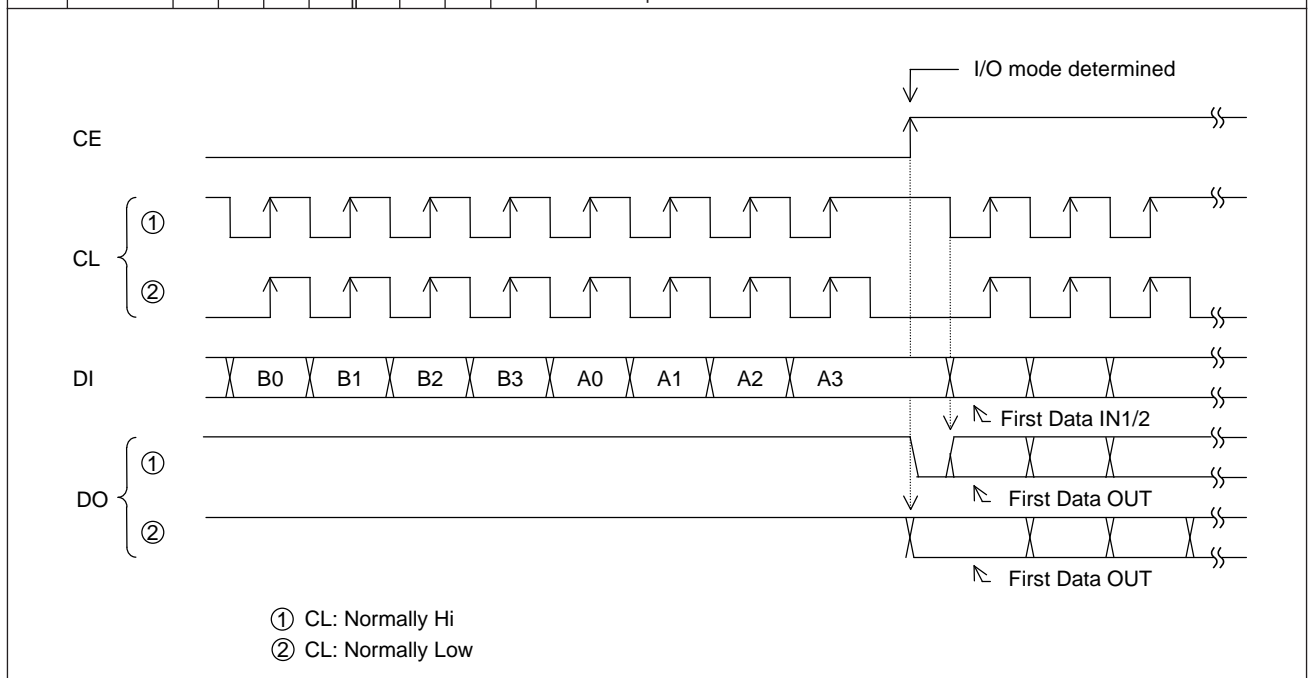
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| Pin No. | Symbol | Usage | Function | Pin circuit |
|---------|--------|---------------------------|---|-------------|
| 4 | XBUF | Crystal oscillator buffer | <ul style="list-style-type: none"> Output buffer for the crystal oscillator circuit When XB in the serial data is set to 1, the output buffer operates and the crystal oscillator signal (a pulse signal) is output. When XB is 0, XBUF outputs a low level. After the power-on reset, the output buffer is fixed at the low level. | |

Serial Data I/O Methods

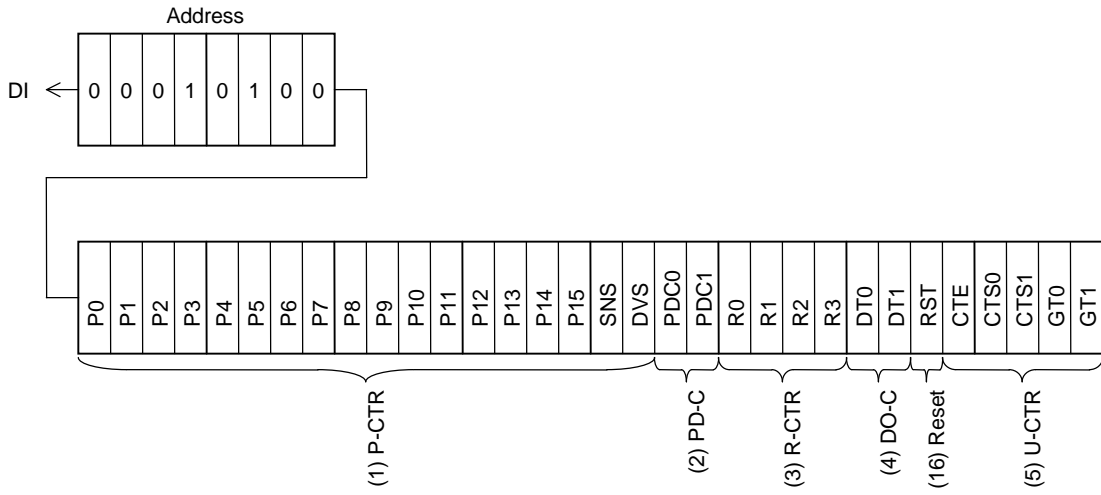
Data is input to and output from the LC72151V using the Sanyo CCB (Computer Control Bus) format, which is the serial bus format used by SANYO audio ICs. This IC adopts a CCB format with an 8-bit address.

| | I/O mode | Address | | | | | | | | Content |
|-----|----------|---------|----|----|----|----|----|----|----|--|
| | | B0 | B1 | B2 | B3 | A0 | A1 | A2 | A3 | |
| [1] | IN1 (82) | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | <ul style="list-style-type: none"> Control data input (serial input) mode. 32 bits of data are input. See the "DI Control Data (Serial Data Input) Structure" item for details on the content of the input data. |
| [2] | IN2 (92) | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | <ul style="list-style-type: none"> Control data input (serial input) mode. 32 bits of data are input. See the "DI Control Data (Serial Data Input) Structure" item for details on the content of the input data. |
| [3] | OUT (A2) | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | <ul style="list-style-type: none"> Data output (serial data output) mode. The number of bits output is equal to the number of clock cycles. See the "DO Output Data (Serial Data Output) Structure" item for details on the content of the output data. |

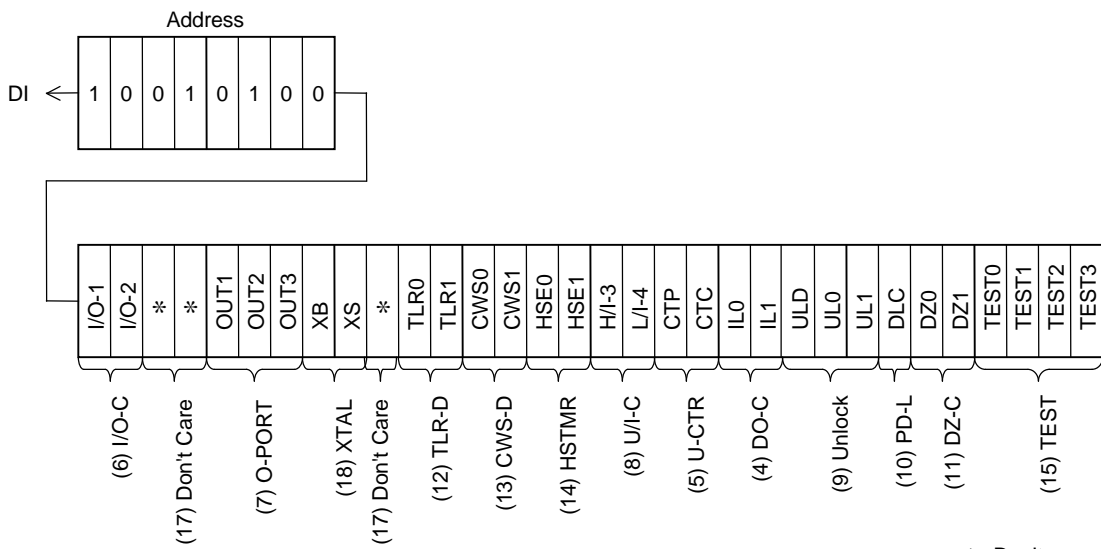


DI control data (serial data input) structure

(1) IN1 mode



(2) IN2 mode



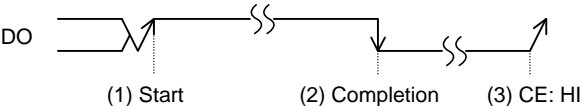
DI control data description

| No. | Control block/data | Content | Related data | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------|--|--|---------------------------------|------------------------------|-----------------------|-----------------|---------------------------|----------------|----|--------------|--------------------------------------|----|----|---|--------------|---|----|--------------|---|---|----|-----------|-----|-----|-----------|---------------------------|----|---|------|---------------------------------|---|------|------|-----------------------------|---|---|------|-------------|---|---|------|---------------|---|---|---|---|-------|---|---|---|---|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|----|---|---|---|---|------------------------------|---|---|---|---|-------------|--|
| (1) | Programmable divider data P0 to P15 DVS, SNS | <ul style="list-style-type: none"> This data sets the divisor for the programmable divider and P15 is the MSB of this binary value. LSB will change according to the DVS and SNS. <table border="1"> <thead> <tr> <th>DVS</th> <th>SNS</th> <th>LSB</th> <th>Set divisor (N)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>P0</td> <td>272 to 65535</td> </tr> <tr> <td>1</td> <td>0</td> <td>P0</td> <td>272 to 65535</td> </tr> <tr> <td>0</td> <td>1</td> <td>P0</td> <td>272 to 65535</td> </tr> <tr> <td>0</td> <td>0</td> <td>P4</td> <td>4 to 4095</td> </tr> </tbody> </table> <p>*: When the LSB is P4, P0 to P3 are invalid.</p> <ul style="list-style-type: none"> Used to select programmable divider signal input pins (FMIN, AMIN) and to switch the input frequency range. <table border="1"> <thead> <tr> <th>DVS</th> <th>SNS</th> <th>Input pin</th> <th>Input pin frequency range</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>FMIN</td> <td>10 to 160 MHz (High-speed mode)</td> </tr> <tr> <td>1</td> <td>0</td> <td>FMIN</td> <td>10 to 160 MHz (Normal mode)</td> </tr> <tr> <td>0</td> <td>1</td> <td>AMIN</td> <td>2 to 40 MHz</td> </tr> <tr> <td>0</td> <td>0</td> <td>AMIN</td> <td>0.5 to 10 MHz</td> </tr> </tbody> </table> <p>*: When the DVS and SNS are set to 1, the high-speed locking mode is selected, the high-speed control data becomes valid. By setting DVS to 1 and SNS to 0 this pin enters FMIN mode, the sub-charge pump control data is valid, the high-speed locking control data becomes invalid.</p> | DVS | SNS | LSB | Set divisor (N) | 1 | 1 | P0 | 272 to 65535 | 1 | 0 | P0 | 272 to 65535 | 0 | 1 | P0 | 272 to 65535 | 0 | 0 | P4 | 4 to 4095 | DVS | SNS | Input pin | Input pin frequency range | 1 | 1 | FMIN | 10 to 160 MHz (High-speed mode) | 1 | 0 | FMIN | 10 to 160 MHz (Normal mode) | 0 | 1 | AMIN | 2 to 40 MHz | 0 | 0 | AMIN | 0.5 to 10 MHz | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DVS | SNS | LSB | Set divisor (N) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | P0 | 272 to 65535 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | P0 | 272 to 65535 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | P0 | 272 to 65535 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | P4 | 4 to 4095 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DVS | SNS | Input pin | Input pin frequency range | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | FMIN | 10 to 160 MHz (High-speed mode) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | FMIN | 10 to 160 MHz (Normal mode) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | AMIN | 2 to 40 MHz | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | AMIN | 0.5 to 10 MHz | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (2) | Sub-charge pump control data PDC0, PDC1 | <ul style="list-style-type: none"> This data controls the sub-charge pump. <table border="1"> <thead> <tr> <th>PDC1</th> <th>PDC0</th> <th>Sub-charge pump state</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>*</td> <td>High impedance</td> </tr> <tr> <td>1</td> <td>1</td> <td>Charge pump operating (at all times)</td> </tr> <tr> <td>1</td> <td>0</td> <td>Charge pump operating (when PLL unlocked)</td> </tr> </tbody> </table> <p>(* : don't care)</p> <ul style="list-style-type: none"> The sub-charge pump can be used in conjunction with the PDM1 or the PDM2 pin (main charge pump pin) to form a high-speed locking circuit. <p>*: FMIN(High-speed mode): Setting DVS and SNS to 1 forces the sub-charge pump to operate for the time set due to the high-speed locking end flag output wait time, and allows the locking time to be reduced after switching to the normal PLL mode. See the "Charge Pump Structure" item for details.</p> | PDC1 | PDC0 | Sub-charge pump state | 0 | * | High impedance | 1 | 1 | Charge pump operating (at all times) | 1 | 0 | Charge pump operating (when PLL unlocked) | HSE0 HSE1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PDC1 | PDC0 | Sub-charge pump state | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | * | High impedance | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | Charge pump operating (at all times) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | Charge pump operating (when PLL unlocked) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (3) | Reference divider data R0 to R3 | <ul style="list-style-type: none"> Reference frequency selection data <table border="1"> <thead> <tr> <th>R3</th> <th>R2</th> <th>R1</th> <th>R0</th> <th>Reference frequency (kHz)</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td><td>0</td><td>50</td></tr> <tr><td>0</td><td>0</td><td>0</td><td>1</td><td>50</td></tr> <tr><td>0</td><td>0</td><td>1</td><td>0</td><td>25</td></tr> <tr><td>0</td><td>0</td><td>1</td><td>1</td><td>25</td></tr> <tr><td>0</td><td>1</td><td>0</td><td>0</td><td>12.5</td></tr> <tr><td>0</td><td>1</td><td>0</td><td>1</td><td>6.25</td></tr> <tr><td>0</td><td>1</td><td>1</td><td>0</td><td>3.125</td></tr> <tr><td>0</td><td>1</td><td>1</td><td>1</td><td>3.125</td></tr> <tr><td>1</td><td>0</td><td>0</td><td>0</td><td>10</td></tr> <tr><td>1</td><td>0</td><td>0</td><td>1</td><td>9</td></tr> <tr><td>1</td><td>0</td><td>1</td><td>0</td><td>5</td></tr> <tr><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>0</td><td>0</td><td>3</td></tr> <tr><td>1</td><td>1</td><td>0</td><td>1</td><td>30</td></tr> <tr><td>1</td><td>1</td><td>1</td><td>0</td><td>PLL inhibit + X'tal OSC stop</td></tr> <tr><td>1</td><td>1</td><td>1</td><td>1</td><td>PLL inhibit</td></tr> </tbody> </table> <p>Note: PLL inhibit (backup mode) The programmable divider block is stopped, the FMIN and AMIN pins are pulled down to ground, and the charge pump output is set to the floating state.</p> | R3 | R2 | R1 | R0 | Reference frequency (kHz) | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 1 | 50 | 0 | 0 | 1 | 0 | 25 | 0 | 0 | 1 | 1 | 25 | 0 | 1 | 0 | 0 | 12.5 | 0 | 1 | 0 | 1 | 6.25 | 0 | 1 | 1 | 0 | 3.125 | 0 | 1 | 1 | 1 | 3.125 | 1 | 0 | 0 | 0 | 10 | 1 | 0 | 0 | 1 | 9 | 1 | 0 | 1 | 0 | 5 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 3 | 1 | 1 | 0 | 1 | 30 | 1 | 1 | 1 | 0 | PLL inhibit + X'tal OSC stop | 1 | 1 | 1 | 1 | PLL inhibit | |
| R3 | R2 | R1 | R0 | Reference frequency (kHz) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 0 | 1 | 50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 1 | 0 | 25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 1 | 1 | 25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 0 | 0 | 12.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 0 | 1 | 6.25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 1 | 0 | 3.125 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 1 | 1 | 3.125 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 0 | 0 | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 0 | 1 | 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1 | 0 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 0 | 0 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 0 | 1 | 30 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 0 | PLL inhibit + X'tal OSC stop | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 1 | PLL inhibit | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| No. | Control block/data | Content | Related data | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----|--|---|-------------------|-----|-----|--------|---|---|---|-------------------|---|---|---|------|---|---|---|-----------|---|---|---|-------|---|---|---|------|---|---|---|------|---|---|---|-----------|---|---|---|-------|-----|-----|----|---|---|------|---|---|-----------------|---|---|-----------------|---|---|-------------------------------|-----------------------|
| (4) | DO pin control data ULD DT0, DT1 IL0, IL1 | <p>• Data that determines the output of the DO pin</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>ULD</th> <th>DT1</th> <th>DT0</th> <th>DO pin</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>Low when unlocked</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>Open</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>end-UC *1</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td>IN *2</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>Open</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>Open</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>end-UC *1</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>IN *2</td> </tr> </tbody> </table> <p>*Note: Open state will be selected at the power-on reset. Note: *1. end-UC: General-purpose counter operation completion check</p> <div style="text-align: center;">  <p style="margin-left: 100px;">(1) Start (2) Completion (3) CE: HI</p> </div> <p>(1) When the count operation starts by setting end-UC with CTE set to 1 from 0, DO pin automatically goes to open state. (2) When the general-purpose counter operation ends, the DO pin goes low, it is allowed to check the count end. (3) DO pin goes to open state according to the serial data input/output state: CE pin = high.</p> <p>Note: *2.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>IL1</th> <th>IL0</th> <th>IN</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>Open</td> </tr> <tr> <td>0</td> <td>1</td> <td>I-1 (pin state)</td> </tr> <tr> <td>1</td> <td>0</td> <td>I-2 (pin state)</td> </tr> <tr> <td>1</td> <td>1</td> <td>DO goes low when I-1 changes.</td> </tr> </tbody> </table> <p>However, if I/O-1 and I/O-2 are set to output mode, they change from IN to the open state.</p> <p>*: DO pin state during data input (IN1, IN2 modes, CE = high) keeps open regardless of the DO pin control data.</p> <p>In addition, Do pin during data input (OUT mode, CE = high) outputs the value for the internal DO serial data synchronized with the CL regardless of the DO pin control data.</p> <p>Caution: Cannot be used in crystal oscillator stop mode: R0 = 0, R1 = R2 = R3 = 1 (The DO pin will not change state.)</p> | ULD | DT1 | DT0 | DO pin | 0 | 0 | 0 | Low when unlocked | 0 | 0 | 1 | Open | 0 | 1 | 0 | end-UC *1 | 0 | 1 | 1 | IN *2 | 1 | 0 | 0 | Open | 1 | 0 | 1 | Open | 1 | 1 | 0 | end-UC *1 | 1 | 1 | 1 | IN *2 | IL1 | IL0 | IN | 0 | 0 | Open | 0 | 1 | I-1 (pin state) | 1 | 0 | I-2 (pin state) | 1 | 1 | DO goes low when I-1 changes. | CTE I/O-1 I/O-2 |
| ULD | DT1 | DT0 | DO pin | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 0 | Low when unlocked | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 1 | Open | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 0 | end-UC *1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 1 | IN *2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 0 | Open | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1 | Open | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 0 | end-UC *1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | IN *2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IL1 | IL0 | IN | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | Open | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | I-1 (pin state) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | I-2 (pin state) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | DO goes low when I-1 changes. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| No. | Control block/data | Content | Related data | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------|---|---|------------------|-----------|-------------------------|------------------|---|---|------|-----------|---|---|------|-----------|---|---|------|--------|-----|-----|-----------------------|--|--|-------------------------|------------------|-----------|--|---------|---------|---|---|------|-----------|-----------|------------|---|---|---|-----------|-----------|------------|---|---|----|-----------|-----------|-------------|---|---|----|-----------|-----------|-------------|--|
| (5) | General-purpose counter control data CTS0, CTS1 CTE GT0, GT1 CTP CTC | <ul style="list-style-type: none"> Selects the general-purpose counter input pins (HCTR, LCTR). <table border="1" style="margin-left: 20px;"> <thead> <tr> <th style="text-align: center;">CTS1</th> <th style="text-align: center;">CTS0</th> <th style="text-align: center;">Input pin</th> <th style="text-align: center;">Measurement mode</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">*</td> <td style="text-align: center;">HCTR</td> <td style="text-align: center;">Frequency</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">LCTR</td> <td style="text-align: center;">Frequency</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">LCTR</td> <td style="text-align: center;">Period</td> </tr> </tbody> </table> General-purpose counter measurement start data CTE = 1: Starts the counter. CTE = 0: Resets the counter. Determines the measurement time (frequency mode) and number of periods (period mode). <table border="1" style="margin-left: 20px;"> <thead> <tr> <th rowspan="3" style="text-align: center;">GT1</th> <th rowspan="3" style="text-align: center;">GT0</th> <th colspan="3" style="text-align: center;">Frequency measurement</th> <th rowspan="3" style="text-align: center;">Period measurement mode</th> </tr> <tr> <th rowspan="2" style="text-align: center;">Measurement time</th> <th colspan="2" style="text-align: center;">Wait time</th> </tr> <tr> <th style="text-align: center;">CTP = 0</th> <th style="text-align: center;">CTP = 1</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">4 ms</td> <td style="text-align: center;">3 to 4 ms</td> <td style="text-align: center;">1 to 2 ms</td> <td style="text-align: center;">One period</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">8</td> <td style="text-align: center;">3 to 4 ms</td> <td style="text-align: center;">1 to 2 ms</td> <td style="text-align: center;">One period</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">32</td> <td style="text-align: center;">7 to 8 ms</td> <td style="text-align: center;">1 to 2 ms</td> <td style="text-align: center;">Two periods</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> <td style="text-align: center;">64</td> <td style="text-align: center;">7 to 8 ms</td> <td style="text-align: center;">1 to 2 ms</td> <td style="text-align: center;">Two periods</td> </tr> </tbody> </table> When CTE = 0, input pull-down is disabled by setting CTP to 1 Note: Wait time: 1 to 2ms. However, CTP must be set to 1 4ms before CTE is set to 1. The input sensitivity is reduced when CTC is set to 1. (Sensitivity: 10 to 30 mV rms) <p>*: Refer to the General-purpose counter structure on page 22 for details.</p> | CTS1 | CTS0 | Input pin | Measurement mode | 1 | * | HCTR | Frequency | 0 | 1 | LCTR | Frequency | 0 | 0 | LCTR | Period | GT1 | GT0 | Frequency measurement | | | Period measurement mode | Measurement time | Wait time | | CTP = 0 | CTP = 1 | 0 | 0 | 4 ms | 3 to 4 ms | 1 to 2 ms | One period | 0 | 1 | 8 | 3 to 4 ms | 1 to 2 ms | One period | 1 | 0 | 32 | 7 to 8 ms | 1 to 2 ms | Two periods | 1 | 1 | 64 | 7 to 8 ms | 1 to 2 ms | Two periods | |
| CTS1 | CTS0 | Input pin | Measurement mode | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | * | HCTR | Frequency | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | LCTR | Frequency | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | LCTR | Period | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GT1 | GT0 | Frequency measurement | | | Period measurement mode | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Measurement time | Wait time | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | CTP = 0 | CTP = 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 4 ms | 3 to 4 ms | 1 to 2 ms | One period | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 8 | 3 to 4 ms | 1 to 2 ms | One period | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 32 | 7 to 8 ms | 1 to 2 ms | Two periods | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 64 | 7 to 8 ms | 1 to 2 ms | Two periods | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (6) | I/O port control data IO-1, I/O-2 | <ul style="list-style-type: none"> Data that specifies the I/O direction of the I/O ports (I/O-1, I/O-2). [Data] = 0: Input port 1: Output port <p>*: After the power-on reset, the I/O-1 and I/O-2 are set up as input ports.</p> | OUT1, OUT2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (7) | Output port data OUT1 to OUT3 | <ul style="list-style-type: none"> Data that determines the output from output ports O-1 to O-3. [Data] = 0: Open 1: Low <p>*: Invalid when the corresponding port is set up as an input port. *: At a power-on reset, open state is selected by setting the data to 0</p> | I/O-1, I/O-2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (8) | General-purpose counter control data H/I-3, L/I-4 | <ul style="list-style-type: none"> Data that switch the function between general-purpose counter and input port. H/I-3 = 0: I-3 (input port) 1: HCTR (general-purpose counter) L/I-4 = 0: I-4 (input port) 1: LCTR (general-purpose counter) | CTS0, CTS1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| No. | Control block/data | Content | Related data | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------|---|---|--|--------------------------------------|--------------------------|------------------|-------|-----|---|---------|------|-------------------|---|-----|---|---------------------------|-------------------|------------|---|------------------|--|-----------|------------------|--|------------------------------|------------------|--|--------------------------------------|---|---|------------------|--|-----------|------------------|--|------------------------------|------------------|--|--------------------------------------|-----------------|
| (9) | Unlock state detection data UL0, UL1 | <ul style="list-style-type: none"> Width selection for the phase error (ϕE) detection function used to determine the PLL locked/unlocked state. When a phase error greater than the ϕE detection width from the table occurs, the PLL circuit is seen as in the unlocked state. <table border="1" style="width: 100%; border-collapse: collapse; margin: 10px 0;"> <thead> <tr> <th>UL1</th> <th>UL0</th> <th>ϕE detection width</th> <th>Detection output</th> <th>X'tal</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">Stopped</td> <td style="text-align: center;">Open</td> <td style="text-align: center;">10.25 M/10.35 MHz</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">Directly outputs ϕE</td> <td style="text-align: center;">10.25 M/10.35 MHz</td> </tr> <tr> <td rowspan="3" style="text-align: center;">1</td> <td rowspan="3" style="text-align: center;">0</td> <td style="text-align: center;">$\pm 0.49 \mu s$</td> <td style="text-align: center;">ϕE is extended by 0.1 to 0.2 ms.</td> <td style="text-align: center;">10.25 MHz</td> </tr> <tr> <td style="text-align: center;">$\pm 0.49 \mu s$</td> <td style="text-align: center;">ϕE is extended by 0.11 to 0.22 ms.</td> <td style="text-align: center;">10.35 MHz (fr = 30/9/3 k)</td> </tr> <tr> <td style="text-align: center;">$\pm 0.43 \mu s$</td> <td style="text-align: center;">ϕE is extended by 0.1 to 0.2 ms.</td> <td style="text-align: center;">10.35 MHz (Other than fr = 30/9/3 k)</td> </tr> <tr> <td rowspan="3" style="text-align: center;">1</td> <td rowspan="3" style="text-align: center;">1</td> <td style="text-align: center;">$\pm 0.98 \mu s$</td> <td style="text-align: center;">ϕE is extended by 0.1 to 0.2 ms.</td> <td style="text-align: center;">10.25 MHz</td> </tr> <tr> <td style="text-align: center;">$\pm 0.97 \mu s$</td> <td style="text-align: center;">ϕE is extended by 0.11 to 0.22 ms.</td> <td style="text-align: center;">10.35 MHz (fr = 30/9/3 k)</td> </tr> <tr> <td style="text-align: center;">$\pm 0.87 \mu s$</td> <td style="text-align: center;">ϕE is extended by 0.1 to 0.2 ms.</td> <td style="text-align: center;">10.35 MHz (Other than fr = 30/9/3 k)</td> </tr> </tbody> </table> <div style="text-align: center; margin: 10px 0;"> </div> <p style="font-size: small; margin-top: 10px;">*: When unlocked, the DO pin goes low and the serial data output is UL = 0.</p> | UL1 | UL0 | ϕE detection width | Detection output | X'tal | 0 | 0 | Stopped | Open | 10.25 M/10.35 MHz | 0 | 1 | 0 | Directly outputs ϕE | 10.25 M/10.35 MHz | 1 | 0 | $\pm 0.49 \mu s$ | ϕE is extended by 0.1 to 0.2 ms. | 10.25 MHz | $\pm 0.49 \mu s$ | ϕE is extended by 0.11 to 0.22 ms. | 10.35 MHz (fr = 30/9/3 k) | $\pm 0.43 \mu s$ | ϕE is extended by 0.1 to 0.2 ms. | 10.35 MHz (Other than fr = 30/9/3 k) | 1 | 1 | $\pm 0.98 \mu s$ | ϕE is extended by 0.1 to 0.2 ms. | 10.25 MHz | $\pm 0.97 \mu s$ | ϕE is extended by 0.11 to 0.22 ms. | 10.35 MHz (fr = 30/9/3 k) | $\pm 0.87 \mu s$ | ϕE is extended by 0.1 to 0.2 ms. | 10.35 MHz (Other than fr = 30/9/3 k) | ULD DT0, DT1 |
| UL1 | UL0 | ϕE detection width | Detection output | X'tal | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | Stopped | Open | 10.25 M/10.35 MHz | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 0 | Directly outputs ϕE | 10.25 M/10.35 MHz | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | $\pm 0.49 \mu s$ | ϕE is extended by 0.1 to 0.2 ms. | 10.25 MHz | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | $\pm 0.49 \mu s$ | ϕE is extended by 0.11 to 0.22 ms. | 10.35 MHz (fr = 30/9/3 k) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | $\pm 0.43 \mu s$ | ϕE is extended by 0.1 to 0.2 ms. | 10.35 MHz (Other than fr = 30/9/3 k) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | $\pm 0.98 \mu s$ | ϕE is extended by 0.1 to 0.2 ms. | 10.25 MHz | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | $\pm 0.97 \mu s$ | ϕE is extended by 0.11 to 0.22 ms. | 10.35 MHz (fr = 30/9/3 k) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | $\pm 0.87 \mu s$ | ϕE is extended by 0.1 to 0.2 ms. | 10.35 MHz (Other than fr = 30/9/3 k) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (10) | Charge pump control data DLC | <ul style="list-style-type: none"> Bit that forcible sets the charge pump output to the low level. <p style="margin-left: 20px;">DLC = 1: Low level DLC = 0: Normal operation</p> <p style="font-size: x-small; margin-left: 20px;">*: If a deadlock occurs due to the VCO control voltage (V_{tune}) going to zero and stopping the VCO oscillator, set the charge pump output to the low level and set V_{tune} to V_{CC} to escape from the deadlocked state (deadlock clearing circuit). Normal operation is selected after the power-on reset.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (11) | Phase comparator control data DZ0, DZ1 | <ul style="list-style-type: none"> Controls the phase comparator dead band. <table border="1" style="width: 100%; border-collapse: collapse; margin: 10px 0;"> <thead> <tr> <th>DZ1</th> <th>DZ0</th> <th>Dead band mode</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">DZA</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">DZB</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">DZC</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> <td style="text-align: center;">DZD</td> </tr> </tbody> </table> <p style="font-size: x-small; margin-top: 10px;">*: The phase comparator operates in DZA mode after the power-on reset. (Recommended modes: DZD, DZC)</p> | DZ1 | DZ0 | Dead band mode | 0 | 0 | DZA | 0 | 1 | DZB | 1 | 0 | DZC | 1 | 1 | DZD | | | | | | | | | | | | | | | | | | | | | | | |
| DZ1 | DZ0 | Dead band mode | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | DZA | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | DZB | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | DZC | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | DZD | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (12) | High-speed locking convergence range control data TLR0, TLR1 | <ul style="list-style-type: none"> Data to control the frequency in the convergence range to judge the high-speed locking control completion. This data is valid when FMIN (high-speed mode) is selected by setting DVS and SNS to 1. <table border="1" style="width: 100%; border-collapse: collapse; margin: 10px 0;"> <thead> <tr> <th>TLR1</th> <th>TLR0</th> <th>Convergence range [kHz]</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">50</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">100</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">150</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> <td style="text-align: center;">200</td> </tr> </tbody> </table> <p style="font-size: x-small; margin-top: 10px;">*:The convergence range is 200 kHz at a power-on reset. Refer to Description of the High-Speed Locking Control System (P.19) for details.</p> | TLR1 | TLR0 | Convergence range [kHz] | 0 | 0 | 50 | 0 | 1 | 100 | 1 | 0 | 150 | 1 | 1 | 200 | DVS SNS | | | | | | | | | | | | | | | | | | | | | | |
| TLR1 | TLR0 | Convergence range [kHz] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 100 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 150 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 200 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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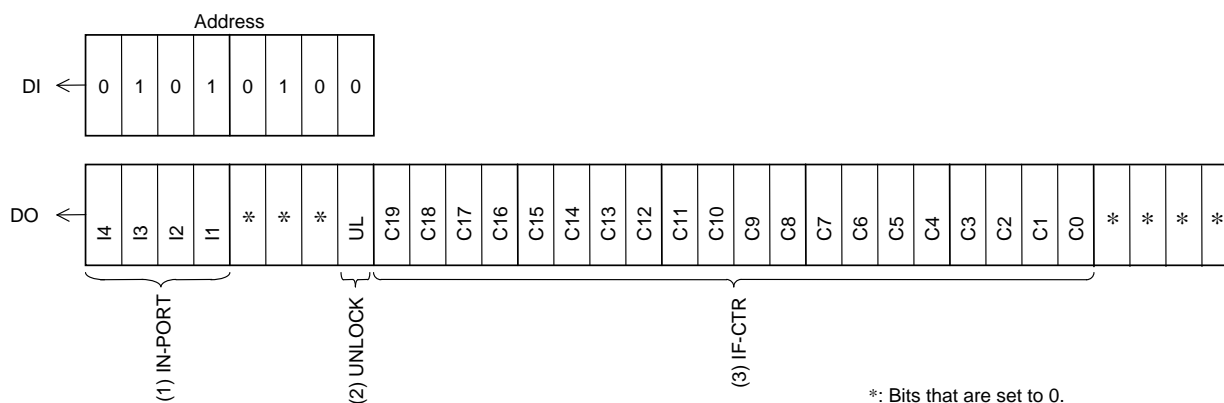
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| No. | Control block/data | Content | Related data | | | | | | | | | | | | | | | |
|------|--|---|--------------|------|----------------------|---|---|-----|---|---|-----|---|---|-----|---|---|-----|----------------------------|
| (13) | High-speed locking charge wait time control data CWS0, CWS1 | <ul style="list-style-type: none"> Data to control the wait time in the high-speed locking. This data is valid when the FMIN (high-speed mode) is selected by setting DVS and SNS to 1. <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>CWS1</th> <th>CWS0</th> <th>Wait time [μs]</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">2.5</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">5</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">10</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> <td style="text-align: center;">20</td> </tr> </tbody> </table> <p>*:The wait time is 20 μs at a power on reset. Refer to Description of the High-Speed Locking Control System (P.19) for details.</p> | CWS1 | CWS0 | Wait time [μ s] | 0 | 0 | 2.5 | 0 | 1 | 5 | 1 | 0 | 10 | 1 | 1 | 20 | DVS SNS |
| CWS1 | CWS0 | Wait time [μ s] | | | | | | | | | | | | | | | | |
| 0 | 0 | 2.5 | | | | | | | | | | | | | | | | |
| 0 | 1 | 5 | | | | | | | | | | | | | | | | |
| 1 | 0 | 10 | | | | | | | | | | | | | | | | |
| 1 | 1 | 20 | | | | | | | | | | | | | | | | |
| (14) | High-speed locking completion flag output wait time control data HSE0, HSE1 | <ul style="list-style-type: none"> Data to control the wait time after the high-speed locking control completes till the operation is switched to the normal PLL operation. This data is valid when the FMIN (high-speed mode) is selected by setting DVS and SNS to 1. <p>During the wait time, the unlock signal is forcibly output, the sub-charge pump allows to be operated. Thereby, reduces the locking time after switching to the normal PLL operation.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>HSE1</th> <th>HSE0</th> <th>Wait time [μs]</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">200</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">400</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> <td style="text-align: center;">800</td> </tr> </tbody> </table> <p>*:The wait time is 400 μs at a power on reset. Refer to Description of the High-Speed Locking Control System (P.19) for details.</p> | HSE1 | HSE0 | Wait time [μ s] | 0 | 0 | 0 | 0 | 1 | 200 | 1 | 0 | 400 | 1 | 1 | 800 | DVS SNS PDC0 PDC1 |
| HSE1 | HSE0 | Wait time [μ s] | | | | | | | | | | | | | | | | |
| 0 | 0 | 0 | | | | | | | | | | | | | | | | |
| 0 | 1 | 200 | | | | | | | | | | | | | | | | |
| 1 | 0 | 400 | | | | | | | | | | | | | | | | |
| 1 | 1 | 800 | | | | | | | | | | | | | | | | |
| (15) | IC test data TEST0 TEST1 TEST2 TEST3 | <ul style="list-style-type: none"> IC test control data <p>These bits must be set as follows during normal operation.</p> <p>TEST0 = 0 TEST1 = 0 TEST2 = 0 TEST3 = 0</p> <p>*: After the power-on reset, the test data is all set to zero.†</p> | | | | | | | | | | | | | | | | |
| (16) | Reset RST | <ul style="list-style-type: none"> This data resets the LC72151V. <p>*: After the power is first applied, the power-on reset circuit initializes the IC. However, the data must be set to 1 to ensure the initialization.</p> | | | | | | | | | | | | | | | | |
| (17) | DNC | <ul style="list-style-type: none"> Set data to 0 | | | | | | | | | | | | | | | | |
| (18) | Crystal oscillator circuit XS XB | <ul style="list-style-type: none"> Crystal oscillator selection data <p>XS = 0: 10.25 MHz = 1: 10.35 MHz</p> <ul style="list-style-type: none"> Crystal oscillator buffer (XBUF) <p>XB = 0: Buffer output is turned off. XB = 1: Buffer output is turned on.</p> <p>*: XB = 0: Buffer output is turned off at a power-on reset.</p> | R0 to R3 | | | | | | | | | | | | | | | |

†Note: After power is first applied, the power-on reset circuit initializes the IC. However, the CCB data (RST) must be input to the IC to ensure the initialization.

Structure of the DO Output Data (serial output data)

(3) OUT mode

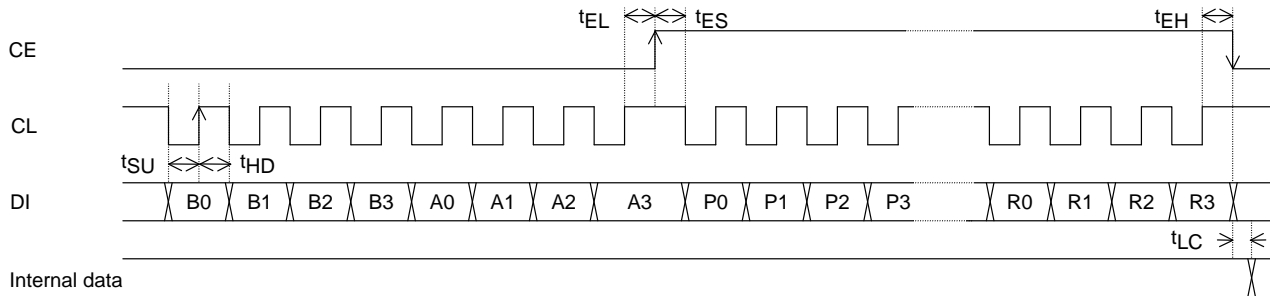


| No. | Control block/data | Content | Related data |
|-----|--|---|----------------------------------|
| (1) | I/O port data I4 to I1 | <ul style="list-style-type: none"> The bits I1 to I4 are set to the latched states of the I/O pins I/O-1 and I/O-2 and the input pins HCTR/I-3 and LCTR/I-4. These states are latched at the point the IC enters data output mode. The pin states are latched regardless of the pin mode (input or output). I1, I2 ← I/O-1 and I/O-2 pin states I3, I4 ← HCTR/I-3 and LCTR/I-4 pin states <p>Pin state = high: 1 low: 0</p> | I/O-1 I/O-2 H/I-3 L/I-4 |
| (2) | PLL unlock data UL | <ul style="list-style-type: none"> Data created by latching the value for the unlock detection circuit UL ← 0: Unlocked 1: Locked or in detection halt mode | UL0 UL1 |
| (3) | IF counter binary counter C19 to C0 | <ul style="list-style-type: none"> Data created by latching the value for the IF counter (20-bit binary counter) C19 ← MSB of the binary counter C0 ← LSB of the binary counter | CTE GT0 GT1 |

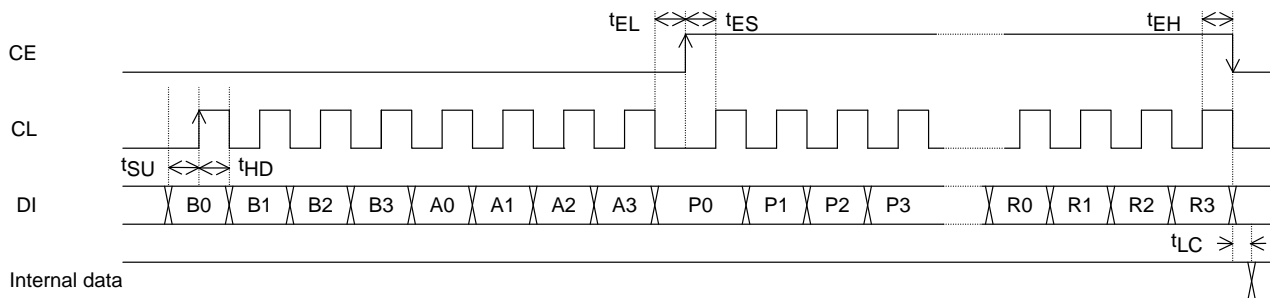
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Serial data input (IN1/IN2) $t_{SU}, t_{HD}, t_{EL}, t_{ES}, t_{EH} > 0.45 \mu s$ $t_{LC} < 0.45 \mu s$

(1) CL: Normally high

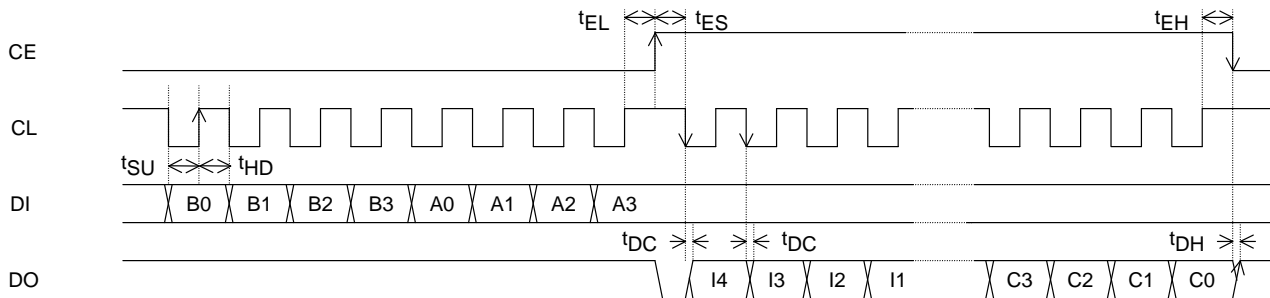


(2) CL: Normally low

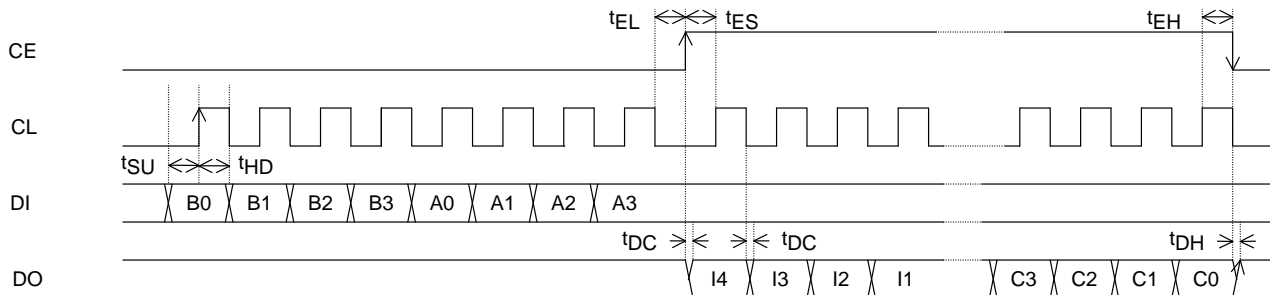


Serial data output (OUT) $t_{SU}, t_{HD}, t_{EL}, t_{ES}, t_{EH} > 0.45 \mu s$ $t_{DC}, t_{DH} < 0.2 \mu s$

(1) CL: Normally high

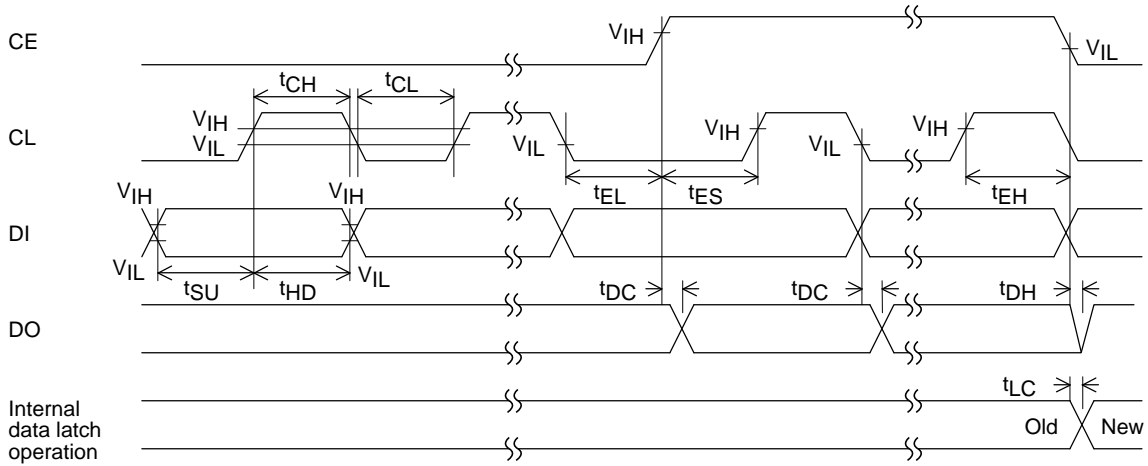


(2) CL: Normally low

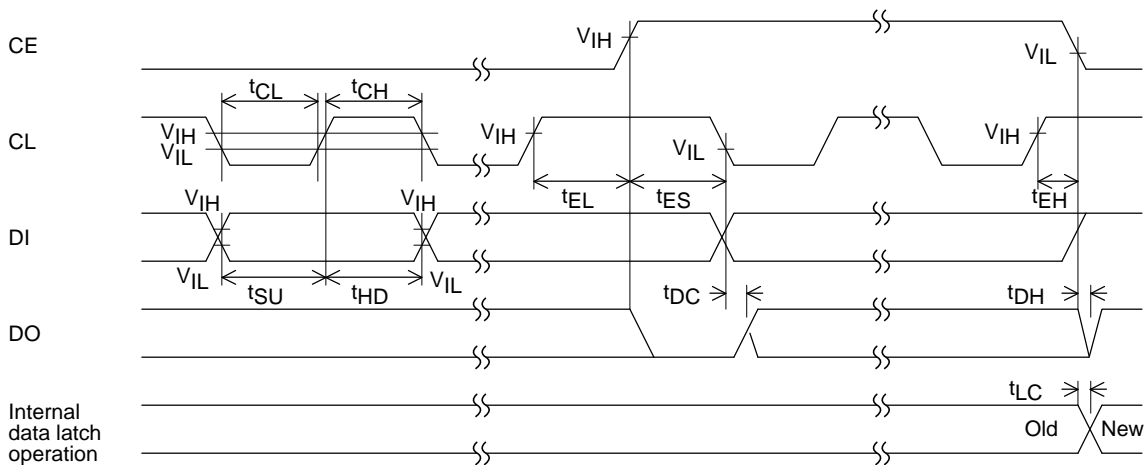


Note: The DO pin is an n-channel open drain output, and thus the data switching time will differ depending on the value of the pull-up resistor used and the printed circuit board capacitance.

Serial data timing



<When CL is stopped at the low level>



<When CL is stopped at the high level>

Allowable Operating Ranges at Ta = -40 to 85°C, VSS = 0 V

| Parameter | Symbol | Pin | Conditions | Ratings | | | Unit |
|-------------------------|-----------------|--------|--|---------|-----|------|------|
| | | | | min | typ | max | |
| Data setup time | t _{SU} | DI, CL | | 0.45 | | | μs |
| Data hold time | t _{HD} | DI, CL | | 0.45 | | | μs |
| Clock low-level period | t _{CL} | CL | | 0.45 | | | μs |
| Clock high-level period | t _{CH} | CL | | 0.45 | | | μs |
| CE wait time | t _{EL} | CE, CL | | 0.45 | | | μs |
| CE setup time | t _{ES} | CE, CL | | 0.45 | | | μs |
| CE hold time | t _{EH} | CE, CL | | 0.45 | | | μs |
| Data latch change time | t _{LC} | | | | | 0.45 | μs |
| Data output time | t _{DC} | DO, CL | Depends on the value of the pull-up resistor used. | | | 0.2 | μs |
| | t _{DH} | DO, CE | | | | | |

Note: See the timing chart for serial data transfers.

Description of the High-Speed Locking Control System

The LC72151V realizes the maximum inter-band edge high-speed locking time 500 μs by optimizing the filter constants and internal status setting when the FMIN (high-speed mode) by setting DVS and SNS to 1. The following describes the high-speed locking control system.

Procedure

The LC72151V operates as shown below when selecting FMIN (high-speed mode) and setting sub-charge pump operation during unlocked.

| | PDF/PDM1/PDM2/PDS/TGI1/TGI2 pin states | | | | | |
|--|--|------|------|-----|------|------|
| | PDF | PDM1 | PDM2 | PDS | TGI1 | TGI2 |
| Change value N | × | ○ | ○ | × | × | ○ |
| ↓ | | | | | | |
| New high-speed locking control (When the value N variation is under 16, only operates the normal PLL.) | ○ | × | × | × | ○ | × |
| ↓ | | | | | | |
| Operates normal PLL when the local oscillation frequency enters the high-speed locking frequency range. (The sub-charge pump operates for the time set by the high-speed locking completion flag output wait time.) | × | ○ | ○ | ○ | × | ○ |
| ↓ | | | | | | |
| Stops the sub-charge pump and only the main-charge pump operates. (Normal locking state) | × | ○ | ○ | × | × | ○ |

*: ○ : operating; × : stopped (high-impedance)

Control Data

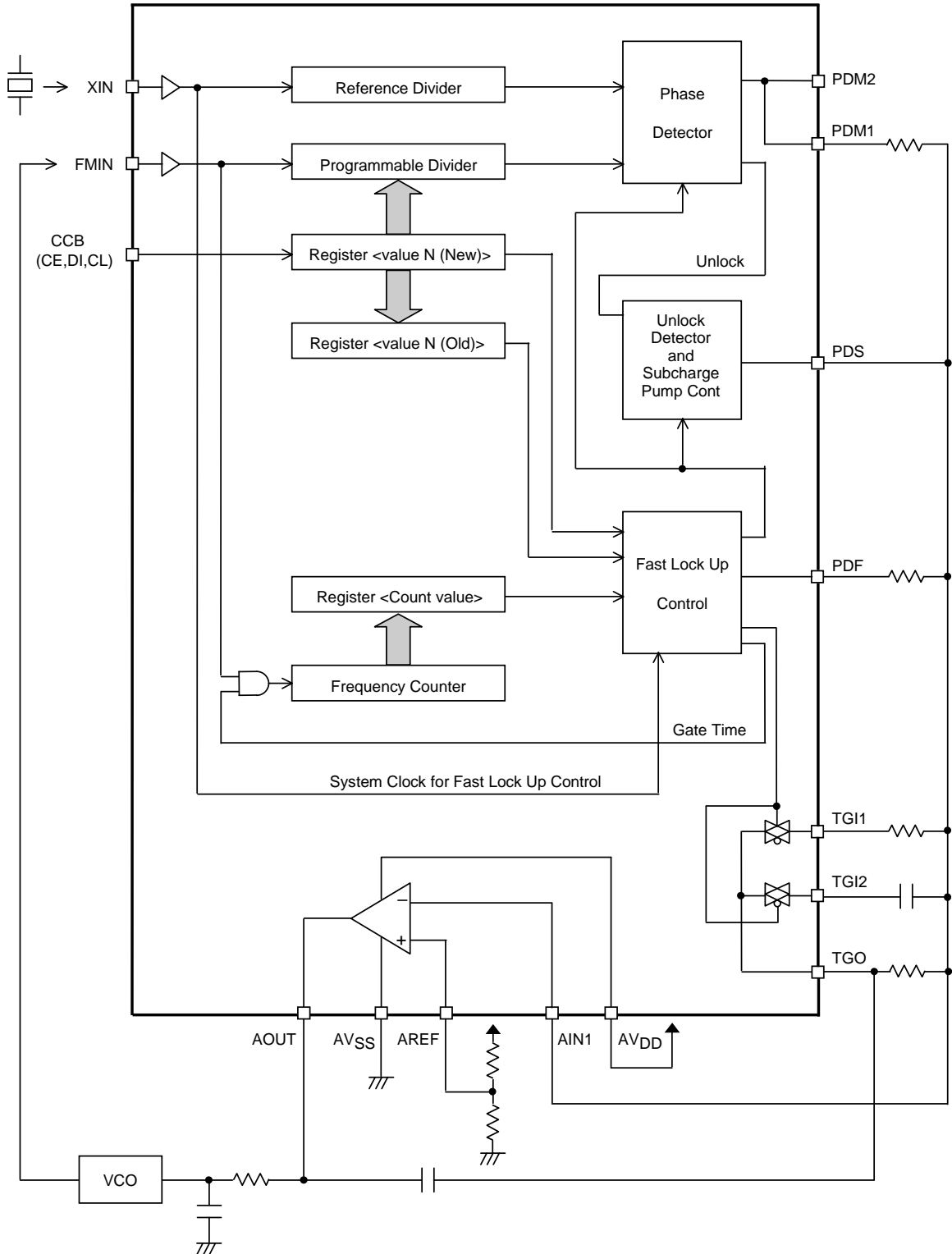
Setting data (CCB) necessary for the new high-speed locking control is described below.

This data is valid when the FMIN (high-speed mode) is selected by setting DVS and SNS to 1.

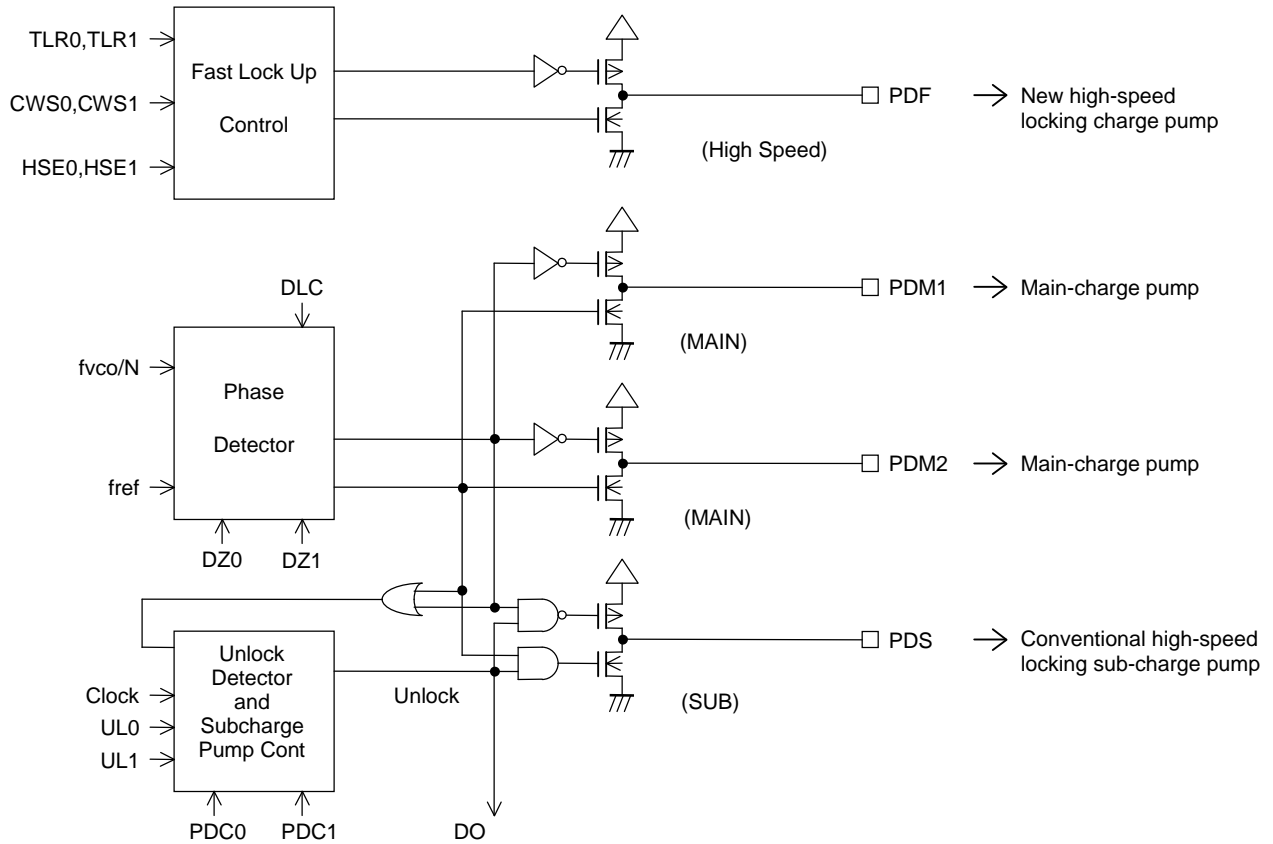
| CCB data | Name (Selectable set value) | Description | Recommended value |
|-----------|---|--|-----------------------------------|
| TLR0/TLR1 | High-speed locking convergence range (±50/100/150/200 kHz) | The new high-speed locking control controls the convergence of the target frequency into the set frequency range. This data can be used to set the frequency range for convergence judgement. *: As the convergence range narrower, the locking time tends to be shorter. | TLR0 = 0 TLR1 = 0 (±50 kHz) |
| CWS0/CWS1 | High-speed locking charge wait time (0/2.5/5/10 μs) | During the new high-speed locking control, charge application from the PDF pin and local oscillation frequency measurement for the FMIN pin are repeatedly implemented. This data can be used to set the Vt voltage stable time after the charge is applied until the local oscillator frequency is measured. *: Voltage stable time Vt changes according to the peripheral circuit. | CWS0 = 1 CWS1 = 0 (5 μs) |
| HSE0/HSE1 | High-speed locking completion flag output wait time (0/100/200/400 μs) | After the new high-speed locking control ends, since the phase remains in convergence state in the internal unlock detection circuit until the locking judgement is implemented, the sub-charge pump will not operate by the sub-charge pump operation setting during unlocked. This data can be used to set the time to force the sub-charge pump to operate for after the new high-speed locking control completes. *: After the new high-speed locking control completes, the locking time tends to be shortened by operating the sub-charge pump for an adequate time. | HSE0 = 0 HSE1 = 1 (400 μs) |

*: The recommended values are for reference purpose only, not the guarantee values for the fastest locking time.

Block Diagram



Charge Pump Structure



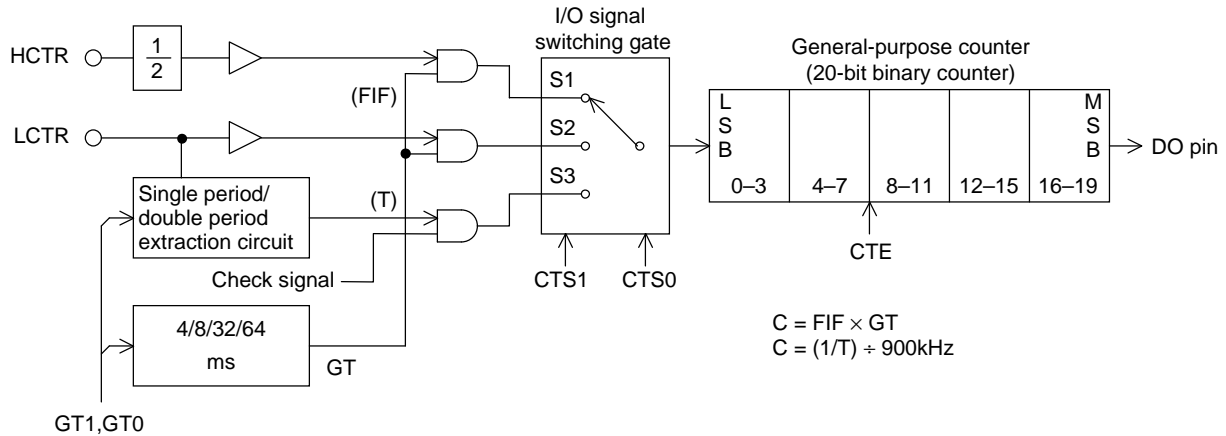
| PDC1 | PDC0 | PDS(Sub-charge pump state) |
|------|------|---|
| 0 | * | High impedance |
| 1 | 1 | Charge pump operating (at all times) |
| 1 | 0 | Charge pump operating (when PLL unlocked) |

| DLC | PDM1, PDM2, PDS |
|-----|------------------|
| 0 | Normal operation |
| 1 | Forced low |

Note: If the unlock state is detected when the channel changes, the sub-charge pump (PDS) operates. Since the sub-charge pump operates concurrently with the main-charge pump, decrease the time constants for the low-pass filter to accelerate the locking.

However, note that when the FMIN (high-speed mode) is selected and when the channel changes (during high-speed locking control), both the main- and the sub-charge pumps do not operate and enter the high impedance state, and forcibly implement an unlock judgement. When locked at a high-speed locking control completion, the output is not extended but locking is instantaneously judged. By selecting sub-charge operation (during unlocked) with FMIN (high-speed mode) selected, the sub-charge pump is forcibly operated to shorten the locking time for the time set by the high-speed locking completion flag output wait time control data (HSE0, HSE1) after switching from high-speed locking control to normal PLL operation.

General-purpose counter structure



| Parameter | LCTR period measurement mode check signal frequency | | |
|--------------|---|---------------------|--------------------------------|
| X'tal OSC | 10.25 MHz | 10.35 MHz | |
| | | fref = 30, 9, 3 kHz | fref = other than 30, 9, 3 kHz |
| Check signal | 1025 kHz | 1030 kHz | 1150 kHz |

| | CTS1 | CTS0 | Input pin | Measurement mode | Frequency range | Input sensitivity |
|----|------|------|-----------|------------------|----------------------------|-------------------|
| S1 | 1 | * | HCTR | Frequency | 0.4 to 25.0 MHz | 40 mVrms *1 |
| S2 | 0 | 1 | LCTR | Frequency | 10 to 500 kHz | 40 mVrms *1 |
| S3 | 0 | 0 | LCTR | Period | 1.0 to 20×10^3 Hz | (Pulse) |

*1: CTC = 0: 40 mVrms
CTC = 1: 70 mVrms

| HCTR: Minimum input sensitivity regulation | | f [MHz] | |
|--|------------------|------------------------------|---------------------|
| CTC | $0.4 \leq f < 8$ | $8 \leq f < 12$ | $12 \leq f \leq 25$ |
| 0 (Normal mode) | 40 mVrms | 40 mVrms (5 to 15 mVrms) | 40 mVrms |
| 1 (Degrade mode) | — | 70 mVrms (40 to 60 mVrms) | — |

| LCTR: Minimum input sensitivity regulation | | f [MHz] | |
|--|-------------------|------------------------------|--|
| CTC | $10 \leq f < 400$ | $400 \leq f \leq 500$ | |
| 0 (Normal mode) | 40 mVrms | 20 mVrms (1 to 10 mVrms) | |
| 1 (Degrade mode) | — | 70 mVrms (15 to 30 mVrms) | |

—: No stipulation (Not guaranteed)
(): Actual value (Reference value)

| GT1 | GT0 | Frequency measurement mode | | Period measurement mode |
|-----|-----|----------------------------|-----------|-------------------------|
| | | Measurement time | Wait time | |
| 0 | 0 | 4 ms | 3 to 4 ms | 1 period |
| 0 | 1 | 8 | 7 to 8 ms | 2 periods |
| 1 | 0 | 32 | | |
| 1 | 1 | 64 | | |

CTC: Input sensitivity select data. Input sensitivity is degraded by setting CTC to 1.

However, the actual value for HCTR is in the range 40 to 60 mVrms at 10.7 MHz, for LCTR is in the range 15 to 30 mVrms at 450 kHz.

CTP: Input pull-down can be inhibited by setting CTP to 1.

Set CTP to 1 4 ms before setting CTE to 1. Set CTP to 0 when the counter is not used.

Wait time will be reduced to 1 to 2 ms by setting CTP to 1.

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The LC72151V's general-purpose counter is a 20-bit binary counter.

The result of the count operation can be read out MSB first from the DO pin.

The measurement time when the general-purpose counter is used for frequency measurement is set to either 4, 8, 32, or 64 ms by the GT0 and GT1 bits. The frequency of the input to the HCTR pin can be measured by determining how many pulses were input to the general-purpose counter during this measurement time.

When the general-purpose counter is used to measure the frequency, the period of the signal input to LCTR pin can be measured by counting the number of check signals input to the general-purpose counter for the one or two periods of the signal input to the LCTR pin.

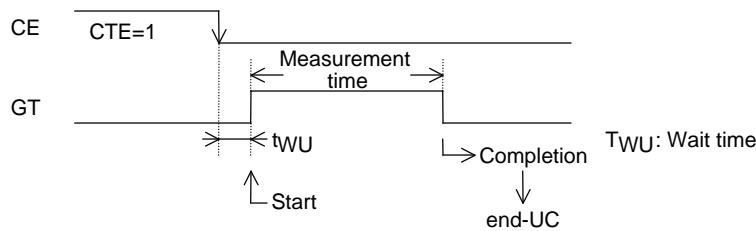
Reset the general-purpose counter in advance by setting CTE to 0 before starting the counter.

A general-purpose counter count operation is started by setting the CTE bit in the serial data to 1. The serial data takes effect internally to the LC72151V when the CE pin input level is changed from high to low. The input to the HCTR pin must be provided before the wait time has elapsed after CE was set low.

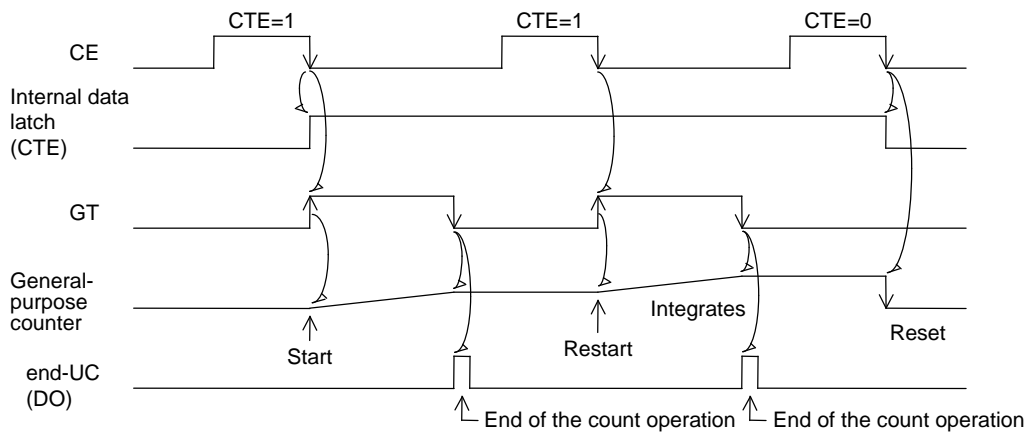
Next, the result of the general-purpose counter count after the measurement completes must be read out while CTE is still set to 1. This is because the general-purpose counter is reset when CTE is set to 1.

Never fail to reset the general-purpose counter before starting the count operation of the general-purpose counter. In addition, the signal input to LCTR pin is directly transmitted to the general-purpose counter.

Note that the signal input to the HCTR pin is first divided by 2 internally to the IC and then input to the general-purpose counter. Therefore, the result of the general-purpose counter count is a value that corresponds to 1/2 of the frequency actually input to the HCTR pin.



When used as an integrating counter



- *CTE: 0 → • Resets the general-purpose counter
- 1 → { • Starts the general-purpose counter
- Restarts the counter if set to 1 again.

In integrating count mode, the count value of the general-purpose counter is accumulated. Care must be taken to handle counter overflow correctly. The count value will be in the range 0_H to FFFF_H.

Other items

(1) Notes on the phase detector dead band

| DZ1 | DZ0 | Dead band mode | Charge pump | Dead band |
|-----|-----|----------------|-------------|-----------|
| 0 | 0 | DZA | ON/ON | --0 s |
| 0 | 1 | DZB | ON/ON | -0 s |
| 1 | 0 | DZC | OFF/OFF | +0 s |
| 1 | 1 | DZD | OFF/OFF | ++0 s |

When the charge pump operates in ON/ON mode, the charge pump generates correction pulses even when the PLL is locked. Here, it is easy for the loop to become unstable, and special care is required in designs that use this mode. The following problems may occur in ON/ON mode.

- Side bands may be generated due to reference frequency leakage.
- Side bands may be generated due low-frequency leakage due to the envelope of the correction pulses.

When a dead band is present (OFF/OFF mode), the loop will be stable, but it will be harder to acquire a good C/N ratio. On the other hand, with the mode that does not have a dead band (ON/ON mode), it will be easier to acquire a high C/N ratio, but harder to acquire loop stability.

Therefore, the DZA and DZB modes, in which there is no dead band, can be effective if either a high signal-to-noise ratio of 90 to 100 dB in FM reception or an increased pilot margin in AM stereo reception is required.

Inversely, if such a high FM signal-to-noise ratio is not required for FM reception, or an adequate pilot margin can be acquired for AM stereo reception, then the DZC and DZD modes, in which a dead band is present, may be more effective.

Dead zone (dead band) definition

The phase comparator compares f_p with the reference frequency (f_r) as shown in figure 1. This circuit outputs a voltage V (A) that is proportional to the phase difference ϕ as shown in figure 2. However, due to internal delays and other factors, the actual IC is unable to compare small phase differences, and thus a dead zone (B) appears in the output. To achieve a high signal-to-noise ratio in the end product, the dead zone should be as small as possible.

However, in popularly-priced models, there are cases where a somewhat wider dead zone may be easier to work with. This is because in some situations, such as when a powerful signal is applied to the RF input, in popularly-priced models there may be RF leakage from the mixer to the VCC. When the dead zone is narrow, outputs to correct this leakage are output, that output in turn modulates the VCO, and generates a beat signal with the RF.

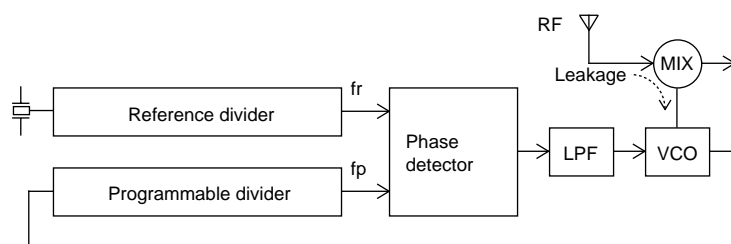


Figure 1

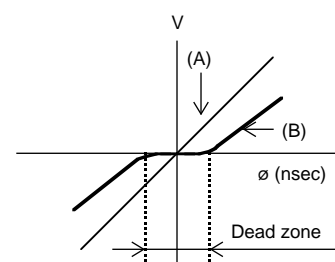


Figure 2

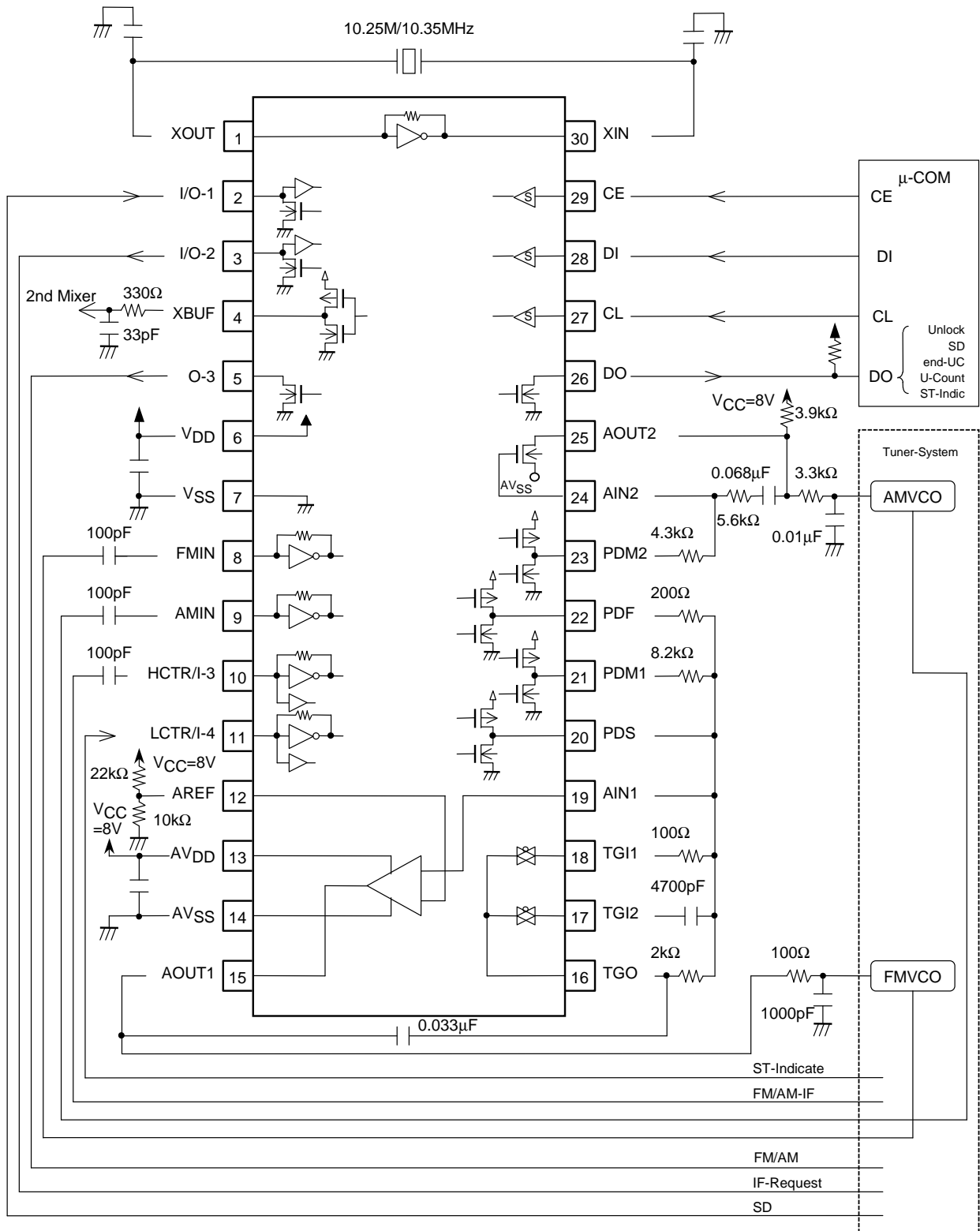
(2) Notes on the FMIN, AMIN, HCTR/I-3, and LCTR/I-4 pins

The coupling capacitor must be located as close as possible to these pins. A capacitance of approximately 100 pF is desirable.

In particular, if the HCTR/I-3 and LCTR/I-4 pin capacitor is over about 1000 pF, the time required to reach the bias level may become excessive, and incorrect counting may occur due to the relationship with the wait time.

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Sample Application Circuit



*: The constants shown are for reference purpose only, but do not guarantee the operation.

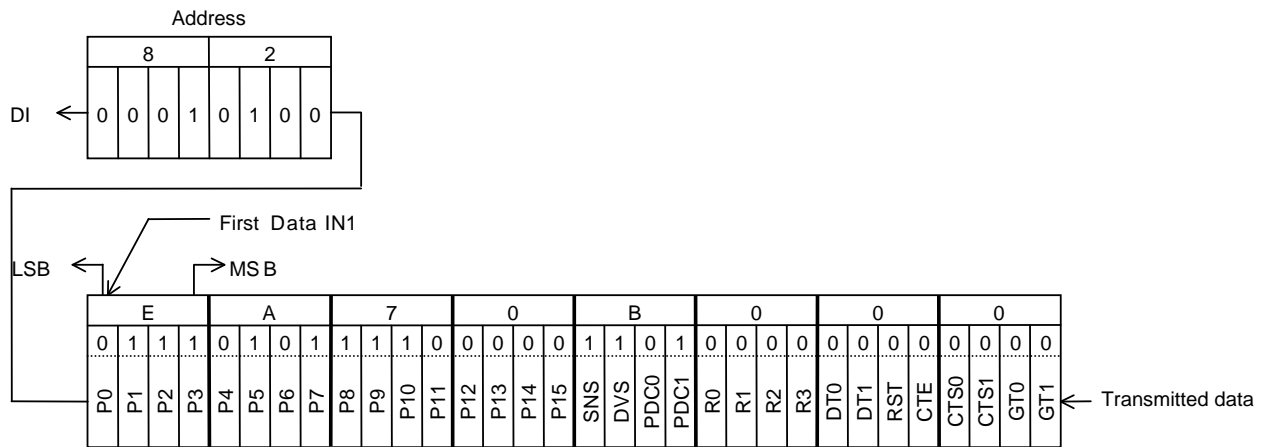
Notes: 1. Power must be applied to AV_{DD} before applying to V_{DD}, and AV_{DD} must be higher than or equal to V_{DD}.

2. AREF is an op-amp reference input voltage pin and must be applied a voltage 1/2 V_{DD}. The applied voltage requires to be applied from another power supply from V_{DD} to prevent affections due to logic system noise or other factors.

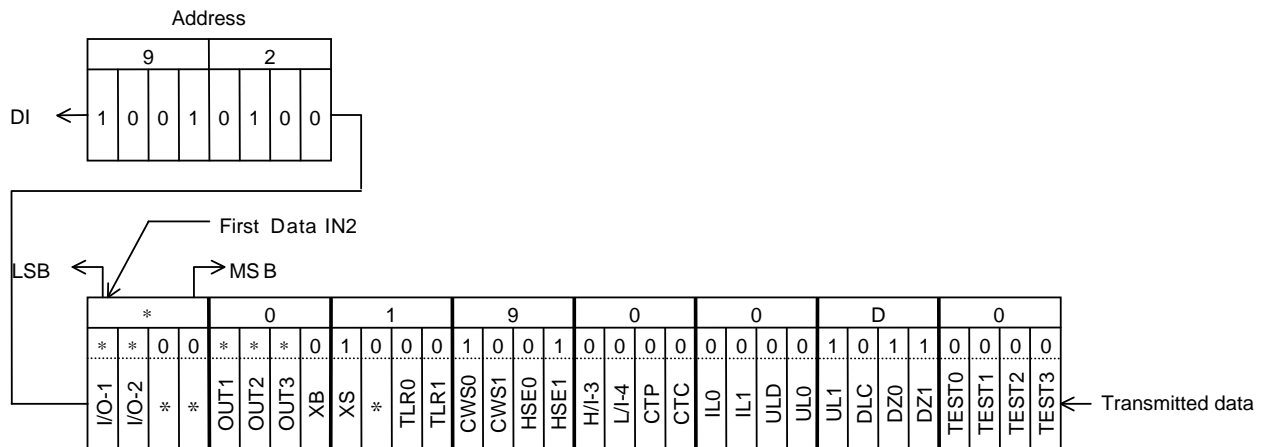
LC72151V State Setting Examples

- In the case of FMRF 87.5 MHz reception (X'tal = 10.35 MHz/IF = +10.8 MHz)
 - FM VCO = 98.3 MHz
 - X'tal = 10.35 MHz, fref = 50 kHz : XS = 1, R0 = R1 = R2 = R3 = 0
 - FMIN (high-speed mode) selected : DVS = 1, SNS = 1
 - Dead-zone mode = DZD : DZ0 = DZ1 = 1
 - Programmable divider divisor
 - 98.3 MHz ÷ 50 kHz = 1966 → 07AE (Hex)
 - High-speed locking control conditions
 - High-speed locking convergence range = ±50 kHz : TLR0 = TLR1 = 0
 - High-speed locking charge wait time = 5 μs : CWS0 = 1, CWS1 = 0
 - High-speed locking completion flag output wait time = 400 μs : HSE0 = 0, HSE1 = 1
 - Unlock detection width = ±0.43 μs : UL0 = 0, UL1 = 1

[IN1]



[IN2]



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2. In the case of AMRF 530 kHz reception ($X^{\text{tal}} = 10.35 \text{ MHz}/\text{IF} = 10.8 \text{ MHz}$)

AM VCO = 11.330 MHz

$X^{\text{tal}} = 10.35 \text{ MHz}$, $f_{\text{ref}} = 10 \text{ kHz}$: XS = 1, R0 = R1 = R2 = 0, R3 = 1

X^{tal} Buffer ON : XB = 1

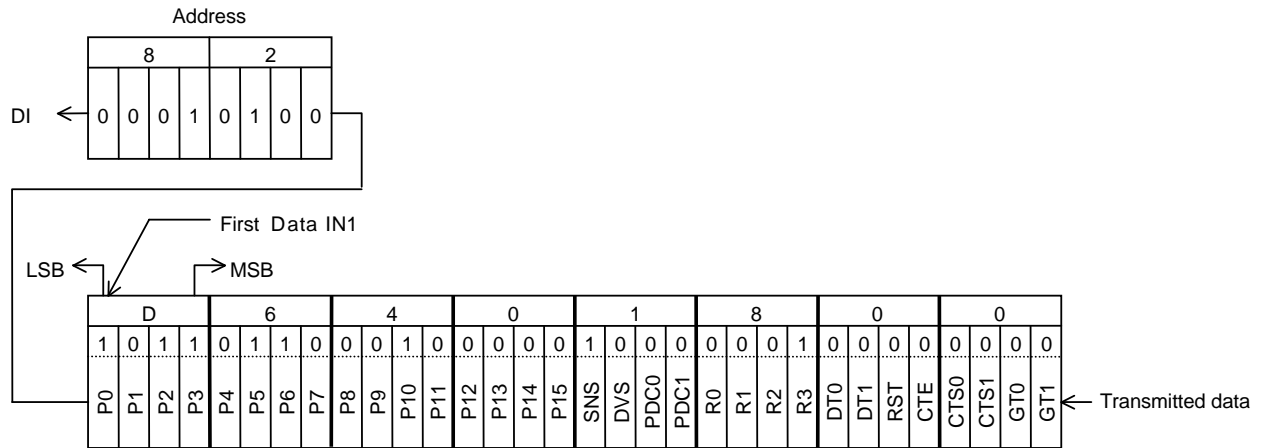
AMIN selected : DVS = 0, SNS = 1

Dead-zone mode = DZD : DZ0 = DZ1 = 1

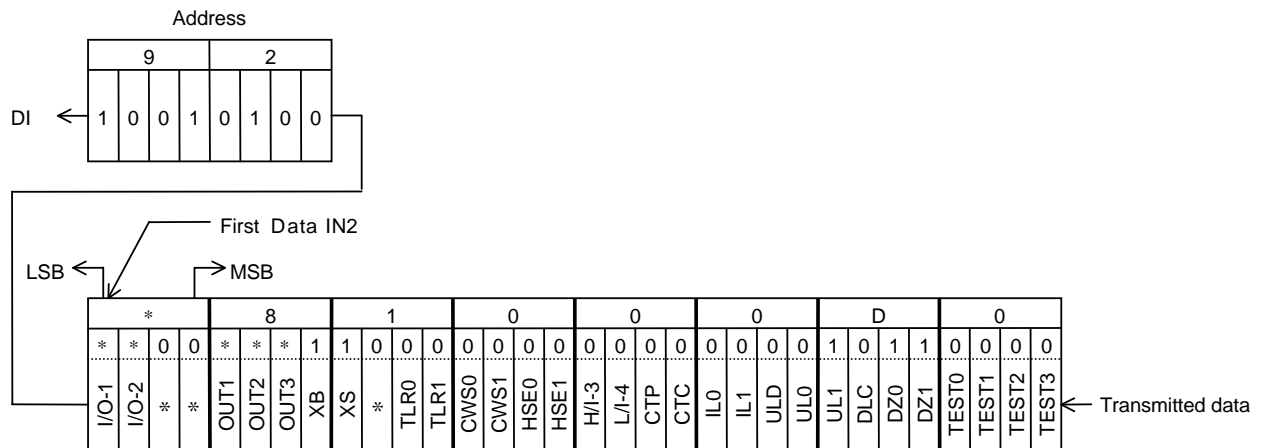
Programmable divider divisor

$11.330 \text{ MHz} \div 10 \text{ kHz} = 1133 \rightarrow 046\text{D}$ (Hex)

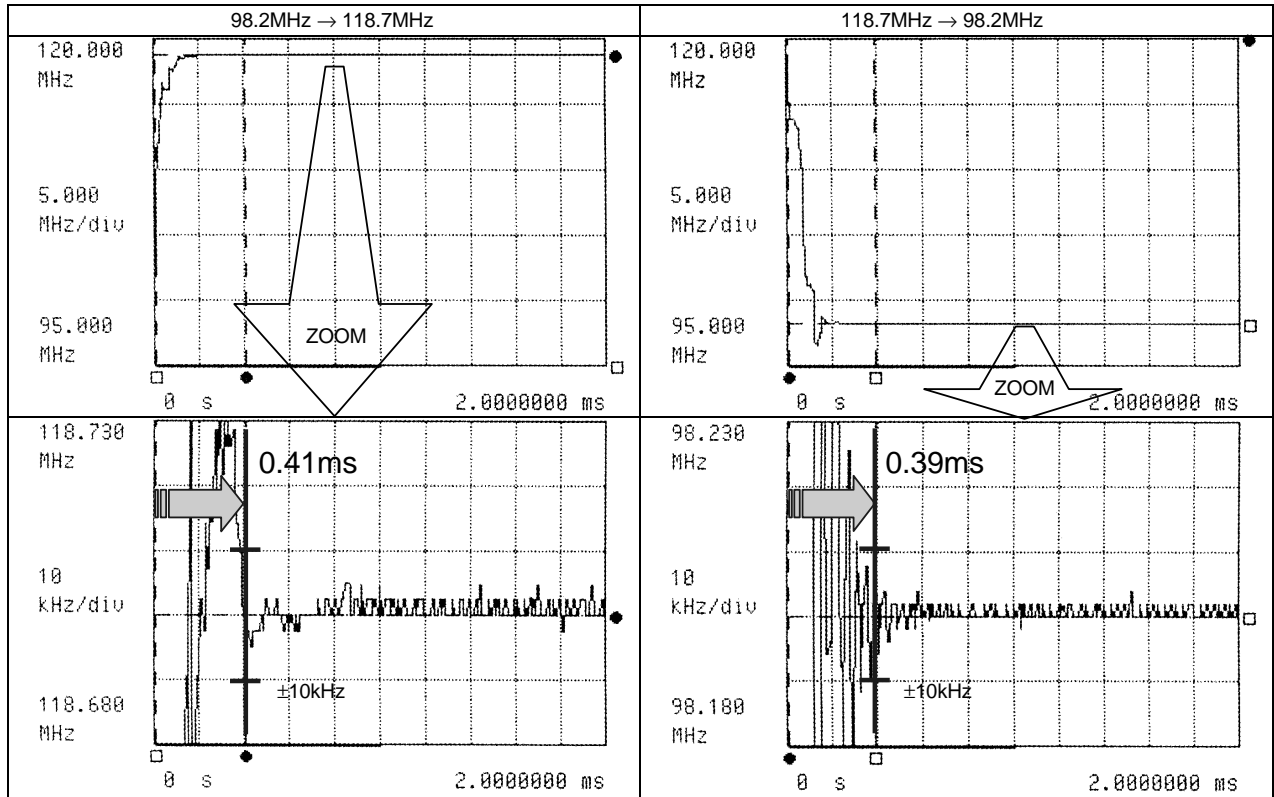
[IN1]



[IN2]



Locking time (Reference data)



*: Data here are measured using a SANYO evaluation board with the peripheral circuits and state setting shown in the Sample Application Circuit and the LC72151V State Setting Examples.

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