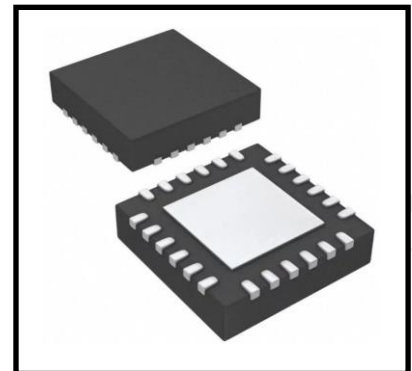




# INS6110 —1: 10 Low-Jitter Clock Buffer

## FEATURES

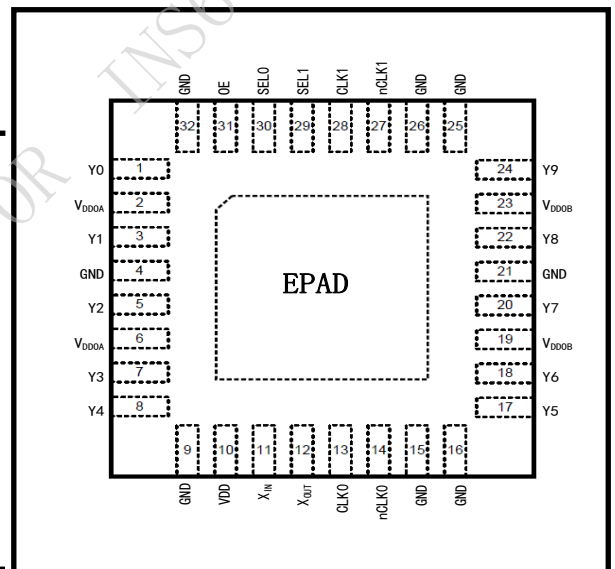
- 10 Single-Ended LVCMOS Outputs (DC~200MHz)
- 3 Clock Inputs
  - 2 Differential or Single-Ended Inputs (DC~200MHz)
  - 1 Crystal Input (8~50MHz) or Single-Ended (DC~50MHz)
- Additive Phase Noise/Jitter: 50fs RMS(Typ.)@25MHz (12KHz~20MHz)
- Output Power Supply: 1.5V, 1.8V, 2.5V or 3.3V
- Core Power Supply: 2.5V or 3.3V
- Temperature: -40°C~+85°C
- Package: QFN32 (5.0mm x 5.0mm x 0.75mm)
- RoHS



## APPLICATIONS

- High-Speed Clock Distribution
- Wireless and Wired Communications
- Medical Imaging
- Measurement

## DESCRIPTION



The INS6110 is a low-jitter clock fan-out buffer. It can distribute to ten LVCMOS clock outputs from one clock input which is selected from two differential/single-ended clock inputs and a crystal input.



### Revision History

| Version | Change Contents  | Prepared by | Revised Date |
|---------|--|-------------|--------------|
| V1.0    | First Version  |             | 2021.05.25   |
| V1.1    | 1. Change the height from $0.9 \pm 0.1\text{mm}$ to $0.75 \pm 0.05\text{mm}$<br>2. Change the size of thermal pad<br>3. Update the table 10. |             | 2021.10.29   |
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FOR INS6110



## 1 Description

The INS6110 is a low-jitter clock fan-out buffer. It can distribute to ten LVCMOS clock outputs from one clock input which is selected from two differential/single-ended clock inputs and a crystal input.

Based on advanced CMOS technology and process, the INS6110 can output 10 LVCMOS clocks with low-jitter, low-skew and low propagation-delay. The input clock frequency range is from DC to 200MHz. The INS6110 could flexibly realize the clock signal level shifter with a 3.3V/2.5V core power and two flexible 3.3V/2.5V/1.8V/1.5V output powers.

Such a buffer is good for use in wireless and wired communications, medical imaging, measurement, etc.

The INS6110 package is QFN32(5.0mm x 5.0mm x 0.75mm).

## 2 Block Diagram & Pin Assignment

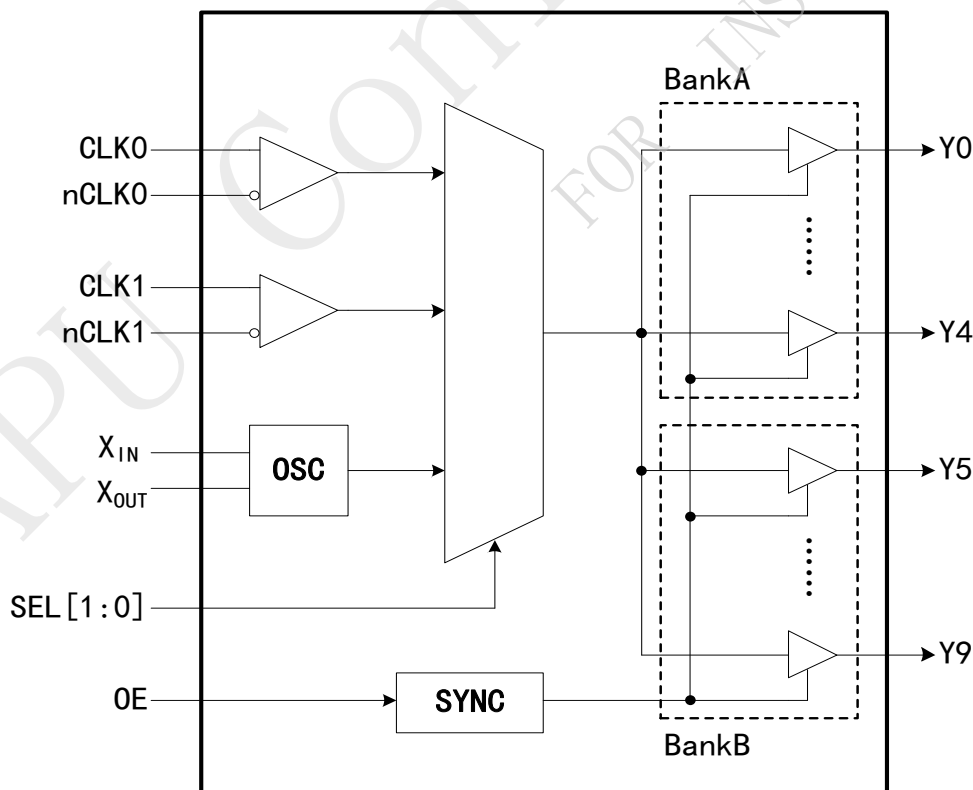


Figure 1. Block Diagram

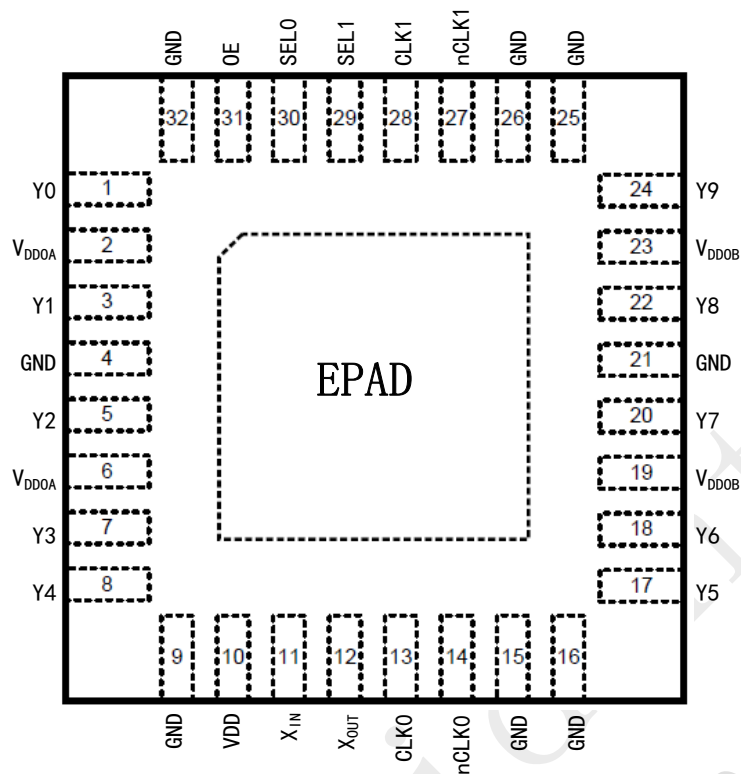


Figure 2. Pin Assignment

Table 1. Pin Descriptions

| Number                       | Name              | Type | Description                             |
|------------------------------|-------------------|------|---|
| 1                            | Y0                | OUT  | LVCOS Clock Output0                     |
| 2, 6                         | V <sub>DDOA</sub> | PWR  | BankA Output Supply                     |
| 3                            | Y1                | OUT  | LVCOS Clock Output 1                    |
| 4, 9, 15, 16, 21, 25, 26, 32 | GND               | GND  | GND                                     |
| 5                            | Y2                | OUT  | LVCOS Clock Output 2                    |
| 7                            | Y3                | OUT  | LVCOS Clock Output 3                    |
| 8                            | Y4                | OUT  | L LVCOS Clock Output 4                  |
| 10                           | V <sub>DD</sub>   | PWR  | Core Power Supply                       |
| 11                           | X <sub>IN</sub>   | IN   | Crystal Input                           |
| 12                           | X <sub>OUT</sub>  | OUT  | Crystal Output                          |
| 13                           | CLK0              | IN   | Non-inverting differential input clock0 |
| 14                           | nCLK0             | IN   | Inverting differential input clock0     |
| 17                           | Y5                | OUT  | LVCOS Clock Output 5                    |
| 18                           | Y6                | OUT  | LVCOS Clock Output 6                    |
| 19, 23                       | V <sub>DDOB</sub> | PWR  | BankB Output Supply                     |



|    |       |     |  |
|----|-------|-----|--|
| 20 | Y7    | OUT | LVC MOS Clock Output 7   |
| 22 | Y8    | OUT | LVC MOS Clock Output 8   |
| 24 | Y9    | OUT | LVC MOS Clock Output 9   |
| 27 | nCLK1 | IN  | Inverting differential input clock1  |
| 28 | CLK1  | IN  | Non-inverting differential input clock1  |
| 29 | SEL1  | IN  | Input clock selection 1, pull down   |
| 30 | SELO  | IN  | Input clock selection 0, pull down   |
| 31 | OE    | IN  | Output enable, pull down<br>0: disable clock output,<br>High-Impedance<br>1: enable clock output |
|    | EPAD  |     | The Exposed thermal Pad. Must be connected with GND.   |

- \* IN: Input Signal  
 OUT: Output Signal  
 PWR: Power Supply  
 GND: Ground  
 EPAD: Exposed thermal PAD

### 3 Electric Parameter

Table 2. Absolute Maximum Ratings

Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

| Parameter                    | Symbol                               | Rating                        | Unit | Comments |
|------------------------------|--------------------------------------|-------------------------------|------|----------|
| Power Supply                 | $V_{DD}$<br>$V_{DDOA}$<br>$V_{DDOB}$ | -0.5~4.6                      | V    |          |
| Input Voltage                | $V_{IN}$                             | -0.5~ $V_{DD}+0.5$            | V    |          |
| Output Voltage               | $V_{OUT}$                            | -0.5~ $V_{DDOA}/V_{DDOB}+0.5$ | V    |          |
| Storage Temperature Range    | $T_{STG}$                            | -65~150                       | °C   |          |
| Maximum Junction Temperature | $T_J$                                | 125                           | °C   |          |
| Thermal Impedance            | $\theta_{JA}$                        | 50                            | °C/W |          |

Table3 Recommended Operating Conditions



Test Condition:  $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ ; It is recommended that the chip operates with the rated electrical range indicated in the table below.

| Parameter                                | Symbol           | Value |      |       | Unit               | Comments                          |
|--|------------------|-------|------|-------|--------------------|-----------------------------------|
|  |                  | Min.  | Typ. | Max.  |                    |                                   |
| Core Power Supply                        | $V_{DD}$         | 3.135 | 3.3  | 3.465 | V                  |                                   |
|  |                  | 2.375 | 2.5  | 2.625 |                    |                                   |
| Output Supply                            | $V_{DDOX}^{(1)}$ | 3.135 | 3.3  | 3.465 | V                  |                                   |
|  |                  | 2.375 | 2.5  | 2.625 |                    |                                   |
|  |                  | 1.6   | 1.8  | 2     |                    |                                   |
|  |                  | 1.35  | 1.5  | 1.65  |                    |                                   |
| Static Device Current                    | $I_{VDD}$        |       | 14   |       | mA                 | $V_{DD}/V_{DDOX}=3.3V$            |
|  |                  |       | 8    |       | mA                 | $V_{DD}/V_{DDOX}=2.5V$            |
|  |                  |       | 20   |       | mA                 | Crystal input                     |
| Power dissipation capacitance per output | $C_{PD}^{(1)}$   |       | 9    |       | pF                 | $V_{DDOX} = 3.3V, F_{OUT}=100MHz$ |
|  |                  |       | 8.5  |       | pF                 | $V_{DDOX} = 2.5V, F_{OUT}=100MHz$ |
|  |                  |       | 8    |       | pF                 | $V_{DDOX} = 1.8V, F_{OUT}=100MHz$ |
|  |                  |       | 7.5  |       | pF                 | $V_{DDOX} = 1.5V, F_{OUT}=100MHz$ |
| Operating Temperature Range              | $T_A$            | -40   |      | 85    | $^{\circ}\text{C}$ |                                   |

\* (1) DDOX: DDOA/DDOB

Table 4. Control Signal Characteristics

Test Condition:  $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ ,  $2.375V \leq V_{DD} \leq 3.465V$ ,  $1.35V \leq V_{DDOX} \leq V_{DD}$ ,  $F_{IN/OUT}=100MHz$ ;  
Unless otherwise noted.

| Parameter                        | Symbol   | Value              |      |                    | Unit          | Comments |
|----------------------------------|----------|--------------------|------|--------------------|---------------|----------|
|                                  |          | Min.               | Typ. | Max.               |               |          |
| Control Signals (OE, SEL0, SEL1) |          |                    |      |                    |               |          |
| Input High Current               | $I_{IH}$ |                    |      | 40                 | $\mu\text{A}$ |          |
| Input Low Current                | $I_{IL}$ | -40                |      |                    | $\mu\text{A}$ |          |
| Input High Voltage               | $V_{IH}$ | $0.7 \cdot V_{DD}$ |      |                    | V             |          |
| Input Low Voltage                | $V_{IL}$ |                    |      | $0.3 \cdot V_{DD}$ | V             |          |

Table 5. CLKx/nCLKx<sup>(2)</sup> Characteristics

Test Condition:  $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ ,  $2.375V \leq V_{DD} \leq 3.465V$ ,  $1.35V \leq V_{DDOX} \leq V_{DD}$ ,  $F_{IN/OUT}=100MHz$ ;  
Unless otherwise noted.

| Parameter | Symbol | Value |      |      | Unit | Comments |
|-----------|--------|-------|------|------|------|----------|
|           |        | Min.  | Typ. | Max. |      |          |



| CLKx/nCLKx DC Characteristic                               |                |              |    |               |     |                  |
|--|----------------|--------------|----|---------------|-----|------------------|
| Input High Current   | $I_{IH}$       |              |    | 40            | uA  | $V_{CLK}=V_{DD}$ |
| Input Low Current  | $I_{IL}$       | -40          |    |               | uA  | $V_{CLK}=0V$     |
| Single-Ended Input DC Characteristic (CLKx) <sup>(3)</sup> |                |              |    |               |     |                  |
| Input High Voltage   | $V_{IH}$       | $0.7*V_{DD}$ |    | $V_{DD}+0.3$  | V   |                  |
| Input Low Voltage  | $V_{IL}$       | -0.3         |    | $0.3*V_{DD}$  | V   |                  |
| Differential Input DC Characteristic (CLK/nCLK)            |                |              |    |               |     |                  |
| Differential Input Voltage Swing                           | $V_{ID}$       | 0.15         |    | 1.3           | V   |                  |
| Input Common-mode Voltage                                  | $V_{CM}^{(4)}$ | 0.5          |    | $V_{DD}-0.85$ | V   |                  |
| AC Characteristic (CLK/nCLK)                               |                |              |    |               |     |                  |
| Input frequency  | $F_{IN}$       | 0            |    | 200           | MHz |                  |
| Input duty cycle   | Duty Cycle     | 40           | 50 | 60            | %   |                  |

\* (2) CLKx/nCLKx: CLK0/nCLK0 和 CLK1/nCLK1

(3) When Differential Input with Single-Ended Interconnect, nCLK must be AC coupled to GND or reference bias voltage to meet  $V_{CM}$ .

(4) When input signal's common-mode voltage is bigger than  $V_{CM}$ 's Max., must be AC coupled.

Table 6.  $X_{IN}/X_{OUT}$  Characteristics

Test Condition:  $-40^{\circ}C \leq T_A \leq 85^{\circ}C$ ,  $2.375V \leq V_{DD} \leq 3.465V$ ,  $1.35V \leq V_{DDOX} \leq V_{DD}$ ; Unless otherwise noted.

| Parameter                                     | Symbol         | Value |             |      | Unit     | Comments |
|---|----------------|-------|-------------|------|----------|----------|
|   |                | Min.  | Typ.        | Max. |          |          |
| Crystal                                       |                |       |             |      |          |          |
| Mode of Crystal                               |                |       | Fundamental |      |          |          |
| Frequency                                     | $F_{XIN/XOUT}$ | 8     |             | 50   | MHz      |          |
| Equivalent Series Resistance                  | ESR            |       | 50          |      | $\Omega$ |          |
| Maximum Shunt Capacitance                     | $C_{XO}$       |       | 7           |      | pF       |          |
| Drive Level                                   | $P_{XIN}$      |       | 100         |      | uW       |          |
| XIN/XOUT Characteristics                      |                |       |             |      |          |          |
| Chip Capacitance                              | $C_{ONCHIP}$   |       | 12          |      | pF       |          |
| Single-Ended Characteristics (Overdrive Mode) |                |       |             |      |          |          |





|  |             |              |  |              |     |                        |
|--|-------------|--------------|--|--------------|-----|------------------------|
| Frequency                                  | $F_{XIN}$   |              |  | 50           | MHZ | X <sub>OUT</sub> float |
| Input signal swing                         | $V_{SWING}$ |              |  | 2            | V   |                        |
| Single-Ended Characteristics (Bypass Mode) |             |              |  |              |     |                        |
| Frequency                                  | $F_{XIN}$   |              |  | 50           | MHZ | X <sub>OUT</sub> float |
| Input High Voltage                         | $V_{XINH}$  | $0.7*V_{DD}$ |  | $V_{DD}+0.3$ | V   |                        |
| Input Low Voltage                          | $V_{XINL}$  | -0.3         |  | $0.3*V_{DD}$ | V   |                        |

Table 7. LVCMOS Characteristics <sup>(5)</sup>

Test Condition:  $-40^{\circ}C \leq T_A \leq 85^{\circ}C$ ,  $2.375V \leq V_{DD} \leq 3.465V$ ,  $1.35V \leq V_{DDOX} \leq V_{DD}$ ,  $F_{IN/OUT}=100MHz$ ,  $C_L=5pF//50\Omega$ ; Unless otherwise noted.

| Parameter           | Symbol                        | Value          |      |                | Unit     | Comments                                       |
|---------------------|-------------------------------|----------------|------|----------------|----------|--|
|                     |                               | Min.           | Typ. | Max.           |          |  |
| Output High Voltage | $V_{OH}$                      | $0.8*V_{DDOX}$ |      |                | V        | $V_{DDOX}=2.375\sim 3.465V$                    |
|                     |                               | $0.7*V_{DDOX}$ |      |                | V        | $V_{DDOX}=1.35\sim 2V$                         |
| Output High Voltage | $V_{OL}$                      |                |      | $0.2*V_{DDOX}$ | V        | $V_{DDOX}=2.375\sim 3.465V$                    |
|                     |                               |                |      | $0.3*V_{DDOX}$ |          | $V_{DDOX}=1.35\sim 2V$                         |
| Output impedance    | $R_0$                         |                | 15   |                | $\Omega$ | $V_{DDOX}=3.3V$                                |
|                     |                               |                | 20   |                | $\Omega$ | $V_{DDOX}=2.5V$                                |
|                     |                               |                | 25   |                | $\Omega$ | $V_{DDOX}=1.8V$                                |
|                     |                               |                | 30   |                | $\Omega$ | $V_{DDOX}=1.5V$                                |
| Output Frequency    | $F_{OUT}$                     | 0              |      | 200            | MHZ      |  |
| Duty Cycle          | Duty Cycle                    | 45             | 50   | 55             | %        |  |
| Output Skew         | $t_{Skew}^{(6)}$              |                | 30   | 50             | ps       |  |
| Part-to-part skew   | $t_{PDP}^{(6)}$               |                |      | 2              | ns       |  |
| Output Delay        | $t_{Delay}$                   | 1.5            | 1.95 | 4.0            | ns       | $V_{DD}=3.3V$<br>$V_{DDOX}=1.35V \sim V_{DD}$  |
|                     |                               | 1.8            | 2.4  | 4.4            | ns       | $V_{DD}=2.5V$<br>$V_{DDOX}=1.35V \sim V_{DD}$  |
| Rise/Fall Time      | $t_{Rise}$<br>/<br>$t_{Fall}$ |                | 250  |                | ps       | $V_{DD}=3.3V$<br>$V_{DDOX}=1.8V$<br>$C_L=10pF$ |
|                     |                               |                | 275  |                | ps       | $V_{DD}=2.5V$<br>$V_{DDOX}=2.5V$<br>$C_L=10pF$ |
|                     |                               |                | 315  |                | ps       | $V_{DD}=3.3V$<br>$V_{DDOX}=3.3V$<br>$C_L=10pF$ |



|                                 |           |    |   |       |  |
|---------------------------------|-----------|----|---|-------|--|
| Additive RMS Phase Jitter (RMS) | $t_J$     | 50 |   | fS    | $F_{OUT}=25MH$<br>Input skew rate $\geq$<br>2V/ns<br>$C_L=5pF$<br>12kHz to 20MHz |
| Output enable or disable time   | $t_{EN}$  |    | 2 | Cycle |  |
| MUX isolation                   | Isolation | 55 |   | dBc   | 125MHz   |

\* (5) LVCMOS AC Parameters are dependent upon output capacitive loading

(6) Parameter is specified by design, not tested in production

## 4 Function Description

### Control Signals

The INS6110 has 3 control signals: SEL0, SEL1 and OE.

SEL0, SEL1: Clock input selection is controlled using the SEL0 and SEL1 as shown in Table 8.

Table 8. Input Selection

| SEL1 | SEL0 | Input Clock                        |
|------|------|------------------------------------|
| 0    | 0    | CLK0/nCLK0                         |
| 0    | 1    | CLK1/nCLK1                         |
| 1    | 0    | $X_{IN}/X_{OUT}$ or Overdrive Mode |
| 1    | 1    | Bypass Mode                        |

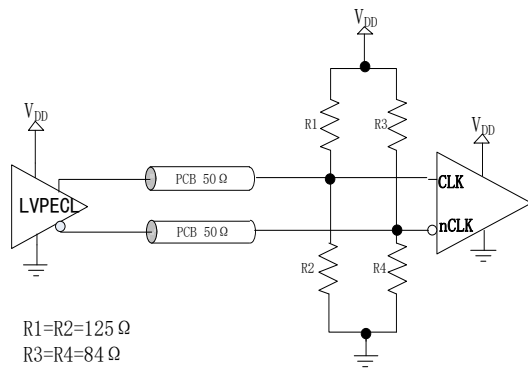
Overdrive Mode: LVCMOS drives  $X_{IN}$  with AC couple

Bypass Mode: LVCMOS drives  $X_{IN}$  with DC couple

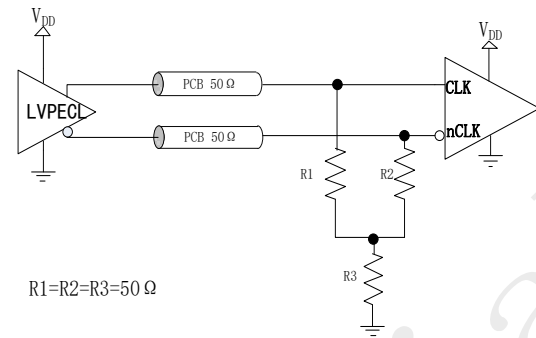
OE: Output Enable. When OE is held high, the output clocks are enabled. When it is held low, the output clocks are held in a high-impedance state as shown in Table 10.

### Input Clock

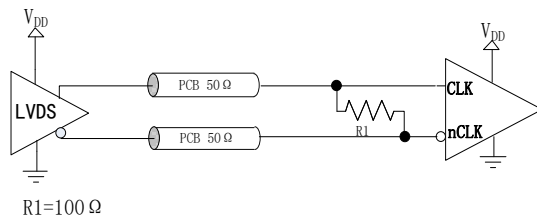
**Differential Input (CLK/nCLK)** : The CLK/nCLK accepts LVDS, LVPECL, SSTL, HCSL differential signals. Signals must meet the characteristics in Table 5. Figures 3 show interface examples for the CLK/nCLK input with built-in  $50\Omega$  terminations driven by the most common driver types.



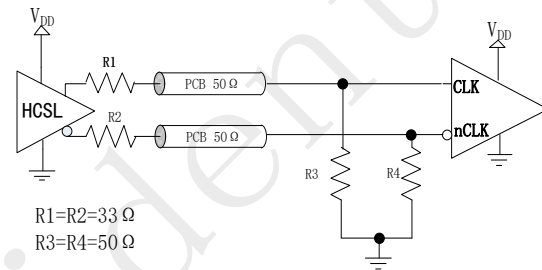
(a) LVPECL Input (Thevenin Parallel Termination)



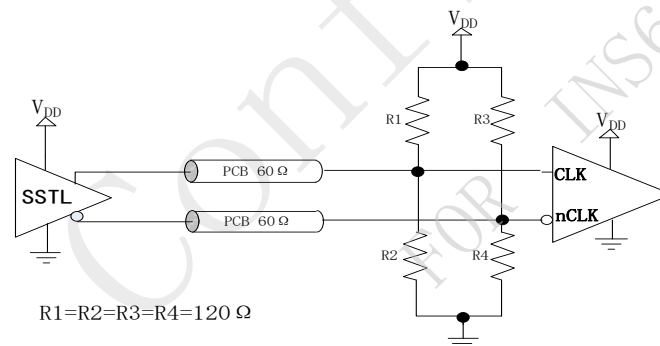
(b) LVPECL Input ("Y" Parallel Termination)



(c) LVDS Input



(d) HCSL Input



(e) SSTL Input

Figure 3. Differential Input Drives CLK/nCLK

Note

- A differential input signal is recommended over single-ended because it typically provides higher slew rate and common-mode noise rejection. It supports wider frequency range and brings better phase noise and jitter performance;
- When input signal's common-mode voltage is bigger than VCM's Max., must be AC coupled to meet characteristics in Table 5;
- For applications not requiring the use of the differential input, both CLK and nCLK can be left floating.



Single-Ended Input (CLK/nCLK): CLK/nCLK also supports LVCMOS input through couple circuit to meet characteristics in Table 5.

Refer to Figure 4, R1 is impedance matching of driver and is placed near the driver; When LVCMOS is 3.3V/2.5V, R2/R3(100Ω) is terminal impedance matching and is placed near the CLK pin; Because of half of the single-ended swing of the driver (VDD/2) drives CLK, nCLK should be externally biased to the midpoint voltage of the attenuated (VDD/2).

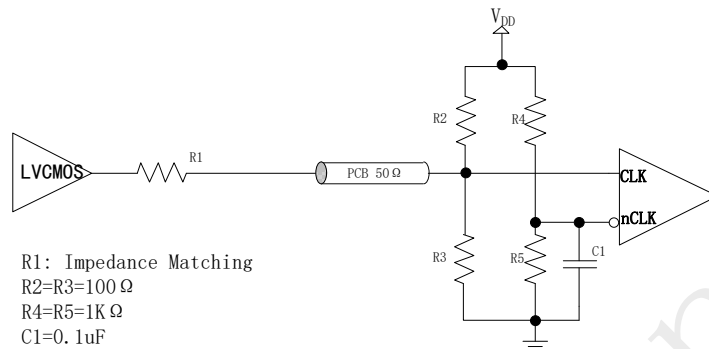


Figure 4. LVCMOS Drives CLK/nCLK

XIN/XOUT: Accept both crystal input and single-ended LVCMOS signals in overdrive and bypass modes. In overdrive mode, it is necessary to ac-couple the input with a capacitor (see Figure 5). Otherwise, in bypass mode, there is no requirement for a coupling capacitor.

When SEL1 is low level, XIN/XOUT could be left floating; When SEL1 is high level, XIN must not be left floating.

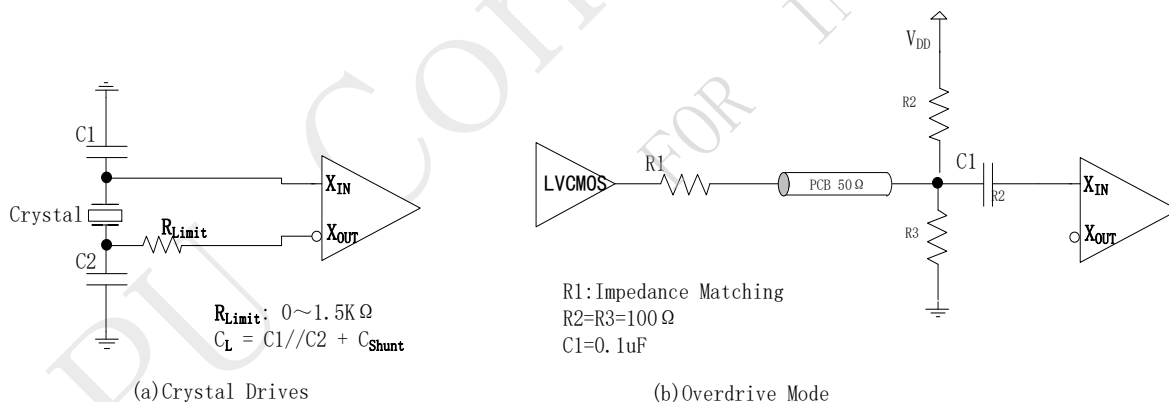


Figure 5. XIN/XOUT

### Output Clock

The INS6110 has two separated banks of clock output (Table 9).

Table 9. Bank of Clock Output

| Bank  | Output Clock       |
|-------|--------------------|
| BankA | Y0, Y1, Y2, Y3, Y4 |
| BankB | Y5, Y6, Y7, Y8, Y9 |

Output impedance is listed in Table 7.



Table 10. Clock Output States

| OE               | SEL[1]           | Input Clock                       | Output Clock           |
|------------------|------------------|-----------------------------------|------------------------|
| H <sup>(7)</sup> | 0                | CLKx=Open nCLKx=Open              | L                      |
|                  |                  | CLKx=H nCLKx=L                    | H                      |
|                  |                  | CLKx=L nCLKx=H                    | L                      |
|                  | 1                | X <sub>IN</sub> /X <sub>OUT</sub> | Active <sup>(10)</sup> |
| L <sup>(8)</sup> | X <sup>(9)</sup> | X                                 | High Impedance         |

- \* (7) H: High Level  
(8) L: Low Level  
(9) X: Do Not Care  
(10) Output Clock is depended on X<sub>IN</sub>/X<sub>OUT</sub>.

---

#### Note

- Unused outputs should be left floating
- 

### Power Supply

The INS6110 separates the core and the output power supplies which allow the output buffers to operate at the same supply as the core supply or at a lower supply voltage. Independent supplies could enable lower power consumption and output-level compatibility.

BankA (Y0–Y4) and BankB (Y5–Y9) may also be operated at different V<sub>DDOA</sub> and V<sub>DDOB</sub> voltages.

The core supply (V<sub>DD</sub>) supports 2.5V and 3.3V, and the output supplies (V<sub>DDOA</sub> and V<sub>DDOB</sub>) supports 3.3V, 2.5V, 1.8V, and 1.5V.

---

#### Note

- V<sub>DDOA</sub> and V<sub>DDOB</sub> must not exceed V<sub>DD</sub>.
  - Don't connect V<sub>DDOA</sub>/V<sub>DDOB</sub> to ground.
-



## 5 Environment

Table 11. Environment

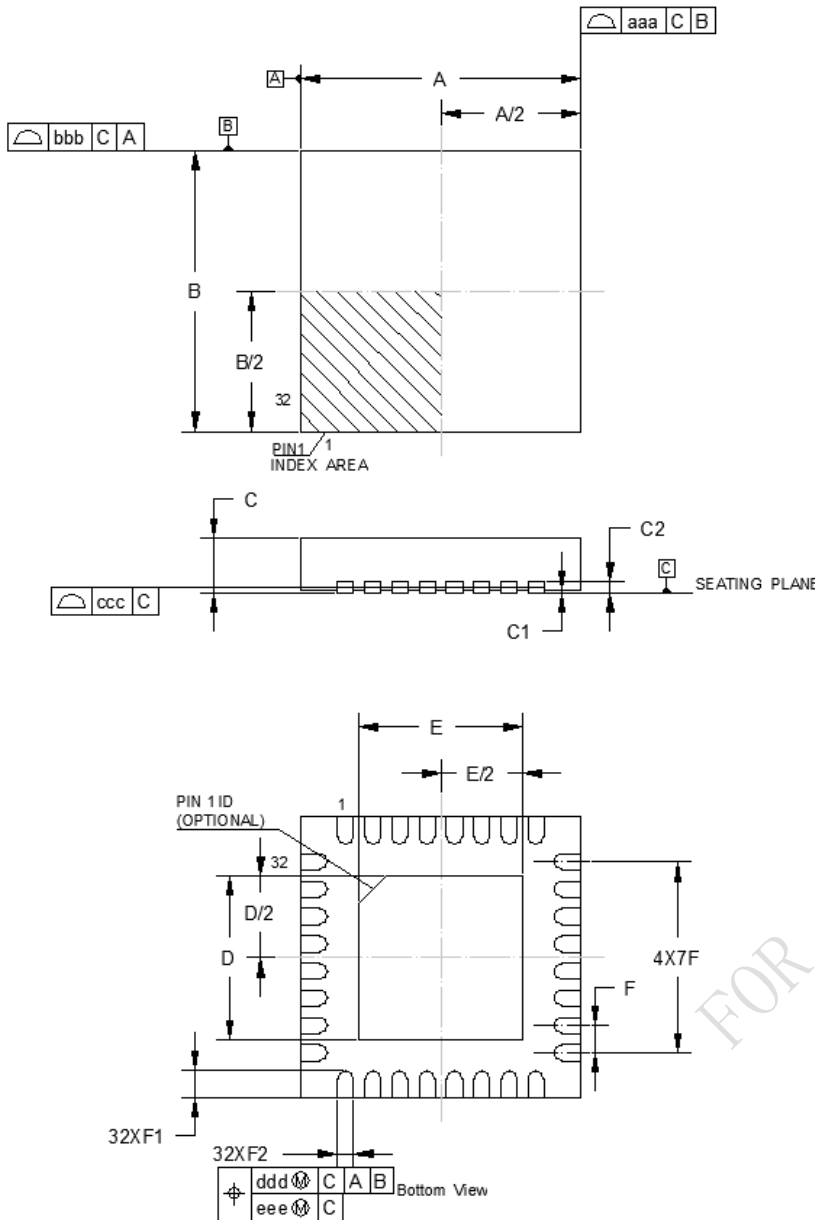
| Attribute            | Value   | Unit | Comments                                      |
|----------------------|---------|------|---|
| ESD Level            | ±2500V  | V    | HBM, refer to ANSI/ESDA/JEDEC JS-001          |
|                      | ±1000V  | V    | CDM, refer to JEDEC specification JESD22-C101 |
| Moisture Sensitivity | Level 3 |      |   |
| RoHS                 | RoHS2.0 |      |   |

\* HBM: Human body model

CDM: Charged-device model



## 6 Package Dimensions



| Dimensions | Min. | Typ. | Max. |
|------------|------|------|------|
| A          | 4.85 | 5.00 | 5.15 |
| B          | 4.85 | 5.00 | 5.15 |
| C          | 0.70 | 0.75 | 0.80 |
| C1         | --   | --   | 0.05 |
| C2         | --   | --   | 0.20 |
| D          | 3.30 | 3.40 | 3.50 |
| E          | 3.30 | 3.40 | 3.50 |
| F          | --   | 0.50 | --   |
| F1         | 0.30 | 0.40 | 0.50 |
| F2         | 0.18 | --   | 0.30 |
| aaa        | --   | --   | 0.15 |
| bbb        | --   | --   | 0.10 |
| ccc        | --   | --   | 0.08 |
| ddd        | --   | --   | 0.10 |
| eee        | --   | --   | 0.10 |

Figure 6. Package Outline (QFN32)

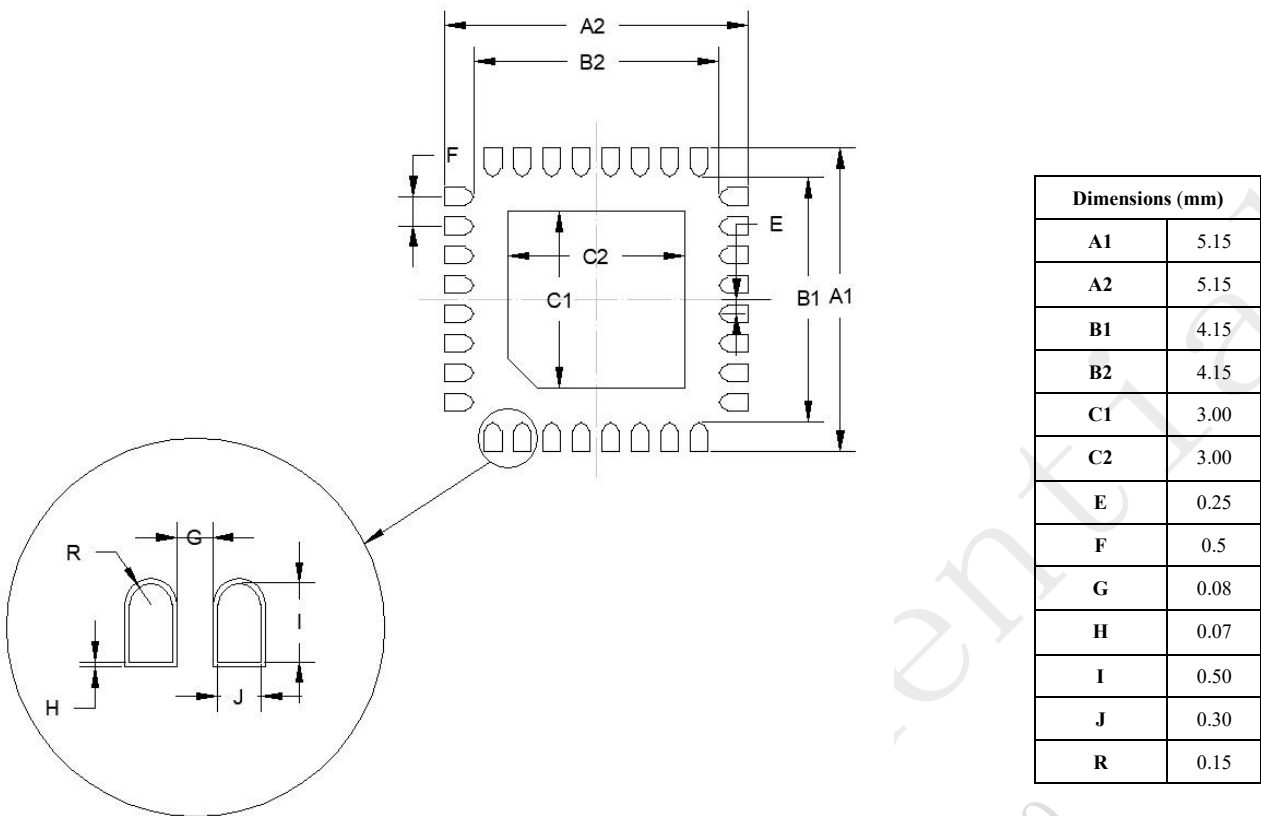


Figure 7. SOLDERING FOOTPRINT RECOMMENDED (QFN32)

Note:

1. All linear dimensions are in millimeters.
2. EPAD must be soldered to PCB