



## Universal Serial Bus Transceiver with Level Translator

### Features

- Complies with USB Specification Rev 1.1 & 2.0.
- Supports Full (12Mbit/s) speed.
- Integrated 5V to 3.3V regulator.
- Used as a USB device transceiver.
- VBUS disconnection indication through VP, VM.
- Two single-ended receivers with hysteresis.
- USB Detection of VBUS via level translator.
- Stable RCV output during SE0 condition.
- Low power operation.
- Supports 1.65 to 3.3V I/O voltage levels.
- Full industrial operating range -40 to 85 °C.
- Available in small HBCC16 Package.

### Applications

- Mobile Phones.
- Digital still cameras.
- PDA (Personal Digital Assistant).
- IA (Information Appliance).

### Product Description

The CM240001HB Universal Serial Bus (USB) transceiver is fully compliant with the USB specification Rev 1.1 and 2.0. It supports a speed of 12Mbits/s (Full Speed).

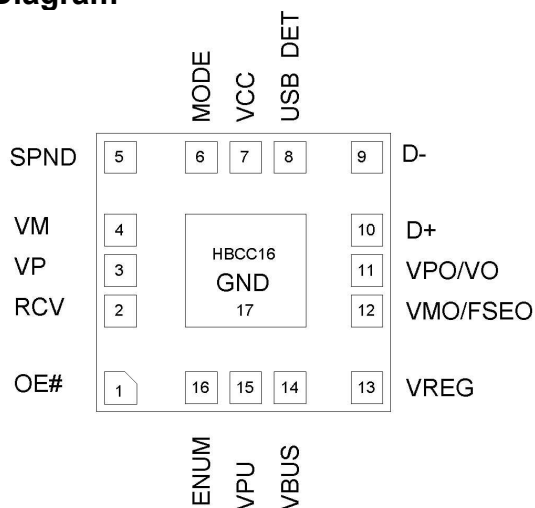
An internal level shifter allows interface to Application specific IC's (ASIC's) and Programmable logic devices (PLD's) running at core voltages of 1.65 to 3.3V.

An internal 5-3.3V regulator is used to power the CM240001HB USB transceiver via the USB supply V<sub>BUS</sub>.

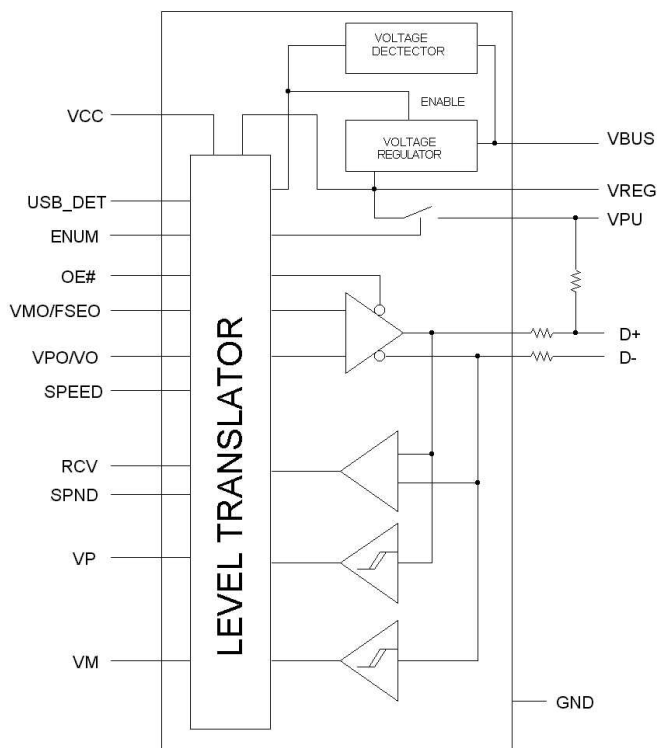
Single and differential input modes are selectable by a mode input pin.

This device is ideal for portable electronic devices such as mobile phones, digital still cameras, PDA (Personal Digital Assistants) and IA (Information Appliances).

### Pin Diagram



### Functional Diagram



### STANDARD PART ORDERING INFORMATION

| Package |        | Ordering Information |              |
|---------|--------|----------------------|--------------|
| Pads    | Style  | Tape & Reel          | Part Marking |
| 16      | HBCC16 |                      |              |



## Pin Functions

| Pin | Symbol           | Description                                                                                                                                                                                                                          |
|-----|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | OE#              | Input for Output enable (Active low) Enables transceiver driver to transmit data on the USB bus. When OE# pin = LOW driver circuitry is enabled.                                                                                     |
| 2   | RCV              | Differential receiver output of D+ and D- input data lines. The output state of RCV is preserved and stable during an SE0 condition.                                                                                                 |
| 3   | VP               | Single-ended D+ receiver output for detection of a single ended zero or error conditions                                                                                                                                             |
| 4   | VM               | Single-ended D- receiver output for detection of a single ended zero or error conditions.                                                                                                                                            |
| 5   | SPND             | Suspend input. Allows the device to enter a low power state while the USB is inactive.                                                                                                                                               |
| 6   | MODE             | Mode input. Selects between differential (VPO, VMO) and single-ended mode (VO, FSEO).                                                                                                                                                |
| 7   | V <sub>CC</sub>  | Supply voltage for digital I/O pins. Voltages supported: 1.65 to 3.3V.                                                                                                                                                               |
| 8   | USB_DET          | I/O level USB detect Output. Logic High indicates that a USB cable is present.                                                                                                                                                       |
| 9   | D-               | Negative USB data connection.                                                                                                                                                                                                        |
| 10  | D+               | Positive USB data connection. Full speed connect mode, connect V <sub>PU</sub> via a 1.5kΩ resistor. Tolerance of this resistor is defined in the USB specification REV 1.1 & 2.0                                                    |
| 11  | VPO/VO           | Driver data input.                                                                                                                                                                                                                   |
| 12  | VMO/FSEO         | Driver data input.                                                                                                                                                                                                                   |
| 13  | V <sub>REG</sub> | Regulated supply voltage output during USB operation of VBUS. 1uF decoupling capacitor is required.                                                                                                                                  |
| 14  | V <sub>BUS</sub> | Supply voltage input. Can be directly connected to USB VBUS.                                                                                                                                                                         |
| 15  | V <sub>PU</sub>  | Pull-up supply voltage. Pin function is controlled by input ENUM.                                                                                                                                                                    |
| 16  | ENUM             | Enumerate, allows software to control connection of the external pull-up via the level translator. If ENUM = LOW then V <sub>PU</sub> is floating. If ENUM = HIGH then V <sub>PU</sub> is internally connected to V <sub>REG</sub> . |
| 17  | GND              | The ground terminal is connected to the exposed diepad (heatsink).                                                                                                                                                                   |

## Functional Description:

The CM240001HB USB Transceiver supports 3 different power supply configurations, which can be configured dynamically. *Table 1* details the various configurations. In **Normal Mode** the internal regulator produces 3.3V from V<sub>BUS</sub> to power the internal drivers and receivers associated with the USB protocol.

In **Disable** and **Sharing Mode**, all input/output pins follow the states defined in *Table 2*.

*Table 3* lists the functions of the modes associated with suspend and OE# pins. When Suspend is low and OE# is high, signal levels on D+ and D- are determined by other USB devices and pull-up/down resistors. In **Suspend Mode** (SPND = HIGH) the differential receiver is inactive and output RCV is always LOW. Out of suspend signaling is detected via the single-ended receivers VP and VM. During suspend and while the output is still enabled (OE# = LOW), D+ and D- lines are driven to their intended states. This is permitted because driving during suspend is used to signal remote wake-up by driving a 'K' signal for a period of 1 to 15ms.

Detailed in *Table 4.1* and *4.2* are the operating modes selected when MODE is set to HIGH and LOW. When

MODE = HIGH, the differential input data interface mode is selected. The 2 driver inputs function as VMO and VPO. When MODE = LOW, the single-ended input data interface mode is selected. The 2 driver inputs function as FSEO and VO.

*Table 5* details the receiving function when OE# is HIGH (driver disabled). RCV denotes the signal level on the output RCV just before an SE0 state occurs. This level is stable during the SE0 period.

Detection of a VBUS voltage is accomplished via an internal Comparator with hysteresis. The output from this Comparator is fed via the level translator to ensure compatibility with processor core voltages and output to pin USB\_DET. When VBUS is over 4.1 volts USB\_DET is HIGH. When VBUS is under 3.6 volts USB\_DET is LOW.

The CM240001HB USB transceiver includes an enumeration pin (ENUM) which internally connects V<sub>PU</sub> to V<sub>REG</sub> when enabled. This allows a processor running at a core voltage different than 3.3V to switch the pull-up resistor in and out without the need for external circuitry.


**Power Supply Configurations: Table 1**

| V <sub>BUS</sub> | V <sub>CC</sub> | Configuration |
|------------------|-----------------|---------------|
| Connected        | Connected       | Normal Mode   |
| Connected        | Not Connected   | Disable Mode  |
| Not Connected    | Connected       | Sharing Mode  |

**Pin states in Disable or Sharing mode: Table 2**

| Pin              | Sharing Mode State      | Disable Mode state |
|------------------|-------------------------|--------------------|
| V <sub>BUS</sub> | V <sub>BUS</sub> < 3.6V | 4.1v to 5.5v       |
| V <sub>REG</sub> | Pulled Down             | 3.3v Out           |
| V <sub>CC</sub>  | Present                 | Not Present        |
| V <sub>PU</sub>  | High-Z (off)            | High-Z(off)        |
| D+, D-           | High-Z                  | High-Z             |
| VP, VM           | H                       | Invalid            |
| RCV              | L                       | Invalid            |
| USB_DET          | L                       | Invalid            |
| Inputs           | High-Z                  | High-Z             |

**Function Selection: Table 3**

| SUSPEND | OE# | D+/D-                    | RCV                 | VP/VM  | Function                                                   |
|---------|-----|--------------------------|---------------------|--------|------------------------------------------------------------|
| L       | L   | Driver & receiver active | Active              | Active | Normal driving mode<br>Differential receiver active        |
| L       | H   | Receiving                | Active              | Active | Driver tri-stated<br>Differential receiver active          |
| H       | L   | Driving                  | Inactive<br>RCV = L | Active | Driving during 'suspend'<br>Differential receiver inactive |
| H       | H   | High-Z                   | Inactive<br>RCV = L | Active | Low-power state                                            |

**Operating Mode (OE# = L): Table 4.1**

| MODE              | VO | FSE0 | Result    |
|-------------------|----|------|-----------|
| L<br>Single Ended | L  | L    | Logic '0' |
|                   | L  | H    | SE0       |
|                   | H  | L    | Logic '1' |
|                   | H  | H    | SE0       |

**Operating Mode (OE# = L): Table 4.2**

| MODE              | VP0 | VM0 | Result    |
|-------------------|-----|-----|-----------|
| H<br>Differential | L   | L   | SE0       |
|                   | L   | H   | Logic '0' |
|                   | H   | L   | Logic '1' |
|                   | H   | H   | Undefined |

**Receiving Function (SPND = L): Table 5**

| D+/D-                | RCV  | VP | VM |
|----------------------|------|----|----|
| Differential logic 0 | L    | L  | H  |
| Differential logic 1 | H    | H  | L  |
| SE0                  | RCV* | L  | L  |

NOTE: \* Denotes RCV is stable in last state before SE0 condition.



## Specifications:

| Absolute Maximum Ratings            |                               |      |
|-------------------------------------|-------------------------------|------|
| Parameter                           | Rating                        | Unit |
| ESD Protection (HBM) (All pins) [1] | 2000                          | V    |
| V <sub>BUS</sub>                    | -0.5 to +5.5                  | V    |
| V <sub>CC</sub>                     | -0.5 to +6.0                  | V    |
| V <sub>I</sub> (Input)              | -0.5 to V <sub>CC</sub> + 0.5 | V    |
| Temperature: Storage                | -40 to +150                   | °C   |
| Operating Junction                  | -40 to +150                   |      |

| Recommended Operating Conditions |                         |            |      |     |                 |      |
|----------------------------------|-------------------------|------------|------|-----|-----------------|------|
| Symbol                           | Parameter               | Conditions | MIN  | TYP | MAX             | UNIT |
| V <sub>BUS</sub>                 | USB VBUS Supply         |            | 4.1  | 5.0 | 5.5             | V    |
| V <sub>CC</sub>                  | DC System Supply        |            | 1.65 | 3.3 | 3.6             | V    |
| V <sub>I</sub>                   | DC Input Voltage        |            | 0    | -   | V <sub>CC</sub> | V    |
| V <sub>I(AI/O)</sub>             | Analog I/O pins (D+,D-) |            | 0    | -   | 3.6             | V    |
| T <sub>AMB</sub>                 | Operating Ambient       |            | -40  | -   | 85              | °C   |

| Static Operating Characteristics: Supply Pins (V <sub>BUS</sub> = 4.1 to 5.5V; V <sub>CC</sub> = 1.65 to 3.6V) |                                                |                                                         |     |     |       |      |
|----------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------|-----|-----|-------|------|
| Symbol                                                                                                         | Parameter                                      | Conditions                                              | MIN | TYP | MAX   | UNIT |
| V <sub>REG</sub>                                                                                               | Regulated supply output                        | Unloaded                                                | 3.0 | 3.3 | 3.6   | V    |
| I <sub>BUS</sub>                                                                                               | Operating supply current                       | Full-speed TX and RX;<br>C <sub>L</sub> = 50pF on D+/D- | -   | -   | 10.0  | mA   |
| I <sub>BUS(IDLE)</sub>                                                                                         | Supply current during full speed idle and SE0  | Full-speed idle: [2]                                    | -   | -   | 500.0 | μA   |
| I <sub>BUS(SUSP)</sub>                                                                                         | Suspend supply current                         | SPND = HIGH [2]                                         | -   | -   | 100.0 | μA   |
| I <sub>CC</sub>                                                                                                | Operating I/O supply current                   | Full-speed TX and RX                                    | -   | -   | 2.0   | mA   |
| I <sub>CC(STAT)</sub>                                                                                          | Static I/O supply current                      | Full-speed idle, SE0 or suspend                         | -   | -   | 10.0  | μA   |
| I <sub>CC(SHARE)</sub>                                                                                         | Supply current during share mode               | V <sub>BUS</sub> not connected                          | -   | -   | 10.0  | μA   |
| I <sub>DX(SHARE)</sub>                                                                                         | D+/D- load current during sharing mode         | V <sub>BUS</sub> not connected; ENUMERATE = LOW         | -   | -   | 10.0  | μA   |
| V <sub>TH(VBUS)</sub>                                                                                          | Vbus supply detection threshold. USB_D output. | Supply Lost(USB_D low)                                  | -   | -   | 3.6   | V    |
|                                                                                                                |                                                | Supply Present                                          | 4.1 | -   | -     | V    |
|                                                                                                                |                                                | V <sub>TH(VBUS)</sub> Hysteresis                        |     | 100 |       | mV   |
| V <sub>TH(VCC)</sub>                                                                                           | Vcc supply Detection threshold                 | Supply Lost                                             | -   | -   | 0.5   | V    |
|                                                                                                                |                                                | Supply Present                                          | 1.4 | -   | -     | V    |
|                                                                                                                |                                                | V <sub>TH(VCC)</sub> Hysteresis                         |     | 200 |       | mV   |

[1] Equivalent to discharging a 100pF capacitor via a 1.5kΩ resistor (Human body model).

[2] Excluding any load current and V<sub>Pu</sub>/V<sub>Sw</sub> source current to 1.5kΩ and 15kΩ pull-up and pull-down resistors (200 μA).



| Static Operating Characteristics: Digital Pins ( $V_{BUS} = 4.1$ to $5.5V$ ; $V_{CC} = 1.8V \pm 0.15V$ ) |                           |                                       |             |     |             |      |
|----------------------------------------------------------------------------------------------------------|---------------------------|---------------------------------------|-------------|-----|-------------|------|
| Symbol                                                                                                   | Parameter                 | Conditions                            | MIN         | TYP | MAX         | UNIT |
| $V_{IL}$                                                                                                 | LOW-level input voltage   |                                       | -           | -   | 0.5         | V    |
| $V_{IH}$                                                                                                 | HIGH-level input voltage  |                                       | 1.2         | -   | -           | V    |
| $V_{OL}$                                                                                                 | LOW-level output voltage  | $I_{OL} = 100\mu A$<br>$I_{OL} = 2mA$ | -           | -   | 0.15<br>0.4 | V    |
| $V_{OH}$                                                                                                 | HIGH-level output voltage | $I_{OH} = 100\mu A$<br>$I_{OH} = 2mA$ | 1.5<br>1.25 | -   | -           | V    |

| Static Operating Characteristics: Digital Pins ( $V_{BUS} = 4.1$ to $5.5V$ ; $V_{CC} = 2.5V \pm 0.2V$ ) |                           |                                       |             |     |             |      |
|---------------------------------------------------------------------------------------------------------|---------------------------|---------------------------------------|-------------|-----|-------------|------|
| Symbol                                                                                                  | Parameter                 | Conditions                            | MIN         | TYP | MAX         | UNIT |
| $V_{IL}$                                                                                                | LOW-level input voltage   |                                       | -           | -   | 0.7         | V    |
| $V_{IH}$                                                                                                | HIGH-level input voltage  |                                       | 1.7         | -   | -           | V    |
| $V_{OL}$                                                                                                | LOW-level output voltage  | $I_{OL} = 100\mu A$<br>$I_{OL} = 2mA$ | -           | -   | 0.15<br>0.4 | V    |
| $V_{OH}$                                                                                                | HIGH-level output voltage | $I_{OH} = 100\mu A$<br>$I_{OH} = 2mA$ | 2.15<br>1.9 | -   | -           | V    |

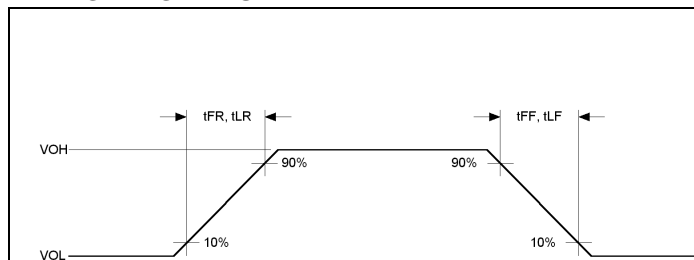
| Static Operating Characteristics: Analog I/O Pins ( $V_{BUS} = 4.1$ to $5.5V$ ; $V_{CC} = 1.65$ to $3.6V$ ) |                                                    |                               |     |     |       |          |
|-------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------|-----|-----|-------|----------|
| Symbol                                                                                                      | Parameter                                          | Conditions                    | MIN | TYP | MAX   | UNIT     |
| $V_{DI}$                                                                                                    | Differential receiver input sensitivity            | $ V_{I(D+)} - V_{I(D-)} $     | 0.2 | -   | -     | V        |
| $V_{CM}$                                                                                                    | Differential receiver common mode voltage          |                               | 0.8 | -   | 2.5   | V        |
| $V_{IL}$                                                                                                    | Single-ended receiver LOW-level input voltage      |                               | -   | -   | 0.8   | V        |
| $V_{IH}$                                                                                                    | Single-ended receiver HIGH-level input voltage     |                               | 2.0 | -   | -     | V        |
| $V_{HYS}$                                                                                                   | Single-ended receiver Hysteresis voltage           |                               | 0.4 | -   | 0.7   | V        |
| $V_{OL}$                                                                                                    | LOW-level output voltage                           | $R_L = 1.5k\Omega$ to $+3.6V$ | -   | -   | 0.3   | V        |
| $V_{OH}$                                                                                                    | HIGH-level output voltage                          | $R_L = 15k\Omega$ to GND      | 2.8 | -   | 3.6   | V        |
| $I_{LZ}$                                                                                                    | OFF-state leakage current                          |                               | -   | -   | +/- 1 | $\mu A$  |
| $C_{IN}$                                                                                                    | Transceiver Capacitance                            | pin to GND                    | -   | 10  | -     | pF       |
| $R_{SW}$                                                                                                    | Internal switch resistance at $V_{PU}$             |                               | -   | 30  | -     | $\Omega$ |
| $Z_{DRV}$                                                                                                   | Driver output impedance (incl. 33 ohm 1% resistor) | steady-state drive [3]        | 33  | 39  | 44    | $\Omega$ |

[3] Rev 2.0 states  $Z_{DRV}$  must be between  $28\Omega$  and  $44\Omega$ , when the driver is not high speed capable.

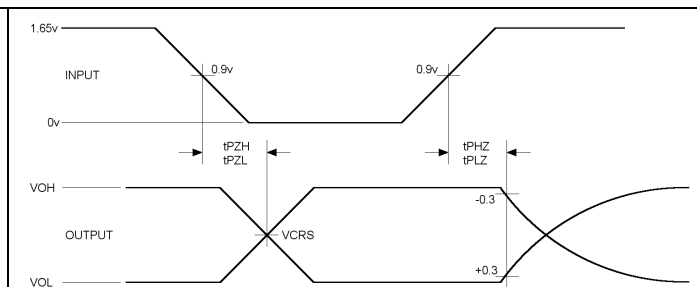


| Dynamic Operating Characteristics: Analog I/O Pins ( $V_{BUS} = 4.1$ to $5.5V$ ; $V_{CC} = 1.65$ to $3.6V$ ) |                                                            |                                                                |     |     |     |      |
|--------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|----------------------------------------------------------------|-----|-----|-----|------|
| Symbol                                                                                                       | Parameter                                                  | Conditions                                                     | MIN | TYP | MAX | UNIT |
| DRIVER CHARACTERISTICS & TIMINGS (Full-Speed mode only)                                                      |                                                            |                                                                |     |     |     |      |
| $t_{FR}$                                                                                                     | Rise Time                                                  | $C_L = 50$ to $125pF$ ,<br>10% to 90% ( $VOH -VOL$ ) See FIG 1 | 4   | -   | 20  | ns   |
| $t_{FF}$                                                                                                     | Fall Time                                                  | $C_L = 50$ to $125pF$ ,<br>10% to 90%( $VOH -VOL$ ) See FIG 1  | 4   | -   | 20  | ns   |
| FRFM                                                                                                         | Differential rise fall<br>time matching( $t_{FR}/t_{FF}$ ) | Excluding the first transition from idle state                 | 90  | -   | 110 | %    |
| $V_{CRS}$                                                                                                    | Output signal<br>crossover voltage                         | Excluding the first transition from idle state<br>See FIG 4    | 1.3 | -   | 2.0 | V    |
| $t_{PLH(drv)}$                                                                                               | Driver Propagation<br>delay.(VO/VPO,FSE<br>O/VMO TO D+,D-) | LOW-To-HIGH; See FIG 4                                         | -   | -   | 18  | ns   |
| $t_{PHL(drv)}$                                                                                               |                                                            | HIGH-To-LOW; See FIG 4                                         | -   | -   | 18  | ns   |
| $t_{PHZ}$                                                                                                    | Driver Disable Delay<br>(OE# to D+,D-)                     | HIGH-To-OFF; See FIG 2                                         | -   | -   | 80  | ns   |
| $t_{PLZ}$                                                                                                    |                                                            | LOW-To-OFF; See FIG 2                                          | -   | -   | 25  | ns   |
| $t_{PZH}$                                                                                                    | Driver Enable Delay<br>(OE# to D+,D-)                      | OFF-To-HIGH; See FIG 2                                         | -   | -   | 15  | ns   |
| $t_{PZL}$                                                                                                    |                                                            | OFF-To-LOW; See FIG 2                                          | -   | -   | 15  | ns   |
| RECEIVER TIMINGS (Full-Speed mode only)                                                                      |                                                            |                                                                |     |     |     |      |
| Differential Receiver                                                                                        |                                                            |                                                                |     |     |     |      |
| $t_{PLH(rcv)}$                                                                                               | Propagation delay<br>(D+,D- to RCV)                        | LOW-To-HIGH; See FIG 3                                         | -   | -   | 15  | ns   |
| $t_{PHL(rcv)}$                                                                                               |                                                            | HIGH-To-LOW; See FIG 3                                         | -   | -   | 15  | ns   |
| Single-Ended Receiver                                                                                        |                                                            |                                                                |     |     |     |      |
| $t_{PHL(se)}$                                                                                                | Propagation delay<br>(D+,D- to VP,VM)                      | LOW-To-HIGH; See FIG 3                                         | -   | -   | 15  | ns   |
| $t_{PHL(se)}$                                                                                                |                                                            | HIGH-To-LOW; See FIG 3                                         | -   | -   | 15  | ns   |

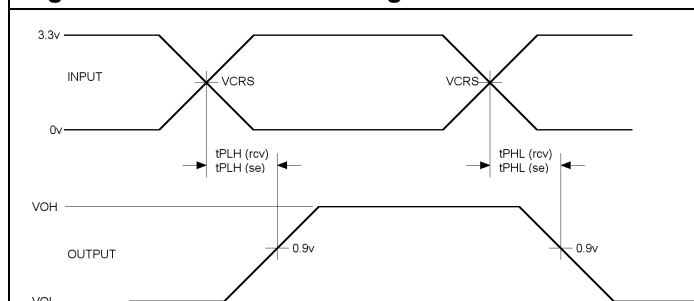
### TIMING DIAGRAMS:



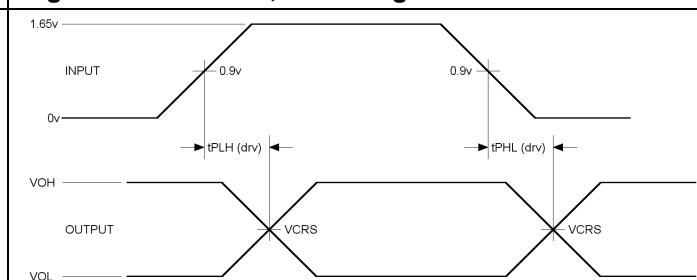
**Figure 1: Rise and Fall Timing**



**Figure 2: OE# to D+, D- Timing**



**Figure 3: D+, D- to RCV, VP, VM Timing**



**Figure 4: VO/VPO, FSE0/VMO TO D+, D- Timing**



## TEST CONDITIONS:

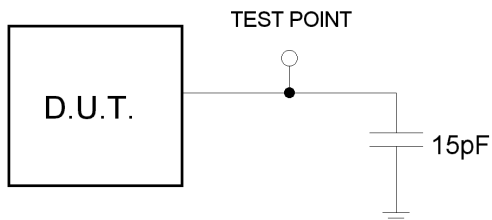


Figure 5: Load for VP, VM and RCV

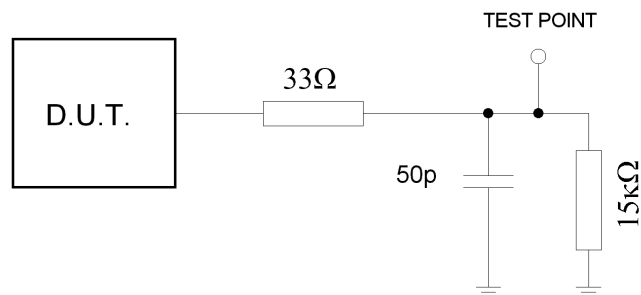
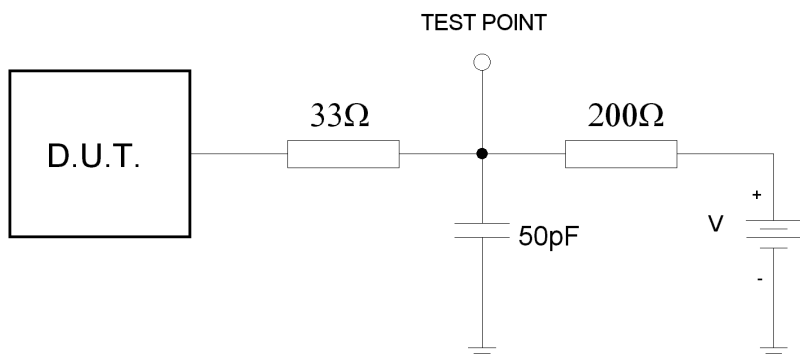


Figure 6: Load D+ and D- ( Max and Min Timing)



$V = V_{\text{REG}(3.3)}$  for  $t_{\text{PZL}}$  and  $t_{\text{PLZ}}$   
 $V = 0 \text{ v}$  for  $t_{\text{PZH}}$  and  $t_{\text{PHZ}}$

Figure 7: Load for enable and disable times.



## IC Package Configuration:

