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_{BUS}.
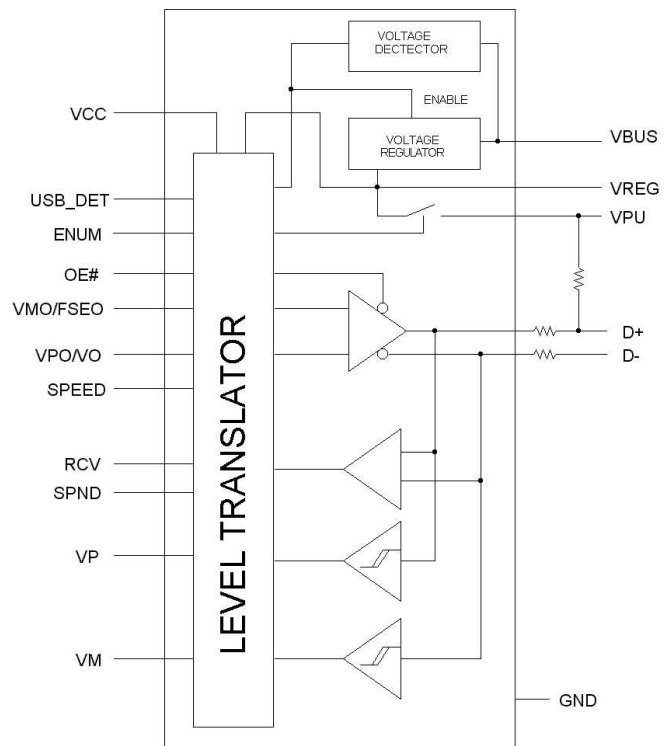
Single and differential input modes are selectable by a mode input pin.

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

Pin Diagram
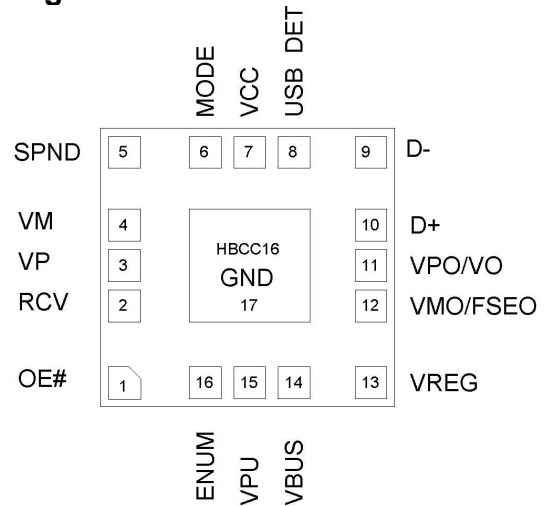
Functional Diagram

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_{CC}	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_{PU} 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_{REG}	Regulated supply voltage output during USB operation of VBUS. 1uF decoupling capacitor is required.
14	V_{BUS}	Supply voltage input. Can be directly connected to USB VBUS.
15	V_{PU}	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_{PU} is floating. If ENUM = HIGH then V_{PU} is internally connected to V_{REG}.
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_{BUS} 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 FSE0 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_{PU} to V_{REG} 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_{BUS}	**V_{CC}**	**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_{BUS}	$V_{BUS} < 3.6V$	4.1v to 5.5v
V_{REG}	Pulled Down	3.3v Out
V_{CC}	Present	Not Present
V_{PU}	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 Differential receiver active
L	H	Receiving	Active	Active	Driver tri-stated Differential receiver active
H	L	Driving	Inactive RCV = L	Active	Driving during 'suspend' Differential receiver inactive
H	H	High-Z	Inactive RCV = L	Active	Low-power state

Operating Mode (OE# = L): Table 4.1			
MODE	**VO**	**FSE0**	**Result**
L	L	L	Logic '0'
Single Ended	L	H	SE0
	H	L	Logic '1'
	H	H	SE0

Operating Mode (OE# = L): Table 4.2			
MODE	**VP0**	**VM0**	**Result**
H	L	L	SE0
Differential	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_{BUS}	-0.5 to +5.5	V
V_{CC}	-0.5 to +6.0	V
V_I(Input)	-0.5 to V_{CC} + 0.5	V
Temperature: Storage Operating Junction	-40 to +150 -40 to +150	°C

Recommended Operating Conditions						
Symbol	Parameter	Conditions	MIN	TYP	MAX	UNIT
V_{BUS}	USB VBUS Supply		4.1	5.0	5.5	V
V_{CC}	DC System Supply		1.65	3.3	3.6	V
V_I	DC Input Voltage		0	-	Vcc	V
$V_{I(AI/O)}$	Analog I/O pins (D+,D-)		0	-	3.6	V
T_{AMB}	Operating Ambient		-40	-	85	°C

Static Operating Characteristics: Supply Pins (V_{BUS} = 4.1 to 5.5V; V_{CC} = 1.65 to 3.6V)						
Symbol	Parameter	Conditions	MIN	TYP	MAX	UNIT
V_{REG}	Regulated supply output	Unloaded	3.0	3.3	3.6	V
I_{BUS}	Operating supply current	Full-speed TX and RX; C_L = 50pF on D+/D-	-	-	10.0	mA
$I_{BUS(IDLE)}$	Supply current during full speed idle and SE0	Full-speed idle: [2]	-	-	500.0	µA
$I_{BUS(SUSP)}$	Suspend supply current	SPND = HIGH [2]	-	-	100.0	µA
I_{CC}	Operating I/O supply current	Full-speed TX and RX	-	-	2.0	mA
$I_{CC(STAT)}$	Static I/O supply current	Full-speed idle, SE0 or suspend	-	-	10.0	µA
$I_{CC(SHARE)}$	Supply current during share mode	V_{BUS} not connected	-	-	10.0	µA
$I_{DX(SHARE)}$	D+/D- load current during sharing mode	V_{BUS} not connected; ENUMERATE = LOW	-	-	10.0	µA
$V_{TH(VBUS)}$	Vbus supply detection threshold. USB_D output.	Supply Lost(USB_D low)	-	-	3.6	V
		Supply Present	4.1	-	-	V
		$V_{TH(VBUS)}$ Hysteresis		100		mV
$V_{TH(VCC)}$	Vcc supply Detection threshold	Supply Lost	-	-	0.5	V
		Supply Present	1.4	-	-	V
		$V_{TH(VCC)}$ 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_{PU}/V_{SW} 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 ± 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} = 100µA I_{OL} = 2mA	- 	- 	0.15 0.4	V
V_{OH}	HIGH-level output voltage	I_{OH} = 100µA I_{OH} = 2mA	1.5 1.25	- 	- 	V

Static Operating Characteristics: Digital Pins (V_{BUS} = 4.1 to 5.5V; V_{CC} = 2.5V ± 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} = 100µA I_{OL} = 2mA	- 	- 	0.15 0.4	V
V_{OH}	HIGH-level output voltage	I_{OH} = 100µA I_{OH} = 2mA	2.15 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	$\lvert V_{I(D+)} - V_{I(D-)} \rvert$	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 = 1.5kΩ to +3.6V	-	-	0.3	V
V_{OH}	HIGH-level output voltage	R_L = 15kΩ to GND	2.8	-	3.6	V
I_{LZ}	OFF-state leakage current		-	-	+/- 1	µA
C_{IN}	Transceiver Capacitance	pin to GND	-	10	-	pF
R_{SW}	Internal switch resistance at V_{PU}		-	30	-	Ω
Z_{DRV}	Driver output impedance (incl.33 ohm 1% resistor)	steady-state drive [3]	33	39	44	Ω

[3]   Rev 2.0 states Z_{DRV} must be between 28Ω and 44Ω, 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, 10% to 90% (VOH –VOL) See FIG 1	4	-	20	ns
t_{FF}	Fall Time	C_L = 50 to 125pF, 10% to 90%(VOH –VOL) See FIG 1	4	-	20	ns
FRFM	Differential rise fall time matching(t_{FR}/t_{FF})	Excluding the first transition from idle state	90	-	110	%
V_{CRS}	Output signal crossover voltage	Excluding the first transition from idle state See FIG 4	1.3	-	2.0	V
$t_{PLH(drv)}$	Driver Propagation delay.(VO/VPO,FSEO/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 (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 (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 (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 (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:
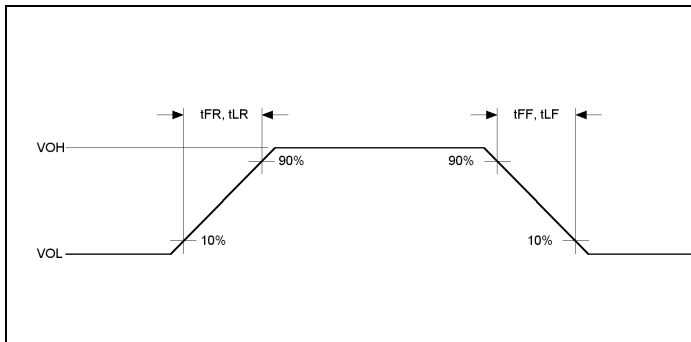
Figure 1: Rise and Fall Timing

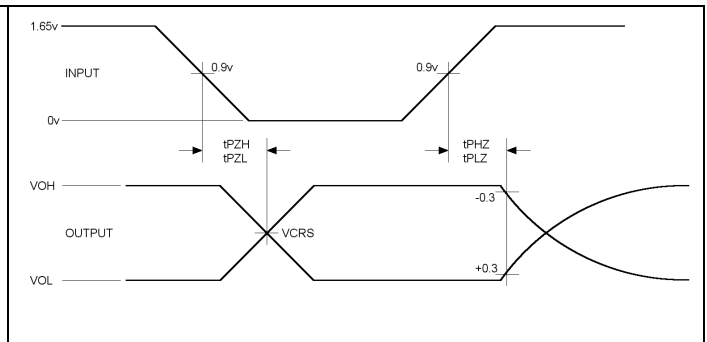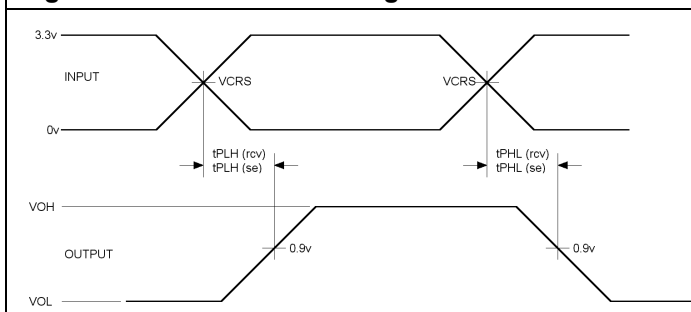**Figure 2: OE# to D+, D- Timing**
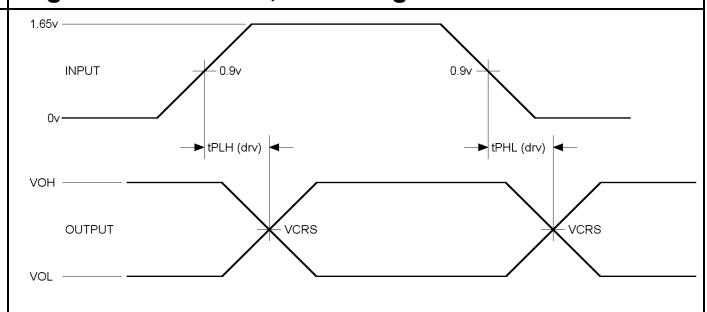

Figure 3: D+, D- to RCV, VP, VM Timing

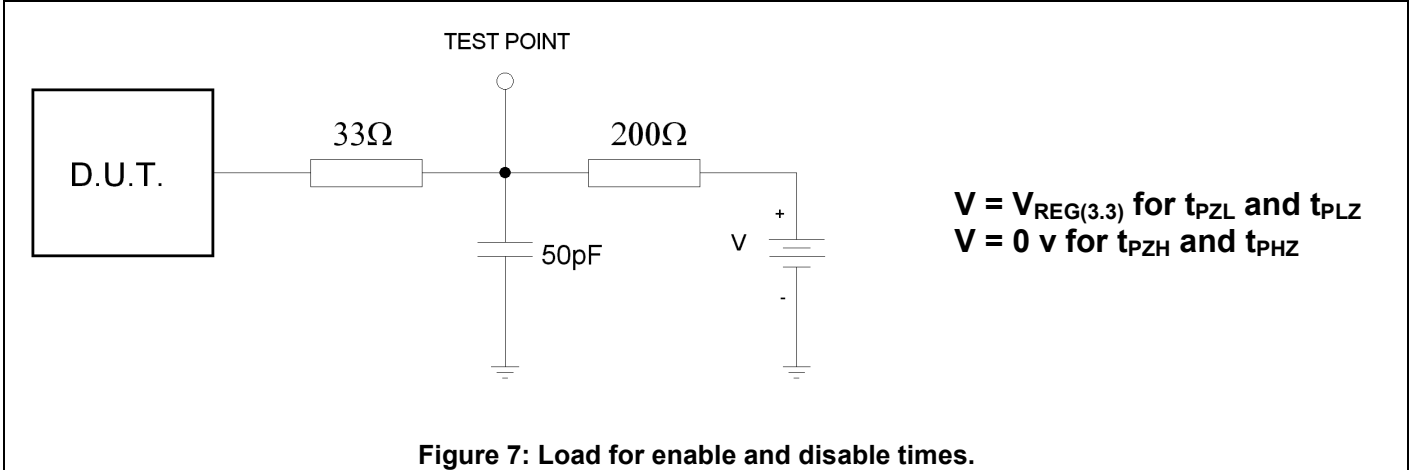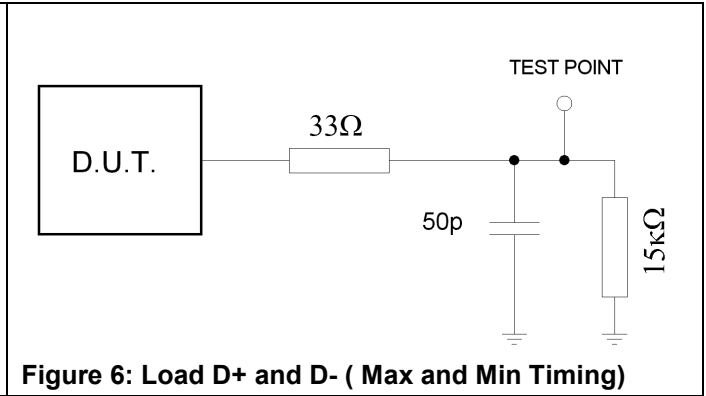

Figure 4: VO/VPO, FSE0/VMO TO D+, D- Timing

TEST CONDITIONS:

Figure 5: Load for VP,VM and RCV

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

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

Figure 7: Load for enable and disable times.
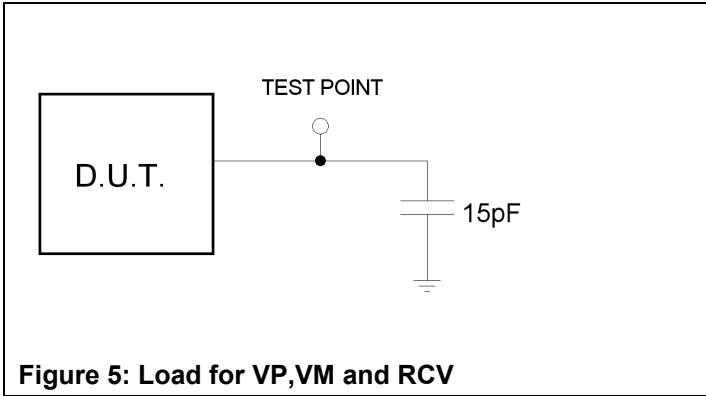
IC Package Configuration: