

## Universal Serial Bus Transceiver with Level Translator

### Features

- Complies with USB Specification Rev 1.1 & 2.0
- Supports Full Speed Mode (12Mbit/s)
- Integrated 5V to 3.3V regulator
- Bi-directional driver input/output pins
- Two single-ended receivers with hysteresis
- USB detection of  $V_{BUS}$  via level translator
- Stable RCV output during SE0 condition
- Low power operation
- Supports 1.65 to 3.6V I/O voltage levels
- Full industrial operating range -40 to 85°C
- Available in tiny HBCC-16 and TQFN-16 packages
- Lead-free versions available

### Applications

- Wireless Handsets
- Digital Still Cameras
- PDAs (Personal Digital Assistants)
- IAs (Information Appliances)
- Pin and functionally compatible with Philips ISP1102

### Product Description

The CM2400-05 Universal Serial Bus (USB) transceiver is fully compliant with USB specification, revisions 1.1 and 2.0. It supports a speed of 12Mbits/s (Full Speed Mode).

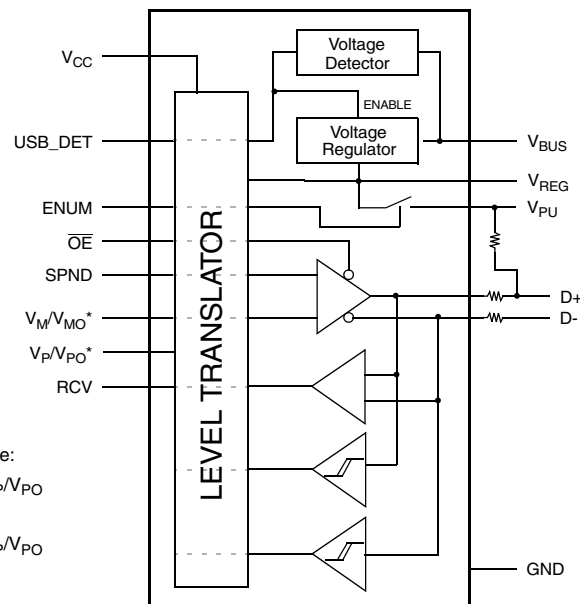
An internal level shifter allows interface to Application Specific Integrated Circuits (ASICs) and Programmable Logic Devices (PLDs) running at core voltages of 1.65V to 3.6V.

An internal 5V to 3.3V regulator is used to power the CM2400-05 USB transceiver via the USB supply  $V_{BUS}$ .  $V_M/V_{MO}$  and  $V_P/V_{PO}$  are bi-directional interface pins. In one mode they function as the differential driver input data. In another mode they function as the output of the single ended receivers. This mode is configured by the  $\overline{OE}$  pin.

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

The CM2400-05 is manufactured in small form-factor 16-lead HBCC or TQFN packages to conserve board space and is available with optional lead-free finishing.

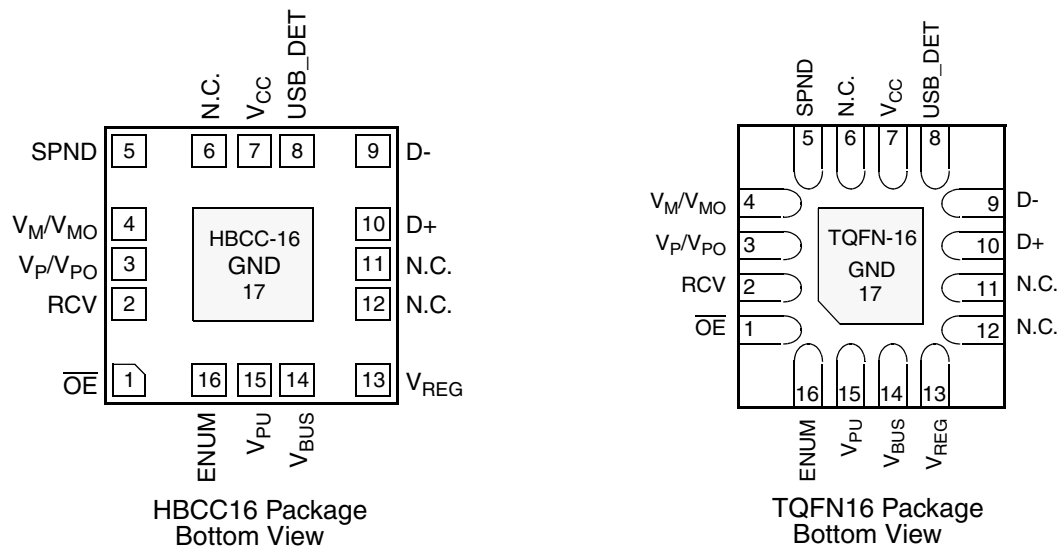
### Simplified Block Schematic



\* Pins are bi-directional based on  $\overline{OE}$  state:

If  $\overline{OE} = V_{CC}$ , then  $V_M/V_{MO}$  and  $V_P/V_{PO}$  are configured as outputs.

If  $\overline{OE} = GND$ , then  $V_M/V_{MO}$  and  $V_P/V_{PO}$  are configured as inputs.

**PACKAGE / PINOUT DIAGRAM**


Note: This drawing is not to scale.

**PIN DESCRIPTIONS**

PINS	NAME	DESCRIPTION
1	$\overline{OE}$	Input for Output Enable (Active low). Enables transceiver driver to transmit data on the USB bus. When $\overline{OE}$ 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	$V_P/V_{PO}$	Bi-directional input output of D+. Configured by $\overline{OE}$ .
4	$V_M/V_{MO}$	Bi-directional input output of D-. Configured by $\overline{OE}$ .
5	SPND	Suspend input. Allows the device to enter a low power state while the USB is inactive.
6	N.C.	No internal connection to circuitry.
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. In full-speed connect mode, connect to $V_{PU}$ via a 1.5k $\Omega$ resistor. Tolerance of this resistor is defined in the USB specification REV 1.1 & 2.0
11	N.C.	No internal connection to circuitry.
12	N.C.	No internal connection to circuitry.
13	$V_{REG}$	Regulated supply voltage output during USB operation of $V_{BUS}$ . 1 $\mu$ F decoupling capacitor is required.
14	$V_{BUS}$	Supply voltage input. Can be directly connected to USB $V_{BUS}$ .
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)

## Ordering Information

PART NUMBERING INFORMATION					
Pads/Pins <sup>1</sup>	Package	Standard Finish		Lead-free Finish <sup>3</sup>	
		Ordering Part Number <sup>2</sup>	Part Marking	Ordering Part Number <sup>2</sup>	Part Marking
16	HBCC-16	CM2400-05HB	CM240 005HB	CM2400-05HA	CM240 005HA
16	TQFN-16	CM2400-05QF	CM240 005QF	CM2400-05QE	CM240 005QE

Note 1: There is one additional GND pad on the bottom of the device not included in this pin count.

Note 2: Parts are shipped in Tape & Reel form unless otherwise specified.

Note 3: Lead-free, 100% tin plated.

## Specifications

ABSOLUTE MAXIMUM RATINGS		
PARAMETER	RATING	UNITS
ESD Protection (HBM, All Pins, See Note 1)	±2000	V
V <sub>BUS</sub>	[GND - 0.5] to +5.5	V
V <sub>CC</sub>	[GND - 0.5] to +6.0	V
V <sub>I</sub> (INPUT)	[GND - 0.5] to [V <sub>CC</sub> + 0.5]	V
Storage Temperature Range	-40 to +150	°C
Operating Temperature Range Junction	-40 to +150	°C

Note 1: Equivalent to discharging a 100pF capacitor via a 1.5kΩ resistor (Human Body Model).

STANDARD (RECOMMENDED) OPERATING CONDITIONS					
SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS
V <sub>BUS</sub>	USB V <sub>BUS</sub> 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>A</sub>	Ambient Operating Temperature Range	-40	-	85	°C

**Specifications (cont'd)**

<b>ELECTRICAL OPERATING CHARACTERISTICS (SEE NOTE 1)</b>						
<b>Static Operating Characteristics</b>						
<b>Supply Pins (<math>V_{BUS} = 4.1V</math> to <math>5.5V</math>; <math>V_{CC} = 1.65V</math> to <math>3.6V</math>)</b>						
<b>SYMBOL</b>	<b>PARAMETER</b>	<b>CONDITIONS</b>	<b>MIN</b>	<b>TYP</b>	<b>MAX</b>	<b>UNITS</b>
$V_{REG}$	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- outputs			10	mA
$I_{BUS(IDLE)}$	Supply current during full speed idle and SE0	Full-speed idle; Note 2			500	$\mu A$
$I_{BUS(SUSP)}$	Supply current during suspend	SPND = logic "1"; Note 2			100	$\mu A$
$I_{CC}$	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	$\mu A$
$I_{CC(SHARE)}$	Supply current during sharing mode	$V_{BUS}$ not connected			10.0	$\mu A$
$I_{DX(SHARE)}$	D+/D- load current during sharing mode	$V_{BUS}$ not connected; ENUMERATE = logic "0"			10.0	$\mu A$
$V_{TH(VBUS)}$	$V_{BUS}$ 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
$V_{TH(VCC)}$	$V_{CC}$ supply detection threshold.	Supply lost			0.5	V
		Supply present	1.4			V
		$V_{TH(VCC)}$ Hysteresis		200		mV
<b>Digital Pins (<math>V_{BUS} = 4.1V</math> to <math>5.5V</math>; <math>V_{CC} = 1.65V</math> to <math>3.6V</math>)</b>						
<b>SYMBOL</b>	<b>PARAMETER</b>	<b>CONDITIONS</b>	<b>MIN</b>	<b>TYP</b>	<b>MAX</b>	<b>UNITS</b>
$V_{IL}$	Logic LOW input voltage				$0.3 \times V_{CC}$	V
$V_{IH}$	Logic HIGH input voltage		$0.6 \times V_{CC}$			V
$V_{OL}$	Logic LOW output voltage	$I_{OL} = 100\mu A$			0.15	V
		$I_{OL} = 2mA$			0.40	V
$V_{OH}$	Logic HIGH output voltage	$I_{OH} = 100\mu A$	$V_{CC} - 0.15$			V
		$I_{OH} = 2mA$	$V_{CC} - 0.40$			V

Note 1: Operating Characteristics are over Standard Operating Conditions unless otherwise specified.

Note 2: Excluding any load current and  $V_{PU}/V_{SW}$  source current to  $1.5k\Omega$  and  $15k\Omega$  pull-up and pull-down resistors ( $200\mu A$ ).

**Specifications (cont'd)**
**ELECTRICAL OPERATING CHARACTERISTICS (CONT'D)**
**Static Operating Characteristics (cont'd)**
**Analog I/O Pins ( $V_{BUS} = 4.1V$  to  $5.5V$ ;  $V_{CC} = 1.65V$  to  $3.6V$ )**

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{DI}$	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 logic LOW input voltage	$\overline{OE} = \text{logic "1"}$			0.8	V
$V_{IH}$	Single-ended receiver logic HIGH input voltage	$\overline{OE} = \text{logic "1"}$	2.0			V
$V_{HYS}$	Single-ended receiver Hysteresis voltage	$\overline{OE} = \text{logic "1"}$	0.4		0.7	V
$V_{OL}$	Logic LOW output voltage	$R_L = 1.5k\Omega$ tied to +3.6V			0.3	V
$V_{OH}$	Logic HIGH output voltage	$R_L = 15k\Omega$ tied to GND	2.8		3.6	V
$I_{LZ}$	OFF-state leakage current				$\pm 1$	$\mu A$
$C_{IN}$	Transceiver Capacitance	Pin to GND		10		pF
$R_{SW}$	Internal switch resistance at $V_{PU}$			30		$\Omega$
$Z_{DRV}$	Driver output impedance (includes 33 ohm 1% resistor)	Measured with steady-state drive; See Note 3	33	39	44	$\Omega$

**Dynamic Operating Characteristics:**
**Analog I/O Pins ( $V_{BUS} = 4.1$  to  $5.5V$ ;  $V_{CC} = 1.65$  to  $3.6V$ )**
**Driver Characteristics & Timings (Full-speed mode only)**

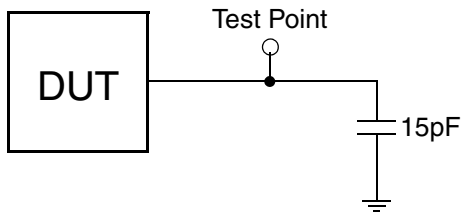
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$t_{FR}$	Rise time	$C_L = 50$ to $125pF$ , measured 10% to 90% ( $V_{OH}-V_{OL}$ ); See <a href="#">Figure 6</a>	4		20	ns
$t_{FF}$	Fall time	$C_L = 50$ to $125pF$ , measured 10% to 90% ( $V_{OH}-V_{OL}$ ); See <a href="#">Figure 6</a>	4		20	ns
FRFM	Differential 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 <a href="#">Figure 9</a>	1.3		2.0	V
$t_{PLH(DRV)}$	Driver propagation delay ( $V_O/V_{PO} \rightarrow D+/D-$ , $FSEO/V_{MO} \rightarrow D+/D-$ )	LOW-to-HIGH transition; See <a href="#">Figure 9</a>			18	ns
$t_{PHL(DRV)}$		HIGH-to-LOW transition; See <a href="#">Figure 9</a>			18	ns
$t_{PHZ}$	Driver disable delay ( $\overline{OE} \rightarrow D+/D-$ )	HIGH-to-OFF; See <a href="#">Figure 7</a>			18	ns
$t_{PLZ}$		LOW-to-OFF; See <a href="#">Figure 7</a>			18	ns
$t_{PZH}$	Driver enable delay ( $OE \rightarrow D+/D-$ )	OFF-to-HIGH; See <a href="#">Figure 7</a>			15	ns
$t_{PZL}$		OFF-to-LOW; See <a href="#">Figure 7</a>			15	ns

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

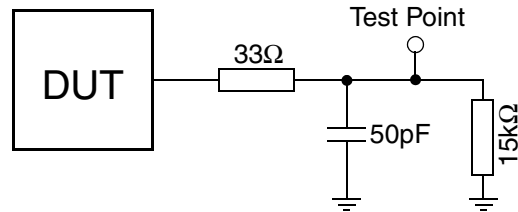
**Specifications (cont'd)**

<b>ELECTRICAL OPERATING CHARACTERISTICS (CONT'D)</b>						
<b>Dynamic Operating Characteristics: (cont'd)</b>						
<b>Analog I/O Pins (VBUS = 4.1 to 5.5V; VCC = 1.65 to 3.6V)</b>						
<b>Receiver Timings (Full-speed mode only)</b>						
<b>SYMBOL</b>	<b>PARAMETER</b>	<b>CONDITIONS</b>	<b>MIN</b>	<b>TYP</b>	<b>MAX</b>	<b>UNITS</b>
<b>Differential Receiver</b>						
$t_{PLH(RCV)}$	Driver propagation delay (D+/D- → RCV)	LOW-to-HIGH transition; See <a href="#">Figure 8</a>			15	ns
$t_{PHL(RCV)}$		HIGH-to-LOW transition; See <a href="#">Figure 8</a>			15	ns
<b>Single-ended Receiver</b>						
$t_{PLH(SE)}$	Driver propagation delay (D+/D- → $V_P, V_M$ )	LOW-to-HIGH transition; See <a href="#">Figure 8</a>			15	ns
$t_{PHL(SE)}$		HIGH-to-LOW transition; See <a href="#">Figure 8</a>			15	ns

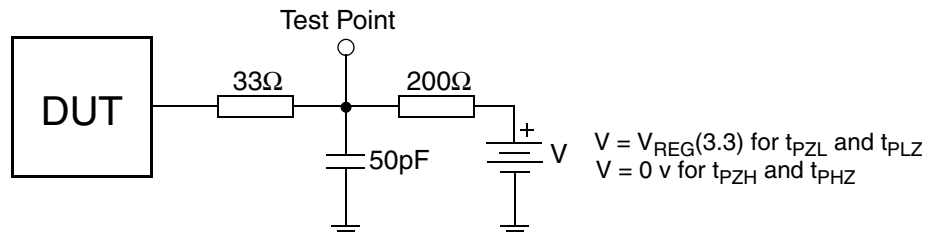
**Test Loads**



Load for  $V_P, V_M$  and RCV delay measurements



Load for D+ and D- delay measurements (Max and Min Timing)



Load for ENABLE and DISABLE delay measurements.

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

**Performance Information**

CM2400-05 Typical DC Characteristics (nominal conditions unless specified otherwise)

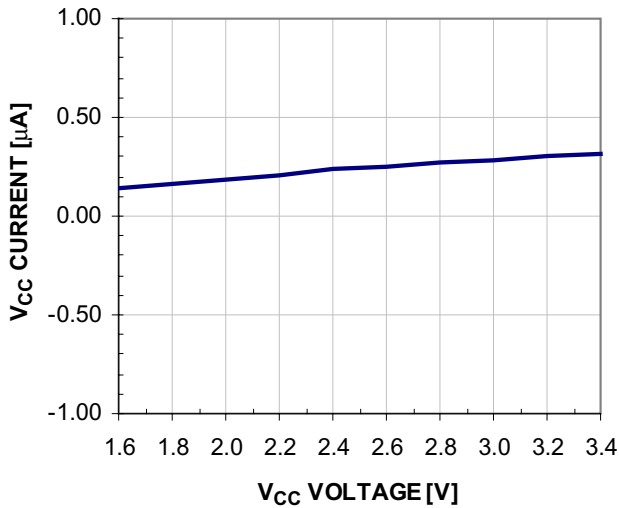


Figure 1. VCC Current in Idle Mode (SPND=LOW)

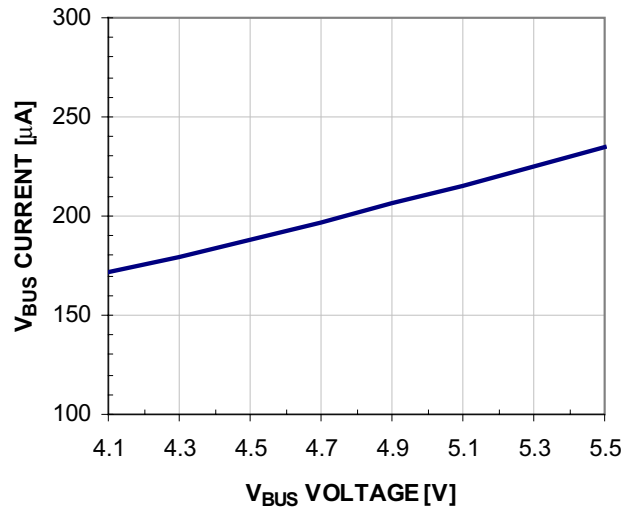


Figure 3. VBUS CURRENT in Idle Mode (SPND=LOW)

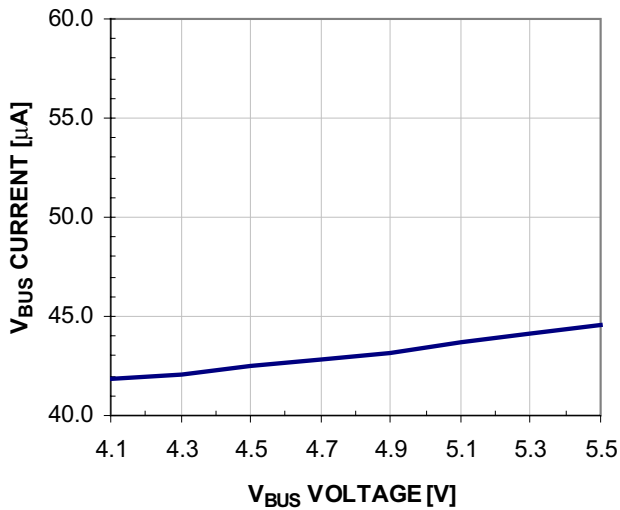


Figure 2. VBUS Current in Suspend Mode (SPND=HIGH)

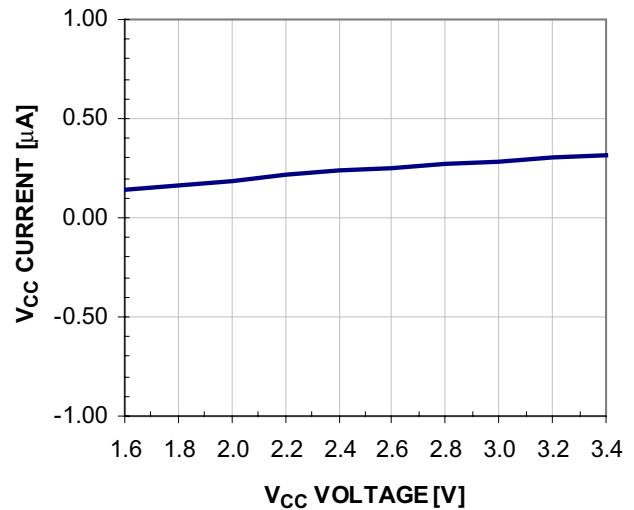
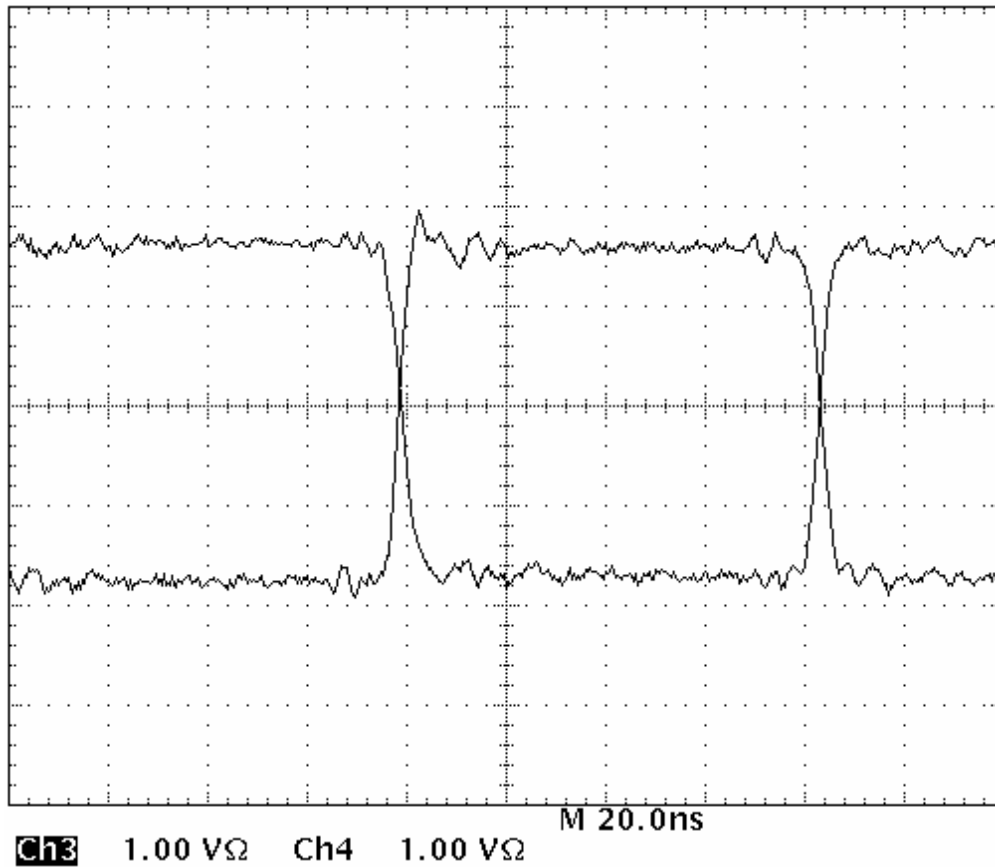


Figure 4. VCC Current in Suspend Mode (SPND=HIGH)

**Performance Information (cont'd)**

CM2400-05 Typical AC Characteristics (nominal conditions unless specified otherwise)

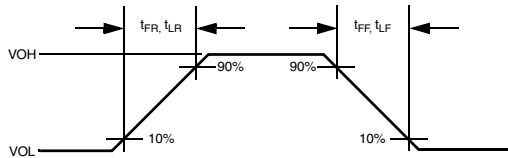


**Figure 5. Rise and Fall Time Matching for Full-Speed Mode**

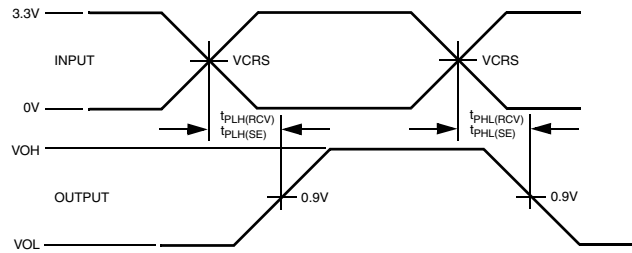


**Performance Information (cont'd)**

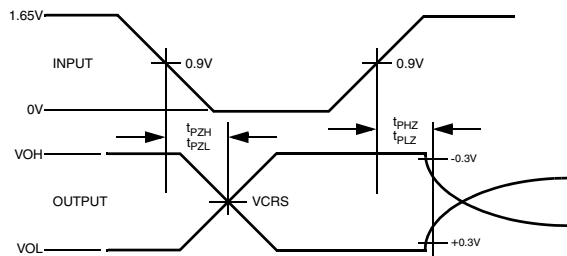
**CM2400 Timing Diagrams**



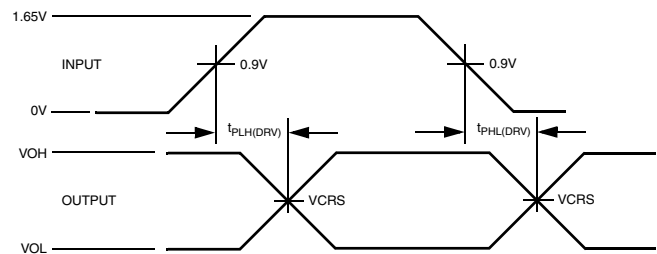
**Figure 6. Rise and Fall Timing**



**Figure 8. D+, D- to RCV,  $V_P$  and  $V_M$  Timing**



**Figure 7.  $\overline{OE}$  to D+, D- Timing**



**Figure 9.  $V_O/V_{P0}$ ,  $F_{SEO}/V_{M0}$  to D+, D- Timing**

## Functional Description

The CM2400-05 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.

$V_{BUS}$	$V_{CC}$	CONFIGURATION
Connected	Connected	Normal Mode
Connected	Not Connected	Disable Mode
Not Connected	Connected	Sharing Mode

**Table 1: Power Supply Connections**

In **Disable** and **Sharing Mode**, all input/output pins follow the states defined in [Table 2](#). In Sharing mode, D+, D- and  $V_{PU}$  can have voltages higher than  $V_{CC}$ . This allows other external signals to share D+ and D- while USB signaling is disabled.

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
$V_P/V_{PO}, V_M/V_{MO}$	H	Invalid
RCV	L	Invalid
USB_DET	L	Invalid
Inputs	High-Z	High-Z

**Table 2: Pin States in Disable or Sharing Mode**

[Table 3](#) lists the functions of the modes associated with suspend and  $\overline{OE}$  pins. When Suspend is low and  $\overline{OE}$  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  $V_P$  and  $V_M$ . During suspend and while the output is still enabled ( $\overline{OE} = \text{LOW}$ ), 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.

SUSPEND	$\overline{OE}$	D+ / D-	RCV	$V_P/V_{PO}, V_M/V_{MO}$	Function
L	L	Driver & Receiver Active	Active	Input	Normal driving mode. Differential receiver active
L	H	Receiving	Active	Output	Driver Tri-stated. Differential receiver active.
H	L	Driving	Inactive RCV=L	Input	Driving during 'suspend'. Differential receiver inactive.
H	H	High-Z	Inactive RCV=L	Output	Low-power state.

**Table 3: Function Selection.**

**Functional Description (cont'd)**

Detailed in [Table 4](#) is the differential result for all variations on  $V_P/V_{PO}$  and  $V_M/V_{MO}$ .

$V_P/V_{PO}$	$V_M/V_{MO}$	Result
L	L	Logic '0'
L	H	SE0
H	L	Logic '1'
H	H	SE0

**Table 4: Operating Mode ( $\overline{OE} = L$ )**

[Table 5](#) details the receiving function when  $\overline{OE}$  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.

D+/D-	RCV	$V_P$	$V_M$
Differential Logic '0'	L	L	H
Differential Logic '1'	H	H	L
SE0	RCV*	L	L

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

Note 1: Denotes RCV is stable in last state before SE0 condition.

Detection of a  $V_{BUS}$  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  $V_{BUS}$  is over 4.1 volts USB\_DET is HIGH. When  $V_{BUS}$  is under 3.6 volts USB\_DET is LOW.

The CM2400-05 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.

## Mechanical Details

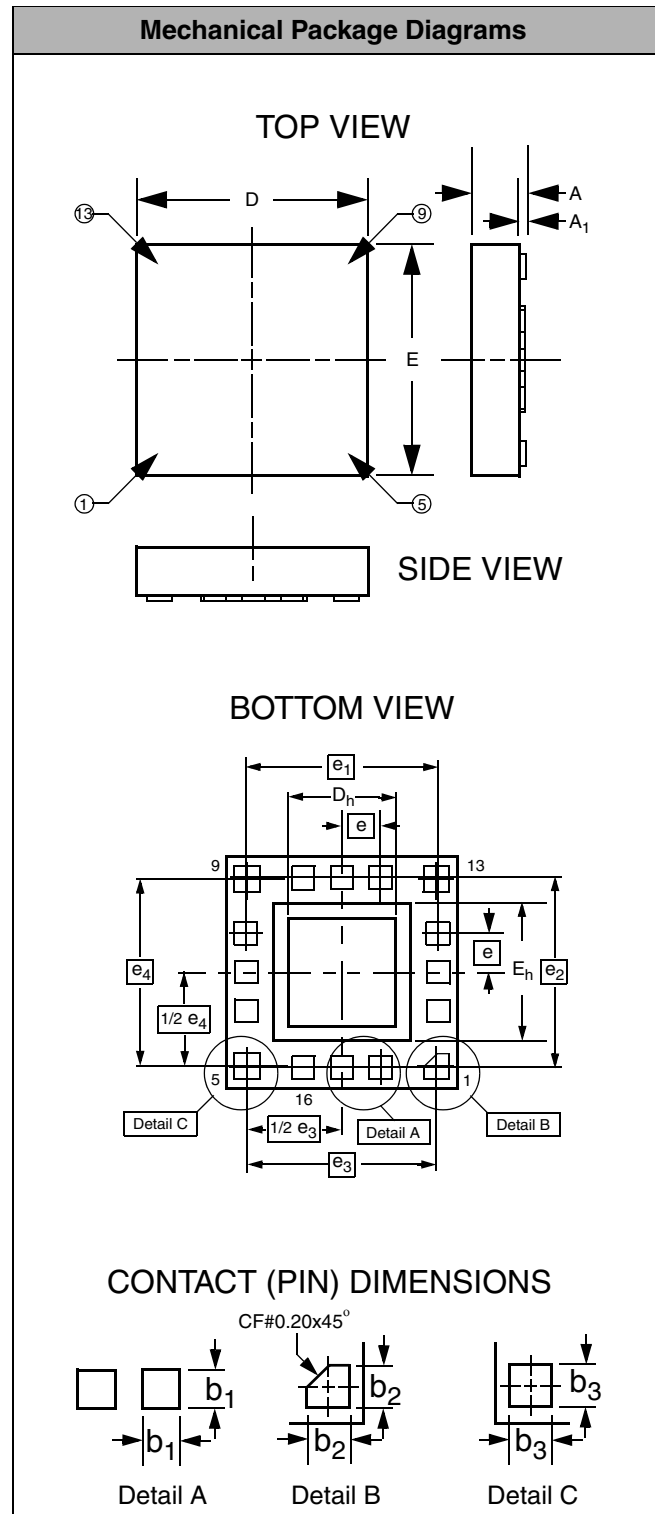
The CM2400-05 is available in both 16-pin HBCC and 16-lead TQFN packages.

### HBCC16 Mechanical Specifications

Dimensions for CM2400-05 devices packaged in 16-pin HBCC packages are presented below.

PACKAGE DIMENSIONS				
Package	HBCC-16			
Pins	16			
Dimensions	Millimeters		Inches	
	Min	Max	Min	Max
A	-	0.80		0.0315
A <sub>1</sub>	0.05	0.10		0.0039
b <sub>1</sub>	0.25	0.35		0.0138
b <sub>2</sub>	0.30	0.40		0.0157
b <sub>3</sub>	0.30	0.40		0.0157
D	2.90	3.10		0.1220
D <sub>h</sub>	1.45	1.55		0.0610
E	2.90	3.10		0.1220
E <sub>h</sub>	1.75	1.85		0.0728
e	0.50 TYP.		0.0197 TYP.	
e <sub>1</sub>	2.50 TYP.		0.0984 TYP.	
e <sub>2</sub>	2.50 TYP.		0.0984 TYP.	
e <sub>3</sub>	2.45 TYP.		0.0965 TYP.	
e <sub>4</sub>	2.45 TYP.		0.0965 TYP.	
# per tube	120 pieces*			
# per tape and reel	3000 pieces			
Controlling dimension: millimeters				

\* This is an approximate number which may vary.



**Dimensions for HBCC16 Package**

**Mechanical Details (cont'd)**

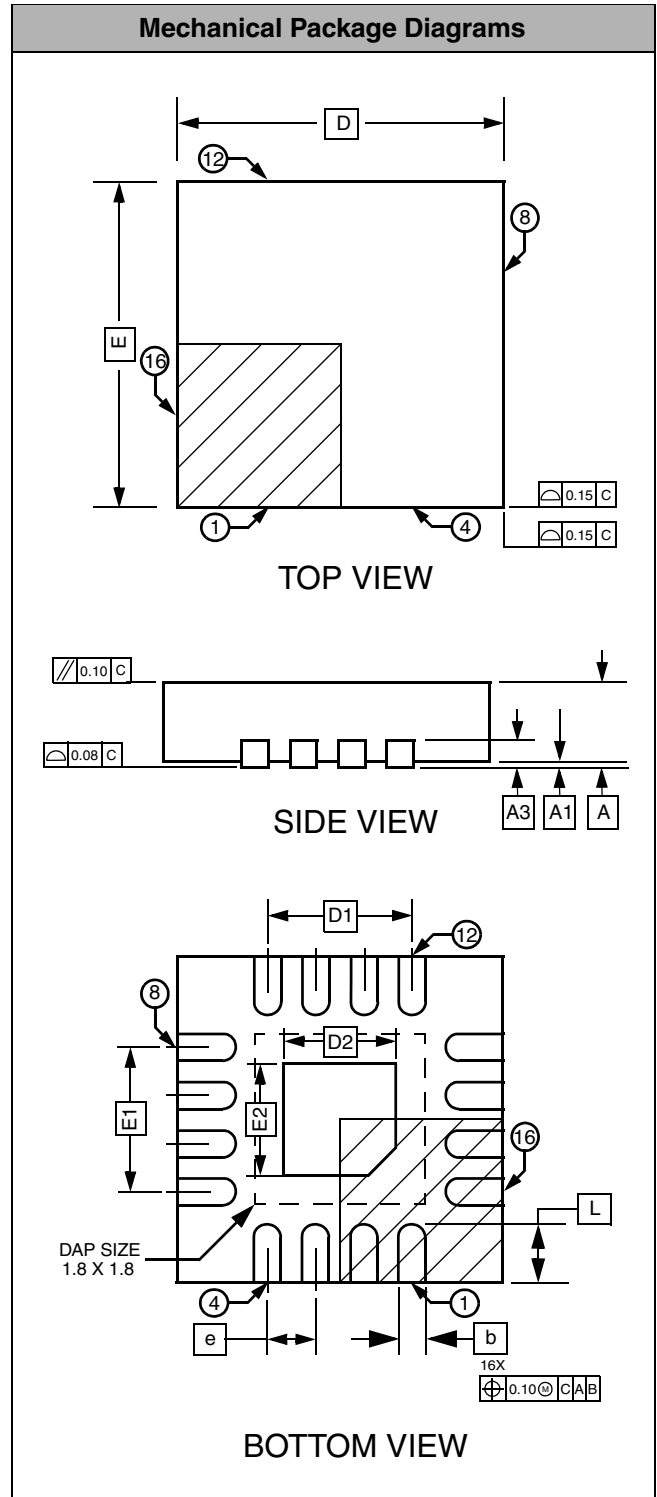
**TQFN-16 Mechanical Specifications**

Dimensions for CM2400-05 devices packaged in 16-lead TQFN packages are presented below.

For complete information on the TQFN-16 package, see the California Micro Devices TQFN Package Information document.

PACKAGE DIMENSIONS						
Package	TQFN					
Leads	16					
Dim.	Millimeters			Inches		
	Min	Nom	Max	Min	Nom	Max
<b>A</b>	0.70	0.75	0.80	.028	.030	.031
<b>A1</b>	0.00	0.02	0.05	0.00	.001	.002
<b>A3</b>	0.20 REF			.008		
<b>b</b>	0.20	0.25	0.30	.008	.010	.012
<b>D</b>	2.9	3.0	3.1	.114	.118	.122
<b>D1</b>	1.50 REF			.059 REF		
<b>D2</b>	1.00	1.10	1.20	.039	.043	.047
<b>E</b>	2.9	3.0	3.1	.114	.118	.122
<b>E1</b>	1.50 REF			.059 REF		
<b>E2</b>	1.00	1.10	1.20	.039	.043	.047
<b>e</b>	0.50 TYP.			.020 TYP.		
<b>L</b>	0.30	0.40	0.50	.012	.016	.020
<b># per tube</b>	120 pieces*					
<b># per tape and reel</b>	3000 pieces					
Controlling dimension: millimeters						

\* This is an approximate number which may vary.



**Figure 10. Dimensions for 16-Lead TQFN Package**