

## 28-Bit Registered Buffer for DDR2

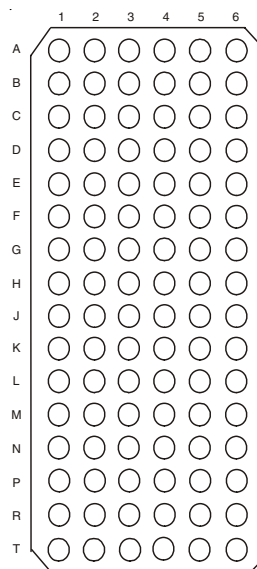
### Recommended Application:

- DDR2 Memory Modules
- Provides complete DDR DIMM solution with ICS98ULPA877A, ICS97ULP877, or IDTCSPUA877A
- Optimized for DDR2 400/533/667 JEDEC 4 Rank VLP DIMMS

### Product Features:

- 28-bit 1:1 registered buffer with parity check functionality
- Supports SSTL\_18 JEDEC specification on data inputs and outputs
- Supports LVCMOS switching levels on  $\overline{\text{RESET}}$  input
- 50% more dynamic driver strength than standard SSTU32864
- Low voltage operation  
 $V_{DD} = 1.7V$  to  $1.9V$
- Available in 96 BGA package

### Pin Configuration



**96 Ball BGA  
(Top View)**

### Functionality Truth Table

Inputs						Outputs		
$\overline{\text{RESET}}$	$\overline{\text{DCS0}}$	$\overline{\text{DCS1}}$	CK	$\overline{\text{CK}}$	Dn, DODTn, DCKEn	Qn	$\overline{\text{QCS}}$	QODT, QCKE
H	L	L	↑	↓	L	L	L	L
H	L	L	↑	↓	H	H	L	H
H	L	L	L or H	L or H	X	Q <sub>0</sub>	Q <sub>0</sub>	Q <sub>0</sub>
H	L	H	↑	↓	L	L	L	L
H	L	H	↑	↓	H	H	L	H
H	L	H	L or H	L or H	X	Q <sub>0</sub>	Q <sub>0</sub>	Q <sub>0</sub>
H	H	L	↑	↓	L	L	H	L
H	H	L	↑	↓	H	H	H	H
H	H	L	L or H	L or H	X	Q <sub>0</sub>	Q <sub>0</sub>	Q <sub>0</sub>
H	H	H	↑	↓	L	Q <sub>0</sub>	H	L
H	H	H	↑	↓	H	Q <sub>0</sub>	H	H
H	H	H	L or H	L or H	X	Q <sub>0</sub>	Q <sub>0</sub>	Q <sub>0</sub>
L	X or floating	X or floating	X or floating	X or floating	X or floating	L	L	L

## Ball Assignments

### 28 bit 1:1 Register

A	DCKE0	D0	V <sub>REF</sub>	V <sub>DD</sub>	QCKE0	QCKE1
B	DCKE1	D1	GND	GND	Q0	Q1
C	D2	DODT1	V <sub>DD</sub>	V <sub>DD</sub>	Q2	Q21
D	DODT0	PTYERR	GND	GND	QODT0	QODT1
E	D3	D4	V <sub>DD</sub>	V <sub>DD</sub>	Q3	Q4
F	D5	D6	GND	GND	Q5	Q6
G	PAR_IN	RESET	V <sub>DD</sub>	V <sub>DD</sub>	NC	NC
H	CK	DCS0	GND	GND	QCS0	QCS1
J	CK	DCS1	V <sub>DD</sub>	V <sub>DD</sub>	NC	NC
K	D7	D8	GND	GND	Q7	Q8
L	D9	D10	V <sub>DD</sub>	V <sub>DD</sub>	Q9	Q10
M	D11	D12	GND	GND	Q11	Q12
N	D13	D14	V <sub>DD</sub>	V <sub>DD</sub>	Q13	Q14
P	D15	D16	GND	GND	Q15	Q16
R	D17	D18	V <sub>DD</sub>	V <sub>DD</sub>	Q17	Q18
T	D19	D20	D21	V <sub>DD</sub>	Q19	Q20
	1	2	3	4	5	6

## General Description

This 28-bit 1:1 registered buffer with parity is designed for 1.7V to 1.9V  $V_{DD}$  operation.

All clock and data inputs are compatible with the JEDEC standard for SSTL\_18. The control inputs are LVCMOS. All outputs are 1.8 V CMOS drivers that have been optimized to drive the DDR2 DIMM load. The **ICSSSTUB32872A** operates from a differential clock (CK and  $\overline{CK}$ ). Data are registered at the crossing of CK going high, and  $\overline{CK}$  going low.

The device supports low-power standby operation. When the reset input ( $\overline{RESET}$ ) is low, the differential input receivers are disabled, and undriven (floating) data, clock and reference voltage ( $V_{REF}$ ) inputs are allowed. In addition, when  $\overline{RESET}$  is low all registers are reset, and all outputs except  $\overline{PTYERR}$  are forced low. The LVCMOS  $\overline{RESET}$  input must always be held at a valid logic high or low level.

To ensure defined outputs from the register before a stable clock has been supplied,  $\overline{RESET}$  must be held in the low state during power up.

In the DDR2 RDIMM application,  $\overline{RESET}$  is specified to be completely asynchronous with respect to CK and  $\overline{CK}$ . Therefore, no timing relationship can be guaranteed between the two. When entering reset, the register will be cleared and the outputs will be driven low quickly, relative to the time to disable the differential input receivers. However, when coming out of reset, the register will become active quickly, relative to the time to enable the differential input receivers. As long as the data inputs are low, and the clock is stable during the time from the low-to-high transition of  $\overline{RESET}$  until the input receivers are fully enabled, the design of the **ICSSSTUB32872A** must ensure that the outputs will remain low, thus ensuring no glitches on the output.

The device monitors both  $\overline{DCS0}$  and  $\overline{DCS1}$  inputs and will gate the Qn outputs from changing states when both  $\overline{DCS0}$  and  $\overline{DCS1}$  are high. If either  $\overline{DCS0}$  or  $\overline{DCS1}$  input is low, the Qn outputs will function normally. The  $\overline{RESET}$  input has priority over the  $\overline{DCS0}$  and  $\overline{DCS1}$  control and will force the Qn outputs low and the  $\overline{PTYERR}$  output high.

The **ICSSSTU32872A** includes a parity checking function. The **ICSSSTUB32872A** accepts a parity bit from the memory controller at its input pin PARIN, compares it with the data received on the D-inputs and indicates whether a parity error has occurred on its open-drain  $\overline{PTYERR}$  pin (active LOW). Package options include 96-ball Thin Profile Fine Pitch BGA (TFBGA, MO-TBD).

Inputs							Output
$\overline{RESET}$	$\overline{DCS0}$	$\overline{DCS1}$	CK	$\overline{CK}$	of inputs = H (D0-D21)	PARIN*	$\overline{PTYERR}^{**}$
H	L	H	↑	↓	Even	L	H
H	L	H	↑	↓	Odd	L	L
H	L	H	↑	↓	Even	H	L
H	L	H	↑	↓	Odd	H	H
H	H	L	↑	↓	Even	L	H
H	H	L	↑	↓	Odd	L	L
H	H	L	↑	↓	Even	H	L
H	H	L	↑	↓	Odd	H	H
H	H	H	↑	↓	X	X	$\overline{PTYERR}_0$
H	X	X	L or H	L or H	X	X	$\overline{PTYERR}_0$
L	X or floating	X or floating	X or floating	X or floating	X or floating	X or floating	H

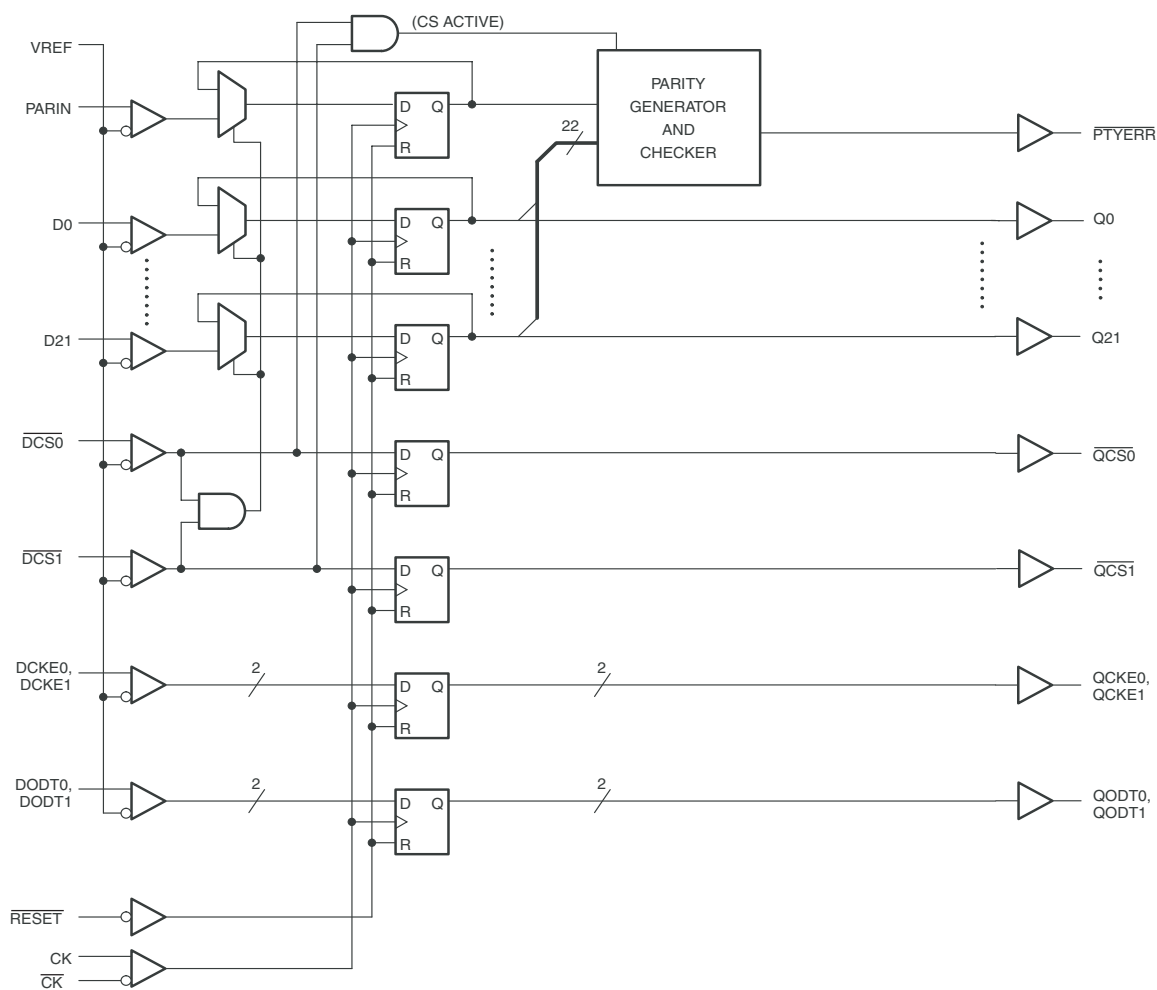
\* PARIN arrives one clock cycle after the data to which it applies.

\*\* This transition assumes  $\overline{PTYERR}$  is high at the crossing of CK going high and  $\overline{CK}$  going low. If  $\overline{PTYERR}$  is low, it stays latched low for two clock cycles or until  $\overline{RESET}$  is driven low.

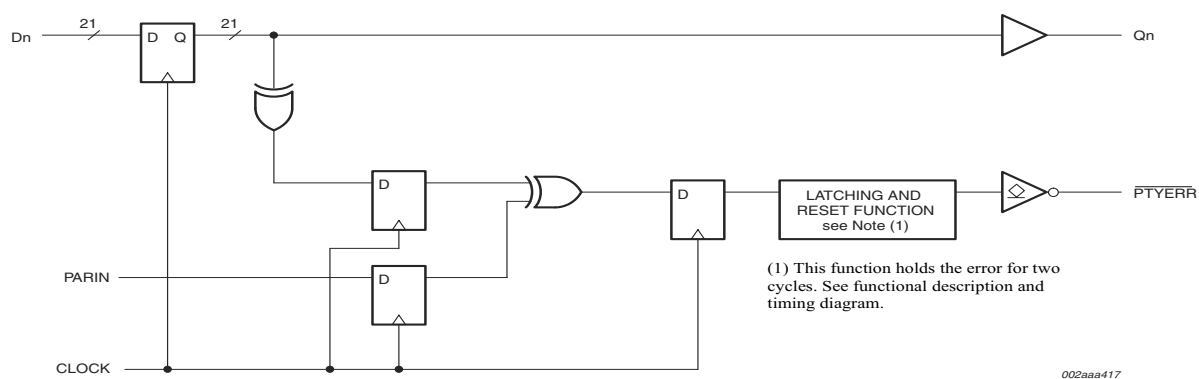
## Ball Assignment

Signal Group	Signal Name	Type	Description
Ungated inputs	DCKE0, DCKE1, DODT0, DODT1	SSTL_18	DRAM function pins not associated with Chip Select.
Chip Select gated inputs	D0 ... D21	SSTL_18	DRAM inputs, re-driven only when Chip Select is LOW.
Chip Select inputs	$\overline{\text{DCS0}}$ , $\overline{\text{DCS1}}$	SSTL_18	DRAM Chip Select signals. These pins initiate DRAM address/command decodes, and as such at least one will be low when a valid address/command is present. The register can be programmed to re-drive all D-inputs when at least one Chip Select input is LOW.
Re-driven outputs	Q0...Q21, $\overline{\text{QCS0-1}}$ , QCKE0-1, QODT0-1	SSTL_18	Outputs of the register, valid after the specified clock count and immediately following a rising edge of the clock.
Parity input	PARIN	SSTL_18	Input parity is received on pin PARIN and should maintain odd parity across the D0...D20 inputs, at the rising edge of the clock.
Parity error output	$\overline{\text{PTYERR}}$	Open drain	When LOW, this output indicates that a parity error was identified associated with the address and/or command inputs. $\overline{\text{PTYERR}}$ will be active for two clock cycles, and delayed by an additional clock cycle for compatibility with final parity out timing on the industry-standard DDR-II register with parity (in JEDEC definition).
Clock inputs	CK, $\overline{\text{CK}}$	SSTL_18	Differential master clock input pair to the register. The register operation is triggered by a rising edge on the positive clock input (CK).
Miscellaneous inputs	$\overline{\text{RESET}}$	1.8 V LVC MOS	Asynchronous reset input. When LOW, it causes a reset of the internal latches, thereby forcing the outputs LOW. RESET also resets the $\overline{\text{PTYERR}}$ signal.
	VREF	0.9 V nominal	Input reference voltage for the SSTL_18 inputs. Two pins (internally tied together) are used for increased reliability.

## Block Diagram



## Parity Functionality Block Diagram



## Register Timing

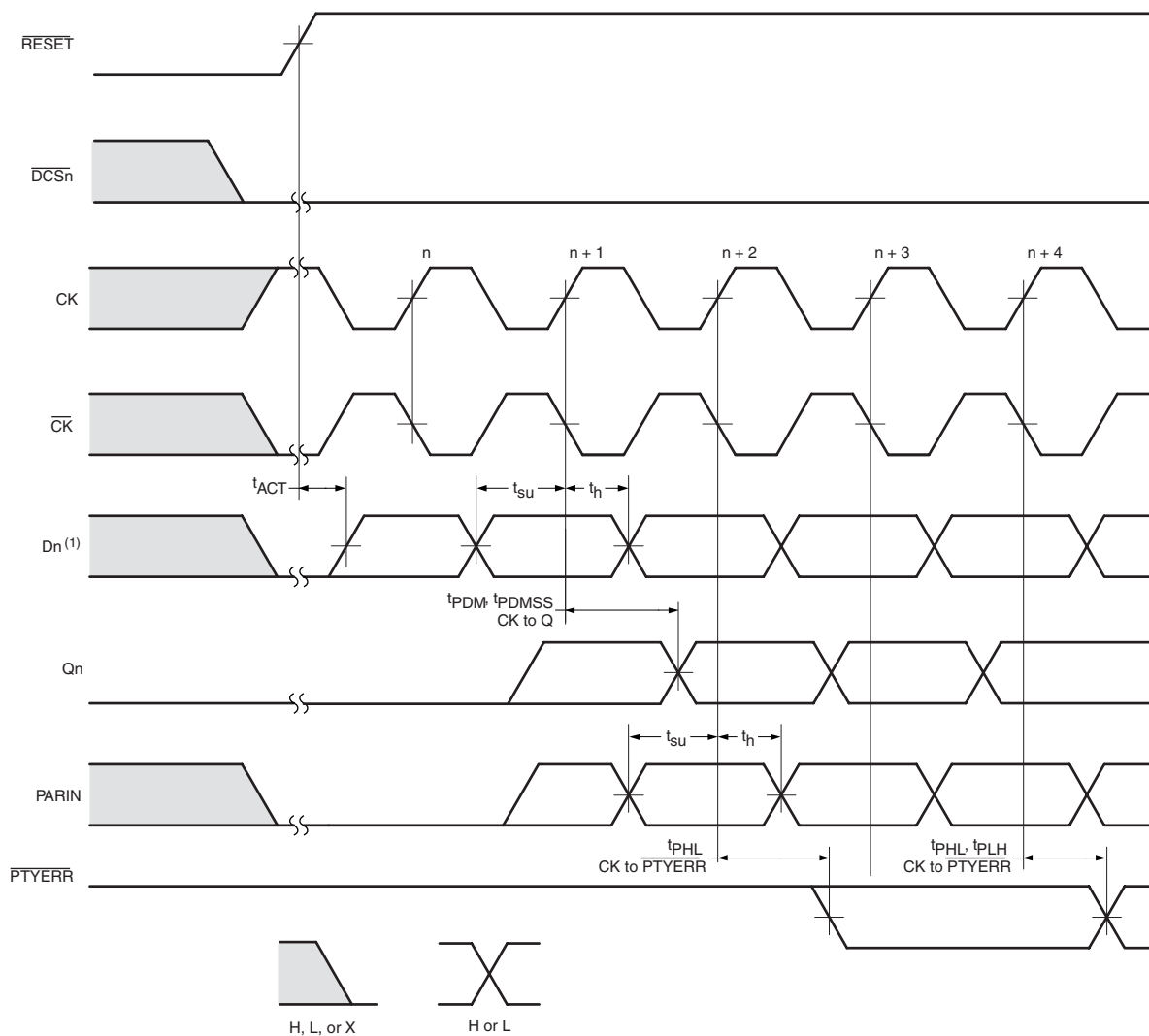


Figure 4 —RESET switches from L to H

(1) After RESET is switched from LOW to HIGH, all data and PARIN input signals must be set and held LOW for a minimum time of  $t_{ACT}(\max)$  to avoid false error.

## Register Timing

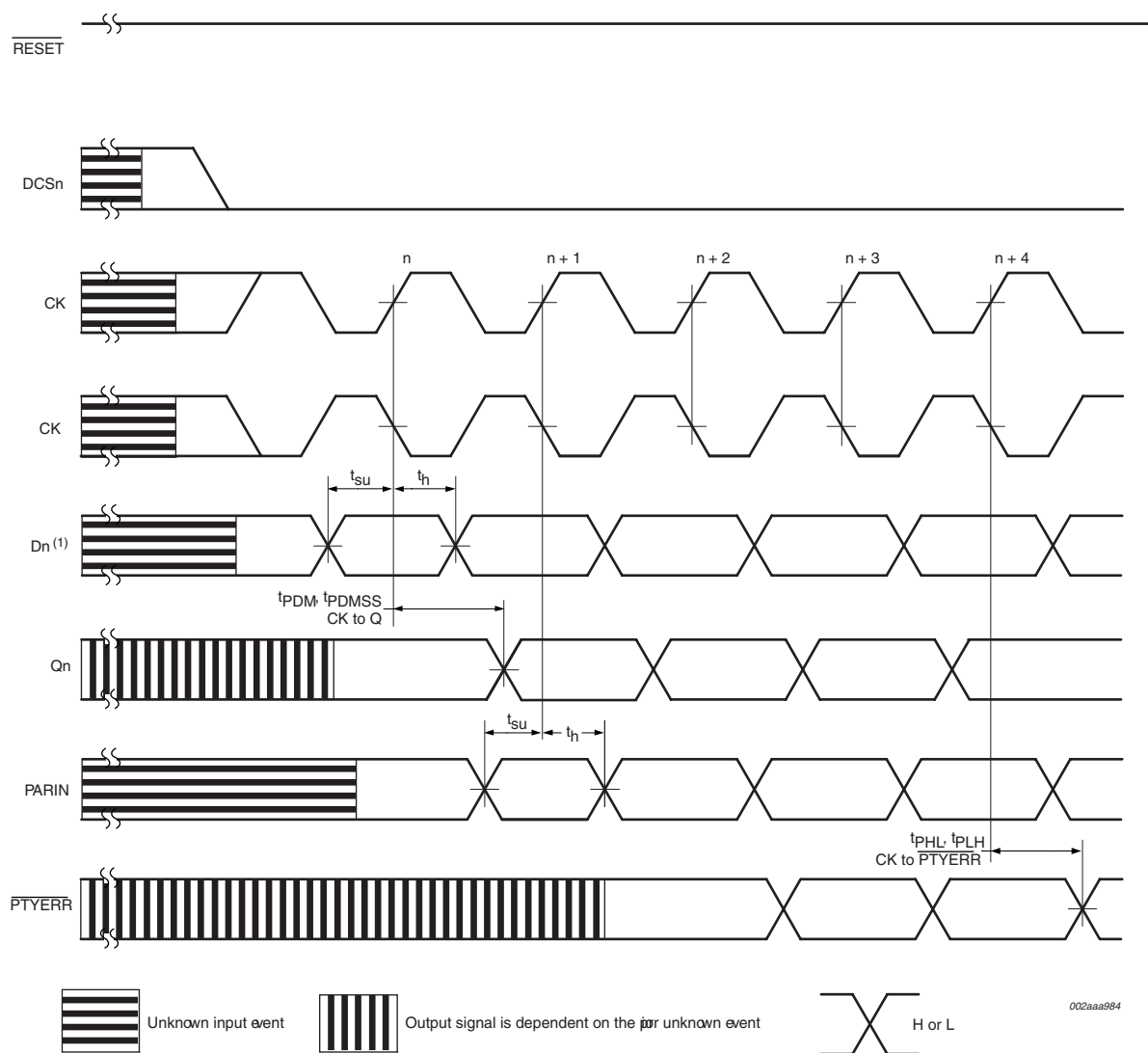


Figure 5 — RESET being held HIGH



## Register Timing

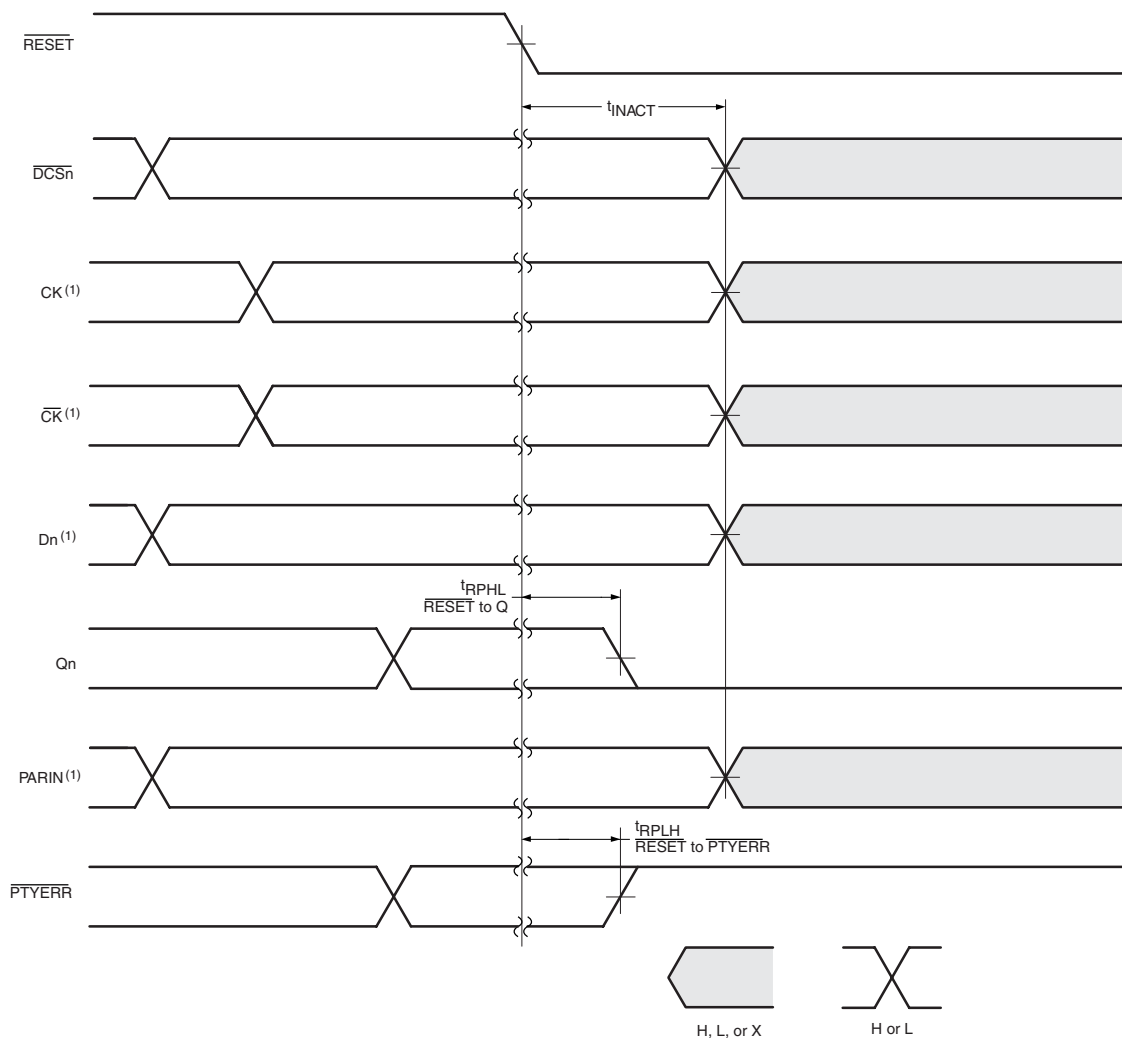


Figure 6 —  $\overline{\text{RESET}}$  switches from H to L

(1) After Reset is switched from HIGH to LOW, all data and clock input signals must be set and held at valid logic levels (not floating) for a minimum time of  $t_{\text{INACT}}$  (max)

## Absolute Maximum Ratings

Storage Temperature	−65°C to +150°C
Supply Voltage	−0.5V to 2.5V
Input Voltage <sup>1</sup>	−0.5V to VDD +2.5V
Output Voltage <sup>1,2</sup>	−0.5V to VDDQ + 0.5V
Input Clamp Current	±50 mA
Output Clamp Current	±50mA
Continuous Output Current	±50mA
VDD or GND Current/Pin	±100mA
Package Thermal Impedance <sup>3</sup>	36°C

### Notes:

1. The input and output negative voltage ratings may be excluded if the input and output clamp ratings are observed.
2. This value is limited to 2.5V maximum.
3. The package thermal impedance is calculated in accordance with JESD 51.

Stresses above those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These ratings are stress specifications only and functional operation of the device at these or any other conditions above those listed in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

## Recommended Operating Conditions

PARAMETER	DESCRIPTION		MIN	TYP	MAX	UNITS
V <sub>DDQ</sub>	I/O Supply Voltage		1.7	1.8	1.9	V
V <sub>REF</sub>	Reference Voltage		0.49 x V <sub>DD</sub>	0.5 x V <sub>DD</sub>	0.51 x V <sub>DD</sub>	
V <sub>TT</sub>	Termination Voltage		V <sub>REF</sub> - 0.04	V <sub>REF</sub>	V <sub>REF</sub> + 0.04	
V <sub>I</sub>	Input Voltage		0		V <sub>DDQ</sub>	
V <sub>IH</sub> (DC)	DC Input High Voltage	Data Inputs	V <sub>REF</sub> + 0.125			
V <sub>IH</sub> (AC)	AC Input High Voltage		V <sub>REF</sub> + 0.250			
V <sub>IL</sub> (DC)	DC Input Low Voltage				V <sub>REF</sub> - 0.125	
V <sub>IL</sub> (AC)	AC Input Low Voltage				V <sub>REF</sub> - 0.250	
V <sub>IH</sub>	Input High Voltage Level	RESET	0.65 x V <sub>DDQ</sub>			
V <sub>IL</sub>	Input Low Voltage Level				0.35 x V <sub>DDQ</sub>	
V <sub>ICR</sub>	Common mode Input Range	CK, CK	0.675		1.125	
V <sub>ID</sub>	Differential Input Voltage		0.600			
I <sub>OH</sub>	High-Level Output Current				-8	mA
I <sub>OL</sub>	Low-Level Output Current				8	
T <sub>A</sub>	Operating Free-Air Temperature		0		70	°C

<sup>1</sup>Guaranteed by design, not 100% tested in production.

Note:  $\overline{\text{Rst}}$  and Cn inputs must be held at valid logic levels (not floating) to ensure proper device operation. The differential inputs must not be floating unless  $\overline{\text{Rst}}$  is low.

## Electrical Characteristics - DC

$T_A = 0 - 70^{\circ}\text{C}$ ;  $V_{DD} = 2.5 \pm 0.2\text{V}$ ,  $V_{DDQ} = 2.5 \pm 0.2\text{V}$ ; (unless otherwise stated)

SYMBOL	PARAMETERS	CONDITIONS	$V_{DDQ}$	MIN	TYP	MAX	UNITS
$V_{OH}$		$I_{OH} = -8\text{mA}$	1.7V	1.2			V
$V_{OL}$		$I_{OL} = 8\text{mA}$	1.7V			0.5	
$I_I$	All Inputs	$V_I = V_{DD}$ or GND	1.9V			$\pm 5$	$\mu\text{A}$
$I_{DD}$	Standby (Static)	RESET = GND	1.9V			200	$\mu\text{A}$
	Operating (Static)	$V_I = V_{IH(AC)}$ or $V_{IL(AC)}$ , RESET = $V_{DD}$				150	mA
$I_{DDQ}$	Dynamic operating (clock only)	RESET = $V_{DD}$ , $V_I = V_{IH(AC)}$ or $V_{IL(AC)}$ , CLK and CLK switching 50% duty cycle.	1.8V		TBD		$\mu\text{A}/\text{clock MHz}$
	Dynamic Operating (per each data input)	RESET = $V_{DD}$ , $V_I = V_{IH(AC)}$ or $V_{IL(AC)}$ , CLK and CLK switching 50% duty cycle. One data input switching at half clock frequency, 50% duty cycle			TBD		$\mu\text{A}/\text{clock MHz/data}$
$C_i$	Data Inputs	$V_I = V_{REF} \pm 350\text{mV}$		2.5		5	pF
	CLK and CLK	$V_{ICR} = 1.25\text{V}$ , $V_{I(PP)} = 360\text{mV}$		2		3.8	
	RESET	$V_I = V_{DDQ}$ or GND			4.5		pF

Notes:

1 - Guaranteed by design, not 100% tested in production.

## Output Buffer Characteristics

Output edge rates over recommended operating free-air temperature range (See figure 7)

PARAMETER	$V_{DD} = 1.8\text{V} \pm 0.1\text{V}$		UNIT
	MIN	MAX	
$dV/dt_r$	1	4	V/ns
$dV/dt_f$	1	4	V/ns
$dV/dt_{\Delta^1}$		1	V/ns

1. Difference between  $dV/dt_r$  (rising edge rate) and  $dV/dt_f$  (falling edge rate)

## Timing Requirements

(over recommended operating free-air temperature range, unless otherwise noted)

SYMBOL	PARAMETERS		$V_{DD} = 1.8V \pm 0.1V$		UNITS
			MIN	MAX	
$f_{clock}$	Clock frequency			410	MHz
$t_W$	Pulse duration		1		ns
$t_{ACT}$	Differential inputs active time			10	ns
$t_{INACT}$	Differential inputs inactive time			15	ns
$t_S$	Setup time	Data before $CK\uparrow$ , $\overline{CK}\downarrow$	0.6		ns
		$\overline{DCS0}$ , $\overline{DSC1}$ before $CK\uparrow$ , $CK\downarrow$ , $\overline{CSR}$ high	0.7		
$t_H$	Hold time	$\overline{DCS}$ , $\overline{DODT}$ , $\overline{DCKE}$ and $Dn$ after $CK\uparrow$ , $\overline{CK}\downarrow$	0.6		ns
	Hold time	$\overline{PAR\_IN}$ after $CK\uparrow$ , $\overline{CK}\downarrow$	0.5		ns

- Notes:**
- 1 - Guaranteed by design, not 100% tested in production.
  - 2 - For data signal input slew rate of 1V/ns.
  - 3 - For data signal input slew rate of 0.5V/ns and < 1V/ns.
  - 4 -  $CK/\overline{CK}$  signal input slew rate of 1V/ns.

## Switching Characteristics

(over recommended operating free-air temperature range, unless otherwise noted)

Symbol	Parameter	Measurement Conditions	MIN	MAX	Units
$f_{max}$	Max input clock frequency		410		MHz
$t_{PDM}$	Propagation delay, single bit switching	$CK\uparrow$ and $\overline{CK}\downarrow$ to $Qn$	1.25	1.9	ns
$t_{LH}$	Low to High propagation delay	$CK\uparrow$ and $\overline{CK}\downarrow$ to $\overline{PTYERR}$	1.2	3	ns
$t_{HL}$	High to low propagation delay		0.9	3	ns
$t_{PDMSS}$	Propagation delay simultaneous switching	$CK\uparrow$ and $\overline{CK}\downarrow$ to $Qn$		2	ns
$t_{PHL}$	High to low propagation delay	$\overline{RESET}\downarrow$ to $Qn\downarrow$		3	ns
$t_{PLH}$	Low to High propagation delay	$\overline{RESET}\downarrow$ to $\overline{PTYERR}\uparrow$		3	ns

1. Guaranteed by design, not 100% tested in production.

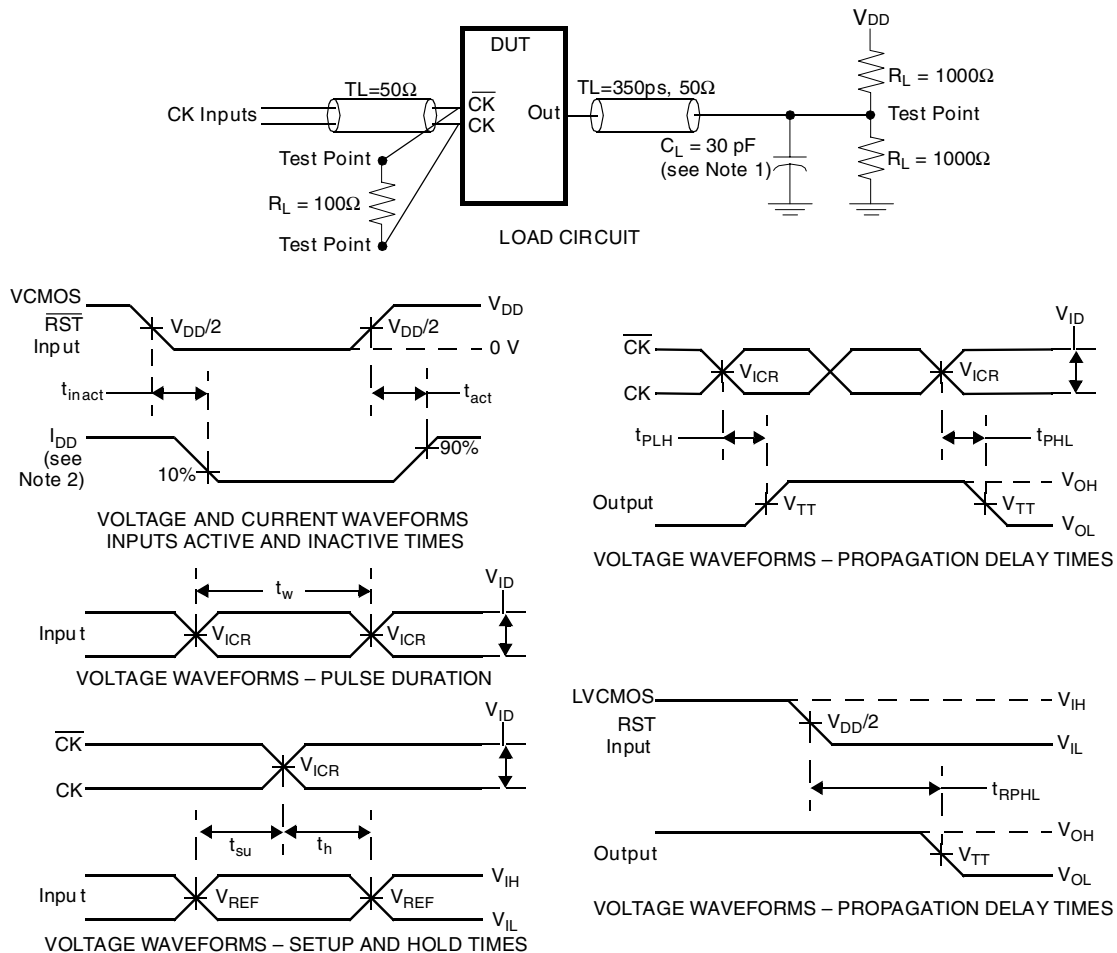


Figure 6 — Parameter Measurement Information ( $V_{DD} = 1.8V \pm 0.1V$ )

- Notes:
1.  $C_L$  includes probe and jig capacitance.
  2.  $I_{DD}$  tested with clock and data inputs held at  $V_{DD}$  or GND, and  $I_o = 0mA$ .
  3. All input pulses are supplied by generators having the following characteristics: PRR  $\leq 10$  MHz,  $Z_o = 50\Omega$ , input slew rate =  $1 V/ns \pm 20\%$  (unless otherwise specified).
  4. The outputs are measured one at a time with one transition per measurement.
  5.  $V_{REF} = V_{DD}/2$
  6.  $V_{IH} = V_{REF} + 250$  mV (ac voltage levels) for differential inputs.  $V_{IH} = V_{DD}$  for LVC MOS input.
  7.  $V_{IL} = V_{REF} - 250$  mV (ac voltage levels) for differential inputs.  $V_{IL} = GND$  for LVC MOS input.
  8.  $V_{ID} = 600$  mV
  9.  $t_{PLH}$  and  $t_{PHL}$  are the same as  $t_{PDM}$ .

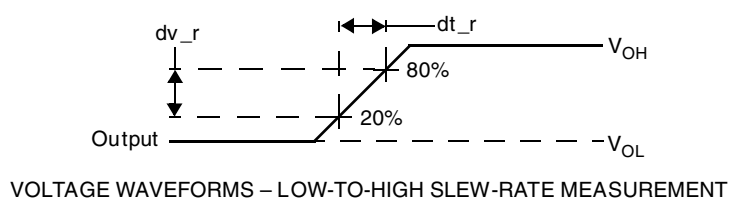
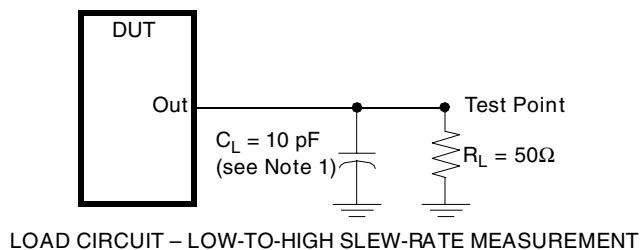
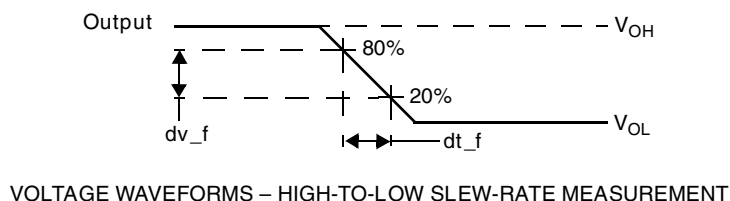
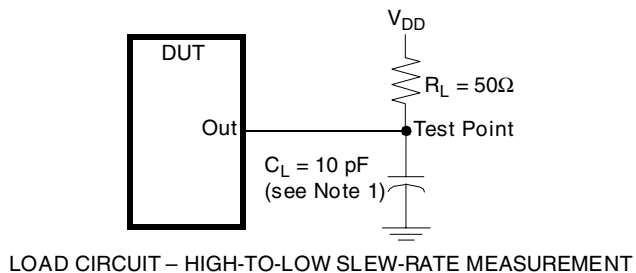


Figure 7 — Output Slew-Rate Measurement Information ( $V_{DD} = 1.8V \pm 0.1V$ )

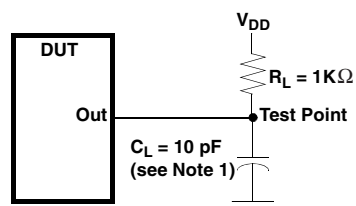
Notes: 1.  $C_L$  includes probe and jig capacitance.

2. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 10MHz$ ,  $Z_O = 50\Omega$ , input slew rate =  $1 V/ns \pm 20\%$  (unless otherwise specified).

### 3 Test circuits and switching waveforms (cont'd)

#### 3.3 Error output load circuit and voltage measurement information ( $V_{DD} = 1.8 \text{ V} \pm 0.1 \text{ V}$ )

All input pulses are supplied by generators having the following characteristics:  $\text{PRR} \leq 10 \text{ MHz}$ ;  $Z_0 = 50 \Omega$ ; input slew rate =  $1 \text{ V/ns} \pm 20\%$ , unless otherwise specified.



LOAD CIRCUIT – HIGH-TO-LOW SLEW-RATE MEASUREMENT

(1)  $C_L$  includes probe and jig capacitance.

Figure 28 — Load circuit, error output measurements

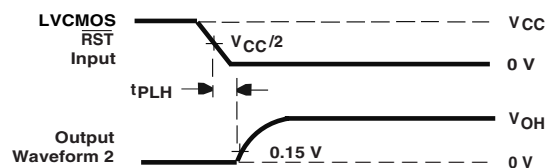


Figure 29 — Voltage waveforms, open-drain output low-to-high transition time with respect to reset input

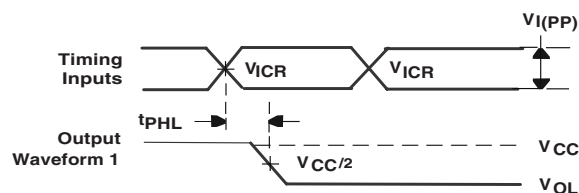


Figure 30 — Voltage waveforms, open-drain output high-to-low transition time with respect to clock inputs

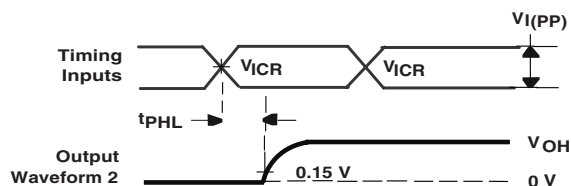
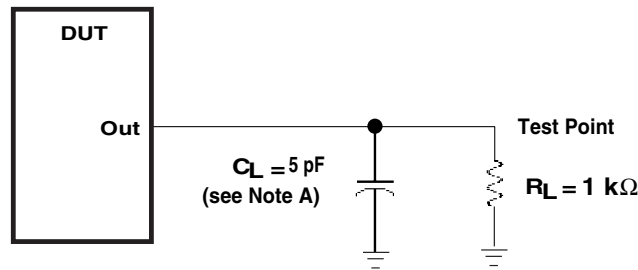


Figure 31 — Voltage waveforms, open-drain output low-to-high transition time with respect to clock inputs

### 3 Test circuits and switching waveforms (cont'd)

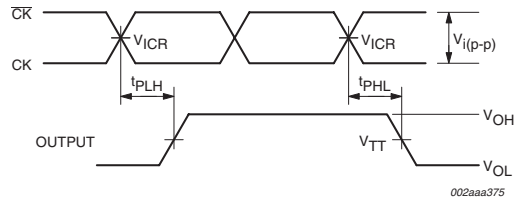
#### 3.4 Partial-parity-out load circuit and voltage measurement information ( $V_{DD} = 1.8 \text{ V} \pm 0.1 \text{ V}$ )

All input pulses are supplied by generators having the following characteristics:  $\text{PRR} \leq 10 \text{ MHz}$ ;  
 $Z_0 = 50 \Omega$ ; input slew rate =  $1 \text{ V/ns} \pm 20\%$ , unless otherwise specified.



(1)  $C_L$  includes probe and jig capacitance.

Figure 32 — Partial-parity-out load circuit,

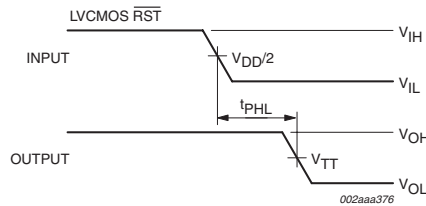


$$V_{TT} = V_{DD}/2$$

$t_{PLH}$  and  $t_{PHL}$  are the same as  $t_{PD}$ .

$$V_{I(PP)} = 600 \text{ mV}$$

Figure 33 — Partial-parity-out voltage waveforms; propagation delay times with respect to clock inputs



$$V_{TT} = V_{DD}/2$$

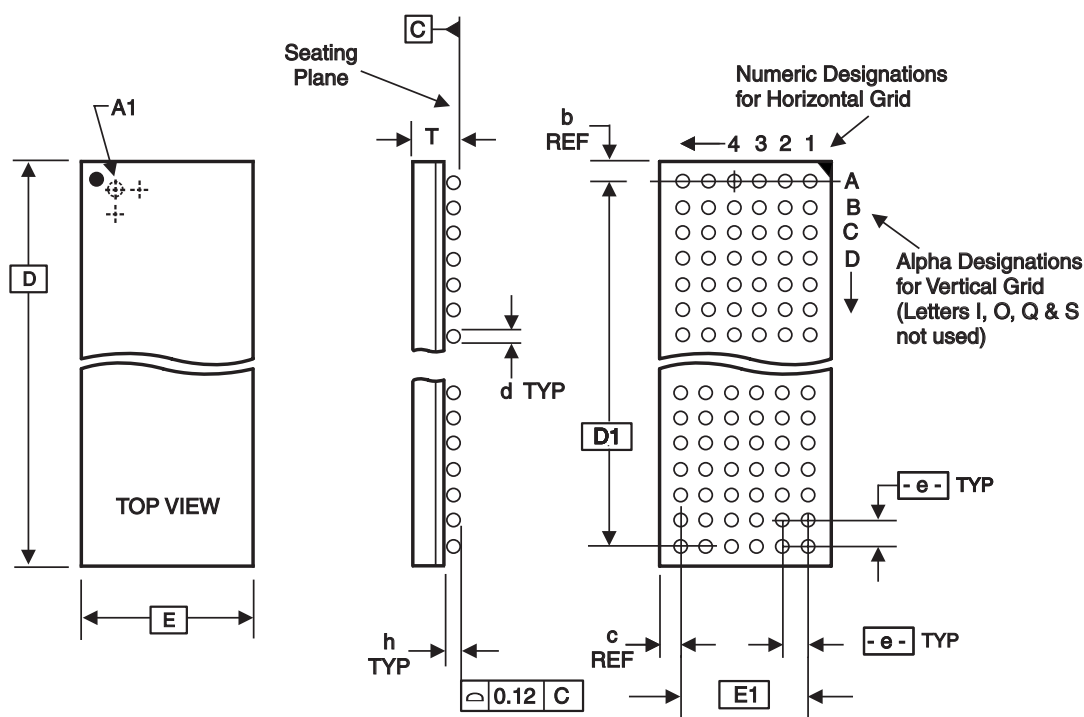
$t_{PLH}$  and  $t_{PHL}$  are the same as  $t_{PD}$ .

$V_{IH} = V_{REF} + 250 \text{ mV}$  (AC voltage levels) for differential inputs.  $V_{IH} = V_{DD}$  for LVCMOS inputs.

$V_{IL} = V_{REF} - 250 \text{ mV}$  (AC voltage levels) for differential inputs.  $V_{IL} = V_{DD}$  for LVCMOS inputs.

Figure 34 — Partial-parity-out voltage waveforms; propagation delay times with respect to reset input





ALL DIMENSIONS IN MILLIMETERS

D	E	T	e	---- BALL GRID ----		Max. TOTAL	d	h	REF. DIMENSIONS	
				HORIZ	VERT				b	c
		Min/Max					Min/Max	Min/Max		
13.50 Bsc	5.50 Bsc	1.20/1.40	0.80 Bsc	6	16	96	0.40/0.50	0.25/0.41	0.75	0.75
11.50 Bsc	5.00 Bsc	1.00/1.20	0.65 Bsc	6	16	96	0.35/0.45	0.25/0.35	0.875	0.875

Note: Ball grid total indicates maximum ball count for package. Lesser quantity may be used.

\* Source Ref.: JEDEC Publication 95, MO-205

10-0055C

## Ordering Information

### ICSSSTUB32872Az(LF)T

Example:

**ICS XXXX y z (LF) T**

Designation for tape and reel packaging

Lead Free, RoHS Compliant (Optional)

Package Type

H = LFBGA (reduced size: 5.5 x 13.50)

HM = TFBGA (reduced size: 5.0 x 11.50)

Revision Designator (will not correlate with datasheet revision)

Device Type

Prefix

ICS = Standard Device

## Revision History

Rev.	Issue Date	Description	Page #
A	5/2/2006	Initial Release.	-
B	12/12/2006	Electrical table, Ci Data input max changed from 3.5 to 5.0, CLK max changed from 3 to 3.8	11
C	12/20/2006	Timing table, ts Data before CK changed from 0.5 to 0.7, th DCS after CK changed from 0.5 to 0.6	12
D	12/21/2006	Applications, removed "800"; Electrical table, Idd Operating max changed from 80 to 150, Ci RESET typ changed from 2.5 to 4.5; Timing table, th Hold Time, changed Q to Dn, Switching table, changed tpdm max from 1.7 to 1.9, thl min from 1 to 0.9, and tpdms max from 1.9 to 2.	1, 11, 12
E	3/6/2007	Timing table, ts Data before CK changed from 0.7 to 0.6; Switching table, fixed typos.	12
F	3/13/2007	Page 1, Recc. List, changed 3rd bullet to "Provides complete DDR DIMM solution with ICS98ULPA877A, ICS97ULP877, or IDTCSPUA877A"; page 11, fixed typos.	1, 11

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