

# NL3HS644

## 2:1 MIPI D-PHY (1.5 Gbps) 4-Data Lane Switch

The NL3HS644 is a 4-data lane MIPI, D-PHY switch. This single-pole double-throw (SPDT) switch is optimized for switching between 2 high-speed or low-power MIPI sources. The NL3HS644 is designed for MIPI specifications and allows connection to a CSI or DSI module.

### Features

- Operating Supply:  $V_{CC} = 1.65\text{ V to }4.5\text{ V}$
- Switch Signal Range: 0 to  $V_{CC}$
- Signal Types: MIPI, D-PHY
- ON-Resistance:
  - $R_{ON} = 8\ \Omega$  (Typ) HS MIPI
  - $R_{ON} = 7.9\ \Omega$  (Typ) LP MIPI
- ON-Resistance Mismatch:
  - $\Delta R_{ON} = 0.09\ \Omega$  (Typ) HS MIPI
  - $\Delta R_{ON} = 0.17\ \Omega$  (Typ) LP MIPI
- ON Resistance Flatness:
  - $R_{ON\_FLAT} = 0.03\ \Omega$  (Typ) HS MIPI
  - $R_{ON\_FLAT} = 0.46\ \Omega$  (Typ) LP MIPI
- Supply Current:  $I_{CC} = 55\ \mu\text{A}$  (Max)
- Hi-Z Supply Current:  $I_{CCZ} = 5\ \mu\text{A}$  (Max)
- Off-Isolation:  $O_{IRR} = -27\ \text{dB}$  (Typ)
- Crosstalk:  $X_{TALK} = -28\ \text{dB}$  (Typ)
- Bandwidth:  $BW = 1,050\ \text{MHz}$  (Typ)
- Channel to Channel Skew:  $t_{SK} = 63\ \text{ps}$  (Typ)
- ON Capacitance:  $C_{ON} = 12.6\ \text{pF}$
- 36-Ball WLCSP Package, 2.36 mm x 2.36 mm
- This device is Pb-Free, Halogen-Free/BFR-Free and are RoHS-Compliant

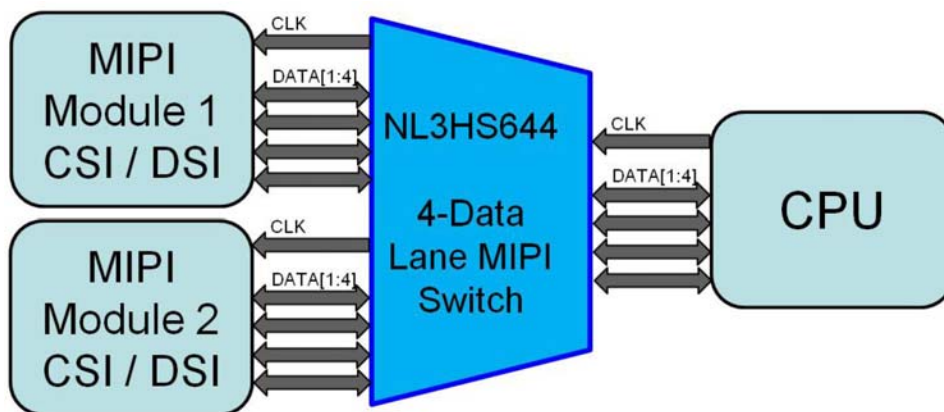


Figure 1. Typical Application – Mobile Phone



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WLCSP36  
FC SUFFIX  
CASE 567LR

### MARKING DIAGRAM



XXXXXX = Device Code  
A = Assembly Location  
WL = Wafer Lot  
Y = Year  
WW = Work Week  
▪ = Pb-Free Package

### ORDERING INFORMATION

See detailed ordering, marking and shipping information in the package dimensions section on page 8 of this data sheet.

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## FUNCTION TABLE

OE	SEL	FUNCTION
L	L	CLKP = CLKAP, CLKN = CLKAN, DnP = DAnP, DnN = DAnN
L	H	CLKP = CLKBP, CLKN = CLKBN, DnP = DBnP, DnN = DBnN
H	X	CLKAP/CLKAN, CLKBP/CLKBN, DAnP/DAnN, DBnP/DBnN Ports at High Impedance

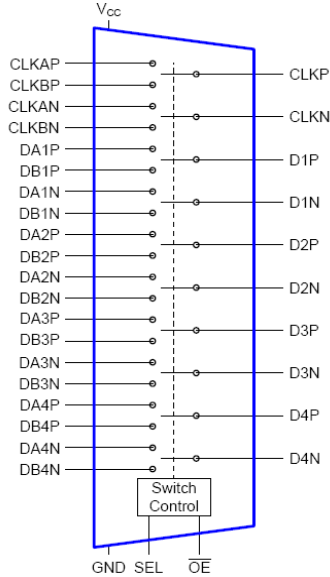


Figure 2. Block Diagram

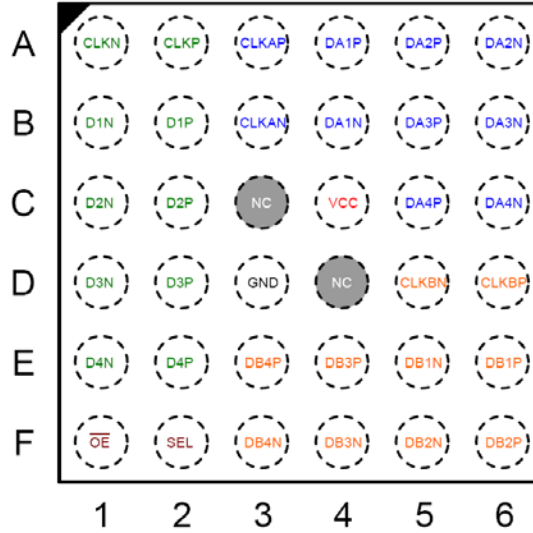


Figure 3. Pinout (Top Through View)

## PIN ASSIGNMENT

Pin Name	Ball	Description	
CLKP / CLKN	A2 / A1	Common Clock Path	
D1P / D1N	B2 / B1	Common Data Path 1	
D2P / D2N	C2 / C1	Common Data Path 2	
D3P / D3N	D2 / D1	Common Data Path 3	
D4P / D4N	E2 / E1	Common Data Path 4	
CLKAP / CLKAN	A3 / B3	A-Side Clock Path	
DA1P / DA1N	A4 / B4	A-Side Data Path 1	
DA2P / DA2N	A5 / A6	A-Side Data Path 2	
DA3P / DA3N	B5 / B6	A-Side Data Path 3	
DA4P / DA4N	C5 / C6	A-Side Data Path 4	
CLKBP / CLKBN	D6 / D5	B-Side Clock Path	
DB1P / DB1N	E6 / E5	B-Side Data Path 1	
DB2P / DB2N	F6 / F5	B-Side Data Path 2	
DB3P / DB3N	E4 / F4	B-Side Data Path 3	
DB4P / DB4N	E3 / F3	B-Side Data Path 4	
SEL	F2	Control Pin	
		SEL = L:	CLKP = CLKAP, CLKN = CLKAN, DnP = DAnP, DnN = DAnN
		SEL = H:	CLKP = CLKBP, CLKN = CLKBN, DnP = DBnP, DnN = DBnN
OE	F1	Output Enable	
VCC	C4	Power	
GND	D3	Ground	
NC	C3 / D4	No Connect	

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## MAXIMUM RATINGS

Symbol	Rating	Value	Unit
$V_{CC}$	Positive DC Supply Voltage	-0.5 to +5.5	V
$V_{IS}$	Analog Input Voltage	-0.5 to $V_{CC} + 0.5$	V
$V_{IN}$	Digital Control Input Voltage (SEL or $\overline{OE}$ )	-0.5 to +5.5	V
$I_{OS}$	Switch Output Current	50	mA
$I_{IOK}$	Switch Input/Output Diode Current	-50	mA
$I_{IK}$	Control Input Diode Current	$\pm 50$	mA
$T_s$	Storage Temperature	-65 to +150	$^{\circ}\text{C}$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

## RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Max	Unit
$V_{CC}$	Positive DC Supply Voltage	1.65	4.5	V
$V_{IS}$	Switch Input / Output Voltage			V
	HS Mode	0.1	0.3	
	LP Mode	0	1.2	
$V_{IN}$	Digital Control Input Voltage (SEL or $\overline{OE}$ ) (Note 1)	GND	$V_{CC}$	V

1. Control input must be held High or Low. It must not float.

## DC ELECTRICAL CHARACTERISTICS

Voltages referenced to GND. All typical values are at  $T_A = 25^{\circ}\text{C}$  unless otherwise specified.

Symbol	Parameter	Condition	$V_{CC}$ (V)	$T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$			Unit
				Min	Typ	Max	

### DIGITAL CONTROL SECTION (SEL or $\overline{OE}$ )

$V_{IK}$	Clamp Diode Voltage	$I_{IN} = -18$ mA	2.8			-1.2	V
$V_{IH}$	Input Voltage High		1.65 – 4.5	1.0			V
$V_{IL}$	Input Voltage Low		1.65 – 4.5			0.4	V
$I_{IN}$	Input Leakage Current	$V_{IN} = 0$ V to $V_{CC}$	1.65 – 4.5			$\pm 100$	nA

### SWITCHES

$R_{ON\_MIPI\_HS}$	Switch ON Resistance for HS MIPI Applications (Note 2)	$I_{ON} = -10$ mA, $\overline{OE} = 0$ V, SEL = $V_{CC}$ or 0 V, CLKA, CLKB, DBn or DAn = 0.1, 0.2, 0.3 V	1.8		9	12	$\Omega$
			2.5		8	9	
			3.6		8	9	
			4.5		8	9	
$R_{ON\_MIPI\_LP}$	Switch ON Resistance for LP MIPI Applications (Note 2)	$I_{ON} = -10$ mA, $\overline{OE} = 0$ V, SEL = $V_{CC}$ or 0 V, CLKA, CLKB, DBn or DAn = 0, 0.6, 1.2 V	1.8		9.5	12	$\Omega$
			2.5		8.5	10	
			3.6		7.9	9	
			4.5		7.6	9	
$\Delta R_{ON\_MIPI\_HS}$	ON Resistance Matching Between HS MIPI Channels (Note 3)	$I_{ON} = -10$ mA, $\overline{OE} = 0$ V, SEL = $V_{CC}$ or 0 V, CLKA, CLKB, DBn or DAn = 0.1, 0.2, 0.3 V	1.8		0.02		$\Omega$
			2.5		0.09		
			3.6		0.09		
			4.5		0.08		

2. Measured by the voltage drop between A and B pins at the indicated current through the switch. ON resistance is determined by the lower of the voltage on the two (A or B) ports.

3. Guaranteed by characterization.

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## DC ELECTRICAL CHARACTERISTICS

Voltages referenced to GND. All typical values are at  $T_A = 25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Condition	$V_{CC}$ (V)	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			Unit
				Min	Typ	Max	
<b>SWITCHES</b>							
$\Delta R_{ON\_MIPI\_LP}$	ON Resistance Matching Between LP MIPI Channels (Note 3)	$I_{ON} = -10\text{ mA}$ , $\overline{OE} = 0\text{ V}$ , SEL = $V_{CC}$ or $0\text{ V}$ , CLKA, CLKB, DBn or DAN = $0, 0.6, 1.2\text{ V}$	1.8		0.17		$\Omega$
			2.5		0.12		
			3.6		0.17		
			4.5		0.09		
$R_{ON\_FLAT\_MIPI\_HS}$	ON Resistance Flatness for HS MIPI Channels (Note 3)	$I_{ON} = -10\text{ mA}$ , $\overline{OE} = 0\text{ V}$ , SEL = $V_{CC}$ or $0\text{ V}$ , CLKA, CLKB, DBn or DAN = $0.1, 0.2, 0.3\text{ V}$	1.8		0.23		$\Omega$
			2.5		0.11		
			3.6		0.03		
			4.5		0.02		
$R_{ON\_FLAT\_MIPI\_LP}$	ON Resistance Flatness for LP MIPI Channels (Note 3)	$I_{ON} = -10\text{ mA}$ , $\overline{OE} = 0\text{ V}$ , SEL = $V_{CC}$ or $0\text{ V}$ , CLKA, CLKB, DBn or DAN = $0, 0.6, 1.2\text{ V}$	1.8		2.09		$\Omega$
			2.5		1.19		
			3.6		0.46		
			4.5		0.08		
$I_{NO(OFF)}, I_{NC(OFF)}$	OFF Leakage Current (CLKAn, DAN, CLKBn, DBn)	CLKn, Dn = $0.3\text{ V}$ , $V_{CC} - 0.3\text{ V}$ , CLKAn, DAN, or CLKBn; DBn = $V_{CC} - 0.3\text{ V}$ , $0.3\text{ V}$ or Floating; $\overline{OE} = 0\text{ V}$	1.65 – 4.5			$\pm 100$	nA
$I_{A(ON)}$	ON Leakage Current of Common Ports (CLKn, Dn)	CLKn, Dn = $0.3\text{ V}$ , $V_{CC} - 0.3\text{ V}$ , CLKAn, DAN, or CLKBn; DBn = $V_{CC} - 0.3\text{ V}$ , $0.3\text{ V}$ or Floating; $\overline{OE} = 0\text{ V}$	1.65 – 4.5			$\pm 100$	nA
$V_{IK}$	Clamp Diode Voltage	$I_{IN} = -18\text{ mA}$	2.8			-1.2	V
$I_{OZ}$	Off-State Leakage Current	$0 \leq \text{CLKn, Dn, CLKAn, CLKBn, DAN, DBn} \leq 3.6\text{ V}$ ; $\overline{OE} = \text{High}$	4.5			$\pm 100$	nA

## SUPPLY CURRENTS

$I_{CCZ}$	Quiescent Hi-Z Supply Current	$V_{IN} = 0$ or $V_{CC}$ , $I_{OUT} = 0$	4.5			0.5	$\mu\text{A}$
$I_{CC}$	Quiescent Supply Current	$V_{IN} = 0$ or $V_{CC}$ , $I_{OUT} = 0$	2.5 to 4.5			55	$\mu\text{A}$
			1.8			30	
$I_{CCT}$	Increase in $I_{CC}$ Current per Control Voltage and $V_{CC}$	$V_{SEL}$ , $V(\overline{OE}) = 1.65\text{ V}$	4.5			4.0	$\mu\text{A}$
			2.5	0.1		1.0	

2. Measured by the voltage drop between A and B pins at the indicated current through the switch. ON resistance is determined by the lower of the voltage on the two (A or B ports).
3. Guaranteed by characterization.

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**AC ELECTRICAL CHARACTERISTICS** All typical values are for  $V_{CC} = 3.3\text{ V}$  at  $T_A = 25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Condition	$V_{CC}$ (V)	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			Unit
				Min	Typ	Max	
$t_{INIT}$	Initialization Time $V_{CC}$ to Output (Notes 4, 5)	$R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ , $V_{IS} = 1.2\ \text{V}$ Figure 4	2.5 to 4.5	100			$\mu\text{s}$
			1.8	150			
$t_{EN}$	Enable Turn-On Time $\overline{OE}$ to Output	$R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ , $V_{IS} = 1.2\ \text{V}$ Figure 5	2.5 to 4.5		120	200	$\mu\text{s}$
			1.8		250	500	
$t_{DIS}$	Disable Turn-Off Time $\overline{OE}$ to Output	$R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ , $V_{IS} = 1.2\ \text{V}$ Figure 5	2.5 to 4.5		25	50	ns
			1.8		50	90	
$t_{ON}$	Turn-On Time SEL to Output	$R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ , $V_{IS} = 1.2\ \text{V}$ Figure 5	2.5 to 4.5		50	100	ns
			1.8		75	125	
$t_{OFF}$	Turn-Off Time SEL to Output	$R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ , $V_{IS} = 1.2\ \text{V}$ Figure 5	2.5 to 4.5		50	200	ns
			1.8		200	325	
$t_{BBM}$	Break-Before-Make Time	$R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ , $V_{IS} = 1.2\ \text{V}$ Figure 6		10	50		ns
$O_{IRR}$	Off-Isolation for MIPI (Note 4)	$R_L = 50\ \Omega$ , $f = 750\ \text{MHz}$ , $\overline{OE} = V_{CC}$ , $V_{IS} = -1\ \text{dBm}$ (200 mV <sub>PP</sub> )	1.65 to 4.5		-27		dB
$X_{TALK}$	Crosstalk for MIPI (Note 4)	$R_L = 50\ \Omega$ , $f = 750\ \text{MHz}$ , $V_{IS} = -1\ \text{dBm}$ (200 mV <sub>PP</sub> )	1.65 to 4.5		-28		dB
BW	-3 dB Bandwidth (Note 4)	$R_L = 50\ \Omega$ , $C_L = 0\ \text{pF}$	3.0	900	1050		MHz
$S_{DD21}$	Differential Data Rate	Inter-Operability Data Rate	3.0		1.5		Gbps

4. Guaranteed by characterization.

5. Wait time required after  $V_{CC}$  power-up to operating level before data access is valid.

## HIGH SPEED-RELATED AC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Condition	$V_{CC}$ (V)	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			Unit
				Min	Typ	Max	
$t_{SK(O)}$	Channel-to-Channel Single-Ended Skew (Note 6)	TDR-Based Method ( $V_{IS} = 0.2\ V_{PP}$ , $C_L = C_{ON}$ ) Figure 7	3.3		63	67	ps
$t_{SK(P)}$	Skew of Opposite Transitions of the Same Output (Note 6)	TDR-Based Method ( $V_{IS} = 0.2\ V_{PP}$ , $C_L = C_{ON}$ ) Figure 8	3.3		17	31	ps

6. Guaranteed by characterization.

## CAPACITANCE

Symbol	Parameter	Condition	$V_{CC}$ (V)	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			Unit
				Min	Typ	Max	
$C_{IN}$	Control Pin Input Capacitance	$V_{CC} = 0\ \text{V}$ , $f = 1\ \text{MHz}$	3.3		14.9		pF
$C_{ON}$	Out ON Capacitance	$V_{CC} = 3.3\ \text{V}$ , $\overline{OE} = 0\ \text{V}$ , $f = 1\ \text{MHz}$	3.3		12.6		pF
$C_{OFF}$	Out OFF Capacitance	$V_{CC} = 3.3\ \text{V}$ , $\overline{OE} = 3.3\ \text{V}$ , $f = 1\ \text{MHz}$	3.3		7.4		pF

Timing Diagrams

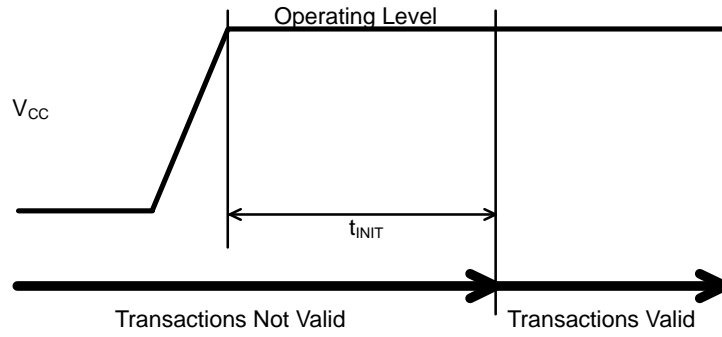


Figure 4.  $t_{INIT}$ , Initialization Time

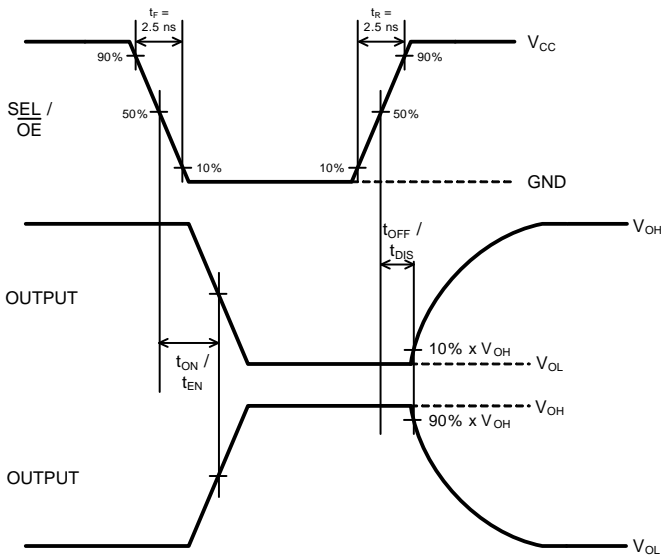


Figure 5.  $t_{EN}$ ,  $t_{DIS}$ ,  $t_{ON}$ ,  $t_{OFF}$  Times

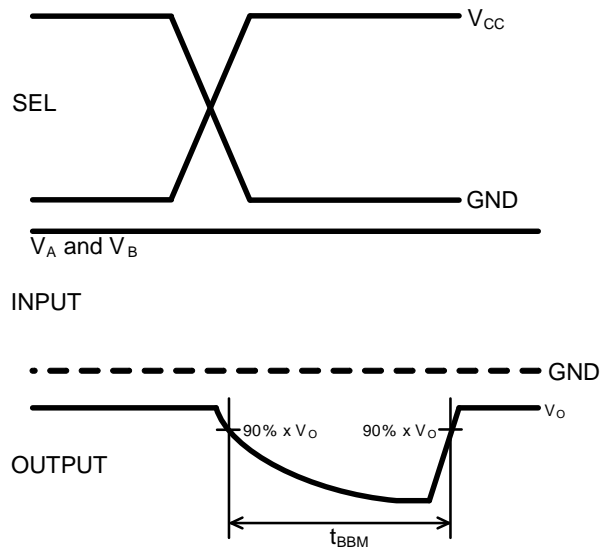


Figure 6.  $t_{BBM}$ , Break-Before-Make Time

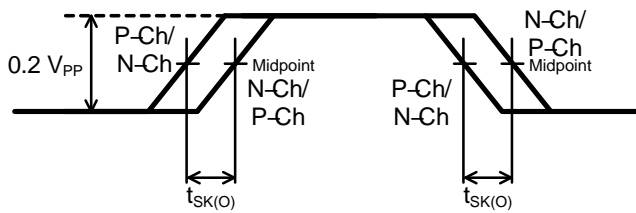


Figure 7.  $t_{SK(O)}$ , Channel-to-Channel Single-Ended

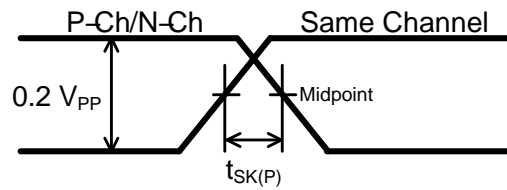


Figure 8.  $t_{SK(P)}$ , Same Channel Opposite Transitions

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## Eye Diagrams

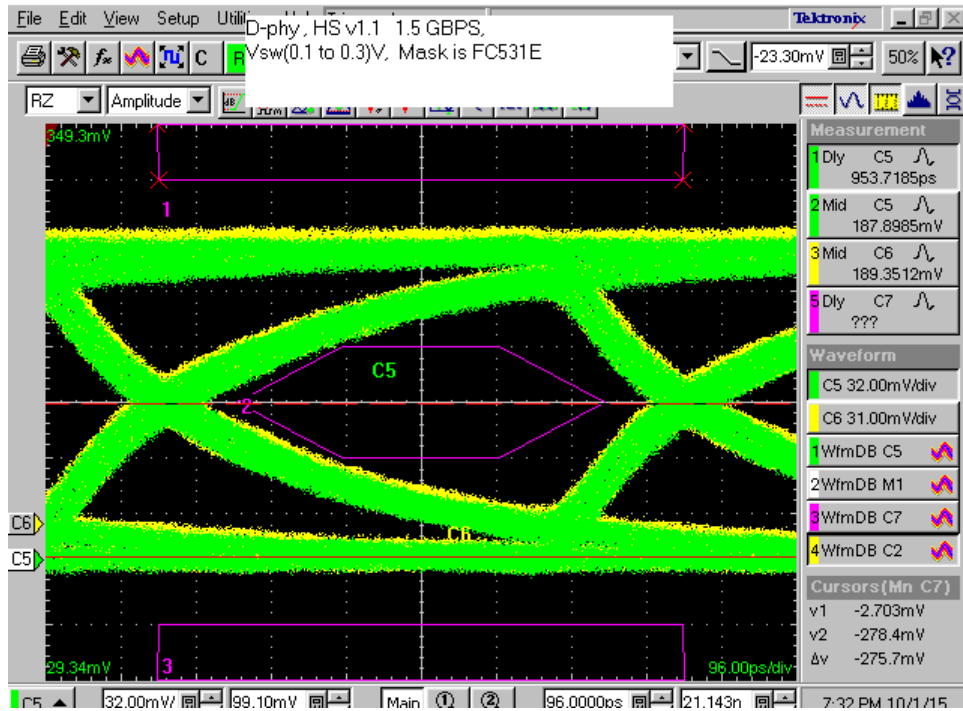


Figure 9. D-PHY HS 1.5 Gbps with Eye Mask

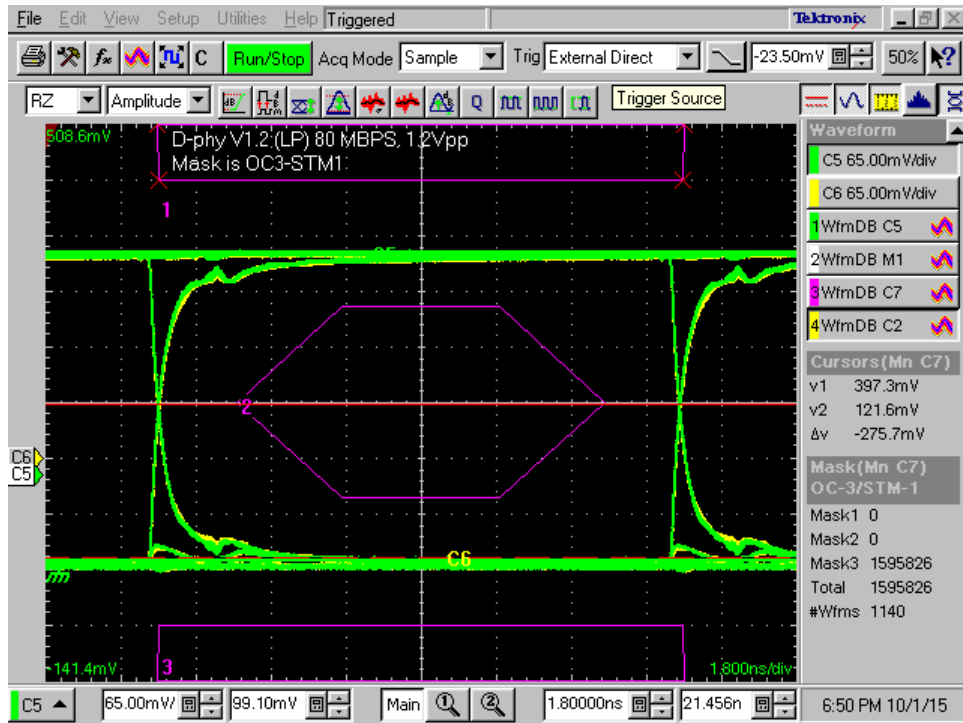


Figure 10. D-PHY LP 80 Mbps with Eye Mask

# NL3HS644

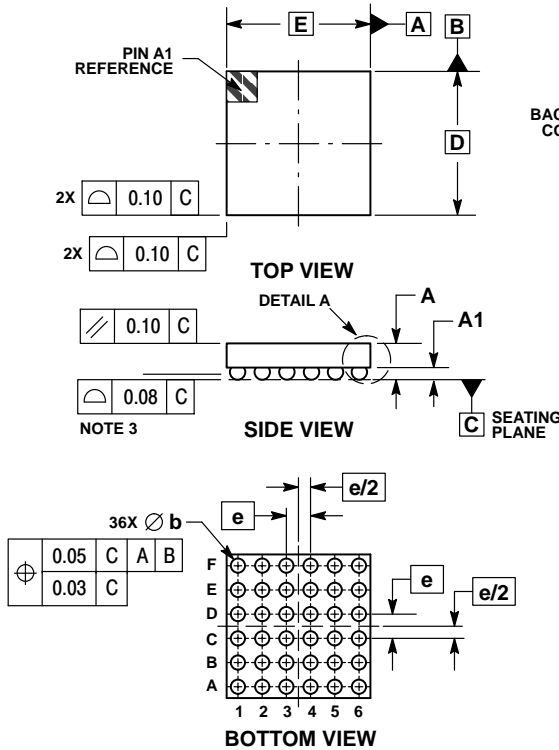
## DEVICE ORDERING INFORMATION

Device Order Number	Device Code	Package Type	Tape & Reel Size†
NL3HS644FCTAG	3HS644	36-ball WLCSP (Pb-Free)	3000 / Tape & Reel
NL3HS644BFCTAG (Backside Coated)	HS644B	36-ball WLCSP (Pb-Free)	3000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## PACKAGE DIMENSIONS

### WLCSP36 2.34x2.34 CASE 567LR ISSUE B

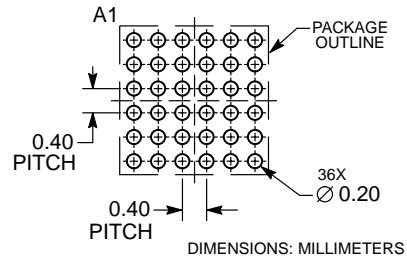


#### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. COPLANARITY APPLIES TO SPHERICAL CROWNS OF SOLDER BALLS.

DIM	MILLIMETERS	
	MIN	MAX
A	---	0.54
A1	0.17	0.23
A2	0.00	0.027
b	0.24	0.30
D	2.34 BSC	
E	2.34 BSC	
e	0.40 BSC	

### RECOMMENDED SOLDERING FOOTPRINT\*



\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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