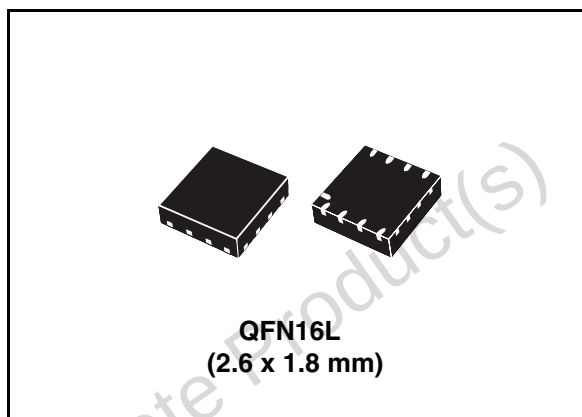


Features

- 90 Mbps (max) data rate when driven by a totem pole driver
- 8 Mbps (max) data rate when driven by an open drain pole driver
- Bi-directional level translation without direction control pin
- Wide V_L voltage range of 1.65 to 3.6 V
- Wide V_{CC} voltage range of 1.80 to 5.5 V
- Power down mode feature – when either supply is off, all I/Os are in high impedance
- Low quiescent current (max 24 μ A)
- Able to be driven by totem pole and open drain drivers
- 5.5 V tolerant enable pin
- ESD performance on all pins: ± 2 kV HBM
- Small package and footprint
QFN16 (2.6 x 1.8 mm) package

Applications

- Low voltage system level translation
- Mobile phones and other mobile devices
- I²C level translation
- UART level translation



Description

The ST2349 is a 4-bit dual supply level translator which provides the level shifting capability to allow data transfer in a multi-voltage system. Externally applied voltages, V_{CC} and V_L , set the logic levels on either side of the device. It utilizes transmission gate-based design that allows bi-directional level translation without a control pin.

The ST2349 accepts a V_L from 1.65 to 3.6 V and V_{CC} from 1.80 to 5.5 V, making it ideal for data transfer between low-voltage ASICs/PLD and higher voltage systems. This device has a tri-state output mode which can be used to disable all I/Os.

The ST2349 supports power down mode when V_{CC} is grounded/floating and the device is disabled via the OE pin.

Table 1. Device summary

Order code	Package	Packaging
ST2349QTR	QFN16 (2.6 x 1.8 mm)	Tape and reel (3000 parts per reel)

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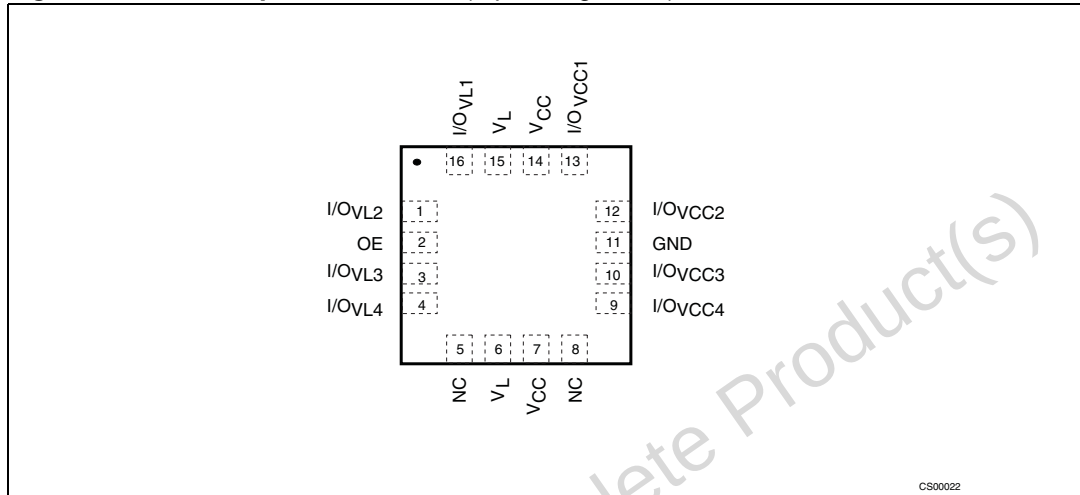
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1 Pin settings

1.1 Pin connection

Figure 1. ST2349 pin connection (top through view)



1.2 Pin description

Table 2. ST2349 pin description

Pin number	Symbol	Name and function
1	I/O _{VL2}	Data input/output
2	OE	Output enable
3	I/O _{VL3}	Data input/output
4	I/O _{VL4}	Data input/output
5	NC	No connection
6	V _L	Supply voltage
7	V _{CC}	Supply voltage
8	NC	No connection
9	I/O _{VCC4}	Data input/output
10	I/O _{VCC3}	Data input/output
11	GND	Ground
12	I/O _{VCC2}	Data input/output
13	I/O _{VCC1}	Data input/output
14	V _{CC}	Supply voltage
15	V _L	Supply voltage
16	I/O _{VL1}	Data input/output

2 Device block diagrams

Figure 2. ST2349 block diagram

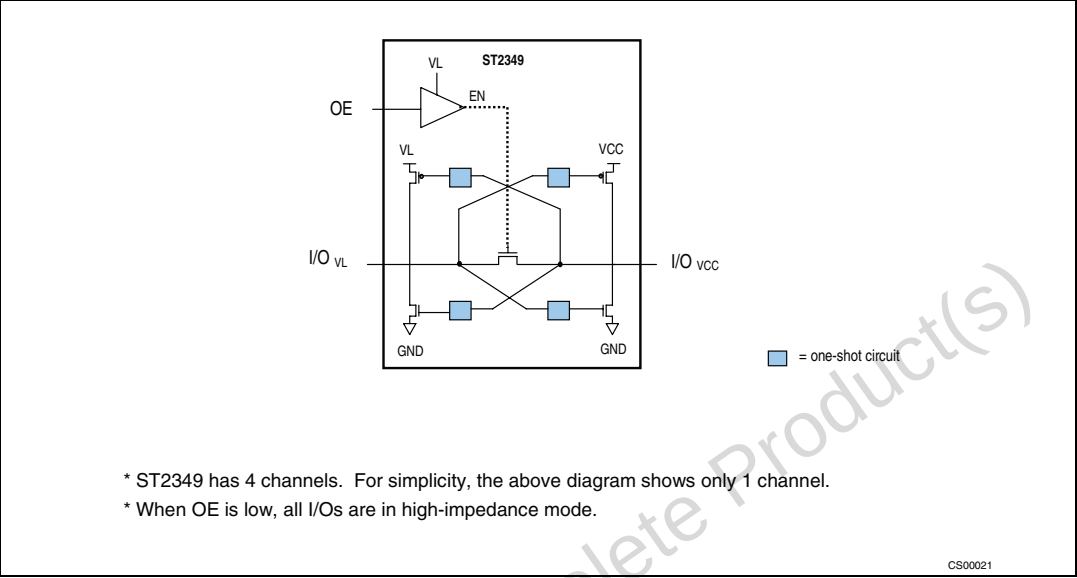
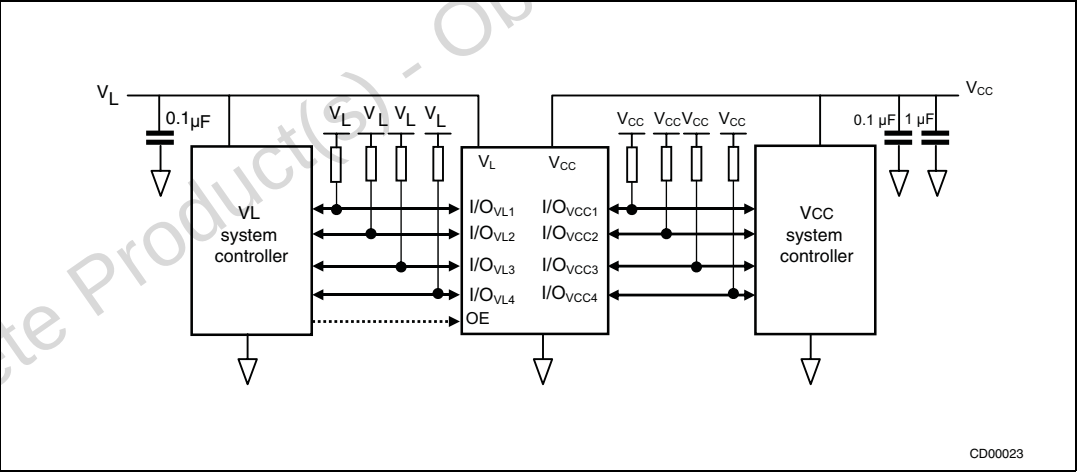


Figure 3. Application block diagram



3 Supplementary notes

3.1 Driver requirement

The ST2349 may be driven by an open drain or totem pole driver and the nature of the device's output is "open drain". It must not be used to drive a pull-down resistor since the impedance of the output at HIGH state depends on the pull-up resistor placed at the I/Os.

As the device has pull-up resistors on both the I/O_{VCC} and I/O_{VL} ports, the user needs to ensure that the driver is able to sink the required amount of current. For example, if the settings are $V_{CC} = 5.5\text{ V}$, $V_L = 4.3\text{ V}$ and the pull-up resistor is $10\text{ k}\Omega$ then the driver must be able to sink at least $(5.5\text{ V}/10\text{ k}\Omega) + (4.3\text{ V}/10\text{ k}\Omega) = 1\text{ mA}$ and still meet the V_{IL} requirements of the ST2349.

3.2 Load driving capability

To support the open drain system, the one-shot transistor is turned on only during state transition at the output side. When it drives a high state, after the one-shot transistor is turned off, only the pull-up resistor is able to maintain the state. In this case, the resistive load is not recommended.

During the translation from V_{CC} side to V_L side, the oscillation might be triggered when the signal is reflected back as a glitch. This is caused by the architecture of the device (auto-direction).

When using the ST2349, care need to be taken in the PCB data-track design and output loading. It is recommended that the load is less than 25 pf .

3.3 Power off feature

In some applications where it might be required to turn off one of the power supplies powering up the level translator, the user may turn off the V_{CC} only when the OE pin is low (device is disabled). There will be no current consumption in V_L due to floating gates or other causes, and the I/Os are in a high-impedance state in this mode.

3.4 Truth table

Table 3. Truth table

Enable	Bi-directional Input/Output	
OE	I/O _{VCC}	I/O _{VL}
H ⁽¹⁾	H ⁽²⁾	H ⁽¹⁾
H ⁽¹⁾	L	L
L	Z ⁽³⁾	Z ⁽³⁾

1. High level V_L power supply referred
2. High level V_{CC} power supply referred
3. Z = high impedance

4 Maximum rating

Stressing the device above the rating listed in the “Absolute maximum ratings” table may cause permanent damage to the device. These are stress ratings only, and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics SURE Program and other relevant quality documents.

Table 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_L	Supply voltage	-0.3 to 4.6	V
V_{CC}	Supply voltage	-0.3 to 6.5	V
V_{OE}	DC control input voltage	-0.3 to 6.5	V
$V_{I/OVL}$	DC I/O _{VL} input voltage (OE = GND or V_L)	-0.3 to $V_L + 0.3$	V
$V_{I/OVCC}$	DC I/O _{VCC} input voltage (OE = GND or V_L)	-0.3 to $V_{CC} + 0.3$	V
I_{IK}	DC input diode current	-20	mA
$I_{I/OVL}$	DC output current	±25	mA
$I_{I/OVCC}$	DC output current	±258	mA
I_{SCTOUT}	Short circuit duration, continuous	40	mA
P_D	Power dissipation ⁽¹⁾	500	mW
T_{STG}	Storage temperature	-65 to 150	°C
TL	Lead temperature (10 seconds)	300	°C
ESD	Electrostatic discharge protection (HBM)	±2	kV

1. 500mW: 65 °C derated to 300 mW by 10W/°C: 65 °C to 85 °C

4.1 Recommended operating conditions

Table 5. Recommended operating conditions

Symbol	Parameter	Min	Typ	Max	Unit
V_L	Supply voltage	1.65		3.6	V
$V_{CC}^{(1)}$	Supply voltage	1.8		5.5	V
V_{OE}	Input voltage (OE output enable pin, V_L power supply referred)	0		3.6	V
$V_{I/OVL}$	I/O _{VL} voltage	0		V_L	V
$V_{I/OVCC}$	I/O _{VCC} voltage	0		V_{CC}	V
T_{op}	Operating temperature	-40		85	°C
dt/dV	Input rise and fall time (for 45 Mbps operation)	0		1	ns/V

1. V_{CC} must be greater than V_L .

5 Electrical characteristics

Table 6. DC characteristics (over recommended operating conditions unless otherwise noted. All typical values are at $T_A = 25\text{ °C}$)

Symbol	Parameter	Test conditions			Value					Unit
		V _L	V _{CC}		T _A = 25 °C			-40 to 85 °C		
					Min	Typ	Max	Min	Max	
V _{IHL}	High level input voltage (I/O _{VL})	1.65	V _L to 5.5		1.4			1.4		V
		2.0			1.6			1.6		
		2.5			2.0			2.0		
		3.0			2.4			2.4		
		3.6			2.8			2.8		
V _{ILL}	Low level input voltage (I/O _{VL})	1.65	V _L to 5.5				0.3		0.3	V
		2.0					0.4		0.4	
		2.5					0.5		0.5	
		3.0					0.6		0.6	
		3.6					0.8		0.8	
V _{IHC}	High level input voltage (I/O _{VCC})	1.65 to V _{CC}	1.8		1.6			1.6		V
			2.5		2.3			2.3		
			3.0		2.7			2.7		
			3.6		3.3			3.3		
			4.3		3.5			3.5		
			5.5		4.2			4.2		
V _{ILC}	Low level input voltage (I/O _{VCC})	1.65 - 2.5	3 - 5.5					0.3		V
		2.7 - 3.6	3.6 - 5.5					0.5		
V _{IH-OE}	High level input voltage (OE)	1.65	V _L to 5.5		1.0			1.0		V
		2.0			1.2			1.2		
		2.5			1.4			1.4		
		3.0			1.6			1.6		
		3.6			2.0			2.0		
V _{IL-OE}	Low level input voltage (OE)	1.65	V _L to 5.5				0.33		0.33	V
		2.0					0.40		0.40	
		2.5					0.50		0.50	
		3.0					0.60		0.60	
		3.6					0.75		0.75	

Table 6. DC characteristics (over recommended operating conditions unless otherwise noted. All typical values are at $T_A = 25\text{ }^{\circ}\text{C}$) (continued)

Symbol	Parameter	Test conditions			Value					Unit
		V _L	V _{CC}		T _A = 25 °C			-40 to 85 °C		
					Min	Typ	Max	Min	Max	
V _{OLL}	Low level output voltage (I/O _{VL})	1.65 to 3.6	V _L to 5.5	IO = 1.0 mA I/O _{VCC} ≤ 0.15 V			0.40		0.40	V
V _{OLC}	Low level output voltage (I/O _{VCC})	1.65 to 3.6	V _L to 5.5	IO = 1.0 mA I/O _{VL} ≤ 0.15 V			0.40		0.40	V
I _{OE}	Control input leakage current (OE)	1.65 to 3.6	V _L to 5.5	V _{OE} = GND or V _L			±0.1		±0.1	µA
I _{IO_LKG}	High impedance leakage current (I/O _{VL} , I/O _{VCC})	1.65 to 3.6	V _L to 5.5	OE = GND			±0.1		±0.1	µA
I _{QVCC}	Quiescent supply current V _{CC}	1.65 to 3.6	V _L to 5.5	only pull-up resistor connected to I/O		6	10		24	µA
I _{QVL}	Quiescent supply current V _L	1.65 to 3.6	V _L to 5.5	only pull-up resistor connected to I/O		0.01	0.1		1	µA
I _{Z-VCC}	High impedance quiescent supply current V _{CC}	1.65 to 3.6	V _L to 5.5	OE = GND; only pull-up resistor connected to I/O		6	10		24	µA
I _{Z-VL}	High impedance quiescent supply current V _L	1.65 to 3.6	V _L to 5.5	OE = GND; only pull-up resistor connected to I/O		0.01	0.1		1	µA

5.1 AC characteristics (device driven by open drain driver)

Table 7. AC characteristics - test conditions: $V_L = 1.65 - 1.8$ V (load $C_L = 15$ pF; $R_{up} = 4.7$ k Ω ; driver $t_r = t_f \leq 2$ ns) over temperature range -40 °C to 85 °C

Symbol	Parameter	$V_{CC} = 1.8 - 2.5$ V		$V_{CC} = 2.7 - 3.6$ V		$V_{CC} = 4.3 - 5.5$ V		Unit
		Min	Max	Min	Max	Min	Max	
t_{RVCC}	Rise time I/O_{VCC}		80		50		30	ns
t_{FVCC}	Fall time I/O_{VCC}		3		3		3	ns
t_{RVL}	Rise time I/O_{VL}		7		6		6	ns
t_{FVL}	Fall time I/O_{VL}		4		5		5	ns
$t_{I/OVL-VCC}$	Propagation delay time I/O_{VL-LH} to I/O_{VCC-LH} I/O_{VL-HL} to I/O_{VCC-HL}	t_{PLH}	5		5		5	ns
		t_{PHL}	5		5		5	ns
$t_{I/OVCC-VL}$	Propagation delay time I/O_{VCC-LH} to I/O_{VL-LH} I/O_{VCC-HL} to I/O_{VL-LH}	t_{PLH}	5		5		5	ns
		t_{PHL}	5		7		7	ns
t_{PZL} t_{PZH} t_{PLZ} t_{PHZ}	Output enable and disable time	En	10		10		10	ns
		Dis	40		40		40	ns
D_R	Data rate ⁽¹⁾		1.6		2.5		4	MHz

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

Table 8. AC characteristics - test conditions: $V_L = 2.5 - 2.7$ V (load $C_L = 15$ pF; $R_{up} = 4.7$ k Ω ; driver $t_r = t_f \leq 2$ ns) over temperature range -40 °C to 85 °C

Symbol	Parameter	$V_{CC} = 2.7 - 3.6$ V		$V_{CC} = 4.3 - 5.5$ V		Unit
		Min	Max	Min	Max	
t_{RVCC}	Rise time I/O_{VCC}		70		40	ns
t_{FVCC}	Fall time I/O_{VCC}		3		3	ns
t_{RVL}	Rise time I/O_{VL}		5		5	ns
t_{FVL}	Fall time I/O_{VL}		3		3	ns
$t_{I/OVL-VCC}$	Propagation delay time I/O_{VL-LH} to I/O_{VCC-LH} I/O_{VL-HL} to I/O_{VCC-HL}	t_{PLH}	2		2	ns
		t_{PHL}	3		3	ns
$t_{I/OVCC-VL}$	Propagation delay time I/O_{VCC-LH} to I/O_{VL-LH} I/O_{VCC-HL} to I/O_{VL-LH}	t_{PLH}	3		3	ns
		t_{PHL}	4		4	ns

Table 8. AC characteristics - test conditions: $V_L = 2.5 - 2.7$ V (load $C_L = 15$ pF; $R_{up} = 4.7$ k Ω ; driver $t_r = t_f \leq 2$ ns) over temperature range -40 °C to 85 °C

Symbol	Parameter	$V_{CC} = 2.7 - 3.6$ V		$V_{CC} = 4.3 - 5.5$ V		Unit
		Min	Max	Min	Max	
t_{PZL} t_{PZH}	Output enable and disable time	En	6		6	ns
t_{PLZ} t_{PHZ}		Dis	40		40	ns
D_R	Data rate ⁽¹⁾		2.5		3.2	MHz

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

Table 9. AC characteristics - test conditions: $V_L = 2.7 - 3.6$ V (load $C_L = 15$ pF; $R_{up} = 4.7$ k Ω ; driver $t_r = t_f \leq 2$ ns) over temperature range -40 °C to 85 °C

Symbol	Parameter	$V_{CC} = 4.3 - 5.5$ V		Unit
		Min	Max	
t_{RVCC}	Rise time I/O_{VCC}		55	ns
t_{FVCC}	Fall time I/O_{VCC}		3	ns
t_{RVL}	Rise time I/O_{VL}		4	ns
t_{FVL}	Fall time I/O_{VL}		3	ns
$t_{I/OVL-VCC}$	Propagation delay time I/O_{VL-LH} to I/O_{VCC-LH} I/O_{VL-HL} to I/O_{VCC-HL}	t_{PLH}	2	ns
		t_{PHL}	4	ns
$t_{I/OVCC-VL}$	Propagation delay time I/O_{VCC-LH} to I/O_{VL-LH} I/O_{VCC-HL} to I/O_{VL-HL}	t_{PLH}	4	ns
		t_{PHL}	4	ns
t_{PZL} t_{PZH} t_{PLZ} t_{PHZ}	Output enable and disable time	En	6	ns
		Dis	40	ns
D_R	Data rate ⁽¹⁾		2.8	MHz

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

5.2 AC characteristics (device driven by totem pole driver)

Table 10. AC characteristics (test conditions: $V_L = 1.65 - 1.8$ V (load $C_L = 15$ pF; $R_{up} = 10$ k Ω ; driver $t_r = t_f \leq 2$ ns) over temperature range -40 °C to 85 °C)

Symbol	Parameter		$V_{CC} = 1.8 - 2.5$ V		$V_{CC} = 2.7 - 3.6$ V		$V_{CC} = 4.3 - 5.5$ V		Unit
			Min	Max	Min	Max	Min	Max	
t_{RVCC}	Rise time I/O _{VCC}			7		3		4	ns
t_{FVCC}	Fall time I/O _{VCC}			7		3		3	ns
t_{RVL}	Rise time I/O _{VL}			6		4		5	ns
t_{FVL}	Fall time I/O _{VL}			4		4		4	ns
$t_{I/OVL-VCC}$	Propagation delay time I/O _{VL} -LH to I/O _{VCC} -LH I/O _{VL} -HL to I/O _{VCC} -HL	t_{PLH}		6		5		4	ns
		t_{PHL}		5		5		5	ns
$t_{I/OVCC-VL}$	Propagation delay time I/O _{VCC} -LH to I/O _{VL} -LH I/O _{VCC} -HL to I/O _{VL} -HL	t_{PLH}		6		5		4	ns
		t_{PHL}		4.5		5.2		7	ns
t_{PZL} t_{PZH} t_{PLZ} t_{PHZ}	Output enable and disable time	En		10		10		10	ns
		Dis		40		40		40	ns
D_R	Data rate ⁽¹⁾			12		32		32	MHz

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

Table 11. AC characteristics (test conditions: $V_L = 2.5 - 2.7$ V (load $C_L = 15$ pF; $R_{up} = 10$ k Ω ; driver $t_r = t_f \leq 2$ ns) over temperature range -40 °C to 85 °C)

Symbol	Parameter		$V_{CC} = 2.7 - 3.6$ V		$V_{CC} = 4.3 - 5.5$ V		Unit
			Min	Max	Min	Max	
t_{RVCC}	Rise time I/O _{VCC}			6		4	ns
t_{FVCC}	Fall time I/O _{VCC}			3		3	ns
t_{RVL}	Rise time I/O _{VL}			5		5	ns
t_{FVL}	Fall time I/O _{VL}			3		3	ns
$t_{I/OVL-VCC}$	Propagation delay time I/O _{VL} -LH to I/O _{VCC} -LH I/O _{VL} -HL to I/O _{VCC} -HL	t_{PLH}		3.5		3	ns
		t_{PHL}		4		4	ns
$t_{I/OVCC-VL}$	Propagation delay time I/O _{VCC} -LH to I/O _{VL} -LH I/O _{VCC} -HL to I/O _{VL} -HL	t_{PLH}		2.5		2.1	ns
							ns
		t_{PHL}		4		4	ns
							ns

Table 11. AC characteristics (test conditions: $V_L = 2.5 - 2.7$ V (load $C_L = 15$ pF; $R_{up} = 10$ k Ω ; driver $t_r = t_f \leq 2$ ns) over temperature range -40 °C to 85 °C) (continued)

Symbol	Parameter		$V_{CC} = 2.7 - 3.6$ V		$V_{CC} = 4.3 - 5.5$ V		Unit
			Min	Max	Min	Max	
t_{PZL} t_{PZH}	Output enable and disable time	En		6		6	ns
t_{PLZ} t_{PHZ}		Dis		40		40	ns
D_R	Data rate ⁽¹⁾			45		45	MHz

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

Table 12. AC characteristics (test conditions: $V_L = 2.7 - 3.6$ V (load $C_L = 15$ pF; $R_{up} = 10$ k Ω ; driver $t_r = t_f \leq 2$ ns) over temperature range -40 °C to 85 °C)

Symbol	Parameter		$V_{CC} = 4.3 - 5.5$ V		Unit
			Min	Max	
t_{RVCC}	Rise time I/O _{VCC}			5	ns
t_{FVCC}	Fall time I/O _{VCC}			3	ns
t_{RVL}	Rise time I/O _{VL}			4	ns
t_{FVL}	Fall time I/O _{VL}			3	ns
$t_{I/OVL-VCC}$	Propagation delay time I/O _{VL-LH} to I/O _{VCC-LH} I/O _{VL-HL} to I/O _{VCC-HL}	t_{PLH}		2.5	ns
		t_{PHL}		4	ns
$t_{I/OVCC-VL}$	Propagation delay time I/O _{VCC-LH} to I/O _{VL-LH} I/O _{VCC-HL} to I/O _{VL-HL}	t_{PLH}		2	ns
					ns
		t_{PHL}		4	ns
					ns
t_{PZL} t_{PZH} t_{PLZ} t_{PHZ}	Output enable and disable time	En		6	ns
		Dis		40	ns
D_R	Data rate ⁽¹⁾			45	MHz

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

Figure 4. Test circuit

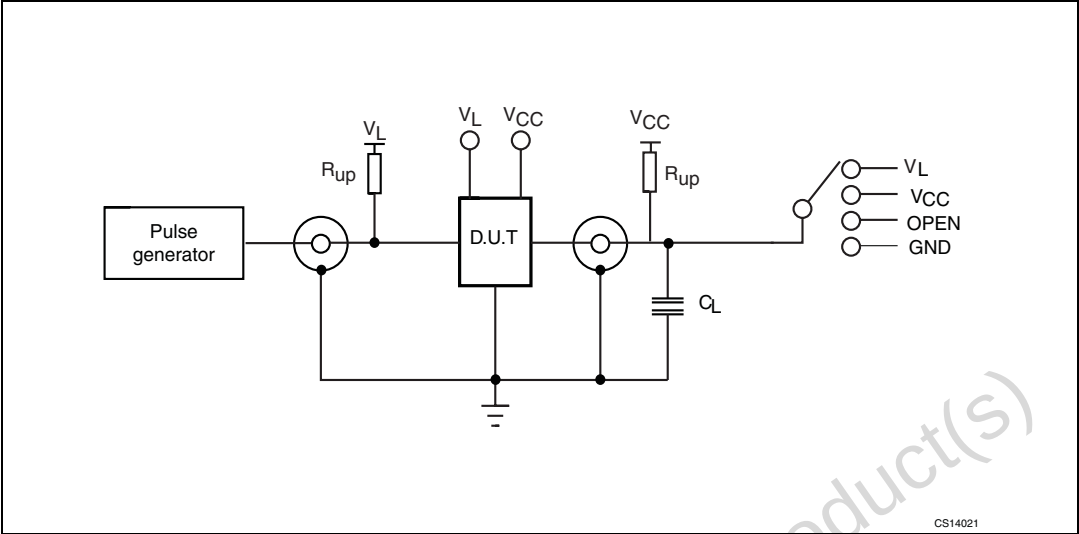


Table 13. Test circuit switches

Test	Switch		
	Driving I/O $_{V_L}$	Driving I/O $_{V_{VCC}}$	Open drain driving
t_{PLH} , t_{PHL}	Open	Open	Open

6 Waveforms

Table 14. Waveform symbol value

Symbol	Driving I/O _{VL}		Driving I/O _{VCC}	
	$1.8\text{ V} \leq V_L \leq V_{CC} \leq 2.5\text{ V}$	$3.3\text{ V} \leq V_L \leq V_{CC} \leq 5.0\text{ V}$	$1.8\text{ V} \leq V_L \leq V_{CC} \leq 2.5\text{ V}$	$3.3\text{ V} \leq V_L \leq V_{CC} \leq 5.0\text{ V}$
V _{IH}	V _L	V _L	V _{CC}	V _{CC}
V _{IM}	50% V _L	50% V _L	50% V _{CC}	50% V _{CC}
V _{OM}	50% V _{CC}	50% V _{CC}	50% V _L	50% V _L
V _X	V _{OL} + 0.15V	V _{OL} + 0.3V	V _{OL} + 0.15V	V _{OL} + 0.3V
V _Y	V _{OH} - 0.15V	V _{OH} - 0.3V	V _{OH} - 0.15V	V _{OH} - 0.3V

Figure 5. Waveform - propagation delay (f = 1 MHz; 50% duty cycle)

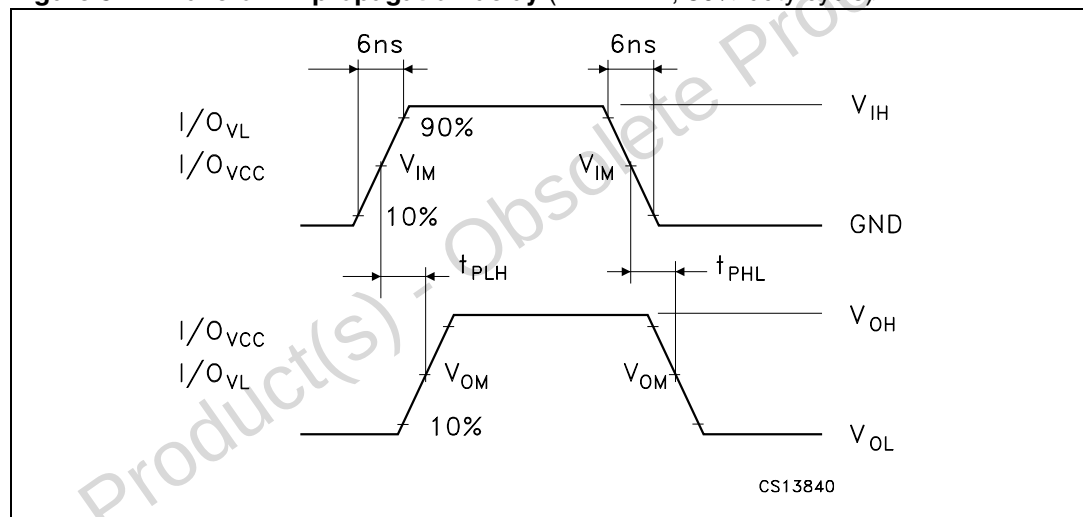


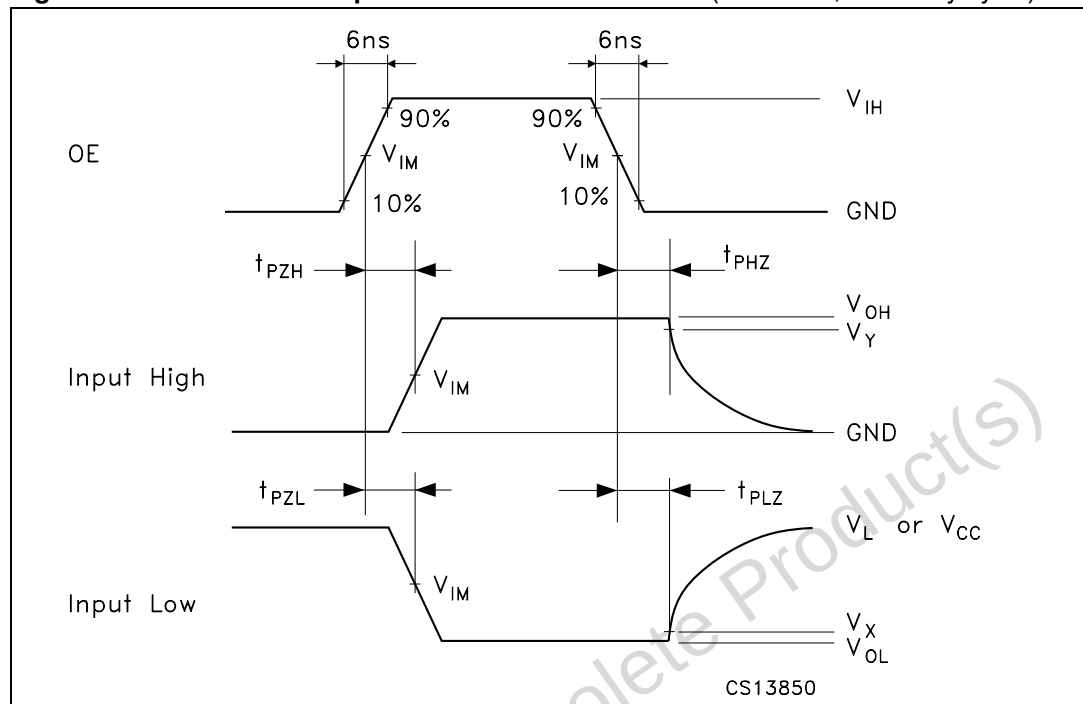
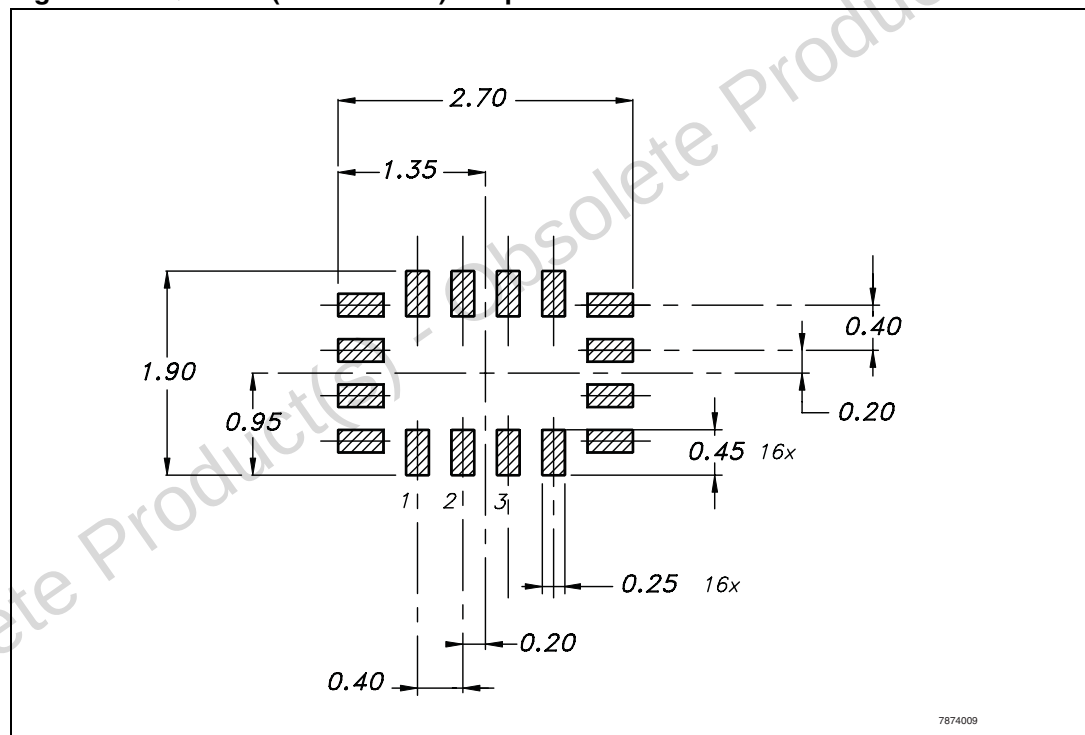
Figure 6. Waveform - output enable and disable time ($f = 1\text{ MHz}$; 50% duty cycle)

Table 15. QFN16L (2.6 x 1.8 mm) mechanical data

Symbol	Millimeters		
	Typ	Min	Max
A	0.55	0.45	0.60
A1	0.02	0	0.05
b	0.20	0.15	0.25
D	2.60	2.50	2.70
E	1.80	1.70	1.90
e	0.40		
L	0.40	0.35	0.45

Figure 8. QFN16L (2.6 x 1.8 mm) footprint recommendations



1. Drawing not to scale.
2. Dimensions are in millimeters.

Figure 9. QFN16L (2.6 x 1.8 mm) carrier tape

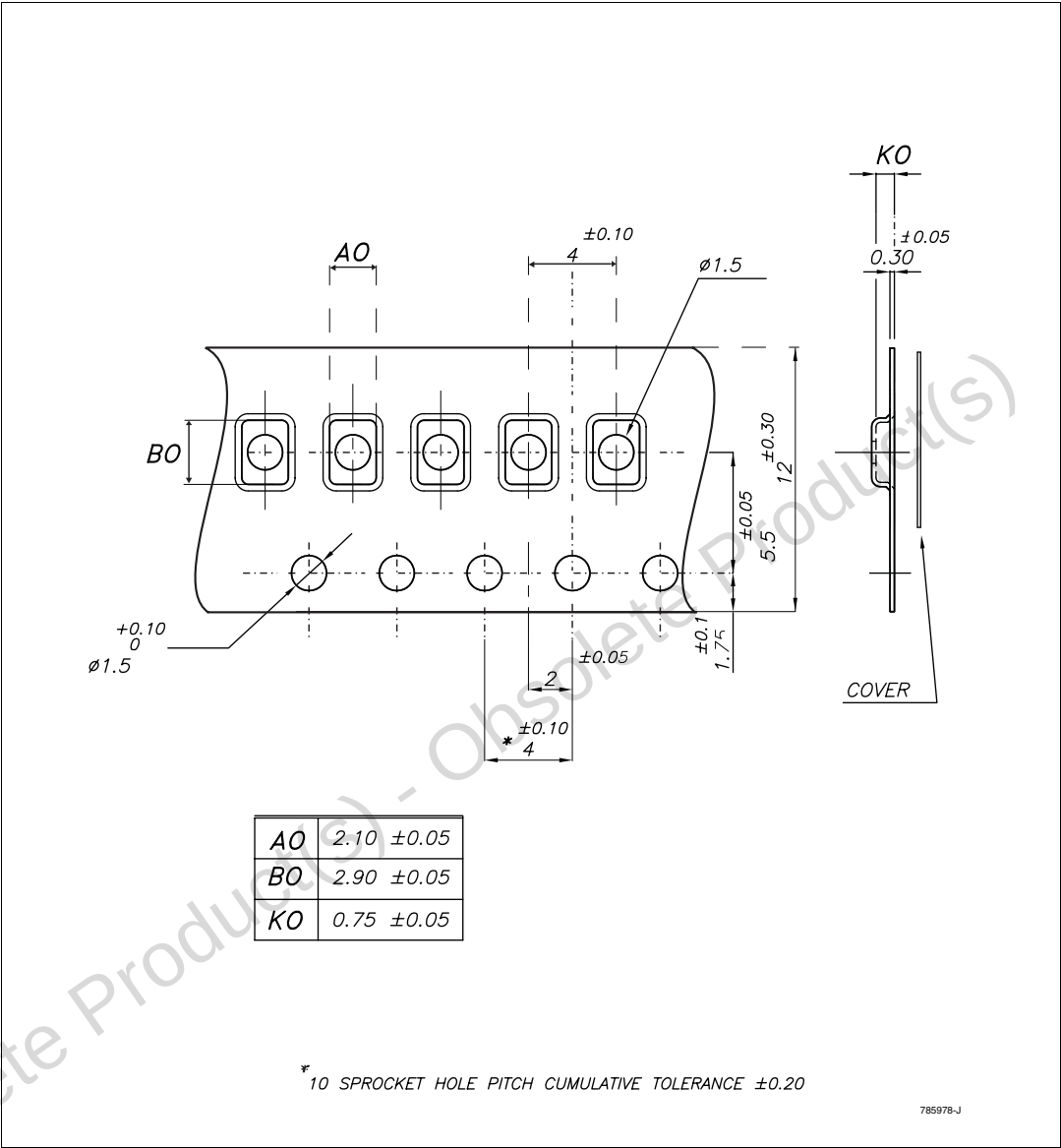
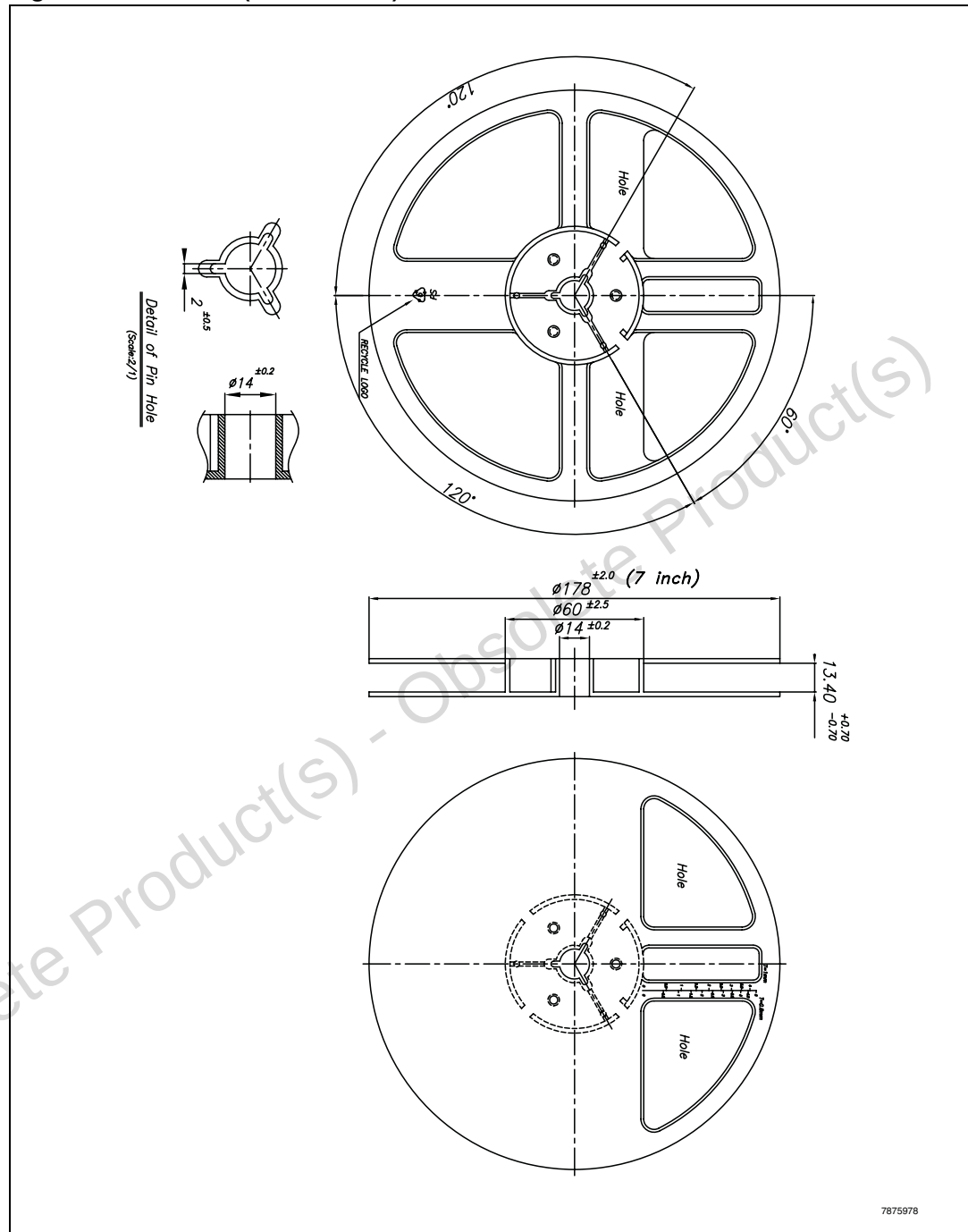


Figure 10. QFN16L (2.6 x 1.8 mm) reel information



1. Drawing not to scale.
2. Dimensions are in millimeters

8 Revision history

Table 16. Document revision history

Date	Revision	Changes
07-May-2007	1	Initial release.
29-May-2007	2	Typo in cover page title.
26-Nov-2007	3	Removed Data Brief classification from the cover page. Modified title and features section, added the following sections: Section 1: Pin settings , Section 2: Device block diagrams , Section 3: Supplementary notes , Section 4: Maximum rating , Section 5: Electrical characteristics Section 6: Waveforms and updated Section 7: Package mechanical data .
07-May-2008	4	Updated data rate values and added paragraph on load driving capability (Section 3.2).

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