ST2149

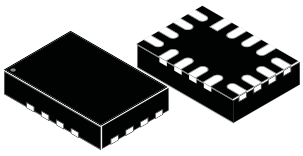
4-bit dual supply level translator without direction control pin

Features

- 42 MHz: 84 Mbps (max) data rate at V_L = 1.8 V, V_{CC} = 3.3 V
- Bidirectional level translation without direction control pin
- Wide voltage range ($V_{CC} \geq V_L$):
  - V_L ranges from 1.65 to 3.6 V
  - V_{CC} ranges from 1.65 to 5.5 V
- Power down mode feature - when V_{CC} supply is off, all I/Os are in high impedance
- Totem-pole driving
- 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 phone and other mobile devices



QFN16
(2.6 x 1.8 mm)

Description

The ST2149 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. Its architecture allows bidirectional level translation without a control pin.

The ST2149 accepts V_L from 1.65 to 3.6 V and V_{CC} from 1.65 to 5.5V, 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 ST2149 supports power-down mode when V_{CC} is grounded/floating or when the device is disabled via the OE pin.

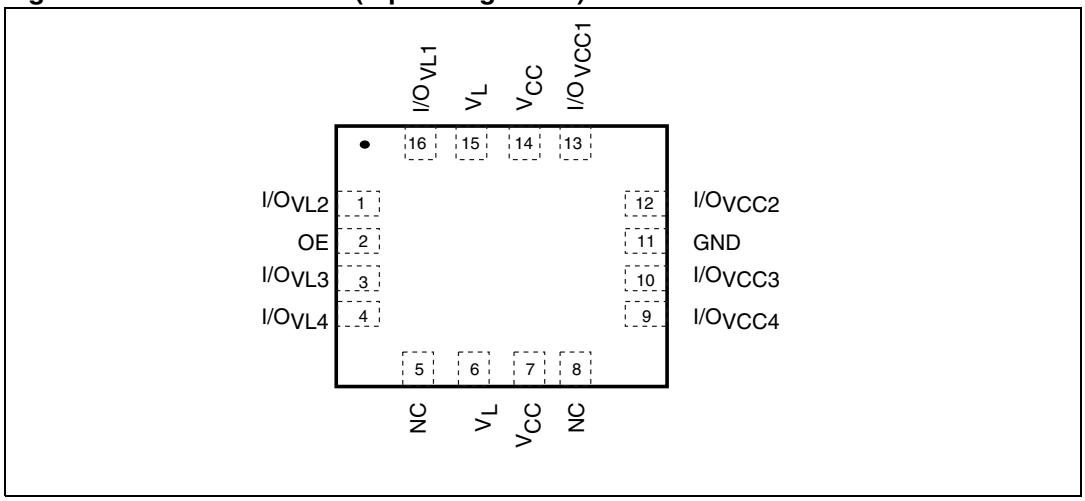
Table 1. Device summary

Order code	Package	Packaging
ST2149QTR	QFN16 (2.6 x 1.8 mm)	Tape & reel (3000 parts per reel)

1 Pin settings

1.1 Pin connection

Figure 1. Pin connection (top through view)



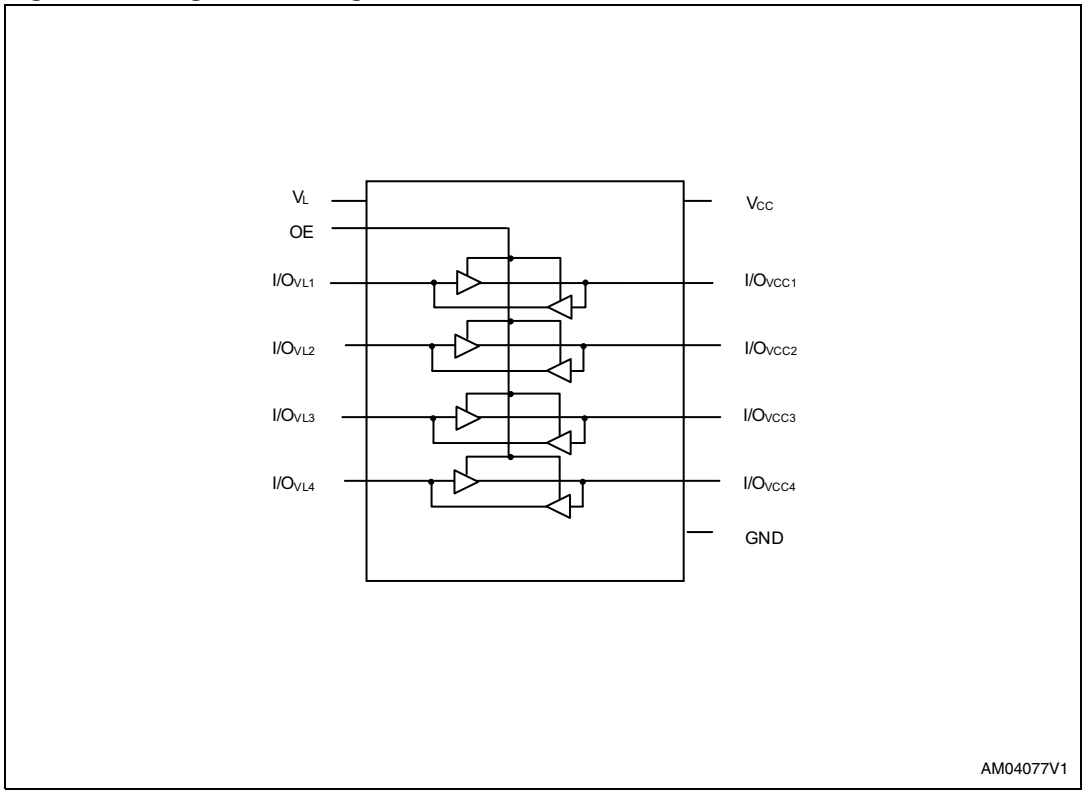
1.2 Pin description

Table 2. 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

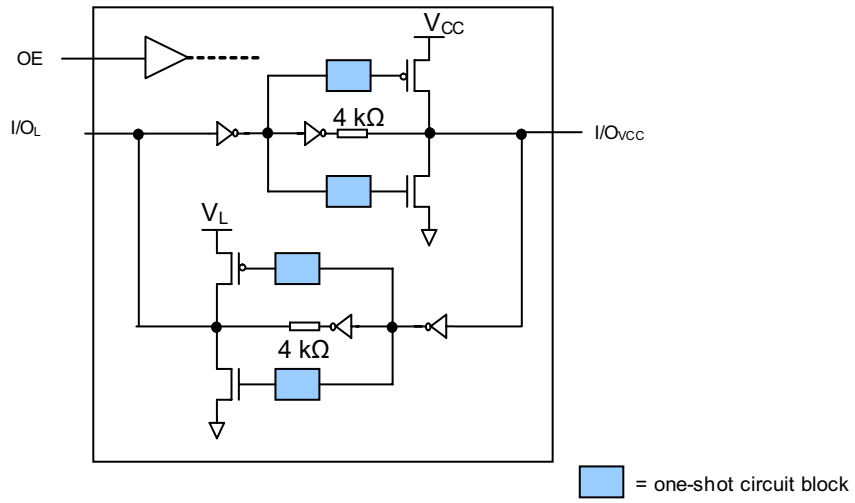
2 Logic diagram

Figure 2. Logic block diagram



2.1 Device block diagrams

Figure 3. ST2149 block diagram



* ST2149 has 4 channels. For simplicity, the above diagram shows only 1 channel.
* When OE is LOW, all I/Os are in High-Impedance mode.

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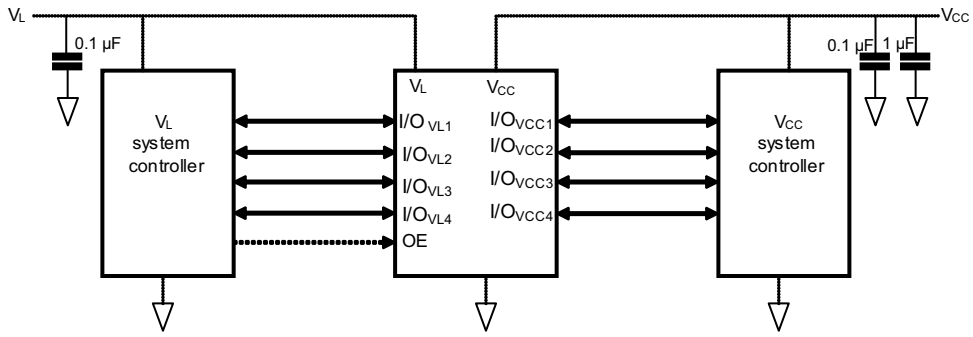
Figure 4. Application block diagram



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3 Supplementary notes

3.1 Driver requirement

For proper operation, the driver from each side of the device must have capability to source and sink a minimum of 1 mA current. The device architecture requires the driver to source/sink maximum current of (V_{CC}/4) mA to/from the weak 4 kΩ output buffer.

3.2 Load driving capability

To support the architecture that allows level translation without direction pin, the one-shot transistor is turned ON only during state transition at the output side. After the one-shot transistor is turned OFF, only the 4kΩ resistor will maintain the state. So, resistive load or pull-up resistor less than 50kΩ is not recommended for proper operation.

3.3 Power off feature

In some application where it might be required to turn off one of the power supplies powering up the level translator. The device will be automatically disabled when V_{CC} supply is turned OFF, even if the OE pin is set to HIGH (enabled). In this mode, all I/Os are in high impedance state.

3.4 Truth table

Table 3. Truth table

Enable	Bidirectional 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 ratings

Stressing the device above the rating listed in *Table 4* 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.

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	500	mW
T_{STG}	Storage temperature	-65 to 150	°C
T_L	Lead temperature (10 seconds)	300	°C
ESD	Electrostatic discharge protection (HBM)	±2	kV

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}	Supply voltage	1.65	–	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	0	–	1	ns/V

5 Electrical characteristics

Over recommended operating conditions unless otherwise noted. All typical values are at T_A = 25 °C.

Table 6. DC characteristics

Symbol	Parameter	V_L	V_{CC}	Test conditions	Value					Unit
					T_A = 25 °C			-40 to 85 °C		
					Min	Typ	Max	Min	Max	
V_{IHL}	High level input voltage (I/O_{VL})	1.65	1.65 to 5.5		1.16	–	–	1.16	–	V
		1.8			1.26	–	–	1.26	–	
		2.5			1.75	–	–	1.75	–	
		3.0			2.10	–	–	2.10	–	
		3.6			2.52	–	–	2.52	–	
V_{ILL}	Low level input voltage (I/O_{VL})	1.65	1.65 to 5.5		–	–	0.50	–	0.50	V
		1.8			–	–	0.54	–	0.54	
		2.5			–	–	0.75	–	0.75	
		3.0			–	–	0.90	–	0.90	
		3.6			–	–	1.08	–	1.08	
V_{IHC}	High level input voltage (I/O_{VCC})	1.65 to 3.6	1.65		1.16	–	–	1.16	–	V
			1.8		1.26	–	–	1.26	–	
			2.5		1.75	–	–	1.75	–	
			3.0		2.10	–	–	2.10	–	
			3.6		2.52	–	–	2.52	–	
			4.3		3.01	–	–	3.01	–	
			5.5		3.85	–	–	3.85	–	
V_{ILC}	Low level input voltage (I/O_{VCC})	1.65 to 3.6	1.65		–	–	0.50	–	0.50	V
			1.8		–	–	0.54	–	0.54	
			2.5		–	–	0.75	–	0.75	
			3.0		–	–	0.90	–	0.90	
			3.6		–	–	1.08	–	1.08	
			4.3		–	–	1.29	–	1.29	
			5.5		–	–	1.65	–	1.65	

Table 6. DC characteristics (continued)

Symbol	Parameter	V_L	V_{CC}	Test conditions	Value					Unit
					T_A = 25 °C			-40 to 85 °C		
					Min	Typ	Max	Min	Max	
V_{IH-OE}	High level input voltage (OE)	1.65	1.65 to 5.5		1.16	–	–	1.16	–	V
		1.8			1.26	–	–	1.26	–	
		2.5			1.75	–	–	1.75	–	
		3.0			2.10	–	–	2.10	–	
		3.6			2.52	–	–	2.52	–	
V_{IL-OE}	Low level input voltage (OE)	1.65	1.65 to 5.5		–	–	0.50	–	0.50	V
		1.8			–	–	0.54	–	0.54	
		2.5			–	–	0.75	–	0.75	
		3.0			–	–	0.90	–	0.90	
		3.6			–	–	1.08	–	1.08	
V_{OHL}	High level output voltage (I/O_{VL})	1.65 to 3.6	1.65 to 5.5	IO = -60 µA	V_L - 0.4	–	–	V_L - 0.4	–	V
V_{OLL}	Low level output voltage (I/O_{VL})	1.65 to 3.6	1.65 to 5.5	IO = +60 µA	–	–	0.4	–	0.4	V
V_{OHC}	High level output voltage (I/O_{VCC})	1.65 to 3.6	1.65 to 5.5	IO = -60 µA	V_{CC} - 0.4	–	–	V_{CC} - 0.4	–	V
V_{OLC}	Low level output voltage (I/O_{VCC})	1.65 to 3.6	1.65 to 5.5	IO = +60 µA	–	–	0.4	–	0.4	V
I_{OE}	Control input leakage current (OE)	1.65 to 3.6	1.65 to 5.5	V_I = GND or V_L	–	–	0.1	–	1	µA
I_{IO_LKG}	High impedance leakage current (I/O_{VL}, I/O_{VCC})	1.65 to 3.6	1.65 to 5.5	OE = GND I/O_{VL} = High I/O_{VCC} = Low	–	–	0.1	–	1	µA
				OE = GND I/O_{VL} = Low I/O_{VCC} = High	–	–	0.1	–	1	µA

Table 6. DC characteristics (continued)

Symbol	Parameter	V_L	V_{CC}	Test conditions	Value					Unit
					T_A = 25 °C			-40 to 85 °C		
					Min	Typ	Max	Min	Max	
I_{OFF}	Partial power down current	1.65 to 3.6	0	OE = V_L or GND I/O_{VL} = High I/O_{VCC} = Low	–	–	0.1	–	1	µA
				OE = V_L or GND I/O_{VL} = Low I/O_{VCC} = High	–	–	0.1	–	1	
I_{QVCC}	Quiescent supply current V_{CC}	1.65 to 3.6	1.65 to 5.5	OE = V_L I/O = Hi-Z	–-	–	7	–	9	µA
I_{QVL}	Quiescent supply current V_L	1.65 to 3.6	1.65 to 5.5	OE = V_L I/O = Hi-Z	–	–	0.1	–	1	µA
		1.65 to 3.6	0		–	–	0.1	–	1	
$I_{Z\text{-}VCC}$	High impedance quiescent supply current V_{CC}	1.65 to 3.6	1.65 to 5.5	OE = GND I/O = Hi-Z	–	–	0.1	–	1	µA
$I_{Z\text{-}VL}$	High impedance quiescent supply current V_L	1.65 to 3.6	1.65 to 5.5	OE = GND I/O = Hi-Z	–	–	0.1	–	1	µA
		1.65 to 3.6	0		–	–	0.1	–	1	

5.1 AC characteristics

Load C_L = 15 pF; driver $t_r = t_f \leq 2$ ns over temperature range -40 °C to 85 °C.

Table 7. AC characteristics - test conditions: V_L = 1.65 - 1.95 V

Symbol	Parameter		V_{CC} = 1.65 – 1.95 V		V_{CC} = 2.3 – 2.7 V		V_{CC} = 3.0 – 3.6 V		V_{CC} = 4.5 – 5.5 V		Unit
			Min	Max	Min	Max	Min	Max	Min	Max	
t_{RVCC}	Rise time I/O_{VCC}		–	5.0	–	3.2	–	2.4	–	1.4	ns
t_{FVCC}	Fall time I/O_{VCC}		–	1.5	–	1.4	–	1.3	–	1.2	ns
t_{RVL}	Rise time I/O_{VL}		–	2.8	–	2.7	–	2.6	–	2.6	ns
t_{FVL}	Fall time I/O_{VL}		–	1.5	–	1.4	–	1.4	–	1.3	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}	–	6.6	–	5.8	–	5.0	–	4.4	ns
		t_{PHL}	–	4.1	–	3.8	–	3.6	–	3.4	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}	–	4.9	–	4.4	–	4.1	–	4.4	ns
		t_{PHL}	–	4.6	–	4.2	–	4.0	–	3.6	ns
t_{PZL} t_{PZH}	Output enable time		–	27	–	27	–	27	–	27	ns
t_{PLZ} t_{PHZ}	Output disable time		–	145	–	145	–	145	–	145	
D_R	Data rate(1)		41	–	66	–	84	–	86	–	Mbps

1. Data rate is guaranteed based on the condition that output I/O signal rise/fall -time is less than 15% of period of input I/O signal; input I/O signal is at 50% duty-cycle and output I/O signal duty-cycle deviation is less than 50% ± 10%.

Table 8. AC characteristics - test conditions: V_L = 2.3 - 2.7 V

Symbol	Parameter		V_{CC} = 2.3 – 2.7 V		V_{CC} = 3.0 – 3.6 V		V_{CC} = 4.5 – 5.5 V		Unit
			Min	Max	Min	Max	Min	Max	
t_{RVCC}	Rise time I/O_{VCC}		–	3.3	–	2.2	–	1.6	ns
t_{FVCC}	Fall time I/O_{VCC}		–	1.7	–	1.6	–	1.4	ns
t_{RVL}	Rise time I/O_{VL}		–	2.2	–	2.0	–	1.9	ns
t_{FVL}	Fall time I/O_{VL}		–	1.3	–	1.2	–	1.2	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}	–	4.6	–	4.3	–	3.9	ns
		t_{PHL}	–	3.6	–	3.3	–	2.9	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}	–	3.9	–	3.5	–	3.5	ns
		t_{PHL}	–	3.6	–	3.0	–	2.5	ns
t_{PZL} t_{PZH}	Output enable time		–	20	–	20	–	20	ns
t_{PLZ} t_{PHZ}	Output disable time		–	130	–	130	–	130	
D_R	Data rate(1)		84	–	85	-	88	–	Mbps

1. Data rate is guaranteed based on the condition that output I/O signal rise/fall -time is less than 15% of period of input I/O signal; input I/O signal is at 50% duty-cycle and output I/O signal duty-cycle deviation is less than 50% ± 10%.

Table 9. AC characteristics - test conditions: V_L = 3.0 - 3.6 V

Symbol	Parameter		V_{CC} = 3.0 – 3.6 V		V_{CC} = 4.5 – 5.5 V		Unit
			Min	Max	Min	Max	
t_{RVCC}	Rise time I/O_{VCC}		–	1.8	–	1.7	ns
t_{FVCC}	Fall time I/O_{VCC}		–	1.3	–	1.2	ns
t_{RVL}	Rise time I/O_{VL}		–	1.6	–	1.5	ns
t_{FVL}	Fall time I/O_{VL}		–	1.1	–	1.1	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}	–	4.1	–	4.1	ns
		t_{PHL}	–	2.6	–	2.3	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-HL}	t_{PLH}	–	4.0	–	4.0	ns
		t_{PHL}	–	2.6	–	2.4	ns
t_{PZL} t_{PZH}	Output enable time		–	15	–	15	ns
t_{PLZ} t_{PHZ}	Output disable time		–	110	–	110	
D_R	Data rate(1)		86	–	89	–	Mbps

1. Data rate is guaranteed based on the condition that output I/O signal rise/fall -time is less than 15% of period of input I/O signal; input I/O signal is at 50% duty-cycle and output I/O signal duty-cycle deviation is less than 50% ± 10%.

6 Test circuit

Figure 5. Test circuit

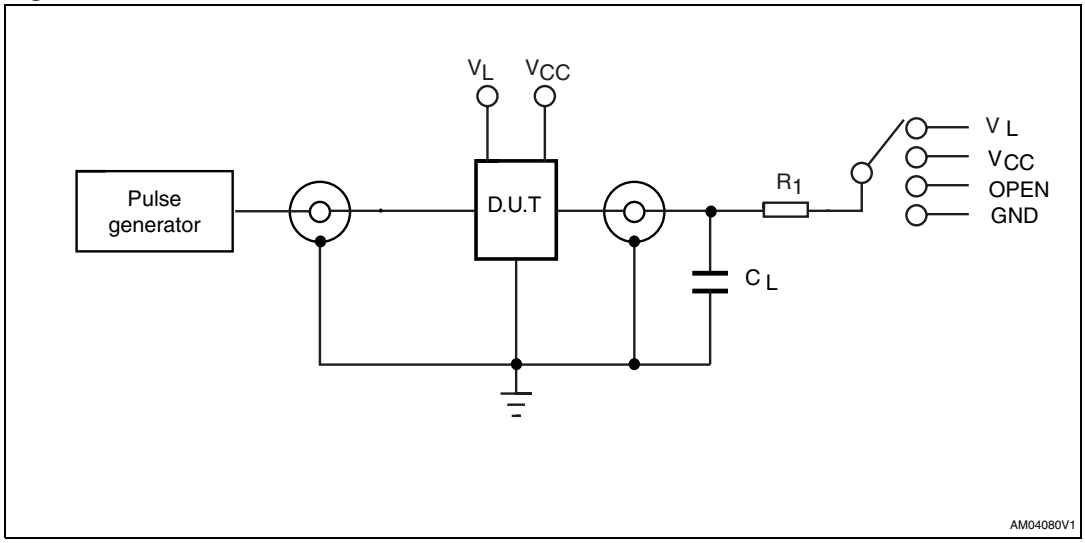


Table 10. Test circuit switches

Test	C_L	R_1	Switch
t_{PLH}, t_{PHL}	15 pF	20 kΩ	Open
t_r, t_f	15 pF	20 kΩ	Open
t_{PZL}, t_{PLZ}	15 pF	20 kΩ	V_L or V_{CC}
t_{PZH}, t_{PHZ}	15 pF	20 kΩ	GND

Table 11. Waveform symbol value

Symbol	Driving I/O_{VL}		Driving I/O_{VCC}	
	1.65 V ≤ V_L ≤ V_{CC} ≤2.5 V	**3.3 V ≤V_L ≤V_{CC} ≤ 5.5 V**	**1.65 V ≤V_L ≤V_{CC} ≤2.5 V**	**3.3 V ≤V_L≤V_{CC} ≤ 5.5 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 6. Waveform - propagation delay (f = 1 MHz, 50% duty cycle)

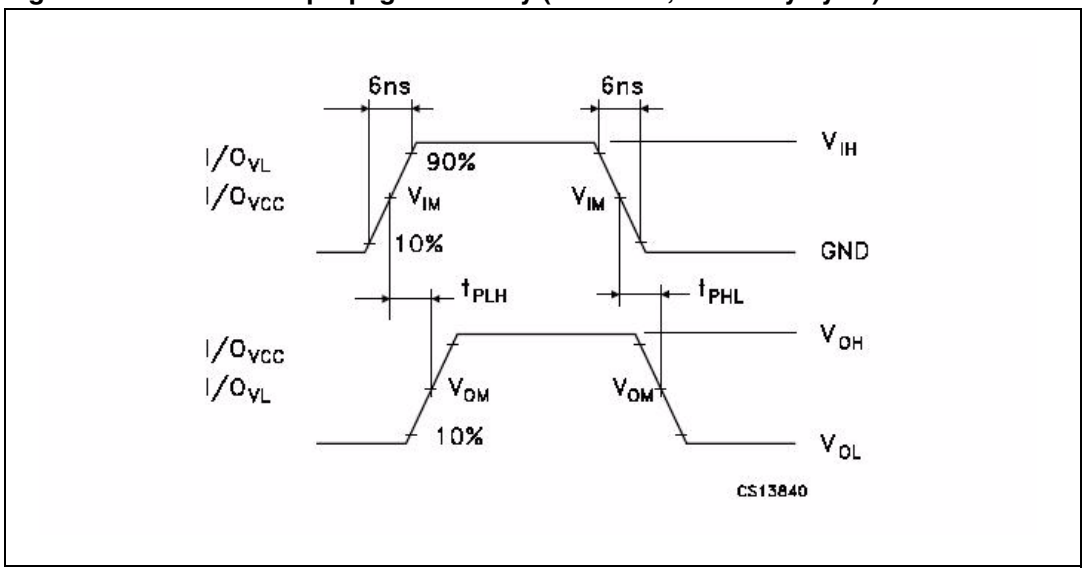
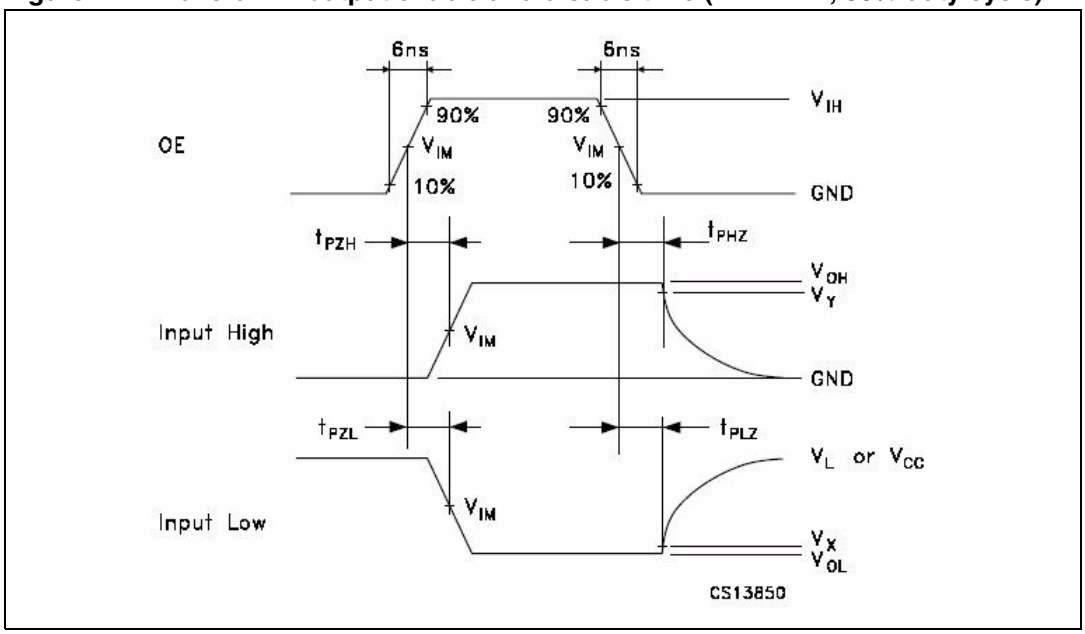


Figure 7. Waveform - output enable and disable time (f = 1 MHz, 50% duty cycle)



7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK® is an ST trademark.

Figure 8. Package outline for QFN16 (2.6 x 1.8 x 0.55 mm) - 0.40 mm pitch

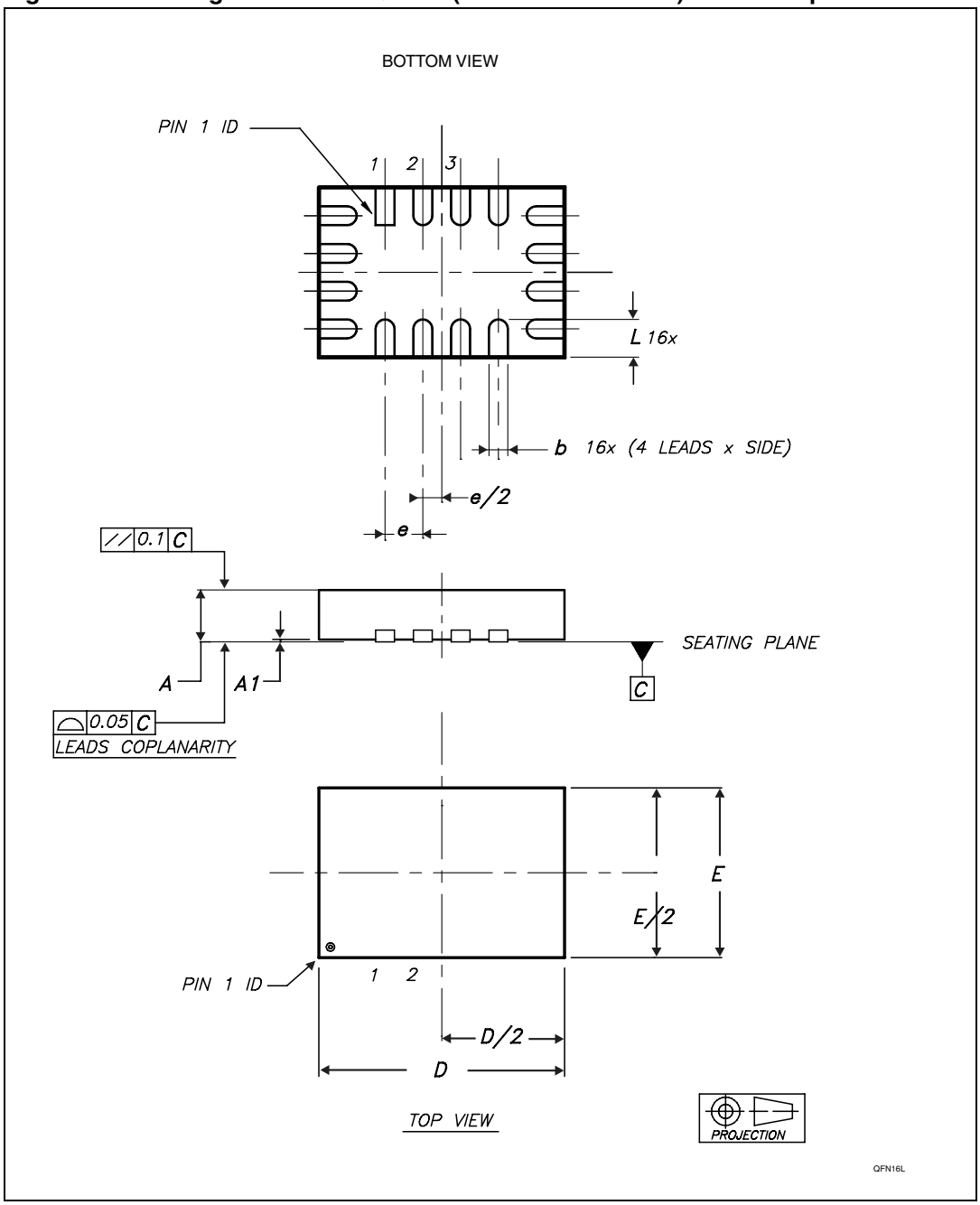


Table 12. Mechanical data for QFN16 (2.6 x 1.8 x 0.55 mm) - 0.40 mm pitch

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 9. Footprint recommendation for QFN16 (2.6 x 1.8 x 0.55 mm) - 0.40 mm pitch

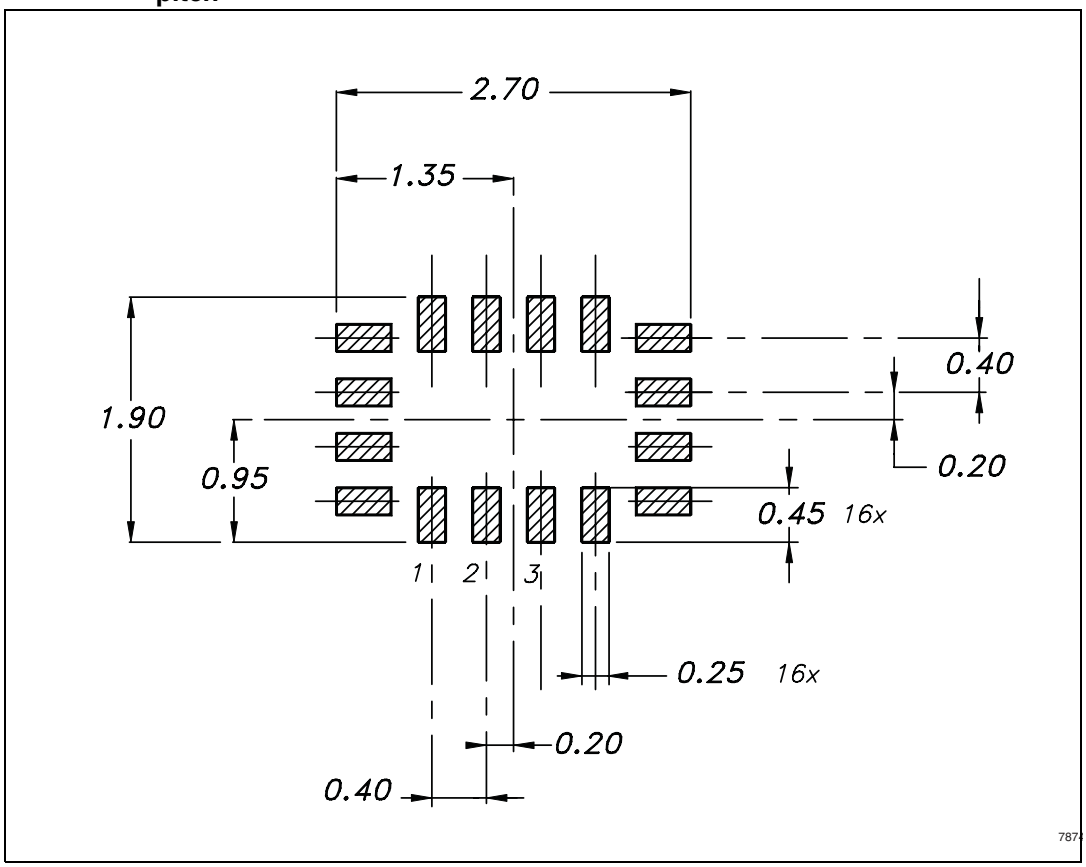


Figure 10. Carrier tape for QFN16 (2.6 x 1.8 x 0.55 mm) - 0.40 mm pitch

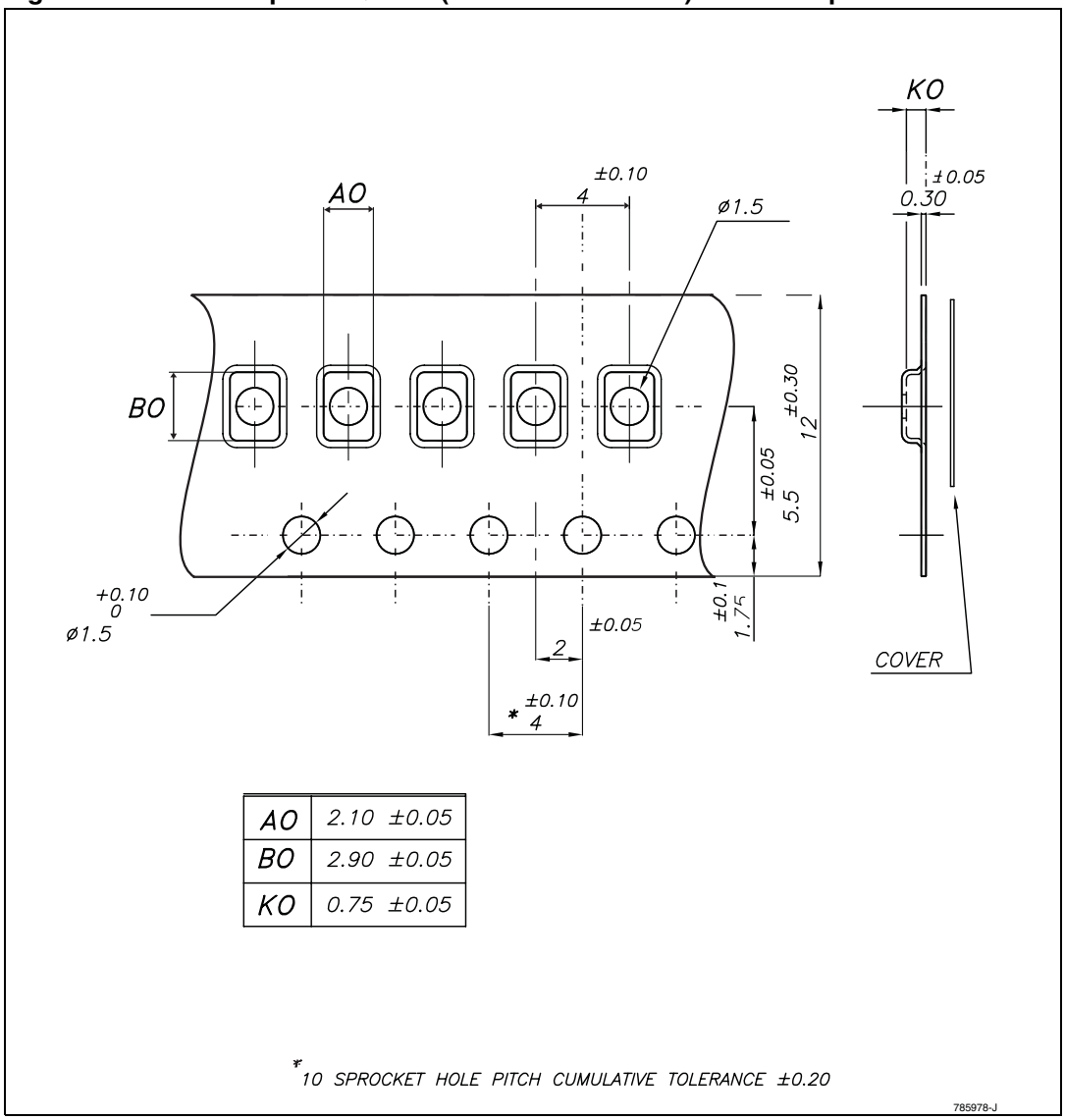
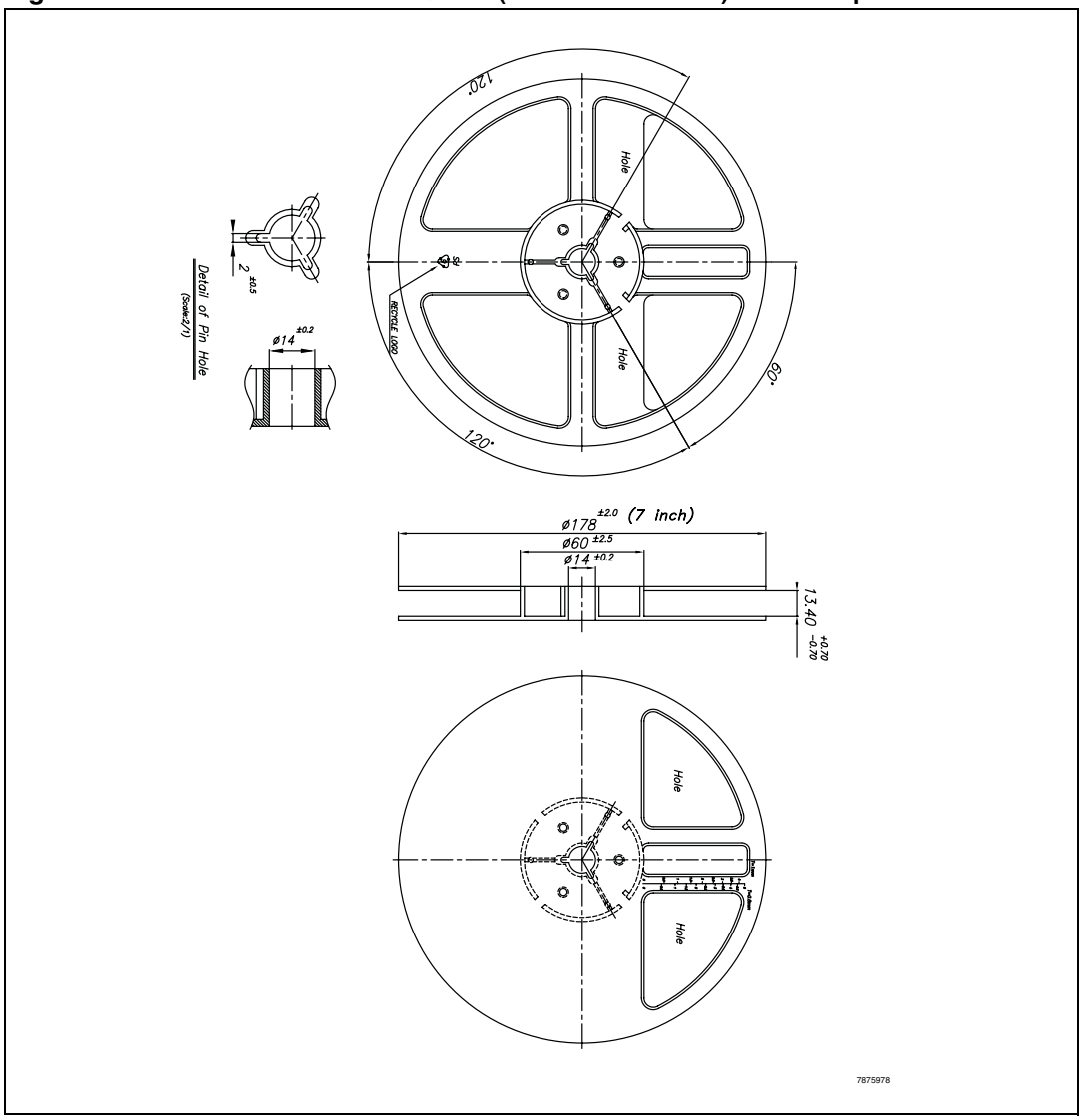


Figure 11. Reel information for QFN16 (2.6 x 1.8 x 0.55 mm) - 0.40 mm pitch



8 Revision history

Table 13. Document revision history

Date	Revision	Changes
07-Sep-2009	1	Initial release.

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