



# STP16DP05

## Low voltage 16-bit constant current LED sink driver with outputs error detection

### Features

- Low voltage power supply down to 3 V
- 16 constant current output channels
- Adjustable output current through external resistor
- Short and open output error detection
- Serial data IN/Parallel data OUT
- 3.3 V micro driver-able
- Output current: 5-100 mA
- 30 MHz clock frequency
- Available in high thermal efficiency TSSOP exposed pad
- ESD protection 2.5 kV HBM, 200 V MM

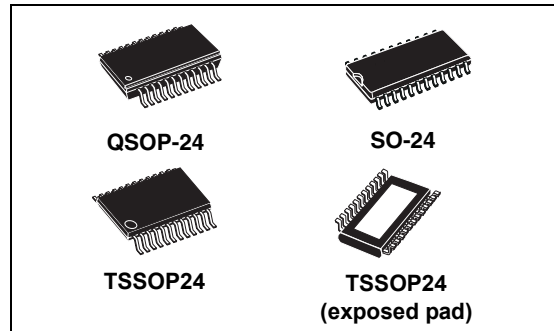
### Description

The STP16DP05 is a monolithic, low voltage, low current power 16-bit shift register designed for LED panel displays. The device contains a 16-bit serial-in, parallel-out shift register that feeds a 16-bit D-type storage register. In the output stage, sixteen regulated current sources were designed to provide 5-100 mA constant current to drive the LEDs.

The STP16DP05 features open and short LED detections on the outputs. The STP16DP05 is backward compatible with STP16C/L596. The detection circuit checks 3 different conditions that can occur on the output line: short to GND, short to  $V_O$  or open line.

**Table 1. Device summary**

Order codes	Package	Packaging
STP16DP05MTR	SO-24 (tape and reel)	1000 parts per reel
STP16DP05TTR	TSSOP24 (tape and reel)	2500 parts per reel
STP16DP05XTTR	TSSOP24 exposed pad (tape and reel)	2500 parts per reel
STP16DP05PTR	QSOP-24	2500 parts per reel



The data detection results are loaded in the shift register and shifted out via the serial line output.

The detection functionality is implemented without increasing the pin count number, through a secondary function of the output enable and latch pin (DM1 and DM2 respectively), a dedicated logic sequence allows the device to enter or leave from detection mode. Through an external resistor, users can adjust the STP16DP05 output current, controlling in this way the light intensity of LEDs, in addition, user can adjust LED's brightness intensity from 0% to 100% via  $\overline{OE}/DM2$  pin.

The STP16DP05 guarantees a 20 V output driving capability, allowing users to connect more LEDs in series. The high clock frequency, 30 MHz, makes the device suitable for high data rate transmission. The 3.3 V voltage supply is well useful for applications that interface any 3.3V micro. Compared with a standard TSSOP package, the TSSOP exposed pad increases heat dissipation capability by a 2.5 factor.

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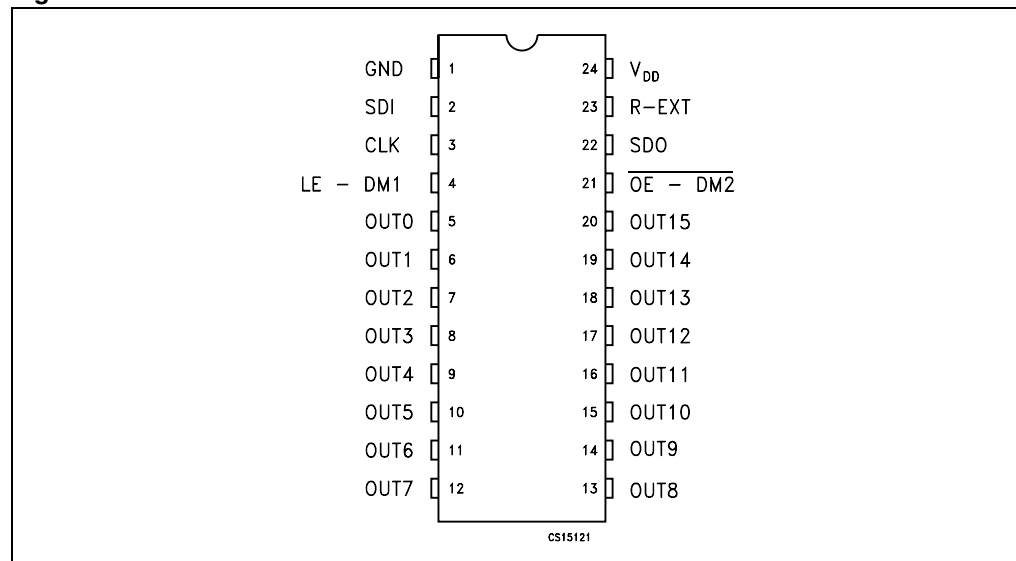
# 1 Summary description

Table 2. Typical current accuracy

Output voltage	Current accuracy		Output current	V <sub>DD</sub>	Temperature
	Between bits	Between ICs			
≥ 1.3 V	±1.5%	±5%	20 to 100 mA	3.3 V to 5 V	25 °C

## 1.1 Pin connection and description

Figure 1. Pin connection



*Note:* The exposed pad should be electrically connected to a metal land electrically isolated or connected to ground

Table 3. Pin description

Pin n°	Symbol	Name and function
1	GND	Ground terminal
2	SDI	Serial data input terminal
3	CLK	Clock input terminal
4	LE-DM1	Latch input terminal - detect mode 1 (see operation principle)
5-20	OUT 0-15	Output terminal
21	$\overline{\text{OE-DM2}}$	Input terminal of output enable (active low) - detect mode 1 (see operation principle)
22	SDO	Serial data out terminal
23	R-EXT	Input terminal of an external resistor for constant current programming
24	V <sub>DD</sub>	Supply voltage terminal

## 2 Electrical ratings

### 2.1 Absolute maximum ratings

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.

**Table 4. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{DD}$	Supply voltage	0 to 7	V
$V_O$	Output voltage	-0.5 to 20	V
$I_O$	Output current	100	mA
$V_I$	Input voltage	-0.4 to $V_{DD}$	V
$I_{GND}$	GND terminal current	1600	mA
$f_{CLK}$	Clock frequency	50	MHz

### 2.2 Thermal data

**Table 5. Thermal data**

Symbol	Parameter	Value	Unit	
$T_{OPR}$	Operating temperature range	-40 to +125	°C	
$T_{STG}$	Storage temperature range	-55 to +150	°C	
$R_{thJC}$	Thermal resistance junction-case	SO-24	42.7	°C/W
		TSSOP24	55	°C/W
		TSSOP24 <sup>(1)</sup> exposed pad	37.5	°C/W
		QSOP-24	55	°C/W

1. The exposed pad should be soldered directly to the PCB to realize the thermal benefits.

## 2.3 Recommended operating conditions

**Table 6. Recommended operating conditions**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{DD}$	Supply voltage		3.0	-	5.5	V
$V_O$	Output voltage			-	20	V
$I_O$	Output current	OUTn	5	-	100	mA
$I_{OH}$	Output current	SERIAL-OUT		-	+1	mA
$I_{OL}$	Output current	SERIAL-OUT		-	-1	mA
$V_{IH}$	Input voltage		$0.7V_{DD}$	-	$V_{DD}+0.3$	V
$V_{IL}$	Input voltage		-0.3	-	$0.3V_{DD}$	V
$t_{wLAT}$	LE\DM1 pulse width	$V_{DD} = 3.0\text{ V to }5.0\text{ V}$	6	-		ns
$t_{wCLK}$	CLK pulse width		8	-		ns
$t_{wEN}$	$\overline{OE}\backslash DM2$ pulse width		100	-		ns
$t_{SETUP(D)}$	Setup time for DATA		10	-		ns
$t_{HOLD(D)}$	Hold time for DATA		5	-		ns
$t_{SETUP(L)}$	Setup time for LATCH		10	-		ns
$f_{CLK}$	Clock frequency		Cascade operation <sup>(1)</sup>		-	30

1. If the device is connected in cascade, it may not be possible to achieve the maximum data transfer. Please consider the timings carefully.

### 3 Electrical characteristics

$V_{DD} = 3.3 \text{ V to } 5 \text{ V}$ ,  $T = 25 \text{ }^\circ\text{C}$ , unless otherwise specified

**Table 7. Electrical characteristics**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{IH}$	Input voltage high level		$0.7V_{DD}$		$V_{DD}$	V
$V_{IL}$	Input voltage low level		GND		$0.3V_{DD}$	V
$I_{OH}$	Output leakage current	$V_{OH} = 20 \text{ V}$			1	$\mu\text{A}$
$V_{OL}$	Output voltage (Serial-OUT)	$I_{OL} = 1 \text{ mA}$			0.4	V
$V_{OH}$	Output voltage (Serial-OUT)	$I_{OH} = -1 \text{ mA}$	$V_{OH} - V_{DD} = -0.4 \text{ V}$			V
$I_{OL1}$	Output current	$V_O = 0.3 \text{ V}$ , $R_{ext} = 3.9 \text{ k}\Omega$	4.25	5	5.75	mA
$I_{OL2}$		$V_O = 0.3 \text{ V}$ , $R_{ext} = 970 \text{ }\Omega$	19	20	21	
$I_{OL3}$		$V_O = 1.3 \text{ V}$ , $R_{ext} = 190 \text{ }\Omega$	96	100	104	
$\Delta I_{OL1}$	Output current error between bit (all output ON)	$V_O = 0.3 \text{ V}$ , $R_{EXT} = 3.9 \text{ k}\Omega$		$\pm 5$	$\pm 8$	%
$\Delta I_{OL2}$		$V_O = 0.3 \text{ V}$ , $R_{EXT} = 970 \text{ }\Omega$		$\pm 1.5$	$\pm 3$	
$\Delta I_{OL3}$		$V_O = 1.3 \text{ V}$ , $R_{EXT} = 190 \text{ }\Omega$		$\pm 1.2$	$\pm 3$	
$R_{SIN(up)}$	Pull-up resistor		150	300	600	$\text{K}\Omega$
$R_{SIN(down)}$	Pull-down resistor		100	200	400	$\text{K}\Omega$
$I_{DD(OFF1)}$	Supply current (OFF)	$R_{EXT} = 970$ OUT 0 to 15 = OFF		5	6	mA
$I_{DD(OFF2)}$		$R_{EXT} = 240$ OUT 0 to 15 = OFF		13	14	
$I_{DD(ON1)}$	Supply current (ON)	$R_{EXT} = 970$ OUT 0 to 15 = ON		6	7	
$I_{DD(ON2)}$		$R_{EXT} = 240$ OUT 0 to 15 = ON		13.5	14.5	
Thermal	Thermal protection <sup>(1)</sup>			170		$^\circ\text{C}$

1. Guaranteed by design (not tested)  
The thermal protection switches OFF only the outputs current

$V_{DD} = 5\text{ V}$ ,  $T = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified

**Table 8. Switching characteristics**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit	
$t_{PLH1}$	Propagation delay time, CLK-OUTn, LE\DM1 = H, OE\DM2 = L	$V_{IH} = V_{DD}$ $V_{IL} = \text{GND}$ $I_O = 20\text{ mA}$ $R_{EXT} = 1\text{ K}\Omega$ $C_L = 10\text{ pF}$ $V_L = 3.0\text{ V}$ $R_L = 60\text{ }\Omega$	$V_{DD} = 3.3\text{ V}$	-	40	65	ns
			$V_{DD} = 5\text{ V}$	-	20	30	
$t_{PLH2}$	Propagation delay time, LE\DM1-OUTn, OE\DM2 = L		$V_{DD} = 3.3\text{ V}$	-	51	77	ns
			$V_{DD} = 5\text{ V}$	-	32	47	
$t_{PLH3}$	Propagation delay time, OE\DM2-OUTn, LE\DM1 = H		$V_{DD} = 3.3\text{ V}$	-	49	77	ns
			$V_{DD} = 5\text{ V}$	-	27	41	
$t_{PLH}$	Propagation delay time, CLK-SDO		$V_{DD} = 3.3\text{ V}$	-	21.5	32	ns
			$V_{DD} = 5\text{ V}$	-	14.5	21.5	
$t_{PHL1}$	Propagation delay time, CLK-OUTn, LE\DM1 = H, OE\DM2 = L		$V_{DD} = 3.3\text{ V}$	-	15	25	ns
			$V_{DD} = 5\text{ V}$	-	11	14.5	
$t_{PHL2}$	Propagation delay time, LE\DM1-OUTn, OE\DM2 = L		$V_{DD} = 3.3\text{ V}$	-	13	20	ns
			$V_{DD} = 5\text{ V}$	-	9	12.5	
$t_{PHL3}$	Propagation delay time, OE\DM2-OUTn, LE\DM1 = H	$V_{DD} = 3.3\text{ V}$	-	11.5	18	ns	
		$V_{DD} = 5\text{ V}$	-	8.5	12		
$t_{PHL}$	Propagation delay time, CLK-SDO	$V_{DD} = 3.3\text{ V}$	-	25.5	38	ns	
		$V_{DD} = 5\text{ V}$	-	17.5	25		
$t_{ON}$	Output rise time 10~90% of voltage waveform	$V_{DD} = 3.3\text{ V}$	-	34	53.5	ns	
		$V_{DD} = 5\text{ V}$	-	12.5	18.5		
$t_{OFF}$	Output fall time 90~10% of voltage waveform	$V_{DD} = 3.3\text{ V}$	-	5.5	8.5	ns	
		$V_{DD} = 5\text{ V}$	-	4.5	6.5		
$t_r$	CLK rise time <sup>(1)</sup>		-		5000	ns	
$t_f$	CLK fall time <sup>(1)</sup>		-		5000	ns	

1. In order to achieve high cascade data transfer, please consider  $t_r/t_f$  timings carefully.

## 4 Equivalent circuit and outputs

Figure 2.  $\overline{OE\backslash DM2}$  terminal

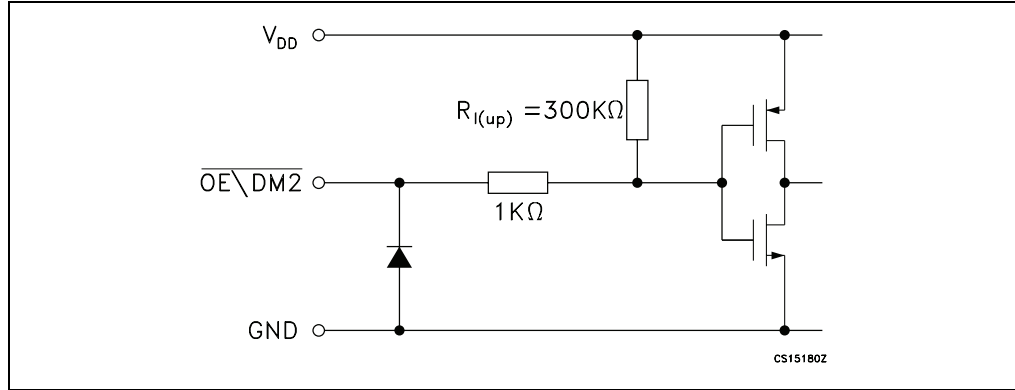


Figure 3.  $LE\backslash DM1$  terminal

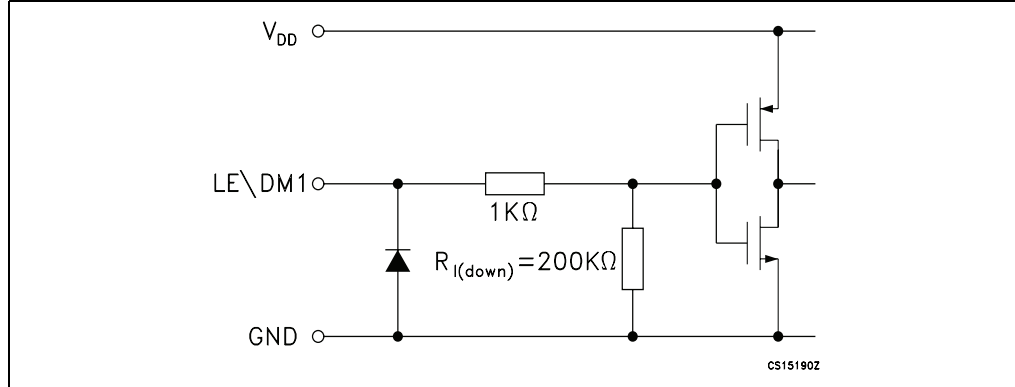


Figure 4. CLK, SDI terminal

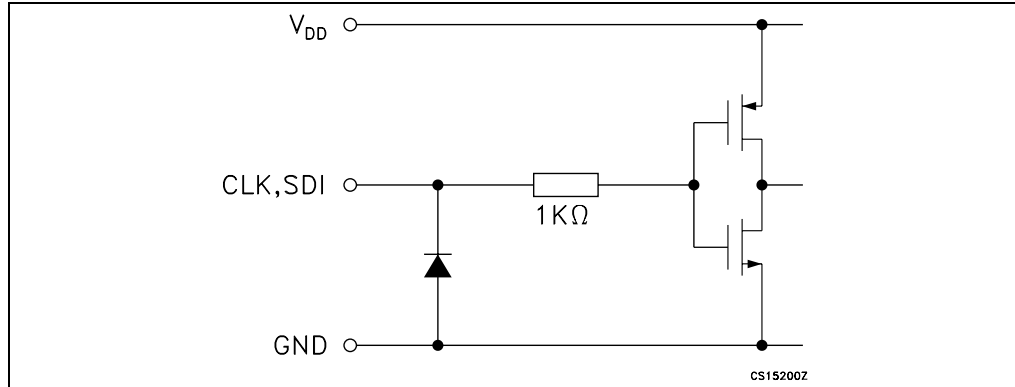




Figure 5. SDO terminal

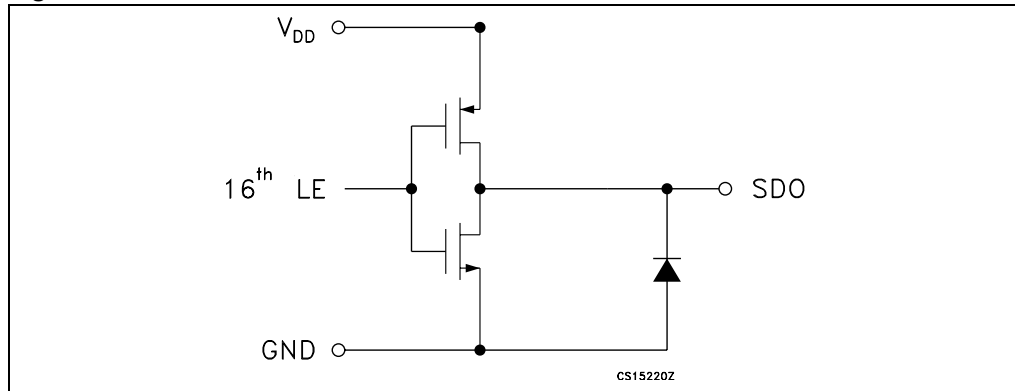
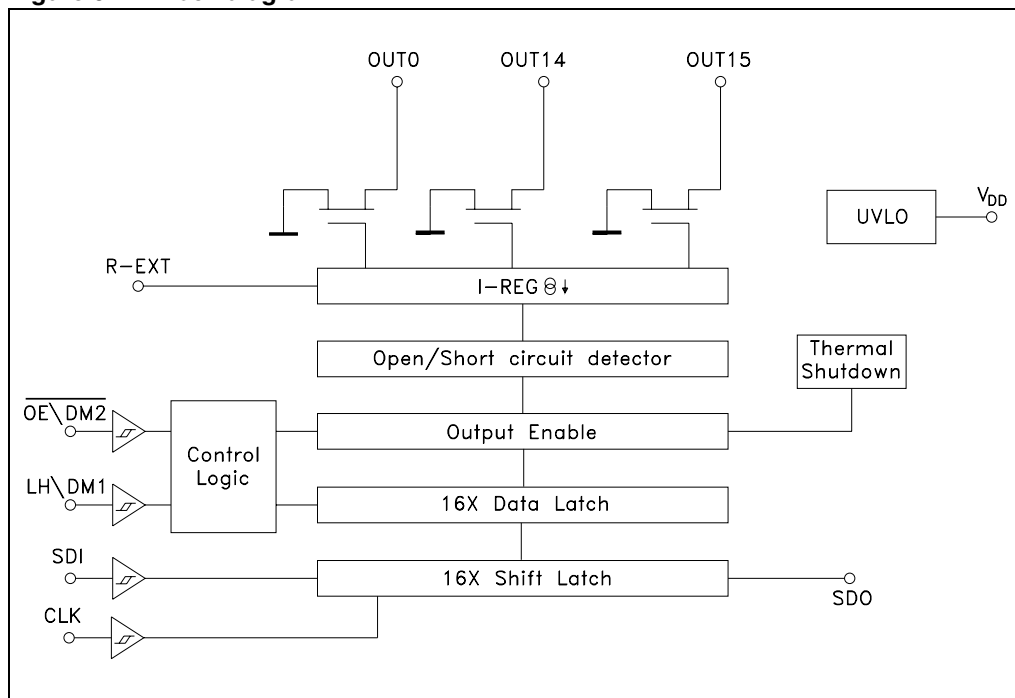


Figure 6. Block diagram



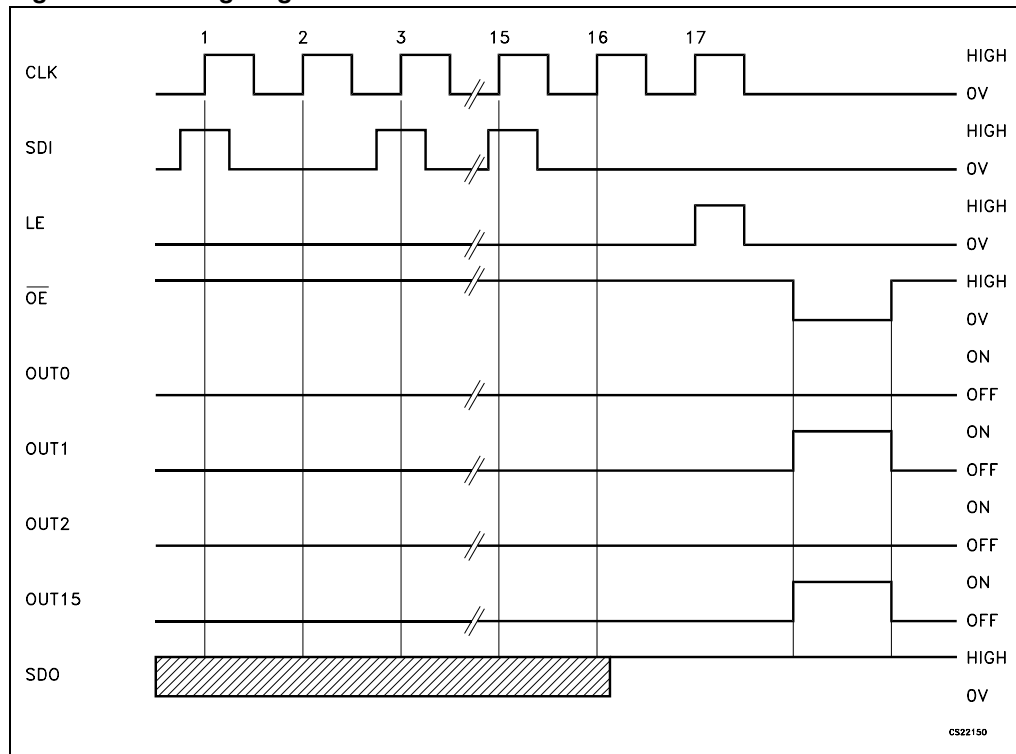
## 5 Timing diagrams

Table 9. Truth table

CLOCK	LE <sub>DM1</sub>	$\overline{OE}$ <sub>DM2</sub>	SERIAL-IN	OUT0 ..... OUT7 ..... OUT15	SDO
	H	L	D <sub>n</sub>	D <sub>n</sub> ..... D <sub>n - 7</sub> ..... D <sub>n - 15</sub>	D <sub>n - 15</sub>
	L	L	D <sub>n + 1</sub>	No change	D <sub>n - 14</sub>
	H	L	D <sub>n + 2</sub>	D <sub>n + 2</sub> ..... D <sub>n - 5</sub> ..... D <sub>n - 13</sub>	D <sub>n - 13</sub>
	X	L	D <sub>n + 3</sub>	D <sub>n + 2</sub> ..... D <sub>n - 5</sub> ..... D <sub>n - 13</sub>	D <sub>n - 13</sub>
	X	H	D <sub>n + 3</sub>	OFF	D <sub>n - 13</sub>

Note:  $OUT_n = ON$  when  $D_n = H$   $OUT_n = OFF$  when  $D_n = L$

Figure 7. Timing diagram



- Note:
- 1 Latch and output enable are level sensitive and ARE NOT synchronized with rising-or-falling edge of CALK signal.
  - 2 When LE terminal is low level, the latch circuits hold previous set of data
  - 3 When LE terminal is at high level, the latch circuits refresh new set of data from SDI chain.
  - 4 When OE terminal is at low level, the output terminals - Out0 to Out15 respond to data in the latch circuits, either '1' for ON or '0' for OFF
  - 5 When OE terminal is at high level, all output terminals will be switched OFF.

Figure 8. Clock, serial-in, serial-out

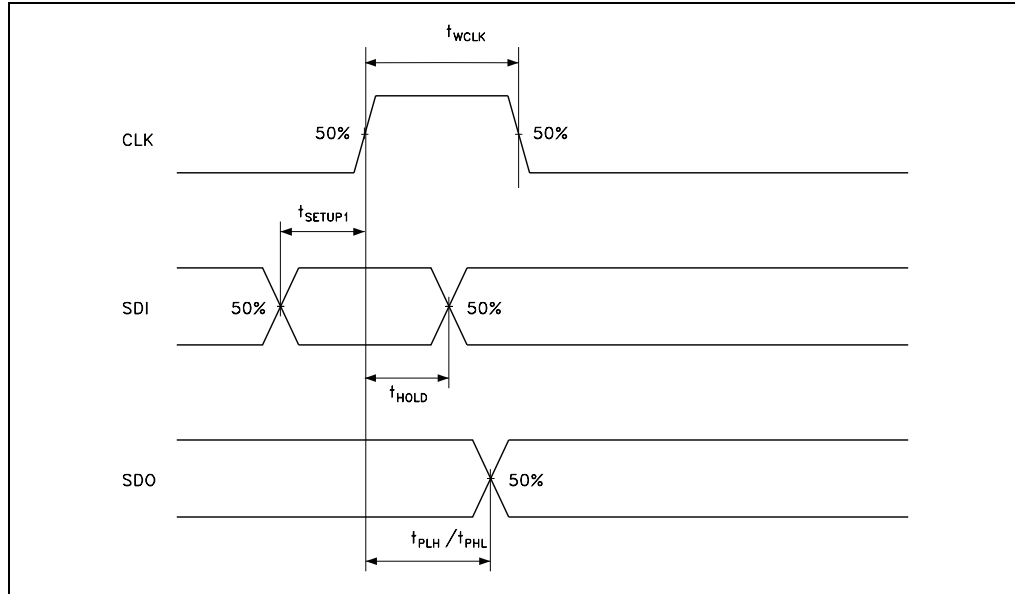


Figure 9. Clock, serial-in, latch, enable, outputs

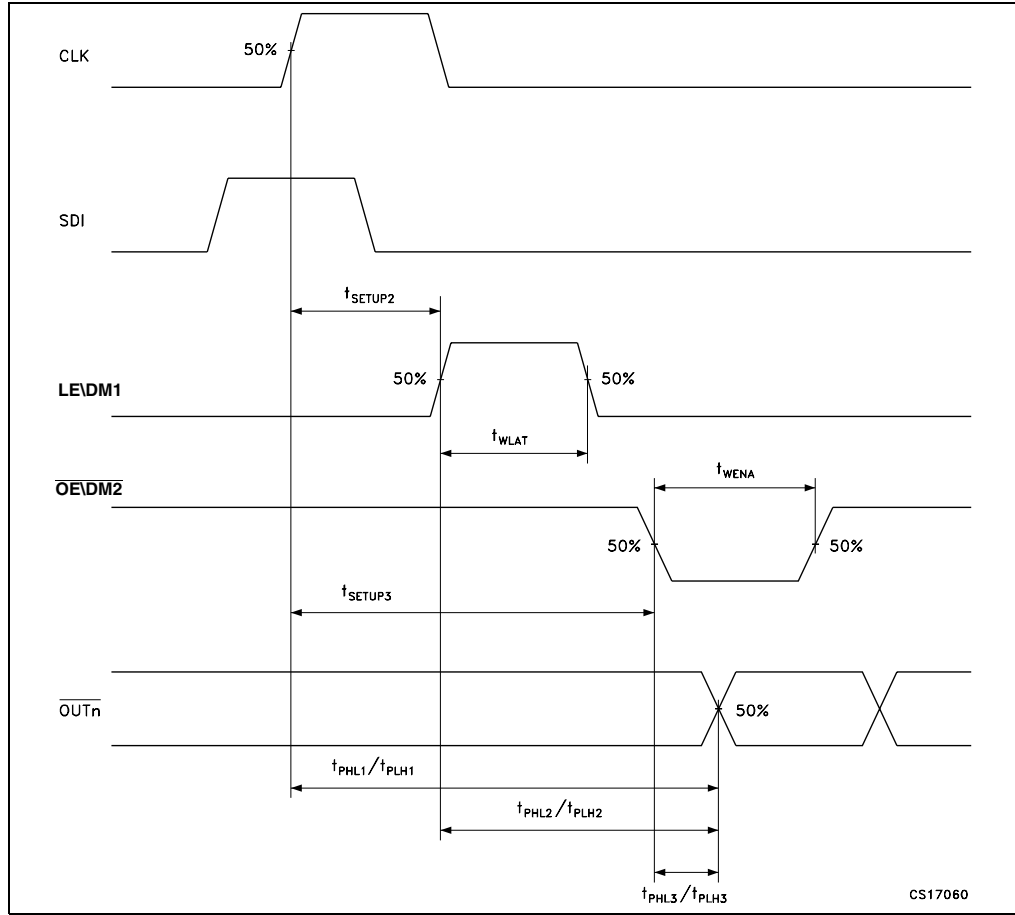
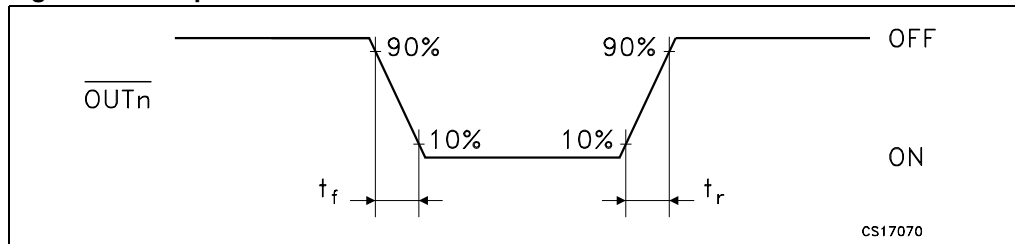


Figure 10. Outputs



## 6 Typical characteristics

Figure 11. Output current- $R_{EXT}$  resistor

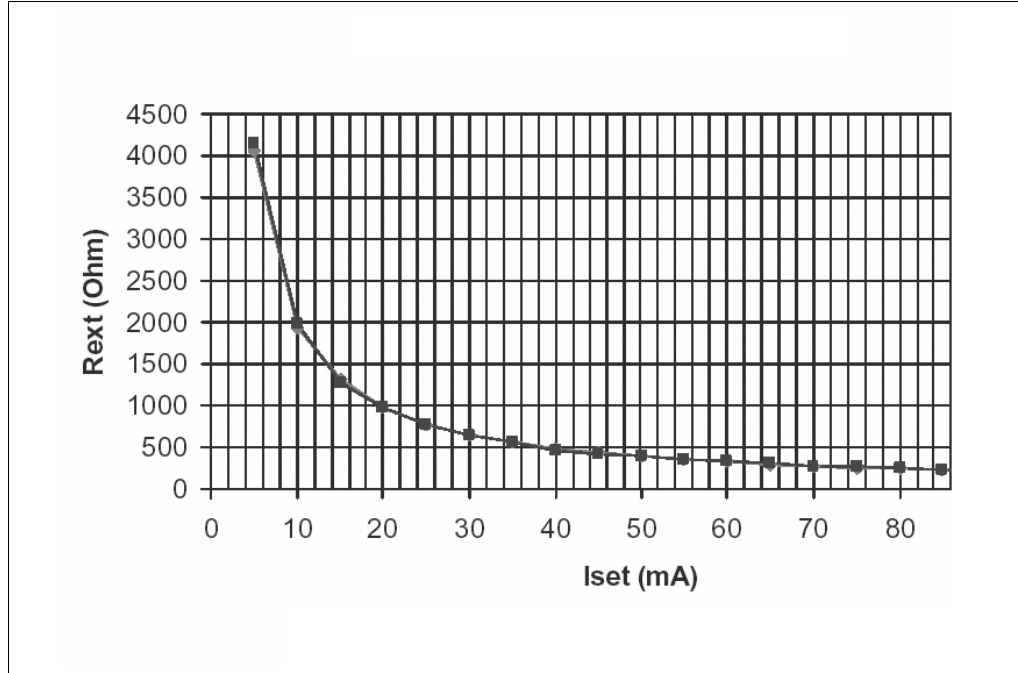


Table 10. Output current- $R_{EXT}$  resistor

$R_{ext}$ ( $\Omega$ )	Output current (mA)
976	20
780	25
652	30
560	35
488	40
433	45
389	50
354	55
325	60
300	65
278	70
259	75
241	80
229	85
215	90

Conditions:  
 Temperature = 25 °C,  $V_{DD} = 3.3\text{ V}; 5.0\text{ V}$ ,  $I_{SET} = 3\text{ mA}; 5\text{ mA}; 10\text{ mA}; 20\text{ mA}; 50\text{ mA}; 80\text{ mA}$ .

Figure 12.  $I_{SET}$  vs drop out voltage ( $V_{drop}$ )

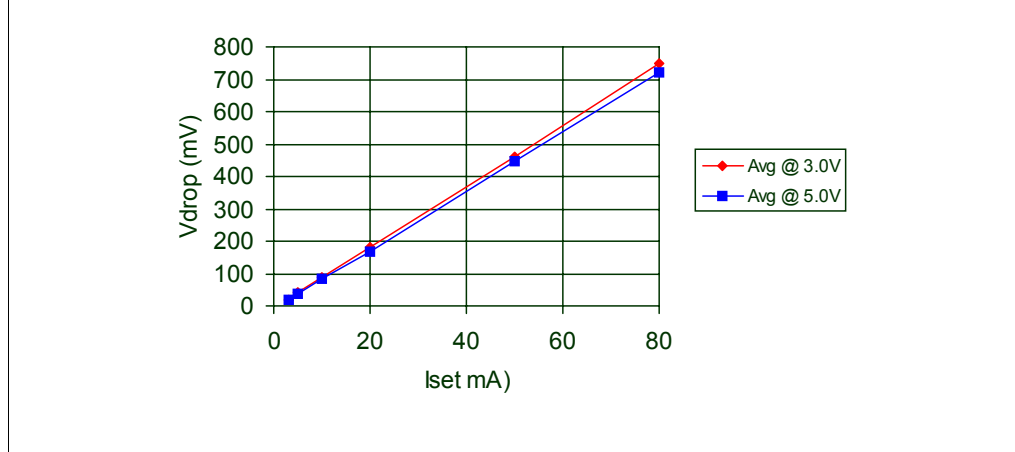


Table 11.  $I_{SET}$  vs drop out voltage ( $V_{drop}$ )

$I_{out}$ (mA)	Avg @ 3.0 V	Avg @ 5.0 V
3	19.33	22.66
5	36.67	40.33
10	77.33	80
20	158.67	157.33
50	406	406
80	692	668

Figure 13.  $I_{DD}$  ON/OFF

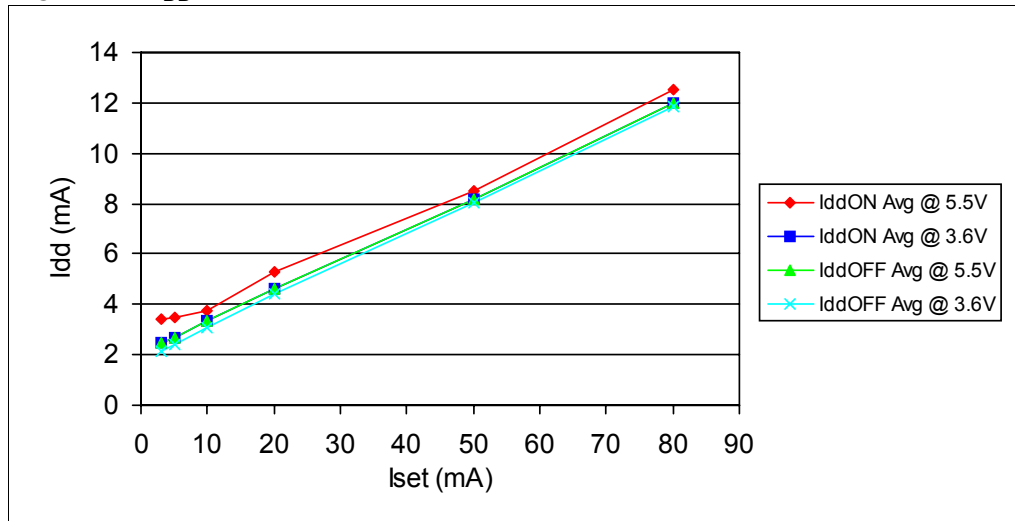
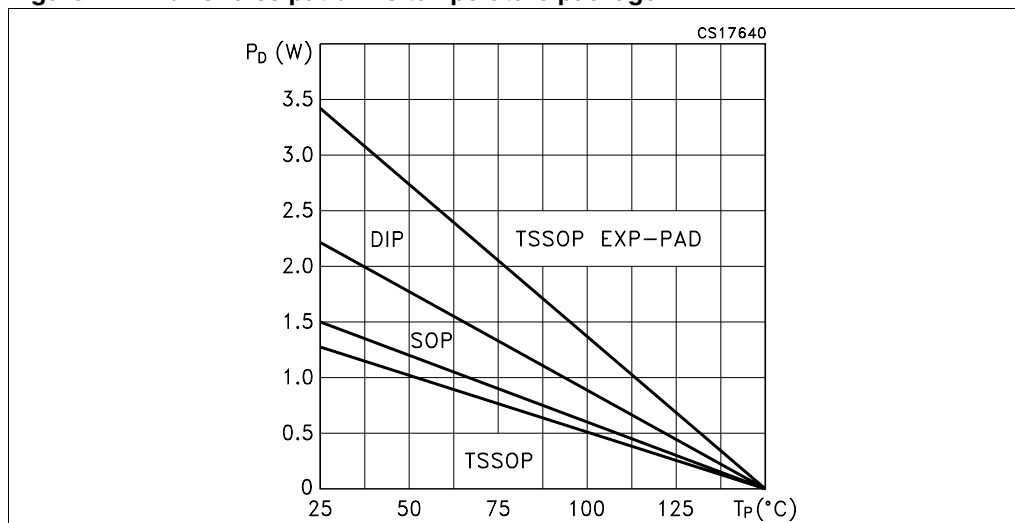


Figure 14. Power dissipation vs temperature package



Note: The exposed pad should be soldered to the PBC to realize the thermal benefits.

## 7 Detection mode functionality

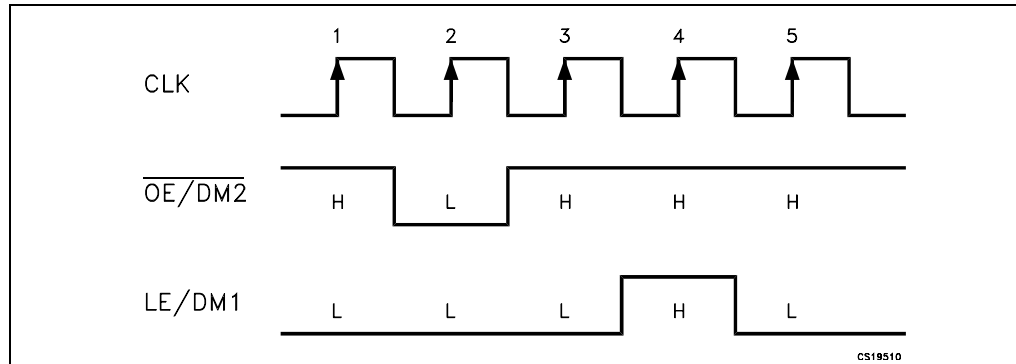
### 7.1 Phase one: “entering in detection mode“

From the “normal mode” condition the device can switch to the “error mode” by a logic sequence on the  $\overline{OE}/DM2$  and LE/DM1 pins as showed in the following table and diagram:

**Table 12. Entering in detection truth table**

CLK	1°	2°	3°	4°	5°
$\overline{OE}/DM2$	H	L	H	H	H
LE/DM1	L	L	L	H	L

**Figure 15. Entering in detection timing diagram**



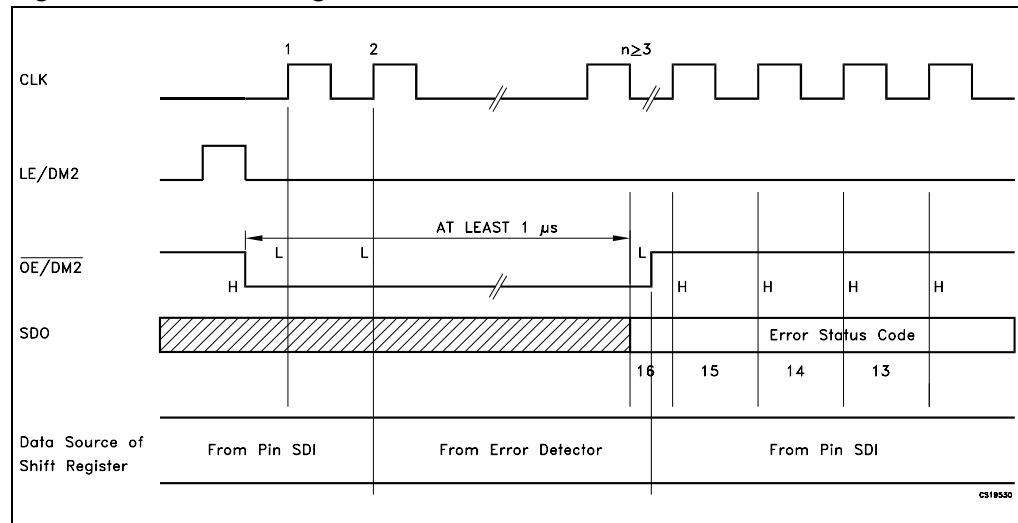
After these five CLK cycles the device goes into the “error detection mode” and at the 6<sup>th</sup> rise front of CLK the SDI data are ready for the sampling.



## 7.2 Phase two: “error detection”

The 16 data bits must be set “1” in order to set ON all the outputs during the detection. The data are latched by LE/DM1 and after that the outputs are ready for the detection process. When the micro controller switches the  $\overline{OE/DM2}$  to LOW, the device drives the LEDs in order to analyze if an OPEN or SHORT condition has occurred.

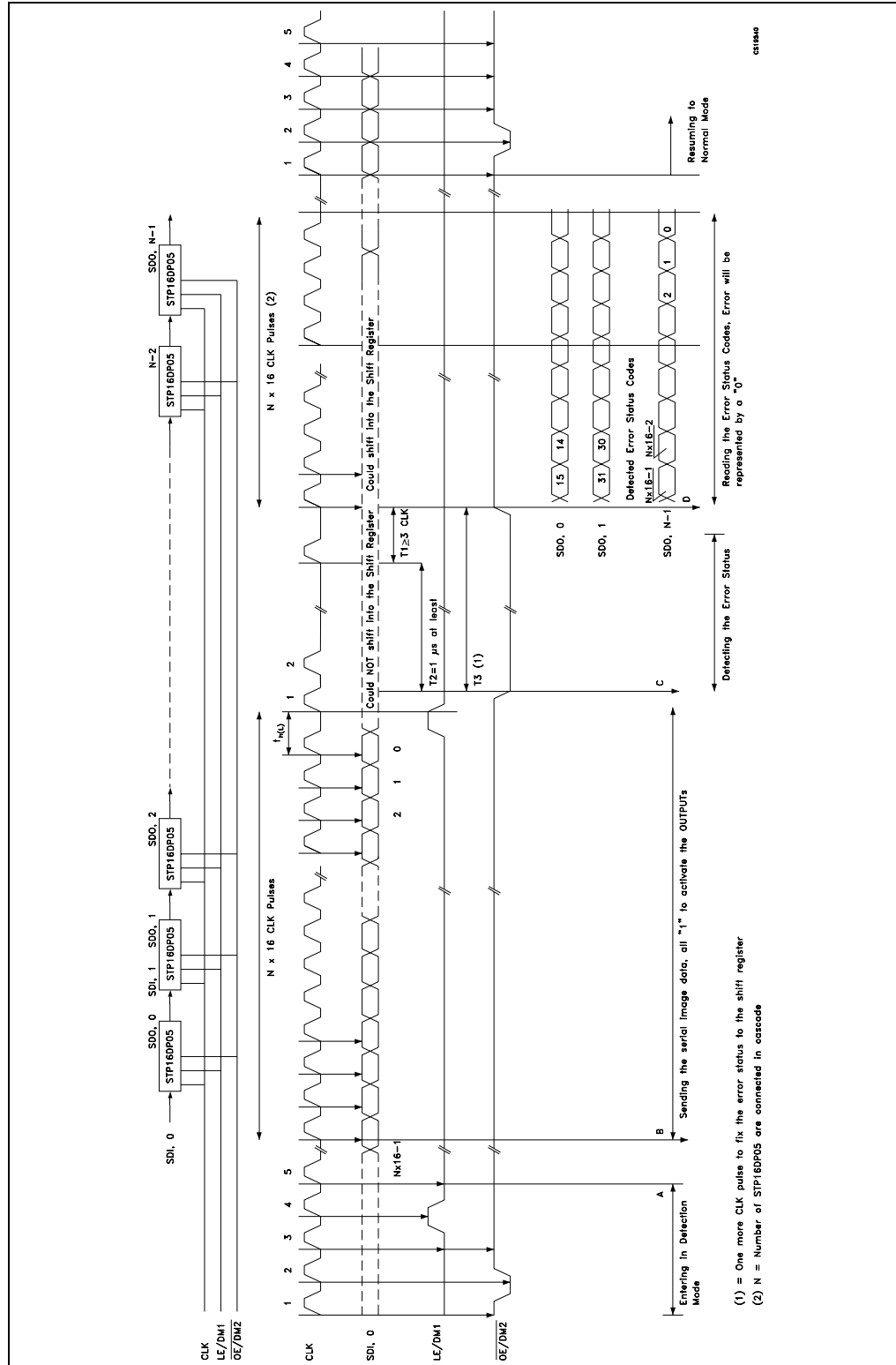
Figure 16. Detection diagram



The LEDs status will be detected at least in 1 microsecond and after this time the microcontroller sets  $\overline{OE/DM2}$  in HIGH state and the output data detection result will go to the microprocessor via SDO.

Detection mode and normal mode use both the same format data. As soon as all the detection data bits are available on the serial line, the device may go back to normal mode of operation. To re-detect the status the device must go back in normal mode and re-entering in error detection mode.

Figure 17. Timing example for open and/or short detection



### 7.3 Phase three: “resuming to normal mode”

The sequence for re-entering in normal mode is showed in the following table and diagram:

**Figure 18. Resuming to normal mode timing diagram**

CLK	1°	2°	3°	4°	5°
$\overline{\text{OE/DM2}}$	H	L	H	H	H
LE/DM1	L	L	L	L	L

*Note:* For proper device operation the “Entering in detection” sequence must be follow by a “resume mode” sequence, it is not possible to insert consecutive equal sequence.

### 7.4 Error detection conditions

$V_{DD} = 3.3$  to 5 V temperature range -40 to 125 °C

**Table 13. Detection conditions**

<b>SW-1 or SW-3b</b>	Open line or output short to GND detected	$\implies I_{ODEC} \leq 0.5 \times I_O$	No error detected	$\implies I_{ODEC} \geq 0.5 \times I_O$
<b>SW-2 or SW-3a</b>	Short on LED or short to V-LED detected	$\implies V_O \geq 2.4$ V	No error detected	$\implies V_O \leq 2.2$ V

*Note:* Where:  $I_O$  = the output current programmed by the  $R_{EXT}$ ,  $I_{ODEC}$  = the detected output current in detection mode

Figure 19. Detection circuit

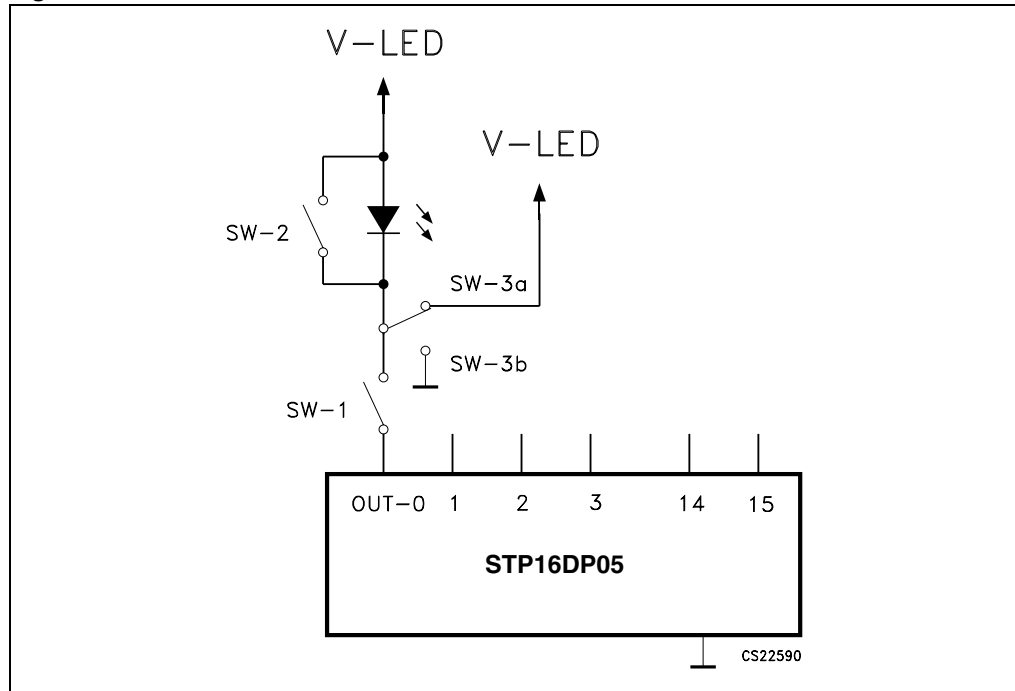
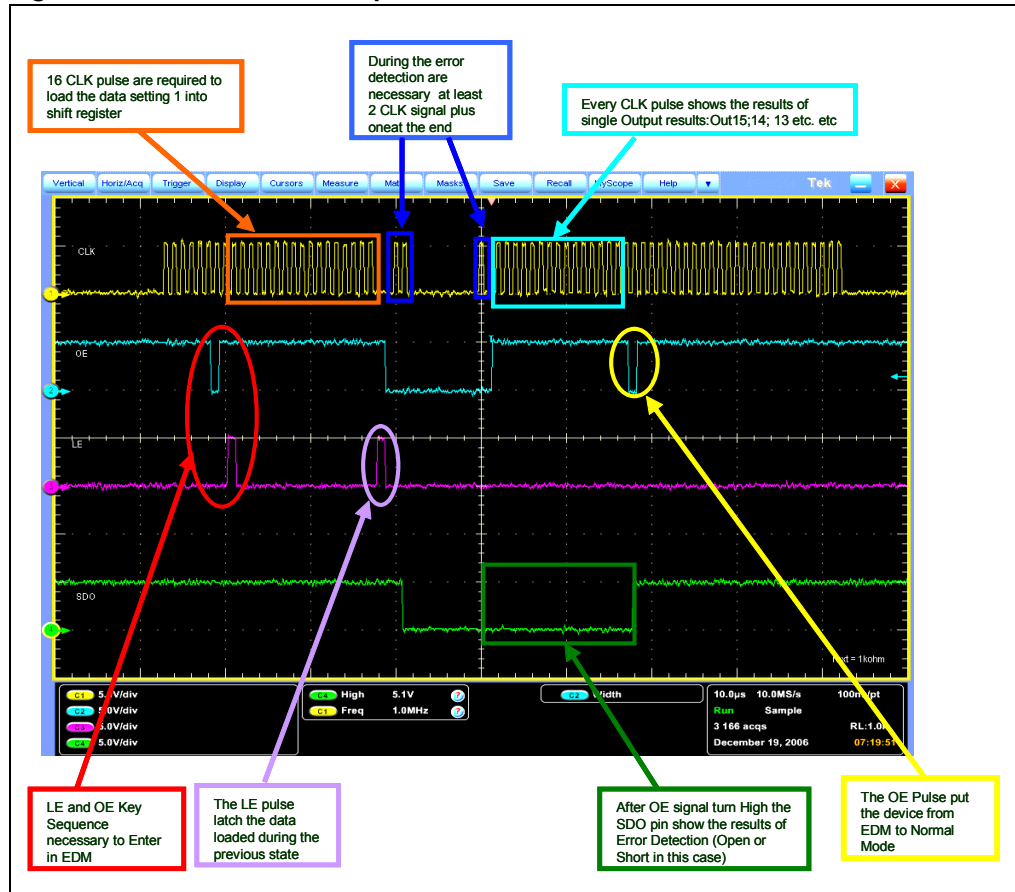


Figure 20. Error detection sequence



## 8 Package mechanical data

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

**Table 14. QSOP-24 mechanical data**

Dim.	mm.			inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.54	1.62	1.73	0.061	0.064	0.068
A1	0.1	0.15	0.25	0.004	0.006	0.010
A2		1.47			0.058	
b	0.31	0.2		0.012	0.008	
c	0.254	0.17		0.010	0.007	
D	8.56	8.66	8.76	0.337	0.341	0.345
E	5.8	6	6.2	0.228	0.236	0.244
E1	3.8	3.91	4.01	0.150	0.154	0.158
e		0.635			0.025	
L	0.4	0.635	0.89	0.016	0.025	0.035
h	0.25	0.33	0.41	0.010	0.013	0.016
<	8°	0°				

Figure 21. QSOP-24 package dimensions

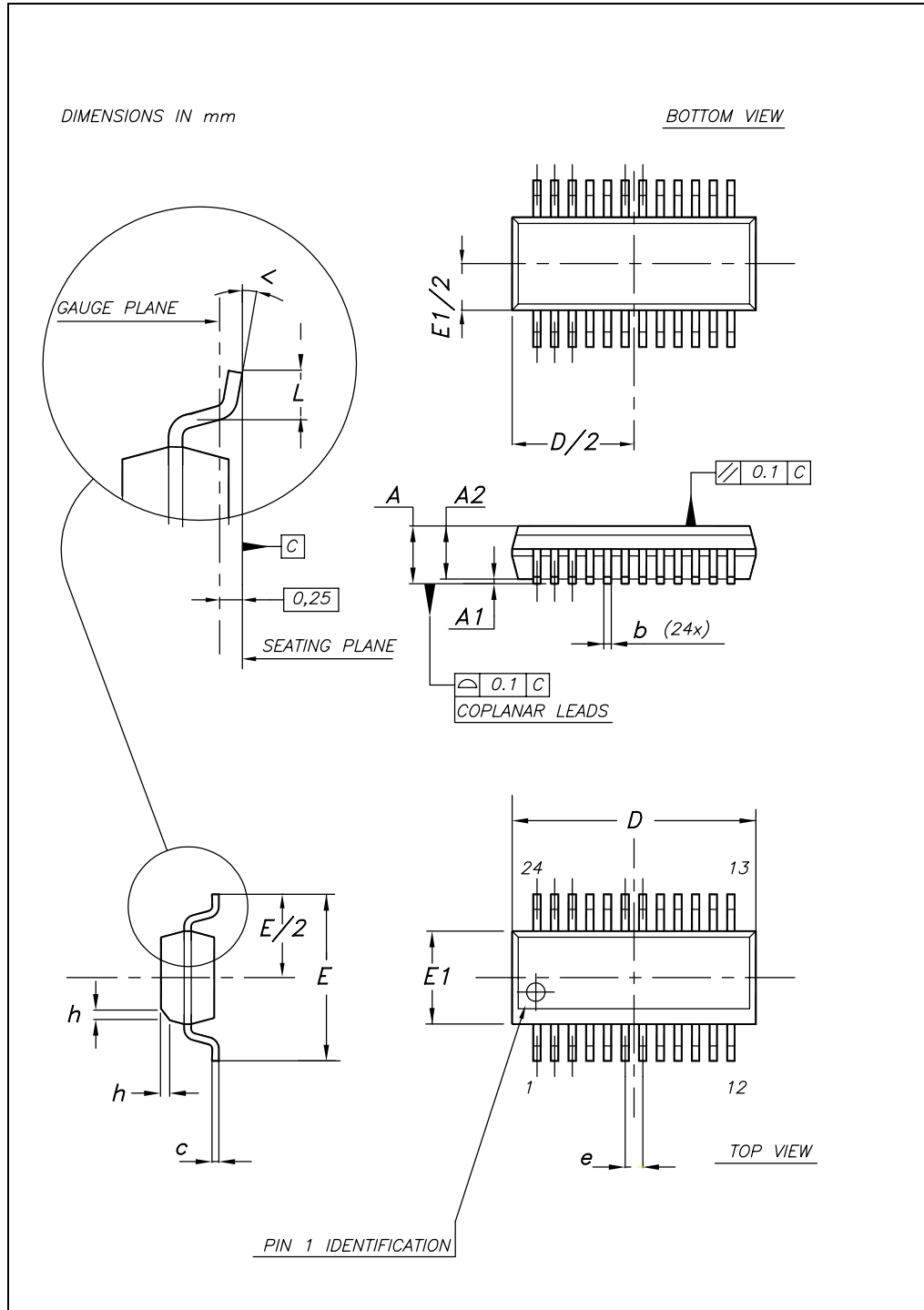
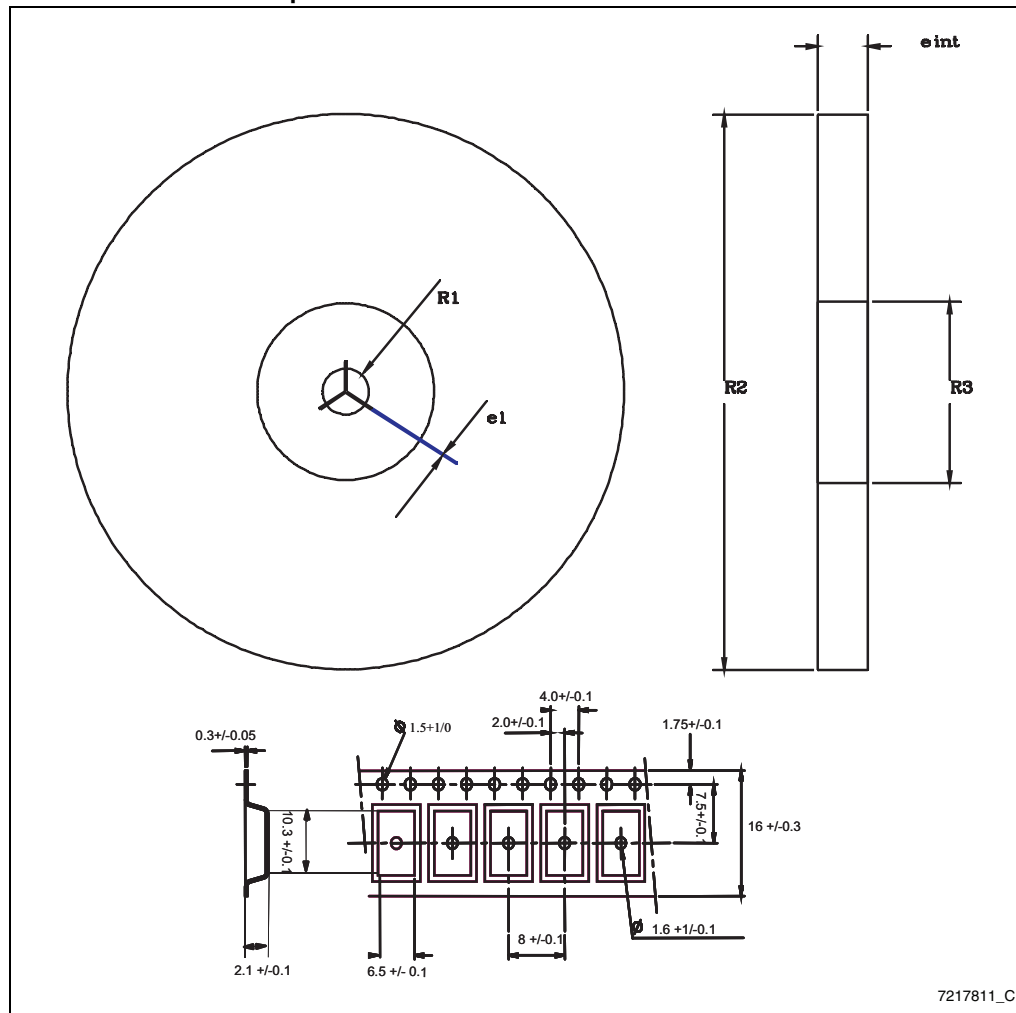


Table 15. QSOP-24 tape and reel

Dim.	mm.			inch		
	Min	Typ	Max	Min	Typ	Max
R1	12.8	13	13.5	5.039	5.118	5.315
R2		330			129.921	
R3		100			39.37	
eint		16.4			6.457	
e1	1.5	2	2.5	0.591	0.787	0.984

Table 16. QSOP-24 tape and reel dimensions



7217811\_C



Table 17. TSSOP24 mechanical data

Dim.	mm.			inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.1			0.043
A1	0.05		0.15	0.002		0.006
A2		0.9			0.035	
b	0.19		0.30	0.0075		0.0118
c	0.09		0.20	0.0035		0.0079
D	7.7		7.9	0.303		0.311
E	4.3		4.5	0.169		0.177
e		0.65 BSC			0.0256 BSC	
H	6.25		6.5	0.246		0.256
K	0°		8°	0°		8°
L	0.50		0.70	0.020		0.028

Figure 22. TSSOP24 package dimensions

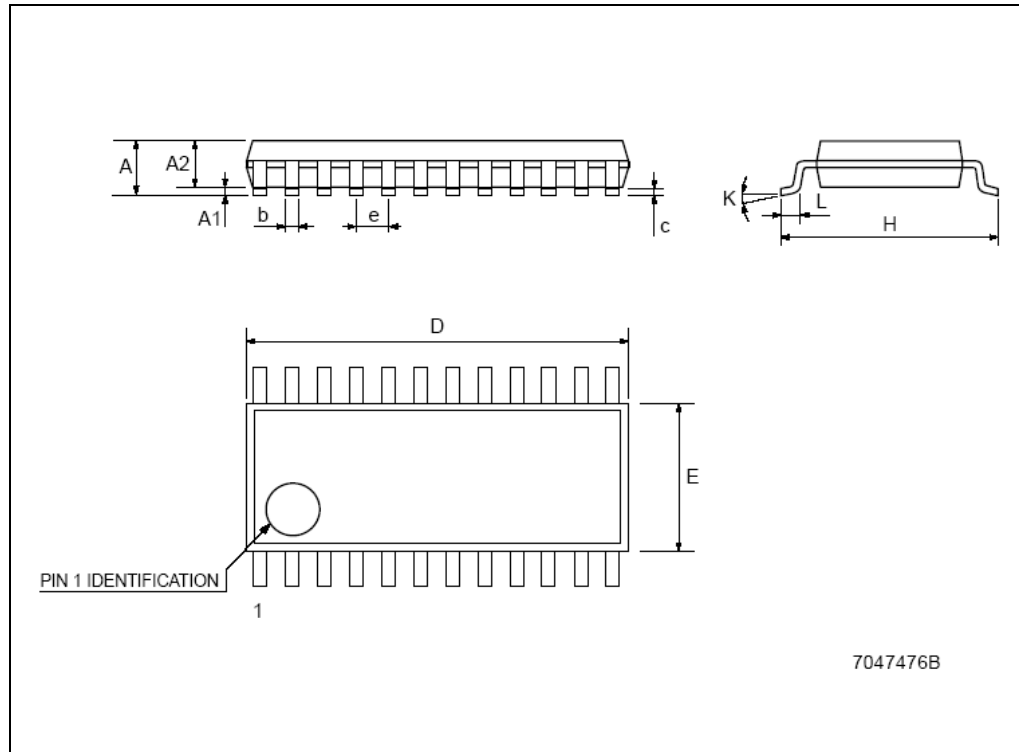


Table 18. Tape and reel TSSOP24

Dim.	mm.			inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			330			12.992
C	12.8		13.2	0.504		0.519
D	20.2			0.795		
N	60			2.362		
T			22.4			0.882
Ao	6.8		7	0.268		0.276
Bo	8.2		8.4	0.323		0.331
Ko	1.7		1.9	0.067		0.075
Po	3.9		4.1	0.153		0.161
P	11.9		12.1	0.468		0.476

Figure 23. Reel dimensions

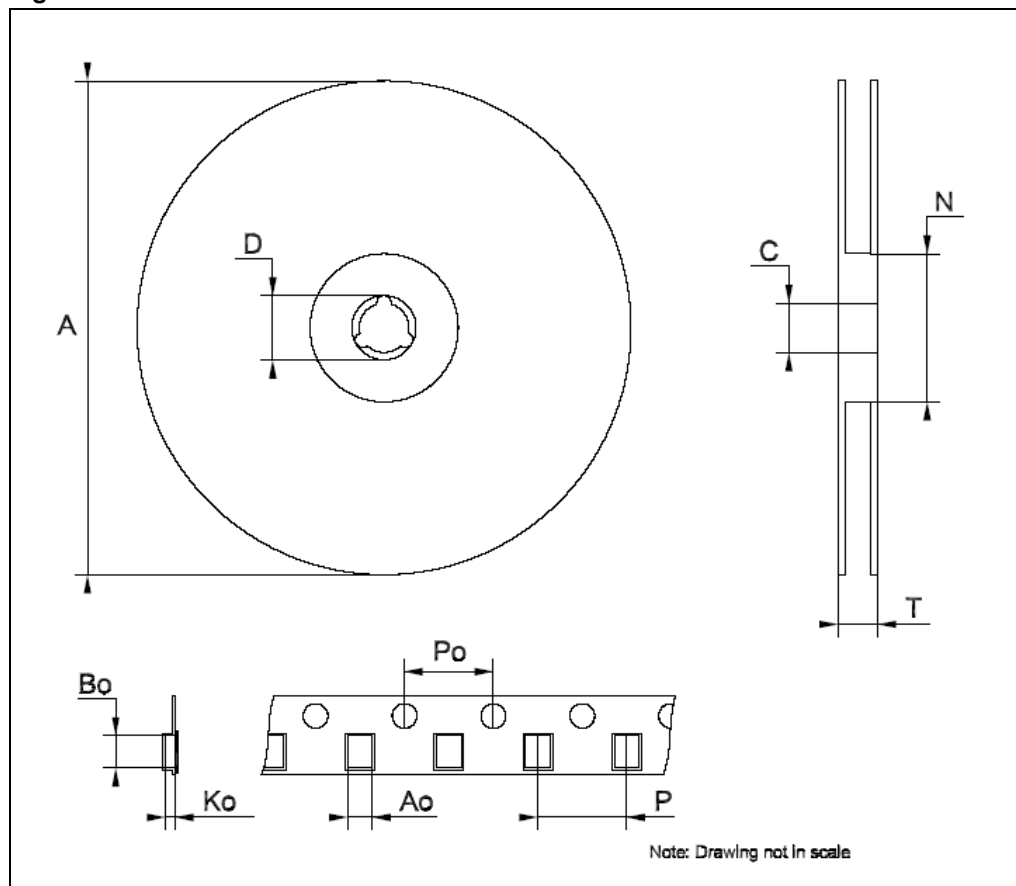


Table 19. SO-24 mechanical data

Dim.	mm.			inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			2.65			0.104
a1	0.1		0.2	0.004		0.008
a2			2.45			0.096
b	0.35		0.49	0.014		0.019
b1	0.23		0.32	0.009		0.012
C		0.5			0.020	
c1	45°(typ.)					
D	15.20		15.60	0.598		0.614
E	10.00		10.65	0.393		0.419
e		1.27			0.050	
e3		13.97			0.550	
F	7.40		7.60	0.291		0.300
L	0.50		1.27	0.020		0.050
S	°(max.) 8					

Figure 24. SO-24 package dimensions

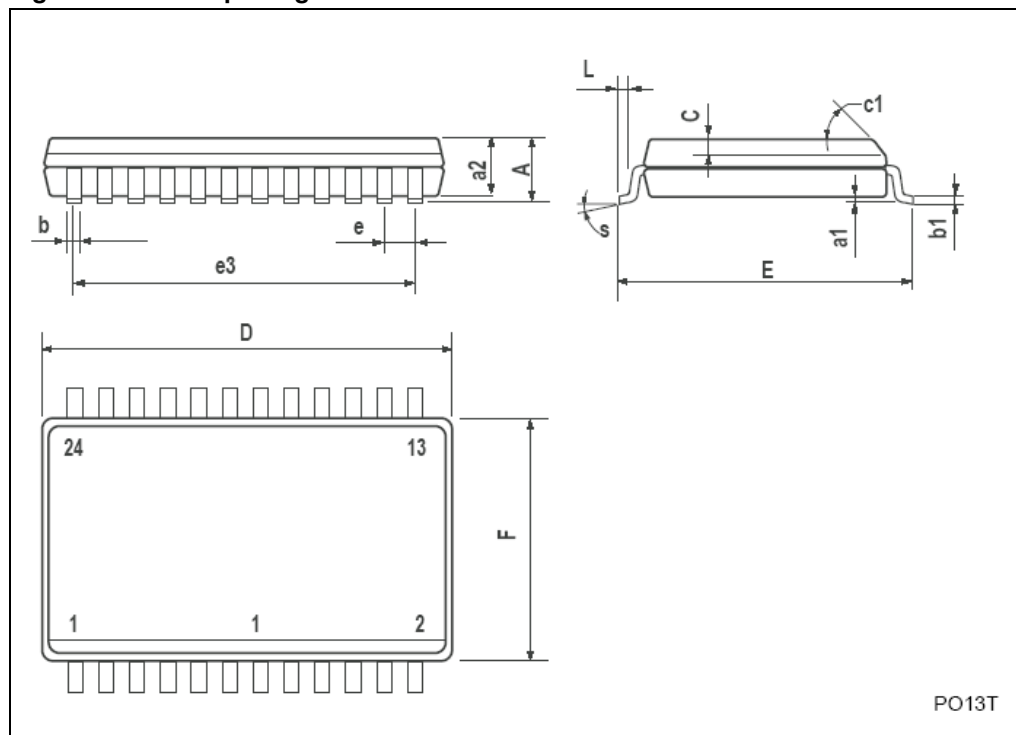


Table 20. Tape and reel SO-24

Dim.	mm.			inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			330			12.992
C	12.8		13.2	0.504		0.519
D	20.2			0.795		
N	60			2.362		
T			30.4			1.197
Ao	10.8		11.0	0.425		0.433
Bo	15.7		15.9	0.618		0.626
Ko	2.9		3.1	0.114		0.122
Po	3.9		4.1	0.153		0.161
P	11.9		12.1	0.468		0.476

Figure 25. Reel dimensions

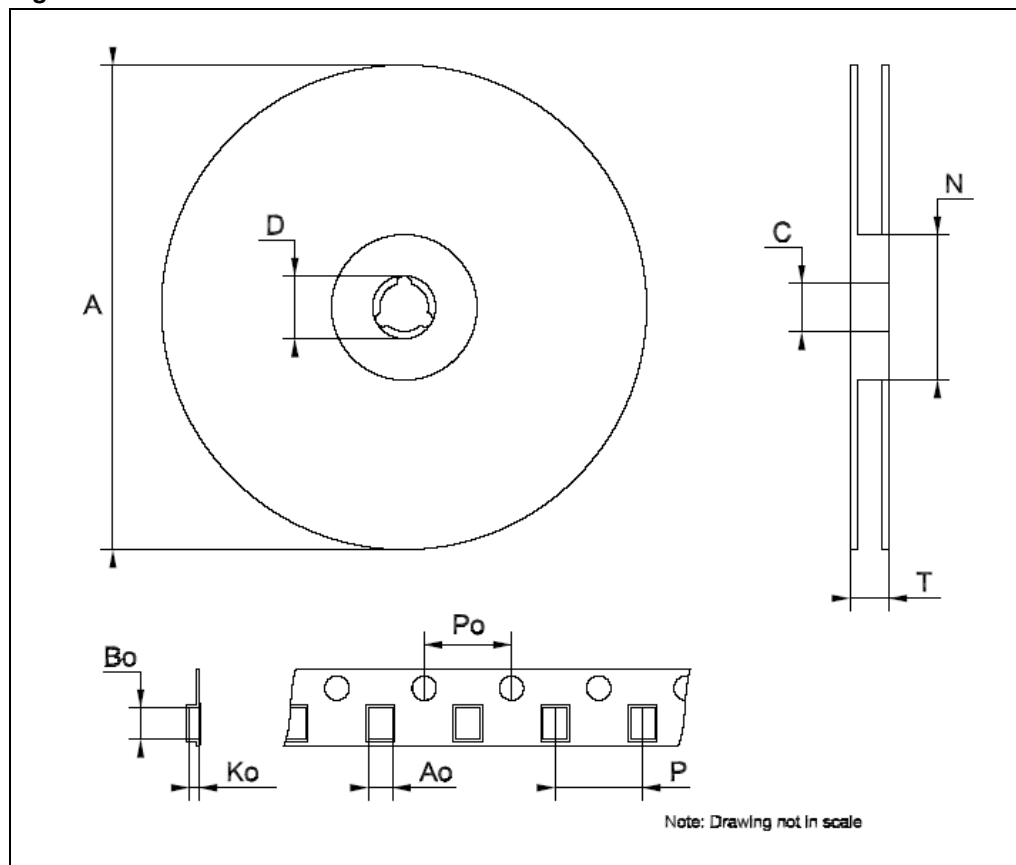
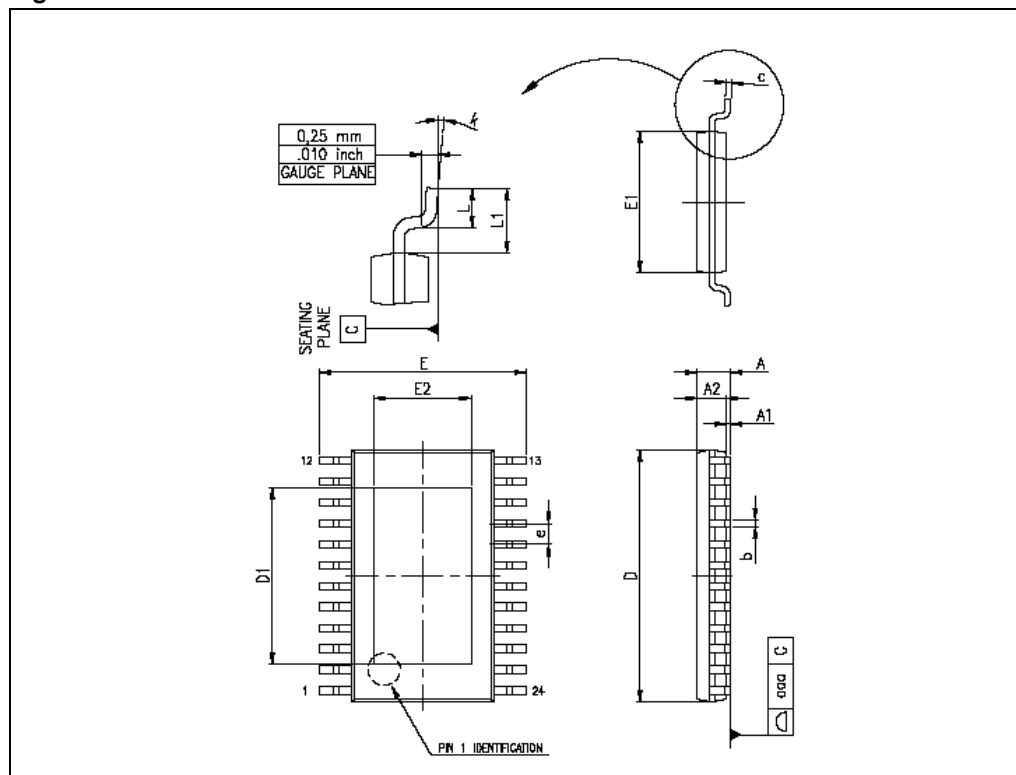


Table 21. TSSOP24 exposed pad

Dim.	mm			inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.2			0.047
A1			0.15		0.004	0.006
A2	0.8	1	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	7.7	7.8	7.9	0.303	0.307	0.311
D1	4.7	5.0	5.3	0.185	0.197	0.209
E	6.2	6.4	6.6	0.244	0.252	0.260
E1	4.3	4.4	4.5	0.169	0.173	0.177
E2	2.9	3.2	3.5	0.114	0.126	0.138
e		0.65			0.0256	
K	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030

Figure 26. TSSOP24 dimensions



## 9 Revision history

**Table 22. Document revision history**

Date	Revision	Changes
9-Jan-2007	1	First release
21-May-2007	2	Updated <a href="#">Table 7 on page 6</a>
10-Jul-2007	3	Updated <a href="#">Table 9: Truth table on page 10</a>
28-Feb-2008	4	Updated <a href="#">Table 15: TSSOP24 exposed-pad on page 23</a> Added QSOP-24 package information <a href="#">Table 14</a> and <a href="#">Figure 21 on page 23</a>
23-Oct-2009	5	Updated <a href="#">Figure 7 on page 10</a> , <a href="#">Chapter 3 on page 6</a>
20-Jan-2010	6	Updated <a href="#">Table 5 on page 4</a>

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