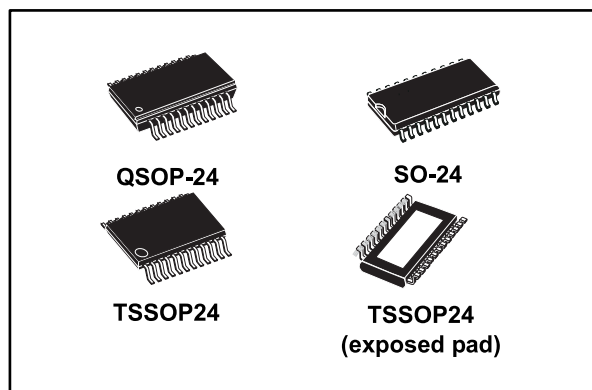


## Low voltage 16-bit constant current LED sink driver

Datasheet - production data



### Description

The STP16CPP05 is a monolithic, low voltage, low current power 16-bit shift register designed for LED panel displays. The STP16CPP05 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 provide from 3 mA to 40 mA constant current to drive the LEDs. The output current setup time is 40 ns (typ), thus improving the system performance. The LEDs' brightness can be controlled by using an external resistor to adjust the STP16CPP05 output current. The STP16CPP05 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 useful in applications that interface with a 3.3 V micro controller.

### Features

- 16 constant current output channels
- Adjustable output current through external resistor
- Output current: 3-40 mA
- Serial data in/parallel data out
- 3.3 V or 5 V supply voltage
- Max clock frequency 30 MHz
- Schmitt-trigger input
- ESD protection 2 kV HBM
- Thermal shutdown

Table 1: Device summary

Order code	Package	Packing
STP16CPP05MTR	SO-24	1000 parts per reel
STP16CPP05TTR	TSSOP24	2500 parts per reel
STP16CPP05XTTR	TSSOP24 exposed pad	2500 parts per reel
STP16CPP05PTR	QSOP-24	2500 parts per reel

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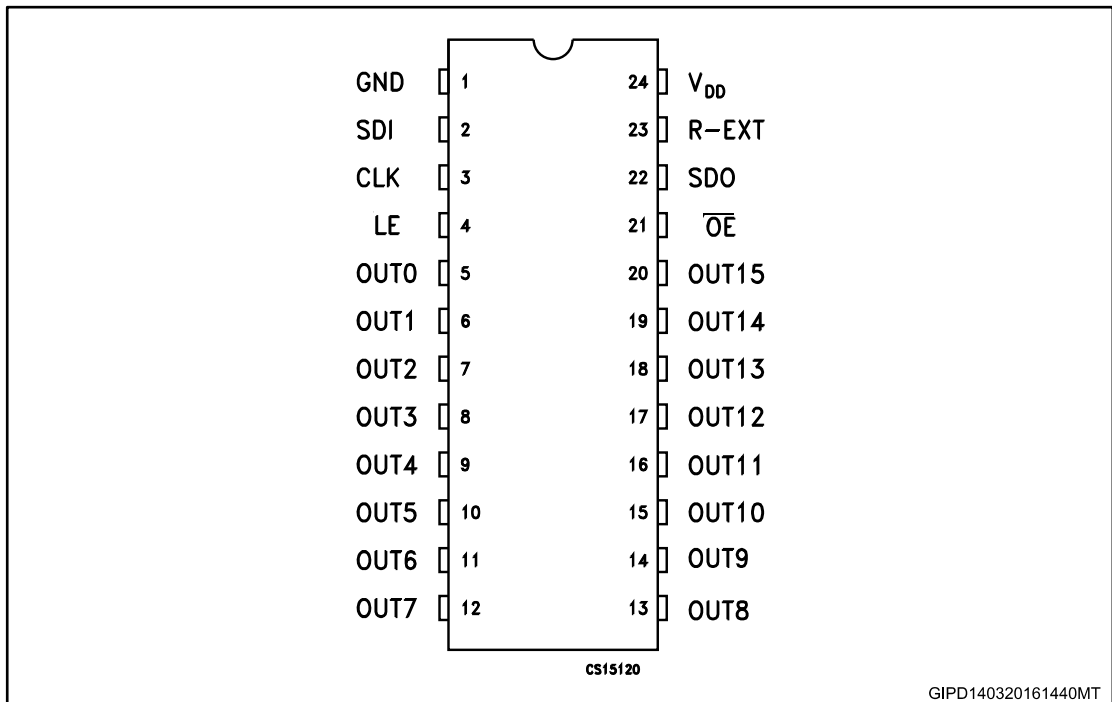
# 1 Summary description

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%	≥ 5 to 40 mA	3.3 V to 5 V	25 °C

## 1.1 Pin connection and description

Figure 1: Pin connection



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	Latch input terminal
5-20	OUT 0-15	Output terminal
21	$\overline{\text{OE}}$	Input terminal of output enable (active low)
22	SDO	Serial data out terminal
23	R-EXT	Input terminal for 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 <sub>DD</sub>	Supply voltage	0 to 7	V
V <sub>O</sub>	Output voltage	-0.5 to 20	V
I <sub>O</sub>	Output current	50	mA
V <sub>I</sub>	Input voltage	-0.4 to V <sub>DD</sub> + 0.4	V
I <sub>GND</sub>	GND terminal current	800	mA
f <sub>CLK</sub>	Clock frequency	50	MHz

### 2.2 Thermal data

**Table 5: Thermal data**

Symbol	Parameter	Value	Unit	
T <sub>OPR</sub>	Operating temperature range	-40 to +125	°C	
T <sub>STG</sub>	Storage temperature range	-55 to +150	°C	
R <sub>thJA</sub>	Thermal resistance junction-ambient	SO-24	60	°C/W
		TSSOP24	85	°C/W
		TSSOP24 <sup>(1)</sup> exposed pad	37.5	°C/W
		QSOP-24	72	°C/W

**Notes:**

<sup>(1)</sup> 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 at 25 °C

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>DD</sub>	Supply voltage		3.0		5.5	V
V <sub>O</sub>	Output voltage				20	V
I <sub>O</sub>	Output current	OUT <sub>n</sub>	3		40	mA
I <sub>OH</sub>	Output current	SERIAL-OUT			+1	mA
I <sub>OL</sub>	Output current	SERIAL-OUT			-1	mA
V <sub>IH</sub>	Input voltage		0.7 V <sub>DD</sub>		V <sub>DD</sub> + 0.3	V
V <sub>IL</sub>	Input voltage		-0.3		0.3 V <sub>DD</sub>	V
t <sub>wLAT</sub>	LE/DM1 pulse width	V <sub>DD</sub> = 3.3 V to 5.0 V	20			ns
t <sub>wCLK</sub>	CLK pulse width		16			ns
t <sub>wEN</sub>	$\overline{\text{OE}}$ pulse width		70			ns
t <sub>SETUP(D)</sub>	Setup time for DATA		5			ns
t <sub>HOLD(D)</sub>	Hold time for DATA		5			ns
t <sub>SETUP(L)</sub>	Setup time for LATCH		15			ns
f <sub>CLK</sub>	Clock frequency		Cascade operation <sup>(1)</sup>			30

### Notes:

<sup>(1)</sup> 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

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

**Table 7: Electrical characteristics**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{IH}$	Input voltage high level		$0.7 V_{DD}$		$V_{DD}$	V
$V_{IL}$	Input voltage low level		GND		$0.3 V_{DD}$	V
$I_{OH}$	Output leakage current	$V_{OH} = 20\text{ V}$		0.15	1	$\mu\text{A}$
$V_{OL}$	Output voltage (serial-OUT)	$I_{OL} = 1\text{ mA}$			0.4	V
$V_{OH}$	Output voltage (serial-OUT)	$I_{OH} = -1\text{ mA}$	$V_{DD}-0.4\text{V}$			V
$I_{OL1}$	Output current	$V_O = 0.3\text{ V}$ , $R_{ext} = 4\text{ k}\Omega$	4.75	5	5.25	mA
$I_{OL2}$		$V_O = 0.3\text{ V}$ , $R_{ext} = 980\ \Omega$	19	20	21	
$I_{OL3}$		$V_O = 1.3\text{ V}$ , $R_{ext} = 490\ \Omega$	38	40	42	
$\Delta I_{OL1}$	Output current error between bit (all output ON)	$V_O = 0.3\text{ V}$ , $I_O = 5\text{ mA}$ , $R_{ext} = 4\text{ k}\Omega$		$\pm 1.2$	$\pm 5$	%
$\Delta I_{OL2}$		$V_O = 0.3\text{ V}$ , $I_O = 20\text{ mA}$ , $R_{ext} = 980\ \Omega$		$\pm 0.5$	$\pm 3$	
$\Delta I_{OL3}$		$V_O = 1.3\text{ V}$ , $I_O = 40\text{ mA}$ , $R_{ext} = 490\ \Omega$		$\pm 1.0$	$\pm 3$	
$R_{SIN(up)}$	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)	$R_{ext} = 980\ \Omega$ OUT 0 to 15 = OFF		5.4	7.5	mA
$I_{DD(OFF2)}$		$R_{ext} = 490\ \Omega$ OUT 0 to 15 = OFF		8.0	9.5	
$I_{DD(ON1)}$	Supply current (ON)	$R_{ext} = 980\ \Omega$ , OUT 0 to 15 = ON		5.5	7.5	
$I_{DD(ON2)}$		$R_{ext} = 490\ \Omega$ , OUT 0 to 15 = ON		8.1	9.5	
Thermal	Thermal protection			170		$^\circ\text{C}$

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

Table 8: Switching characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit	
$t_{PLH1}$	Propagation delay time, CLK- $\overline{\text{OUTn}}$ , LE = H, $\overline{\text{OE}} = \text{L}$	$V_{IH} = V_{DD}$ $V_{IL} = \text{GND}$ $C_L = 10\text{ pF}$ $I_O = 20\text{ mA}$ $V_L = 3.0\text{ V}$ $R_{\text{ext}} = 1\text{ K}\Omega$ $R_L = 60\text{ }\Omega$	$V_{DD} = 3.3\text{ V}$	-	44	58	ns
			$V_{DD} = 5\text{ V}$	-	24	32	
$t_{PLH2}$	Propagation delay time, LE- $\overline{\text{OUTn}}$ , $\overline{\text{OE}} = \text{L}$		$V_{DD} = 3.3\text{ V}$	-	43	56	ns
			$V_{DD} = 5\text{ V}$	-	24	32	
$t_{PLH3}$	Propagation delay time, $\overline{\text{OE}} - \overline{\text{OUTn}}$ , LE = H		$V_{DD} = 3.3\text{ V}$	-	63	82	ns
			$V_{DD} = 5\text{ V}$	-	37	48	
$t_{PLH}$	Propagation delay time, CLK-SDO		$V_{DD} = 3.3\text{ V}$	-	17	22	ns
			$V_{DD} = 5\text{ V}$	-	11	14	
$t_{PHL1}$	Propagation delay time, CLK- $\overline{\text{OUTn}}$ , LE = H, $\overline{\text{OE}} = \text{L}$		$V_{DD} = 3.3\text{ V}$	-	22	28	ns
			$V_{DD} = 5\text{ V}$	-	16	21	
$t_{PHL2}$	Propagation delay time, LE- $\overline{\text{OUTn}}$ , $\overline{\text{OE}} = \text{L}$	$V_{DD} = 3.3\text{ V}$	-	19	25	ns	
		$V_{DD} = 5\text{ V}$	-	15	20		
$t_{PHL3}$	Propagation delay time, $\overline{\text{OE}} - \overline{\text{OUTn}}$ , LE = H	$V_{DD} = 3.3\text{ V}$	-	16	21	ns	
		$V_{DD} = 5\text{ V}$	-	13	17		
$t_{PHL}$	Propagation delay time, CLK-SDO	$V_{DD} = 3.3\text{ V}$	-	21	27	ns	
		$V_{DD} = 5\text{ V}$	-	13	17		
$t_{ON}$	Output rise time 10~90% of voltage waveform	$V_{DD} = 3.3\text{ V}$	-	26	35	ns	
		$V_{DD} = 5\text{ V}$	-	12	16		
$t_{OFF}$	Output fall time 90~10% of voltage waveform	$V_{DD} = 3.3\text{ V}$	-	4	6	ns	
		$V_{DD} = 5\text{ V}$	-	3	5		
$t_r$	CLK rise time <sup>(1)</sup>		-		5000	ns	
$t_f$	CLK fall time <sup>(1)</sup>		-		5000	ns	

**Notes:**

<sup>(1)</sup> In order to achieve high cascade data transfer, please consider  $t_r/t_f$  timings carefully.

### 4 Equivalent circuit and outputs

Figure 2: OE terminal

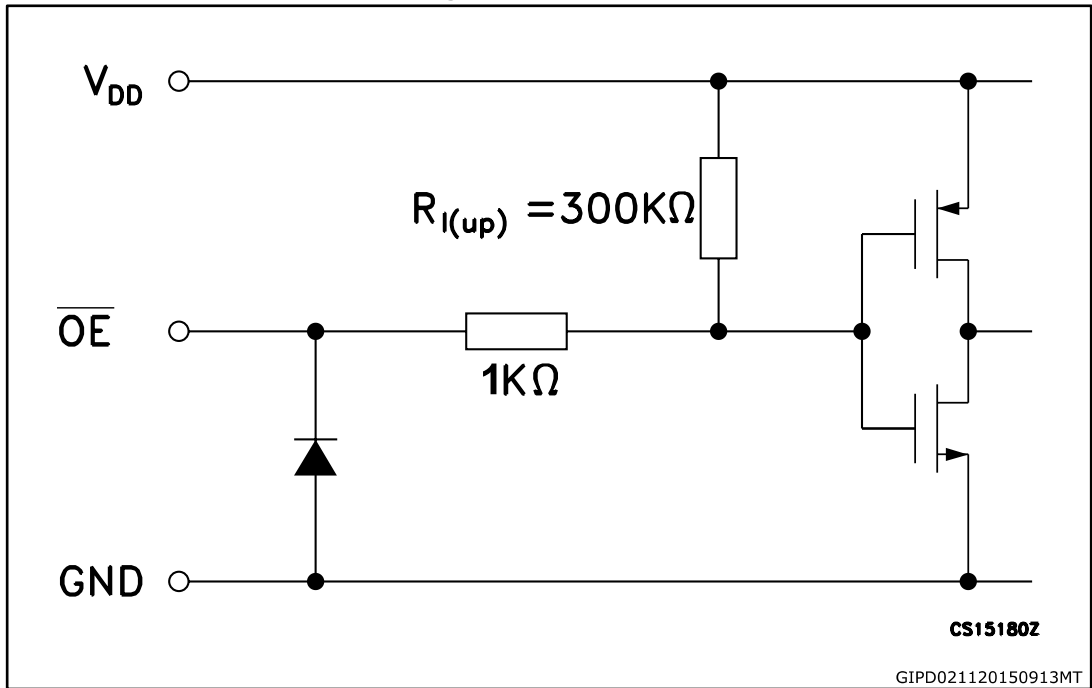


Figure 3: LE terminal

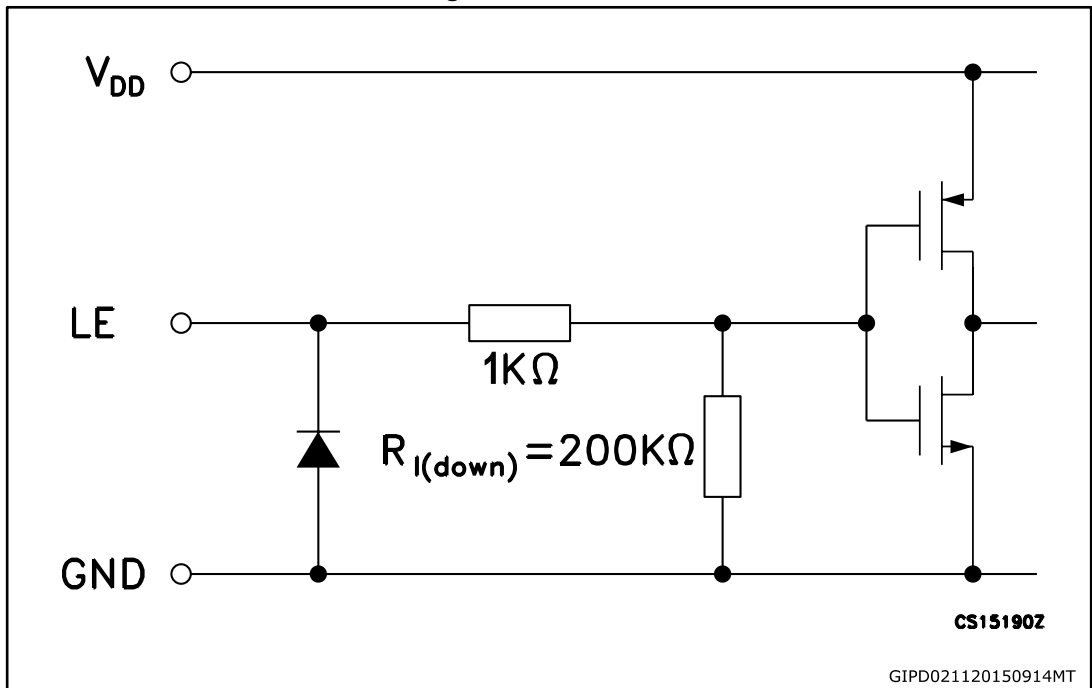
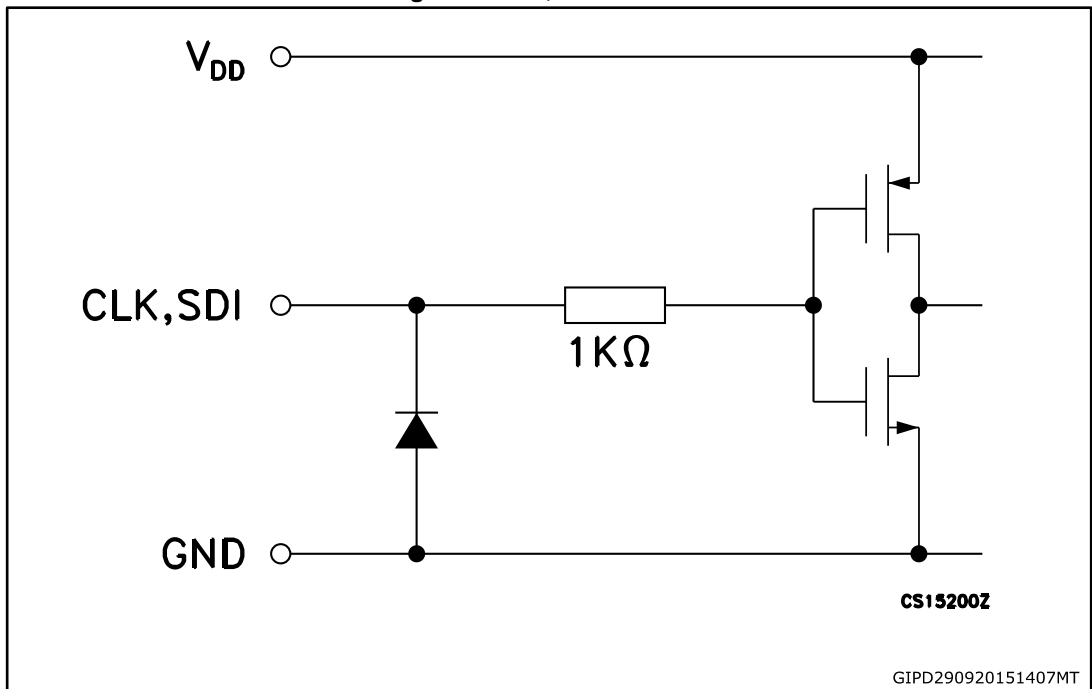


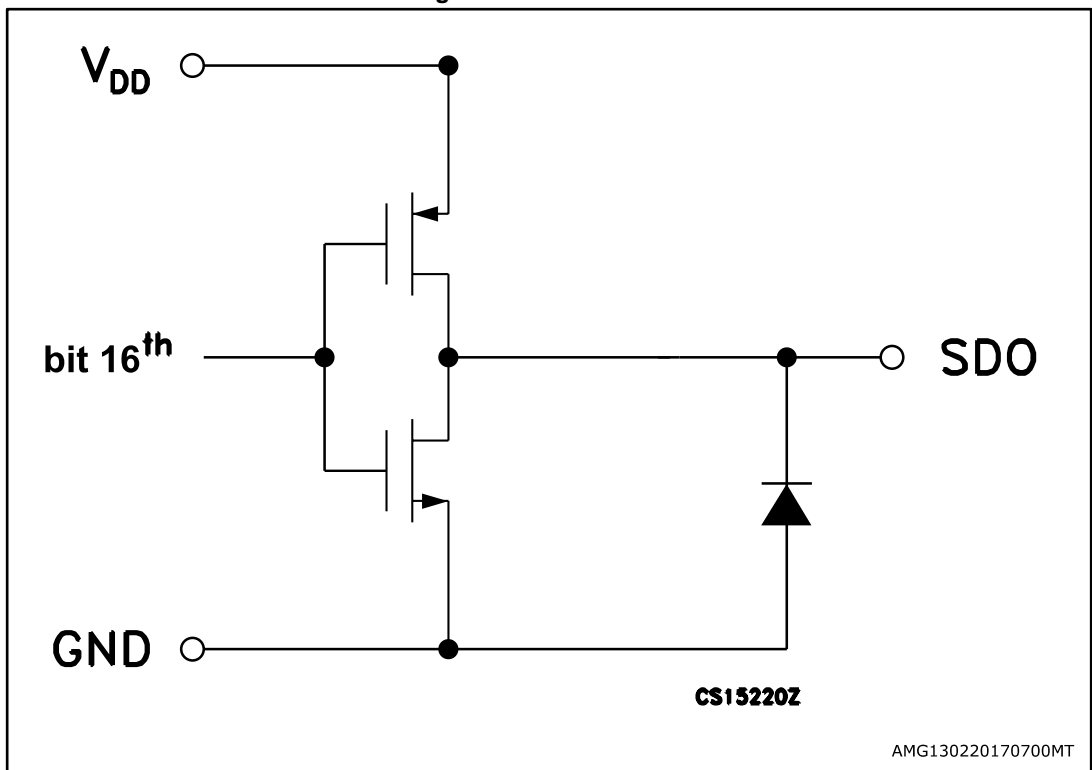


Figure 4: CLK, SDI terminal



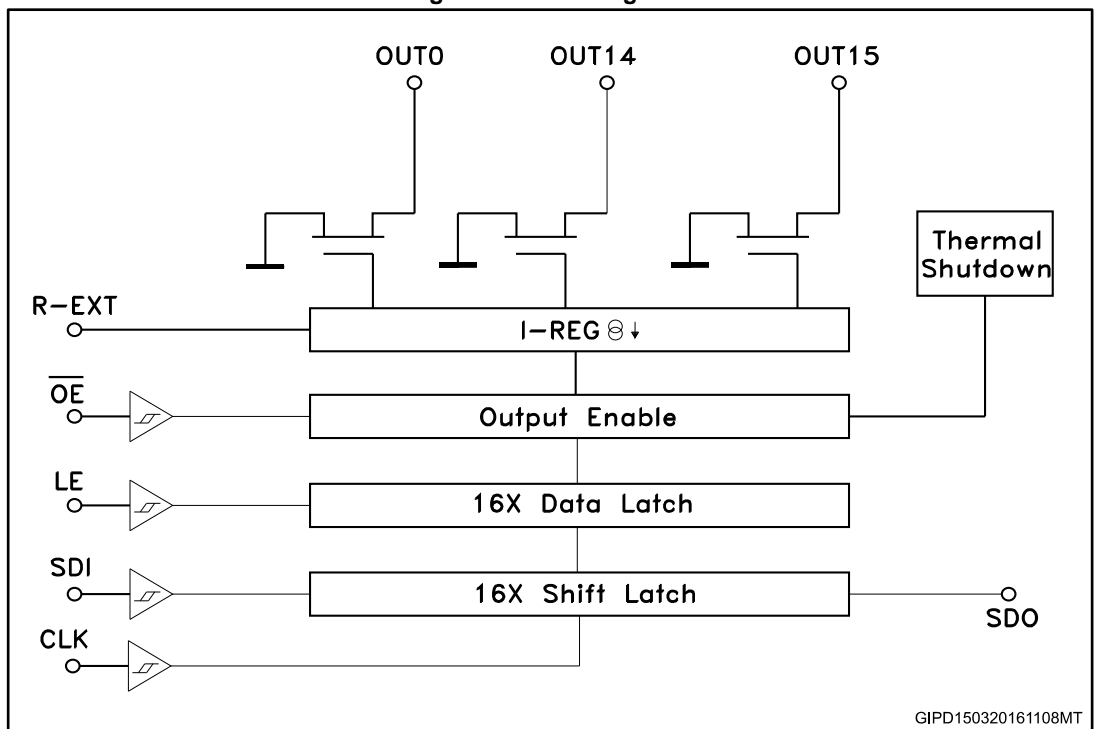
GIPD290920151407MT

Figure 5: SDO terminal



AMG130220170700MT

Figure 6: Block diagram



# 5 Timing diagrams

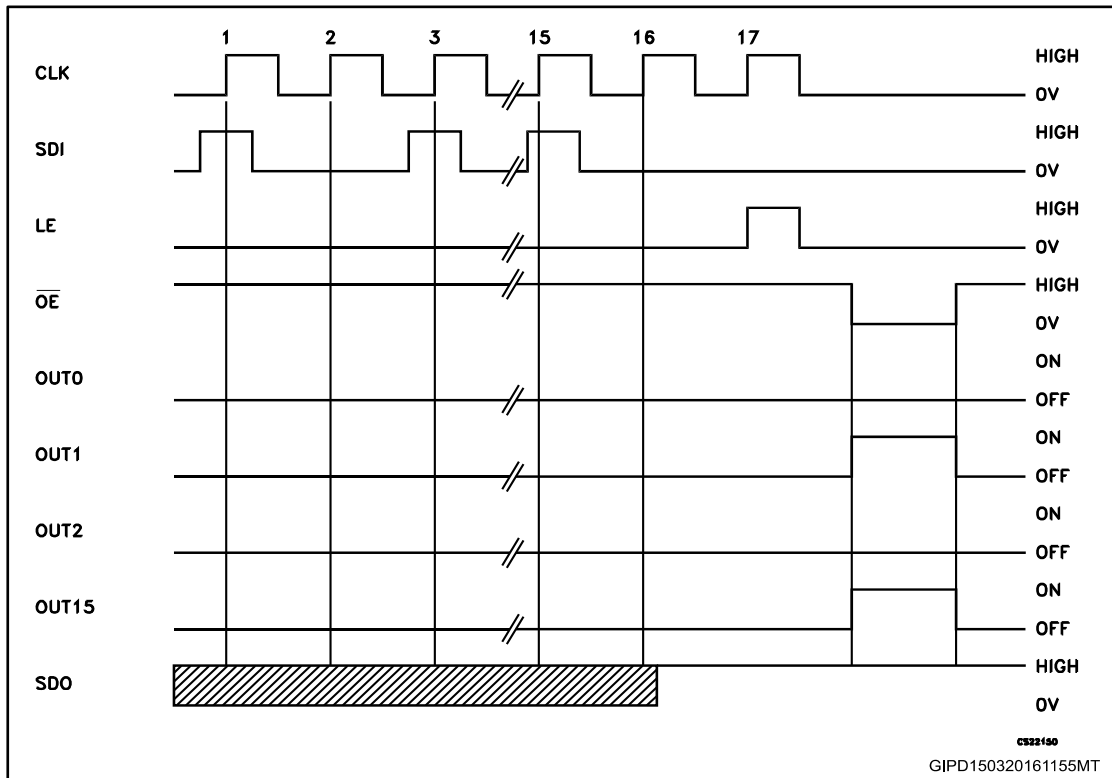
Table 9: Truth table

CLOCK	LE	$\overline{OE}$	SERIAL-IN	$\overline{OUT0}$ ..... $\overline{OUT7}$ ..... $\overline{OUT15}$	SDO
$\downarrow$	H	L	Dn	Dn ..... Dn - 7 ..... Dn - 15	Dn - 15
$\downarrow$	L	L	Dn + 1	No change	Dn - 14
$\downarrow$	H	L	Dn + 2	Dn + 2 ..... Dn - 5 ..... Dn - 13	Dn - 13
$\downarrow$	X	L	Dn + 3	Dn + 2 ..... Dn - 5 ..... Dn - 13	Dn - 13
$\downarrow$	X	H	Dn + 3	OFF	Dn - 13



OUTn = ON when Dn = H OUTn = OFF when Dn = L.

Figure 7: Timing diagram



The latches circuit holds data when the LE terminal is Low.

1 When LE terminal is at high level, latch circuit does not hold the data it passes from the input to the output.

2 When  $\overline{OE}$  terminal is at low level, output terminals OUT0 to OUT15 respond to the data, either ON or OFF.

3 When  $\overline{OE}$  terminal is at high level, it switches off all the data on the output terminal.

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

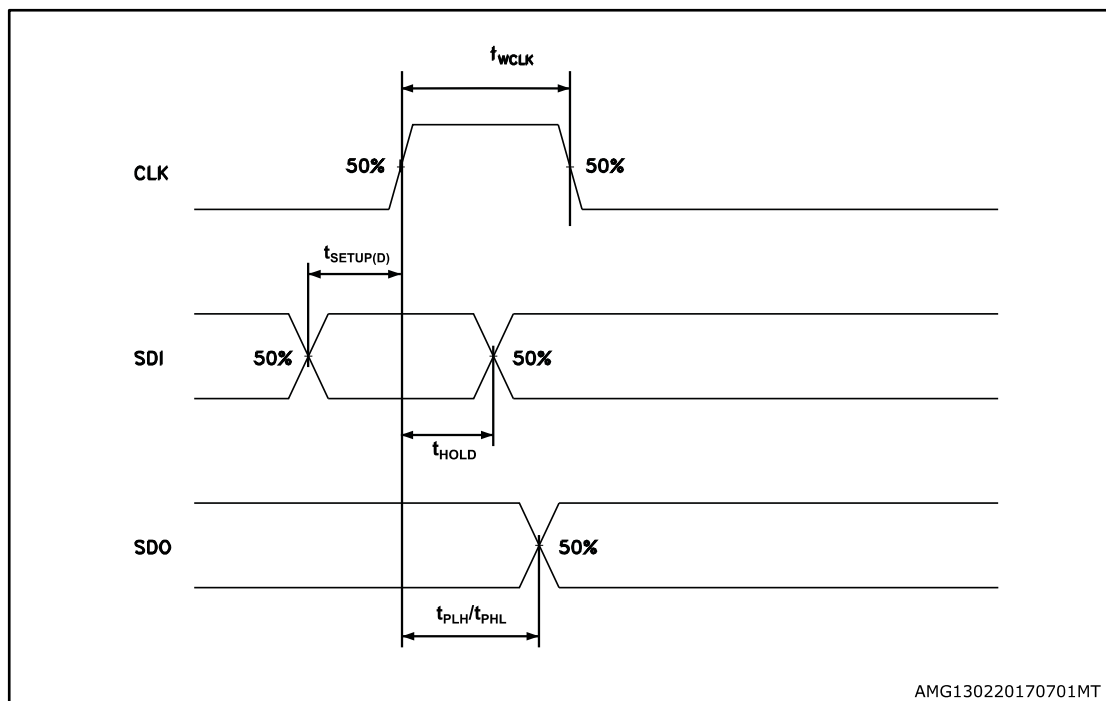


Figure 9: Clock, serial-in, latch, enable, outputs

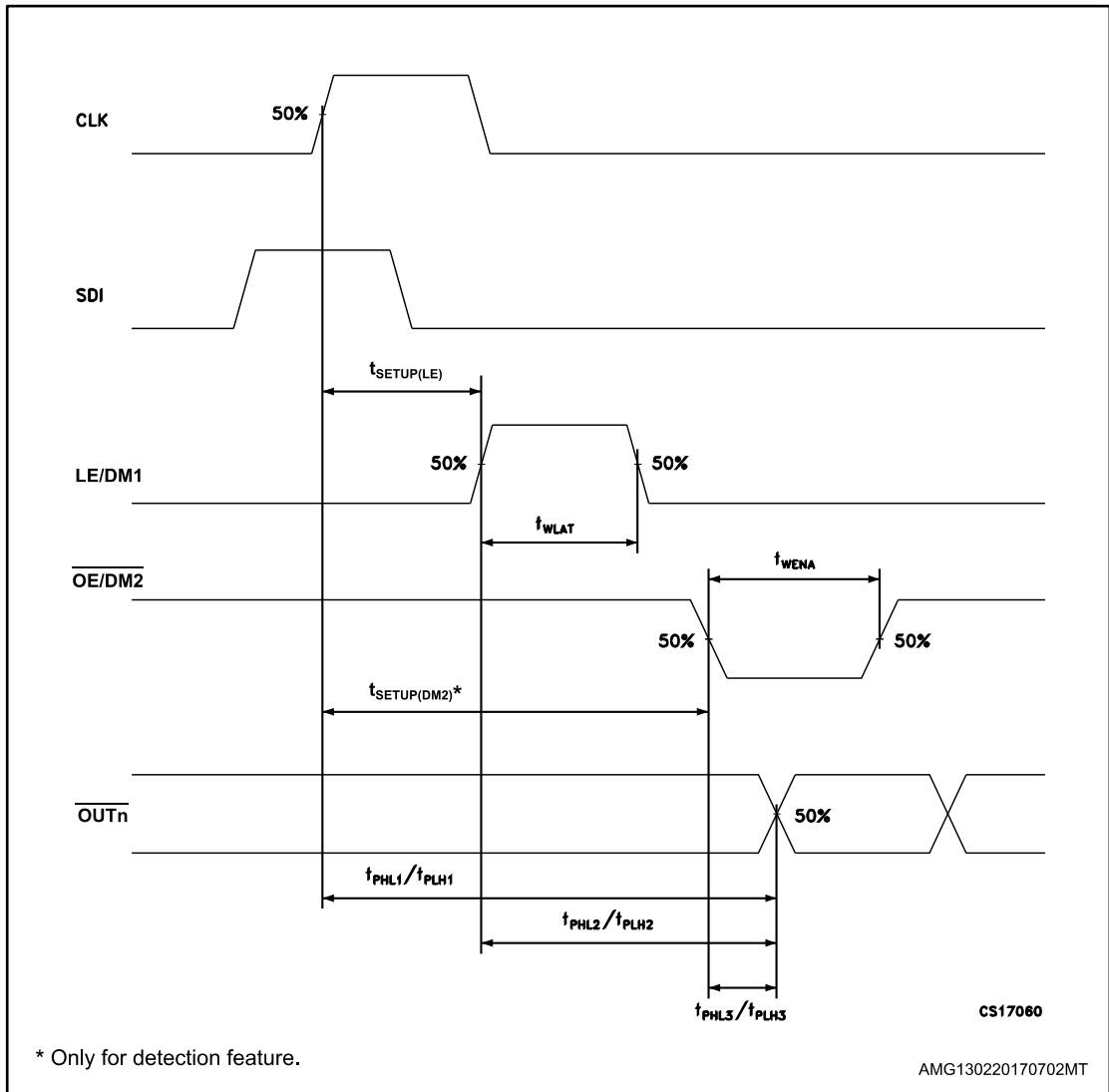
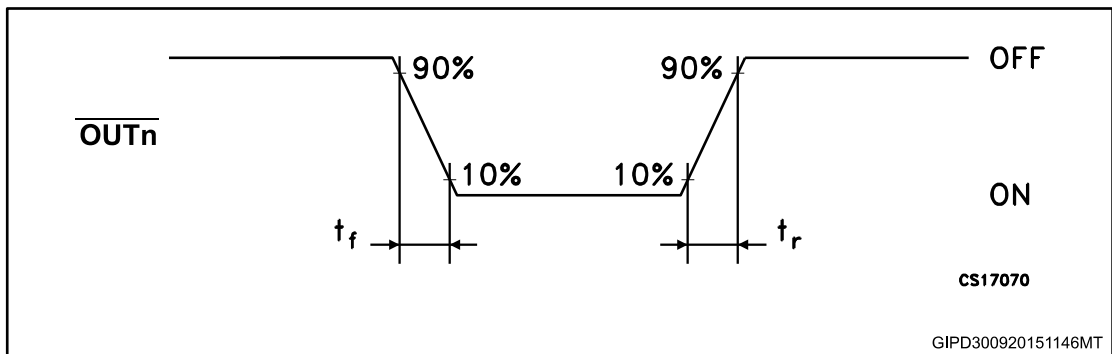


Figure 10: Outputs



## 6 Typical characteristics

Figure 11: Output current vs Rext resistor

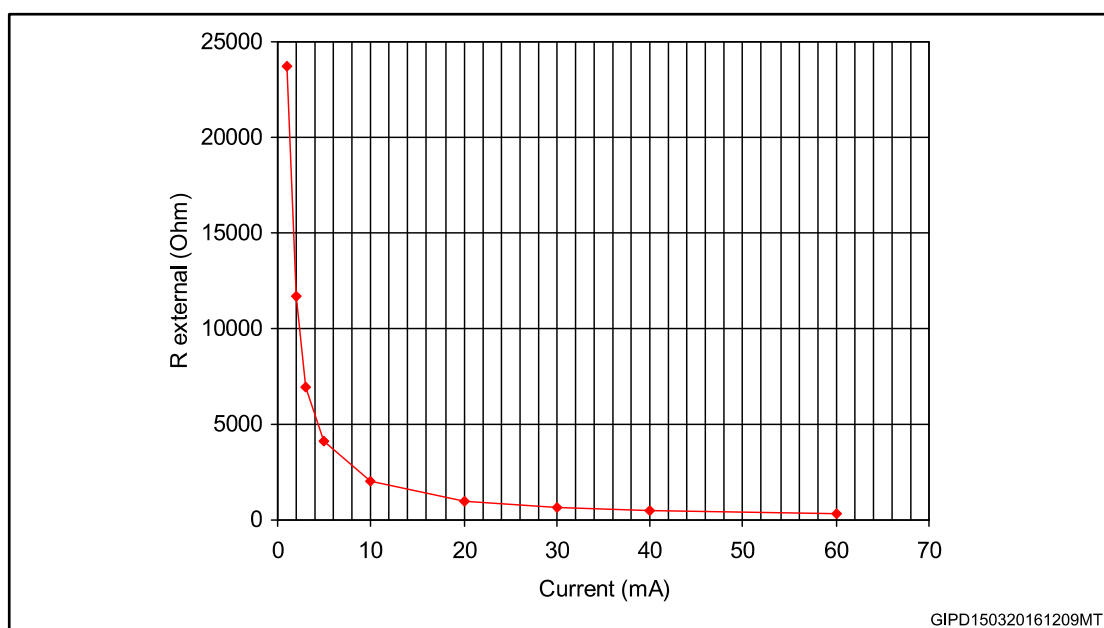


Table 10: Output current vs Rext resistor

Rext (Ω)	Output current (mA)
23700	1
11730	2
6930	3
4090	5
2025	10
1000	20
667	30
497	40
331	60

Figure 12: Output current vs  $\pm \Delta I_{OL}(\%)$  (temp. = 25 °C,  $V_{dd} = 5 V$ , pin = all outputs)

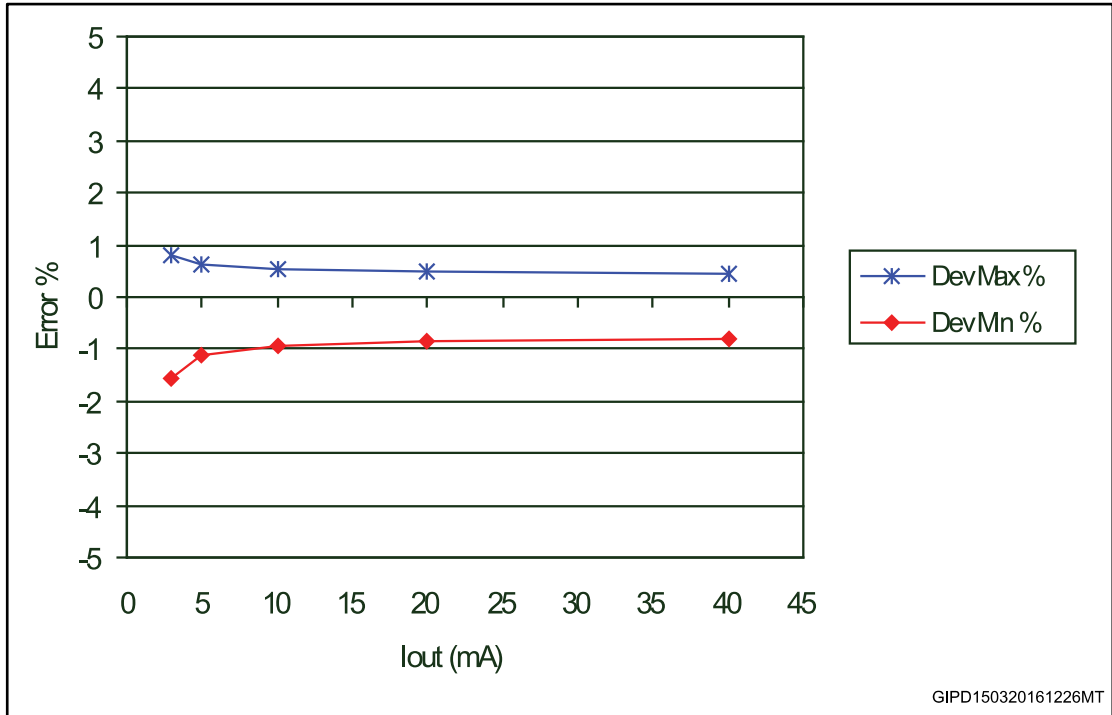


Figure 13:  $I_{SET}$  vs drop out voltage ( $V_{drop}$ )

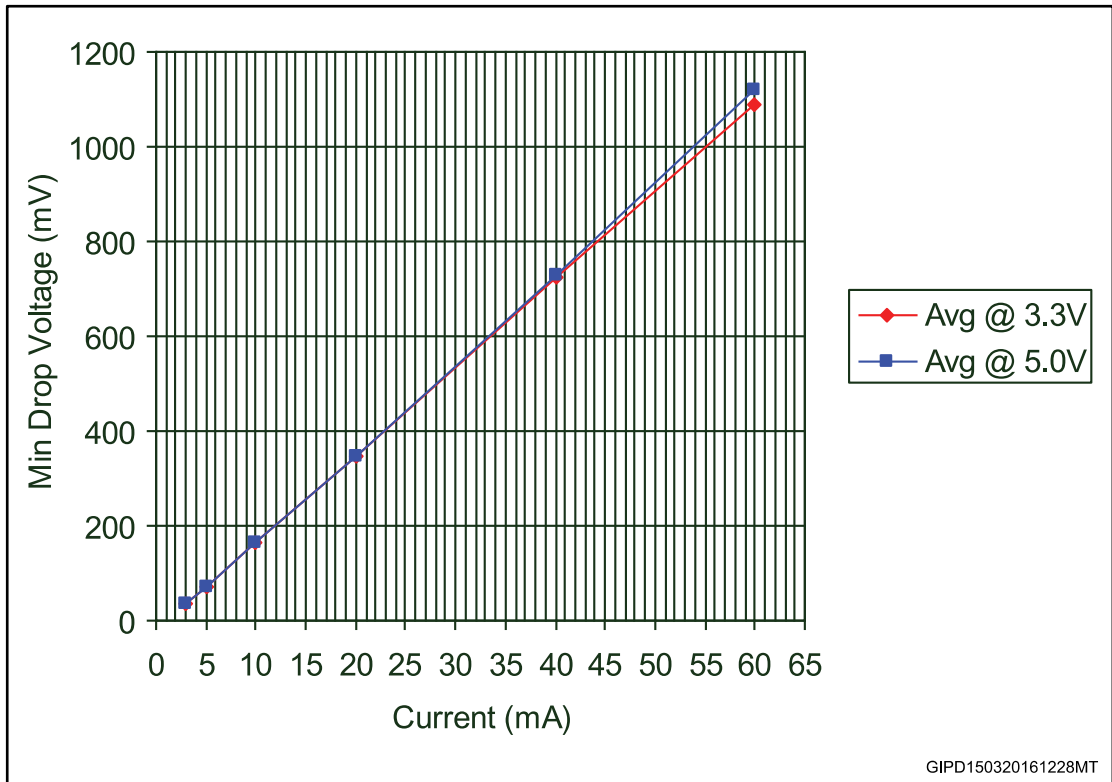


Table 11: I<sub>SET</sub> vs drop out voltage (V<sub>drop</sub>)

Vdd (V)	Iset (mA)	Min (mV)	Max (mV)	Avg (mV)	Vdd (V)	Iset (mA)	Min (mV)	Max (mV)	Avg (mV)
3.3	3	35	37	36	5.0	3	37	37	37
	5	71	72	71		5	72	73	72
	10	162	165	163		10	162	164	163
	20	347	348	347		20	345	347	346
	40	724	724	724		40	725	728	726
	60	1080	1090	1080		60	1090	1140	1110



# 7 Tast circuits

Figure 14: DC characteristic

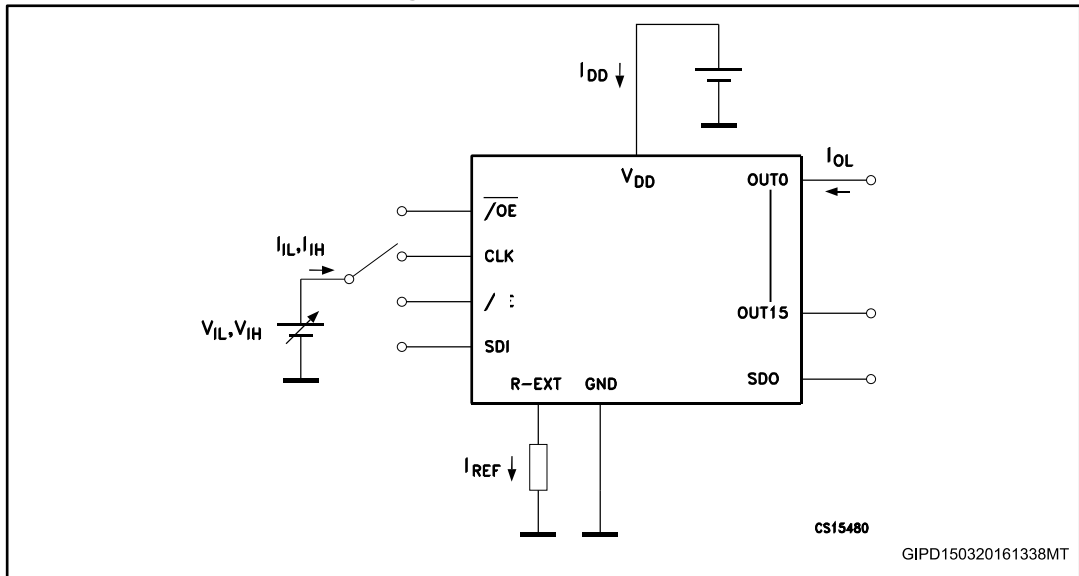


Figure 15: AC characteristic

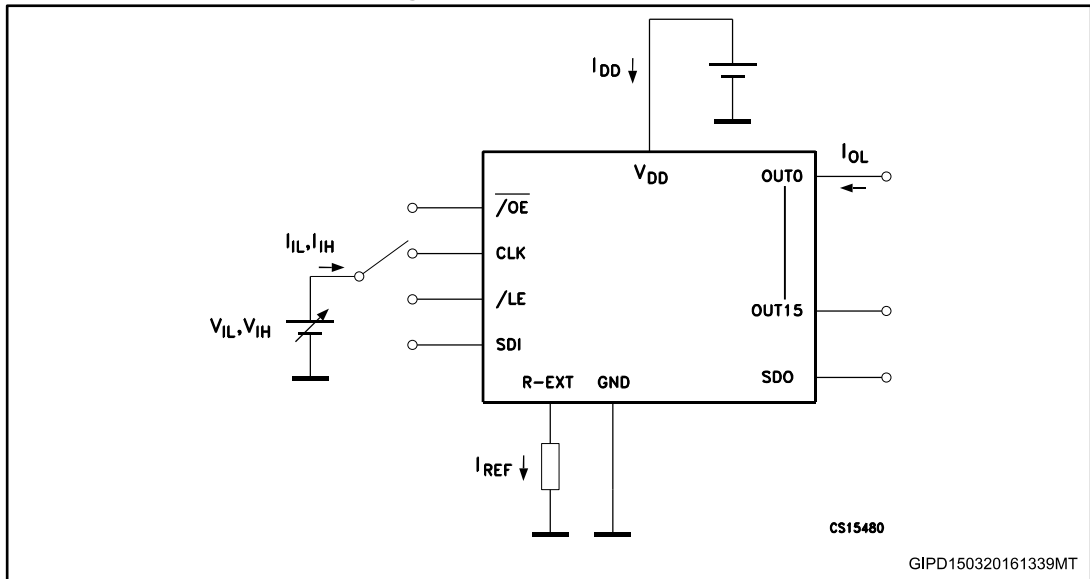
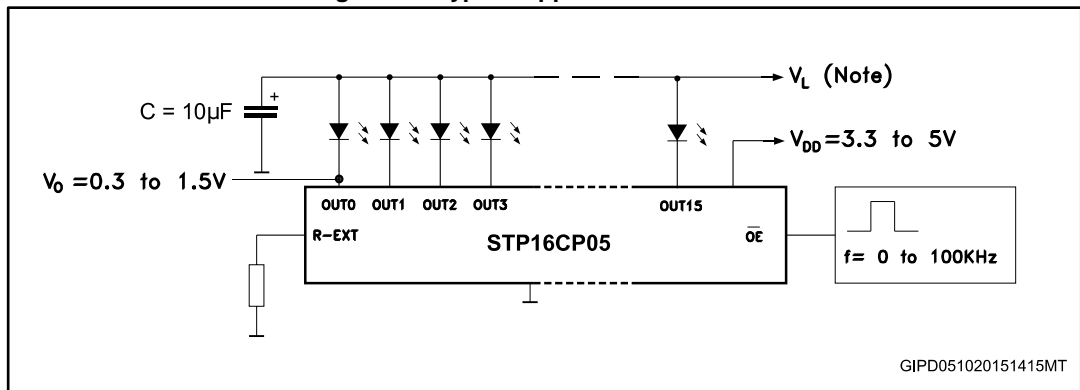


Figure 16: Typical application schematic



V<sub>L</sub> will be determined by the V<sub>F</sub> of the LEDs.

Test condition:

Temp. = 25 °C, V<sub>DD</sub> = 3.3 V, V<sub>IN</sub> = V<sub>DD</sub>, C<sub>L</sub> = 10 pF, Freq. = 1 MHz, Ch1 = CLK, Ch2 = SDI, Ch3 = OUT<sub>n</sub>, Ch4 = V<sub>OUT</sub>

Figure 17: Turn ON output current setup

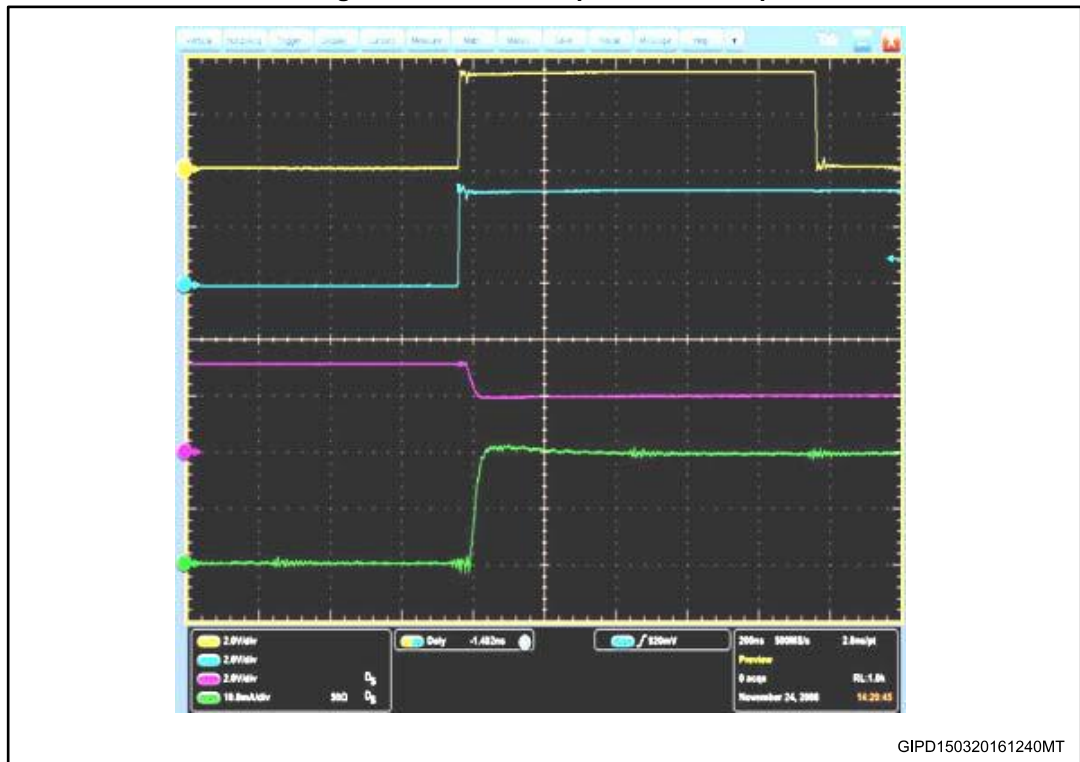
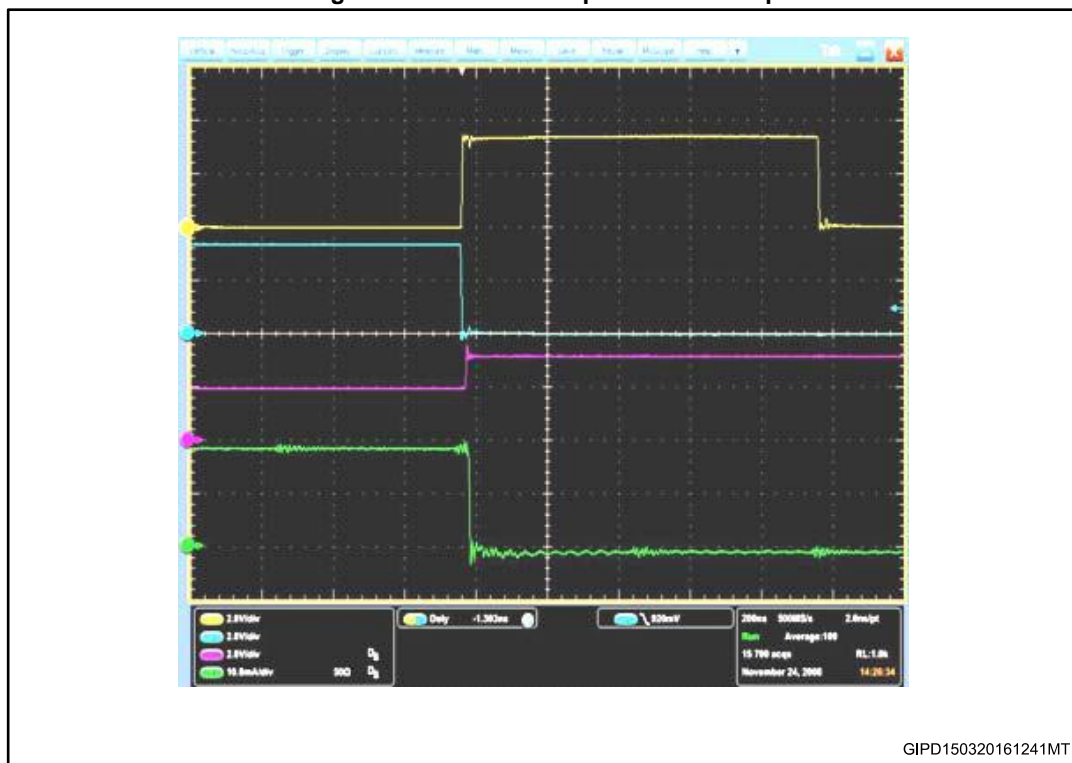


Figure 18: Turn OFF output current setup



GIPD150320161241MT

## 8 Package information

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](http://www.st.com). ECOPACK® is an ST trademark.

### 8.1 QSOP-24 package information

Figure 19: QSOP-24 package outline

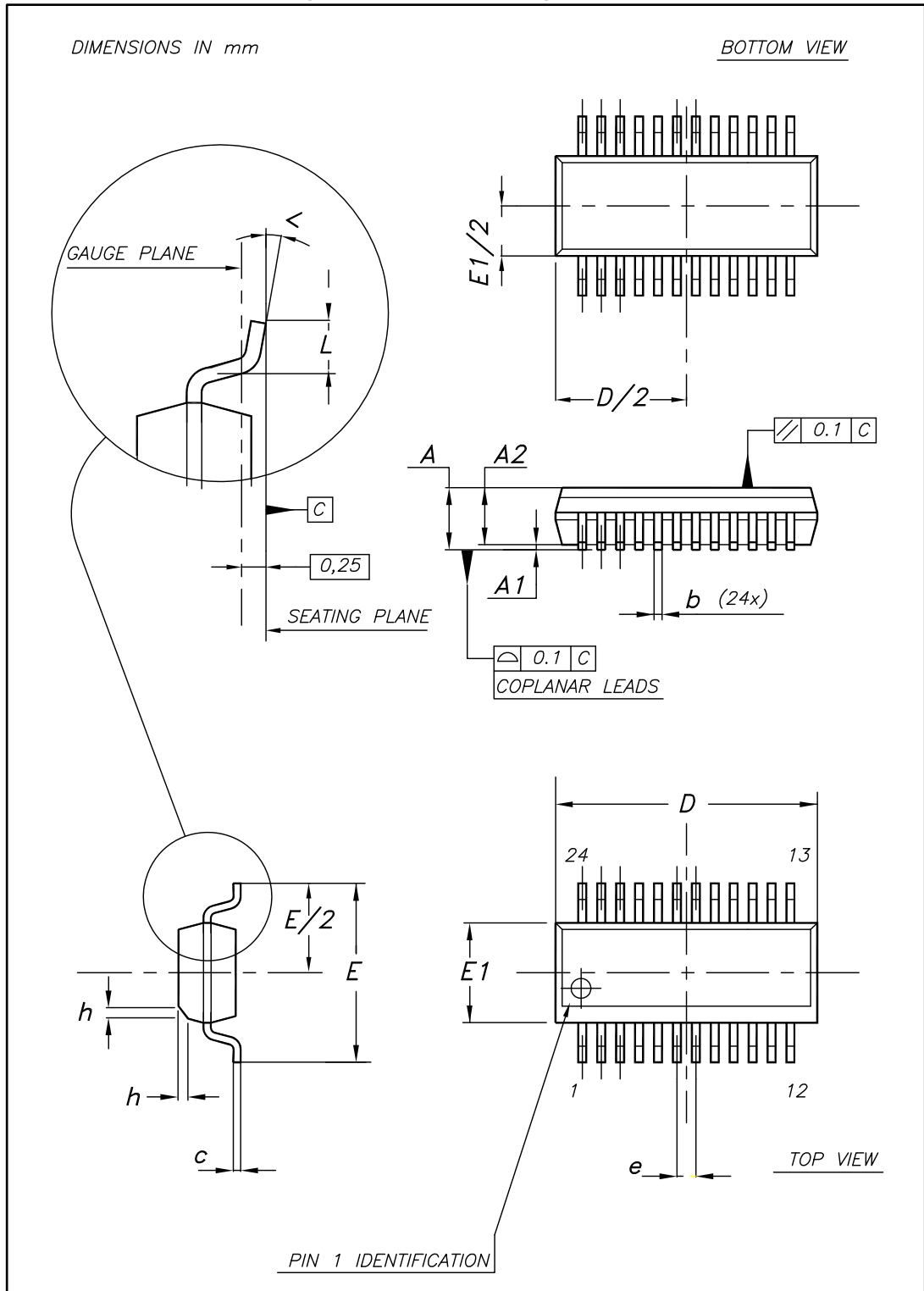


Table 12: QSOP-24 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	1.54	1.62	1.73
A1	0.10	0.15	0.25
A2		1.47	
b	0.20		0.31
c	0.17		0.254
D	8.56	8.66	8.76
E	5.80	6.00	6.20
E1	3.80	3.91	4.01
e		0.635	
L	0.40	0.635	0.89
h	0.25	0.33	0.41
<	0°		8°

### 8.2 SO-24 package information

Figure 20: SO-24 package outline

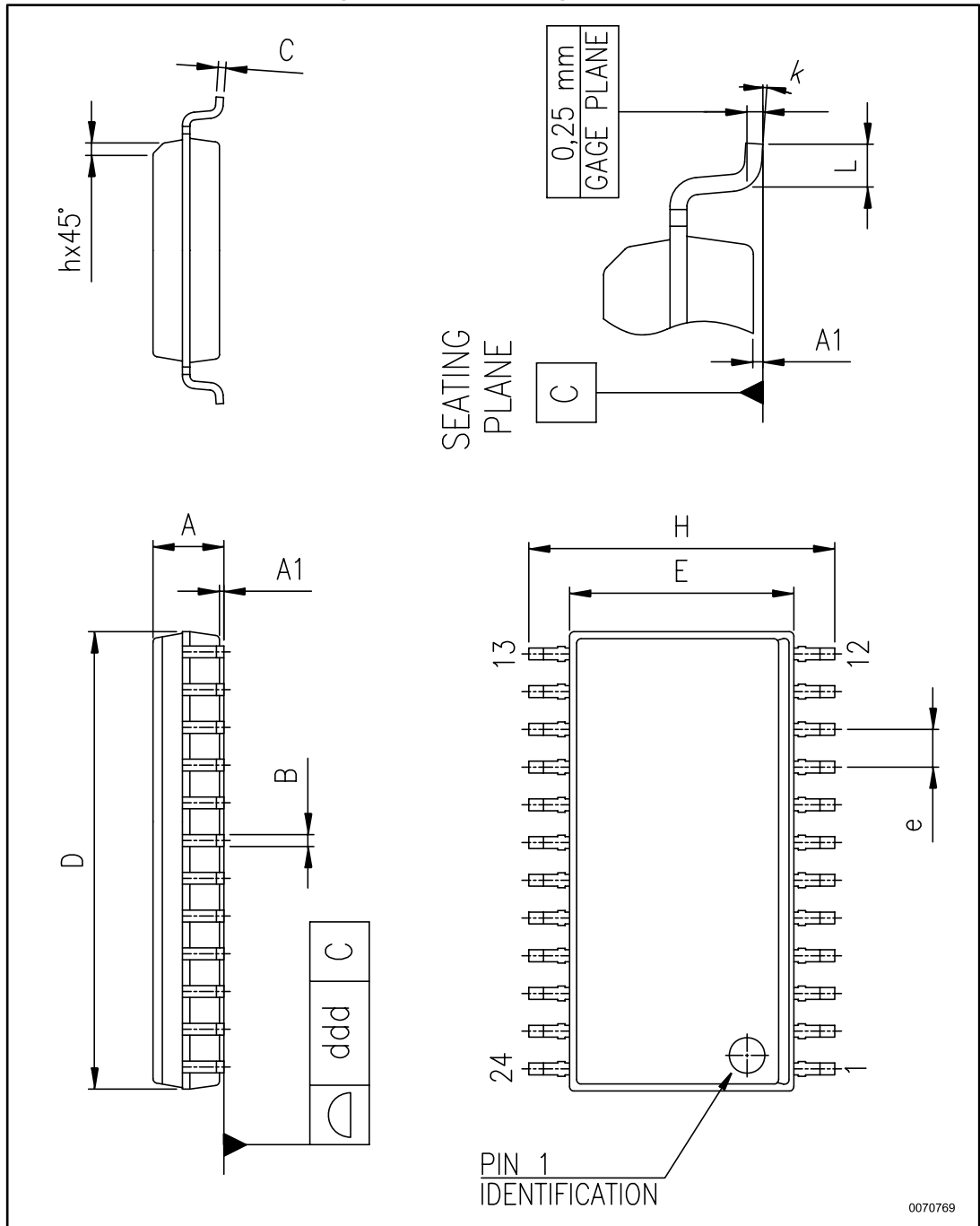


Table 13: SO-24 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	2.35		2.65
A1	0.10		0.30
B	0.33		0.51
C	0.23		0.32
D	15.20		15.60
E	7.40		7.60
e		1.27	
H	10.00		10.65
h	0.25		0.75
L	0.40		1.27
k	0		8
ddd			0.10

### 8.3 TSSOP24 package information

Figure 21: TSSOP24 package outline

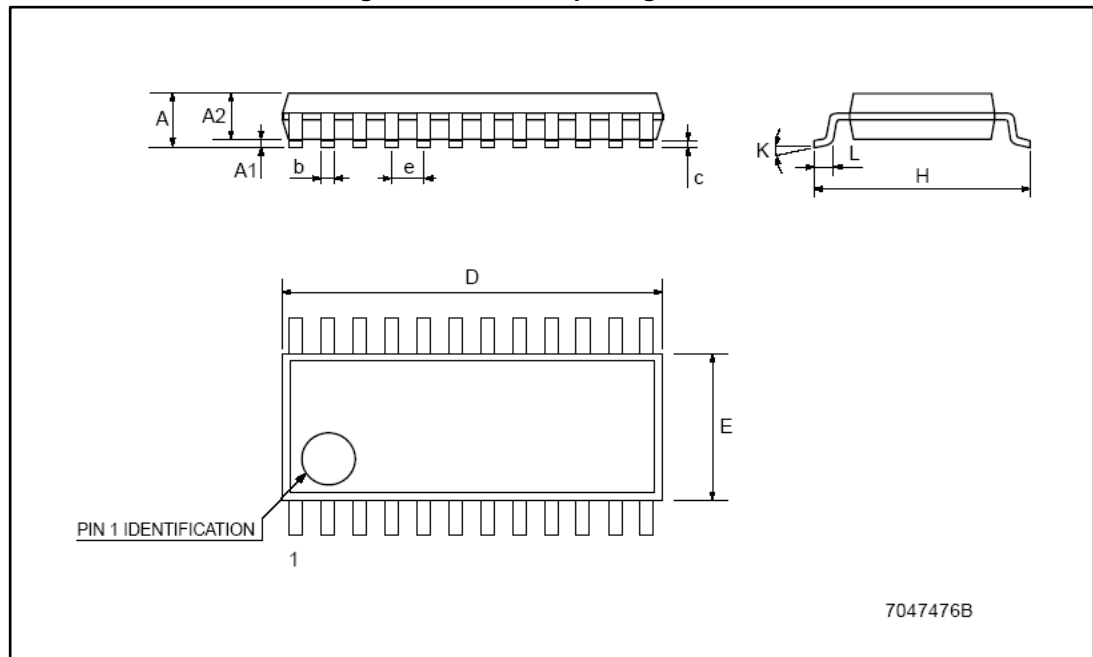




Table 14: TSSOP24 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			1.1
A1	0.05		0.15
A2		0.9	
b	0.19		0.30
c	0.09		0.20
D	7.7		7.9
E	4.3		4.5
e		0.65 BSC	
H	6.25		6.5
K	0°		8°
L	0.50		0.70

### 8.4 TSSOP24 exposed pad package information

Figure 22: TSSOP24 exposed pad package outline

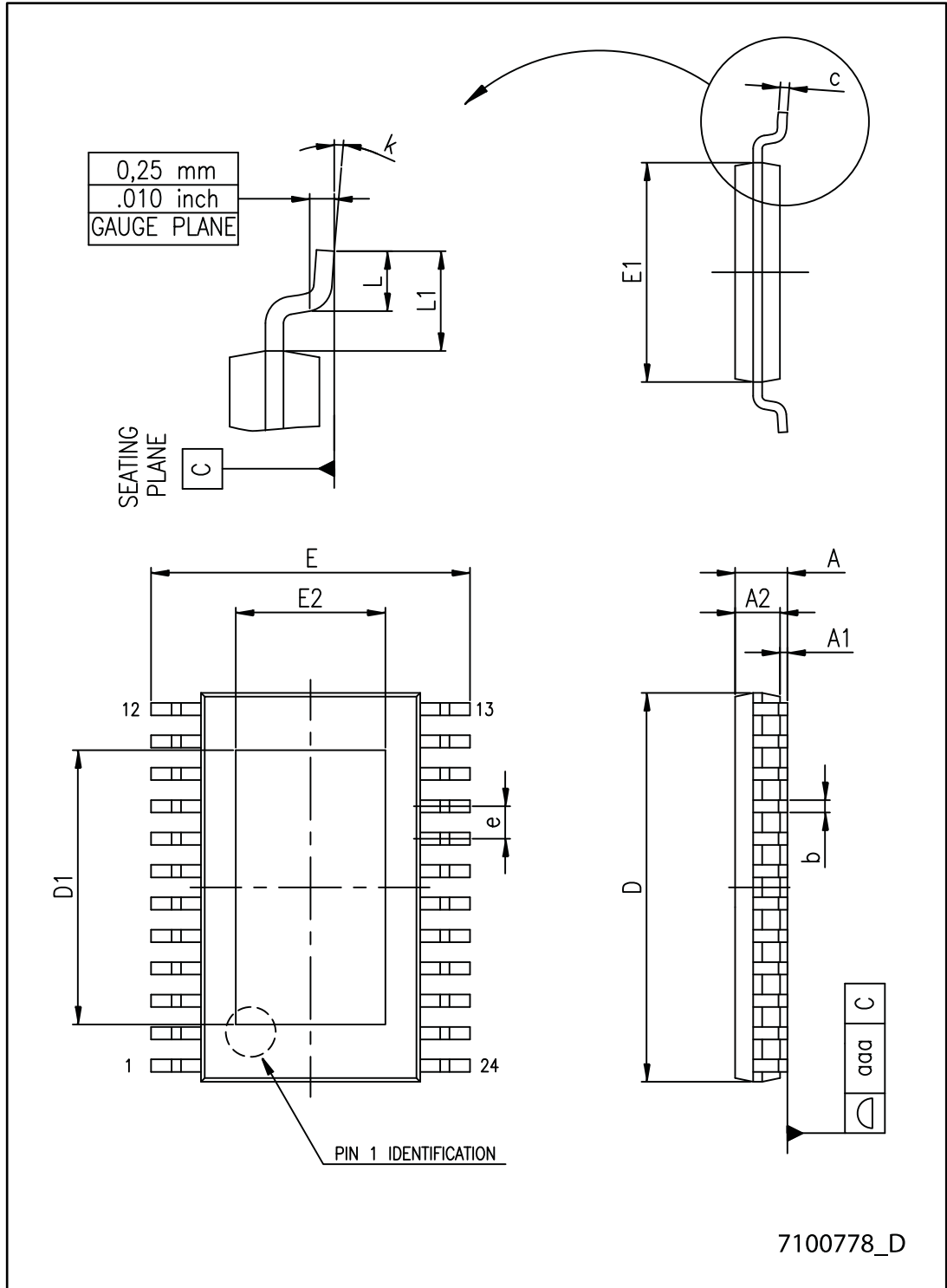


Table 15: TSSOP24 exposed pad mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			1.20
A1			0.15
A2	0.80	1.00	1.05
b	0.19		0.30
c	0.09		0.20
D	7.70	7.80	7.90
D1	4.80	5.00	5.2
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
E2	3.00	3.20	3.40
e		0.65	
L	0.45	060	075
L1		1.00	
k	0°		8°
aaa			0.10

### 8.5 TSSOP24, TSSOP24 exposed pad and SO-24 packing information

Figure 23: TSSOP24, TSSOP24 exposed pad and SO-24 reel outline

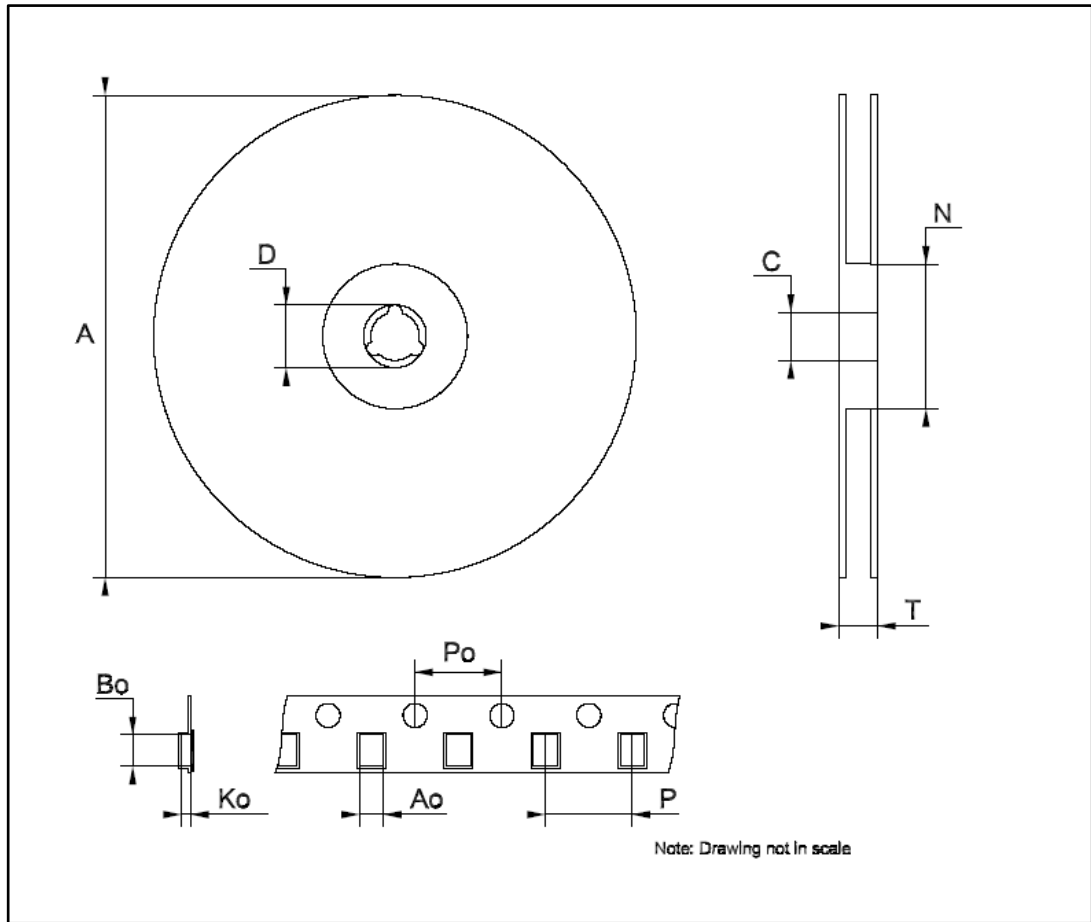


Table 16: TSSOP24 and TSSOP24 exposed pad tape and reel mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A		-	330
C	12.8	-	13.2
D	20.2	-	
N	60	-	
T		-	22.4
Ao	6.8	-	7
Bo	8.2	-	8.4
Ko	1.7	-	1.9
Po	3.9	-	4.1
P	11.9	-	12.1

Table 17: SO-24 tape and reel mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A		-	330
C	12.8	-	13.2
D	20.2	-	
N	60	-	
T		-	30.4
Ao	10.8	-	11.0
Bo	15.7	-	15.9
Ko	2.9	-	3.1
Po	3.9	-	4.1
P	11.9	-	12.1

## 9 Revision history

**Table 18: Document revision history**

Date	Revision	Changes
11-Feb-2009	1	First release
22-Oct-2009	2	Updated Figure 11 on page 14 and Figure 10 on page 14.
10-Jun-2014	3	Updated <i>Section 8: Package mechanical data</i> . Added <i>Section 9: Packaging mechanical data</i> . Minor text changes.
08-Apr-2016	4	Updated <i>Section 8.1: "QSOP-24 package information"</i> . Minor text changes.
09-Mar-2017	5	Updated <i>Figure 5: "SDO terminal"</i> , <i>Figure 8: "Clock, serial-in, serial-out"</i> and <i>Figure 9: "Clock, serial-in, latch, enable, outputs"</i> . Minor text changes.

**IMPORTANT NOTICE – PLEASE READ CAREFULLY**

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