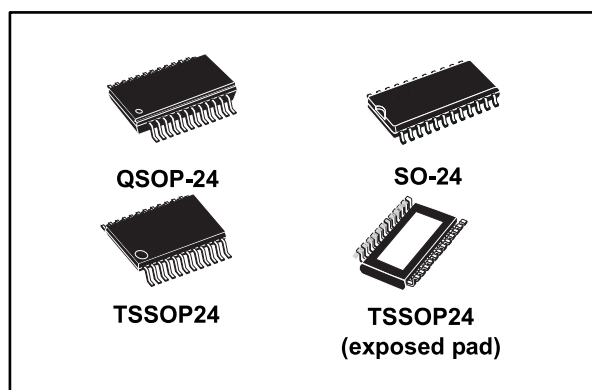


## Low voltage 16-bit constant current LED sink driver

Datasheet - production data



### Description

The STP16CP05 is a monolithic, low voltage, low current power 16-bit shift register designed for LED panel displays. The STP16CP05 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 5 mA to 100 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 STP16CP05 output current.

The STP16CP05 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

- Low voltage power supply down to 3 V
- 16 constant current output channels
- Adjustable output current through external resistor
- Serial data IN/parallel data OUT
- Can be driven by a 3.3 V microcontroller
- Output current: 5 to 100 mA
- Max clock frequency 30 MHz
- ESD protection: 2 kV HBM, 200 V MM

Table 1: Device summary

| Order code    | Package             | Packing             |
|---------------|---------------------|---------------------|
| STP16CP05MTR  | SO-24               | 1000 parts per reel |
| STP16CP05TTR  | TSSOP24             | 2500 parts per reel |
| STP16CP05XTTR | TSSOP24 exposed pad | 2500 parts per reel |
| STP16CP05PTR  | QSOP-24             | 2500 parts per reel |

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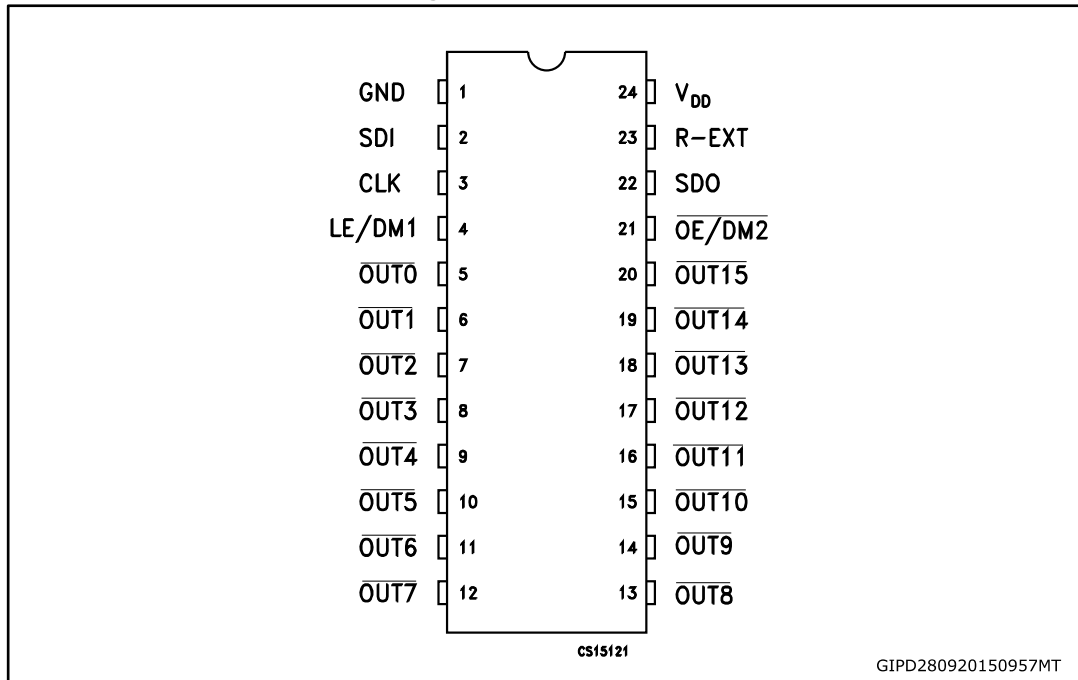
# 1 Summary description

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 %       | 20 to 100 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/DM1                     | Latch input terminal   |
| 5-20   | OUT 0-15                   | Output terminal  |
| 21     | $\overline{\text{OE/DM2}}$ | 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 ratings 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 condition 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             | 100                     | mA   |
| V <sub>I</sub>   | Input voltage              | -0.4 to V <sub>DD</sub> | V    |
| I <sub>GND</sub> | GND terminal current       | 1600                    | mA   |
| f <sub>CLK</sub> | Clock frequency            | 50                      | MHz  |
| T <sub>J</sub>   | Junction temperature range | -40 to +170             | °C   |

### 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 <sup>(1)</sup> | SO-24                                 | 42.7 | °C/W |
|                   |  | TSSOP24                               | 55   | °C/W |
|                   |  | TSSOP24 <sup>(2)</sup><br>exposed pad | 37.5 | °C/W |
|                   |  | QSOP-24                               | 55   | °C/W |

**Notes:**

<sup>(1)</sup> According with JEDEC standard 51-7.

<sup>(2)</sup> The exposed pad should be soldered directly to the PCB to realize the thermal benefits.

## 2.3 Recommended operating conditions

@  $T_A = 25\text{ °C}$

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                                    | 3   | -    | 100          | mA   |
| $I_{OH}$       | Output current                  | SERIAL-OUT                              |   | -    | +1           | mA   |
| $I_{OL}$       | Output current                  | SERIAL-OUT                              |   | -    | -1           | mA   |
| $V_{IH}$       | Input voltage                   |   | $0.7 V_{DD}$  | -    | $V_{DD}$     | V    |
| $V_{IL}$       | Input voltage                   |   | -0.3  | -    | $0.3 V_{DD}$ | 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   |
| $t_{wEN}$      | $\overline{OE/DM2}$ pulse width |   | 100   | -    |              | ns   |
| $t_{SETUP(D)}$ | Setup time for DATA             |   | 5   | -    |              | ns   |
| $t_{HOLD(D)}$  | Hold time for DATA              |   | 3   | -    |              | ns   |
| $t_{SETUP(L)}$ | Setup time for LATCH            |   | 18  | -    |              | ns   |
| $f_{CLK}$      | Clock frequency                 |   | Cascade operation <sup>(1)</sup><br>$V_{DD} = 5\text{ V}$ |      | -            | 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                           | $V_{OH} = 20 \text{ V}$                                 |                      |           | 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                                   | $V_O = 0.3 \text{ V}$ , $R_{ext} = 4.2 \text{ k}\Omega$ | 4.25                 | 5         | 5.75         | mA               |
| $I_{OL2}$        |  | $V_O = 0.3 \text{ V}$ , $R_{ext} = 1 \text{ k}\Omega$   | 19                   | 20        | 21           |                  |
| $I_{OL3}$        |  | $V_O = 1.3 \text{ V}$ , $R_{ext} = 200 \Omega$          | 96                   | 100       | 104          |                  |
| $\Delta I_{OL1}$ | Output current error between bit (all output ON) | $V_O = 0.3 \text{ V}$ , $R_{ext} = 4.2 \text{ k}\Omega$ |                      | $\pm 5$   | $\pm 8$      |                  |
| $\Delta I_{OL2}$ |  | $V_O = 0.3 \text{ V}$ , $R_{ext} = 1 \text{ k}\Omega$   |                      | $\pm 1.5$ | $\pm 3$      | %                |
| $\Delta I_{OL3}$ |  | $V_O = 1.3 \text{ V}$ , $R_{ext} = 200 \Omega$          |                      | $\pm 1.2$ | $\pm 3$      |                  |
| $R_{SIN(up)}$    | 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)                             | $R_{ext} = 1 \text{ k}\Omega$ , OUT 0 to 15 = OFF       |                      | 4         |              | mA               |
| $I_{DD(OFF2)}$   |  | $R_{ext} = 250 \Omega$ , OUT 0 to 15 = OFF              |                      | 11.2      |              |                  |
| $I_{DD(ON1)}$    | Supply current (ON)                              | $R_{ext} = 1 \text{ k}\Omega$ , OUT 0 to 15 = ON        |                      | 4.5       |              |                  |
| $I_{DD(ON2)}$    |  | $R_{ext} = 250 \Omega$ , OUT 0 to 15 = ON               |                      | 11.7      |              |                  |
| 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,<br>CLK- $\overline{\text{OUTn}}$ , LE/DM1 = H,<br>$\overline{\text{OE/DM2}} = \text{L}$ |   | $V_{DD} = 3.3\text{ V}$ | -    | 45   | 74   |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 24   | 38   | ns |
| $t_{PLH2}$ | Propagation delay time,<br>LE/DM1- $\overline{\text{OUTn}}$ ,<br>$\overline{\text{OE/DM2}} = \text{L}$          |   | $V_{DD} = 3.3\text{ V}$ | -    | 48   | 77   |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 27   | 46   | ns |
| $t_{PLH3}$ | Propagation delay time,<br>$\overline{\text{OE/DM2}} - \overline{\text{OUTn}}$ ,<br>LE/DM1 = H                  |   | $V_{DD} = 3.3\text{ V}$ | -    | 75   | 128  |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 43   | 64   | ns |
| $t_{PLH}$  | Propagation delay time,<br>CLK-SDO  |   | $V_{DD} = 3.3\text{ V}$ | -    | 19   | 28   |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 11   | 16.5 | ns |
| $t_{PHL1}$ | Propagation delay time,<br>CLK- $\overline{\text{OUTn}}$ , LE/DM1 = H,<br>$\overline{\text{OE/DM2}} = \text{L}$ | $V_{IH} = V_{DD}$<br>$V_{IL} = \text{GND}$ $C_L = 10\text{ pF}$<br>$I_O = 20\text{ mA}$ $V_L = 3.0\text{ V}$<br>$R_{ext} = 1\text{ K}\Omega$ $R_L = 60\ \Omega$ | $V_{DD} = 3.3\text{ V}$ | -    | 15   | 23   |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 10   | 14   | ns |
| $t_{PHL2}$ | Propagation delay time,<br>LE/DM1 $\overline{\text{OUTn}}$ ,<br>$\overline{\text{OE/DM2}} = \text{L}$           |   | $V_{DD} = 3.3\text{ V}$ | -    | 13   | 18.5 |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 9    | 12   | ns |
| $t_{PHL3}$ | Propagation delay time,<br>$\overline{\text{OE/DM2}} - \overline{\text{OUTn}}$ ,<br>LE/DM1 = H                  |   | $V_{DD} = 3.3\text{ V}$ | -    | 17   | 24.5 |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 14   | 19.5 | ns |
| $t_{PHL}$  | Propagation delay time,<br>CLK-SDO  |   | $V_{DD} = 3.3\text{ V}$ | -    | 23   | 35   |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 14   | 21   | ns |
| $t_{ON}$   | Output rise time 10~90% of<br>voltage waveform  |   | $V_{DD} = 3.3\text{ V}$ | -    | 35   | 68   |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 21   | 31.5 | ns |
| $t_{OFF}$  | Output fall time 90~10% of<br>voltage waveform  |   | $V_{DD} = 3.3\text{ V}$ | -    | 10.5 | 15   |    |
|            |   |   | $V_{DD} = 5\text{ V}$   | -    | 11   | 15.5 | ns |
| $t_r$      | 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/DM2 terminal

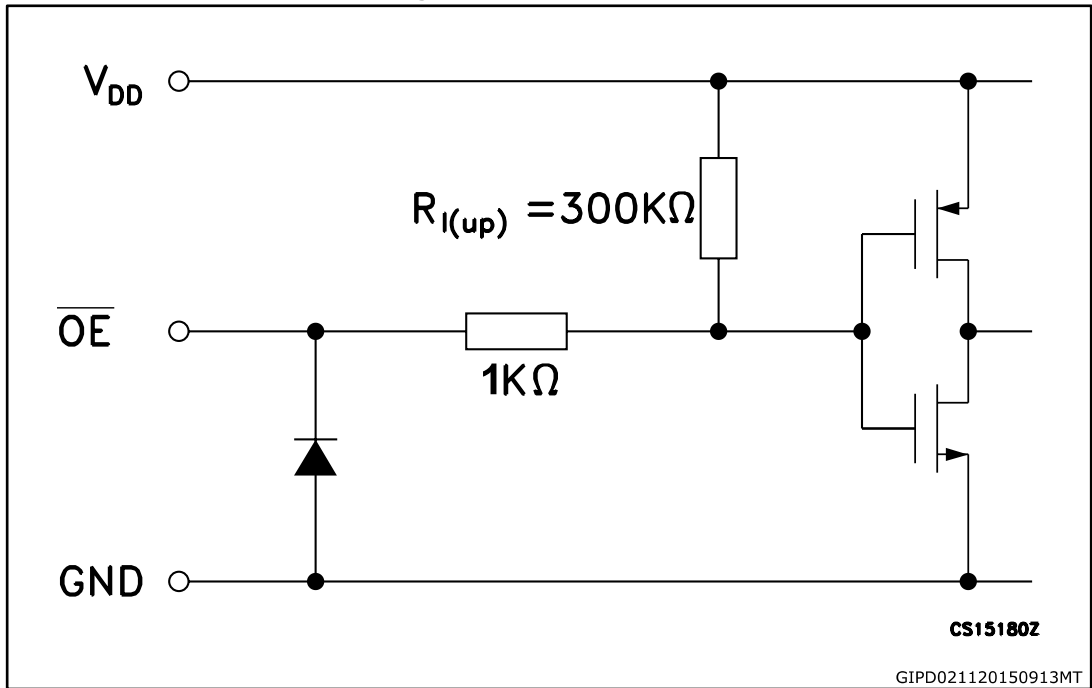


Figure 3: LE/DM1 terminal

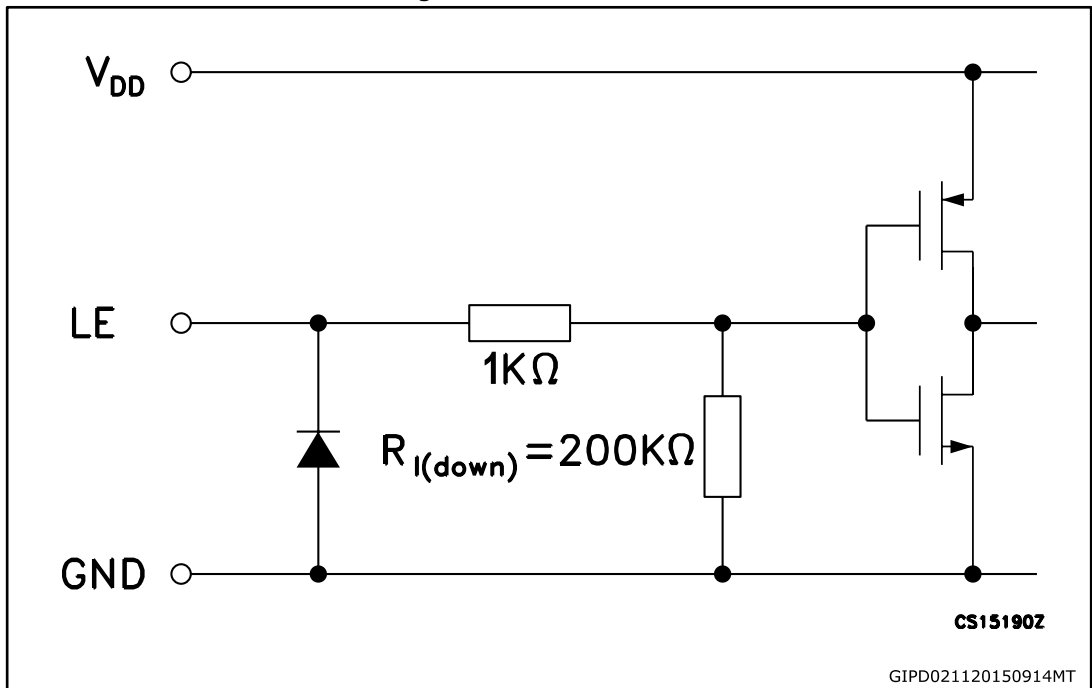




Figure 4: CLK, SDI terminal



Figure 5: SDO terminal

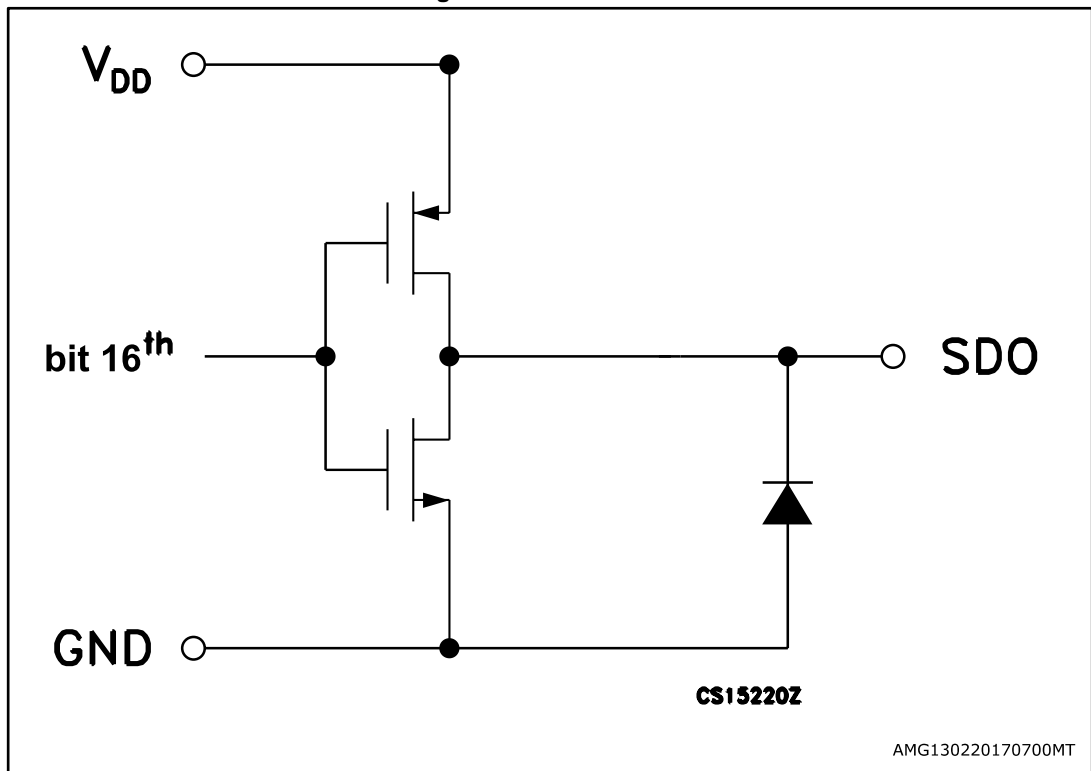


Figure 6: Block diagram



## 5 Timing diagrams

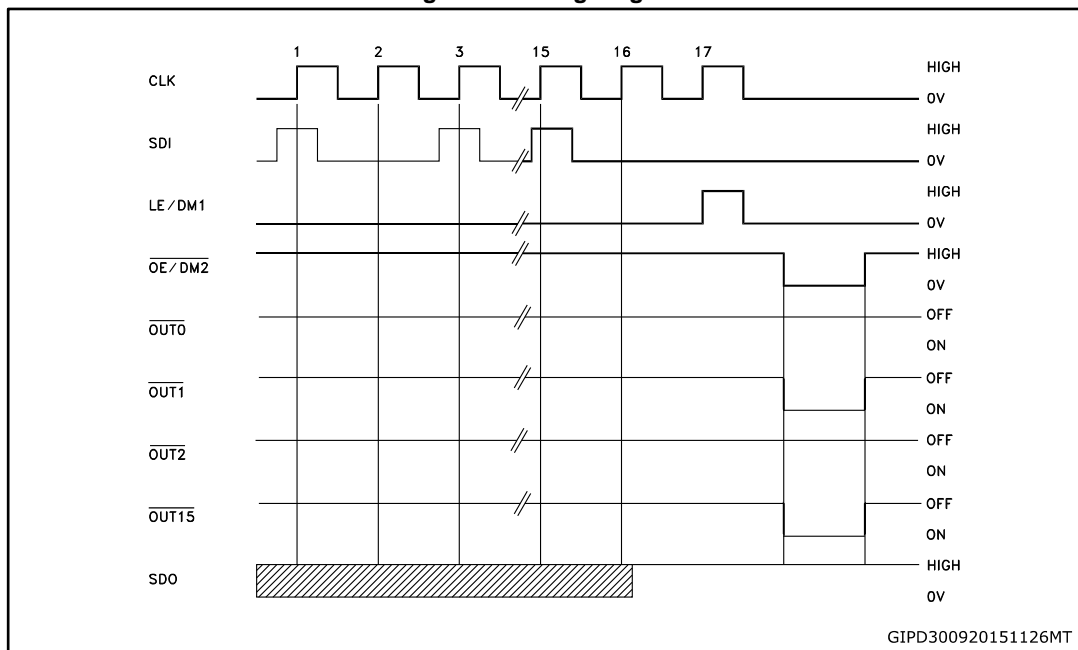
Table 9: Truth table

| CLOCK | LE/DM1 | OE/DM2 | SERIAL-IN | OUT0 ..... OUT7 ..... OUT15      | SDO     |
|-------|--------|--------|-----------|----------------------------------|---------|
| ┌     | H      | L      | Dn        | Dn ..... Dn - 7 ..... Dn -15     | Dn - 15 |
| ┌     | L      | L      | Dn + 1    | No change                        | Dn - 14 |
| ┌     | H      | L      | Dn + 2    | Dn + 2 ..... Dn - 5 ..... Dn -13 | Dn - 13 |
| ┐     | X      | L      | Dn + 3    | Dn + 2 ..... Dn - 5 ..... Dn -13 | Dn - 13 |
| ┐     | X      | H      | Dn + 3    | OFF                              | Dn - 13 |



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

Figure 7: Timing diagram



1 Latch and output enable terminals are level-sensitive and are not synchronized with rising or falling edge of CLK signal.

2 When LE/DM1 terminal is low level, the latch circuit holds previous set of data.

3 When LE/DM1 terminal is high level, the latch circuit refreshes new set of data from SDI chain.

4 When OE/DM2 terminal is at low level, the output terminals Out 0 to Out 15 respond to data in the latch circuits, either '1' for ON or '0' for OFF.

5 When OE/DM2 terminal is at high level, all output terminals are switched OFF.

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

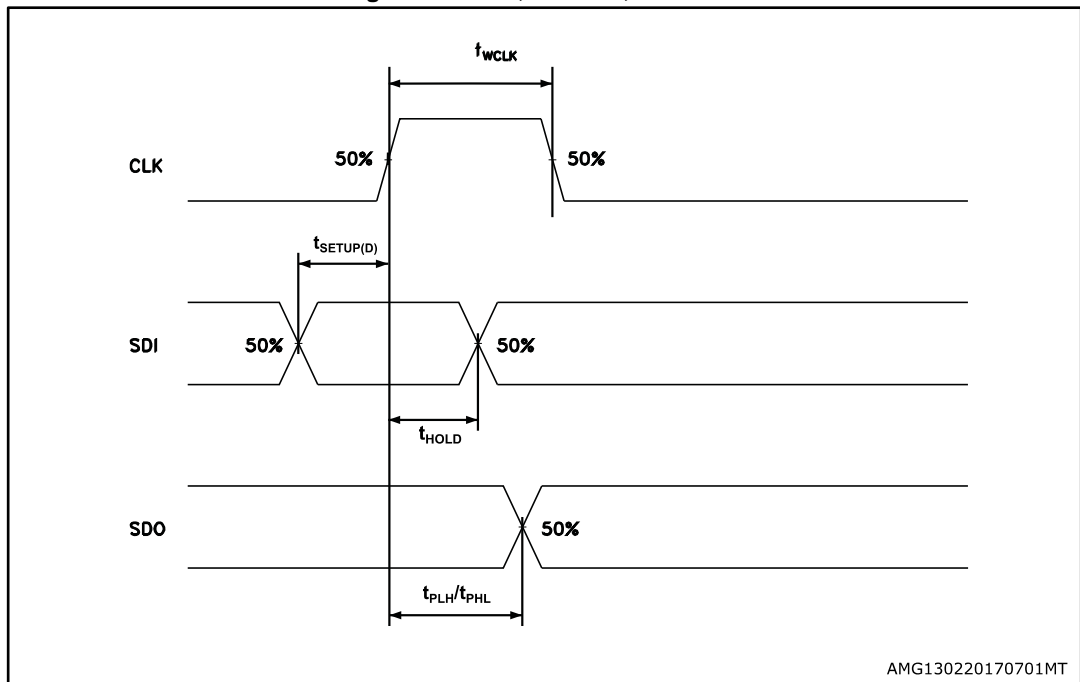


Figure 9: Clock, serial-in, latch, enable, outputs

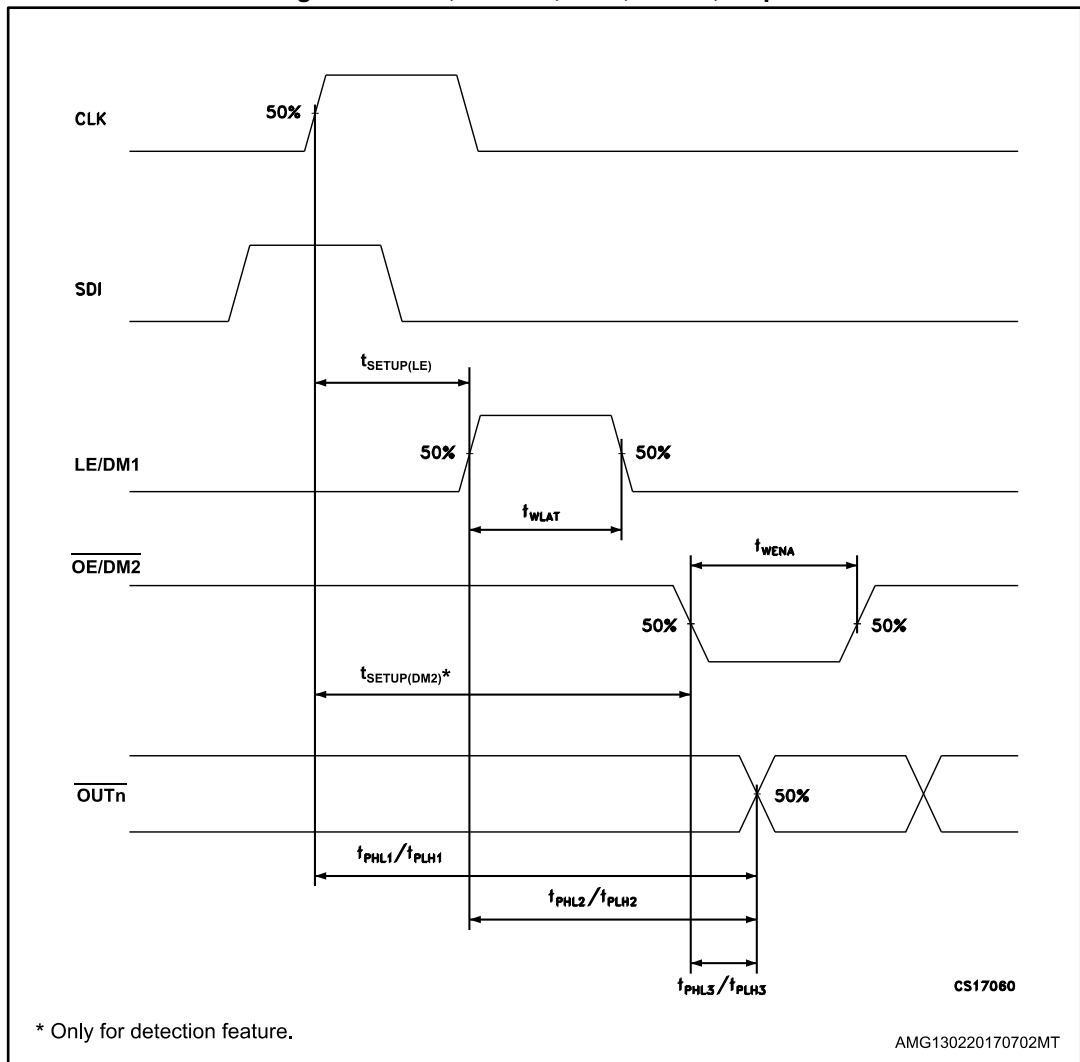
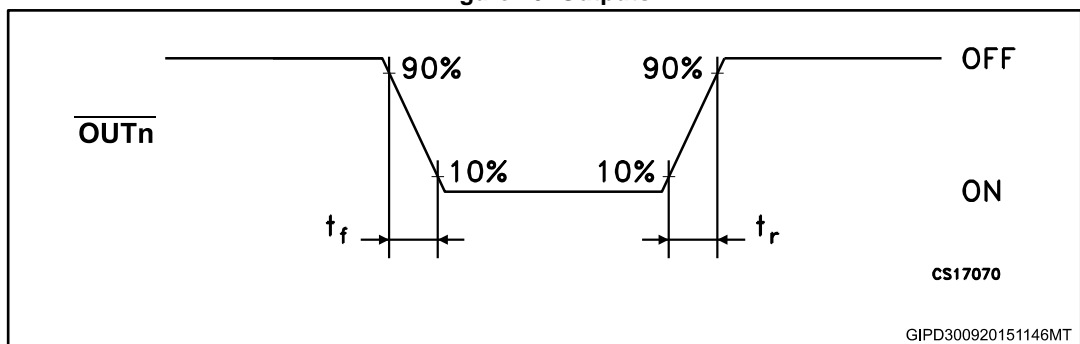


Figure 10: Outputs



## 6 Typical characteristics

Figure 11: Output current-R-EXT resistor

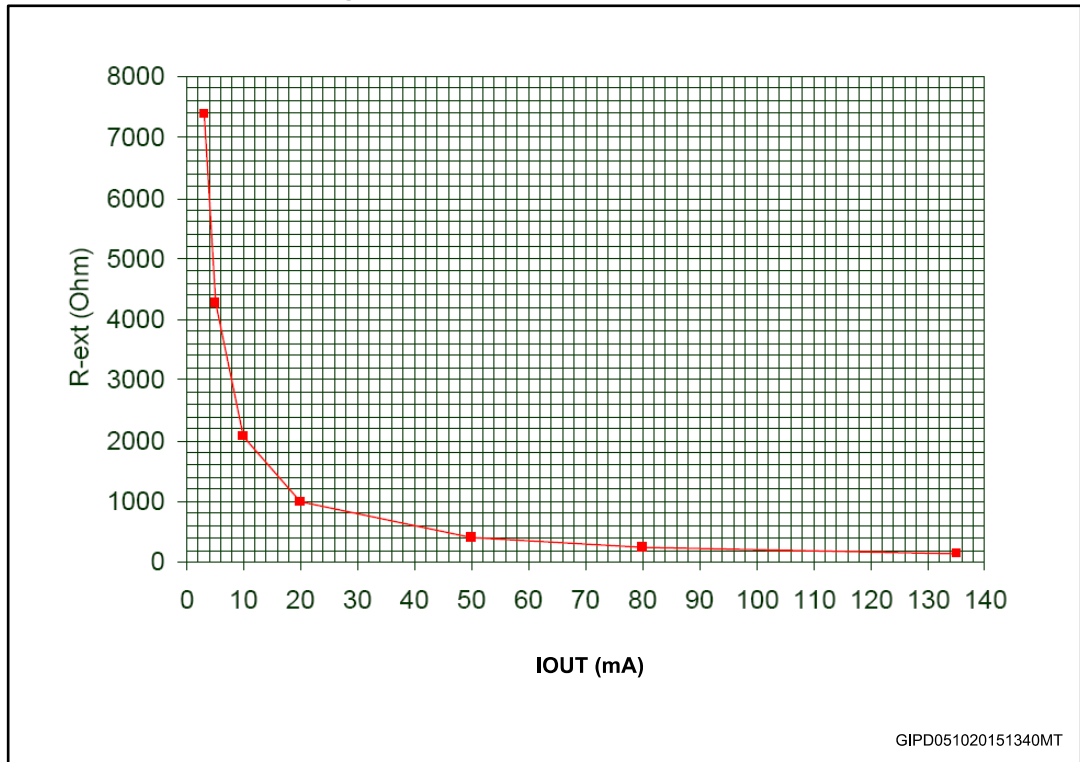


Table 10: Output current-R-EXT resistor

| R-EXT (Ω) | Output current (mA) |
|-----------|---------------------|
| 7370      | 3                   |
| 4270      | 5                   |
| 2056      | 10                  |
| 1006      | 20                  |
| 382       | 50                  |
| 251       | 80                  |
| 200       | 100                 |

Figure 12: Output current vs  $\pm \Delta I_{OL}(\%)$   $T_A = 25^\circ C$



Figure 13: ISET vs drop out voltage ( $V_{drop}$ )  $T_A = 25^\circ C$



Table 11: ISET vs dropout voltage ( $V_{drop}$ )

| Iout (mA) | Avg (mV) @ 3.3 V | Avg (mV) @ 5.0 V |
|-----------|------------------|------------------|
| 3         | 20               | 22               |
| 5         | 37               | 40               |
| 10        | 79               | 79               |
| 20        | 160              | 158              |
| 50        | 422              | 415              |
| 80        | 700              | 690              |
| 100       | 880              | 870              |

Figure 14:  $I_{DD}$  ON/OFF,  $T_A = 25\text{ }^\circ\text{C}$





# 7 Test circuit

Figure 15: DC characteristic

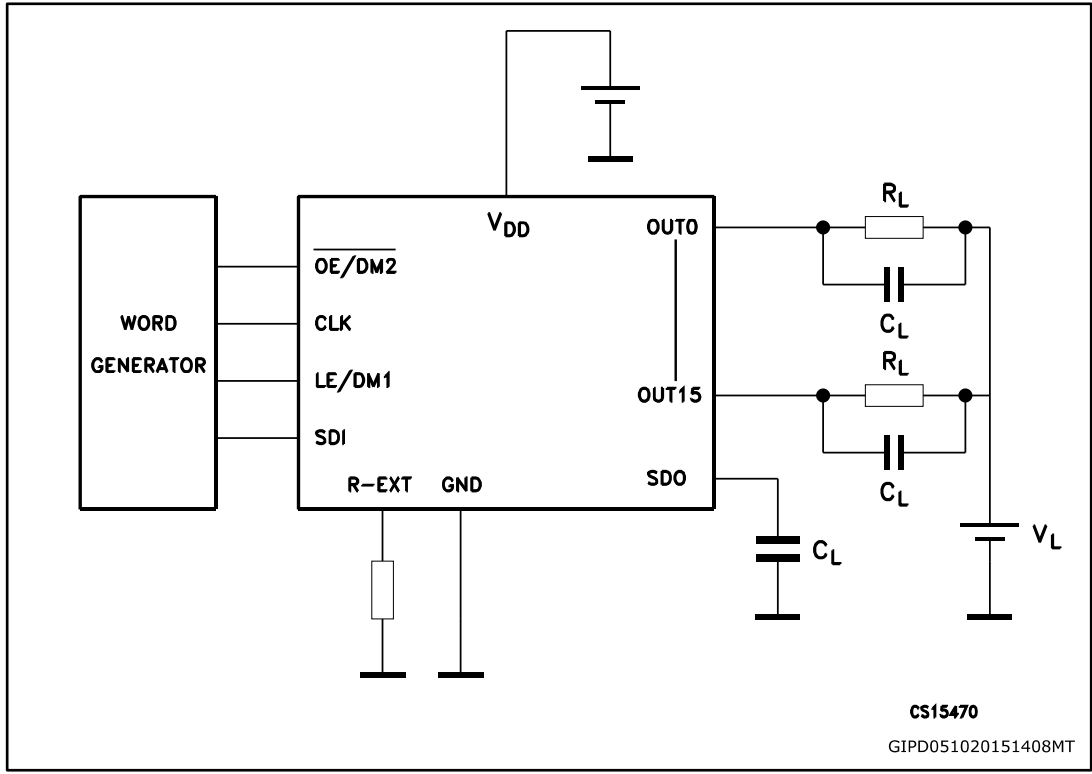


Figure 16: AC characteristic

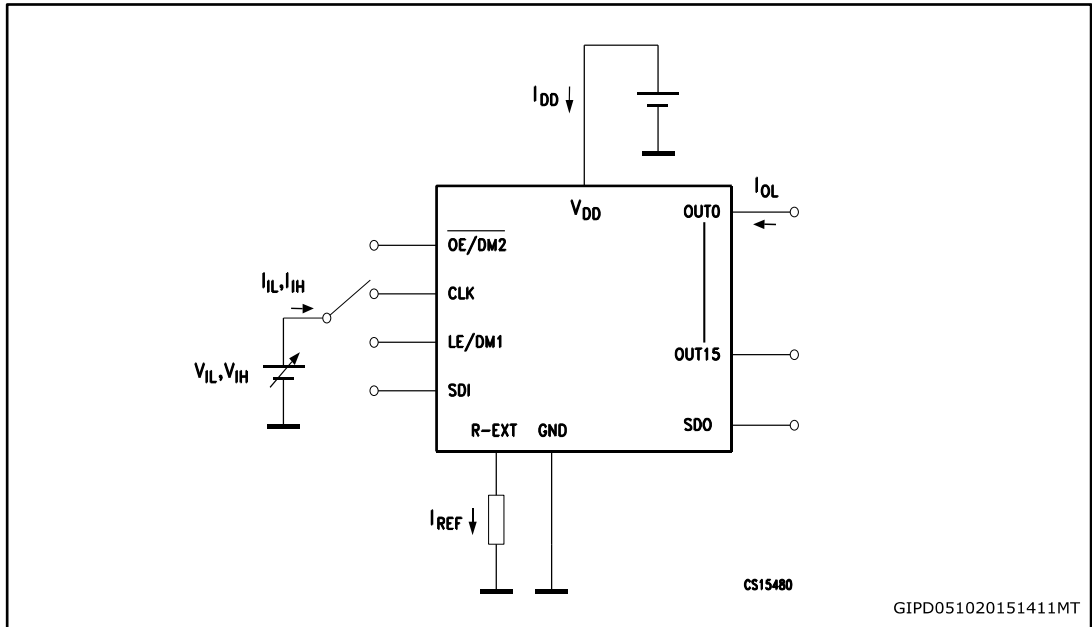
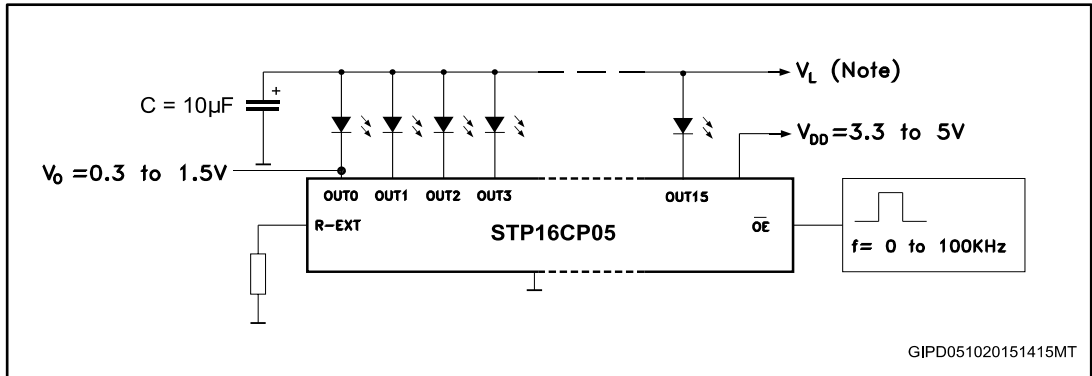


Figure 17: Typical application schematic



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> = 3.0 V, V<sub>IN</sub> = V<sub>DD</sub>, C<sub>L</sub> = 10 pF, freq. = 1 MHz, Ch1 =  $\overline{\text{OE/DM2}}$ , Ch2 = SDI, Ch3 = V<sub>OUT</sub>, Ch4 = I<sub>OUT</sub>

Figure 18: Turn ON output current setup

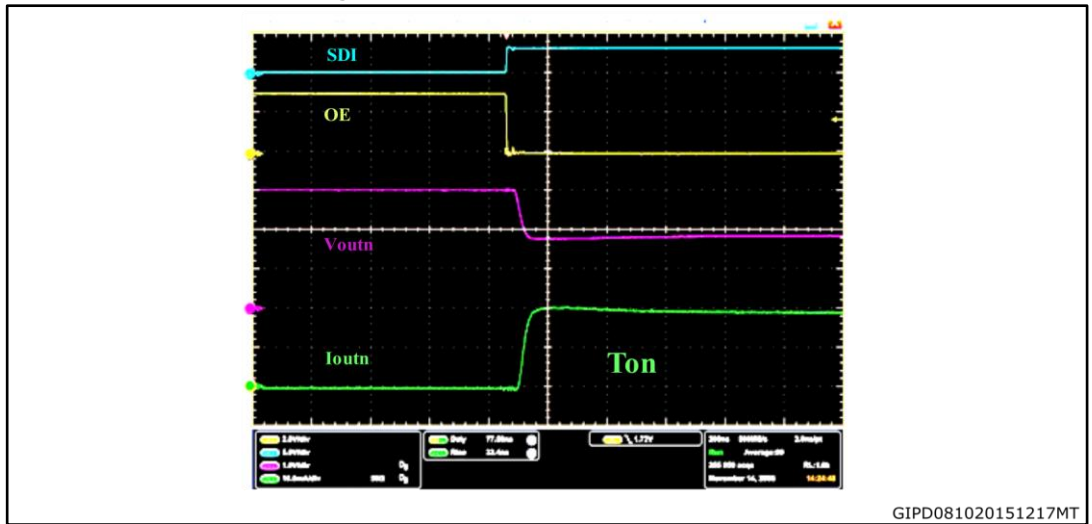
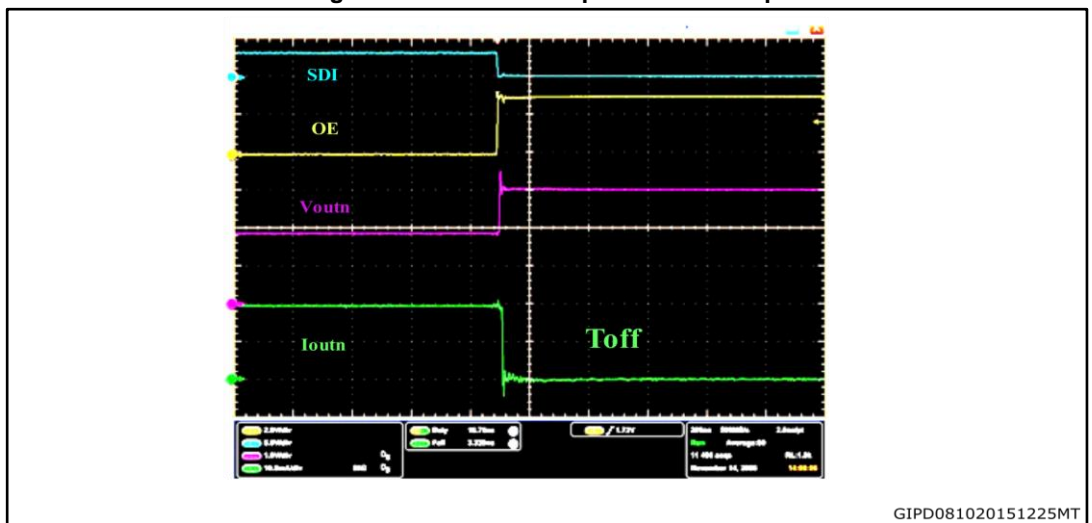


Figure 19: Turn OFF output current setup



## 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 20: QSOP-24 package outline

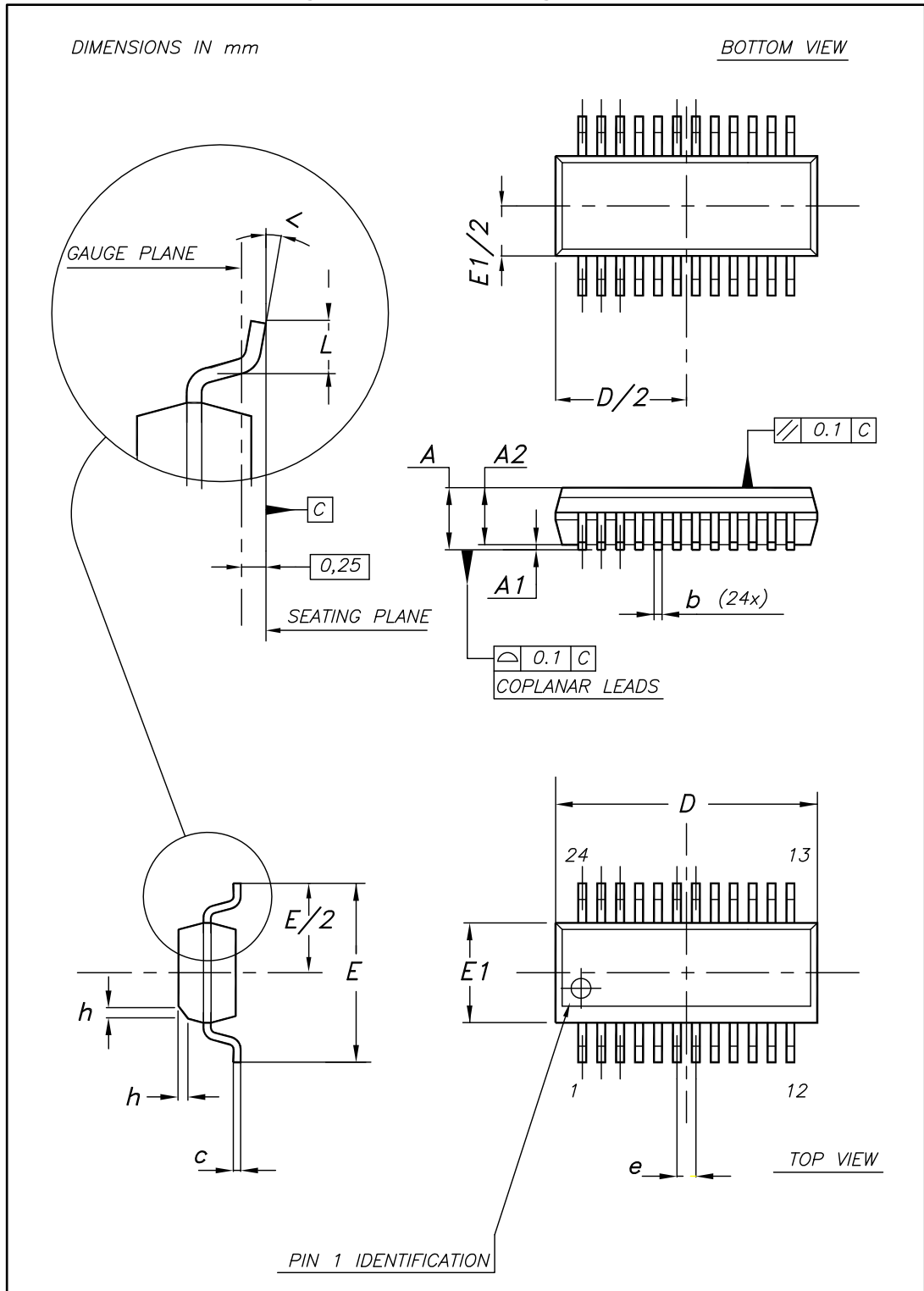


Table 12: QSOP-24 mechanical data

| 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 21: 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 22: TSSOP24 package outline

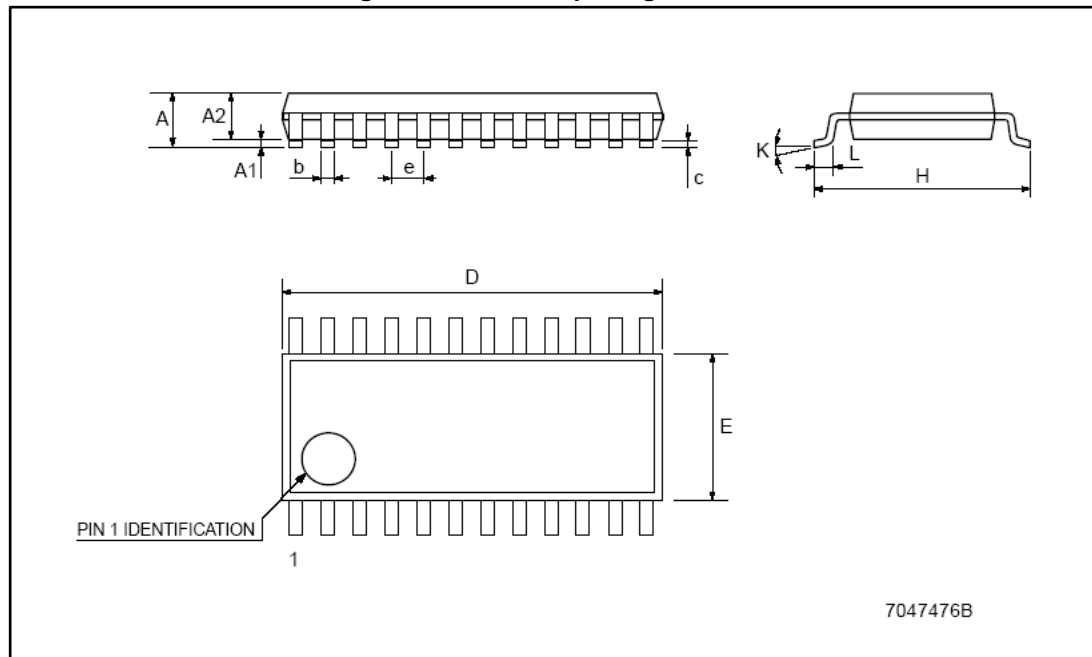


Table 14: TSSOP24 mechanical data

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

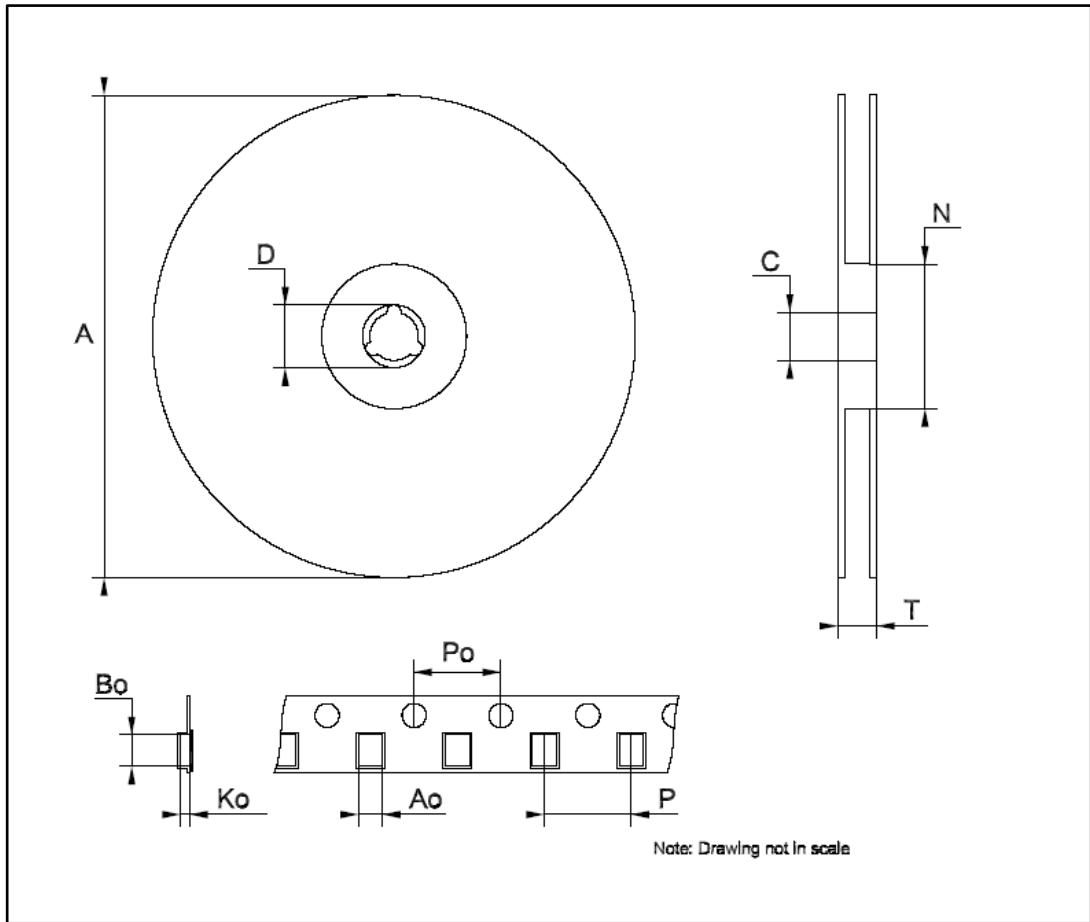


Table 16: TSSOP24 and TSSOP24 exposed pad tape and reel mechanical data

| 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   |
|-------------|----------|---|
| 28-Jul-2006 | 1        | First release   |
| 21-Dec-2006 | 2        | Final datasheet   |
| 17-May-2007 | 3        | Updated Table 7 on page 6   |
| 10-Jul-2007 | 4        | Updated Table 9: Truth table on page 10   |
| 12-Mar-2008 | 5        | Updated Table 15: TSSOP24 exposed-pad on page 23, added QSOP-24 Table 12 and Figure 2 on page 19  |
| 07-May-2008 | 6        | Updated Section 5 on page 10  |
| 03-Dec-2008 | 7        | Updated cover page, Table 6 on page 5, Table 7 on page 6, Table 8 on page 7, Figure 2 on page 13, Table 10 on page 13, Figure 2, 2, and Figure 2 on page 15                     |
| 12-May-2009 | 8        | Updated cover page, Table 6 on page 5, Table 7 on page 6, Table 8 on page 7   |
| 22-Oct-2009 | 9        | Updated Note: on page 3   |
| 20-Jan-2010 | 10       | Updated Table 5 on page 4   |
| 18-Jun-2014 | 11       | Updated Section 8: Package mechanical data and Section 9: Packaging mechanical data.  |
| 01-Apr-2016 | 12       | Updated <i>Table 12: "QSOP-24 mechanical data"</i> . Minor text changes.  |
| 08-Mar-2017 | 13       | 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. |

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Телефон: 8 (812) 309-75-97 (многоканальный)

Факс: 8 (812) 320-03-32

Электронная почта: [ocean@oceanchips.ru](mailto:ocean@oceanchips.ru)

Web: <http://oceanchips.ru/>

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А