

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

Datasheet - production data



feeds a 16-bit D-type storage register. In the output stage, sixteen regulated current sources are designed to provide 3 to 40 mA of constant current to drive the LEDs. The STP16DPP05 features open and short LED detection on the outputs. The detection circuit checks for 3 different conditions that can occur on the output line: short to GND, short to V_O or open line. The data detection results are loaded in the shift registers and shifted out via the serial line output. The detection functionality is implemented without increasing the pin count, 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 exit from detection mode. The STP16DPP05 output current can be adjusted through an external resistor to control the light intensity of the LEDs. LED brightness is adjustable from 0% to 100% via the $\overline{OE/DM2}$ pin. The STP16DPP05 guarantees a 20 V output driving capability, allowing users to connect more LEDs in series. The high 30 MHz clock frequency makes the device suitable for high data rate transmission. The 3.3 V supply is well suited for applications which interface a 3.3 V MCU. Compared to a standard TSSOP package, the TSSOP with exposed pad increases heat dissipation capability by a factor of 2.5.

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 MCU-driving capability
- Output current: 3 to 40 mA
- 30 MHz clock frequency
- Available in high thermal efficiency TSSOP exposed pad
- ESD protection: 2 kV HBM, 200 V MM

Description

The STP16DPP05 is a monolithic, low voltage, low current power 16-bit shift register designed for LED panel displays. The device features a 16-bit serial-in, parallel-out shift register that

Table 1: Device summary

| Order code | Package | Packing |
|----------------|-------------------------------------|---------------------|
| STP16DPP05MTR | SO-24 (tape and reel) | 1000 parts per reel |
| STP16DPP05TTR | TSSOP24 (tape and reel) | 2500 parts per reel |
| STP16DPP05XTTR | TSSOP24 exposed pad (tape and reel) | 2500 parts per reel |
| STP16DPP05PTR | 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 _{DD} | Temperature |
|----------------|------------------|-------------|----------------|-----------------|-------------|
| | Between bits | Between ICs | | | |
| ≥ 1.3 V | ± 1% | ± 2% | 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/DM1 | Latch input terminal - detect mode 1 (see operation principle) |
| 5-20 | OUT 0-15 | Output terminal |
| 21 | 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 for an external resistor for constant current programming |
| 24 | V _{DD} | 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 _{DD} | Supply voltage | 0 to 7 | V |
| V _O | Output voltage | -0.5 to 20 | V |
| I _O | Output current | 50 | mA |
| V _I | Input voltage | -0.4 to V _{DD} | V |
| I _{GND} | GND terminal current | 800 | mA |
| f _{CLK} | Clock frequency | 50 | MHz |
| T _J | Junction temperature range ⁽¹⁾ | -40 to +170 | °C |

Notes:

⁽¹⁾ Such absolute value is based on the thermal shutdown protection.

2.2 Thermal data

Table 5: Thermal data

| Symbol | Parameter | Value | Unit | |
|--------------------|--|---------------------------------------|------|------|
| T _A | Operating free-air temperature range | -40 to +125 | °C | |
| T _{J-OPR} | Operating thermal junction temperature range | -40 to +150 | °C | |
| T _{STG} | Storage temperature range | -55 to +150 | °C | |
| R _{thJA} | Thermal resistance junction-ambient ⁽¹⁾ | SO-24 | 42.7 | °C/W |
| | | TSSOP24 | 55 | °C/W |
| | | TSSOP24 ⁽²⁾ exposed pad | 37.5 | °C/W |
| | | QSOP-24 | 55 | °C/W |

Notes:

⁽¹⁾ According with JEDEC standard 51-7.

⁽²⁾ The exposed pad should be soldered directly to the PCB to obtain 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 | | 5.5 | V |
| V _O | Output voltage | | | | 20 | V |
| I _O | Output current | OUT _n | 3 | | 40 | 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 V to 5.0 V | 20 | | | ns |
| t _{wCLK} | CLK pulse width | | 10 | | | ns |
| t _{wEN} | $\overline{\text{OE/DM2}}$ pulse width | | 100 | | | ns |
| t _{SETUP(D)} | Setup time for DATA | | | | | ns |
| t _{HOLD(D)} | Hold time for DATA | | 5 | | | ns |
| t _{SETUP(L)} | Setup time for LATCH | | 8 | | | ns |
| f _{CLK} | Clock frequency | | Cascade operation ⁽¹⁾ | | | 30 |

Notes:

⁽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

$V_{DD} = 3.3\text{ V to }5\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, 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 | μA |
| 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 | |
| I_{OL2} | | $V_O = 0.3\text{ V}$, $R_{ext} = 1\text{ k}\Omega$ | 19 | 20 | 21 | |
| I_{OL3} | | $V_O = 1.3\text{ V}$, $R_{ext} = 497\text{ }\Omega$ | 38 | 40 | 42 | mA |
| ΔI_{OL1} | Output current error between bit (all output ON) | $V_O = 0.3\text{ V}$, $I_O = 5\text{ mA}$ $R_{ext} = 4\text{ k}\Omega$ | | ± 1 | ± 5 | |
| ΔI_{OL2} | | $V_O = 0.3\text{ V}$, $I_O = 20\text{ mA}$ $R_{ext} = 980\text{ }\Omega$ | | ± 0.5 | ± 3 | % |
| ΔI_{OL3} | | $V_O = 1.3\text{ V}$, $I_O = 40\text{ mA}$ $R_{ext} = 490\text{ }\Omega$ | | ± 0.5 | ± 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) | $R_{ext} = 1\text{ k}\Omega$, $I_{OUT} = 20\text{ mA}$, OUT 0 to 15 = OFF | | 5.4 | 7.5 | mA |
| $I_{DD(OFF2)}$ | | $R_{ext} = 497\text{ }\Omega$, $I_{OUT} = 40\text{ mA}$ OUT 0 to 15 = OFF | | 8 | 9.5 | |
| $I_{DD(ON1)}$ | Supply current (ON) | $R_{ext} = 1\text{ k}\Omega$, $I_{OUT} = 20\text{ mA}$, OUT 0 to 15 = ON | | 5.5 | 7.5 | |
| $I_{DD(ON2)}$ | | $R_{ext} = 497\text{ }\Omega$, $I_{OUT} = 40\text{ mA}$ OUT 0 to 15 = ON | | 8.1 | 9.5 | |
| Thermal | Thermal protection | | | 170 | | $^\circ\text{C}$ |

$V_{DD} = 3.3\text{ V to }5\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, 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/DM1 = H, $\overline{\text{OE/DM2}} = \text{L}$ | | $V_{DD} = 3.3\text{ V}$ | | 35.5 | 44.5 | |
| | | | $V_{DD} = 5\text{ V}$ | | 18.5 | 24 | ns |
| t_{PLH2} | Propagation delay time, LE/DM1 - $\overline{\text{OUTn}}$, $\overline{\text{OE/DM2}} = \text{L}$ | | $V_{DD} = 3.3\text{ V}$ | | 41.5 | 50 | |
| | | | $V_{DD} = 5\text{ V}$ | | 23 | 29 | ns |
| t_{PLH3} | Propagation delay time, $\overline{\text{OE/DM2}} - \overline{\text{OUTn}}$, LE = H | | $V_{DD} = 3.3\text{ V}$ | | 45 | 54 | |
| | | | $V_{DD} = 5\text{ V}$ | | 25 | 31 | ns |
| t_{PLH} | Propagation delay time, CLK-SDO | | $V_{DD} = 3.3\text{ V}$ | 15 | 21 | 31 | |
| | | | $V_{DD} = 5\text{ V}$ | 11 | 15 | 21 | ns |
| t_{PHL1} | Propagation delay time, CLK- $\overline{\text{OUTn}}$, LE/DM1 = H, $\overline{\text{OE/DM2}} = \text{L}$ | $V_{IH} = V_{DD}$ $V_{IL} = \text{GND}$ $C_L = 10\text{ pF}$ $I_O = 20\text{ mA}$ $V_L = 3.0\text{ V}$ $R_{ext} = 1\text{ K}\Omega$ $R_L = 60\text{ }\Omega$ | $V_{DD} = 3.3\text{ V}$ | | 13.7 | 18 | |
| | | | $V_{DD} = 5\text{ V}$ | | 8.8 | 12.5 | ns |
| t_{PHL2} | Propagation delay time, LE/DM1 - $\overline{\text{OUTn}}$ $\overline{\text{OE/DM2}} = \text{L}$ | | $V_{DD} = 3.3\text{ V}$ | | 17 | 22 | |
| | | | $V_{DD} = 5\text{ V}$ | | 13 | 17 | ns |
| t_{PHL3} | Propagation delay time, $\overline{\text{OE/DM2}} - \overline{\text{OUTn}}$, LE/DM1 = H | | $V_{DD} = 3.3\text{ V}$ | | 12.7 | 17 | |
| | | | $V_{DD} = 5\text{ V}$ | | 9.5 | 13 | ns |
| t_{PHL} | Propagation delay time, CLK-SDO | | $V_{DD} = 3.3\text{ V}$ | 17.5 | 24 | 36 | |
| | | | $V_{DD} = 5\text{ V}$ | 12.5 | 17 | 25 | ns |
| t_{ON} | Output rise time 10~90% of voltage waveform | | $V_{DD} = 3.3\text{ V}$ | | 28 | 39 | |
| | | | $V_{DD} = 5\text{ V}$ | | 17 | 23 | ns |
| t_{OFF} | Output fall time 90~10% of voltage waveform | | $V_{DD} = 3.3\text{ V}$ | | 4.5 | 6 | |
| | | | $V_{DD} = 5\text{ V}$ | | 3.5 | 5 | ns |
| t_r | CLK rise time ⁽¹⁾ | | | | 5000 | ns | |
| t_f | CLK fall time ⁽¹⁾ | | | | 5000 | ns | |

Notes:

⁽¹⁾ 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

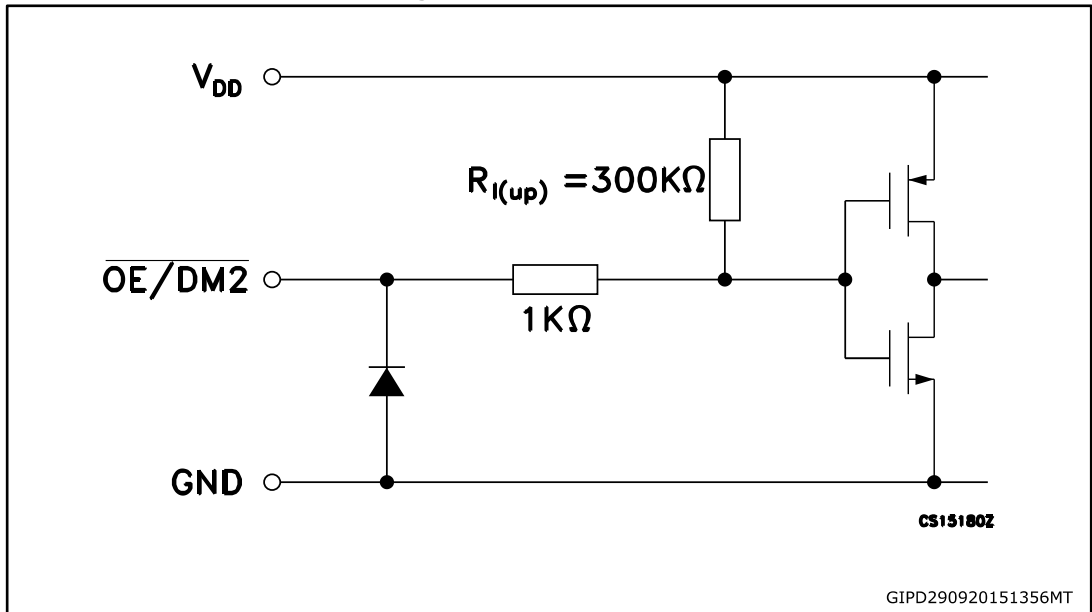


Figure 3: LE/DM1 terminal

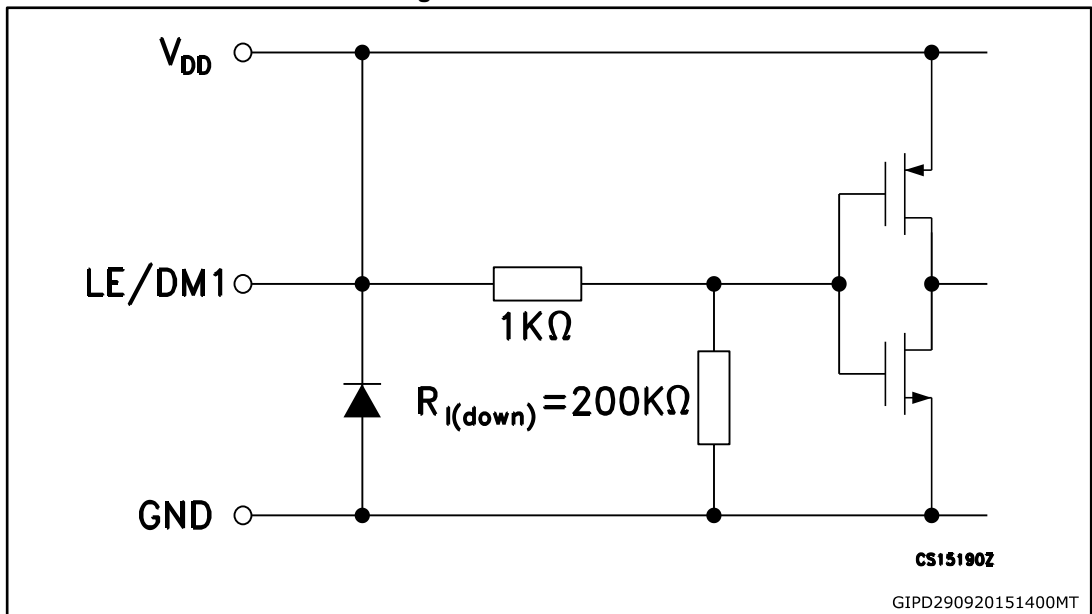
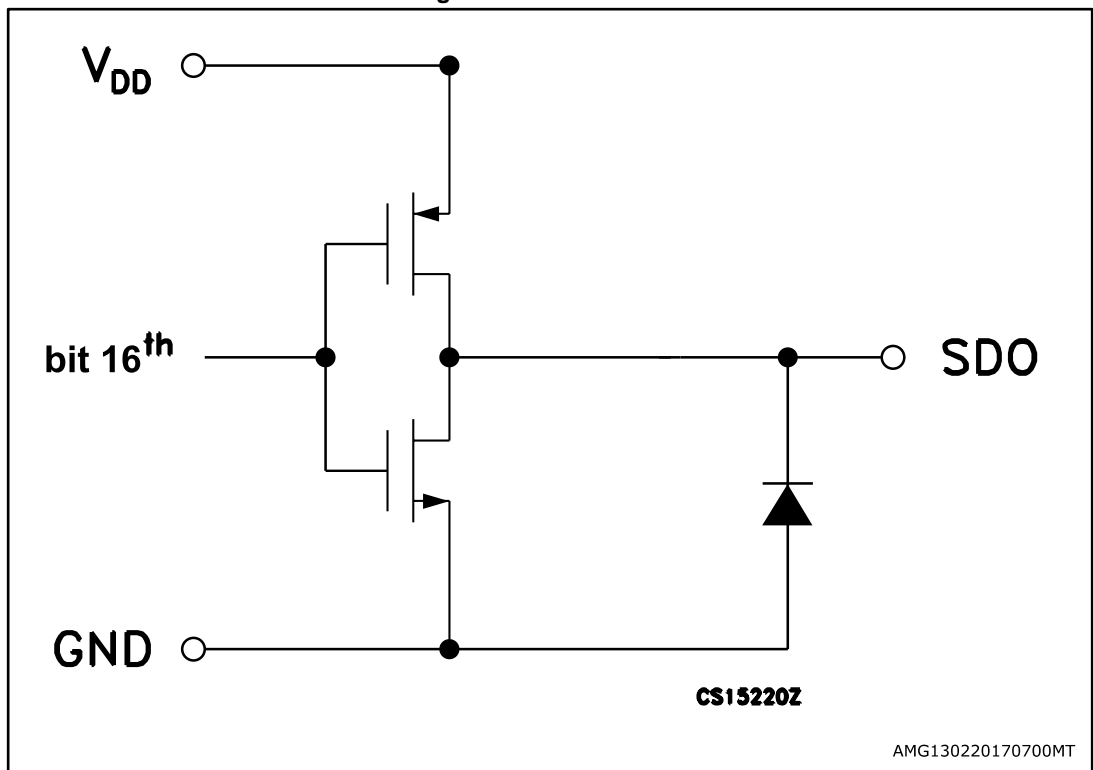


Figure 4: CLK, SDI terminal



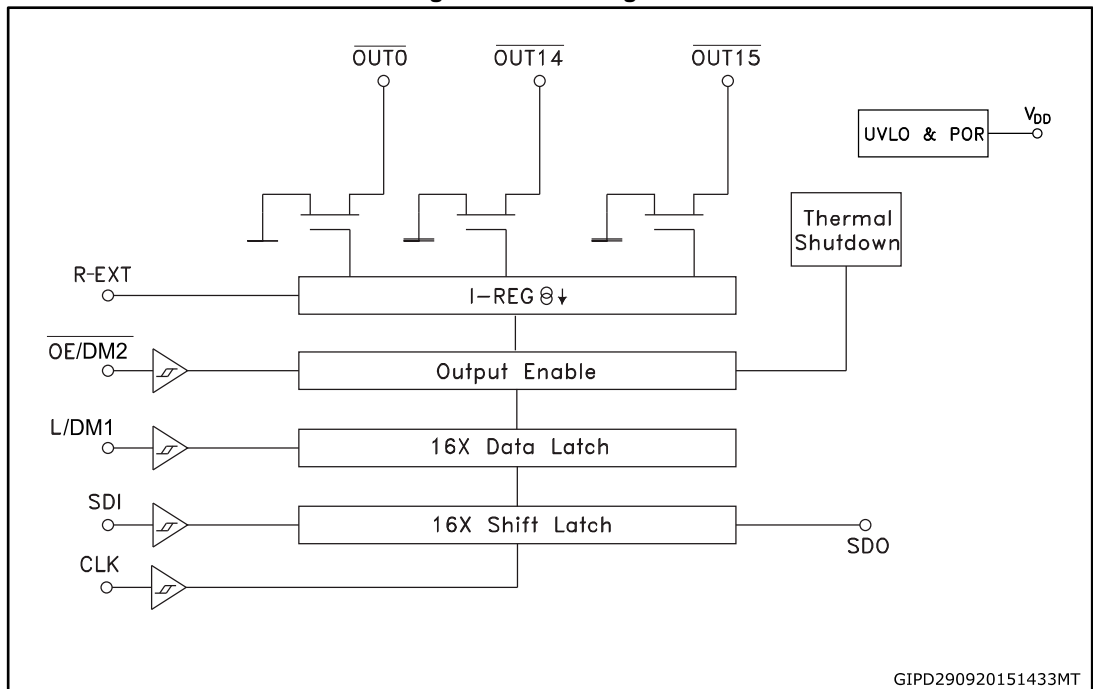
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Figure 5: SDO terminal



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Figure 6: Block diagram



5 Timing diagrams

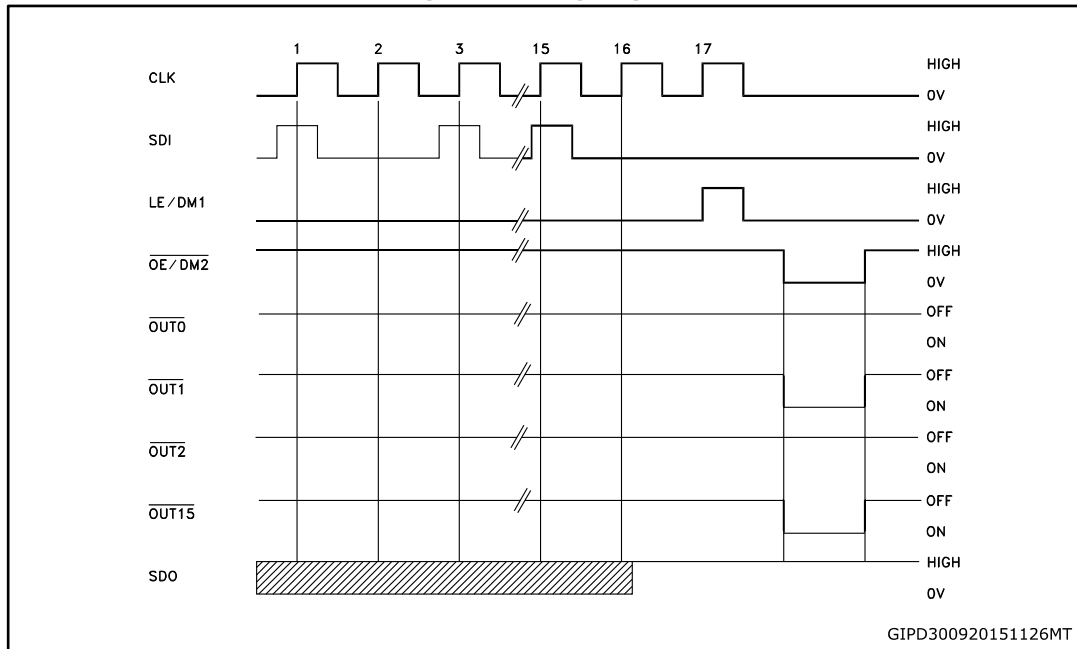
Table 9: Truth table

| CLOCK | LE/DM1 | $\overline{\text{OE/DM2}}$ | SERIAL-IN | $\overline{\text{OUT0}}$ $\overline{\text{OUT7}}$ $\overline{\text{OUT15}}$ | SDO |
|------------------------------|--------|----------------------------|-----------|---|---------|
| $\text{┌} \text{─} \text{┐}$ | H | L | Dn | Dn Dn - 7 Dn -15 | Dn - 15 |
| $\text{┌} \text{─} \text{┐}$ | L | L | Dn + 1 | No change | Dn - 14 |
| $\text{┌} \text{─} \text{┐}$ | H | L | Dn + 2 | Dn + 2 Dn - 5 Dn -13 | Dn - 13 |
| $\text{┌} \text{─} \text{┐}$ | X | L | Dn + 3 | Dn + 2 Dn - 5 Dn -13 | Dn - 13 |
| $\text{┌} \text{─} \text{┐}$ | 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 $\overline{\text{OE/DM2}}$ 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 $\overline{\text{OE/DM2}}$ terminal is at high level, all output terminals are switched OFF.

Table 10: Enable IO: shutdown truth table

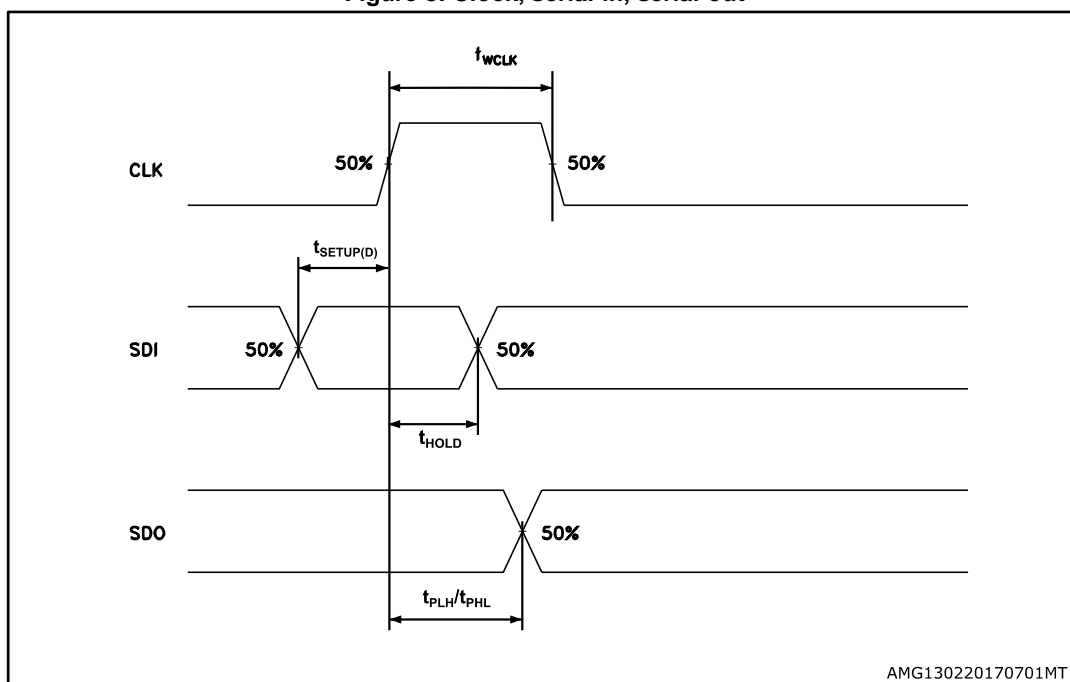
| CLOCK | LE/DM1 | SDI0SDI7..... SDI15 | SH | Auto power-up | OUTn |
|-------|--------|---------------------------|------------|---------------------------|------------------|
| | H | All = L | Active | Not active ⁽¹⁾ | OFF |
| | L | No change | No change | No change | No change |
| | H | One or more = H | Not active | Active | X ⁽²⁾ |

Notes:

⁽¹⁾ At power-up, the device starts in shutdown mode.

⁽²⁾ Undefined.

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



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



Figure 10: Outputs



6 Typical characteristics

Figure 11: Output current vs. R-EXT resistor

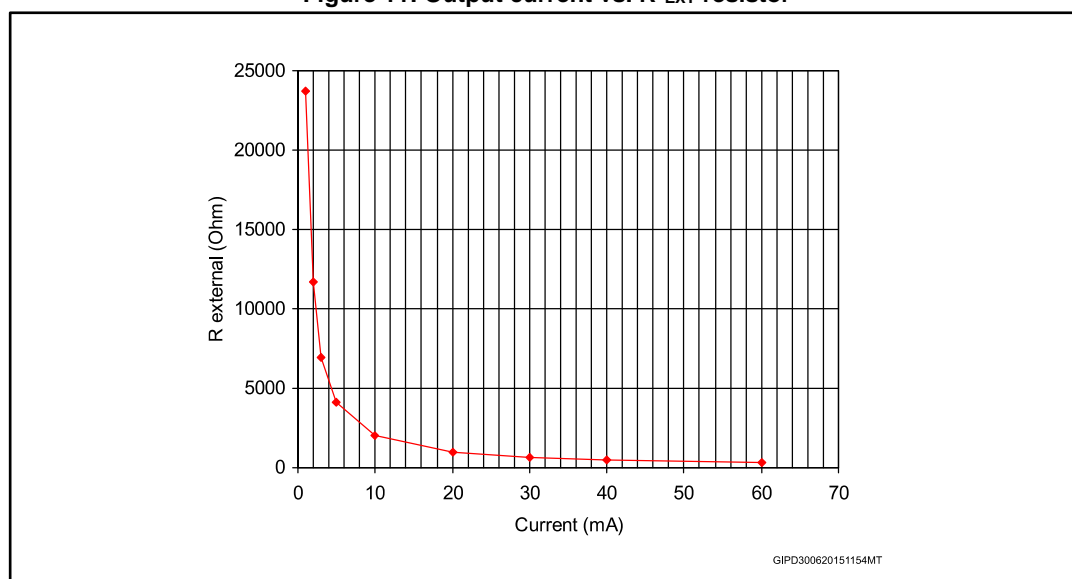
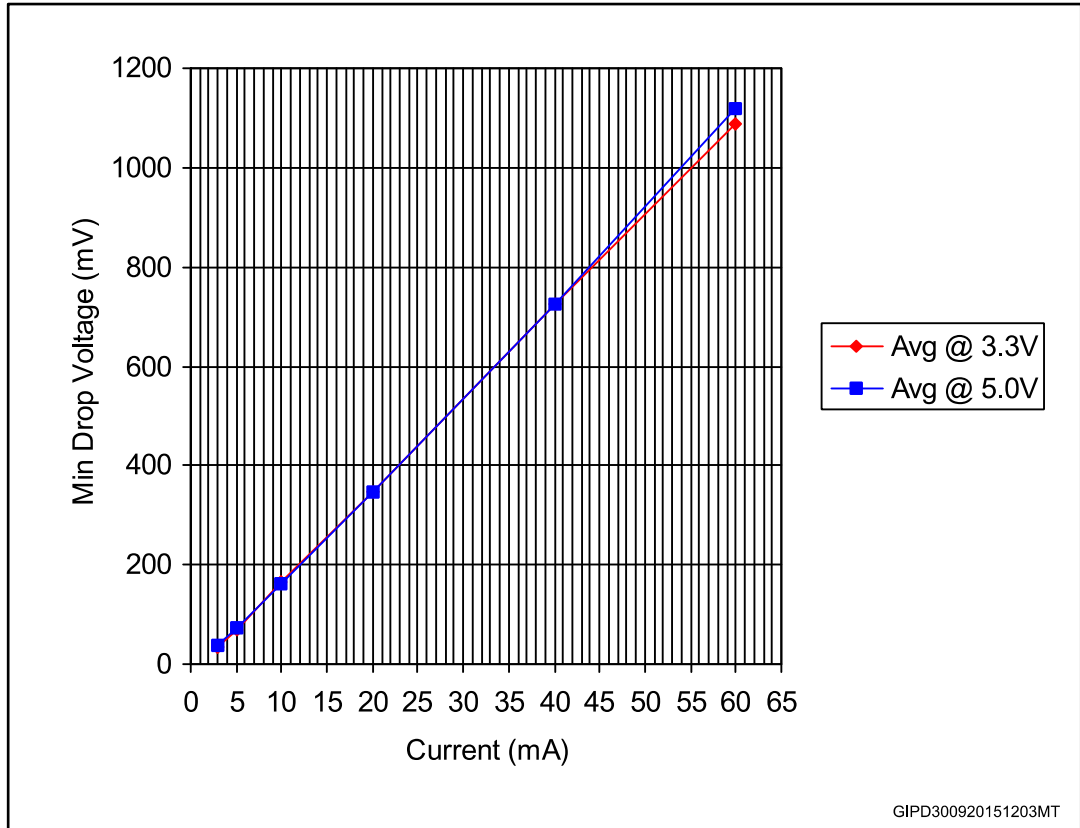


Table 11: Output current vs. R-EXT resistor

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

Conditions: temperature = 25 °C, $V_{DD} = 3.3\text{ V}; 5.0\text{ V}$, $I_{SET} = 3\text{ mA}; 5\text{ mA}; 10\text{ mA}; 20\text{ mA}; 50\text{ mA}; 60\text{ mA}$.

Figure 12: I_{SET} vs. dropout voltage (V_{drop})



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Table 12: I_{SET} vs. dropout voltage (V_{drop})

| I_{out} (mA) | Avg (mV) @ 3.3 V | Avg (mV) @ 5.0 V |
|----------------|------------------|------------------|
| 3 | 36 | 37 |
| 5 | 71 | 72 |
| 10 | 163 | 163 |
| 20 | 346 | 347 |
| 40 | 724 | 726 |
| 60 | 1080 | 1110 |

$T_A = 25\text{ }^\circ\text{C}$, $V_{dd} = 3.3\text{ V}; 5\text{ V}$

Figure 13: Output current vs. $\pm \Delta I_{OL}(\%)$

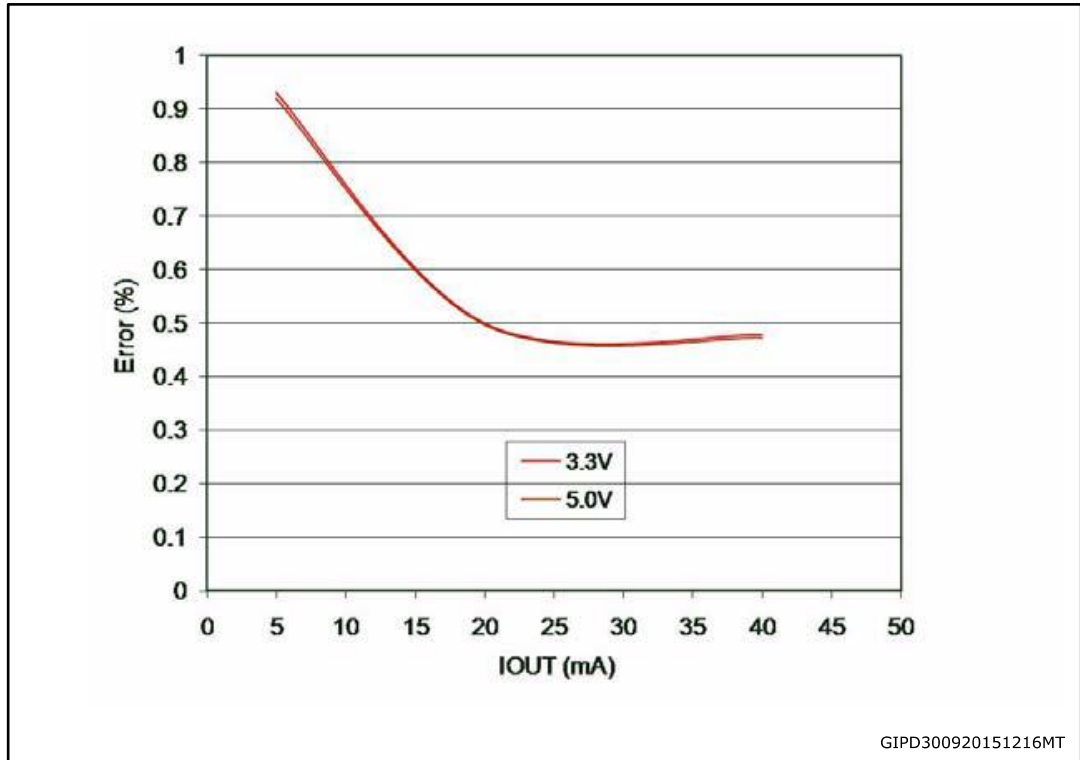


Figure 14: I_{dd} ON/OFF

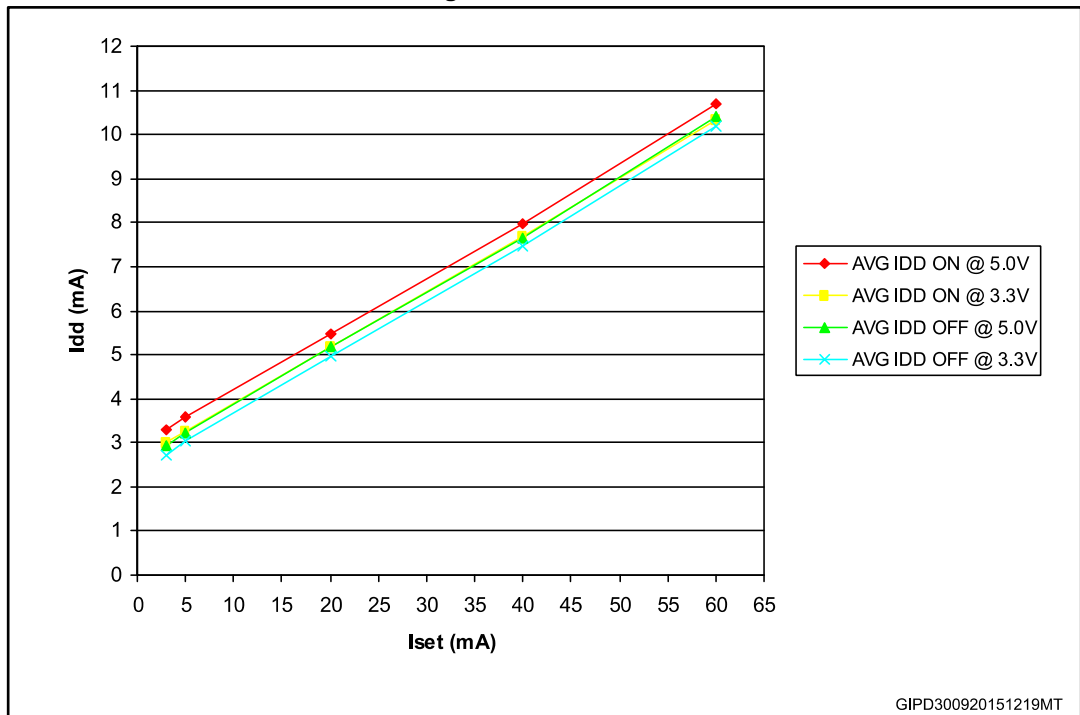
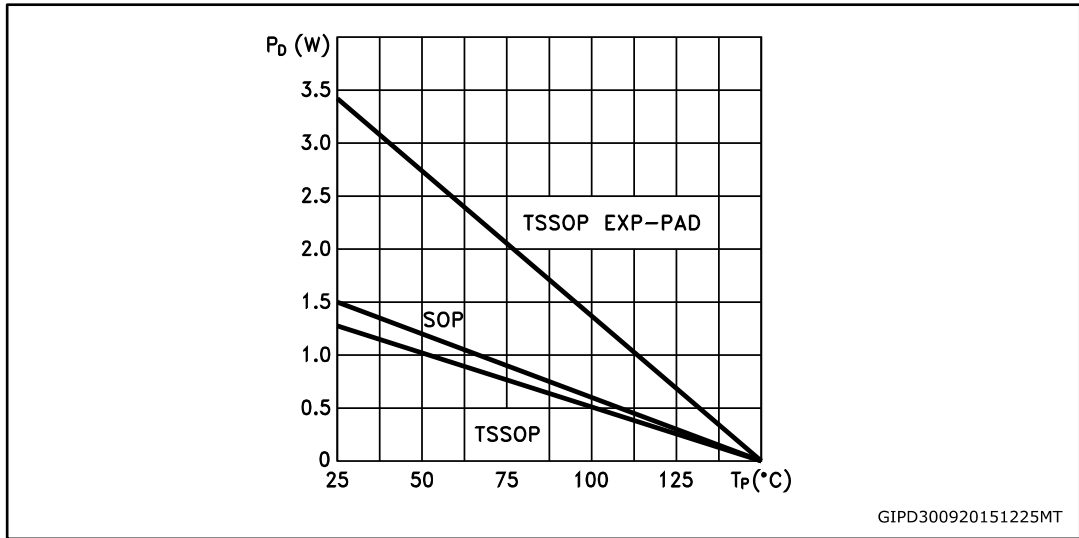


Figure 15: Power dissipation vs package temperature



The exposed pad should be soldered to the PCB to obtain the thermal benefits.

Figure 16: Turn ON output current characteristics⁽¹⁾

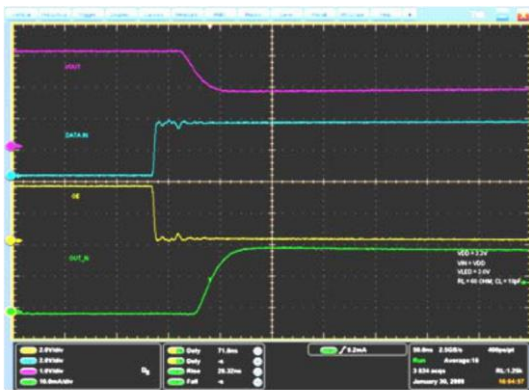
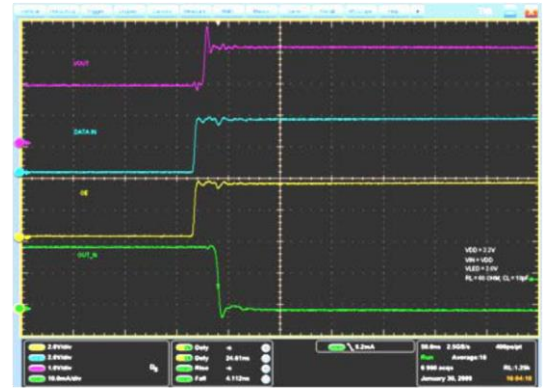


Figure 17: Turn OFF output current characteristics⁽²⁾



Notes:

- (1) The reference level for the TON characteristics is 50% of $\overline{OE/DM2}$ signal and 90 % of output current.
- (2) The reference level for the TOFF characteristics is 50% of $\overline{OE/DM2}$ signal and 10 % of output current.

Electrical conditions: $V_{dd} = 3.3\text{ V}$, $V_{in} = V_{dd}$, $V_{led} = 3.0\text{ V}$, $R_L = 60\ \Omega$, $C_L = 10\text{ pF}$ Ch1 (Yellow) = $\overline{OE/DM2}$, Ch2 (Blue) = SDI, Ch3 (Purple) = VOUT, Ch4 (Green) = OUT

7 Error detection mode functionality

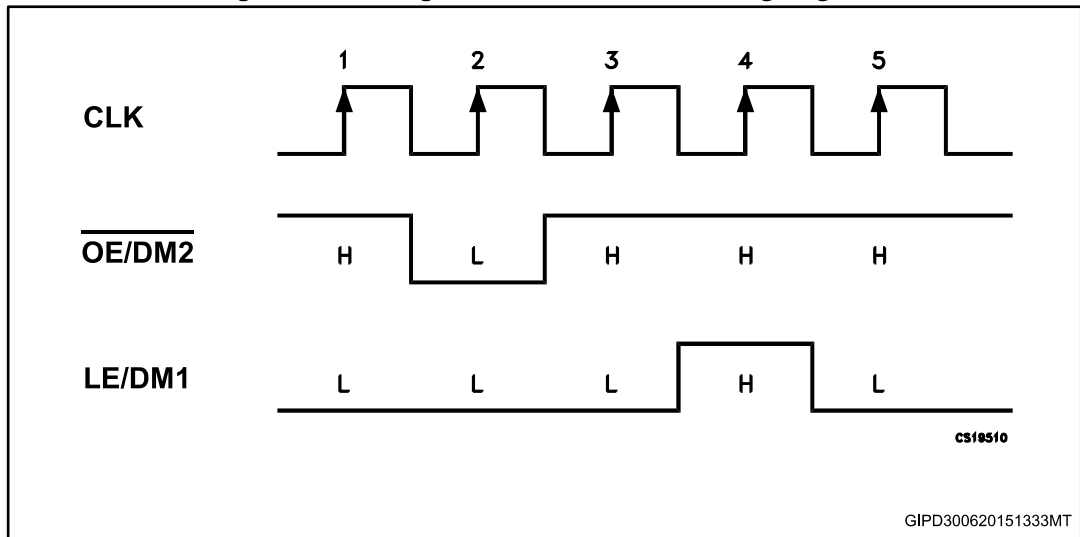
7.1 Phase one: entering error detection mode

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

Table 13: Entering error detection mode - truth table

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

Figure 18: Entering error detection mode - timing diagram

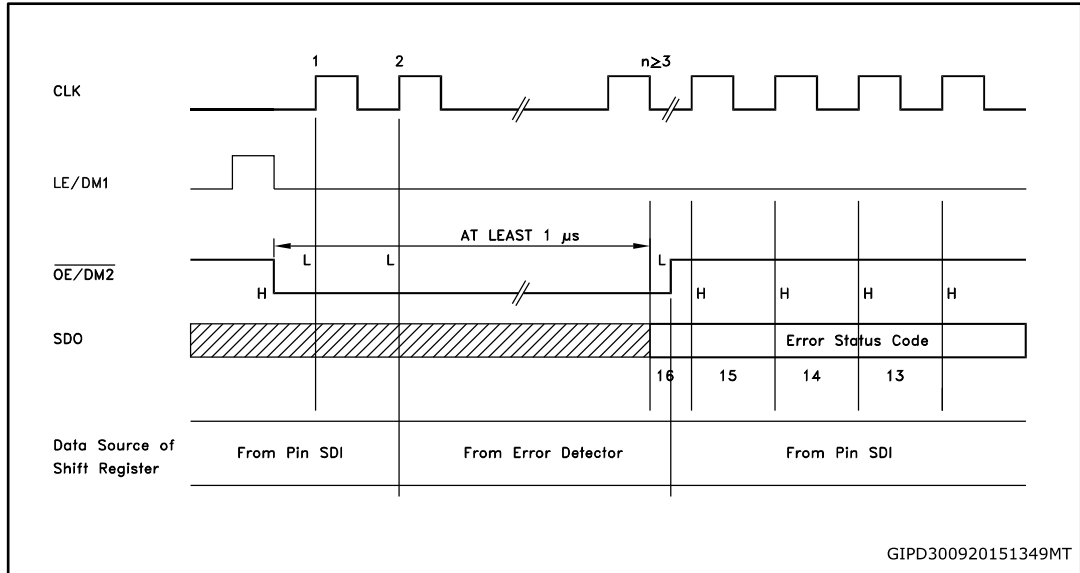


After these five CLK cycles, the device goes into “error detection mode” and at the rising edge of the 6th CLK cycle, the SDI data are ready for sampling.

7.2 Phase two: error detection

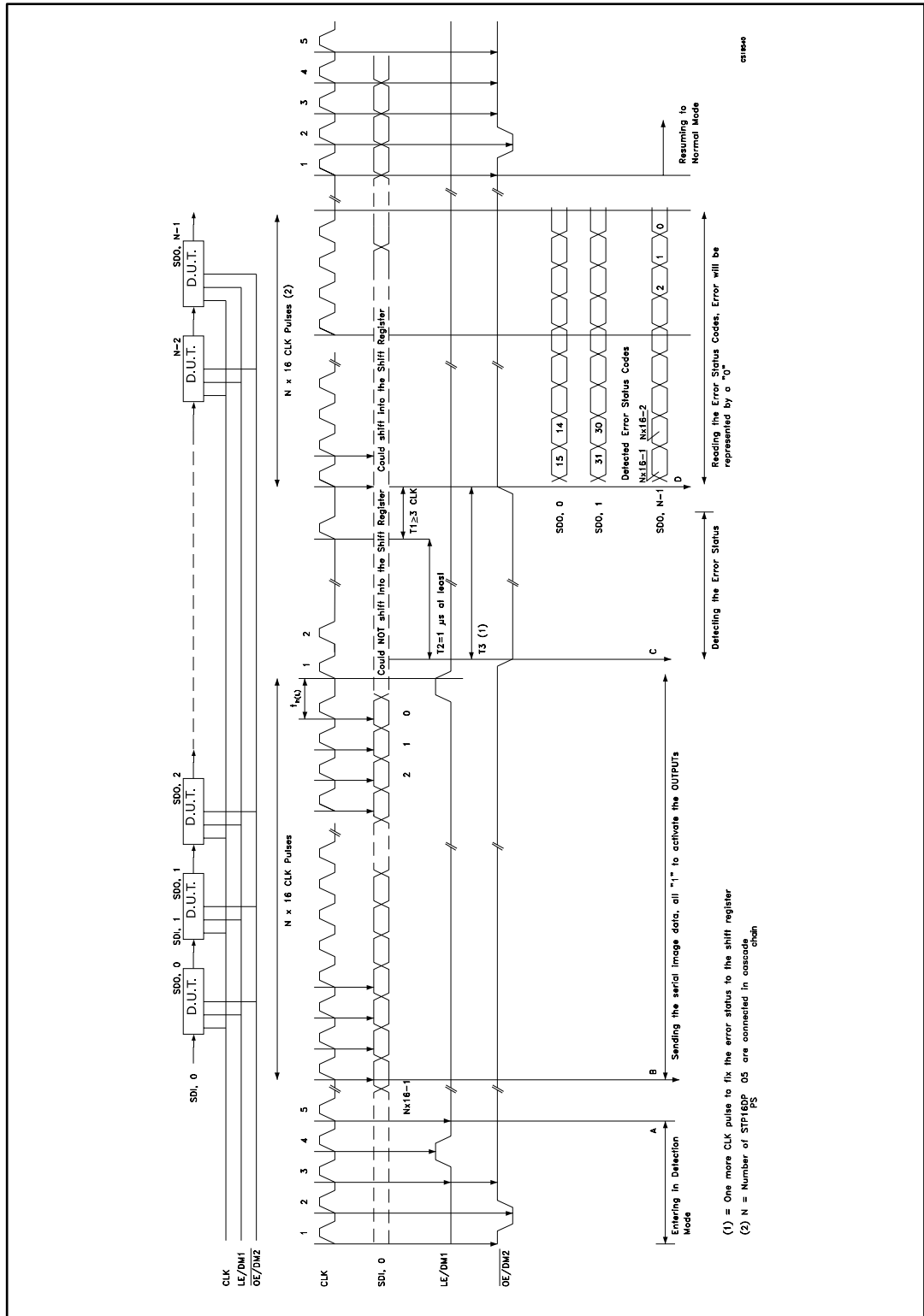
The 16 data bits must be set to “1” in order for all the outputs to be ON during error detection. The data are latched by LE/DM1, after which the outputs are ready for the detection process. When the microcontroller switches the $\overline{\text{OE/DM2}}$ to LOW, the device drives the LEDs to analyze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

Figure 19: Detection diagram



The status of the LEDs is detected in at least 1 microsecond, and after this period the microcontroller sets $\overline{\text{OE/DM2}}$ to HIGH state and the output data detection result is sent to the microcontroller via SDO. Error detection mode and normal mode both use the same data format. As soon as all the detection data bits are available on the serial line, the device may return to normal mode of operation. To re-detect the status, the device must first return to normal mode and reenter error detection mode.

Figure 20: Timing example for open and/or short-circuit detection



7.3 Phase three: resuming normal mode

The sequence for reentering normal mode is shown in the following table:

Table 14: Resuming 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 |



For proper device operation, the “entering error detection” sequence must be followed by a “resume mode” sequence, it is not possible to insert consecutive equal sequences.

7.4 Error detection conditions

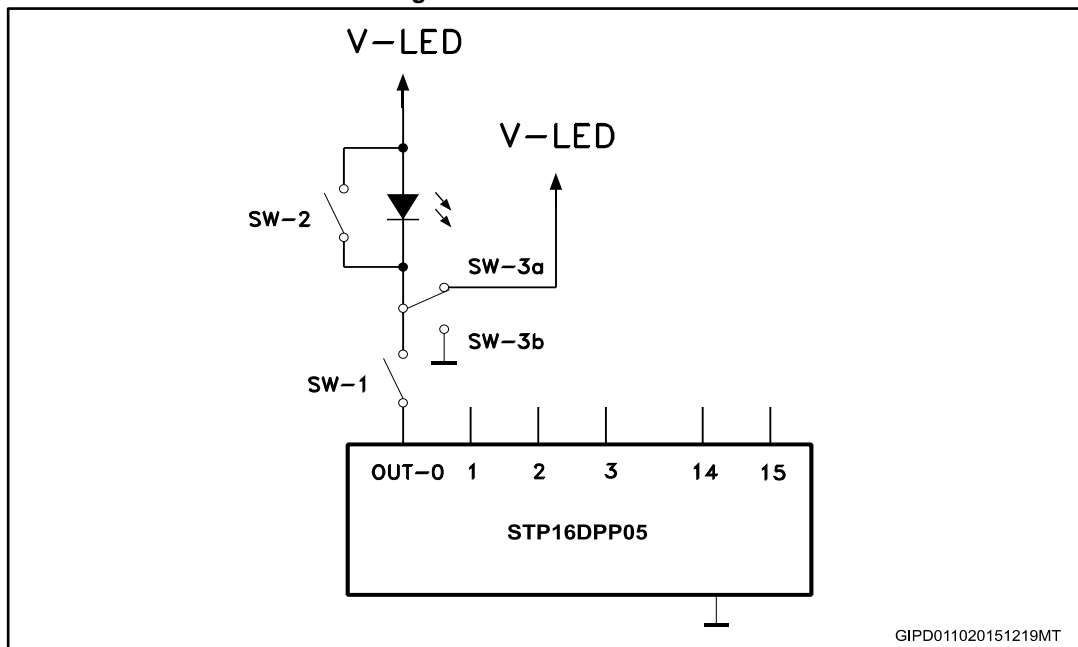
Table 15: Detection conditions (VDD = 3.3 to 5 V, temperature range -40 to 125 °C)

| Configuration | Detect mode | Detection results | | |
|---------------|---|--|-------------------|--|
| SW-1 or SW-3b | Open line or output short to GND detected | $\implies I_{\text{ODEC}} \leq 0.5 \times I_o$ | No error detected | $\implies I_{\text{ODEC}} \geq 0.5 \times I_o$ |
| SW-2 or SW-3a | Short on LED or short to V-LED detected | $\implies V_o \geq 2.6 \text{ V}$ | No error detected | $\implies V_o \leq 2.3 \text{ V}$ |



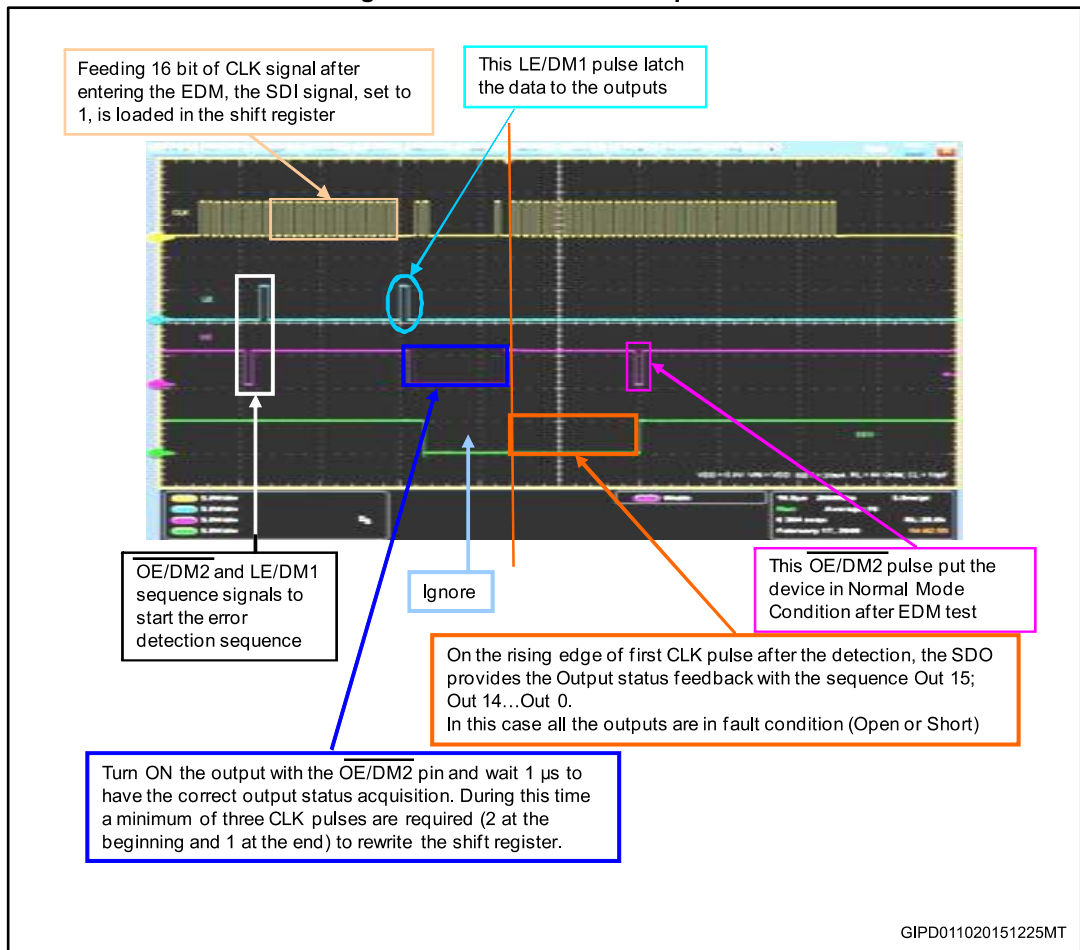
Where: I_o = the output current programmed by the R-EXT, I_{ODEC} = the detected output current in detection mode

Figure 21: Detection circuit



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Figure 22: Error detection sequence



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. ECOPACK® is an ST trademark.

8.1 QSOP-24 package information

Figure 23: QSOP-24 package outline

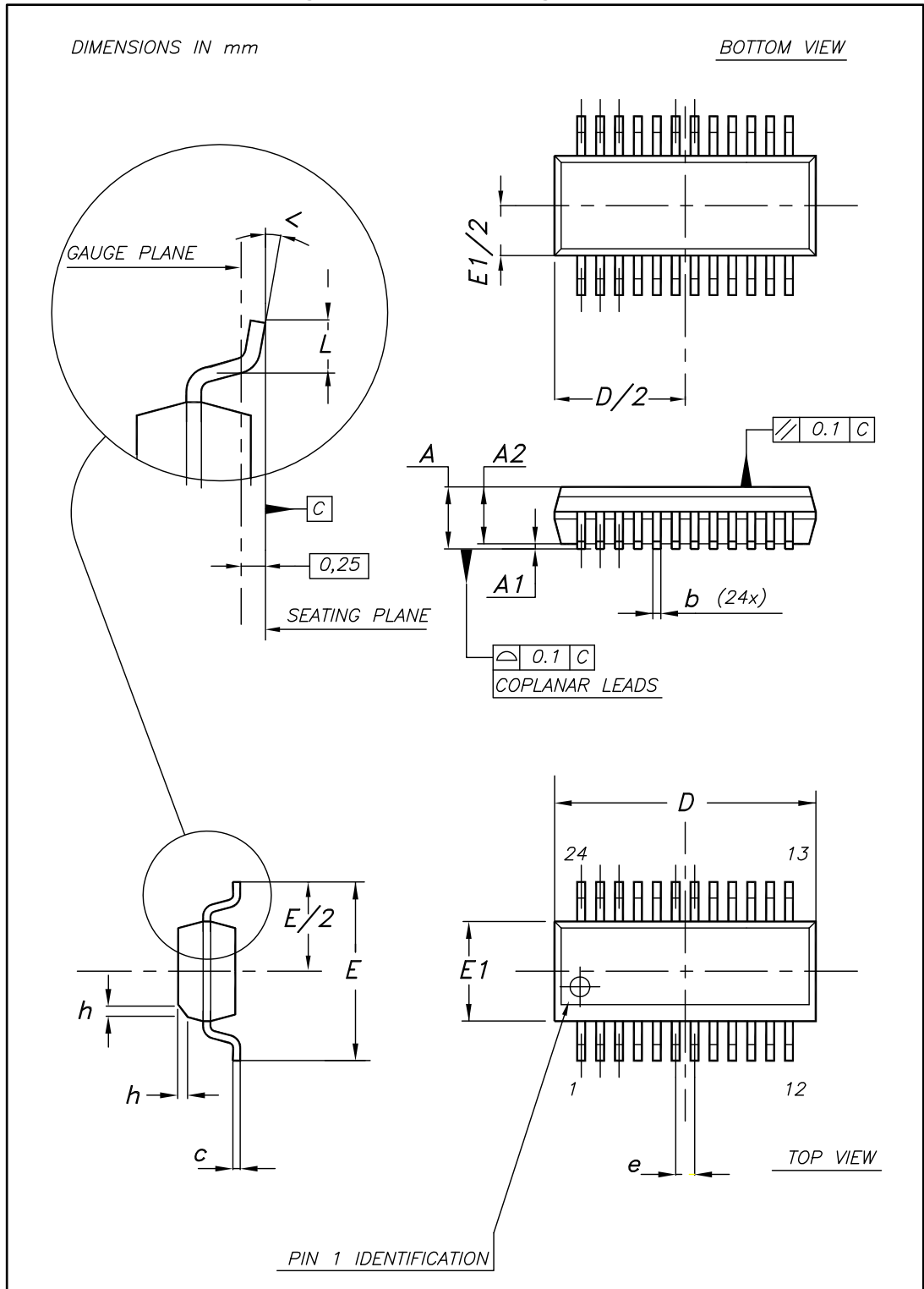


Table 16: QSOP-24 mechanical data

| 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 24: SO-24 package outline

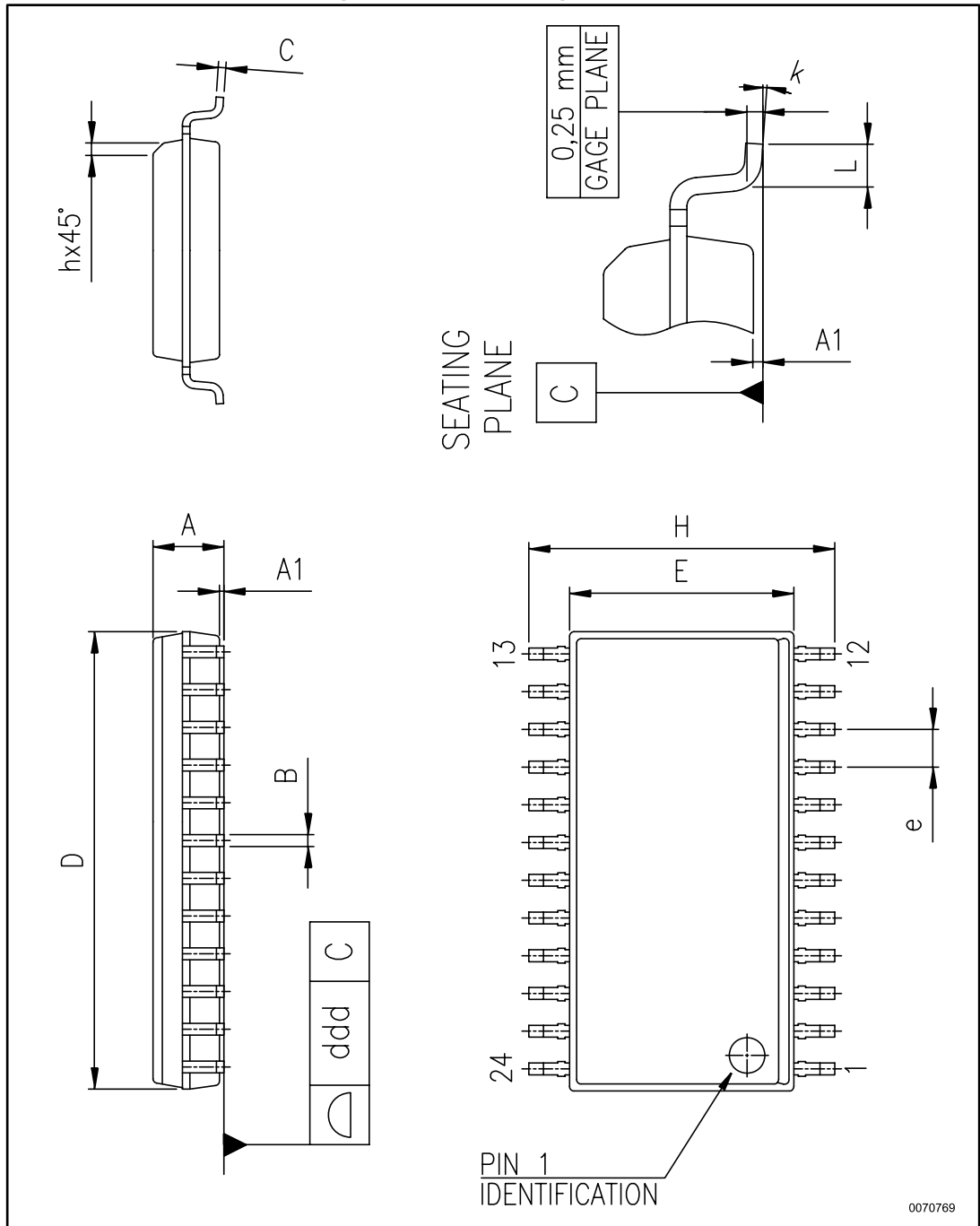


Table 17: SO-24 mechanical data

| 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 25: TSSOP24 package outline

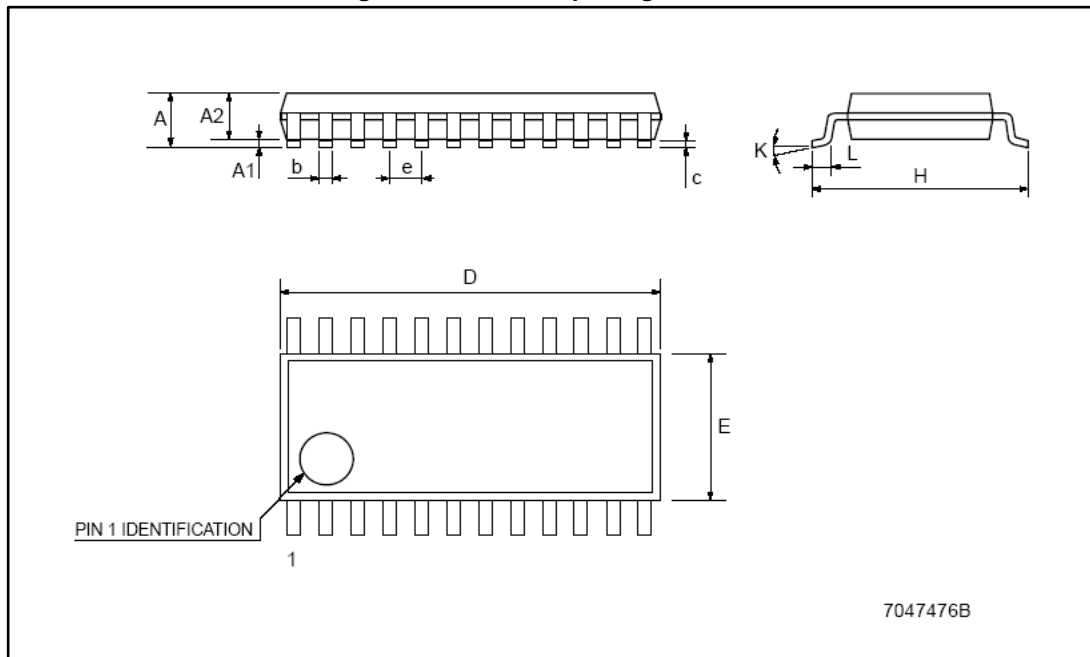


Table 18: TSSOP24 mechanical data

| 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 TSSOP exposed pad package information

Figure 26: TSSOP24 exposed pad package outline

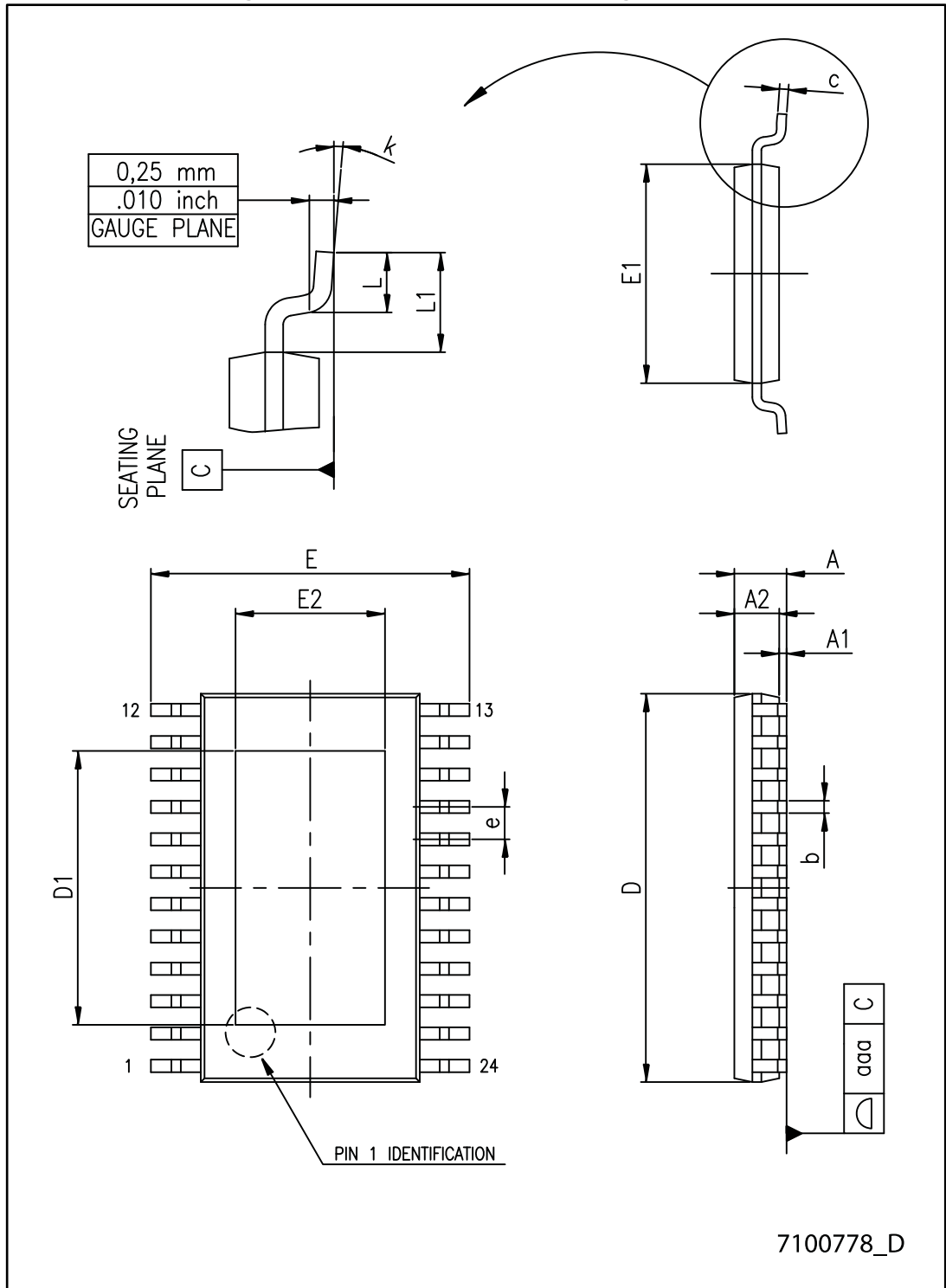


Table 19: TSSOP24 exposed pad mechanical data

| 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 27: TSSOP24, TSSOP24 exposed pad and SO-24 reel outline



Table 20: 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 21: 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 22: Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 22-Oct-2009 | 1 | First release. |
| 19-Jun-2014 | 2 | Updated Section 8: Package mechanical data. Added Section 9: Packaging mechanical data. Minor text changes. |
| 04-Apr-2016 | 3 | Updated <i>Table 16: "QSOP-24 mechanical data"</i> . Minor text changes. |
| 04-Apr-2017 | 4 | 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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