TLC59025 Low-Power 16-Channel Constant-Current LED Sink Driver

1 Features

- 16 Constant Current Output Channels
- Matches Industry Standard IOUT to External Resistor Ratio
- Constant Output Current Invariant to Load Voltage Change
- Output Current Accuracy:
  - Between Channels: < ±5% (Maximum)
  - Between ICs: < ±6% (Maximum)
- Constant Output Current Range: 3 mA to 45 mA
- Output Current Adjusted By External Resistor
- Fast Response of Output Current, $\overline{OE}$ (Minimum): 100 ns
- 30 MHz Clock Frequency
- Schmitt-Trigger Inputs
- 3.0 V to 5.5 V Supply Voltage
- Thermal Shutdown for Overtemperature Protection
- ESD Performance: 1 kV HBM

2 Applications

- Gaming Machine / Entertainment
- General LED Applications
- LED Display Systems
- Signs LED Lighting
- White Goods

3 Description

The TLC59025 device is designed for LED displays and LED lighting applications. The TLC59025 contains a 16-bit shift register and data latches, which convert serial input data into parallel output format. At the TLC59025 output stage, 16 regulated-current ports provide uniform and constant current for driving LEDs within a wide range of VF variations. Used in system design for LED display applications (for example, LED panels), the TLC59025 provides great flexibility and device performance. Users can adjust the output current from 3 mA to 45 mA through an external resistor, R_{ext}, which gives flexibility in controlling the light intensity of LEDs. TLC59025 is designed for up to 17 V at the output port. The high clock frequency, 30 MHz, also satisfies the system requirements of high-volume data transmission.

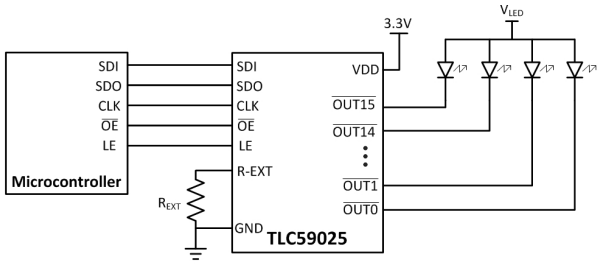
The serial data is transferred into TLC59025 through SDI, shifted in the shift register, and transferred out through SDO. LE can latch the serial data in the shift register to the output latch. $\overline{OE}$ enables the output drivers to sink current.

Device Information (1)

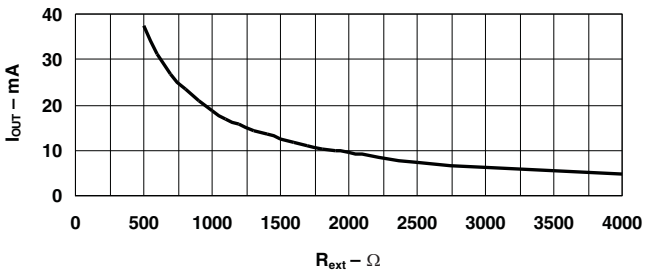
PART NUMBER	PACKAGE	BODY SIZE (NOM)
TLC59025	SSOP (24)	8.65 mm × 3.90 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical Application Diagram



I_{OUT} vs R_{EXT}



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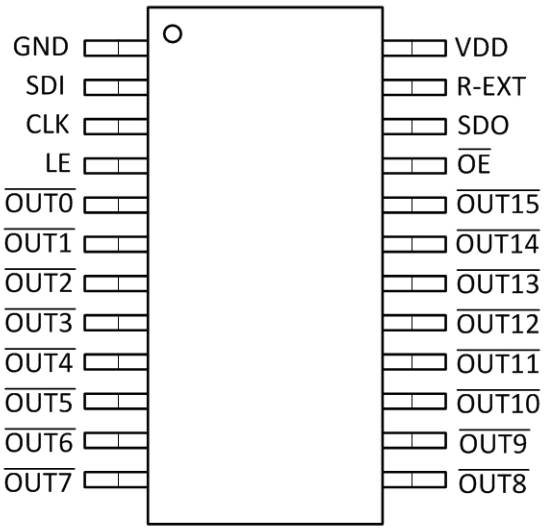
4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (March 2013) to Revision B	Page
• Added *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section	1
• Deleted the *Ordering Information* table	1

5 Pin Configuration and Functions

DBQ Package
24-Pin SSOP
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
CLK	3	I	Clock input for data shift on rising edge
GND	1	—	Ground for control logic and current sink
LE	4	I	Data strobe input Serial data is transferred to the respective latch when LE is high. The data is latched when LE goes low. LE has an internal pulldown resistor.
$\overline{OE}$	21	I	Output enable When $\overline{OE}$ is active (low), the output drivers are enabled. When $\overline{OE}$ is high, all output drivers are turned OFF (blanked). $\overline{OE}$ has an internal pullup resistor.
$\overline{OUT0}$	5	O	Constant-current output
$\overline{OUT1}$	6	O	Constant-current output
$\overline{OUT2}$	7	O	Constant-current output
$\overline{OUT3}$	8	O	Constant-current output
$\overline{OUT4}$	9	O	Constant-current output
$\overline{OUT5}$	10	O	Constant-current output
$\overline{OUT6}$	11	O	Constant-current output
$\overline{OUT7}$	12	O	Constant-current output
$\overline{OUT8}$	13	O	Constant-current output
$\overline{OUT9}$	14	O	Constant-current output
$\overline{OUT10}$	15	O	Constant-current output
$\overline{OUT11}$	16	O	Constant-current output
$\overline{OUT12}$	17	O	Constant-current output
$\overline{OUT13}$	18	O	Constant-current output
$\overline{OUT14}$	19	O	Constant-current output
$\overline{OUT15}$	20	O	Constant-current output
R-EXT	23	I	Input used to connect an external resistor (R_{ext}) for setting output currents

Pin Functions (continued)

PIN		I/O	DESCRIPTION
NAME	NO.		
SDI	2	I	Serial-data input to the Shift register
SDO	22	O	Serial-data output to the following SDI of next driver IC or to the microcontroller
VDD	24	—	Supply voltage

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

		MIN	MAX	UNIT
V_{DD}	Supply voltage	0	7	V
V_I	Input voltage	–0.4	V_{DD} + 0.4	V
V_O	Output voltage	–0.5	20	V
I_{OUT}	Output current		45	mA
I_{GND}	GND terminal current		750	mA
T_J	Operating virtual-junction temperature	–40	150	°C
T_{stg}	Storage temperature	–55	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±1000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 (2)	±500	

(1) JEDEC document JEP155 states that 500 V HBM allows safe manufacturing with a standard ESD control process. Pins listed as ±1000 V may actually have higher performance.
(2) JEDEC document JEP157 states that 250 V CDM allows safe manufacturing with a standard ESD control process. Pins listed as ±500 V may actually have higher performance.

6.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{DD}	Supply voltage		3	5.5	V
V_O	Output voltage			17	V
V_{IH}	Input voltage		0.7 × V_{DD}	V_{DD} + 0.4	V
V_{IL}	Output voltage		GND	0.3 × V_{DD}	V
I_{OUT}	Output current	V_O ≥ 0.6 V	3		mA
		V_O ≥ 1.0 V		45	mA
I_{OH}	High-level output current, source		–1		mA
I_{OL}	Low-level output current, sink		1		mA
T_A	Operating free-air temperature		–40	125	°C

6.4 Thermal Information

THERMAL METRIC (1)			TLC59025 DBQ (SSOP) 24 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	Mounted on JEDEC 1-layer board (JESD 51-3), No airflow	99.8	°C/W
		Mounted on JEDEC 4-layer board (JESD 51-7), No airflow	61	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics for 3-V Input Voltage

V_{DD} = 3 V, T_J = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
I_{leak}	Output leakage current	V_{OH} = 17 V	T_J = 25°C			0.5	µA
			T_J = 125°C			2	
V_{OH}	High-level output voltage	SDO, I_{OL} = –1 mA		V_{DD} – 0.4			V
V_{OL}	Low-level output voltage	SDO, I_{OH} = 1 mA				0.4	V
$I_{O(1)}$	Output current 1	V_{OUT} = 0.6 V, R_{ext} = 1440 Ω			13		mA
	Output current error, die-die	I_{OL} = 13 mA, V_O = 0.6 V, R_{ext} = 1440 Ω, T_J = 25°C			±3%	±6%	
	Output current error, channel-to-channel	I_{OL} = 13 mA, V_O = 0.6 V, R_{ext} = 1440 Ω, T_J = 25°C			±1.5%	±5%	
$I_{O(2)}$	Output current 2	V_O = 0.8 V, R_{ext} = 720 Ω			26		mA
	Output current error, die-die	I_{OL} = 26 mA, V_O = 0.8 V, R_{ext} = 720 Ω, T_J = 25°C			±3%	±6%	
	Output current error, channel-to-channel	I_{OL} = 26 mA, V_O = 0.8 V, R_{ext} = 720 Ω, T_J = 25°C			±1.5%	±5%	
I_{OUT} vs V_{OUT}	Output current vs output voltage regulation	V_O = 1 V to 3 V, I_O = 13 mA			±0.1		%/V
		V_{DD} = 3.0 V to 5.5 V, I_O = 13 mA to 45 mA			±1		
	Pullup resistance	$\overline{OE}$			500		kΩ
	Pulldown resistance	LE			500		kΩ
T_{sd}	Overtemperature shutdown (1)			150	175	200	°C
T_{hys}	Restart temperature hysteresis				15		°C
I_{DD}	Supply current	R_{ext} = Open			7	10	mA
		R_{ext} = 1440 Ω			9	12	
		R_{ext} = 720 Ω			11	13	
C_{IN}	Input capacitance	V_I = V_{DD} or GND, CLK, SDI, SDO, $\overline{OE}$				10	pF

(1) Specified by design

6.6 Electrical Characteristics for 5.5-V Input Voltage

V_{DD} = 5.5 V, T_J = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
I_{leak}	Output leakage current	V_{OH} = 17 V	T_J = 25°C			0.5	µA
			T_J = 125°C			2	
V_{OH}	High-level output voltage	SDO, I_{OL} = –1 mA		V_{DD} – 0.4			V
V_{OL}	Low-level output voltage	SDO, I_{OH} = 1 mA				0.4	V
$I_{O(1)}$	Output current 1	V_{OUT} = 0.6 V, R_{ext} = 1440 Ω			13		mA
	Output current error, die-die	I_{OL} = 13 mA, V_O = 0.6 V, R_{ext} = 1440 Ω, T_J = 25°C			±3%	±6%	
	Output current error, channel-to-channel	I_{OL} = 13 mA, V_O = 0.6 V, R_{ext} = 1440 Ω, T_J = 25°C			±1.5%	±5%	
$I_{O(2)}$	Output current 2	V_O = 0.8 V, R_{ext} = 720 Ω			26		mA
	Output current error, die-die	I_{OL} = 26 mA, V_O = 0.8 V, R_{ext} = 720 Ω, T_J = 25°C			±3%	±6%	
	Output current error, channel-to-channel	I_{OL} = 26 mA, V_O = 0.8 V, R_{ext} = 720 Ω, T_J = 25°C			±1.5%	±5%	
I_{OUT} vs V_{OUT}	Output current vs output voltage regulation	V_O = 1 V to 3 V , I_O = 26 mA			±0.1		%/V
		V_{DD} = 3.0 V to 5.5 V, I_O = 13 mA to 45 mA			±1		
	Pullup resistance	$\overline{OE}$			500		kΩ
	Pulldown resistance	LE			500		kΩ
T_{sd}	Overtemperature shutdown (1)			150	175	200	°C
T_{hys}	Restart temperature hysteresis				15		°C
I_{DD}	Supply current	R_{ext} = Open			9	11	mA
		R_{ext} = 1440 Ω			12	14	
		R_{ext} = 720 Ω			14	16	
C_{IN}	Input capacitance	V_I = V_{DD} or GND, CLK, SDI, SDO, $\overline{OE}$				10	pF

(1) Specified by design

6.7 Power Dissipation Ratings

				MIN	MAX	UNIT
P_D	Power dissipation	Mounted on JEDEC 4-layer board (JESD 51-7), No airflow, T_A = 25°C, T_J = 125°C	DBQ package		1.6	W

6.8 Timing Requirements

V_{DD} = 3 V to 5.5 V (unless otherwise noted)

			MIN	MAX	UNIT
$t_{w(L)}$	LE pulse duration		15		ns
$t_{w(CLK)}$	CLK pulse duration		15		ns
$t_{w(OE)}$	$\overline{OE}$ pulse duration		300		ns
$t_{su(D)}$	Setup time for SDI		3		ns
$t_{h(D)}$	Hold time for SDI		2		ns
$t_{su(L)}$	Setup time for LE		5		ns
$t_{h(L)}$	Hold time for LE		5		ns
f_{CLK}	Clock frequency	Cascade operation		30	MHz

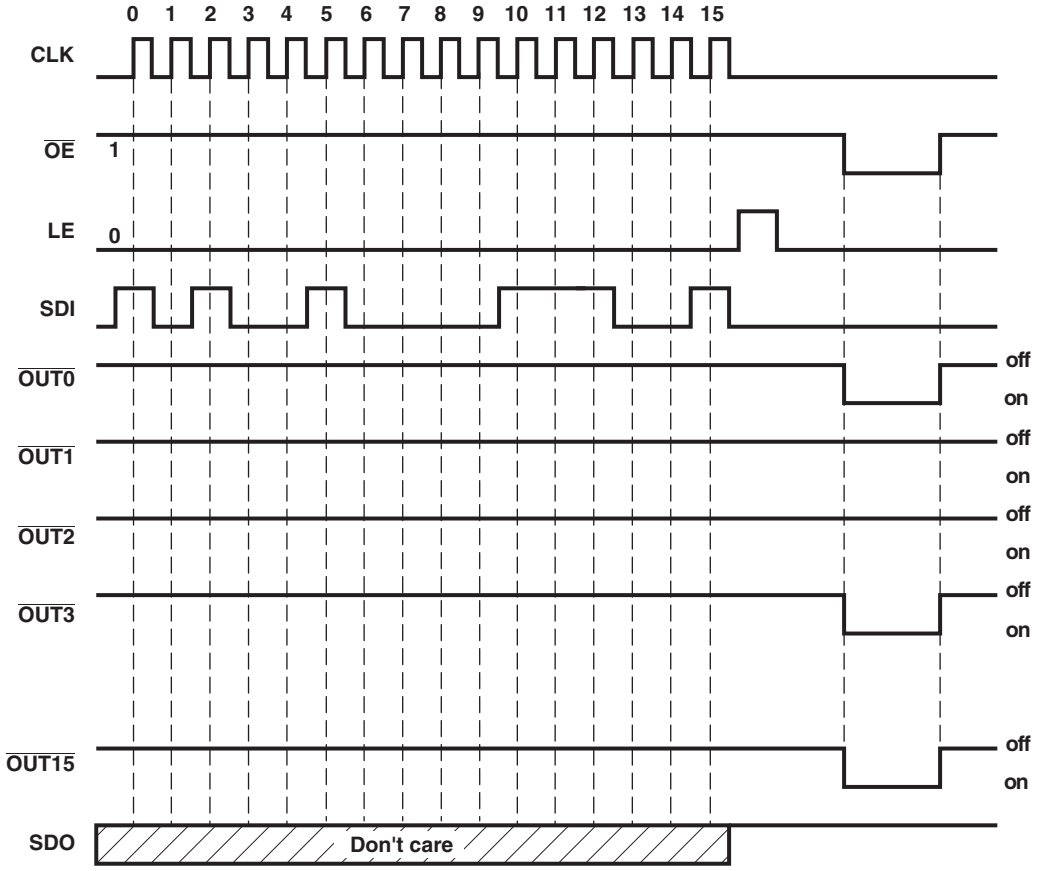


Figure 1. Timing Diagram

6.9 Switching Characteristics for 3-V Input Voltage

V_{DD} = 3 V, T_J = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH1}	Low-to-high propagation delay time, CLK to $\overline{OUTn}$	$V_{IH} = V_{DD}$, V_{IL} = GND, R_{ext} = 720 Ω, V_L = 4 V, R_L = 88 Ω, C_L = 10 pF	30	45	60	ns
t_{PLH2}	Low-to-high propagation delay time, LE to $\overline{OUTn}$		30	45	60	ns
t_{PLH3}	Low-to-high propagation delay time, $\overline{OE}$ to $\overline{OUTn}$		30	45	60	ns
t_{PLH4}	Low-to-high propagation delay time, CLK to SDO			30	40	ns
t_{PHL1}	High-to-low propagation delay time, CLK to $\overline{OUTn}$		40	65	100	ns
t_{PHL2}	High-to-low propagation delay time, LE to $\overline{OUTn}$		40	65	100	ns
t_{PHL3}	High-to-low propagation delay time, $\overline{OE}$ to $\overline{OUTn}$		40	65	100	ns
t_{PHL4}	High-to-low propagation delay time, CLK to SDO			30	40	ns
$t_{w(CLK)}$	Pulse duration, CLK		15			ns
$t_{w(L)}$	Pulse duration LE		15			ns
$t_{w(OE)}$	Pulse duration, $\overline{OE}$		300			ns
$t_{h(D)}$	Hold time, SDI		2			ns
$t_{su(D)}$	Setup time, SDI		3			ns
$t_{h(L)}$	Hold time, LE		5			ns
$t_{su(L)}$	Setup time, LE		5			ns
t_r	Rise time, CLK (1)				500	ns
t_f	Fall time, CLK (1)				500	ns
t_{or}	Rise time, outputs (off)		35	50	70	ns
t_{of}	Rise time, outputs (on)		15	50	120	ns
f_{CLK}	Clock frequency	Cascade operation			30	MHz

(1) If the devices are connected in cascade and t_r or t_f is large, it may be critical to achieve the timing required for data transfer between two cascaded devices.

6.10 Switching Characteristics for 5.5-V Input Voltage

V_{DD} = 5.5 V, T_J = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH1}	Low-to-high propagation delay time, CLK to $\overline{OUTn}$	V_{IH} = V_{DD}, V_{IL} = GND, R_{ext} = 720 Ω, V_L = 4 V, R_L = 88 Ω, C_L = 10 pF	20	35	55	ns
t_{PLH2}	Low-to-high propagation delay time, LE to $\overline{OUTn}$		20	35	55	ns
t_{PLH3}	Low-to-high propagation delay time, $\overline{OE}$ to $\overline{OUTn}$		20	35	55	ns
t_{PLH4}	Low-to-high propagation delay time, CLK to SDO			20	30	ns
t_{PHL1}	High-to-low propagation delay time, CLK to $\overline{OUTn}$		15	28	42	ns
t_{PHL2}	High-to-low propagation delay time, LE to $\overline{OUTn}$		15	28	42	ns
t_{PHL3}	High-to-low propagation delay time, $\overline{OE}$ to $\overline{OUTn}$		15	28	42	ns
t_{PHL4}	High-to-low propagation delay time, CLK to SDO			20	30	ns
$t_{w(CLK)}$	Pulse duration, CLK		10			ns
$t_{w(L)}$	Pulse duration LE		10			ns
$t_{w(OE)}$	Pulse duration, $\overline{OE}$		200			ns
$t_{h(D)}$	Hold time, SDI		2			ns
$t_{su(D)}$	Setup time, SDI		3			ns
$t_{h(L)}$	Hold time, LE		5			ns
$t_{su(L)}$	Setup time, LE		5			ns
t_r	Rise time, CLK (1)				500	ns
t_f	Fall time, CLK (1)				500	ns
t_{or}	Rise time, outputs (off)		25	45	65	ns
t_{of}	Rise time, outputs (on)		7	12	20	ns
f_{CLK}	Clock frequency	Cascade operation			30	MHz

(1) If the devices are connected in cascade and t_r or t_f is large, it may be critical to achieve the timing required for data transfer between two cascaded devices.

6.11 Typical Characteristics

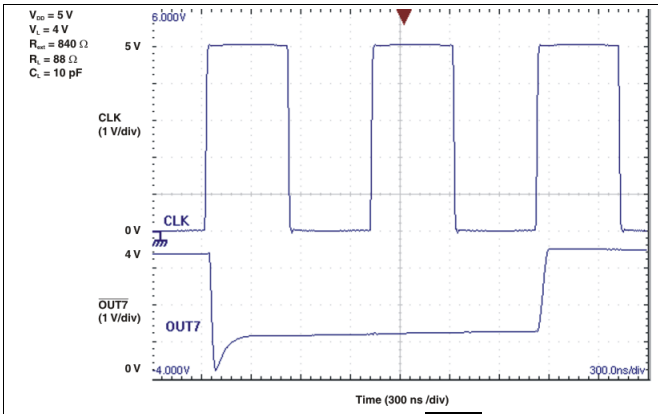


Figure 2. CLK to $\overline{OUT7}$

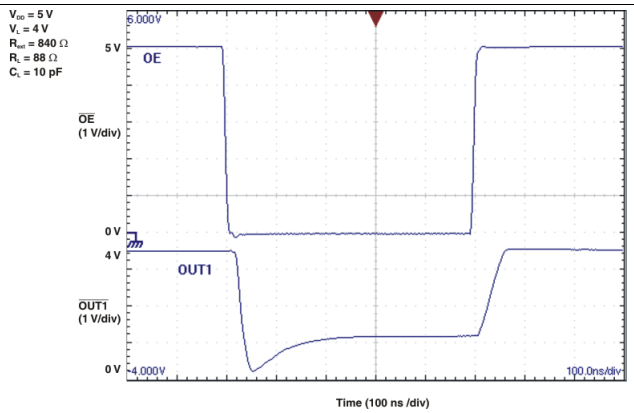


Figure 3. $\overline{OE}$ to $\overline{OUT1}$

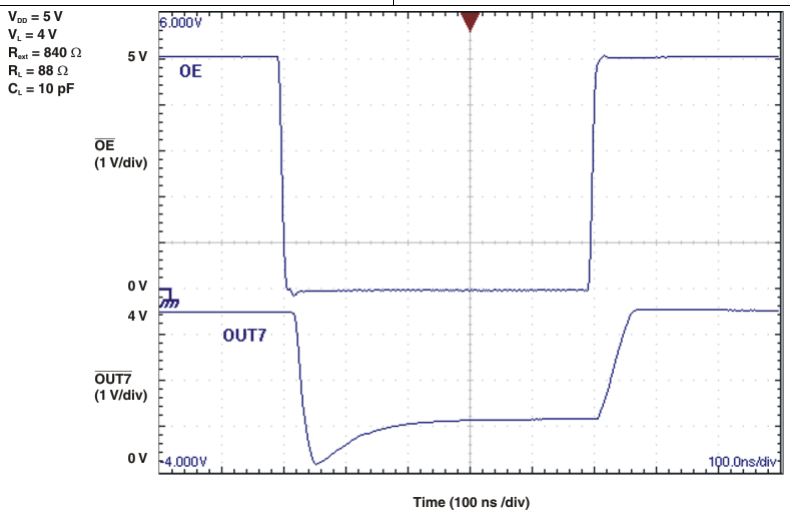


Figure 4. $\overline{OE}$ to $\overline{OUT7}$

7 Parameter Measurement Information

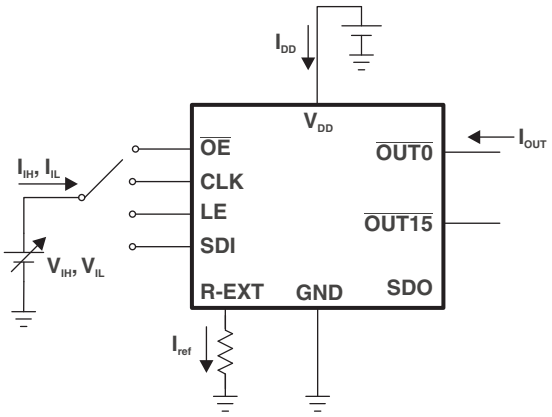


Figure 5. Test Circuit for Electrical Characteristics

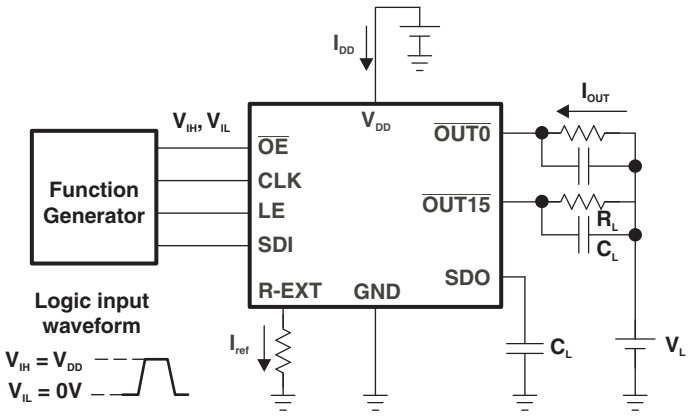


Figure 6. Test Circuit for Switching Characteristics

Parameter Measurement Information (continued)

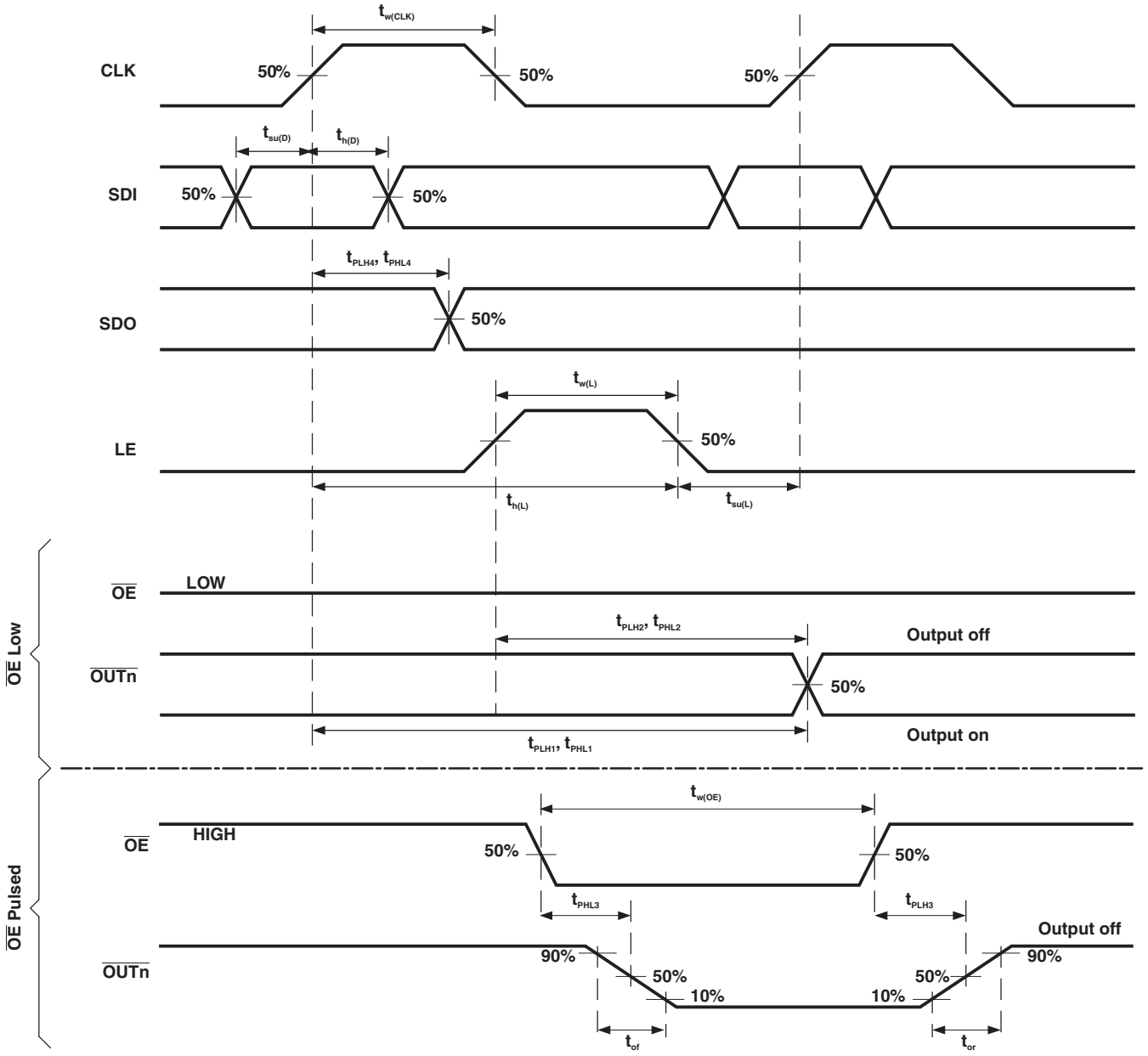


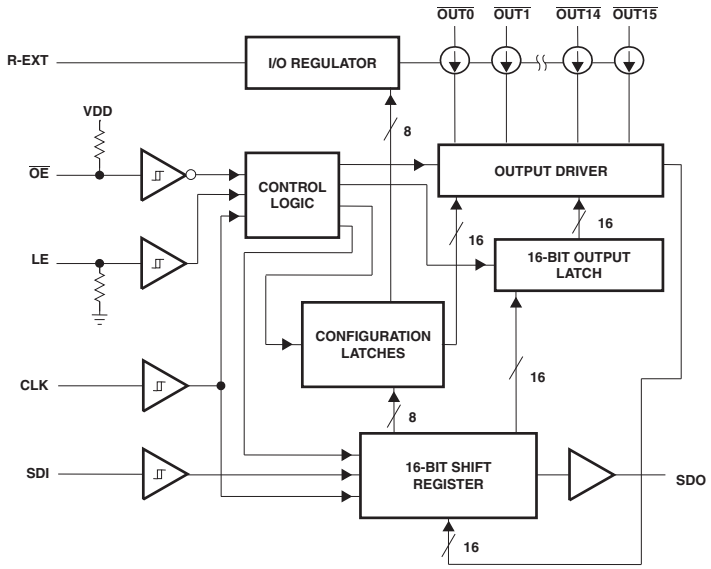
Figure 7. Normal Mode Timing Waveforms

8 Detailed Description

8.1 Overview

The TLC59025 is a 16-channel LED driver designed for LED displays and LED lighting applications. The TLC59025 contains a 16-bit shift register and data latches, which convert serial input data into parallel output format. At the TLC59025 output stage, 16 regulated-current ports provide uniform and constant current for driving LEDs within a wide range of VF variations. Used in system design for LED display applications (for example, LED panels), the TLC59025 provides great flexibility and device performance. Users can adjust the output current from 3 mA to 45 mA through an external resistor, R_{EXT}, which gives flexibility in controlling the light intensity of LEDs. TLC59025 is designed for up to 17 V at the output port. The high clock frequency, 30 MHz, also satisfies the system requirements of high-volume data transmission.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Constant Current

In LED display applications, TLC59025 provides nearly no current variations from channel to channel and from IC to IC. While $I_{OUT} \leq 45$ mA, the maximum current skew between channels is less than ±5% and between ICs is less than ±6%.

8.4 Device Functional Modes

Table 1 lists the functional modes for the TLC59025.

Table 1. Truth Table in Normal Operation

CLK	LE	$\overline{OE}$	SDI	$\overline{OUT0}$...$\overline{OUT15}$...$\overline{OUT15}$	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

9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

9.1.1 Turning on the LEDs

To turn on an LED connected to one of the outputs of the device, the output must be pulled low. To do this, the SDI signal must let the device know which outputs should be activated. Using the rising edge of CLK, the logic level of the SDI signal latches the desired state of each output into the shift register. Once this is complete, the LE signal must be toggled from low to high then back to low. Once /OE is pulled down, the corresponding outputs will be pulled low and the LEDs will be turned on. The below diagram shows outputs 0, 3, 4, 5, 10, 13, and 15 being activated.

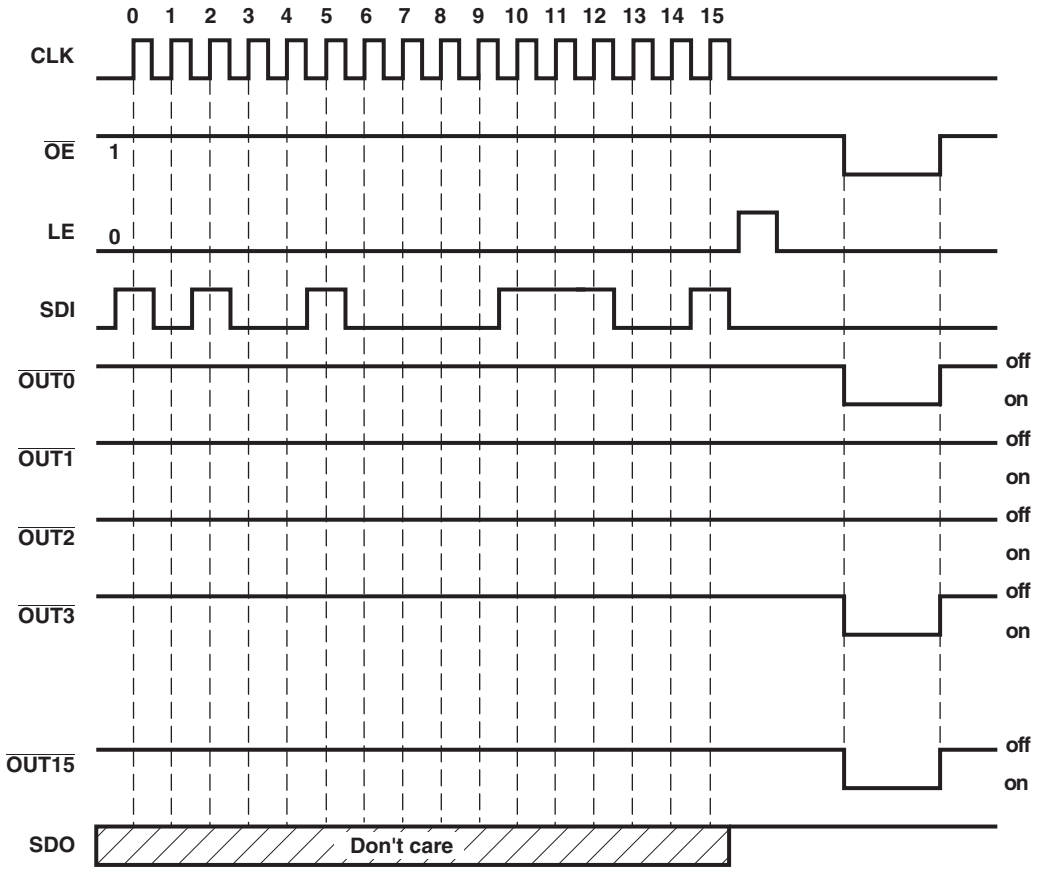


Figure 8. Timing Diagram

9.2 Typical Application

This application shows how to calculate the output current for $\overline{OUT0}$ through $\overline{OUT15}$.

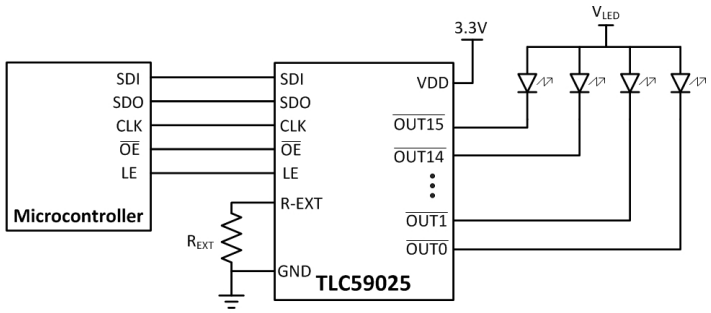


Figure 9. Typical Application Diagram

9.2.1 Design Requirements

For the following design procedure, the input voltage (V_{DD}) is between 3 V and 5.5 V.

9.2.2 Detailed Design Procedure

9.2.2.1 Adjusting Output Current

TLC59025 sets I_{OUT} based on the external resistor R_{EXT}. Users can follow the below formula to calculate the target output current $I_{OUT,target}$ in the saturation region:

$I_{OUT,target} = (1.21\ V / R_{EXT}) \times 15.5$

Where R_{EXT} is the external resistance connected between R-EXT and GND. Using this equation, the output current is calculated to be approximately 26 mA at 720 Ω and 13 mA at 1440 Ω.

9.2.3 Application Curve

The default relationship after power on between $I_{OUT,target}$ and R_{EXT} is shown in Figure 10.

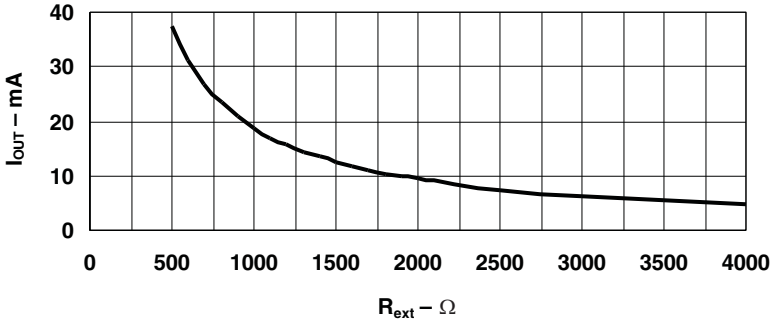


Figure 10. Default Relationship Curve Between $I_{OUT,target}$ and R_{ext} After Power Up

10 Power Supply Recommendations

The TLC59025 is designed to operate with a VDD range between 3 V and 5.5 V.

11 Layout

11.1 Layout Guidelines

The SDI, CLK, SDO, LE, and $\overline{OE}$ signals should all be kept from potential noise sources.

All traces carrying power through the LEDs should be wide enough to handle necessary currents.

All LED current passes through the device and into the ground node. There must be a strong connection between the device ground and the circuit board ground.

11.2 Layout Example

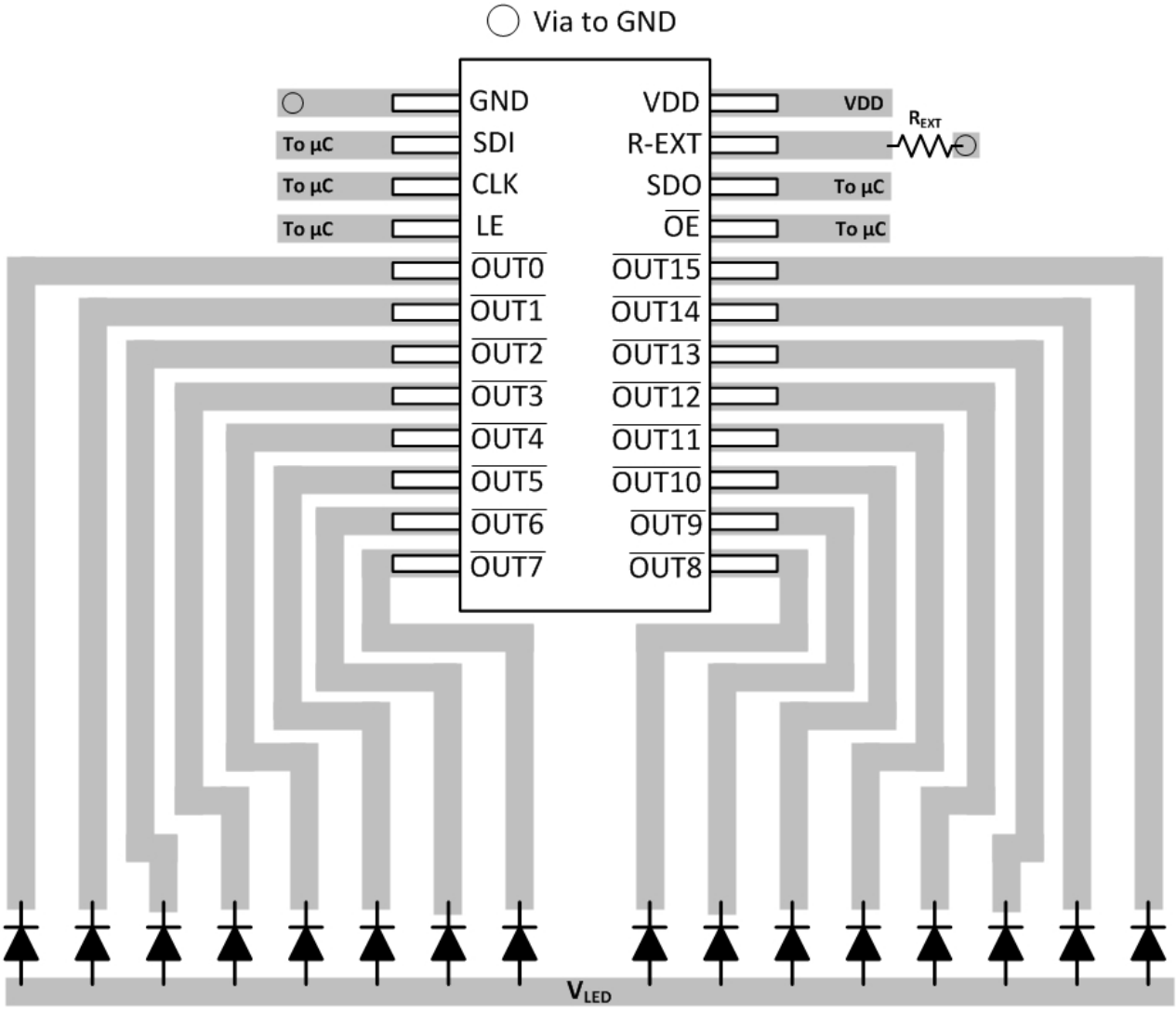


Figure 11. Layout Recommendation

12 Device and Documentation Support

12.1 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.2 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

12.3 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

12.4 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLC59025IDBQR	ACTIVE	SSOP	DBQ	24	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	TLC59025I	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

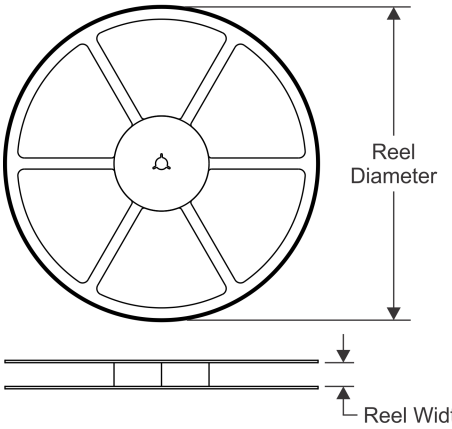
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

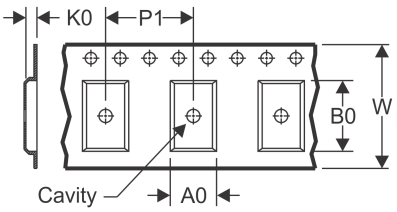
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

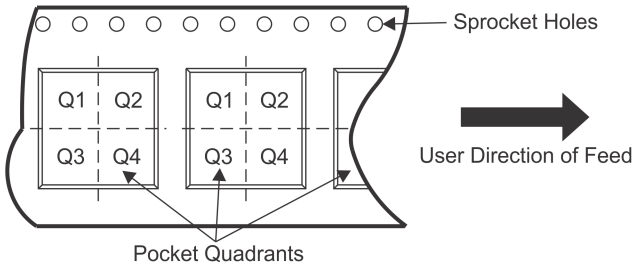


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

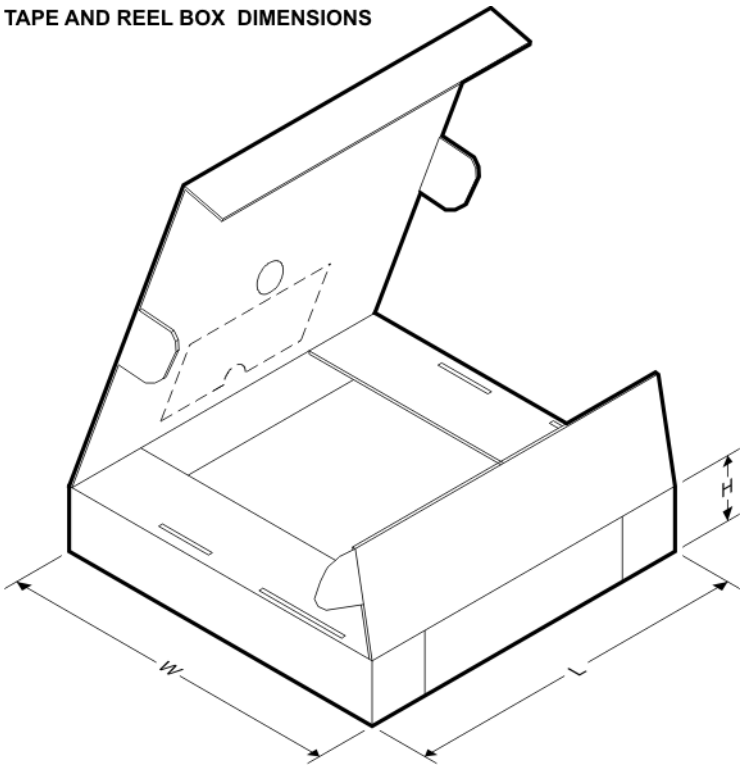
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLC59025IDBQR	SSOP	DBQ	24	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

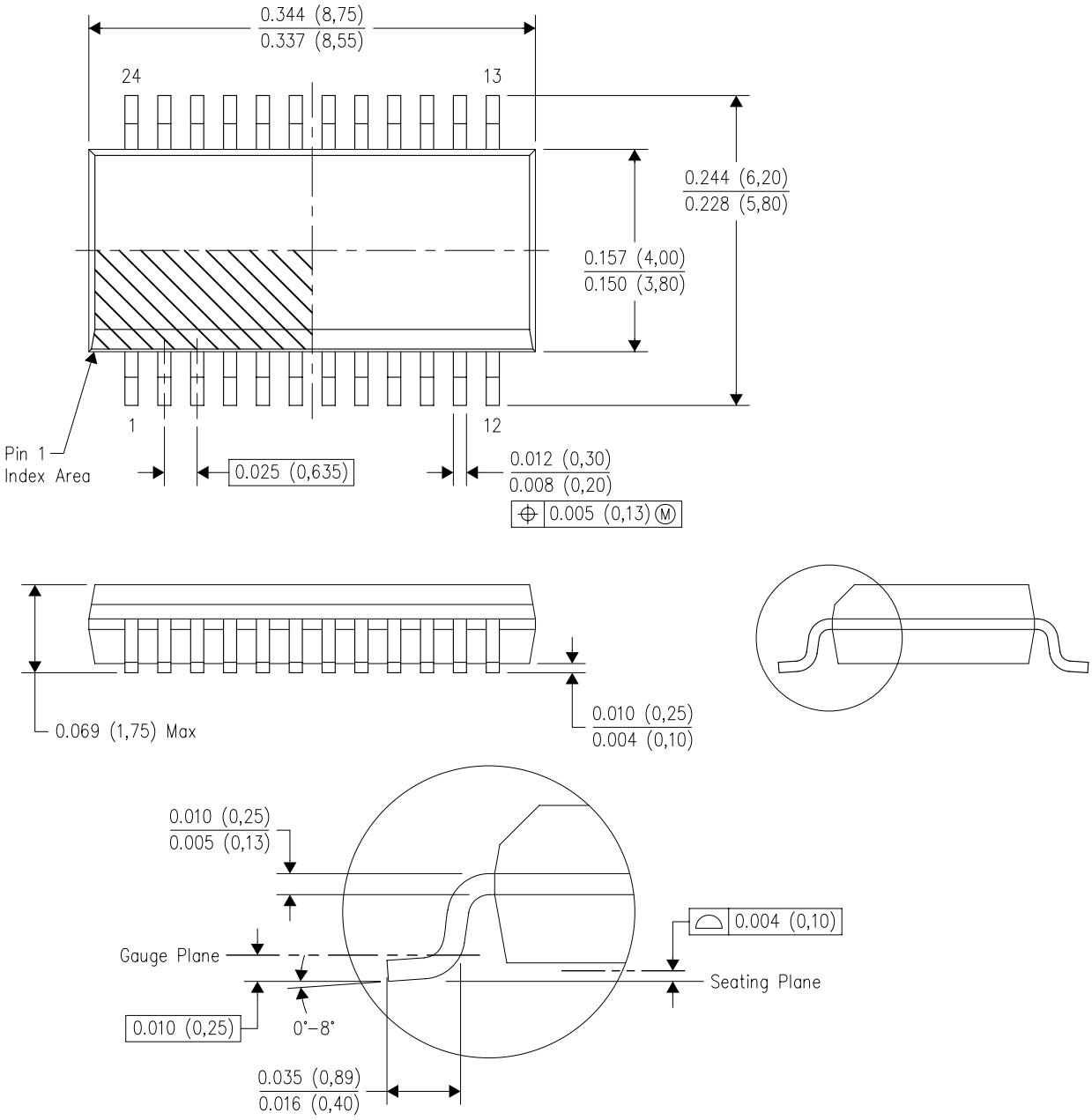
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

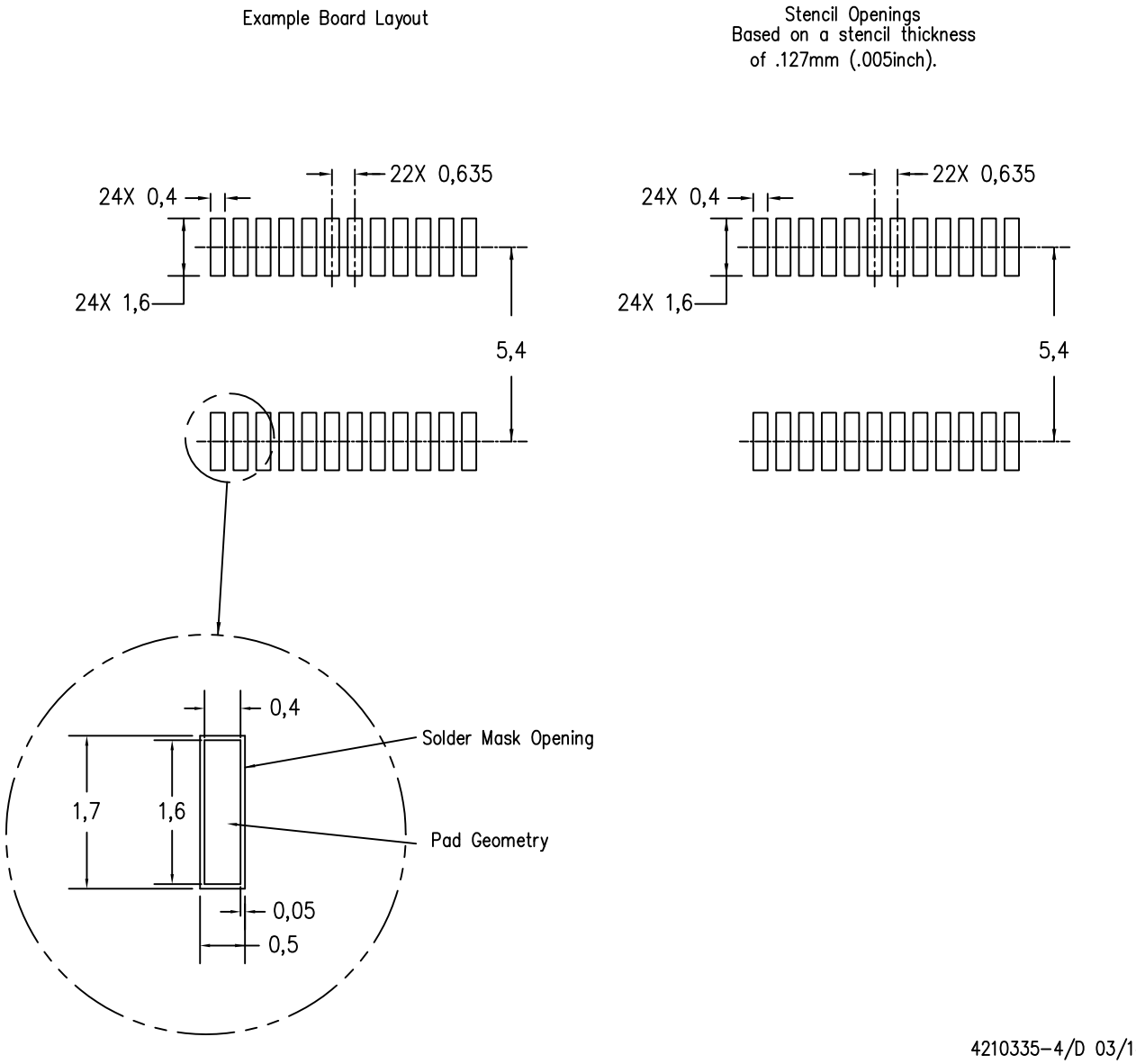
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLC59025IDBQR	SSOP	DBQ	24	2500	367.0	367.0	38.0

DBQ (R–PDSO–G24) PLASTIC SMALL–OUTLINE PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15) per side.
D. Falls within JEDEC MO–137 variation AE.

DBQ (R–PDSO–G24) PLASTIC SMALL OUTLINE PACKAGE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC–7525 for other stencil recommendations.

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