TLC6C598 8-Bit Shift-Register LED Driver

1 Features

- Wide V_{CC} From 3 V to 5.5 V
- Output Maximum Rating of 40 V
- Eight Power DMOS Transistor Outputs of 50-mA Continuous Current With V_{CC} = 5 V or 200-mA PWM Current With Single-Pulse Duration Less Than 1 ms and Average Current Less Than 50 mA
- Thermal Shutdown Protection
- Enhanced Cascading for Multiple Stages
- All Registers Cleared With Single Input
- Low Power Consumption
- Slow Switching Time (t_r and t_f), Which Helps Significantly With Reducing EMI
- 16-Pin TSSOP-PW Package

2 Applications

- Appliance Display Panel
- Elevator Display Panel
- PLC Function Indicator
- Seven-Segment Display

3 Description

The TLC6C598 device is a monolithic, medium-voltage, low-current power 8-bit shift register designed for use in systems that require relatively moderate load power, such as LEDs.

This device contains an 8-bit serial-in, parallel-out shift register that feeds an 8-bit D-type storage register. Separate clocks are provided for both the shift and storage register. Outputs are low-side, open-drain DMOS transistors with output ratings of 40 V and 50 mA continuous sink-current OR 200-mA PWM current with single-pulse duration less than 1 ms and average current less than 50 mA capabilities when V_{CC} = 5 V. The device contains built-in thermal shutdown protection and provides up to 2000 V of ESD protection when tested using the human-body model and the 200 V machine model.

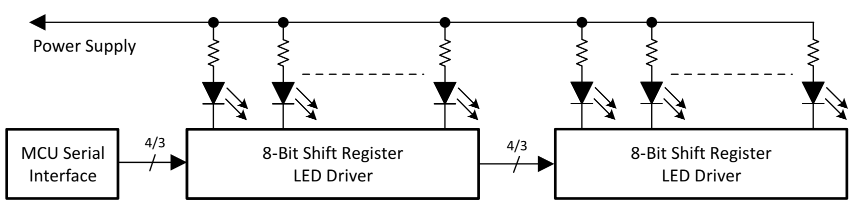
The TLC6C598 characterization is for operation over the operating ambient temperature range of −40°C to 105°C.

Device Information(1)

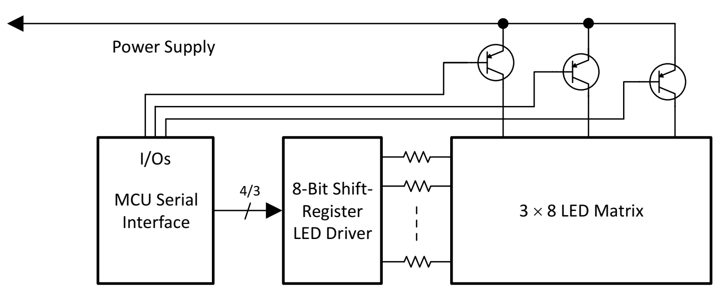
PART NUMBER	PACKAGE	BODY SIZE (NOM)
TLC6C598	TSSOP (16)	5.00 mm x 4.40 mm

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

Typical Application Schematic



Typical Cascade Topology



Typical Scan Topology

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4 Revision History

DATE	REVISION	NOTE
May 2016	*	Initial release

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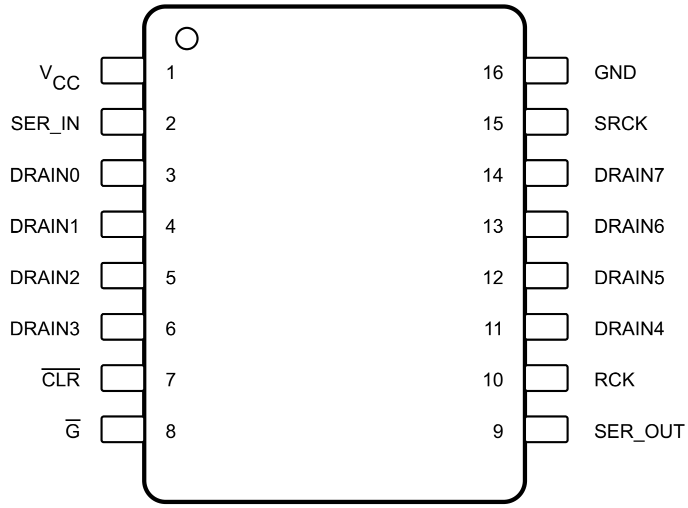
5 Pin Configuration and Functions

PW Package
16-Pin TSSOP
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
$\overline{CLR}$	7	I	Shift register clear, active-low. The storage register transfers data to the output buffer when $\overline{CLR}$ is high. Driving $\overline{CLR}$ low clears all the registers in the device.
DRAIN0	3	O	Open-drain output, LED current-sink channel, connect to LED cathode
DRAIN1	4	O	Open-drain output, LED current-sink channel, connect to LED cathode
DRAIN2	5	O	Open-drain output, LED current-sink channel, connect to LED cathode
DRAIN3	6	O	Open-drain output, LED current-sink channel, connect to LED cathode
DRAIN4	11	O	Open-drain output, LED current-sink channel, connect to LED cathode
DRAIN5	12	O	Open-drain output, LED current-sink channel, connect to LED cathode
DRAIN6	13	O	Open-drain output, LED current-sink channel, connect to LED cathode
DRAIN7	14	O	Open-drain output, LED current-sink channel, connect to LED cathode
$\overline{G}$	8	I	Output enable, active-low. LED-channel enable and disable input pin. Having $\overline{G}$ low enables all drain channels according to the output-latch register content. When high, all channels are off.
GND	16	—	Power ground, the ground reference pin for the device. This pin must connect to the ground plane on the PCB.
RCK	10	I	Register clock. The data in each shift register stage transfers to the storage register at the rising edge of RCK.
SER IN	2	I	Serial data input. Data on SER IN loads into the internal register on each rising edge of SRCK.
SER OUT	9	O	Serial data output of the 8-bit serial shift register. The purpose of this pin is to cascade several devices on the serial bus.
SRCK	15	I	Serial clock input. On each rising SRCK edge, data transfers from SER IN to the internal serial shift registers.
V_{CC}	1	I	Power supply pin for the device. TI recommends adding a 0.1-µF ceramic capacitor close to the pin.

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6 Specifications

6.1 Absolute Maximum Ratings

over operating ambient temperature range (unless otherwise noted)[1]

		MIN	MAX	UNIT
V_{CC}	Logic supply voltage	–0.3	8	V
V_I	Logic input-voltage range	–0.3	8	V
V_{DS}	Power DMOS drain-to-source voltage	–0.3	42	V
	Continuous total dissipation	See *Thermal Information*		
T_J	Operating junction temperature range	–40	125	°C
T_{stg}	Storage temperature range	–55	165	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and 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 AEC Q100-002[1]		±2000	V
		Charged device model (CDM), per AEC Q100-011	All pins	±750	
			Corner pins (1, 8, 9, and 16)	±750	

(1) AEC Q100-002 indicates HBM stressing is done in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

		MIN	MAX	UNIT
V_{CC}	Supply voltage	3	5.5	V
V_{IH}	High-level input voltage	2.4		V
V_{IL}	Low-level input voltage		0.7	V
T_A	Operating ambient temperature	–40	105	°C

6.4 Thermal Information

THERMAL METRIC[1]		TLC6C598 PW (TSSOP) 16 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	129.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	55.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	65.8	°C/W
ψ_{JT}	Junction-to-top characterization parameter	9.9	°C/W
ψ_{JB}	Junction-to-board characterization parameter	65.2	°C/W

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

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6.5 Electrical Characteristics

V_{CC} = 5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
	DRAIN0 to DRAIN7. Drain-to-source voltage					40	V
V_{OH}	High-level output voltage, SER OUT	I_{OH} = –20 µA	V_{CC} = 5 V	4.9	4.99		V
		I_{OH} = −4 mA		4.5	4.69		V
V_{OL}	Low-level output voltage, SER OUT	I_{OH} = 20 µA	V_{CC} = 5 V		0.001	0.01	V
		I_{OH} = 4 mA			0.25	0.4	V
I_{IH}	High-level input current	V_{CC} = 5 V, V_I = V_{CC}			0.2		µA
I_{IL}	Low-level input current	V_{CC} = 5 V, V_I = 0			–0.2		µA
I_{CC}	Logic supply current	V_{CC} = 5 V, no clock signal	All outputs off		0.1	1	µA
			All outputs on		88	160	
$I_{CC(FRQ)}$	Logic supply current at frequency	f_{SRCK} = 5 MHz, C_L = 30 pF	All outputs on		200		µA
I_{DSx}	Off-state drain current	V_{DS} = 30 V	V_{CC} = 5 V			0.1	µA
		V_{DS} = 30 V, T_C = 105°C	V_{CC} = 5 V		0.15	0.3	
$r_{DS(on)}$	Static drain-source on-state resistance	I_D = 20 mA, V_{CC} = 5 V, T_A = 25°C, Single channel ON		6	7.41	8.6	Ω
		I_D = 20 mA, V_{CC} = 5 V, T_A = 25°C, All channels ON		6.7	8.3	9.6	
		I_D = 20 mA, V_{CC} = 3.3 V, T_A = 25°C, Single channel ON		7.9	9.34	11.2	
		I_D = 20 mA, V_{CC} = 3.3 V, T_A = 25°C, All channels ON		8.7	10.25	12.3	
		I_D = 20 mA, V_{CC} = 5 V, T_A = 105°C, Single channel ON		9.1	11.13	12.9	
		I_D = 20 mA, V_{CC} = 5 V, T_A = 105°C, All channels ON		10.3	12.28	14.5	
		I_D = 20 mA, V_{CC} = 3.3 V, T_A = 105°C, Single channel ON		11.6	13.69	16.4	
		I_D = 20 mA, V_{CC} = 3.3 V, T_A = 105°C, All channels ON		12.8	14.89	18.2	
$T_{SHUTDOWN}$	Thermal shutdown trip point			150	175	200	ºC
T_{hys}	Hysteresis				15		ºC

6.6 Timing Requirements

		MIN	NOM	MAX	UNIT
t_{su}	Setup time, SER IN high before SRCK↑	15			ns
t_h	Hold time, SER IN high after SRCK↑	15			ns
t_w	SER IN pulse duration	40			ns

6.7 Switching Characteristics

V_{CC} = 5 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	Propagation delay time from $\overline{G}$ to output, low-to-high level	C_L = 30 pF, I_D = 48 mA		220		ns
t_{PHL}	Propagation delay time from $\overline{G}$ to output, high-to-low level			75		ns
t_r	Rise time, drain output			210		ns
t_f	Fall time, drain output			128		ns
t_{pd}	Propagation delay time, SRCK↓ to SER OUT	C_L = 30 pF, I_D = 48 mA		49.4		ns
t_{or}	SER OUT rise time (10% to 90%)	C_L = 30 pF		20		ns
t_{of}	SER OUT fall time (90% to 10%)	C_L = 30 pF		20		ns
$f_{(SRCK)}$	Serial clock frequency	C_L = 30 pF, I_D = 20 mA			10	MHz
t_{SRCK_WH}	SRCK pulse duration, high		30			ns
t_{SRCK_WL}	SRCK pulse duration, low		30			ns

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6.8 Timing Waveforms

Figure 1 shows the SER IN to SER OUT waveform. The output signal appears on the falling edge of the shift register clock (SRCK) because there is a phase inverter at SER OUT (see Figure 13). As a result, it takes seven and a half periods of SRCK for data to transfer from SER IN to SER OUT.

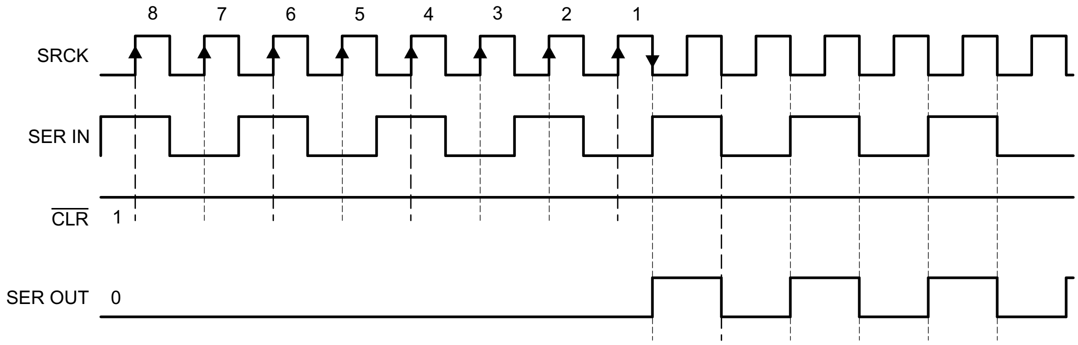

Figure 1. SER IN to SER OUT Waveform

Figure 2 shows the switching times and voltage waveforms. Tests for all these parameters took place using the test circuit shown in Figure 11.

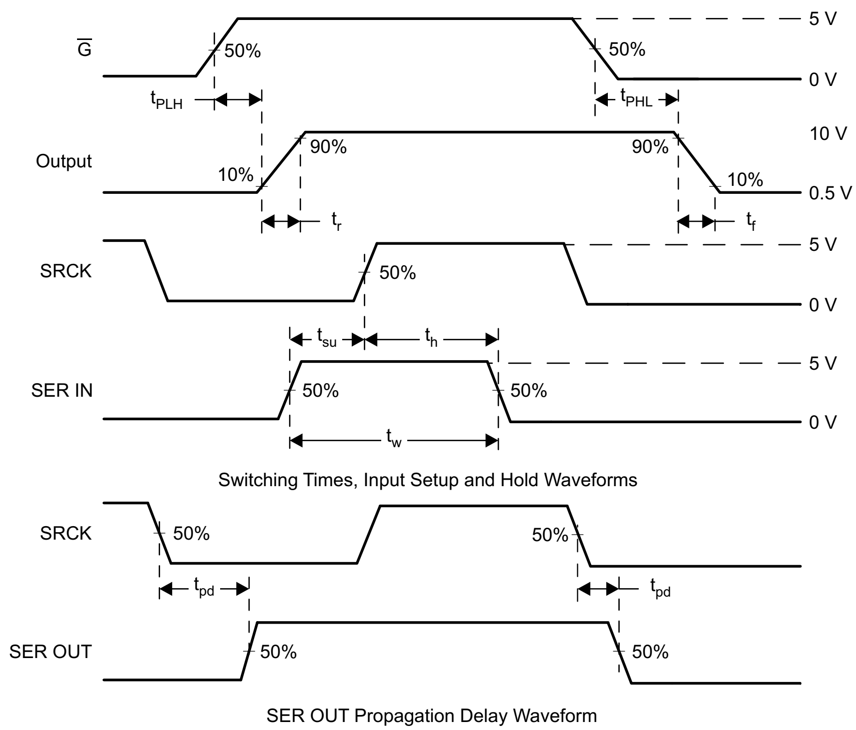

Figure 2. Switching Times and Voltage Waveforms

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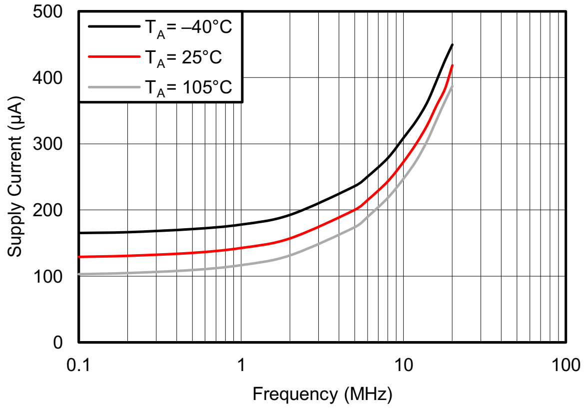
6.9 Typical Characteristics



V_{CC} = 5 V

Figure 3. Supply Current vs Frequency

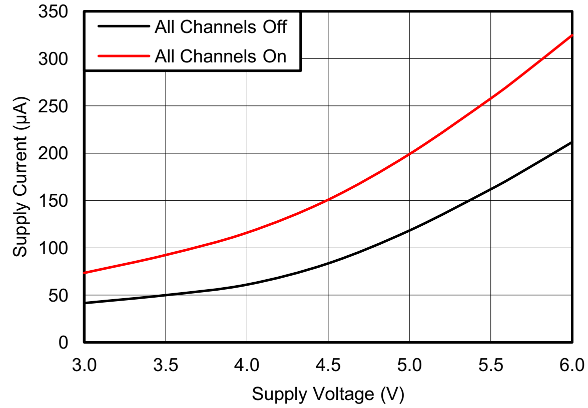
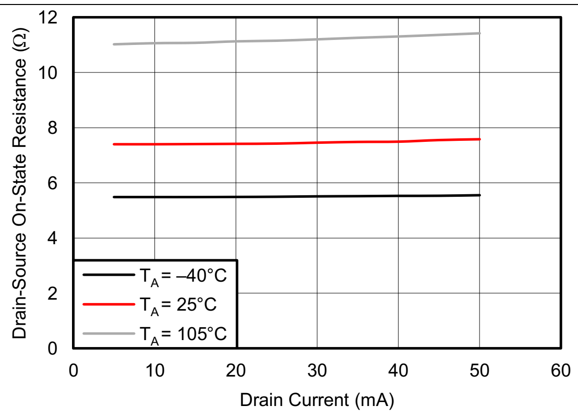
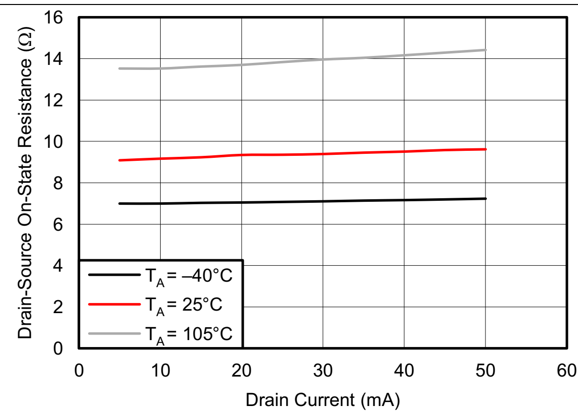


Figure 4. Supply Current vs Supply Voltage



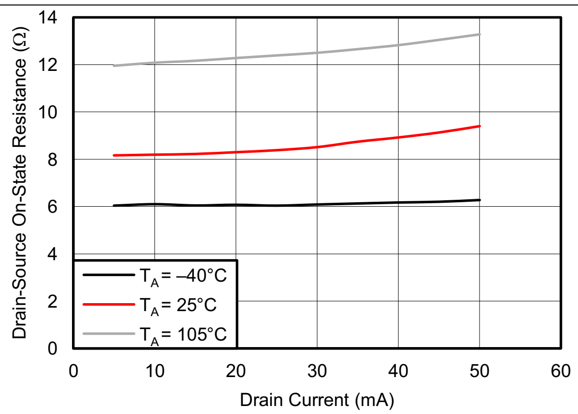
Single channel on V_{CC} = 5 V

Figure 5. Drain-to-Source On-State Resistance vs Drain Current



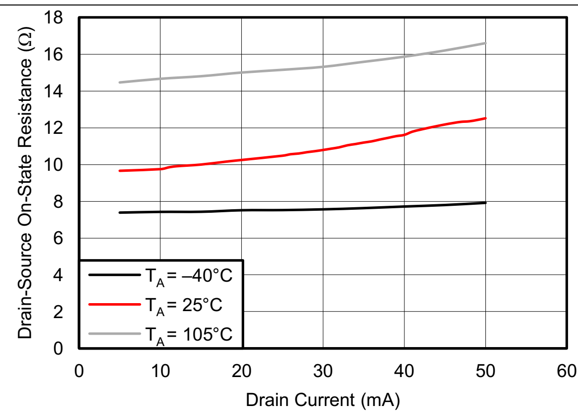
Single channel on V_{CC} = 3.3 V

Figure 6. Drain-to-Source On-State Resistance vs Drain Current



All channels on V_{CC} = 5 V

Figure 7. Drain-to-Source On-State Resistance vs Drain Current



All channels on V_{CC} = 3.3 V

Figure 8. Drain-to-Source On-State Resistance vs Drain Current

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Typical Characteristics (continued)

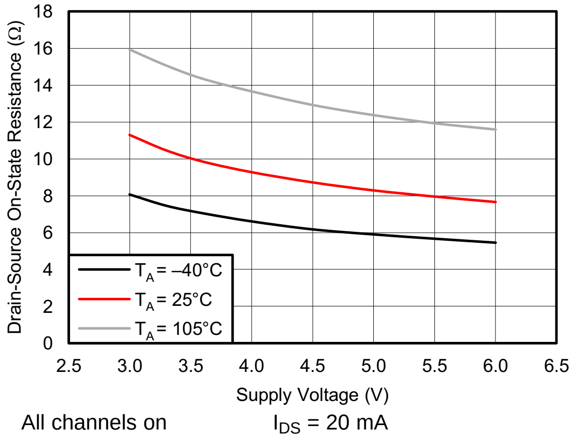


Figure 9. Drain-to-Source On-State Resistance vs Supply Voltage

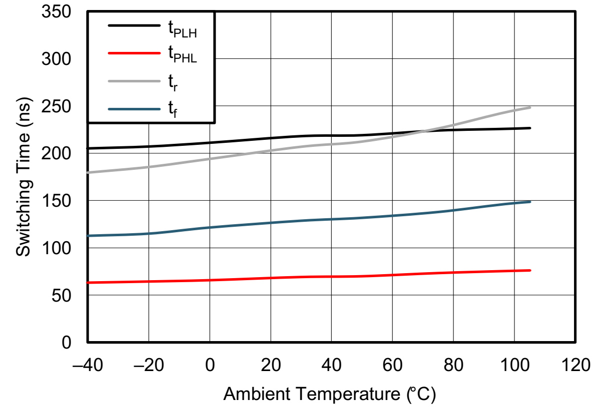
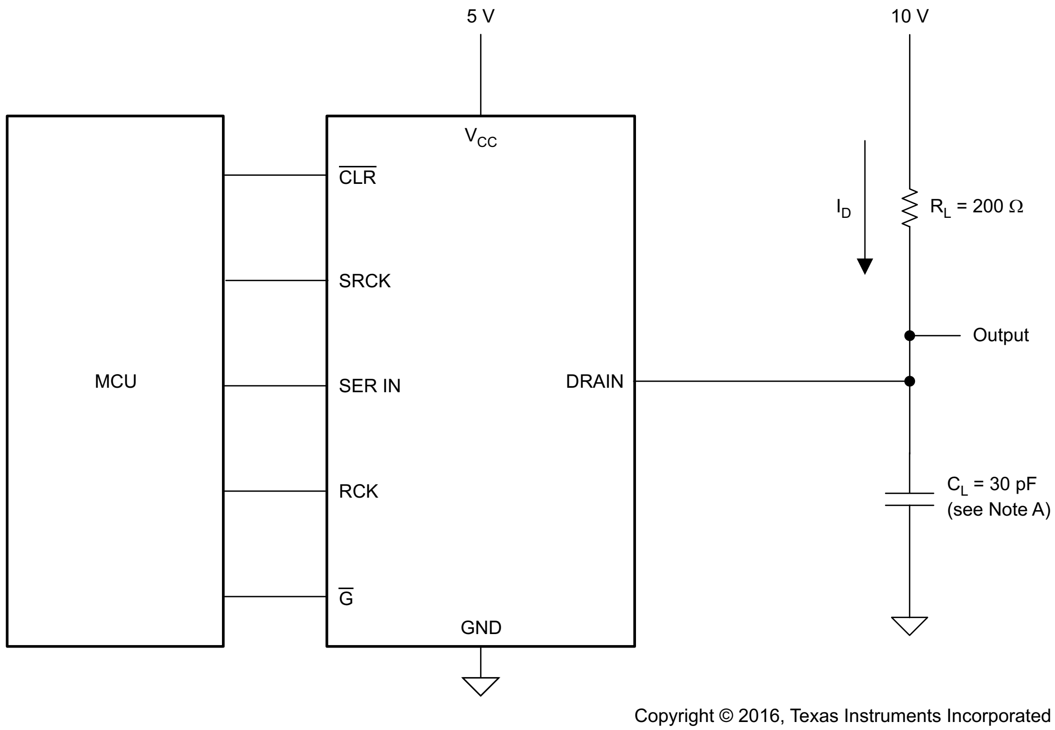


Figure 10. Switching Time vs Ambient Temperature

7 Parameter Measurement Information

Figure 11 and Figure 12 show the resistive-load test circuit and voltage waveforms. One can see from Figure 12 that with $\overline{G}$ held low and $\overline{CLR}$ held high, the status of each drain changes on the rising edge of the register clock, indicating the transfer of data to the output buffers at that time.



A. C_L includes probe and jig capacitance.

Figure 11. Resistive-Load Test Circuit

Parameter Measurement Information (continued)

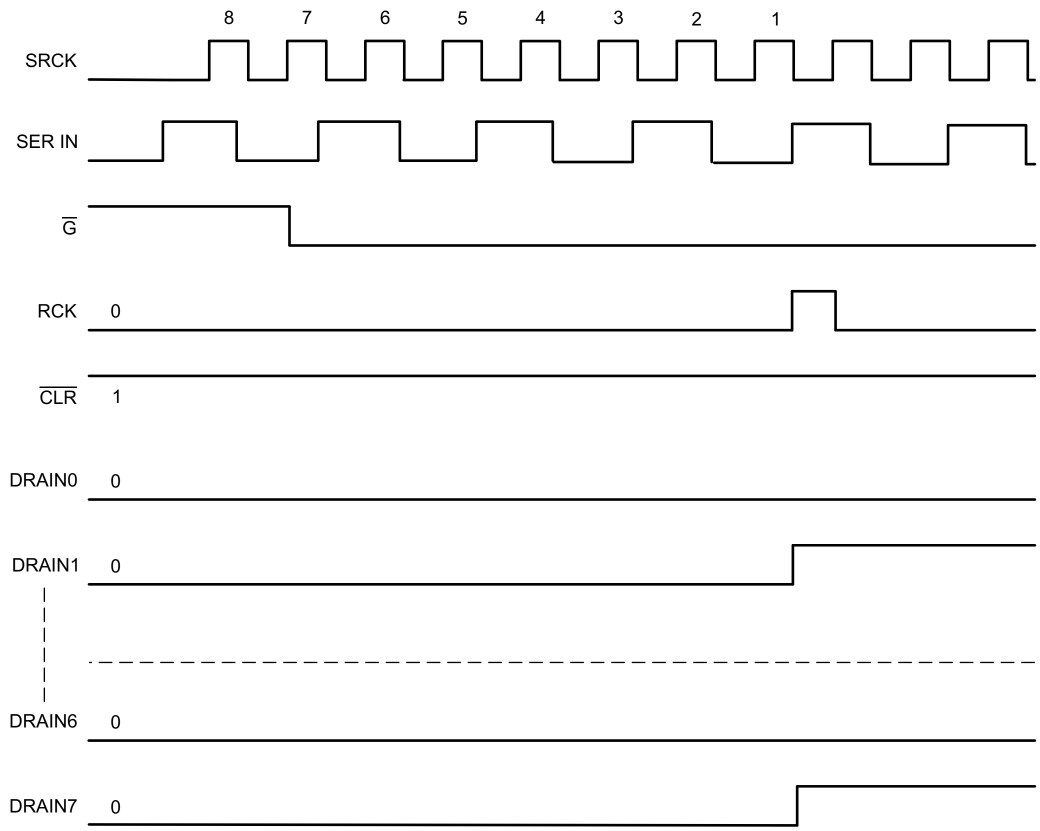


Figure 12. Voltage Waveforms

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8 Detailed Description

8.1 Overview

The TLC6C598 device is a monolithic, medium-voltage, low-current 8-bit shift register designed to drive relatively moderate load power such LEDs. The device contains an 8-bit serial-in, parallel-out shift register that feeds an 8-bit D-type storage register. Thermal shutdown protection is also built-into the device.

8.2 Functional Block Diagram

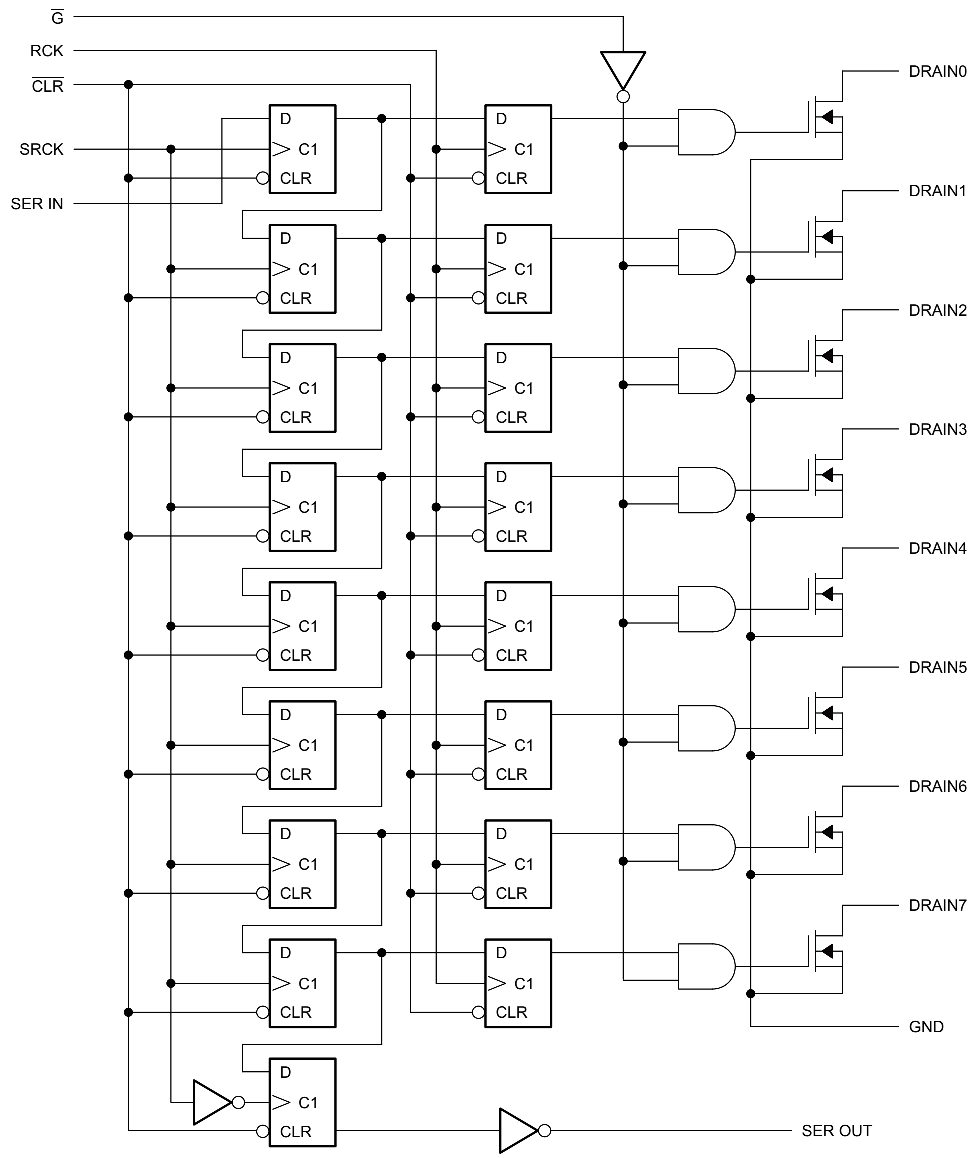

Figure 13. Logic Diagram (Positive) of TLC6C598

8.3 Feature Description

8.3.1 Thermal Shutdown

The device implements an internal thermal shutdown to protect itself if the junction temperature exceeds 175°C (typical). The thermal shutdown forces the device to have an open state when the junction temperature exceeds the thermal trip threshold. Once the junction temperature decreases below 160°C (typical), the device begins to operate again.

8.3.2 Serial-In Interface

The TLC6C598 device contains an 8-bit serial-in, parallel-out shift register that feeds an 8-bit D-type storage register. Data transfer through the shift and storage registers is on the rising edge of the shift register clock (SRCK) and the register clock (RCK), respectively. The storage register transfers data to the output buffer when shift-register clear ($\overline{CLR}$) is high.

8.3.3 Clear Registers

A logic low on the $\overline{CLR}$ pin clears all registers in the device. TI suggests clearing the device during power up or initialization.

8.3.4 Output Channels

DRAIN0–DRAIN7. These pins can survive up to 40-V LED supply voltage.

8.3.5 Register Clock

RCK is the storage-register clock. Data in the storage register appears at the output whenever the output enable ($\overline{G}$) input signal is high.

8.3.6 Cascade Through SER OUT

By connecting the SER OUT pin to the SER IN input of the next device on the serial bus in cascade, the data transfers to the next device on the falling edge of SRCK. This connection can improve the cascade application reliability, as it can avoid the issue that the second device receives SRCK and data input on the same rising edge of SRCK.

8.3.7 Output Control

Holding the output enable (pin $\overline{G}$) high holds all data in the output buffers low, and all drain outputs are off. Holding $\overline{G}$ low makes data from the storage register transparent to the output buffers. When data in the output buffers is low, the DMOS transistor outputs are off. When data is high, the DMOS transistor outputs are capable of sinking current. This pin also can be used for global PWM dimming.

8.4 Device Functional Modes

8.4.1 Operation With V_{CC} < 3 V

This device works normally within the range 3 V ≤ V_{CC} ≤ 5.5 V. When the operating voltage is lower than 3 V, correct behavior of the device, including communication interface and current capability, is not assured.

8.4.2 Operation With 5.5 V ≤ V_{CC} ≤ 8 V

The device works normally in this voltage range, but reliability issues may occur if the device works for a long time in this voltage range.

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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

The TLC6C598 device is a serial-in, parallel-out, power and logic, 8-bit shift register with low-side open-drain DMOS output ratings of 40-V and 50-mA continuous sink-current capabilities when V_{CC} = 5 V. The device is designed to drive resistive loads and is particularly well-suited as an interface between a microcontroller and LEDs or lamps. The device also provides up to 2000 V of ESD protection when tested using the human body model and 200 V when using the machine model.

9.2 Typical Application

Figure 14 shows a typical cascade application circuit with two TLC6C598 chips configured in cascade topology. The MCU generates all the input signals.

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Typical Application (continued)

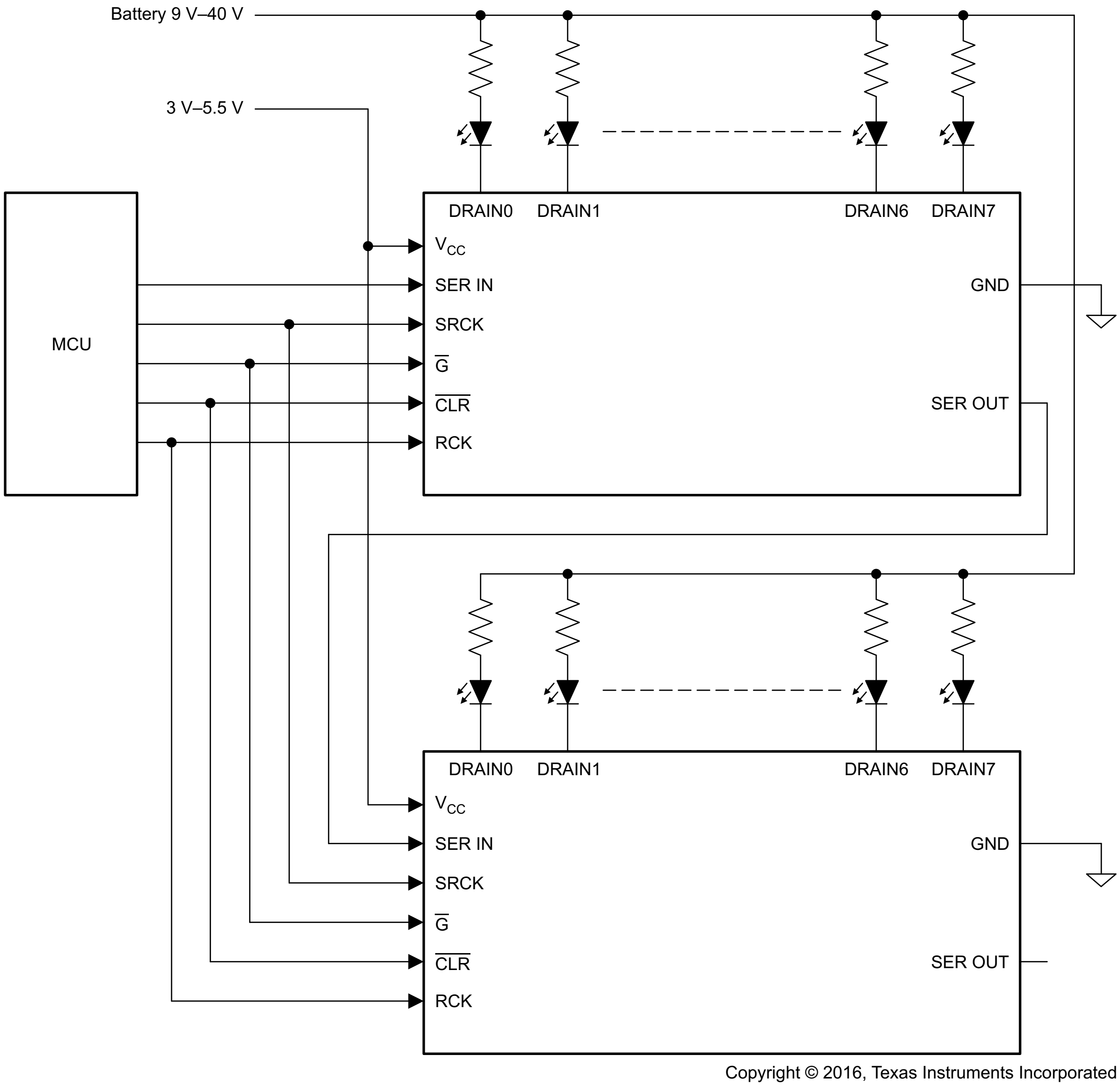

Figure 14. Typical Application Circuit

9.2.1 Design Requirements

DESIGN PARAMETER	EXAMPLE VALUE
$V_{Battery}$	9 V to 40 V
V_{CC_1}	3.3 V
I(D0), I(D1), I(D2), I(D3) , I(D4), I(D5), I(D6), I(D7)	30 mA
V_{CC_2}	5 V
I(D8), I(D9), I(D10), I(D11) , I(D12), I(D13), I(D14), I(D15)	50 mA

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9.2.2 Detailed Design Procedure

To begin the design process, the designer must decide on a few parameters, as follows:

- V_{supply}: LED supply voltage
- V_{Dx}: LED forward voltage
- I: LED current

With these parameters determined, the resistor in series with the LED can be calculated by using the following equation:

$$R_X = (V_{Supply} - V_{Dx}) / I \quad (1)$$

9.2.3 Application Curve

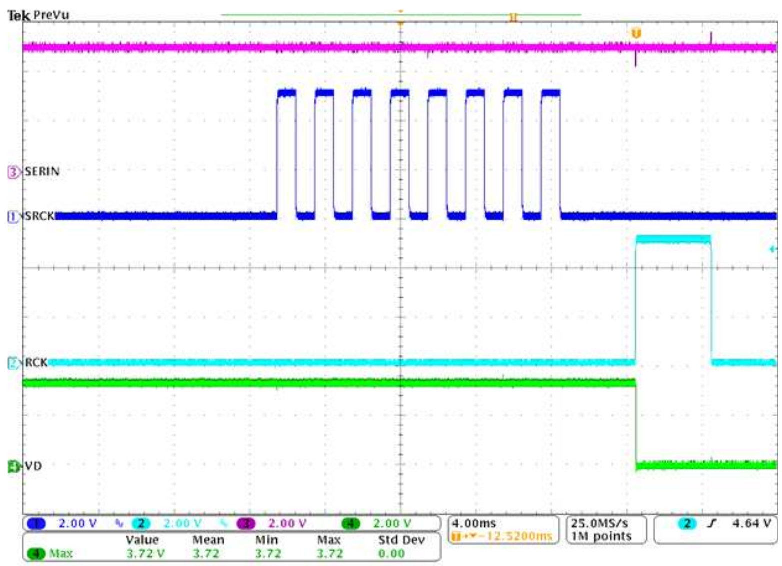

Figure 15. TLC6C598 Application Waveform

10 Power Supply Recommendations

The TLC6C598 device is designed to operate with an input voltage supply range from 3 V to 5.5 V. This input supply should be well regulated. TI recommends placing the ceramic bypass capacitors near the V_{CC} pin.

11 Layout

11.1 Layout Guidelines

There are no special layout requirements for the digital signal pins. The only requirement is placing the ceramic bypass capacitors near the corresponding pins.

Maximize the copper coverage on the PCB to increase the thermal conductivity of the board. The major heat-flow path from the package to the ambient is through the copper on the PCB. Maximizing the copper coverage is extremely important when the design does not include heat sinks attached to the PCB on the other side of the package.

Add as many thermal vias as possible directly under the package ground pad to optimize the thermal conductivity of the board.

All thermal vias should be either plated shut or plugged and capped on both sides of the board to prevent solder voids. To ensure reliability and performance, the solder coverage should be at least 85%.

11.2 Layout Example

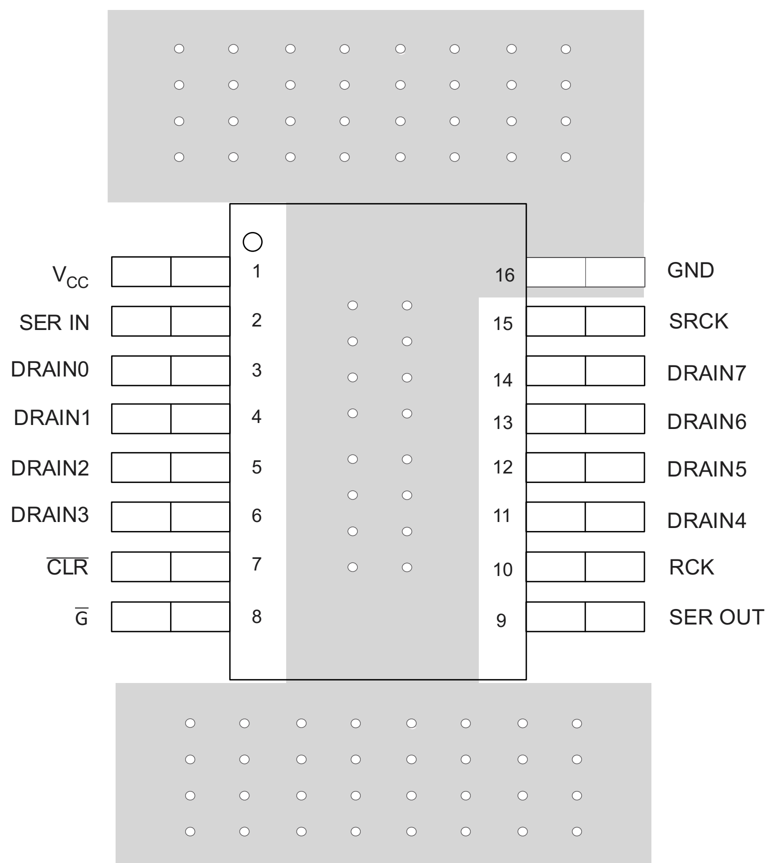

Figure 16. TLC6C598 Example Layout

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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 device. This data is subject to change without notice and without revision of this document. For browser-based versions of this data sheet, see the left-hand navigation pane.

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TLC6C598PWR	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 105	6C598I
TLC6C598PWR.A	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 105	6C598I

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

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

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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OTHER QUALIFIED VERSIONS OF TLC6C598 :

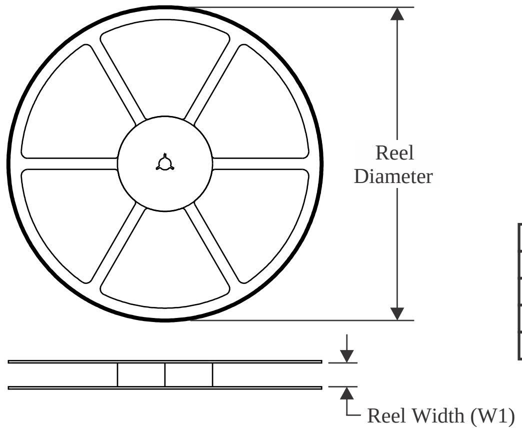
- Automotive : TLC6C598-Q1

NOTE: Qualified Version Definitions:

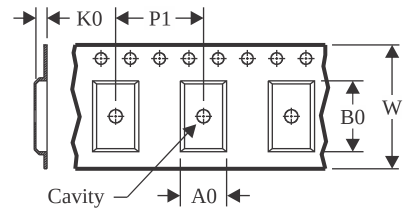
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

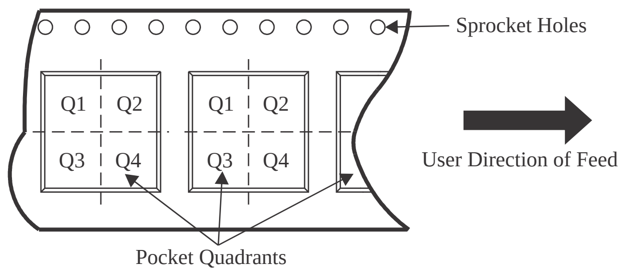


TAPE DIMENSIONS



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

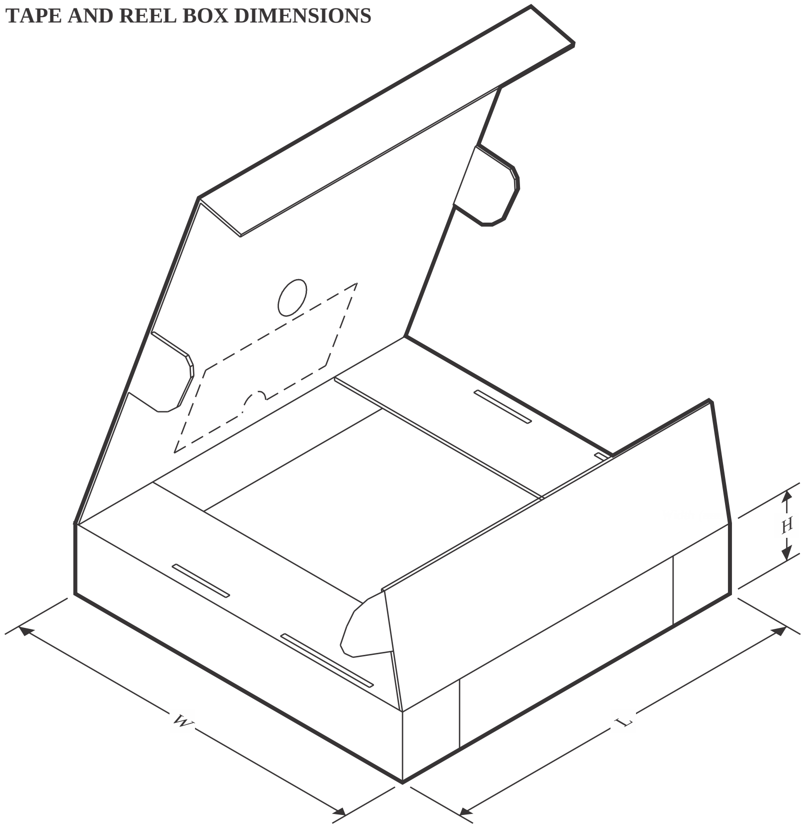
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

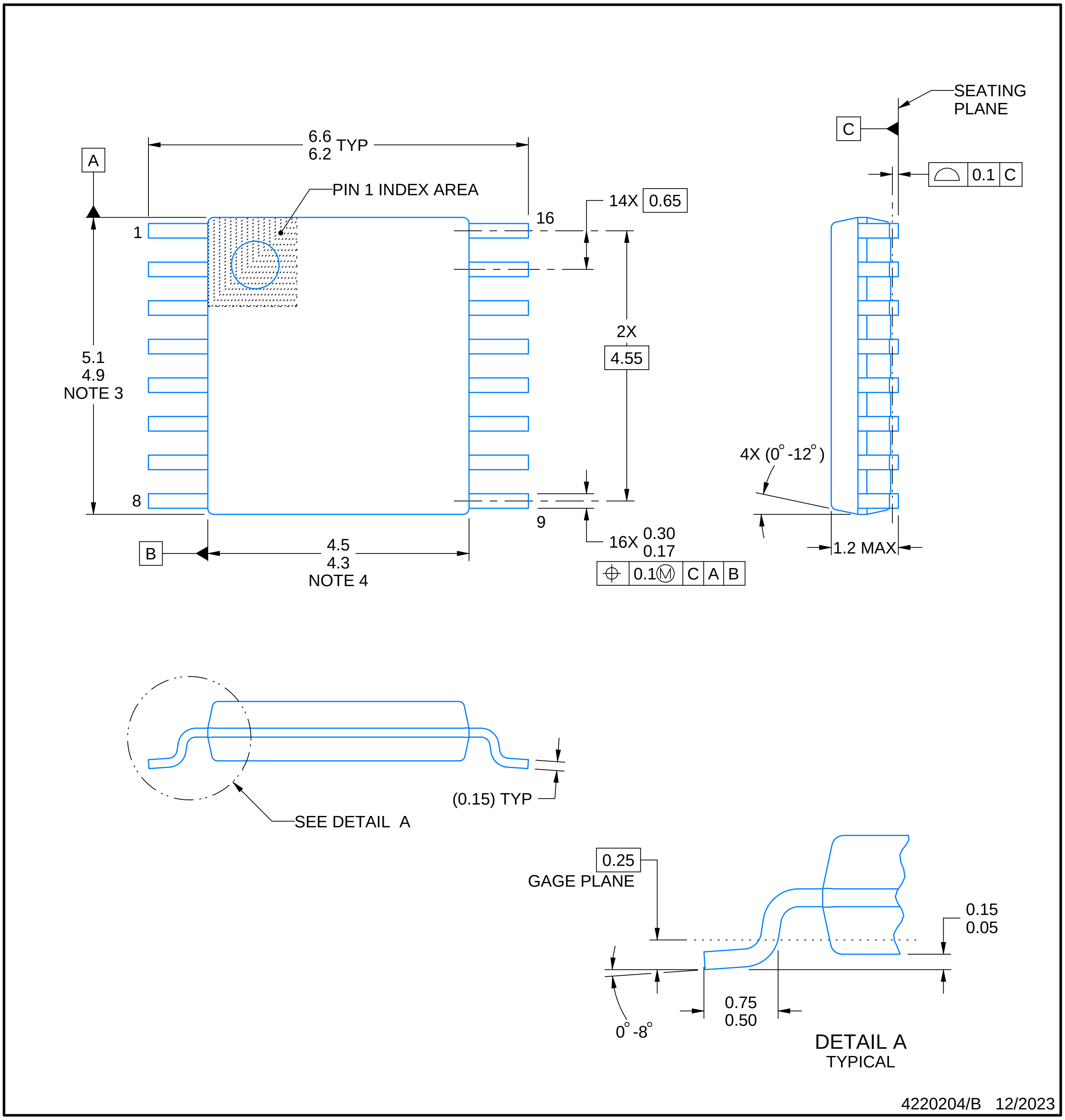
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLC6C598PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



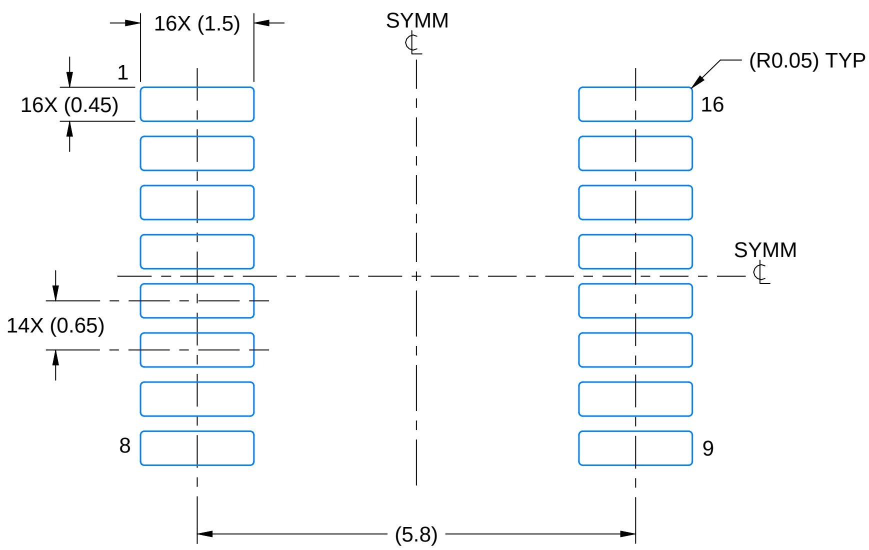
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLC6C598PWR	TSSOP	PW	16	2000	350.0	350.0	43.0

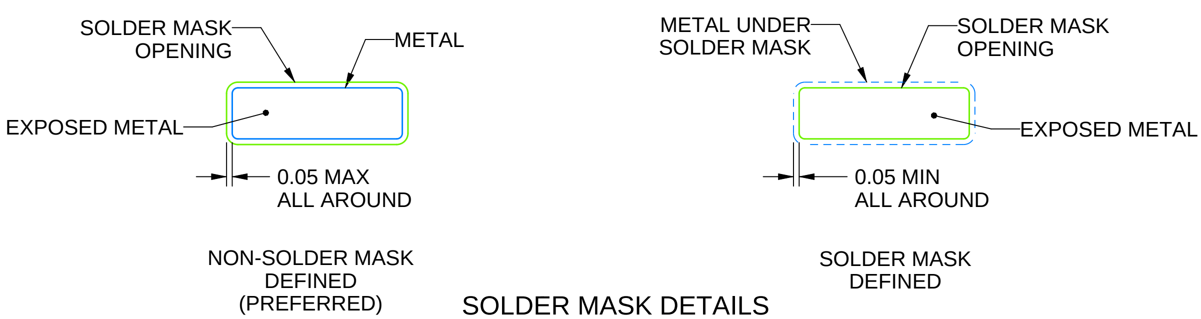


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

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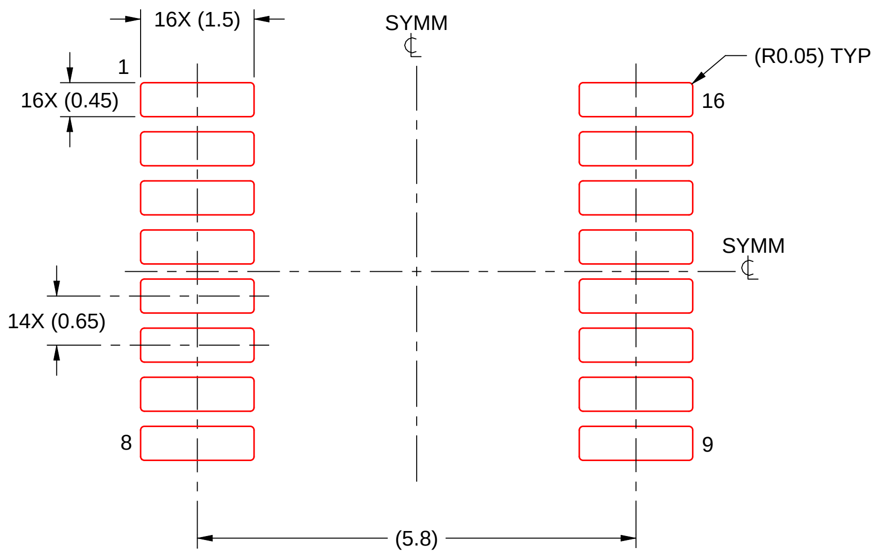
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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