

Programmable LED Driver

Check for Samples: [LP5522](#)

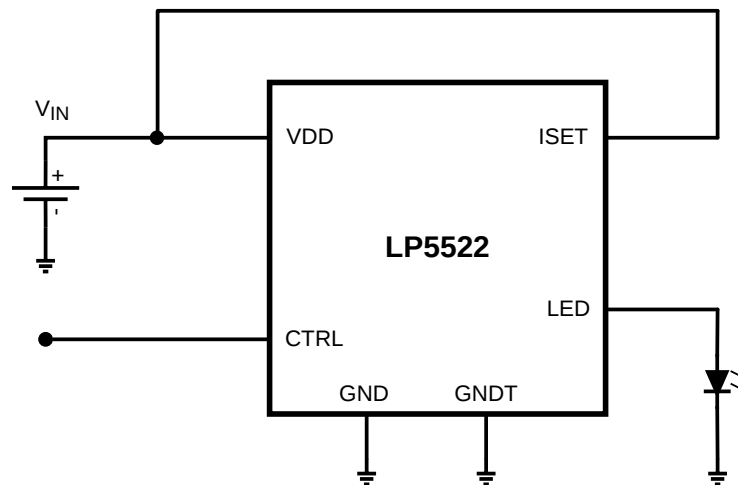
FEATURES

- **Programmable Blinking Sequence**
 - 1 to 3 Programmable Pulses
 - 1 ms to 255 ms LED on Time
 - 10 ms to 2500 ms LED Off Time
 - Single or Continuous Run of Programmed Blinking Sequence
- **Constant Current High Side Output Driver**
- **Adjustable Current with External Resistor**
- **0.2 μ A Typical Shutdown Current**
- **Autonomous Operation without External Clock**
- **DSBGA-6 Package with 0.4 mm Pitch:**
 - 1.215 mm x 0.815 mm x 0.6 mm (LxWxH)

APPLICATIONS

- **Indicator Lights**
- **Phone Cosmetics**
- **Toys**

Typical Application



DESCRIPTION

The LP5522 is a simple single wire programmable LED controller in six bump DSBGA package. It provides constant current flow through high side driver. Output current can be set from 1 mA to 20 mA by using an external resistor on the ISET pin. If no external resistor is used, output current is set to 5 mA default current. The LP5522 is controlled using only one signal. The signal controls either directly the LED driver or it launches previously programmed blinking sequence.

The LP5522 works autonomously without a clock signal from the master device. Very low LED driver headroom voltage makes possible to use supply voltages close to LED forward voltage. Current consumption of the LP5522 is minimized when LED is turned off and once controller is disabled all supporting functions are also shut down. Very small DSBGA package together with minimum number of external components is a best fit for handheld devices.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

Connection Diagrams

DSBGA-6 package, 0.815 x 1.215 x 0.60 mm body size, 0.4 mm pitch, Package Number YFQ0006

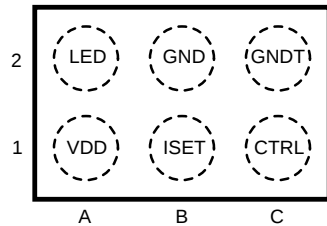


Figure 1. Top View

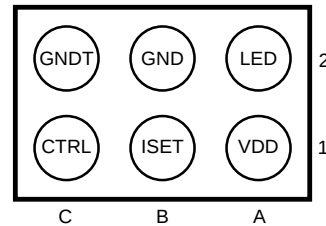


Figure 2. Bottom View

PIN DESCRIPTIONS⁽¹⁾

Pin	Name	Type	Description
A1	VDD	P	Power supply pin
B1	ISET	AI	Current set input
C1	CTRL	DI	Digital control input
A2	LED	AO	Current source output
B2	GND	G	Ground
C2	GNDT	G	Ground

(1) A: Analog Pin, D: Digital Pin, G: Ground Pin, P: Power Pin, I: Input Pin, O: Output Pin



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.

Absolute Maximum Ratings⁽¹⁾⁽²⁾⁽³⁾

V (VDD, LED, ISET)	-0.3V to +6.0V
Voltage on logic pin (CTRL)	-0.3V to VDD +0.3V with 6.0V max
Continuous Power Dissipation ⁽⁴⁾	Internally Limited
Junction Temperature (T _{J-MAX})	125°C
Storage Temperature Range	-65°C to +150°C
Maximum Lead Temperature (Reflow soldering, 3 times) ⁽⁵⁾	260°C
ESD Rating ⁽⁶⁾ Human Body Model	2 kV

(1) Absolute Maximum Ratings indicate limits beyond which damage to the component may occur. Operating Ratings are conditions under which operation of the device is ensured. Operating Ratings do not imply ensured performance limits. For ensured performance limits and associated test conditions, see the Electrical Characteristics tables.

(2) All voltages are with respect to the potential at the GND pins.

(3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Office/ Distributors for availability and specifications.

(4) Internal thermal shutdown circuitry protects the device from permanent damage. Thermal shutdown engages at T_J=160°C (typ.) and disengages at T_J=140°C (typ.).

(5) For detailed soldering specifications and information, please refer to Application Note AN1112 : DSBGA Wafer Level Chip Scale Package [SNVA009](#).

(6) The Human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin. MIL-STD-883 3015.7

Operating Ratings ⁽¹⁾⁽²⁾

Voltage on power pin (VDD)	2.7V to 5.5V
Recommended Load Current	1 mA to 20 mA
Junction Temperature (T _J) Range	-30°C to +125°C
Ambient Temperature (T _A) Range ⁽³⁾	-30°C to +85°C

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the component may occur. Operating Ratings are conditions under which operation of the device is ensured. Operating Ratings do not imply ensured performance limits. For ensured performance limits and associated test conditions, see the Electrical Characteristics tables.
- (2) All voltages are with respect to the potential at the GND pins.
- (3) In applications where high power dissipation and/or poor package thermal resistance is present, the maximum ambient temperature may have to be derated. Maximum ambient temperature (T_{A-MAX}) is dependent on the maximum operating junction temperature (T_{J-MAX-OP} = 125°C), the maximum power dissipation of the device in the application (P_{D-MAX}), and the junction-to ambient thermal resistance of the part/package in the application (θ_{JA}), as given by the following equation: $T_{A-MAX} = T_{J-MAX-OP} - (\theta_{JA} \times P_{D-MAX})$.

Thermal Properties

Junction-to-Ambient Thermal Resistance (θ _{JA}) ⁽¹⁾	87°C/W
--	--------

- (1) Junction-to-ambient thermal resistance is highly application and board-layout dependent. In applications where high maximum power dissipation exists, special care must be paid to thermal dissipation issues in board design.

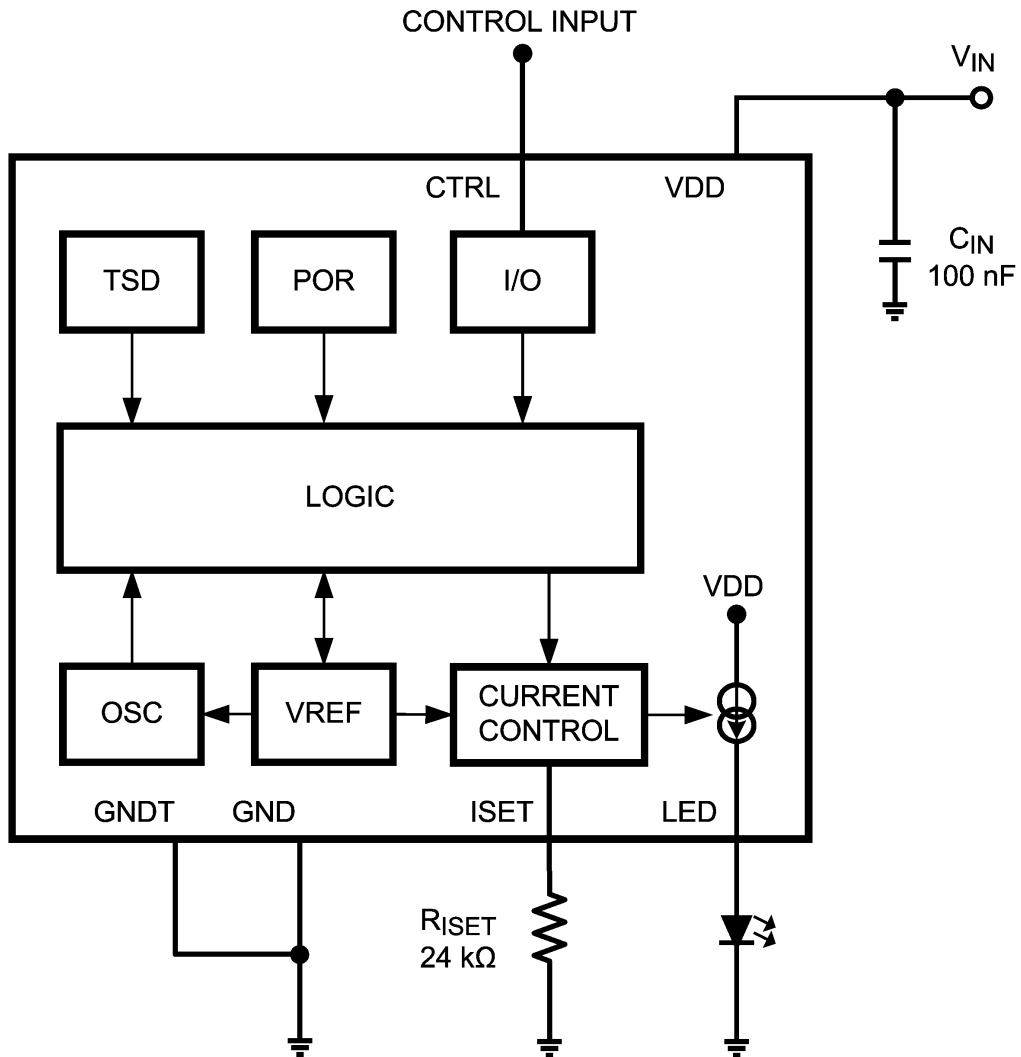
Electrical Characteristics ⁽¹⁾⁽²⁾

Limits in standard typeface are for $T_J = 25^\circ\text{C}$. Limits in **boldface** type apply over the operating ambient temperature range ($-30^\circ\text{C} < T_A < +85^\circ\text{C}$). Unless otherwise noted, specifications apply to [LP5522 Block Diagram](#) with: $V_{IN} = 3.6\text{V}$, $R_{ISET} = 24\text{ k}\Omega$, $C_{IN} = 100\text{ nF}$.

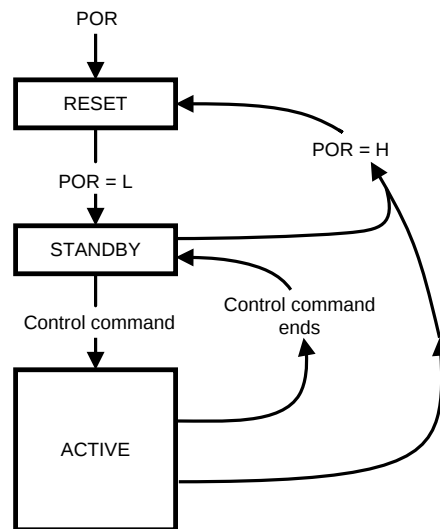
Symbol	Parameter	Condition	Min	Typ	Max	Units
I_{VDD}	Standby supply current	CTRL = L		0.2	1	μA
	Active Mode Supply Current	CTRL = H, LED = off		40	55	μA
$I_{LEAKAGE}$	LED Pin Leakage Current				1	μA
I_{OUT}	LED Output Current	Without external resistor	-8	5	+8	mA %
	LED Output Current	With external $24\text{ k}\Omega$ 0.04% resistor	-8	20	+8	mA %
I_{MIRROR}	External R_{ISET} Mirroring Ratio			1:400		
V_{ISET}	ISET Reference Voltage			1.23		V
V_{HR}	Minimum Headroom Voltage ($V_{IN} - V_{LED}$) ⁽³⁾	I_{OUT} set to 10 mA		35	50	mV
		I_{OUT} set to 20 mA		70	100	mV
T_{CYCLE_H}	Minimum LED On Time		0.9	1.0	1.1	ms
T_{CYCLE_L}	Minimum LED Off Time		9	10	11	ms
$ON_{RESOLUTION}$	LED On Time Resolution			1		ms
$OFF_{RESOLUTION}$	LED Off Time Resolution			10		ms
$T_{Timeout_H}$	LED Timeout On Time		287	319	351	ms
$T_{Timeout_L}$	LED Timeout Off Time		2.87	3.19	3.51	s
V_{IL}	Logic Input Low Level				0.5	V
V_{IH}	Logic Input High Level		1.2			V
I_{IN}	CTRL Input Current		-1		1	μA
t_{ON}	CTRL Pulse ON Time		15			μs
t_{OFF}	CTRL Pulse OFF Time		30			μs
t_{ENTER}	Command Entering Period		500			μs
$t_{ENTER}+t_{BLANK}$	Command Entering Period + Blank Period				1500	μs

- (1) All voltages are with respect to the potential at the GND pins.
- (2) Min and Max limits are ensured by design, test, or statistical analysis. Typical numbers are not ensured, but do represent the most likely norm.
- (3) The current source is connected internally between V_{IN} and V_{LED} . The voltage across the current source, ($V_{IN} - V_{LED}$), is referred to a headroom voltage (V_{HR}). Minimum headroom voltage is defined as the V_{HR} voltage when the LED current has dropped 10% from the value measured at $V_{LED} = V_{IN} - 1\text{V}$.

LP5522 BLOCK DIAGRAM



Modes of Operation



RESET In the reset mode all functions are off and all registers are reset to the default values. Reset is entered always if internal Power On Reset (POR) is active. Power On Reset will activate during the device startup or when the supply voltage V_{IN} falls below 1.5V (typ.).

STANDBY: After Power On Reset device is in Standby mode. This is the low power consumption mode, when all circuit functions are disabled.

ACTIVE: Once rising edge of CTRL signal is detected device goes into Active mode. In Active mode four sub modes are present:

RUN: Run mode is divided into two sub modes depending on whether a blinking sequence is programmed into memory or not.

Non-programmed mode: No blinking sequence programmed to memory. LED output follows CTRL input

Programmed mode: Blinking sequence programmed to memory. LED output follows the programmed blinking sequence

RUN ONCE: In Run once mode, programmed blinking sequence is performed once and after that device returns into Standby mode. Run once mode is available only if a blinking sequence is programmed into memory.

TRAINING: In Training mode new blinking sequence can be programmed. LED output follows CTRL signal during the programming

TSD: If chip temperature rises above 160°C (typ.) device goes into Thermal Shut Down (TSD) mode. In TSD mode output is disabled but supporting functions are on.

LED Driver Operational Description

The LP5522 LED driver is constant current source. Current can be set with external resistor (R_{ISET}) so that the current ratio between resistor and LED is 1:400. R_{ISET} current correlates to ISET reference voltage (V_{ISET}). Consequently, current through LED can be adjusted using equation $I_{OUT} = 480/R_{ISET}$.

Use of external resistor is optional. If external resistor is not connected, default output current is 5 mA. When external resistor is not used ISET pin should be connected to VDD.

LED Driver Typical Performance Characteristics

$T_J = 25^\circ\text{C}$. Unless otherwise noted, typical performance characteristics apply to [LP5522 Block Diagram](#) with: $V_{IN} = 3.6\text{V}$, $R_{ISET} = 24\text{ k}\Omega$, $C_{IN} = 100\text{ nF}$.

Output Current vs R_{ISET} (Expanded Range)

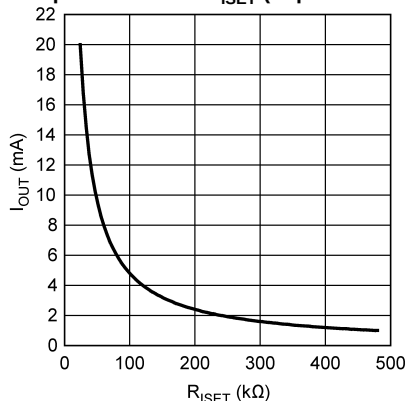


Figure 3.

Output Current vs R_{ISET}

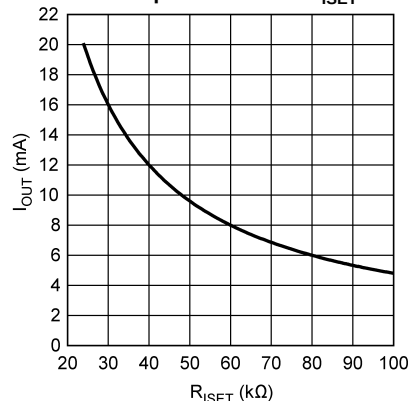


Figure 4.

Output Current vs Input Voltage
(ISET Connected To VDD)

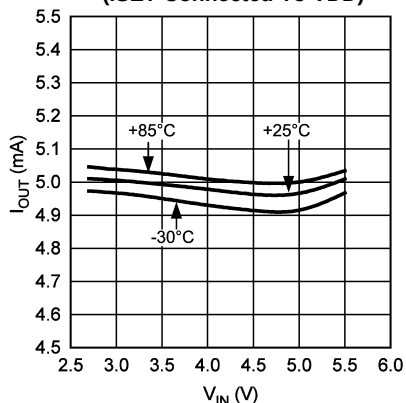


Figure 5.

Output Current vs Headroom Voltage

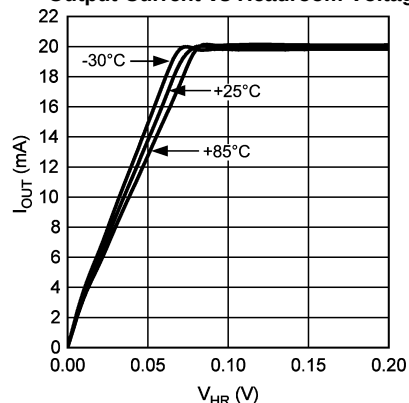


Figure 6.

Line Regulation

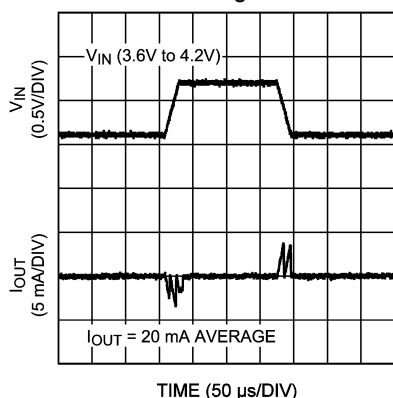


Figure 7.

LED Startup

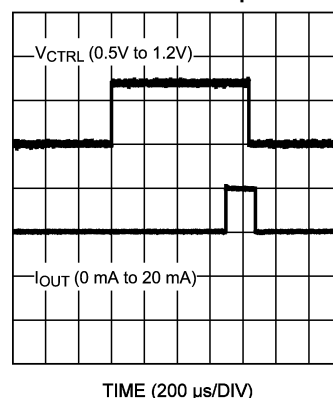
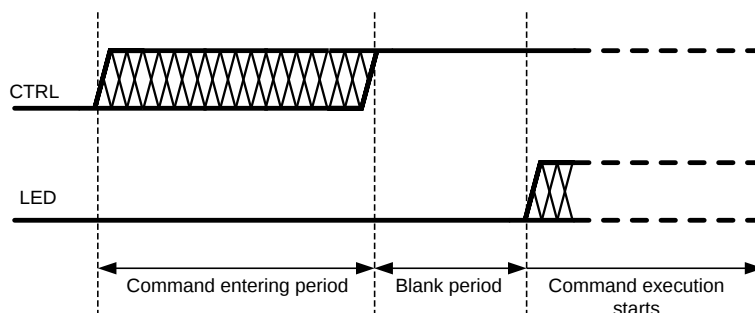


Figure 8.

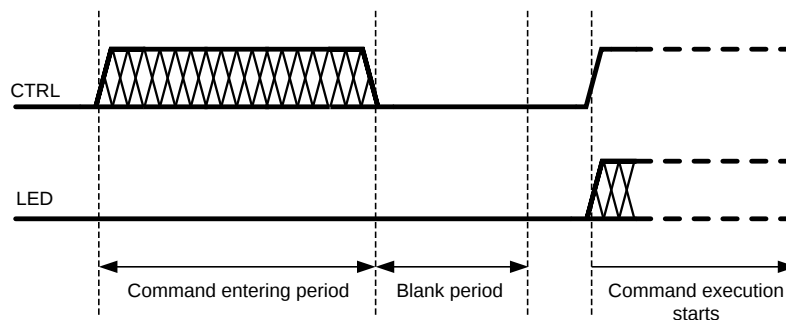
CONTROL INTERFACE OPERATIONAL DESCRIPTION

LP5522 has one digital control input, CTRL. Threshold levels of CTRL input are fixed to enable control from low voltage controller. CTRL signal is used to control the mode of the circuit. A rising edge of the CTRL signal activates the circuit and starts a command entering period. During the command entering period all rising edges are counted. After command entering period there is a blank period when no rising edges are allowed. If CTRL is left high after command entering period, the consequent command is performed right after the blank period.

Note that timing diagrams are not on scale!



If CTRL signal is low after command entering period, command execution starts when CTRL is pulled high. This does not apply to Run command. With Run command CTRL must be high. Note that no rising edges are allowed during blank period.



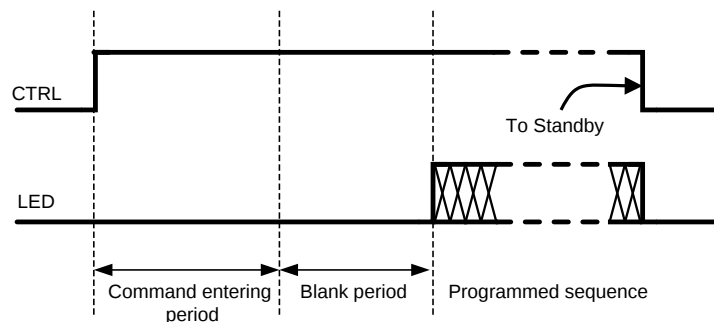
LED Controller Commands and Operation

There are four commands available for LP5522.

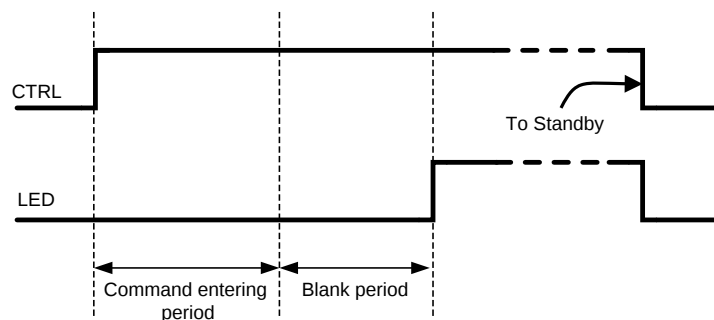
Command	Number of rising edges during command entering period
Run	One rising edge
Training start	Two rising edges
Training end	Three rising edges
Run once	Four rising edges

RUN COMMAND

One rising edge of CTRL signal within command entering period is interpreted as Run command. In programmed mode blinking sequence is started right after Blank period and it is repeated as long as CTRL signal is kept high. When CTRL signal is set low device goes into Standby mode.

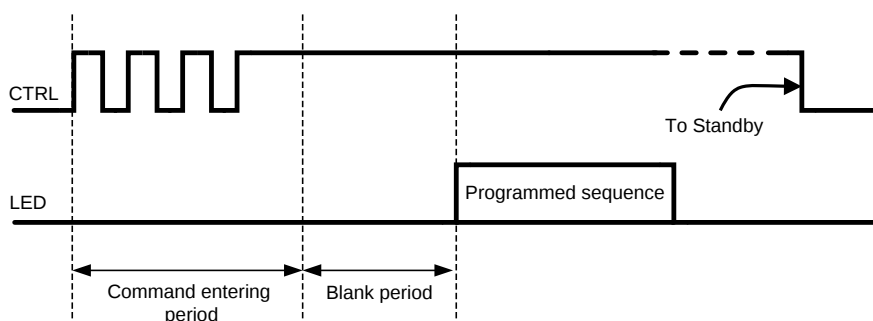


In non-programmed mode LED is on as long as CTRL is kept high. When CTRL signal is set low device goes into Standby mode.

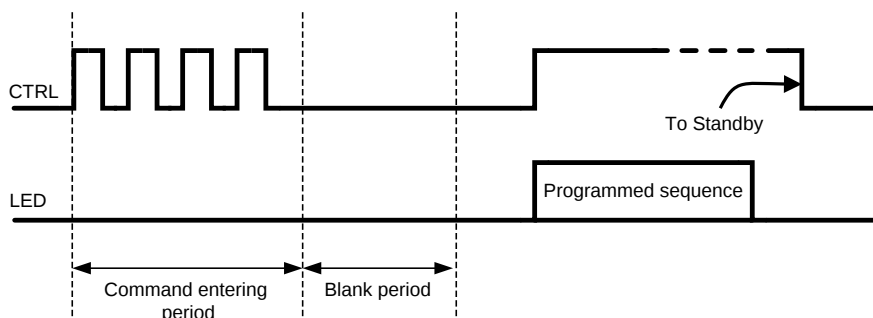


RUN ONCE COMMAND

Programmed blinking sequence is performed once after Run Once command. Four rising edges of CTRL signal within command entering period is interpreted as Run Once command. If CTRL is kept high after command entering period the programmed blinking sequence starts right after the blank period has elapsed. CTRL signal must stay high as long as programmed blinking sequence is executed. If CTRL is set low during execution of blinking sequence, device goes to standby and execution of blinking sequence is stopped.



If CTRL signal is low after command entering period, Run Once command is executed once the CTRL is set high.

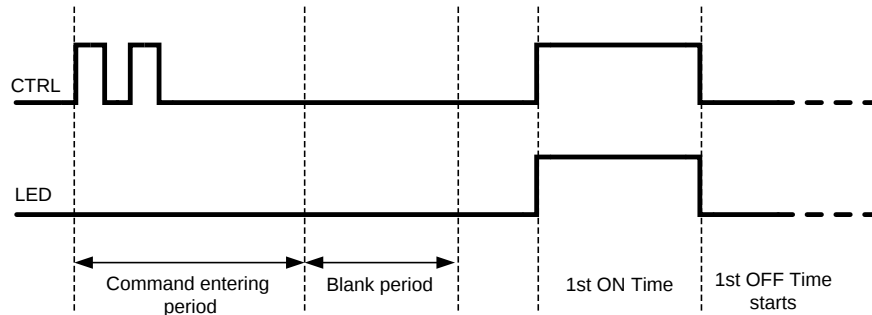


TRAINING START COMMAND

Blinking sequence is programmed into memory in training mode. Blinking sequence is stored into volatile memory, thus removing input voltage V_{IN} resets the memory. Memory can also be reset by giving Training Start and Training End commands without any valid LED ON/OFF times.

LP5522 enters to Training mode after Training Start command. Two rising edges within command entering period is interpreted as the Training Start command. The first LED ON time capturing is started once the rising edge of CTRL signal is detected after the blank period. LED output follows CTRL signal during the programming.

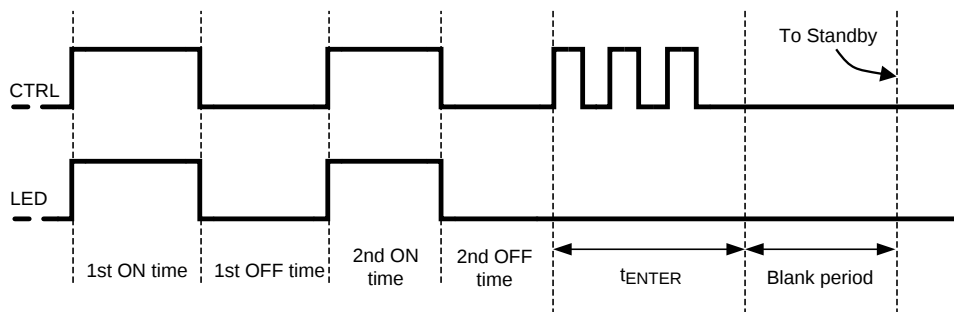
The first LED ON time is recorded once CTRL signal is set low. Same time the first LED OFF time capturing is started. Programmed blinking sequence can have one to three LED ON/OFF times. In order to be programmed correctly, at least one valid LED ON and LED OFF time must be recorded.



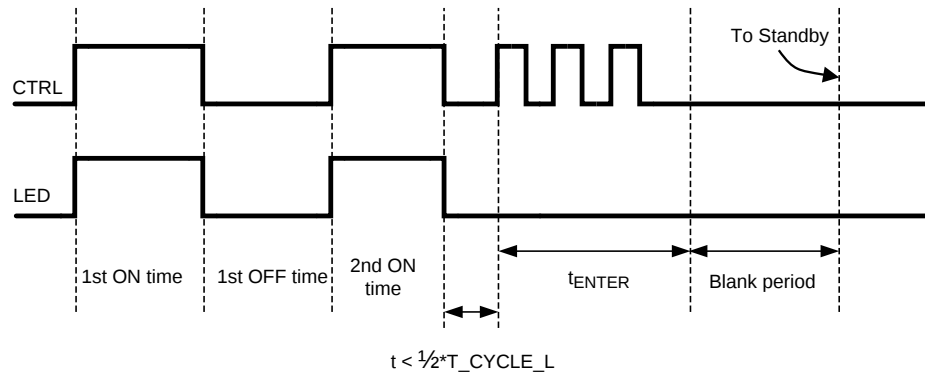
TRAINING END COMMAND

Blinking sequence programming ends once Training End command is introduced. Three rising edges within time period of t_{ENTER} is interpreted as Training End command. Note that blank period is also required after Training End command. During blank period no rising edges are allowed.

When Training End command is introduced during LED OFF time capturing, LED OFF time is recorded and chip goes to standby mode.



If Training End command is introduced during LED ON time capturing, the associated LED ON period is not recorded and hence neither OFF time. Notice that valid OFF time before Training End is longer than half of Minimum LED OFF period (T_{CYCLE_L}).

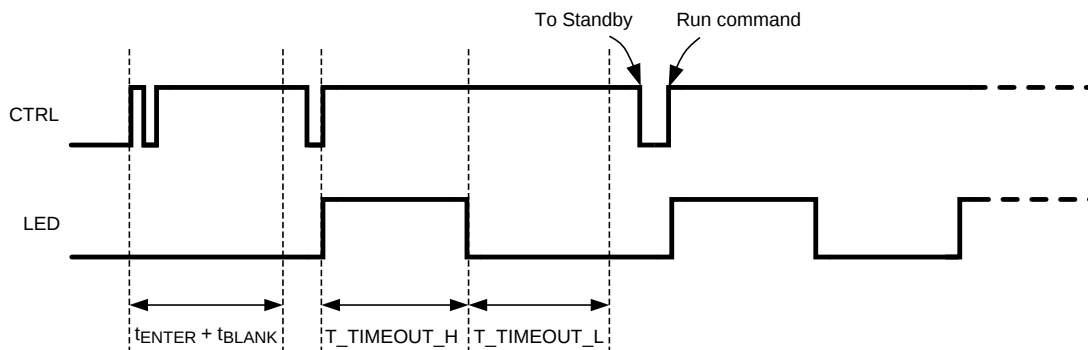


LED TIMEOUT ON/OFF TIMES

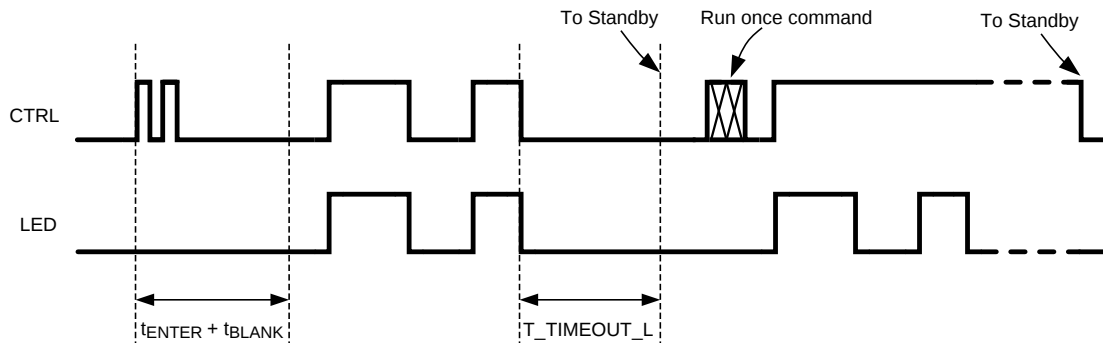
When LP5522 is in training mode and CTRL signal is high longer than LED Timeout ON time, the ON time counter saturates. In this case saturated ON time is recorded and LED OFF time capturing is started. At the same time LED is switched off even if the CTRL signal is still high.

If ON time counter has saturated, LED OFF time recording is terminated either by giving a Train End command or setting the CTRL signal to low and back to high. Setting the CTRL signal back to high records the LED OFF time and starts next ON time capturing.

If anyhow CTRL is still high after the LED Timeout OFF time has been elapsed the OFF time counter saturates and saturated OFF time is recorded. After that chip waits the CTRL signal to go low which cause the chip to go Standby.



LED OFF time counter can saturate also if Training end command is not given or no new ON time has been started. In this case saturated OFF time is recorded and chip goes to Standby.



Recommended External Components

INPUT CAPACITOR, C_{IN}

Although not required for normal operation, a capacitor can be added to V_{IN} to reduce line noise. A surface-mount multi-layer ceramic capacitor (MLCC) is recommended. MLCCs with a X7R or X5R temperature characteristic are preferred.

CURRENT SET RESISTOR, R_{ISET}

If other than 5 mA current is required, R_{ISET} resistor can be used to adjust the current. For 20 mA current 24 k Ω resistor is required. Accuracy of the resistor directly effects to the accuracy of the LED current. 1% or better is recommended.

LED

Forward voltage of LED must be less than minimum input voltage minus minimum headroom voltage (V_{HR}). For example with 2.7V input voltage and 20 mA LED current the maximum LED forward voltage is 2.7V - 100 mV = 2.6V.

List of Recommended External Components

Symbol	Symbol Explanation	Value	Unit	Type
C_{IN}	VDD Bypass Capacitor	100	nF	Ceramic, X7R or X5R
R_{ISET}	Current Set Resistor for 20 mA LED Current	24	k Ω	1%
LED		User defined		

REVISION HISTORY

Changes from Original (March 2013) to Revision A	Page
• Changed layout of National Data Sheet to TI format	12

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LP5522TM/NOPB	ACTIVE	DSBGA	YFQ	6	250	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-30 to 85	6	Samples
LP5522TMX/NOPB	ACTIVE	DSBGA	YFQ	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-30 to 85	6	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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side Marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION


*All dimensions are nominal

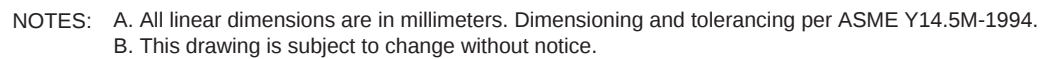
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LP5522TM/NOPB	DSBGA	YFQ	6	250	178.0	8.4	1.04	1.4	0.76	4.0	8.0	Q1
LP5522TMX/NOPB	DSBGA	YFQ	6	3000	178.0	8.4	1.04	1.4	0.76	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LP5522TM/NOPB	DSBGA	YFQ	6	250	210.0	185.0	35.0
LP5522TMX/NOPB	DSBGA	YFQ	6	3000	210.0	185.0	35.0



IMPORTANT NOTICE

Texas Instruments Incorporated (TI) reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

TI's published terms of sale for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>) apply to the sale of packaged integrated circuit products that TI has qualified and released to market. Additional terms may apply to the use or sale of other types of TI products and services.

Reproduction of significant portions of TI information in TI data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such reproduced documentation. Information of third parties may be subject to additional restrictions. Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyers and others who are developing systems that incorporate TI products (collectively, "Designers") understand and agree that Designers remain responsible for using their independent analysis, evaluation and judgment in designing their applications and that Designers have full and exclusive responsibility to assure the safety of Designers' applications and compliance of their applications (and of all TI products used in or for Designers' applications) with all applicable regulations, laws and other applicable requirements. Designer represents that, with respect to their applications, Designer has all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. Designer agrees that prior to using or distributing any applications that include TI products, Designer will thoroughly test such applications and the functionality of such TI products as used in such applications.

TI's provision of technical, application or other design advice, quality characterization, reliability data or other services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using TI Resources in any way, Designer (individually or, if Designer is acting on behalf of a company, Designer's company) agrees to use any particular TI Resource solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

Designer is authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY DESIGNER AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Unless TI has explicitly designated an individual product as meeting the requirements of a particular industry standard (e.g., ISO/TS 16949 and ISO 26262), TI is not responsible for any failure to meet such industry standard requirements.

Where TI specifically promotes products as facilitating functional safety or as compliant with industry functional safety standards, such products are intended to help enable customers to design and create their own applications that meet applicable functional safety standards and requirements. Using products in an application does not by itself establish any safety features in the application. Designers must ensure compliance with safety-related requirements and standards applicable to their applications. Designer may not use any TI products in life-critical medical equipment unless authorized officers of the parties have executed a special contract specifically governing such use. Life-critical medical equipment is medical equipment where failure of such equipment would cause serious bodily injury or death (e.g., life support, pacemakers, defibrillators, heart pumps, neurostimulators, and implantables). Such equipment includes, without limitation, all medical devices identified by the U.S. Food and Drug Administration as Class III devices and equivalent classifications outside the U.S.

TI may expressly designate certain products as completing a particular qualification (e.g., Q100, Military Grade, or Enhanced Product). Designers agree that it has the necessary expertise to select the product with the appropriate qualification designation for their applications and that proper product selection is at Designers' own risk. Designers are solely responsible for compliance with all legal and regulatory requirements in connection with such selection.

Designer will fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of Designer's non-compliance with the terms and provisions of this Notice.