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AS1122

12-Channel LED Driver with Dot Correction and Greyscale PWM

General Description

The AS1122 is a 12-channel, constant current-sink LED driver. Each of the 12 channels can be individually adjusted by 4096-step greyscale PWM brightness control and 64-step constant-current sink (dot correction).

The dot correction circuitry adjusts the brightness variations between the AS1122 channels and other LED drivers. Greyscale control and dot correction circuitry are accessible via a simple SPI-compatible serial interface.

The open LED detection function indicates a broken or disconnected LED at one or more of the outputs. The overtemperature flag indicates that the device is in an overtemperature condition.

A single external resistor sets the maximum current value of all 12 channels.

The AS1122 is available in a 24-pin QFN 4 × 4mm package.

Ordering Information and Content Guide appear at end of datasheet.

Key Benefits & Features

The benefits and features of the AS1122, 12-Channel LED Driver with Dot Correction and Greyscale PWM, are listed below:

Figure 1:
Added Value of Using AS1122

Benefits	Features
• High resolution LED brightness control	12-bit (4096 steps) Greyscale PWM Control
• Independent fine tuning of LED current of each channel to adjust brightness deviation	6-bit (64 steps) Dot Correction
• Suitable for high-power LEDs	Drive capability up to 40mA
• Multiple white LEDs in series per channel	LED Power Supply up to 30V
• Inrush current control	Delayed enabling of each output channel

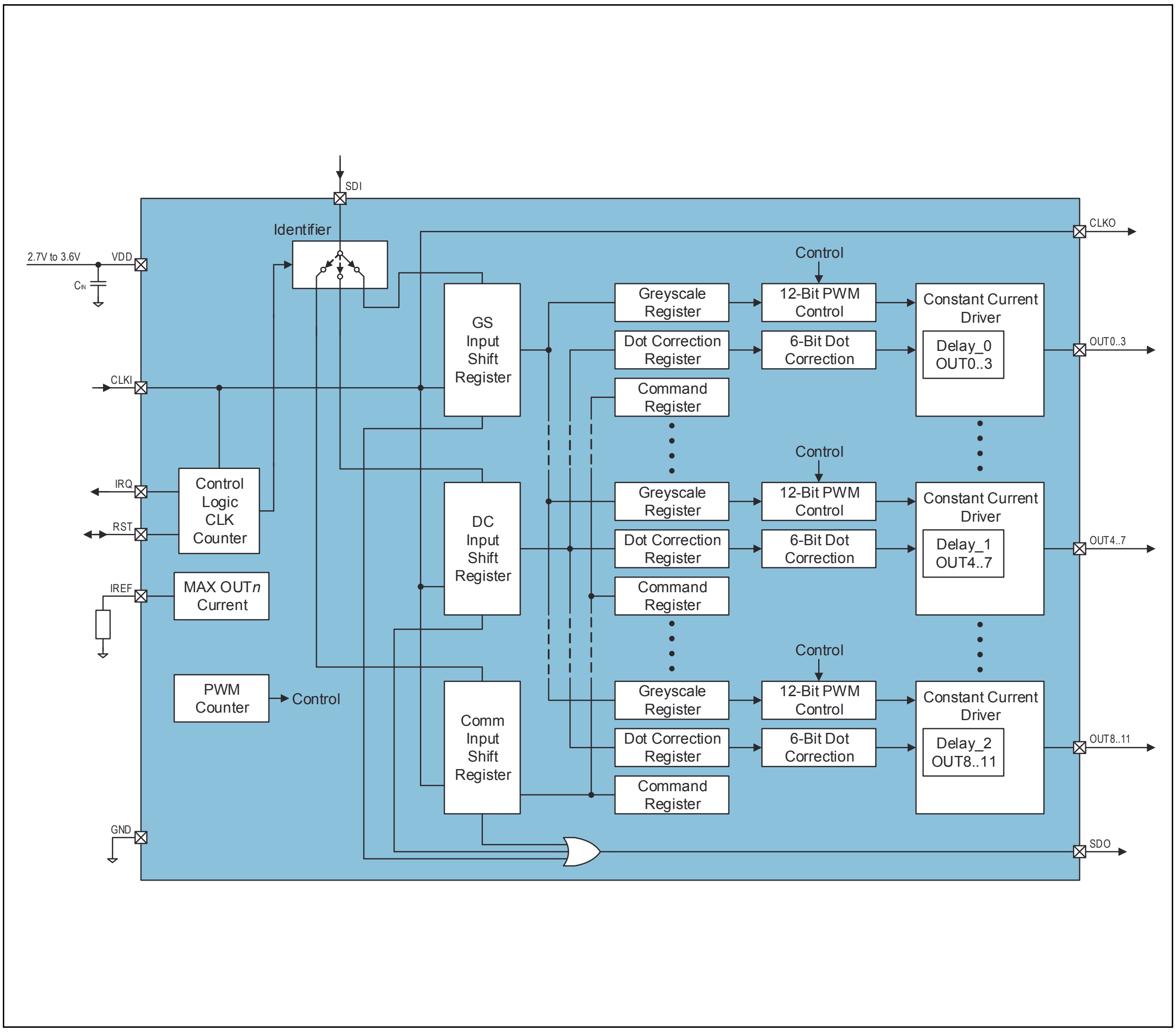
Applications

The device is ideal for mono-color, multi-color, and full-color LED displays, LED signboards, and display backlights.

Block Diagram

The functional blocks of this device for reference are shown below:

Figure 2:
Functional Blocks of AS1122



Pin Assignments

Figure 3:
Pin Assignments (Top View)

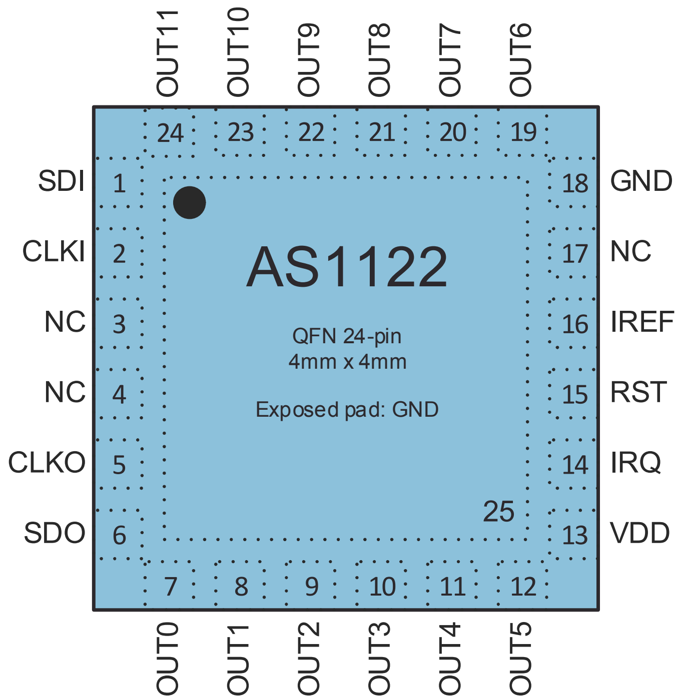


Figure 4:
Pin Descriptions

Pin Number	Pin Name	Description
1	SDI	**Serial Data Input**
2	CLKI	**Serial Data Clock Input**
5	CLKO	**Serial Data Clock Output**
6	SDO	**Serial Data Output**
7:12, 19:24	OUT0: OUT11	**Constant-Current Outputs 0:11**
13	VDD	**Power Supply Voltage**
14	IRQ	**Interrupt Request Output:** Open drain pin, can be left open if not used.
15	RST	**Reset Input:** Pull this pin to high to reset all registers (set to default values) and to put the device into shutdown. Connect this pin to GND for normal operation.

Pin Number	Pin Name	Description
16	IREF	**Reference Current Terminal:** A resistor connected to this pin sets the maximum output currents.
18	GND	**Ground**
3,4,17	NC	**Not Connected:** Connect to GND if not used.
25	Exp Pad	**Ground:** This pin must be connected to GND to ensure normal operation.

Absolute Maximum Ratings

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Figure 5:
Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Units	Comments
Electrical Parameters					
	VCC to GND	-0.3	5	V	
	All other pins to GND	-0.3	V_{DD} + 0.3	V	
	VOUT0: VOUT11 to GND	-0.3	30	V	
	Output Current		50	mA	
	Input Current (latch-up immunity)	-100	100	mA	Norm: JEDEC JESD78D Nov 2011
Electrostatic Discharge					
ESD_{HBM}	Electrostatic Discharge HBM	±2		kV	Norm: JEDEC JESD22-A114F
Temperature Ranges and Storage Conditions					
T_{AMB}	Operating Temperature Range	-40	85	°C	
T_J	Operating Junction Temperature	-40	125	°C	
R_{THJA}	Junction to Ambient Thermal Resistance		37	°C/W	
T_J	Junction Temperature		150	°C	
T_{STRG}	Storage Temperature Range	-55	150	°C	
T_{BODY}	Package Body Temperature		260	°C	Norm IPC/JEDEC J-STD-020 (1)
RH_{NC}	Humidity non-condensing	5	85	%	
MSL	Moisture Sensitivity Level	3			Represents a max. floor life time of 168h

Note(s) and/or Footnote(s):

1. The reflow peak soldering temperature (body temperature) is specified according IPC/JEDEC J-STD-020 "Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices". The lead finish for Pb-free leaded packages is "Matte Tin" (100% Sn)

Electrical Characteristics

All limits are guaranteed. The parameters with min and max values are guaranteed with production tests or SQC (Statistical Quality Control) methods.

Figure 6:
Electrical Characteristics of AS1122

Symbol	Parameter	Condition	Min	Typ	Max	Unit
		Input Supply				
V_{DD}	Supply Voltage		2.7		3.6	V
I_{CC}	Supply Current	All outputs ON, R_{IREF} = 1kΩ		9.5	12	mA
		All outputs ON, R_{IREF} = 10kΩ		4	6	
I_{PD}	Power Down	RST = High, T_{AMB} = 25°C		40		nA
		Output				
R_{IREF}	Reference Current Resistor		1		10	kΩ
V_{OUT}	Output Voltage	OUT0:OUT11			30	V
I_{COC}	Constant Output Current (1)	All outputs ON, V_{OUT} = 1V, R_{IREF} = 10kΩ	38	40	42	mA
ΔI_{COC}	Constant Output Current Error	V_{OUT} = 1V, R_{IREF} = 1kΩ, OUT0:OUT11		±0.8	2	%
		V_{OUT} = 1V, R_{IREF} = 10kΩ, OUT0:OUT11		±1.5	4	
		Device to device, average current from OUT0:OUT11, V_{OUT} = 1V, R_{IREF} = 1kΩ		±0.5		
		Device to device, average current from OUT0:OUT11, V_{OUT} = 1V, R_{IREF} = 10kΩ		±0.6		
I_{LEAK}	Leakage Output Current	All outputs OFF, V_{OUT} = 30V, R_{IREF} = 1kΩ, OUT0:OUT11		20		nA
ΔI_{LNR}	Line Regulation	V_{OUT} = 1V, R_{IREF} = 1kΩ OUT0:OUT11		±0.1	±1.5	%/V
		V_{OUT} = 1V, R_{IREF} = 10kΩ OUT0:OUT11		±0.2	±1.5	
ΔI_{LDR}	Load Regulation	V_{OUT} = 1V to 4V, R_{IREF} = 1kΩ, OUT0:OUT11		±0.1	±0.4	%/mA
		V_{OUT} = 1V to 4V, R_{IREF} = 10kΩ, OUT0:OUT11		±0.01	±0.4	

Symbol	Parameter	Condition	Min	Typ	Max	Unit
Logic Levels						
V_{IH}	High-Level Input		0.8 × V_{DD}		V_{DD}	V
V_{IL}	Low-Level Input		GND		0.2 × V_{DD}	V
V_{OH}	High-Level Output	I_{OH} = -1mA, SDO, CLKO	V_{DD} - 0.5			V
V_{OL}	Low-Level Output	I_{OL} = 1mA, SDO, CLKO			0.5	V
		I_{OL} = 3mA, IRQ			0.5	V
V_{LOD}	Open Detection Threshold			0.3	0.4	V
V_{IREF}	Reference Voltage	R_{IREF} = 1kΩ	1.24	1.27	1.30	V

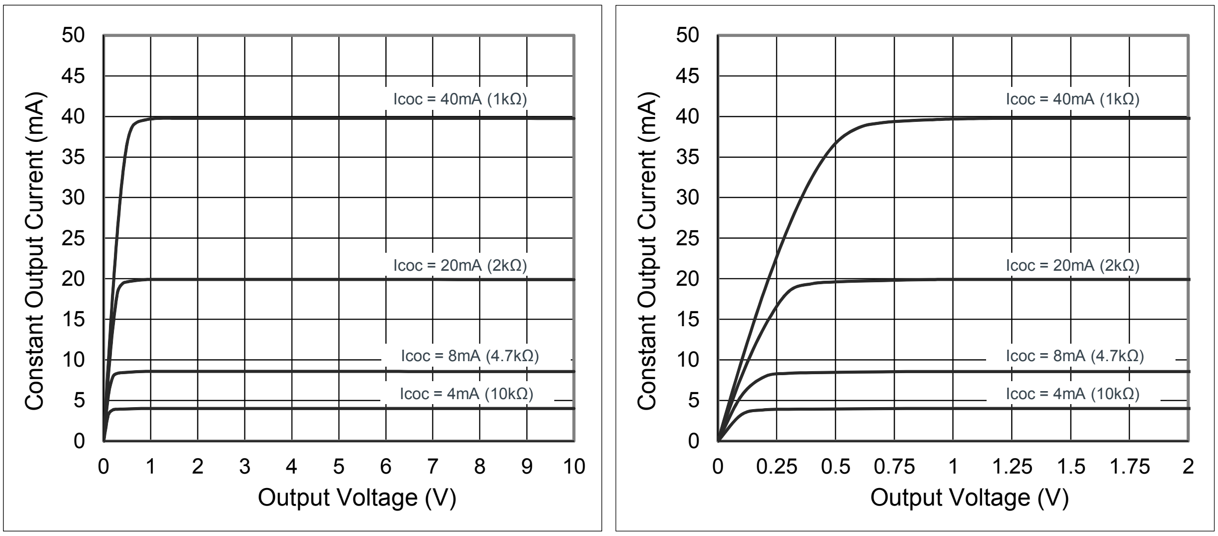
Electrical Characteristics: VDD = +2.7V to +3.6V, Typical values are at T_{AMB} = 25°C, VDD = 3.3V (unless otherwise specified).

Note(s) and/or Footnote(s):

1. $I_{coc} = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} \times 100$

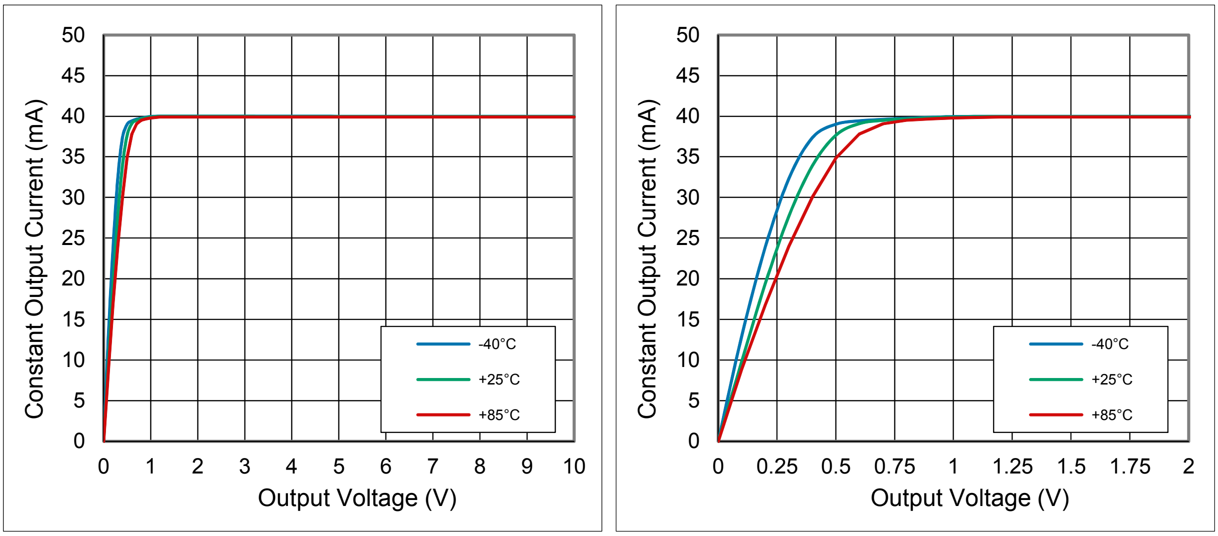
Typical Operating Characteristics

Figure 7:
Constant Output Current vs. Output Voltage



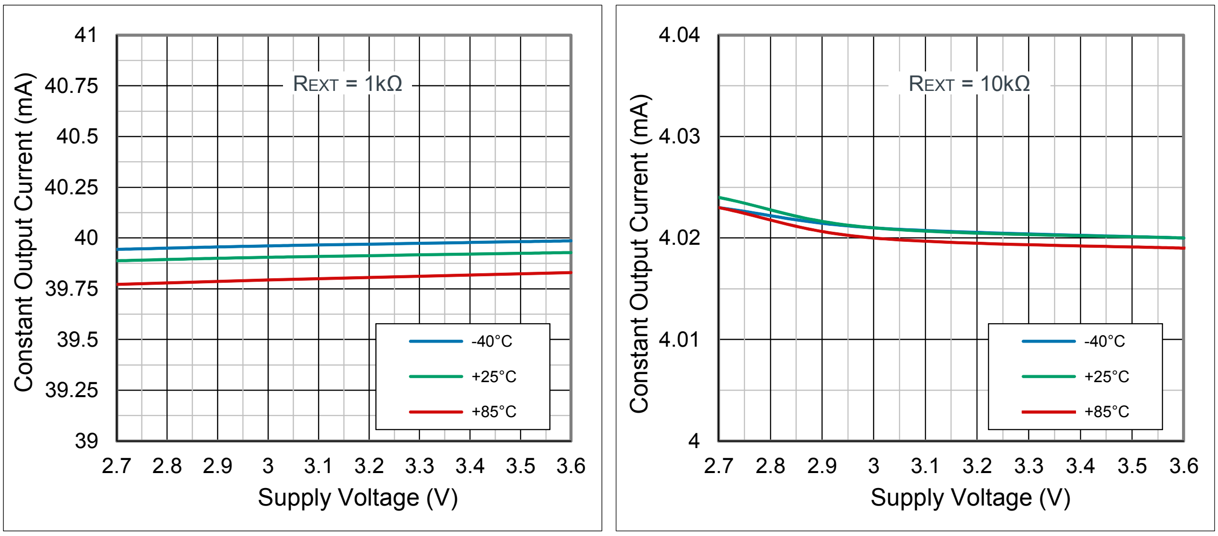
Constant Output Current vs. Output Voltage: These graphs are showing the behavior of different Constant Output Current settings versus the Output Voltage. V_{DD} = 3.0V, T_{AMB} = 25°C

Figure 8:
Constant Output Current vs. Output Voltage (cont.)



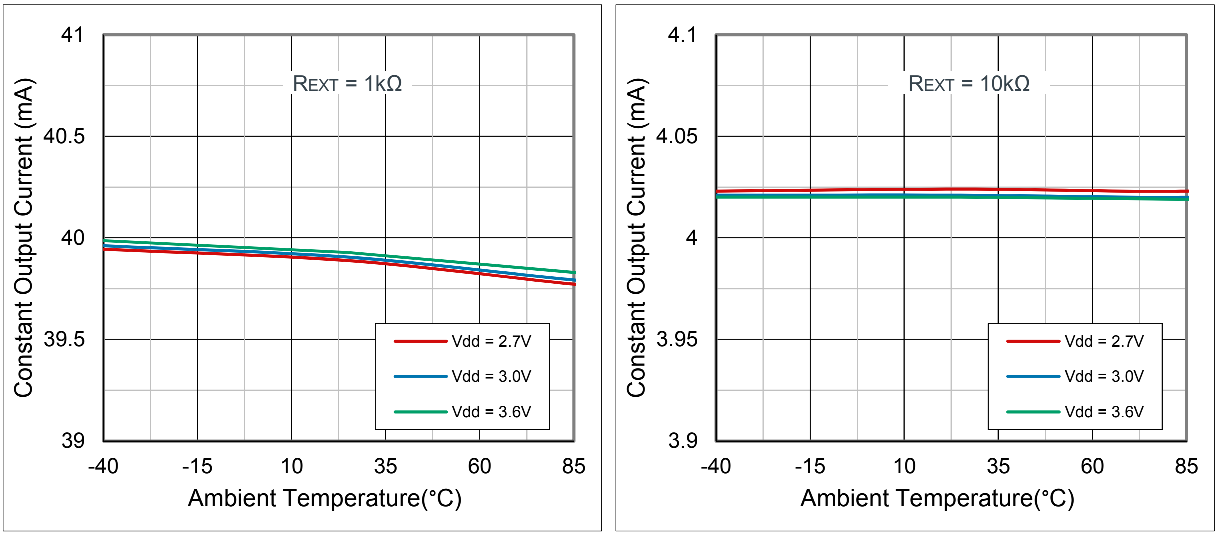
Constant Output Current vs. Output Voltage: These graphs are showing the behavior of the 40mA Constant Output Current settings versus the Output Voltage over temperature. V_{DD} = 3.0V, R_{IREF} = 1kΩ

Figure 9:
Constant Output Current vs. Supply Voltage



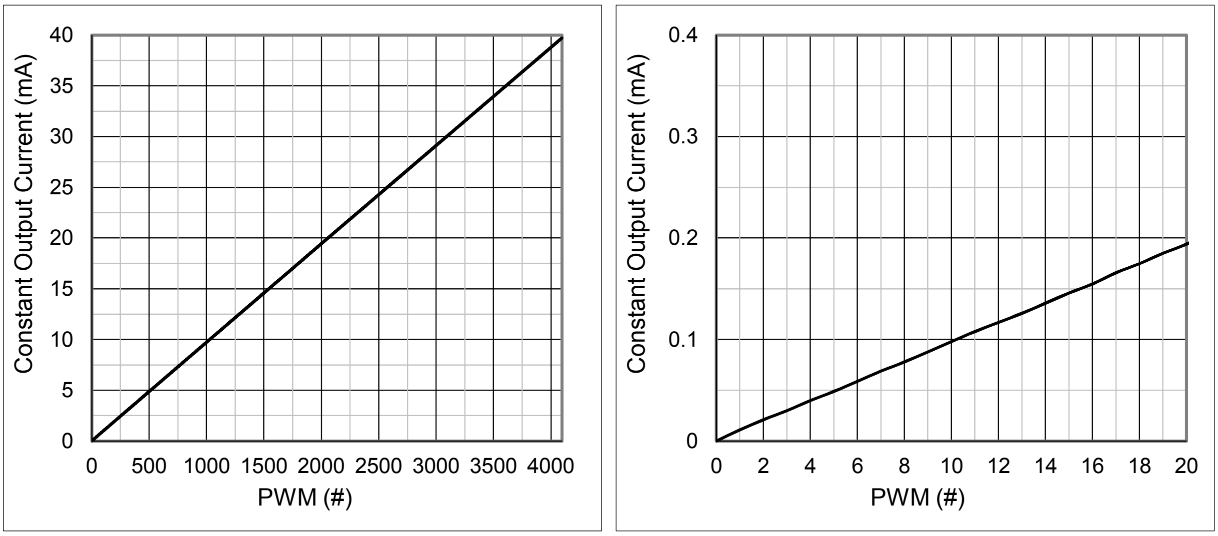
Constant Output Current vs. Supply Voltage: These graphs are showing the behavior of the Constant Output Current versus the Supply Voltage over temperature.
V_{OUT} = 1.0V, R_{IREF} = 1kΩ (left graph, I_{COC} = 40mA), R_{IREF} = 10kΩ (right graph, I_{COC} = 4mA)

Figure 10:
Constant Output Current vs. Temperature



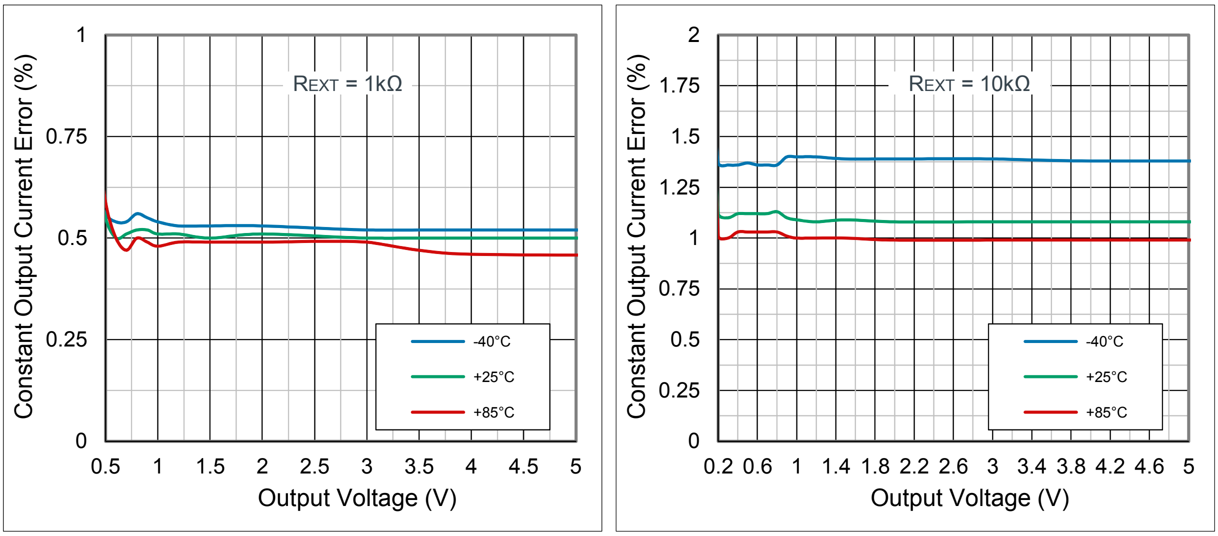
Constant Output Current vs. Temperature: These graphs are showing the behavior of the Constant Output Current versus the Temperature for different Supply Voltages.
V_{OUT} = 1.0V, R_{IREF} = 1kΩ (left graph, I_{COC} = 40mA), R_{IREF} = 10kΩ (right graph, I_{COC} = 4mA)

Figure 11:
Constant Output Current vs. PWM



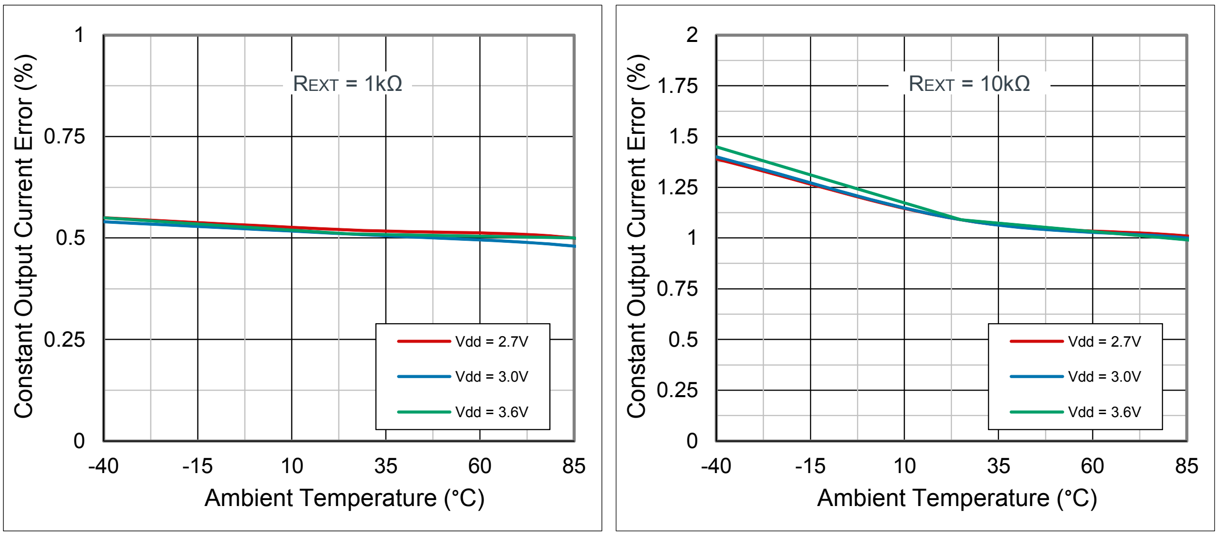
Constant Output Current vs. PWM: These graphs are showing the behavior of the Constant Output Current versus the PWM bit setting.
V_{OUT} = 1.0V, R_{IREF} = 1kΩ, V_{DD} = 3.0V, T_{AMB} = 25°C

Figure 12:
Constant Output Current Error vs. Output Voltage



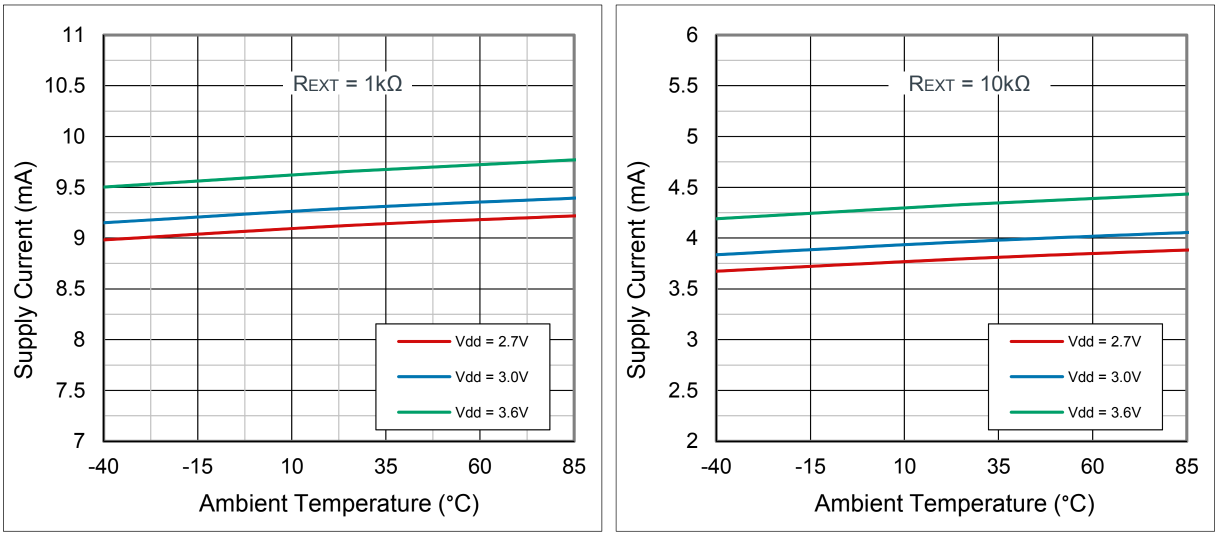
Constant Output Current Error vs. PWM: These graphs are showing the Error of the Constant Output Current versus the Output Voltage over temperature.
V_{DD} = 3.0V, R_{IREF} = 1kΩ (left graph, I_{COC} = 40mA), R_{IREF} = 10kΩ (right graph, I_{COC} = 4mA)

Figure 13:
Constant Output Current Error vs. Temperature



Constant Output Current Error vs. Temperature: These graphs are showing the Error of the Constant Output Current versus temperature for different Supply Voltages.
V_{OUT} = 1.0V, R_{IREF} = 1kΩ (left graph, ICOC = 40mA), R_{IREF} = 10kΩ (right graph, ICOC = 4mA)

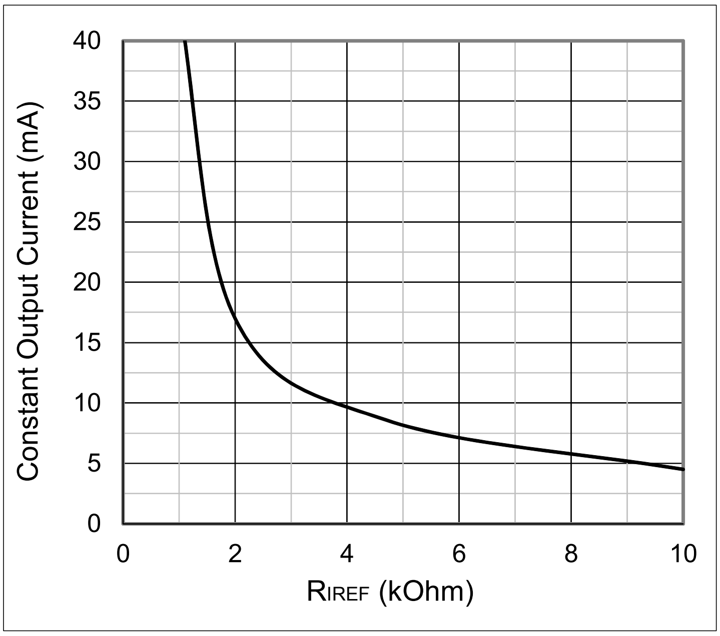
Figure 14:
Supply Current vs. Temperature



Supply Current vs. Temperature: These graphs are showing the Supply Current versus Temperature for different Supply Voltages.
V_{OUT} = 1.0V, R_{IREF} = 1kΩ (left graph, ICOC = 40mA), R_{IREF} = 10kΩ (right graph, ICOC = 4mA)

Constant Output Current vs. Reference Current Resistor: This graph is showing the Constant Output Current versus Reference Current Resistor.
V_{OUT} = 1.0V, V_{DD} = 3.0V, T_{AMB} = 25°C

Figure 15:
Constant Output Current vs. Reference Current Resistor



Constant Output Current vs. Dot Correction: This graph is showing the Constant Output Current versus Dot Correction.
V_{OUT} = 1.0V, V_{DD} = 3.0V, T_{AMB} = 25°C, R_{IREF} = 1kΩ

Figure 16:
Constant Output Current vs. Dot Correction

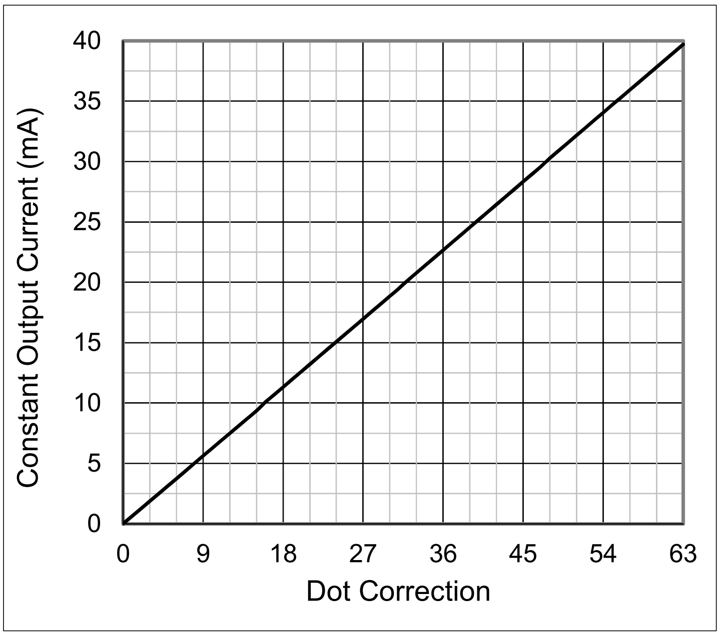


Figure 17:
LED Open Detection Threshold vs. Temperature

LED Open Detection Threshold vs. Temperature: This graph is showing the LED Open Detection Threshold versus Temperature for different Supply Voltages.

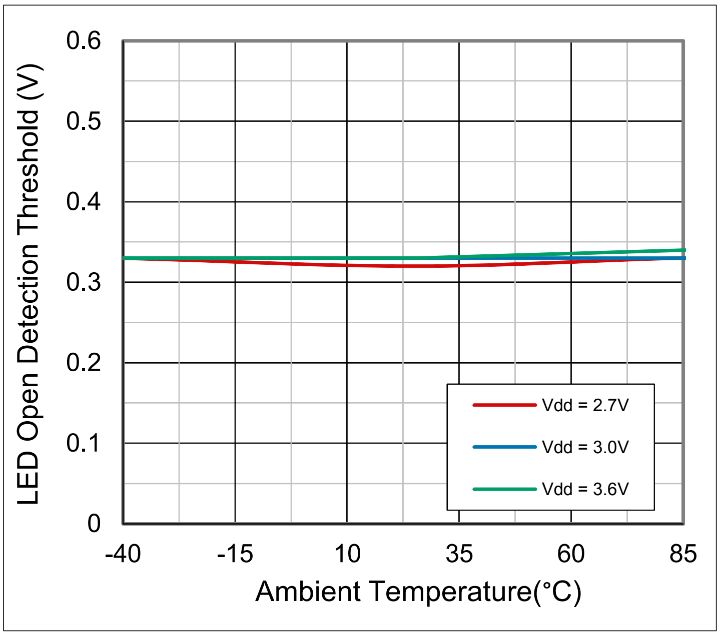
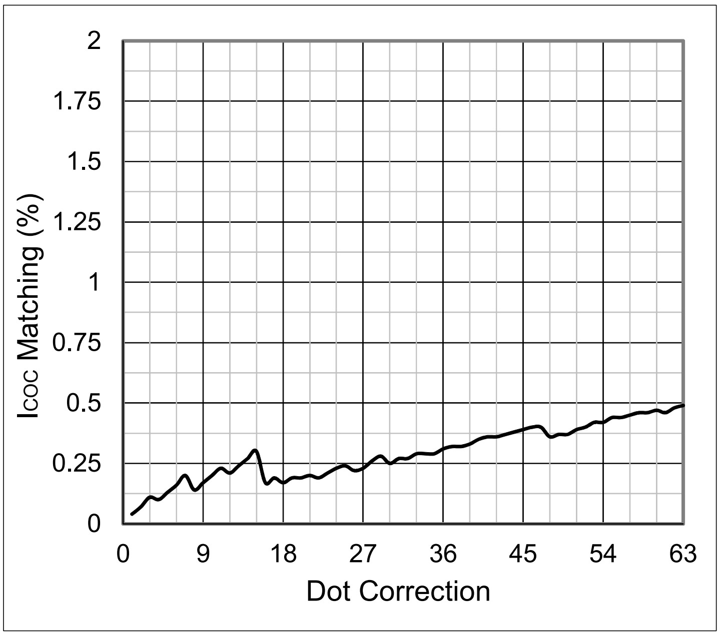


Figure 18:
Constant Output Current Matching vs. Dot Correction

Constant Output Current Matching vs. Dot Correction: This graph is showing the Matching of the Constant Output Current versus Dot Correction.
V_{OUT} = 1.0V, V_{DD} = 3.0V, T_{AMB} = 25°C, R_{IREF} = 1kΩ



Detailed Description

Timing Characteristics

Figure 19:
Output Timing Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Unit
t_{R_OUT}	Rise Time OUT (1)			20		ns
t_{F_OUT}	Fall Time OUT (1)			20		ns
t_D (2)	Average Output Delay Time			25		ns

Timing Characteristics: V_{DD} = 2.7V to 3.6V, T_{AMB} = -40°C to 85°C. Typical values are at T_{AMB} = 25°C, V_{DD} = 3.3V (unless otherwise specified).

Note(s) and/or Footnote(s):

1. Value can be factory trimmed for EMI improvement.
2. Can be turned OFF on request.

Figure 20:
Serial Interface Timing Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{OSC}	Oscillator Frequency		8	10	12	MHz
f_{CLK}	Data Shift Clock Frequency		1		5	MHz
t_{LOW}	CLK low time during data shift				1	µs
t_{CAPT}	CLK low time for data capture		1.5	1.8	2.85	µs
t_{SETUP}	Setup Time	SDI, CLKI	12			ns
t_{HOLD}	Hold Time	SDI, CLKI	12			ns
t_{PD_rising}	Delay CLKI to CLKO (1)	rising CLKI to rising CLKO	2	3.5	8	ns
$t_{PD\_falling}$	Delay CLKI to CLKO (1)	rising CLKI to falling CLKO	72	103.5	138	ns
t_{PD_SDO}	Delay CLKO to SDO (1)	falling edge CLKO	0.8	1.5	3	ns
t_{H_CLKO}	High Time of CLKO (1)		70	100	130	ns

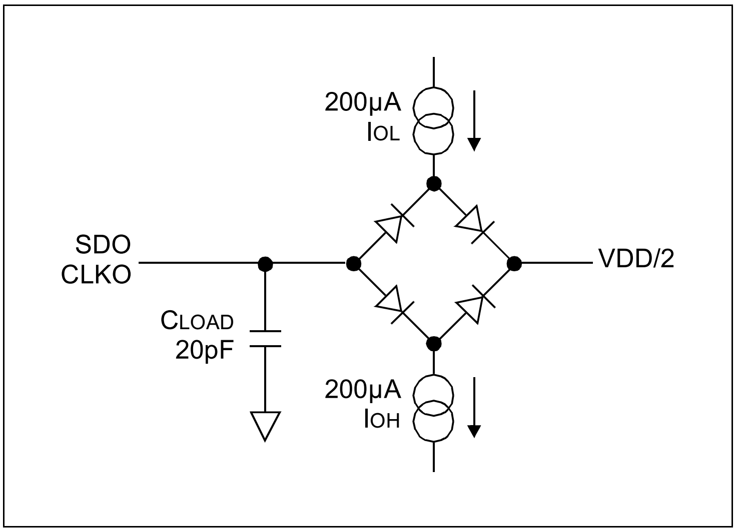
Symbol	Parameter	Condition	Min	Typ	Max	Unit
t_{R_CLK}	Rise Time CLK [1]	C_{LOAD} = 20pF			10	ns
t_{R_DATA}	Rise Time Data [1]	C_{LOAD} = 20pF			10	ns

Timing Characteristics: V_{DD} = 2.7V to 3.6V, T_{AMB} = -40°C to 85°C. Typical values are at T_{AMB} = 25°C, V_{DD} = 3.3V (unless otherwise specified).

Note(s) and/or Footnote(s):

1. Guaranteed by design and not production tested.

Figure 21:
Load Circuit for Digital Output Timing Specifications



Timing Diagrams

Serial Interface

The AS1122 features a 4-pin (CLKI, CLKO, SDI, and SDO) serial interface, which can be connected to microcontrollers or digital signal processors.

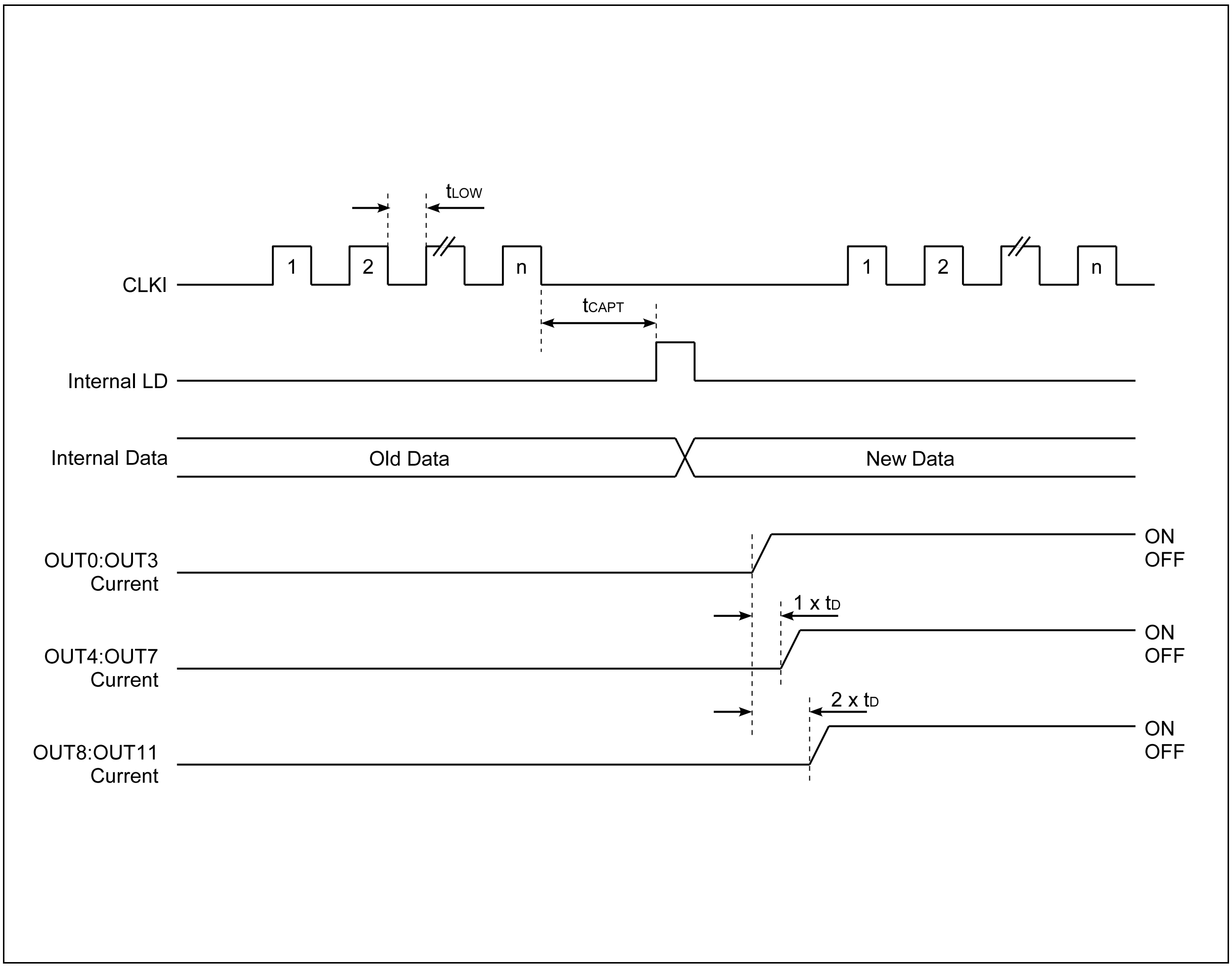
The rising edge of the CLKI signal shifts data from pin SDI to the internal register. After all data are clocked in, the serial data are latched into the internal registers at the rising edge of the internal LD signal. The internal LD signal is triggered after the clk is low for a time t_{CAPT} and all Data are clocked in.

With the first 8 clk-cycles an 8 bit identifier needs to be send to the device to distinguish between Status Information, Dot Correction, PWM or command data.

After the internal LD signal the internal counter is set to 0 again and the data are latched into the register according to the prior identifier. If the LD triggers and the counter has no valid value (80 bit for Dot-Correction, 152 bit for PWM data or 16 bit for command data), the counter is set to 0 but the data will be ignored.

With the falling edge of the CLKO the data is shifted to SDO.

Figure 22:
PWM Cycle Timing Diagram



Register Access

Before data are accepted by the AS1122, an identifier needs to be sent in advance. Only 3 defined identifiers will be recognized, all other bit combinations will be ignored.

Figure 23:
Identifier

Identifier	Bit								Data Section Length	Description
	7	6	5	4	3 (1)	2	1	0		
Dot Correction	1	1	0	0	1/0	0	0	1	72 bits	Dot Correction Register
PWM	1	1	0	0	1/0	0	1	0	144 bits	PWM Register
Command	1	1	0	0	1/0	1	0	0	8 bits	Command Register

Note(s) and/or Footnote(s):

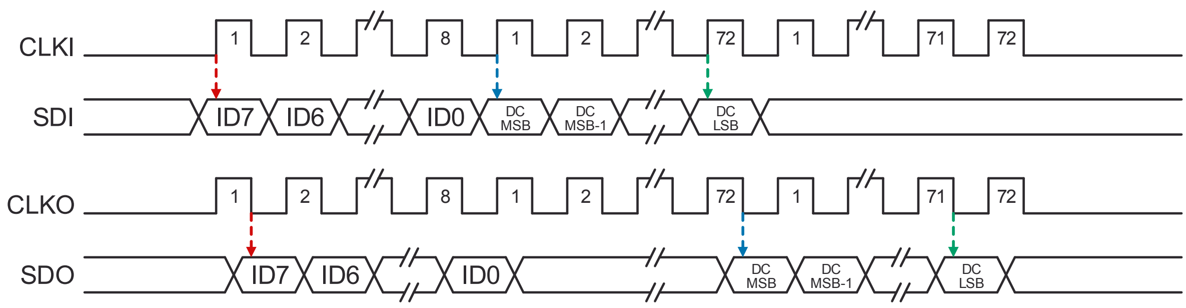
1. Bit3 of the identifier is a global ON/OFF bit. When bit3 of any identifier is set to logic ‘0’ and the OEN bit of the command register is ‘0’ (per default), the output channels are immediately turned ON.

The identifier maps the input register to the identified register and all data on pin SDI will be clocked into this register. This selection is valid as long as no internal LD signal is triggered. When data is latched into the device the identifier selection is reset and for the next data word a new identifier needs to be send. Every identifier requires a certain data section length. If this length is not corresponding with the identifier, the data will be ignored.

Dot Correction (DC)

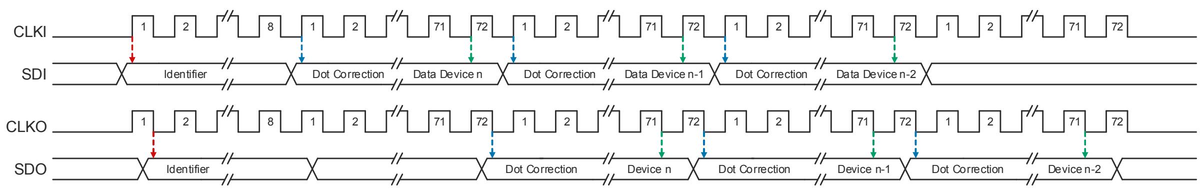
The AS1122 offers a 6 bit (64 steps) Dot Correction per Output channel. After sending the 8 bit identifier for access to the DC register the device is waiting for 72 bits to receive. If more or less bits are sent the whole dataword will be ignored.

Figure 24:
Dot Correction Input Timing Diagram



For n devices in a chain only one identifier is needed to set all n devices to the same register setting.

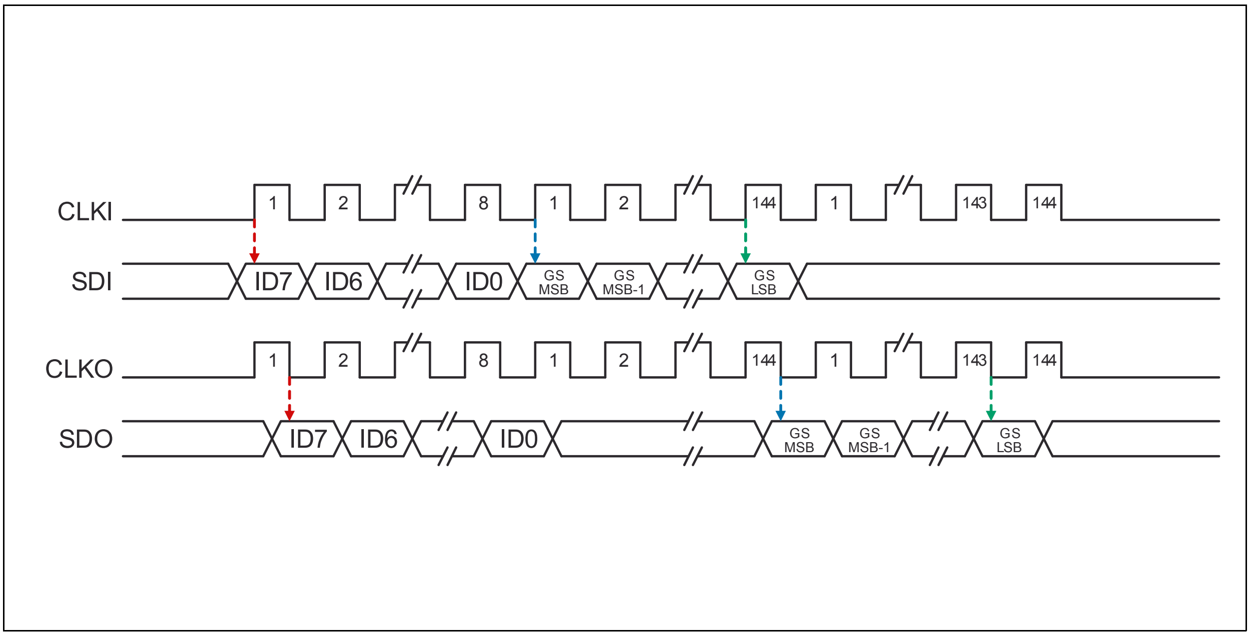
Figure 25:
Dot Correction for N Devices



PWM Data (Greyscale)

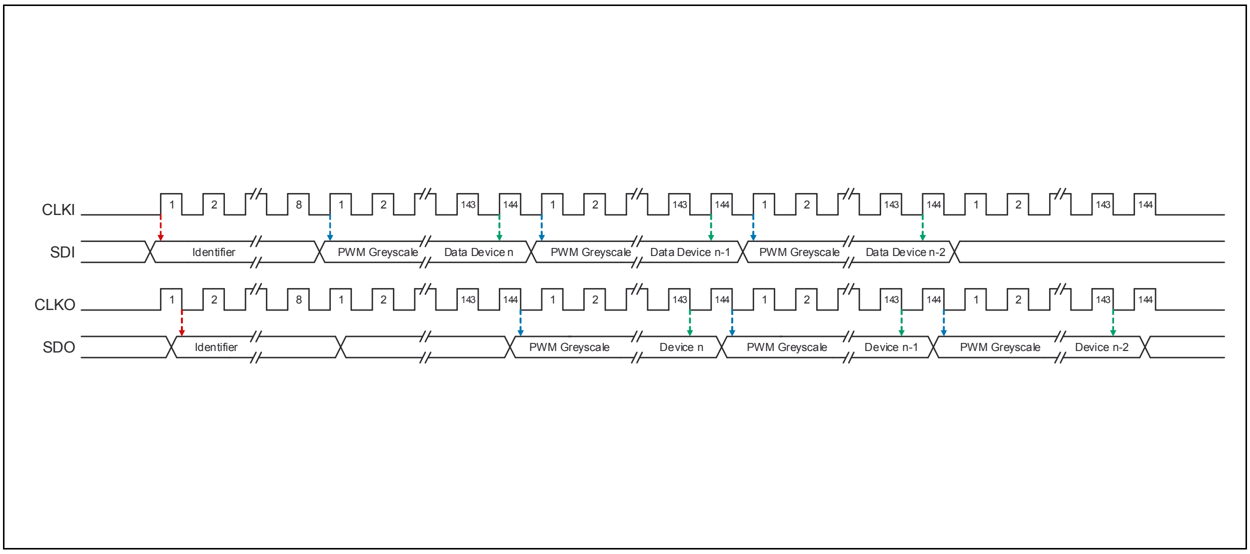
To set the PWM, 12 bit (4096 steps) per Output channel can be used. After sending the 8 bit identifier for access to the PWM Data register the device is waiting for 144 bits to receive. If more or less bits are sent the whole dataword will be ignored.

Figure 26:
PWM Input Timing Diagram



For N devices in a chain only one identifier needs to be set all n devices to the same register setting.

Figure 27:
PWM Data for N Devices



Command Data

The AS1122 offers a command register for setting the configuration of the device. The command register is again accessible via an identifier and is 8 bits long. If more or less bits are sent the whole dataword will be ignored.

Figure 28:
Command Input Timing Diagram

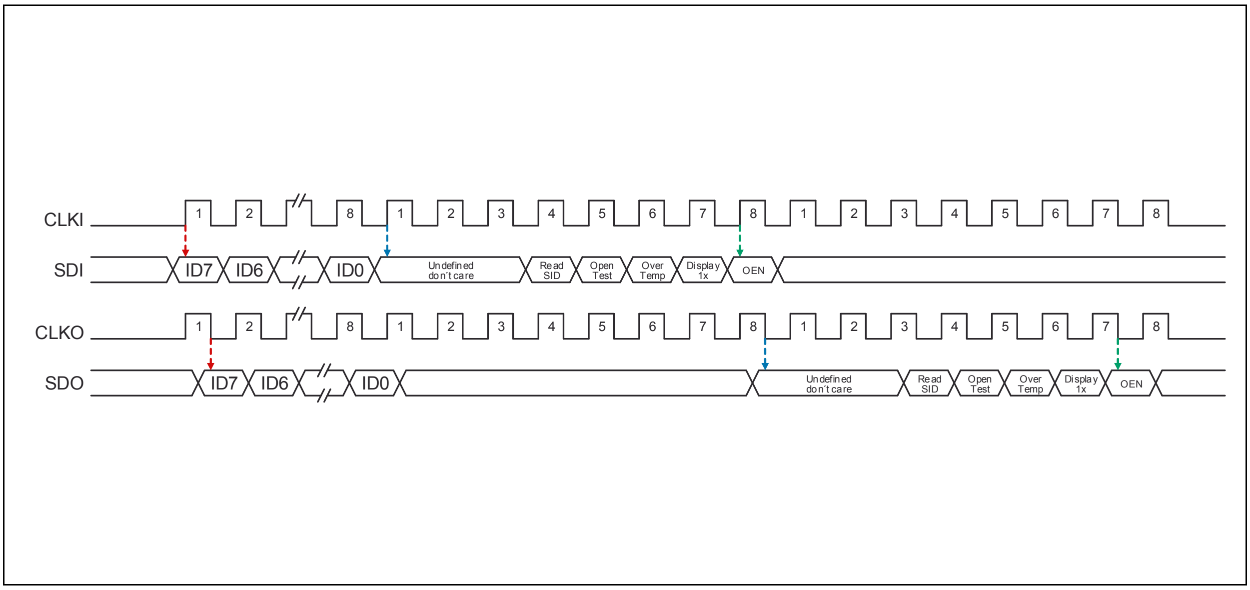
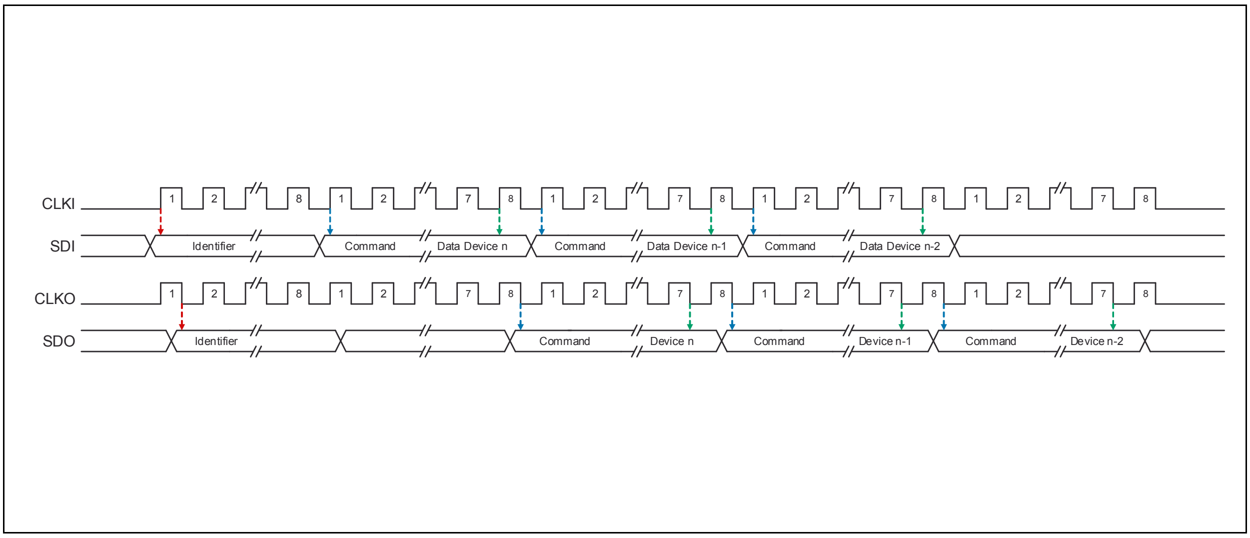


Figure 29:
Command Data for N Devices



Typical Operating Characteristics

Setting Dot Correction

The AS1122 can perform independent fine-adjustments to the output current of each channel. Dot correction is used to adjust brightness deviations of LEDs connected to the output channels (OUT0:OUT11).

The device powers up with the following default settings: DC = 0 and GS = 0.

The 12 channels can be individually programmed with a 6-bit word for Dot Correction. The channel output can be adjusted in 64 steps from 0% to 100% of the maximum output current (I_{MAX}). The output current for each OUT_n channel can be calculated as:

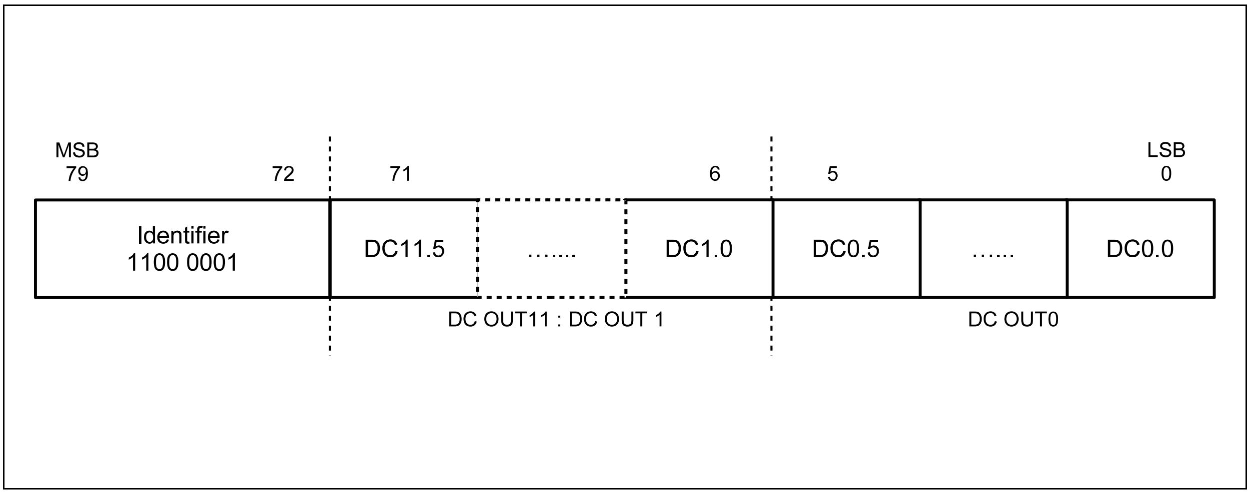
(EQ1)
$$I_{OUT_n} = I_{MAX} \times \frac{DC_n}{63}$$

Where:

- I_{MAX} is the maximum programmable output current for each output;
- DC_n is the programmed dot correction value for output (DC_n = 0 to 63);
- n = 0 to 11

Dot correction data are simultaneously entered for all channels. The complete dot correction data format consists of 12 x 6-bit words, which forms a 72-bit serial data packet and 8-bit for the identifier. Channel data is put on one by one, and the data is clocked in with the MSB first.

Figure 30:
Dot Correction Data Packet Format



The Dot Correction data is only valid if the exact identifier byte was sent. Otherwise the data will be ignored.

Setting Greyscale Brightness (PWM)

The brightness of each channel output can be adjusted using a 12 bits-per-channel PWM control scheme which results in 4096 brightness steps, from 0% to 100% brightness. The brightness level for each output is calculated as:

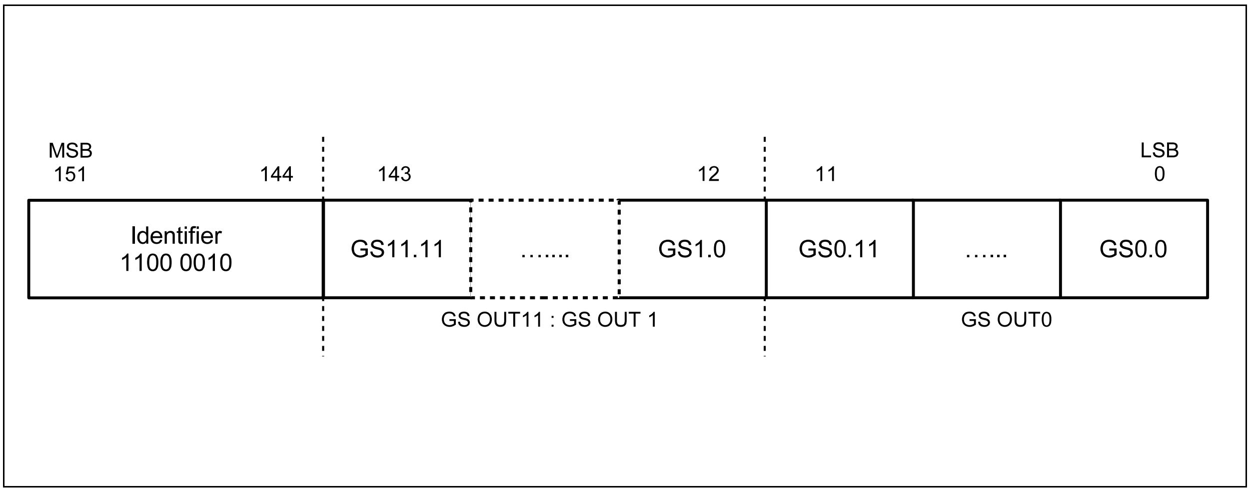
(EQ2) $$\%Brightness = \frac{GS_n}{4095} \times 100$$

Where:

- GS*n* is the programmed greyscale value for output (GS*n* = 0 to 4095);
- *n* = 0 to 11 greyscale data for all outputs.
- The device powers up with the following default settings: GS = 0 and DC = 0

The input shift register shifts greyscale data into the greyscale register for all channels simultaneously. The complete greyscale data format consists of 12 x 12 bit words, which forms a 144-bit wide data packet plus the 8 bit for the identifier.

Figure 31:
PWM Data Packet Format



The PWM data is only valid if the exact identifier byte was send. Otherwise the data will be ignored.

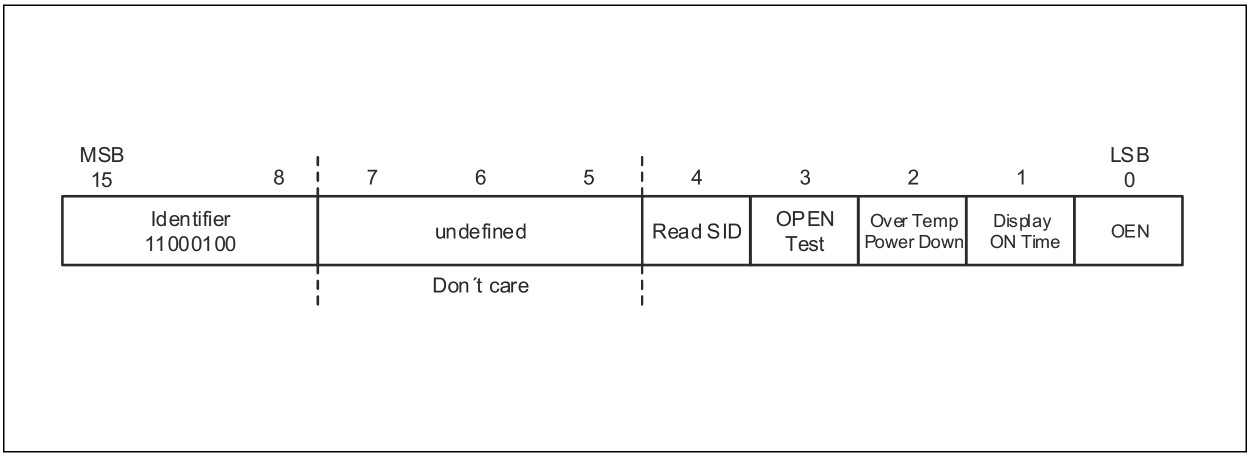
Command Data

In the command register of the AS1122 some configuration of the device can be done. After sending the correct identifier the 8 bits of the command register are accessible.

Figure 32:
Command Register Format

Bit	Bit Name	Default	Access	Bit Description
7:5	-	000	n/a	
4	Read SID	0	W	0: normal operation 1: read Status Information Register (SID)
3	OPEN Test	0	W	0: no test is running 1: start OPEN test
2	Over Temperature Power Down	0	W	0: If an overtemperature condition occurs the OUT_n are NOT switched OFF automatically. 1: If an overtemperature condition occurs the OUT_n are switched OFF automatically.
1	Display ON Time	0	W	0: The PWM is running endless 1: The PWM is running for one cycle
0	OEN	0	W	0: This bit must be '0' as well as bit3 of the last valid identifier to turn ON all channels. 1: all channels are OFF

Figure 33:
Command Packet Format

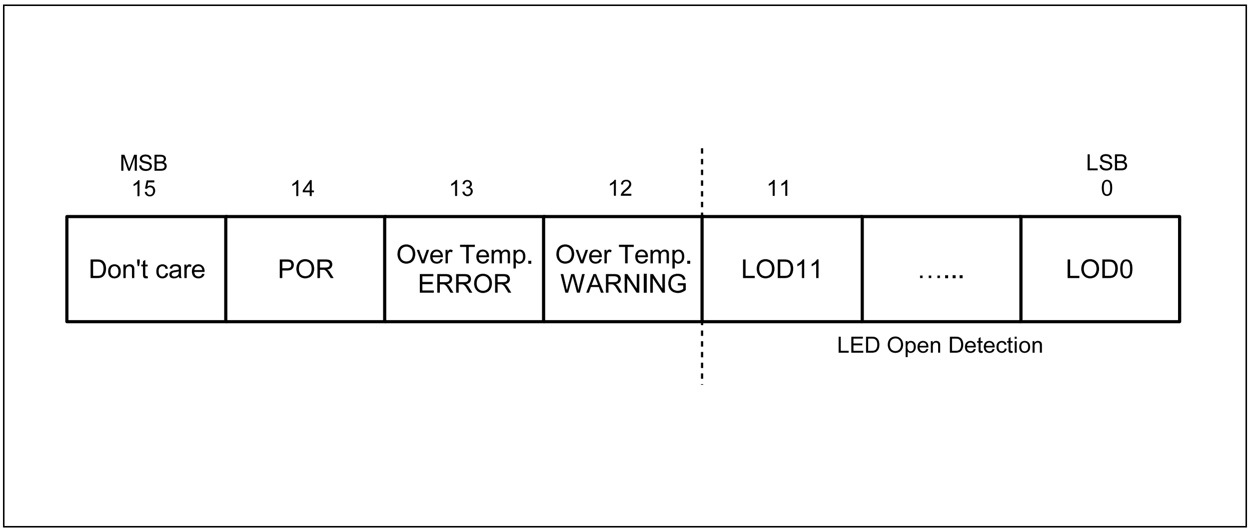


Status Information Data (SID)

The AS1122 contains an integrated status information register. After latching the correct identifier with a 16 bit data word the input shift register data is replaced with status information data.

With the next 16 clock cycles the Open LED information, the Overtemperature-Warning and -Error flag as well as the power-ON reset (POR) flag can be read out at pin SDO. The status information data packet is 16 bits wide. Bits 11:0 contain the open LED detection status of each channel. Bit 12 is the overtemperature-warning flag, bit 13 is the overtemperature-error flag and bit 14 indicates if the POR was triggered.

Figure 34:
Status Information Data Packet Format



Note(s) and/or Footnote(s):

1. Bit14 (POR) is set to '1' after start-up and after triggering a power-ON reset due to a supply voltage drop. Must be set to '0' manually.