AN2415
Application note

Using the output detection feature of the high-brightness LED driver STP08CDC596 evaluation board

Introduction

This document describes how to implement a complete solution for driving a high-brightness LED array. Based on STP08CDC596 drivers and controlled by an ST7FLITE3x microcontroller, there are two versions of the evaluation board:

- STEVAL-ILL002V1 using OSRAM LEDs
- STEVAL-ILL002V2 using Toshiba LEDs

Note: The STP08CDC596 LED driver is replaced by the new, higher performing STP08DP05 LED driver. The two available versions of the evaluation board with the STP08DP05 replace the STEVAL-ILL002V1 and the STEVAL-ILL002V2, and are described in application note AN2478.

The new boards available are:

- STEVAL-ILL002V3 using OSRAM LEDs
- STEVAL-ILL002V4 using VISHAY LEDs

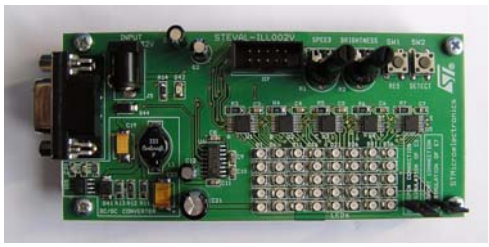
Forty high-brightness LEDs are arranged on the board in a 5x8 matrix. The matrix is driven by five 8-channel STP08CDC596 drivers.

The main features of the evaluation board are:

- Brightness and blinking regulation
- Animated text
- Error detection on output
- GUI (graphic user interface)
- DC-DC converter

The innovative feature of the STP08CDC596 is the full output error detection function which enables output status checking without invasive testing (via software only).

Figure 1. STEVAL-ILL002Vx evaluation board



For more information about other boards based on the STPxxC/L596 driver family, refer to application note AN2141 which provides details concerning the basic features of the driver family, the microcontroller interface and chip power dissipation. Refer to user manual UM0181 for information about how to get started using the evaluation boards.

Contents

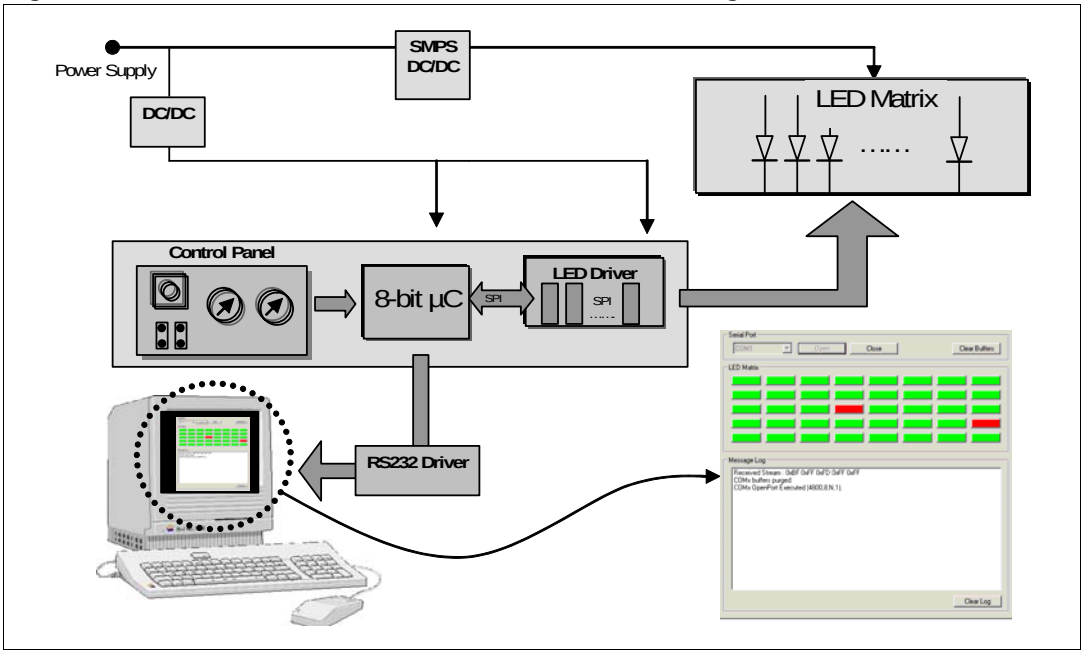
List of figures

1 Overview

The STEVAL-ILL002Vx evaluation board can be powered with voltages from 7 V up to 32 V. The SMPS DC-DC converter block is based on the L5970D step-down switching regulator and the DC-DC block is based on the LE50ABD voltage regulator. The power topology makes it possible to power the board using a laptop power supply.

Figure 2 shows the block diagram of the evaluation board.

Figure 2. STEVAL-ILL002Vx evaluation board block diagram



The brain of the board is the 8-bit ST7FLITE39 microcontroller. It receives inputs from the control panel, sends and receives data from the LED drivers through the serial peripheral interface (SPI) and enables PC communication through the serial communications interface (SCI). The control panel consists of switches, potentiometers and jumpers. Switches are used to reset the microcontroller and to enter Detection mode. Potentiometers change the brightness and text speed. Jumpers are used to simulate errors (open and short circuit) on the LED matrix.

A LED matrix consists of 40 LEDs arranged in a 5x8 matrix. A dedicated PC GUI displays the status of the LEDS.

2 Operation mode switching

To enter Error Detection or Normal mode, the drivers must receive a particular sequence on the OE and LE pins.

When a one-clock-wide short pulse “101” is sent on the OE pin, the drivers enter the switching phase. If the LE pin is sampled as high voltage at the 4th rising edge of CLK, the drivers switch to Error Detection mode (*Figure 3*). Otherwise, they switch to Normal mode (*Figure 4*).

Note: In the firmware, with SW2 pressure only the drivers enter Error Detection mode, and after an error detection check, they re-enter Normal mode.

Figure 3. Error Detection mode

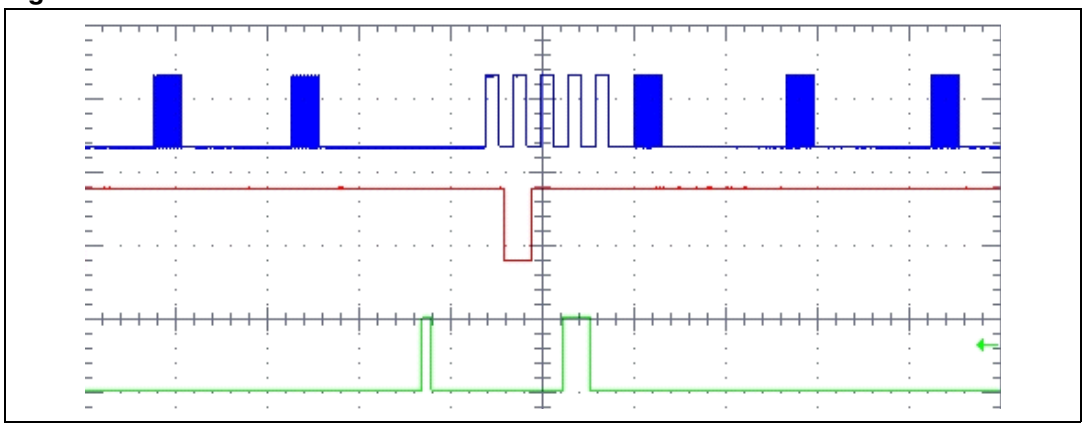
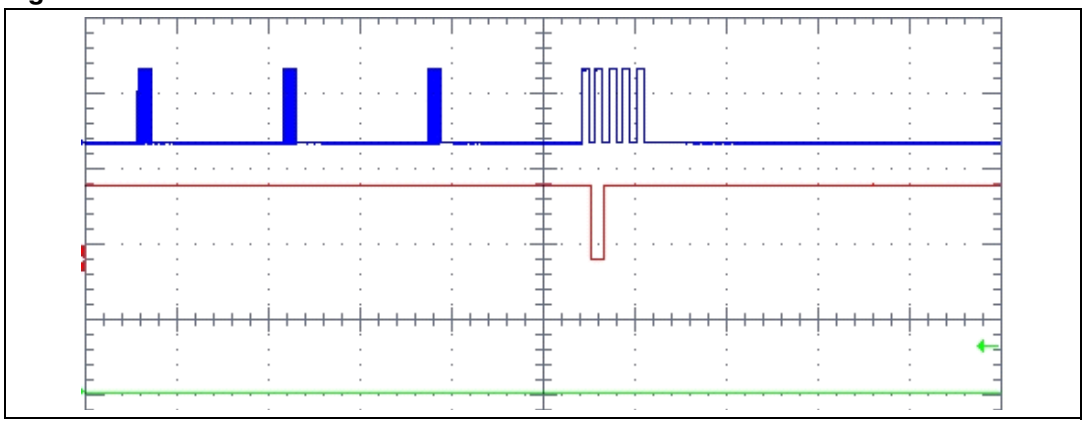


Figure 4. Normal mode



2.1 Normal mode

In Normal mode, the serial data is transferred from the microcontroller to the drivers via the SPI. The serial data from microcontroller is sent to the drivers via the SDI pin, undergoes a shift in the Shift Register, and exits via the SDO pin. The LE pin can latch the serial data in the Shift Register to the output latch. The OE pin enables the output driver sink current. Current is modulated by the potentiometer, which changes the PWM duty cycle on the OE pin (PWM frequency is set at 244 Hz).

Note: At start-up, the evaluation board works in Normal mode.

2.2 Error detection mode

After entering Error Detection mode as shown in *Figure 3*, it is recommended to send all data to the drivers as “1”.

As long as the OE pin is high, the serial data can still be shifted to the Shift Register via the SDI pin, and out via the SDO pin. The LE pin can also send the data in the Shift Register to the output latch.

When the state of the OE pin is pulled down to low voltage for at least 2 µs, the drivers execute the error detection function and load the error status into the Shift Register. The error status codes saved in the Shift Register can then be shifted out via the SDO pin bit-by-bit along with the clock. The SDO pin of the last driver of the chain is connected to the MISO pin of the microcontroller. Incoming data can be sent to the PC through the SCI and displayed on the GUI. For more information, refer to the timing diagram shown in *Figure 5*.

3 Firmware implementation

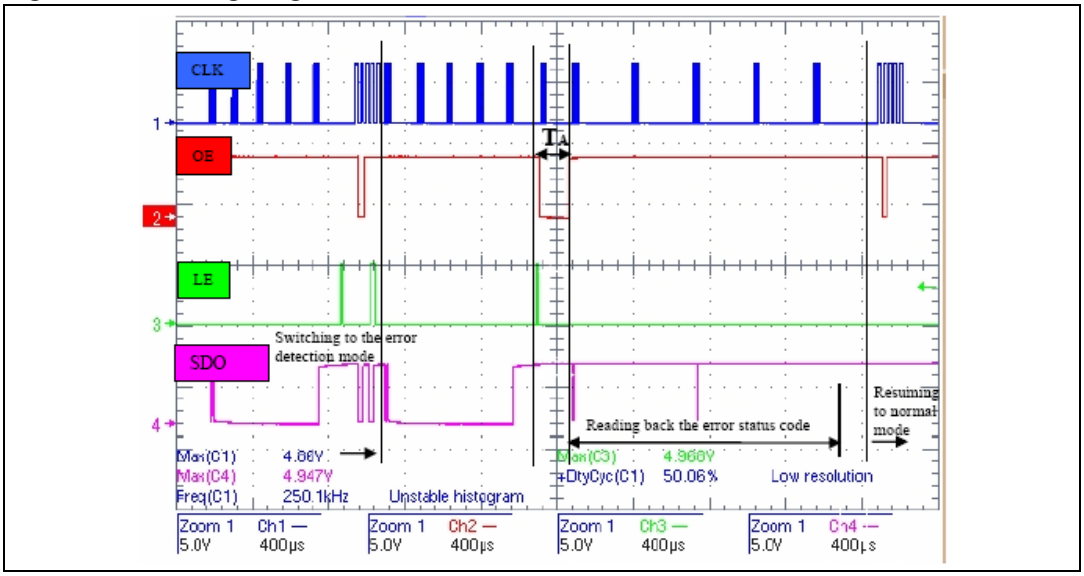
The purpose of this application note is to explain how to manage the error detection features of the drivers. Refer to AN2141 for an explanation of the basic driver features.

3.1 Timing diagram

At power-up, the microcontroller sends data to the drivers’ Shift Register via the SPI configured at 250 kHz. The maximum communication frequency for this driver is 25 MHz to satisfy high volume data transmissions. (Please refer to the device datasheet for more details). The two potentiometers are connected to ADC inputs. The analog voltage inputs are converted to a digital value. According to this digital value, it will change the PWM duty-cycle signal for brightness and data time delay for text speed. By default, the microcontroller works in Normal mode and only enters Error Detection mode when an external interrupt pin connected to SW2 is triggered. The related ISR disables the SPI I/O function and sends a specific sequence to the driver via the CLK, OE, and LE pins as shown in *Figure 5*.

After the driver has received the specific sequence, the microcontroller enables the SPI and sends 0xFF data for each driver. The drivers have already entered Error Detection mode and the microcontroller maintains pin OE low for detecting the error status. Drivers send back the LED status to the microcontroller via the MISO pin (connected to the SDO pin). Then, the microcontroller resumes Normal mode operation, sending the specific sequence to the drivers. *Figure 5* shows each phase, switching from Error Detection to Normal modes.

Figure 5. Timing diagram



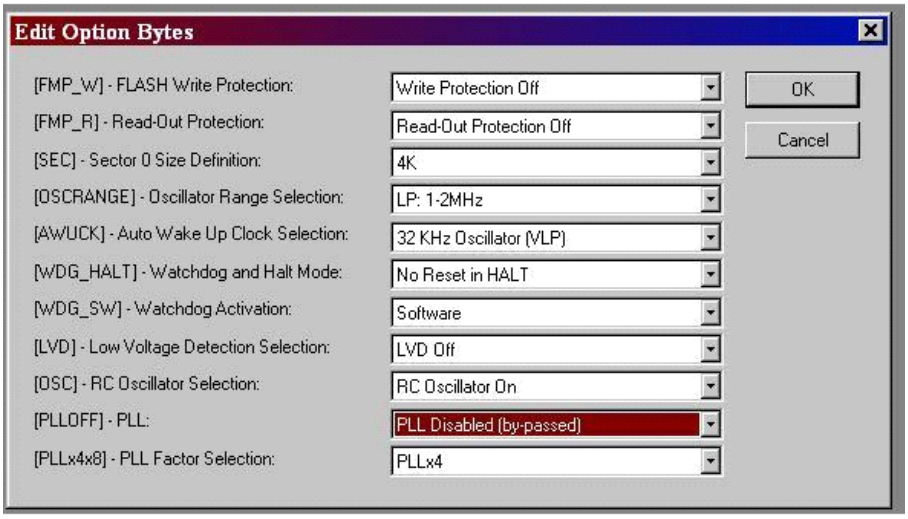
Note: T_A must be at least 2 µs to detect the error status.

Note: The SDO of the E driver is connected to the MISO pin of the MCU.

3.2 Option byte

Figure 6 shows the option byte settings.

Figure 6. MCU option bytes



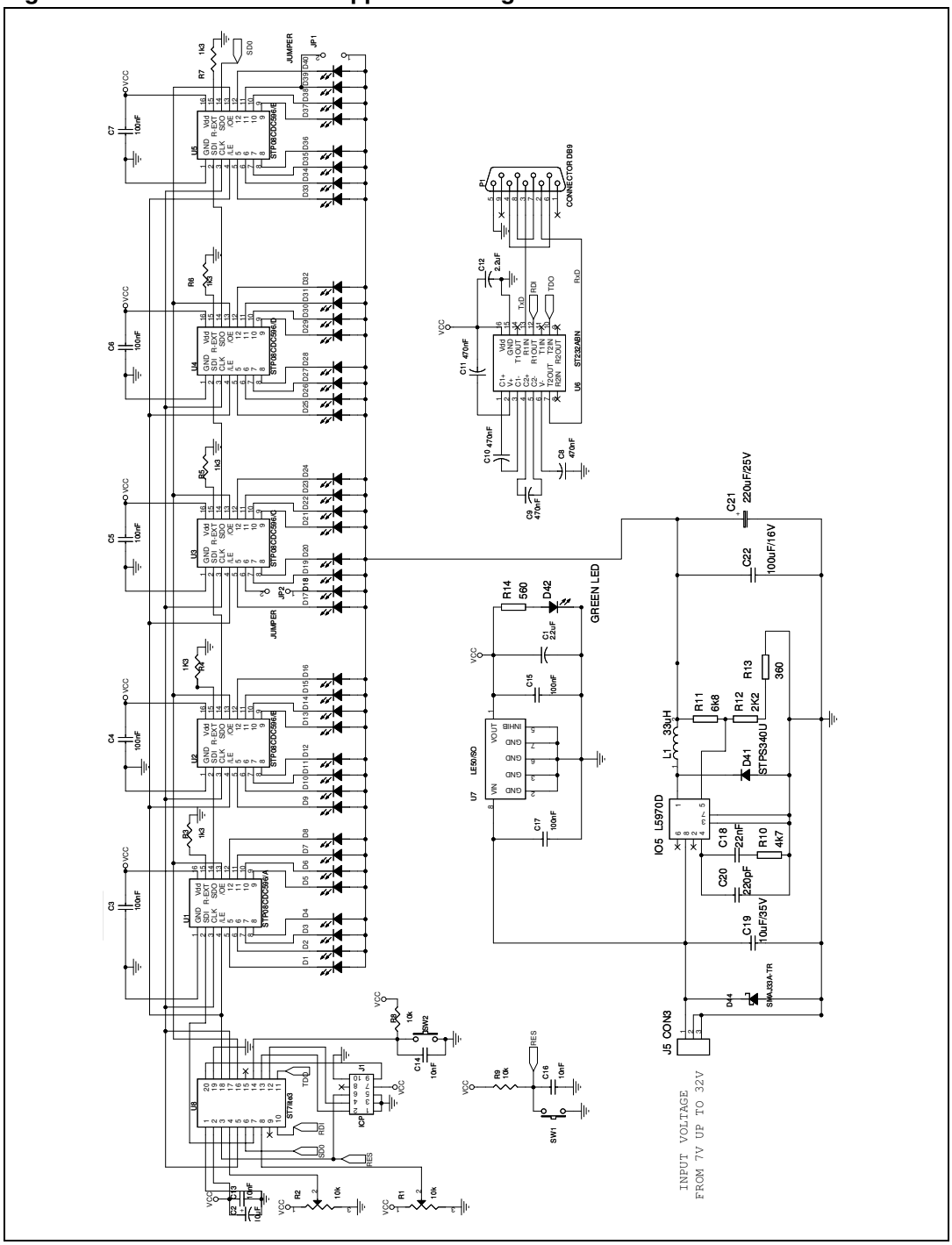
3.3 GUI features

A dedicated graphical user interface (GUI) displays the LEDs, status on the PC. The serial parameters are: 4800, 8, N, 1 (baud rate, 8 bit, parity none, 1 bit stop). The microcontroller,

after resuming Normal mode, manages the SCI peripheral and sends data to the PC using the ST232ABN driver interface.

Appendix A Application diagram

Figure 7. LED matrix board application diagram



Appendix B Bill of materials

Table 1. Bill of materials

Item	Qty	Reference	Part	Description	Order code	Supplier
1	2	C1 and C12	2.2 µF/50 V	Electrolytic capacitor		
2	1	C2	10 µF/35 V	Electrolytic capacitor		
3	7	C3, C4, C5, C6, C7, C15 and C17	100 nF/50 V	Ceramic capacitor SMD 0805		
4	4	C8, C9, C10 and C11	470 nF/16 V	Ceramic capacitor SMD 0805		
5a	2	C14 and C16	10 nF/50 V	Ceramic capacitor SMD 0805		
5b	1	C13	10 nF/50 V	Ceramic capacitor SMD 1206		
6	1	C18	22 nF/50 V	Ceramic capacitor SMD 0805		
7	1	C19	10 µF/35 V	Tantal capacitor		
8	1	C20	220 pF/50 V	Ceramic capacitor SMD 0805		
9	1	C21	220 µF/25 V	Electrolytic capacitor		
10	1	C22	100 µF/16 V	Tantal capacitor		
11	40	D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16, D17, D18, D19, D20, D21, D22, D23, D24, D25, D26, D27, D28, D29, D30, D31, D32, D33, D34, D35, D36, D37, D38, D39 and D40	LED	OSRAM SMD BLUE LED LB T68C-P2S1-35 or TOSHIBA LED - TLGE1100		OSRAM or TOSHIBA
12	1	D41	STPS340U	Diode	STPS340U	STMicroelectronics
13	1	D42	GREEN LED	SMD LED 1206		
14	1	D44	SMAJ33A-TR	Transil	SMAJ33A-TR	STMicroelectronics
15	1	IO5	L5970D	DC-DC converter	L5970D	STMicroelectronics
16	2	JP1 and JP2	JUMPER	Jumpers + switches		
17	1	J1	ICP	Programming connector		
18	1	J5	CON3	Input connector		

Table 1. Bill of materials (continued)

Item	Qty	Reference	Part	Description	Order code	Supplier
19	1	L1	33 µH	Inductor	DO3316P-333ML	Coilcraft
20	1	P1	CONNECTOR DB9	CAN connector - 9 pin		
21a	2	R1 and R2	10 k	Potentiometers with axis		
21b	2	R8 and R9	10 k	SMD resistors 0805		
22	5	R3, R4, R5, R6 and R7	1k3	SMD resistors 1206		
23	1	R10	4k7	SMD resistors 0805		
24	1	R11	6k8	SMD resistors 1206		
25	1	R12	2K2	SMD resistors 1206		
26	1	R13	360	SMD resistors 1206		
27	1	R14	560	SMD resistors 1206		
28	2	SW1 and SW2	Push-button switch	Switch		
29	5	U1, U2, U3, U4 and U5	STP08CDC596	LED drivers	STP08CDC596TTR	STMicroelectronics
30	1	U6	ST232ABD	RS232 driver	ST232ABD	STMicroelectronics
31	1	U7	LE50/SO	Linear voltage regulator	LE50ABD	STMicroelectronics
32	1	U8	ST7lite3	Microcontroller	ST7FLITE39F2M6	STMicroelectronics

4 Revision history

Table 2. Revision history

Date	Revision	Changes
7-Sept-2006	1	Initial release.
31-Jan-2007	2	*Bill of materials* table and *LED matrix board application diagram* modified.
08-Feb-2007	3	*Bill of materials* table modified.
30-Aug-2007	4	Minor text changes

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