



# **STR-NCV7685-REAR-GEVK**

## **User Manual**



Automotive



Lighting

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**Warnings**

- Individual LED current can be changed in this system, however continuous operation of multiple LEDs with large current setting makes heat sink, PCB and devices extremely hot. Please operate under appropriate environmental conditions.
- LED board mounts 72 of high-efficient type power LEDs and there are very bright, even if LED current is small. Please avoid staring into the LED source without light guide.



## Description

STR-NCV7685-REAR-GEVK is an evaluation board for car taillights application with BLE function in automotive which driven by NCV7685 and controlled by RSL10. This kit focuses multi-chips design to complete sophisticated patterns and animations. Seventy-two LED nodes which are driven by six NCV7685 chips to implement both pre-defined animations with configurable parameters and customized pattern by controlling each single LED node.

To maximize the reusability of this evaluation board, the kit is divided into three parts: LED board, LED driver and control board, RSL10 Linked board. Each board can be reused separately for evaluation of similar applications. In firmware, the drive APIs are divided into four levels: peripheral, chip, board and customer application. User can directly include the chips and board APIs in their own project and modify the customer APIs according to their own applications, which can accelerate the developing stage. The kit has two kinds of user interfaces: Strata GUI and general mobile BLE apps. Strata GUI has two tabs: “Animation Demo” controls pre-defined animations; “Customized Test” controls each single LED node to realize one pattern for verification. These functions also can be done by BLE mobile App (LightBlue, BleScanner, etc.), or customer can create specific app which is following the protocol with RSL10.

It is also an interior or exterior lighting reference design for ambient lights to realize general sequential or high-end pixelated LEDs controlling in-vehicle network. The skills of how to improve flash rate for animation, floating address method of NCV7685 and other design tips can be found by this evaluation board.

## Features

- Strata GUI and general mobile BLE Apps
- Pre-defined Animations with configurable parameters
- Customized Pattern Design
- Reusability of each sub board
- Floating Address Method for Multiple NCV7685 Chips
- Hardware and Firmware Design skills for high flash rate of Animation
- On-Chip 150, 300, 600 and 1200 Hz PWM
- Logarithmic or Linear Independent PWM Dimming
- 2 MHz fixed-frequency low quiescent current buck controller with spread spectrum that operates up to 38 V
- Bluetooth® 5 Certified with LE 2M PHY Support
- Arm Cortex-M3 Processor and LPDSP32

## Applications

- Rear Lighting of Automotive
- Ambient Lighting
- Ceiling Roof Lighting
- Automotive Synchronous Buck Power Supplier

## Hardware Design

### Architecture of the Kit

The kit is divided into three parts on the hardware: LED board, LED driver and control board and RSL10 Linked board. So, Control board and Linked board can be re-used in other lighting applications.

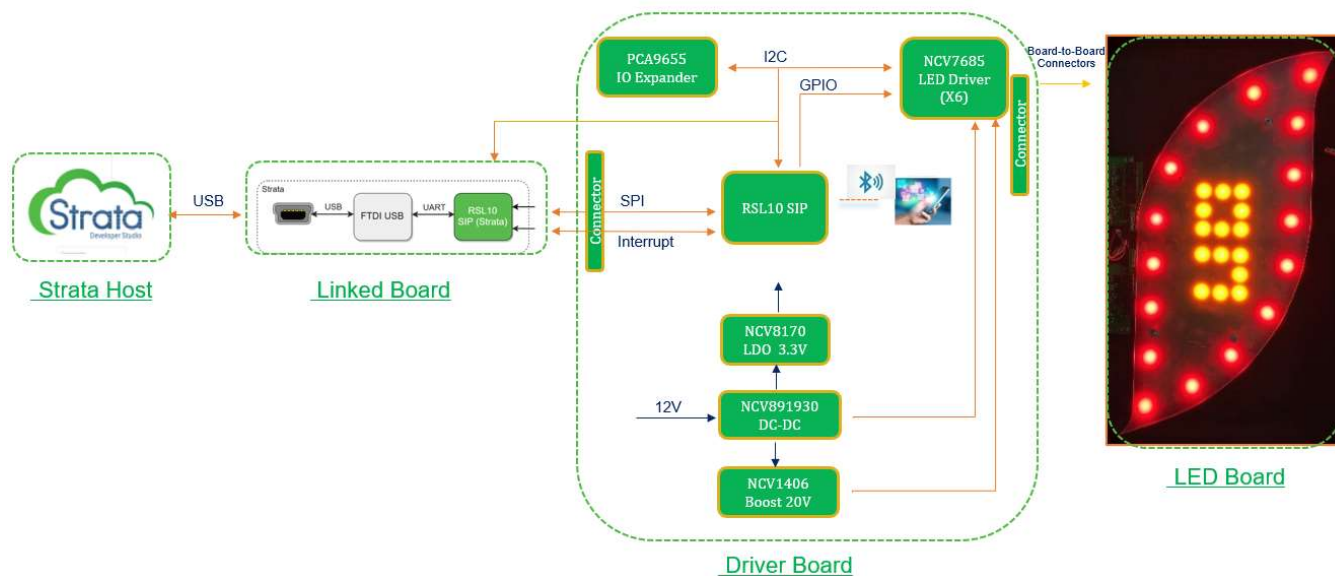


Figure 1: Architecture of the Rear Lighting Kit

### LED board

Here are 72 high-efficient power LEDs, 20 in yellow and 52 in red, to show specific pattern or animation. For each NCV7685 chip, here is one jumper in their channel to test the “one off, all off” function.

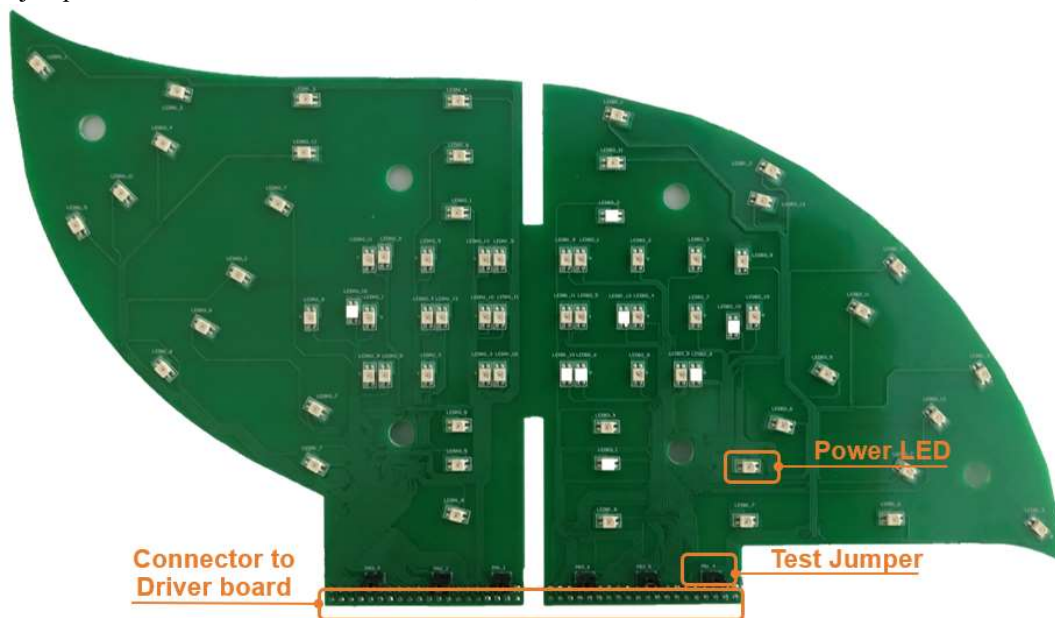


Figure 2: Top of the LED Board

### LED driver and control board

Supply the power for each part, 6 pieces of NCV7685 to drive power 72 LEDs, RSL10 is the controller to communicate with both linked board and mobile BLE apps, also send commands to NCV7685.

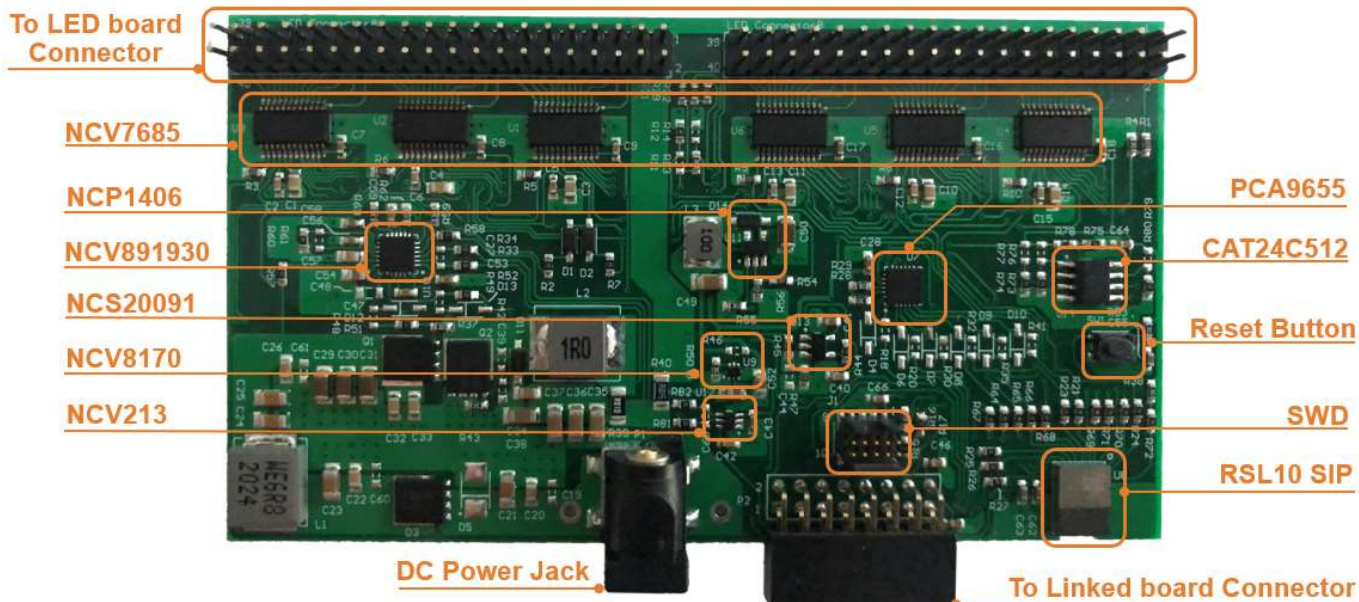


Figure 3: Top of the LED Driver and Control Board

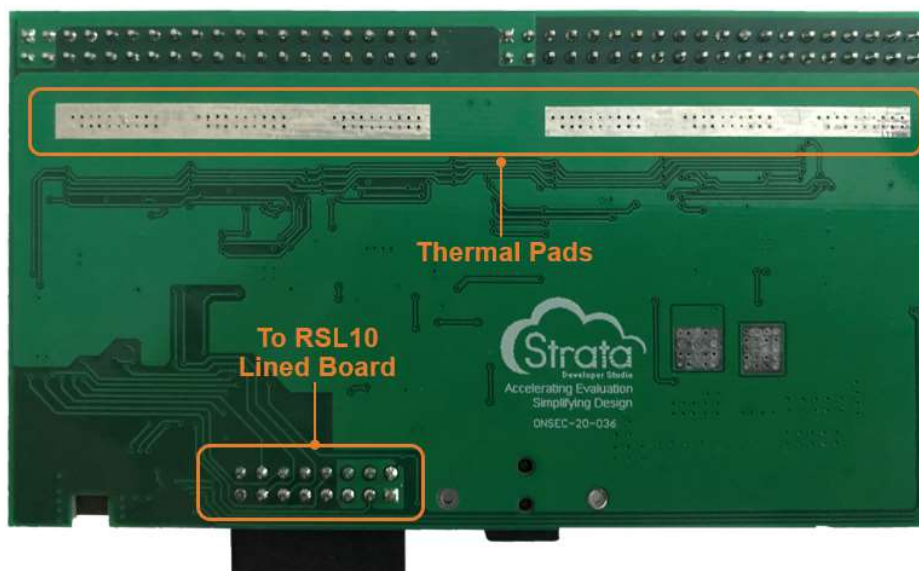


Figure 4: Bottom of the LED Driver and Control Board

**Function of key Parts**

Below table lists the function of key part in the LED driver and control board.

**Table 1. Chip DESCRIPTION**

| Chip Part | Description   |
|-----------|---|
| NCV7685   | 12 Channels 60 mA LED Linear Current Driver I2C Controllable for Automotive |
| RSL10 SIP | System-in-Package, Bluetooth® 5 Certified                                   |
| NCV891930 | Low Quiescent Current 2 MHz Automotive Synchronous Buck Controller          |
| NCV8170   | Ultra-Low IQ 150 mA CMOS LDO Regulator                                      |
| NCS20091  | Operational Amplifier, 5.5V Rail-to-Rail Input and Output, 350 kHz, Single  |
| NCS213    | Current Sense Amplifier   |



|         |   |
|---------|---|
| NCP1406 | Boost Converter                                       |
| PCA9655 | Remote 16-bit I/O Expander for I2C Bus with Interrupt |

**RSL10 Linked board**

Interface to Strata system. Find more details in Onsemi webpage.

If the re-fresh rate of the LED board is acceptable, the control function of LED driver board can be shift to RSL10 linked board to save cost. In this kit, ADC functions for LED voltage and current sampling were shifted from control board.

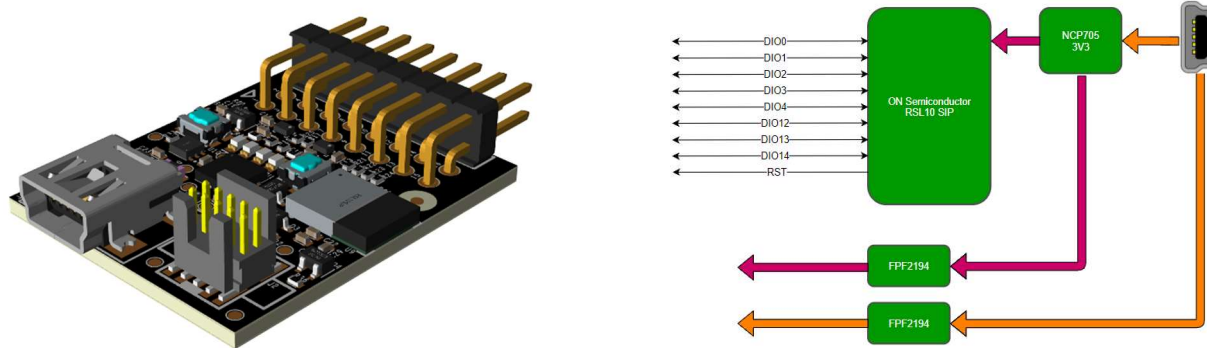


Figure 5: Strata Linked Board

**Board Assembling**

1. Following the below illustration to get assembling done.

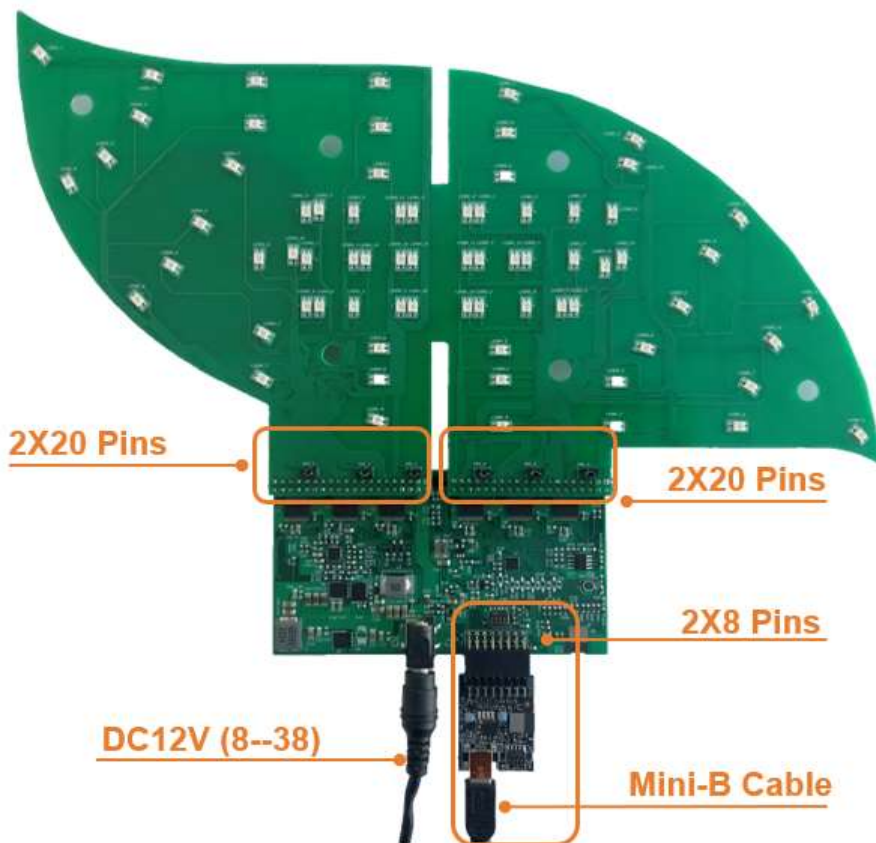


Figure 6: Assembling of the Evaluation Kit

- As high-efficient type power LEDs are very bright, assemble light guide before power on the kit. Keep the height of gap is greater than 3 centimeters at least.

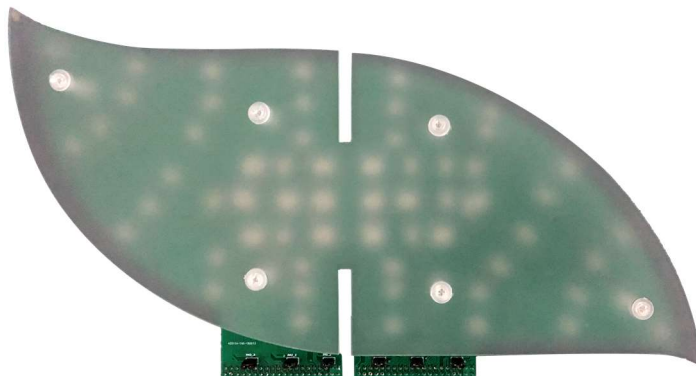


Figure 7: Assembling the Light Guide

## Strata GUI

### Setup Procedure of Strata GUI

- Go to [www.onsemi.com/strata](http://www.onsemi.com/strata) to download the latest version of Strata and follow the installation prompts.
- Launch and login to Strata with your registered account or guest.

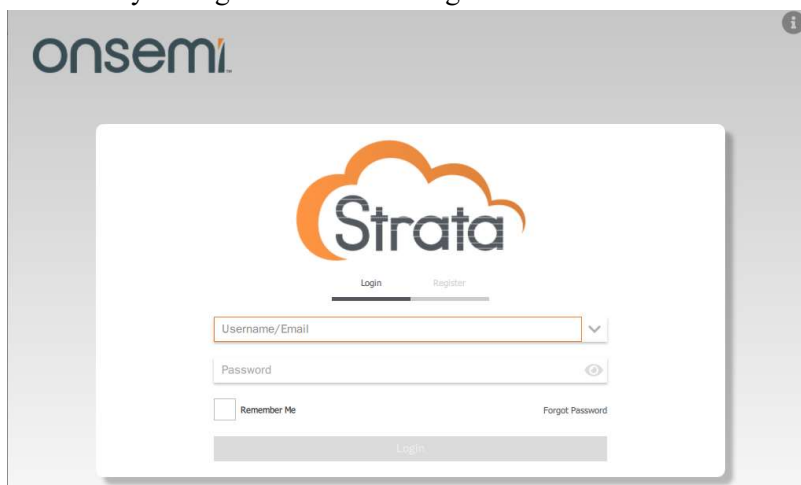


Figure 8: Strata System Login

- Plug in 12V DC power and connect the USB Mini-B cable with the computer or laptop.
- Strata system will recognize the evaluation board automatically, then just click “Open Hardware” button on the right of the bar to demo and test.

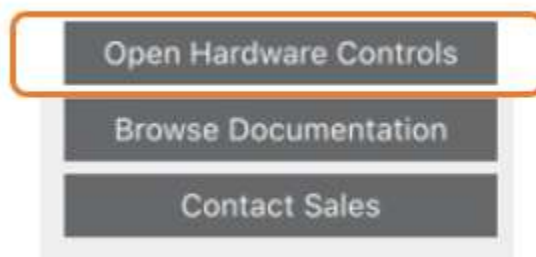



Figure 9: Open Hardware Controls



**Getting Help information of NCV7685 Rear Lighting Kit**

Just click  icon on top-right corner to show quick help in each panel. Each part's function will be detailed one by one. Here is an example: The "Right Turn" button is highlighted, the others keep fading out, the popup window shows the function and usage or parameters for "Right Turn" animation.

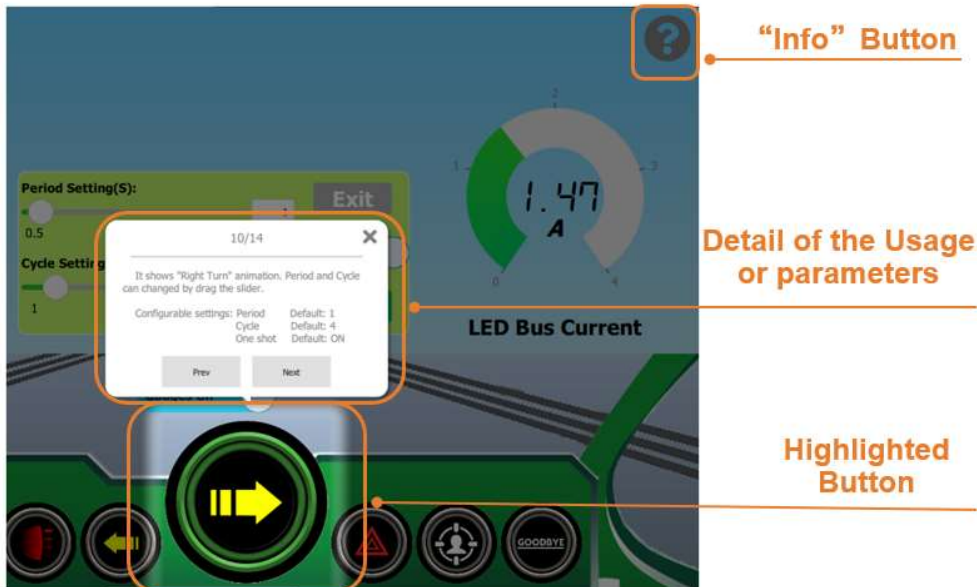


Figure 10: Quick Help Example

**"Animation Demo" Panel**

"Animation Demo" page demonstrate seven kinds of animations and each one has configurable parameters.

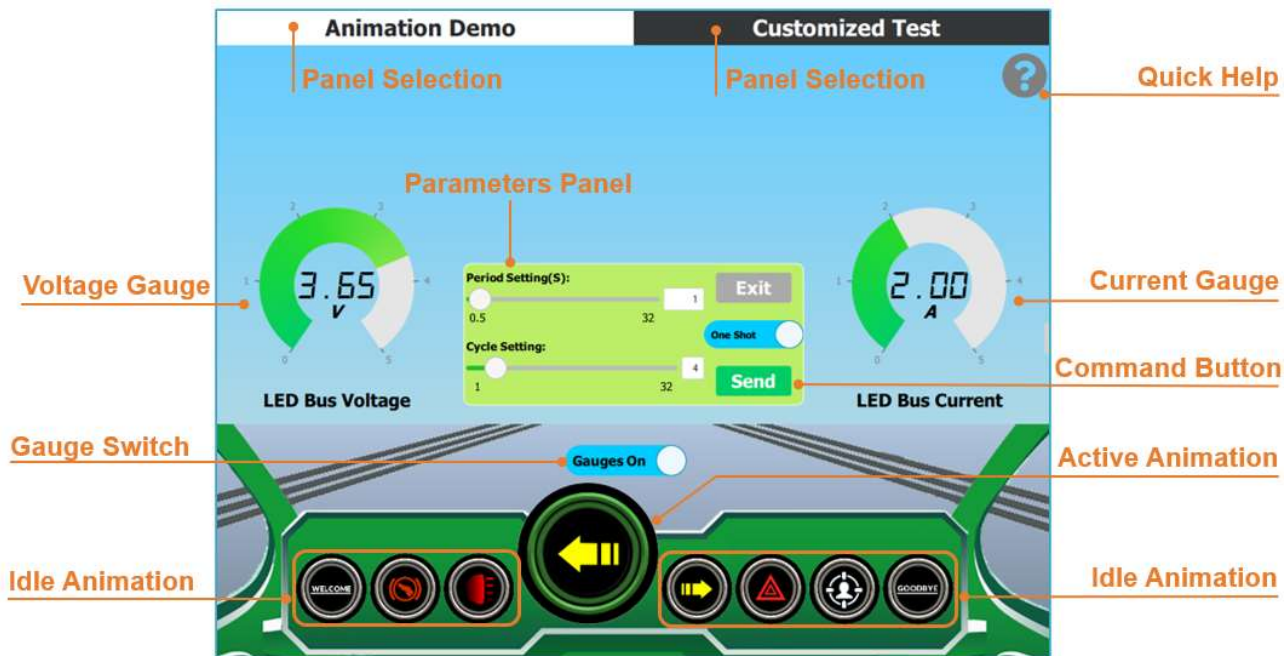


Figure 11: Animation Demo Panel

Here is a brief for pre-defined animations.

“**Welcome**” and “**Goodbye**” animation: It demoes as "Leaving Home" or “Going Home” in the automotive lighting.

“**Left Turn** ” and “**Right Turn**” animation: It shows left or right turn signal function. Period and Cycle can be easily changed by drag the slider.

“**Brake**”: It shows brake light function in the car. Intensity (PWM duty) can be changed by drag the slider.

“**Warning**”: It shows hazard lights animation.

“**Fading**”: It shows breathing animation. It can be parsed as “In Charging” or other meaning functions.

“**Setting**” button: It change NCV7685’s driving characters, e.g. PWM Frequency, PWM drive mode is either logarithmic or linear.

The below shows three state of icons:

“Idle”: Ivory and keep the original size.

“Ready”: When hovered in, the icon will be larger and in orange. After hovered out, the icon resumes the original.

“Active”: After clicked, the icon keeps larger and in green.

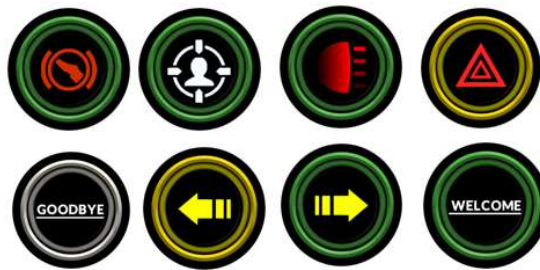


Figure 12: Icon Status

#### “Customized Test” Panel

“**Customized Test**” page shows one frame, which contains seventy-two LEDs, twenty in yellow and fifty-two in red, Each LED's intensity can be set individually to implement one pattern. The specific features of NCV7685 also can be enable or disable in this page.

It is in grey when Les is off. Hovering in the specific LED, the intensity slider popup, drag it and regulate to expected value. The slider is in yellow when LED’s color is yellow, slider is in red when hovering in a read LED. the slider will be fading out after hovering out the setting LED for three seconds.

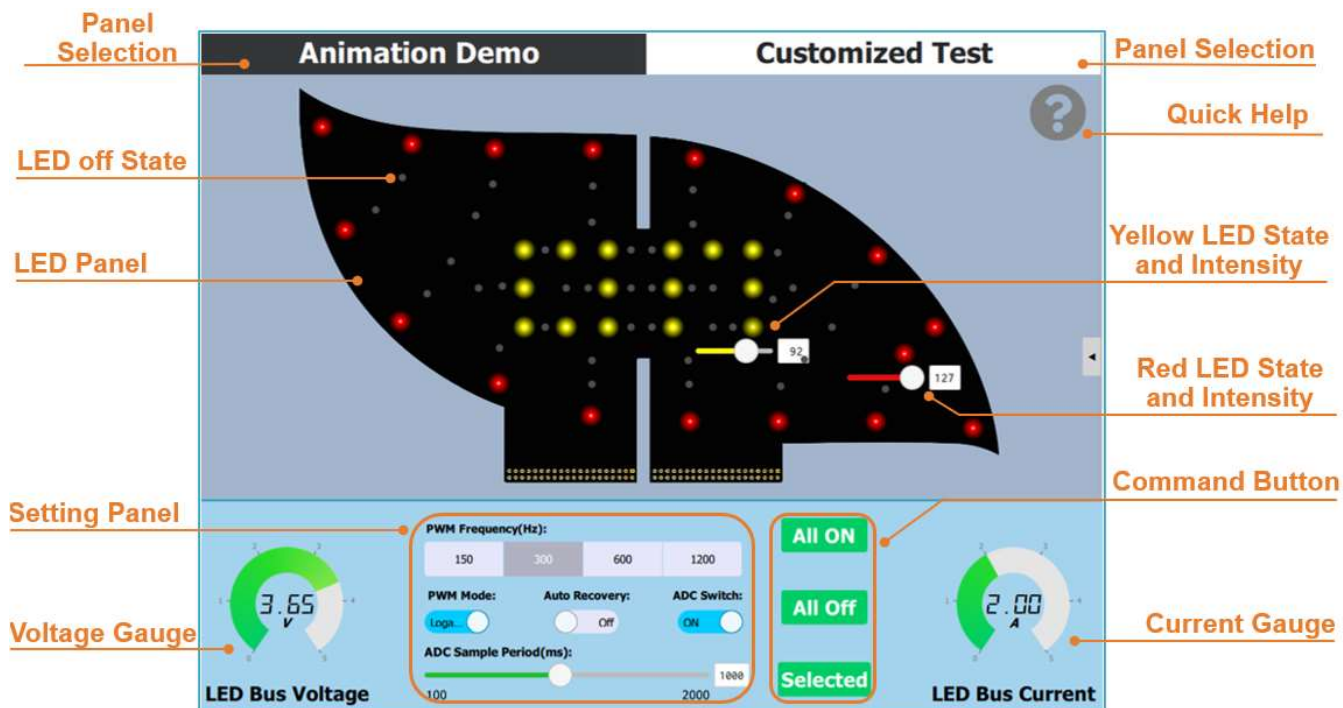


Figure 13: Customized Test Panel

### BLE Mobile Apps Access

The NCV7685 Rear-Lighting Evaluation Kit also can access by general mobile Apps. E.g. LightBlue, BleScanner... Here is an example using “Light Blue” App to control the kit:

1. Open LightBlue in the mobile.
2. Find and choose Peripheral of “Strata\_NVC7685”.
3. Tap “BLE\_TX\_VALUE” character.
4. Set command and parameter and send out data following the below protocol.

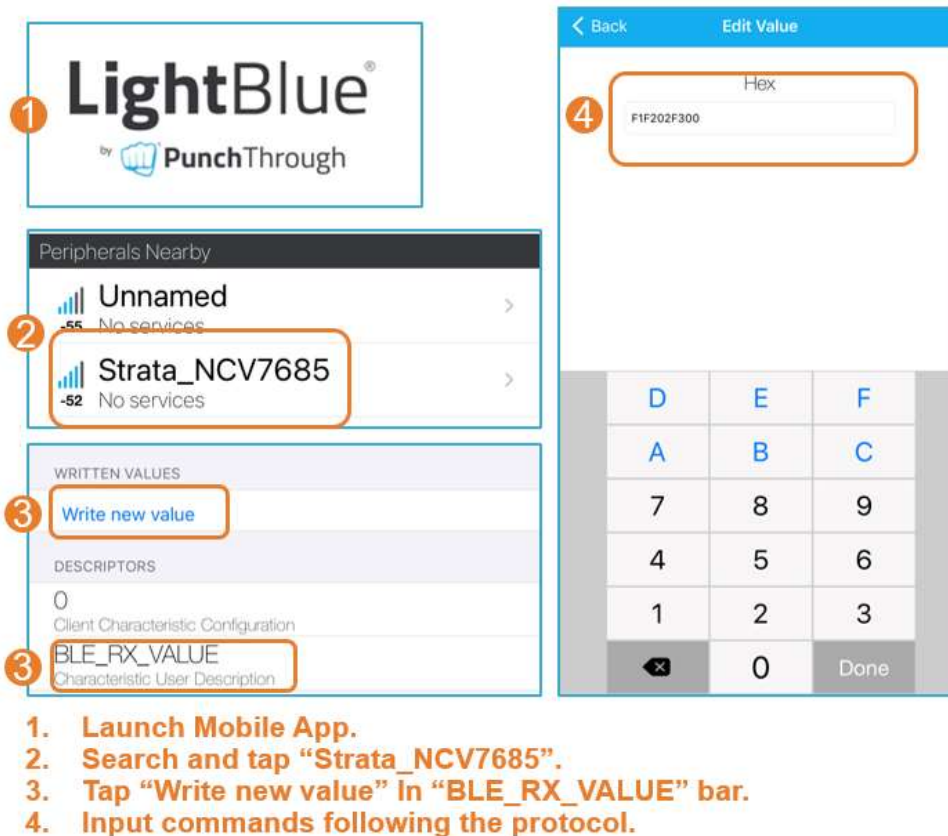


Figure 13: Using Light Blue App

The protocol between NCV7685 rear lighting kit with mobile app is very simple. Find the detail in the below table. For better security and reliability, users had better to work out the private protocols according to their application.

Table 2. Protocol of Demo Kit

| Command   | Header<br>(Byte 0--1) | Length<br>(Byte 2) | Code<br>(Byte 3) | Parameters<br>(Byte 4 -- 15) | Examples  |
|-----------|-----------------------|--------------------|------------------|------------------------------|---|
| WELCOME   | F1 F2                 | 2                  | F3               |                              | f1 f2 02 f3 00<br>Demo welcome animation once.  |
| LEFTTURN  | F1 F2                 | 5                  | F4               |                              | f1 f2 05 f4 00 06 d0 07<br>Demo left turn animation once; cycles = 6 times; period = 2000ms.    |
| RIGHTTURN | F1 F2                 | 5                  | F5               |                              | f1 f2 05 f5 01 06 d0 07<br>Repeat demo right turn animation; cycles = 6 times; period = 2000ms. |
| BRAKE     | F1 F2                 | 2                  | F6               |                              | f1 f2 02 f6 7f<br>Demo brake light to maximum value.  |
| FADING    | F1 F2                 | 5                  | F7               |                              | f1 f2 05 f7 00 02 40 1f<br>Demo breathing animation once; cycles = 2 times; period =8000ms.     |
| WARNING   | F1 F2                 | 5                  | F8               |                              | f1 f2 05 f8 01 02 e8 03<br>Repeat demo hazard light; cycles = 2 times; period =1000ms.          |
| BYEBYE    | F1 F2                 | 2                  | F9               |                              | f1 f2 02 f9 01<br>Repeat demo goodbye animation.  |
| LEDALL    | F1 F2                 | 2                  | FA               |                              | f1 f2 02 fa 01<br>All 72 LEDs turn on.  |
| SETPWM    | F1 F2                 | 5                  | FB               |                              | f1 f2 05 fb 00 12 0c 01<br>autor disable, PWM freq=300Hz; Logarithmic mode                      |
| CHIP_1    | F1 F2                 | 12                 | C1               |                              | f1 f2 0d c1 61 62 63 64 65 66 67 68 69 6a 6b 6c<br>Update 12 LEDs of chip_1 values.             |
| CHIP_2    | F1 F2                 | 12                 | C2               |                              | f1 f2 0d c2 71 72 73 74 75 76 77 78 79 7a 7b 7c<br>Update 12 LEDs of chip_2 values.             |
| CHIP_3    | F1 F2                 | 12                 | C3               |                              | f1 f2 0d c3 71 72 73 74 75 76 77 78 79 7a 7b 7c<br>Update 12 LEDs of chip_3 values.             |
| CHIP_4    | F1 F2                 | 12                 | C4               |                              | f1 f2 0d c4 71 72 73 74 75 76 77 78 79 7a 7b 7c<br>Update 12 LEDs of chip_4 values.             |
| CHIP_5    | F1 F2                 | 12                 | C4               |                              | f1 f2 0d c5 71 72 73 74 75 76 77 78 79 7a 7b 7c<br>Update 12 LEDs of chip_5 values.             |
| CHIP_6    | F1 F2                 | 12                 | C6               |                              | f1 f2 0d c6 71 72 73 74 75 76 77 78 79 7a 7b 7c<br>Update 12 LEDs of chip_6 values.             |

\* Length byte only counts in parameters and command bytes as it's simple protocol example.

## Design Discussion

### Floating Address for NCV7685

In general, the user is preferring to use fixed address in multiple NCV7685 application. It leads to add one more procedure to pre-programming each chips' address in mass production stage. In addition, it is inconvenient for maintenance in the aftermarket. In firmware of this evaluation board, it uses floating address setting method, each time when power on the board, the NCV7685 will be assigned an address which defined by customer, but not locked into OTP registers. The user can realize this function by using either RSL10's GPIO or IO expander (PAC9655).

### Improve Re-Flash Rate in Multiple NCV7685 chips design

In multiple NCV7685 chips application, the re-flash rate can be improved both in firmware and hardware.

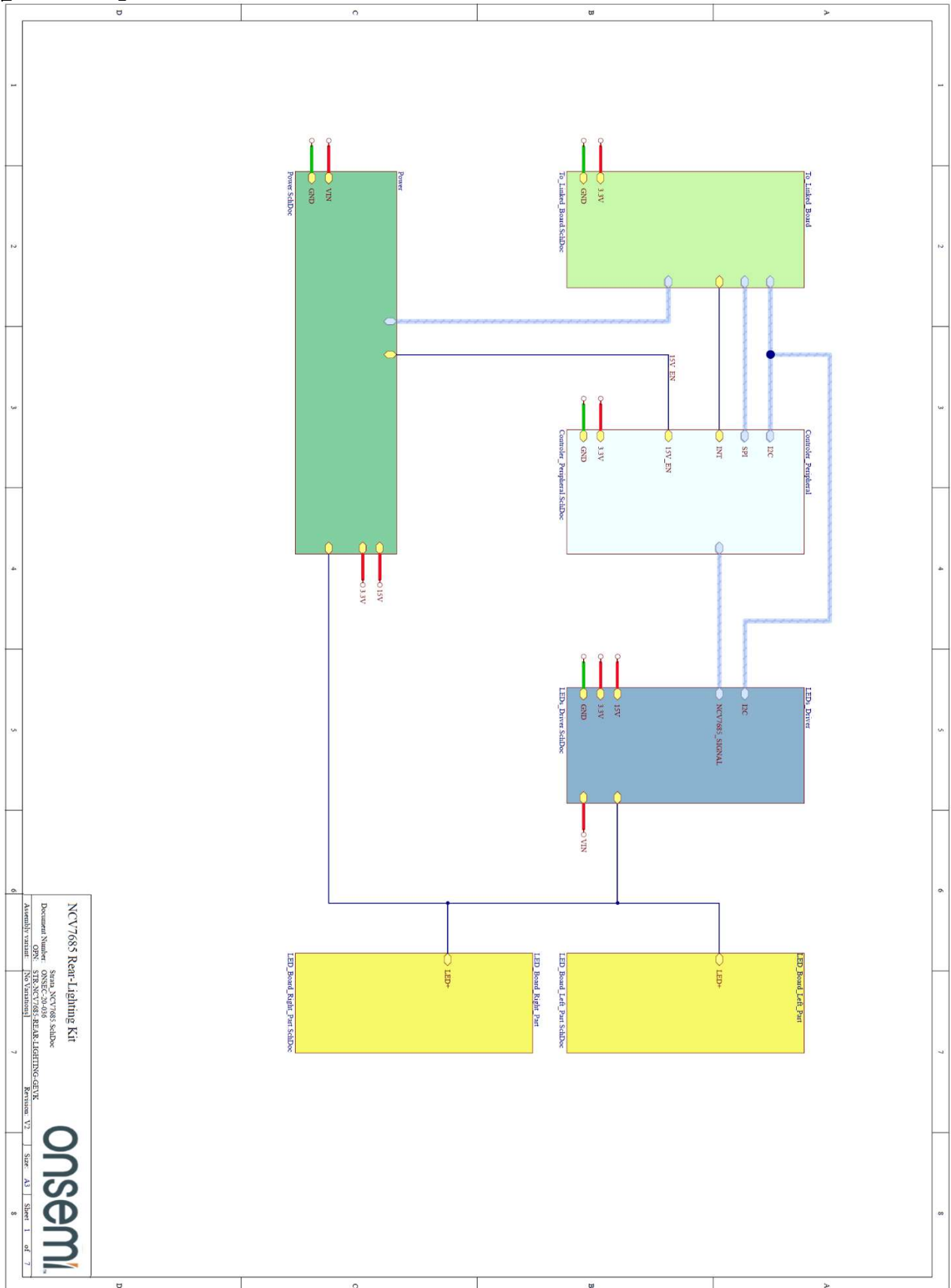
In firmware, had better use short command to reduce the traffic in I2C bus to realize the same function. For instance, use "ID\_PWM" commands instead of "ID\_PWM\_ALL" if all channel's intensity is the same.

In hardware design, Utilize the maximum function of hardware features. For example, we want to implement two patterns switched frequently, how about set values in SAM1 and SAM2 firstly, then drive PWM on the CONF pin? NCV7685 is an excellent chip in automotive lighting applications, it needs you to explore more.

### Operation Notes

1. As here are two I2C masters in the kit, if "LED and Control Board" is not initialized correctly, just press "Reset" button to reset driver board. It shows "startup" animation after reset.
2. In "Customized Test" Panel of Strata GUI, "Selected LED ON" command is divided into several JSON sentences and then sending to driver board. If the LED responded incorrectly in some situation, initialize "Customized Test" Page by switching to "Animation Demo" page and then switch back to "Customized Test" Page.

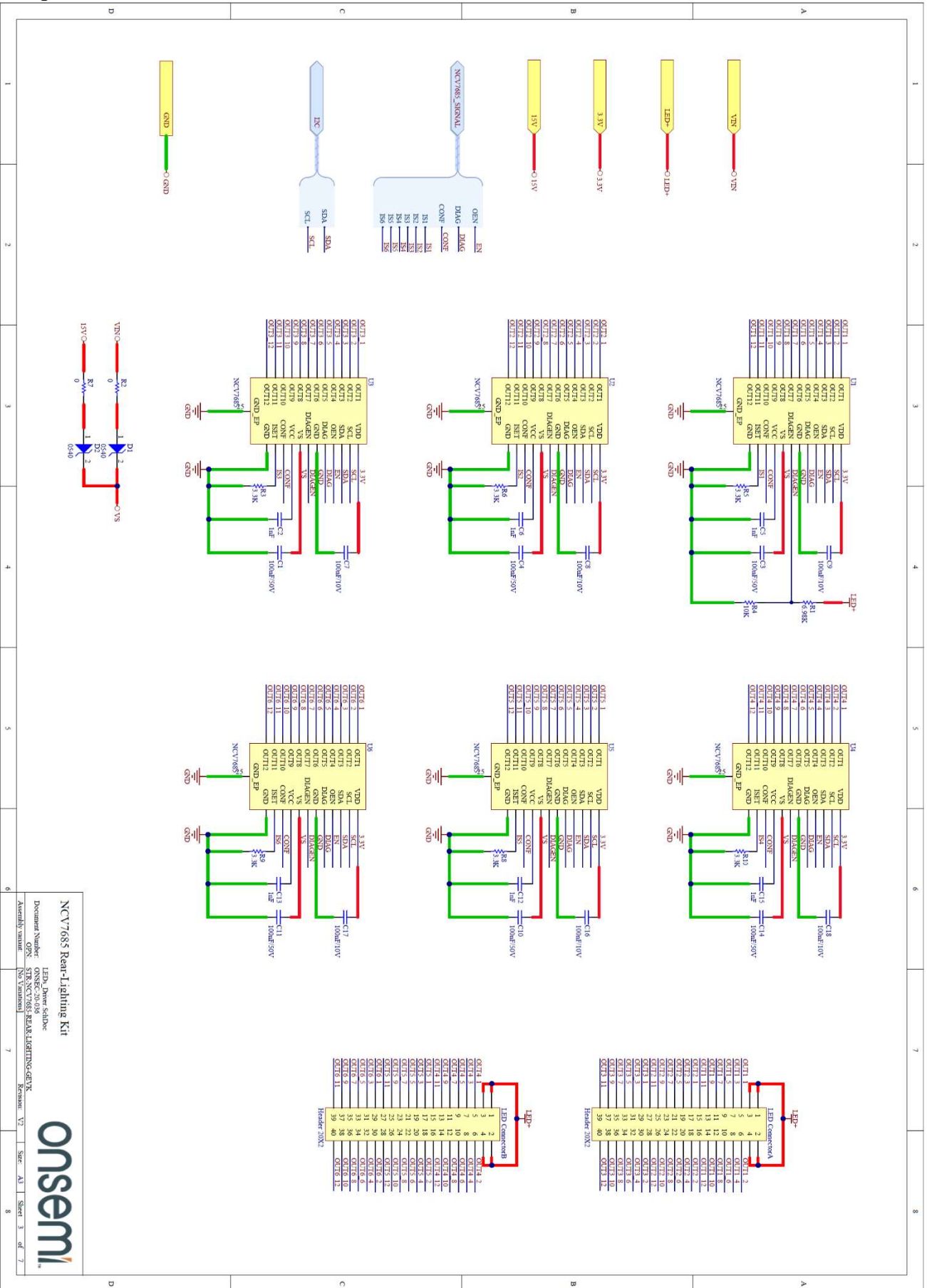
Schematic  
Strata\_NCV7685 Page



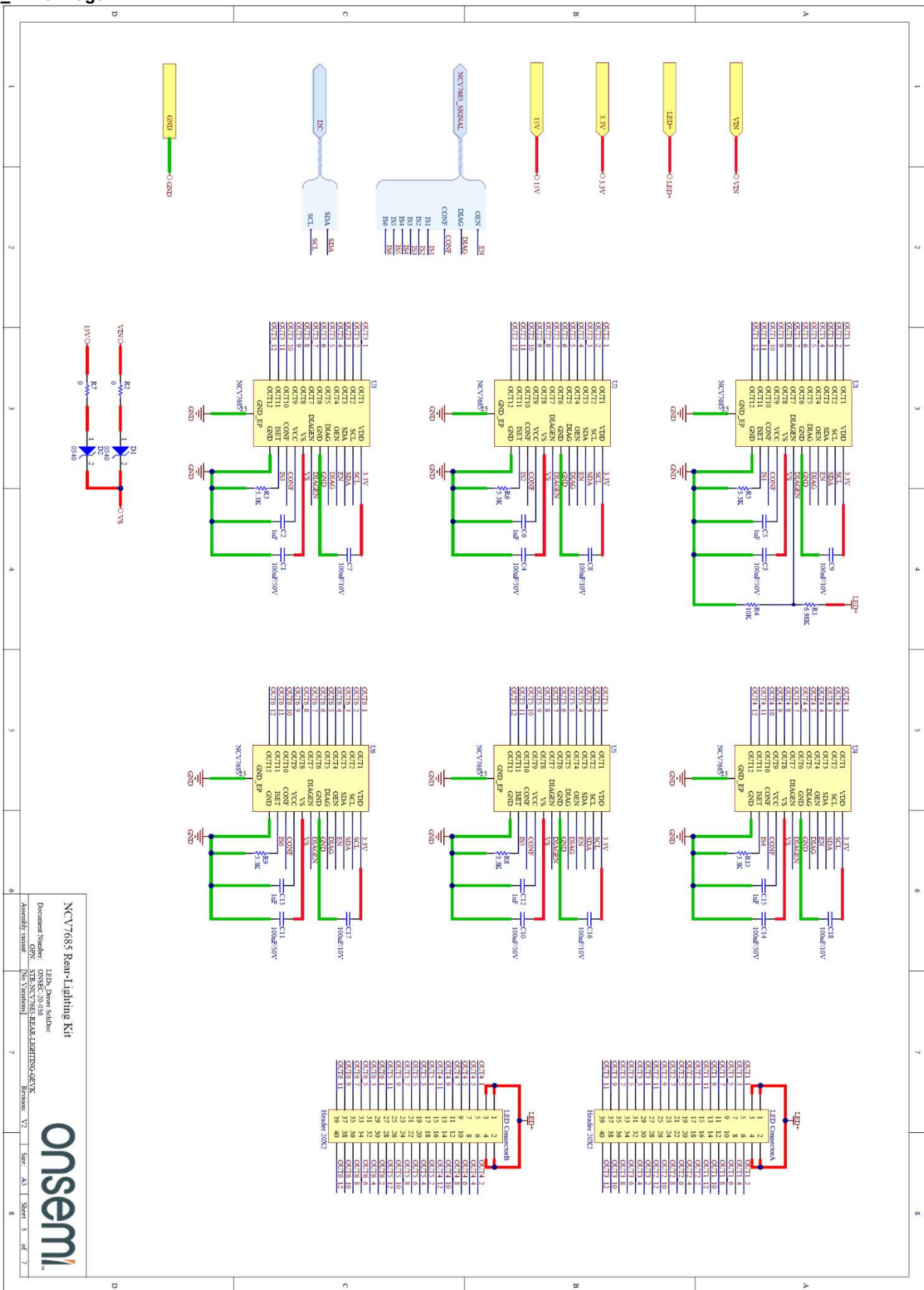
NCV7685 Rear-Lighting Kit  
 Strata\_NCV7685 SLDBox  
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 Assembly variant: No Variational  
 Revision: V1  
 Size: A1  
 Sheet 1 of 3







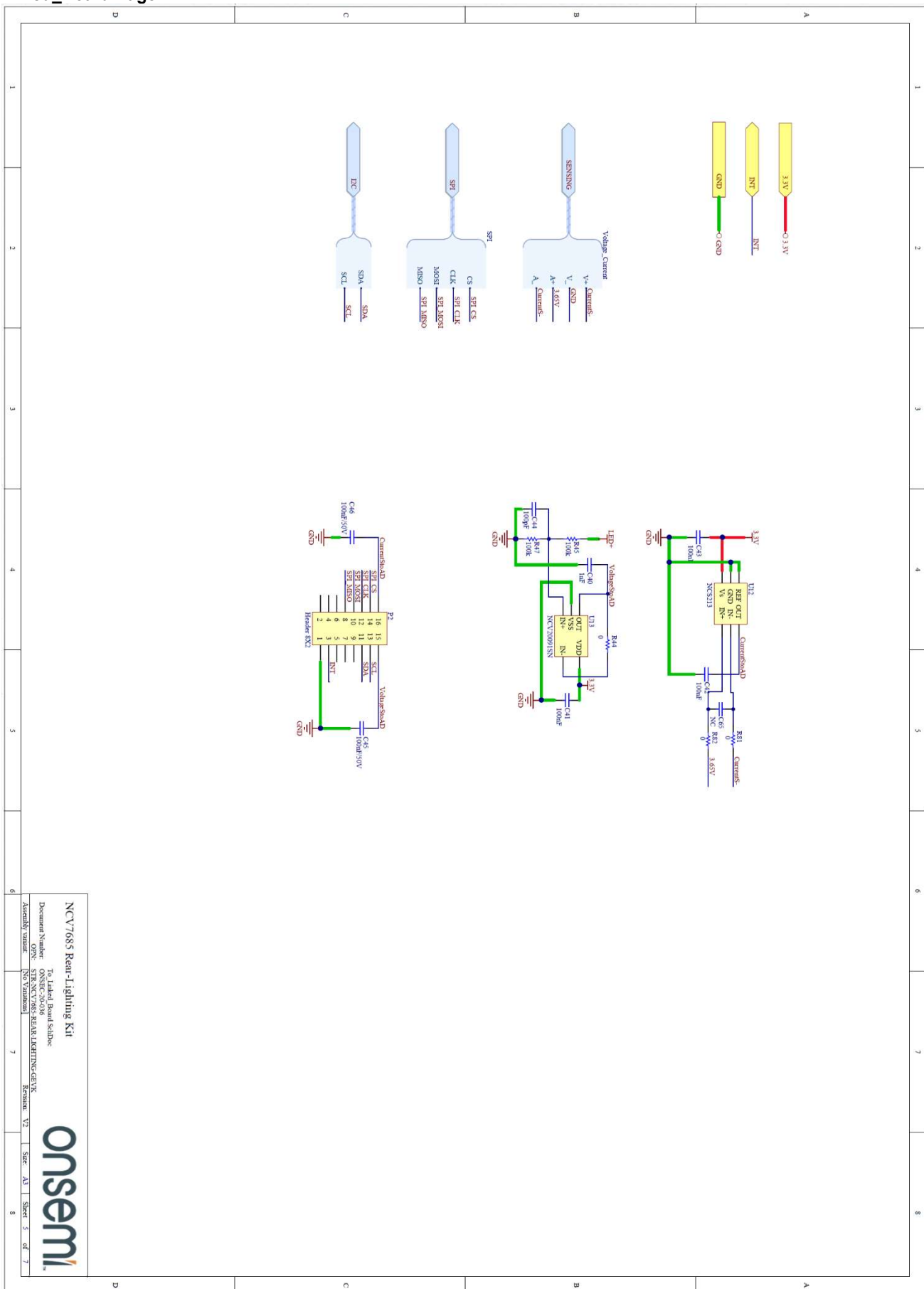
NCV7685 Rear-Lighting Kit  
 Document Number: ONSEK23018  
 LEDx Driver Subcircuit REAR LIGHTING-GEVK  
 Revision: V17



NCV7685 Rear-Lighting Kit  
 LED Driver Schöck  
 Document Number: ONSEK-20-038 REAR-LIGHTING-GEVK  
 Assembly Number: NCV7685-00000  
 Revision: V2



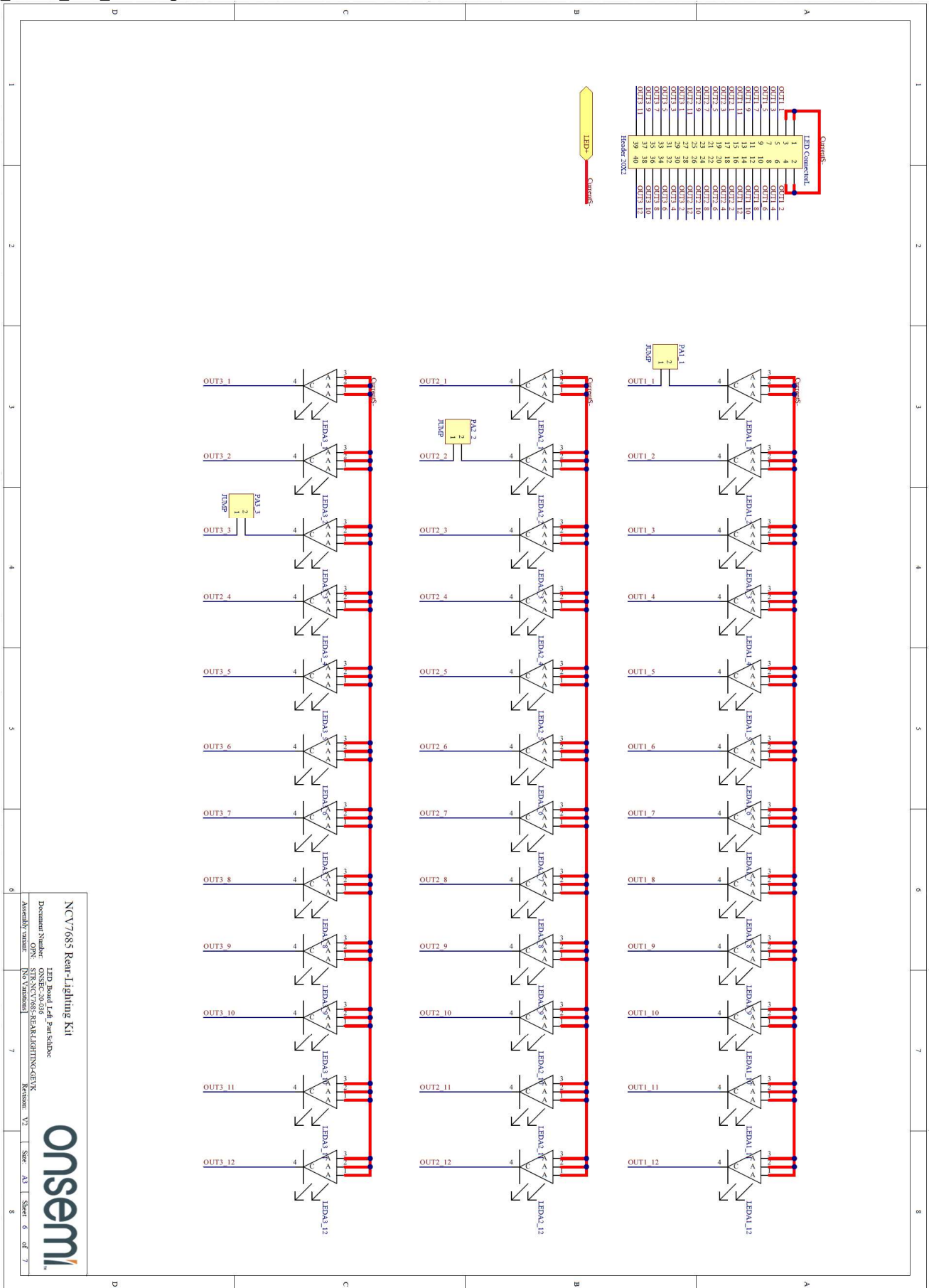




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 To\_Linked\_Board\_Schematic  
 Assembly number: [blank]  
 Revision: V1  
 Size: A1  
 Sheet 5 of 7

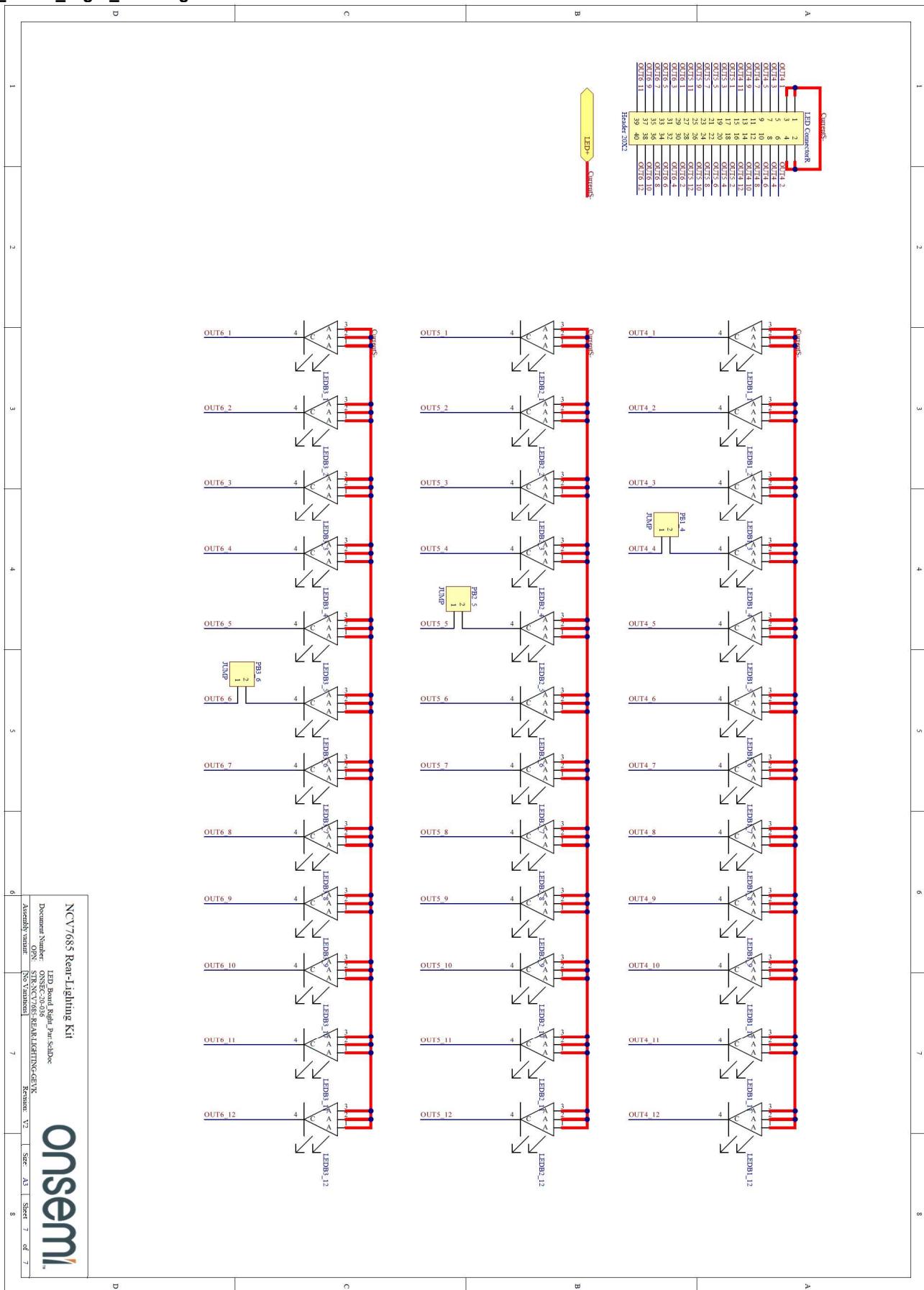


LED\_Board\_Left\_Part Page



NCV7685 Rear-Lighting Kit  
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 Assembly Number: NCV7685-REAR-LIGHTING-GEVK  
 Revision: V2  
 Date: A3  
 Sheet: 6 of 7

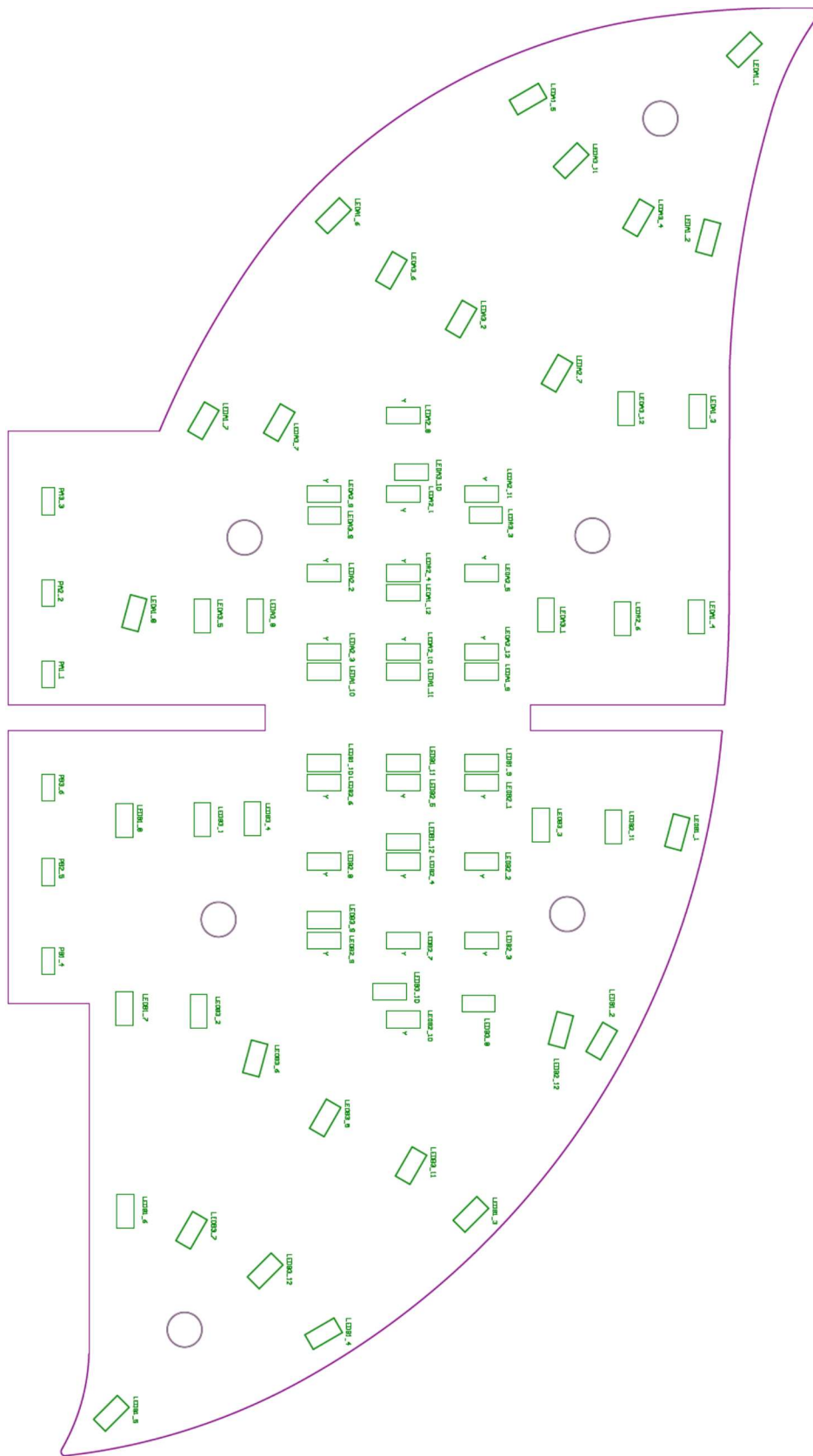




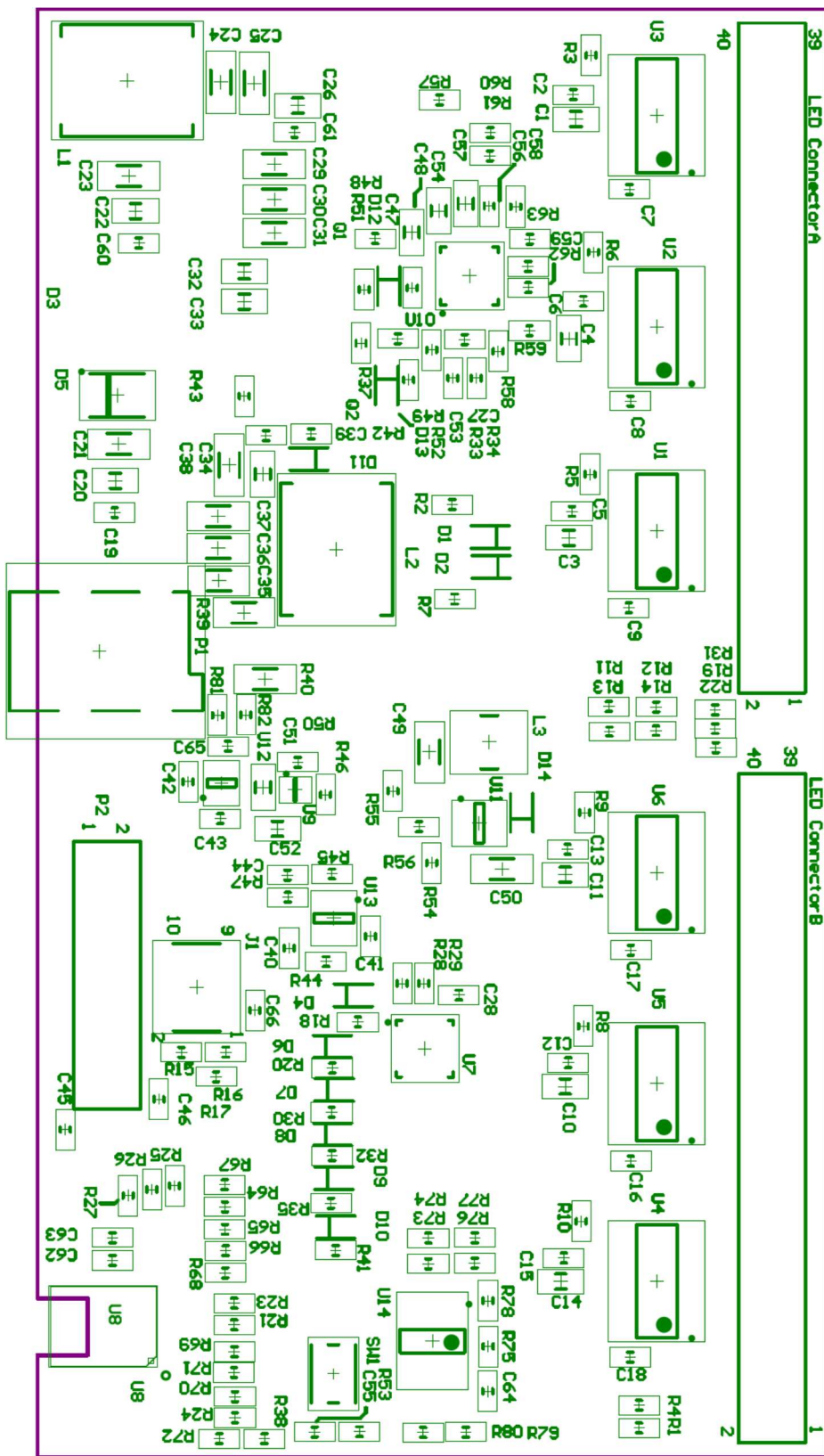
NCV7685 Rear-Lighting Kit  
 LED Board Right Part Schematic  
 Document Number: STR-NCV7685-REAR-LIGHTING-GEVK  
 OPN: STR-NCV7685-REAR-LIGHTING-GEVK  
 Assembly Name: (No Variations)  
 Revision: V2  
 Spec: A3  
 Sheet 7 of 7



Top Overlayer of LED Board



Top Overlayer of Control Board



BOM

Bill of Materials for the STR-NCV7685-REAR-GEVK Evaluation Board



| Designator   | Quantity | Description                       | Value       | Tolerance | Footprint | Manufacturer | Manufacturer Part Number | Substitution Allowed | Lead Free |
|--|----------|-----------------------------------|-------------|-----------|-----------|--------------|--------------------------|----------------------|-----------|
| <b>LED Driver and Control Board</b>  |          |                                   |             |           |           |              |                          |                      |           |
| U1, U2, U3, U4, U5, U6   | 6        | 12 Channel 60mA linear LED driver |             |           | SOP24EP   | Onsemi       | NCV7685DQR2G             |                      | YES       |
| U7   | 1        | I/O Port Expander, I2C            |             |           | WQFN24    | Onsemi       | PCA9655EMTTXG            |                      | YES       |
| U8   | 1        | System in Package                 |             |           | SIP51 8X6 | Onsemi       | NCH-RSL10-101S51-ACG     |                      | YES       |
| U9   | 1        | LDO                               | 3.3V, 150mA |           | SOT563    | Onsemi       | NCV8170AXV330T2          |                      | YES       |
| U10  | 1        | Sync Buck Controller              |             |           | QFNW24    | Onsemi       | NCV891930MW01R2G         |                      | YES       |
| U12  | 1        | Current Shunt Monitor             |             |           | SC70-6    | Onsemi       | NCV213RSQT2              |                      | YES       |
| U13  | 1        | OP                                |             |           | SOT23-5   | Onsemi       | NCV20091SN2T1G           |                      | YES       |
| U14  | 1        | EEROM 512K                        |             |           | SO8       | Onsemi       | CAT24C512                |                      | YES       |
| Q1,Q2  | 2        | NMOS                              | 60V, 15mOhm |           | SO8FL     | Onsemi       | NVMF55C677NL             |                      | YES       |
| D1,D2  | 2        | Schoktty Diode                    | 0.5A, 40V   |           | SOD123    | Onsemi       | MBR0540T1G               |                      | YES       |
| D3   | 1        | Trench J34Schoktty Diode          | 5A, 60V     |           | SO8FL     | Onsemi       | MBR5100MFST1G            |                      | YES       |
| D11  | 1        | Trench Schoktty Diode             | 2A, 60V     |           | SOD123    | Onsemi       | MBR2H100SFT3G            |                      | YES       |
| D5   | 1        | Bidirectional TVS, 600W           |             |           | SMB       | Onsemi       | P6SMB27CAT3              |                      | YES       |
| U11  | 1        | Boost Controller                  |             |           | TSOP-5    | Onsemi       | NCV1406SNT1G             |                      | YES       |
| D14  | 1        | Schoktty Diode                    | 1A, 40V     |           | SOD123    | Onsemi       | MBR140SFT1G              |                      | YES       |
| J1   | 1        | Smatec FTSH-105-1-F-DV            |             |           | FTSH-105  | Smatec       | FTSH-105-1-F-DV          |                      | YES       |
| SW1  | 1        | Switch                            |             |           | 4.2x3.2   | Würth        | 434133025816             |                      | YES       |
| P1   | 1        | DC Power Jack                     | 5A, 24V     |           |           | Würth        | 694106106102             |                      | YES       |
| L1   | 1        | Power Inductor                    | 6.8uH, 5A   |           | 8030      | Würth        | 74437356068              |                      | YES       |
| L2   | 1        | Power Inductor                    | 1uH, 12.5A  |           | 7050      | Würth        | 74437356010              |                      | YES       |
| L3   | 1        | Power Inductor                    | 10uH, 1.2A  |           | 4020      | Würth        | 74437321100              |                      | YES       |
| LED Connector A, LED Connector B   | 2        | 2.54mm 20Pinx2 Header             |             |           | HDR2X20   | Würth        | 61304021121              |                      | YES       |
| P2   | 1        | 8Pinx2 PHD Angled Dual Socket     |             |           | HDR2X8    | Würth        | 613016243121             |                      | YES       |
| C1, C3, C4, C10, C11, C14, C20, C22, C26, C32, C33, C34, C57   | 13       | CAP CER                           | 100nF/50V   |           | 0805      |              |                          |                      | YES       |
| C2, C5, C6, C12, C13, C15, C40, C42  | 8        | CAP CER                           | 1nF/10V     |           | 0603      |              |                          |                      | YES       |
| C7, C8, C9, C16, C17, C18, C28, C41, C43, C45, C46, C47, C53, C55, C56, C58, C59, C62, C63, C64, C66   | 21       | CAP CER                           | 100nF/10V   |           | 0603      |              |                          |                      | YES       |
| C21, C23, C24, C25   | 4        | CAP CER                           | 2.2uF/50V   |           | 1206      |              |                          |                      | YES       |
| C29, C30, C31, C50   | 4        | CAP CER                           | 4.7uF/50V   |           | 1206      |              |                          |                      | YES       |
| C35, C36, C37, C38, C49  | 5        | CAP CER                           | 10uF/10V    |           | 1206      |              |                          |                      | YES       |
| C51, C52, C54  | 3        | CAP CER                           | 2.2uF/16V   |           | 0805      |              |                          |                      | YES       |
| R1   | 1        | Resistor                          | 6.98k       | 1%        | 0603      |              |                          |                      | YES       |
| R2, R7, R12, R21, R23, R24, R25, R26, R27, R33, R34, R44, R51, R52, R57, R58, R60, R64, R65, R66, R67, R68, R69, R70, R71, R72, R73, R74, R75, R80, R81, R82, R15, R17   | 34       | Resistor                          | 0           |           | 0603      |              |                          |                      | YES       |
| R3, R5, R6, R8, R9, R10  | 6        | Resistor                          | 3.3k        | 1%        | 0603      |              |                          |                      | YES       |
| R4, R13, R16, R28, R29, R31, R37, R38, R43, R50, R53, R55, R59, R63  | 14       | Resistor                          | 10k         | 1%        | 0603      |              |                          |                      | YES       |
| R19, R22,  | 2        | Resistor                          | 3.3k        | 1%        | 0603      |              |                          |                      | YES       |
| R39  | 1        | Resistor                          | 10mOhm      | 1%        | 1206      |              |                          |                      | YES       |
| R40  | 1        | Resistor                          | 15mOhm      | 1%        | 1206      |              |                          |                      | YES       |
| R45, R47   | 2        | Resistor                          | 100k        | 1%        | 0603      |              |                          |                      | YES       |
| R54  | 1        | Resistor                          | 1.3M        | 1%        | 0603      |              |                          |                      | YES       |
| R56  | 1        | Resistor                          | 110k        | 1%        | 0603      |              |                          |                      | YES       |
| R62  | 1        | Resistor                          | 46.4k       | 1%        | 0603      |              |                          |                      | YES       |
| C48  | 0        | CAP CER                           | n/a         |           | 0805      |              |                          |                      | YES       |
| C19, C27, C39, C44, C60, C61, C65,   | 0        | CAP CER                           | n/a         |           | 0603      |              |                          |                      |           |
| R11, R14, R18, R20, R30, R32, R35, R41, R42, R46, R48, R49, R61, R76, R77, R78, R79  | 0        | Resistor                          | n/a         |           | 0603      |              |                          |                      |           |
| D4, D6, D7, D8, D9, D10, D12, D13  | 0        | Schoktty Diode                    | n/a         |           | SOD123    | Onsemi       | MBR0540T1G               |                      |           |
| <b>LED BOARD</b>   |          |                                   |             |           |           |              |                          |                      |           |
| LEDA1_1, LEDA1_2, LEDA1_3, LEDA1_4, LEDA1_5, LEDA1_6, LEDA1_7, LEDA1_8, LEDA1_9, LEDA1_10, LEDA1_11, LEDA1_12, LEDA2_6, LEDA2_7, LEDA3_1, LEDA3_2, LEDA3_3, LEDA3_4, LEDA3_5, LEDA3_6, LEDA3_7, LEDA3_8, LEDA3_9, LEDA3_10, LEDA3_11, LEDA3_12, LEDB1_1, LEDB1_2, LEDB1_3, LEDB1_4, LEDB1_5, LEDB1_6, LEDB1_7, LEDB1_8, LEDB1_9, LEDB1_10, LEDB1_11, LEDB1_12, LEDB2_11, LEDB2_12, LEDB3_1, LEDB3_2, LEDB3_3, LEDB3_4, LEDB3_5, LEDB3_6, LEDB3_7, LEDB3_8, LEDB3_9, LEDB3_10, LEDB3_11, LEDB3_12 | 52       | Power TOPLED                      |             |           | PLCC-4    | Osram        | LR E6SF-ABCA-1-1         |                      | YES       |
| LEDA2_1, LEDA2_2, LEDA2_3, LEDA2_4, LEDA2_5, LEDA2_8, LEDA2_9, LEDA2_10, LEDA2_11, LEDA2_12, LEDB2_1, LEDB2_2, LEDB2_3, LEDB2_4, LEDB2_5, LEDB2_6, LEDB2_7, LEDB2_8, LEDB2_9, LEDB2_10   | 20       | Power TOPLED                      |             |           | PLCC-4    | Osram        | LY E6SF-ABDA-36-3B5A     |                      | YES       |
| LED ConnectorA, LED ConnectorB   | 2        | Header, 20-Pin, Dual row          |             |           | HDR2X20   | Würth        | 62004021821              |                      | YES       |
| PA1_1, PA2_2, PA3_3, PB1_4, PB2_5, PB3_6   | 6        | Jumper, 2-Pin                     |             |           | HDR1X2    | Würth        | 60910213421              |                      | YES       |
| PA1_1, PA2_2, PA3_3, PB1_4, PB2_5, PB3_6   | 6        | Header, 2-Pin                     |             |           | n/a       | Würth        | 61300211121              |                      | YES       |
| R1, R14, R27, R40, R53, R66  | 0        | Resistor                          | n/a         |           | 0603      |              |                          |                      |           |

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