Using the Fading Feature of the NCV7430

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APPLICATION NOTE

Introduction

The NCV7430 is an automotive RGB LED driver with a LIN protocol communication interface. It is a fully integrated device capable of controlling current through 3 LEDs to provide a full spectrum of colors (as shown in the CIE xy chromaticity diagram below) and intensities for use in ambient lighting for the interior of an automobile.

An integrated RGB LED is designed to stimulate the human eyes 3 different receptors (cones) for short, middle, and long wavelengths (blue, green, and red). By controlling these three colors which are seen by the eyes (also known as tristimulous), we are able to include all possible combinations of color.

Color theory enables us to break down the system to brightness and chromaticity, or intensity and color. The NCV7430 is programmed through the LIN protocol input pin to control the RGB LED scaling factor for intensity and color.

Typical Application

The typical application diagram for the NCV7430 is shown below. It is comprised of 4 sections.

1. Battery input (VBAT) shown with a reverse battery diode and an optional filter capacitor.
2. The external RGB LED.
3. The current programming resistors to ground.
4. The LIN communication bus.

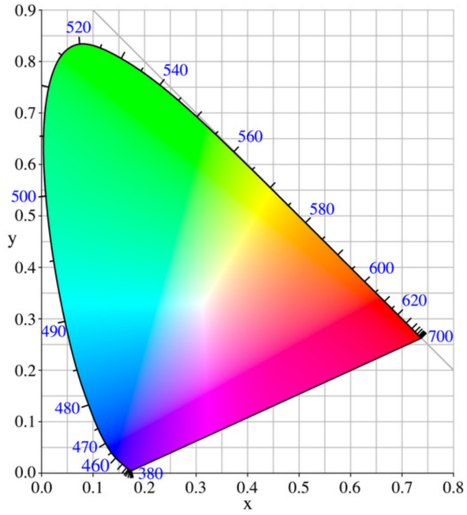

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Figure 1.

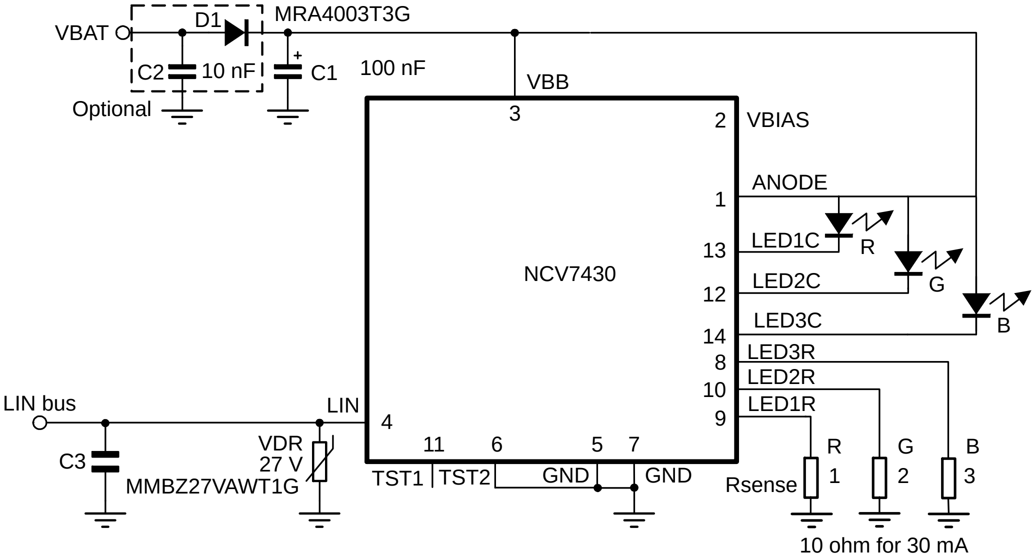

Figure 2. Typical Application

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Light

Light is an inherent linear function. If you double the intensity, the amount of light is doubled. But this is not how our eyes perceive intensity (particularly at low levels). The response to the cone sensors in our eyes is a logarithmic function. Small differences in intensity at low voltage levels are more easily detectible by our eyes. This is the reason the NCV7430 controls the intensity function as a logarithmic function in the IC (a linear change function is offered as an option).

Color

The three primary colors of red, green and blue are added together in different combinations to create all the colors in the CIE chromaticity diagram. The combining of primary colors is a linear function. The NCV7430 offers control fading between colors in a linear format. Logarithmic fading times between colors in the device is not a supported function as it does not have any practical applications.

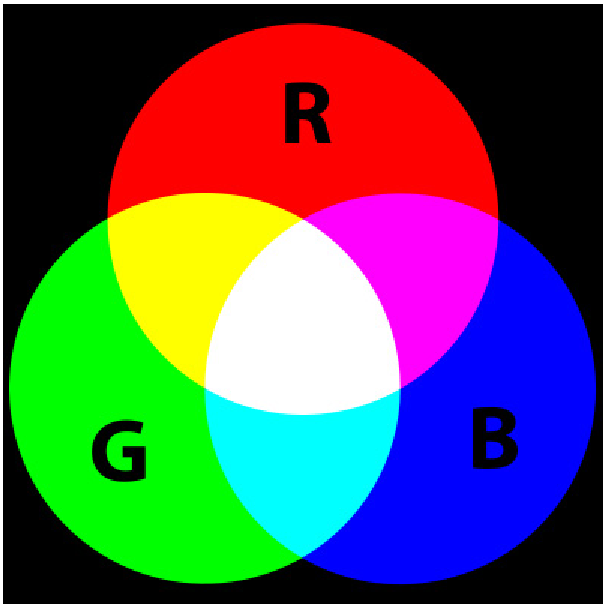

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Figure 3. Additive Color

Controlling FADING in the NCV7430

A theatre Dimming function is incorporated into the IC. This effect provides a smooth transition between two modes for both intensity and color change. Per the previous paragraphs, the fading (or dimming) function is segmented with the following attributes:

Intensity – Linear or logarithmic dimming.

Color – Linear dimming only.

Communication via the LIN bus for setting the function is included in the Fading Slope Register. This is accessed using the Set_Color Writing Frame.

Table 1. REGISTERS AND FLAGS

Register	Mnemonic	Length (bit)	Related Commands	Comment	Reset State
Fading Slope	FADING SLOPE	1	`Set_Color` `Get_Actual_Param`	“0” : Fading slope logarithmic “1” : Fading slope Linear	“0”

Table 2. Set_Color WRITING FRAME

Byte	Content	Structure							
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Identifier	0	1	1	0	0	1	0	0
1	Data 1	Broad	1	AD[5:0]					
2	Data 2	GROUP[7:0]							
3	Data 3	GROUP[15:8]							
4	Data 4	UPDATE COLOR[1]	UPDATE COLOR[0]	Fading time[5:0]					
5	Data 5	FADING ON/OFF	FADING* SLOPE	LEDs ON/OFF	1	Intensity[3:0]			
6	Data 6	LED color value LED 1 [7:0]							
7	Data 7	LED color value LED 2 [7:0]							
8	Data 8	LED color value LED 3 [7:0]							
9	Checksum	Classic Checksum over data							

It should be noted when setting the FADING SLOPE for color control, only a linear function is supported although there is nothing stopping the user from setting the bit for a choice of logarithmic.

Transition time is programmable in steps of 0.1 s.

Timing Accuracy is by synchronization via LIN

Both Fading-in and Fading-out have 24 steps with linear interpolation in between.

Logarithmic Color Control

As previously discussed, a color change along with a logarithmic change is not supported and should not be selected by the designer. The details below are for informational purposes only.

Figures 4 and 5 are some instances observed when attempting to use a logarithmic setting for color control.

Test results may or may not be reproducible by the customer. They are presented here as examples only.

Performance Control

Proper use of the SET_LED_Control WRITING FRAME is limited to one command of “LEDs ON/OFF”. Multiple SET_LED_CONTROL commands of “LEDs ON/OFF” originating from the SET_LED_Control WRITING FRAME alternating the state of the IC will result in unstable times and slopes.

Additional requests should use the “LEDs ON/OFF” command in the Set_Color commands for proper operation.

Intensity Peak

Channel 4 – VRsense is a voltage across one of the sense resistors and is directly proportional to the modulated LED current.

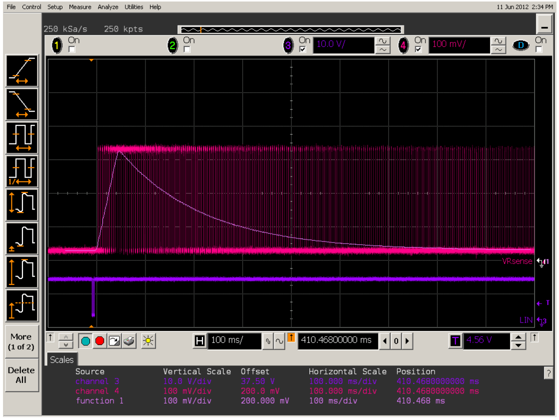
The “function 1” is low-pass filter of VRsense and represents the LED intensity.

This happens when changing between two setting that should result is modulation value 0:

1. fading set to logarithmic, fading time 1s (basically any value)
2. set intensity to 15 and color to 0 ≥ modulation = 0
3. then vice-versa: intensity 0 and color 255 ≥ modulation = 0

This sequence results in the intensity peak that you can see in the figure (while the intensity should be 0 during this test execution).

It is unlikely for someone to change the modulation from 0 to 0, but is documented here.



Source	Vertical Scale	Offset	Horizontal Scale	Position
channel 3	10.0 V/div	37.50 V	100.000 ms/div	410.4680000000 ms
channel 4	100 mV/div	200.0 mV	100.000 ms/div	410.4680000000 ms
function 1	100 mV/div	200.000 mV	100 ms/div	410.468 ms

Figure 4. Intensity Peak

Unstable Fading Time

Testing Sequence

1. Set fading to logarithmic, any fading time.
2. Change color to any value – the slow blue waveform fading in the picture shows the device acting in a linear fashion as is normal for color transitions.
3. Change intensity to any value – after this change, the fading time for color change is different.

4. Change color to any value – now the fading time is different (fast pink fading)
5. It will sometimes return back to normal after any change of fading time.

Source	Vertical Scale	Offset	Horizontal Scale	Position
channel 3	10.0 V/div	37.50 V	100.000 ms/div	418.4700000000 ms
channel 4	100 mV/div	200.0 mV	100.000 ms/div	418.4700000000 ms
function 1	100 mV/div	200.000 mV	100 ms/div	418.470 ms
memory 1	100 mV/div	200.000 mV	100 ms/div	418.470000000000 ms

Figure 5. Unstable Fading Time

Additional Performance with Logarithmic Settings

Testing Sequence

1. Power up the NCV7430 device.
2. Choose logarithmic setting.
3. Run device with color change.
4. Result is 100 ms fading time similar to the previous example.
5. Choose linear fading time.
6. Change back to logarithmic fading time.
7. Color change will be logarithmic.

Reverse Battery Protection

Most automotive electrical specifications require the ability to withstand a reverse battery condition. This is usually accomplished with the use of discrete diodes in series with the battery line where the reverse breakdown capability of the discrete diode is enough to hold off the voltage. One way to do this is shown in Figure 6. In this setup each individual module has its own diode unit.

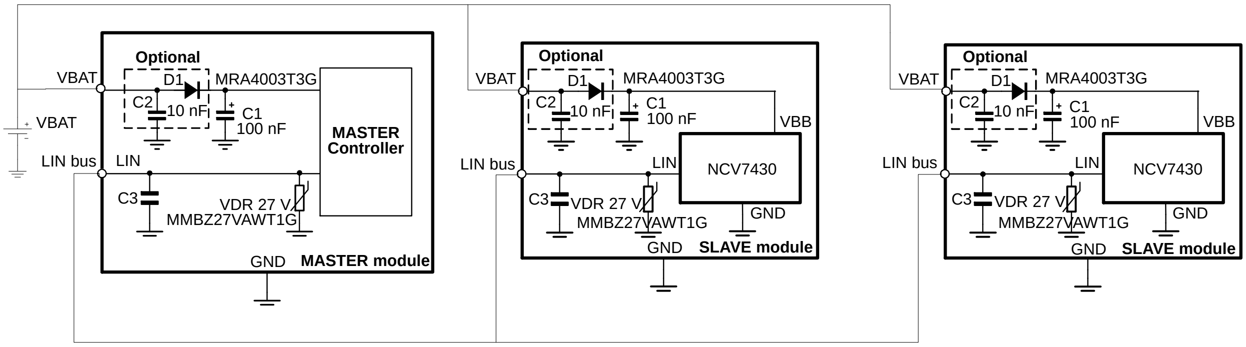


Figure 6. Master-Slave Reverse Battery Setup

A way to save system component cost in the BOM is to make use of a central load dump diode as shown in Figure 7. In this case the reverse battery diodes have been removed from each of the slave devices creating a savings of 1 diode per each slave module.

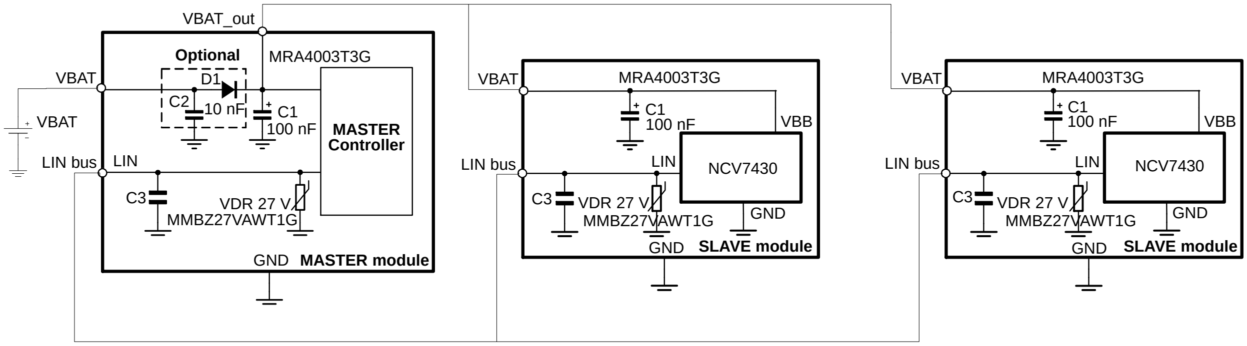


Figure 7. Common Reverse Battery Component

Additional Battery Line Protection

In order to increase system robustness against disturbances coming from the battery harness (primarily EMC events generated by fast pulses), it is recommended to add an additional protection to the ANODE pin.

Figure 8 shows an RC low-pass filter with $R_{prot} = 10\ \Omega$ and $C_{prot} = 1\ \mu F$ used for this purpose. This provides additional protection for the NCV7430 and the LED diodes.

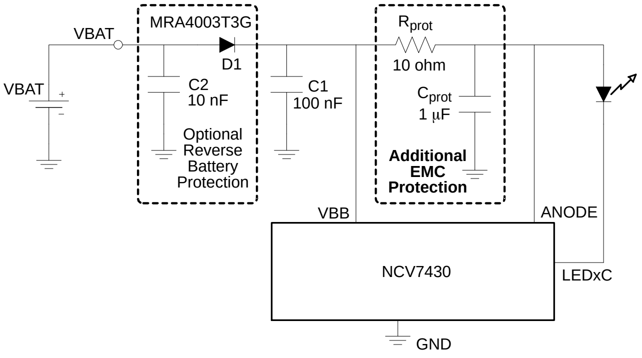


Figure 8.

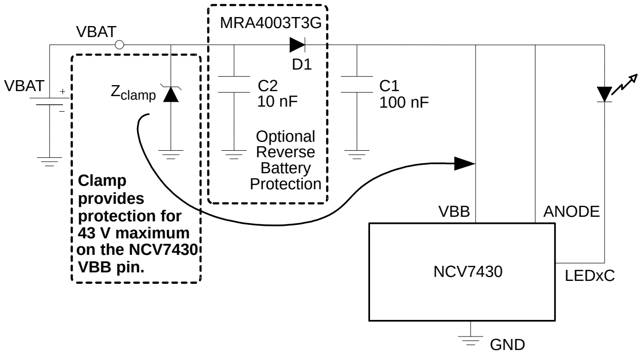


Figure 9.

Additional protection to the battery line can be realized by the use of a clamp. The NCV7430 device has an absolute maximum voltage rating of 43 V on the VBB pin. Selection of the clamp should be made using a 43 V maximum rating for the clamp component and can be placed either locally on the module or in the common Master module (reference Figure 9).

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