

# ON Semiconductor

## Is Now

The logo for onsemi, featuring the word "onsemi" in a dark teal, lowercase, sans-serif font. The letter "i" is stylized with a white dot and a teal vertical bar. A small orange triangle is positioned above the top right of the "i". A trademark symbol (TM) is located to the right of the logo.

To learn more about onsemi™, please visit our website at  
[www.onsemi.com](http://www.onsemi.com)

---

**onsemi** and **onsemi** and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi** product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner. Other names and brands may be claimed as the property of others.

## Using the Fading Feature of the NCV7430



ON Semiconductor®

<http://onsemi.com>

### 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 tristimulus), we are able to include all possible combinations of color.

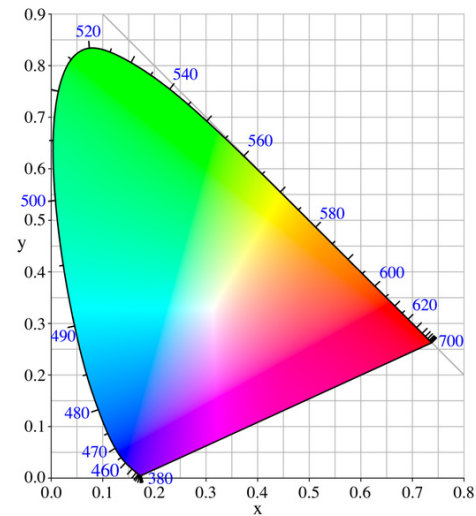
Color theory enables us to break down the system to brightness and chromaticity, or intensity and color. The NCV7430 is programmed through the LIN protocol input pin to control the RGB LED scaling factor for intensity and color.

### 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.

### APPLICATION NOTE



Public Domain file from Wikipedia: The Free Encyclopedia. Wikimedia Foundation Inc. Retrieved from <http://en.wikipedia.org/wiki/File:CIExy1931.png>

Figure 1.

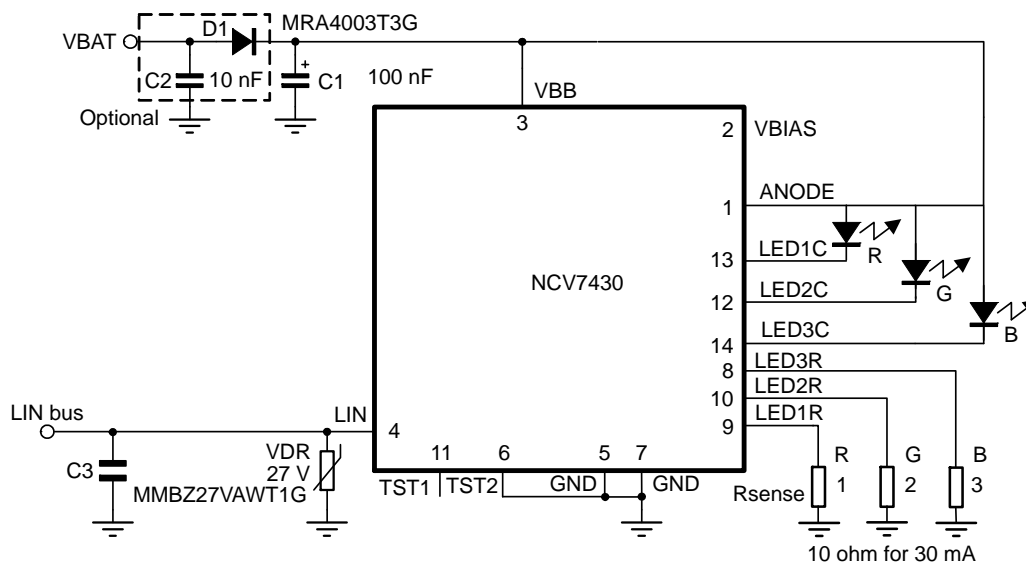


Figure 2. Typical Application

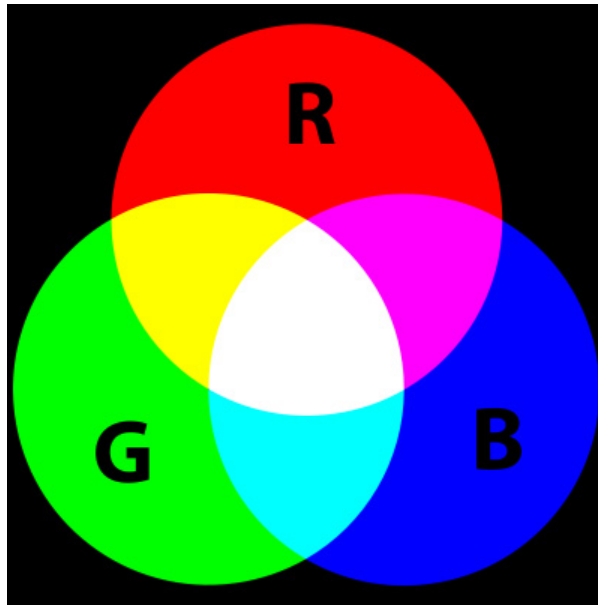
# AND9103/D

## 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.



Public Domain file from Wikipedia: The Free Encyclopedia. Wikimedia Foundation Inc.  
Retrieved from <http://en.wikipedia.org/wiki/File:AdditiveColor.svg>

**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	<a href="#">Set_Color</a> <a href="#">Get_Actual_Param</a>	"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.

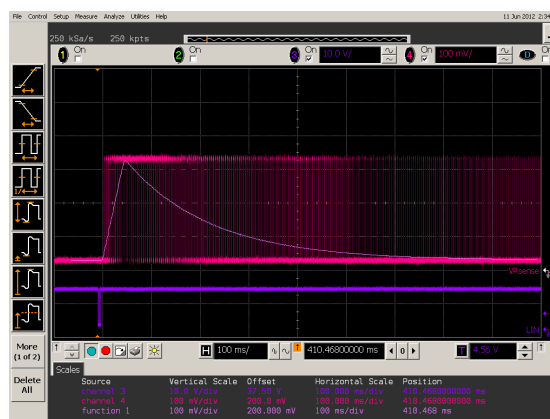


Figure 4. Intensity Peak

**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.

# AND9103/D

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.



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.

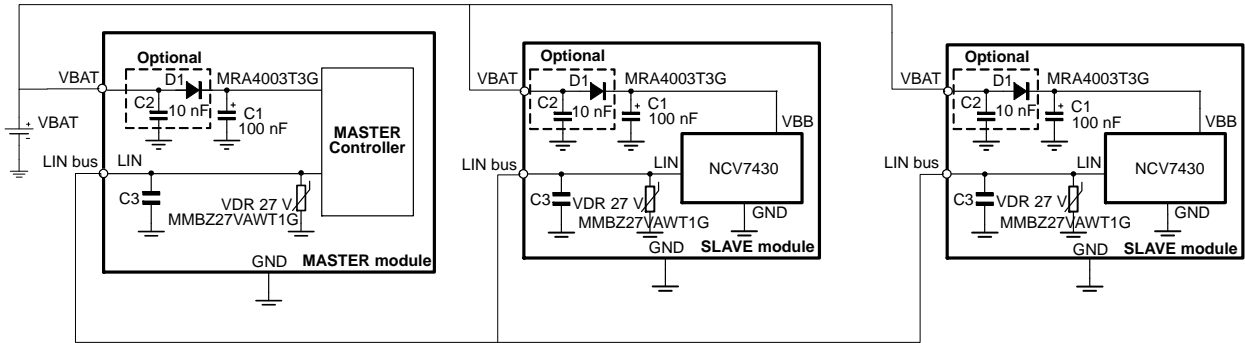


Figure 6. Master-Slave Reverse Battery Setup

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.

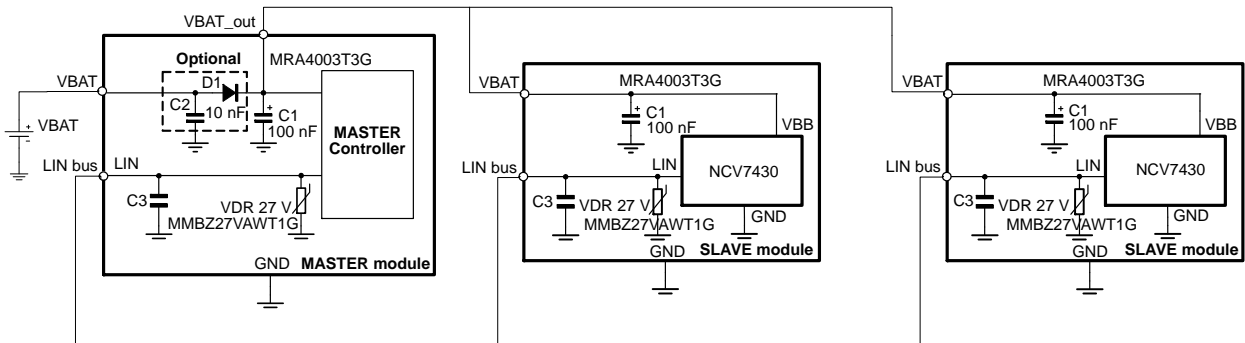
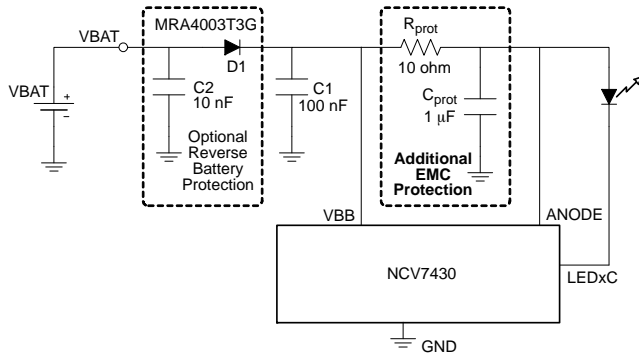


Figure 7. Common Reverse Battery Component

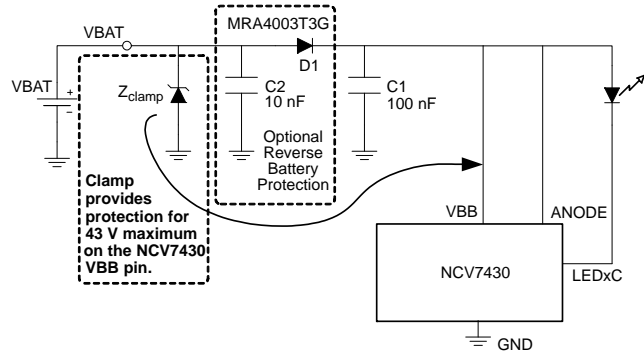
**Additional Battery Line Protection**

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.**


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 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).

ON Semiconductor and the  are registered trademarks of Semiconductor Components Industries, LLC (SCILLC) or its subsidiaries in the United States and/or other countries. SCILLC owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of SCILLC's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

**PUBLICATION ORDERING INFORMATION**

**LITERATURE FULFILLMENT:**  
Literature Distribution Center for ON Semiconductor  
P.O. Box 5163, Denver, Colorado 80217 USA  
**Phone:** 303-675-2175 or 800-344-3860 Toll Free USA/Canada  
**Fax:** 303-675-2176 or 800-344-3867 Toll Free USA/Canada  
**Email:** [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

**N. American Technical Support:** 800-282-9855 Toll Free  
USA/Canada  
**Europe, Middle East and Africa Technical Support:**  
Phone: 421 33 790 2910  
**Japan Customer Focus Center**  
Phone: 81-3-5817-1050

**ON Semiconductor Website:** [www.onsemi.com](http://www.onsemi.com)  
**Order Literature:** <http://www.onsemi.com/orderlit>  
For additional information, please contact your local Sales Representative