AND9149/D

NCN5120 - Driving Relays in an Efficient Way

ON Semiconductor®

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APPLICATION NOTE

INTRODUCTION

NCN5120 is a receiver−transmitter IC suitable for use in KNX® twisted pair networks (KNX TP1−256). It supports the connection of actuators, sensors, microcontrollers, switches or other applications in a building network.

NCN5120 handles the transmission and reception of data on the bus. It generates from the unregulated bus voltage stabilized voltages for its own power needs as well as to power external devices, for example, a microcontroller.

NCN5120 assures safe coupling to and decoupling from the bus. Bus monitoring warns the external microcontroller for loss of power so that critical data can be stored in time.

NCN5120 has several voltage regulators to generate different voltages. One of these voltage regulators is a 20 V low drop linear regulator typically used for driving relays. Because NCN5120 has a high efficient adjustable DC−DC converter, driving of relays can be done in a more efficient way. This application note describes how to use the adjustable DC−DC converter for driving relays in an efficient way under all operating conditions.

STANDARD RELAY APPLICATION

Figure 1 gives the block diagram of the relay driving principle as used in KNX relay actuators today. A 20 V LDO is used to power the relays. Because 12 V relays are generally used, this 20 V needs to be converted down to 12 V. To minimize the required power to drive the relays, bistable relays are used which are controlled by H−bridges. The H−bridges itself are controlled by a microcontroller (microcontroller not displayed in Figure 1). Although bistable relays are used still a relatively high current is required to change the state of the relays. This current cannot be requested from the 20 V LDO because this would result in a too high current taken from the KNX bus. To make sure not too much current is sourced from the KNX bus a current limit circuit is added. A big storage capacitor (10 mF or higher) is used to store the energy required to drive the relays. Every time the relays are activated the voltage on the big storage capacitor will drop. Recharging of this capacitor will be relatively slow (due to the current limiter) but because these relays are not operated at a very high rate this approach works perfectly.

NCN5120 RELAY APPLICATION

The 20 V LDO is not an efficient regulator to be used. NCN5120 has an adjustable DC−DC converter which is high efficient (DC2). One could decide to use DC2 to drive the relays. However, due to some limitations of NCN5120 this DC2 voltage could drop too much under certain situations (mainly when the capacitor needs to be charged). This would result in a too low voltage to drive the relays. Also, to store as much as possible energy in the big storage capacitor it's advised to have an as high as possible voltage.

Figure 2 gives the schematic for driving relays with DC2 and assures a stable voltage under all situations. Figure 3 displays only the DC2 part (which gives a more clear view on the operation).

With exception of DC2, the schematic as given in Figure 2 is very basic (see also NCN5120 datasheet). The connection between the KNX bus (see connector A and B) and NCN5120 makes use of all the standard components as given in the datasheet. A standard 16 MHz crystal is used and a clock signal is supplied back to the microcontroller (uC CLK). It's not mandatory to work in this way. The relay driving principle will also work when the microcontroller supplies the clock to NCN5120. RESETB and SAVEB are supplied to the microcontroller for monitoring of the status. A standard UART interface is used as communication between microcontroller and NCN5120 but any of the other interfaces will also do. DC1 is used as normal. FANIN/WAKE−pin is pulled to ground. Although this is not necessary, it's advised to do this. When FANIN/WAKE−pin is pulled to ground, more power can be taken from the KNX bus to recharge the big buffer capacitor faster (C_{13} in Figure 2). V20V is not used in Figure 2 because we use DC2 to drive the relays.

Table 1 gives the components list for all required DC2 components. All components from Figure 2 which cannot be found back in Table 1 can be found back in the NCN5120 datasheet.

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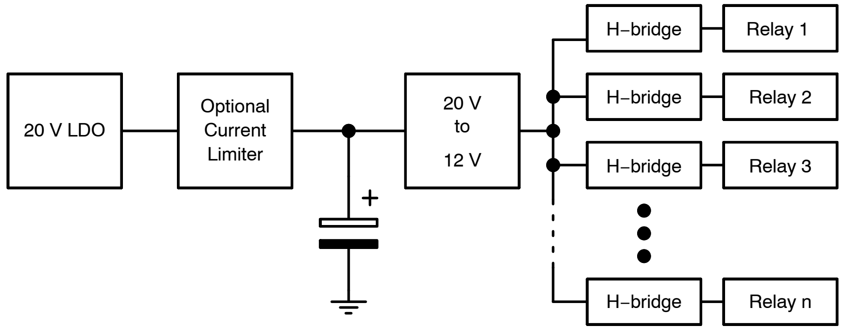

Figure 1. Relay Block Diagram

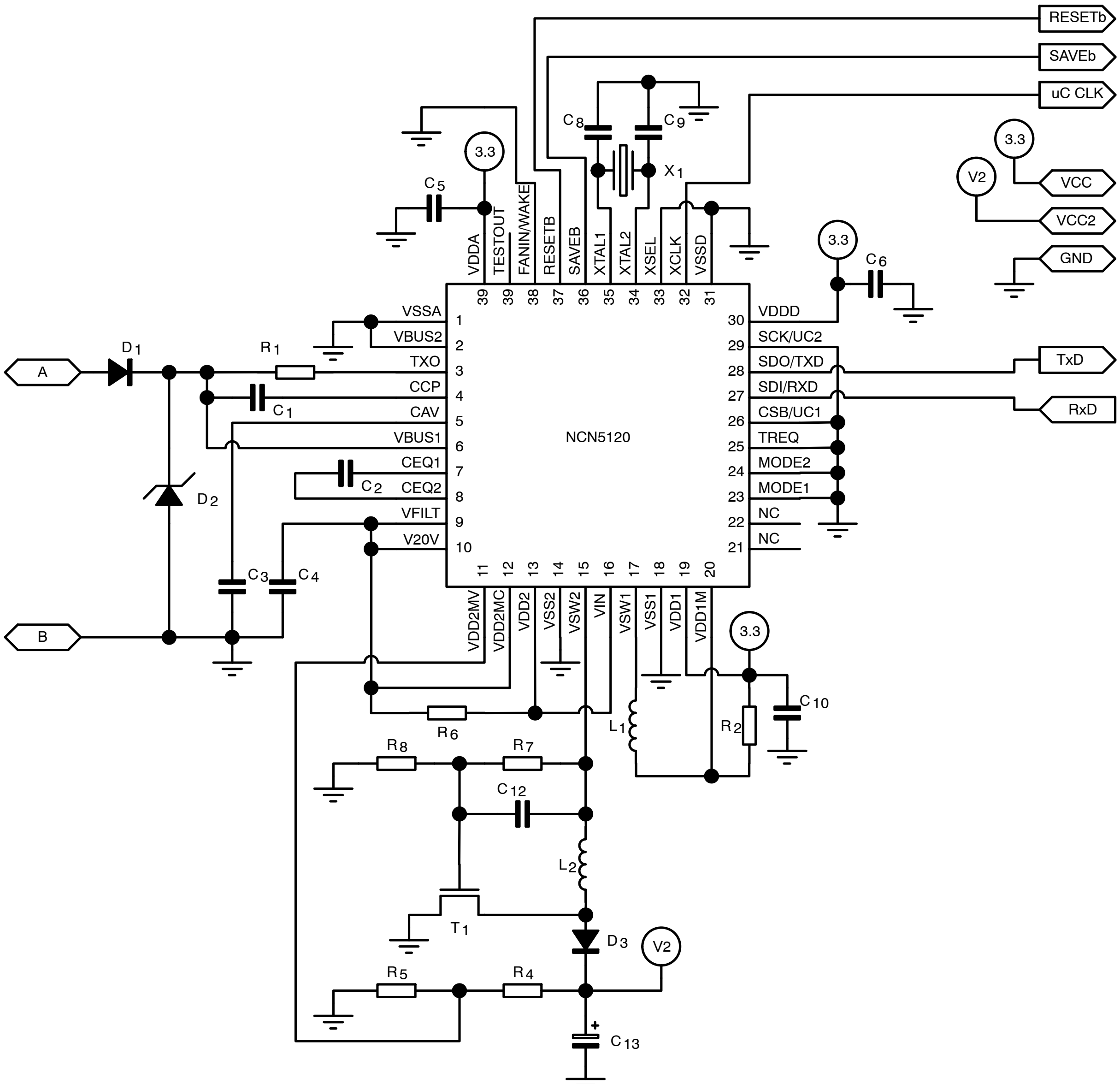

Figure 2. Application Example for Driving Relays

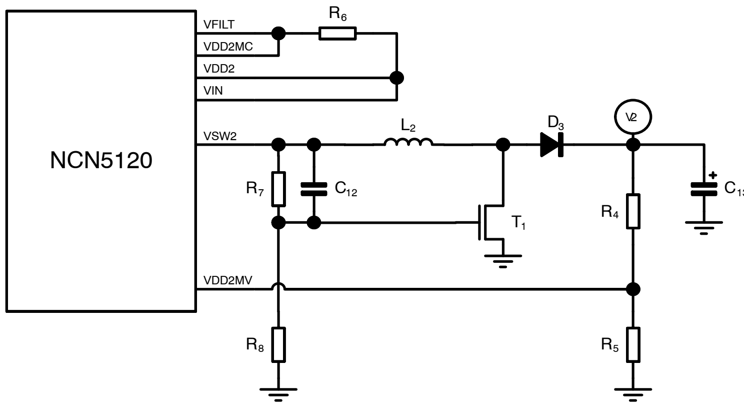

Figure 3. DC2 Schematic for Driving Relays

Table 1. DC2 BOM

Comp.	Value	Tolerance	Remarks	Notes
C_{12}	56 pF	±10%		1
C_{13}	12 mF	±20%		2, 4
D_3	MBR1H100SFT3G		ON Semiconductor	
L_2	220 μF	±10%	Coils Electronic DA54NP−221K	
R_4	39 kΩ	±5%	0.0625 W	4
R_5	10 kΩ	±5%	0.0625 W	4
R_6	2.7 Ω	±1%	0.0625 W	3, 4
R_7, R_8	100 kΩ	±1%	0.0625 W	
T_1	2N7002LT1G		ON Semiconductor	

1. It's advised to take this value as close as possible to the input capacitance of T_1.
2. The value of this capacitor will depend on the required energy for driving the relays.
3. R_2 (see Figure 2) should be lower than R_6!
4. See below for defining the value.

R_4 and R_5 can be calculated as next:

$$R_4 = \frac{R_5 \times R_{VDD2M}}{R_5 + R_{VDD2M}} \times \frac{V_2 - 3.3}{3.3}$$

The current limiting resistor R_6 can be calculated as next:

$$R_6 = \frac{V_{OC}}{\sqrt{\frac{2 \times I_{FILT} \times T}{L_2\left(\frac{1}{V_{FILT}} + \frac{1}{V_2}\right)}} - \frac{V_{FILT} \times t_{del}}{L_2}}$$

where:

- VOC = 0.15 (0.165 worst case)
- I_{FILT} = the maximum VFILT current
- V_{FILT} = VFILT voltage when relays are active (advised value is 12 V)
- T = 4 (5 worst case)
- L_2 = inductance of DC2 (in μH)
- V_2 = output voltage when relays are active (advised value is 13 V or 14 V)
- tdel = 0.15 (0.25 worst case)

The capacitor C_{13} can be calculated as next:

$$C_{13} = \frac{n \times i_{relay} \times t_{act}}{V_{drop}}$$

where:

- n = number of relays that are switched simultaneously
- i_{relay} = current required by one relay (V2 / R_{relay} gives a good estimation)
- t_{act} = activation time of the relays
- V_{drop} = the allowed drop on VOUT

A calculator is provided on the ON Semiconductor website as a guide for defining the optimum values (http://www.onsemi.com/PowerSolutions/supportDoc.do?type=tools&rpn=NCN5120).

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