NCV7750GEVB

NCV7750 Eval Board User's Manual

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EVAL BOARD USER'S MANUAL

Description

The NCV7750 is a quad low−side relay driver for automotive applications, targeted for use in a Body Control Unit (BCU) or Engine Control Unit (ECU). Communication to the NCV7750 is accomplished through a SPI bus using the SPI defined communication pins SI, SO, SCLK and CSB.

This evaluation board is set up to demonstrate the output drivers, the protective features of the device, and the various modes of operation that the device is capable of.

The NCV7750 has four independently controlled channels. Each of these channels has Overcurrent Detection, Overtemperature Detection, and Open Load Detection. These conditions are reported back to the user through data received during SPI communication.

Each of these four channels uses an NEC EX2 automotive relay as a load that switches an LED load on the output of the relay. Each relay has an accompanying button to generate an Overcurrent condition, and a jumper to generate an Open Load condition.

Output control is realized by DIP switches that may be set by the user. There is a pushbutton to transmit the configuration set by the DIP switches over SPI. There is also a switch to allow for continuous transmission over SPI, without the user needing to manually press the transmit button. The state of the NCV7750 along with inputs and outputs are displayed on the LCD. Silkscreened reference tables are present on the board to give the user further information about what is displayed on the LCD.

A demo mode may be accessed by pressing the transmit button while continuous transmission is enabled.

Features

- Demo Mode
- Individual Output Drive Control
- On−board Relay Demonstration
- LCD Display for Input, Output and Chip State
- Option for Off−board Operating Voltage and Input Control

Application

The NCV7750 includes four low−side drivers. Each of these drivers contains an internal clamping device which permits safe switching of inductive loads. This clamp voltage has a minimum specification of 36 V.

Each power transistor output driver may sink 600 mA of current, with the source of the transistor connected to the ground pins and the drain connected to the output pin.

The primary target for this device is to control relay coils. The output of the relay circuit may be connected to a wide variety of devices, including but not limited to loads for a BCU or ECU, windshield wipers, sunroof motor, cruise control system, window defrosters, fog lights, HVAC fans, ignition, headlights, tail lights, hazard lights, horn, instrument cluster, heated mirror, keyless entry, fuel pump. The NCV7750 may also be used to directly drive LEDs and other devices with similar current requirements.

Communication

The NCV7750 uses SPI (Serial Peripheral Interface) for communication while operating in "Normal Modes". SPI uses the following four pins for communication:

- SI – Serial Input
- SO – Serial Output
- SCLK – Clock
- CSB – Chip Select Bar

When data is about to be transmitted to the NCV7750, CSB goes low. Data is then clocked into the SI pin while data is clocked out onto the SO pin simultaneously. Data is clocked in on the negative edge of the clock; data is clocked out on the positive edge of the clock. This is vital for correct operation of the device, and may require specific configuration of the device controlling the NCV7750. These edges must also match properly if the NCV7750 is to be used in daisy chain configuration with other NCV7750s or other SPI controlled devices. It should also be noted that data on SO is available as soon as CSB goes low, without needing to wait for a clock edge. For more information on the specifics of SPI communication with the NCV7750, see the documentation entitled NCV7750/D.

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User Interface Locations

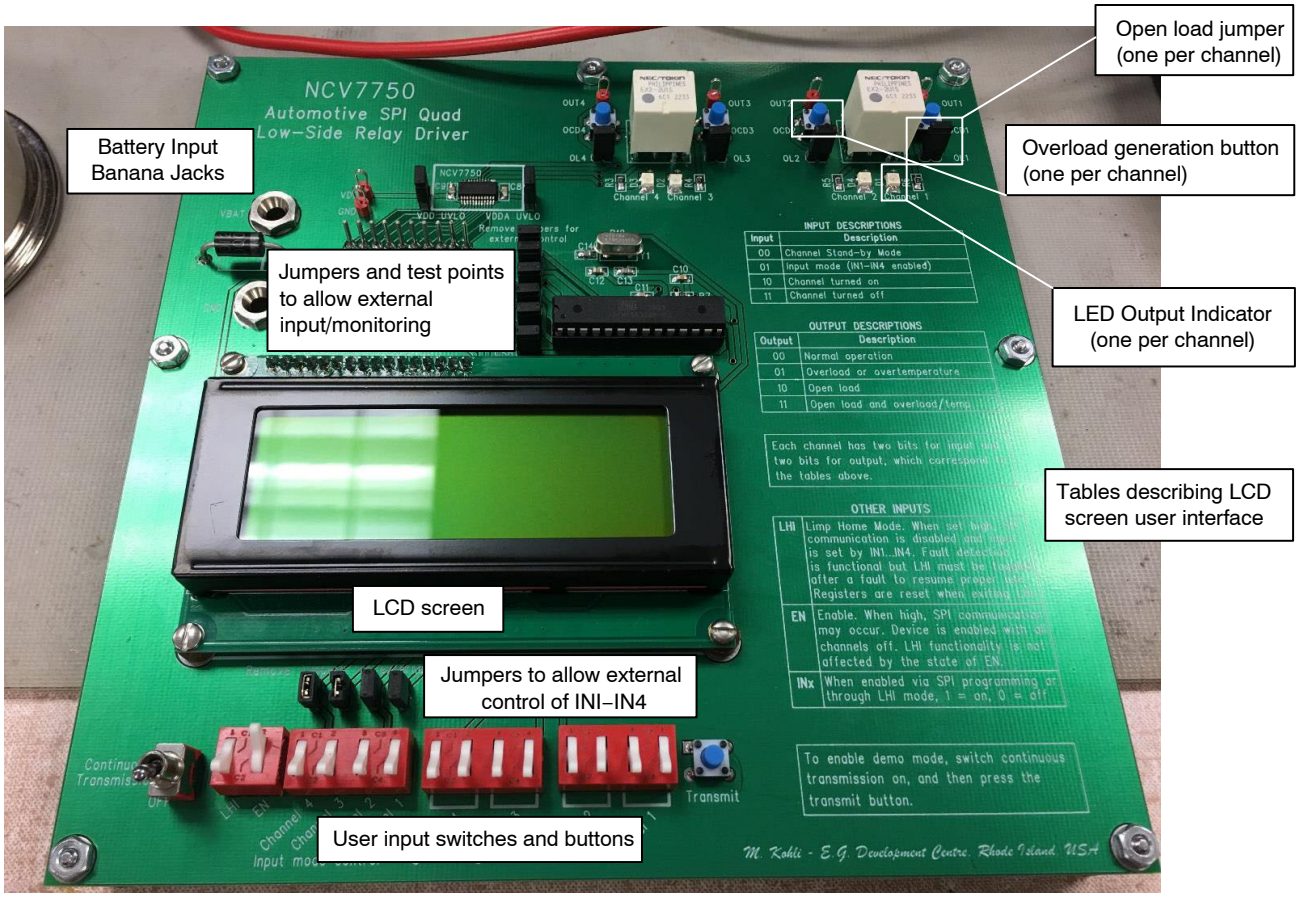


Figure 1. Board and Notable Components

Using the NCV7750GEVB

The first thing the user must do is ensure that all jumpers are connected. Also ensure that all DIP switches and the continuous toggle switch are all in the downwards position. After this is confirmed, the user can connect a ~14 V supply to VBAT banana input and a ground connection to the GND banana input. After this, the board will power on and a splash screen will appear.

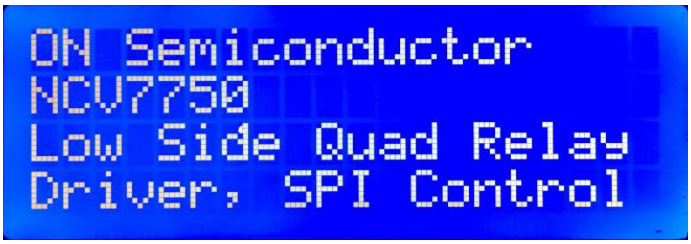


Figure 2.

After three seconds, this display will clear and the input and output screen will appear.



Figure 3.

At this point we can explain the user interface. The top line displays the current status of the NCV7750. The second line shows column headers, where C1, C2… stand for Channel 1, Channel 2, etc. The third and fourth lines show the least significant eight bits of the input and output from SPI transmission. The most significant eight bits are unused by the NCV7750, and are thus not displayed.

The possible statuses/modes that the chip may be in are listed below:

- Disabled – EN is set to low. The NCV7750 will not respond to SPI transmission, but may enter Limp Home state
- Ready – The NCV7750 is able to accept a new SPI transmission. In this state, the current output is maintained until the transmit button is pressed
- Continuous – The NCV7750 is continuously accepting SPI transmission. Thus, a change in the DIP switches for Channels 1−4 is immediately realized on the outputs
- Demo – The NCV7750 is accepting a pre−coded sequence of SPI transmissions. User input is disabled for the duration of the demo. The demo is accessed by pushing the transmit button while in continuous mode (Continuous Transmission switch up), and it drives the LEDs to light up in a pattern
- Demo ending – The demo will finish after the current sequence loop finishes
- Demo over – The demo has completed and the user may release the transmission button
- Limp Home – The NCV7750 is in LHI (Limp Home) mode. The display will reflect this by displaying Xs over the input, as SPI input is disabled in this state. User control is instead accepted from the IN1−IN4 switches. When SPI input is sent, it will not update the outputs, but SPI output will be received as normal to diagnose faults
- Done – SPI transmission is complete and the user may release the transmit button

Demo Mode

While in continuous mode (Continuous Transmission switch up), the user can press the transmit button to enter demo mode. In demo mode, a pre−programmed sequence of SPI inputs is sent to the NCV7750. It lasts for roughly 6 seconds, and will loop. In order to stop the looping, hold the transmit button again until “Demo ending” appears as the status. After it is complete, the NCV7750 will return to either Continuous or Ready state, depending on if the continuous switch was switched off during the demo. If the user has not yet released the transmit button, a “Demo over” status will show.

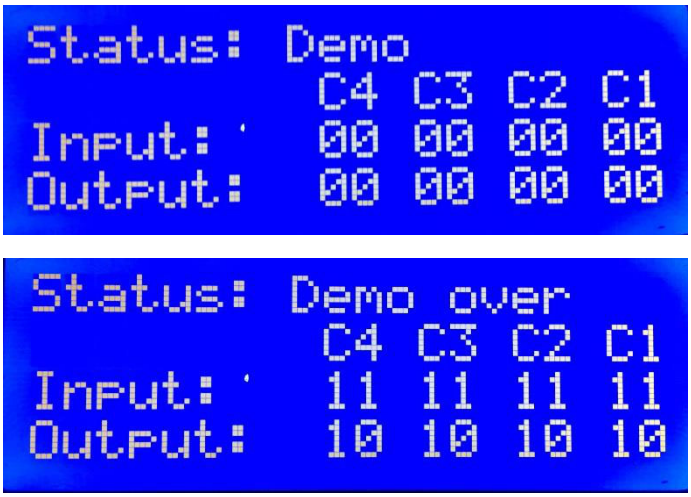


Figure 4.

The sequence of LED lights is as follows:

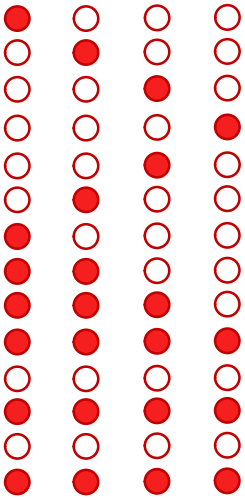


Figure 5. Demo Light Pattern

While in Demo Mode, the chip will not respond to changes in the EN or LHI DIP switches. The demo mode must be exited to enter Limp Home or Disabled Mode through the process described above. It should be noted that this is a feature of the Arduino and not the NCV7750 itself.

Transmitting SPI Commands

The evaluation board is able to transmit a single command or continuously transmit commands. The first thing to ensure is that the NCV7750 is not in the disabled state. Flip the EN DIP switch to the upwards position. The screen should update to the following:



Figure 6.

This screen indicates NCV7750 is in the “Ready” state and may now accept SPI commands. To program an SPI command, use the rightmost two DIP switches to program the four channels. Each channel has two bits. A table describing the meaning of the bit pairs is below:

Table 1. SPI INPUT

Bit pair	Meaning
00	Channel stand−by mode Fast channel turn off Fault reset – if a fault occurs on this channel (Over Current, Over Temperature, Open Load), then the channel must be sent a 00 through SPI before it is turned on again through SPI
01	Input mode Channel accepts input through the IN1−IN4 inputs, akin to LHI mode
10	Channel turned on
11	Channel turned off

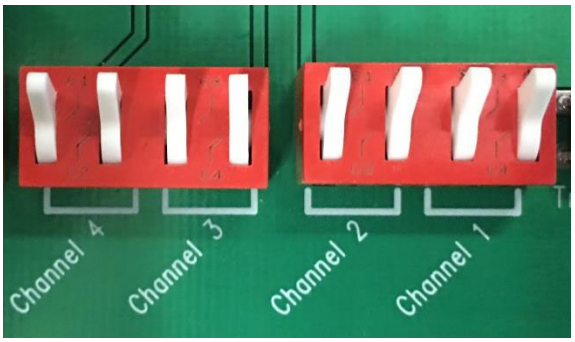


Figure 7. Channel Configuration DIP Switches

After setting the DIP switches to the desired input, the transmit button may be pressed. SPI transmission is very fast so the “Done” status should pop up almost immediately. At this point the user may release the transmit button so another SPI transmission may be setup.



Figure 8.

Alternatively, the user can enable continuous input using the toggle switch labelled “continuous transmission” which is the leftmost one. Continuous input is not a feature of the NCV7750, but rather the Arduino is programmed to simply not wait for the user to press the transmit button in this mode. As a result, the NCV7750 will respond practically immediately to any change in user input on the DIP switches.



Figure 9.

Limp Home Mode

To enter LHI mode, the user must put the LHI DIP switch into the upwards position. No matter what mode the NCV7750 was in before, it will enter LHI mode. In this mode, the transmit button and continuous mode still send SPI input, but actual control of the outputs is diverted to the IN1−IN4 DIP switches. SPI transmission will only retrieve faults, not change the state of the outputs.

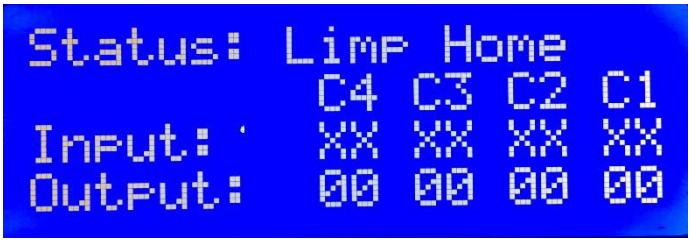


Figure 10.

Using external input

The NCV7750GEVB allows the user to disconnect internal inputs to the NCV7750 and replace them with external inputs. This is done by removing the jumpers shown below:

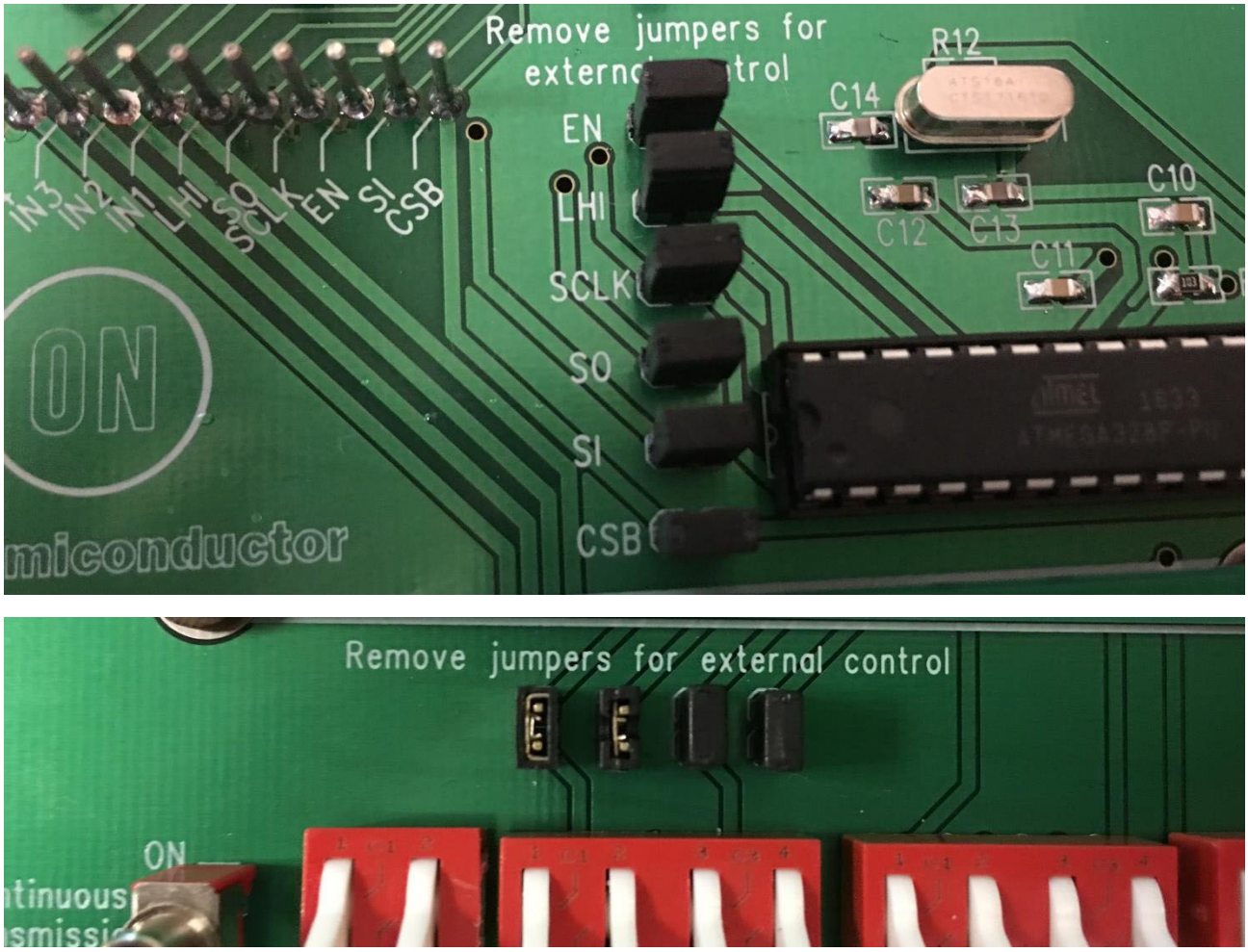


Figure 11. Jumpers for External Control

After doing this, the corresponding test post shown in the first image may be used to input a signal from a different source. This may be useful if the intended application SPI controller is at hand, as it can be used to replace the Arduino and DIP switches as SPI input and SPI control. It may also be useful if a Limp Home controller is available, as it can replace the DIP switch input for the NCV7750's LHI mode (second image).

Because the NCV7750 is designed for 5 V or 3.3 V digital logic levels, it is also possible to replace the 5 V supply to the NCV7750's VDD pin with a 3.3 V supply. To do this, remove the jumper labelled VDD UVLO shown below and use the nearby test post to provide a 3.3 V input.



Figure 12. UVLO Jumper and VDD Test Post Locations

It should be noted that the Arduino will not be able to output 3.3 V digital logic levels and as such, this change from 5 V to 3.3 V should only be done if an external input control is to be used for all inputs to the NCV7750. This feature is therefore useful if an external SPI controller or Limp Home controller outputs in the 3.3 V digital logic range.

Generating Fault Conditions

The NCV7750 is capable of detecting and reporting the following error conditions:

- Overload/Overcurrent Detection (OCD)
- Overtemperature Detection (OTD)
- Open Load Detection (OLD)
- Undervoltage Lockout (UVLO)

During SPI transfer, the data sent out of the NCV7750 corresponds to the status of each channel. Similar to the input, there are two bits for each channel in the output. The meaning of each bit pair is explained in the table below:

Table 2.

Bit pair	Meaning
00	Normal operation
01	Overload or overtemperature
10	Open load
11	Open load and overloard or overtemperature

Overload generation

An overload fault may be generated by pressing an "OCD" push button near the relays on the board. There are four push buttons; one for each channel, positioned and labelled according to which channel they correspond to.

These buttons produce an OCD fault by shorting VBAT to GND through the output driver. As a result of the high current, there will be a quick shutdown of the output driver to protect it.

Open load generation

An open load can be generated by removing the jumpers labelled "OL" near the relays. Like the push buttons for OCD generation, these are positioned and labelled according to which channel they correspond to.

These buttons produce an OLD fault by simply disconnecting the relay coil from the output driver.

These jumpers and buttons are shown in Figure 13.

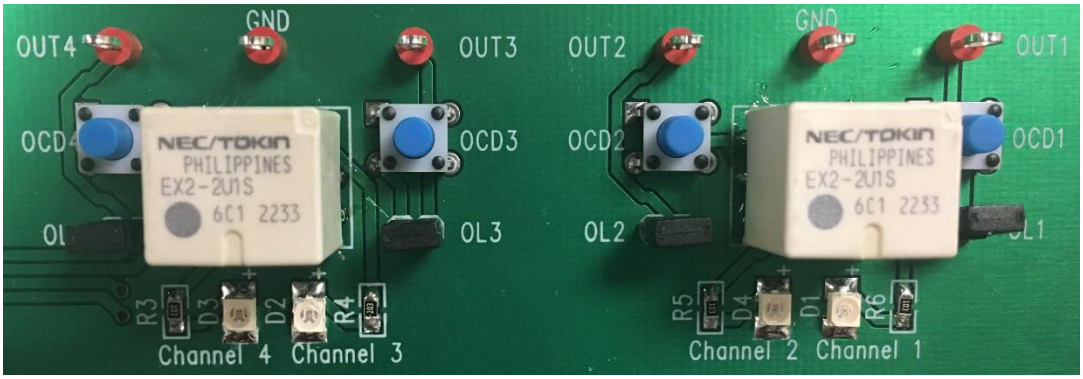


Figure 13. Open Load and Overcurrent Generation

Undervoltage lockout generation

There are two supply voltages for the NCV7750 chip; VDD and VDDA. For normal operation, both VDD and VDDA must be above a certain threshold voltage; 2.625 V falling edge for VDD and 3.5 V for VDDA. The chip may operate in LHI mode with only VDDA's voltage above threshold.

In order to generate a UVLO fault, which is not reported to the LCD display and instead results in the chip turning off all outputs, remove one or both of the UVLO jumpers in Figure 12.

After a UVLO fault, the chip will turn back on with all outputs off. EN will have to be toggled to return the chip to the Ready state.

Overtemperature generation

There is no on−board method to generate an OTD fault. It is not recommended to use an oven to generate these faults, as certain components such as the LCD screen are prone to permanent damage at temperatures even far below the OTD fault threshold of the NCV7750.

Transmission error

When CSB is asserted low, a bit called TER is immediately put onto the SO pin of the NCV7750. This bit, when high, means that the chip has just exited LHI mode, a UVLO fault, EN has just been set high, or that there was a fault during SPI transmission.

This feature is not displayed on the evaluation board. It may be observed with the use of an external SPI controller.

Arduino (ATMega328P)

The NCV7750GEVB is a self−contained board, meaning that it requires no external connections other than power. This is accomplished through the use of an ATMega328P chip configured as an Arduino, with a program preinstalled. The ATMega328P is able to read the user inputs, determine the state of the NCV7750, and report this to the user on the LCD screen that accompanies it. This makes for simple, hassle−free use even when a computer is not present.

Schematic

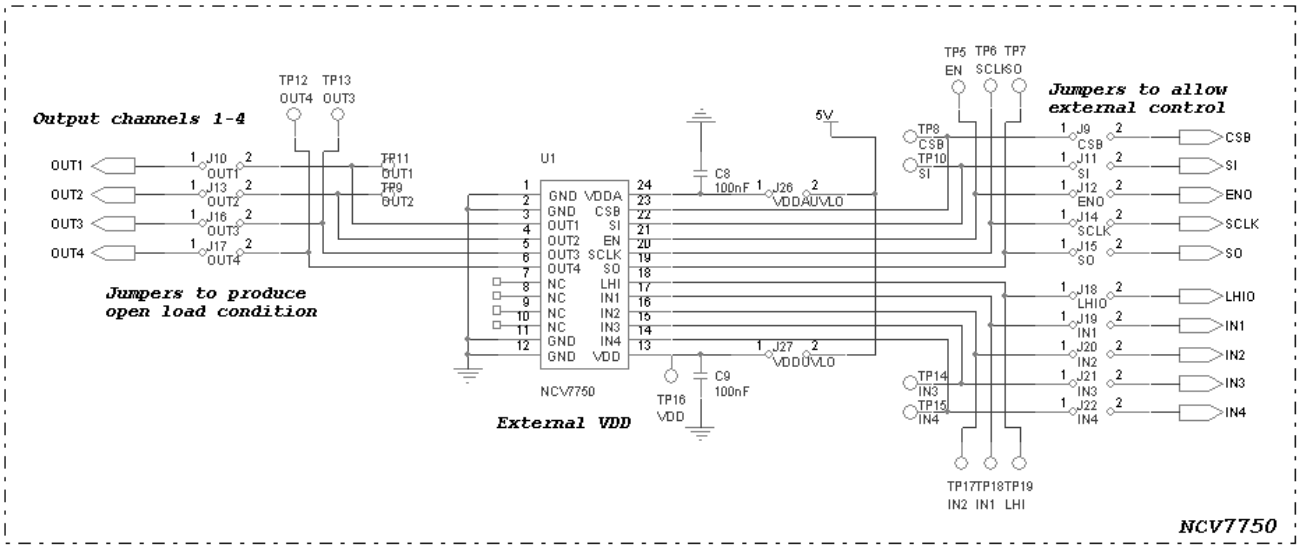


Figure 14. NCV7750 Evaluation Board Schematic – NCV7750 Circuit

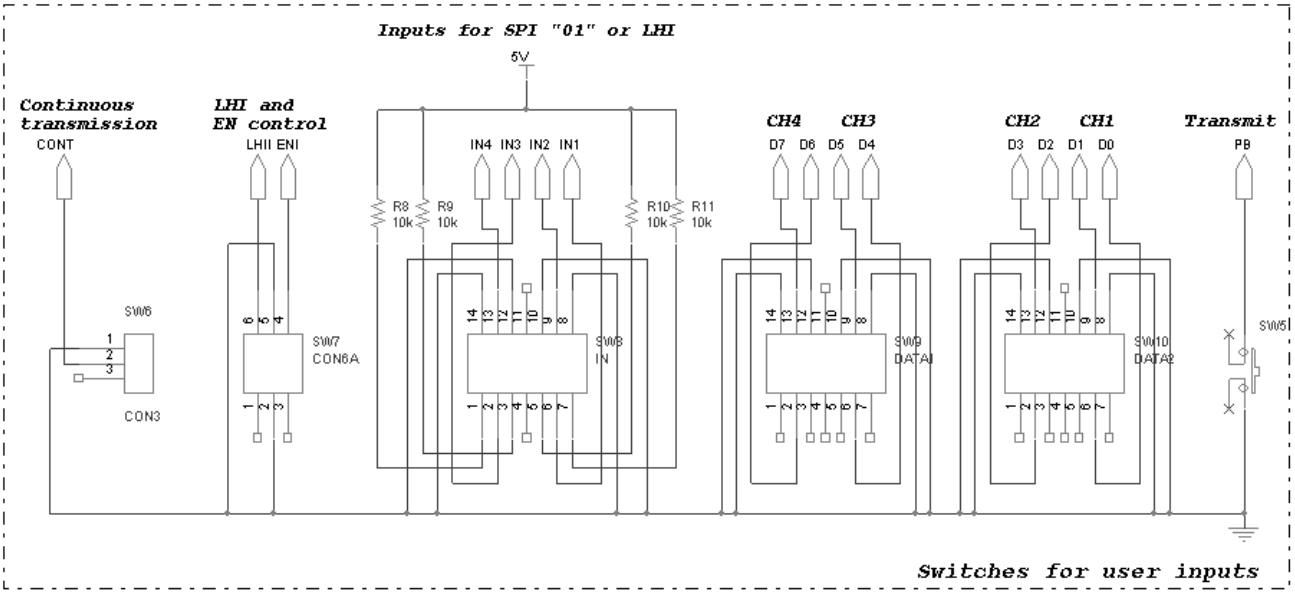


Figure 15. NCV7750 Evaluation Board Schematic – User Inputs for SPI and Chip State

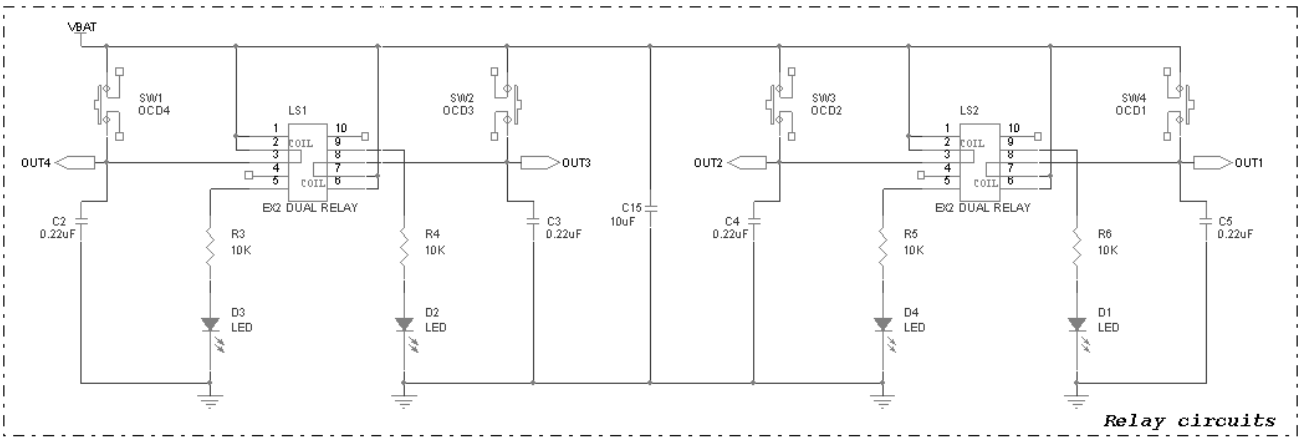


Figure 16. NCV7750 Evaluation Board Schematic – Relay Circuits

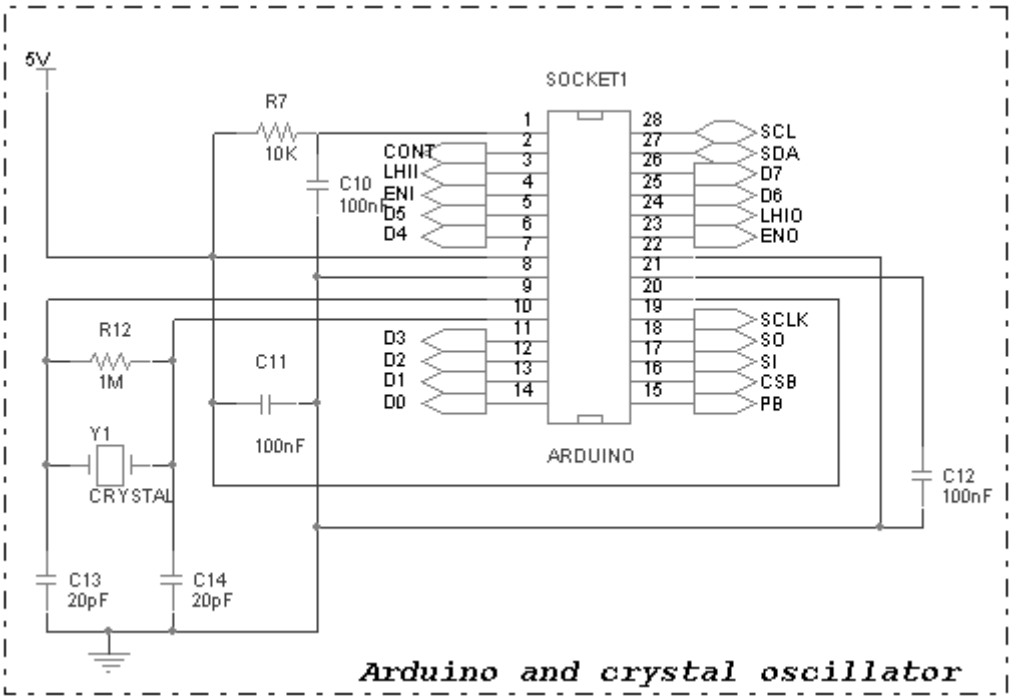


Figure 17. NCV7750 Evaluation Board Schematic – Arduino SPI and LCD Display Controller

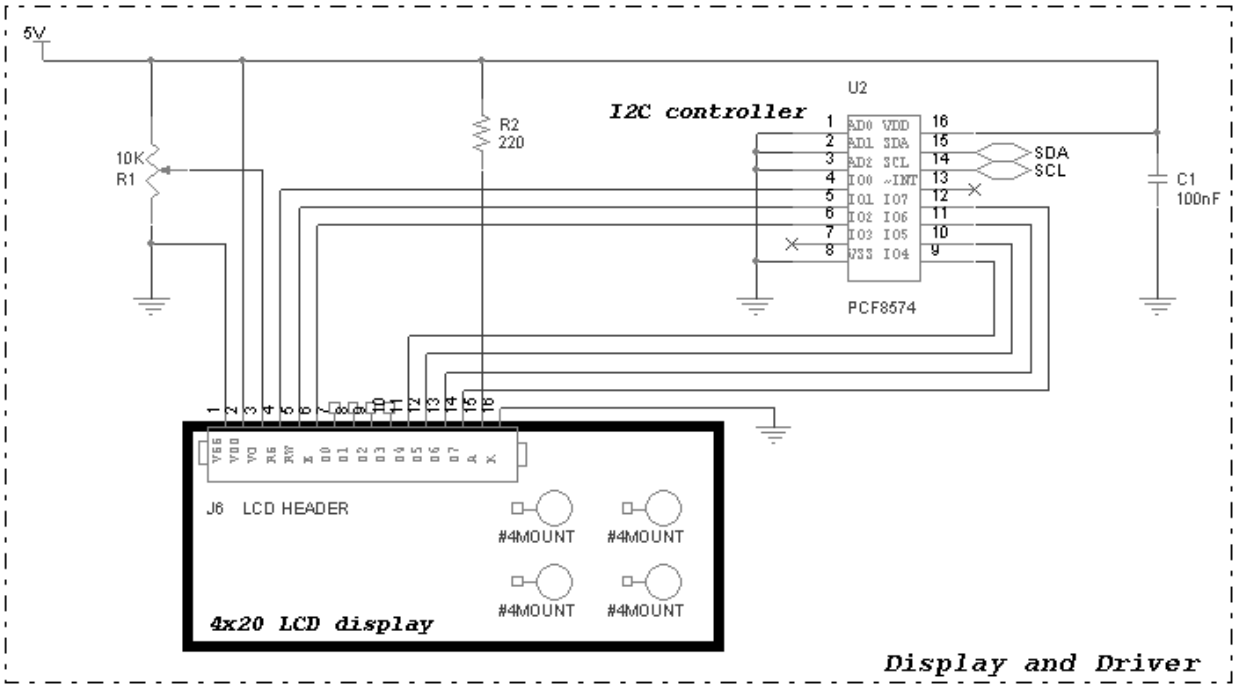


Figure 18. NCV7750 Evaluation Board Schematic – LCD Display and I2C Controller

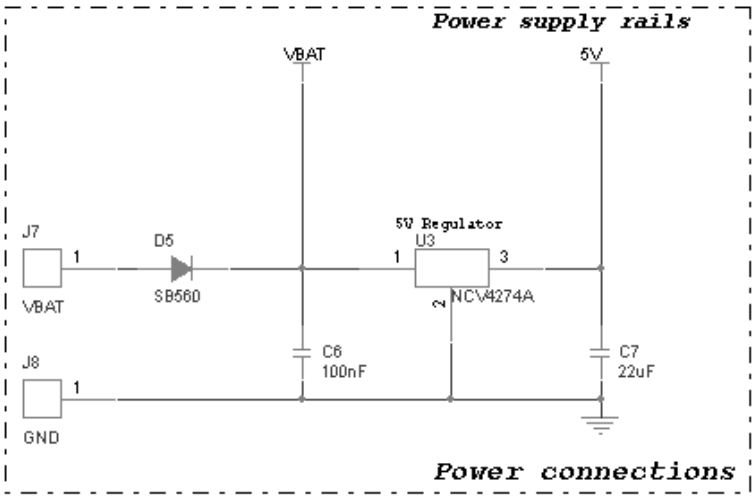


Figure 19. NCV7750 Evaluation Board Schematic – Power Connections and 5 V Regulator

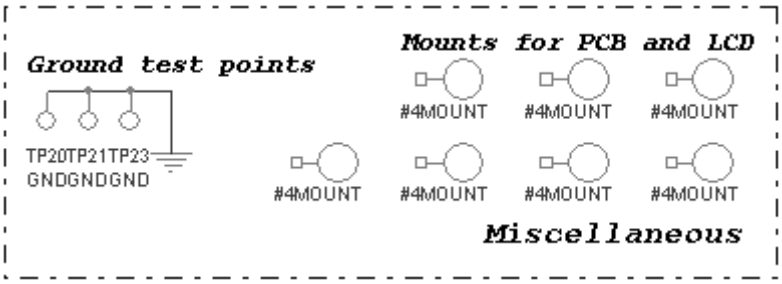


Figure 20. NCV7750 Evaluation Board Schematic – Miscellaneous Circuitry

PCB

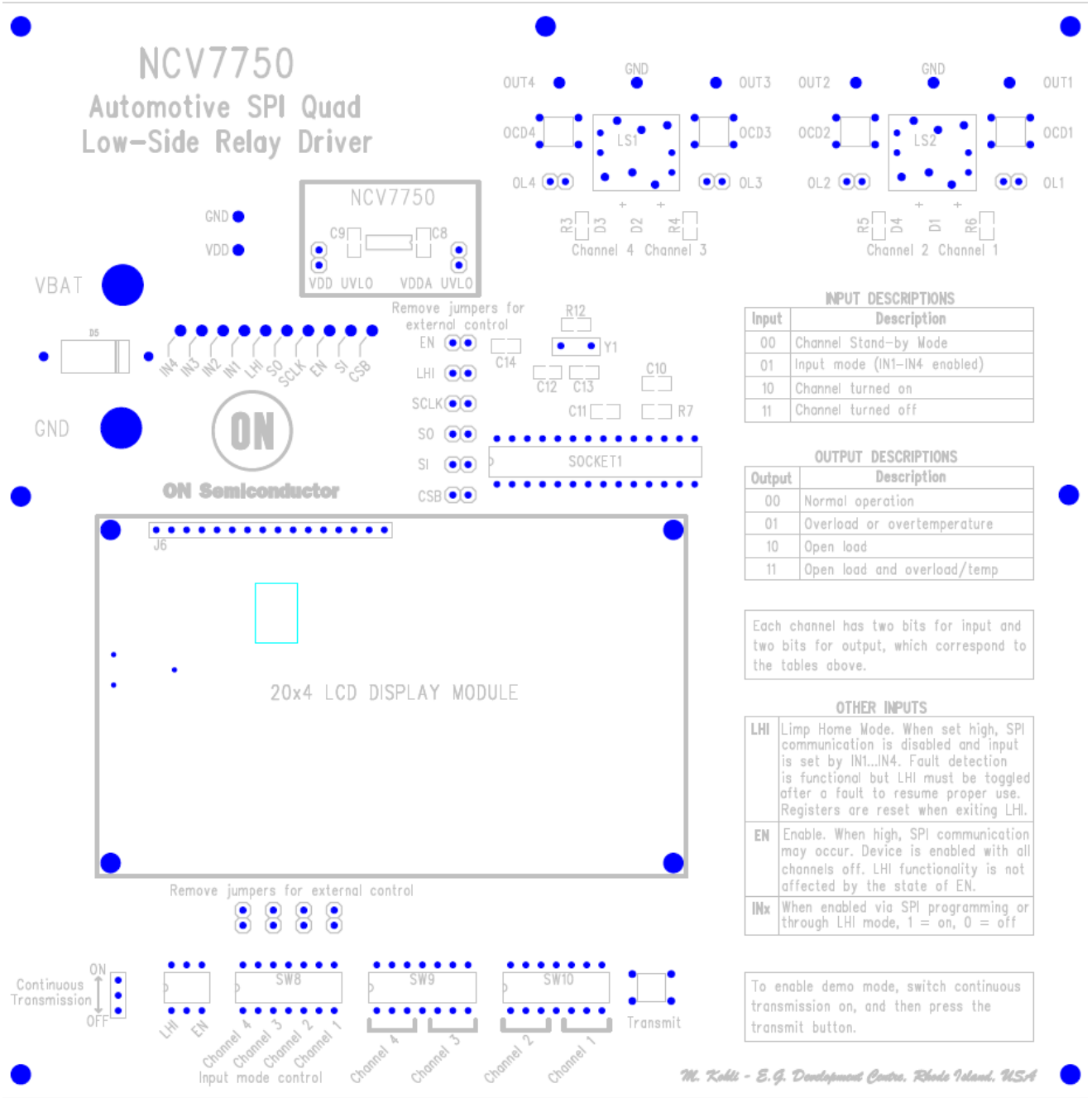


Figure 21. Printed Circuit Board

Table 3. BILL OF MATERIAL

Refdes	Description/ Function	Value	Tolerance	PCB Footprint	Manufacturer	Part Number	Quantity	May substitute?
VBAT	Connector for 14 V	–	–	BANANA	Cinch Connectivity Solutions	108−0740−001	1	Y
GND	Connector for 0 V	–	–	BANANA	Cinch Connectivity Solutions	108−0740−001	1	Y

Table 3. BILL OF MATERIAL(continued)

Refdes	Description/ Function	Value	Tolerance	PCB Footprint	Manufacturer	Part Number	Quantity	May substitute?
C1, C6, C8, C9, C10, C11, C12	Bypass capacitors	100 nF	10%	0805	KEMET	C0805C104K5-RACTU	7	Y
C2, C3, C4, C5	Output capacitors	100 nF	10%	0805	KEMET	C0805C106K4-PACTU	4	Y
C7	Voltage regulator output capactior	22 μF	10%	1210	KEMET	C1210C226K4-PACTU	1	Y
C13, C14	16 MHz oscillator capacitors	20 μF	10%	0805	KEMET	C0805C200J5-GACTU	2	Y
C15	Supply line capacitor	10 μF	10%	1210	KEMET	C1210C106K3-RACTU	1	Y
R1	Potentiometer for LCD contrast	10 K	20%	3352E_POT	Bourns Inc.	3352E−1−103LF	1	Y
R2	LCD backlight pullup resistor	220 R	1%	0805	Vishay Dale	CRCW0805220RFKEA	1	Y
R3, R4, R5, R6, R7, R8, R9, R10, R11	Pullup resistors	10 K	1%	0805	Vishay Dale	CRCW080510K0FKEA	9	Y
R12	16 MHz oscillator shunt resistor	1 M	1%	0805	Vishay Dale	CRCW08051M00FKEA	1	Y
D1, D2, D3, D4	Relay circuit LEDs	–	–	PLCC2_LED	Vishay Semi Opto	VLMS30K1L2−GS08	4	Y
D5	Reverse supply diode	5 A/60 V	–	DO−21	Vishay	SB560−E3/54	1	Y
U1	NCV7750	–	–	SSOP24	ON Semiconductor	NCV7750	1	N
U2	I2C −> Parallel for LCD	–	–	SOIC16_W	NXP Semiconductor	PCF8574T	1	N
U3	5 V regulator	–	–	DPAK3_SMD	ON Semiconductor	NCV4274ADT50RKG	1	Y
SOCKET1	Socket for arduino	–	–	DIP28	Onshore Technology Inc	ED281DT	1	Y
<Arduino>	Arduino	–	–	–	Atmel	ATMEGA328P−PU	1	N
Y1	16 MHz Crystal oscillator for arduino	20 pF	30ppm	XTAL	CTS−Frequency Controls	ATS16A	1	Y
LS1, LS2	Dual relays	–	–	EX2_RELAY	KEMET NEC−Tokin	EX2−2U1S	2	N
J6	Header for LCD	–	–	SIP−16P	Sullins Connector Solutions	PRPC016SAA-N−RC	1	N
–	LCD	–	–	–	Cofufu	LCM TM204A	1	Y
J9−22, J26, J27, J28	Jumper posts, 100 mil, 2 post	–	–	JMP	3M	961102−6404−AR	16	Y
TP5−TP24	Hook test points	–	–	TP	Keystone electronics	5012	18	Y
SW1−4, SW5	Over current simulation switch, Transmit	–	–	SW_6x6_TACTILE	TE Connectivity Alcoswitch	1−1825910−0	5	Y
SW8, SW9, SW10	User input DIP switches (4)	–	–	DIP14	Grayhill	76STC04T	3	N

Table 3. BILL OF MATERIAL(continued)

Refdes	Description/ Function	Value	Tolerance	PCB Footprint	Manufacturer	Part Number	Quantity	May substitute?
SW7	User input DIP switches (2)	–	–	DIP6	Grayhill	76STC02T	1	N
SW6	Continuous mode switch	–	–	SIP−3P	Multicomp	2MS1T2B2M2-RE	1	N
MNT1−11	Jumper shunts, 100 mil spacing	–	–	–	Sullins Connector Solutions	QPC02SXGN−RC	16	Y

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