NCV7748GEVB

NCV7748 Evaluation Board User's Manual

Eight Channel Low-Side Relay Drivers with LIN Communication

ON Semiconductor®

EVAL BOARD USER'S MANUAL

Description

The NCV7748 is an octal low-side relay driver for automotive applications targeted for use in a Power Distribution Box (PDB). Communication to the device is through a LIN bus compliant to SAE J2602 and LIN 2.x. All drivers have passive output clamps for limiting output voltage spikes during flyback events during inductive relay turn-off events.

This evaluation board is intended for evaluation of the output drivers, and highlights many of the features of the device.

The NCV7748 has two types of low-side drivers. One is intended to run outside of the module and the other is targeted for use inside the module. All outputs have Overcurrent Detection, but the output drivers intended for use external to the module (OUT4, OUT8) have added Open Load detection and individual Overtemperature (Thermal Shutdown) detection. The evaluation board includes NEC EX2 automotive relay loads, with the option to disconnect these loads and use customer defined external loads.

Output control is interfaced with the use of dip switches and a push-button. Output Control Commands as well as Output errors can be read from the LCD display. Truth tables are included in silk screen on the PCB for ease of use for both command control and error deciphering.

Features

- Individual Output Drive Control
- On-board Relay Demonstration with Option for Off-board Connections
- Get Status Request for Error Reporting from ERR and APPINFO Registers

Application

The NCV7748 device includes 8 low-side drivers. Each includes an output clamp for inductive loads. A 41 V (typ) clamp from the drain to gate of the output driver helps protect the output driver from seeing excessive voltage during a flyback event from an inductive load. The minimum specification for the clamp voltage is 38 V. It is important to limit external DC supply voltages to less than 38 V to avoid a high power situation.

Primary target loads are coils of relays for a power distribution box (PDB). These can include, but not limited to loads for Engine Control Unit (ECU), Windshield Wipers, Sunroof, Cruise Control, Rear Window Defroster, Fog Lights, Cooling Fans, Ignition, Headlights, Tail Lights, Hazard Lights, Horn, Cooling Fan, Cluster, Heated Mirror, External Accessory Voltage, Instrument Cluster, Keyless Entry, Fuel Pump, etc.

Figure 1. NCV7748 Evaluation Board
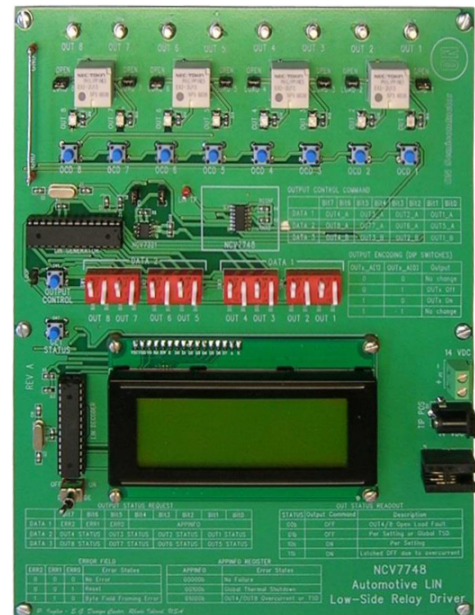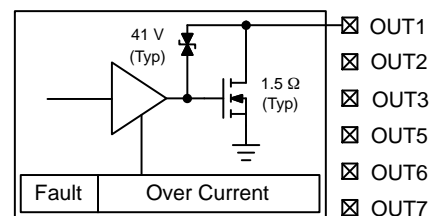

Figure 2. 1.5 Ω Output Drivers

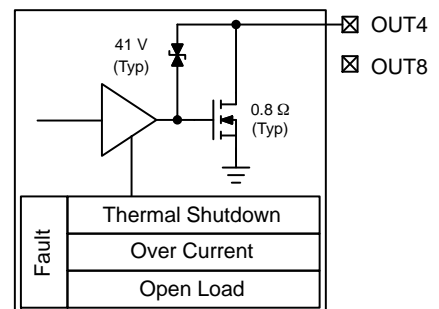**Figure 3. 0.8 Ω Output Drivers**

Communication

The NCV7748 utilizes a LIN protocol for all communication. LIN is a single wire communication network which utilizes a master/slave configuration. The NCV7748 is the slave and receives its commands from an external master device and also reports on the same pin (LIN) to the master device after a request is made. Figure 4 shows the basic LIN schematic. The LIN bus is driven high through a 30 kΩ resistor in series with a diode and its read capability is filtered to an internal RxD comparator.
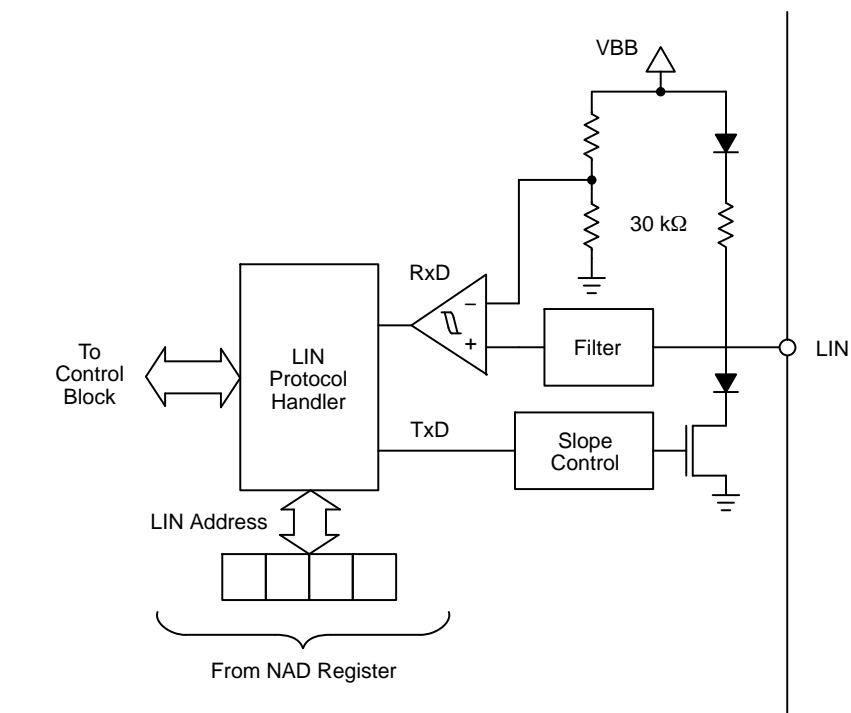

Figure 4. LIN Controller

A table (Table 1) of supported commands of the NCV7748 is listed below from the NCP7744/D data sheet. Note the NCV7744 reference is to a sister part which is comprised of 4 outputs instead of the 8 outputs of the NCV7748.

Table 1. SUPPORTED LIN COMMANDS

PID[7:0]	Frame Type	Description	Data Length	Spec
Depends on NAD	Output Control	Sets all outputs in one virtual node.	8	N/A
Depends on NAD	Get Node ID	Reads identity of prime device in virtual node. (In frame slave Response)	8	N/A
Depends on Rconfig and NAD	Get Status	Reads diagnostics of one device (LS driver). (In frame slave Response)	8	N/A
0x3C	Targeted Reset Master Request	Re-initialization of one virtual node. This includes all devices on the virtual node.	8	J2602−1
0x7D	Targeted Reset Slave Response	Positive response by prime device.	8	
0x3C	Read by Identifier Master Request	Reads identity of device supplier.	8	LIN2.2
0x7D	Read by Identifier Slave Response	Successfully processed request.	8	
		Slave could not process the request.	8	
0x3C	Broadcast Reset	Re-initialization of all nodes.	8	J2602−1
0x3C	Goto Sleep	All devices enters Sleep Mode.	8	LIN2.2

The NCV7748GEVB is capable of demonstrating:

- **Output Control**
  A one-way command which sets all outputs in one virtual node (see NCP7744/D data sheet for virtual node definition).
- **Get Status**
  A two-way command which requests device diagnostics and receives a response with an in-frame response.
- **Display of Sleep Mode**
  After timeout.

Practical setup limitations do not allow the display of Get Node ID, Targeted Reset, Read by Identifier, Broadcast Reset, and Goto Sleep on this board. A further enhanced setup using enriched software is needed to display all device features.

The operation of the NCV7748 evaluation board works as a standalone presentation for the customer highlighting LIN communication for turning on and off low-side drivers (both 1.5 Ω and 0.8 Ω). Dip switches provide the user programmability for the Control Frame. Jumpers provide convenient access to TxD, RxD, and the LIN pin which are normally connected to the on-board microprocessor. Jumpers are also included for use with external loads. A jumper is included to maintain output control to avoid going to sleep after the NCV7748 "Time to go to sleep" electrical parameter. Pushbuttons are included for implementing the user control of Output Control and Get Status. Pushbuttons are also included to provide overcurrent conditions (OCD) of the loads. A demo mode is provided via a toggle switch.

The user must adhere to the absolute maximum ratings when using off-board connections.

Table 2. MAXIMUM RATINGS

Rating	Value	Unit
Supply Voltage to Board (14 VDC) (Using On-board NEC Relays)	–0.3 to 16	V
Supply Voltage to Board (14 VDC) (Removing LOAD1–8 Jumpers)	–0.3 to 40	V
TxD	–0.3 to 5.25	V
RxD	–0.3 to 5.25	V
LIN	–40 to 40	V
Output Pin Voltage (OUT1– OUT8) (Removing LOAD1–8 Jumpers) Using External Loads	–0.3 to 38	V
Junction Temperature (NCV7748)	–40 to 150	°C
Temperature (Evaluation Board)	–40 to 105	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Table 3. RECOMMENDED BOARD OPERATING CONDITIONS

Rating	Min	Max	Unit
External Supply Voltage (14 VDC)	–	16	V
Junction Temperature (NCV7748)	–40	150	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.
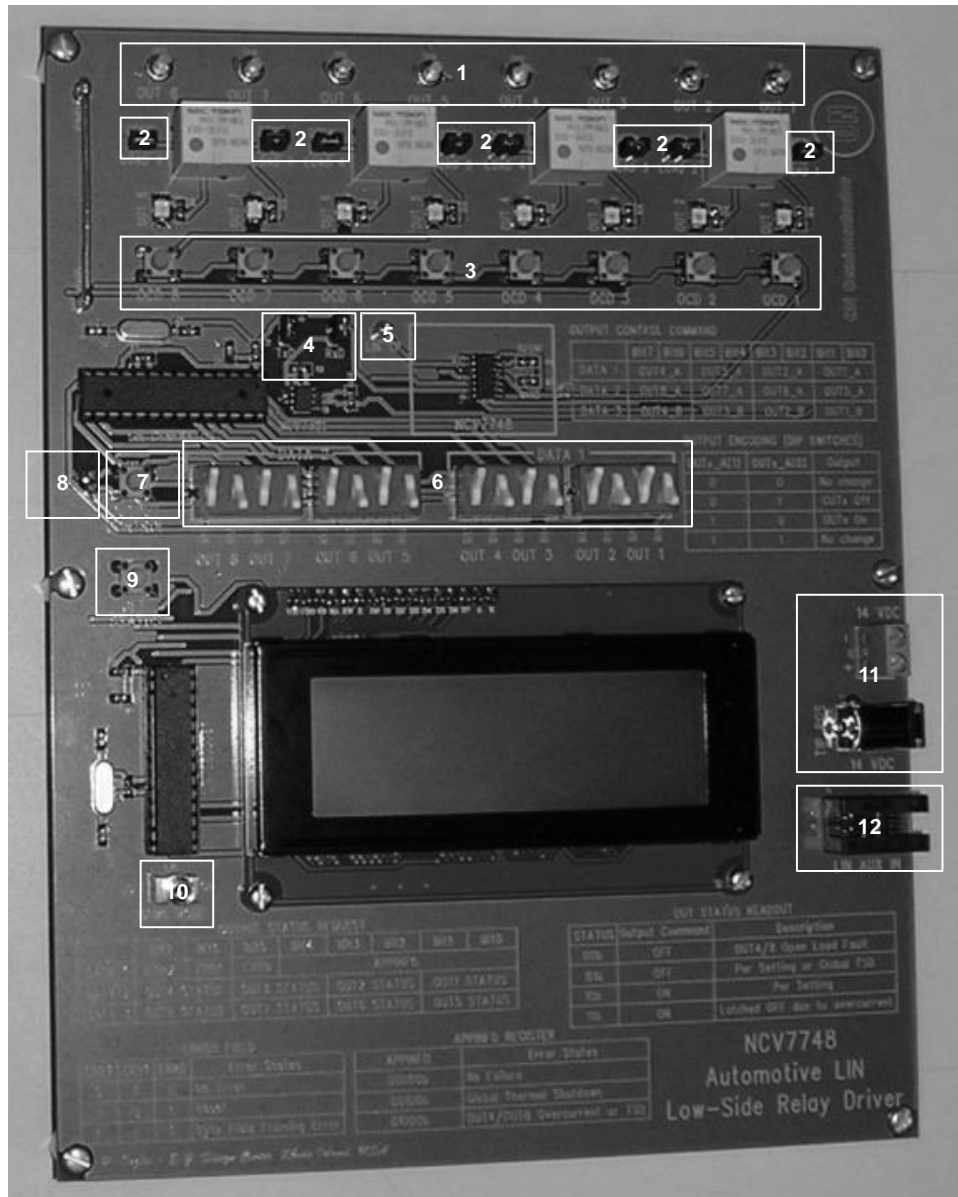
Table 4. PIN FUNCTION DESCRIPTION

Connector	Pin Number	Terminal Name	Description
Power	J12, J13	14 VDC	Power Supply Input Voltage (14 V)
	GND	GND	Ground
Test Points	J1	LIN	LIN Bus
	J2–8, J11	LOAD 1–8	On-board Relay Disconnect
	J9	OUTPUT CONTROL	LIN Command for Output Control (Pushbutton Shorts to Ground)
	J10	HEADER 16	Header for LCD Display
	J14–J19	N/A	Board Post Mount Holes
	J20–J23	N/A	LCD Display Post Mount Holes
	J24	TxD	NCV7321 TxD Input
	J25	RxD	NCV7321 RxD Output

User Interface Locations

Figure 5 shows all the user interface locations. This lists all the user options available on the evaluation board.

1. OUT1–8 External Post Connections
2. External Relay Jumpers
3. Overcurrent (OCD) Pushbuttons
4. TxD, RxD Jumpers
5. LIN Test Point
6. Output Control Command Input Data
7. Output Control Pushbutton
8. LOOP Jumper for Continuous Operation without Four Second Timeout
9. Get Status Pushbutton
10. Demo Mode Toggle Switch
11. 14 VDC Power Supply Inputs
12. LIN Auxiliary Input

Figure 5. User Interface Locations

OPERATIONAL GUIDELINES

The material necessary to successfully use the evaluation board is listed below.

- NCV7748 Evaluation Board
- 14 V Power Supply Capable of Drive 1 A

Configure the Board

Typical Board Configuration with On-board Components
1. Connect all jumpers on the board with the exception of the LOOP jumper (J9) for output control. This jumper is located directly next to the OUTPUT CONTROL pushbutton.
2. Set the DEMO MODE toggle switch OFF.

Demo Mode
1. Configure the board as per above.
2. Connect the 14 V power supply.
3. Turn on the power supply.
4. The splash screen will be shown (see Figure 6).
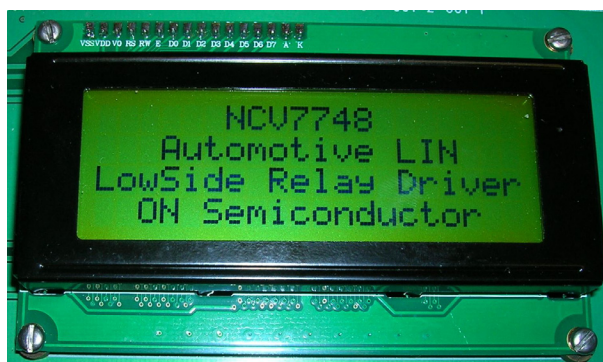5. Move the DEMO MODE toggle switch to the ON position.

Figure 6. Splash Screen

At this point, the relays will individually sequence from OUT1 to OUT8 and repeat. This is indicated on the board with the illumination of the LEDs connected to the outputs of the relays. Figure 7 shows the board when OUT2 is illuminated. This will continue indefinitely. Switching the demo mode toggle switch off, the sequence will continue and stop on OUT8 until the NCV7748 device times out and OUT8 will also turn off.
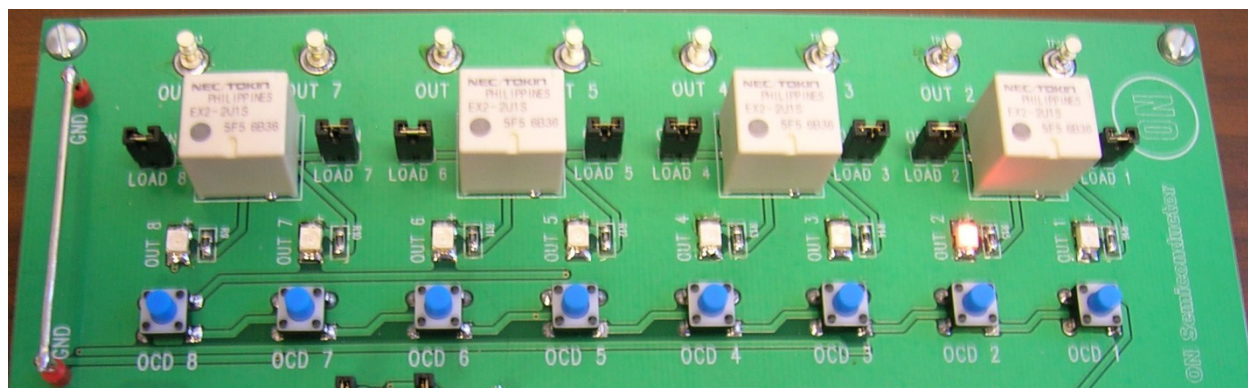

Figure 7. Sequencing Demo Mode

Normal Operation
1. Move the DEMO MODE toggle switch to the OFF mode.
2. This sets the NCV7748 ready to receive LIN commands from the on-board microprocessor.
3. Set the DIP switches using the OUTPUT CONTROL COMMAND for DATA 1 and DATA 2 for the targeted outputs and the OUTPUT ENCODING for the output state. In this mode, DATA 3 will always display all zeros.
4. Press the OUTPUT CONTROL pushbutton (Figure 9) located to the left of the DIP switches.
5. The selected outputs will turn on.
   NOTE: Figure 8 displays the setup for all 8 outputs to turn on.
   NOTE: Figure 12 highlights the dip switches settings and the resultant display of the settings.

All selected outputs will remain illuminated until the NCV7748 sleep timer has expired. This is indicative of no communication on the LIN bus. When the sleep timer expires, all outputs will turn off. When in sleep mode, a GET STATUS command will display "Sleep Mode". All 1's are displayed (Figure 10) because the bus is recessive in sleep mode.
6. To circumvent the sleep timer and maintain a continuous output state, connect the jumper (LOOP) next to the OUTPUT CONTROL pushbutton (see Figure 9). This will repeatedly send LIN commands. As a result the device will not go to sleep. DIP switch activity is allowed with the loop jumper connected. This allows for real time switching selection of the output drivers.

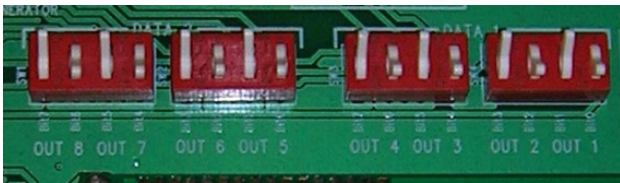**Figure 8. OUTPUT CONTROL DIP Switches (All Outputs On)**

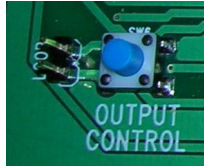**Figure 9. OUTPUT CONTROL Button**
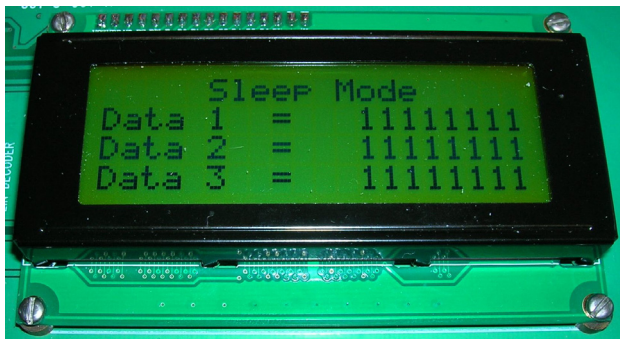

Figure 10. Sleep Mode

Output Control Command

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
DATA_1	OUT4_A		OUT3_A		OUT2_A		OUT1_A	
DATA_2	OUT8_A		OUT7_A		OUT6_A		OUT5_A	
DATA_3	OUT4_B		OUT3_B		OUT2_B		OUT1_B	

Output Encoding (DIP Switches)
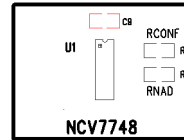
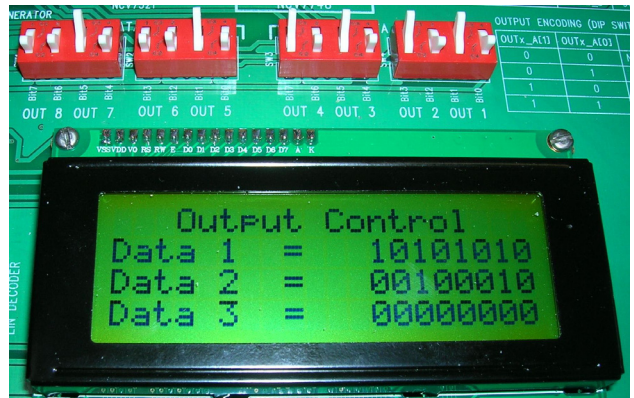| OUTx_A[1]	OUTx_A[0]	Output
0	0	No Change
0	1	OUT x Off
1	0	OUT x On
1	1	No Change

Figure 11. OUTPUT CONTROL and OUTPUT ENCODING

Figure 12. OUTPUT CONTROL Display

GET STATUS

To retrieve the outputs status including the state of the output and any information stored in the error field and APPINFO registers, simply press the GET STATUS button located directly below the OUTPUT CONTROL button. Note, if you have the LOOP jumper connected, the GET STATUS information will only be displayed while the button is depressed. Remove the LOOP jumper if a continuous display of error information is desired.

All zeros in the ERR and APPINFO register are indicative of normal operation with no issues.

Errors which can be detected on this board include:

ERR

1. No Error.
2. Reset. A reset error will be displayed with VBB por.
3. Byte Field Framing Error. An error can be seen here when there is conflict on the bus such as when two opposing signals are sent from DEMO MODE and OUTPUT CONTROL followed by a GET STATUS command.

To see this error:
   a. Put the toggle switch in demo mode.
   b. While in demo mode, press the output control pushbutton.
   c. Release the output control pushbutton.
   d. Leave demo mode using the toggle switch before OUT8 turns on.
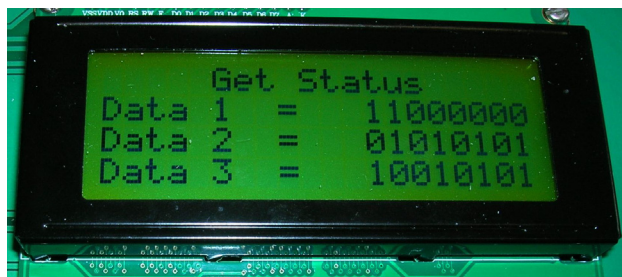   e. Press the Get Status pushbutton. Multiple attempts may be required to see this result.

Figure 13. Byte Field Framing Error

APPINFO

4. No Failure.
5. Global Thermal Shutdown*.
6. OUT4/OUT8 Overcurrent or Thermal Shutdown*.
   a. Overcurrent setups are created with the individual OCD (1–8) pushbuttons. Only OUT4 and OUT8 are reported in the APPINFO register by design.
   b. Overcurrent is also reported in the output status readout (Figure 14). This is a latched off event. A successful turn-off command must be sent before an output in an OCD condition will turn back on.

* Thermal Shutdown events are not advised on this board due to the potential damage.

OUTPUT STATUS REQUEST

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
DATA 1	ERR2	ERR1	ERR0		APPINFO			
DATA 2	OUT4 STATUS		OUT3 STATUS		OUT2 STATUS		OUT1 STATUS	
DATA 3	OUT8 STATUS		OUT7 STATUS		OUT6 STATUS		OUT5 STATUS	

ERROR FIELD

ERR2	ERR1	ERR0	Error States
0	0	0	No Error
0	0	1	Reset
1	1	0	Byte Field Framing Error

APPINFO REGISTER

APPINFO	Error States
00000b	No Failure
00100b	Global Thermal Shutdown
01000b	OUT4/OUT8 Overcurrent or TSD

OUT STATUS READOUT

STATUS	Output Command	Description
00b	OFF	OUT4/8 Open Load Fault
01b	OFF	Per Setting or Global TSD
10b	ON	Per Setting
11b	ON	Latched OFF due to overcurrent

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Figure 14. Output Status and Error Reporting Decoding

Open Load

Open load conditions are reported in the status reporting for OUT4 and OUT8. Jumpers labeled Load 1–Load 8 are included on the board. Figure 14 shows how open load faults are reported in the OUT STATUS READOUT. These are reported in the output off state.

External LIN Communication

The NCV7748GEVB uses an NCV7321 LIN transceiver for communication from the microprocessor to the LIN bus pin of the NCV7748 device. Jumpers are include for the TxD and RxD pins with and adjacent LIN connection pin providing the user with flexibility for an external LIN based master device.

Additionally an RJ11 connector provides an alternative for a connection to the LIN bus with a connection to VBB, and ground.
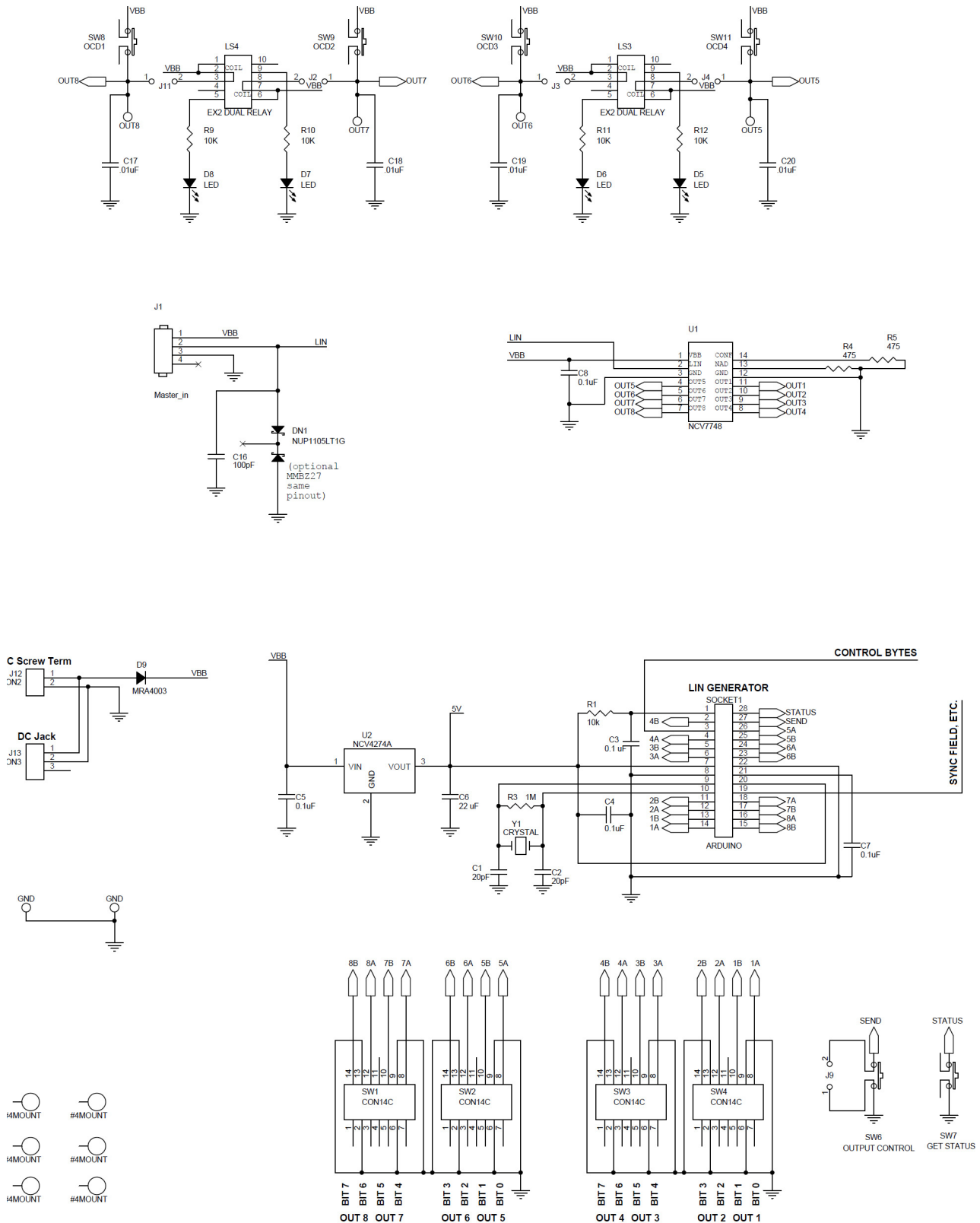
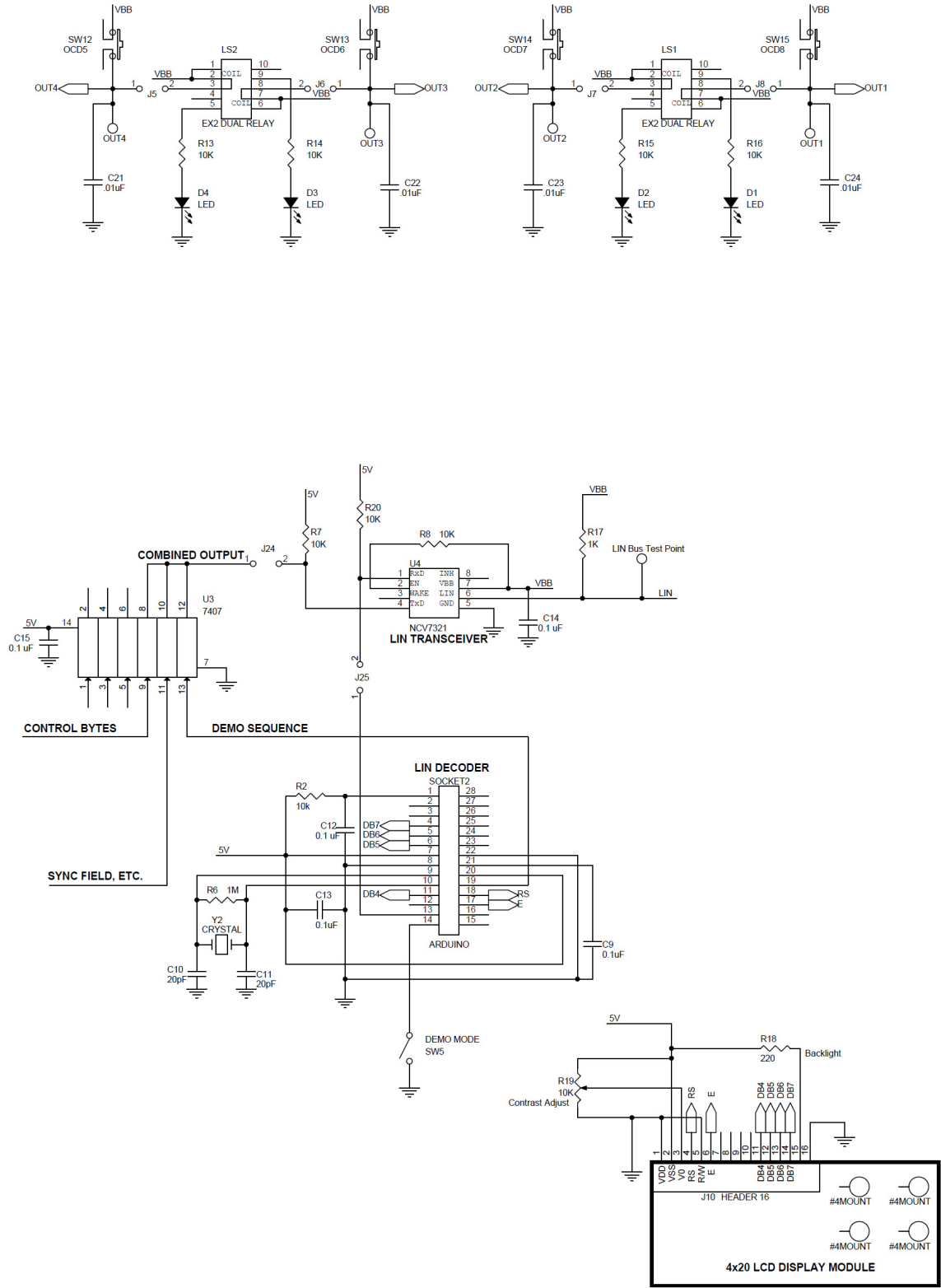## SCHEMATIC

Figure 15. Evaluation Board Schematic (1 of 2)

Figure 16. Evaluation Board Schematic (2 of 2)

PCB

OUTPUT CONTROL COMMAND

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
DATA 1	OUT4_A		OUT3_A		OUT2_A		OUT1_A	
DATA 2	OUT8_A		OUT7_A		OUT6_A		OUT5_A	
DATA 3	OUT4_B		OUT3_B		OUT2_B		OUT1_B	

OUTPUT ENCODING (DIP SWITCHES)

OUTx_A[1]	OUTx_A[0]	Output
0	0	No change
0	1	OUTx Off
1	0	OUTx On
1	1	No change

OUTPUT STATUS REQUEST

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
DATA 1	ERR2	ERR1	ERR0	APPINFO				
DATA 2	OUT4 STATUS		OUT3 STATUS		OUT2 STATUS		OUT1 STATUS	
DATA 3	OUT8 STATUS		OUT7 STATUS		OUT6 STATUS		OUT5 STATUS	

OUT STATUS READOUT

STATUS	Output Command	Description
00b	OFF	OUT4/8 Open Load Fault
01b	OFF	Per Setting or Global TSD
10b	ON	Per Setting
11b	ON	Latched OFF due to overcurrent

ERROR FIELD

ERR2	ERR1	ERR0	Error States
0	0	0	No Error
0	0	1	Reset
1	1	0	Byte Field Framing Error

APPINFO REGISTER

APPINFO	Error States
00000b	No Failure
00100b	Global Thermal Shutdown
01000b	OUT4/OUT8 Overcurrent or TSD

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Low–Side Relay Driver

P. Ingles – May, 2016

Figure 17. Printed Circuit Board

BILL OF MATERIALS

Table 5. BILL OF MATERIALS OF NCV7748GEVB

Designator	Qty.	Description	Value	Tolerance	Footprint	Manufacturer	Part Number	Substitution Allowed
C1, C2, C10, C11	4	Oscillator Load Capacitors	20 pF	5%	0805	KEMET	C0805C200J5GACTU	Yes
C3, C4, C5, C7, C8, C9, C12, C13, C14, C15	10	Bypass Capacitors	0.1 μF	10%	0805	KEMET	C0805C104K5RACTU	Yes
C6	1	5 V Regulator Output Capacitor	22 μF	20%	1206	KEMET	C1206C226M4PAC7800	Yes
C16	1	LIN Bus Capacitor	100 pF	5%	0805	KEMET	C0805C101J5GACTU	Yes
C17–C24	8	Output Capacitors	0.01 μF	10%	0805	KEMET	C0805C103K5RACTU	Yes
DN1	1	LIN Bus Protector	–	–	SOT23	ON Semiconductor	NUP1105LT1G	Yes
D1–D8	8	Relay LEDs	Red	–	PLCC2_LED	VISHAY SEMI OPTO	VLMS30K1L2–GS08	Yes
D9	1	Reverse Battery Diode	MRA4003	–	SMA_DIODE	ON Semiconductor	MRA4003T3G	Yes
J1	1	RJ11 Right Angle Socket	LIN Aux	–	FCI_87180_044LF	MOLEX	432024101	Yes
J2–J9, J11, J24, J25	11	Jumper Posts 100 mil Spacing	JUMPER	–	JMP	3M	961102–6404–AR	Yes
J2–J9, J11, J24, J25	11	Jumpers	–	–	N/A	SULLINS CONNECTOR SOLUTIONS	QPC02SXGN–RC	Yes
J10	1	16 Pin Header for LCD Module	–	–	SIP–16P	SULLINS CONNECTOR SOLUTIONS	PRPC016SAAN–RC	Yes
J12	1	2 Position Screw Terminal Block	VBB	–	MKDSN2	PHOENIX CONTACT	1729128	Yes
J13	1	DC Jack	VBB	–	PWRJACK	CUI, INC	PJ–102A	Yes
LS1, LS2, LS3, LS4	4	Dual Automotive Relay	25 A	–	EX2_RELAY	KEMET NEC–TOKIN	EX2–2U1S	No
R9–R16	8	LED Resistors	10 kΩ	1%	0805	VISHAY DALE	CRCW080510K0FKEA	Yes
R1, R2, R7, R20	5	Pull-up Resistors	10 kΩ	1%	0805	VISHAY DALE	CRCW080510K0FKEA	Yes
R3, R6	2	Oscillator Bias Resistors	1 MΩ	1%	0805	VISHAY DALE	CRCW08051M00FKEA	Yes
R4, R5	2	NAD and CONF Program Resistors	475 Ω	1%	0805	VISHAY DALE	CRCW0805475RFKEA	Yes
R17	1	LIN Pull-up Resistor	1 kΩ	1%	0805	VISHAY DALE	CRCW08051K00FKEA	Yes
R18	1	LCD Backlight Resistor	220 Ω	1%	0805	VISHAY DALE	CRCW0805220RFKEA	Yes
R19	1	Thumbwheel Potentiometer	10 kΩ	20%	3352E_POT	BOURNS INC	3352E–1–103LF	Yes
SOCKET1,2	2	28 Pin DIP Sockets for Arduinos	–	–	DIP28	ON SHORE TECHNOLOGY INC	ED281DT	Yes
SW1–SW4	4	Output Command DIP Switches	–	–	DIP14	GRAYHILL	76STC04T	No
SW5	1	Demo Mode Switch	–	–	MINITOGGLE	MULTICOMP	2MS1T2B2M2RE	Yes
SW6	1	Output Control Pushbutton	–	–	SW_6x6_TACTILE	TE CCONNECTIVITY ALCOSWITCH	1–1825910–0	Yes
SW7	1	Get Status Pushbutton	–	–	SW_6x6_TACTILE	TE CCONNECTIVITY ALCOSWITCH	1–1825910–0	Yes
SW8–SW15	8	OCD Pushbutttons	–	–	SW_6x6_TACTILE	TE CCONNECTIVITY ALCOSWITCH	1–1825910–0	Yes
TP13–TP20	8	Off-board Load Turrets	–	–	TURRET	MIL–MAX	2501–2–00–44–00–00–07–0	Yes
TP21	1	LIN Bus Test Point	–	–	TP	KEYSTONE ELECTRONICS	5010	Yes
TP22, TP23	2	GND Test Points	–	–	TP	KEYSTONE ELECTRONICS	5010	Yes
U1	1	NCV7748 LIN Relay Driver	–	–	SOIC14_N	ON Semiconductor	NCV7748D2R2G	No
U2	1	NCV4274A 5 V Regulator	–	–	DPAK3_SMD	ON Semiconductor	NCV4274ADT50RKG	Yes
U3	1	7407 Open-collector Hex Buffer	–	–	SOIC14_N	TEXAS INSTRUMENTS	SN7407DR	Yes
U4	1	NCV7321 LIN Transceiver	–	–	SOIC8_N	ON Semiconductor	NCV7321D11R2G	No

Table 5. BILL OF MATERIALS OF NCV7748GEVB (continued)

Designator	Qty.	Description	Value	Tolerance	Footprint	Manufacturer	Part Number	Substitution Allowed
Y1, Y2	2	16 MHz Microprocessor Crystals	20 pF	30 ppm	XTAL	CTS–FREQUENCY CONTROLS	ATS16A	Yes
LIN Generator	1	Arduino-based Microprocessor	–	–	N/A	ATMEL	ATMEGA328P–PU	No
LIN Decoder	1	Arduino-based Microprocessor	–	–	N/A	ATMEL	ATMEGA328P–PU	No
LCD	1	20 x 4 LCD Module	–	–	N/A	COFUFU	LCM TM204A	Yes