

# NCV7748GEVB

## NCV7748 Evaluation Board User's Manual

### Eight Channel Low-Side Relay Drivers with LIN Communication



ON Semiconductor®

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#### 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.

## EVAL BOARD USER'S MANUAL

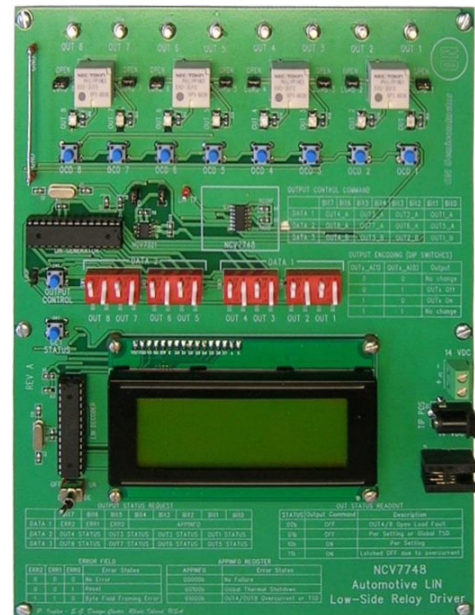


Figure 1. NCV7748 Evaluation Board

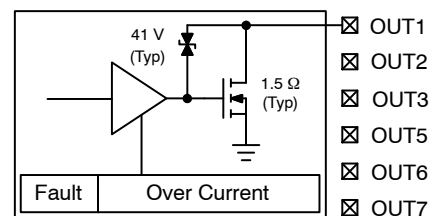


Figure 2. 1.5 Ω Output Drivers

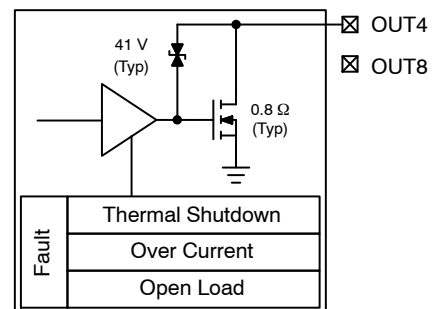


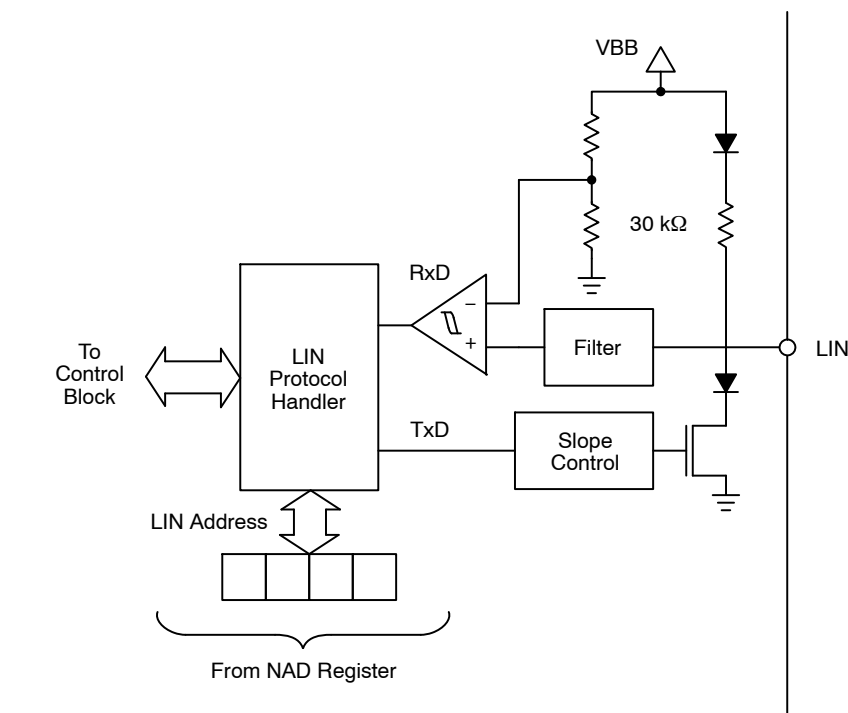
Figure 3. 0.8 Ω Output Drivers

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## 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  |

## NCV7748GEVB

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  $\Omega$  and 0.8  $\Omega$ ). 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.

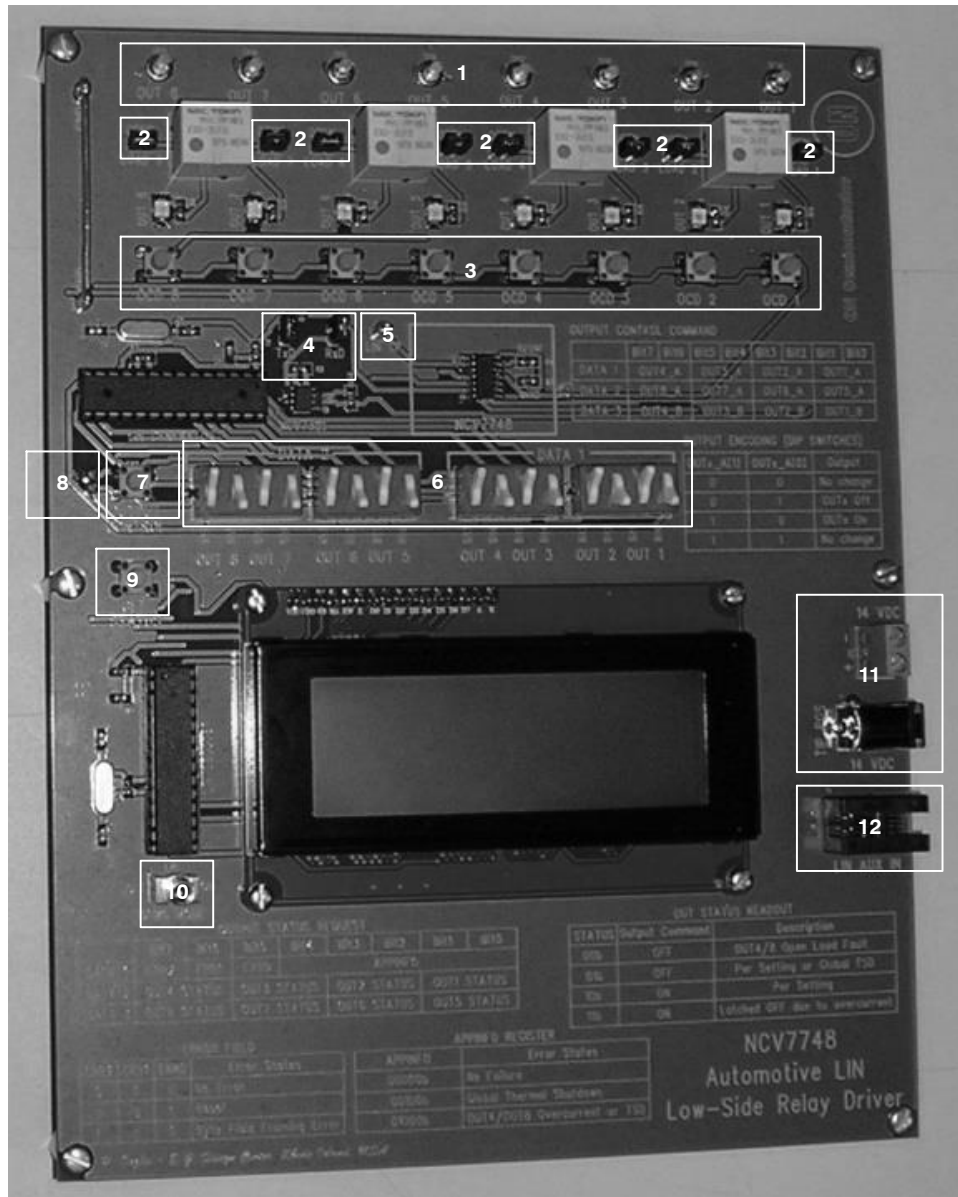
**Table 4. PIN FUNCTION DESCRIPTION**

| 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   |

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

**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

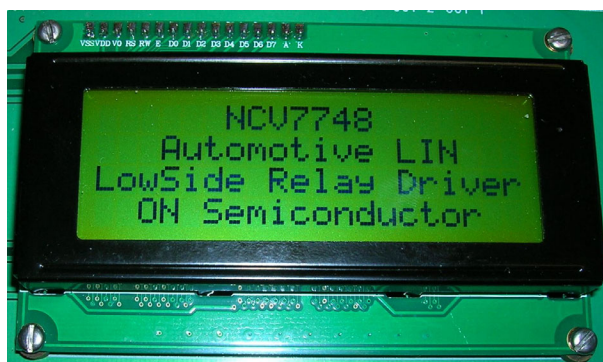
### Configure the Board

#### 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.

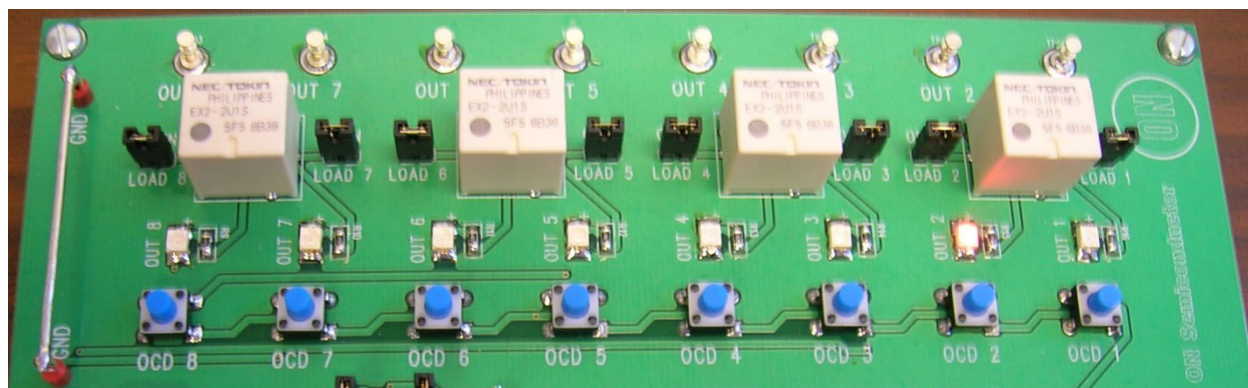
### Demo Mode

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.

6. 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.

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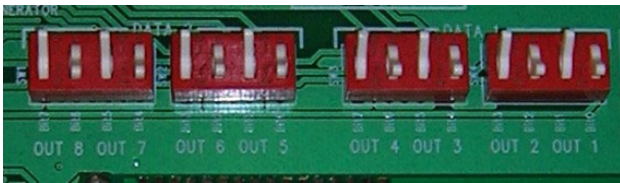


Figure 8. OUTPUT CONTROL DIP Switches (All Outputs On)

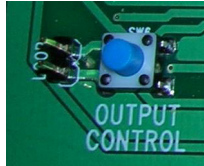


Figure 9. OUTPUT CONTROL Button

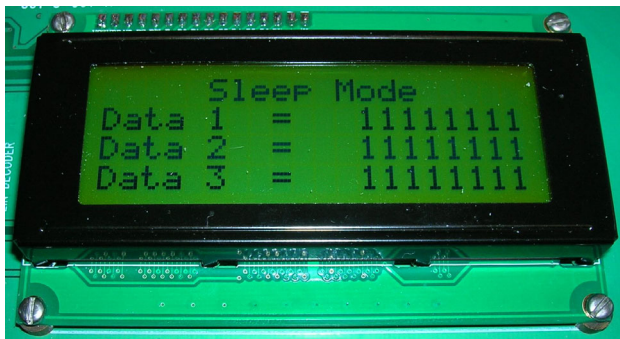
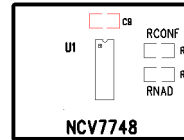


Figure 10. Sleep Mode

## 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

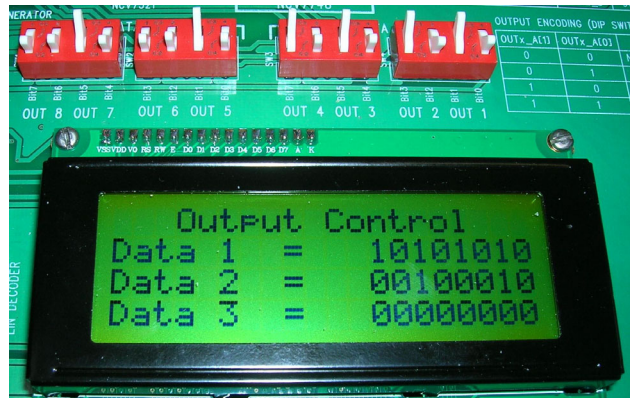


Figure 12. OUTPUT CONTROL Display

**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.

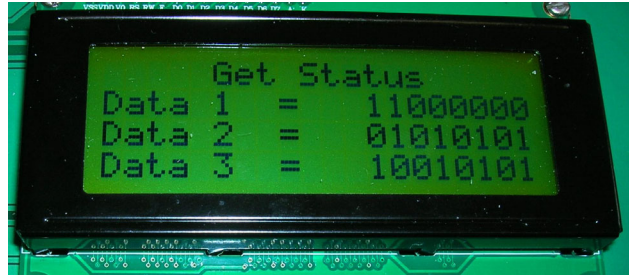
Errors which can be detected on this board include:

**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 |      |      |      |      |

| 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 |

**NCV7748**  
**Automotive LIN**  
**Low-Side Relay Driver**

*P. Ingles - E.G. Design Center, Rhode Island, USA*

**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.

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## SCHEMATIC

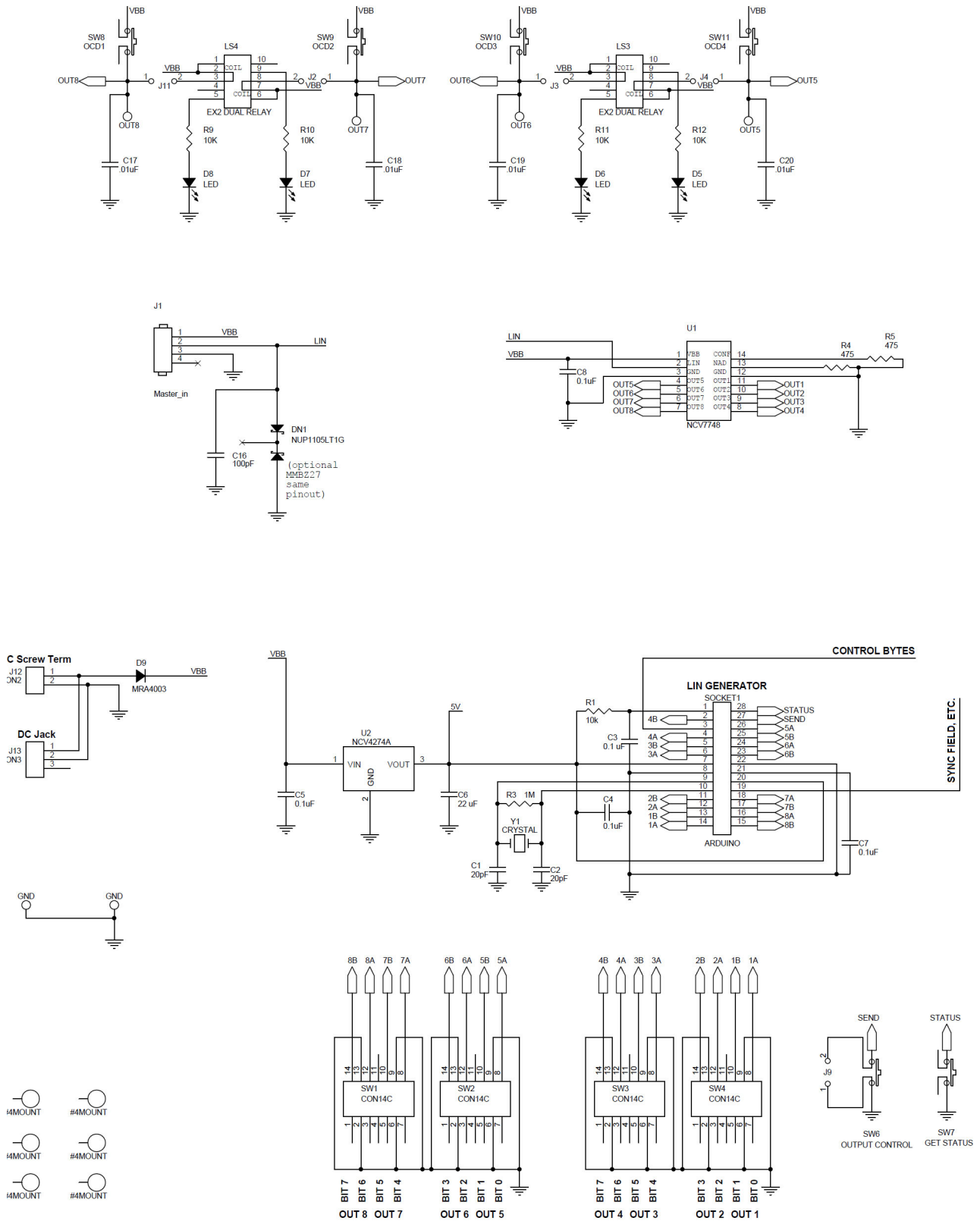


Figure 15. Evaluation Board Schematic (1 of 2)



# NCV7748GEVB

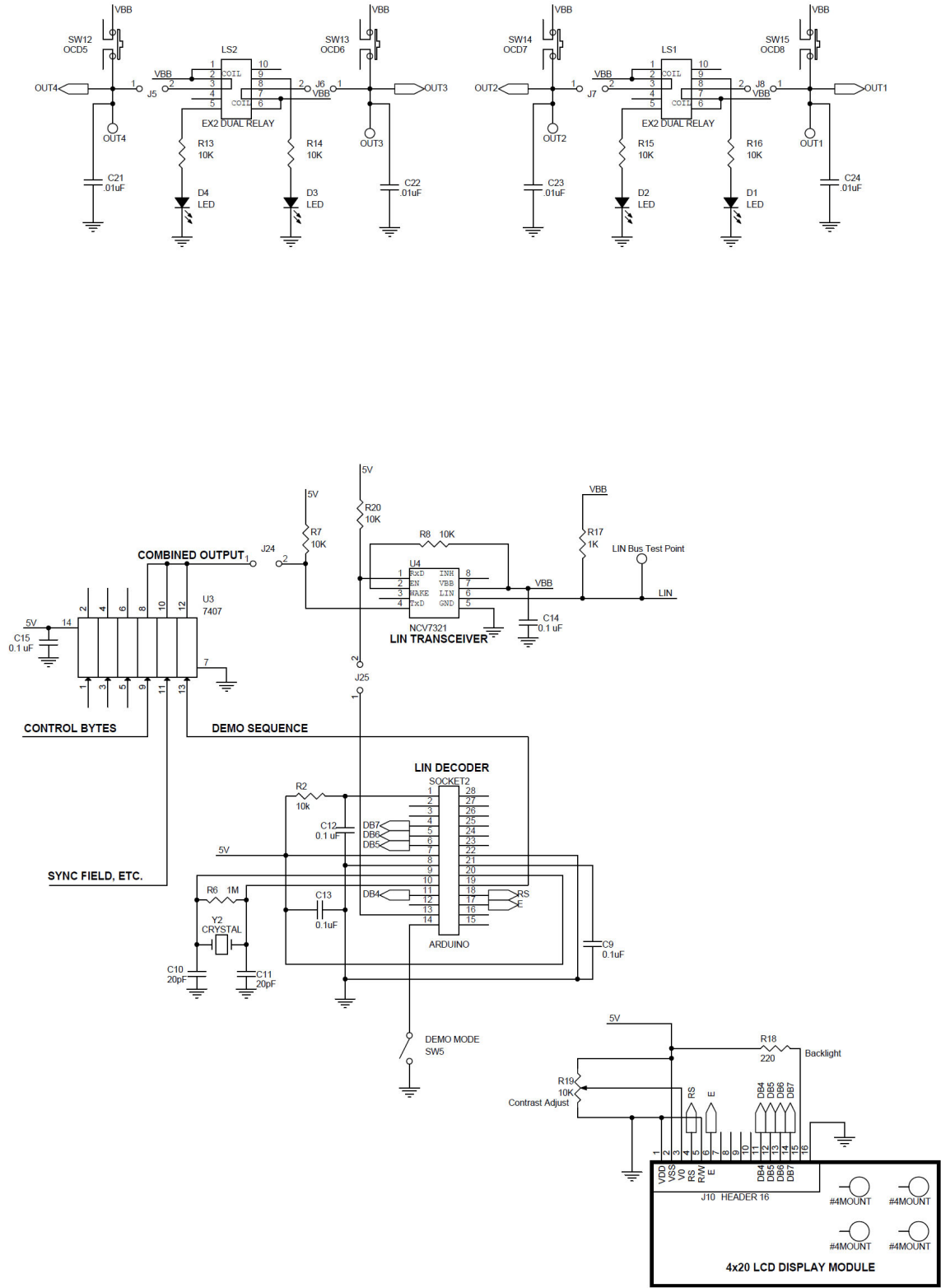


Figure 16. Evaluation Board Schematic (2 of 2)

# NCV7748GEVB

PCB

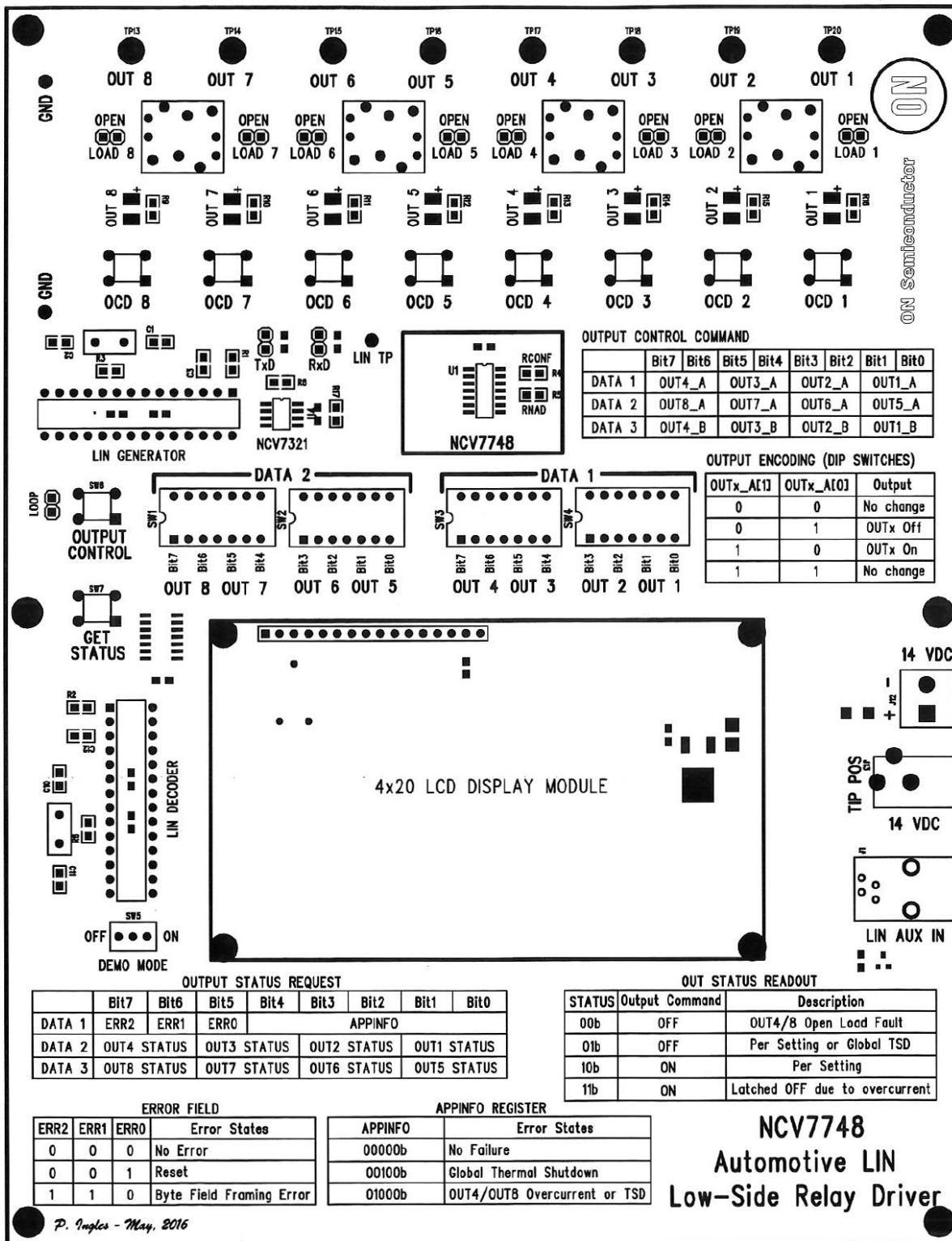


Figure 17. Printed Circuit Board

# NCV7748GEVB

## 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 $\mu$ F   | 10%       | 0805            | KEMET                       | C0805C104K5RACTU        | Yes                  |
| C6   | 1    | 5 V Regulator Output Capacitor  | 22 $\mu$ F    | 20%       | 1206            | KEMET                       | C1206C226M4PAC7800      | Yes                  |
| C16  | 1    | LIN Bus Capacitor               | 100 pF        | 5%        | 0805            | KEMET                       | C0805C101J5GACTU        | Yes                  |
| C17–C24                                    | 8    | Output Capacitors               | 0.01 $\mu$ F  | 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 k $\Omega$ | 1%        | 0805            | VISHAY DALE                 | CRCW080510K0FKEA        | Yes                  |
| R1, R2, R7, R20                            | 5    | Pull-up Resistors               | 10 k $\Omega$ | 1%        | 0805            | VISHAY DALE                 | CRCW080510K0FKEA        | Yes                  |
| R3, R6                                     | 2    | Oscillator Bias Resistors       | 1 M $\Omega$  | 1%        | 0805            | VISHAY DALE                 | CRCW08051M00FKEA        | Yes                  |
| R4, R5                                     | 2    | NAD and CONF Program Resistors  | 475 $\Omega$  | 1%        | 0805            | VISHAY DALE                 | CRCW0805475RFKEA        | Yes                  |
| R17  | 1    | LIN Pull-up Resistor            | 1 k $\Omega$  | 1%        | 0805            | VISHAY DALE                 | CRCW08051K00FKEA        | Yes                  |
| R18  | 1    | LCD Backlight Resistor          | 220 $\Omega$  | 1%        | 0805            | VISHAY DALE                 | CRCW0805220RFKEA        | Yes                  |
| R19  | 1    | Thumbwheel Potentiometer        | 10 k $\Omega$ | 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 Pushbuttons                 | –             | –         | 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                   |

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**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                  |



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