

# LTC4331 I<sup>2</sup>C Device Extender Over Rugged Differential Link

## DESCRIPTION

Demonstration circuit 2754A extends an I<sup>2</sup>C based QuikEval™ interface to up to 450 feet and features the LTC®4331. In order to realize the QuikEval interface, this demo circuit includes two complete I<sup>2</sup>C extenders and a remote side power supply formed from an LT®3461 boost converter and two LT1761 LDOs.

The LTC4331 is a SMBus compatible I<sup>2</sup>C slave device extender designed for operation in high noise industrial environments. The I<sup>2</sup>C/SMBus is extended over a single twisted pair by a ±60V fault protected differential transceiver. The LTC4331's extended 15V common mode voltage range allows it to bridge across different ground potentials.

When used as a QuikEval extender, the DC2754A requires the use of the DC2026 USB serial adapter. The DC2754A is NOT compatible with the DC590 USB serial adapter because the DC590 does not support clock stretching.

The DC2754A's jumpers and turrets allow easy re-configuration for use in other applications and/or demonstrating other application circuits. The circuit board is fabricated with a score between the local and remote sides

to allow physical separation. The link cable connections are made using either pluggable terminal blocks or an Ethernet cable.

Two complete I<sup>2</sup>C extenders are present. The first extender has a full set of diagnostic LEDs, jumpers, turrets and large (0805) resistors for simple user reconfiguration and connection for customer specific application(s). The second extender is configured specifically for the QuikEval EEPROM with no LEDs; however, it may be reconfigured and used for customer specific application(s) via 0603 jumpers and resistors and unpopulated test points on 0.1" centers.

The LTC4331 data sheet gives a complete description of the part, its operation and application information. The data sheet should be referred to when reading this demo manual. The LTC4331 is available in a 20-lead QFN package and three temperature grades (commercial 0°C to 70°C, industrial -40°C to 85°C, and high temperature -40°C to 125°C).

**Design files for this circuit board are available.**

All registered trademarks and trademarks are the property of their respective owners.

## DC2754A CONNECTION DIAGRAM

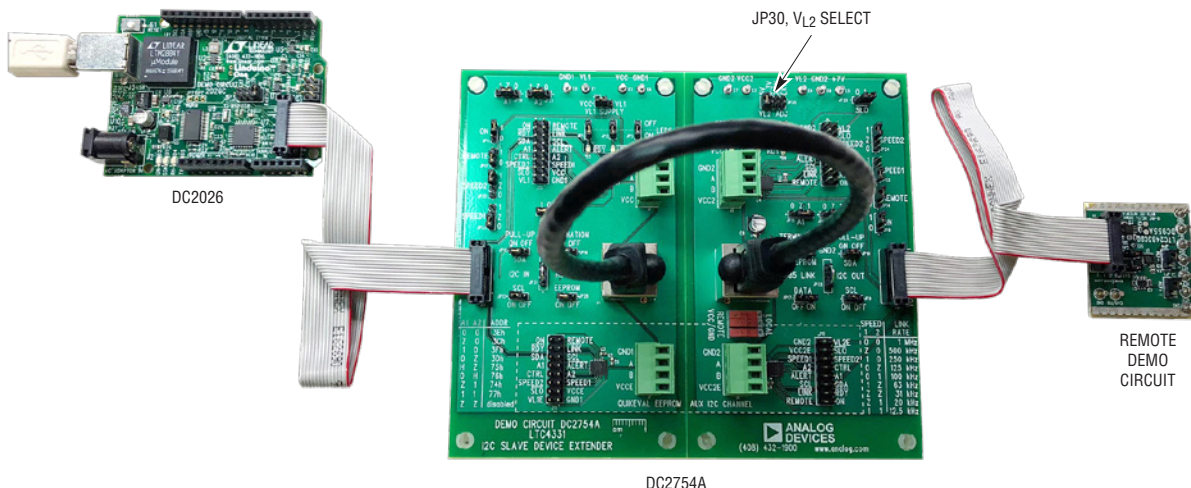


Figure 1. DC2754A Setup

# DEMO MANUAL DC2754A

## PERFORMANCE SUMMARY Specifications are at $T_A = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{IN}$	Input Supply Range		2.6		5.5	V
$I_{IN}$	Input Supply Current ( $V_{CC} + V_L$ )	$V_{CC} = V_L = V_{L2} = 5\text{V}$ , $I_{(V_{L2})} = 15\text{mA}$		70		mA

## QUICK START PROCEDURE

Demonstration circuit 2754A is easy to set up to evaluate the performance of the LTC4331 using a DC2026 USB serial controller and an I<sup>2</sup>C interfaced demo circuit. Refer to Figure 1 for proper equipment setup and follow the procedure below:

1. Connect the DC2754A's QuikEval input, J3 to a DC2026 USB serial controller using the 14-conductor ribbon cable supplied with the DC2026.
2. Connect the DC2754A's local side interface to its remote side interface using the supplied Ethernet cable to connect between J4 and J6.
3. Connect the DC2754A's QuikEval output, J5, to the remote demo circuit using the supplied 14-pin ribbon cable. The DC2754A is compatible with most demo circuits whose feature part utilizes an I<sup>2</sup>C interface.
4. Set the  $V_{L2}$  adjust jumper JP30 to the proper interface voltage for the remote demo circuit. Refer to the remote demo circuit's documentation for information on acceptable voltage levels.  $V_{L2}$  is the low voltage supply for the attached demo circuit and it also sets the logic level for the remote-side I<sup>2</sup>C signals.
5. Following the remote demo circuit's documentation, make any remaining connections required by the remote demo circuit.
6. Connect the DC2026 to a host PC with a standard USB A/B cable. While the DC2754A will work with any of the available  $V_{CCIO}$  voltages from the DC2026, 5V is recommended to maximize the available power for the remote demo circuit.
7. Run QuikEval on the host PC and the remote demo circuit's control panel will appear. Refer to the remote demo circuit's documentation for information on using the control panel.

## DC2754A JUMPERS AND SWITCHES

As shipped, the jumpers and switches on the DC2754A are set to enable operation as a QuikEval extender with power provided by the DC2026.

See the LTC4331 data sheet Pin Functions for a complete description of the LTC4331 control pin functions.

**JP1:** Local Side Ready LED Enable. Default ON.

**JP2:** Local Side Link LED Enable. Default ON.

**JP3:** Local Side  $V_{CC}$  LED Enable. Default ON.

**JP4:** Local Side ON Input. Default ON.

**JP5:** Remote Side Ready LED Enable. Default OFF.

**JP6:** Remote Side  $V_{CC2}$  LED Enable. Default OFF.

**JP7:** Remote Side Link LED Enable. Default OFF.

**JP8:** Remote Side ON Input. Default ON.

**JP9:** Remote Side SCL 5.1k Pull-Up Enable. Default ON.

**JP10:** Remote Side SDA 5.1k Pull-Up Enable. Default ON.

**JP11:** Local Side SDA 5.1k Pull-Up Enable. Default ON.

**JP12:** Local Side SCL 5.1k Pull-Up Enable. Default ON.

**JP13:** Local Side VL1 Supply Selection. Connect to either  $V_{CC}$  to use  $V_{CC}$  or VL1 to use VL1 turret. Default  $V_{CC}$ .

**JP14:** Remote Side REMOTE Input. Configures LTC4331 to be either a local or remote device. Default 1.

**JP15:** Local Side REMOTE Input. Configures LTC4331 to be either a local or remote device. Default 0.

**JP16:** Reserved.

**JP17:** Reserved.

**JP18:** Remote Side A1 Input. Configures internal I<sup>2</sup>C device address. Default Z.

**JP19:** Local Side A1 Input. Configures internal I<sup>2</sup>C device address. Default Z.

**JP20:** Remote Side A2 Input. Configures internal I<sup>2</sup>C device address. Default Z.

**JP21:** Local Side A2 Input. Configures internal I<sup>2</sup>C device address. Default Z.

**JP22:** Remote Side SPEED1 Input. Configures I<sup>2</sup>C bus timing and link baud rate. Default 0.

**JP23:** Local Side SPEED1 Input. Configures I<sup>2</sup>C bus timing and link baud rate. Default 0.

**JP24:** Remote Side SPEED2 Input. Configures I<sup>2</sup>C bus timing and link baud rate. Default 1.

**JP25:** Local Side SPEED2 Input. Configures I<sup>2</sup>C bus timing and link baud rate. Default 1.

**JP26:** Remote Side  $\overline{SLO}$  Input. Limits link transmitter slew rate which also limits maximum link baud rate. Default 1.

**JP27:** Local Side  $\overline{SLO}$  Input. Limits link transmitter slew rate which also limits maximum link baud rate. Default 1.

**JP28:** Reserved.

**JP29:** Reserved.

**JP30:** Remote  $V_{L2}$  Voltage Adjust Selector. Select  $V_{L2}$  voltage for 5V, 3.3V, 2.5V or EXT for external  $V_{L2}$  voltage. Use EXT to disable on-board switching supply. Default 5V.

**S1:**  $V_{CC2}$  Local/Remote Selection. When using an Ethernet cable to connect the local and remote sides, this switch selects the source location for  $V_{CC2}$ . Select Remote to connect  $V_{CC}$  to  $V_{CC2}$ . Select Local for no connection between  $V_{CC}$  and  $V_{CC2}$ . S1, S2 and S3 should all be in the same position. Default Remote.

**S2:**  $V_{CC2E}$  Local/Remote Selection. When using an Ethernet cable to connect the local and remote sides, this switch selects the source location for  $V_{CC2E}$ . Select Remote to connect  $V_{CCE}$  to  $V_{CC2E}$ . Select Local for no connection between  $V_{CCE}$  and  $V_{CC2E}$ . S1, S2 and S3 should all be in the same position. Default Remote.

**S3:** GROUND Local/Remote Selection. When using an Ethernet cable to connect the local and remote sides, this switch selects if the local and remote grounds are connected. Select Remote to connect the grounds and Local to disconnect the grounds. S1, S2 and S3 should all be in the same position. Default Remote.

## DC2754A FEATURES

### SEPARABLE LOCAL AND REMOTE SIDES

The DC2754A comes as a single printed circuit board with the local and remote side circuits located on either side of a score. Breaking this score will allow the circuits to be physically separated. *Note that the scored edges are sharp after separation and they should be de-burred before handling.*

### QuikEval INTERFACE

The QuikEval interface consists of two data channels plus power and ground. One data channel uses I<sup>2</sup>C to interface to the EEPROM which stores identification information for the connected demonstration circuit. The second data channel is used by the DC2026 to communicate with the demonstration circuit. Depending on the demonstration circuit, this data channel may be I<sup>2</sup>C or SPI based. A limited number of demo circuits use both SPI and I<sup>2</sup>C interfaces. The DC2754A is only compatible with demonstration circuits which use an I<sup>2</sup>C data channel, see the Demo Circuit Compatibility section for more details.

### DATA I<sup>2</sup>C CHANNEL

The DC2754A's data channel is the primary I<sup>2</sup>C extender channel. The QuikEval interface extender uses this channel once the remote demo circuit's EEPROM has been read via the auxiliary I<sup>2</sup>C channel.

When not using the DC2754A as a QuikEval interface extender, this channel may be easily configured for other applications via its jumpers and 0.1" pin headers.

### AUXILIARY I<sup>2</sup>C CHANNEL

The DC2754A includes a complete second I<sup>2</sup>C extender channel to access the remote demo circuit's EEPROM. The QuikEval interface uses this dedicated I<sup>2</sup>C channel to identify the connected demo circuit. Once the host PC has read the EEPROM's contents, this channel is not used (unless the host PC re-reads the EEPROM to confirm the demo circuit is still connected).

When not using the DC2754A as a QuikEval interface extender, this 2nd extender channel is available for other uses, such as a two-spoke star network or a multi-tier network.

### PIN HEADER CONNECTIONS

All control and I/O pins for the four LTC4331 extenders are available on 0.1" center pin headers.

The data channel's headers are populated and include jumpers to V<sub>L</sub> or GND for configuring the input pins. A small series resistor protects external circuitry from driving into a connected jumper.

The auxiliary channel's headers are unpopulated and the LTC4331 input configuration is set for the QuikEval application via 0Ω pull-up or pull-down resistors. *Note that no series protection resistors are present in the auxiliary channel.*

### LOCAL – REMOTE LINK CONNECTION

The DC2754A provides two options for connecting the local and remote sides. A standard straight through Ethernet cable connects power, ground and both the data and auxiliary channels in a single cable. Pluggable terminal blocks allow the use of different cable types as well as access to V<sub>CC</sub> and GND for incorporating modified bias or protective networks into RS-485 bus link and/or separating the power and ground connections between the local and remote sides.

Switches S1 – S3 allow the power and ground connections from the Ethernet cable to be broken at the remote side which allows the remote side to be separately powered and/or a ground potential difference. For most applications, all three switches should be in the same position.

The DC2754A includes biasing networks on the local and remote sides for the data and auxiliary channels. This network consists of 619Ω pull-up and pull-down resistors and 120Ω terminating resistors and should be acceptable for most nonisolated applications. Using the pluggable terminal blocks, additional parallel resistors may be easily added to reduce the network's effective resistor values as needed.



## DC2754A FEATURES

### DC POWER SUPPLY

The remote side of the extender interface may be powered from the local side if  $V_{CC}$  and GND are included in the connecting cable(s). In order to protect the remote side from a resonant overvoltage when hot plugging a long cable, the  $V_{CC2}$  supply includes an electrolytic capacitor to provide damping and a Zener clamp diode to limit any overvoltage. Depending on the cable's length and conductor size and the remote side load current, an external supply may be required even though  $V_{CC}$  and GND are connected.

The power supply configuration for the data channel of the DC2754A can be configured by jumper settings. This allows for the same or separate  $V_{CC}$  and  $V_L$  supplies.

The auxiliary channel's power supplies are connected via  $0\Omega$  resistors to the corresponding data channel supply (or QuikEval interface). The supplies may be separated between the two interfaces by removing R38 and R29. Overvoltage protection for the remote side's auxiliary channel's  $V_{CC}$  ( $V_{CC2E}$ ) is present only when R29 is connected.

To fully support the QuikEval interface, the DC2754A includes an LT3461 switching power converter on the remote side to power two LT1761 LDO regulators for the +7V and  $V_{L2}$  supplies. The  $V_{L2}$  supply's output is selectable by JP30 to be 5V, 3.3V or 2.5V. To disable the onboard supplies, set jumper JP30 to EXT and provide  $V_{L2}$  and +7V (if required by the remote demo circuit) at the turret(s).

When using the DC2754A as a QuikEval interface extender, the  $V_L$  supply is provided by the DC2026 which is limited to approximately 100mA. If  $V_L$  and  $V_{CC}$  are connected by JP13 and switches S1 – S3 are in the local position, then the DC2026 will power both the DC2754A and the remote demo circuit. For maximum available power to the DC2754A, the DC2026's  $V_{CCIO}$  jumper should be set to 5V. Under these conditions, there is approximately 15mA available to power the remote demo circuit. This is sufficient for many, but not all demo circuits. The available

output current may be increased by using an external 5V, 400mA supply connected to either  $V_{CC}$  or  $V_{CC2}$ . If the cable between the local and remote sides is long, then the external supply should be connected to  $V_{CC2}$ . When using an external supply, the upstream supply needs to be isolated or disabled.

### DEMO CIRCUIT COMPATIBILITY

The DC2754A is compatible with the demo circuits which only use the I<sup>2</sup>C interface to communicate with the feature part. Some demo circuits use one or more digital signal line(s) (pins 5, 6 and/or 14 of the QuikEval connector interface) in addition to the I<sup>2</sup>C interface and in many cases, the DC2754A is compatible with these demo circuits. Some demo circuits use a combination of I<sup>2</sup>C and SPI interfaces and the DC2754A is incompatible with these demo circuits.

Most demo circuits with additional signal lines only use pin 6 as a demo circuit input. A limited number of demo circuits use pin 5 as a demo circuit alert output. The DC2754A is compatible with these demo circuits because it uses the LTC4331's CTRL signal to pass-through pin 6 from the DC2026 to the remote demo circuit and the LTC4331's ALERT signal to pass-through pin 5 from the remote demo circuit to the DC2026.

The DC2754A does not pass-through pin 14 of the QuikEval interface. Therefore, the DC2754A will have limited to no compatibility with demo circuits which use this pin.

The DC2754A is incompatible with the following I<sup>2</sup>C demo circuits: DC726-B, DC812, DC935, DC936, DC1187, DC1815-A/B/C/D, DC1808-A/B, DC1840 and DC1843.

The DC2754A is not compatible with demo circuits which use a SPI interface to communicate with the feature part.

The DC2754A is not compatible with the DC590 because the DC590 does not support clock stretching. The LTC4331 uses clock stretching to accommodate the communications transit and overhead times of the extender link.



## ESD Caution

**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

## Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.