

## LTC6400 and LTC6401 Low Noise/Distortion Differential ADC Drivers


### DESCRIPTION

Demonstration circuit 987 features the LTC6400 and LTC6401 ADC Drivers. It incorporates a variety of passive components to support configurations for varied applications. Single-ended or differential input and output configurations are possible, and there is a calibration circuit to null out the effects of other circuit components.

The LTC6400/1 is a high-speed differential amplifier with superior distortion and noise performance, perfect for demanding communications transceivers, cellular base-stations, and other high-speed signal chain applications.

The LTC6400/1 accepts single-ended or differential inputs with almost no difference in distortion performance. One standout feature of the LTC6400/1 is the ability to independently adjust the output common-mode voltage without any additional components.

**Design files for this circuit board are available. Call the LTC factory.**

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### QUICK START PROCEDURE

Table 1 shows the function of each SMA connector on the board. Refer to Figure 1 and Table 1, and follow the procedure below:

1. Connect the power supply VCC. The power labels of VCC, EN, and GND on the board directly correspond to the VCC, EN, and VEE pins of the LTC6400/1, respectively. Jumper JP1 enables or shuts down the LTC6400/1.
2. For network analyzer use, calibrate out board and transformer effects using J6 and J7. There is a 1:1 impedance transfer from J6 to J7, so external termination may be necessary for a 50Ω match.
3. Apply an input signal to J1. A low-distortion, low noise signal source with an external high-order filter will yield the best performance. DC987's input is impedance-matched to 50Ω; no external termination is necessary.
4. Observe the output via J4. By default, the unfiltered outputs of the LTC6400/1 are used. The output is imped-

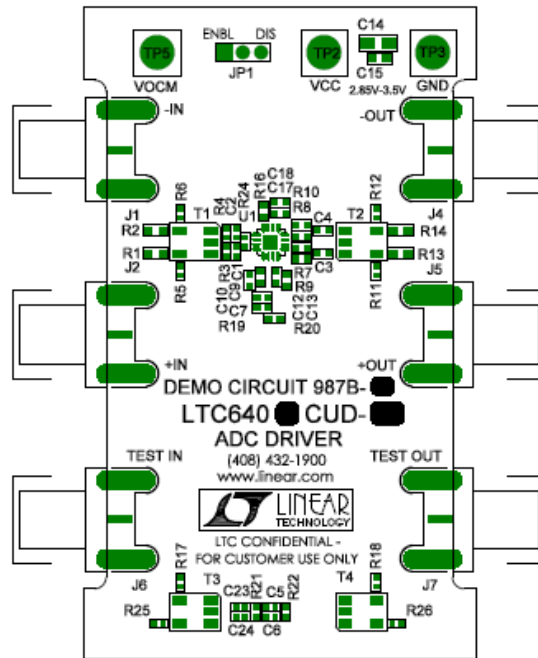
ance-matched to 50Ω, suitable for the input of a network or spectrum analyzer.

**Table 1: DC987 SMA Connector Descriptions**

CONNECTOR	FUNCTION
J1 (+IN)	Differential Input. Use this connector to supply an input to the DC987. Drive from a 50ohm signal source, no external termination necessary.
J2 (-IN)	Differential Input. <b>Not connected by default.</b> Resistor R6 can be installed and R2 removed to drive the DC987 differentially.
TP53 (VOCM)	Output Common-Mode Adjust. <b>By default, 1.25V is supplied to this pin by two resistors (VCC=3V).</b> Override this voltage with any DC voltage source.
J4 (+OUT)	Output. Impedance-matched to 50 ohms, can be used to drive a 50ohm network/spectrum analyzer input.
J5 (-OUT)	Differential Output. <b>Not connected by default.</b> Resistor R12 can be installed and R14 removed for differential output drive.
J6 (TEST IN)	Calibration network input. Use with network analyzer to calibrate out effects of board trace parasitics, transformers, and SMA connectors.
J7 (TEST OUT)	Calibration network output.

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Picture of DC987 Top Silkscreen

### ADDITIONAL INFORMATION

Although the DC987 demo board is ready to use out of the box, it has features that you can access by adding, removing or changing components on the board. These are described below.

#### DEMO BOARD VERSIONS

DC987 has eight versions to support all of the different gain options of the LTC6400/1. DC987B-A through DC987B-D contain the LTC6400-8, LTC6400-14, LTC6400-20, and LTC6400-26, respectively. DC987B-E through DC987B-H contain the LTC6401-8, LTC6401-14, LTC6401-20, and LTC6401-26. See the schematic (last page of this guide) for component differences between the versions.

#### DIFFERENTIAL INPUTS

To drive the inputs differentially, remove resistor R1 and install R5. J1 and J2 can now be driven differentially from a

50Ω signal source. The input to the DC987 will still be matched to 50Ω (differential) when driven in this manner.

#### DRIVING THE INPUTS WITH DC COUPLING

It is possible to drive the DC987 inputs differentially with DC coupling. Capacitors C1 and C2 should be shorted or replaced with 0Ω resistors. As a warning, the low input impedance of the LTC6400/1 can cause large input bias currents if DC987 is driven DC coupled. If transformer T1 is a transmission-line transformer (the transformer included on-board is a TLT), DC voltages and currents will propagate through. See the LTC6400/1 datasheet for additional information about DC coupling and input bias currents.

#### DIFFERENTIAL OUTPUTS

To use the both outputs of the DC987, remove resistor R13 and install R11. The output now appears differentially

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across J4 and J5. The output of the DC987 will still be matched to  $50\Omega$  (differentially) when used in this manner.

### CHANGING THE OUTPUT COMMON-MODE VOLTAGE

Turret TP5 controls the output common-mode voltage of DC987. This function can be used to level-shift the DC output voltage for optimum system performance. However, if used for this purpose, AC-coupling capacitors C3 and C4 can be shorted or replaced by  $0\Omega$  resistors to allow the DC bias to reach the output. Transformer T2 is a transmission-line type, which means DC voltages will couple from input to output of the transformer. By default, resistors R19 and R20 supply 1.25V voltage to the common-mode pin (with  $VCC=3.0V$ ).

### OUTPUT DRIVE

Since the output of the LTC6400/1 is a low-impedance operational amplifier output, performance will degrade when the output is directly driving low impedances such as  $50\Omega$ . See the LTC6400/1 datasheet for more information.

### ENABLE (SHUTDOWN)

Jumper JP1 controls the enable function of DC987. When set to the ENBL position, the part will be on and draw quiescent current. In the DIS position, the part will be in shutdown and draw a very small amount of quiescent current.

**NOTE.** The output common-mode bias resistors R19 and R20 draw current from VCC to GND, and must be accounted for when measuring the current of the LTC6400/1, especially in shutdown.

### GROUND AND VCC CONNECTIONS

DC987's GND connector is not only connected to VEE of the LTC6400/1, it also serves as the board ground. For best

performance, a low-impedance return path to the power supply from GND is crucial. Short, low impedance wires to the VCC and GND connectors of DC987 will yield the best performance from the LTC6400/1.

### CABLES AND CONNECTORS

Long BNC or SMA cables are transmission lines, and for best circuit performance should be kept as short as possible. BNC or SMA cables or barrels should be characterized (or nulled out through calibration) for good high-frequency performance.

Connectors also fall under the category of circuit elements, and must be of good quality and well characterized to ensure predictable results.

### SCHEMATIC NOTES

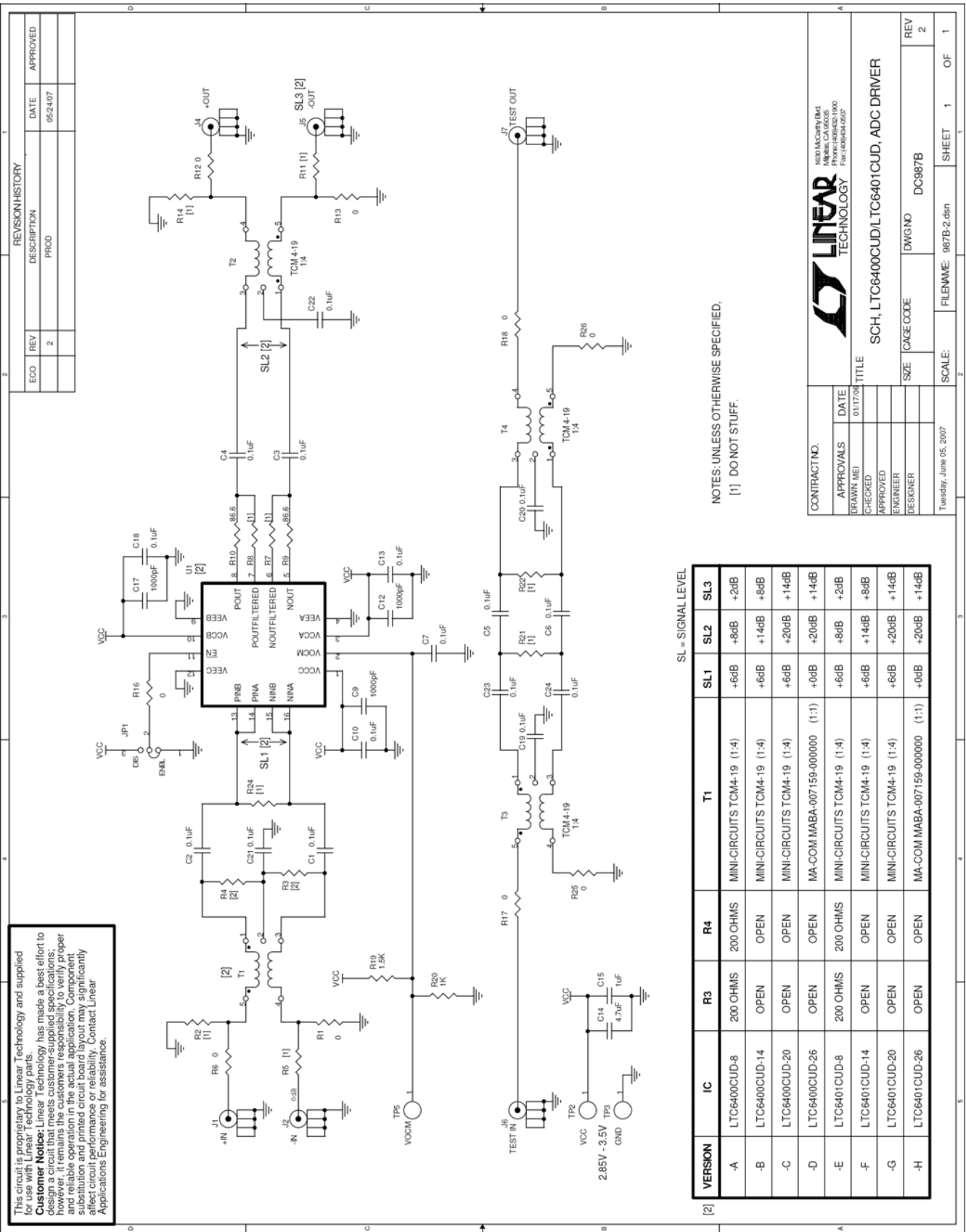
The schematic included with this Quick Start Guide includes approximate signal levels seen at various points along DC987's signal chain. The signal levels shown (SL1-SL3) assume that the signal level at the input(s) is 0dB, and that there is a  $50\Omega$  load at the output(s), from an oscilloscope, spectrum/network analyzer, et cetera. If the output load is a high-impedance load, the signal levels at SL2-SL4 will vary from the schematic.

Note that transformer T2 and the series resistors at the LTC6400/1 outputs create a 13dB attenuation that will affect the measured gain of the demo board. This is done so that the output of DC987 can plug directly into a  $50\Omega$  analyzer input, but the amplifier sees a more benign  $400\Omega$  load resistance.

The calibration circuit, as shown in the schematic, contains two extra resistors R21-R22. These resistors are included for added circuit flexibility, and are not typically populated.

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This circuit is proprietary to Linear Technology and supplied under a non-disclosure agreement. Linear Technology has made a best effort to design a circuit that meets customer-supplied specifications; however, it remains the customer's responsibility to verify proper and reliable operation in the actual application. Component substitution and printed circuit board layout may significantly affect circuit performance or reliability. Contact Linear Applications Engineering for assistance.

NOTES, UNLESS OTHERWISE SPECIFIED,  
[1] DO NOT STUFF.

SL = SIGNAL LEVEL

VERSION	IC	R3	R4	T1	SL1	SL2	SL3
-A	LTC6400CUD-8	200 OHMS	200 OHMS	MINI-CIRCUITS TCM4-19 (1:4)	+6dB	+8dB	+2dB
-B	LTC6400CUD-14	OPEN	OPEN	MINI-CIRCUITS TCM4-19 (1:4)	+6dB	+14dB	+8dB
-C	LTC6400CUD-20	OPEN	OPEN	MINI-CIRCUITS TCM4-19 (1:4)	+6dB	+20dB	+14dB
-D	LTC6400CUD-26	OPEN	OPEN	MA-COM MABA-007159-000000 (1:1)	+0dB	+20dB	+14dB
-E	LTC6401CUD-8	200 OHMS	200 OHMS	MINI-CIRCUITS TCM4-19 (1:4)	+6dB	+8dB	+2dB
-F	LTC6401CUD-14	OPEN	OPEN	MINI-CIRCUITS TCM4-19 (1:4)	+6dB	+14dB	+8dB
-G	LTC6401CUD-20	OPEN	OPEN	MINI-CIRCUITS TCM4-19 (1:4)	+6dB	+20dB	+14dB
-H	LTC6401CUD-26	OPEN	OPEN	MA-COM MABA-007159-000000 (1:1)	+0dB	+20dB	+14dB

**REVISION HISTORY**

ECO	REV	DESCRIPTION	DATE	APPROVED
	2	PROD	05/24/07	

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**LINEAR TECHNOLOGY**

SCH, LTC6400CUD/LTC6401CUD, ADC DRIVER

**APPROVALS**

DATE	TITLE
01/17/06	

DESIGNED BY: [ ]  
CHECKED BY: [ ]  
APPROVED BY: [ ]  
ENGINEER: [ ]  
DESIGNER: [ ]

SIZE: [ ]  
CAGE CODE: [ ]  
DWG NO: DC987B

SCALE: [ ]  
FILENAME: 987B-2.dsn

SHEET 1 OF 1