



National Semiconductor

LVDS – LVDS Buffer Evaluation Board

LVDS001EVK Revision 1.0

April 2001

The LVDS – LVDS Buffer Evaluation Board

The LVDS – LVDS Buffer Evaluation Board is used to demonstrate the use and performance of the DS90LV001 device. Input LVDS or LVPECL signals or complementary signals from a signal generator can be probed differentially and output LVDS channels can be probed single-ended or differentially.

The DS90LV001 can be used as a “stub-hider.” In many systems, signals are distributed across backplanes, and one of the limiting factors for system speed is the “stub length” or the distance between the transmission line and the unterminated receivers on the individual cards. Although it is generally recognized that this distance should be as short as possible to maximize system performance, real-world packaging concerns and PCB designs often make it difficult to make the stubs as short as the engineer would like. The DS90LV001, available in the LLP (Leadless Leadframe Package) package, can improve system performance by allowing the receiver to be placed very close to the main transmission line either on the backplane itself or very close to the connector on the card. Longer traces to the LVDS receiver may be placed after the DS90LV001. This very small LLP package is a 75% space savings over the SOIC package.

Shown below in *Figure 1* and *Figure 2* are two typical applications for the DS90LV001, the cable repeater application and the backplane stub-hider application.

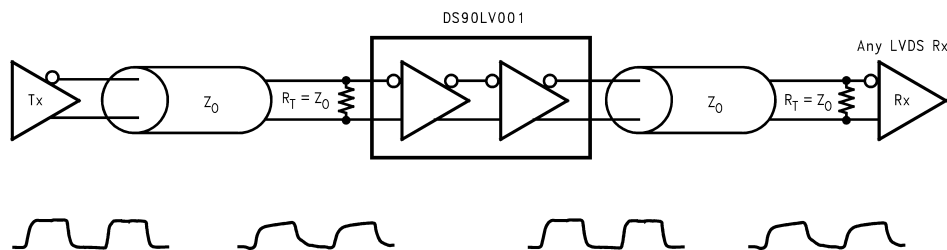


Figure 1: Cable Repeater Application

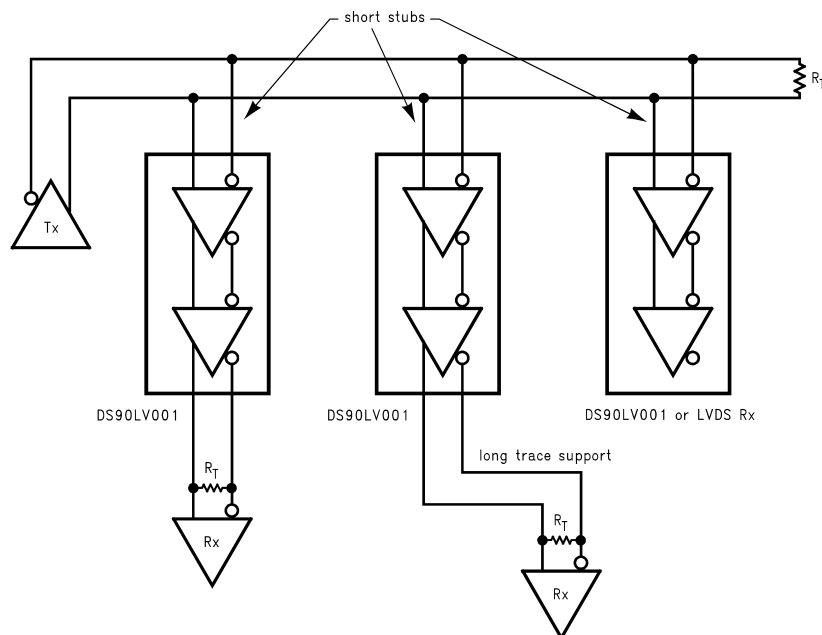


Figure 2: Backplane Stub-Hider Application

Purpose

The purpose of the Low Voltage Differential Signaling (LVDS) Evaluation Printed Circuit Board (PCB) is to allow the user to evaluate the performance of the device. The part number for the Evaluation Kit is LVDS001EVK.

Board Description

The simplified block diagram of this board is shown in *Figure 3* below.

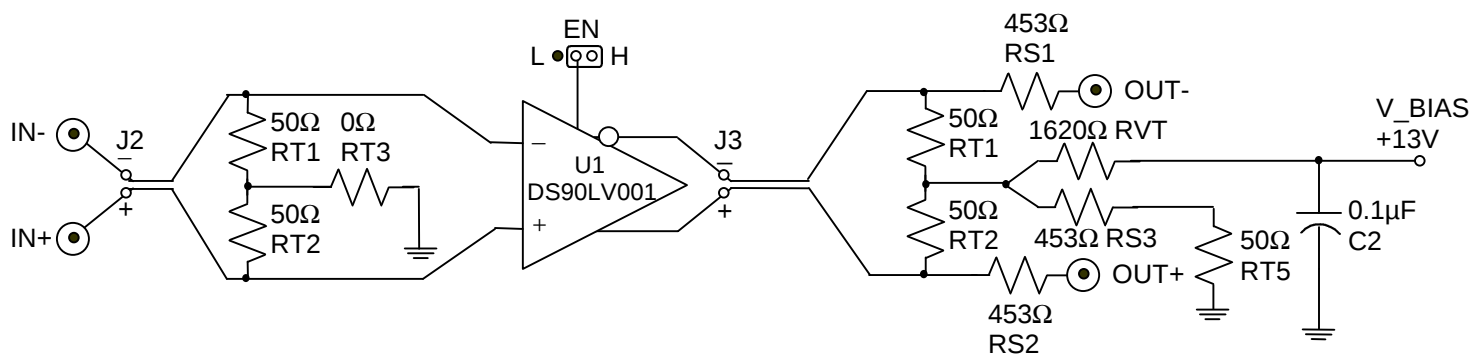


Figure 3: PCB Block Diagram

Termination options on the buffer inputs (IN- and IN+) accommodate either two separate 50 Ohm terminations (RT1 and RT2) (each line to ground when RT3 of 0 Ohms is in place) on the bottom of the board or a 100 Ohm resistor connected across the inputs (differential) when RT3 is removed. The first option allows for a standard signal generator interface. The second option allows for the DS90LV001 to be driven by an LVDS driver. Input signals are connected at test points IN- and IN+. A direct probe connection is possible with a TEK P6247 differential probe high impedance probe (>1GHz bandwidth) on the LVDS signals at test point J2.

The termination load of a standard 100 Ohm differential termination along with series 453 Ohm resistors (RS1 and RS2) are implemented since 50 Ohm probes are employed on the buffer output signal through the SMA connectors OUT- and OUT+. The LVDS driver cannot drive the 50 Ohm load to ground, so a V_BIAS voltage of +13V is used with additional resistor network circuitry to minimize this additional load. Note that the scope waveform is an attenuated signal ($50\text{ Ohm}/(450\text{ Ohm}) = 50\text{ Ohm}$) or $1/10^{\text{th}}$ of the output signal.

A direct differential probe connection is possible with a TEK P6247 differential high impedance probe (>1GHz bandwidth) on the output LVDS signals at test point J3. The series 453 Ohm resistors (RS1 and RS2) must be removed to allow a clean test point.

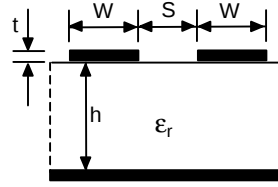
PCB Design

Due to the high speed switching rates obtainable by LVDS a minimum of a four layer PCB construction and FR-4 material is recommended. This allows for 2 signal layers and full power and ground planes. The stack is: signal (LVDS), ground, power, signal. The DS90LV001 demo board is a six layer board of FR-4 material with the following stack: signal (LVDS), ground, power, ground, ground, signal. This stack sandwiches the power plane with two ground planes creating good decoupling capacitance.

Although differential traces are highly recommended for LVDS signals, due to the short distance on this demo board, 50 Ohm single-ended microstrip lines are used. Equations for calculating impedance are contained in National application note AN-905 for both microstrip and stripline PCB traces.

For the microstrip line, the microstrip impedance, Z_0 , is:

$$Z_0 \cong \frac{6}{\sqrt{0.475\epsilon_r + 0.67}} \ln \left[\frac{4h}{0.67 (0.8w + t)} \right] \text{ Ohm}$$



For the new evaluation board $h = 9$ mils, $w = 15$ mils and $t = 2.1$ mils. Calculating the impedance, Z_0 , is:

$$Z_0 \cong \frac{6}{\sqrt{0.475\epsilon_r + 0.67}} \ln \left[\frac{4h}{0.67 (0.8w + t)} \right] \text{ Ohm}$$

$$\cong \frac{6}{\sqrt{0.475\epsilon_r (4.3) + 0.67}} \ln \left[\frac{4(9)}{0.67 (0.8(15) + 2.1)} \right] \text{ Ohm}$$

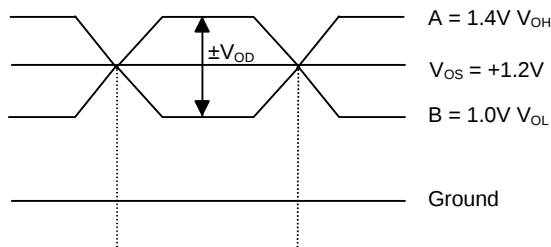
$$\cong 48.7 \text{ Ohms}$$

Bypassing capacitors are recommended for each package. A $0.1 \mu\text{F}$ is sufficient on the buffer device (CB1) however, additional smaller value capacitors may be added (i.e. $0.001 \mu\text{F}$ at CB21) if desired. Traces connecting V_{CC} and ground should be wide (low impedance, not 50 Ohm dimensions) and employ multiple vias to reduce inductance. Bulk bypassing is provided (C1, close by) at the main power connection as well. Additional power supply high frequency bypassing can be added at CB2, CB12, and CB22 if desired.

Sample Waveforms from the LVDS Evaluation PCB

Single-ended signals are measured from each signal (true and inverting signals) with respect to ground. The buffer ideally switches at the crossing point of the two signals. LVDS signals have a V_{OD} specification of 250mV to 450mV with a typical V_{OS} of 1.2V. Our device has a typical V_{OD} of 325mV, but for the example below, we will use a signal between 1.0 V (V_{OL}) and 1.4 V (V_{OH}) for a 400 mV V_{OD} . The differential waveform is constructed by subtracting the OUT- (inverting) signal from the OUT+ (true) signal. $V_{OD} = (\text{OUT+}) - (\text{OUT-})$. The V_{OD} magnitude is either positive or negative, so the differential swing (V_{SS}) is twice the V_{OD} magnitude. Drawn single-ended waveforms and the corresponding differential waveforms are shown in *Figure 5*.

Single-Ended Waveforms



Differential Waveform

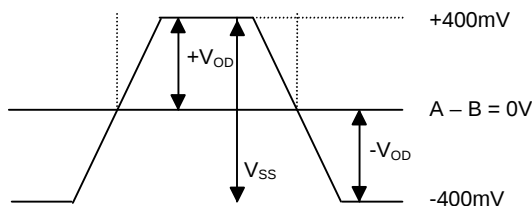
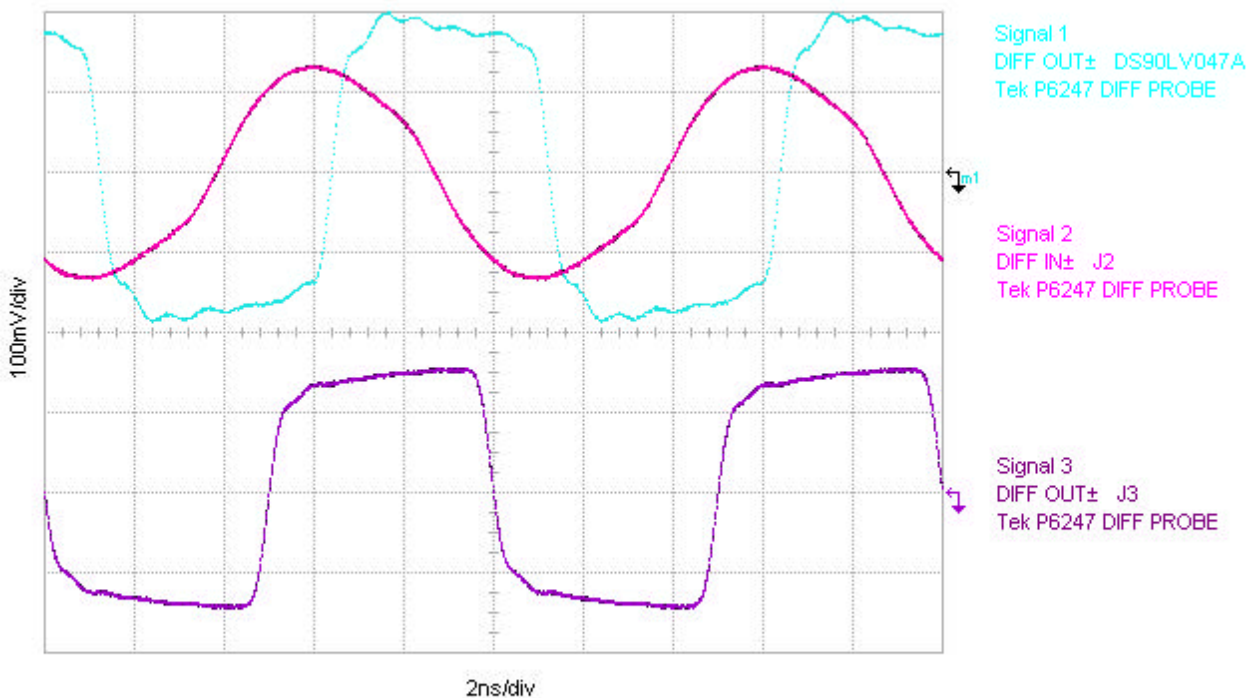


Figure 5: Single-ended and Differential Waveforms

Probing of High Speed LVDS Signals

Probe specifications for measuring LVDS signals are unique due to the low drive level of LVDS (3 mA typical). For this board design, either a 50 Ohm scope module (SD-22) or the TEK P6247 differential probe (>1 GHz bandwidth) must be used. The capacitive loading of the probe should be kept in the low pF range, and the bandwidth of the probe should be at least 1 GHz (4 GHz preferred) to accurately acquire the waveform under measurement.

National's Interface Applications group employs a wide range of probes and oscilloscopes. One system that meets the requirements of LVDS particularly well is an Agilent 86100A Wide-Bandwidth Oscilloscope (>20GHz bandwidth), Agilent 86112 20GHz module and TEK P6247 differential probe heads. The probe offers 200k Ω , 1pF loading and a bandwidth of 1GHz. This test equipment was used to acquire the waveforms shown in Figure 6.



Note: 6dB attenuators used to reduce signal amplitude by half

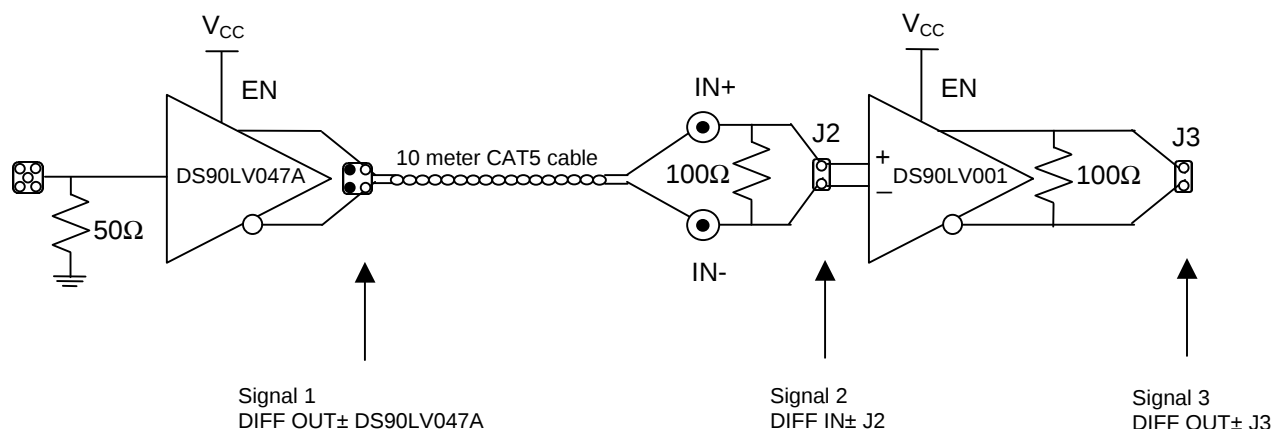


Figure 6: Input and Output LVDS Signals in Cable Repeater Application

In this figure, a DS90LV047A quad LVDS driver was used to drive the DS90LV001 buffer through a 10 meter CAT5 cable. Signal 1 is the differential signal at the output of the DS90LV047A driver. Signal 2 is the differential signal entering the DS90LV001 buffer at the end of the 10 meter cable and signal 3 is the differential output of the DS90LV001 buffer. Note the clean re-driven signal (signal 3), this is the role of a repeater.

Demo PCB Option

Option 1: Disabling the LVDS Buffer

The DS90LV001 buffer features an enable pin. On the evaluation PCB, the active high input (EN) is routed to a jumper (EN). The jumper provides a connection to the V_{CC} plane ("H") or to the Ground plane ("L"). To enable the buffer, connect the jumper to the power plane ("H"), to disable (TRI-STATE) the buffer, connect the jumper to ground ("L").

Note that RT4 is saved for a future use.

Plug & Play

The following simple steps should be taken to begin testing on your completed evaluation board:

- 1) Connect signal common (ground) to the header marked GND
- 2) Connect the power supply lead to the header marked VCC (3.3V)
- 3) Connect +13V to the circuit bias V_{BIAS} (depending on the resistor tolerances, this voltage should be adjusted to ensure that the output V_{OS} is +1.25V...monitor the voltage at the voltage node before the 1620 Ohm resistor on top of the board...this should be +1.25V)
- 4) Set EN jumper to the power plane ("H") to enable the buffer
- 5) Connect a complementary signal by a signal generator to the buffer input (IN- and IN+) with:
 - a) frequency = 100 MHz (200 Mbps)
 - b) $V_{IL} = 1.0V$ & $V_{IH} = 1.4V$
 - c) t_r & $t_f = 2ns$
 - d) duty cycle = 50% (square wave)
- 6) Connect a differential probe to test point J2 and either a differential probe to test point J3 or RG142B cables to an SD-22 module to OUT- and OUT+. Do not attempt to connect only one output as the +13V bias voltage assumes that both outputs are loaded with 50 Ohms.
- 7) View LVDS signals using the same voltage offset and volts/div settings on the scope with the TEK P6247 differential probes and/or SD-22 module and RG142B cables

Summary

This evaluation PCB provides a simple tool to evaluate how the DS90LV001 LVDS – LVDS buffer can be used to regenerate an LVDS signal and to determine signal quality for high speed data transmission applications.

Reference Material

- DS90LV001 datasheet
- LVDS Owner's Manual
- AN-905 Transmission Line RAPIDESIGNER Operation and Application Guide
- AN-1187 Leadless Leadframe Package (LLP)

Additional Information available on the Internet: <http://www.national.com/appinfo/lvds>

Appendix

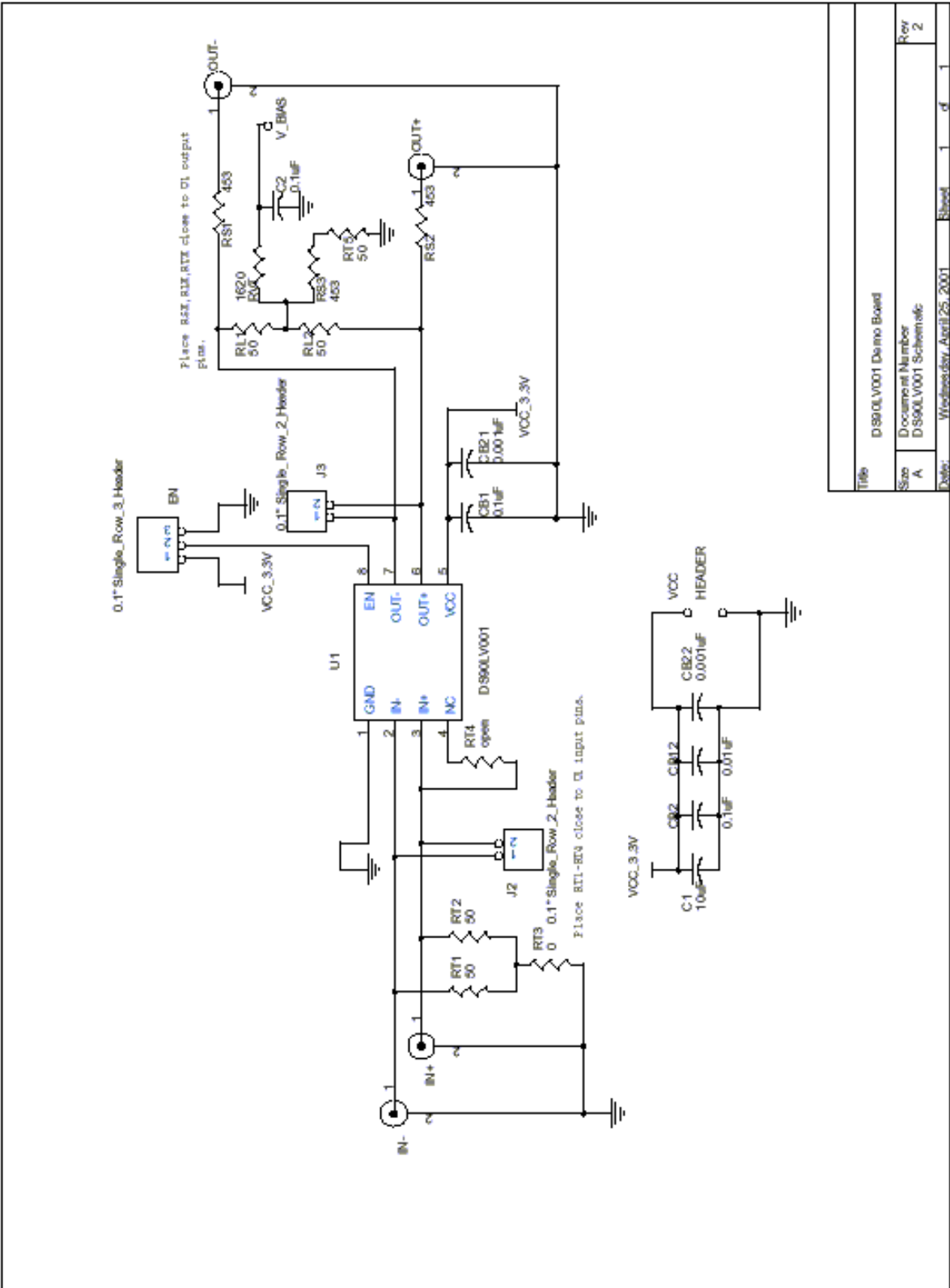
Typical test equipment used for LVDS measurements:

Signal Generator	HP 8133A Pulse Generator
Oscilloscope	Agilent 86100A Wide-Bandwidth Oscilloscope, 86112A 20GHz module
Probes	TEK P6247 differential probe, Tek 1103 TEKPROBE Power Supply
Attenuators	Pasternack 6dB attenuators

Bill of Materials

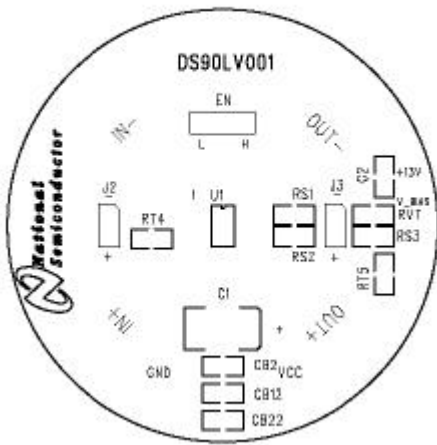
Type	Label	Value/Tolerance	Qty	Footprint	Part Number
IC	U1	(Buffer)	1	8-L SOIC	DS90LV001TM
SMA Jack	IN-, IN+, OUT-, OUT+		4	SMA Connector	Johnson P/N 142-0801-811
Resistor	RT3	0 Ω	1	RC0805	
Resistor	RT1, RT2, RT5, RL1, RL3	50 Ω	5	RC0805	
Resistor	RS1, RS2, RS3	453 Ω	3	RC0805	
Resistor	RVT	1620 Ω	1	RC0805	
Resistor	RT4	open	1	RC0805	not loaded
Capacitor	CB1, CB2, C2	0.1 μ F	3	CC0805	
Capacitor	CB12	0.01 μ F	1	CC0805	
Capacitor	CB21, CB22	0.001 μ F	2	CC0805	
Capacitor	C1	10 μ F, 35V	1	D	Solid Tantalum Chip Capacitor
Headers	EN	3 lead header	1		100 mil spacing (single row header)
Headers	J2, J3	2 lead header	2		100 mil spacing (single row header)
Jumpers		0.1" jumper post shunts	1		
Headers	V _{CC} , GND, V _{BIAS}	1 lead header	3		
PCB			1		LVDS001PCB

Schematic

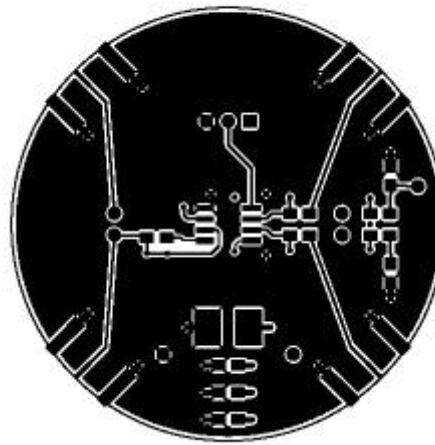


Demo Board Layers

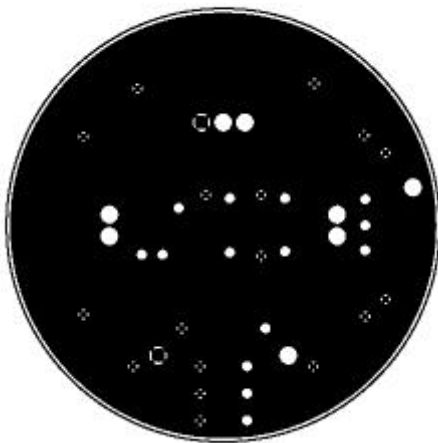
Layer: Silk Top



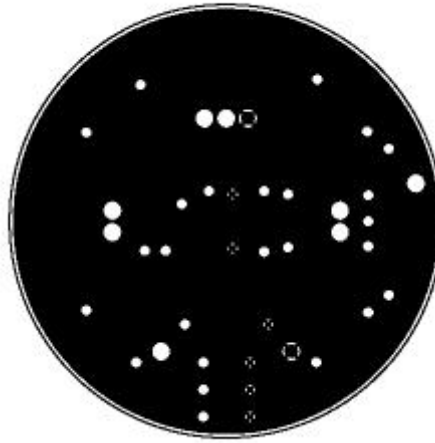
Layer 1: TOP Signal



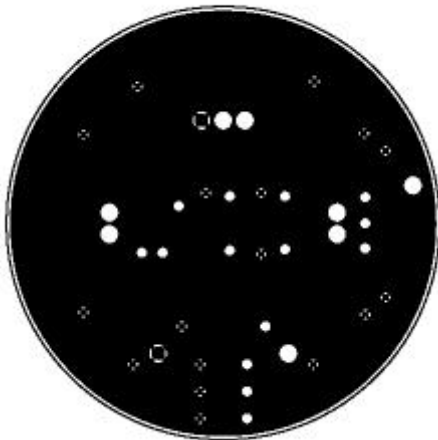
Layer 2: GND



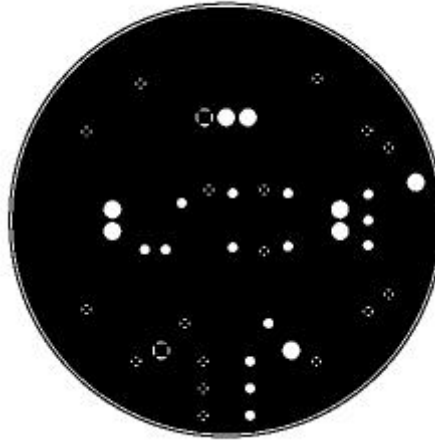
Layer 3: VCC



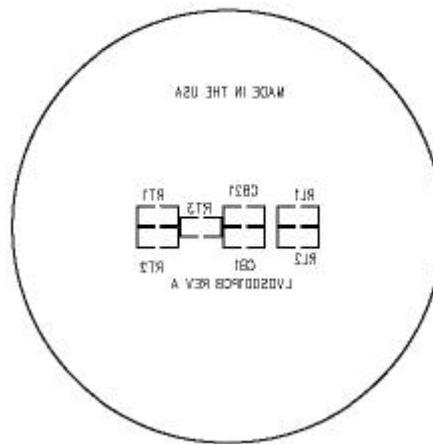
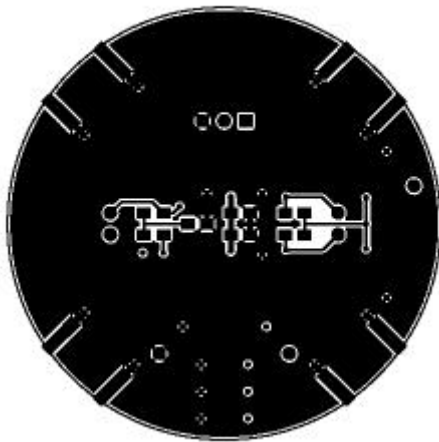
Layer 4: GND



Layer 5: GND



Layer: Silk Bottom



A circular diagram representing a field of view with a diameter of 2.00 DIA. Inside the circle, numerous small symbols are scattered, representing different types of organisms or features. The symbols include various combinations of plus signs (+), asterisks (*), and other characters, some of which are grouped together. A line points from the text "2.00 DIA." to the right edge of the circle.

50ohm traces

SIGNAL	.009	.5/.5 15mil TRACES AT 50 ohms
GND	.005	1/1
VCC	.005	
GND	.024	1/1
GND	.009	
SIGNAL		.5/.5

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2012, Texas Instruments Incorporated