

## COMPARING THE ADS1201 TO THE CS5321

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### INTRODUCTION

The ADS1201 is a high dynamic range, low-cost,  $\Delta\Sigma$  modulator. Although the performance of the ADS1201 can be assessed with the DEM-ADS1201U demonstration board, there have been numerous independent evaluations of the ADS1201 in a variety of systems. The comparisons were undertaken due to the high performance and significant cost savings of the ADS1201 over alternative solutions. By direct comparison to other solutions, the exceptional value of the ADS1201 becomes apparent.

The intent of this application bulletin is to provide a simple means of comparing the operation of the ADS1201  $\Delta\Sigma$  modulator to Crystal's CS5321  $\Delta\Sigma$  modulator. It is not the intent of this document to describe the theory or the operation behind  $\Delta\Sigma$  modulators, it is merely to provide the methodology, configuration, and results of tests that were performed using these modulators with a common digital filter. The theory of operation and device specifications can be found in the individual data sheets for these parts.

### TEST OVERVIEW

The tests were performed by an independent evaluator, Martin Company, using the CS5321 evaluation board. The CS5321 evaluation board was designed to demonstrate the performance of the CS5321  $\Delta\Sigma$  modulator with the CS5322 digital filter. The CS5321 accepts an analog input and outputs a high-rate, low-resolution bit-stream to the CS5322 digital filter. The result from the digital filter is a low-rate, high resolution (24-bit) digital representation of the analog value. Since the basic operation of the ADS1201 and CS5321 is the same, the ADS1201 modulator can be used with the CS5322 filter to obtain the same 24-bit digital representation. The following paragraph is an overview of how the CS5321 evaluation board was setup to accommodate both the ADS1201 and the CS5321.

The CS5321 was removed from the evaluation board and replaced with socketed pins. The ADS1201 was evaluated by inserting the DEM-ADS1201UADP board into the socketed pins. It should be noted that the CS5321 evaluation board was optimized to demonstrate the performance of the CS5321. The CS5321 evaluation board does not demonstrate the optimum performance of the ADS1201, therefore, the actual in-circuit performance of the ADS1201 with the digital filter may be significantly better than the test results indicate.

Some key points about the comparison are listed below:

1. HBR = 1 mode was used with a MCLK frequency of 1.024MHz, which according to the CS5321 specification, gives the best performance of the part. In this mode, the CS5321 internally divides MCLK by 4, resulting in an MDATA rate of 256kHz (to the CS5322 digital filter).

The ADS1201 does not internally divide MCLK by 4; the ADS1201 shifts data out at the MCLK rate. Therefore an external counter (divided by 4) was required to slow the MCLK to the ADS1201 and thus, the MDATA rate from the ADS1201 to the CS5322. Due to this limitation of the CS5322 digital filter, the ADS1201 MCLK rate was run at 256kHz, not the optimal rate of 320kHz.

2. The ADS1201 operates from a single +5VDC supply and has a differential voltage range of  $\pm 5V$  with respect to the  $A_{IN+}$  and  $A_{IN-}$  pins (the differential voltage range is  $\pm 10V$  when  $V_{BIAS}$  is used).

The CS5321 operates from both a +5VDC and -5VDC supply and has a single-ended voltage range of  $\pm 4.5V$  with respect to ground.

3. The CS5321 uses an LTC1019-4.5 voltage reference. The ADS1201 requires a 2.5V reference. The DEM-ADS1201UADP demo board allows two options for the ADS1201 reference. First, the REF1004-2.5 on the DEM-ADS1201UADP board can be used. Alternately, an LTC1019-2.5 can be inserted in the socket on the CS5321 demo board in place of the LTC1019-4.5. The REF1004-2.5 offers comparable performance to the LTC1019 at a lower cost.

# TEST SETUP

## CS5321 SETUP AND CONFIGURATION

In order to use the DEM-ADS1201UADP with the CS5321 evaluation board, U2 (CS5321) must be replaced with the DEM-ADS1201UADP board (see Figure 1). All components needed for the modification are included with the DEM-ADS1201UADP kit. The instructions for making the modifications are listed below.

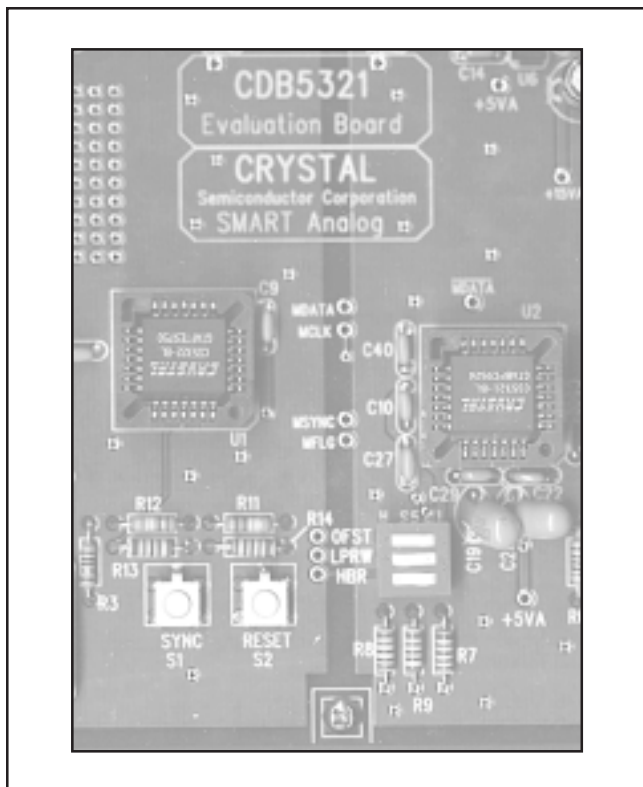


FIGURE 1. Socketed CS5321.

To insert the DEM-ADS1201UADP into the CS5321 evaluation board, the CS5321 must be first be removed from the board. It is recommended to install socketed pins in the CS5321 evaluation board to allow for ease in inserting and removing the DEM-ADS1201UADP board and the socketed CS5321. The socketed pins are provided with the DEM-ADS1201UADP, but may also be obtained from Robinson Nugent (part number SBE-100-S-TG30, and the web site is [www.robinsonnugent.com](http://www.robinsonnugent.com)). Figure 2 shows the CS5321 evaluation board after insertion of the socketed pins.

The DEM-ADS1201UADP should be inserted as shown in Figure 3. Note the orientation reference on the DEM-ADS1201UADP to the CS5322 (silkscreen arrow pointing to the CS5322).

The CS5321 uses a 4.5V reference and the ADS1201 uses a 2.5V reference. The DEM-ADS1201UADP provides two options for the voltage reference. The on-board REF1004-2.5 can be used, or optionally, the LTC1019-4.5 on the CS5321 evaluation board can be replaced with the LTC1019-2.5.

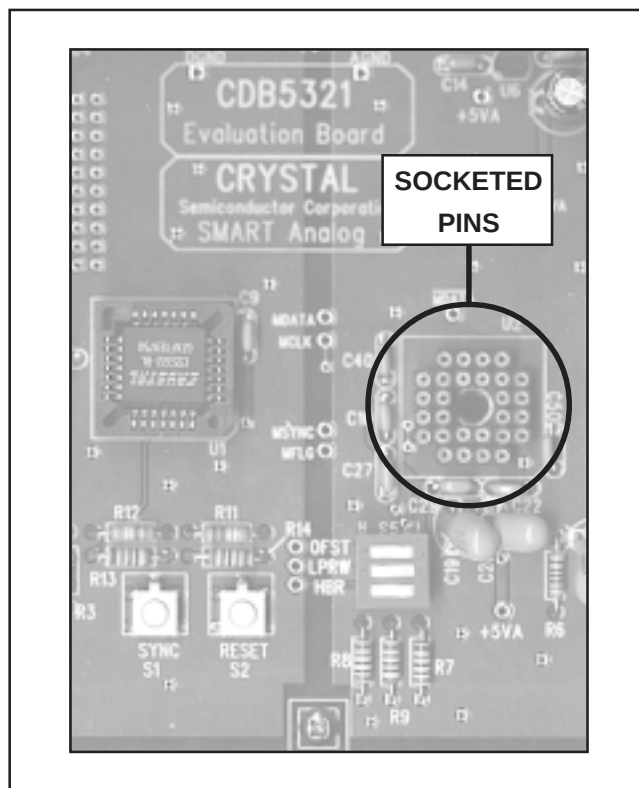


FIGURE 2. CS5321 Socketed Pins Replacement.

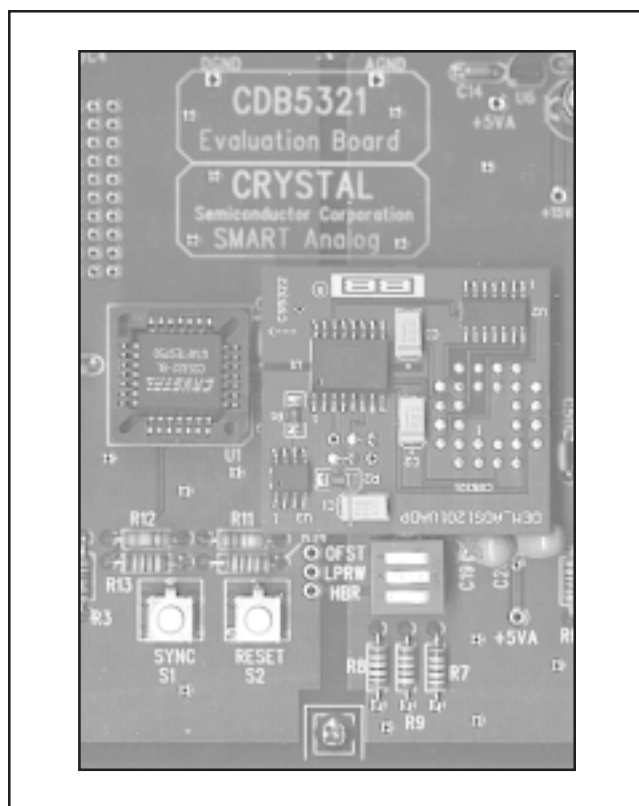


FIGURE 3. Insertion of the DEM-ADS1201UADP into the CS5321 Evaluation Board.

The switch settings on the CS5321 board should be set to their recommended default states for optimal performance with the CS5321. The default settings are listed in Table I.

| S3 SETTINGS                               | S4 SETTINGS | S5 SETTINGS |
|-------------------------------------------|-------------|-------------|
| USEOR = ON                                | DECA = OFF  | OFST = 1    |
| ORCAL = ON                                | DECB = OFF  | LPRW = 0    |
| SID = OFF                                 | DECC = ON   | HBR = 1     |
| ERR = OFF                                 | PWDN = ON   |             |
| RSEL = OFF                                | H/S = OFF   |             |
| CS = ON                                   | CSEL = ON   |             |
| R/W = OFF                                 | TDATA = ON  |             |
| JP13 CLOSED                               |             |             |
| J4 = CLK/2 (1.024MHz CLKIN to the CS5321) |             |             |

TABLE I. CDB5321 Evaluation Board Settings.

### DEM-ADS1201UADP SETUP AND CONFIGURATION

The operation of the DEM-ADS1201UADP is straightforward. The schematic is shown in Figure 4.

The interface of the DEM-ADS1201UADP to the CS5321 evaluation board is accomplished through the seven signals described in Table II. The pin numbers listed below reference the pin number on the CS5321 socket as shown in Figure 4.

| PIN # | NAME              | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2     | V <sub>DD1</sub>  | Positive Analog Supply Voltage                                                                                                                                                                                                                                                                                                                                                                                        |
| 5     | V <sub>REF+</sub> | This pin is the Reference Voltage from the LTC1019-4.5. For the CS5321, a 4.5V reference is used. For the ADS2101, a 2.5V reference is used. The LTC1019-2.5 may be used as an alternative voltage reference to the REF1004-2.5. This is accomplished by replacing U8 (LTC1019) on the CS5321 evaluation board with the appropriate voltage reference and modifying the jumper settings on the DEM-ADS1201UADP board. |
| 9     | A <sub>IN+</sub>  | Positive Analog Input                                                                                                                                                                                                                                                                                                                                                                                                 |
| 18    | MDATA             | Modulator Output Data from the ADS1201/CS5321 to the CS5322. The MDATA is shifted out of the ADS1201/CS5321 at a 256kHz rate.                                                                                                                                                                                                                                                                                         |
| 22    | V <sub>DD2</sub>  | Positive Digital Supply Voltage                                                                                                                                                                                                                                                                                                                                                                                       |
| 20    | MCLK              | Modulator Input Clock from the CS5322 to the ADS1201/CS5321. The evaluation board default setting for MCLK is 1.024MHz. The CS5321 internally divides this clock by 4 to clock the modulator. Since the ADS1201 uses MCLK to directly clock the modulator, an external divide by 4 is needed to ensure synchronization with the CS5322. Therefore, a counter (74HCT393) is used.                                      |
| 25    | MSYNC             | This is used by the CS5322 to synchronize MCLK with MDATA for the ADS1201/CS5321. This is needed as the CS5321 internally divides MCLK by 4 to clock the modulator. This signal is tied to the CLR pin of the 74HCT393 to ensure synchronization when using the ADS1201.                                                                                                                                              |

TABLE II. Pin Descriptions.

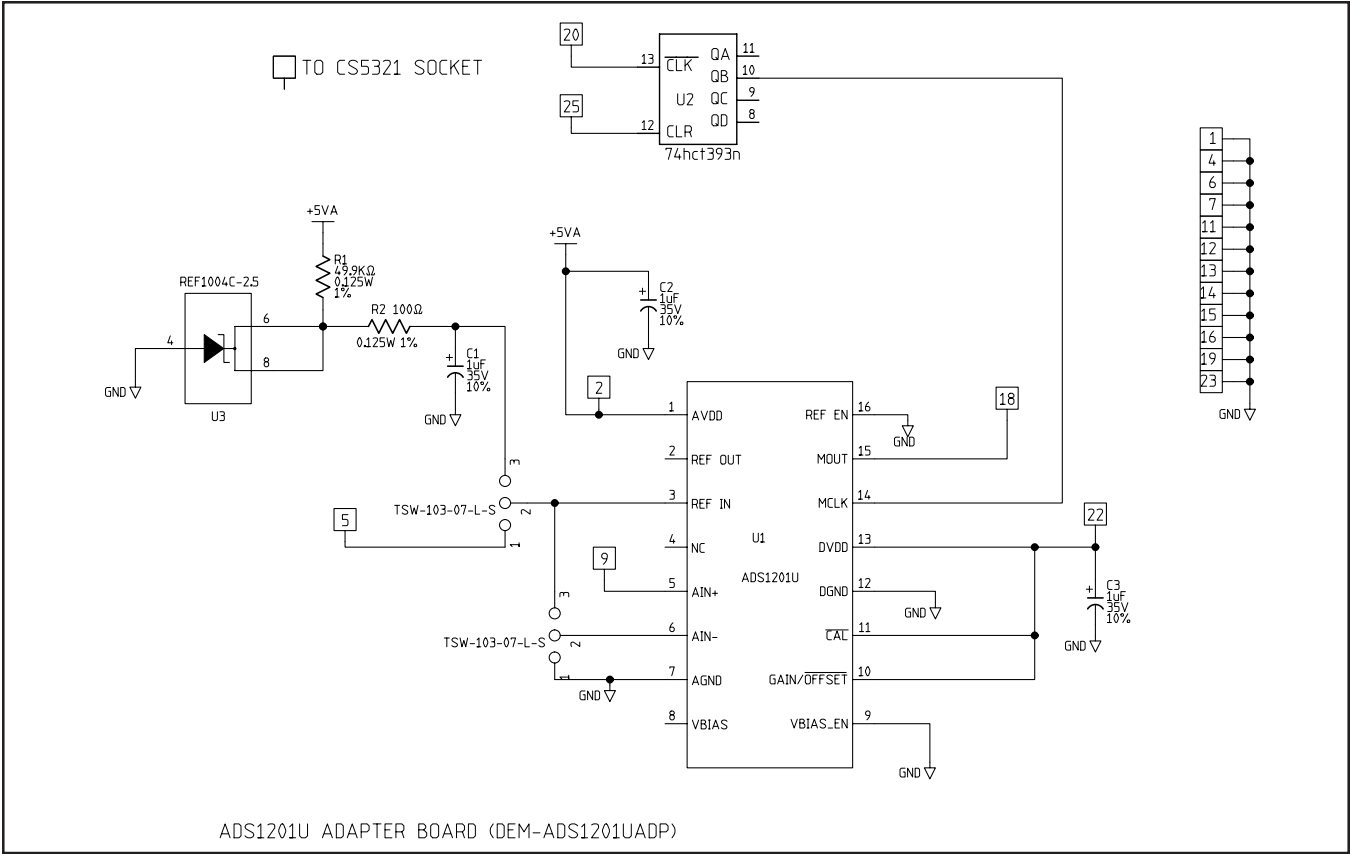


FIGURE 4. DEM-ADS1201UADP Schematic.

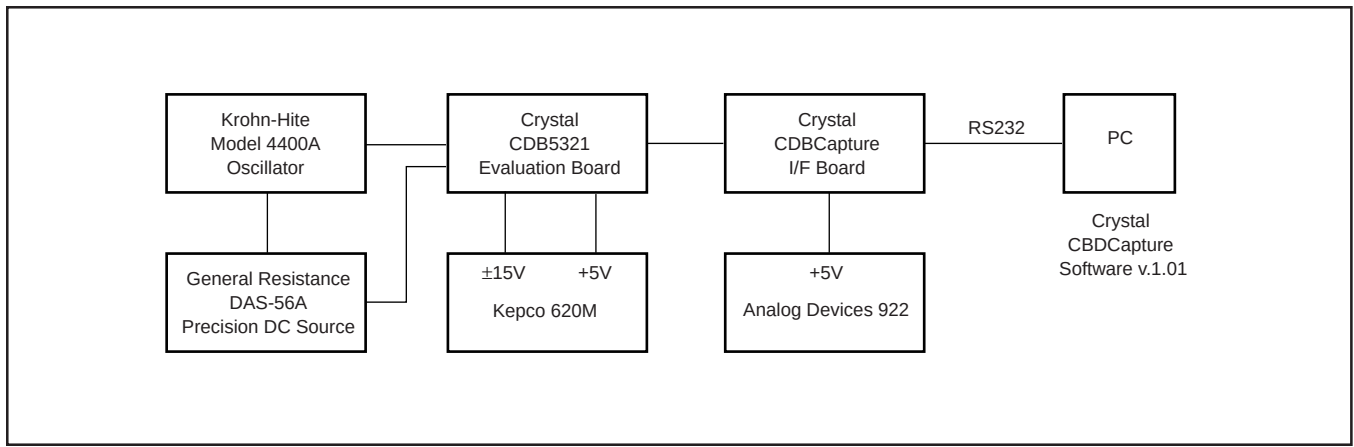


FIGURE 5. Test Equipment Setup.

The DEM-ADS1201UADP has two sets of through holes for configuring the  $V_{REF}$  and the  $A_{IN-}$  Input.

The three through holes near R2 on the DEM-ADS1201UADP control whether  $V_{REF}$  comes from the REF1004-2.5 or the LTC1019-2.5. When a wire is placed in the two through holes near U3 and R2 (the default setting), the REF1004-2.5 is the source for  $V_{REF}$  (see Figure 3). When a wire is placed in the two through holes near C2, the LTC1019-2.5 is the source for the  $V_{REF}$ . Note that when using the DEM-ADS1201UADP board with the LTC1019  $V_{REF}$  enabled, the LTC1019-4.5 (U8 on the CS5321 evaluation board) must be replaced with the LTC1019-2.5. Refer to Table III.

| WIRE SETTINGS | CONDITION                               |
|---------------|-----------------------------------------|
| Upper (by R2) | $V_{REF}$ tied to REF1004-2.5 (default) |
| Lower (by C2) | $V_{REF}$ tied to LTC1019-2.5           |
| Open          | $V_{REF}$ unconnected                   |

TABLE III.  $V_{REF}$  Wire Settings.

The three through holes near  $U_1$  (at the  $A_{IN-}$  input) control whether  $A_{IN-}$  is tied to AGND or  $V_{REF}$ . When a wire is placed in the upper two through holes near R1, the  $A_{IN-}$  pin is tied to the  $V_{REF}$  (see Figure 3). When a wire is placed in the lower two through holes near C2, the  $A_{IN-}$  pin is tied to AGND (the default setting). Refer to Table IV.

| WIRE SETTINGS | CONDITION                            |
|---------------|--------------------------------------|
| Upper (by R1) | $A_{IN-}$ tied to external $V_{REF}$ |
| Lower (by C2) | $A_{IN-}$ tied to AGND (default)     |
| Open          | $A_{IN-}$ unconnected                |

TABLE IV.  $A_{IN-}$  Wire Settings.

## TEST EQUIPMENT SETUP AND CONFIGURATION

### TEST EQUIPMENT

1. Krohn-Hite 4400A Oscillator
2. General Resistance DAS-56A DC Source
3. CDB5321 Evaluation Board
4. CDBCAPTURE Interface Board
5. Kepco 620M Power Supply
6. Analog Devices 922 Power Supply
7. ADS1201 Adaptor Board

### TEST CONFIGURATION

The test equipment was set up as shown in Figure 5. Data was taken with no signal input and a 32Hz sinewave input for both devices. The Krohn-Hite Oscillator was configured for a 5.0Vp-p 32Hz input. The General Resistance DAS-56A was configured for a 2.5V offset.

### TEST RESULTS

The test results are shown in Figures 6 through 10. Figure 6 shows the performance of the ADS1201 in the DEM-ADS1201U Demo Board with no input signal (for reference purposes). Figure 7 shows the ADS1201 in the CS5321 evaluation board with no input signal. Figure 8 shows the CS5321 in the CS5321 evaluation board with no input signal. Figure 9 shows the ADS1201 in the CS5321 evaluation board with a 32Hz signal input. Figure 10 shows the CS5321 in the CS5321 evaluation board with a 32Hz signal.

The test results summary is shown in Table V. The test results were calculated by the CS5321 evaluation board software from data taken with a 32Hz, 5Vp-p, sinewave input.

| PARAMETER  | ADS1201 | CS5321 |
|------------|---------|--------|
| S/N+D (dB) | 93.949  | 96.294 |
| S/D (dB)   | 97.896  | 99.684 |
| S/N (dB)   | 95.836  | 98.602 |

TABLE V. Data from 32Hz, 5Vp-p Sinewave Source.

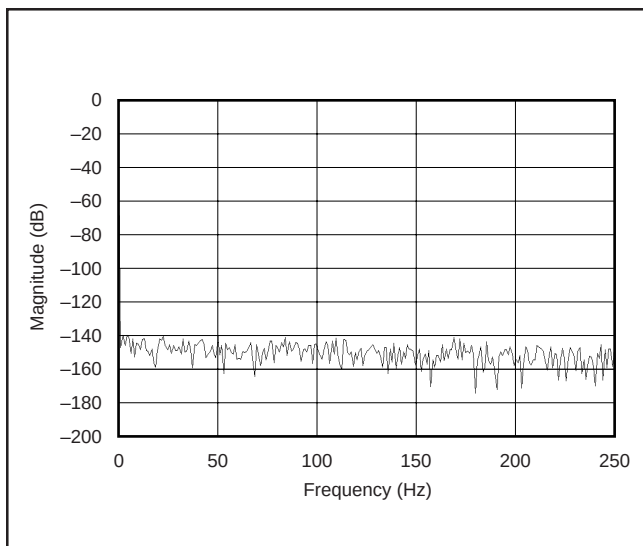


FIGURE 6. ADS1201 in the DEM-ADS1201U Demo Board with No Input Signal.

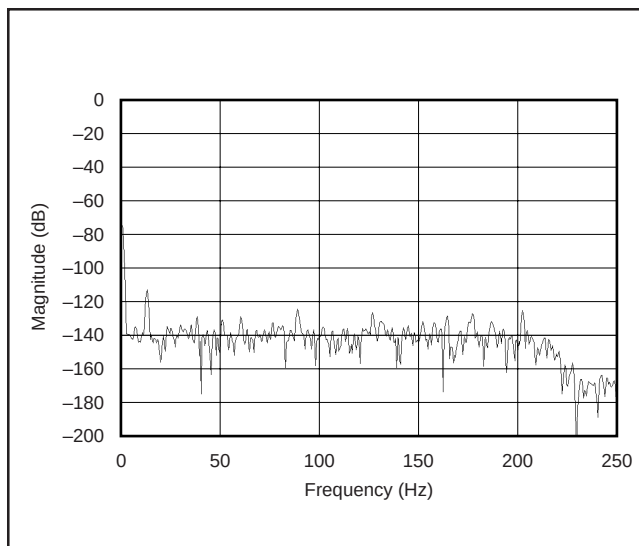


FIGURE 7. ADS1201 in the CS5321 Evaluation Board with No Input Signal.

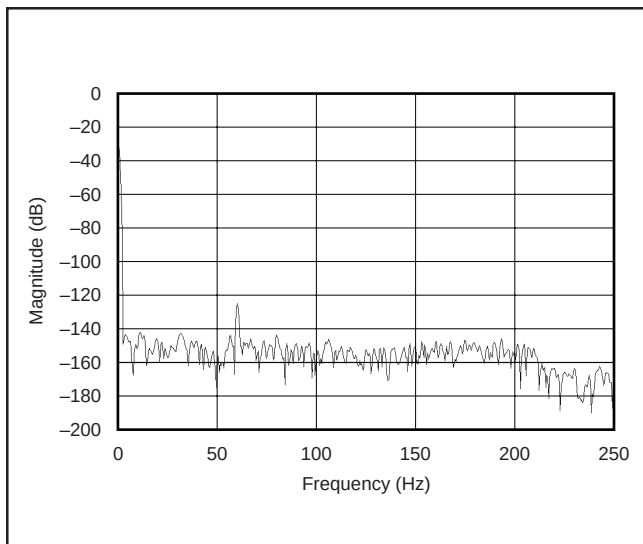


FIGURE 8. CS5321 in the CS5321 Evaluation Board with No Input Signal.

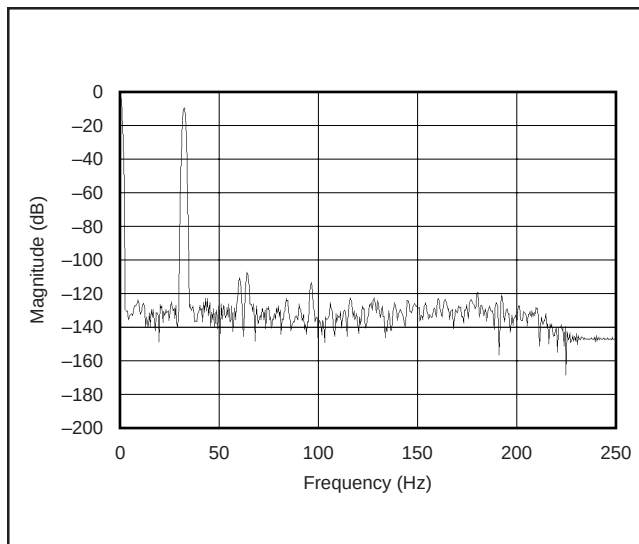


FIGURE 9. ADS1201 in the CS5321 Evaluation Board with a 32Hz, 5Vp-p Sinewave Input.

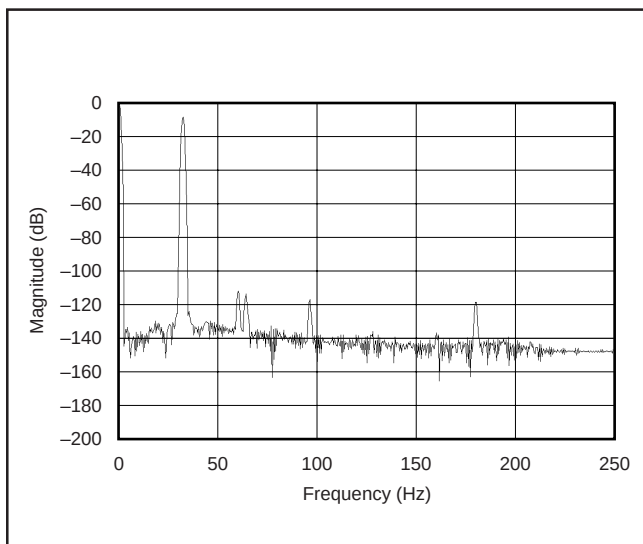


FIGURE 10. CS5321 in the CS5321 Evaluation Board with a 32Hz, 5Vp-p Sinewave Input.

Testing Performed by:

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## DEM-ADS1201UADP BILL OF MATERIALS

| REF<br>DESIGNATOR  | QUANTITY | PART NUMBER    | DESCRIPTION                                                     | VENDOR          |
|--------------------|----------|----------------|-----------------------------------------------------------------|-----------------|
| R1                 | 1        | CRCW12064992F  | 50k $\Omega$ Resistor<br>0.125 $\Omega$ , 1%<br>Chip Thick-Film | Dale            |
| R2                 | 1        | CRCW12061000F  | 100 $\Omega$ Resistor<br>0.125 $\Omega$ , 1%<br>Chip Thick-Film | Dale            |
| C1, C2, C3         | 3        | T491A105K016AS | 1 $\mu$ f, 20V, 10%<br>Tantalum Chip-Molded<br>Capacitor        | Kemet           |
| U1                 | 1        | ADS1201U       | Delta-Sigma Modulator                                           | Burr-Brown      |
| U2                 | 1        | 74HCT393       | 4-Bit Counter                                                   |                 |
| U3                 | 1        | REF1004C-2.5   | 2.5V Voltage Reference                                          | Burr-Brown      |
| Male Socket Pins   | 28       | 09-8090-2-03   | PLCC-28 Socket<br>Replacement Pins<br>(Male)                    | Concord         |
| Female Socket Pins | 28       | SBE-100-S-TG30 | PLCC-28 Socket<br>Replacement Pins<br>(Female)                  | Robinson Nugent |

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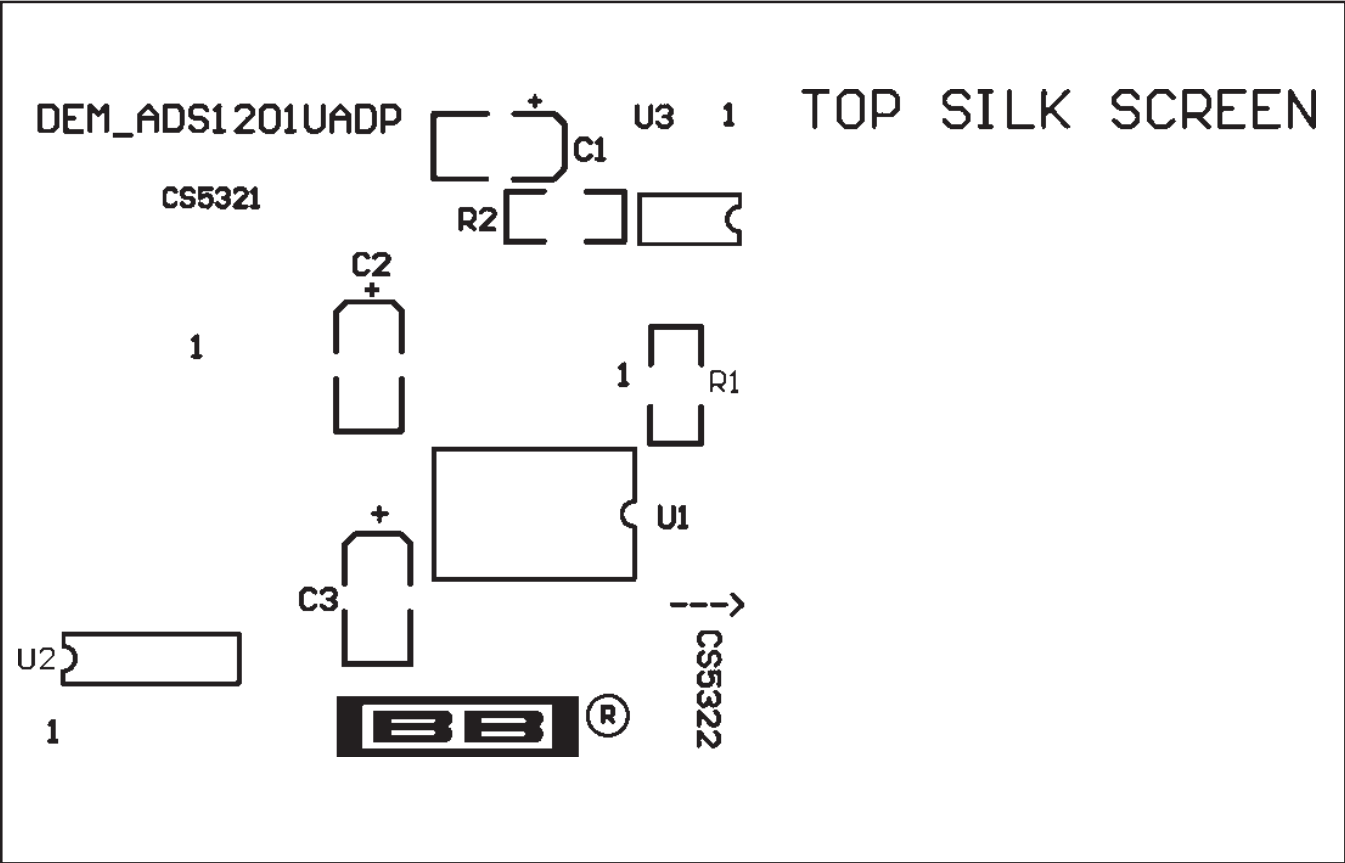


FIGURE 11. Top Silkscreen (Scale 2.5:1).

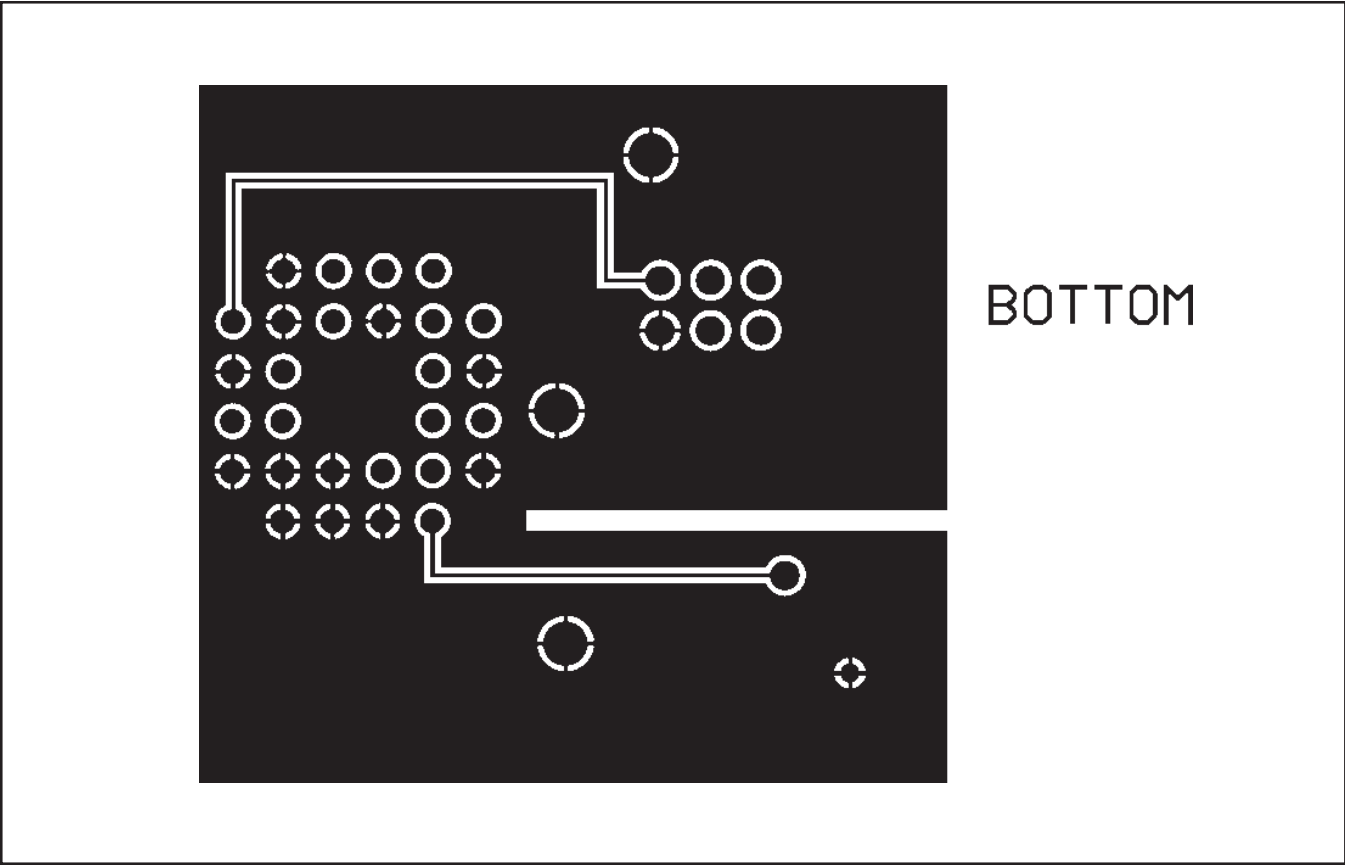


FIGURE 12. Top Layer (Scale 2.5:1).

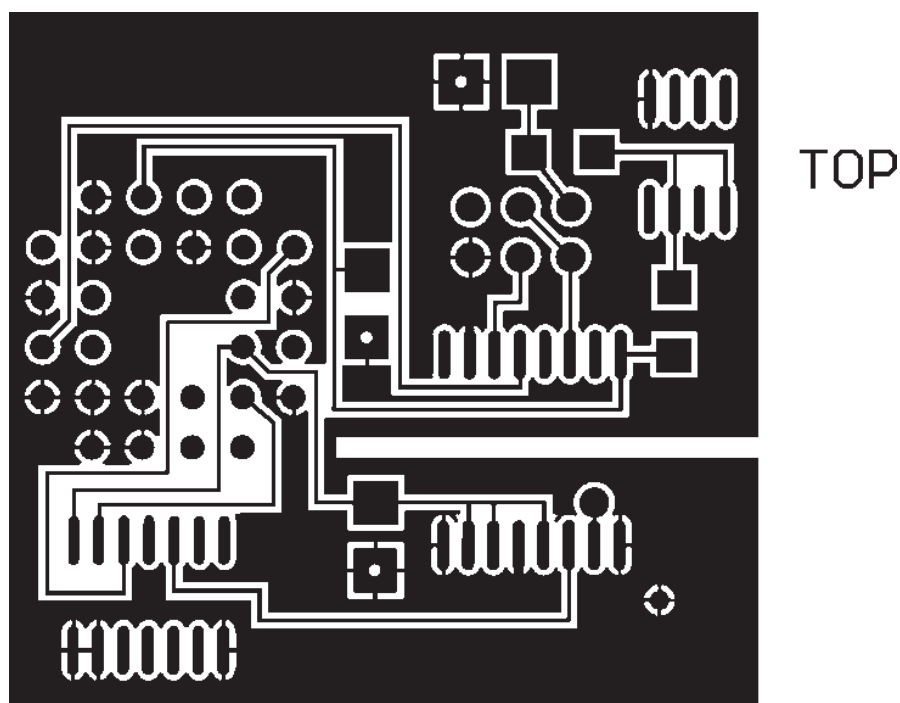


FIGURE 13. Bottom Layer (Scale 2.5:1).