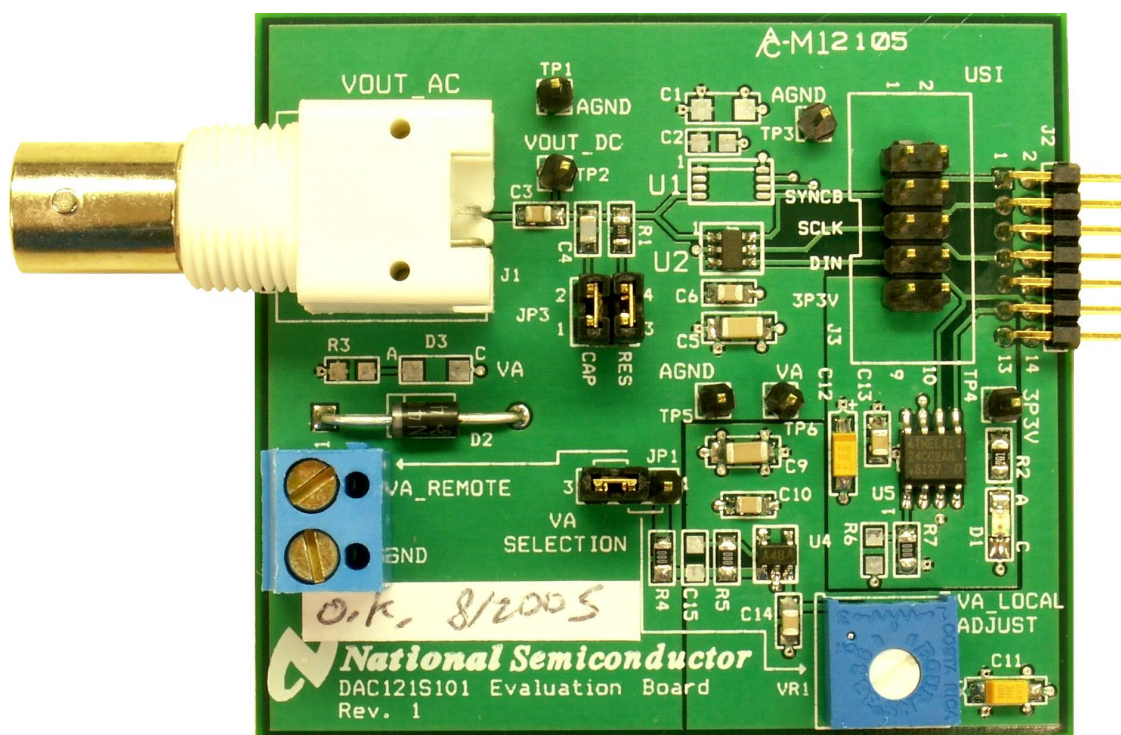


# Evaluation Board User's Guide

DAC121S101 12-Bit, DAC101S101 10-Bit, and DAC081S101 8-Bit

**Micro Power Digital-to-Analog Converter  
with Rail-to-Rail Output**



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## 1.0 Introduction

The DAC121S101EVAL Design Kit (consisting of the DAC121S101 Evaluation Board and this User's Guide) are designed to ease evaluation and design-in of the National Semiconductor DAC121S101 12-bit, DAC101S101 10-bit, and DAC081S101 8-bit Micro-Power Digital-to-Analog Converters with Rail-to-Rail Output. This family of pin-compatible DACs, will be referenced throughout this document as the DAC121S101.

The evaluation board can be used in either of two modes. In the Stand-Alone mode, suitable test equipment, such as a pattern generator and signal analyzer, can be used with the board to evaluate the DAC121S101 performance.

In the Computer mode, data capture and evaluation is simplified by connecting this board to National Semiconductor's Data Capture Board (order number WAVEVSN BRD 4.0) with a custom interface cable

(part number WV4DACIFCABLE at [www.national.com](http://www.national.com)). The Data Capture (WV4) Board is connected to a personal computer running WaveVision software through a USB port. The WaveVision4 software runs on Microsoft Windows, and the latest version can be downloaded from the web at <http://www.national.com/adc>.

*Note: WaveVision Software version 4.2 or later is required to evaluate this part with the WV4 Evaluation System.*

The WaveVision software allows the user to drive the DAC121S101 with a variety of preset waveforms and custom waveforms. The software also allows the user to select the clock frequency of the serial interface.

Data transmitted to the DAC121S101 via a serial interface is converted to an analog waveform by U1/U2, the DAC121S101.

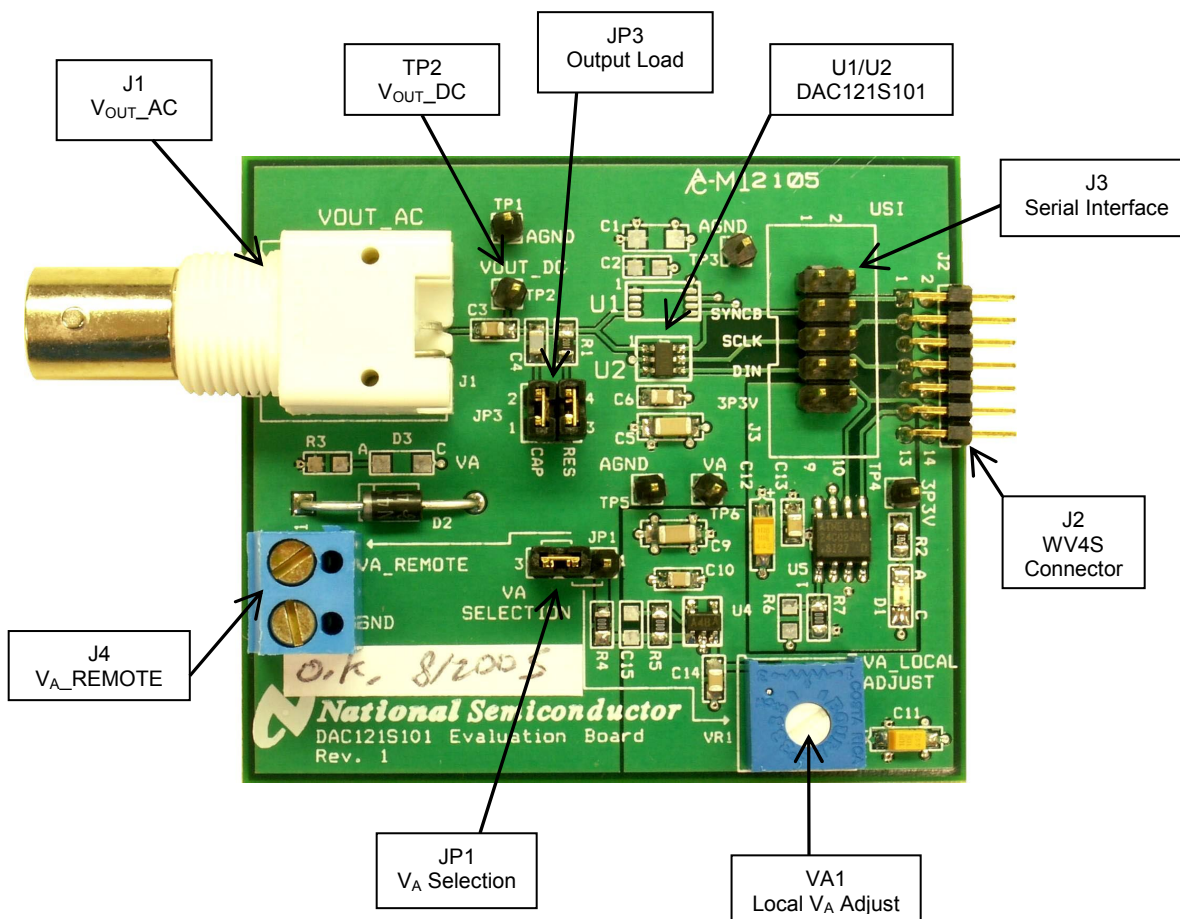


Figure 1: Component and Test Point Locations

## 2.0 Board Assembly

The DAC121S101 evaluation board comes fully assembled and ready for use. Refer to the Bill of Materials for a description of components, to *Figure 1* for major component placement, and to *Figure 4* for the Evaluation Board schematic.

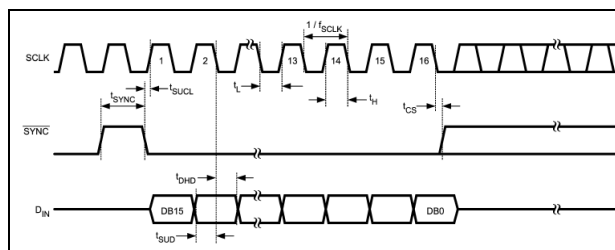
## 3.0 Quick Start

The DAC121S101 evaluation board may be used in the Stand-Alone mode or Computer mode. In Stand-Alone mode, a Pattern Generator is used to drive the DAC121S101, and a Signal Analyzer is used to evaluate the analog output signal. In Computer Mode, a WaveVision4 Board is used to drive the DAC121S101 and a Signal Analyzer is used to evaluate the analog output signal.

### 3.1 Stand-Alone Mode

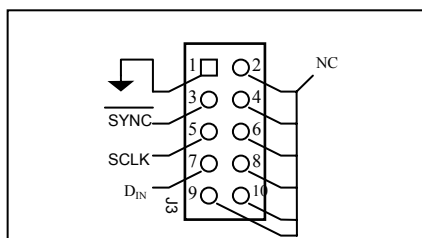
Refer to *Figure 1* for locations of test points and major components.

1. Connect a clean analog (not switching) +5V power source to Power Connector J4 on the DAC121S101 board and turn on the power. Place a jumper across pins 2 and 3 of JP1 to select VA\_REMOTE.
2. Create the digital waveforms seen in *Figure 2* with your Logic Generator. Ensure that SCLK doesn't exceed 30MHz. Refer to "Section 4.1: Serial Interface" and the DAC121S101 Datasheet for further details.



**Figure 2: Digital Input Timing Diagram**  
(Refer to Appendix 2.0 for an enlarged version)

3. Connect your Logic Generator to Serial Interface header J3. Refer to *Figure 3* below for connection details.



**Figure 3: J3 Serial Interface Header**

4. The Analog Output signal can be seen DC coupled at TP2, or AC coupled at BNC connector J1. See the board schematic of *Figure 4* for details.

5. Select the desired output load by adding jumpers to JP3. Connecting a jumper across pins 1 and 2 connects a 200pF load capacitance to ground. Connecting a jumper across pins 3 and 4 selects a 2kΩ resistive load. See *Table 1* for jumper configurations.

### 3.2 Computer Mode

Refer to *Figure 1* for locations of test points and major components.

1. Run the WaveVision4 program. While the program is loading, continue below.
2. Connect the "WV4DACIFCABLE" cable between J3 of the DAC121S101 evaluation board and J3 of the WV4 board. Note: the "WV4DACIFCABLE" is available at [www.national.com](http://www.national.com).
3. Connect a USB cable between the WaveVision4 Board and the PC running the WaveVision4 software.
4. Connect a clean analog (not switching) +5V power source to Power Connector J1 on the WaveVision4 Board.
5. Place a jumper across pins 2 and 3 of JP1 on the DAC121S101 board to select VA\_REMOTE.
5. Using a jumper cable, connect TP9 of the WaveVision4 board to TP6 of the DAC121S101 board.
6. Using another jumper cable, connect TP10 of the WaveVision4 board to TP4 of the DAC121S101 board. See *Section 4.4* for detailed Power Supply Information.
7. Perform steps 4 and 5 of section 3.1 above.
8. Refer to section 5.0 on Software Operation and Settings.

## 4.0 Functional Description

Table 1 describes the function of the various jumpers on the ADC121S625 evaluation board. The Evaluation Board schematic is shown in *Figure 4*.

| Jumper | Pins 1 & 2                      | Pins 2 & 3               |
|--------|---------------------------------|--------------------------|
| JP1    | Select VA_LOCAL from VR1 adjust | Select VA_REMOTE from J4 |
| JP2    | Not used                        |                          |

| Jumper | Pins 1 & 2                           | Pins 3 & 4                        |
|--------|--------------------------------------|-----------------------------------|
| JP3    | Select 200pF Output Load Capacitance | Select 2kΩ Output Load Resistance |

**Table 1: Jumper Configurations**

## 4.1 Serial Interface

*In Computer Mode*, the serial interface is driven by the WaveVision4 board. The WaveVision4 software allows the user to drive the DAC121S101 with various digitized signals. Refer to “Software Operation and Settings” for further information.

*In Stand-Alone Mode*, The serial interface must be driven by an external device. The three-wire interface (SCLK, SYNC, D<sub>IN</sub>) is compatible with SPI, QSPI and MICROWIRE, as well as most DSPs. See the Timing Diagram (*Figure 2*) for information on a write sequence.

The maximum digital input level of the three-wire interface is independent of the analog supply voltage (V<sub>A</sub>). The range of all digital inputs is 0V to 5.25V regardless of V<sub>A</sub>.

A write sequence begins by bringing the SYNC line low. Once SYNC is low, the *Binary* data on the D<sub>IN</sub> line is clocked into the 16-bit serial input register on the falling edges of SCLK. On the 16th falling clock edge, the last data bit is clocked in and the programmed function (a change in the mode of operation and/or a change in the DAC register contents) is executed. At this point the SYNC line may be kept low or brought high. In either case, it must be brought high for the minimum specified time before the next write sequence as a falling edge of SYNC will initiate the next write cycle.

Since the SYNC and D<sub>IN</sub> buffers draw more current when they are high, they should be idled low between write sequences to minimize power consumption.

Please refer to the DAC121S101 datasheet for more information.

## 4.2 DAC Reference Circuitry

The supply voltage for the DAC121S101 serves as its voltage reference, and does not need to be supplied separately. The analog output range of the DAC121S101 can be scaled by adjusting the supply voltage (V<sub>A</sub>). This voltage can be set anywhere from +2.7V to +5.5V.

## 4.3 Analog Output

The analog output of this Eval board is available at the BNC connector, J1. The output at J1 is AC coupled. The board also provides a DC coupled output at TP2.

If you are using a spectrum analyzer to look at the output of the DAC121S101, the AC coupled output (J1) is recommended.

For very low frequency (i.e. less than 1kHz), use TP2 to see the output signal DC coupled. For an AC coupled output at low frequencies, simply replace the AC coupling capacitor at C3 with a larger capacitor.

## 4.4 Power Supply Connections

In Computer mode, the board can be powered by either an external supply or the local WaveVision4 board supply. In Stand-alone mode, the DAC121S101 board

must be powered by an external supply. In either case, remember that the supply voltage and reference voltages are tied together on the DAC121S101.

*If you wish to supply V<sub>A</sub> externally*, connect a DC voltage supply to connector J4 and place a jumper across pins 2 and 3 of JP1 to select V<sub>A</sub> REMOTE. This voltage (V<sub>A</sub>) can be set anywhere from +2.7V to +5.5V. Note: For computer mode, +3.3V must be supplied to the DAC121S101 board at TP4.

Since the supply voltage (V<sub>A</sub>) serves as the reference for the DAC121S101, ensure a clean power supply is used.

*If you wish to use the local supply from the WaveVision4 Board*, place a jumper across pins 2 and 3 of JP1. Using a jumper cable, connect TP9 of the WaveVision4 board to TP6 of the DAC121S101 board. This connection will supply +5V to V<sub>A</sub> on the DAC121S101 board. Using another jumper cable, connect TP10 of the WaveVision4 board to TP4 of the DAC121S101 board.

## 5.0 Software Operation and Settings

The WaveVision software is included with the WaveVision4 board and the latest version can be downloaded from National's web site at <http://www.national.com/adc>. WaveVision software version 4.2 or later is required to evaluate this device with the WV4 system.

To install this software, follow the procedure in the WAVEVSN BRD 4.0 User's Guide. Once the software is installed, run it and set it up as follows:

*Note: Before continuing, ensure that the WaveVision Hardware is setup according to Section 3.2.*

1. From the WaveVision main menu, go to Settings, then Capture Settings to open the System Settings dialog.
2. Under board type, select WaveVision4 (USB).
3. Turn on the power to both boards, then click on the **"Test"** button and await the firmware download. *After the firmware has downloaded, WaveVision will open up a control panel for the DAC121S101.*
4. Click on the **"Accept"** button to close the System Settings Dialog.
5. From the DAC121S101 Control Panel, configure the digital waveform to be converted by the DAC. *Please see the WaveVision4 User's Manual for detailed instructions. The ability to drive preset waveforms or custom data is provided.*
6. Press the **"Start"** button to begin driving the digital waveform to the DAC.

The WaveVision4 Board will continuously send the waveform out to the DAC121S101 until the **"Stop"** button is pressed. Please refer to *Section 4.3* for details on measuring the Analog Output of the DAC.

The Digital Waveform is plotted in the main WaveVision window for added convenience. This waveform may be further analyzed by clicking on the magnifying glass icon, then clicking and dragging across a specific area of the plot for better data inspection. See the WaveVision4 Board User's Guide for details.

If this board is used in conjunction with the WAVEVSN BRD 4.0 Data Capture Board and WaveVision software, a USB cable is needed to connect WAVEVSN BRD 4.0 to the host computer. See the WaveVision4 Board User's Guide for details.

## **6.0 Evaluation Board Specifications**

|                          |                                                     |                  |
|--------------------------|-----------------------------------------------------|------------------|
| Board Size:              | 2.44" x 2.19" (6.2 cm x 5.6 cm)                     |                  |
| Power Requirements       | Min: +2.7V , 3mA                                    | Max: +5.5V, 5 mA |
| Max Clock Frequency:     | 30 MHz                                              |                  |
| Analog Output            |                                                     |                  |
| AC Coupled Output Range: | -(V <sub>A</sub> /2) to (V <sub>A</sub> /2)         |                  |
| Impedance:               | User Selectable: 2K $\Omega$ , 200pF, or $\infty$ . |                  |

## 7.0 Hardware Schematic

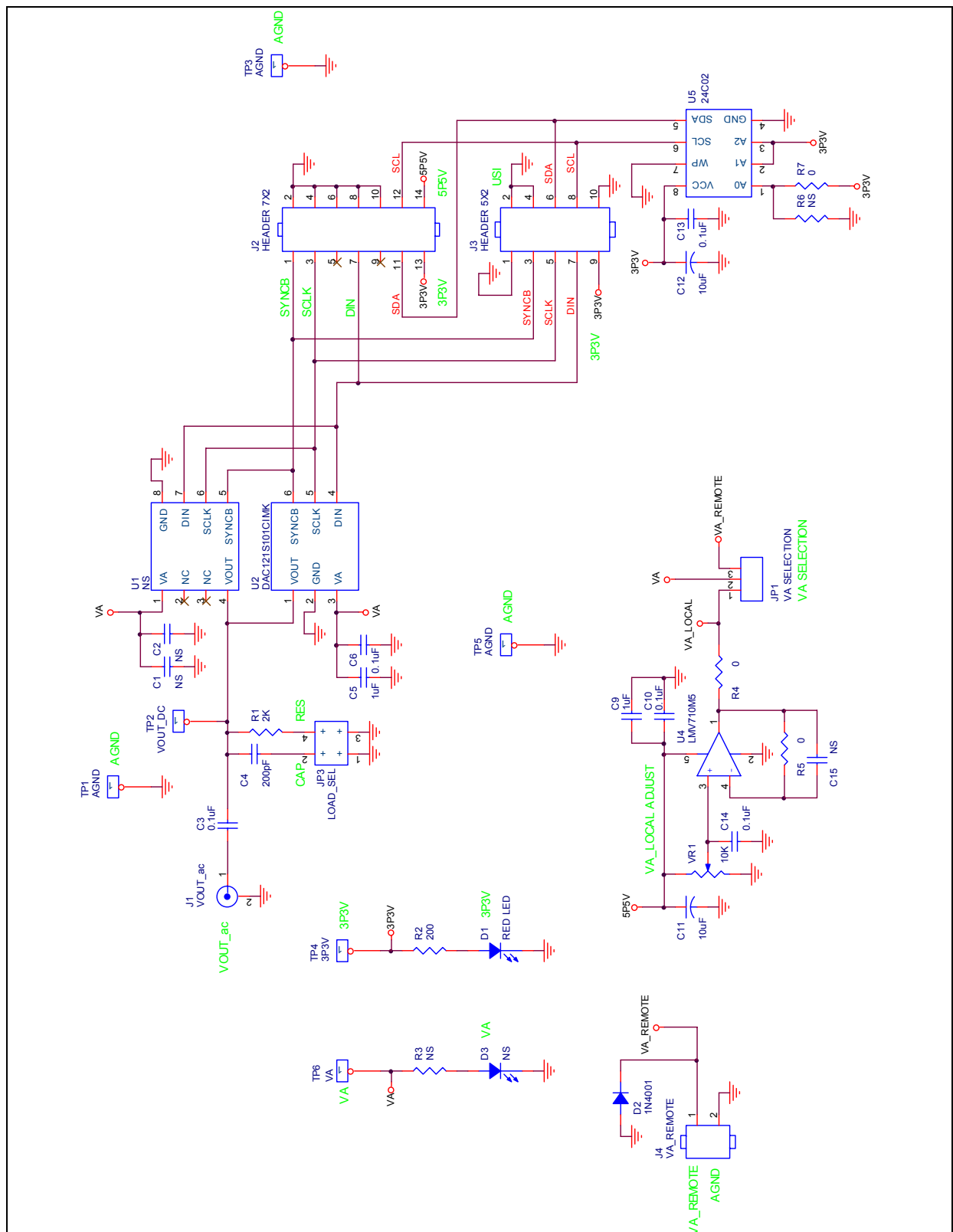


Figure 4: DAC121S101 Evaluation Board Schematic

## 8.0 Evaluation Board Bill of Materials

| Qty. | Reference             | PCB Footprint               | Source  | Source Part # | Rating | Value                                              |
|------|-----------------------|-----------------------------|---------|---------------|--------|----------------------------------------------------|
| 1    | C1                    | sm/c_1206                   |         |               | 10V    | NS                                                 |
| 2    | C15,C2                | sm/c_0805                   |         |               | 10V    | NS                                                 |
| 5    | C3,C6,C10,<br>C13,C14 | sm/c_0805                   |         |               | 10V    | 0.1uF                                              |
| 1    | C4                    | sm/c_0805                   |         |               | 10V    | 200pF                                              |
| 2    | C9,C5                 | sm/c_1206                   |         |               | 10V    | 1uF                                                |
| 2    | C11,C12               | sm/ct_3216_12               |         |               | 10V    | 10uF                                               |
| 1    | D1                    | sm/led_21                   | Digikey | 516-1440-1-ND |        | RED LED                                            |
| 1    | D2                    | DAX2/DO41                   | Digikey | 1N4001GICT-ND |        | 1N4001                                             |
| 1    | D3                    | sm/led_21                   | Digikey | 516-1440-1-ND |        | NS                                                 |
| 1    | JP1                   | blkcon.100/vh/tm1sq/w.100/3 | Digikey | A26513-40-ND  |        | VA SELECTION                                       |
| 1    | JP3                   | blkcon.100/vh/tm2oe/w.200/4 | Digikey | A26529-40-ND  |        | LOAD_SEL                                           |
| 1    | J1                    | rf/bnc/r1.350_21            | Digikey | ARF1177-ND    |        | VOUT_ac                                            |
| 1    | J2                    | blkcon/2mm/ra/tm2oe/w2mm/14 | Digikey | S2200-07-ND   |        | HEADER 7X2                                         |
| 1    | J3                    | BLKCON.100/.../shroud       | Digikey | A26529-40-ND  |        | HEADER 5X2                                         |
| 1    | J4                    | term_block/.200/2pos        | Digikey | ED1609-ND     |        | VA_REMOTE                                          |
| 1    | R1                    | sm/r_0805                   |         |               |        | 2K                                                 |
| 1    | R2                    | sm/r_0805                   |         |               |        | 200                                                |
| 2    | R6,R3                 | sm/r_0805                   |         |               |        | NS                                                 |
| 3    | R4,R5,R7              | sm/r_0805                   |         |               |        | 0                                                  |
| 3    | TP1,TP3,TP5           | blkcon.100/vh/tm1sq/w.100/1 | Digikey | 5011K-ND      |        | AGND                                               |
| 1    | TP2                   | blkcon.100/vh/tm1sq/w.100/1 | Digikey | 5011K-ND      |        | VOUT_DC                                            |
| 1    | TP4                   | blkcon.100/vh/tm1sq/w.100/1 | Digikey | 5011K-ND      |        | 3P3V                                               |
| 1    | TP6                   | blkcon.100/vh/tm1sq/w.100/1 | Digikey | 5011K-ND      |        | VA                                                 |
| 1    | U1                    | sog.65m/8/wg4.80/l3.00      |         |               |        | NS                                                 |
| 1    | U2                    | sm/sot23-6                  |         |               |        | DAC121S101CIMK<br>DAC101S101CIMK<br>DAC081S101CIMK |
| 1    | U4                    | sm/sot23-5                  | Digikey | LMV710M5CT-ND |        | LMV710M5                                           |
| 1    | U5                    | sog.050/8/wg.244/l.200      |         |               |        | 24C02                                              |
| 1    | VR1                   | vres4                       | Digikey | 3386F-103-ND  |        | 10K                                                |

# APPENDIX

## A1.0 Summary Tables of Test Points, Jumpers, and Connectors

### Test Points on the DAC121S101 Evaluation Board

|              |                                                                              |
|--------------|------------------------------------------------------------------------------|
| TP1: AGND    | Ground. Located at the top center of the board.                              |
| TP2: VOUT_DC | DC Coupled Analog Output test point. Located at the top center of the board. |
| TP3: AGND    | Ground. Located at the top Right of the board.                               |
| TP4: 3P3V    | 3.3V test point. Located at the right edge of the board.                     |
| TP5: AGND    | Ground. Located in the center of the board.                                  |
| TP6: VA      | V <sub>A</sub> Test Point. Located in the center of the board.               |

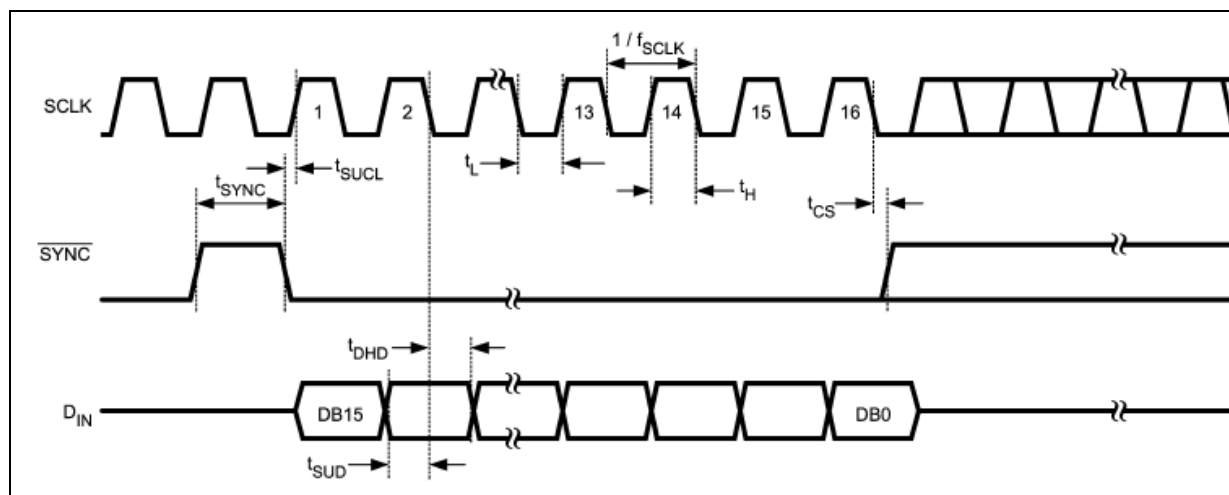
### Connectors on the DAC121S101 Evaluation Board

|                             |                                                                                            |
|-----------------------------|--------------------------------------------------------------------------------------------|
| J1: BNC Connector           | VOUT_AC. AC Coupled Analog Output.                                                         |
| J2: WV4S Header             | Wave Vision 4 Serial connector (Future Use)                                                |
| J3: Serial Interface Header | Serial Interface connector. Logic Input. (Refer to <i>Figure 3</i> for a pin-out diagram.) |
| J4: Terminal Block          | VA_REMOTE. External power supply connector.                                                |

### Selection Jumpers on the DAC121S101 Evaluation Board (Refer to *Table 1* in Section 4.0 for configuration details)

|                  |                                    |
|------------------|------------------------------------|
| JP1: VA SEL      | Selects source of V <sub>A</sub> . |
| JP2: Not Used    | Not Used.                          |
| JP3: Output Load | Configures the output load.        |

## A2.0 Enlarged Timing Diagram



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|                               |                                                                                          |
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