

# **AN4574 Application note**

STEVAL-CCA057V2 evaluation board user guidelines for dual operational amplifiers in an MSO8 package

### Introduction

The STEVAL-CCA057V2 evaluation board from STMicroelectronics is designed to help customers quickly prototype new dual op amp circuits in an MSO8 package and reduce design time.

The evaluation board can be used with almost any STMicroelectronics dual op amp in various configurations and applications. The evaluation board is a bare board (that is, there are no components or amplifier soldered to the board; these must be ordered separately).

This document provides:

- A description of the evaluation board
- A layout of the top and bottom layers

Some examples of classic configurations that can be tested with the board.

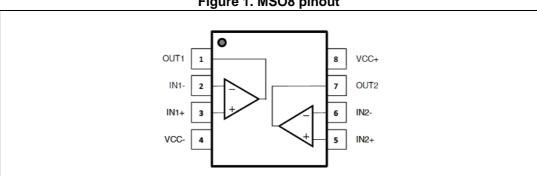
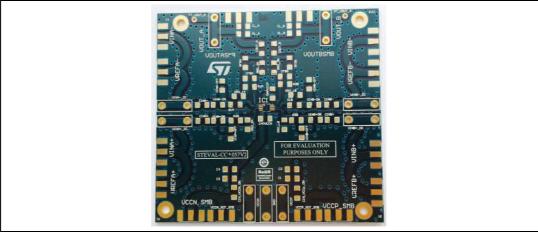


Figure 1. MSO8 pinout





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AN4574 Description

## 1 Description

This board is designed with versatility in mind, and allows many circuits to be constructed easily and quickly.

A few possible circuits are as follows:

- Voltage follower
- Non-inverting amplifier
- Inverting amplifier
- Sallen-key filter
- Instrument amplifier
- AC-coupled circuit
- Out-of-loop compensation circuit

### Circuit

The circuit schematic in *Figure 3* shows the connections for all possible components. Each configuration uses only some of the components.

The board is designed for surface-mounted components and can be used to perform onboard characterization prior to the integration of STMicroelectronics products in your designs. Resistor and capacitor footprints are implemented for the 1206 series. Description AN4574

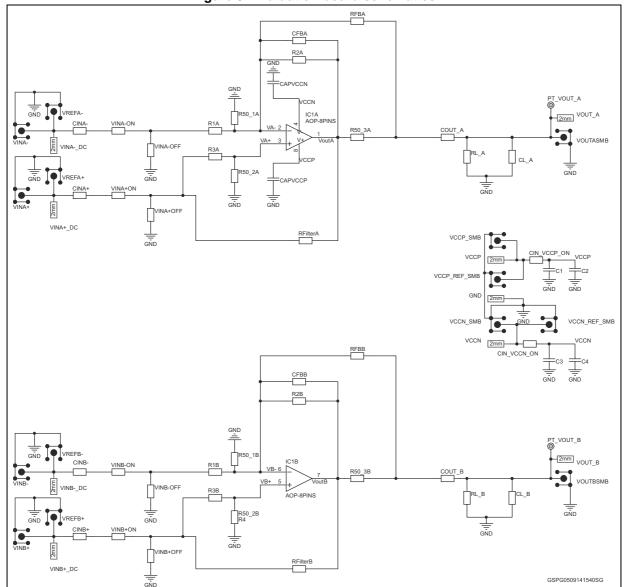


Figure 3. Evaluation board schematics

### **Power requirements**

A 0  $\Omega$  resistance must be connecting on CIN\_VCCN\_ON and CIN\_VCCP\_ON in order to supply power to the dual amplifier.

A set of two decoupling capacitors (C1, C2 and C3, C4) have been implemented on both power supply pins, so as to benefit from the maximum performance of ST products. In order to reject low frequencies, 1  $\mu$ F and 10  $\mu$ F are good values for these.

Others decoupling capacitors (CAPVCCN, CAPVCCP) as close as possible to the SO8 package, might also be used to obtain excellent power supply decoupling. 100 pF values can be used in order to reject high frequencies.

When using single-supply circuits, the negative supply is shorted to ground by bridging C3 or C4 capacitances. Power is therefore between VCCP and GND.

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AN4574 Description

### **Output options**

The outputs have additional resistor (RL\_A, RL\_B) and capacitor (CL\_A, CL\_B) placements for loading. Or it might be used as an anti-alias filter, or to limit amplifier output noise by reducing its output bandwidth.

Note:

Operational amplifiers are sensitive to output capacitance and may oscillate. In the event of oscillation, reduce output capacitance by using shorter cables, or add a resistor in series on COUT\_A, COUT\_B placement with a suitable value in order to improve amplifier phase margin.

### **Measurement tips**

In the datasheet, some measurements, such as settling time and peaking, have been performed with 50  $\Omega$  output equipment. In order to keep the integrity of the square input signal, the input tracks from VINA+, VINB+, VINA-, VINB+, have an impedance of 50  $\Omega$ .

And in order to adapt input impedance, 50  $\Omega$  resistances can be added on the R50\_1A, R50\_2A and R50\_1B, R50\_2B.

Layout AN4574

# 2 Layout

The board has the following physical characteristics:

- Board dimensions: 3526 x 3300 mils (89.6 x 83.8 mm)
- 2-layer PCB
- Both sides have a ground plane.

For Vout\_A, Vout\_B, VinA+, VinA-, VinB+ and VinB- female SMB or female 2 mm connectors can be implanted. You can also implant test points on these voltages. They will facilitate the visualization of your signals.

Top and bottom layers are shown on Figure 4 and Figure 5:

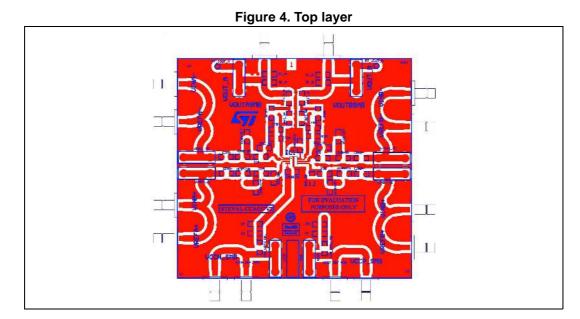
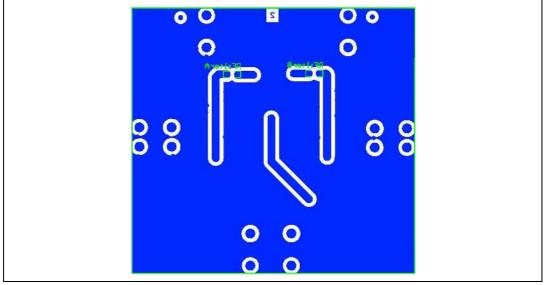


Figure 5. Bottom layer



### 3 Different possible configurations

The following provides some instructions on how to set up the board in order to perform several classical configurations.

- Figure 6: Low-pass Sallen-key filter order 4
- Figure 7: High-pass Sallen-key filter order 4
- Figure 8: Instrumentation amplifier
- Figure 9: Transimpedance configuration
- Figure 10: AC coupled configuration

You can also put several boards in cascade which allows you to obtain a more complex configurations.

### 3.1 Low-pass Sallen-key configuration

The following low-pass Sallen-key configuration is a fourth order filter configuration. This circuit has 80 dB roll-off per decade.

### The transfer function is:

#### **Equation 1**

$$\frac{Vout}{Vin} = \frac{1 + \frac{RFA}{RGA}}{1 + \left(R1.C2\left(1 - \frac{RFA}{RGA}\right) + C1(R1 + R2)\right)j\omega + R1.R2.C1.C2(j\omega)^2} * \frac{1 + \frac{RFB}{RGB}}{1 + \left(R3.C4\left(1 - \frac{RFB}{RGB}\right) + C3(R3 + R4)\right)j\omega + R3.R4.C3.C4(j\omega)^2}$$

### The low frequency gain is:

### **Equation 2**

$$G = \left(1 + \frac{RFA}{RGA}\right) * \left(1 + \frac{RFB}{RGB}\right)$$

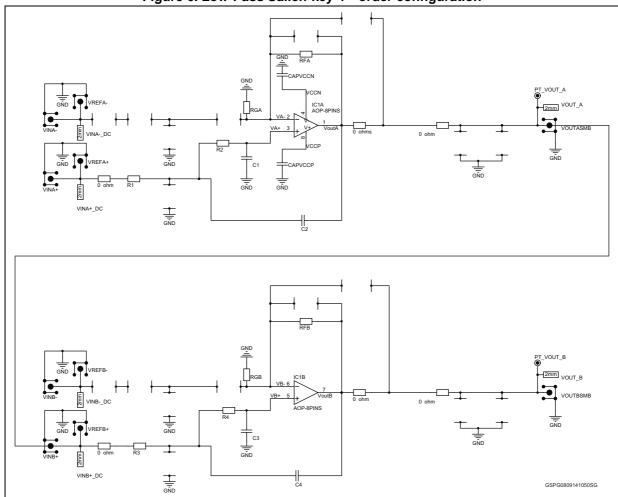


Figure 6. Low-Pass Sallen-key 4th order configuration

### 3.2 High-pass Sallen-key configuration

Like the low-pass Sallen-key configuration above, this one is also a fourth order. It has a slope of +80 dB per decade.

### The transfer function is:

### **Equation 3**

$$\frac{Vout}{Vin} = \frac{\left(1 + \frac{RFA}{RGA}\right) R1.R2.C1.C2.(j\omega)^2}{1 + \left(R2(C1 + C2) - R1.C2.\frac{RFA}{RGA}\right) j\omega + R1.R2.C1.C2(j\omega)^2} * \frac{\left(1 + \frac{RFB}{RGB}\right) R3.R4.C3.C4.(j\omega)^2}{1 + \left(R4(C3 + C4) - R3.C4.\frac{RFB}{RGB}\right) j\omega + R3.R4.C3.C4(j\omega)^2}$$

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### The high frequency gain is:

### **Equation 4**

$$G = \left(1 + \frac{RFA}{RGA}\right) * \left(1 + \frac{RFB}{RGB}\right)$$

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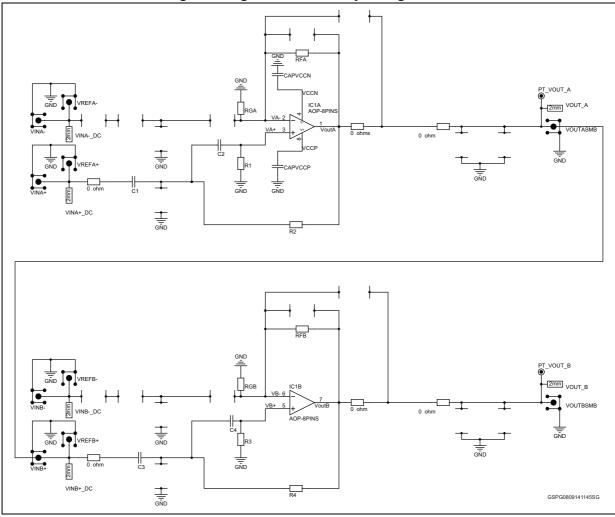


Figure 7. High-Pass Sallen-key configuration

The upper limit of the frequency range is determined by the GBP of the op amp ( $F \ll \frac{GBP}{1+\frac{RE}{2}}$ .)

## 3.3 Instrumentation amplifier

The instrumentation amplifiers are generally used for precise measurement in a differential way.

The architecture of the instrumentation amplifier with dual op amps is the simplest one. The input impedance is high as the non-inverting of the both op amps are used as input.

By considering R1.R2 = RFA.RFB

And Vout = Vreference for Vdiff = 0 V

The gain can be expressed as follows:

### **Equation 5**

$$G = 1 + \frac{RFB}{Rg} + \frac{R1}{Rg} + \frac{R1}{RFA}$$



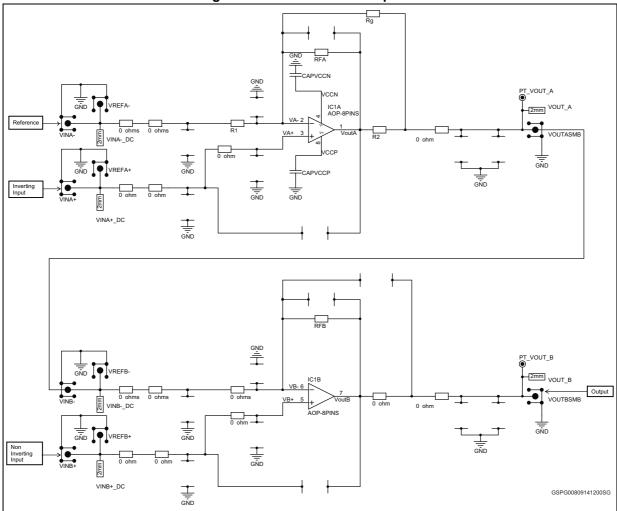


Figure 8. Instrumentation amplifier

### 3.4 Transimpedance configuration

The *Figure 9* shows how to configure op amp IC1A as a transimpedance amplifier (TIA). The output voltage of the TIA is the input current multiplied by the feedback resistor RFA:

### **Equation 6**

$$VOUT_A = (Iin + Ibias) * RFA - Vos$$

where Iin is defined as the input current source applied at the VINA- pad, IBIAS is the input bias current, and VOS is the input offset voltage of the op amp. For the type of usage, the feedback resistor RFA is generally high and the impedance seen on the VA- node is pretty capacitive (ex: photodiode). In order to stabilize the op amp it is recommended to connect a feedback capacitance CF.

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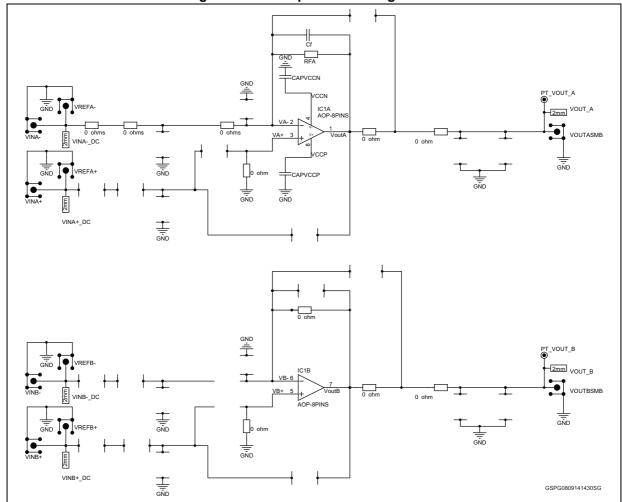


Figure 9. Transimpedance configuration

Note: If only IC1A op amp is used as transimpedance amplifier, the second one, IC1B, should be configured in follower mode in order to avoid any undesired oscillation on its output.

## 3.5 AC coupled circuit configuration

This typical configuration allows you to amplify the AC part of the input signal only; for example, a typical stereo audio amplifier.

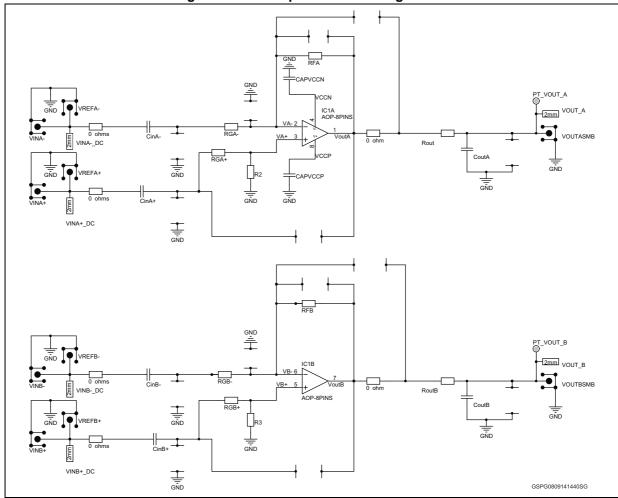


Figure 10. AC coupled circuit configuration



# 4 Associated products

**Table 1. Associated products** 

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TSV358IST General purpose low voltage rail to rail input/output op amp  TSV522IST High merit factor (1.15 MHz for 45 μA) CMOS op amps  TSV522AIST High merit factor (1.15 MHz for 45 μA) CMOS op amps  TSV612IST Rail to rail input/output CMOS op amp  TSV612AIST Rail to rail input/output CMOS op amp  TSV6192IST Rail to rail input/output CMOS op amp  TSV6192AIST Rail to rail input/output CMOS op amp  TSV622IST Micro-power CMOS op amp  TSV622AIST Micro-power CMOS op amp  TSV6292IST Micro-power CMOS op amp  TSV6392IST Micro-power CMOS op amp  TSV6392AIST Micro-power CMOS op amp	TS972IST	Output rail-to-rail very low-noise op amps
TSV522IST High merit factor (1.15 MHz for 45 μA) CMOS op amps  TSV522AIST High merit factor (1.15 MHz for 45 μA) CMOS op amps  TSV612IST Rail to rail input/output CMOS op amp  TSV612AIST Rail to rail input/output CMOS op amp  TSV6192IST Rail to rail input/output CMOS op amp  TSV6192AIST Rail to rail input/output CMOS op amp  TSV622IST Micro-power CMOS op amp  TSV622IST Micro-power CMOS op amp  TSV6292IST Micro-power CMOS op amp  TSV6292AIST Micro-power CMOS op amp  TSV6392IST Micro-power CMOS op amp  TSV6392IST Micro-power CMOS op amp  TSV6392IST Micro-power CMOS op amp  TSV6392AIST Micro-power CMOS op amp  TSV712IST High accuracy	TSU102IST	Nanopower 5 V CMOS op amp
TSV522AIST High merit factor (1.15 MHz for 45 µA) CMOS op amps  TSV612IST Rail to rail input/output CMOS op amp  TSV612AIST Rail to rail input/output CMOS op amp  TSV6192IST Rail to rail input/output CMOS op amp  TSV6192AIST Rail to rail input/output CMOS op amp  TSV622IST Micro-power CMOS op amp  TSV622AIST Micro-power CMOS op amp  TSV6292IST Micro-power CMOS op amp  TSV6292AIST Micro-power CMOS op amp  TSV6329AIST Micro-power CMOS op amp  TSV632IST Micro-power CMOS op amp  TSV6392IST Micro-power CMOS op amp  TSV6392AIST Micro-power CMOS op amp	TSV358IST	General purpose low voltage rail to rail input/output op amp
TSV612IST Rail to rail input/output CMOS op amp  TSV612AIST Rail to rail input/output CMOS op amp  TSV6192IST Rail to rail input/output CMOS op amp  TSV6192AIST Rail to rail input/output CMOS op amp  TSV622IST Micro-power CMOS op amp  TSV622AIST Micro-power CMOS op amp  TSV6292IST Micro-power CMOS op amp  TSV6292AIST Micro-power CMOS op amp  TSV632IST Micro-power CMOS op amp  TSV632IST Micro-power CMOS op amp  TSV632AIST Micro-power CMOS op amp  TSV6392AIST Micro-power CMOS op amp  TSV6312IST Micro-power CMOS op amp	TSV522IST	High merit factor (1.15 MHz for 45 μA) CMOS op amps
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TSV622AIST Micro-power CMOS op amp  TSV6292IST Micro-power CMOS op amp  TSV6292AIST Micro-power CMOS op amp  TSV632IST Micro-power CMOS op amp  TSV632AIST Micro-power CMOS op amp  TSV6392IST Micro-power CMOS op amp  TSV6392AIST Micro-power CMOS op amp  TSV6392AIST Micro-power CMOS op amp  TSV712IST High accuracy	TSV6192AIST	Rail to rail input/output CMOS op amp
TSV6292IST Micro-power CMOS op amp  TSV6292AIST Micro-power CMOS op amp  TSV632IST Micro-power CMOS op amp  TSV632AIST Micro-power CMOS op amp  TSV6392IST Micro-power CMOS op amp  TSV6392AIST Micro-power CMOS op amp  TSV6392AIST Micro-power CMOS op amp  TSV712IST High accuracy	TSV622IST	Micro-power CMOS op amp
TSV6292AIST Micro-power CMOS op amp  TSV632IST Micro-power CMOS op amp  TSV632AIST Micro-power CMOS op amp  TSV6392IST Micro-power CMOS op amp  TSV6392AIST Micro-power CMOS op amp  TSV712IST High accuracy	TSV622AIST	Micro-power CMOS op amp
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TSV712IST High accuracy	TSV6392IST	Micro-power CMOS op amp
	TSV6392AIST	Micro-power CMOS op amp
TSV732IST High accuracy	TSV712IST	High accuracy
	TSV732IST	High accuracy

Associated products AN4574

Table 1. Associated products (continued)

Part number	General description
TSV852IST	Low-power, high accuracy, general-purpose operational amplifier
TSV852AIST	Low-power, high accuracy, general-purpose operational amplifier
TSV912IST	Rail to rail input/output widebandwidth op amps
TSV912AIST	Rail to rail input/output widebandwidth op amps
TSV992IST	Rail to rail input/output high merit factor op amps
TSV992AIST	Rail to rail input/output high merit factor op amps
TSX562IST	Micropower, wide bandwidth 16 V CMOS op amps
TSX562AIST	Micropower, wide bandwidth 16 V CMOS op amps
TSX632IST	Micropower, rail-to-rail 16 V CMOS op amps
TSX632AIST	Micropower, rail-to-rail 16 V CMOS op amps
TSX922IST	10 MHz, rail-to-rail 16 V CMOS op amps
TSX9292IST	16 MHz, rail-to-rail 16 V CMOS op amps
TSZ122IST	Very high accuracy (5 μV) zero drift micropower 5 V

AN4574 Revision history

# 5 Revision history

Table 2. Document revision history

Date	Revision	Changes
10-Sep-2014	1	Initial release.

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