Application description AN1013

Voltage amplifier IC – AM461– with adjustable output voltage for industrial applications

Initial situation

Converting a voltage signal with an offset, such as a sensor output signal of 0.5...4.5 V, for example, into a signal whose minimum value should be as close to 0 V as possible (e.g. 0...10 V), is a problem electronics designers face on an almost daily basis. A secondary requirement is often that the number of components be reduced while retaining all system features, such as protection, immunity to EMC, component size, etc. Bearing both factors of miniaturization and cost in mind, in many cases solving the offset problem often proves more difficult than expected. In its integrated circuit AM461 Analog Microelectronics has developed an IC for this particular application which with its adjustable output voltage for industrial applications provides a viable alternative to the solutions currently in practice.

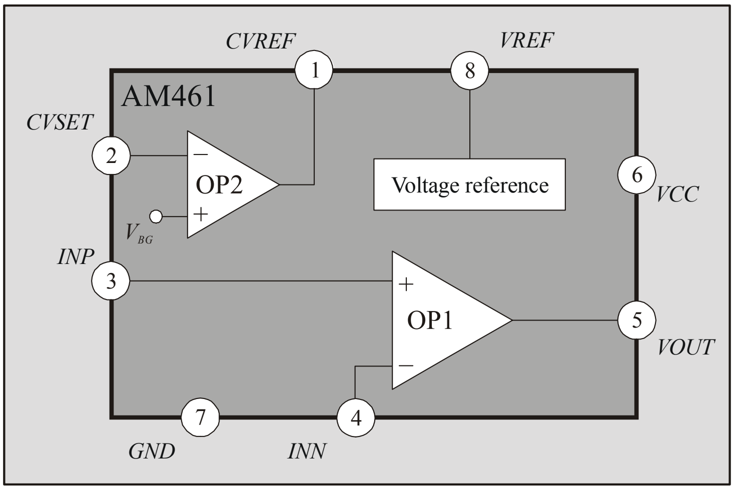

Figure 1: Block diagram of AM461

Circuit description

By way of example, in this article a SM5812 pressure sensor from AMSYS in Mainz [1] is used as a signal source for the 15 PSI range. This sensor provides an offset signal of 0.5 ± 0.08 V and a span signal of 4 ± 0.08 V. Using an AM461 from Analog Microelectronics, which together with the SM5812 makes up a sensor system, this output signal is to be converted into a system output signal of 0 to 10 V. See figure 2.

The following observations can be generally applied to all signal sources with a 0.5...4.5 V output and is applicable also to the AM401 [2].

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AM461 [2] is a modular multifunctional IC which can transform e.g. an input voltage into an adjustable output voltage. It consists of three different modules which are individually specified and separately configured.

a) Amplifier

Via the amplifier stage the output voltage can be set as required to up to V_{CC} -6 V (max. 29 V). The amplifier is unity gain stable and can be used as a buffer amplifier.

AM461 has an integrated adjustable voltage reference (band gap) with which other components can be supplied. The voltage can be programmed to a fixed 5 V or 10 V and can be charged to 10 mA. Interim values of voltage can also be set using a voltage divider.

b) Operational amplifier

An operational amplifier whose positive input is connected internally to the reference can be used as an additional voltage or current source.

Solution

With an AM461 the required output voltage of 0 to 10V can be set using just a few external components. Use is also made of the ability to power the upstream signal source (here the transducer SM5812) via the integrated voltage reference. As AM461 can be directly connected up to a 24 V voltage supply so the IC acts as a voltage regulator. The need for economy is thus satisfied and the three required function units (signal amplification, power and voltage supply) supplied at system level (see Figure 2).

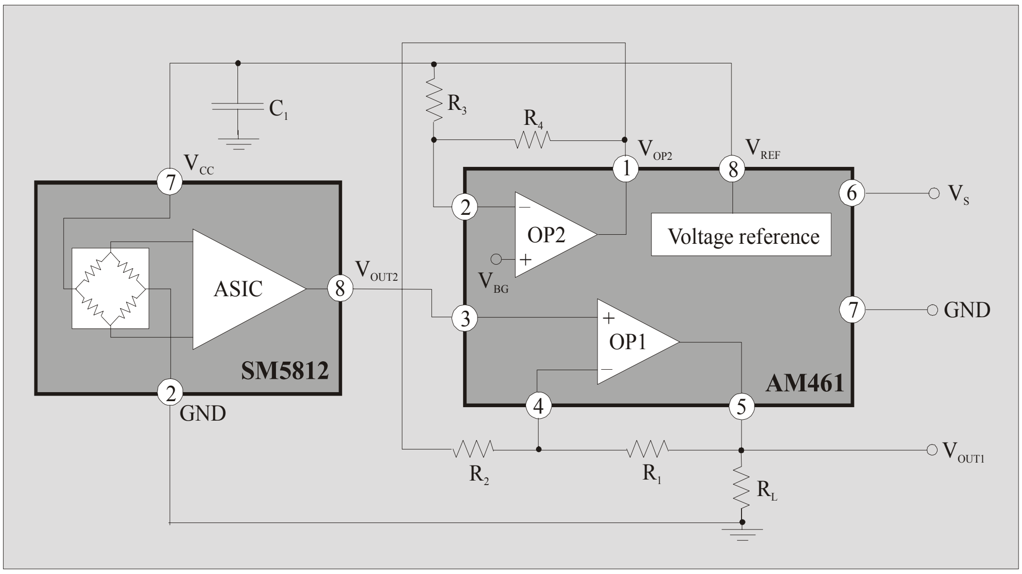

Figure 2: Combined SM5812 and AM461 sensor system

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DIMENSIONING

Resistances R_1 and R_2 (Figure 2) can be calculated using the equation:

$$\frac{R_1}{R_2} = \frac{\max V_{OUT1} - \min V_{OUT1}}{\max V_{OUT2} - \min V_{OUT2}} - 1$$

where the boundary condition is $R_1 + R_2 = 20 \ldots 200\ k\Omega$. In this example $R_1 = 72\ k\Omega$ and $R_2 = 46\ k\Omega$.

Resistances R_3 and R_4 can be calculated using the equation:

$$\frac{R_3}{R_4} = (V_{BG} - V_{OP2}) \cdot (V_{REF} - V_{BG}) \qquad \text{with } V_{OP2} = \frac{(R_1 + R_2) \cdot \min V_{OUT2}}{R_1}$$

where the boundary conditions are $R_3 + R_4 = 20 \ldots 200\ k\Omega$, $V_{REF} = 5$ V and $V_{BG} = 1.27$ V. In this example $R_3 = 121\ k\Omega$ and $R_4 = 15\ k\Omega$, with $C_1 = 2.2\ \mu F$ according to the data sheet.

Results

Using these dimensions offset voltage V_{OUT1} was measured dependent on the load resistance R_L at $V_{CC} = 24$ V within the specified limits of 2 to 100 kOhm (see Figure 3).

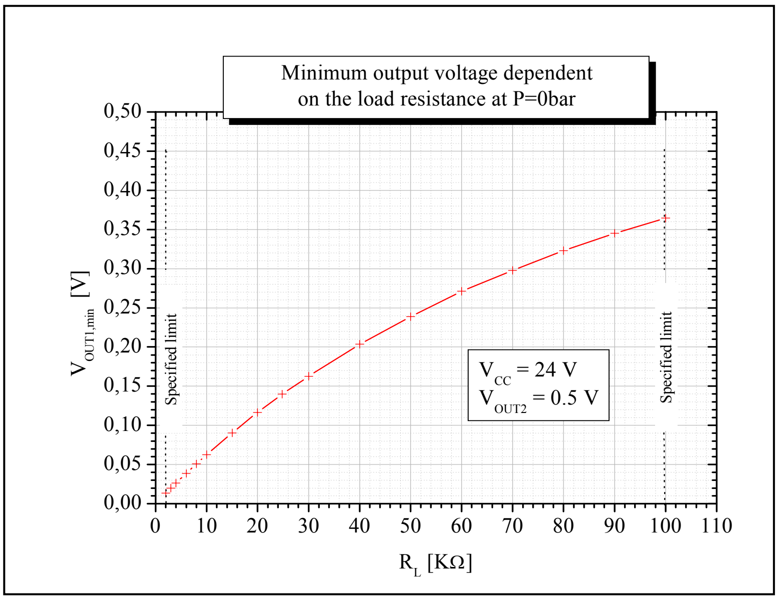

Figure 3: Offset voltage dependent on the load resistance

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The system power consumption (pressure sensor MS5812 and AM461) was also determined dependent on the load resistance R_L. Figure 4 gives the power consumption of SM5812 superimposed onto that of AM461, where at ca. 6 mA the power consumption of the pressure sensor is independent of the load resistance.

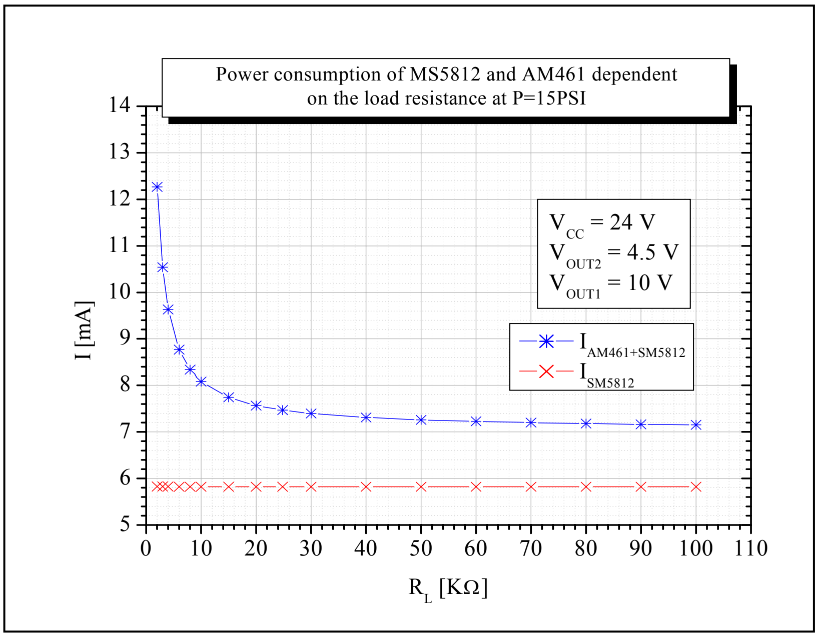

Figure 4: Power consumption dependent on the load resistance

The achievable offset value at the system output min. V_{OUT1} is dependent on load resistance R_L and on the available supply current. In this example, where R_L = 2 kΩ and the supply current = 12.3 mA, an offset value of 20 mA was obtained at the output.

Conclusion

Taking the current consumption of the signal source and the bias current of the IC and thus the related overall power consumption into consideration, it is the system parameters (required temperature range, load resistance, thermal resistance of the IC package and the supply voltage range) which determine which minimum value can be achieved for V_{OUT1}.

Further reading

[1] www.amsys.de
[2] www.analogmicro.de

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