Concentration Measurement with AS6031

How to use the AS6031 Development Kit with a Single Transducer

AS6031 application note

Revision: 1

Release Date: 2022-10-1414

Document Status: Production

Content

AS6031 is an ultrasonic flow converter for the next generations of ultrasonic water and heat meters. It is highly integrated and is based on the TDC-GP30 platform. It uses the same high-performant front-end for driving the transducers and processing the receive signal to extract the time of flight information. An additional programmable amplifier allows handling weaker receive amplitudes.

The AS6031 generic task management is dedicated to flow and therefore operation with a pair of transducers. For concentration measurements one transducer is typically enough as only one time of flight measurement is necessary.

1 Introduction

In this application note you can find the description of how to use the AS6031 Development Kit together with one single transducer for concentration measurement. This document describes the additional components and the connections needed to the Development Kit.

In addition, this application note includes an example of dish soap concentration measurement and guidelines for characterization and calculation of the concentration.

For general description of the usage of the Development Kit please refer to the manual AS6031-QF_DK Development Kit User Guide and the AS6031 Datasheet, which could be found under: https://www.sciosense.com/products/ultrasonic-flow-converters/as6031/.

2 Additional Hardware for AS6031 Development Kit

For operation of one single ultrasonic transducer an analog switch needs to be added to the AS6031 Development Kit.

In the following example an analog switch TS5A3160 is used and connected to the Development Kit. The ultrasonic transducer (Jiakang 2 MHz [PSC2.0M014083H2AD0-B0]) is directly glued to a container and connected to the analog switch.

2.1 Schematics and Wiring Diagram

To enable the operation of the AS6031 Development Kit with single transducer we connect a TS5A3160 analog switch to the GPIO0 and GPIO5 ports. The supply voltage for this switch is also coming from the Development Kit.

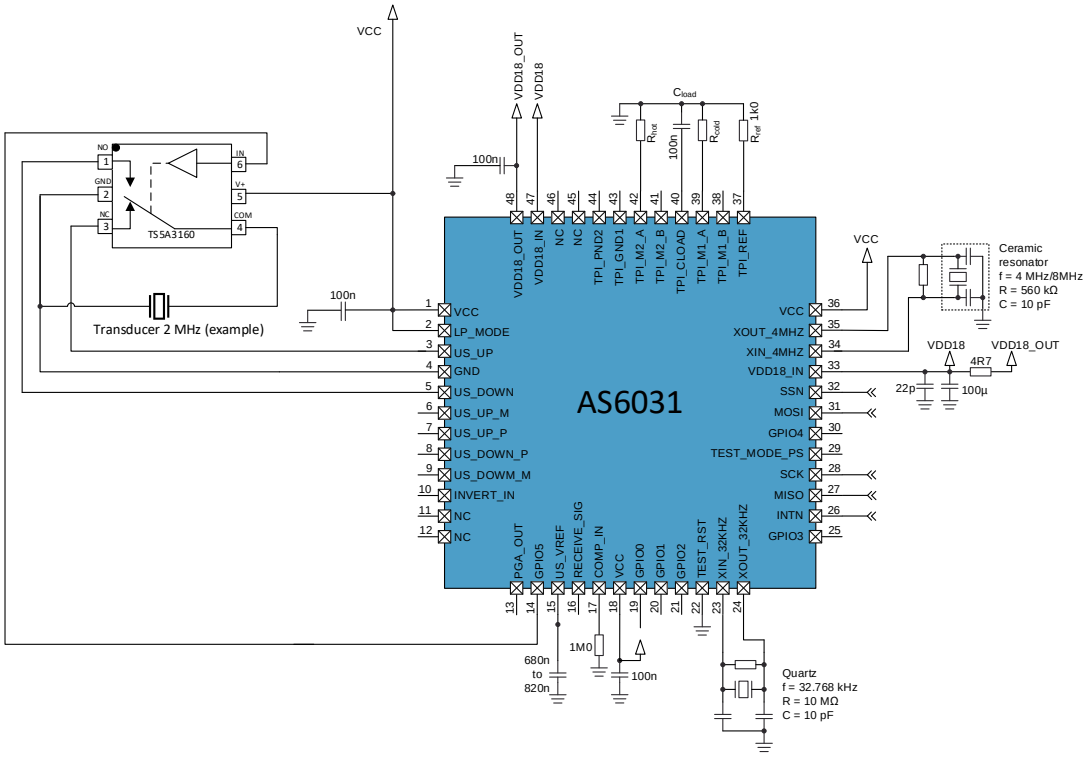


Figure 1: Schematics AS6031 with TS5A3160

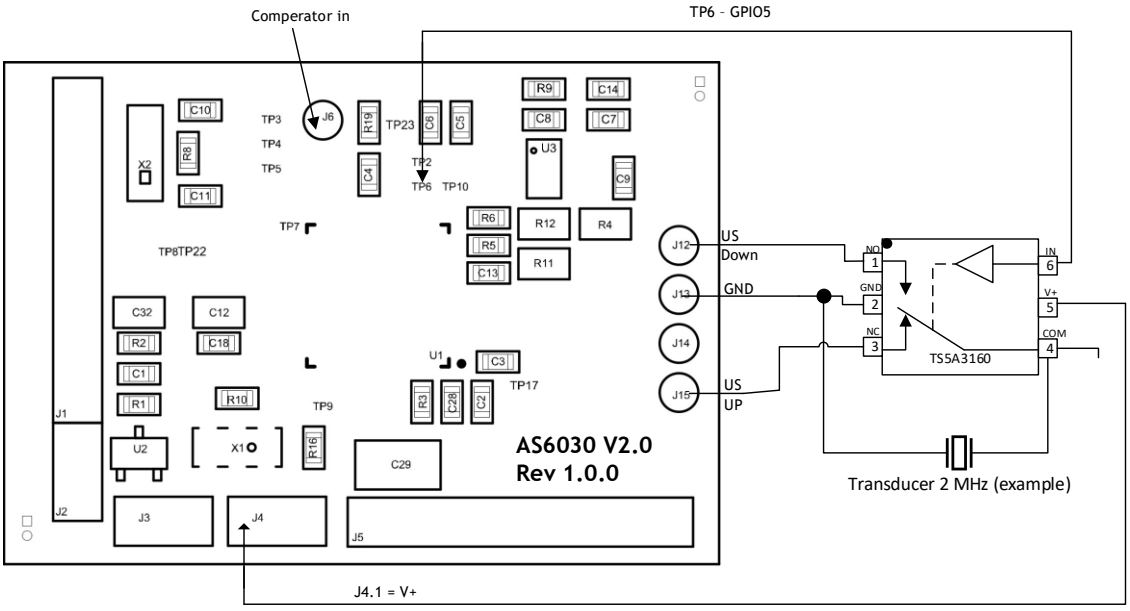


Figure 2: Wiring diagram AS6031 V2.0 Rev 1.0.0 Development Kit with TS5A3160

2.2 Container Box with Transducer

A plastic box of about 3 cm (width) x 3 cm (lengths) x 2 cm (heights) is used as container. The transducer is directly glued to the outside of the box with standard superglue.

Picture 1: Container box with glued on transducer and filled up dish soap

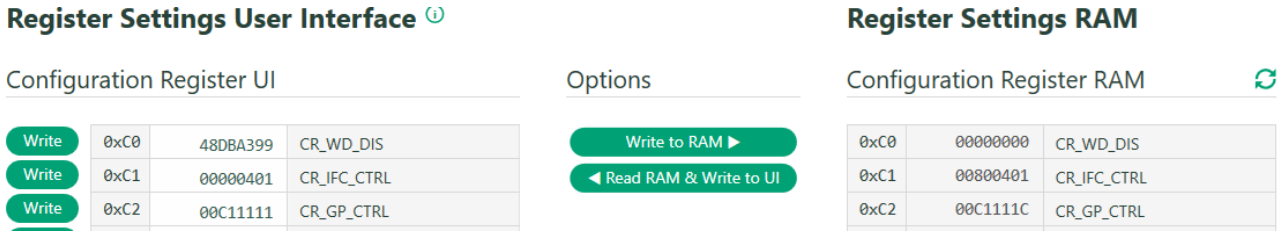
3 Configuration of the UFC Evaluation Software

GPIO configuration needs to be set up with special GPIO settings to enable the single transducer with the analog switch. Those special settings are hidden in the generic GPIO Interface selection, so you need to set the register settings in the register user interface section (see also screen shot below).

You have to manually write the value 0x00C11111 to register 0xC2 (CR_GP_CTRL) in the register tab of the GUI. This sets the GP5 Port to Output (GP5_Dir=b00) and GP5_SEL=b11 to “blank/not used” which in this case is a special functional usage for Ultrasonic Receive Burst Enable. The GP0 to GP4 Ports are all set to b01 (Input Pull Down)

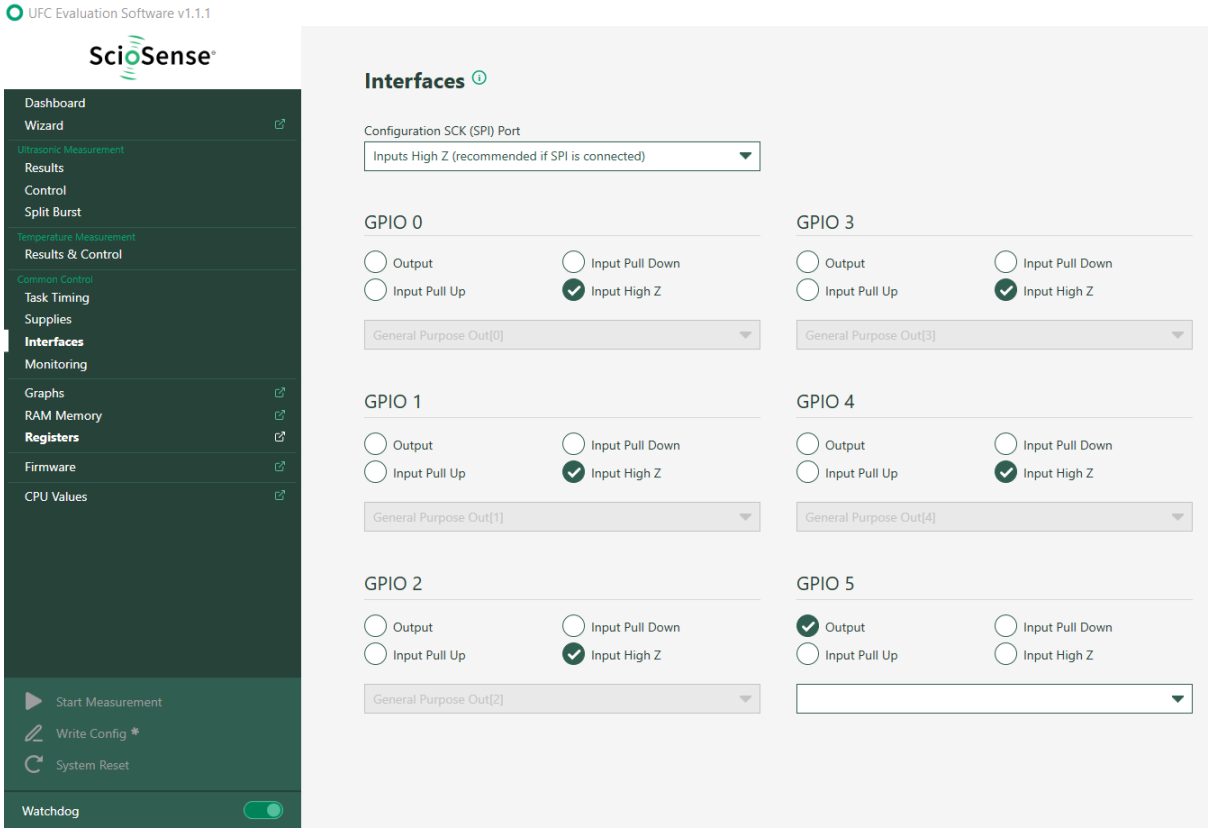
Please also ensure that the Interface Control Register 0xC1 is set to 0x00000401 which sets the inputs to High Z which is recommended when SPI is connected.

The Register Settings User Interface should then look like the following picture:



Screenshot 1: Register Settings User Interface: needed values for operating

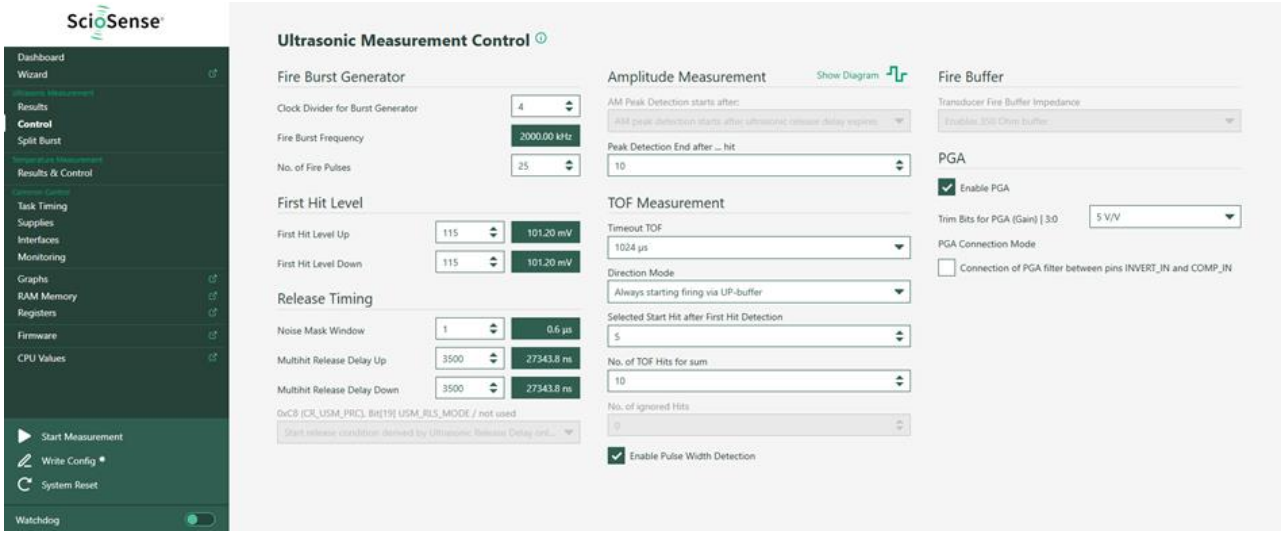
The corresponding Interfaces tab should look like:



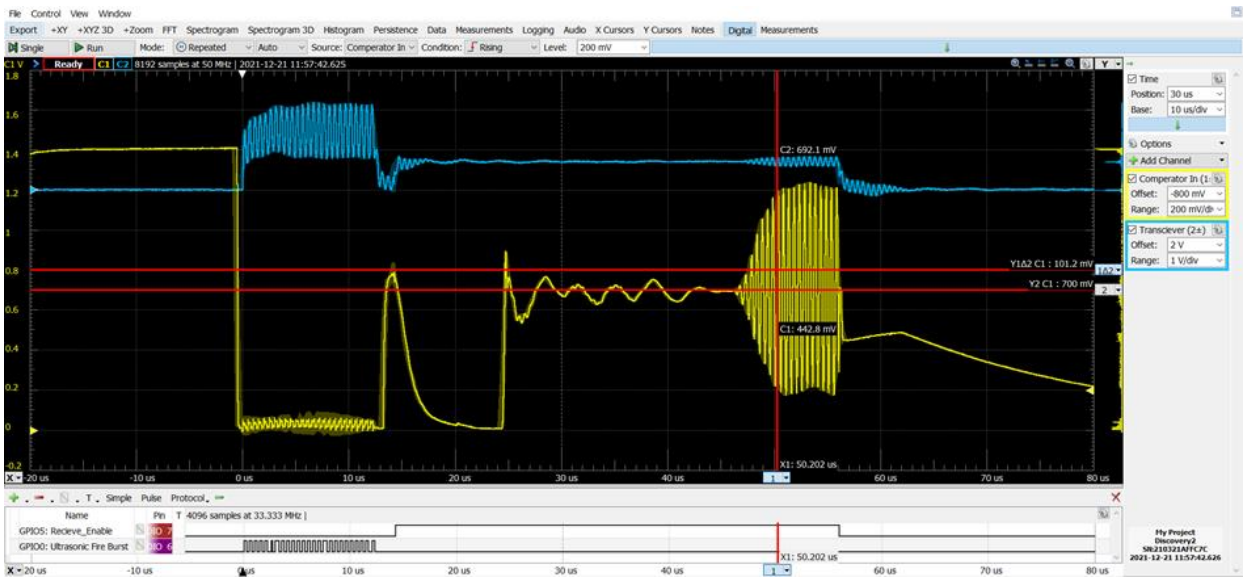
Screenshot 2: Interfaces settings

4 Ultrasonic Measurement Set-up and Transducer Signal

With an Ultrasonic Measurement Control set up similar to the values you can see in Screenshot 3 you should get an oscilloscope picture similar to the Picture 2.



*Screenshot 3: Example Ultrasonic Measurement Control set up when using 3*3*2 cm (w*l*h) box and 2 MHz transducer.*



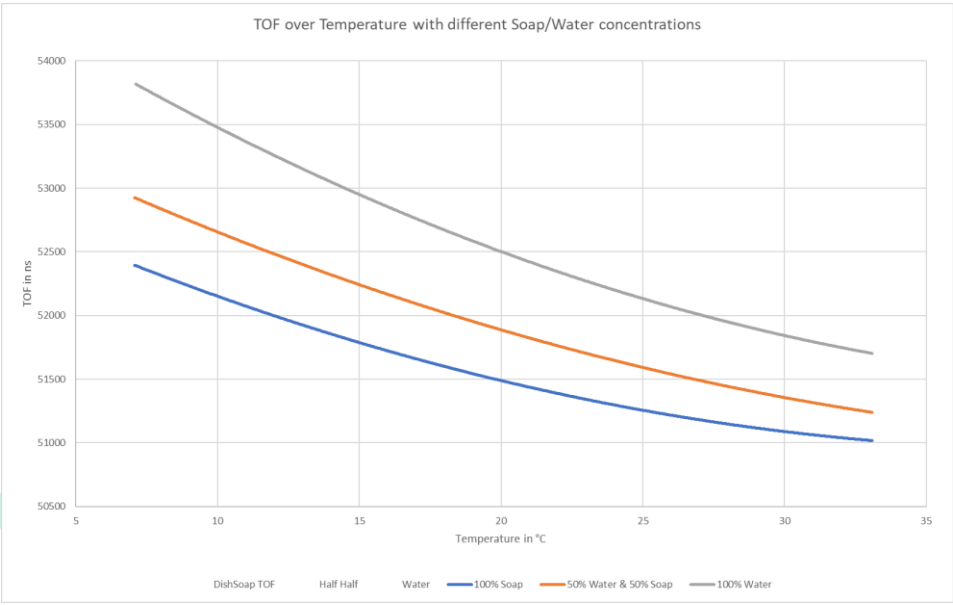
*Picture 2: Example of oscilloscope graph when using 3*3*2 cm (w*l*h) box and 2 MHz transducer.*

Yellow (ch1) is the receiving signal (after internal amplifier) measured on pin J6 of the AS6030-DK Board and blue (ch2) is the fire pulse and receiving signal measured directly on the transducer.

5 Measurement Results and Concentration Calculation

5.1 Example characterization water/dish-soap concentration

A typical soap/water concentration TOF over temperature graph should look like the Picture 3 below. Gray is the curve of 100 % water, orange is half dish soap and half water, blue is 100 % dish soap.



*Picture 3: Example of TOF over temperature at different soap concentration when using 3*3*2 cm (w*l*h) box and 2 MHz transducer.*

The data (TOF, temperature, content concentration) where put into a multiple linear regression calculator and the output for this model was:

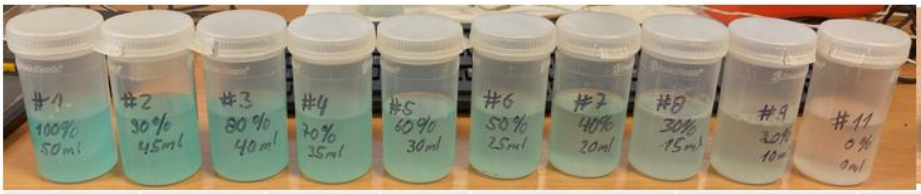
$$Content\ Concentration = 5357.5 - 6.462 * \text{Temperature} - 0.09964 * \text{TOF}$$

5.2 Verification with Different Soap Concentrations

For verification of the formula 9 premixed soap-water mixtures were used. Due to availability of the original dish soap used in the characterization a different colorized dish soap from the same brand was used.

The testing was started after about 3 hours of mixing the different soap-water concentrations, to assure stable temperature conditions. The testing was done without permanent measurement of the content temperature. It was only measured once directly after poring the premixed sample into the container box with an IR thermometer. For measuring the TOF the UFC Evaluation Software [Label Name: TOF Sum Average Up (ns)] was used.

Test results:



Soap concentration [%]	Water amount [ml]	Soap amount [ml]	Canister Sample Nr.	Temperature measured with IR Thermometer [°C]	TOF [ns] 10-30sec after pouring	TOF difference to Water [ns]	Calculated Concentration´* [%]	Deviation [%]
100	0	50	1	17.2	51687	-942	96	-4
90	5	45	2	17.2	51802	-827	85	-5
80	10	40	3	17.2	51905	-724	75	-5
70	15	35	4	17.2	52031	-598	62	-8
60	20	30	5	17.2	52077	-552	58	-2
50	25	25	6	17.2	52180	-449	47	-3
40	30	20	7	17.2	52237	-392	42	2
30	35	15	8	17.2	52271	-358	38	8
0	50	0	11	17.2	52629	0	3	3

*= Calculated concentration is based on "white Soap" Data: percentage = 5357,6 - 6,462*Temperature - 0,09964*TOF

*Picture 4: Test results of different concentrations when using 3*3*2 cm (w*l*h) box and 2 MHz transducer.*

We could show that even with the slightly different dish soap there is a good correlation between the calculated concentration and the real concentration. During the testing of each sample it could be seen that there is a small drift in the TOF data which could be an effect of temperature changes/balancing between the poured in sample and the container box. So when having temperature differences and/or temperature changes a measurement of the temperature should be done in parallel to the TOF data.

6 Summary

With this application note we could verify that in principle the AS6031 Development Kit board in combination with an analogue switch and single transducer provides a compact solution for concentration measurement.

The AS 6031 has a very high resolution and accuracy for time measurement, however the accuracy in applications like concentration measurement is mostly based on the accuracy of the transfer function.

In this application note a simple linear regression was used, for higher accuracy a better model/ transfer function (e.g. lookup table) could be used.

Keep in mind that the TOF Values are changing with temperature. Therefore, you need to make sure that you have stable concentration mixture conditions (both mixtures at same temperature or wait until the mixture is temperature stabilized). For better accuracy it could be that you need to have a permanent temperature measurement directly in the concentration.

7 Copyrights & Disclaimer

Devices sold by ScioSense B.V. are covered by the warranty and patent indemnification provisions appearing in its General Terms of Trade. ScioSense B.V. makes no warranty, express, statutory, implied, or by description regarding the information set forth herein. ScioSense B.V. reserves the right to change specifications and prices at any time and without notice. Therefore, prior to designing this product into a system, it is necessary to check with ScioSense B.V. for current information. This product is intended for use in commercial applications. Applications requiring extended temperature range, unusual environmental requirements, or high reliability applications, such as military, medical life-support or life-sustaining equipment are specifically not recommended without additional processing by ScioSense B.V. for each application. This product is provided by ScioSense B.V. “AS IS” and any express or implied warranties, including, but not limited to the implied warranties of merchantability and fitness for a particular purpose are disclaimed.

ScioSense B.V. shall not be liable to recipient or any third party for any damages, including but not limited to personal injury, property damage, loss of profits, loss of use, interruption of business or indirect, special, incidental or consequential damages, of any kind, in connection with or arising out of the furnishing, performance or use of the technical data herein. No obligation or liability to recipient or any third party shall arise or flow out of ScioSense B.V. rendering of technical or other services.

8 Revision information

Table 1: Revision history

Revision	Date	Comment	Page
1	14.10.2022	First edition	All

Note(s) and/or Footnote(s):

1. Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
2. Correction of typographical errors is not explicitly mentioned.

Address: Sciosense B.V.
High Tech Campus 10
5656 AE Eindhoven
The Netherlands

Contact: www.sciosense.com
info@sciosense.com