Introduction

The superior gas sensing capability of IDT’s SGAS line of solid-state gas sensors is best realized though a precision analog front-end circuit design that incorporates low-noise, high-accuracy heater control and resistance measurement. The reference design shown in this application note corresponds to circuitry used in the electronic module included as part of the SMOD7xx Evaluation Kit, which can be used to evaluate IDT’s SGAS701, SGAS707, and SGAS711 sensors. See Figure 1 for the reference design circuit and the locations of the components and signals discussed in the following sections.

Circuit Description

Two voltage-controlled constant-current drivers separately drive the heater and sensor current. U1 and Q1-A force a voltage drop across R1 equal to $V_{input}$. The current $i_{R1}$ through the R1-Q1A-R2 network is consequently fixed at a value proportional to $V_{input}$ as calculated with Equation 1.

$$i_{R1} = i_{Q1-A} = i_{R2} = \frac{V_{input}}{R1}$$  \hspace{1cm} \text{Equation 1}

The voltage drop across R2 is determined via Equation 2:

$$V_{R2} = i_{Q1-A} \times R2 = \frac{V_{input}}{R1} \times R2$$  \hspace{1cm} \text{Equation 2}

The voltage drop across R3, which is controlled by U2 and Q1-B, is the same as the drop across R2 as shown in Equation 3:

$$V_{R3} = \frac{V_{input}}{R1} \times R2 = i_{R3} \times R3$$  \hspace{1cm} \text{Equation 3}

Solving the right-side of the equality in Equation 3 for $i_{R3}$ gives Equation 4:

$$i_{R3} = \frac{V_{input} \times R2}{R1 \times R3}$$  \hspace{1cm} \text{Equation 4}

The R1 through R3 resistor values given in the reference design circuit bill-of-materials (BOM) listed in Table 1 produce the voltage-to-current relationship shown in Equation 5:

$$i_{R3} = V_{input} \times 0.06032$$  \hspace{1cm} \text{Equation 5}

At $V_{input} = 2.5V$, the heater current is equal to approximately 151mA, which is enough to operate all SGAS7xx sensor types. Tests of the above circuit have shown current-drive accuracy of better than 1% for currents across a range of 5mA to 150mA.

The sensor current drive circuit shown in the top half of Figure 1 operates the same as the heater drive circuit, but within a much smaller current range set by R4 through R6. At $V_{input} = 2.5V$, the heater current is equal to approximately 41.5µA. Applying this current to a gas sensor having a resistance of 50kΩ would result in a voltage of approximately 2.07V.

Designers using this reference design as the basis for modified circuits should keep the following in mind:

- Amplifiers operate at or near the supply rails in most cases, requiring use of rail-to-rail type amplifiers.
- Heater amplifiers must be voltage compliant with the heater-drive voltage, which can go as high as 7V.
- Currents (particularly in the sensor driver) are very small. Ensure that the input bias current is small enough that it does not significantly subtract from the targeted drive current.

This reference design takes into consideration requirements for compatibility with MCU applications. Additional circuit elements (such as signal filtering and attenuation) are purposely not included in Figure 1 since design of these elements is specific to the MCU selection and other application driven requirements.
Figure 1. SMOD Analog Front End Reference Design

Output current = Vin * 0.06032
Constant Current Heater Driver

Output current = Vin * 1.666e-5
Constant Current Sensor Driver

C2
4.7uF

R3
4.99

Q1-A
DMC2700UDM

Q1-B
DMC2700UDM

U1
LPV511MG

C1
0.01uF

C3
0.01uF

C4
0.1uF

R2
30.1k

R4
10.0k

R1
100k

U2
LPV511MG

U3
LPV511MG

U4-A
LTC6081IMS8

U4-B
LTC6081IMS8

9V
+3.3V

SENSOR_VOLTAGE_OUT

SENSOR_CURRENT_DRIVE_IN

HEATER_CURRENT_DRIVE_IN

HEATER_VOLTAGE_OUT
Table 1. Bill of Materials

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<th>Reference</th>
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Revision History

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<td>October 19, 2017</td>
<td>Initial release</td>
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