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Low Noise or Low Power? Yes!

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Introduction

A survey of MEMS accelerometers reveals that the lowest noise and lowest power are not available in the same product at this time. When comparing a low noise accelerometer, such as the ADXL355, with a popular low power accelerometer, the ADXL355 presents the following trade-offs:

- At 20 μ*g*/Hz^½, the noise density is 9× lower.
- At 338 μW, the power dissipation is ~13× higher.

For applications that will *power cycle* their sensors to save energy when they are not in use, the noise/power relationship can actually be quite different. This difference comes from a source that may be surprising to some: settling time. In applications that need to average a sequential array of sensor data to achieve key uncertainty criteria, the time it takes to fill that array has a direct impact on the overall settling time. For example, the Allan Variance curve in the ADXL355 data sheet suggests that an averaging time of 0.01 seconds will reduce its uncertainty to less than 100 μ*g*. Achieving a similar level of uncertainty in the low power sensor will require an averaging time that is 81 times longer than the ADXL355, since noise reduction in an averaging filter is proportional to the square root of the averaging time.

Equation 1 and 2 quantifies this trade-off in terms of the energy it takes for each sensor/filter combination to support this level of precision in a single data record. The results of this estimation are quite interesting, because the much shorter averaging time ($t_{LP} = 81 \times t_{ADXL355}$) causes the energy requirement for the ADXL355 ($E_{ADXL355}$) to be six times lower than the energy requirement for the low power component (E_{LP}).

$$\begin{aligned} E_{ADXL355} &= t_{S355} \times V_{MIN355} \times I_{355} \\ E_{ADXL355} &= 0.01\ s \times 2.25\ \text{V} \times 0.00015\ \text{A} = 3.38\ \mu\text{J} \end{aligned} \tag{1}$$

$$\begin{aligned} E_{LP} &= t_{LP} \times V_{LP} \times I_{LP} \\ E_{LP} &= 81 \times t_{S355} \times V_{LP} \times I_{LP} \\ E_{LP} &= 81 \times 0.01\ s \times 2\ \text{V} \times 0.000013\ \text{A} = 21.1\ \mu\text{J} \end{aligned} \tag{2}$$

Equation 3 captures the power dissipation that will come from these energy levels, with respect to the time between each measurement (T).

$$\begin{aligned} P_{ADXL355} &= \frac{E_{ADXL355}}{T} = \frac{3.38\ \mu\text{J}}{T} \\ P_{LP} &= \frac{E_{LP}}{T} = \frac{21.1\ \mu\text{J}}{T} \end{aligned} \tag{3}$$

The graphical view of this relationship (Figure 1) offers a couple of interesting observations. First, at measurement cycle times (T) that are lower than 0.81 seconds, the low power device will support continuous operation. Second, for measurement cycle times that are greater than ~0.13 seconds, the ADXL355 solution will consume less power. The bottom line is that with an open mind, sometimes we can achieve the lowest power *solution*, by using the lowest noise (highest performing) *components*.

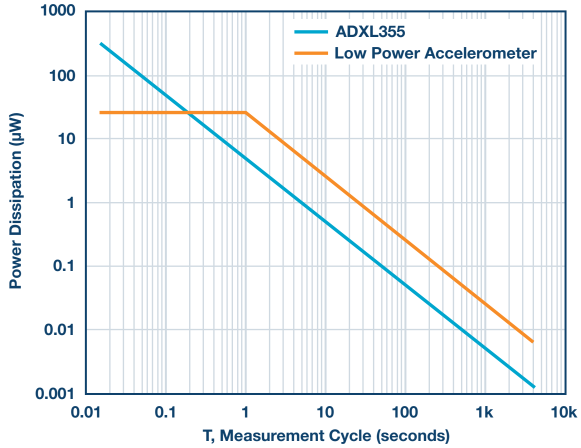

Figure 1. Power dissipation vs. measurement cycle time.

About the Author

Mark Looney is an *i*Sensor® applications engineer at Analog Devices in Greensboro, North Carolina. Since joining ADI in 1998, he has accumulated experience in sensor-signal processing, high speed analog-to-digital converters, and dc-to-dc power conversion. He earned a B.S. (1994) and an M.S. (1995) degree in electrical engineering from the University of Nevada, Reno, and has published several articles. Prior to joining ADI, he helped start IMATS, a vehicle electronics and traffic solutions company, and worked as a design engineer for Interpoint Corporation. He can be reached at *mark.looney@analog.com*.

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