

$\pm 1.5g$ Dual Axis Micromachined Accelerometer Power Supply Rejection Ratio (PSRR) Suggestions

by: Peter Schultz
Product Engineer

COMPONENT DESCRIPTION

The MMA6200Q series is a two axis (X and Y) accelerometer family with sensitivity parallel to the device's mounting plane. The device utilizes variable capacitance sensing elements and a two-channel interface IC all in a 16-pin QFN package.

This section provides a general description of the device power supply rejection ratio (PSRR), how it affects device performance, and suggestions for improvement.

INTRODUCTION TO POWER SUPPLY

Rejection Ratio

The power supply rejection ratio is a measure of how well the device rejects the noise on the power supply line. The MMA6200Q series is capable of being used in several different applications. In some cases it may be possible for supply line noise to adversely affect the output signal. This phenomenon can create large output signals when the supply line noise frequencies are roughly equal to the device's oscillator frequency and/or harmonics. The oscillator drives the g-cell sampling as well as the internal low pass filter. When the difference between the frequency of the noise on the supply and the oscillator frequency is less than the low pass filter cutoff frequency the aliased signal passes through the filter. This aliased signal is then amplified internally by the device creating an even more adverse effect. This noise at the output can be as much as ten times the amplitude of the input noise at the oscillator frequency or its harmonics.

IMPROVING THE POWER SUPPLY

Rejection Ratio

If the power supply contains noise approaching the oscillator frequency, large amounts of noise may be observed at the output of the device. This does not become an issue until the noise frequency is a little larger than the oscillator frequency; a little larger here meaning still within the internal low pass filter's bandwidth. In application a simple low pass

filter at the input helped to resolve this issue by attenuating much of the offending noise before it enters the device.

A simple two element low pass filter at the input of the device, made up of a resistor in series with a capacitor in shunt with V_{dd} , works rather well (see [Figure 1](#)).

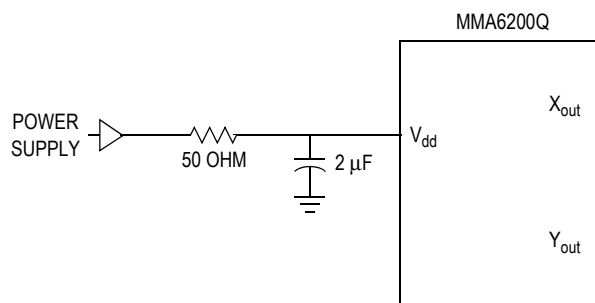


Figure 1. RC Input Loading for PSRR at V_{dd}

With this combination of a 50 ohm resistor and a 2 μF capacitor there is a large reduction in the PSRR, roughly 10X. This is now well below unity gain; meaning at the output of the device there is noticeably less noise than was supplied to the device, at the oscillator frequency and/or its harmonics. The first harmonic is at the oscillator frequency of roughly 15 KHz. The following illustration shows the effect on the PSRR when placing different values of capacitance at the input and retaining the 50 ohm resistor. There is six harmonics represented in the illustration the first of which is at about 15 KHz. These data points at the different harmonics represent the ratio of the output noise to the input noise. Depending on the application needs one can use this illustration to help determine the capacitive needs for the filter (see [Figure 2](#)). The plot is given in Log scale.

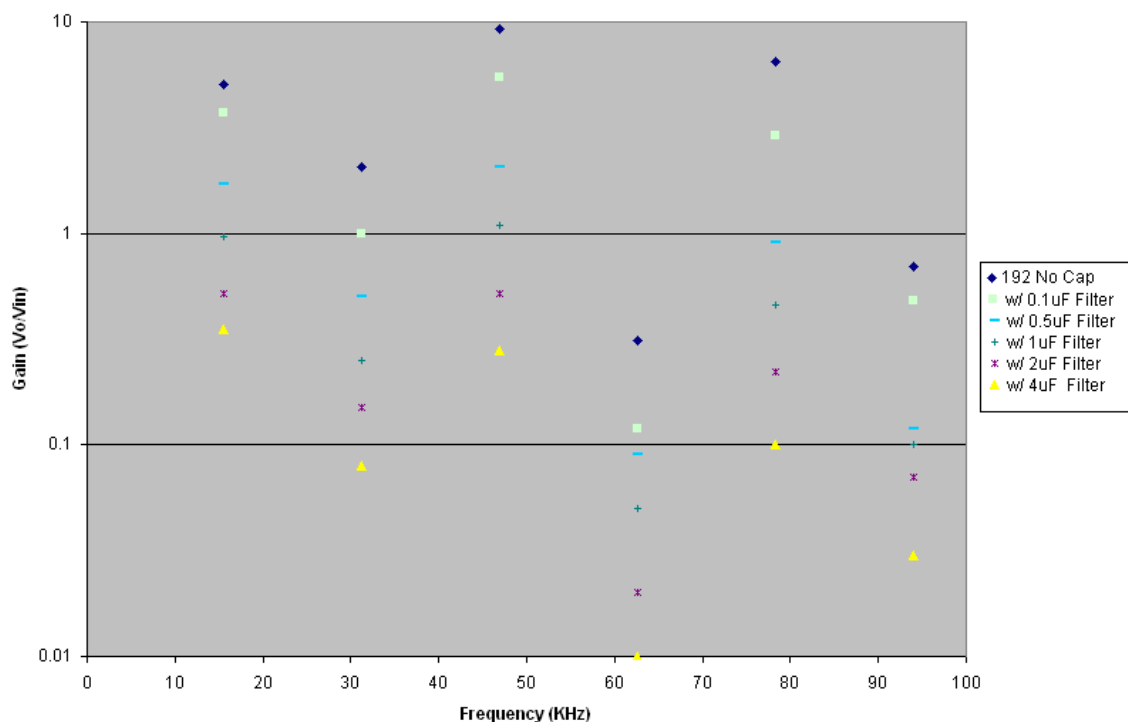


Figure 2. PSRR with 50 Ohm and Varying Input Capacitance

One can see the PSRR has improved by roughly a factor of 10 with a 2 μF capacitor at the input. Not only can the plot be used as a guide in the design of an input filter, it can also help put in perspective the possible amplitudes of the signal and about what frequencies they may occur. From looking at the plot one can see that for a capacitance of 1 μF the gains at the two most predominate noise frequencies is unity. This means the aliased signals will not be larger in amplitude than the input noise that created it; giving the recommended smaller capacitance filter in the following illustration (see Figure 3).

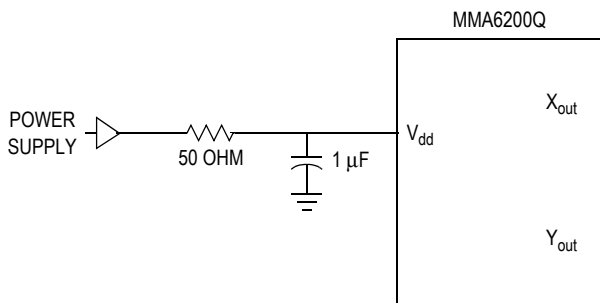


Figure 3. Recommended RC Input Loading for PSRR at V_{dd}

With cost as one of the deciding factors, this is a recommended filter design for reducing the PSRR. One should note however that variations in the individual devices and the different axes of the device produce plots that may look significantly different. The intent here is only to give an idea of the effects of different capacitances on the oscillator induced frequency gains. One must also remember to absorb any impedance the source may have into the RC filter as the source will also add its own impedance to the network.

If the series resistance and/or reactance is increased the amount of noise at the output will be decreased. The series reactance can be increased with the use of an inductor in series with the resistor (see Figure 4). This is more advantageous than adding more resistance due to the fact that it does not produce a large DC voltage drop.

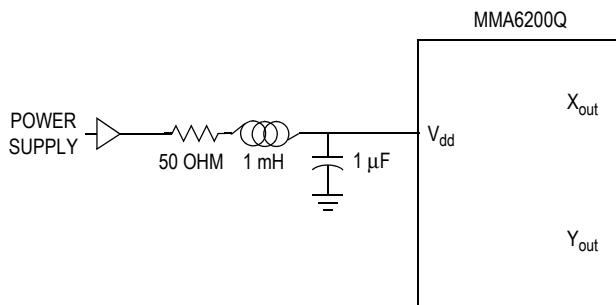


Figure 4. Recommended RCL Input Loading for PSRR at V_{dd}

The device was designed to operate with 3.3 Vdc at V_{dd} . If this input voltage is allowed to drop by more than half a volt the device may not operate correctly; hence the use of an inductor. With the use of an application board there was found to be greater than a factor of two drop in the output noise at the first harmonic with the use of the 1 mH inductor. The later harmonics incur a larger improvement due to the higher reactance of the inductor at the higher frequencies. As a result there was greater than a factor of eight improvement with the third and fifth harmonics. This RC and RLC circuit produced the following PSRR plot (see Figure 5).

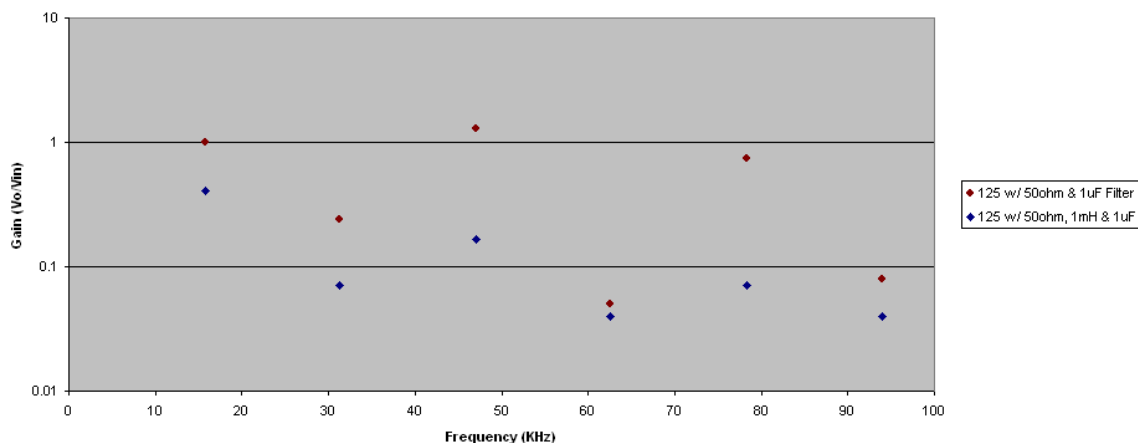


Figure 5. PSRR with RC and RLC Input Filter

If a smaller capacitance is desired in application with no inductor one can increase the value of just the series resistor. However one must take into consideration the tradeoffs involved. In order to get roughly the same improvement in the PSRR with a 0.5 μ F capacitor as there was with the 50 ohm and 2 μ F RC combination one must increase the series impedance to 150 ohms (see Figure 6).

This alternate RC circuit produces the following effect on the PSRR (see Figure 7). Notice the similarity in the gain when compared with the 50 ohm 2 μ F filter. It is still well below unity for this configuration.

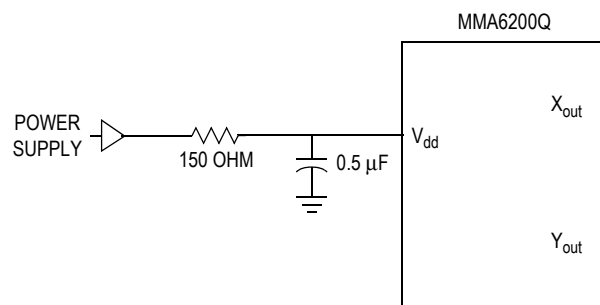


Figure 6. Alternate RC Input Loading for PSRR at V_{dd}

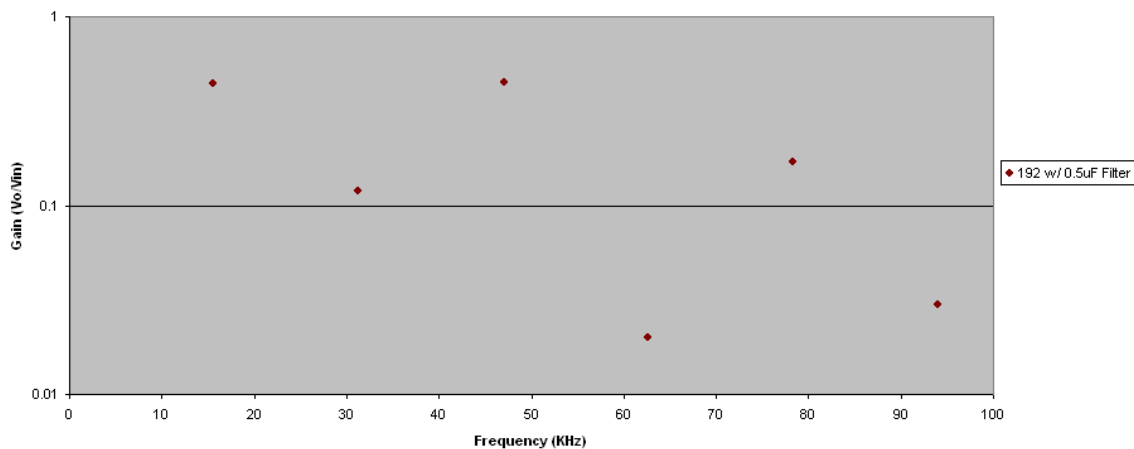


Figure 7. PSRR with 150 Ohm and 0.5 μ F Input Capacitance

As stated before this large value of resistance creates a DC voltage drop at the input of the device. However, it could be reduced some and still achieve less than unity gain. With the same voltage at the input of the filter the output voltage of the device is lowered. In this case it drops by roughly 5 percent. In turn, this loss in DC voltage also lowers the ratio-metric error. However if the voltage at Vdd is allowed to drop much lower than 2.7 volts the device may not operate at all. If cost and space permits, one should consider, as stated previously, the substitution of a series inductor in place of at least part of this series resistance. This can greatly decrease the DC voltage drop problem.

To get a 150 ohm impedance at the frequency of the first harmonic we have $X = 2\pi \cdot (15 \text{ KHz}) \cdot L = 150 \text{ ohm}$. Solving for L gives the somewhat large value of 1.6 mH for the

inductor. A 1 mH inductor at 15 KHz has an impedance of about 95 ohms and these devices can be had in quantity (1000 or more) for less than twenty cents each.

CONCLUSION

The MMA6200Q series family of devices require external RC and possibly L components to correct power supply rejection ratio issues caused by noisy power supply lines. This may not be of concern in many applications; however, it may be in some. The preceding gives an introduction to power supply rejection ratio as well as some information to better understand this potential problem. Also included are some example filters, the effects on PSRR, as well as suggested choices.

NOTES

NOTES

NOTES

How to Reach Us:

Home Page:

www.freescale.com

E-mail:

support@freescale.com

USA/Europe or Locations Not Listed:

Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
+1-800-521-6274 or +1-480-768-2130
support@freescale.com

Europe, Middle East, and Africa:

Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:

Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:

Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

For Literature Requests Only:

Freescale Semiconductor Literature Distribution Center
P.O. Box 5405
Denver, Colorado 80217
1-800-441-2447 or 303-675-2140
Fax: 303-675-2150
LDCForFreescaleSemiconductor@hibbertgroup.com

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals", must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.

Freescale™ and the Freescale logo are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners.

© Freescale Semiconductor, Inc. 2005. All rights reserved.