SYSTEM REPORTER

TECHNICAL NOTE #2

Resolution and noise in accelerometers

- Resolution and noise when measuring acceleration in low frequencies
- Two different accelerometers and 2 different A/D converters

Two different Analog/Digital (A/D) converters are used in the study:

- 12 bits (current industry standard)
- 16 bits

A higher bit rate enables more accurate measurements (see Analog/Digital converter below).

Table of contents

Introduction

Vibrations in e.g. revolving machinery are often measured using accelerometers, which delivers an output current which is proportional to the acceleration that the object to be measure is subjected to.

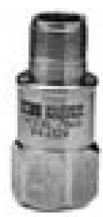
Measuring the acceleration at higher frequencies is typically quite easy since the acceleration is relatively large. At low frequencies in the range of 1 - 10 Hz, the acceleration is small, which makes measuring the acceleration accurately more difficult.

This document describes a study on resolution and noise when measuring acceleration in low frequencies, using two different accelerometers (see Materials below for a detailed description of the accelerometers used):

- a standard multi-purpose accelerometer.
- a more expensive low frequency accelerometer.

Materials

The accelerometers used for this study:



1. Wilcoxon[1] 786 (called 786 in this document):
   - Sensitivity: 100 mV/g
   - Frequency range: 1 – 8000 Hz (±10%)
   - Noise at 1 Hz: 30 µg/Hz
   - Noise at 10 Hz: 10 µg/Hz
   - Price: Approx. US $ 200

2. Wilcoxon[1] 797LF (called 797 in this document):
   - Sensitivity: 500 mV/g
   - Frequency range: 0.3 – 1200 Hz (±5%)
   - Noise at 1 Hz: 3 µg/Hz
   - Noise at 10 Hz: 1 µg/Hz
   - Price: Approx. US $ 450

As can be seen from the data above, the noise is decreased when the frequency increases.

Definitions

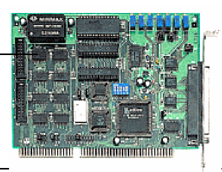
Resolution

Resolution refers to the smallest change in acceleration that can be measured, and is related to the number of bits in the A/D converter (see Analog/Digital converter below).

Noise

Noise is random variations that are not related to the vibrations measured. The major source of noise when measuring vibrations originates from the electronic components used. All electronic components produce noise.

Analog/Digital converter



[1] www.wilcoxon.com

The alternating current from the accelerometer is transformed into digital for (i.e. into numbers) in the computer using a Analog/Digital (A/D) converter, which is typically a card in the computer.

An A/D converter works with a predefined number of bits that are used when sampling the input currents into digital form. With A/D converter using:

- 12 bits, the input current is divided into 4096 levels.
- 16 bits, the input current is divided into 65536 levels.

Let's assume that the input current range for the A/D converter is ± 5 V, and that the accelerometer delivers an output 0 – 5 V. With A/D converter using:

- 12 bits, the 0 to 5 V is divided into 2047 levels.
- 16 bits, the 0 - 5 V is divided into 32767 levels.

AMPLIFICATION

An accelerometer produces an alternating current as output. This current is often amplified several times. The amplification is typically called GAIN. Note that during amplification the noise is also amplified.

VELOCITY

The data from an accelerometer is displayed in the unit g (1 g = 9.81 m/s^2). For each frequency the acceleration is converted into velocity (unit: mm/s).

Calculation of resolution and noise

The output from the accelerometer is given as mV/g. After amplification the signal is transferred to the A/D converter. By using the amplification, the output current range and the number of bits in the A/D converter as described in Analog/Digital converter above, it is possible to calculate the resolution.

Upplösningen fås i acceleration (g). För frekvenserna 1 – 10 Hz räknar vi om acceleration till hasthet så att vi får upplösningen även i hastighet.
In Appendix A - D, diagram 3-14, visar ena kurvan beräkningar av upplösning för hastighet. I diagram 3 anges '0,30mg givare', upplösningen i acceleration.

För givaren 797LF anges bruset till 3 mikrog vid 1Hz, 1 mikrog vid 10 Hz, brus per Hz.
För givaren 786 är bruset 10 gånger större,
30 mikrog vid 1Hz, 10 mikrog vid 10 Hz, brus per Hz. I ovan nämnda bilagor finns
bruset för acceleration omräknat till hastighet. Vid kurvan för brus anges bruset i mg.

Conclusions

Figure 1 and Figure 2 contains a summary of the results shown in Appendix A - D. The results show that for a given amplification the resolution and noise are equal.
Vi får följande förstärkningar och maximum av upplösning,brus.

Table 1

För givaren 786 med 12 bitars A/D-omvandlare är upplösning och brus lika för
förstärkningen 30 gånger.

The results from this study clearly show that:

- a 16 bit A/D converter
- an accelerometer designed for low frequencies

are required in order to perform accurate vibration measurements at low frequencies.

Transducer	Bits in A/D	GAIN	Max g	Max av upplösning, brus		
				acc (mg)	1 Hz (mm/s)	4 Hz (mm/s)
786	12	10	5	2.4	4	1
786	12	30	1.7	0.9	1.5	0.3
786	16	10	5	0.15	0.5	0.1
797LF	12	4	2.5	1.2	2.0	0.5
797LF	12	10	1	0.5	0.8	0.2
797LF	16	4	2.5	0.08	0.12	0.03
797LF	16	10	1	0.03	0.05	0.01

Table 1. Caption. Max g is the highest measurable acceleration.

Den billigare givaren (200$) kräver 16-bitars analog/digitalomvandlare för att ge ungefär samma prestanda som den dyrare givaren (450$) med 12-bitars analog/digitalomvandlare vid låga frekvenser. Industristandard är 12-bitars analog/-digitalomvandlare.

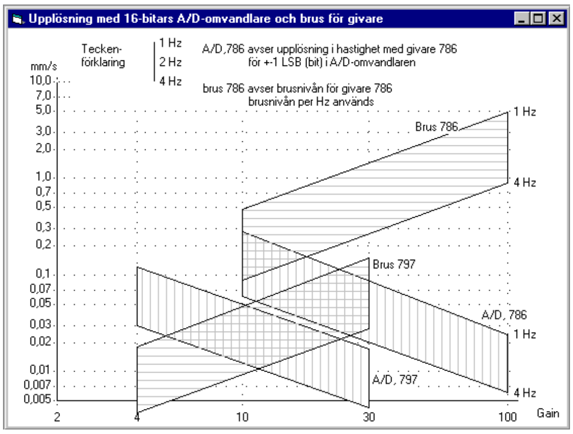


Figure 1. Summary for 16 bit A/D converter for transducer 786 (right) and 797 (left)

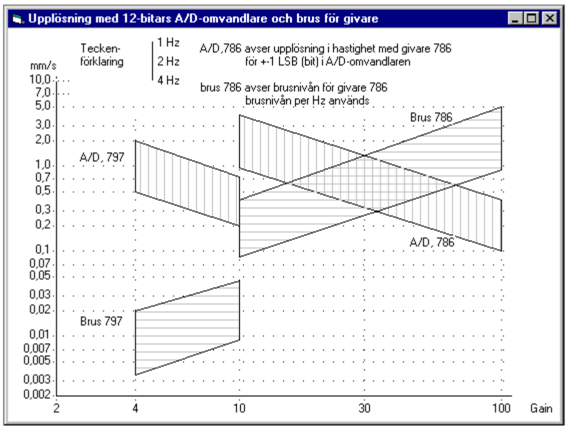


Figure 2. Summary for 12 bit A/D converter for transducer 786 (right) and 797 (left).

Appendix A. Resolution and noise for 786 with 16 bit A/D

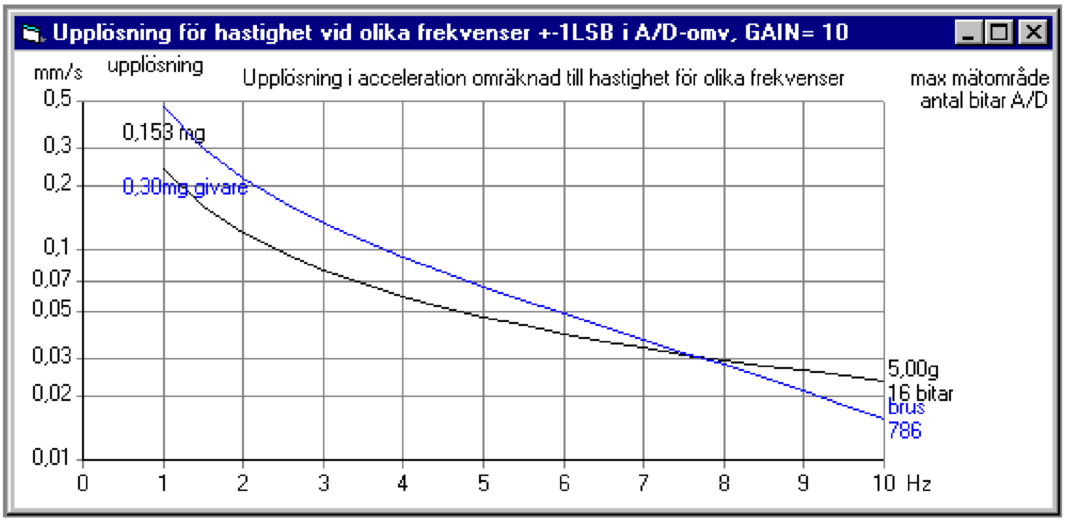


Figure 3. Transducer 786 with 16 bit A/D and GAIN 10. Black curve = resolution. Blue curve ("Brus") = noise.

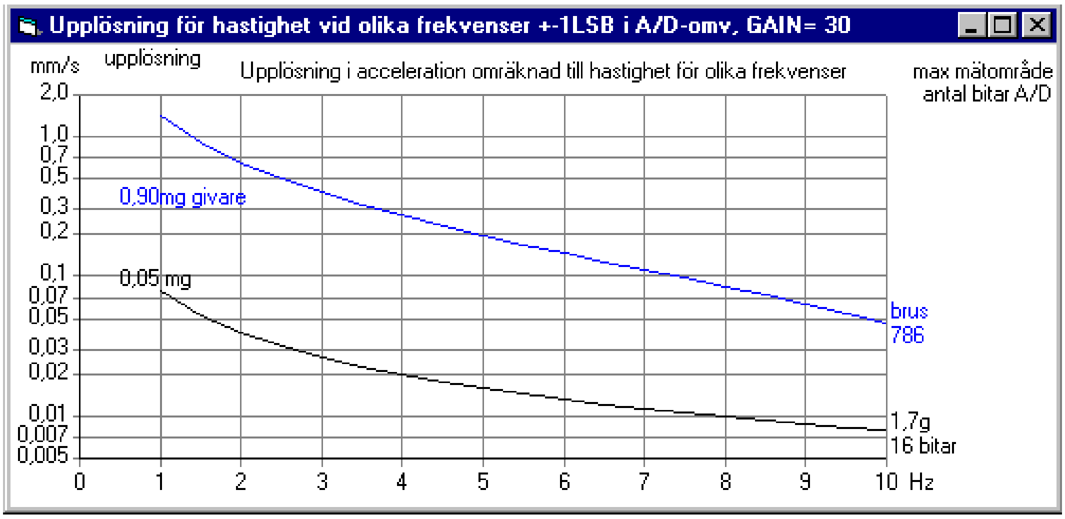


Figure 4. Transducer 786 with 16 bit A/D and GAIN 30. Black curve = resolution. Blue curve ("Brus") = noise.

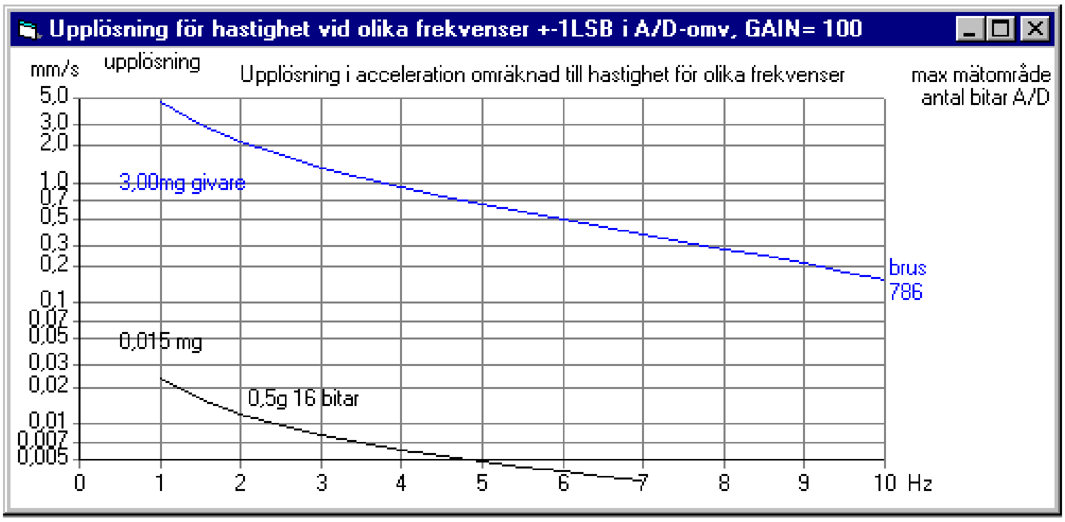


Figure 5. Transducer 786 with 16 bit A/D and GAIN 100. Black curve = resolution. Blue curve ("Brus") = noise.

Appendix B. Resolution and noise for 797 with 16 bit A/D

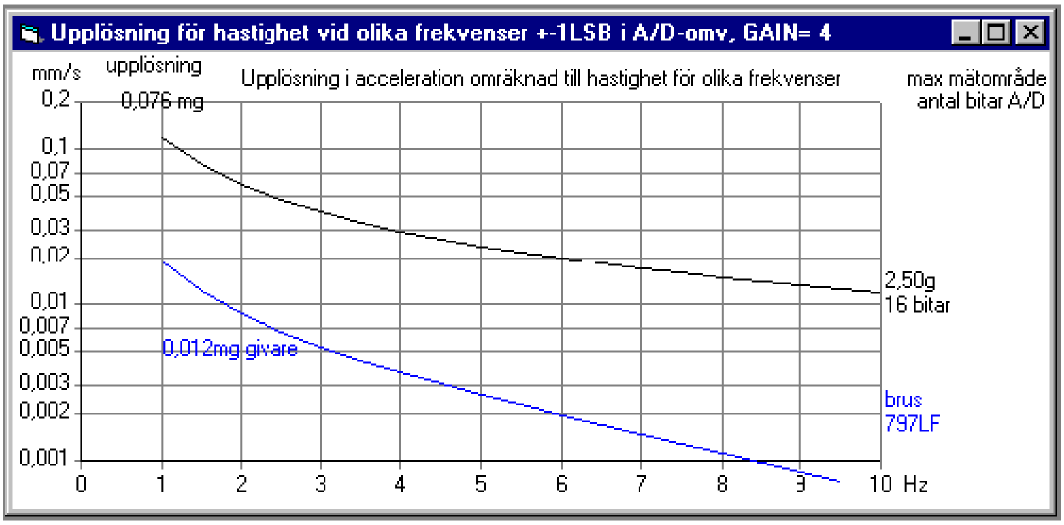


Figure 6. Transducer 797 with 16 bit A/D and GAIN 4. Black curve = resolution. Blue curve ("Brus") = noise.

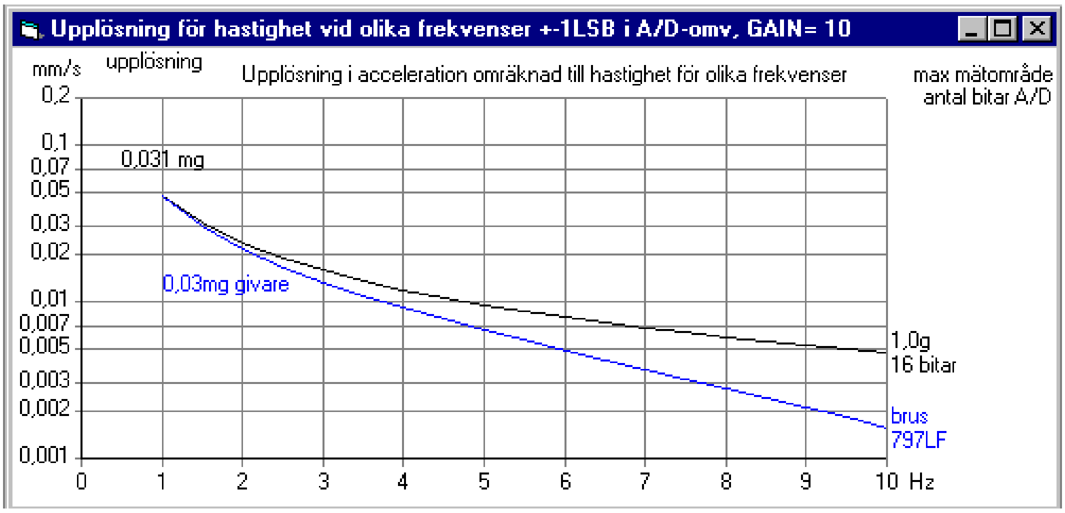


Figure 7. Transducer 797 with 16 bit A/D and GAIN 10. Black curve = resolution. Blue curve ("Brus") = noise.

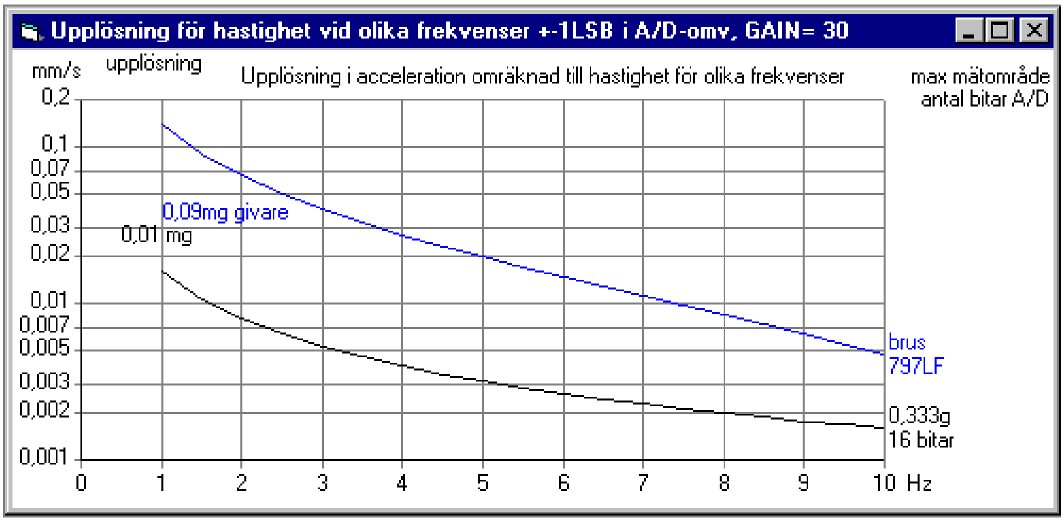


Figure 8. Transducer 797 with 16 bit A/D and GAIN 30. Black curve = resolution. Blue curve ("Brus") = noise.

Appendix C. Resolution and noise for 786 with 12 bit A/D

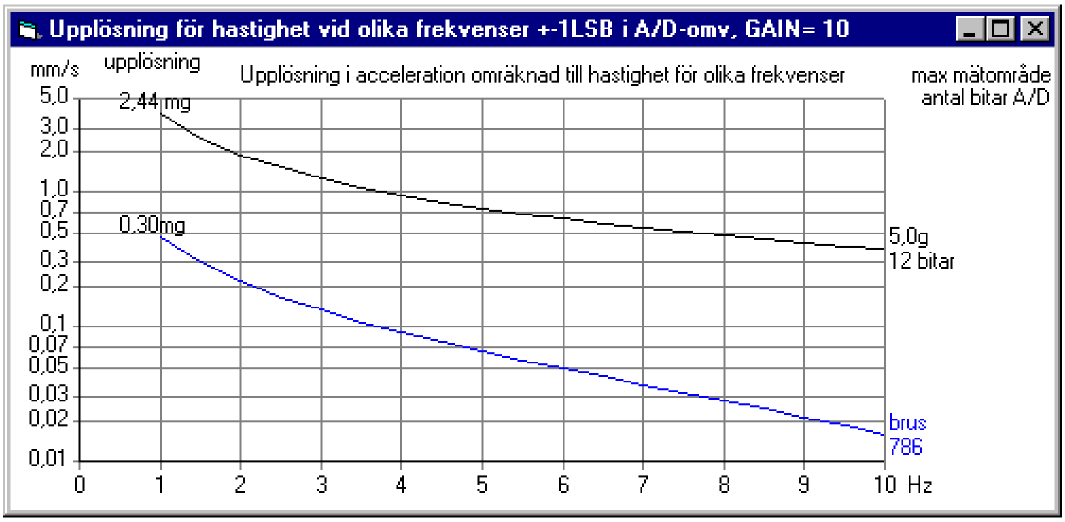


Figure 9. Transducer 786 with 12 bit A/D and GAIN 10. Black curve = resolution. Blue curve ("Brus") = noise.

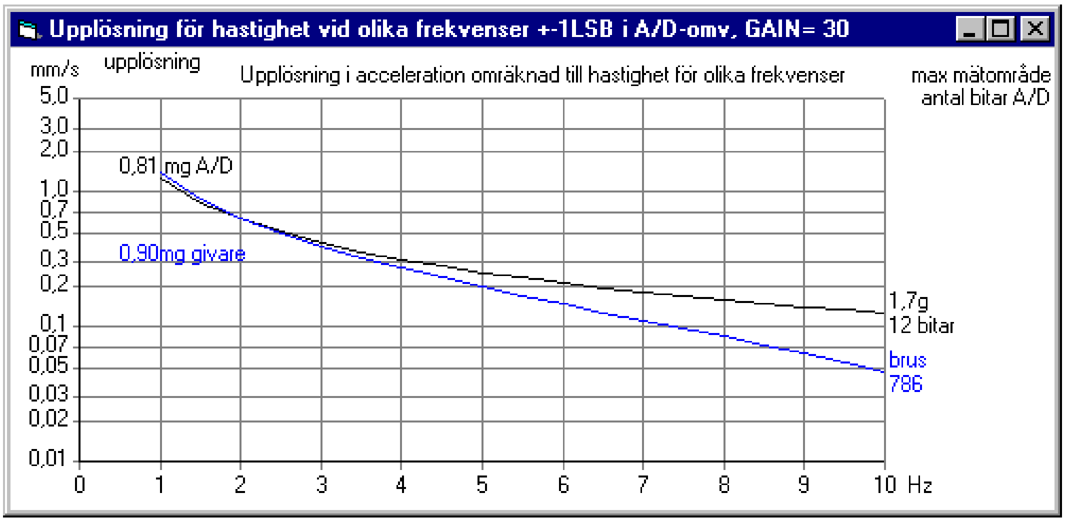


Figure 10. Transducer 786 with 12 bit A/D and GAIN 30. Black curve is resolution and blue curve ("Brus") is noise.

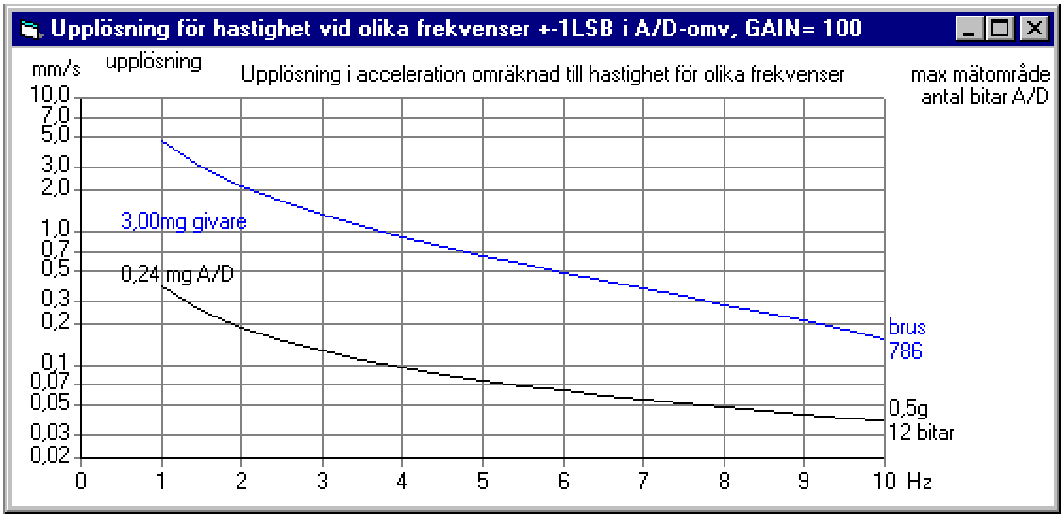


Figure 11. Transducer 786 with 12 bit A/D and GAIN 100. Black curve = resolution. Blue curve ("Brus") = noise.

Appendix D. Resolution and noise for 797 with 12 bit A/D

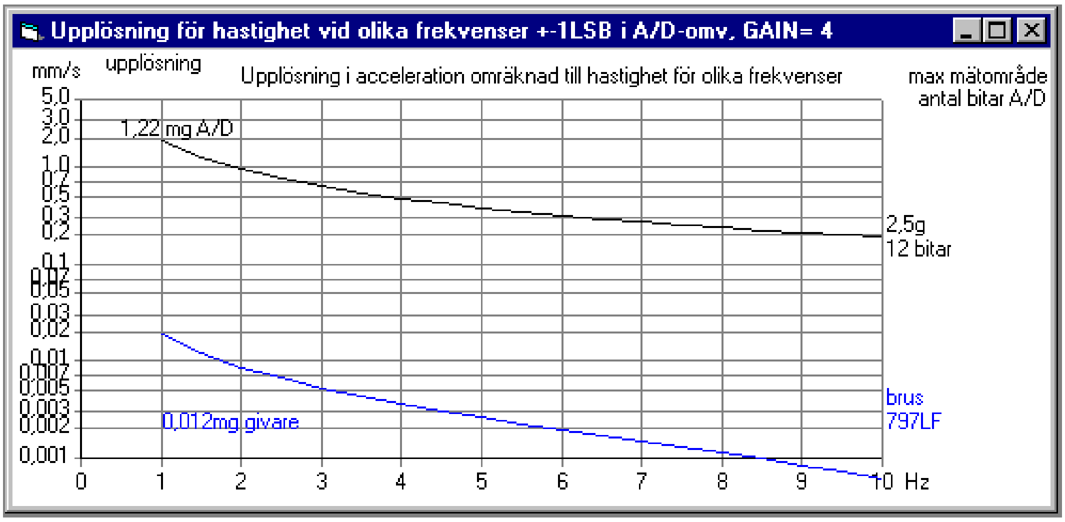


Figure 12. Transducer 797 with 12 bit A/D and GAIN 4. Black curve = resolution. Blue curve ("Brus") = noise.

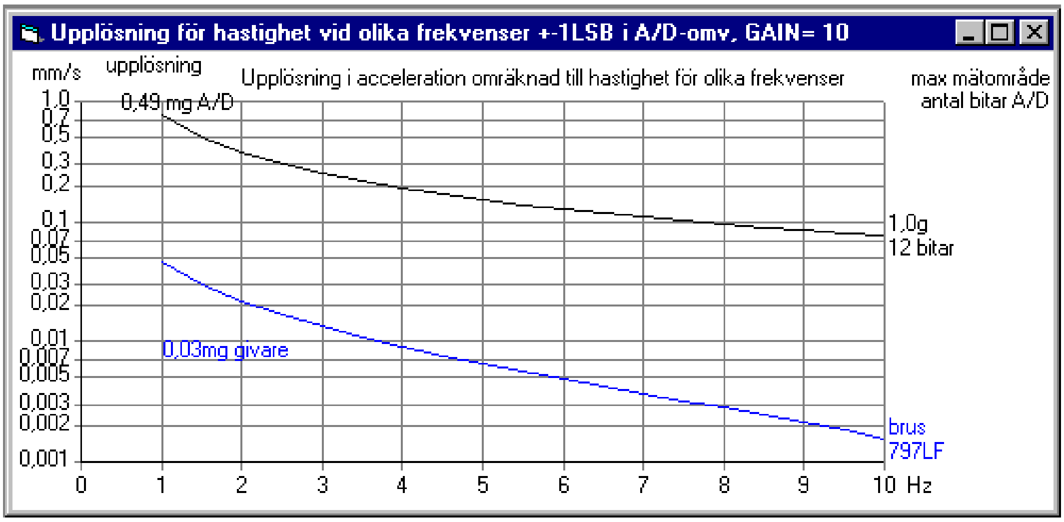


Figure 13. Transducer 797 with 12 bit A/D and GAIN 10. Black curve = resolution. Blue curve ("Brus") = noise.

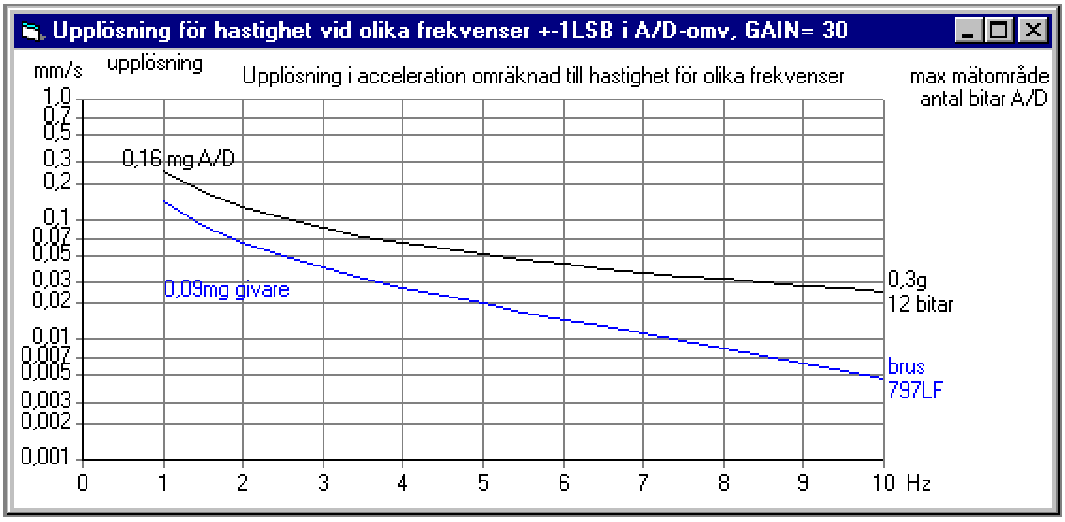


Figure 14. Transducer 797 with 12 bit A/D and GAIN 30. Black curve = resolution. Blue curve ("Brus") = noise.

Montörvägen 9, S-853 50 Sundsvall, Sweden
telephone: +46-(0)60 61 39 47
facsimile: +46-(0)60 61 39 67
email: info@lagge.se
www: http://www.lagge.se
VAT #: 556053695401