

MEMS GYROS

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Why?

- Turning
 - Angle independent of wheel slip
- Straight line steering
 - resolve angle and offset

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Well, why not?

Micromice seem to have stepped improvement curves.

Specification

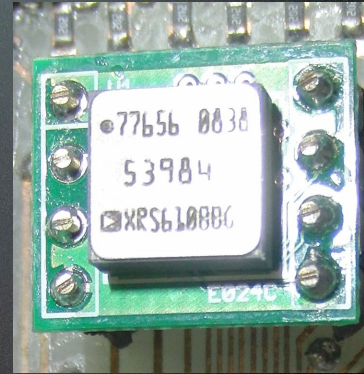
- Analogue output
- 300 °/sec
 - too slow
- 1200 °/sec
 - 90° turn in 75ms

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Specification is a compromise. Few devices ready-to-use at purchase.

Analog Devices

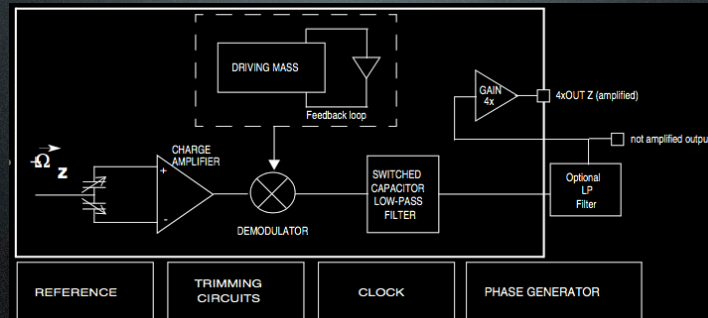
- ADXRS610
- $\pm 300^\circ/\text{sec}$
- £40
- 5V
- BGA32



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One of the earlier devices. Still common if you must.

ST Microelectronics LY530ALH



3.3V

300 °/sec and 1200 °/sec

LGA-16L (5mm x 5mm)

£5 (Future Electronics)

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Cheap and convenient. One of several devices from ST. Or raid your Wiimote etc

Problems

- Rate limited
- Noise
- Drift
- Temperature sensitivity

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These are not perfect devices and need some care and thought in their use.

Drift

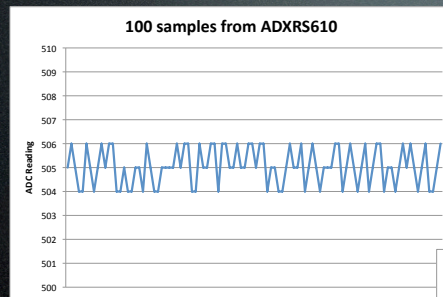
- Noise
 - intrinsic
 - angle random walk
- Quantisation
 - sampling
 - linear drift

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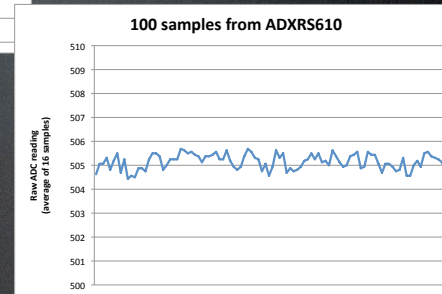
Drift is the most widely noticed shortcoming of gyros. It is caused by intrinsic noise.

the measurement technique has a great significance as well.

Sampling



Single samples taken direct from the ADC

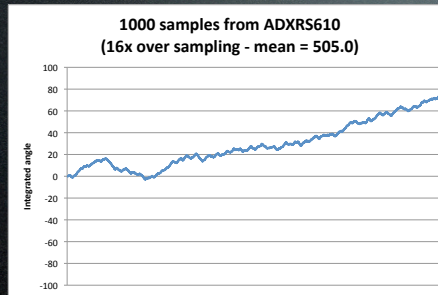


16x over sampling

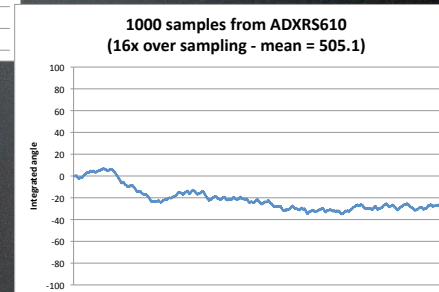
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For spot measurements of angular velocity, oversampling reduces noise. Only one bit improvement for each doubling though.

Angle Random Walk



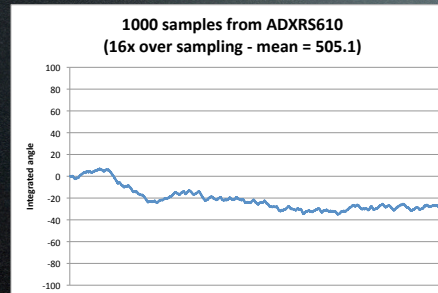
Small changes in the calibration
can significantly change the
accumulated error



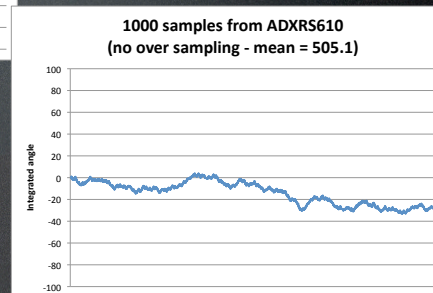
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Observed angle random walk depends heavily upon the bias level used.

Angle Random Walk



Over a long period, random noise tends to cancel out and oversampling may not be needed

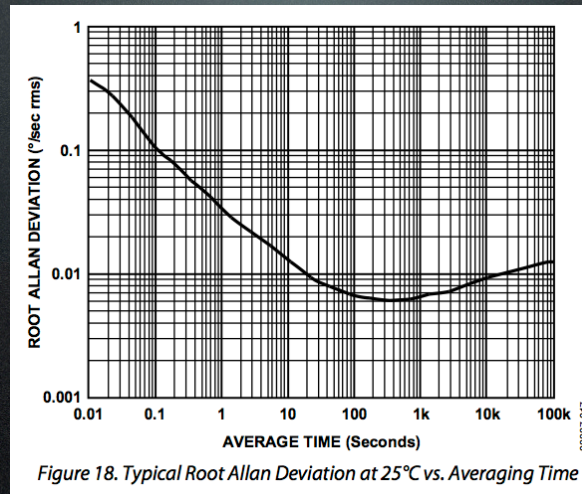


Or this trial could have been lucky. A controlled comparison has not been done.

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Since integration is an excellent way of removing random noise, oversampling may be unnecessary when recording angles by integration.

Allen Deviation



ADXR620 - from the Analog Devices Datasheet

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Allen Variance tells us that short term averages are less likely to be accurate than longer ones. however, beyond a point (the bias [in]stability), things can get worse. here, an average over 1 second should put 63% of averages within ± 0.03 deg/second of the true value.

Drift from quantisation

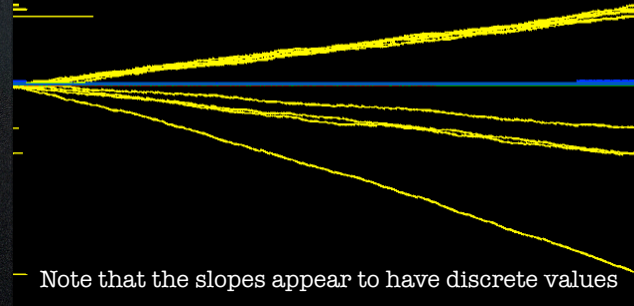
- Every reading is rounded
- Rounding errors accumulate
- Oversampling reduces effect
- Cannot be eliminated

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Many simple decimal fractions cannot be represented as binary fractions. There is ALWAYS a potential problem with cumulative errors.

Longer term drift

10 minute records of angle



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A combination of changes in temperature and the short term average taken at the start of each run means that the runs all show different drifts. I think that the discrete slopes indicate rounding effects in the ADC

Temperature sensitivity

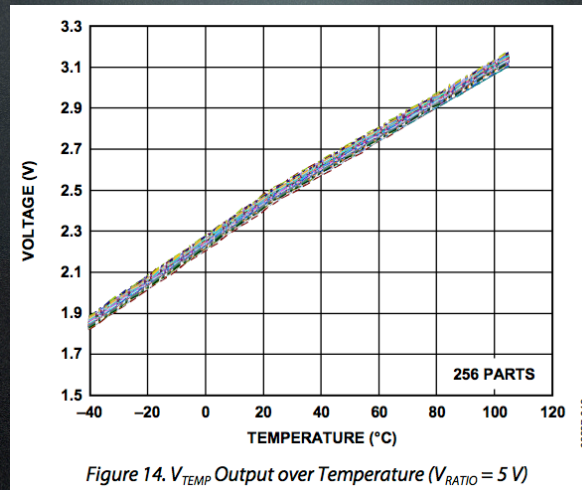


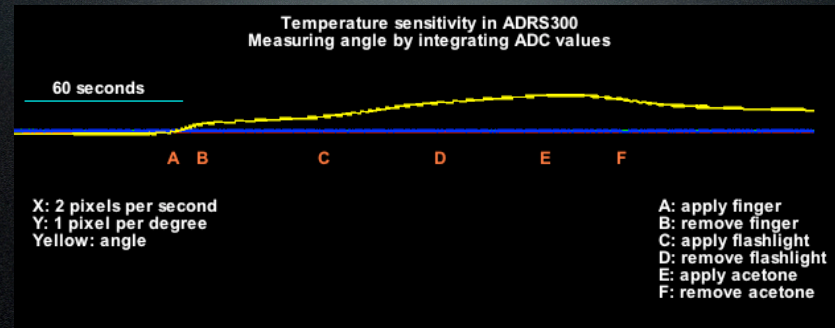
Figure 14. V_{TEMP} Output over Temperature ($V_{RATIO} = 5 V$)

ADXRS620 - from the Analog Devices Datasheet

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Since we care about small changes in the output bias when integrating to get angles, the changes in that bias due to temperature might become a problem

Temperature Sensitivity



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Angle is badly affected by temperature.
Effects should be small over short timescales

How?

- Only used in rotation controller
- need a rotation controller
- steering
- whenever moving

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task is much easier with separate forward and rotation controllers

How?

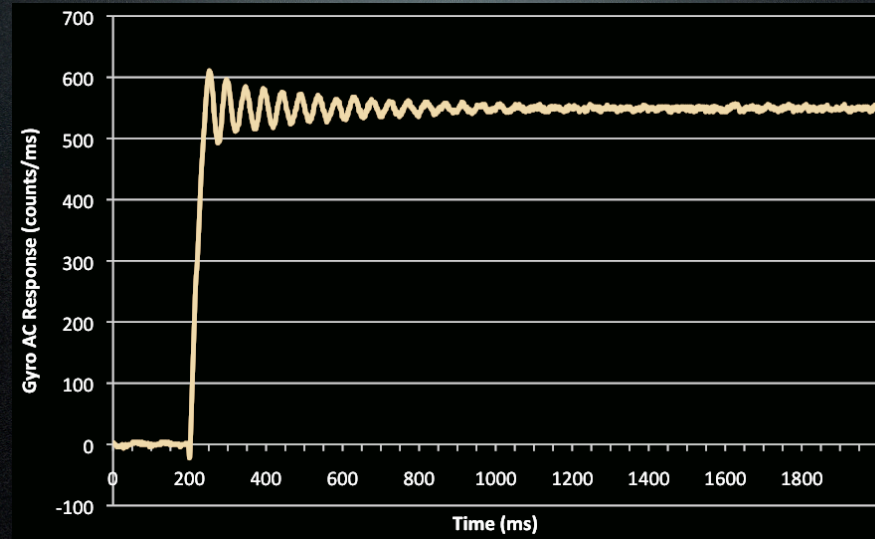
- Moving
 - Steering/attitude correction
- Turning
 - Use rate information for profile
 - Integrate to get angle
- Stationary
 - Don't - the drift is ugly

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Only use the gyro when you are moving.

Calibration

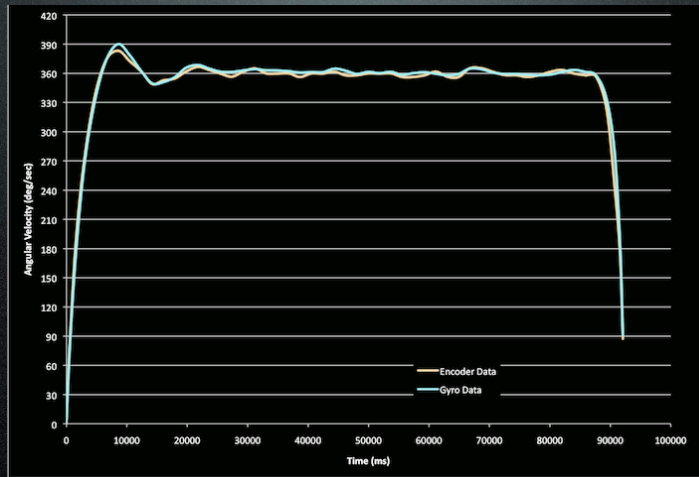
360 deg/sec on rotary table



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Sampled every millisecond. So, approximately 500000 counts per revolution.
Very high resolution.

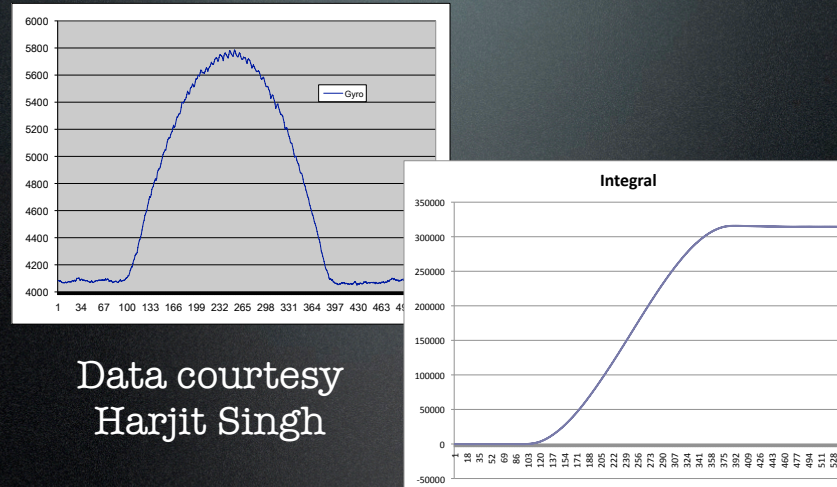
Single turn 360 deg/sec Encoders vs gyro



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Close agreement between Gyro and encoders.
Time scale incorrectly shown here.

Zeetah V



Data courtesy
Harjit Singh

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Note that the curve is continuous and has no constant radius portion
integral value depends upon sample rate and ADC resolution

Thank You

Peter Harrison

www.micromouseonline.com