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ENRG 3199A

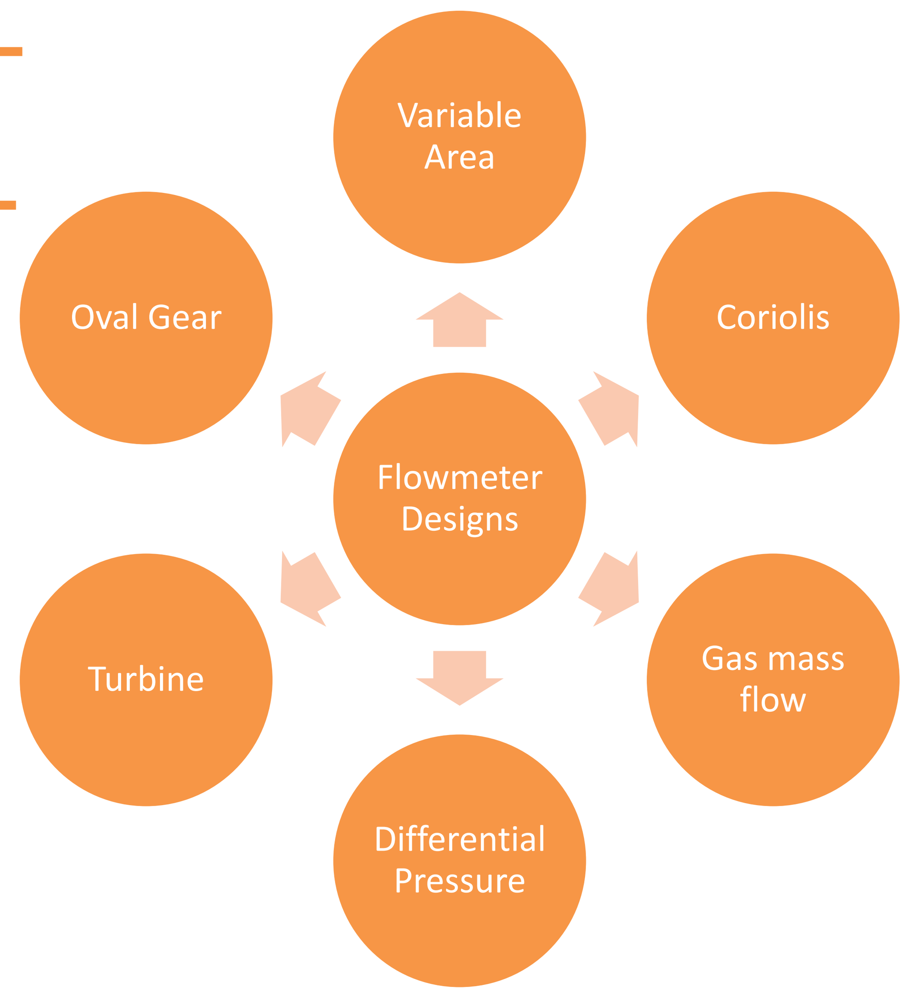
TURBINE FLOWMETER DESIGN

SPRING 2010

Adaptation of a Camelbak flowmeter for measuring volumetric flowrates of 0.08 to 222 ml/s

Background:

- High velocity flowmeter required to measure flow rates in a research project.
- Existing flowmeters were too expensive.

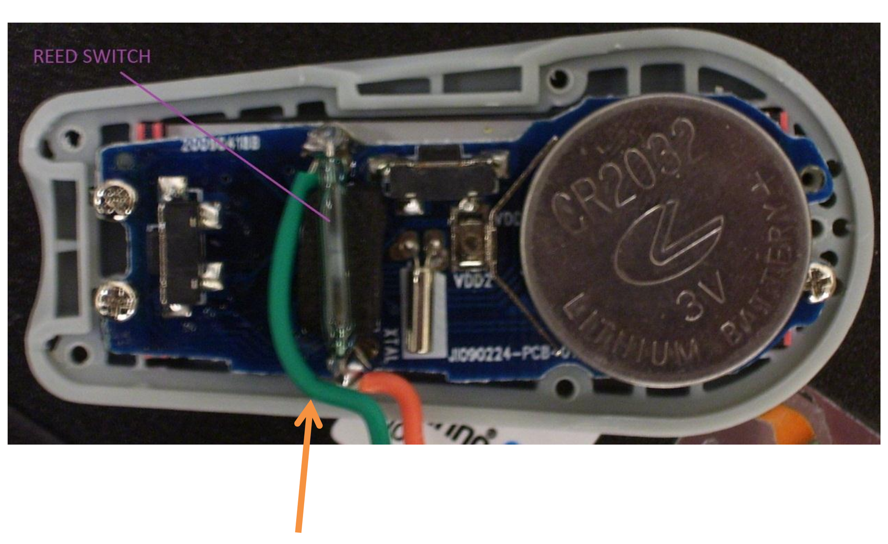


Turbine Flowmeter chosen as:

- Low cost (<$200)
- Robust against temperature fluctuations
- Easy to develop circuitry

Camelbak Flowmeter

Originally designed to provide hydration rate information for users of Camelbak's hydration packs

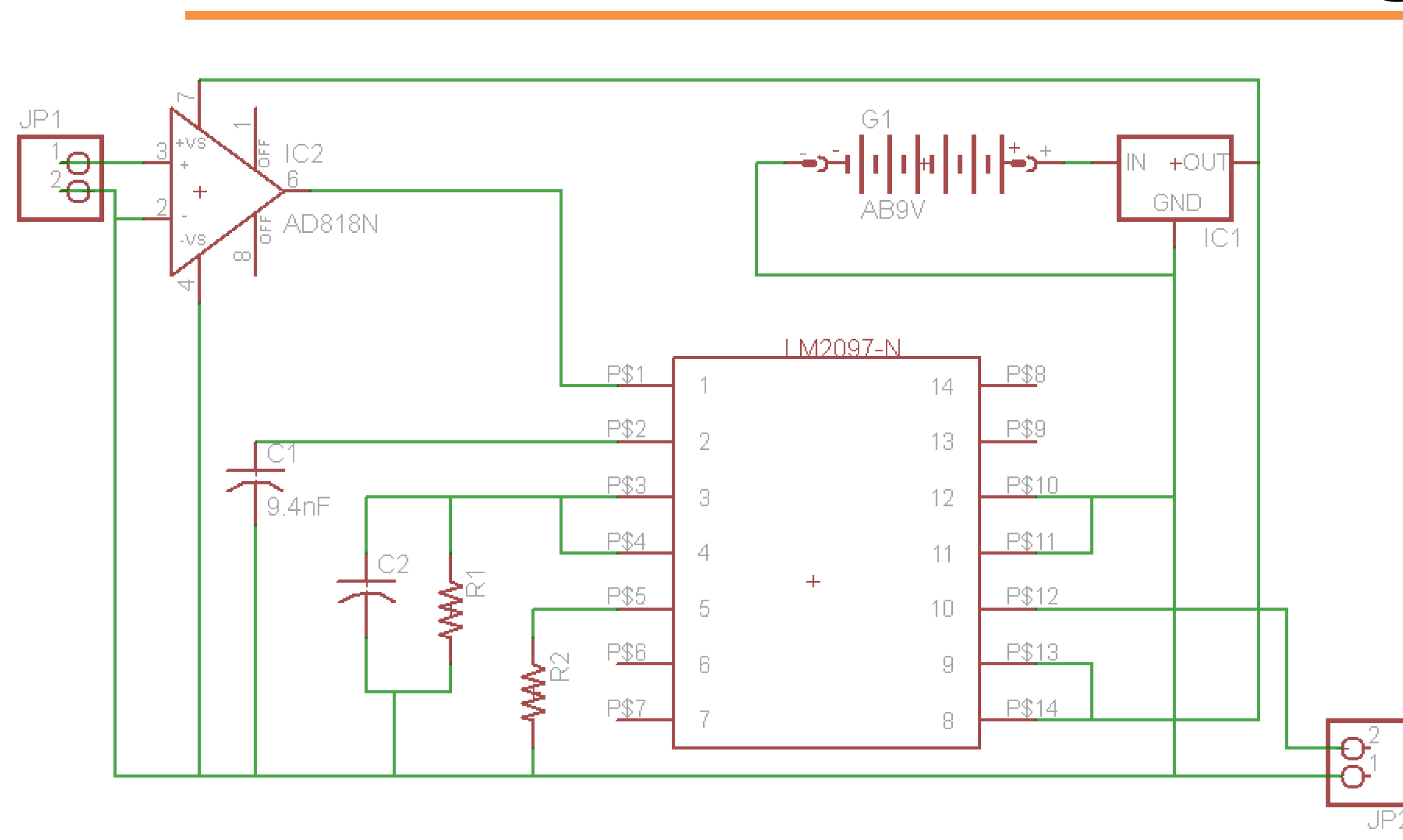


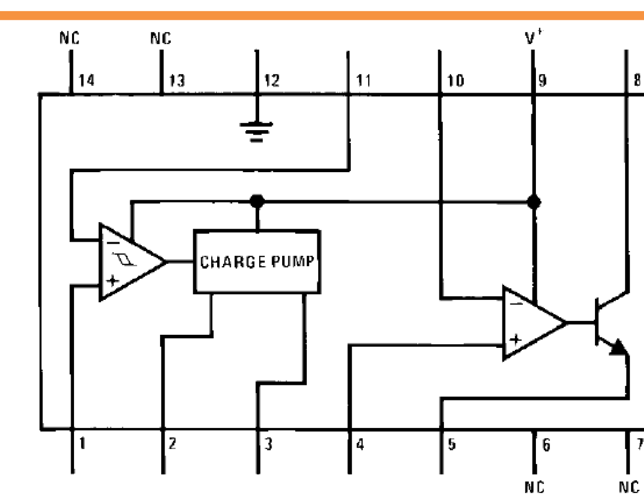
Signal leads giving the square wave input

Theory of Operation

- Fluid flow causes turbine to rotate
- Magnet in turbine trips a reed switch periodically as the turbine rotates
- Voltage across reed switch is in the form of a square wave where the frequency is proportional to the turbine's angular velocity

Circuit Design





LM2097-N IC

- Opamp used to amplify input signal
- Input signal sent through opamp in IC to normalize voltage
- Charge pump used to convert frequency to voltage
- Output opamp used to drive a floating transistor

$$V_{ripple} = \frac{V_{CC}}{2}\frac{C_1}{C_2}\left(1 - \frac{V_{cc} f_{IN} C1}{I_2}\right)$$

$$V_O = V_{CC} \times C1 \times R1 \times K \times f_{IN}$$

$$t_s \propto C2$$

$$R1 = 1M\Omega$$
$$C1 = 9.4nF$$
$$C2 = 10uF$$

Key Specifications

Linearity:
- Determined by operating range of the

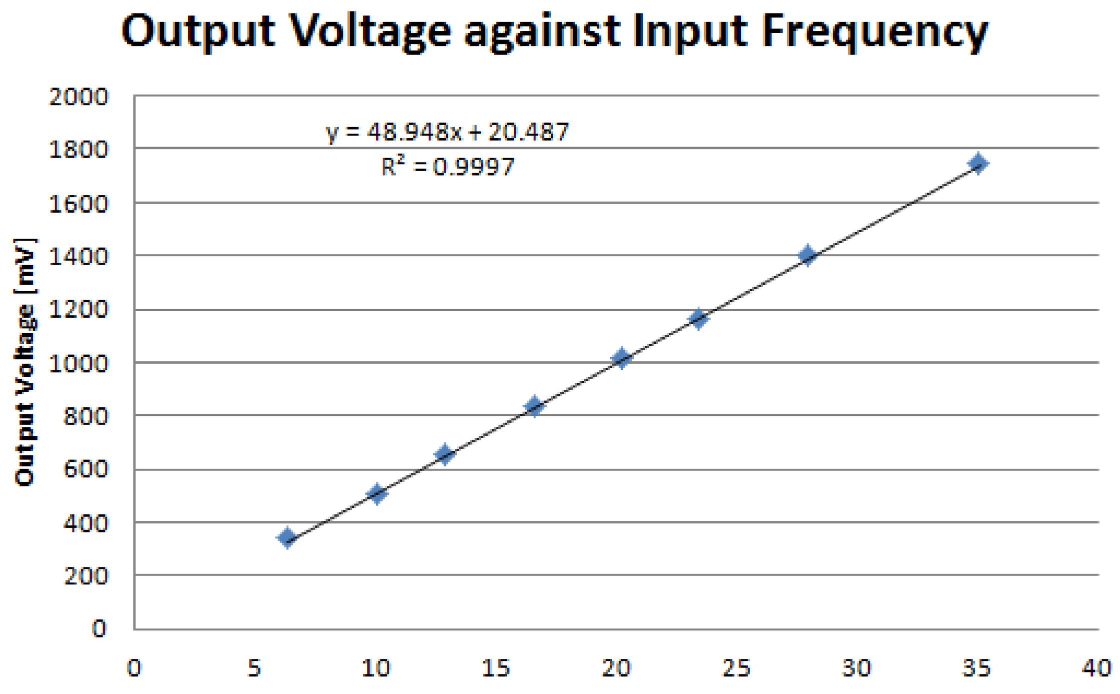
Ripple Voltage:
- Determined mainly by ratio of two capacitor values (C1 and C2)

Settling Time:
- Determined by value of C2.
- t_s is proportional to C2.

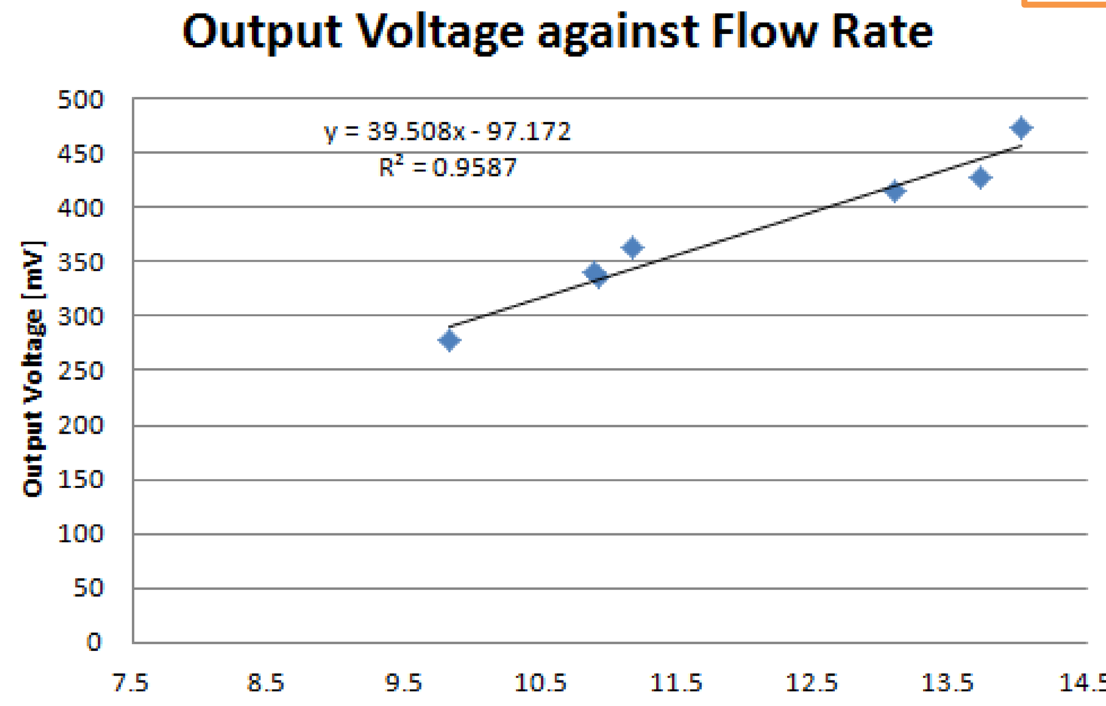
Calibrate input frequency against output voltage → Calibrate flow rates against output voltage

$$Q\left[\frac{ml}{s}\right] = \frac{V_{out}[mV] - 117.7}{39.5}$$

Output Voltage against Input Frequency



Output Voltage against Flow Rate



Future work

- Develop mechanical assembly with lower starting flow rate
- Choose different circuitry which is more suited for low frequency signal measurement
- Develop more repeatable testing and calibration procedures

Acknowledgements: Thanks to Prof Kent Lundberg for his advice.