

Linear Systems / Electronics in GW Interferometers

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Applications

- Mechanical Systems
- Electronics
- Hydraulics
- Optical Resonant Cavities
- Quantum Field propagation
- Feedback Systems

$$L\ddot{Q} + R\dot{Q} + \frac{1}{C}Q = V(t)$$

Some Correspondence

$$m\ddot{x} + b\dot{x} + kx = F(t)$$

	Mechanics	Electronics	Hydraulics	?
	displacement	charge	volume	
	velocity	current	flow	
	friction	resistance	constriction	
	mass	Inductance		
	stiffness	1/Capacitance	tank volume/ potential	
	bv^2	I^2R		
	k/m	1/(LC)	?	

Electronics

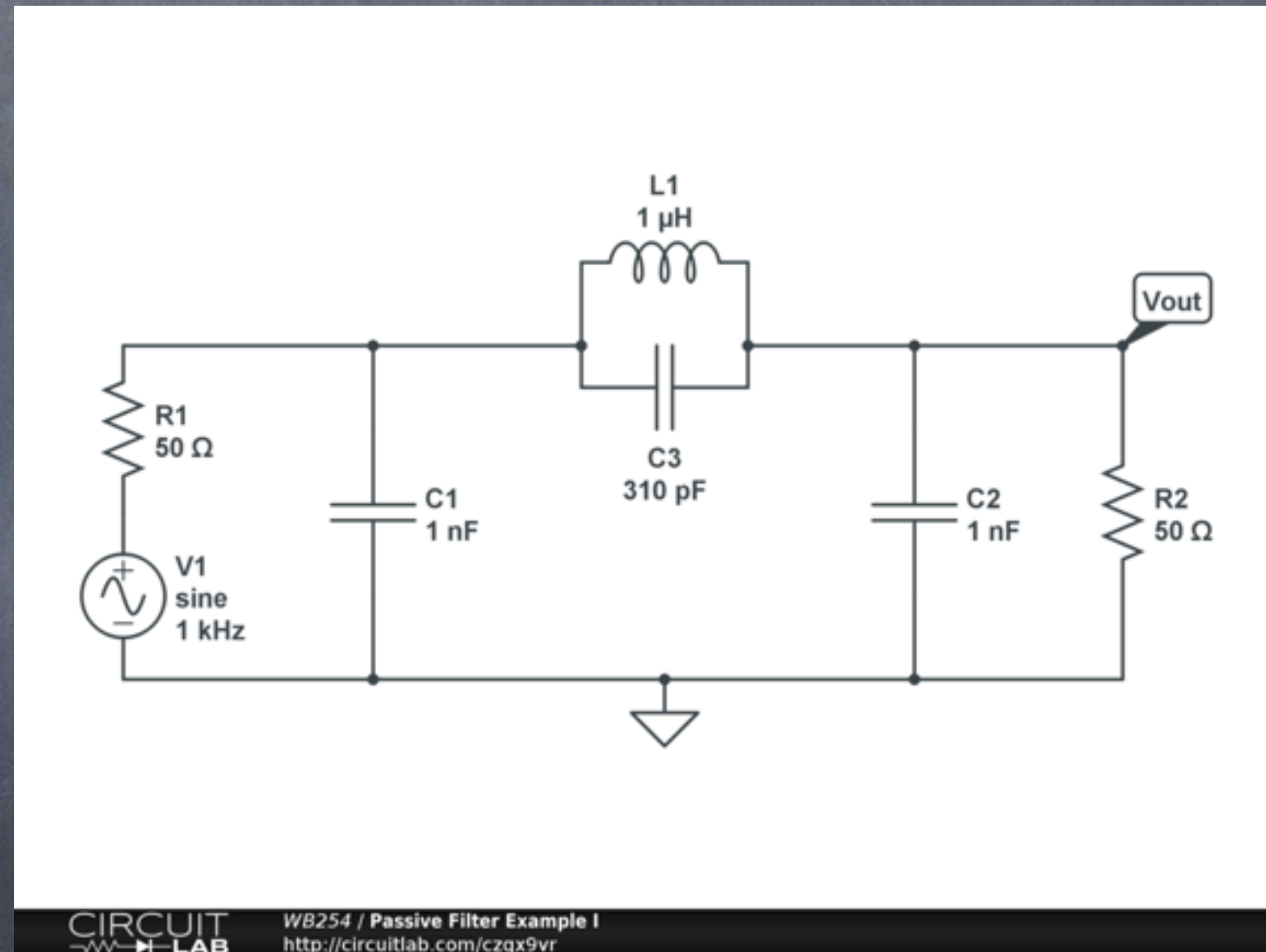
- Passive Circuits
- Noise in passive circuits
- Active Components
- Noise in Op-Amp circuits
- Non-ideal circuit behavior
- Low Noise Practices

Passive Circuits

- "The Art of Electronics", Horowitz & Hill
- "Noise Reduction Techniques...", H.W. Ott
- "Grounding and Shielding", Morrison
- www.circuitlab.com
- LTSpice
- LISO (similar to Finesse), G. Heinzel

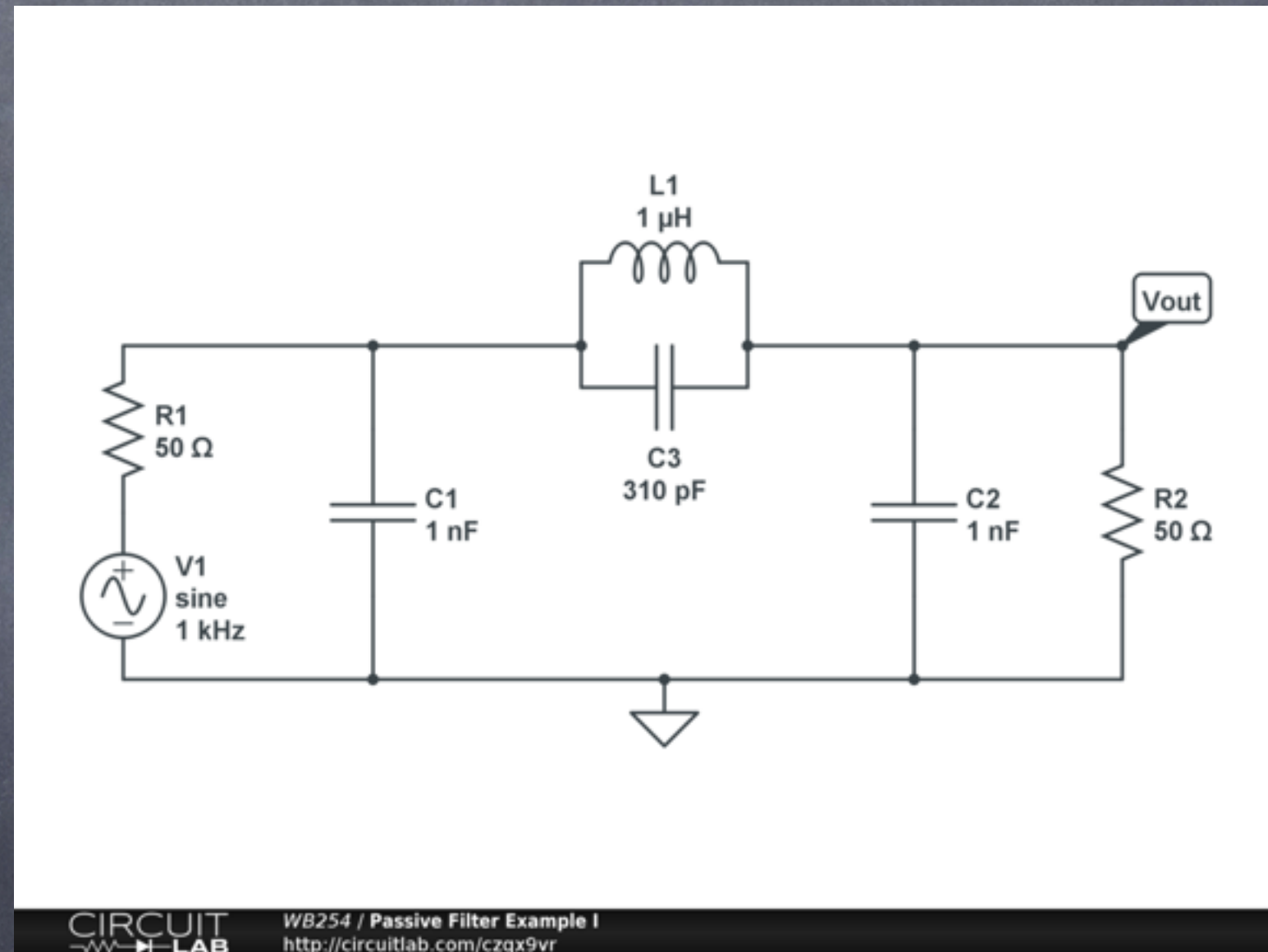
Transfer Functions

1. Convert components into complex Z
2. Arrange components as voltage dividers
3. Compute node-to-node TFs
4. Factor Laplace-domain polynomial
5. Plot

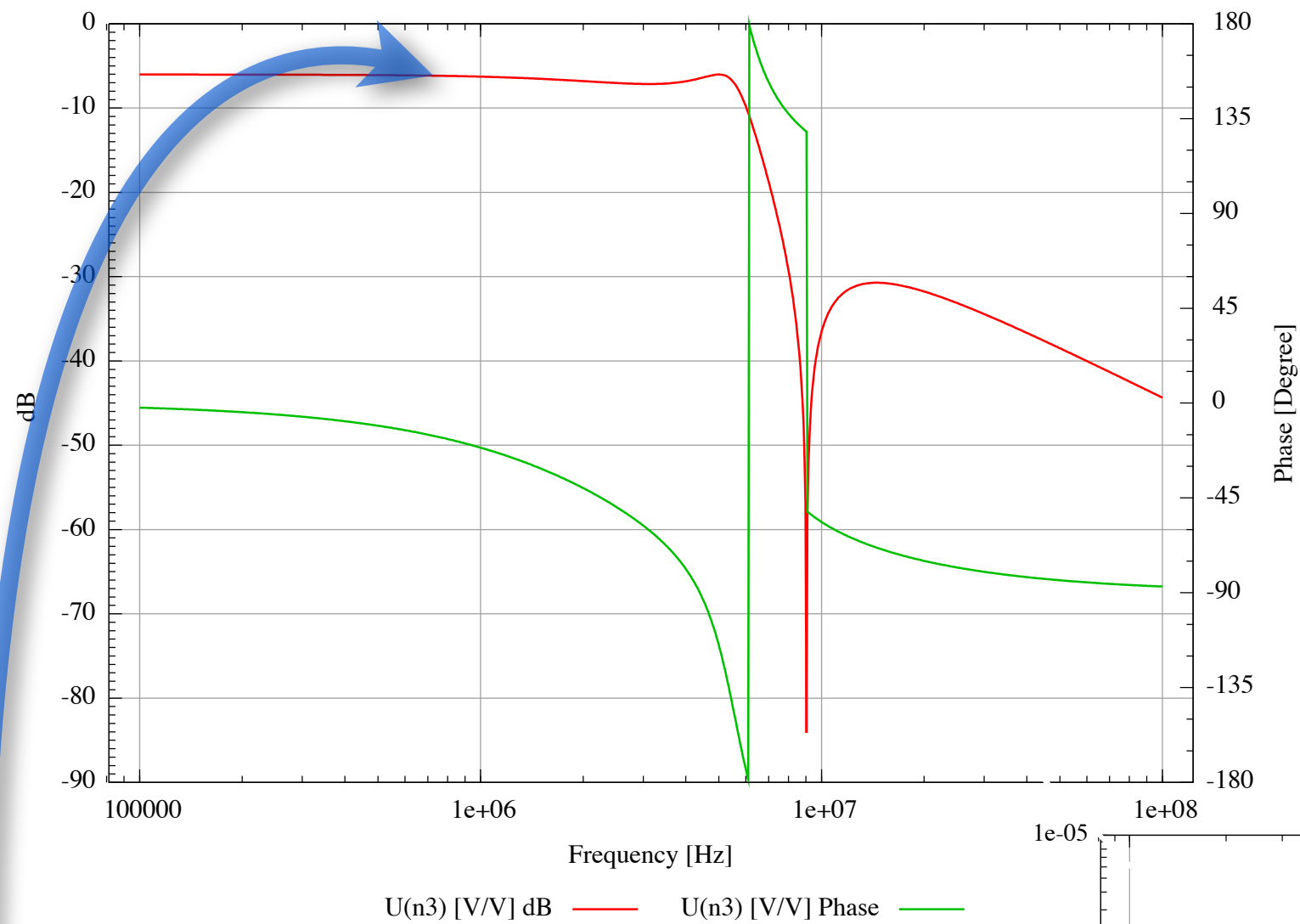


Noise

1. Convert components into complex Z
2. Find total impedance from V_{out} to GND
3. $V_n(f) = \sqrt{4 k_B Re(Z) T}$
4. Plot

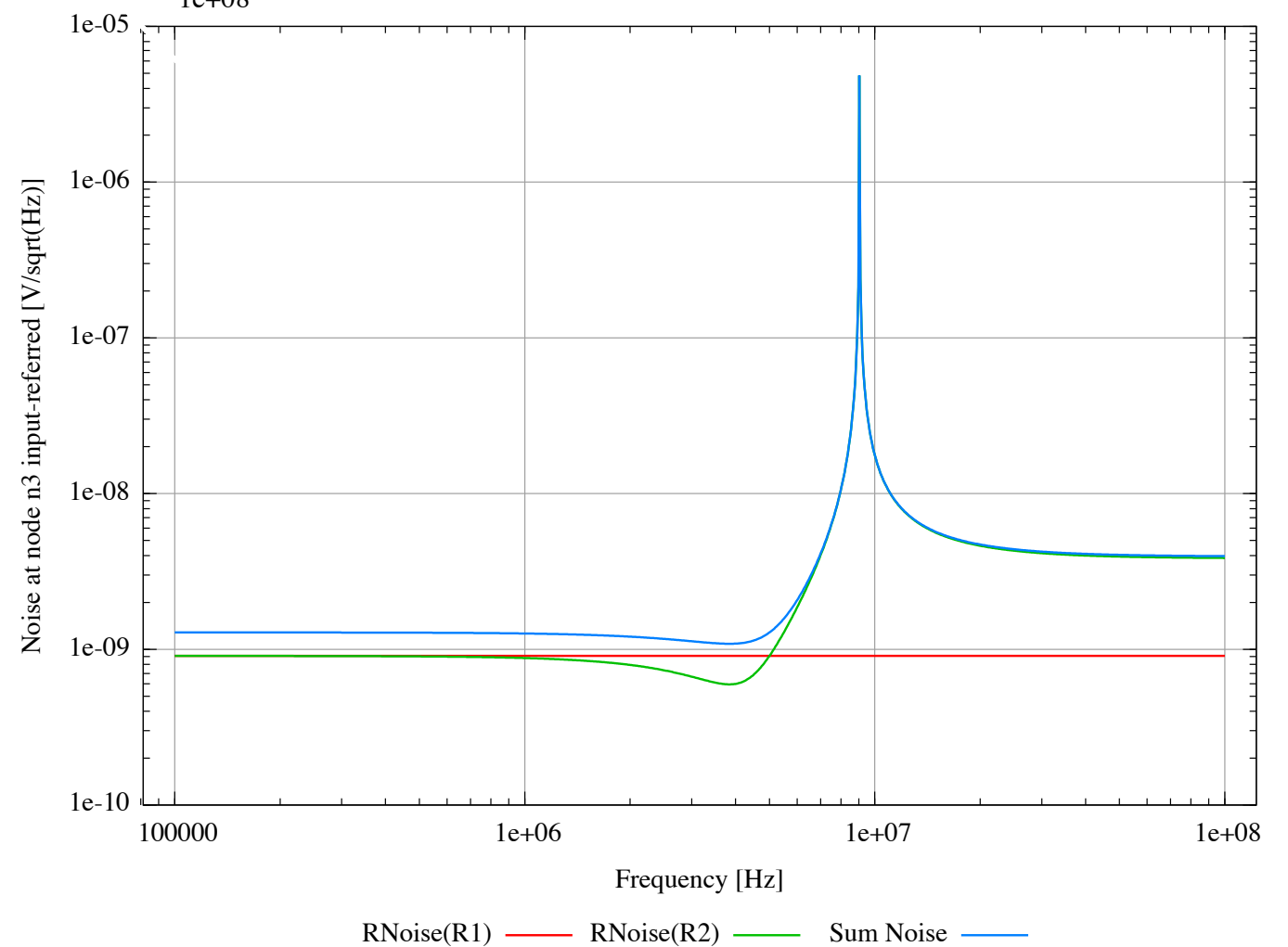


LISO Outputs



Input Referred Noise:

- 1) Measure Noise at Readout point
- 2) Use TF to transform to the input (where the signal comes in)



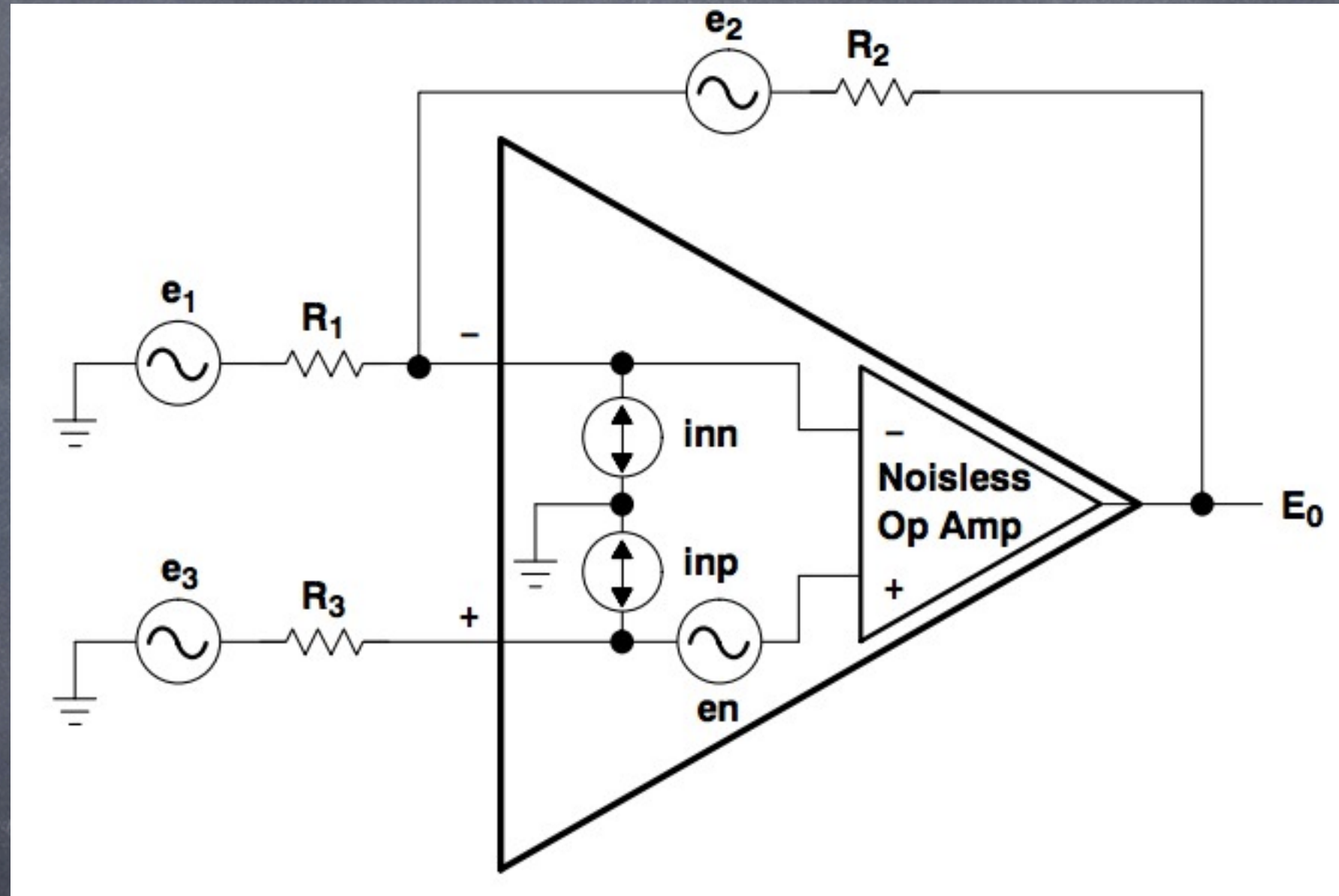
Noise

- Johnson/Nyquist Noise (cf. Fluctuation-Diss)
- OpAmp input voltage noise
- OpAmp input current noise
- “Noise Analysis in Op Amps”, Texas Instruments.

<http://www.ti.com/lit/an/slva043b/slva043b.pdf>

Ideal OpAmp Calculations

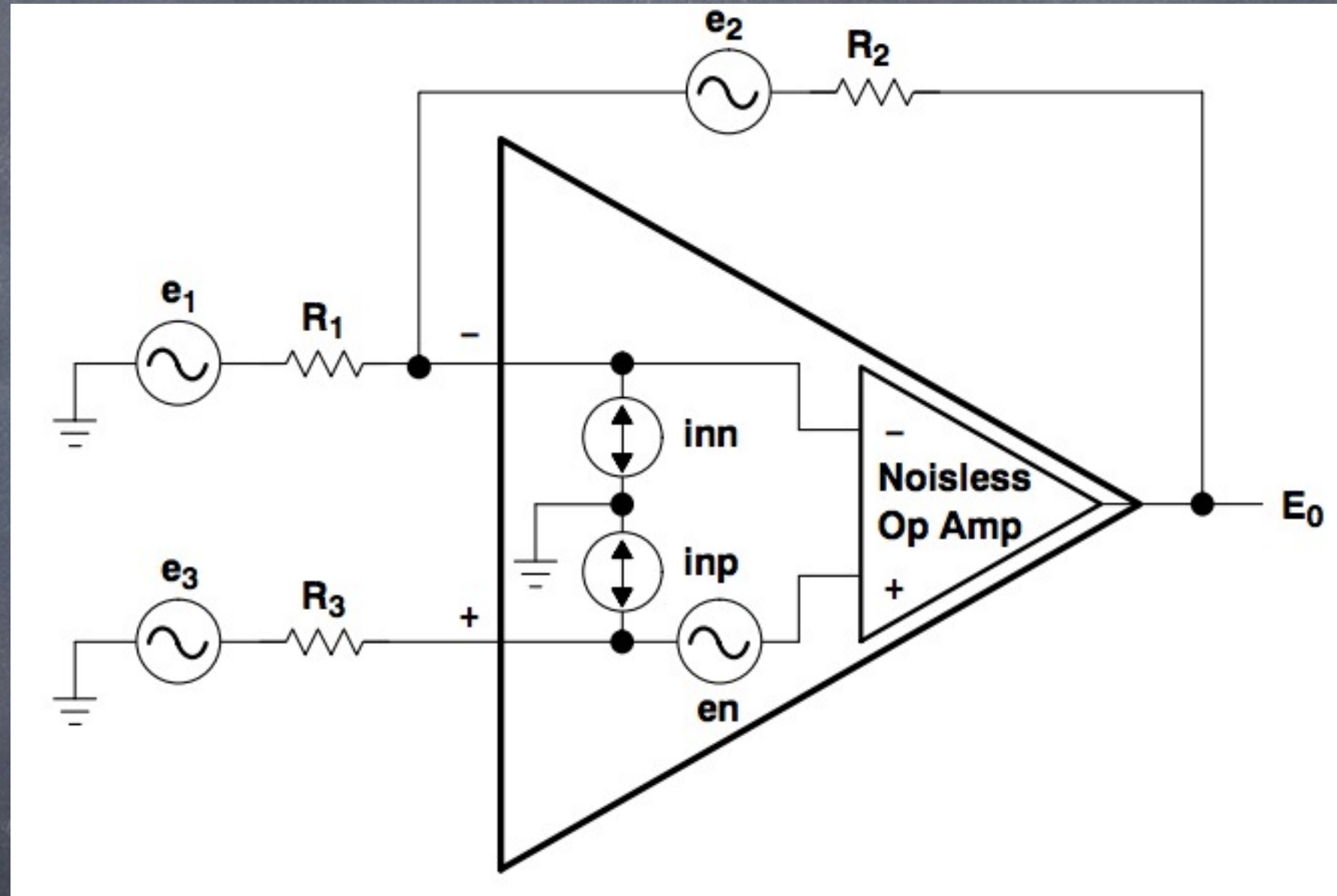
- Infinite Open Loop Gain
- Infinite Input Impedance
- $V_+ = V_-$



● <http://www.ti.com/lit/an/slva043b/slva043b.pdf>

OpAmp Noise Calculations

- Noiseless Amp
- Add voltage noise to inputs
- Current noise leakage out of inputs
- All voltage and current noises are independent and uncorrelated.
- Infinite input impedance



● <http://www.ti.com/lit/an/slva043b/slva043b.pdf>

GW Electronics

- RFPD Electronics
- Low Noise Coil Driver
- DC PD Preamplifier
- High BW Laser locking servo
- HV Electro Static Driver
- ?