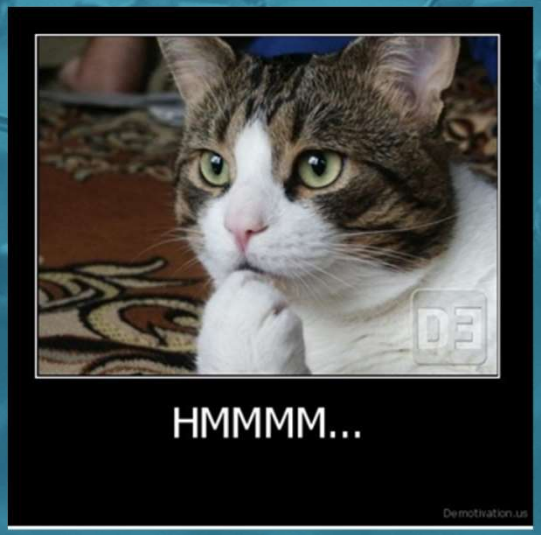
What are Load Cells?



DAVE VE3OOI

APRIL 2022

Agenda

1. Why I did this?

2. Wheatstone Bridge Basics

3. Load Cells, Stain Gauges and all that

4. Load Cell Measurements/Simulation

5. What about SWR?

Danger Will Robinson

This is my journey:

- Preceding are my rambling
- This is not an engineering tutorial
- Quote Charlie Morris, ZL2CTM:

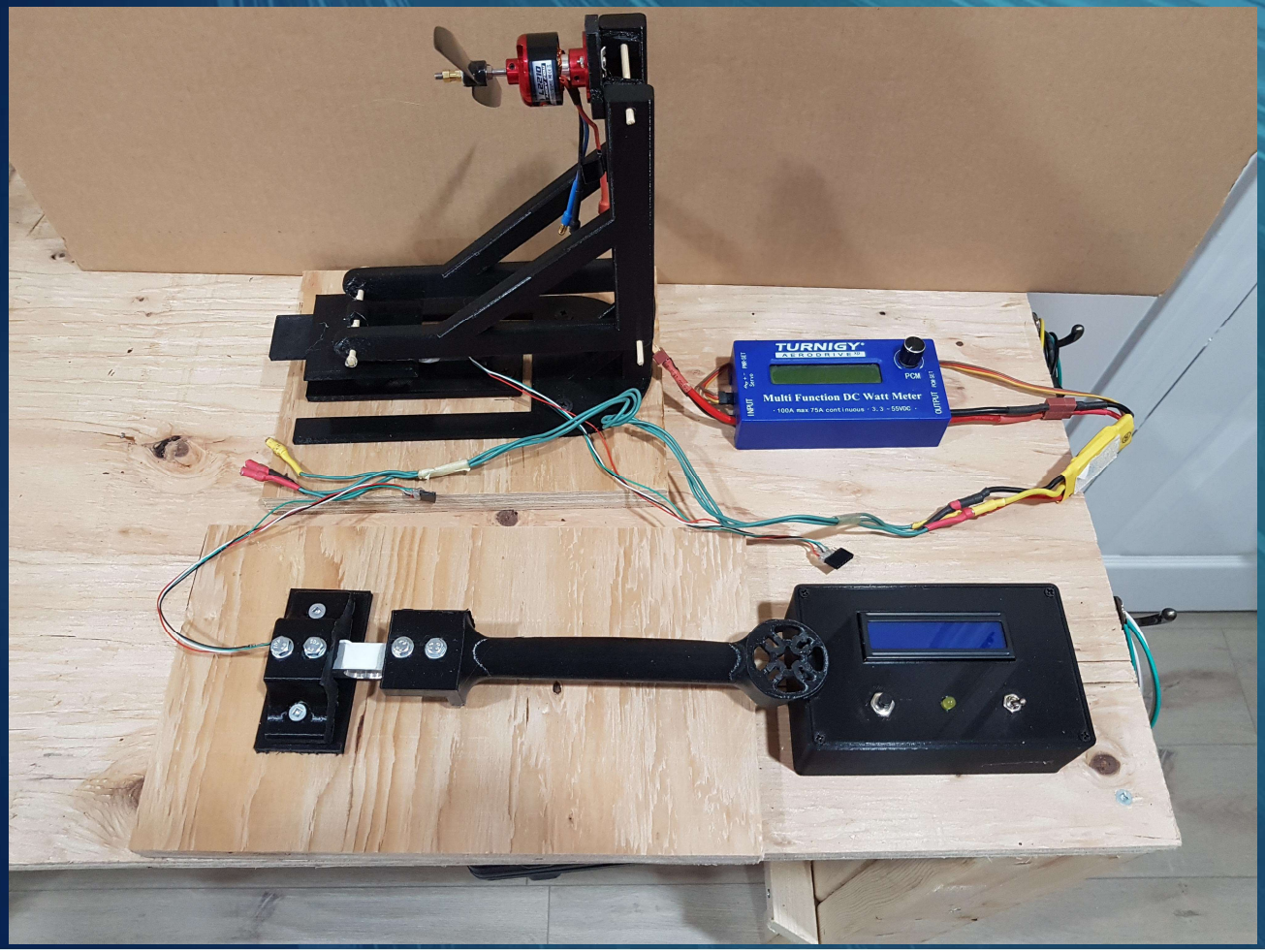
This NOT a tutorial. Its a log of my journey. Right or wrong.

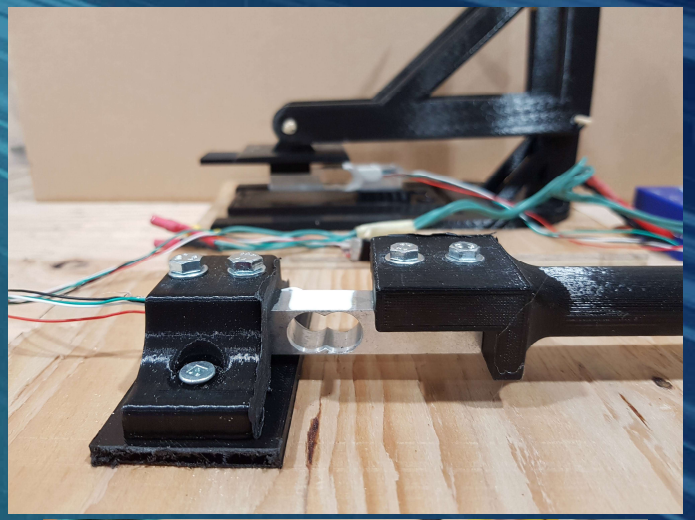
HOW THIS STARTED…

- I have crashed MANY airplanes and Helicopters
- Many due to stupidity…
- Others due to underpowered aircraft.
  - ❖ Thrust-to-Weight ratio too small
- Needed a mechanism to measure thrust from motor & propeller.

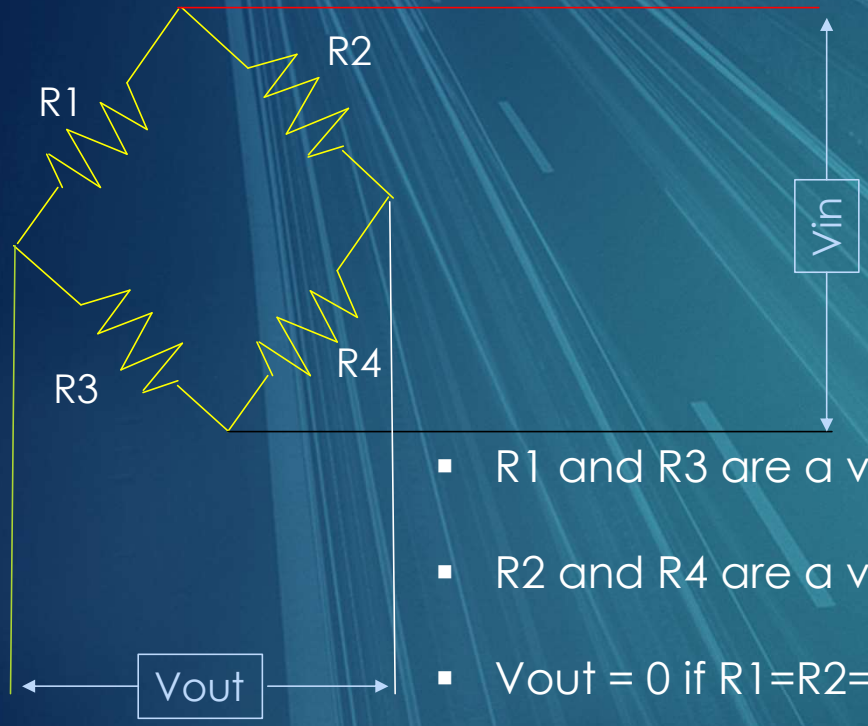
Built a "Thrust Measurement Bench"

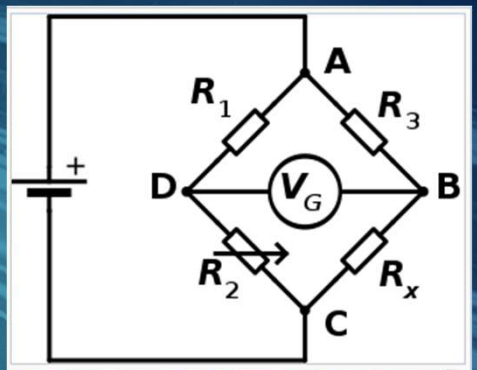
The Final Product





Wheatstone Bridge

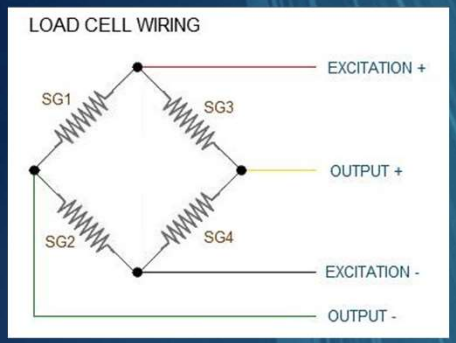




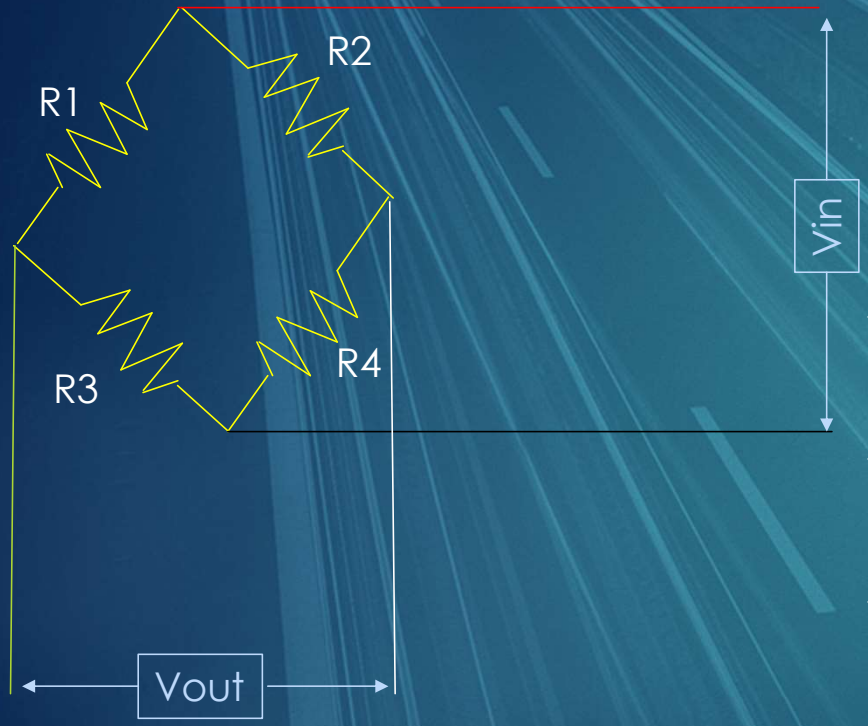
Wheatstone bridge circuit diagram. The unknown resistance R_x is to be measured; resistances R_1, R_2 and R_3 are known, where R_2 is adjustable. When the measured voltage V_G is 0, both legs have equal voltage ratios: $R_2/R_1 = R_x/R_3$ and $R_x = R_3R_2/R_1$.

- R1 and R3 are a voltage divider for Vin
- R2 and R4 are a voltage divider for Vin
- Vout = 0 if R1=R2=R3=R4
- If any R changed by small amount, there will be a small voltage at Vout
- **Temperature tolerant**

Load Cell


LOAD CELL WIRING
EXCITATION +
SG1
SG3
OUTPUT +
SG2
SG4
EXCITATION -
OUTPUT -

Wheatstone Bridge Calculations



From Video,

- Resistances measured 997 and 748 ohms

✓ If resistance between Red and Black is 997 (i.e. R2+R4//R1+R3)

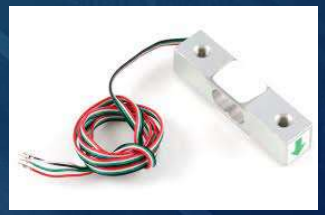
✓ If resistance between White and Black in 748 (i.e. R4//R1+R2+R3)

✓ If R1=R2=R3=R4, then
  - 997 = R2+R4//R1+R3
  - 748 = R4//R1+R2+R3

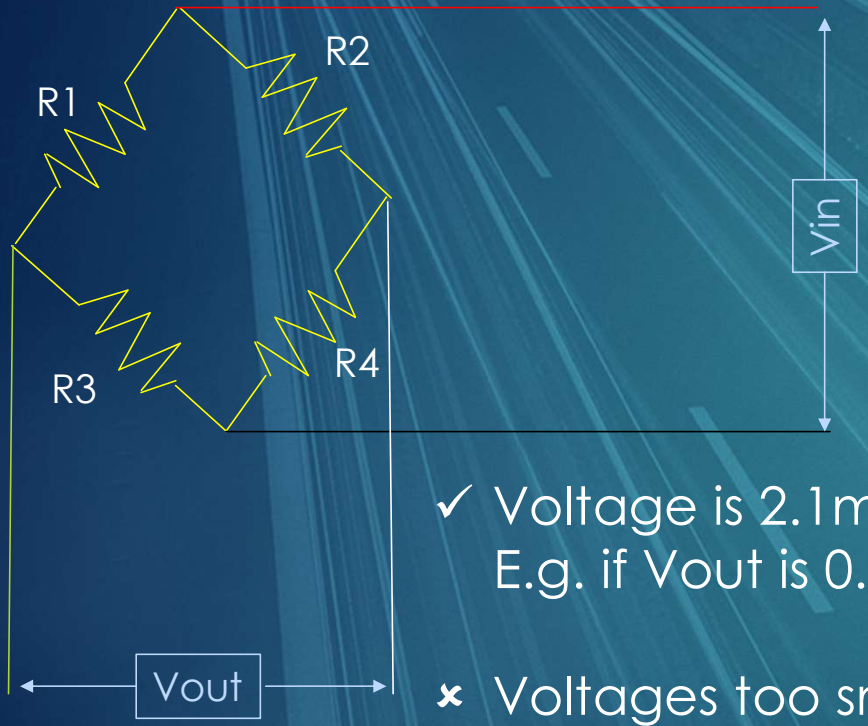
.... 997 = R+R//R+R, R=997

.... 748 = R//R+R+R, R=997

So for my Load Cell, R=997 ohms



Load Cell Calculations



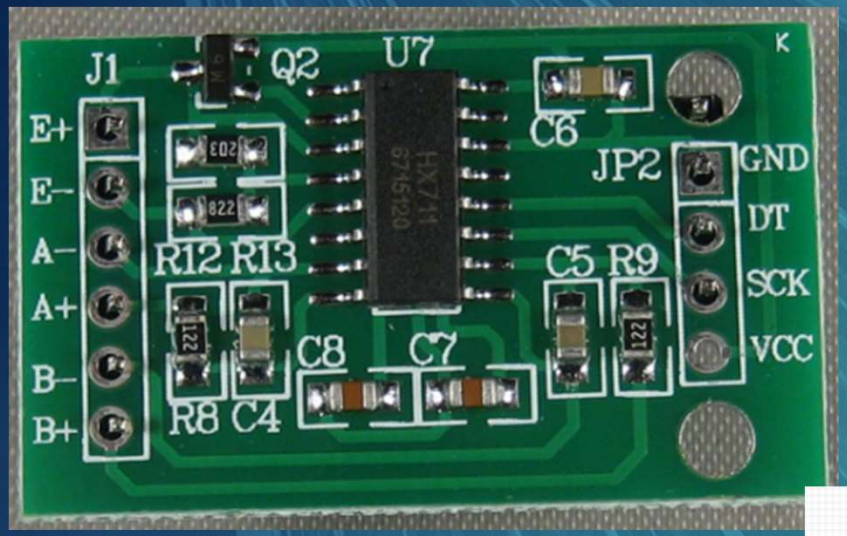
From Video,

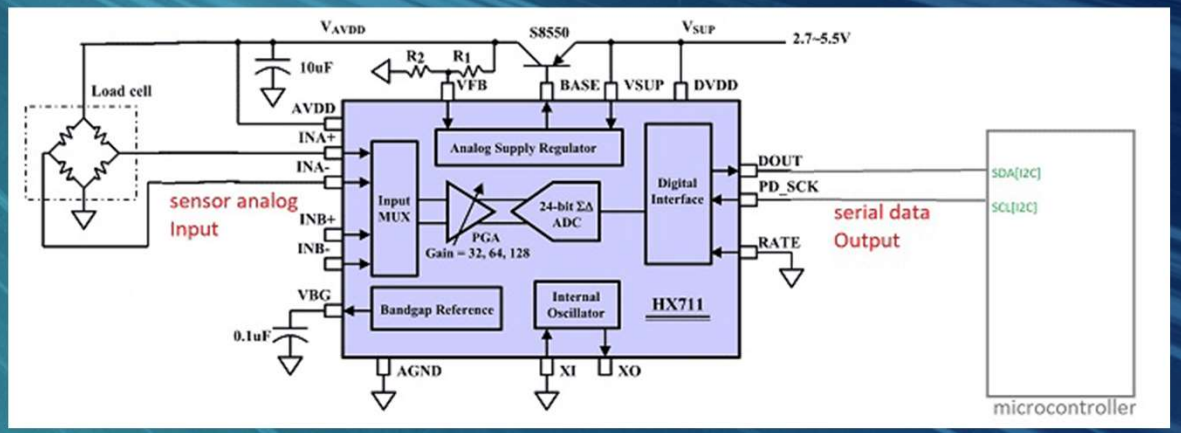
- Vout measured 2.1mV for 600g

✓ Voltage is 2.1mV for 600g or 3.5uV/g or 0.286g/uV
E.g. if Vout is 0.5 mV, weight is 143g

✗ Voltages too small to measure with uC. Need amplification.
Us HX777 amplifier and 24bit ADC

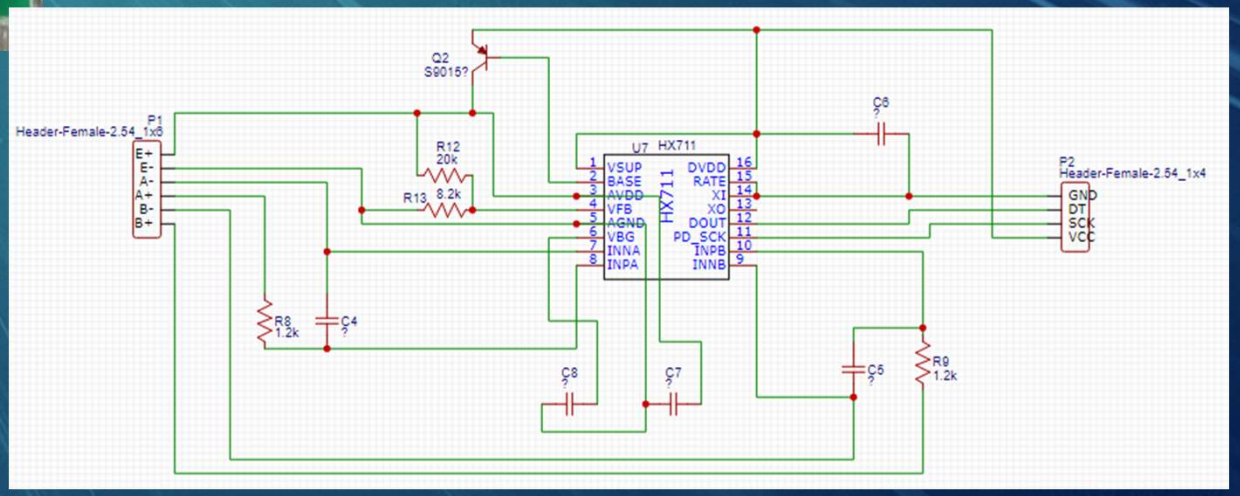
HX777





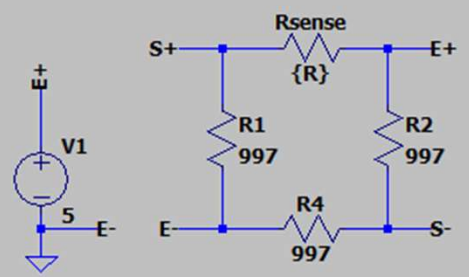
$$V_{AVDD}=V_{BG}*(R1+R2)/\ R1$$

$$=1.25*(20+8.2)/20$$
$$=1.7625\ V$$



Load Cell & LTSpice

.param R=998.8

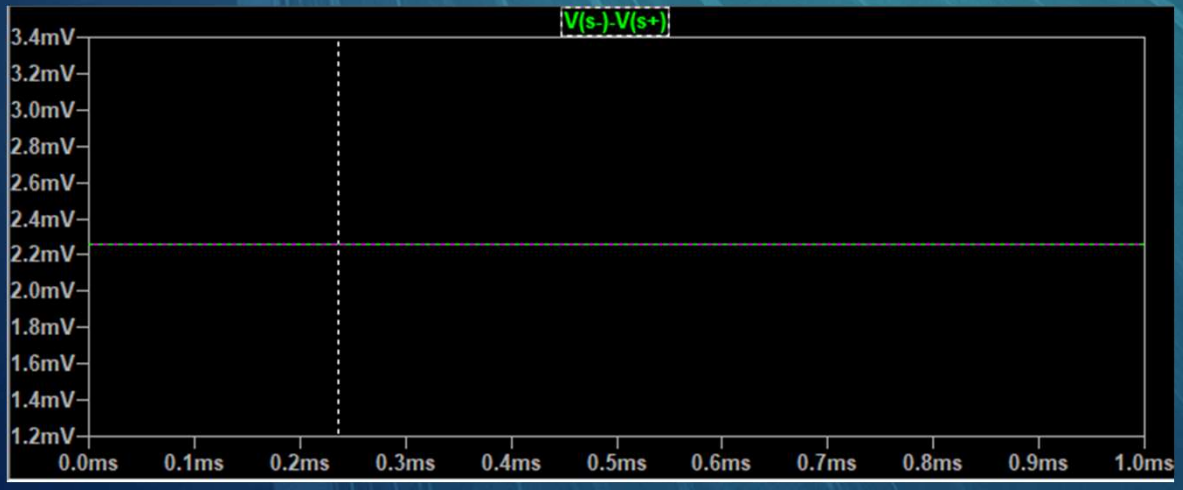


.param Ag=128
.param ADC=1677216/1.7625
.paran GF 457

.meas TRAN Vp AVG V(S+)
.meas TRAN Vn AVG V(S-)
.meas TRAN Vd PARAM (Vn - Vp)
.meas TRAN Vm PARAM Vd*Ag
.meas TRAN Vadc PARAM Vm*ADC
.meas TRAN SF PARAM Vadc/600
.meas TRAN Gms PARAM Vadc/GF

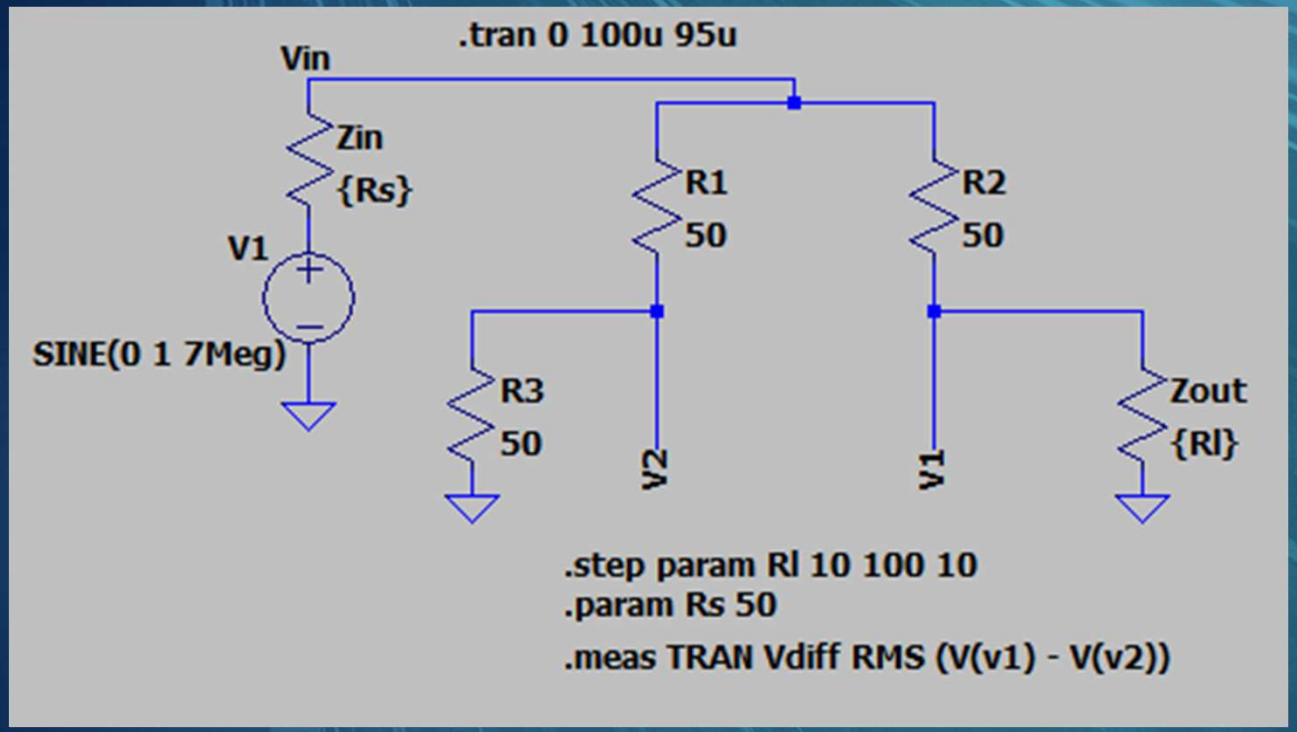
.tran 1m

```
vp: AVG(v(s+))=2.49775 FROM 0 TO 0.001
vn: AVG(v(s-))=2.5 FROM 0 TO 0.001
vd: (vn - vp)=0.00225472
vm: vd*ag=0.288605
vadc: vm*adc=274640
sf: vadc/600=457.733
gms: vadc/gf=600.962
```



Cursor 1
V(s-)-V(s+)
Horz: 236.8214µs Vert: 2.2547245mV
Cursor 2
Horz: -- N/A-- Vert: -- N/A--
Diff (Cursor2 - Cursor1)
Horz: -- N/A-- Vert: -- N/A--
Freq: -- N/A-- Slope: -- N/A--

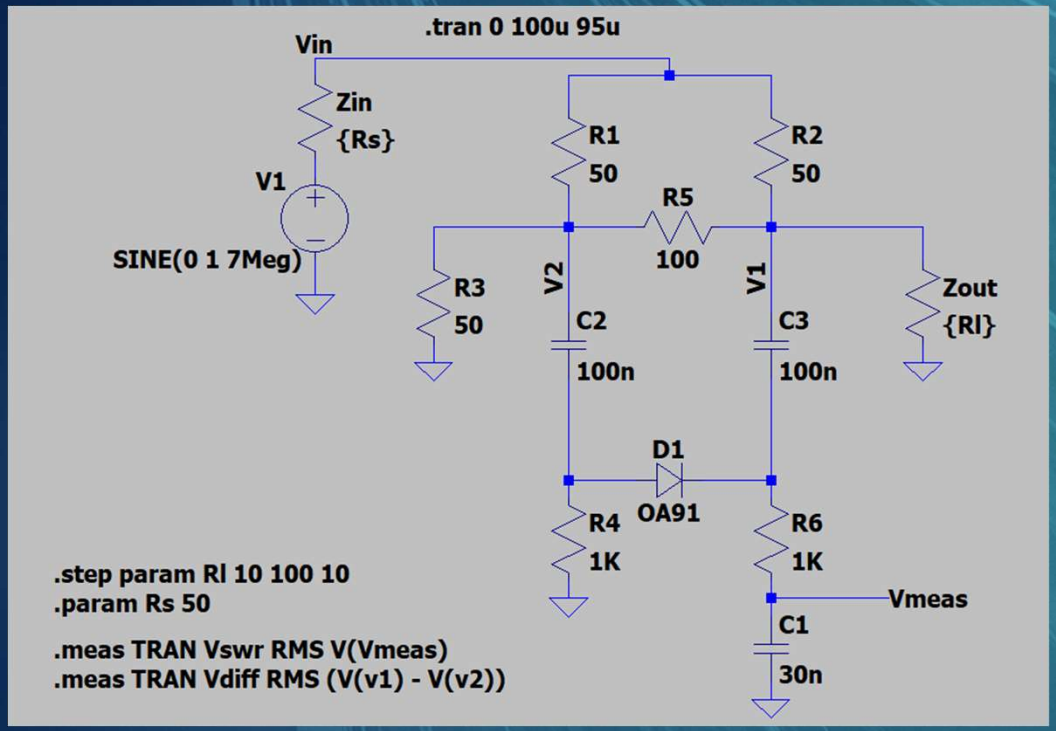
SWR with Wheatstone Bridge



Measurement: vdiff

step	RMS(v(v1) - v(v2))
1	0.0986397
2	0.0668205
3	0.0406164
4	0.0186616
5	0
6	0.0160576
7	0.0300208
8	0.0422742
9	0.0531137
10	0.0627707

Detector

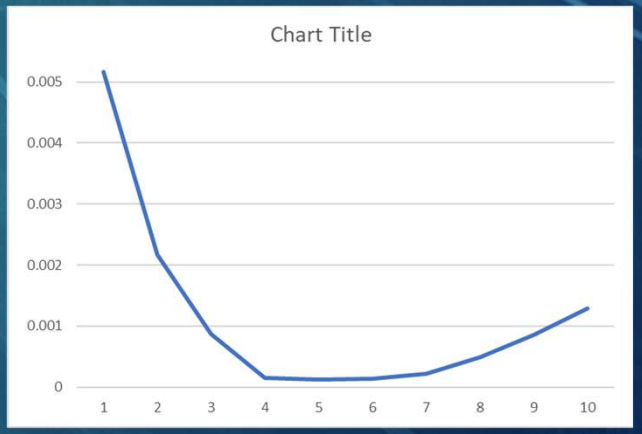


Measurement: vdiff

step	RMS(v(v1) - v(v2))
1	0.0700472
2	0.0454747
3	0.0267262
4	0.0120013
5	1.96664e-006
6	0.00989201
7	0.0181911
8	0.0252524
9	0.031334
10	0.036642

Measurement: vswr

step	RMS(v(vmeas))
1	0.00516979
2	0.00217436
3	0.000863429
4	0.000148736
5	0.000121162
6	0.000138377
7	0.000224854
8	0.000488699
9	0.000851575
10	0.00128201

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