HAM Radio Board of Education

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Antenna Summit

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Session 3 – Components

Chapter 4.1 to 4.5.6

+ Other Material

Instructor:

Phil Brunner – AE7OH (was K9DTD, W6GOL)

- ARRL HANDBOOK for Radio Communications
  - (Reference for detailed information)
- Q & A via Chat or at the end of each hour
- Email questions to: phil.brunner@gmail.com
- Viewgraphs are at HamRadioEdu.com

Chapter 4 – Components

- The World of electronics is changing rapidly
  - Landlines replaced by Cell Phone, Zoom, Skype
  - Vacuum Tubes Disappearing – (Light Bulbs, CRTs, Radio Tubes)
- Computers and DSPs are replacing individual components and units (e.g., Modems)
- We will concentrate on characteristics and skip the details!

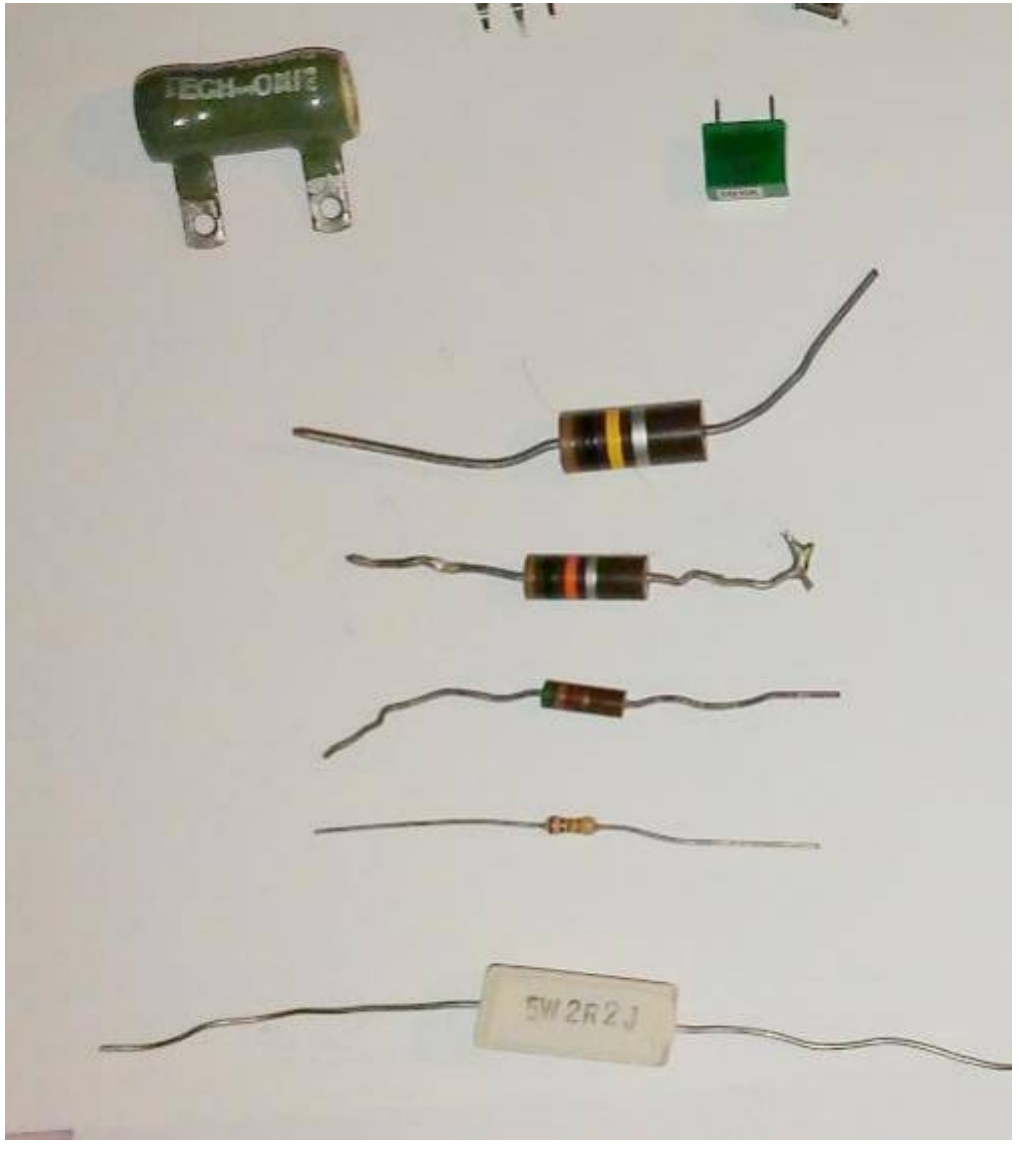
Components Characteristics

- Practical Resistors, Capacitors and Inductors
- Transformers
- Semiconductors

- Circuit Simulation and AnalysisTools
- Examples

Resistors

- Wire size suitable for max current
- Resistance usually increases with temperature
- Component Resistors
  - Carbon, Metal-oxide
  - Wirewound- low-frequency due to inductance
  - Metal-film, Carbon-film – deposit on insulating substrate
- Power rating and temperature stability are considerations
- Tolerance often unimportant – 20%, 10%, 5%, 1%
- Potentiometers – variable resistors

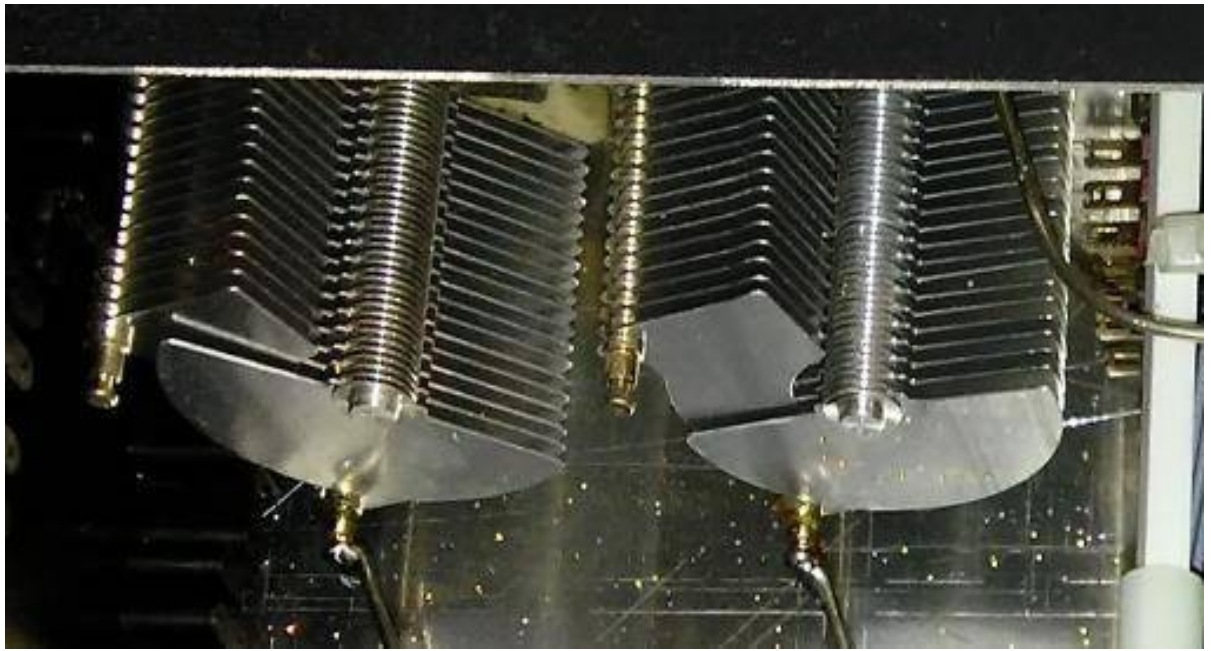


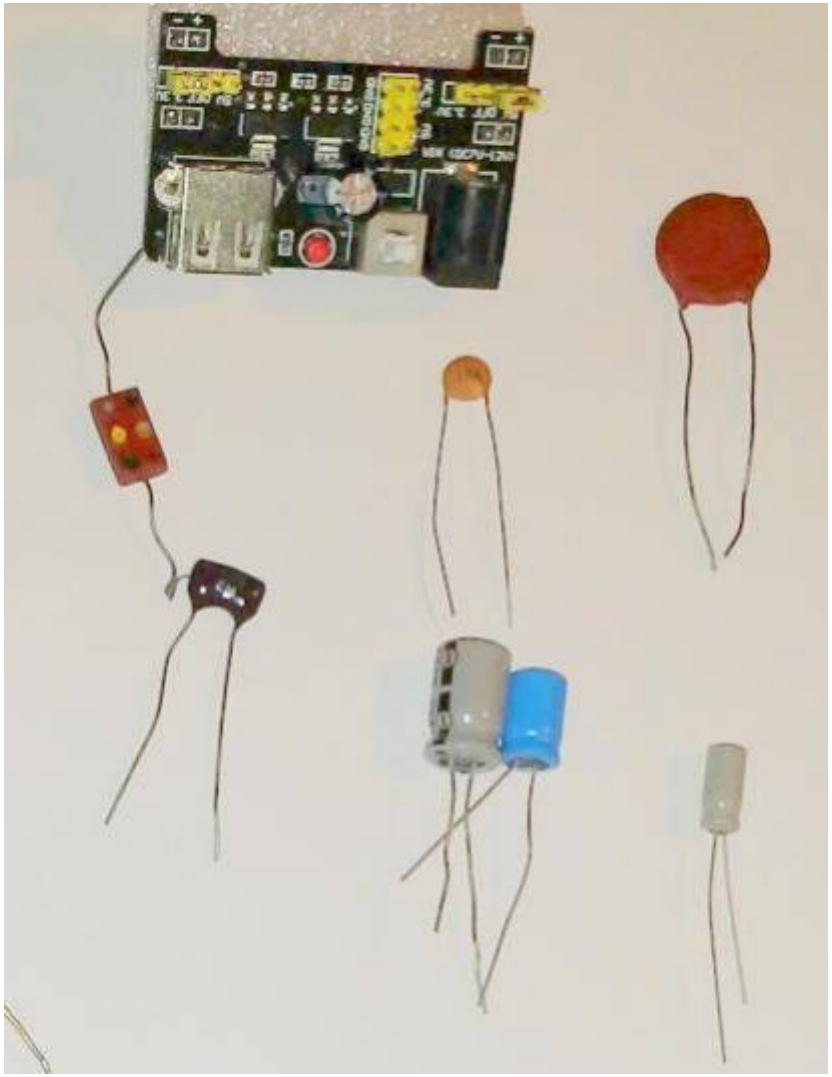
Resistors

Capacitors

- Ideally blocks DC, no leakage, no energy loss
- Tolerance and temperature coefficient
- Voltage rating and breakdown
- Frequency, resistance, leakage, inductance considerations
- Ceramic, plastic film, mica, electrolytic, air-variable, vacuum
- Electrolytics are high capacity and polarized - low frequency filtering

Capacitors

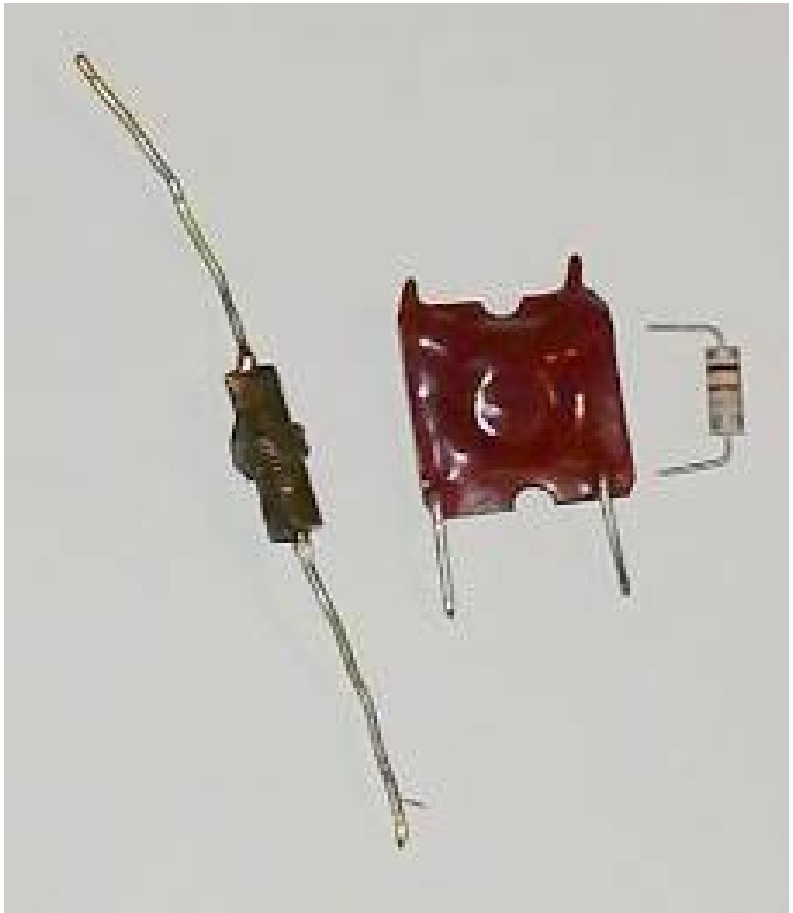


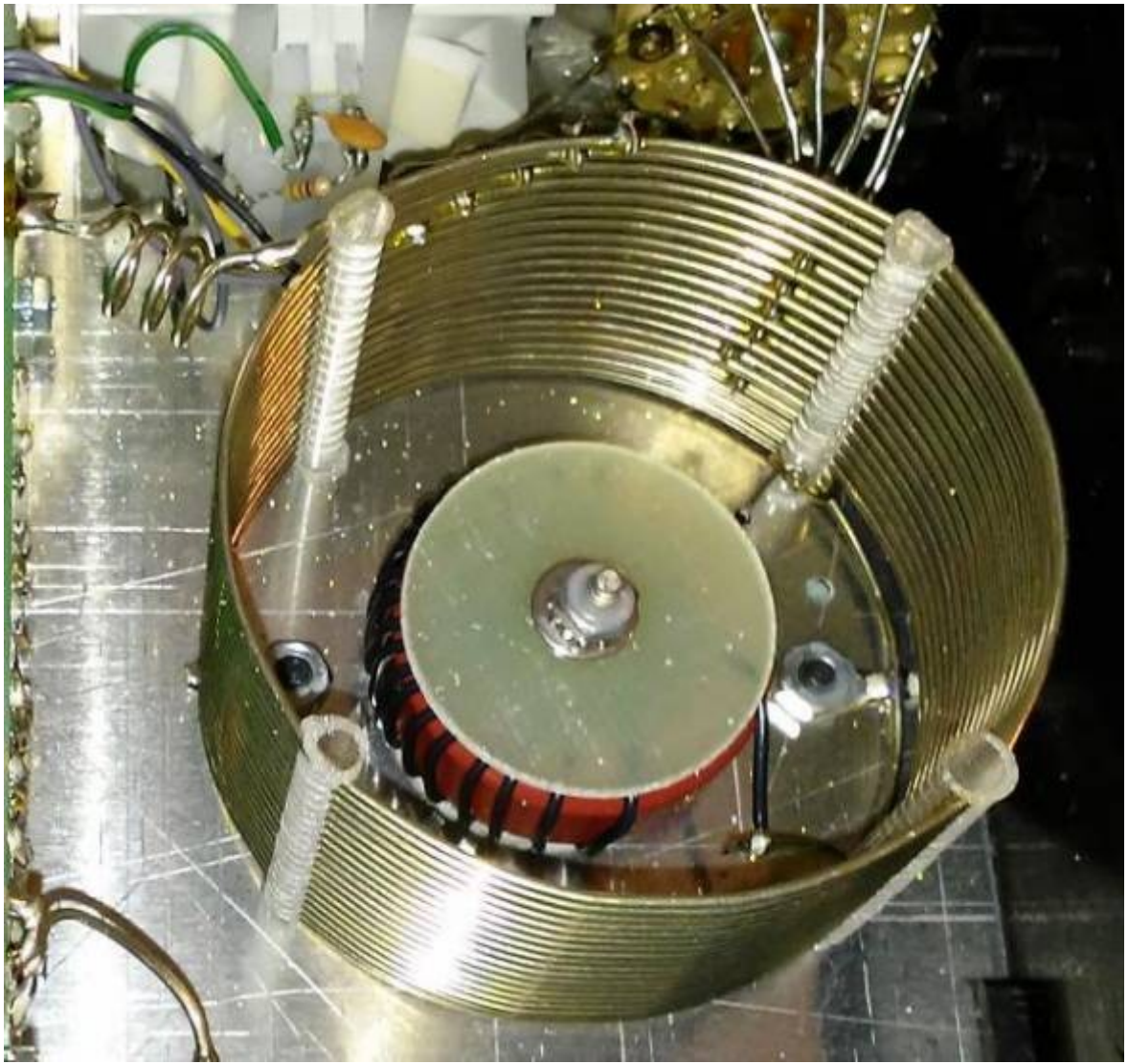


Inductors

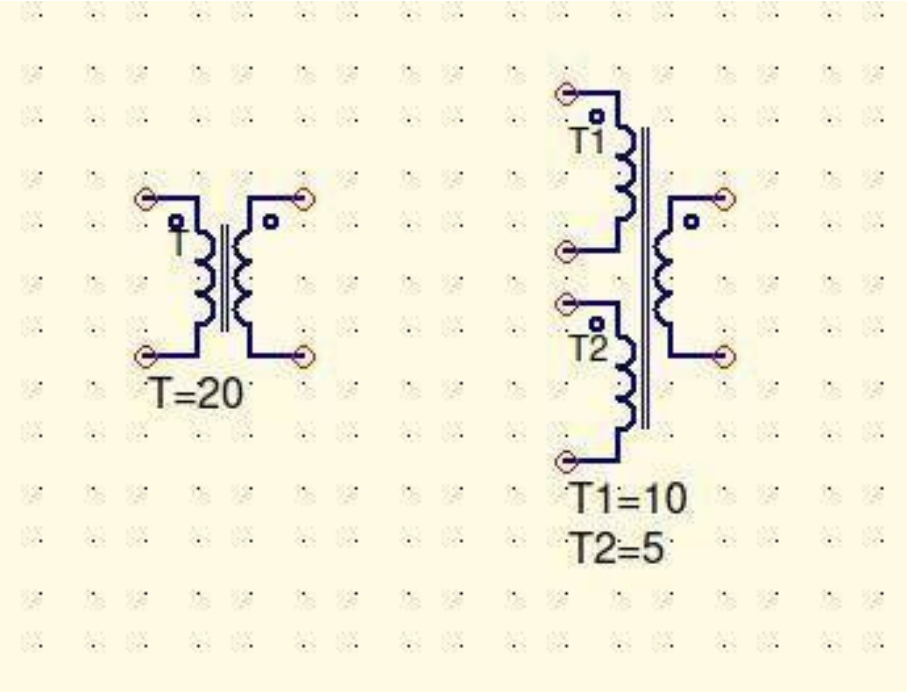
- Air-core or iron-core
- Encapsulated (looks like resistor)
- Slug tuned (variable)
  - magnetic or non-magnetic core inside coiled inductor
  - Adjust with screw-driver

Inductors



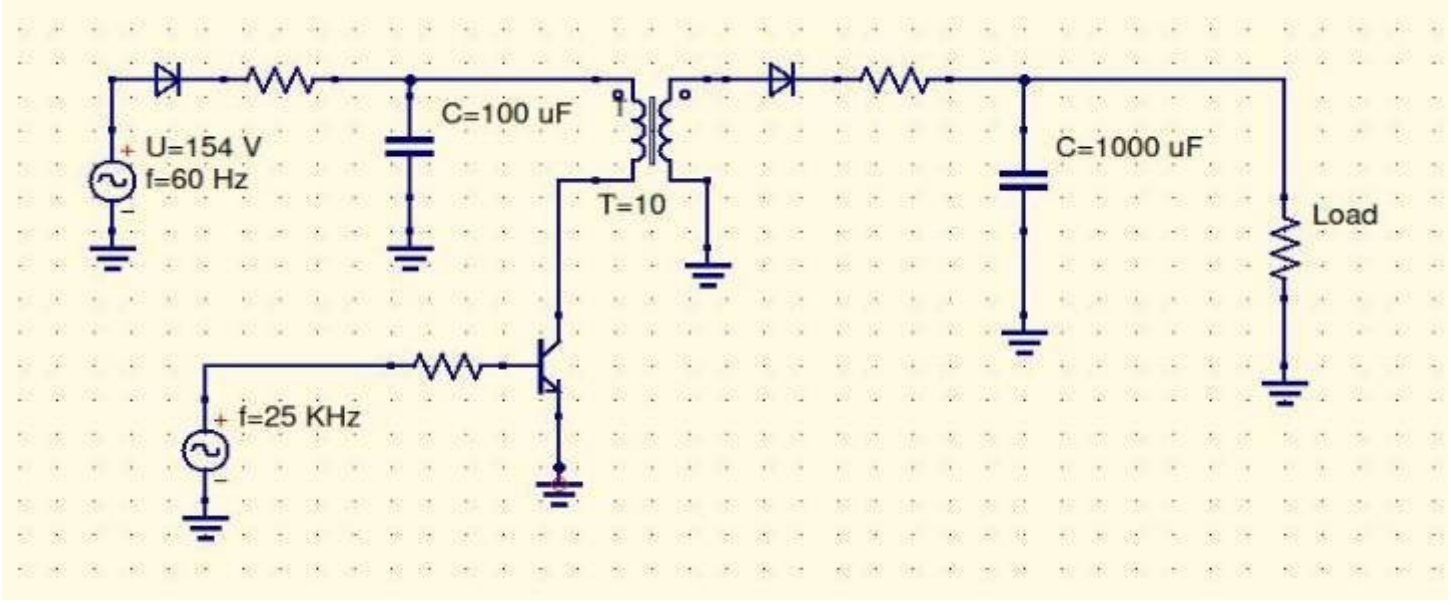


Transformers



Switching Power Supply (Conceptual)

- Use high frequency to minimize transformer size/weight
- Needs careful design/shielding to avoid HF interference



Semiconductors

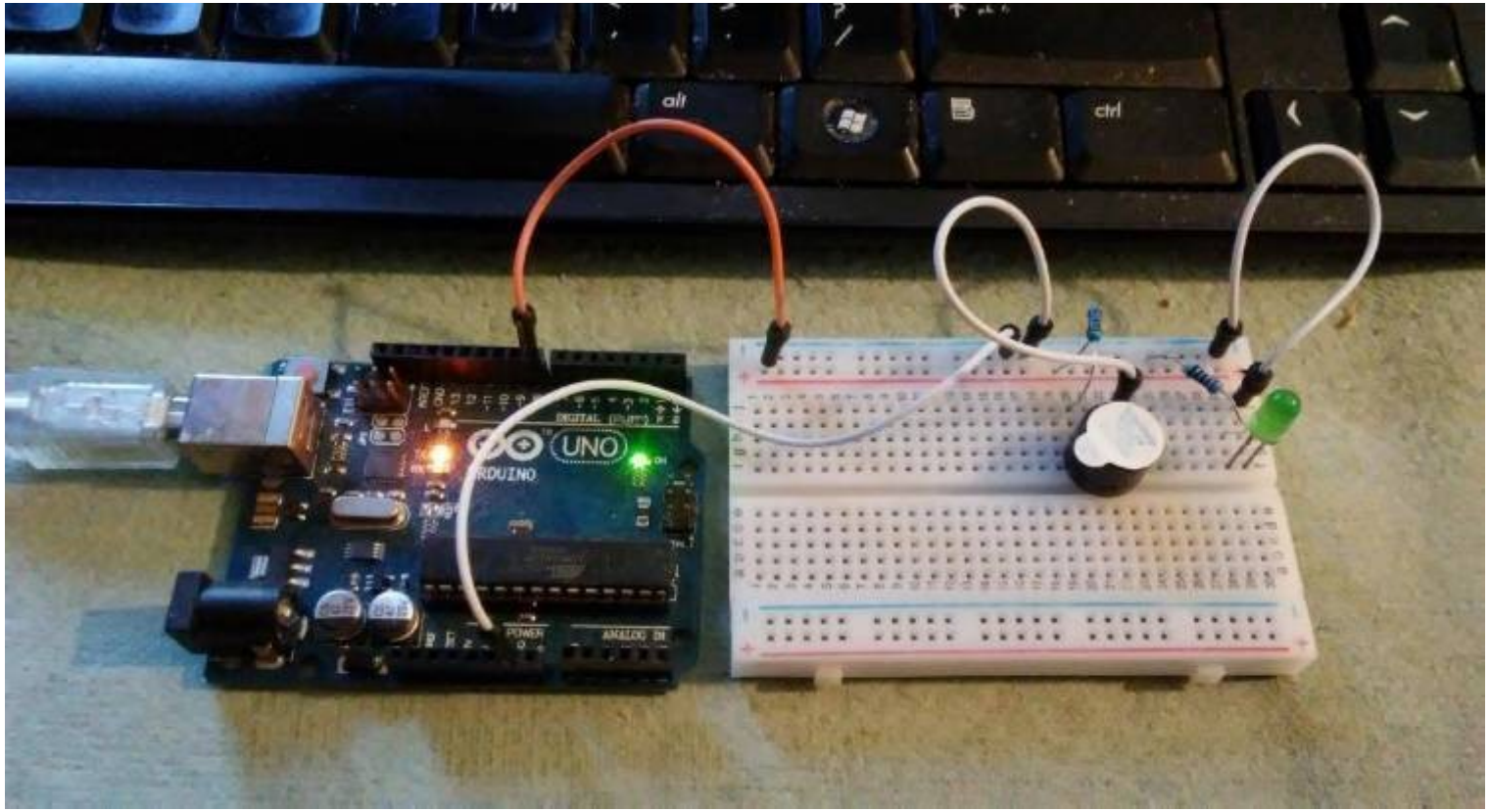
- Diodes – Point Contact, Pin, Schottky, Varactor, Zener
  - Current, PIV, Speed, Reverse Current
- Transistors – BJT, JFET, MOSFET
  - Gain, Operating Regions and Parameters
- Optical – Photo, LED, Laser, Optoisolators

TOOLS

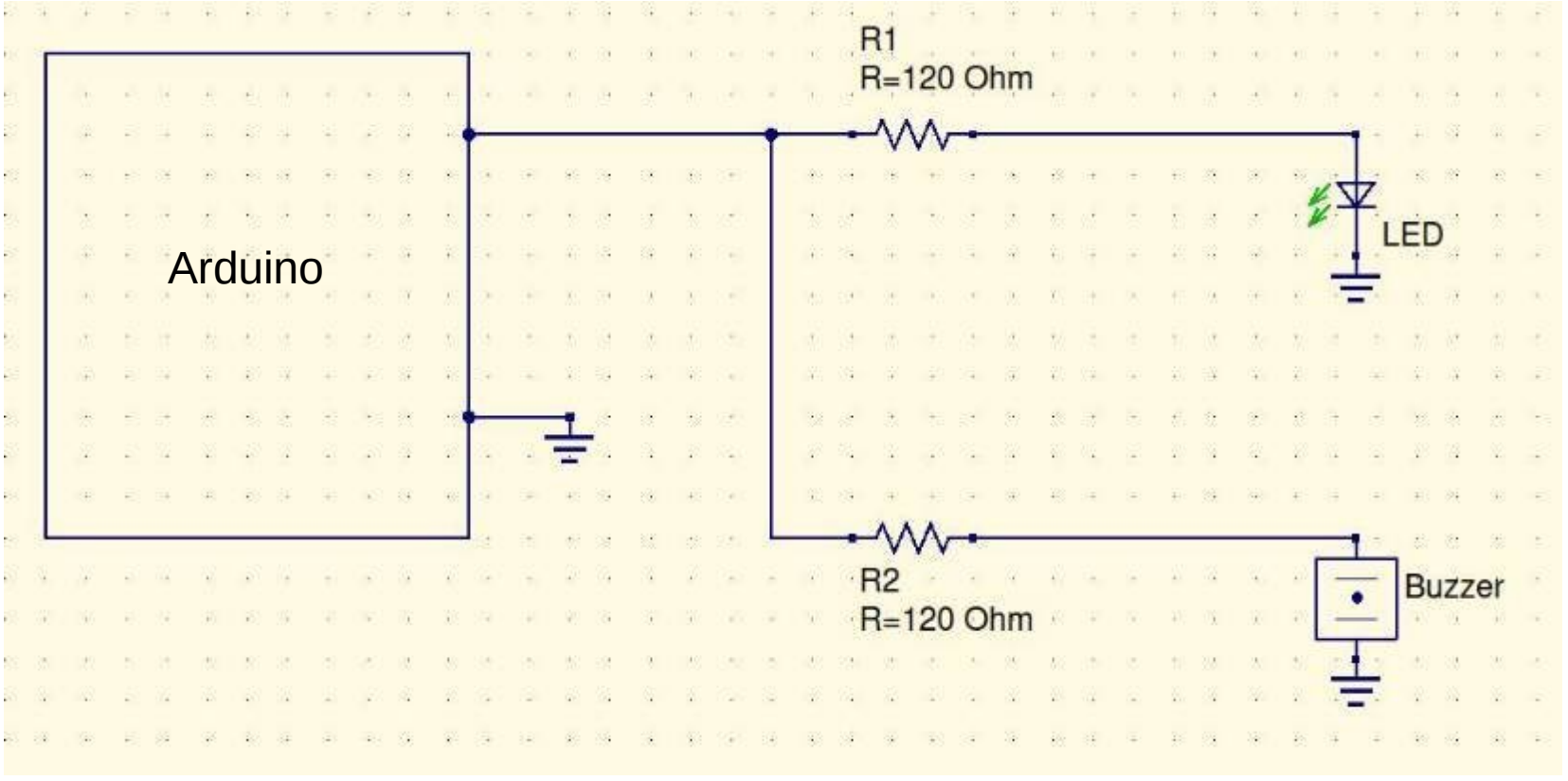
- Arduino UNO + Breadboard
- QUES – Quite Universal Circuit Simulator (Free)
  - https://sourceforge.net/projects/qucs/files/latest/download
- Circuit Calculations with Complex Numbers and Spreadsheets (Excel or LibreOffice CALC)
  - Free LibreOffice Download: https://www.libreoffice.org/

Arduino and Breadboard

CQ CQ DE AE7OH K



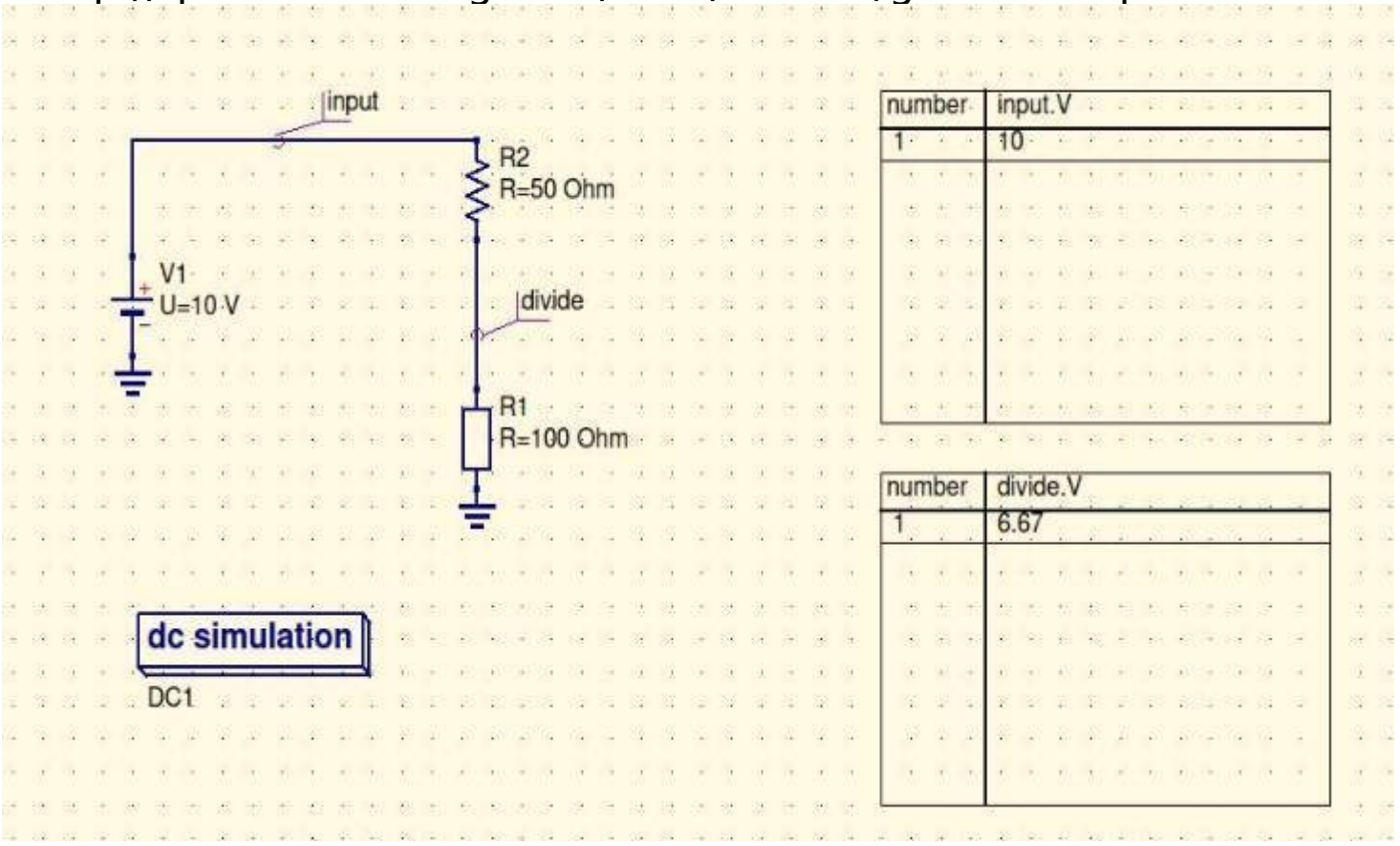
Arduino+Breadboard Schematic



QuiteUniversalCircuitSimulator

https://sourceforge.net/projects/qucs/files/latest/download

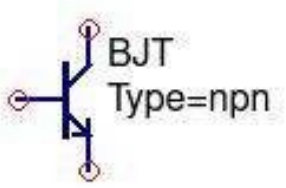
Manual: http://qucs.sourceforge.net/docs/tutorial/getstarted.pdf

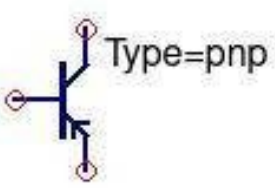


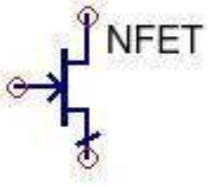
number	input.V
1	10

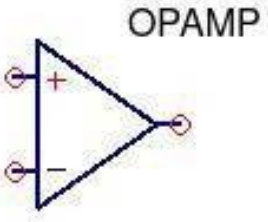
number	divide.V
1	6.67

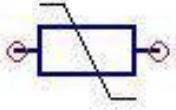
Some Semiconductor Symbols

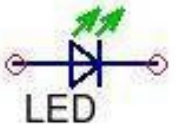


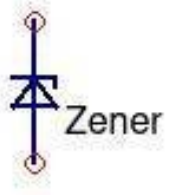




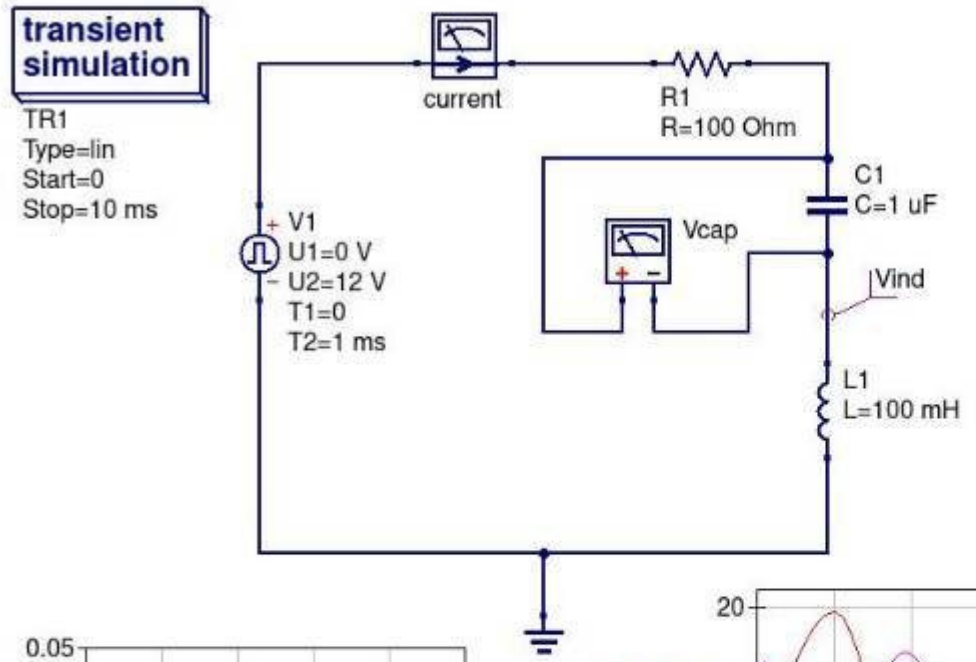




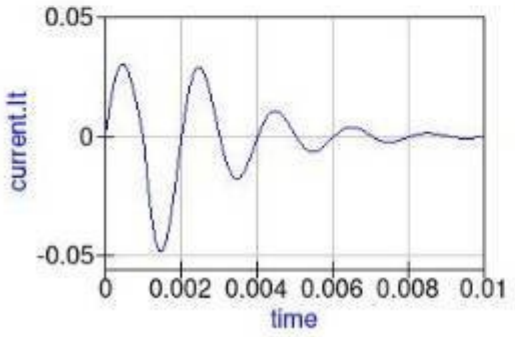


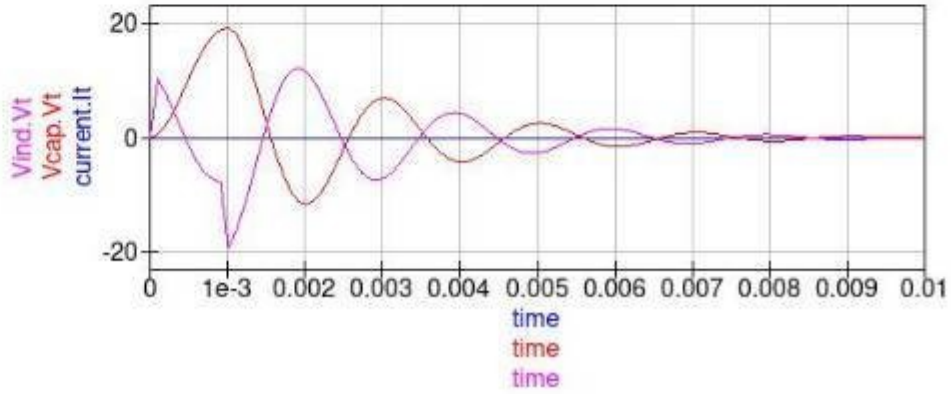


RLC Transient Simulation

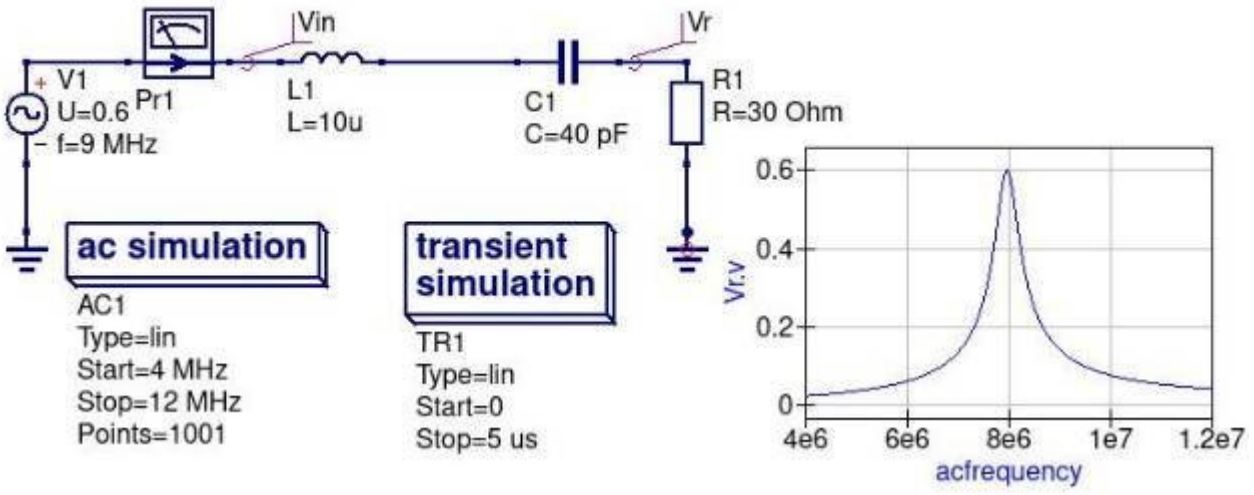


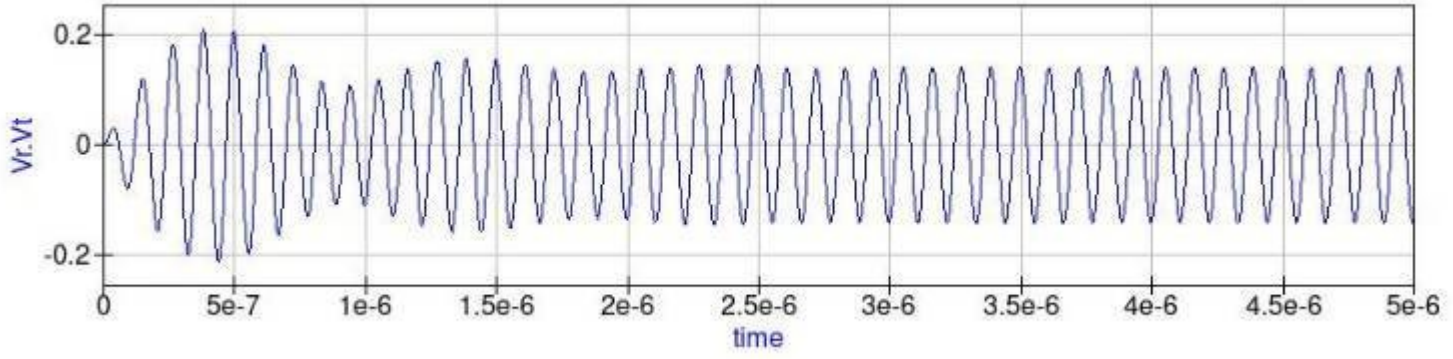
time	current.It	Vcap.Vt	Vind.Vt
0	0	0	0
0.000101	0.0113	0.587	10.3
0.000202	0.0205	2.21	7.74
0.000303	0.0268	4.63	4.69
0.000404	0.0299	7.52	1.49
0.000505	0.0299	10.6	-1.55
0.000606	0.0269	13.5	-4.15
0.000707	0.0217	15.9	-6.1
0.000808	0.0149	17.8	-7.27
0.000909	0.00729	18.9	-7.64
0.00101	-0.000903	19.3	-19.2
0.00111	-0.019	18.2	-16.3
0.00121	-0.0335	15.5	-12.2
0.00131	-0.0433	11.6	-7.29
0.00141	-0.0481	6.97	-2.16
0.00152	-0.0478	2.09	2.69
0.00162	-0.0429	-2.53	6.82



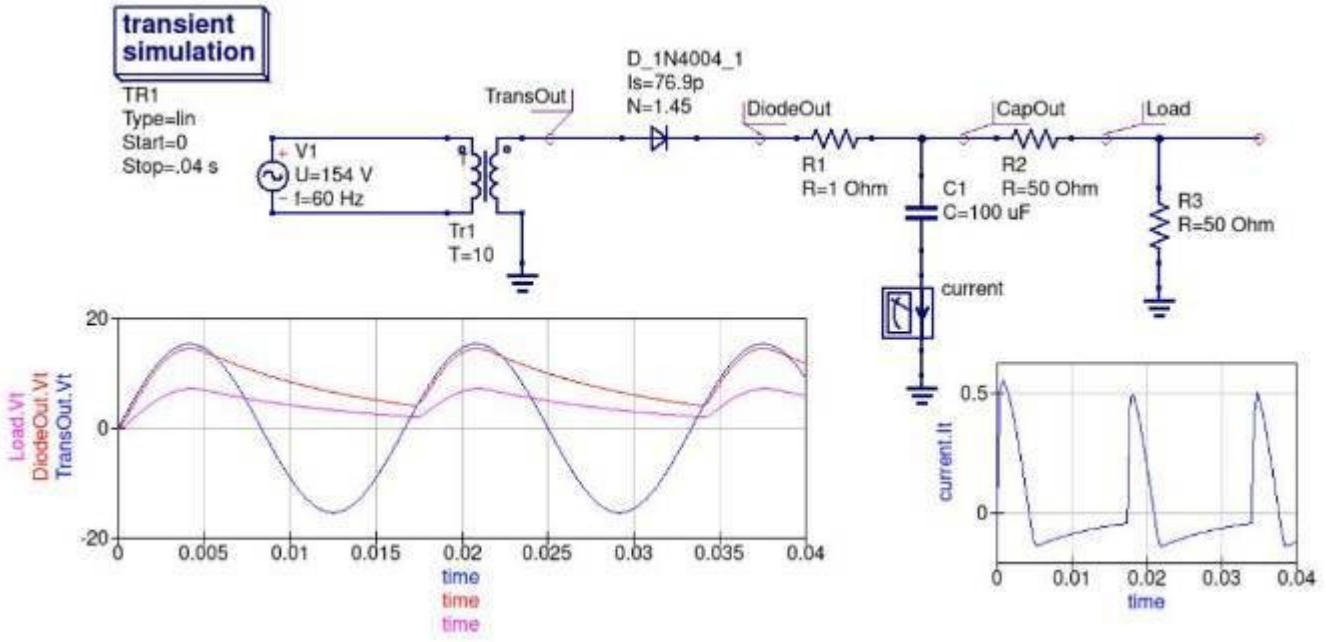


RLC Frequency And Transient Simulations

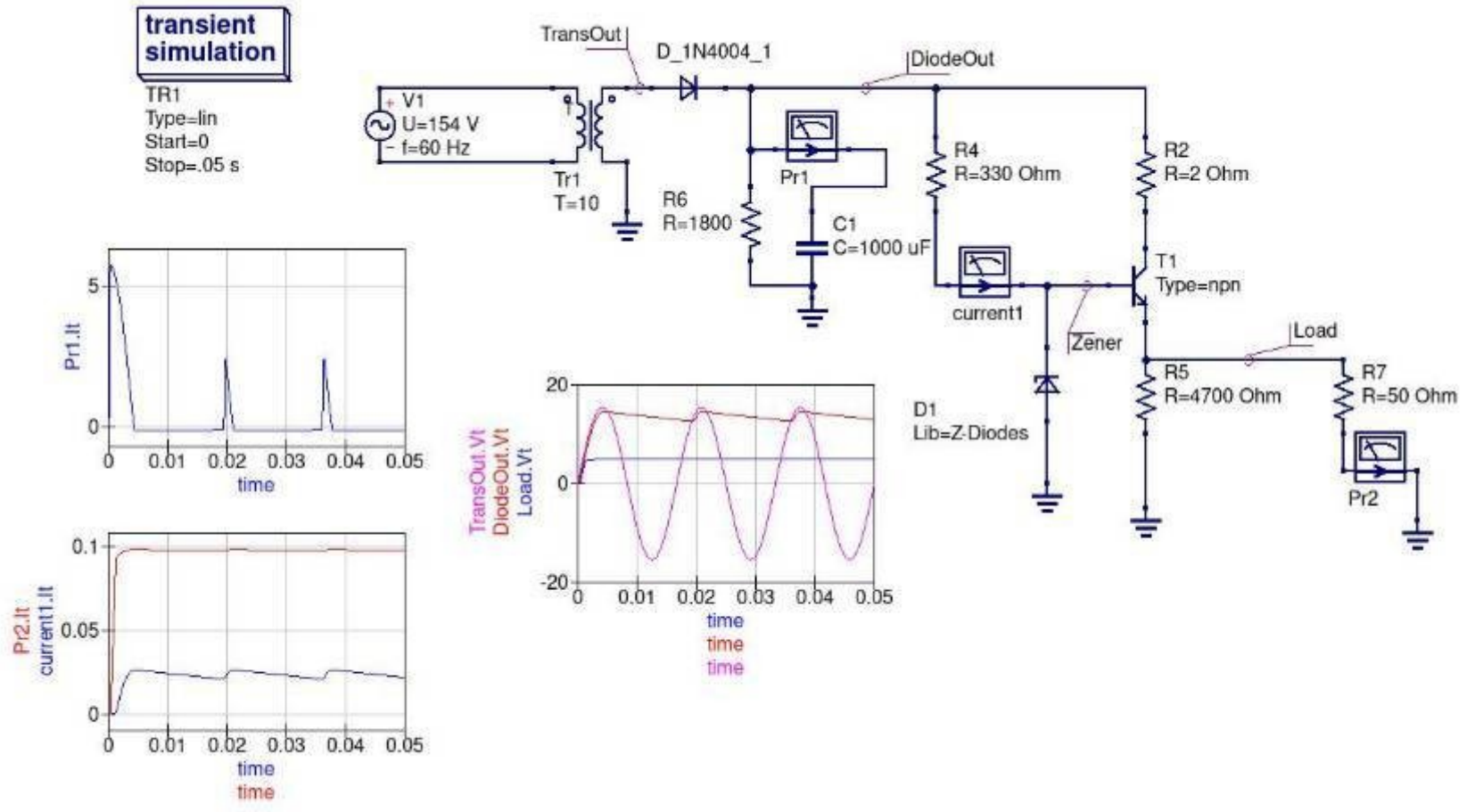


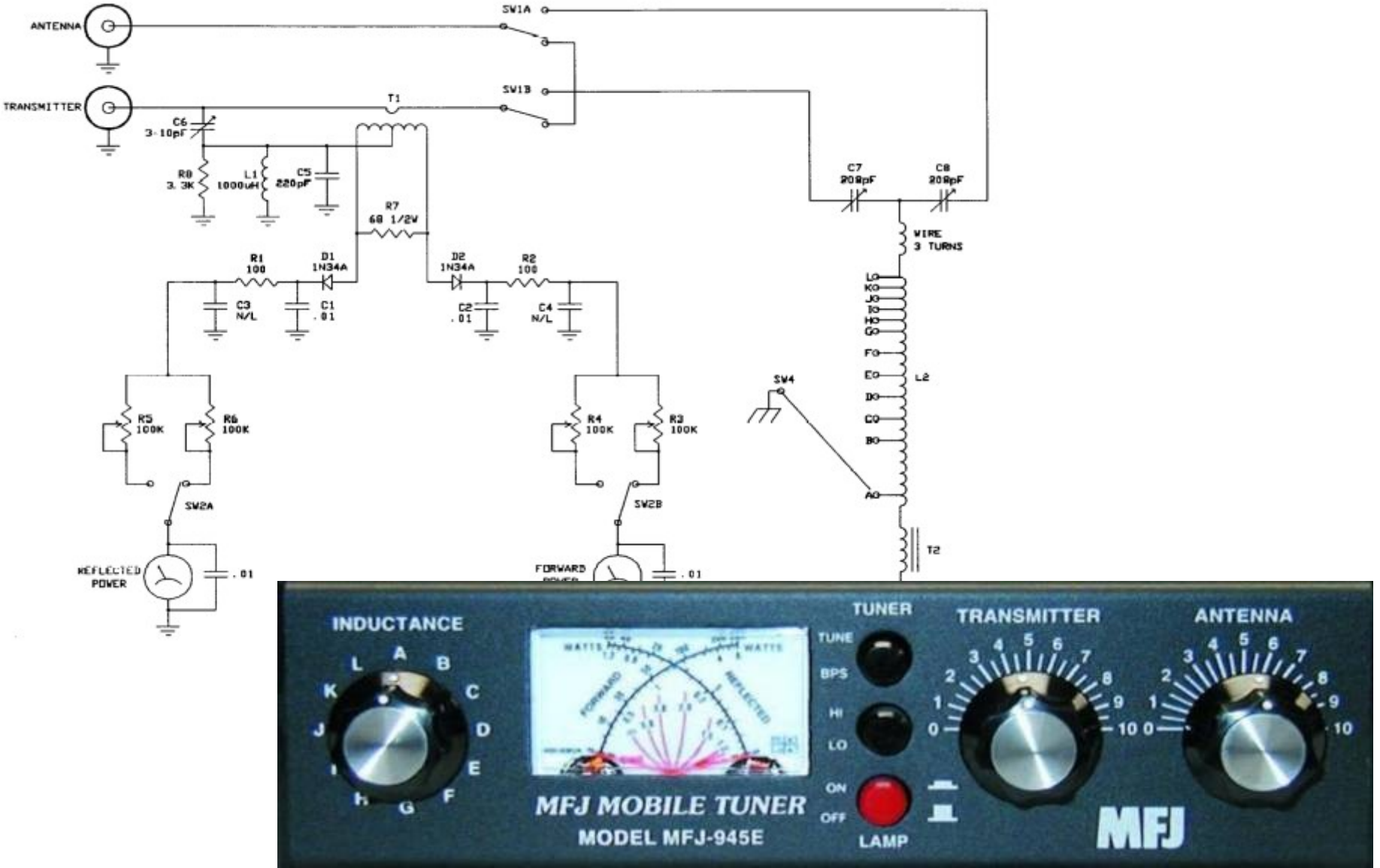


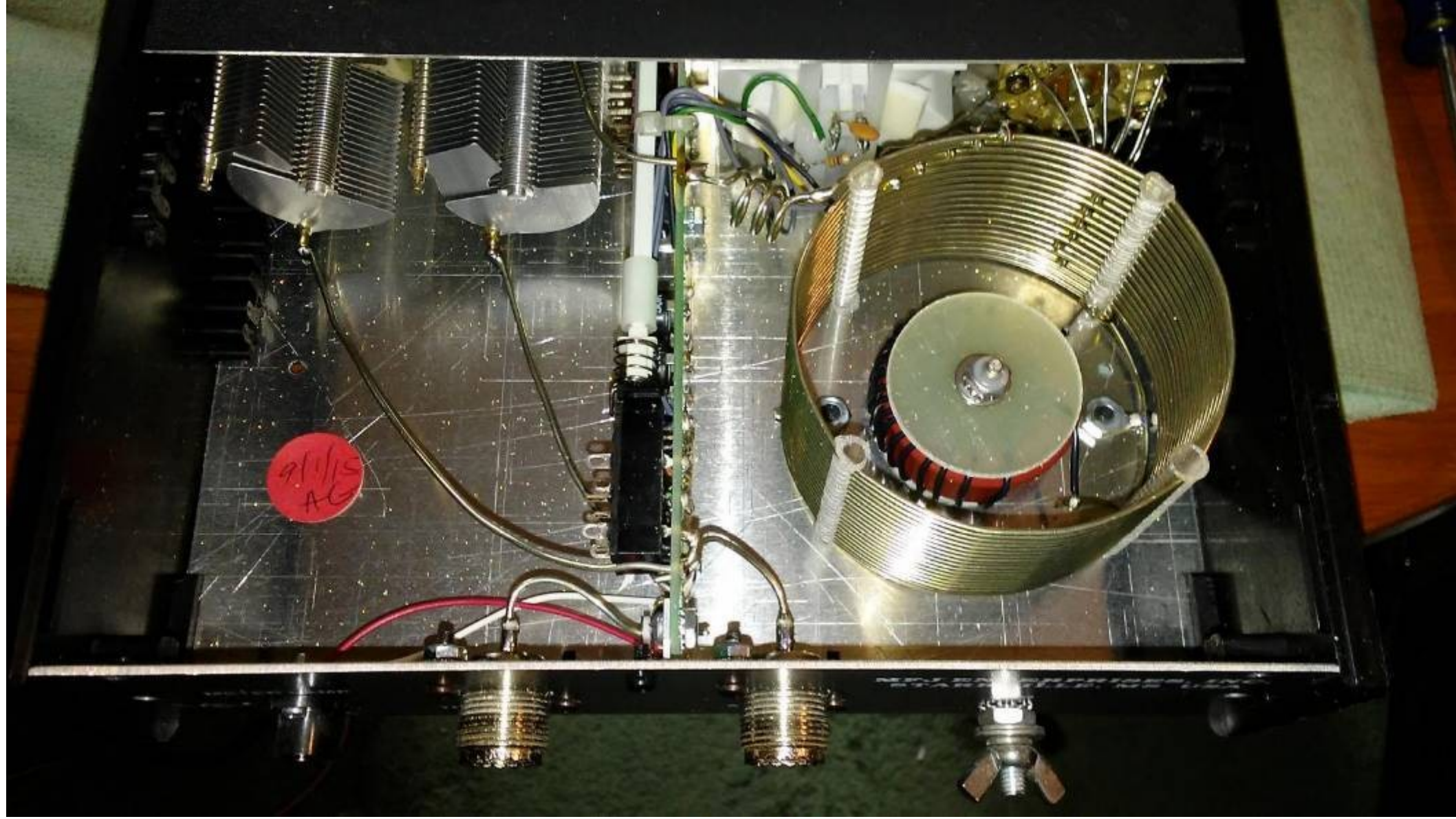
Simple Power Supply



Regulated Power Supply




ANTENNA
TRANSMITTER
SW1A
SW1B
T1
C6
3-10pF
R8
3.3K
L1
1000uH
C5
220pF
R7
68 1/2W
C7
209pF
C8
209pF
WIRE
3 TURNS
L2
T2
R1
100
D1
1N34A
D2
1N34A
R2
100
C3
N/L
C1
.01
C2
.01
C4
N/L
R5
100K
R6
100K
R4
100K
R3
100K
SW2A
SW2B
SW4
REFLECTED
POWER
FORWARD
POWER
.01
.01
INDUCTANCE
TUNER
TRANSMITTER
ANTENNA
TUNE
BPS
HI
LO
ON
OFF
LAMP
MFJ MOBILE TUNER
MODEL MFJ-945E
MFJ

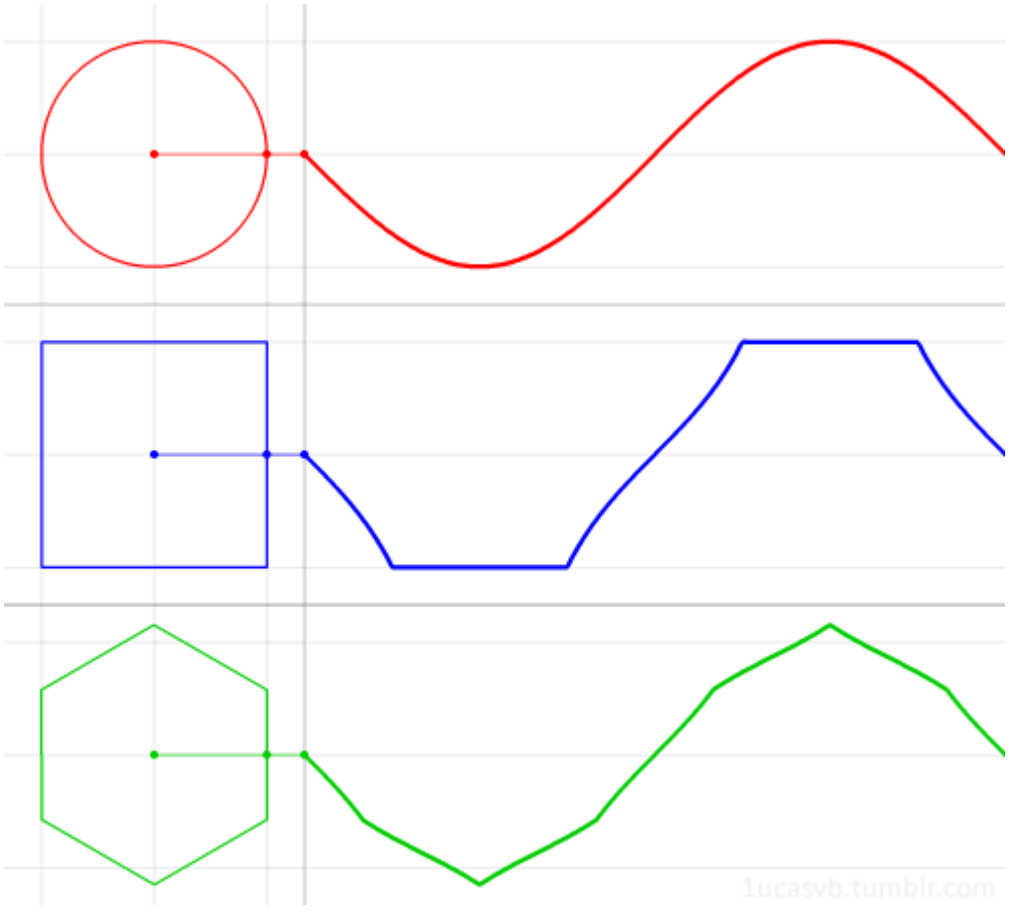

9/1/15
AC

Alternating Current Sine Waves

Radial rotates at f cycles per second
to create a sine wave

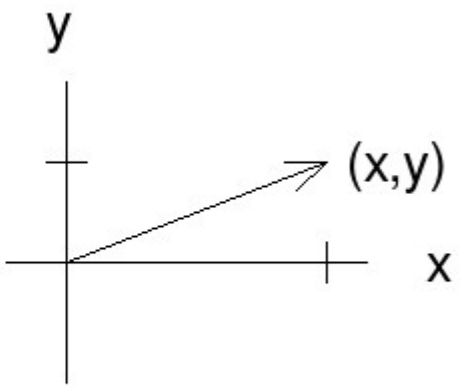
Imaginary axis
(j or i)

Real
axis

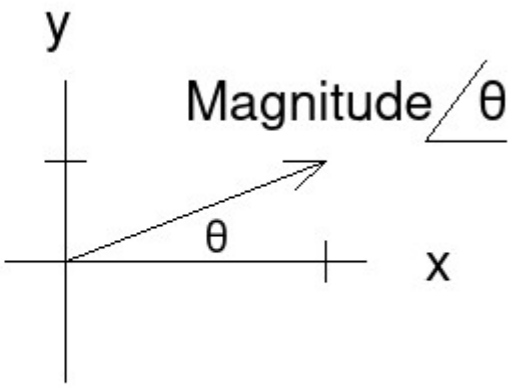

1ucasvb.tumblr.com

AC Representations

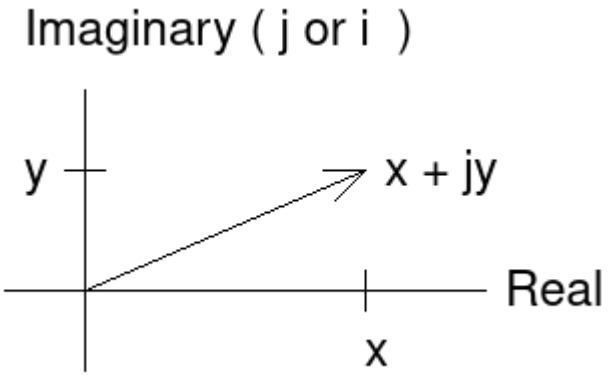
Vectors



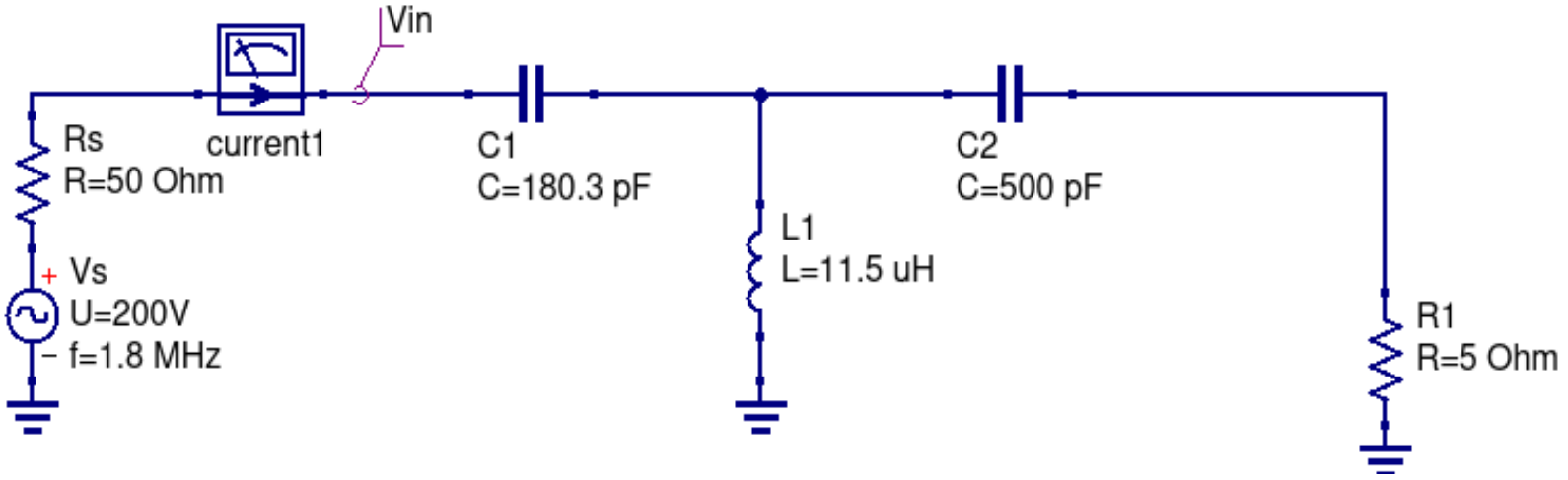
Polar Form



Complex Numbers (easy calculations)



Calculate Impedance Match



$$\frac{1}{j\omega C1}+\frac{1}{\frac{1}{j\omega L1}+\frac{1}{R1+\frac{1}{j\omega C2}}}$$

Impedance Match Calc Spreadsheet

(See Figure 24.4 in Antenna Book)

	A	B	C	D	E	F	G	H	I
1				T NETWORK			ANTENNA/LOAD		
2	component		C-xmtr		C-antenna		x	y	
3				L					
4									
5									
6	value		1.80E-10	1.15E-05	5.00E-10		5	0	
7			(180.3 pf)	(11.5 uhenry)	(500 pf)				
8									
9	reactance		-490.402038344852i	130.061826i	-176.838975027154i		5		
10									
11					38.2180330964639-2.79408640923299i				
12	(1.8 Mhz)	freq	1.80E+06		answer				
13	radian_freq	rad. Freq.	11309724						
14									
15									
16		Q	1000	200	1000				
17			0.490402038344852-490.402038344852i	0.65030913+130.061826i	0.176838975027154-176.838975027154i		5		
18									
19					49.0615676552388-4.68763200560596i				
20	per Figure 24.4 Antenna Book				answer				
21									
22				IMSUM(C17,IMDIV(1,IMSUM(IMDIV(1,D17),IMDIV(1,IMSUM(E17,G17)))))					
23									

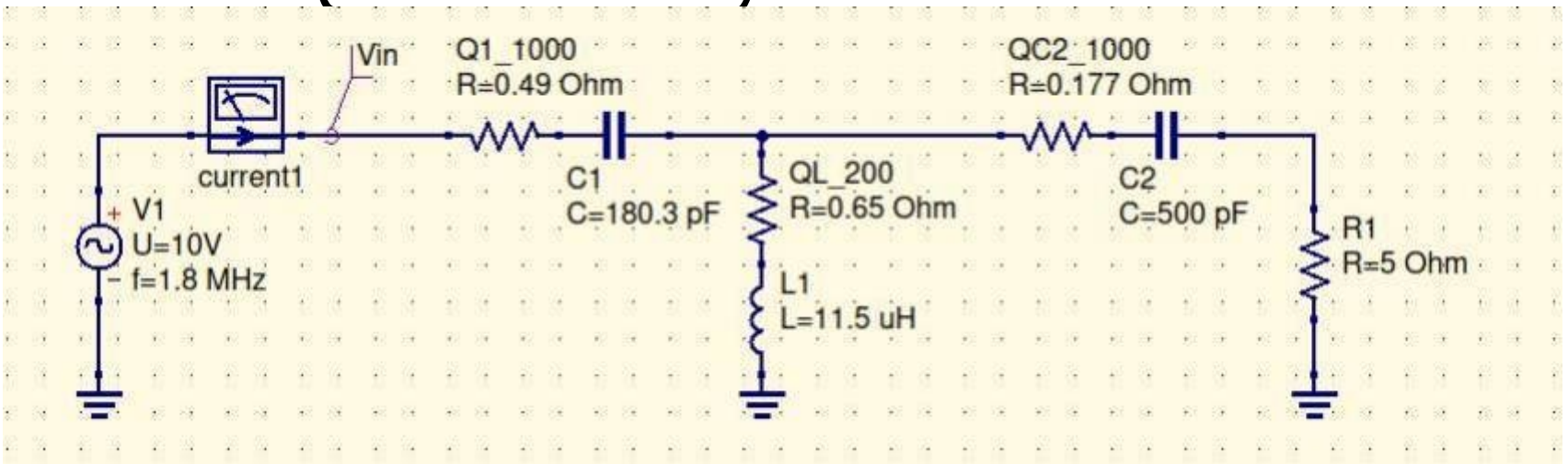
=IMSUM(C9,IMDIV(1,IMSUM(IMDIV(1,D9),IMDIV(1,IMSUM(E9,G9)))))

Excel or CALC Complex Functions

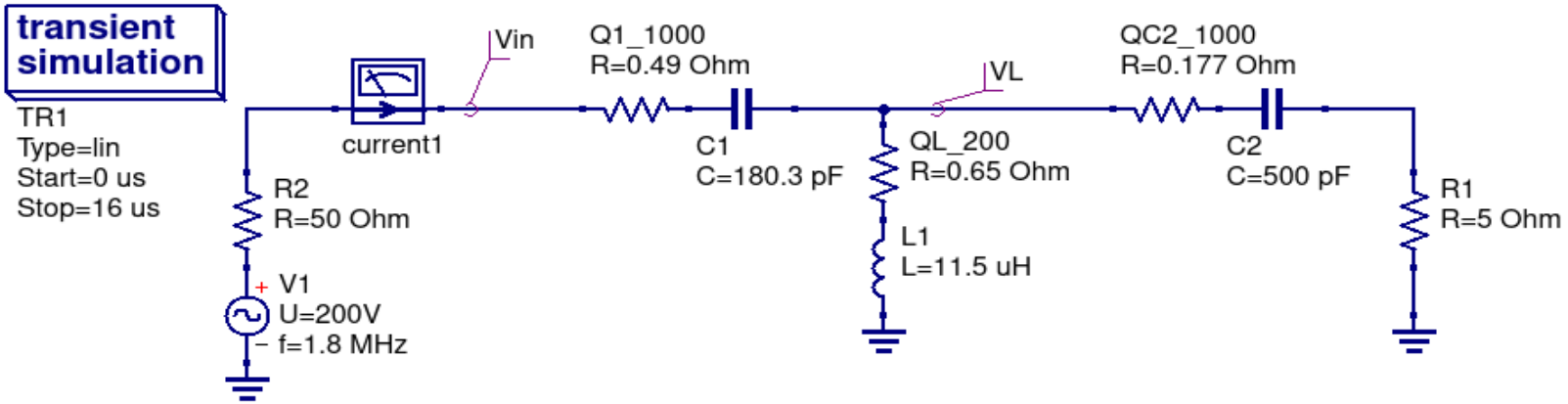
COMPLEX	Returns a complex number, given real and imaginary parts as numbers.	IMLOG10	Returns the base-10 logarithm of a complex number.
IMABS	Returns the absolute value of a complex number.	IMLOG2	Returns the base-2 logarithm of a complex number.
IMAGINARY	Returns the imaginary part of a complex number.	IMPOWER	Returns a complex number raised to a power.
IMARGUMENT	Returns the argument of a complex number.	IMPRODUCT	Returns the product of complex numbers.
IMCONJUGATE	Returns the complex conjugate of a complex number.	IMREAL	Returns the real part of a complex number.
IMCOS	Returns the cosine of a complex number.	IMSEC	Returns the secant of a complex number.
IMCOSH	Returns the hyperbolic cosine of a complex number.	IMSECH	Returns the hyperbolic secant of a complex number.
IMCSC	Returns the cosecant of a complex number.	IMSIN	Return the sine of a complex number.
IMCSCH	Returns the hyperbolic cosecant of a complex number.	IMSINH	Returns the hyperbolic sine of a complex number.
IMCOT	Returns the cotangent of a complex number.	IMSQRT	Returns the square root of a complex number.
IMDIV	Returns the result of dividing one complex number by another.	IMSUB	Returns the difference between 2 complex numbers.
IMEXP	Returns e to the power of a complex number.	IMSUM	Returns the sum of complex numbers.
IMLN	Returns the natural logarithm of a complex number.	IMTAN	Returns the tangent of a complex number.

Adjustments for Component Q

- Match adjusted 5-Ohm Antenna to 38 ohms
- Ant. Book assumed Q-values for components
- Added Q-Resistors yield 50 ohms

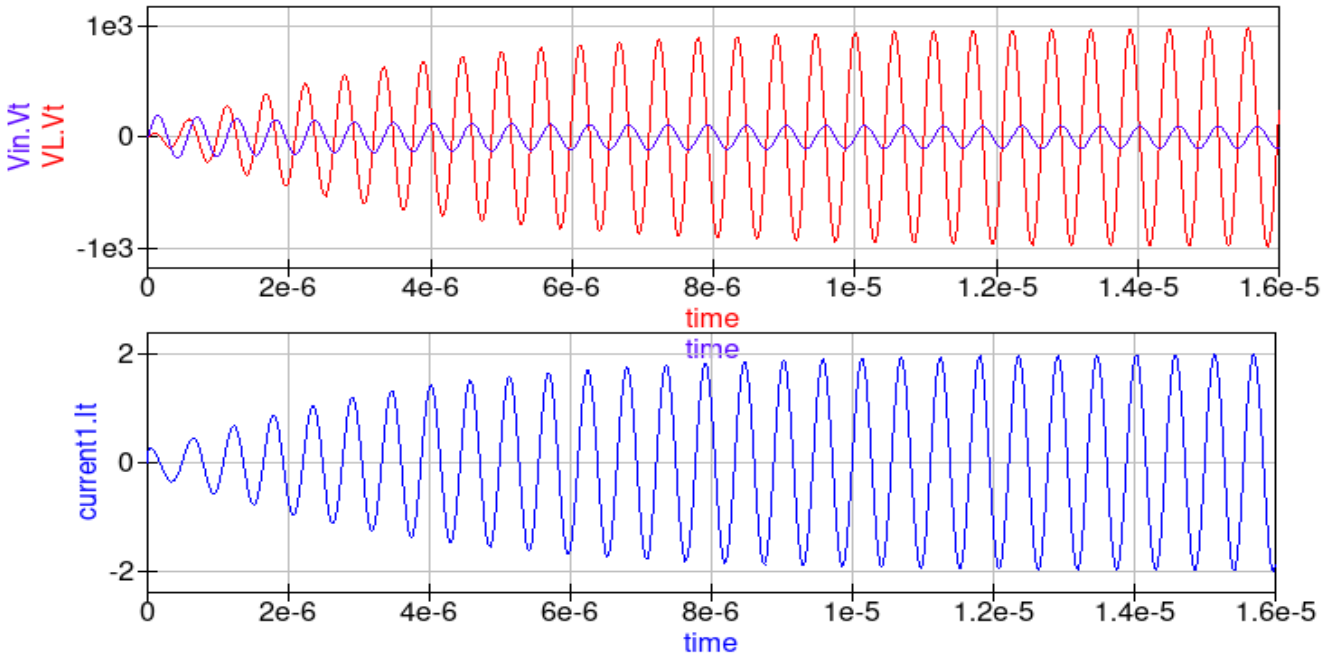


Match



Input voltage: 100V

But peak voltages across tuner elements are 1000V

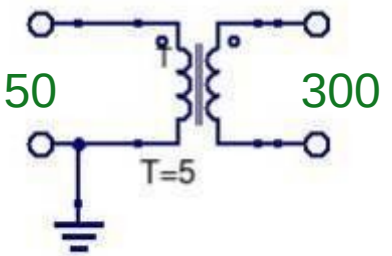


High RF Tuner Voltages

- High Voltage in tuner elements
  - 100 volts peak source
  - 1000 volts peak across components
- Arcing and RF burns potential

- Solutions include better antenna design
  - e.g., a Balun can help match

Example: 5:1 transformer
Matches 50 ohm coax
To 300 ohm antenna



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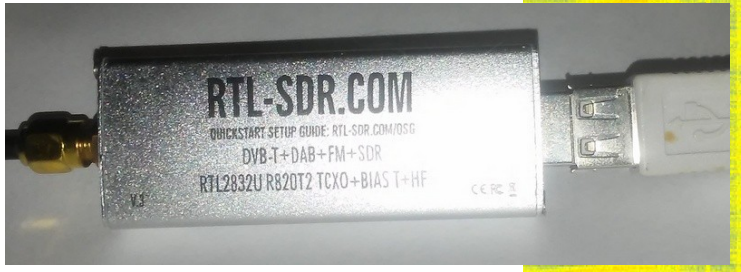
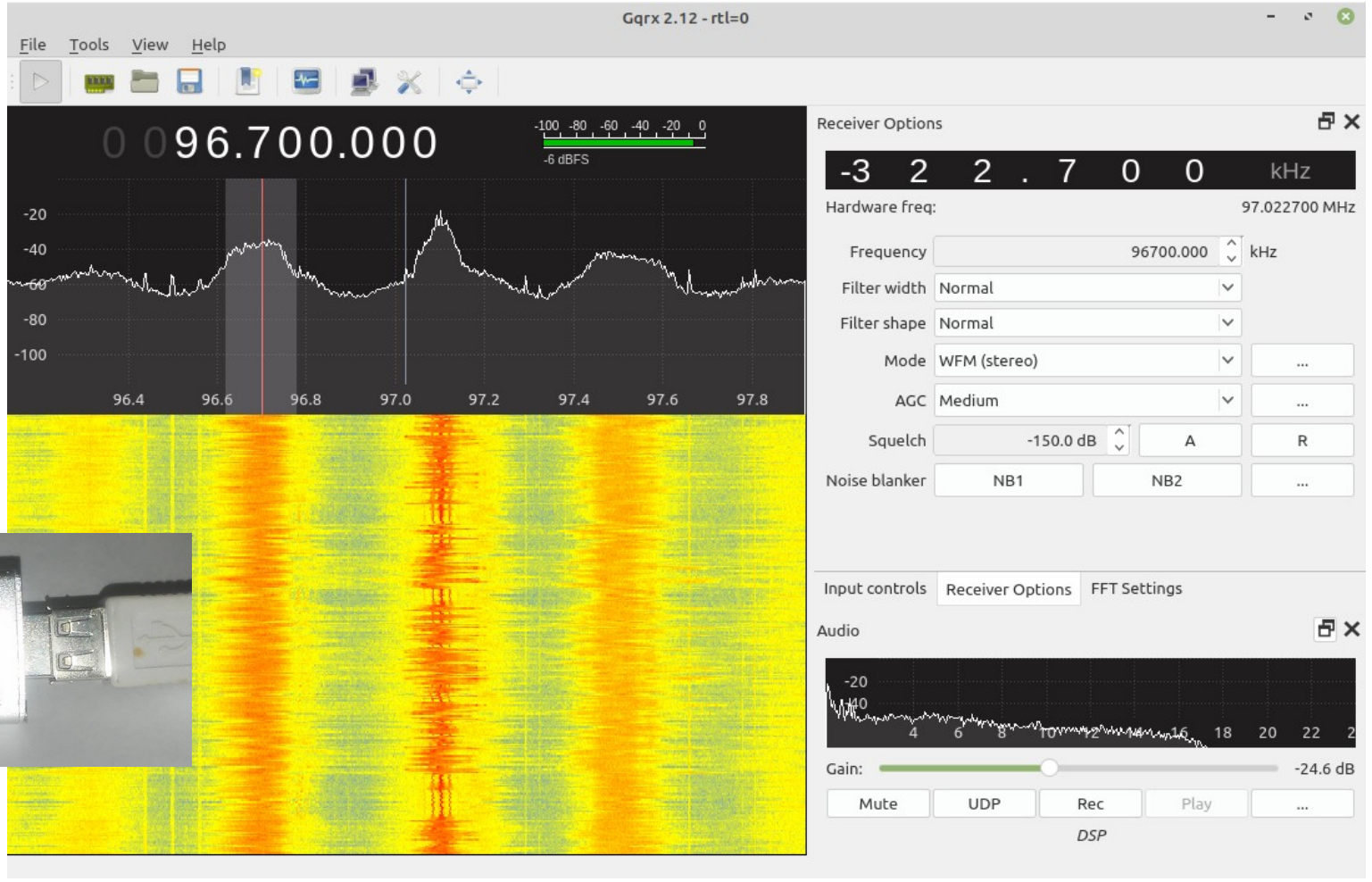
Questions?

You may email questions later to
phil.brunner@gmail.com

SDR - Software Defined Radio





GQRX (Linux, etc.) https://gqrx.dk/download
SDR# (Windows) https://airspy.com/download/