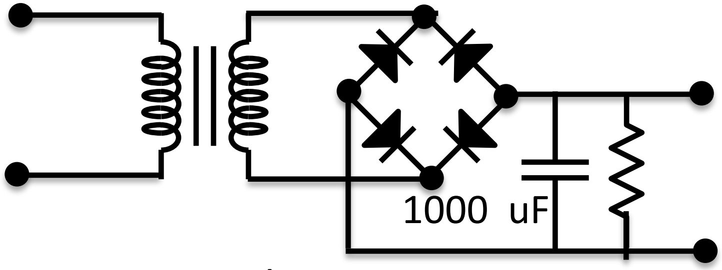


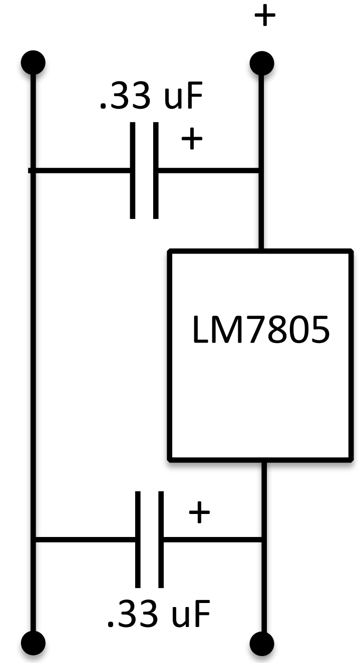
Power supply

For transformer

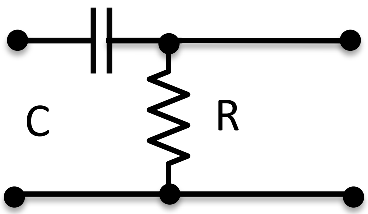
$$V_s = \frac{N_s}{N_p} V_p$$

$$\frac{V_s}{I_s} = \left(\frac{N_s}{N_p}\right)^2 \frac{V_p}{I_p}, \text{ so}$$

$$Z_s = \left(\frac{N_s}{N_p}\right)^2 Z_p$$

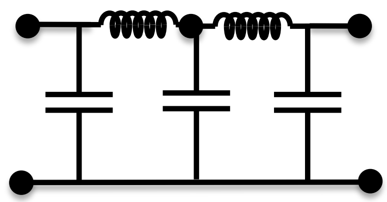


Voltage regulator

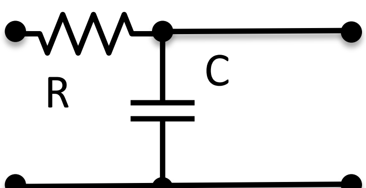


RC-high pass filter

$$H = \left(1 - \frac{j}{\omega RC}\right)^{-1}$$

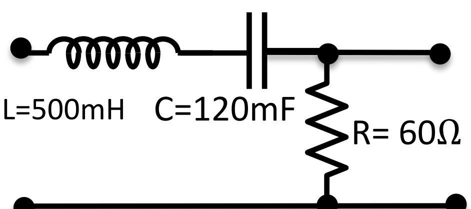


Line filter



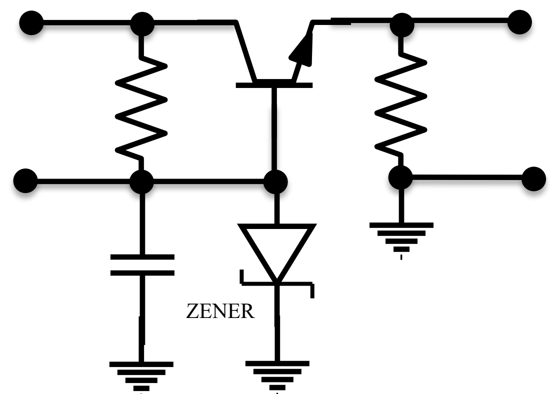
RC low pass filter

H= $R(1+j/(wRC))^{-1}$

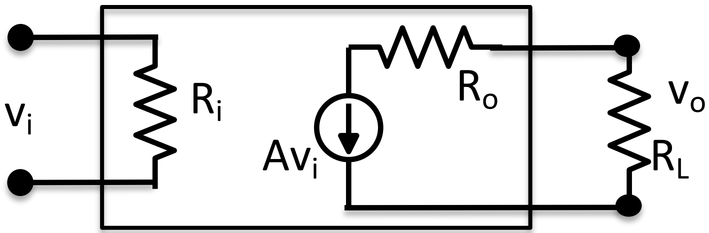


RC Band-pass filter

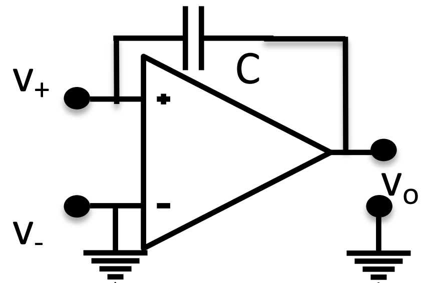
H= $R(R+j(wL-1/(wC)))^{-1}$



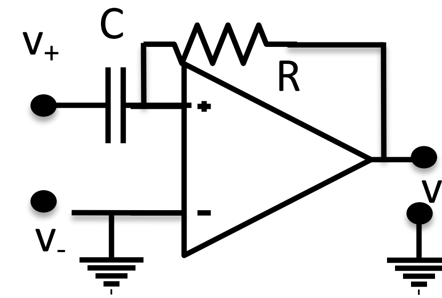
Voltage regulator



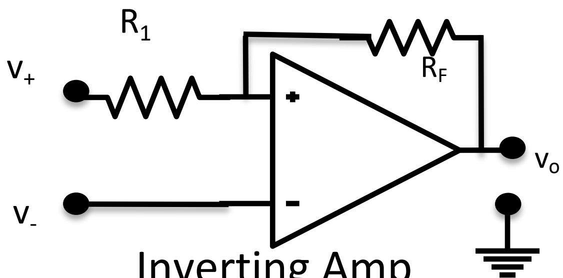
Ideal Amplifier



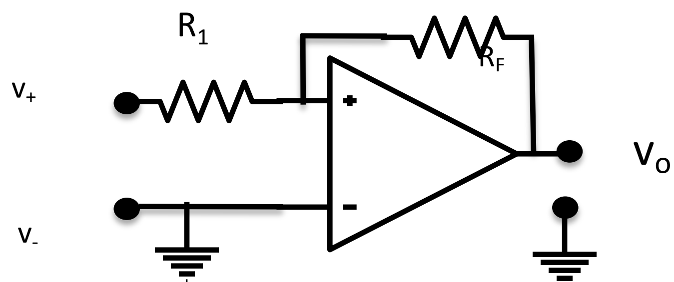
Integrator



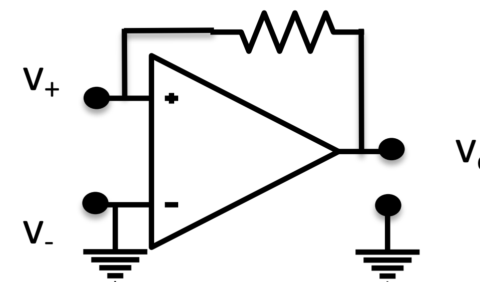
Differentiator



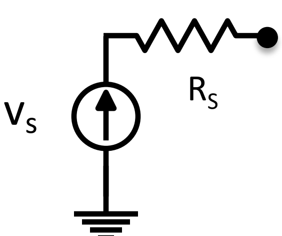
Inverting Amp



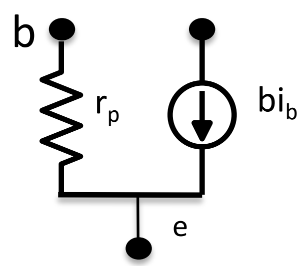
Non-inverting Amp



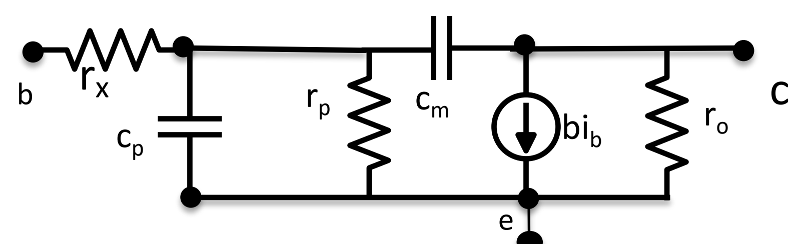
Follower as buffer



Bipolar source model

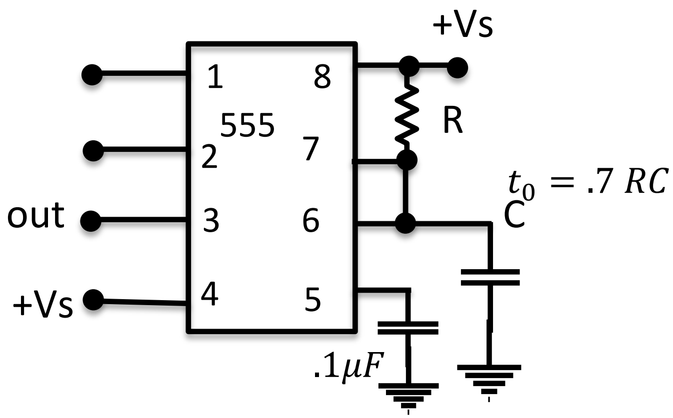


Simple bipolar model



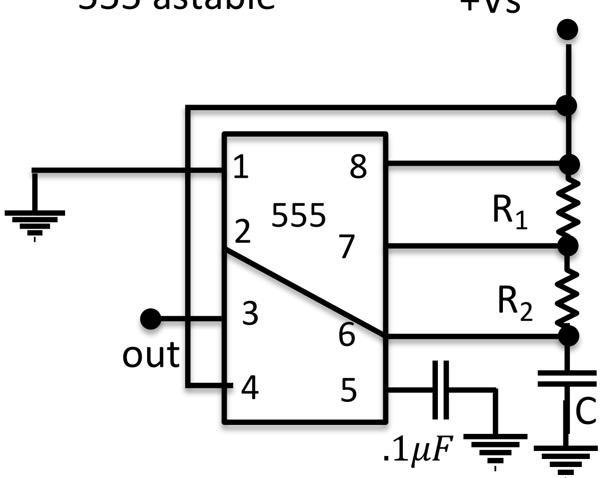
High frequency bipolar model (npn)

555 one shot



Pin 1: -Vs
Pin 8: +Vs
Pin 2 (Trigger): Out HIGH if V < V_{CC}/3. Pin 2 controls pin 6. If pin 2 is LOW, and pin 6 LOW, output goes and stays HIGH. If pin 6 HIGH, and pin 2 goes LOW, output goes LOW while pin 2 LOW. Pin 2has a very high impedance (about 10M) and will trigger with about 1uA.
Pin 3 (Output): (Pins 3 and 7 are "in phase.") Goes HIGH (about 2v less than rail) and LOW (about 0.5v less than 0v) and will deliver up to 200mA.
Pin 4 (Reset): Internally connected HIGH via 100k. Must go below 0.8v to reset the chip.
Pin 5 (Control): voltage applied to this pin will vary the timing of the RC network (quite considerably).
Pin 6 (Threshold): HIGH if > 2 V_{CC}/3, make output LOW only if pin 2 is HIGH. Pin 6 has very high impedance (~10M) and will trigger with about 0.2uA.
Pin 7 (Discharge): Pin 7 is equal to pin 3 but pin 7 does not go high - it goes OPEN. When LOW it sinks about 200mA.

555 astable

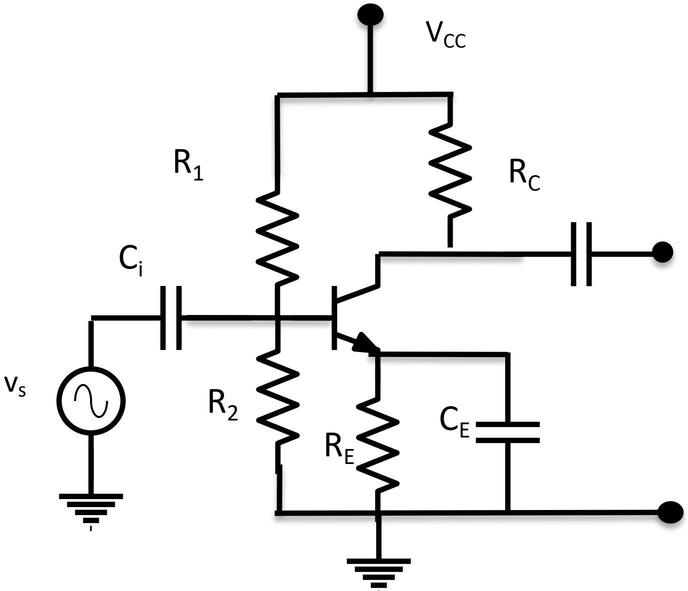


$$t_0 = .7C(R_1 + 2R_2)$$

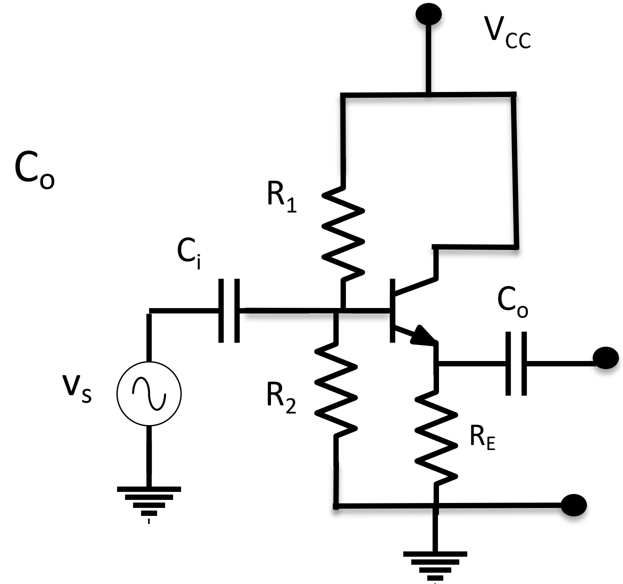
$$duty - \text{cycle} = \frac{R_1 + R_2}{R_1 + 2R_2}$$

324 op amp

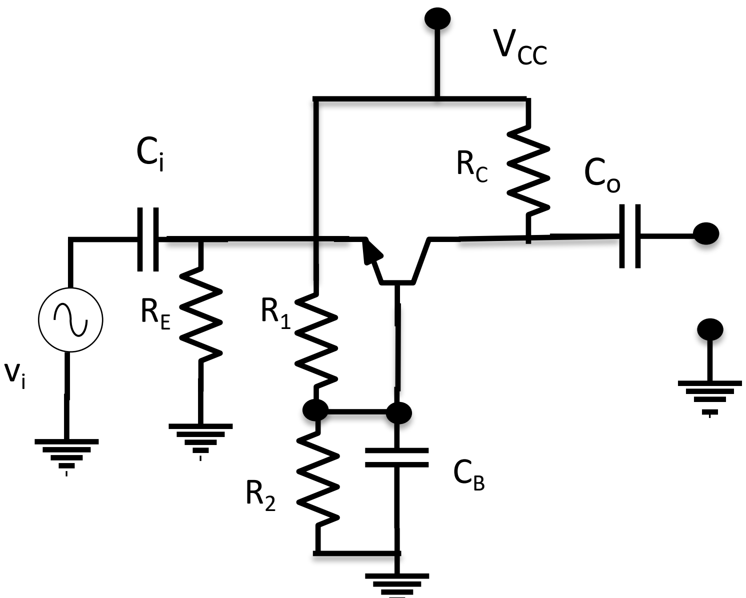
1 (o1)	(o4) 14
2 (i1-)	(i4-) 13
3 (i1+)	(i4+) 12
4 (V+)	(GND) 11
5 (i2+)	(i3-) 10
6 (i2-)	(i3+) 9
7 (o2)	(o3) 8



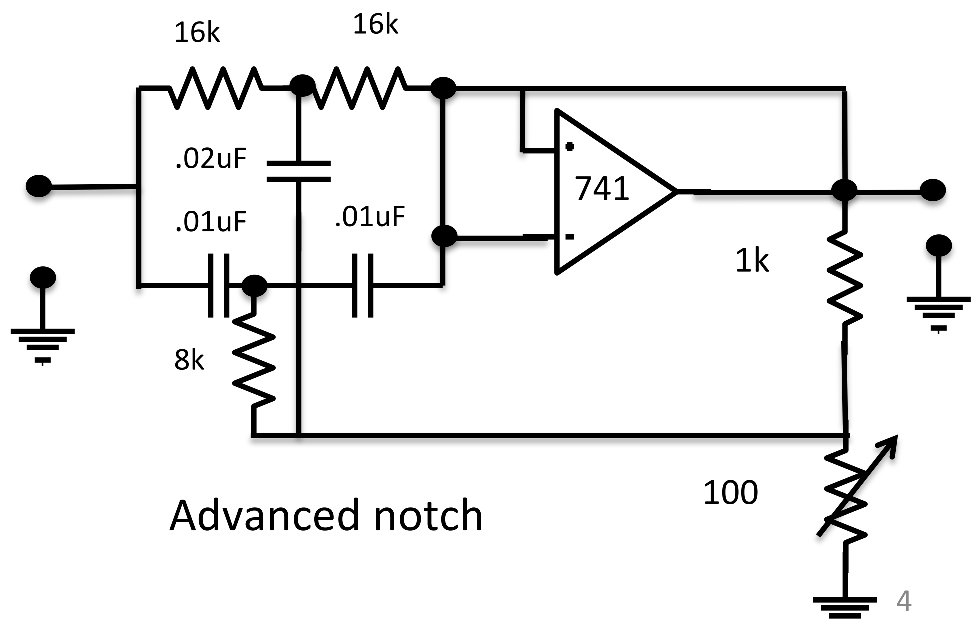
Common emitter amp



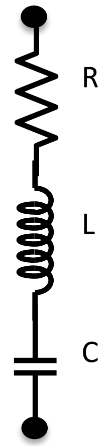
Common collector amp (Emitter Follower)



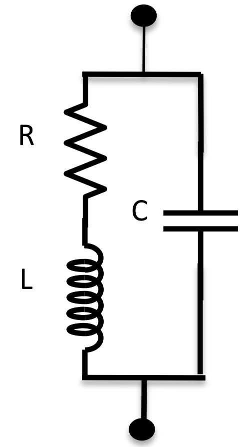
Common base amp



Advanced notch

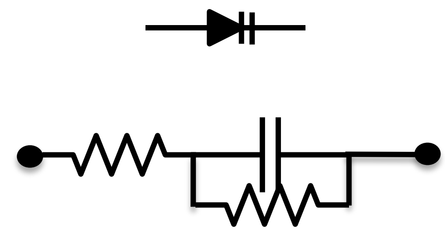


$Z^2=R^2+(wL-(1/wC))^2$



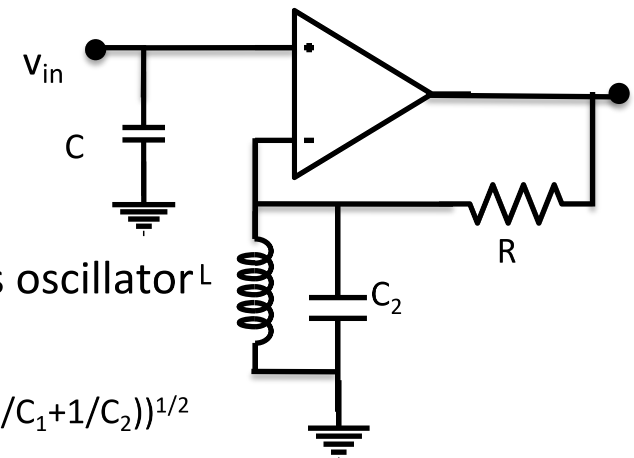
$Z=(L/C-j(R/wC))(R+j(wL-(1/wC))^{-1}$

$f_0= (2p)^{-1}(LC)^{-1/2}$



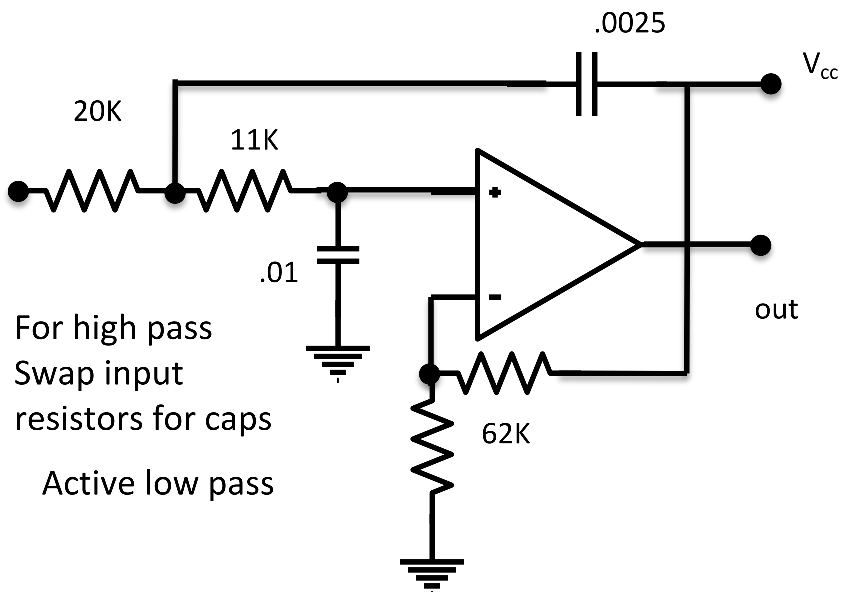
$$C_j = \frac{C_{j0}}{\sqrt{V_{on} - V_{revbias}}}$$

Varactor model



Colpitts oscillator

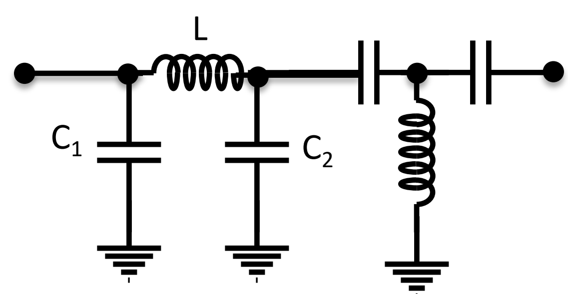
$f= (2p)^{-1}((1/L)(1/C_1+1/C_2))^{1/2}$



For high pass
Swap input
resistors for caps

Active low pass

Flat side transistor (L to R): E, B. C



π and T impedance matching

SN74LS00

1 (A)	(V+) 14
2 (B)	(A) 13
3 (Y)	(B) 12
4 (Y)	(Y) 11
5 (B)	(Y) 10
6 (A)	(B) 9
7 (Gnd)	(A) 8

4 NAND

SN74LS02

1 (Y)	(V+) 14
2 (A)	(Q) 13
3 (B)	(!Q) 12
4 (Y)	(C) 11
5 (A)	(R) 10
6 (B)	(K) 9
7 (Gnd)	(J) 8

4 NOR

SN74LS06

1 (A)	(V+) 14
2 (!A)	(D) 13
3 (B)	(!!D) 12
4 (!B)	(E) 11
5 (C)	(E!) 10
6 (!C)	(F) 9
7 (Gnd)	(!F) 8

6 Inverter

SN74LS10

1 (A1)	(V+) 14
2 (A2)	(A3) 13
3 (C1)	(AO) 12
4 (C2)	(B3) 11
5 (C3)	(B2) 10
6 (CO)	(B1) 9
7 (Gnd)	(BO) 8

3 3-NOR

4013

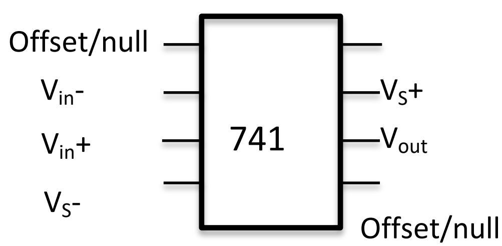
1 (Q)	(V+) 14
2 (!Q)	(Q) 13
3 (C)	(!Q) 12
4 (R)	(C) 11
5 (D)	(R) 11
6 (S)	(D) 10
7 (Gnd)	(S) 9

Dual D-FF

4017

1 (5)	(V+) 16
2 (1)	(R) 15
3 (0)	(CLK) 14
4 (2)	(CKE) 13
5 (6)	(CO) 12
6 (7)	(9) 11
7 (3)	(4) 10
8 (Gnd)	(8) 9

Counter

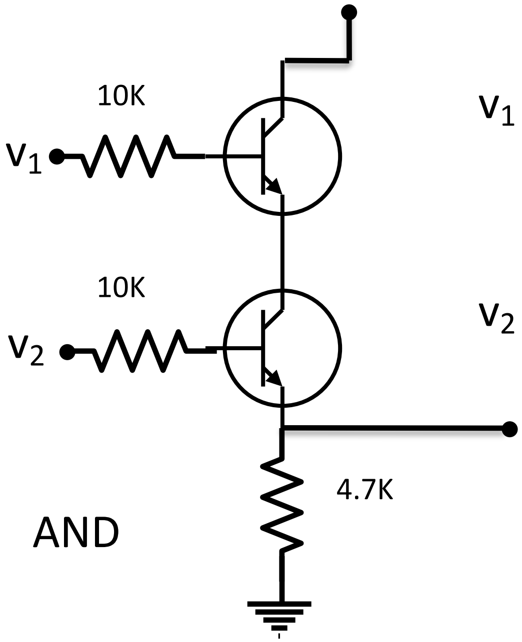


1 (o1)	(o4) 14
2 (i1-)	(i4-) 13
3 (i1+)	(i4+) 12
4 (V+)	(GND) 11
5 (i2+)	(i3-) 10
6 (i2-)	(i3+) 9
7 (o2)	(o3) 8

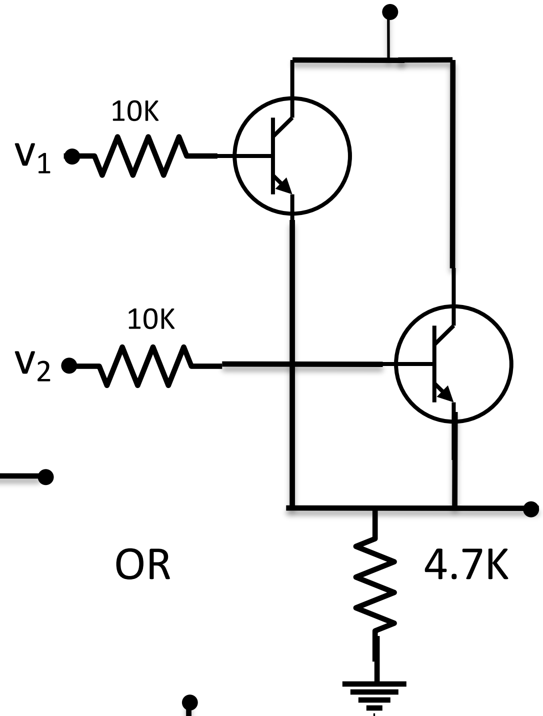
324 op amp

1 (GAIN)	(GAIN) 8
2 (IN-)	(BYP) 7
3 (IN+)	(V+) 6
4 (GND)	(OUT) 5

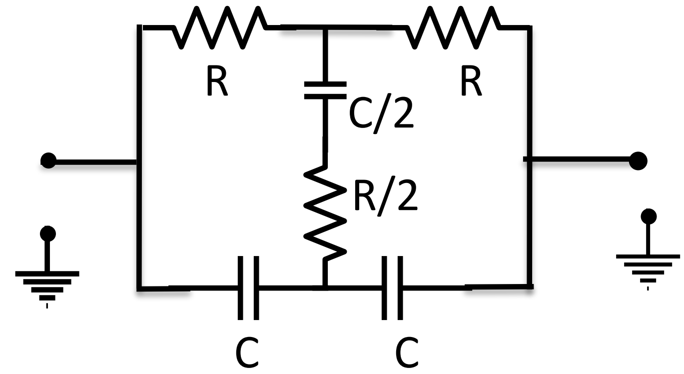
386 amp



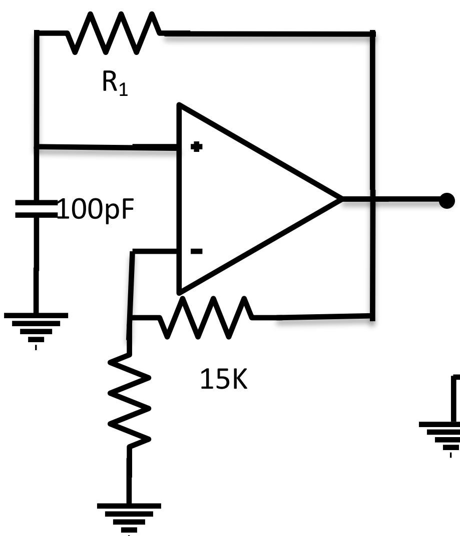
AND



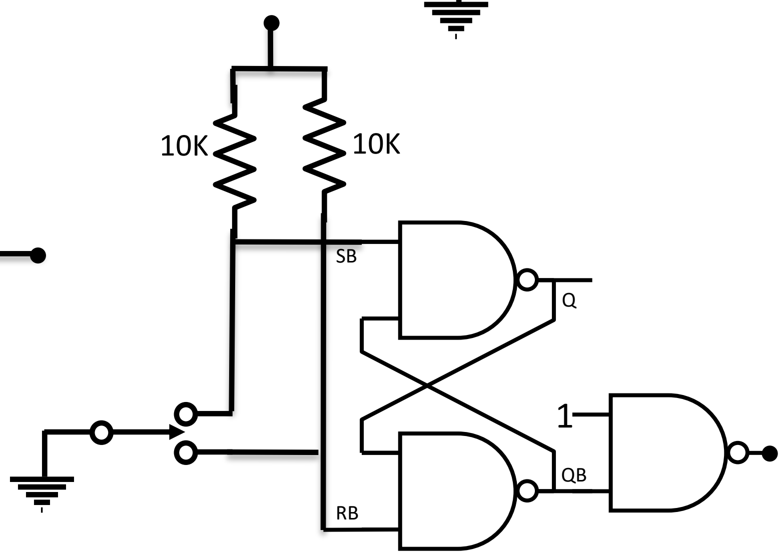
OR



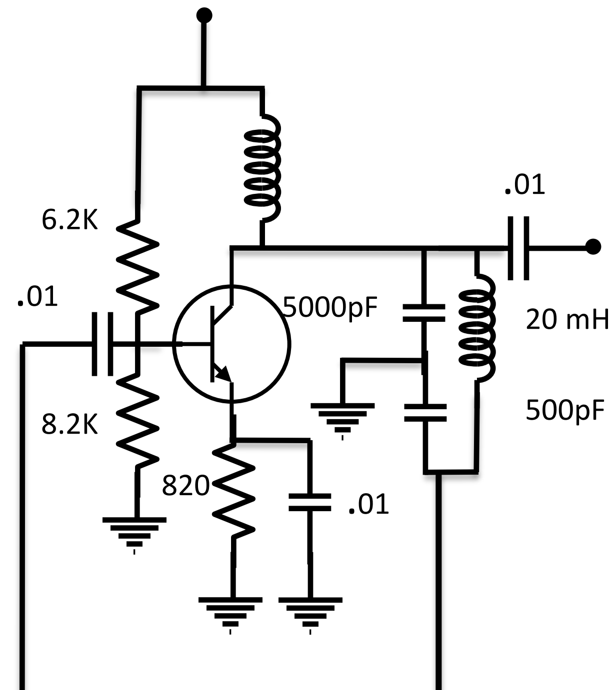
Notch Filter



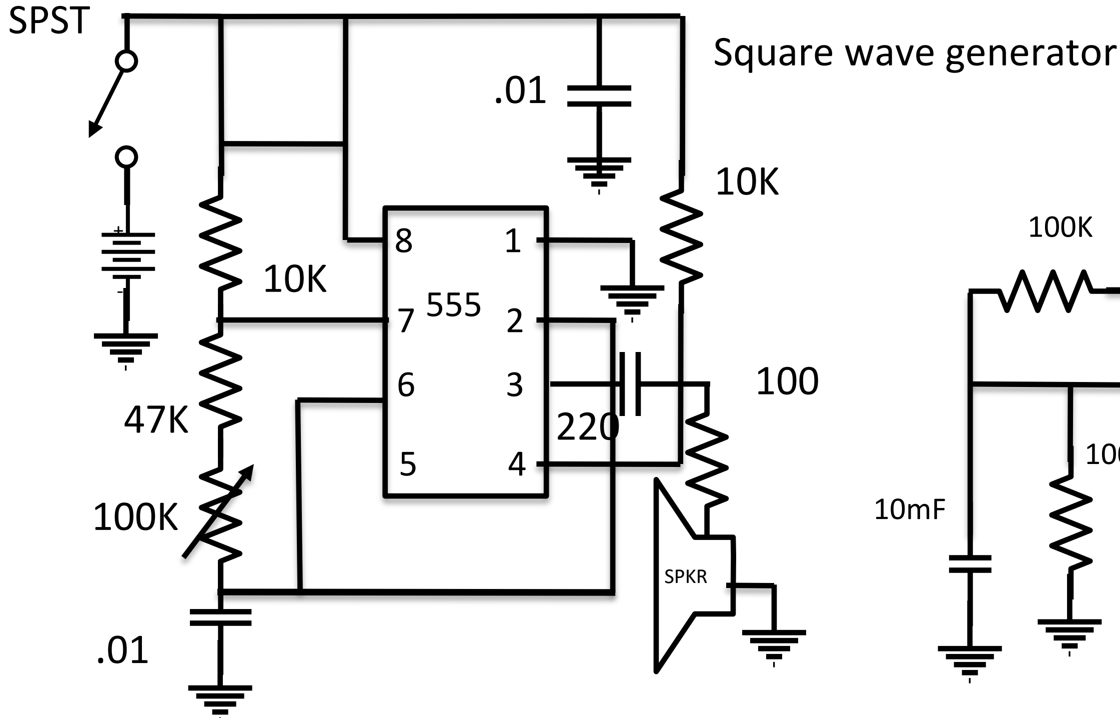
Square Wave generator

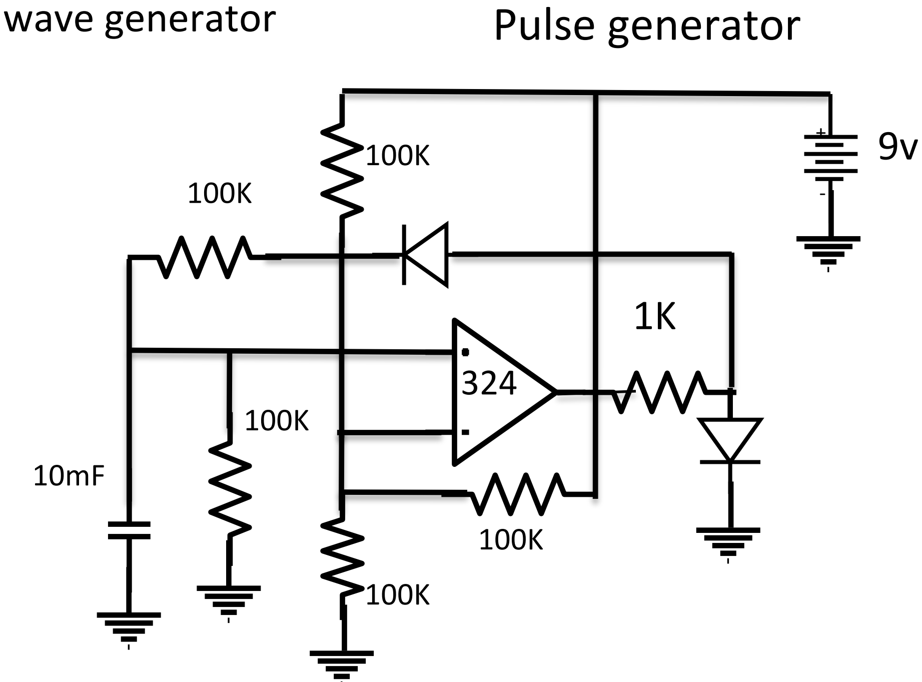


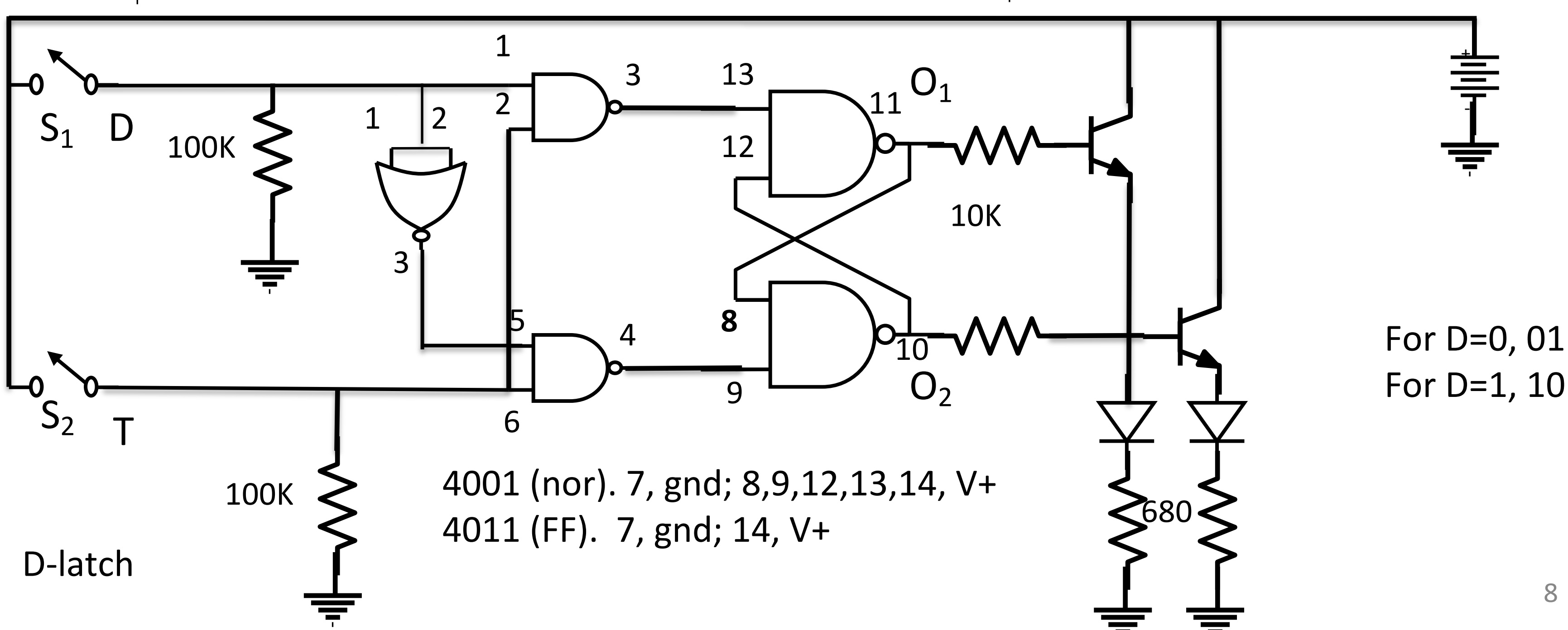
Debounce

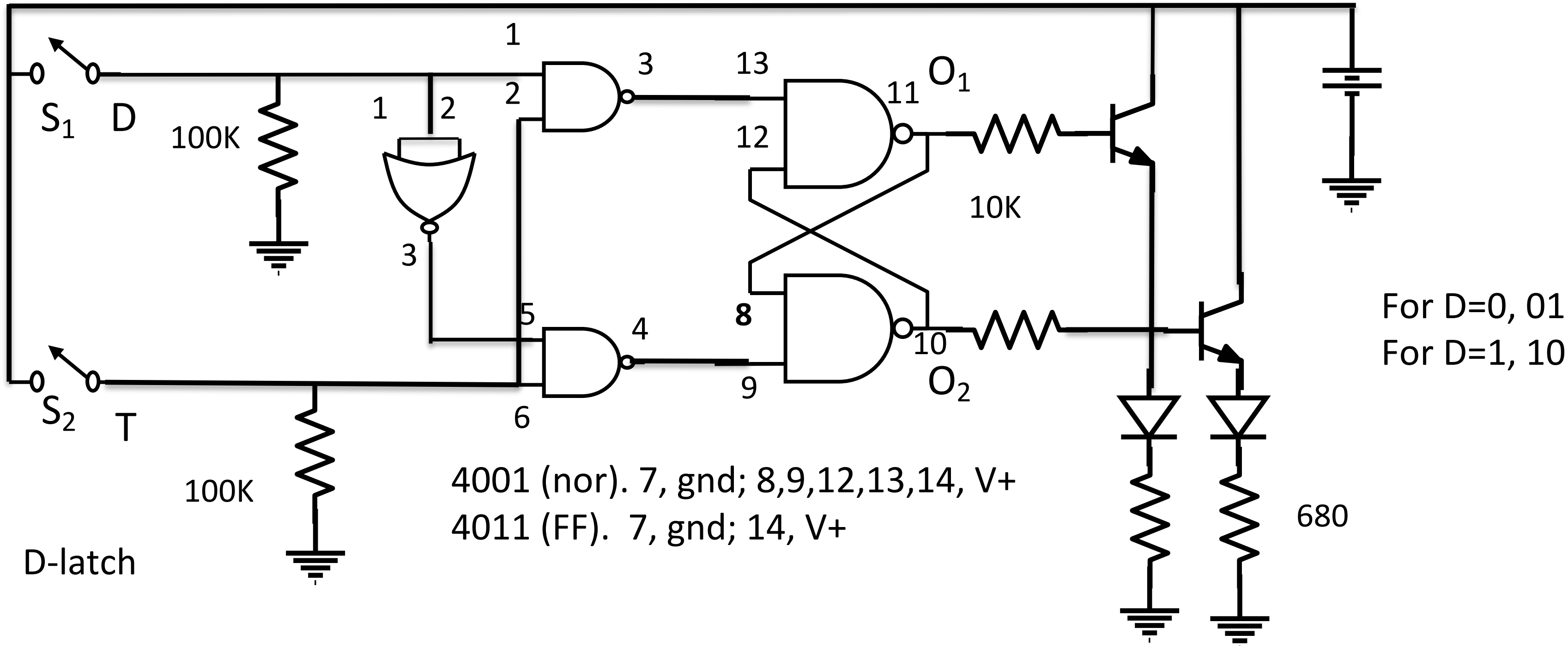


Oscillator $f = (2p)^{-1}(LC)^{1/2}$

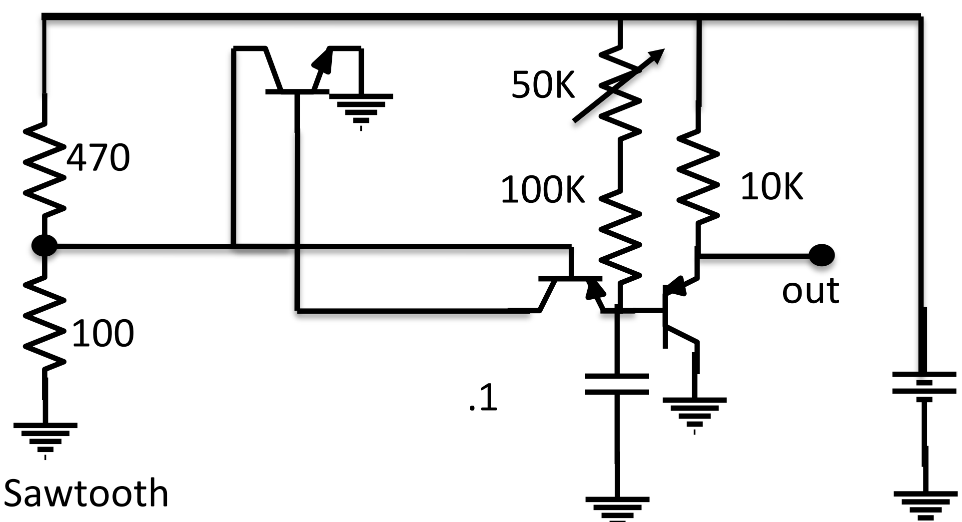

Square wave generator
SPST
.01
10K
10K
555
8
1
7
2
6
3
5
4
220
100
47K
100K
SPKR
.01


Pulse generator
9v
100K
100K
324
1K
100K
10mF
100K
100K

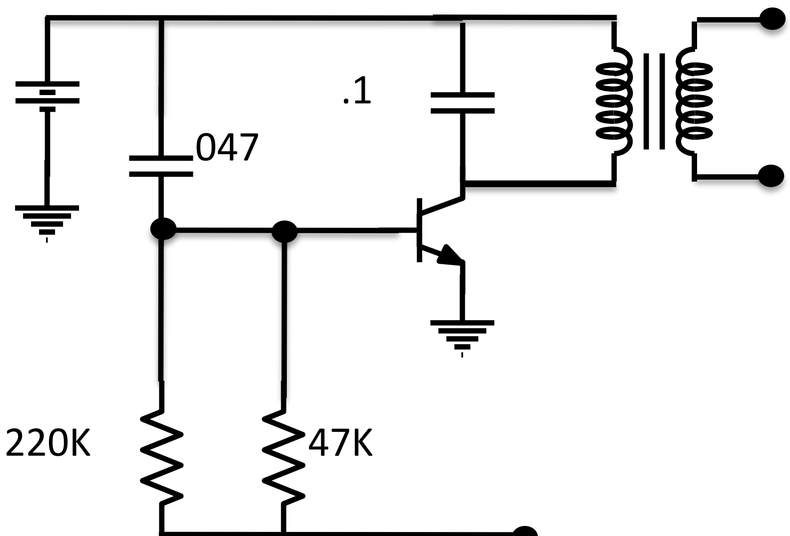

S1 D
S2 T
100K
100K
1
2
3
13
11
12
O1
O2
10K
5
4
8
10
9
6
680
4001 (nor). 7, gnd; 8,9,12,13,14, V+
4011 (FF). 7, gnd; 14, V+
For D=0, 01
For D=1, 10
D-latch



D-latch

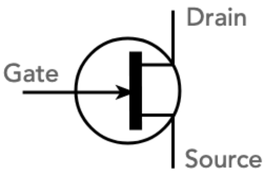


Sawtooth

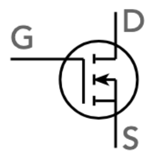


Frequency Shift Oscillator

FETs



N channel JFET



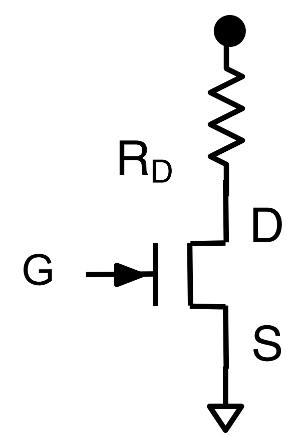
N channel enhancement insulated MOSFET

source gate drain
2N-7000 package

From electronics notes

- Small signal model
- $i_D = i_{DSS}(1 - \frac{V_{GS}}{V_p})^2, 0 \leq V_{GS} \leq V_P$
- Ohmic ($V_{DS} < 1.8$), $R_{GS} = \frac{k}{g_m} V_{GS}$.
- Saturation ($V_{DS} > 2$), $i_d = g_m V_{GS}$
- For 2N-7000, $I_{DSS} = 60, g_m = 320$

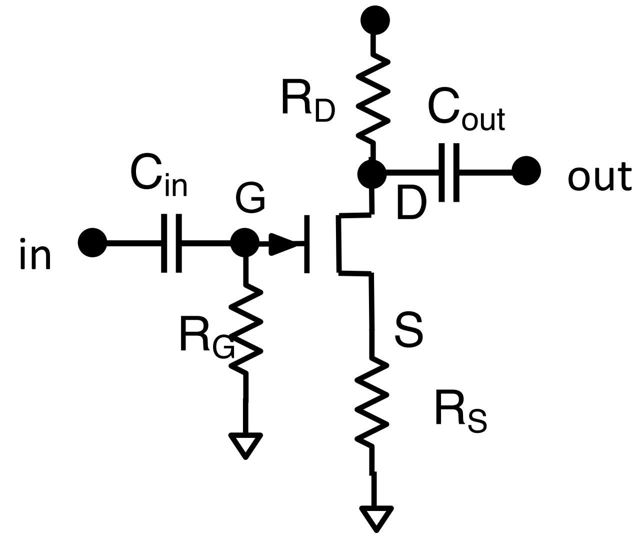
- JFETs generally don't operate in enhancement mode ($V_{GS} < 0$)



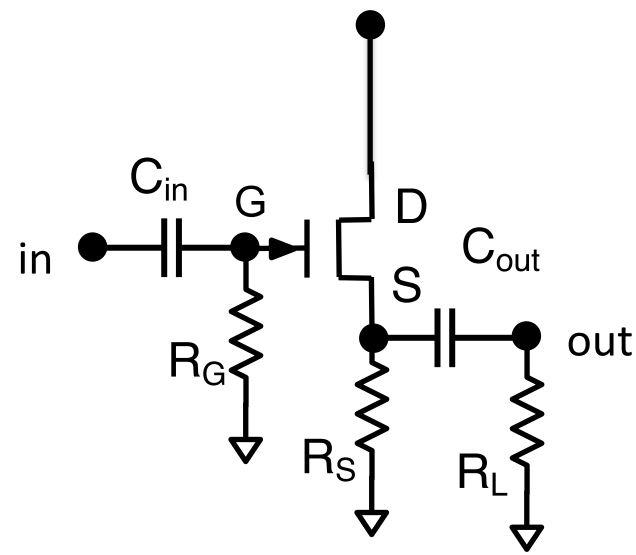
FETAmps

- Common Source

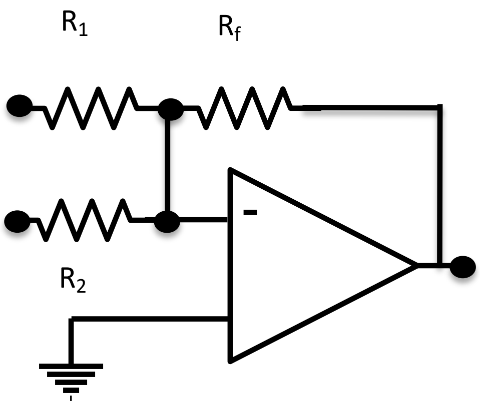
1. $V_{DD} = 12v, i_{DSS} = 35mA, V_p = -3v$
2. $A_V = 10, i_{DQ} = 10mA$
3. $R_S = -\frac{V_P}{i_{DQ}}(1 - \sqrt{\frac{i_{DQ}}{i_{DSS}}})$= 139 (say 150Ω)
4. $A_V = -\frac{R_D}{R_S}, R_D = 1{,}500\Omega$



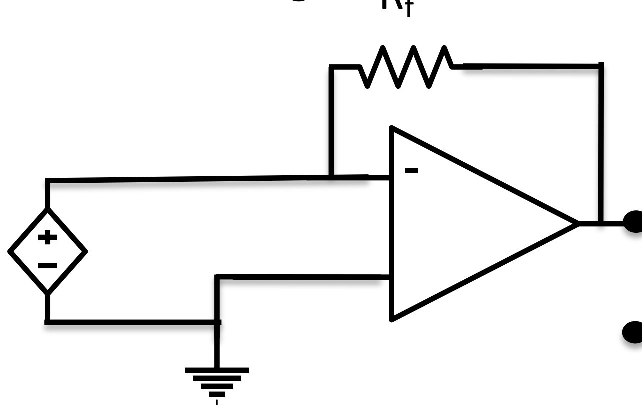
- Common Drain



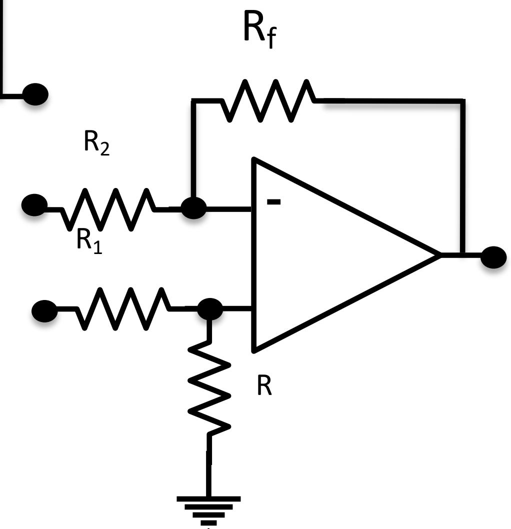
Summing amp



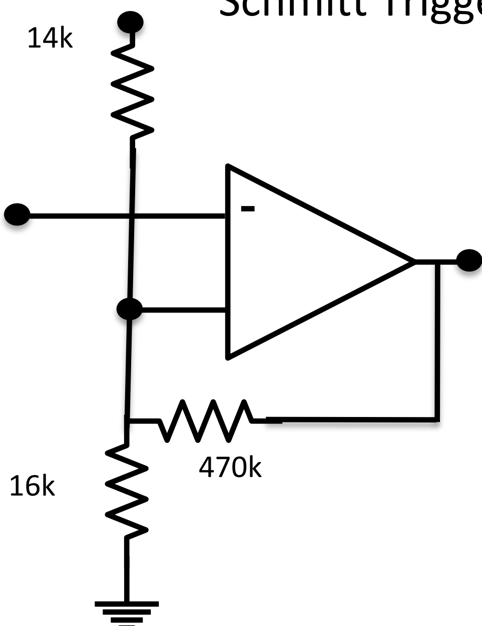
Current to Voltage

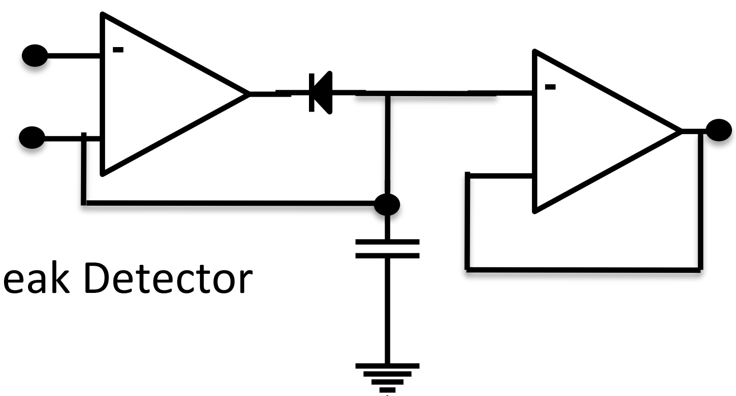


Difference Amp

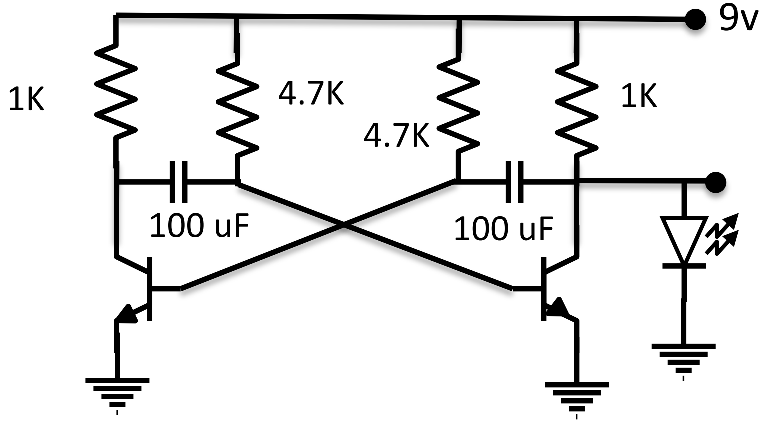


Schmitt Trigger



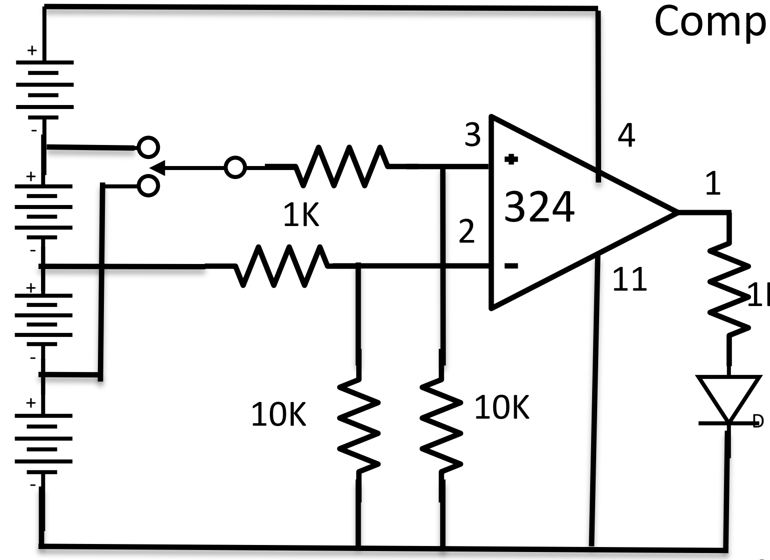


Peak Detector

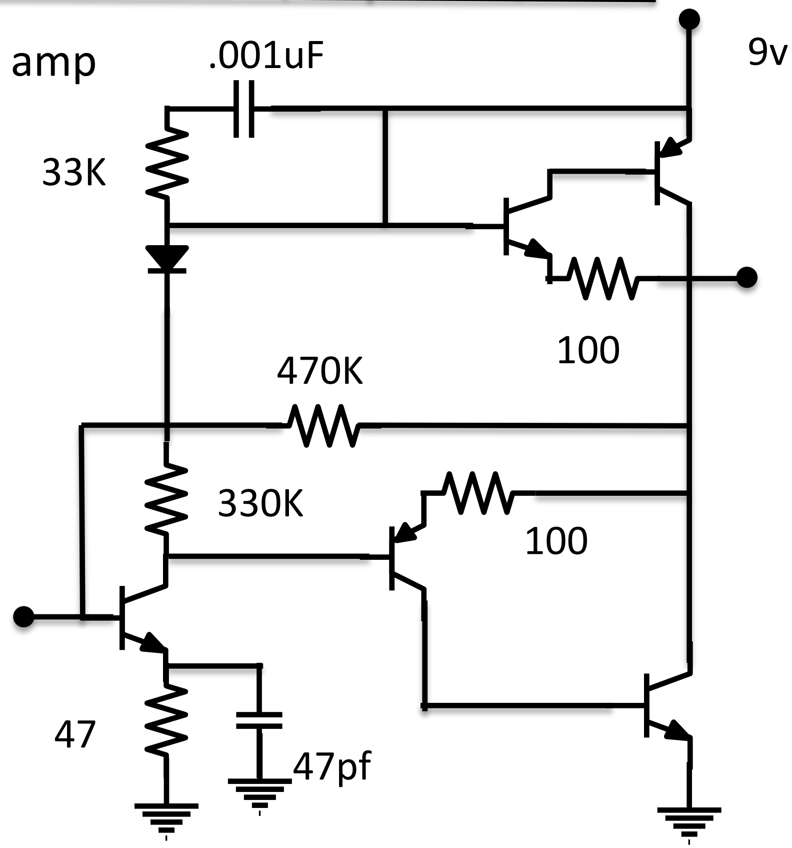


Astable Multivibrator

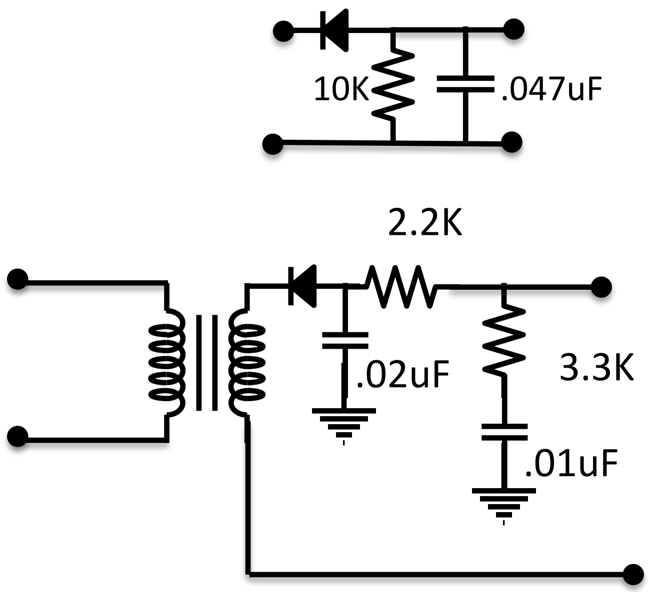
Comparator



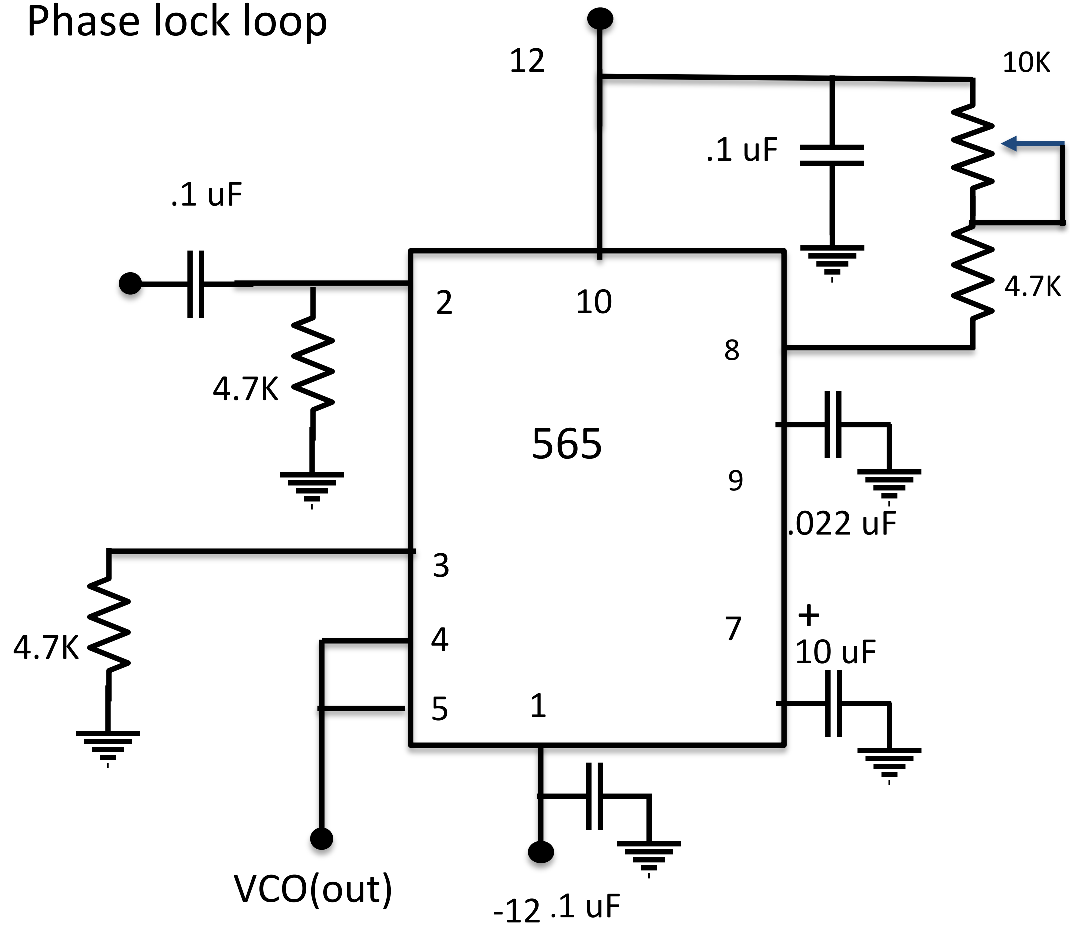
Push-pull amp



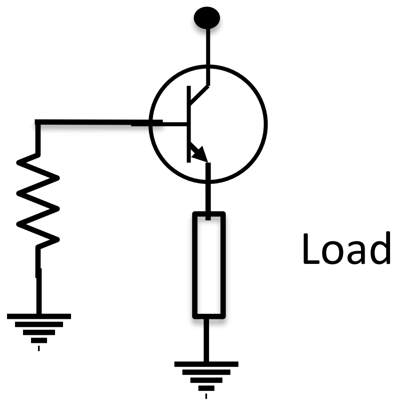
AM Detectors

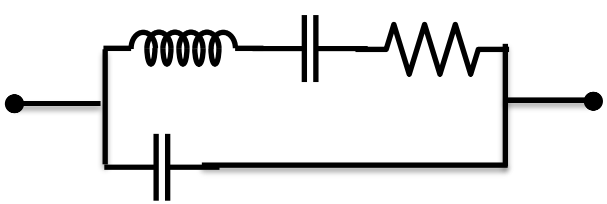


Phase lock loop



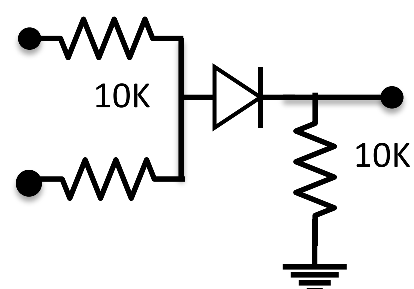
Current source



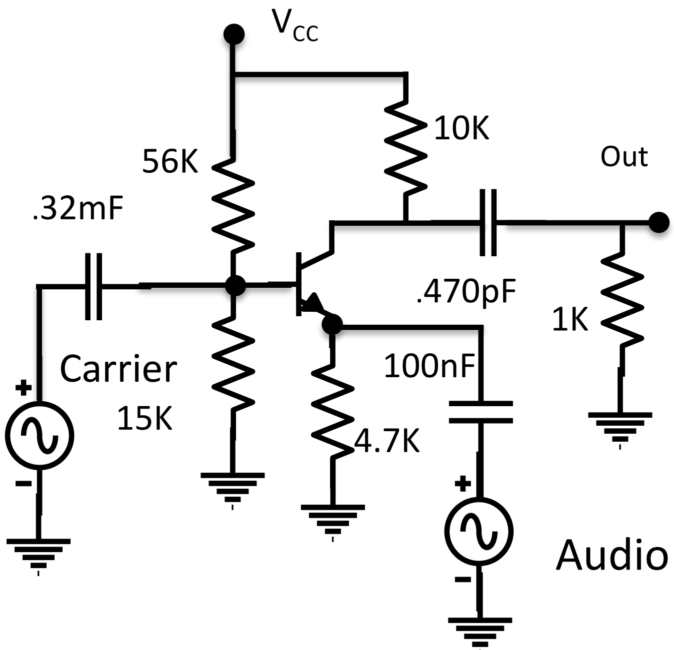


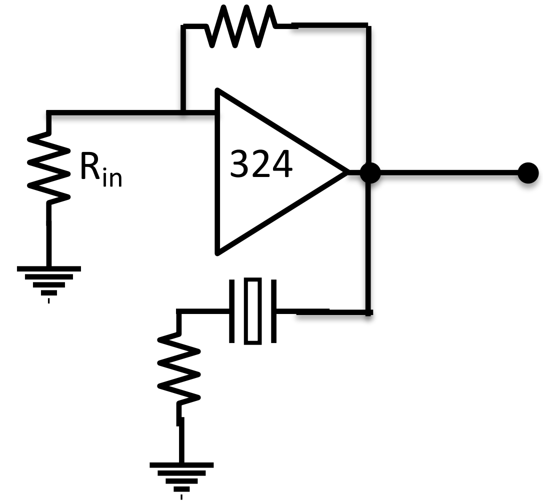
Crystal equivalent

Mixer



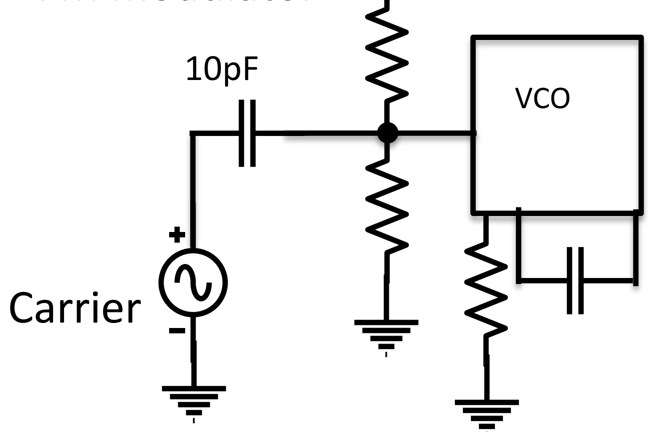
AM modulator

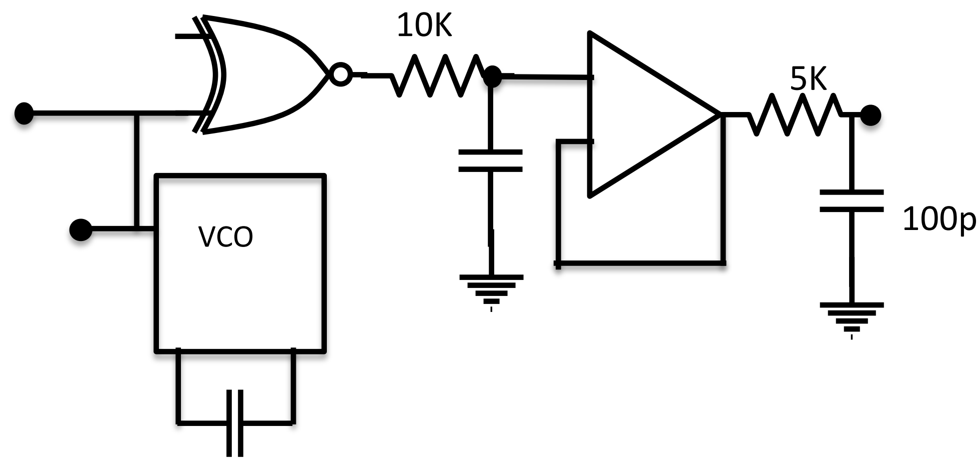




Crystal oscillator

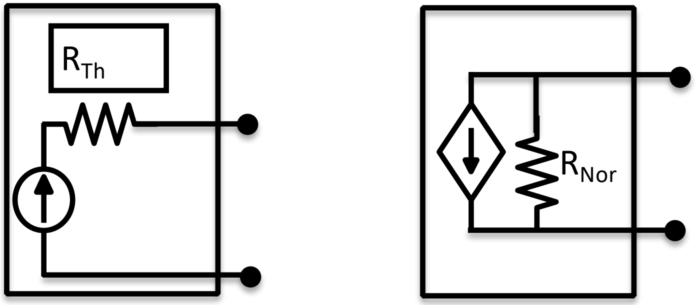
FM modulator





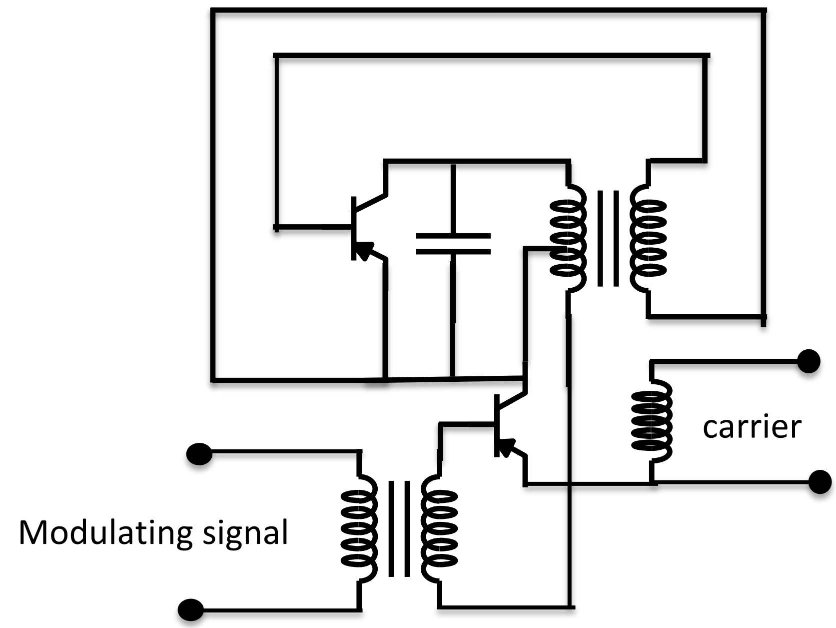
FM demodulator

Thevenin, Norton and two port models

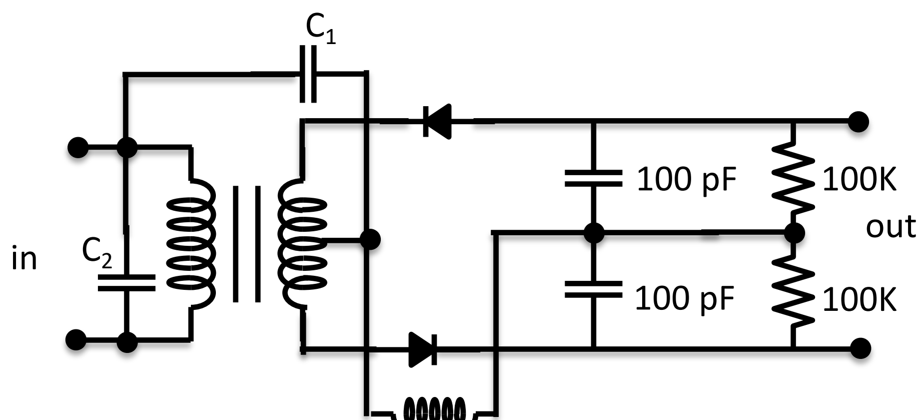


- Two port model
- $\begin{pmatrix} i_1 \\ i_2 \end{pmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix}$
- $\begin{pmatrix} v_1 \\ i_2 \end{pmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h \end{bmatrix} \begin{pmatrix} i_1 \\ v_2 \end{pmatrix}$

FM Ratio Modulator



FM Ratio Detector



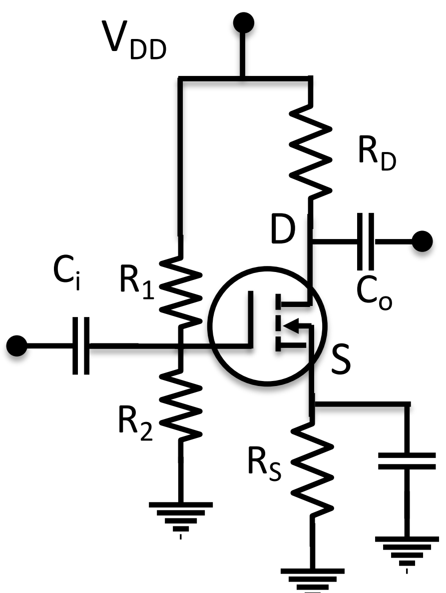
$$f_c = \frac{1}{2\pi\sqrt{L_1 C_2}}$$

L_1 is the transformer input inductance

C_1 is a DC block

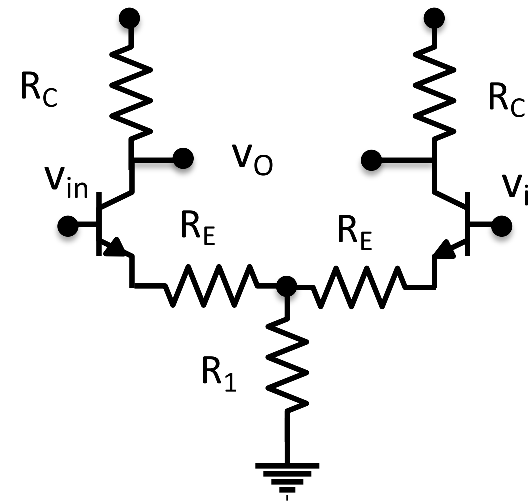
CMOS Common Emitter amplifier

- Pick power
- $V_{DD} = i_D R_D + V_{DS} + i_D R_S$
- $V_{GS} = V_G - i_S R_S$
- $V_G = V_{DD} \frac{R_1}{R_1+R_2}$
- $i_D = k(V_G - V_{TH})^2$
- Bias around $\frac{V_{DD}}{3}$
- Pick gain, $A = \frac{R_D}{R_S + \frac{1}{g_m}}$



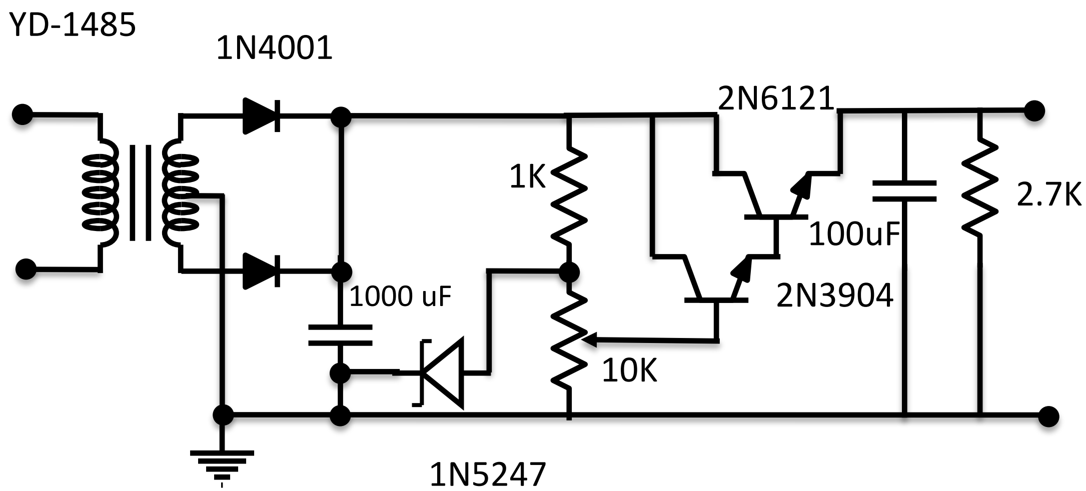
- Two port model
- $\begin{pmatrix} i_1 \\ i_2 \end{pmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix}$

Differential amplifier

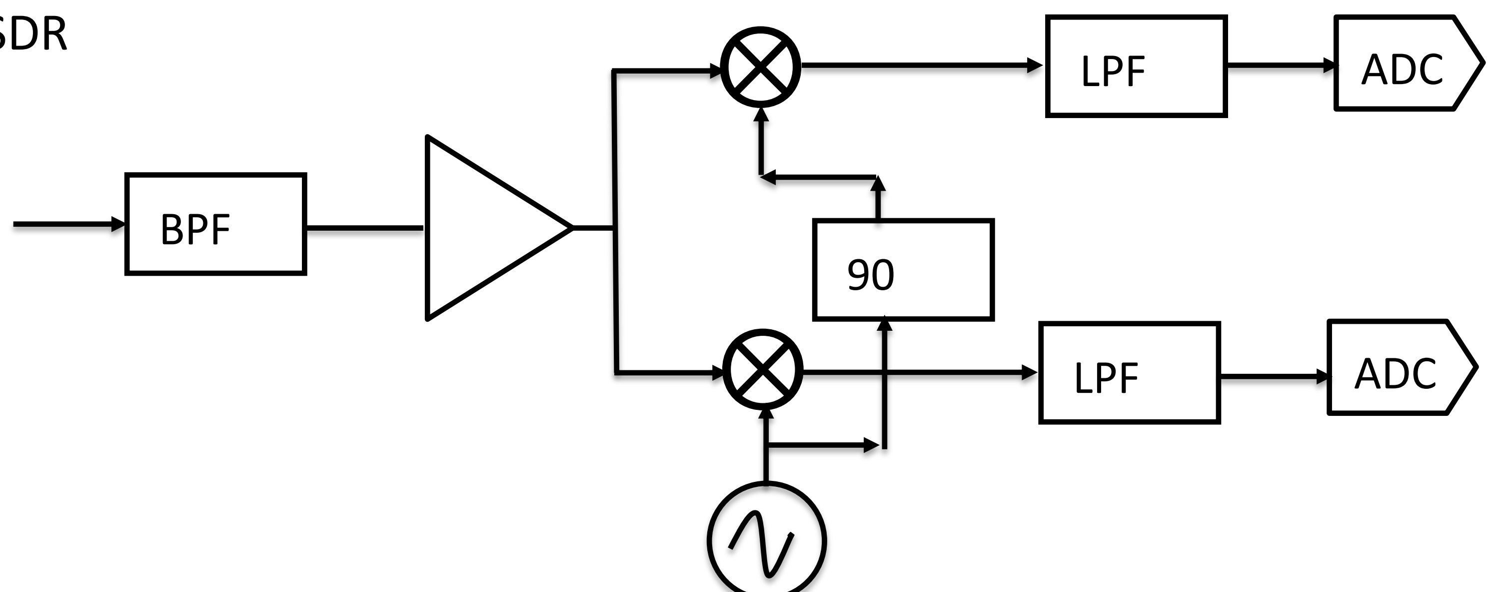


- Pick power ∓ 12
- Choose collecter current $(2mA)$ by picking R_1
- Pick gain, $A = \frac{R_C}{2R_E}$

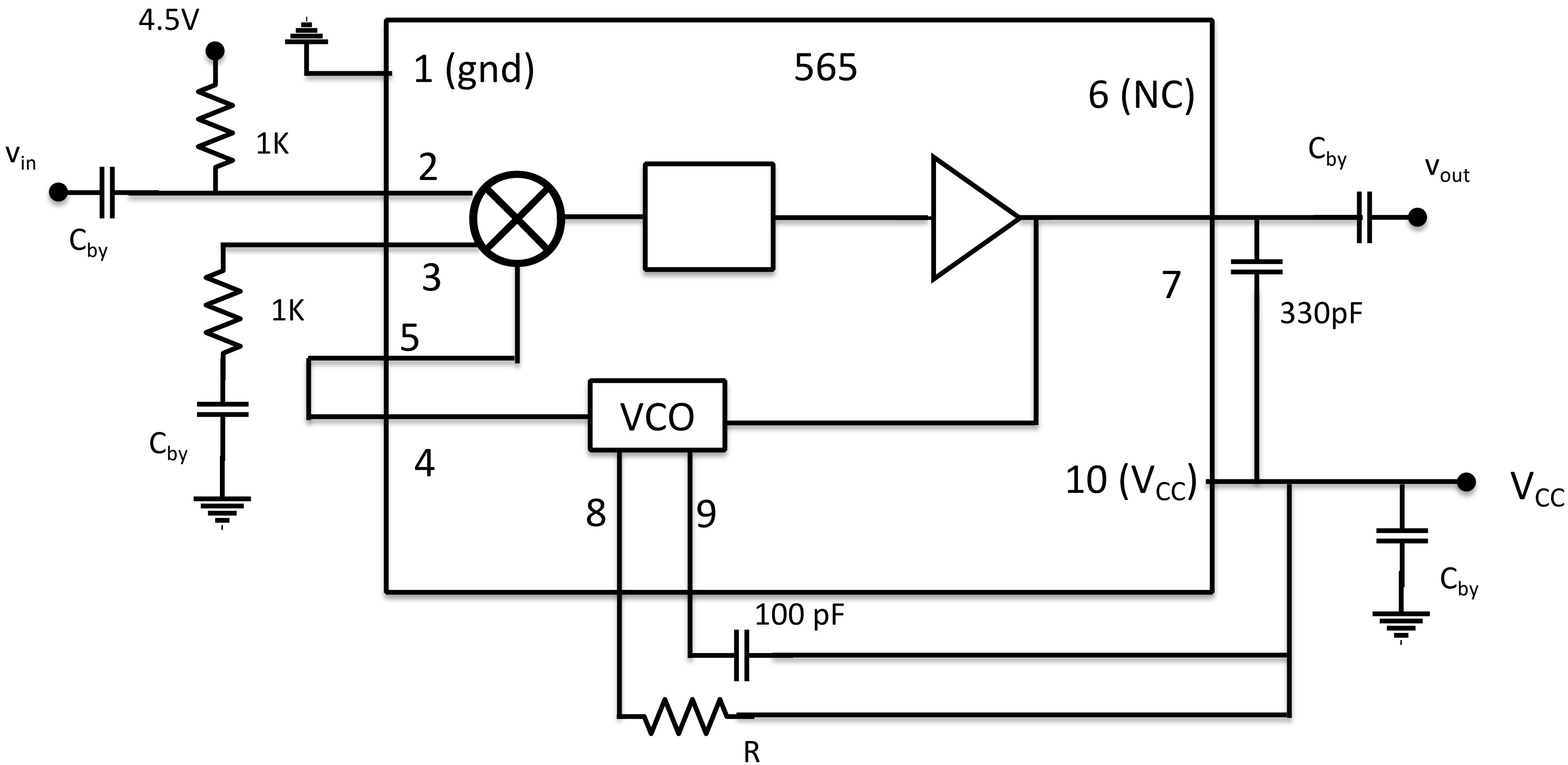
Variable power supply



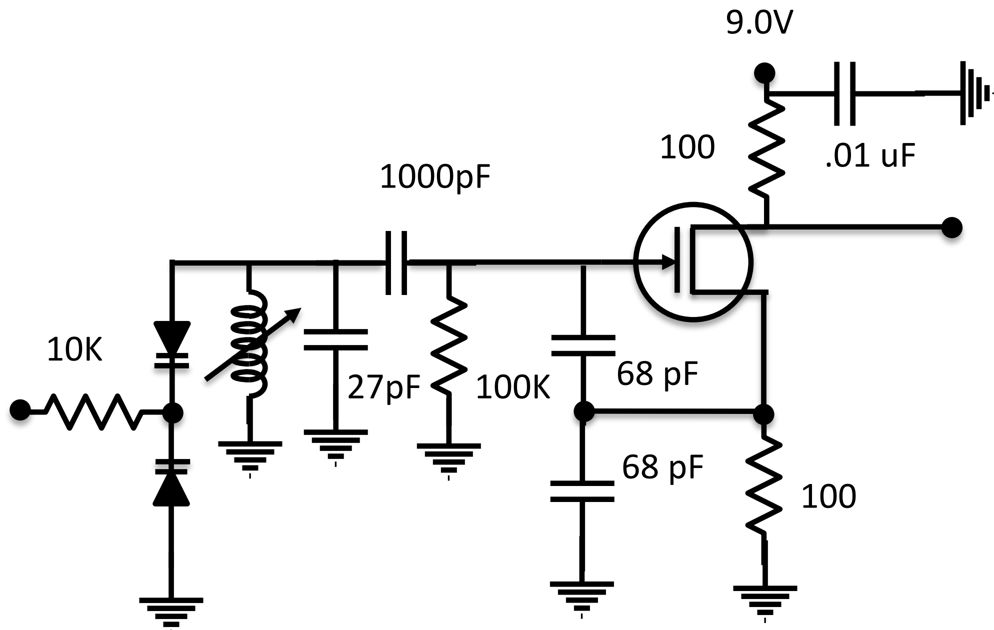
SDR



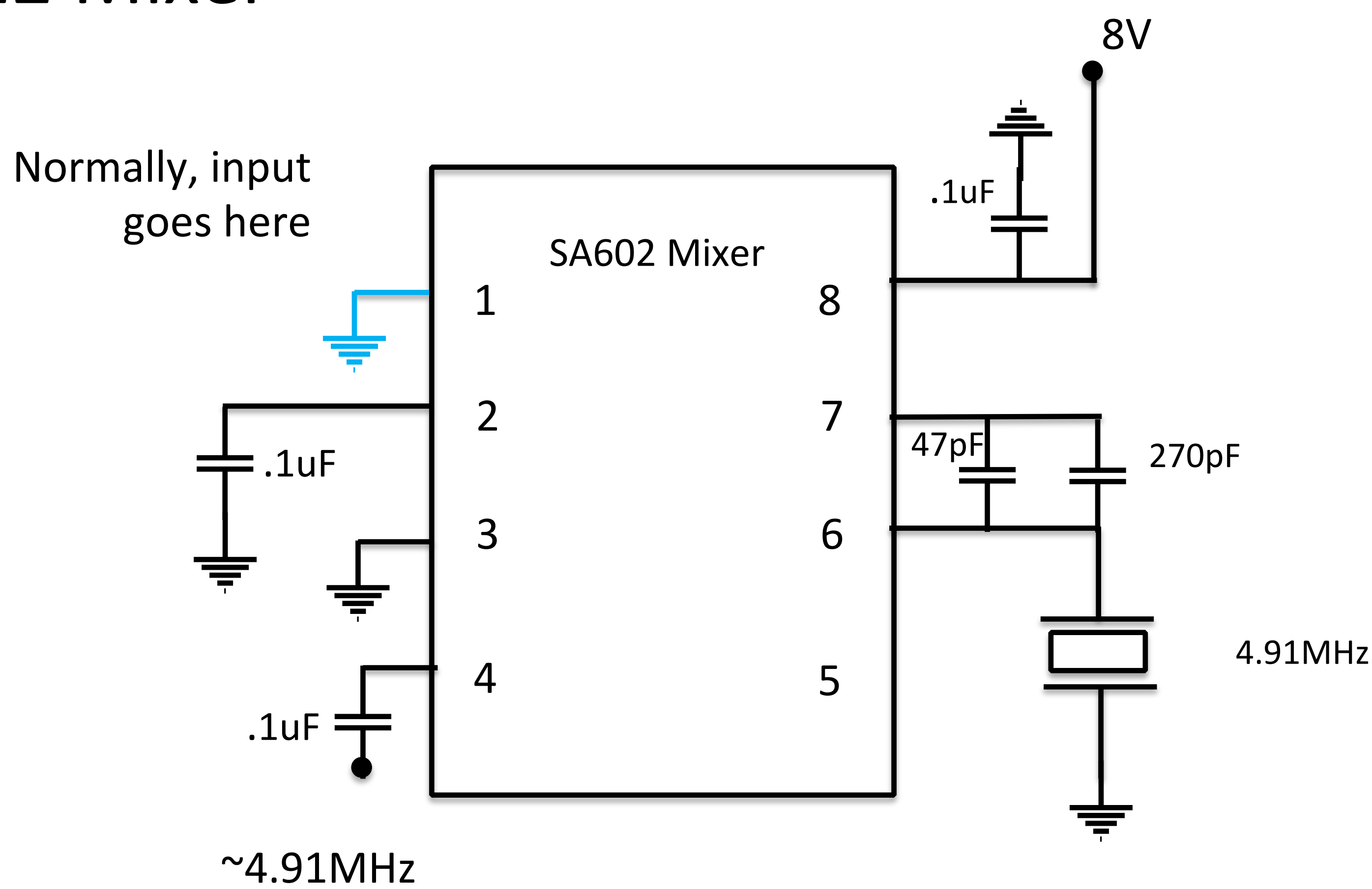
PLL as FM detector with 565



VCO



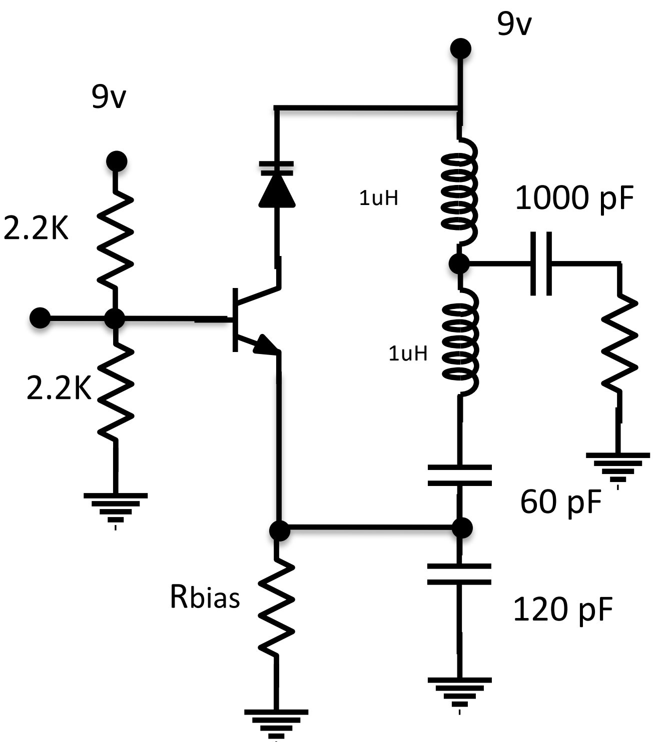
SA612 Mixer



Outputs (4,5) are 180 degrees out of phase

Colpitts 1

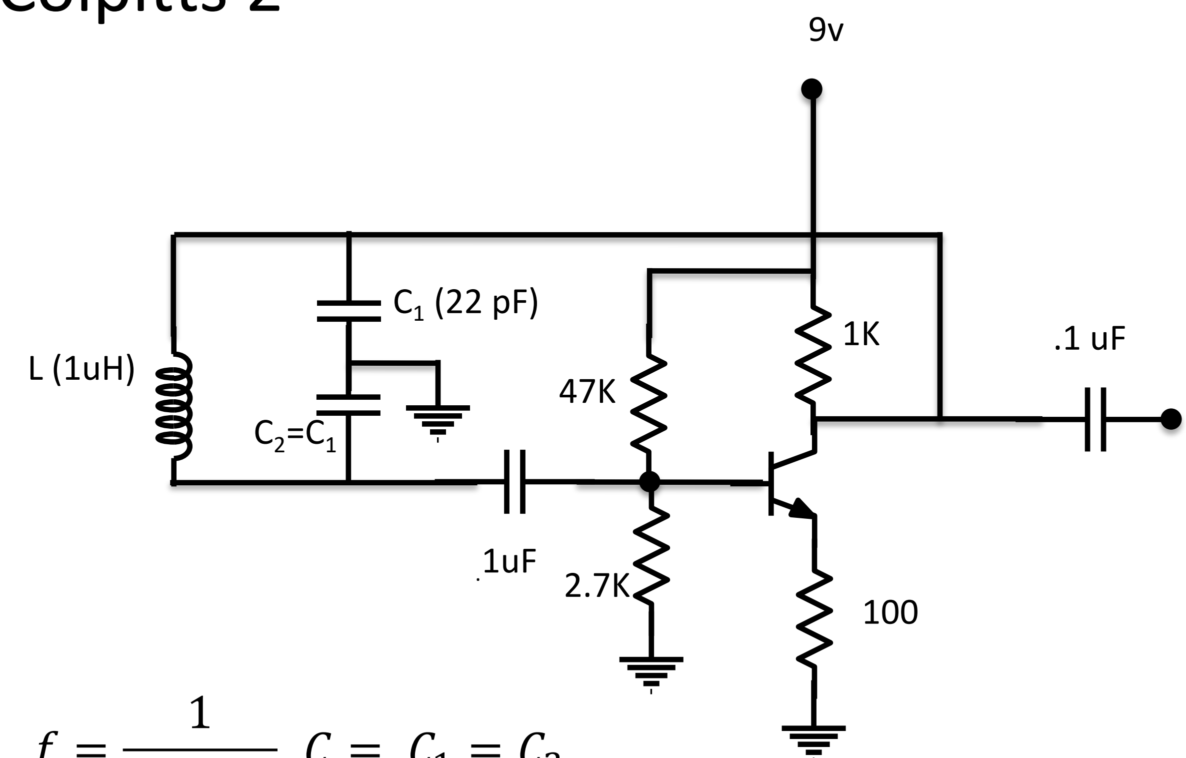
25.3MHz
.5uA through R_{bias}



Noise

$$P_N = kTB$$

Colpitts 2

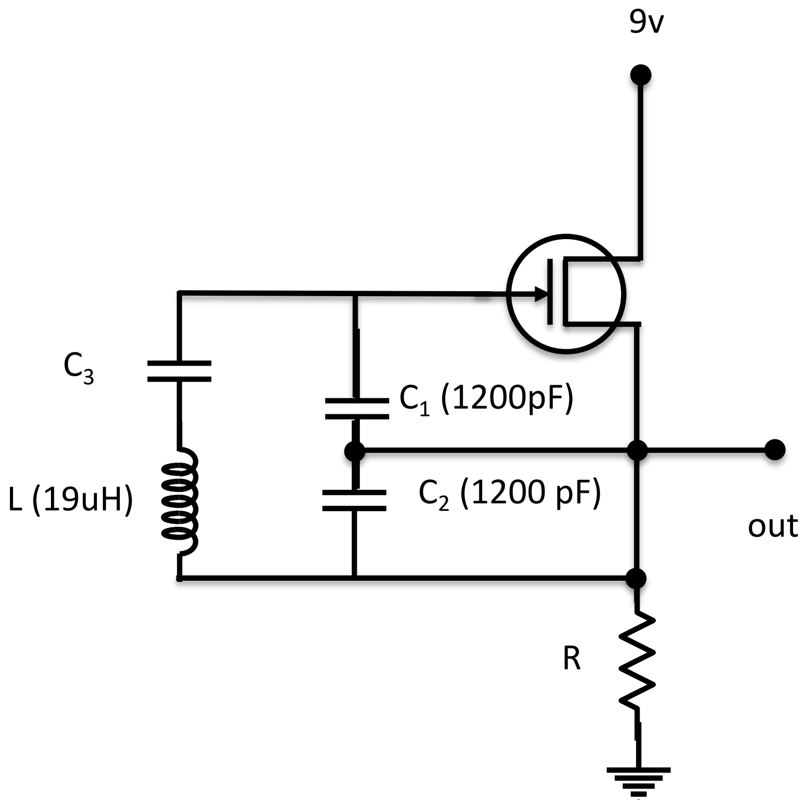


$$f = \frac{1}{2\pi\sqrt{LC}}, C = C_1 = C_2$$

About 32MHz in this example

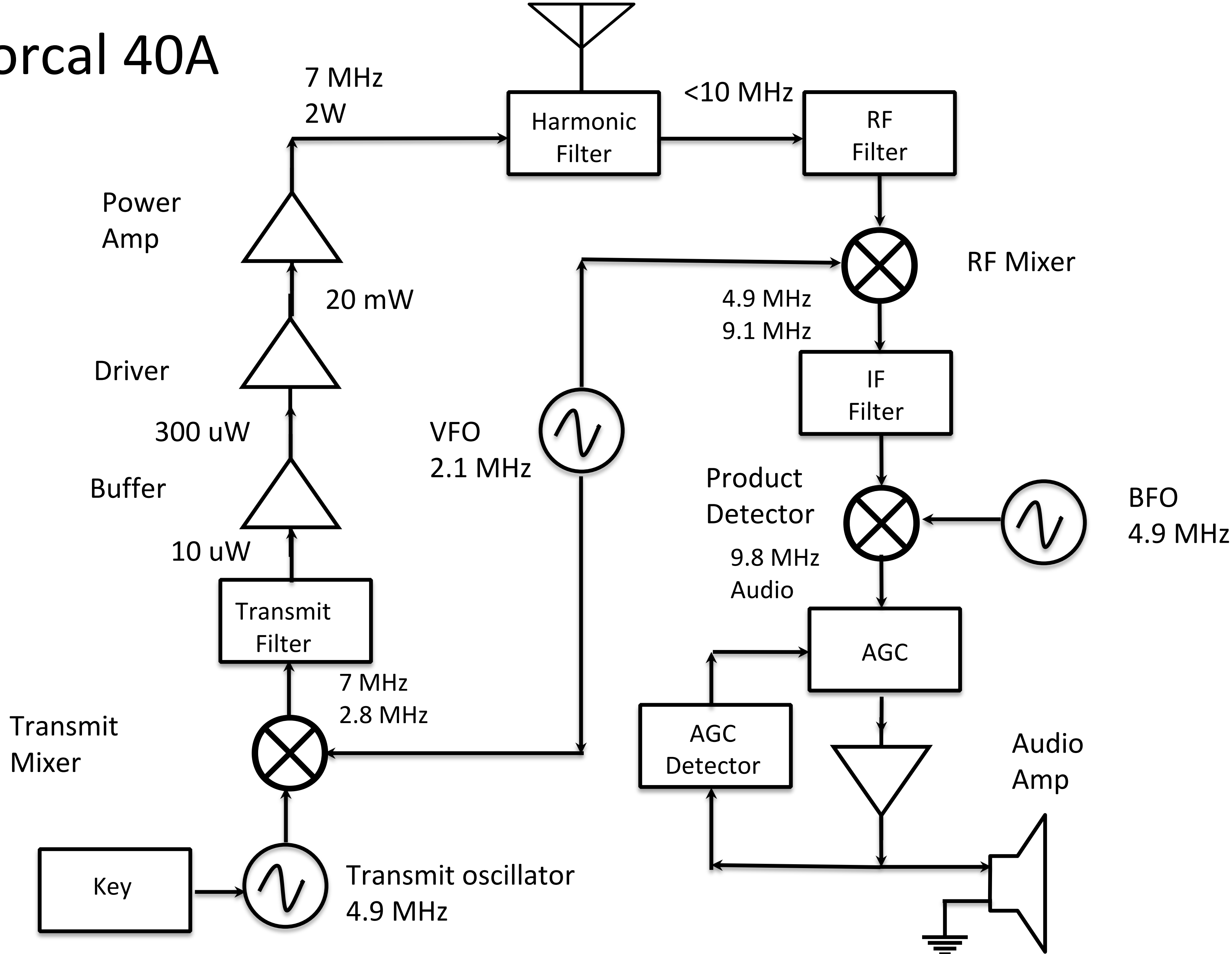
About 23MHz if C= 47pF

Norcal Clapp



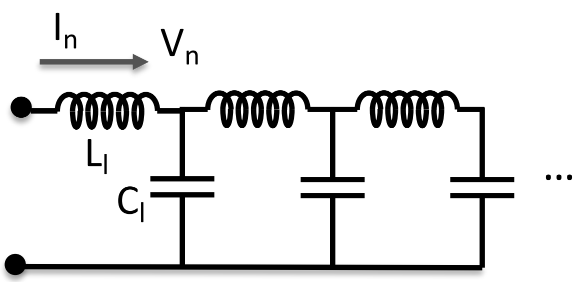
- $i_d = g_m v_{gs}$
- Resonance: $-\frac{1}{j\omega_0 C_2} = j\omega_0 L + \frac{1}{j\omega_0 C_3} + \frac{1}{j\omega_0 C_1}$
- $\omega_0 = \frac{1}{\sqrt{LC}}$, $C = C_1||C_2||C_3$
- At resonance, $v_{gs} = Ri_d \frac{C_1}{C_2}$, $L = \frac{C_1}{RC_2}$
- Oscillation continues if $g_m > \frac{C_1}{RC_2}$
- $v_{gs} = 2v_s$

Norcal 40A



7 MHz
2W
Harmonic Filter
<10 MHz
RF Filter
Power Amp
RF Mixer
20 mW
4.9 MHz
9.1 MHz
Driver
IF Filter
300 uW
VFO
2.1 MHz
Buffer
Product Detector
BFO
4.9 MHz
10 uW
9.8 MHz
Audio
Transmit Filter
AGC
7 MHz
2.8 MHz
AGC Detector
Transmit Mixer
Audio Amp
Key
Transmit oscillator
4.9 MHz

Transmission Lines



Power

$\tau = \frac{V}{V_+} = 1 + \rho = \frac{2Z}{Z+Z_0}, V = 2V_+$

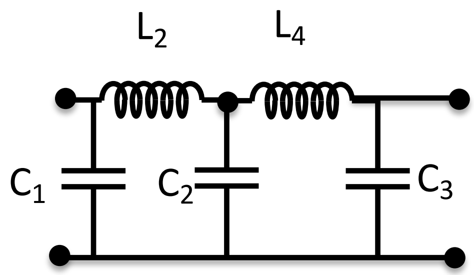
Lookback resistance is $R_s = Z_0$

$P_+ = \frac{{V_+}^2}{2Z_0} = \frac{{V_0}^2}{8Z_0}$, This is the total available power

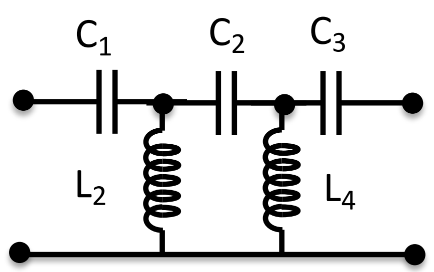
- $V_{n+1} - V_n = -L_l \frac{\partial I_{n+1}}{\partial t},\ L = \frac{L_l}{l}$
- $I_{n+1} - I_n = -C_l \frac{\partial V_n}{\partial t},\ C = \frac{C_l}{l}$
- $\frac{\partial^2 V}{\partial z^2} = LC \frac{\partial^2 V}{\partial t^2}$ and $\frac{\partial^2 I}{\partial z^2} = LC \frac{\partial^2 I}{\partial t^2}$
- Solution is $V(z - vt), v = \frac{1}{\sqrt{LC}}$, for forward wave
- $V' = vLI',\ \frac{V}{I} = \sqrt{\frac{L}{C}},\ Z_0 = \sqrt{\frac{L}{C}}$
- Another solution is $V(z + vt), v = \frac{1}{\sqrt{LC}}$, for r everse wave
- $Z_0 = \frac{V_+}{I_+}, -Z_0 = \frac{V_-}{I_-}, V = V_+ + V_-$
- $P_+(t) = \frac{{V_+}^2}{Z_0},\ P_-(t) = -\frac{{V_-}^2}{Z_0}$
- $\rho = \frac{V_-}{V_+},\ \mathrm{Z} = \frac{V}{I} = \frac{V_+ + V_-}{I_+ + I_-} = \frac{V_+}{I_+} \frac{1 + \frac{V_-}{V_+}}{1 + \frac{I_-}{I_+}} = Z_0 \frac{1+\rho}{1-\rho}$
- $\rho = \frac{Z - Z_0}{Z + Z_0}$
- $\rho_i = \frac{i_-}{i_+} = -\rho$

Filters

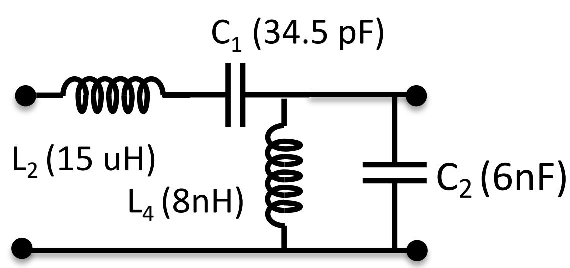
Low pass



High pass



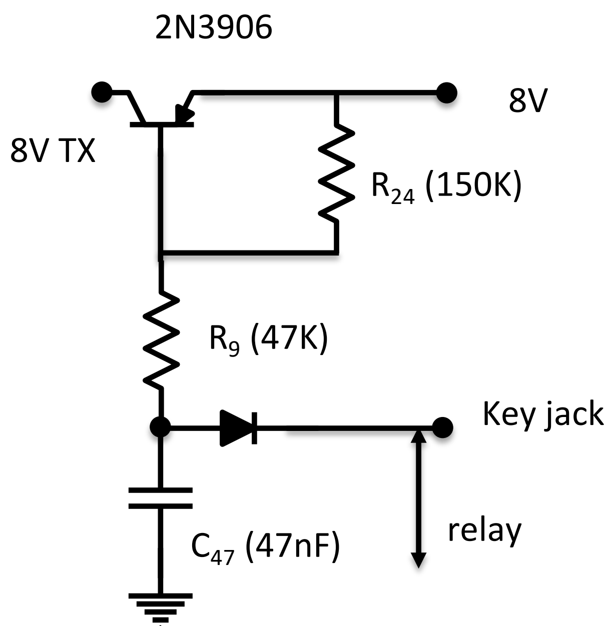
7 MHz bandpass



Acoustics

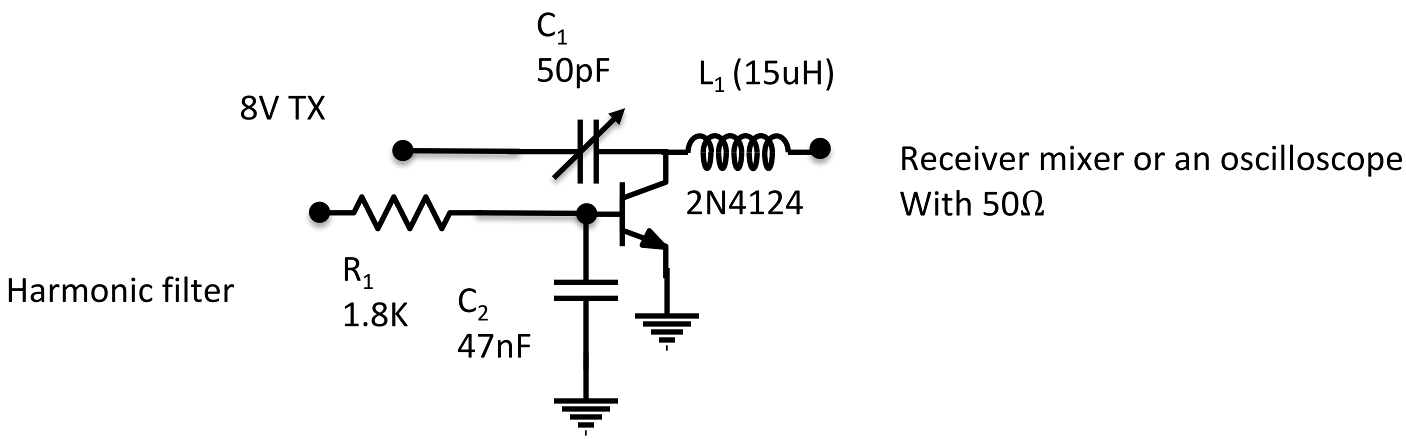
- $\frac{\partial^2 P}{\partial t^2} = \frac{\gamma P}{\rho}\frac{\partial^2 P}{\partial x^2}, v = \sqrt{\frac{\gamma P}{\rho}} = = 332\,\frac{m}{s}$
- $SWR = \frac{\lambda^2}{2\pi A}$, A is the area of the tube

Transmitter switch



- When key is down, transistor conducts

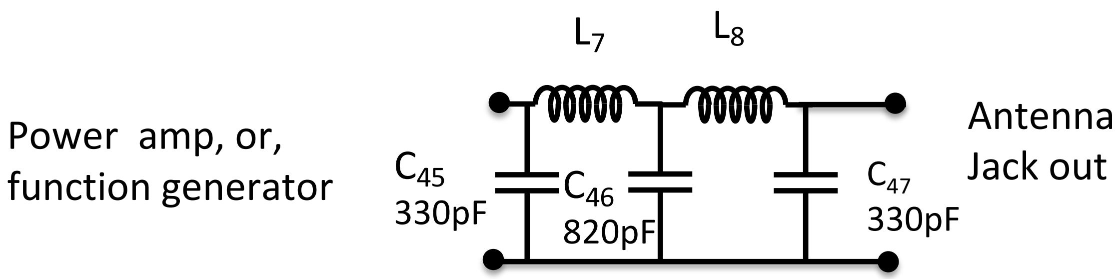
Receiver switch



If using function generator
use a 1.8K resistor

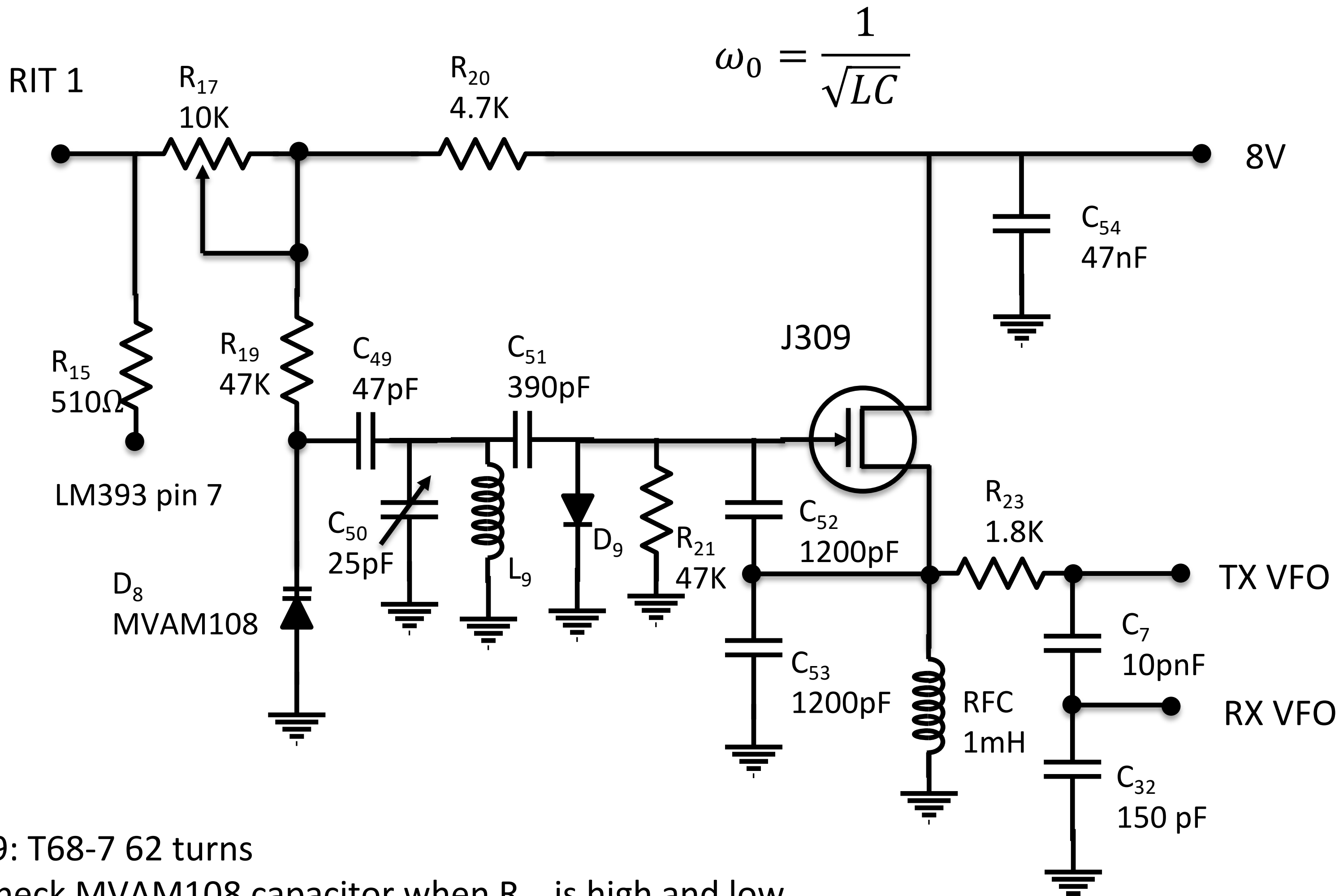
- When transistor conducts the receiver filter shorts

Norcal Harmonic Filter



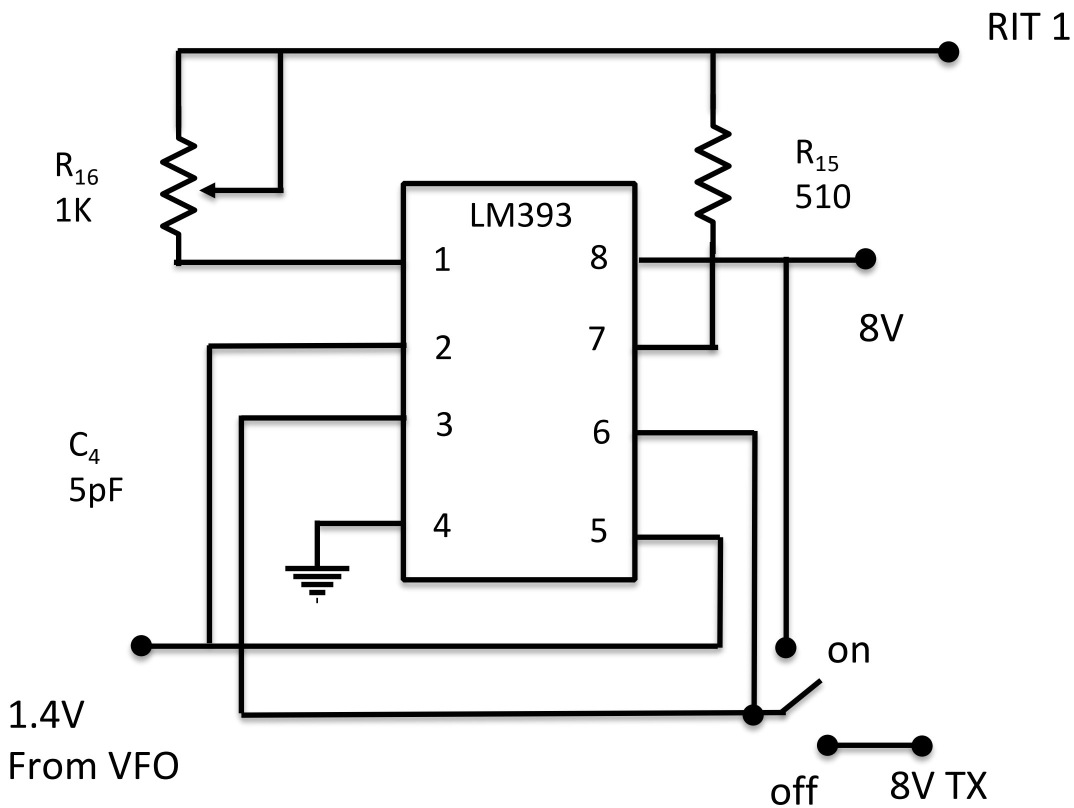
- L_7, L_8 use T37-2 core, 18 turns, 1.3uH
- Compare loss at 7MHz and 14MHz

Norcal VCO



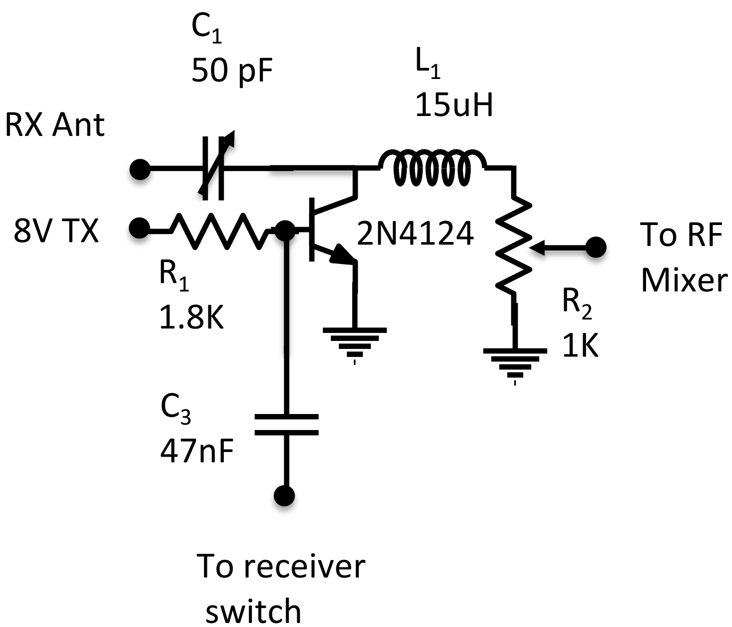
- L9: T68-7 62 turns
- Check MVAM108 capacitor when R_{17} is high and low
- Start resistor (R_{21}) pulls gat to ground at start
- When gain limiting diode (D9) conducts, it pulls gate negative
- Oscillator keeps growing as long as g_m>1/R

Norcal Receiver Incremental Tuning (RIT)

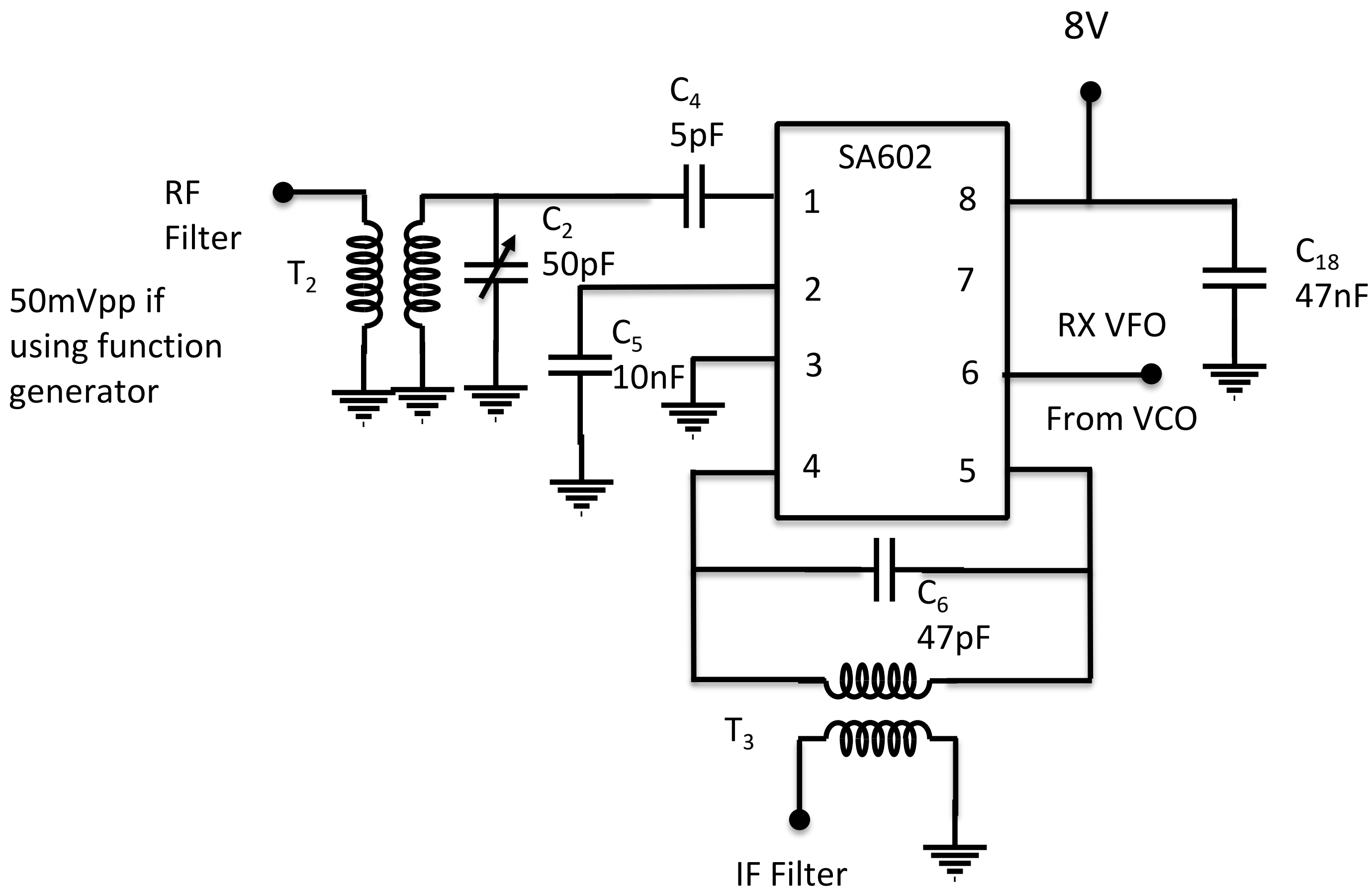


- LM393 is a comparator
- For function generator connect through 1.5K

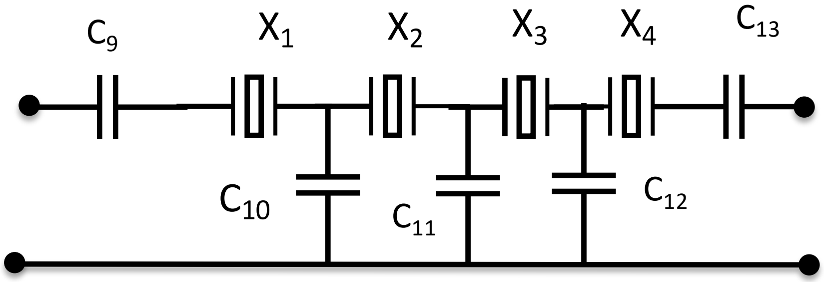
Norcal RF Filter



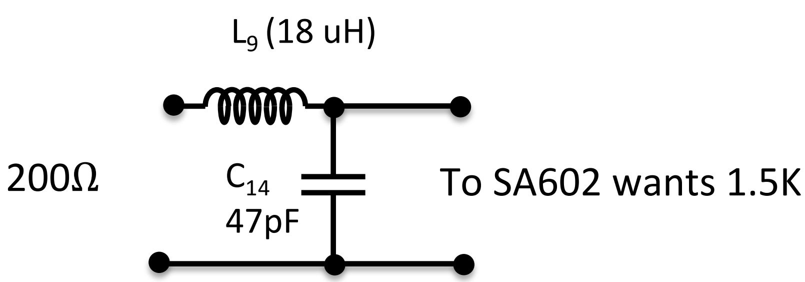
Norcal RF Mixer



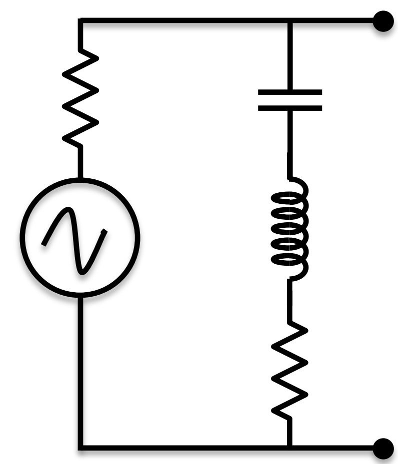
Norcal IF Cohn Filter



- X_1 through X_4 are 4.91 MHz
- C_{10}, C_{11}, C_{12} are 270 pF
- Set function generator to 50mV$_{pp}$ from function generator
- Calculate R and X for filter

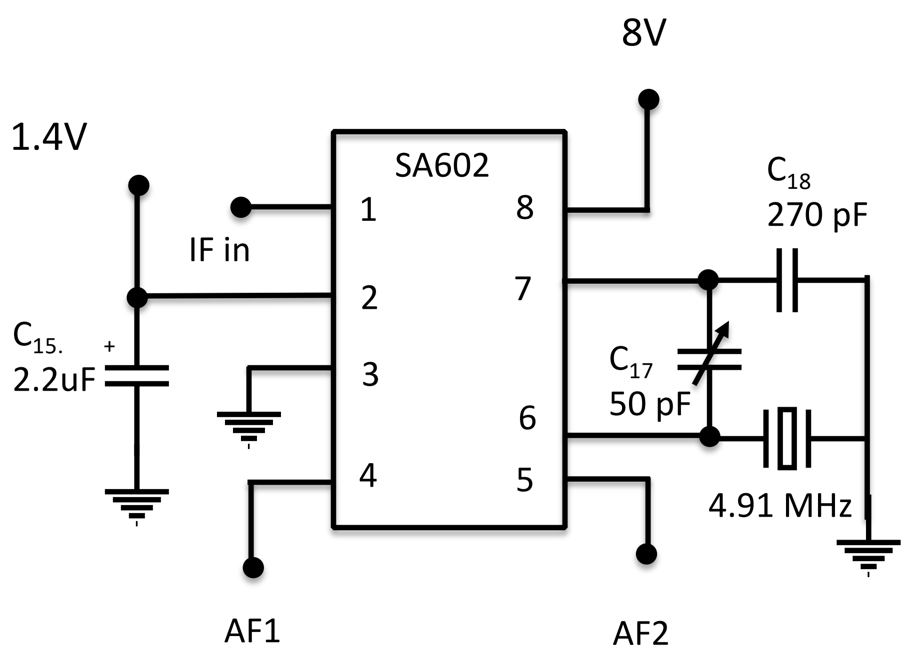


Matching network



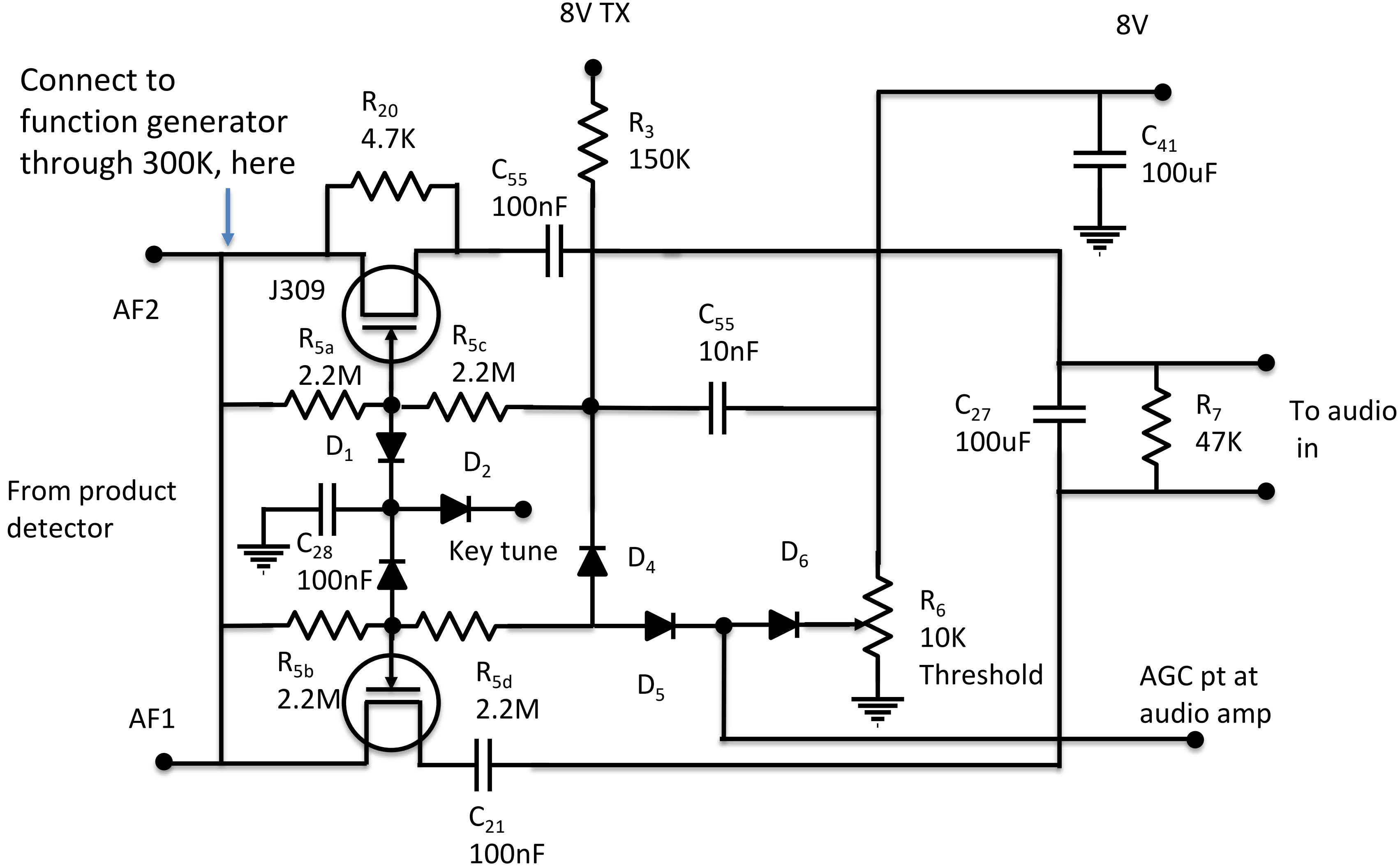
Equivalent circuit for crystal and generator

Norcal Product Detector

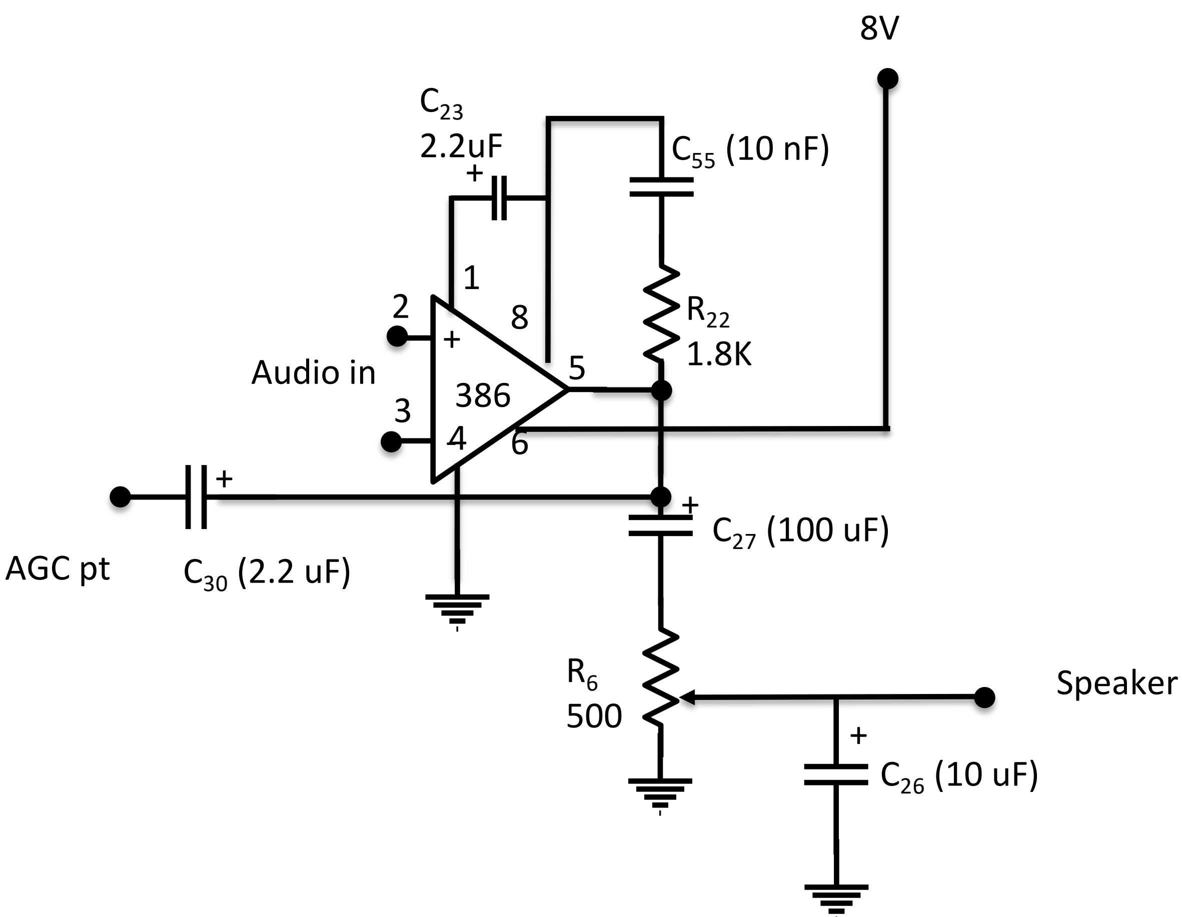


- 620 Hz output through AF1 and AF2

Norcal AGC


8V TX
8V
Connect to
function generator
through 300K, here
R20
4.7K
R3
150K
C55
100nF
C41
100uF
AF2
J309
R5a
2.2M
R5c
2.2M
C55
10nF
C27
100uF
R7
47K
To audio
in
D1
D2
From product
detector
C28
100nF
Key tune
D4
D6
R6
10K
Threshold
R5b
2.2M
R5d
2.2M
D5
AGC pt at
audio amp
AF1
C21
100nF

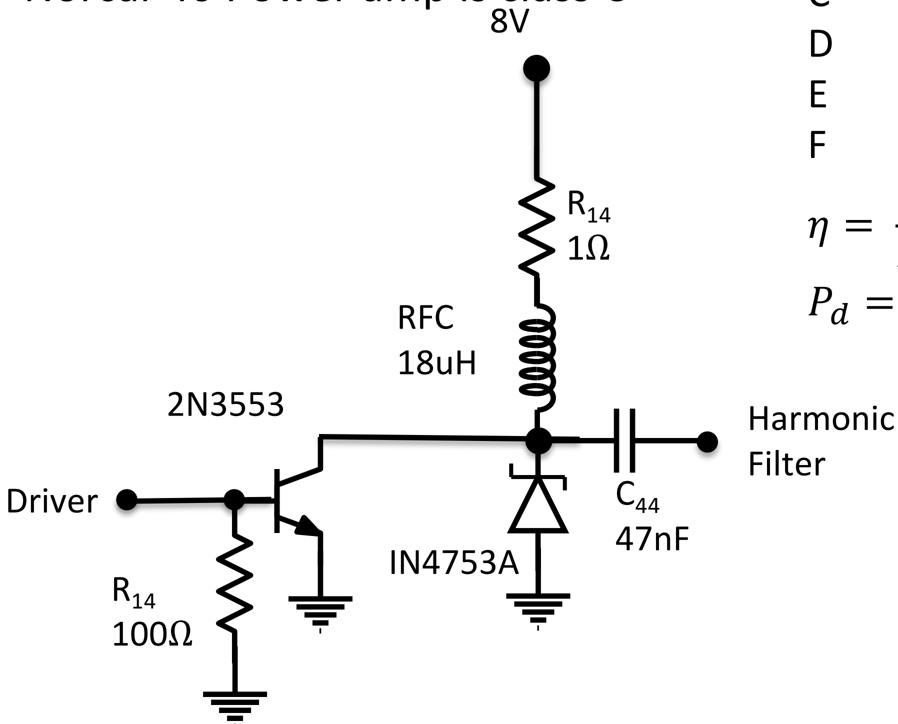
Norcal Audio Amp



Norcal Power Amp

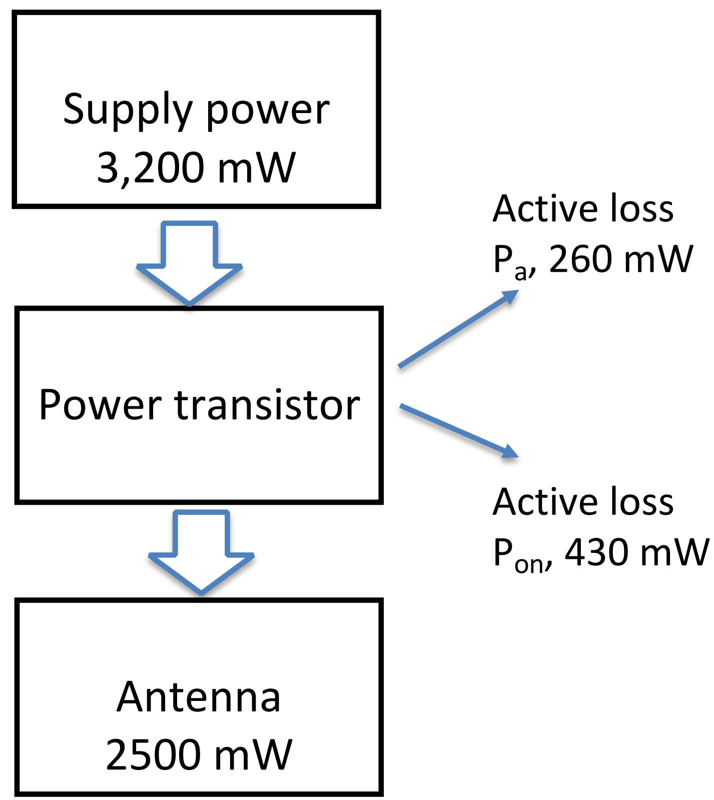
Class	Efficiency	Characteristics
A	35%	Full bias
B	60%	Low bias
C	75%	Saturating
D	75%	Switch in pass-band
E	90%	Voltage switch
F	80%	Harmonic resonators

Norcal-40 Power amp is class C



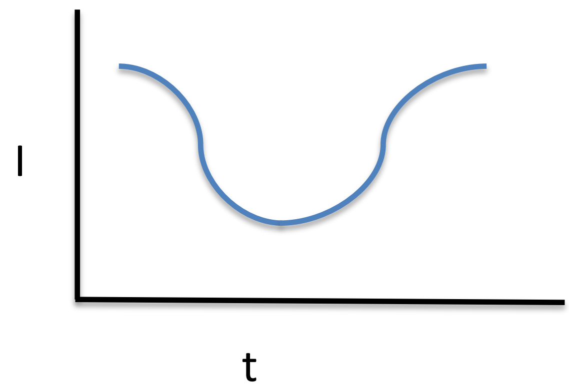
$$\eta = \frac{P}{P_0}, P_d = P_0 - P_i$$

$$P_d = P_a + P_{on}$$

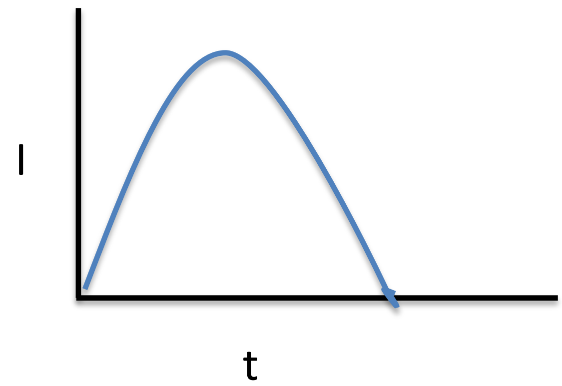


- $R_t = \frac{T - T_0}{P_d}$
- T_0 is ambient temperature, T is heat sink temperature

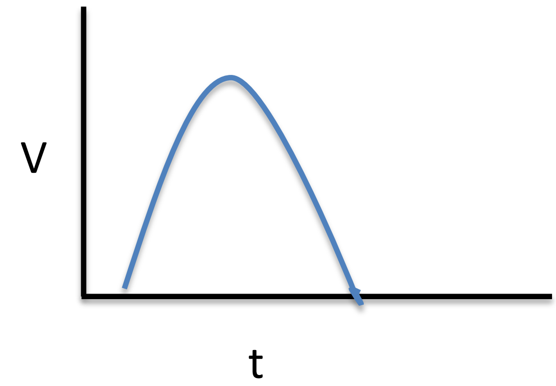
Amplifier classes



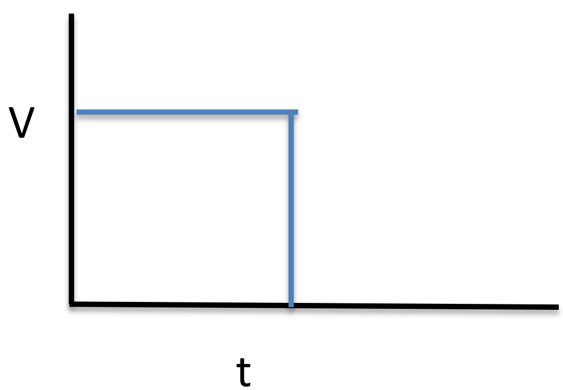
Class A



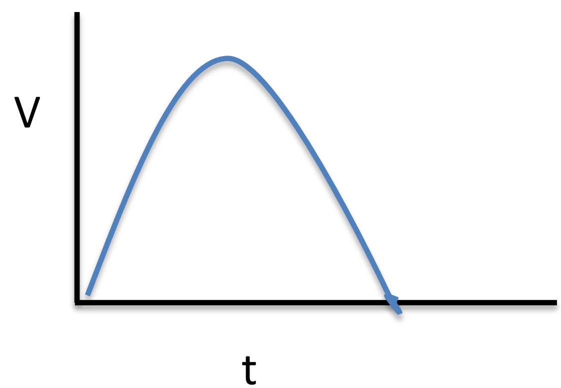
Class B



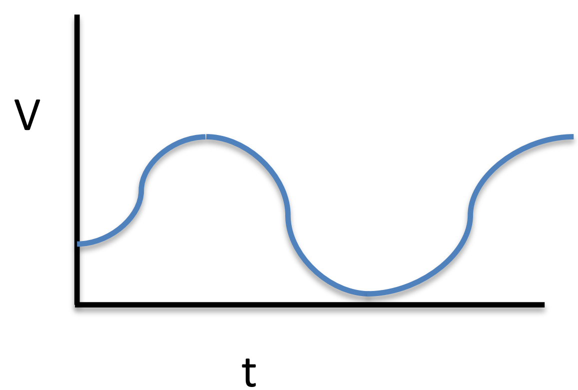
Class C



Class D



Class E

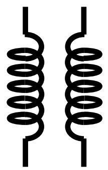


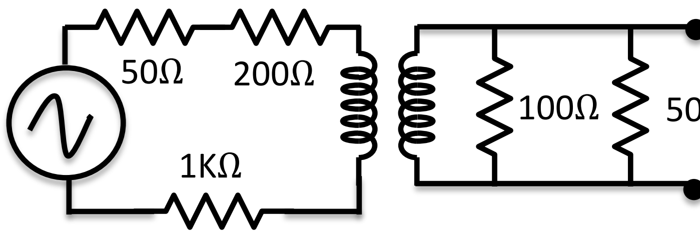
Class F

Norcal matching transformers

- T_1 is driver matcher uses FT 37-43
- Measurement circuit below

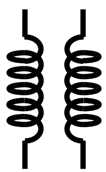
T_1, 14:4

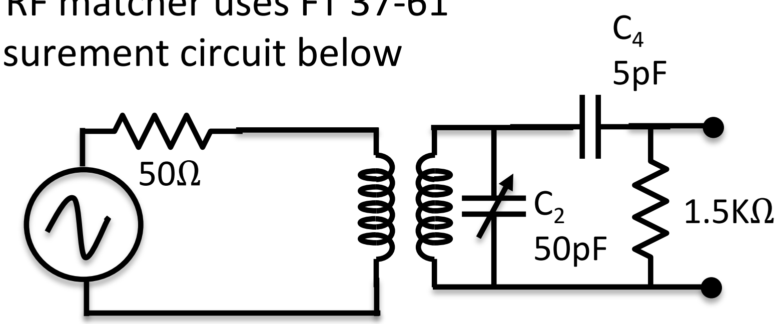




- T_2 is RF matcher uses FT 37-61
- Measurement circuit below

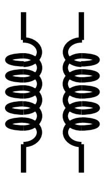
T_2, 1:20

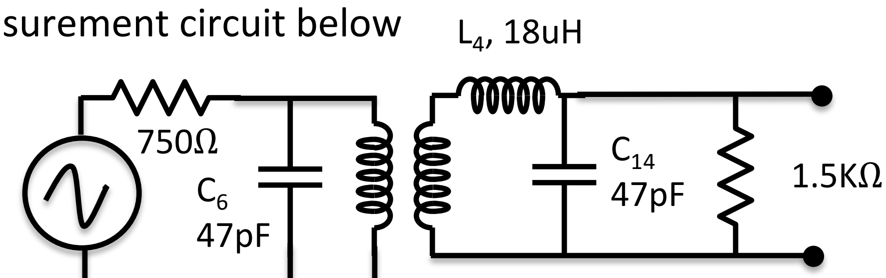




T_3, 23:6

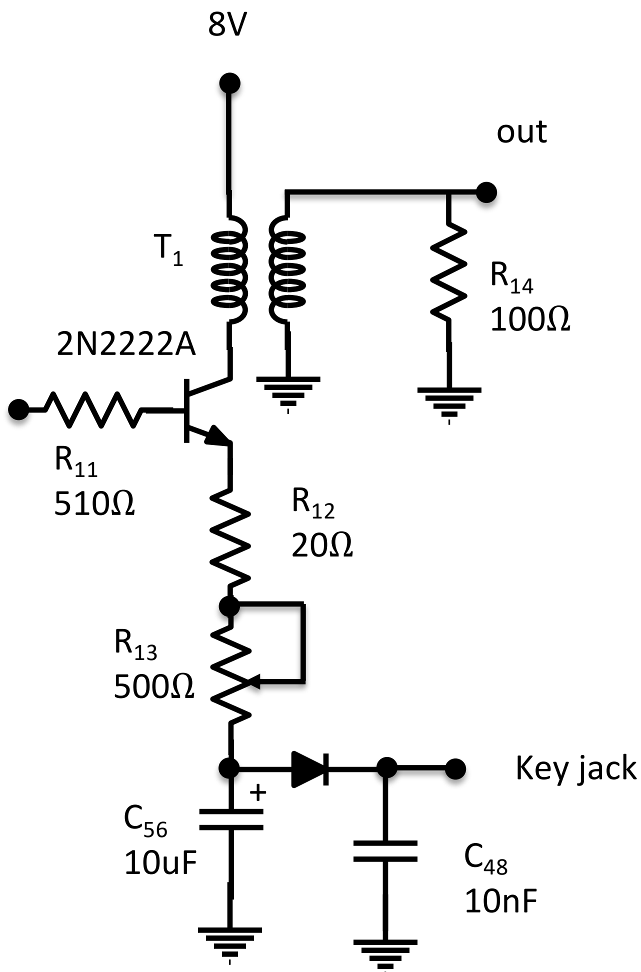
- T_3 is IF matcher uses FT 37-61
- Measurement circuit below



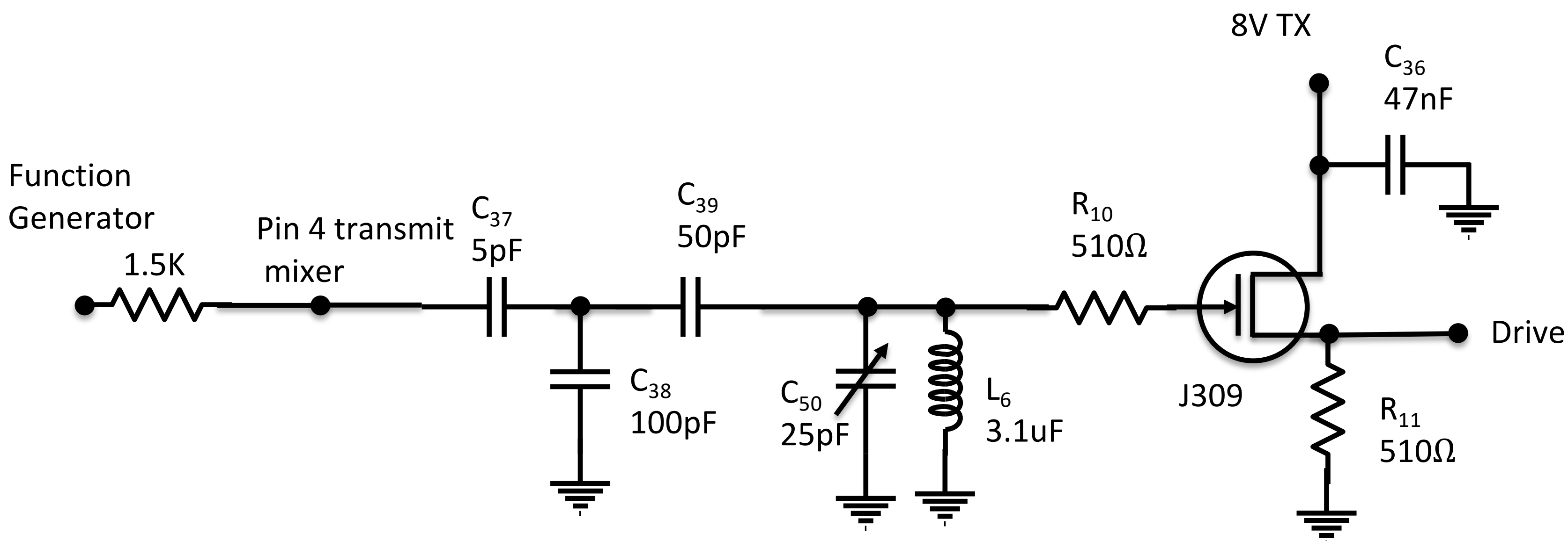


Norcal Driver

- Use 50Ω scope probe

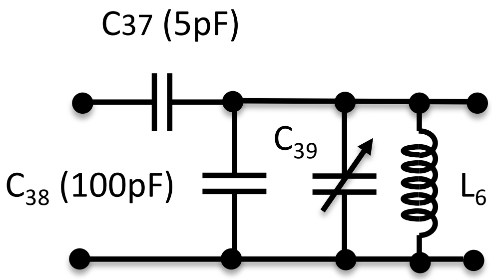


Norcal Buffer



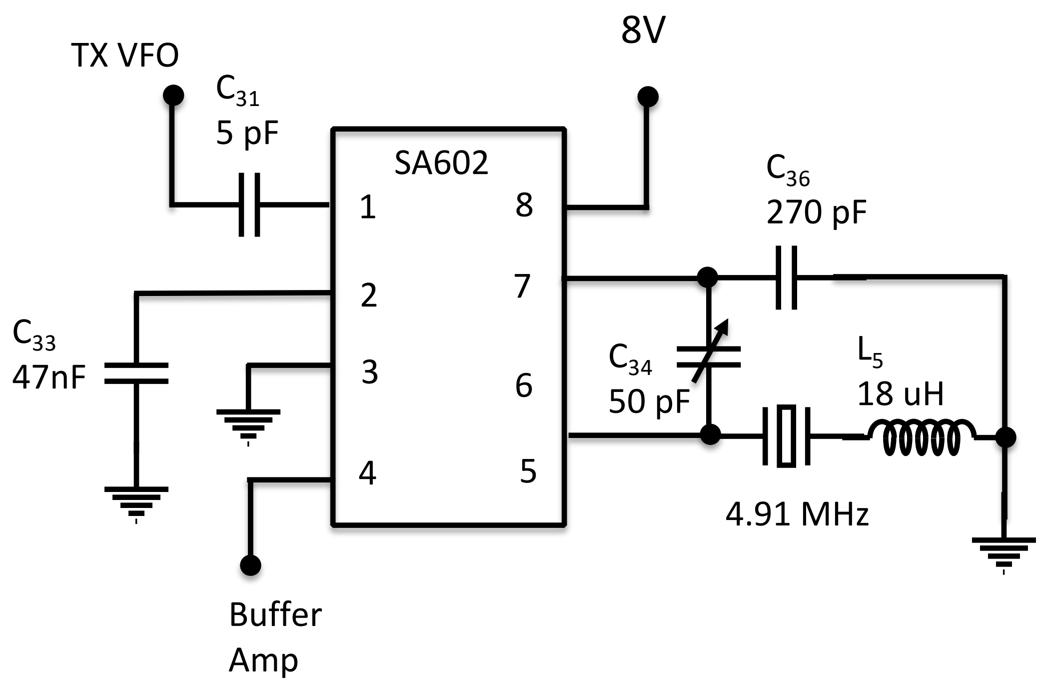
$$G_V = \frac{V}{V_i}$$

Norcal transmit bandpass filter



- $C_{39} = 50pF,$
- L_6 is 36 turns #28 on T37-2 which has $A_l = 4\,\frac{nH}{turn^2}$
- $L_6 = A_l \cdot 36^2 = 3.1\mu H$
- $Z_2 = -\frac{j}{(C_{38}+C_{39})\omega_o},\; Z_3 = jL_6\omega_o, Z_1 = \frac{j}{C_{37}\omega_o}$
- $Z_{2,3-eq} = \frac{jL_6\omega_0}{L_6(C_{38}+C_{39})\omega_0{}^2-1}$
- Resonance is when $Z_{2,3-eq} \rightarrow \infty, \omega_o{}^2 = \frac{1}{(C_{38}+C_{30})L_6} \approx \frac{10^{18}}{465}$, when almost all the voltage drop is across $Z_{2,3-eq}$ $\omega_o = \frac{10^9}{\sqrt{465}} \approx 50.8\times10^6, f_0 = \frac{\omega_o}{2\pi} \approx 7.1\ MHz$
- Q of filter is: $Q_s = \frac{X_s}{R_s}$. R_s comes from the other compon ents and must be measured
- Note that $Z_{2,3-eq}$ is small for the other modulation prod uct

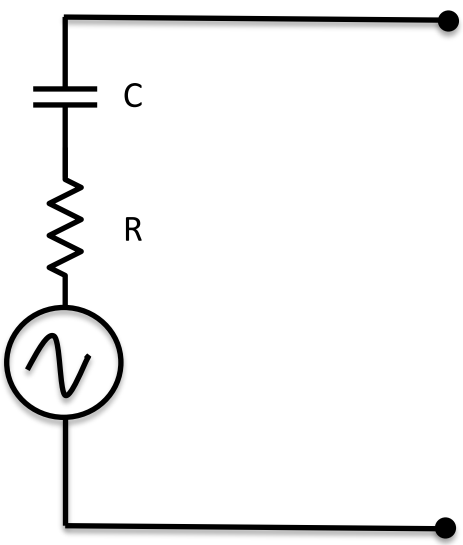
Norcal transmit mixer and oscillator



Antennas and propagation

- From Maxwell, for a plane wave (E in x direction, H in y direction), wave is of form $\exp(j\omega t - j\beta z)$
- $\nabla\times E = -j\mu_0\omega H$
- $\nabla\times B = j\epsilon_0\omega E$
- $\beta\hat{z}\times E = \mu_0\omega H, \beta E_x\hat{y} = \mu_0\omega H$
- Substituting and taking the restricted cross products, we get: $\beta E_x = \omega\mu_0\frac{\omega\epsilon_0}{\beta}$, so $\beta = \omega\sqrt{\mu_0\epsilon_0}$
- Power density: $S = Re\left(\frac{E_x\overline{H_y}}{2}\right) = \frac{(|E_x|)^2}{2\eta_0}$
- $\eta_0 = \frac{E_x}{H_y} = \sqrt{\frac{\mu_0}{\epsilon_0}} = 377\Omega$
- Impedance: $P_t = \frac{R|I|^2}{2}$, R is real part of Z, $R = R_r + R_l, \eta = \frac{R_r}{R}$
- Power density for isotropic antenna: $S_i = \frac{P_t}{4\pi r^2}$
- Define $G(\theta,\phi) = \frac{S(\theta,\phi)}{S_r}$. $S(\theta,\phi)$ is just the Poynting vector
- For isotropic reference, $G = \frac{4\pi r^2 S}{P_t}$

Receiving antenna Thevenin

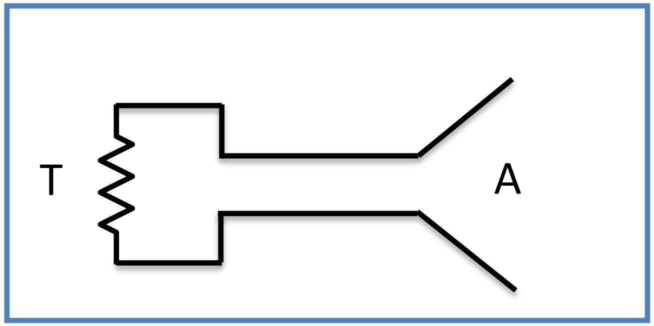


Antennas and propagation

- Receiving antenna:
- $V_0 = hE$, h is effective antenna length ($h = \frac{l}{2}$ for short antenna)
- For dipole: $V_0 = \frac{l}{2} E \sin(\theta)$
- $A(\theta, \phi) = \frac{P_r}{S(\theta,\phi)}$. This is the definition of the effective area, A.
- By reciprocity, $A(\theta, \phi) = \frac{\lambda^2}{4\pi} G(\theta, \phi)$
- $P_r = \frac{|V_0|^2}{8R_a} = \frac{|hE|^2}{8R_a}$, so
- $P_r = \frac{h^2 S \eta_0}{4R}$
- $A = \frac{h^2 \eta_0}{4R}$

Antennas and propagation

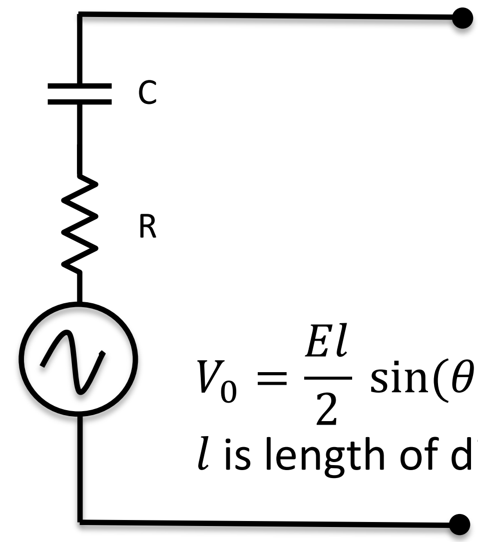
Insulated cavity



- Antenna theorem: $\oint A \, d\Omega = \lambda^2$
- For cavity on right, T is constant at thermodynamic equilibrium and the same power is transmitted and emitted, the Johnson noise is kT. The energy received is $E = \frac{4\pi kT}{c\lambda^2}$. Set $B = \frac{kT}{\lambda^2}$. $kT = \oint BA \, d\Omega = \oint A \frac{kT}{\lambda^2} \, d\Omega$, which gives the antenna theorem
- For transmitting/receiving antenna pairs: $G_1 A_2 = \frac{|V|^2 \pi r^2}{|I|^2 R_1 R_2} = G_2 A_1$. So $\frac{G_1}{A_1} = \frac{G_2}{A_2} = \frac{4\pi}{\lambda^2}$
- Friis formulas
- $S = \frac{P_t G}{4\pi r^2}, P_r = SA = \frac{P_t G A}{4\pi r^2}$

Reciprocity and dipole

Dipole Thevenin equivalent circuit



$V_0 = \frac{El}{2} \sin(\theta)$

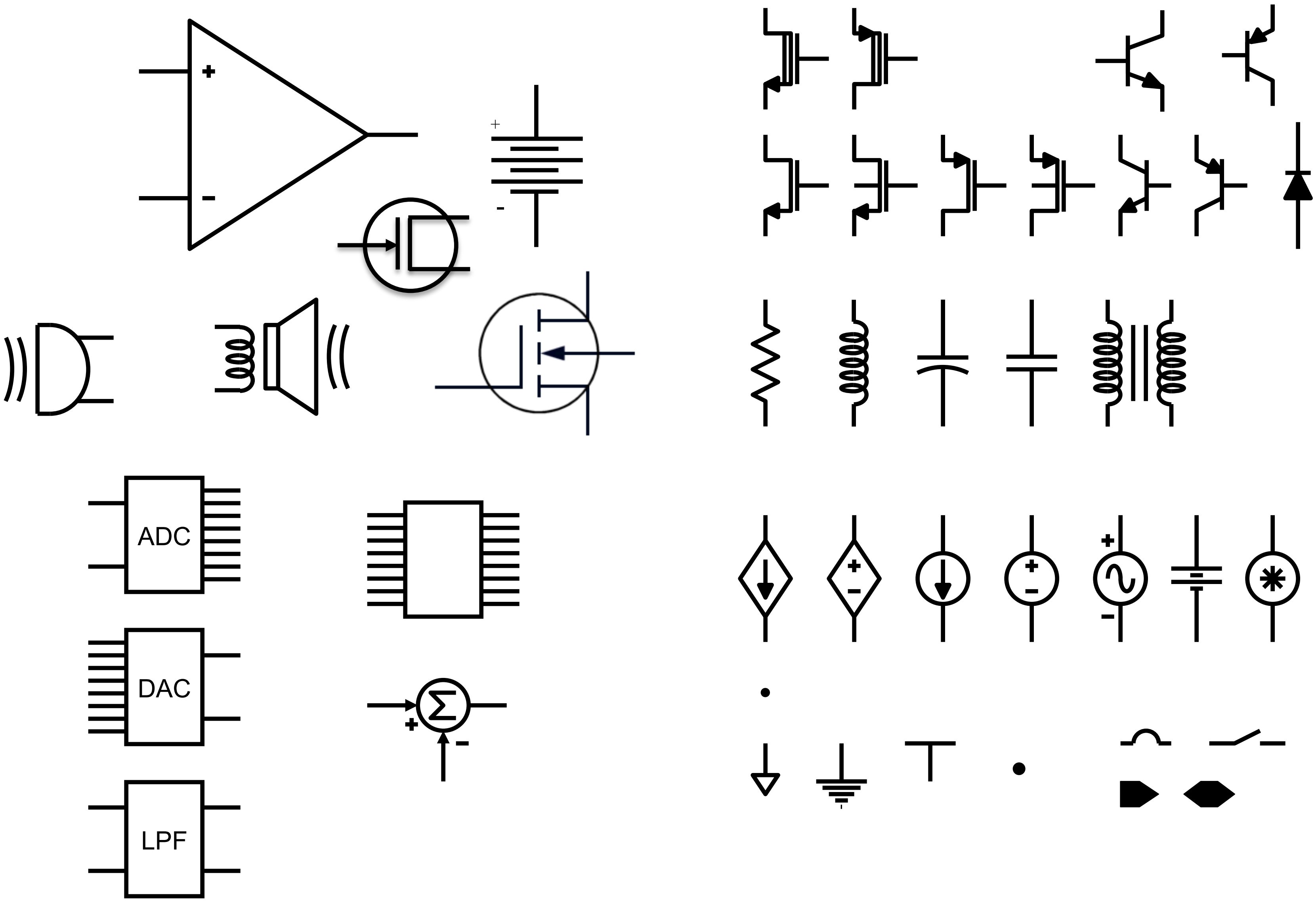
l is length of dipole

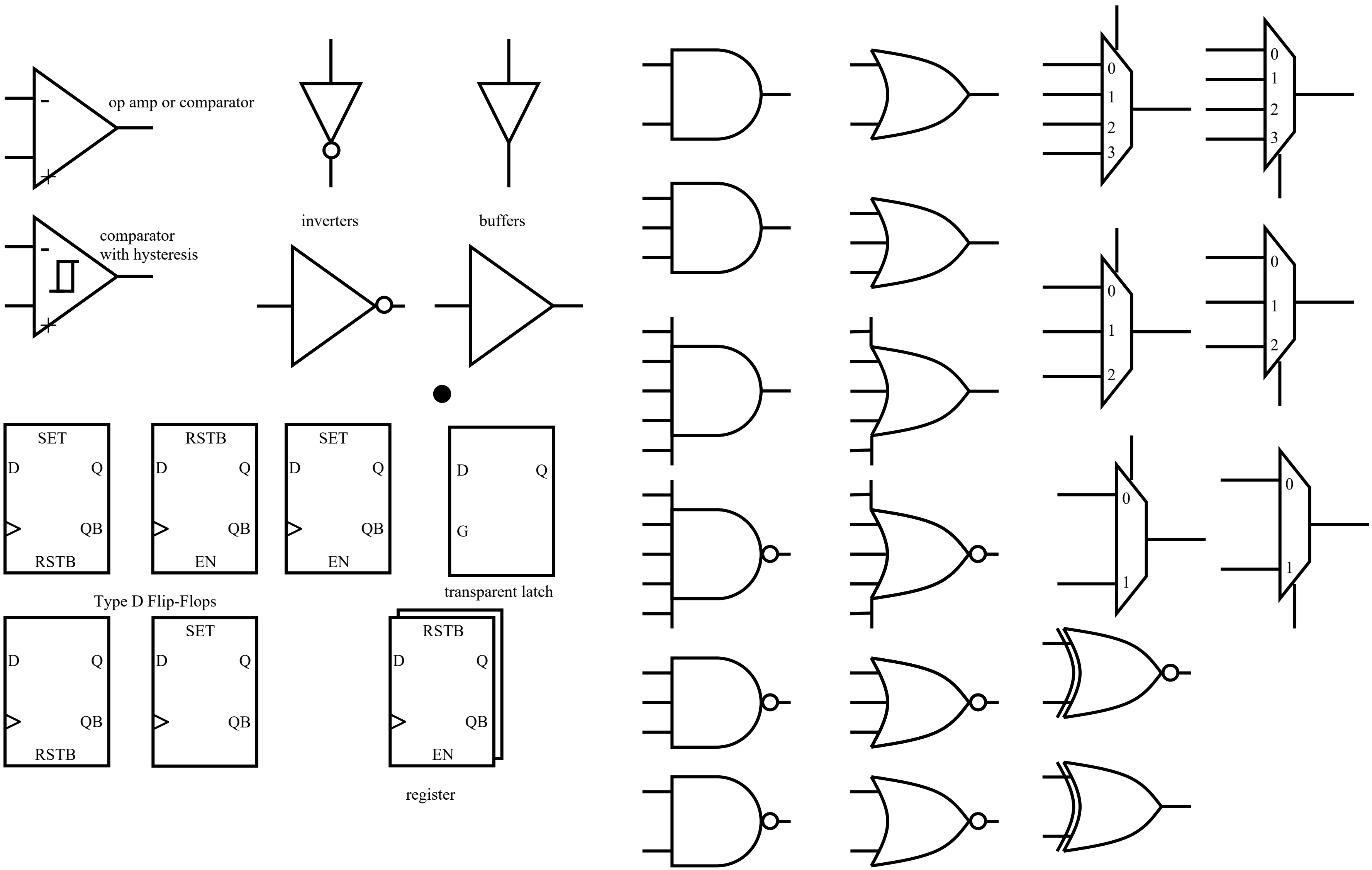
- For dipole (Length: $l = \frac{\lambda}{2}$)
- $\lambda^2 = \int A \, d\Omega = \int \frac{h^2 \eta_0}{4R_r} \, d\Omega$, so
- $R_r = \frac{l^2 \eta_0}{16\lambda^2} \int sin^2(\theta) d\Omega = \eta_0 \frac{\pi}{6} \, (\frac{l}{\lambda})^2$
- $A = \frac{3\lambda^2}{8\pi} \, sin^2(\theta)$ and $G = 1.5 \, sin^2(\theta)$. . Note we used $h = \frac{l}{2} \sin(\theta)$

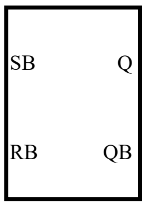
- For Norcal, $G = 1$, $A = 150m^2$, for $r = 2000 \, m, P_r = 6pW$

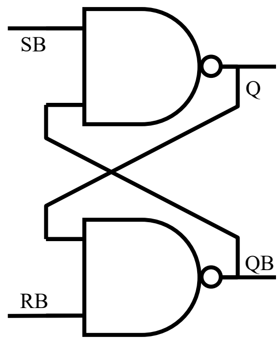
Noise

- $V_{n(rms)} = \sqrt{\frac{1}{\tau}\int_0^{\tau} V(t)^2 \ dt}$
- $P_n = \frac{{V_{n(rms)}}^2}{R}$, R is load resistance
- $SNR = \frac{P}{P_n}$
- $MDS = \frac{P_n}{G}$
- Nyquist
- $V_C = \frac{1}{j\omega C}\frac{V_n}{R+j\omega L+\frac{1}{j\omega C}}$
- $\overline{|V_c|^2} = \frac{\overline{|V_n|^2}}{|1-\omega^2 LC+j\omega RC|^2}$
- Expected energy at resonance is $kT = \frac{C}{2}\int_0^{\infty} |V_c|^2 df$
- $\int_0^{\infty}\frac{1}{|1-\omega^2 LC+j\omega RC|^2} df = \frac{1}{4RC}$
- So, $\overline{|V_c|^2} = 8\mathrm{kTR}$

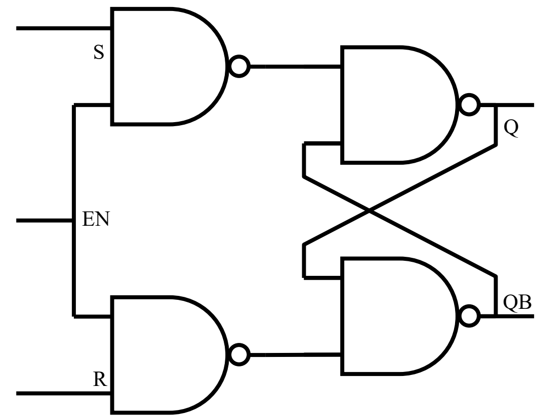

ADC
DAC
LPF


op amp or comparator
comparator
with hysteresis
inverters
buffers
SET
D
Q
QB
RSTB
RSTB
D
Q
QB
EN
SET
D
Q
QB
EN
D
Q
G
transparent latch
Type D Flip-Flops
D
Q
QB
RSTB
SET
D
Q
QB
RSTB
D
Q
QB
EN
register
0
1
2
3
0
1
2
3
0
1
2
0
1
2
0
1
0
1

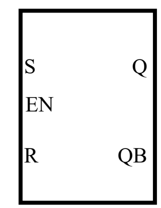




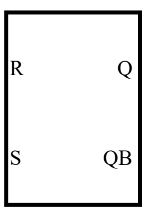
SB	RB	Action
0	0	Q=1 QB=1
0	1	Q=1 QB=0
1	0	Q=0 QB=1
1	1	Keep state

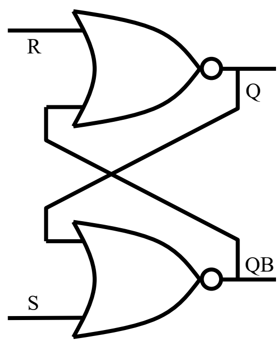


EN	Action
0	Keep state
1	same as SR latch

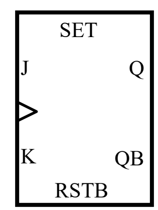


Gated SR Latch

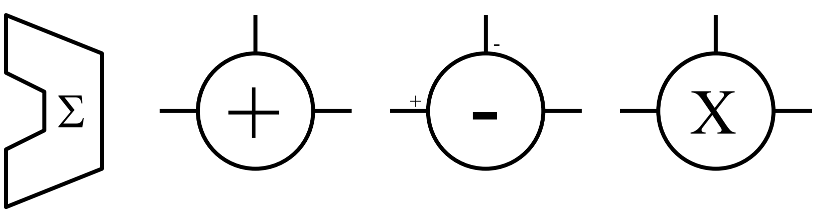


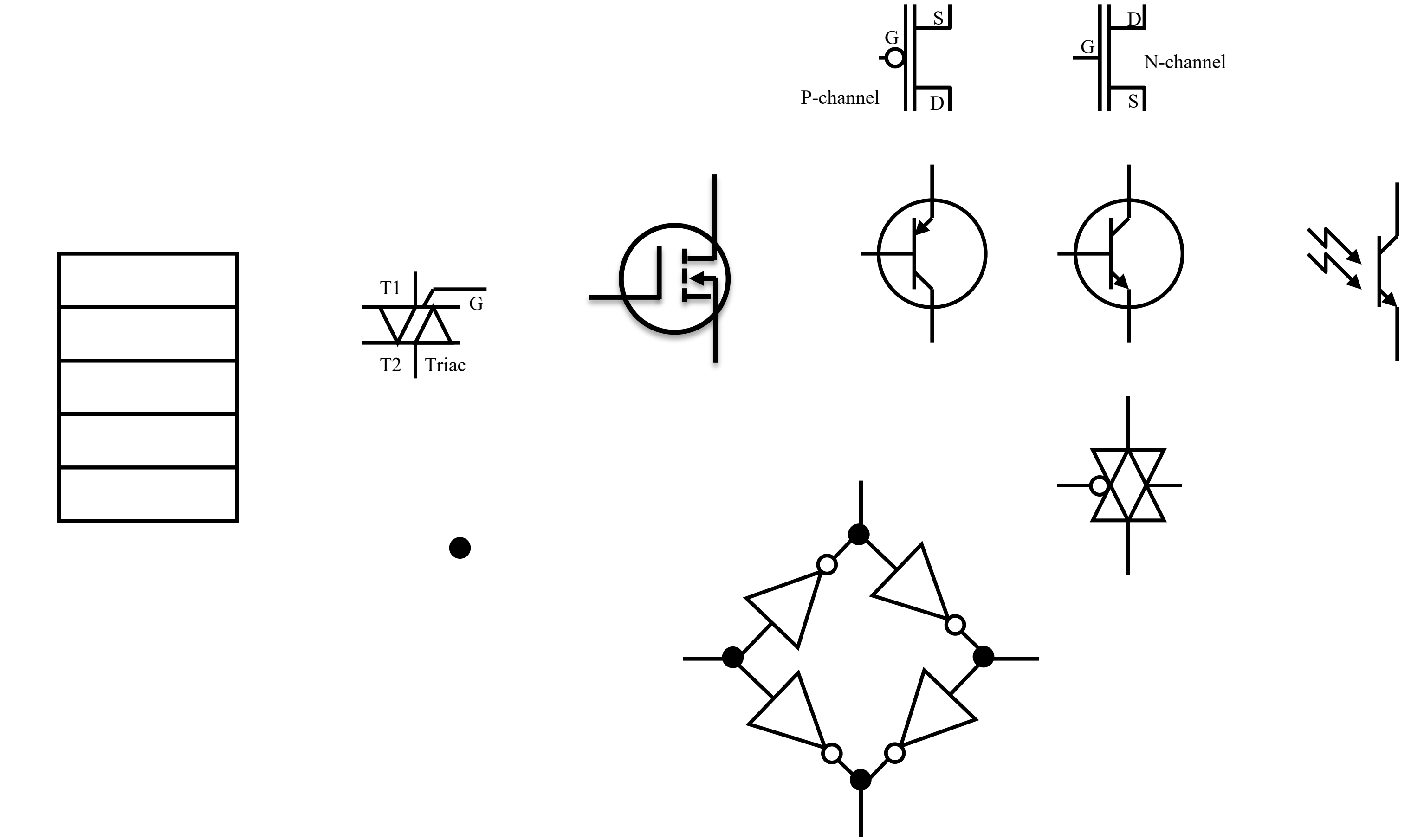


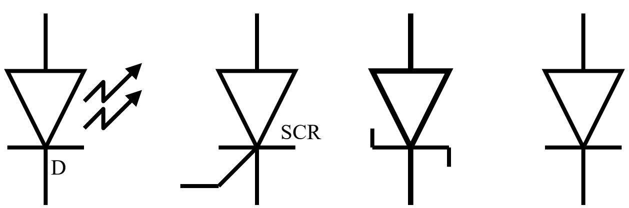
S	R	Action
0	0	Keep state
0	1	Q=0 QB=1
1	0	Q=1 QB=0
1	1	Q=0 QB=0



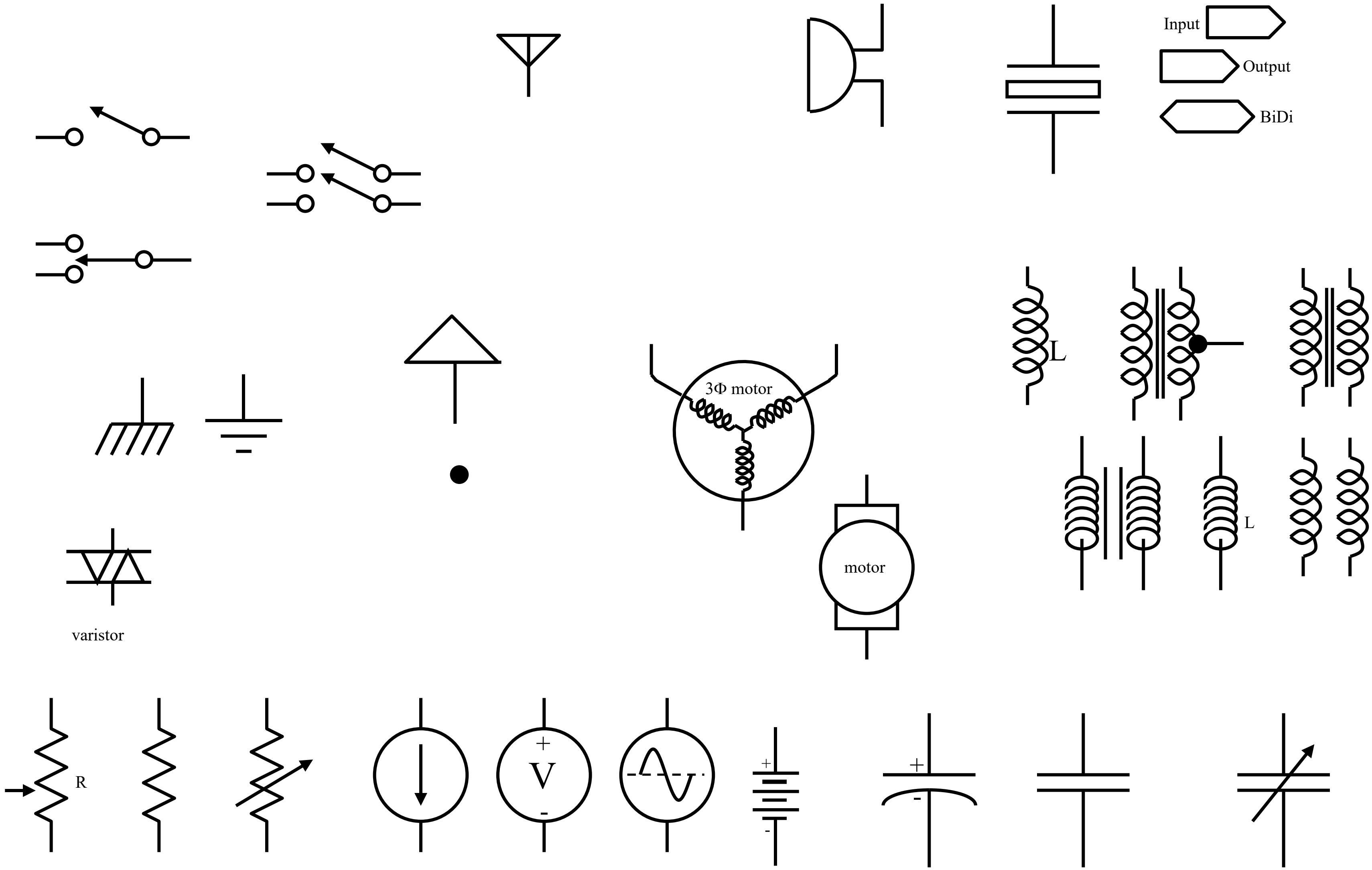
J	K	Next Value
0	0	No Change
0	1	Q=0
1	0	Q=1
1	1	Toggle







http://www.eehomepage.com/symbols.ppt


Input
Output
BiDi
L
3Φ motor
L
motor
varistor
R
+
V
-
+
-
+
-