Načrti vezij za seminarske naloge (Pri sestavljanju vezja imejte v mislih, da vsa vezja niso preizkušena, zato bo morda potrebno nekaj več dela z nastavitvami. Napisani predlogi lahko služijo tudi kot orientacija pri samostojnem načrtovanju ali iskanju vezja za seminarsko nalogo. Načrti vezij pod točko "FILTRI" bodo na razpolago na laboratorijskih vajah.):

AKUSTIKA

OSCILATORJI

RADIJSKA VEZJA

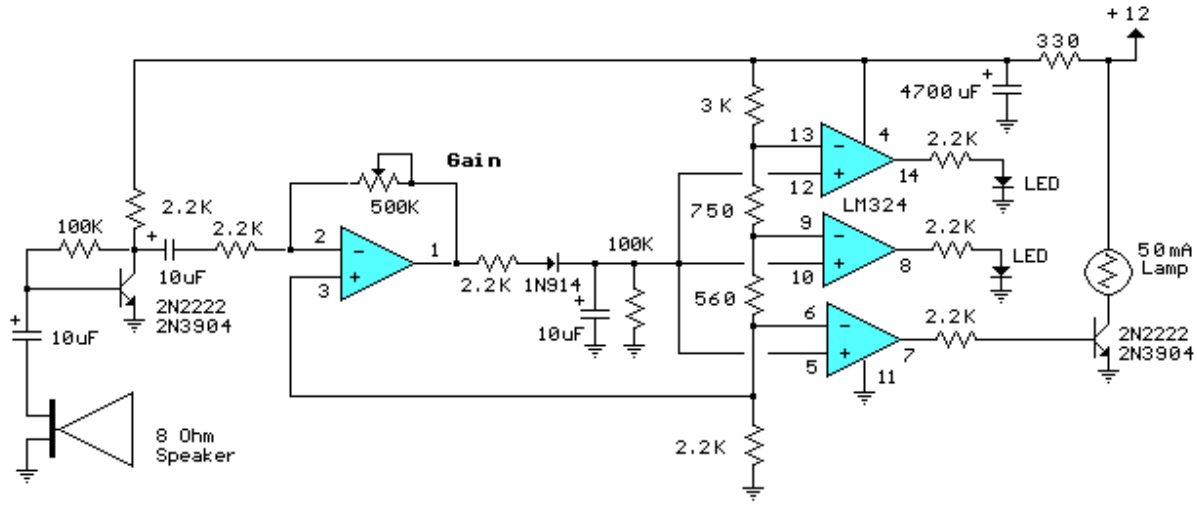
FILTRI (glej: Johnson D, Hilburn J, *Rapid Practical Design of Active Filters*, Wiley&Sons, 1975)

1. dB – meter

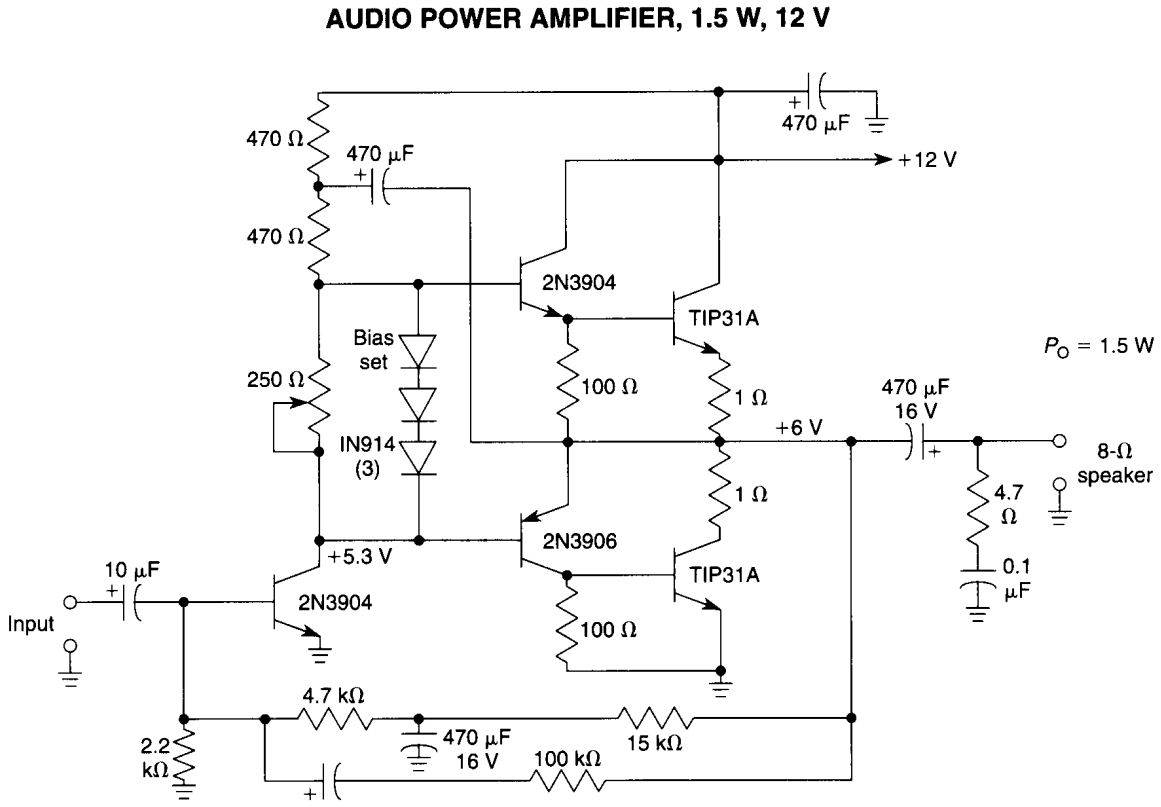
The circuit below responds to sound pressure levels from about 60 to 70 dB. The sound is picked up by an 8 ohm speaker, amplified by a transistor stage and one LM324 op-amp section. You can also use a dynamic microphone but I found the speaker was more sensitive. The remaining 3 sections of the LM324 quad op-amp are used as voltage comparators and drive 3 indicator LEDs or incandescents which are spaced about 3dB apart. An additional transistor is needed for incandescent lights as shown with the lower lamp. I used 12 volt, 50mA lamps. Each light represents about a 3dB change in sound level so that when all 3 lights are on, the sound level is about 4 times greater than the level needed to light one lamp. The sensitivity can be adjusted with the 500K pot so that one lamp comes on with a reference sound level. The other two lamps will then indicate about a 2X and 4X increase in volume. In operation, with no input, the DC voltage at pins 1,2 and 3 of the op-amp will be about 4 volts, and the voltage on the (+) inputs to the 3 comparators (pins 5,10,12) will be about a half volt less due to the 1N914 diode drop. The voltage on the (-) comparator inputs will be around 5.1 and 6.5 which is set by the 560 and 750 ohm resistors.

When an audio signal is present, the 10uF capacitor connected to the diode will charge toward the peak audio level at the op-amp output at pin 1. As the volume increases, the DC voltage on the capacitor and also (+) comparator inputs will increase and the lamp will turn on when the (+) input goes above the (-) input. As the volume decreases, the capacitor discharges through the parallel 100K resistor and the lamps go out. You can change the response time with a larger or smaller capacitor.

This circuit requires a well filtered power source, it will respond to very small changes in supply voltage, so you probably will need a large filter capacitor connected directly to the 330 ohm resistor. I managed to get it to work with an unregulated wall transformer power source, but I had to use 4700uF. It worked well on a regulated supply with only 1000uF.

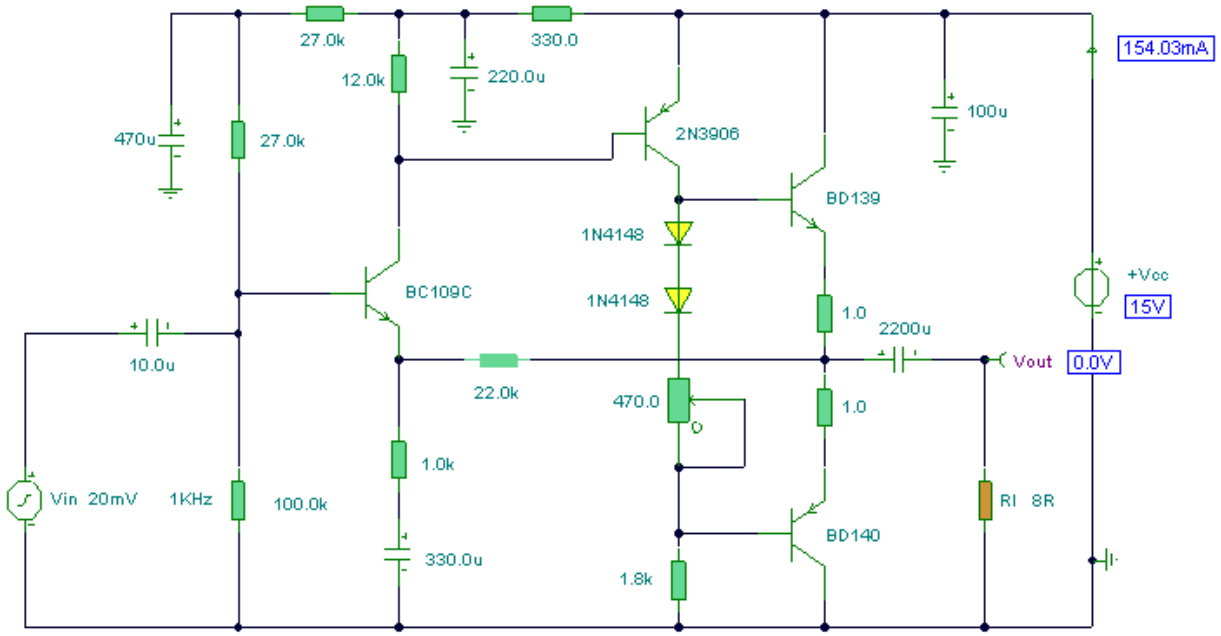


2. Audio ojačevalnik, 1.5W



Although ICs have largely replaced circuits such as this, this circuit still finds use where the flexibility of a discrete device design is desirable. Parts are easy to obtain and the problem of IC obsolescence is eliminated. The TIP31A can be heatsinked to a small metal heatsink, if desired.

3. Audio ojačevalnik, 2W



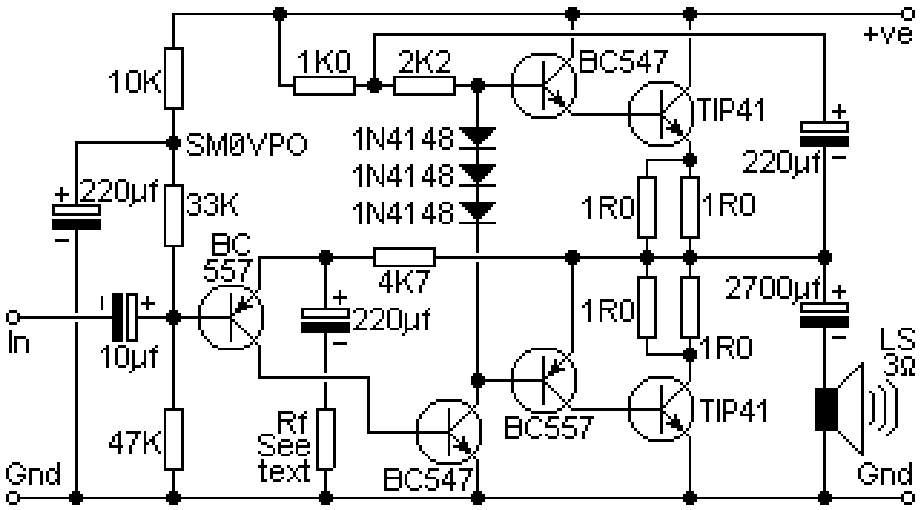
Notes:
This was one of the earliest circuits that I ever designed and built, in Spring 1982. At that time I had only an analogue meter and a calculator to work with. Although far from perfect, this amplifier does have a wide frequency response, low distortion, and is capable of driving an 8 ohm speaker to output levels of around 5 watts with slightly higher distortion. Any power supply in the range 12 to 18 Volts DC may be used.

Circuit Description
The amplifier operates in Class AB mode; the single 470R preset resistor controls the quiescent current flowing through the BD139/140 complimentary output transistors. Adjustment here, is a trade-off between low distortion and low quiescent current. Typically, under quiescent conditions, standby current may be 15 mA rising to 150 mA with a 50 mV input signal.

The circuit is DC biased so that the emitters of the BD139 and BD140 are at approximately half supply voltage, to allow for a maximum output voltage swing. All four transistors are direct coupled which ensures:-
(i) A good low frequency response
(ii) Temperature and bias change stability.

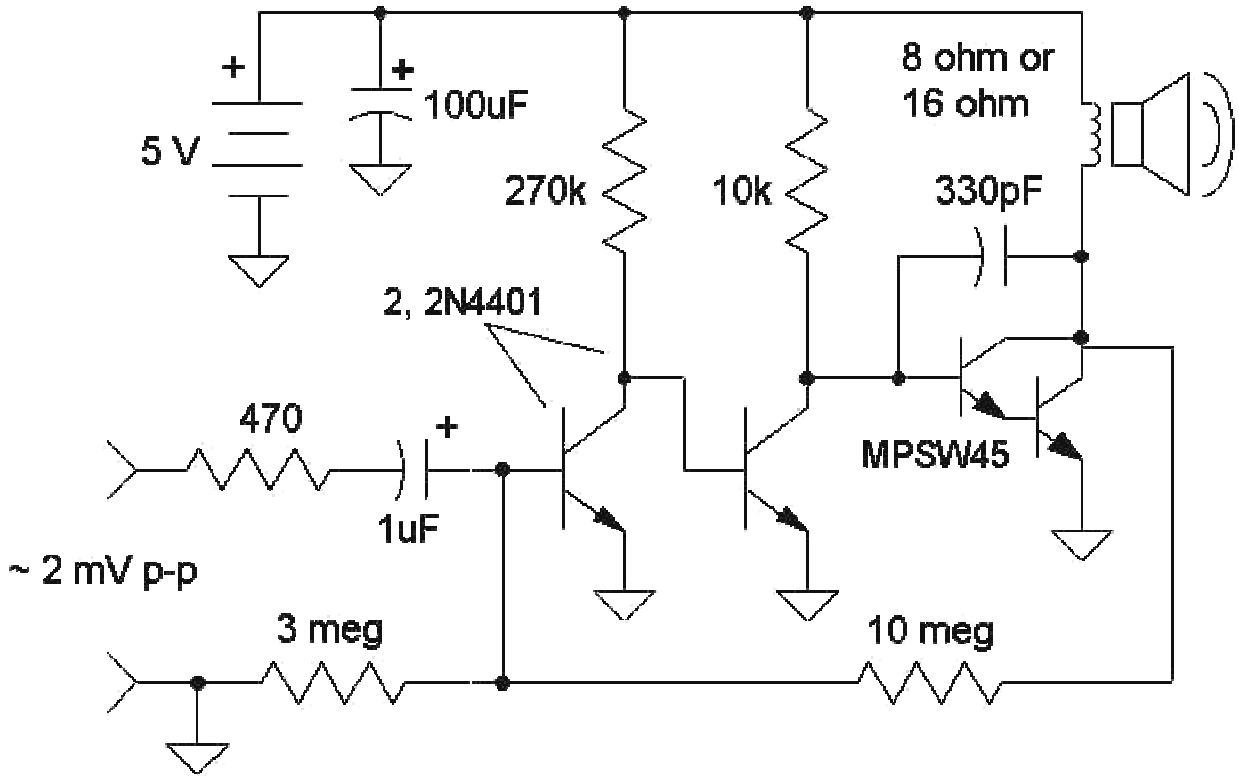
The BC109C and 2N3906 operate in common emitter. This alone will provide a very high open loop gain. The output BD139/140 pair operate in emitter follower, meeting the requirements to drive low impedance speakers. Overall gain is provided by the ratio of the 22k and 1k resistor. A heat sink on the BD139/140 pair is recommended but not essential, though the transistors will run "hot" to the touch.

4. Audio ojačevalnik, 4W



5. Audio ojačevalnik v razredu A

A class-A audio amplifier is pretty wasteful of power but when plenty of power is available the simplicity is attractive. The 5 volts should be provided by a regulated power supply. The efficiency is below 25% and significant DC current flows in the speaker and that additional power should be figured in to the power rating of the speaker. But look how simple it is! The voltage gain is only about 20 and the input impedance is about 12k. The schematic shows two values of bias resistor to be used with the corresponding speaker impedance. With the 150k bias resistor and 8 ohm speaker, the circuit draws about 210mA (1 watt) and can deliver about 250 mW to the speaker which is plenty of volume for most small projects. The speaker should be rated at 500 mW or more and should exhibit a DC resistance near 8 ohms (perhaps 7 ohms). Check the candidate speaker with an ohmmeter; much below 7 ohms will cause excessive current draw. With the 220k resistor and 16 ohm speaker, the circuit draws about 100 mA (500 mW) and delivers about 125 mW to the speaker. The 16 ohms speaker should be rated at 200 mW or more and exhibit nearly 16 ohms of DC resistance. (Most small speakers have a DC resistance near the rated impedance and that resistance is used to set the quiescent current level in this circuit.) Other NPN darlington transistors will work but choose one that can dissipate 1 watt minimum. Most power types don't need a heatsink but tiny TO92's might overheat.
If the inefficiency of the class-A hasn't dissuaded you yet, here is a 4-transistor amplifier suitable for small signals:



The input impedance is about 5000 ohms and the frequency response is flat from 30 Hz to over 20,000 Hz. With the 8 ohm speaker the current drain is about 215 mA and the gain is about 1700 (64 dB). With the 16 ohm speaker the current gain is about 110 mA and the gain is about 2500 (68 dB). A volume control may be added by connecting one end of a 5k potentiometer to ground, the wiper to the amplifier input. The other end of the pot becomes the input.

6. Audio ojačevalnik v razredu B

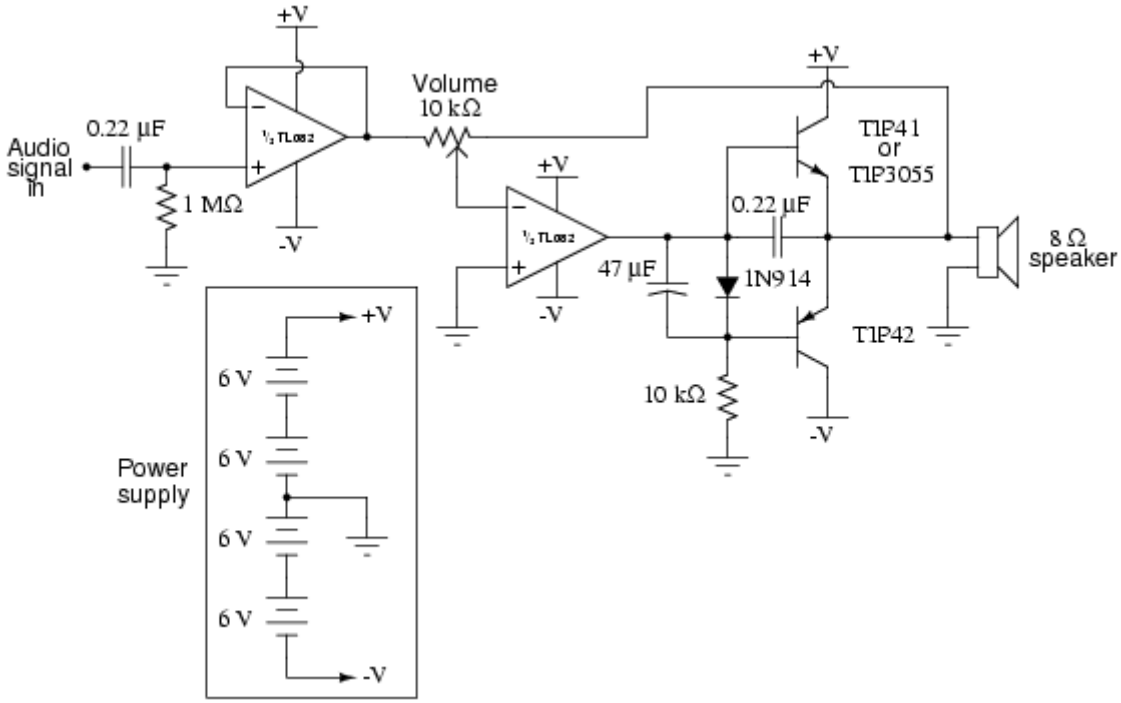
PARTS AND MATERIALS

- Four 6 volt batteries
- Dual operational amplifier, model TL082 recommended (Radio Shack catalog # 276-1715)
- One NPN power transistor in a TO-220 package -- (Radio Shack catalog # 276-2020 or equivalent)
- One PNP power transistor in a TO-220 package -- (Radio Shack catalog # 276-2027 or equivalent)
- One 1N914 switching diode (Radio Shack catalog # 276-1620)
- One capacitor, 47 µF electrolytic, 35 WVDC (Radio Shack catalog # 272-1015 or equivalent)
- Two capacitors, 0.22 µF, non-polarized (Radio Shack catalog # 272-1070)
- One 10 kΩ potentiometer, linear taper (Radio Shack catalog # 271-1715)

Be sure to use an op-amp that has a high *slew rate*. Avoid the LM741 or LM1458 for this reason.

The closer matched the two transistors are, the better. If possible, try to obtain TIP41 and TIP42 transistors, which are closely matched NPN and PNP power transistors with dissipation ratings of 65 watts each. If you cannot get a TIP41 NPN transistor, the TIP3055 (available from Radio Shack) is a good substitute. Do not use very large (i.e. TO-3 case) power transistors, as the op-amp may have trouble driving enough current to their bases for good operation.

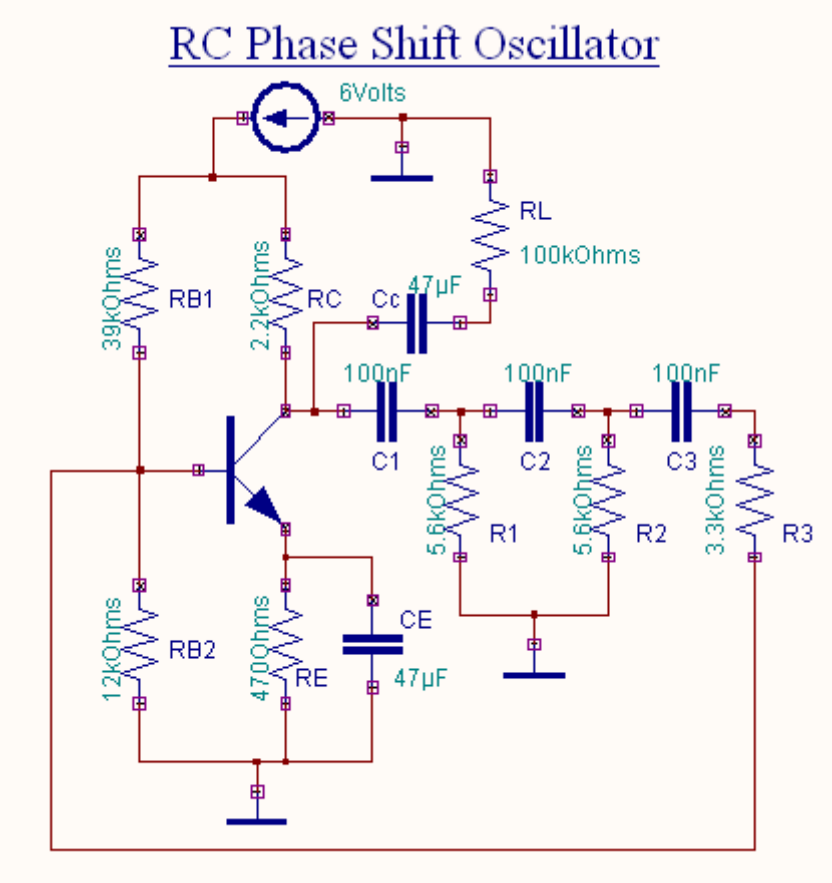
SCHEMATIC DIAGRAM



7. RC oscilator z bipolarnim tranzistorjem

An oscillator is a circuit, which generates ac output signal without giving any input ac signal. This circuit is usually applied for audio frequencies only. The basic requirement for an oscillator is positive feedback. The operation of the *RC Phase Shift Oscillator* can be explained as follows. The starting voltage is provided by *noise*, which is produced due to random motion of electrons in resistors used in the circuit. The noise voltage contains almost all the sinusoidal frequencies. This low amplitude noise voltage gets amplified and appears at the output terminals. The amplified noise drives the feedback network which is the phase shift network. Because of this the feedback voltage is maximum at a particular frequency, which in turn represents the frequency of oscillation. Furthermore, the phase shift required for positive feedback is correct at this frequency only. The voltage gain of the amplifier with positive feedback is given by

$$A_f = \frac{A}{1 - A\beta}$$



From the above equation we can see that if $A\beta = 1 \quad A_f = \infty$. The gain becomes infinity means that there is output without any input. i.e. the amplifier becomes an oscillator. This condition $A\beta = 1$ is known as the *Barkhausen criterion* of oscillation. Thus the output contains only a single sinusoidal frequency. In the beginning, as the oscillator is switched on, the loop gain $A\beta$ is greater than unity. The oscillations build up. Once a suitable level is reached the gain of the amplifier decreases, and the value of the loop gain decreases to unity. So the constant level oscillations are maintained. Satisfying the above conditions of oscillation the value of *R* and *C* for the phase shift network is selected such that each *RC* combination produces a phase shift of 60°. Thus the total phase shift produced by the three *RC* networks is 180°. Therefore at the specific frequency f_o the total

phase shift from the base of the transistor around the circuit and back to the base is 360° thereby satisfying *Barkhausen criterion*. We select $R_1=R_2=R_{3*}=R$ and $C_1=C_2=C_3=C$

The frequency of oscillation of RC Phase Shift Oscillator is given by

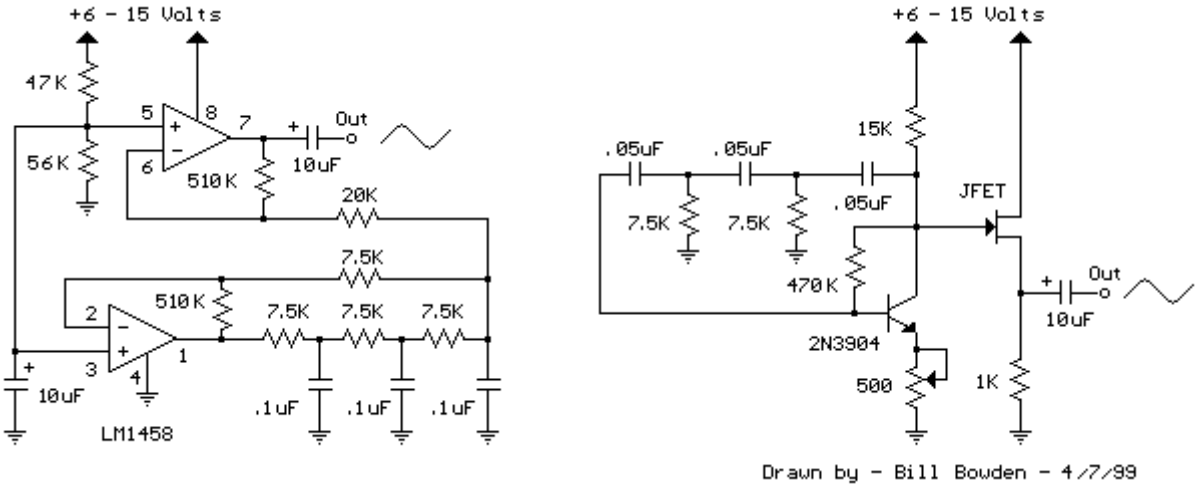
$$f_o = \frac{1}{2\pi\ RC\sqrt{6}}$$

At this frequency, the feedback factor of the network is $\beta = \frac{1}{29}$. In order that $|A\beta| < 1$ it is required that the amplifier gain $|A| > 29$ for oscillator operation.

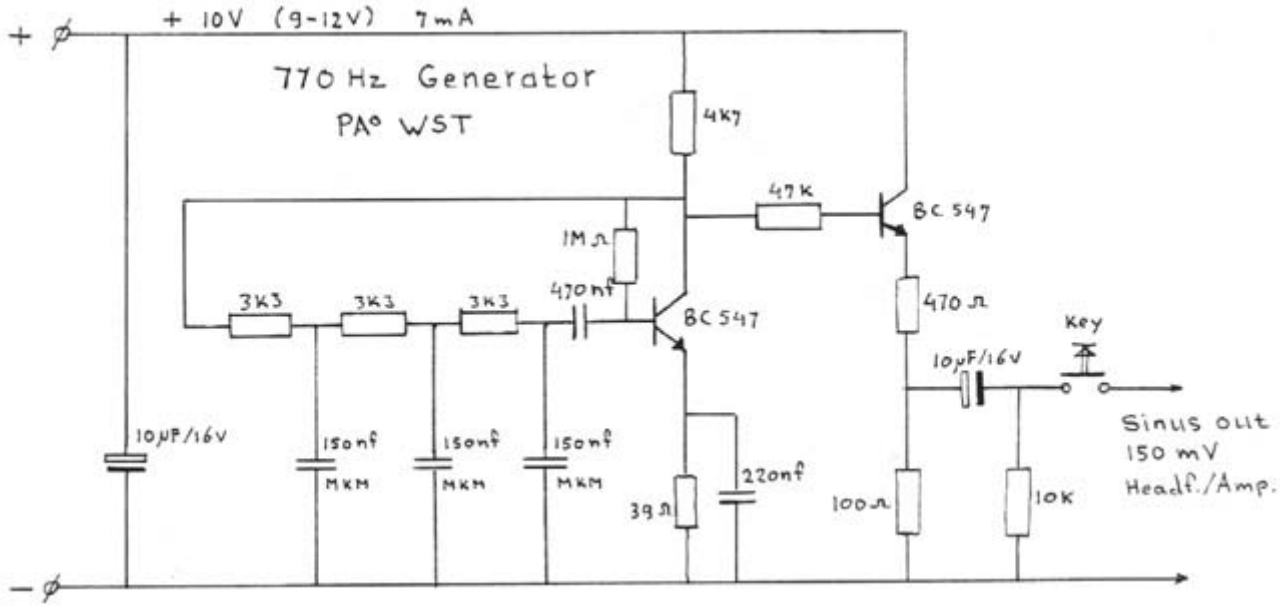
8. RC oscilator z operacijskim ojačevalnikom

The two circuits below illustrate generating low frequency sinewaves by shifting the phase of the signal through an RC network so that oscillation occurs where the total phase shift is 360 degrees. The transistor circuit on the right produces a reasonable sinewave at the collector of the 3904 which is buffered by the JFET to yield a low impedance output. The circuit gain is critical for low distortion and you may need to adjust the 500 ohm resistor to achieve a stable waveform with minimum distortion. The transistor circuit is not recommended for practical applications due to the critical adjustments needed.

The op-amp based phase shift oscillator is much more stable than the single transistor version since the gain can be set higher than needed to sustain oscillation and the output is taken from the RC network which filters out most of the harmonic distortion. The sinewave output from the RC network is buffered and the amplitude restored by the second (top) op-amp which has gain of around 28dB. Frequency is around 600 Hz for RC values shown (7.5K and 0.1uF) and can be reduced by proportionally increasing the network resistors (7.5K). The 7.5K value at pin 2 of the op-amp controls the oscillator circuit gain and is selected so that the output at pin 1 is slightly clipped at the positive and negative peaks. The sinewave output at pin 7 is about 5 volts p-p using a 12 volt supply and appears very clean on a scope since the RC network filters out most all distortion occurring at pin 1.



9. RC oscilator 770 Hz



10. RC oscilator 1 kHz

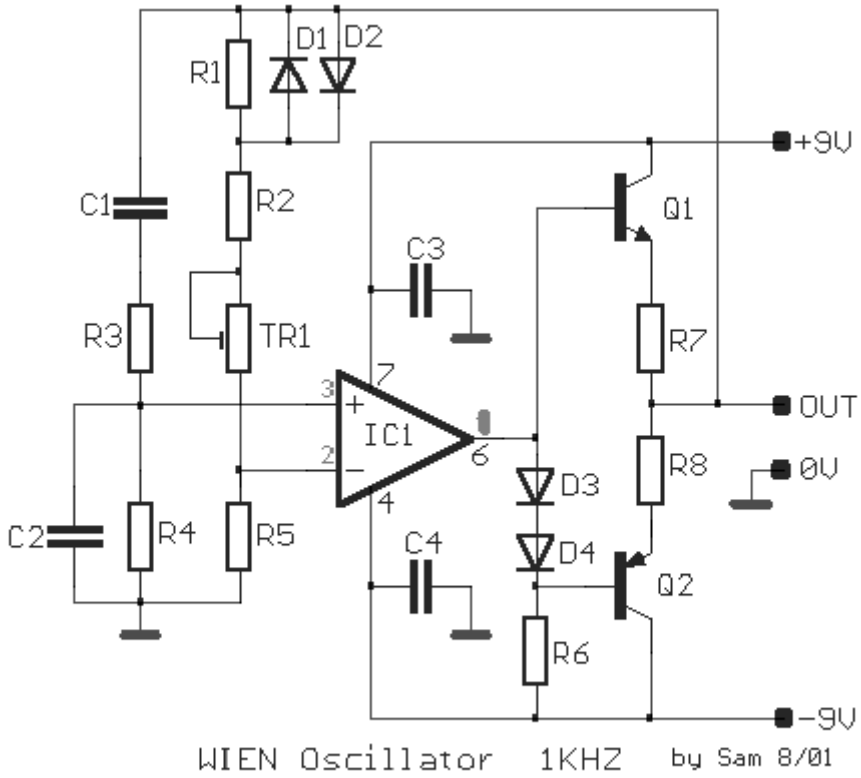
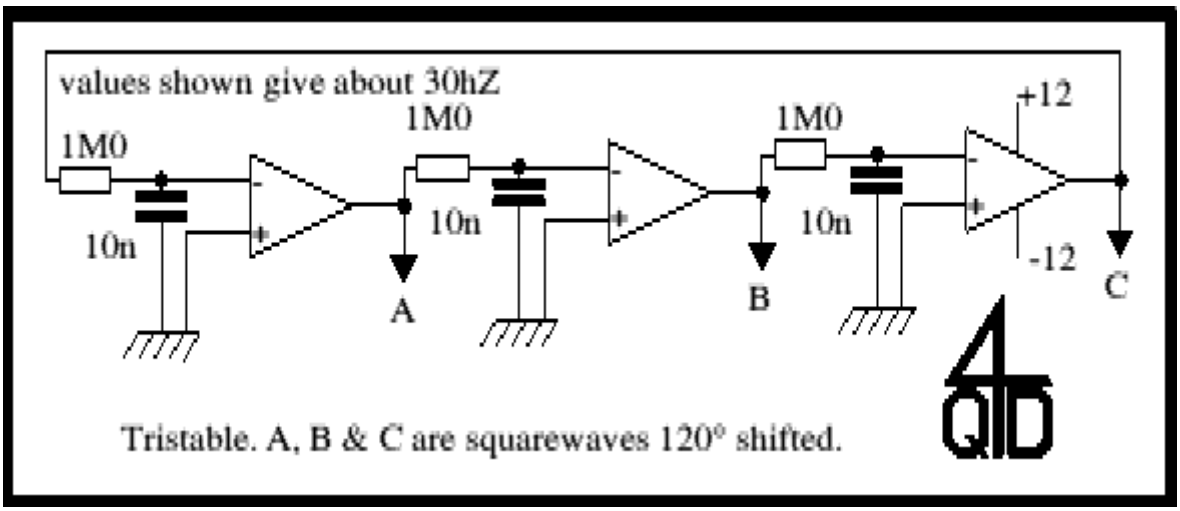


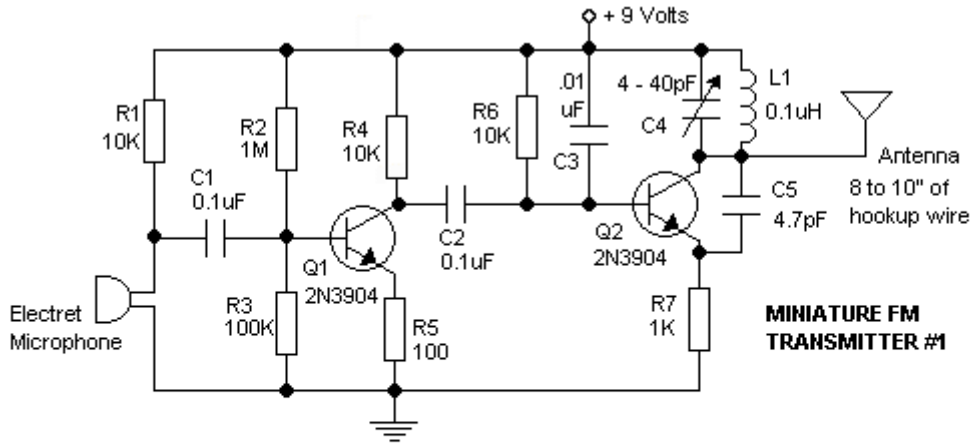
Fig. 2

Q1= BC550C
Q2= BC560C
R1= 1.5K
TR1= 10K
R2= 12K
R3-4-5= 10K
R6= 2.7K
R7-8= 10
C1-2= 10nF 100V polyester
C-3= 100nF 100V
D1-4= 1N4148
IC1= LM741 (NE5534, TL071)

11. Tristopenjski RC oscilator



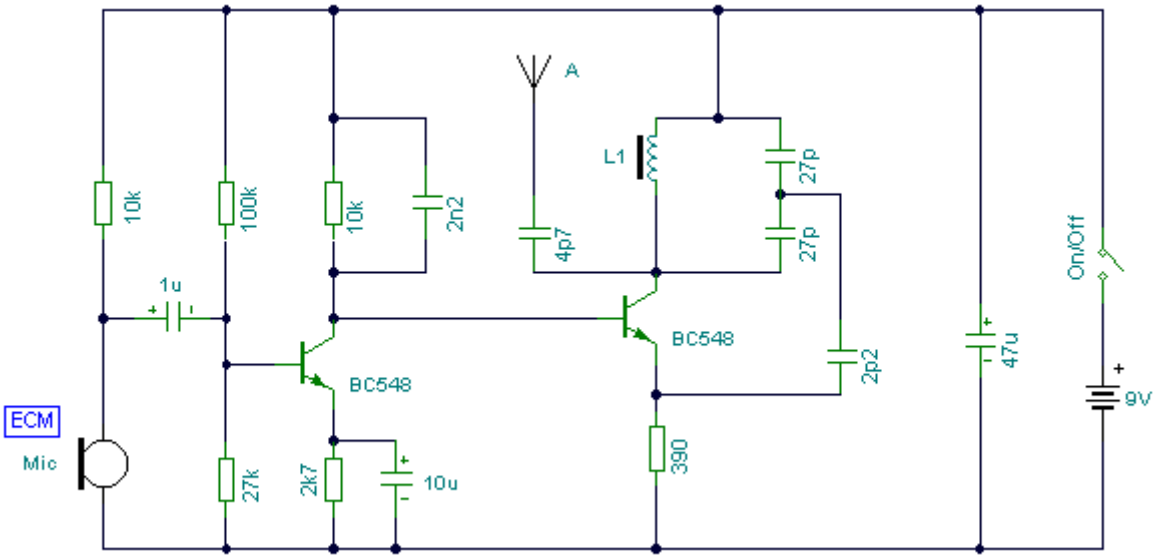
12. FM oddajnik 1



This miniature transmitter is easy to construct and it's transmissions can be picked up on any standard FM receiver. It has a range of up to 1/4 of a mile or more. It is great for room monitoring, baby listening, nature research, etc. L1 is 8 to 10 turns of 22 gauge hookup wire close wound around a non-conductive 1/4 inch diameter form, such as a pencil. C4 is a small, screw-adjustable, trimmer capacitor. Set your FM receiver for a clear, blank space in the lower end of the band. Then, with a non-conductive tool, adjust this capacitor for the clearest reception. A little experimenting and patience may be in order. Most of the parts values are not critical, so you can try adjusting them to see what happens.

13. FM oddajnik 2

Take care with transmitter circuits. It is illegal in most countries to operate radio transmitters without a license. Although only low power this circuit may be tuned to operate over the range 87-108MHz with a range of 20 or 30 metres.



Notes:
I have used a pair of BC548 transistors in this circuit. Although not strictly RF transistors, they still give good results. I have used an ECM Mic insert from Maplin Electronics, order code FS43W. It is a two terminal ECM, but ordinary dynamic mic inserts can also be used, simply omit the front 10k resistor. The coil L1 was again from Maplin, part no. UF68Y and consists of 7 turns on a quarter inch plastic former with a tuning slug. The tuning slug is adjusted to tune the transmitter. Actual range on my prototype tuned from 70MHz to around 120MHz. The aerial is a few inches of wire. Lengths of wire greater than 2 feet may damp oscillations and not allow the circuit to work. Although RF circuits are best constructed on a PCB, you can get away with veroboard, keep all leads short, and break tracks at appropriate points.

One final point, don't hold the circuit in your hand and try to speak. Body capacitance is equivalent to a 200pF capacitor shunted to earth, damping all oscillations. I have had some first hand experience of this problem.