DIY Kit 28. SOUND ACTIVATED FM TRANSMITTER

This Kit combines two Kits in one - a powerful two stage FM transmitter and a sound activated switch. These two parts of the circuit can clearly be seen from the schematic diagram. The sound activated switch is at the top of the circuit. The FM transmitter is underneath. A trimpot adjusts the level of sound which will turn on the Kit. When there is no sound the transmitter turns off after a short delay.

The kit is constructed on a single-sided printed circuit board (PCB). It has a silk screen overlay on top to aid construction. On the bottom there is a solder mask to help in soldering. Protel Autotrax and Schematic were used to design the board.

ASSEMBLY INSTRUCTIONS

We suggest you assemble & test the VOX section first. See description of how to do this below. Assembly is straight forward and components may be added to the PCB in any order. The electret microphone should be inserted with the pin connected to the metal case connected to the negative rail (that is, to the ground or zero voltage side of the circuit.) This is marked with a '-' sign at the MIC on the circuit board.

To save space all the resistors are inserted standing on their ends. Be careful to get the electrolytic capacitor, diodes and IC around the correct way.

- check that the tips of each coil have solder on them. If not scrape off the enamel and apply solder to make sure the coil will form a proper connection.
- A connection (or tap) is required from the top of the first turn of the L1 coil to the pad next to the coil. Solder a piece of wire to the top of the turn as shown on the overlay. Then solder the other end to the pad immediately next to the L1 coil. Spread out the turns of the coil so they do not touch each other.
- there is a single LINK to add on the board.

CIRCUIT DESCRIPTION

The microphone and first audio amplifier stage are common to both the transmitter (Tx) and the sound activated switch (VOX) stages. Let us look at the electret microphone in more detail. An electret is a permanently charged dielectric. It is made by heating a ceramic material, placing it in a magnetic field and then allowing it to cool while still in the magnetic field. It is the electrostatic equivalent of a permanent magnet. In the electret microphone a slice of this material is used as part of the dielectric of a capacitor in which the diaphram of the microphone forms one plate. Sound pressure moves one of its plates. The movement of the plate changes the capacitance. The electret capacitor is connected to an FET amplifier. These microphones are small, have excellent sensitivity, a wide frequency response and a very low cost.

The amplifier is a standard self-biasing common emitter amplifier. The amplified signal is taken directly to the Tx section. The signal goes to the VOX stage via a 100K potentiometer sensitivity control. Two 100n capacitors isolates the microphone from each of the following stages which allows only alternating current signals to pass.

VOX Section.

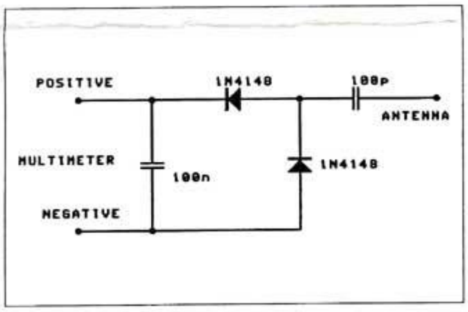
The input to the VOX has a second amplifier stage to amplify the signal so it is suitable for the use by the Schmidt triggers. The input to this digital section is biased mid-way between the supply voltage by the two 1M resistors. Before we look at the digital section let us review the operation of the 74C14, the Inverting Schmidt Trigger IC, from National Semiconductor. At the operating voltage (6V) there is about 2.4V hysterisis gap between 1.6V and 4V. This means that as the input voltage increases from zero to six volts the Schmidt circuit will not trigger until it gets to about 4V. But as the voltage falls from six volts to zero the circuit must fall to 1.6V before it changes state.

COMPONENTS

Resistors 1/4W, 5%:			
100R	brown black brown		1
390R	orange white brown		1
4K7	yellow violet red		1
10K	brown black orange		2
22K	red red orange		1
47K	yellow violet orange		1
150K	brown green yellow		1
470K	yellow violet yellow		1
1M	brown black green		4
2M2	red red green		1
100K KOA trimpot			1
Capacitors:			
100nF (104) monoblock			7
22uF elcap			1
10pF ceramic			1
100pF ceramic/mono			1
27pF ceramic			1
47pF ceramic			2
22nF (223)			4
1nF (102) ceramic			1
1N4148 diode			5
6 turn coil tined copper wire		L1	1
6 turn coil enamelled wire		L3	1
8 turn coil enamelled wire		L2	1
BC547 or 548			4
PN3563 or ZTX320			1
National Semiconductor 74C14/40106 IC			1
14 pin IC socket			1
Electret microphone, ECM-60B1P			1
Red trimcap 5 - 20pF			1
PCB mounted switch			1
Aerial wire about 160 cm			1
6V Battery snap			1
Documentation			

Assume that pin 1 of the IC is taken HIGH by sound input to the microphone. This means that pin 2 is LOW. The electrolytic capacitor will charge very quickly via the diode D3. The low on pin 2 will make pin 9 LOW which will make pin 8 HIGH. This will turn ON transistor T3 and supply power to the Tx section of the circuit.

When the sound input stops the circuit starts to time out with a time constant determined by R10 and C6. This is about 25 seconds. (The trigger point of 1.6V ie 73% of 6V which is just over one time constant of decay.) If the delay is too long then use a 10uF capacitor (RC = 10 seconds.) If you want a longer delay then use a 47uF capacitor (RC = 47 seconds.)



Peaking Circuit

The two Schmidt triggers in the feedback circuit ensure that the time out actively turns off T3 and brings pin 1 LOW.

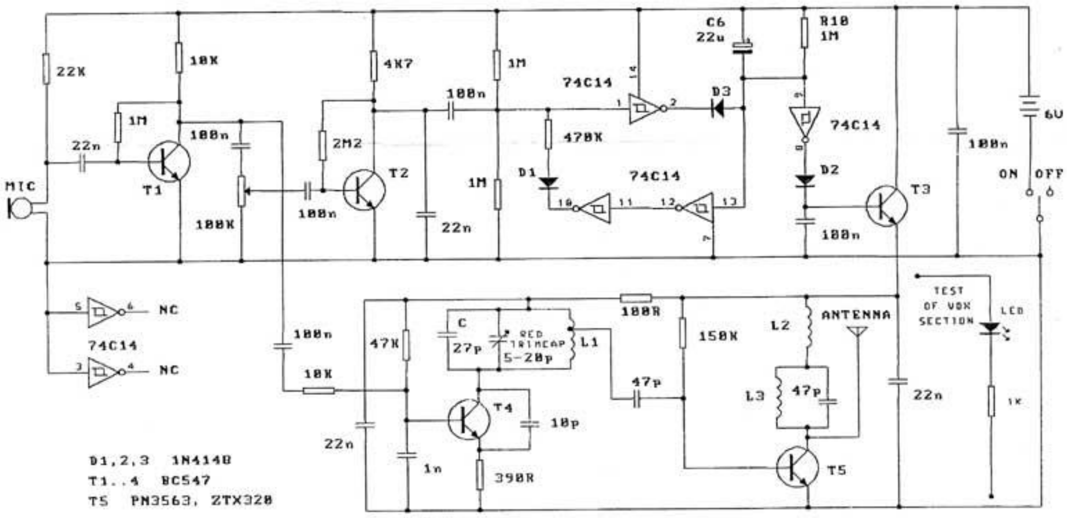
We have made this circuit very sensitive. It is usually the complaint about voice-activated devices that they are not sensitive enough. Well this one is sensitive. The sensitivity potentiometer really only starts to reduce sensitivity in the last quarter of its turning range. If you want to further decrease the sensitivity then you should reduce the gain of the second amplifier stage based on T2. (Decrease the 2M2 resistor.)

Note that in this circuit we are using cmos logic in its linear range. This means from the point of view of making a kit that we must stay with IC's made by the same company. The 74C14/40106 can be a trap if you change to IC's made by a different manufacturer. (We know!) A 74C14 IC from two different suppliers may perform its logic functions in exactly the same way yet have different linear region operating characteristics. We are using the National Semiconductor 74C14/40106 at this time. It has both part numbers printed on it.

Testing the VOX Section. Place an LED & current limiting resistor (about 1K) in the 22n position from the emitter of T3 to ground. (See schematic below.) The LED will turn on when the circuit is active and off when it turns off. This will tell you for sure that the transmitter section is receiving power under what conditions.

Transmitter Section.

The circuit is basically a radio frequency (RF) oscillator that operates around 100 MHz. Audio picked up and



Sound Activated FM Transmitter.

amplified by the electret microphone is fed into the audio amplifier stage built around the first transistor, T1. Output from the collector is fed into the base of the second transistor where it modulates the resonant frequency of the tank circuit (L1 coil and the red trimcap) by varying the junction capacitance of the transistor. Junction capacitance is a function of the potential difference applied to the base of the transistor T4. The tank circuit is connected in a Hartley oscillator circuit. The final stage built around the RF transistor T5 amplifies the output RF signal.

Let us look at the individual blocks of the circuit more closely:

Oscillator stage: every transmitter needs an oscillator to generate the RF carrier waves. The tank circuit, the transistor and the feedback capacitor are the oscillator circuit here. An input signal is not needed to sustain the oscillation. The feedback signal makes the base-emitter current of the transistor vary at the resonant frequency. This causes the emitter-collector current to vary at the same frequency. This signal fed to the aerial and radiated as radio waves.

The name 'tank' circuit comes from the ability of the LC circuit to store energy for oscillations. In a pure LC circuit (one with no resistance) energy cannot be lost. (In an AC network only the resistive elements will dissipate electrical energy. The purely reactive elements, the C and the L, just store energy to be returned to the system later.) Note that the tank circuit does not oscillate just by having a DC potential put across it. Positive feedback must be provided.

Trim Cap. The slots inside the trim cap are shaped like the head of an arrow. The maximum capacitance value is when the arrow is in pointed to the 12 o'clock position. A 180° turn brings the trimcap value to its minimum rated value. With experimentation you will be able to build up a table of total capacitance value (remember to add in the 27pF) to FM frequency. You can also change the frequency by altering the space between the coils of L1.

The 27pF ceramic capacitor in parallel with the red trim cap will enable you to tune the Tx in the 88 MHz to 100 MHz range of the commercial FM band. If you use a lower value (for example, 10pF) you will move the frequency up towards the other end of the FM band. This end generally has less commercial stations in it. You can experiment.

Final Amplification Stage: this RF stage adds amplification to the RF signal. It needs an RF transistor to do this efficiently. We use a ZTX320 or PN3563. L2 (an RFC - radio frequency choke) and the 10p capacitor in parallel with it are designed to reduce harmonics from the circuit.

Output power from this stage will be maximum when it is tuned to oscillate at the same frequency as the previous stage. This can be done with an RF power meter attached to the aerial pad as describrd below.

A small (10pF) coupling capacitor on the aerial is optional to minimise the effect of the aerial capacitance on the final stage LC circuit. (We have not used one in this circuit.)

Peaking Circuit. The theory is that when the frequency of the two oscillating circuits are the same there will be maximum power delivered to the antenna. We have supplied in this Kit a simple power meter which consists of just 2 diodes and 2 capacitors connected to a multimeter set on a low voltage (0 - 5V) range. No circuit board is supplied; just solder the components together and use them. The circuit is a simple RF detector using diodes to charge a capacitor. The potential difference reached is then read using the multimeter.

You should use the peaking circuit after you have got the Kit working and it is transmitting in the FM band successfully.

When the tuning circuit is attached to the multimeter and the Antenna point is soldered in place (remove the Antenna wire), take pin 9 of the IC to ground (LOW.) This will turn on the Tx all the time so you do not have to keep making a noise as you peak the Kit. The aim is to move the coils of L3 closer or farther apart so that the voltage reading is a maximum. Use a wooden or plastic stick to do this. When the voltage is a maximum then the circuit is tuned as well as it can be. (Actually there will be a small difference since the loading on the Antenna is not the same but these are small differences so far as we are concerned.)

WHAT TO DO IF IT DOES NOT WORK

Poor soldering is the most likely reason that the circuit does not work. Check all solder joints carefully under a good light. Next check that all components are in their correct position on the PCB. Did you add the connection from the coil L1 to the pad? Did you de-enamel the leads of the two coils L2 and L3? Did you add the link. Use a multimeter to check they resistance across the solder pads between the coils to check that a proper connection has been made.

Check that you have not accidently formed a solder connection between two pads which are next to each other. Did you turn the switch 'on'. Check that you did not interchange the 4K7, 47K & 470K resistors.

Web Address & Email

You can email us at **peter@kitsrus.com** if you have any problems or requests. See our Web page at:

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