

CK217 - FM TRANSMITTER

This is an improved kit 18. At first sight it looks similar to the original Kit 18 – especially the inductor etched onto the PCB – but it has been tinkered with by Harry Lythall in Sweden to give the best distance and stability for its size.

The battery supply rails have been well tied together with respect to radio frequencies (C1, C2 and C7.) The tracks are also thicker. This makes the circuit a single 'solid' block eliminating RF currents in different parts of the circuit. This also means the battery no longer has RF on it which makes the whole unit a lot more frequency stable.

C6 – new component. The trimmer capacitor is 2pF – 30pF and is much too high a capacitance range to cover just 98MHz +/- 10%.

C5 – 2p7. Reduced from the old 10pF. The old component had too much capacitance preventing the transmitter from operating above 100MHz.

C1 & C2 – new components for supply decoupling. To force the supply rails to become an RF ground/earth there should be more than one decoupling capacitor. Electrolytic caps have resonances in the VHF region. The physical position of the caps on the PCB is very important.

C3 - Changed from 4n7 to 10nf. The LF response "filled out" a little more and sounds better on the air. C2 is also probably operating to damp the HF response, but for general microphone use this is not a problem. It probably adds to the overall RF stability.

C4 - Changed from 4n7 to 3n3 - it allows the upper frequency response to become over 12KHz.

R4 - R3 - Biasing changes to the AF amplifier transistor. This now gives a more stable bias arrangement that is less dependant upon transistor characteristics. It is important that TR1 is stable - changes in bias affect the frequency range and modulation depth.

R2 - 100K - New component - This works together with R3 to form a voltage divider to prevent overmodulation. With 100K the complete project is sensitive to a normal conversation at 1/2 metre distance. Here are some suggested line level input levels and resistor values:

R2 = 47K - Conversational voices at 5m to 15m (3m minimum)
R2 = 100K - Conversational voices at 0.5m to 5m
R2 = 470K - Conversational voices at 0.2m to 0.5m
R2 = 2M2 - Line input level (computer LINE OUT, also remove R1. Open circuit.)
R2 = 100K - Conversational voices at 300mm using low-level dynamic mic (remove R1. Open Circuit.)
R2 = 470K - Magnetic guitar pickup (also remove R1.)

The frequency determining elements (L1, C5 and C6) form a simple LC tuned oscillator. The inherent problem with this type of circuit is that any external load (antenna) will change the operating frequency. This is normal. If the antenna load is heavy then the transmitter could be moved off frequency by 1MHz, or perhaps even more.

The tuned coil, L1, has two output tapings for the antenna connection, marked "A" and "B". These are both low-level outputs and you choose which tapping you want to use. Most other kits of this type have fixed output tapings. In this Kit you have a choice of stable low range, or more unstable but higher range.

Tap B (2.5%) takes just a very small portion of signal from the oscillator circuit and therefore gives a very frequency stable transmitter. The output level (around 2.5mW) and range are therefore somewhat reduced.

Tap A (10%) delivers very much more power (around 10mW) to the antenna load. This gives you a **greater range**, but at the expense of frequency stability. Touching the antenna wire will therefore have a noticeable effect on the transmitter frequency.

When assembling the project, take care to fit even the resistor orientation as shown on the component overlay. Although resistors are symmetrical and non-polarised, vertical mounting makes them become asymmetrical: one lead is longer than the other. This can alter VHF circuits by adding greater capacitance to other components. All component leads should be kept as short as possible. The LINK wire on the PCB should lay flat on the PCB. Use the cutoff from a resistor leg.

Antenna length. This varies with frequency for optimum distance. 90MHz 80 cm, 95MHz 75cm, 100MHz 70 cm, 105 MHz 68 cm.

Supply Voltage. This is limited by the voltage rating of the ceramic capacitors to 16VDC. If you use an external supply a regulated one is best.

Operation. When you connect the power to the assembled kit make sure to take the receiver at least 10 yards/meters away from the transmitter so as not to pick up harmonics. The frequency range of the fundamental should be about 89MHz – 109MHz. Output power is about **9mW** at 9V, antenna at tap **A**. Tapping the antenna at **A** has approximately triple the range of tapping at point **B**.

For a review of the theory behind two and three stage FM transmitter circuits download

<http://www.crowcroft.net/kitsrus/fmtx.zip>

For general FM transmitter information go to

<http://www.members.tripod.com/~transmitters/>

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COMPONENTS		
Resistors 5%, 1/4W.		
100R brown black brown	R7	1
1K brown black red	R5	1
22K red red orange	R3	1
100K brown black yellow	R2 R4	2
12K brown red orange	R1 R6	2
Ceramic capacitors		
2p7	C5	1
3n3 332	C4	1
10n 103	C3	1
22n 223	C2	1
22p	C6	1
Electrolytic capacitors		
10uF/25V	C1	1
100uF/16V	C7	1
Microphone JinIn ECM-60P B1		1
0-30pF tuning capacitor		1
BC338		1
BC548B		1
K18V2 PCB		1
Aerial wire		1
9V battery snap		1

More Discussion about Kit18V2

(Harry Lythall, the kit developer, talking into a tape recorder at the First Bungalow Hotel. Koh Samui, seated next to the pool. March 11, 2004.) The K18V2 has got much more lands of copper for the earth compared to the original K18. These are effectively inductors in parallel which makes a reduced inductance. The wider the tracks the less inductance which means they are all at the same signal potential. So that an earth at one side of the PCB is still an earth at the other side of the PCB. The true inductor is the copper spiral coil tuned circuit which has thin tracks. It is a good inductor. The old K18 had thick tracks and was not as good an inductor. Also the battery supply connections on the old k18 were very, very thin which means there were more inductors. Thus there were RF potentials everywhere and everytime you touched something it interfered with the RF potentials which changed something – usually frequency.

This type of Tx was developed in the 1950's. The feedback for K18V2 is through C5. C5, C6 and the tuning capacitor modify the frequency of L1. And that is what determines the frequency the transmitter operates at. But there is also a capacitor in the collector of the transistor and there is capacitance from the aerial connected to the inductor so that if anyone touches the antenna the capacitance is changed and the frequency is unstable. An extra transistor stage here would buffer the antenna from the tuned circuit to give more stability. However, this is not really necessary here.

The aerial tap at position B is just a few % of the total number of turns. The signal picked up is a small output signal. There is virtually no loading on the tuned circuit

so you can touch and hold the antenna with no perceptible effect. (A couple of kHz deviation in 50kHz wide channels is not noticed.)

But if you attach the antenna to tap A you will get a lot more power out, like 9 to 16 times more power out since it has 3-4 times the length of wire.) But handling the antenna will have 9 to 16 times more effect on the frequency instability.

The question arises what if we have a tap C at the bottom right of the coil. The answer is you will get a lot more instability as well as increasing the load on the oscillator. It will eventually stop oscillating. As you go up the coil you will get to a point where the losses are greater than the gain and it stops oscillating. We have not investigated this.

Note the capacitance of Q2 will vary with the supply voltage which will affect the frequency of the tuned circuit. Thus the circuit is frequency unstable which will vary with the supply voltage as well as touching the antenna.

Halfwave Unbalanced Antenna

Normally the output of the transmitter should be conveyed to an antenna using coaxial cable: braid to the ground and center to the RF output. Connect the other end of the 50 ohm or 75 ohm co-ax to an unbalanced antenna. To make an unbalanced antenna take a piece of wire which is half a wavelength long (150/MHz meters), cut it in the middle (giving 2 quarter wavelengths) and attach to the co-ax one to the braid and one to the RF then you will have an antenna with more gain than just the simple wire antenna used in K18V2. Another advantage is that this gets the antenna radiation away from the kit oscillator and power amplifier. If they are close you can get loop over and the transmitter could become unstable.

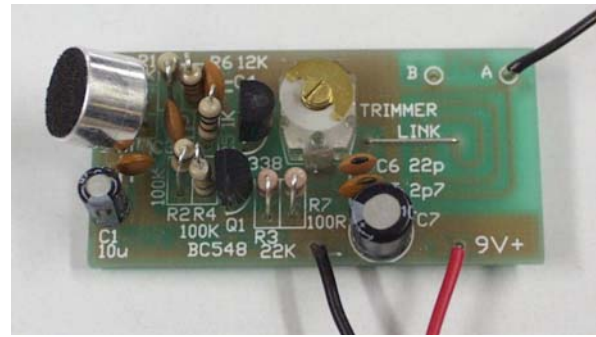
Choke Balun. Consider the operation of the antenna. A current going up one element of the antenna is equal to the current going in the opposite direction in the other half of the antenna. Thus there is current flowing in the braid of the co-ax cable and this RF current will flow back to the Kit along the braid. It could cause a standing wave, and it could destroy the radiation pattern of the antenna. The usual solution is to add a balun inductor, but an even simpler solution in our case is to just make 2 turns of the co-ax itself about 3cm in diameter and fix it with a plastic zip tie.

J Pole Antenna. This is another form of antenna. It is a $\frac{3}{4}$ wavelength pole with a $\frac{1}{4}$ wavelength antenna parallel to it a few mm apart at the side of it. It is easy to mount it on a thin strip of wood with a couple of nails. The center core of the co-ax goes to the $\frac{1}{4}$ wavelength antenna with the braid to the $\frac{3}{4}$ antenna. Connection is best about 20% up from the junction of the two antennas.

Folded Dipole & 3 Element Yagi Directional Antenna. The impedance of the halfwave antenna is

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about 75 ohm. Now suppose you connect each end with another piece of halfwave length wire. You now have a folded dipole antenna with an impedance of about 150-200 ohms. But if you then add a reflector wire on one side of the folded dipole and and some directors on the otherside you form a Yagi which is a directional antenna and the impedance comes back to 50 ohms again. The spacing between every element is 0.2 wavelengths. The reflector is 0.55 wavelengths long. Each director is about 0.45 wavelengths long. These are simple rule-of-thumb guidelines. The reflector and directors are parallel to the folded dipole but not electrically connected to it; they are just hanging in air fixed on a piece of wood. Again a balun should be made with the coax.



Antennas and Yagis is a huge topic. For one web site try

<http://www.ee.surrey.ac.uk/Personal/D.Jefferies/yagiuda.html>

Finally. So the kit is small and cheap but it has frequency stability problems. It is an excellent first kit for people to learn about FM transmitters.

