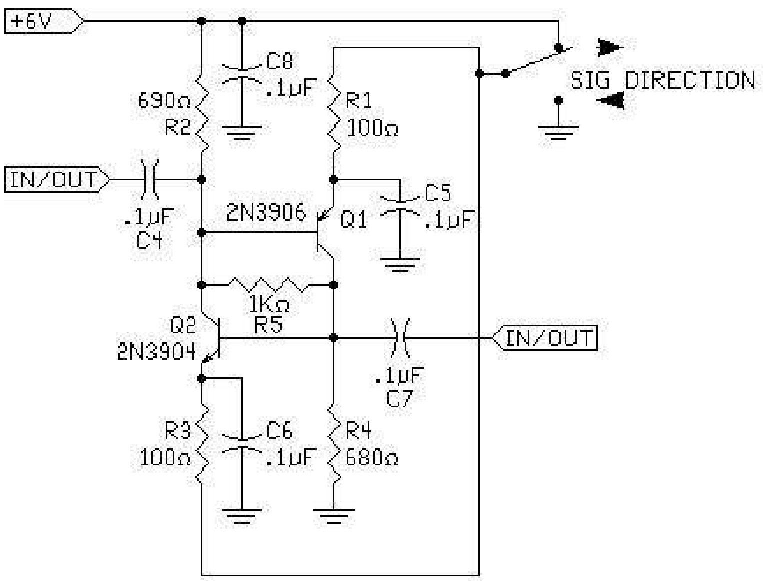
Exciter with Bi-directional amplifiers and analog switching mixers

This experimental 14 MHz SSB exciter uses bi-directional amplifiers and analog switching mixers. This results in a reasonably simple design, as the amplifiers and mixers can be used for both receiving and transmitting.

The Bi-Directional amplifier

The bi-directional amplifiers used were found in the "Experimental Methods in RF Design" by W7OZI, KK7B and W7PUA and published by the ARRL. These authors credit the original design of the amplifier to one similar to one used in some "manpack" radios made by Plessey. The circuit is interesting in that it uses a complementary PNP and NPN stage, with the direction of signal flow selected by a single SPDT switch. In one direction the PNP transistor is turned on and in the other signal direction, the NPN transistor is turned on. A relatively low supply voltage is used so that the base-emitter reverse breakdown voltage of the reverse biased transistor is not exceeded. This amplifier has good gain (about 17dB), uses a minimum of components and is easy to switch signal flow direction. Three of these amplifier stages were used in the final design of the exciter and result in good receiver sensitivity.

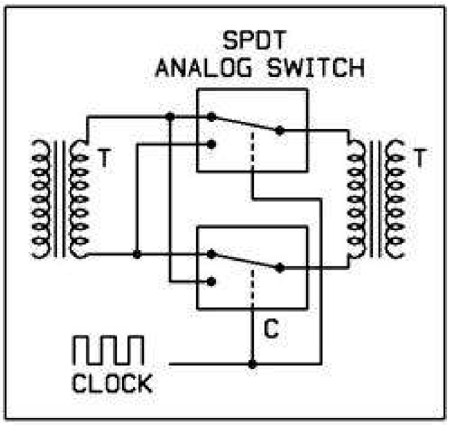


Bi-directional amplifier.

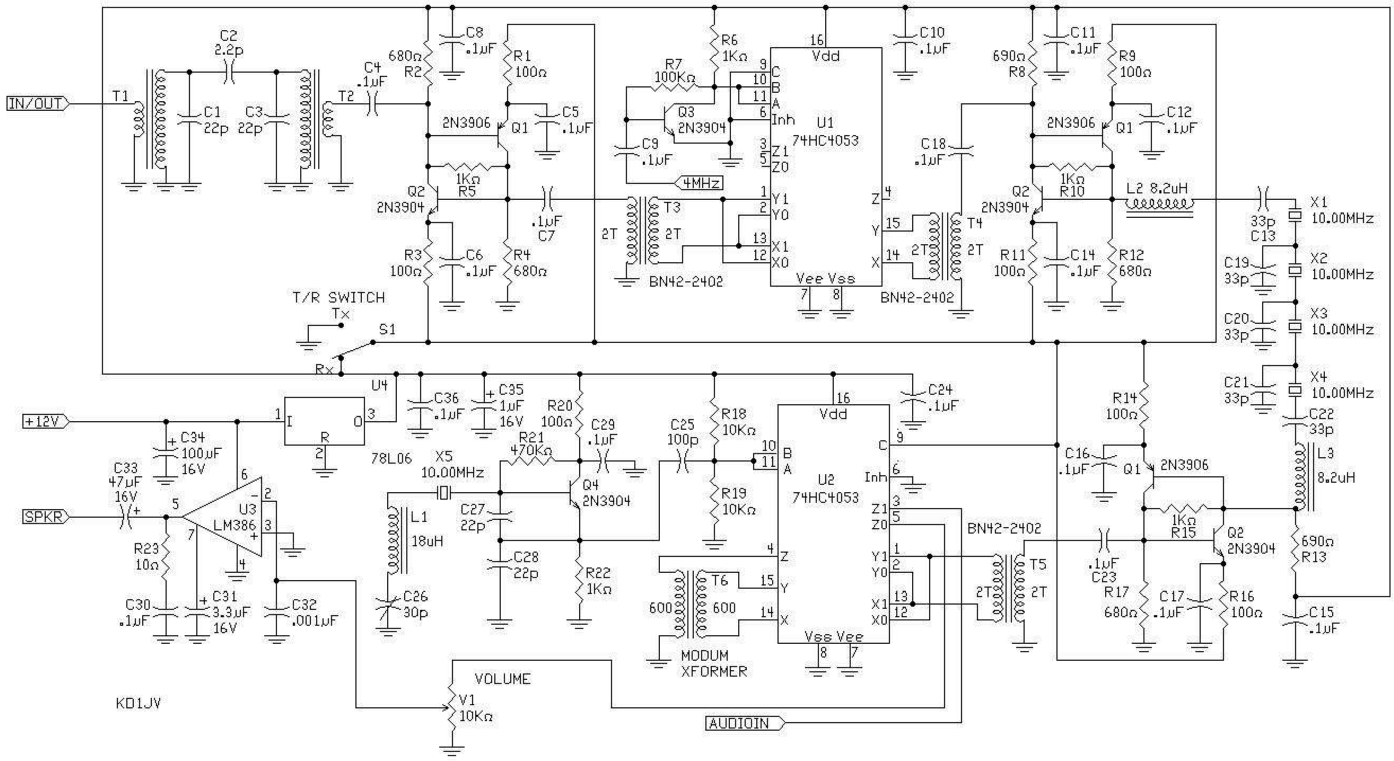
Bi-Directional analog switch mixer:

The mixers use a 74HC4053 analog switch. This chip contains three SPDT analog switches, of which two are used to form a doubly balanced mixer, simply by adding transformers to the input and output of the switches. This mixer works in a manor identical to that of a diode ring mixer. The advantage to using the analog switch mixer instead of a diode ring mixer is that the analog switch requires significantly less drive than the diode mixer and simpler transformers. The switches are wired so that the signal polarity on one of the transformers is reversed at the switching frequency of the clock. The basic switch configuration is shown below. Large dynamic range equal to the supply voltage used to power the switches can be achieved by biasing one of the transformers to 1/2 the supply voltage at a center tap. However, it has been found that bias is not required for the signal levels normally encountered by Amateurs, so they are not used in order to simplify the circuit. I have not seen the 74HC4053 used as a mixer in this configuration before I started to use it several years ago, so I will take credit for the idea.

Analog switch mixer configuration.



Complete SSB exciter circuit:



NOTES:

To print schematic, save the image to your PC, then use print set up to select landscape and fit to page before printing.

The band pass filter on the input/output is made with 10.7 MHz IF transformer cans. The internal cap is removed from the bottom of the can for use on 20 meters.

A local oscillator is not shown and can be any suitable variable oscillator. Minimum signal level should be about 100 mv p-p to the input of Q3, which squares up the sine wave input to drive the switch control gate of the analog switches.

T3, T4 and T4 are 1:1 wide band transformers. I used small ferrite binocular cores, since I have a bag of them and they take up little space. However, since they are 1:1 transformers, they could also be made with ferrite cores with bi-filer windings.

The crystal filter has some ripple in it's response. Some tweaking of the capacitor values and/or the termination impedance could improve this.

T6 is a 1:1 600 ohm audio transformer removed from a junk PC modem card. A small audio interstage transformer from a very old transistor radio could also be used and would provide some passive gain, depending on the turns ratio.

The output of T6 is feed through the third analog switch in U2. The transmit audio is feed into the terminal labeled "AUDIOIN". A 50 mv p-p audio signal results in a 50 mv p-p RF signal on the output of the band pass filter. A simple emitter follower to buffer an Electret mic element would probably be all that would be needed for modulation.

The LM386 really requires a 3.3 ufd "gain boost" capacitor connected between pins 1 and 8 of the IC. I forgot to draw this in. Although signals as low as 0.2 uVs can be heard, it really requires headphones to copy these signals. Audio level when driving an 8 ohm speaker is adequate, but not exceptionally loud, even with strong signals and the volume turned all the way up. The only time the volume needs to be reduced is when tuned to an exceptionally strong station.

T/R control is supplied by S1, a SPDT switch. Switching the input of the band pass filter to the antenna will likely be done with a reed relay for simplicity. A suitable power amplifier will have to be developed for transmitting.

The only adjustments required are the peaking of the band pass filter transformers and setting of the BFO trimmer. Carrier suppression relies heavily on the crystal filter, so the BFO has to be set so little carrier leaks through the filter.

Trying to come up with a single sided board layout for the bi-directional amplifiers turned into a mess. Though the circuit is simple, getting ground connections to the by-pass caps became a problem. It will really require a double sided board, with one side a ground plane to do the job correctly. However, the topology turned out to be very well suited for "dead bug" construction, so the proof of concept exciter circuit was built this way and shown below.