**Design Decisions in the Direct Conversion Receiver**

**Why did we do it this way?**

In thinking about how to design this receiver, we had to make early design decisions on almost every stage. Here are some of our key considerations.

**VARIABLE FREQUENCY OSCILLATOR:**

Normally we might have used a variable capacitor to change the frequency of this oscillator. But variable capacitors are now expensive and hard-to-source. Our friend Farhan in Hyderabad used a simple variable inductor for this purpose in his “Daylight Again” transceiver. The coil form for this part could be 3D printed. A metallic screw would vary the inductance as it is screwed in and out of the coil.

We also decided to use the same simple Colpitts oscillator circuit used by Farhan in his own high school direct conversion receiver. This circuit is unusual in that the feedback capacitors are also the frequency determining elements (along with the variable inductor). This simplified the circuit and reduced the parts count, and proved to be remarkably stable.

For the VFO buffer we used the simple JFET buffer from Farhan’s Daylight Again design.

Based on suggestions from other radio amateurs, we developed a simple frequency readout based on the position of the end of the tuning screw.

We selected the 40 Meter band for this receiver because we thought it would be easier to get the VFO stable on this frequency, and because Farhan had built his receiver for 40 meters.

**MIXER:**

At first we hoped to use a simple singly-balanced mixer using two diodes and a single trifilar transformer. But we found unacceptably high levels of AM breakthrough (mostly from Radio Marti on 7335 kHz) when using this circuit. So we switched to a diode ring. This required two more diodes and an additional trifilar transformer. We believed the students would have great difficulty building and installing two trifilar transformers so early in their building experience. So we used transformers that had been wound in Hyderabad by a women’s collective employed by Farhan in India, and developed a scheme for fool-proof installation of these transformers.

We also found that the mixer needed a diplexer at its output – this would provide a 50 ohm termination at all frequencies and would result in much cleaner action by the mixer and greatly reduced AM breakthrough from Radio Marti. We used the same circuit used by Roy Lewellen W7EL in his Optimized Transceiver circuit.

**BANDPASS FILTER:**

This was the simplest board in the project but it required the students to wind two coils on toroidal cores. A simple dual-tuned circuit design would be sufficient. We used component values from the QRP Labs website. We showed them how to wind the coils, and made a video about the technique. Students used a simple Vector Network Analyzer (Nano VNA) to tune the filter.

**AUDIO AMPLIFIER:**

We had to make several design decisions here. First, we rejected the idea of using an IC amplifier like the ubiquitous LM-386. We wanted this to be a completely analog and discrete component experience. Then we rejected the idea of using a push-pull output circuit. While this would have eliminated the need for an audio output transformer, it would have resulted in a more complicated circuit. In the end we opted for three simple RC-coupled common emitter amplifiers with an audio output transformer. There was no feedback in these circuits. We found there is a lot of gain (hFe) variation in the 2N3904 transistors that we used. Care needs to be exercised in making sure that transistors of moderate (but not too high) gain are used.

This AF amplifier chain probably presented a 1500 ohm impedance to the mixer (instead of the desired 50 ohms), but we think this problem may have largely been taken care of by the diplexer.

We found some very small (one square inch) speakers that could be easily used in this circuit.

**ANTENNA:**

While the students could use a wide variety of antennas, we recommended a simple ¼ wave antenna with a ¼ wave counterpoise. We thought that this antenna – of only 33 feet in length would provide good performance with low complexity, and would be well suited to the “upper floor bedrooms” from which many of the students would be listening. Also, this antenna would not require the use of coaxial cable or an impedance matching transformer. We made a video on how to build and use this antenna.

**POWER SUPPLY:**

We opted for the use of 9 volt batteries. This proved to be a safer and wiser choice that limited the kind of mayhem that could occur should a variable voltage supply be used.

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