

Rev. George Dobbs G3RJV's Carrying on the Practical Way

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Mixer Experiments

This month the Rev. George Dobbs G3RJV treats his regular readers to some interesting 'mixer experiments' – after the 'appropriate quotation' has been enjoyed first!

"Nice looking circuit construction does not always equate to good circuit performance" From Experimental Methods in RF Design by Haywood, Campbell and Larkin.

Welcome to *Carrying on the Practical Way (CoTPW)* and regular readers of this column, who have seen photographs of my prototype projects will know how this quotation pleases me! *Experimental Methods in RF Design* by **Wes Haywood W7ZOI**, **Rick Campbell KK7B** and **Bob Larkin W7PUA** is, without doubt, the best book on practical Amateur Radio published for many years. So I'm endorsed by the book at the top of the pile!

I was pleased to be able to return to the Dayton Hamvention, the world's largest Amateur Radio event, in May of this year. It's held in Dayton, Ohio, and also includes an event called "Four Days in May". This is a symposium and social gathering arranged for QRP enthusiasts organised by the **American QRP Amateur Radio Club International** (QRP ARCI).

Four Days In May

The QRP ARCI block-book a large hotel in Dayton for a one day symposium with international speakers, a QRP banquet and many other evening events. This is on the Thursday before the Hamvention on Friday, Saturday and Sunday – hence the "Four Days in May".

I arrived at the hotel on the Wednesday evening to find there was an unexpected parcel for me. I opened it to find a nicely built receiver with associated paperwork. The parcel proved to be from **Paul Daulton K5WMS** containing an example of his SESE80 3.5MHz (80m) receiver. Paul had been kind enough to send it to me as a gift. Please note that I didn't say he



This month George experiments with mixers and tries a 'basic' receiver set-up.

had "gifted me". (However did the word "gift" become a verb!).

The 3.5MHz receiver was nicely built on a printed circuit board (p.c.b.) and enclosed in a metal case. The design had first appeared in the QRP ARCI magazine *QRP Quarterly* in the winter edition of 2011. I recalled having read the article when it first appeared. Paul hoped that I may find the receiver suitable for inclusion in the G QRP Club journal *Sprat*. The *SESE80* title comes from *"Something Easy, Something for Everyone 80* metre receiver.

The p.c.b. was produced by **Fred Reimers** of **Far Circuits**. Fred produces a wide range of p.c.b.s for published American Amateur Radio projects. Those who have been to the Dayton Hamvention will remember the Far Circuits large tent at the edge of the flea market and the hundreds of p.c.b.s he has on offer. Fred even sells a board for the original version of the *Sudden* receiver.

For those who want a look at the SESE80, go to the website **www. farcircuits.net** and scroll down the opening page to "Receivers". Under the column "publication" find "QRP Quarterly Winter 2011". There's a "Click here" tab which brings up a *Word* document with the manual for building the receiver.

Unfortunately, I had no way of testing the receiver at the hotel. I had neither a 12V supply nor a loudspeaker. My companion on this trip to Dayton was **Colin Turner G3VTT** and when we flew back to Manchester, Colin stayed with me for a couple of days.

Colin is an avid c.w. (Morse) operator and 3.5MHz is one of his favourite bands – so we tested the SESE80 in the evening after we arrived back home. We used a modest antenna for 80m, a W3EDP antenna and a Z-Match tuner. Colin and I were very pleased by the performance of the receiver. It was very lively with plenty of stations. We heard many of Colin's friends on the band. It will certainly find a place in *Sprat* and I may ask if I can use it in *PW*.

The Receiver Mixer Circuit

I was interested in the mixer circuit used in the SESE80. It's a superhet receiver so two mixers are required; from radio frequency (r.f.) input to the intermediate frequency (i.f.) filter and from i.f. filter to an audio frequency amplifier (a.f.) amplifier. Both of these mixers are singly balanced using bipolar transistors.

In recent years the NE602 (and NE612) doubly balanced, Gilbert cell, mixers have become the mainstay of simple QRP receiver design. They are small integrated circuit (i.c.) 4-pin dual-in-line (DIL) devices that not only contain a mixer but also have internal components for a variable frequency oscillator (v.f.o.).

Two of the most important parts of a receiver in one small package have made them very attractive to the constructor. So it was refreshing to see a discreet component circuit using inexpensive parts.

The diagram, **Fig. 1(a)**, shows a basic differential amplifier mixer formed using three transistors – there are two input ports and 1 output port. The diagram, Fig. 1(b) adds a few components to show the basis of a direct conversion receiver mixer.

In the case of a direct conversion (DC) receiver, the input signals are 'r.f. in. from the input signals and 'local oscillator (l.o.) in' from a local oscillator. The output signal 'a.f. out' is



Fig. 1(a): The diagram shows a basic differential amplifier mixer – there are two alternative signal input and output ports, though only one local oscillator input.



Fig. 1(b): adds a few components to show the basis of a direct conversion receiver mixer.



5mt

The 3.5MHz band-pas filter built using a modified 'Island' technique.



*68p

0.25

4× Ex

8mhz

Su

338

822

The singly balanced mixer, built up using the stick-down 'Island' technique.

The variable crystal oscillator, using a ceramic resonator – the blue component, low centre left, that's soldered to the two islands.

Fig. 2: The full circuit of the singly balanced mixer, as used in the SESE80.





Fig. 3: A simple layout for a direct conversion receiver using the mixer described above.



Fig. 4: To save the trouble of finding last month's magazine, here's a copy of last month's VXO circuit that uses a resonator rather than a crystal, giving a wider frequency swing.



Fig. 5: A simple 3.5MHz bandpass filter based upon the band-pass filter data supplied by *PW* author Stefan Niewiadomski in his book *The Filter Handbook*. And inset the pin-view layout of the Toko or Spectrum 10K coils.

the audio product from mixing the two input signals. This is the heart of a DC receiver.

To put it simply – the required Amateur Radio signals, after some filtering are fed into T1. The local oscillator gives a signal at the required receiver frequency which it fed into T3. The mixed signals have audio products above and below the local oscillator frequency. These are extracted from T2 and fed to an audio amplifier. The required amateur band signals have been directly converted from r.f. to a.f.

The full circuit of the singly balanced mixer used in the SESE80 is shown in **Fig. 2**. In this configuration, the mixer is said to have a single ended input and output. A balanced input and output arrangement would produce better isolation between the input and output but Fig. 2 is capable of good results.

The lack of balanced ports also gives some signal loss in the mixer over a balanced arrangement. But bear in mind that we are using a relatively simple circuit with a few inexpensive parts. The transistors are all 2N3904, or similar devices.

I built the mixer circuit using the 'Manhattan' style of construction; insulated pads on a 45 x 60mm piece of p.c.b. material. This roughly followed the layout of the circuit diagram. I described the Manhattan construction technique, and some other methods, in this column for May of this year. Notice, from the photograph, that some of the resistors in the prototype are mounted vertically to save space.

What I didn't mention in that earlier article was my practice of using quite a large soldering iron bit for Manhattan construction. I use a Weller TCP (temperature controlled) soldering iron with quite large chisel bit (PT-DD7). This may appear huge to some constructors – but it does make good solder joints and does not harm the components in this type of circuit.

Weller soldering irons are expensive but I have not used anything else for many years. The finished mixer board is certainly not beautiful – but remember the quotation at the beginning this month!

Having built the mixer, **Fig. 3** shows how it can be incorporated in a direct conversion receiver. This is the barebones of such a receiver. A local oscillator (l.o.) is required at the desired reception frequencies.

Regular readers will recall that last month (September) I did some experiments with ceramic resonators in oscillator circuits. The final circuit was a voltage controlled ceramic resonator variable crystal oscillator (VXO) using a 3.58MHz resonator instead of a quartz crystal. For those who do not have a copy of last month's VXO circuit to hand, it's repeated here in **Fig. 4**.

Colpitts Oscillator

The VXO is a Colpitts oscillator using a 2N3904 transistor with the 3.58MHz resonator controlling the frequency. A varicap diode (D2) in conjunction with an inductor (L1) allows variation of the oscillator frequency.

The inductor L1 is homemade by threading 10 turns of small gauge enamelled copper wire (about 32s.w.g.) through a ferrite bead. A suitable ferrite bead is the FB73-10, although any similar ferrite bead would serve the purpose provided the hole is large enough to take 10 turns of wire.

For the diode D2 I used the MV209 varicap diode with a voltage swing controlled by the $100k\Omega$ linear potentiometer. The MV209 has a capacitance of some 5pF at 12V and 40pF at 1V; there are many similar varicap diodes. This arrangement enabled the oscillator to tune across the c.w. (Morse) section of the 3.5MHz band.

We now have the mixer and local oscillator as required in Fig. 3. However, the receiver requires some input tuning between the antenna input and the mixer.

In this very simple receiver input tuning will provide the only selectivity to select the desired stations and reject adjacent signals. This could be a single tuned circuit but that wouldn't be very effective. A better method is to use a band-pass filter for better selection of the wanted signals.

A circuit favoured by many receiver constructors is two parallel tuned circuits at the desired frequency loosely top coupled by a low value capacitor. This is shown in **Fig. 5**. The circuit is based upon the band-pass filter data supplied by *PW* author **Stefan Niewiadomski** in his book *The Filter Handbook*; now sadly out of print.

Stef used the Toko range of 10K, slug adjustable, coils. These coils are no longer available but the most useful ones to Amateur constructors have been replaced by the **Spectrum Communications** 10K range of coils. The Spectrum range of coils is supplied by yet another *PW* author, **Tony Nailer G4CFY** who writes the *Doing It By Design* column. The coils are also available through the G QRP Club.

In the band-pass filter design shown in Fig. 5, the inductors for the tuned circuits are Spectrum 45u0L coils. Notice that the values of capacitor are not the same for each tuned circuit.

The values shown were empirically derived when experimenting with the 3.5MHz version of the G QRP Club kit for the *Sudden* receiver. Note that the antenna input goes to the link winding of the 45u0L coil. This is to match the typical 50Ω antenna input. The side of the coil with two pins is the link winding and the side with three pins is the tuned winding. On the antenna input coil the two outer pins are used with no connection to the inner pin.

The side of the band-pass filter that feeds the output to the mixer is a little more complex. The centre pin on the tuned winding does not go to the centre of the winding. On the 45u0L coil there is a total of 56 turns of wire divided into 42 turns and 14 turns as shown in the drawing of the coil connections.

All 56 turns are used for the tuned circuit with the 47pF capacitor but for the output to the mixer, the 42 turn tapping is used. The appropriate connections are shown in the drawing. This should give a good match into the mixer circuit. Note that the drawing is shown from the underside of the coil (looking at the pins).

Using the 10K style of coils in Manhattan construction isn't difficult if the constructor has some 4-pin DIL



carriers for 8-pin i.c. chips. I have described how to make these in the past and commercial chip carriers are also available. Solder the four outer pins of the coil to the outer pads of the carrier.

The middle pin of the tuned winding should rest between the middle two pads of the DIL carrier. I found it was possible to solder this pin to both middle pads using a big blob of solder. Failing that, a very short wire line can connect the pin to both pads. This method of mounting the coil is shown **Fig. 6** and the photograph.

Almost There!

We're almost there! We now have the mixer, bandpass filter and VXO sections built. All that remains is to add an audio amplifier. I have several available audio

amplifiers built for past projects so rather than build yet another one; I used one of the ready-made amplifiers. It's based on the common LM386 chip.

My prototype receiver resembled a rat's nest with individual boards connected together on the bench. How did it work? Well the mixer certainly mixes but I confess to being a little disappointed in the gain of the receiver. The 80 metre signals could be peaked using the cores of the coils and the VXO had adequate stability.

The inevitable *PW* deadline precluded much more tweaking of the circuit but I offer the ideas to the reader, perhaps for further development. Let me know how you get on with your own version of the project. Keep those soldering iron busy!

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