

Magnetically-coupled Fast Stabiliser

Written by Hans Summers

Friday, 04 September 2009 20:41 - Last Updated Monday, 22 December 2014 07:06

When a toroid is placed in a magnetic field, its permeability decreases, causing a decrease in inductance. A varying magnetic field can be generated by applying a varying voltage to a relay coil. In this way a correction can be applied to the VFO by the stabiliser circuit, with the relay coil and magnetic field replacing the conventional varicap diode which you see in all the usual Huff & Puff circuits.

I used a 12V open-frame [Relay Frequency Counter](#) project.

{gallery}fast/5{/gallery}

The results (click above right) show a nice linear variation of frequency shift with applied coil voltage. According to my understanding of the theory, increased magnetic field reduces the permeability of the toroid, decreasing the inductance and hence increasing the VFO frequency. However, in my case I found the opposite to be true! I do not know why this is, if anyone knows please tell me.

27-Aug-08: Cor Eiff PE1GTV (Analog RF engineer) wrote to me with his theory for why the permeability of the toroid appears to be opposite to the expectation:

I think I have an answer why the tuning direction of the permeability steered toroidal core seems to go the wrong way ie frequency down instead of up.

The initial permeability of most ferrites is lowish, so the range in which the VCO oscillates [small amplitude] does use only the part of the curve around zero. As you force an external magnetic field on the core the permeability goes up, so the inductance goes up and the frequency of the VCO down.

Only with a very strong magnetic field [for most ferrites around 300mT] saturation sets in and inductance goes down forcing the frequency up.

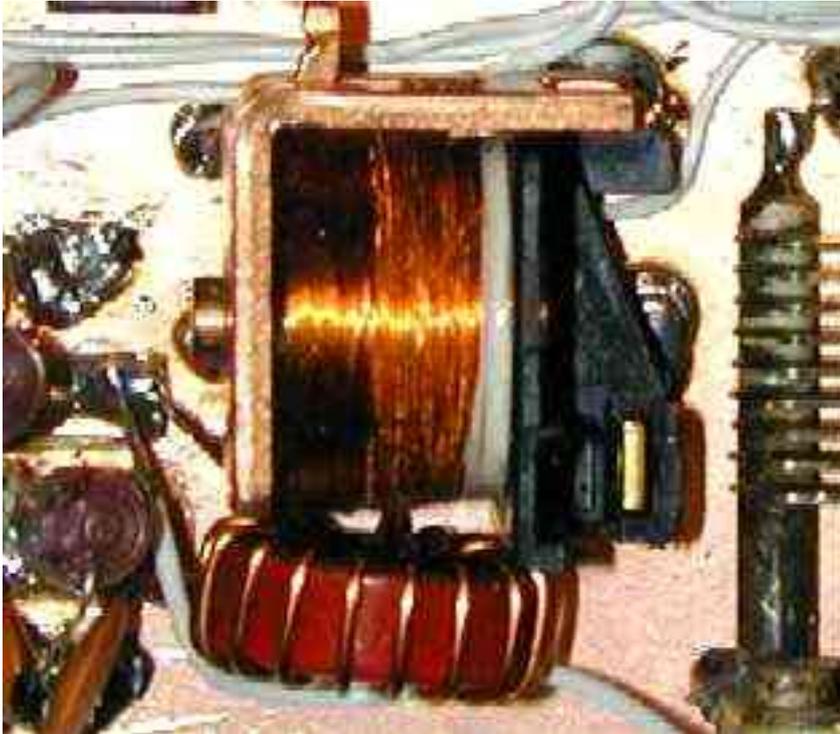
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Also using the core in an oscillator with an higher amplitude will skip over the lower starting permeability, but using too much power is not so good for stability for which all was started..

Relay Coil amplifier and Driver

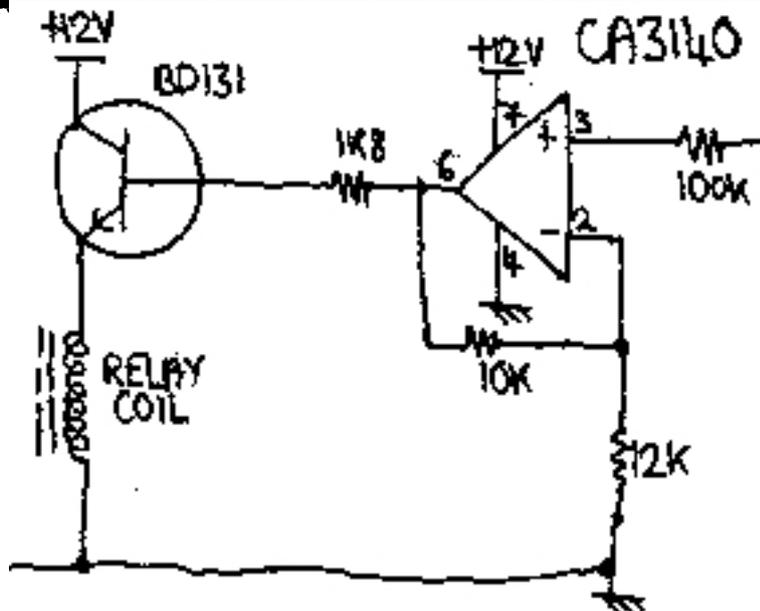
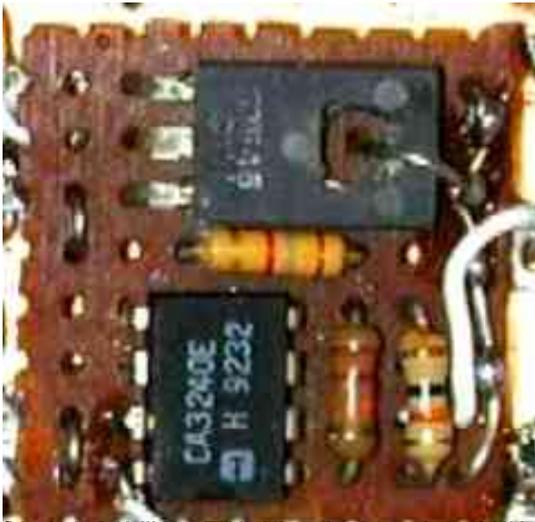


David White simply used a CA3140 to drive his relay coils, but they can only source 10mA. I found that my coil has a resistance of only 100 ohms so needs more current than this. Therefore I purchased a power op-amp type L2726. When it arrived I realised it was a surface mount device arrggh. I managed to fix it to a piece of PCB material, and it worked Ok. However, I decided I wanted to get maximum frequency shift, so drive the relay coil at more than the 0-5V of the Huff & Puff integrator. It is a 12V coil, after all. So I configured the driver op-amp as a x2 amplifier.

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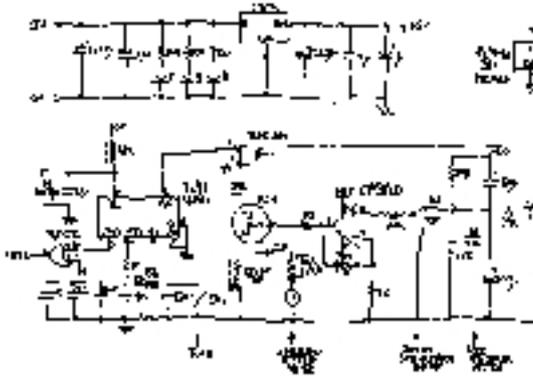
{gallery}fast/2{/gallery}
Circuit diagram

The full circuit diagram of my VFO and magnetically coupled Huff & Puff stabiliser can be viewed by [clicking here \(1096 x 608, 57K\)](#). I included a +5V regulator on the board, with plenty of large electrolytic capacitors. The supply to the CMOS oscillator chip is additionally smoothed with a choke and capacitor. The output of the oscillator is buffered by an unused XOR gate to try to minimise any nasty effects arriving from the direction of the frequency counter.

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Unstabilised VFO drift experiment

To test how much the 7 MHz VFO would drift when (838 to 603 to 076) opened the stabilisation loop and

A small Huff & Puff theory experiment

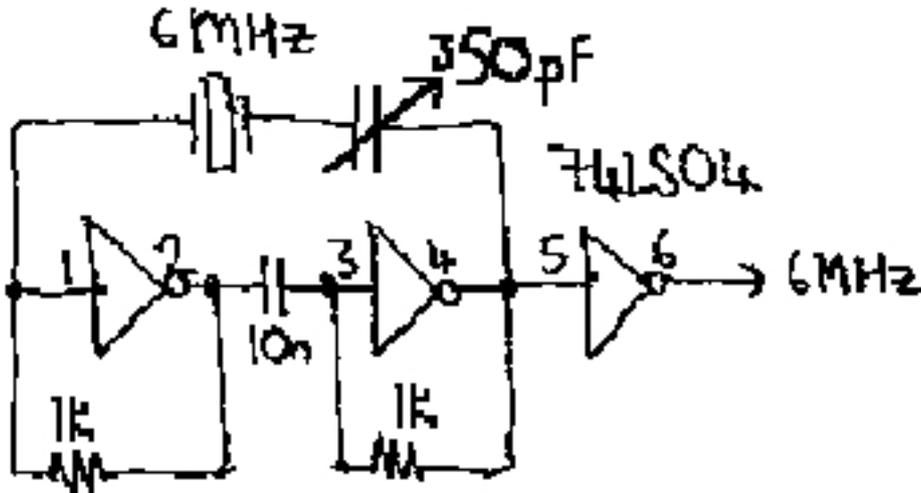
To test the Huff & Puff theory, I decided to see how the integrator output varies with the incoming frequency, without closing the stabilisation loop. Ok, that's not strictly true, in reality nothing was working and I didn't know why so I needed to find a way to debug it. It's very hard to test if the stabiliser is working properly when you have a VFO which is moving around all over the place. If the stabiliser is working the VFO stays dead on frequency, but otherwise there's little indication of what's wrong. This was when I was using the 5 MHz crystal as the reference oscillator.

I built a VXO (variable crystal oscillator) using a 6 MHz crystal and 74LS04, all from the junk box of course. The 5 Mhz crystal oscillator that I used before I got the 64 MHz canned one (see above) also used this same type of circuit, but without the 350pF tuning capacitor in series with the crystal to pull the frequency. This circuit is shown in the diagram below left. In this way I found I could vary the frequency from 5,997,386 Hz to 6,000,293 Hz, yet it was very stable so it was possible to find out what was happening in the stabiliser circuit. Or, what wasn't happening. Of course, the measurements below were taken when everything which should happen was happening.

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Stabiliser Photographs

[fast/p1{/gallery}](#) **Top View of the Huff & Puff Stabiliser board**

The VFO is at the bottom left. Top left is the 64 MHz canned crystal oscillator. Along the top is the power

[fast/p2{/gallery}](#) **Another view from above**

In this view the crystal oscillator can't be obscured by the flash reflection. I never claimed to be any kind

[fast/p3{/gallery}](#) **Stabiliser with Frequency counter**

Here you can see the stabiliser with my frequency counter. The counter is resting on top of a breadboard

[fast/p4{/gallery}](#) **From the front**

Here's a nice photo showing the integrator voltage meter, with my hand drawn calibrated dial for 0 to +5

[fast/p5{/gallery}](#) **A darkened view showing the meter illumination**

With a little less lighting and by switching off the flash on the camera, I was able to obtain this photo whi

[fast/p6{/gallery}](#) **Stabiliser at Night!**

Here's my attempt with no light at all. So, it's not great but it's better than those "London at Night" postca

[fast/p7{/gallery}](#) **At work on the Stabiliser**

A view of the workbench. Various chips and non-used components and my multimeter litter the area. No

[fast/p8{/gallery}](#) **At work on the next receiver module**

Here you see a view of the [Fibre method of linking the Huff & Puff stabiliser project](#), which my staple base network. Thi

[fast/p9{/gallery}](#) **The polyphase network**

A sneak preview of the 90-degree audio polyphase network mentioned above. The network has 8 stages