An all band huff & puff oscillator.

(Before you start to read these +59 pages… In 2023 I built a stabilizer based on PA2OHH's SUSI frequency counter. This circuit has a LED binary readout which I used to create a frequency locked loop. All my stuff uses now this stabilizer. This circuit is superior, easier to build and has less components than a Huff and Puff circuit in my opinion. I actually scrapped my 'all band H&P' in 2024. Now I would only consider a H&P for a one band rig. https://www.qsl.net/on1mws/frequentie%20koppelus.pdf)

Part 1, trying to understand a H&P circuit.

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My planned all-band homebrew SSB transceiver needed a stable oscillator over many frequencies. I have made free-running oscillators in the past and have learned some tricks to calm them down. However, all of my previous circuits were no way near stable enough for a transmitter.

Maybe I should try to build a **really** stable free-running oscillator? My friend Frank W Harris has described in his online book, "From crystal set to sideband", how to construct an oscillator that only drifts 5Hz/min, wow! Regrettably, it seems to be a painstaking amount of effort and is as far as I can tell only practical with a low-frequency oscillator with a limited range, so many crystal controlled frequency converters are necessary for a wide range receiver/transceiver.

Already I had constructed two homebrew PLL oscillators and rationally you would expect I would build a third version. It does the job and I have the experience? Hmm, it's a lot of work and building three times the same thing in a row is plain boring….

DDS chips don't appeal to me, because they are black boxes to me and there is no homebrew fun in that. Arguably, the PLL chip's (MC145151-2) I used in my two 'homebrew PLLs' contain 7000 FET transistors each and are therefore also black boxes.

1) A mysterious circuit.

The final option is a huff and puff stabilizer for a free-running oscillator. What's a huff and puff? The oscillator construction is less critical, it is allowed to drift. The huff and puff behave like a human, regular it checks the frequency and keeps it close to one of many close by lock-points. As a bonus, It can be built with very cheap standard components. 1970s ICs in fact.

So far, so good, but then the misfortune starts. There is very little to be found on the net. Inherently inferior to an PLL or DDS a H&P hasn't been build or used much I guess. Most of what you find is just the stabilizer (**not** complete H&P stabilizer/oscillator circuits) without pictures of working prototypes or specifications or construction tips. I suspect that verry few people have ever build an working H&P. Most articles avoid any explanation of how the circuit actually work and remain verry vague. Sometimes there is an explanation. What do you think about this one?

'Since the function is averaged over complete cycles, the discriminator is insensitive to phase. The Huff & Puff stabilizer is a frequency-locked-loop (FLL). It evaluates the auto-correlation function of the reference square-wave by a Monte-Carlo statistical method, which relies for its accuracy on the VCO-clocked samples falling evenly throughout the reference cycle:

$$\int_0^{2\pi} f(\theta)\, f(\theta+\tau)\, d\theta = k\tau$$

,

Whit this kind of talk we have reached a station where lots of us, including me, must leave the train.

I tried to build this circuit in 2008 and again in 2010 and failed, to my embarrassment, on both occasions. Especially in 2010 I was very disappointed because I had planned to really take my time. I had set up a real R&D lab and the end result was an unmitigated failure. My homebrew oscillator drifted more with the stabilizer connected than without. So it's not only difficult to find any information, it is also not straightforward to build.

2) The fog clears.

Giving this circuit a third go seemed mindless. Until I saw a design that looked different and was called a 'fast' H&P in 2014. It took me a couple of days to realize that the circuit was called 'fast'. I did find a small but complete reference library on the website of Hans Summers G0UPL but it remained difficult to make sense of all the short articles. Luckily I'm curious and like to read because it took lots of time/effort to realize that there seemed to be basically three different variations in H&P designs.

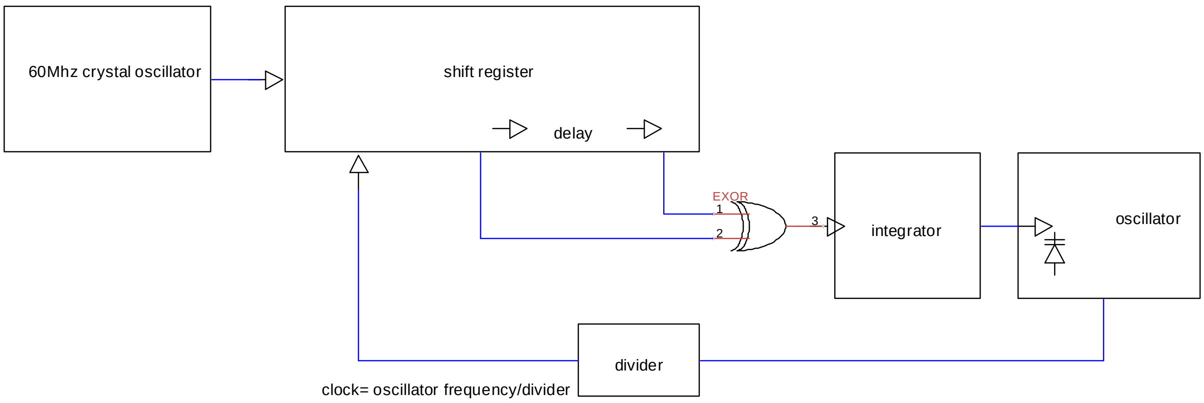
The 'basic' huff and puff stabilizer was invented by Klaas Spaargaren PA0KSB in 1973. It was a frequency locked loop stabilizer. It seems it's this circuit I've tried to copy in 2008 and 2010, aha…. Now I realized that this circuit had no chance against my drifting home brew junk, it can only tame an already pretty stable oscillator. Being rude about this basic stabilizer, Klaas Spaargaren thought up a completely original, useful, circuit that can be built by very cheap standard components. That's so much more than most of us will ever do.

In 1996 Klaas published 'the improved huff and puff stabilizer' capable of comforting more wild oscillators.

Finely in 1998, Peter Lawton G7IXH came up with the even better 'fast huff and puff stabilizer'.

Later on, this ‘fast’ circuit was much simplified by Hans Summers G0UPL.

Maybe this ‘fast’ design can tame one of my homebrew oscillators? But still after all the research, I had no idea how these circuits worked?



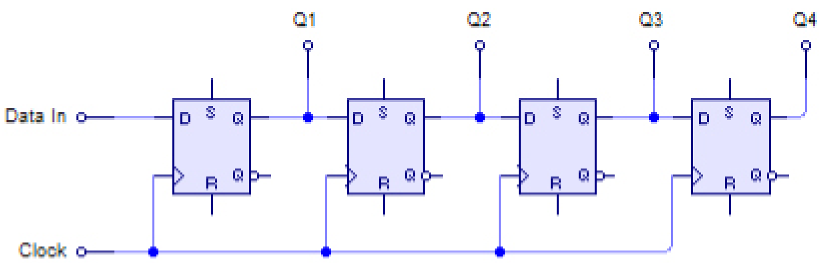
block scematic huff and puff stabelizer

Above the block schematic of a ‘fast’ H&P.,

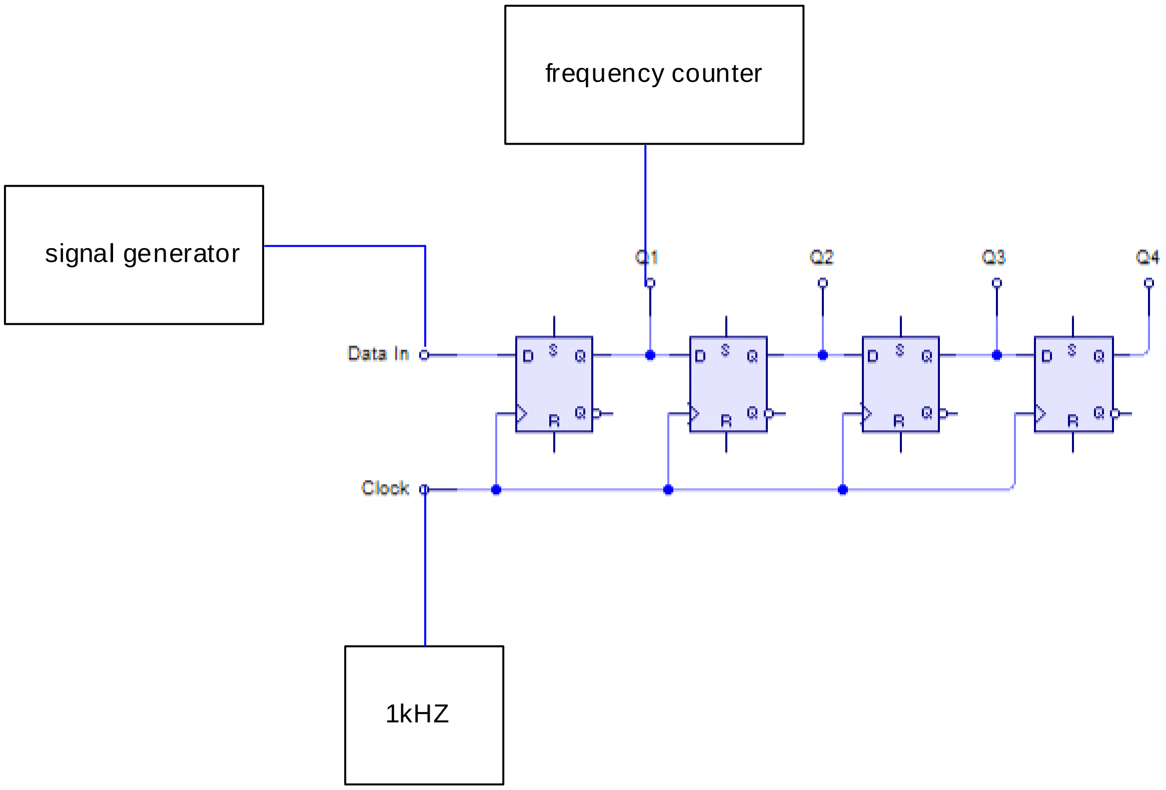
I wanted to understand how this ‘fast’ circuit works with as less math as possible before attempting to build one. Building something without having any clue how it works is something to avoid. Many, many hours were spend drawing timing diagrams in 2014.

3)Puzzling with timing diagrams.

Where to start? The shift register. Typically a shift register is used to send and receive information (bits) serial.

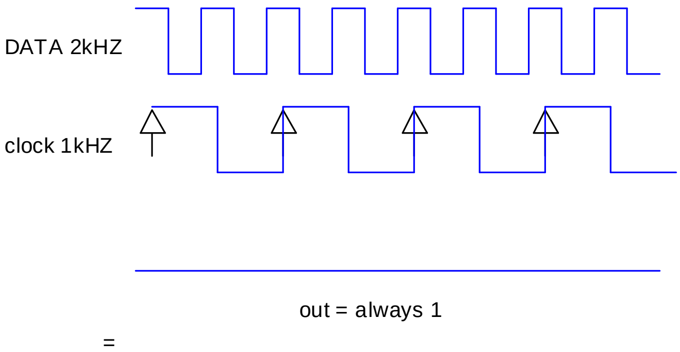


This is a shift register with 4 stages, also called FIFO stages. When a clock pulse arrives each block will check it’s input and write whatever it's sees, a 0 (0Volt) or 1 (5 VOLT), in the following block. So if the first bit on the data input is a 1 on the first clock pulse, four clock pulses later it will appear on output four (Q 4). In a shift register, the bits are passed on from one block to another. The speed on which it does this is determent by the frequency of the clock pulse. It's important to realize that while the shift register is waiting around for the next clock pulse to arrive the bit's on data-in may change as much as they like, the shift register won't change any output. Only when a clock pulse appears, **actually on the rising edge of the clock pulse**, the shift register will check it's inputs. Another name for this action is sample and hold.

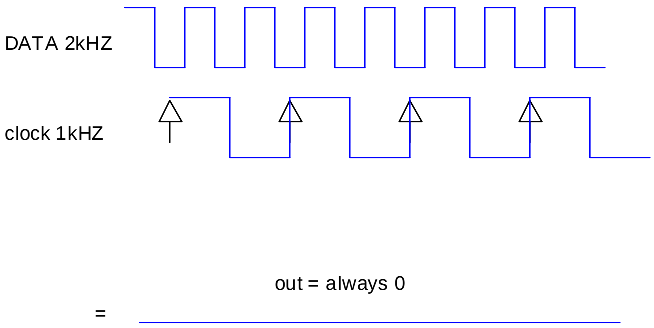


How does that translate to the huff and puff stabilizer? In the above schematic, a signal generator is connected to data in. suppose the clock is a professional signal generator **set on 1kHZ**. On the **1st output (Q1)** a pulse train will appear. The frequency of this signal will be in-between 0 Hz and 500Hz.

0Hz, if by chance every time the shift register checks the data input it sees a 0 or a 1.

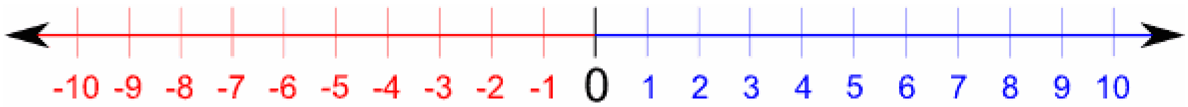


the output on Q1 is permanently 5V, the frequency is 0 Hertz.



the output on Q1 is permanently 0V, the frequency is 0 Hertz.

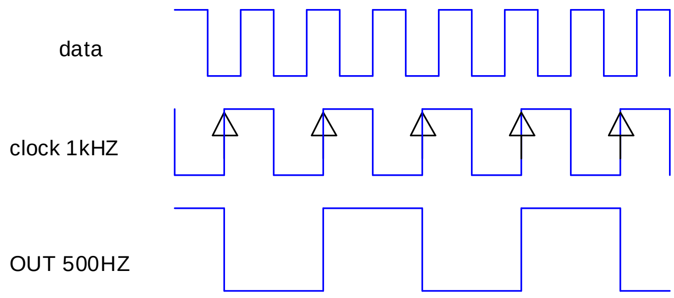
This will be the case if the clock frequency ‘fits in’ exactly with the data frequency. For example, if the clock is exactly 1kHZ and the data is exactly 2Mhz. This will only happen when their ratio is an integer number.



2000Hz/1000Hz = 2

DATA/CLOCK = N (ratio)

What’s the **maximum possible frequency** on the output of Q1? This time the clock-cycles no longer ‘fit in’ the data-cycles. As we can see if on every rising edge of the clock pulse the data is different. First a 0 than a 1 then a 0 again and so on. The output frequency on Q1is **clock/2**. In this case 500Hz. Guys into digital circuits call this the Nyquist- frequency. Sometimes I hear my young colleague Robin talk about “ghost frequencies”. If you look carefully you’ll see that the data fits 1,5 times in the clock so N=1,5 or N+1/2



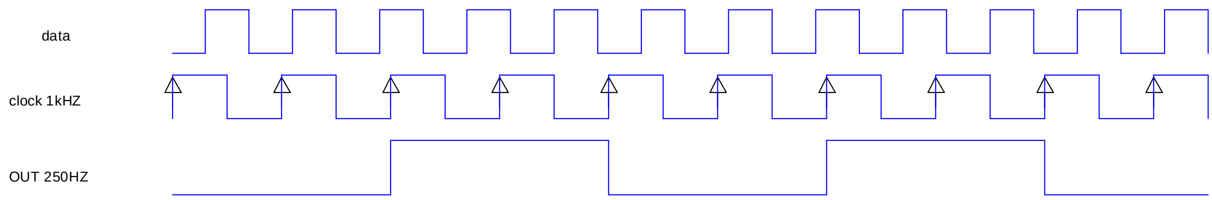
N (ratio)= DATA/CLOCK

DATA = N x CLOCK = 1,5

x 1000HZ = 1500HZ = 1,5kHZ

The data in this case is 1,5kHz.

If the frequency can change between 0Hz and clock/2, the halfway point must be at clock/4.



In the above drawing, the frequency on Q1 is 250Hz = clock/4. If you look carefully you'll the data fit 1,25 times in the clock so N=1,25 or N+1/4

N (ratio)= DATA/CLOCK

DATA = N x CLOCK = 1,25

x 1000HZ = 1250HZ = 1,250kHZ

The data in this case must be 1,25kHz.

To summerise.

N (ratio)= DATA/CLOCK

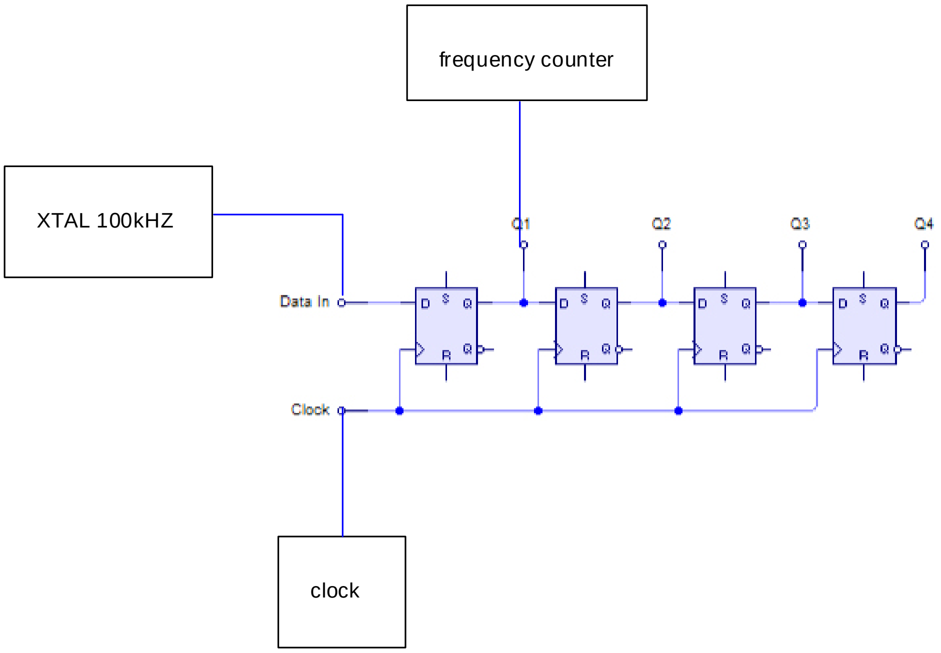
CLOCK= DATA/ N

If N is integer the frequency on Q1 is 0HZ

If N = N+1/2 the frequency on Q1 is maximum = clock/2

If N = N+1/4 the frequency on Q1 is halfway = clock/4

Now for a more realistic setting.



Data in is connected with a crystal stable oscillator, let’s choose 100kHz as frequency. The clock is a signal generator and let us choose 2,5kHz as starting point.

Xtal/CLOCK = N (ratio) =
100000Hz/2500Hz= N = 40

40 is an integer number so even without measuring the output frequency on Q1 we can be sure its 0HZ. The Xtal frequency is pretty high so there must be many different clock frequencies ‘fitting in’. If I was to decrease the clock frequency, what would be the closest clock frequency?

N

(ratio) = Xtal/CLOCK

CLOCK = XTAL/N

100000Hz/41= 2439Hz

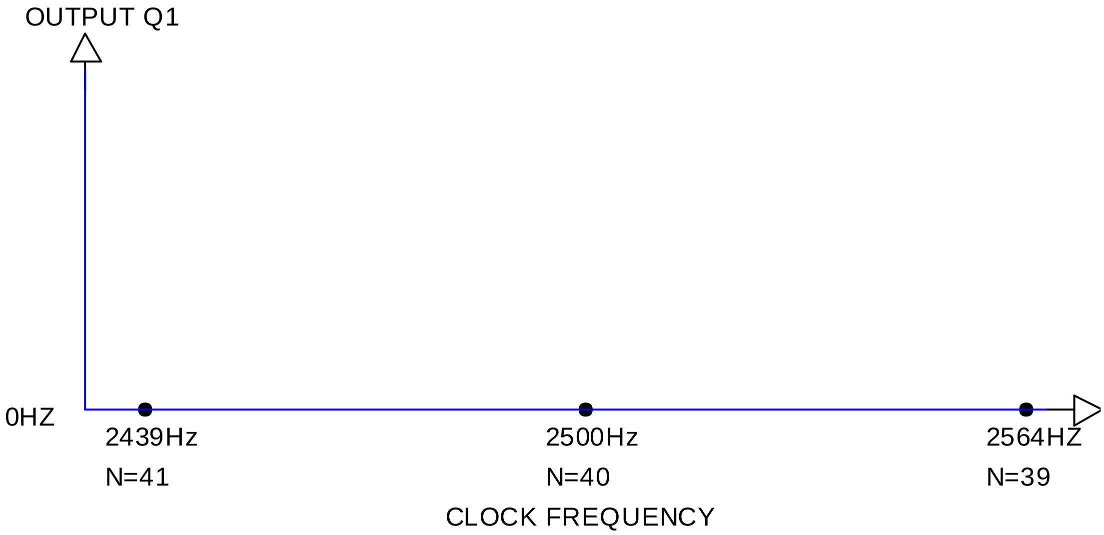
If the clock frequency is 2439 the output frequency on Q1 is again 0HZ. What if decrease the clock even further?

100000Hz/42= 2380Hz

Now I go back to 2500hz (n=40) and for a change, I increase the clock frequency.

100000Hz/39= 2564Hz

Obviously, there are a lot of frequencies where the frequency on Q1 will be 0Hz.



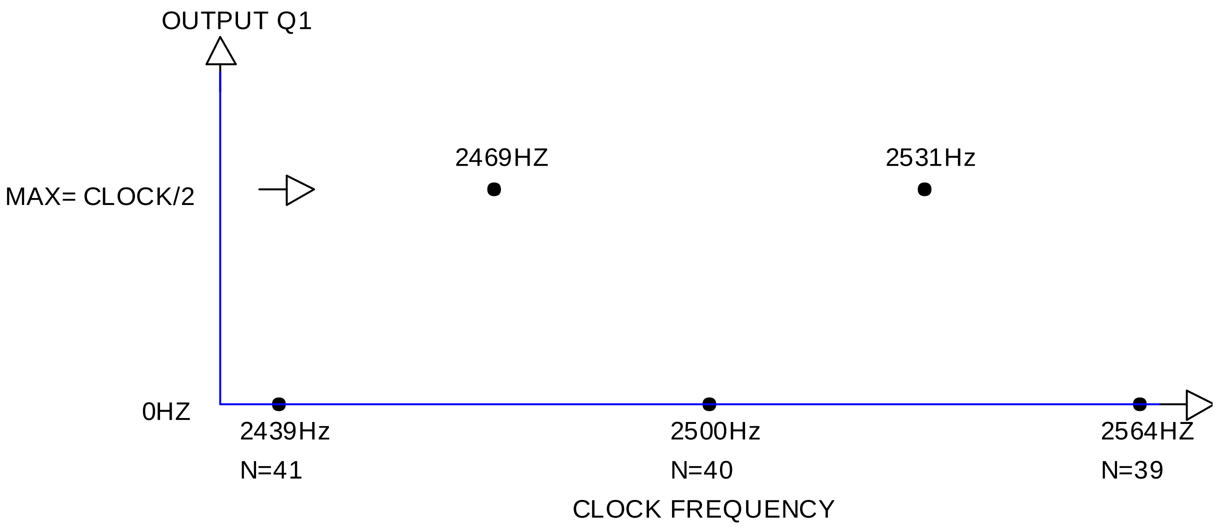
Now let's determine where I should set the clock signal generator to reach maximum frequency on Q1.

CLOCK = XTAL/N

N must now be n+1/2

100000Hz/40,50= 2469Hz

100000Hz/39,50= 2531Hz



Its already obvious where the half waypoints will be but let us calculate them anyway.

CLOCK = XTAL/N

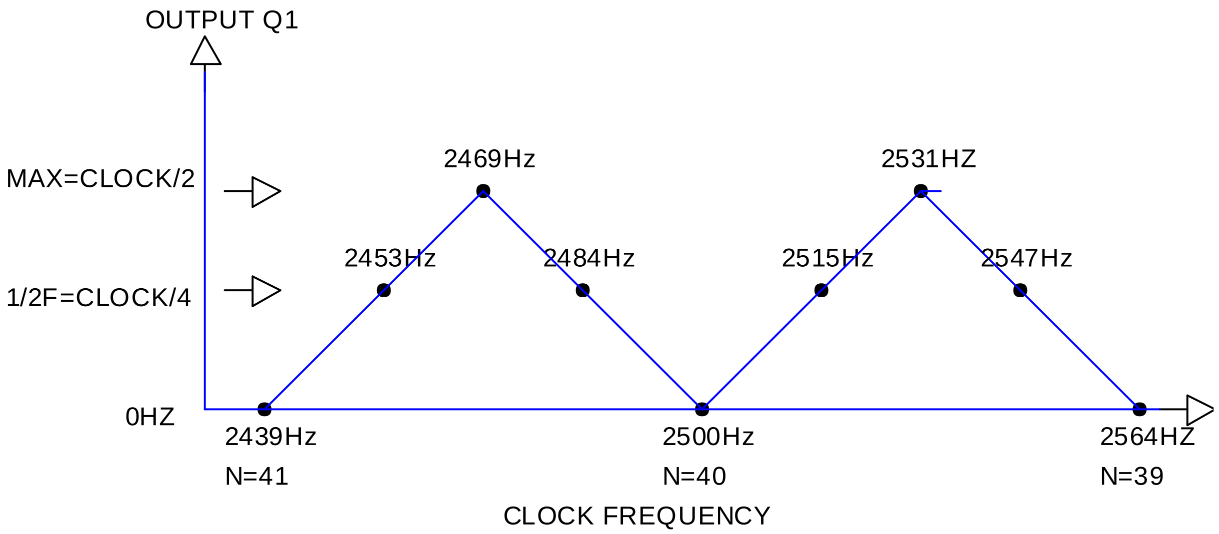
N must now be n+1/4

100000Hz/40,75= 2453Hz

100000Hz/40,25= 2484Hz

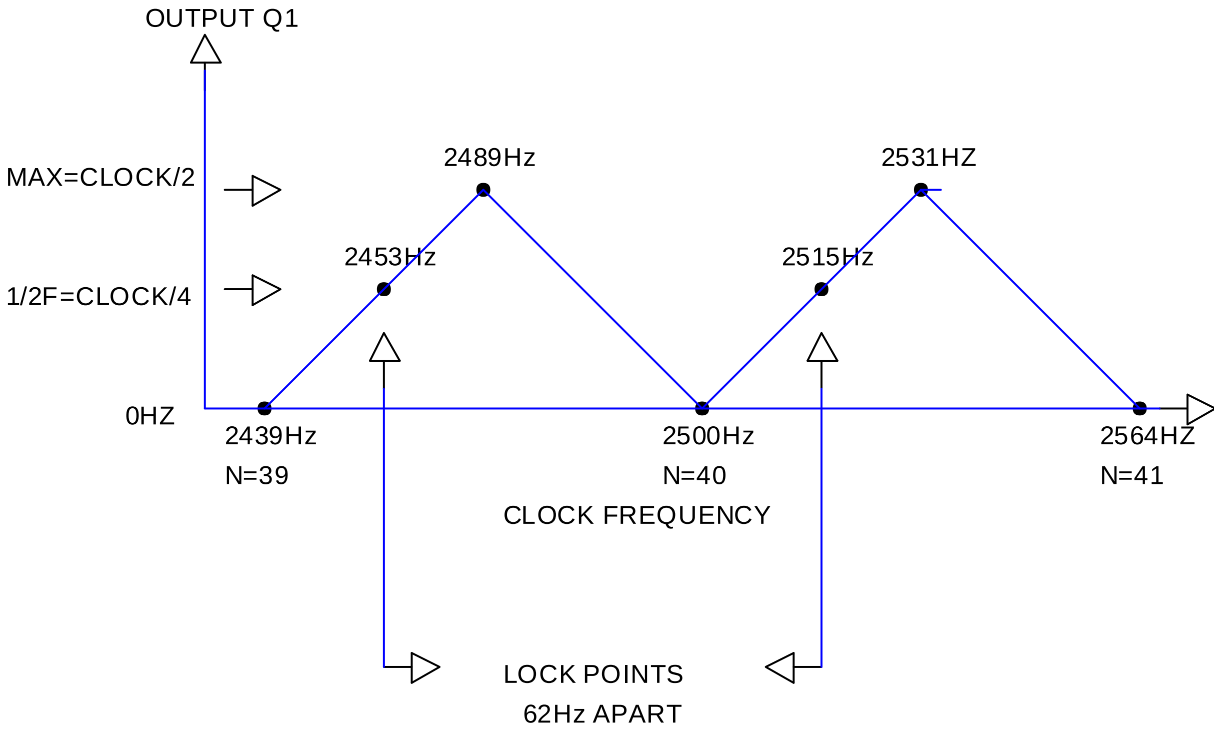
100000Hz/39,75= 2515Hz

100000Hz/39,25= 2547Hz



4) the H&P is an frequency drift detector.

Now it becomes clear that if you steadily adjust the clock frequency up or down you will see the frequency on Q1 constantly go up and down and then back up again. From zero to clock/2 and then back to zero and so on. If you would monitor this frequency on Q1 it would tell you nothing about what values the clock or data-input frequencies could have, but if your data input is a rock-steady crystal oscillator, **the frequency on Q1 will tell you if the clock frequency is drifting or not.** By using the oscillator signal, which we want to stabilize, as the clock signal, we have got ourselves a cheap and easy to build **oscillator-drift-detector.** All that's needed now are lock-points. Obviously, the halfway points are convenient. If you had a circuit that compares the frequency on Q1 to a pre-set value and regulates the oscillator, and therefore the clock frequency, you would have created a frequency locked loop. The pre-set value can be made with a super simple clock-divide by 4 circuit.



In our example, the lock-points would be 62Hz apart. In practice, you can tune your oscillator to any frequency you desire. The stabilizer is too slow to intervene. But when you stop adjusting the oscillator the magic starts, the clock frequency will always be close to a certain N-point. Immediately the frequency locked loop will settle on the closest N+1/4 point, which in this case is never more than 31Hz away, consequently keeping your oscillator on a tight leash until you decide to re-tune the oscillator.

Two important observations, make the same calculations with a 10 times higher Xtal oscillator frequency and you will find lock points 10 times closer. That's why all huff and puff circuits have a relatively high reference frequency.
And even more important, if you choose a higher clock frequency the lock points will become further apart. This implies that if you stabilize a wide range oscillator with this circuit the lock points will be further away from each other as you reach the upper frequencies of your oscillator. In reality, an Xtal frequency of 100kHz is way too low. Also, a clock of 2,5kHz is chosen much too high.

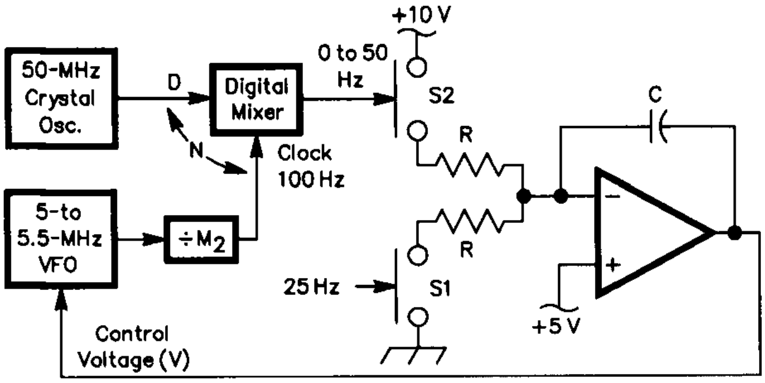
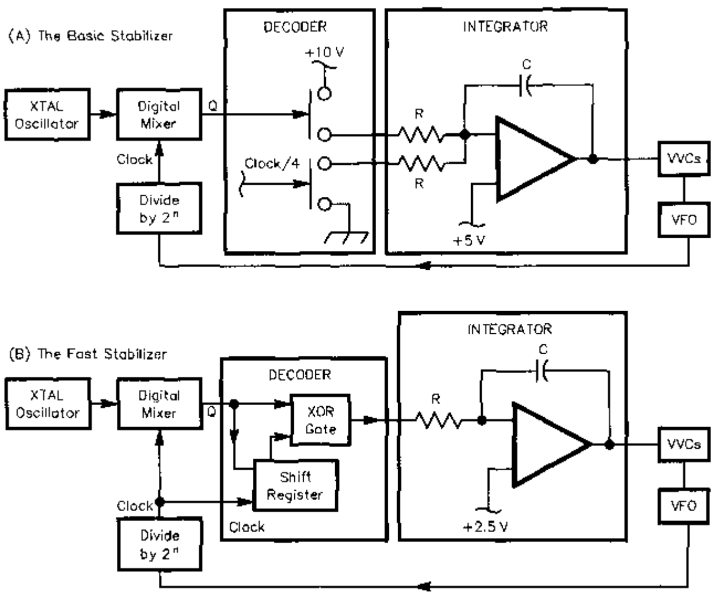


Fig 2—Block diagram of an improved system.

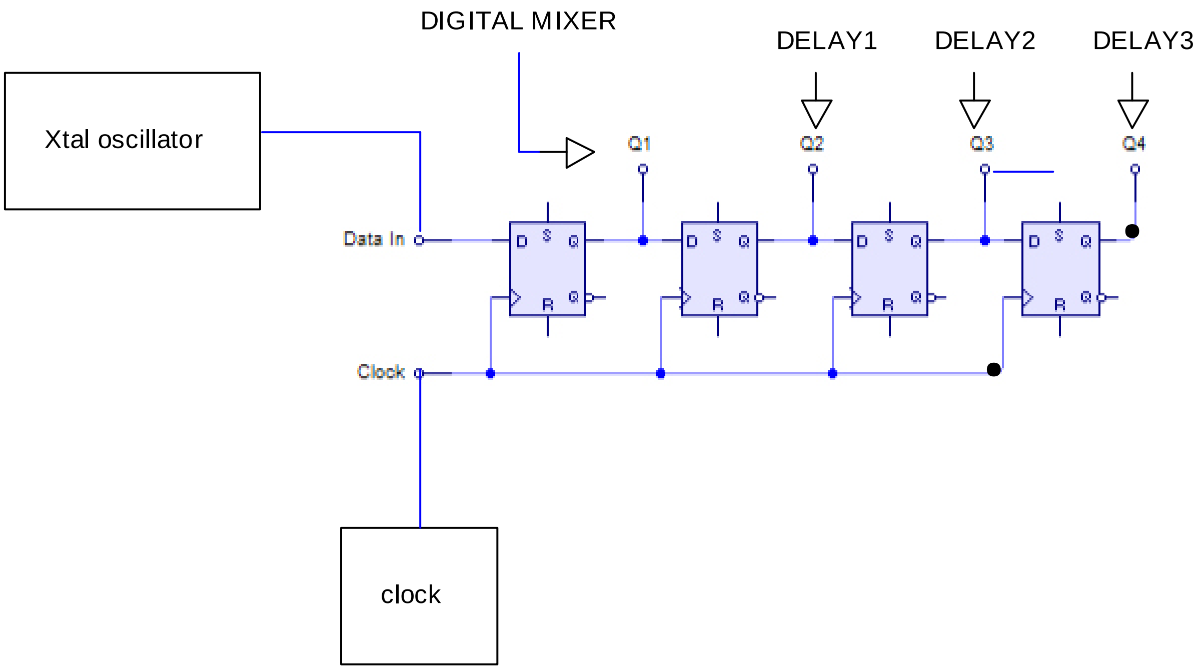
The locking mechanism described above is by the way exactly what the ‘improved huff and puff stabilizer’ , fig2 above, designed by Klaas Spaargaren does. This **real practical circuit** above has oscillator lock points 10Hz apart. The 5MHz oscillator frequency is divided by 50000 to provide a clock of 100Hz. A little arithmetic learns that to have oscillator lock points of 10Hz apart, the lock points at the output of the digital mixer are only 0.0002Hz!!!! away.

The ‘fast huff and puff stabilizer’ designed by Peter Lawton uses the same ‘drift-detector’ but instead of comparing the frequency output of the mixer to a reference frequency a frequency to voltage converter circuit is used. This circuit is formed by a shift register and an EXOR gate. The output voltage is then compared to a pre-set voltage...



A is the ‘improved’ huff and puff by Klaas Spaargaren. B is the ‘fast’ huff and puff by Peter Lawton.

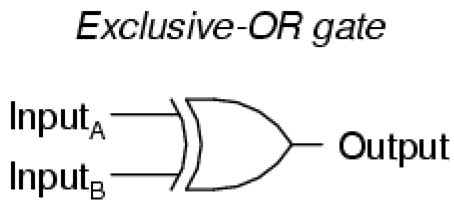
Twice you can see a circuit block called ‘digital mixer’. the digital mixer is the drift-detector. Hans Summers must be the kind of guy who likes to keeps things simple and minimal. He managed to simplify the pretty complex schematic published by Peter Lawton, one of the things he omitted was the digital mixer. One day he must have realized that the output of the first stage of the shift register can be used as the digital mixer. This way you can get rid of one IC.



So the signal on Q1 is the output of the digital mixer. It’s important to realize that therefore the output on say Q4 is not delayed 4 times but only 3 times instead!

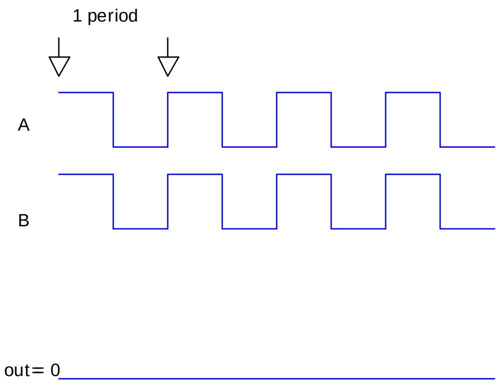
5) the fast design.

Let’s look at the EXOR gate first. This EXOR gate has two inputs and one output. The output can only be 1 (=5V) or 0 (=0V). it’s already in the name, OR, meaning if input 1 OR input 2 is 1 (5V) the output will also be 1. If both inputs are 0 the output will be 0. When both inputs are 1 the output will also be 0. Pictures say more than words so here’s a nice truth-table.

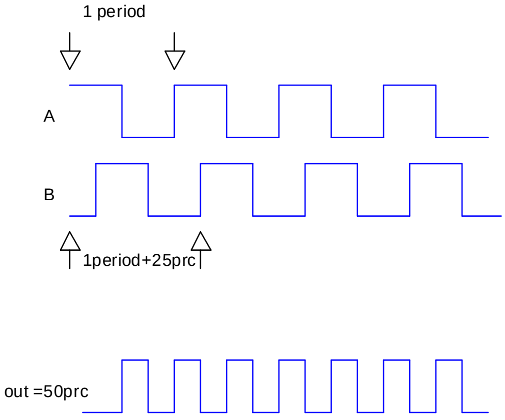


A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

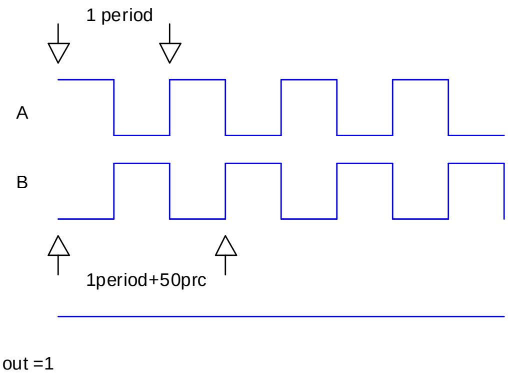
What will happen if we connect two pulse-trains to input A and B?



If the input is in faze (N=integer), meaning that there edges rise and fall at the same time the output is 0 (=0V).



When one of the pulse-trains is shifted 25prc (N+1/4) the output will be 50prc on. if you were to rectify these pulses on the output, the voltage over your buffer capacitor would be 2,5V if we suppose the supply voltage is 5V, which is typical for logic IC’s.

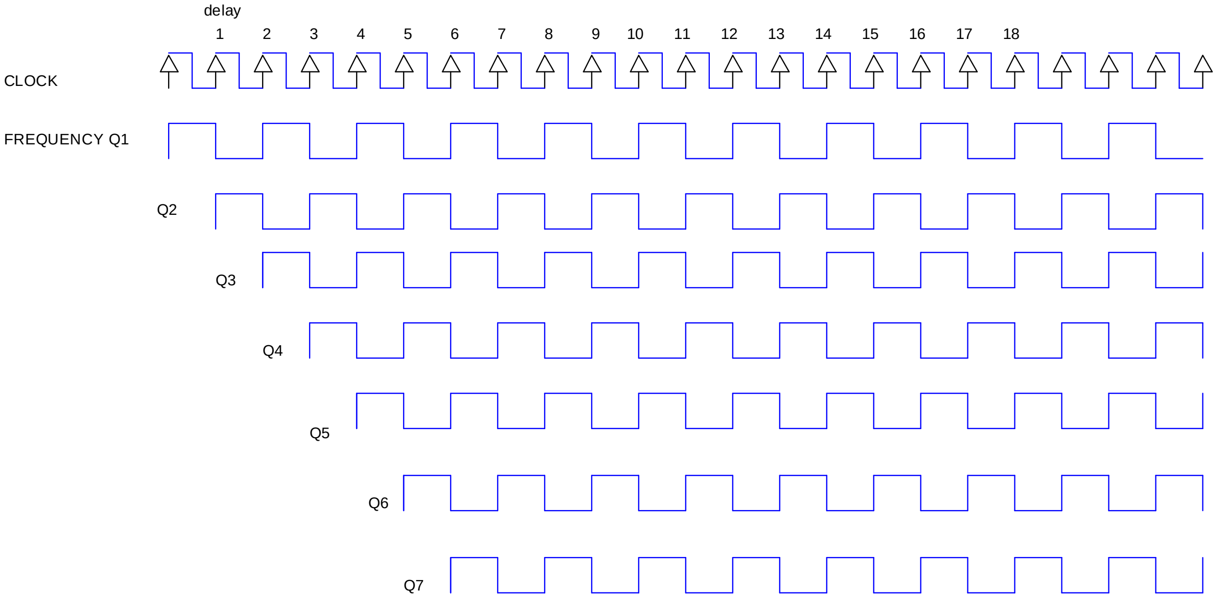


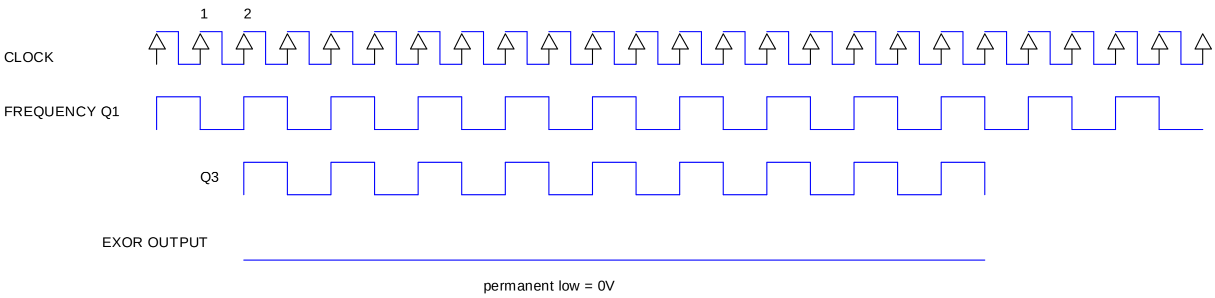
If input B shifts even further to 1 period +50prc (N+1/2) the output will be 1 (5V).

by measuring the average voltage on the output of the EXOR gate we can determine the phase difference between signal A and B. our EXOR gate is a faze detector.

in the fast huff and puff circuit, the two inputs are connected to the shift register. One input to Q1 and the second one to a delayed output; a Q1 signal of the past if you like. I was especially intrigued how this speeds up the huff and puff stabilizer. Unfortunately, Peter Lawton’s 1998 QEX article is rather an outline instead of a detailed explanation, so I had a hard time figuring out why.

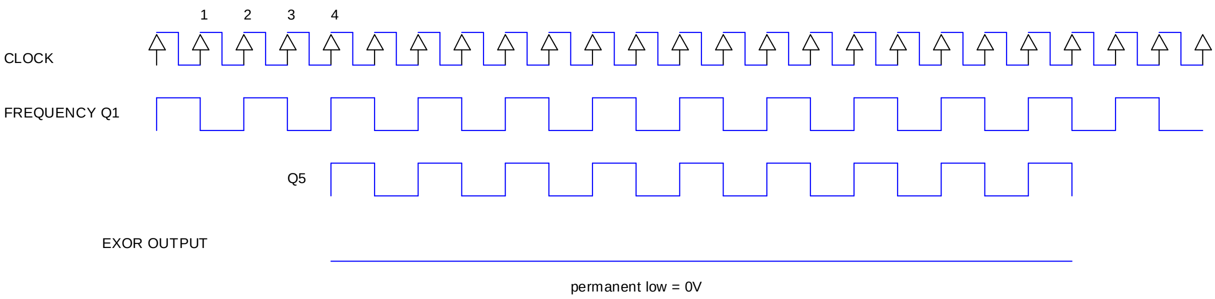
Below we see what happens inside the shift register. On every clock pulse, the bits are being shifted further. In this case, the frequency on Q1 is maximum (clock/2).



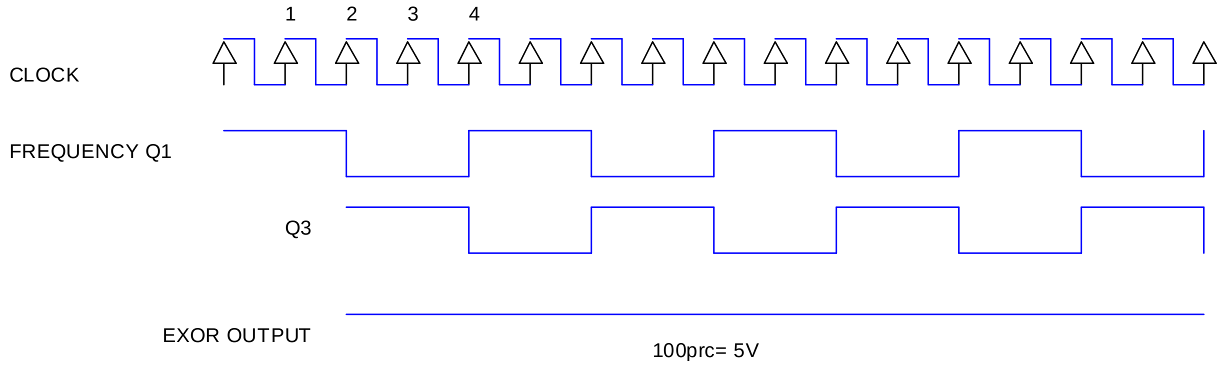


If we look at Q3, the signal the EXOR will see are in faze. The output will be permanently low.Q3 fits right in Q1. Q3 (delay 2) only fits in Q1 when Q3 is shifted 2 times. If the frequency on Q1 is maximum (clock/2) it must mean that the ratio between the Xtal and clock is N+1/2. Multiply this whit the number of stages (Z) and what the EXOR sees is an integer number again.

In this case N+1/2 x2 = 3 = integer = output EXOR 0V.

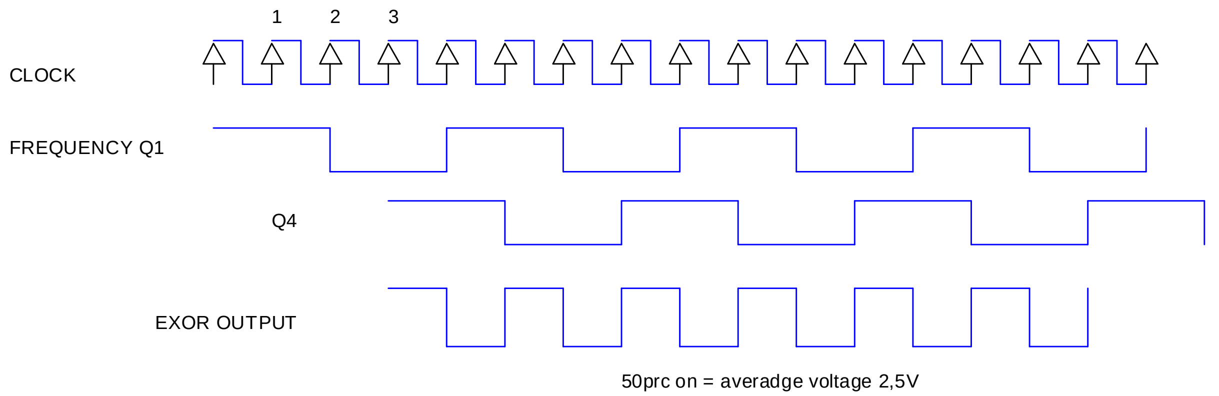


Above N+1/2 x 4 = 6 = integer = output EXOR 0V



This time the output on the EXOR will be permanently high. The frequency on Q1 is clock/4. This is only possible when the ratio between Xtal and clock is N+1/4.

N+1/4 x 2 = 2,5 not a integer number in fact its N+1/2. We have seen what the EXOR does whit signals who are N+1/2 out of phase. The output will be permanently high =5V.



Above exactly the same only the EXOR is this connected to Q4 (Z=3).

N+1/4 x 3 = 4-1/4. The signals are N+1/4 out of phase resulting in a halfway point = 2,5V.

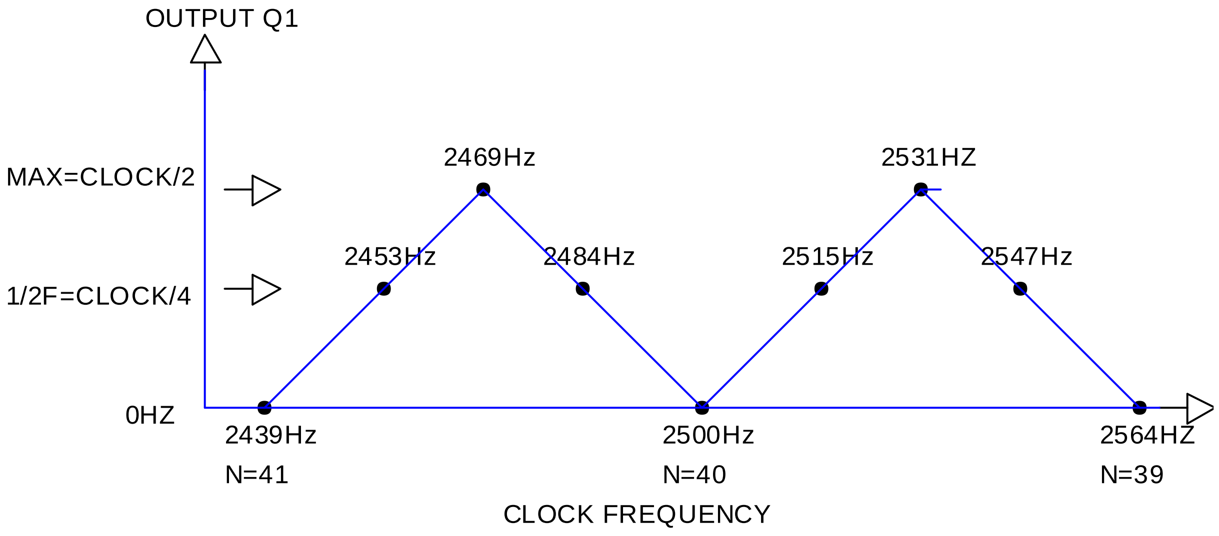
To summarize, the ratio of the digital mixer (N=XTAL/clock) multiplied with the number of delays (Z) is the ratio the signals will have on the inputs of the EXOR gate (Nexor).

XTAL x Z / clock = Nexor

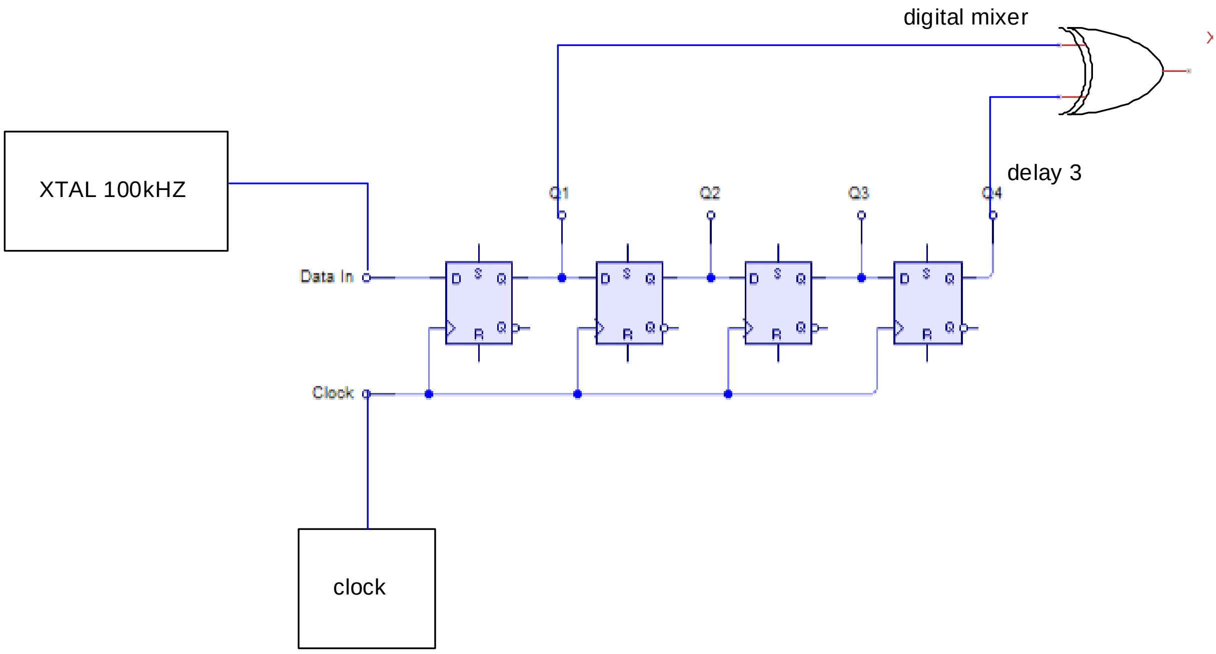
If Nexor is integer the output of the EXOR will be 0V

Nexor +1/4 = the average output of the EXOR will be 2,5V

Nexor +1/2 = the output of the EXOR will be 5V



Let's use our previous result (above) and use it to see what happens on the output of the EXOR gate in the schematic below.



First, we need to find a Nexor point, let's start at clock frequency 2500HZ. XTAL is again 100000Hz and Z is 3 (Q4).

XTAL x Z

/ clock = Nexor

100000 x 3 /2500 = Nexor =120, that's integer so the output voltage will be 0V.

XTAL x Z

/ Nexor = clock

100000 x3 / 121 = 2479Hz

100000 x3 / 122 = 2459 Hz

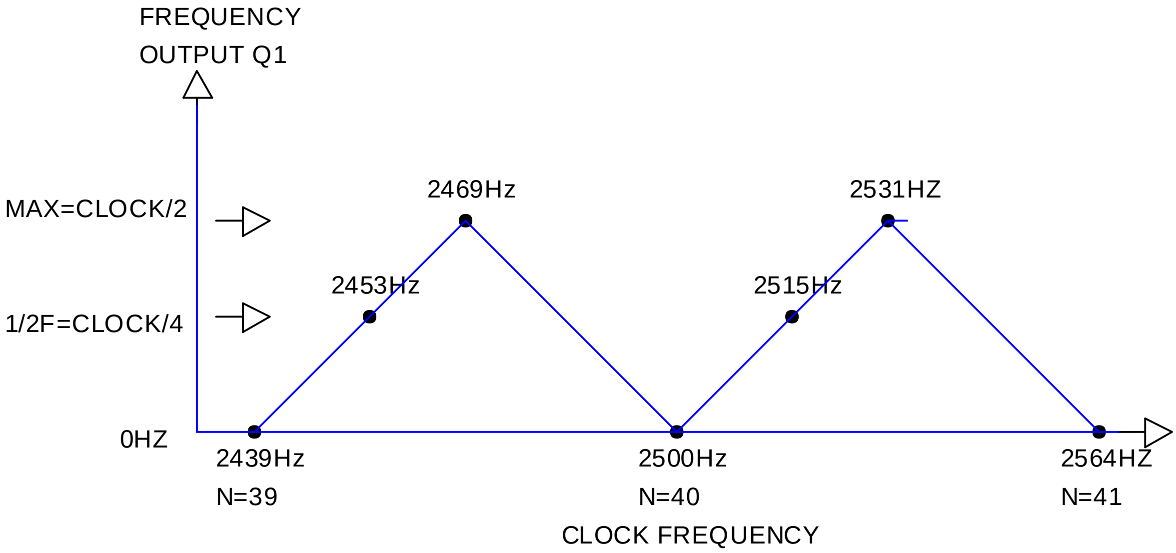
100000 x3 / 123 = 2439 Hz

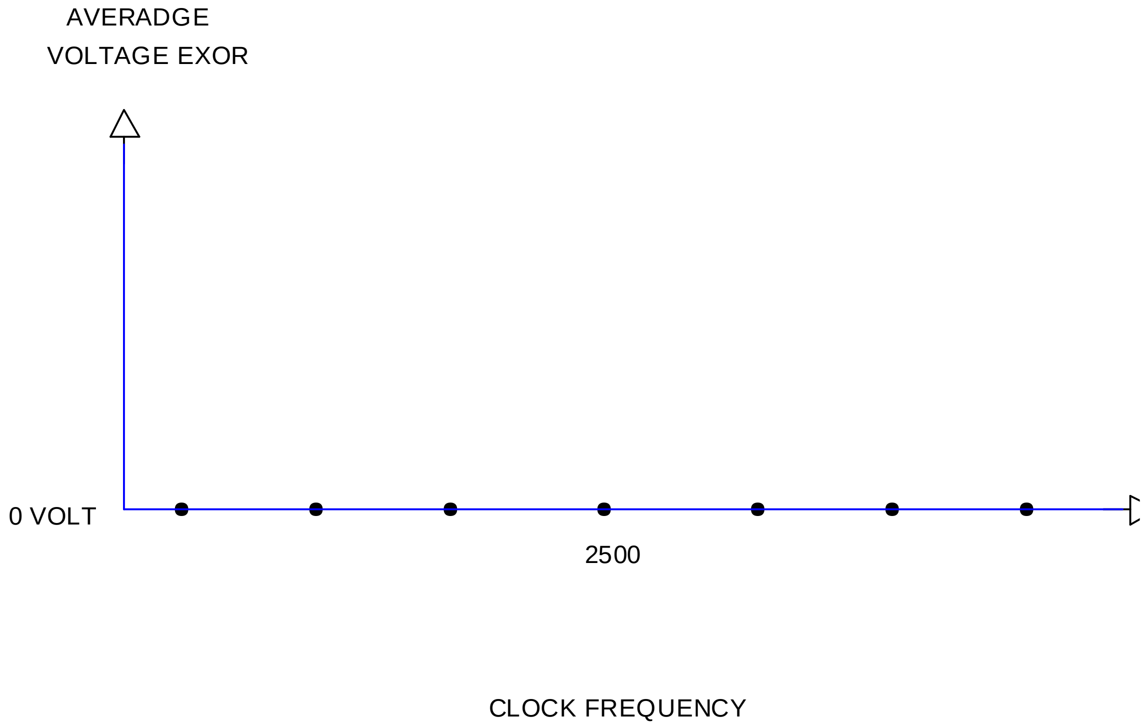
100000 x3 / 119 = 2521 Hz

100000 x3 / 118 = 2542 Hz

100000 x3 / 117 = 2564 Hz

All these integer Nexor points will produce 0V at the EXOR output.





To find on witch frequencies the EXOR output will be 5V the Nexor ratio must be Nexor +1/2. Let's find them!

XTAL x Z / Nexor = clock

100000 x3 / 120,50 = 2489Hz

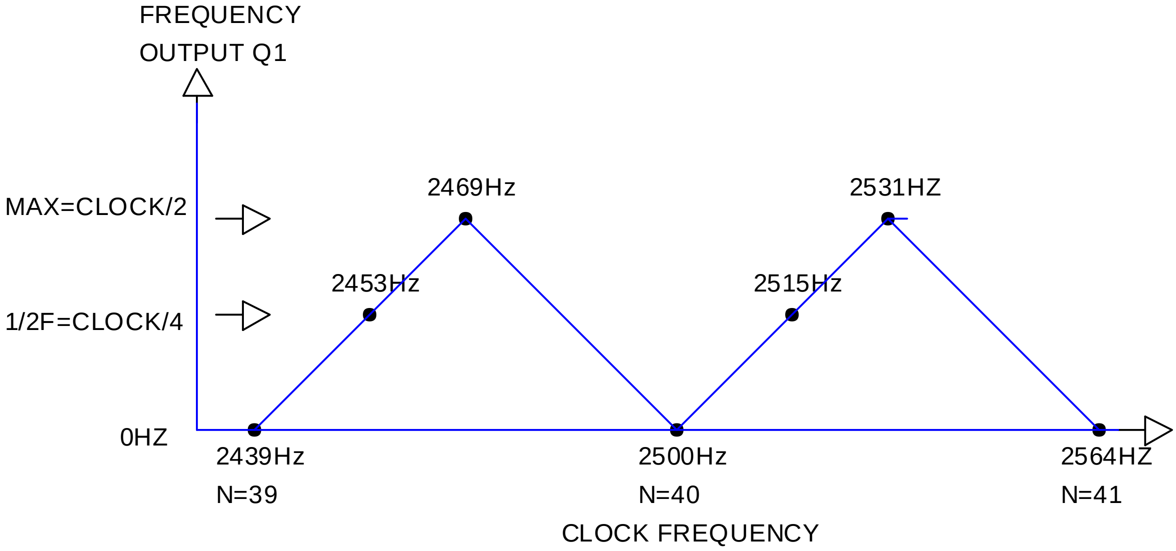
100000 x3 / 121,50 = 2469 Hz

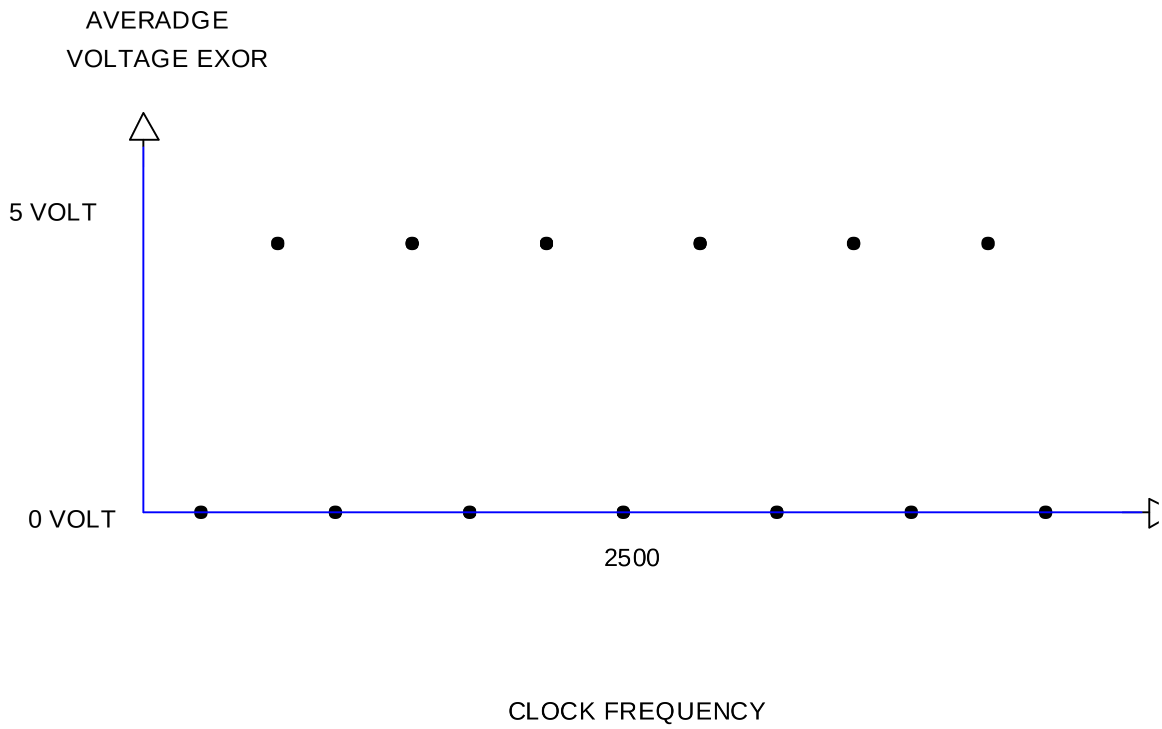
100000 x3 / 122,50 = 2449 Hz

100000 x3 / 119,50 = 2510 Hz

100000 x3 / 118,50 = 2531 Hz

100000 x3 / 117,50 = 2553 Hz



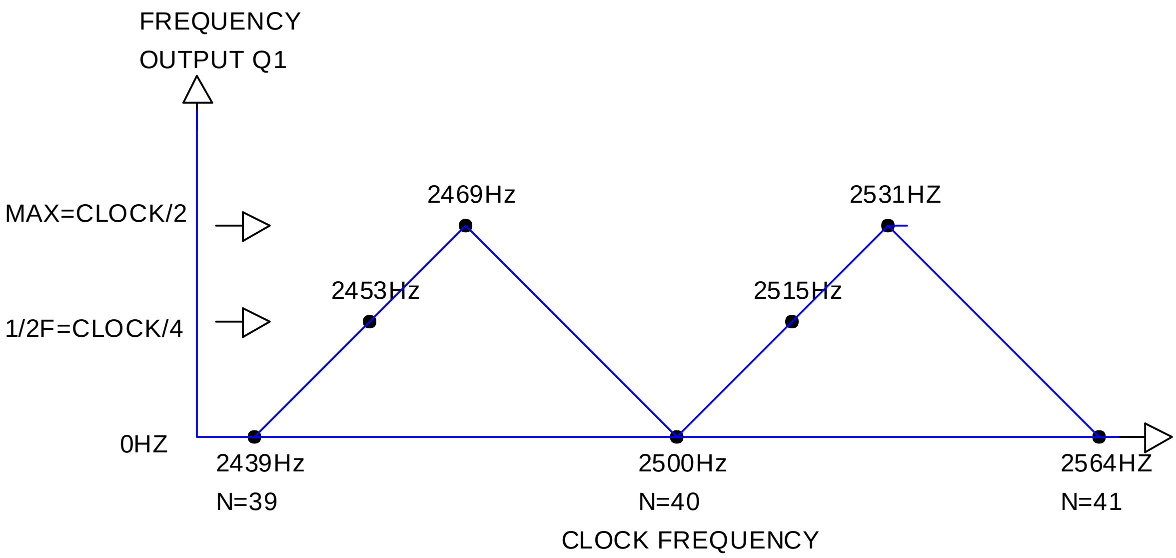


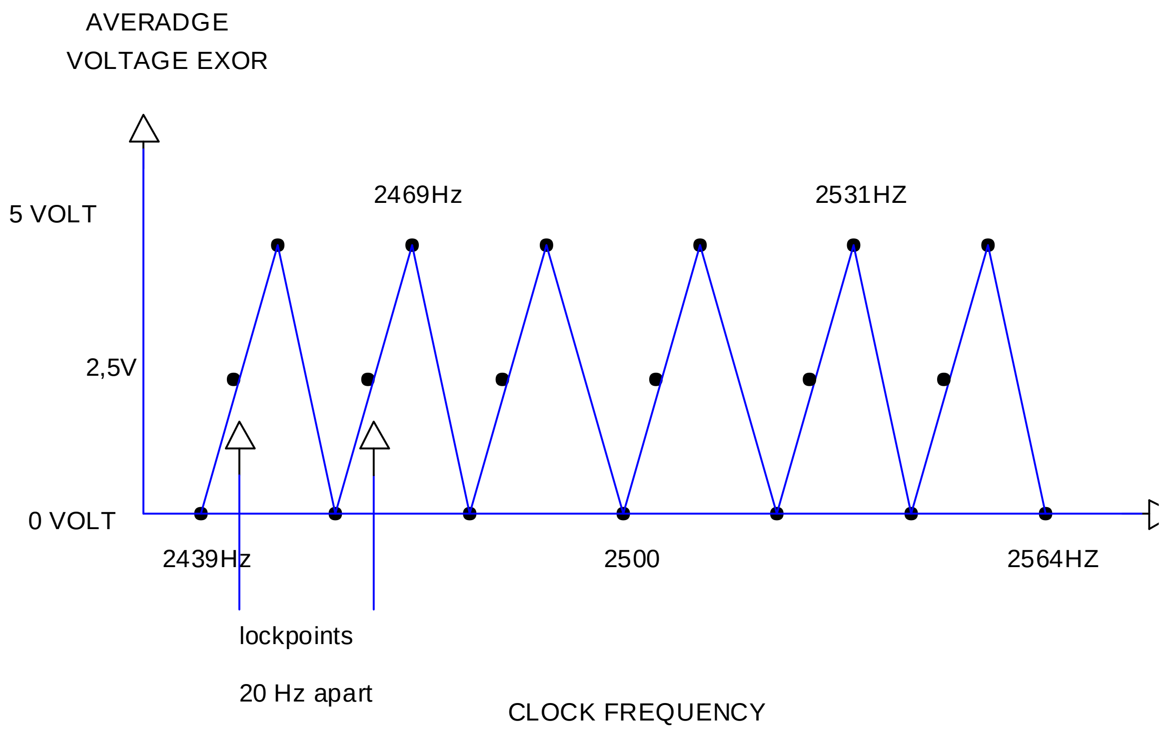
clearly the halfway points must be in-between. I only bothered to calculate two of them.

XTAL x Z / Nexor = clock

100000 x3 / 120,25 = 2494Hz

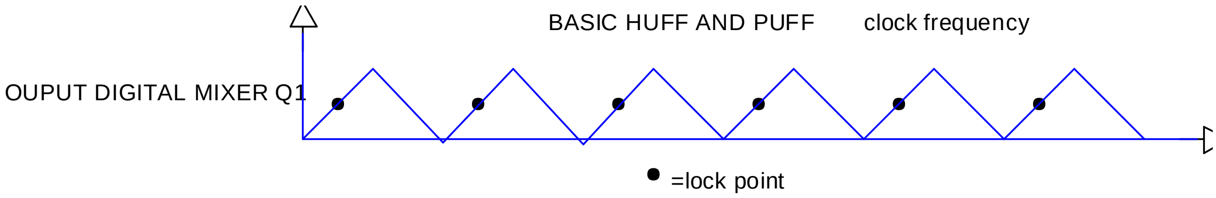
100000 x3 / 119;25 = 2515 Hz

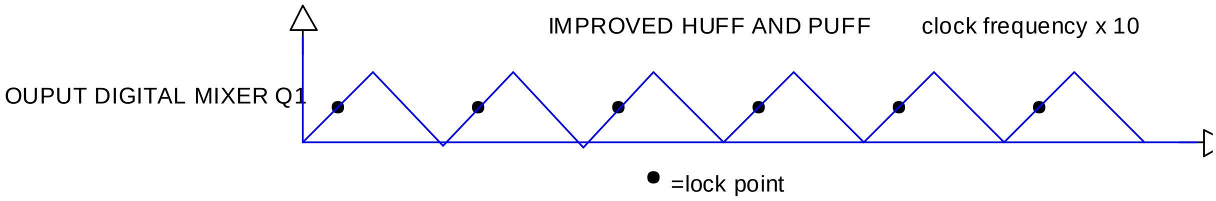


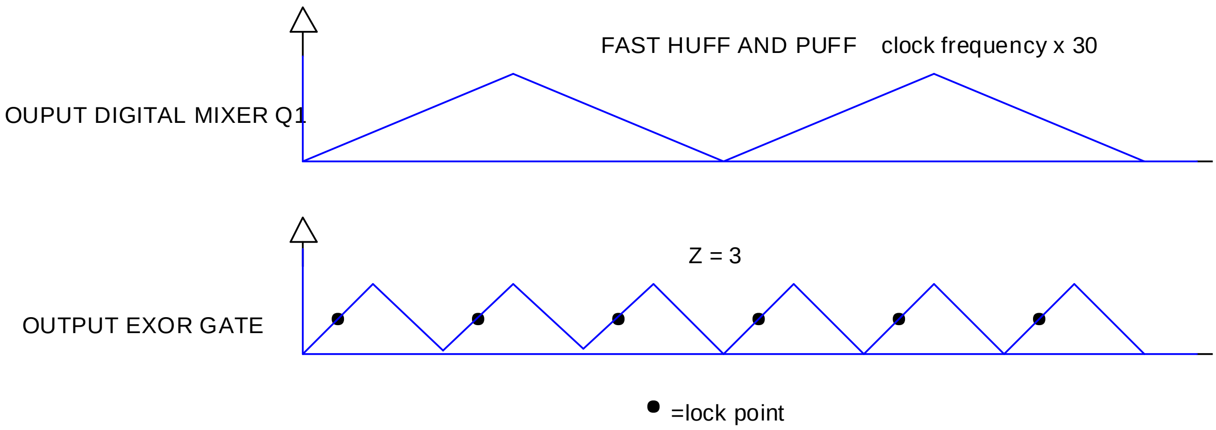


Here's the final result. The merge shift register-EXOR is more than just a frequency to voltage converter, there's more than meets the eye. Just as stated in Peter Lawton's article **the mixer output (Q1) is copied Z times.** In this case 3 times. If we use the halfway points (2,5 Volt) as locking points, we have locking point 3 times closer to each other in comparison to the 'improved huff and puff'! you can use as many delays as you want, each one will decrease the steps between locking points.

6) Why is the 'fast' circuit faster?







At the top the 1973 basic circuit, it was possible to have lock points at a certain clock frequency. Remember that the digital mixer only checks the drift at the up-going flank of the clock frequency. **In between these up-going flanks, the mixer is completely blind**! If in this 'blind' time interval the oscillator drifts more than a half an N point, the circuit will, on each new clock pulse, try to lock on a different N+1/4 point causing the oscillator to hunt. This is exactly what my first two prototypes did. **Logically you would like to increase the clock frequency to counteract this but unfortunately, the trade-off is that the distance between lock points will also increase, eventually to a point where the circuit is no longer practical.**

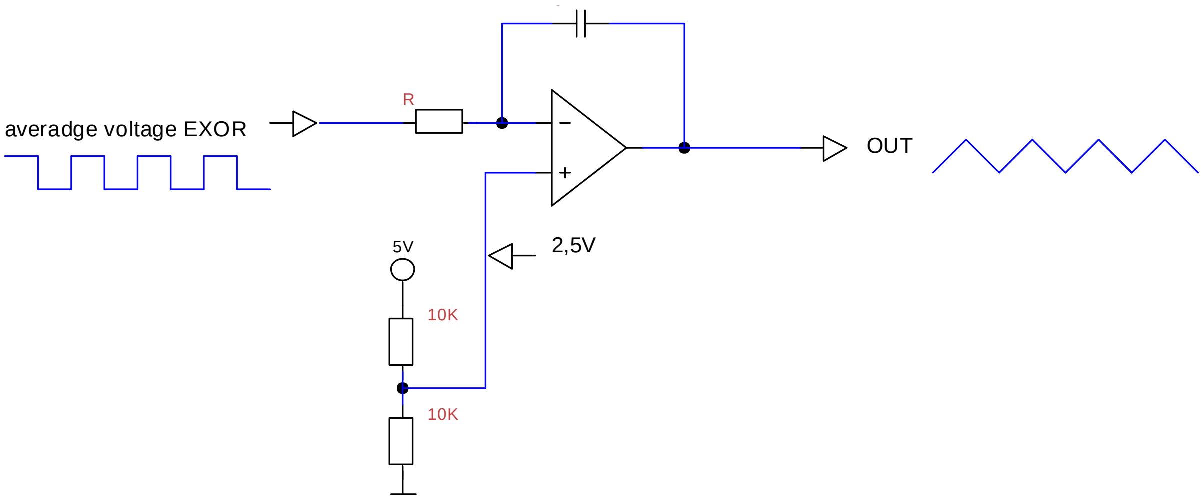
The 'improved huff and puff' enables a ten times greater clock frequency and keeping the same distance between lock points.

Consequently, it can handle an oscillator witch drifts ten times more.

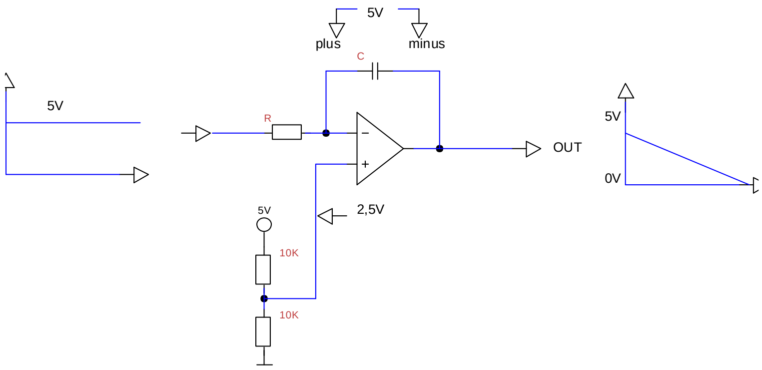
In the fast design, the clock can be as high as you like, you just add delays to reduce the steps between locking points again. Peter Lawton 1998 design featured 256 delays! The ‘fast’ design should, therefore, be able to control the drift of any oscillator. In our example (Z=3)the clock is 30 times higher in comparison with the clock of the ‘basic’ 1973 circuit, enabling it to tame a 30 times more nomadic oscillator and still keep the same steps.

7) closing the loop.

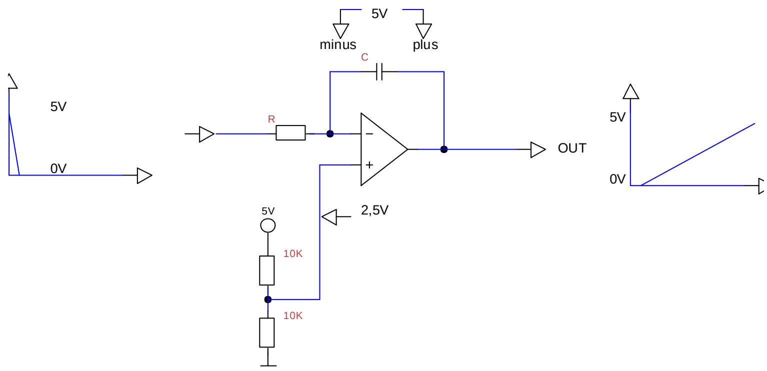
Next and final step. The oscillator signal must be divided to provide a clock frequency for the shift register to create a control loop. The only thing left to do is feeding the output to a circuit that compares the average voltage on the EXOR gate to a fixed 2,5V. This circuit should be able to alter the oscillator frequency to keep the output voltage as close as possible to 2,5V. this circuit is an integrator, fortunately, a simple opamp can do the job. The circuit gets its name from the mathematical function it performs but without math, you can understand it anyway.



The non-inverting input is connected to 2,5V. that's our reference voltage. On the inverting input stands the output of the EXOR gate. It will always be either 0V or 5V. the circuit acts as a comparator, it will amplify any difference between the 2,5V and the output of the EXOR. Because the signal is connected to the inverting input, a voltage of 5V will bring the integrator output down to 0V, and 0V input will drive the integrator output up to 5V. In practice, the pulses from the EXOR will be erratic. So the integrator will react to the average voltage EXOR output.



Suppose the opamp output is 3V, and suddenly the input is permanently 5V. because there is no resistor feedback between in and output the opamp can unleash it's full amplification and will want to bring the output right to 0V. but the opamp can’t remember that the voltage over a capacitor can’t change instantly? In this example, there will be 2V over the capacitor, before the output of the opamp can drop to 0V the capacitor needs to charge up to 5V. the charge current can only flow via the resistor at the input. The bigger the resistor and capacitor the longer it will take.



Let’s assume that after the output has become 0V the input becomes permanently low. Now the opamp will want the output to become 5V, but again it is chained by the resistor-capacitor. The capacitor is already charged to 5V but in the opposite polarity. First, the capacitor has to discharge via the resistor and then it has to charge up again to 5V in the opposite polarity. once more, depending on the value of the resistor and capacitor this will take time.

Because the polarity on the capacitor can be both ways the capacitor has to be a non-electrolyte type! To summarize, the integrator reacts very ‘laid back’ to the average voltage of the EXOR gate. in conclusion, the output of the opamp is connected to a varactor that has a little influence on the oscillator frequency and therefore the clock frequency. You can make the integrator inverting or non-inverting, it doesn’t matter. Depending on what you choose the stabilizer will lock on the Nexor +1/4 points or the Nexor -1/4 points. **Et voila, we have a frequency locked loop!**

8) Calculating made relaxed for guys like me.

The steps between lock points can be calculated with this formula.

$S = (F_{vfo})^2 / (z.M.F_{xtal})$

S = steps in Hz

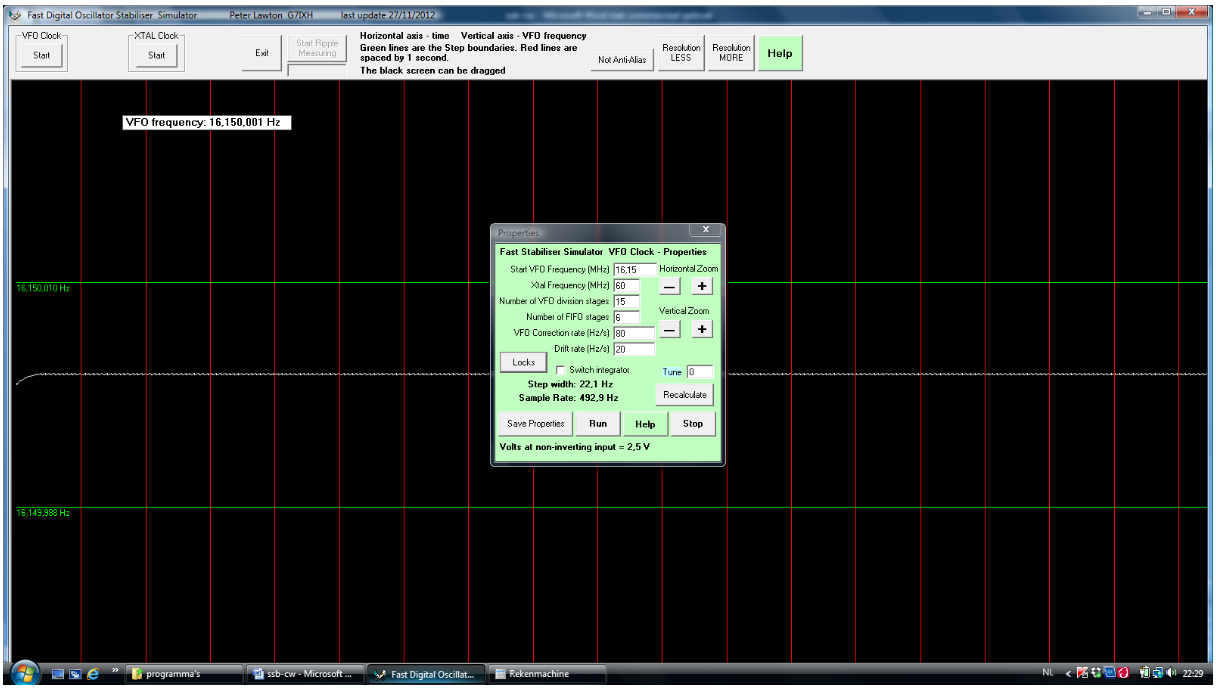
F_{vfo} = VFO frequency in Hz

z = numbers of shifts

M = 2^n met n number “divide by 2” steps of VFO divider

F_{xtal} = reverence frequency in Hz

Peter Lawton’s personal website features a huff and puff calculator that you can download and install on your PC. Pffff ☺ What a luxury!



First press VFO clock, then you simply have fun with the parameters. The first two are obvious. The oscillator frequency you want to stabilize and secondly your reference frequency (which will be your canned oscillator) With ‘number of VFO division stages’ is meant the ‘divide by 2’ steps. FIFO stages are the number of delays. Every time you press RUN you’ll see immediately if you’ll get a lock, and if so, the steps between lock points. The last two windows are very interesting. Drift rate (Hz/s), standard it’s set on 20Hz/s, meaning that your oscillator is allowed to drift utmost (20x60s) 1200Hz/min! Feasible for all homebrew oscillators. Secondly, VFO correction rate

80Hz/s, this simply means that the integrator should correct the oscillator as close up to 80Hz per second maximum. **This window saves hours of trial and error on the workbench because this is the only tricky part involved with a huff and puff stabilizer.** Evidently, if the integrator is to slow the control loop can never stabilize but if the integrator is to 'speedy 'it will cause the oscillator to 'overshoot' to other Nexor +1/4 points.

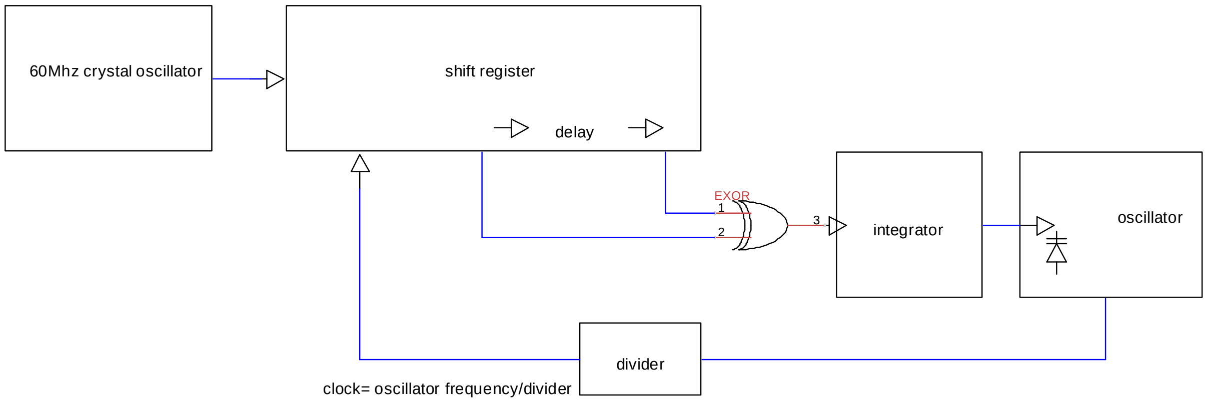
Et voila, that's how I believe a H&P stabilizer works.

But I could be totally wrong….

An all band huff & puff oscillator.

Part 2, building it.

On1mws bossuytdanny@gmail.com



block scematic huff and puff stabelizer

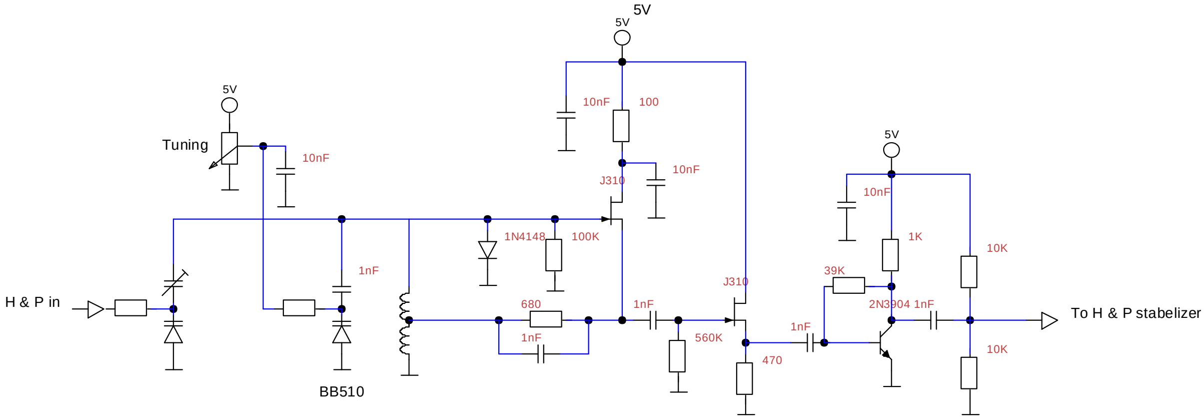
1) The proof is in the pudding.

So now I think I figured out how a H & P works, it's time to test If a 'fast' H&P truly can keep one of my homebrew junk oscillators on a tight leash. It had turned in 2019 before I found time to really give it a try. What I'm looking for is a oscillator that's capable of tuning from about 5 to 35 MHz. And stable enough to be used in a transmitter.

Obviously I had to start out with an oscillator. I planned a relatively low-frequency oscillator to attempt to stabilize as a simple test. Any attempt to start straight off with a high-frequency wide range oscillator will surely fail.

Early 2019 I build an Hartley oscillator followed by a high impedance J310 buffer. Later I encountered that the output voltage is slightly too low for the frequency counter and I added an extra amplifier. This added amplifier does not need to have a high input impedance so I used a junk box transistor.

My experience is that Hartley circuits always work at first turn on. All the Colpitts circuit I tried in the past always were bad-tempered things. Amazed to see that nearly all the homebrew oscillators on the net seem to be Colpitts.

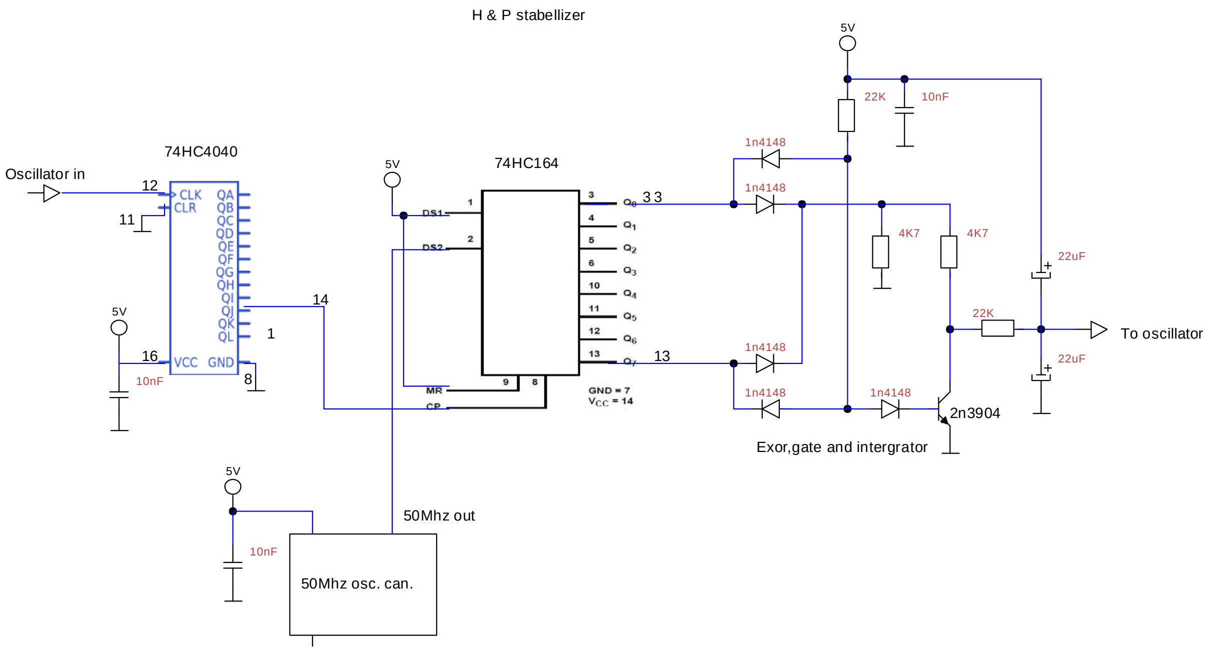


(there should be 100pF capacitor between the tank circuit and gate of the J310, drawing error)

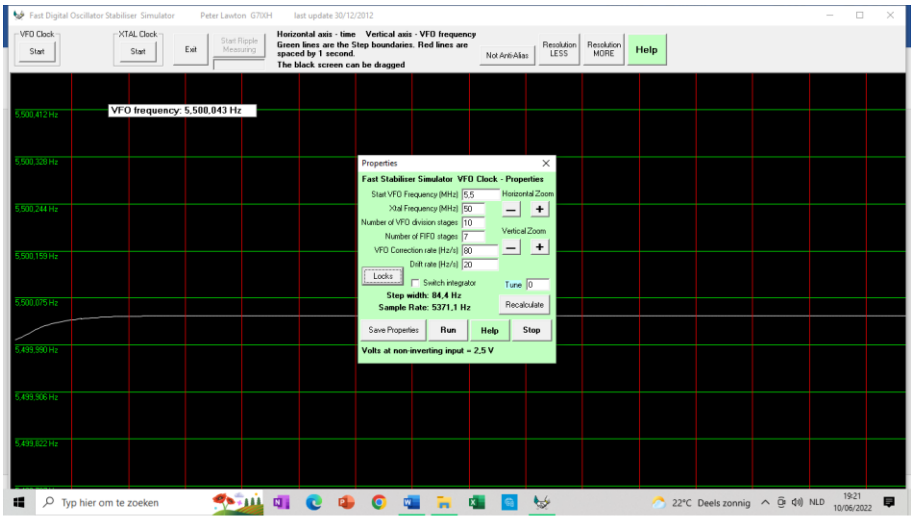
The varicap is a 500pF type used in MW radios. A BB212 should do just as well. Finding a varicap diode with such a big capacitance is an immense problem in modern times. Look for BB212's on eBay. Or try to find a good old fashion mechanical tuned capacitor. A separate varicap diode is added for the H&P. I'm not sure of the type, my eyesight has gone back, but it's a VHF varicap diode. Likely a BB329, a 3-30pF varicap. Any VHF varicap will do (later on I learned a normal 1N4001 can be used) The trimmer capacitor in series has his origins from my junk box and I have no idea of the value. Probably 40 or maybe 60pF. The coil has 20 turns of small wire on a 6mm plastic cylinder which is salvaged from a ballpoint. An air coil will give you much more stability than a coil wound on a ferrite core.

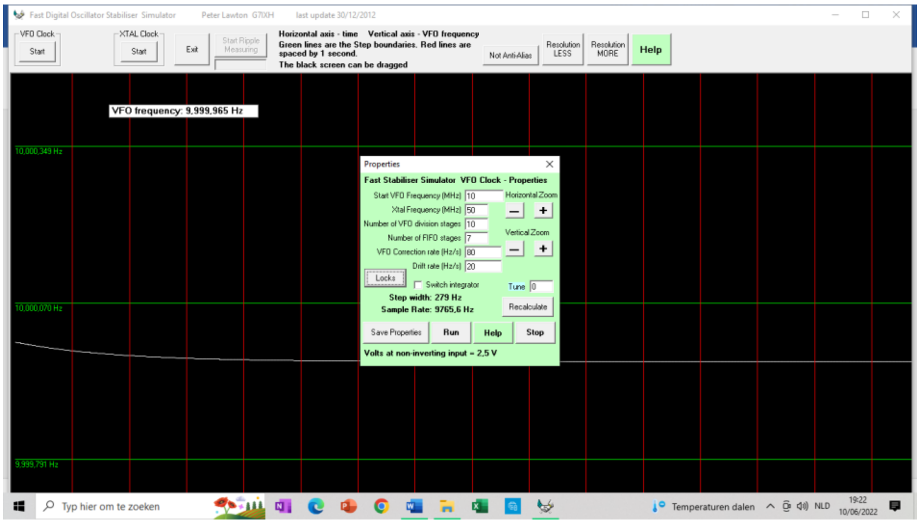
How does it perform? The oscillator turned out to tune from about 5 to 10Mhz. Evidently, it drifts. How much? Well, it goes up and sometimes comes back again after some hours but the short term stability isn't so bad. Less than the standard 80Hz/S I noticed in the H&P calculator. That wasn't so difficult because building this oscillator wasn't my first.

One thing was worrying me a lot. Say the overall capacitance of the small varicap/trimmer is on average say 20pF. A quick look at the datasheet of the main tuning varicap (BB510) learns me that the capacitance will be between 500pF and 100pF. So when tuned to the lowest frequency the ratio between the two Varicap's will be 1/25 and when tuned to the highest frequency 1/5. Plainly the control voltage of the H & P circuit will have much more effect when tuned to a higher frequency. The oscillator will react much more violently on anything the H & P says when it is tuned on higher frequencies. The right speed will be very important for a stable control loop. And a constant stabilization speed is clearly impossible for a wide range oscillator. The only **complete H&P oscillators** circuits I have found after a long search are 3 circuits build by Hans Summers. The frequency ranges of his designs are not clearly stated but one look at the component values tell me that his circuits have a narrow frequency range. So I wasn't even sure if a lock over a wide frequency range is possible at all.

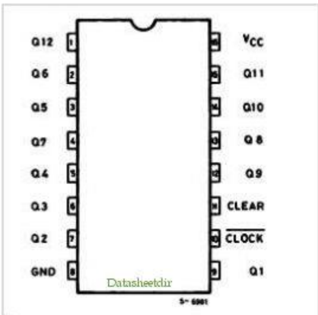


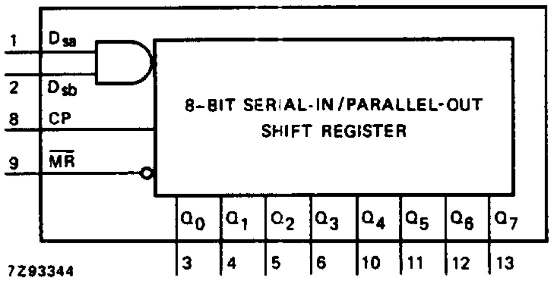
And above the H & P stabilizer… After measuring the oscillator frequency and playing with the H & P calculator (page25) I connected “divide/2 step” x10 (pen 14) to the shift register (74HC164) which should result in a lock points steps of about 84Hz when the oscillator is operating at 5,5MHz and 279Hz when it is operating at its highest frequency of 10MHz.





The lock points, above say 6,5Mhz, are obviously to widely spaced for a practical ham receiver/transceiver but the above setup is just a test. I figured the H & P is more likely to lock when I set my goals not too ambitious. A success, even a modest one, to build on is what I need, not endless frustration.





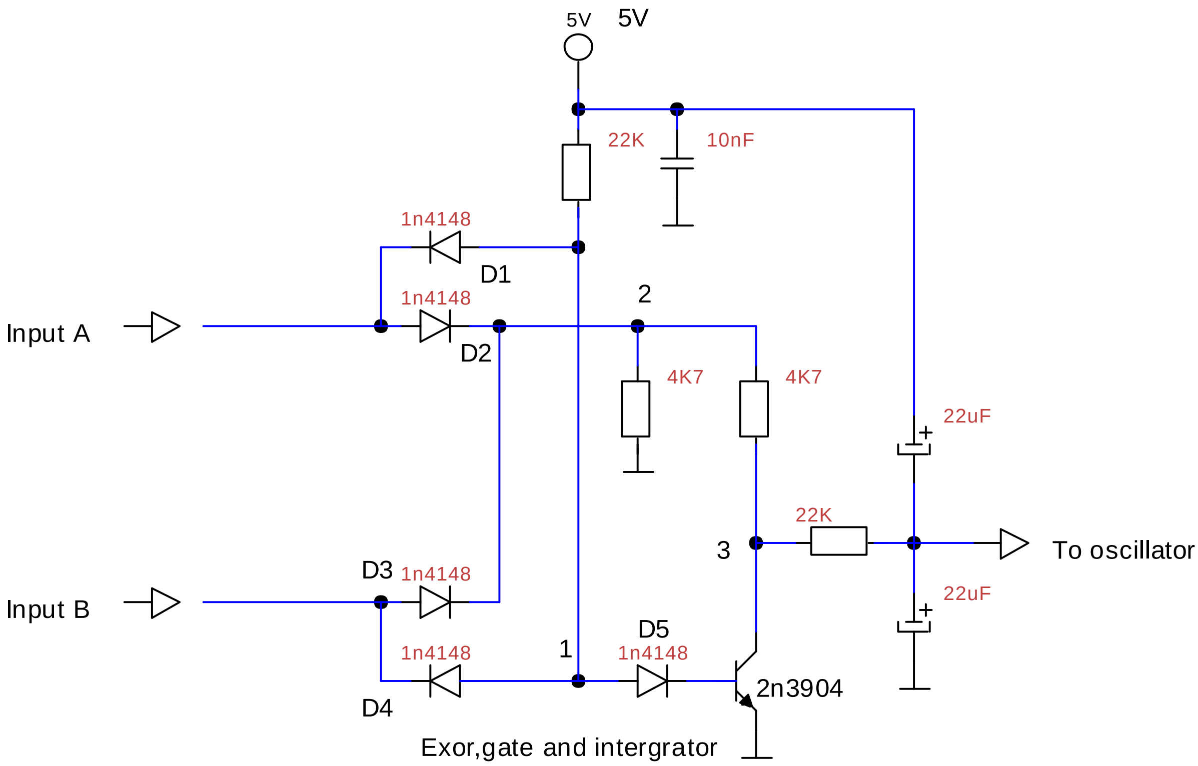
Pinout of a 74HC4040.   Functional diagram of a 74hc164 shift register.

The discrete exor gate and integrator are discrete and not IC's and are a copy of a circuit from Hans Summers G0UPL. I liked it more than using a logic IC that contained an exor gate and an opamp IC. Takes much less space. Soldering two IC's dead bug style is no fun present as well. And using an opamp integrator implies using a relatively high, expensive capacitor. To be on the safe side I would have to order several different values while Hans Summers G0UPL's design uses ordinary electrolytic capacitors, and I have many in my junk box to play with. However, how his circuit worked was not clear to me.

Exclusive-OR gate

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

So this is the function we need to achieve.



G0UPL's design

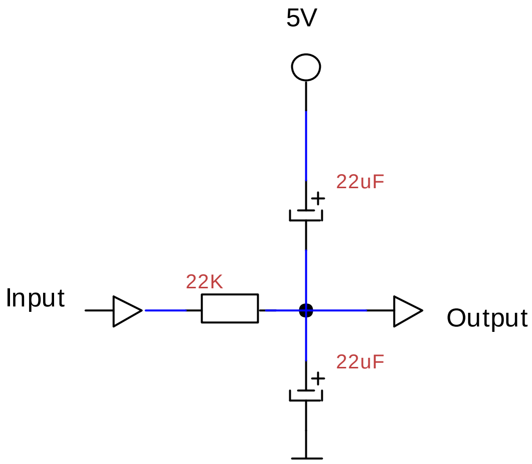
First, there's the transistor. It can only conduct when the voltage on point 1 is 1,2V. the 22K resistor will make this possible **provided D1 or/and D4 do not conduct.** Any voltage on the output of the integrator (point 3) will also provide a collector voltage for the transistor. If input A or/and B are 0 these diodes will conduct resulting in a voltage of 0,6V on point 1 hence disabling the transistor.

If both inputs are 0 the transistor will not conduct (both D1 and D4 conduct) and the voltage on point 3 will not increase or change because in that case D2 and D3 will also not conduct.

If one of the inputs is 1 the transistor will still not conduct (either D1 or D4 will conduct) but via D2 or D3 the voltage will increase on point 3.

Finally when both inputs are 1, both D2 and D3 conduct and should increase the voltage on point 3 but this won't happen because in that case, the transistor is able to conduct via his 22K base resistor since both D1 and D4 do not conduct. The transistor will counteract the combined action from D2/D4.

Clever design! The voltage on point 3 will only increase if only one of the inputs is 1.

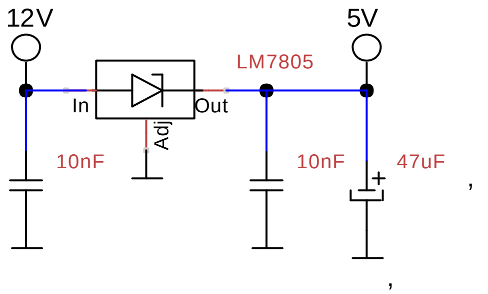


;

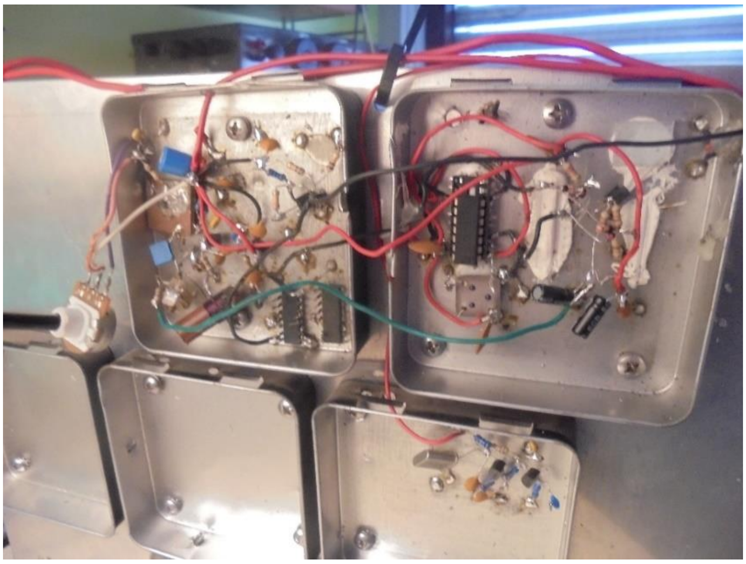
The integrator function is done by the time Constance of the combination of the 22K resistor and capacitors. The output voltage will follow the average voltage of the pulse train on the input and this pulse train will be rectified into a DC voltage. The capacitors need time to charge or de-charge if the average voltage changes from a changing pulse train and the speed of voltage change will be dependent on the component values. A bigger resistor or capacitors will slow the voltage change and vice versa….. One aspect I don't understand, where's the voltage reference?

Nevertheless, Hans Summers design was too tempting not to try. Simple, less space, much less construction time and using "house and garden" electrolytic capacitors.

In his Sprat article, Hans G0UPL claims the circuit needs a uniquely dedicated 7805 regulator. So I did do just that. The frequency counter is connected to another 7805.

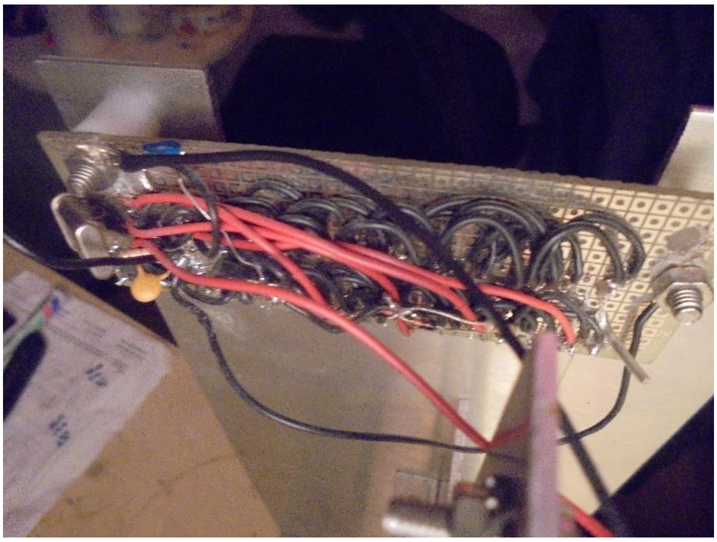


I'm a great fan of cigar boxes! Tnx to my cigar smoking colleague Patrick I can get them for free. With a little bit of sanding it'd easy to solder circuits "dead bug style" inside these boxes. The boxes in the picture above should contain the different circuits for the future SSB transceiver and two of them are reserved for the oscillator and H & P. Every box can be closed by a lid and therefore it's a piece of cake screening circuit modules from each other. The aluminum chassis is obviously connected to ground and every box is bolted and therefore connected in the shortest way possible to ground. You won't see any ground wiring in the picture below, can't be any less a low lead inductance construction than that.



Left, the oscillator and divider. The tuning potentiometer is dangling in the breeze. To the right, the shift register, exor gate, and integrator.

The frequency counter is a copy of the design by Wolfgang “Wolf” Buscher DL4YHF. All information can be easily found on the net. His design is perfect and has many cool features like adding or subtracting frequencies. I can recommend his design but if you copy it as I have, you’ll have a tooth grinding chore ahead.



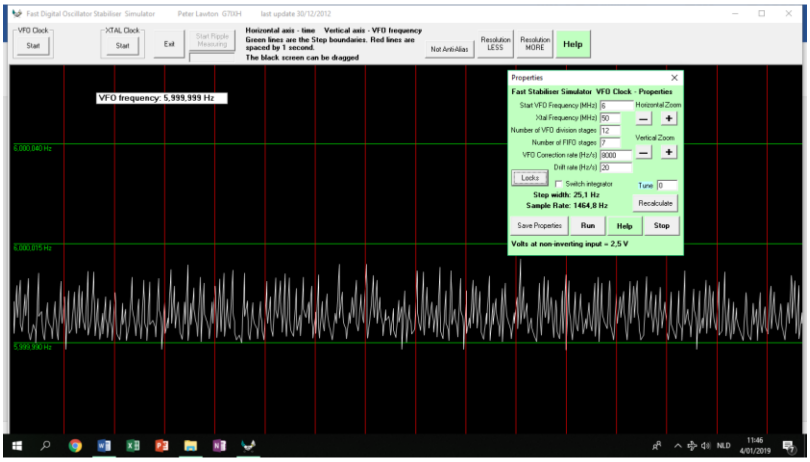
Before testing the control loop I fed the oscillator signal to the H&P and **didn’t** connect the output voltage to the oscillator. On pen 14 I could clearly see the divided oscillator signal. I closely examined the on/off time of the signal. Looked like a perfect 50% duty cycle. On pen’s 3 and 13 of the shift register two pulse trains were visible. Astonishingly erratic (!) pulse trains and clearly of a much lower frequency than the signal that’s on pin 2 (input). Checking the 50MHz signal of the canned oscillator required some taught. The datasheet told me that the canned oscillator had a "stand by" function but incredibly **not** how this "feature" was turned off or on, pfff, truly, so I needed to be sure. My old Hameg scoop only can handle 20MHz. But something could be seen moving at 2,5V and disconnecting the canned oscillator stopped the pulse trains on the outputs of the shift register. Must be okay. Much, later on, I realized that all that worrying and testing could have been avoided in a couple of seconds by just connecting the frequency counter on the canned oscillator. Finally, I monitored the average DC voltage at the output of the integrator. Clearly, the voltage was going up and down a bit. As far as I could tell the H & P circuit was doing anticipated things.

2) Plug and pray.

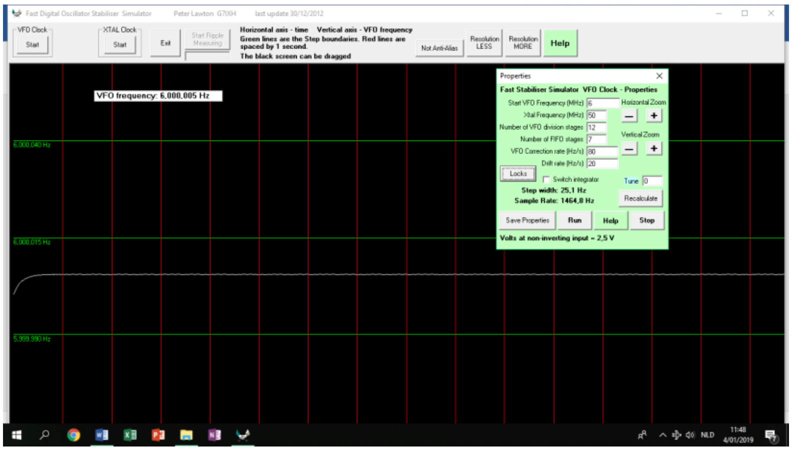
And then came the moment of closing the control loop….. yes the H & P locks on 😊. It locks over the complete range of the oscillator. Homebrew is very satisfying on such moments. Did I mention my previous two H & P stabilization attempts with the basic PA0KSB circuit that failed? Well, the "fast" G7IXH design can indeed do better and truly tame a drifting "homebrew" oscillator. The smallest resolution on my frequency counter is 100Hz, one look at it and its clear that the H & P does what it's supposed to do. Keep the oscillator on a very tight leash. For hours I couldn't see the 100Hz digit move….. Wow.

Now it's time to play with the circuit, to get a "feel" about it. I changed the variable capacitor in series with the VHF varicap diode on minimum and maximum to see if the H & P keeps locking. And yes it does 😊. Setting this capacitor on minimum significantly reduces the influence (and speed) of H & P on the oscillator however the H & P keeps on locking flawlessly. When the shift register is connected to pin 15 (divide/2 x11) the H & P keeps on locking on the whole range of the oscillator provide that the trimmer capacitor is set to minimum. The trimmer set on maximum results in a wobbly oscillator. The lock points with this setting should be 42Hz at 5,5Mhz and 140Hz at 10MHz. In conclusion, I connected the shift register to pin 1 of the divider (divide/2 x 12 instead of x10) which should result in real-world lock points of 21Hz at 5,5MHz and 70Hz lock points at 10Mhz, acceptable for an SSB transceiver or even a CW transceiver. At first, I thought that there was a lock on 5,5MHz provided that the capacitor trimmer was set on minimum but after some minutes it was clear that the H&P loses his lock. With the trimmer set on maximum, it couldn't lock at all. On 10MHz the H&P never locked and the oscillator started hunting.

The trimmer settings convinced me that my integrator reacted to quicly. And if the lock points are chosen closer, this becomes more obvious. Then, the H&P is more likely to "overshoot".

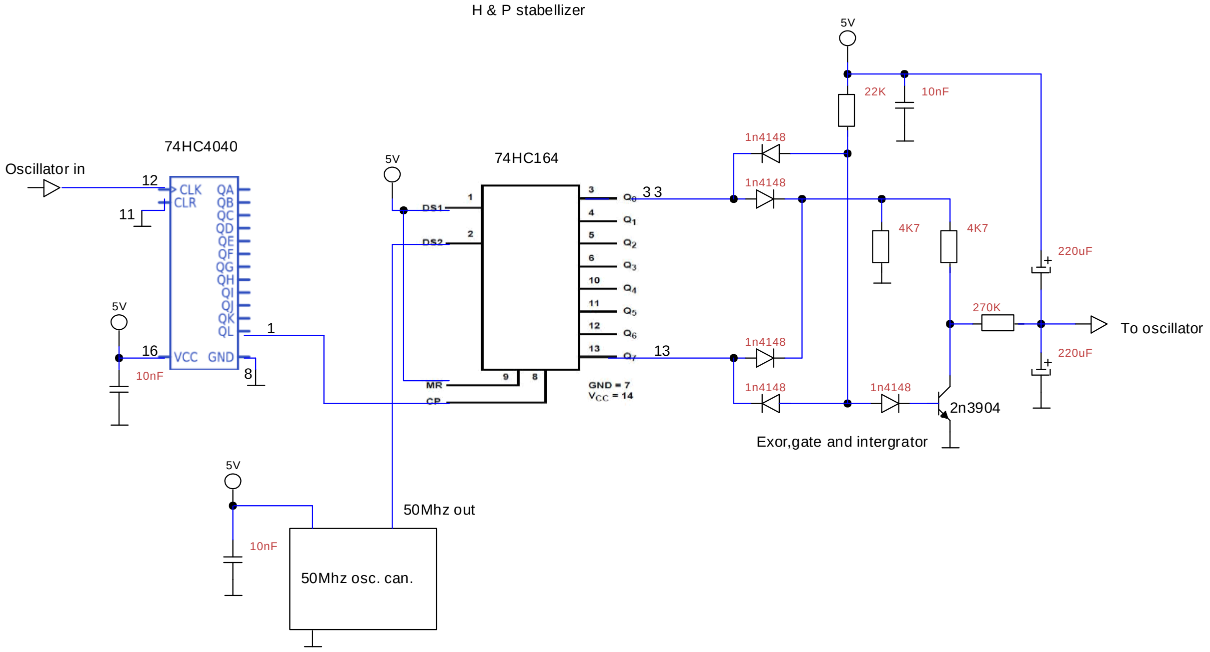


Lock points 25Hz apart, N12. Yes, the H & P starts to overshoot.



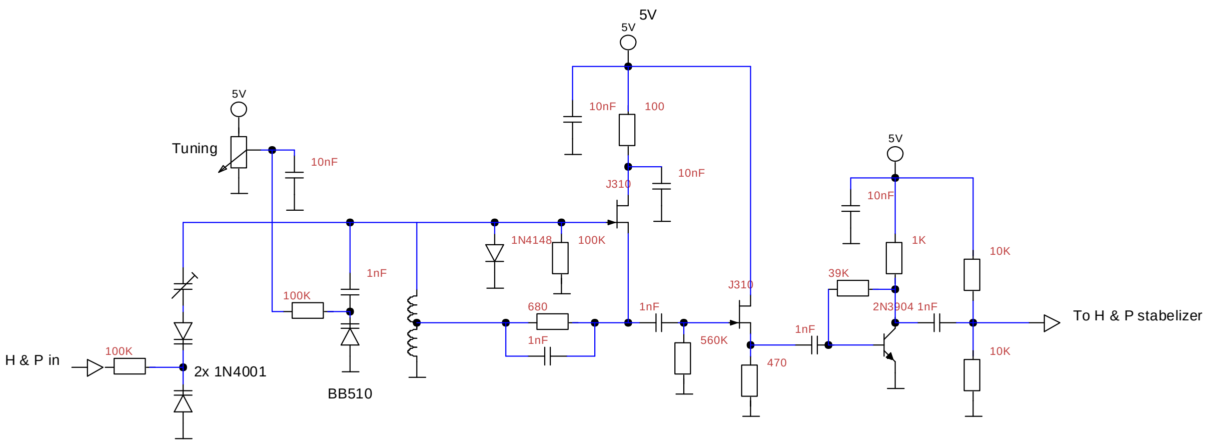
Lock points again 25Hz, N12, apart but with a much lower correction from the H & P. What a difference.

Two things could be done to stop the H&P to overshoot. First, reduce the frequency change that the H&P varicap causes and secondly, lower the speed of the integrator function. After much trial and error, I ended up with the schematic below.



The speed of the correction is much lowered by increasing the elco’s (220uF instead of 22uF) and resistor (270K instead of 22K) of the integrator.

(above experiment was done early 2019. At the time I could not get my head around the fact that my values for the integrator were so much higher than the ones I saw in Hans Summers schematics. In 2022 I got in contact with John Kleinbauer who has built an 3,5Mhz H&P oscillator. John is the only guy I know who actually build an working H&P. The values of his integrator are 22K and 100uF, also higher than Hans values. The final version of my project ended up with 470K/220uF (page 58). This oscillator runs at a significantly higher frequency than John’s. The logical conclusion might be that the higher the oscillator frequency is, the slower the integrator must be?)



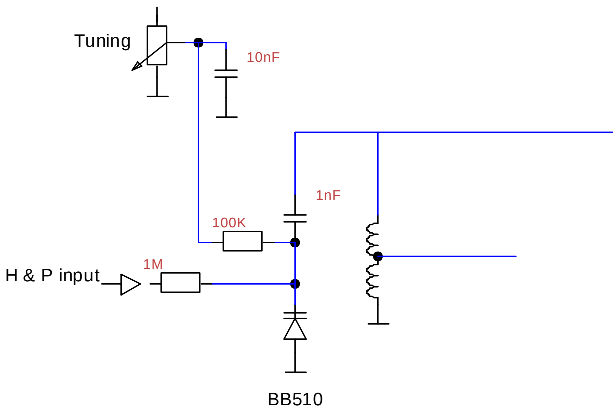
(there should be 100pF capacitor between the tank circuit and gate of the J310, drawing error)

Reducing the tuning range of the H&P proved to be more difficult. I replaced the VHF varicap with an ordinary rectifying diode. To my bewilderment ordinary 1N4001 diode's proved to be just as effective as real VHF diode's. Two of them in series proved to be an slight improvement.

It does lock connected to N10 and N11 but…. When connected to N12 (with usable lock points between 25 and 78Hz) the lock is no longer reliable. This new, slower H&P **can lock** on both 5 or 10MHz but need two different settings of the trimmer capacitor to do that. It seems like a wide range oscillator, like my 5 to 10MHz, cannot be locked over the entire range if you choose lock point close.

Because of the wide change of capacitance of the main tuning varicap, unavoidably the speed of the correction of the stabilizer is considerably different over the frequency range.

Time for a different approach.



Getting rid of the H&P varicap altogether, seemed like a good idea. I've seen this in the schematics of Hans Summer. Yes, it does lock reliable but I found out the resistor value is very critical. Connected to N12 a lock over the entire 5 to 10 MHz range proved again impossible.

3) Verdict?

So I have learned a lot. A 'fast' H&P can truly tame one of my homebrew oscillators, which is astonishing. Only with a couple of standard logic 1970's IC's. This 'fast' H&P is a completely different beast than the 'basic' H&P that I tried in '08 and '10.

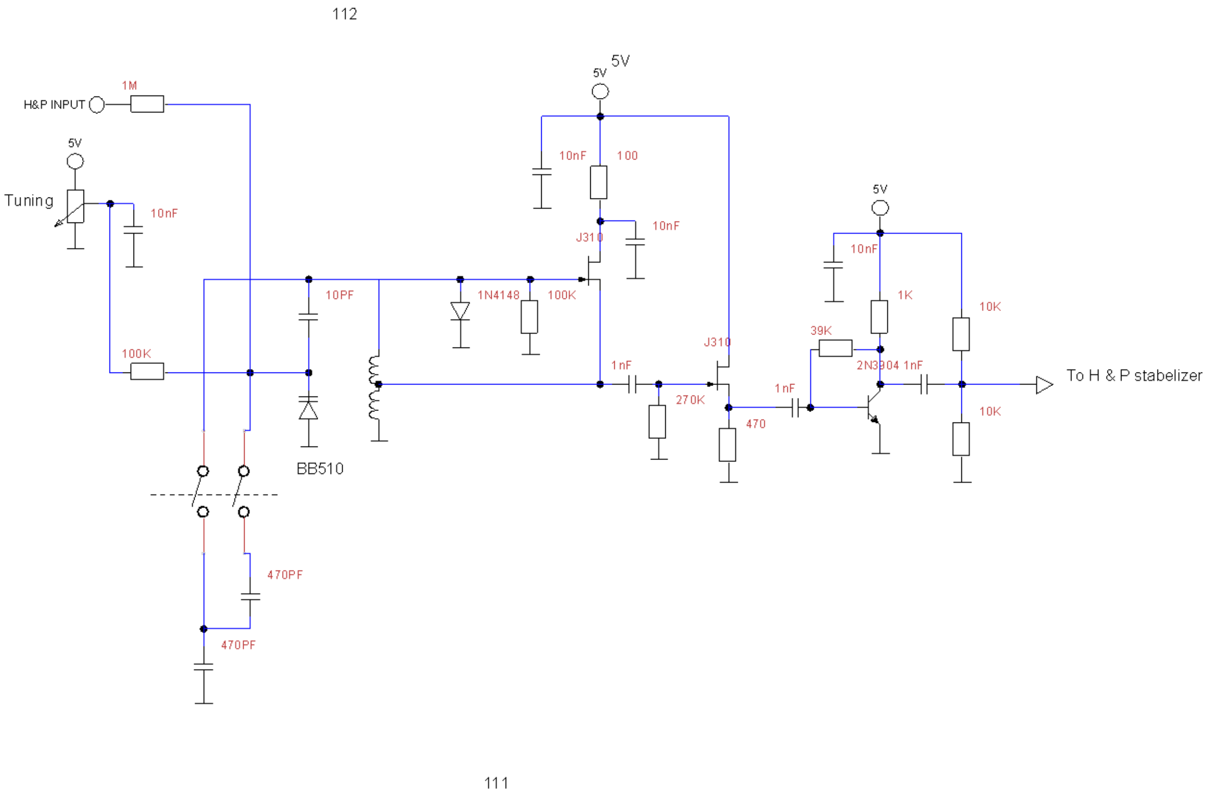
Unfortunately, I have also learned that I can't stabilize the wide frequency range oscillator I'm after (with practical lock points) Regrettably that's exactly what I need, a +- 6 to 34Mhz oscillator for the future transceiver.

4) A change of tack.

I connected a resistor in series with the tuning potentiometer limiting the tuning range from 5.5 to 7Mhz and yes this time the H & P locks on over the entire range with practical lock points.

Stabilizing a homebrew oscillator with bandwidth over 1Mhz is quite impressive. All amateur bands cover less than 1Mhz (except 10M) Aha, the solution seemed obvious. Nine separate tuning ranges with a bandwidth of +-1Mhz.

It took a lot of trial and error to find a way to change between different frequencies and **keep a 1Mhz tuning bandwidth for each frequency band.** It really took masses of effort but I was motivated… the alternative was eight or nine separate narrowband oscillators… not an attractive alternative...



(there should be 100pF capacitor between the tank circuit and gate of the J310, drawing error)

Eventually, I came up with the above two-band test circuit pretty close to the minimum and maximum frequency I need for my future SSB transceiver.

The BB510 is an MW varactor. According to the datasheet, it has a capacitance between 600 and 100pF if it is controlled with 0 to 5V as I do. When the switch is open, a tiny 10pF capacitor is in series with the BB510. Effectively altering the large MW varactor into a small VHF varactor, resulting in a tuning range of 28,9 to 29,9Mhz. When the switch is closed, a 470pF lowers the frequency **and another** 470pF is switched in series with the BB510 resulting in a tuning range from 4,9 to 5,9Mhz.

See? Both the high range and low frequency range have a similar tuning range of 1Mhz.

I tried several ways to switch the capacitors "electronically". I tried switching with diodes, transistors, FET's, all attempt failed. So the only way is with "real" switches located close to the oscillator.

I figured **not** to use a separate H & P varactor but use the direct resistor coupling. Using the same varactor for tuning and stabilizing. Therefore the 0 to 5V control voltage originating from the H & P will always have the same frequency change whatever the frequency-range of the oscillator is. I hoped that this would result in a **constant correction speed** over **all** the frequency settings.

It turned out as hoped. The H & P locked impeccably in both the 4,9/5,9 MHz and the 28,9/29,9 MHz range for hours and hours on end.

From that moment on, I knew I would succeed and that my SSB transceiver will, one way or the other, end up with an all-band H&P oscillator.

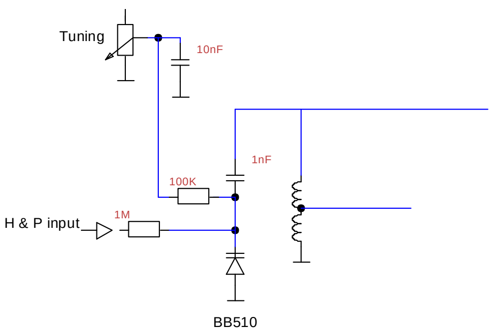
5) a new verdict.

A wide frequency range H&P oscillator, say something like 5 to 30MHz, isn't going to happen.

But a… multi "1Mhz bandwidths" H&P oscillator with practical lock points is possible…

one value for the integrator resistor and capacitors seem to suit for both the lowest and highest 1Mhz bandwidth range of the oscillator, which is very convenient.

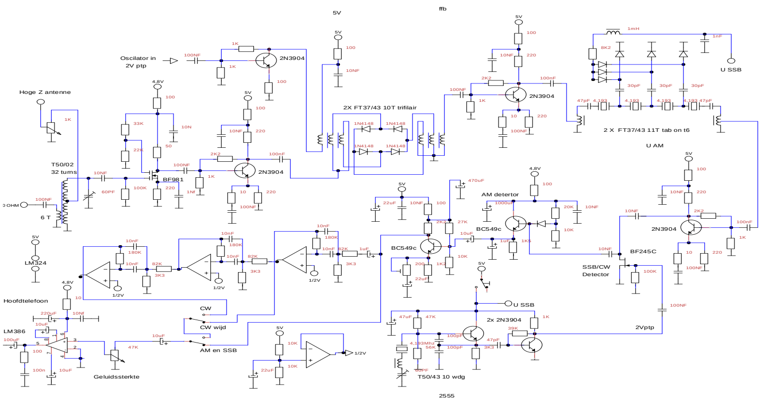
A multi "1Mhz bandwidths" oscillator is only possible with a varicap tuned oscillator and with the control H&P voltage fed into the main tuning varicap.



To avoid a modern DDS for my planned all-band SSB transceiver, and have some real homebrew pleasure, I'll gladly settle for this kind of oscillator.

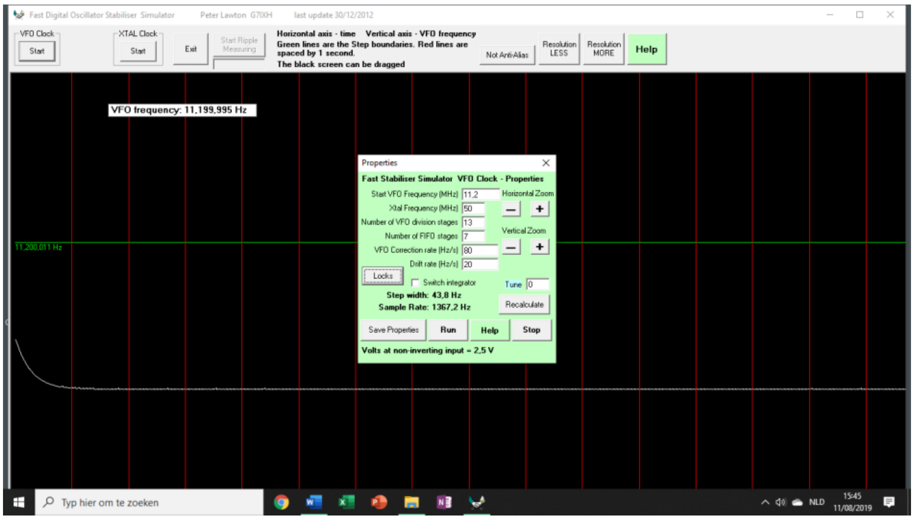
6) A enticing side-project.

Now I had a clear idea of how to make a multi-range H&P oscillator but before starting I had an inkling for a side project. I have this little battery-powered 40 M band receiver. It is a simple, fun radio that goes along on holidays. Even a simple piece of wire of say, 2 M, brings in stations.

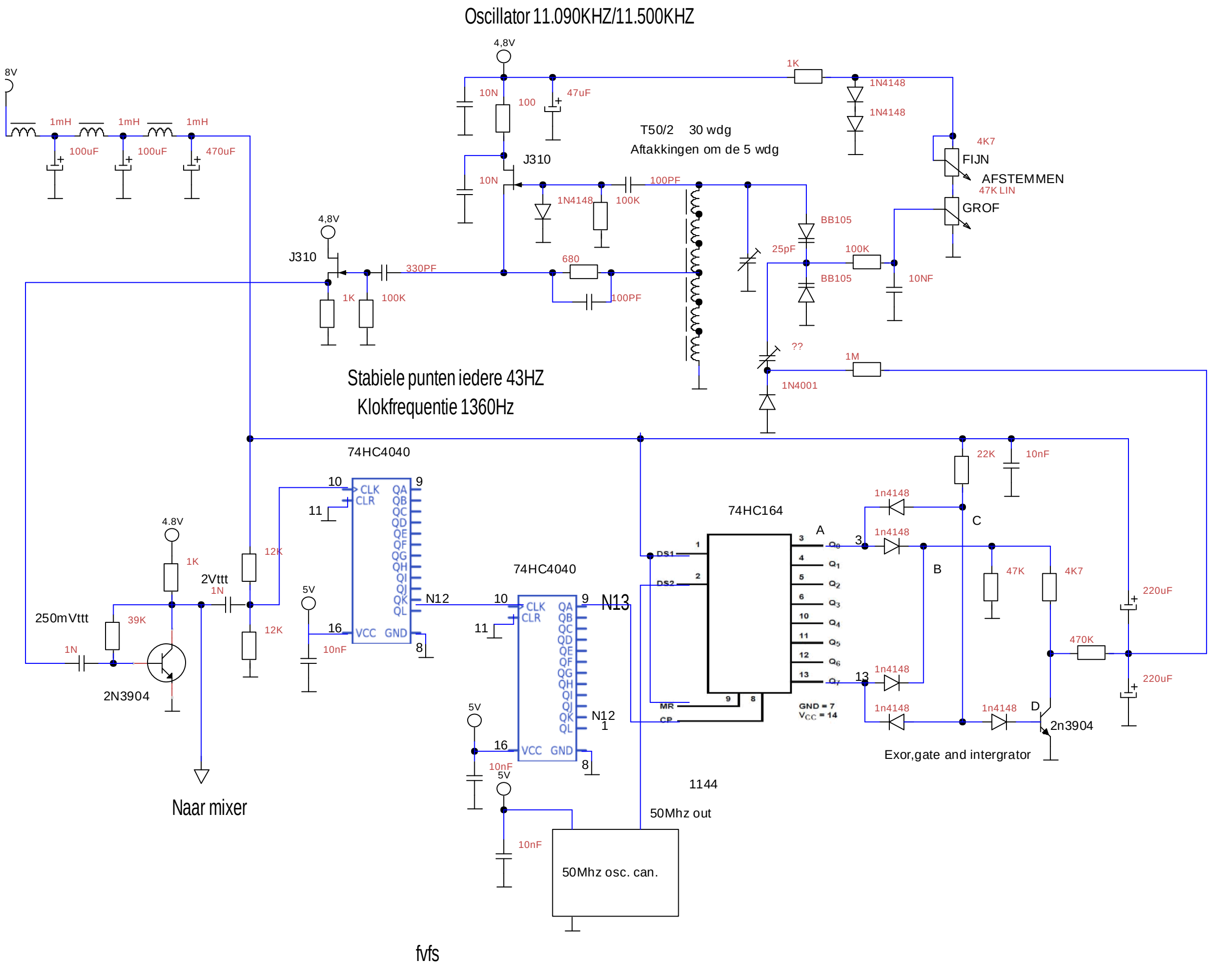


Obviously, this simple set has one big failing. It’s humble free-running oscillator. Every few minutes, you're busy re-tuning. It’s difficult to measure the drift. It all depends. Still, the drift is always lower than 80HZ/sec. The inexpensive components for the H & P were ordered double so soon I figured to uses these excess parts for a quick fix for the frequency drift.

With the hands-on experience of the test H & P, the construction was easy. With the help of Peter Lawton’s calculator, I chose lock points 43Hz apart. Practical lock points and even pretty ambitious as well.



Because the oscillator only needs one tuning-range of 0.5 MHz (from 11 to 11,5 MHz) I opted for the separate H&P varicap design (which is an ordinary 1N4001).



Above, the final schematic of the oscillator and H & P control. It turned out to work flawlessly. Once tuned into a station… you simply stay tuned. You can walk away, make you're self a coffee. When you return the radio is still on track. What a luxury.

7) Getting a lock on any frequency you want.

Obviously you first need to check if your oscillator is actually capable of operating in the frequency of your interest. A maximum 1Mhz of tuning range is about it.

What if you have little or no experience in building oscillators? How hard is it? The Hartley oscillator on page 28 works always. Normally on 5V but it also works on 8 or even 12V. Just center-tap the tank coil. The varicap on the schematic on page 28 can be swapped with a ‘vintage’ variable capacitor. Finding the values for the coil and capacitor is easy with the many online ‘resonant frequency calculators’. After you measure the frequency of your oscillator you might be slightly off but you’ll be in the right ballpark. And then there is ‘Coil phobia’, the fear of winding coils. Winding coils isn’t that hard. After you have established the value of the coil that you need, you will likely need a T50/2 (red) or T50/6 (yellow) Amidon toroid core. There are ‘Amidon power iron coils calculators’ online. Just fill in the value that you want, The size core you have (say, T50 or T68) and the material (red=2, yellow=6) and press calculate. The calculator will tell the number of turns. Building a working oscillator is easy, getting it not to run around like a madman is the difficulty.

Finding the correct divider N-number that you need for practical locking steps in advance, is easy whit Peter Lawtons online calculator (page25). I have experienced that lock steps of about 70 a 80 Hz are still practical to listen to CW. Anything less than 50Hz is striving. Hans Summers H&Ps use a 60Mhz canned reference oscillator, I couldn’t find them and used 50Mhz canned oscillators. The calculator can be set for any reference frequency.

Finding the right value's for the integrator was easy to. Tnx to the test oscillator, I had a method.

First I started with a resistor of 22K and elco’s of 22uF (like in the schematics of Hans Summers) and searched for a lock on a low N-number. A N-number which will have a way to large and impractical lock step. But easy to lock for the H&P.

Secondly, after I was convinced I had a lock, I connected the EXOR to the next higher N number.

If the lock remained, fine. Move to the next higher N number. If not, it meant the H & P was too fast and then I increased the values of the resistor and elco’s. And therefore lowering the speed of the H & P.

Once I had a new lock, the divider was locked to the next higher lock point and checked if the lock remained. If not, the integrator resistors/capacitors were increased again to further slowdown the integrator.

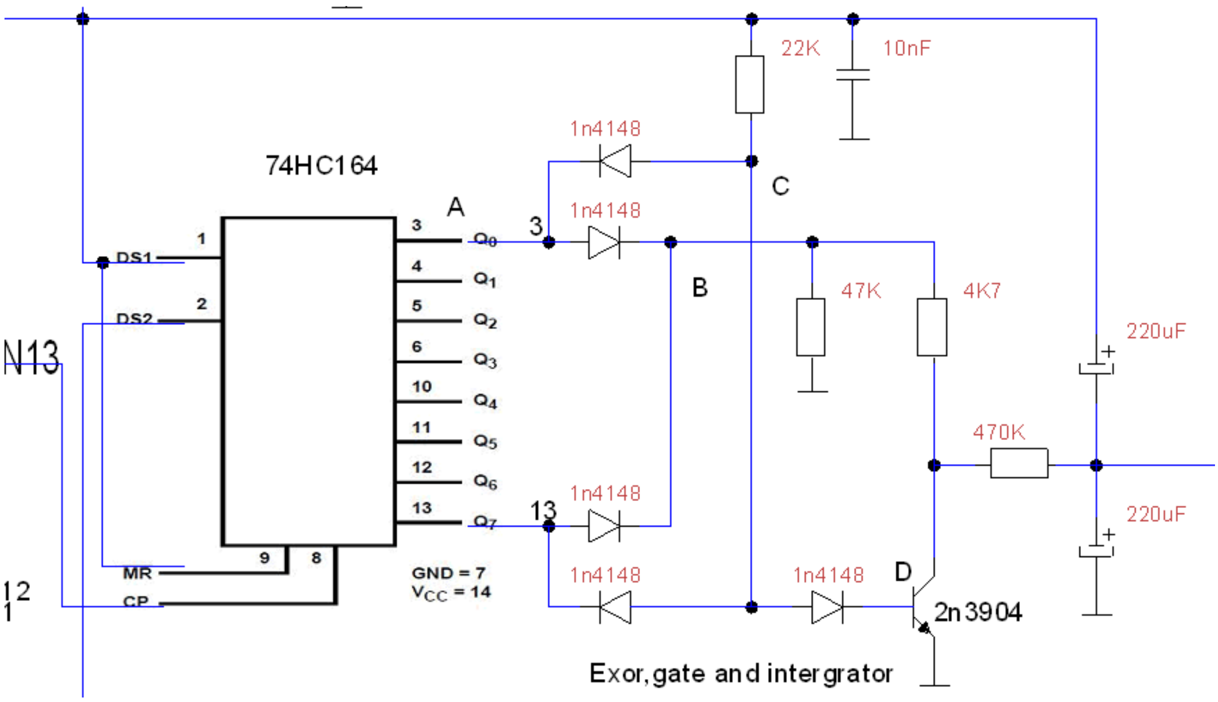
My experience was that every single time I lost a lock after connecting to a higher N-number, the lock returned after lowering the speed of the integrator.

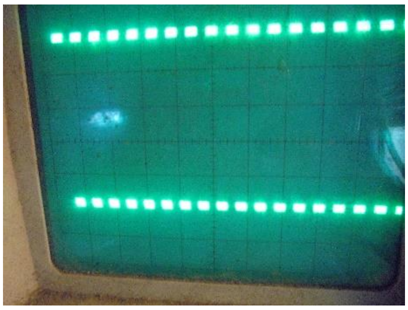
This way I work my way up, step by step, to the N-point I needed to have a practical step with.

In case of the holiday radio I eventually ended up with an resistor of 470K and elco's of 220uF for the integrator.

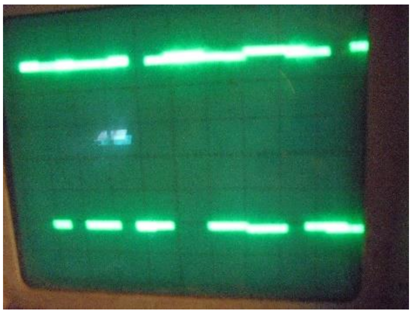
Worked like a charm for me.

So, how can you be sure that the H & P is doing his job?

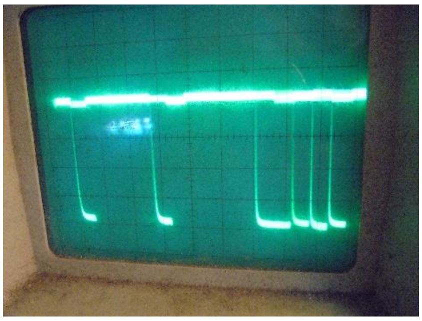




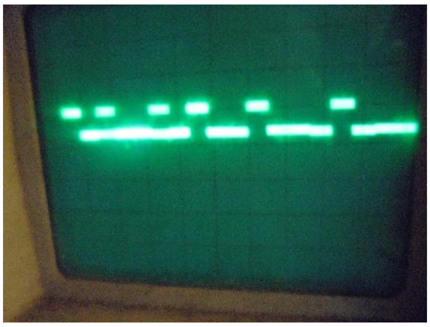
At pin 8 of the 74HC164, you should see the divided oscillator signal. A continuous 5V pulse train.

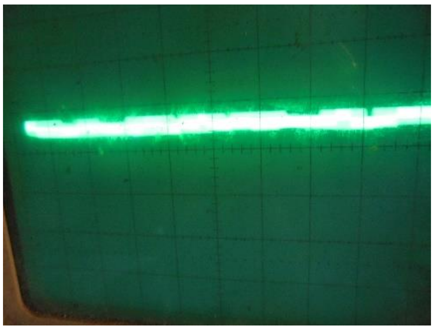


At pins 3 and 13 of the 74HC164, you should see an erratic 5V pulse train of much **lower frequency** than the one on pin 8. A very erratic pulse train!



So what’s to see in the EXOR circuit? On the spot marked “B” on the schematic, you should see the 5V pulses shown above.





The pic left shows the signal on the spot marked “C”. No longer 5V pulses. The pic on the right shows the signal seen on the base of the transistor. This signal is exactly the same as on spot “C”, only half the size

Some conclusions?

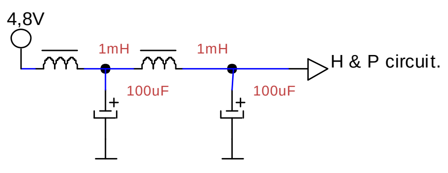
1) Don’t stare yourself blind on the integrator from Hans Summers schematics. My resistor and capacitors are a magnitude higher, still the H&P Locks flawlessly (whit the values of Hans, my oscillator starts hunting violently)
2) Don’t be afraid to really slow down your integrator. The higher your oscillator runs, the slower your integrator will be.
3) At one point I had to increase the intermediate frequency of the SSB transceiver. So, the all-band H&P oscillator frequencies had to be changed to. Obviously, with new N-points but I could keep the same integrator values of the first version despite the fact that the H&P had to lock on a completely new set of frequencies.
   Apparently a oscillator and H&P have a ‘hand in glove’ integration time for the control loop, which might be kind of independent of the actual frequency the loop runs on?

8) Every solution creates a new problem to solve.

However….. there were clouds on the horizon.

I had solved the annoying frequency drift of the holiday-radio, but as always in homebrew, I created a new problem. The audio of the radio was now howling and whistling.

This came as a surprise. I was actually so ecstatic with the frequency stability I didn’t notice the whistling at first. The source of the trouble was without a doubt the new add-on H & P circuitry. I was very disappointed. Three causes seemed probable. Radiation, contamination of the power supply or maybe even the correction pulses leaking into the oscillator frequency? The latter didn’t seem possible to me due to the long integrator time. Radiation was a probable cause I really dreaded because that meant reconstructing the circuit in a shielding of some sort. It turned out to be contamination of the power supply.



5

This was fixed with a 2 pole LC filter uniquely dedicated for the H & P circuitry.

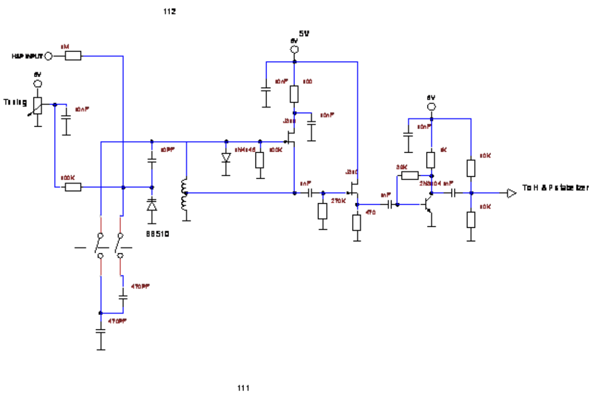
The H & P circuitry can be seen at the bottom of the picture.

Compared to a PLL or DDS the H&P has only one drawback. It can't handle physical shocks.

You can walk around with a PLL/DDS, drop it, put your coffee mug violently on the table, use it in a submarine under depth-charge attack… but not an H&P. Any shock will make the circuit jump to another locking point.

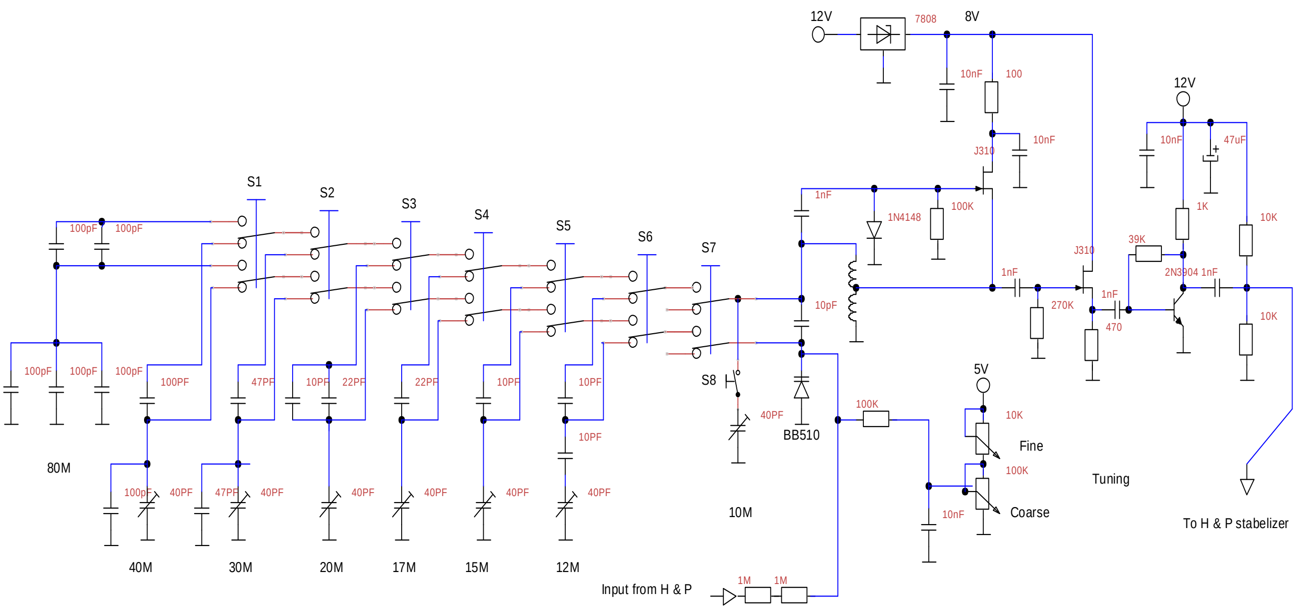
Yet, The H&P is ideal to provide a frequency stabilization for such a simple homebrew radio. It's simple too and cheap. Much simpler than a PLL circuit. It doesn't take much space. And once completed, and working, you're sooo pleased with yourself. No DDS pre-fabricated kit can ever give the same pleasure.

9) The home stretch.



Remember the double-range test oscillator? Below the expanded multi-range H&P for the planned SSB tranceiver. There are 8 bands with about 1MHZ bandspread eatch. The switches are differentely connected to the oscillator than in the test version. They are connected in such a way that the switches/tuning capacitors that are not used are ‘inviseble’ for the oscillator. Every switch adds capacitance to the oscillator bringing the maximum frequency down, up to a point, that I could no longer reach the 10M band. So they had to be connected this way.

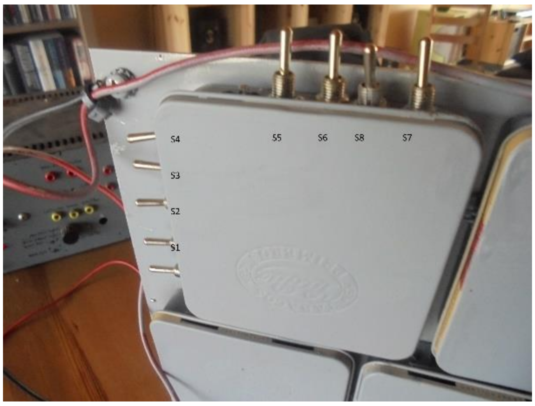
yfyy



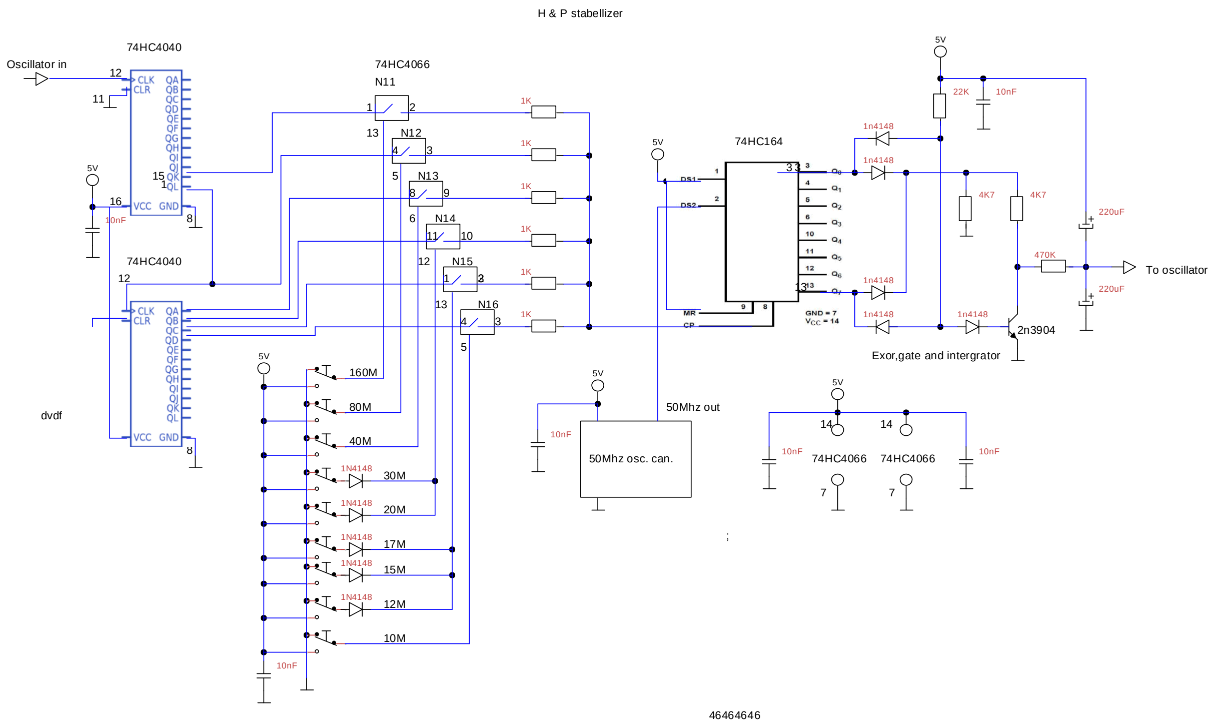
yfyy

But the basic idea is the same as the test version. Every switch connects a capacitor to ground **and** a second capacitor parallel on the capacitor in series to the varicap. After a lot of fiddeling **every range has a bandspread of about 1MHz.** I found out that 8 bands is the maximum that worked and that I had to increase the voltage to 8V, otherwise the oscillator doesn’t start up. 8 Ham bands out of 9 isen’t bad. I scrapped the 160M band.

If you close S7, you go to the 12M band. When S7 and S6 is closed you go to 15M, when S7,S6 and S5 is closed = 17M and so on… Works more practical than it sounds.



Left, the switches to choose the band.   Right, the innards.



Above the H&P for the multi-ranged oscillator. On different bands the H&P needs to be switched on different N numbers to have a practical lock points. This is done with a different set of switches on the front panel (also used to switch the band filters of the transceiver) The front panel switches operate digital 4066 IC's that do the actual switching. As expected one set of values (470K and 220uF) for the integrator fits all frequency bands.

(John Kleinbauer pointed out a possible drawing error to me. The resistor to ground from the collector of the integrator transistor should be 47K instead of 4K7. I know, I copied the integrator circuit from a Dutch Ham who copied it wrong from Hans Summers. Later on, after seen the original work of Hans, I realized the mistake. However, the H&P locks fine, so I left the 4K7 resistor in)

Left cigar box, the tuning range. Middle cigar box, oscillator and dividers. Right cigar box, H&P and 4066 switches.

Band/Frequency (MHZ)	Actual tuning range (MHZ)	Division	locks every(HZ)
80M; 3,5/4	3,3/4,2	N12	42/46
40M; 7 /7,3	6,5/7,7	N13	43/46
30M; 10,1/10,15	9,6/10,5	N14	35/
20M; 14/14,3	13,5/14,7	N14	57/59
17M; 18,068/18,168	17,6/18,9	N15	43
15M; 21/21,45	20,7/21,6	N15	55
12M; 24,89/24,99	24,4/25,3	N15	73
10M; 28/29,7	28,2/28,9	N16	44/50

Actual oscillator frequency is 4,193MHZ higher than the tuning frequency.

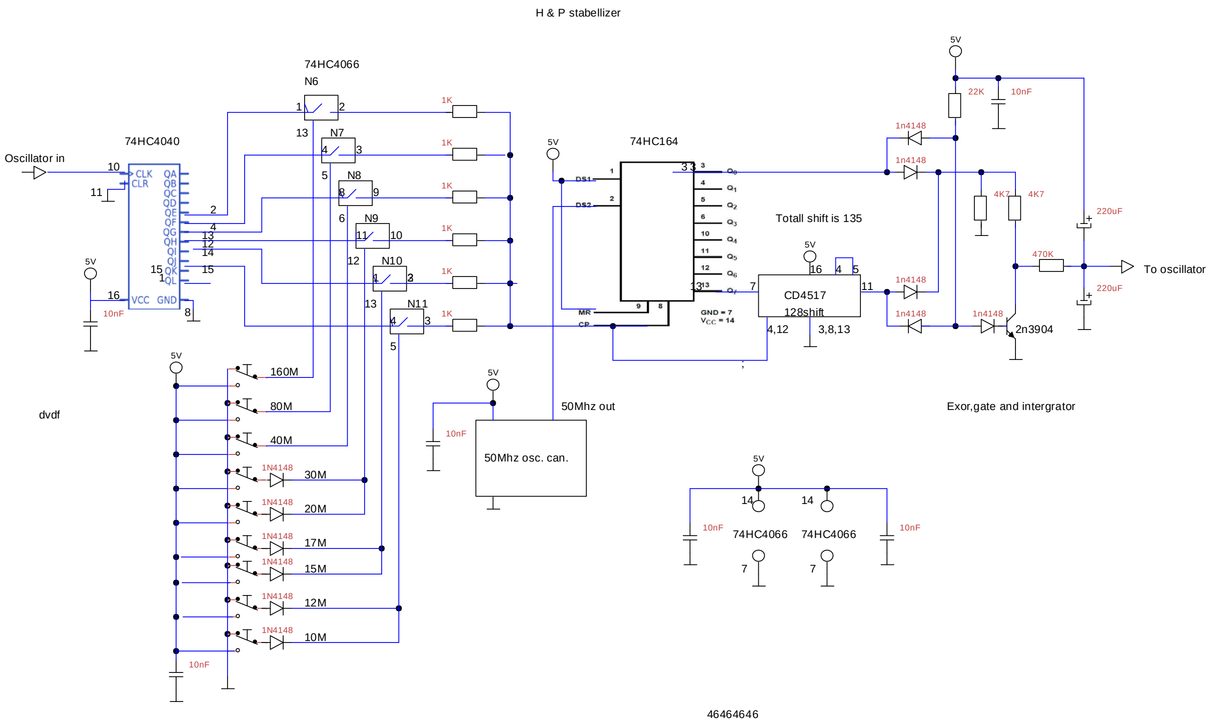
Finding the appropriate N-points to have practical lock steps was done whit peter lawtons calculator (page 25, part 1). For the integrator I ended up whit much higher values that the values seen in Hans Summer schematic. Turns out that the values I use seem for the integrator seem to be fitting for all the frequencies bands the oscillator needs to cover.

The multi range H&P worked right away and ever since. For hours the frequency doesn't move a budge. Except, the 10M band. On that band the oscillator runs on 4,193+28,5= about 32,5Mhz, the lock wasn't reliable there.

When the transceiver is started up, the slow integrator has to take his time to 'get up to speed'. First the oscillator frequency drops and drops until it starts locking. This takes a few minutes. This start-up instability takes a lot less time when I turn on the 'Holiday' radio. The reason is unclear to me. The fact that the Holiday has a unique varicap for the H&P might play a role?

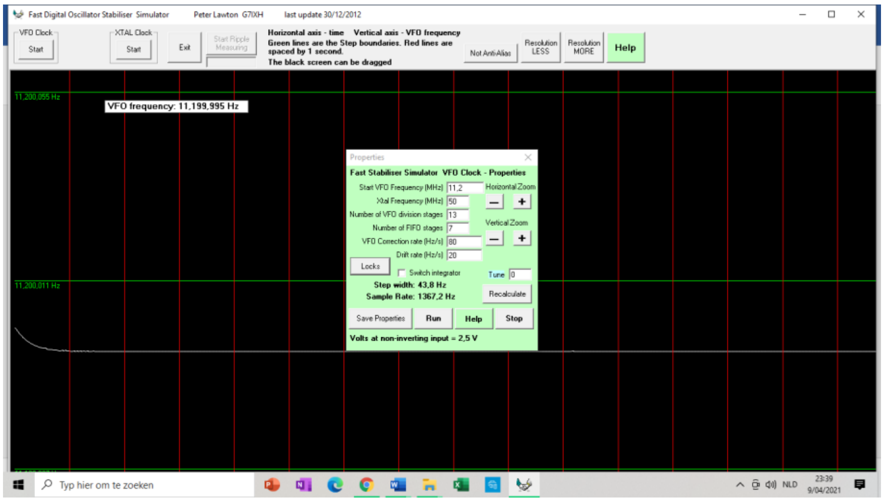
Retuning however never causes start-up instability. Even when you retune from one end of the band to the other in a fast way the H&P instantly locks again.

Nevertheless, I still wanted to try a further improvement. In one of his articles Hans Summers G0UPL suggest to further increase the shift with a CD4517 IC. This would increase the shift from 7 to 7+128= 135. That's a huge difference. A higher shift means a higher clock frequency and thus a , in theory, faster lock.

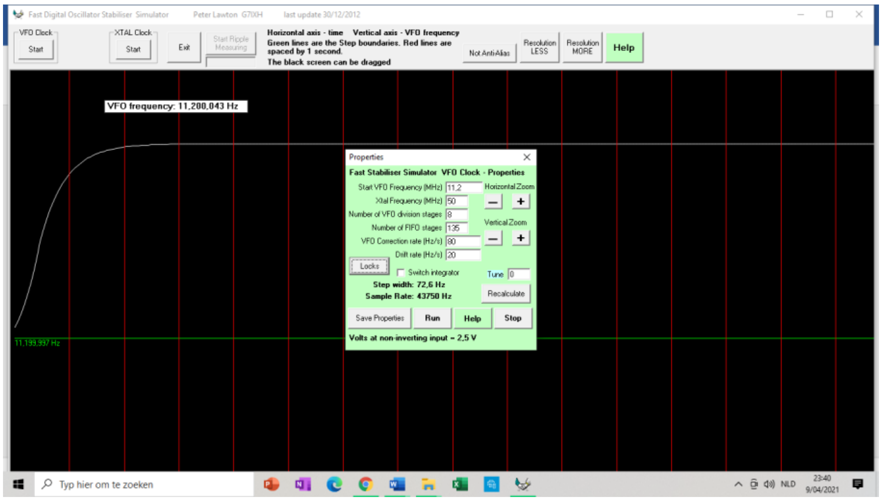


Band/Frequency (MHZ)	Actual tuning range (MHZ)	Division	locks every(HZ)
80M; 3,5/4	3,3/4,2	N7	70
40M; 7 /7,3	6,5/7,7	N8	75
30M; 10,1/10,15	9,6/10,5	N9	60
20M; 14/14,3	13,5/14,7	N9	92
17M; 18,068/18,168	17,6/18,9	N10	72
15M; 21/21,45	20,7/21,6	N10	91
12M; 24,89/24,99	24,4/25,3	N11	61
10M; 28/29,7	28,2/28,9	N11	69

Actual oscillator frequency is 4,193MHZ higher.



Above an example of the first version with a shift delay of 7. The H&P is connected to N13. The oscillator frequency is about 11,2Mhz (in the 40M band of my transceiver) and the lock points are 43Hz spaced apart. Sample rate is 1,3KHz.

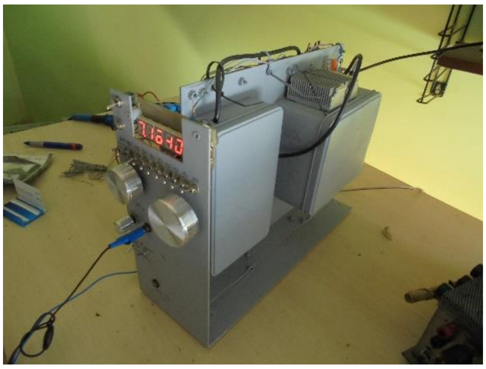


The new version has a shift delay of 135. The H&P is now connected to N9. Same oscillator frequency and lock steps are 72HZ apart. However, the sample rate or clock frequency is now 43,7KHz… That's a 32 fold increase. This version should have a much tighter hold on the wandering oscillator.

So is it better whit an additional shift register? I was hoping that the faster version would allow me to make the integrator faster but that wasn't possible. The version with the increased shift seems to me the same. Not really better. It locks impeccably on all bands, however the lock on the 10M band (+-32,5Mhz) remained unreliable.

10) Letting the circuit loose in the wild..

During the Corona lockdowns I was able to get the transceiver working. And I have a QSO card to make it official. Stan DF8WZ did complain about my signal quality but **not** about frequency drift.



At this moment ('21), after some redesigning of the SSB generator, the SSB transceiver is operational on 40M. Many QSO's have been made. The complaints about signal quality are gone and So far there were no complaints over frequency drift.

In March 2021 I had a QSO with special event station DL21EURO. The operator was fluent Italian. But after I answered his call it turned out he was Flemish like me. On the HF bands it's rare to be able to talk to a guy with the same language if you are from a pocket sized European country. Jef told me he couldn't hear that my signal was homebrew. My H&P gamble seems to have paid off. To be really sure the transceiver has to be expanded to other bands. We'll see.

The tank coil windings has been glued together. Making the H&P slightly more resistant to physical chocks. Anno 2022 QSOs were made, also on 80M and even 20M. The inability to handle physical shocks is doable. As long as you don't put your coffee mug violently on the shack table you're fine.

Had many complaints, normally my set sounds to weak. But never complaints of frequency drift.

I will certainly agree that a PLL or DDS are in a different league, in terms of frequency stability, but if a H&P is good enough for a transmitter… It can't be called bad! And lots of fun to build and operate!

My shack has no heating. In the winter it never freezes inside but it can come close. On such days the H&P keeps his locks. When the H&P is in the living room it can be say, 21°C. Also then it keeps locking. So you would conclude the H&P is immune for temperature, right? Wrong!

For about a year, from to time, I thought the H&P was defect. It sometimes just couldn’t keep his lock for a long period, then it locked again?

It took me about a year to realize that the H&P only is able to lock when the entire transceiver is on ‘room temperature’. It apparently doesn’t matter what the room temperature actually is. So if you move the transceiver/ H&P to a room with a different temperature you have to wait for a ‘lock’ until the whole transceiver has the same temperature as the room temperature. Can take up to an hour, coooooool.

The switches to select the bands on my transceiver, are the same switches that select the N-points for the H&P. So selecting the N-points can’t go wrong and go ‘unnoticed’.

11) My H&P vacation was over.

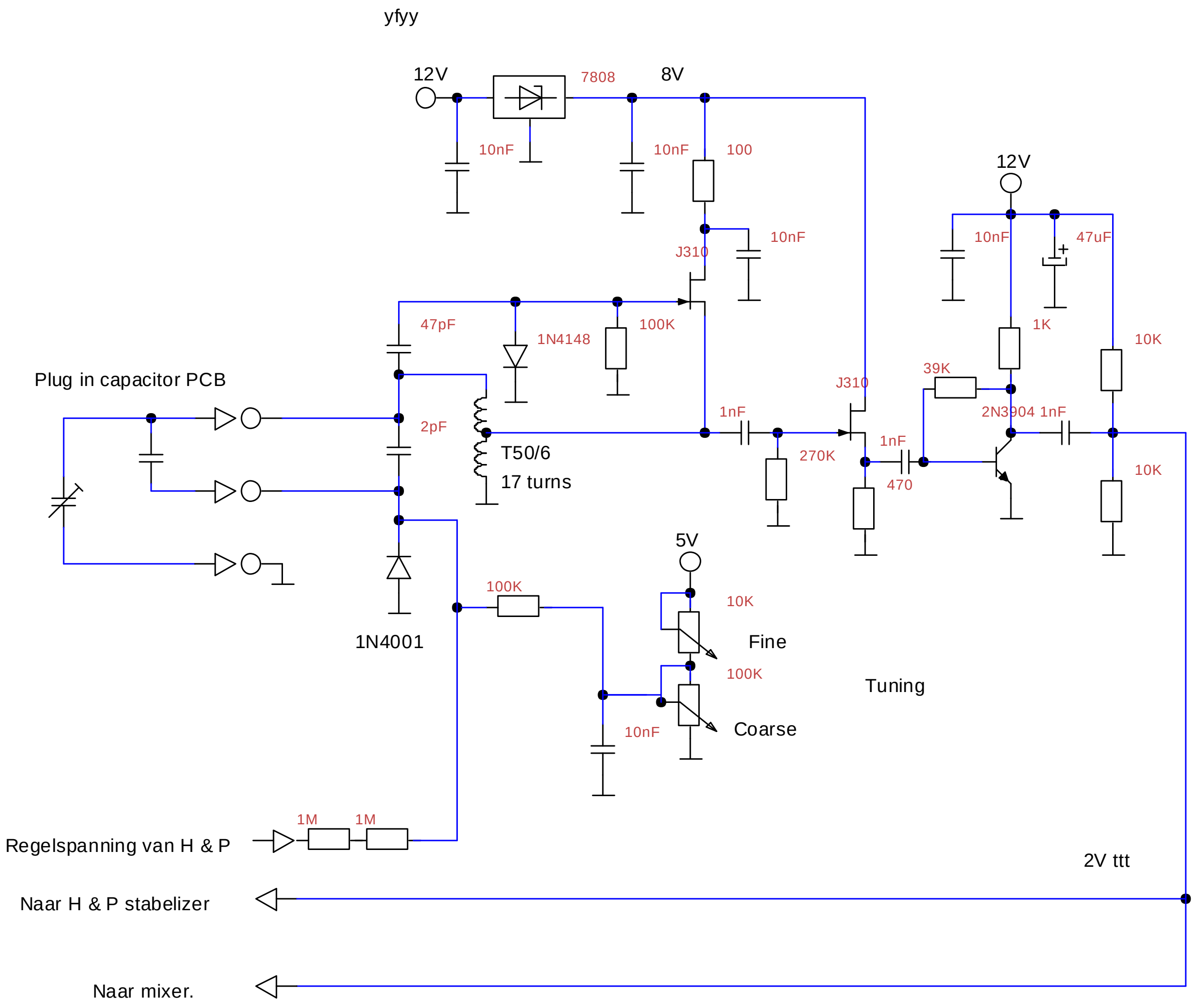
Anno 2022 the SSB transceiver is all band! For this feat, I needed to increase the Intermediate frequency of the transceiver from 4,194Mhz to 11Mhz and thus, consequentially, all the oscillator frequencies, pfff.

However, before I could tackle that I noticed a flaw in the design. The (cheap) oscillator switches had become intermittent.

Above, the culprits!

I could replace them with better, more expensive, switches but, instead, I opted for plug-in PCB’s for every band.

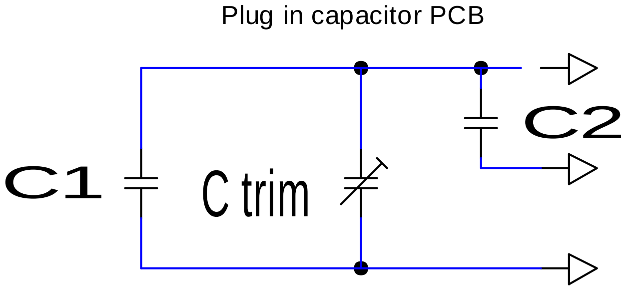
12) Could this be the final version?



Above the new oscillator schematic. Looks a lot simpler, doesn't it? Notice that the varicap now is an **ordinary** "garden variety" **1N4001** (instead of an difficult to obtain BB510 "medium wave" varicap)

Caused by the new higher intermediate frequency of the transceiver the all-band H&P oscillator has to work on an entirely new set of frequencies.

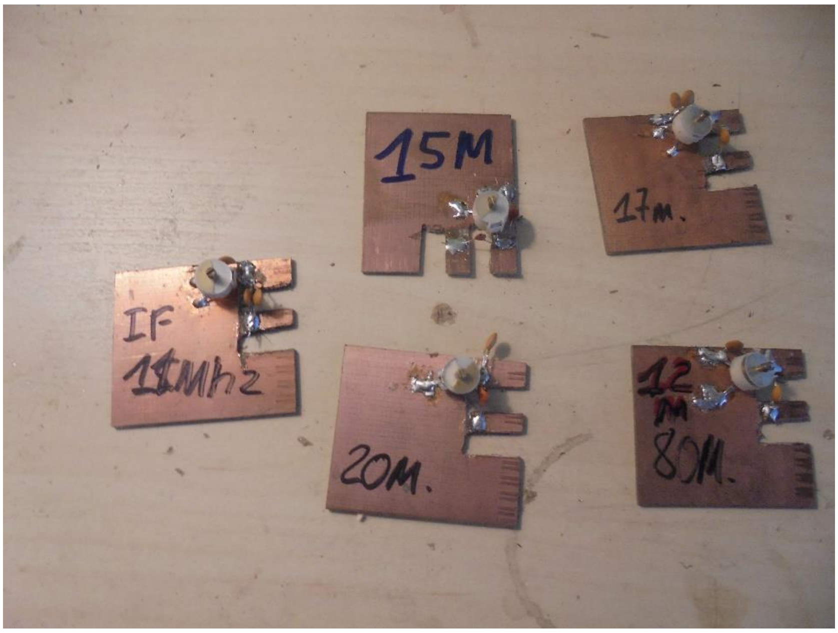
Every band has his own PCB and has **again about 1Mhz tuning range.**



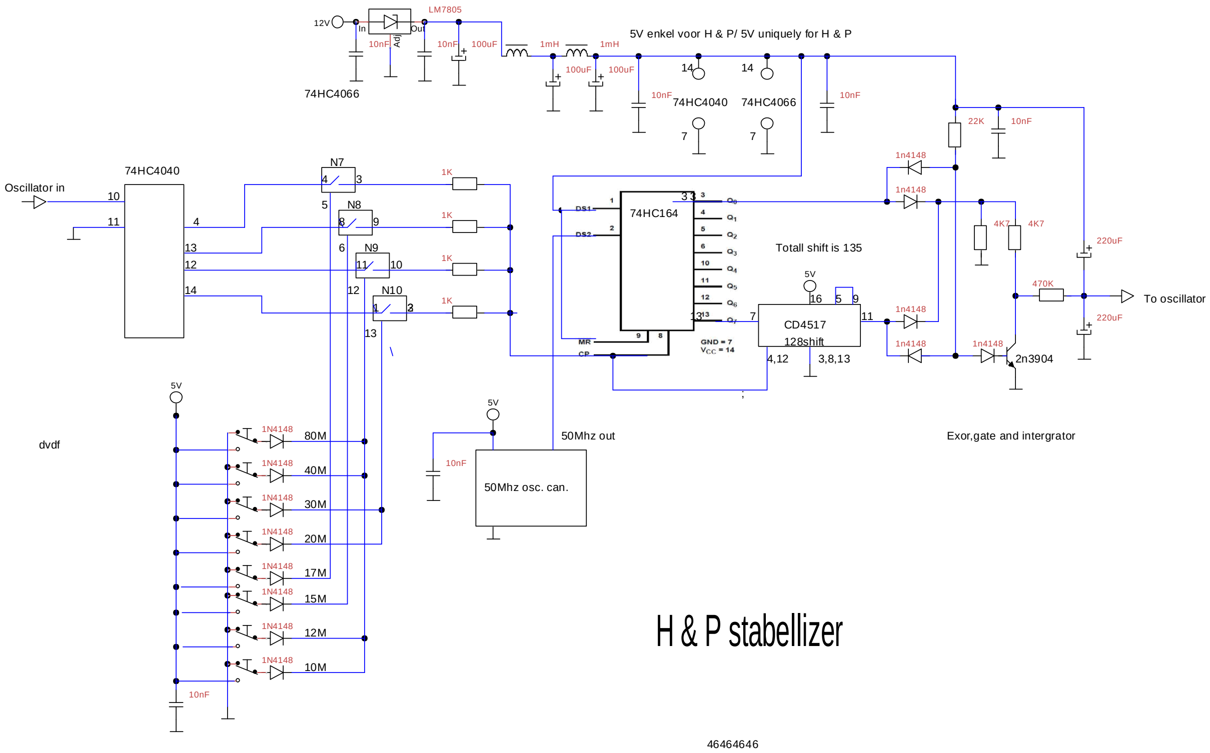
	Ctrim	C1	C 2	Oscillator Frequency	IF
80 and 12M	40p	47p	47p	14,5MHz	11 Mhz
40 and 10m	40p	/	22p	18Mhz	11 Mhz
20M	22p	/	10p	25MHz	11 Mhz
17M	60p	220p	470p	7MHz	11 Mhz
15M	40p	47p	47p	13Mhz	8 Mhz

(17, 15, 12 and 10M are upconverted in the transceiver)

Above, the practicle construction. The PCB holder is bought super cheap via Ali express.



Various plug-in oscilator PCBs for my SSB transceiver.



Band/Frequency (MHZ)	Division	Step (HZ)	Clock frequency
80M; 3,5/4	N9	61	28.5kHz
40M; 7 /7,3	N9	95	35.4kHz
30M; 10,1/10,15	N10	63	20.5kHz
20M; 14/14,3	N10	91	24.5kHz
17M; 18,068/18,168	N7	58	55.4kHz
15M; 21/21,45	N8	96	50.7kHz
12M; 24,89/24,99	N9	61	28.5kHz
10M; 28/29,7	N9	95	35.4kHz

80 and 12 use the same PCB. 40 and 10 use the same PCB.

The second version of the all band H&P uses diferent frequencies than the first version because of the much higher intermediate frequency of the transceiver. For example, 20M = 14 Mhz so then the oscilator runs at 14+11= 25Mhz whit a band spread of about 1Mhz. Finding the new divider settings (Ns) for the stabelizer was easy thanks to Peter Lawtons online calculator.

I chose to downconvert for 80/40/20 and upconvert for 17/15/12/10M thus avoiding really high frequencies like say, the 10M band, that would turn out as 28+11=39Mhz. Upconverting turn out as 28-11=17Mhz for the oscilator frequency of my transceiver. So if you wanna know if a H&P can stabelize a oscilator running on 39Mhz? Well, I don't know…

The values of the integrator remained the same, so one conclusion is that once you have the ‘fitting’ values for your integrator/oscilator you can change the operating frequency ranges of the oscilator without being penalized.

So?

The “plug-in PCB” version turned out to have one masive improvement over the old “switches” version.

With the “plug in” oscilator PCB’s, the H&P stabelizes in seconds when turned on!

The switches must have been of greater influence on the oscilator then I antisipated. Aldo the H&P was stable, the turn-on time was considerable. When the transceiver was switched on it took minutes before the H&P finaly stabelised.

It seems like the all band H&P project might be finnisched? Just thaught of the fact that the verry first H&P attempt was in 2008 and now it is 2022…

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